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ENERGISING INNOVATION, INNOVATING ENERGY

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Bit Bang II

Energising Innovation, Innovating Energy

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Foreword

Bit Bang - Energising Innovation, Innovating Energy is the second multidisciplinary graduate course for Aalto University doctoral students. A total of 23 students were selected from the three Aalto University schools: School of Science and Technology, School of Economics and School of Art and Design

Bit Bang is part of the MIDE (Multidisciplinary Institute of Digitalisation and Energy) research program which the Helsinki University of Technology started as part of its centenary celebration of university level education and research. Professor Yrjö Neuvo, the MIDE program leader and Nokia's former Chief Technology Officer, is the force behind this course.

The specific learning objectives of this course were elements of creativity and innovation and sustainable energy with emphasis on changing consumer behaviour. During the fall teamwork the students wrote reports on topics such as open innovation and sustainable ICT extension in Namibia. The textbooks used during the fall term were Dany Jacobs's Adding Values - the Cultural Side of Innovation and Richard Florida's The Rise of the Creative Class. Distinguished guest lecturers from industry and academia complemented the textbook material.

In the spring term the topic of energy was covered on global and national level, focusing on the role innovations play in addressing the challenges. The spring teamwork topics varied from ecocities to smart grids. The literature supporting the spring term subject were David JC MacKay's Sustainable Energy - Without the Hot Air, John & Doris Naisbitt's China's Megatrends and Shell Energy Scenarios to 2050. In addition to the lectures and course literature the Bit Bang group made an intensive study tour to Shanghai.

The objective of this course was to teach the students essential skills such as teamwork, multidisciplinary collaboration, global perspective, industry and business foresight, and scenario building. Passing the Bit Bang course required active attendance to lectures and seminars as well as contributing to this joint publication based on the fall and spring group assignments. The texts have been written by the students and present their views. We want to give our special thanks to Annika Artimo for her devotion and hands-on support from the beginning to the very end of this ambitious project.

We hope you all enjoy this book and find it full of refreshing new ideas.

Yrjö Neuvo & Sami Ylönen
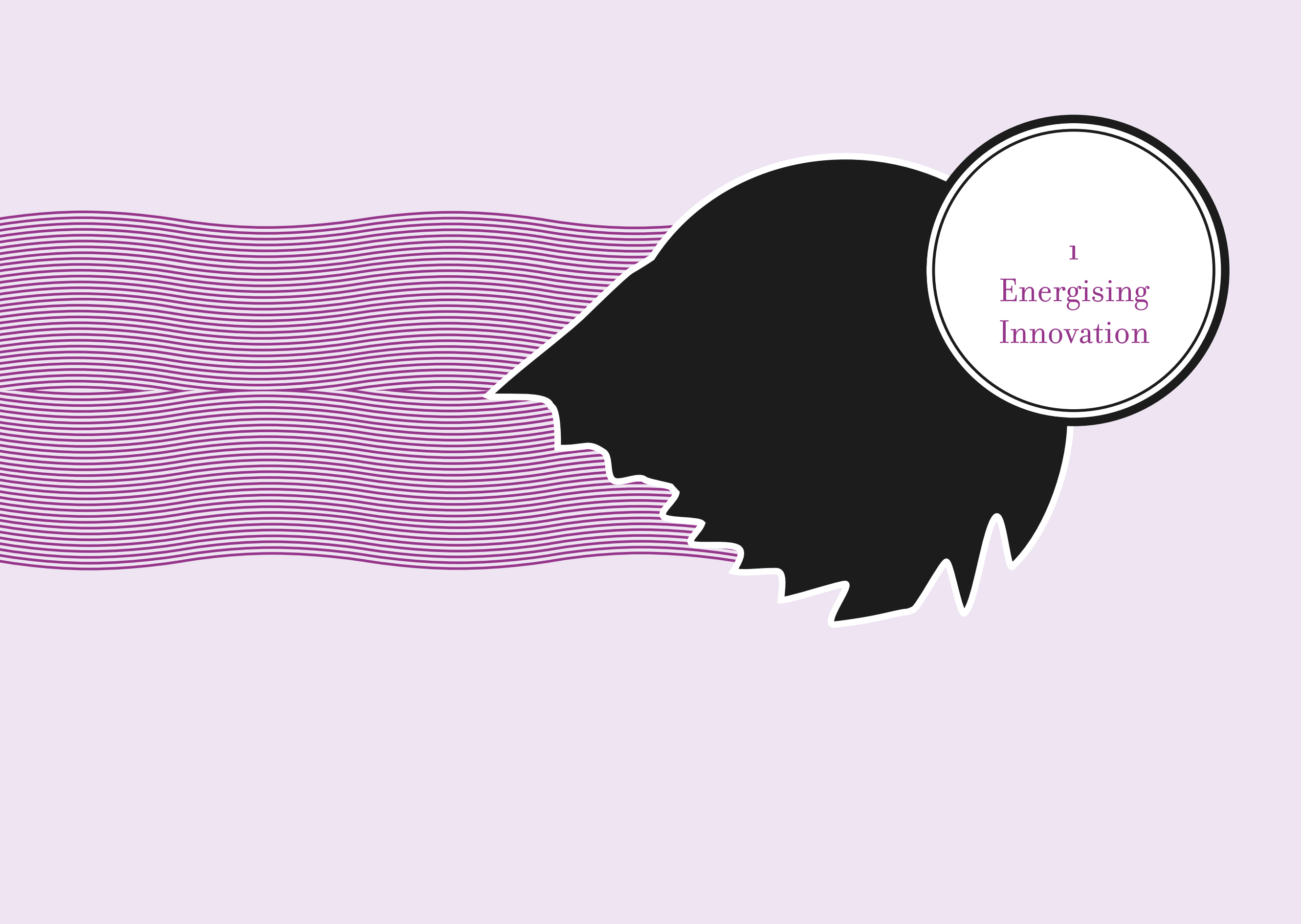
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Energising
Innovation

1.1 Creating a Flourishing Innovation Climate

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Abstract

In this chapter, we present the conditions that are needed to sustain a climate of innovation at various levels of organization and to make innovation flourish. We first look at some critical trends that affect the world and then proceed by adopting a broad, systems-theoretic perspective to studying innovation. We elaborate motivation and managing motivation for innovation climate. Next we present how innovation can be nourished by infrastructural issues like physical and virtual spaces. Innovation leadership and organization culture show how we can cultivate innovative values and motivations in organizational context. Next, we present three real-world cases of in-novation climates to highlight the importance of these factors: a Finnish case of two academic innovative spaces, a US open innovation based case and an Indian case of scaling up grass-root innovations. Finally, we conclude with practical recommendations for creating a flourishing innovation climate.

Keywords: innovation climate, motivation management, innovative spaces, virtual innovative structures, innovation leadership, systemic approach.

1 Introduction

Innovation[1] has become an all-encompassing buzzword that promises a better future, efficient solutions for human kind, improved products, financial gains and happiness in one form or another. There is no doubt about the importance of innovation for today's wealthy and prosperous future. Innovation is the term that societies and countries want to be identified with and connected to. Innovative organizations attract better people and are noticed in the media. People want be part of innovative cultures and spaces. Co-creative and empowered innovation climates foster collaborative innovations, bringing better career paths and higher salaries or satisfaction while creating solutions to serve humankind. How do we make innovations grow and flourish; how do we create an environment for innovations? In this article we focus on these questions by illustrating how innovation is embedded in a broad scale in societies undergoing change, the way it is reflected in changing valuations of people and workplace, and finally through enriched physical infrastructure and virtual spaces.

1.1 The World is Changing - New Challenges for Innovative Climates

Innovation reflects the changes in the world. Bjark Ingels, a Danish architect, said, "as an architect, one cannot create in a vacuum. One has to adapt and improvise to the accidents and opportunities that are provided by the turmoil of the world". The same is true for any innovator. To remain at the cutting edge of innovation, any innovation climate must deeply engage with the changing world. How is the world changing today? In what directions do opportunities and challenges lie?

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1   There are many definitions of innovation; in this article we define innovation as a new product, idea, process or way of thinking which is taken into practice. An innovation is substantially better than previously existing standards, and therefore highly valued. Innovation takes place simultaneously at different levels, starting from the individual, progressing through loosely-defined subgroups and formally-defined teams, up to the level of an organization, city or nation.

The world is changing from tethered to mobile. While the large-scale internet revolution brought information and virtual networks of people into homes, the latest information revolution is the mobile web. Access to the Internet through a mobile device enables people to be connected to information on the go. This, in turn, is a disruptive change leading to various innovative ways in which people interact and facilitate communication.

The world is changing from isolated to connected. Greater efficiency and creativity is being leveraged from large networks of human talent and ambition, as opposed to the solitary artists or genius inventors of yesteryear working away furiously in their basements.

The world is changing from homogeneous to diverse. Several large cities are microcosms of the world. Cultural exchange has moved from the workplace (global city) to the neighborhood (global village). In absolute numbers larger than ever before, people are changing from passive consumers of goods and services to active creators of their lifestyle. For example, so called pro-ams (professionally-skilled amateurs and hobbyists) have contributed to the open source movement in software. Hardware is poised to open up to innovators in the coming decade. Smart phones which come equipped with a software development kit, precisely to empower the crowd of innovators, arguably constitute just the tip of the iceberg.

What implications does the changing world have on career expectations and life in the workplace? Work is moving from linear to diffuse. Earlier, career paths were straightforward. Hard work, a good attitude and an amicable relationship with one's employer took you far. Today, however, at any given time, one can expect to be influenced by several factors beyond one's control. Job demands are moving from fixed to flexible, from predictable to chaotic. Rather than being able to perform one task or possess one type of skill very well, the average employee is expected to be creative all the time. Part of the reason is that to be successful in the modern economy, organizations have to form and reform alliances in dynamic networks.

A good innovation climate must be poised to counter global challenges. Some of the most imminent challenges are climate change and energy sufficiency for our growing demands as well as the shift in balance of global power and food security.
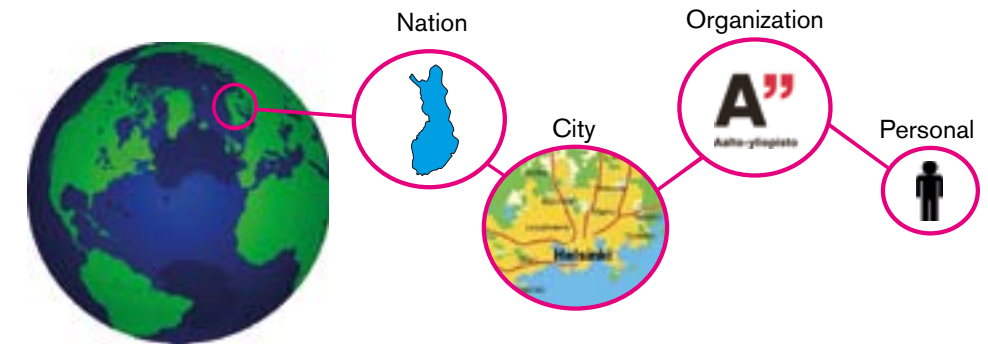

Figure 1. An innovation climate functions at several scales. Using macro indices, we can discuss national or city scales of innovation. With a closer look, organizational and even personal scales can be studied.

A contrary perspective to Ingels is provided by the famous computer scientist, Alan Kay, who coined the phrase, "the best way to predict the future is to invent it". In that vein, an innovation climate must also infuse its participants with the necessary confidence to ignore trends and go against the grain. Next we look at how innovations are always parts of larger systemic processes.

2 A Systems-view to Understanding Innovation -Weak Signals Also Matter

While the main focus of this chapter is on organizational innovation, we must recognize that organizations do not operate in a vacuum. In order to fully understand the impact of innovation policies, organizations must be studied in the context of their interactions with other organizations in a larger ecosystem [56, 58]. Thus for instance, two comparable high-tech companies with identical innovation policies such as compensation, challenge and work culture located in two different cities (say A and B) might perform vastly differently due to their differing proximity to good technical universities, the different capacities of cities A and B to attract and retain a talent pool of employees, the number of competing tech companies in the two cities, the different levels of motivation that the cultural milieu inspires, and so on. Paul Graham in Ambition and Cities [1] compares his experience in three different cities: Boston, New York and San Francisco. Being large hubs, all three cities attract ambitious people. While New York attracts people inspired by wealth, San Francisco attracts people inspired by enterprise, and Boston draws people inspired by ideas. Using this as the premise, he proceeds to describe the nature of innovations emerging from each city. Such analysis may be attributable to a systems-theoretic approach.

Systems theory is a concept that took root in biology in the 1920s to explain how organisms interact in a complex environment to produce a certain result. Since then,

systems theory has been applied in a variety of fields including engineering, physics, sociology and organizational studies. Proponents of systems theory or systems thinking advocate viewing any system under study as part of a larger environment with complex interactions between components of the system, and with external systems. This approach encourages a holistic as opposed to a reductionist view [57, 58]. Explaining individual parts of the system is necessary but not sufficient to explain the behavior of the system, as the complexity of the interactions between the parts of the system can produce unforeseen (chaotic or emergent) behavior. This approach is in direct contrast to the traditional reductionist approach in which individual parts of a system are understood by their input-output behavior.

The benefits of applying systems thinking enables one to see out-of the-box solutions, expand perceived patterns of causal interactions, and identify new interactions and weak external signals that are influencing the system. In the context of an innovation climate, such a holistic view enables one to consider the ethics and alternative interpretations of progress, environmental challenges, new forms of social interaction in virtual spaces, new motivations for businesses, and new forms of organizations and innovation climates [59–62]. One could also acknowledge the multiple time-scales at which the various components of the system interact. For instance, it is arguable that long-term goals must be prioritized because creating the innovation climate on a large scale is a challenging task and takes years to result in measurable innovation. Innovation policy makers may actively challenge themselves to take into account issues that might not be identified/relevant at the planning stage but emerge and gain relevance in upcoming years. It may also be taken into consideration that goals evolve and take shape because of variations in the larger ecosystem. Thus for instance, relevant factors at the planning stages, such as physical location, might be challenged by spontaneous co-operation in virtual spaces.

Additionally, one could anticipate and design for weak but significant causal relationships between various factors governing innovation. It is possible to imagine that these factors are interrelated. For instance, a well-designed, accessible, aesthetic and healthy workplace might impact motivation levels, which may in turn impact productivity and innovation. Improving infrastructure to get people more closely connected might increase motivation as people would talk to each other more openly and frequently, which then might increase the sense of empowerment and lead to innovation.

Thus, a systemic approach ultimately boils down to adopting a broad view of what components constitute a system and the possible complex causal relationships between them. We have identified few factors that are critical for an innovation climate to flourish–motivation, infrastructure, and organizational culture (including organizational structure, diversity and value systems). In the forthcoming sections, we discuss how these factors might impact innovation.
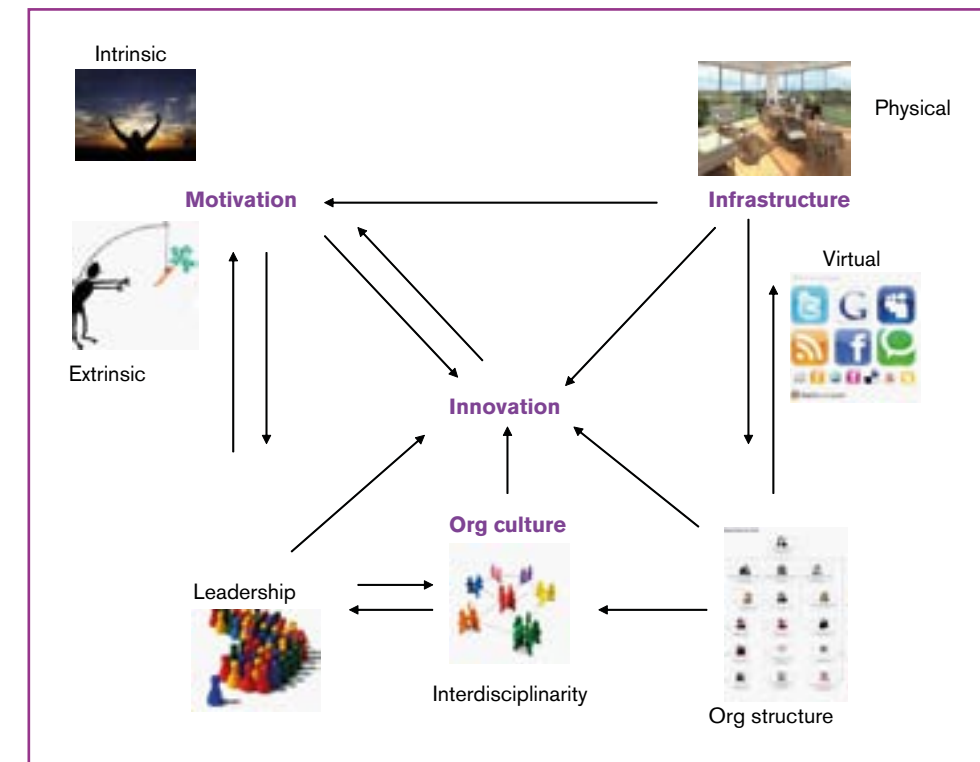

Figure 2. A systems-theoretic approach to studying innovation. The factors affecting innovation through complex causal interactions among themselves.

3 Motivation Management

Motivation may be defined as the activation or energization of goal-oriented behavior. Motivation is what is thought to cause humans to engage in various forms of behavior. In this section, we proceed to set up and answer the following questions pertaining to motivation and motivation management.

1. What factors motivate employees to innovate?
2. How can the management enhance these factors?
3. How can the management best incorporate individual differences in employees' aptitude for a specific type of problem solving?

3.1 Theories of Motivation: Intrinsic and Extrinsic Motivators

To understand what factors motivate an employee to innovate, let us briefly survey some psychological theories of motivation. The pioneering work of this field is perhaps Abraham Maslow's hierarchy of needs. Motivation studies acknowledge Maslow's need hierarchy. However, recent motivation theories like the self determina-

tion theory [12, 13, 14] take the individual and societal system into the consideration. Individual motivation is connected and enacted or constructed with the actions with environment. Maslow suggested that humans have a hierarchy of needs ranging from physiology, safety, belongingness, self-esteem and self-actualization and that behavior is driven by unfulfilled needs.

Broadly, motivation may be extrinsic or intrinsic. Extrinsic systems of motivation arise from outside of the individual, are incentive-based and cater to belongingness and self-esteem needs. Money is an obvious motivator, but social rewards such as recognition from peers and superiors, and threat or punishment can be strong motivators as well. Studies have shown that short delays between action and reward are more effective than longer delays. Such rewards are strongly associated with behavior, and over time desirable behaviors can be learned by receiving appropriate rewards. Intrinsic motivators arise from rewards inherent to the task itself, such as the love of playing or the satisfaction of solving a challenge, and cater to self-actualization needs of the individual. Intrinsic motivation towards a goal can result from a perceived challenge, a sense of autonomy, perceived growth, fulfillment inherent in the task, and a strong sense of purpose.

Herzberg's two-factor theory of motivation [2] distinguishes between "hygiene factors" (status, job security, fringe benefits, i.e. extrinsic factors) and "motivators" (challenging work, peer recognition, responsibility, i.e. intrinsic factors), both of which are necessary but not sufficient conditions for employee motivation. Theories of self-efficacy [3] suggest that perceived self efficacy for a particular skill/task is important for an individual to take up a new challenge. Victor Vroom's expectancy theory combines self-efficacy (which he calls expectancy: to what extent the individual believes s/he is capable of completing a task), external rewards and awareness (which he calls instrumentality: to what extent the individual believes that completion of task will result in a reward) and intrinsic motivation (which he calls valence: to what extent is the reward meaningful) into a set of necessary conditions for goal-directed behavior. Motivation is the product of expectancy, instrumentality and valence.

A now-classic study at Vauxhall Motors [4] introduced the concept of orientation to work. Three types of worker orientation were identified: work as a means to an end (instrumental), work as a source of status, security and immediate reward (bureaucratic), or work for membership in a social group (solidarity).

According to Dan Pink [5], three types of intrinsic motivations are most relevant to the creative employee: autonomy — the desire to direct one's life, mastery — the desire to get better and better at the job, and purpose — the desire to believe that one contributes to a larger cause than onself. These are quite similar to what Tony Hseih [6], CEO of the e-commerce success story Zappos.com, considers to be the four keys to employee happiness: perceived progress, perceived control, connectedness, and vision/meaning.

Of late, an attractive psychological theory of immersive experience has been described by Csíkszentmihályi [7, 8]. He uses the term *flow* to describe the mental state

of full involvement in an activity, and the feeling of energized focus resulting in a perceived sense of accomplishment and a desire to return to that state more often. Experiencing *flow* at the workplace motivates people to achieve that flow state again. Owing to enhanced positive emotions aroused during this state, it serves as a powerful intrinsic motivator.

According to Csíkszentmihályi [7, 8], some but not all of the following factors accompany an experience of flow*:* clear goals, a balance between challenge level and perceived ability, a distorted sense of time, complete immersion, a loss of self-consciousness, immediate and apparent feedback, the sense of being in control, and an intrinsically rewarding feeling.

Intrinsic and extrinsic motivation interact in interesting ways. The over-justification effect is particularly noteworthy. This effect is defined as the observed decrease in intrinsic motivation when offered a tangible extrinsic reward [9, 10]. The standard explanation of the effect is using the cognitive evaluation theory, which postulates that tangible reward is coercive and draws attention away from the intrinsic enjoyment of the task itself. However, not all extrinsic rewards are detrimental. For instance, informational rewards such as praise have been shown to increase self-efficacy and intrinsic motivation [11]. Further, it has been shown that extrinsic motivation is effective in situations where the task is not challenging or pleasant enough to be accomplished by intrinsic motivation. David McClelland, a noted American psychological theorist, advocated the view that workers could not be motivated by the mere need of money although money could be used as an indicator of success for various motives, e.g., keeping score. In keeping with this view, his consulting firm, McBer & Company, had as its first motto: "To make everyone productive, happy, and free." For McClelland, satisfaction lay in aligning a person's life with their fundamental motivations. To summarize the interaction between different motivators: (1) intrinsic motivators work best for creative work, (2) some extrinsic motivators reinforce intrinsic motivation while (3) other extrinsic motivators weaken intrinsic motivation, and (4) negative extrinsic motivators can increase creativity.

3.2 Motivation Management for Innovation

Why is it important to have motivated employees for innovation? Motivated employees always look for better ways to do a job. Motivated employees are more quality-oriented. Motivated employees enhance motivation of their co-workers, customers and other relations. Motivated workers are more productive. Motivated employees bring their motivation outside the workplace for their friends and families.

Maslow held money at the lowest level of the hierarchy and showed that other needs are better motivators for employees [15]. McGregor placed money in his Theory X category and claimed it is a poor motivator [16]. Praise and recognition are placed in the Theory Y category and are considered stronger motivators than money. Dan Pink [5] also recommends paying people adequately and fairly (getting the

money off the table) and then giving them lots of autonomy, i.e. autonomy of time, task, team, and technique. Indeed, the 20% time policy introduced by Google, where employees are free to work on their own projects for 20% of their time, has resulted in some leading technologies such as Gmail and Google News.

An effective leader must understand how to manage all types of characters, and more importantly, the manager must utilize avenues that allow room for employees to work, grow, and find answers independently. Steinmertz [17] discusses three common character types of subordinates: ascendant, indifferent, and ambivalent – all of whom react and interact uniquely, and must be treated, managed, and motivated accordingly. Robbins & Judge [18], identify 5 factors for an employee incentive program: recognition of employees' individual differences and clear identification of behavior deemed worthy of recognition, allowing employees to participate, linking rewards to performance, rewarding of nominators, and visibility of the recognition process. Prather [19] identified three factors that determine the motivation to innovate: resources (i.e. idea time, idea support, challenge and involvement), interpersonal factors (i.e. trust, openness, playfulness, humor, absence of interpersonal conflicts), and exploration (i.e. risk taking, debating issues, freedom of operation). Healthy competition without petty comparisons can also be a driver towards innovation as individuals and teams strive to achieve success through self differentiation. Individual and team incentives can thus be designed around competitive events. Result-only work environments, which emphasize the final result rather than adherence to protocol and schedules, have been shown to be among the optimal environments for innovatioEmployees in most organizations would like to feel that their ideas can make a difference in their workplace. For many people, there are few things more motivating than seeing a successful implementation of an idea they suggested. All too often, supervisors overlook the possibility that their employee might be an untapped gold mine of good ideas. Jacobson [20] outlines five practices, which represent an integrated approach to innovation and employee motivation that has proven to be very effective. Get to know every employee, challenge them to improve the operation, have each employee be a "customer for a day" to look at the operation from the client's point of view, institute a great idea award, and actually implement one of these great ideas.

Role models are powerful motivators. Role models offer people tangible evidence that it is possible to become what they desire to be. People relate to their role model's values and admire their personality traits. Thus, it is important for leaders and managers to lead by example.

Negative constraints can sometimes reinforce motivation by presenting a challenge. The aphorism "necessity is the mother of invention" indeed holds true. If not for the constraints on the size of electronic memory registers and buffers in the 1960s, efficient computational algorithms would not have evolved. In computer science, constraints in time and storage of memory spawned the entire field of computational complexity theory.

Shared goals, a sense of purpose and meaningful work, drive people to collaborate in the arena of innovations [21, 22]. As people co-operate, their collective consciousness plays a role in innovative work [23].

Engaging people in the right way is also a crucial factor. Tyler and Blader [24] show that a fair workplace creates engagement, which then creates better performance and happiness. Quite often, targets for work are already set without engaging those responsible for the work; consequently, their empowerment is limited and might even be detrimental to performance. On the other hand, too much empowerment might bring happiness and self-fulfillment but produce sub-optimal results. Employee empowerment should be strategically, operationally and personally aligned in such a way that there is enough space at work for charging one's batteries, joy, productive mental states and avenues for new opportunities in order to be innovation-driven. Ultimately, there is no one way to create psychological incentives for innovation.

Several authors consider the role of consciousness to be relevant in innovations. For example, Scharmer [25, 27] uses the term 'presensing' meaning that a team or group of people focus on the shared goal with purposive mind and start going deeper in sensing by consciously forbidding early answers to questions. Nonaka [26] uses the term Ba for shared space for innovation.

Csíkszentmihályi suggests several ways [7] in which a group could work together so that each individual member could achieve flow. The characteristics of such a group include creative spatial arrangements with pin walls, charts for information inputs, progress charts, craziness, a safe place where people may speak with confidence, a result wall, advanced visualization etc.

Challenges for innovation climate arise from new forms of organizations, new conceptualizations of strategy and work. Innovation is embedded in new organizational forms such as virtual worlds and open innovation arenas. All these call for new concepts of strategies, innovation and stakeholders participating in the creation of innovation and the climate. Socially constructed Innovation Designs [28] consider interpretive and social elements critical for innovation models. The strategies of organizations are seen more as complex constellations with interrelated connections to different players in the market place or global arena. New roles of the stakeholders arise as when traditional customers participate in the creation of products, services and virtual processes. The work is no longer conceptualized by the work created by one employer, but rather by constellations of participation from several arenas including co-creative places, micro-organizations (e.g. one-person entrepreneurs) and also traditional paid projects for one or many employees. The traditional wage format is transformed to include new intangible rewards, for example: respect, trust, self-actualization, meaningfulness and connected to one's own personal goal and collective aspirations of a bigger whole. Some authors encourage a more holistic mindset [24, 29, 30] for taking these challenges into account and developing new collaborative ways for organizations, businesses, educators and people within the global ecosystem [24, 29, 61]. These new ways may require a new ethical stance [30] where the in-

dividual egoistic ethics are no longer appropriate as people belong to more socially sustainable and ecologically sensitive ethical constructions.

A creative climate and its ability to create economic performance and welfare are also of utmost interest to the European Commission, its individual nations and different global players. Hollanders and van Cruysen [31] have scored the EU Member countries' relative performance in creating optimal climates for innovation. The performance in the index is based on creative education, self expression and openness together with tolerance. The top five countries are Sweden, Denmark, Netherlands, Belgium and UK. Interestingly, education for creative sectors is prospering in Finland according to the results, but openness and tolerance are quite low compared with the top five countries. This supports the assertion that the soft factors for innovative and creative cultures, such as mental models, communication and motivations are of utmost importance. The evaluation report [32] for the Finnish National Innovation System takes a more optimistic stance on the national innovation culture: the report even states that Finnish Innovation system might be the best in the world. The truth might be somewhere in between, as the results reflect the parameters of the evaluation.

Innovation literature tends to be biased towards technology as the driver of innovation over social and cultural factors [33]. In this section, we argue that mental attitude and motivational forces are also driving factors of innovation by enabling the organization to identify new opportunities and choices, allocate resources and exploit new innovations. Mental models are constructed collectively in organizations and teams. Individuals bring in their own mental frames of reference, values and attitudes. They hold active agency and intentionality. As mental models are not static but evolve through social interaction, mental models that enhance innovation also can be molded and trained, and mental models that inhibit innovation can be consciously reduced. Certain classes of mental models are also better suited to certain types of organizational culture.

4 Physical and Virtual Infrastructure

Physical spaces can have a tremendous impact on innovation. Although the effect of physical infrastructure on innovation is difficult to measure, it is possible to see the effect on creativity and inventions — all crucial parts of innovation.

Richard Florida [34] discusses the new workspace in *The Rise of the Creative Class* in which he describes the working environments for creative work. Just as some working space designs and arrangements were found to be beneficial to productivity in factories, different spaces are needed where people interact. Product development environment is discussed by Santamäki [35]. The goal is a healthy, functional and pleasant working environment where workers from different professions can be more effective, productive and creative. According to Santamäki, communication flow and interaction between different professions is the key element in creativity.

In addition to creativity, a link between physical surroundings and employee satisfaction exists [36]. If employees like their working environments, they are inclined to spend more time at work. Also, the environment outside the workplace can play a role when attracting a talented workforce. The surrounding neighborhood can offer services to employees that otherwise would have to be provided by the employer. The surroundings at a larger scale also affect the companies in the area, and this is one of the main theses in Florida's book.

4.1 Physical Infrastructure

If we take a closer look at the physical environment, the common factor in successful innovation space seems to be contact between people. As stated by Santamäki [36] and references therein: "Innovation is a social interactive process driven by creative people, [...] creativity takes place in a physical context." Therefore, the goal of the physical infrastructure is to put the right people together. On the other hand, by creating a bad physical environment where the right people do not share ideas and communicate, one can negatively impact creativity.

Environments for creativity are stimulating when information about e.g. work in progress, work of others and ideas under development are freely available. Resources should also be available for developing ideas further. Also, these resources should be available without excessive hierarchy, making the creativity more free in this sense. Employees should not be afraid of failing, and trying different ideas should be encouraged. Because different tasks in creativity, such as developing, research, prototyping, thinking, relaxing, communicating, etc. demand different infrastructures, these should be available. That is, there should be the right environment for each work step, and they should be controllable: a quiet space for thinking and writing, a place for teamwork where it is not distracting others' work, a place for laboratory work, a place for casual communication, and so on. And importantly, the spaces should be arranged in an efficient way, which can be different for different companies, research institutes, etc.

4.2 Virtual Infrastructure

As the world is getting smaller every day with advancing communications technology, the physical infrastructure of creativity and innovation is also bound to change. Innovation may also benefit from today's virtualization technology. Exchange of ideas over continents is easy with modern communication tools, and they may add to the invention process as long as human interaction is not forgotten.

Innovation is not necessarily limited to a certain company — it may be user-driven or in another form that benefits from a larger audience. Innovation can be distributed into networks, hubs, open spaces, and living labs. For example, Open Living Labs [37] is a Europe-wide network of living labs: "A Living Lab is both a methodology for User Driven Innovation (UDI) and the organizations that primarily use it." There

are differences between different living labs, but the common factor is human-centric involvement. As discussed in [38], the openness of living labs has been questioned due to lack of competing business and technology models. For a living lab or other virtual innovation to function fairly, the question of intellectual property rights between participants (IPRs) should be addressed accordingly.

We believe that existing *good* innovation environments can benefit from virtual infrastructures, communication tools and environments, as long as fruitful communication between people — whether physical or virtual — is not forgotten.

5 Organizational Culture

Today's organizations depend upon innovations for their survival. Only innovators will survive in the global market. ''Innovate or die'' is a genuine proposition. Are companies organized to innovate? In this section, we will explore the innovation culture in a corporation to determine how innovation impacts the management, strategy, research and development, and so on.

According to [39], cultures vary in solutions to common problems. Cultures have dominant or preferred value orientations. The five basic problems that cultures are concerned with are:

1. Relational orientation: the relationship between individuals
2. Time orientation: temporal focus of human life
3. Activity orientation: modality of human activity
4. Man-nature orientation: relationship between human and nature
5. Human nature orientation: character of innate human nature

Culture has explicit and implicit impact on decisions, which are made during meetings, interactions, negotiations and compromises. In addition, culture also has significant impact on performance, assessment and reward systems, marketing and advertising blunders, problems with cross-border alliances, integration of acquisitions, and frustration.

Culture is meaningful only as a within-group phenomenon. A culture group can be organized in various levels, such as national, corporate, professional, sub-groups level, and so on. In this chapter, we mainly focus on corporate culture from the innovation point of view.

Ekvall [40] classified the creative climate in a large number of Swedish organizations as high, low, or average in terms of innovative development of products/services, or operational processes. The results showed that, on average, innovative organizations scored differently from "stagnated" organizations on some key factors. Innovative climate organizations were characterized by open and trusting relationships with debates and discussions about ideas and not by personal conflicts. Senior management welcomed new ideas. The people were committed and highly involved in their work, creating a fun, exciting and dynamic workplace.

The results are clearly stating that open communication, easy access to people and information, good interpersonal relationships, trust, personal engagement, joy and meaningful focus of time are important for innovative culture[2].

Companies around the world are keen to innovate to improve their brand image, to increase shareholder wealth as return on investment support, and to increase market share. A culture of innovation can be a company's primary source of competitive advantage, and it can pay off steadily over the years. It ensures that all human capital is in step and striving to produce outcomes of value for the organization. But innovation is not a commodity that can be purchased or installed like computer software. Rather, it is mainly a culture which must be adopted and nurtured. Most importantly, competitors cannot copy an innovative culture.

5.1 Organizational Structure

The style of organizational innovation structure is a key factor, which can inhibit or foster creativity and innovation. It results from several sub-factors, including history, strategy, operational design, product diversity, logistics, marketing, client base and supplier base. For leaders in a company, there is no recipe for complete structural change, but insights into the properties of nurturing structures are needed to update the existing structures.

There are two basic innovation structures in a corporation: the bottom-up and the top-down innovation structure. The top-down innovation structure includes centralized command and control, clearly defined tasks, vertical communication links and obedience to supervisors usually with rigidity and inflexibility. It has the advantage that leaders set the pace, targets, and objectives. Leaders take care of the fundraising, and the implementation of the innovation is left and arranged to the appropriate, well-paid employees. In this type of innovation structure, the people in power define the future of the company. Ordinary managers and employees do not need to care about or doubt as to where their firm will find its future. Canon is one example of top-down innovation. In 1982, Canon began developing a replacement concept for the plain-paper copier business and investigated the opportunities for lightweight compact copiers [41]. The management knew that the new copier would not come into being by minor improvements in component and assembly designs. It would need a thorough analysis of the market to establish the required features, advantages and benefits. Canon approached the opportunity with a high-level project team which included a hierarchical partition.

In contrast with top-down innovation, bottom-up innovation involves decentral-

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2   Related information on this subject can be found in Chapter 1.3. What's under the open innovation umbrella? Case-studies in non-IT sectors.

ized authority, loosely defined tasks, horizontal communications, greater individual authority and flexibility. It is the innovation that originates in the bowels of the firm. Everyone is welcome to participate in bottom-up innovation. It provides the greatest challenges to innovators who come up with various ideas and are willing to go through the laborious process of first convincing themselves and then convincing several levels of management of the value of their ideas [42]. One good example of bottom-up innovation is 3M, which now operates in 63 countries and promotes entrepreneurial spirit worldwide [43]. Innovation is part of 3M's culture that has been fostered for more than seventy-five years. That culture, which provides freedom of action and opportunities for exploring new ideas, was guided by operational and financial discipline. Flat organizations with a bottom-up structure are generally preferred over hierarchical ones with a top-down structure. But experience shows that the above can be misleading. There is no innovation without leadership [44]. Flat organizations are also hierarchical to some extent. Leaders are able to inspire innovation. This they can do with their attitude manifested in their willingness and ability to listen, to encourage and to appreciate intelligent failure.

Thus, we believe both structures are important. Without the top-down support, bottom-up innovation isn't going to be very effective and vice versa: without the bottom rungs buying into the common goals of the organization, innovation will be difficult as well. In addition, creativity and innovation are not talents of a few gifted people, like those of the employees in R&D department. Innovation can come from any employee at any level. For a specific firm, whether to focus more on bottom-up or top-down structures depends on business, strategy, company history and numerous other factors.

5.2 The Value of Interdisciplinarity

With exponentially increasing specialization of knowledge, interdisciplinary teams are becoming more the norm than the exception. Today more than ever, interdisciplinarity is a necessity because most problems cannot be solved using specialized knowledge of one field alone. But interdisciplinarity is also largely an asset that can be used to continuously renew strategies, practices and goals.

David Wiley, an educationist and author, suggests that every organization needs to have its expertise covered through the following knowledge portfolios (composed by individuals or teams) [45]: the *bard* is the wise and experienced mind who "knows what's out there"; the *artisan* is the one who brings core knowledge and practices to the team; the *monk* is aware of competition and intellectual property; and the *merchant* is the "fixer" or expert negotiator who puts the team "in business".

While interdisciplinary teams bring in obvious advantages of new knowledge and diversity of thinking, they also present certain challenges. The principal challenges are efficient communication and quality control of information. Bestselling author Edward de Bono [46] proposes some methods for efficient communication within

teams. In Six Thinking Hats, he suggests six different modes of thinking represented by six colored hats. In the white hat mode, conversation is about facts and information. In the red hat mode, feelings and emotions take priority. In the green hat mode, new ideas are encouraged. In the black hat mode, critical thinking is the main focus, while in the yellow hat mode, optimism and opportunity get their deserved place. Finally, in the blue hat mode, the focus is on the big picture and the common goals of the team. By varying the color of the hat used by the facilitator throughout the meeting, it is possible to appropriately control attention and improve efficiency of discussion. These ideas have steadily gained popularity in the UK among facilitation companies since the We have discussed the role of diversity of people in an organization. But what about the diversity of knowledge and skills in one person? What is the role of peripheral knowledge in creativity/innovation? For quality control of information, we believe that the solution lies in bringing more generalists with a facilitatory mindset to the table. Our conviction, curiously enough, comes from a parable in the history of the popular science revolution. In 1959, British scientist and author C.P. Snow wrote a highly controversial essay titled "The two cultures and the scientific revolution" [47]. Snow lamented the large rift between the two kinds of scientific intellectuals, the natural scientists and the social scientists. His essay came at a time when knowledge of history and culture was more valued than scientific or procedural knowledge by the intellectual society. This in turn spawned the popular science revolution as we know it today. Scientists began taking the matter of communicating their findings to the general public into their own hands. Indeed, the book by John Brockman entitled "The Third Culture" [48] traces some of success of the popular science movement through the life and work of 23 selected scientists. We thus argue that more "third culture people" with a mindset to bridge communication gaps and mediate among intellectuals are required to leverage true value from interdisciplinary settings. An example of such an intellectual is Sir Ken Robinson, an educationist who is a Humanities major with an intuitive understanding of the digital revolution.

5.3 Leadership and Change Management

In order to create an innovation culture in a company, it should first start by leading from the top. An innovation culture is seldom built up from scratch. It has to deal with existing relationships between people, overcome traditional mindsets and embrace change. The most effective way to modify a company culture is to gradually bring about a modified behavior of employees – initiating the change from the top. A program for change can cover dozens of things ranging from dress code and office design to working hours. According to [49], leadership-driven change is typically the first step in changing a culture. Truly effective leaders have to be able to do a number of things. They have to be able to create a sense of urgency throughout the organization, artificially if necessary. Leaders also have to be able to identify and align the

best resources for the job. Besides, they have to create and communicate the vision of what they are about. This involves painting a picture of the better world that is to come from the changes that are being undertaken. Leaders must believe that innovation is what will drive business improvement. Leaders must have the ability to overcome adversity. And finally, leaders must have the necessary clout to be able to reallocate the firm's best people, resources and knowledge in a way that will support pervasive innovation throughout the company.

If leadership sets the tone for the culture of innovation, instituting a process for innovation is a tool that can help shape it. That process is an essential tool for creating an innovative culture. Otherwise, innovation will be random and subject to "divine" intervention. Shapiro [50] describes a four-step process for moving toward innovation.

1 **Envision**. This sets out to create new perspectives on everyday facts and figures and to explore, between them, relationships and patterns that might open the door to truly revolutionary insights.
2 **Enable**. This aims to bring the insights sufficiently down to earth so that it becomes possible to see the first glimmer of a solution to whatever the issue at hand.
3 **Explosion**. This step is where traditional brainstorming approaches to innovation begin.
4 **EmpowerTool**. This final step is where the really good ideas are equipped with the capability that they need in order to make them actually work in practice.

In order to move in the right direction, a company not only needs an impassioned leader but also the right people with the right skills. In addition, as Lafey and Charan pointed out [50], structuring for innovation is not a one-size-fits-all exercise. We need to design and install the right organization structures to suit the business strategy, motivation, and innovation model. In addition, innovation is neither a one-off event nor even a series of one-off events, though such events are an integral part of innovation. Innovation should be a sustainable process in which employees are always encouraged and inspired to think creatively and invited to take calculated risks with new ideas and concepts. Once embraced by employees, innovation becomes a way of life, which is the key to long-term, sustainable success in these rapidly changing circumstances. As said in [49], innovation 24 hours a day and 7 days a week is no mystery: it is the ability of an organization and the people in it to come up with new ideas to satisfy the changing whims of ever fickle customers without any special stimulation and without interruption. Innovation should permeate the organization, be everywhere, everyday, by everyone to the point where innovation feels as natural as breathing.

Finally, it must be acknowledged that innovation cultures vary tremendously across organizations. Take, for example, the Finnish meteorological instruments company Vaisala Inc. Vaisala's business is based on continuous innovation. It is at the very core of their global business. The organization has been able to sustain innovation for decades and has met all its financial goals. At Vaisala, the innovation culture follows the "engineer's dream" to invent, make the products even more fascinating, complex and efficient from an engineering point of view. On the other hand, in new start-ups at Design Factory Power Kiss Inc and Seos Inc, innovations are driven by different angles. For example at Seos, equality, close and timid co-operation and continuous communication drive the innovation culture. Equality, deep engagement and company vision for customers needing sustainability-based services are the driving force for high motivation which has been crucial for their success.

6 Case Studies

We proceed to survey three different climates for innovation from Finland, the USA and India. We focus on describing the innovation climate and providing a few examples of success stories that have led to, in some cases, a fundamental change in mindsets or policy-level impacts. For the Finnish case study, we base our description on first-hand experiences and some interviews. The others are based on readings.

6.1 The Design Factory and the Multidisciplinary Institute of Digitalisation and Energy

The Design Factory [51] is a physical, social and mental environment, which aims at supporting interdisciplinary co-operation among parties interested in innovative design and development. Architecture, working traditions and methods of the Design Factory are supporting interdisciplinary problem-based project education and research. It is an experimental platform of Aalto University and currently there are seven company partners including Nokia, Kone Oyj, Aito, Bravo Media, Powerkiss, Seos Design and Veturi Growth Partners. In order to evaluate the setup, we interviewed the Managing Directors of two company partners: Powerkiss, Ms. Maija Itkonen and Seos, Mr. Antti Pitkänen. Itkonen believes the horizontal structure and equality within the Design Factory is a boosting factor for her company's employee motivation. On the innovative climate of the Design Factory, she said "it is peaceful and at the same time provides the opportunity to increase the company's visibility". The company already has a few patents and the first product was planned for launch in Nov-Dec 2009.

In response to a question on key driving factors behind their innovative climate, Pitkänen listed some of the most important ones: effective information flow, lots of discussions with people, boosting team enthusiasm, high energy levels and connection with the outside world. Mr. Pitkänen also mentioned the effectiveness of the Design Factory that provides them with "machinery, space and visibility". The company was previously located at the Arabus incubation centre, which offered training courses for start-ups, and unlike the Design Factory, it consists of several small companies providing a useful atmosphere for a new company to communicate with other start-ups.

Based on our interviews and experience at Design Factory we describe below some issues that enhance and on the other hand set challenges for an innovative climate for the companies at the Design Factory. First, access to diverse resource pools (technology, raw materials, finance, mentorship) is made easy by maintaining an open-door atmosphere. Second, equality among different stakeholders, shared responsibility and minimal bureaucracy ensures independence to all players involved. Next, the physical infrastructure is rich, contemporary, playful, and dynamic and accommodates diverse people and events. The Factory's closeness to the Aalto University School of Science and Technology (TKK) enables them to utilize students as operative resources in testing and even in developing innovative materials. The fame of the Factory provides high visibility for the stakeholders; top executives from corporate and public sectors get to know the start-ups. All in all, the Factory provides a launching pad for fast absorption of ideas and innovations. This being said, there is a key challenge for innovation at the Design Factory: the space is limited and a growing company does start to feel this. A related issue is that the total number of start-ups is quite low, restricting discussion and quality of feedback compared to large scale innovation hubs.

Aalto's Multidisciplinary Institute of Digitalisation and Energy (MIDE) [52] also promotes radical innovation. However unlike the Design Factory it is more focused on academic research. At TKK's 100th anniversary, it received donations from industry. TKK was fairly free to allocate the money and decided to establish the MIDE program and nominated Prof. Yrjö Neuvo to lead it. Prof. Neuvo had the freedom to organize MIDE, therefore the new structure was launched in the academic world without heavy bureaucracy or reporting to back himself up. MIDE is an exceptionally liberal research program and gives room for innovations. It accommodates different projects, which are likely to produce many kinds of results. Some of them are focusing on basic technology while others study more user-oriented issues. For example, the UI-ART project headed by Prof. Samuel Kaski utilizes expertise from Computer Science, Statistics, Neuroscience, Media Technology, Architecture, and the Nokia corporation to materialize the concept of augmented reality, where human vision will be coupled with useful history, intention and recommendation by just a small set of glasses. Most of these projects have ambitious scientific goals, and they aim to create commercial products. The key innovative climate elements in MIDE, based on our interview and experience, is the freedom for professors and researchers to create in a new way in the academic world. The core projects are of strong collaborative and interdisciplinary nature opening up avenues for radical innovation.

6.2 Business Innovation Factory: Experience Labs Meet Systems-Theoretic Approach for Radical Business Overhaul

The Business Innovation Factory (BIF) [53] is an independent non-profit entity established in 2004. They are strategically located in Rhode Island, halfway between Boston and New York, with access to a diverse skill set. In their own words, "BIF brings partners together to collaborate across traditional boundaries on experiments that deliver transformative, systems-level innovation and address the most pressing problems of our time. We are committed to creating a community of innovators that is passionate about radically re-thinking how value is delivered across the public and private sectors".

The BIF philosophy ties in with two important issues we are discussing: (1) open innovation concepts/living labs and (2) a systems-theoretic approach. They have pioneered the "Experience Labs" approach to pilot various innovation projects. Again, in their own words, "collaborative Innovation Projects in the BIF Experience Labs enable innovators to test new business model designs and create proofs-of-concept, learn how others overcome implementation challenges, understand implementation realities to speed time-to-scale, and justify the return on innovation investment. BIF offers Experience Lab partners access to this unique innovation test bed — a real-life laboratory where innovators can think big, start small and scale fast. We call this capability Innovation@Scale". With a clever graphic design approach, they bring to light unique perspectives on the problem that aid re-conceptualization and redesign.

Since 2004, the Experience Labs model has re-conceptualized and delivered effective solutions in several areas such as a port security communications network, primary and trauma care, and a state-wide robotics research program. Their two Experience Lab projects for elderly care and student counseling are in progress and promise innovative improvements in the way such services are delivered and experienced.

In addition to their logistical genius and unique approach, BIF is also very outspoken about their work. To that end, they have established an extensive physical and digital outreach program. Besides sharing their work through the now already traditional online channels such as Facebook and Twitter, they distribute a monthly newsletter and convene an annual TED-like conference (http://www.ted.com) for radical ideas. Through the BIF Innovation Studio program, they curate these talks and make them freely available online.

6.3 Honeybee Network: Scouting, Recognition and Scaling up of Grass-Root Innovations

The Honeybee Network [55] forms an innovation climate of a very different kind from the ones discussed so far. One of the greatest historical examples of 'user-driven innovation' is innovation taking place at the grassroots, in the practice and renewal of so-called traditional knowledge. These innovations are largely need-based and developed by people with no formal education.

In the late 1980s, Dr. Anil Gupta [54], a professor at the Indian Institute of Management, Ahmedabad, was working in agriculture and renewable energy. He was intrigued by the ingenuity of people in the informal sector both in the villages and in the urban fringe. He had already encountered people at the bottom of the economic pyramid: farmers, artisans and the like who had relied on their own in-

tellectual faculties to solve their day-to-day problems. It struck Dr. Gupta that if a low-cost solution addressing a problem in one place can be applied to solve a similar problem elsewhere, and if this could be converted into a product which could generate revenue for the solution provider, then the search for such innovations was justified. To this end, he pioneered a series of initiatives to scout for such innovators, recognize them within their communities, reward them justly with revenue from their solution wherever possible, and create a culture of respect for traditional forms of knowledge as well as share new ideas. The result is the Honeybee Network, which in their own words is "a crucible of like-minded individuals, innovators, farmers, scholars, academicians, policy makers, entrepreneurs and NGOs". As of today, the network has a presence in 75 countries and has identified and rewarded more than 10,000 grassroots innovations since 1989!

One of the HBN's most famous scouting initiatives has been the Shodh Yatra [55], a week-long walk of 100-200 km through a selected rural district. Scientists, students, NGOs, entrepreneurs, policy makers, and social workers participate in the walk. The yatris (walkers) come together with an attitude to discover, learn and celebrate creativity at the grassroots. During the village walks, meetings are held to initiate a dialogue on innovation, identify and recognize creative individuals and encourage them to share their ideas, organize biodiversity competitions, recognize scholars writing in local languages, study local literature, involve the local and national press, and conduct ecological surveys.

Innovations discovered during such scouting initiatives are methodically documented. If they are found to be novel and scalable, with prior consent of the knowledge owner, they are either scaled up commercially or non-commercially. Today, several rural districts are aware of HBN's initiatives and regularly receive applications from grass-root innovators themselves, requesting them to consider the novelty of a potential invention or discovery.

7 Conclusion

For plants to grow they need the right environment, for organizations to innovate they need the right climate. If an organization wants to be innovative, it needs to ensure that the organizational climate is one which allows innovation to flourish. The climate of a team or organization can either foster or stifle innovation and creativity. We summarize this chapter by proposing that designers of an innovation climate must care about the "connectomics" of innovation foremost. Thus, we recommend that the following types of connections need urgent attention.

1. *Connect the local to the global through awareness and engagement.* This essentially ensures that innovation does not happen in a vacuum. It calls for players in an innovation climate to take into account existing success stories from around the world,

not just their city or country, build on them, establish global networks, and apply universal principles of success.

2. *Connect the leadership to the grassroots by aligning motivation.* This ensures that a balance exists between top-down and bottom-up approaches to innovation. Aligning motivations by creating win-win-win situations for all players in the innovation network, is key to sustainable innovation. It ensures a steady supply of resources and talent, a constant growth in global visibility, and a well-oiled creativity machine.

3. *Connect the diversity of disciplines through "third culture" people.* As we discussed in Subsection 5.2, third culture persons–generalists and facilitators with broad and adaptable interests–are the key to efficient interdisciplinary communication. To derive maximum value from continuous contact between people of different disciplines and motivations, third culture people are required.

4. *Connect the creators to the consumers through open systems of information exchange and empowerment.* Lastly, innovation must never operate too independently from the consumers of innovative products and services. To chisel ideas out of their time and place into workable solutions for existing problems, a system of open communication between creator and consumer must exist. Allowing consumers to participate in the creativity process can significantly reduce efforts and free up resources for more creative projects.

Above all, creating an innovation climate is like gardening. You can prepare the soil but cannot force the plants to grow.

Acknowledgements

References

1. Graham, P.: Cities and Ambition, 2008. Retrieved from: http://www.paulgraham.com/cities.html
2. Herzberg, F.: One more time: how do you motivate employees? Harvard Business Review, 46, 53–62 (1968)
3. Bandura, A.: Self-efficacy: The Exercise of Control, W.H. Freeman, New York, (1997)
4. Goldthorpe, J.H., Lockwood, D., Bechhofer, F. and Platt, J.: The Affluent Worker: Attitudes and Behaviour Cambridge: Cambridge University Press (1968)
5. Pink, D.: The surprising science of motivation. TED Global Conference July 2009
6. Hseih, T.: Happiness as a business model. TED India Conference November 2009
7. Csíkszentmihályi, M.: Flow: The Psychology of Optimal Experience, Harper & Row, New York (1990)
8. Csíkszentmihályi, M.: Good Business: Leadership, Flow, and the Making of Meaning. Penguin Books, New York (2003)
9. Deci, E., Koestner, R., & Ryan, R.: A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. Psychological Bulletin, 125, 627-688 (1999)
10. Deci, E. L., Koestner, R., Ryan, R. M.: Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. Review of Educational Research, 71, 1-27 (2001)
11. Enzle, M. A. & Ross, J. M.: Increasing and decreasing intrinsic interest with contingent rewards: A test of cognitive evaluation theory. Journal of Experimental Social Psychology, 14, 588-597 (1978)
12. Deci, E.L., Ryan, R.M. Intrinsic motivation and self-determination in human behavior. New York: Plenum (1985)
13. Deci, E.L., Ryan, R.M. The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry, 11, 227-268 (2000)
14. Ryan, R.M., Deci, E.L. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55, 68-78 (2000)
15. Maslow, A.H.: Motivation and Personality, Harper & Row, New York (1970)
16. McGregor, D.: Theory X and Theory Y. Workforce. 81, 32 (2002)
17. Steinmetz, L.L. Nice Guys Finish Last: Management Myths and Reality. Horizon Publications Inc., Boulder, Colorado (1983)
18. Robbins, S.P., Judge, T.A.: Essentials of organizational behavior, Prentice Hall, New Jersey (1997)
19. Prather, C.: How's you climate for innovation?, R&D Innovator Magazine, 5, 216 (1996)
20. Jacobson, D.: The link between motivation and innovation, http://govleaders.org/motivation.htm
21. Kahn, W.A.: Psychological conditions of personal engagement and disengagement at work. Academy of Management Journal 33, 692–724 (1990)
22. Ryan, Richard M. and Deci. E.L.: On Happiness and Human Potentials: A Review of Research on Hedonic and Eudaimonic Well-Being. Annual Review of Psychology. 52, 141-166 (2001)
23. Scharmer, C.O.: Theory U: Leading from the Future as It Emerges. Harvard University Press (2007)
24. Tyler, T.R., Blader, S.L.: The Group Engagement Model: Procedural Justice, Social Identity, and Cooperative Behavior, Personality and Social Psychology Review, 7 349–361 (2003)
25. Scharmer, C.O.: Self-transcendenting knowledge: sensing and organizing around emerging opportunities. Journal of Knowledge Management, 5, 137-150 (2001)
26. Nonaka I., Krogh. G.: Tacit Knowledge and Knowledge Conversion: Controversy and Advancement in Organizational Knowledge Creation Theory, Organization Science, 20, 635-652 (2009)
27. Botero, A., Johansson, M.,, Karhu. K. Pitkänen, O. Vihavainen, S.2009.: Flexible Services. Uner Driven Open Innovation Foundations UDOI Booster Project Working Paper v1 (2009)
28. Senge, P.M.: Taking Personal Change Seriously: The Impact of Organizational Learning on Management Practice, Academy of Management Executive, 17, 47-50 (2003)
29. Chowdhury, D.: The education of a transcendent generation. On the Horizon, 17, 153-162 (2009).Richter, J.: Future-focused learning ecologies in a rapidly evolving global ecosystem, On the horizon, 17, 163-170 (2009)
30. Lazslo, A., Laszlo, K.C. and, Dunsky, H.: Redefining Success: Designing Systemic Sustainable Strategies. Systems Research and Behavioral Science, DOI: 10.1002/sres.982 (2009)
31. Hollanders, H., van Cruysen, A.: Design, Creativity and Innovation: A Scoreboard Approach. Pro Inno Europe. Innometrics (2009)
32. Evaluation of the Finnish National Innovation System - Full Report, Taloustaito. http/: www.evaluation.fi (2009)
33. Jacobs, D.; Adding Values. The Cultural Side of Innovation. ArtEZ Press and d'jonge Hond. Arnheim. Netherlands (2007)
34. Florida, R.: The Rise of the Creative Class, Basic Books. New York (2002)
35. Santamäki, E.-M.: Introduction to re-designing product development working spaces, Helsinki University of Technology, Master's Thesis, Espoo, Finland (2008)
36. Seppänen, O. (ed.), Hongisto V., Holopainen, R., Kemppilä, S., Korhonen, P., Lahtinen, M., Lehtovaara, J., Niemelä, R., Palonen, J., Penttilä, J., Nykyri, E., Reijula, K., Saari, A., Seppänen, O., Siitonen, T., Takki, T., Tissari, T., Tuomainen, M., Valkama. E.: Tuottava toimisto 2005. Final Report, Report B77, Helsinki University of Technology. Department of Machinery Engineering. Laboratory of Heating, Ventilation and Air-Conditioning, Espoo, Finland (2004)
37. Open Living Labs -- European Network of Living Labs, http://www.openlivinglabs.eu/
38. Eriksson, M., Niitamo, V.-P., Kulkki S.: State of the art in utilising Living Labs approach to user-centric ICT innovation - a European approach. CDT, Luleå University of Technology, Sweden (2005)
39. Liisa S., Janne L. and Irmeli L. Introduction to Intercultural Communication. http://moniviestin.jyu.fi/ohjelmat/hum/viesti/en/ics
40. Ekvall, G.: Organizational climate for creativity and innovation. European journal of work and organizational psychology, 5, 105-123 (1996)
41. Canon http://en.wikipedia.org/wiki/Canon_(company)
42. Gaynor, G.H.: Innovation by Design: What It Takes to Keep Your Company on the Cutting Edge, Amacom (2002)
43. 3M http://en.wikipedia.org/wiki/3M
44. Morris, L.: Bottom-up innovation: Insights, ideas and innovation. http://www.realinnovation.com/content/c070430a.asp
45. Wiley, D.: Openness and the Disaggregated Future of Higher Education. http://www.slideshare.net/opencontent/openness-and-the-disaggregated-future-of-higher-education-presentation
46. De Bono, E.: The Six Thinking Hats. Penguin Publishers (1985)
47. Snow, C.P.: The Two Cultures and the Scientific Revolution. The New Statesman (1956)
48. Brockman, J.: The Third Culture: Beyond the Scientific Revolution. Simon & Schuster (1995)
49. Shapiro, S.M.: 24/7 Innovation: A Blueprint for Surviving and Thriving in an Age of Change. McGraw-Hill (2002)
50. Lafey, A.G., Charan, R: The Game Changer: How You Can Drive Revenue and Profit Growth with Innovation. Crown Business (2008)
51. Aalto University Design Factory http://aaltodesignfactory.fi/
52. Aalto University Multi-Disciplinary Institute of Digitalization and Energy http://mide.tkk.fi/
53. Business Innovation Factory http://businessinnovationfactory.com/
54. Anil Gupta http://www.iimahd.ernet.in/~anilg/
55. Honeybee Network http://www.sristi.org/hbnew/scout.php
56. Checkland, P.: Systems thinking, systems practice, J. Wiley & Sons (1999)
57. Jackson, M.C.: Systems Thinking. Creative holism for managers. John Wiley & Sons Ltd, West Sussex, England (2003)
58. Jackson, M. C.: Creative holism: a critical systems approach to complex problem situations. Systems Research and Behavioral Science, 23, 647-657 (2006)
59. Senge, P.M.: Innovating Our Way to the Next Industrial Revolution. MIT Sloan Management Review Winter 2001, 42, 24-38 (2001)
60. Senge, P.M.: Presense, Exploring, profound change in people, organizations and society. Nicholas Brealey Publishing, London (2006)
61. Senge, P.M, Lichtenstein, BB., Kaueufer, K.H. and Carroll, J.S.: Collaborating for Systemic Change. MIT Sloan Management Review, Winter 2007, 44-53 (2007)
62. Scharmer, C.O., Arthur, W.B., Day, J. Jaworski, J.,Jung, M., Nonaka,I., Senge, P.M.:. Illuminating the Blind Spot: Leadership in the Context of Emerging Worlds. McKinsey – Society for Organizational Learning (SoL) Leadership Project (1999-2000)

Interviews

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1.2 User Driven Innovation

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Abstract

The source and driver of user driven innovation (UDI) is a profound understanding of customer needs. Three main approaches to user driven innovation exist: the traditional sequential approach, the lead user approach and customer co-creation. The trend is toward increasing user participation throughout the innovation process. Today the leading companies successfully engage users into creative processes of their innovation activities. In the energy sector, user driven innovation methodologies appear promising, in particular as a means to improve energy efficiency and save energy.

Keywords: user driven innovation, ontology, energy sector, innovation toolkit, living lab, design research

1 Introduction

Innovation is a successful practical application of something new and useful. There are different types of innovations, such as product, process, service or paradigm innovations. Innovations can be classified into incremental, radical, sustaining or disruptive innovations.

Innovations have often been thought as technical, sometimes economical, but quite seldom cultural. Culture is seen as a source of inspiration rather than as actual innovations [1]. However, Jacobs extends this view by arguing that innovation is a cultural process through which new concepts and meanings can be created [2]. Innovation is a change in the mindset of people as it changes their cultural value systems: new necessary connections will be formed and the values will be revaluated.

1.1 Need for Innovations

Innovation is something novel, which is carried into practice; an invention that does not find its way to use does not qualify as an innovation. An idea without an application, – and in the case of private firms, without the acceptance of the markets, – is not yet an innovation. Innovations create distinctiveness and value on the market and entrepreneurial profit to the inventor. Profit motivates the pursuit of innovations.

Innovations are essential for the progress and prosperity of societies. As a consequence, many countries have a national innovation policy and strategy. Innovation strategies take into account, as broadly as possible, entrepreneurs' willingness to invest, research and design institutions and so forth. Policymakers are aware that the system must fulfill certain basic conditions that would favor the emergence of innovations. A hierarchy of needs of innovation by Sanders [3] introduces the fundamental grounds for the emergence of innovations. It consists of five stages; culture, mindset, methodology, methods, and tool and techniques (see Figure 1).
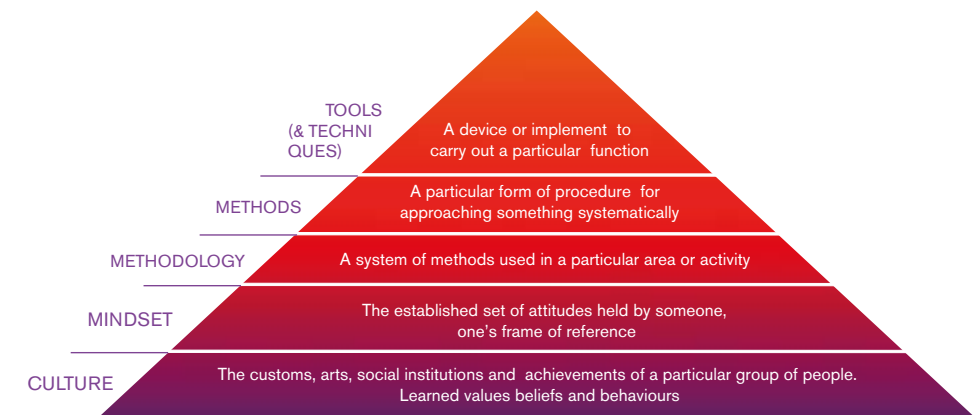

Figure 1. Sanders' hierarchy of needs of innovation [3]

1 The foundation of the pyramid is culture, consisting of customs, arts, social institutions and achievements of a particular group of people who have assimilated more or less common values, beliefs and behaviors, such as a national state. Everything done within a culture takes place with the support of that culture and will also affect it in return. Cultures are in a slow movement, affecting and being affected by the surrounding cultures and environmental changes [4].

2 A certain kind of cultural environment gives a basis for sets of attitudes held by groups of people in the culture. In a particular area or study this innovative mindset can be put into work. Ways of affecting the mindset can be very different, especially where users are involved.

3 Methodologies are aligned with the characteristics of the culture in question. They are applied according to the demands of that culture and form the theoretical grounds or a system of methods used in a particular area or activity.

4 The methods are forms or procedures for accomplishing or approaching something in a systematic or established way.

5 In order to be effective, the methodologies linked to innovation should contain tools and techniques. Tools are the actual vehicles that are visible to the end-user or co-creator, and the innovator must have the knowledge to use them. [3].

No matter which method is used for the development or design work, the five stages of Sanders' pyramid must be followed. An important factor for innovation is the individual's mood. According to Maslow's hierarchy of needs, the individual must be in the self-actualization stage, i.e. all the other stages must be satisfied before one is able to step to the uppermost level [5]. There are indications that working conditions of researchers and designers have a large impact on their innovative output [6].

The following chapter focuses on user driven innovation (UDI). According to Rosted [7], the source and driver for user driven innovation process is a profound understanding of customer needs. Next we present an ontology for user driven innovation. It is followed by a state-of-the-art analysis of user driven innovation, including case studies. We then analyze the energy sector from the perspective of user driven innovation, and finally we try to predict how user driven innovations could be applied in the energy sector in the future.

2 User Driven Innovation Ontology

A wide array of terms is associated with user driven innovation. Literature refers to user driven innovation, user innovation, lead users, participatory design, co-creation and user-centric innovation etc. Definitions of these terms are overlapping and at times confusing. Thus, reading literature related to user driven innovation can be confusing. To overcome this confusion, this chapter examines the ontology of user driven innovation. An ontology can be defined as a representation of a set of concepts, their properties and the relations between them.

To build the ontology, we shortly defined the related terms in the context of user driven innovation (see Table 1. and Table 2.). The word 'product' is expected to include also services and not just physical goods. Also in the scope of our work, users and customers are considered synonymous in this context.

Table 1. User driven innovation: definitions for various innovations

Term	Definition
demand driven innovation	user demand is the primary factor while markets, users and applications are the key drivers for innovation [8]
supply driven innovation	technology is the driver for innovation [8]
user driven innovation	a profound understanding of customer needs is the source and driver of the innovation process [7]
user/ user-centered/ user-developed innovation	innovation developed by users [9]
user-centric innovation	characterised by early involvement of users in the creation of innovations [10]
manufacturer-centric innovation	a user has needs which the manufacturer identifies and attempts to meet [11]
non-user driven innovation	non-customers are targeted in order to avoid sustaing innovation trajectory of old established markets [12]
outcome driven innovation	a needs-first approach to innovation, an approach to innovation that is focused on the job the user is trying to get done [13]
community driven innovation	a widely distributed innovation by innovation community, achieved by cooperation [11]
open innovation	a paradigm that assumes that firms should use both external ideas and internal ideas, as well as internal and external paths to market [14]
distributed innovation	decentralized problem solving [11][15]
value innovation	a business strategy that involves thinking about strategy in terms of creating new markets or redefining existing markets [16]

Table 2. User driven innovation: definitions of related terms

Term	Definition
user	a company or an individual consumer that benefits from using a product or a service [11]
lead user	users whose current needs will become general in a marketplace in the future [17]
participatory design, co-creation	developing systems, products, or services through the collaborative execution companies and customers
user-oriented/user-centric/ human-centered/user-centered design	design approaches that focus on the user, process that transforms a bundle of technology into a "product" that people desire [18]
living lab	an innovation area, trying to involve users in the innovation process in real life environments [19]
innovation toolkit	allows users themselves to customise products [20]
Blue ocean strategy	success comes from making the competition irrelevant by creating "blue oceans" of uncontested market space; value innovation is the cornerstone of the blue-ocean strategy [21]

The terms related to user driven innovation are mapped in Figure 2. The graphical representation is simplified in order to keep it readable. For example, user innovation could be connected to other innovations, as user innovation is often an input to further development. In Figure 2, three main approaches to user driven innovation can be detected. The first one is the lead user approach where the lead user is the innovator. The second approach is co-creation where both users and the company are innovators. In the third approach the company innovates based on user needs.
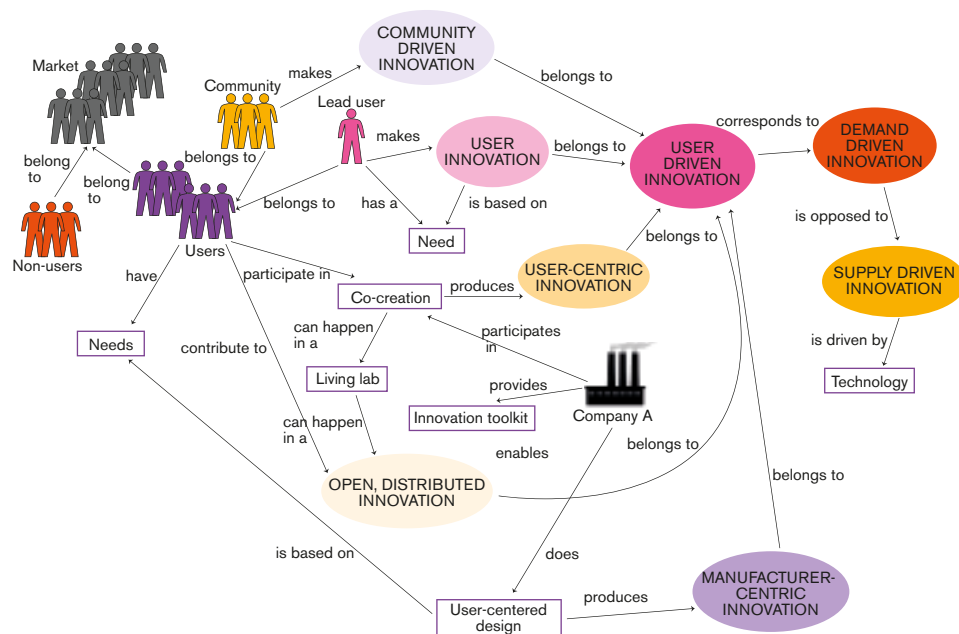

Figure 2. Mapping of terms related to user driven innovation

3 *State-of-the-art*

In parallel with the overall development of society, traditional product and service development methodologies must evolve as well. The general mantra, over the years, for these development processes has been to gather what the customer needs are and produce artifacts which would meet or exceed the needs. This user centered approach has lead to many innovations and has lead to the flourishing of many companies, but it is slowly becoming obsolete.

In order to provide innovative artifacts, companies are now actively including users in the creative process. The traditional approach has been to include users in the final stages of development in order to assess if the product or service satisfies their needs; the new approach gives users the possibility to influence the design much earlier on (Figure 3). As mentioned by Eriksson et al. [22], users should not be seen as "guinea pigs" for experiments, but rather, companies should focus on accessing the users' ideas and knowledge. An overview of the traditional and new approaches of including users in product development is proposed by Schumacher & Feurstain [23].

The purpose for this early inclusion of users is to minimize the misunderstandings between them and the development team. Indeed, when users are merely asked to state their needs, the data is often incomplete or even incorrect. It is difficult to pinpoint the exact nature of one's needs but also to state it in a way which is comprehensible to another party. Through the incomprehension, the development process is often then made up of many trips back and forth between the customer and the company and trials and errors in order to satisfy the need as represented by the upward arrows in Figure 3.
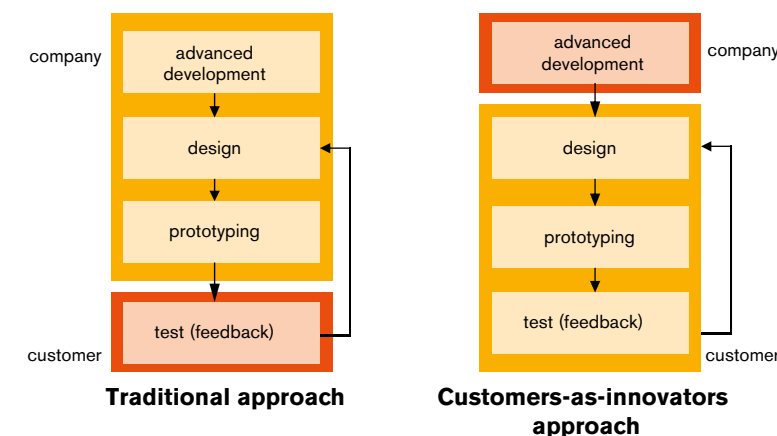

Figure 3. Traditional and new development approach

The changes in the development process must also be accompanied by changes in the company structure and people's minds. Indeed, the new approach redefines the concept of innovation ownership, which often previously was the sole property of

the company. Many parts of companies are also in need of clarification of their new tasks, for example the types of market studies required are changing and the development teams must now be in direct contact with users. That rarely happened in the traditional approach.

In the following sections, two methods of involving the users straight in the innovation process are presented as well as a case study on the different user driven innovations offered through LEGO products. The methods and points raised in the current section will be employed as a basis for proposals of user driven innovation in the energy sector in Section 7.

3.1 Toolbox Approach

User-innovation through toolkits provides companies with a different approach to scoping user or consumer needs than traditional market research does. The *toolkits for user innovation and design* allow users to create the exact product to fit their needs at their own pace and convenience. The arrival of new technology facilitates the establishment of such toolkits through, for example, user friendly web interfaces [24].

In traditional product development, the manufacturer takes on the responsibility of proposing a solution based on what has been gathered on the user needs during the final stage of the development. It is rare that the solution is accepted as is and, in many cases, changes will need to be made. Through the different changes, the development team will look at the actual user needs, which were not clearly stated or identified at the start.

The tool kit approach allows the company to outsource part of the product development to the customers. The process of trial and error is still a necessary step and will take place at the customers' convenience, therefore greatly reducing the time and monetary resources needed by the company. Once a solution suiting the customer needs is found, the development can return to the company to be finalized.

In order to provide successful solutions, the tool kits provided must be adequate for the job. The tool kits should:

1 allow users to go through multiple design cycles in order to favor the discovery of their real needs. Computer simulation is a platform which can be used in order to quickly look at multiple design options. If physical products are needed, there are many rapid prototyping options.
2 integrate a user-friendly interface which saves the users the trouble of learning a new language. For example, in the flavoring industry, specialists will talk in terms of chemical components whereas users understand in terms of different tastes such as salty or bitter.
3 indicate the production process limits, so that the users do not create something which the company providing the tool kit cannot produce.

The tool kits have been mainly used in the B2B sector with products such as industrial flavoring or micro-chips. The use of tool kits has allowed many companies to stay competitive and work with clients who were not part of their target group prior to the use of tool kits. For example, in the B2B sector, the main providers shied away from providing customized products to smaller clients because the development costs would have been prohibitively high.

The B2C sector is now also following the tool kit trend with major corporations such as DELL providing the possibility for each user to customize their own computer and have it quickly delivered. Due to the fast development of user-friendly user interfaces online, it is also possible to design one's own clothing, photography books, etc. The amount of user input at the early stages of the design is still very limited. In the case of customized computers, the customers only have the choice among a limited set of components, and they cannot adequately test their choice to see if the machine fits their requirements before ordering.

3.2 LivingLabs

A step further into the involvement of users in the innovation process, the concept of LivingLab, is a user-centric research methodology, which aims to bring together the different stakeholders in the design of a product. The concept of a LivingLab started at MIT, Boston and is based on MediaLab and city planning. The basic aspects of LivingLab are openness and neutrality in respect to technology or business models.

LivingLabs are being created all over the world: some of them evolve independently whereas others are linked through networks. The concept gives bilateral access where the users get to experience new and emerging products and services while companies receive feedback and contributions. Given the close proximity between the users and the development teams, the approach strives to forgo the repetitious trial and error process described in the previous paragraphs and associated with product development. The different LivingLab projects are useful for both large corporations as well as SMEs and start-ups. For the latter, a LivingLab is the perfect opportunity to demonstrate market attractiveness of proposed artifacts and receive more funding or capital. For the perennity of a LivingLab project, all stakeholders along the value-chain should be involved [25].

Below there are some examples of LivingLab activities covering multiple areas, which range from environmentally friendly houses to mobile services. As the authors do not have an extensive knowledge of the different LivingLabs, the descriptions are meant as examples and are by no means complete:

1 European Network of Living Labs [26]: the network was set up in 2006 in order to coordinate different LivingLabs throughout Europe. The project is funded by the EU and aims to support the "innovation lifecycle" which includes all the actors in the system (end-users, SME´s, corporations, public sector and academia).

2 Airport LivingLab [27]: the aim of the LivingLab is to develop ways of turning the Stockholm-Arlanda Airport into one of the world's most innovative ones.
3 Helsinki LivingLab [28]: started in 2007, the Helsinki LivingLab connects different innovation stakeholders in the Helsinki area. There are many different LivingLabs which are part of the Helsinki LivingLab, each focusing on different sectors and innovations.

The concept of LivingLabs is relatively recent and although it has already provided promising results, it needs to be validated in the long run. The different stakeholders should provide sufficient resources, both material and immaterial, in order to keep the different projects running.

3.3 UDI Case Study: LEGO

Several terms and approaches related to user-driven innovation have been defined and presented in Sections 2 and 3. Their applicability will be further explored in the following paragraphs dealing with user-driven innovation through examples about the LEGO Group, a Denmark headquartered toy manufacturer. The company operates in a global niche market.

Well-known for colorful, interlocking plastic bricks, with an accompanying array of gears and mini figures, LEGO grew from its beginnings as a small carpenter's workshop to become the world's fifth-largest toymaker. The company has been extremely successful with its extensive subculture that supports LEGO movies, games, competitions, and four LEGO-themed amusement parks resulting in considerable increases in both sales and profit. LEGO keeps a fast step, with two-digit growth rates in 2008 and revenue amounting to DKK 9,526 million against DKK 8,027 million in 2007 [29]. One of the cornerstones behind LEGO's glory is innovation. In recent years, LEGO has transformed its design process, and these changes have streamlined its product development: the processes developed by the in-house design function are now being used as a method to improve innovation across the entire business. The LEGO innovation model and tools help the entire company to [30]:

1 participate in the early stages of the design process in order to define project objectives and the innovation approach needed to deliver this,
2 anticipate and acknowledge the resources and skills required for succeeding, and
3 enable the assessment of results against set objectives at different stages of the project.

In order to avoid unnecessary redesign and replication of work, which can have a stagnating effect on creativity, the LEGO innovation model is applied to all its fundamental business sectors. These sectors include business, product, process and communication, in which activities are constantly reviewed and the right level of change is selected. User-driven innovation, as mentioned, offers great advantages over traditional innovation processes to develop exactly what consumers really desire. It is therefore not surprising that a company like LEGO figures in many examples of user-driven innovation.

3.3.1 Lead User as Co-designer

The term "lead user", defined by Eric von Hippel, refers to a specific type of user whose creativeness and innovativeness can become a source for new ideas, concepts or inventions, with or without company involvement. Lead users are characterized by two aspects: (1) They are at the leading edge of important market trends, and (2) they have a strong incentive to find solutions for the novel needs they encounter at the leading edge [17]. They innovate to solve their own problems and often develop new products or services for their own demands. Moreover, lead user innovation can also become the basis of commercial mass production.

A famous example of a lead user innovation is LEGO Mindstorms, which is a set of motors, sensors, stackable plastic bricks and a programmable NXT microcomputer for creating intelligent robots, vehicles, or whatever else one's imagination can produce [31]. The central controller of the Mindstorms brick was reverse-engineered by an Internet user group after the original product's release. The new version of the software was more efficient, and the number of potential innovators outside the company quickly increased, so that their number was even far greater than that of LEGO's original team of programmers. LEGO's response was to embrace the contributions from customers and to give a number of its lead users a license to co-design software and a new product based on their own needs and resources. Through the lead user approach, LEGO reduced the risk involved in developing new products and managed to develop a best-selling product range.

3.3.2 Community Innovation

Community innovation doesn't just happen. Community innovation is based on the creation of a better community performance through open knowledge, discussions and maturing bright ideas and solutions from outstanding individuals. Principally, it requires learning, improvement and spreading.

LEGO as a commercial company has developed standard practices and structures to support community innovation. LEGO has designed and spawned online customer communities, one example of which is "DESIGN by ME" [32], known as "LEGO Factory" prior to 2009. It provides a service which allows the users to build their own virtual LEGO models. These virtual creations can be uploaded to a gallery to be shared with the community of users around the world. Customers can view, modify, rebuild or customize and then purchase the models. The collaboration with the fan community helps LEGO create an eco-system of value creation. The community also

provides a window for LEGO into potential lead users.

LUGENT [33] is another example of community innovation. It is an adult LEGO enthusiasts' community totally independent from the company. The community discusses LEGO-related issues, follows new products or business changes, posts about creations, and polls for new ideas and the future of LEGO. The community aims to "enrich the online experience for the LEGO enthusiast in a growing number of new ways" and have users co-design open source based software to create great expert constructions.

3.3.3 Co-creation in LEGO

Co-creation, as a practice of well-collaborative execution between a company and people outside the company when they want to associate themselves with developing products or services, could be considered as a systematic approach to involve company, customers, employees and other stakeholders in product development. It provides a deep understanding of customer behavior for the company, allowing it to reduce the cost of development, increase the rate of adoption of new technologies and ideas, and most importantly deliver what customers really want. Meanwhile, co-creation offers customers the experience of creating products.

One of the most fascinating examples of co-creation with LEGO is, again, from Mindstorms. In 2004, LEGO invited four Mindstorms enthusiasts to help design the next generation of LEGO robotics. In the following years, fresh thinking from outside the company was tapped into the project with more and more expert users, corporations and organizations joining the developers› circle. Another example is LEGO Factory, more specifically, LEGO Hobby Train. Made through the LEGO Factory platform, LEGO Hobby Train is the first LEGO product completely designed by the fans. The success of LEGO Hobby Train implies that consumers can also decide about the size and content of the product range and is a strong manifestation of company and consumer co-creation.

3.3.4 LEGO'S Toolbox

Toolkits perfectly bridge the gap between a company's deep problems solution knowledge and the customer's deep problem space knowledge. In other words, customers are given the means to capture their own domain knowledge and design their own solutions while grasping the company›s resources and professional knowledge. As an innovation-led company, LEGO is always active in developing tools. For instance, the original Mindstorms was complex with its programming language, which was challenging for children. A simper language, named ROBOLAB, was developed with some help from National Instruments. It is a GUI-based and progressive programming language designed for users ages 8 and above, and it also allows the programming level to match the users› knowledge and skills. The complex

programming language has been transferred into programming blocks, and sequence beams which are the basic elements of the programming language and can be easily clicked and dragged from a palette to the programming area in order to draw the action flow of Mindstorms robots.

LEGO Digital Designer [34], another LEGO toolkit, is a CAD-like software to design virtual LEGO models. It visualizes the LEGO models users want to design, allows the creation of 3D images for interactive guidance of the building of the models and shares the models with other LEGO fans.

Moreover, LEGO Universe [35] is designed as a Massive Multiplayer Online Game (MMOG) like "World of Warcraft" and others of the kind. The characters and creatures in LEGO Universe are digital models created by the children who play in the game. As LEGO knows how to create custom toys from users' designs through projects like LEGO Factory, it is possible to have not only a digital character playing in a virtual game but also have its physical representation to play with in the physical world. In this process LEGO unites its storytelling tradition with its brick-making and platform advantages, enabling the creativity and imagination of its users to shape the real and virtual elements in the game.

LEGO is definitely one of the frontrunners in the domain of innovation. As we can see with the example of the LEGO Group, even the conventional term for an individual end user, "consumer," implicitly suggests that users are not active in product and service development. Nonetheless, there is now very strong empirical evidence that product development and modification by users is frequent, pervasive, and important.

4 Challenges, Opportunities and Enablers in User Driven Innovation

Norman [36] claims that there is no evidence that any of the new innovative products have ever been developed with the help of user driven design. He presented some examples like SMS-messages, first thought to only be of use to service operators, the light bulb, automobile, telephone, etc. None of those inventions were developed with the user driven design research method.

Norman also claimed that most of the inventions are usually technically driven. The idea of a horseless carriage, therefore an automobile, did not come from users, who would have requested a faster horse instead. They are technical solutions, which are either taken in the use by "early adapters", for example artists who often apply new innovations.

Lots of inventions that fail are being made all the time. Norman mentioned some of his designs for Apple computer like the QuickTake 200 digital camera, digital picture frame, personal digital assistant (PDA) called Newton, etc. All of them failed at the time. But now we have witnessed that the PDA and digital camera were presented much too early. They still live as a product category and they have become a big busi-

ness, although when they were invented and first presented, they all proved big flops. On the other hand, we could think that the camera had already been invented and digital technology was only an application in order to make the camera more usable for users; thus, in the development work of the camera, the user-driven approach was a method to accomplish it.

The argument is that the user driven innovation paradigm is fading because it mainly drives the sustaining innovation trajectory of old established markets because the users in the innovation process are the customers of the client and not the non-customers of the client. Thus a community of users constituting numerous non-customers is a key for future success and for a sustained presence on a market [12]. Moreover, users' insights into new product needs and possible solutions are constrained by their real-world experience [17], further calling for the inclusion of non-users in product development.

The limitations mentioned above help position user driven innovation design in the innovation field and define its possible future. As a whole, user driven innovation is gradually becoming one of the most interesting approaches to product development for certain industries. As seen in previous sections, it can provide benefits for both users and companies. For example, users are offered customized goods and services at prices close to those of mass produced ones. Users who innovate can develop specifically what they want, and innovation by users appears to increase social welfare [11]. Moreover, because there are also cost cuts for companies, they can target new markets and customers previously out of reach.

There are multiple means of achieving successful user driven innovation in a project. The evolution of communication tools can be seen as a great enabler, as it provides ways for companies and users to keep in touch easily as well as for users to discuss amongst themselves. This ease of communication also favors any further development of projects such as LivingLabs where networking and information sharing are the key. User interfaces in these are also much easier to access for average users, and this has given birth to new generations of *toolkits for user innovation and design* and has brought them to the B2C sector. More sophisticated toolkits such as small laboratory kits are common in the B2B sector for cutting costs and saving development time and play a major role in user driven innovation as shown in the previous section. The different products and services developed through toolkits sometimes do not match in complexity the ones developed in-house by companies, but the removal or abstraction of complexity appears to be an important user innovation enabler. An example of abstraction of complexity is the recent phenomenon of platforms for which users can create "applications": one example of such a platform is the Mozilla Firefox browser for which users can contribute different plug-ins.

As touched upon in the previous section, the inclusion of users from the early stages of development requires changes in mindsets and company structures. Companies need to develop new abilities, which differ from standard market research such as spotting lead users willing to be active in development. Timescales also sometimes differ between projects involving user innovation and traditional development. Open innovation projects, for example, which fall under the user innovation umbrella, do not usually have a set due date – an arrangement quite impossible to imagine for most company projects.

5 Energy Sector and User Driven Innovation

The energy sector is here defined as parties involved in producing and selling energy and includes fuel extraction, refining and distribution. One can also take a wider view and include business that is inherently linked to energy use, such as the automobile or paper industry. User driven innovation has shown promise in product design, but what might its role be in the energy sector? It has been argued that, rather than large technological leaps, fine-tuning for local conditions may well be a better focus for user driven innovation. For many reasons, there are also plenty of informed energy users who could serve as lead users.

There are two main pressures on the status quo in the energy industry. The first of these is global climate change [37]. To mitigate climate change, the world's total greenhouse gas emissions need to be reduced. There are different economic policies that try to achieve this. Since the energy sector is a large source of greenhouse gas emissions, these policies will affect it significantly. Also, business in general, and especially the energy sector, must nowadays carefully protect its reputation because news about environmental irresponsibility quickly circulates through Internet and customers are increasingly aware of environmental issues. The second main pressure on the energy sector is the diminishing reserves of crude oil. The so-called peak oil theory [38] observes that in individual oil producing countries the production rises to a certain point, the peak, where increased production is no longer economically viable, and then drops rapidly. So far the decline in some countries has been compensated by growth in others. An open question is when the worldwide peak will arrive. In the World Energy Outlook 2009, the International Energy Agency (IEA) maintains that there are available reserves, but that without large investments into the added capacity the world energy security will be at risk [39]. If oil demand exceeds supply, prices will rise and pressure on other energy sources will grow, and then energy prices could become central to business success or failure.

Both the idea of global climate change and that of peak oil have their skeptics. Here we take the stand that, as non-experts, it is sensible to assume the experts are mostly correct, despite the existence of skeptics. If either, or both, of the threats referred to turn out to be less serious than predicted then that is good news, but both are to be taken seriously with our current knowledge.

The most straightforward way to reduce greenhouse gas emissions and dependency on oil is to reduce energy consumption. Unfortunately, economic growth is generally associated with growing energy use, and a country would risk increasing poverty

without economic growth. Luckily, the link between the economy and energy can be broken to some extent by using energy more efficiently. Almost always the actual need of a person is not energy itself but rather heat, cooling, food, a manufactured product, transportation and so on. If these are produced with less energy, then less coal or oil is needed. Similarly, reusing or recycling materials can reduce the need for energy-intensive processes [40]. Apart from energy conservation, it is also possible to produce more energy from alternative energy sources. These include non-renewable ones, such as nuclear power, and renewable ones, such as solar, wind, hydro, biomass and geothermal energy. For the moment renewable energy sources can be more expensive than fossil fuel energy, and they can also have problems characteristic to them, for example wind power produces electricity only when there is adequate wind.

The energy sector is currently at a cross road. On the one hand, fossil fuels are known to almost be things of the past and, on the other, there is a lack of clear innovations linked to the energy sector. As shown in the previous sections, users can be a great source for innovations, and in the following paragraphs user driven innovation in the energy sector will be discussed.

5.1 User Driven Innovations to Energy

Energy conservation is something that everyone can do and there is already an economic incentive, savings on the energy bill! However, many people are not very innovative and do not find ways of reducing that bill. For example, they may own and live in houses where better insulation would be cheaper overall and save the environment. The green movement has been effective at getting quite a few people aware of environmental problems and the need to save energy. It has been less effective at getting "normal" people to act, even if money could be saved at the same time! A way forward could be identifying the lead users that are already conserving energy and developing their innovations into new products. There are plenty of *lead users* thanks to the green movement. For example, there are hypermilers who drive regular cars in ways that achieve great mileage, including turning the engine off when going downhill, never braking and slipstreaming large vehicles [41]. Similarly, there are biofuel enthusiasts who take waste vegetable oil from restaurants and refine it themselves for use in cars [42]. A quite different example of lead users is the environmentalist movement called Permaculture, which strives to build whole systems (e.g. farms or villages) so that fulfilling human needs for food and shelter can be done with very little energy use. The main technique is to position things properly so that they benefit one another and use the features of a particular location as well as possible [43]. Considering the difficult and dangerous tasks, the lead users mentioned above are voluntarily taking them on, using unconventional approaches. Empowering these lead users further would benefit society through increased innovation. We now turn to those technologies and trends that could empower energy users further.

The status quo as an energy user is that energy is bought, whether as electricity or gasoline, from large companies. The user can perhaps choose between renewable electricity and "traditional" electricity, but otherwise their influence over the energy production side is limited. There are emerging technologies that could empower the user to make better decisions regarding energy production and use, thus enabling UDI. A key factor is knowing one's energy use. If electricity consumption is only measured once a year, it is very difficult to know how it is used and where it is wasted. **Smart meters** measure electricity consumption continuously and can give detailed reports of consumption [44]. The **smart grid** is a technology where one plugs a device into the electric socket, and the device is connected to the provider of electricity who can charge different prices at peak hours compared to off-peak hours. Smart appliances could use this information to run during off-peak hours, and this could also reduce the peak capacity requirements, which are the most problematic to satisfy. However, currently the smart grid is suffering from problems related to users' privacy: the system would give electricity providers very detailed information about people's use of appliances and the power to shut down appliances at will [45]. Despite these problems the technology of the smart grid has potential for user-driven innovation by giving mechanisms for people to change their behaviors according to the needs of the whole system. **Decentralized production** is another important trend. It means producing electricity in many small facilities, rather than in a few central ones. For example, electricity can be produced more efficiently if the "waste" heat is not wasted but rather used for heating. This cogeneration is easier using smaller production units. In Germany, there have been trials with natural gas power plants small enough to fit in place of a heater in apartment building basements. Instead of just providing heat, as a traditional heater, electricity is provided as well for the building and the neighboring buildings. Many renewable energy sources, such as solar or wind power, are well suited for local electricity production. If technologies are developed to allow anyone to set up a small energy production facility and sell it to their neighbors, many user driven innovations become possible. As renewable sources provide energy only at certain times of the day or year, plenty of innovation is also needed on the usage side. Knowing one's own consumption is important but might not prompt action in the same way as knowing one's neighbor's consumption. In the U.S. a trial was performed where the electric bill contained also information about the consumption in the neighborhood and tips on how to reduce consumption to the levels of the most energy efficient neighbors. This **social pressure to be green** turned out to reduce overall energy consumption significantly [46]. This kind of infrastructure gives lead users a larger audience to spread energy efficiency best practices rapidly.

User driven innovation is not yet a large part of the energy sector but, as discussed above, there is a great margin for changes. The final section deals with how the energy sector might look in 2030 with the inclusion of user driven innovation.

6 Future 2030: How Does the Energy Sector Change

In order to predict how user driven innovation will impact on the energy sector in 2030, it is important to also predict the development in the surrounding fields. In the previous section we have presented the energy sector as of today and in the following paragraphs we will discuss the energy sector in the future. We cover generic trends, which will affect user driven innovations in future.

6.1 Generic Trends

Rise of the fun and game approach: We see a rise in the use of persuasive design and of a playful approach in the design of user interfaces and different touch points of everyday services. These design changes count on the fact that humans take a lot of pleasure in doing things which are playful and game-like. Instead of making the consumer feel guilty about global warming and other such phenomena, the new trend is to persuade them to adopt a better behavior by using techniques such as the game theory and making workflows enjoyable at the same time. [46]

Rise of ICT usage in non-ICT fields: A recent report from Ericsson claims that ICT usage in non-ICT sectors can bring down CO2 emissions by as much as 15%. [48]. In the future, based on the conclusions of the report, ICT in non-ICT sectors should play a crucial role.

Rise of connectivity: A recent article mentions the fact that "people change behavior for good because peer information was provided to them" [46]. It seems inevitable that further similar evidence will appear as more and more people get connected through networks. If we take a look at the numbers of connected people, 300 million users alone are on Facebook and there are 4.2 billion mobile phone users worldwide. It is a growing platform and, once most of us are onboard, the community will have a much wider impact on how we can do things collectively. There is no doubt that social media is a big enabler and that mobile Internet will also play an important enabling role. Moreover, there is also a trend in data transparency, for example Pachube is a website where companies like Helsingin Energia publish their feed about energy usage in real time [48].

If we think of our world 20 years from now, we can definitely assume significant progress in many technological fields. Some of the possible advances could be: a world which is much more connected (not only human to human but human to thing and thing to thing), ubiquitous information (democratic nature of information because of the DNA of Internet), and smart materials (wall paints which can sense, display and connect to Internet, etc.) There are already some applications which can use the data coming from networked objects to help us in better decision-making and

that will most likely be much more developed in the future. [49]

Restructuring of energy sector: With the growing demand in the energy sector and depletion of fossil fuels and a significant pressure for cleaner energy production, it is very difficult for the major energy producers to maintain the status quo. Further, with the trend of consumer generation of energy, using renewable sources like solar cells or wind farms is getting affordable with time. Personal production of energy might form a major chunk of the entire energy produced in the future as the linked technologies are getting cheaper and easier to procure for households.

We might also see a shift in the ways cities and communities are designed, as they will become more and more self sufficient and sustainable [51]. The new era of sustainable design would trigger a change in the lifestyle of people in terms of co-location of shopping and work places with residential buildings; this would reduce the commute time and save energy.

a) Emergence of decentralized production and smart grid. There is a big push for building nationwide smart grids with decentralized production units distributed as per the demand levels, which is contrary to the current centralized energy production [52]. As of today there is also a bottleneck in the energy production for storage. Storage capabilities are limited or inexistent, which means that production units are designed for peak consumption and facilities remain under-utilized most of the time. With distributed production, peak consumption limits could be lowered and local storage solutions could be developed. One such example is the electric car company Better Place [53]. Better Place is deploying a nationwide grid of electric charging points in Denmark and elsewhere; the grid could store the energy produced from wind power and make it available to the electric cars for recharging.

b) Shift from production to services. In the context of the points above, energy producers might need a shift in their business models. They might very well switch from being energy producers to being service providers, as shifting to services might help them sustain their businesses. These new services could perhaps buy back unused electric energy from personal households, provide households and enterprises with flat rate electricity subscriptions which can give them an opportunity to replace older inefficient equipment with newer efficient equipment, provide ICT solutions for energy profiling and sharing collective intelligence, and provide ICT solutions for exchange of energy between grids.

Future Personal Device: We are heading towards a generic device, which will act as a user interface for most of our daily use equipments. It will have the ability to connect to multiple networks and it evolves from the design of the current Smartphone. The device allows simple functions such as making calls but also can serve other functions through its ability to connect and share data. For example, with it one is able to see the consumption of a friend's car and compare it to his or her own. One of these future devices will be SPIME, an object that can be tracked through space and time

throughout its lifetime, a neologism coined by Bruce Sterling [53]. All manufactured consumer devices will have the capability to remember their usage and track their own history.

7 Conclusion

User-driven innovation appears to be a general trend that has yet to reach its full potential. Design research has led to the development of multiple methods and methodologies, many of which are already being applied in certain industries. Methods such as user-centered, human-centered, participatory, open innovation, community-driven design and so forth have emerged as possible solutions from research and will be further studied and the results applied. New paradigms will arise as a result.

User-driven innovation has already changed the way companies develop products and services, and they will change further in the near future. The study of the case of the LEGO Group shows that enthusiasts are willing to participate in the development phase and create products which not only benefit them but also the company. With the rise of new technologies, it is possible to develop many kinds of cooperation or co-creation platforms that are open to everyone and facilitate the inclusion of more participants in the development process.

In certain fields, user driven innovation already plays an important role, whereas in other fields, such as the energy sector, it has yet to have an influence. The energy sector is one of the industrial sectors that have changed the least over the last decades. However, with ever mounting political, social and economical pressure, it has come to a tipping point. New path-breaking inventions and changes in this sector can be foreseen for the future. The coming decades will, most likely, see a growing breed of individual innovators and further applications of user driven innovation. These will lead the way in fine-tuning the products and services for the energy sector and partially contributing to the overcoming of the energy crisis and other challenges such as global warming.

References

1. Proposal for National Innovation Strategy (2008)
2. Jacobs, D.: Adding Values: The Cultural Side of Innovation (2007)
3. Sanders, E.: Keynote speech at IASDR2009 Conference, Seoul, South Korea (2009)
4. Hofstede, G.: Culture's Consequences – Comparing Values, Behaviours, Institutions and Organizations Across Nations. Sage publications. p 11-12 (2001)
5. Maslow, A.: Maslow on Management. John Wiley & Sons, Inc. (1998)
6. Government's Communication on Finland's National Innovation Strategy to the Parliament. (2008), http://www.tem.fi/files/21010/National_Innovation_Strategy_March_2009.pdf
7. Rosted, J.: User-driven innovation Results and recommendations. The Ministry of economic and business affairs' division for research and analysis, pp106 (2005)
8. Chidamber S.R., Kon H.B.: A research retrospective of innovation inception and success: the technology-push, demand-pull question. International Journal of Technology Management 9 (1), 94-112 (1994)
9. Henkel, J., Von Hippel, E.: Welfare Implications of User Innovation. The Journal of Technology Transfer. 30 (1), 73-87 (2004)
10. Schaffers, H et al.: Exploring business models for open innovation in rural living labs. 13th International Conference on Concurrent Enterprising, Sophia-Antipolis, France, 4-6 June 2007 (2007)
11. Von Hippel E.: Democratizing innovation: the evolving phenomenon of user innovation. Journal für Betriebswirtschaft, 55 (1) 63-78 (2005)
12. Burgaard P.: Applied innovation strategies in a network society. Terranova weblog about virtual worlds (2007), http://terranova.blogs.com/terra_nova/2007/06/applied-innovat.html#more
13. Ulwick A.: What customers want: Using outcome-driven innovation to create breakthrough products and services. McGraw-Hill, New York, 256 p. ISBN-10: 0071408673
14. Chesbrough H., Vanhaverbeke W. and West J.: Open innovation – researching a new paradigm. Oxford University Press, Oxford, pp 392 (2006)
15. Lakhani K.R., Panetta J.A.: The principles of distributed innovation. MIT Press Journals, 2 (3), 97-112 (2007)
16. Kim W.C., Mauborgne R. Value innovation – The strategic logic of high growth. Harvard Business Review, July-August, 1-11 (2004).
17. Von Hippel, E.: Lead Users: A Source of Novel Product Concepts. Management Science, 32, no. 7, 791-805 (July 1986)
18. Veryzer R.W. and Borja de Mozota B.: The impact of user-oriented design on new product development: an examination of fundamental relationships. J Prod innov manage 22, 128-143 (2005)
19. Almirall, E. and Wareham, J.: Living Labs and open innovation: roles and applicability. The electronic journal for virtual organizations and networks, 10(August), 22-46 (2008)
20. Franke, N., von Hippel E. Satisfying heterogeneous user needs via innovation toolkits: the case of Apache security software. Research Policy 32 1199-1215 (2003)
21. Kim W.C., Mauborgne R. Value innovation: a leap into the blue ocean. The Journal of Business Strategy 26 (4) 22-28 (2005)
22. Eriksson, M., Niitamo, V., Kulkki, S., Hribernik, K.: State of the Art and Good Practice in the Field of Living Labs. Proceediings of the 12th International Conference on Concurrent Enterprising: Innovative Products and Services through Collaborative Networks, pp. 341-348, Milan, Italy. (2006)
23. Schumacher, J. and Feurstain, K. : Living Labs - the User as co-creator, 13th International Conference on Concurrent Enterprising, pp. 27-32 (2007)
24. Franke N, Piller F.: Value creation by toolkits for user innovation and design: The case of the watch market. J Prod Innov Manag 21:401–415 (2004)
25. Niitamo, V., Kulkki, S., Eriksson, M., & Hribernik, K.: State-of-the-Art and Good Practice in the Field of Living Labs. Proceedings of the 12th International Conference on Concurrent Enterprising: Innovative Products and Services through Collaborative Networks, pp. 341-348, Milan, Italy. (2006)
26. Open Living Labs, http://www.openlivinglabs.eu/
27. Airport LivingLab, http://www.airportlivinglab.com/
28. Helsinki LivingLab, http://www.helsinkilivinglab.fi
29. LEGO Annual Report 2007, http://lego.com/dan/info/default.asp?page=pressdetail&contentid=63606&countrycode=2057&yearcode=2008&archive=true
30. Design Council.: LEGO case study: LEGO's innovation mode, http://www.designcouncil.org.uk/About-Design/managingdesign/Design-at-EGO/LEGO-Case-study-LEGOs-Innovation-model/
31. LEGO Mindstorms, http://mindstorms.lego.com/en-us/products/8547.aspx
32. DESIGN by ME, http://designbyme.lego.com/en-US/default.aspx
33. LUGENT, from http://www.lugnet.com/
34. LEGO Digital Designer, http://ldd.lego.com/default.aspx
35. LEGO Universe, http://universe.lego.com/en-gb/Splash/Default.aspx?ReturnUrl=%2fen-gb%2fdefault.aspx
36. Norman, Don A.: Keynote speech at IASDR2009 Conference, Seoul, South Korea (2009)
37. Intergovernmental Panel on Climate Change (IPCC), Climate change 2007: the physical science basis (summary for policy makers) (2007)
38. Hubbert, Marion King. Nuclear Energy and the Fossil Fuels 'Drilling and Production Practice', Spring Meeting of the Southern District. Division of Production. American Petroleum Institute. San Antonio, Texas: Shell Development Company. pp. 22–27 (1956)

39. International Energy Agency (IEA), World Energy Outlook 2009 (2009)
40. Lovins, Amory B., Lovins L. Hunter, Hawken, Paul, A Roadmap for Natural Capitalism, Harvard Business Review, (May-June 1999)
41. Wikipedia: Hypermiling, http://en.wikipedia.org/wiki/Hypermiling
42. Make your own biodiesel, http://www.journeytoforever.org/biodiesel_make.html
43. Wikipedia: Permaculture, http://en.wikipedia.org/wiki/Permaculture
44. Wikipedia: Smart Meter, http://en.wikipedia.org/wiki/Smart_meter
45. Wikipedia: Smart Grid http://en.wikipedia.org/wiki/Smart_grid
46. Tsui B.: Greening With Envy, http://www.theatlantic.com/doc/200907/green-envy (2009)
47. The Fun Theory http://thefuntheory.com/
48. Assessing the climate-positive effects of ICT http://www.ericsson.com/technology/whitepapers/pdf/methodology_high2.pdf
49. Pachube http://www.pachube.com/
50. Ted: Ideas worth spreading, http://www.ted.com/talks/pattie_maes_demos_the_sixth_sense.html
51. Wikipedia: Sustainable city, http://en.wikipedia.org/wiki/Sustainable_city
52. Kari Alanne, Arto Saari, Distributed energy generation and sustainable development, Renewable and Sustainable Energy Reviews, Volume 10, Issue 6, Pages 539-558, ISSN 1364-0321 (December 2006)
53. Better Place http://www.betterplace.com/
54. Wikipedia: Bruce Sterling, http://en.wikipedia.org/wiki/Bruce_Sterling#Neologisms

1.3 Understanding Open Innovation

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Abstract

The term "open innovation" coined by Chesbrough in 2003 has created a lot of interest in both academia and industry. But what is open innovation? Is open innovation sustainable or is it just hype? How does it differ from traditional practices of buying and selling technology? Why is it implemented and how is it managed? For different actors, such as large companies, small companies or communities, the answers to these questions differ.

Keywords: open innovation, case studies, non-IT sector

1 Introduction

As early as 1934, a scholar called Schumpeter noticed the great dynamic effect of innovation on the economy [1]. Innovation used to be mainly focused on in-house R&D laboratories of large corporations. However, over the past several years, many erosion factors have emerged that have weakened the closed innovation model. One of these erosion factors is the growth in numbers of highly educated and mobile people. As a consequence, today a lot of relevant knowledge exists outside the company boundary. Another erosion factor is the increased accessibility to venture capital, which improves the situation for small entrepreneurial enterprises in the process of developing their own ideas into products. One more factor is the increasing importance of suppliers within the supply chain [2]. With the effects of these erosion factors, company innovation systems have transformed from closed to more open, a phenomenon described by Chesbrough in 2003 as the "open innovation paradigm" [2]. After 2003, the interest in open innovation from both academia and industry has increased drastically. Figure 1 shows how the number of published items and citations on open innovation has increased in the past two decades.
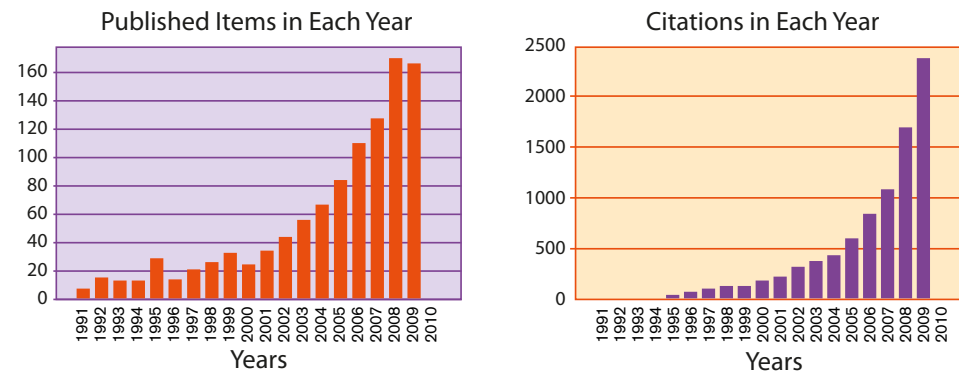

Figure 1. Published items and citations on open innovation in the past two decades [3].

Open innovation started in the information and communication technology (ICT) sector, where we can find many success stories; MySQL, Linux, Apache, Mozilla, Open Office, and Wikipedia, to name a few. We can find a lot of open innovation activity in high-tech areas such as pharmaceuticals and ICT. Moreover, the increased interest in open innovation has spread the process to other industries.

How is open innovation defined today by different actors? How does it differ from traditional practices of buying and selling technology? Why is it implemented and how is it managed? What is the difference between open innovation and open source? For different actors such as large corporations, small companies, or communities, the answers to these questions differ, and they also have somewhat different definitions of the open innovation concept. This chapter will highlight and explore the different understandings of open innovation.

1.1 Open Innovation

In the traditional closed innovation model, companies rely primarily on their own R&D departments to innovate. If these innovations do not fit to the company's strategy, they often remain unused within the company (Fig. 2) [2].
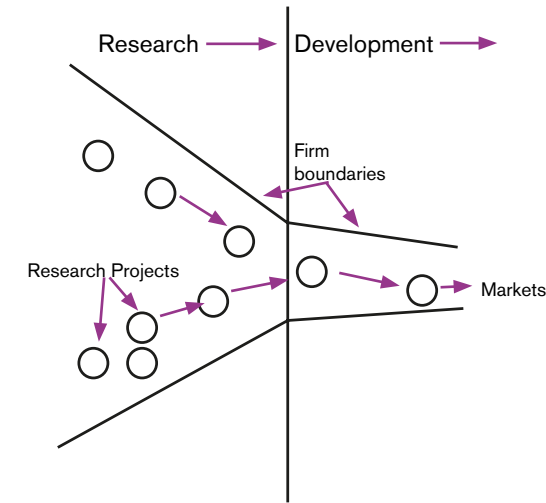
Figure 2. Closed innovation model [2].

In an open innovation system, companies look both "outside-in" and "inside-out". Outside-in means that companies outsource and integrate the external knowledge of customers, suppliers, universities, research organisations, competitors, etc. for innovation. Inside-out means that companies let unused ideas be used by other companies. Company boundaries are becoming more permeable, enabling innovation to move more easily between the external environment and the companies' internal innovation process (Fig. 2) [2].

Figure 3. *Open innovation model [2].*

According to Chesbrough, who coined the concept, "Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. Open innovation means that companies should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology" [4].

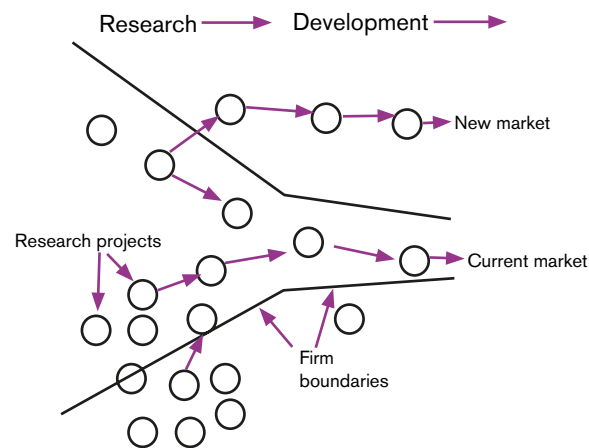In practice, this means using outside help to develop new products and processes and becoming increasingly active in licensing and selling results of innovation to third parties [5]. Companies continuously build distributed global R&D networks to sense local market trends, to tap into local knowledge, and to provide further sources of new technology. Open innovation may provide small companies with an opportunity to innovate in a global context. Open innovation can offer sources of knowledge and technology and reduce R&D costs. Furthermore, open innovation can accelerate the globalization of innovation in small high technology companies.

2 Case Studies

The following section includes six case studies from various open innovation systems and from different perspectives. The first case study explores open innovation in a traditional consumer product company, Procter & Gamble, which uses open innovation to improve the process of new product development. The case study illustrates the challenges that arise when adopting an open innovation process. It further clarifies the key success factors in organizing and operating within an open innovation environment. The second and third case focus on two relatively small companies from Denmark, Gabriel Ltd and Quilts of Denmark. Gabriel has dealt with transformation from traditional closed innovation to open innovation process whereas Quilts of Denmark has used open innovation since its establishment. The fourth case study explores how IDEO, an innovation consulting company with strong design

background, helps their clients to achieve open innovation. The last two case studies, Electric Cars – Now! and OpenStreetMap, focus on communities working with open innovation. The main interests of community open innovation are the possible development into commercial success and the motives and drivers needed in the community before possible financial benefit.

2.1 Open Innovation in a Large Corporation: Case Study P&G

In less than 200 years, Procter & Gamble (P&G) grew from a small family owned soap and candle company to a large consumer product multinational with over 130,000 employees in 80 countries. The future success of such a large global company depends, to a certain extent, on increasing their 300-brand portfolio by new product development [6]. Consequently, innovation is an important element in P&G's strategy. A few years ago, P&G changed their innovation practice from a closed to an open innovation system. Three questions arise: (1) why did P&G change their innovation practice, (2) how did P&G shift towards an open innovation system, and (3) how do they manage open innovation nowadays. To answer these questions, this case study first introduces P&G's research activities. This is followed by a description about how P&G managed the organizational changes. Finally, the case study introduces P&G's open innovation management.

2.1.1 From a Network of Trusted Suppliers to a More Open Innovation System

P&G invests more than any other company in consumer and market research ($1.6 billion in 2003). Approximately five million consumers in about 60 countries interact with P&G, and P&G conducts 15,000 research studies every year. Nearly 7,200 R&D employees of the company are exploring topics in approximately 150 sciences. P&G has been very successful in their efforts, owning today about 28,000 patents [7].

"In the past, P&G relied on internal capabilities and those of a network of trusted suppliers to invent and develop new products and services [7]." Competitive pressure, reduced R&D productivity (due to increasing R&D costs) and stagnated innovation success rate (defined by the percentage of new products that become commercial successes) forced the company to rethink their closed innovation practice [8]. The company analyzed their innovation model and discovered that the most successful products originated from internal cooperation and externally developed product ideas. Consequently, P&G decided to focus on those areas. In the future 50 percent of new products will be acquired from outside and 50 percent developed internally. P&G's new innovation model, which was introduced in 2000, was called "connect and develop" by the company. Today open innovation at P&G works in- and outbound and it covers everything from trademarks to packaging, from marketing models to engineering, and from business services to design [7]. Where previously only

15 percent of new products had an element that was developed outside P&G, today 35 percent comes from external partners. At the same time, R&D's productivity increased by 60 percent and the innovation success rate doubled [8]. The underlying idea of connect and develop is to tap into a larger pool of potential innovators. P&G estimated that about 1.5 million researchers would be interested in working with them [8]. The challenge yet for P&G was to adapt to this new strategy in terms of company culture and organizational structure.

One of the major challenges P&G faced in the transformation process was to change people's attitude from "not invented here" to "proudly found elsewhere". P&G had to address the corporate culture to change their innovation process successfully. Management had also to tackle the fear of losing R&D jobs and to promote outside innovation and internal communication. P&G did so by changing the reward system within the R&D department. The new reward system guarantees the same benefit for an employee involved in the development regardless, whether the product was developed internally or externally. The amount of the benefit actually depends on the speed of product development, which indirectly prioritises external inventions. With their new reward system, P&G ensures that employees utilise open innovation. The standard operating procedure for innovations was introduced. The guideline is: (1) look for solutions internally, and (2) look for a solution externally. Only if those two ways to look for solutions yield nothing, the company will start to research the issue from scratch [8].

The aim of connect and develop is to find and bring in good ideas. To achieve this goal, P&G works together with individuals and organizations around the world. For efficiency, P&G introduced some guidelines for external ideas – with whom and to what extent to collaborate. The company decided that an outside idea or product must have some degree of success (the product is feasible and consumer interest exists). At the same time, P&G will concentrate on ideas and products that could potentially benefit from P&G's capabilities. In addition, P&G chose to focus the open innovation process on a particular field. P&G has over 300 brands and it would have been easy to get off track [8].

2.1.2 Utilizing Both Proprietary and Open Networks

P&G utilizes two main networks: proprietary networks and open networks [8]. The main proprietary networks connect P&G with technology entrepreneurs and suppliers. The technology entrepreneur network is made up of 70 P&G employees around the world. Their responsibility is to establish the need lists, develop adjacency maps and technology game boards. They are also the main contact persons to outsiders (e.g. university or industry researchers). These technology entrepreneurs are actively seeking for new ideas. The network is organized in six regions: China, India, Japan, Western Europe, Latin America, and the U.S., and each of these regions is focusing on a specific area that is a key strength of this region. For example, China is concentrating on cost innovations, which reflects China's unique ability to

produce at a low cost. To tap into suppliers' innovation potential (the top 15 P&G suppliers combined have approximately 50,000 research employees), P&G enables a supplier network through a secure IT platform. The platform allows P&G to share technology briefs with their suppliers. This network alone led to an increase of 30 percent in joint research projects. The supplier network is only an enabler; the researchers still meet and work together at one of the partners or at the P&G research laboratory [8].

In addition to the proprietary networks, P&G collaborates in open networks. The main open networks, according to Huston and Sakkab [8], are NineSigma, InnoCentive, YourEncore, and Yet2.com. One of the founders of NineSigma was P&G. Its aim is to connect companies that have science and technology problems to organizations that can provide a solution. NineSigma publishes technology briefs, and anyone in the network can respond with a solution directly to the company with the problem. InnoCentive is comparable to NineSigma. The difference is that InnoCentive is focusing on a more specific area. YourEncore connects approximately 800 retired scientists with companies. This network allows the connecting companies with highly qualified and experienced researchers to establish short-term research projects as well as consulting. Yet2.com, on the other hand, was established by a group of Fortune 100 companies. The aim of the network is to exchange intellectual property. P&G utilizes the Yet2.com network to share research findings with other companies [8].

2.1.3 Summary of P&G Case Study

The case study of P&G shows that open innovation can add value to a big company by improving the innovation process. Transformation from a traditional innovation process to an open innovation platform is challenging, but also rewarding. A company that shifts to open innovation has to involve employees and create an innovation friendly environment. The case study illustrates that a company can utilize open and closed networks. After all, not every innovation is produced in the open marketplace.

2.2 Introducing Car Technology to Furniture Technology: An Insight Into Gabriel's Open Innovation

Gabriel Ltd was established in Aalborg, Denmark in 1851. The company is one of Europe's leading suppliers of furniture textiles. The company has 117 employees and its turnover in Danish Kroners was 280 million (approx. EUR 38 million [9]) in 2008. As the most innovative company in Denmark, Gabriel won the Danish Innovation Cup in 2007. This study explains the method of selection of partners in Gabriel and the challenges facing the company. Sustainability of the company's open innovation projects is also highlighted.

2.2.1 From Traditional Innovation to Open Innovation Process

Gabriel Ltd is one of the five Danish companies that have been very successful in open innovation projects. The company implements open innovation through innovation networks (called InnovationMaster in Gabriel) [10]. By innovating in an open environment, Gabriel is able to cooperate with the best partners in its business and take advantage of their expertise built up over many years. The company considers that open innovation is close collaboration with external partners, i.e. customers, consumers, or others that may contribute to the future development of the company in its area of business. Gabriel manages 35 open innovation projects at the moment. Around five radical innovations are credited to the company [10].

The InnovationMaster network is operated by a British company called Pera on behalf of Gabriel Ltd. Pera is one of Europe's leading innovation and business support organizations with a presence in eight European countries [11]. Gabriel's goal for the future is to become the preferred development partner and supplier to the majority of leading manufacturers of furniture, seats, and upholstered surfaces in Europe and across the world. To achieve the goal, Gabriel needs a huge input of high value product ideas and significant R&D resources to develop them into commercial products. Starting this kind of capability from scratch would have been a massive challenge [11]. Here is where Pera came in, with its methodologies to create highly differentiated ideas and its international network of research institutes in many technology areas [11].

InnovationMaster allows partnerships with international, market-leading businesses and knowledge institutions through which both radical innovation and process innovation are accomplished. As a process consultant, Pera provides its services under the following scopes; idea generation, value innovation, partner and technology scouting, consortium creation, and process and project management. Ideas can be developed, especially outside the company; InnovationMaster designs and eases the way for processes that are purposed to procreate and initiate ideas. Value innovation is a tool for the value chain and can help assess a partner's business model. The essence of value innovation is to keep doors open for different sources of innovation. For partner and technology scouting, InnovationMaster assists in finding right partners or right technology that are essential to innovation process. For consortium creation, the company maximizes original resources on the basis of working in an open innovation environment. For process and project management, since processes and projects are often innovative in nature, InnovationMaster provides support for the management of the innovation process.

One key success factor in Gabriel's open innovation process is the balanced scorecard as a management tool. The introduction of the balanced scorecard made the company more process-oriented. The use of the balanced scorecard has given the company a clear idea about where open innovation and value are created both within and outside the company. Another key success factor of Gabriel's open innovation

is its decision to participate in diverse networks. Each department in the company participates in the network and invites other groups to the company. The network has helped generate many ideas from the partners to Gabriel and vice versa, but it is hard to conclude that Gabriel benefits most from the networking. Gabriel adds new technologies to its existing technologies at the request of its network partners. Gabriel is now well established in China, but it is being careful about the practice of open innovation there because of Intellectual Property Right (IPR) concerns.

2.2.2 Selection of Partners in Open Innovation Activities

The company has been very selective in choosing its partners in open innovation activities. The company only engages with partners who have something to offer in what is being developed. Before collaborating, it always signs a confidentiality agreement with its proposed partners to assure that information and knowledge related to the open innovation remains within the partnership. Gabriel has been successful in a number of incremental innovations developed by working with its customers and partners. The company has been innovating with close to 60 furniture manufacturers around the world, but it is also making progress by working with some other industries [10]. In the area of radical innovation, the company has done some projects with Danish universities on organization and innovation.

2.2.3 Evolvement of Car Technologies Into Gabriel's Furniture Technology

One of the greatest achievements of Gabriel is the introduction of car seat technology into its furniture products because the company believes that car seats have been more innovative-looking than traditional furniture seats for years. Gabriel has also introduced the production processes from the car industry into the traditional furniture industry. In cooperation with Hay, which also deals in furniture making, Gabriel has introduced a fabric electro-welding technology to furniture manufacturing. This technology has been traditionally used by Fiat. By introducing innovative lamination of the fabric and the filler rather than the traditional method of sewing the two, this technology has yielded a reduction in the production cost of furniture. Gabriel has also been successful in collaborating with its Italian competitor, who also delivers to the car industries. The two partners see competition as insignificant if they can gain more value together through collaboration [10].

2.2.4 Benefits and Challenges of Open Innovation to Gabriel

It is the company's belief that open innovation has contributed a lot to its progress and cut its development costs. The company sees that right partnering can make better use of its investment on development. According to Pera, if three percent of the turnover is used on development without using open innovation it will yield the three percent effect. But if open innovation is implemented, the company is convinced that it will end up with an effect that doubles the development cost. The effect increases considerably with the inclusion of EU funding. The company achieves a shorter development process. The most important challenge in open innovation is to make all partners aware of their stakes and expectations. Gabriel is keeping to the rule of making its partners understand each other's positions. The company has not witnessed any negative effect of open innovation. In the nearest future, the company is trying to work on radical innovation in order to secure large EU grants. Gabriel has not experienced complications with intermediaries spinning in and out of the company. By contrast, the employees are enthusiastic about new people from outside their establishment. As it is a part of Gabriel's culture to look for help and ideas from the outside, the company does not suffer from the Not-Invented-Here syndrome or the Not-Sold-Here virus, although unused ideas that are developed by Gabriel often are handed over to other companies [12].

2.2.5 Sustainability of the Company's Open Innovation Process

Gabriel is keen to expand its open innovation culture in the future. It is hoping that more success will come up in its continued exploration of open innovation strategies. Presently, Gabriel approaches potential customers for valuable information and feedback regarding its products, and more contracts are attracted to the company due to its success in the recent innovation cup competitions.

2.2.6 Summary of Gabriel Case Study

This study has discussed some of the developments of open innovation in Gabriel Ltd. The company's open innovation group, called InnovationMaster, has done brilliantly in incremental innovation. However, so far the company has made very little progress in radical innovation. To Gabriel, open innovation reduces production cost of its innovative furniture, and consequently limits the selling price. From the viewpoint of InnovationMaster, the introduction of modern IT technology might enhance the company's open innovation process in the future.

2.3 Quilts of Denmark

Quilts of Denmark is a small company that was named as one of the most innovative companies in Denmark in 2007. This case study is looking into their sources of success. Further, the challenges and opportunities they have experienced since the company's establishment in 2000 will be addressed in the case study. Last but not the least, the prospects of their innovation are discussed as well.

2.3.1 Successful History

Quilts of Denmark is one of the international leaders in the field of high quality sleep [12]. The company has been working on manufacturing quilts and pillows since it was established in 2000. It is located in Vamdrup, Denmark, and has around 100 employees [13]. By 2007, Quilts of Denmark was named as the most innovative company in Denmark by Danish Innovation Cup in the category of small companies with less than 100 employees [12]. Quilts of Denmark bases its business strategy mainly on open innovation. It forms consortiums in which the partners decide who will own the technology from the start. Quilts of Denmark has innovated in technologies and licensed these technologies to their competitors and partners. Consequently, the company makes agreements about the areas and markets their competitors and partners can use these technologies in. Quilts of Denmark used to have no knowledge or partner in the field of high quality sleep. Therefore, it has used its networks to attract sleep researchers to co-operate with them.

2.3.2 Working with NASA on Healthy Sleep

Traditionally, making quilts was based on a sleep researcher team's idea. Sleep researchers focus their ideas on comfort, but when it comes to the difficulty of falling or staying asleep the main concern is temperature regulation in quilts. At first, Quilts of Denmark tried to develop a technology inside the company to solve this problem. However, they discovered a need for a partner. On the other side of the world, NASA had invented a technology called TEMPRAKON, which could solve Quilts of Denmark's problem. The technology was developed to protect astronauts from extreme temperature fluctuations during their missions in space [5]. By using Outlast temperature regulating material, TEMPRAKON reduces overheating and sweating and provides the individual with a comfortable sleep. In other words, TEMPRAKON technology absorbs excess body heat and releases it back when the body temperature decreases [13]. One challenge was that NASA had already sold the technology rights to Outlast Company, which used it in insulation materials in houses. In addition, there was no confidentiality agreement signed between Quilts of Denmark and NASA. Quilts of Denmark and Outlast signed an agreement on a joint development

project in which Outlast kept the technology rights for insulation materials while Quilts of Denmark would own the rights for quilts and pillows [12].

2.3.3 Advantages and Disadvantages of Open Innovation

Quilts of Denmark has the advantages of a big company when co-operating with external partners [12]. The development costs were reduced and the development time was shortened as well. There was a problem, however, with open innovation, and it was related to how to build a fair process. It is essential for any partner participating in a joint development project to have an ownership and interest in the project. Further, it would be ideal if the partners shared the same project schedule as well. Quilts of Denmark realized that working in a joint development project and with a distant partner, e.g. from China, is problematic. Therefore, Quilts of Denmark considered it would be better working in the future with partners not so far away and with the same schedule. Today, open innovation is focused on customer and product development. As a result, all partners involved in the processes of innovation are benefiting. In other words, inventors, researchers, technology and product developers, manufacturers, and customers benefit to a certain extent from these innovation processes.

2.3.4 Summary of Quilts of Denmark Case Study

The next challenge Quilts of Denmark is going to face is how to extend their area of production into other sectors such as clothing, furniture, shoes, car industry, and housing [12,13]. Innovation processes have to be continuously developed and modified for the sustainability of the company. With their limited resources, small companies like Quilts of Denmark are more reluctant than large companies to enter a high risk business. Business diversification can be used to increase the revenues in such small companies. For example, by extending the company's portfolio of products or services a regular revenue stream can be ensured. Thus, a partnership strategy based on open innovation gives small companies an opportunity to start new business with large companies. This can be done only by keeping open innovation strategies active all the time. Therefore, while development time is shortened, R&D costs are reduced. Furthermore, high profits and the company's sustainability are maintained afterward.

2.4 IDEO

IDEO was founded in 1991 by merging three industrial design firms created by their founders: David Kelley Design (by David Kelley), Matrix product design (by Mike Nuttall) and ID Two (by Bill Moggridge) in California Palo Alto. Currently, IDEO has 550 employees in eight locations: New York, Boston, Chicago, San Francisco, London, Munich, Shanghai, and the headquarters in Palo Alto. The revenue in 2007 was 90 million US dollars [14].

Traditionally, IDEO was a product design company. In its early days, the company was known for having designed the first Apple computer mouse and the first laptop Grid Compass in the early 1980s. Over the past decades, the company has evolved from a product design consultancy to an innovation consultancy. IDEO uses design thinking to help their clients achieve open innovation. The company has expanded its business from pure product design to other areas such as service design, executive training, and innovation strategy consulting services. The clients of IDEO range from small start-ups to many big Fortune 500 companies (e.g. Microsoft, Procter & Gamble, Apple, and Nokia) in a variety of industries such as computing, telecommunication, health, and education.

2.4.1 IDEO's Way of Innovation

Tim Brown (current CEO of IDEO) believes that innovation is not a continuous activity but a project-based activity. The process for choosing projects, starting projects, doing projects, and ending projects is vital for innovation [15]. The following paragraphs show how IDEO helps their clients to achieve open innovation.

Phase 1: Choosing projects
Currently, IDEO does not sell its own brand of products. Most projects are initiated when an existing company or venture-capital funded start-up identifies a technology, an unmet human need, or a strategic business [14].

Phase 2: Starting projects
IDEO creates a Hollywood-like studio system for quickly building teams around projects and disciplines. In the Hollywood studio system, a producer will pull together a team of actors, technicians and others to make a film [16]. Similarly, after a project is initiated, IDEO will quickly create a multidisciplinary team for the project. A team can consist of psychologists, anthropologists, and designers among others. The client company employees are also included in the project team. IDEO office is set up as a collection of studios. Each studio consists of about 10-20 people. Project teams operate within or across studios. The membership of project teams is drawn from across the entire organization, and participation seems to be based on recruitment rather than assignment. A team could consist of as few as three people or as many as a dozen depending on the nature of the work. A project will last from a few months to a few years.

Phase 3: Doing projects
IDEO emphasises hands-on learning on the customer requirements through a partnership between IDEO employees and client organizations. IDEO helps clients understand their company's products and services from consumers' point of view. IDEO's experts and scholars will go to in-depth research related to consumers' real-

life experience and try to understand consumers' requirements from anthropologists', art designers', engineers', psychologists' and other perspectives. Generally, IDEO will require their clients to participate in the whole process, from customer research to analysis and to conclusions, and thus arrive at meaningful solutions: by the end of the process, the clients should know what they need to do and how to implement the solution fast [17].

The outside-in and inside-out principles of open innovation are presented clearly and vividly in the IDEO innovation process. IDEO utilises outside knowledge from diverse sources (e.g. clients, customers, vendors, suppliers, manufacturers etc). They believe that the key to their success as a design and innovation company is the insights they derive from understanding people and their experiences, behaviours, perceptions and needs. For example, through observing how little children brush their teeth, they noticed that they use their whole fist namely all fingers wrapped around the handle, in contrast with older kids, who point fingers up the shaft. Consequently, they designed Oral-B's Squish Grip youngster toothbrush with a large, fat handle, so that children will feel more comfortable with the toothbrush and like to brush their teeth more often [18]. IDEO has wide-ranging collaboration experience with many different industries, which is a great advantage for them in leveraging diverse outside innovation ideas.

Inside-out in open innovation means that companies let internally unused knowledge, technologies, and inventions be used by outsiders through licensing-out, spin-off, divestment etc. However, for IDEO, inside-out means that IDEO is willing to open up its own innovation process and methodologies to outsiders such as clients, potential clients, vendors, reporters, researchers, job candidates, participants in executive programs, and students. They let outsiders to the backstage by giving interviews, inviting outsiders to brainstorming sessions, etc. [19], and they publish their innovation experiences in blogs, videos, and books. There are many benefits for letting outsiders to the inside of IDEO. For example, it is beneficial to build trust and rapport between IDEO and clients. Nevertheless, IDEO is careful to protect clients' confidentiality. As a consequence of all this, the clients will understand the IDEO innovation process better and are more likely to collaborate with them in the future.

Phase 4: Ending projects
In a Hollywood-like studio system, once the film is done the team dissolves, and its members will re-form in new combinations around other ideas [16]. Similarly, after one project is finished in IDEO, the project team will disband and its members will join in different new projects [18].

2.4.2 Summary of IDEO Case Study

The IDEO case study shows the process of IDEO as an innovation consultancy to help their clients achieve open innovation. Hands-on learning, understanding

customers' requirements from multiple perspectives as well as outside-in and inside-out principles are vital for open innovation. IDEO acts as a bridge or intermediary between clients and their customers. What they do is help clients connect with their customers in a much more effective way to understand their needs and to make their experience fundamentally better.

2.5 Community Based Open Innovation – Electric Cars – Now!

Electric cars – Now! is an open source community project that converts conventional driveline passenger cars into electric cars. This non-profit community was founded in 2007 in Finland and its aim is to produce a pool of knowledge that enables anyone to start their own conversion project. Nonetheless, when designing conversion blueprints, mass production ability is kept in mind so that any willing participant can start mass converting, using community produced knowledge. Mass conversion ability is achieved by using components available in the market as much as possible.

The community has been able to prove the feasibility of the concept by converting a used Toyota Corolla into an electric driveline car called eCorolla. eCorolla was officially presented to the general public on the 2nd of November, 2009. Electric cars – Now! is a non-profit organisation. The R&D is sponsored mainly by Fortum. For now, nobody in the community has gained any financial benefit. All the work done has been based on voluntary work.

The community states that the key success factor for the conversion work is to gain a critical mass of people willing to acquire converted electric cars. Electric cars – Now! has estimated that in the first phase 500 conversions would be enough to reduce the cost per converted car to the same base cost as that of a new conventional car.

It was the success of open source projects in the IT world that provided the inspiration for founding this community. For example, an open source operating system, Linux, has taken a major share in server markets and captured a small market share from the Windows operating system as PC home users' operating system. Open source in IT has created new business models in the field and forced the conventional closed model business to rethink their own business models and products. The community makes a strong statement that eventually open source thinking will also revolutionize the non-IT world [20].

2.5.1 Structure and Operations of the Community

There are two community workspaces: one is the assembly hall and the other is the web forum [20]. In context of this chapter, we will focus on the web forum. The forum's key function is to enable open exchange of information. It is accessible to all, not just to the members of the community, so all information is public. The contents of the forums have been placed under Creative Commons Attribution-Share Alike 3.0 licence [21]. This makes it easy to say that the project truly is an open innovation project.

So far, the forum has connected people from various backgrounds all sharing the same enthusiasm for electric cars. Marketing people, electrical engineers, mechanical engineers as well as people with background in information technology have been able to connect and work for the same goal.

The participants are divided into two groups. The first group uses forum aliases. The second group can be described as key personnel and they use their own names and share their contact information in the forum. That group consists of 25 core persons. They are more active in the project and promote the project in fairs and media, acquire contacts, and negotiate sponsorships [20].

2.5.2 How About Business?

It has been stated that the community is a non-profit organisation that only seeks to promote electric car emergence. But is there any underlying financial agenda? The community states in their operating principles [20]: "It is clear that getting a better car is a financial benefit. That is the principal motivation for getting an electric car to yourself. This is however different from pursuing profit." And later on: "Project participants can pursue for financial benefit, but this action, supplying project with products from company they are employed by, must be placed on the same line as other suppliers of products or services. It is clear however that mass converting benefits financially those who produce batteries, electric motors or other parts, import vehicles or make conversions. It is clear that people already working in that field have interest to the project and possible financial benefits it might yield."

It seems that while enthusiasm probably is the sincere primary motivation for the participants, converting 500 vehicles in a decent timeframe requires a little bit more than good will and enthusiasm. The community creates a pool of technical and non-technical knowledge that is usable by anyone. Especially the core personnel and the active members have created significant know-how. How can this know-how be capitalised?

2.5.3 From Open Innovation to Closed Business

One possibility is that part of this community decides to follow the traditional path of founding a new company or companies. The community provides enough technical and non-technical expertise to run a potentially successful company. One important step for a start-up company is to find its first customers and thus gain references for the future. Based on the critical mass assumption of 500 customers it can be deducted that at this point the initial customer base has already been gained. The operating principles of the community and the "going green" trend has brought a fair amount of publicity for the community and can be used by this start-up company. The community has already made contacts with component suppliers. These contacts and suppliers are a good basis for building a supply chain for this start-up company.

What impact would a transition to a closed business model have to the community? One possibility is that a critical mass of core personnel forms a company or companies and the community fades away. An important question is whether the community can attract enough new active members to keep it running when its members are leaving. Successful novel business ventures might attract more people to join it.

2.5.4 From Open Innovation to Open Business

Let's consider the possibility of a cooperative association as a business model for Electric cars – Now! Operating as a cooperative association, the community could operate as close as possible to its original model, such as open information with its operating methods and principles, while gaining status as a legal entity and thus being able to engage in business transactions.

It is highly possible that the open and proven business concept combined with technical information will attract competition and copycats. Being first in the market does not necessarily guarantee success. In case of copycats, we have to think about small economies such as Finland and niche business like this particular case. There might not be enough tech savvy people willing to enter competition where the learning curve is quite steep. Then again, does this differ from other small business areas? Finland as a nation does not have any history to talk of in automotive manufacturing. This keeps big players out of the game. Valmet Automotive [22] is the only automotive manufacturing company operating in Finland. Their business model is based on licensed manufacturing and golf carts, not retrofitted electric drivelines as in the case of Electric cars – Now! Therefore, their interests wouldn't overlap.

If the big players are thought to be out of the game at least in the Finnish market, it means that potential competitors are small companies as well. This situation can actually be seen as beneficial for the whole conversion cluster. If these small companies were to work in an open innovation structure, cooperating in procurement, they could benefit from economies of scale (e.g. procurement) and therefore reduce customer prices. So far, the biggest challenge of this business area has been the purchase price of an electric car for the end-user. A reduction in price could potentially lead to a larger customer base and further contribute to the success of the cluster.

Another thing that has to be considered is maintenance. New technology applied to electric cars means that traditionally trained mechanics cannot do the required maintenance work. Any new personnel has to be trained or old personnel have to acquire new skills. If these small conversion companies reach out beyond the normal closed business model and form strategic alliances with each other, they could create a better maintenance network and thus improve customer satisfaction. Electric vehicles require a charging infrastructure even in urban areas. So far, there has been no national initiative for building fast charge stations. A larger alliance of cooperative associations could, if well planned, organise a decent fast charge network at least for larger urban areas in Finland and potentially have some influence in governmental initiatives.

2.5.5 Summary of Electric cars – Now! Case Study

Electric cars – Now! has done a quite remarkable job by converting conventional Toyota Corolla into a fully electric car from scratch. The required components were acquired as donations. Know-how and personnel were coordinated with the help of a web forum where information is for all to see, even for project outsiders. This proves that strict rules are not a necessity if the community has agreed on a certain code of conduct.

Since conversions are niche business, market share can be divided between a number of small companies. Using openness and strategic alliances to operate as a cluster can provide a key to success even when competing with big car manufacturers for customers.

2.6 OpenStreetMap – a Global Community Mapping Project

This case study is about OpenStreetMap and is concerned with the question of why people work for free in an open innovation community. The OpenStreetMap project (www.openstreetmap.org) provides free street maps and other free geographical data [23]. In this project, the maps are indeed free instead of having legal or technical restrictions on their use, making it possible to use these maps creatively and in new ways. Typical restrictions of proprietary maps are what are called Copyright Easter Eggs – errors that are intentionally left in the map to reveal unlicensed use.

2.6.1 How Does It Work?

In the OpenStreetMap project, users with GPS devices and/or personal experience and knowledge of the area collect the geographic data [23]. The users have to register, but the registration is open to everyone and free of charge. Use of already existing maps is prohibited unless they are compatible with the OpenStreetMap License (the terms of the Creative Commons Attribution-Share Alike 2.0 licence, see ref. [24]). For example, Google Maps is not compatible with this license even though it is free to access because Google Maps content is provided under license from others. There are also sister projects to the OpenStreetMap project, like OpenCycleMap (www.opencyclemap.org), OpenRouteService (www.openrouteservice.org) and Open-SeaMap (www.openseamap.org), that are specialised maps for cycle routes, routing in general, and nautical information. OpenStreetBugs (www.openstreetbugs.appspot.com) contains known errors and technical bugs in the maps and thus makes it easier to fix and manage them.

2.6.2 Financing and Management

The project was founded in July 2004 by Steve Coast at University College London (UCL), and UCL is still hosting the main server infrastructure [25]. The community claims that there are approximately 180,000 members with 300 new members added each day [26]. Approximately 8% of the members contribute to the data collection monthly [27]. The project is funded by donations, retail affiliation schemes and registration fees for the State of the Map conference [23]. There is a supporting non-profit organization called OpenStreetMap Foundation, but the foundation does not have control over the project. In 2009, the foundation was lead by three officers and a board of five people constituted of members. The membership of the foundation is available for anyone and costs £15 a year. The members of the foundation have a say on the activities of the foundation and may vote for officers and the board but they do not have a say in the OpenStreetMap project. The foundation is mandated by its members to use 60% of the gathered funds for hardware, 20% for promotion, and 20% for legal matters [23].

A company called CloudMade (www.cloudmade.com) started by the founder of OpenStreetMap, Steve Coast, is also related to the project as it provides software related to OpenStreetMap data [28]. The company's products include map style editors, mapping tools, mobile applications, routing applications, etc. The company is involved in the community in two ways. First, its employees are contributing to OpenStreetMap [23]. In addition, CloudMade's software can be used to modify and style the map. The users of the map are strongly encouraged to modify the map for their own needs.

2.6.3 Why Does It Work?

According to Haklay and Weber [25], there are reasons varying from ideological views on free information to anti-national mapping agency views; some enjoy going out and mapping, some enjoy writing computer code. In addition, the joy of being a part of the project is mentioned as a motivator, and improving the map can also be seen as working for the good of the community, just like volunteering in general. Haklay and Weber also mention mapping parties (short events used for mapping a certain area together) as a way of creating social connections between the mappers in a community and thus increasing the participants' commitment to the project.

According to user profiles available at the OpenStreetMap website [23], people work on the map for example for fun, to learn new things like playing with GPS trackers and editing the map, or it is somehow related to their work. Some have even gone for cartography or GIS (geographic information system) courses because they have been so excited about the OpenStreetMap project and have wanted to learn more. It can also be satisfying being able to fix errors near one's home, instead of just having to tolerate, for example, a wrong house number, street name or inaccurate information of the type of road use (pedestrians, bicycles, cars, etc.) allowed. The sister projects might also create information unavailable elsewhere and this might be the driving force for the members to work on the project.

2.6.4 Summary of OpenStreetMap Case Study

In conclusion, for the volunteering members of the community the OpenStreetMap project seems to be a hobby they do for fun. A part of this might be due to the community structure, lack of strict rules, and almost instant results. Perhaps working in the OpenStreetMap community has some of the same aspects and motives as volunteering at a hospital or helping friends move. The primary driver is not money but reciprocity – if you help your friends move, they will help you move. The same applies for the OpenStreetMap project: if you map your own neighbourhood, it might help someone travelling there and vice versa. Possible disadvantages for the community members include that CloudMade makes money with the result of their work – the map. It might seem unfair, but the primary product of CloudMade is not the map but the applications for it, the map can still be used for free. This is also similar to other volunteer work: some people work at hospitals and are paid for it, and some volunteer without salary.

3 *Conclusion*

The world is changing. In many fields, it has already changed dramatically. One driver for this change has been the open paradigm. Open source software, open source crowd sourcing projects, and transparent supply chain management have all been success stories in opening up the traditional borders of innovating organizations. The definition for innovation was originally introduced by Schumpeter and has been since redefined many times to meet the definer's needs. The traditional innovation model has eroded due to various factors. Reaching out towards the open paradigm in R&D and innovation is a phenomenon Chesbrough defined as open innovation. Now it is clear that open innovation has become something more than what Chesbrough had in mind when he defined the term in 2002. The frame he set up is not broad enough anymore to cover all the different instances of open innovation. Chesbrough perhaps started the trend of open innovation, but it has grown beyond that and now it has a life of its own. At the moment of writing these conclusions, open innovation is a term that everyone wants to use when describing their own R&D model, and therefore we have as many definitions of open innovation as there are open innovation systems.

In this chapter, open innovation was studied through six different cases from non-IT sectors. This choice was made to find out if open source-like innovation systems could be successful even outside the IT sector. What was discovered is that the open innovation system depends on the size of the company. Open innovation system enables small companies to exchange technology or intellectual property (IP), and as a consequence allows the company to compete with large corporations in R&D. Another advantage is that small companies and communities can pursue joint ven-

tures, lowering the financial risk of an individual company. Strong strategic alliances enable a group of small companies with the same interests to achieve the benefits of a large corporation without being one. In large corporations, open innovation is used to maximise the output of the R&D process. Products or ideas that would not fit into the company's product portfolio can be outlicensed. Vice versa, large companies can buy licenses from outside to improve their own R&D. However, regardless of company size the key idea of open innovation is to make the R&D process more effective.

Open innovation is implemented and managed through innovation networks, which are used to bring together the customer, supplier, and innovators for the R&D process. Larger companies are able to manage the network by themselves. The management of networks is complex and expensive, and therefore smaller companies utilize facilitators such as PERA.

Regardless of company size, the key factor in successful implementation of open innovation is careful partner selection and confidentiality agreements. An optimal situation is where both companies share the same interest with different target products or markets. Partnering in open innovation networks between companies of different sizes has similar problems as partnering in any business networks. That is: how to ensure information and resource sharing without the larger corporation taking advantage of the smaller one? In niche business, small companies divide the market share. Therefore, open innovation and open business models can be utilised by small companies as well. Openness and strategic alliances create possibilities for these small companies to operate as a cluster, and this could possibly be the key factor when competing in the markets with large corporations.

It has been shown that strict rules are not necessarily needed if the community is using the same code of conduct. In addition to the common code of conduct, a better defined agreement is also necessary. The community counterpart of confidentiality agreements in the corporate world can be the Creative Commons license, for example. Communities provide a good spin-off platform for business ideas. As in the case of small companies, the communities can compete with bigger players in the market by adopting the so-called swarm ideology, joint pool of knowledge, joint procurement, and joint ventures.

In general, community-based open innovation seems to be closer to open source projects especially because there is the bidirectional information flow but no immediate financial benefit. While partnering between companies and research institutions is more similar to the traditional models of technology exchange, in open innovation there is the continuous exchange of information and knowledge instead of buying and selling knowledge.

Transfer from closed innovation to the open innovation model has a lot to do with non-technical issues. The mindset and skills of R&D personnel have to go through a transformation process, changing the company R&D model is not enough. Open innovation is more about managing and appreciating networks than managing technology.

References

1. Schumpeter, J.: The Theory of Economic Development. Harvard University Press, Cambridge (1934)
2. Chesbrough, H. W.: Open Innovation: The New Imperative for Creating and Profiting from Technology. Boston: Harvard Business School Press, Boston (2003)
3. ISI Web of Knowledge, isiknowledge.com
4. Chesbrough, H. W.: Open Business Models: How to Thrive in the New Innovation Landscape. Harvard Business School Press, Boston (2006)
5. Open Innovation in Global Networks, OECD Publishing, Paris (2008)
6. Procter & Gamble, http://www.pg.com
7. Procter & Gamble - Connect & Develop, https://www.pgconnectdevelop.com
8. Huston, L., Sakkab, N.: Connect and Develop. Inside Procter & Gamble's New Model for Innovation. Harvard Business Review 84 (3), 58—66 (2006)
9. European Central Bank: Euro Exchange Rates DKK on December 31st 2008, http://www.ecb.int/stats/exchange/eurofxref/html/eurofxref-graph-dkk.en.html
10. Gabriel Ltd., http://www.gabriel.dk
11. PERA- The Innovative Network, http://www.pera.com
12. Monday Morning Ltd., Open Innovation: Case Studies from Denmark, Copenhagen 200http://www.mm.dk/filer/open_innovation-rapport.pdf
13. Quilts of Denmark, www.qod.dk
14. IDEO, http://www.ideo.com
15. Mendonca, L. T., Rao, H.: Lessons from Innovation's Front Lines: An Interview with IDEO's CEO. The McKinsey Quarterly (2008)
16. Florida, R.: The Rise of the Creative Class, Basic Books, New York (2002)
17. Wang, Z.: The Experience Economy of IDEO. Global Entrepreneur (2004)
18. Kelley, T., Littman, J.: The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm, Broadway Business, New York (2001)
19. Sutton, R. I., Kelley, T. A.: Creativity Doesn't Require Isolation: Why Product Designers Bring Visitors "Backstage". vol. 40, pp. 75—91. California Management Review (1997)
20. Electric Cars – Now!, http://www.sahkoautot.fi/eng
21. Creative Commons Attribution-Share Alike 3.0 Licence, http://creativecommons.org/licenses/by-sa/3.0/
22. Valmet Automotive, http://www.valmet-automotive.com/automotive/cms.nsf/pages/indexing
23. OpenStreetMap wiki, http://wiki.openstreetmap.org
24. Creative Commons Attribution-Share Alike 2.0 Licence, http://creativecommons.org/licenses/by-sa/2.0/
25. Haklay, M., Weber, P.: OpenStreetMap: User-Generated Street Maps. IEEE Pervasive Comput. October-December 2008, 12—18 (2008)
26. OpenStreetMap – Fast Facts, http://community.cloudmade.com/blog/wp-content/uploads/2009/10/091106-OSM_Facts.pdf
27. OpenStreetMap User Contribution Statistics, http://wiki.openstreetmap.org/wiki/Image:Osmdbstats8.png
28. CloudMade, http://www.cloudmade.com/about

1.4 Sustainable ICT Extension to Developing Rural Areas of Namibia: The Entrepreneurial Perspective

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Abstract

Lack of ICT is a serious issue for developing regions. We introduce a Rural Village model that provides communications and energy services using existing low-cost technological solutions to extend network coverage into rural populations, who are

often the poorest at the bottom of the economic pyramid. This not only fulfills a humanitarian need but also provides an entrepreneurial opportunity as well as a platform for entrepreneurship. This report focuses on Namibia, as this country represents well the challenges of working in underdeveloped areas. These challenges include large income inequality. We show that entrepreneurship, built on our combined energy and mobile ICT solution, could promote innovation in the Namibian economy for a diverse set of partners and in this way benefit the whole society. We also present a future scenario analysis based on Foresight methodology.

Keywords: microfinance, innovation, entrepreneurship, Village Phone model, telecommunications infrastructure, sustainable energy sources, eDelphi survey, African time, Ubuntu, Sulata, ICT

1 Introduction

Currently, approximately one-fourth of the world's population does not have access to electricity or Information and Communication Technology (ICT) [1]. The lack of ICT and energy infrastructure is a severe and daily problem for large populations in developing nations since it plays a major role in all different functions of a modern society. Business, culture, health care, transportation, agriculture, education, entrepreneurship – almost every component in a society is in some way dependent on this infrastructure and related services.

Extending the availability of ICT and electricity fulfills a humanitarian need for development. However, it is also a business expansion opportunity for infrastructure providers as well as a platform for flourishing local entrepreneurship. According to a study done by the London Business School, an increase of ten mobile phones per every 100 people in low-income countries increased GDP growth by 0.6 percent [2], indicating a direct relationship between economic development, creation of new businesses activities, and mobile phone penetration.

In this article, we will explore the current status and challenges of energy and ICT infrastructures in developing rural areas. We will proceed to discuss in detail our Rural Village model—a novel business framework that **combines sustainable energy and ICT infrastructure extension** to underdeveloped areas. The economic feasibility of the model and how our solution will foster local entrepreneurship will be investigated in this paper. Our framework is applied to Namibia, as this country represents well the challenges that exist in developing nations with large rural populations. Finally, we state our conclusions and recommendations on how to leapfrog the technology gap in order to advance energy and ICT infrastructure provision for developing rural areas.

2 Current Challenges for Energy and ICT Infrastructure in Developing Rural Areas

In this section, we describe the status quo and challenges in rural developing areas in the field of energy and ICT infrastructure.

2.1 Energy Infrastructure

Today one quarter of the world's population, i.e. 1.6 billion people, do not have access to electricity in their homes, and if no new policies are put in place, this situation will little improve. More than 80 percent of these people are living in rural areas of the developing world. Rural areas are isolated and remote; usually they have low population densities and are typically populated by the poor at the bottom of the economic pyramid. According to the *World energy outlook* of 2006 [3], only 8% of the rural population in Sub-Saharan Africa has access to electricity, whereas in South Asia the figure is 44 percent. The lack of electricity not only deprives people of basic needs such as lighting and communication, but also hampers productivity and economic development of rural areas. Despite the benefits that electricity provides, the rate of electricity coverage remains very low across most developing countries. The reason behind this is that supplying electricity to rural areas is considerably more expensive than electricity supply to urban areas. Moreover, at least in the early stage of electrification, consumption is very low, resulting in a poor load factor. Additionally, distribution cost rises as the distance between connections increases. Therefore, utility providers have been reluctant to extend service to rural areas. In most cases, governmental support is needed to make electrification feasible. Even though grid extensions have focused on electrifying rural areas, they do not seem to be the best way forward because of the high cost and the high level of maintenance required. Therefore, a possible solution for rural electrification is to use decentralized designs. The most popular decentralized solutions to date are home systems powered by solar energy, mini-hydro power, wind power, diesel, and biomass gasification.

While there is a broad consensus among researchers and stakeholders that electricity access is an essential ingredient for rural development, electricity itself is not a commodity that can help decrease poverty or improve rural livelihood conditions. Instead, the demand for electricity is only derived from the demand for goods or services it provides or makes possible. One of the studies done by the World Bank mentions that the welfare of people in rural areas does not expand further beyond a stable level after prolonged exposure to electricity [4], since it is energy services and not the energy alone that creates wealth. A huge quantity of money is being spent in rural electrification, but the bitter truth is that most of the electrification programs have been unable to address the real problems of commercialization in this field so far. Therefore, it is very important to investigate how to achieve the long-term benefits of rural electrification, not only for the household but also for the rural economy.

2.2 ICT Infrastructure

Two thirds of the people in Sub-Saharan Africa reside in rural areas, and about 99 percent of the localities in Sub-Saharan Africa are villages [5]. Fixed-line telecommunications cover less than 3 percent of the villages due to the high cost of infrastructure and lack of electricity. Mobile communication has developed much faster, and the African mobile market is experiencing an outstanding growth rate. In 2006, the mobile signal had already covered about 45 percent of Sub-Saharan African villages [5]. In 2007, there were over 60 million new mobile subscribers worldwide, a large portion of them from Sub-Saharan areas [6]. Currently, the mobile telephony market in the area is mainly shared among Vodacom South Africa, MTN South Africa and MTN Nigeria, and Celtel [6].

Compared to telecommunications, access to the Internet is even less common in Sub-Saharan Africa. The rate of Internet access is extremely low: only 1.3 percent of the inhabitants had subscribed to an Internet Service Provider (ISP) by 2006 [7]. Mobile phones in Africa are rarely connected to the Internet because of the low speed of mobile networks. Deploying broadband Internet is more difficult in Africa than in other continents because there are no proper backbone broadband connections yet. Among the one tenth of the world's Internet subscribers that have access to broadband Internet [8], Sub-Saharan Africa only occupies a very limited share of about 0.12 per 100 inhabitants.

Deploying ICT in rural areas is much more difficult than in urban areas because commercial ICT systems are conventionally designed for deployment in urban areas, where the high population density, concentrated resources, basic infrastructures and active social communications assure an excellent ICT market. Though the urban market may still have great potential to expand, thanks to the introduction of new services enabled by technology development and lifestyle shifts, the traditional ICT players are increasingly interested in the rural market. Winning the last few billion subscribers is indeed attractive despite the challenges of exploiting a new market that does not have most of the success factors of the current urban market. There are new environments to evaluate, new technology and services to develop, new social and business values to create, and new cultural conventions to adapt or social barriers to break before the new requirements can be met.

The major reasons for the disparities of ICT development among areas can be categorized by the following aspects: lack of infrastructure, education and language, human resources, cost, distance, bandwidth, and maintenance resources [9].

All in all, the most essential problem of rural settings disfavouring the existing solutions for ICT rollout is the low income of the rural populations. Together with the relatively low population density and long distance between rural settlements, the ARPU (Average Revenue Per User) is normally too low for ICT operators to survive financially with respect to the commonly high CAPEX (Capital Expenditure) and considerably increased OPEX (Operational Expenditure). Thus the problem is actually, how to cut down the TCO (Total Costs of Ownership) and still meet the users' (villagers') substantial needs.

In general, it has been observed in rural settings that most communications remain local (within a village) or regional (within several neighbouring villages). Thus it makes sense to move the call management control point closer to the terminal and even delegate the billing of local services directly to local micro operators. In this way, the expensive long haul signal transfer can be avoided, which not only reduces the costs of higher capacity infrastructure, but also the maintenance costs. Though the telecommunication services (e.g. voice call and short message service) must be reliable, data services that offer access to the Internet can be more dynamic. The most necessary information required by the villagers, such as weather forecasts and news, does not have to be available instantly. A daily update of such information, which can be delivered by temporarily connected networks at a much lower price, should be sufficient. Information such as a knowledge database for production tips and educational materials can be updated less frequently. The emerging research activities in such challenging networking environments [10] have great potential to provide practical solutions in the future.

Though the rural market is attractive in terms of potential subscribers, the investment risk remains high due to the variety of settings and prolonged break-even point. A joint incentives solution combining the ICT vendors, ICT operators, financing entities, government, and the rural residents themselves is needed to share the risk in order to turn the wheel.

3 The Rural Village Model: Our Framework for Sustainable ICT and Energy Infrastructure Extension to Developing Rural Areas

In order to enable local entrepreneurship, the villagers need to be provisioned with infrastructure and there should be adequate financial support to start new initiatives. Our Rural Village model incorporates both energy and ICT infrastructure. Besides this, our model necessitates a combination of different stakeholders (government, service providers, microfinance institutions, local communities) in order to bring sustainable entrepreneurship to developing rural areas.

The first practical problem the Rural Village model must solve is the availability of basic energy infrastructure to enable the population to have sustainable access to lighting and possibilities to charge devices such as radios or mobile phones. Secondly, there should be sufficient network coverage to originate and receive mobile calls, and finally, there should be access to financial loans with reasonable conditions for the villagers. This role would need to be filled by experienced organizations, like the Grameen bank[1], in this type of socioeconomic environment and in the microfinancing mode of operation in rural settings.

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1   http://www.grameen-info.org/

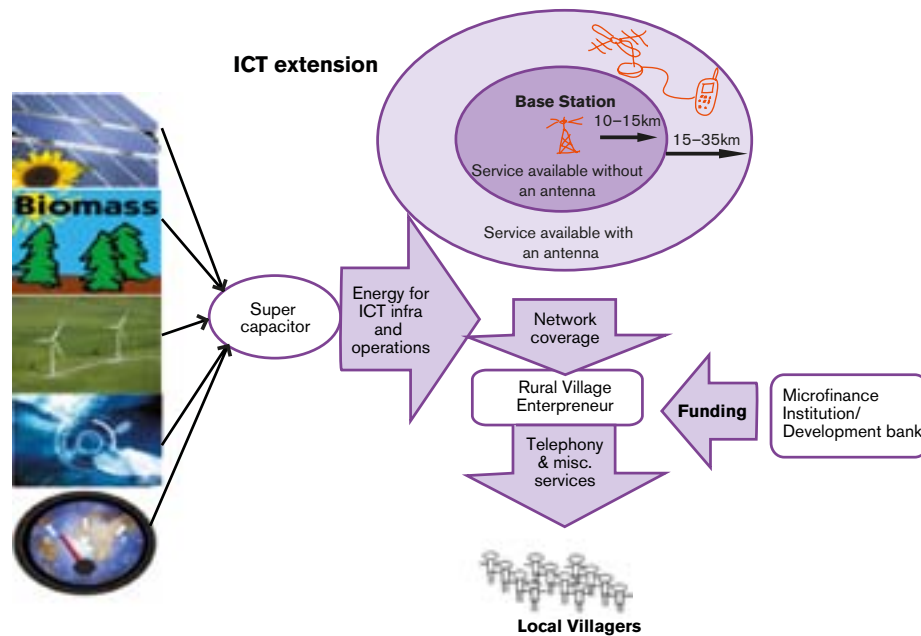Figure 1 depicts the overall solution scenario of our Rural Village model, including the relevant parties.

Figure 1. Our Rural Village model scenario depicting the bundling of energy sources (solar cells, biomass, wind, hydro and diesel) and energy storage capacity (supercapacitor), combined with ICT and microfinancing services.

In the following sections of this chapter, we will analyse in greater detail how to provision the needed infrastructure for the villagers, the role of the microfinancing institutions, and how this framework could serve to empower local villagers to engage in new entrepreneurial activities.

3.1 Energy Infrastructure Extension

Many rural communities are far from existing electricity grids. The terrain might be inhospitable for transmission lines, and there might be few or no access roads. Moreover, the sparsely populated rural areas make distribution even more challenging and costly. According to some available calculations for African micro grid pilots, beyond 15km (approximately) the grid connection is an expensive solution. Meter reading from those areas is not profitable in relation to the amount of energy sold. Additionally, the power quality from the main grid in rural areas is not reliable because of technical problems, such as voltage drops and unstable frequency. Even the urban areas in many developing countries suffer from power fluctuations and frequent blackouts. From the consumer's point of view, the initial connection fee to the central grid is unaffordable for villagers

who live on less than $1 USD per day. Where grid extension is not possible, there is a need to look for an alternative solution. A sustainable way to expand electrification is decentralized production of electricity, also called a micro grid.

3.1.1 Energy Sources

Traditionally, the primary energy source for a micro grid is a generator, powered by liquid (fossil) fuel. Since the price of oil has been rising rapidly, renewable energy systems are becoming a viable alternative. Also, the increased interest and focus on climate change has accelerated the development of sustainable energy solutions that can be used in micro grid systems. Large-scale production and utilization of sustainable technology will drive the costs down, meaning that sustainable technology becomes more accessible in developing areas where price is a major issue.

The current viable renewable energy sources are hydropower, biomass, wind and solar power. A modern rural power supply system can utilize either one of the above renewable energy sources or a combination of them, striving for maximum efficiency. The combination of various energy systems is often called a Rural Area Power Supply system (RAPS). Such systems are usually small scale (usually < 50 kW) self-contained units, providing electricity independent of the main electricity grid or mini grid network. RAPS systems range from small petrol generators that power appliances directly to more complex installations using only renewable energy or in combination with diesel or petrol generators [11]. Advanced systems are called hybrid energy systems, as they combine different energy sources with a charging system and batteries.

Figure 2 depicts the typical RAPS system than can be used in our Rural Village model:
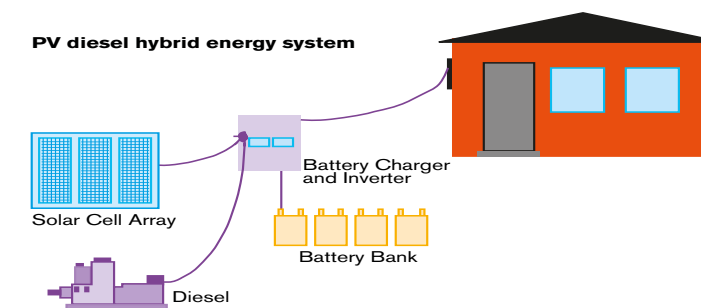

Figure 2. Hybrid Rural Area Power Supply (RAPS) system powers rechargeable batteries using a combination of solar cells and diesel generators. Various RAPS systems can be adapted in applications of our Rural Village model.

These systems can be used in different areas and in varying environments. The combination of power sources must be adapted to the local environment and available

electricity sources. For instance, some areas are better suited for solar power, while others may be better suited to wind power. Biomass is often used as a simple fuel, but it can also be utilized as liquid biofuel or processed via gasification. Different emerging solutions can utilize, e.g., agricultural waste. Various adaptations of RAPS systems can be used in our Rural Village model, depending on the geographical and socioeconomic conditions of the village.

3.1.2 Energy Storage

In addition to energy sources, energy storage is another essential component of RAPS systems. In brief, energy storage serves as an energy reservoir or buffer, in terms of time and/or location, between the energy production location and the point of consumption.

One of the most common energy storage devices is the rechargeable battery, which is disadvantaged by memory effects that reduce the storage efficiency after each recharge cycle, and the risk of explosion due to chemical reactions during the charging/discharging process. Moreover, the recharging speed, energy and power density are usually insufficient for demanding applications.

The latest in nanotechnology, however, brings significant improvement to the performance of rechargeable batteries [12]. For example, the core-shell silicon nanowires [13] previously used in solar cells are now used in rechargeable lithium-ion batteries and result in an energy density, which is 5 ~ 10 times higher at a given power density than in normal wires. In other words, the battery can be much lighter and still store the same amount of energy.

Another common energy storage device is the capacitor, which has good power density but poor energy density compared to batteries. Supercapacitors, on the other hand, not only charge and discharge extremely fast (i.e. high power density), but they hold much higher energy density than normal capacitors. Although the energy density of the supercapacitor is 25 times less than that of a lithium-ion battery, it still has good potential to increase to a level at which it becomes a feasible alternative [14].

Such new energy storage technology can greatly change the RAPS landscape. The ultra-fast charging speed and higher energy density of this technology may allow energy distribution by transportation of batteries. High power density and energy density may together significantly reduce the costs of a power plant because the peak load can be compensated by supercapacitors instead of higher capacity networks. Both nano-enhanced batteries and supercapacitors are expected to be commercialized by mass production in five years, thanks to the adoption of conventional production processes and infrastructure.

As shown in Figure 1, our Rural Village model incorporates these new energy storage technologies as part of the electricity grid.

3.2 ICT Infrastructure Extension

There are generally two approaches to developing ICT infrastructure in rural areas. The mobile telecom approach is mainly about radio coverage and call control, and can be extended to the rural areas by enhancing the terminal signal strength and customized sparse spot coverage, as well as by delegating partial control to the local operator. The Internet access approach typically consists of a mesh network built with economical off-the-shelf equipment using directional antennae to enhance the communication distance. The reliability and capacity of the infrastructure are compromised for lower costs, which results in a network of intermittent connectivity and greater throughput and delay dynamics.Note that the convergence of the technology in both approaches may further reduce the costs. For instance, with guaranteed quality of service, the Internet connections can serve as a backhaul infrastructure to connect mobile base stations. On the other hand, the mobile telecom infrastructure can provide data service for Internet access as well.

A solution for terminal enhancement (i.e., using signal boosters for the antenna to enhance the cell phone signal) is the basis of the Grameen Village Phone Business Kit [15]. The main idea is two-fold. First, the existing ICT service is shared in order to increase the average revenue per user. Second, both the capital expenses and operational expenses are cut to a minimum, so that the risk is minimized. Normal operators do not need to further extend their infrastructure at all, because this model operates in villages that already have adequate ICT coverage. A villager running such a business merely needs to invest $300 USD at the most as capital expenditure for the terminal hardware, which barely requires any maintenance after the installation and yields very low operational expenditure. In exchange for the low costs, the service may not always be available and the solution only applies to areas close enough (15 km further away from the base station than the normal 20 km range) to the existing mobile network coverage.

Another solution for local infrastructure extension comes from the efforts of ICT vendors and deployment solution providers such as Ericsson (Packet Abis for GSM Transport [16]) and Nokia Siemens Network (Village Connection [17]). Despite the difference in implementation details, several common approaches can be summarized as follows. First, the common continuous coverage in urban areas is adapted to regional continuous coverage or even spot coverage that suits the scale in isolated towns and villages. The base stations then need much less power and capacity. Second, due to the isolated regional or spot coverage and the fact that most communications remain local, the control of the service can be delegated to local micro operators. In this way, much of the traffic load can be reduced, and it also makes maintenance much easier. Third, the connection between base stations is provided by a great variety of technologies, from expensive satellites and microwave transmitters to enhanced Internet routers that are much cheaper. The variety in transmission options is due to the development of technology such as soft switches that enables

the convergence of the Internet and the telecom services to all-IP (Internet protocol) networks. While the local service is much improved by the terminal enhancement solution with less deployment requirements, the service based on the connection to the outside world will not be satisfactory unless the infrastructure connecting the local to the outside is enhanced. The expenditure increase necessary for enhancing this connection becomes feasible only when the average revenue per user increases.

One potential scenario not considered in the existing commercial solutions is intermittent service, especially for Internet access. By using inexpensive end-user hardware with less reliability and capacity, a less reliable network can be established. There is, for example, the (non-commercial) VillageNet model [18] that is designed to establish ICT networks in densely populated areas in India. In this mesh network, gateway nodes are established in big cities or in dense and large population areas with high-bandwidth connection to Internet. Other nodes are established in the surrounding villages. All the nodes connect to each other by point-to-point wireless nodes. Some nodes directly connect to the gateway nodes; some connect to the gateway through other nodes. The distance between the village nodes is about 10 km to 15km. High-gain directional antennas are used in the nodes in order to transfer the signal across such distances. The village node requires little equipment and can be hosted in a village kiosk. The equipment includes a personal computer and some communication cards, such as the PCI or WiFI card, to generate radio. The radios connect to the directional antenna mounted on a tower, and an Ethernet interface will route the traffic of local nodes [19]. The low cost of VillageNet mainly relies on the low cost of the off-the-shelf Institute of Electrical and Electronics Engineers (IEEE) 802.11 equipment. The major expense of building the network is the antenna tower, so an optimal height for the tower and topology are required to minimize the cost and maintain performance. However, VillageNet also has its disadvantages, especially in terms of reliability. If some of the nodes stop working due to equipment malfunction or electricity cut-off, some other nodes may also be adversely affected.

Due to the lack of management in traffic load, the end user may experience intermittent connectivity and great dynamic variations in transmission delay and speed. This may not be acceptable for an urban broadband service, but may still be valuable for isolated villagers' information exchange and update [20].

In our Rural Village model, ICT extension can be implemented in various phases, depending on the available infrastructure (cf. Subsection 4.2).

3.3 Microfinancing

Limited access to credit and lack of availability of small loans has been identified in a number of United Nations reports [21] as some of the major constraints that hinder the process of empowering the poor to break out of the poverty circle and start new business activities. Usually, these micro credits provided by microfinance institutions

are characterized by the following parameters [21]:

1 Small loan amounts (on the order of a few hundred Euros)
2 Relatively short repayment period
3 Focus on women as target group
4 Destination of funds for projects such as agriculture, distribution, trading, small craft and processing industries
5 A generally light administrative process

Our proposed framework requires that local villagers in underdeveloped areas are provided with loans following the above mentioned guidelines at reasonable interest rates. Under these conditions, it would be possible for them to acquire the needed equipment and start using it, despite their very low income levels (ranging from $1–2 USD per day). Therefore, the role of microfinance institutions is truly critical for enabling the local villagers to borrow initial capital in order to start their economic activities and introduce dynamism in the economy.

3.4 Business Logic

Energy and ICT bundling is a powerful response to the challenge of the rural telecommunication deficit. Our Rural Village business model is unique from the socioeconomic perspective: the model is strongly based on the premise that economic transformation of the rural population can be brought about by combining various infrastructures with entrepreneurial incentives. Energy, being a driving force behind the economy, should be the essential backbone of all other infrastructure. Our business model provides the following benefits:

- it gives the local operator access to capital subsidies.
- synergy provided by combining energy and ICT will stimulate the community's economy significantly.
- access to communication and energy enables the rural community to establish new business activities.
- it makes use of local resources and knowledge to run business.

In our case, a local telecommunication operator engages in the rollout and maintenance of an energy solution that will empower the local villagers, enabling them to make use of modern communications systems. The initial upfront investment needed to deploy a sustainable energy infrastructure in developing rural areas comes with a significant risk, e.g. in terms of the number of years needed to recover the investment for the party taking ownership of the energy rollout. On the other hand, once a basic energy solution is available for local villagers, and thanks to the proposed network extension mechanism, the local population would be able to start using ICT equip-

ment practically at no additional costs for the local operator.

In this model, the provision of electricity and ICT involves various stakeholders, thereby distributing the risks among many parties, including the government which provides subsidy for the rollout.

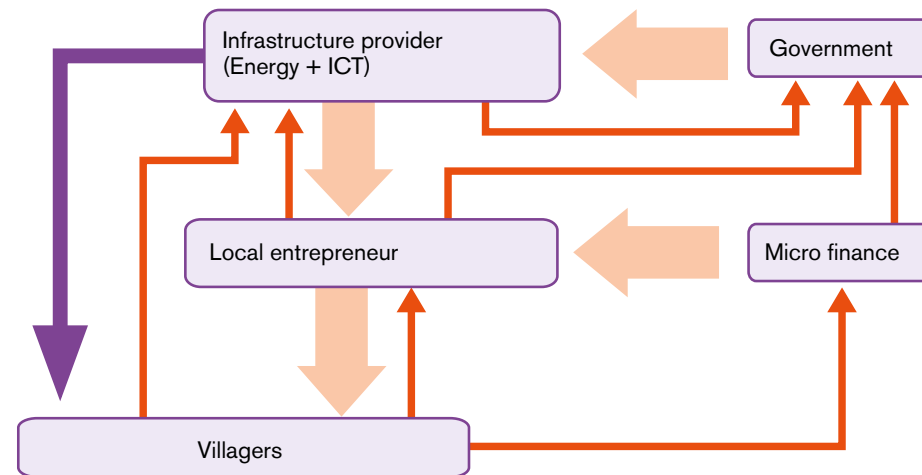Figure 3 shows a schematic of the ecosystem of various stakeholders.

Figure 3. The stakeholders' ecosystem in our Rural Village model. Block arrows indicate the flow of capital, green arrows indicate revenue flow.

3.5 Entrepreneurship in Local Villages

With the deployment of our Rural Village model, the villagers will be enabled to take action and start new business activities. In this chapter, we study the case where some of the local villagers engage themselves in the buying and re-selling (at a premium) of airtime minutes.

This kind of activity provides a revenue source for local entrepreneurs and also fulfills some of the needs of the local community. Person-to-person basic communication will be enabled and business-related communications will be eased, making buying and selling of products more efficient, i.e. doing away with the need of commuting (frequently walking) large distances. This main scenario for entrepreneurship could be complemented with some other activities falling within the educational, health, agricultural, emergency management and tourism categories. The combination of all these activities, in addition to bringing additional income to the villagers, acts as a catalyst for the community's economy and promotes the improvement of living conditions, thereby fulfilling a social need. We will analyse, in more detail, some examples of these activities in our case study of how our Rural Village model can be applied in Namibia.

4 Namibia Case Study

As with many developing countries, Namibia has a colonial history. First, it was claimed by Imperial Germany, then the British Commonwealth and South Africa. South African rule did finally end in a peaceful transition to independence in 1990, but the process had taken decades. Despite the history of South African apartheid and guerrilla warfare, the UN-led transition process was a success. As a legacy of the colonial period, Namibia now has a reasonable infrastructure for, e.g., the mining industry, but it also has debts. Namibian society is relatively stable and there is a functioning democracy and government. It has less internal or social problems than some other African countries; for instance, there are few slums or street children [22].

Namibia is far from being the poorest country in Africa. The population is 2,108,665 and the GDP per capita is $6400 USD (2008 est. [23]), which is reasonable for a developing country; however, the unequal share of wealth is a big issue in Namibia (24). The majority of people live below the poverty line. The Gini coefficient, a standard for measuring inequality, is 0.63 for Namibia, meaning that the level of inequality is one of the highest in the world [24].

Economically, Namibia is heavily dependent on mining of its natural resources, which employs only a small part of the population. Half of the population gets their livelihood from agriculture, although agriculture revenue constitutes only 9 percent of the GDP (2008 estimate), while 37 percent of the population is classified as urban. Therefore, a rural village is a rather typical place of residence for many Namibians.

The official language of Namibia is English, but there are several other recognized languages that often are learned as the first language. Due to poverty and a large number of young people, there is a great need for education in many Sub-Saharan regions. The literacy in Namibia is high for a Sub-Saharan country (88 percent [25]), although the lack of higher education is an issue. The ethnic diversity has been a cause for conflicts in the region. In some cases, the borders are causing conflicts – some were drawn arbitrarily during the colonial period.

At the moment, the electricity network covers only a small part of rural Namibia. The reason for this is poverty and low population density. The geography also affects the energy sources available to the population. In the case of Sub-Saharan Africa, there are many different possible energy sources available: most types of fossil fuels, a variety of biomass, hydropower, and uranium as well—at least as an ore. The sun is an abundant source of energy, as is the wind, and both are very suited for rural areas with limited infrastructure. There are Namibian development programs, such as the Electrification & Distribution Master Plan of 2000/2005. The aim of that program is to cover 80 percent of rural Namibia by 2030 – the coverage in 2009 is 23 percent [26]. At the moment, the areas outside the national grid depend mostly on diesel generators, although there are some solar and wind power solutions. New energy production methods could replace fossil fuel-based technologies as they become available. In this sense, rural electrification and the trend towards greener energy run along common paths.

Namibia has several cell phone service providers, and over half of the popula-

tion has a phone [27]. Still, a large proportion of the population, especially in the rural areas, do not have a phone, and many people have no reasonable access to modern communications at all. Even if the network and phones are available, funds are needed in order to be able to use the service. The use of the Internet depends on the availability of electricity and communications equipment. Still, only around 5 percent of Namibians use the internet [23]. Personal computers are not available to the majority of the population, which also lacks skills to use them. The statistics that represent the availability or "penetration" of various consumer goods have often served as indicators of wealth of the population. For instance, the availability of television or radio tells us that people are generating enough income to purchase gadgets and have access to electricity. However, the cell phone is a different story. Of course, it can function as a status symbol or provide entertainment, but most of all it is a platform for communications and services.

The effects of technological development are reaching all corners of the world. In many ways this is good—ICT can create economic opportunities and it is a platform for education. Sustainable entrepreneurial opportunities could benefit the whole Namibian society, allowing it to reach an equal level with the rest of the developed world.

Taking into account these socioeconomic conditions, we have selected Namibia as the country for our case study to investigate how to apply our framework detailed in the previous chapter.

4.1 Energy Infrastructure Extension

To model the access to energy infrastructure, we designed a hypothetical village consisting of 500 households and one kiosk for our Rural Village model. We assumed that a refrigerator runs in the kiosk to store medications, and therefore requires an uninterrupted power supply to run continuously (i.e. 24 hours/day). Our village contains two lamps per household (8W each), one in the kiosk (8W), and hundred lamps (13W) in the streets. We assumed that 10 percent of households can afford television (75W) and 20 percent can afford a radio (20W). In addition, we assumed that there is a school that requires power for running a computer during the day.

Table 1. Appliances and their power consumption in the hypothetical village

Appliance	Power (W)
Refrigerator (kiosk)	500
Lamp (household and kiosk)	8
Street lamp	13
Television	75
Radio (household and kiosk)	20
Total	**616**

To design the energy system, we estimated the power usage as a function of time and used this to determine the best power usage time and duration for various appliances as well as their load curves.

The peak power consumption in the village was 14 kW, and it occurred in the evening. Among various rural energy options, Namibia has wind power potential only along its coastal area [28], but solar energy is available in all its regions since Namibia lies along the equator.
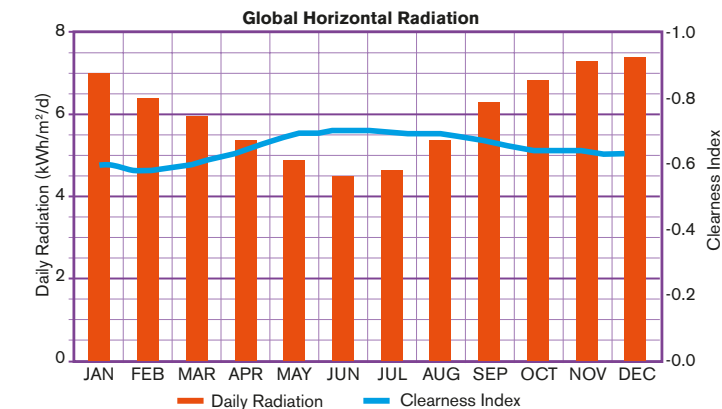

Figure 4. Estimated total daily radiation (kWh/m2/d) in Namibia throughout the year for each month. Red line indicates average daily solar radiation [29].

Figure 4 shows the estimated total daily radiation (kWh/m²/d) in Namibia throughout the year for each month [29]. The average daily solar radiation (red line) is 5.6 kWh/m², which is sufficient to power the energy needs of our hypothetical village. Moreover, there is, on average, solar radiation for 7 to 9 hours per day in Namibia year-round. This makes it possible to use solar energy throughout the year to power the energy micro grid. We propose to incorporate solar electricity into the power system, utilizing a diesel generator for supplementary battery charging in case of system failures. This would drastically reduce the amount of fuel required to power the village. Additionally, a combined solar-diesel system provides reliable and higher quality green power compared to diesel alone. Our simulations using the HOMER [29] renewable energy simulation tool developed by the National Renewable Energy Laboratory (NREL) USA showed that the 20-year amortized costs of the hybrid energy system were substantially lower than the amortized costs of the diesel system alone; the difference was dependent on the price of diesel and solar panels.

In addition, the carbon offset by the usage of renewable and clean energy sources could be used by Namibia's government in the context of cut and trade negotiations, assuming that our model is successful and scalable, i.e. successive rollouts of the solution are completed across Namibian territory.

4.2 ICT Infrastructure Extension

The communications component of our Rural Village model focuses on the promotion of modern ICT in underdeveloped communities. Figure 5(d) is an overlay map of Namibia and includes population density (Figure 5(a) [30]), mobile telecom network coverage (Figure 5(b) [31]), and the rural off-grid area electrification plan (Figure 5(c) [32]). According to Figure 5, the afore-discussed ICT development solutions can be applied to suitable areas in Namibia, systematically and case-by-case.
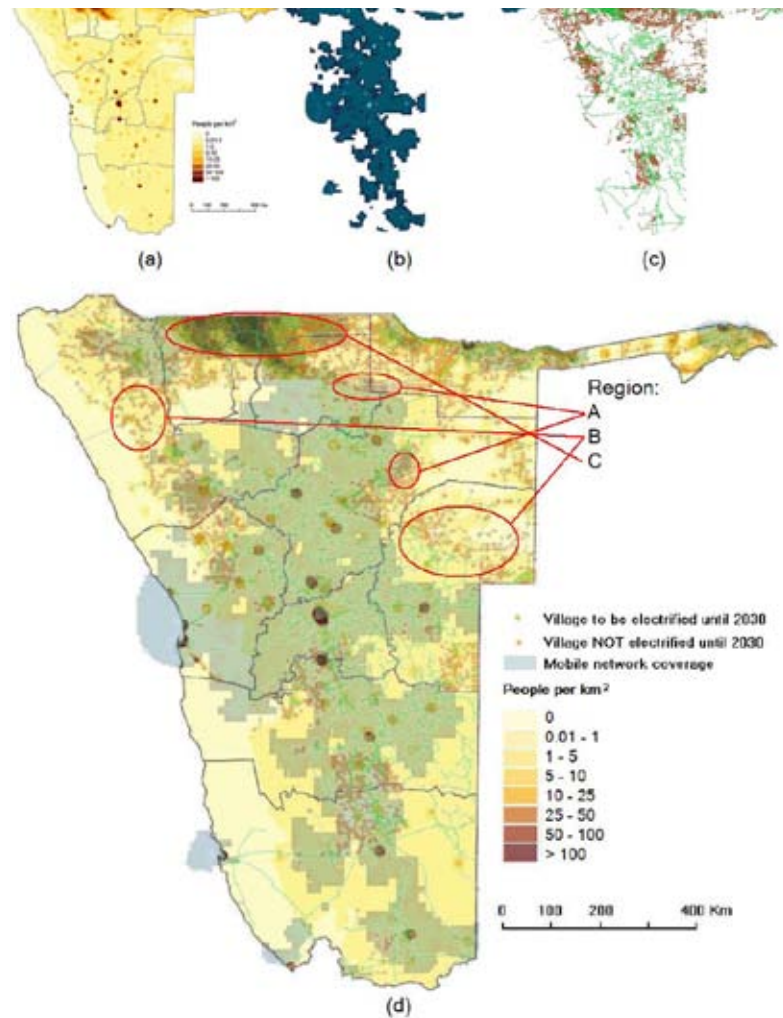

Figure 5. Namibia map of (a) population density [30], (b) mobile telecom coverage [31], (c) off-grid settlements electrification plan [32], and (d) combination of the former maps. In (d), example areas close to rural residential settlements (red dots) are shown in region A, example areas currently without mobile network coverage and yet contain sufficient rural residential settlements (small red dots) are shown in region B, and C shows example areas (small green dots) to be electrified before year 2030.

In the first phase, mainly the terminal enhancement solution (i.e., using signal boosters for the antenna to enhance the cell phone signal) will be applied together with the electrification process. Areas (red dots) such as those shown in region 'A' on the edge of the grey mobile network coverage 'clouds' in Figure 5(d) are suitable for the application of our proposal. These areas are close to rural residential settlements marked as small dots in the electrification plan.

Once the first phase has proved economically feasible, the local infrastructure extension can be taken to its second phase. Suitable areas indicated in Figure 5(d) by large brown blotches are currently without mobile network coverage and yet contain sufficient rural residential settlements (e.g., region 'B'). Because most of the settlements are quite close to each other (within about 20 kilometres), the mobile telecom base stations can be connected by Internet technology such as long-range Wi-Fi rather than to expensive microwave transport or satellite.

During the second phase, the dark brown area in the north part of Namibia (region 'C') is more likely to develop ICT infrastructure relatively fast due to its considerably higher population density. If the local economy is developing along with ICT as expected, it will reach a level that affords the enhancement of external connections from the local/regional settlements. At this point, more reliable ICT backbone infrastructure with higher capacity to provide reliable, good-quality connection between the rural and the urban can be established.

While only the villages marked with green dots in region 'C' will be electrified before year 2030 [32], most villages (red dots), such as those in region 'A' and 'B' will not. Hence our proposal may well complement the current electrification plan for the off-grid rural villages.

4.3 Microfinance Institutions

According to studies done by the Bank of Namibia [33] and other organizations [34], Namibia's microfinance ecosystem is far from ideal:

- collateral is required by one third of the organizations (15 percent of them required ATM cards, while 14 percent needed savings and property as security).
- loan terms were in general too short-term. Approximately 60 percent of the loans were offered for a period less than 3 months, 30 percent for a period between 3 and 12 months, and 10 percent for a period between 1 and 3 years.
- loan amounts with acceptable terms ranged between $13 to $2600 USD. The interest charged was on average extremely high, with monthly rates around 19 percent (the lowest recorded was 2 percent and the highest was 35 percent monthly).

In summary, the general performance of microfinance institutions in Namibia has been poor, mainly due to their limited outreach, high default rates, low efficiency and profitability, extremely high interest rates for loans and high operational costs.

Changes in regulations are needed in order to protect customers from abusive lending and collection practices. Microfinance institutions like the Grameen bank[2] are good candidates to improve the poor's access to funds in Namibia.

4.4 Business Logic

As we detailed in previous sections, the cornerstone of our Rural Village model is a multidisciplinary approach where the risk is shared by different stakeholders. We now summarize the roles of the different parties involved in the solution's deployment.

Role of Infrastucture Provider

The combined ICT and energy infrastructure provider is an operator who has a macro network backbone and also has billing services. The operator must undertake the following actions:

- select the village into which to expand services by performing feasibility studies in conjunction with the local villagers. For our Nambian pilot case, the following conditions should be met in order to kick off the development project:
  - areas without electricity and far enough from the national electricity grid to make the construction and maintenance of solar and diesel energy micro grid more economic than extension of the actual national grid.
  - locations with telecommunications network coverage that would allow the use of mobile phones with the Grameen Village Phone Business Kit [15].
  - areas with enough solar radiation to maximize the output of the photovoltaic system and enough population density to allow the local entrepreneur to have profitable business activities (buying and selling minutes of airtime).
- once the energy source has been selected, the operator should apply for a government subsidy and establish the energy infrastructure in the selected village.
- collect revenue from the sale of energy and air time minutes.

Role of Namibia's Government

- examine the proposal from the infrastructure provider and grant right to establish energy service.
- subsidise the infrastructure provider according to the national rural energy strategy.
- protect the interests of all the players and ensure quality service delivery to the customer by legislation.

Role of Local Entrepreneur

- reply to the call for applications floated by the microfinance institution and become its local business partner. If required, access capital from microfinance or local development banks.
- help infrastructure rollout, providing local input, help in collecting bills and also doing some troubleshooting.

Role of Microfinance

- receive and evaluate applications for financing from the local villagers; grant successful applicants with micro-credit.
- examine possible business opportunities and advertise the business idea among villagers.
- support in marketing and training local villagers in the usage of newly available infrastructure and ICT equipment.
- select local entrepreneurs after screening and short-listing and provide them with a mobile phone kit and antenna.
- collect timely payment form the local entrepreneur.

Role of Villagers

- they are the final recipient of the service and are a key component in the business ecosystem.
- they participate in the decision-making process through e.g. community meetings so that their interests are also met.

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2   http://www.grameen-info.org/

Table 2. summarizes the key stakeholders and their main roles.

Table 2. Business logic for stakeholders and main responsibilities in our Rural Village model.

Government	Infrastructure provider	Local entrepreneur	Microfinance	Villagers
	Identify the prospective business areas and make feasibility study			Involvement in the design phase
Validate operator and provide subsidy	Apply for the subsidy and right to operate			
	Market/explain the technological solution to local villagers Call for applications of interest	Respond to the application of interest	Market/explain the technological solution to local villagers Call for application of interest	
	Approve local entrepreneur	Apply for finance	Validate and provide financing	
	Construct energy system and sell energy	Sell minutes and energy services		Buy minutes of air time and energy services
Collect tax. Provide secure environment for all parties	Collect minutes charge	Collect bills	Collect loan payments	Pay bills

We analysed the feasibility of the infrastructure rollout in Namibia's territory over a period of ten years, building a model that evaluated the profitability of such a rollout from the numerical point of view.

For our analysis, we assumed that the Namibian government subsidised approximately 60 percent of the upfront cost of the photovoltaic system and a 10 percent weighted average cost of capital, reflecting risk, opportunity costs, and inflation (taken from other technology-related projects in the same geographical area). More details about the energy system costs used in this analysis can be found in Appendix 2.
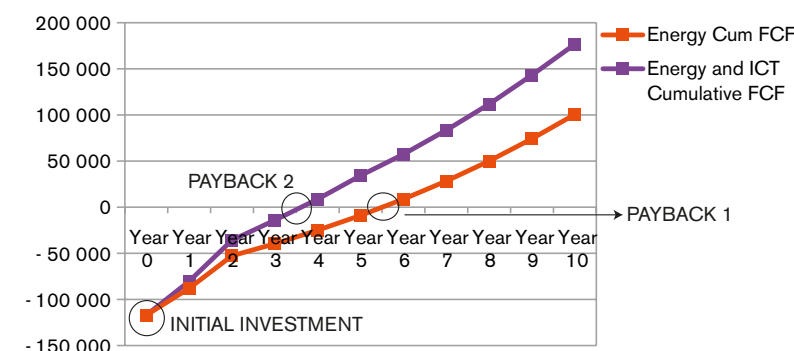

Figure 6. Comparison of cumulative free cash flows for the energy micro grid project and energy plus ICT extension projects (10-year projection).

Figure 6 shows the resulting cumulative free cash flows for rollouts of energy micro grids alone and with the ICT extension. The payback period decreases by two years when the same infrastructure provider combines energy with ICT rollout (3.5 years vs. 5.5 years). Payback period analysis is very simple and straightforward and provides us with the period of time in which the initial required investment is recovered. After the third year, the network effect (whereby the value of a product or service rises as more people use it) continuously increases; thus, the profitability of our model increases year after year until the end of the projected time frame.

In order to estimate the economic value creation of the projects (in addition to the payback method), an estimation of the expected future free cash flows generated by the infrastructure rollout is needed. We will discount them at the already mentioned weighted average cost of capital. In both projects (energy and ICT), we estimated the economic value creation calculated through the Net Present Value (present value of future free cash flows subtracted from the value of initial investment). Table 2. shows the economic value creation indicators calculated based on the cost breakdown given in Appendix 2.

Table 3. Comparison of economic value creation indicators for two scenarios. NVP = Net Present Value; IRR = internal rate of return.

	NPV (USD)	IRR
Energy hybrid micro grid project	19 k	14%
Energy hybrid micro grid project and ICT extension	67 k	23%

The indicators analysis provides clear evidence that important benefits exist between the combined ICT and energy infrastructure rollouts in the rural areas, providing not only an earlier payback period but also superior profitability and rates of return

for the stakeholders.

Other players could also pursue this business opportunity and implement a similar vision. Table 4. provides a summary of the competitive landscape of the possible players in the Nambian market in the fields of ICT and energy infrastructure.

Table 4. Strengths and weaknesses of Nambia's ICT and Energy infrastructure providers.

Player			Competitive strength		Success factor		Barrier and limitation	
Mini-grid solution provider	Solar Age Namibia		Strong in solar energy solution R&D in various conditions		Affordable, renewable, and reliable technology		Expensive product. Difficult sales promotion to off-grid villages	
	DRFN: Energy Trailer		Mobile energy supplier, flexible service sites		Efficient and reliable technology Slow rollout of stationary solution		Very limited capacity, mobility depends on road condition	
Telecom operator	Mobile	MTC	Owner of local cellular infrastructure		High population density & telecom demand		Low ARPU for network rollout	
	Fixed	Namibia Telecom	Owner of local landline infrastructure			Clustered residence		Expensive network extension
	MTN		Virtual operator, regional roaming service		Increase of international roaming in off-grid areas		Insufficient roaming	
	Grameen: Village Phone		**Inexpensive, feasible business aid**		**Efficient micro finance, close to existing cellular coverage**		**Poor micro-finance, insufficient existing coverage**	
Telecom vendor	Ericsson		Experience in telecom network deployment	Better know-how	Affordable and reliable technology for sparse network deployment. Flexible control for local micro operator		Insufficient scale of penetration, too long break-even period	
	NSN							
	Huawei			Inex-pensive				
Energy supplier	**NamPower: Energy Shop**		**Owner of national grid, government support**		**Pilot shops significantly increase penetration**		**Lack of niches to stimulate energy consumption**	
Transportation	TransNamib		Owner of transport network		Good coverage of off-grid settlements		Roads barely cover off-grid villages	

As we have shown in our analysis, our Rural Village model is an attractive business opportunity for infrastructure providers but it does not come free of risks. The following table categorizes the main risks tied to the implementation of this model in Namibia

and highlights the most critical items (**bolded text**) requiring additional focus.

Table 5. Risk analysis of the deployment of our Rural Village model.

Description of risk	Likelihood	Severity	Consequences	Mitigation
Political instability and economic crisis slows the economy and discourages foreign direct investment	1	2	Difficulty to raise capital for investment in the project	
Bureaucracy delays the project development (e.g. it takes 35 days to start a company in Namibia)	**1**	**1**	**Delays in pilot implementation and in ROI**	**Work with Namibian institutions to speed up the procedures**
Problems to implement proper network coverage	2	1	Lack of network coverage prevents mobile phone calls	Work with local institutions /operators to select areas with coverage for the pilot
Difficult to build proper ecosystem to support local entrepreneurship	1	1	Entrepreneur cannot start business and Business Case (BC) fails	Work with Namibian institutions to improve the microfinance support in Namibia
Sabotage of micro grids ruins the business plan	**1**	**1**	**Energy supply and investment is lost and project fails**	**Support from government, paid security**
Lack of support for renewable energies in Namibia	**2**	**1**	**Profitability of the project is delayed due to lack of subsidy**	**International funding. Work with local institutions for improvements**
Increase in diesel prices	1	2	Profitability of the project hindered due to higher OPEX	Implement stronger renewable power scenarios
Supply chain problems	3	3	Delays in the infrastructures/project	Ensure suppliers' quality and avoid dependencies
Problems in collecting payments impact the project's viability	2	2	Cash shortages and pilot failure	Explore pre-paid mechanisms as far as possible
Difficulty to get skilled workers	2	2	Delays in operations	Deploy temporarily skilled workers and train locals

Table 5 shows that cross-functional and multidisciplinary coordination between all the stakeholders is mandatory to ensure successful deployment of our Rural Village model in Namibia.

4.5 Entrepreneurship in Namibian Villages

Schumpeterian entrepreneurship is described as a two-fold force by followers such as Milton Friedman and John Maynard Keynes [35]. The first force is entrepreneurial leadership, which has nothing to do with the administrative management side of business. This leadership is the source of creative energy for innovation and evolution. The second force is profit, which gives economic return on the personal activity

of the entrepreneur to the temporary monopoly created.

Based on the availability of infrastructure and micro credit from the microfinance institutions, some of the villagers would be able to purchase the village phone's kit [15] and pay the monthly electricity charges. They could then resell minutes of airtime to other villagers without a phone.

The actual population in the village will have to be considered to determine any market opportunity; i.e. the number of potential customers and the average number of minutes per day that other villagers will buy, among other things. According to data from the Grameen bank [36], the average Village Phone Operator in densely-populated Bangladesh sells 50 minutes of incoming and outgoing calls. In Uganda, where only outgoing calls are charged, 14 minutes per day on average are sold.

Due to the low population density in Namibia, it is reasonable to estimate that the village operator will not sell more than 14 minutes per day. With the price per minute in Namibia [37] of approximately $0.19 USD, the local entrepreneur could, as an example, resell the minutes of air time at $0.24 USD per minute (at approximately 20 percent premium).

According to these parameters, and considering a village of approximately 500 households and an average GDP of $500 USD per year, the economic value of the entrepreneurial activity of the village's entrepreneurs increases from year to year, as shown in Figure 7 (calculated through the present value of future free cash flows, discounted at a weighted average cost of capital of 10 percent).
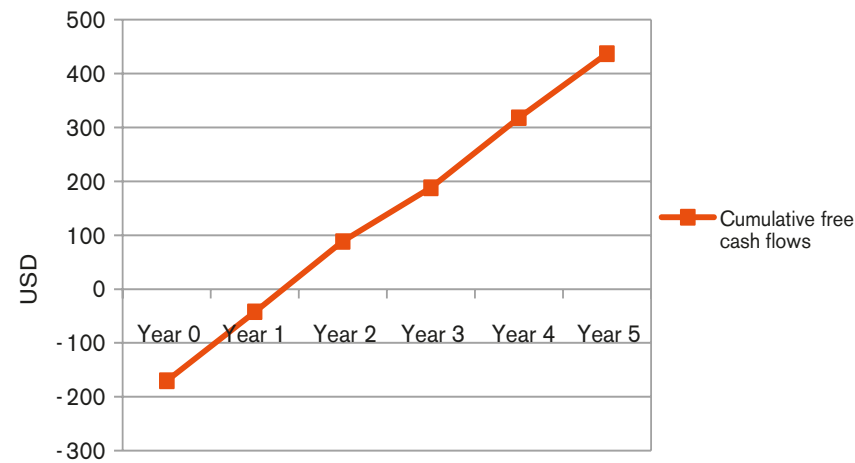

Figure 7. Five year projection of the entrepreneur's financial return (cumulative sum) from the net present value.

The positive cash flows and rapid break-even point for the local entrepreneur indicates the viability of business activity that could benefit her/himself and the rest of the community, enabling the access to modern communication.

In order to understand the affordability of the combined infrastructure usage from the local villager's perspective, we calculated the percentage of the villager's gross income that would be spent in electricity and ICT-related costs. We estimated a price of $0.6 USD per kWh and a daily consumption of 162 Whr per household in our modeled village. Figure 8 shows that entrepreneurs' maximum expenditure is only about 10 percent of their GDP, indicating that our Rural Village model is feasible from the local villager perspective.
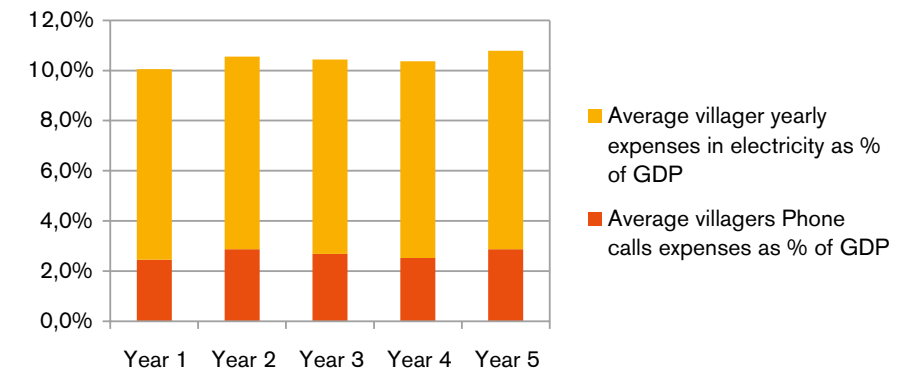

Figure 8. Five year projection of the percentage of villagers' GDP spent in energy and ICT consumption.

In addition to re-selling minutes of airtime, the newly-deployed energy and communications infrastructure in rural areas allows the local population to engage in numerous complementary activities. Here are some examples:

- **Water pumping for irrigation or consumption.** The deployment of our solar-powered energy micro grid could be extended and further developed to facilitate photovoltaic irrigation drip systems that could in turn become a key element for local agricultural development. Despite the upfront cost, solar energy could be a sustainable solution for irrigation systems and is already piloted in several areas in Sub-Saharan countries [38].
- **Recharging of other devices at a premium.** Local entrepreneurs could utilize their early access to electricity to charge other villager's devices (phones, batteries for radios, etc).
- **Cold storage for goods and medicines.** The energy-generating micro grid in our model is sized to power at least one refrigerator (approximately 500 Watt) which could be used to store medicines, thereby helping to mitigate the diseases of local population. The refrigerator could also be used as a limited storage (at a cost) for goods needing special conservation or simply to store and sell cold drinks.
- **Enabling further development of tourism industry.** Namibia is known for

its natural ecosystems and the diversity of wildlife found in many of its natural parks (like the emblematic Etosha national park [39]). Tourism in Namibia is a growing industry with nearly one million travellers visiting the country on a yearly basis, and an increasing number of people in rural areas are employed. The deployment of sustainable energy solutions would facilitate the goals of the Namibian government in these areas, including managing, controlling, maintaining, utilizing and promoting the national interest in wildlife resort services, while encouraging training and research with a view to increasing productivity in the wildlife resorts service sector.

- **Education related improvements.** The deployment of electricity could facilitate lighting in schools and the usage of computers and technology for education. A possible development scenario involves downloading of content for electronic books during the night that could then be utilized in education. This would avoid the transportation costs and other logistics in providing books to remote classrooms.
- **Software services using mobile devices as a platform to help bridge the digital divide in emerging countries.** In 2009, Nokia introduced a range of services aimed at emerging markets under the name of Nokia Life tools3. These solutions focus on agriculture (providing information on weather, agriculture tips and techniques, and market prices), education (simple English courses and general knowledge) and entertainment. All of these could be complemented with text to speech services that could support pre-literate villagers to communicate with others and stay within reach.

4.6 The Possible and Probable Future Paths for Namibia in 2030

Governments increasingly consider entrepreneurship and innovation to be the cornerstones of a competitive national economy [40].

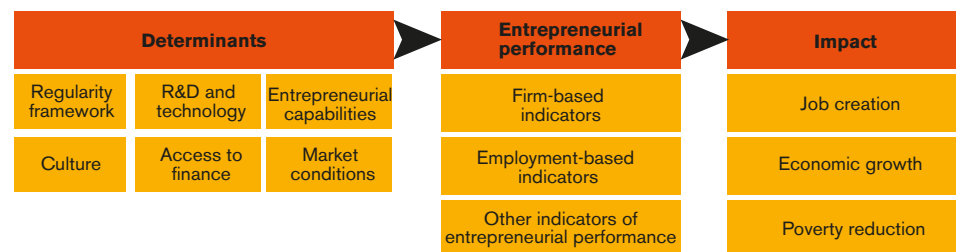Figure 9. shows the top categories for entrepreneurship indicators according to the OECD [41].

Figure 9. OECD Entrepreneurship determinants, performance and impact measures.

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3   www.nokia.com

We took the OECD determinants as a basis for our eDelphi survey discussed below, especially the ones that are related to regulatory framework, market conditions and culture. The impacts of this framework are evaluated in futures scenarios.

4.6.1 The eDelphi Survey Method and Other Data

Scenario working in futures studies is regarded as qualitative according to Rafael Popper (2007) [42]. The concept of scenario was originally used in theatre and film-making. Scenario thinking and the use of scenario methods have come to futures studies through operation analysis and through Delphi methods [43]. The Delphi method is one of the official semi-quantitative futures research methods [42], first introduced in 1969 and used in 1970 [44]. In this method, by weighting opinions, mathematical principles are applied to quantify subjectivity, rational judgments and the viewpoints of experts and commentators. Delphi methods are most often employed to elicit views as to whether and when particular developments may occur, but the technique can be used for any sort of opinion or information—such as desirability or possibility of specific outcomes, impacts of policies or technologies [45]. When the Internet is used for a Delphi study, the study is referred to as an eDelphi survey. Scenario working using the Delphi method includes five or six phases and the results are known as the possible futures paths. The results fall into two main futures categories, namely, the most *probable* and the most *desirable* futures.

We conducted an eDelphi survey entitled "The most probable futures path for Namibian entrepreneurship in 2030". Using our student colleagues as an expert group, we carried out only one round instead of two to three possible rounds, due to limited timeframe. Therefore, the results are somewhat less reliable than in usual Internet-based Delphi surveys.

Out of 30 informants, 14 evaluated possible future paths regarding Namibian ICT and energy development. The informants were provided with our case study material about telecommunications in rural areas beforehand and some Namibia-specific information during the survey. We singled out some answers that were in agreement or disagreement and analysed them together with our secondary data, comprising cost analysis of the electric grid, telecommunications, and ICT development in Namibia. We also underlined the key words, or the most critical issues, in these statements, based on Delphi survey development guidelines. Examples of these analyses are given in Appendix 1.

In a separate analysis, we interviewed two ICT and Namibian culture specialists for their expert opinions, especially with regard to telecommunications and its improvement in Namibia.

4.6.2 Survey Outcomes: Two Futures Paths for Entrepreneurship

The survey revealed that the most probable futures path contained three main aspects based on three statement categories, varying from sustainable energies and international cross-functional collaboration to the role of central governments.

Firstly, our informants expressed their concern about the use of sustainable energies and about proper value-added service innovation needs they foresee in undeveloped countries. Secondly, the informants primarily believed that some advanced technology solutions and international financial support might be possible in the next ten years. Thirdly, all informants agreed that, most probably, central governments would provide more security, project management support and valid laws to enhance entrepreneurship in Namibia in 2030. They also discussed new job creation, economic growth and poverty reduction opportunities at the municipal level. The informants mostly disagreed about whether there is sufficient agreement among governments and municipalities that would allow country-specific solutions. They also argued whether we really have a "lingua franca" to deal with undeveloped countries.

Regarding the most desirable futures path for Namibia, our informants were concerned, above all, about the sustainability of energy sources. They wanted to involve the local governments and municipalities in the hunt for international help. Both the survey informants and the Namibia experts stressed the importance of local people, their cultural characteristics and the role of leadership. The informants mostly did not agree with the statements about international collaboration, leading us to think more about national or local collaboration.

4.6.3 Interview Outcome: a Namibian Perspective

The interviews showed us a totally different picture of the entrepreneurship in Namibia compared with the results of the Delphi surveys. Veli-Antti Savolainen, a distinguished Finnish journalist and ICT-pioneer, has been involved with Namibian governmental and municipal projects from the beginning of this century. He found a wife and a second home in Namibia, a far away country to most Finns but familiar to many of them from Martti Ahtisaari's[4] history. Savolainen and researcher Inkeri Huhtamaa talk about African culture and how you first have to know the differences in "African time" in each country and how this spirit etches into you. Veli-Antti Savolainen also talks widely about "sulata", which means that you have to give some of the little you have to your fellow neighbour and get it back when you need it, through a similar kind of favour; in this particular research case, this would be phone usage.

Savolainen and Huhtamaa both say that the villagers have mobile phones but they do not have money to pay the phone usage costs, so it is just a question of who would

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4   Nobel Peace Prize Winner 2008, President Martti Ahtisaari

have some money to buy value for their phone cards at that particular moment. Then they circulate the phone usage time, which is called "going to sulata". Another cultural issue related to entrepreneurship in Namibia, and in all Sub-Saharan Africa, is the concept of "Ubuntu". You have to have "Ubuntu" time for your neighbour at all times. You cannot be too busy to discuss and solve problems with your friend; therefore, in Namibia, people do not talk about business management, instead they talk about leadership.

The ICT specialists we talked to mentioned the Namibian crafts sector and its huge potential to improve entrepreneurially if the logistics problems were solved by smart mobile phone services, since there is not sufficient Internet coverage. Savolainen has been creating e-offices in Namibian villages and regards it as amazing that these people are more willing to share computers, for example, than Europeans. There are also strong monopolistic powers like Namibian Telecom, who are not willing to leap from early technologies to smart phones.

5   Conclusion

Among the most critical services to society, energy and ICT are the foremost, without which people at the bottom of the economic pyramid will be deprived of their basic needs. Our Rural Village model proposes to provide these basic needs while forecasting a net investment return for all stakeholders. However, there are many challenges to address.

Designing a marketable business logic is a challenging task. Especially when it is a groundbreaking one, the amount of risk such model possesses is high, and failure can hit the entrepreneurs. Moreover, when this business logic is targeted at the bottom of the economic pyramid, the return of the end user, who has comparatively lower paying capacity, might be jeopardized. Therefore, the corporate world is sceptical about entering this market.

We have described a business logic that will divide the risk and makes business more viable. In the business logic we have proposed, generally speaking one service (ICT) stimulates another service (electricity) and vice versa. In developing rural areas where the formal economy does not exist and people are still living in grassroots conditions, the only way to leapfrog the existing technology gap is to provide a package of services—in our case, a package of two interdependent services that have the ability to stimulate each other. This will double or triple the economic effect compared to a single service alone. Therefore, our concept of marketing our product also involves creating a niche for business and creating a business environment where people have enough economic activities to allow them to start using the services. Unfortunately, related players including rural entrepreneurs, governments, and finance sector institutions have overlooked this opportunity.

Our combined infrastructure solution involves many different stakeholders, providing long-term benefits for the government, the villagers and the infrastructure provider. This collaboration between multiple players also minimizes the overall risks involved with rolling out basic ICT/energy infrastructure in rural areas. According to our analyses, the rural area power supply (RAPS) system is a sustainable way to electrify the rural villages in the developing world. Even though the cost of the renewable system is higher in the initial phase, it is economically sustainable in the long term if compared with the diesel/petrol system. Since the capital investment for the renewable energy is high, it is mandatory to have governmental participation through subsidies in order for the renewable energy micro grid to be economically viable.

New avenues in the field of energy storage provided by nanotechnology have opened up an opportunity to improve the energy solution for rural areas. One example we have studied is supercapacitor usage, a technology that can decrease the expensive and excessive carbon-consuming power usage peaks. Other examples include the emerging technology of the paper battery that is expected to be ultra-light, thus making storage systems more flexible and transportable.

So far, in developed countries, energy and ICT infrastructure rollout have followed separate paths. In this article, we strongly advocate changing such policy and introduce instead a unified ICT and energy approach, both from the perspective of governmental regulation and that of infrastructure deployment. This changes the dimensions of rural business economics and can profit millions of customers, maximizing the return of investments (as we have seen in our Namibia study case). Our concept forms a strong foundation that can be further refined with the development of marketing strategies.

In conclusion, we support the view of the ICT Advisory Group [46] that a novel approach for delivering energy to rural areas will provide an excellent opportunity for leapfrogging the technology gap while developing new, highly-distributed service-oriented business processes where a growing number of providers and consumers will interact.

References

1. http://www.worldenergyoutlook.org/database_electricity/electricity_access_database.htm.
2. Leonard Waverman, Meloria Meschi and Melvyn Fuss. The Impact of Telecoms on Economic Growth in Developing Countries.
3. World energy outlook, 2006.
4. Khandker, Shahidur R.; Barnes, Douglas F.; Samad, Hussain; Minh, Nguyen Huu, Welfare impacts of rural electrification: evidence from Vietnam, 2009, world bank publications.
5. Measuring village ICT in Sub-Saharan Africa. 26 International Telecommunication Union, www. itu.int/ITU-D/ict/statistics/material Africa_Village_ICT_2007.pdf.
6. Underdeveloped ICT areas in Sub-Saharan Africa. Alfonso AVILA. Informatica Economica Journal,Vol. 13, no. 2/2009.
7. The Current State of Internet Penetration in Africa. Sante J. Achille. Aug 18 2008. http://appfrica.net/blog/2008/08/16/the-current-state-of-internet-penetration-in-africa/.
8. Savolainen Veli-Antti, Huhtamaa Inkeri interviews, December 2009.
9. ICT in developing countries. Parliamentary Office of Science and Technology postnote March 2006 Number 261.http://www.parliament.uk/documents/upload/postpn261.pdf.
10. K. Fall, A Delay-Tolerant Network Architecture for Challenged Internets, Intel Research Berkeley, 2003. http://www.dtnrg.org/docs/papers/IRB-TR-03-003.pdf.
11. Lecture Notes on Energy Systems, Alex Zahnd, Project director, RIDS Nepal. Available at www. rids-nepal.org.
12. Roadmap Report Concerning the Use of Nanomaterials in the Energy Sector. http://www.nanet.nu/upload/centre/nanet/links_ikoner/rapporter%20under%20links/milj%C3%B8%20og%20energi/roadmap%20report%20concerning%20the%20use%20of%20nanomaterials%20in%20the%20energy%20sector.pdf.
13. High-performance lithium battery anodes using silicon nanowires. http://www.nature.com/nnano/journal/v3/n1/full/nnano.2007.411.html.
14. Researchers fired up over new battery. http://web.mit.edu/newsoffice/2006/batteries-0208.html.
15. Grameen Foundation: The Village Phone Direct Manual - Enabling microfinance institutions to bring affordable communication services to the poor. http://www.villagephonedirect.org.
16. Ericsson: How Efficient Mobile Backhaul and Packet-switched GSM Will Help Win the Final Coverage Race. http://www.ericsson.com/technology/whitepapers/telecom_expansion/mobile-backhaul-and-packet-based-switched-gsm.shtml.
17. Nokia Siemens Networks Village Connection: Bring Affordable Communications to Rural Villages. http://www.nokiasiemensnetworks.com/insight/internet-for-the-next-billion/nokia-siemens-networks-village-connection.
18. VillageNet: A Low-Cost, IEEE 802.11-Based Mesh Network for Connecting Rural Areas. Partha Dutta, Sharad Jaiswal, and Rajeev Rastogi. Bell Labs Technical Journal. Volume 12 , Issue 2, 2007.
19. Minimum Cost Topology Construction for Rural Wireless Mesh Networks. The 27th Conference on Computer Communications. IEEE 2008, page 771-779.
20. N Vallina-Rodriguez et al. Goose: Social Network Services for Developing Worlds, http://conferences.sigcomm.org/sigcomm/2009/demos/sigcomm-pd-2009-final58.pdf.
21. http://www.un.org/documents/ga/docs/53/plenary/a53-223.htm.
22. Wikipedia, http://en.wikipedia.org/wiki/Namibia.
23. CIA World Factbook, Namibia, https://www.cia.gov/library/publications/the-world-factbook/geos/wa.html.
24. National Planning Commission, Central Bureau of Statistics, A Review of Poverty and Inequality in Namibia, http://www.npc.gov.na/publications.
25. UNICEF, Country statistics, http://www.unicef.org/infobycountry/namibia_statistics.html#55.
26. Ndhlukula, Kudakwashe. Planning Power: Review of Electricity Policy in Namibia - Case of Renewable Energy, Institute for Public Policy Research Workshop 10 September 2009, Windhoek. http://www.ippr.org.na/Comments/IPPR-%20Review%20of%20Electricity%20Policy%20-Kudakwashe%20Ndhlukula.pdf.
27. World Bank, Key Development Data & Statistics, Country profiles, http://www.worldbank.org/.
28. Wind Regimes of Africa, International Weiterbuildung und Entwicklung GMBH, May 2004, available at http://www.afriwea.org/en/namibia.htm.
29. HOMER Database, HOMER can be downloaded free from http://www.homerenergy.com/.
30. Succulent Karoo Ecosystem Programme (SKEP) Namibia. http://www.nnf.org.na/SKEP/skep_pics/map_popdense.jpg.
31. Namibia GSM 900/1800 Coverage Map. http://www.gsmworld.com/roaming/gsminfo/cou_na.shtml.
32. The Renewable Energy and Energy Efficiency Institute (REEEI). http://www.reeei.org.na/projects/docs/1.13%20Energy%20Shops%20-%20DRFN%20-%20Executive%20Summary.pdf.
33. Promoting micro financing activities in Namibia. A regulatory and supervisory framework. Bank of Namibia research department.
34. Factors Influencing the Financial Sustainability of Selected Microfinance Institutions in Namibia. Jonathan Adongo and Christoph Stork.
35. Lahti Arto, Globalization, International Trade, Entrepreneurship and Dynamic Theory of Economics. Working papers HSE W-436,2007, p.8.
36. http://www.itu.int/dms_pub/itu-d/opb/hdb/D-HDB-VPD-2007-R1-PDF-E.pdf.
37. http://www.telecom.na/index.php?go=domestic&sel=domesticcharge.
38. http://news.stanford.edu/news/2010/january4/solar-irrigation-africa-010610.html.
39. http://www.met.gov.na/nwr.htm.
40. OECD, Measuring Entrepreneurship, A Digest of Indicators, 2008, p.5.

41. OECD, Measuring Entrepreneurship, A Digest of Indicators, 2008, p.7.
42. Popper Rafael, Foresight Methodology, University of Manchester, 2007, An extract, p.1.
43. Rubin Anita, About eDelphoi, Scenario working in futures studies, www.edelphi.fi/TSE, 2009.
44. http://www.is.njit.edu/pubs/delphibook/ch3b1.html.
45. Popper Rafael, Foresight Methodology, University of Manchester, 2007, An extract, p. 7.
46. FP7 ICT ADVISORY GROUP, Working Group on "ICT and Sustainability (including Energy and Environment)".

Appendix 1: Some Examples of eDelphi Arguments

I The first category of statements is: Which futures do you find the most probable for entrepreneurship in Africa in 2030?

1. The use of renewable technology will be the most critical success factor in ICT entrepreneurship in rural areas within the next 20 years. Disagree: "Renewable technology should be divided into two; renewable or sustainable energy sources and innovative technologies or service innovation methods." According to our secondary data analysis, there are possibilities in sustainable energy sources and service innovation. Is the solar power operated light bulb among these opportunities?

2. International cross-functional collaboration is fundamental to enable entrepreneurial innovation in African rural areas in 2030. Disagree: "It is inevitable to seek more international and cross-functional collaboration to enable entrepreneurial innovation as a result of advanced technology and financial support."

3. Local entrepreneurship in rural areas should be managed by the local people and the central governments should remain in a facilitating role. Agree: "Central governments still need to provide basic security etc. Governments in these areas are often corrupt, and might not have incentive to provide the services needed."

II The second category of statements was: Which futures in African rural areas' entrepreneurship in 2030 do you find as the most desirable?
Out of 30 respondents, 14 commented on the following statements:

1. The use of renewable technology will be the most critical success factor in ICT entrepreneurship in rural areas within the next 20 years.
   Completely agree: "Global warming, for example, makes it inevitable to create new and renewable technologies and use sustainable energies in the Futures"

2. International cross-functional collaboration is fundamental to enable entrepreneurial innovation in African rural areas in 2030.
   Neutral: "A good working environment is needed, but entrepreneurship cannot be "planted".

3. Local entrepreneurship in rural areas should be managed by the local people and the central governments should remain in a facilitating role
   Completely agree: "The involvement of the local people will be more significant if they also have the power to manage it instead of some central government. Leaving the management to the government will also hinder people from learning the management themselves and thus cause difficulties for the future development of entrepreneurship".

Appendix 2: Energy system cost

System Cost	Costs (USD)
PV modules	13000
Batteries	16000
Control and Power conditioning	3000
Building and materials	10000
Project design, commissioning and legalization	30000
Subtotal Equipment, Materials and execution	72000
Distribution grids	40000
Generator set	5000
Total initial investment (fixed assets)	**117000**
Fixed costs	
Salaries	1000
Spare Parts and maintenance	800
Administrative	300
Battery replacement	0
Technical support	0
Subtotal	2100
Variable costs	
Fuel and lubricant	538
Fuel transport	27
Subtotal	565
Total OPEX costs	**2665**

2

Innovating
Energy

2.1 Smart Grids – Power to the People, Power from the People

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Abstract

The topic of "smart grids" is trendy, as the energy sector is undergoing numerous changes. Smart grids are seen as very possible solutions which can help provide energy security, meet growing electricity demands, and generate energy in sustainable ways. Several test smart grids have been set up, but there is still a long road ahead with many challenges, such as negative social response. Enablers in the field include

mature technology, favourable legislation, and growing awareness of environmental impacts from human activities. The future development of smart grids will depend on the willingness of all the stakeholders to adopt and adapt to new set-ups and will most likely vary from region to region.

Keywords: smart grid, energy sector, electric grid

1 Introduction

The energy sector is facing numerous challenges, including higher energy demands, new generation methods, energy conservation, fossil fuel shortage, and green house gas emissions. The current energy distribution network relies heavily upon electric grids which were designed and installed many decades ago [1, 2]. 'Smart grids', or 'intelligent grids', are expected to help overcome the shortcomings of the existing grids and empower all actors along the energy network, from generators to customers. Along the whole chain, smart grids and individual energy users, everyday people, are closely linked. Smart grids can bring more energy security and empower individuals with ways to innovate around the energy sector while also gaining power from people, literally through small generation stations and, metaphorically, through high social acceptance of smart grid set-ups.

1.1 What is a 'Smart Grid'?

'Smart grids' have become a trendy subject, from the EU setting up a Smart Grid platform to help the deployment of smart grids in Europe to Barack Obama mentioning smart grids in his speeches; they are on everyone's lips. Yet, there is no unanimous definition as to what makes a 'smart grid' and there are many approaches being developed. The different actors who have been working on taking the notion from a theoretical state to a working system tend to agree that the main role of a smart grid is to use digital technologies to enable real-time control of the power grid, from generation to use [2]. A smart grid needs to empower the different stakeholders to define new interactions and transactions around the energy network. It must also be self-healing and withstand system anomalies as well as provide utility companies full pervasive control of their assets [3].

1.2 Why Smart Grids and Why Now?

The existing energy generation and distribution set-up is built to meet and withstand maximum anticipated peak demand. It is over-engineered and, therefore, inefficient 95% of the time. Utility companies also face increasing demand but cannot respond by building new generation and distribution systems, which puts an increasing bur-

den on the existing systems and causes blackouts and power shortages [1, 4]. The current response to these issues is the implementation of Energy Management Systems (EMS), Special Protection Schemes (SPS) and Remedial Action Schemes (RAS) to protect the grid. Such approaches help stabilise the response to demand and help the grid, but they are often only based on theoretical studies and signal problems once they become 'visible', at which time it is often too late [1]. The technology, such as Automated Meter Reading (AMR) and Automated Metering Infrastructure (AMI), is now available to provide two-way communication and to control loads along the electric grid. These control technologies also provide ways to continually optimise the use of the generators and the grid, thereby optimising resource use and reducing GHG emissions while minimising linked costs. They should also allow a self-healing smart grid which predicts looming failures and has the possibility to take corrective actions in a way that system problems can be avoided or, at least, reduced.

The energy produced today is mainly based on fossil fuels (coal, oil and gas), nuclear and hydro sources. Renewable energy sources such as windfarms and solar photovoltaic (PV) and thermal set-ups are increasingly popular as these technologies become mature and companies are urged to reduce their carbon footprint. The integration of these generation methods into existing electrical grids is not the easiest task, as their output is often difficult to predict and control [2]. As generation is becoming more dispersed in order to respond to increasing peak demands, new ways of controlling the grid are needed [1]. Moreover, customers now have the possibility to produce their own power, but they often face difficulties when trying to resell extra power generated back to the grid [5]. In a smart grid set-up, customers are no longer just customers but rather they become buyers and sellers. The grid has to monitor in real time the consumption and generation at every entry and exit point [6]. The AMR and AMI technologies mentioned above can contribute to the creation of such a two-way communication system, as well as the current spread of fast Internet connections [7].

Smart grids are complex structures to put into practice and they cannot be expected to replace the existing system. Instead, they should be a complement to the electrical grid as we know it today and provide a more stable and secure service while empowering all linked stakeholders, from utilities to high-tech companies to customers. As with any technology, the full implementation of smart grids faces many challenges, such as security and privacy issues, the legacy from the existing system, and moving the energy sector from product to service providers. Privacy and security issues include granting utility companies pervasive control over the grid, which should facilitate the control of loads and peaks. But how much control should the customer retain over personal appliances and energy production choices? The continuous transmission of private data also demands a secure and reliable communication system to guarantee privacy [8]. Furthermore, the energy sector is well set-up and has a certain legacy, especially in developed countries. Market deregulations, shifts in customer behaviour, and pressure for more environmentally-conscious choices have

already pushed things towards change, but the smart grid set-up can only be expected to happen in progressive stages. The energy sector is also turning towards providing services such as heating or cooling instead of raw power; the notion is not new, but time is needed for the changes to be accepted [9].

The progress in the field of smart grids has shown that individual users are important stakeholders in the energy sector, yet they are often overlooked. Smart grids represent an opportunity to include individuals more actively, bringing power to the people and gathering power from the people. Smart grids, of course, have the ability to bring power to the people by providing energy security and energy efficiency, but they can also empower people and foster innovations in a stagnant sector, as shown in the chapter on User-Driven Innovation. People have a great potential for energy production through small generation set-ups which can be incorporated into the grid through a smart grid system. Moreover, the proliferation of smart grid set-ups will greatly depend on social acceptance. A strong backing from individual users is necessary and can power up and accelerate the implementation of smart grids. The following sections discuss the current technological state of the art, challenges and enablers for smart grids, and the future that these systems face.

2 State of the Art

2.1 The Energy Value Chain

In this subsection, we describe the energy value chain and the various stakeholders in the smart grid industry. In Figure 1, we illustrate the energy value chain and the various technological upgrades or service interventions which need to be made in order to upgrade the existing electric grid.

Where does the grid become smart?

Demand & supply prediction

Large scale storage management

Power quality management

Integrating generation & storage

Efficient transmission

Outage prevention

Demand prediction and response

Demand monitoring

Home area networking

Distributed generation
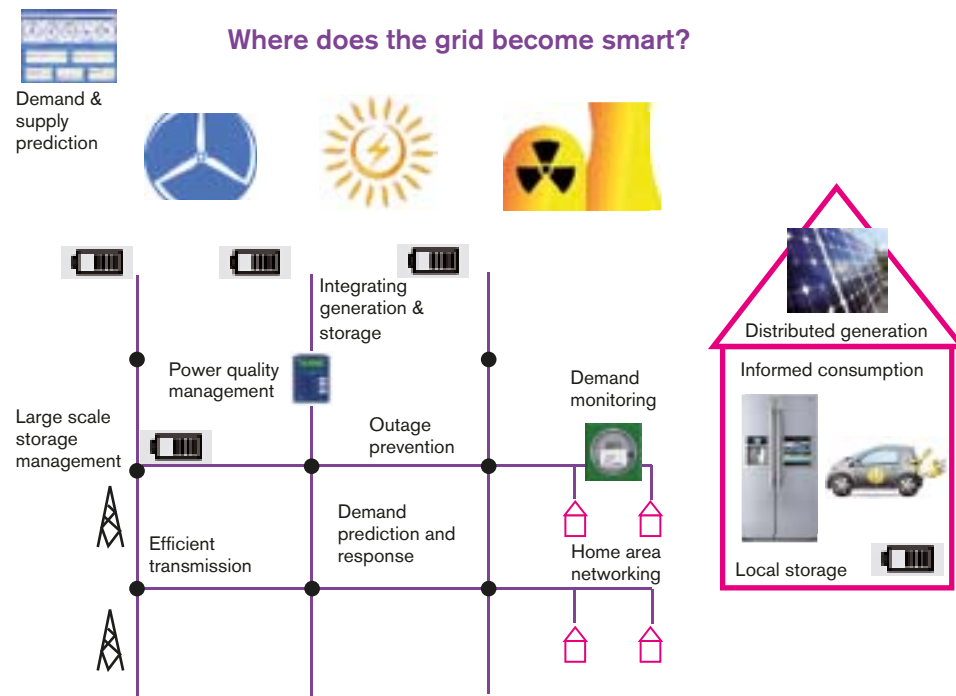
Informed consumption

Local storage

Figure 1. The energy value chain. Key technologies that make the electric grid smart. From generation through transmission, distribution, consumption and storage, there are various technological interventions which can make the electric grid more robust, efficient and dynamic.

Who are the key players along the smart grid value chain and how will their relationships change as a function of the smart grid? We think the largest players would be the utilities, government, industrial consumers and individual consumers. The key technology players in the network include hardware vendors for power plants, grid infrastructure providers, networking infrastructure providers, storage technology providers, small-scale power plant and storage providers (PV roofs, windmills, bloom boxes, UPS systems), smart meter vendors, plug-in smart cars, smart appliance manufacturers, and home area networking providers. Once the technology players have established their businesses, there would be sufficient room for service providers to emerge. These include monitoring and prediction services for utilities and power plants, control services for substations and utilities, information and networking service providers for consumers and utilities, as well as commodity traders and carbon markets which influence the real-time prices. Figure 2 illustrates these players and their possible relationships.
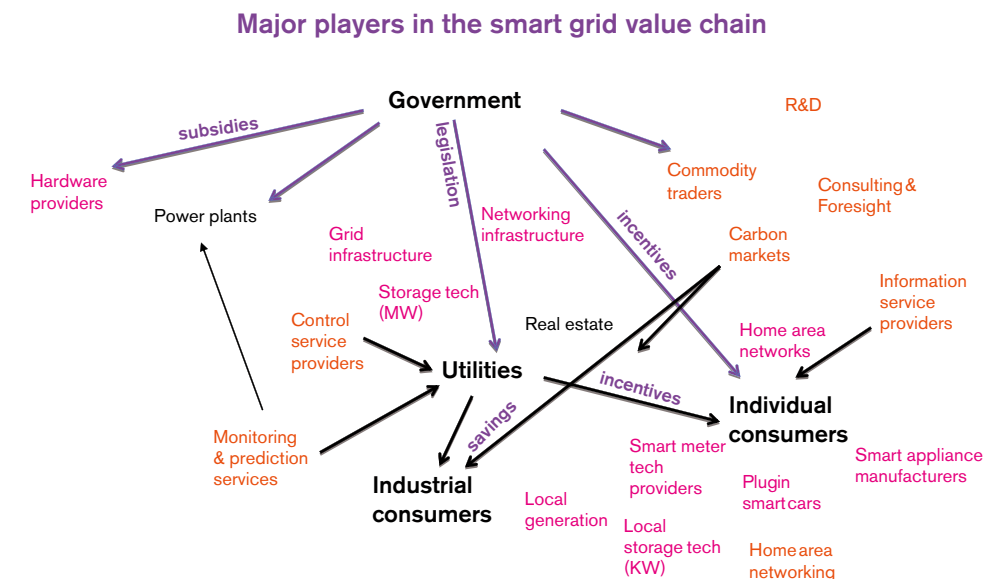

Major players in the smart grid value chain

Figure 2. The key players in the smart grid value chain. The technology players are illustrated in blue and the service players in red.

2.2 What Technologies Constitute the Smart Grid?

Owing to the complexity of the energy value chain in terms of its multiple players and functions, the smart grid is not one single technological disruption. Rather, it is a conceptual disruption which requires the deployment of several technologies in concert. Here, we summarize the key technologies that comprise the electric grid. We focus on those technologies which have a maximum potential to modernize the grid.

Integrating Generation and Storage. There are three kinds of power plants, which are classified according to how they operate: base load power plants (operate all the time), peak load power plants (operate only during peak hours), and load following power plants (operate by closely monitoring the load). *Supply side control* deals with sophisticated control technologies for operating power plants in sync with demand and the aggregation of power from various sources.

Despite sophisticated control technologies for operating power plants in a demand-matched fashion, surpluses are often generated. These need to be stored efficiently for peak demand periods. Energy from renewable sources with high fluctuations must also be stored. Storage technologies must advance not only to provide security of supply but also for economic reasons. Cheaply-generated energy can be stored and sold when the price is high.

The most common and reliable large-scale storage is pumped storage hydroelectric. The concept involves pumping water up from a lower reservoir to a higher reservoir during off-peak hours, and instantly regenerating energy with a hydroelectric turbine during peak demand. Integrating flywheels with wind turbines for storage has also been highly advocated and actively pursued. For smaller scales, such things as Li-ion batteries and UPS systems may be more appropriate.

Demand and Supply Prediction. Technologies which enable demand and supply side prediction are closely tied to demand monitoring and demand response. Sophisticated weather monitoring tools, for instance, can provide real-time prediction of maximum realizable power from renewable energy sources like solar and wind. The monitoring of such things as wind speed and cloud cover is especially relevant for renewable sources of energy. Likewise, the monitoring of temperature and humidity is relevant for predicting heating and cooling demands. Thus, providing utilities with access to real-time weather data should be high on the agenda of a smart grid project.

Transmission. Currently, the bulk transmission of power is done with a three-phase alternative current (AC) in most grids. High voltage helps to reduce power lost during transmission. High voltage direct current (HVDC) lines are alternatively used. The proposal for the EU's smart grid contains HVDC technology. In the US, there are advocates for both HVDC and HVAC lines. HVDC is promising because it integrates several AC lines operating asynchronously or at different frequencies. The power loss in HVDC lines over long distances (a few 100 km) is significantly lower than in HVAC lines, but, for short distances, the cost as well as losses associated with rectification (conversion from AC to DC) and inversion (conversion from DC to AC) is quite high.

High-temperature superconductors (HTSCs) are a promising new technology for addressing transmission efficiencies. The development of superconductors with transition temperatures higher than the boiling point of liquid nitrogen has made the concept of superconducting power lines commercially feasible. Some companies such as Consolidated Edison and American Superconductor have already begun commercial production of such systems. However, significant technological innovations spanning decades may be required before liquid hydrogen HTSCs can be deployed.

Volt-var optimization (VVO) is yet another technology which can be deployed to decrease transmission losses if the demand is accurately known.

Power Quality Management. Smart control of generated AC power is required to monitor, separate and, accordingly, route high grade (for industrial processes, data servers, etc.) vs. low grade energy (for charging/operating home appliances, etc.). Phasor measurement units (PMUs) measure the quality of the waveform and help engineers to subjectively describe the power quality. If PMUs were integrated within a vast communication network, it would be possible to remotely and objectively manage power quality.

Metering Infrastructure. Advanced metering infrastructure (AMI) is the latest mature technology for two-way communication of consumption between utilities and consumers. It enables better monitoring of consumption for supply management and fault detection and leads to increased efficiency of power distribution. Despite the availability of mature technology, only about 8% of the 2.7 billion meters installed worldwide are digital. The US has been the most aggressive country to date, converting 46% of its installed meters to automated meter reading (AMR) technology. However, AMI penetration is still at about 5% and growing at ~5% annually [10]. This is perhaps due to a lack of incentives for utilities to invest heavily in light of uncertainties in the regulatory environment. Energy giants such as Landis+Gyr (Switzerland), Itron (US) and Esco (US) dominate this market [10].

Demand Generation and Response. AMI enables transparency and real-time information about consumption to be used for fast and efficient demand response from utilities. Management of home energy consumption, either directly by the utility or indirectly through transparent price information, enables better response to demand. The class of technologies that enable this is broadly referred to as demand response.

Demand generation refers either to direct or indirect remote control (through transparent real-time pricing information) of local power sources (at the household level: generators or bloom-box fuel cells, or stored energy from PV panels and Li-ion car batteries), which can be turned on automatically or by the homeowner during times of low supply to meet energy needs. For effective demand generation, local energy sources must have a two-way connection to the grid so that surpluses can be uploaded. Regional substations can also upload reserves of stored energy in times of high demand.

Smart Appliances. Manufacturers of electrical appliances need to be incentivized to equip the appliances with remotely controllable switches. These are connected to the grid and operated during off-peak hours, if applicable, to minimize costs and load on the grid.

Security. According to an industry update report [10], security is one of the primary concerns of the smart grid network and, thus, represents a large opportunity: 'We find security play an emerging sweet spot along the smart grid value chain. Indeed security vulnerability is indeed the primary concern for this nascent industry, which is apt to spawn a host of smart grid security start-ups. Such dynamics could be analogous to the $30 bn network security industry created with the emergence of the internet over the past 15 years. We favour companies that are at the forefront of security innovation and standards (Trilliant Networks), driving strategic interests from traditional network security leaders (Cisco, IBM), as well as vertically integrated AMI providers.'

Home Energy Portal. Once the smart grid infrastructure is in place, utilities or third parties can also sell services to home owners to monitor their energy consumption efficiently and plan ahead for predicted shortages. These may be in the form of web-based home energy portals, which can then be accessed via mobile phones or PDAs. In fact, profit sharing between utilities and customers for reduced energy use can manifest itself in the form of such energy services.

Enterprise Applications. Similar centralized portals or enterprise apps can be designed for utilities, power plants and substations. A centralized portal would maximize transparency and allow faster reaction to unexpected changes.

Information and Communications Infrastructure. Information and communication technology (ICT) is the glue holding the smart grid together. From electricity generation to consumption, the ICT infrastructure networks the smart grid components, carries two-way secured information flows to support interactions between components, and provides a platform with access to extensive information for the development of innovative services. The following paragraphs illustrate how ICT acts in the smart grid for both power generation and consumption, not only as the smart enabler in the beginning but also as the innovation platform in the long run.

For utilities of bulk energy provisioning services, the efficiency and reliability of the grid, in a word, depends on the performance of the dynamic load monitoring and control network, which consists of various and massive intelligent electronic devices (IEDs) distributed across a wide geographical area. A grid with a certain adaptability against load dynamics, though still far from cost-efficiently effective and robust in practice, is reckoned smart from the provisioning perspective. An ideal smart grid must be able to adapt to much more complex load dynamics, which are caused by three things: 1) more frequent transmission operations which select the optimal electricity providers for the least cost and emission footprint; 2) the intrinsic instability of the renewable/sustainable resources used by distributed electricity generation; and, 3) possibly more variable patterns of electricity usage and sell-back by the individual grid customers. To achieve such adaptability, the legacy grid must evolve towards a smarter grid with enhanced load monitoring and control infrastructure by adopting existing and emerging ICT, including an upgrade of the intelligent electronic devices (IEDs) to enable more efficient, flexible and interoperable application task deployment, and an upgrade of the communication networks to link the IEDs with more demanding communication quality [11].

The supervisory control and data acquisition (SCADA) system is one example of ICT infrastructure which has been successfully applied to the power grid since the 1990s. As an evolving legacy system, SCADA opts for interoperability in the future and sees a shift in the trend of communication protocols facilitating interaction among IEDs and control centres towards more open ones, such as distributed network protocol (DNP3) and inter-control centre communication protocol (ICCP)

[12]. These protocols are at the application layer, which is on the top of the open system interconnection (OSI) reference model, but the guidelines for their implementation over the lower layer protocol stacks, including the transport, the network and the data link layers, complete full communication solutions. A typical combination of the transport and network layer protocols is the transmission control protocol (TCP) and the Internet protocol (IP), respectively, which are also mainstreams in the Internet [12]. Built upon the essential communication protocol suite of the Internet, SCADA inherits great scalability and reliability, which ensures the success of the Internet. As for the data link layer and the physical layer, numerous technologies lay the high speed core network and the last mile access network with very different properties in terms of QoS metrics, such as bandwidth and latency, communication range, deployment and maintenance costs, scalability, and so on [13]. Undoubtedly, the large-scale deployment of the advanced metering infrastructure (AMI) exerts great influence on the planning of the network infrastructure.

The IEC 61850 protocol attempts to push it further by introducing the object oriented model, which eases the operation logic description in application development and the extensible mark-up language (XML), allowing for full interoperable data exchange using a standard data descriptive model. This already represents a significant achievement in moving towards full interoperability using open and standard communication protocols. The NIST [14] and the IEEE P2030 project, which also targets smart grid interoperability, cover a much more comprehensive scope extending to the end-user applications.

In addition to the ICT infrastructure for the provisioning side application, the smart grid, after all, has to empower the people by facilitating consumer side applications. Such applications should help the customers of the grid to participate in real-time pricing with timely and fine-grained feedback on their electricity usage in order to make more informed decisions about their electricity provider selection and usage planning regarding their home appliances [15]. Hence, a gap appears between the massive real-time data collected by the AMI, the two-way smart meter which can interact with the service provider, and the smart home appliances with universal interfaces which allow automatic and remote control. Due to the difficulty in optimally utilizing real-time pricing, new supportive services should emerge from the innovation platform enabled by AMI and offer a transparent solution package to help customers with their optimal electricity usage. Such services require high performance and a cost-efficient computing system such as the emerging cloud computing platform, which allows massive concurrent user requests and responds in a timely manner. Due to the involvement of detailed user information, a practical and usable security infrastructure is needed to cover all players in the smart grid with a special concern regarding privacy [16, 17, 18, 19].

2.3 Existing Smart Grids

Smart grids are definitely gaining momentum around the world, but what is today the state of the world's most advanced electric grids? Electronic devices have been in our daily lives from the 70's, affordable Internet connections have been available around the world for over a decade and nowadays the software industry is quite mature. Surely we have had the technology required for smart meters and individual energy monitoring already for a while? In the following section we discuss how smart some of the latest grid instalments actually are and see if there have been some problems in the execution so far.

Xcel Energy, a producer and distributor of energy in Minneapolis, Minnesota, has built an experimental monitoring system in Boulder, Colorado. The aim of this SmartGridCity project is to assess if the expected benefits of a smart grid system manifest themselves [20]. Xcel and its partners have funded SmartGridCity without any grant money; therefore, it also acts as a financial feasibility study for the whole smart business. Today, SmartGridCity provides real-time individual energy monitoring via smart meters and claims to possess a more reliable and fault-tolerant power supply [21]. In the future, SmartGridCity will provide changing price rates, electric-car charging and more advanced personal web tools for energy-consumption monitoring.

Meanwhile, in Italy, a large energy company, ENEL, has already installed 30 million smart meters in houses [22]. The meters collect data, allow remote connection and disconnection capabilities with household machines, and also communicate with them. The energy company can read the meters remotely and adjust customers' power levels. However, customers have not yet benefitted from the meters, as there is no possibility to monitor individual energy consumption or to make demand-response choices. To date, customers are not enjoying the benefits promised by the smart grid concept.

Many other smart grid projects are being initiated around the world. An R&D project in Stockholm has been started as part of a larger initiative to cut emissions by two-thirds by 2020 [23]. It is a project with the focus on 'sustainable and efficient generation, transmission and distribution of power'. The goals include using electric cars as batteries, flexibility and transparency in the distribution grid, and lowering consumption and peaks without forgetting the active role of the consumer.

The Italian company ENEL has also started a project in Spain with Endesa called Málaga smartcity. The project includes many companies and research institutes in addition to ENEL and Endesa [24]. Integration of renewable energy sources into the grid is one of the goals of the project; photovoltaic panels in public buildings, micro-generation of energy and small wind turbines have been planned. As in the Stockholm project, it has been planned that electric cars with batteries will be used for energy storage. Charging stations and experimental electric vehicles will also be introduced to enhance urban mobility. This time ENEL claims that it will involve the final users at every stage. New electric meters, telecommunication, and remote-control systems should allow real-time control.

Power distribution grids in general have different legacies in different parts of the world. In North America, as well as in Europe, the national grids are getting old and are, in any case, in need of modernization. The case is different, for example in China and in India, where power consumption is rapidly increasing as more and more houses are being connected to the power grid due to rapid economic growth [25]. These countries may decide to leapfrog to advanced IT-based systems, as the grid needs to be expanded anyway, and, therefore, they have the potential to be fore-runners in adopting the smart meters on a large scale.

Smart grids have aroused much interest in companies and also in research institutions, but it remains to be seen how carefully the individual end-user issues are being addressed, as the incentives for the companies to allow individual control may be limited in the absence of strict regulations.

3 Challenges and Enablers

3.1 Challenges

A smart grid has many potential benefits, but there are also some challenges involved in building and operating one successfully. In this discussion, we divide the liabilities into three groups: energy producers, smart grid and consumers. These challenges affect each other and have an important influence on how to build and operate a smart grid successfully. Figure 3 shows on overview of the challenges of building and operating a smart grid.
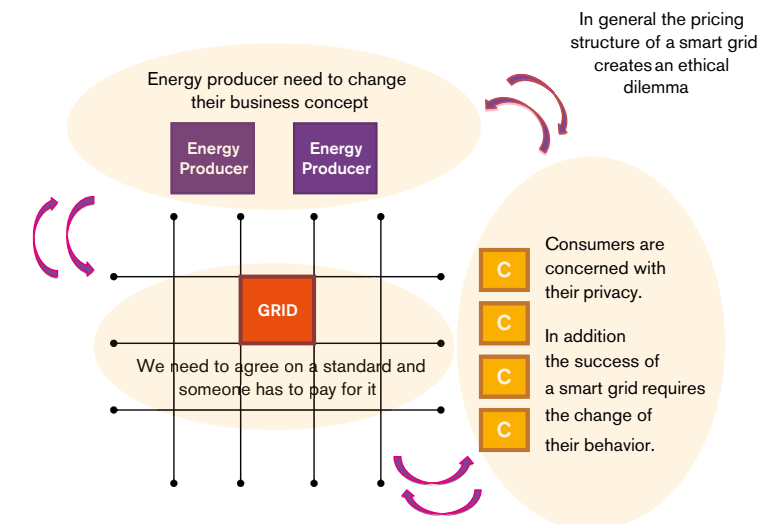

Figure 3. Challenges linked to smart grids

The challenges of the energy producers can be summarized as security issues and required behavioural changes. The grid challenges are related to technological and financial problems. Consumers are concerned with privacy. At the same time, they must adapt their behaviour to make the smart grid successful. One incentive for changing consumer behaviour is pricing. However, pricing leads us to an overall ethical dilemma regarding smart grids.

Security Issues and the Required Change for the Energy Producer. According to Fox-Penner [26], the business model of utilities was based on increasing energy output, which allowed for the strategy of economics of scale and lower costs in producing energy. Economics of scale, through large investments, combined with government regulation led to a monopoly situation for many utilities. With the introduction of a smart grid and loosening regulatory protection, utilities must rethink their business model. A utility's goal might not only be to sell more energy, but also, for example, to sell also other services. This will be quite a challenge for an industry which previously operated in a very stable business environment and even enjoyed a monopoly. The protected business environment led the industry to be risk adverse [27]. The highly uncertain outcome of smart grids for utilities requires them not only to change their business model, but also to change their attitude regarding risk.

One general concern about the installation of smart grids is security. 'We hear a lot of concerns about cyber terrorism and attacks on our energy infrastructure' (Bob Gilligan, GE's Vice President for transmission and distribution in Bullis, 2009) [29], is one of many statements concerning national security. According to Greenfield [27], the security challenges related to a smart grid are much more complex than those related to IT in general. Cyber attacks on an electrical grid have happened already. For example, in 2002, 70 per cent of power companies experienced some kind of cyber attack to their computing or energy management [27]. It has also been shown that viruses exist which can infect meters. A virus in the meter system could seriously affect or interrupt energy services. This problem must be addressed seriously when introducing a smart grid. Without a secure smart grid, the liabilities of a smart grid might overweigh the benefits.

Technological and Financial Challenges. Other challenges are related to the grid itself. Greenfield (2009) estimates the cost of the update to the US grid to be between $50 and $100 billion. The utilities' risk aversion and governmental deregulation policies discourage utilities from doing this upgrade. Also, the consumers seem unwilling to pay for the smart grid. An article from the *New York Times* [28] shows that 95 per cent of electricity customers would like to have information about their electricity consumption, but only 20 per cent are willing to pay for it.

Another challenge will be to agree on a common standard for a smart grid. The current hype about the smart grid might lead to suboptimal standards, which will not be upgradeable in the future. As an example, Zigbee (an older low-power protocol for sensor network) is supported as a standard without careful attention to newer and potentially better protocols [27]. To be successful, we need a well established upgradeable smart grid which allows for competition; otherwise, one of the weaknesses of existing grids, the lack of competition, is not addressed. Another challenge related to technology is the massive amount of data generated by the smart grid [29]. However, to take advantage of a smart grid, a utility must be able to process the massive amount of data.

Privacy and Required Changes of Consumers. One main concern which has to be addressed is the privacy of consumers. The information available for utilities could be used for things like telemarketing. Utilities would also know exactly what consumers are doing during every minute of their life. Preventing the misuse of this information is of key importance when it comes to consumers accepting smart grid technology. Smart devices would also allow utilities to stop or shut down electronic devices without the knowledge of the consumer. A question that needs to be addressed is what happens if this shutdown was not expected by the consumer. These issues have to be addressed when building a smart grid.

Installing meters is one thing, but using them is another. To change consumer behaviour, the industry has discussed monetary incentives. But how high must this incentive be so that consumers would actually adjust their behaviour? The incentives need to be very high so that one would adjust one's behaviour. We have seen the difficulties in changing human behaviour in other fields, for example in the consumption of cigarettes or in using low emission vehicles. Another question is if people can comprehend and manage their energy consumption. Companies employ experts to manage their energy consumption, but how will a regular consumer respond to ever-changing energy prices? There is also an underlying assumption that consumers waste a lot of electricity and we are able and willing to adjust to this misbehaviour.

Is the Pricing of a Smart Grid Ethical? Last, but not least, we need to discuss whether or not a smart grid is ethical. The different pricing during periods of low and peak energy consumption might be ethically questionable. Imagine an energy peak during summer time. A lot of air conditioners are running, and so the price will increase. Does this mean that only rich people can afford to run their air conditioning? Or, consider, for example, hospitals, which cannot afford to turn off their air conditioning. There is an implicit fee for companies and consumers who are not able to change their energy consumption practices. How do we address these challenges?

3.2 Enablers

Energy Situation and Technological Advantages. One of the major enablers of smart grids is the current energy situation. Energy sources that can be put into operation at fairly short notice (i.e., within hours, or a day or two at most) are needed

nowadays to correspond to fluctuation on the demand side. With the growing use of wind power and solar energy (e.g., in the form of photovoltaic cells), the fluctuations on the supply side will only increase, both in the short ('slews') and the long term ('lulls'). With smart grids and smart electronics, the demand could be adjusted to match these fluctuations, especially the slews, which are otherwise tricky to deal with, because the current technology is not able to increase the supply as fast as the rapid fluctuations would require.

This type of fluctuation control may be one driving force for energy companies providing electricity. The maintenance and running of peak energy supply forms (e.g., coal-fired power plants) is costly. Being able to avoid using the peak energy supply would cause large savings for the company, thus making it profitable to compensate their customers for volunteering for bidirectional metering and controlling some of their appliances (e.g., water heaters, freezers, refrigerators). This type of deal has been available for some customers of the Baltimore Gas & Electric Company (BGE) in the form of their PeakRewards Program [30].

Legislative Action. Another significant enabler is legislation forcing energy companies to implement smart grids. Finland has decided to make smart metering obligatory, at least for new connections, by 2014 [31]. The EU has recently implemented directive (2009/72/EC) [32], which makes intelligent metering obligatory by 2022 throughout the European Union. In Ontario, Canada, legislation (Green Energy Act, Bill 150) is currently being considered which seeks to define smart grids and their intended uses, with the emphasis on renewable energy, uploading energy to the grid, and the innovative use of information available through smart metering [33].

The US Department of Energy has started a subsidy program called the 'Best-in-Class Appliances Deployment Program' which provides subsidies to manufacturers, retailers, and distributors for providing the most efficient appliances and recycling the old ones. Also, governments might subsidize the development of products which are more energy-efficient. The program is based on the American Clean Energy and Security Act 2009 (Section 214) which has been authorized for the years 2011–2013 [34].

People. The consumers can be seen as a major enabler in the whole smart grid project. Lead users, energy-efficiency enthusiasts, students and other technology-oriented people can make a huge difference in the whole smart grid market. Of course human behaviour is difficult to predict but, for example, recycling newspapers, cartons, glass and metal has taken off in the last two decades and there the incentive is not even as clearly financial as in the case of the smart grids.

4 The Road Ahead

4.1 Phases of Technological Deployment: An Optimist's Timeline

Here, we present a roadmap of how we think the smart grid should be developed and expanded. Savings produced due to informed consumption and profits from energy services can be re-invested into efficiency improvements and for creating large-scale deployments. Throughout these stages, regulatory bodies must follow through with open and fair incentives.

With strong government commitment already in place in 2010, especially in the US, China, and the EU, there is legislative pressure to invest in large-scale deployment. We imagine that by 2014–15 AMI will be installed in the majority of homes in developed countries. Communication standards and network security will soon follow suit. If utilities invest in large-scale deployment of AMI, they will seek a return on investment, which will result in simple information services for consumers. On the other hand, if consumers invest in the deployment themselves, there will be a large consumer-side pressure for services. Such an eco-system will be suitable for enterprise software and service companies to provide third-party solutions, thereby increasing competition and driving down prices. Open-software or free-service movements could also become a reality through the presence of large Internet giants like Google.

Towards the end of the decade (2017–2020), the winning third-party service companies will drive home-area networking standards in concert with new smart appliance vendors, thus enabling smart and remote home energy management by consumers themselves.

It is harder to predict what might happen in the subsequent decade (2020–2030). One possibility is that various attempts by utilities at real-time pricing (clearly a strong business case for utilities) will result in a stabilized model which consumers would prefer. This scenario will, in turn, incentivize consumers to manage their energy consumption patterns efficiently. One possibility to take advantage of real-time pricing would be to store energy at off-peak hours and use the stored energy during peak hours. This can be significantly enabled by local storage and generation technologies (kW scale batteries and PV roofs or bloom boxes) reaching the consumer. The consumer will be able to realize a shorter payback time than the currently infeasible 20–25 years for solar panels, for instance.

By the middle of the decade, to accelerate this payback time, it is possible to imagine that pressure from the consumer side and the local generation/storage device manufacturers would result in the first two-way grid and in community-scale markets. Consumers with surplus energy would be able to upload their energy to the grid. Various innovative business models combining the public and private sectors and consumers would then emerge around this technology.

Meanwhile, towards the middle of the decade it would be a meaningful stage for home electronics giants such as Philips, GE, Samsung, and LG, together with a host of smart appliance manufacturers, to collaborate on hardware standards for communication and two-way grid control.

In short, with an optimistic stance on the next two decades, we are able to see a lot of room for new companies, new partnerships between existing companies, and new ventures for large companies to emerge.
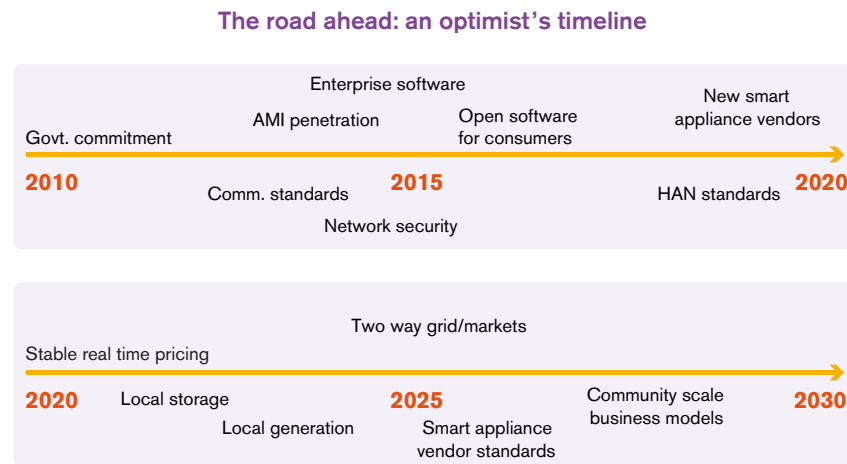
The road ahead: an optimist's timeline

Figure 4. An optimistic timeline for the stages of smart grid deployment.

4.2 Future Enablers

In this subsection, we describe some plausible enablers and attractive deal-structures between various actors in the energy value chain.

Social Incentives for Widespread Consumer Adoption. It is possible to imagine several scenarios which would incentivize consumer adoption of smart grids. Once real-time consumption data is available, various third parties can create attractive visualization and management systems. Integrating these visualization services with existing social media trends will enable consumers to share and have a conversation about their energy consumption patterns. Social media-based services will also bring down the cost for the consumer because service companies can provide the service for close to free and recover their investment through advertising revenue. Internet content giants such as Google are thus well positioned to take advantage of the smart grid revolution. Indeed, in February 2010 Google Energy obtained the right to sell energy and services at market rates [35].

A Service-centric Business Model for Utilities. In 1898, almost 20 years after the invention of the incandescent bulb, New York Edison began selling current in kilowatt-hours instead of the original unit of light-hours – the number of hours a light bulb was lit. Edison strongly disagreed with this change. He said 'The reason I wanted to sell light instead of current was that the general public did not understand anything about electric terms or electricity' [9]. To address the price increase of energy in the 1980s, Sant [9] proposed a simple but profound change, according to which energy could be conceptualized and sold. Why not revert back to the Edisonian model? Perhaps Sant's suggestion was too ahead of its time.

Just as the mobile service providers sell talk-time instead of bits, utilities may one day sell services such as comprehensive home energy packages. With real-time two-way monitoring and control of devices, coupled with economies of scale, utilities can redefine themselves as energy-service companies. Such a model would incentivize utilities to decrease overall energy consumption by making the distribution more efficient and to partner with device manufacturers to make individual devices energy efficient. To ensure consumer co-operation, utilities could incentivize consumers who meet certain usage targets by recognizing them in their newsletters or rewarding them with discounts. Examples of usage targets could be opt-ins for renewable energy. Such a model would empower utility companies and make them the central actors in the energy value chain. They would not only be interested in buying larger power plants or increasing the capacity of existing ones, but would also push for efficient distribution. The timing is right for Europe, with the opening up of the energy sector ushering in competition between utilities. According to the EU Directives 2003/54/EC and 2003/54/EC, which came into force in 2004 and 2007, industries and private households are, in theory, free to choose their energy supplier.

Real-estate Developers as Possible Early Investors. Given the large investment requirement for smart meter deployment and the relative comfort zone of utility companies, would there be other potential investors willing to partner with utilities? Real-estate developers with a large customer base who develop new housing might be willing to partially invest in and install smart meters provided by utilities or third parties. Alternatively, they could bundle the smart meters with the cost of the property, thus sourcing the investment from the consumer. From home owners' point of view, if a fractional increase in cost can result in a return on the investment provided by energy savings, the proposition might be attractive. In this scenario, the real-estate industry would serve as a middle man and key enabler in the second and third phases of technology development outlined above.

Subsidising Home Energy Storage. For real-time demand management to be highly effective, it must be possible in the future for utilities to control not only non-time-critical appliances such as refrigerators or washing machines, but also time-critical ones such as cooking or heating appliances. This could be enabled by a hybrid power

supply source which would switch between a home energy storage system and direct power supply from the grid. Such a concept would require a minimum change in day-to-day consumer behaviour, subject to an initial investment on the part of consumers. The adoption of home energy storage systems could be enabled by widespread adoption of grid-linked home energy storage. With the mass introduction of plug-in hybrids, electric-car batteries could double as home energy storage devices. Alternatively, an electric-car subsidiary company could sell Li-ion batteries exclusively for home energy use.

The investment from the consumer end could be incentivized either by bundling home energy storage with the property cost (which would then be an option provided by a real-estate developer) or from government subsidies for home owners.

4.3 Potential Scenarios

In this subchapter, we discuss how different outcomes can be reached and what the key success factor for an ideal smart grid is. We then introduce the ideal smart grid.

Decision Tree. The following decision tree (Fig. 5) shows potential outcomes of a smart grid. We believe that consumers are the key success factor for a smart grid to achieve its full potential. The smart grid will fail even if all actors besides the consumers support it. In our opinion, the initial signal for a smart grid will come from the government. However, the government will only support the building of a smart grid if the consumers create some political pressure. Also, other actors will try to influence the government. This means that smart-grid advocates should try to find support within the general public for their concerns. This could be achieved by working together with non-profit organizations like Greenpeace to increase awareness for smart grids.
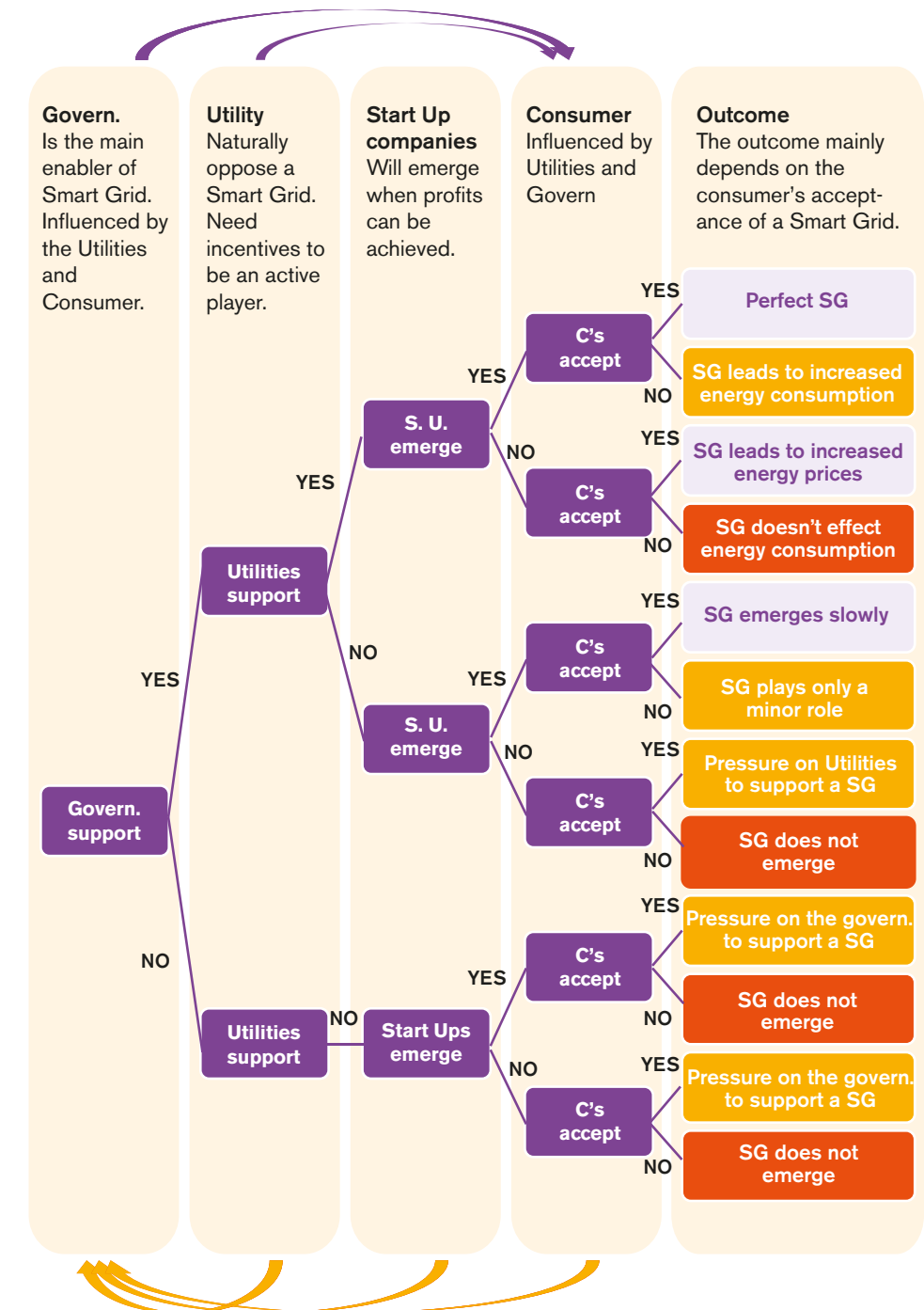

Figure 5. Decision tree linked to the implementation of smart grids.

The Ideal Smart Grid in 2030. The electric grid would be a modern, self-healing grid with two-way metering information available up until the level of distribution substations to detect disruptions in the energy supply as soon as possible. The main grid would be at the interstate level or even worldwide so that renewable energy would be used as much as possible. This would cut down the need for emergency power plant usage, even though electric grids would not be completely taken out of use in order to prepare for natural disasters, conflicts and other unforeseen disasters.

In 2030, energy companies will no longer sell electricity and heat directly to the customers but to communities and the communities will sell it to the customers. This will move the monitoring of energy consumption of a single customer to the community level, and the energy company, which will decide the energy price, will only obtain information regarding the consumption of the whole community. The community could be a geographical area based on distribution substations, for example. This would still facilitate real-time pricing based on consumption and, thus, might reduce the peak level demand and time. The pricing would have a relatively stable variation during all hours and it would be predictable to some extent.

The meter in a household would show current and predicted pricing information and real-time consumption in terms of both power and money per unit of time. Uploading to the grid would also be possible with certain meters and the upload price would be shown to the user the same as the price in consumption mode. Consumption data could also be downloaded from the community website and shared online either anonymously or with a network of friends and family via some form of social media. The idea of sharing anonymously enables comparison based on apartment size, type, and location. Naturally, it would be possible for a person to compare his or her current energy use with earlier use.

Some appliances at home could communicate with the meter and tell the user the assumed price for, for example, a washing machine cycle right now and what it would cost in 30/60/120 minutes with the predicted price. Some appliances could also have a tag on their side telling how much it would cost to use it, for example how much heating up a litre of water in a kettle would cost at a certain price of energy. This would make comparison at the time of purchase easier, especially if the parameters would be standardized within a product category; for example, a standard coffee maker would be set to make four cups of coffee and keep the coffee hot for 5 minutes.

5 Discussion – Conclusion

The future of smart grids is not yet set and will most likely vary from region to region and company to company. Many positive effects are expected as a result of smart grid set-ups, such as a decrease in GHG emissions, less frequent blackouts and a more informed and less costly usage of energy. However, the trend of smart grids can be seen as a double-edged sword. For example the appearance of multiple energy providers, thanks to the deregulation of the market, creates a potential and interest which can lead to many developments. As competition sets in and becomes tighter, companies must innovate in order to remain competitive, applying the latest finds in order to increase overall benefits. Strong competition often also goes hand in hand with lowered prices, which benefit users but can lead to increased energy use. Currently, many users are not fully aware of their energy spending and bills. By lowering prices, energy use may increase as some users would care even less about where energy savings can be made.

The full scope of smart grids and their impact on the energy market, society and the environment has yet to be defined. The high interest in smart grids and their evolution can be linked to that of mobile phones and some parallels can be drawn for future developments. In both cases, several companies had a monopoly on the market up until a few years ago. Deregulation increased the number of players and the pace of changes made to the system. In the case of mobile phone technologies, the changes were extremely fast since the cost of deployment was relatively low. Initial investments linked to the energy and electricity markets are more important, as whole portions of the electric grid need to be upgraded and new technology needs to be installed which, unlike mobile phones, cannot be bought (so far) by individuals in stores. Social acceptance has played a large part in the success of mobile phones. The first mobile phones were met with doubts about their usefulness and with respect to privacy and the effects of transmission towers are still debated today, but the majority of the population has come to embrace the technology. As discussed in previous sections of the chapter, smart grids face many challenges in terms of social acceptance. Privacy is a big issue, as the appropriate amount of information which utility companies should be able to see regarding a person's energy use has not been defined. Based on the mobile phone example, more work should be done to increase the interest of the population in smart grids and to prove their usefulness and ensure secure use. Overall, the evolution of the mobile phone and energy markets present many similarities, but the time necessary for the implementation and acceptance of smart grids will most likely be much longer than the time that was needed for mobile phones. Smart grids must also deal with the legacy of the energy sector, which is quite imposing, since it includes established companies, infrastructures and industries which rely heavily on energy providers. Drastic overnight changes cannot be done in such a context, but gradual implementations of the different aspects of smart grids should lead to a better overall use and distribution of energy.

Changes are necessary for an energy system which has been in place for over a century in many parts of the world. The concept of smart grids, although it still lacks a set definition, takes on the challenge. Smart grid set-ups face a tremendous legacy from the energy sector as well as the need to satisfy a great number of stakeholders, yet many enabling schemes are being put into place to facilitate the evolution of the current energy systems. Individual users are now stakeholders involved in the emerg-

ing set-ups and they are the ones who can greatly benefit from smart grids as well as facilitate their set-up. Smart grids empower people through energy security and innovation opportunities, but individuals have the potential for providing energy to the grid and accelerating smart grid deployment through social acceptance. Governments and utility companies are no longer the only ones involved in the energy sector; high-tech companies and start-ups, as well as individual users, play important roles and all must collaborate in order to encourage the evolution of the energy sector.

References

1. Giri, J., Sun, D., Avila-Rosales, R.: Wanted: A more intelligent Grid. Power and Energy Magazine, IEEE, 7(2), 34–40 (2009)
2. Neville, A.: Boulder to be first "Smart Grid City". Power, 152 (5) (2008)
3. Farhangi, H.: The Path of the Smart Grid. Power and Energy Magazine, IEEE, 8(1) (2010)
4. Gupta, A.P., Sathaye, J.: Electrifying India. Power and Energy Magazine, IEEE, 7(5) (2009)
5. Lison, C.: Solaire: La France sort de l'ombre. National Geographic France, October 2009, 28–31 (2009)
6. Jiyuan Fan Borlase, S.: The Evolution of Distribution. Power and Energy Magazine, IEEE , 7(2), 63–68 (2009)
7. Gustavsson, R.: Agents with Power. Communications of the ACM, 42, 41–47 (2009)
8. Rahman, S.: Smart Grid Expectations – What Will Make It a Reality. Power and Energy Magazine, IEEE, 7(5) (2009)
9. Sant, R.W.: Thinking Ahead. Harvard Business Review, May-June (1980)
10. GP Bullhound: Smart Grid Report June 2009, http://www.slideshare.net/jpocalles/smart-grid-report-2009-june-1904881?src=related_normal&rel=1129111 (2009)
11. Hopkinson, K., et al.: Quality-of-Service Considerations in Utility Communication Networks. Power Delivery, IEEE Transactions on, 24, 1465–1474 (2009)
12. Mohagheghi, S., Stoupis, J. and Wang, Z.: Communication Protocols and Networks for Power Systems - Current Status and Future Trends, 1–9 (2009)
13. Gungor, V. C. and Lambert, F. C: A Survey on Communication Networks for Electric System Automation. Comput. Netw., 50, 877–897 (2006)
14. NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0. NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0. (2010)
15. Mattern, F., Staake, T. and Weiss, M.: ICT for Green - How Computers Can Help Us to Conserve Energy. (2010)
16. McDaniel, P. and McLaughlin, S.: Security and Privacy Challenges in the Smart Grid. IEEE Security and Privacy, 7, 75–77 (2009)
17. Khurana, H., et al.: Smart-Grid Security Issues. IEEE Security and Privacy, 8, 81–85 (2010)
18. Metke, A.R. and Ekl, R.L.: Smart Grid Security Technology, 1–7 (2010)
19. NISTIR 7628 Smart Grid Cyber Security Strategy and Requirements. NISTIR 7628 Smart Grid Cyber Security Strategy and Requirements (2010)
20. Sweet, W.: How Smart Can You and Your Local Electricity Grid Get? IEEE Spectrum (2009)
21. Xcel Energy SmartGridCity, http://smartgridcity.xcelenergy.com/, retrieved on 10.4.2010 (2010)
22. King, C.: What Happened with ENEL, the World's Largest Smart Meter Deployment? Smart Grid Watch, http://smartgridwatch.wordpress.com/2009/10/02/whatever-happened-with-enel-the-world's-largest-smart-meter-deployment/ (2009)
23. ABB and Fortum to Develop a Large-Scale Smart Grid for Sustainable City Project, http://www.abb.com/cawp/seitp202/466d98448638db07c125766d00206461.aspx, retrieved on 15.4.2010 (2010)
24. Málaga Smartcity, http://www.enel.com/en-GB/media/news/malaga/, retrieved on 15.4.2010 (2010)
25. Fehrenbacher, K.: 5 Reasons Why Developing Countries Need Smart Grids, too http://earth2tech.com/2010/02/11/5-reasons-why-developing-countries-need-smart-grids-too/, retrieved on 20.4.2010 (2010)
26. Fox-Penner, P.: Fix Utilities Before They Need a Rescue. Harvard Business Review, July/August (2009)
27. Greenfield, D.: Is the Smart Grid a Dumb Idea? Baseline, November (2009)
28. Burnham, M.: Survey Shows Huge Challenges for 'Smart Grid,' Efficiency Efforts. New York Times, 05.03.2009 (2009)
29. Bullis, K.: The Big Smart Grid Challenges. Technology Review, July (2009)
30. PeakRewards – a BGE Smart Energy Savers Program, http://peakrewards.bgesmartenergy.com/what-is-peakrewards, retrieved on 24.3.2010
31. Laki energiamarkkinoilla toimivien yritysten energiatehokkuuspalveluista, http://www.finlex.fi/fi/laki/ajantasa/2009/20091211, retrieved on 19.5.2010
32. Directive 2009/72/EC of the European Parliament and the Council, Official Journal of the European Union L211, 55–93 (2009).
33. Ontario Bill 150, Green Energy and Green Economy Act, Chapter 12 Statutes of Ontario, 2009, http://www.greenenergyact.ca/Storage/26/1769_Bill_150_as_of_Oct_2009.pdf, retrieved on 24.3.2010.
34. American Clean Energy and Security Act of 2009, Section 214, Best-in-Class Appliances Deployment Program, http://thomas.loc.gov/cgi-bin/cpquery/?&sid=cp111wLXCN&refer=&r_n=hr137.111&db_id=111&item=&sel=TOC_523310&, retrieved on 24.3.2010.
35. Kanellos, M.: It's Official: Google Can Sell Power Like a Utility. Wired Mag, Feb. 2010 http://www.wired.com/epicenter/2010/02/google-can-sell-power-like-a-utility/

2.2 Designing an Ecocity

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Abstract

In 2008, the United Nations estimated that half of the world's population lived in cities. Global economic transformation is the force which causes people around the world to migrate to cities looking for jobs and quality of life. Mass urbanisation increases housing costs and the poor parts of population end up in shadow cities. There is an urgent need for new cities which provide quality of life for all parts of society. Since the building of new cities is inevitable, could they be built in an ecologically sustainable way? The paper presents guidelines for making a blueprint for an ecocity, which can be used as starting point for the design of any eco-city project. A close look at the literature on eco cities shows that there is no dominant design yet and a wider consensus on any particular approach is missing. However, certain design directives have started to emerge, which tackle the problem from different angles [3]. Traditionally, these design directives have inclined more towards engineering solutions, but recently people have also recognised that aspects other than just the technical ones are important as well. In this paper, we take a holistic approach to different elements in designing an eco city, using a clean slate approach.

Keywords: Eco city, ontology, energy sector, sustainability

1 Introduction

"Eco city" has emerged as the popular term to describe future cities and we can trace the origin of this term to the year 1987[1]. A quick survey of ongoing future city projects around the world reveals that nearly every project uses the term eco city somewhere in its title [2]. However, what is often not clear is what these projects mean by an eco city. There are multiple definitions of the term instead of one concrete definition. Here, we present an understanding of the term based on a survey of the relevant literature and later, in the next section, we synthesize a definition of eco city based on our own understanding of the term and our survey of the literature.

In an article titled 'Dimensions of an Eco City' [4], Mark Roseland presents a very comprehensive survey of the eco city concept. He talks about the historical origin of several parallel concepts like sustainable development, sustainable urban development, sustainable communities, bioregionalism, community economic development, appropriate technology, social ecology and the green movement. For him, eco city is a concept which does not stand-alone but is situated in a complex array of relevant variations on one of these concepts.

Another author, J R Kenworthy, in his article on eco cities presents an eco city model [5] in which he talks about two key processes needed for the model to function. One process involves vision-oriented, reformist thinking ("debate and decide") rather than the extrapolation of existing trends ("Predict and provide") and the other involves a strong, community-oriented sustainability framework for decision-making.

Also worth mentioning is the concept of "circular economy" (CE), which has been a core concept in recent eco city projects in China [6]. The concept of circular economy refers to a closed loop for materials, energy and waste flows.

In this chapter, we present guidelines for designing an eco city. These guidelines can be utilised when designing a completely new eco city, in other words, using a clean-slate approach. The design is divided into three parts: financing, infrastructure and socio-economic vibrancy, which are further divided into six segments, called building blocks. These building blocks are chosen because they represent the most important aspects of city design.

1.1 Definition of Eco City: Ecocity

To distinguish between different ideas about an eco city as they appear elsewhere in the literature and the type of eco city we envision, we will use the term Ecocity. So, whenever we refer to Ecocity, it means our definition of an Ecocity.

In this chapter, we define the Ecocity as, "a future city, which provides quality of life by using ICT (Information and Communication Technologies), futuristic design, and architecture, and, above all, allows its citizens to sense and react to different city-level issues in favour of reducing environmental impact without hindering development and productivity, while, at the same time, maintaining economically sustainable development, culture and aesthetics. The design of the eco city is dynamic, evolving and self-correcting. It adapts in a sustainable way as per its usage. "
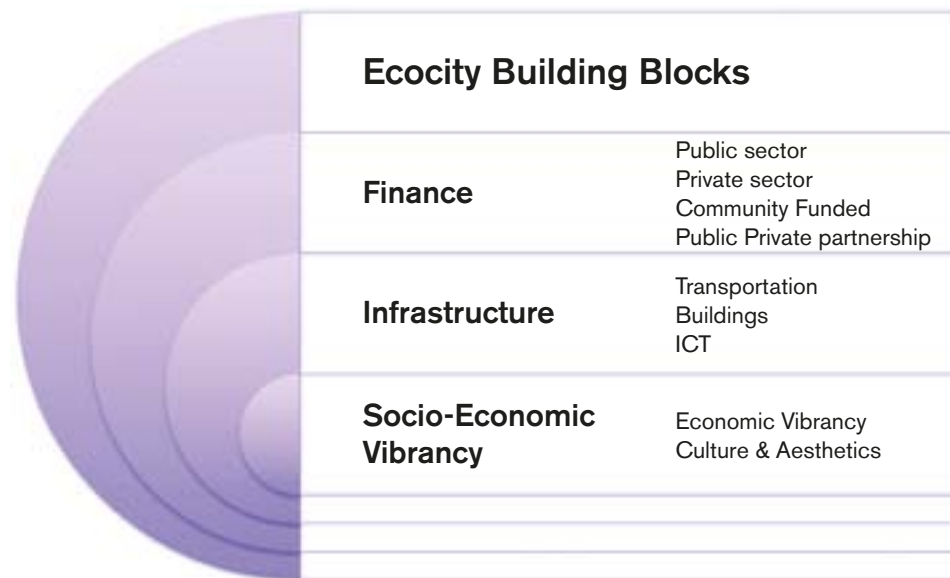
2 *Building Blocks*

Figure 1. Ecocity building blocks.

Figure 1 above shows the relationships between the different building blocks. Finance is in the outermost shell since it needs to be addressed at the beginning of an Ecocity project. However, the figure reflects the idea that financing affects the infrastructure available within the city and that, in turn, affects the socio-economic vibrancy in the city.

2.1 Financing the Ecocity

The inception of a city building project, and seeing it through from the blueprint stage to it becoming a lively city, requires an execution strategy. How the city project is financed will have a long-term effect on the city's dynamics and continuous infrastructure development and the everyday life of its residents. Several eco city financing models have emerged around the world. It is important to discuss and understand what the possible models for financing the Ecocity are, and what is going to be dominant model for the future.

In addition, we are also at a point in time where a very large portion of world's population is going to move to urban areas in a very short amount of time. New cities are needed and a large amount of money is needed to finance these projects. On a broad level, three main components can be identified in any city project:

1 **Core infrastructure:** Core infrastructure deals with the entire public infrastructure like roads and bridges. This infrastructure has a definite lifecycle and needs to be rebuilt once that period is over. So, though there is a high initial cost in building and renewing the infrastructure, the maintenance costs might be relatively low.
2 **Utilities:** Utilities include providing water, electricity, waste management and communication services etc. These services have a onetime setup cost, but also might be costly to run and maintain.
3 **Real Estate:** Real estate comprises of all plots of land which can be developed into business, public service and residential areas.

In theory, all these different components can be financed by single or multiple parties. Below, we present the different stakeholders who could potentially finance them singlehandedly, a hybrid approach to financing the different components, and an Ecocity financing model.

a. Government/Publicly Funded: The government-funded city projects are popular in countries which have a communist or socialistic political system. This approach is more common in countries where the planning is centralized and is done by the government. A typical government-funded city might be inexpensive for the citizens to live in. However, in the long term, the upkeep of the infrastructure is not very good [7].

b. Privately Funded: In developing countries, the public sector has been slow to respond to the demands of a growing population, which has made private funding crucial for infrastructure development. Also, the enterprising nature of private developers is another reason, apart from many other reasons, for bringing in private funding. Many of growing cities have been funded by the private sector. However, these cities have a high cost of living and, in many ways, they might not be sustainable [11].

c. Community Funded: In theory, it is possible for all the potential citizens of a city to pool their money and set up a foundation which could finance a smaller-scale city. One can easily see this kind of pooling of money on a smaller scale for setting up small residential communities, especially in developing countries like India, where the development in real estate has mainly come from the private sector or is community owned.

d. Public-Private Partnership/Hybrid Approach: In practice, when it comes to the financing of a city, the hybrid approach mainly represents a public-private partnership compared to the other approaches suggested above. Also, a quick survey of eco-city projects around the world suggests that public-private partnership is the dominant approach. However, what still remains important is to understand which components the government finances and which components other parties finance.

Recently, a popular way has been to use the "Build-Own-Operate-Transfer" model, commonly known as BOT or BOOT [12]. In the BOOT model, a private entity builds and operates the infrastructure. After a long time period, when a sufficient profit has been made, its ownership is handed back to the public sector. One typical example of this could be a toll road [13]. However, one thing to realise is that even though governments are quite willing to use this kind of financing model for building roads and other infrastructure, they also then have to often build alternate side roads and infrastructure for poor people who cannot pay to use this privately/publicly built infrastructure.

Looking at the different eco city projects around the world and the classification of the components of an Ecocity [8,9], we can see some emerging trends. That is, the core infrastructure is financed and maintained by the public sector and the utilities by the private sector. Real estate is financed primarily by the private sector as well as by communities and the public sector [8,9].

As stated in the definition, the Ecocity is evolving and self-correcting. The financing of the utilities will have implications for these aspects of the city. What policy makers would need is a scorecard approach for the private sector. It would drive them towards a sustainable way of providing resources to the citizens and continuously improving the city's infrastructure, instead of just maximizing profits. The big enabler here could be the use of ICT. It would enable citizens and the community to monitor and report on the functionality and status of the service infrastructure.

For the Ecocity to be economically vibrant, it will need to cater to different sectors of society [10]. This puts some constraints on the financing of real estate in the city. The regulators have to make policies for real estate to be developed in a way that all sectors of society can be a part of it. Buildings for middle and lower class people could be community owned, whereas the wealthy could access real estate developed for the free market.

In the future, large-scale projects will not just be for large financial institutions. Communities could use crowdsourcing to raise the funding needed for large projects. Some recent successes with fundraising using Internet portals have shown the extent

of innovation in business models one can do [13]. So, it is time for societies to make the right financing choices. Hence, making the future cities more habitable!

2.2 Infrastructure

As in any other city, in an Ecocity the infrastructure also provides means for its operations. In this section, we examine the infrastructure of an Ecocity from viewpoints of transportation, city planning, buildings and ICT. In a clean-slate approach, these can be designed without the constraints faced by already established cities.

City planning is interlinked with transportation system planning. Combining these in the design phase can produce a convenient and pleasant city environment and also lead to reduced energy usage. When building an Ecocity, special attention is needed when choosing materials for construction. A building's lifecycles have to be planned and sustainable. With proper design principles, buildings themselves can contribute to energy production and, thus, create a distributed power production network. Managing power production requires sophisticated ICT solutions. ICT is also used in almost all operations of the Ecocity, including waste management, traffic management and providing a variety of services which improve the quality of life of its inhabitants. When addressing eco cities, energy issues must be brought up. All sections of this chapter provide guidelines for designing an eco city and this also applies to energy issues. They must be solved by taking into consideration climate, geographical location and socio-politic factors. A general principle is that all operations of the Ecocity should be designed from the very beginning to be emission neutral. An Ecocity's buildings should aim to be at least self-sufficient in terms of energy. Renewable and distributed energy production should be promoted, but it should also be acknowledged that using only renewable energy might not be a feasible solution if industrial production is located within the Ecocity. Also, in this case the emission-neutral principle must prevail - other operations of the city should be designed to compensate for emissions created by non renewable energy producers.

2.2.1 Transportation and City Planning

The design of a transportation system and city planning are inseparable. Use of virtual meeting spaces and sophisticated remote work environments and systems definitely reduce the need for transportation, but it does not make the need to move around obsolete. Real interaction, where people are physically present, will remain as the most important form of social interaction.

The commoditisation of the car in the 20th century made car-centric city planning the most dominant design type. However, various global challenges have opened our eyes to look at this design critically. In a clean-slate approach to city design, the car-centric approach can be deemed antiquated and alternatives should be looked for.

The key components of an Ecocity transportation system include:

1. No combustion-based motorised vehicles
2. An emphasis on the use of bicycles and walking
3. Efficient public transportation
4. The need for motorised private transport is minimized

In this section, we present a conceptual city plan. It includes different districts of the city, each with their own functionality, and a transportation system which combines both private and public forms of transportation.

City Design

In this chapter, the Ecocity is not attached to any particular location. Obviously, city planning has to be done so that the city's ecological environment, its economical climate, the number of inhabitants and its geographical location is taken into account. Therefore, we can only provide conceptual guidelines in this section.

Figure 2 below shows a conceptual city plan. A similar radial design with lobe-shaped districts was proposed by J.H. Crawford in his book, Carfree cities [14]. In this chapter, we explain the basic design concept of our Ecocity based on five different functional areas: the city centre, habitation districts, industrial areas, recreational areas and energy parks, and the outer rim.
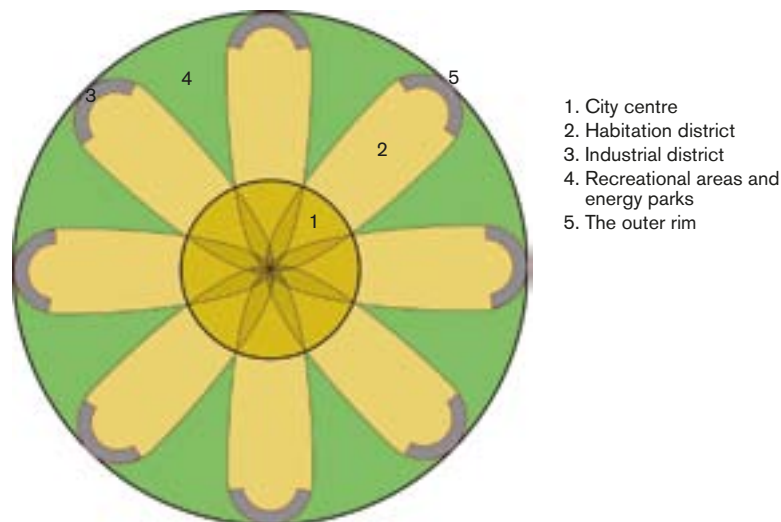
1. City centre
2. Habitation district
3. Industrial district
4. Recreational areas and energy parks
5. The outer rim

Figure 2. Conceptual city design of an Ecocity

1) City centre

The city centre has shopping centres, offices, theatres, services, museums, high-value apartments, parks and everything else you would expect from a city centre at the beginning of the 21st century. Architecturally, the city centre has the highest population density and the highest average height of buildings. A few high-rise buildings might give the city its unique skyline.

Regarding transportation, motorised transportation lanes are very limited inside the rim surrounding the city centre. Ideally, there would be no mixed transportation, motorised and non-motorised transportation, at all. The necessary transport logistics for businesses would be placed underground and open-air areas would be wholly reserved for bicycles and pedestrians. If the centre rim's diameter is large, some lanes for public transportation would be necessary.

2) Habitation districts

Most of the city's population would live in these lobe-shaped districts. Within these districts, housing might consist of any types of buildings, but generally the height of the buildings and the population density would get lower the farther you would travel from the city centre. Public transportation operates primarily on the sides of the lobe. For a public transportation system to be effective, the distance to nearest station must be kept to a minimum. Depending on the size of the lobe, there might be a need for a third transportation line which would be placed at the centre of the lobe and run from the city centre towards the outer rim.

3) Industrial areas

Heavy industry and manufacturing would be placed along the outer rim, as far as possible from habitation districts. Industry-related logistics would be kept out of the habitation areas and the outer rim would function as an interface for the material flow between the city and the outer world. Imports and exports would be brought to warehouses in these areas and distributed thereafter with a fleet of lighter supply vehicles. Each lobe's network of transportation routes would enable commuting to these areas.

4) Recreational areas and energy parks

These areas would have a two-fold purpose. First, they would satisfy the demands for a decent quality of life by providing places for recreation, such as parks, lakes, sports fields and open-air theatres or stadiums. These areas would be reserved for that purpose.

On the other hand, the Ecocity would strive to be as self-sustaining as possible energy-wise. These large land areas could be used for renewable energy parks. Depending on the climate and geographical conditions, suitable method for producing energy, for example wind turbines, solar panels or water-power station, would be placed here. Sadly, most of the time providing a mixed use for energy production and

recreational purposes is impossible. Therefore, a feasible split for both these purposes has to be made.

5) The outer rim
The outer rim would connect the far edges of the lobes via a fast two-way railway. The railway would enable the transportation of peoples, but also the transportation of materials for industrial areas. Possible airports and harbours would be located beyond this rim.

Public Transport

Without knowing the location-specific constraints presented in a city design section, it is impossible to say which technological solutions would be best for organising public transport. Still, the main constraint is the size of the service area. With regard to energy efficiency, the larger the area gets, the more feasible it becomes to build a railway system [3]. Then again, studies which make calculations on energy efficiency [3] use full trains for their calculating efficiencies. This would lead to the conclusion that the structure of the train itself must be more modular. Railway carriages should be lighter to minimise energy consumption, but the number of carriages in a train should be more flexible so that the train would be composed of a near-optimal amount of carriages for the estimated mass transit requirements [15]. This would require that carriage structure be very modular and enable changes to the number of carriages in the train every time it stops. So, the configuration of the train could be changed easily, if needed, to include more carriages for busier sections of the line and release them at the station when the capacity of the current configuration would exceed the predicted number of passengers. In addition, some parts of the service area would be served using electric busses. Trolley busses would be another alternative, but for this fixed instalments and wires would be required. This can reduce aesthetics and would be unnecessary if all the required energy could be carried within the bus.

Private Transportation

In this context, private transportation refers to walking, bicycling, and electric bicycles as well as to motorised transportation, for example electric cars and electric scooters. Already it has been shown in a few cities around the world that bicycling is an efficient way of moving around if the infrastructure supports it. Infrastructural support means that mixed traffic is minimised and bicycles and electric bicycles are readily available [16].

A need for private motorised transportation will exist in the Ecocity. As mentioned in the list of the key components of an Ecocity transportation system, electric vehicles should be used instead of combustion-powered vehicles. City planning and infrastructure should be designed so that every part of the city is within easy reach with cars, but roads should not dominate bicycle and pedestrian traffic, which is the case in most cities in 2010. Even if the quality of service of public transportation is good, people will most likely still need to use some kind of private transportation. According to the contemporary mindset, private transportation vehicles are owned by the individuals who use them. This is not necessarily the best practice, which means that the whole idea of car ownership should be changed. The use of cars should be provided as a service [16, 17].

Today the typical use rate of the cars is very low. Most of the time the cars are parked. This service-based model would improve the use rate of vehicles and the fixed and variable costs of owning a car would be removed from the user. Of course, these costs would, to a certain extent, be transferred to cost of using this service, but the costs would be more directly related to actual use.

How would this work? The service provider would own a pool of autonomous vehicles and would be capable of responding to a service request at any time. People have different needs at different times; sometimes these needs are ad hoc, sometimes they are pre-planned. In ad hoc situations, individuals could use a portable device to point out the nearest available vehicle. If the distance to the nearest available vehicle is deemed by the user to be too long, the car could autonomously drive itself to the user, just like the cabs we use today. In a pre-planned situation, people could reserve a car with the same level of ease as it takes to make a table reservation for restaurants these days. The car would be delivered to the desired address at a desired time with the batteries charged. The cars themselves would recognise when they would not be capable of providing the service and automatically head for a fast-charging station just like robot vacuum cleaners today. The user would pay only for the use of the car, just like people currently do when renting a car [17]. The technology for all this is already here [18] and user acceptance will probably mature at the same rate as the technology. A system like this will not exclude ownership, but incentives for that would be low because of the high quality of service offered by the public transportation system.

Transportation of Goods Inside the Outer Rim

Logistics would still be needed inside the outer rim. Shops, offices and homes all need their supplies. At the moment, the logistical operations of shops and offices are very similar. In these cases, replenishing products is usually done by a demand-driven order, by a demand-predictive order or simply by a manual order. It is suggested that this kind of delivery process could also be implemented in the case of home goods. The reasoning behind this is that it reduces the need for motorised transport, both public and private.

The basic idea is that orders would be made online. They would be delivered by autonomous robot vehicles from central warehouses located on the outer rim to distribution depots. Each customer would be given his or her own depot located within a reasonable walking distance of their home. Each customer would have her or her own storage space within the depot and it would be accessible at all times. This kind of delivery system would not be meant to remove the option of going shopping; rather, it would be there to provide choices. Sometimes it would probably be nice to obtain your basic groceries more conveniently. Paper clips and pens for the office are already delivered in this way, so why not the groceries for your Ecocity home?

The issues involved in implementing this type of a system for groceries are not technological. Automated warehousing and autonomous robot vehicles are technologies which already exist today. So far, the failure to adopt this concept has been because of present business models. Online grocery shopping only adds cost to products and not any added value or other benefits [19].

2.2.2 Buildings

The design of the city was discussed in the previous section; now the focus will be on building the Ecocity. The built environment has a large ecological impact both on the landscape and the climate. In this section, the focus is on energy use and carbon emissions from the built environment. Carbon emissions are generated both during the construction phase and during the lifetime of the structure. We do not discuss roads and other aspects of heavy infrastructure in great detail, as their impact depends mostly on decisions made during the urban planning process. For instance, public transportation uses less road space, which means that fewer roads are needed. Still, there are ways to reduce the emissions from roads, such as using recycled materials.

Buildings are complex structures and use energy throughout their lifetime, which mean that the choice of materials and design are important factors. In Finland, buildings consume about 40% of energy – almost as much as the whole industry combined [20]. In today's world, high energy consumption means both high energy costs as well as high carbon emissions. Even if some are not convinced of climate change, the price and scarcity of oil mean that reducing energy consumption is a high priority. Buildings and transportation are a part of everyday life and the choices made by an individual can have a major impact on emissions. This means that sustainable buildings are a much-discussed topic and there are countless ideas, concepts and products related to the subject. Ecological buildings are not a new concept, but earlier the focus has mostly been on local ecosystems, not climate change on a global scale. There are a large number of sustainable building concepts and products, but unfortunately there are some reoccurring issues with them. A common problem is the narrowness of focus: the discussion is often focused on specific details, or areas of interest, rather than on the big picture.

When discussing carbon emissions, low energy consumption during the use of a building is a very important factor, but not the only one. Some wall materials may have good insulation values, but if the emissions from manufacturing them are high, those have to be offset first before there are any real savings on carbon emissions. This is an important aspect, as many experts say that humanity must act on climate change now. The current climate issues are even more concerning as there is an enormous urbanization process taking place in all parts of the world. It also means that if the concepts include new methods or materials, they must be available now or in the near future, not in the next decades. Cost-effectiveness is also an issue in eco city projects; plans have to be realistic. Some concepts can be implemented in rich countries, but they would be impossible to implement in poorer regions of the planet. Yet urban communities are growing everywhere. As both the climate and economics vary a lot in different regions, there are no easy universal solutions; rather, there are only universal principles. Finally, a big challenge for sustainable building is the conservative construction sector itself, due to the required standardization of methods and materials, which is usually a long process. Compared to other industries, construction is very slow to introduce new concepts.

There is no single answer, concept or a design which would solve the environmental challenges of building an Ecocity. Some general guidelines can be used though. The life cycle of the building should be planned thoroughly. Traditionally, the life-cycle of a building is far longer than that of consumer goods – from tens of years to hundreds. In some cases, the designers do not intend the building to have a long service life. Examples of these are cheap and fast housing programs, such as the concrete suburbs built in many European countries in the 1960s and 70s or the so-called 'Katrina trailers' in the US. The reason for the short service life may have been dictated by the circumstances, such as an urgent need for housing. Yet, it happens often that the buildings are kept in service longer than originally intended – it is a rather difficult decision to replace a building with a new one, even more so in the case of an apartment block. As a result, the service life of the different technical systems in the buildings and the general ease of maintenance and serviceability are very important. Good examples of this are the plumbing renovations in old apartment buildings, which are unavoidable and often very challenging and expensive projects.

There are also lifestyle and cultural aspects to consider when discussing the life cycles of buildings. For instance, traditional buildings and neighbourhoods appeal to many people, which means that they stay popular despite their perceived outdated technical performance. Examples of this trend can be seen in many old cities, such as in Käpylä and other wooden residential areas in Finland or in Victorian buildings in London. The function or the purpose of a certain part of a city can also change over time; lower income communities can be transformed into trendy neighbourhoods and industrial districts can become commercial and residential areas. Examples of both can be seen in New York City (for example, in Harlem or the former meat-packing district). Also, the end of the life cycle is an important consideration – if a building must be taken down, how can the waste be used in the most effective way?

The buildings should be easy to recycle and made into new materials or sources of energy. Should the builder, owner or the city be responsible for the action at the end of the life cycle?

This all means that the buildings of the future must be flexible; the materials must be sustainable, energy efficient and have a long service life. This leads to questions regarding to the choice of materials used in the sustainable buildings. As the lifecycle is very long, the obvious choices are materials which are energy-efficient in the long term. The trouble is that most materials can achieve this objective – given enough material, mass or thickness. So the question is: What is the total lifecycle impact? To assess the impact of a building or a community on environment/climate change, it must be considered when these emissions occur: if it is deemed important to act right now and cut emissions immediately, there is no point in using products which have large manufacturing emissions, however good their performance might be.

When considering the choice of materials used in buildings, it is necessary to look also at the big picture. In addition to energy, for every physical product that is manufactured, the raw materials must come from somewhere: from mines, fields or forests, or, increasingly, from recycling facilities. Some materials are more energy consuming to process than others; some can be conveniently recycled to form energy, while others can be easily recycled to form new goods. If there is no unlimited energy source, it is very important to consider how and where different materials are used, especially as there are countless millions of people aspiring to have a more comfortable life and the whole developed world seems to be consuming at an ever increasing rate. For example, in the field of energy production, there are worries that subsidized biofuels and bio-energy production could compete with food production and the forest products industry, leading to price increases and raw materials shortages. Higher food prices affect the poorest populations, and, in the case of forest products, higher prices could lead consumers to substitute bio-based materials with less sustainable materials. This challenge is not restricted to just the use of the land or biomass; minerals and metals are also used in variable applications with very differing lifecycles. It takes lots of energy to convert raw ore first to aluminium or steel and then further to usable products, but much less when recycled waste metals are used as raw material. Since more and more material things are needed, there is not enough recyclable material in circulation now – and probably never will be, if energy is not free. As some raw materials are increasingly more difficult to harvest and more energy intensive to process, they should be used in applications where the lifecycle is relatively short. Therefore, airplanes should be made of aluminium, or, even more preferably, of organic bio composites. Houses, on the other hand, should be made of organic materials, which can be harvested from forests and agricultural land.

Traditionally, forests have been the largest source of organic raw material for construction. Logs can be processed to form planks of timber or various types of panel products, such as plywood or particle boards. Wood can also be turned into pulp, which is processed further into products such as fibre board or paper. The finished wood fibres are the source of strength in the final product. However, the amount of forestland is limited, especially in areas with a high population. This has been one of the primary reasons for the use of non-wood fibres, such as agricultural waste, in building products. Many current building products could be made of non-wood fibres. It means that there is a huge source of sustainable raw material, which could also be used also in other fields than traditional forest products. The concept of biorefinery is good example of this. In a biorefinery, organic materials are separated and converted into multiple products: energy, fibre, power, heat, fuels and chemicals. These can replace current petroleum-based products. However, the price of oil is the deciding factor when many of these organic products really become viable commercial alternatives. [21].

Biomass can also be turned into nanomaterials: nanoscale components can be separated from biomass and used in various applications, from nano-engineered batteries to fuel cells and construction materials. Nanomaterials can be used in many ways, but when they are used in construction products they can change the way buildings are built. Better adhesives enable stronger composite materials, which leads to thinner and lighter structures. More effective insulation, for example in the form of nanofoam [22], can improve energy efficiency and reduce the volume of insulation in a building. Also, the surfaces of a building can become functional: nanocoatings can improve the durability of a building, and nanoscale photovoltaic cells [23] or microturbines on surfaces can provide power [24].

Technological development can improve the buildings of the future. Still, even current technology can be used to construct buildings with a very low carbon impact. For instance, in the Solar decathlon competition, products and technologies are currently being used in extremely energy-efficient buildings [25, 26]. One of this year's competing teams is from Aalto University. Their project, called Luukku, is an energy-independent wooden house which functions as a zero-energy building, even in the harsh Finnish winter conditions. Even if these projects are still prototypes, and not yet in wide use, they show that the future of buildings is already here.

2.2.3 The Eco City & ICT

"The sustainable city needs ICT to meet its goals and manage its changes", says Philippe Mathonnet in the Sustainable City & ICT report, 2009 [27].

The past decade witnessed great technological achievements, such as high speed network and space technology. Emerging technology, such as the Internet of Things and 3D virtual reality, offers us a greater vision of the future. All of these technologies offer a unique opportunity to break through the bounds of space-time in the Ecocity design. People can use ICT to communicate and share information with each other anytime and anywhere. ICT would become an integrated part of the Ecocity. It would act as an information service system supporting the Ecocity's decisions via a continuous collection of city information and by dynamically monitoring all possible

aspects of the city, including housing, transportation, healthcare, roadways, waste collection and material recycling. This section focuses on better understanding the role and contribution of ICT in building an Ecocity.

The Goals of ICT in the Ecocity

There are several goals ICT would achieve in the Ecocity. And, at the same time, these goals also represent challenges for current ICT so that it might evolve into a more mature technology for the Ecocity.

First of all, ICT can connect various Ecocity operations and manage them efficiently. For example, we could use ICT to collect, store and utilise information involving finances, transportation and buildings to work together to form a database serving our daily life and commercial use. Second, with the help of ICT, we could have a more convenient and efficient life and, at the same time, minimize energy consumption. Third, ICT could offer an information-ready living space which would provide us with the convenience of accessing all kinds of information. ICT would also facilitate the management of public services, like air quality, public lighting, roadways and waste recycling. It would help reduce the Ecocity's energy consumption while improving the quality of life and the wellbeing of its residents.

Housing

The amount of energy unwittingly consumed at home due to bad usage behaviour is not small. A feasible toolkit to measure and control energy use within homes would help reduce the unintended waste. The impact of such a toolkit would be to personalize action on climate change and help enable the sustainable development of eco cities. The digital household is a promising solution to achieve this goal because it will transform people's relationships with their homes and help improve people's resource-consumption behaviour. As illustrated in Figure 3, a digital household refers to a residence with devices that are connected through a computer network. A digital home would have a network of consumer electronics and mobile and PC devices which would cooperate transparently and simplify the use of devices in the home. All computing devices and home appliances would conform to the same standard system in a digital home so that everything could be controlled by a computer. Network sockets, such as AC power receptacles, would be installed in every room. Figure 3 is a simplified example of a digital home
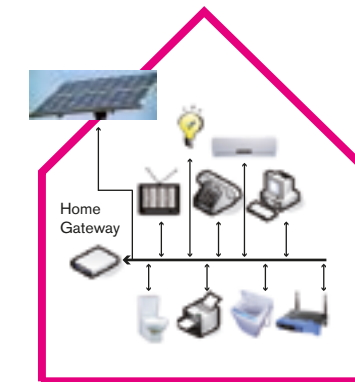

Figure 3. Digital household services

The digital household is not a concept for the future. Over the past few years, the digital household technologies industry has undergone rapid growth. For example, the DEHEMS (Digital Home Energy Management System) project [28], sponsored by the European Commission, brings together sensor data in areas such as household heat loss and appliance performance to give real-time information about emissions and the energy performance of appliances and services. It enables changes to be made to those appliances and services remotely from a mobile phone or PC. This project works with householders in four cities across the EU, using a living-labs model.

Transportation Management

Transportation efficiency is a critical measurement criterion and also a core challenge for an Ecocity. The ultimate goal of transportation in eco cities is to provide good quality of service while minimising energy consumption. This might not mean that there would be no traffic jams in eco cities and that citizens would always be able to find their destinations conveniently. ICT-based technologies, for example mobile networks, sensor networks and satellite networks, can actively contribute to city traffic management by providing individuals with real-time transportation information. Using this information, people could optimize their travel plans, get high-precision navigation, and know the city traffic conditions and the parking lot conditions.

City traffic management is actually an old and still a challenging issue for every large or middle-sized city around the world. Two existing city traffic management systems are given as examples:

- Berlin Traffic Management Centre [29] records and evaluates the traffic situation in Berlin using ICT technologies. Specifically, the aim was to integrate all Berlin transport into an efficient city traffic management system. This has included both individual, public passenger transportation and commercial trans-

portation. The data gathered has been used to generate comprehensive traffic information and aid in making informed management decisions to improve the traffic situation in Berlin.

- The New York State Police and Department of Transportation established a centre from which to operate a high-tech system to monitor, assess and respond to roadway emergencies on some of the busiest highways in the Capital Region. Since then, the traffic flow has improved for all Capital Region highway users [30].

An Ecocity should combine the ideas from the existing city traffic management systems and its own local traffic situation to gain a satisfying Ecocity-oriented traffic management system.

Virtual Workplaces

The Internet has revolutionized the workplace, allowing office workers to work from remote locations, such as their homes, while still remaining in close contact with their colleagues and bosses. However, the applications of virtual workplaces at that time were mainly limited to voice and data communication areas. According to Wayne F. Cascio [31], 'virtual workplaces, in which employees operate remotely from each other and from managers, are a reality, and will become even more common in the future.' The emergence of 3D virtual reality has made his vision a reality, and also brings us a prospective future of the sustainable development of an Eco City.

The 3D-virtual-reality technique offers a completely new definition of mobility using a 3D virtual-communication system which allows us to appear at a venue in 3D and in real time. Proper virtual meeting spaces can reduce the need for transportation. There are a lot of commercial applications for virtual meeting spaces. For example, Second Life [32] is an Internet-based virtual world where 'inhabitants' can create, buy, sell and experience virtual content. Though mostly contained within a virtual domain, Second Life reaches into the outside world. There are large organizations present in Second Life which link the real world and the virtual world together. Another example is Lively [33], which was launched by Google to compete with Second Life, but which could be much more valuable to business users in real-world applications.

Waste Management

Worldwide, humans generate more than 2 billion tons of waste annually. In the US, each individual produces about 1.5 tons of solid waste per year. Waste management has a significant impact on such things as air quality, landfill space, greenhouse gas emissions and reusable resources. An Ecocity must address the waste issue effectively. It must find ways to reduce waste and make recycling easier and more streamlined.

In many cases, waste management is a slow, costly and labour intensive process. Along with the development of ICT, researchers around the world have been seeking a high-tech spin on what has been a low tech and mostly unmanageable problem. They are now focusing on the so-called removal chain in an attempt to address the long-standing problem: How to track the garbage, save landfill space, improve recycling rates, and prevent the flow of toxic materials into the environment. The key technology involved is RFID (Radio Frequency Identification) [34] which is the use of a tag incorporated into an object for the purpose of identification and tracking using radio waves. Some tags can be read from distances up to 30 m. By attaching the RFID tags to trash bins like illustrated in Figure 4, we could track the trash through a city's waste management system to provide practical waste tracking information to improve the waste management system.
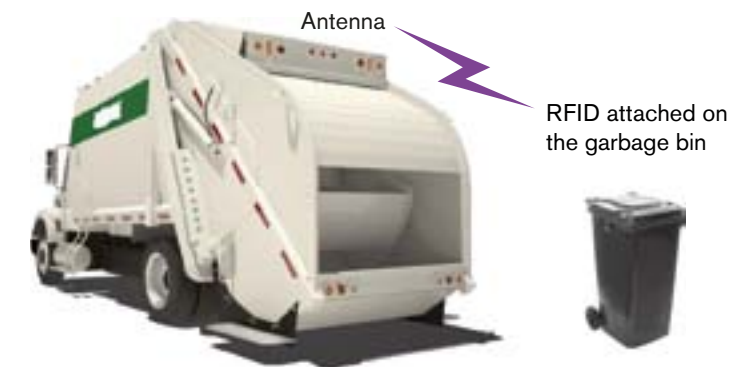

Antenna

RFID attached on the garbage bin

Figure 4. RFID solution for waste management

In a system called TrashTrack [35] uses hundreds of small, smart, and location-aware RFID tags as a first step toward the deployment of smart-dust networks of tiny locatable and addressable micro-electromechanical systems. So far, researchers have tagged more than 3,000 pieces of Seattle and New York City garbage to track the garbage processing flow and use this information to improve the disposing of garbage and their recycling. In Philadelphia, an RFID-based recycling system called RecycleBank [36] was piloted in 2006. A high-tech bin measures the volume of recyclables contained within it and when a truck picks up the items, it transmits the data to an onboard computers. Households receive cash awards based on the amount of plastic, glass, and other materials they contribute.

2.3 Economic Sustainability

The ultimate objective of our Ecocity is to apply ecological principles to urban planning, design and management for sustainability development. Defined in a comprehensive rather vague manner in the 'Brundtland Report' [37], 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' The UN 2005 World Summit Outcome Document [38] refers to the 'interdependent and mutually reinforcing pillars' of sustainable development as economic and social development and environmental protection, meaning that the Ecocity also should be economically, environmentally and socially sustainable.

Figure 5 below shows three important dimensions which must be considered when developing an Ecocity. First, development of the Ecocity must not compromise the ecological environment. Second, the Ecocity must be able to improve economic development by means of keeping the economy vibrant and providing enough employment opportunities. Third, the Ecocity must be able to meet social considerations, including strengthening social harmony among its residents and respecting local heritage [39]. In pursuit of eco cities, the three dimensions of harmony or sustainability must be balanced and met simultaneously.
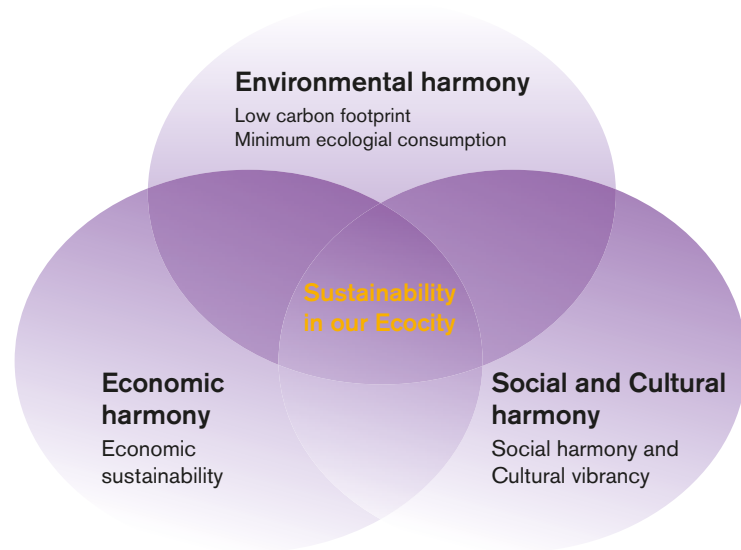

Environmental harmony
Low carbon footprint
Minimum ecologial consumption

Sustainability in our Ecocity

Economic harmony
Economic sustainability

Social and Cultural harmony
Social harmony and Cultural vibrancy

Figure 5. Ecocity's development in three dimensions

An eco city would not be sustainable if any of the dimensions were to be neglected. The world Conservation Strategy of 1980 [40] already proposed an idea for sustainable development, which targeted the integration of development and the environment. However, the strategy did not fully succeed because of a failure to integrate economic developments with the environment. Merely emphasizing environmental protection and social and cultural needs, while at the same time neglecting economic growth and gainful employment, will cause the eco city to fail in the long run. In order to achieve a balance with the other two dimensions, the economy of the Ecocity must be environmentally, socially and monetarily sustainable and focus on delivering better returns on natural, human and economic capital investments, while at the same time reducing the impact of human economic activities on climate change, the requirements for natural resources and social disparities.

Natural capital [41], the extension of economic capital to production and services related to the natural environment, is often unaccounted for in a traditional economy. However, it is absolutely crucial for sustainable development. The economy of the Ecocity should not regard a total valuation of economic capital and natural capital as the sum of each type of capital, as the traditional economy does [42, 43], but, rather, should maintain these two forms of capital separately. In order to achieve economic sustainability, the traditional economic approaches are insufficient and new criteria should be added to economic values within the context of decision making concerning changes in environment. From the perspective of economic sustainability in the Ecocity, we address some guidelines for creating the sustainable economy in the following sections, while, at the same time, focusing on positioning, vitality, business and the economic infrastructure, business and enterprise support, the social infrastructure and employment, and the leadership vehicle.

Economic Positioning

Generally speaking, the task of economic development in the Ecocity is to achieve economic sustainability and provide a suitable platform for a diversified, vibrant, innovative and productive local economy. Therefore, it is essential to determine an economic vision and unique position as a banner that can translate growth in revenues and profits into benefits for the environmental and social aspects of the city as well as continuous competitiveness for local businesses.

Huangbaiyu is a model sustainable village in China built in 2006. However, the construction methods and plan have been strongly criticized. Critics argue that the project was built upon unrealistically high expectations and ambiguous definitions of economic development and sustainable development. A high expectation of job opportunities and economic stimulation from villagers, which never materialized, together with the unaffordable new housing costs, ultimately caused the project to fail [50]. Based on the lesson learned from Huangbaiyu and the recommendations of the

eco-towns economy worksheet of TCPA (Town and Country Planning Association) [44], a full and detailed study of the local and surrounding regional context should be done beforehand to develop an economic baseline. The principle of the baseline, which should capture the characteristics, trends and dynamics of the eco Ecocity and its surroundings in order to establish a set of economic specializations, find that there are potential economic opportunities and a sustainable way of developing an eco city. Besides, extensive baseline analysis, in conjunction with an economic forecasting of trends in key economic development indicators, should be considered as a basis for identifying appropriate target sectors among agricultural-, manufacturing-, and environmentally-based economies, as well as among retail-related, financial- and business-related, ICT-related, and social- and cultural-related sub-sectors. However, the selected target sectors should express an effective linkage of the Ecocity's specialized economic sectors and, complementarily, with the surrounding sub-region to avoid unnecessary reliance on a small number of key sectors and economic conflicts with the surrounding sub-regions. It is also important for the target sectors to embrace carbon-minimizing and resource-efficient processes and sector development. However, this does not necessarily demonstrate specialization in environmental technologies, unless requirements from other sectors or sub-regional economies demand such a thing.

Vitality

According to Ooi Giok Ling and Belinda Yuen, world cities have placed more stress on economic vitality rather than the impacts of population growth and territorial expansion with respect to the world economy [45]. Sustainable economic development requires a diversified local economy in order to offer a promising sustainable, competitive and prosperous future for the city [46]. A vital economy depends upon successful businesses in the target sectors, prosperous individuals and vibrant communities which provide a diverse and nurturing social fabric to reinforce economic robustness and a healthy and skilled population by means of providing education, health, housing choices, services and recreational opportunities for residents and visitors. Economic vitality can also be reinforced through a diverse economy among public and private sectors and non-profit organizations. Moreover, the economy should be unique to attract investment and a skilled workforce.

Economic and Business Infrastructure

For the economic and business infrastructure of the Ecocity, a good practice of using resource efficiently is to exemplify mixed-use and resource sharing which accommodate a range of different types of businesses and enterprises [46, 48]. Mixed-use

refers to the mixing of living, working, leisure, social and other different land uses to combine working life and family life in order to fully utilize the land use of different sectors, especially in residential and commercial areas. The ICT infrastructure could be utilized for this purpose by introducing a way of working for individuals, which would combine office-based collective work with individual work from home. Meanwhile, it is important to take the demands of both the inhabitants and business organizations into consideration when combining the infrastructure in order to provide enough flexibility for companies to grow and more sustainable lifestyles for the people. Besides, the mixed-use type of approach decreases transport demands and increases the flexibility to adapt to changing economic climates in the long run.

Business and Enterprise Support

Cities have to take a more entrepreneurial stance to increase the attractiveness of acquiring investment, residents and visitors [49]. Thus, it is important to embed enterprises, including traditional commercial enterprises and social enterprises, within the overall economy of the Ecocity. At the same time, business support services need to be considered as a necessary link with the target economic sectors to minimize the carbon footprint and improve low-carbon technologies and processes. Key services [44] could be i) advisory services designed for business planning, formation, management and investment to reduce business-related carbon emission, ii) monitoring, measurement and research services for local economies to gain deep understanding of environmental issues and green technologies, and iii) professional services like legal, accounting, financial and insurance services regarding environment-related products and processes, as well as volunteers-, leisure- and lifestyle- related services.

Social Infrastructure and Employment

An innovative and robust social infrastructure providing quality education, health, leisure and community facilities, along with a strong housing market, would be necessary for the Ecocity to ensure economic vibrancy and social stability. For example, 'Eco-Neighbourhood Trinitat Nova' is a master plan for renewing the north-eastern outskirts of Barcelona [47]. One of its target missions is to restore the population of Trinitat Nova, which has been losing population since 1978 and where 31% of the population was over 65 years of age in 1996. The problem was caused by a low education and health care level, which led to social exclusion and younger residents with a middle-level and higher education leaving town. So integrating the social component into the Ecocity would be important in order to cultivate an attractive environment for different labour groups and to maintain social harmony. Moreover, the social infrastructure would also play a crucial role in maintaining full employ-

ment in the Ecocity since it can generate an appropriate number of employment opportunities and also provide skill training for employees to improve the infrastructure and economy.

Leadership Vehicle

Economic development needs to stick to the principles and vision of the Ecocity, thus the main stakeholders of the Ecocity, which includes politicians, business operators, community administrators and residents, must work closely in partnership to ensure that each group of stakeholders commits to the city's objectives and supports sustainable economic growth.

2.4 Culture and Aesthetics

In general, all eco city planning seems to currently be very technology-oriented. Aesthetic and other cultural characteristics are generally missing from current ecocity planning. Moreover, environmental aesthetics and sustainable living, in synchronization with nature and building a sense of community, security and caring, seem to be missing from the design options. In addition, high-tech or academic beehive systems are currently overpowering the market, and different life-style choices, for example slow-life options, are not there [5].

In April 2009, Yale Environment 360 reported on China's failed experiments with eco cities in the following manner: 'Dongtan and other highly touted eco-cities across China were meant to be models of sustainable design for the future. Instead, they have become models of bold visions that mostly stayed on the drawing boards — or collapsed from shoddy implementation. More often than not, these vaunted eco-cities have been designed by big-name foreign architectural and engineering firms who plunged into the projects with little understanding of Chinese politics, culture, and economics — and with little feel for the needs of local residents whom the utopian communities were designed to serve' [52].

Furthermore, in his book Cities and creative class [53], Richard Florida states that it might be difficult to interpret the needs of individuals in terms of where they really want to live and 'There can be little doubt that the age we are living through is one of tremendous economics and social transformation'.

The importance of culture interacting with politics and financing

The Concerto initiative has been a European success story in applying politics to financing futures eco cities, enhancing the current living conditions in 18 areas around Europe [54]. The Concerto initiative, which was financed by one of the sixth frame-work programs in the European Union, has provided a platform for the exchange of ideas and experiences between the 45 Concerto demonstration communities and other cities that are committed to introducing similar strategies. Participating communities will benefit from the shared expertise of Europe's most advanced communities, active in the field of energy sustainability.

In September 2009, Singapore was one of the first cities in the world to launch the 'Theme—Eco city Planning: Policies, Design and Practice' initiative [55]. In the general part of the proposition they state, 'Eco-city planning is a key element of the ongoing debate of environmental urban sustainable development with a spatial and practical dimension.' They also mention community participation and empowerment as some of most important investment criteria, together with communal and government collaborative efforts for sustainability.

Culture is an essential part of politics and, therefore, it is critical for financial decision-making processes in each country. Hamburg's eco city harbour is considered the best example of a sustainable creative-industrial space in the world and it is based on abiding governmental and local political strategic decision-making processes grounded in Germany's environmental initiatives.

Environmental Aesthetics and Appreciation of Nature

In his book, The Aesthetics of the Environment, Arnold Berleant[56] presents a paradigm for an urban ecology. Berleant suggests that aesthetics means more than appreciating gardens, parks, or urban vistas. He continues by saying that 'The aesthetics is crucial in our very own perception of environment. It entails the form and quality of human experience in general. The environment can be seen as the condition of all such experience, where the aesthetic become the qualitative centre of our daily lives.' Berleant further states that valuing an environment aesthetically is not just a question of appreciation and evaluation; it is also a question of politics, economics and ethics.

Finnish environmental aesthetic Ossi Naukkarinen [57] says in his book, Aesthetics of the Unavoidable, that manifestations of aesthetics are usually tacit and unoriginal; therefore, they are volatile. On the other hand, they can be extremely stable. This might be true for the appearances of things, which represent everyday examples of aesthetics, but, it can also be true for experiencing living conditions and spatial concerns.

'Landscapes, too, bear the mark of their inhabitants', says Berleant[58]. He continues by saying that these landscapes are human artefacts, as much the result of skilful manufacture as any other cultural object. Since the artefacts of human culture include the environment in which we live as well the objects we construct for use and delight, they acquire shape through our technology and our characteristic activities. Putting it differently, we might say that culture is the fundamental constituent in environmental aesthetics and, perhaps, in the way we comprehend nature in future ecocity planning.

Building a Sense of Community, Security and Caring

In their work, International Management Behavior, Henry W. Lane and Joseph DiStefano introduce what they call the influence pattern map[59], which focuses on the value of orientations for the first time. These six value orientations include: 1) the relationship of humans to nature; 2) time orientation; 3) a belief about basic human nature; 4) activity orientation; 5) relationships among people; and, 6) orientation to space. All these value orientations must be taken into account when planning future eco cities to a greater extent than has been done in previous endeavours. As well as these orientations, the interpretation of these value orientations has changed over the years and one of the best current models is the one introduced in Kristian Möller and Senja Svahn's [60] working paper on intercultural business networks. They assert that, in reality, we will never find an ideal value system for intercultural management. This might be true for the management of future eco city multicultural communities as well. Culture is an incremental part of a person's value-system. If we want to make radical changes in old value systems and cultural characterizations, we have to identify the current value-systems first. In the following cultural consumer behaviour (MacKay, 1997) and value-system continuum (Möller & al. 2005) diagram, we see how the shift from old and well-established value-systems to new value-systems of a future ecocity could possibly be made.
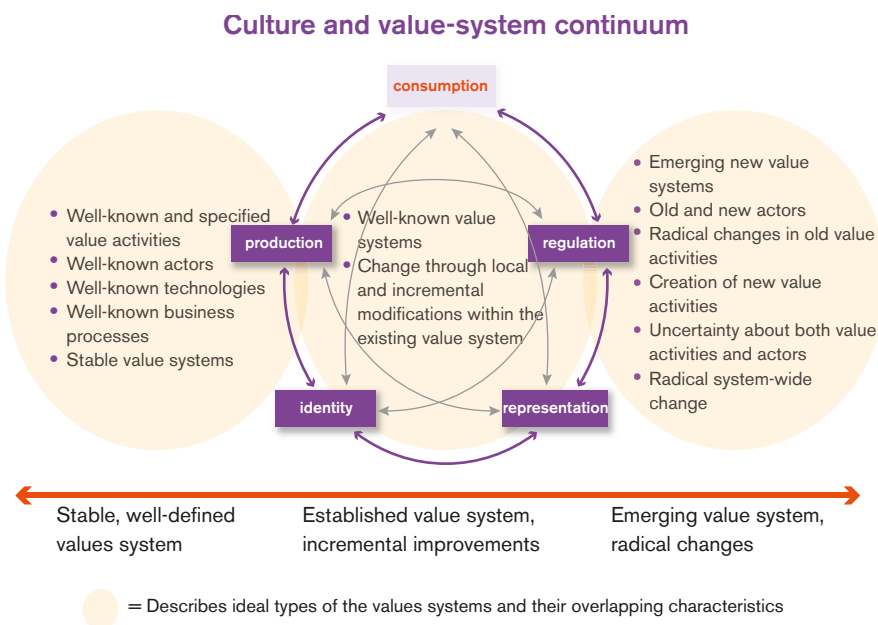

Figure 6. Culture and value-system continuum

Hence, many strategic networks broaden their value system from one stated loop to another, as shown above. For this continuum, Möller & Svahn build their argument on HC Triandis' (1964) original idea of a 'cultural syndrome as pattern characterized by shared beliefs, attitudes, norms, roles, and values that are organized around a theme and that can be found in certain geographic regions during a particular historic period.' As a result, in the future eco city perhaps community spirit and responsibility could not be engendered by design.

Appreciating Different Life-styles

One of the main elements of sustainable lifestyles in the previously-mentioned Singapore 'Theme –Eco city Planning: Policies, Design and Proactive' initiative were issues of shortened commuting distances and an environmental awareness of consumption patterns.

In addition, the current eco city models indicate that the circuit of culture is still valid. We could argue about whether consumption is determined by production or how this picture might change if food was produced in the future 'perfect-world' eco city. Mackay, in his book Consumption and everyday life [61], discusses consumption and its consequences. According to him, the general classification of people has traditionally been based on kinship, and people acted mainly according to normative expectations. Besides, he states that people formed particular and local communities which were gradually overwhelmed by larger forces that uprooted them and replaced identities based on kinship first with identities based on class and later with forces such as the state, which increasingly favoured homogenized and global institutions to which each individual related as an independent unit. Could the futures solution be a community that appreciates genuine diversity and simple values? The quest for a slower lifestyle, downshifting as it is called, is a current phenomenon which is widely attributed to the work of John Drake, co-founder of the HR consulting firm, Drake Beam Morin. He defines downshifting as 'changing voluntarily to a less demanding work schedule in order to enjoy life more [62]'. Drake suggests some guidelines for appraising the landscape's own unique conditions and traits by saying that the creative economy is currently making the places where people live the most important decisions in their lives [51]. We can experience the multiple realities within a futures ecocity as architectural aesthetics, landscape aesthetics, everyday aesthetics, green aesthetics or urban aesthetics.

3 Conclusions

This chapter is not a blueprint for any particular eco city; rather, it gives design principles and guidelines for designing an Ecocity using a clean-slate approach. These principles will assist policy makers and other actors in reflecting on different aspects of design for an Ecocity. City design must be flexible and kept open to let it evolve and adapt to local settings. Therefore, we need guiding principles rather than detailed designs. These design principles are divided into building blocks, with each principle representing different but equally important aspects of an Ecocity design.

To summarize, by considering the essence of the building blocks and the concept of an Ecocity, we can conclude that the choices made for one building block affect the other building blocks and the city as whole. For example, the effect of a transportation system on city design, the effect of financing on the lifestyles of citizens, and the effect of culture & aesthetics all give a city a character and soul. It is important to realize their individual importance and complex relationship with each other. The ecocity of the future will require more active participation from every inhabitant and, whatever the situation, the environment should always be inclusive and encompass a multiplicity of social, physical, and perceptual features.

Building a city from scratch will be expensive. Using conventional business models, this would lead into situation in which only the wealthy would be able to afford to live in this new Ecocity. But, as stated in the building block descriptions, an Ecocity should be a place to live for all segments of society. A heterogeneous demography decreases disparity and improves social harmony and increases cultural vibrancy and creativity.

Using design principles and guidelines given in this chapter, an Ecocity building project can be undertaken within a variety of different financial environments and geographical locations.

References

1. Ecocity Berkeley: Building cities for a healthy future, Richard Register, 1987
2. Wikipedia: Eco City Examples, http://en.wikipedia.org/wiki/Sustainable_city#International_examples, reference: 28.05.2010
3. Sustainable energy without the hot air, MacKay, David JC, UIT Cambridge Ltd, 2009
4. Dimensions of the eco-city, Roseland, M, 1997
5. The eco-city: ten key transport and planning dimensions for sustainable city development, Kenworthy, J.R., 2006
6. Implementing China's circular economy concept at the regional level: A review of progress in Dalian, China, Geng Y, Zhu Q, Doberstein B, Fujita T, 2009
7. Financing Infrastructure in the 21st Century City, Pagani, M.A. and Perry, D., 2008
8. Wikipedia: Sino-Singapore Tianjin City, http://en.wikipedia.org/wiki/Sino-Singapore_Tianjin_Eco-city, referenced: 28.05.2010
9. Wikipedia: G.I.F.T., http://en.wikipedia.org/wiki/Gujarat_International_Finance_Tec-City, referenced: 28.05.2010
10. The economy of cities, Jane Jacobs, 1970
11. Wikipedia: Noida, http://en.wikipedia.org/wiki/Noida#Real_Estate_Issues, referenced: 28.05.2010
12. Wikipedia: B.O.T., http://en.wikipedia.org/wiki/Build-Operate-Transfer, referenced: 28.05.2010
13. Business Model Generation, Alexander Osterwalder, 2010
14. Carfree Cities, Crawford, J.H., International Books 324 p.
15. City Sense, http://www.citysense.net/, referenced: 28.05.2010
16. Velo'v, URL: http://www.velov.grandlyon.com/?L=1, referenced: 12.5.2010
17. CityCarclub, URL: http://www.citycarclub.com/, referenced: 12.5.2010
18. DARPA Urban challenge 2007,URL:http://www.darpa.mil/grandchallenge/index.asp , referenced: 12.5.2010
19. A long-term case study of an e-Grocery concept, Ahola, H & et al. 2003, URL: http://www.docstoc.com/docs/2380453/A-long-term-case-study-of-an-e-grocery-concept/ , Referenced: 12.5.2010
20. Hidas asuminen ja energia vähähiiliyhteiskunnassa. Heinonen, Sirkka. 2003. Sitran selvityksiä, http://www.sitra.fi/julkaisut/Selvityksi%C3%A4-sarja/Selvityksi%C3%A4%202.pdf?download= , referenced: 1.5.2010
21. Forest Cluster Presentation in BitBang course on 28.04.2010, Lars Gädda (Forestcluster Ltd), Aalto University.
22. Nano and the environment, Report from the workshop organized by Nanoforum and the Institute for Environment and Sustainability, JRC Ispra., http://www.nanowerk.com/nanotechnology/reports/reportpdf/report75.pdf, referenced 26.5.2010
23. Optical Absorption Enhancement in Silicon Nanohole Arrays for Solar Photovoltaics, Sang Eon Han and Gang Chen, Nano Lett., 2010, 10 (3), pp 1012–1015, online: http://pubs.acs.org/doi/full/10.1021/nl904187m?, referenced 26.5.2010
24. Nano Vent-Skin, http://nanoventskin.blogspot.com/, referenced 26.5.2010
25. Solar Decathlon Europe, http://www.sdeurope.org/, referenced 26.5.2010
26. Solar Decathlon Team Finland, http://www.sdfinland.com, referenced 26.5.2010
27. Sustainable City & ICT, http://www.thefreelibrary.com/The+sustainable+city+&+ICT:+how+does+ICT+contribute+to+the...-a0221850882
28. DEHEMS, http://www.smart2020.org/case-studies/digital-home-energy-management-system-dehems/, referenced 28.5.2010
29. Berlin Traffic Management, http://www.roadtraffic-technology.com/projects/vmz/, referenced 28.5.2010
30. New York Traffic Management, http://www.troopers.state.ny.us/Traffic_Management/, referenced 28.5.2010
31. Managing a Virtual Workplace, Wayne F. Cascio, 2000. http://www.jstor.org/pss/4165661
32. Second Life, http://secondlife.com/?v=1.1, referenced: 28.05.2010
33. Google Lively, http://www.lively.com/goodbye.html
34. Wikipedia: RFID, http://en.wikipedia.org/wiki/Radio-frequency_identification, referenced: 28.05.2010
35. Global Pix, http://www.globalpixinc.com/products.html , referenced: 28.05.2010
36. Tracking garbage. Greengard, S. Commun. ACM 53, 3 (Mar. 2010), 19–20.
37. Our Common Future: The World Commission on Environment and Development, Bruntland, G (ed), Oxford. 1987
38. 2005 WORLD SUMMIT OUTCOME. http://daccess-ods.un.org/access.nsf/Get?OpenAgent&DS=A/RES/60/1&Lang=E, referenced: 28.05.2010
39. Report of the Working Group Meeting on the Environment: Towards a Livable and Sustainable Urban Environment: Eco-Cities in East Asia, http://www.ceac.jp/j/pdf/neat_07wg02.pdf, referenced: 28.05.2010
40. IUCN, UNEP and WWF: World Conservation Strategy: Living Resource Conservation for Sustainable Development. International Union for Conservation of Nature and Natural Resources, Gland, 1980
41. Investing in Natural Capital: The Ecological Economics Approach To Sustainability, Ann Marie Jansson, Monica Hammer, Carl Folke, and Robert Costanza., pp4,1994
42. Intergenerational equity and exhaustible resources, Solow, R.M., Review of Economic Studies 41 pp29–45, 1974
43. Intergenerational equity and the investing of rents from exhaustible resources. Hartwick, J. M., American Economic Review 67: pp972-974, 1977
44. TCPA eco-towns economy worksheet: developing effective economic strategies for eco-towns, http://www.tcpa.org.uk/data/files/20090327_et_ws_economy.pdf, referenced: 28.05.2010

45. World Cities: Achieving Liveability and Vibrancy, Ooi Giok Ling.,Belinda Yuen, pp1. 2009
46. Eco city Book I A better place to live, Philine Gaffron, Gé Huismans, Franz Skala, pp96, 2005
47. Eco city Book I A better place to live, Philine Gaffron, Gé Huismans, Franz Skala, pp53, 2005
48. Eco city Book II How to make it happen, Philine Gaffron, Gé Huismans, Franz Skala, pp26–27, 2008
49. The Condition of Postmodernity. Harvey David, Oxford: Basil Blackwell. 1989
50. Sustainable Urban Development and the Chinese Eco-City. www.fni.no/doc&pdf/FNI-R0509.pdf, Referenced: 28.05.2010
51. Who's Your City?, Florida, Richard. 2009
52. China Digital Times: China's Grand Plans for Eco-Cities Now lie Abandoned, April 2009
53. Cities and Creative Class: chapter cities and creative class revisited-preview, Florida, Richard. 2004
54. Concerto, www.concertoplus.eu , referenced: 28.05.2010
55. Ecocity Policies: Planning, Design and Practise: http://www.sip.org.sg/documents/Ecocity_Planning_2nd_Call_for_Papers.pdf , referenced: 28.05.2010
56. The Aesthetics of Environment, Berleant, Arnold. Temple University Press, 1992, p.57–58.
57. Aesthetics of the Unavoidable, Naukkarinen, Ossi. Gummerus, 1998, p. 147–48.
58. Living in the Landscape, Berleant, Arnold. University Press of Kansas, 1997, p.11.
59. International Management Behavior, Lane Henry W. & DiStefano Joseph J. Nelson Canada, 1998 p.36–37.
60. Crossing east-west boundaries: knowledge sharing in intercultural business networks, Möller Kristina, Svahn Senja. HSE, working papers w-347, 2003, p.10.
61. Consumption and Everyday life, Hugh Mackay, Sage, 1997
62. Downshifting, http://www.humanresourcesmagazine.com.au/articles/56/0c036f56.asp , referenced: 28.05.2010

2.3 A Sustainable Helsinki Metropolitan Area

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Abstract

Climate change is currently one of the most important challenges. As half of the world's population lives in urban areas, cities have an important role in climate change mitigation. The three largest sources of greenhouse gas emissions in the Helsinki Metropolitan Area are heating of buildings, electric power consumption and transportation. This chapter discusses the means for reducing such emissions. Moreover, we also discuss what kind of policies and strategies a person, city or country could apply and present a roadmap for more sustainable future.

Keywords: sustainable city, metropolitan area, greenhouse gas emission, emissions reduction, energy, transport, policy

1 Introduction

Currently, half of the world's population lives in cities and urban areas and the trend is expected to continue. Thus, sustainable urban development is crucial for the well-being of the Earth. A sustainable city aims to create as small an ecological footprint as possible. The ecological footprint can be measured as the human demand on the Earth's ecosystems compared to the Earth's ecological capacity to regenerate itself; in other words, the amount of land and sea needed to restore the resources humans consume and absorb and render harmless the corresponding waste. The resources that humans consume include energy, water and food. The produced waste includes air pollution, water pollution and land pollution in addition to solid waste. For a city to be more sustainable, building design and practice, the transportation of people and goods, urban planning and the lifestyles of inhabitants need to be adjusted.

This chapter focuses on the Metropolitan Area of Finland (see **Fig. 1**). The aim is to provide insight into how to enhance sustainability of the Helsinki Metropolitan Area (HMA).

Metropolitan Area of Finland

Municipality	Area	Population	Population density
Helsinki	213.66 km²	583,549	2,731.2/km²
Espoo	312.22 km²	244,474	783.02/km²
Vantaa	238.38 km²	198,039	830.77/km²
Kauniainen (Grankulla)	5.88 km²	8,606	1,463.61/km²
Helsinki Metropolitan Area	**770.14 km²**	**1,034,668**	**1,343.48/km²**
Outer municipalities	2,780.94 km²	296,600	106.65/km²
Greater Helsinki, total	3,551.08 km²	1,331,268	374.89/km²

- emissions in 2008 5.9 million t CO₂ (~10 % of Finland's emission)
- per capita emission figure 5.7 CO₂ in 2008 (aim for year 2030 4.3 t)
- per capita electricity consumption 8000 kWh in 2008
- 400 000 passenger cars in metropolitan area
- 71,6 % commuters going to centrum use public transport
- 15,8 % commuters travelling sideways use public transport
- 90 000 cars travelling daily on ringroad I
- 25 000 commuters using bicycle on summertime, 3000 on wintertime

Figure 1. Facts about the Helsinki metropolitan area

Helsinki has greenhouse gas emissions lower than the average amount for European cities as a whole, but higher than other Nordic cities such as Oslo and Stockholm [1]. In 2008, the greenhouse gas emissions per capita were 5.7 t CO₂-e [1]. The aim for 2030 is 4.3 t CO₂-e per capita [2]. Electric heating, the consumption of electrical power, transport, district heating, separate heating, industry & machinery, and the treatment of solid waste and wastewater all produce greenhouse gas emissions [2].

Moreover, the three main sources of greenhouse gas emissions are the **heating of buildings** (43%), **electric power consumption** (28%) and **transportation** (23%). Together, they are responsible for 94% of greenhouse gas emissions [2]. Of the total emissions, households generate half of all emissions, services generate 39% of emissions and industry generates 13% of emissions [2].

The most important measures for minimizing emissions which can be controlled by cities themselves include reducing energy consumption, CO₂ comparison and criteria in purchasing, energy use rationalizing, the promotion of public transportation, cycling and walking instead of driving cars, and rationalizing land use near rail traffic stations [2]. Land use and urban structure planning are relevant to green house gas emissions because the decisions have long-term effects. The choice of location when building accommodations, workplaces and services impacts traffic and emissions as well as the possibility to utilize district heating. In the metropolitan area, the urban structure has scattered due to growth, leading, correspondingly, to an increase in passenger car traffic and longer journeys to work. When compared to other European cities, Helsinki's metropolitan area is quite scattered. The citizen-per-hectare ratio is around 25 and the developed gross floor area to land ratio is 0.25 [2].

In this chapter we focus on the possibilities for reducing greenhouse gas emissions from energy production and usage and transportation, as those are the main greenhouse gas emission sources. We also discuss policies and strategies from the government level which favour sustainability in the Helsinki Metropolitan Area.

2 Energy Generation and Energy Usage in Buildings

Emissions from energy production and energy usage in buildings generate 75% of total green house gas emissions in the area. Thus, they are important factors when discussing energy saving practices. Next, we will present current energy generation and usage practices in the area and ways to reduce emissions in buildings.

2.1 Energy Generation

Combined heat and power (CHP) production is the main technology used for energy production in the area. The process is illustrated in Fig. 2. The combined production of electricity and heat increases fuel efficiency from 40–50% to 90% and emissions are reduced 25–40% compared to separate means of production [3, 4, 5]. All of the largest power plants in the area use coal and/or natural gas as energy sources. District heat is produced and sold locally, whereas electricity can be bought from or fed to the national grid. For more about CHP, see the article on cogeneration at the Wikipedia website [6].
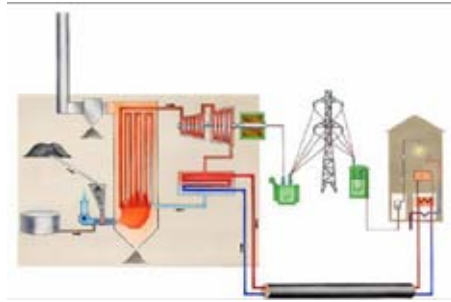
Figure 2. Operation of a CHP power plant fired by solid fuels [4].

The energy sector currently faces several challenges: increasing consumption, an end to the era of cheap oil, environmental problems and climate change. Energy production causes such environmental problems as air quality problems, acidification and green house gas emissions. To reduce greenhouse gas emissions, the whole energy generation system - energy sources, transfer, distribution, storage, energy generation and end use - needs to be taken into account. Various measures are presented in Table 1 and different energy sources are compared in Table 2. Information for Tables 1 and 2 was collected from [3, 4, 5, 7, 8, 9, 10, 11, 12, 13]. The most important measure for achieving the targeted emission reduction level is to improve efficiency. In addition to technical means for reducing emissions, emissions trading, Kyoto mechanisms, energy savings agreements and customer advisory practices are used. In practice, however, we cannot ignore the slow development of technology, the long operating life of investments, slow structural change, financial issues, security and the reliability of supply.

Table 1. Various means to reduce greenhouse gas emissions from energy production

Technique	Description	Benefits	Potentiality
New types of CHP units	Larger part of production for electricity	Better adaptation to the energy consumption structure	Under development, large potential
Increasing energy efficiency	Different means, such as waste energy utilization, modernization of power plants	Emissions are reduced, cost reductions	Constantly used and under further development
Reduction of intrinsic emissions	e.g., process optimization by modelling and simulation	Reduced emissions and costs	Emissions controlled by international agreements
Fuel switching	Switching fuels to more environmentally-friendly fuels	Emissions can be reduced	Might require boiler conversion, multiple investments made
Multi-fuel power plant	Various fuels, such as biomass, waste and coal, are used	High efficiency, low emissions, flexibility	Implementation in practice takes years, under development
District cooling	District cooling uses local resources that otherwise would be wasted	80% less greenhouse gas emissions than in building-specific cooling systems	Currently, district cooling is available in the Helsinki city centre
Computer halls in tunnels	Computers are cooled by district cooling and the produced heat is used for district heating	Energy can be saved and waste heat exploited	Infrastructure exists in central Helsinki, somewhat in use
Carbon capture and storage (CCS)	CO_2 created in energy generation is captured and sequestered permanently	Reduction of CO_2-emissions into the atmosphere	Huge expectations, still under development, relatively expensive
Energy storing	Heat accumulators and cooling water storage systems	Regulation of 24-hour production	Somewhat in use
Heat pumps	Can be used for combined production of heat and cooling	Utilisation of sea water, air-source or ground-source, flexible, efficient	Consume electricity, large potential for efficient heating and cooling, little exploited currently
Fuel cells	Electrochemical cell that converts a source fuel into an electrical current	Many combinations of fuels and oxidants are possible, efficiency 50-70%	Not used in the area, large future potential
Multiple energy carrier system	Combining electricity, natural gas and district heating networks	Best properties of each system remain in place	Implementation in practice takes 30-50 years

Table 2. Comparison of various energy sources

Energy source	Benefits	Challenges	Potentiality
Coal	Availability, reasonable and stable price, easy to store and transport	Pollution, energy security risk due to dependence on certain countries, easily available sources declining, extensive environmental degradation	Largely exploited, technology and infrastructure exist, economical
Natural gas	Less emissions than other fossil fuels, small transmissions losses, high efficiency		
Oil	Superior energy density, easy to transport and store		Mainly used for peak consumption generation
Biomass	By-products can be exploited, carbon-free energy source	Large amounts of land needed, competition with food production	In use, most suitable close to origin
Biogas	E.g., by-products and gas from landfills can be exploited, reduction of greenhouse gases	Gas needs to be cleaned after gasification of biomass	Landfill gases are used for energy production
Biocoal (torrefacted biomass)	High energy-density, properties close to those of coal, transportation and storing systems exist	Technology under development, exact costs unknown	Future fuel, significant parallel fuel for coal plants
Waste	Replaces coal, generates less CO2-emissions than coal, reduces waste at landfills	Requires constant flow of waste	Power plant under construction in Vantaa
Hydro	Agility, no primary waste or pollution	Possibly serious environmental impact on the surrounding areas and animals	A sufficient and continuing supply of water needed, in Finland no new capacity
Wave	No fuel costs, no water or air pollution	Technology under development	Large future global potential, ongoing research projects
Wind	No water or air pollution	An eyesore, unsuitable for base-load generation	Several units already in use with multiple units in the planning stage
Solar	No air pollution	May be unavailable because of weather conditions, relatively high cost	Passive or active exploitation, huge global potential in future
Heat content from ground, water and air	Exploitation of heat/cooling content that would otherwise be lost	Large-scale use, costly initial investment needed	Used on a small scale, potential for larger use
Nuclear	No primary air pollution, fusion reaction more efficient than fission	Poisonous and radio-active waste production, waste storage	In use, plans to increase it, commercial fusion reactor not expected before 2050
Hydrogen	Steam only emission, large energy content per mass unit, can be stored	Storing and transport problematic	Promising future fuel, under development

2.2 Energy Use in Buildings

Energy usage is divided into three main sectors: the building sector (residential and commercial buildings), the industrial sector and the transportation sector. These sectors are also called the economic sectors [14]. However, this section concentrates only on the energy use in buildings. The building sector includes homes, offices, hospitals, restaurants, schools, and stores. Heating, cooling, lighting, cooking and other electrical appliances are the main consumers of energy in buildings [14]. About 80% of the energy consumed in a residential building goes for heating and hot water (Table 3). The main sources of heating in buildings in the Helsinki Metropolitan Area are shown in Table 4. District heating is the largest source of heating in these buildings. Other heating sources include electricity and separate heating sources. Usually, separately heated buildings have oil-fired heating systems.

In the year 2005, the electricity consumption of residential appliances in Finland (electrical heating is excluded) was 10.3 TWh, which accounted for 10% of the total electricity supply [14]. However, in the same year, the amount of electricity used for appliances in commercial buildings (14.7 TWh) was higher than that used in residential buildings. Currently, electricity use is increasing especially in private homes [14].

Refrigerators, consumer electronics and ICT, cooking appliances and the lighting devices consume the majority of electricity in Finnish households. For example, both a refrigerator and a computer consume 500 kWh/year [14]. Computers and other entertainment devices such as televisions and DVD players consume much energy because they are on standby mode most of the time. It is estimated that electronics appliances in Finnish households consume about 0.8 TWh in standby energy every year [14]. Currently, the total electricity consumed by electronics devices in Finland is around 1.6 TWh [14]. There are two possible solutions for reducing the electricity consumed by these devices: the first is to unplug them when they are not in use and the second is to buy only devices with as low energy consumption as possible. It is expected that the number of people using electronics devices will increase in the next two decades due to the increased number of new buildings [14].

On the other hand, the building sector in the EU consumes over 40% of the energy used and emits over 40% of all carbon dioxide emissions into the atmosphere [15]. To improve energy efficiency and reduce carbon dioxide emissions, the level of a building's total energy demand should be reduced and renewable energy sources must be utilized [14]. To help achieve this, the European Parliament has adopted Directive 2002/91/EC on the energy performance in buildings [15].

Table 3. Activities which consume the most energy in a household [3]

Energy user type	%
Heating	50
Hot water	30
Electrical appliances	20

Table 4. Heating sources in buildings by floor space in 2006 [2]

Source	Helsinki	Espoo and Kauniainen	Vantaa
District heating	86 %	67 %	68 %
Electricity	6 %	17 %	17 %
Separate heating	6 %	15 %	13 %
Unknown	3 %	2 %	2 %

2.2.1 Energy-Saving Potentials

Overall, an energy savings potential of 75% can be achieved in the building sector [14, 15, 16]. This can be done by adopting net zero site energy use concepts. These concepts consist of three stages: stage 1) building-level demand reduction measures; stage 2) optimal utilization of all available heat gains and renewable energy sources; and, stage 3) compensation for strongly reduced non-renewable energy consumption by renewable energy sources. Stage 1 includes good thermal insulation, professional and careful planning, dimensioning and construction. Stages 2 and 3 include solar collectors (photovoltaic and thermal), ventilation with a heat recovery unit, and a ground and air heat pump. The IEA5 house in Pietarsaari, Finland (see Fig. 3) which was built in 1993 combines outer-shell building engineering with integrated and distributed energy production solutions. The energy consumption of this house is only one quarter of that of an ordinary house [7, 14, 15, 16].

Figure 3. The IEA5 concept house, Pietarsaari, Finland [7]

2.2.2 Lighting Use and Savings Potentials

In 2005, the world consumed about 2650 TWh of electricity for lighting, which is equivalent to 19% of total global electricity consumption [14]. Lighting consumes the largest amount of the electricity in buildings. For example, 50% of the electricity used in European office buildings goes to lighting, in contrast to 20-30% in hospitals, 15% in industries, and 10-15% in residential buildings. Currently, fluorescent lights are the dominant lighting technologies used in buildings. Fluorescent lights, also known as discharge lights, are a very efficient type of lighting. In the future, LEDs are expected to become the critically important technology used for lighting [14]. The small size, long lifespan, and high luminous efficacy of LEDs make them more advantageous than conventional light sources. Furthermore, unlike fluorescent lights, LEDs do not contain mercury or radiant heat and operate at a low ambient temperature. Compared to FLs, LEDs are also more suitable for dimming [14].

Lighting in Finland has a considerable energy saving potential as well. The total lighting energy use depends on lamps, ballasts, luminaires and lighting design. Reducing the electric power use for a lighting system and using the right control system represent the energy saving options in buildings. The control system unit involves the application of occupancy sensors, manual dimming, automatic switching and dimming according to the availability of daylight. Currently, the most efficient light sources are fluorescent lights; however, LEDs can replace them in the near future because of their higher energy saving potential in terms of luminous efficacy [14].

3   Transportation

The transportation system is the key enabler for urban and socioeconomic architecture and development in modern societies. Private and public vehicles facilitate the transporting of goods and people, both of which are of key importance for a healthy and prosperous economy, as well as the modern suburban way of living. In addition to the necessary development of the infrastructure, the transportation of passengers and goods currently accounts for a significant part of Finland's energy use. Moreover, in the Helsinki Metropolitan Area the amount of daily trips to and from home and places of business is forecasted to grow strongly until at least 2030 [17], as depicted in the following figure (Fig 4).
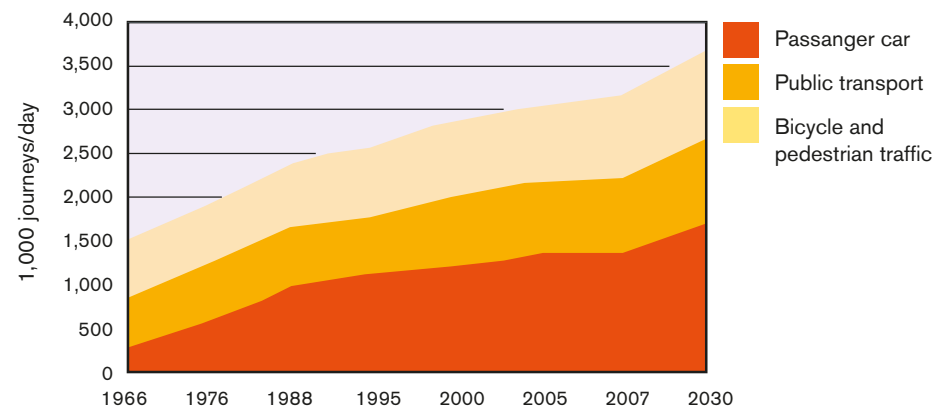
Figure 4. Traffic development in the Helsinki Metropolitan Area (1966–2030) [17]

The current transportation system, specifically when it comes to private vehicles, is fully dependent on petrol and internal combustion engine technology. According to the International Energy Association, the oil price in real terms is assumed to rebound from around $60 per barrel in 2009 and, with the economic recovery, reach $100 by 2020 and $115 per barrel by 2030 according to World Energy Outlook's reference scenario [18]. These facts indicate an urgent need for change, both from economic and environmental perspectives, towards a more sustainable transportation system. In the following sections of this chapter, we will analyze the role of public transportation and the different alternatives to internal combustion vehicles, focusing in particular on bicycles and electric vehicles. We will study the foreseeable impacts that the use of electric vehicles might have on the Finnish economy and society, as well as the extent to which the Helsinki Metropolitan Area is ready to accommodate such a change in the way vehicles are used. Finally, we will detail a roadmap on how such a transition could be implemented.

3.1 Public Transport

Roughly 23% of HMA energy goes to transportation [2]. Can we reduce the consumption of energy by either improving or utilizing alternative sources of transportation? At its best, shared public transport is far more energy-efficient than each individual driving his or her own car-. A diesel-powered coach, carrying 49 passengers and doing 24 l/100 km at 104 km per hour, uses 6 kWh per 100 p-km – this is 13 times better than a single individual driving his or her own car [9]. The same holds true for HMA metro, which consumes 11-13 times less fuel per person per kilometre (p-km) at average loads compared to a motor vehicle [1]. Figure 5 shows the energy consumption rates for buses, trams and commuter trains with an average amount of city traffic.

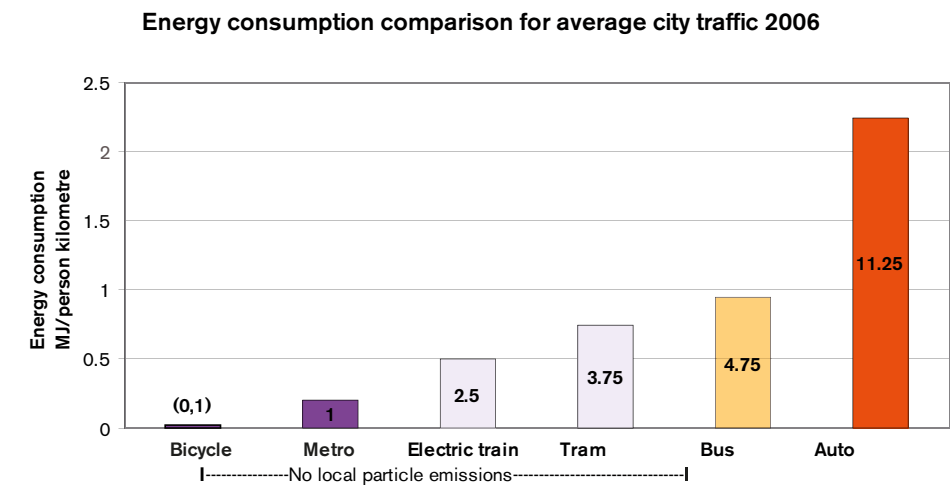**Energy consumption comparison for average city traffic 2006**

Figure 5. Energy consumption per p-km at average loads when comparing the Metro to other forms of transportation. The largest energy users are also responsible for the most particle emissions, not only from engine emissions but also from road dust. Light vehicles or vehicles running on rails cause less road dust [7, 9, 25].

The ownership and use of private automobiles has increased greatly in Finland since the 1960s. Today, well over 80% of Finns live in households which own at least one car [1], thus the relative popularity of public transportation has fallen continually; however, this has levelled off in the recent years as public transport prices have stabilized and improvements have been made to the public transportation system (Fig. 4).

About 40% of all trips to or from home and places of business are made by public transport, but these cause only about 10% of the greenhouse gas emissions produced by various forms of transportation. Private automobiles, used for 60% of all trips, account for more than 50% of such emissions [7]. Thus, every percentage point increase in the popularity of public transport would immediately cut the overall greenhouse gas emissions from transportation by about 0.6% (Fig 6). With the consequent fall in traffic congestion, the actual impact is somewhat greater than this. Encouraging the use of public transport thus enables the greatest and swiftest reductions in traffic emissions.
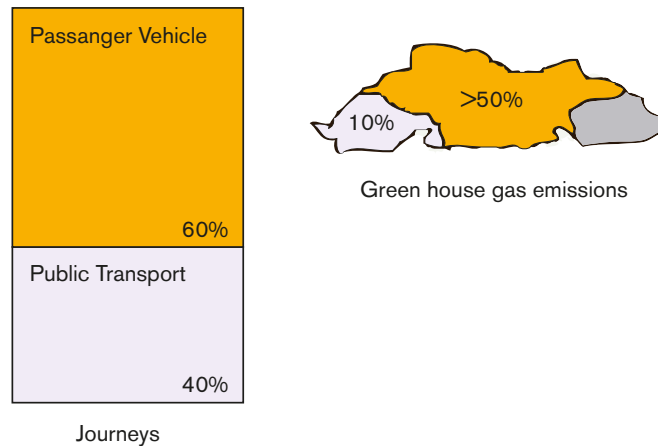
Figure 6. Different forms of travel in Finland and their corresponding contribution to overall green house gas emissions from the transportation sector.

The main airport for the Helsinki Metropolitan Area, Helsinki-Vantaa International Airport, accounts for about 75% of Finland's total air passenger traffic. Air traffic passenger volumes increased by 48% between 1996 and 2006. The number of passengers on international flights has seen particularly substantial growth (80%) [20]. Carbon dioxide emissions have risen at a slower rate, however, with technological progress reducing specific energy consumption by as much as 70% over the last 40 years [20]. Air traffic emissions will be reduced in the future chiefly through technological progress, the optimized use of air space and emissions trading.

To summarize, public transport (especially electric trains, trams, and buses) seems to be a promising way of handling the increasing numbers of people travelling around metropolitan areas – better in terms of the energy per passenger-km, and perhaps five to ten times better than cars.

3.1.1 Current Policies and Actions

The MOMO project [51] is an Intelligent Energy Europe (IEE) project, which is supported by the European Union. The acronym MOMO stands for more options for energy efficient mobility through Car-Sharing. The project will last for 36 month from 1 October 2008 to 30 September 2011.

YTV (HSL) Regional and Environmental Information is involved in the EUCO2 80/50 project, which has measured the greenhouse gas emissions of 18 European urban regions according to commensurable and comparable criteria. As mentioned before, the comparison of urban regions indicated that the per capita greenhouse gas emissions of the Helsinki Metropolitan Area were slightly lower than average, but nevertheless double those of Stockholm and Oslo [1]. Nowadays, passenger cars accounts for 80% of all passenger transport, which explains why Finland had the third

highest amount of passenger kilometres in road traffic per capita in the EU, surpassed only by Italy and Luxembourg [23]. Energy consumption resulting from transport, together with a continuing increase in the amount of energy consumed by space heating, has undermined all the energy savings from the other sectors. Consequently, in 2005 Finland had the largest energy consumption per capita of all the EU member countries [24].

3.1.2 Discussion

Compact urban planning reduces not only the need for new roads but also the need for district heating. The environment affects the attitude indirectly. The VTT found that a comfortable and secure environment leads to an increase in the number of people cycling and walking [7]. Thus, the planning and management of traffic systems should consider the system as a whole.

In urban areas, the objective of the Ministry of Transport and Communication [21] is to increase the combined market share of public transport and non-motorized transport. It plans to develop public transport into an environmentally sustainable, user-friendly, safe and smooth mode of transportation which is reasonably priced. Cities and municipalities play a major role here. The importance of transport system plans and the need to reconcile land use with public forms of transportation will be emphasized particularly in cities and urban areas where public transport development calls for making traffic arrangements: setting aside streets and lanes for public transportation and making priority signals and parking arrangements, among other things. In terms of market share increase, the Helsinki Metropolitan Area (HMA), Tampere and Turku show the greatest potential for developing their transportation systems (see Fig. 7). These three areas also exhibit the greatest need for public transport development and present the greatest challenges.
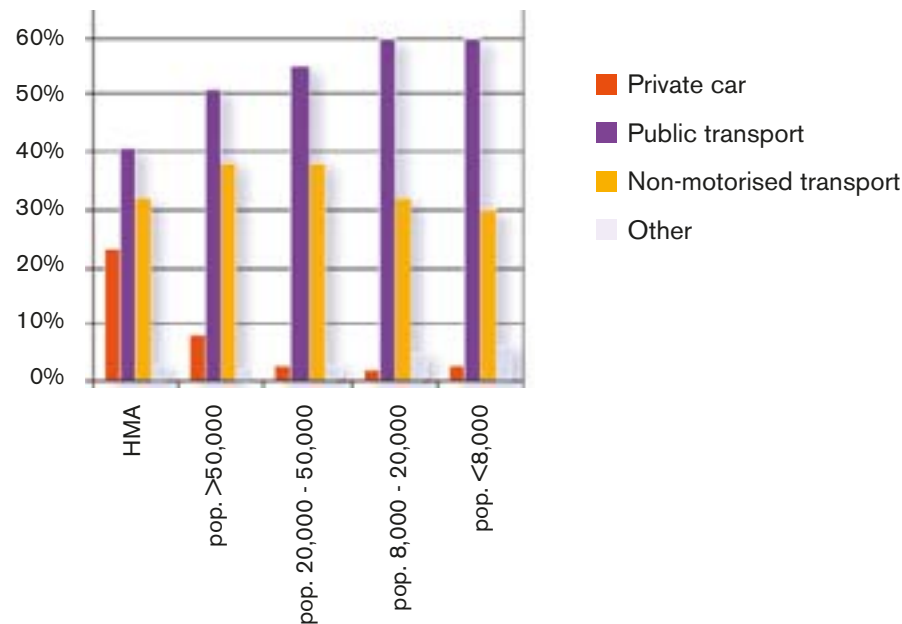
Figure 7. Distribution of different modes of transportation according to the number of daily trips in municipalities of different sizes [20].

By European standards Finland is a large and sparsely populated country with few large cities, so effective transport connections are vital for the economy both nationally and regionally. Due to scattered settlement patterns, road transportation is the most significant mode of transport in most areas. Flying and using passenger cars should be avoided and public modes of transport, like trains and buses, should be favoured. In Finland in 2001 the average energy consumption of a passenger car per passenger kilometre was double that of a bus and triple that of an electric train.

Projects like building a metro, which would begin west of the HMA in the Helsinki city centre and run all the way to Espoo in the east, would certainly aid in promoting public transport and minimizing the usage of private cars. Upon completion, the project aims to transport around 100,000 passengers every day. Even with such a massive project, its ability to extend to enough locations and connect enough people would remain an issue. One of the critical factors behind the success of metro lines is their ability to cover an entire urban area; examples of metro lines which manage to do this include the well-functioning networks in Paris and Stockholm. Due to the sparse population of Finland, this poses a challenge; thus, other means of public transportation become crucial. Buses and trams can bridge the gap. However, the level of comfort needs to be elevated.

The general attitude of the government towards motorized vehicle users also dictates the end result. When a driver observes clear traffic signs for a road block as compared to bicyclist, who has a more difficult time finding his or her way around

the obstruction, this highlights the lower priority the government places on the latter. Parking places and parking fees are another means of controlling the number of vehicles and there are numerous other means as well that the government can utilize to monitor the flow of traffic.

As a consumer, one can also have an influence by choosing to support a particular means of transportation; we can lower the carbon footprint of the various forms of transportation by choosing, for example, locally produced food. In the end, however, the most important decision is whether we walk or drive to the shop. While we should favour public transportation and, especially, train traffic to minimize carbon dioxide emissions, economic development has often in fact had the opposite effect. As we get richer we tend to travel more, and change from public transport to passenger cars.

3.1.3 Scenario 2030: A Public Transport Perspective

Private car users in growing metropolitan regions value individuality, comfort, speed and the freedom of choice. Since the passenger of the future does not always have time to wait around for public transportation, he or she also appreciates speed as well as comfort and reliability. Enhancing the speed, reliability and enjoyment factor of public transportation thus becomes the key goal. Technology can be used to provide information of a high standard, while intelligent transport systems help create a well-functioning public transportation environment.

People of the future will want to be able to flexibly combine different modes of transport when they travel. Public transport must fit seamlessly into the overall transport system and also be supported through park-and-ride systems for pedestrian and bicycle traffic; for instance, Finland's City Car Club offers Segways [22], which can reduce transportation time and increase comfort while maintaining limited emissions. Currently, there are two rental fleets. These vehicles weigh 38 kg and have a maximum speed of 20 km/h. They use two powerful electric engines. It can operate 13-19 km on a single charge, depending on the landscape.

The relentless pursuit of economic growth will, however, lead to a substantial rise in traffic volume, which in turn is on a direct collision course with the goal of sustainable development. It would seem that the emissions reductions imposed on traffic are impossible to achieve without restrictive measures. In all likelihood, even financial steering mechanisms will prove insufficient on their own and will need to be supplemented with other restrictive means, which may vary according to the time, location and type of technology employed.

3.2 Cycling and Electric Bikes: Light Traffic in the Metropolitan Area in the Year 2030

Light traffic planning should be prioritized together with public transport during the next decades. Today, there are roughly 400 000 personal cars in the Helsinki Metropolitan Area [26], and if new motor roads are built like during the last decades, there will not be an upper limit to the numbers of personal passenger cars on the road. Whether these cars are equipped either with a combustion engine or an electric motor, there will no longer be enough space in the metropolitan area if we want to live in a comfortable city. Clean, quiet, healthy and fast transportation is needed, and cycling together with public modes of transport could provide this.

In many cities, the younger generation is looking for better solutions to the problem of city traffic. Cities are becoming overcrowded with private cars, traffic congestion, a lack of parking facilities, pollution and noise. All of these factors have made private cars less attractive. Today, 41% of all households in Helsinki have no car at all, and these families have already now chosen alternative modes of transport [27].

The metropolitan area has a lot of potential for increasing the amount of cyclists, especially commuters. Estimations are that 16% of commuting trips are made by bicycle in Helsinki in the summertime, but in the wintertime this drops to one-tenth the amount. In comparison with other Finnish cities, Oulu does much better. There, 46% of the people who cycle to work in the summer continue cycling throughout the wintertime. In Helsinki, this figure is 13% [28]. Mainly, this is because of poor road maintenance during wintertime. For a long time Helsinki has had a plan to double the amount of cyclists who commute to work [29], but until now it has failed in these attempts. Luckily, the future looks brighter because cycling has received more attention lately.

Compared to Copenhagen, the numbers for the Helsinki area do not look good. In Copenhagen, 37% of commuters cycle to work, and the aim for the year 2015 is to get more than 50% of commuters using bikes. And these are year-round numbers, not only summertime figures! For more detailed plans and information about cycling in Copenhagen, please check the city's bicycle account, which has been published bi-annually since 1996 [30].

The bicycle is superior to the city vehicle when comparing energy consumption and vehicle mass and space. Even electric cars and busses are responsible for particle emissions since as heavy vehicles, they grind roads and sand, making dust. The lighter bicycle does not give off any particle emissions [Fig. 5].

3.2.1 Speed and Safety

More people would choose cycling over using a private car if cycling would be a faster way of moving around in the city. Time has become a luxury, and cycling offers an easy and flexible door-to-door solution without unnecessary stops. For quick travel through the city with a bicycle, good cycling paths are needed. Copenhagen has chosen to make bicycle-only roads and lanes, and to prioritize these bicycle routes in all directions. This means planning, building and maintenance. One part of Copenhagen's city planning is devoted to the bicycle highways which receive most of the traffic [Fig. 8]. One technological feature of these lanes is green waves, which make it possible to ride without stopping through sets of traffic lights at a constant speed. Some advanced plans suggest using green LEDs embedded in the street to create easy-to- follow green waves through traffic lights [Fig. 9]. In some Danish and Dutch cities these are already in use. For many, these lanes provide the fastest means of travel in the city area [30, 31]. In metropolitan area, these cycling roads and lanes are fragmented and not as well-maintained, and unsatisfactory stretches present drawbacks to an otherwise good system of bicycle routes [Fig. 8].
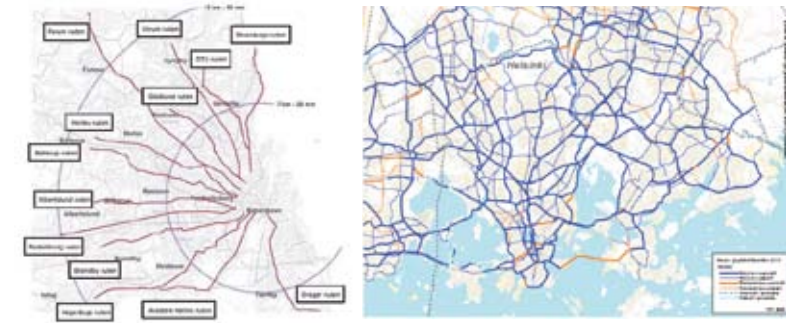

Figure 8. The city of Copenhagen has built fast 'bicycle highways'. Maintenance of these main roads is prioritized year round [31]. The metropolitan area has a vast network of light traffic roads, but good and well-maintained roads are fragmented. Realizing this problem leads to improvements [27].

Special bicycle lanes and roads also offer advantages other than speed. These lanes are also safer, because cyclists have their own place among cars and pedestrians. A greater number of bikes also help attract more attention from car drivers.

Independent and fast traffic lanes for bikes and e-bikes are also cheaper to build than motor roads or tram systems and usually take less space. The lanes should only be for wheeled traffic, because pedestrians slow down faster traffic too much. These fast and light bicycle lanes could offer much higher driver densities than the uses of private cars and, for many citizens, more flexibility than public transport. The year 2030 we will see many of these small, quiet, fast and clean vehicles in motion on the streets of metropolitan areas.
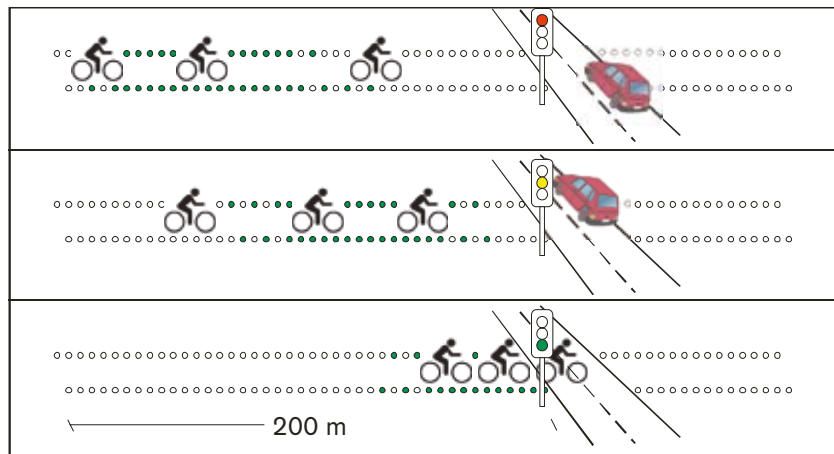
Figure 9. Greenwav LEDs are embedded in the road. LEDs make waves of green light from 200 meters before the traffic lights. The front lights travel slower than the posterior lights, thus gathering cyclists into one group, helping them effectively cross the motorway and the sets of lights.

3.2.2 Comfort

Better and well-maintained bike lanes, better bikes and the right amount of clothing to handle the, at times, very cold Finnish weather add comfort for cyclists, but there is one big change which is still neglected in Finland. When visiting China, we were amazed by the amount of electric bicycles everywhere, both in Shanghai and in countryside. It is estimated that today there are up to 120 million e-bikes in China [32]. There are still plenty of traditional bicycles, and the amount of cars in Chinese cities has been growing rapidly but city centres are quickly reaching their limit in the number of cars which they can accommodate. Between these two extremes there are now light electric two- and three-wheeled vehicles. These vehicles offer faster and cheaper transport than cars in congested cities. Cycles also offer more transport capability than public transport for carrying groceries and other stuff we sometimes need to transport. An interesting point is that these e-bikes in China have replaced internal combustion engines in scooters. Nine out of every ten scooters which we saw was electric. Electricity is available everywhere, and it is cheap to load batteries. Even small roads can bear a lot of these light vehicles, which can go where cars cannot go, like city centres. An electric motor makes travel easier than pedalling only, and makes these vehicles an interesting choice for many. We claim that these light e-bikes will also be more and more popular in Europe, including Finnish metropolitan areas. Thus, it is important to recognize this trend, and adapt transportation planning to these trends early enough.

Another trend which might affect traffic planning is cargo bikes (Fig. 10). These were abundant in China as well, and 6% of households in Copenhagen also have

them. Twenty-two per cent of these households use their cargo bike as a replacement for the car, and many other households have switched from making trips by car to making trips by bicycle [30]. These bikes could transport cargo and groceries, but also provide good alternatives for transporting kids.

Figure 10. Special bikes could replace personal passenger cars in city traffic. Two- and three-wheeled cargo bikes offer transport capacity, and three-wheeled electrically-assisted bikes could offer independent travel for the elderly [33].

3.3 Private Passenger Cars

As we have detailed in the introduction of this chapter, the current ICE (Internal combustion engine) does not seem to be a sustainable solution in light of the oil prices forecasted for the near future and the requirements to mitigate climate change. We will now proceed to present a high-level analysis of the technologies that could compete with the internal combustion engine:

- Fuel-cell technology offers the promise of a highly efficient technology with no local emissions and quick refills, but its high price and development needs prevent it from being deployed on the market. It remains a highly promising solution for the future.
- Biofuel-related technology offers attractive properties, like a wide range and reduced fuel prices. Also, the readiness of the technology allows deployment in the market (10 million biogas cars in use already, 15,000 filling stations already in the world). Biogas can be transported in the same pipelines as natural gas because it is basically the same product (CH_4). If using natural gas, the CO_2 reduction is about 25%. Its main drawbacks include the limited availability of resources for generating fuel and the fact that efficiency of the engine is limited by the carnot cycle when compared to fuel cells.
- Electric cars offer about 60% greater 'tank to wheels' electric motor efficiency than the ICE [34] and up to 70% less 'well to wheels' greenhouse emissions in plug-in hybrid vehicles vs. conventional vehicles if electricity is based on renewable sources [35]. The 'well to wheels' greenhouse emissions are about 35% less in hybrid vehicles vs. conventional vehicles [35] and hybrid electric technology is already commercially available. The main drawback of electric cars is their

higher upfront costs and that both the battery technology and electric infrastructure need a lot of development before the EV (electric vehicle) can be fully commercialized. Overall, among current alternatives, electric cars offer the most promising technology as a replacement for the internal combustion engine. The following table (Table 5) summarizes the current modalities surrounding the concept of the electric vehicle.

Table 5. Summary of different electric vehicle technologies

Car modality	Description
HEV (hybrid electric vehicle)	All the energy comes from the internal combustion engine and the fuel (diesel or gasoline). The braking system reuses the energy to recharge the battery, which does not charge externally but, rather, internally with the combustion engine and brakes.
PHEV (Plug-in hybrid electric vehicle)	Battery could be charged from external source, e.g. an electric grid. They help in solving two fundamental issues: 1) limited operating distance and 2) expensive energy storage. Based on electricity, the car can run for about 20 to 50 km. Battery development is critical in terms of the battery capacity; currently, the typical battery capacity is about 4 kWh, which is equivalent to 15 km
Parallel Hybrid	A combustion engine placed parallel with an electric engine which can work independently, but typically works in a smart combination.
Serial hybrid	Combustion engine and electric engine are coupled
EV (electric vehicle)	There is no combustion engine or generator. There is only the battery (charging from external sources) and the electric engine

3.3.1 Innovation for Electric Cars is Needed in Different Technological Areas

Innovation and research in different technological areas are keys to ensuring the development of electric cars. In this section, we will describe the main technological areas where research and development is needed in order to accelerate the successful marketing and use of the electric car:

- Advanced battery engineering manufacturing and recycling: battery costs, performance, safety and size are absolutely critical for the success of the electric car. Capacitive storage and Nano technology offers a number of innovative properties: they are fast charging, reliable, have long-term cycling and a high power density [36]. Super capacitors based on CNT-Conductive paper show excellent performance and could be used to replace the metallic light-weight current collectors in Li-Ion batteries [37].
- Smart electricity grids: Successful manufacturing of electric cars will require electrical network development [38].
- Motor, control and power electronics.
- ICT and ITS (intelligent transportation systems) for smart cars

3.3.2 Electric Vehicle Cluster Status in Finland

The success of the electric car will offer several key benefits, such as long-term energy savings and efficiency, improvements in the trade balance, reduction in emissions and significant business opportunities. The European Union requires that 2005 emission levels be reduced by 16% by the year 2020, whereas for 2050 the reduction targets will be in the order of 60% to 80% [34]. This must be coupled with potential oil price rises. With this above scenario as background, the cluster for electric car development in Finland would include local vehicle manufacturers, mobile machinery manufacturers, component suppliers, and infrastructure development companies as well to support players. The following picture (Fig. 11) summarizes the list of players and the cluster's estimated turn out for 2010.
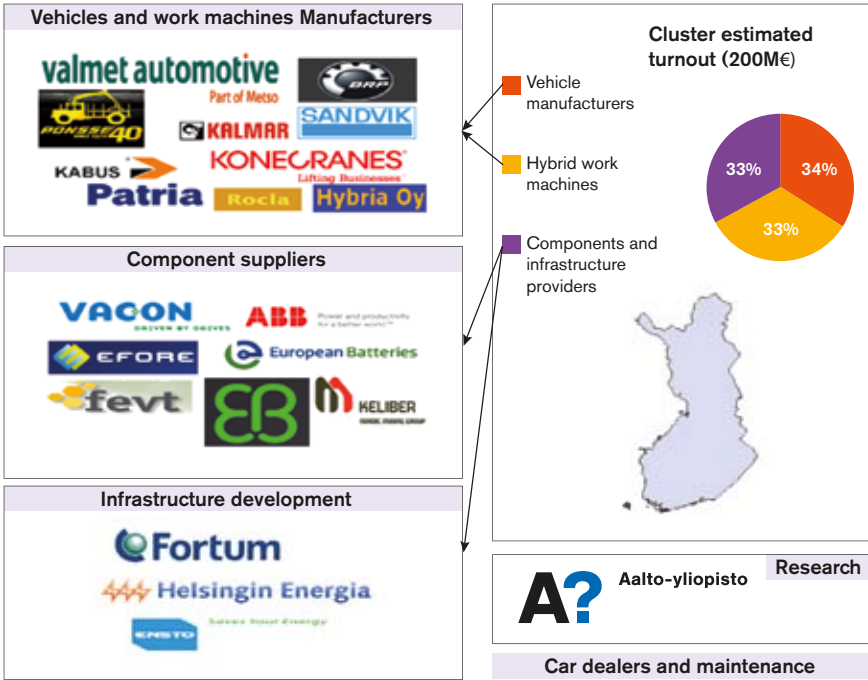

Figure 11. Sample snapshot of an EV cluster in Finland.

3.3.3 Electric Vehicle Cluster Development in Finland

According to several projections and scenarios for growth, the electrical vehicle can provide sustainable growth for Finland during at least the coming decade, as can be seen in Figure 12 [34].
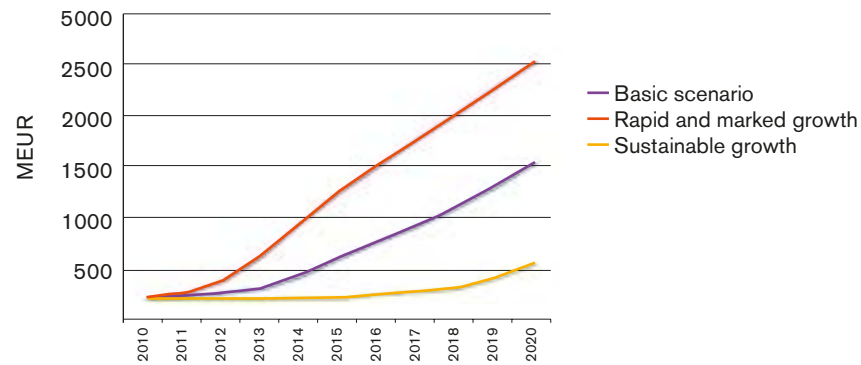
Figure 12. Scenarios and business potential for the EV in Finland [34].

This will in turn facilitate the creation of thousands of new jobs and improve the commercial balance for the country, acting as a catalyst for economic activity and facilitating a means to overcome the current economical crisis. According to the same study [34], this economic growth could be coupled with reduced dependency on foreign oil resources as well as a reduced amount of CO_2 emissions.

3.3.4 A Roadmap for the Internal Combustion Engine: Alternatives Lasting Until 2030 and Conclusions

As detailed in this chapter, environmental factors (green house emissions) and increasing oil prices will force a change in the private transportation system. We foresee a future in which several competing solutions will coexist and the development of technology will allow a transition towards more sustainable technologies. Governmental policies will be key transition facilitators, but these policies should be complemented with market-driven initiatives. A good example of such an initiative would be the solution proposed by the group Electric Cars - Now! [39]. Based on the open source approach, it aims to facilitate the replacement of an ICE car with an electric car while maximizing the re-use of the car's components. With this kind of approach, the largest constraint on electric cars (their high upfront cost) could be diminished thanks to the reutilization of the car's components. The following graphics (Fig. 13) depict the roadmap for these changes through the year 2030.
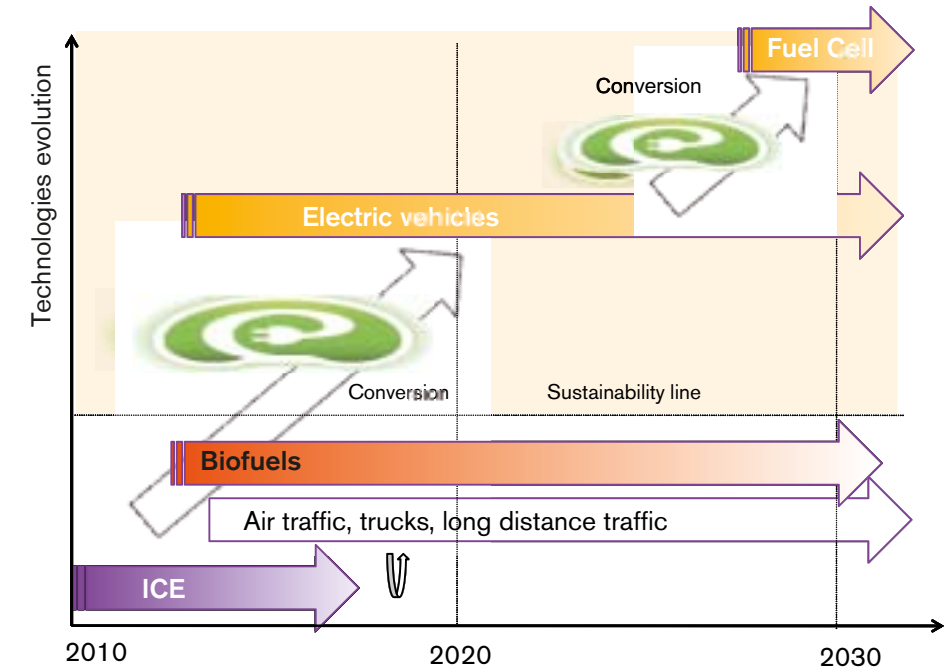

Figure 13. Roadmap until 2030 for vehicle technologies.

4 Policies and Strategies - a Roadmap to a Sustainable Helsinki Metropolitan Area

Technology, such as the electric vehicles and energy production topics discussed above, is an indispensible key factor in the construction of a sustainable metropolitan area. However, in addition to these technical considerations, we should not underestimate the influence of consumption patterns, policies and strategies.

4.1 Adopt Sustainability Thinking in the Perception of Life

The history of human civilization can be traced back thousands of years. Throughout this history, one constant idea has been to make our lives better, which is a strong driving force for the progress of human society. Over the past century, the rapid progress of human civilization has significantly improved the quality of life, making it easier and more convenient. At the same time, the planet's resources are being consumed rapidly; for example, between 1961 and 2001 the consumption of fossil fuels such as coal, gas and oil increased by almost 700 percent [41]. At the current rate natural resources are being used and waste is being produced, two planets will be required to meet all our needs by the 2030s [41]. Therefore, while we are reaping the rewards from having attained an advanced level of civilization, we should also think about our future and the next generations. The energy consumption per

capita in Finland is 7182 kg oil [42], whereas the average consumption per capital in the 27 European countries is 3694 kg oil [42]; thus, Finland ranks 26 out of the 27 countries that make up the EU. The high consumption is linked to the Finnish geographic and climatic environment and heavy industry. But, on the other hand, we should also look at our current energy consumption when seeking a reasonable solution for saving energy.

Thought is a guide to action. When the idea of sustainable development prevails in public, people will also have an awareness of how to adapt their daily behaviour to meet strategies for sustainable development. Ideological transformation and education are inseparable, and it is the responsibility of the government to promote environmental education and awareness as one of its strategies for sustainable development. For example, the government should set up a specific agency to be responsible for environmental education. With a highly sophisticated media, the ways of publicizing strategies and educating people about them are manifold. Television has been a traditional and effective tool for disseminating information. The agency can set up a television channel dedicated to providing all aspects of sustainable-development-related information so that people can obtain comprehensive information and an understanding of the concept and practice of sustainable development. In addition, some promotional videos and advertisements should be recorded and played on some other television channels and updated frequently. These videos would provide information closely related to real life, such as how to save energy at home and with transportation. Furthermore, some dedicated websites should be established to introduce the relative information; also, people can exchange information in web forums and at social networking sites. A specialized channel for the public to provide comments or suggestions as feedback to the policy making organization should be provided, which will help the government make more effective policies.

4.2 Policies in Sustainable Production and Consumption

Adopting sustainable thinking can influence people's daily behaviour and save energy. Industry, however, is the main consumer of the resources. In 2007, industry and construction consumed 53% of electricity in Finland, while households and agriculture consumed only 25% [43]. Thus, environmental regulations are indispensable for guiding both enterprises and individuals towards efficient and reasonable consumption of energy. Conventional opinion is that environmental regulation will restrict economic development, but recent studies have shown that good environmental regulations do not harm overall economic development; on the contrary, it will nourish a competitive economy which will the reduce costs of industry and business, create markets for environmental goods and services, and drive innovation [44].

In 2002, sustainable consumption and production (SCP) projects were proposed at the World Summit on Sustainable Development, which would result in a global framework for action. Sustainable consumption and production is defined as 'the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations' [45]. Sustainable consumption emphasizes different aspects in developing and developed countries. In developed countries, due to the excessive use of resources and waste, the emphasis lies on changing consumption patterns to reduce overall energy use [46]. Sustainable production aims to reduce the consumption of resources and waste in the production process and the final product. In 2005, the Finnish government issued an action plan for the SCP programme called 'Getting More and Better from less', which describes an overall vision for SCP [47]. The overall vision is to build an eco-efficient Finland. The measures [48] for the fields of production, construction and transportation are summarized in Table 6. These measures show that government's comprehensive and thoughtful consideration of the issue will help guide the behaviours of producer and consumer in daily production and life.

Table 6. Summarized measures for the fields of production, construction and transportation

Field	Measures
Production	Set up a material-efficiency service centre; reshape the taxation system; co-operation with related research institutes; research to prevent the generation of waste; constructive dialogues among multiple sectors; renew energy-saving agreements; new means to safeguard biodiversity
Construction	Improve material- and energy-efficiency; use economic or other incentives to encourage environmentally favourable renovation work; develop quality systems; develop new product-service concepts to encourage the adoption of environmentally-favourable solutions; promote the lowering of unnecessarily high room temperatures; promote the rental of existing holiday homes
Transportation	Increase the usage of public transportation and renewable fuels (construction of a metro link between Helsinki and Espoo, a rail link from Helsinki to Vantaa Airport); develop ticket charging systems based on travelled distance; promote the adoption of gas- or hydrogen-fuelled buses; develop favourable service concepts, including well-linked centres - tourist, cycling, others; promote cycling and walking, including an improved infrastructure for cycle paths and footpaths; service providers commit to energy-saving programs.

With scholars continuously conducting research on energy and environment, new conclusions are constantly being generated. Policy makers should also frequently update the information they provide about new policies for sustainable development. For example, recent research shows that lowering the speed limit for cars to 80 km/h can reduce CO_2 emissions on highways by 30% in the longer term [49]. Moreover, as the vehicles burn less fuel per kilometre at a lower speed and the lower speed results in longer travel time, lowering motorway speeds will also cause a shift from private cars to public transportation. Given this research conclusion, a new speed

limit system should be adopted in the Helsinki area to encourage the adaptation of public transportation. For example, Ring road I speed limits could be reduced from 80 km/h to 70 km/h or even 60 km/h to reduce emissions and noise. The effects on public transport and safety would be positive.

Market-based instruments are always very effective at changing consumer behaviour. A flexible charging system based on consumption can be very useful as well as a taxation control. Until January 2008, energy tax rates in Finland were raised by 9.8% on average [42]. For people living in blocks of flats, the price of electricity and water should be based on the household and not on the entire building. The price of electricity and water can be dynamically determined by the accumulated consumption in terms of each person in each household; the more electricity and water are consumed, the higher the cost per unit. The property fee for housing should also be decided based on sustainable levels; for example, this would include the energy used, whether it is renewable or not.

4.3 Policies to Promote the Use of Electric Vehicles

The research on electric vehicles has been conducted for years. Due to the pressure to reduce carbon dioxide emissions, the development of electric vehicles draws more and more attention not only from the automobile industry but also from the government. At the same time, governments are also introducing a series of plans to promote the usage of electric vehicles. In 2009, the government of Great Britain plans to allocate £250m towards promoting low-carbon transport over the next five years[1]. The money includes the installation of charging points and the infrastructure needed for electric cars, and up to £5,000 for the buyers of electric cars. The Finnish government is also drafting a policy to stimulate the shift to electric cars.

Taxation is always a very effective means of control. In order to encourage the usage of electric vehicles, the government should provide more favourable taxation rates for those who use electric cars. The tax for gasoline cars, hybrid cars and rechargeable hybrid cars in the year 2009 has been calculated and is shown in Table 7. Assume the car will be used for ten years, and each year the driving distance is 10,000 km, then from the calculation we can see that rechargeable hybrid cars only have a slightly favourable tax policy. However, if the driving distance is more than 10,000 km, the rechargeable hybrid cars will pay much less tax due to the much lower tax on electricity compared to fuel. Furthermore, there is still much room for the tax policy to favour electric vehicles. First, the government could provide a certain amount of money to electric car buyers to compensate them for the high purchase price. Second, currently the car purchase taxes related to carbon dioxide emissions range from 12.2% (when CO_2 emission is below 68 g/km) to 48.8%. The electric car tax is levied at a rate of

12.2%, but the CO_2 emissions of electric cars are much lower than 68 g/km; thus, if this index is decreased, then gasoline cars and hybrid cars will have a higher purchase tax rate and, in turn, electric car buyers will pay even less for this item. Vehicle tax is a tax payable annually and divided into two parts: basic tax and propulsion tax. In 2009, the basic tax was €127 a year for all fuel cars and €20 for all electric cars. Since 2010, the basic tax is collected according to CO_2 emissions as well, and it ranges from €20 to €605. A propulsion tax is levied on all vehicles except gas-fuelled cars with a fuel tax lower than that for gasoline. In this case, it is only applied to electric cars, which is proportional to the total mass of the car. Since the propulsion tax is a big part of the tax for electric cars, the government can reduce this tax by reducing the mass being calculated for each car or wave the taxes for the first couple of years after purchase. In addition to favourable taxation, the government might also adopt many other policies favourable to electric cars. For example, this might include giving electric cars priority for parking spaces or allow them to park free of charge in some parking areas [50].

Table 7. Tax calculation for Gasoline, Hybrid and Rechargeable hybrid cars in 2009 [50]

	Gasoline	Hybrid	Rechargeable hybrid
Trade Price 2009	20 000	30 000	40 000
Car Tax rate	22 %	17 %	12,2 %
Car purchase tax€	4500	5000	4880
Car tax € / year	450	500	488
Vehicle tax € / year	127	127	20
Propulsion Tax €			450
Fuel tax (VAT 22%) € / l	0,861	0,861	
Fuel consumption l/100 km	7,00	4,00	
Fuel excise taxes € / 10 000 km	602	344	
Electricity consumption kWh / 100 km			20
Electricity (22% VAT) € / kWh			0,01077
E-Taxes € / 10 000 km			21
tax revenue (10 000 km is equivalent to 1 year)	1180 €	971 €	980 €

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1   http://www.walesonline.co.uk/news/wales-news/2009/04/17/government-offers-5-000-incentive-to-encourage-electric-car-sales-91466-23404358/

5 Conclusions

Climate change is one of the most important challenges of the twenty-first century. As half of the world's population lives in urban areas, cities have an important role in climate change mitigation. The three largest sources of greenhouse gas emissions in the Helsinki Metropolitan Area are the **heating of buildings** (43%), **electric power consumption** (28%) and **transportation** (23%). In this chapter, we have discussed manners to reduce emissions in these areas. Figure 14 highlights our conclusions about some of the most important measures.

Energy production and usage are responsible for most of the emissions, thus they have a critical role in helping achieve emission reduction targets. In the Helsinki Metropolitan Area, the main energy production technology is the combined production of heat and power (CHP). Emissions can be reduced by increasing efficiency, carbon capture and storage, and switching the fuel source from coal and natural gas to renewable energy sources.

Computers and other entertainment devices, such as televisions and DVD players, consume much energy because they are most of the time on standby mode. There are two possible solutions for reducing the electricity consumed by these devices: the first is to unplug them when they are not in use and the second is to buy only devices with as low energy consumption as possible. Potential savings on energy and lighting can be achieved in buildings by adopting zero energy house concepts and using efficient light sources such as LEDs.

The government has taken active steps to make policies and strategies to nourish an overall environmentally-favourable situation in which individuals, companies and public sectors adopt sustainability thinking when it comes to making choices about lifestyle, production and consumption. Furthermore, politicians could devote more effort to leading the whole community towards shaping a sustainable Helsinki Metropolitan Area.

For example, light traffic could be increased to make a sustainable and lively city area. Cycling facilities could be improved by prioritizing the maintenance of cycling paths, especially in wintertime. When planning new traffic routes and roads, there should be good quality design and a focus on light traffic, and not just a focus on passenger cars. Cycling could be promoted in many ways, and basic rules of the road should be taught already in primary school. Favouring commuter cycling also directly benefits bus and car traffic since it helps reduce car traffic during rush hours.
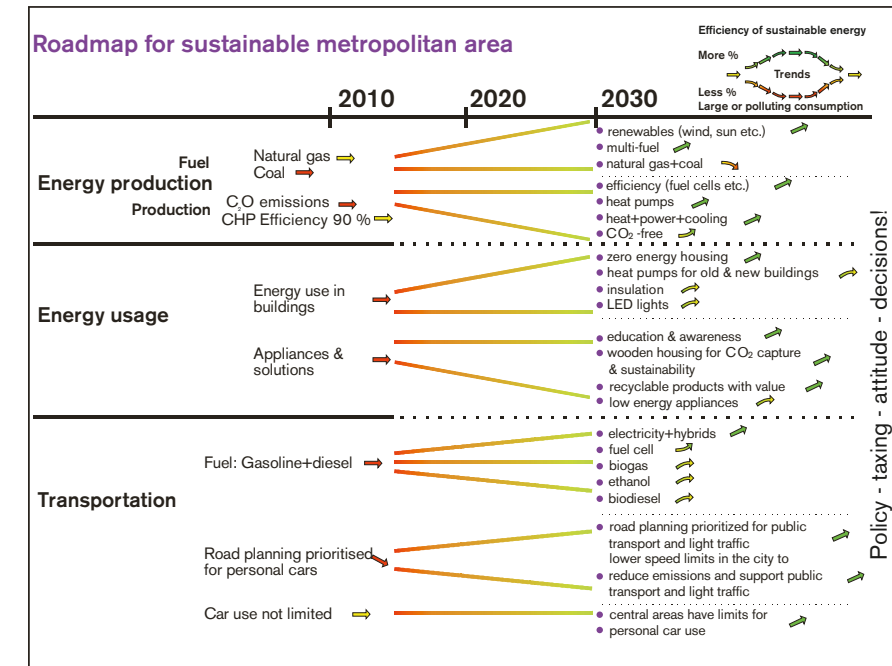

Figure 14. Roadmap for a more sustainable metropolitan area

References

1. YTV. Progress in Helsinki Metropolitan Area climate work, review January-June 2009. (2009), 8 p.
2. YTV. Pääkaupunkiseudun ilmastostrategia 2030 (The Helsinki Metropolitan Area climate strategy to the year 2030). Painoprisma Oy, 2007, 98 p.
3. Vantaan Energia, http://www.vantaanenergia.fi/
4. Helsingin Energia, http://www.helen.fi/
5. Fortum, http://www.fortum.fi/
6. Wikipedia: Cogeneration, http://en.wikipedia.org/wiki/Cogeneration
7. VTT: Energy use Visions and technology opportunities in Finland. Edita (2007), 234 p. ISN 978-951-37-4742-8.
8. Wikipedia: Energy development, http://en.wikipedia.org/wiki/Energy_source
9. MacKay, D.JC: Sustainable energy - without the hot air. UIT Cambridge Ltd. (2009), 368 p. ISBN 978-0-9544529-3-3.
10. VTT: Energy visions 2050 Yhteenveto. VTT (2009), 31 p.
11. Anderson, S., Newell, R. Prospects for carbon capture and storage technologies. Annu. Rev. Environ. Resour. 2004, 29:109-42.
12. Fortum: Fortum and climate change 2009. (2009) 32 p.
13. Vantaan Energia: Yhteiskuntavastuuraportti 2008. (2009) 60 p.
14. Energy vision 2050. VTT.EDITA 2009, ISBN 978-951-37-5595-9
15. Directive 2002/91/EC of the European Parliament and the Council of 16 December on the energy performance of buildings, ASnc
16. VTT: energy efficient solutions, the IEA5 concept house, www.vtt.fi, accessed, 2010-05-18
17. City of Helsinki Urban Facts, Statistics and Information Service www.hel.fi/tietokeskus
18. World Energy Outlook 2009 Energy Sector Implications Post-Copenhagen. Laura Pozzi.
19. Public Transport – an Attractive Alternative; Ministry of Transport and Communications, Plans and Strategies 4/2002. ISBN: 951-723-472-4.

20. Helsinki Metropolitan Area Climate Strategy to the Year 2030, by YTV Helsinki Metropolitan Area Council
21. Sources: Finavia –VRGroup Ltd; Helsinki City Transport; Finnish Road Administration; Finnish Maritime Administration; Finavia
22. CityCarClub: http://www.citycarclub.com/
23. Environment and Natural Resources 2008, Statistics Finland, Helsinki 2008
24. Eurostat. News release 126/2006
25. LIPASTO is a calculation system for traffic exhaust emissions and energy consumption in Finland. http://lipasto.vtt.fi
26. Liikenteen kehitys Helsingissä vuonna 2009, Helsingin kaupunki, kaupunkisuunnitteluvirasto, [online] www.hel.fi/ksv
27. Pääkaupunkiseudun jalankulun ja pyöräilyn strategiasuunnitelma, YTV, Hanna Strömmer, Linea konsultit Oy, 2006, Pääkaupunkiseudun julkaisusarja PJS Nro B 2006:23, Sivuja 66, ISSN 0357-5470, ISBN 951-798-619-X, Suomi, (Strategy for cycling and pedestrian traffic in metropolitan area)
28. Talvipyöräily 2003: Laajuus, motiivit ja esteet, terveysvaikutukset (winter cycling) [online] http://tiny.cc/nobym/
29. Helsingin pyöräilyn kaksinkertaistamisohjelma 2004, [online] http://tinyurl.com/nkl5bz
30. Bicycle account 2 0 0 8, Published in August 2009, City of Copenhagen
31. www.copenhagenize.com,   blog, date 18 August 2009
32. Electric Two-Wheelers in China: Analysis of Environmental, Safety, and Mobility Impacts, Christopher Robin Cherry, Doctoral dissertation, 2007, University of California, Berkeley
33. Pictures from three different bicycle manufacturers: Bakfiets (www.bakfiets.nl), Kangaroo (www.kangaroobike.com) and Helkama (www.helkamavelox.fi)
34. Sähköajoneuvot Suomessa – selvitys. Biomery OY
35. Regional Economic Impacts of Electric Drive Vehicles and Technologies: Case Study of the Greater Cleveland Area. Electric power research institute. http://my.epri.com/portal/server.pt?
36. Nano-structured Materials for Electrical. Energy and Power Storage. George Grunner. UCLA University.
37. Highly conductive paper for energy-storage devices. Departments of aMaterials Science and Engineering and Electrical Engineering, Stanford University, Stanford, CA 94305
38. http://www.betterplace.com/solution/charging/
39. http://ecars-now.wikidot.com/
40. Publisher and enquiries City of Helsinki Urban Facts, Statistics and Information Service. www.hel.fi/tietokeskus
41. Living Planet Report 2008. Gland, Swiezerland : WWF–World Wide Fund For Nature (formerly World Wildlife Fund), October 2008.
42. 2008 Environment policy review. European Communities, 2009.
43. Statistics Finland. [Online] http://www.stat.fi/til/ekul/2007/ekul_2007_2008-12-12_kuv_009_en.html.
44. The Contribution of Good Environmental Regulation to Competitiveness. Network of Heads of European Environment Protection Agencies, November 2005.
45. Report of the Symposium on Sustainable Consumption. Oslo : Norwegian Ministry of the Environment, 1994.
46. Programme, United Nations Environment. Mainstreaming sustainable consumption and production and resource efficiency into development. 2009.
47. Szlezak, Jozsef. National Sustainable Consumption and Production (SCP) Strategies in the EU. European Topic Centre on Resource and Waste Management, 10 Mar 2008.
48. The committee on sustainable consumption and production, Finland. Getting more and better from less- Proposals for Finland's national programme to promote sustainable consumption and production. June 2005.
49. Matthijs Otten, Huib van Essen. Why slower is better-Pilot study on the climate gains of motorway speed reduction. s.l. : Delft, February 2010.
50. Sähköajoneuvot Suomessa – selvitys. Biomeri Oy, 2009.
51. MOMO Project: http://www.momo-cs.eu/

2.4   Changing Life Style and New Luxury

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Abstract

In this chapter, we present the study of changing lifestyles and their impact on the meaning of luxury. We connect the change to trends in the deployment of energy sources and changing mindsets on a global scale. We show how changes in sustainable behaviours regarding energy use, consumption and work change the lifestyles and create an emphasis on new values such as aesthetics, family time and harmony. Connecting sustainability to changes in mindsets and values with broadened luxury

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dimensions means new horizons to production, energy, lifestyles and new consumption in virtual worlds. In the chapter we present a model to evaluate these new luxury dimensions. The model we use is a development tool for unpacking the hidden assumptions and opening the horizon to enhanced dimensions for sustainable luxury.

Keywords: sustainability**,** luxury, energy, values, mindset, virtual consumption

1 Introduction

Luxury is about wants, not needs. In affluent societies, luxury is accepted. But, in a future world where ecological resources are scarce, what should the role of luxury be? Should all forms of luxury be discouraged by society, or can some forms even be beneficial as we make our way towards a sustainable society? We believe there are opportunities for sustainable luxury. Many people agree that electric cars could play a role in a sustainable future energy system (see, for example, [1]), but developing cars which are suitable for the mass market is very expensive. Tesla Motors is approaching this in an interesting way: first, they are producing an electric sports car, the Tesla Roadster, which is sold as a luxury product to affluent customers; later, an affordable electric car, the Tesla Sedan, will be introduced on the mass market. The development of environmentally-friendly technology is being funded by luxury consumption. Sustainability is typically perceived as being about avoiding vicious circles and creating options which are less harmful to the environment. But this is not the best we can do. For example, when a tree grows and dies, it does not leave behind a contaminated area, nor does it leave the area as it was before; rather, it creates habitat for new trees and cooperating species, such as undergrowth, fungi and squirrels. Nature creates a virtuous circle which improves with every generation. Imagine products that would do the same! If these products are too expensive for regular consumption, perhaps they can find a niche in the luxury segment.

In this paper, we review how luxury has been perceived traditionally and how it might develop in the future. We identify factors which we believe have a key role for the future of luxury. Our first factor is sustainability – there is only one planet, but if everyone would consume at the current North American level five planets would be required [2]. Our second factor is mindset – this includes the particular kinds of glasses or lenses through which we look at the world and use as a reference point for taking action. We face a difficult challenge in creating a fair and sustainable world. If we approach the problem with the wrong mindset, we will tend to end up with bad solutions. For example, with fixed mindsets we predict the future in overly technical terms and underestimate the systemic nature of the world. This results in solutions which create more problems. For example, we might grow biofuel crops because of energy problems, but then end up with food security issues and environmental consequences related to intense use of fertilizer and pesticides, which are more severe

than the energy problems were in the first place. Our third factor is economic development – the middle class in emerging countries is growing very rapidly, but also the number of very poor is increasing. Is there room for luxury markets there as well? Our fourth factor is digitalization – information technology is improving rapidly and plays a central role in solving many sustainability problems. The fifth and final factor is societal values – individualism tends to grow with economic growth and, in individualistic societies, the attitude towards luxury is positive. We combine the factors into a single luxury model which can be used for discovering opportunities for new luxury products and services. Finally, we present possible development directions for luxury towards the year 2030 and conclude by suggesting some possible outcomes based on the model. For instance, concerning the increasing number of very poor in the world, we consider how this group of people could be a major target group for future luxury items. Or, could the affluent societies make a big shift towards the consumption of intangible luxury items? Who will determine the level of luxury to be pursued? Will it be the producers or the users, or will it be co-created by them both?

We define luxury as something the consumer believes is pleasant to have or consume, but which is not necessary to have for either social or other reasons. Luxury items are typically widely desired by consumers, and can therefore be used for showing social status. They are also typically highly refined according to current standards.

2 State of the Art of the Luxury Concept

In this section, we elaborate on the luxury concept, present some problems with the current state of the luxury concept and present diverse factors affecting the meaning of the luxury concept.

2.1 What is Luxury?

Luxury is classically defined as the opposite of necessity. One easily identifies luxury with very expensive products or services, for instance yachts, private jets or butlers, but luxury exists at many economic levels. In contrast, how should we define necessity? Consider the following story:

Asim is a man in his twenties who comes from a middle-class family in a developing country. He has access to electricity, basic transportation, running water, a house made of concrete, and facilities such as a nearby kiosk, and some entertainment, for instance a television and a cassette player. His parents originate from the hilly region of the country which lacks electricity and where houses are made of traditional materials – brick and cement. They grew up with a three-to-four-hour walk to the nearest road in a community with a traditional lifestyle. Asim's parents migrated to a suburban area, but his grandparents are still living in the hilly region, running a local business. When Asim is on vacation, he goes to visit his grandparents. There life is

hard compared to his modern life in the suburban area. He has to use an open toilet instead of a modern hygienic toilet, collect water from the river or pump it from a well by hand, use kerosene lamps and not electric lighting, postal letters rather than land-line phones, and so on. Despite this lack of comfort, Asim finds happiness in being close to nature. He enjoys eating fresh fruit and swimming in the open streams of water. The fresh vegetables, running streams of water, and closeness to nature are a luxury for him.

By contrast, Asim's grandfather has spent most of his life in the village, where modern services do not exist. He has lived without artificial light most of his life; he has seldom used a telephone and does not have a television set at home. Because he grows his own food, he has never bought food from the market. In old age, he also moves to the suburban area. He finds city living luxurious, with a smokeless stove, smokeless and sufficient light from electric light bulbs, and effortless transport by motorcycle.

This story illustrates how the perception of luxury is not universal but varies from person to person and is affected by personal history. Also, many of the things perceived as luxurious by Asim's grandfather are considered necessities for people in the suburbs. True, they like to go to the countryside, but if someone suggested removing sanitation from their suburban dwellings, they would be less than happy. We can observe that the luxury concept is quite complicated and we present shortly the motivation for our definition that is based mainly on Berry [3], and also Hilton [4] and Kemp [5].

Throughout history, different definitions of necessity and luxury have been proposed. Plato states that: '*the first and greatest of necessities is food, which is the condition of life and existence... The second is a dwelling, and the third clothing and the like*' (The Republic, book 2). But, already in this discussion, we can see that it is not easy to separate necessity and luxury. People become accustomed to things they are used to having, so-called comforts, and consider them necessities even though they are completely unnecessary for survival. In Plato's discussion, the dialogue is interrupted by Glaucon, who calls a city of pure necessities a *'city of pigs'*, and calls for *'the ordinary conveniences of life. People who are to be comfortable are accustomed to lie on sofas, and dine off tables, and they should have sauces and sweets in the modern style.'* (The Republic, book 2)

The ancient Greeks and, later, Romans thought of luxury mainly as a *moral* decision. They perceived of luxury as a threat to society. The ancient Greeks argued that luxury makes a person *'soft'* and undermines his virtue. The Greeks and the Romans considered softness a dangerous thing because they feared it would make men bad warriors, which would lead to a weak nation. Later Christians also took a negative attitude towards luxury, but for a different reason. They considered luxury to be based on *'unnatural'* needs.

In the 1700s, foreign trade became an important source of power. At first, luxury was accepted reluctantly. Berry quotes Bernard Mandeville arguing: '*if you wish power*

and plenty then you must also have luxury'. Later, liberal thinkers argued for an increasingly positive view of luxury. Adam Smith stated that individual greed is necessary to stimulate the economy. As a result, in contemporary western thought luxury status is not a moral consideration. Most people in western society see the will of the individual as a source of good things and do not see virtue as serving only the collective.

How can we then separate luxury and necessity within this view? Perhaps, the most dominant way, in purely economical terms, is to use the concept of Income Elasticity of Demand (IED). It measures how much a person would consume a given product if her or his income increases? So, if you would make 1000 EUR extra, would you spend it on bread and butter or champagne and entertainment? If IED > 1, it means that when income doubles, consumption of the product more than doubles, and the product is considered a luxury product; if $0 \le IED \le 1$ then the product is a necessity; and, if IED < 0 the product is deemed an 'inferior product' which people avoid if they can afford something else. Luxury can also be measured by price elasticity: How much less would you buy something if its price doubled? Presumably, you would need to buy just as many necessities, but the luxury items could be omitted, so their consumption would drop[3, 4].

The downside of this economic definition is that it tells us very little about what luxury is like. We can say for a given product in a marketplace whether it's a luxury product or not, but we can say nothing about a new or hypothetical product. Berry states that a requirement for luxury is that the consumer believes that possessing the product is pleasing, rather than believing it relieves an unpleasant state [4]. What this means is that certain products cannot be luxury. Berry gives the example of health care. If a person is sick (an unpleasant state), relieving it is not something considered a luxury, but a necessity. Of course, there is luxury health care, but it refers not to the actual care, but more to the level of comfort at the hospital. As a further example, one can consider sugar. When first introduced, sugar was a luxury for the upper class in Europe, but then it became a part of mass consumption. Why? The reason is that sugar appealed not only to the upper class, but also to the whole population. In Berry's terminology, they found it 'pleasing'.

To a large degree, luxury consumption is primarily driven by universal wants; individuals desire things which are pleasant, and these wants are mostly the same between individuals. If many individuals want the same things, but they are scarce, only the most wealthy or powerful ones will be able to have those things. This leads us to conspicuous consumption, which means consuming to show social status. It has been an important motivation for luxury consumption throughout history, so much so that in medieval England there were even laws that specified which kinds of clothes members of a certain social class were allowed to wear.

Luxury status also depends on the specific consumer. For example, the mayor of a city might need to ride around in a Rolls-Royce so that other mayors will pay their due respect. This is then a case of instrumental necessity; the Rolls Royce is necessary to reach a certain goal. Similarly, a yacht may be luxury item, but the trailer needed to transport it is not.

Luxury items are highly refined products when compared to what is available on the market. Sugar was initially a luxury product, but now it is treated more like a resource, and perhaps very fine chocolate might have the corresponding luxury status. As technology progresses, so does the level of refinement. Notions of what constitutes luxury status become transformed as well.

Luxury is an inherently political topic, because societies seem to operate on a principle that providing necessity for all is more important than providing luxury for a few [3,5]. But as we have seen, necessity is a concept that develops over time. Berry argues that societies have a shared standard for what is considered a necessity. For example, in Finland there have been attempts to make broadband Internet a right. This means that Finnish society considers broadband Internet a necessity, not a luxury. However, when Simon Kemp asked people to rate the luxuriousness of various items, there was plenty of individual variation for certain items, even people mostly agreed [5]. This makes luxury related politics difficult.

2.2 Factors Affecting the Meaning of Luxury

We have seen that luxury and necessity are dynamic concepts which have developed and been contested throughout history. We integrate these insights into one model where different factors affect what is perceived as a luxury.

Figure 1. Diverse factors that affect luxury status

In Fig.1, we see five categories of factors which can affect the definition of luxury. They affect the availability of items, how pleasing individuals perceive them to be, how society views them, and how they affect the current level of refinement.

1 Economic factors: for example, GDP, supply and demand relationship, personal income
2 Technological factors: for example, ICT, production technology, logistics.
3 Environmental factors: for example, natural resources, energy
4 Psychological factors: for example, mindset, motivation
5 Social factors: for example, culture, customs, lifestyle, law, policy

In this chapter, we will focus on a few specific aspects of these factors. Regarding economic factors, we will look at the development of luxury markets in the emerging world, with China as an example. Regarding the technological factors, we will look at growing Internet use. For environmental factors, we will look mainly at ecological-sustainability issues. For psychological and social factors, we will look at mindset and values.

2.3 Sustainability and Luxury

Rising oil prices and the global financial crisis has led to a historical point of transition, raising questions about an energy revolution. Yet, there are unnerving challenges in front of us. Tackling climate change and enhancing energy security require a massive decarbonization of the energy systems. Figure 2 below shows just how significant the change must be. We need to break the historical link between CO_2 emission and economic output [6]. This necessitates changes to our currently unsustainable lifestyles. We also see that this is mainly something concerning wealthy nations. As seen in the Figure 2 below, wealthy countries account for the greatest per capita share of consumption and the largest ecological footprints. According to an estimate by the World Wildlife Fund (WWF), three planets would be required were everyone to adopt the same consumption patterns and lifestyle as the average citizen from the United Kingdom and five planets were they to live like the average North American [2].
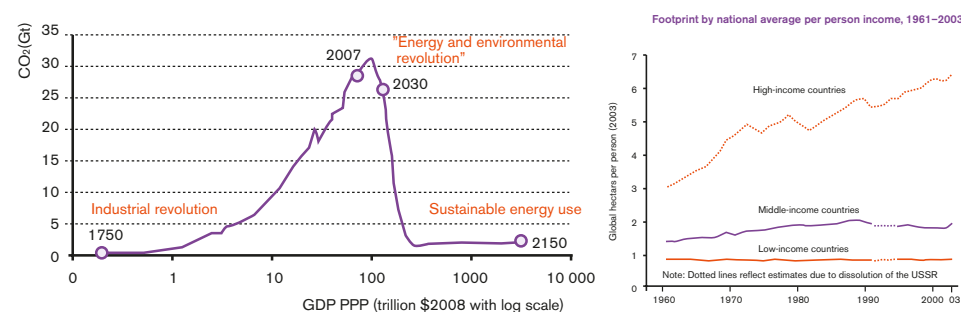
Figure 2. Left: The required reduction in CO2 and its relation to GDP over time [6]. Right: Ecological footprint of different countries according to their levels of affluence. [7]

Sustainability is defined as a way of thinking and living and it involves making conscious decisions about how our actions (how and what we consume) impact the environment, the community, the people around us and the people around the world. A report by the IUCN explains that humanity must take no more from nature than nature can replenish. The concept has been elaborated by stating that this in turn means adopting lifestyles and development paths that respect and work within nature's limits. It can be done without rejecting the many benefits that modern technology has brought, provided that technology also works within those limits. The World Commission on Environment and Development (WCED) defines sustainability as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' [8].

Luxury is traditionally perceived as the opposite of sustainability. In an article called 'Is sustainable luxury an oxymoron?', Martin C. Petersen defines sustainable luxury as an illogical pairing of words only a marketing executive could love (or tolerate) [9]. On the other hand, Josh Dorfamn, CEO of Vivai, says that equating sustainability with luxury is like equating technology with luxury. He explains this relationship by reminding us that thirty years ago Bill Gates was still tinkering in a garage, Gordon Moore was still refining his law, and personal technology devices were a luxury which few could afford. Today, items like PCs are a commodity and, while some technology is expensive, much of it is affordable. With this explanation, he claims that sustainably-designed products are moving down the same path. Today's best sustainably-designed consumers products are out of reach for many, but that will change [10]. Many technologies, perhaps especially ICT, have a huge potential for sustainability, for example through replacing paper, video conferencing, Internet banking, eBooks and so on.

Luxury is associated with pleasure and individualism and sustainable development is synonymous with ethics, collectivity and restraint. So, it is a bigger challenge for luxury makers to find their market while still advocating sustainability. However, Francois-Henri Pinault, chairman and CEO of the luxury group PPR, identifies a common value they share: the timelessness of lasting worth and the passing on of knowledge as well as the protection of natural resources.

An appealing definition of sustainable luxury has been provided by Tengku Zatashah [11], an international corporate communications manager at L'Oreal: innovation, respect, ethics, the reorganization of processes such as ethical way of making jewellery, or electric powered cars, human respect and reasonable consumption. The term that needs to be noted here is *'reasonable consumption'*. This point is important because, in most cases, the word luxury has been associated with words like such things as waste, unnecessary, where the meaning of all these word reflects consuming more than necessary for maintaining a lifestyle.

According to Christian Blanckaert, executive vice president of Hermes, now is a difficult time to talk about luxury when the world is in a deep economic and environmental crisis. Therefore, there is a need to change the future and to change the word luxury. Luxury not only refers to selling high-end products to keep a store afloat, but also to something deeper and more lasting. Consumers are slowly becoming aware of what they are consuming and they are seeking more information regarding the product they are buying. Therefore, undoubtedly luxury brands must find a niche for their market where sustainability is valued. Moreover, luxury brands have a margin and mandate to do this. World Wildlife Fund UK calls upon the luxury industry to bring to life a new definition of luxury, with deeper values expressed through social and environmental excellence. The role of business can be described in three different dimensions: namely, innovation, choice influencing and choice editing [12].

Innovation applies to the business processes for the development of new and improved products which do not compromise on quality, price or performance in the market. Consumers are increasingly aware of the products they are consuming. There has been a major change in the luxury paradigm emerging from major challenges to social dynamics. Innovation can be made in eco-efficiency by creating more values and less impact. Other areas where business can bring innovation are in product innovation and design.

One very interesting and novel example of innovation can be found in the concept known as green design. The architect William McDonough practices green architecture on a massive scale and believes that green design can prevent environmental disaster. In reality, it is not only able to prevent the disaster but also make ecology better while driving economic growth. This green design idea is called cradle-to-cradle design, and it considers the full life cycle of a product, from its creation with sustainable materials to a recycled afterlife [13]. This concept of cradle-to-cradle design can also be used for producing new luxury goods. In such a case, luxury can be used positively to improve sustainability.

Choice influencing pertains to the way in which business or any actor other than the consumer, such as government or NGOs, seeks to influence consumer preferences in the direction of more sustainable consumption. One strategy which can be used for choice influencing is marketing or advertising. Marketing, which has the ability to facilitate both innovation and choice influencing, plays a vital role in decoupling material values from consumer values, thus promoting sustainable consumption. However, the challenge is to reduce the gap between consumer demand

and innovation. As an example, it took decades for Toyota to fully convince consumers to purchase their hybrid cars since the technology was first introduced. Another example of a successful brand which seeks to influence consumer consumption is NOKIA. Nokia users can download information about their products' environmental attributes, including material use, energy consumption, and recycling, and third-party content, including hints and tips on choosing a sustainable lifestyle. Among its many influential programs, NOKIA's recycling program is responsible for collecting not only old unused mobile phones via its 5000 collection points in 85 countries, but also for developing a series of campaigns and activities through which it aims to provide information to its consumer about why, how and where to recycle their old mobile phones and phone accessories.

Lastly, choice editing is about controlling the direct impacts of consumption. Businesses can edit choice by controlling the elements of their supply chain or by eliminating product components which pose a risk to the environment and human well-being. This can be carried out in partnership with other actors in society, such as government, consumers, policymakers, retailers and activists. However, the biggest challenge is transparency. In order to win consumer trust, there should be a common, robust set of indicators and a transparent way of reporting product performance in economy environment and society. Tight cooperation and understanding is essential in choice editing, as sustainable consumption can be perceived differently by different actors.

2.4 Digitalization

Information and Communication Technologies (ICT), such as the Internet and Web2.0, have a far-reaching effect on nearly every aspect of society, including the economy, culture and life. Luxury brands also cannot be immune to the digitalization trend. Traditionally, the innate attributes of luxury brands are scarcity and exclusivity. However, these attributes are changing now largely because of the Internet. The world's top luxury brands, like Louis Vuitton and Hermes, have now established an online presence. There are also many online luxury shops, like Net-A-Porter (www.net-a-porter.com), and many online private luxury clubs, like ASmallworld.com [14]. There are some reasons why traditional brick-and-mortar luxury brands have gone digital:

1 The pressure from counterfeits and competitors [15]
2 The development of the Internet, Web2.0 and the mobile Internet
3 The rise of virtual consumption [16]
4 A new generation of tech-savvy consumers
5 To take advantage of the long-tail sales theory to gain more profit
6 To improve brand awareness and recognition

2.5 Mindset

Mindset is our reference point. Our behaviour in any sector is based on attitudes and the stances we take towards the world. Mindset is our guide or roadmap in the intangible and tangible world; it offers certain kinds of glasses or lenses through which we look at the world and a reference point to take action. Mindset affects how we interpret things in economic terms, how effective we are at creating more sustainable ways to use energy for producing products and services. So mindsets are valuable guides and simplifications, but they might be hindrances as well – especially when we like to predict the future. With fixed mindsets [17] we tend to predict the future in more technical terms and underestimate the systemic nature of the world. Innovations call us to look at the world with fresh eyes, to form a more holistic picture of it, to see the unifying concepts and find out-of-the-box solutions to everyday challenges on both a small and a global scale. This approach calls for a mindset which is more complex [18] and which evolves according to the challenges we face.

2.6 Economic Factors

Undoubtedly, luxury is closely related with the status of economic development. Although not all expensive commodities are luxuries, by its nature luxury usually sets a premium in terms of price. The greater the number of rich people (middle-class or upper-class) in a market, the more prosperous the luxury markets will be. That is why luxury markets prosper in Japan, the US, Europe and China. For example, with a high annual GDP growth in the past decade, China has prospered, and the current numbers for the Chinese middle class have reached 23% of the total population, which is more than the total population of the US [19]. More and more Chinese consumers have the power to buy luxury goods. Actually, according to the World Luxury Association statistics report, by January of 2009 China accounted for 25% of global luxury market and had surpassed the US to become the second largest luxury-consuming country after Japan. By the year 2015, China will account for 32% of the global luxury market and surpass Japan to become the largest luxury-consuming country. When the economy experiences a downturn, luxury sales will encounter setbacks. For example, the economic crisis of September 2008 witnessed different degrees of setbacks for different luxury markets.

With economic development, more and more people have the power to buy certain kinds of luxury items. This causes another phenomenon, the democratization of luxury or mass luxury. In mature markets, like the US, people can even buy such luxury items as Chanel cosmetics and LV bags in supermarkets. It's hard to judge people's fortune only by their purchasing behaviour in these markets. They may be private entrepreneurs, white-collar workers or even high school students. On the other hand, luxury companies like the Mercedes Benz Company have different product series to satisfy the needs of different market segments like high-end and middle-to-low-end consumers.

2.7 Luxury Consumption and Cultures

Luxury is deeply connected to cultural values and norms as well as to the economic structure of society. Culture is understood here as a collective mindset of a certain group of people. Culture is made up of common symbols, heroes and rituals. It is influenced by outside forces like nature or forces of man. Outside forces affect societal norms through such things as technology, history, or urbanization; it is not always direct. Societal norms are the value systems of major groups of people, which are formed through symbols, like words, gestures and general behaviour. Heroes are important people, whether dead or alive, within a certain culture. And rituals are actions engaged in by a group of people, whether the actions are legislated by those in power or whether they are just normative. All these factors form values which are commonly shared by a certain group of people. This entire complex system is in constant change and the picture below attempts to explain how it functions [20].

Ingelhart and Weltzel have drawn a cultural map of the world which shows that cultural values are closely correlated according to geography, the political system, religion and language. The data is based on the information of the World Value Survey Organization, which has surveyed the changes in socio-cultural and political values in the world from 1981 to 2007 [21]. In the map, the Y-axis describes traditional versus secular-rational values and the X-axis stands for survival versus self-expression values. When the traditional values are stronger (lower position on the map), the religion and mythical ideals of a sacred nation or other community are strong. When the rational ideal of a secular community are stronger, then the community is positioned higher on the map. This polarity is about the ideals of the community.

Values are relatively stable, but constantly and slowly changing. Ronald F. Ingelhart shows that, in Western Europe, the younger generations seem to move towards self-expression and in the direction of secular and rational values [22]. The figure below shows the trend happening in the long-term perspective. We can see how the locations of some of the countries on the value map have been changed during the last 25 years. Some of them follow the general trend, but there are variations too [23].
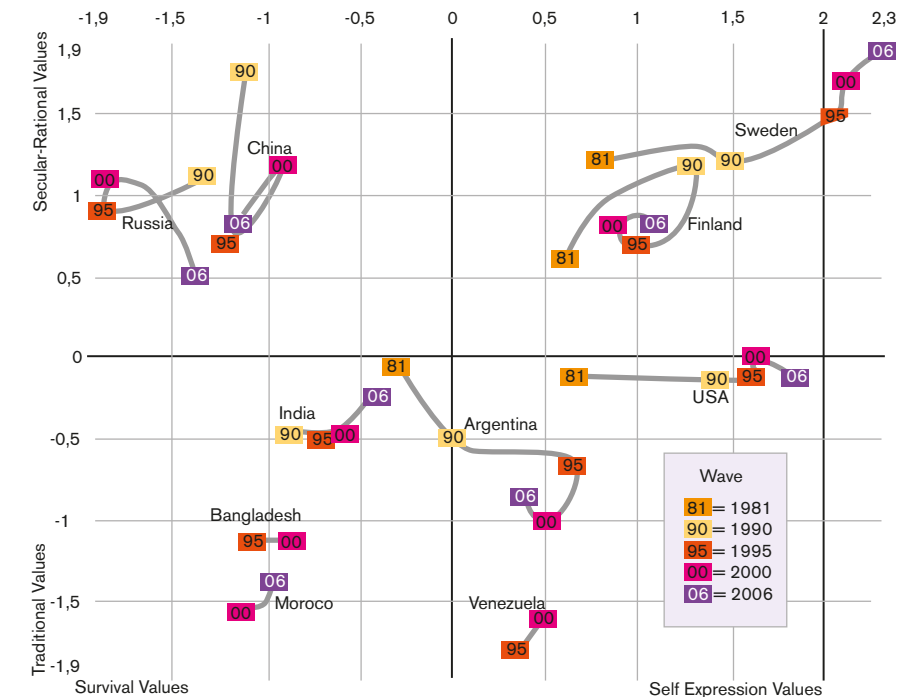

Figure 3. We have chosen a few countries to show the tendency for values to slowly change in the direction of being more liberal and more self-expressive as younger generations seem to assimilate more liberal values than their parents. The further down the country is located on the map, the more the traditional values are valued there, and the further to the right the country is located on the map, the more self-expression values are valued there.

Finland (along with a few other countries) seems not to behave according to the trend. Finland is located in the upper right quarter of the map. As we can see, Finland moved in the direction of traditional and survival values after the year 1990. Finland then suffered greatly because of the global depression of the early 1990s and we can see how it very quickly turned in the direction of survival and traditional values. However, the economic growth in the later part of the 1990s was remarkable, the values turned in the direction of survival. They slowly turned back towards the "normal" direction as late as the first half of the first decade of the twenty-first century. We can also see that the political atmosphere turned more towards family and other traditional value directions.

The trend seems to be that each generation of people is more secularist and more towards the side of self-expression values, and each generation is more educated than their parents. The cultures situated on the self-expression value side believe that the affluence and welfare of the individual are the most important factors because they give you freedom to put your personal desires in the front, in contrast to the survival

dimension, where it seems that people are more collective and prioritize needs of the community. We use China as an example to show the cultural changes and their effect on luxury consumption. We choose China because: 1) Chinese culture is very different from Western culture; and, 2) the increasing importance of China in the global luxury market. Wong et al. [24] compare the cultural differences between Eastern Confucian societies (like China and Japan) and Western societies. In Europe and United States the values are more in the direction of self-expression or individualism than in China. For Western societies, those can be the main motivator for consuming luxury goods. In contrast, in Eastern countries the social aspects have been considered as a driving force. For example, Western consumers will place emphasis on the private meanings of their possessions and hedonistic experience, while East Asian consumers will place more emphasis on the public meanings of their possessions and be more likely to acquire their luxury goods through gift exchange [24]. Doctoroff introduces the differences between Chinese Confucianism and Western individualism and buyer motivation from the perspective of middle-class, empowered women and the younger generation in detail [25]. In a more recent report by the KPMG company on the status of luxury goods in China [26], we can see the new changes in the Chinese luxury-consumption culture. We summarize these changes in Table 1.

Table 1. Changes in China's luxury-consumption culture

Luxury	Traditional	New
Motivation	Social aspects like social circle influences	Individual aspects like personal taste, reward, etc.
Attitudes towards luxury brands and luxury owners	More negative. Luxury is extravagance. Luxury owner is corrupt	More positive. Luxury demonstrates my success and taste. Luxury owner is successful.
Judging luxury quality	Judge luxury by its name and origin	Judge by quality, brand loyalty declines.
Main channels for a luxury items	Gift exchange	Self-reward
Luxury consumers	Traditional social elites, like stars, government senior officers	Rising middle class, empowered women, and the younger generation

As an emerging luxury market, the motivation for luxury consumption in China has also changed from conspicuous consumption to gradually rational consumption [27, 28]. For example, in the early stage of economic development, Chinese consumers bought luxury items just to show off their wealth or gain social status, even without knowing the cultural background and connotation of the luxury brands. Now Chinese consumers have more awareness and recognition of luxury brands and pay more attention to the match between luxury brands and their taste and personality.

3 A Model to Evaluate Luxury Dimensions

In this chapter, we draw the factors together to form a single view, which we call the luxury model, in order to make the complexity more concrete and show the deep systemic interconnectedness of the above-mentioned factors. The model is based on Laszlo & al. [29], Jacobs [30], Wong and Ahuvia [24] and Lehdonvirta [16] among others. The luxury model allows us to analyze the system as a whole and helps us to discover possible underlying contradictory assumptions and false interpretations. The model can also be used as a tool for working groups in different arenas, such as in strategy, marketing, material economics, or in the research and development of new luxury products, services and in creating life-cycle upgrades to existing ones. The model allows us to approach the target from different viewpoints. The user of the model can create a separate scenarios taking different factor selections into account and stressing the factors by using different values. The model works as a self-evaluation tool, making the underlying assumptions and values more transparent. The model is powerful in explaining the resistance to change, as well as in opening up paths to collaboration in multi-stakeholder undertakings in various arenas in business and communal services.

Cultural values vary remarkably according to national cultures, but they also vary within a society. Can we compare, for example, the poor rural immigrants in a metropolis of China and the super rich who live prosperously and surf on the wave of skyrocketing economic growth to Northern countries which provide affluence for all of their citizens? Could grasping the underlying combination of factors help identify the clusters or niches? We believe in a reality in which the environment is interpreted and constructed with the participants, in which resources are available, and in which the intangible values and norms include the collective and individual mindsets of the participants. The luxury model reflects these selected underlying factors and their systemic interconnectedness and impact on the whole.

3.1 Factors in the Model

We chose the factors based on the interdisciplinary, multicultural and multigenerational view. We believe that these factors, based on the arguments made in previous chapters, form interdependencies which have been underestimated, oversimplified or unconscious in previous literature and business models. Even highly regarded experts in industry and academia usually pose future scenarios without combining changes in lifestyles, sustainability, energy and underlying mindsets within the same picture. Next, we describe the factors in more detail. Each of the factors contains three levels: in the first level the factor is fixed, in the middle there are more opportunities, and in the third level the transformation is evident. The economic factor is the exception to this logic. The model is presented in Figure 4. Its factors and levels are presented in table 2.
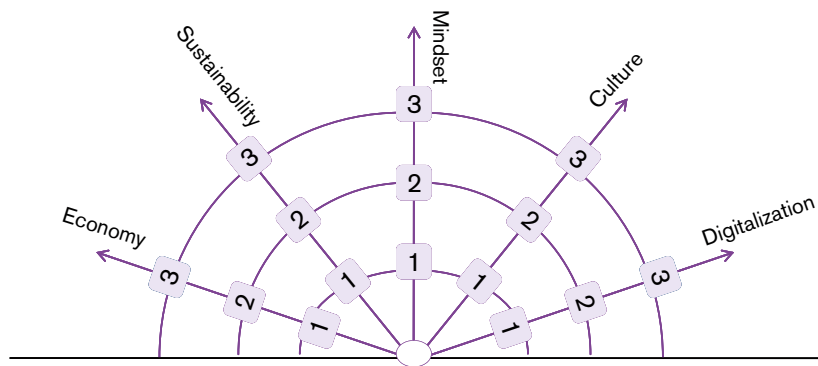
Figure 4. The dimensional model of opportunities for luxury

Table 2. The factors and stages of the model.

Factors/ Scores(1-3)	Fixed score 1	More opportunities score 2	Transformation score 3
Sustainability	Sustainability is defined in economic terms from the individual point of view. Fossil energy sources, together with nuclear energy, are the dominant energy sources. Energy consumption is decided by the cost and easy access to supplies of the energy sources.	Energy is connected to other users' points of view. For example, smart grids and renewable energy sources are preferred. The economy, material flows and energy are connected.	Sustainability is understood as combining ecological, social and human sustainability. For instance, the values and assumptions at the workplace are considered as important factors for well-being. Sustainability is created at the beginning of any product or service.
Mindset	In the egocentric mindset, the worldview is fixed, deterministic and explains the future based on past history. The mindset assumes the scarcity of resources and competition (win-lose) as unquestionable facts.	Homo-centric people are concerned with the wealth of humankind. There are possibilities for win/win games and cooperation. However, ecological issues are considered to be superficial, the human race is considered the king of the world.	The eco-centric mindset is more reflective and relational. The mindset allows for self-reflection and understanding complexities and allows for evaluating the ecological systemic whole.
Culture This factor demonstrates the norms and values of different cultures and groups.	People are more in the traditional value mode, in which religion and superstition are quite visible.	Self-expression and secularism are highlighted. People in such societies can fulfil their individual goals which are not accepted traditionally and others might down-source their lifestyles.	The cultural factors are reflected as possible opportunities, but people choose their attitudes respecting individual, collective and desired outcomes based, rather, on geographic, occupational or subculture values.
Economy This factor is based on societies or economic groups wealthy.	The economic standard is poor. People cannot afford food, education or other requirements for a good standard of living.	The economic standard allows for economic wealth, education and transportation. At this stage are the current Western countries, for instance.	Consumption of goods and services well beyond needs which are considered affluent, but exclusive in economic terms.
Digitalization / technology This factor describes the development and impact of digital technology. This factor is important, as it reflects the distance between the tangible and intangible dimension.	Technology is considered its own separate domain. Experts develop the technology and other people use it. The technology itself, together with resources and the authorities, determine the development of the technology, not the users.	User needs are understood as an important factor. The technology is created to fulfil the users' needs and preferences; however, development is still pushing the technology onto the lives of the people and is not designed for the people. Because of better tools for networking, people have more choice.	Designers have engaged in a deep understanding of human, societal and aesthetic knowledge and consider them to be important for the whole. Human consciousness and digital technology have merged into one more systemic whole.

3.2 The Structure of the Model

The model allows for evaluating the factors on 1-3 scale. The model is not normative by its very nature. Rather, the factors are continuums and the small scores on the factors show the fixed nature of the factor and the larger number shows the growth of opportunities and a new level with increased complexity. In certain situations the small number might be better for achieving a certain goal. It totally depends on what it is you want to achieve.

4 Development to Year 2030

In this chapter, we create scenarios for the new luxury conceptions and give hypotheses regarding future changes to the concept of luxury based on the luxury model presented in the previous chapter.

4.1 Opportunities for the Luxury Conception in 2030

The model can be applied to describe the traditional conception of luxury and show undiscovered opportunities for new luxury products or services. Figure 5 shows our view on how traditional luxury could be characterized in the model.
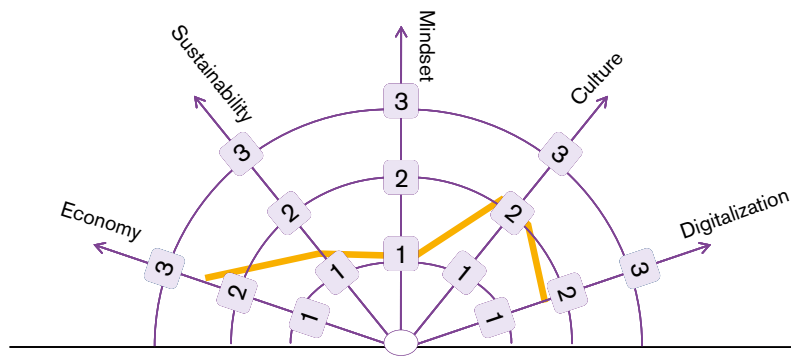
Figure 5. Traditional luxury conception

The traditional conception of luxury is strongly tied to the economically very affluent category: stage 3 in the economic factor and, for the middle class, stage 2, aspiring to wealth. We illustrate this by assigning the value 2.5 to the Economy factor. The luxury model shows that there is room to expand the luxury category further towards the middle class and even to the very poor of the world.

The sustainability factor for traditional luxury is slightly over 1. Luxury brands want to be perceived as sustainable and might, for example, use better materials than other products, but their track record is not very good [31]. There are plenty of opportunities for creating luxury items which are truly sustainable. Moving to stage 2 is, to a large extent, a question of technology; for example, the smart grid could easily be sold as a feature of a new building. Stage 3 is more difficult to package, but existing attempt is found in eco-city concepts where different aspects of sustainability are combined into a whole. Despite the fact that these concepts represent a move in the right direction, many more things need to be considered for level 3 in order to avoid ecologically sound but, for example, culturally unsuitable solutions.

The mindset of traditional luxury is dominated by egocentric views. There is plenty of space to move in more homo-centric and eco-centric directions. Certain charities which promote people values or ecological values could perhaps be considered existing 'luxury products' in that category.

Luxury has promoted individualization and, therefore, we assign it to stage 2 in culture. Moving up the culture dimension could mean incorporating values that people aspire to into the products. As Seth Godin has said, *'The market for something to believe in is infinite.'*. However, it should also be possible to move down the culture dimension and build products with very strong cultural references. Luxury products are often associated with a long tradition of the craft and a certain geographical region. In combination with sustainability, we can observe the current trends favouring locally grown food. Perhaps, we could have products which are designed for a specific region, rather than the mass market, or a specific segment, such as a cell phone for skateboarders, or clothing stores for computer enthusiasts. The former might be very durable and have a good video camera, and the latter might feature computerized

body measurements, minimizing the need to try on clothes, and an automatic personalized recommendation system, similar to the one at Amazon.com.

Luxury products are not especially digitalized because their still perceive the digital, online world as a separate entity. Products which use online content could be considered to be at stage 2. There are many such products, but few of them are luxury products. Perhaps the Apple iPod, with its easy integration to online music, could qualify. Stage 3 is challenging, since it would imply that a large part of the value is from co-creation activity, presumably online. This could be something like being able to customize a luxury car to one's own needs, while at the same time sharing the design with others so that they could develop it further. This kind of service would clearly be valuable, but what would happen to the brand identity, and how would manufacturing be organized?

We have now looked at the factors in isolation, but the true power of the model is when the factors are combined. For example, if we consider products with sustainability at stage 3 and with digitalization also at stage 3, we notice many opportunities. Digital replacements for tangible products are often better from a sustainability perspective as well. Also, the systemic sustainability at stage 3 can be very challenging to manage, and digital technology would help a great deal here. Co-creation of these technologies would make them available to a larger population, and they could more easily be adapted to local conditions. What might this mean in practice? Perhaps we want to get rid of our old couch. The garbage collection system then knows the manufacturer, the materials used, and so on. It automatically finds someone who wants it, either for themselves or perhaps for people in a less affluent area, or a manufacturer who will use its material in new products. Either way, all we need to do is carry the couch outside to the 'garbage'. We will even get a small compensation for our contribution. What does this have to do with luxury? Perhaps it is first implemented as a luxury feature of some neighbourhood.

4.2 Future Scenarios for 2030

The world's population is expected to grow from 6.5 billion in 2005 to 8 billion in 2030. More than 97 percent of this growth will take place in developing countries like China and India. Although the recent global economic crisis will have some degree of influence in the short- and medium-term on economic performance, the basic long-term economic boom trends are fairly impervious to all but the most severe and sustained shocks. The output of the global economy will rise from $35 trillion in 2005 to $72 trillion (at constant market exchange rates and prices) in 2030. Developing countries' share in global output will increase from about 23% in 2005 to 31% in 2030. By 2030, fully 1.2 billion people in developing countries —15 per cent of the world's population—will belong to the global middle class, up from 400 million in 2005 [32-34]. The meaning of these trends for luxury items is that in the future luxury will become more evenly distributed geographically.

As both population and the economy grow, it is obvious that global consumption will rise, including the consumption of luxury goods. If the current trend continues, we will face irreversible and disastrous environmental consequences. However, as everyone is being made aware, though it is a slow process, we find it reasonable to envision a future where we will not only be living but living well and within the sustainable limits of the planet. In this part of chapter, we will explore what must happen in the future in order to guarantee the existence of our planet.

Changes in the mindset of people and societies might have a major impact on the future by the year 2030. We have no other choice other than live in this complex world. Rather, the option is whether we are able to mould and let our mindsets grow or mature to understand more complexities instead of denying or oversimplifying them. Our frame of mind and the ability to accept the complexity of the world around us might be more important factors than we have considered traditionally. The bias of the focus tends to be towards the technical issues (technical here being defined as technology and processes) and controllable factors rather than increasing our adaptive capacity [17]. This has been a natural tendency, as technology can be objectified and studied as a separate scientific domain and the smooth running of business has favoured such a short-sighted timeframe. However, people do interact with their environment, they take an active stance and participate in both defining the concepts and terms, and they take indirect and direct actions and produce new innovations around customs, values and technologies.

We illustrate the change in mindset here by practical examples of 1) ego-centric, 2) homo-centric or people-centred and 3) eco-centric mindsets. The dominant mindset for the current time has been the *ego*-centric worldview [29]. The success of the outcomes of the behaviour has been defined by the wealth, freedom and independence of individuals or by other words in *ego*-logical terms. In practice, this means that society has been considered successful and wealthy if particular individuals have been successful and able to create a prosperous life for themselves, and not by stressing social values or a sense of community as criteria for success. Table 3 illustrates the possible evolution towards a people-centred or homo-centric mindset which values co-operation and win-win solutions needed in a network society and the third stage of a growth mindset or *eco*-centric mindset, which means the capacity to participate and contribute to the systemic whole.

Table 3. Mindset changes towards 2030

Ethical stance	Success criteria and Beliefs	Reference point
Egoistic	If I get rich, all is fine! Competition, since resources are limited. Win/loose game.	Individual
Homo-centric	If me and you get rich! Win/Win game. Exploiting the resources.	Group
Eco-centric	If all the people and the globe are sustained! Human and ecological systems view. Respecting and sustaining the intangible and tangible resources. Win/evolve as a systematic whole.	People and the ecological system together are equally important. Awareness

In ethical terms, this means that the dominant ethic, the ego-centric ethic, is fading. People's mindsets are becoming more diverse. In some subgroups, people understand that win-win agreements are more productive in deeply connected networked systems. Furthermore, the ethical stances evolve by understanding that we are deeply connected to the environment, the planet and other species. If money has been the means for assessing success and power in recent times, in the future a high ethical stance is a value unto itself. The green movement no longer needs to force companies towards sustainability, but companies respect the interconnected whole and take sustainability into account from the beginning of their planning activities and carry the concept into the whole life cycle of the products and services. This really is a landmark for mindset change.

By 2030, this mindset shift will not be comprehensive, but there will be more mindset shifts towards the second and third levels in different subgroups. For example, in the Western world the overall age of the population will rise. There will be more individuals who have all the material goods they need already. The creative class [35] will search for values which fulfil their sense of creativity and this might mean an opportunity for a change in mindset. Luxury products which carry the value basis of more ecological goods and services might look lucrative for these subgroups. There are also the new generations, who will come to value more social relations and sustainable values and, as a consequence, might like luxury services which tend to reflect their mindset. There is special opportunity for a change in mindset in the fastest growing societies in Asia. In Asia, the fastest growing societies might take advantage of the changes in the Western world and speed up the change towards more sustainable views. If the deep traditional cultural values of these societies could be carried into the latest trends in technology, there might be opportunity for a remarkable mindset shift towards a more meaningful and human future.

ICT technology and virtual worlds will pioneer the change towards a shift in mindset. This trend has already started as open-source technology and co-creational forms are taken as standards for the industry. This tradition will be adopted by more traditional industry sectors, like energy and communal services for instance.

In summary, traditional luxury product will be transformed towards services instead of tangible products. This can be done by adding-up the services into the traditional products. There will also be product categories which carry the created luxury products and services into virtual worlds. The traditional role of consuming might be changed towards more co-creational modes, containing both producers and users, instead of the current dichotomous producer-consumer division of labour, as people increasingly understand their impact and response as consumers to the products and services produced. The brands of the products may carry the social value created towards more humanitarian needs. This form of capital cannot be valued in traditional monetary terms or brand values, but will constitute a new form of capital affecting the monetary value of the firms and products.

5 Discussion and Conclusion

We have elaborated on the factors affecting luxury conception and created a model illustrating the new luxury dimensions. The model makes the hidden assumptions and false interpretations transparent and open for discussion. The model can be used to help a group of innovators or any organization developers or single individuals to self analyze the current state of the luxury concept and study the possible future locations on the dimensional luxury model as well as related luxury definitions. The model reveals the new dimensions of the luxury concept and, therefore, is useful for any undertaking targeting luxury markets. Sustainable luxury in particular can offer interesting positions. New luxury is not necessarily expensive or difficult to obtain, but it is of high quality and fulfils the needs of changing lifestyles.

As already discussed in section 2.7, 'Luxury Consumption and Cultures', a general trend seems to be that each generation is both more secularist and moves more in the direction of self expression than their parents, and as general awareness of, for example, sustainability and ethical matters continue to grow, we can make an assumption that in the production of luxury products the environment must be taken into account. We know that different cultures and their values are not going to change radically within the next 20 years. Global warming is an outside force which most probably will radically affect our behaviour and, thus, also our values. Value changes will then be a force, which, for its part, will affect societies and cultures.

As described earlier, new target groups can be determined with the help of the new luxury model. It will be a bit more challenging figuring out how to map the model onto the 'real world'. To find a target group with the desired values, one suggestion is to exploit, for example, the information provided by the World Value Survey. It will be somewhat more difficult to find sub-groups within the countries, but the survey's web page also gives some tools for doing it.

We predicted that by the year 2030 there will be changes in the global mindset, as we believe that mindset will have a major impact in accordance with sustainability, the economy, energy and values. At the core of our predictions is the possibility of increasing the ability to grasp increased complexities and systemic interconnectedness by fostering a more growth-oriented or eco-centric mindset. This mindset will be able to reflect on the impact of certain aspects of behaviour and use these contradictory forces and complexities as a launching pad for innovations for the future. We have wanted to look at the changing lifestyles as opportunities for a more sustainable future. This may be an unusual approach, but we believe it is better to pose the question in a new manner and find alternative views rather than to stagnate at an unsustainable status quo.

References

1. MacKay, D.: Sustainable Energy - Without Hot Air: UIT (2008)
2. World Wildlife Fund (WWF): Living Planet Report 2008 (2008)
3. Berry, C.: The Idea of Luxury: Cambridge University Press (1994)
4. Hilton, M., The Legacy of Luxury. Journal of Consumer Culture: 4(1), pp. 101–123 (2004)
5. Kemp, S.: Perceiving luxury and necessity: Journal of Economic Psychology 19(5) pp. 591–606 (1998)
6. Tanaka, N.: Uncertainty and Opportunity in a Changing Energy Landscape: MIT Energy Conference, http://www.iea.org/speech/2010/tanaka/MIT.pdf (2010)
7. University of British Columbia (UBC): What is Sustainability? http://leap.ubc.ca/what-is-sustainability/ (2010)
8. United Nations World Commission on Environment and Development (WCED): Our Common Future: Oxford (1987)
9. Pedersen, M.C.: Is Sustainable Luxury An Oxymoron? [cited 2010 May 24] http://www.metropolismag.com/story/20060515/is-sustainable-luxury-an-oxymoron (2006)
10. Dorfman, J.: The Sustainable Luxury Myth. [cited 2010 May 24], http://www.worldchanging.com/archives/004407.html (2006)
11. Zatashah, T.: Is sustainable luxury sustainable?: The Egde Malaysia, http://www.theedgemalaysia.com/component/content/article/16265.html (2009)
12. World Business Council for Sustainable Development (WBSCD): Sustainable consumption facts and trends, from business perspective: The Business Role Focus   Area, (2008)
13. McDonough, W., Braungart, M.: Cradle to Cradle/ Remaking the way we make things: North Point Press (2002)
14. Tungate, M.: Luxury World: The past, present and future of luxury brands: Kogan Page, (2009)
15. Phillips, T., Knockoff: The Deadly Trade in Counterfeit Goods: The True Story of the World's Fastest Growing Crime Wave: Kogan Page, (2007)
16. Lehdonvirta, V.: Virtual Consumption. Series A-11. Doctoral Dissertation. Turku School of Economics: Turku (2009)
17. Dweck, C.: Mindset: The New Psychology of Success: Random House   Macmillan, New York (2007)
18. Keagan, R. and Lahey, L.: Immunity of change. How to overcome it and unlock   potential in Yourself and Your Organization: Harvard Business Press. Boston, Masschusetts (2009)
19. Lu, X.Y.: Social structure of contemporary China: Social Sciences Academic Press. (2010)
20. Hofstede G.: Culture's consequences comparing values, behaviors, institutions, and organizations across nations: Thousand Oaks (Calif.) Sage Publications, cop. (2001)
21. World Values Survey, www.worldvaluessurvey.org
22. Inglehart, R. F.: Changing Values Among Western Publics from 1970 to 2006. West European Politics Vol. 31 nos 1–2, 130–146, January-March 2008 (2008)
23. Inglehart, R. F.: National-level Value scores on Traditional/Secular-rational values and Survival/Self-expression values for all available surveys (wave 1=1981, 2=1990,3=1995,4=2000, 5=2006), Institute for Social Research. http://margaux.grandvinum.se/SebTest/wvs/SebTest/wvs/articles/folder_published/article_base_111/files/wvs_value_scores.doc (2006)
24. Wong, N.Y., Ahuvia A.C.: Personal Taste and Family Face: Luxury Consumption in Confucian and Western Societies. Psychology & Marketing, 15(5), p. 423–441. (1998)

25. Doctoroff, T.: Billions Selling To The New Chinese Consumer: New York: Palgrave Macmillan (2005)
26. KPMG: Luxury brands in China (2007)
27. Ernst&Young, China: The new wave of luxury: EYGM Limited (2005)
28 Zhou, W., Wu Y.: Luxury Goods Consumption in China: Marketing Research, 2007. 1 (2007)
29. Lazslo, A., Laszlo, K.C., Dunsky, H.: Redefining Success: Designing Systemic Sustainable Strategies: Systems Research and Behavioral Science, DOI: 10.1002/sres.982 (2009)
30. Jacobs, D.: Adding Values. The Cultural Side of Innovation: ArtEZ Press and d'jonge Hond. Arnheim. Netherlands (2007)
31. Bendel, J., Kleanthous A.: Deeper Luxury (2007)
32. The World Bank: Global Economic Prospects: Commodities at the Crossroads. Washington (2009)
33. The World Bank: Global Economic Prospects: Technology Diffusion in the Developing World: Washington (2008)
34. The World Bank: Global Economic Prospects: Managing the Next Wave of Globalization: Washington (2007)
35. Florida, R.: The Rise of the Creative Class: Basic Books. New York (2002)

3
Appendices

1 The Bit Bang People

Neuvo Yrjö – Bit Bang and MIDE leader
Professor and Research Director. Ph.D. in Electrical Engineering from Cornell University. He is former CTO of Nokia Corporation. He has been National Research professor at Academy of Finland and visiting professor at University of California, Santa Barbara.

Artimo Annika – MIDE Admin Assistant, MA from Helsinki University, major Nordic languages minors in communication sciences and social psychology. Studied also the vocational teacher education. Worked before TKK with for ex. product PR.

Ylönen Sami – MIDE Project Manager.
Dr.Tech., in automation technology from Helsinki University of Technology.

Tutors

Laukkanen Seppo – A PhD researcher with close to two decades of executive experience at Nokia. In the Tekes funded Innoboard research project he explores the act of innovating as a combination of self organizing and orchestrated effort. The underlying goal of the research is to identify leadership and governance practices to foster entrepreneurial ways of working and to improve their effectiveness in innovating.

Nangini Cathy – A postdoctoral scientist at TKK´s Brain Research Unit. University background is in physics, with an MSc in geophysics and a PhD in medical biophysics. Scientific interests also includes education and media communication, written newspaper articles in both Canada and the US, and also produced two television pieces for the Discovery Channel during a summer internship.

Pitkänen Olli – D.Sc. in Information Technolgy, Master of Laws, senior researcher and group leader at TKK, Helsinki Institute for Information Technology HIIT, Adjunct Professor at HSE. Currently working on social media services, user-driven open innovations, IPR and privacy issues.

Temmes Armi – Dr Agr. For., Project Director at HSE, Organisations and Management. Experience on paper industry, industrial R&D, environmental and corporate responsibility management. Research interest in strategic decision-making.

Participants

Amogpai Ater - TKK / Master´s thesis of electrical engineering, postgraduate student in the Department of Electronics, subject LED lightning. Studied light sources and energy and lightning and energy use in Sudan.

Chen Xi – TKK / Studied measuring precision instruments for master´s degree in China. Doctoral student at the Department of Computer Science, research interest in the image and information retrieval.

Medyna Galina – TKK / Master´s thesis in engineering from the University of Toulon France, currently doctoral student in the fields of engineering design with a strong predominance in environmental aspects.

Omidiora Michael – TKK / Doctoral student in the Electrical Engineering Department. Research focuses on the protection of power system network from environmental disturbances.

Gaur Sachin – TKK / Master's degree programme in Security and Mobile Computing, a researcher in social media at the Data Communications Software lab, studied new platforms, like Facebook applications, iPhone app store, also the research focus of doctoral studies. Worked in past as a software engineer in Adobe Systems on a world class product and C.E.R.N. Geneva.

Faisal Ali – TKK / Computer engineer, finished master´s studies in Edinburgh. Current research interest in untangling the molecular network of human being by developing probablistic models towards finding better cures for diseased patients. Also been involved with the university and the regional Microsoft center on Systems biology in Trento Italy.

Paajanen Olli – TKK / MSc Tech., degree programme in Forest Products technology, minor in strategy and international business. Doctoral studies in wood product technology, research topic is plywood manufacturing process, specifically veneer drying. Works also as a teacher at the Department of Forest Products Technology.

Graff Daniel – HSE / MBA honors degree from HSE with a concentration in General Management & Strategy. Currently working within the International Design Business Management (IDBM) platform, an Aalto initiative to develop a multidisciplinary master program in 2010. Research interest in the impact of culture on functionally diverse teams.

Halme Jukka – TKK / PhD researcher in the Laboratory of Automation Technology. Doctoral theses focuses on different methods and strategies of hybrid and electric driveline control and energy optimization: "Power bus control and energy optimization in series hybrid and electric vehicles".

Jin Zhihua – TKK / Msc. Tech, works as a researcher in the Data Communications Software research group, Department of Computer Science and Engineering. Research direction is adaptive transport service. Currently working in the FI-SHOK3 project which concentrates on energy efficient data communication.

Karilainen Antti – TKK / PhD student in the Faculty Graduate School of Electronics and Communications Engineering. Research topic "Electromagnetic composite material and their applications".

Kohonen Oskar – TKK / PhD student in Computer Science at the Adaptive Informatics Research Centre. Research focuses on developing machine learning methods for discovering structure in large corpora of natural language texts. Worked also as a software developer at the web retailer Verkkokauppa.com.

Kouva Sonja – TKK / Master´s from the Laboratory of Industrial Chemistry from the TKK, interest in post graduate studies is to combine traditional catalysis research with modern computational techniques.

Li Ming – TKK / MSc from the School of Computer Science and Technology, Beijing University of Posts and Telecommunications. PhD candidate in th Department of Computer Science and Engineering, research interest focuses on network architecture, network security, mobile service composition, etc.

Lozano Victor – TKK / International MBA and Engineer MSc with international corporate exposure northern and southern Europe and USA in technical and management positions in software industry. Currently works at Nokia as a manager in planning and forecasting.

Poudyal Aditya – TKK / Electrical engineer, postgraduate studies at the Department of Energy Technology are in the field of energy economics, focus on the rural electrification theme. Has studied the rural electrification also in the field in Nepal.

Ramkumar Pavan – TKK / Bachelor's degree in electrical engineering from the Indian Institute of Technology, master's degree in Bioinformatics from the TKK. Currently works as a researcher at the Brain research in developing and applying advanced computational modeling and signal analysis methods for neuroimaging data.

Rusanen Aira – TaiK / Master of Science in Economics, doctoral thesis topic focuses on future research (eDelfoi) techniques in creating scenarios on the the S-theories based on cases an interviews in Finland and in Japan. Worked also for media YLE and MTV3 and teached and planned business courses in TaiK.

Saarelainen Tanja – TKK / Master´s degree in mechanical engineering, doctoral student in product development and foundry engineering. The work has lately concentrated on improving competitiveness of Finnish foundry industry and environmental issues in foundries.

Salminen Pauli – TKK / Master´s thesis on the development of the Continuously Variable Transmission, currently working at the Department of Machine Design. Work is related to small power plants utilizing solid oxide fuel cell (SOFC) -technology.

Tang Tingan – TKK / PhD student in SoberIT lab of the Computer Science Department. Research direction is about user-driven innovation, community of innovation, social computing etc. Taken part in many projects on innovation themes such as OIBS (Open Innovation Banking System) and OtaSizzle.

Tenhunen Juhani – TaiK / Master of Arts, working as project manager and researcher at Taik's Media Lab. Doctoral studies in the same department. Research topic, New Practices in New Media Project Management, is related to innovative organizations and innovation management topics.

Turunen Marja – TKK / PhD student, master´s degree both in psychology and in business administration, MBA. Research interest is in the area of social innovations and in special leveraging human potential in strategy and innovation processes. Gained experience in HR and ICT positions incompanies like Rautaruukki Oyj, Icon Medialab Oy and HSE Executive Education Oy.

Wang Le – TKK / MSc Tech., Degree Programme in Communications Engineering. Doctoral student in the Department of Communications and Networking. One of work tasks has been as a technical support engineer in ZyXEL Communication Corp located in Wuxi, China mainland was to setup relationships and cooperate with engineers and customers from different countries.

2 Bit Bang Guest Lecturers
Fall 2009–Spring 2010

Aaltonen Mika, Head and Chairman of the Board StraX, BIT Business Innovation Technology, "The Third Lens – Appropriate Sense-making and Effective Decision-making"

Eloranta Jorma, President and CEO of Metso, "Energy Innovations, Case Metso"

Englund Marja, Project Manager at Fortum Ltd., "Smart Grids"

Forsén Kjell, President and CEO of Vaisala

Gädda Lars, Research Director of Forestcluster, "Opportunities for Renewal in Forest Industry"

Hu Zhongliang, PhD and Bit Bang 1 student academic year 2008–2009, "How to Survive Bit Bang"

Hurri Pasi, President and CEO of BaseN corporation

Jacobs Dany, Professor of Industrial Dynamics and Innovation at the University of Amsterdam, Seminar on "The Cultural Side of Innovation"

Korhonen Antti, Vice President of DigiEcoCity Ltd., "DigiEcoCity Projects in China"

Laukkanen Seppo, PhD researcher and Bit Bang 2 tutor, "Innovation –What is it and How Does it Matter?"

Lemström Thomas, CEO of Horizon Wellness Ltd., "An Entrepreneur´s View on the Finnish Innovation System"

Lund Peter, Professor at the Department of Applied Physics at Aalto University School of Science and Technology, "Sustainable Development"

Lundström Petra, CTO of Fortum Ltd., "Challenges of the Energy Systems and Possible Solutions"

Nangini Cathy, postdoctoral scientist at Aalto University´s Brain Research Unit and tutor at Bit Bang 2, "How to Make a Good Presentation"

Pasanen Jari, Vice President of Sitra, Strategic Renewal

Suomela Jussi, Dr. and Project Manager of MIDE project HybLab at Aalto University School of Science and Technology, "Hybrid Electric Machines"

Temmes Armi, Dr. Agr.For. and Bit Bang 2 tutor, "Wicked Problems"

Vanjoki Anssi, Executive Vice President of Nokia

3 Course Literature

Florida, Richard (2002). The Rise of the Creative Class. Basic Books. New York.

Jacobs, Dany (2007). Adding Values - The Cultural Side of Innovation. ArTEZ press and d´jonge Hond. Arnhem.

Naisbitt, John & Doris (2010). China´s Megatrends: The 8 Pillars of a New Society. Harper Collins. New York.

MacKay, David JC (2009). Sustainable Energy – Without the Hot Air. UIT Cambridge.

Shell Energy Scenarios to 2050, www.shell.com/scenarios.

4 Study Program in Shanghai
February 28th – March 5th 2010

Saturday February 27th 2010

15:00 Meeting at the airport (Terminal 2, "Finnair lobby")

17:10 AY 057 Helsinki - Shanghai
Hotel in Shanghai:
Hilton Hotel Shanghai
250 Hua Shan Road, Shanghai
Tel: +86-21-6248 0000
shanghai.hilton.com

Sunday February 28th 2010 (Background info group D, report group A)

07:30 Arrival in Shanghai by AY057
Pick up by bus with 'Finpro' sign

10:00 Check in Hilton Shanghai

12:00 Get together
Venue: Magnolia Room,2nd Floor, Hilton Hotel

13:00–15:00 Finpro presentation
Mr. Mauri Francke, Head of Finpro Shanghai
Venue: Hilton meeting room

17:00 Free evening

Monday March 1st 2010 (Background info group A, report group D)

08:15 Departure from hotel

09:00 Arrival in Finchi Innovation Center
Venue: Room 401, No.2 building, 690 Bi Bo Road

09:10 Tekes presentation
Ms. Karen Jiang, Project Manager, Tekes Shanghai

09:50 FECC presentation
Mr. Yang Fenghui, Manager of FECC China

10:30 coffee break

10:45 Nokia and university cooperation (history and today) in China,
especially new models for open innovations
Mr. Jian Ma

12:30 Lunch
Fei Ni Ge Restaurant nearby Finchi

13:30 Finchi presentation
Ms. Kristal Li, General Manager, Finchi Innovation Center

14:00 leave for Shanghai Technology Center

15:00 visit Shanghai Technology Center
Host: Mr. Wang Zhen, Assistant Director
Venue: 100 Qinzhou Road
www.incubator.sh.cn

18:00 Arrival at hotel

Tuesday March 2nd 2010(Background info group B, report group C)

07:30 Leave hotel by bus for Vacon Suzhou
Accompanied by Ms. Lisa Li from Finpro Shanghai
(mobile: +86-1590 0900 322)

09:00 Arrival at Vacon Suzhou
Host: Mr. Wang, Plant Manager

10:45 Leave

11:15 quick lunch

13:30 Wuxi Suntech Co., Ltd.
Host: Director Wang, FAO Department
9 Xin Hua Road, Wuxi New District
www.suntech-power.com

14:15 leave

15:00 arrival at Wuxi SensingNet Industry Institute

18:30 Back in Shanghai

Wednesday March 3rd 2010 (Background info group C, report group B)

08:30 Leave by bus for Tongji University
Venue: Tongji University, Jiading Campus

10:00 one day in Tongji University on 'innovation' topic

Thursday March 4th 2010 (Background info group D, report group A)

08:15 Leave hotel by bus for Kone Kunshan
Accompanied by Ms. Lisa Li from Finpro Shanghai
(mobile: +86-1590 0900 322)
Host: Mr. Chen Bo, GM

09:30 arrival at Kone

11:30 lunch in Kone

13:00 Leave for Urban Planning Center
Venue: 100 Ren Min Avenue

14:30   visit Shanghai Urban Planning Center

19:00 Chinese dinner

Friday March 5th 2010

06:45 Leave by bus for Pudong Airport

10:20 Flight AY058 back to Finland

Contacts Finpro Shanghai:
Ms. Li Xia (Lisa)   Mob: 1590 090 0322
Mr. Mauri Francke   Mob: 1381 667 8981

5 Shanghai Study Visit Reports

Summary of Sunday 28th February and Thursday 4th March

FinPro (FEB: 28th)

We arrived on 28th in Shanghai and had a presentation by FinPro that started after lunch at around 1:30 pm. The day was blossomed by the good news of Finland hockey team's victory over Slovakia leading to a bronze medal in Olympic tournament.

Mr. Mauri Francke head of FinPro Shanghai delivered the presentation. He has an extensive experience in shipbuilding industry and after working for 15 years he joined Kone as shipyard and harbor manager. He then switched as managing director in foundry and electrical sector.

The business culture in china is quite different than the European culture and therefore it is challenging for a Finnish company to operate in China. In China everything is possible, but nothing is easy. The western logic does not apply and personal relationships are valued over laws. Social network is very important and family and relatives can only be fully trusted. The income has to be shared between all the parties that are involved in the process. There are no strict deadlines for projects, but you have to be persistent and patient. Marketing products and services are currently the most important reasons for European companies to enter China. Regional governments are more or less independent but initial decisions are taken from Beijing. However Chinese market is huge and besides the ample labor class there the number of local researchers/students is increasing rapidly.

The Suzhou geographic region is quite rich, containing around 30 Finnish companies. Yangtze River Delta (Jiangsu, Zhejiag and Shanghai) accounts for 25% of China's GDP. The whole region is only 2.2% of the area of China and has 11% of its population.

China's development is independent from the western world. The growth comes from construction, infrastructure, environmental and energy investments as well as from increasing domestic consumption. The export industry is important but not anymore the only growth factor. It is comparable to the US in the early 20th century where e.g. the railway networks bears high speed connections between all main cities; 1000 km can be covered in 3 hours. However Shanghai is becoming unaffordable for the average middle class of China. The cost of the land has reached roughly 2000 euro/sq-meter, while the normal worker has a salary of 300 euro/month. China's living standard has increased and thus people in general do not argue about human rights.

FinPro helps Finnish companies establish in China. It provides the companies the basic information of business in China and helps companies to search partners, check the market situation and study the market. It gives a full help for establishing a company from the location evaluations, company form definition, paper work,

negotiations with authorities etc. And it is free of charge. It has 10 to 20 consultants and is a part of Finnode community that includes TEKES, FinPro, Finchi and VTT. The capital investment by a company should equate the money taken back home. A 30% loan can be granted by state on top of the capital investment by a foreign owned company in China.

There is a high predicted inflation from spring 2010, thus the currency may not strengthen as much as predicted. Ship business, banking sector and telecommunication market have restrictions which may be relaxed slowly – taking China's best interest in account. There are also proactive steps taken to build industrial parks for future growth that may increase the GDP. Finland's position from China perspective is its strength that lies in free education and the brand Finland itself.

KONE (MAR. 4th)

KONE corporation is Finnish based company that deals in the Escalator and Elevator business. The presentation at Kone was about the supply operations and the supply facility. The business was registered in 1996, and the phase-I (including construction of first factory) was completed in 1998. The facility utilized roughly 90 km2 area. The second phase was opened in 2006 with 52 km2. The current facility acquires roughly a 150 km2 large area. There are around 1300 people in China that include approximately 100 people from R&D and Product change management.

The escalators are usually used at places that have higher humidity and heavy loads for example metros, airports, stadiums and commercial areas etc. The striking difference of the elevator product is its machine room less capability, instead the eco disc (electric motor) is installed within the hoist cable.

The escalators are made in three different factories: standard, non-standard and EJV factory. The standard factory produces around 1000 escalators per year targeting for the commercial market. The non standard factory produces about 500 units per year and targets the heavy loads requirements. The EJV facility produces roughly 2500 units per year. So totally roughly 4000 units are delivered per year.

There are also three factories for elevators; car, mx and electrical factory that operate on different parts of the elevator, these can roughly produce 22000 units per year. The company enjoyed a boom in sales in 2005-06 with 78% increase in elevator and 138% increase in escalator sales. The recent economic crisis had more impact on the escalator market compared to the elevator demand. The elevators are mainly delivered for Chinese market although around 4000 units are exported as well. Escalators are mainly for the foreign export.

The Kone supply unit exercises a Supply Excellence Program which is based on six factors: customer focus, manufacturing excellence, minimized shop floor waste, six sigma in china supply operation, employee empowerment and health safety. For the employees a skill matrix is used in shop floors that depicts skill improvement and promotes multi-skill development. This matrix has five levels, beginner, practitioner,

competent practitioner, knowledge sharer and expert. For taking the employees feedback an idea management system is implemented. In this system a feedback to a suggestion is delivered in maximum of three weeks. The suggestion should focus on improved efficiency and/or enhanced quality; increase capacity, reduced waste or one of the Five S principles (Sort, Set in order, Shine, Standardize and Sustain.) and EHS. Till February 2010 idea per employee reached 1.3.

Shanghai Urban Planning Exhibition Center
Shanghai Urban Planning Exhibition Center was founded in the early 2000 and is an important place to exhibit Shanghai's history, today and future development to the outside world. The main exhibition theme is "City, People, Environment and Development". The center provides a way for the Shanghai citizens to get to know the city planning. First we visited the city model hall which exhibited a huge model of Shanghai's urban area. The guide introduced the history of the development of the city and the main features in each district. Pudong district across the Huangpu river was farmland twenty years ago. The main settlement of Shanghai was in the Puxi district which is on the west side of the river. Amazingly after twenty years, numerous skyscrapers have appeared in Pudong and many of them are nowadays the monuments of Shanghai. In the city model, there was also a big area about the Expo with many exhibition halls models rescaled according to the original design. Later we visited the harbor, airport and urban traffic exhibition halls. Pudong airport has two main terminals, and the Terminal 2 was put into use in 2008. It has a capacity for 40 million passengers p/a. However, the development doesn't stop there. Currently a third passenger terminal and two more railways are   planned to be constructed by 2015. From 2010 to 2020 eight new subways are planned to be built and put into use and five current subways are to be extended. In 2020 the whole Shanghai urban area will be fully cover by the subways which will significantly facilitate the citizen's traveling. One exhibition hall reviewed the history of the planning of the Shanghai Expo. Several candidates of the Expo zone were exhibited. To end the visit we took a virtual tour of Shanghai and had a very real experience of for example taking different traffic tools to fast exploit Shanghai.

Summary of Monday 29th of February

Time 9:00

Address: Finchi innovation center, venue: Room 401, No.2 building, 690 Bi Bo Road

Topic: Tekes activities in China & innovation opportunities between Finland and China

Host: Tekes Shanghai Karen Jiang Senior manager

Content:

General introduction about Tekes China

Financing can also be awarded to foreign-owned companies registered in Finland.

Foreign companies with R&D activities in Finland are not required to have a Finnish partner to be eligible for funding. The financed projects should, however, contribute to the economy of Finland. No other Nordic countries offer this.

Tekes is under the Ministry of Employment and Economy, Ministry of Education (Academy of Finland), similar to Chinese structure.

Tekes China will review on S&T policy every 3 years.

Introduction to the Innovation environment in Finland

China closely cooperates with Finpro and Tekes.

R&D

- In Finland, Nokia took most funds (two billion Euros) from Tekes.
- In China, it's unlikely that one company would dominate the funds.

To the Chinese, the most well-known words about Finland are: Nokia, Sauna, Santa Claus.

The Chinese government wants to keep these good Finnish companies.

Enterprises account for 3.8 billion Euros, public sector only 1.6 billion Euros (2008). China should learn this from Finland. However, Finland should also grow its public funding.

The Chinese government realizes that enterprises should find matching R&D funding.

The achievements of Tekes in the past 5 years (2003–2008):

- Tekes has funded
  - 2,700 public research projects
  - 4,400 corporate R&D and innovation projects

- The projects have resulted in
  - 2,400 products
  - 1,700 service innovations
  - 1,000 production processes
  - 3,500 patent applications
  - 4,900 academic theses
  - 11,300 publications

Tekes reviews the output and provides guidelines every month.

Tekes has different departments for different goals, activities.

Finland has good technology while China has a big market. It's a win-win collaboration between Finland and China.

Tekes China Beijing office is more focused on the government and education while Tekes China Shanghai office is more focused on business.

Questions and answers?

1.   Explain what's public research?

Public research is a funding category for Tekes. Another is corporate or company research. Tekes prefers to fund company research because it's easy to measure the output. Basically, public research can only get short term funding, while companies can apply for the whole year funding.

2.   How to collaborate or communicate (because we cannot fly all the time?)

Before you come, you can email, fax to Tekes China. Tekes China utilizes their networks, teleconference, face-to-face discussion etc. Every month Tekes evaluates the Finnish partners.

Time: 10:00
Address: Finchi innovation center, venue: Room 401, No.2 building, 690 Bi Bo Road
Topic: FECC, Supporting Green Opportunities
Host: Yang Fenghui, Manager of FECC China
Content:
The environmental condition in Finland was no.1 in environment, sustainability and performance (2001, 2005, 2006).

From 2000, GDP increases while energy and material consumption decrease. China should learn this from Finland.

Finland is good at water resource management, waste management, energy efficiency, renewable energy, energy efficiency in buildings during winter time and energy monitoring.
Introduction FECC mission and operations:
FECC gets its 50% fund from public (MOEE, Ministry of Education and Economy), 30% from regional development centers and 20% from private sectors.
Introduction FECC activities and recent successful references.

Time: 11:00
Address: Finchi innovation center, venue: Room 401, No.2 building, 690 Bi Bo Road
Topic: Nokia open innovation models in China, true win-win deal across scientific and business domains.
Host: Jiang Ma, Nokia research center, Beijing, principal scientist
Content:
Nokia has four research focus areas:
Rich context modeling, new user interface, high performance mobile platforms, cognitive radio.
It's important for Nokia to understand different cultures and emerging markets like Africa.
From 2008, China has surpassed U.S to become the no.1 country in Internet user population. Most Internet users actively use all kinds of Internet services like:
86% music, 79% news, 72% IMS, 69% search, 66% video, 64% game (only China market).
Internet use on PCs is decreasing while on mobiles it is increasing. Mobiles are becoming a more and more important window to access the Internet.
The number of mobile Internet users grows quickly (in millions) by CNNIC (China Internet Network Information Center) report.
The 3G network is the accelerator for mobile Internet development.
Mobile Internet brings new opportunities for Chinese innovators. In 2008's most popular WAP website ranking, big companies dominated the top 20. But in the ranking of 2009, new companies appear at the top of the list.
Since 2007, Nokia wants to become Service Company and competes with China mobile operators.
Successful university cooperation builds on win-win strategy.

Some modes of Nokia cooperation with universities:

- Club in Tongji University
- Developer community

- Post doctoral researchers (with Tsinghua University)
- Joint labs, research projects, internship, training, course, fellowship
- Nokia innovation contest

Time: 13:30
Address: innovation center, venue: Room 401, No.2 building, 690 Bi Bo Road
Topic: Finchi background, today and success stories
Host: Ms. Kristal Li, General Manager, Finchi Innovation Center
Content:
Finchi was founded by Mr. Kari Häyrinen in 2005. It's based on cooperation with local authorities. It's an extension of Finnish innovation environment into China. Tekes support on R&D.
Finchi provides office space, wallet care, landing care (housing, schools, domestic help and Mandarin courses), business support and networking services, staff recruiting, information support, total care (business visits, exhibitions, meetings, training and seminar organization), patent help, IPR issues.

According to Chinese law, foreign companies cannot have bank accounts until a corporation is registered in China. Finchi can help during this set up period.

Time: 15:00
Address: Shanghai Technology Center, venue: 100 Qinzhou Road
Topic: The exploration and practice of city-based incubation system
Host: Shanghai Technology Center
Content:
Overview of business incubation in shanghai.

Now there are 35 incubators in Shanghai with 600,000 m2 incubation space and 2000 tenant companies as well as 33,000 employments.
Some statistics data (by 2008):
Graduated enterprises: 799
Incubators: 35
Incubation area: 585,281 m2.
Cover all parts except Chongming Island.
Incubation service platform:

- Training service (CTO training, MBA etc.)
- Project application, consulting service
- Law, HR, IPR
- Financing, VC, bank loan
- Marketing exploration

- Physical facilities
- Capacity building, professional incubation and mentoring service
- Internationalization
- "One incubator, several bases", one stop service

Summary of Wednesday 3rd March

Tongji University

Our visit at Tongji University started with a presentation by Prof. Neuvo about our Bit Bang course. Next, Associate Dean, Prof. Fuqiang Liu made an introduction for the university ("Introduction to Tongji University, School of Electronics and Information Engineering").

The Tongji University was founded in Shanghai 1907 by Erich Paulun, a German doctor. The university has 24 colleges/schools, 55,000 students, and about 8,000 staff members including 3,000 teachers and researchers.

Some of the focus areas of the schools at the Jiading campus are:

- Hybrid-powered automobiles,
- Magnetic levitation trains,
- The Beijing-Shanghai express train,
- Testbed for B3G/4G cellular systems.

The School of Electronics and Information Engineering (EIE) is located at the Jiading campus, northeast from the Shanghai city center. The EIE School comprises of 5 departments, staff of 305, 176 doctoral students, 1830 master's students, and 2450 undergraduate students.

After the presentations and lunch, our Bit Bang course presented our book chapter topics from autumn 2009. The audience included Li Wei and some post-graduate students. After the "Open Innovation in Non-IT Sector" presentation, some discussion stirred from the role of open innovation in industrial projects at Tongji University.

Next, the topic moved to the innovation climate. The Jiading campus has lots of brand-new space, but still the question "what if there is no physical place for meeting other people?" was asked. As we had learned, at least social networking is stronger in China than in some other countries but the situation of physical space is similar and quite conservative in academic environments. When the talk moved to user-driven innovation, printed circuit boards (PCBs) were used as an example; in China it is relatively easy to design your own PCB, order it with low expenses and finally tweak it by yourself. This used to be the case in Finland but nowadays expenses have increased and customization of PCBs is no longer the norm.

Lastly we listened to Li Wei's presentation on DC-DC converters in electric cars and supercapacitors. We learned that supercapacitors have the advantage of a very high power density, which is extremely good for quick and large fluctuating loads (e.g. fast acceleration of electric cars). However, since they have relatively low energy density compared with Li-ion batteries, a hybrid technology with fuel cells, which have high energy density, but low power density, would optimize size and perform-ance. We also learned that compared with Li-ion batteries, fuel cells have a much larger temperature operating range.

Summary of Tuesday 2nd March

Vacon, Suntech and SensingNet Industrialization

Visit to Vacon unit in Suzhou
Host: Mikko Kannisto, R&D Manager
Keywords: electrical ac drives, motors, energy

The tour of Vacon unit first started with a presentation about the company by Mr. Mikko Kannisto. Kannisto is the R & D manager and working for the Chinese unit of Vacon. Kannisto described the operation of an AC drive and its significance. It was quite interesting how the various forms of the same AC drive can be used in different applications like from an electric motor to a wind mill.

Some of the figures mentioned by Kannisto about Vacon were that it started in Vaasa by a small group of former ABB employees and is now 1200 people strong with 293,2 million in revenues. Also the future projections mentioned by Vacon were that it aims to be a 500 million company by 2012. Vacon has R&D and production facilities in China, Finland, US and Italy. The head office is in Vaasa.

Also, an interesting part of the presentation was how Vacon managed to operate in China and other units considering the cultural differences. According to Kannisto, Chinese engineers are less inclined to take responsibility about their work and therefore European team managers are preferred. Education level is about the same when comparing Finnish and Chinese engineers. Kannisto really appreciated attitude and teamwork skills of Chinese engineers. One key point in integrating Chinese to work according to Vacon policies was a training period in Finland.

Like each geographical unit had the full ownership of one product line. The China unit is specialized in compact AC drives. 50 % of factory's output is for export. Also, highlighted by Kannisto, was the point that the core of the product was in software, which is hard to copy because of a secure process. Kannisto pointed out that while the products can be and are customized according to customer requirements, 98 % of applications can be made using off-the-shelf products.

After the presentation we were given a tour of the facility and we could see all the stages of the product manufacturing.

Visit to Suntech-power in Wuxi
Keywords: solar panel

The tour of Suntech-power was given to us by Suntech employees. The Suntech facility was covered with solar panels and it could generate 1,2 MW of electricity to power Suntech facilities. Suntech was started by Dr. Zhengrong Shi in the early

2000. The electricity output capacity has risen from 10 MW in 2002 to 1,8 GW in 2009. Also mentioned during the facility tour was Suntech's involvement in the Shanghai World Expo. The main pavilion has a roof of solar panels provided by Suntech and will be generating 3,2 MW of electricity from it.

In the beginning of the guided tour we were first explained all the steps involved in the manufacturing of a solar panel. Suntech was not involved in manufacturing of silicon wafers and they were imported. However, the rest of the process is done in their own manufacturing unit. The cost of energy from Suntech solar panels was about 20 RMB (Chinese Yuan)/watt and the product life is about 25 years, although the panels should operate with lowered capacity still further. Their solar panels had an efficiency up to 19%.

Suntech model of Expo 2010 in Shanghai.

Bit Bang student Le Wang in front of Suntech facilities in Wuxi, March 2010

Suntech has its own unique technology known as the Pluto technology to manufacture panels, which could also use low purity wafers. After the explanation of all the steps involved in the manufacturing process we were given a tour of the facility where we could see all the steps happening in real.

Visit to Wuxi SensingNet Industry Institute
Host: Jie Shen, PhD, Research Director
Keywords: Middleware, Internet of Things, sensors

The visit to the SensingNet Industry Institute started with a presentation of a miniature model of the Wuxi Internet of Things model city. The city is based around a lake and had ecological design. It was covering an area of 20 square kilometers. It was to house 20000 people and various industrial players, such as Intel and IBM, were to be involved in this experimental setup. The area as a whole is still under development, as numbers of buildings were under construction and others have not been started yet.

The origin of Internet of Things in Wuxi comes from Chinese Academy of Science

initiatives. They were working on sensor networks already in 1999. They were also involved in standardization of sensor networks. One of the standards was ISO/IEC JTC1. The SensingNet institute was also involved in deploying the sensor networks in Pudong airport in an area of 27 square kilometers. The institute has nearly 400 people working and they are involved in designing the specifications for the sensor network middleware. The middleware was to use 400, 780 MHz and 2,4 GHz bands. The IEEE standard 802.15.4c for sensor network has been made especially for China.

The main application of all the different sensors shown to us in exhibition were in military field, intrusion detection, traffic, environmental monitoring, public security, smarthome, smartgrid, high speed railway, medicare and health, chemical, smart buildings and seismic activity. Currently China Mobile is involved with SensingNet institute in making the middleware for Internet of Things infrastructure which will be then available to service providers to build services on top of it.
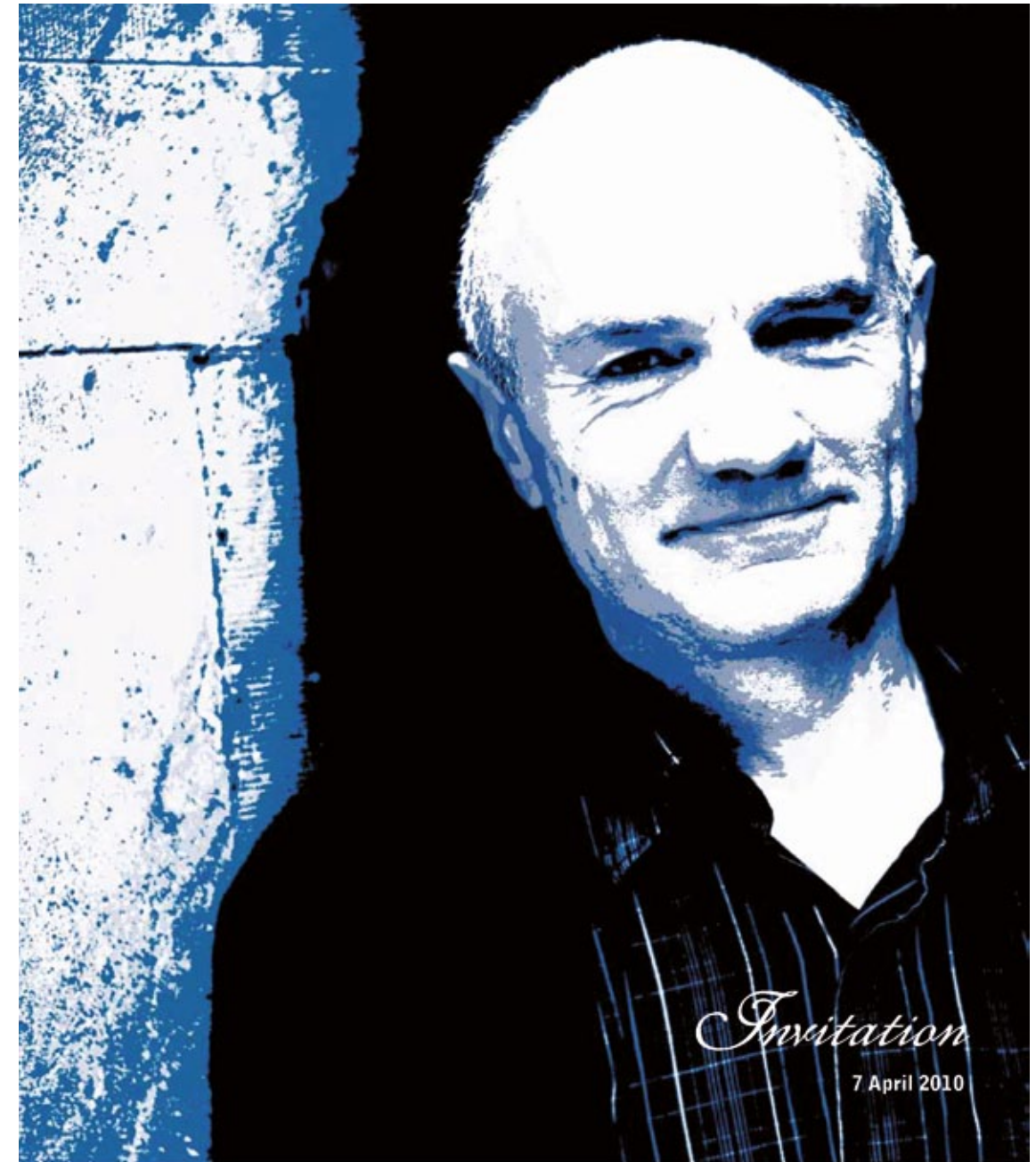

Professor Yrjö Neuvo and some Bit Bang students admiring the SensingNet model in WSN center, Wuxi

Some SensingNet information boards

The day ended with a dinner where several students from Tongji University attended and discussions ranged from the presentations from earlier in the day to the daily lives of post-graduate students in China. At the dinner we also met students participating in Aalto University Design Factory's course on product development. They were studying workshop environments for welding in Finland, Japan and China in order to design and develop better welding machines.

6 Dany Jacobs Seminar Invitation

Invitation

7 April 2010

A! Aalto University School of Science and Technology   SITRA

Interactive Seminar on

- The Cultural Side of Innovation
- Innovation Routines ...
- Mapping Strategic Diversity

Aalto University's MIDE research program
and SITRA invites you to

The Dany Jacobs Seminar
7th of April 2010 9.30 am–14.30 pm

Crowne Plaza,
Mannerheimintie 50, 00260 Helsinki

▸ **Registration by 25 March**
to Ms. Ullapia Weckström
email: ullapia.weckstrom@sitra.fi
tel (09) 6189 9214

To have an interactive atmosphere we have put a limit on the
number of participants. We kindly ask you to inform us in your
earliest convenience whether you will/will not attend the seminar.

Thank you and welcome.

Yrjö Neuvo and *Jari Pasanen*

Prof. dr. Dany Jacobs

*Since 2007 Dr. Dany Jacobs (1954) has been Professor of Industrial
Dynamics and Innovation in the Faculty of Economics and Business
at the University of Amsterdam (UvA). He is also Professor of
Art, Culture and Economy at the University of Applied Sciences
ArtEZ and at the University of Applied Sciences HAN in Arnhem,
the Netherlands.*

*For more than twenty years Dany Jacobs has been researching
innovation in the knowledge and creative economy. Between 1988
and 1997 he worked as a senior researcher and advisor at the TNO
Center for Technology and Policy Studies. From 1998 to 2007 he
was Professor of Strategic Management at the University of
Groningen in the Netherlands. Between 2003 and 2007 Dr. Jacobs
also held a professorship at the Amsterdam Fashion Institute (AMFI).*

*Dr. Jacobs has published 25 books and many more articles for
academic and popular audiences. His books include Adding values:
The Cultural Side of Innovation (2007), and Mapping Strategic
Diversity (2010). Additionally, Dr. Jacobs performs various ad-
visory functions. He is for instance a member of the 'Commission
of Wise People' on Knowledge and Innovation, which advises the
Dutch Government on large innovative projects.*

Programme

9:30–10:00 Registration and coffee

10:00–12:15 Morning session:
Stimulating Innovation Success

1. Adding values: the cultural side of innovation
Technology-oriented people often overestimate the future
speed of diffusion of innovations, as they do not sufficiently
take into account the cultural aspects of innovation. In this
lecture Dany Jacobs talks about the diversity of innovation
and then concentrates on the technical versus the non-technical,
cultural aspects of innovation. He then presents a Darwinian
approach with the help of which even more radical innovation
can be enhanced.

2. Innovation routines of successfully innovative firms
In 2007-2008, together with Hendrik Snijders, Dany Jacobs
did a study on 20 organisations in a variety of industries (even
museums were included) which had been repeatedly successful
with their innovations. Quite to their surprise a kind of success
formula emerged from these diverse practices: ten disciplines
in which all of them excelled!

12:15–13:00 Lunch

13:00–14:15 Afternoon session:
Mapping Strategic Diversity

Dany Jacobs demonstrates that the real world of strategic
management is wide and rich. First he makes a basic distinction
between 'cockpit theories' of strategy, which bring rational
analysis to the forefront, and process-oriented social science
approaches, which bring in a wider array of influences to the
theory and practice of business planning. Then no fewer than
22 different approaches to strategic thinking are presented.
All of these are inspiring perspectives, depending on the
situation. Being able to work with them enhances strategic
'style flexibility' of strategy practicioners.

14:15–14:30 Closing discussion

A warm welcome!

Bit Bang – Energising Innovation, Innovating Energy
was the second multidisciplinary graduate course
for Aalto University doctoral students. A total of 23
students were selected from the three Aalto University
schools: School of Science and Technology, School
of Economics and School of Art and Design.

The learning objectives of this course were elements
of creativity and innovation and sustainable energy
with emphasis on changing consumer behaviour.
During the fall the teams wrote reports on topics such
as open innovation and sustainable ICT extension in
Namibia. In the spring term the topic of energy was
covered on global and national level, focusing on the
role innovations play in addressing the challenges. The
spring topics varied from ecocities to smart grids. This
joint publication contains the teamwork reports.

The texts have been written by the doctoral students
who were encouraged to take fresh and even radical
views on the energy and innovation related topics.

http://mide.tkk.fi

A! **Aalto University**
School of Science
and Technology