Open Sustainability

Supporting Local Community and Citizen Interaction for Sustainability

Håkan Gulliksson
Thomas Mejtoft

Nr 1/2011

Interaction and Media Technology Report Series

Department of Applied Physics and Electronics

Abstract

The objective of this research report is to analyze and illustrate how open source and the ideas behind the open source movement can be used to enhance sustainable behavior in a community through information on local, regional and global problems related to a sustainable society. The foundation lies within the fact that sustainability is crucial for survival and is a long-time process including social, economic and environmental issues. In general, many of the sustainability problems are increasingly global and intertwined, which necessitates the need for global solutions.

The ideas behind open source software and open source as a philosophy are based on the right to redistribute, make derivate works and use different solutions for free. One fascinating thing behind open source is how it brings people together to work for a common cause without clear personal gain. This is one of the reasons why open source has been very prominent and successful in the software industry and today most software necessary for a common family or firm can be accessed for free by open source license. However, taking the incentives from open source and trying to apply to sustainability issues might be a solution for increasing the participation from the population in a local community in creating a sustainable society and living. In the long run it is an important marketing effort for both the local community and commercial firms to be part of such development and give incentives for a co-creative environment.

This report briefly touches upon the environmental impact of energy consumption and transportation and given examples of how these sustainability issues can be addressed with different ICT solutions. In both of these areas the problem is to collect data at a detailed level and use it to provide feedback to the citizens, to the community administration and to the commercial interests involved. By exploiting the business and working models from the open source community the citizens can be engaged in improving the system while at the same time raising their knowledge level, adapting their behavior and attitude.

Keywords: open source; sustainability

Structure

Introduction

The objective of this research report is to analyze and illustrate how open source and the ideas behind the open source movement can be used to enhance sustainable behavior in a community through information on local, regional and global problems related to a sustainable society.

We will start from some assumptions. *The first* is that sustainability is crucial for our survival and a long time process including social economic and environmental issues. The problems are increasingly global and intertwined, which is true also for some of the solutions. Most solutions are however local and demand effort and engagement from individuals and the local communities. *The second* is that we assert that the local community, citizens and organizations of that community are interdependent. One example is that political pressure from individuals affects rules and policies, which in turn will regulate and normalize the everyday lives of the citizens. A model describing the main stakeholders for this report is shown in figure 1. The main relationship discussed will be that between the local community/municipality and the citizen.

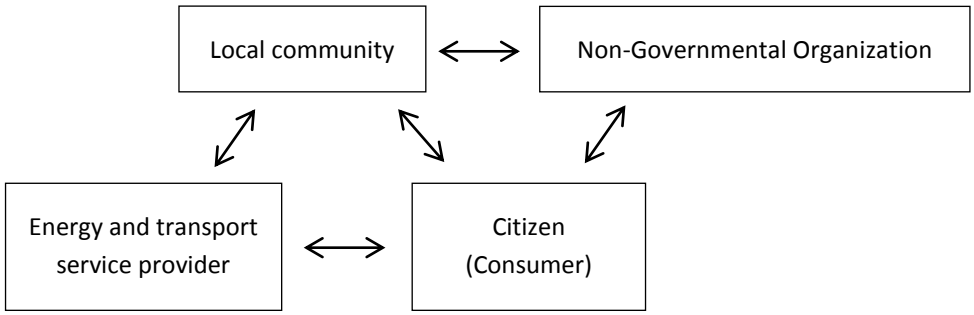

Figure 1. Main stakeholders in this report.

Typical areas of consideration in the local community are health and care, schooling, CO_2 transmission in transportation and energy consumption. In this report we will focus on sustainability issues and solutions for the latter two. The local community needs to plan, organize and manage the transport system and it also wants to minimize unnecessary energy consumption, in particular energy consumption in homes and community owned premises. If the citizens become involved and engaged in these issues, this work might be simplified.

The type of NGO (Non-Governmental Organization) that we will discuss is the open source community. Open source is a way of developing the systems in a cost efficient way but could also be a way of engaging individuals in the community when designing and implementing them. Furthermore, the open source movement could provide development strategies to be used, i.e. how to organize development, and finally there could be business models from the open source community that could be used for open designs and implementations in local communities. Why is a talented programmer contributing without much in return and how do some companies manage to profit on open source software? We will shortly discuss some reasons for contributions of this kind.

The stakeholders (figure 1) depend on crucial information systems built on top of the Internet. These systems will also be discussed in relation to open source, communities and citizens.

Methodology

Firstly, this report provides a theoretical background to open source and sustainability; this is done by a background literature study on community – citizen interaction in sustainability issues, green IT and tools for sustainability. The ideas and philosophy of open source are given a more detailed treatment, also by means of a literature study. Secondly, a couple of examples of the phenomenon were illustrated. The cases described in this report can be regarded as critical or unique cases (Yin, 2003), which are used to extend an idea and document unique features. Hence, generalization is not the goal for this study but rather to give a brief illustration.

Sustainability

Sustainability was described in "Our common future" from 1987. This UN report, which is also called the Brundtland report (United Nations, 1987), says that:

> *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:*
>
> *the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and*
>
> *the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."*

Hence, we do need to consider solutions that are socially, economically and ecologically viable for several generations ahead. This is not a simple task. The problems that we will face if we fail are enormous and the time at our disposal is quite short. This is not the place delve into this issue so we settle for stressing the importance of the issue by some quotes from literature on the topic.

> *"Today we find ourselves faced with the imminent end of the era of cheap oil, the prospect (beyond the recent bubble) of steadily rising commodity prices, the degradation of forests, lakes and soils, conflicts over land use, water quality, fishing rights and the momentous challenge of stabilising concentrations of carbon in the global atmosphere. And we face these tasks with an economy that is fundamentally broken, in desperate need of renewal."* (Jackson, 2011, p. 5)
>
> *"We are in a race between political tipping points and natural tipping points. Can we cut carbon emissions fast enough to save the Greenland ice sheet and avoid the resulting rise in sea level? Can we close coal-fired power plants fast enough to save the glaciers in the Himalayas and on the Tibetan Plateau, the ice melt of which sustains the major rivers and irrigation systems of Asia during the dry season? Can we stabilize population by reducing fertility before nature takes over and stabilizes our numbers by raising mortality?" (Brown, 2009, p. xii-xiii)*

Consequently, we need to mitigate the climate change and manage the effects that still hit us. At the same time we will run out of oil and the population will grow. Many solutions will have to be devised and public education is badly needed to understand the issues, what they mean to us, what we can do and what we need to do. This report is a small contribution.

It is all too easy to accept simple solutions that does not involve us or at least does not force us to change our daily lives. Some common truths of that kind are listed below (Power & Mont, 2010). They are all valid to some extent, so there is no need for apathy, but the danger is to rely on any of them as the sole or even all of them as final solutions:

1. More information leads to sustainable behavior
2. Small environmental actions will have a "spill-over effect" to bigger change
3. If everyone does a little we will achieve a lot
4. Green consumption is the solution
5. Consumers should lead the shift to sustainability
6. Appealing to people's self-interest is the path to sustainable behavior

The crucial point here is to not be satisfied with simple small solutions but for everyone to try everything. One thing to be wary of as we do this is the rebound effect.

A (simplified) model for the energy sector was constructed by Parag & Darby (2009) (figure 2). The government referred to in the figure is the national government. This model refines the one shown in figure 1 and if we exchange "Energy supplier" for "Transport service provider" it is possible to apply most of it also for the transport sector. Some of the details describing the interactions will change but many of the characteristics of the relationships will be the same.

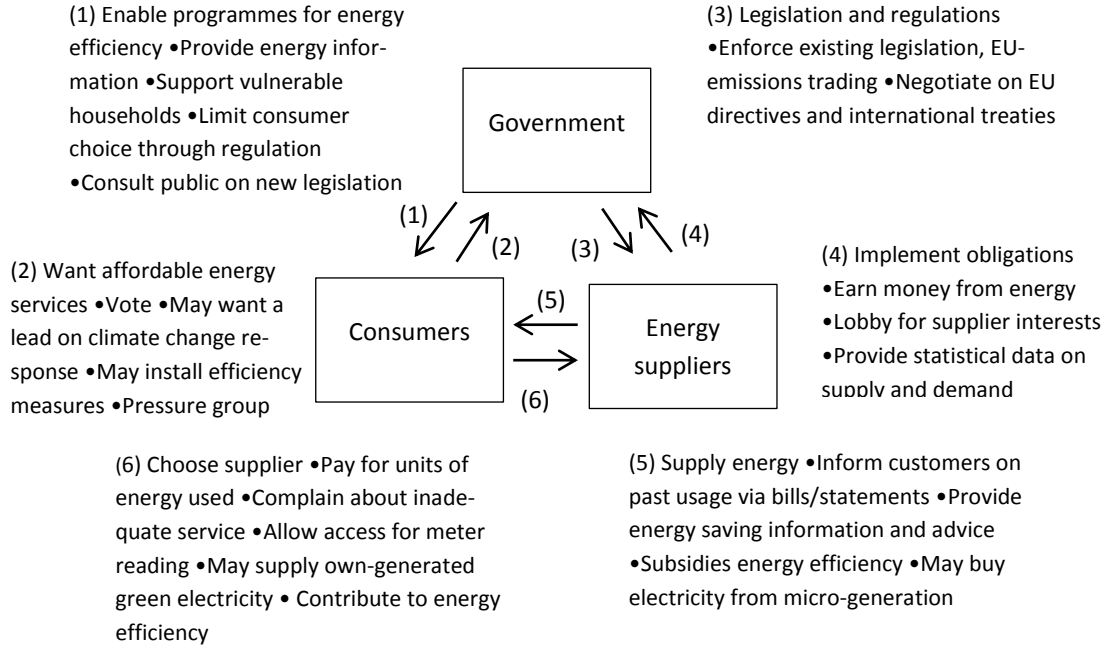

Figure 2. Stakeholder relationships in the energy sector (Parag & Darby, 2009).

There are several interesting interactions related to figure 2. The government for instance wants a combination of a low-carbon future and active citizens working hard using infrastructures of the society for growth. Citizens will not necessarily accept this bargain and will also mistrust the intentions of energy suppliers as well as the information provided by them. The municipality and NGOs could have a key role here since they can give tangible evidence of behavior that could earn them trust and credibility.

In the following, this section will discuss the problem of the rebound effect and two examples of sustainability problems, energy consumption in the home and community premises and emissions in the traffic sector.

Rebound effect

The rebound effects refer to feedback loops that compensate for the positive effects won by efforts for sustainability. One example is that money saved by keeping the indoor temperature low is spent on a holiday in a warmer country far away. Similar effects can be caused by falling prices, increased capacity or better availability. If the price of a product decreases due to intelligent sustainable production the result could be increased sales, which in the end could result in an overall negative net effect on the environment (Tomlinson, Silberman & White, 2011).

There are three kinds of rebound effects – direct, indirect and economy wide. The direct rebound effect is one where savings, for instance in fuel consumption, allow for increased consumption of fuel. The indirect one is at work when money or other resources saved by energy smartness are used to consume other things with embodied resources. The third effect is an economy wide effect where for instance a lower energy price has a positive effect on economic growth.

Note that any new general purpose technology, such as the Internet, has a built in potential for increased energy demands since it enables new innovative ways of doing things (Tomlinson, Silberman & White, 2011). We will return to the rebound effects later.

Energy consumption in homes and community premises

One of the key problems discussed in this report is energy consumption in homes and in community premises. We can establish the level of consumption 2010 by noting that the CO_2 emission from homes and different kinds of premises is estimated to 6% of the emission in Sweden (i.e. 4 out of 64 million ton CO_2 eq). This is 62% less than in 1990 mostly because houses are now heated by other sources than oil. The total energy consumption dropped dramatically in the beginning of 1980 and has since then dropped another 8%. Emission from domestic transports amounts to 33% (4 out of 64 million ton CO_2 eq), an increase with 14% since 1990 (Energimyndigheten, 2010a; Naturvårdsverket, 2011).

There are opportunities to save energy and one example is that has been estimated that community premises (offices, schools, sports centers) can save up to 30%. These savings mainly come from better technology for lighting and ventilation (Energimyndigheten, 2009). Measurements have also been reported on private homes. In one of them the energy consumption of 400 homes was traced in detail. For a family in a house the results were quite varied. The annual consumption differed from approximately 8000 KWh to 48000 KWh with a mean value of 18500 KWh/year. By comparing the usage patterns possible savings were identified. They also varied widely from 400 to 4800 KWh with a mean of 1500 KWh/year. This indicates a mean savings potential of approximately 10%. The most effective saving was usually to replace light bulbs with more energy efficient ones (550 KWh/year) and replacing cold appliance (540 KWh/year) turning off computer equipment (150 KWh/year) and audiovisual equipment (166 KWh/year) or changing to equipment with low energy stand by consumption (Zimmermann, 2009b)

There has been a decrease of 8% in energy consumption in the homes since 1983. At the same time the number of homes has increased as well as the number of appliances. The conclusion is that there have been changes in behavior and use of energy smart technical solutions. As for the attitudes to energy savings in Sweden; in 2006, as many as 84% regarded this an important issue (Konsumentverket, 2007).

Another indication of where energy is spent is that doing the dishes in the kitchen sink claimed 38% of the hot water, bath and shower 44% and wash basins the remaining 18%. Typically one person used 130 liters of water where 42 liters were hot water. It takes 58 kWh to heat 1000 liters of water 50 degrees Celsius. A rough estimation is then that each person spends 1.5 kWh per day on heating water. Over a year this amounts to approximately 450 kWh to be compared with the savings listed above (Energimyndigheten, 2010b).

There are many different ways to try to control and influence energy consumption, Legislation is one way. One such attempt is the *Directive on energy end-use efficiency and energy services and repealing* issued in 2006 by the EU Parliament. In the preamble of this directive it says that (EU, 2006):

> *(28) In defining energy efficiency improvement measures, account should be taken of efficiency gains obtained through the widespread use of cost-effective … innovations, e.g., electronic metering…*
>
> *(29) to enable final consumers to make better-informed decisions … they should be provided with a reasonable amount of information … consumers should be actively encouraged to check their own meter readings regularly.*
>
> *Article 13:*
>
> *(1) Member States shall ensure that, in so far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings, final customers … are provided with competitively priced individual meters that accurately reflect actual energy consumption and that provide information on actual time of use.*

Hence, the directive wants the member states to give their citizens (energy customers) ample tools to follow their energy consumption in real time.

The estimated direct rebound effect for household heating (or cooling) is less than 30% in developed countries but could be much higher in other parts of the world (UK energy research centre, 2007). As for the size of indirect and economy-wide rebound effects there is no consensus but *"several studies suggest that economy-wide rebound effects may frequently exceed 50% (i.e. less than half of the expected energy savings will be achieved). Moreover, these estimates do not take into account the amplifying effect of any associated improvements in the efficiency with which capital, labour or materials are used"* (UK energy research centre, 2007, p. vii).

Some examples of indirect rebound effects for energy savings in homes are that improving energy efficiency at home (e.g. better thermal insulation) will itself require energy, cost savings are spent on other goods or services which require energy for production and use, these goods or services could increase consumption of capital, labor and materials speeding up the whole economy further increasing energy consumption. Productivity increases as the economy grow and even more goods and services with embodied energy can be consumed. Reduction of energy prices, for whatever reason, will encourage increased energy consumption, real income, investments and productivity. Lower prices of energy will also favor energy intensive solutions rather than non-energy alternatives which might hamper innovation for developing alternatives.

CO_2 emission from transportation

Our second target area for discussion in this report is local transportation, and in particular the CO_2 emissions caused by it. The following is a short summary of the development with figures from Ingenjörsvetenskapsakademin (2002). In the EU, CO_2 emissions from transport have increased by more than 20% since 1990. This can be compared with emissions from household that has decreased with approximately 3%. The utility from transport measured in number of passenger-kilometers or

kilometers of transported goods over the same period of time has increased more than the energy cost, around 40%, which indicates more energy efficient transport systems. The global domestic product has at the same time increased even more, around 60%.

In accordance with the rest of the EU, transport emissions in Sweden 1970-2002 have also increased steadily, apart from a reduction around 1980. The increase can be estimated to 30% with a significant increase in diesel and ethanol. In 2000, the transport sector was responsible for about 35% of the total Swedish CO_2 emissions and most emissions in the transport sector, approximately 75%, came from traffic on the roads. As a comparison the emissions related to consumption in homes in the same year was 14%. A later traffic analysis, from 2010, shows that there in fact has been a decrease in emission rates from cars while cargo transport has increased its emission with more than 40% since 1990. In Sweden there was about 4.3 million cars 2009 and 6% of these were considered as adapted to the environment. Each year approximately 250 000 new cars are sold (Trafikanalys, 2010).

As for the rebound effects in the transport sector the direct rebound effect for transport is not as high as for household heating, probably around 10% (UK energy research centre, 2007).

Green IT

The information network currently emerging is an extremely important factor for future sustainability. The word “green” is truly multifaceted and has all sorts of environmental, political and industrial connotations. In the literature, “green” is defined as *“any object or process, animate or inanimate, dynamically invested in and actively in support of harmonious and sustained environmentally friendly coexistence”* (Mann, Grant & Singh Mann, 2009, p. 2). Consequently, in combination with IT, green is just as multifaceted, but here it is possible to adopt a definition geared at business that describes green IT as processes that involves *“the strategic deployment of operations and information technology to dynamically, sustainably and responsibly align business-oriented goals with green objectives for the entire duration of operations”* (Mann, Grant & Singh Mann, 2009).

If we exchange the word business above for an appropriate word we can apply the definition in any area, for instance by using the word “society-oriented” instead of “business oriented”. An extended definition could read like (Molla, 2009):

> *“Green IT is an organization’s ability to systematically apply environmental sustainability criteria (such as pollution prevention, product stewardship, use of clean technologies) to the design, production, sourcing, use and disposal of the IT technical infrastructure as well as within the human and managerial components of the IT infrastructure.”*

From this definition an information system or organization can foster Green IT along two dimensions. The first can be called “Green IT reach” and is based on the number of activities that take sustainability into account and the second is to what extent this is done, “Green IT richness” (Molla, 2009).

Impact from information systems

This section gives some examples on how and where IT can make a difference from a sustainability perspective. The effects can be structured into three categories, first, second and third order effects relating to the directness of the effect of the particular technology on sustainability.

First order effects are direct impacts from information technology on the environment. These are mostly negative such as resource use for building computers, waste when throwing them away and energy consumption when running data centers (Berkhout & Hertin, 2001). One estimate is that the IT industry is directly accountable for 2 % of global CO2 emissions. *"The average amount of energy consumed by a PC in 1 year corresponds to the emission of 1 ton of CO_2 […] 70% of the landfills of lead, cadmium and mercury derives from the IT industry."* (Capra, 2009).

When information technology is applied in different activities *second order effects* can give results that are often positive. One positive effect is that information technology can be more about managing ideas rather than materials which could reduce the load on the environment. Information can support environmentally smart production processes, provide means to design and operate products that use less energy or other resources, reorganize material flows and logistics, virtualize products (e-mail rather than report based postal mail), support system analysis (life cycle analysis and other), and in general increase system efficiency. We can for instance use IT to monitor environmental impact and increase efficiency in energy use. In the best case the formula energy + information < energy is valid (Berkhout & Hertin, 2001).

Just to give some examples some areas and activities benefiting from IT use are (Chiabai, Rübbelke & Maurer, 2010; Edwards, 2010; Easterbrook, 2010):

- Observation and monitoring, e.g. of environmental parameters. There is now a vast amount of geosocial data available.
- Visualization, e.g. increasing awareness of sustainability issues. One example is tools for calculating ecological footprints available. Good visualization is essential.
- Modeling and simulation, e.g. socio-economic analysis.
- Planning support, e.g. identifying strategic plans by forecasting.
- Cooperation support, e.g. video conferencing or reputation systems for quality control and credibility control. To this we can add collective intelligence tools.

The communication infrastructure for enabling second order effects is now in place and the potential for instance to save energy is high. *"A large part of the massive growth of energy consumption in the past few decades is due to the manufacture and use of computing and communication technologies, and the technological advances they make possible. Energy efficiency has never been a key requirement in the development of software-intensive technologies, and so there is a very large potential for efficiency improvements"* (Climate group, 2008).

The *third order effects* are indirect results from using information technology. They are the long-term effects on life-styles and economical systems because of information technology. How these affect sustainability issues are sometimes difficult to assess. Does for instance the increased growth supported by information technology mean that resources are spent more quickly than we can virtualize old ways of doing things? The rebound effect is clearly something to consider here (Berkhout & Hertin, 2001).

Model of Information system

An information system is modeled as in figure 3 below. The information system is shown in the middle with supplies coming in from the left and a demand from the right (Watson, Boudreau & Chen, 2010).

In general figure 3 shows how the information system senses objects (people or things) through sensors and this information is distributed through sensor networks. The flow network supports the movement of other more tangible resources such as water, oil, cars, or other products. The information system in the middle of the figure works a as a common hub to the stakeholders. It has several functions.

- Collect data from the sensor network and use it to optimize flow networks.
- Collect and analyze information about suppliers' behavior and manage flow network on basis of this analysis.
- Effectuate the optimization in the flow network, e.g. by providing flow network managers with information so they can manage and monitor their networks.
- Collect information from consumers and supply data to them about their consumption of resources, e.g. information for social comparison of use.
- Manage supply and demand avoiding resource depletion at peak loads.
- Support consumers' control of their energy consumption.
- Supply information to governments on flow networks' resource use.

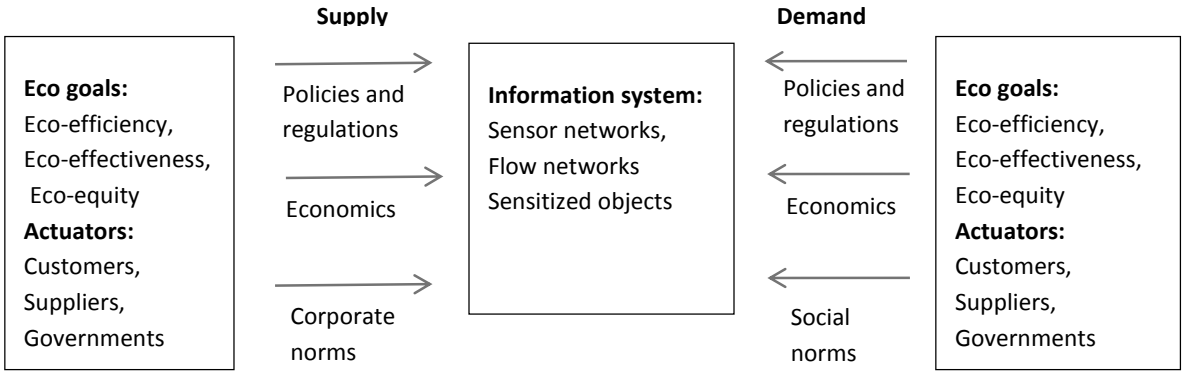

Figure 3. Model of an information system adopted from (Watson, Boudreau & Chen, 2010).

The terms eco-efficiency, eco-effectiveness and eco-equity (figure 3) overlaps the terms previously presented, i.e. the first, second and third order effects of IT. The difference is that the new terms are activity based rather than explanatory. Eco-efficiency means to do more with less, it should bring quality of life while reducing impact on the physical environment. One or more of the stakeholders (government, consumer or supplier), could benefit from the cost reduction. Eco-equity stresses the fact that the state of the world and the results of the activities should be acceptable or beneficial to everyone, independent of nationality, sex, age, and this should be true over generations. This is a real challenge and needs a major realignment of norms, both individual and organizational. Eco-effectiveness means to do the right thing, finding the ultimate solution for ecological problems. Less negative effects is not enough in many cases and sustainability, restoration, and regeneration as standard organizational aspirations. As organizations change, so will the laws and regulations (Watson, Boudreau & Chen, 2010).

The Citizen

Information technology has enabled many life-style changes for the general population during the last couple of years. The mobile phone is perhaps the device that affects our daily life the most. Global values, easily promoted over the internet, affect what we buy and how we behave in an ever increasing pace. Consequently, the Internet could make us into more informed consumers enforcing sustainability and ethical products. On the downside increased communication over the internet will probably increase travelling for meetings and pleasure.

Another possible effect of networking is the effect of "empowerment" where the network lets individuals gain control socially, politically, economically and psychologically through (Nikkah & Redzuan, 2010):

- access to information, knowledge and skills
- decision making based on the access
- individual self-efficacy by the possibility of taking informed decisions
- community participation
- perceived control through social support from community participation and autonomy from informed decision making

To support this process NGOs are often created. They can also support "capacity building", enabling participants to do things, and self-reliance. A person that relies on his/hers own abilities is more free to explore new ideas and independent from constraining traditional economical and social structures (Nikkah & Redzuan, 2010).

In the following two subsections we suggest a framework for analyzing citizen behavior. We reuse the models introduced in the sections above to study and exemplify the activities of a citizen from an information technology and sustainability perspective. The main stakeholders were introduced in figure 2 (citizens, government and suppliers). Activities are described through eco-efficiency, eco-effectiveness, eco-equity and the analysis divided into first, second, and third order effects. The analysis is only exemplified and we leave the full analysis for further research. Here we just introduce a framework for analysis.

The final part of this section presents another model related to the citizen. In this case the purpose is to analyze the different stimuli that could be used to engage a citizen in working for sustainability.

Energy consumption

First order effect of information technology (eco-efficiency, eco-effectiveness, eco-equity)

- Citizen <-> Government: The government controls the taxes for energy. Changing them will be a first order effect. Raising the tax will give incitement for eco-efficiency and eco-effectiveness. Eco-equity can be based on different reasoning. One idea is that families with lower incomes could be given a tax reduction allowing all citizens the same amount of energy to spend irrespective of income.

- Citizen <-> Energy supplier: The citizens could form their own organizations negotiating prices through this NGO.

Similar reasoning and examples can be given also for Second order effects (eco-efficiency, eco-effectiveness, eco-equity) and Third order effects (eco-efficiency, eco-effectiveness, eco-equity).

Transport emission of CO_2

First order effect of information technology (eco-efficiency, eco-effectiveness, eco-equity)

- Citizen <-> Government: The citizens could abandon a political party that threatens to raise taxes on fuels. By buying cars that are classed as environmentally acceptable citizens can point out to politicians that sustainability is a prioritized question.
- Citizen <-> Transport service supplier: The transport service supplier sells petrol to customers. By lowering prices more customers buy more than they usually do and emissions increase.

Similar reasoning and examples can be given also for Second order effects (eco-efficiency, eco-effectiveness, eco-equity) and Third order effects (eco-efficiency, eco-effectiveness, eco-equity).

Stimulating individual behavioral change

Why should anyone care about sustainability? The obvious reason is that caring is a better alternative than not caring. Indirectly or directly we see a loss in quality of life by not acting sustainably. There can be practical reasons such as saving money and/or time, as well as comfort. We have physical, affective, social and other needs and wants. The moral values and beliefs we have form attitudes, behavior and habits. Attitudes matter, but not always and it is not only the attitude that matters. Figure 4, below, is an attempt to summarize the short introductory discussion that follows.

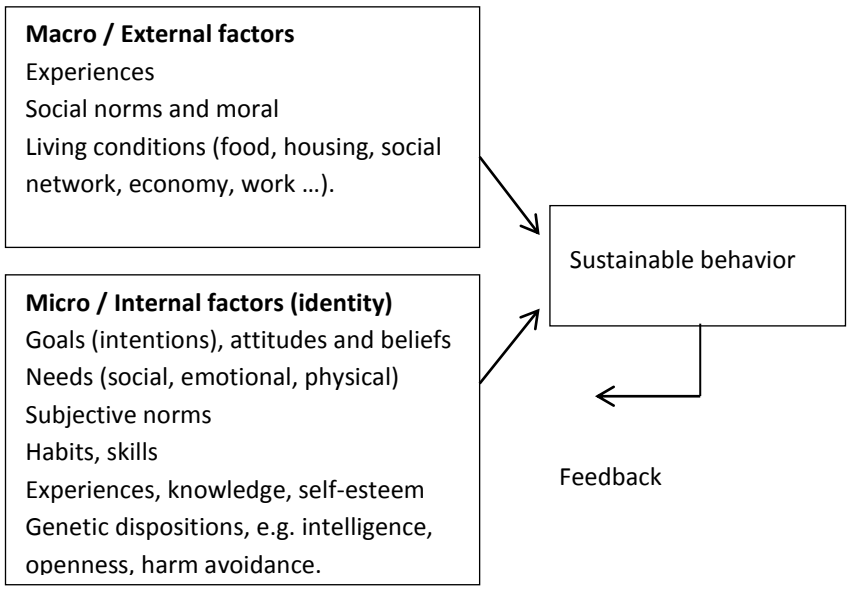

Figure 4. Some factors in the adaptation of sustainable behavior (cf. Jackson, 2005, p. 99-101).

All of these factors help to form a decision in a certain situation. Often both taking the decision and understanding why we took that particular decision is difficult; *"Choice, in these circumstances, is never a straightforward process of individual rational deliberation. Intentions and desires are moderated by social, cognitive, situational and cultural factors."* (Jackson, 2005, p. 99-101). One example where some of the factors come into play is if we get a request for centralized control of our energy consumption. The reason behind this request is that electricity is more expensive at peak load and by remotely turning off our devices at that time both the energy provider with our TV habits and we could earn some money and act sustainably. One problem with this request is privacy. Do we trust the energy provider? Will our neighbors accept the offer and should we follow suit?

To indicate what is involved in individual behavioral change we will sum up some results from a review of research. First we look at details of the individual. A positive attitude and knowledge about environmental problems are favorable for behavioral change. The same goes for skills such as reflexivity, enthusiasm, motivation, curiosity and skills in negotiation. If we instead consider the context of the activity then factors favorable for behavioral change are if the behavior is culturally accepted, publicly visible, supported by a community-based organization, activity locally important, well-funded and competently managed. To be engaging the activity should also concern both social and environmental areas. If we look at mechanisms that stimulate behavioral change social support is important as well as ways of thinking about the problem and potential solutions. Support for discussions on the topic is important as well as standards of behavior to meet and maintain.

Reciprocity and confirmation that even a seemingly small action matters are other methodological components. Finally personal gain, e.g. money, is supportive. A third set of factors stimulating behavioral change is the results of the behavior. To begin with positively changing of other behavior will increase motivation. Perhaps a healthier life style will follow the decision of leaving the car at home some mornings. If the change help others that have the same problem or if it benefits democratic values are other good features. Increased skills, improved physical skills, more and deeper social relations, deeper knowledge, confidence and self-worth ends the list (Middlemiss, 2008, p. 78-93). A model illustrating the problems faced when changing everyday behavior is shown in figure 5.

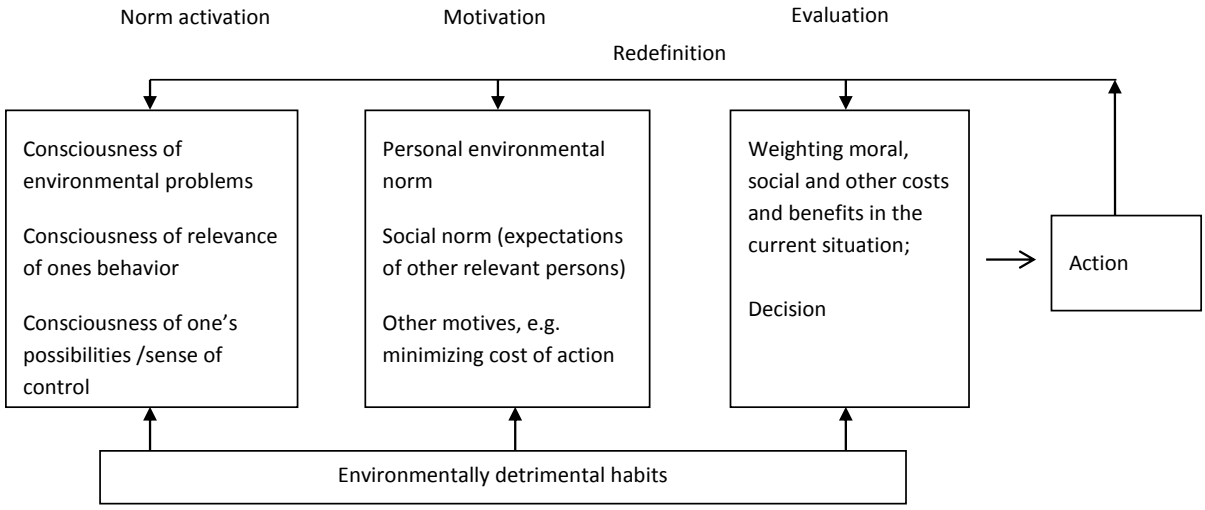

Figure 5. Model of environmentally relevant behavior, adapted from (Fischer, 2008).

The institution - Local community

The local community is important for achieving sustainability. For one thing a majority of humanity now lives in cities and a city demand more organization since many people live in a small area (Steffen, 2011). In fact, urban living can help us reduce our ecological footprints on the same grounds. Efficiency in scaling is applicable, but if it is to succeed the local community must be up to the challenge. In this section we will discuss the local community which we will see as a kind of institution, comparable to a business organization.

In order to make a change for sustainability institutions genuinely must accept the challenge and see this quest as something beneficial with possible rewards such as lower operational costs, competitive advantages, status and recognition in fellow communities, improved public relations, strengthening of brand, better risk management in areas related to sustainability and staying ahead of regulation (Paquette & Wiseman, 2006).

Some tools for improving sustainability are life cycle analysis (LCA, ISO 14000 series of standards). LCA is about analyzing the environmental impact of any activity or product. Another important standard is the new ISO 26000 which is more focused on social responsibility (ISO 26000 series of standards). See reference (United Nations, 2009) for an overview.

Striving for sustainability will affect relationships with many stakeholders, not just citizens. Numerous suppliers, consultants and companies involved in the community will be affected and can be swayed in a sustainable direction. Procedures such as audits of suppliers, benchmarking, demand for

certifications and life cycle analysis of products will have to be implemented. Also there is a need for internal developments shaping up the departments for instance updating their equipment or working methods (Erek et al., 2009). Interactions with peer municipals as well as with government will also change the behavior of the local community, as will be described next.

Stimulating institutional change

To better understand the incentives for a local community to work for sustainability we will present a model from institutional theory. Institutional theory concerns social structures and behaviors and has been used to study institutions' environmental behavior. According to the model, and illustrated in figure 5, institutions are faced with three types of pressures for change, normative, mimetic, and coercive pressure (Chen et al., 2009).

Mimetic pressure comes from other organizations that already have adopted a certain behavior. If a large number of organizations already have accepted the change then the mimetic pressure increases. The pressure will also be high if there is a favorable outcome associated with a new behavior (outcome based) or if there is another, in some way important, organization that has made the change (trait based). Normative pressures instead occur when organizations feel obliged to follow certain cultural expectations society at large or from science. Coercive pressures finally come from powerful stakeholders to the organization. This could be an important citizen groups or the government. Law or industrial standards are typical components in such a pressure (Chen et al., 2009).

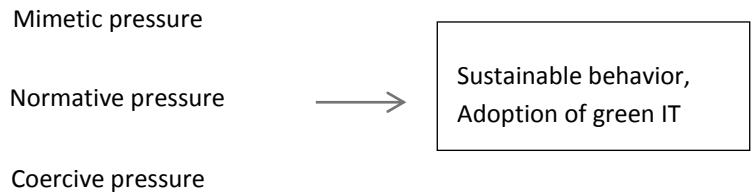

Figure 6. Model of pressures on organization from institutional theory (Chen et al., 2009).

Some means of sense making is needed in order for an organization to understand that there is a pressure in the first place. An information system, as we described above, is useful for this. The problem behind the pressure must then be accepted as a problem, solutions devised (stolen, borrowed or invented), decisions taken and the organization educated on the issue.

A typical main incentive for any organization is cost reduction by more efficiently using resources If possible this is preferred to raising taxes which is not a popular solution to problems. The confidence voters gave at the last election is perhaps the most valued asset in a government at any level so citizen respect is important. Innovative thinking is one way of earning this respect and another could be a transparent planning process where the utility for citizens is more important than political rhetoric. A transparent process gives citizens access to the internals of the planning process (Steffen, 2011). Such transparency could for instance make planning more interesting.

> *"Planning is an exercise of power, and in a modern state much real power is suffused with boredom. The agents of planning are usually boring: the planning process is boring; the implementation of plans is always boring. In a democracy boredom works for bureaucracies and corporations as smell works for a skunk. It keeps danger away. Power does not have to be exercised behind the scenes. It can be open. The audience is asleep. The modern world is forged amidst our inattention."* (White, 1996, p. 64)

A list of objectives and positive outcomes for companies when working with sustainability, valid also for a local community, can be summarized as (Waage, Shah & Girsheck, 2003, p. 81-95):

- Innovation - perceive of, and adapt to, competitive pressures and changing contexts
- Operational efficiency
- Brand equity – attracts citizens and talented employees
- Lower risk – regarding public relations disasters, fines, clean-up costs

With the use of innovative tools for sustainability the following can be gained now and in the near future (Waage, Shah & Girsheck, 2003, p. 81-95):

- Support tracking and compliance with regulations, e.g. through sensor technologies
- Increased eco-efficiency by control and tracking of life-cycle costs
- Enable sustainability-oriented product design by citizens
- Increased knowledge, innovation and creativity by giving access to information
- Engagement among stakeholders for sustainability issues and concerns.

The NGO - Open source

This section will discuss a particular NGO, the Open source community. In the context of this report open source systems are built on top of the current networked information economy, i.e. Green IT. It empowers people along three dimensions fundamental to the open source movement:

1. They can do more by themselves
2. They can do more together by others without the constraints of traditional social and economic organization
3. They can exploit new non-traditional types of organizations.

The fundamental concept of open source is old, really old. Sharing basic ideas of how to make different things such as buildings, food etc. and at the same time handing over the sources on how to make and alter the final product, has been around since the dawn of man. The same was true in the early ages of computer software, when the source code often was distributed along with the end product. Even though software companies started to seal the source and only distributed the retail product that could be installed and used, the idea of free and open software was kept alive. The term *open source* is a relatively late addition to the phenomenon and was coined at a meeting in the beginning of 1998 in in Palo Alto, CA (Bretthauer, 2002; Open Source Initiative, n.d.). Bretthauer (2002, p. 9) state that *"the term was proposed and voted on by a group of people who were meeting on a regular basis in late 1997 and early 1998 and who were interested in spreading awareness of the sophisticated tools that had been developed outside the proprietary software development model"*. A related issue is the discussion about a common on economics where common is used in the sense of *"belonging equally to, or shared alike by, two or more or all in question: common property; common interests."* (Dictionary.com, n.d.; Hardin, 1992).

The idea of open source is rather broad in terms of definition. Property in open source is based around the right to distribute and not the right to exclude, which is otherwise a fundamental cornerstone of property[1] (Weber, 2004). Open source software is based around *"revolutionary new model of software development and distribution, originating from the ideology that software should be free and open"* (Xu & Jones, 2010, p. 69). Benkler (2006, p.63) state that *"The quintessential instance of*

[1] When you buy something and it becomes your property, you usually have the right to exclude someone (or everyone) from using this particular product. This is also the case with software that you develop, using your copyright, you can refrain others from using your software.

commons-based peer production has been free software. Free software, or open source, is an approach to software development that is based on shared effort on a nonproprietary model. It depends on many individuals contributing to a common project, with a variety of motivations, and sharing their respective contributions without any single person or entity asserting rights to exclude either from the contributed components or from the resulting whole". Additional to the, obvious, need for open source to have an free and open source code, the Open Source Initiative (n.d.) have defined several other criteria, that have to be met for a software to be regarded as open source:

- Free Redistribution
- Derived Works
- Integrity of The Author's Source Code
- No Discrimination Against Persons or Groups
- No Discrimination Against Fields of Endeavor
- Distribution of License
- License Must Not Be Specific to a Product
- License Must Not Restrict Other Software
- License Must Be Technology-Neutral

This is a rather technical definition and the philosophy behind open source provides much greater possibilities. Open source has, in general, two characteristic features (Ramond, 1999; von Krogh & Spaeth, 2007, p. 237) (1) a license, as mentioned above, that gives users the right to use, inspect, modify and distribute derivatives of the software and (2) a development process that includes volunteers. The last feature is not a requirement but the development process of open source software is often based on a project leader that initiate the open source project and later on volunteers join the project to take part of different tasks in the development process. These volunteers can be both individual developers and companies with (most often) an interest in the final product or just an interest in the development process.

That most people involved in open source projects are volunteers makes the development model very interesting and much harder to understand than traditional firms with a majority of resources integrated or in controlled strategic alliances (cf. Williamson, 1975; 1985). Research has found that *"the patterns of time spending for developing OS/FS [Open Source/Free Software] show that this activity still resembles rather a hobby than salaried work"* (Ghosh et al., 2002, p. 66). When characterizing successful open source works four principles can be identified (Weber, 2004, pp. 243ff):

- Empower people to experiment. *"This is a familiar concept. To make it work depends on technology (people need easy access to tools) and on socially constructed incentives."*
- Enable bits of information to find each other. *"This is an engineering concept. A diverse set of experiments will produce a little signal and a lot of noise, and in many different places. The bits of information that are signal need to be able to find each other and to recognize each other as signal."*
- Structure information so it can recombine with other pieces of information. *"This is also an engineering concept, an extension of the notion of modularization. Signals need to be essentially to be in the same 'language' so, when they find each other, they can recombine without much loss of information."*
- Create a governance system that sustains this process. *"This is a social concept, often (but not necessarily) expressed in rules and law. The GPL prevents this private appropriation of a solution, which is an important part of what governance needs to do. Governance of a distributed innovation system also needs to scale successfully (organized effectively, more eyeballs really are better than fewer). And it needs to do this at relatively low overhead costs."*

Two parameters specify the type of commons involved (Benkler, 2006). The first separates commons into those who allow anyone to join and those where only a particular group can join. Everyone is entitled to air for breathing so air is an example of an open common or a public good. The second parameter is whether a commons is regulated or not. The rules can be more or less formally described. A sidewalk and a road are typical examples where the rules are more or less formal. Open source (and particularly the open source code) is a type of public goods, which are defined by two common properties – jointness of supply and impossibility of exclusion (Hardin, 1982). One of the problems with the idea behind open source is the logic of collective actions. Olson (1965, p. 2) describes this as: *"rational, self-interested individuals will not act to achieve their common or group interest"*. Basically this implies that large groups are less likely to achieve the goals they have set out to accomplish than small groups. Consequently, this leads to an *"under-supply of public goods"* (von Krogh and Spaeth, 2007, p. 238) due to the free and unrestricted use of the end result. However, by restricting access to the resource and constricting the behavior of the group an open source project could still succeed over a longer time, as Wikipedia has shown (Ostrom, 1990). At the end of the day open source (and other public goods) are common. The success of such projects is due to the different rewards that the participants perceive as a part of such projects (Hardin, 1982).

According to Bretthauer (2002, p. 3), *"the philosophy of open source is based on a variety of models which sometimes conflict; indeed it often seems there are as many philosophies and models for developing and managing OSS [open source software] as there are major products"*. In the essay *The Cathedral and the Bazaar*, Raymond (1999) describes two different models for development of free software – the Cathedral and the Bazaar model. In the Cathedral model the source code is developed in a restricted closed group and is released with each version, whilst in the Bazaar model the software is developed over the internet and the source code is continuously viewable for the general public. These two models are often connected to two different types of open source communities – the ones sponsored by corporate organizations and autonomous communities (West & O'Mahony, 2008). A crucial difference is the control of the end product. While in autonomous communities' open source projects are driven by the individual participants' personal goals to be part of the project, corporate organizations open source projects are driven by a desire to retain some control of the end product. West & O'Mahony (2008, p. 162) argue that *"on the one hand, firms wished to retain control over technologies fundamental to their business success. On the other hand, providing the opportunity structure for others to participate was a prerequisite for gaining the benefits from developing an external community. Thus, when designing a participation architecture, firms mediate between surrendering control and offering opportunities for outside participation that could lead to community contributions and growth"*. Hence, it is important to take all independent contributors personal interests and values into account when deciding if and how to create an open source community to co-develop a product since *"sponsored open source software communities are fundamentally different from autonomous communities in the potential for goal conflict between sponsor and community members"* (West & O'Mahony, 2008, p. 163). Nevertheless, the two main rewards identified when volunteering in open source projects - career and ego gratification incentive (Lerner & Triole, 2002), do not fundamentally collide with the idea of sponsored open source projects. Participating in sponsored projects might strengthen the career possibilities and, depending on personal values, affect the ego gratification since the peer network might be experiences as similar even though there is a corporate sponsor. The value that a corporate firm gets is a tricky business when it comes to open source and is to some extent similar to the values a firm perceives when engaging in collaboration.

Incentives for development of open source communities

In this section we introduce a simple model that will be refined later. The model is shown in figure 7 where two levels, macro and micro are illustrated. The macro level corresponds to the perspective of an organization, e.g. a company or local government, on a collaborative project while the micro level models the individual participants' view on the project. The model is deceptively simple and is directly

compatible to the model by Melville (2010). (1) Social structure, norms and patterns inform individuals on how to behave. (2) The information and the current situation are evaluated and cognitive states, beliefs, attitudes emerge. (3) In the third step this evaluation results in activity of individuals. The combined activities make up the behavior of the whole system.

Each of the arrows represents a substantial area of research and the model can be extended by assuming several concurrent social structures that the individual relates to, e.g. family, work organization, and nation.

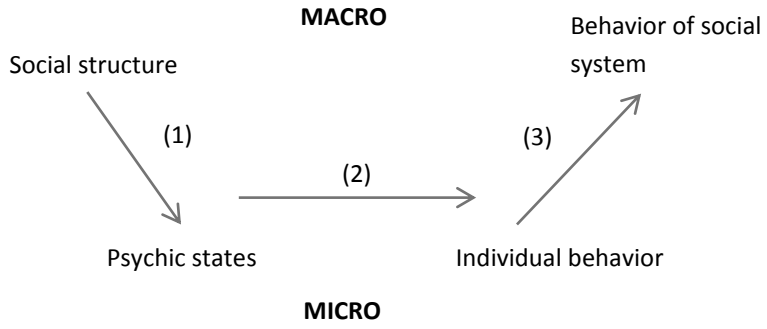

Figure 7. Model of organization-individual interaction.

One example of where the model can be applied is when the people behind mySociety provide tools aiming for democracy and transparency of the UK government. The two objectives of mySociety are described as: *"The first is to be a charitable project which builds websites that give people simple, tangible benefits in the civic and community aspects of their lives. The second is to teach the public and voluntary sectors, through demonstration, how to use the internet most efficiently to improve lives."* (mySociety, n.d.).

Macrofoundations

This section takes a top down view on open source, i.e. taking a macro view on opens source. How it is organized and what motivates supporting it. The section continues the discussion on citizen driven innovation.

One hypothesis is that open source is a necessity for future business. *"The expectation is that there is now in operation a law of asymmetric competition, which hypothesizes that any for-profit company that does not integrate participation, is at a competitive disadvantage against those that do, and that any for-profit entity that is faced with competition from a for-benefit entity, will have a difficult time to survive."* (Bauwens, 2007).

According to Bauwens (2007), three forms of peer-to-peer production can be identified (figure 8). There is one relationship illustrated by a dashed arrow between the developer's community and the users community. This indicates the close relationship / overlap between the two communities. In the right hand site of the figure a relationship between the open source object and a code base for the object is shown. The code base could be code from another open source project or it could be a (de-facto) standardized component such as an API or a protocol.

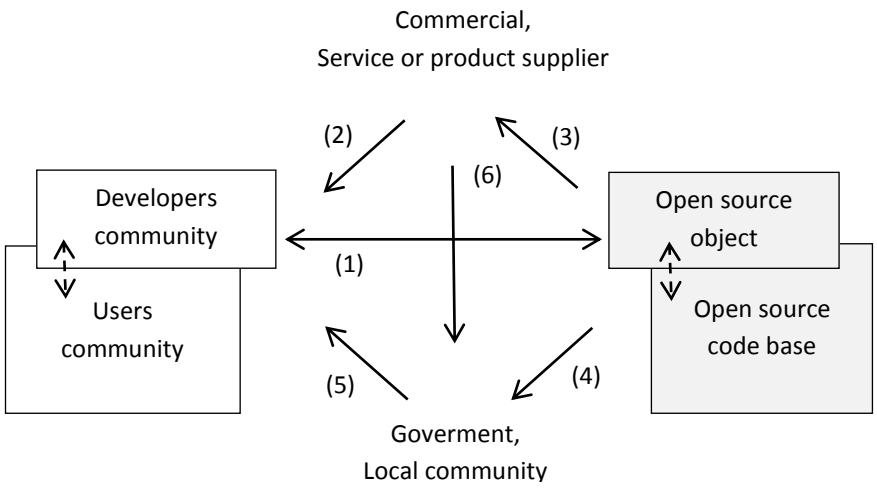

Figure 8. Relationships for different open source projects, Sharism, (2, 1), Commonism, (1) or (1, 3, 6) or (1, 4), Crowdsourcing (2, 1), or (5, 1).

(1) Sharism: Proprietary platforms are used to by creative individuals to create additional values. One example here is the social web platforms. In the figure, above, this type of production typically corresponds to the links (1) and (3). It is possible that a more offensive local community could follow the (5, 1) production. In this case the local community needs a code base / API to start from, preferably a standardized one. This base could be either commercial or open source, i.e. via (6) or (4). Many other arrangements are possible, some of which might not have been tested. The figure could serve as a basis for strategic discussions on open projects, we leave this as an exercise to the reader.

(2) Commonism: Here commons are created by self-organized communities. The result might be exploited by companies for profit. Examples are Apache Foundation, Mozilla Foundation, Wikimedia Foundation. The companies might add new components to the common base of resources. The typical paths in the figure below are (1) or (1, 3, 6) or (1, 4). Here the Bazaar and Cathedral models discussed previously can be mapped into the figure.

(3) Crowdsourcing: The idea is to outsource a task publicly evaluating the eventual results, perhaps awarding a price for the best solution (Bauwens, 2007; Brabham, 2009). There are also more general tasks assigned to crowdsourcing, such as marking up images on Facebook. This has for instance been used on the planning process for public transportation and by Innocentive.com. Paths in the figure could start either as a commercial initiative or as a governmental one, i.e. paths (2, 1), or (5, 1). If the result is not available as an open source object it is not an open source project, but rather an open peer-to-peer development project.

A successful project needs to survive over a longer period of time. In order for a community to continue working on a project the must be no incentives to fork, norms on ownership and decision-making must be established and there have to exist a viable technical solution to the problem (Weber, 2004). To survive the open source community also cannot ignore the regulatory framework: *"open source needs to interact, deeply and effectively, with existing structures of capitalist economies and legal structures like copyright, patent law, and licensing"* (Weber, 2004, p. 18).

There are other ways to think about commons and the contributions by an open source community: *"Heller and Eisenberg call this [substitution of existing but by ways of intellectual property rights unavailable resources] 'the tragedy of the anticommons' to distinguish it from the routine under use that is a part of any functioning intellectual property rights system (and is justified as a bargain for*

incentivizing production in the first place). This is not just theory; it is an increasingly visible problem - for example in pharmacogenomics research in which complex and overlapping patent claims on genetic code make it difficult to assemble the package of rights needed to produce a drug." (Weber, 2004, p. 245). Another argument on commons is that: *"the participation in creative activity by individuals, simply for the sake of participation itself. In other words creative action is an individual good regardless of whether it contributes to measurable aggregate creativity, innovation or social welfare. […] We value the explosion of individual creativity facilitated by the web even though the vast majority of what is 'published' there adds little that is measurable to society's stock of knowledge."* (Weber, 2004, p. 246).

Microfoundations

Success of an open source project is more likely if the developers and the project have the following characteristics (Weber, 2004):

- Contributors can estimate the possibility of success of the project
- A potential contributor can assess the possibility of making a contribution
- Developers have longer term motives that are beyond economic gain
- Developers learn valuable knowledge by doing
- Participants are positive toward the process.

In many cases an individual developer chooses between two different scenarios – giving away the result and end product for free or keeping the result private. According to Raymond (1999) there is evidence of higher future returns when giving the result away for free since this can encourage other developers to do the same with their results and products. This, consequently, gives each individual developer a higher reward since a larger common knowledge is created, which can be used by each and every one of them.

The rest of this section discusses some of the benefits and motivations for participating in a collaborative open source project. Previous work (e.g. Dalle & Dauphine, 2003; Lerner & Tirole, 2002; Raymond, 1999) on open source discuss the reward a participant in an open source project gets and Lerner & Triole (2002) identify two major incentives – (1) the career concern incentive and (2) the ego gratification incentive. This refers to that the participants may benefit from taking part of the project by receiving e.g. job offers or access to venture capital. The ego gratification is also important and reflects the need for peer recognition. Also, the lack of contribution to a collaborative project may result in so-called social punishment, i.e. loss of reputation, shadow of future collaboration and other social and psychological influences (Cai & Kock, 2009). These incentives are both potential future rewards and not something that can be expected when entering the project. This can be associated with the 'self-interested individuals' that Olson (1965) describes. Which one of these two incentives that is to be regarded as most prominent differs between different researchers. Zeitlyn (2003) suggests an approach to clarify the gratification of open source software by comparing the development process to how a family works, with no calculated economic relationships but rather a situation were different individuals benefit from different actions divided over time. Even though there are key factors that can be observed the general knowledge of motivations among open source developers is still in an early stage (e.g. Sauer, 2007; Zeitlyn, 2003).

Figure 9 shows some factors involved at the micro level, compare figure 4 where factors for adapting sustainable behavior were presented. Note that many factors are of a social nature.

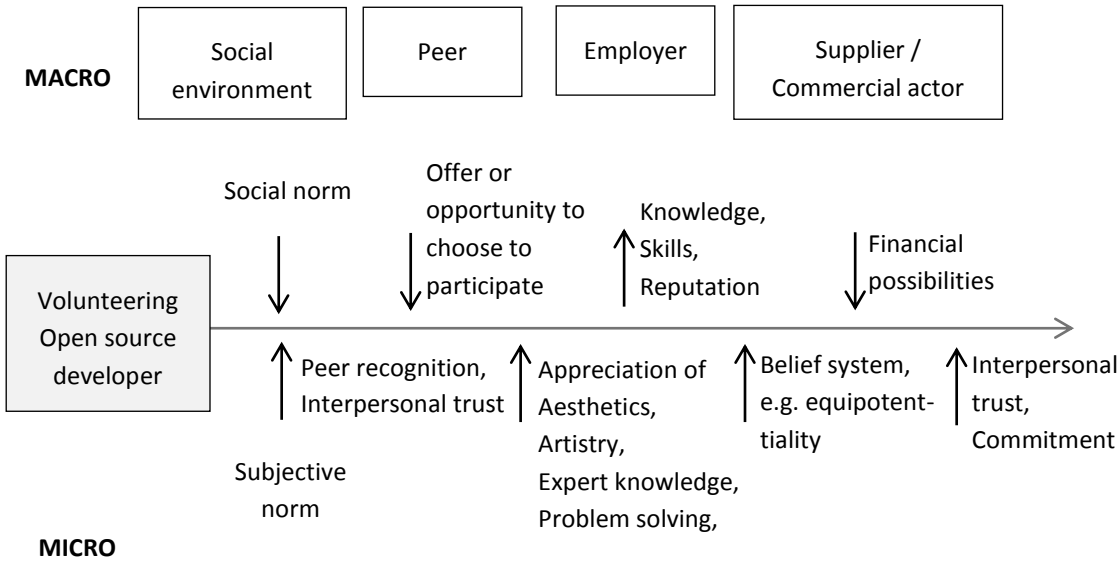

Figure 9. Factors affecting the individual developer during an open source project.

The Identity of the open source developer could include strands of the following. An altruistic motivation concerning art and beauty, the artistry and joy of solving complex problems and the enjoyment of participating in an innovation process. A particular area can be interesting enough for an individual to be both a job and something that he or she spends spare time on. There might be benefits at work from the expert knowledge gained from this, but motivation could also be a joint enemy, e.g. mistrust of authority in general, ego boosting and building a reputation for some other social reason. Some belief systems are supportive, for instance a belief that information should be free, that people should be judged by what they do, the necessity of cooperative relationships or a belief that experimentation is the highest form of human behavior.

There is a case for intrinsic positive motivation: *"Passionate production is based on the voluntary engagement and therefore structurally eliminates coercion. […] Motivation studies show that the most productive form of motivation is the intrinsic positive format, surpassing intrinsic negative and extrinsic positive in its results. Peer production structurally weeds out such motivations retaining only intrinsic positive 'passionate' motivation."* (Bauwens, 2007).

Self-selection of the task is important: *"Peer production is not organized as a predetermined division of labor, but on a modularization of granular tasks that can be self-selected. Individuals will naturally select those tasks for which they feel an interest, a fitness and for which they think they have the requisite skills. Less appealing tasks are not concentrated but are distributed as well, and can be taken up by volunteers. Some peer projects require that the less appealing elements of a task are supplied together with the rest of the contribution, thereby insuring a fair distribution of the unappealing requirements."* (Bauwens, 2007). Furthermore equipotentiality and anti-credentialism are important factors: *"The self-selection task is associated with a particular vision of the human and a particular form of evaluation judgment, based on the concept of equipotentiality. Anti-credentialism signifies that there is no longer a strong separation between the informal and formal curriculum that an individual represents. What count is demonstrated ability, not prior formal proof. It is therefore based on the goal of inclusion rather than a mechanism of exclusion. […] Individuals are no longer judged on any kind of 'unified essence' but are recognized as complex*

beings, and the granular self-selected tasks will those that the individual judges to correspond to a particular skillset. This is the principle of equipotentiality." (Bauwens, 2007).

For citizen interaction with a community-based organization to work well it is important that there is strong social interaction and mutual trust. A strong sense of identity in the surrounding community makes behavior easier to change as well as if the community provides resources for the process (Middlemiss, 2008). In all forms of cooperation, trust between partners and commitment to the project is essential for a successful outcome (Lynch, 1990; Morgan & Hunt, 1994; Sherman & Sookdeo, 1992). In many cooperative projects between companies trust and commitment can partially be controlled using formal agreements etc. by controlling and limiting the risk in the project between partners (Child, Faulkner & Tallman, 2005; Das & Teng, 1998; Geringer & Herbert, 1989; Medcof, 1997). However, in volunteer projects the idea of using agreements to control independent developers may not be a fruitful path to success. Consequently, open source projects rely heavily on the individuals involved in the project and the communication in the project group - interpersonal trust is a key factor (e.g. Child, Faulkner & Tallman, 2005; Moorman, Deshpandé & Zaltman, 1993; Morgan & Hunt, 1994; Narayandas & Rangan, 2004; Young-Ybarra & Wiersema, 1999; Zaheer, McEvily & Perrone, 1998). The fundamentals of open source radically limit one of the greatest dangers when getting involved in collaborative projects, opportunistic behavior (Das, 2005; Gnyawali & Madhavan, 2001; Gulati, Nohria & Zaheer, 2000; Hamel, 1991; Williamson, 1975). Having an open source license, eliminating that someone claims restricted access to the end product, lessens the dangers of someone taking advantage of the decentralized and collaborative production.

Collaboration, co-creation and Innovation

The hypothesis in this report is that open source working methods and results can contribute to the sustainability work in the community. A bonus would be if the citizens are the ones contributing in the open source project. This could work at any level at the community, but presumably collaboration should be easier to achieve in a local community.

In open source projects the actual consumers of the final product are most often also involved in the development process. Even though not fundamentally stated, open source philosophy is based on the concept of creating value together – so-called co-creation. Co-creation is typically used in the context of creating a continuous stream of joint firm-customer value, which is closely related to the service dominant logic (Vargo & Lusch, 2004a; 2004b; 2006), this theoretical framework proposes that the value creation occurs when customers actually consumes products (or services). This is a customer centric approach that makes it more important to focus on the value that the customer experience and render possible to personalize the experience when consuming a product to maximize the perceived value. Co-creation and even the dialog between a firm and its customers or in-between a firm' customers have historically been a tricky business and has most often been controlled by the firm. However, the rise and spreading of the Internet and global and cheap communication in the late 1990s facilitated firm-customer and inter-customer communication, dialogs and development.

Technologies give different possibilities; they promote culture and will be used in different ways in different cultures. One possibility is that internet can be used to promote commons, i.e. where people share something. (Benkler, 2006). The internet also allows for new types of commons to be created. Efficient decentralized collective action practices tailored at the problem at hand. IT *"provides a platform for new mechanisms for widely dispersed agents to adopt radically decentralized cooperation strategies other than by using proprietary and contractual claims to elicit prices or impose managerial commands"* (Benkler, 2006, p. 63). Prahalad & Ramaswamy (2000, p. 80) emphasize the importance of the Internet as "*consumers have been increasingly engaging themselves in an active and explicit dialogue with manufacturers of products and services"*. Even more

important for co-creation and open source is the shift of the ownership in the dialog as the "*dialogue is no longer being controlled by corporations. Individual consumers can address and learn about businesses either on their own or through the collective knowledge of other customers"* (Prahalad & Ramaswamy, 2000, p. 80). Hence, the control and power of the dialog has shifted from being controlled by the firm to being controlled by the consumer. This is most prominent today in social media. The ideas that Tim Berners-Lee (1999, p. 169) had in the early days of the web was that it would become "*a much more powerful means of collaboration between people"*. Today we live in an era that makes all this possible and, what is popularized as, Web 2.0 is all about "*harnessing collective intelligence*" (O'Reilly, 2005). User generated content (e.g. Blackshaw & Nazzaro, 2006; OECD, 2007) and co-creation is a common and daily part of the life of the web, as in the endless amount of open source projects carried out each day. Tools built on collective intelligence are already common, e.g. Wikipedia, and there is no reason why this development should not happen in the sustainability field also, given an open society. *"A particular challenge is to make the steps used in quantitative and qualitative analysis visible and open, to allow massive collaboration, so that a broad community can collaboratively test and tweak the assumptions, see how those assumptions are used in the analysis, and to link steps in the analysis to sources of evidence."* (Easterbrook, 2010, p. 102).

Open sources is not only a phenomenon among individual developers but also a business model for firms and potential development model for local communities. Discussing the philosophy behind open source in a firm's perspective is not that different from a small individual developer, however, the size of the project often differs. A key factor of many open source projects is the collaboration between different actors and open source is one way for a firm to collaborate to reduce the risk in a project.

Open source projects are basically decentralized intellectual collaborative projects to solve some kind of problem that according to the participants (or a commercial sponsor) needs to be solved. The collaboration is an important part of the open source movement and a critical factor behind the success of this model for development. The high modularity that is a foundation of open source *"militates in favor of specialization and the effective use of local knowledge… if we do not subdivide tasks, everyone must do everything, which means that everyone must know how to do everything"* (Langlois & Garzarelli, 2008, p. 131). In general there are quite specific reasons to why several independent actors decide to collaborate and this is, of course, also the case for open source. Even though there might be differences between open source projects and commercial businesses, there are fundamental similarities, such as the need for some kind of reward. Previous research has shown collaboration, or cooperation, as an important strategic path in business (e.g. Gulati, 1998; Jarillo, 1988; Mejtoft & Nordin, 2007; Todeva & Knocke, 2005). Faulkner (1995) suggests several common external forces that explain why a cooperation is to be preferred (in contrast to e.g. vertical integration) – turbulence on the market, economics of scale and scope, globalization and regionalization, fast technological changes, shorter product life cycle and high economic uncertainty. These forces all create unstable conditions, which makes it harder to anticipate future changes and, consequently, how to invest and which resources should be controlled within a firm. In today's economic and technological climate many of these factors affect most industries and communities around the world each and every day and are something the favors collaborative projects, such as open source projects. Collaboration in open source can, simplified, be broken down in two different collaborative models – collaboration during the initial phase and collaboration to refine the product over time. While some open source projects have been developed by an individual, the open source license and popularity of some products have turn it into a collaborative project over time. The magnitude of some open source projects today makes the collaboration complex and Langlois & Garzarelli (2008, p. 125) state that the collaborative model of open source resembles a hybrid between the bazaar *and* the cathedral models *"manifesting both voluntary production and conscious planning"*. One important thing about open source development is that the individual tasks of different collaborators arise from their voluntary choices (Langlois & Garzarelli, 2008). Hence, the collaborating effort might have a disadvantage due to the lack of central control and ability to hand out

task to be completed. Hence, it is important and often needed to create an organized structure even for autonomous communities. Even though it is difficult to control the development when engaging in open-source projects, *"treating your users as co-developers is your least-hassle route to rapid code improvement and effective debugging"* (Raymond, 1999, p. 27).

Work on open source favors another phenomenon in the industry, cooperation between competitors. In many global (and sometimes local) industries collaboration between competitors is possible, since the same actors can collaborate on certain tasks and compete on others (Lou, 2004; 2007). This is common when an industry consists of a few strong actors, such as the telecom, airline and automobile industry. Even though strong competition in an industry in general favors the formation of alliances (Eisenhardt & Schoonhoven, 1996; Shan, 1990), competition between companies is a difficult task to handle when discussing cooperation. One example closely related to open source, from the telecom industry, is the software company Symbian, which was a joint effort between SonyEricsson, Nokia, Panasonic, Samsung, Siemens and Sony Ericsson (Symbian, 2006). While these companies cooperate in developing the platform Symbian OS, they are also fierce competitors regarding their end products. However, this case of coopetition ended when Nokia decided to acquire Symbian from the other partners. With several new mobile OS for smart phones, the competition today is rather between the rivalling mobile OS, such as Android, iOS, RIM and Symbian, than between the mobile phone manufacturers.

Innovations process

Innovation and innovative processes are complex issues. Whether the initiative comes from the local government or from a particular citizen the system development of innovations can be more or less user centered. According to Hallqvist (2010), the following four levels can be identified:

- User focus – development process is supported by knowledge from users (consultative)
- Work-centeredness - development process is supported by knowledge from work situation
- User participation - development process is supported by user participation (representative)
- System personalization – the resulting system can be modified by the user to suit him or her.

This is a classification of to what extent the innovative process is supported by users. In the case for participation, it can then be further elaborated as:

- Type of participation (all users or representatives);
- Degree of participation (level of responsibility for the participants)
- Content of participation (involvement in different design aspects)
- Extent of participation (variation in scope in different phases of the development process)
- Formality of participation (formal or informal organization of participation activities)
- Influence of participation (effect of participation on the development effort).

Since participation, as discussed in this repost, is also a political process it is important to be careful. Three questions could, and should, be asked before deciding if participation is appropriate in the present project (Hallqvist, 2010):

1. What is the political and cultural context?
2. Who wants to introduce participation, and why?
3. Who is participation sought from? Do they want to, and can they, participate?

Also, the participating end-users should carefully consider the pros and cons of joining a common project since *"management often perceives participation as a cheap solution to problems of low productivity, high absenteeism, poor quality, and conflict with the workforce. [...] developers might have working life democracy ambitions that clash with managerial reasons for participation. These questions imply that user participation is not self-evident in any situation; instead we need to elaborate on the context of participation, when to propose user participation, for whose reasons participation is suggested and by whom"* (Axelsson, Melin & Lindgren, 2010, p. 303). Currently user participation is quickly explored and many possibilities are open. One intriguing suggestion is a *"shift in how we view citizen involvement; going from discussing how governments should involve citizens to discussing how citizens will involve governments in their networks. There is a possibility that these societal changes will enforce citizen participation and involvement in e-government issues"* (Axelsson, Melin & Lindgren, 2010, p. 317).

Democracy can be seen as giving the means and responsibilities for development to a few that decide where to spend resources and where to develop a community or a nation. Missing in this description is the possibility of direct citizen participation in the development process, and in particular when exploring new innovative ways of living.

> *"User-Innovation means that lead users develop innovations that they need, then make it freely available. Lead users foreshadow a more general demand. But the concept should not obscure the fact that many users innovate, and that such innovation is distributed amongst different players offering incremental parts of the solution."* (P2P foundation, 2010)

The user/citizen innovation process could start by one individual developing an idea into a prototype or a concept. This is diffused through networked media and a community is formed around the idea that develops it into a working prototype. As a complementary step there could be some commercialization of the idea to a product (Hippel, 2005). Some pros of this process is that citizens can develop the idea into something that is exactly what they want for situations they are experts on, they do not have to start from the beginning because they can reuse innovations developed and shared by others. There are indications that "*users are the first to develop many and perhaps most new industrial and consumer products. Further, the contributions of users are growing steadily larger as a result of continuing advances in computer and communications capabilities."* (Hippel, 2005). Furthermore user communities are efficient. They *"can increase speed of innovation, implementation, test and dissemination of the result. There are also social benefits of communities."* (Hippel, 2005). Also when it comes to adapting a product or a service user innovation is a key. *"Most aesthetic innovation takes place 'after' production. It happens 'after' the wage labour relation, in consumption, in communities, on the street, and on the school yard."* (P2P foundation, 2009).

Manufacturers know the solution approach and they have resources at hand such as technology and business know how. Why then not hire an external expert? For one thing experts need clear specifications and need to be monitored. The expert must be trusted to work for the right goal, keeping the costs down. Experts are not interested in minimizing costs, quite the opposite. The expert will build valuable information on the project that will not be accessible to the community. A potential problem could be intellectual property rights and patents (Hippel, 2005).

How can government support such innovation? To start with they can acknowledge and measure the effects of user s' contribution. They can also support infrastructures such as open standards, collaborative tools and open up for communication. Finally they can remove or at least adjust regulatory frameworks that hinder citizen participation (Hippel, 2005).

The guiding principles of the vision of innovation by user participation are (P2P foundation, 2011):

- In a networked society, Investment is about sharing beliefs, leading towards decentralized financing platforms.
- In a networked society, Design is about sharing ideas, leading towards a common design vocabulary.
- In a networked society, Production is about sharing tools and workshops, leading towards flexible, small-scale production
- In a networked society, Retail is about sharing interests, leading towards a reconnection between makers and buyers.
- In a networked society, Consumption is about sharing experiences, leading towards customer-driven innovation.
- In a networked society, Recycling is about sharing materials, leading towards closed material cycles

Tools

This section will look at some tools for managing energy consumption in the home and supporting public transportation.

Energy preservation

"If you can not measure it, you can not improve it." / Lord Kelvin

This section will discuss energy conservation through displays: A general discussion on displays will be followed by discussions on some ongoing projects, some of which are open source. The idea explored is that feedback on consumption via the display will change attitudes and behavior. The main ideas can be described in the following way. *"Feedback has a role, the argument goes, in bridging the gap between concern and action, by giving energy users a sense of efficacy, more important to most people than an abstract sense of moral obligation [...] If individuals can experiment with energy in their homes or workplaces and see the consequences of their usage through frequent meter reading, improved billing or some sort of dedicated display, the research literature demonstrates that they increase control over their consumption. The conservation effect varies according to circumstances, but participants in feedback trials have typically reduced their energy consumption by up to 10% when given 'indirect' feedback (processed for them and presented through a bill or statement, or via the web) and between 5 and 15% when they use 'direct' feedback."* (Darby, 2008, p. 71). Even though a display and feedback can support energy conservation there is no guarantee and a complementary contact with an advisor when needed along with training and social infrastructure are complementary activities (Darby, 2008). We could compare the current situation with no real-time feedback on energy usage to the situation when we go shopping and there are no visible prices in the grocery store. We just get a bill at the end of the month (Helft, 2008).

Additional benefits when implementing real time feedback are a possible change of relationship between consumer and energy supplier. The supplier hopes to sell additional services, get rid of manual meter reading, and be able to convince the customer to avoid using energy at the peak load of the day. The customer gets bills based on actual consumption rather than bills based on estimates of usage. There are also no more problems with manual readings of the meter. From a governmental perspective the hope is that energy consumption will be reduced (Darby, 2008).

At an abstract level, what is gained by the energy display is energy literacy. *"Energy literacy is the understanding of energy concepts as they relate both on the individual level and on the national/ global level. Solving the world energy crisis will require everyone to understand how energy is*

generated and consumed, so that they can make more informed choices in their lives and as informed citizens involved in their communities. Defining and assessing energy literacy are therefore keys to any attempt to improve energy literacy." (Brewer, Lee & Johnson, 2011).

Previously we listed a number of factors for stimulating a change towards sustainability. In the context of designing and adopting energy displays they are all relevant. However, isolating and prioritizing the factors in any particular context is not easy. A typical subset of factors are (Jonsson & Bylund, 2011):

- Emotional bonding, e.g. referring to the polar bear on the melting ice
- Adaptive muddling, acting upon a certain role in an attempt of bringing about a change
- Committing the users to formulate private commitments and telling them that the results will be publicly available
- Teaching others, typically both the student and the teacher increase their understanding
- Social comparison, e.g. setting an example for others
- Competition
- Personalized information
- Loss over gain, visualizing the loss rather then what the user has gained is more powerful
- Choices, giving users choices could increase engagement
- Challenge to understand
- Ecological arguments, supporting peoples' beliefs, e.g. living in harmony with nature.
- Financial arguments, of course.

Features of the display

The following is a list of typical features of a display (Anderson & White, 2009):

- A clear analogue indicator of current rate of consumption
- Current rate of consumption as measured in money (numeric, power as an optional unit)
- Cumulative daily spending (numeric)
- History of spending last seven days, day by day, last complete week, last complete month
- The historic periods should match the utility's billing periods
- Mains-powered but have an internal battery to enable mobility in the home

The energy display must make energy and energy consumption visible and comprehensible to the user, Furthermore the measurements should build on what the user already knows about their home, routines and practices. User interest must be kept for a long time, which means that the information must be useful and the interaction allow for learning. Finally the display should work both as an ambient display showing the most important data at a glance and also be possible to use for detailed interrogations (Anderson & White, 2009).

Example from Umeå

A residential area was built in 2010 and the apartments included an energy display called Echolog that was placed in the hallway. The display shows a weather forecast as well as the amount of electricity, hot- and cold water consumed in the household. The start screen is shown in figure 10.

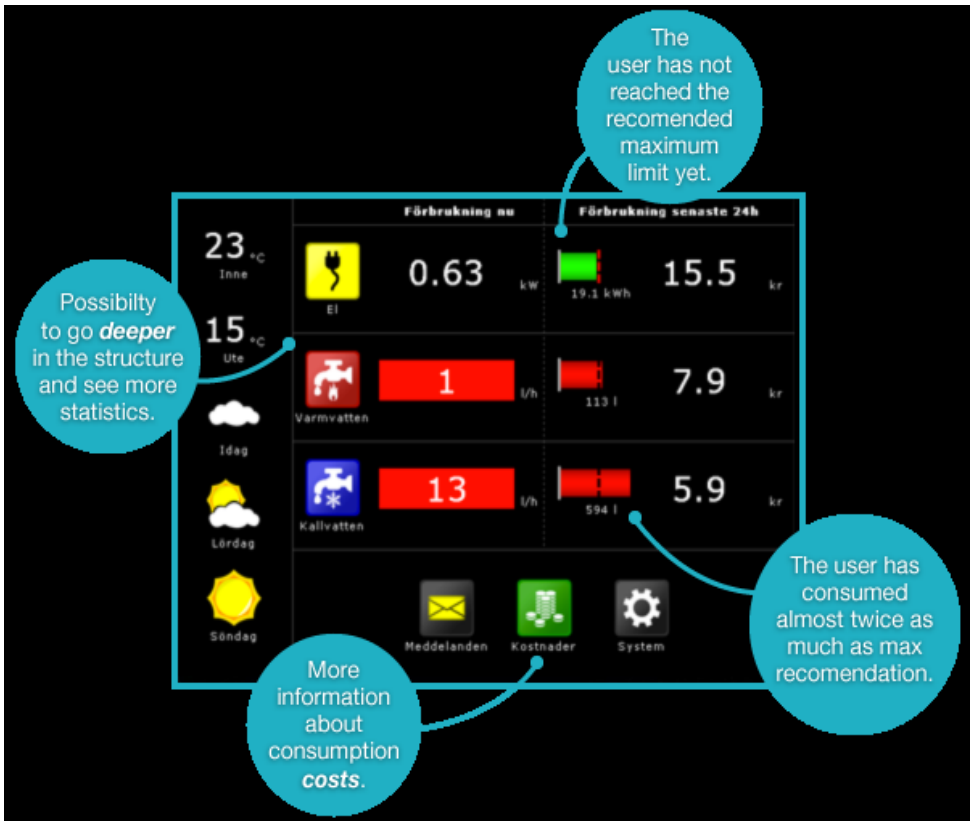

Figure 10. This is the start screen of Echolog, showing the current consumption status (Jonsson & Bylund, 2011).

There is still much to learn about how to build displays that change behavior: *"In particular, we highlight a lack of research investigating: (i) the effects of feedback on specific behaviors, attitudes, and understandings of users (e.g., what specific behaviors account for the measured reductions?), (ii) the effects of feedback on individual 'experience' (e.g., is the implemented system subjectively experienced as pleasing, engaging, desirable, useful?), (iii) social and cultural factors related to feedback (e.g., how does feedback affect social relations within the home?), (iv) factors related to domestic consumption in terms of everyday practices (e.g., how is the system symbolically and materially 'domesticated' or appropriated over time by users?), and (v) broader critiques of energy feedback research including the philosophical assumptions underlying the research (e.g., what is meant by 'effective'?, and what precisely are 'sustainable energy systems' attempting to sustain?)."* (Pierce et al., 2010).

Sometimes the user will refuse to change: *"Another crucial finding of both of our studies has to do with the 'non-negotiability' of many domestic interactions and practices—a term which owes to Elizabeth Shove's sociological investigations of everyday 'inconspicuous consumption'. For example, we described how one participant was surprised at how much energy the dryer consumed yet was unwilling to alter this practice: 'I'm not gonna not wash my clothes!' Examples of this nonnegotiability abound in both of our studies. Such examples point unambiguously to the fact that awareness does not imply conservation action. This is not to suggest that certain practices are in fact incapable of being altered; indeed REFS [energy displays] can and should aim to re-configure 'nonnegotiable' practices. Rather, REFS must seriously take into account the non-negotiability of everyday practices and the power of habit."* (Pierce et al., 2010).

A variation of the rebound effect is in play when displays: *"actually work against intended goals such as reducing consumption, as well as against other goals of sustainability. For example, installing a*

feedback device on the automatic clothes dryer may help negate its being displaced by the clothesline. Implicit in the act of monitoring the appliance is the assumption that people will use it rather than, for example, switching usage by drying clothes on a clothesline. Similarly, presenting dwellers with their 'baseline' may actually encourage the sustainment of the baseline rather than more drastically challenging the amount of energy demanded by dwellers" (Pierce et al., 2010).

One example of an open source solution for display of energy consumption is Wattdepot which *"is designed to collect, store, and analyze data from a wider range of locations using the Internet as the transmission mechanism, and our performance analysis tests indicate that it can easily process several thousand sensor data storage requests per minute given adequate network bandwidth. Our goal for WattDepot is to provide a mechanism to accelerate innovative research and development in energy analysis and visualization by providing an extensible architecture and well documented, open source software platform"* (Brewer, Lee & Johnson, 2011). There are also other attempts to solve the problem, for instance Oshan (http://sourceforge.net/projects/oshan/) and of course several commercial alternatives such as Hohm by Microsoft (http://www.microsoft-hohm.com/).

The basic idea is to collect data from meters that are sent by Wattdepot sensors to a server. The user can run client software to inspect the resulting statistics. A similar project is Google's PowerMeter which focuses on single homes (figure 11).

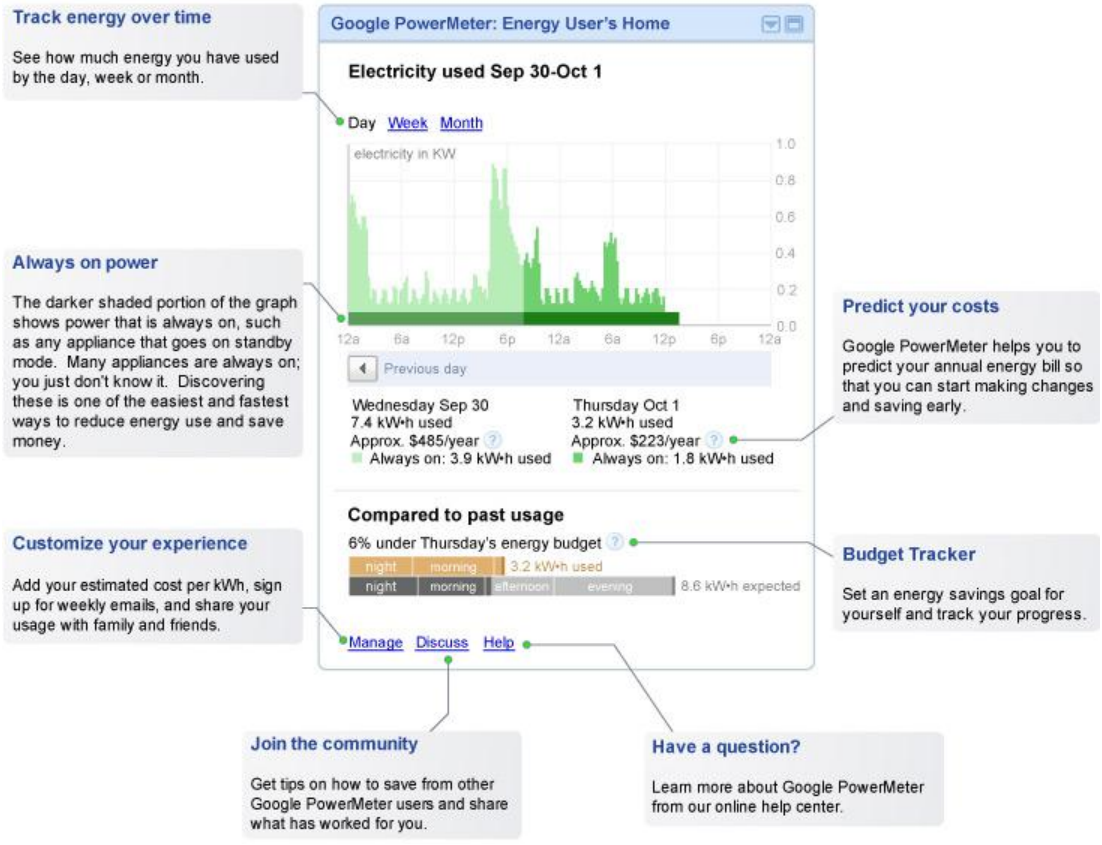

Figure 11. Google's PowerMeter user interface (Google, n. d.).

Typical benefits when working with open source is platform language and meter neutrality. Brewer says that; *"To avoid platform lock-in, we develop all components using technologies such as Java, Python, Javascript, and Google Visualizations that are available on Windows, Macintosh, and Linux platforms. To avoid language lock-in, the system observes a service-oriented architecture, where components communicate with each other over HTTP via a RESTful API. This isolates language*

dependencies to individual services. Finally, to avoid metering technology lock-in, the system architecture involves 'sensors' that query any given meter using its native protocol, which then translates the data into a common format for use in the rest of the system. Thus, adapting the system to a new meter technology simply involves implementing the sensor for that technology." (Brewer, Lee & Johnson, 2011).

Use of display

Adding new equipment in a home is challenging since *"the habitat of the household is messy, often irrational, lacks certainty, carries risk, and contains constantly shifting and changing expectations and norms. Although smart metering interventions enter the field of domestic life, the tools and information they provide are still firmly embedded within the logic of energy or water management"* (Fischer, 2008). Comfort and cleanliness are two examples of social norms. Two or more showers per day do not affect health but significantly affects energy consumption. However, there are clear social opinions on sweat, body odor and dirtiness (Strengers, 2008). The relationship between behavior and technology (equipment) is often complicated and descriptions oversimplified which the following example illustrates (Wilhite, 2008):

> *"[S]aving space was also an important motive for the first generation of refrigerator purchasers in the 1950s. Interest in the refrigerator was slow in developing […] as late as 1970, only 60% of the UK population had a refrigerator […] people bought refrigerators when food cellars and cool rooms began to disappear […] changes in housing design, with the elimination of cabinets and shelf space for food storage, and the increase of central heating both contributed to increased interest in refrigerators.[…] Once in the home and inserted into home practices, the subsequent history in Great Britain reveals that the refrigerators embedded potentials are highly agentive. This is reflected in the total amount of energy use dedicated to refrigeration. Garnett estimates that food refrigeration in production, transportation and residences together contribute 3.5% of the United Kingdom's total climate gas emissions."*

Many things in our daily lives affect behavior and the language we use is one of them. The vocabulary used for describing energy consumption could affect behavior. If we have names for particular behaviors they are easier to talk about. One suggestion for some terms to use is cutting, trimming, switching, upgrading and shifting. The term "Cutting", for instance, should refer to an extremely low power state, while "Trimming" indicates the use of an energy efficient, e.g., lowering the thermostat setting (Pierce, Schiano & Paulos, 2010).

A summary of some findings in one project where consumer behavior after installation of a display was investigated as follows (Anderson & White, 2009):

- Those who are already careful with how they spend energy may have little scope for action
- A domestic energy champion needs to tread carefully not to annoy the rest of the family
- Unreliable performance wrecks any opportunity for change
- Poor information on the user interface leads to poor conclusions
- Consumption may be lower than anticipated but the information remains powerful
- Information without motivation goes nowhere
- The systematic enthusiast thinks of everything even experimenting by turning everything off.
- Even an effective evangelist can tire of his own good news
- Those used to budgeting know exactly what to do

Impacts of installing a meter can be substantial: *"Participants rapidly learnt about the differences in power consumption of the lights and appliances in their homes. They were often aghast at what they found and, in most cases, this led to specific actions to reduce energy. These included single actions with lasting effects, such as changing light bulbs, or changes in on-going behaviour, such as only filling the kettle with the water that is needed. Those who did not make changes usually said they had*

no scope for change because they were already frugal in their energy use. As the trial period was only eight days, the study could not explore the important issue of the long-term impacts of using a home energy display." (Anderson & White, 2009).

Some other surprises from the investigation were the following. *"Participants knew very little about their energy consumption. Those on prepayment meters had the best sense of what they were spending but this did not translate into an understanding of what used more or less energy in their homes. Consequently, the displays enabled all participants to learn about the differences in the power consumption of different lights and appliances."* (Anderson & White, 2009).

The types of knowledge gained included knowing the difference between Watts and kilowatts, the costs to run different appliances, baseload consumption, the range of their energy consumption levels, daily consumption or money spent on energy (Anderson & White, 2009).

Sustainable transportation support

The following section will focus on OneBusAway, an open source tool for promoting public transportation by giving more accurate arrival times. Public transport is a good example since there are many benefits from using it. Along with reducing CO_2 emissions, which was discussed in an earlier section, public transport "provides mobility to those who cannot or prefer not to drive, including access to jobs, education and medical services (Ferris, Watkins & Borning, 2011). There are many other initiatives explored in the world today to counter the problem of sustainable transport that we will not discuss. From road pricing schemes, electric cars, lift sharing, and free bicycles, to other innovative public transport system (MIT Mobile Experience Lab, 2011; Nash, 2009; Niches+, 2011). We will also give some additional comments on open source in relation to this particular solution.

The overall architecture for most systems that support distributed functionality similar to OneBusAway is shown in figure 12 below. There is a set of distributed sensors that collect data to some storage through a sensor network. The data can be accessed by client software using an API. In this case the user interface is presented on a mobile device. Note that the Wattdepot system in the previous section had the same structure.

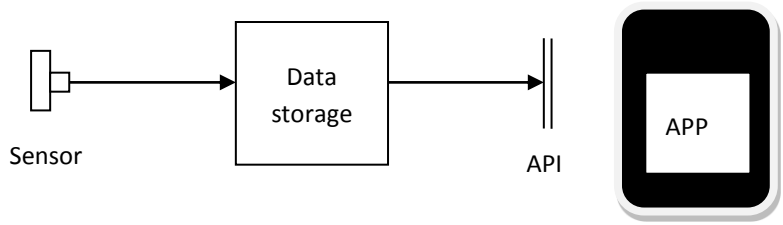

Figure 12. Typical architecture for distributed support system.

It is important to note that standardized data formats and protocols are crucial for open systems. Also, the stability of tools, protocols, and programming languages will determine whether such systems will be built and survive over a longer period of time. Efficient systems usually have to learn about their environment through sensing and if the system is distributed a sensor network is needed. We can identify three different types of sensor networks. *"Most examples fit the first, a network of static, inert sensors designed to capture specific measurements of their local environments. Less commonly cited are sensors carried by humans, vehicles, or animals. For example, much useful research is emerging from projects that have equipped children with sensors of air pollution, in an effort to understand the factors affecting asthma. A third type of sensor network, and in many ways the most interesting, consists of humans themselves, each equipped with some working subset of the five senses and with*

the intelligence to compile and interpret what they sense, and each free to rove the surface of the planet." (Goodchild, 2007). Using humans as sensors seems to be a viable solution if they can be persuaded to contribute. The reasons that people volunteer to collect data are similar to what we previously have described for citizen driven innovation and in the open source community. One reason is self-promotion.

> *"Selfpromotion is clearly an important motivator of Internet activity, and in its extreme form can lead to the exhibitionism of personal webcams. Despite the vast resources of the Web, it is still possible to believe that someone will be interested in ones personal site. [...] Contributors to OpenStreetMap may derive a certain personal satisfaction from seeing their own contributions appear in the patchwork, and from watching the patchwork grow in coverage and detail, but there can be no question of selfpromotion in this essentially anonymous project*." (Goodchild, 2007)

The goal of OneBusAway is to provide bus riders with appropriate arrival times of busses. This should reduce the time spent waiting for the bus, give an increased feeling of safety, which research has shown to be an objective for taking the bus. The data provided also makes new types of planning possible. If the position of each bus is known it is possible to schedule buses differently. OneBusAway is open source software licensed under the Apache 2.0 license (http://code.google.com/p/onebusaway/) (Ferris, Watkins & Borning, 2010).

The main standard used in the project is "Google transit" which has been used extensively in these kinds of projects; *"Although not real-time information, more recently, Google Transit began providing transit trip planning for more than 400 cities around the world. In addition to providing information to transit riders around the world, Google Transit is also significant for establishing a de facto standard for exchanging transit schedule data: the General Transit Feed Specification (GTFS). Many of the transit agencies participating in the Google Transit program have also released their transit scheduling data in the GTFS format for third-party developers to work with, creating development ecosystems out of the public availability of this data, with many so-called 'transit-hackers' working on innovative uses of transit data. The Portland TriMet third-party applications page lists over 20 applications using Portland's transit data."* (Ferris, Watkins & Borning, 2011). Another standard used in the project was Keyhole Markup Language (KML), which allows a developer to display symbols, e.g. for buses, in the Google Earth application.

A survey of users evaluating OneBusAway showed a number of positive outcomes. The system *"strongly increased overall satisfaction with public transit, decreased waiting time, increased transit trips per week, increased feelings of safety, and even a health benefit in terms of increased distance walked when using transit"* (Ferris, Watkins & Borning, 2011). An alternative solution would be to have a display at every bus stop, but this is very expensive with current technology.

The system was soon used by people in unexpected ways; One user commented: *"OBA makes [it] much easier to avoid standing room only busses by letting me know there's a follow up bus right behind the current full bus"* (Ferris, Watkins & Borning, 2011).

Concluding discussion

This report illustrates how open source can be used to work towards a sustainable society. The report acknowledges the fact that sustainability is crucial for our survival and a long time process including social economic and environmental issues. In general, many of the problems are increasingly global and intertwined, which necessitates the need for global solutions. As described and discussed in the report, the ideas behind open source software and open source as a philosophy are based on the right to redistribute, make derivate works and use different solutions for free. One of the most fascinating

things about open source is how it brings different people together to work for a common cause without clear, and direct, personal gain. Nevertheless, it is evident that such gratifications as boosting ego and potential future career goals drive some of the micro level incentives for participating in open source projects. Open source development has been very prominent and successful in the software industry and today most software necessary for a common family or company can be accessed for free by open source license. Furthermore, taking the incentives from open source and trying to apply this to sustainability issues might be a solution for increasing the participation of the population in a local community in order to create a sustainable society and living.

This report has briefly touched upon the environmental impact of energy consumption and transportation and given examples of how these sustainability issues can be addressed with different ICT solutions. In both of these areas the problem is to collect data at a detailed level and use it to provide feedback to the parties involved. Feedback to the citizens, to the community administration and to the commercial interests involved. Using this feedback each party in their own way can adapt their behavior knowing that the same information is known also to the others. The community administration can use the information to compare its results with other communities and to set up the rules and regulations for the other parties. Service providers need the information to optimize their systems, hopefully to provide the service to a low cost. The citizens finally are the new key players in our scenario. By exploiting the business and working models from the open source community they can be engaged in improving the system while at the same time raising their knowledge level, adapting their behavior and attitude. To accomplish this more knowledge is needed on how to operate open source frameworks in this environment and towards the goals of sustainable society. In the report we exemplify some examples and problems when doing this. We also point at some of the problems when it comes to building tools for everyday use, in the home or for public transportation. Here more knowledge on the psychosocial and economical conditions are needed in order to design, build and provide tools that will be used.

The most important lesson from the report is that there is a lot to gain from active the participation of the citizens in the development of the next generation society.

Acknowledgement

The authors would like to thank the Open Kvarken project for providing financial support for this research study during late spring 2011. Furthermore, Fredrik Granström and Olle Eriksson are gratefully acknowledged for their support throughout this project.

Literature cited

Anderson, W., & White, V. (2009). *Exploring consumer preferences for home energy display functionality*. Report to the Energy Saving Trust, Centre for Sustainable Energy.

Axelsson, K., Melin, U., & Lindgren, I. (2010). Exploring the importance of citizen participation and involvement in e-government projects: Practice, incentives, and organization. *Transforming Government: People, Process and Policy, 4*(4), 299-321.

Bauwens, M. (2007). *P2P and human happiness*. Paper presented at the 3rd International Confrence on Gross National Happliness, Nongkhai/Bangkok, Thailand. Retrieved May 26, 2011, from http://www.gnh-movement.org/papers/bauwens.pdf

Benkler, Y. (2006). *The wealth of networks: how social production transforms markets and freedom*. Yale University Press.

Berkhout, F., & Hertin, J. (2001). *Impacts of information and communication technologies on environmental sustainability: Speculations and evidence*. Report to the Organisation for Economic Cooperation and Development. Brighton: University of Sussex

Berners-Lee, T. (1999). *Weaving the web: The past, present and future of the world wide web by its inventor*. London: Texere.

Blackshaw, P., & Nazzaro, M. (2006). *Consumer-generated media (CGM) 101: Word-of-mouth in the age of the web-fortified consumer* (2nd ed.). Retrieved May 13, 2011, from http://www.nielsen-online.com/downloads/us/buzz/nbzm_wp_CGM101.pdf

Brabham, D. (2009). Crowdsourcing the public participation process for planning projects. *Planning Theory, 8*(3), 242-262.

Bretthauer, D. (2002). Open Source Software: A History. *Information Technology and Libraries, 21*(1), 3-10.

Brewer, R. S, Lee, G. E., & Johnson, P. M. (2011). The Kukui Cup: A Dorm Energy Competition Focused on Sustainable Behavior Change and Energy Literacy. *44th Hawaii International Conference on System Sciences (HICSS)*, 1-10.

Brown, L. R. (2009). Plan B 4.0: Mobilizing to save Civilization. W. W. Norton & Co. Retrieved May 1, 2011, from http://www.earth-policy.org/images/uploads/book_files/pb4book.pdf

Cai, G., & Kock, N. (2009). An evolutionary game theoretic perspective on e-collaboration: The collaboration effort and media relativeness. *European Journal of Operational Research, 194*(3), 821-833.

Capra, E. (2009). Green IT: everything starts from the software. *ECIS 2009 Proceeding, Paper 221*. Retrieved June 3, 2011, from http://aisel.aisnet.org/ecis2009/221/

Chen, A. J., Watson, R. T., Boudreau, M.-C., & Karahanna, E. (2009). Organizational Adoption of Green IS & IT: An Institutional Perspective. *ICIS 2009 Proceedings, Paper 142*. Retrieved May 29, 2011, from http://aisel.aisnet.org/icis2009/142

Chiabai, A., Rübbelke, D., Maurer, D. (2010). *ICT Applications in the Research for Environmental Sustainability*. Working paper, University of Connecticut. Retrieved May 31 2011, http://ideas.repec.org/

Child, J., Faulkner, D., & Tallman, S. (2005). *Cooperative Strategy, Managing Alliances, Network and Joint Ventures* (2nd ed.).Oxford, NY: Oxford University Press.

Climate Group. (2008). SMART 2020: Enabling the low carbon economy in the information age. *The Global eSustainability Initiative, Brussels, Belgium, 2008*.

Dalle, J.-M., & Dauphine, P. (2003). *The allocation of software development resources in 'open source' production mode*. SIEPR Discussion Paper No. 02-27. Stanford Institute for Economic Policy Research.

Darby, S. (2008). Why, what, when, how, where and who? Developing UK policy on metering, billing and energy display devices. *Proceedings of ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, August 17-22, 2008*, 7.70-7.81.

Das, T. K. (2005). Deceitful behaviors of alliance partners: potential and prevention. *Management Decision, 43*(5), 706-719.

Das, T. K., & Teng, B.-S. (1998). Between Trust and Control: Developing Confidence in Partner Cooperation in Alliances. *Academy of Management Review, 23*(3), 491-512.

Dictionary.com. (n.d.). *common*. Retrieved June 7, 2011, from http://dictionary.reference.com/browse/common

Easterbrook, S. (2010). Climate Change: A Grand Software Challenge. *Proceedings of the FSE/SDP workshop on Future of software engineering research, Santa Fe, NM, USA, November 7-11, 2010*.

Edwards, P. N. (2010). *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. Cambridge, MA: MIT Press.

Eisenhardt, K. M., & Schoonhoven, C. B. (1996). Resource-Based View of Strategic Alliance Formation: Strategic and Social Effects in Entrepreneurial Firms. *Organization Science, 7*(2), 136-150.

Energimyndigheten. (2009). *Energianvändning av lokaler 2009*. Retrieved May 30, 2011, from http://www.energimyndigheten.se/sv/Statistik/Forbattrad-energistatistik-i-bebyggelsen/Inventering-av-energianvandningen-i-lokaler-/

Energimyndigheten. (2010a). *Energiindikatorer 2010, Uppföljning av Sveriges energipolitiska mål, ET 2010:2*. Retrieved 29 May, 2011, from http://energimyndigheten.se/sv/Statistik/Energiindikatorer/

Energimyndigheten. (2010b). *Mätningar av varm- och kallvattenförbrukning, 2007 och 2008*. Retrieved May 25, 2001, from http://www.energimyndigheten.se/sv/Statistik/Forbattrad-energistatistik-i-bebyggelsen/Matning-av-varm--och-kallvattenforbrukning/

Erek, K., Schmidt, N.-H., Zarnekow, R., & Kolbe, L. M. (2009). Sustainability in Information Systems: Assortment of Current Practices in IS Organizations. *AMCIS 2009 Proceedings, Paper 123*. Retrieved May 29, 2011, from http://aisel.aisnet.org/amcis2009/123

EU. (2006). *Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC*. Retrieved May 23, 2001, from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32006L0032:EN:NOT

Faulkner, D. (1995). *International Strategic Alliances, Co-operating to Compete*. London: McGraw-Hill.

Ferris, B., Watkins, K., & Borning, A. (2010). OneBusAway: Results from Providing Real-Time Arrival Information for Public Transit. *Proceedings of CHI 2010, Atlanta, GA, USA, April 10-15, 2010*.

Ferris, B., Watkins, K., & Borning, A. (2011). OneBusAway: Behavioral and Satisfaction Changes Resulting from Providing Real-Time Arrival Information for Public Transit. *Proceedings of the 2011 Transportation research board annual meeting*.

Fischer, C. (2008). Feedback on household electricity consumption: a tool for saving energy? *Energy Efficiency, 1*, 79-104.

Freeman, R. E., & Reed, D. L. (1983). Stockholders and Stakeholders: A New Perspective on Corporate Governance. *California Management Review, 25*(3), 88-106.

Geringer, J. M., & Hebert, L. (1989). Control and Performance of International Joint Ventures. *Journal of International Business Studies, 20*(2), 235-254.

Ghosh, R. A., Glott, R., Krieger, B., & Robles, G. (2002). *Free/Libre and Open Source Software: Part 4: Survey of Developers*. International Institute of Infonomics, University of Maastricht.

Gnyawali, D. R., & Madhavan, R. (2001). Cooperative Networks and Competitive Dynamics: A Structural Embeddedness Perspective. *Academy of Management Review, 26*(3), 431-445.

Goodchild, M. (2007). Citizens as sensors: The world of volunteered geography. *Geojournal 69*(4), 211-221.

Google (n.d.). *What is Google PowerMeter*. Retrieved June 9, 2011, from http://www.google.com/powermeter/about/about.html

Gulati, R. (1998). Alliances and Networks. *Strategic Management Journal, 19*, 293-317.

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic Networks. *Strategic Management Journal, 21*(3), 203-215.

Hallqvist, C. (2010). True Participation - a challenge for design of sustainable e-services. *Proceedings of the 33rd IRIS Seminar 2010*, 1-13.

Hamel, G. (1991). Competition for competence and inter-partner learning within international strategic alliances. *Strategic Management Journal, 12*, 83-103.

Hardin, R. (1982). *Collective action*. Baltimore, MD: John Hopkins University Press.

Helft, M. (2008, October 28). Google's energy ideas might emerge under open source licenses — or not. *The New York Times*. Retrieved June 20, 2011, from http://greeninc.blogs.nytimes.com/2008/10/28/googles-energy-ideas-might-emerge-under-open-source-licenses-or-not/

Hippel, E. (2005). *Democratizing innovation*. MIT press.

Ingenjörsvetenskapsakademin. (2002). *Energianvändning I transportsektorn 2002*, Retrieved May 23, 2011, from http://www.iva.se/upload/Verksamhet/Projekt/Energiframsyn/Transport%20komplett3.pdf

Jackson, T. (2005). *Motivating Sustainable Consumption: a review of the evidence on consumer behaviour and behavioural change*. A report to the Sustainable Development Research Network. London: Policy Studies Institute. Retrieved May 15, 2011, from http://www.c2p2online.com/documents/MotivatingSC.pdf

Jackson, T. (2011). *Prosperity without growth? The transition to a sustainable economy*. Sustainable Development Commission, Retrieved May 26, 2011, from http://www.sd-commission.org.uk/data/files/publications/prosperity_without_growth_report.pdf

Jarillo, J. C. (1988). On Strategic Networks. *Strategic Management Journal, 9*, 31-41.

Jonsson, F., & Bylund, L. (2011). *Design of a Household Concept Motivating Sustainable Consumption Behavior*, Master's Thesis, Umea university.

Konsumentverket. (2007). *Konsumentverkets rapporter 1991-2006. Genomgång av konsumentundersökningar*. Retrieved May 23, 2001, from http://www.borgco.se/library/KOV

Langlois, R. N., & Garzarelli, G. (2008). Of Hackers and Hairdressers: Modularity and the Organizational Economics of Open-source Collaboration. *Industry & Innovation, 15*(2), 125-143.

Lerner, J., & Tirole, J. (2002). Some simple economics of open sources. *Journal of industrial economics, 20*(2), 197-234.

Luo, Y. (2004). *Coopetition in International Business*. Copenhagen Business School Press.

Luo, Y. (2007). A coopetition perspective of global competition. *Journal of World Business*, 42(2), 129-144.

Lynch, R. P. (1990). Building Alliances to Penetrate European Markets. *The Journal of Business Strategy, 11*(2), 4-8.

Mann, H., Grant, G., & Singh Mann, I. J. (2009). Green IT: An Implementation Framework. *AMCIS 2009 Proceedings, Paper 121*. Retrieved May 29, 2011, from http://aisel.aisnet.org/amcis2009/121

Medcof, J. W. (1997). Why Too Many Alliances End in Divorce. *Long Range Planning, 30*(5), 718-732.

Mejtoft, T., & Nordin, Å. (2007). Strategic Alliances in the Digital Printing Industry. *Taga 2007 Proceedings*, 38-62.

Melville, N. (2010). Information Systems Innovation for Environmental Sustainability. *MIS Quarterly, 34*(1), 1-21.

Middlemiss, L. (2008). Influencing individual sustainability: a review of the evidence on the role of community-based organisations. *International Journal of Environment and Sustainable Development, 7*(1)

MIT Mobile Experience Lab. (2011). *Sustainable public transportation*. Retrieved May 15, 2011, from http://mobile.mit.edu/connected-urban-development/sustainable-public-transportation

Molla, A. (2009). Organizational Motivations for Green IT: Exploring Green IT Matrix and Motivation Models. *PACIS 2009 Proceedings, Paper 13*. Retrieved June 3, 2011, from http://aisel.aisnet.org/pacis2009/13/

Moorman, C., Deshpandé, R., & Zaltman, G. (1993). Factors Affecting Trust in Market Research Relationships. *Journal of Marketing, 57*(1), 81-101.

Morgan, R. M., & Hunt, S. D. (1994). The Commitment-Trust Theory of Relationship Marketing. *Journal of Marketing, 58*(3), 20-38.

mySoceity. (n.d.). *mySociety.org – What's it all about then, eh?* Retrieved June 7, 2011, from http://www.mysociety.org/about/

Narayandas, D., & Rangan, V. K. (2004). Building and Sustaining Buyer-Seller Relationships in Mature Industrial Markets. *Journal of Marketing, 68*(3), 63-77.

Nash, A. (2009). *Web 2.0 applications for improving public participation in transport planning*. Retrieved May 15, 2001, from http://www.andynash.com/nash-publications/2009-Nash-Web2forPT-14nov09.pdf

Naturvårdsverket. (2011). *Prognoser för Sveriges utsläpp av växthusgaser*. Retrieved May 31, 2011 http://www.naturvardsverket.se/sv/Start/Klimat/Utslapp-av-vaxthusgaser/Prognoser/Prognoser-for-Sveriges-utslapp-av-vaxthusgaser/

Niches+. (2011). *Results summary web page, 2011.* Retrieved May 15, 2011, from http://www.niches-transport.org/index.php?id=7

Nikkah, H. A., & Redzuan, M. B. (2010), The Role of NGOs in Promoting Empowerment for Sustainable Community Development, *J. Hum Ecol, 30*(2), 85-92.

O'Reilly, T. (2005). *What is Web 2.0: Design patterns and business models for the next generation of software*. O'Reilly Media. Retrieved May 13, 2011, from http://oreilly.com/web2/archive/what-is-web-20.html

OECD. (2007). *Participative web: User-created content*. Retrieved May 13, 2011, http://www.oecd.org/dataoecd/57/14/38393115.pdf

Olson, M. (1965). *The logic of collective action: Public goods and the theory of groups*. Harvard University Press.

Open Source Initiative. (n.d.). *History of the OSI*. Retrieved April 14, 2011, from http://www.opensource.org/history

Open Source Initiative. (n.d.). *The Open Source Definition*. Retrieved April 16, 2011, from http://www.opensource.org/docs/osd

Ostrom, E. (1990). *Governing the commons: The Evolution of Institutions for Collective Action*. Cambridge University Press.

P2P foundation. (2009). *Diffuse innovation*. Retrieved June 1, 2011, from http://p2pfoundation.net/Diffuse_Innovation

P2P foundation. (2010). *User-centred innovation*. Retrieved May 31, 2011, from http://p2pfoundation.net/User-Centered_Innovation

P2P foundation. (2011). *Design*. Retrieved June 1, 2011, from http://p2pfoundation.net/Category:Design

Paquette, S., & Wiseman, E. (2006). Knowledge for Sustainable Development: The Role of Knowledge Networks & Organizational Learning. *AMCIS 2006 Proceedings, Paper 215*. Retrieved May 29, 2011, from http://aisel.aisnet.org/amcis2006/215

Parag, Y., & Darby, S. (2009). Consumer - supplier - government triangular relations: Rethinking the UK policy path for carbon emissions reduction from the UK residential sector. *Energy Policy, 37*(10), 3984-3992.

Pierce, J., Fan C., Lamas D. , Marcu G., & Paulos E., (2010), Some considerations on the (in)effectiveness of resident energy feedback systems. *Proceeding of DIS Conference on Designing Interactive Systems, Arhs Denmark, DIS'10*. New York: ACM Press.

Pierce, J., Schiano D. P., & Paulos, E. (2010). Home, Habits, and Energy: Examining Domestic Interactions and Energy Consumption. *CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA*.

Porter, M. E., & Kramer, M. R. (2011). Creating Shared Value. *Harvard Business Review, 89*(1/2), 62-77.

Power, K., & Mont, O. (2010). Dispelling the myths about consumption behaviour. *ERSCP-EMSU 2010, Conference. Delft. 25-29 October*. Retrieved January 12, 2011, from http://www.cri.dk/images/downloads/DispellingTheMyths.pdf

Prahalad, C. K., & Ramaswamy, V. (2000). Co-opting customer competence. *Harvard Business Review, 78*(1), 79-87.

Raymond, E. S. (1999). *The Cathedral and the Bazaar*. Sebastopol, CA: O'Reilly Media.

Reina Y., Arakji, R. Y., & Lang, K. R. (2007). The Virtual Cathedral and the Virtual Bazaar. *The DATA BASE for Advances in Information Systems, 38*(4), 33-39.

Sauer, R. M. (2007). Why develop open-source software? The role of non-pecuniary benefits, monetary rewards, and open-source licence type. *Oxford Review of Economic Policy, 23*(4), 605-619.

Shan, W. (1990). An Empirical Analysis of Organizational Strategies by Entrepreneurial High-Technology Firms. *Strategic Management Journal, 11*(2), 129-139.

Sherman, S., & Sookdeo, R. (1992). Are Strategic Alliances Working? *Fortune, 126*(6), 77-78.

Steffen, A. (2011). *World changing*. Retrieved May 5 2011 at http://www.rockefellerfoundation.org/news/publications/century-city-no-time-lose

Strengers, Y. (2008). Smart Metering Demand Management Programs: Challenging the Comfort and Cleanliness Habitus of Households. *Proceedings of the 20th Australasian Conference on Computer-Human Interaction: Designing for Habitus and Habitat*.

Symbian Ltd. (2006). *Symbian Limited, Reports and Financial Statements*. Retrieved October 30, 2007, from http://www.symbian.com/files/rx/file9400.pdf

Todeva, E., & Knocke, D. (2005). Strategic alliances and models of collaboration. *Management Decision, 43*(1), 123-148.

Tomlinson, B., Silberman, M. S., & White, J. (2011). Can More Efficient IT Be Worse for the Environment? *IEEE Computer 44*(1), 87-89.

Trafikanalys. (2010). *Uppföljning av de transportpolitiska målen Rapport 2010:1*. Retrieved May 10, 2011, from http://www.trafa.se.

UK Energy research centre. (2007). *The rebound effect, An Assessment of the evidence for economy-wide energy savings from improved energy efficiency*, Main report 2007

United Nations. (1987). *Report of the World Commission on Environment and Development: Our Common Future*. Document A/42/427. Retrieved May 26, 2011, from http://www.un-documents.net/wced-ocf.htm

United Nations. (2009). *Life Cycle Management - How business uses it to decrease footprint, create opportunities and make value chains more sustainable*. United Nations Environment Programme Division of Technology, Industry, and Economic. Retrieved May 31, 2011, from, http://www.unep.fr/scp/publications/details.asp?id=DTI/1208/PA

Vargo, S. L., & Lusch, R. F. (2004a). Evolving to a New Dominant Logic for Marketing. *Journal of Marketing, 68*(1), 1-17.

Vargo, S. L., & Lusch, R. F. (2004b). The Four Service Marketing Myths: Remnants of a Goods-Based, Manufacturing Model. *Journal of Service Research, 6*(4), 324-335.

Vargo, S. L., & Lusch, R. F. (2006). Service-dominant logic: What it is, what it is not, what it might be. In S. L. Vargo & R. F. Lusch (Eds.), *The service dominant logic of marketing: Dialog, debate and directions* (pp. 43-56). Armonk, NY: M.E. Sharpe.

von Krogh, G., & Spaeth, S. (2007). The open source software phenomenon: Characteristics that promote research. *Journal of Strategic Information Systems, 16*(3), 236-253.

Waage, S., Shah, R., & Girsheck, S. (2003). Information technology and sustainability: enabling the future. *International Journal of Corporate Sustainability, 10*(4), 81-95.

Watson, R. T., Boudreau, M.-C., & Chen, A. J. (2010). Information Systems and Environmentally Sustainable Development: Energy Informatics and New Directions for the IS Community. *MIS Quarterly, 34*(1), 23-38.

Weber, S. (2004). *The success of open source*. Harvard University Press.

West, J., & O'Mahony, S. (2008). The Role of Participation Architecture in Growing Sponsored Open Source Communities. *Industry & Innovation, 15*(2), 145-168.

White, R. (1996). *The Organic Machine: The Remaking of the Columbia River*. Hill and Wang.

Wilhite, H. (2008). New thinking on the agentive relationship between end-use technologies and energy-using practices. *Energy Efficiency, 1*, 121-130.

Williamson, O. E. (1975). *Markets and Hierarchies: Analysis and Antitrust Implications*. New York, NY: Free Press.

Williamson, O. E. (1985). *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*. New York, NY: Free Press.

Xu, B., & Jones, D. R. (2010). Volunteers' Participation in Open Source Software Development: A Study from the Social–Relational Perspective. *The DATA BASE for Advances in Information Systems, 41*(3), 69-84.

Yin, R.K. (2003). *Case study research, design and methods* (3rd ed.). Thousand Oaks: SAGE Publications.

Young-Ybarra, C., & Wiersema, M. (1999). Strategic Flexibility in Information Technology Alliances: The Influence of Transaction Cost Economics and Social Exchange Theory. *Organization Science, 10*(4), 439-459.

Zaheer, A., McEvily, B., & Perrone, V. (1998). Does Trust Matter? Exploring the Effects of Interorganizational and Interpersonal Trust on Performance. *Organization Science, 9*(2), 141-159.

Zeitlyn, D. (2003). Gift economies in the development of open source software: anthropological reflections. *Research Policy 32*(7), 1287–1291.

Zimmermann, J. P. (2009b). End-use metering campaign in 400 households In Sweden, Assessment of the Potential Electricity Savings. *Enertech*. Retrieved May 30, 2011, from http://www.energimyndigheten.se/Global/Energifakta/F%C3%B6rb%C3%A4ttrad%20energistatistik/Festis/Final_report.pdf

Department of Applied Physics and Electronics
901 87 Umeå
Telefon 090-786 50 00
www.umu.se