Sectoral Energy Report

Synthesis Report: ICT for Energy Efficiency Buildings and Strategic Environmental Assessment for Smart Grids

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The EU's ambitious energy and climate objectives require a coordinated approach by all involved stakeholders. While policy sets the legal framework, the decision for investments in the energy sector and the implementation of climate protection measures rests with a variety of actors (e.g. energy supplier, network operators, municipalities, industries, business and households) who have different economic preferences. Often individual decision makers lack sufficiently reliable information in advance to assess the ratio of costs and benefits of their own options and the effects of their decisions for the collective energy system and the environment. To enable sustainable decision support for all relevant decision makers in energy systems, instruments are needed which allow a dynamic system analysis, taking into account the interactions between political, technical and economic conditions and the behaviour of individual actors.

The Sectoral Energy Reports focus on the energy profiles of specific industry sectors and seek to identify action areas for ensuring competitiveness in a context of stringent climate change mitigation requirements and increased global market competition. The reports provide a knowledge base that goes beyond the specific sector in focus as new goals will have to be defined at the strategic level, requiring a broader system approach and involvement of multiple stakeholders. The Sectoral Energy Reports provide the broad contextualized background of the challenges being faced by industry sectors in Europe.

The Energy Systems Analysis Agency (ESA²) builds on knowledge and experience of 14 European research groups/companies in the field of energy systems analysis. ESA² has its starting point in an innovation project developed within the Knowledge and Innovation Centre (KIC) InnoEnergy. KIC InnoEnergy is an initiative created under the leadership of the European Institute of Innovation and Technology (EIT) and aims to be the leading engine for innovation and entrepreneurship in sustainable energy.

Bibliographical data

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Table of Contents

List of tables

List of figures

List of abbreviations

ICT	Information and Communication Technologies	SEA	Strategic Environmental Assessment
EIA	Environmental Impact Assessment	REEB	Roadmap to ICT enabled Energy-Efficiency in Building
BMS	Building Management System	ETC	Electricity Trading Company
PPP	Policies, plans and programmes		

Synthesis Abstract

Following is a synthesis of an investigation into how smart grids may be deployed to leverage improved end-use electric efficiency and environmental performance. The two complementary approaches are:

1. How ICT solutions can be leveraged to increase energy efficiency (specifically for electricity) and improve environmental performance in the real estate sector in Sweden. This report shows that ICT for energy efficiency in buildings is primarily interesting in single family homes and in commercial property. Single family homes are important for the growth of this sector because of the large amount of electricity that is consumed in the sector (in particular for heating purposes) as well as the fact that the billing structure implies a significant incentive for home-owners to be interested in advanced solutions to decrease costs. In commercial property such solutions are interesting principally because such properties are already technically advanced, and there is an existing structure for energy management with specific interest in the kinds of technologies considered.

2. The second part looks at the development of smart grids from the point of view of Strategic Environmental Assessment (SEA). The report concludes that there is currently little application of SEA in the energy sector due to the fact that many of infrastructure decisions are made by private companies and not public authorities. A proposed solution to this is to apply SEA in the context of corporate sustainability initiatives. Further benefits from SEA for smart grids are its benefits in environmental enhancement and knowledge brokering.

PART 1: ICT for improved energy efficiency and environmental performance in the real estate sector

1 Summary

The overall question that is addressed in the report is how ICT solutions can be leveraged to increase energy efficiency (specifically for electricity) and improve environmental performance in the real estate sector in Sweden.

- What sort of ICT applications are significant in achieving greater energy efficiency and improved environmental performance in the building sector?

- For which electricity end-uses should ICT solutions of the kind envisaged be prioritised?
- Who are the actors on the electricity market that can influence the above?
- How can ICT be used to communicate between utility companies and utility customers?
- How can ICT be used to communicate energy use directly with electricity customers and users?

Key target groups for the information are ICT companies and electricity customers.

ICT applications for increased energy efficiency and environmental performance have been categorized according to (Hannus 2010) and the relative opportunities for ICT to improve energy efficiency in the built environment has been assessed. Of the three sectors considered in the report, two were identified as particularly promising for the intitial deployment of ICT in this sector for this purpose:

Single and two family homes: This sector is interesting since it is a large user of electricity for heating purposes (and will continue to be so in the future) comprising both heat from electric resistance-based systems as well as more efficient and environmentally benign heat pumps.

Commercial properties: These are interesting because they are technically complex, and have well established technical systems and organizational structures for managing electricity use that new ICT systems could support, probably in combination with systems for managing heat demand (based on district heating). Possibilities may be tempered by the fact that the owner-tenant structure, both in terms of physical investment and electricity billing may pose barriers to the introduction of ICT.

Multifamily properties were judged to be less prioritized because of the relatively lower electricity use in the sector and the relatively simple organizational structure and technical systems for energy management.

2 Goal and scope

The overall question that is addressed in pert 1 is how ICT solutions can be leveraged to increase energy efficiency (specifically for electricity) and improve environmental performance in the real estate sector. The following questions are addressed:

- What sort of ICT applications are significant in achieving greater energy efficiency and improved environmental performance in the building sector?
- For which electricity end-uses should ICT solutions of the kind envisaged be prioritized?
- Who are the actors on the electricity market?
- How can ICT be used to communicate between utility companies and utility customers?
- How can ICT be used to communicate energy use directly with electricity customers and users?

Key target groups for the information are ICT companies and electricity customers.

3 Delimitation

Only the Swedish real estate sector is considered. This simplification is useful in since in spite of powerful globalization trends, real estate is highly location-specific and does not exhibit the same degree of international standardization as other economic sectors. Nevertheless, the trends identified here can be interesting for other regions.

4 Definition of types of ICT application in real estate

The capacity for ICT applications to improve communication about energy consumption in real estate is huge, and initially some broad areas are established that can be used to describe the field. Due to the communicative nature of the ICT technologies, these are naturally highly interrelated and the demarcation below should be better considered a convenient labeling system to facilitate this analysis of the capability of ICT in this field.

This demarcation is based on REEB - The European Strategic Research Roadmap to ICT enabled Energy-Efficiency in Building and Construction (completed 2010 under 7th European Union framework Program for Research and Technical Development) as reported in (Hannus 2010) and further analyzed and described in (Kramers 2011).

Described in more detail in the subsections below, the areas identified are:

- User awareness and decision support
- Intelligent and integrated control
- Integration technologies
- Energy management and trading

4.1 User awareness and decision support

As its name suggests, this area is specifically applied to how energy users can become better informed of their energy use.

4.1.1 Smart metering and display systems

The concept behind this area is the metering of electricity consumption in real-time, allowing local and remote data output.

Until recently, measurement of a customer's electricity consumption was carried out by manual meter reading (ca. once a year) with payment to utility providers based on estimated consumption based on the yearly meter reading. In this way neither customer nor electric utilities had very much knowledge about actual consumption.

As has recently happened in Sweden, new metering technology is available that allows for automatic meter reading much more regularly. This has led not only to the possibility to bill customers throughout the year based on real consumption data, but also for customers to inform themselves about actual consumption through e.g. bills and also internet applications kept by a utility company showing e.g. monthly consumption.

(Hannus 2010) gives the following examples of best practices:

- Smart meters deployment in France by ERDF
- Google Powermeter
- Intelligent Metering
- Edelia "Energy box"

4.2 Intelligent and Integrated control

4.2.1 Building Management Systems (BMS)

A building management system is a computerized system for the management and operation of mechanical and electrical equipment in a building, e.g. air conditioning, heating, cooling, ventilation, lighting, electricity production and storage, maintenance management, security, access and fire systems.

Normally a BMS is a closed-loop active control system that uses a network of sensors to gather information about environmental conditions in the building (temperature, daylight, humidity, flow rates) that it uses to monitor and control the building's mechanical and electrical systems to achieve setpoints for the various properties that are measured.

REEB (Hannus 2010) provides the following examples of best practice in this field:

- Domotic control system for the "Advanced studies and research centre" of the Basque Country University, Vitoria, Spain
- Marino Lopez XXI Headquarters,
  http://www.knx.org
- Power Logic from Schneider Electric,
  http://www.schneider-electric.com/

4.2.2 Wireless Sensor Networks

A sensor network is a group of specialized electronic devices designed to take measurements from the surrounding environment and transfer that data into a central computer (i.e. a BMS, see section 4.2.1 above). Such a sensor network may be used as the means of communication in a BMS to monitor and record environmental conditions (temperature, humidity, daylighting) and other parameters (electricity consumption, ventilation flow rates) at different locations in the building.

REEB (Marechal and Bourdeau 2010) provides the following examples of best practice in this field:

- ERI Building, UCC, Lee Road, Cork, Ireland
  http://www.eri.ie/

- Aldo Leopold Legacy Center – awarded Platinum LEED ® Certification from the U.S. Green Building Council.
  http://www.aldoleopold.org/legacycenter/

- Juwi Headquarters - the world's most energy efficient office building.
  http://www.juwi.com/

4.3 Integration technologies

4.3.1 Protocols and standards for energy data exchange

In order to facilitate the exchange of data between sensors and control systems both inside a given building and externally on a grid-based energy system or between certain energy systems, the use of a unified data communication standard will be of great value.

Examples from (Marechal and Bourdeau 2010) are as follows:

PPP-Modell für Neues Regionshaus Hannover. Germany.

- UK3.0 - UK Integrated Systemic Action (World-class "next generation" homes). Cambridge – United Kingdom.
- ZigBee Smart Energy wireless communication standard.
- e3Portal – Information for the Building Energy management in municipalities. Finland and Estonia.

4.3.2 Protocols and Standards for Building Life-cycle Management

Buildings and the projects that create buildings incorporate many different stakeholders spread out of the lifetime of the building. At the design phase of a building, for example, architects may use CAD programs, and engineers may use energy simulation programs, or programs for simulating daylighting etc. By using a common data standard and protocol in these phases of the building's lifetime, the actors above may be able to make use of the information and programs created by other actors, and all work can be based on a single Building Information Model (BIM).

Moreover, standards and protocols for BIMS that are unified with standards and protocols for energy data exchange (see section 4.3.1 above) will facilitate the communication between the actors involved in the planning, design and construction of the building (e.g. architects and engineers) and those responsible for the buildings operation (e.g. facilities managers).

4.4 Energy Management and Trading

4.4.1 Smart grids

In a broad sense, the smart grids technology area encompasses most of the other technological areas that are considered in (Hannus 2010). Meanwhile, (Hannus 2010) actually gives a somewhat narrower definition of a smart grid as "an advanced electricity grid that integrates with many other sub-networks (or microgrids), consisting of communications and ICT systems. That is, many sub-systems with various ownership and management boundaries are interconnected to provide end-to-end services between stakeholders and among intelligent electronic devices”.

5 The building stock

Figure 1 divides the building stock up into 3 main building types: commercial buildings (this consists of any building that is not primarily residential, i.e. office, administration, healthcare, retail, sports facilities, schools, universities etc.). The second group considered are multifamily buildings, i.e. apartment buildings with anywhere from 3 up to about one hundred units per building. Finally, the largest group considered in terms of area is the group of one- and two-family houses.

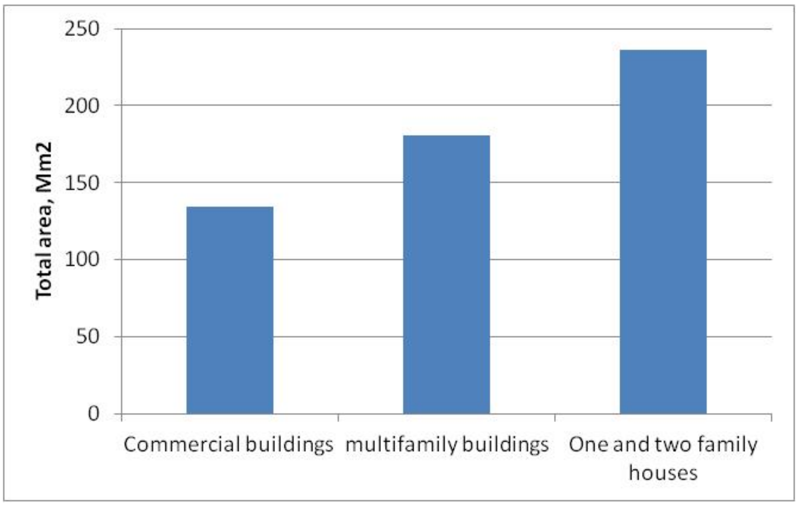

Figure 1: Total heated floor area for different types of commercial property in Sweden ((Energimyndigheten 2011aa), (Energimyndigheten 2011bb) and (Energimyndigheten 2011cc)).

5.1 Commercial buildings

Figure 2 below shows the ownership structure of Swedish commercial property based on (Energimyndigheten 2011aa). The state owns predominantly higher education buildings (university premises) as well as a smaller amount of office and administration buildings. County properties are up to 90 % made up of healthcare buildings (the counties are responsible for healthcare in Sweden). Municipal buildings are overwhelmingly school properties. On the national level, these public building owners are represented by the Swedish Association of Local Authorities and Regions (Swedish: Sveriges Kommuner och Landsting).

Those buildings owned by private companies are spread out amongst a variety of different functions, including hospitality (hotels and restaurants), retail, healthcare facilities, although the largest single function is for office and administration buildings.

State, county and municipal (public) owners clearly have different drivers than private owners, though it is not always clear how these are expressed in terms of company policy with respect to investment in new technology. The short-term profit motive may be considered a barrier to investment in physical improvement measures under which ICT solutions may be considered. However, interviews with some representatives for property owners are suggesting that relatively investment-intensive measures that reduce energy use in properties (at least new-build properties) are being perceived on the commercial property market as an added-value in distinguishing properties from competitors both in the rental market and the sale-and-acquisition market for commercial property owners.

Such a motive is clearly not present for public owners, and a different analysis may apply. On the one hand, the short-term profit motive is not present, and it may therefore appear that investments in physical improvements with longer pay-off times may be more interesting for these property owners. Having said that, public owners may be limited by the fact that they need to operate within established yearly budgets or at minimum requirement for yearly returns.

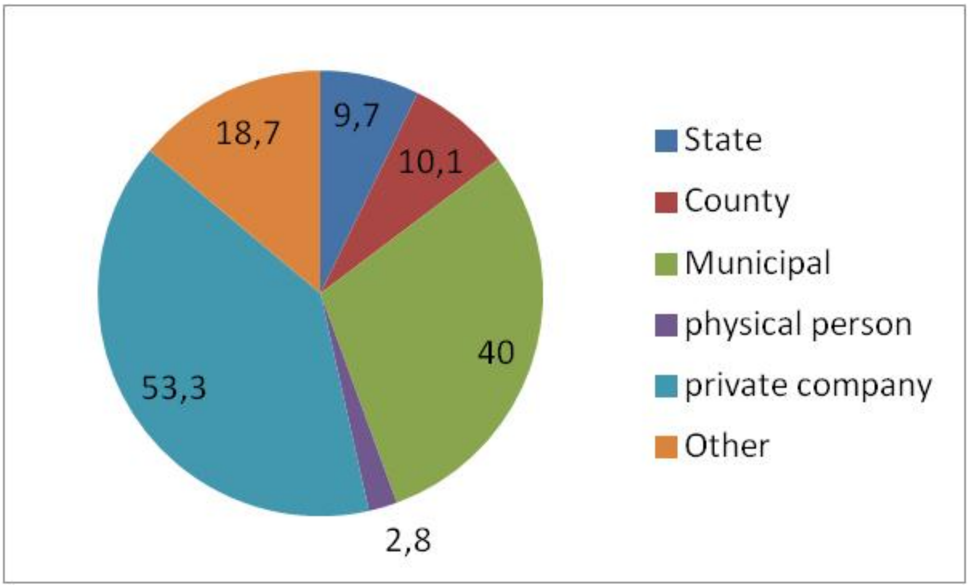

Figure 2: Ownership structure of commercial property in Sweden, in Mm² Heated floor area. Total 134 Mm² (Energimyndigheten 2011a).

5.2 Residential Buildings

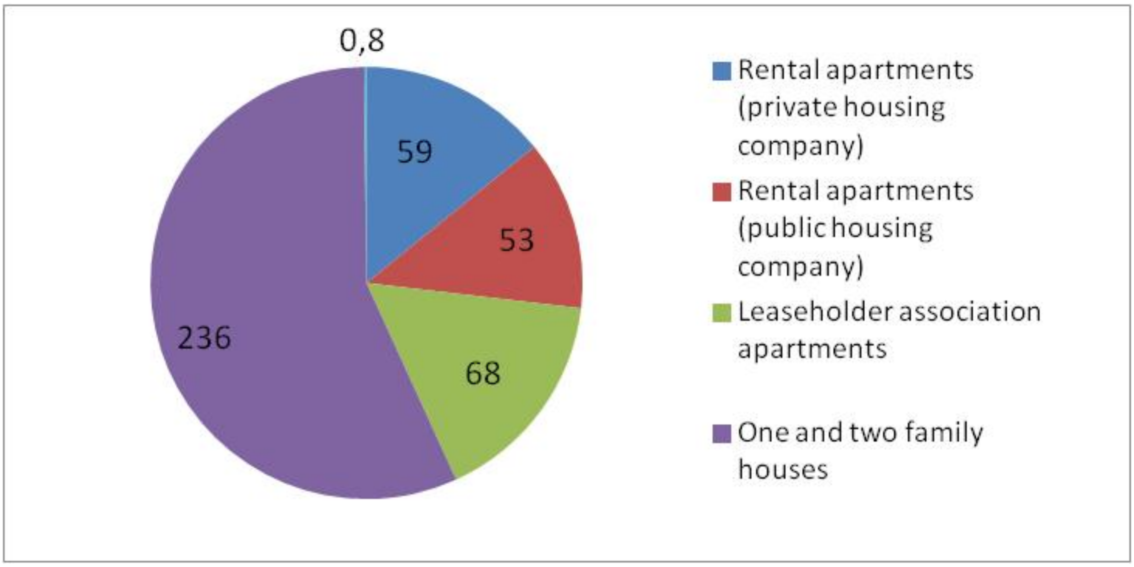

Figure 3: Ownership structure of residential property in Sweden, in Mm^2 heated floor area. Total 416 Mm^2.

Figure 3 shows the ownership structure in the residential property sector in Sweden. By far the largest proportion of property in this area is made up of one- and two family houses. In this category of ownership, the homeowner owns the entire building and land on which the house is built. The owner is therefore personally and directly responsible for all investment decisions and all energy costs. The group is particularly interesting because of the currently high electricity use (and in particular use of electricity for heating) in the sector (see Figure 4). On a national level, the ownership category is represented by the group the Swedish Homeowners Association (Swedish: Villaägarnas Riksförbund).

As shown in Figure 3 apartment buildings are made up of rental properties and those owned by leaseholder associations. Electricity use in this group is relatively less than amongst one- and two family house owners because a large majority of the energy for heat in this category of ownership comes from district heating, not electricity.

Housing tenants' rental payments for multifamily rental properties (private and public) are strictly regulated in Sweden, and are based to a great extent on tenants' ability to pay rather than building owners' operation costs. This has significant implications in owners' possibilities for investment. The further difference between private and public rental building owners is that private owners operate buildings on for-profit basis as compared to public who may be required to deliver a certain minimum rate-of-return for municipal authorities (i.e. owners of public rental properties). In both private and public rental properties, the owners themselves may pay directly for electricity used for communal services (lighting in corridors, staircases, outside; common laundry rooms; ventilation systems) whereas electricity used in each separate apartment is predominantly billed directly to tenants. In Sweden, public housing companies are represented by the Swedish Association of Public Housing Companies (Swedish: SABO – Sveriges Allmännyttiga Bostadsföretag). Private companies (as for private commercial property owners) are represented by The Swedish Property Federation (Fastighetsägarna).

Leaseholder associations are essentially cooperative housing associations made up of anything from about 10 to several hundred separate apartments in the same area. Each apartment is owned privately by the leaseholder. Though it varies, residents are generally billed directly for the electricity consumed in their respective apartments, though other energy costs (electricity in communal areas and district heating) are billed to the leaseholder association. The association subsequently bills the leaseholder for these costs in the form of a monthly fee that is most often determined on the basis of the area of each apartment rather than on specific consumption data.

6 Electricity demand in the building stock

In describing the market potential for ICT for improved energy efficiency and environmental performance, energy data on many different levels is interesting. On the one hand, the scale of the market may be understood in terms of the current usage. An estimate of the current usage is given in Figure 4.

Significant factors that affect the values are the fact multifamily buildings and commercial properties use district heating, compared with one and two family houses where electricity is used for heating (either electric resistance radiators, electric boilers or heat pumps).

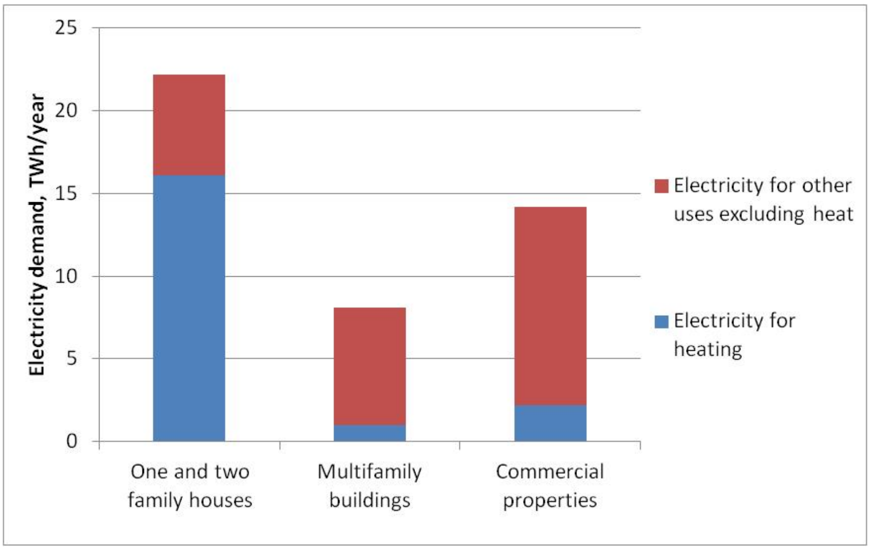

Figure 4: Total final electricity consumption in the Swedish building stock in TWh/year. Own estimate based on diverse sources ((Energimyndigheten 2011dd)

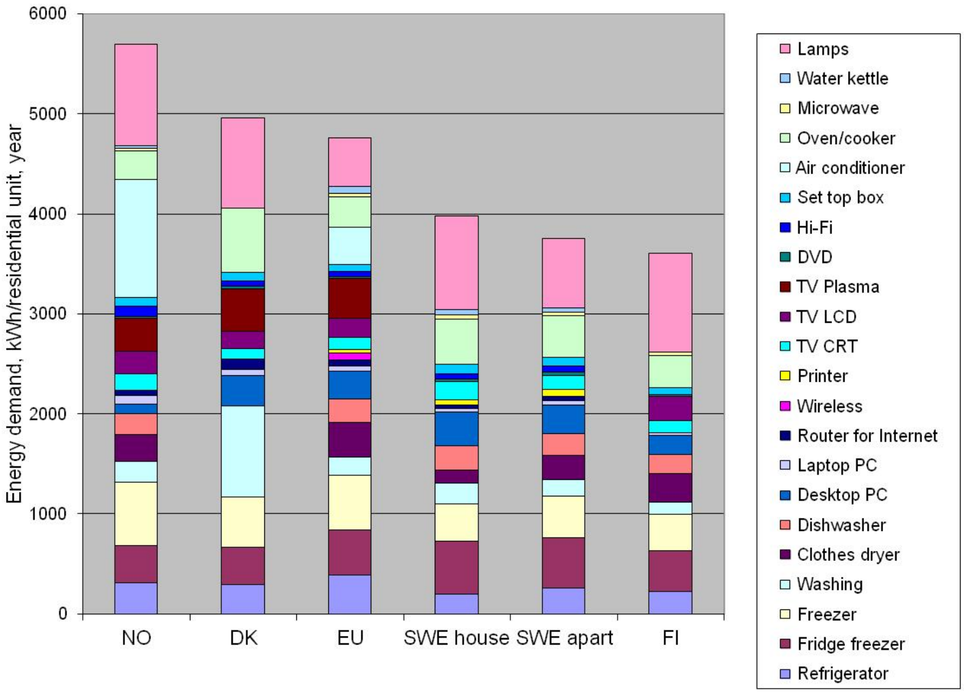

Figure 5: Electricity use (non-space heating) in kWh/year, residential unit for different European countries (NO- Norway, DK- Denmark, EU – European Union, SWE house – Sweden single and double family house, SWE apart – Sweden apartment in multifamily building, FI- Finland) (Öfverholm 2009).

Figure 5 and Figure 6 show the end-uses to which electricity is put in residential buildings and commercial buildings repsectively. Figure 7 shows how the breakdown of consumption may be expressed on a national level for significant commercial building types.

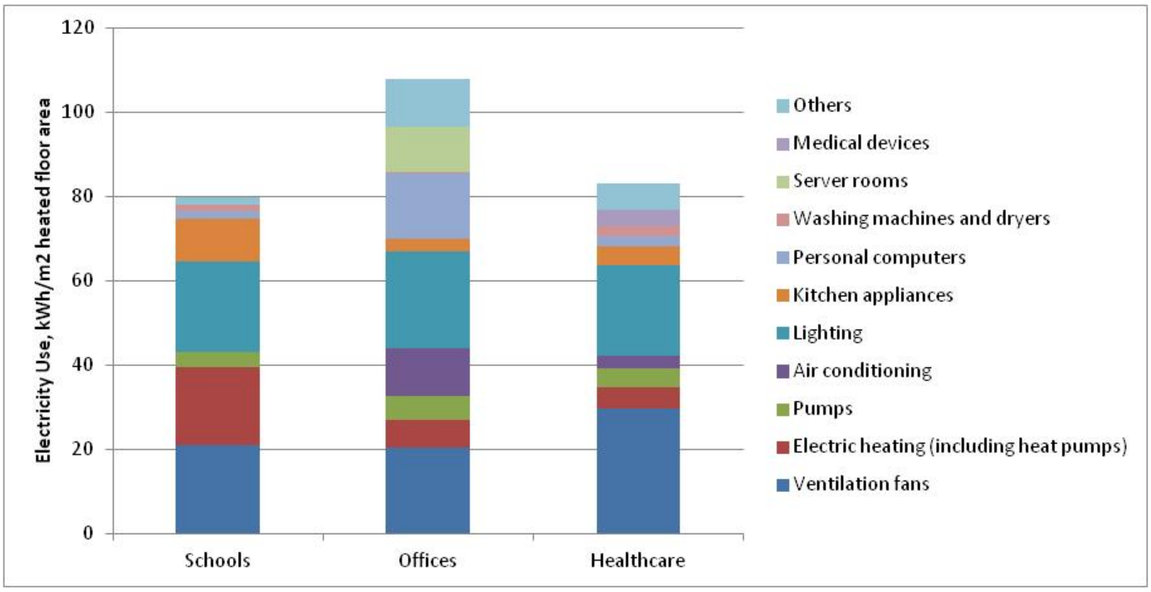

Figure 6: Specific electricity consumption in commercial buildings in kWh/m^2 heated floor area.

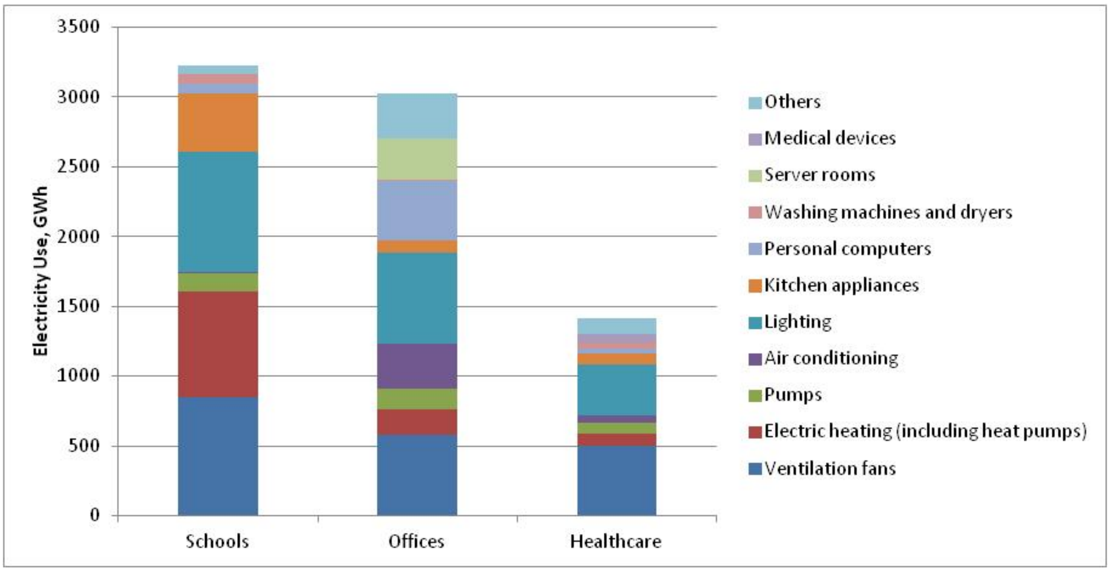

Figure 7: Total national electricity demand for selected commercial building types in Sweden.

7 Electricity billing schemes

One point at which electricity consumption data is (for obvious reasons) recorded is at the point of purchase. The electricity customer in Sweden is billed for electricity by 2 different actors: A bill for electricity production, from an electricity trading company and a bill for transporting electricity from the local distribution monopoly. The customer has no choice as to which local distribution monopoly it chooses – this is determined by the customers' geographical location. However, a customer may freely choose "the best deal" from any one of many electricity trading companies.

The billing tariffs that are used in each case are explained under the subheadings below.

7.1 Structure of the Swedish Electricity Sector

The Swedish electricity sector was restructured in the mid-1990s to facilitate more market-based interaction in the production and use of electricity. The following actors are important to consider:

Users: Here, we consider those who derive the direct benefit from electricity use. This person may the same as the customer, though often they are not.

Customer: This is the actor who is billed for electricity that is used. As mentioned above, this is most often a different person than the user.

On the other side of a customer's electricity meter, are the following actors:

Generators: These are companies that own and operate power stations that produce electricity. Large actors in this market are companies such as Vattenfall, E.On (hydropower and nuclear power) and to a certain extent Fortum (chiefly through CHP plants).

Svenska Kraftnät: This a nationalized company that operates the high-voltage transmission lines that move the electricity long distances at high-voltage from the point of generation to load centers (customers). Svenska Kraftnät also has a final responsibility for balancing load with generation on the network.

Local Distribution Monopolies: In each region of Sweden, one company owns the local network that distributes electricity at lower voltages from the national transmission grid to the electricity meter.

Electricity trading companies (ETCs): These companies do not own physical assets on the grid, they rather function as electricity marketers, who buy from generators and sell to customers. In buying from generators, ETCs may enter bilateral agreements with specific generating companies, though the majority of the electricity produced is traded through the spot market at the Nordic electricity exchange, Nordpool.

Nordpool: This institution functions as an electricity exchange between generators and producers. Although electricity may also be traded in long-term contracts between producers and consumers, in general a large majority (between 70 % and 80 %) is traded through the Nordpool exchange.

8 Electricity consumption information at the point of purchase

The price of electricity also plays a significant role in a customer and a users behaviour.

The time resolution of the measurement depends on the size of the user, which is determined according to the size of the main fuse that connects a given customer to the grid. Customers with a fuse rating over 63 A have consumption measured on an hourly basis, while those with fuse rating less than 63 A have consumption measured on a monthly basis.

The electricity customer in Sweden is billed for electricity by 2 different actors: A bill for electricity production, from an electricity trading company and a bill for transporting electricity from the local distribution monopoly. The customer has no choice as to which local distribution monopoly it chooses – this is determined by the customers' geographical location. However, a customer may freely choose "the best deal" from any one of many electricity trading companies.

The billing tariffs that are used in each case are explained under the subheadings below.

8.1 Billing for distribution services

There are in general three different types of tariff for billing of distribution services, shown in the table below:

Table 1: Predominant tariff types for electricity distribution in Sweden

Tariff type	20 A Max fuse rating	Max fuse ratings between 20 and 200 A	Power-based tariff
Tariff structure	Standing charge (kr/year) + Constant transfer fee (kr/kWh)	Standing charge (kr/year) + Transfer fee, high load periods (kr/kWh)(b) + Transfer fee, low load periods (kr/kWh) (b)	Standing charge (kr/year) + Transfer fee, high load periods (kr/kWh) + Transfer fee, low load periods (kr/kWh) + Monthly maximum power fee (kr/kW, month)(a)
Type of customer	All apartments, single and two family houses that do not use electricity for heating purposes	All customers from single and two family houses with electric heating (direct, electric boiler, heat pump) up to large commercial properties	Commercial properties

(a) This refers to the highest active power extraction made by the customer for each calendar month.

(b) High load periods are defined as 6 am to 10 pm on weekdays, November to March inclusive. All other periods are low load.

8.2 Billing for production

The principal guiding documents for agreements between an electricity trading company (ETC) and the customer are the electricity law (Notisum 2012) as well as general guidance notes drawn up by the industry group Svensk Energi and the Swedish Agency for Consumer Protection (see e.g. (Eon 2012)).

Customers pay for electricity production in kr/kWh, with the actual price that is determined according to the type of contract a customer has with the ETC:

1. Until further notice (tillsvidare): This is the “default” contract that customers who have not indicated otherwise to their local distribution monopoly are assigned, most often with an electricity trading company with which the local distribution monopoly collaborates. Under such a contract the electricity trading company may change the electricity price, though is required to inform the customer of changes a certain time (a number of months) in advance. Such contracts can normally be terminated on short notice, around one month.
2. Non-fixed price (rörligt pris): The customer pays the spot price on the Nordic electricity exchange (NordPool) plus a fee for the ETC’s administrative costs. Customers with fuse rating above 63 A have electricity use measured on an hourly basis, and when such customers buy electricity on a non-fixed price they are billed the specific hourly average spot price. Customers with a fuse rating less than 63 A have electricity measured monthly and are therefore billed the monthly average spot price. Notice time for terminating a non-fixed price contract varies among ETCs between 1 and 3 months.
3. Fixed price: In this case, a customer has a contract with an electricity trading company for a fixed price per kWh for the agreed timespan of the contract, this can range from as short as 6 months up to a period of a few years. A customer who breaks a contract during the period of agreement may be liable to pay penalty fees payable to the ETC.

The distribution of customers amongst the different forms is shown in Figure 8 below.

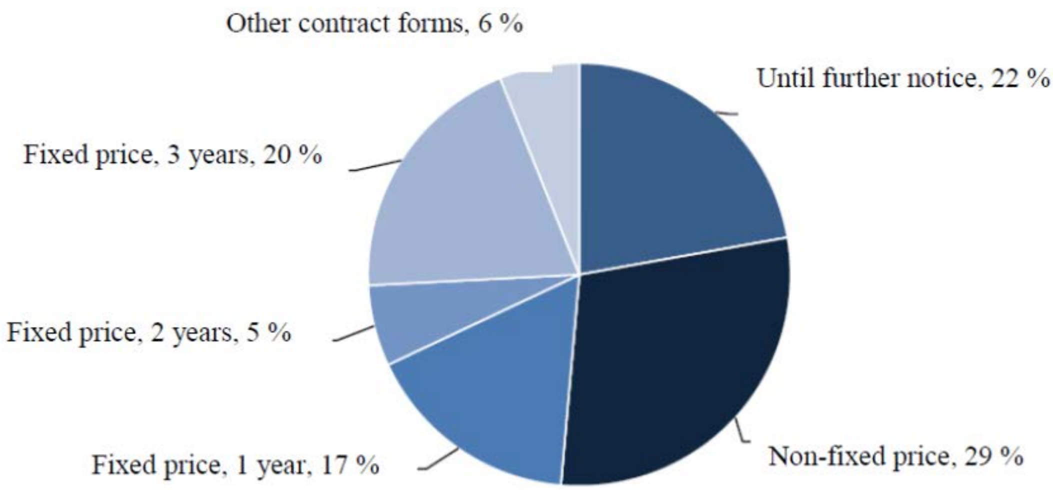

Figure 8: Distribution of contract types between customers and ETC. Other contract forms may be fixed price contracts with time periods longer than 3 years or mixed contracts, where a certain portion is sold at a fixed price, and a certain portion at a non-fixed price. (Energimarknadsinspektionen 2011).

8.3 Future Billing Schemes

8.3.1 Fixed price with Right to Rebate (fastpris med returrätt)

Experiments using the tariff were carried out by Göteborgs Energi AB and reported in (Fritz 2009). This scheme for charging for electricity production consists of the following:

1. The customer fixes the price of a certain proportion of their yearly electricity consumption (based on previous years' consumption), between 0 and 100 % of consumption.
2. For every separate hour, if the hourly consumption exceeds the "fixed price consumption level" (as calculated according to 1 above), the customer pays spot price for that particular hour for the excess. On the other hand, if the customer consumes less for that given hour, then the customer is reimbursed for the difference between actual and projected consumption at the market spot price as well.

Note that in these experiments, a standard distribution tariff was used, consisting of a standing charge and a fixed price per kWh electricity delivered.

8.3.2 Direct spot price

In experiments with smart grids in Norra Djurgårdsstaden, the customer's electricity cost will be directly related to the spot price on the Nordic electricity exchange (Nordpool) and it is intended that they be informed of hourly prices for each day one day in advance (Bergerland 2011). This is essentially the way in which large customers with hourly measurement choose to be billed today.

9 Discussion

Some literature suggests that price sensitivity for electricity customers is low, e.g. (SOU 2008). However, other literature (Hawken, Lovins et al. 1999) points out that in order to understand a customer's market behavior it is not enough to look at just the price only, rather we also need to look at how well-informed customers are about prices and consumption, and moreover the extent to which customers are empowered to change behavior in light of pricing and consumption information. ICT has an important role to play in both increasing customer information about energy prices and consumption as well as in empowering customers to act based on price information.

In general, control systems are commonplace in buildings of all varieties (e.g. thermostats of all different varieties, daylight control systems, motion sensors, timed switches etc.) and there are large companies that specialize in such systems (e.g. Landis and Gyr, TourAndersson). The significance of ICT in this context is that in can contribute to significant improvement of the control systems' functionality and value. Any new ICT solutions need to be developed with such control systems in mind. This is important since the ability to retrofit new ICT based control technology with current control systems give good market opportunities for the new technology.

9.1 One and two family buildings

The key interest for ICT solutions in one and two family buildings is due to the fact that many such buildings use electricity for heating purposes. Though this may be considered to be decreasing in the future since houses with direct electrical heating are changing out such systems for more efficient kinds. However, heat pumps will be continue to play a significant role in heating for such homes in the future, and therefore there will continue to be applications for ICT in the single- and two family home ownership group.

Having said that, by their nature, single and two family home-owners are a heterogeneous group. Level of knowledge about the connection between the decisions made and how they influence energy consumption and costs would understandably vary considerably in the group. With so many separate decision makers, market penetration may be limited as compared to say commercial property.

A possible barrier here is that currently single- and double family home owners do not have access to energy data in high resolution in the way that commercial customers do. It is possible that this is set to change, with a recent report from the Energimarknadsinspektionen (the Swedish Energy Markets Inspectorate) recommending that customers with yearly electricity consumption over 8000 kWh (which includes many customers in single- and double family houses with heat pumps as well as other forms of electric heat) have hourly measurement (Lundgren 2010). The same report also shows that such a measure may likely lead to reduced total costs on the order of 2000 Mkr. The extent to which decision makers will act on this recommendation is not currently known, and the suggestion is still under investigation.

9.2 Commercial properties

There is significant potential for ICT to improve energy systems in commercial property since the properties are complex in terms of the heating, ventilation, air conditioning and lighting sytems. BMS's are commonplace in such properties, though there is of course a varying degree to which the systems are integrated, as well as the kind of information available and the options for changing behavior based on the system. The fact that most such buildings have professional property management may be seen as positive, since property management companies may be a natural target group for the deployment of new ICT technologies in the sector.

An important actor-related aspect in this sector are the split incentives that arise from billing practices in the sector. Often, though not always, for example a large office/administrative building will have one measurement point where the landlord buys electricity from the grid, which is then divided up according to area occupied by each tenant (SOU 2008). This fact may be a double-edged sword for the potential for ICT here: One the one hand there is little incentive under this system to increase efficiency of electricity use, on the other hand ICT solutions may be useful in supplying low-cost measurement systems to ensure measurement of each tenant's actual consumption.

A further actor-related aspect is the typical occurrence of split incentives, that is that whereas tenants may see the benefit of investment in ICT, the cost of the investment is borne by the building owner.

The fact that the sector does not use electricity for heating purposes does of course mean that ICT for electrical efficiency per se may not have as large a potential for energy efficiency as in the one- and two family houses sector. On the other hand, as mentioned above, buildings that have BMS can easily integrate control of the heating system (predominantly district heating) with control of electrical systems.

9.3 Multifamily buildings

In general, multifamily buildings do not seem like a high priority for the deployment of ICT for increased energy efficiency. This is due to the fact that the sector is not a major electricity consumer compared to the others considered. Secondly, the billing structure is generally such that each separate apartment has a separate grid connection, and each customer consumes relatively small quantities of electricity (since heating is supplied in general by district heating).

Finally, in contrast with the commercial property sector, but in common with single- and two family homes, multifamily buildings are somewhat less complex in terms of the heating, ventilation, air-conditioning and lighting systems than commercial properties. Though some kind of BMS may exist in multifamily buildings, it is likely simple and connected specifically to the heating system. An important actor aspect here is the fact that heating tends to be paid for by the housing company (in the case of rental property) and the leaseholders' association directly, whereas electricity used in the households is billed directly by the apartment.

10 Conclusions

ICT applications for increased energy efficiency and environmental performance have been categorized according to (Hannus 2010).

Due to the significance of heating as an end use it seems initially that this should be prioritized as an application for ICT.

The relative opportunities for ICT to improve energy efficiency in the built environment has been assessed. Of the three sectors considered in the report, two were identified as particularly promising for the intitial deployment of ICT in this sector for this purpose:

Single and two family homes: On the basis of the fact that the sector is a large user of electricity for heating purposes (and will continue to be so in the future, particularly for heat pumps).

Commercial properties are interesting because they are technically complex, and have well established technical systems and organizational structures for managing electricity use that new ICT systems could support, probably in combination with systems for managing heat demand (based on district heating). Possibilities may be tempered by the fact that the owner-tenant structure, both in terms of physical investment and electricity billing may pose barriers to the introduction of ICT.

Multifamily properties were judged to be less prioritized because of the relatively lower electricity use in the sector, somewhat simpler technical systems for energy management and a billing structure that focuses on the large number of individual apartment occupants.

PART 2: Strategic Environmental Assessment and Smart Grids

11 Introduction

The transition towards sustainable energy system is a key challenge for the entire society. Smart grids are seen to have a key role in this transition and are identified as a key component in the EU energy strategy. (EC JRC, 2011) However, strategic decisions and planning processes that influence smart grids deployment exist among a much wider group of actors. Standing on the verge of a smart grids revolution, it is legitimate to be concerned about the management of its sustainability aspects. Strategic environmental assessment (SEA) is a well researched process for assessing policies, plans and programmes with respect to environmental criteria. This study attempts, in a summarized manner, to review current applications of SEA for smart grids deployment and propose areas for future research. The aim of the study is to:

3. Provide introductions to SEA and smart grids respectively.
4. Identify areas for which smart grids challenges and opportunities may be of relevance for SEA.
5. Discuss the opportunities for SEA to assess strategic actions[1] related to smart grids.
6. Identify areas which may be of interest for future research on the applicability of SEA for strategic actions related to smart grids.

This study reviews the literature, authority guidance and other written materials. In addition, interviews with authorities, academics and private sector representatives are carried out for insight into current practices. The study is delimited to the EU context. When specific country contexts are used, this is specified in the text.

12 Strategic Environmental Assessment (SEA)

12.1 What is SEA?

12.1.1 Definitions

Many definitions of Strategic Environmental Assessment (SEA) have been proposed over the years. An often cited generic definition of SEA is the following:

SEA is a systematic process for evaluating the environmental consequences of proposed policy, plan or programme initiatives in order to ensure they are fully included and appropriately addressed at the earliest appropriate stage of decision making on par with economic and social considerations. (Sadler and Verheem 1996)

[1] A strategic action is here referred to as any decision of strategic character, including policy, plan and programmes decisions.

This definition emphasizes the procedural nature of SEA and the integration of environmental consequences into decision processes of policies, plans or programmes (PPP)[2].

However, these definitions pertain to the generic SEA and not specifically SEA that is required in all EU member states, according to the European Union Directive 2001/42/EC (a.k.a. the European SEA directive). In this legal framework, SEA is limited to assessments of plans and programmes carried out by the public sector. In the Practical Guidelines on Strategic Environmental Assessment of Plans and Programmes (Swedish Environmental Protection Agency 2010), SEA is defined as

…a process involving a number of stages which government agencies and municipal authorities should carry out when they draw up or amend certain plans or programmes whose implementation may be supposed to entail significant environmental effects. Within the framework of the strategic environmental assessment, the positive and negative significant environmental effects that the implementation of the plan or programme may be supposed to entail should be identified, described and assessed.

12.1.2 SEA Differs from Environmental impact Assessment (EIA)

SEA has its root in Environmental Impact Assessment (EIA) of projects and can in a simplified manner be said to be the strategic form of EIA. SEA has been developed due to the recognition of the limitations of project EIAs, which tend to be reactive to development proposals and not well positioned for assessing cumulative effects. It is argued that SEA differs from EIA by its strategic dimension, its emphasis on process and its increased reference to contribution of sustainable development (Bina 2007; Dalal-Clayton & Sadler 2005; Glasson et al 2005). In EU, SEA and EIA fall under different directives. Whereas EIA is required by the EU EIA directive (Directive 85/337/EEC), SEA is required by the EU SEA directive (Directive 2001/42/EC).

12.2 What does SEA assess?

12.2.1 Environmental Effects of concern for SEA

SEA is applicable to a range of different types of impacts. The effects to be assessed by SEA as specified by the EU SEA directive include (EC 2001)

The likely significant effects on the environment, including on issues such as biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors; (The significant effects stated here are secondary, cumulative, synergistic, short, medium and long-term permanent and temporary, positive and negative effects.)

12.2.2 Decision making subject to SEA

According to the EU SEA directive, SEA is required for plans and programmes that fulfill the following criteria:

- subject to preparation and/or adoption by an authority, and
- are required by legislative, regulatory or administrative provisions, and

[2] "A policy may be considered as the inspiration and guidance for action, a plan as a set of co-ordinated and timed objectives for the implementation of the policy, and a programme as a set of projects in a particular area." (Glasson et al 2005)

- are likely to have significant environmental effects and
    - are prepared for agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism, town and country planning or land use and which set the framework for future development consent of projects listed in the EIA directive or
    - in view of the likely effects on sites, require an appropriate assessment under the Habitats Directive or
    - are other plans and programmes determined by Member States to set the framework for future development consent of projects and
- are begun after 21 July 2004 or are completed after 21 July 2006.

A list of plans and programmes on which SEA must be carried out have been specified in authority guidelines. The Swedish Environmental Protection Agency's practical guidelines categorize plans and programmes in different groups. SEA is almost always required for certain plans and programmes which state the conditions for future permits. These plans and programmes belong to "Group 1" and comprise inter alia Municipal energy plans, County transport plans, Action programmes, Municipal comprehensive physical plans and National plans for transport infrastructure.

SEA may also be required for "Group 2" plans and programmes, which include Housing support programmes, Programmes for detailed development plans, Regional development programmes, Management plans for national parks and natural and cultural reservations and Traffic support plans.

Screening to determine the need for SEA is required for a number of plans and programmes, which include detailed development plans and other plans and programmes under certain conditions.

In the academic literature, decision making processes which are subject to environmental assessment are broader. To start with, SEA is strongly recognized as a tool for supporting policies. The approach for undertaking SEA differs depending on the PPP tier of concern (Runhaar 2009). It is also recognized that decision making processes may not be rationally hierarchical and that SEA needs to adapt to the decision making context (Nilsson & Dalkmann 2001). It has further been discussed whether SEA may extend beyond "decisions" and address "emergent strategies" (Cherp et al. 2007).

12.3 How is SEA used?

12.3.1 Different SEA Approaches

In the literature, two commonly discussed approaches include the objective-led and baseline-led SEA. The objective-led SEA takes the point of departure from sustainable objectives of the policy, plan or programme and evaluates the strategic action alternatives against these objectives. The baseline-led SEA starts by describing the baseline environment through SEA themes, objectives and indicators. The information is then used to influence the objectives of the PPP of concern. In practice, the two approaches may be used jointly.

12.3.2 Stages of the SEA Process

As SEA can be applied to a number of different decision-making processes, the generic stages and the order of the steps of an SEA process may vary accordingly. SEA may also be an iterative process where some phases are recurring.

Screening is conducted in order to determine whether SEA is required, either by legal requirements or by the significance of the possible impacts. The screening stage is sometimes defined as a pre-SEA stage (Swedish Environmental Protection Agency 2010). A number of basic stages that are common for good practice EIA-based SEAs are described below (Dalal-Clayton & Sadler, 2005, p. 15; Glasson et al, 2005; Jones et al, 2005, pp. 18-21). Below, stakeholder consultation and public participation are not separated out as a stage as they are seen as an integrated part of the process.

- **Scoping** is the determination of key issues to address and may also include preliminary identification of key stakeholders, identification of impact themes, plan for involvement and outline of final report.
- **Collection of relevant environmental data** and understanding of the assessed policy, program or plan.
- **Consideration of scenarios** is a thorough analysis and description of different possible future scenarios as well as the “no action” scenario. Scenarios may differ through alternative scales, activities, locations etc.
- **Impact identification, prediction and evaluation** involve environmental analyses and take a range of different types of impacts into account.
- **Presentation of the Environmental report**
- **A final review** could be a formal requirement for assuring the quality of the SEA.
- The **follow-up** audits and verifies the actual impacts, the implementation procedures as well as the mitigation measures.

12.3.3 Methods and tools connected to SEA

A number of methods and analytical tools may be included in an SEA process. The Swedish Environmental Protection Agency’s practical guidelines on SEA of plans and programmes provide a list of appropriate tools which is not accounted for here.

For use in the energy sector SEAs, Finnveden et al. (2003) examines a selected number of qualitative and quantitative tools:

- **Future studies** are often used in SEAs. Approaches include forecasting, back-casting and scenario analyses. Modeling is frequently used for to support future studies as quantitative terms may be included. Use in the energy sector includes future energy use analyses and energy system studies. Backcasting may be used for formulation of alternatives.
- **Life cycle assessment (LCA)** is used to quantitatively assess the environmental impacts throughout the lifecycle of a product. The tool is particularly used for environmental analysis and is best covered for emissions to air.
- **Environmentally extended input/output analysis** is a quantitative method best covered for accounting emissions to air within a nation or region.
- **Risk assessment of chemicals and accidents** is used in environmental analysis for hazard identification, consequence analysis and frequency estimation.

- **Impact pathway approach** is a systematic and quantitative risk assessment approach mostly applicable to air pollutants.
- **Ecological impact assessment** encompasses a family of tools with different approaches. Finnveden et al (2003) did not identify any ecological impact assessment tool specific to the energy sector.
- **Multiple criteria analysis** is used to structure multiple objectives and can be applied as a process in expert analysis as well as stakeholder participation.
- **Environmental objectives** can be used as guiding principles for the SEA. From the Swedish perspective, national environmental objectives can used to benchmark PPP objectives, to identify impacts, to select indicators as well as to valuate impacts.
- **Economic valuation** can be used in the valuation stage of SEA and for analyses of trade-offs between different objectives**.**
- **Valuation methods based on mass, energy and area** are not primarily developed for SEA but could be useful where inputs are relatively certain**.**

13 Smart Grids

13.1 What are smart grids?

There are no universally accepted definitions of the concept or scope of “smart grids” (Energy Markets Inspectorate 2010; SMB Smart Grid Strategic Group 2010). The European Technology Platform for Smart Grids focuses on the use of smart grids and describes it as

…an electricity network that can intelligently integrate the actions of all users connected to it - generators, consumers and those that do both - in order to efficiently deliver sustainable, economic and secure electricity supplies (SmartGrids ETP, 2011).

The basis for smart grids lies in the development in integration of information and communication technology (ICT) with electricity delivery systems, i.e. “computerizing” of the electric utility grid.

Smart grids is intractably interlinked with other types of technologies and infrastructures, e.g. renewable energy production, plug-in electric vehicles (PEVs) and decentralized production resources etc. (Cédric 2011). When addressing the environmental impacts of smart grids, such interdependencies are considered.

13.2 Application of smart grids along the electricity value chain

To provide an overview of the various applications of smart grids, this section examines the smart grid relevance along the electricity value chain, namely generation, transmission, distribution and consumption.

13.2.1 Generation

Generation concerns the production of electricity (Jay 2005). The benefits of applying ICT for the integration of the renewable generation of electricity are some of the most important arguments for promoting smart grids. Grid limitations are some of the most significant obstacles to the proliferation of wind and solar power (Alldritt and Hopwood 2010).

Renewable power plants deliver electricity intermittently depending on weather conditions. ICT can help balancing out these unpredicted fluctuations, e.g. by providing grid operators with real-time data from single units, and by establishing virtual power plants (interconnected pool of small generation units with characteristics of a large plant).

Renewable power plants are also inherently decentralized. In this aspect, communicative integration and wireless solutions may make offshore plants cheaper to maintain (Wissner 2011). In addition, smart grids can contribute to increased knowledge of demand and allow optimization of production resources (Clastres, 2011).

13.2.2 Transmission

Transmission is the long-distance transfer of electricity at high voltage (Jay 2005). Transmission companies may also be responsible for reserve power stations, which are used to equalize net deviations. Possible applications for ICT in transmission and reserve power include rapid communication to improve the communication between reserve power providers, central contact station and transmission grid operator (Wissner 2011). To cope with the emerging smart grids transition in the industry, new transmission lines are not necessarily needed. However, the design of transmission grid developments may be adapted for future smart technologies, e.g. bidirectional distribution grids etc. (Rescia, personal communication 2011). For management of and communication with the increasing numbers of small reserve energy providers, ICT will be indispensable (Wissner 2011).

13.2.3 Distribution

Distribution concerns the generally low voltage transfer of electricity to consumers (Jay, 2005). The “smartening” of distribution grid involves demand-side management (DSM) and demand response programs. Price- and incentive-based demand response programmes are two methods to manage load and increase grid stability with the help of ICT. This means that smart grids offer the possibility for distribution operators to anticipate high loads and thus, better opportunities to maintain grid stability and to balance load (Wissner 2011).

13.2.4 Consumption

Benefits of smart grids to consumers include reduced outages, increased control of costs and electricity savings. ICT may also enable automation and interaction with in-house appliances, realizing the concept of “intelligent building” (Wissner 2011). However, issues regarding for instance user interface, privacy, personal data management remain to be solved (Clastres, 2011). Electricity consumption by electric vehicles is further expected to rise, and is anticipated to spur smart grids developments. Deployment of electric cars may not only increase demand of smart communication, but will also have the possibility to act as distributed electricity storage for intermittent renewable power production (Gunther 2010).

13.3 Challenges to the deployment of smart grids

Challenges to implement smart grids in Sweden have been analyzed by the Energy Markets Inspectorate. Identified impediments that need further attention include lack of knowledge, lack of incentives for grid operators to invest, lack of national action plan for transmission grids, and sub-optimized electricity rates (Energy Markets Inspectorate 2010).

13.4 Environmental aspects of smart grids

Analyses of environmental impacts of smart grids mainly focus on the prospects for significant emission reduction through inter alia promotion of consumer energy conservation, efficient deployment of decentralized renewable energy resources and facilitate transition to non-fossil based transportation. One of the more comprehensive reports on environmental impacts of smart grids has been produced by the U.S. department of Energy. The report concluded that smart grids will allow electricity to be managed more efficiently, although is not clear whether smart grids will reduce net electric power production due to possible increase in electricity demand (U.S. Department of Energy 2011). Hledik (2009) concludes, based on a series of simulation of the U.S. power system that smart grids would allow CO_2-emissions reductions by 5-16 % by 2030 thanks to technologies enabled by electricity infrastructure upgrades.

Other types of environmental impacts, e.g. land-use change, related to the smart grid-enabled technologies appear to be less connected to smart grids in the reviewed literature. Negative environmental aspects such as land-use in connection to development of renewable energy production and grids have been discussed in the literature, but no direct relations to smart grids were found. According to Mr. Englund (personal communication 2011), the need for grid expansion is in general reduced with implementations of smart grids as the electricity efficiency increases.

14 The power sector

14.1 Players

There are a range of different players in the power sector and stakeholders of smart grids developments. The interests and roles of the players for strategic planning in relation to smart grids are diverse and complex, and might be relevant and important to understand for the undertaking of an effective and adaptive SEA.

14.1.1 The electricity industry

Decision makers in the electricity industry include players in the competitive component (i.e. generation companies, trading companies, retail companies, holdings of vertically integrated companies and electricity customers), players in the regulated segments (i.e. transmission companies and transmission system operators, distribution companies and distribution system operators) and regulators (Weber 2005).

The electricity generators own power production facilities and are responsible for metering the electricity delivered from the facilities to the grid. For renewable electricity generation, the availability of grids and smart grids may be significant for development decisions (Energy Markets Inspectorate 2010).

The national high-voltage transmission grid operator in Sweden is the state-owned public utility Svenska Kraftnät. Grid operators of all transmission and distribution are due to hold grid concessions. According to the Swedish electricity law, grid operators are responsible for maintaining, development of new grids and in some cases grid connections to external grids. In addition, grid operators are responsible for the reliability and effectiveness of the girds, as well as the long term requirements of power transmission and distribution. Grid operators are, thus, responsible for grid planning and developments in order to meet the need for connecting the increasing renewable generation. They are also responsible for addressing grid instability issues that may arise due to increased renewable energy production and charging units (Energy Markets Inspectorate 2010). Distribution system operators are seen to have a leading role to play for smart grids implementation (EC JRC 2011). Smart grids applications, such as energy storage and load steering, are expected to reduce the need for larger investments in the grids (Energy Markets Inspectorate 2010).

Consumers may be private customers or businesses (Electric Markets Inspectorate, 2010). Consumers may not be part of formal decision makers in policies, plans or programmes, but is thought to influence decisions indirectly through demand of renewable energy, acceptance of technologies and as stakeholder in PPP processes.

14.1.2 Government bodies

From a wider perspective, a range of government bodies may be direct or indirect decision makers for electricity infrastructure developments, from national bodies regarding energy policies, to municipalities who are concerned with comprehensive development planning or energy planning.

It is not certain that planning explicitly addresses smart grids. This is the case in Gotland in Sweden, where the energy plan as well as the comprehensive development plan emphasize renewable energy developments but take no direct account of necessary technologies. According to Helena Andersson (Gotland municipality, personal communication 2011), the need for smart grids technologies are concerns for the implementation phase and implicitly acknowledged in the plans.

14.1.3 Other Sectors

In addition, the enabled technologies of smart grids also open up for a range of industries in other sectors, e.g. vehicle, transport and construction. For instance, the development of electric vehicles is seen as both a driver for smart grids and as a technology whose implementation is facilitated by smart grids (Gunther 2010).

14.2 Power system planning tools

Approaches for power sector planning are continuously developed. Many tools are not developed for environmental aspects in particular, but may include analyses parameters of environmental relevance, e.g. CO_2-emissions and energy efficiency.

One example of power system expansion analysis tool is integrated resource planning (IRP), which was frequently used prior to the deregulation of the sector. Hu et al (2010) has developed an extension of IRP, called Integrated resource strategic planning (IRSP), for support of government's macro-strategic planning in China. The new approach considers both the supply and the demand side, and the output parameters include CO_2 mitigation potential. Hu et al (2010) claims that the IRSP will be an asset for the implementation and design of smart grids at the national level.

15 The application of SEA in the Power Sector

SEA is virtually not used in the energy sector (Cherp 2007) and when it is used, the scope is often limited and focuses mainly on the energy supply, to some extent energy conservation and rarely in electricity networks. The scope of the energy SEAs carried out also tends to focus on either high-level energy policies or narrowly defined components of the industry (Jay 2005). At first view, this seems odd, as many environmental issues are to a large extent associated with energy supply. Some reasons for this lack of uptake of SEA in this sector include lack of legislative requirements, lack of know-how on how to carry out SEA in business context and lack of incentives for private companies to carrying out SEAs.

The EU SEA directive limits plans and programmes for which it is applicable to those "prepared and/or adopted by an authority" and "which are required by legislative, regulatory or administrative provisions" (EC 2001). Guidelines of SEA (e.g. the Practical Guidelines of the Swedish Environmental Protection Agency) are also typically directed towards government agencies and municipal authorities, and not companies.

However, the electricity sector is to a large extent comprised of privatized companies. Considering that SEA is primarily designed for public strategies carried out by public agencies, there is certain lack of knowledge and experience of SEAs in the business context. SEA often assumes certain degree of central decision making, whereas, with the deregulation reform, the electricity sector has lost such coordinated, strategic and public interest driven infrastructure planning. This leaves SEA without any clear strategic decision-making process to relate to (Jay 2005).

The public sector has a range of objectives, whereas the strategies in the private sector are first and foremost profit-driven (Cherp 2007). For voluntary SEA to be carried out, strong incentives must be in place. For the public sector, increased accountability and transparency itself may be a strong enough driver, whereas these added-values may not be sufficiently attractive for the private sector (Cherp 2007).

Nevertheless, there are some discussions on the possibilities for SEA to be relevant in the private sector and in particular the electricity sector.

In general terms, for SEA to be relevant for industry, SEA needs to contribute to corporate objectives and the corporate environmental policy. An idea is for SEA to establish strategic decision framework that may assist in reducing also environmental impacts that may be costly for private companies in the long run. From a procedural point of view, a business SEA needs to be adaptive and responsive to the decision-making processes of industry and be "incorporated into the language and processes of business practices". From these perspectives, it has been suggested that objective-led SEA might be more advantageous in a business context. (Jay 2005).

The electricity industry can be divided into two categories for the application of SEA: the competitive components of the industry (i.e. generation and supply), and the regulated monopolies (i.e. transmission and distribution). The competitive components can be described to generally act on a lower strategic level, with shorter timeframe and more site-specific perspectives. The regulated monopolies, however, have statutory responsibilities for the grids according to given concessions and are obliged to connect transmission lines to power generation projects of the generation companies. Even though the regulation seems to doom transmission and distribution companies to reactive grid developments, this is not entirely the case in reality. Transmission and distribution companies prepare strategic plans in which they provide guidance for generation developments. These strategic plans are seen as most promising for SEA to have a role (Jay 2005). In section 16.1, a case example of an SEA prepared for a national transmission grid development plan is provided.

Another possibility for SEA to be relevant for the electricity sector is that it be placed on a higher strategic level. Central energy policy, industry regulators, regional planning are three suggested levels for SEA to assert strategic influence and provide certain guidance for company strategies (Jay 2005).

16 Case examples

16.1 Case - SEA of national transmission grid development plan in italy

Pursuant to Italian law and the EU SEA directive, an SEA was carried out by the international consultancy firm Golder Associates for the National Electricity Transmission Grid Development plan 2011. The transmission grid development plan and the SEA were carried out for Terna, the major Italian electricity grid owner and operator company.

The undertaken SEA was objective-led, EIA-based and considered environmental goals on par with economic and social ones. The SEA included support for spatial selection and assessment of the corridors for the transmission lines. The SEA also checked cohesion of the transmission horizontally and vertically, i.e. interactions with other type of plans on the same level as well as plans at lower levels.

Smart grids solutions were described, but not explicitly analyzed or assessed in the SEA. In the scoping stage of the SEA, smart grids solutions in the transmission line context were considered to have only limited environmental impacts and were, therefore, excluded for further analyses. It was considered that smart grids solutions were of more significant concern for the distribution grid than for the transmission grid. In the transmission grid development plan, smart grids solutions were not included, but the grid design was made to enable smart grid solutions. For instance, the new grids were indirectly designed to meet future smart grids developments, e.g. to be bidirectional, to accommodate more storage points etc. However, it is noteworthy that the reviewing authorities required additional analysis and incorporation of smart grids into the plan and the SEA.

Since Terna operates under concession agreements, the allocation of transmission grids are to larger extent based on energy production and emerging grid demands and to lesser extent based on strategies formulated by the company. Smart grids concerns were not one of the main concerns for this particular SEA. Some possible and simplified explanations for this may be: 1) the low relevance of smart grids for transmission grids in comparison with for instance the distribution grids; 2) the environmental assessments were focused on more spatial than technological character; and 3) low incentives for Terna as a company to push and to take risks for smart grids developments.

This case description is based on information provided by Mr. Rescia (personal communication, 2011) and Terna (2011).

16.2 Case – smart grids in the Stockholm Royal Seaport

The Stockholm Royal Seaport is an urban district under development that has been targeted as a prioritized sustainability city initiative. To achieve the targeted environmental goals, the development of smart grids has been identified as key innovations to be carried out (Stockholm City 2011).

The smart grids solutions that are to be incorporated as in the district include (Bergerland 2010):

- Smart homes/buildings and demand response.
- Distributed energy systems.
- Integration and use of electric vehicles.
- Energy storage for customers and the grid.
- Smart primary sub-stations

The planning of the Royal Seaport is based on the Stockholm comprehensive development plan ("Översiktsplan") from 1999. Contradictory to the hierarchy earlier defined (p. 22) where plans precede programmes, the programmes in the Royal Seaport precede the detailed development plans, see Figure 9. In practice, however, the detailed development plan shares similarities with projects, whereas SEA shares similarities with EIA. The SEA for the programme of Royal Seaport was not available for review. However, in the SEA report for the detailed programme of Hjorthagen and the detailed development plan of the area Norra Phase 1, no smart grids solutions, decentralized power generation or related issues were explicitly addressed. In both the detailed programme for Hjorthagen and the local plan of Norra Phase 1, the idea of a climate positive district is mentioned but not further explained.

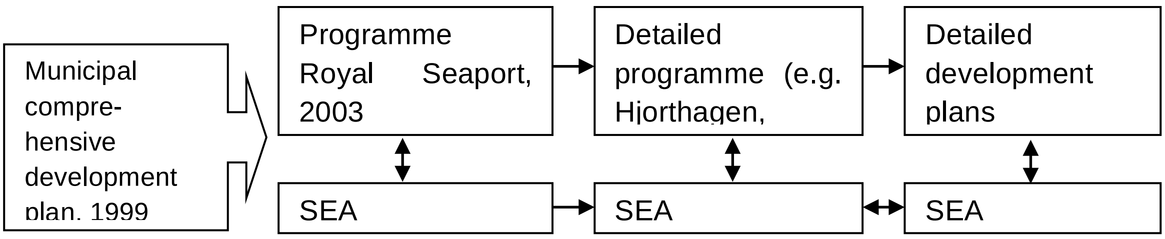

Figure 9 Plan and SEA process.

Apart from the legally required SEAs, environmental concerns are also manifested in a comprehensive programme for environmental and sustainability (hereafter referred to as "environmental programme"). The environmental programme derives from the policy documents Stockholm Vision and its six environmental objectives. According to these policy level documents, the Stockholm Royal Seaport is to be a climate positive district with sustainable energy system. Operational objectives were defined in the environmental programme based on the overall environmental objectives, and explicitly include decentralized generation as well as smart grids. Based on the operational objectives in the environmental plan, action plans are prepared and include minimum environmental requirements for contractors to meet. In the action plan for the area Ängsbotten, specified requirements include ICT for individual metering, system of sustainable transports and connection of decentralized electricity production to the grid.

The preparation of the environmental programme was coordinated by the Stockholm Development Administration. During the preparation, a consultation process with key players was carried out, involving inter alia construction companies, electricity technology providers, research institutes, building contractors, utility operators and consultants (Stockholm City 2010).

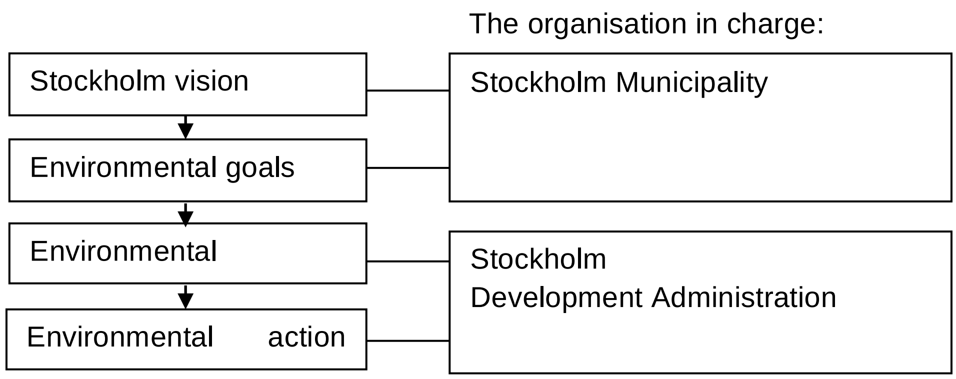

Figure 10 Implementation of environmental goals.

17 Discussions

17.1 Environmental enhancement

SEA is recognized as an instrument for improving and enhancing positive environmental impacts (Swedish Environmental Protection Agency 2009). However, there are indications that SEA in practice focuses mainly on mitigation of negative impacts and neglects the improvement opportunities of positive impacts. In a study in Scotland, nine out of 15 SEA reports were found to have minimal or no recognition of enhancement opportunities. Further research was claimed to be needed, in order to investigate international variations and to identify the causes for the lack of enhancement promotion. Possible causes stated in the paper include lack of experience, resources, time and inadequacy in guidelines (McCluskey and João 2011).

Smart grids are promoted as a way to enable greater use of renewable electricity, reduce peak loads, reduce consumption and create opportunities for active electricity customers. Considering these positive environmental effects commonly associated with smart grids, research on SEA’s potential for environmental enhancement appears to be of high relevance.

17.2 Knowledge brokerage

One of the key challenges that face smart grids technology diffusion is the lack of knowledge of the new technology and the benefits of it (Energy Market Inspectorate, 2010). The potential for SEA approaches and techniques to promote knowledge brokerage was found in a study that reviewed several cases in the U.K. and Portugal (Sheate and Partidário 2010). Learning potential through SEA is also acknowledged in other cases with respect to organizational and social learning of SEA and environmental impacts (Fischer et al. 2009). Through different techniques, including public participation, SEA may support knowledge brokerage that moves beyond information provision, and that facilitate the knowledge sharing and improve linkages between science and policy (Sheate and Partidário 2010). The literature reviewed in this study does not specifically investigate the potential for SEA to act as knowledge broker for emerging technologies such as smart grids. Exploration of this potential could be relevant for further research, considering the large number of stakeholders and players in the electricity sector (see section 14.1) and the identified need for knowledge augmentation.

17.3 Understanding smart grids relevant decisions

There are reasons to believe that the full extent of smart grids relevant decisions needs to be investigated in further detail. There are direct decisions regarding the incorporation of smart grids, such as highlighted in the Environmental programme of the Royal Seaport case. These decisions may in turn affect the formation of decisions regarding other domains, such as the introduction of distributed generation or infrastructure of electric vehicles. There are also reasons to believe that decision influence work in both directions, so that decisions in other domains may indirectly drive changes with implications for smart grids. Wind energy generation has for instance tested and in some cases driven changes to technical and industry arrangements (Passey et al. 2011). Others claim that electric vehicles will accelerate the deployment of smart grids (Gunther 2010; Goodell 2008). If decisions in different domains are compared to movements of nodes in a mesh, movements in one node may thus indirectly affect others. For SEA to be relevant in such a complex mesh of decisions, the significance and the relationships between the decision nodes in this sector may need further investigation.

17.4 Understanding decision making processes subject to SEA

The understanding of decision making processes is central for effective SEA integration and improved SEA influence, and many perspectives of this issue have been put forward in the literature.

A recent study of the Danish energy sector suggests that the sector is characterized by a "continuous interaction between policy-making and planning in windows of opportunities rather than approvals of plans and policies" (Lyhne 2011). This interaction may contradict the notion of distinct decision-making levels and the widely suggested tiering[3] concept of SEA. In fact, Lyhne (2009) concluded that neither policy- nor plan-oriented SEA methodologies were ready to address these interactions. Challenges include responsibility assignments with continuously changing responsibility, timing of SEA when informal choices are made and tiering of SEA in non-hierarchical decision making. To address the identified inadequacies, the study called for wider international studies of interaction in decision making processes and further discussions on how to increase the influence of SEA.

The smart grids concept is essentially a technological concept, which can be approached from a wide range of different perspectives and by a range of different players. Smart grids further transcend a number of different sectors, which might or might not interact. Given the diversity of ongoing processes, future research could ask whether SEA has a role to play in this context. If yes, why should SEA be involved, how should it be positioned in relation to these processes and which are the processes for SEA to be concerned about? How can SEA be strategically linked or integrated with these processes? How effectively does current SEA address smart grids issues? What are the lessons to learn from past SEAs?

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[3] Tiering is the distinction of SEA for policy, plans and programmes respectively.

In addition, given the deregulations in the power sector, significant strategic decision making take place in the private sector. Jay (2010) suggests that SEA could for instance be "incorporated into existing environmental practices with a company" and thus contribute to corporate sustainability initiatives, see also section 15. This potential to integrate SEA with corporate environmental processes could be further elaborated theoretically and investigated empirically. Given the private sector's role for smart grids, the extent and benefits of voluntary SEAs in the private sector could be of relevance for future research.

17.5 Linking SEA with other processes

In the case of Stockholm Royal Seaport (see section 16.2), it appears that smart grids solutions were explicitly introduced through the environmental programmes rather than addressed in the SEA reports. It is also possible that the smart grids solutions were mainly promoted in the planning process as a technological innovation project. In any case, based on the reviewed information, it was not clear if or how smart grids for environmental enhancement were recognized in the SEA process. Due to the complexity of the project, a proper case study would be necessary to bring clarity in the decision processes and the interaction between SEA and other processes with respect to smart grids. What is SEA's role for the promotion of smart grids? Did the SEA process at any stage consider or assess the effects of smart grids or smart grids related solutions? What are the links between the environmental programme and SEA?

17.6 Linking SEA tools with power planning tools

Considering that power planning tools are already used for decision support in the energy sector (see section 14.2), integration or linking of SEA tools may potentially improve the planning efficiency as well as achieve other synergistic benefits. However, challenges for such integration may exist in the form of knowledge gap, timing, professional language barriers etc. Future research could investigate how such linkages or integration may be designed, and explore the challenges as well as the co-benefits of such methodological integration.

18 Conclusions

Smart grids are an enabling technology inextricably linked with other types of technologies and infrastructures, i.e. renewable energy production, plug-in electric vehicles (PEVs) and decentralized production resources etc. When analyzing the environmental impacts of smart grids, these relationships are considered.

SEA's use in the energy sector is limited, which according to Jay (2005) is due to lack of legislative requirements, lack of know-how on how to carry out SEA in business context and lack of incentives for private companies to carrying out SEAs. Based on the preliminary findings of the two studied cases (see section 16), SEA didn't appear to have explicitly addressed smart grids.

Future research could in further detail investigate the arguments for relating SEA to smart grids as well as the ways in which SEA should be conducted in smart grid relevant contexts. SEA's potential for environmental enhancement and knowledge brokering have been identified as possible areas to explore for arguments to relate SEA to smart grids. It is further thought that a comprehensive understanding of the smart grids context is indispensable. The contextual understanding includes in particular the decision making processes, the stakeholders involved and their concerns. Due to the deregulations in the power sector, a business perspective is considered relevant to analyze further. In addition, in view of the diversity of players, processes and tools relevant for smart grids, research on integration and tool linking is suggested.

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