Exploring opportunities of implementation of White Certificates in Sweden

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Abstract

Consideration to phase out nuclear power in Sweden has been accelerated by the decision of Sweden's Parliament. Moreover, Sweden has committed itself to reduce its CO2 emissions. Although numerous policies developed to ensure an increase electricity supply from non-nuclear sources and a decrease in electricity consumption have been not sufficient to substitute nuclear power yet. Renewable energy sources have received strong support recently. However, without accelerated efforts to exploit the huge potential for electricity savings politics will fail to phase out nuclear power within the next 35 years.

My analysis of the present Swedish energy efficiency policies suggests that the demand side still have not been addressed sufficiently. A so-called White Certificate scheme may thus complement effectively existing policies.

This paper analyzes the appropriateness of a White Certificate scheme in the specific Swedish framework. The limited experiences with such systems in Italy and the UK are considered as well as practice with the Green Certificate schemes in Sweden and abroad.

Existing conditions on Sweden's electricity market are found to be appropriate for the implementation of a White Certificate scheme. Implementation of the instrument is recommended. Several design particularities of White Certificate scheme are suggested. The quantitative target is calculated in respect to the lifetime of nuclear power plants. Suppliers are suggested as appropriate obligated parties for fulfilling the obligation to increase electricity savings on the demand side. While designing White Certificate system, using of already existing institutional capacities was considered as supportive factor to faster implementation.

The paper does not consider making a comparison of White Certificate scheme with other policies. White Certificate scheme is consider as a part of existing policy framework for decreasing electricity consumption. However, further research can be done with the purpose to analyze White Certificate instrument in terms of economic efficiency.

List of abbreviations:

DSM - Demand Side Management
DISCOs - Gas and electricity distribution companies
EU – European Union
ESCO – Energy Services Companies
EECT - Energy Efficiency Certificate Trading
EE - energy efficiency
EEI - Energy Efficiency Index,
EC - European Commission
GC – Green Certificate
IEA - International Energy Agency,
R&D -Research and Development,
DEFRA - The Department of Environment, Food and Rural Affairs
OFGEM - The Office of Gas and Electricity Markets
EEC - Energy Efficiency Commitment
IPMVP - International Performance Measurement and Verification Protocol
WC White Certificate
MVP - Measurement and Verification Protocol

Contents

1 Introduction

1.1 Background and problematization

Since the 1970s' oil crises the Swedish government considered diminishing of the country's dependence on oil. The government aimed at substituting oil with low cost electricity sources. Currently, as a result of such policy, hydropower and nuclear power account for about 95 percent of total electricity generated (depending on a yearly weather fluctuation). About 40 percent of total electricity supply in the country comes from nuclear power plants (Swedish National Energy Administration, 2001).

Since the nuclear power plants were built, the nuclear power has been a topic of political and public disputes in Sweden. Nuclear waste issues become central in the debates. There was a strong opposition against nuclear power during the 1970s. Large demonstrations during national referendum in 1980s called for safety concerns. As a result Swedish Parliament approved a decision to phase out nuclear power by 2010. After long and heated political debates one reactor out of twelve has been decommissioned. (Löfstedt, 2003)

In the 1997 guideline for energy policy required the closure of the two nuclear power plants.

Sweden is a signature of the Burden Sharing Agreement of the EU and of the Kyoto protocol. Under the Kyoto protocol Sweden can increase its GHG emission up to 4 percent compare to the level of 1990. In 2001 Swedish government passed a Bill on Climate Change Strategy, where the new target for the reduction of GHG emission was established. The new target became by 4 percent lower then the level of 1990. (Nilson, 2003) Sweden is one of the countries that established taxes on CO_2 emissions, as well as taxes on SO_2 and NO_x emissions. (IEA, 2000)

Due to Swedish Climate Change strategy the nuclear electricity production has to be compensated either by new electricity production from renewable sources or reduced use of electricity. Policies aimed at increase in additional electricity supply and decrease in the current electricity consumption reduced "the correlation between economic growth and energy consumption". (IEA, 2000) Nevertheless, all these policies were not sufficient to provide enough additional electricity capacity for closure of the operating nuclear reactors. Despite the fact that the second nuclear reactor was due to be closured in 2001, it still operates and the new date for phasing it out is not set. (IEA, 2000)

Currently, the issue of gradual decommission of nuclear plants in one of the central focuses under the European Union (EU) programs. In the case of Sweden, replacement of nuclear power with imported coal-fired power is a proposal under consideration. (Kärrmakck, 2001) However, shift towards conventional sources for electricity production would reduce self-sufficiency of Sweden and increase Swedish contribution into global GHG emissions. Such shift would be contradictory to the environmental and climate change policies of Sweden.

Currently, the government follows strong policy for increasing of additional renewable energy capacities. There is an overall quantitative goal of increasing the production of renewable electricity by 10 TWh by the year 2010 from the level of 2002 (Swedish National Energy Agency, 2003c) However, this goal does not cover the entire demand of electricity in a case of phasing out of nuclear energy, especially if increase in renewables will be developing at the same rate as it is going now (see the justification of this point in Ch. 4.2.1 *Estimation of the quantitative target*). In addition, development of hydropower has limited potential in Sweden. Further growth of hydropower electricity generation is not planned (OECD/IEA, 2000). The plans to close all the nuclear reactors by the year 2010 seem unrealistic, due to lack of appropriate alternatives for substituting 40 % of total electricity production in the country.

Decrease in electricity consumption has not reached level required for phasing out nuclear, although the situation was improved due to the recently introduced energy policies.

Increase in energy efficiency[1] can lead to successful achievement of climate change goals or more efficient production. However, it does not necessary lead to decrease in consumption. In condition of phasing out of nuclear greater decrease in consumption of electricity is needed to be addressed with stronger policy framework.

Encouragement of energy savings[2] on Swedish electricity market is a subject for the research in this paper.

1.2 Main objectives of the study

A case of Sweden illustrates a situation where a choice of optimal energy efficiency policy is essential in order to complete decommissioning of nuclear reactors and to keep development of the electricity system in sustainable way.

Tradable scheme of Wight Certificates (WC) (or Energy efficiency trading certificates) is considered as an effective policy framework to support increase in energy savings in conditions of liberalized market. The objective of the research is to look at the opportunities to implement WC scheme in Sweden.

WC scheme is a new policy instrument. It was introduced in Italy and the United Kingdom (UK) and currently under implementation. These countries are in focus of the attention of the EU members as countries generating experiences of application of WC. As suggested by similarities of WC to the emission trading and tradable green certificate scheme, WC scheme can be an effective policy framework for decreasing consumption of electricity. Although quite new, the tradable green certificates scheme was successfully tested in some cases (Midttun, Koefoed, 2003).

Sweden has significant experience in undertaking energy saving and energy efficiency measures. A number of new measures are planed to reduce energy consumption in the future. Among other policy options WC system was found as an interesting approach (Wuppertal Institute et al., 2003a). However, there was not much research done on the implementation of tradable WCs in Sweden. An extensive literature search did not uncover data on the issue.

This thesis does not aim at the comparison of possible policies to reduce energy intensity. It is focused on finding possibilities (or barriers) to implement WC system, as part of possible strategy for decreasing electricity consumption in Sweden.

The objective to analyze implementation of WC in Swedish electricity market is addressed through following research questions:

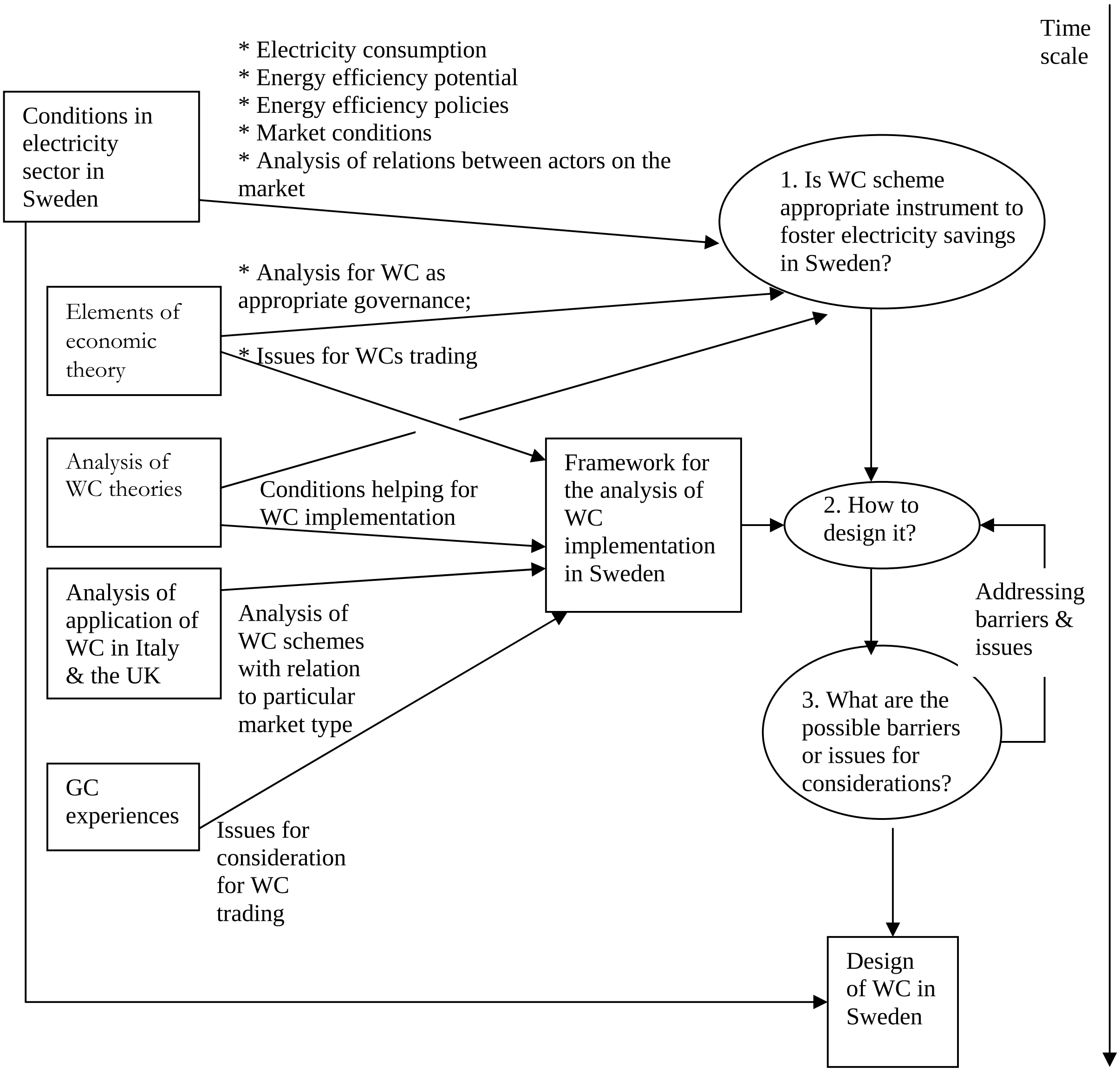
1. Is WC scheme appropriate instrument to foster electricity savings in Sweden?
2. How to design it?

[1] “Energy efficiency – getting any given energy results with the smallest possible (energy) inputs, or getting the maximum possible outputs from given energy resources” (Mundaca, 2003)

[2] Energy / Electricity savings - absolute savings, that can be achieved by decreasing in consumption. (Neij and Öfverholm, 2001)

3. What are the possible barriers or issues for considerations, while implementing WC?

1.3 Analytical framework and method of inquiry



Scheme 1. *Scheme of analytical framework for WC implementation in Sweden*

For the analysis of Swedish electricity sector, an analysis of electricity consumption and potential for electricity savings are required. This analysis is needed in order to identify optimal direction for application of WC instrument and for accessing level of savings, which can be achieved.

1. In order to answer the first question, appropriateness of WC is needed to be established.

Some elements of Transaction Cost Economics (TCE) theory were considered while defining appropriateness of WC system in Sweden. Relations of market participants under the conditions of liberalized market rely on principles of mutually beneficial behavior. Any transaction on the market entails cost. According to Solomon (1999), broad definition of transaction cost integrates negotiation cost, approval costs, regulatory and market risk, monitoring costs, enforcement costs, insurance costs, credit discounting and geographic restrictions. Investments into electricity savings might not take place due to high transaction cost. According to TCE, choice of organization of appropriate governance for investments is a key factor to reduce transaction cost and, thus, to encourage more electricity savings. Type of governance depends on the conditions of the market. WC can be appropriate governance to encourage electricity efficiency under the conditions of deregulated market.

Effect of policies aiming at efficient use of electricity in the country is not sufficient to compensate for phasing out nuclear power. Analysis of existing policies for decreasing electricity consumption is needed in order to identify barriers towards achieving better efficiency in electricity use. If WC instrument can address existing barriers, then it is considered to be an appropriate instrument to complement Swedish energy policies.

In addition, as it is mentioned above, there is a consideration to achieve specific goal in electricity savings in Sweden. There is also a consideration to avoid administratively demanding policies under conditions of Swedish liberalized electricity market. If trading of certificates occurs, then it would help to achieve electricity savings using more flexible market mechanism. In this case WC is identified as a proper instrument to encourage electricity savings under the conditions of liberalized market. Trading can encourage higher electricity savings, than it is required by the specific target, depending on the conditions of particular electricity market. Implementation of WC mechanism is considered as appropriate for Swedish case if trading of certificates will actually take place.

Thus appropriateness of WC is defined by three conditions. First, WC should be appropriate governance to encourage more electricity savings under the conditions of liberalized market. Second, WC should be capable to address existing barriers for electricity savings. Third, market of White Certificates should be created within existing conditions of the electricity market.

With respect to the defined appropriateness of WC scheme, the strategy for answering the first research is consists of two steps, as it is shown in Scheme 1:

First, some elements of TCE are discussed in order to analyze applicability of WC scheme as governance to foster electricity efficiency under the conditions of liberalized market.

Second, the author focuses on the ability of the instrument to address existing barriers towards energy efficiency. The undertaken review of the implemented policies for increasing energy efficiency identified existing barriers towards energy efficiency, which were not addressed or addressed to the limited extent. Review of the potential contribution of WC scheme into further decrease of electricity consumption and identification of the scheme as possible instrument addressing the barriers covers the first part of the first question.

The third part of the question is to analyze the necessary preconditions of Swedish electricity market for possibility of creating market for trading of the certificates.

2. The second research question could be answered by analyzing options for optimal design for WC scheme. Existing institutional capacity and relations between actors on the electricity market define an optimal approach for framing the demand for WC and for designing the main elements of WC scheme.

As it is pointed out in the Scheme 1, framework for WC implementation integrates several steps.

Comparison of cases for implementation of WC was used as a method for analysis of possible implementation of WC scheme in Sweden. The implementation of WC was based on experiences of the UK and Italy. Currently, the implementation of WC scheme is on the way. There are yet no clear evidences of success or failure of the WC instrument. However, there are some facts on the processes and organization of WC schemes. Comparative analysis of application of WC in Italy and the UK with respect to the market type gave a direction for appropriate design of the elements of the WC scheme in the conditions of Swedish electricity market.

There are also studies and theories on the possible ways of development of WC systems. These sources gave insights for understanding of issues to consider while designing different elements

of WC scheme. These materials also helped to formulate conditions necessary for “appropriate” implementation of WC scheme.
Because of the similarities in organization of certificate trading system in White Certificate and Green Certificate schemes, some considerations for designing of WC system in Sweden were taken from experiences in implementation of Green Certificate (GC) system. The European experiences in implementation of GC system are much larger than for WC system, as economic and environmental benefit from energy efficiency increase has been realized just recently on the EU level.

3. Issues for the considerations and possible design of WC scheme are examined, while looking for the opportunities to apply WC scheme to the Swedish case. Specific design of the scheme might create specific barriers, as well as specific barriers can be addressed through specific design of WC scheme. As it is shown in the Scheme 1 an arrow from research question 3 to research question 2 is a feedback allowing adjustments to the design.

The author wished to look at the opportunities to implement the system of WC in a cost effective way. That is why existing institutional capacities were considered to be used for implementation of WC.
For answering the research questions literature review (secondary data sources) was conducted.
Data for analyzing conditions on Swedish electricity market are obtained from literature.

1.4 Structure of the paper

Chapter 2 *Electricity Consumption, Energy Efficiency potential and Energy Efficiency Policies* reviews conditions in Swedish electricity market and consists of three parts. First. A review of consumption of electricity by sectors shows optimal direction for the application of WC to provide further decrease in sectors with highest electricity consumption. (section 2.1 *Electricity consumption*). Second, it explores an existing potential for electricity savings in Sweden and assesses the level of electricity savings that can be achieved, when addressing decrease in consumption. (section 2.2 *Energy efficiency potential*). Third, it reviews undertaken Swedish energy efficiency policies and highlights existing barriers towards increase in energy savings. (section 2.3 *Energy policy analysis; identifications of barriers towards energy efficiency*)

Chapter 3 *Theory of White Certificates*, provides an analytical framework for application of WC scheme on Swedish electricity market.

Chapter 4 *Swedish case; Design of White Certificate scheme*, explores advantages of the WC scheme in stimulation of electricity savings within the particular Swedish context. The section also analyses features facilitating implementation of DSM on the Swedish electricity market. (Section 4.1 *General market conditions in Sweden, favoring for WC scheme*) The chapter analyses possible approaches for framing the demand for WC and for designing of WC system mechanism in Swedish conditions. (section 4.2 *Demand for WC* and section 4.3 *WC system mechanism*).

2 Electricity Consumption, Energy Efficiency potential and Energy Efficiency Policies

Through reviewing of electricity consumption and energy efficiency potential, this chapter identifies optimal direction for application of WC instrument in Sweden. Review of policies identifies main barriers towards energy efficiency.

2.1 Electricity consumption

In order to direct policies for bringing down electricity consumption in appropriate way, sectors with the highest electricity consumption are identified in this chapter.
As it is mentioned before, Sweden has one of the highest consumption of electricity all over the world - it is 16.300 kWh per capita/year. In the year 2000, Sweden became the forth in electricity consumption after Norway, Island and Canada. Total increase in electricity consumption in the period from 1990 to 2001 was estimated as 7.6 percent. With the correction on the temperature conditions it is 5.8 percent. (Swedish National Energy Agency, 2003a)

Table 1. *Electricity consumption between 1990 and 1999, and forecasts for the years 2000, 2001 and 2010, TWh, Sours Electricity Market, 2001, p.8*

	1990	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2010**
Industry, of which	53.3	51.7	50.9	52.6	52.8	53.5	55.4	55.4	58.6
Pulp and paper	20	19.1	19.3	20.5	21.1	22	22.8	22.7	23.2
Basic chemical	6.2	5.6	5.5	5.8	6	5.9	7	7	8.1
Ironworks and steelworks	4.8	5	4.9	5	5	5	5.2	5.3	5.8
Engineering industry	7.2	7.1	7	7	7.1	7	7	7	7.5
Residential, commercial, services of which	63.3	72.3	73	69.6	69.5	70	69.5	73	75
Electric heating	25.8	25.3	27.3	26.1	23.9	21.5	20.8	23.8	28.9
Domestic electricity	17.9	19.7	20.1	18.7	19.5	19.2	19.7	19.9	21.1
Electricity for appliances	19.6	27.3	25.6	24.8	26.1	29.3	29	29.3	25
Transport	2.5	2.5	2.5	2.4	2.5	2.5	2.6	2.6	3.2
District heating, refineries	10	7.5	6.3	6.2	6.4	6.1	6.6	6.6	6.6
Conversion and distribution losses	10.7	8.3	9.4	11.6	12.7	11.4	10.7	10.6	11.3
Total net consumption	139.7	142.2	142.2	142.5	143.9	143.4	144.8	148.1	154.6
Total net temperature corrected consumption	142.9	142.5	141.2	143.2	144.9	144.7	147.6	148.1	154.6

2.1.1 Trends in industry consumption

Industrial consumption grows with respect to the economic activities.
During the 1980s, the production of industries grew by 2 percent per year, while electricity consumption grew above 3 percent per year.
In the recession period of early 1990s, production significantly fell, causing drop in consumption by 3.2 percent until 1992.
Between 1997 and 2002, electricity consumption increased by 1 percent annually, mainly due to the growth of pulp & paper industry.
According to the data from 2003, energy intensive industries account for about 70 percent of total industrial electricity consumption. Consumption of engineering industry was 13 percent. (Swedish National Energy Agency, 2003a)

2.1.2 Trends in residential, commercial and services sector consumption

Normally, the main use of electricity in the society goes to the satisfaction of the following needs: heating of single family and multi family dwellings and commercial and public premises; domestic electricity in dwellings; appliances in commercial and public premises; street and road lighting; electricity for water and sewage treatment.
Electric space heating is account for about 30 percent of total electricity consumption in the society. It varies during years, depending on the temperature.
Domestic electricity in dwellings is accounted by 25 percent of total electricity consumption.

Electricity for appliances is accounted for over 40 percent of the electricity consumption in the society. The increase of this figure was mainly in the 1990s, due to increase in using appliances in the services sector. (Swedish National Energy Agency, 2003a)

2.1.3 Trends in transport electricity consumption

The main consumption of electricity in transport sector is attributed to powering trains, underground trains and trams. Transport sector accounts at 2 percent of total national electricity consumption and it is rather stable over years. (Swedish National Energy Agency, 2003a)

2.1.4 Trends in district heating and refineries electricity consumption

Consumption of electricity in district heating and refineries mainly goes to suppliers to electric boilers and heat pumps. Electricity supply to electric boilers decreased from 6.3 TWh in 1990 to 1.3 TWh in 2002. Electricity supplied to heat pumps amounted to 2 TWh in 2002. Electricity for refineries is relatively stable and accounted for 0.7 TWh in 2002. (Swedish National Energy Agency, 2003a)

2.1.5 Assumptions about electricity consumption for the year 2010

According to (Electricity Market, 2001), the predictions for electricity consumption for 2010 are based on a number of studies related to economic development and estimations of future changes in oil prices. It was assumed that electricity consumption would increase in average by 0.7 percent per year until year 2010.

As it is shown in the table 1, the highest electricity consumption in Sweden is attributed to two sectors: industrial and residential and service sectors. The main consumers of electricity are energy intensive industries such as iron and steel, pulp and paper, and chemicals. Industries consume more than one third of total electricity volume. Residential, commercial, services etc. area consume more then a half of electricity. (Swedish National Energy Agency, 2003a)

2.2 Energy efficiency potential – identification of electricity savings

The section considers reviewing potential for savings in Swedish electricity sector.

2.2.1 Definition of energy efficiency potential

Potential for increasing energy efficiency is a parameter used for assessment of changing on energy demand side, in case of energy efficiency improvement. According to Neij and Öfverholm (2001), a potential for increasing of energy efficiency could be defined, as “a measure of absolute savings, that can be achieved”.

Based on a number of case-studies for estimation of energy efficiency potential, it is considered to distinguish between theoretical, technical, techno-economic and market potential. These potentials are based on two main aspects: technical and economic, and they are changing due to technological achievements and economical growth over time.

Referring to Jochem (1991), the theoretical potential is defined as an achievable energy savings, according to the laws of thermodynamics. Therefore, it defines a theoretical maximum level of energy efficiency. Theoretical potential to improve energy efficiency always exists.

According to Storey (1996), the technical potential, estimates an energy savings that could be achieved by implementing the most energy-efficient technologies, existing on the market or going to be available soon. The technical potential is not considering a cost for the advanced technology.

The techno-economic potential includes cost-effective measures, which take into account investments into efficient technologies. Projects for increasing energy efficiency are usually profitable. However, time frame is taken into the account, when calculating techno-economic potential. (Neij L., Öfverholm E., 2001)

The market potential is an evaluation, based on existing practices of energy use or, in the other words, on real market conditions (Storey, 1996). It is difficult to define the market potential, as through such factors as energy policies, energy prices, consumer behavior etc., it might be linked to market obstacles and imperfections.

2.2.2 Technical potential

There are no overall quantitative assessments of technical energy efficiency potential of Swedish electricity sector in available sources of information. According to the definition of technical potential, it can be accessed through reviewing of patterns in technology innovations currently existing on the market.

According to the data from Swedish National Energy Agency (2003b), there is a considerable technical energy efficiency potential in Sweden in most areas. In the examples, listed below, estimations are based on the comparison of energy consumption by equipment currently in use and the most efficient ones currently available on a market. This is a definition of technical energy efficiency potential.

Industry

There are some new lighting technologies, which might considerably increase efficiency in industry lighting. For example, high frequency lighting (30 000 – 70 000 Hz) with new "full-spectrum" tubes is 50 percent more energy efficient in comparison to the commonly used lighting system. A new designed tube for high-frequency lighting can reduce energy consumption by 25 percent further. Occupancy sensor for controlling energy consumption is a technology innovation, which increase the lifetime of lamps by 40 percent. (Swedish National Energy Agency, 2003b)

The other industrial area for improving efficient of electricity consumption is industrial ventilation used in various processes by number of industries, including energy intensive ones (e.g. pulp & paper, iron & steel). Current consumption of energy by fans is estimated as 7 TWh per annum. This number can be notably reduced by using electronic variable speed control mechanism in fans' motors. (NUTEK, 1997) The difference in motor power demand between speed variable funs and funs with inlet vane control, vary from 14 to 73 kWh, depending on the model.

Under the national technology procurement program a concept of more efficient motor was recently designed. The International Energy Agency (IEA) organized a competition for the highest energy efficient electric motor, as a part of its pilot project for designing of motors with 25-50 percent lower energy consumption. (OECD/IEA, 2000) As a result of the competition, two motors won. The efficiency of those motors was higher than efficiency of the best commonly used motors by 90.5% and 96% correspondingly. Installation of the motors is planned into fans for driving industrial pumps and for ventilation systems in residential houses.

There was also en estimation of great energy efficiency potential in small industries, which is possible to achieve by relatively low investments through making repairs or changing a system of operation work. (Swedish National Energy Agency, 2003b)

Households, commercial, and services sectors

A lot of improvements could be done to reduce energy consumption in households. According to Swedish Energy Agency (2003), "white goods" in apartments might be one third or one half more efficient due to technical innovations. For example, one third or more of domestic electricity consumption can be reduced by using electrically efficient refrigerators. New energy efficient washing machines, recently available on the market, are twice more energy efficient than before.

Double improvement in electricity use could be done with the technologically advanced tumble dryers that appeared as a result of a technology procurement competition. (see section 2.3. *Energy policy analysis; identifications of barriers towards energy efficiency*)

Lighting in apartment buildings could be improved by using the same high frequency lighting and occupancy sensor as for industry's lighting. It would increase energy efficiency and a lifetime of lamps by rate similar to this in industrial conditions. In addition, there are a variety of low-energy lamps available on the market, which have lifetime of about 10000 hours and need for about six times less energy than commonly used lamps with the same lighting characteristic. (Swedish National Energy Agency, 2003b)

Technological improvement is the main driving force to improve energy efficiency. According to the figures illustrating energy efficiency improvements due to the technological innovation, all technically possible energy savings show quite high level of the potential for energy savings in Sweden. An assessment of physical stock of these technologies requires detailed wide-scale studies.

2.2.3 Techno-Economic potential

Practical saving could be achieved if energy savings potential is economically feasible. Techno-Economic potential is more meaningful assessment in terms of cost-effectiveness for energy savings on the market. At the same time it is more difficult task to assess market potential, because the parameter includes information related to commercial implementation of new technologies and various number of market conditions on sectoral level. Estimation of energy potential requires energy audit with life cycle assessment for all operating, maintenance and capital costs. There are several examples of assessments of energy and electricity potential savings in Sweden and Western Europe.

Swedish National Energy Administration made assumptions for possible energy efficiency changes by the year 2050. (Azar and Lindgren, 2001) The estimation is based on a range of case studies on future energy use, such as Elmberg et al. (1996), Svenson and Kaberger (1992), IPCC (1996), Steen et al. (1997). The study shows possible energy-use improvements as part of the global consideration to reduce greenhouse gas (GHG) emissions. The estimation aims to develop technically possible future scenarios with high probability to achieve the new energy demand. Technical potential of the best technologies from 1996-1997 was taken as average achievements for technologies in 2050. There are different opinions about criticality of different parameters in the scenarios. The average level of change in efficiency for using electricity in household sector is estimated at 40 percent by 2050. If post-materialistic vision of the society will be prevalent, a considerable potential of energy efficiency through change of the consumption level can also be expected. The scenario assesses possible level in consumption change in electricity sector by 15 percent, according to the increase in level of activity in the sector by 40 percent. Prediction for efficiency change in electricity use for industrial sector is 25 percent.

Table 2. *Energy use in the year 2050, source Building sustainable energy systems – Swedish experiences, 2001*

Sector	**Energy use 1995 TWh/year**	**Activity % change**	**Efficiency % change**	**Level % change (consumption)**	**Fuel (TWh/year)**	**Elec. (TWh/year)**
Households and services	157				80	37
Heating	103	+15%	-40%	-31%	69	2
Electricity generation	42	+40%	-40%	-15%		35
Other	12	+30%	-30%	-9%	11	
Transport	92				42	3
Car	55	-15%	-75%	-80%	12	
Train	2	+100%	-30%	+40%		3
Air	14	+100%	-50%	0%	14	
Trucks	12	0%	-30%	-30%	8	
Other	9	+40%	-40%	-16%	8	
Industry	146		Elec. –25% Fuel –35%		77	46
Manufacturing industry (Sek/year)		150%				
Other industry (tonne/year)						
Total	**395**				**199**	**86**

More general assessment on techno-economic energy savings potential in Sweden was estimated by Swedish National Administration at the level from 10 to 50 percent or more, depending on a sector. (Swedish National Energy Agency, 1990)

Energy efficiency potential in Sweden can be assessed by sectors, according to the data on economic energy efficiency potentials on 2020 in Western Europe (UNDP, 2000)

Table 3. *Economic energy efficiency potentials in Western Europe, source Word Energy assessment, 2000*

Sector and technological area	**Economic potential 2020 (%)**
Industry	
Iron and steel	13-20
Pulp and paper	50
Glass production	15-25
Refineries	7-10
Investment and consumer goods	15-25
Residential	
Existing buildings – boilers and burners	20-25
Existing buildings – building envelopes	10-20
New buildings	20-30
Electric appliances	35-45
Commercial, public and agriculture	
Commercial buildings Electricity	20-37
Public buildings	30-40
Agriculture and forestry	15-20
Office equipment	40-50

According to Groenenberg (2002), energy efficiency in industries in Western Europe, assessed by Energy Efficiency Index (EEI), is estimated to be 1.2. EEI is defined as the amount of energy, that has been used, divided by the amount of energy that is needed to produce the same amount of goods at the reference level of energy efficiency.

Thus, according to the different sources of estimation of energy efficiency potential in Sweden, as well as in Western Europe, there can be an assumption that Sweden has sufficient techno-economic potential in electricity sector to consider further decrease in electricity consumption.

Factors to influence EE techno-economic potential

Choices for taking energy efficiency measures depend on a number of factors. One of the significant factors for energy efficiency improvement is energy prices, which influence energy consumption. Thus, energy savings potential depends on energy prices. If the price reflects a real cost of energy, i.e. if it includes externalities (any sort of environmental damage), then it works as a stimulating mechanism to increase energy efficiency. It encourages investments for more efficient technology or for correspondent structural changes in economy system. Subsidized prices would not make technological improvements cost efficient, at least not only for the reason of more efficient energy use. As a result, low prices of energy would keep the energy saving potential on a high level (IEA, 1998).

According to data from January 2003, the electricity prices in Sweden consist of price on electrical energy, accounted for 40 percent, the network tariff, accounted for 20 percent, and taxes, accounted for 40 percent. Prices for electricity energy vary, depending on the market price. Taxes for electricity consumption are charged by the government. Some industries, such as the manufacturing and mining industry have been exempt from electricity taxes since 1994. In addition, all fuels used for power generation are exempt from energy and carbon dioxide taxes (The electricity market, 2003). Lowering prices on electricity by number of exemptions can be an identification of high level of energy saving potential in electricity sector of the country.

Price is one of the examples of possible factors that could influence the decision to stop improving energy efficiency in Sweden. There could be a number of other factors, such as lack of information on projected energy prices, policies, new technologies, etc. (IEA, 1998).
As pointed out in IEA report (1998), there is a difference in suppliers' and consumers' approaches to invest, which creates so-called "the payback gap". The suppliers' main function is to supply energy. Thus, if supplier makes an investment in new technologies, it is an improvement for the general business anyway. It makes suppliers willing to improve energy efficiency in general. Consumers foster energy efficiency as one of the services to improve. Often life-cycle costs are not included into consideration; therefore, measures to improve energy efficiency receive low priority when investing.
The factors discussed in this section point at possible reasons for resistance to change towards more energy efficient use. However, there is always a tendency to improve energy efficiency over time. There are some additional factors, such as 70s oil crises or, for example, need to phase out nuclear power in Sweden, that could contribute to success of energy efficiency measures and might keep improving energy efficiency in a long run (Olerup, 1995).

2.2.4 Comparison of Technical and Techno-Economic potential in Sweden

Comparison of techno-economic energy savings potential with technical potential clarify how fast would be practical implementation of the energy efficient measures in different sectors. Thus, it is a method to understand significance of factors that limit increase in electricity savings. These factors are depended on consumption of electricity, fostering measures/policies and other aspects listed in section *Factors to influence energy efficiency potential.*
Comparison of assessments of technical and techno-economic potential in Sweden gives possibility to evaluate how strong the factors, influencing efficiency on the Swedish electricity market.

Table 4. *Technical and Techno-economic potential in Industry and Household, commercial, service sectors*

Sector	***Technical potential***	***Techno-economic potential***
Industry	*25-50% or more*	*- National Energy Agency: Efficiency change –25% by 2050* *- World Energy Assessment: energy efficiency assessment, including electricity 7-50% by 2020* *- STEV: energy efficiency assessment, including electricity 10 – 50%, depending on sector*
Household, commercial, services	*30-50% or more*	*- National Energy Agency: Efficiency change –40% by 2050; level change in consumption – 15% by 2050* *- World Energy Assessment: energy efficiency assessment, including electricity 10-50% by 2020* *- STEV: energy efficiency assessment, including electricity 10 – 50%, depending on sector*

According to data from National Energy Agency, comparison of electricity efficiency techno-economic potential to technical potential in the in industry sector demonstrates that there is a big difference between these two potentials. This means that there are some factors on the market that limit fast increase in electricity efficiency. For example, resistance to make fast increase in electricity efficiency in industries can be in a result of low electricity prices. According to data from World Energy Assessment, comparison of techno-economic potential to technical potential in industry sector demonstrates that increase in energy efficiency can be two times higher.
Assumption on technical potential in household sector is similar to technical potential in the industry sector. Techno-economic potential in household sector is about two times higher then in industry sector. The difference between technical and techno-economic potentials at the household sector is less, comparing to the industrial sector. Therefore, the barriers to increase electricity efficiency at the household level are less then at the industrial level.
Industrial and household sectors are the sectors with the highest electricity efficiency potential. As a result of the comparison, it is assumed that barriers towards fast increase in electricity savings exist at the level of industrial and household sectors. In order to figure out what type of barriers they are, analysis of existing energy efficiency policies is needed.

Then it can be figured out whether WC is an appropriate scheme to address existing type of barriers towards increase in energy efficiency or not. (in terms defined in section 1.3 *Analytical framework and method of inquiry*)

2.3 Energy policy analysis; identifications of barriers towards energy efficiency

This chapter analyzes existing energy efficiency policies in order to identify barriers to fostering energy savings in electricity market. Swedish policies, addressing energy efficiency, foster efficiency on the electricity market. That is why, in order to define general tendency of barriers on electricity market, the policies for entire energy market are reviewed.

The overall target of energy policy in Sweden is to ensure an optimal supply of electricity and other type of energy on a cost-efficient basis. Sweden considers improving energy efficient market in a long- and short-term. Energy policy measures are intended to create conditions for a cost-efficient supply of energy and for enforcement of more energy efficient consumption. In addition, the government is also considers environmental energy goals. (OECD/IEA, 2000)

According to the 1997 Bill on Sustainable Energy Supply, importance of the energy efficiency measures were emphasized through research and development programs, procurement programs, standards, trainings and agreements, services advises, subsidies, labeling, information dissemination campaigns, taxes. (Neij and Öfverholm, 2001)

2.3.1 Taxes

In the case of Sweden, taxation system can potentially influence energy system in several ways. First, it can work as an instrument to make particular energy source more competitive on the market. Second, taxation can incorporate external costs, such as climate change, emissions, risk of human health, etc., into energy prices, which would probably lead to market equilibrium. Third, taxation is an instrument to foster energy efficiency measures through levy of energy prices.

If reaction of customers on tax-corrected energy prices increase, more efficient use of energy would be expected. Another positive factor from tax levies would be implementation of energy efficiency measures throughout the production chain. As a result of such reaction on taxation, GHG emission would be considerably decreased.

However, there are some differences between influences on energy efficiency from existing system of taxation and “an ideal case”.

Energy taxation system in Sweden is complex. (Swedish National Energy Agency, 2003a) There are several types of taxation to govern energy production:

A carbon tax is an environmental tax. It is applied on fossil fuel combustion. Biofuels are excluded from carbon taxation, as it is considered to be a fuel, not influencing global warming (SFS, 1994).

Sulphur tax is also an environmental tax. It is a tax for sulphur emissions from fossil fuel combustion processes (SFS, 1994).

An energy tax is a fiscal revenue rising instrument. It applies on all fuels, with exception of biofuels (SFS, 1994).

An electricity tax is a part of energy taxation. It is put on the electricity use.

Electricity taxes, as well as other taxes, are set depending on geographical location of electricity consumer (north, south of Sweden). They might also vary according to status of the consumer, such as industries, households, energy sector, etc. (SFS, 1994)

Correspondingly, energy efficiency effects takes place, if at all, dependent on the tax specificity. For example, manufacturing industry has 65 % of discount rate from carbon tax, for the sake of competitiveness on the international level. In addition, it was given exemption from energy tax and electricity tax. Thus, in this case, taxes are not the best regulatory measure to increase energy savings or efficiency.

In general, there is a strong resistance from a taxpayer to taxes. Increase of prices decrease a consumer’s willingness to purchase. Consequently, demand on the production decreases, creating disadvantage of the producer. As a result, producers become creative in designing ways to avoid taxes. Swedish complex and frequently changed tax legislative system has some imperfections, which might be used as options for taxpayer to not pay or to pay less.

There is an example of application of current tax system for cogeneration plants, generating heat and electricity. Cogeneration plants can use different fuels, such as coal and biofuel. Fuels, used for electricity generation, are not taxed by energy and carbon taxes. Biofuel, used for producing heat in cogeneration plants, is taxed by 50 percent less. Use of biofuel becomes, comparing to use of fossil fuel. The same amount of coal and biofuel used for heating and electricity production but distributed differently between these processes, would make producer pay different taxes. In practice, coal and biofuel are used equally for heating and electricity production. However, the producer would pay less, if he would declare, that 100% of coal was used only for electricity production and 100% of biofuel was used for heating. (OECD/IEA, 2000)

Another common version of "cost effective decision" for the producer, who operates mostly with coal for producing electricity and heat, would be to burn additional amount of biofuel, wasting a heat. Then, the distribution of the fuels for heating and electricity might be declared in a way that permits paying less taxes. (Sjödin, 2002)

These are some of the widely used practices for "optimal" decision to avoid taxes. At the same time, the only factor apart from tax, which might stimulate a decision to improve energy efficiency, is increase in energy price. Taxes do not work as fostering instrument for energy efficiency in all the cases they were planed as such.

According to Neij and Öfverholm (2001), who refer to data from Swedish National Energy Administration, in Swedish case "the effects of energy taxes on energy efficiency have been difficult to evaluate".

Tax ineffectiveness in energy efficiency improvements might be not only due to resistance at the level of consumer and producer. According to Hillring (1998), structures to administrate energy policies were not organized in the best way.

2.3.2 Research and development program

The idea behind establishing research and development (R&D) program was to have a knowledge-developing base in area of energy. (Neij, Öfverholm, 2001) R&D was seen as:

- promising scientific potential for finding technical solution for solving energy problems;
- mediator for energy policy conflicts;
- contributor to develop energy system towards sustainable one.

Since 1975 Sweden started energy research program. The program supported fast switching from oil dependence after the 70s oil crises and development of nuclear technology. The programs were well financed by the government and industry, which was one of the conditions for success.

Since the beginning of 90s, energy efficiency consideration was planed as integral part of objectives set for the energy sector. Overall energy research program were consider to deal with the following issues: sustainable energy system strategies and issues, climate change; research related to decommission of nuclear power; support to programs for promotion of energy conservation and supplementation of energy supply and development of new technologies. The implementation was planed as long-term programs. However, in the end of 90s several factors caused delay in the planning and implementation of the program. Reorganization of authorities for administration of the set objectives contributed to the delay. Swedish National Energy Administration was established as a new authority responsible for implementation of the targets.

In 1995, Sweden become a full member of the EU. Energy program set up by European Commission (EC) become a priority for the government in directing economic and financial resources. It appears as a shift form the national research energy program, as well as a delaying factor for its implementation. Deregulation of the electricity market changed strategic plans of industries that, traditionally, financed considerable part of R&D programs. After the deregulation of the electricity market, consideration in R&D of industries shifted towards new business opportunities and short-term programs. Many politicians agree with an opinion that R&D program was not successful enough, because sufficient funding for R&D was not provided even for the case of short-term projects. (Neij L., Öfverholm E., 2001)

However, transition period takes time. Although Swedish R&D program have been limited, in general, it contributed to increase of energy efficiency in building, industrial processes and transport. R&D encouraged development of programs for providing trainings and education in the area of energy efficiency, raising awareness and encouraging penetration of new energy efficiency technology on the market. (Neij L., Öfverholm E., 2001)

2.3.3 Subsidies, labeling & efficiency standards

Governmental subsidies helped to increase market share of energy efficient appliances. Subsidies helped to introduce new technologies, facilitating their penetration on the market through lowering cost of the products.

However, this policy for industry was not successful in all cases. Dependence on subsidies of heat pump industry led to its inefficient functioning after removal of subsidies. National labeling program for household appliances started in 1993. It was coupled with informational and promotional activities. Information campaigns included energy cost estimation and awareness rising activities. Labeling program marked products with the information to show a consumer efficiency of the product, according to common testing standards. The main goal of the information and labeling program was to stimulate decision of consumers to choose more energy efficient products, consequently stimulating manufacturer to produce more efficient products. (Neij L., Öfverholm E., 2001)

The program stimulated about 25 percent of appliances' shops to make a profitable promotion, based on the increasing interest of consumers towards energy-efficiency labeled production.

In 1995, national labeling program was successfully complemented by EU labeling program. EU labeling program promoted efficient refrigerators/freezers. Efficient refrigerators/freezers constitute of around 70 percent of total refrigerators' share on the market. This is a result after three years from the start of the program. (OECD/IEA, 2000)

The combination of the national labeling and information program and EU labeling scheme successfully increased sales of energy efficient appliances on the market. Labeling and Standards influenced the market of energy-efficient products. Labeling gave an opportunity to consumers to choose among products, informing them about energy consumption of these products. Efficiency standards set a minimum efficiency value for products, as a result, reducing market of products, which do not meet the standards. Efficiency standards are changed every several years, as they stimulate manufacturer to meet a minimum requirement. (OECD/IEA, 2000)

Standards is an effective instrument for cutting down inefficient products on the market. However energy efficiency improvements stimulated by this instrument are limited to the currently available market of technologies. (Neij, Öfverholm, 2001)

2.3.4 Technology procurement

Technology procurement is a successful example of integrated use of measures to increase energy savings.

All the policies listed above might support consumer's decision to purchase more efficient product on the market. However, there might be a situation when required technology would not be commercially available. Technology procurement program was created by NUTEK (or STEM) as an instrument to coordinate the supply and demand of energy efficiency production on the market. (Nilsson L., 2003)

The program brings together potential purchasers of technologies and groups of expert in order to draft particular energy efficiency and other requirements for the new technological improvements. Development of the new technology prototypes was fostered through competition between manufacturers, who received grants for introduction and commercialization of new products, in case if they managed to meet the announced requirement. Simultaniously, NUTEK partly subsidies purchasing of the new products in order to avoid risk associated with introduction of new products to the market.

About 30 technology procurement projects were started: refrigerators, heat pumps, windows for residential sector, etc. Regulation of demand and supply for new technologies, as well as financial and other assistance of manufacturers and purchasers, helped to expand market of energy efficient technologies. (Swedish National Energy Agency, 2003b)

Subsidizing policy and, thus, price reduction of the new technologies, significantly speeded up penetration of efficient technologies to the market. Technology procurement, combined with informational and advisory services increased awareness of consumers and producers about energy efficiency potential, which also contributed to faster promotion of electricity efficiency. During an implementation process of market transformation program and technology procurement, as a part of it, some factors might appear as barriers. Program requires a significant investment. Resistance of innovative technologies is a well-known problem. For example, first attempt for energy efficient windows implementation failed, because manufacturers had conventional windows, which market value was still significant, in stock. (Neij, Öfverholm, 2001) Delaying factors might be various and implementation of new technologies might take time. That is why a key factor of success for technology procurement is a possibility to arrange long-term investments. Additional limiting factor, learned from the case study of procurement of refrigerators, was split incentives in rented apartments. (Neij, Öfverholm, 2001)

2.3.5 Voluntary agreement- eco-energy

The goal of voluntary agreements (or eco-energy) was to initiate practices for energy efficiency improvement in a most appropriate form for each participating company. The program has started in 1994. About 80 plants and 30 companies became participants of the program. Voluntary agreement was implemented in a form of contract between companies and the government. The eco-energy agreement was similar to ISO 14001 and EMAS with focus on energy system improvements. (Nilsson L., 2003) NUTEK provided a strong encouragement for industries to be involved in the program, offering them full free investigation of their energy systems. It included audit of energy flow and environmental trainings in energy efficiency procurement. Companies that commited themselves were supposed to design company’s environmental policy for a short- and a long-term The programme was expected to have energy saving objectives, policy for reaching the goals, and system for verification of the progress. (Uggla U., 2003) Thus, the program aimed at creating long-term payback, that would result from increase in of awareness through the educational programs and implementation of objectives of the environmental policy. In addition to sponsoring process of industry audit, financial encouragement was given through eco-energy competition. As a result of the competitions, companies, which reached their objectives in a shortest time or with greater savings, were awarded with eco-energy price.

The program was successful for reaching energy-efficiency goals. In particular, electricity consumption in industries was reduced by 25 percent. At the same time this considerable result was achieved through considerable investments. (IEA, 1998)

2.3.6 Deregulated market

Deregulation of the electricity market in Sweden began in 1996. The main goal of the process was to open competition between electricity suppliers and to let other entrants join the competition. An opportunity to choose a supplier stimulated competition. Lowering of electricity prices was an expected result, as well as one of the objectives of the deregulation. At the same time, lowering of electricity prices became a factor that slowed down increasing energy efficiency.

Demand side management (DSM)[3] programs were not applied systematically in the deregulated market. After liberalization of the electricity market, DSM programs were eliminated from the policy framework for improving energy efficiency. In the conditions of liberalized market offering of energy efficiency services become popular among electricity suppliers. According to Neij, Öfverholm (2001), suppliers offered about 80 percent of energy efficiency services. However, they mainly aimed at encouragement of the main suppliers' business, and worked as a tool to stimulate larger energy sales. Thus, even if energy services could, with some hesitation, be considered to be supportive instrument for energy efficiency, they did not contribute much to the energy savings. "So far, the follow up of these services seems to be poor" (Neij, Öfverholm, 2001)

Energy efficiency improvement in household and small companies provided by energy efficiency services is characterized as low. At the same time, it was assumed that efficiency improvement through indirect services, such as auditing and advice services, did not require considerable investments into small companies. (Neij, Öfverholm) One of the factors, contributed to lack of incentives, was relative passivity of consumers in changing their suppliers after the deregulation. (Kärrmakck, 2001)

Table 5. *Main policies to improve energy efficiency and critical factors for reaching the objectives or for implementation of the policies*

Policies/programs, aiming at energy efficiency improvement	*Objectives*	*Barriers to energy efficiency or issues for consideration*
Taxation	Fostering energy efficiency through levy of energy prices	Ineffective in improvements, due to 1) resistance of consumers and producers; 2) not sufficient administration
Research and development	Development of scientific potential for solving energy problems; Provision of education and training, aiming at energy efficiency technology penetration	Successful, however not enough, as funding for the programs was not sufficient for short- and long-term programs
Subsidies	Facilitation of implementation of energy efficient technologies on the market	There were improvements, but strong dependence on subsidies in some cases created difficulties after removal of subsidies. Considerable funding is required
National labeling and information program / EU labeling	Increasing sales of energy efficient appliances on the market	Introduction of labels was successful. The programs require investments
Efficiency standards	Cutting down a number of inefficient products on the market	Effective instrument, however, it does not provide stimulation to encourage efficiency beyond of the established objective
Market transformation (technology procurement)	Fostering development and commercialization of energy efficiency technologies	Successful, however, following factors are critical: 1) split incentives; 2) required long-term investments, and 3) allocation of time for implementation
Voluntary agreement (or eco-energy)	Initiation of practices for energy efficiency improvements in industries	The program required considerable investments
Deregulation of the electricity market	Introduction of energy efficiency services	Energy services did not contribute much; Lowering prices, as a result of introduced competition, was crucial for improving energy savings; elimination of DSM programs

2.3.7 Summary: Classification of barriers towards electricity savings

The framework of the policies, used to stimulate energy efficiency in energy and, in particular, in electricity sector in Sweden was impressive. Significant results of some of the innovative policies, which were designed by the national energy administration, were recognized at the

[3] Demand Side Management (DSM), broadly defined by Haaland and York (1993), as any measure, undertaken by an individual, household or firm to change the end use towards a specific objective, including conservation, improved energy efficiency, load management and strategic load building. Within the context of this broad definition, for the purpose of this research DSM is specified as any measure, undertaken by energy companies and mentioned implementers (individual, household, firm) in order to achieve specific goal in electricity savings.

international level as useful experiences. However, considering large potential for energy efficiency improvements, cost-effectiveness of the instruments and speed of the implementation were considered to be lower than it could have been. (Neij L., Öfverholm E., 2001)

Reaching competitive prices on the electricity market is one of the key objectives of Swedish energy policy. (OECD/IEA, 2000) Low prices on electricity is a competitive advantage of the country. Therefore, deregulation on the market, resulted in lowering of prices on electricity, is a successful direction of development of the electricity system. However, increasing of electricity savings and more efficient electricity use in conditions of deregulated market is a considerable challenge. At the same time, electricity savings are essential for Sweden. The country aims at reduction of electricity consumption as a precondition for phasing out nuclear energy. Main measures and policies, which were recently used to reduce energy consumption, including electricity sector, are listed in table 5. Although some of the policies led to considerable increase in efficiency, total effect of the policies was evaluated as neutral or slightly positive. (Wuppertal Institute et al., 2000)

Measures for knowledge building and information dissemination might be assumed as being in a process of successful adoption. Many of the policies are devoted to energy efficiency promotion through increase of awareness. In the liberalized market many services are not offered free of charge. Support or subsidizing of audit and advising services might raise unfair competition for energy services companies (ESCOs), and, thus, discrimination on the market (Wuppertal Institute et al., 2003a). Thus, deregulation might be a factor that makes lack of information and knowledge for customers critical. Issues of investments for energy efficiency programs and a time for payback are crucial.

Barriers to energy efficiency in Sweden, which are listed in table 5, are identified as barriers on the demand side. Barriers for energy efficiency on the end-use in Swedish electricity market are not a unique among the EU members. In its research of problems attributed to energy efficiency on liberalized market, Wuppertal Institute for Climate, Environmental, and Energy identified some common barriers and imperfections on energy markets among European Union countries (Wuppertal Institute et al., 2000). These barriers are similar to the demand-side barriers, existing in the Swedish case (table 5). The barriers, identified by Wuppertal Institute, are:

- "The disparity of discount rates (the "pay-back gap": energy companies with access to low discount rates build power plants and lines, although they are more expensive than end-use efficiency;
- Lack of information, both for energy users and with suppliers of end use equipment;
- The investor-user-dilemma ("split incentives": owners, e.g. of buildings and offices, seek to minimize investment cost since they will be paid the energy cost by the users);
- Financing problems, mainly for households, small and medium sized companies, and public entities;
- The rules of public budgeting make it difficult for public entities to finance energy efficiency investments from savings in energy costs;
- A perceived risk of new, more efficient technologies;
- Disincentives to suppliers of end-use technologies." (Wuppertal Institute et al., 2000)

A situation with the "pay-back gap" may be interpreted in Swedish case as possibility to decrease electricity consumption, instead of using electricity, produced by the nuclear power plants. Quantitative assessment of consumption in relation to existing energy saving potential, compared to nuclear electricity production, might give more precise evaluation of the "pay-back gap". (Swedish National Energy Agency, 2002).

Thus, after liberalization of energy markets in Sweden, the set of barriers to energy efficiency is not fully addressed. The problems exist on the demand side. According to the study by Wuppertal Institute (2002), policy, encouraging the competition from the supply side cannot address barriers for energy efficiency on the demand side. Therefore, the barriers should be addressed through demand-side management[4]. It is important to address demand side energy efficiency, because it offers large potential for improvements in Swedish case as well as among the other EU members (Wuppertal Institute et al., 2000).

Representatives from various energy consultancies, energy companies, ESCOs and the government realize importance of addressing efficiency at the end-use for the future development of the energy system and electricity market as a part of it. (Wuppertal Institute et al., 2003a) The most appropriate policy framework is considered to be characterized by the following key options. (Wuppertal Institute et al., 2003a):

- "Avoid short term investments subsidies and "resource acquisition" policies. Provide policy mechanisms that can be stable and long term. Promoting energy efficiency is a long term endeavor that requires combinations of efforts.
- Focus policy on the situation of the end-user and his/her needs. Use demand-pull and not supply push policies for promoting energy efficiency services. In particular, White Certificate scheme was found as an interesting option, however was not discussed in detailed.
- Provide an equal playing field for all actors and avoid obligations on, or agreements with, certain actors."

2.3.8 From DSM to WC

According to the analysis of policies aiming at increase of energy savings, demand side energy efficiency has not received enough attention, that it is required. As it is discussed, various barriers to energy efficiency still exist on Swedish liberalized electricity market. Such problems as split incentives, lack of funding, resistance from consumers and suppliers, etc., which are associated with demand side, are poorly addressed. Lack of sufficient policy framework, addressing the barriers of the demand side, is a common problem in the EU. In conditions of regulated market, DSM addresses such barriers. In conditions of liberalized market DSM is needed to be stimulated by policies rely on market principles.

General principles of successful policy frameworks for promotion energy efficiency on demand side were recently developed by Wuppertal institute. The framework is based on currently developed schemes in Denmark, Netherlands, the UK, Italy, and Belgium. Among other instruments, it also includes financing mechanism for energy efficiency programs.

There are three general principles for designing the supportive policy framework:

- "An agreed or mandated quantified target for energy savings should be set
- A channel or an allowance for rising funding, and for avoiding net losses should be designed
- A standardized and mandatory scheme for cost benefit evaluation of the energy efficiency activities is to be designed as well" (Wuppertal Institute et al., 2002)

All of the examined cases in the EU use a combination of policy mechanisms, which consists of mechanisms for creating a quantitative target combined with mechanisms for rising funding. Quantitative targets usually rely on some category of energy suppliers and consumers as energy efficiency quota.

Only two of the cases, in Italy and the UK, use the framework of policies coupled with a trading system for energy efficiency certificates[5]. Such scheme are called White Certificate (WC) or Energy Efficiency Certificate Trading (EECT) scheme. The instrument relies on market principles.

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[4] see the definition of demand side management in footnote 3

[5] The UK system does not provide trading of the certificates, however, allows some limited possibilities of trading of energy savings and individual obligations.

The WC system opens some additional possibilities to address barriers to energy efficiency on the demand side. Those are discussed in section 3.1.2 *How does White Certificate scheme work*. The WC scheme is considered to be appealing because of its potential contributions to elimination of the barriers towards greater energy savings on the end use.
The thesis is focused at the opportunities for implementing such scheme in Swedish electricity market.

3 Theory of white certificates

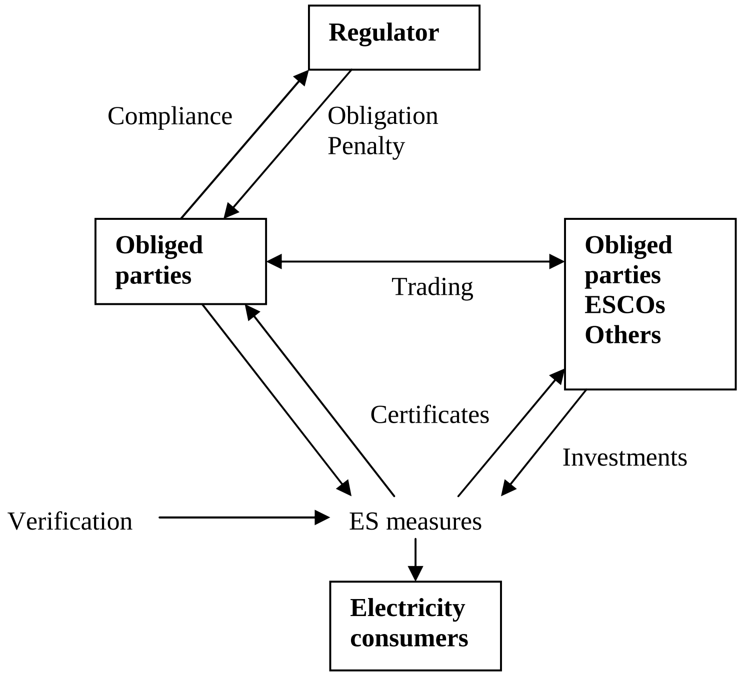
If WC scheme is appropriate choice for Sweden, theoretical framework for designing of WC scheme for electricity market should be formulated. Such framework should include conditions necessary for design and for appropriate implementation of WC scheme. Appropriateness here is defined in section 1.3 *Analytical framework and method of enquiry*.

3.1 White certificates – a preferable choice under the conditions of liberalized market

White certificates is an instrument to support incentives for energy efficiency measures towards achieving defined targets. It is a market instrument, which provides opportunities to reach a specific target at least economic cost. (Mundaca, 2003) One of the main functions of WC scheme is to reduce transaction cost for energy efficiency measures.

3.1.1 WC – mixed type of governance

In this section WC instrument is discussed in the context of applicable governance for investments into electricity savings under the conditions of liberalized market. Transaction Cost Economies gives some ideas how different governances can influence investments into electricity savings under the conditions of different types of markets. Under the conditions of deregulated market actors make their decision to invest on the basis of mutually beneficial behavior. High transaction cost of measure can be a limiting factor to investment. Appropriate governance for the investments is needed (Solomon, 1999).
According to TCE, there are two categories of governance that is possible on the market. First type of governance is one under conditions of regulated market. This type of governance is similar to the relations set up by command and control system of governance. It can allow more specific investments. Specific investments are related to high sunk cost. Specific investments are assigned to the specific purposes and, therefore, might lead to the higher energy savings (Langniss, 2003).
Second type of governance is governance under conditions of liberalized market. It is characterized by greater flexibility of the actors. Market governance operates with less specific or, so called, generic investments. This allows easily transfer of investments to another project. In a case of less specific investment, energy saving measures might lead to the lesser results than that in the conditions of the high specificity investments. At the same time, generic investments are more acceptable form of governance in the conditions of the liberalized market (Langniss, 2003).
Governance for the investments under conditions of regulated market guarantees the payback over the entire lifetime of energy efficiency measure. In the situation when the regulation is phased out, no one would guarantee the payback for the investments. Thus, there is a risk that in such situation energy saving measure will not take place. (Fisher and Rothkopf, 1989).
Mix of command and control and market governance might give an optimal scheme for encouraging energy efficiency investments under conditions of deregulated market. WC scheme integrates high specificity of the investments with market flexibility mechanisms. WC is capable to achieve a specific goal in electricity savings (common and control obligation). This allows obliged parties to make the best economic choice through market instruments, such as trading energy efficiency certificates and energy efficiency measures (Langniss, 2003).



Scheme 2. *Concept of White Certificate market*

3.1.2 How does White Certificate scheme work?

The concept of WC scheme is illustrated on the scheme 2. The government sets a target for electricity savings. The obliged parties, which could be generators, distributors, suppliers or customers, have to fulfill the obligation. They have to demonstrate their compliance by presenting necessary amount of certificates in a certain period of time to the regulator. Certificates are corresponding to necessary amount of electricity saved. The certificates can be obtained by performing electricity saving measures on the demand side or by buying certificates. This way the demand for WCs in created.

Trading can take place between the obliged parties as well as between the other participants on the market.

A possibility of trading of energy efficiency (EE) certificates would give an opportunity to the obliged parties to fulfill their obligations, choosing the best economic option to achieve the target. Obligated parties can obtain EE certificates following one (or combination) of the three possibilities (Pagliano L., 2003):

- through increasing their own energy efficiency measures;
- through buying certificates from other obliged parties;
- through bilateral contracts between obliged party with ESCOs or other market participants, acting on behalf of the obliged party.

Trading of certificates take place on the separate financial market. Thus, generation of certificates is not based on any specific assets (the investments are made into energy efficiency), and, therefore, does not require complex governance (Langniss, 2003). Price of certificates is set on the market.

Cost of the electricity efficiency measure can be covered through the sale of certificates on the market. This way the cost is recovered.

Verification procedure is based on metering of increase in electricity efficiency resulted form implemented measure. It is one of the key issues in the WC scheme (see section 3.5 *Verification: Measurement of energy efficiency*).

WC scheme guarantees a market value of energy efficiency measures. Therefore, it reduces a need to set complex governance. In this case, WC scheme is a right choice of appropriate governance for energy savings investments in the liberalized market (Pagliano et al, 2001).

WC scheme might not create big income from trading certificates. Compare to energy efficiency investments, income from the certificates could be rather negligible. At the same time securing prices of the certificates is less crucial than to provide more choices for market governance. Opening more choices for governance of WC will give an opportunity to reduce total cost of energy policies (Langniss, 2003).

Thus, positive contributions from WC scheme could be summarized as the following:

- Advantage to reduce total cost of energy policies, through assigning market value to energy savings and opening market for trading certificates, corresponding to amount of electricity saved;

- Giving more freedom of choice for the obliged operators, who use EE certificates to reach their obligations;
- Allowing market participants, apart of obliged parties, to make investments in end-use energy efficiency measures and benefiting through selling gained certificates to the obliged parties;
- Could provide more appropriate governance of investments in energy efficiency under conditions of liberalized market.

Through all of the listed options, WC creates market of equal players with the possibility to fulfill their obligations at lowest economic cost. In such conditions, energy saving activities would not require complex governance to secure investments. For some players, who do not have an obligation, income from the WC trading will be profitable enough to participate in trading. (see section 4.3.6 *Number of actors on the market; who is expected to trade certificates*)

Thus, WC scheme creates appropriate governance to encourage greater efficiency through addressing barriers for energy efficiency on the demand side under the conditions of liberalized market.

3.2 Main elements of White Certificate scheme

In this section the main elements of WC scheme are summarized. There are three main conditions of energy efficiency trading certificates scheme. (Langniss, 2003), (Pagliano, 2003)

First, the overall target for energy savings should be set.

Second, obliged parties should be nominated and the target to achieve energy efficiency should be distributed among the obliged parties.

Third, energy efficiency measures should be set optimally, meaning that the definition of the measures could be wide enough to not increase a cost of fulfilling this obligation. At the same time, the definition of EE measures have to have some limitations, in order to not miss comparability, measurability and, as a result, tradability of the EE certificates. There are some examples of EE measures sets:

- The scheme might be oriented to only certain measures (for example, wall insulations or light bulbs);
- The scheme might be designed to foster only hardware installation programs or informational and educational programs;
- The scheme might be dealing only with measures for one energy carrier (for example, electricity/ gas);
- The scheme might be designed to implement EE measures only for "customers of the individual obliged party".

In addition to the highlighted conditions, control of any transactions on energy efficiency market and penalties for non-compliance should be established.

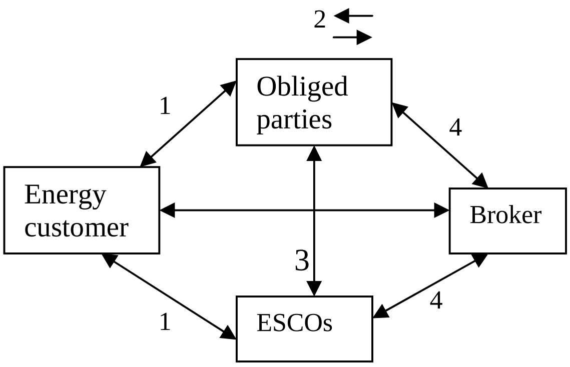
Note. There could be a limitation for each party to buy only certain amount of certificates from the market, in order to encourage each party to perform energy efficiency measures. However, the lower would be a share of the certificates, bought from the market, the smaller would be the size of the created market, and the closer would be WC scheme to the command and control regulation.

3.3 Market participants in WC scheme and transactions between them

As briefly mentioned before, there are several possibilities for transactions in the WC scheme (see scheme 3):

- between obliged parties and users of EE measures (energy customer);
- between obliged parties themselves;
- between obliged parties and ESCOs, who independently investing in EE measures and getting certificates;
- through a broker who acts as an intermediary between all of the participants.

The first type of transaction shows interaction between obliged parties, energy customers and energy service companies (ESCOs), in a case when *certificates are allocated to the customers*.



Scheme 3. *Transactions between market participants, source Langniss (2003)*

Obliged parties might be any kind of energy suppliers. Customers suppose to invest in energy efficiency measures and than trade obtained certificates to suppliers (the obliged party). (Langniss, 2003) Obliged parties or ESCOs also could be investors into energy efficiency measures at the end-use. In a case when investor is a customer, if a customer does not want to take a risk, the transaction might not take place. If obliged party or ESCO invest, the transaction of certificates should be transferred to the investor and, in case of investments from ESCO, certificates are to be traded to the obliged party. In all three cases investments might be highly specific. Thus, securing the transaction through non market governance, such as long-term contract, could be a method to ensure the investments, although limiting freedom of all market participants and, possibly, the size of the market. (Langniss, 2003)

EE certificates can be allocated to the investor. In this case there is no transaction of certificates. Obliged parties will fulfill their own obligations, trading certificated only among themselves.

Allocation of certificates to the investor is more reasonable choice. In this case the market governance for the investments allows to the obliged party has options to choose of how to fulfill the obligations.

Trade between obliged parties is possible when marginal costs of energy efficiency measures are different among different suppliers. As a result of energy efficiency measures, reduction in sales for energy supplier takes place. That is why for supplier, as an obliged party, buying of the certificates on the market could be seen as reasonable option, even if the price for them is higher than a cost of measures. A price for certificates (marginal cost for energy efficiency), offered by suppliers might be higher, as supplier tends to incorporate a cost for reduction in energy sales into the total price. Thus, trading might take place due to expected difference in the marginal costs. (Fisher A., Rothkopf M., 1989)

EE measures might be applied to “proven effectiveness” cases, such as building insulation. In these cases the risk to invest might be assigned to the regulator, instead of obliged parties or consumers. In order to apply such practice, energy efficiency certificates, which will be generated over the entire lifetime of the energy efficiency measure should be allocated to the investor as soon as the investments take place. However, this procedure requires complex governance.

An allocation of certificates in a period after fulfilling obligation is one of the factors to stimulate incentive for energy efficiency. (Langniss, 2003)

ESCO

Providing energy services, including energy efficiency services, is a primary business of ESCOs. That is why additional income from WC while undertaking energy efficiency measures, is expected to be of interest for ESCOs. ESCO will trade EE certificates to the obliged parties. In relation to customers ESCO plays the same role as the obliged parties. For both, the obliged parties and ESCOs, if a long term commitment for energy efficiency investments takes place, the need for more strict governance to secure the commitment might creates a risk for reducing of the additional income. (Langniss, 2003)

Broker is an intermediary between all of the participants in a process of trading.

3.4 Examples of designs of White Certificates. The case of the UK and Italy

In this part general characteristics of WC scheme implementation are shortly presented. Issues for consideration, learned from these schemes, are taken into account, when discussing possibilities of applying WC scheme in Sweden.

3.4.1 UK

The main guideline for energy efficiency measures in the UK was set by the Energy Efficiency Commitment (EEC) in 2002. According to DETR (2000), the main purposes of energy efficiency measures implementation are: a) to contribute to reduction of GHG emissions; b) to reduce energy consumption and to reduce fuel prices; c) and to help low-income consumers ("priority group"), thus contributing to poverty alleviation.

Major electricity and gas suppliers are obliged parties in the UK scheme. Major energy suppliers are those who have at least 15000 customers.

The obliged parties are expected to reach energy efficiency savings of 62 fuel standardized TWh during the period from 2002 to 2005 (Costyn, 2002).

Individual targets are shared between obliged parties according to their number of customers. Regulator defines individual targets, assigning to each party a set of measures and, thus, quantitative results are expected from the implementation. It means that the transaction cost is lower because there is no need to make evaluation of measures one by one. However, the scheme requires a control system for approval of all transactions. A possibility to change the system into more flexible one, where a regulator does not introduce a set of measures to perform, still exists (DETR, 2000). Such new scheme would require individual verification procedures (Langniss, 2003).

According to The Electricity and Gas Energy Efficiency Obligations (The Electricity and Gas Order 2001), at least 50% of saved energy should be undertaken on low-income customers.

An investor into energy efficiency measures, that is energy supplier, gets overall savings from energy efficiency measure during lifetime of the measure. ESCOs are involved into implementation of energy efficiency measures. In a case of investing in low-income customers, energy services companies receive 50 percent of additional remuneration, as an encouragement to invest.

According to The Electricity and Gas Order (2001) and Eoin Lees (2003), the following number of measures for energy savings was set in UK: cavity wall insulation, loft insulation, double glazing of windows, use of low emissive glass, installation of condensing boilers, improvement of heating control, promotion of high efficiency technologies and compact fluorescent lights, enforcing of higher efficiency standards of building. These measures are assumed to be cost-effective in the UK case.

The suppliers can choose the most cost-effective measures to deal with.

The overall target and policies are set by The Department of Environment, Food and Rural Affairs (DEFRA).

Administration and monitoring are undertaken by The Office of Gas and Electricity Markets (OFGEM). An approval of all transactions goes through OFGEM. All the approvals should be performed in order to get eligibility. Transactions between suppliers might include trading of energy savings as a result of EE measures as well as trading of obligations (Costyn, 2002).

The WC is not a scheme based on certificate trading. However, the government proposed trade of energy savings and obligations between companies and obliged parties (DETR, 2000). According to The Energy and Gas Order (2001), energy supplier can " a) treat qualifying action taken by another such supplier (the second supplier) as achieving the whole or any part of its target; b) transfer the whole or any part of its target to the second supplier".

Although there are certain possibilities for energy savings trading, the system does not provide conditions for market. "Bilaterial over-the-counter trade" is the only option for trade. There are no possibilities to create spot trade or anonymous trade, which reduce difference in marginal costs. Thus, the WC scheme is "rather conventional command and control policy with some restricted flexibility, concerning fulfillment of obligations"(Langniss, 2003).

3.4.2 Italy

Italian EE scheme is more ambitious compare to the UK one. In order to achieve EE target, it aims at implementation of EE certificate trading.

Even though the EE scheme is implemented since January 2002, the first compliance with the targets to fulfill is going to be in 2004. Italian scheme is a mix of command and control mechanisms, market and tariff mechanisms (Huld and Bertoldi, 2003). Command and control instrument is represented by obligation of distributors with energy saving targets. Energy efficiency measures are market instruments, with obliged distributors and ESCOs. "Cost recovery mechanisms through electricity rates" (Malaman and Pavan, 2002) are tariff mechanisms.

The quantitative target for 2002 – 2006 years period is to reduce electricity and gas consumption of by 18.6 TWh/a and 15.1 TW/h respectively.

Gas and electricity distribution companies (DISCOs) are obliged parties to fulfill EE obligations. That is expected to achieve through direct investments and buying certificates from each other or ESCOs. (There are eight electricity suppliers and twenty two gas suppliers. The obligations are assigned to suppliers with more than 100 000 customers. Distribution of the overall target among the distributors is made proportional to their shares on the market.

The obligations should be fulfilled at least by 50 percent at the electricity sector.

There exists a set of fourteen categories of eligible measures .

In April 2001, Italian Ministry of Industry set the goal to the companies-distributors to achieve certain quantitative targets (Pagliano, 2003)

The Regulatory Authority issues EE certificates to obliged parties and ESCOs, who undertake energy efficiency measures. Trade is allowed in a various forms, such as transactions on anonymous markets or bilateral contracts. Bilaterial contracts are expected to be dominated, due to small number of market participants. An official approval for trading certificates is not required (Langniss, 2003).

In a case of not compliance financial penalties are set.

Cost recovery mechanism for compensating price for programs/measures implementation is set as a fraction of distribution tariff.

3.5 Verification: Measurement of energy efficiency

When implementing energy saving measures and programs on the demand side, risks of poor performance might accrue due to a number of reasons. However, procedure of verification for saved units of electricity as a result of the program/measure implementation would be helpful in reducing and correcting problems, and consequently, in encouraging quality of performance.

According to Langniss (2003), measurement of energy efficiency measure is not an easy task. A lot of issues should be taken into the account for adequate estimation of energy savings. First of all, the question is how to define a "business as usual case". An energy efficiency measure could have a various number of meanings. It could be a measurement of technical characteristics of the new technology compared to the old one; it also could be a comparison of similar type of technologies; or it might be an approach to compare a heat supply system to a mix of electricity supply. Evaluation of environmental impact from the new technology with respect to the old one could be another principle to measure the energy efficiency. Investment' potential of energy efficiency programs might also be criteria to define EE measure. (Langniss, 2003)

Energy efficiency measure might be defined on local, regional, national or international levels.

3.5.1 Measurement and verification through International Performance Measurement and Verification Protocol

International Performance Measurement and Verification Protocol (IPMVP) is one of the most developed and, consequently, widely used measurement and verification methods.[6] The methods of verification were designed for commercial and industrial facilities are based on the best practices to measure energy conservation, water efficiency, as well as reduction in energy use in a result of changing of operational processes and retrofitting of equipment. There are four approaches in Measurement and Verification Protocol. (IPMVP, 2002) The difference between the approaches is scope of application and continuity of verification, i.e. short term or continues.

1. Partially Measured Retrofit Isolation option allows verification of energy saving measure for part of the facility separately from the whole system. Some parameters might be stipulated. For this option measurement might be either short term or continues.

2. Retrofit isolation option is similar to the option a) by metering approach, however, full measurement of the system is required without any stipulations. Metering of the energy saved is applied to the part of the system where energy saving measure is applied, separately from the rest of the system. Verification might be of two kinds – short term and continues.

3. Whole Building option has wider scope. It requires collective savings from all the undertaken measures in the system or part of the system. Monitoring of the system goes under single meter. Verification might be short or continues. Continues metering is practiced more often, because it includes metering of energy use for the whole facility before and after retrofitting period.

4. Calibrated Simulation is an option based on computer's simulation of energy consumption of the whole facility. Calibration of energy demand and energy use of the system through this approach is quite effective in application. However, the option is quite costly, because it requires considerable data input and skills of experts for optimal calibration of energy consumption in particular system.

There are two approaches to verify electricity savings for any scope of application. (IPMVP, 2002)

Standard Saving Factor approach uses standard saving factors for calculation of energy savings. Metering of electricity savings is done by identifying of certain measures, such as installation of CFLs, with certain kWh saved. For example, in Italy there was a set of measures for undertaking. Each of the measures was associated with exact lifetime and corresponding amount of certificates. The allocated amount of certificates was the same each year during the lifetime of measure. The lifetime of measure is defined. Such approach is the way to avoid uncertainties. However, defined parameters for measure would tend to limit further stimulation for reducing in energy consumption after the measure once got implemented and there is no actual metering of consumption.

The other approach is *Metering Approach*, which assume metering of electricity consumption before and after the energy measure / program took place. Energy savings are calculated as a difference of the consumption "before and after". (IPMVP, 2002)

Metering Approach in comparison to Standard Saving Factor Approach is more accurate, as it is meters real consumption in the system, including the part, where improvement of the system took place. Metering of actual energy savings is essential in a case of big industries, where the potential of energy savings is high. In a case of Metering Approach the amount of certificates to be allocated each year is defined with regard to the amount of energy saved.

[6] ASHRAE guideline and FEMP M&V guide are complementary documents to IPMVP. FEMP is an application document, based on 1997 version of IPMVP, specified for the federal sector in the US. ASHRAE and FEMP M&V guides are more detailed guidelines for specific energy conservation measures. (www.ipmvp.org)

3.6 Penalty

Penalty is a necessary element in WC scheme that keeps the obliged parties fulfilling their obligation. According to Öko-Institut (2000), there are two possible options to establish penalties: *First, penalty is a fixed price per certificate or per kWh*. Usually a level of penalty is a maximum price of certificates. That was preferable choice in Italian scheme. However, if the level of penalty is set lower than the maximum market price, than it might distort the maximum price.
Second, penalty is a factor above one times the average market price in the compliance period (average price + x). In this case the level of the penalty will always be higher than the maximum market price. In order to consider such option, the body, imposing penalty should have information on average price on the market.

3.7 Summary – critical factors in designing white certificate scheme

All the positive contributions of WC scheme can be materialized if trading of certificates is feasible. This is the main condition, which would lead to the creation of market of equal players with possibility to obtain certificates for compliance at least economic cost. As a result, some of non-obliged parties would be involved into trading certificates, contributing to the greater increase in electricity savings. (see section 3.1.2 *How does White Certificate scheme work?*)
According to the theoretical and empirical studies (Italy and the UK), the following considerations need to be addressed, when designing market of WC: decree of flexibility for trading rules, possible market conditions, number of actors on the market, allocation of certificates with respect to lifetime of measure for increasing of energy efficiency. Definition of appropriate institutional capacities to regulate the system (issuing, allocation, verification, registration, penalty system) should also be done. Verification mechanism is a key element for WC scheme.
Penalty should be defined as mechanism to deal with poor performance in reaching the obligation. Penalty should not be perceived as a punishment action, but as a support to keep obliged parties fulfilling their obligations.
Cost recovery mechanism should be set according to the type of the electricity market.
Demand on WCs should be set with respect to feasible quantitative target for the country. Choice of appropriate parties to perform the obligation should be done due to the existing type of the market and relations between different actors on the market.
Table 6 summarizes the main components for design of WC scheme.

Table 6. Critical components for design of white certificate scheme

Demand for WC
• Estimation of the quantitative target • Target distribution among the obliged parties • Specific requirements • Whom to oblige?

WC system mechanism	
Market of WC	***Mechanisms***
• Preferable design of trading rules; decree of flexibility • Possible WC market conditions • Number of actors on the market;	***Verification*** • Verification methods • Preferable approach to measure energy savings • Verifiers • Registration and allocation procedure

• Regulator • Whom to allocate certificates • Length of compliance period • Allocation of certificates with respect to lifetime of energy saving measures	***Penalty (Non-compliance case)*** • Penalty is a fixed price • Penalty is a factor above 1 times the average market price ***Cost recovery*** (In conditions of free market)

All the issues for considerations are going to be addressed, while looking at the possibilities for the WC scheme in Sweden.

4 Swedish case; Design of WC scheme

4.1 General market condition in Sweden, favoring for WC scheme

Presently, Swedish electricity market has barriers for energy saving activities on a larger scale.
In the conditions of Swedish electricity market, there is a significant difference in marginal cost for implementation of energy efficiency measures by different actors. Therefore, undertaking energy efficiency measures without flexible mechanisms, i.e. trading, could become too costly for some of the actors. This might affect their current status under conditions of the liberalized market. For the actors who can archive electricity savings by reasonable cost, there are not enough incentives to invest. Consequently, investments in energy efficiency activities have low priority on the competitive market.
Implementation of WC scheme on Swedish electricity market can create beneficial conditions for parties, obliged to increase electricity savings. Difference in cost for implementation of energy saving measures will create difference in marginal cost for certificates. Difference in marginal costs for certificates is a guarantee for creation of minimum market size for certificate trading (Fisher, Rothkopf, 1989). Trading of certificates is a strategy for market participants to fulfill their obligations at least economic cost. It means that favorable conditions for trading certificates will create market with equal players, stimulating increase in energy savings. Therefore incentive to invest into electricity savings is created with creation of market of WC. Resistance towards stricter regulations in Swedish electricity market makes the flexibility through trading of certificates a key issue to consider, while implementing WC scheme.
WC is an instrument to promote efficiency on the demand side under the conditions of a deregulated electricity market. Swedish electricity market has positive characteristics for implementation of DSM. These characteristics are: decentralized electricity market, unbundling for supply and distribution companies, high level of retail competition between electricity suppliers on the market, and less specialized electricity suppliers (Wuppertal Institute et al., 2000). Thus, WC mechanism is considered as appropriate instrument for effective stimulation of electricity savings under the existing conditions in electricity market. In this context "appropriateness" is used as defined in section 1.3 *Analytical framework and method of inquiry.*

4.2 Demand for WC

As it mentioned above there is a consideration to avoid administratively demanding policies under the conditions of liberalised Swedish electricity market. (Wuppertal Institute et al., 2003a) Possible design of WC scheme in Swedish case would tend to structure the scheme in less administrative form. There is a consideration to implement similar system to the Italian scheme, where "trade is allowed in a various forms, such as transactions on anonymous markets or bilateral contracts" and "an official approval for trading certificates is not required." (Pagliano, 2003)

4.2.1 Estimation of the quantitative target

Operation of nuclear reactors, which lifetime to be expired in the coming years, involve social risk. Therefore, principal target can be formulated as a decision to phase out nuclear power after ending of nuclear plants' lifetime.

Sweden has political commitment to reduce CO_2 emissions. After decommissioning of second nuclear reactor, development of electricity market aims at the continuous use of clean electricity.

That is why renewables is a preferable choice to substitute nuclear energy. The overall target in increasing of electricity production from renewables is 10 TWh by the year 2010 from the level of 2002. The proposal was issued by the government in 2002. (Swedish National Energy Agency, 2003c)

Currently, electricity generated from nuclear plants consists of 65.6 TWh, which constitutes about 40 percent of entire electricity production in Sweden. (Swedish National Energy Agency, 2003a)

Ten TWh of electricity from renewables is not enough to substitute the supply of electricity currently provided by the nuclear power plants. Nuclear plants might still be supplying electricity by the year 2010, depending on the commissioning year of the reactors. The latest commissioning year for the reactors, Forsmark 3 and Oskarshamn 3, is 1985 (Swedish National Energy Agency, 2003a). Assuming that period of amortisation for the reactors is about 50 years, it could be expected that by the year 2035 (1985+50 years) all the nuclear power should be decommissioned.

Due to the considerable potential in energy savings in Sweden (see Ch. 2.2 *Energy efficiency potential - identification of electricity savings*), increase in energy savings should be able to cover necessary demand in electricity, which is not covered by increase of renewables only. The quantitative target on increasing of energy savings might be roughly estimated through assessment of feasible increase in electricity production form renewables by 2035 (the end of lifetime for nuclear). The rest of the production, which is needed to cover lost production from nuclear sources, can be compensated through increase in energy savings.

The overall target for increasing energy savings is estimated as a long-term objective by the year 2035.

65 TWh is taken as an average of annual nuclear production. It varies from year to year due to fluctuation of electricity generated from hydropower. (Swedish National Energy Agency, 2003a)

10 TWh of electricity from renewables is a target for the period from 2002 to 2010. It means that increase should be approximately by 1.25 TWh per year (Increase in production is not necessarily would take place gradually year by year, it depends on building of the new facilities. However, for simplification of the assessment, the increase in production is assumed as liner function).

Thus, if it would be possible to continue increase in electricity from renewables by the same rate as it is planed by the year 2010, the increase in electricity production from renewables by 2035 from the level on 2002 could be estimated by about 41 TWh (1.25TWh x 33 years = 41.25 TWh).

Thus, the difference between nuclear production and predicted production of electricity from renewables by 2035, is about 24 TWh. (65 TWh – 41 TWh = 24 TWh).

Thus, 24 TWh is a possible estimated quantitative target for increasing of energy savings (or decreasing in electricity consumption) by the year 2035. 24 TWh is 16 percent of current total electricity consumption. (total electricity consumption is about 150 TWh)

Targeting increase in energy savings by 16 percent of current total electricity consumption by the year 2035 or 0.5% annually, seems feasible for Sweden, which electricity saving potential is evaluated as considerable (see Ch. 2.2 *Energy efficiency potential - identification of electricity savings*).

Set of the quantitative target would create demand for energy savings[7].

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[7] According to Wuppertal institute (2003a), the participants agree, that it is important to set targets. However, many argued that quantitative target might lead to complicated administrative system involved into the process of monitoring.

4.2.2 Target distribution among the obliged parties

The target is distributed among the obliged parties with respect to the amount of electricity supplied.

4.2.3 Specific requirements

As it was reviewed in section 2.1 *Electricity consumption* and 2.2 *Energy efficiency potential - identification of electricity savings*, there is a high level of consumption and high level of electricity efficiency potential in the household and industrial sectors. Investments into electricity efficiency measures at the household level might have higher transaction cost. The overall target for energy savings should more specifically direct energy savings measures towards household sector. The obligation can require certain share of obtained certificates for fulfilment of the obligation at the level of household sector.

In addition, specific requirements might be placed on certain share of certificates, obtained in a result of measures and programs undertaken on a level of small companies (see ch. 4.3.2 *Possible WC market condition*).

4.2.4 Relations on electricity market

Understanding of relations on electricity market is necessary when choosing parties that should be obliged for performing reduction in electricity consumption. The data are taken from Swedish National Energy Agency (2003a).

Institutions dealing with regulation of electricity system

There is a number of institutions dealing with regulation of electricity system. The main institutional actors are:

Government, which deals with legislation system, controls flow of electricity and regulates prices of the network;

The Ministry of Industry, Employment and Communication, which gives concessions to owners and advises to the Swedish Energy Agency on prices of transmission;

The Swedish Energy Agency, which provides guidelines for grid transmission and distribution prices and monitors network tariffs and other conditions within monopoly part of the industry (distribution companies – see below);

Swenska Kraftnat - state owned company, which operates national transmission and grid and balances production and consumption on the grid through agreements with electricity trading companies;

Swedish Electricity Safety Board, which provides guidelines to secure of the network operation.

Electricity system in Sweden

Swedish electricity grid is composed of about 15 200 km of 220 kV and 400 kV transmission lines with stations. Svenska Kraftnat is responsible for the grid. (Swedish National Energy Agency, 2001) The high voltage (400 kV and 220 kV) grid was transferred from Vattenfall to the responsibility of Svenska Kraftnät after the liberalization of the energy market.

According to the functions in the electricity system, actors can be divided in the following way (see scheme 4):

Generators generate electricity;

Transmission and distribution companies are the grid operators. These companies distribute electricity, i.e. sell transport service in the grid. Distribution grid operator usually operates the

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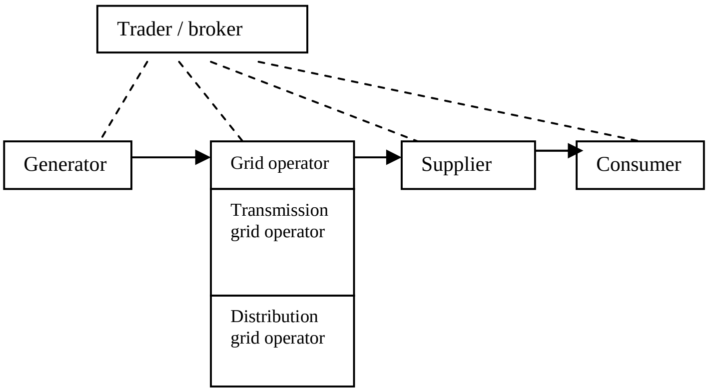
Indicative target was considered as preferable choice to the quantitative type of target at least for national level. It would be costly and difficult to handle. Although in business or public sector it can be set.



lines up to 20 kV. Transmission companies operate the lines above 20 kV. Regional network transmit electricity at the voltage up to 130kV;
A function of *suppliers* is to sell electricity to final customers; [8]
Consumer is a final consumer of electricity.
Traders and brokers are intermediaries between all the actors in the system. They sell electricity from generator or from other customers; they operate as balance providers, having additional responsibility of maintaining balanced generation and consumption (agreement between Svenska Kraftnat and trading companies). Electricity trading companies buy electricity from a number of electricity generators or through North Pool.
In Sweden, the General Electricity Act (SFS, 1997:857) and the National Decree of electricity are key peaces of the electricity legislation for regulation of production, transmission and use of electricity. Electricity act (SFS 1997:857) established clear distinction between electricity production, sales and electricity transmission. Competition is opened for production and sales. At the same time, network operators, "which in practice are monopoly, continue to be regulated and supervised by a Network Authority - is responsible for delivery concessions and network concessions, norms and supervising of the network tariffs." (ENER, 2000)

4.2.5 Whom to oblige?

There are four potential candidates to carry an obligation for reaching higher electricity savings on the electricity market: generators, distributors, suppliers and consumers. In order to choose a party to oblige, each of the possible candidates should be evaluated by the following criteria (Langniss, 2003):
1.Hierarchy in relations between the party and the final consumer; Knowledge and information on the demand side
"Close location" to the consumer by functioning on the market gives to obliged parties access to the information on the demand side and, therefore, more sufficient knowledge.
2. Experience in undertaking of energy saving measures;
Specific knowledge and information in undertaking energy efficiency measures would lead to a possibility for the parties to create economies of scale
3. Market conditions (monopoly, administrative functions, etc.);
Companies acting under regime close to monopolistic, as it is often a case for distribution companies even within the liberalise market, are less sensitive to price competition on the market. It might be a sign of their low interest to trade certificates in order to achieve their target at least economic cost. However, incentives to lower cost should be of interest of parties, acting under the competition on the energy market.
1&2&3. Transaction cost for DSM measures implementation
The first, the second and the third criteria influence transaction cost. Knowledge and information on the demand side, as well as specific experience in energy efficiency and energy saving measures and programs, would significantly reduce transaction cost for implementation. Market conditions for an obligated party also influence transaction cost.
4. Number of the companies and their size;

[8] Supply company is "an independent company or a part of an integrated energy company, which has the task to sell electricity to final customers" (Wuppertal Institute, 2002)

There is a necessary condition that certain number of companies should trade certificates, in order to create a minimum market size. Difference in size of the trading companies is important. A few large scale participants, among small and medium size ones, would tend to create a monopolistic conditions, when trade would be controlled by the largest parties.

1.Hierarchy in relations between the party and the final consumer; Knowledge and information on the demand side

1.1. Generators. Generation companies sell electricity to the trading companies and other customers. Generators can sell their output directly to end-users and to intermediaries such as supply and trading companies.
1.2. Transmission and Distribution grid operators. Transmission companies transmit electricity from the national grid to distribution companies and big industries. (Swedish National Energy Agency, 2003a)
1.3. Suppliers. Supply companies sell electricity to all possible kind of consumers (households, residential and services, industries)
1.4. Consumers. Final consumers have some knowledge on the demand side.

Final consumers have some knowledge on the demand side of energy system. However, in a context of knowledge for creating economies of scale it is not sufficient.
Generators in Sweden have some knowledge on the consumer level, especially large industries. However, considering meeting of specific requirements on the household and industrial level, generators do not have enough direct connection to households.
In principle, network companies are better positioned because of their access to consumption data. Supply companies have sufficient knowledge on the demand side, as they sell electricity to all possible kinds of consumers. Comparing them to the grid operating companies, suppliers have more detailed trends on demand from the customers, while distribution and transmission companies operate due to more aggregated demand.

2. Experience in undertaking of energy saving measures;

There is no easily obtainable information on experience in DSM with regards to any of the parties. Before the liberalization, production, sales and electricity transmission was performed by large integrated utilities. Some DSM has been done by the utilities, but not through systematic and regulatory incentives. Under the conditions of liberalized market DSM activities was stopped. Therefore, assumption on a possibility to create economy of scale can be done with respect to the knowledge on the demand side and on the basis of organization of the electricity system. In this case, the assumption would be identical to the previous paragraph (1).
Note. ESCO
None of the four candidates has sufficient experience in undertaking of energy saving measures.
After the deregulation if the market, ESCO should be or should become one of the main providers of information on the demand side. The information on the demand side should be collected for analysis of measures implementation. In Swedish case ESCOs did not contribute much to decreasing of electricity consumption. WC instrument might work as a supportive instrument to make ESCOs functioning on the market better.

3. Market conditions (monopoly, administrative functions, etc.);

Generators. Generation is fully open to competition and trade is decentralized.
3.2 Transmission and Distribution grid operators . The grid operators are regulated as monopoly segments by the office for electricity and gas regulator (a part of the Swedish Energy Agency),

who regulate network tariff and other conditions within the monopoly part of the industry. Distributors can choose between electricity suppliers as well as between consumers.

3.3 *Suppliers*. There is a competition on the market between suppliers. According to General Electricity Act, Consumers are free to choose their suppliers, as well as suppliers can choose their customers. (ENER, 2000)

Consumers. Consumers are free to choose among suppliers in the area. Such opportunity is given to consumers by the General Electricity Act.

The WC schemes are expected to be successful in the countries with monopolistic history. Both Italy and the UK experienced regulation of electricity industry under monopolistic regime. Distributors and transmitters, act under control of Swedish National Energy Administration. They are less sensitive to the market competition. However, as the candidates to implement DSM (to be obliged) in the condition of the competitive market and under existing legislation, grid operators may lack competence in a short term. (Wuppertal Institute et al., 2002) Distribution activities are required by law to be managed by separate legal entities, which are not allowed to engage in other electricity supply activities.

Obliged parties are the main actors on the market, which would trade certificates. Suppliers are more sensitive then distributors to the competition, and thus, more sensitive to cost changes. (Langniss, 2003) It means that they would be interested (compare to distributors) in finding ways to fulfil their obligation at least economic cost. Thus, sensitivity to the variations of cost might be an advantage, which would stimulate establishment of the certificate market.

In a context of competition, generators are could be good choice to trade certificates, however, lack of the knowledge on the demand side do not make them well positioned as possible obliged parties.

Consumers, as obliged parties, would be interested in reducing cost for energy saving measure implementation. However, in the case of consumer, investments are highly specific, and, thus, would take place if sufficient governance would be established.

1&2&3. Transaction cost for DSM measures implementation

1&2&3.1 *Generators*. Transaction cost might be too high due to “distance” to the customers and, thus, lack of knowledge on the demand side.

1&2&3.2 *Transmission and Distribution grid operators*. Regulation by the Energy Authority might raise transaction cost for implementation of measures.

1&2&3.3 *Suppliers*. Suppliers are involved in more close relations with consumers through their relations to the infrastructure. Transaction cost for measures implementation should be lower for supplier than for generator and, perhaps, grid operating companies, because of suppliers’ better knowledge and information on the demand side. This would give them an opportunity to lower transaction cost while dealing with end users or with regulator.

1&2&3.4 *Consumers*. In the case of customers, transaction cost could be too high, due to highly specific investments, which would require complex governance. Another factor, contributing to increasing of transaction cost is limited knowledge of the demand side.

4. Number of the companies and their size;

4.1 *Generators*. There are more than 30 companies, generating electricity. Trend for the production of electricity shows that dominance of the largest producers increased significantly during the last years. Five biggest companies produced about 90 percent of electricity in the country (Vattenfall, Sydkraft AB, Birka Energi, Forum Kraft AB; Graninge)[9], according to data from 2002. (Swedish National Energy Agency, 2002) Generation companies in Sweden have large number of customers.

4.2 *Transmission and Distribution grid operators*. The number of these companies decreased due to merging and acquisition process and, currently, there are about 184 grid operators. The total number of their customers is 5.3 millions. (OECD/IEA, 2000)
As it mentioned above, due to mixed ownership between companies in Swedish electricity system, there are a lot of companies, performing integrated functions in the system. Vattenfall and Sydkraft are biggest distribution, as well as retail supply companies in Sweden. Vattenfall has 1 100 000 distribution customers, Sydkraft has 600 000 distribution customers. (OECD/IEA, 2000)

4.3 *Suppliers*. Presently there is no reliable statistic, but it is known that now there are slitly more than 200 supply companies in Sweden. There was a drop in number of suppliers after 1996. However, some other players begun to sell electricity to final customers (e.g. Statoil, Shell, etc.).
Vattenfall and Sydkraft are largest retail supply companies in Sweden. Vattenfall has 1 525 000 retail supply customers, and Sydkraft has 700 000 customers. (Swedish National Energy Agency, 2003a)

Consumers. There are many consumers on the electricity market and they are different in size.

Any of the parties, as possible actors to carry an obligation, have sufficient number of participants for creation of minimum market size for certificate trading. A few largest companies (e.g. Vattenfall and Sydkraft) that integrate functions of generators, distributors and suppliers, might have a tendency to create oligopoly on the market of certificates. In a case of consumers, a risk of having monopoly or oligopoly is also involved, due to big difference in size of participants.

According to the chosen criteria, supply companies in Sweden are considered the most appropriate actors to oblige. Suppliers are well positioned towards final consumer and have sufficient knowledge on the demand side. This can lead to the possibility to create economies of scale with comparatively low transaction cost. Suppliers act within fully competitive market. They are sensitive to prices on the market. Therefore, suppliers are expected to be interested in trading of certificates, using it as possibility to implement energy saving measures and programs at least economic cost. Due to presence of a few largest companies among the suppliers, there is a risk of oligopoly on the certificate market. That is why bilateral contracts could be expected as dominant form of trade among all parties that considered trading (see Ch. 4.3.1 *Preferable design of trading rules; decree of flexibility*).

4.3 WC system mechanism

4.3.1 Preferable design of trading rules; decree of flexibility

Sweden has fully liberalized electricity market and there is a consideration to avoid administratively demanding scheme in policy (Wuppertal Institute et al., 2003a). Wuppertal Institute pointed out that policies for the EE should be “non-discriminating between actors” and “not be administratively burdensome” (Wuppertal Institute et al., 2003a)
That is why preferable WC scheme for Sweden should allow trade in various forms, from transactions on anonymous markets to bilateral contracts. Obliged parties should have more choices to fulfill the obligations. (similar to Italian case of WC) It is also considered to allow any

[9] Vattenfall generate and deliver more than a half of all the electricity in Sweden. Birka is the largest power utility in terms of customers (842 000 customers). (www.stem.se)

market actors (not only obliged parties) to trade on the market. Electricity efficient measures could be achieved through:

- increasing companies own energy efficiency measures;
- buying certificates from other obliged parties;
- bilateral contracts between obliged party with ESCOs or other market participants, acting on the name of the obliged party.

Increase of certificate traders on the market would increase difference in marginal cost of the certificates and, thus, increase probability of successful certificate trading.
Number of actors on the market, as well as decree of flexibility in trading, would influence size of the market.
In Sweden, suppliers are considered as preferable obligated parties. (see ch. 4.2.5 *Whom to oblige?*) Suppliers have sufficient number of participants for certificate trading. However, a few largest companies among suppliers might form oligopoly conditions on the market.

4.3.2 Possible WC market conditions

Considering trading on the market, oligopoly is better then monopoly conditions, which can be expected if, for example, Kraftnät would be one of the obligated parties. However, in conditions of oligopoly, market can be dominated by the largest participants who would be able to collectively exert control over supply and market prices on the certificates. On the one hand, it might bring stability on the market. At the same time, dependency on a group of actors on a market would reduce equality of the market players, and, thus, would limit opportunities to fulfill the obligation at least economic cost. In such situation, bilateral contracts might be expected as preferable form of trading.
There are two forms of certificate exchange, which can reduce such risk and provide more transparency and stability on the market.
Trading on spot market can be an option to provide competition. (Öko-Institut, 2000) Spot market is a market for short-term oriented exchange of certificates. Stimulation of trading on the spot market can increase transparency of prices. Trading on the spot market can be organized through requirement to buy, for example, 50 percent of certificates form the market. According to experiences of trading in Swedish electricity market, “a benefit of trading on the exchange is that the transaction costs are lower than those in bilateral trade agreements.” (Swedish National Energy Agency, 2003a)
Stability can be provided by bilateral long-term contracts. Contracts offer the most security, reducing risk of variations in supply and demand. This would reduce variations on price of certificates. Bilateral contracts are a form of WC exchange, which not necessary lead to competition between market actors. However, they increase transparency on the market and provide certainty in the future. At the same time, it would lead to competition of certificates generation that could consequently increase energy savings.
In principle, contracts might contain confidential information. However, in order to impose penalty price, controlling body needs to have the information on prices. The information on the average market prices is needed because it is to be published over the compliance period as a market indicator. Publishing of prices would lead to the increase of transparency on the market. It would also reduce a need to encourage transparency on the market through stimulation of trading on spot market. In order to publish the prices, the controlling body needs to keep track of certificates on the market.

4.3.3 Preferable form of certificates and accounting system

Certificates might exist in electronic form or/and in a form of paper. If certificates exist only in a form of paper, it would be difficult to keep their track on the market. (Huld, Bertoldi, 2003) Electronic form of certificates is preferable because it accelerates access to the information on prices. In addition, transaction of certificates can be easier provided through electronic form of certificates. Electronic form of certificates sets less complex handling and accounting system. Electronic system of certificates is a database of accounts, which is possible to operationalize with rules similar to rules for operating bank accounts.

Registration body for certificates

Trade registrars, who administrate registration of ownership of certificates and transactions, have to be accredited by the issuing body and should not be involved in trading. Banks might be possible registrars of certificates accounts.

4.3.4 Possible marketplace for trading certificates

"The Nord Pool electricity exchange is an organized marketplace for trading in electricity. On the Nord Pool exchange electricity is traded on the spot market and on the forward market." (Swedish National Energy Agency, 2003a) There is a consideration in several countries to use trading pools as a capacity for setting up trading of Green Certificates. There is a successful example of trading of "Green tickets" in California through the Californian Automated Power Exchange. (Öko-Institut, 2000) Sweden can consider Nord Poll exchange as a marketplace for trading of both types (White and Green) certificates, and, in particular, for White Certificates.

4.3.5 Minimum market size

According to economic theory, difference in marginal costs is required for creation of functioning market. In Swedish case it is guaranteed by existing market conditions (see ch. 4.1 *General market condition in Sweden, favoring for WC scheme*).

Number of programs and measures also influences difference in marginal costs. Larger would be the set of program and measures larger would be the difference in marginal costs of the certificates on the market. More choices would guarantee larger difference in prices of certificates. (Langniss, 2003) That should be considered, while designing the set of measures for implementation on the demand side.

Number of traders on the market will also influence the market size.

4.3.6 Number of actors on the market; who is expected to trade certificates

A consideration would be that energy saving activities, performed by not obligated companies, should be counted in the target to increase electricity savings. That is why the market of the certificates should be opened to all the market participants to trade certificates. Potentially interested parties among not obliged ones in Sweden to participate in the market are undertakers of energy savings measures, for whom an additional income from WC is of their interests.

ESCO participation

As it was explained in the ch. "Theory of white certificates", ESCO is the player on the market, which is expected to be the party most interested in additional income from trading WC. ESCOs do energy efficiency measures as their primary business, contributing to energy savings increase. At the same time, WC scheme gives more freedom to ESCO. Instead of being dependant on one customer through contractual arrangements, ESCO would have a possibility to sell certificates to any participant on the market.

The additional income from the certificates would intensify activities of ESCO in energy saving measures performance at industrial level, especially at the level of large industries. Thus, an interest of ESCO to trade certificates would be increased.

Trading of certificates is expected to improve a functioning of ESCO on the market. At the same time, ESCO is expected to increase a market size by its participation.

However, implementation of energy savings measures at the level of small companies and households would be questionable. According to the condition of free market, ESCO would offer

services to large customers. Medium and small companies would have too high transaction cost for implementation of measure, considering their comparatively low energy saving potential. Thus, ESCO, as well as obliged parties, would not consider small companies and households to be priority for investment.
Note. Addressing of this consideration might be done through specific requirements in the overall target. Certain share of certificates to fulfill the obligation might be required to be obtained at the level of small companies and households. Consideration to obtain certificates on household level was already discussed as preferable requirement in the overall target. A certain share of certificates, obtained through measures and programs undertaken for small companies, should also be required (similar to the case of the UK).

Large industries
For large industries exemptions form many type of taxes create lower electricity prices. It could be a factor reducing their interest in energy savings. However, they are expected to participate on the market of certificates. Generally, large-scale consumers consider reduction of electricity consumption. Additional income from WC can be quite notable for large-scale projects.

4.3.7 Regulator

Regulation system should preferably integrate functions of verification, registration and issuance.
In organization of electricity system in Sweden, the most appropriate candidate on the role of regulator, who would issue and allocates certificates, is Svenska Kraftnat (other regulatory authority in the are mentioned in Ch *Electricity system in Sweden*). Svenska Kraftnat is a state-owned operator. Svenska Kraftnat has system responsibility for overall national electricity grid. It owns, runs and manages the main grid, and balances production and consumption of electricity through agreements with electricity trading companies.[10]
As Sweden has a regulator for the electricity system, there is no need to set special body for controlling the certificate market.

4.3.8 Introductory phase; minimum price guarantee

Minimum price on the certificates guaranties their demand. Minimum price guarantee could be provided by government, as well as by independent body accredited by government. The list of Kraftnat functions, as the regulator, could also include guarantee of the minimum market price on the market.
Minimum market price is not stable over the time. Knowing the minimum price in advance will give more security on the market. That is why guarantee of the minimum price on the market during introductory stage is one of the issues to consider.
As it was done in the case of implementation of the Green Certificates scheme in Sweden, the minimum price of the certificates can be guaranteed during the first several years of implementation of the WC system. The guarantee might mean that certificates which were not sold can be paid by government. (Swedish National Energy Agency, 2003c)The payment then should be gradually reduced during several years, in order to minimize artificial incentives for creating demand on WCs.

4.3.9 Whom to allocate certificates

Allocation of the certificates to investor in energy saving measure would be a preferable solution as it follows from the discussed parameters (see ch. 3 *Theory of white certificates*). More specifically, there would not be transaction of certificates taking place. Another advantage of

[10] Kraftnat was chosen on the role of regulator for Green Certificate trading system in Sweden. (Swedish National Energy Agency, 2003c)

allocation certificates to the investor is involvement of other parties apart from obligated ones. This choice would tend to create not only trading, but also an opportunity to achieve more energy savings, than it is required by the demand.
Thus, in the end of the period of compliance the certificates will be given to the investor into energy saving measures or programs. Then s/he can sell the certificates to any participants on the market.

4.3.10 Length of compliance period

We assume that the length of compliance period would be one year and allocation of the certificates would be done at the end of the period of compliance.
If the compliance period long, for example 5 years, trading on spot market would tend to take place only at
the end of the period, leading to minimizing transparency on the market. Prices for the certificates could be very low at the beginning of the compliance and very high right before the period of compliance ends. This issue could be addressed through requirements of proof of fulfilling the obligation several times during the period of compliance. (Öko-Institut, 2000)
Alternatively, shorter period of compliance, such as monthly or every quarterly, would lead to continues spot market, and would positively influence the market liquidity and transparency of prices. However, the transaction cost might be higher then it is in the case of longer period of compliance, because of the higher controlling cost.

4.3.11 Allocation of certificates with respect to lifetime of energy saving measures

Energy savings are generated during lifetime of a measure.
Allocation of certificates can be done right after commissioning of investments into energy savings.. In this case, neither investor no obliged party would need to prove that energy savings actually took place. Instead, the risk would be shifted to the regulator. In addition, if the allocation took place right away after the commissioning and the lifetime is restricted, a lot of certificates need to be sold in a limited time period. It might create barriers for large projects, such as thermal renovation of entire area or some other industry projects. This effect would take place because "the impact on the certificate market is larger in terms of the relation between the number of certificates from an individual project to the total number of certificates traded." (Langniss, 2003). That is why scenario, where allocation of certificates takes place in the end of the period of compliance, for example, in the end of every year, during the life time of measure, seems more reasonable.
Lifetime measure is usually defined through methods for verification of energy savings.

4.3.12 Verification

Verification methods

As it is discussed in section 3.5 *Verification: Measurement of energy efficiency*, defining the base-line as well as measurement of savings is a difficult task. However, choosing methods for verification is one of the key issues when designing scheme of WCs. Currently, four methods of verification in commercial and industrial facilities, defined by International Performance Measurement and Verification Protocol (IPMVP, 2002), are widely used (see Ch. 3.5.1 *Measurement and verification through International Performance Measurement and Verification Protocol*). These methods should be used with respect to a type of the undertaken program or measure. The methods are different by scope of application (part of the facility or the whole facility) and by continuity of verification (short- or long-term).

Preferable approach to measure energy savings

There are two approaches to verify electricity savings for applications.
Standard Saving Factor approach is metering electricity savings by identifying of certain measures, for example, installation of more efficient bulbs, with certain kWh saved. In this case the lifetime of measure is defined. (section 3.5 *Verification: Measurement of energy efficiency*)
The other approach is Metering Approach, which assumes metering of electricity consumption before and after the measure took place. Energy savings are calculated as a difference of the consumption "before and after". (section 3.5 *Verification: Measurement of energy efficiency*)
For Swedish case, the goal of increase in energy savings is considered. It means that through introduction of Metering Approach it is possible to identify not only increase in energy efficiency of the system, but the actual decrease in consumption. Therefore, Metering Approach (MA) is preferable in Swedish case.
However, MA has its disadvantages. It cannot accurately identify electricity savings when, for example, company cut production in a long-term period, or when an individual went on the vacation. (Huld, Bertoldi, 2003,). In the fist example, even is long-term energy savings took place, it might be difficult to identify. In the second example, it would be easier to identify difference in consumption, however, there was not an evidence of long-term energy saving improvements.
MA, including monitoring of general condition of the facility would represent more advanced approach in verification of increase in electricity savings. Metering before and after the measure/program took place would require report, containing data on consumption, as well as specific data needed to evaluate more complex changes in the system. For example, such approach considers data on increase or decrease in load due to the installation of more energy-efficient equipment or a number of hours per day that the equipment is used before and after retrofitting.
A baseline for energy savings metering in MA is the level of electricity consumption before the improvement in the system. It should be carefully defined.

Specific considerations when measuring energy savings

Effects of some of the instruments for increasing energy savings for example, trainings or awareness raising, cannot be measured directly in kWh. Such measures are essential, when planning a decrease in electricity consumption. Such measures can be ranked and associated with certain amount of certificates or kWh saved. If such measures are integrated within the other programs, the certificates, obtained from the integrated projects can be valued higher.

Verifiers

The regulator should approve the guideline for verification and monitoring.
The verification should be performed through organizations that is independent from implementers of energy saving measures. This would minimize risk of incorrect measuring. These organizations could be accredited by the regulator. For example, Kraftnat could serve the role of the accreditation body to the verifiers of the energy saving measures.
Verifiers could be assigned by Kraftnat. They also could be any type of organizations, which have necessary expertise and follow guidelines, provided by Kraftnat. The National Energy Agency is an example of possible verifier on behalf of Energy Administration. It has experiences and skills in monitoring and implementing of energy efficiency programs and measures, however not at the end-use level.

4.3.13 Registration/ allocation procedure (allocation on virtual account)

As mentioned above (see ch. 4.3.3 *Preferable form of certificates and accounting system*), preferable form of certificates is electronic ones.

After the verification procedure, the compliance should be registered in a database to record an achievement of the overall target. Then, the certificates should be transferred to the investor's certificate account. In the end of the compliance period (one year, for example), obligated parties should transfer the certificates to the regulator's account (to the account of Kraftnät). Those certificates are counted as being used and finished.

As it was done in the case of Green Certificates in Swedish case, certificates did not exists in a hard copies, but were electronically registered in the certificate register, which was maintained by the regulator. (Swedish National Energy Agency, 2003c) The system for WC could be organized in the same manner.

After the regulator will compare transferred certificates with the allocated obligation for each party, there are three actions that could be potentially pursued:

If the number of delivered certificates is equal to the required number, the regulator issues a confirmation of reaching an obligation to the obligated party.

If the number of delivered certificates is higher than required, surplus of certificates can be used for the future compliance or it can be traded. In this case, the surplus certificates could be kept in the stock on the account of the obligated party.

If the number of delivered certificates is less then required, special procedures accompanying trading of certificates are enacted. If borrowing is allowed on the market, then the regulator can add missing share of certificates to the account of the obligated party, until the next period of compliance. However, borrowing should be allowed only if the number of delivered certificates is not less than certain agreed level. Otherwise, the obligated party should pay penalty.

4.3.14 Non-compliance case; Penalty

Body dealing with penalties

In case of non-compliance, penalty should be imposed on the obligated parties. Penalty is an instrument similar to taxes. Thus, the existing body, dealing with taxes, might enforce penalties.

Options to choose

White certificate scheme makes increase in energy savings, following the demand. Penalty is necessary element in such scheme to keep the obligated parties to fulfilling their obligation. Level of penalty should not be too high, because it might cause very high prices for certificates in case of their shortage. In such case a possibility for borrowing and banking on the market would be critical. According to practices of imposing penalties for WC scheme (Italy) or for GC schemes (for example, Danish case), penalty is chosen close to the level of maximum price of certificates.

As it is described in section "Theory of white certificates", there are two options for setting penalties:

Penalty is a fixed price per certificate or per kWh.

Penalty is a factor above 1 times the average market price in the compliance period (average price + x).

In the second case, as compared to the first one, the penalty price will be always higher then the maximum price on the market. When comparing two options, the second one would be the preferred one, as it would not cause distortion of the maximum market price. However, in the second case, the controlling body needs to have an access to the information about prices on the market. Access to the information on prices for every transaction is possible if the accounting system for certificates is organized in electronic way (see ch 4.3.3 *Preferable form of certificates and accounting system*). The other option to obtain this information would be if the stock market were highly liquid and transparent.

Money from penalty

There are several alternatives to use money accumulated from penalty collection. The penalty money might be directed at the general needs of the country. However, in many cases it was considered that penalty money, directed in such a way might cause the tax burden in the country. To avoid such situation the penalty money can be re-directed to the obligated parties in one or another way. For example, in Dutch green label system, obligated parties, which do not fulfill their targets, suppose to buy the lacking amount of certificates by the higher price than it was during the period allocated for reaching compliance. The certificates are to be purchased from the parties who have completed their obligation.

Alternatively, the penalty money can form a White Certificate fund. Money from the fund might be used, for example, as a mechanism to sustain the demand on WC market. The actions of such fund might be buying certificates when they are too many and the price is low and selling them when the price is high. The money can be also partly used for the purpose of recovering cost for measures and programs implementation.

Each of the option might be acceptable in Swedish case, because all of them have certain advantages. The money from penalties could be redistributed according to the development on the market.

4.3.15 Cost recovery

Cost recovery is a mechanism for compensating cost for energy saving activities or, alternatively, cost of certificates, bought on the market. The cost for energy saving measure will be an addition to the price for the electricity that, in turn, consists of cost for generation or distribution.

In conditions of regulated market, utilities would undertake energy saving measure (or buy certificates). Then the regulator would decide whether to accept the extra costs in the price for compensation or not. In a WC scheme for not fully liberalized market, cost for energy saving activities can be recovered through taking fraction from tariff or some other specially created compensative funds (Italian case).

In the conditions of free market, which is a case in Swedish electricity market, prices depend on decisions of the market actors. Thus, extra cost for the energy saving measures and programs are to become a part of the electricity prices and to be paid by the final consumer. Suppliers will send to consumers a bill with included cost for WC.

With respect to the calculated overall target (16% by 2035), which requires annual increase in electricity savings by 0.5 % from the level of current electricity consumption, increase in electricity prices will be still reasonable for the consumer.

If consumer's bill for electricity will include payment for energy efficiency measure (or WC), the price will be changed in the following way. 99.5% of the price stays the same. 0.5% of the price will represent a fee for saved electricity, which will include price for non-sold electricity plus price for energy efficiency measure. For example, the price for saved electricity will be higher than a current price by 25%. Price for electricity will increase each year, due to increasing in savings by 0.5% each year. Thus, calculation of electricity price per each year will be bases on the price for previous year. Assuming, $P(n)$ – is a price for electricity (Öre per kWh), where n is the number of year from 2003,

$P(n) = P(n\text{-}1)*99.5\% + P(n\text{-}1)*125\%*0.5\%$; or $P(n) = P(n\text{-}1)*1.00125$;

Assuming, the current price is 50 Öre/kWh, the price for the next years will be: $P(1) = 50.0625$; The function $P(n)$ is linear. The increase per year is $D = P(0) – P(1) = 0.0625$.

Thus, $P(2) = 50.125$; …; $P(10) = 50.625$; …; $P(32) = 52$.

Thus, based on the assumption made before, the price on electricity bill for customer, including fee for WCs, will gradually increase from 50 Öre/kWh in a year 2003 to 52 Öre/kWh by the year 2035. The calculation of increase in price is made only due to increase of fee for WCs.

According to Wuppertal Institute (2003a), there was a discussion on more optimal way of organizing funds for energy efficiency increase in Sweden. The participants were split in their opinions. One part of participants insisted on a need to regulate network tariffs in order to have more variable charges while another thought about usefulness of real time pricing to end users. (Wuppertal Institute et al., 2003a)

4.3.16 Dealing with risks on the market

As it is pointed out in section 1.3 *Analytical framework and method of inquiry*, issues for consideration can be addressed through specific design of WC scheme.

Transparency on the market, as it is discussed above, can be achieved through publishing average market prices on certificates and allowing contracts as one of the form of trading certificates.

In cases of non-compliance, penalty would be a method to keep suppliers (obligated parties) to carry out their obligations.

For dealing with possible speculation on the market, all necessary flexibility mechanisms, such as banking, borrowing, futures, etc. should be allowed on the market. However, it would cause difficulties to calculate actual electricity savings. Disadvantage of banking and borrowing might postpone compliance. Alternatively, the compliance might be done in time, if the regulator would assume a risk, allocating certificates in the beginning of compliance period.

Investments into electricity efficiency at the household and small companies level are more difficult or expensive. As a result, there is a risk that the investments might not take place. It can be addressed by requirement for obliged parties to undertake certain amount of certificates at the household and small companies level. (sections 4.2.3 *Specific requirements* and 4.3.2 *Possible WC market conditions*)

5 International issue: Common system of W&G certificate trading

In general, sustainable energy and, in particular, electricity system are represented by a) supply of renewable electricity and b) by efficient final use of electricity.

Among series of measures to increase production of renewable electricity and to reduce energy consumption, Green Certificates (GC) and White Certificates (WC) systems are considered to be effective policy instruments. (Huld, Bertoldi, 2003)

Current European experiences with energy efficiency trading system are limited. However, their remarkable economic and environmental benefits, as well as their ability to secure supply and employment, were recognized. They also are recognized as being above to deliver possibilities to encourage energy efficiency market. (Wuppertal Institute et al., 2002)

The idea of trading of WC and GC in a single market under the single obligation was found reasonable by the EU (T. Huld, P. Bertoldi, 2003). Such united system would help to stimulate additional supply of renewable electricity with respect to potential for increase in energy efficiency in final use. Both W&G systems have common rules for trading of certificates. Non-compliance regime can be defined similarly too. That is why organization of common W&G certificate trading system is feasible.

There is a consideration to stimulate wider scale support for increase in renewables and energy efficiency through allowing of international trading of W&G certificates. Currently, the most advanced project for implementation of such plan is trading of W&G certificates via the Internet. It aims at creation of inexpensive open system for trading with publication of prices for all the market participants. (Huld, Bertoldi, 2003)

Trade of GCs is planed to occur between several countries already within the coming two years. (Öko-Institute, 2002) If the evolution of development for WC system would be fast enough among the countries, then testing of the project of common W&G certificate international trading can take place soon as well.

In Sweden, GC system is already implemented and, according to the analysis done in this paper, there are no major barriers for starting WC trading system in the country. Use of the existing capacities for GC system for the purpose of trading both W&G certificates is a great possibility to reduce cost for implementation of WC market. Trading of certificates requires similar bodies,

doing similar procedures for both markets. Brokers and other bodies are needed to deal with all market operations for certificate trading: selling and buying procedures, futures, banking, borrowing, etc. Use of existing capacities might speed up a process of development of WC market.
Harmonization of these two systems on the national level can be a good start for preparation to join international W&G international trading system.

6 Conclusions

Sweden considers phasing out nuclear power. About 40 percent of total electricity stems from nuclear power. At the same time, Sweden has committed itself to reduce its CO_2 emissions considerably. A number of policies to increase renewable energies and bring forward energy efficiency have been undertaking. However these policies have been not sufficient to substitute nuclear power. Policy makers are facing the challenge to design more effective energy efficiency policies, which address existing barriers towards energy efficiency on the demand side while relying on free-market principles. The goal of the paper is to look at the possibilities to apply the White Certificate (WC) instrument in Sweden. WC scheme was found as an instrument corresponding to the listed requirements.
The instrument was found optimal to supplement Swedish energy policies, because it addressed demand side under conditions of deregulated market.
The main advantage of the WC scheme is that it opens the possibility for increasing electricity savings at the least economic cost. This possibility comes from the opportunity to trade white certificates. Difference in marginal prices for certificates is necessary conditions for creation of minimum market size for certificate trading. In the conditions of Swedish electricity market, the difference in marginal cost for implementation of energy efficiency measures vary significantly between different actors. Therefore, undertaking energy efficiency measures without flexibility mechanisms, i.e. trading, would become too costly for some of the actors. At the same time, parties, which can increase better energy efficiency at reasonable cost, could not make profit out of it. Thus, difference in cost of implementation for energy efficiency measures that exists between the actors, is a barrier for decreasing energy consumption.
An application of WC instrument seems reasonable (working) option in Sweden, because minimum market size for certificate market could be guaranteed within the existing conditions on electricity market. WC instrument has advantages in comparison to the policies, which were used to address energy efficiency in Sweden. The instrument creates market with equal players through the opportunity provided by trading certificates. ESCO and big industries are expected to be non-obliged parties, making profit from participating in the WC market, and thus, contributing to a greater increase in electricity savings. Thus, WC scheme is expected to be an effective instrument for increasing energy savings in Sweden, reducing cost for programs and measures implementation and maximizing benefits for the actors on the market.

Possible energy saving target (demand for WC) was calculated with respect to the lifetime of nuclear reactors in Sweden and on the bases of assumptions, made on possible increase in production of renewable electricity. It was assumed that bringing down electricity consumption by 16 percent by the year 2035 is feasible task for Sweden because of the considerable potential for electricity savings. Suppliers of electricity, in the condition of Swedish electricity market, were found to be the most appropriate parties to carry the obligations to reach the target.

While designing WC system mechanism, implementation of the instrument was found potentially inexpensive, as most of the actors (regulatory, issuing, etc. bodies) performing functions, similar to the ones needed for the WC scheme, are already exist on the market. Thus, using existing institutional capacities, instead of creating the new ones, seems to be an optimal option for implementing the instrument at the lowest cost.

Several issues were found to require special considerations, when looking for the options to design market for tradable white certificates. The largest electricity supply companies dominating the electricity market will possibly also dominate the market of certificates, and, thus, competition on the free market can become inefficient. Basically two forms of certificate exchange may occur both having different profiles concerning risk, transparency and stability on the market. Trading on spot market can be an option to provide competition. Stability can be provided by bilateral long-term contracts. However, as long as suppliers manage to compete on the electricity market, there is a probability that they can manage to create equal competition on the certificate market.

Investments in electricity savings at the household level and at the level of small companies could be not an attractive option because of the insufficient potential in electricity savings. This consideration can be addressed through specific requirements attached to the overall target. Such requirements could be requests to obtain certificates through measures undertaken at the level of small companies and households.

The thesis considers white certificate scheme to be a part of existing policy framework for decreasing electricity consumption.

There is a demand for further research in terms of economic efficiency in comparison with other instruments, and, particularly, the political feasibility of a WC under Swedish conditions.

7 List of references

Azar C. and Lindgren K., 2001, Low carbon dioxide emissions and no nuclear power – towards a renewable energy system in Sweden and the world in Building sustainable energy systems. Swedish experiences. STEV, Bulls Tryckeriaktiebolag, Halmstad, pp. 445-474.

Costyn, J., 2002, Certificate trading for the UK's Energy Efficiency Commitment. Retrieved August, 2002, from the World Wide Web: http://dsm.iea.org/NewDSM/Work/Workshops/EECertTrad/EECT-Milan020417-B2.ppt.

DETR, 2000, Energy Efficiency Commitment. Department of Environment, Transport, and the Regions. Retrieved September 2003, from the World Wide Web: www.defra.gov.uk/environment/energy/eec/provisional/pdf/eec2002.pdf.

Elmberg A., Elmroth A., Wannheden C., 1996, Hus I Sverge – Perspektiv på energianvandningen (Houses in Sweden – perspectives on energy use). Byggforskningsrådet.

Eoin L., 2003, Potential savings from energy efficiency to the year 2010. Retrieved September 2003, from the World Wide Web: http://www.est.co.uk/pdf/achieve_challenge.pdf

ENER, 2000, Analysis of the legislation regarding renewable energy sources in the EU. Retrieved October, 2003, from the World Wide Web: (http://www.jrc.es/cfapp/eneriure/Reports/SWE%20ele.pdf.

Fisher A., Rothkopf M., 1989, Market value and energy policy. A rationale for selective conservation. Energy policy, 17, 4, pp. 397-406.

Haaland H. O. and York D., 1993, Incentives for DSM in deregulated markets, ECEEE summer study 1993, France

Heleen Groenenberg, 2002, Development and convergence. A bottom up analysis for the differentiation of future commitments under the Climate Convention

Hillring B., 1998, National strategies for stimulating the use of bioenergy: Policy instruments in Sweden. Biomass and Bioenergy, 14, pp. 425-439.

Huld T. and Bertoldi P., 2003, Design of a new scheme for tradable certificates for renewable electricity and energy efficiency. Time to turn down energy demand, Energy intelligent solutions for climate, security and sustainable development. Proceedings of ECEEE summer study 2003.

IEA, 1998, Energy efficiency initiative, Energy policy analysis, Vol. 1. Retrieved October, 2003, from the World Wide Web: http://www.iea.org/pubs/studies/files/danish/dan1.htm.

IPMVP, 2002, Concepts and options for determining energy and water savings, International Performance Measurement and Verification Protocol. Vol. 1. Retrieved October, 2003, from the World Wide Web: http://www.ipmvp.org.

IPCC, 1996, Impact, adaptation and mitigation options. International Panel on Climate Change IPCC working group 2, Cambrige University press, UK.

Jochem E., 1991, Long term potential of rational energy use – the unknown possibilities of reducing greenhouse gas emissions. Energy and environment, vol. 2(1), pp. 31-44.

Kärrmakck U., 2001, Reform of the Swedish electricity market, in Building sustainable energy systems. Swedish experiences. STEV, Bulls Tryckeriaktiebolag, Halmstad, pp. 197-236,.

Langniss, Ole., 2003, How much market do market-based instruments create? An analysis of "white" certificates. Time to turn down energy demand, Energy intelligent solutions for climate, security and sustainable development. Proceedings of ECEEE summer study 2003.

Löfstedt E., 2003, Fairness across Borders: The Barsebäck Nuclear Power Plant. Retrieved August, 2003, from the World Wide Web: http://www.piercelaw.edu/risk/vol7/spring/lofstedt.htm

Malaman R., Pavan M., 2002, Market based policy approaches for end-use energy efficiency promotion, proceedings of the IEECB conference on Energy Efficiency in Commercial Buildings, Nice, 2002

Mark Storey, 1996, Demand side efficiency: Voluntary agreements with industry, Policies and measures for common action, Working paper 8, OECD: Paris.

Midttun, Koefoed, 2003, Greening of electricity in Europe: Challenges and developments. Energy Policy, article in press, Norway.

Mundaca, 2003, White and Green. Presentation of the project, March 2003, Lund University, IIIEE, Lund, Sweden.

Nilsson L., 2003, Information on Industrial Energy Efficiency Program Delivery Mechanisms in Key Industrialized Countries, draft, Lund.

Neij L., Öfverholm E., 2001, Strategies for improving energy efficiency in Building sustainable energy systems. Swedish experiences. STEV, Bulls Tryckeriaktiebolag, Halmstad, pp. 301-333.

NUTEK, 1997, Programme requirements for lower cost and greater energy efficiency for industrial fans, Stockholm, Retrieved July, 2003, from the World Wide Web: http://www.stem.se/web/biblshop_eng.nsf/FilAtkomst/flakteng.pdf/$FILE/flakteng.pdf?OpenElement.

Öko-Institut, 2000, Options for design of tradable green certificate systems, Retrieved August, 2003, from the World Wide Web: http://www.ecn.nl/docs/library/report/2000/c00032.pdf

Olerup B., 1995, Managing external demands, Department of Environmental and Energy systems Studies, Lund University, Lund, Sweden.

OECD/IEA, 2000, Energy policies of IEA Countries, Sweden 2000 Review, rue Andre-Paskal, Paris.

Pagliano L., Alari P., Irrek W., Leprich U., Ruggieri G., Thomas S., 2001, Price regulation to remove EE-DSM disincentives and pressure for increasing energy sales in monopoly segments of restructured electricity and gas markets – The multiple drivers target (MTD) tariff scheme. Proceedings of ECEEE summer study 2001.

Pagliano L., 2003, The Italian Energy Saving Obligation to Gas and Electricity Distribution Companies. Time to turn down energy demand, Energy intelligent solutions for climate, security and sustainable development. Proceedings of ECEEE summer study 2003.

SFS, 1994, Law on Energy Tax (Lag om skatt på energi). Swedish Parlament, p. 1776

Sjödin J., 2002, Modeling the impact of energy taxation, Linköping Institute of technology, Sweden. International journal of energy research, 26, pp. 475-494.

Solomon B. D., 1999, New directions in emission trading: the potential contribution of new institutional economics, Ecological economics 30:371-387

Steen P., 1997, Farder i Framtiden – transporter i ett barkrafftigt samhalle, Forskningsgruppen för miljöstrategiska studier, KFB rapport 1997, p. 7.

Svenson S.and Kaberger T., 1992, Handla eleffektivt. Vardagshandbok om energisparande ach miljö, Naturskyddsföreningen.

Swedish National Energy Agency, 1990, Effectivare elandvändning, STEV 1990:6, Stockholm, Sweden.

Swedish National Energy Agency, 2001, Electricity market 2001, Retrieved July, 2003, from the World Wide Web: www.stem.se.

Swedish National Energy Agency, 2002, Electricity market 2002, Retrieved July, 2003, from the World Wide Web: www.stem.se.

Swedish National Energy Agency, 2003a, Electricity market 2003, Retrieved September, 2003, from the World Wide Web: www.stem.se.

Swedish National Energy Agency, 2003b, Save energy, Retrieved July, September, from the World Wide Web: www.stem.se.

Swedish National Energy Agency, 2003c, Electricity certificates – new legislation for the environment and for the future, Retrieved September, 2003, from the World Wide Web: www.stem.se.

The Electricity and Gas Order (Energy Efficiency Obligations), 2001, Retrieved July, 2003, from the World Wide Web: http://www.legislation.hmso.gov.uk/si/si2001/20014011.htm.

Uggla U., 2003, The result from eko-energy in Sweden, a voluntary agreement for energy efficiency in industries. Time to turn down energy demand, Energy intelligent solutions for climate, security and sustainable development. Proceedings of ECEEE summer study 2003.

UNDP, 2000, Word Energy Assessment, Energy and the Challenge of Sustainability, New York.

Kärrmakck U., 2001, Reform of the Swedish electricity market. Building sustainable energy systems. Swedish experiences, Bulls Tryckeriaktiebolag, Halmstad, pp. 197-236.

Wuppertal Institute et al., 2000, Completing the Market for Least-Cost Energy Services, Strengthening Energy Efficiency in the Changing European Electricity and Gas Markets. A Study under the SAVE Program, Project final report, Wuppertal.

Wuppertal Institute Institute et al., 2002, Bringing Energy Efficiency to the Liberalised Electricity and Gas Markets, How Energy Companies and Others can Assist End-Users in Improving Energy Efficiency, and How Policy can Reward Such Action, Wuppertal.

Wuppertal Institute Institute et al., 2003a, Documentation of results of the European Conference "Bringing Energy Efficiency to the Liberalised Market", Wuppertal.