A review of industrial energy and climate policies in Japan and Sweden with emphasis towards SMEs

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Title:

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Abstract

The threat of increased global warming resulting from the use of fossil fuels stresses decision-makers to formulate and adopt policies towards different sectors of the economy. In light of the great earthquake in Japan 2011, energy efficiency also plays an important role in meeting the challenge of power supply shortage. Energy policies towards industry are of particular importance as a major part of the energy in the Economy is used in industrial production. The number of papers investigating and presenting experience from energy end-use policies are scarce. Furthermore, for those present, they often only include a very brief analysis.

From a public point of view, evaluations of energy programs are of major importance to measure the performance of the programs. From an energy policy designer point of view, it is of major importance to not only see the cost-effectiveness of the policy but also to understand the fundamental mechanisms for the success or failure of an industrial energy program, in order to learn how to improve future programs.

The aim of this paper is to present a review of energy end-use policy instrument in Japan and Sweden towards the industrial sector from 1990-2014, with special emphasize on industrial SMEs. From the results presented some general conclusions can be made, (1) results show that the cost-

effectiveness differs substantially between the evaluated programs, and (2) that from a governmental point of view, subsidies towards energy audit programs seems like the most cost-effective policy. In addition to this (3) the results from the review also stresses the importance of a clear strategy for every energy program on how the program is going to be evaluated, ex-ante or ex-post, and how the performance of the program is to be measured. This structure should be included from the start of the program.

Keywords: Energy end-use, policy instrument, industry, SME, energy efficiency

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1. Introduction

The threat of increased global warming resulting from the use of fossil fuels stresses decision-makers to formulate and adopt policies towards different sectors of the economy. In particular,

improving energy efficiency through the adoption of energy policy instruments is of importance as improved energy efficiency is one of the major means of reducing GHG (Green House Gas) emissions. In light of the great earthquake in Japan 2011, energy efficiency also plays an important role in Japan in overcoming the challenge of power supply shortage. Energy end-use efficiency policies towards industry are of particular importance as a major part of the energy is used in industry. Energy policy decisions-making is often inspired by mainstream economic theory which in short states that an energy policy should only be adopted if a market failures or a market imperfection exists. Moreover, solely the existence of a market failure or a market imperfection may not justify adoption of a policy if it is not clearly shown that the policy is cost-effective. Apart from these theoretical implications of policy adoption, there is also the perspective of financial constraints when it comes to financing public energy policies. If there are several policy alternatives on how to improve energy efficiency, it is important for the authorities to evaluate where public money can be most cost-effectively invested, i.e. where policy do have the largest net impact in relation to investments of public money. In order to adequately design future programs, it is thus of importance to evaluate current programs in terms of the program's cost-effectiveness and the achievement or not of the fundamental aim of the policy.

Energy end-use efficiency policy has an important role to remove market barriers to energy efficiency. There are three approaches in such policy intervention; *administrative or regulation directed policies*, different types of *information policies*, and *economic policies* like subsidies. *Administrative or regulative polices* include laws, technology standards, performance standards, and management standards. The last type, which is also called enforced self-regulation or management-based regulation, is a way of regulation which requires firms to have management systems, and the firms determine the details of the management systems by themselves [1-2]. The Japanese Energy Conservation Law on firms is a good example of administratively-based regulation [3-4]. The second policy type, *information policies*, includes guidelines, manuals and training. Energy audit programs belong to this category. The third category, *economic policies* includes subsidies, and tax reduction. Often, polices are a combination of different types, for example a subsidized energy audit program

which includes both an economic part, the subsidy, and an information part, the energy audit report delivered to the company. Another example is the European law of energy audits for large companies that are both an administrative and an informative policy [5].

A review of about 300 industrial energy policy programs in the IEA countries was conducted by Tanaka (2011), stating that many of the programs did not target SMEs [6]. [6] explicitly outlined some programs towards industrial SMEs like the German Special Fund for Energy Efficiency in SME, Japanese, UK and French low interest rate loans for investments. For energy-intensive industry, two of the foremost policies are energy audits and so called long-term or Voluntary Agreements (VAs), a policy where an agreement on improved levels of energy efficiency between the government and either a sector organization or individual companies is set [7]. A review of 23 Voluntary Agreements in 18 countries was made by Price [8] who made a categorization of three different type of VAs. [8] stated that the VAs that are completely voluntary show lower participation and weaker results while VAs with regulatory or economic components, showed higher participation rates and improved results [8]. Rezessy and Bertoldi [9] reviewed EU VAs and found that VAs, though historically focused on process-industry, now also have started to include medium-sized companies, and outline eight EU Member States that include industrial SMEs in their VA. Cornelis [10] evaluated the Belgium auditing VA in Flanders, comprising medium-sized companies, and showed that the economic strength of the company had impact on the adoption of measures. Most VAs, like the one in Flanders, includes energy audits as one major component. Linden and Carlsson-Kanyama [11] and Ugglå and Avasoo [12] presented an evaluation of the Swedish VA EKO-Energi and stated that the energy audit within the LTA was one of the most appreciated gains according to the participating companies. Price and Lu [13] presents a review of 22 industrial energy audit program from 15 countries, and Johansson et al [14] shows an overview of the current Swedish industrial energy policy mix, presenting an overview of current demand and supply policies towards the Swedish industry. Thollander et al. [15] evaluated a regional Swedish energy audit program and also presents an overview of Swedish industrial energy-end use programs. Thollander and Dotzauer [16] presented the logics behind the Swedish energy audit

program. Ottosson and Petersson [17] presented the major functions of the Swedish VA PFE. Stenqvist and Nilsson [18] and Henriksson and Soderholm [19] evaluates the Swedish PFE program showing a gross impact of more than three percent improved electrical efficiency where 30 % of participating companies are SMEs.

Kimura and Noda [3-4] present an evaluation of the effectiveness of regulation, the Japanese Energy Conservation Law and showed that it indeed is a successful policy towards medium-sized companies. Johansson et al. [14] in their presentation of industrial energy end-use policies in Sweden outlined that the Swedish law enforcement, the Swedish Environmental Code is a not an extensively used policy even though it holds juridical power.

Harris et al [20] evaluated the Australian EEAP, primarily targeting larger companies, and found that a deployment rate of five out of six proposed measures from the energy audits were implemented. Anderson and Newell [21] and Corbett et al. [22] present evaluations of the American IAC, the world's largest energy audit program in terms of participating companies. They showed that about half of the suggested measures were implemented, where measures with low investment costs were preferred [21-22]. Fleiter et al [23] presents an evaluation of the German energy audit program and show that participating SMEs adopted 1.7–2.9 of the measures. Farla and Blok [24] found that the investment subsidy, the Dutch Energy Bonus, suffered from a large degree of free-rider effects. Gruber and Brand [25] presented results for a German grant for energy audits in SMEs, and found that the German subsidy for energy audits were not known to even exist by most SMEs, and some that were aware of the subsidy, did not know that they could apply for it. Yet another type of policy is benchmarking schemes, e.g. USEPA who developed plant energy benchmarks known as Energy Star Energy Performance Indicators for more than 10 industrial sectors [26]. Also, a more recent type of policy that has only recently been scientifically evaluated are energy networks or learning energy efficiency networks, emerging form of policy that have proven to be successful in Switzerland and Germany, especially for medium-sized companies [27]. Energy networks show a double impact compared with stand-alone energy audit [27].

Xu et al. [28] investigated the Energy conservation and CO₂ emission reductions in China's 11th Five-Year Plan from a top-down perspective, showing that economic growth is the biggest driver for increased energy use and GHG emissions. The paper concludes that renewable energy and promoting economic restructuring to limit the increase of energy-intensive sectors are the main challenges to overcome [28]. Li et al. [29] summarizes the Chinese energy policies for energy-intensive industry and evaluates these using indicators. Wang and Chang [30] examined the development of Chinese low-carbon policy instruments and suggest more rigid law enforcement towards in particular the industrial sector to improve efficiency and reduce GHG emissions. In another study of the Chinese automotive industry, Wachtmeister [31] stated that regulative measures using command-and-control are the most effective climate policy measures but state that market oriented measures are underrepresented in the policy mix compared with Europe. Lo [32] states that industry uses 60-70 % of the Chinese energy use and therefore is an important sector to focus on, in relation to renewable energy and energy efficiency policies, and states that currently, China has four strategies; energy efficiency obligation, forced closure, energy efficiency funds, and electricity pricing.

Brannlund et al [33] studied the Swedish carbon tax and found that the tax have had impact in decoupling economic output and GHG emissions. Ericsson et al. [34] studied the strategic changes in the Swedish pulp- and paper industry and found that change was driven by both economic market conditions, e.g. electricity price increase, as well as policies such as the EU ETS, the Swedish VA, the PFE, and the electricity certificate scheme. Backlund and Thollander [35] studied the impact of the Swedish energy audit program and its cost-efficiency.

Napp et al. [36] conducted a review of more energy efficient technologies for climate change mitigating in the industrial sector, and made some concluding remarks on suitable policies for various cost-effective energy efficient technologies.

Wakabayashi [37] presents results from three case studies of voluntary agreements in Japanese industries, and conclude that voluntary activities are more effective compared with alternative policy measures, taken a proper institutional framework exists.

Sugino et al. [38] in their study of carbon pricing mechanisms found that such scheme would create an uneven burden on sectors which are energy-intensive and heavily dependent on international trade when applied to the Japanese economy. Mochizuki [39] also conducted an ex-post evaluation of Japanese voluntary emission trading systems and concludes that, while these systems worked to some extent, they are still in a pilot phase and there remain substantial barriers for effective implementation.

Kuramochi [40] presents a comprehensive review of recent developments of Japanese energy and climate policy, and argues that the current national policy for climate mitigation in Japan is weak. His review, however, focuses on economic instruments such as emission trading schemes and carbon taxes as well as supply-side policy such as the feed-in tariff (FIT) scheme, and does not cover demand-side energy efficiency policy.

Chou and Liou [41] studied Taiwanese energy intensive industries and its climate change policies and concluded that policies aimed towards industry, not give rise to absolute energy savings. Rather, energy use is increasing. They conclude that this may be a general challenge for newly industrialize countries [41]. Their study is further supported by Wang et al. [42] stating that industrial economic growth together with increased fossil dependency in Chinese industry is the main drivers for the increased carbon dioxide emission.

From a management perspective, firms are well motivated to behave responsibly, if proactive environmental practice has a positive impact on firm's financial performance. Both positive and negative relationship between firm's environmental performance and financial performance has been reported. Sariannidis et al. [43] suggested that different features of investment behavior may account for this divergence; socially responsible firms are likely to be punished when CO₂ increases while conventional firms are not. Their argument implies that motivating mechanisms are more needed for SMEs than large firms, considering most SMEs lack for financial incentives.

From a public point of view, evaluation of an energy program is of major importance if a program is to be considered or not. From an energy policy designer point of view, it is of major importance to not only grasp the cost-effectiveness of the policy but also to understand the fundamental

mechanisms for the success or failure of an industrial energy program. Both Japan and Sweden are two countries which are known to have been working proactively with the issue of energy end-use efficiency and climate change mitigation wherefore these two countries are of particularly importance to study. The aim of this paper is to present a review of energy end-use policy instrument in Japan and Sweden towards the industrial sector from 1990-2014, with special emphasize on industrial SMEs.

The paper is providing new results on industrial energy end-use efficiency policies from the two countries Japan and Sweden. The primary method when conducting the review of energy policies in Japan and Sweden from 1990-2011 was a literature review primary including scientific references where those were available, but also including information on public homepages like the national energy agencies. What distinguishes this paper from previous international reviews in the field of energy policies, are that the authors are active in the field of energy policy evaluation in respective country, wherefore a stronger validity is gained than a desk review consisting of internationally published policy reviews and evaluations. The paper is delimited to study industrial energy end-use and climate change mitigation policies and programs. The unit used is kWh (as primary energy) and Euro, to which Japanese Yen (JPY) is converted by an exchange rate of 130 JPY/Euro. In cases where the evaluation figures have other units, the figure has been converted to kWh and Euro. Where that has been done, it is explicitly stated in the paper.

The analyzing model used in the review is Transactional Analysis (TA), which states that in a relationship, between two stakeholders, one may take three roles (parent, child, adult) leading to six different types of relationships (child-child/parent/adult; parent-parent/adult; adult-adult). TA was founded by Eric Berne [44] and is now a widely used model in various scientific disciplines. Within industrial energy policy decision-making, the model was first introduced by [45].

Questionnaires, interviews and actual energy metering are means of collecting data for energy program evaluation [46]. The most commonly used methods for industrial energy program evaluation are interviews and questionnaires [46]. Sometimes, evaluations include a minor part of the population being re-metered, i.e. some companies receive a second round of energy metering in order for the

effect of the program to be quantitatively derived [46]. One distinguishes between ex-ante and ex-post evaluations where the latter includes an evaluation made after the program or activity has ended, while the former includes an evaluation made before the program or activity has ended [16]. If programs are not evaluated, or evaluated incorrectly, energy policy decision-makers have little left but to qualitatively assume the outcome of a future policy. In the worst case scenario, a policy which in reality is effective in improving energy efficiency may in fact, due to lack of evaluation, be regarded as a failure. One example of this was the evaluation of the Australian energy audit program, where the policy program was considered a failure among many before it could be evaluated, and when evaluated it was found that the majority of the suggested measures from the energy audit program, had in fact, been implemented [20]. Another example of this was the Swedish local energy program Project Highland, which up until 2011 was the largest Swedish program for the last 20 years and involved 340 companies [15]. A part of the program was evaluated ex-post in 2006 [15]. The evaluation showed the cost-effectiveness of an energy program providing low-cost energy audits to small and medium-sized enterprises [15], a policy which had never existed on a national basis in Sweden. Later on, the ex-post evaluation provided a basis for the Swedish Energy Efficiency Investigation, commissioned by the Swedish government, in their decision to design a national energy audit program in Sweden (c.f. [47-48]).

2. Industrial energy end-use programs in Japan and Sweden, 1990-2014

2.1 Japan, industry and energy

In Japan, the industrial sector uses 45% of the aggregated domestic energy use. Even though that figure is similar to that of Sweden the structure of the energy use is different. The Japanese industry uses annually 1,701 TWh, of which 666 TWh is oil, 213 TWh is gas, 184 TWh is coal, and 398 TWh is electricity in 2012 [49]. In Japan, the iron and steel industry is using 29%, chemical industry 32%, cement 6%, pulp and paper 4%, and other industries 29%.

In Japan improving energy efficiency has been an important policy agenda particularly since the Oil Crises. One reason for this is security of energy supply, i.e. Japan imports almost all of its energy sources, except for hydro power, which contributes to approximately 17% of domestic power generation in 2008 [49]. Another reason is existence of the target to reduce carbon dioxide emissions, which is based on Kyoto Protocol and aims to decrease levels with 6 % to 2008 to 2012 compared to the 1990 level.

There have been three major types of policies directed towards improving industrial energy end-use efficiency in Japan, the Energy conservation Law, national and local energy audit programs, and investment subsidies. Another program concerning industrial energy efficiency is Voluntary Action Plans (VAPs) by various industrial associations. While VAPs are voluntary actions by industry and not VAs in a strict sense, they are formulated through informal negotiations between industry and the government and are subject to periodical evaluation by the government. They are, therefore, considered to be an important policy instrument since their first settlement in 1996. These four policies are presented below.

2.2 Japanese energy end-use industrial policies 1990-2014

2.2.1 Energy Conservation Law of Japan

The Japanese Energy Conservation law has a long history. It was established in 1980 and has been amended in 1993, 1998, 2002, 2005, and 2008. Every time it was amended the regulatory requirements have become severer and severer in scope and obligations. It covers large facilities. The regulated firms sum up to more than 14,000 facilities, among where the industrial sector stands for 90%.

Table 1 shows various requirements by the law. While the law basically intends to reinforce firms' energy management by introducing management tools, such as responsible organizations, reporting systems, and management standards, it also have voluntary standard for improving energy

intensity (calculated as energy per unit of GDP). The government has been conducting on-site visits to all facilities consuming more than 32.3 GWh (i.e. 3,000 kilo liters in crude oil equivalent) per year to enhance compliance [3].

Table 1

Major requirements of the Japanese Energy Conservation Law

1. Assignment of qualified “Energy Manager” (mandatory), both from working- and executive-levels
2. Development of responsible organization (mandatory)
3. Reporting (mandatory), including:
- Energy use, flow, related equipments, CO2 emissions
- Actions taken and plans for energy conservation
- Compliance status with standards
4. Management standards (mandatory):
- Develop firms’ own “Standards for Energy Management” for major energy-using equipments (boilers, furnaces, motor-systems, etc)
5. Performance standard (voluntary): 1% decrease in energy intensity annually (in five-year average)

Although there are no ex-post evaluations for industry, it seems that the law was effective in improving energy efficiency in regulated firms to some extent. Fig. 1 shows the declining trend of energy intensity in regulated firms (a 3% decrease from 1999 to 2007 in the industrial sector).

Fig. 1. Trends of average energy intensity of companies regulated by the Japanese Energy Conservation Law. 1999 level = 100. (Source: [4])

Arimura and Iwata (2007) made an econometric analysis by focusing on the hotel sector as an example [50]. Based on panel data of the regulated 142 companies in the sector, they estimate that tightening of the regulation from 2002 to 2004 decreased fuel consumption and fuel intensity by 2.8% and by 2.4%, respectively [50].

How do firms respond to the Law? Based on interviews in 12 manufacturing firms, [3] found four ways as to how firms respond to the regulation of the law (Fig. 2). In the figure, the vertical axis shows the level of energy management, and the horizontal one shows status of compliance. The compliance rate of the law is very high, leaving only 1 to 2 percent of non-compliance [3], which is shown by type IV in the figure. In compliant firms, there were three types of compliance. Firms of type I have excellent energy management. They are doing more than the law requires even before being regulated, because they are mostly large facilities in energy-intensive industries, such as steel, cement, or pulp industries, so energy is one of the major cost factors for them. They are excellent but independently of the regulation. There are also firms of Type II. Their energy management was not so good before being regulated, but they started some activities and improved their management in order to be compliant with the law's requirement. This can be seen as a success case, because the law improved their energy management. Type III can be seen as failure cases of the regulation, because firms became compliant with the law but did not improve their energy management very much.

Fig. 2. How Energy Conservation Law impacted firms. Four types of impact of regulation are illustrated. (Source: [3])

2.2.2 Energy Audit Programs in Japan

In Japan, the government has been conducting several energy audit programs since the oil crisis. They are operated either by governmental subsidiary organizations, such as ECCJ (Energy Conservation Center Japan) and NEDO (New Energy and Industrial Technology Development Organization), or by local governments. The ECCJ audit program has been conducting about 300 to 1,000 audits annually in small-and-medium sized enterprises (SMEs) since 1980, while NEDO's program offered about 40 to 100 audits per year to large facilities from 1999 to 2007. Most of the audits were provided for firms in non-energy intensive industry which did not have enough expertise in energy management in-house. Most of the recommendations are operational improvement that requires no investment, but also include investment measures with short payback periods (usually less than three years).

Many of the local governments also have energy audit programs, although no figures are available of the number of companies included in these.

Fig. 3. Number of energy audits in Japan, 1990-2008. Number of audits by local governments are estimated by [51]. SMESJ: SME Support, JAPAN (Organization for Small & Medium Enterprises and Regional Innovation, JAPAN)

Table 2 shows an estimation of the energy audit program's cost-effectiveness [51]. As can be seen in the table, evaluation figures for the SMESJ program are not available, The program costs per CO₂ emission avoided were around 10 to 20 Euro/t-CO₂ (i.e. 1,300 to 2,600 JPY/t-CO₂), which is in the same order with the cost-effectiveness of similar audit programs in European countries..

Table 2

Energy intensity in regulated firms by industry, 1999-2007.

	Program costs [Mil. Euro]	Energy savings [TWh]	Governmental cost-effectiveness *3) [Euro cent/kWh]
ECCJ audits for SMEs, 2004-2007 *1)	7.7	2.38	0.32
NEDO audits for large companies, 1999-2007 *2)	12.9	6.95	0.19

*1) 2,409 audits conducted during 2004-2007.

*2) 501 audits conducted during 1999-2007.

*3) Program costs per CO₂ emission avoided. Japanese Yen (JPY) was converted to Euro by an exchange rate of 130 JPY/Euro.

(Source: [51])

2.2.3 Subsidy for high-efficiency industrial equipment and systems

Subsidy programs for high-efficiency industrial equipment and systems have been implemented since the late 1990s. Most of them give firms subsidies for initial investments by one third up to one to half. The biggest program is called “Support program for rational use of energy”. This program subsidizes energy efficiency projects which install new or improve existing industrial equipment and systems, such as boilers, furnaces, and co-generation systems. Eligible projects have to achieve energy savings of more than 1 % of the firm’s energy consumption or more than 10.8 GWh (i.e. 1,000 kilo liters in crude oil equivalent) compared to the baseline.

Table 3

Overview of participating firms and program budget for the Japanese “Support program for rational use of energy”.

Fiscal Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Number of projects	15	30	32	66	120	105	65	314	399	331	388	305	n.a.
Program budgets [Mil. Euro]	47		39	70	70	95	106	156	200	220	235	228	208

Note: Japanese Yen (JPY) was converted to Euro by an exchange rate of 130 JPY/Euro.

The cost-effectiveness of the program has been studied by Kimura and Ofuji (2014) [52]. Based on a self-report approach which is widely adopted in utility program evaluation in US [53-54], they

estimated the free-rider ratio of the Japanese subsidy program as 56 to 61 %. In spite of the high free-ridership the cost-effectiveness of the program was favorable: the estimated governmental cost of saved energy was 2.5 Eurocents per kWh [52]. Evaluations of other subsidy programs reveal a particularly high degree of free-rider effects for subsidy program, e.g. Farla and Blok (1995) estimated the degree of free-rider for the Dutch Energy Bonus to be as high as 85 % [24]. This could be compared with estimations for Long-Term Agreements (LTAs) estimated to be 0-50 % for the current Swedish LTA-program PFE [18], and for energy audits; 0 % as a general estimation based on a compilation of 42 European industrial energy programs [46], up to 9 % found in the German program [23].

2.2.4 Voluntary initiatives by industry associations

Voluntary business activities for enhancing energy efficiency and/or mitigating climate change are active in Japan. Among several successful programs, the VAPs conducted by Japanese industry associations are the greatest in terms of their wide coverage of the economy, which is approximately 80 percent of greenhouse gas emissions from the industrial and energy conversion sectors of Japan [55].

In the VAPs, each of industry associations established either CO₂ emission reduction or energy conservation target at the industry level. Despite the name of voluntary, participating companies were somehow compelled to comply with the plan [56]. The capability of industry association is an important key to make the plan effective. They provide a platform for sharing information, developing common expectations among member companies and promoting coordinated actions to overcome common difficulties [55].

Keidanren (2013), the Japan Business Federation, inclusively evaluated the program and declared that 34 industries successfully met the uniform target to reduce CO₂ emissions from the industrial and energy conversion sectors between fiscal 2008 and 2012 to below the level of fiscal 1990. The target was overachieved by 12.2 percent reduction from fiscal 1990 level. Keidanren

concluded that efficiency improvement, which is represented by 14 percent reductions in CO₂ emissions per unit of output during five years from 2008 to 2012 compared to 1990, was the key driving force to meet the target.

2.3 Sweden, industry and energy

The Swedish industry uses about 151 TWh annually where about 56 TWh is electricity, 52 TWh is biofuels, 17 TWh is oil, and 16 TWh is coal and coke. In addition, about 6 TWh district heating and about 4 TWh natural gas is used [57]. In Sweden, the pulp- and paper industry is using about 50 % of the industrial energy use and the Iron and Steel industry, 15 %, chemical industry, 8 %, the engineering industry, 7 %, and other industries 20 % [57].

Improved energy efficiency has been an important policy agenda in Sweden, especially after the Oil Crises. One major change in the structure of the supply has been the conversion from oil to other energy carriers, which has been very successful. Sweden has reduced its share of oil in the industrial sector from contributing to nearly half of the energy use 1970 to only about 10 % in 2008 [57].

As a means to improve energy efficiency in Europe, the European Union launched the European Energy End-use Efficiency and Energy Services Directive (ESD) in 2006, which propose a 9% reduction in the use of energy within the Member States to be achieved by the ninth year of application of the directive [58]. In addition to promoting energy services, the directive was addressing a number of other activities and services such as the availability of high quality independent energy auditing for SMEs. Beyond the targets for 2016 are the 2020-targets with the aim of reducing emissions of GHG with 20%. The ESD was replaced by the European Energy Directive (EED) in 2012 further emphasizing energy end-use efficiency [5].

From a Swedish perspective, being part of the European Union since 1995, it has to comply with EU laws and directives. The industrial energy programs in Sweden, launched after the ESD (2006)

was presented, are thus a result from that [58]. Prior to that, launched energy policies in Sweden have been due to national attempts rather than to comply with EU directives.

[15] made a review of Swedish programs in Sweden, showing that that Project Highland and the PFE were the by far largest programs, in terms of participating companies, up until 2007, in Sweden for industrial and commercial customers. However, the current Swedish energy audit program is forecasted to cover around 1,000 companies up until 2014 [16], and has now turned out to be the largest program in terms of number of companies in Sweden. Preliminary results show that the number of firms applying for the subsidy is 987 [59]. There was also a national program, EKO-Energi [11-12], a VA, between the years 1994 and 2001 including 72 large energy-intensive industrial companies. Apart from actual industrial energy-end-use programs, there is one administrative policy, the Swedish Environmental Code. There has thus been five major policies directed towards improving industrial energy end-use efficiency in Sweden, Swedish Environmental Code, the PFE, the Swedish energy audit program, the EKO-Energi, and the energy audit program, project Highland. These five policies are presented below.

2.4 Swedish energy end-use industrial policies 1990-2014

2.4.1 The Swedish Environmental Code

The Swedish environmental legislation is currently mostly gathered in the Environmental Code, in which energy conservation is an independent objective. The Swedish Environmental Code came into force in 1988. The energy efficiency requirements from the Code have recently gained increased attention when environmental permits for companies are issued. The environmental code has potentially an important place, and something of a unique position in the Swedish policy mix, as it combines permits as well as well as a supervision procedure. It should be noted that even though legal grounds exist, this instrument is quite slow and has only recently begun to be practiced. [14]

Major emphasize has been towards energy-intensive companies, and the methodology has focused on a best available technology (BAT). Only in recent years, and only in some counties, the

county board of administration together with the municipality environmental protection offices have directed some of their effort towards industrial SMEs, through, e.g. site visits. No formal evaluation of the code's impact on energy performance has been conducted yet. However, it may be estimated that the impact from the Code on energy performance has been very limited so far in Sweden, as it has only recently begun to be practiced [14]

2.4.2 PFE (the program for improving energy efficiency in energy-intensive industries)

The PFE (program for improving energy efficiency in energy-intensive industries) was initiated in 2005 as a consequence of the introduced electricity tax in July 2004 of 0.5. EUR/MWh and is an LTA (Long-Term Agreement) between the Swedish authorities and the electricity-intensive Swedish industry [17]. In the program, electricity-intensive firms are offered a full discount of 0.50 €/MWh on the tax on electricity for Swedish industry if the company fulfills the requirements [17]. The requirements include, within the first two years, that the participating companies must undertake an energy audit with a systems approach. The audit should result in a number of energy efficiency measures that could be implemented over the remainder of the period (the last three years), and the implemented measures should result in energy cost reductions at least equivalent to the tax discount [17]. The program also includes mandatory elements such as the implementation of an energy management system, the introduction of standardized routines for purchasing of energy-efficient technologies and planning, energy systems, and plants [17].

Of the approximately 1,200 firms that are eligible for participation, only about 100 have joined the program (SEA, 2011). The gross outcome was an end-use electricity saving of 1.45 TWh/year [18].

2.4.3 The Swedish energy audit program

The Swedish energy audit program was initiated in 2010 and will last until 2014. The program targets companies using more than 500 MWh/year, and offers a subsidy of up to 3,000 EUR, for 50 %

of the audit cost. After the audit is finished the company must, within 6 months, report the energy audit report, including an energy action plan on which measures to actually implement. After 2 years the company submits its final report including which of the measures from the energy action plane were implemented. For a more thorough presentation of the logics of the program, please see [16].

2.4.4 The EKO-Energi

EKO-Energi was a national program, a VA, between the years 1994 and 2001 and included 72 large energy-intensive industrial companies [11-12]. A qualitative evaluation of EKO-Energi revealed that in particular the audits gave rise to increased priority to energy efficiency and environmental issues [12]. Despite great efforts, it was not possible to evaluate the programme quantitatively [11].

2.4.5 Project Highland

Project Highland was up until 2010 the largest Swedish energy program since the 1990, in terms of participating companies. The program offered energy audits in six municipalities. A total of about 340 energy audits where conducted, of which approximately 140 audits, were directed towards the industrial sector and the rest towards the services and sales sector. Due to limited amount of time assigned to each audit, and partly due to the fact that the SEA (the Swedish Energy Agency) did not allow complete audits, due to a risk of competitive disadvantages for enterprises not included in the program, less than half of the recommended measures were quantified, i.e. only half of the proposed measures were quantified in terms of energy saved per year [15, 60].

Table 4, presents results from the previous evaluation of the industrial part of project Highland together with the evaluation for the service and sales sector from project Highland [15, 60].

Table 4

Key figures for project Highland [15, 60].

	Service and sales firms in project Highland	Industrial firms in project Highland ^a
Number of firms	28	47
Total energy savings, including electricity (GWh/year)	0.35/0.7 ^b	7/16 ^b
Total energy use (MWh/yr)	12 029	181 691
Total energy saving potential (MWh/yr)	3 227	39 889
Number of measures	48/90 ^b	142/281 ^b
Subsidy, including program administration (EUR)	42 600	81 600 (adm.+audit costs)
Cost-effectiveness for all measures (kWh/EUR)	0.12/0.061 ^b	0.012/0.0051 ^b

Results indicate that the degree of implementation for the two sectors, industry and service and sales, differs substantially. While the relative percentage of proposed measures is equivalent, the degree of adoption of measures are higher for the industrial sector. This fact will affect the outcome of

^a Thollander et al. (2007).

^b Planned and implemented measures.

the cost-effectiveness of the audits as the cost for the audits did not differ substantially between audits made in service and sales firms versus audits made in industrial firms.

3. Conclusion discussion

3.1 Policy comparison between Japan and Sweden

This paper shows, by comparing conducting a review of industrial energy end-use efficiency and climate change mitigation policies in two developed countries that are known to work proactively with improved energy efficiency, that Japan has a rather strong law enforcement in its industrial energy end-use policy mix, while Sweden, so far, has basically lacked emphasis on such enforcing regulation. The law enforcement in Japan through the Energy Conservation Law reveals that this could be a means to be more strongly emphasized also in the Swedish policy mix, as well as for any country aiming to improve energy efficiency in the industrial sector. Results for Japan showed that in particular towards medium-sized companies, the law is a strong policy [3]. The fact that such law already exists in Sweden means that the costs for implementing such stronger regulation can be assumed to be low.

The review also shows a lack of standardized means to evaluate industrial energy end-use policies, both in Japan and Sweden. To the author's awareness, the need for such standardized evaluation procedure has not been stated in previous research.

3.2 Theoretical implications

Transaction Analysis (TA) is applied, in the analysis of the industrial energy policy review of Japan and Sweden. The administrative policy applied in Japan, the Energy Conservation Law, showed to be effective for medium-sized companies. Using, TA this approach is similar to a parent-to-child relationship between the government and the companies. This is different to a VA (Voluntary Agreement) which for both countries has been a cornerstone in the industrial energy policy mix, where the relationship between the government and the companies may be seen as adult-to-adult, i.e. both parties are taking mature actions in relation to improving energy efficiency [44]. For energy-intensive

and large companies which have staff capacity to sign on to a VA; this adult-to-adult policy might be more effective than solely law enforcement [3]. For small companies, energy audit programs, seems to be an effective choice. Energy audit programs, relating to TA, may also be seen as more of a parent-to-child approach where the government, through a policy, tries to inform companies on actions to take which would benefit the nation's interest. However, unlike a law, an energy information program may be seen more like a "curling" parent, i.e. a parent which are unwilling to take strong actions (law enforcement) but rather simply provides guidelines (energy audits providing information) on how to behave. Relating TA to energy policies in Japan and Sweden, results show that Japan has adopted a diversified strategy with both parent-to-child, and adult-to-adult policies. While the same applies to Sweden, results show that Sweden may contribute from a stronger law enforcement activity towards in particular medium-sized companies (parent-to-child relationship).

3.3 Policy recommendations

One outcome of this paper is a suggestion to implement more standardized means on how industrial energy end-use and climate change mitigation policies should be evaluated. Harris et al., (2000) showed that without evaluation, policies might be considered useless [20]. A standard procedure on how to evaluate a policy, even before it is launched could therefore be a major improvement, and could later in a formative evaluation process be a means to even further improve the policy during its program lifetime. Such a standard or recommendations should include methods on how to frame the degree of free-rider effects, both in regard to participating in, e.g. an energy audit program, as well as in regard to actual energy efficiency technology implementation. Moreover, recommendations on how to include spill-over effects, a very rarely included factor so far in policy evaluation, is suggested to be included in such framework. Moreover, how to take into account price elasticity should preferably also be included. Finally, even though the policy evaluation field does not directly include rebound-effect in its analysis, such widened perspective in policy evaluation is suggested in these recommendations.

A analytic generalization of the reviewed programs indicate that clean-cut energy audit programs towards small- and medium sized and non-energy-intensive industry is more cost-effective from the governmental point of view, than LTA-programs or VAs towards energy-intensive industry followed by clean-cut energy audit programs directed towards small- and medium sized and non-energy-intensive service and sales enterprises. However, results is not unambiguous as Backlund (2014) showed that the cost-effectiveness from a welfare economic point of view, when also including the firm's investments shows a higher cost-effectiveness for the Swedish VA towards energy-intensive industry, than the energy audit program towards small- and medium-sized companies, major reason be is that the VA is supported by a tax which may not be seen as a cost for the government while the subsidy for the energy audit program is seen as a cost [61].

It should be noted that this analytical generalization is based on multiple case studies in two countries, and a limited number of evaluated companies. It is therefore strongly suggested that further research is conducted in this area, using both multiple case study methodology and other approaches.

Improved methods and tools is emphasized in the area of energy policy evaluation, and the procedures for including a standardized structure for industrial energy and climate policy program evaluation, in order to gain more precise figures in regard to actual energy savings achieved from industrial energy programs in terms of public money invested as well as the estimation of free-rider effects. Moreover, the paper has shown that local industrial energy programs in Japan and Sweden seems to not be evaluated at all, or evaluated without a consistent methodology stressing once more the importance of a standard or array of recommendations prior to policy launch, on how policies should be evaluated.

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