# Market transformation for energy efficiency

- a case study of the introduction and diffusion of heat pumps in Sweden and Switzerland

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## 1. Introduction

The first heat pump (HP) was developed already in the 1850s. Ever since the market for heat pumps has developed and today we have heat pumps for space heating, hot water, cooling and industrial processes. Residential heat pumps for space heating and hot water have a significant market share in countries such as Sweden Switzerland USA, Germany, France Austria and Canada (IEA, 2008).[1] These heat pumps significantly reduce primary energy use and support a more energy-efficient energy use.

Since 1970s the development and introduction of heat pumps for space heating and hot water have been supported in many countries as a strategy to improve energy efficiency in order to face the great challenge of energy price risk, energy dependency, environmental degradation and climate change. Several policy instruments, such as R&D, subsidies, information campaigns, labels and quality improvement measures have been developed and applied. Moreover, international collaboration has been supported and in the 1990s Heat Pumping Technologies Implementing Agreement was initiated by the IEA (Zogg, 2008) referring to Groff (2005). As a result of the policy strategies heat pump installations have been developed, introduced and commercialized on a large scale in Sweden and Switzerland (IEA, 2008). The number of installed heat pumps per inhabitants in these two countries is high and has been rapidly growing in the past decade (Scherer, 2008; IEA, 2008). Today, Sweden has the largest market for ground source heat pumps (number of installations) in Europe. In 2006, more than 40,000 ground source heat pumps were sold in Sweden and abroad. Between 1993 and 2006 the market growth has exceeded 1100%. In 2006, about 15,800 ground source heat pump systems were sold in Switzerland, which since 1993 shows an increase of 620% of market sales.

[1] The heat pump moves heat from a low temperature heat source (i.e. bedrock, surface soil, water and outdoor air) to a higher temperature heat sink (i.e. the indoor space) by using energy with high exergy content. Most common heat pumps are motor-driven (electrically powered or gas fueled). The ratio of thermal energy gained to electricity power used (i.e. the COP factor) is in the order of 2,5-5. In the case electrical space heating is replaced by a heat pump, considerable electricity will be saved; in the case a heat pump will replace an alternative heating system, savings will depend on the configuration (including primary energy conversion efficiency and distribution losses) of the energy system. (Heat pumps may not only be used as an alternative indoor space heating system, but reverser processes are also possible for indoor air cooling).

In general, the interest for heat pumps in Europe has been heavily growing in the past couple of years, e.g. Germany, France, UK, and Finland. Sweden has started to show some signs of saturation on the internal market, however, with the increasing export, the overall sales figures are still growing. In recent years, between 30-50% of the ground source heat pump production has been exported annually (Andersson, 2007; K. Persson, 2007). Ground source heat pumps represent a technology that has proven to be energy efficient and cost effective for consumers. The emerging markets in Europe may benefit from lessons learned in countries with essential experience, such as Sweden and Switzerland.

In this paper we will discuss the market development of heat pumps in Sweden and Switzerland with a focus on heat pumps for space heating and hot water. The key question is "How to design policy instruments for the introduction of new energy technologies in a successful way?" In this paper, we would like to highlight the experience in policy making, the success and failure of the policy interventions, and the barriers and drivers of change in Sweden and Switzerland. Evidence for the Swiss case is strongly based on Rognon (2006), Rognon (2008) and Zogg (2008) that well summarize the history of heat pump use in Switzerland. The paper is presenting results from ongoing research. Therefore, the results published are not to be seen as a final outcome but rather as tentative outcomes to be discussed.

## 2. Market development of heat pumps in Sweden

Over the years the number of sold and installed heat pumps in Sweden has increased rapidly. In total, around 800 000 heat pumps have been sold since the early 1980´s.[2] More than 200 000 small heat pumps and approximately 70-100 large heat pumps (over 5 MW thermal/heat output) prior to 1993, and approximately 600 000 heat pumps between 1993 – 2006 were sold in Sweden (see Figure 1). Ground source heat pump sales takes 40% of the heat pump market, and approximately 62% of the sold ground source heat pumps are in the size order of 7-10 kWh (SVEP, 2007).

[2] Brunnsarkivet *(Swedish well register)* confirms the estimation on the current number of ground source bedrock heat pumps in Sweden (SGU, 2007). However, not all the wells are registered in the archives, SGU usually counts with 25% uncertainty. According to Geotec (Trade Association of Swedish Drilling Indsutry), there are only 400 000 smaller ground source (bedrock) heating installations, and there are more and more larger installations for department stores and rental apartment houses (Karlberg, 2007). A survey made by SCB (Statistiska Central Byrån) in 2003 shows that the total number of heat pumps is 226 000 in Sweden. According to SCB this amount is much below the real amount of heat pumps, which depends probably on the followings: a) house-owners did not pay attention to the question that was for the first time included in the survey in 2003 or b) they did not want to say that they have installed a heat pump (Energimyndigheten, 2003). The reason for that is that heat pump installations influence real estate taxes; higher real estate tax shall be paid with the installation of a heat pump (Boverket, 2005).

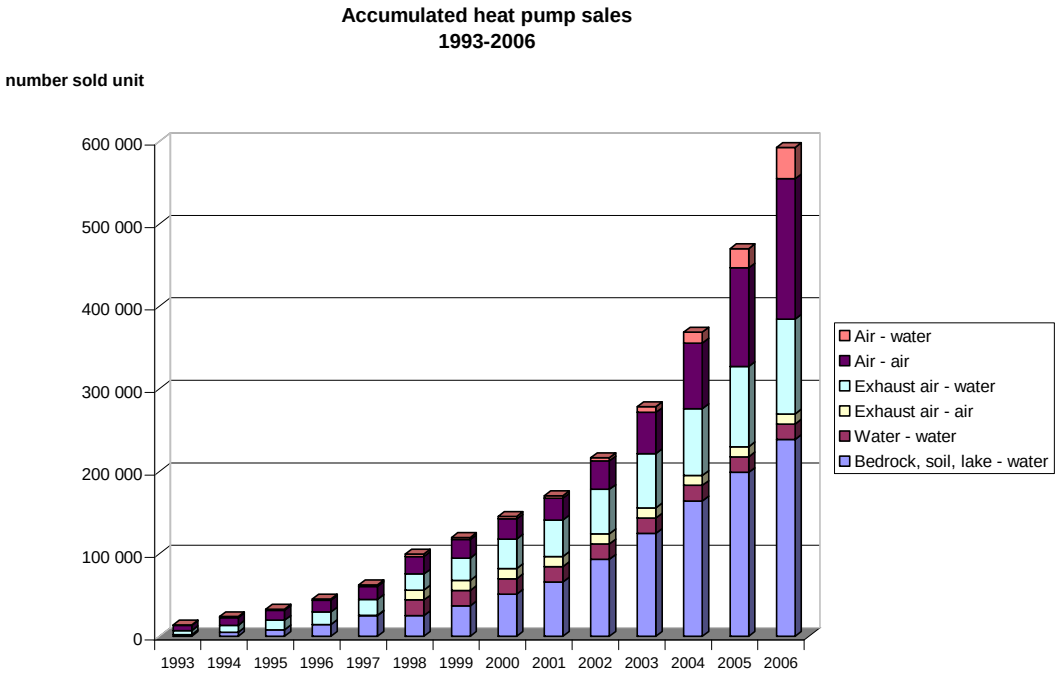


*Figure 1 Accumulated sales statistics for heat pumps in Sweden 1993 – 2006. (Based on data from Swedish Heat Pump Association (SVEP, 2007) completed with estimates for "small air to air heat pumps").*

## *Sweden in the 1970s and 1980s*

In the 1970s and 1980s the heat pump market took off as a result of the oil crisis. The first energy research program was introduced in 1975 (see Box 1), and heat pumps were identified as a promising technology option of future energy system, especially for residential heating. The period is characterized by high fossil oil prices and low electricity prices. Moreover, Sweden had a very well developed drilling industry, and competence needed for the market development of ground source heat pumps.[3] The geological circumstances for heat pumps were also good.[4]

In the early 1980s number of heat pump installation boosted rapidly. Installations were entitled generous governmental subsidies and favourable loans (see Box 1). The boom did not only include smaller heat pumps but also larger heat pumps in district heating systems. By 1985 there were roughly 100 large heat pumps installed in district heating and 110 000 small ones in residential houses. The average support by the loans and

[3] In Sweden, there are a 1.7 million one and two family houses and lot of summer houses, where people have been drilling after water (SVEP, 2007). The drilling industry could relatively fast switch from water wells to energy wells.

[4] In middle and northern Sweden, the bedrock constitutes of crystalline rock, which simplifies drilling. It does not apply to the southern part of Sweden though, there we find more soil heat pumps and lately many air-water heat pumps have been installed (as the climate is much milder).

subsidies was 10-15% of the total investment. The subsidies and favourable loans attracted many new heat pump manufacturers and installers to enter the market.

Box 1. R&D and subsidies for heat pumps in Sweden

In Sweden governmental R&D program has been continuously supported since 1975 and onwards, with different focus over the years. In addition industrial funding has also supported development of heat pumps. In the mid 1970s companies like AGA-Thermia and the governmental owned energy utility Vattenfall dedicated budgets for demonstration and research of heat pumps and energy storage systems. Nowadays, all big Swedish heat pump manufacturers have their own research and development laboratories, and do research together with the universities and institutes.

R&D was complemented by subsidies in the 1970s and 1980s: The subsidies were characterised by their short-term design and discontinuous outline. The subsidies to private households were introduces 2 to 3 years length; i.e. 1977-79; 1979-1980; 1980-1981; 1981-1983; 1983-1984; 1984-1985. During the 1980s there were quite a few demonstration projects with a special type of loan from the government. It was called "experiment building loan" and if the demonstration project didn't succeed economically, the loan did not have to be paid back (Törnell, 2007).

The investment support to private households for heat pump installations was reintroduced in 2006 for conversion from oil burning or electric resistant heating to heat pumps or pellets burners in single family houses. The Swedish state contributed with 540 million SEK/year (1 Jan 2006 - 31 Dec 2010) to convert from oil and direct electricity to other sources of energy. As a result, heat pump sales increased fast.

In the mid 1980s the prices on heating oil was reduced and in 1985 governmental subsidies for domestic heat pumps was terminated (K. Persson, 2007). Phasing out CFC-refrigerants did not place heat pumps into a favourable position on the heating systems market.[5] The second half of the 80´s the demand for heat pumps was decreasing significantly. In the mid 1980s there were about 130 heat pump companies in Sweden, including installers. Most of these companies where small and working locally. With the cessation of the government support, about 120 out of 130 companies left the market (Törnell, 2007). Moreover, several technical malfunctioning heat pumps were registered of those that had been installed. Due to these factors, heat pumps in general got a poor reputation on the Swedish market.

The crisis in mid 1980s articulated a need for high quality heat pumps and re-ignited a slumbering technology development. Performance of heat pumps was improved and new concepts of heat pumps were introduced. A relatively large number of air-to-air heat pumps were installed, plate type heat exchanger was introduced and compressors became more efficient. As a consequence of market competition and rationalization, the price for drilling was reduced. Due to stricter environmental regulations, environmental issues came into consideration, such as the type of refrigerants used in heat pumps, and the prevention and minimization of fluorinated gas emissions.[6] By phasing out CFC/HCFC, new types of refrigerants were to be investigated. Thus, by the end of 1980s research was focused on CFC replacement and performance improvements.

[5] ("EC Regulation No 842/2006 on certain fluorinated greenhouse gases," 2006).

[6] After the phase-out of CFC/HCFC, presently HFC is used in heat pumps as refrigerant, while $CO_2$ and propane are seen to be the refrigerants of the future (Lundqvist, 2007).

*Sweden in the 1990s and 2000s*

In the 1990s oil and electricity price started to increase. At the same time, electricity used for heating in the household sector peaked; increasing from 4TWh in 1970 to 29 TWh in 1990. Since, that time there were around half million houses in Sweden heated with direct electricity, heat pumps were considered as an energy efficient technology to replace them. In 1993, a technology procurement program for ground source heat pumps was initiated (see Box 2) with the objective to foster energy efficiency and electricity savings. In this program the Swedish Energy Agency co-ordinated potential buyers and experts to identify improvements of heat pumps and to articulate these improvements in a specification. In 1995 a specification was announced and manufacturers were invited to enter prototypes of heat pumps in a competition; the heat pumps were to meet the requirements of the specification. The winner was to be awarded an initial order of 2000 units by the end-users/buyers involved in the process. The specification did not only require an effective bedrock- or soil heat pump but also a price reduction of approximately 30% compared to the heat pumps on the market.

Box 2 Technology procurement

In 1993-1995 the technology procurement process of heat pumps was performed. The goal of the procurement was to stimulate the development of more efficient, more reliable and cheaper heat pumps and heating systems for use in detached houses previously being heated by direct-acting electric heaters, and in those being heated partly or wholly by electricity (electric boilers, combination boilers etc.). The objective was to achieve the potential energy saving within 15 years, which would involve sales of about half a million heat pump systems in the Nordic countries. To achieve this objective new, creative solutions were required that could make the heat pump into a viable, attractive investment for individual property-owners – despite, at that time, a bad reputation on the market.

In the technology procurement process, the development of the technology was set by requirements of the potential purchasers and users. Besides helping to draw up the performance specification and evaluating the entries received, the purchaser group also ensured that at least 2000 units would be sold of the winning model. (The purchaser group included two large property-owners having a relatively large number of directly electrically heated properties, four energy suppliers who also had market energy services, two energy service/service companies, the Swedish Testing and Research Institute (SP), the Norwegian Water Resources and Energy Administration (NVE) Heat Pump Programme and the Finnish Energy Efficiency Information Centre (Motiva). The performance specification was also reviewed (without comment) by the Danish Technological Institute.) The specification defined a heat pump 30% more effective and 30% cheaper than the existing models on the market. In the requirements, NUTEK set high quality and reliability standards and to ensure the credibility had third party testing of the prototypes*.

The procurement process had two winning models meeting the requirements of the procurement and the two winning companies were given an initial market of 2000 units. To further support market introduction of these energy efficient heat pumps, the procurement program was supported with investment subsidies and information and education programs. The technology procurement program involved several actors from start – organizations and institutions, including heat pump manufacturers, researchers, retailers, potential buyers and agencies. After the first year, sales exceeded the expectations. In the meantime, interest for heat pumps from abroad started to increase and according to the biggest heat pump manufacturers 30% of the production went to export already in 1996.

* The heating system prototypes were tested by Vattenfall Utveckling AB. The heat pumps were tested by SP in its laboratories (Lögdberg, 2007).

After the technology procurement (1995) sales figures for ground source heat pumps doubled between 1995 and 1996, and the number of installations of bedrock-, soil- and lake heat pumps increased with 465% between 1996 and 2001. Initially the price of heat pumps fell, but shortly after the program it started to increase.

In the early 2000s market took off significantly. Governmental subsidies were given to replace oil based heating systems and to reduce electrically heated houses (see Box 1). Air to water heat pumps seemed to pick up quickly and several new models have been appearing on the market. The number of bedrock heating facilities installed was between 35 000 – 38 000 in 2005 (SVEP, 2007)[7]. Exhaust air heat pumps were primarily implemented in new built houses as heat recovery for tap water heating in accordance with the then new building code. Complicated machines and installations from the early days were simplified and more or less standardized. Normal HVAC (heating, ventilating and air conditioning) firms, electricians, well drillers and plumbers took up heat pump installation as a part of their normal business.

Today, the Swedish heat pump market is very structured. There are more than 300 000 ground source heat pump installations in Sweden and recent reports show that ground source heat pumps add value to properties (Boverket, 2008). The heat pump technology is further developed and new products (such as variable speed compressors) and new concepts (passive cooling[8]) enter the market. A growing interest for heat pumps in the size 25-40 kW for small multi family dwellings or offices/industries are growing, which might open new solutions for the by now stabilized Swedish heat pump market.

## 3. Market development of heat pumps in Switzerland

The production and use of heat pumps was introduced in several waves in Switzerland (see). The technical development took off already in the 19th century and the first prototypes of heat pumps for space heating and domestic hot water heating were developed between 1920 and 1950 (Zogg, 2008). However, after an attempt to deploy heat pumps into the market place in the late 1970s and early 1980s, it was as from 1993 that the growth of heat pump sales in Switzerland took off (see Figure 2). Most of the sales have been small heat pumps (<20kW) that were predominantly installed in new single family houses. Since the 1990s, the share of ground source heat pumps as compared to all heat pump types varied between 40% and 45%, the share of air-water HP between 50% and 55% and the share of water-water HP between 2% and 5%. An overview of promotion and market development activities in Switzerland is given in Table 1.

[7] This figure is a slightly more than the one indicated in the figures, which depend on the experience of households not registering their GSHP:s installations, due to higher tax level on their property (Boverket, 2005).

[8] Passive cooling can be implemented by using the cold from the borehole.

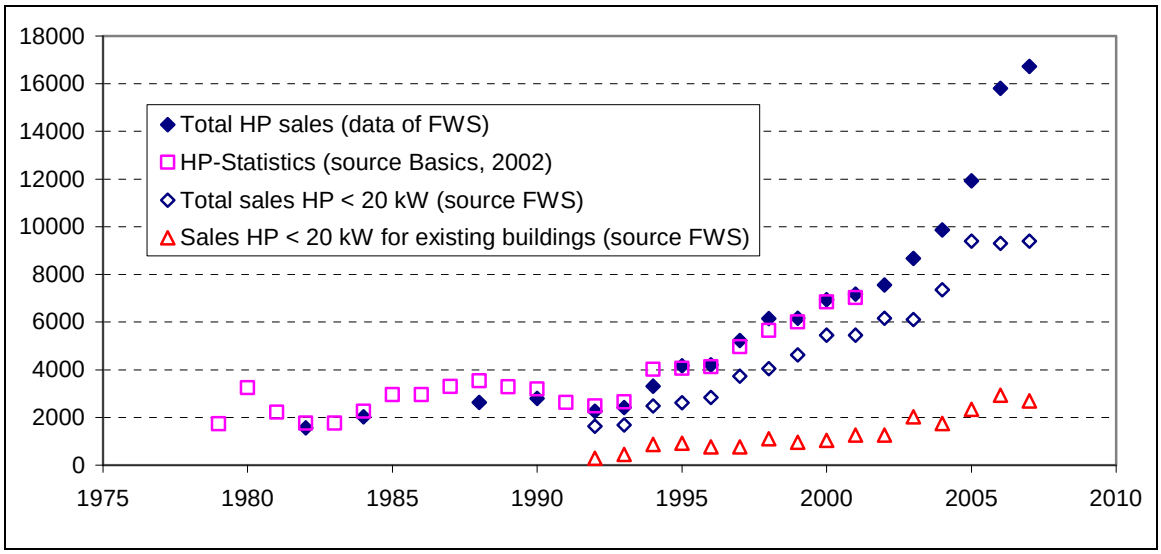


*Figure 2 Sales statistics of heat pumps in Switzerland 1982 – 2006 (all types of heat pumps). Based on data from Swiss Heat Pump Promotion Group (FWS, 2008) and (Basics, 2002)*

*Switzerland in the 1970s and 1980s*

As in Sweden, the main drivers for technology and market development of heat pumps in Switzerland were the oil price shocks of 1973 and 1979/1980 and energy supply security considerations. Technically, developments included compressors (scroll compressors), refrigerants (replacement of CFS due to the Toronto Protocol), heat exchangers (introduction of plate heat exchangers), electronic control (instead of mechanical control, allowing for more precise process temperature control, also through more sensors and actors), see Zogg (2008) for details. In the 1980s, considerably increased production precision became possible due to computer aided manufacturing which ultimately allowed for improving the energy-efficiency of heat pumps. Also, the production of some important components of heat pumps was more and more produced internationally which allowed for significant cost decreases (note that many components of refrigeration systems are also used in heat pumps). Technical developments not only included the heat pump as such but also various kinds of heat sources. In the first phase from the early 1970s and still in the early 1890s, next to ambient air, horizontal ground heat exchangers were developed and used as a heat source in the case of small systems. Due to its quite intrusive installation process, high property prices and rather small building plots, alternatives were sought and vertical borehole heat exchangers were developed as from 1980 (after pioneer activities as from 1974) and soon commercialised.

In Switzerland, the 1970s were characterised by pioneer work of some few individuals and companies, mainly of the producing sector. Due to scepticism of the traditional heating installing sector and of planners and architects, these pioneering actors also had to take care of sales and installing activities. As could be observed in many fields of energy use, only the second oil price shock of 1979/1980 induced a widespread impact of using energy more efficiently and a literal “boom” of small and medium size heat pump

companies started (Zogg, 2008). As opposed to the initial market development phase, when heat pumps systems were fairly large (several dozens up to few hundred kW, see Zogg, 2008 for details), only relatively few large heat pump systems have been installed in the new heat pump era.

Due to this "boom"[10] of new companies in the early 1980s and due to a lack of experience and reliable commercial products, some of the installed systems did not work well or entailed high maintenance costs. Although the number of these cases might have been small, it was sufficient to deteriorate the reputation of the heat pump heating systems. This had a particularly significant adverse impact regarding further market development; indeed, new technologies need rather an above-average reputation to compete successfully with traditional well established technologies. As a consequence, heat pump sales stagnated and even decreased rather than to take off and to take advantage of the initial boom and high expectations (*Figure 2*).

During the the late 1970s and the 1980s public policy and promotion measures for heat pumps consisted of some few but path-leading activities. It included in the creation of a Swiss Heat Recovery Commission. As from 1977, it funded extensive theoretical studies and as from 1982 also technical ones, including the development of guidelines of use ambient heat of rivers and lakes (Zogg, 2008). Heat pump performance testing activities were first started in 1980 by the public Swiss Federal Institute of Technology in Lausanne (EPFL) and then extended trough funds of the Swiss government (Office of Business cycle Issues). The transfer of know how and experience was facilitated through R&D conferences organized on behalf of the Swiss Federal Office of Energy (SFOE) and by demonstration projects. The private sector, more particularly the manufacturers and distributors, founded the association called "Working group Heat pumps". It aimed at developing a common language and planning guidelines, the exchange of exchange of experience and professional training as well as the harmonisation and simplification of approval procedures (of using heat sources). The latter was also supported by the SFOE. In addition, together with Association of the Swiss Utilities (VSE), SFOE worked out "recommendations for the electrical connection" which were followed by other recommendations and guidelines (Zogg, 2008).

*Switzerland in the 1990s and 2000s: the success story*

In 1990, the general ten-year energy promotion programme of the Swiss Federal Office of Energy called Energy2000 was launched, which in 2000 was followed by Energy Switzerland. These programmes aimed at increasing the use of renewable energies (and to increase energy-efficiency). Separate targets were formulated for the cases of heat and electricity, to be reached by 2000 and 2010 respectively. The use of heat pumps was considered as one of the promising pillars to reach the quite ambitious goals.

[10] As compared to the sales number of the 1990s, the number in this "boom" phase was still small. Boom rather refers to a relative development, to the rapidly growing number of small heat pump companies and to the euphoric expectation.

Yet, policy measures and activities of the 1970s and 1980s were obviously not sufficient to prevent stagnation and even decrease of HP sales in the early and the late 1980s (also caused by decreasing oil prices). At the beginning of the 1990s, following barriers hindered a further diffusion of heat pumps: high investment costs, higher energy costs as compared to other heating systems, scepticism of owners and investors as well as of architects, planners and installers, and awkward and patchy approval procedures to tap water and ground as heat sources (Rognon, 2006). Moreover, most of the Swiss electricity utilities were indifferent or even opposite against heat pumps. Installers and builders, mostly small companies, were reluctant to collaborate with public authorities and large utilities. And last but not least, the general public and public advice centres were rather little informed about heat pumps and the latter rather advised against them. Hence, a coherent set of policy measures that tackle these issues on the public, technical, economic and informative/educational level was necessary.

According to Rognon (2006), the periode between 1990 and today (2008) can be structured into several phases, see Table 1. As from 1993, market development takes off. Several policy measures from the public sector and actions from the private sector made the strong growth possible. To a large extent, these factors were coordinated and complemented each other, as Rognon (2006) and Rognon (2008) pointed out. Also, policy measures changed over time as they were adjusted technical, institutional and economic developments.

At the Swiss Federal Office of Energy (SFOE) a position that was simultaneously responsible for research, development, technology transfer and market development (Rognon, 2006) was created and a heat pump promotion programme was initiated. In 1993, as a result of a two years' process which was driven by a representative of the energy authority of Canton of ZH and mediated by the SFOE, the Swiss Heat Pump Promotion Group (FWS) was constituted to coordinate market forces. FWS started from an existing structure of the region of Zurich and involved heat pump producers, distributors, installers, some leading electricity utilities sector and cantonal authorities and a professional marketing company (Zogg, 2008). The responsibility of FWS grew over years. From the beginning it was the goal to reduce public funding over time. Since 2001, task sharing has changed and FWS is defining action plans whereas SFOE is accompany and supervising FWS' activities (Rognon, 2006).

Âlso, quality control was an important issue in the early 1990s. Accordingly, a test centre was created in 1993 (even before FWS was officially constituted) in Winterthur-Töss, mostly on the initiative of the same persons and institutions that founded the FWS. After some scepticism and reluctance, heat pump companies agreed to test their products which increased confidence of the heat pump technology in the market place. Also in 1993 a public subsidy programme for heat pumps in existing buildings was initiated. In relative terms, the sales increase significantly (by about a factor of two), but after the subsidy period in 1996, sales was reduced again (see Figure 2). Although the subsidy programme did not have a tremendous impact in absolute terms (about 800 units sold per year), it was seen as a catalyser for market development (Rognon, 2006).

Interestingly, it was an outsider of the sector who played a prominent role in the whole process of constituting FWS and the Test centre: Ms G. Brugger, representative of the energy authorities of Canton of ZH, was neither technician nor salesman, but a lawer and as a female she was an exception in the field

In the period of consolidation between 1996 and 2000, marketing activities were reinforced (in 1996, the first HP exhibition took place), some subsidy programmes and special electricity tariffs were launched and professional education and training was improved, All these activities were important for creating a common "Branch gefyl". Moreover, boundary conditions were improved, e.g. in the case of approval procedures.

In 1997, the canton of Zurich, one of the leading cantons in Switzerland, legally restricted the share of non-renewable energies for heating and hot water purposes to 80% of the allowed useful energy demand per square metres for the case of new buildings. Subsequently this requirement was implemented also by most other cantons. The requirement could either be satisfied either by additional insulation, the use of wood or solar energy or by using heat pump. Since electrically driven heat pumps[11] were a cost-effective option to satisfy the requirement, this legal measure represents is one of the strongest policy measures for the promotion of heat pumps. To a certain extent, the creation of energy-efficiency and housing comfort quality label "Minergie" in 1997 was a further driver of using heat pumps. The Minergie concept has supported the use of heat-pumps, the use of heat pumps facilitates to satisfy the Minergie requirements (through a set-up that is similar to the mentioned the building codes). Note however that the number of Minergie houses is much smaller than the number of heat pump units sold.

A further driver of heat pump deployment was the significant market consolidation in the first half of the 2000s. (fewer, but larger companies, increased degree of industrialisation) The number heat pump companies was from about 40 reduced to 15 and manufacturing was displaced by a more industrial-type production. Small producers end their own production and rather buy form abroad, particularly from Germany.

All these developments enabled a significant decrease of costs (see subsequent section). As a result, heat pump systems are not an alternative but rather the reference heating system in the case of new buildings.

[11] Electricity was weighted by a factor of 2, but with an seasonal COP of more than 2, energy-efficiency improvement were nevertheless possible..

Table 1 Phases of heat pump development and deployment and policy action in Switzerland. Based on Rognon (2006), Rognon (2008), Zogg (2008).

| **Phase** | | **Policy action and market development** |
|---|---|---|
| 1973 - 1989 Enthusiasm and dis-illusionment | | 1974 (?): first guidelines of the Swiss Association for Refrigeration<br>Around 1980: heat pump testing facility at EPFL<br>1980: Foundation of AWP: Association of producers and suppliers<br>1981/82: start of field testing, supported by NEFF and SFOE Early<br>1980 ongoing: know how and experience transfer through conferences<br>1980s: testing of commercial HP, funded by Swiss Authorities |
| 1990 - today The success story | 1990-1992 First steps | 1990: Launch of Energy2000 (general promotion programme of SFOE)<br>1992: Draft of heat pump promotion programme as part of Energy2000 |
| | 1993-1995 Bundling of activities | 1993: Formation of Heat Pump Test Centre (WPZ) in Winterthur-Töss<br>1993: Formation of FWS: Swiss Heat Pump Promotion Group<br>1993 to 1996: Subsidy programme for heat pumps in existing buildings |
| | 1996-2000 consolidation | 1996 to 2003: Heat pump field tests, initiated by SFOE<br>1996: first heat pump exhibition (trade fare for the general public)<br>1997/1998: HP subsidies from some electricity utilities<br>1997: max. 80% of heat and hot water of new buildings may be covered by non-renewable energies in the canton of Zurich<br>1998: Creation of HP quality seal DACH (Germany, Austria, Switzerl.) |
| | 2001-2005 Industrialisation | 2000: Launch of SwissEnergy (follow-up programme of Energy2000)<br>2001: FWS gets more independence through a framework contract<br>2001 to 2005: significant market consolidation (fewer, but larger companies, increased degree of industrialisation)<br>2003: market share of HP reaches 50% (case new single family house) |
| | 2006-2010 Path to independency | 2006 ongoing: number of sold heat pumps reaches number of oil and gas heating systems (whole market of new and existing buildings) |

AWP: Arbeitsgemeinschaft Wärmepumpen (Working group heat pumps)
EPFL: Ecole Polytechnique Fédéral de Lausanne (Swiss Federal Institute of Technology in Lausanne)
FWS: Fördergemeinschaft Wärmepumpen Schweiz (Swiss Heat Pump Promotion Association)
NEFF: Nationaler Energie-Forschungs-Fonds (National Energy Research Founds
SFOE: Swiss Federal Office of Energy

To summarize the analysis, the period between 1990 to today can be called a success story of a public private partnership. A significant market transformation on the technical, economic, institutional and societal level has been achieved.

## 4. Market transformation in Sweden and Switzerland

As described, market of heat pumps developed over time in Sweden and Switzerland. The development was to a large extent initiated and also supported by the oil crises and high oil prices. Policy interaction has however been important in both countries. In this chapter, we will discuss how the different policy instruments have affected the introduction of heat pumps; we will specifically discuss how policy instruments have affected technology development, cost reduction as well as the involvement and development of actors´ role.

***Technology development***

The development of heat pumps in modern time, i.e. the 1970s and onwards has been supported by different kinds of policy instruments. In Sweden, continuous research since the 1970s has been a major driver for technology development. The R&D program was an important stabilizer for discontinuous incentives. The boom in heat pump sales in the early 1980s, supported by generous subsidies, led to development and installation of heat pumps with technical problems. It resulted in poor reputation of heat pumps on the market. In the mid 1980s technology improvements was supported by research funding, but it was not until the early 1990s` Technology procurement program that the market took off again. The Technology procurement program focused on quality and reliability and required third party testing of the prototypes. The Technology procurement program managed to restore and re-establish the credibility of heat pumps on the market.

As a result, in the early 1990s, the increasing demand for heat pumps called for immediate action to assure quality and services as well as to provide more protection to consumers. In order to guarantee the performance of ground source heat pumps, the whole system was to be assessed, i.e. heat pump product, installation process (including installer) and drilling process (including the well itself). The Test Laboratory of the Swedish Energy Agency started proof checking on heat pumps; these continued over the years (1995, 1999, 2002, 2003, 2004, 2005, and 2006). Moreover, The Swedish National Research and Testing Institute (SP) began performance testing. In 2005, SP together with Swedish heat pump market actors developed a quality label for heat pumps: “P-label” (SPCR 130) that sets requirement on the product function, documentation and continuous control over the production process (SP, 2005). Normbrunn-97, the Swedish energy well standard sets requirements on the installation of the geothermal system: borehole, equipments and competence of the drillers. Competence of drillers and installers, being recognized as a key component of the ground source heat pump system, is also assured by a voluntary certification scheme, which was initiated by The Swedish Institute for Technical Approval in Construction (SITAC) and can be obtained from SVEP from 2006 onwards. SVEP together with EHPA (European Heat Pump Association) organises certification courses for installers. However, there is still no requirements set on the drilling itself, namely that the installation of the entire heat pump systems has to be carried out by certified installers.

The experience from Switzerland also indicates the need of a test centre to assure quality and support technology development. In Switzerland the Test Centre in Winterthur-Töss, founded in 1993, has supported technology development: Due to testing and education at the Test Center, heat pump companies obtained incentive to increase the energy efficiency of heat pumps which indeed has significantly increased up to 1996. An improvement could be observed for all considered HP types (heat sources Water, Borehole or Air). The Coefficient Of Performance (COP), which is a measure for energy-efficiency, increased from about 3.5 by about 0.8 (brine-water), from about 2.5 by about 0.9 (air-water) and from about 4.4 by about 1.1 (water-water) which is equivalent to an

improvement of 23% (brine), 36% (air) and 25% (water) respectively.[12] To a certain extent, also the quality seal DACH provided some incentives to suppliers to satisfy some minimal efficiency requirements. However, since 1996, the increasing trend is much lower than before (see *Figure 3*).

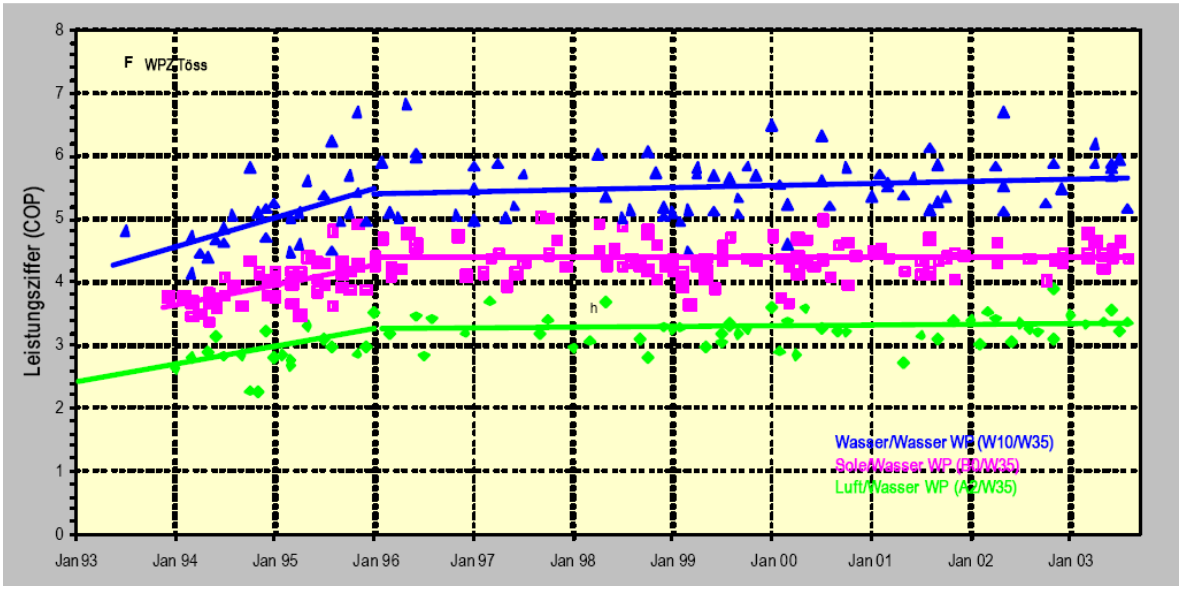


*Figure 3 Development of measured Coefficient Of Performance (COP) at Töss Test Centre in Switzerland. Source: WPZ-Bulletin [translations: Wasser: water, Sole: bringe; Luft: air; Leistungsziffer: coefficient of performance]*

The results form Switzerland also show that quality assurance is an important element of market success. Whereas conventional heating systems (oil, gas, wood etc.) are still more or less reliable and provide sufficient heat even in the case of low product quality (specially if over-dimensioned as it used to be common), this might not be the case for heat pump systems. Even if actual cases poor quality might have been low, further market development was hindered by the induced dented reputation. As such, quality assurance and improvements are important elements of effective policy instruments. Due to decreasing sales figures as from 1988, the Swiss electricity sector and other actors founded and funded a test centre where heat pump companies could give mandates to test their products. Consequently, test results were an import sales argument and it helped to increase sales figures again (together with other policy measures).

It should be mentioned that testing activity is a driver for quality assurance, but that market may still fail and deliver non-functioning heat pumps. Between 2000 – 2003, 26% of the installed ground source heat pumps reported to have some faults (Snaar, 2004). In 2003, there were 3 712 heat pumps announced as malfunctioning in Sweden (Svensson, 2006)[13]. A continuous guarantee for quality checks, technical guidelines, contractors' certifications, quality labels and awards can boost market penetration, but not necessarily

[12] In 2006, the market shares of HP was as follows: air-water HP: 55%, brines-water HP (borehole heat exchangers): 43%, water-water HP: 3% (Source FWS).

[13] However, these are mostly air-to-air heat pumps not included in any quality program. Good sing is that the share of reported malfunctioning ground source heat pumps has started to drop.

protect the industry and the consumers against poor quality and insufficient longevity of geothermal heat pump systems.

***Cost development***

The increase in sales of heat pumps in Sweden and Switzerland has provided opportunities for cost reductions. In Switzerland cost reduction is reflected in strongly decreasing consumer prices for ground source heat pumps for the case of new single family houses, see *Figure 4*. Costs have been reduced by more than a factor of two. In the early 1980s, total costs for heat pump systems were almost twice as high as compared to fossil heating systems, but currently, HP investment costs are in a comparable range. Important drivers of cost reduction were economies of learning and experience and economies of scale (mass production), not only for heat pumps as such, but also for borehole drilling (for instance, capital costs of drilling systems could be distributed to more clients). Further important drivers for cost reduction are the technology development and the market reformation in the early 2000s when the number of HP producers and suppliers was significantly reduced. The reduction of the number of producers made it possible to improve and rationalize the production. Moreover, parts of the heat pumps are now imported and thus cost less to produce.

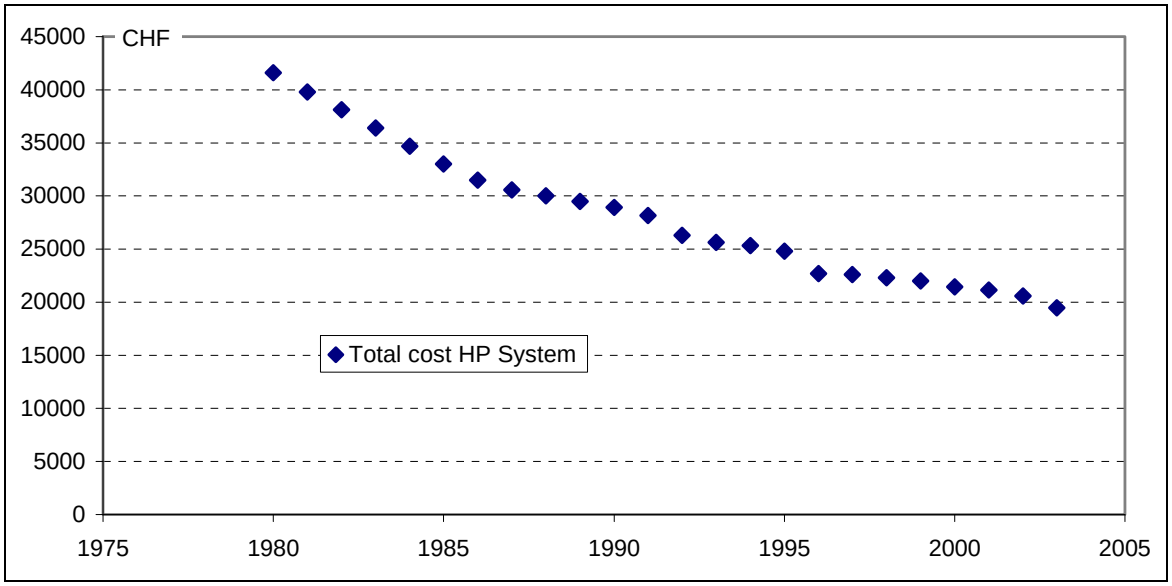


*Figure 4 Estimated total cost development of HP systems using vertical borehole as a heat source (example new single family house, including drilling and installation costs). Source: FWS (2008).*

In Sweden, the consumer prices of heat pump systems have been slowly increasing even though the production costs of heat pumps are said to be dropping or at least not growing in the past ten years (Andersson, 2007; K. Persson, 2007) (see Figure 5*)*. In the beginning of the 1990s, the total price of GSHP installations was around 80-90 000 SEK. That time, there were much bigger heat pumps installed, sometimes up to 15 kW per house. Since then, heat pumps have become more effective; today the average size of a heat pump per house is 9 kW (K. Persson, 2007). The total installation cost of such a GSHP is in the

range of 120 – 160 000 SEK. Figure 5 represents the cost development of the heat pump product, excluding the cost of borehole drilling and installation. The only price decrease over the years that can be clearly identified is a slight drop in 1995, realised through the requirements of technology procurement program. In all, consumer price of HP shows a fairly stable level until the end of 1990s and an increase from the beginning of 2000.

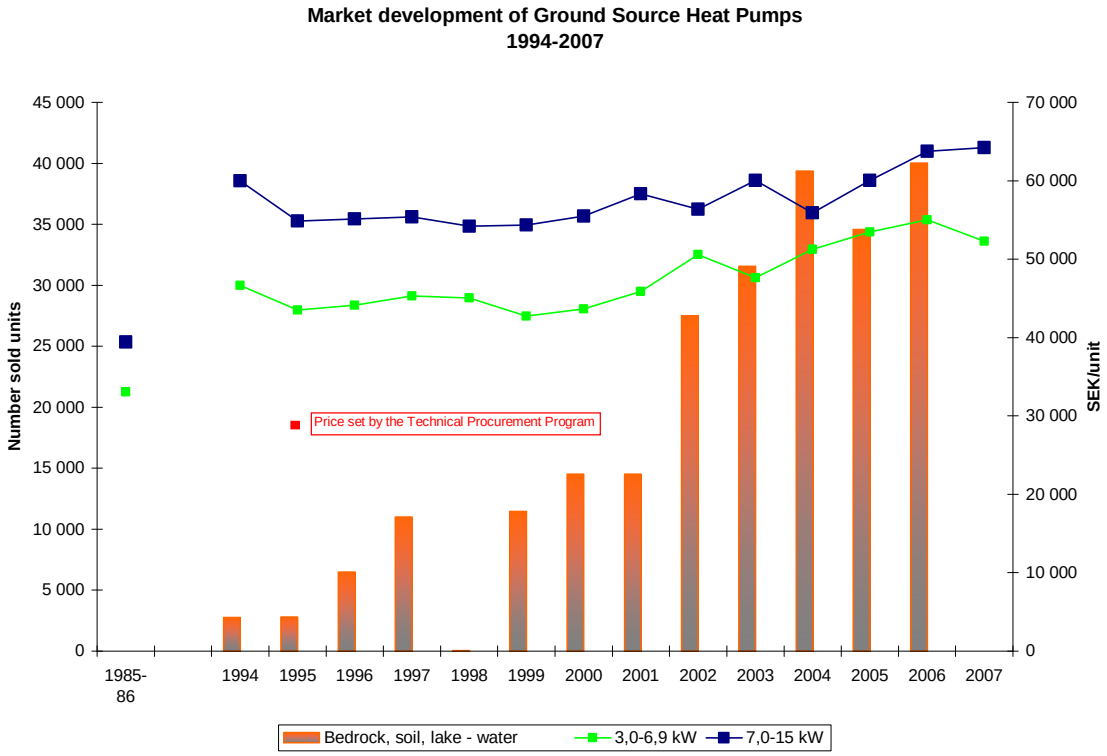


*Figure 5 Cost development of ground source heat pumps in Sweden. (Based on figures obtained from Energimyndigheten and Konsumentverket and interviews)*

Box 3 Distribution of cost of heat pump systems in Sweden

The cost of GSHP:s consists of three components: 1) the heat pump, 2) the drilling and 3) the installation; thus the total cost depends on factors such as effect- and energy demand of the building, the capacity of the heat pump required, the geographical site of the building (type of bedrock/soil, groundwater level and water flow, depth of soil on the bedrock) the distance to other heat pump installations, etc.

Depending on these aspects, the heat pump itself represents between 33-55% of the total cost. The size of the installation is one of the most determining factors when it comes to cost division. In case of a larger investment (500 000 SEK), the heat pump can be as little as one fifth of the total installation cost. In 2007, the price of a bedrock GSHP was between 44 000 - 97 000 SEK (including VAT) depending on the size and the different fittings included. As approximately 80% of the heat pump cost relates to components, such as the compressor and the heat exchanger, raw material prices have a considerable influence on the total heat pump cost.

Drilling cost depends on factors such as the depth of the well, the bedrock and the soil type and can vary between 11 000 – 75 000 SEK (inclusive VAT) (Energimyndigheten, 2006). The cost of drilling covers disposition time, human resources and investment costs of drilling equipment. All these components, including human resources are costly; however due to the traditional competence in borehole drilling in Sweden, effective drillers can drill one well (i.e. 120 meter) per day (K. Persson, 2007). Drilling

equipments are also pricey – drilling machines together with van and compressors can be around 4 million SEK.
The installation cost cover amongst others competence in installation, own costs, local costs, employees, overhead, sales locals, etc. Competence has become a relevant factor when setting the consumer price of entire heat pump installations (T. Persson, 2007). Since 2006, certified installers are available on the market.

The cost development of heat pump systems should be looked at from a) system and b) market perspective. Beyond the constant rise of consumer prices in Sweden, both stands the increasing price of raw materials, such as copper, stainless steel and brass – the components of heat pumps made of – as well as different means of price setting, by integrating fittings (e.g. as hot water tank) in the consumer price. Drilling and installation activity, that takes two third of the GSHP installation cost, due to (certified) expertise and costly manpower value. Looking at the price increase from a European market perspective, Switzerland has now reached that price level Sweden has set a decade ago. Sweden is a considerable exporter of GSHP:s to the European market; a lower consumer price setting might have destroyed the importer national markets, including Switzerland.

***Development of actor and network***

As described in the text above, the boom in the early 1980s supported the introduction of many actors for the production and sale of heat pumps in both Sweden and Switzerland. Most of these were small and locally working. Due to lack of experience, technical problems occurred for many heat pumps being installed. As a consequence, heat pump sales stagnated and the market almost collapsed.

In Sweden, the subsidies in the 1970s and 1980s did support the involvement of actors as well as networking and interaction of local actors such as heat pump manufacturers, retailers, driller and installation suppliers, buyers (households), research organizations, authorities, certifying bodies and test institutes. The subsidies were, however, fragmented and uncertain. In 1985, the withdrawal of the subsidy (and drastically reduced prices on heating oil) resulted in the market collapse. Uncertainty in length and size of subsidies limited manufacturers to long-term investments in technology development. The fragmented subsidies led to poor quality heat pumps and disruption of market development. In the mid 1990s more than 90% of companies left the market (Törnell, 2007) – this in turn decreased the trust of the costumers since there now was a lack of personal for maintenance.

In the 1990s, the technical procurement incentive opened up for a revival of heat pump technology and market development. The procurement program initiated reliable standard for heat pumps in combination with subsidies. As a result of the procurement programme the market of heat pumps started to develop again. This time, and as a consequence of end-users demand, “all-in-one contractors” were developed – taking responsibility for the entire heat pump installation process (design, installation, and start-up). In the past years, the Swedish heat pump market has stabilized; there have been four larger established manufacturers dominating the market, covering 85-90% of the total sales (K. Persson, 2007). Due to the few manufactures and the development of “all-in-one contractors” competition is very low. This may be one explanation for high prices.

In Switzerland the market of heat pump stabilised in the 1990s. A major driver of the subsequent take-off was the establishment of several organisations, such as a test centre and of the promotion group FWS, which supported the assurance of technology quality and networking between actors. Moreover, the market development was supported by subsidies, and marketing activities such as general information campagns, HP exhibitions, publicity and training programmes. The establishment of organisations for networking in Switzerland has been very important for market development; Rieder (2003) identifies the development of 13 important organisations (Scherer, 2006).

## 5. Concluding remarks

The study indicates that R&D was important for long term knowledge and technology development - but not enough to assure quality when the market boomed in the 1980s. The boom in the early 1980s invited new actors with lack of experience, which resulted in malfunctioning systems and high maintenance costs. This, in turn, deteriorated the reputation of the heat pump heating systems. When the subsidies were terminated in the mid 1980s and oil prices were reduced, the market collapsed. It was not until test, certification and collaboration processes were developed and formalised that trust in heat pumps started to increase again. To support quality, Sweden and Switzerland has come to develop testing system for heat pumps, education and certification schemes for drilling companies, drillers and installers. Due to an emphasis on quality assurance in the early 1990s, the market of heat pumps started to grow again. This market development was partly further supported by subsidies and the establishment of several organisations supporting networking between actors. In the 2000s, the heat pump market in Sweden and Switzerland is stable (and in Switzerland still growing), with a limited number of well established actors. To summarize, the market was not only transformed in technical, economic and institutional terms, but also in terms of attitude of involved actors (builder-owner, owners, architects, planners/installers, utilities, authorities, advisers) and their perception of heat pumps.

Altogether, technology and market development have provided opportunities for cost reductions. In Switzerland, it has led to reduced consumer prices; however, in Sweden consumer price has increased. In Sweden, the price of heat pumps has increased over time, with an exception of the early 1990s when the technology procurement program required heat pumps with a reduced price. The reason for the rising consumer prices could be discussed. One reason may be the high installation and drilling costs (see distribution of cost in Box 3), as well as the cost of the highly required competence and expertise behind. Another may be the high demand in both Sweden and on the European market and the generous subsidies applied in Sweden in the 1990s and 2000s. A third reason may be the fragmented subsidies resulting in disruption of market development. And fourthly, the extension of national markets to European ones that calls for competitive price settings.

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