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# The use of heat pumps in Norwegian homes: Accounting for the comfort rebound effect.

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Working paper CREE:

**“The use of heat pumps in Norwegian homes: Accounting for the comfort rebound effect.”**

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**Abstract**

In quantitative studies by SSB Norway, a rebound effect has been detected after households have installed a heat pump. In this paper we use an interview sample with 28 households to attempt to identify and interpret changes in practices that may have contributed to rebound in electricity consumption after a heat pump is taken into use. The results show that a comfort rebound effect (direct rebound) is at work in two specific senses. First, what we refer to as the temporal rebound occurs as people expand the time period in which they heat the home (both daily and seasonally). Second, we identified a spatial rebound as users expand the total space of the house heated after heat pumps are taken into use. We point to a general attitude among many of the respondents that these changing practices were justified because of their investments in and anticipated savings from the heat pump. Finally, we found that people did not keep a close accounting of money saved by the heat pump nor could they associate any particular investment or purchase with the savings. This lack of accounting by the users makes it difficult to pin down indirect rebound effects.

**Keywords:** Temporal and spatial rebound, comfort, convenience, practice, practical knowledge, expert knowledge

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## 1. Introduction

The 'rebound effect' is a term used to characterize a paradox or anomaly in energy savings policies and programs: the purchase and use of an energy efficient appliance seldom leads to the anticipated reduction in household energy consumption. Research efforts on why there is rebound in consumption and whether there are ways to avoid or diminish the rebound have most often been conducted from an economic perspective, looking at costs, reinvestment and substitution effects of a purchase. In this paper, we explore rebound from a practice perspective. Drawing on research conducted in the greater Oslo region in 2012 and 2013, we focus on Norwegian households who have installed a heat pump and interrogate the ways in which home practices are affected. How and why do practices change, and specifically what are the causes of rebound in energy consumption? We begin with a brief review of theoretical approaches to studying rebound, giving attention to an approach grounded in social practice theory. We then discuss our methodology and give a summary of findings. We conclude with tentative thoughts on the implications of our study for energy savings policy.

## 2. Theoretical approaches to rebound

The concept of rebound can be traced back to the work of Jevons in the 19<sup>th</sup> century. He wrote that in a capitalist growth economy, money saved as a result of reducing the direct energy costs of energy-using technologies and equipment would be invested in other energy using products or practices, the net result of which is a decline in anticipated energy savings or even an increase in energy use. This so-called paradox has been a ghost that has haunted energy savings policy from its inception after the oil embargos of the 1970s. A persistent and overarching goal in this policy domain has been to encourage the diffusion of energy efficient technologies. However, empirical evidence from the 1980s and onwards suggested that the Jevons paradox is at work in spoiling energy efficiency gains (for reviews and examples see Brannlund et al. 2007; Sorrell et al. 2009; Turner 2009).

Whereas one can discuss the rebound effect at the macro-economic level, where in fact rebound in a growth economy is regarded as positive, it also occurs in places where energy is consumed and where it is presumably saved through the installation of energy efficient equipment. There is widespread agreement among those who have researched the consumption rebound effect that it takes two forms. The direct rebound effect is used to describe the situation when money saved from the installation of an energy efficient technology such as an efficient heating system is used to buy more of the same service, such as heating more floor space or increasing the thermostat setting. The indirect rebound is when the saved money is used to finance some other energy using activity, such as purchasing other appliances or travelling more.

According to a recent review of the rebound literature by Dutshke et al. (2013), there is widespread agreement that these rebound effects exist, but there is disagreement regarding the dimensions of the rebound and next to no

direct evidence as to what people actually do when they rebound. Furthermore, most of the research on consumption rebound has focused on transport. Very few studies have focused on inside-the-home rebounds, and these have mainly had an economic framing, examining price elasticities as well as other price and income effects associated with rebound (Thomas and Azevedo 2013; Frondel et al. 2012; Fouquet and Pearson 2012; Biswanger 2001). Aside from economics, the main contributors to studying rebound have come from social psychologists, who have examined the role of changing attitudes, norms and social behaviors in fostering rebound (de Haan et al. 2006; Hofstetter et al. 2006; Dutschke et al. 2013).

In this study, we approach rebound from a social practice perspective, drawing on efforts over the past decade to apply practice theory to an understanding of home energy consumption. These efforts draw on work by Bourdieu (1977) and Giddens (1984), revisited and renewed by Schatzki (1996) and Reckwitz (2002), and applied specifically to energy consumption by Warde (2005), Halkier et al. (2011) and Wilhite (2013). This framework allows for the development of new perspectives on consumption in domesticated environments (Warde 1996; Southerton and Shove 2000). A practice framework acknowledges that people are not interested in energy per se, but rather the services that energy provides (light, heat, comfort, convenience, cleanliness), the demand for which is strongly influenced by cultural practices and social norms (Shove 2003; Wilhite et al. 1996). The perspective emphasizes the role of lived experience in a socio-cultural space (the home). Practical knowledge is embedded in the regular interactions between people and their built environment, forming dispositions for future practices. Drawing on earlier work by Mauss (1935) and Merleau-Ponty (1962), recent research shows how practical knowledge constitutes a competing source of agency in practices with cognitive or reflexive knowledge in the form of information and incentives (Warde and Southerton 2012). Practical knowledge is the glue that holds routines and habits together and yet it has until recently been largely ignored in sustainable energy policy.

Routines and habits can be disrupted by the purchase of a new technology, such as a heat pump, which brings its own set of dispositions (agency) for influencing practices. One can say that changes in practice are influenced by practical knowledge based on routinized behavior, by cognitive knowledge associated with the purchase decision and conveyed in the know-how transfer involved in talking with installers, reading manuals and so on, and by the “scripts for use” (Akrich 1994) embedded in the technology. These sources of knowledge and their contribution to stability or change in practices become the subjects of research in a social practice framework. Concerning the installation of heat pumps, important questions for rebound are: what are the relative influences on practices of practical knowledge (existing routines), reflexive knowledge (know-how), and technology scripts (material agency); and from an energy savings policy perspective, how can policy intervene in this process in order to minimize rebound. This latter point raises other important research questions about indirect rebound and how other household practices are affected by the installation.

To date, only a smattering of rebound studies have applied a social practice perspective. Herring (2011) advocates the use of a practice framework, but does not apply it in an empirical study. Christensen et al. (2011) used a practice approach to examine rebound effects of air-to-air heat pumps in Denmark. In a large quantitative sample they were able to identify energy savings in homes that had installed heat pumps, but the savings were far below predictions. Using data from the sample of 76 households, they found that about half of the sample reported that they ‘kept temperatures generally higher’ after installation. Also, about half of the sample reported that they used heat ‘for a longer period of the year than previous’. Interviews were done with a small sample of 8

households in order to contextualize why these heating changes were made and to identify other practices that were associated with the installation. One important finding from the qualitative sample was that heat pumps were often installed in conjunction with a larger home renovation or improvement project in which the space of the home was expanded. The Danish study provides tantalizing evidence for the power of a practice perspective to elicit new knowledge about rebound. However, the qualitative sample was small and the ambitions limited regarding indirect rebound and the changes in non-heating related practices. In our study, an effort has been made to both broaden the scope of the study of changes in practice associated with heat pumps, and to give special attention to the ways that heat pumps affect comfort practices.

### 3. The research design

Our empirical data derives from 28 in-depth interviews with Norwegian households conducted in their homes. We also draw on conversations with an installer of heat pumps. Of the 28 households, 25 of them had owned (or used) the heat pump for at least a year. Two of the families were visited during the period when a heat pump was in the process of being installed and one family had just recently moved into a home with a heat pump. The respondents were interviewed in two rounds. In the first round, participants were recruited through a national survey that had been conducted by Statistics Norway (SSB) in 2009.<sup>1</sup> A letter of invitation for interview was sent to all the 97 respondents in the SSB-survey who had reported having a heat pump and who lived in Oslo or the neighboring county Akershus. The participants were informed that they would be given a gift card worth 500 NOK as compensation. Based on this procedure, 14 families in Oslo and Akershus responded and were interviewed in their homes in January and February 2013. Putting these together with the results of a test interview conducted in Oslo, there were altogether 15 first round interviews. The second round of 13 interviews was accomplished in June and July 2013.<sup>2</sup> Two of these families (in Oslo) were recruited through a supplier, and the remaining 11 families were recruited through our research assistant's social network, though none of the interviewees are related to her personally.<sup>3</sup> 4 of these families live in Vestfold (ca 150 km south of Oslo) and 7 are located in Trøndelag (5-600 km north of Norway, in the towns of Namsos and Trondheim).

The interviews were conducted in people's homes and lasted from 30 to 90 minutes.<sup>4</sup> After asking for general information about family size, type of dwelling, duration of residence and time of acquisition, the interviewees were invited to explain their motivation for purchasing the heat pump, how and from whom they had learned how to use it, and how they interact with the heat pump in daily life and in various seasons. We also focused on how this type of heating practice relates to the former means of heating their home, how the heating pumps are being used in combination with other heating sources, as well as other routines and concerns such as comfort,

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<sup>1</sup> The Norwegian Survey of Consumer Expenditures for the year 2009 and an additional questionnaire concerning energy consumption (Halvorsen and Larsen 2013)

<sup>2</sup> In this round, one of the researchers participated during the first interview, and a research assistant conducted 12 interviews by herself.

<sup>3</sup> We do not consider the link between interviewer and interviewees in these cases as having caused a problem with regard to the validity and reliability of the data. On the contrary, as the transcripts revealed, and a point generally recognized in qualitative research; establishing a good relation in the interview setting enhances the probability for making respondents relax, be interested and openly share their views.

<sup>4</sup> The interviews were recorded and transcribed.

time management and convenience. The potential for economic gain was discussed, including how people spend the extra money if they manage to save energy. While bringing up these topics for discussion, we sought to follow up people's opinions and reflections in an open way. We obtained gender specific data and touched on wider issues such as their degree of environmental concern and views on energy policy.

Participants were aware that we were researching from an energy savings perspective and this might have led them to bias their answers. We tried to compensate for this by asking both open-ended questions and questions that demanded a specific response (e.g. Do you sometimes turn off the heat pump? When? At what times during the day and over the year? Why/why not?). Also, we invited participants to be reflexive. Towards the end of the interview we explained the direct rebound effect and asked the interviewees to comment on the hypothesis that savings from the heat pump might lead to increased indoor temperature or other increases in energy use, the responses to which we discuss below.

Table 1 provides a summary of the sample's general characteristics. All the families in the sample live in some form of detached house with a chimney, thus having access to the use of wood (oven or fireplace). In addition to using electricity for running the heat pump, almost all respondents have and use electric floor heating cables in bathrooms (and in a few cases also other rooms) and electric resistance ovens in several rooms.

Characteristic		No	Percent
Geographic location	Oslo and Akershus	17	61 %
	Vestfold	4	14 %
	Trøndelag	7	25 %
Type of home/building	Detached	26	93 %
	Semi-detached	1	3.5 %
	Flat in detached house	1	3.5 %
Type of tenure	Own	27	96 %
	Rent	1	4 %
Time of acquisition of heat pump/ moving into home with heat pump	Installation phase/just moved	3	11 %
	1-2 years	8	29 %
	3-5 years	12	43 %
	6-15 years	5	17 %
Type of heat pump	Air-to-air	22	79 %
	Air-to-water	2	7 %
	Geo thermal, water-to-water	4	14 %
Gender of respondents	Male	4	14 %
	Female	8	29 %
	Both male and female	16	57 %
Age of respondents	20s and 30s	6	21.5 %
	40s and 50s	13	46.5 %
	60s and 70s	9	32 %
Small children living at home	Yes	15	54 %
	No	13	46 %

Table 1 Selected characteristics of the 28 families interviewed. The figures show the number of families and percentages of the total sample.

## 4. Respondents' explanations for why they purchased a heat pump

Overall, the feature of the heat pump most appreciated by Norwegian families in the study was its capacity to provide increased heating comfort. To many, this comfort consideration tended to override financial considerations, though many carefully weighed the costs and thought about potential savings while deciding to buy the pump. However, compared to their often stated economic rationale for investment, economic aspects were rarely in focus when families recounted their experiences with the pump. Although some kept a record of how much energy they used and might have saved (see below), none of our respondents were able to tell us what the saved money had been spent on. "It all goes down the big drain", was a typical statement. This absence of an overview over how potential savings might have been spent makes it difficult to assess *the indirect rebound effect*, i.e. what kinds of consumption increase resulted from money savings attributable to the pump. Our analysis will focus on *the direct rebound effect* and how people's uses of the heat pump affect their energy-using practices.

Three families had moved into a house in which a heat pump was already in place. Looking at the 25 families who had purchased<sup>5</sup> a heat pump, seven (28%) were concerned with getting rid of the oil-heated system<sup>6</sup>. Some of them mentioned that they expect oil-based heating to become banned in Norway in the near future<sup>7</sup>; many said they had been concerned with high and shifting fuel oil prices; and others said they felt comfortable shifting from fossil to renewable heating sources for environmental reasons. Aesthetics and safety were also given as reasons for removing the oil heaters. An interesting observation is that many people viewed the possession and use of a heat pump as defining them as green and providing a rationale for increasing their use of heating energy. One woman said: "It's very special to feel like being environmentally friendly and staying in a house heated to 23 degrees." 48% (12) of the 25 families had introduced the heat pump in conjunction with a home renovation (11 families) or the construction of a new home (one family). Three of them had expanded the physical space of the home in the process, which partly supports findings from the Danish study accounting for the rebound effect. Another two families had poorly functioning heating devices (old wood oven and Eswa electric cables in the ceiling) which needed replacement. Only seven families, i.e. 28% of those who purchased a heat pump, had kept the existing structure of the house and simply added the heat pump to be used in combination with (and partly substituting the use of) electric resistance ovens (*panelovner*) and wood stoves. The motivation for the remaining 72% families who made major changes was multifaceted, as indicated above. Some had felt "forced" to change the heating system either because of perceptions of forthcoming regulations, because their old technology was considered inappropriate/costly/useless and/or because they were in a phase in which larger changes were desired. Potentially, of course, thinking about investing in a heat pump may also have triggered a demand for initiating a renovation project. The accounts we received nonetheless underscore that heat pump installments are

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<sup>5</sup> The investment cost for air-to-air heat pumps tended to be approximately 20-25 000 NOK. For the other heat pump systems (water carried heat), the costs had sometimes included new floors, thus the exact cost of pump and drilling was difficult to establish, but 70 000 to 150 000 NOK were sums that were mentioned.

<sup>6</sup> Either centrally located oil burners with radiators or paraffin stoves.

<sup>7</sup> Through Enova, a public enterprise owned by the Ministry of Petroleum and Energy, the Norwegian Government has launched a campaign and intends to phase out the use of oil burners in Norway by 2020. See Enova 2013.

often associated with larger renovations involving an expansion of the size of the home. The expanded space obviously demands more heating energy and is a source of rebound.

Four families gave purely economic reasons for buying the heat pump, emphasizing its potential economic profitability. Another four referred solely to the need “to get warmer” (*få det varmere*) or to obtain a more stable temperature, thus referring uniquely to comfort. Most often, respondents gave a mix of reasons, spanning from comfort to convenience (“it’s easy to use”) to financial matters when explaining why they had obtained their heat pump. It was clear from our interviews *that comfort plays at least an equally important role as financial considerations* when people decide to acquire a heat pump.

## 5. Practical knowledge associated with comfort, convenience and safety

Most of the families in the study had previously used wood stoves or fireplaces to provide additional heat during cold periods. We found that heat pump owners continue to use wood stoves, though less frequently. However, there were many complaints about the lack of comfort offered by wood-based heating. Many respondents pointed to the discomfort associated with starting a fire on a cold winter morning or when returning to a cold house from work, because it took time to prepare the fire and for it to produce heat. The temperature is difficult to control with wood based heating, and several respondents pointed out that the house often got overheated. One family who normally keeps the air-to-air heat pump on at 23 degrees day and night compared the heat pump with wood heating in this way: “[with the heat pump] it’s easier to control the temperature because with wood either its cold or its damn hot.” Similar complaints were made about the former oil burner: “It would become too hot inside and we were obliged to open the windows for relief.” Many referred to the cozy atmosphere provided by wood stoves and fireplaces. However, when having guests over, several respondents found that the heat from wood-burning would become uncomfortably high: “it looks quite good with the fire on, but it’s not a good way of heating when you’ve got guests”. One family was pleased with their modern wood stove/fireplace enclosed with a glass cover, which produces so little heat that they may use it even when having many guests over.

In terms of convenience, several families highlighted the time and effort they had had to use fetching wood from the outside while at the same time trying to attend to other tasks, such as cooking and attending to children. Similar comments were made about the hassle people had experienced when filling up the oil tank and organizing the supply of oil. With regard to small children and their comfort, one elderly couple said that the heat pump enables their visiting grandchildren to wake up to a reasonable temperature for watching television on week-end mornings. They had previously had to wake up early to start the wood-stove.

In sum, the most important qualities of the heat pump for most of the families interviewed are the added comfort and convenience, as well as added safety for those who formerly relied on wood and oil. Compared with the relatively physically demanding set of tasks of starting and attending to a fire, the heat pump’s remote control function is considered easy to handle. Nonetheless, apart from the cases where oil systems were replaced, people continue to use wood stoves and electric resistance ovens, though to a lesser extent than before. It is precisely the *combined* use of heat pump and other heat sources which is perceived to provide a new, flexible heating system. Many households continued to use the wood stove on really cold days. A few emphasized the quality of the heat

pump to distribute the hot air from the stove to other parts of the house, highlighting how the two heating technologies jointly produce the desired level of comfort. Many also use a mix of electric heating sources, for example as indicated in this quote: “I keep on the electric floor heating cables in the entrance at given temperature (controlled by a thermostat), and these will turn off automatically when the pump has provided a satisfactory indoor temperature in the whole house.” This resonates with Annette Henning’s (2005) finding from Sweden where people stressed the importance of being able to rely on various sources which together provide a high degree of heating flexibility.

## 6. Temporal rebound

The shifts in practices referred above reflect that the families who have heat pumps tend to keep a higher average indoor temperature in the winter, particularly during the night and when the house is unoccupied. Some also refrain from turning off the heat pump or reducing its thermostatic setting when going away for week-ends or even longer periods of time. Although most of our respondents denied that they now keep a higher indoor temperature, the reported higher temperatures during night time and when not being at home, imply that a rebound effect has been at work. This “denial” reflects that people are more conscious of the peaks (which have not increased) rather than average temperatures (which have increased). Although a few households reported that they keep the heat pump on all year round, most of our families claimed they have not extended the heating season after having obtained the pump. This contrasts the Danish study and the SSB study in Norway, where people reported to have extended the heating season. In our material most people said that they tend to start the heating season in September and turn off the heating in May, but the usage also depends on shifting outdoor temperatures. Some also heat their houses in the summer. In Trøndelag, for example, the outdoor temperature was 11 degrees at the time of the interviews (in June), and the heat pumps were working. As mentioned, five families (18%) in our sample (all living in the Oslo area) said they use or will use the heat pump for cooling in warm periods, and this summer heating is responsible for an increase in total energy consumption. More significantly, because it involves nearly all the families, the concern for avoiding cold mornings and afternoons leads to an expansion in total daily heating time. We refer to this expansion of heating time as *the temporal rebound effect*.

## 7. Spatial rebound

“It’s the circulation of the air”, one of our respondents answered when asked to explain why he appreciates the heat pump. The pump had been installed 5 years previously during a major renovation of the house. He said he had obtained the pump for purely economic reasons, and when asked whether environmental concerns played a role in the decision he answered no. He believes he might have saved 10 000 kWh per year (current consumption 28 000 kWh) compared to what he would have used on panel ovens and cables uniquely (he also keeps a fireplace). He later added that he often leaves the laundry to dry in front of the heat pump which is located in the living room with an open connection to a large kitchen. He said that the main advantage of the heat pump its

capacity for distributing the heat to all the rooms in the house. Many interviewees pointed out that they liked the circulation provided by the pump, as well as the dryness of the heat produced and the general air quality. A few expressed that the heat pump delivered ‘clean heat’ compared to a wood stove.

The issue of circulating air was brought up and appreciated by most of our respondents, both as a quality in itself and because the circulation is considered to be cost-efficient. For example, one man said: “this is different from the resistance ovens where one gets the try, burned heat. This [the heat from the pump] is a very nice heat”. In addition, one family who was about to install a heat pump highlighted the advantage of keeping the doors open between the bedrooms during night-time so that they can hear their young children waking up in the middle of the night.

The only family in our study who was not content with the circulation function was an elderly couple living in a very old house with many small rooms. They also found the direct flow of air from the pump in the kitchen to be uncomfortable and unhealthy (stiff neck) and they mostly used the pump during night when grandchildren were staying over. Before they retired, they had mainly used the pump during the day when they were at work so that they would return home to a decent temperature in the kitchen. But their overall assessment was that the house was not really suited for a heat pump because the air could not be distributed efficiently.

Air-to-air heat pumps are designed for distributing hot (or cold) air to relatively large spaces in an efficient way (cf. script). In contrast to wood stoves and electric panel ovens, which our interviewees referred to as “point sources” that provide intense heat in close approximation to the source, heat pumps are also designed to transport the heat. During installations, the positioning of the device (indoor and outdoor parts) is therefore the most important issue, and installers and users are concerned with placing the pump in a central place in the house (thereby deploying cognitive knowledge associated with the new item). Homes designed with open solutions (e.g. open space between kitchen and living room) are perceived to be well suited (i.e. fit with the heat pump’s technology script). Thus people who consider renovating and know they will be installing a heat pump, have an incentive for choosing open solutions. As confirmed by many of our respondents, the air-to-air pump initiates a practice of keeping doors open between rooms, such as between kitchens, living rooms, entrances and bedrooms, especially the doors to children’s rooms. An important change in heating practice associated with the air-to-air heat pump is *an expansion in dimensions of the heated space in the home*.

This expansion in heated space is a practice that contributes to rebound. We refer to this expansion as *spatial rebound*. Together, the increases in daily heating (temporal rebound) and in the amount of heated space (spatial rebound) demand increases in energy use. These shifts contribute to a change in the ways people establish heating comfort, which underlines the general observation that perceptions of comfort are dynamic and culturally contingent (Wilhite et. al. 1996; Shove 2003). Illustrative of this point, one respondent, who was about to have a heat pump installed, reflected that her parents “go crazy when seeing that all the doors are left open and it becomes cold”. She grew up in the same house, and said she could not remember the house having been as cold as it is today. “It must be something about the way we use the house” she reflected. At the same time, she insisted on their need to keep all the doors open because of their concerns for the children while also complaining that the cold house “makes it embarrassing when people visit and ask to borrow woolen socks”. Another man also acknowledged a generational difference in terms of comfort: “When my grandparents used to

live here they kept as many doors closed as possible because they only wanted heat in the place they were sitting. So it would become really hot. But we are more used to things being open. It [home space] is supposed to be open and accessible . That kind of generation.”

The examples of situations when people deal with the pumps and remote controls illustrate how the physical characteristics of the heat pump *together* with people’s own considerations and experiences (practical knowledge) contribute to forming the new heating practices. The close thing-person relationship was also sometimes reflected in people’s way of speaking about the pump. They often seemed to assign a substantial amount of agency and personal attributes to the pump itself, for example: “It will sometimes go wild”, “it makes some noise, but we have become accustomed to it”, “it is a friend”, “my sister calls her pump Fredrik”. Moreover, at least to the researchers speaking the Oslo dialect, the grammar of the dialect spoken in Trøndelag further underscores the agency aspect of the device, making it seem even more like a person. Here people would use masculine, feminine or neutral indefinite articles depending on the gender of the noun. Because people regard the “pump” as feminine, they would refer to the pump as a “she” when telling us about how the pump behaves.

## **8. Cognitive knowledge communicated by the installer, the manual and other people**

Two external sources of knowledge were particularly important to our respondents in their decision to purchase the heat pump and in their everyday interactions with the pump. We found that social networks were crucial in the phase where people were considering the purchase. Among those who had installed a pump, all but two confirmed that they had talked to and received advice from other people in their network, spanning from sons, brothers and other relatives to friends, neighbors, colleagues and handy-men with whom they were already familiar. The issue for discussion not only seemed to have centered on whether heat pumps are good or not, which is probably related to the fact that heat pumps have become rather common (approximately 25% of Norwegian families keep heat pumps today). The topics for discussion had also been the characteristics of various heat pump models, such as which models are best suited for temperatures below minus 15 degrees.

The person installing (and maintaining) the heat pump, together with manuals (what Akrich 1994 refers to as “de-scription”) constitute the main sources of cognitive knowledge. We know from observing a couple of installations that the person checking the premises and mounting the device might not spend too much time explaining how things work and what people should do with the heat pump, but this person nonetheless seems to influence the user patterns in significant ways. The most striking example of such influence concerns the issue of what constitutes a technically optimal usage of the heat pump. Should it regularly be turned on and off or should it run all the time (either by adjusting the temperature manually/automatically or keeping a constant temperature)? The following dialogue is illustrative:

- Question: So that means you keep it on twenty three day and night?
- Wife: Now we do, yes.
- Husband: And that was recommended too, he [the installer] was quite clear on that, “you don’t mess with that, you just find your temperature and let it work on its own”.
- Wife: According to him, it would mean more, um – it would use more electricity than we would save by regulating, because...
- Husband: It would use quite a lot of energy to speed up the temperature when you have turned it down. So he said “Well if you’re going to leave for a week or two then you can turn down the temperature. But you shouldn’t do that during the night because it will use too much power in the morning to get the temperature again.”

Following the advice, this family and many others in our sample keep the temperature constant during the heating season. Others would say that they manually lower the temperature at night and increase it in the morning (very few use a programming function). What many of these families shared was an explicit reference to the installer having advised them to follow such user patterns, which underlines the significance of this type of expert knowledge. Moreover, the technical advice of not “messing” with the temperature matches people’s stated appreciation of the even temperatures and increased comfort provided by the pump. In short, they lean on the expert technical advice when legitimizing everyday habits. It was beyond the scope of this study to technically assess the effect on consumption of regularly modifying the temperature versus letting it remain constant.<sup>8</sup> The issue also appears unclear among suppliers promoting heat pumps.<sup>9</sup> As one of our respondents pointed out, the conclusion would probably depend on a range of factors such as outdoor temperature and the amount of insulation. Uncertainty on this question discourages people from experimenting with lowering the temperature. This technical uncertainty together with a reluctance to learn how to program shifting temperatures strengthens the potential for rebound.

## 9. Savings

When accounting for the potential for savings of using a heat pump, many referred to what they had heard generally: “they say that you may save one third of the costs”. On the whole, most air-to-air respondents seemed confident that the investment cost would be paid back before the end of the pump’s lifetime. The installer we

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<sup>8</sup> Without technically having assessed the issue, we presume that turning on and off or reducing temperatures at night time and when leaving the home for several days leads to less energy consumption than letting the machine run constantly.

<sup>9</sup> The Norwegian Heat Pump Association (Norsk varmpumpeforening, NOVAP) gives contradicting advice on this matter. On one of their home pages they refer to ENOVA’s calculations for potential savings (factor 2,4), and write that “Models which have timer controlled temperature setbacks consume less electricity than those with only a thermostat) [http://www.varmepumpeinfo.no/besparelse\\_for\\_varmepumpe](http://www.varmepumpeinfo.no/besparelse_for_varmepumpe) On another page NOVAP write that they consider it optimal to keep a stable temperature day and night and point out that daily temperature increases may cause damage to the heat pump. <http://www.varmepumpeinfo.no/content/varmepumper-demper-energibruken>

spoke with said that before installing a new pump in a home, he always discusses the potential for saving electricity with the customers. He normally presents a graph showing how much time will elapse before the investment is paid back. Several of our respondents referred to such calculations made by the supplier (ranging from 3-5 years for air-to-air heat pumps), and in the many cases where they do not keep track of consumption, they would use such standardized “expectations” for savings when telling us (and their peers/themselves) what they think the economic benefit has been. Some of our interviewees did keep track of their consumption, though, and the costs connected to their former heating sources are of course the reference for calculating savings: Some of those who have *reduced their consumption of wood and oil* think that their electricity consumption has risen or stayed the same. Three families who had reduced *wood and electricity consumption* presented numbers on how much electricity they have saved, ranging from 15% to 30% in reduced consumption. One of these families stated clearly that the only reason for getting the heat pump had been to obtain “more heat”, so they have not been zealous about tracking saved electricity and costs.

Many of our interviewees often had a *feeling of saving* – rather than concrete evidence for doing so – as a consequence of using the pump. For example, an elderly couple who has a geo-thermal heat pump (they invested 120 000 NOK) showed us their electricity bills (1300-1500 NOK/month) and said it would probably have been doubled had they used resistance heaters. When we asked how many years they think it will take to pay back the investment, they smiled and said that they do not know, the woman adding “No, but I feel that it has been profitable all the time.” Another man who invested in an expensive geo thermal system reasoned in a similar way. He said that due to the new heating system they have reduced electricity consumption by 15000 kWh per year. However, because they purchased the heat pump at the time of constructing the house, he considers the investment as embedded in the bank loan they took for covering the general project and not as a separate energy-saving investment. Thus when asked about the pay-back time, he turned his attention to the mortgages/bank payment which has a 25 year period: “So you know, 125 000 NOK over 25 years is not too much per month. So I think the saving came instantly.”

With reference to “what they had heard” about the potential for saving, it was interesting to note that a couple of respondents were critical to the general claim that heat pumps lead to saved energy and money. One man has colleagues who work with energy. He said that he thinks that the savings potential of heat pumps is over-estimated. Another respondent said she had read an article about the SSB-study on the rebound effect and that she is a little skeptical about the potential for saving that is normally claimed. She is among the few in our study who turns the heat pump on and off on a daily basis. Another family who was about to install a pump referred to the potential for saving while also explicitly acknowledging the potential comfort rebound: “Potentially, we expect a 50 percent reduction of costs, but this will probably be eaten up by increased comfort”.

When heat pumps are promoted in Norway, suppliers claim that one may reduce electricity costs by 35% by shifting to this heating device. Reducing costs is presented as the most important argument for purchasing, and in making the calculations the heat pump is thought to simply replace other electricity consuming heating sources while providing a similar service as before (if also a potential cooling service). As a result, one expects energy

savings in terms of reduced electricity consumption and costs. This line of reasoning is presented in the top of Figure 1.

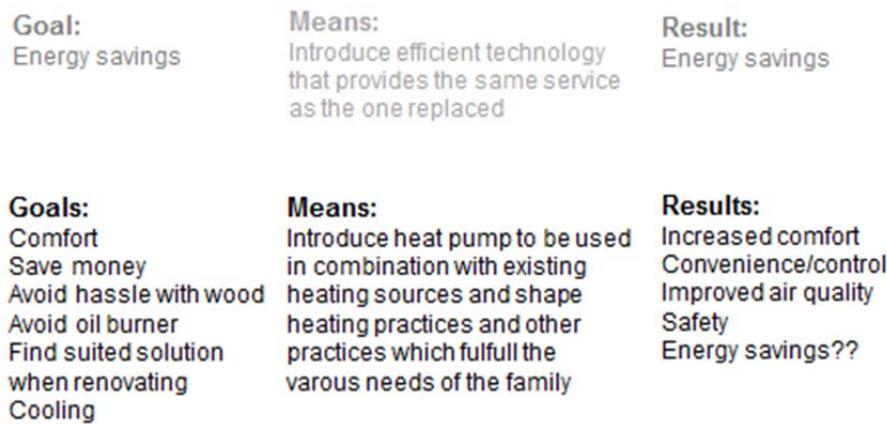


Figure 1 The role and purposes served by heat pumps in people’s homes

However, what the presented material has shown is that people’s motivations for obtaining the pump are multiple and include a range of concerns such as comfort, economy and other aspects (Figure 1, highlighted at the bottom). An interesting finding in relation to economic rebound is that very few of our respondents could pinpoint how they used the money saved from the reduced energy costs. And quite strikingly, when assessing how the heat pump has affected everyday life, the issue of comfort is further highlighted while economic factors are mostly downplayed or left unexamined (though sometimes represented as a “feeling of saving”). We have sought to disentangle the motives and ways which people take heat pumps in use, that is, the ways heat pumps form part of – and modify – the social practices into which they are integrated, whether related to heating, time management, drying clothes, attending to children’s safety or other routines and concerns. Far from observing energy saving as the main drive and result when adapting heat pumps, the families we met socially organize the heat pump and other technologies to make them fulfill their various needs.

## 10. Conclusion

Through the analysis of 28 in-depth interviews and observations of the placement and uses of the heat pump in people’s homes, this paper has sought to develop new perspectives on the rebound effect. We have identified two main changes of practice that are all generally related to improving comfort. First, there is the spatial rebound, the extension of the total space of the house that is heated. Second, we identified a temporal rebound, which implies an extension of heating time.

Approximately half of our families introduced the pump in connection with a major house renovation. The embedding of the heat pump purchase in a larger renovation camouflages to these users how much energy they might have saved by replacing other heat sources with the pump. Also important with regard to spatial rebound, the embedded agency of the heat pump, what we have referred to as the script for use, has observably affected

practices. The air-to-air heat pump is designed to produce and transport /circulate air to function optimally, thus it favors open solutions during renovations and encourages the practice of keeping doors between rooms open constantly and heating (or cooling) larger volumes of space. This effect of the script is strengthened through the advice and information provided by installers and it also matches people's preferences for an extension of comfort through the capacity to move from one room to another without experiencing any parts being colder than others. The new type of comfort is even associated by some families as best suited to the younger "free" generation in contrast to members of the older generation who were content to sit next to point sources of heat and to keep the doors closed.

The practical knowledge derived from previous heating practices ("I used to hate entering the cold entrance foyer") is important to the shift to heating more space. Thus we see how three sources of agency; the heat pump's script, the appeal to expert knowledge associated with the information accompanying the pump, and the practical knowledge people possess together shape the transformation to this new heating practice that involves a larger heated space. We see a clear spatial rebound in that the potential gains from saving electricity by using a more efficient technology is eaten up by the expansion in heated space.

The temporal rebound effect involves using energy for heating (or cooling) during an extended period of time. When coming home to the house or waking up in the morning, the families appreciate entering space with a comfortable temperature instead of having to endure a cool house while waiting for the optimal temperature. People appear to be in a hurry to be comfortable. As a result, most families let the heat pump run constantly in cold periods, including when going away for a week-end or even longer. Similar to the spatial rebound, the socio-technical script of the pumps contributes to providing this shift, but here the script for usage is more open to interpretation. It remains an open question also to the authors whether turning on and off (or lowering the temperature at night time) in cold periods leads to less consumption or not, or if permanent heating is technically optimal. As we have indicated, on their home pages, suppliers provide conflicting technical advice on temperature setback. This naturally leads to uncertainty on what is the optimal temperature setting procedure. Most families conclude that keeping a constant temperature (for longer or shorter periods) is technically optimal, in addition to providing the desired level of comfort.

As a third, residual category, which we may label "multi-purpose rebound" we clustered other relevant considerations and practices which also contribute to increased energy consumption. In the presented material this included attending to children at night, maintaining safety and air quality, and conjoint practices such as drying clothes. Contextual factors will always affect the concerns that may potentially drive (or reduce) energy consumption. Another observation confirmed in the present work is that energy consumption is socially conditioned (e.g. thinking about children, grandchildren and guests) and that perceptions of comfort are shifting and culturally contingent (e.g. generational variation). Gender relations and intra-household dynamics have not been examined in the present work, but are also likely to affect household consumption patterns (e.g. Henning 2005, Winther 2012).

In terms of the potential for promised savings of energy and costs, the results from this study underline that the potential for saving electricity varies considerably between different types of users depending on their existing heating practices. Not surprisingly, the potential for saving electricity was low or negative amongst families who

shifted from oil or mainly wood to heat pumps, and highest among families who replaced electric resistance ovens with heat pumps. The latter shift is what is presumed in the information promoting heat pumps. In our sample, where only a few reported to know the reduced amount of electricity consumption resulting from the use of the heat pump, many developed new heating habits involving the expansion of the home's heated space as well as the time period for heating, thus rebound seemed to occur in most cases.

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