IEA DSM TASK 24 Subtask 2 report - NORWAY

Implementing large-scale energy efficiency measures. The case of Finnfjord AS

IEA-DSM Operating Agent Sea Rotmann being shown around the heat recovery plant by Finnfjord CEO Geir-Henning Wintervoll. Photo: Henrik Karlstrøm

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Introduction to this study

This report details the process within a large Norwegian SME, Finnfjord AS, as they decide to implement an innovative energy efficiency technology scheme involving the reuse of excess heat and off-gases from the ferrosilicon production process to produce electricity locally, as well as the interaction with Norwegian energy efficiency authorities (Enova) as they try to balance the twin but sometimes opposing concerns of fair support for risky innovation and designing good incentives and subsidy schemes for energy efficiency measures. The goal is to present some lessons and difficult trade-offs for Subtask 2 of the IEA-DSM task 24, "Closing the Loop – Behaviour Change in DSM: From Theory to Practice". The data detailed here comes from in-depth interviews with representatives from Finnfjord AS, conducted on a field trip to their ferrosilicon processing plant in Finnsnes, as well as through an in-depth interview with a representative from the Norwegian funding agency, Enova. Additional information has been gathered from the web pages of the company and Enova.

The report details the process from the initial decision to go forth with the project to the point when FInnfjord were able to produce 15 GW from its own internal power plant. It also points out some possible points of contestation for future policies for providing incentives for similar projects at other ferrosilicon plants. First, the report gives some background information about the heat recovery project, before presenting contextual factors to be borne in mind when assessing the case. Then it presents the case in light of the International Energy Agency's Demand Side Management framework for behaviour related energy efficiency programmes, arguing that a more organizational approach yields better results when analysing firms than more individually oriented behaviourally based ones. Finally, it discusses a controversy that arose between Finnfjord and Enova about the nature of Norway's subsidy schemes before concluding with a nice story.

The Finnfjord heat recovery project

With the aid of a large grant from the Norwegian energy efficiency agency, Enova, Finnfjord has recently installed a new heat recovery plant to convert excess heat from the smelting process into electricity, which has resulted in a 35 % reduction in electricity consumption. At a total cost of about € 120 million (of which about € 20 million was provided by Enova), the project was costly for an SME, even for one in an extremely high-revenue industry like the ferrosilicon industry. It had cost overruns of about 15 % and a year's delay, speaking to the complexity of the project.

The industrial process of ferrosilicon refinement produces an enormous amount of heat, which must be vented out to avoid damaging the equipment. Traditionally, this has been done by simply funneling it as fast as possible out of the smelting plant by running it through water-cooled pipes and then releasing it into the air. Finnfjord's proposition has been to use the excess heat from the ferrosilicon production for electricity production in a boiler plant located next to the factory building. This way some of the heat can be put to productive use before being released, which again both reduces the plant's reliance on buying electricity, their operational costs, and contributes to reducing their carbon footprint.

This section gives a short introduction to the company and the project they implemented in terms of concrete details on the size and scope of operations.

Concrete details of the project

Years: 2007-2013
Name: Finnfjord AS
Country: Norway
Geographical scope: Northern Norway
Type: project

About the company: Finnfjord AS is a Norwegian ferrosilicon processing company operating a plant in Finnsnes, which is located in the second-most northern county in Norway, Troms:

Location of Finnfjord AS

The somewhat unusual location for a semi-large industrial operation, far from core markets and in a municipality of only 4000 inhabitants, is due to a combination of factors: a nearby hydro-electricity power station, guaranteeing abundant and cheap access to one of the main production factors in ferrosilicon production, electricity; a tax regime that favours industrial development in the northernmost regions of Norway; and the fact that Finnfjord is a family-owned business where the grandfather of the current CEO started the plant in his home town in the years after WWII.

Finnfjord is one of the few ferrosilicon plants operating in Norway that is still owned by Norwegians, as most others – including those originally owned by the state company responsible for such operations in post-war Norway, Hydro – have now been bought up by international actors. The company employs around 125 people, most of whom are from the area around Finnsnes, making it a cornerstone enterprise in the local area and one of the largest industrial actors in the whole of the northern region of Norway.

Ferrosilicon production requires an enormous amount of energy, and Finnfjord is responsible for about half of the electricity demand of the entire county of Troms as well as well over half of its CO2 emissions – a point of some political contention in the region. This means that there is a vast potential for energy efficiency measures to reduce the demand for electricity and hence free up scarce hydropower resources for other industrial, commercial or residential use.

Inside the ferrosilicon smelting plant. Photo: Henrik Karlstrøm

Available resources for the project: Out of the company's workforce, about half were at some point directly involved in the construction of the new heat recovery plant, while all employees were affected by it, as the construction of the new plant required the moving of several on-site workshops and some of the administrative offices (as well as the waste processing facilities of the company). In budgetary terms, the total costs of the project took up some 60 % of income for the company on top of the subsidy from Enova, meaning it represented a substantial risk for the future of the company should the investment not pay off.

Preparation, implementation and evaluation: At a board meeting in 2007, the board of directors of Finnfjord AS decided on a new formulation of the company vision: to become the world's first carbon neutral smelting plant. Considering that this industry is extremely energy intensive and with large off-gas residues from production, the goal is certainly a hairy one. In order to reach this goal, a planning group was set down to examine all parts of the company's operations in light of potential energy efficiency savings and emissions-reducing measures. A list of potential projects was compiled, and the heat recovery was the first project to be initialized from it. Having completed the heat recovery plant, Finnfjord are currently working on implementing other EE measures on a smaller scale.

The new heat recovery system required the construction of a whole new building onsite (see photo on the next page), as well as the design of a new type of boiler[1]. The initial cost estimate was for about NOK 850 million (€ 108 million), of which Enova were to provide a grant of NOK 175 million (€ 22 million). Construction started in 2010, and was finished in May 2013. Due to technical complications during installation the project ran over time and ended up having a cost overrun of more than NOK 100 million (€ 16 million).

The installation of new boilers and the pipes that go to and from them required a restructuring of the entire operational area of the plant, including tearing down a workshop building and the reconstruction of this in a different location on the plant premises. The work itself took place over a period of more than 18 months, not including planning and post-installation fine-tuning.

[1] Delivered by the Danish engineering company Aalborg Engineering: http://www.aalborg-engineering.com/en/projects/steamgen-10-projects/107-finnfjord.html

Inside the new heat recovery plant control room which is attached to the main production plant. Photo: Henrik Karlstrøm

During the building phase, large parts of the company had to adjust to changes in their daily operations, with several buildings being demolished and new ones being erected elsewhere on the company grounds. Ferrosilicon production is a 24-hour production cycle, with any stop in the system taking days of cooling and re-heating for simple maintenance tasks on the equipment and any unexpected stops being costly and time-consuming. This means that the new boiler equipment had to be constructed next to the factory building while the plant was in continuous operation, only to be connected and started up during one of the yearly routine maintenance shut-downs of the plant. In the meantime, employees were relegated to temporary arrangements and sharing cramped office spaces.

How did this affect the working environment and employee satisfaction at Finnfjord? Internal evaluations done by Finnfjord point to a general satisfaction with the new operative and administrative arrangements among employees[2], and with heat recovery and electricity generation targets being met

[2] Here it must be pointed out that this is based on the interview done with management, so it is possible that another version of this story exists among the employees. However, nothing we encountered during our field visit

just a few months after start-up, the energy efficiency part of the project (after all, the most important in this context) seems to be covered.

Enova also reports that they consider the Finnfjord project a success, and have entered into negotiations with other ferrosilicon companies (most notably, Elkem) to setup similar subsidy schemes for projects that aim to utilize excess heat to produce electricity on-site and hence reduce general demand. This has led to some tension between Finnfjord and Enova, more on which later.

Behavourial model: With a project of this size, involving hundreds of people in a multi-year project, it is difficult to speak of behavioural models on an individual level. However, any project such as this one requires the cooperation of the entire organization in order to stand a chance of meeting targets and successfully implementing the required measures, and this again relies on the active participation of various layers of the organization and a successful interaction between management and the general workforce who are the ones training for and actually implementing the new measures once they are put in place. This points to the importance of bringing energy efficiency into the company culture itself, which in turn strengthens the use of an energy cultures perspective in understanding how energy efficiency can be implemented in SMEs and other enterprises.

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points to any dissatisfaction regarding these matters or the energy efficiency project itself – rather, people directly told us about their satisfaction with finally getting modernised office locations.

Theoretical model

This section provides a rough analysis of the integration of theoretical models underlying the supporting actions of the Norwegian energy efficiency authorities and the actual implementation of this specific project. The key question in the IEA-DSM Task 24 work is how changes in energy use can be related to questions of people's behaviour (and, furthermore, how behaviour can be changed to affect changes in energy use). The literature on behaviour change largely focuses on individual actions and how these can be affected by an outside intervention.

With a large workforce and a mostly automated energy efficiency system, Finnfjord is not an obvious candidate for behaviour change analysis. It would seem that there are too many individual behaviours to relate the behaviour literature to this context. However, institutional change will seldom be effected entirely top-down; it requires the enrolment of support from all levels of an organization. Reluctant or outright hostile employees can sabotage the most carefully planned change in corporate culture or workplace habits.

Work done within organizational sociology on the role of institutional expectations points to the way mobilising towards shared goals can help increase internal support for reforms or organizational changes (Borup et al. 2006). In the parlance, shared visions and goals are said to be *performative*, in that formulating a new vision can have an effect on the actions of employees in itself, if management can garner support for the new vision.

This ties into the initial decision of the Finnfjord board in 2007 to become the world's first carbon neutral ferrosilicon plant. While the new heat recovery plant is mainly a technical question and not something that relies heavily on support from employees in itself, it represents a substantial share of the company's economy and thus a liability for its continued existence. By taking on a risky project, management was effectively putting the jobs of their employees on the line, something which in itself involves them. Keeping in mind that this comes from an interview with management itself, they claimed that the project was met with great support from employees. The idea that they were part of making their workplace a greener, more energy efficient place seemed to go over well.

The role of Enova

While the actual implementation of and most substantial financial investment in the energy efficiency measure was the responsibility of the company itself, it would not have come about with an active support policy on the behalf of Enova. Their stated overall aim, formulated in their government mandate[3], is to maximize the reduction of energy demanded both in industry and the commercial and residential sectors with the minimum amount of money invested (as well as introducing new energy technologies to the market and the increased uptake of new recyclable energy). The focus on kWh per NOK is a constant reminder of the importance of identifying new areas of achieving energy efficiency through minimal investments. Of course, financial support ranging in the millions of euros for a single project does not exactly constitute a minimal investment, but considering the size of the demand

[3] Which can be read here: http://www.enova.no/innsikt/rapporter/resultatrapport-2012/4-rapportering-pa-energifondet-2012-/enovas-hovedmal/enovas-hovedmal/589/1362/.

reduction that would potentially be effected, it was considered a viable support scheme from the perspective of the Norwegian government.

The intervention also has a less outspoken goal of addressing the reasons for a perceived lack of what is basically a cost-efficient and hence economically rational policy for companies in similar situations as Finnfjord to pursue. Why aren't more companies in internationally competitive fields working harder to reduce one of their main costs of operation? From an organizational perspective, the situation can be ascribed to a behavioural problem of management. It is easy to get stuck in tried and true ways of operation, and potential avenues for achieving increased efficiency – and thereby profits, as long as one has a head start on the competition – will go unexplored. It is also not uncommon for companies to display a certain risk aversion in testing out new methods or technologies.

In terms of concrete goals and targets for the intervention on behalf of Enova, it can be said to be directed at effecting a market change in the context of large energy demanders with a hitherto undetected potential for energy savings. If by making an initial investment of some size the government can help reduce the demand for electricity by a substantial amount over a long period of time, this would prove a clear success story of and case for both the specific mandate of Enova and for government intervention in demand markets in general. This in return would help justify the reason for Enova itself.

Another clear goal for Enova is geared towards replicability of the project. If the project model can be exported to other companies within the same sector, and potentially to other similar sectors, then the initial investment will seem to be both smaller and less risky in the eyes of the main funders, i.e. the Norwegian taxpayers. Hence, the target group of the project, while initially limited to a single company, can in an expanded sense be said to be all SMEs that operate within

Barriers and drivers

The Finnfjord project did not come about as a clear-cut case of a company identifying ways of saving money, although that is a part of the process as well. There are several factors that play into the decision to implement the new technology, some of which can be said to be drivers and some of which are clear barriers to be overcome.

The barriers to the project were substantial. Even with a projected payback time that was considered acceptable by the company[4], the large investment would cut into company profits and hold up available funds for the short- to medium-term future. Consequently, this carried alternative costs for the company, which would have to factor in the possible other uses of their available funds.

Another barrier was the very real risk of something going wrong when implementing a novel technology of high complexity. The potential gains in terms of reducing costs vis-à-vis their competition were seen as high enough as to offset the risk, but the company management made no secret of the fact that they

[4] Finnfjord did not want to specify the exact payback time, but indicated that it was probably slightly longer than most financial investors would consider worth it, but well within a time frame that was acceptable to their type of long-term industrial ownership.

considered this to be one of the riskier decisions they have made in the last decades. For many others, this barrier might be high enough for them not to make the investment.

The final barrier is the technical complexity of the project, which of course feeds into the cost and risk analysis of the project. This type of heat recovery technology is an innovation, and the systems and technical apparatus had to specifically designed and fitted for the plant in Finnsnes. As explained, the project ended up with some delays and extra costs due to technical problems, but they were deemed as acceptable in light of their relatively minor consequences compared to the possibly much more serious ones should the project fail completely.

Among the drivers for implementing this sort of large-scale energy efficiency measure is the existence of a company leadership that was committed to implementing energy efficiency measures, and a company structure that allowed for the participation of all employees in decision processes (although it was never in doubt who called the shots in the final instance) due to the short lines between uppermost management and the general workforce.

Lastly, the availability of government support schemes that helped alleviate the risks and costs associated with such projects must be seen as a major driver in this issue. Finnfjord spent a couple of years in negotiations with Enova regarding the support scheme before starting the project, with the understanding that the project would be dropped if it was impossible to secure government support. Several detailed plans were submitted, revised and re-submitted before a support scheme that suited both parts could be agreed upon. This process of negotiation, which is not usually provided for in more standardised subsidy schemes that Enova offers to households or other commercial or retail actors, must in this respect be seen as an important aspect of this driver.

Context, methodology and limitations of findings

As with all specific cases, there are contextual factors that complicate any neat theoretical considerations. These are some of the more important factors to taken into account when analysing the Finnfjord.

Policy context

Due to its abundant supply of cheap, clean hydroelectricity, Norway has a large ferrosilicon industry which produces various products related to the purification and alloying of metals. The Norwegian government has maintained a policy of subsidising electricity to so-called power-intensive industry since the mid-1940s, both to make use of an available natural resource and to encourage industrial development.

Since the oil crisis of the mid-1970s, Norway has had a national policy for energy efficiency, first by mandating electricity suppliers to introduce efficiency measures and later through a separate energy efficiency agency called Enova. Enova do counselling and information work, but mainly act as funder of various efficiency projects ranging in scale from small grants to heat pump installation in private homes to large industrial projects like the Finnfjord one.

The main point of the subsidy schemes for more industrial or commercial projects is not to act as innovation support but rather to help ensure that energy efficiency projects that would not have gone through by normal cost-reducing efforts will be realized. While it can be hard to identify specifically whether a project would have gone through without government support or not, it is known that even in supposedly utility-maximising enterprises energy efficiency measures are not necessarily carried out, even at quickly recuperated costs.

Institutional context

Finnfjord itself is not a typical industrial company. With its 125 employees but sizable income it stretches the definition of an SME, but it is still one of the smallest such plants in the world. The output per employee is high, which can be surmised from the development over time of the company. It employs about as many people as it did in the 1960s, but produces six times the ferrosilicon it did at that time. It is also a family business, with the current CEO being third-generation operator of the plant.

The combination of small operation and family ownership means that Finnfjord is able to make decisions that more investor-based, short-term profit oriented industrial companies normally will not take, due to risk or long payback time. While this means that the company takes on a lot more risk than most openly traded companies, it also means that the organisation can respond to new developments more rapidly and is able to set other types of goals.

The innovation/implementation controversy

The project has not been without its controversial sides. While they were initially very happy with the support from Enova, Finnfjord are now voicing some misgivings they have about Enova’s policy for funding such projects. In order to stimulate new approaches to saving energy, Enova has a sum of money set aside for innovation projects within industry that carry higher risk than the usual funding schemes for energy efficiency measures. The Finnfjord project fell into this category. However, once it has been established as a viable option for other industrial companies, Enova has signalled that it is willing to approve similar projects for other ferrosilicon producers in Norway, under the pretext that this will help make the Norwegian ferrosilicon industry much more energy efficient in the years to come, something which both increases their international competitiveness and frees up a lot of cheap renewable electricity for export to Norway's neighbouring countries.

In the time since it became clear that the heat recovery project would go through without too many teething problems, Enova has changed their risk calculations of these types of projects. Because of the way their support structure is designed, this has made it possible for them to support similar projects with a larger sum of money than what they gave Finnfjord. This has, understandably, annoyed executives at Finnfjord, who took a large initial risk in order to increase competitiveness through increasing efficiency.

Enova on their hand say that it is not their job to act as funders of innovation to deal with questions regarding fair competition – they are mandated to fund projects that deliver the maximum amount of kWh saved per NOK invested. Since the decision to support a project depends on the project's score on a set of variables such as payback time, projected savings, scope relative to the size of the company's budget and risk of failure (to mention a few), a change in any of these variables will affect Enova's possibility for funding the project. In this particular case, the actual demonstration of the viability of the project that came from the successful implementation at Finnfjord made it possible for Enova to downgrade the riskiness of these types of projects. Since the risk calculations exist to provide a funder with an estimate of the actual cost of the kWh saved (risk of the project failing against the projected savings), a lowered risk decreases the projected cost per kWh.

The fallout of the conflict between Finnfjord and Enova is still unclear, as negotiations over a possible restructuring of the initial grant are still underway, and both parts are disinclined to comment too much on the process. One possible solution is for Enova to retroactively grant Finnfjord the same amount as the recently entering actors, another is to create an embargo time for other projects so Finnfjord can take advantage of their first mover status and lowered operational costs to recoup more of their initial investments.

The story of Finnfjord, and key lessons learned[5]

Once upon a time...a little ferrosilicon plant far north of the Arctic Circle decided to become the world's first climate neutral such company.

Every day...they pondered how to go about achieving such an ambitious goal – could it even be done?

But, one day...they found a way to make use of the excess heat and offgases from the production to power a power-generating steam turbine, which would produce electricity for the company, along the way reducing their demand significantly and vastly increasing efficiency.

Because of that...they struck an agreement with Enova that they would receive a grant of 125 mill NOK which would go to reducing the number of kWh used by a lot.

But then...they discovered that there were a lot of technical difficulties in getting the technology to work, resulting in a year's delay of work and a large budget overrun. Still, when it was finally started, the new boilers immediately lowered demand by a large amount, showing the feasibility of the project.

Because of that...other companies are now making use of Finnfjord's technology to improve their efficiency, but at less risk. This has unlocked more funds from Enova, something which has caused a fissure in the cooperation between them and Finnfjord, who feel they have taken on a lot of risk only to see competitors getting more support than they did.

So, finally...there was a crash between to Norwegian policies – one stimulating for efficiency, the other for innovation. And yet, the end result was very successful, with savings of up to 35 % for an investment with a payback time of 7-8 years.

5 For a description of the use of storytelling as a methodology see Mourik and Rotmann (2013).

Concluding remarks and key lessons learnt

The overall evaluation of the Finnfjord heat recovery project must be that it can be called a success. Both the company itself and the main funder Enova claim to be pleased with the result according to their evaluation metrics (mostly in terms of energy saved in relation to money invested on the part of Enova, but also in factors such as employee satisfaction for Finnfjord). This can also be inferred from the fact that Enova are looking to implement similar schemes elsewhere.

As mentioned above, the key lessons to take home from the Finnfjord case might not be the usefulness of any particular behavioural model of energy efficiency, but rather the interplay between several factors that must be in place for a project such as this to succeed:

- An organisational culture that heeds all levels of the organisation, which makes the creation of a positive energy culture throughout the organisation possible.
- Management that is willing to take on substantial risk in the pursuit of competitive advantages. This also relates to the ownership structure of the company, which allows for more long-term industrial concerns in planning than a more capital-driven form of ownership.
- A public support system which involves both the existence of subsidy schemes which see past pure competitive logics of most government dealings with business in order to realise gains that benefit both companies and public over the long term and a certain flexibility for the funders to enter into negotiations and devise flexible plans tailored to the specific needs of energy-demanding industry (which often vary quite a lot in comparison to e.g. households).

As should be clear from the nature of these factors, there are limits to this type of intervention, both in terms of replicability and transferability to other sectors. The ferrosilicon industry has certain input factors and economies of scale that do not exist elsewhere. However, the points above are general enough to be applicable to other situations, and both the point about organisational design and that about flexibility of support agency mandates should carry some weight when designing policies for energy efficiency in the future.

In terms of theoretical insights, this study demonstrates the need to be careful in relying too much on theoretical concepts at the cost of an individual approach to the empirical situation at hand. Regardless of the model employed (Enova relies on a home-cooked modification of the Theory of Planned Behaviour (Ajzen 1991) in its overall energy efficiency strategy), there must remain a sensitivity to the ways in which the model might not fully explain the factors involved.

The cost of this type of intervention is substantial, and most companies would be unwilling to undertake such a project on its own. However, the fact that Finnfjord put up more than 80 % of the final costs on its own and still find the project worthwhile points to the importance of energy as an input factor in the production process in the ferrosilicon industry and the huge potential for savings that benefit both companies and society as a whole. It also functions as a business case for this type of energy efficiency measure, which could help make Norwegian industry more competitive as well as providing the basis for growth in connected technology provider industries.

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