Constructing the Norwegian smart grids: To fix what is not broken?

William Throndsen
Department of Interdisciplinary Studies of Culture,
Norwegian University of Science and Technology (NTNU)
N-7491 Trondheim
Norway
william.throndsen@ntnu.no

Keywords

smart metering, infrastructure, actors, regulation, strategic niche management

Abstract

The first step towards the so called smart grid is currently in undertaking by most industrial countries, represented as the development and implementation of the smart meter. The smart meter will digitalize our relationship with electricity consumption, and vastly increase the amount of data as well as its resolution. The availability of this information in the energy markets is defined as the necessary prerequisite for creating the 'energy networks of the future', which among other things could ease the integration of renewables, help reduce peak demands, empower and enable end-users to make better decisions, and further integrate markets across national borders, thus contributing to a continuation of a sound social economic management of our liberalized energy markets. However, developing this new technology and implementing it in the most optimum of manners is a constant challenge, and its success will depend heavily on its utilization. This paper explores such challenges in a Norwegian context, where new regulations have charged somewhat unwilling network companies to achieve full penetration of smart meters within 2017. The empirical material is composed mainly of participatory observation and interviews at a medium-sized network company as they have been struggling to define, develop and implement smart metering. Informed mainly by a Science and Technology Studies-perspective, the paper attempts to summarize what both drove and impeded the process, and to map out the many and various actors involved in constructing the first pieces of the Norwegian smart grid. Though the decision has been made, many actors are not convinced by the largely abstract rationales for smartness presented to them, and inertia and uncertainties continue to define the situation.

Introduction

Smart metering is a hot topic in the energy industries these days and no less so in Norway, where the Water Resources and Energy Directorate, the national regulator, recently decreed new regulations for introducing AMI, or smart metering, within 2017. This stone-written decision leaves no other option for the country's strictly regulated distribution sector but to develop solutions for and implementing smart metering in every Norwegian measurement point, some 2.7 million, before the deadline expires. This has left everyone concerned immensely busy, ever since the government started making clear their intentions for full scale implementation of AMI in 2008, and even more so as the project gained momentum and a final set of regulations concerning implementation was agreed upon in the summer of 2011. However, the wording of the regulations concerning smart metering are spacious and leaves out anything and everything about the specifics of *how*. This has forced the network owners into engaging with the regulator in interpretation work to discover what the functional specifics of the regulation entail for the introduction from scratch of smart metering in a Norwegian context.

This paper seeks to gain insight into this process of regulatory and technological implementation, seen through the case of one mid-size local network owner in the mid-Norway region. It draws on empirical evidence from approximately 120 hours of participatory observation at the network owner, as well as four 1,5 hour interviews with its AMI-project members. A

number of policy and hearing documents were also part of the study. Arguably, due to the situation of enforced implementation through a regulatory framework with a deadline, the Norwegian case is somewhat unique among the many countries that are implementing AMI. Thus it becomes relevant to look closer at this as a process of policy implementation through technology regulation. Seeking to counterbalance the current overly optimistic focus on the benefits of smart grids and their meager beginnings with the roll out of smart meters, this paper will look at some challenges that have been encountered by the industry and regulator through their efforts at establishing a tentative consensus on the regulation for smart meters, and later on what this might mean for an actual integrated smart metering infrastructure. This will yield lessons of specific value to the successful implementing of smart metering in Norway, but also prove an interesting case study of how energy policy is made to perform through regulated technology deployment in the Norwegian energy sector. At any rate, it will give an insight into what happens when regulated industry is forced to enter into technology pioneering.

The following sections will first embark on a short stage-setting mission, where the most important tenets and actors of the Norwegian energy situation will be outlines. Second, a theoretical framework for understanding the relationships between innovators, regulation, and policy makers will be described. After some short methodological considerations, the empirical material is allowed to prelude a final discussion.

Setting the stage: smart metering in Norwegian

First we need to take a brief look at the Norwegian energy situation, some trends and main stakeholders. Production, distribution and consumption of energy in Norway are all defined largely by a single characteristic, namely that it is renewable. Almost all of the power produced in-land comes from hydroelectric production (NOU, 2012), and in 2010 the share of renewables in total energy consumption in Norway was around 65 % (Bøeng, 2011)[1]. The other defining characteristic is more common elsewhere in the EU as well, namely that the grid operation is a regulated monopoly, whilst the electricity supply companies are not. In the social democratic spirit common to Norwegian politics, everyone's access to power is deemed an interest of the government on behalf of the people, in a modest paternalistic tradition. Thus a comprehensive regulatory system defines the activity of both private and publicly owned network companies.

Beneath the Ministry of Petroleum and Energy several organizations have been established to manage the Norwegian energy network. The Norwegian Water Resources and Energy Directorate acts as regulator, appoints licenses for grid operation and production facilities, including the publicly owned regional operator, Statnett SF. They also work on developing regulatory matters for the government, in close co-operation with the various network companies. Grid operation is monopolized in Norway, meaning that each and one of the network companies have sole responsibility for their population. They are charged by the license to oversee grid management, distribute electricity to their consumers, and handle all grid related investments. They get their revenues solely from the network tariff, paid from consumers to the network owner over a separate bill. How much the operators are allowed to charge is calculated by the Directorate according to every network company's special circumstance (e.g. number of users, length of grid, amount of refurbishing or new construction and even geographic peculiarities). Margins are pushed by efficient operation, and the companies' performances are routinely benchmarked. The difference between spending and tariffs may then be split between the owners of the companies, often comprised of local municipalities and counties, making the local DSOs important sources of income for many areas. Thus, the individual company's revenue cap is a governing factor of any network company endeavor and, as we shall later discover, has direct implications for the Norwegian AMI project as placed in the hands of the Norwegian network owners.

Theorizing Norwegian energy policy

The focus of this paper is to explore how regulation and the technology it prescribes is performative of energy policy, and this section will introduce some theoretical framework that may help guide such an inquiry. In trying to map out how regulation puts energy policy to work in shaping smart metering technology in the Norwegian context, it is first helpful to view this case of technology development as an innovation process through interaction between the regulator and the industry. Several times such processes have been argued within the Science and Technology Studies tradition to require a non-linear and symmetrical analysis (Bloor 1973, Pinch & Bijker 1987). Latour (1987) for instance, introduces a translation model of innovation, which states that innovation processes are shaped by innovator's strategic attempts at convincing users of the usefulness of the innovation through interaction. In this sense our regulation may be considered an artifact that needs to translate into something useful to those whom it is supposed to apply to, in this case the Norwegian network industry. The interaction between the regulator and the industry has to a large degree been focused on such translation challenges, as the co-shaping of the regulation pertaining to the smart meters was the first step in defining the characteristics of the new technology. It was in a sense imperative for the regulator to make the industry see the regulation as an improvement upon what went before.

Furthermore, for my hypothesis to hold true, it could be argued that the relevant policy measures must have been translated into particular technological specifications. To this end the work of Akrich (1992) becomes noteworthy, as she has implied the importance of a non-linear characteristic of technologies in use, and argued that they must be understood as containing textual scripts, built into the design, which have implications for the subsequent reading and use of the technology. So in this way, the use of technology becomes interpretation work, but designing technology also needs to be understood as framing work, in the sense that some kinds of use and what results is more intended than others. However, unintended use through anti-programs countering the intended program may also occur. This viewpoint becomes useful both when looking at the process surrounding the shaping of the metering regula-

1. The transport sector is mainly fossil fuelled and is the largest single contributor to Norwegian CO_2 emissions.

tion, but also the subsequent and quite tangible interpretation work that takes place at the network company as it engages in the technological development process, actually quite strictly guided by fuzzy regulatory prescriptions.

Recent contributions in STS have been looking at how economic theory is made to perform on markets, shaping them in the image of economic theory ideals (MacKenzie 2006) through the introduction and use of specific tools called calculative devises (Callon, Millo & Munieza 2007). Drawing on this work Godbolt, Karlstrøm & Sørensen (2009) have explored whether or not Norwegian energy policy is in fact influenced by and as such performing economic theory when constructing users, specifically related to the process of de-regulation of the Norwegian energy market of the early 1990s, but also in dealing with energy markets and conservation in general, through looking at the energy economization policies first introduced in Norway during oil-crisis times of the early seventies, and their development up until the present day (see also Sørensen 2007, Ryghaug & Sørensen 2009). The findings were not able to conclude with any straightforward uptake by the lawmakers of the (predominantly) economic advice they were given through the processes of policy regulation, and needed to include other explanations as well. For instance, in the early days, policy maker's thinking about consumers was in fact influenced by *homo economicus* ideals, but tempered by an admission of a moral and knowledge deficit, meaning that consumers either would lack information about or how to act on price information, and that they in fact would not care about saving energy because they "lacked the virtue of thriftiness" (ibid: 11). However, the Energy Act of 1989 de-regulating the energy markets was implemented with a construction of users *predominantly* guided by the *homo economicus* ideal, supposedly supported by a short reign in government by a centre-right coalition. This ideal was met with some resistance from the left flank comprised of Labor and the Social Left Party, who called for a more paternalistic view of the consumer, emphasizing consumer's right to purchase electricity at reasonable prices. Toward the present day however, where policies again have mainly been influenced by the left (but a left that has moved ever further towards the right), yet another shift occurred. Now, a stronger focus was emphasized on the availability of energy efficient technologies through subsidies, as the energy crisis of 2003/2004 demonstrated consumers lack of response to price variation, and less confidence in the consumers conforming to *homo economicus* ideals could be traced (Karlstrøm, 2012).

In this way the authors find that the latter policy making strategy is still linked with economic rationality, but the need for the thrifty consumer is alleviated, and is instead left with concrete offers to act efficiently *in spe* through investing in more efficient technology. Arguably this implies that a different kind of performativity partially replaced the economic, a performativity carried within technological fixes. As policymakers observed that consumers were unable to respond in the manner intended by the purist *homo economicus* ideals of the market, a different strategy would be to lower the bar, so to speak, by introducing technologies that would be energy efficient for us. This solves the problem of knowledge, morals and habits that has riddled the reality shaped by economic performativity, as they relied too heavily on the contribution of the right kind of behavior from the consumer. Introducing a technological fix contributes by factoring the erratic human right out of the equation.

And thus the question arises; can the introduction of smart meters be viewed as a continuation of the latest energy policy regime, as a technological fix to make the perfect energy market? After a review of the methods employed, the following sections will draw on the empirical evidence, and look at some of the drivers and barriers towards AMI implementation in Norway, seen from one medium sized Norwegian network owner. An analysis of the rationales for implementing smart metering seen from the network owner perspective ensues to try and answer whether there are policy implications in the technology introduced. I will also explore some implications for the kinds of change smart meter implementation may have on the Norwegian energy market and their actors. If this is indeed an energy policy measure, what are its ambitions, and what could it possibly achieve?

To be able to answer the questioned above, a triangle of ethnographic methods were employed in an attempt to capture the fault lines and processes of change in one particular development process, a case study (Flyvbjerg, 2006). In trying to capture complexities in the study of the particular case, the choices of method(s) are first and foremost instructed by the case itself and a strict adherence to a single method needs to be abandoned. In this case, it was deemed helpful to engage in prolonged participatory observation, undertaken at a medium sized (80,000 connections) network company in mid-Norway from November 2011 (in the beginning of the AMI-project) to the summer of 2012 (when the final regulation draft was settled upon). The some 120 hours of observation was expanded with government and industry white papers and hearing documents, as well as four 1,5 h interviews conducted with AMI-project members and managers at this company, in the spring of 2012. In this sense, the methods employed compose the above mentioned triangle.

However, a more abstract idea of triangulation has also been advocated by Stake (2005) as incurring a triangulation of understanding, and in this way one would think he is talking about the practice of reflexivity. In this way a triangulation of understandings (and not only methods) may contribute to capturing several ways of understanding the phenomena under scrutiny, and thus is an activity that needs to be attended to regularly (ibid: 454). The point of conducting a case study is to gain experience based knowledge of what goes on in the case, and the focus remains on the case a singular thing (unlike ethnomethodology which seeks to understand the basis of constructed *activities* within a case). In this case the relevant *boundedness* (ibid: 447) encompasses the development process of smart meters in one network company.

The above mentioned reflexivity of understandings (and methods) becomes relevant for this case study, as it has been guided mainly by participatory observation. Stake (2005) describes participatory observation as the act of "placing your best intellect in the thick of what is going on" (ibid: 449). Another and even more intimate development of this method is to be found in the work of Czarniawska (2007). With her concept of shadowing she contributes a method that fits nicely into the focus on practice and the strand within sociology that calls for symmetric treatment of all processes and incumbent actors, both the human and non-human (Bloor 1973, Pinch & Bijker

1987, Latour 1987). In her mind, participatory observation is able to capture both the self-production of a field, as well as the many versions of this work, and in this way one is able to study not only the finished product as it were, but indeed the different stages of development that contributes to it. This entails looking at not only what versions are selected, but also what is not selected, or un-selected. And of course, as mentioned above, it is possible as well to shadow non-humans, often referred to as "following the objects".

Czarniawska's experience with participatory observation is particularly useful in that it focuses a lot on the problem of objectivity and the struggles with reflexivity, and she offers ways to deal with these matters in a pragmatic way. For instance, gone is the idea of the mute and invisible observer, trying not to interfere with the case and thus be able to capture it in its natural state. Still present, however, is the important challenge for the researcher to avoid "going native" and lose sight of reasonable objectivity. As she says: "A truly symmetric field-work consists, then, not of 'being nice to the natives,' but of allowing one self to be problematized in turn" (Czarniawska, 2007: 12). This allows for the researcher to interact somewhat with the actors and matter in the case study, something which undoubtedly helps toward gaining experience based knowledge. Keeping in mind the importance of reflexivity (and Stake's triangulation of understanding), it is indeed allowed to put forward one's own viewpoint alongside those of the natives, and thus avoid becoming a mouthpiece for them.

Some problems of participatory observation are related to access and the inability to be everywhere at once. In the modern day complexities of society, involving such below-radar activities as e-mail, phones, on-line collaboration tools, as well as simple things such as spatial distance, it will be impossible to actually commit to full scale shadowing, as Czarniawska well admits (ibid: 15). That is why this study also has been guided by document analysis and interviews. Not only do these methods provide answers to questions that arise in the everyday heat of the moment, but they are in turn vastly informed by the participatory and observational setting.

Implementing AMI in Norway

IT IS THE LAW FROM 1 JANUARY 2017

In 2007 the Ministry of Petroleum and Energy included "two-way communication" in their ambitions for the electric grid "in order to increase efficiency in the market and enhance metering data" (NVE 2008, OED 2007)[2]. They subsequently appointed the Norwegian regulator, the Water Resources and Energy Directorate the task of investigating the feasibility of implementing AMI[3] in the power grid, and decided on making the roll out mandatory in order that the technology developed ensured "the highest fulfillment of social economic gains". Thus the regulator made a list of specifications for AMI, implemented them in a draft of regulation 301 (pertaining to metering and calculation of consumption), and at this point set the deadline for complete roll out as early as within the end of 2013. Considered "reasonable" at the time by the regulator, this sudden change in the regulation caused a riot with the industry when released for hearing in fall of 2008, as the common view held was that it would be impossible to implement a mature technological solution in line with the specifications demanded in such a short time. Indeed, some of the technological solutions that were needed to meet the requirements of the regulation were all but non-existent. The industry's cry of distress was heard in the end, and the deadline was pushed to within the end of 2016 as the regulation was passed summer of 2011. Still, this is sooner than the EU goals for smart grid penetration, which is set to 80 % within 2020 (EC 2009). The AMI challenge presented the Norwegian network owners therefore was considered serious even by the most resourceful of them.

The fact that AMI in Norway has been forcibly introduced is a strong indicator that the Ministry, acting through the regulator, has strong ambitions regarding the AMI project which implies that in fact the Norwegian AMI project above all can be understood as a political project. As a project manager for the AMI project at the network owner stated:

> The government is definitely involved with concrete projects to take a greater part in this picture. […] The entire AMI project is a politically motivated project. It is not a profitable project from the view of the customers, at least to a certain extent it isn't […] and it is definitely not an industry driven project. It is a political resolution, made from some overarching social economic priorities […].

So it seems there are some larger political ambitions driving the Norwegian AMI project which has led the regulators, on behalf of the government, to hurry the implementation along. In this case, a mandatory deadline from the regulator has worked as an important driver, as a policy tool perhaps, in not only bringing the project to reality, but also in bringing the (slightly reluctant) DSOs together in facing the challenge. The introduction of the new regulation, demanding as it was in the outset, acted as somewhat of a common enemy to many of the network operators, who responded by pooling their resources in an offensive attempt to meet the challenge of shaping both technological and regulatory demands. Combined by Energy Norway, their industry organization, a collaborative AMI-project was established with an aim at collectively interpreting the regulatory demands and translating them into representations of an actual, integrated and satisfactory AMI solution in a Norwegian setting. As a project member stated in regards to the deadline and its effect as a driver for the Norwegian AMI project overall:

> It has definitely driven the development. The discussion about two-way-communication has been going on for at least the past fifteen years. But it's only two years ago everyone started hiring people to man projects and have them on full time, and thereby establishing a greater focus and an

2. In the Ministry's state budget proposal of 2006–2007 (OED 2007) main goals and performance measures for the Water Resources and Energy Directorate indicated that they "should continue addressing the problem of two-way communication and automatic meter reading, with the goal of implementing new technologies in the energy market." (ibid: 39). The letter of concession granted the Directorate from the Ministry for 2007 further specified that an analysis be undertaken by the Directorate by 1 June that year to examine the "possibilities of increasing the use of new technology to further efficiency and better calculation basis in the power market, hereunder two-way communication. The analysis shall also contain suggestions for measures to further the use of such technology in Norway" (NVE, 2008: 8).

3. The slightly fuzzy concept of smart metering will, for the analysis, be replaced by the slightly more specific term Advanced Metering Infrastructure, or AMI.

> understanding that AMI was not just swapping the meter or creating some communication solutions – we got, after a while, the impression that this was a very large ICT project […]. Cooperation became important. And I think the threat assessment, a common enemy, or … The challenge is so great, that it is only natural that it spurs some cooperation.

This indicates that the mandatory regulation combined with a strict and rather close deadline, has also served the purpose of setting in motion a large an inert mass of actors such as the Norwegian distributors quite effectively. This of course has created the sense of being bullied a bit, and a distinct air of grudging admission can be traced. At the simple question "why are you doing this?" a project member stated:

> [long pause] I think it is because the regulation says we must [laughs]. No, but one has to look behind it all a bit and I don't think … [pause] This is one of those questions it's difficult to answer, but if we did not have the regulation on AMI in place, would we then have a program for smart metering internally driven, which is seen through the company's strategies, business plans, and future visions – would we on our own initiative have established AMI? Personally, I don't think we would.

In Norway the DSOs have by and large been focused on keeping the present day infrastructure up and running. Introducing AMI naturally falls on them, since it is a piece of the grid infrastructure. However they are rather reluctantly facing the fact, as introducing AMI is going to be costly, not immediately beneficial, and is perceived to be a fix to something which is not really broken. So for Norway to get its AMI in place, it seems it was necessary that the government set the change in motion with a mandatory deadline. The reasons behind the strong push by the government on this issue will perhaps be more evident as the analysis progresses, although it is thus far clear that AMI in Norway probably not would have come about bottom-up any time soon.

IT WILL MAKE THE DSOS MORE EFFICIENT

It is often stated (albeit loosely maintained by network operation personnel) that AMI will provide network companies with a better information basis and wider possibilities of remotely managing the grid. This argument claims that AMI may have implications for efficiency increases in so called core activities, which pertain to managing the distribution grid, measuring consumption and collecting meter data and managing the connectivity of each point of consumption. Furthermore the potential for automation, grid monitoring and remote operation that the AMI introduces could reduce costly man hours working in the grid, which makes even more sense when considering the dispersed population and rugged topography of Norway. In this regard, the optimal and desired "outcome" of AMI implementation is a kind of self-regulating grid. Also, the denser quality of information about the grid provided to the operators by the AMI could possibly aid the network companies with the planning and development of the grid, as more information could lay the foundation for better decision making when faced with investment needs. Finally, the regulator has also signaled that they would like to see fewer network companies in the future (however, no incentives are as yet on the table). Many of the network companies in Norway today, act in large geographies with dispersed connections in the low thousands which could have implications for efficiency. One project leader explains whether or not the AMI-regulation and its heralded efficiency increase might have a "consolidating effect" on the network companies:

> It doesn't have to. But the regulator has been sending signals that it might be impractical to have that many network companies in the future. They've said as much. […] They've also said that the most expensive companies all consist of an overweight of smaller companies. […] Expensive as in less efficient. And who are then subsequently dealt lower income caps than average, which in turn might lead to an increase in the transmission tariff for the customer. […] So such companies are expensive for customers. In these cases economies of scale might apply.

In this case, it is clear that such tendencies of inefficiency are unwanted by policy wielders, who have stated that the overarching goal of AMI is higher efficiency in the name of sound social economics. However, at the moment it is highly uncertain whether AMI has clear efficiency benefits for network companies, and they will certainly not be yielded without some form of restructuring. Government and regulator tend to focus on this issue as *network benefits*, perhaps as a translation exercise, however in which manner these benefits will manifest themselves (or at all) is clearly still uncertain when talking to network operators. A project manager on the issue:

> [Network benefits themselves] are not covered by the regulation. There are no requirements for network benefits in the regulation. It yields possibilities for it, that it does, but it will be up to the individual company to be forward enough and increase efficiency or raise the quality of their services […]. And there must be a will to invest in it. And that it is to a very small extent. The bigger companies are doing it. This company, which in their statements claim they have a goal to be the most efficient, does not have a single concrete activity ongoing to create higher levels of network benefits [with AMI].

Clearly, network benefits might be a buzzword to an extent, for it is too early to state whether they will present themselves as AMI-implementation progresses. Possibly, whether or not these network benefits in fact are on the agenda will probably vary according to where and who one might ask, as different definitions of them are prevalent. One thing is clear however, and that is that they will not come around as a side-effect of AMI, and the companies themselves need to figure out how to obtain benefits using different strategies with the new technologies. However, it seems quite clear the potential is there, and as rational actors aim for higher levels of efficiency, some of it is bound to be taken out. Also, it is also a clear goal of the government initiative to make actors obtain network benefits, in order to further the efficiency of the energy market. But, as a project lead generally stated:

> Smarter grids are irrelevant for this project because AMI has been decided on and will be implemented, regardless of what we will use it for later on.

IT WILL MAKE THE POWER MARKET MORE EFFICIENT

It is in regards to the power market of Norway generally, and more specifically the political ambition for its future role as more closely embedded in the globalized power market in addition to increasing its efficiency, one can perhaps most clearly see the government in active involvement. As concrete projects on the smart grid side of power Norway goes, it is perhaps Statnetts centralized ICT-solution for meter data management that is the most relevant, both in terms of scope and determination. Statnett SF is the government company that among other things manages the transmission lines at regional and national level, and act as a crucial component in balancing the power situation in Norway. It also collects and aggregates measured meter data from the network companies on behalf of the regulator. This makes it an important actor in regards to the markets, and it has on this note been given the task from the regulator to develop an overarching ICT-system in to which the country's combined metering infrastructure can be plugged. In all likelihood they will choose to implement a centralized data hub which will connect customers with regulator, distributors, suppliers, producers and other energy related actors and third parties, as well as keep all data on these actors centralized. The hub will thus function as the sole data source and information aggregator for all power market purposes. As stated in the resolution by the regulator, the mandate decrees that Statnett:

> […] explore and have the chief responsibility for developing a common ICT solution for the power market, which can facilitate the efficient exchange of information and establish support systems for business processes within measurement, calculation, billing and coordinated behavior in the power market.

This is really nothing special for Norway, many countries are on the same page as AMI gets implemented, Denmark for instance are connecting theirs in the spring of 2013. Information in the hub is supposed to be freely exchanged between those who need it when they do in a *customer-centric* model. If this solution prevails and is successful, there would be no need for the customer to know of any separation between network owners and energy suppliers for instance, and customer's choice of supplier, always the most rational one as information nears perfection, could be executed instantaneously with a click of a mouse button.

These visions all pertain to the technological potential of the new solutions that are being implemented. But the interesting part is that these visions are in fact coinciding with the goals of policy, and it seems clear that what the government wants with AMI and the data hub is to implement these technologies as a means to making the power market as streamlined as possible. The regulator in their mandate, as stated by one of their directors at an industry conference, wants Statnett to "not only focus on AMI, but keep in mind that they must also have an overarching focus on a well-functioning market." This puts the development of the centralized data hub and the AMI in general into the wider energy policy of the country, and it is the role of this inherent in these specific technologies that contribute to their energy policy significance, and thus puts them in the center of attention for policy makers. The regulator has stated quite clearly that their focus for these changes mainly must benefit the customers, and the number one premise for the restructuring process ahead is the customer-centric model. As one regulator said at a joint industry meeting:

> The point here is not to be the cleverest one, but rather to try and create robust systems at a national level. You will do this not to make the technological solutions better for yourself. The paramount goal must be on the customers. You need to remember, you are doing this for *someone*. Not for yourself, but for the customer.

A strong focus has been maintained these last years in making the industry come together to create robust solutions, helped along by deftly stirring the network companies with a sudden and drastic regulatory revision, and the message from the top has been harping customer focus since then. There is also considerable power in a message, not to be underestimated, if the conveyor claims to be speaking on behalf of "the people".

This general concern is also evident in the regulator's focus on a principle of neutrality they want embedded in the technological system. As one director stated at an industry conference "no single actor shall receive any special benefits in the future power market" and that "[solutions] must not compromise customer possibilities or security, and shall not facilitate lock-in or in any way hinder the customer's access to an open power market". This leaves little doubt that what they desire from these technological implementations is for an efficient, liberal market solution to prevail. The concern seems also to include third party actors on the power market, and yet another stated reason for this "principle of neutrality" is that one wishes to "facilitate for heavy product development on the outskirts of the data hub," but that "without knowing what this will look like yet, neutral solutions are needed". In fact, one of the project leads for the data hub stated, using the example of collective billing, that they "were not going to implement it, but they would make a system where it *could be* implemented in the future if that was feasible".

Apparently there is quite a bit of concern for the outcome of the technological solutions traceable in the communications from the regulator. The regulator is of course an important conveyor of political will, even though political ambitions might not have their origin there. But, seeing as the regulator tries to implement the new technologies with some pretty clear market and customer related concerns in mind, it seems evident when keeping in mind the relation between the regulator and the ministry, that these ambitions have their source in general energy policy. This implies that the technologies in question are viewed by the policy makers as comprehensive tools for implementing policy. To what extent the technologies implemented will have such a restructuring effect however is still too early to say.

Barriers to the development of AMI in Norway

FEW INCENTIVES FOR WOULD-BE AMI PIONEERS

In Norway as we have seen, the deadline for full scale implementation is enforced top-down by the Water Resources and Energy Directorate, on behalf of the Ministry of Petroleum and Energy. We have also seen that the ones given the task are the country's network companies, which are licensed monopolists in their regions, but also submitted to revenue caps set by

the regulator in accordance with specific variables pertaining to their operations. This fact has, as stated in the introduction, some implications for how the network companies go about the task of developing technologies to meet regulatory demands, and what sorts of solutions are selected. In short, each company's revenue cap is calculated by the regulator for each network companies according to the costs of reasonable operation and development of the company's grid. In addition, the individual company operations are benchmarked with that of the other companies (through rather complicated models, as every DSO are subject to their various specific constraints). The company is then allowed to claim the costs of operations and necessary investments from their customers, which receive a tariff for this in a separate bill. The costs are covered in total by this tariff.

This system works well by and large, as it keeps down the cost for consumers and of course allows for a more comprehensive planning of the grid as a whole, as opposed to network operators in competition. Also, meeting new demands with well-known technologies is very different from having to create these technologies from scratch. However it might not in its present form be the best system for incentivizing the operators to pioneer new technology through ambitious and long term R&D projects, as money spent in the here and now towards R&D is categorized purely as cost, thus eating away at the individual network company's efficiency rating. As one project manager explained:

> The overall plan is construed roughly with a three-year horizon. […] And relatively little R&D is rewarding after three years. That is, it takes at least five, ten, maybe twenty years to actualize rewards from R&D […]. This means it doesn't pay off for DSOs to get involved in R&D. In the long term, you might uphold levels of Norwegian know-how, which is really important. But that does not have any direct ramifications. And some spend more on R&D than others. Those who spend less in fact are rewarded by other companies' R&D spending. […] So being a first mover is very risky.

The network companies are facing uncertain times. Undoubtedly, investing in research on unproven technology like in this case demands a certain state of mind which might not be shared by all actors. In larger integrated power companies, where the network companies often are just one division among others, long term R&D might be an integrated activity, and the intangible value of it more widely appreciated. The logic goes that if others might do the risky development and implementation, the ones in waiting on the fence, so to speak, would be able to benefit from the others experience, thus cutting risk and cost. One project lead said at a meeting:

> The winner is he who lurks like a pike in the rush[4], waiting, because it is considered unfortunate to make less than the other network companies. Trial and error is not profitable.

Having all the network companies think like this of course would offer problems, and luckily far from all of them do, hence the focus on joint venture by the regulator and industry organizations mentioned above. But the network companies are more inert and traditional in comparison with other divisions in the corporate structure, like for instance market, in the sense that they are focused on the long term optimization of a relatively homogenous, well known technological infrastructure. The restructuring of routine operations and fortified value chains becomes a serious challenge in the face of a would-be game changer like AMI. A project member elaborates:

> It is because the goals needed to be met are societal ones, not necessarily goals that would benefit the network company. It might not be feasible, seen from a corporate economic perspective, even though many countries have introduced automated reading, AMR voluntarily. So, internal drivers don't really exist in any comprehensive form, either for AMI in Norway or within the grid companies.

It seems the overarching script of macro social economic benefits has not been adequately translated to the boys on the ground. After all, talking about smart grid benefits really is a big pictures thing.

ONE HUNDRED YEARS OF STATUS QUO

To invoke a cliché, change is difficult, especially if there are few clear incentives to reward it. To try and meet it, this particular company introduced Open Innovation-thinking (Chesbrough, 2003) into their AMI-project. In this particular strand of business ideology, the goal is to learn from the ways of Silicon Valley, and focus on co-developing technological solutions with competitors. The ultimate goal is that everyone can utilize each other's innovation, creating better products, and making winners of all. The problems with introducing such a way of thinking into the network division of the company, however, were soon evident.

> Thinking like this is very demanding. And in addition, the network company can't think that way. They think bounded by their immediate requirements, and they don't think that if they are part of developing a supplier, this might benefit them if the supplier ultimately impacts the market better; they can't necessarily see this. I believe operating with this kind of innovation within a grid company is difficult at best. […] The culture is over 100 years old […] AMI is just a small part of a smart grid future, but it does represent the start of the digitalization, in a way I think not everyone have comprehended.

So it seems that the network companies are experiencing some divisiveness, both amongst themselves and also from within, as traditional thinking within network companies especially is opposed by the structural changes that AMI introduction heralds. One project member elaborates about the internal conflict:

> There is a very fragmented view in the network company about what AMI should be. There are different groupings; AMI is largely challenging the network company now, because of its level of innovativeness, more IT, faster technological change, and the size of the project which is very demanding. And we get the impression when talking to different parts of the network division that they aren't, or well,

4. A direct translation of the infamous Norwegian "Gjedda i sivet", a very ungracious characteristic given to those who unwelcomingly feed off of unsuspecting others.

> they are more or less enthusiastic about the project. Some are not enthusiastic at all, and would like the money to go towards something, call it more traditional stuff.

In the face of this it seems clear that the actors most closely involved with the AMI projects more clearly feel the stakes for success are high, and are most in favor of proactively meeting challenges in spite of short-term risk and uncertainty. This means that network owners by and large are moving in the right direction. There are those that see the benefits of accepting high stakes in order to reap larger benefits in the future.

> It's always a good thing to be a first mover, because you will be better fitted to handle challenges, better equipped and so forth. Those who are waiting it out on the fence will not have enough decisive know-how, and they will end up at the mercy of third party actors, and they might have to seek external help in acquiring their solutions, both in terms of procurement and handling operation later on. They won't be able. […] They end up as non-actors.

This particular AMI project was placed within the network division of a larger, integrated power company, involved with production, markets and also some more or less related investment activities through an independent holding division. In such a configuration, showing the value of long term commitment to the development of robust technological solutions and relevant know-how for what might seem an isolated project is difficult not only in the local context of the division, but also sometimes in the larger, integrated context. Vertically integrated corporations have the possibility to work out synergies between divisions, but this can be difficult due to a number of reasons, both pertaining to cultural issues and of course legislative anti-trust issues that would govern any healthy market situations these divisions might operate in when delivering their different services. As a project lead asked:

> Is it a corporation, or is it a collection of companies with a single ownership? In my mind those are two different things, and I believe that in this line of business we tend to look like the latter. […] People tend to think that "this is my hill", and then not care too much for their neighbors, the production company, for instance. Then the point of running it in corporate fashion is lost, and to try to head away from sub-optimal solutions to more corporate optimal solutions.

Of course there are support- and management benefits to a corporate structure, but supposedly an AMI implementation will make it possible to work even more closely across these divides. Today this is difficult, both due to cultural and legal issues. A lack in ownership of the project, partly due to an underestimation of the size and scope of it, at corporate level, may also prove one explanation for the inertia characterizing the development. Owning up projects in a corporate climate is not easy, as it requires the ability to indicate return on investment. This is difficult because network companies have little experience with the kind of radical innovation that AMI implementation represents, needing long term commitment and uncertainty mitigation, and least of all doing it in a corporate environment.

"WE DON'T HAVE THE TECHNOLOGY"

The process of rolling out AMI for the network companies in this study can be said to have been characterized above all by what is perceived as an unfortunate combination of haste and a level of uncertainty introduced by said haste. Haste is brought on by the deadline introduced by the government and its regulator. The uncertainty is among other things due to the currently immature technological solutions available to meet the demands set by the new AMI-regulation. As one project lead stated, when talking about the difficulty of making a push for new meters:

> After looking at the regulatory demands and gauging what this would mean technically, it became clear to our suppliers that this was more extensive than predicted. Thus there are no technological solutions [on the market] today that meet the goals of this company.

This statement came in the spring of 2012, and a long struggle between the industry and the regulator had been ongoing since 2007, regarding the deadline for AMI implementation in Norway. Indeed, much of the energy dedicated to AMI-related work in Norwegian network companies initially went towards pushing the deadline further into the future. However, it is a stated wish both by the network companies *and* the regulator that the technology implemented need be as mature as possible upon implementation. There is just a slight argument over when maturity is reached.

The disagreement between regulator and industry is of course due to industry's opinion that the government is moving too fast, and that a full scale implementation by 2017 could result in higher uncertainty regarding the solutions developed. This has led to what many regard as an up-side-down way of developing technology, where the objective is to create turn-key solutions without having clearly defined use-cases. As an IT specialist working with the AMI-project said:

> It is evident that the timing of this project in Norway is one of the greatest risk-factors in the AMI-project. […] The problem in Norway is that we are casting technology without having a clear idea of what we want to use it for. Before we invest 10 billion kroner, we should have drafted use-cases for all the different functionalities, and made some guidelines for how the technology is supposed to work. We are in danger of implementing technology that will show us later on that, 'this use-case won't work, because we chose this solution'. This has been under analyzed. […] When half the cost is associated with infrastructure, it is not wise to first build the infrastructure, and then decide everything else later on.

The argument against this kind of position would of course be that in the face of ever developing and incrementally improved technological solutions, one has to eventually make a choice. This is retorted by the IT-specialist again, by the claim that we are quite close to nothing less than a paradigm shift in metering. He makes an analogy to a one time revolution in farming:

> There is a very rapid technological development going on right now, with the standardization work taking place in the EU and partly the USA. A lot will change within a relatively short time-span. […] Replacing the old meters with AMI

> is sort of like what happened in agriculture, when they replaced the horse with the tractor. That was a paradigm shift. And that means there will be no half measures, where we're filling up our horse with diesel.

The biggest stated challenge regarding the choice of premature solutions is that they could have poorer functionality especially in one of the areas the IT-specialist figures lay-people would know the least about, namely information and data security. This aspect is complex and hard to easily grasp, but still an important issue when plugging the power grid into the Internet. The horse analogy again:

> The most important bit is the security technology. There are some solutions coming up that will not be implemented into the horse. Especially, regarding security, we need state of the art, not because we need it from day one, but because we need it in the last stages of the life-time of the technology.

The statements above prove to point out that there is considerable concern among the industry actors, although perhaps most strongly stated among the specialized professionals within IT and communication, that the technology that is forcibly implemented by the government is not in fact mature enough as of yet.

At first, when the network companies knew very little about what AMI entailed, they met proactively with the regulator to make sure the deadline would not be set too early, and to partake in writing the new regulation pertaining to metering. This resulted in a longer deadline than was initially set by the regulators, and indeed also served to unite large parts of the distribution industry to pooling their resources into figuring out exactly what AMI would mean for Norway, and how to go about implementing it. However, as they learned more, they also discovered new challenges unforeseen by any at the time the regulation was passed, especially related to the communication infrastructure and security design. This has led many to believe the present deadline is too close as well, and as we have seen, some believe a short wait would be a small price to pay for making the technology more robust in the long run. There is quite clearly a considerable gap between what regulator and industry consider good enough for AMI-implementation in Norway.

Finally, the layout of the centralized solution will have crucial implications for the ability to meet demands of the AMI regulation within the work being done by the network companies in their AMI projects, and thus far it is clear that there is a risk of overlapping functionality between the hub and the metering technology, both of which are now being developed in parallel. Also, without the hub the AMI-revolution will in fact turn out to be little more than swapping the old meter for one with a digital display. Clearly there is a fracture surface between the AMI side and the ICT side, where it seems possible that developing them side by side constantly beckons the question as to what solution pertains to which side.

As uncertainties add up, what is "good enough?"

This paper looked at statements made by policy makers both in the setting of meeting with industry actors, and also through official white papers on the regulation as well as the regulation itself. These observations were weighted against the experience made by actors engaged in an AMI-project at a network company. A clear fracture line between regulators and industry was observed, and indicated differing constructions regarding the purpose of AMI, both in terms of it as a would be game changer and as "finished" technology. It also seems that the conception of many of the actors involved is that AMI is "politics", and evidence also indicates that there is concise energy policy concerns embedded in the regulation related to the shaping of this technology.

As we have seen, the focus of the regulator mainly went towards making clear the market benefits of the new technology as a means toward creating a new and more efficient energy markets, with more enlightened consumers as a result. This was also the stated purpose when constructing the common data hub for the AMI, which was introduced not only as a tool to manage Norwegian meter data, but indeed also as a market resource for would-be third party energy service providers. In addition to this we know that one stated goal of Norwegian energy policy is to further integrate energy markets in the Nordic regions and Europe in general.

Network companies were seen to struggle with uncertainties and risks in their AMI development projects, mostly due to the need to adhere to a fuzzy, in technological terms, but strict in functional terms, regulation. The process surrounding the rewriting of the regulation 301 pertaining to measuring and metering did in fact include several hearings and meetings where the opinion of the industry was admitted to add their voice to the shaping of the regulation, and indeed most of their urgent objections were heard in the end. As we have seen it was spurred by self-interest on part of the network companies in the face of dramatic change and a close dead line, and no small amount of co-operation between the industry members went into the effort to shape the final draft of the regulation. However, it is evident from the empirical evidence that what we could call the social learning (Sørensen, 1996) on part of the network companies may have been cut a little too short for their comfort. There was indication that more work was considered necessary in terms of communications infrastructure and security as well as with use-cases, experts stating that the risk of opting for suboptimal technology in the long perspective was considered too high at this point. Indeed, as the draft was finalized in 2011, and the work started focusing on technological development, more objections have accumulated, and now threaten to force the Ministry of Petroleum and Energy to extend the deadline.[5]

Furthermore, it was evident that more translation work could have been needed, especially to get people on the ground in the network companies on board with the so called "necessity" of the new technologies. Rationales given from the regulator was more often focused on the larger, long term social economic benefits not readily evident to those committed to day to day operation of a grid that in their opinion met the demands of the current operations in a satisfactory way. Lofty promises of potential benefits towards more efficient operation were not sufficient to convince skeptics, and were probably aimed higher up in the organization anyway. However, more focus could have been allocated to such a task by the network companies

5. Teknisk Ukeblad, retrieved 291212. http://www.tu.no/energi/2012/12/19/smart-strom-forst-i-2019

themselves, but this brings us to the question of resources both in terms of time and knowledge. The deadline have companies aiming for the fastest possible way to formally meet the demands of the regulation, and are content to eventually deal with the fall out later (an attitude it seems they may have learned from the regulator). In addition, smart meter know-how is not easily acquired these days. Many smaller companies are not equipped to partake in this kind of social learning at all, since they are fully committed to day-to-day operation. In these cases the future will probably bring about a consolidation effect as was mentioned earlier, because of their growing need to pool resources. In many cases, smaller companies will see the need to outsource activities related to AMI implementation to other companies, and in worst case end up at the mercy of their suppliers, further contributing to the turning of tables this sector has witnessed in the last three decades. Outside the scope of this paper are of course the many differences between the network companies committed to their charge over the grid, and suppliers committed to their bottom line.

In the face of this controversy between the regulator and industry, it is striking how adamant the push towards smart metering has been on part of government and regulator, despite the substantial amount of objections raised by grid operators. It largely indicates the government is eager to implement the technology, and hopeful about its "impacts" as they are relied upon to bring about a more efficient, integrated, and user friendly energy market. The approach is paternalistic and top-down, and what many experts would characterize as serious challenges are being pushed aside to be dealt with later, after the technology is in place. A stated goal of introducing the abovementioned data hub was not to create a finished technology, but rather to rely on the market to take care of solutions (software, hardware) for smarting up consumption. This seems to indicate a large trust in the market, both in terms of push from the suppliers of such technology, but especially in the much needed pull from the customers in this case. This seems slightly contradictory to the stated goals of smarting up end users, and it seems the introduction of these technologies might cater more to the macro aspects of energy policy. This would also explain the apparent carefree attitude towards the controversy, which mainly rests around technical details. As the AMI is forced in place, it could be it is deemed "good enough" by policy makers to simply serve as a bridge to the European energy market, and market actors are given the challenge of taking care of the rest. They should in this case learn from the process through which regulators and network owners have been grappling with the smart grid, and the social learning which took place there. For society's benefit this process needs to find its equivalent among the market actors as well, and this should be recognized as a challenge to them.

References

Akrich, M. (1992). The De-Scription of Technical Objects. In W. Bijker and J. Law (Eds.) Shaping Technology, Building Society: Studies in Sociotechnical Change. Cambridge, Mass, MIT Press: 205–224.

Bøeng, A. C. (2011) Hvordan kan Norge nå sitt mål om fornybar energi i 2020? Statistisk Sentralbyrå, *Økonomiske Analyser*, 6/2011. Bloor 1973.

Callon, M., Y. Millo, and F. Munieza (2007) *Market Devices,* Oxford: Blackwell.

Czarniawska, B. (2007): *Shadowing and Other Techniques for Doing Fieldwork in Modern Societies.* Oslo: Universitetsforlaget.

European Commission (2009): Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency.

Flyvbjerg, B. (2006): Five Misunderstandings About Case-Study Research. *Qualitative Inquiry, 12, 2,* 219–245.

Godbolt, Karlstrøm & Sørensen (2009) *Constructing consumers. Efforts to make governmentality through energy policy.* Article in proceedings of ECEEE Summer Study 2009.

Karlstrøm, H. (2012) *Empowering Markets? The Construction and Maintenance of a Deregulated Market for Electricity in Norway.* Doctoral theses at NTNU, 2012, 79.

Latour, B. (1987): *Science in Action.* Cambridge, MA: Harvard University Press.

MacKenzie, D. (2006) *An Engine, Not a Camera: How Financial Models Shape Markets.* Cambridge, MA: MIT Press.

NOU (2012): Official Norwegian Reports 2012:9, Energiutredningen – verdiskaping, forsyningssikkerhet og miljø.

NVE (2008): Norwegian Water Resources and Energy Directorate. Avanserte male- og styringssystem (AMS). Forslag til endringer i forskrift 11. mars 1999 nr. 301, Høringsdokument oktober 2008.

NVE (2011): Norwegian Water Resources and Energy Directorate. Avanserte male- og styringssystem (AMS). Høringsdokument, februar 2011.

OED (2007): St.prp. nr. 1 (2006–2007). Oslo: The Ministry of Petroleum and Energy.

Pinch, T. & Bijker, W.E. (1987): The Social Construction of Facts and Artefacts: Or How the Sociology of Science and Sociology of Technology Might Benefit Each Other. In Bijker, W.E., Hughes, T.P., and Pinch, T. (1987): *The Social Construction of Technological Systems.* London: The MIT Press.

Ryghaug, M., & Sørensen, K.H. (2009): How Energy Efficiency Fails in the Building Industry. *Energy Policy 37:* 984–991.

Stake, R.E. (2005) Qualitative Case Studies. I Denzin, N.K og Lincoln, Y.S., red. (2005) *The Sage Handbook of Qualitative Research*, 443–466. Thousand Oaks, CA: Sage Publications Inc.

Sørensen, Knut H. (1996): 'Learning technology, constructing culture. Socio-technical change as social learning' STS working paper no 18/96, University of Trondheim: Centre for technology and society.

Sørensen, K.H.(2007): Energiøkonomisering på norsk: Fra ENØK til Enova. In: Aunse, M., Sørensen, K. H., (eds.), *Mellom klima og komfort – utfordringer for en bærekraftig energiutvikling.* Tapir Akademisk forlag, Trondheim: 29–45.