The power of buildings in climate change mitigation: The case of Norway

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Abstract

Centralized power production mainly from fossil fuels is increasingly challenged by decentralized power production from renewables. This is a trend caused by the greening of the European power grid which is to be carbon neutral by 2050. As a part of this trend, the number of power-producing buildings is growing. Even in Norway, which has a highly centralized power production based on hydropower, buildings are increasingly equipped with solar power panels. The introduction of cross-sectoral innovations like power producing buildings is likely to encounter resistance, as the conventional system and its powerful actors are challenged. The strategies to either promote or block the growth of power producing buildings in Norway have been explored employing the Strategic Niche Management framework.

For this paper, 32 interviews were conducted with decision-makers and experts, both advocates and opponents of power-producing buildings. It has been found that narratives have the potential to work as a *bridging device* between the niche and the regime. If the narrative supporting power-producing buildings should become a bridging device, it would have to address challenges as defined by the regime incumbents. In Norway, this would be equivalent to addressing the challenge of peak load.

Keywords

Power-producing buildings, niche, empowerment, resistance, narratives, bridging device

Abbreviations: see footnote[1]

1. When buildings become power stations

"Make it, dammit. It is not exactly rocket science. It demands something from the power industry, of course, but they think differently and that is probably some of the problem". [2] Entrepreneur

[1] EPBD - Energy Performance in Buildings Directive
NVE- The Norwegian Water Resources and Energy Directorate
RED - Renewable Energy Directive
ZEB - The Research Centre on Zero Emission Buildings
ZEN – The Research Centre on Zero Emission Neighbourhood

Europe is greening its power system which is due to be carbon-free by 2050 {Foundation, 2010 #119}. Buildings in Europe are responsible for about 40% of total final energy use and 36% of its CO_2 emissions {European Commission, 2016 #165}, and the challenges, in particular, are to increase energy efficiency and to decarbonize the power system {The European Climate Foundation, 2010 #119}. The decarbonization of the power system is part of an even larger transition towards a low-carbon society. Power-producing buildings, mainly utilizing solar power, are part of this trend towards more renewable production and also more local, small-scale production. As buildings are major energy consumers, it is a great energy potential in the building stock if less energy is used, or produced locally. Buildings tend to have a fairly predictable energy profile and in cold climates, peak power demand is related to low temperatures and household activities like for example cooking. Solar power production is low during winter which means buildings will rely on power from the grid. In addition, the development of energy efficient equipment does not necessarily focus on reducing peak load which is a main issue when optimizing the grid capacity. These are issues that are challenging to the electric utilities and add to other concerns, such as loss of income due to lower demand. Resistance is a likely reaction.

This study explores the introduction of power-producing buildings in Norway. A recent White Paper on energy {Olje- og energidepartementet, 2015–2016 #146}, the first major policy document on the topic in 17 years, did not lay out any solar power policy. The solar power potential was discussed but seems to have been downplayed. At the same time, Norway's construction related policies aim at the imminent market break-through of zero energy/emission buildings – which in most cases implies local renewable energy production on the building.

1.1 The Norwegian case

Nearly all Norwegian electricity production is based on hydropower {Olje- og energidepartementet, 2015 #123}, and electricity is therefore perceived as clean. However, since the late 1980s, there has been a general consensus in the Norwegian Parliament that the period of great hydropower development projects is over, due to the demands of nature conservation. Norwegian households are world-leading in their use of clean energy, as electricity – predominantly hydropower – amounts to 80% of domestic energy use, a large portion of which is used for heating {Bøeng, 2014 #168}. Since electricity is inexpensive, there is low economic motivation for energy efficiency projects and other sources of renewable energy production that struggle to compete without support schemes. However, electricity demand is increasing as electricity is replacing other and more polluting energy sources, for instance in the transport sector. Norway has the largest fleet of electric vehicles (EVs) per capita in the world, achieved through extensive use of incentives {Holtsmark, 2014 #150}.

The implications of the European objective to decarbonize the power sector are less obvious for Norway than to most other countries, since nearly all electricity is renewable already. The formal reasons for advocating building concepts that include power production are found in particular in two EU directives: the Renewable Energy Directive (RED) and the Energy Performance in Buildings Directive (EPBD) {The European Parliament and the Council, 2010 #115}. The EPBD is still not fully adopted into Norwegian legislation, and it is vital that the concept of 'nearly zero energy' and the 'renewable sources produced on-site or nearby' objective in the EPBD are defined in the Norwegian context. Building concepts that include power production are normally also particularly energy efficient and will therefore contribute to additional available power by using less energy. This makes it beneficial to the requirement in the RED of an increased *share* of renewable energy. Excess power could be used to electrify the sectors that are responsible for Norway's per capita CO_2 emissions that

[2] All quotes from the interviews have been translated by the author.

are on a par with the rest of Europe. However, the increased electrification in Norway as well as in other countries leads to increased strain to the power distribution grid.

In this context, leading actors in the building industry, supported by generous governmental R&D funding, are advocating building concepts that are power-producing entities, most notably with the use of distributed generation of solar power (photovoltaics/PVs) or in some cases local cogeneration in combined heat and power (CHP). To achieve this, the relevant concepts demand innovative solutions that are challenging to the industry, but they represent incremental rather than radical change {Slaughter, 1998 #153}. The notion of power-producing buildings is an opportunity for the building industry to contribute to climate change mitigation and at the same time position for new business domains.

Energy-generating buildings have been part of Norwegian energy and climate policy for more than a decade; they have been assisted through investment support schemes on selected technologies like heat pumps, which recently have been extended to include solar power among other technologies {Enova, 2016 #166}. There are a few examples of investment support for buildings that generate an intermittent power surplus, such as the Powerhouse Kjørbo pilot project {Enova, 2016 #167}. The absence of an explicit inclusion of renewable local power production in energy policy, as described above, stands in contrast to the existence of state-supported projects. There is ambivalence on the policy level towards power-producing buildings and the distributed energy production they represent. This is a common situation when new technologies are introduced {Kemp, 1998 #205}.

1.2 Perspective and previous research

The potential for solar power production, or lack thereof, is frequently given as an explanation as to why authorities in Norway are reluctant to advise households and other building owners and developers to invest. The allegedly limited potential is due to the geography of Norway, where it is generally colder and darker than most of Europe, and where solar power production would be highest in summer although energy needs peaks in the winter. However, any prospects for solar power are highly dependent on assumptions regarding prices of electricity, solar panels and installations, in addition to lifetime costs, solar panel efficiency, storage technology and more. According to the aforementioned White Paper {Olje- og energidepartementet, 2015–2016 #146}, the calculated solar power potential is 1.5 TWh by 2020 and 3.8 TWh by 2030, if suitable roof area is utilized when buildings are erected or renovated. In relation to the total power production in Norway,[3] this is rather insignificant. However, there has been substantial growth in installations on *existing* roofing in 2016,[4] but existing roofing and detached production sites are not included in the calculated potential. Furthermore, even though Norway extends through 13 degrees of latitude, the majority of the population lives in eastern and southern Norway, areas that have the same solar irradiance as for example Northern Germany {Andresen, 2008 #201}. The potential is thus bigger than suggested by the government, yet how big is not known.

A payback time of between 18 and 23 years for installations in 2016 was calculated, sinking to between 8 and 15 years in 2030, disregarding any subsidies {Zaitsev, 2016 #202}. Depending on further development and cost reductions regarding solar panels, in the foreseeable future they could make a cost-effective contribution to the Norwegian energy system.

[3] In 2015, the total power production in Norway was 145 TWh, according to Statistics Norway.
[4] According to an interview with Otovo in October 2016, around 500 solar power installations on existing household roofs had either been installed or were planned to be installed during 2016.

Little research has been done on the societal implications of the transformation of the Norwegian energy system so far, with some exceptions, (e.g. {Christiansen, 2002 #132}, {Gullberg, 2014 #131} and {Skjølsvold, 2013 #133}). Transformation of the building sector has been studied in Nykamp as well as in Ørstavik {Nykamp, 2016 #260;Orstavik, 2014 #261}. Studies on transformation in other national frameworks may also be relevant (e.g. {Geels, 2016 #134}, {Hess, 2013 #135}, {Konrad, 2008 #126}, {Smith, 2005 #199} and {Verbong, 2010 #136}). This article extends the literature, in particular by focusing on narratives and anti-narratives in the latter phase of the development of a niche {Raven, 2016 #193}. Linking the niche of power-producing buildings to a regime environment also illustrates that niche empowerment is a highly political process involving power and antagonism. The transformation of power systems is about to take place all over Europe, and issues of decentralized power production are therefore also relevant in other settings.

In this article, in order to limit the extent of the discussion to politics and strategies located within and around the niche of power-producing buildings, a boundary has been drawn around the supply side including the policy measures for implementation, thus excluding the demand-side issues, which should be given attention in a subsequent article.

The rest of the paper is structured as follows: the next section summarizes the conceptual foundations in this paper as well as the methodology. Section 3 presents empirical findings which primarily enlighten the arguments and actions by advocates and opponents of power-producing buildings. In section 4, the empirical results are analysed and discussed. This section also looks at how power-producing buildings could develop to become an essential part of the sustainable transition that lies ahead. Finally, conclusions and policy implications are drawn.

2. Conceptual framework and method

2.1 The regime and its incumbents

The regime concept has been cultivated in particular by Geels through the Multi-Level Perspective (e.g. in {Fuenfschilling, 2014 #139} {Geels, 2007 #140;Geels, 2011 #81;Geels, 2002 #203}) as well as within the Strategic Niche Management framework {Schot, 2008 #14;Raven, 2010 #262;Kemp, 1998 #205}. A regime is understood as a dynamically stable structure consisting of actors, networks and institutions.

Regime actors have vested interests in regime preservation and can resist and block pressures to change. Hence, the implementation of a potential path-breaking innovation is typically resisted according to Geels {, 2014 #129} and Hess {, 2014 #143}. By not only consuming but also producing power, buildings turn into *prosumers* of energy; and become at the same time a potential path-breaking innovation {Raven, 2016 #193;Schot, 2008 #14}, which aims at changing the present regime through altering the selection environment (see explanation in the next subsection). In the context of this paper, path-breaking innovation refers to power producing buildings that influence the evolution of the power system.

The incumbents and their relation to the political level and other actors do not constitute *one* single regime but rather several adjacent regimes. In this case, *a part of* the building sector, together with related trade associations, policy actors, etc., could be described as the building regime. And the same goes for the power sector: the power sector and related trade association(s) can be linked to certain actors on the policy level, and in turn, they constitute a power regime. To focus only on the building regime would give a rather one-dimensional picture, since context and interaction with the power regime would be downplayed (e.g. {Raven, 2007 #125;Raven, 2009 #128;Smith, 2010 #82}).

2.2 A sustainable transition

A transition can be conceptualized as the process of moving from one stable socio-technical regime to another in such a way that the structure of the regime has fundamentally changed {Smith, 2010 #82;Verbong, 2010 #136}. The changes needed for a transition to take place involve several interrelated actors, networks and institutions. Transitions are systemic by nature and therefore also hard to initiate and manage. Distributed energy production is part of a large-scale transformation that is referred to as *socio-technical* since the changes that are needed will not only imply changes of a technological character but also changes in policy, markets, user practices and cultural meanings {Geels, 2004 #137} {Unruh, 2000 #138}.

Transition theory is developed from evolutionary economics and constructivism, which means there is focus on variety, selection and retention but also emphasizes that the selection environment is wider than users and markets {Geels, 2002 #203;Geels, 2010 #79;Rip, 1998 #142}. A selection environment consists of several features of the regime, such as industry structures, markets and dominant practices, the established knowledge base, dominant technologies and infrastructures, cultural significance and public policies and political power {Smith, 2012 #90}. Changes in the selection environment can destabilize a present regime and make the introduction of a niche innovation more or less successful.

2.3 Niche innovation

Solutions like power-producing buildings that might challenge the power regime and its incumbents are often developed in *niches*, which are outsiders or sites where innovations can be nurtured and mature {Kemp, 1998 #205;Smith, 2012 #90}. According to Kemp et al. (ibid. 1998 p 186), “niches are platforms of interaction; they emerge out of a process of interaction shaped by many actors”. Successful niche innovation is dependent upon a balance between protection and exposure to the selection environment {Smith, 2012 #90}. The development of the power-producing building niche and consequent interaction with the regime(s) will be discussed within the framework of niche protection as presented by Smith and Raven {, 2012 #90}, among others.

Niche protection

Niche protection is broken down into three components: shielding, nurturing and empowerment. Shielding is defined as “processes that hold at bay certain selection pressures from mainstream selection environments” (ibid. p 1027). Nurturing refers to processes that supports technology development within the niche {Boon, 2014 #200}. It implies interacting processes that focus on learning, networking and the articulation of technological expectations {Raven, 2016 #193}. The least developed of the protection strategies, according to researchers, (e.g. {Smith, 2012 #90} and {Raven, 2016 #193}), is how niche empowerment is working and complementing the other strategies. Empowerment strategies are working at changing the selection environment to make it easier for the niche to enter the regime.

Niche management

The empowerment of protective spaces can be achieved in two ways, according to Smith and Raven {, 2012 #90}: firstly, the niche can be developed so that it fits into and conforms to a moderately changed selection environment. This is referred to as *fit and conform* empowerment. Alternatively, empowerment can imply that the niche itself is able to change its selection environment, rather than be subordinated by it. Such empowerment is referred to as *stretch and transform.* The process of

empowerment will be decisive as change will be resisted. This resistance materializes in different forms of power exercise, described by e.g. Geels {, 2014 #129}.

Niche protection strategies could be inwards as well as outwards looking {Smith, 2014 #265}. By looking inwards, it is oriented more towards knowledge creation and networking. Alignment of experiments in a research centre could be another example. When facing the broader selection environment in the latter stage of niche protection, outward looking processes involve actors in for example lobbying and narrative work. According to Smith et al. (ibid.), outward-oriented narratives are used to expand the space for niche development and their associated socio-technical configurations. The narrative work of niche advocates also involves the countering of anti-narratives, as will be illustrated in section 3.

Based on this literature, the research questions can be drawn. In this paper, the interaction between niche advocates and niche opponents will be studied in the case of power-producing buildings. Consequently, the analytical questions that will guide the discussion are: **What niche empowerment strategies – and counterstrategies – are implemented in the case of power-producing buildings? How can the policy ambivalence regarding such buildings be understood given the narratives that are established? And in what way could narratives function as a bridging device in this context?**

2.4 Method

The empirical material was collected through 32 qualitative interviews with expert representatives. The experts were from the building sector (five from the private and five from the public sector); the power sector (three); trade associations (six); one environmental organization; academia and research institutions (four); and the policy level, including central authorities (eight). Their roles were as advisors or senior advisors (12), leaders ranging from project leaders to managing directors (17), and academic staff in research/academia (three). Since Norway is a relatively small country, the size of the community with knowledge and an understanding of the impact on the development of power-producing buildings is limited and transparent. It could be described as a close community which, according to Guy and Shove, permits interaction across disciplinary and sectoral boundaries {Guy, 2000 #156}.

Interviewees were chosen because of their knowledge of, experience with or their position regarding power-producing buildings. From the building and the power sector, the interviewees had knowledge of or, more commonly, experience from relevant projects. At the policy level and within the trade associations, most interviewees had positions with a high influence on policymaking and/or implementation regarding power-producing buildings.

The qualitative method is preferred when there is insignificant research-based knowledge on the area in focus {Kvale, 2009 #97}. It allows the researcher to adapt to new knowledge and encourage thick descriptions. Experts are chosen as interviewees, as the research focus is not part of general knowledge and few people have any experience with the problem to be addressed {Littig, 2009 #69}. At first, the selection strategy was to include experts from the building regime to do a system analysis of zero emission buildings. However, once the interviewing had started, power and resistance became evident as major obstacles to the wider diffusion of power-producing buildings. This led to a shift in focus where actors from the power sector were included. The interviewing continued until new arguments ceased, following the principle of saturation {Mason, 2010 #107}.

The interviews were based on a semi-structured interview guide, which was slightly adjusted during the process. The political nature of the topic favoured a situation where open-ended questions were required. Each interview lasted approximately one hour and was transcribed with the exception of two

shorter interviews (lasting about 30 minutes each) that had a more supportive character. The respondents did not, in general, seem to take any notice of the recording of the interview, although in one particular interview the respondent made it clear that recording would alter their responses. In this case, we made a deal to turn off the recording after the main part of the interview and the dialogue continued thereafter. Both the recorded and unrecorded parts of the interview are included in the empirical material. In general, the policy level seems more concerned about the prospect of being quoted on politically sensitive questions. Because of this, most quotes in this paper are anonymized. After the interviews were transcribed, they were analysed using open-ended coding focused on finding patterns within or across the regimes {Corbin, 2014 #154}.

3. Strategies of niche empowerment

In line with the conceptual framework presented in the previous section, the introduction of a potentially path-breaking niche will induce resistance from the power regime incumbents. This section studies which niche protection strategies are chosen in the latter stage of the niche development. It is evident from the interviews that representations of the same reality result in different narratives which can be used to make the public oppose or be in favour of a particular development. The material elaborated upon in this section is mainly drawn from the interviews. However, in particular the anti-narrative finds support in policy documents. This is unsurprising as the power sector is of major significance to the Norwegian economy. The supporting versus blocking narrative to respectively advance or hinder niche development is explored and illustrated in the following sections.

3.1 Supporting narrative

The role of buildings in climate change mitigation is generally accepted. However, as will be illustrated, this standpoint is mainly confined to energy efficiency measures and, to some degree, also the reduction of embodied energy, i.e. energy used in the process of producing materials. Power production on the building site is less commonly advocated in its own right, but is instead seen as part of an overarching narrative of Norway's role in a future European power system mainly shared by the proponents of the niche.

When exploring the narrative in favour of power-producing buildings, the most prominent arguments are the *alternative use* argument and arguments that portray the building sector as clever and solution-oriented, whereas opponents are seen as primarily protecting their own business interests.

Emissions are global, and Norway has a responsibility to contribute to reducing emissions. Energy that is saved or produced in buildings could be used for alternative purposes and thereby contribute to much larger emission-saving potential than in the building itself. Alternative uses could, for example, be in the transport sector, industry or for export. This argument focusses on the global effect of emissions. Households in Norway allegedly only contribute 1.4% of domestic emissions {energidepartementet, 2015–2016 #146}. This is due to the extensive use of electricity from hydropower, which is regarded as emission-free, and the narrow focus on the *operational* phase of the building. However, saving or producing power in buildings gives the opportunity to reduce emissions in other sectors, as illustrated by these quotes:

"I think it is a bit strange: the world is not exactly overflowing in clean energy … It seems odd that we can waste it; why should we not be able to share this energy with others? You need not save much energy in the building sector to be able to electrify the whole transport sector". Trade association 2

"You can export power in two ways: either by cable or by aluminium, to put it simply". Academia/research 1

These quotes illustrate that indirect effects are seen as an important motivation for the building sector to participate in the sustainable transition. As the building sector uses 23% of the domestic end use of energy {Olje- og energidepartementet, 2015–2016 #146}, the potential is significant, and it would be even greater if all buildings produced their own energy.

Another aspect of the supporting narrative focusses on the ability to build these concepts. The building industry has demonstrated that it is possible to build power-producing buildings, and that it is in fact not particularly difficult:

"Technically, we are able to make such buildings. … And if you look at Powerhouse, a zero emission building by definition, it was not particularly challenging. And we are getting more and more solutions, and prices are going down. If we know where we are going, the achievement is technically obtainable". Trade association 3

Innovative building concepts like power-producing buildings represent a challenge to the building industry, but the innovation that is needed is incremental and does not threaten to alter the structures of the industry. However, excess power needs to be stored or exchanged. Some actors argue that barriers to power exchange are exaggerated, and they expressed a suspicion that the alleged difficulties were due to business interests, as this quote illustrates:

"It is exaggerated and mostly nonsense. Norway has a well-developed power grid; we can do it. Germany has a much more challenging system. I think it is ridiculous that people are pointing at this as a problem in Norway. Thermal energy is much more complicated to exchange, but power, dear me! It should just have been done. I think this reluctance is due to business interests; they [a specific company in the power sector] said that they were terrified of small power producers". Academia/research 2

This demonstrates that the niche opponents are assigned protectionist motives by the niche advocates, and this is viewed as the primary reason why power-producing buildings are problematized.

3.2 Anti-narrative

The supporting narrative is countered by an anti-narrative which aims to block the niche development. How do the opponents of power-producing buildings express their doubts?

The anti-narrative lies close to the official energy policy in Norway. However, here the ambivalence becomes visible as there are both state-supported projects and absence of a vision that includes power producing buildings. The most prominent arguments against the niche are that electricity supply is already clean and abundant, and that the notion of power-producing buildings is not an answer to the challenges that the power system is facing. Opponents argue that the existing electricity supply is abundant and cost-efficient, whereas distributed power production is the opposite. The current power system simply possesses superior qualities compared to the alternative technologies. Neither power-producing buildings nor solar power is currently part of any national policy. Many respondents were puzzled by the prospect of a future with a substantial number of power-producing buildings as it is more costly and the grid can offer cleaner energy as well:

"If you build new Norwegian hydropower, this accounts for 6 g/kWh [CO_2 equivalents]. Is it better to build solar power on the building that counts for between 40 and 70 g/kWh than building hydropower that counts for 6 g/kWh?" Trade association 1

These numbers have been confirmed by several studies. Furthermore, the interviewee expressed some frustration about how the building sector interprets emissions calculations from buildings:

"My experience is that the building sector does not take seriously that it is actually a framework that regulates emissions from production. It doesn't matter to them; they don't care. They make their own regulations. But I think we have a duty to contribute to the achievement of national emission targets". Trade association 1

Interestingly, this actor focusses on 'national emission targets', whereas the building sector focusses on 'international emission targets'. This suggests that these targets are contradictory or open to interpretation.

Under the anti-narrative, it is also argued that power-producing buildings are not contributing to alleviating the (some might say principal) challenge of securing the supply of electricity by reducing the peak power demand from these buildings. Rather, they create new challenges, for example by producing power mainly in periods when demand is low. The risk of blackouts is typically a wintertime problem, related to low temperatures and patterns of behaviour {Olje- og energidepartementet, 2012 #158}. The focus on reduction of energy use has led to the invention of new products, for example on-demand water heaters, typically coinciding with user patterns in general. This reduces the overall energy use but increases the peak power demand:

"Some of these energy efficient solutions require relatively a lot of power. The power peaks are not reduced as a consequence of these buildings with a low energy need". Policymaker 1

In addition to these arguments, the overall solar power potential is portrayed as minor:

"It will take much to give a significant contribution to the energy supply in Norway. It takes a lot of roofs, and the contribution is largely restricted to the summertime". Policymaker 2

How to get rid of surplus energy is also a challenge, both selling it back to the grid company and selling it to a neighbouring building, as is uncompetitive battery technology. Delivering to one's next-door neighbour is problematic, because building a grid is the responsibility of the grid monopolist. Neighbourhoods are areas where several buildings or constructions can be seen in relation to one another and are planned as such. When establishing infrastructure to distribute energy between buildings/constructions, it is referred to as a microgrid. The Norwegian Water Resources and Energy Directorate (NVE) explains why microgrids are undesirable:

"In NVE's opinion, it is most serviceable if everyone has access to the [power] market by having a choice from whom to buy power. Therefore, it is not, as of today, permitted to establish a grid in a neighbourhood and instruct customers to buy from the owner of this grid. We think it is right that the customer is attached to a neutral grid company and can choose [a] power company freely. The grid company should own the grid and supply everyone. If a building owner wants to sell to the neighbour building he quickly becomes a monopolist". {Fladen, 2016 #169}

Among other things, the responsibility of NVE is to ensure an efficient power trade and a cost-efficient power system {NVE, 2016 #170}. As the present system functions well, there is no incentive to insert measures that could alter the very foundations of the system. As a regulator, NVE possesses great

jurisdictional power. This power is working at present against the introduction of power-producing buildings, and illustrates how the anti-narrative coincides with national policy. However, not all respondents thought it necessary to uphold the current system, and the idea of self-sufficient areas was brought up:

"In Norway, many grid companies would be willing to pay for customers to go off-grid. Not within the city, of course, but the area need not be very sparsely populated before it becomes expensive to operate a grid." Power company

The last quote illuminates an important point: the grid's customers pay for the service of a power cable to their door. If buildings produce their own power, without going off-grid, there will be fewer consumers to share the cost of further grid development and maintenance. This indicates that a shift in demand caused by, for example, distributed power production and more energy efficient buildings could be expected to have a large effect on the income of the grid companies. This could lead to a potential restructuring of the business, and hence the development is met with resistance.

The next subsection explores how politics affect the protective space dynamics.

3.3 Politics in protective space dynamics

The niche actors perform their niche understanding by not only forming alliances and networks, but also by developing narratives which could be an effective measure in political work to increase (or decrease) support for a specific niche {Raven, 2016 #193}. The supporting narrative presented in section 3.1 was arguing that saved or produced energy has an alternative use. This argument has a logic that is nevertheless contested by representatives from national authorities, as in the case of this interviewee:

"We cannot say that saving 1 TWh can be used in the transport sector or another sector, because it is not our area of responsibility. In the public sector, we are careful not to interfere with each other's responsibility". Policymaker 3

Other interviewees belonging to the policy level marginalized the alternative use argument as political rhetoric. Since this is the preferred argument of the niche proponents, it punctuates the debate before it has even started. In the interviews, niche advocates stated that they have to interpret the direction of the development in the building sector largely by themselves:

"The building industry has shown, for a long time, that the industry itself has been leading the development, ahead of the authorities, for example by developing BREEAM-NOR[5] *and such things. It is always the industry, at least the cleverest part of it, that is pushing the development, rather than the authorities".* Trade association 4

The niche proponents claim to take climate change seriously by showing what is possible, thereby pushing the limits for building codes and regulations. One of the interviewees argued that the authorities and the power industry simply do not want more energy efficient buildings because of their vested interests:

"The building sector is working every day to increase the focus on energy efficiency in buildings, but the Ministry of Petroleum and Energy and the Ministry of Finance are not very fond of us because of that.

[5] A Norwegian green label certificate which builds on the British label BREEAM.

… It is difficult to increase the focus on energy efficiency in buildings … [as] the energy industry is not very interested in energy saving". Trade association 2

This reinforces the assumption that policymakers are in favour of the anti-narrative. The lack of enthusiasm regarding largely uncontroversial energy efficiency measures was explained by some of the interviewees as being due to the interdependencies between the power sector and the authorities. The power sector is closely connected to the public authorities in several ways, not least because of the revenues it generates and ploughs back to its public owners. There is a lack of autonomy between the power sector and government authorities which, according to Hess {Hess, 2013 #135}, makes it difficult to resist attempts by the incumbents to block a transition or the introduction of a particular innovation.

3.4 The niche development process

The niche development process has been fragmented and suffered from the lack of a common thread. Although buildings have been energy producers for some time, there is reluctance among the authorities to institutionalize power producing buildings. Narratives in line with the anti-narrative have worked to downplay the potential of the niche over many years, and these conceptualisations of reality are deeply entrenched in society. However, authorities are responsive of pressure from the increasing number of such buildings as well as the improvement of the technology itself, among other things. Knowledge and learning have accumulated in particular through a research centre on zero emission buildings (ZEB) established in 2009. The recent establishment of a research centre on zero emission neighbourhoods (ZEN) as well as public support schemes launched by the state-owned enterprise Enova are indications of a more receptive selection environment. As is common when new technologies are introduced, contradicting forces appear to be present, and this results in an ambivalent policy. Strategies have nevertheless shifted from emphasis on inward-oriented strategies towards more outward-oriented but conflicting strategies offering competing views about the niche.

On the whole, within the interviews, representatives from the building regime advocate the supporting narrative, whereas interviewees belonging to the power regime advocate the anti-narrative. The success of the niche is affected by the ability to form a narrative that is in line with assessment criteria used by the public authorities. It is worth noting that the anti-narrative is part of the current national energy policy. This makes it even more resilient and harder to challenge. Being able to link the niche to a broader socio-political agenda seems imperative for the niche to succeed {Raven, 2016 #193}. So far, the niche advocates have not succeeded in getting acceptance for their narrative, although strategies that align to (fit and conform) national policies have been seen, for example with the support for the electrification of the transport sector. This is clearly also in accordance with the alternative use argument. However, linking the narrative in favour of power producing buildings to the challenge of peak power demand is likely to be a more efficient strategy.

This section has dealt with strategies of niche empowerment, when the niche is increasingly exposed to its selection environment. This has been highlighted by drawing from interviews with actors representing both niche advocates and niche opponents.

4. Not simply a question of implementation

The previous section presented empirical findings that illustrate how niche protection materializes and that niche empowerment is in fact a highly political process. In this section, the findings are analysed further to comprehend the policy ambivalence regarding power-producing buildings. Additionally, how could narratives function as bridging devices in this context?

When introducing a niche that also could be a path-breaking innovation, its spread is not merely a question of users and markets, but a wider selection environment must be taken into account. The forms of power and resistance towards power-producing buildings materialize in different ways, and narratives and anti-narratives are formed as part of the discourse. The niche-supporting narrative could become a bridging device between the niche and the regime if addressing challenges as defined by the regime. Generally, fit and conform strategies have a larger chance of succeeding than stretch and transform strategies, although a combination has proven to be even more successful {Raven, 2016 #193}.

4.1 The materialization of power and resistance

As evidenced for example by the financial support provided for the installation of heat pumps in Norwegian households, energy-producing buildings have been part of Norwegian policy for many years. Within the theoretical framework described above, niche development is part of a socio-technical transformation that is affected by protected space dynamics through the global context, networks and alliances, technological and market development and more. There are different strategies of protection through the development process of a niche. Friction arises when the shielding is removed and the niche faces the selection environment. This often results in the exercising of different forms of power and resistance which materializes in a number of ways, for example through narratives and lobbyism. Even if outward-oriented activities are growing, inwards-oriented activities are still needed, as experiments and knowledge creation have to be acquired in the actual environment. This socio-political process that aims to create a productive relationship between niche- and regime-processes could be described as a negotiation. However, it is an uneven one, as the niche opponents have access to more forms of power compared to the niche advocates. Actors on both sides reveal a lack of trust in one another and a suspicion that the opposing party is merely interested in protecting its business. Both are claiming to advocate sustainable solutions through narratives. According to Smith and Raven {, 2012 #90}, the existence of different narratives is expected when a niche emerges from its protected space, because institutions are weak or there might also be institutional void.

The regime which is challenged resists change, not only by producing anti-narratives but also by using its institutional power to hamper the development of power-producing buildings, for example through legislation. In addition, it downplays the potential and basically every other aspect of the niche in the arenas that are available. For instance, as seen in the White Paper on energy {Olje- og energidepartementet, 2015–2016 #146}, the calculation of the potential for solar power production selectively chose not to include existing roofing or detached production sites.

The development of power-producing buildings could take place without any support from the government and largely be driven by a rising demand side due to environmental concerns and new actors seeing business potential. For the time being, the incumbents in the power industry seem to be awaiting the development. The advantage of being first is not clear, and a “waiting game” begins {Parandian, 2012 #155}, which is the main danger in the situation described as follows: the extension of renewable energy production becomes part of the waiting game.

4.2 Narratives as bridging devices

Although ambivalent policy is rather normal in connection to the development of new technologies {Kemp, 1998 #205}, ambivalent policy is nevertheless an important barrier. However, when challenging a stable regime, ambivalent policy could also be interpreted as an outcome of policies that are supporting the niche development. This gives a window of opportunity in which the selection environment could be altered to be more receptive to the niche.

Government, firms and other actors tend to form alliances due to interdependencies {Geels, 2014 #129}, but firms and industries depend on government to provide a favourable environment for development. Government possesses a power superior to the other actors, although it is not omnipotent. Ambivalent policy could be harmful in several ways. The development of less favourable solutions is one consequence. The insecurity upheld by ambivalence in policies leads to reluctant approximation, and opportunities can be spoiled. In order to reduce the ambiguity, this subsection explores whether narratives could bridge the distance between the regime and the niche, and, if so, how?

The nurturing and empowering activities by both regime and niche actors can be interpreted as a possibility for niche growth. As long as the regime is not using its institutional power to completely block the niche, it is possible that it will prosper, even if regime actors do not seem thrilled. One development favourable to niche growth was the recent public support for the research centre ZEN which demands that niche advocates and opponents negotiate further development of the niche in close interaction. Another development is the extensive discussion of solar power in the much referred to White Paper on energy {Olje- og energidepartementet, 2015–2016 #146}. Even if the calculation downplayed the potential and no strategy was laid out, the solar power potential was discussed in detail. Hence, solar power and thereby power producing buildings are about to be taken seriously.

The supporting narrative is backed by these recent developments as well as indirectly through the support for electric vehicles. Raven et al. {Raven, 2016 #193} suggest that if a narrative succeeds in framing the developing technologies as solutions to specific regime challenges, it has a greater chance of succeeding. Following this logic, niche proponents should be more focused on the role of buildings in alleviating the risk of blackouts, which is a primary concern for the authorities. If power-producing buildings could represent a solution to problems as defined by incumbents, this could result in regime actors embracing the niche instead of resisting it. In this way, the narrative could function as a bridging device.

One development that would render powerless several objections to power-producing buildings would be if there was a competitive battery technology to handle the surplus energy. This might be the situation in the near future, but it is not yet. Storage technology, in particular batteries, has improved immensely over the last few years {Norwegian Climate Foundation, 2015 #147}. Batteries are available, and costs are likely to decrease. Also, the market diffusion of electric vehicles offers a potential battery for the building. Competitive battery technology is apparently reducing the conflict as buildings can produce and use their own energy as they like. Yet, if this were to become a widespread solution, it would very likely threaten the income structure of in particular the grid companies. We would therefore see the need to reorganize not only the structure of the business, but also the income basis. As part of the niche narrative, the prospects of competitive battery solutions should therefore be framed as a possibility to reduce power peaks, which is perceived as a challenge to the power regime. In this way, the narrative could be bridging the interests of the regime actors and the niche proponents.

The extensive national and partly international power grids have been immensely important to the development of the industrialized world. Despite this successful project, or rather in addition to its further expansion, an increased focus on microgrids in the coming decades seems likely. Driven by environmental concerns and/or EU regulations, distributed power production is of growing significance to the total power production. The aforementioned support for the ZEN research centre is a signal that further development of microgrids will be explored. This is reinforced by financial incentives supporting conceptual development plans for areas. This could also be framed as areas that

could be more or less self-sufficient and thus also contribute to reduced power peaks as well as reducing strain on further development and maintenance of the electricity grid.

5. Conclusion and policy implications

Power-producing buildings could be seen as a path-breaking innovation and be described as a *niche*. In this paper, niche protection strategies – and counterstrategies – in the latter stage of a niche development have been explored. Government policy is ambivalent towards the niche, and its proponents and opponents have developed different narratives to persuade the 'public' about the (dis)advantages of the niche. Largely, the narratives are developed from the interviews. However, the anti-narrative finds resonance in policy documents as the power regime partly overlaps the policymakers. Finally, the paper explored in what way the supporting narrative could function as a bridging device between the regime and the niche.

The power of buildings in climate change mitigation is disputed in Norway, mainly due to the clean and abundant supply of hydropower. Yet, building concepts that result in intermittent surplus of distributed power production are developed mainly with a reference to environmental concerns. These power-producing buildings represent a potentially path-breaking niche that can take on different strategies in the development process. In this paper, the latter part of niche development has been studied where the shielding of the niche is removed, and it becomes exposed to a wider selection environment. Actors backing the niche are developing strategies to enable the niche to break through by advocating the advantages of the niche through a supporting narrative, network building and other empowerment activities, whereas niche opponents are developing counterstrategies like anti-narratives {Boon, 2014 #200}.

The supporting narrative portrays power-producing buildings as a measure that could cut emissions, in particular if the power produced were used to reduce emissions from the transport sector, industry or for export. In addition, power-producing buildings are not very difficult to build.

The anti-narrative stresses the superior qualities of the current power system and emphasizes that there are virtually no emissions from the building sector. Furthermore, the niche opponents argue that power-producing buildings do not alleviate the principal problem which is to reduce peak power demand; rather, they only create more.

Ambivalent policies are common in connection to new technology developments, and they could be interpreted as an outcome of policies that support niche innovation that depart from the stable regime structure. It is nevertheless important for the pace and direction of the development that policies become unified. Ambivalent policies create insecurity, and action may be delayed or misguided. The sectoral responsibility in politics is likely to contribute to the ambiguity as different ministries have separate areas and are careful not to interfere with the responsibility of others. This makes it even more challenging for a niche that crosses different regimes and therefore relies upon actors with divergent interests to unite.

However, there is a possibility that the supporting narrative could function as a bridging device between the power producing niche and the power regime, in particular. As suggested by Raven {, 2016 #193}, the possibility for this would increase if the supporting narrative addressed problems perceived by the niche opponents – primarily actors within the power regime. If the narrative were able to bridge the differences, the niche would have a greater chance to grow. For clarification; if the supporting narrative embraced one or more of these arguments, it could work as a bridging device:

- If battery technology improves, this would limit the objections concerning production and deliverance in a period of low power demand (mainly summertime). Buildings could store power for their own use but would probably still need to be connected to the grid. The reduction in power demand that this would cause is likely to alter the income structure of the grid companies. However, as a result of competitive battery technology, peak power could be reduced.
- The return to the microgrid is a trend caused by the decarbonization of the power sector in many regions of the world, including in the EU. This is adding to the pressure of the power-producing building niche due to rapid development in solar power technology and reduced prices. If microgrids were accepted, this could reduce the development costs of the grid infrastructure at large. In places with very few people, self-sufficient areas could be erected. Microgrids would also contribute to reducing the power peaks.
- Solutions and products should not only focus on the overall energy use, but also on reducing peak load.

These arguments would be in line with the challenges as defined by the power regime incumbents, which make them more likely to succeed as bridging devices between the niche and the regime. However, if demand for solar power panels rose sharply due to environmental concerns or the development of more cost-efficient products, this could be a challenging situation. It would call for a change of the 'rules of the game' and could therefore be described as a *stretch and transform* strategy. According to Raven {, 2016 #193}, research indicates that a combination of both fit and conform and stretch and transform strategies would have the most empowering effect on the niche.

The ambivalent policy regarding power-producing buildings could be sustained by an unsuccessful narrative that has not been sufficiently convincing about the benefits of the niche. To gain acceptance, the narrative should target challenges as perceived by the regime. In doing so, it could work as a bridging device between the niche and the regime.

5.1 Policy implications and suggestions for further research

Niche actors promoting power-producing building concepts have underestimated the need to work on a convincing narrative. Being a potential bridging device, narratives are of political significance. The interplay between narratives and anti-narratives has not been widely researched and could be further investigated.

Grid companies would likely be willing to pay for areas to go off-grid in the future because it is expensive to develop and maintain a well-functioning grid in a sparsely populated country like Norway. This requires increased research on zero energy neighbourhoods that could be self-sufficient. Another possible implication of power-producing buildings is that energy will be paid per kW instead of per kWh. The implications of this development should be further researched.

The demand-side issues connected to power-producing buildings have not been explored in this paper. This should be done in a subsequent paper, for example by exploring the motivation to invest in solar panels among the population of more than 500 households that have already installed or have concrete plans to install such equipment.

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7. References