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BEYOND INNOVATION

Towards an extended framework for analysing technology policy

by Knut H. Sørensen

This paper analyses technology policy as a scholarly concern and political practice that needs to be taken beyond the present somewhat singular focus on innovation and deployment. We also need to include an interest in the making of infrastructure, the provision of regulations, and democratic engagement. Consequently, this paper introduces the concepts of socialisation and domestication to overcome the instrumental, economic framing of technology policy. These concepts highlight the importance of embedding and enacting new technology. The suggested conceptual framework is used in a brief synthetic analysis of four examples of technology policy and technological development in the Norwegian context: cars, wind power, hydrogen for transport, and carbon capture and storage (CCS).

Keywords: Technology policy, innovation, deployment, socialisation, domestication

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Introduction: what is technology policy?

Technology plays a prominent role in many kinds of discourses concerned with improving human conditions and the political management of challenges like global warming, sustainability and employment. In particular, this is expressed through widespread use of concepts like 'innovation' and 'knowledge-based society', which form the basis of much of today's public policies and governance. Arguably, the development of technology has become a sublime that focuses the hope for a better future in a particular manner. This paper is concerned with how we may conceptualise the scope of policy issues involved in pursuing technological development as a way of improving modern societies. Presently, many scholars agree about the need to supersede the present dominance of a fairly singular focus on technological innovation for economic growth, albeit for different reasons, like the need for sustainable transitions (Schot and Geels 2008, Steward 2012), the impact of non-technological regulations (Paraskevopulo 2012), concerns for the role of activists (Hess 2007), the need to include broader political economy perspectives (Tyfield 2012), or the importance of pursuing public engagement and perceptions of risk (Felt et al. 2007).

In early science and technology studies (STS), the analysis of science and technology policy was a main concern (Spiegel-Rösing and Price 1977). However, the main focus of these efforts was science-government relations centred on R&D, in particular the analysis of how social interests shaped such policies (Cozzens and Woodhouse 1995, Elzinga and Jamison 1995). While these are important issues, this paper moves in a different direction. Rather than emphasising the role of science policy as an articulation of social interests and power to influence innovation, I want to pursue what may be considered "downstream" issues arising from efforts to integrate technologies in society. Thus, the intention is to complement the efforts of broadening science and technology or innovation policy analysis by developing an inclusive concept of technology policy. This concept should help providing a comprehensive agenda with respect to what the analysis of policy-making with respect to technology may involve.

As a scholarly term, technology policy is not widely used in the social sciences, including policy analysis. The concept is not common in public political discourses either. For example, using 'technology policy' (in Norwegian: 'teknologipolitikk') to search Norwegian news media through the comprehensive database Retriever, we find that the term is rare – in striking contrast to 'science policy' or 'innovation policy'. Maybe 'technology policy' triggers unpopular images of governmental planning and thus runs counter to the present dominance of neoliberalism and the belief in the all-powerful market? Or is it that the concept does not fit the heralded visions of globalisation since it seems to refer to the nation state?

What should we mean by 'technology policy'? Lewis M. Branscomb (1993:3) provides the following definition:

> A technology is the aggregation of capabilities, facilities, skills, knowledge, and organization required to successfully create a useful service or product. Technology policy concerns the public means for nurturing those capabilities and optimizing their applications in the service of national goals and the public interest [...]. Technology policy must include not only science policy ... but also all other elements of the innovation process, including design, development, and manufacturing, and the infrastructure, organization, and human resources on which they depend.

In a similar vein, Charles Edquist (1994:68) defines technology policy as "all public intervention in the process of technical change. More specifically technology policy is implemented by a number of public policy-making bodies that use specific instruments to influence the process of technical change". Further, Edquist makes a distinction between direct and indirect technology policy. The first is expressly intended to influence technical change, while the latter includes policies that are not primarily designed to shape technical change, but still have such effects. This includes trade policies, military policy and industrial policy.

Thus, supposedly, technology policy is a comprehensive scholarly concern, but how comprehensive in practice? Both Branscomb and Edquist frame technology policy as primarily an economic issue. Branscomb (ibid.) states that: "Technologies are created for economic reasons and the investments they call for must be economically justified". Edquist (p. 70) claims that: "The most important goal of (civilian) technology policy is in practice increased productivity growth and competiveness". This suggests a limited and fairly instrumental interpretation of technology policy as mainly science and/or innovation policy to serve economic interests.

A twist on such an interpretation is found in Mowery et al. (2010). They propose developing a technology policy approach aimed at managing the threat of global climate change. Mowery et al. argue the need for a large-scale, concerted effort to develop and deploy energy technologies that can be tools for climate change mitigation, and they criticise suggestions that such efforts can modelled after the Manhattan project or the Apollo programme. They call their alternative a R&D support programme, making R&D the core of the effort of climate change mitigation. The problem of deploying technologies for sustainable energy is mainly conceived as a challenge for governments to stimulate the demand for such technologies. Again, we observe the dominance of an economic framing, even if Mowery et al.'s main concern is global warming.

If we turn to STS, we find a number of studies that are relevant to the understanding of technology policy, like work on standards (Bowker and Star 1999), genetics (Wright 1994, Jasanoff 2005) or gender (Sørensen, Faulkner and Rommes 2011, Wajcman 2004). Arguably, the co-production approach of STS (Jasanoff 2004) could be useful, for example by considering technology policy as a co-production of technology and policy or of development and deployment. However, the concept of technology policy is usually not part of these scholarly contributions.

Some efforts have been made to provide a more policy-oriented version of STS (Sørensen & Williams 2002, Hommels et al. 2007, Raven et al. 2009). One way of doing this is to extend the concept of technology policy to be more concerned with downstream issues, like use or domestication of technology (Sørensen 2002a). Sørensen (2002b) suggests that studies of technology policy should have four main concerns to transcend the dominant economic framing and focus on R&D: (1) Support for innovation, (2) The provision of infrastructure, (3) Regulation, and (4) Public engagement.

This paper will use the latter effort as a stepping stone to develop a framework for conceptualising and analysing technology policy. In doing so, there is a need to be reflexive with respect to the relationship between technology policy as an analytic and as a normative concept. Since we find relatively few instances where policy-making efforts are characterised by the practitioners as technology policy, relevant efforts have to be re-assembled (Latour 2005). Scholarly contributions have to be treated in the same manner. Using 'technology policy' as a generic term for issues of governance with respect to technology and technological development is meant to emphasise the need to study such governance as a set of possibly interrelated activities. This is intended to provide analytic benefit but it is also a normative stance in the sense of an implied critique of policy-making efforts that appears to be split up or are rendered invisible.

As suggested above, technology policy issues related to research and innovation have been fairly thoroughly researched. This is above all true with respect to the literature on innovation systems (Archibugi and Lundvall 2001) but also through the concept of triple helix (Etzkowitz 2008). To go beyond innovation-centred perspectives, this paper starts by moving downstream to consider what Mowery et al. call deployment issues, the rate of adoption of given technologies. I argue that from an STS perspective deployment is closely related to the processes of socialisation and domestication of technology, and thus to sense-making and use. However, as we shall see this is not a one way trip, but rather involves complex navigation upstream, downstream and sideways. The next section introduces some relevant theoretical perspectives that may help in the navigation. Then, I turn to some empirical examples mostly related to sustainable energy to demonstrate potential achievements from drawing on an inclusive concept of technology policy.

Technology in use: deployed or domesticated?

It is a truism that demand plays a crucial role in successful innovations. This is considered to be related to understanding user needs as well as user experiences and the related processes of learning (Andersen and Lundvall 1988). Kline and Rosenberg (1986) introduced the chain-linked model to transcend linear understandings of innovation by emphasising how knowledge and information moved through a variety of chains involving a diversity of actors. Lundvall (1988) proposed an interactive learning model, where innovations were shaped by producer-user interactions. The more recent national system of innovation literature integrates these and supplementary perspectives (Lundvall et al. 2002, Fagerberg and Sapprasert 2011) as do triple helix-oriented research (Etzkowitz 2008). Still, the innovating company or organisation is at the centre of attention, in some ways similar to classic actor-network theory's understanding of translation as being performed by entrepreneurial scientists or engineers (Latour 1987).

The concept of deployment transcends this focus through the acknowledgement of the need for policy actions to bring new technologies into use. Deployment policies are concerned with changing the premises of demand as well as users' engagement with given technologies, rather than with analysing consumption and use. Such policies may of course affect innovation efforts, for example by leading to increasing investments in innovation (Hoppmann et al. 2013), but that is not the prime target. The main aim is getting new or existing but underutilised technologies in place so that they can contribute to, for example, production of energy without emissions of CO_2.

Müller et al. (2011) perceive this aim above all as a need to remove barriers of deployment. They classify such barriers in the following way (p. 32-33):

1) Techno-economic barriers related to relative costs compared to competing technologies.
2) Non-economic barriers that related to factors preventing deployment or increasing costs
    - o Regulatory and policy uncertainties
    - o Institutional and administrative barriers
    - o Market barriers, for example inconsistent pricing structures
    - o Financial barriers
    - o Infrastructure barriers
    - o Lack of awareness and skilled personnel
    - o Public acceptance and environmental barriers.

This list of barriers covers a broad spectrum of technology policy issues, which makes the thinking with respect to deployment pretty comprehensive. Nevertheless, there is an ontological problem in the identification of deployment and barriers. The concern of Müller et al. seems to be to identify and remedy features that may curb the diffusion of renewable technologies through the stages of initiation, take-off and consolidation (see for example p. 50-51). The resulting frame of interpretation largely black-boxes technology through the use of quantitative indicators. Deployment is measured by counting the number of installations, energy production, investment levels, etc. Thus, the concept becomes predominantly economic with a singular focus on market competition. The actual dynamics of the appropriation processes are overlooked, like what happens when new technologies are moved into "the real world", where the concern for demand might be extended into a concern about use. In a sense, the deployment perspective also black-boxes demand by making it into an issue only of accounting, overlooking the potentially dynamic and reinforcing effects of creative use.

As already suggested, an alternative to the fairly instrumental deployment thinking is to be concerned with processes of appropriation of technology – the ways in which technologies embedded in society, and how technologies are affected by the processes of embedding, including cycles of embedding, dis-embedding and re-embedding (Giddens 1990). This would be in line with basic tenets of STS. How may we theorise such processes of technological change, focusing on use and the ways in which a diversity of publics engage with new technologies?

STS offers a host of overlapping possibilities. In the light of the focus on R&D, so prevalent in technology policy studies, an interesting proposal is to study the socialisation of scientific and technological research (Bijker and d'Andrea 2009). This could mean reframing the policy issues related to innovation and deployment as a need also to develop specific socialisation policies to provide what Mowery et al. (2010) call R&D support programmes. Actually, the socialisation perspective goes further in its insistence that the embedding of new technologies potentially implies a very comprehensive set of tasks, distributed over many areas.

Bijker and d'Andrea identify six such socialisation areas: (1) scientific practices, (2) scientific mediation, (3) scientific communication, (4) evaluation, (5) governance, and (6) innovation. Consequently, potentially, there are a manifold of agents of socialisation, which should be found in scientific institutions, NGOs, government agencies, etc. The problem is, according to Bijker and d'Andrea, that the work of socialisation is not done: "(I)n Europe, the "agents of socialisation" seem to be few; they often work in hostile environment, where resistance and hindrances limit the "systemic" impact of their action; the degree of acknowledgement that they receive from public institutions varies country by country, but overall it appears to be limited; they prevalently act in an "atomised" way, or create short and scarcely visible operation chains" (ibid, p. 22-23, emphasis in the original).

Compared to the deployment perspective with an ontology characterised by an economic framing and a focus on barriers, the socialisation approach as outlined by Bijker and d'Andrea is broader and more concerned with the potential for facilitation of societies' and social communities' appropriation of science and technology. Their concept of 'agents of socialisation' is helpful in identifying who should be expected to do the work of bringing science and technology out of scientific institutions and into use.

Of course, the idea that scientific and technological research or technology needs to be socialised is a basic STS tenet. Technologies only exist as sociotechnical entities. They are developed through reflections about achievements and use, including commercial intentions. As Latour (2005) reminds us, there is a lot of work by a diversity of actors involved in the translation efforts through which new embedded technologies emerge. Thus, actually, much socialisation is and has to be done. However, this work as well as the technologies involved are often rendered invisible and forgotten (Winner 1977). This means that the efforts of the agents of socialisation are easily overlooked. Bijker and d'Andrea are correct in their call for more and improved socialisation efforts. Still, if we are aware of the lack of visibility of the efforts of agents of socialisation, we may be able to observe more of it. This is important when we are concerned about the potential scope of technology policy.

We should also recognise that non-human actors too may be important agents of socialisation. While we may discuss how we should understand the ways in which humans and non-humans interact (Pinch 2012), we should not overlook the importance of infrastructure in shaping and facilitating the shaping as well as embedding of new technologies, including how new technologies are interpreted (Bowker and Star 1999). For example, fuel-cell cars will not be socialised without a network of hydrogen filling stations, which facilitate the practice of refuelling hydrogen as well as signifying that fuel-cell cars are a viable alternative to petrol-powered cars. Equally important are regulations, which set standards and provide risk management that are vital socialisation efforts. Thus, we need to multiply the number of socialisation areas that Bijker and d'Andrea identify.

To summarise, the paper has argued an extended conceptualisation of technology policy to include concerns about socialisation, together with innovation and deployment, as well as the interaction of these sets of activities. However, we need to explore the processes through which new technologies are embedded in society; how they may be enacted and made sense of by users. This concern points towards domestication theory as an approach to study such enactments and sense-making (Sørensen 2006). Domestication takes place in many areas and involves a multitude of actors. It results in practices with regard to use, provides meaning to the technology in question, and depends on users managing cognitive challenges related to learning and understanding the technology. Some technologies are domesticated swiftly across a broad

spectrum of the population, while other technologies become domesticated slowly and/or by small communities, and some technologies are not domesticated at all. Arguably, socialisation efforts should help technologies, or scientific knowledge for that matter, become domesticated. Domestication of a given technology means that it has been deployed, but the observation that the technology has been deployed tells us nothing about sense-making and the development of practices. To get such knowledge, we need to study the actual process of domestication.

This means that the study of domestication provides measures from which we may assess innovation, deployment and socialisation. With respect to innovation, the understanding of user needs is vital. Technologies have to be domesticated to be considered employed, and domestication failures may indicate socialisation flaws. However, these relationships may be contested, competitive and filled with conflict. Technology policy is a field of articulation of interests and thus of controversy. Thus, it has to be approached with this in mind. There may be good reasons that some technologies do not become deployed, socialised and/or domesticated, and anti-deployment and anti-socialisation strategies may be acceptable, even fruitful, for a host of reasons.

In a concept of technology policy concerned with innovation, deployment, socialisation and domestication, it is important to note that in relation to new technologies the public may play a complex of roles, as consumers, citizens and users. Technology policy may address these roles more or less explicitly, depending on scope and focus. If we are to improve our understanding of technology policy, we need to study how the different roles are catered for – if at all.

Let us briefly consider some examples. Today, nearly everyone in Norway is familiar with SMS (short message service), which is an integral part of mobile telephones and developed as part of the telecommunication standard called GSM (General System for Mobile Communication). The domestication of SMS happened incredibly swift through young mobile phone users who discovered this application as a cheap, quick and handy way of communicating with each other. The emergent practices, including shorthand and symbols, were produced by the collective of users in a distributed fashion where nobody credibly may claim intellectual property rights. This collective of users socialised SMS without any policy effort outside standard regulation of mobile telecommunication. In this case, technology policy with respect to mobile telecommunication did not really address any of the three potential roles of the public.

This may be contrasted to electric vehicles, where current technology policy in Norway includes comprehensive socialisation efforts to make such vehicles attractive as well as to facilitate an interpretation of them as environmentally and climate friendly (Ryghaug and Toftaker forthcoming). In this way, the population is addressed as citizens (to understand and accept the special conditions provided to electric cars), as consumers (making electric cars attractive) and as users (providing meaning to as well as some suggestions about the use of electric cars).

An interesting example of a non-embedded technology in Norway is nuclear power. Norway got its first atomic reactor in 1951 as the fifth country in the world. The reactor was primarily intended for research and experiments, and the director of the Institute for Atomic Energy (today, Institute for Energy Technology), Gunnar Randers, made a very substantial effort to socialise atomic energy (Randers 1975). However, Norway and Norwegians never domesticated nuclear power, and the Parliament eventually decided against the construction of nuclear power in Norway. Relatively speaking, no other technology has received as much funding as atomic energy in Norway, but as a technology policy object it became a failure because neither the practices involved in producing nuclear power nor the meaning attributed to the technology was considered attractive. The anti-socialisation efforts of the anti-nuclear movement (the public enacting the role of citizens) stopped innovation and deployment and thus made the roles of consumers and users unavailable.

These examples also nicely illustrate some consequences of domestication with regard to technology policy. In the case of SMS, a quick, successful domestication based on a distributed, collective user-driven socialisation effort, made any form of policy intervention superfluous. With electric cars, policy-makers saw a need for facilitating actions and launched an active technology policy for deployment and use, leaning on explicit socialisation efforts. Nuclear power exemplifies the potential role of conflict in rendering technology policy ineffective. The comprehensive socialisation efforts, in particular by the research community throughout the 1950s and 1960s failed when confronted with strong anti-socialisation actions. Thus, nuclear power did not lend itself to be domesticated by the general public or even by energy companies.

So far, this paper has provided an argument for analysing technology policy in a comprehensive manner by going beyond innovation and adding the issues of deployment, socialisation – including infrastructure and regulation – and domestication. Deployment should be considered because, often, policy efforts are made to get technologies employed. Socialisation is similarly important as a set of actors and activities that may or may not be mobilised in order to embed new technologies in society, while the analysis of domestication throws light on the effectiveness of policy achieving employment and embedding. Above all, socialisation efforts should be thought of as means to facilitate domestication.

In the next section, the aim is to demonstrate the potential of the proposed framework to analyse technology policy activities, with an emphasis on socialisation and domestication. We shall also see that such policy-making is complex, multi-sited and multi-actor. Such observations are not new to policy analysis, but this is still important to observe.

Exploring technology policies in a Norwegian context

In this section, I analyse four examples of development of technology in Norway from a technology policy perspective: (1) The appropriation of the car in the 19th and 20th century, (2) Wind power development, (3) The so-called Hydrogen Road as an experiment in supplying hydrogen for transport, and (4) The development of carbon capture and storage (CCS) technology. The choice of these examples is partly a pragmatic one; I have been involved in studying them. However, as hopefully will become clear, they display interesting diversities with respect to scope, aims, achievements, timing, and policy efforts. The analysis is synthetic and draws on printed sources to explore theoretical considerations. I do not present full-blown empirical accounts but try to demonstrate how the extended concept of technology policy brings forward observations that are more difficult to make with a singular economic focus on innovation and deployment. Thus, as a consequence, the paper highlights socialisation efforts. This is done by identifying areas, actors and strategies involved in the socialisation as well as considering domestication activities and their effects. First, we turn to a fairly long-term historical example, that of the motorcar in Norway.

The embedding of the car in Norway[1]

The appropriation of the car in Norway during the 19th and 20th century provides many lessons with respect to the role of socialisation in technology policy as well as regarding deployment and domestication. Also, it points to the possible problem of conflicting policy aims. Initially, the story of the introduction of the car in Norway was initially very much about development of regulation and provision of suitable infrastructure, neither of which really predated the automobile. The first legal term for a car was 'a rail-free vehicle', contrasting it to the railway. Thus, the making of non-human socialisation actors was critical and the main element of technology policy with respect to cars.

Initial regulations meant cars could only be considered to be a hobby for the wealthy, since the expensive vehicles were slow and not very comfortable, while the rules for driving them were very strict. This changed, and a main socialisation actor was the Directorate of Public Roads whose managing director Hans Hagerup Krag in the late 19th century publically demonstrated car driving and sent employees abroad to learn about making roads suitable for automobiles. Regulatory efforts were developed to become more accommodating; including the making of traffic rules as well a system for certification of drivers and vehicles. In combination with advertising efforts and newspaper coverage – done by socialisation actors outside of policy-making circles – this resulted in an extensive sense-making with respect to cars as well as the development of driver practices. Infrastructure was built to include petrol stations, car repair shops, car dealers, etc.

The result is that cars became a pervasive feature of modern Norwegian society with a comprehensive infrastructure as well as a diversity of car-related practices of individuals and communities. Policy-making activities related to provide regulations and infrastructure clearly were effective socialisation measures. This resulted in a widespread domestication of cars in Norway. For example, when Hans Hagerup Krag was the head of the Directorate of public roads, he could be seen as developing a policy to deploy cars in Norway. This effort was made above all by being a socialisation actor, which included removing the barrier of unsuitable roads by improving transport infrastructure. On the other hand, politicians were not too keen on a speedy deployment. Norway early began to tax cars and car-use relatively heavy. This was legitimized by labelling the car as luxury, as a relatively expensive and unnecessary artefact. Since Norway was (and is) without its own car industry, cars are imported and from an economic point of view, they are a negative item on the trade balance. Such considerations led to the introduction of import quotas on cars from 1945 to 1960. During this period, those who wanted to buy a private car had to apply for an import license, and such licences were granted on the basis of assumed needs. This favoured people who could argue that they needed a car to facilitate their professional activities, like doctors, shop-owners and craftsmen. Overall, the labelling of cars as luxury items represented a technology policy that at least partly employed an anti-socialisation strategy.

Thus, technology policy with respect to cars could be seen as ambivalent, a mix of deployment and impediment efforts. Such ambivalence may be more common than most of the literature about technology policy suggests. Further, technology policy with respect to cars was not a concerted action. Rather, it was distributed, involving a multitude of actors with a diverse set of interests, objectives and instruments. Deployment was important to some, but most actors were socialisation agents contributing to the adaption of cars and related technologies to Norwegian society – some policy-making insiders, others being outsiders. However, one cannot understand the predominant role of the car in transporting people in Norway without acknowledging car owners' domestication of their vehicle as a combination of a necessary good and as an object of comfort, identity, and freedom. In this sense, deployment and socialisation had strong tail wind, despite import quotas (lifted in 1960) and high taxes.

Cars are definitively technology policy objects, but we have to be aware – as suggested above – that the technology policies that

1 This section is based on Sørensen (1991) and Østby (1995).

are meant to influence the deployment and use of cars may not be confluent. Some measures, like building better roads, may stimulate ownership and use of cars. Other measures, like taxes or road pricing, may work as anti-socialisation strategies. The lack of confluence may also be due to different interpretations of the public, like environmentally concerned citizens versus impatient consumers. Moreover, considering the historical process of appropriation of cars in Norway, it should be clear that the massive deployment was not mainly a policy outcome. It is easier to see socialisation agents – inside and outside of policy-making - that facilitated sense-making, but arguably, Norwegians were easily persuaded to become car owners and drivers. In this sense, the outcome of the Norwegian domestication of cars has shaped technology policy with respect to transportation, most obviously so by motivating anti-socialisation strategies.

Wind power development – in headwind?

Like the car, the deployment of wind power in Norway is basically about imported technology. Technological innovation has been a marginal and backstage issue. Moreover, deployment has been slow, mainly because of a general lack of investments in the production of electricity. Compared to hydro power, wind power has always been considered to be too costly, and technology policy with respect to wind power has mainly been an issue of how and how much to subsidise. In 2012, Norway joined Sweden in establishing a system of so-called green certificates to stimulate investments in renewable electricity through subsidies. While this deployment effort seems particularly beneficial to hydro power, it has also spurred increased willingness to invest in wind power. Per 2012, there were only 315 wind turbines in Norway, with a capacity of 704 MW. The capacity is expected to reach between 3 000 and 3 500 MW in 2020.[2]

With respect to socialisation efforts, the situation is more complex. Existing regulation provide a licencing system that calls for developers of wind power to inform and engage the local public, while the power grid infrastructure has imposed limitations with respect to constructions (Gjerald 2012). Gjerald shows that industrial actors working with wind power see the licencing system as bothersome because it is time consuming, but they also acknowledge the usefulness of the system exactly because it acts as a socialisation machinery. Two public institutions are part of the system as socialisation and deployment actors; the Norwegian Water Resources and Energy Administration (NVE) and the energy transformation directorate Enova. Enova oversees funding support while NVE grants licences.

For a long time, news media together with environmental organisations were the most important socialisation agents with respect to the interpretation of wind power. In the 1980s, wind power was framed positively as an environmentally friendly technology, but this changed during the 1990s. Increasingly, the framing of wind power became critical, with an emphasis on wind turbines being in conflict with conservation of nature, as noisy, ugly and dangerous to birds (Bye and Solli 2007, Solli 2010). Some scientists have tried to counter these views, and according to surveys, the general public is quite positive to wind power (Karlstrøm 2012). Moreover, most of the constructed wind power parks have met with little local resistance. Actually, local communities may want such parks because of benefits in terms of income, employment and improved roads. To some extent, this is the result of local governments acting as socialisation agents (Rygg 2012).

It is interesting and important to note that the Plan and Building Act – a legal instrument that regulates all kinds of major construction work in Norway – actually works as a piece of important socialisation machinery for wind power technology and many other technologies as well. This shows how technology policy to some extent has been automated in a way that has little visibility. The lack of concern for grid capacity, which has been and still is a bottleneck for wind power, is another indication that policy-makers may have thought financial measures, including R&D investments, to be sufficient efforts to achieve deployment of wind power. The existence of standard institutional procedures like the Plan and Building Act may cloud the issue of what technology policy should accomplish.

The situation with offshore wind, a priority area in Norwegian energy research, reflects a similarly narrow technology policy focus. Policy-makers have granted funding for R&D, which is so-to-speak end of story. The involved R&D institutions, together with their industrial partners, have been left with the task of innovating and commercialising offshore wind technology. There are no policy efforts to support any kind of training ground like a home market for offshore wind electricity. While industry is complaining about lack of government support (Hansen and Steen forthcoming), the involved scientists appear to be reluctant to take on any kind of responsibility to socialise the technology besides talking to their industry partners (Heidenreich forthcoming). Presently, there are no visible public deployment efforts and socialisation initiatives are meagre. There are no concrete plans to build offshore wind parks in Norway either.

A hydrogen road to nowhere?[3]

The HyNor project was established in 2003 as an effort to construct a network of filling stations for hydrogen that would provide infrastructure for fuel-cell vehicles to drive the 343 miles between Oslo and Stavanger along the south coast of Norway. The idea underlying the project was to provide a basis for a realistic experiment with the use of hydrogen for transport by building an early stage infrastructure for the provision of hydrogen, which later could become part of something more permanent. The project also included local experiments with the production of hydrogen, trying out several technological options like making hydrogen from gas from waste or reforming natural gas.

2 http://www.vindportalen.no/vind-i-norge.aspx (accessed 9.9 2013).

3 This section is based on Kårstein (2008).

The initiative to make the Hydrogen Road came from Norsk Hydro, a company that had large quantities of hydrogen available. It gained support from other interested parties, like bus companies, and obtained funding from Research Council of Norway and the Ministry of Transport. The project was presented as a user-directed, market close innovation project. The main innovations foreseen were linked to the set-up of a filling station network and related technologies. As a technology policy initiative, the HyNor project has increasingly been presented as a deployment effort with respect to hydrogen vehicles. HyNor is presently applying for funding "for a new permanent fleet of hydrogen cars in Norway, which through the project will identify remaining barriers for a larger introduction of hydrogen cars".[4] Support for such initiatives is sought through Transnova, a public technology policy institution set up to provide grants and advice for pilot and demonstration projects to encourage new sustainable mobility solutions.

From my technology policy perspective, it seems more pertinent to interpret HyNor as a socialisation effort than as an innovation or deployment initiative. The project has not been linked to any short or medium term plan to introduce fuel-cell cars in Norway on a commercial basis. Of course, HyNor could be said to have contributed to innovations regarding supply, storage and filling of hydrogen for vehicles. However, the main issue has been the construction of a sociotechnical imaginary (Marcus 1995) of hydrogen for transport, which includes an image of hydrogen vehicles as clean, safe and with a long range. However, the extent to which this imaginary, this socialisation effort, has been picked up by the public is unclear. Of course, one should not dismiss the technological learning achieved through HyNor. Surely, useful experiences have been reaped. Nevertheless, in the long run, the socialisation gains will certainly prove more important.

CCS – the Norwegian "moon landing" project

The idea that climate change mitigation could be achieved through technologies for capturing, transporting and storing CO2 has played a vital role in Norwegian politics to create broad consensus around energy and climate policy (Tjernshaugen and Langhelle 2009). When Prime Minister Jens Stoltenberg in his televised annual New Year speech in 2007 announced CCS as Norway's "moon landing" project, he launched a large innovation initiative while he performed an important socialisation effort. Still, the technology policy with respect to developing CCS for natural gas power plants has been carried through mainly as innovation policy through large R&D investments with little public visibility. To be fair, the underlying sociotechnical imaginary – gas power plants without CO2 emissions and thus a climate friendly use of an abundant source of fossil energy – has also been communicated, but mainly by ENGOs Bellona and Zero. These ENGOs, together with news media, have been the main socialisation agents.

News media coverage has been a mix mainly of recirculating the sociotechnical imaginary of CCS as a strategy for climate friendly fossil energy and complaints that the innovation and deployment efforts have been half-hearted. There have been nearly no critical voices with respect to whether CCS technology actually can deliver on the promises (Klimek and Sørensen forthcoming). On the other hand, the scientific expertise working with CCS technology is not particularly eager to engage in socialisation efforts, claiming that this is a job for somebody else (Klimek forthcoming). There is little doubt that the international situation with respect to CCS is quite challenging (Scott et al. 2013) and that a supportive technology policy needs to be comprehensive (Markusson et al. 2012). However, Norwegian CCS technology policy is fairly narrowly focused on innovation with little visible reflection among policy actors with respect to the socialisation of CCS, including the challenges of providing infrastructure and regulatory framework. It seems that CCS technology is believed to mitigate climate change in a way that to the public is 'out of sight, out of mind'. Thus, socialisation efforts are left to news media and ENGOs. This suggests that current CCS technology policy is not geared to embed CCS in Norway, but rather to innovate for use in other countries.

Conclusion: Technology policy as an embedding effort

Innovation policy may be described as a broad set of activities (Borrás and Edquist 2013); deployment policies similarly (IEA 2011). Still, as I have argued in this paper, a focus on innovation and deployment is too narrow as a point of departure for analysing as well as making effective technology policies. When innovation and deployment are the main concerns, this facilitates an economic, R&D centred approach that overlooks the challenges emerging from the need to embed new technologies in the relevant social practices. Thus, we need to extend the focus by including the concepts of socialisation and domestication of technology. Innovation, deployment, socialisation and domestication represent overlapping areas of concern, but also distinct issues that need to be considered separately. 'Innovation' is about the development of technology (or other goods) that has economic and/or social

4 Translated from Norwegian; «[...]en ny flåte hydrogenbiler som vil bli i Norge på permanent basis, og vil gjennom prosjektet identifisere gjenværende hindre før en større introduksjon av hydrogenbiler kan igangsettes.» http://hynor.no/art/hynor-prosjektet-i-endring (accessed 10.9 2013).

significance. 'Deployment' concerns putting innovations to use. 'Socialisation' points to the activities needed to embed new technology in society as well as to processes affecting the embedding (Skjølsvold 2012). 'Domestication' focuses on the enactment of technologies in specific contexts, with a view to the development of practices and sense-making.

These interrelated concepts are important to identify and understand the policy actions that are taken to make sociotechnical change happen (or not). Also, they are helpful as a basis from which to criticize missing features of a given technology policy, like the lack of emphasis on socialisation identified in the case of CCS above.

For example, an effective technology policy to reduce the use of petrol-fuelled cars should be based on an understanding of the ways in which such cars have been domesticated in Norway. It may include support of innovations to reduce emissions, develop new fuels or new ways of conducting transport as well as efforts to deploy more environmentally friendly practices. However, in the end, socialisation efforts are needed as an on-going concern to help pave the way for technologies that may mitigate climate change and reduce pollution – in parallel with anti-socialisation measures directed at technologies that should be phased out. This is needed to foster demand for the new technologies but also to actually change the currently well-embedded practices as well as the culture of transportation in the context of everyday life.

Thus, technology policy should address innovation, deployment and socialisation by supporting, mobilising and limiting human as well as non-human actors. Further, technology policy should be informed by concerns as well as knowledge about domestication of the technology or set of technologies that are to be affected. Thus, domestication has a different role than the three other concepts. Understanding domestication, the activities undertaken by customers, citizens and users to finally embed the technology in question, is important to be able to select and shape measures to effectively stimulate innovation, deployment and socialisation towards intended outcomes. In particular, socialisation efforts should be developed from insights into the performance of domestication or at least in dialogue with such performances.

Bijker and d'Andrea (2009) rightly observe that socialisation in most cases is given insufficient attention or even neglected. To some extent, this may be due to the assumption that there are systems already in place that cater to socialisation so that policy-makers may remain unconcerned about such issues (cf. the wind power example). On the other hand, such systems of socialisation also need to be acknowledged when we analyse technology policy practices. Analysing these systems may also remind about their existence as well as allowing assessments of their effectiveness. For example, there is a well-articulated expectation that scientists should engage in explaining their research to the public, but the systems set up to achieve this are not working very well (cf. the CCS example).

The neglect of socialisation challenges is probably also related to policy-makers' way of understanding demand as primarily an economic issue of consumption, downplaying the fact that consumers are also citizens and users. As citizens, the public may want to be involved in innovation and deployment of new technologies, at least to feel informed to the extent that they trust innovation and deployment actors. As users, people want to understand and make sense of the practices they may develop from new technologies. Socialisation efforts should cater to both needs.

The four examples discussed above may be analysed to show – unsurprisingly – that technology policy actions are multi-sited, multi-actor and multi-purpose. This complexity has not been dealt with in this paper, because the main concern has been to argue the need to include more sites and actors – in particular related to the inclusion of socialisation concerns. In order to deal with technology policy-making processes, further development is necessary to provide a better understanding of the role of non-human actors. One avenue to explore, given the emphasis on socialisation and the need to think about domestication, would be a concept of reflexive policy-making regarding technology. This could draw upon suggestions found in Beck (2006) and Latour (2007) to study policy-makers' processes of learning about and interpreting the embedding of new technologies.

Thus, there is considerable need for scholarly work to explore and systematise the analysis of technology policy as theory as well as practice. Hopefully, this might benefit the doing of technology policy. When technology is seen as sublime with respect to the society of the future, it would be nice to be hopeful that the embedding happens in ways that increase the probability that the assumed sublime qualities are realised.

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