

Transition strategies: a technological and industrial perspective

A main objective of the research of CenSES is to contribute to new knowledge on how we can transform our society and economy to reduce climate emissions significantly. There are different strategies possible, but the dominant political strategy focuses on technological change as the main solution to the defined problem.. The aim is to develop various types of technologies which that all contribute to reduction of emissions through saving energy technologies increased energy efficiency, develop new process technologies that which reduce emissions, or introduction of create renewable energy production supply as an alternative to fossil energy technologies.

At the TIK centre (during the first phase of the CenSES period) the main thematic focus is on development, introduction and use of new technologies producing renewable energy, particularly electricity (RETs). We analyse the transition from a 'hydro carbon energy regime' to a 'renewable energy regime'. Based on the academic tradition of innovation studies we focus on firms as main actors in the dynamics. Not only are (private and public) firms important actors in technological dynamics, they are also central actors to invest in using the new technologies. The transition processes therefore have an industrial aspect, linked to the production of new energy technologies (supply industries) and in investment to use the technologies (energy companies, users of energy).

Building innovation systems

- The perspective chosen is that if new technologies (RETs) will be successfully developed and used in the economy/society, it demands the build-up of innovation systems which support a number of processes that influence the dynamics of which in total makes a new technology production ed and used in the wider society. Analysis of the emergence and growth of new technologies has a long background from technological history (Hughes 1983) and innovation studies. Recently We have chosen to use a Technology Innovation System (TIS) is introduced specifically to analyze new renewable energy technologies (RET). TIS is approach which is a tool to study dynamic techno-social processes linked to the emerging technology where t. The main focus is on processes creating knowledge, mobilizing resources, creating markets and legitimacy of the technology among crucial actors in the society. This approach has close links to the wider literature on transition strategies called multi-level analysis. TIK's research is

inspired by these new approaches, and the aim is to contribute to development of theories on transition strategies.

The industrial aspect of our analysis of transition processes and strategies is linked to former studies of dynamics of natural resource based industries and economies. The policy objective to transform the energy regime from one based on fossil fuels to one based on renewable energy sources involves transforming our natural environment (like wind, sun, waves) into an economic resource (electricity, fuels) and the development of a dynamic process to increase production and improve efficiency. This involves development of innovation systems through implementation of various core processes, and emphasizes particularly the dynamic relationship between knowledge intensive knowledge sectors (R&D, KIBS, ICT, capital goods, etc.) and the energy producing industries.

Empirically we will focus on mainly on processes taking place in Norway, which implies that we study transition processes in the specific context defined by national boarder. However, this approach forces us to relate to a wider European context. In Norway, specific institutional set-up blocks for successful system building processes. This distinguishes Norway from the neighbouring countries which have played core role in the development and introduction of new RETs (Denmark in wind, Germany in solar, Sweden in bioenergy). The Europeanisation of electricity systems and markets open for Norwegian actors to enter into system building processes in other geographical settings than the national.

TIK's focus is directed towards technologies where Norwegian actors play a significant role internationally. We focus on solar energy, offshore wind technology, transmission systems/sub-sea grid), and to some extent on CCS.

Selected empirical research problems and topicsub-system analysis: Norwegian challenges

Within this wider framework we will study specific challenges arising from creating a transition strategy in Norway. The specific local context raises issues of interest relating to local policy/political power relationships, dominating cognitive frameworks, industrial and technological trajectories, as well as how Norwegian actors relate to a changing of the European/global energy markets. These selected issues are important for analyzing the specific national development, and analysis of an 'extreme case' as Norway also opens for discussions of wider theoretical interest.

System building and technology efficiency: making new technologies cost efficient

In political discussions on introduction of new RETs, a main emphasis is on 'cost efficiency'. A traditional economic perspective is that investments in new production units should not be subsidized. In this way the market will make/force investors to use the most efficient production technology available, and the total economy will be cost-efficient. This approach has a static perspective: It focuses on defining what technologies which are the most cost-efficient today. In a transition perspective the relevant policy question is different: The challenge is how the new RETs will become cost-efficient, and what technical, social, economic and political processes it takes to be successful.

This is a central aspect of policy making for transitions. New technologies are 'hopeful monsters' which have low efficiency but may have great potential for the future. The most obvious case is that of solar energy where efficiency has increased through long term learning processes. By 2013 the cost of production of solar energy is close to the market price. The core question is how the emerging technologies can be protected from market forces' selection power during a long period of time in order to become cost efficient. This is central to public policy making, also in Norway.

In the narrative describing the development of offshore wind in Norway from the early entrants in 2005 and until today, we can see that efforts to establish large demonstration facilities in Norway has been perhaps the most important issue for the entire industry. These efforts were made because the industry recognized that the lack of learning arenas was a significant barrier for industrial development and further innovation in the domestic industry. Offshore wind represents an interesting case where the relationship between state and group interests can be explored. Moreover, the case could reveal the challenges that meet actors within new industries when relations with state actors need to be forged, in competition with actors representing incumbent industries.

System building and public policy: Interest groups and political power

Public policies play a central role in system building of RETs. Traditionally public policy is treated as an exogenous factor in analysis of innovation systems. Empirical analysis of how public policies in the energy sector are shaped, indicate however that policy making should be analysed as an integrated part of system building. There is an emerging field of research trying to develop the understanding of how policy is shaped within innovation system framework or a multi-level perspective.

In general, the field of energy is dominated by strong vested interests and powerful institutions. At the same time, the development and deployment of RET are often seen as political tools that can help us to meet increasingly pressing environmental challenges. Thus, to make us able to evaluate the feasibility of introducing new technologies, it is of crucial importance to understand the influence and interplay of interests and

institutions in energy policy. We therefore analyse how various strong actors influence and shape the direction of energy policies and the transition strategies (at nation level).

This is particularly important for understanding the potential synergies and antagonisms between incumbent energy technologies and RETs and their relationships to established norms and power relations (both nationally and internationally). Norway is today a major producer of fossil fuels and of “established” RETs (hydropower). It is also a major *potential* producer of and supplier to new RETs (vast potentials for new energy production). This has national and international political implications. It is impossible to understand transitions in without analysing the broader political framework for the transition and its concrete effects on transition processes in specific geographical areas and for specific RETs.

This topic is a challenge to the field of innovation studies, which has traditionally neglected socio-political factors when analyzing innovation processes.

System building and the role of the old regime: Do new technologies emerge from old industries?

What is the role of incumbent actors and regimes in energy transition? Are they purely antagonistic towards novelty or can they play a dynamic role with regards to transition processes? This question is relevant given that regimes are often seen to provide barriers to (radical) change because they stabilise technological trajectories. Out of such a perspective change must conform to the “rules” of the regime. This constrains its development path: it is path dependent. Regimes also function as “focusing devices”; they impact on the search directions of actors and enable continuous knowledge development. Moreover, regimes can be important in the creation of new “branches” or paths that depart from the original trajectory of the regime because incumbent actors can be embedded in networks with related industries that enable trajectory shifts.

If we want to understand the politics behind renewable energy policies, we therefore need to see new renewable energy in relation to the existing electricity production regime and hydro-power as the incumbent technology within this regime. The emergence of a solar PV industry in Norway is illustrative in this instance. Incumbent actors in the well established ferro-alloy industry continuously pursued diversification processes. Given that the processes of change were taking place within an embedded regime, it provided order and structure to the activities and choices made during the process of diversification. Actors, networks, resources and infrastructures served as a fundament for transition processes. At the same time the wide-spun networks with actors embedded in different industries and sectors enabled critical knowledge flows that supplemented existing knowledge bases.

Moreover, we also need to see renewable energy in relation to the hydro-carbon regime, which is the dominant energy regime both on a global and national level. Offshore wind

represents a technology, and an industry that is very much attached to both of these regimes. One of the main drivers for the increased political and industrial attention towards offshore wind a few years ago can be explained by reduced activity in the oil and gas sector, and a need for the industry to diversify. This connection between oil and gas and offshore wind has been documented on firm level by Hansen and Steen (2011, 2013). Other factors include EU ambitions for offshore wind and to some extent symbolic uses of politics. More recently, the motivation to diversify and the need for symbolic politics have decreased and this can explain some of the reduced activity in the offshore wind sector. However, there is a niche market for suppliers of petro-maritime services to an international market as long as the EU ambitions are maintained.

System building and system boundaries: Building international innovation systems

Processes of system building for new RETs take place in the nexus between the national (local/regional) and the international. In part this is due to knowledge flows between actors embedded in many different contexts. Knowledge is distributed differently across actors, industries, sectors and countries so the flows between these constitute an important source of dynamic for the development of RETs. Firms seeking to develop RETs not only draw on local knowledge bases, but can be part of international networks with firms and other actors that enable a flow of knowledge between them.

Similarly, due to the global nature of a TIS, value-chains can be distributed across many countries. In terms of value chains for solar PV, Germany is a key actor in supply of manufacturing equipment, whereas Norway is an important producer of raw-materials. At the same time domestic deployment tools can be associated with major spill over effects. For instance the use of feed-in tariffs to create markets for new RETs in Germany has had pervasive effects for actors in many countries. In turn, global investment flows can be linked to deployment measures taken in individual countries.

Investment in supply capacities globally, such as in offshore wind or solar PV, therefore constitutes an important part of the system building process even in absence of domestic markets. In turn this stimulates the overall development of a larger user base that can feed back on the actors that produce technologies. The investigation of the nature of the truly global linkages contributes to our understanding of what it takes to build systems for RETs. This has political and industrial implications for Norway's attempt to build an offshore wind industry and capacity. Lacking national markets, the firms involved (both technology and energy producers) will have to be included in the networks of global/international innovation system builders.

System building and the role of infrastructure: Norway's grids to European electricity markets

Infrastructure is a key structural component of an innovation system. It is a crucial element of the selection environments for technologies and innovations, and thus strongly influences the direction of innovation activities. In consequence new technologies and technological systems (notably 'radical' ones) are associated with and require a specific infrastructure in order to emerge and diffuse. It is intuitively clear that it is difficult to really grasp how large-scale technologies are developed, become established and are diffused without taking into account the role of infrastructures. Therefore each 'techno-economic paradigm' has its unique infrastructure (Freeman, 2001). The same is true for e.g. EU 2050 vision of a low-carbon society which requires a near total decarbonization of electricity production. Such a low-carbon transition cannot take place without the development and deployment of a low-carbon infrastructure and simultaneously a creative destruction of our existing fossil-fuel infrastructure.

Infrastructure is particularly relevant for renewable energy due to its geographical dispersion (potential is concentrated) and intermittency (supply is unstable; the wind doesn't always blow). These two factors imply that renewable energy sources must be connected (and eventually stored) across sufficiently large territories to avoid intermittency, and in turn constitute a credible alternative to carbon energy. In the EU this is discussed as developing 'EU super grids' and 'electricity highways' which inter alia involve developing a North Sea offshore grid for electricity transmission. The EU sees Norway as playing a key role for developing a low-carbon infrastructure for Europe. Seen from Norway's perspective the EU low-carbon vision constitutes an opportunity for exploiting its vast renewable energy potential, developing an industrial export sector, and becoming a proactive participant in the low-carbon transition process. In Norway development and diffusion of RETs has stagnated inter alia due to lacking demand for (renewable) energy which in turn hinders RETs from achieving post-introduction improvements. We argue that the lack of renewable energy infrastructure both domestically (battery grid) and transnationally (to EU/ North Sea) is an important barrier for Norway's chances of benefitting from EU's transformation.

The development of infrastructure nationally and its linkages to Europe, is part of the wider international demand for rapid expansion of grid capacity both on-shore and off-shore. There is a demand for improvements of grids (smart grid, increased capacity, long distances, deep off-shore), and at the same time a demand for rapid increase in capacity to produce grid technology (cables, transformers, etc.).

System building and transition strategies in local context: Norway

There is a stated goal that the CenSES research output should “*support public and private decision makers in strategic decisions and policies that will promote environment-friendly energy technologies and lead to a sustainable energy system*”. The multi-level perspective and technological innovation system frameworks are two directions that have developed in the last decade with an ambition to provide policy relevant research. The output of TIS analysis will often be concrete policy advice that goes beyond the usual market failure recommendations, but address systemic problems related to innovation and diffusion of particular renewable energy technologies. Conclusions can for instance be that there is a need for particular incentives such as feed-in tariffs and a lack of a home market (Jacobsson & Karltorp, 2012), a need for more variety (A. Bergek & Jacobsson, 2003), or that there is a lack of qualified engineers (Jacobson and Karltorp 2012). It is further assumed that government can address these system weaknesses through publicsocial policy. This has perhaps become most visible in the Netherlands where transition management, which is closely related to the multi-level perspective, has become an integral part of the government strategy towards a transition to more sustainable practices (Smink, Hekkert, & Negro, 2010). Empirical based studies that teach us more about system building and transition strategies in Norway can therefore provide CenSES with an opportunity to become more visible towards politicians and the bureaucracy.

However, what many of these studies fail to address is the difficulty of implementing such policy changes. As a consequence there is an emerging field of research trying to develop the understanding of how policy is shaped within innovation system framework or a multi-level perspective. This represents an opportunity for CenSES research to be visible towards journals and academics within this field.