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LEARNING TO MAKE TECHNOLOGY WORK – A STUDY OF LEARNING IN TECHNOLOGY DEMONSTRATION PROJECTS

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Abstract

Building working demonstrations of new technologies within sustainable energy and transport has become an important activity in the move towards a more energy efficient society. The work involved in building these demonstrations is usually organised in a project with a variety of different participants, including users. The aim of the project is usually to test the technology and promote changes in users habits, while learning is frequently cited as the main outcome. In this paper we review existing studies of demonstration projects and try to gain an overview of the main aims and effects of these projects. We then discuss concepts of learning and develop an analytical framework for our study of demonstrations within sustainable energy and transport in Scandinavia.

Key words: Technology demonstration, learning, sustainability

Introduction

Modern firms are familiar with the concept of building models and prototypes and running trials of their new products. Sometimes these are in laboratories, sometimes they are on the internet in the form of Beta versions of software and sometimes they are out there among the public who swallow new pills, test new payment systems or test-drive new vehicles. This paper introduces the concept of the demonstration project within the context of technological development and innovation. It then discusses the challenge of identifying and understanding the effects of these projects. After reviewing how earlier studies of technological development have considered the theme of learning, its role in technological development and how it is perceived as an activity within the development process we suggest studying the outcomes of demonstration projects in terms of learning processes. We confine our study to projects within the field of sustainable energy and transport. We then develop an analytical framework for analysing learning in demonstration projects and introduce our empirical study[1]. This is followed by a discussion of our findings.

Demonstration projects and their role in the move to sustainable energy and transport

We find early examples of public funds being made available for technological field trials In the 1970s in the US (Macey & Brown, 1990). These trials enabled entrepreneurs to construct

[1] At time of writing this paper is still a work in progress and the analysis of new data is not yet complete.

working versions of their designs of agricultural machinery, medical diagnostics technology, energy and transportation technologies. The aim of these trials was to bridge the gap between designs and working technologies by making more information available to producers, allowing them to correct production problems, improve efficiency and move towards mass production. In theory the demonstration project also makes information available to users of the technology thus easing the process of bringing new a technology to the market. The early demonstration project can thus be viewed either as a kind of experiment or as the construction of exemplars of their working technologies.

As the concept of the demonstration project developed, the aims became more specific and differentiated. Some projects aimed at building a working version of a new technology in order to demonstrate to investors that a marketable version of the technology was indeed possible. (Sagar & Gallagher 2004). Some demonstration projects were designed to shorten the time to market of a new technology (Lefevre 1984), to simulate new industries and to allow public administration to understand their responsibilities when a new technology becomes the norm (ibid). Lefevre also sees the demonstration project as the place to resolve difficulties between various partners, typically public and private actors (ibid). Demonstration projects where users were included were also designed to test the market and to inform the market in general that this new technology would soon be available. Some demonstrations had a more technological aim, where eradication of faults and improving performance were the main activities during the demonstration period. Within the specific context of technologies related to sustainable energy, we would expect broader aims attempts to embed new habits in society, such as using new modes of transport or using energy in different ways.

The definition of the demonstration project used in this paper is based upon Hellsmark, (2011). Hellsmark's starting point is the concept of the technological innovation system (Carlssen & Stankiewicz 1991) and he identifies a number if roles which the demonstration projects should fulfill in this respect (2011:34):

- Contribute to the formation of knowledge networks.
- Reduce technical uncertainties.
- Facilitate learning that can be instrumental for decisions on technology choice.
- They may also raise public awareness of the technology, strengthen its legitimacy and expose system weaknesses such as various institutional barriers.

This brief introduction[2] to the theme of the technological demonstration project describes a range of activities which play an important part in both the progress and the content of technological development. We can also observe that these demonstration projects can have multiple aims and are based on the assumption that various participants will develop new understanding of the technology and its use during the course of the demonstration project. In this paper we view this process as a learning process and in the next section we look at how concepts of learning have been used to understand technological development.

Learning in the context of innovation and demonstration

Studies of technological development and innovation have frequently referred to learning as an important part of the process and use of the term learning has expanded and developed

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[2] For a more in depth review of stuides of demonstration projects please see Klitkou et *al*. 2013

within the context of technological development. Traditionally Scientific research was viewed as the central learning activity in technological development (Kline & Rosenberg 1986). Studies of technological development, which have taken an historical viewpoint and looked back at how the technology developed, frequently start with basic science, where the learning concerns the laws of nature and the opportunities or limitations they exercise on the chosen technology. This kind of learning has been described as a search process whereby firms search within a given framework such as material engineers trying to find a way of sticking anti-viral nanoparticles on the surface of material coatings used in hospitals (Olsen 2009). The engineers are not exploring the unknown; they are searching within a defined area for the best solution. Thus this kind of learning is based on pre-existing knowledge which is used to direct, structure and limit the search for the best solution. This somewhat limited view of learning has traditionally been referred to as "learning-by-searching" (Nelson & Winter 1982) or learning by studying (Garud 1997). Another form of learning identified by economist Arrow (1962) was the kind of learning which happens when a firm produces a technological product. Not from producing it *once*, but from reproducing it multiple times. In other words the activity which a firm engages in provides the opportunity to improve their production process by carefully observing best practice over time and tuning out weakness and inefficiencies. This has been referred to as "learning-by-doing". Neither of these definitions of learning includes users or the public in the process, however this was remedied by Rosenberg (1982) and vonHippel (1976) who wanted to account for customer preferences and how they influenced the development of technology. The challenge according to Rosenberg was to design the optimal technology to suit the user and he referred to this as "learning-by-using" i.e. the user had to try out the product and give feed-back. In such cases users could be helpful by suggesting solutions to problems which engineers had not yet resolved, additionally these users came up with suggestions for improvements or new functionality. More recently the concept of learning-by-interacting was introduced by Lundvall (1988) and further developed in (Jensen et *al*. 2007). The main difference here being that the feed-back from users, producers, suppliers, policy makers and that it was a continuous two-way communication.

Learning in demonstration projects has also been studied as part of a transition process aimed at moving from fossil fuel based energy and transport to sustainable solutions (Hoogma 2000; Hoogma et *al.* 2002). They view the demonstration project as an experiment which can be designed to learn about different aspects of the transition to a new technology:

- Technical development and infrastructure: this includes learning about design specifications, required complementary technology and infrastructure;
- Development of user context: this includes learning about user characteristics, their requirements and the meanings they attach to a new technology and the barriers to use they encounter;
- Societal and environmental impact: this entails learning about safety, energy and environmental aspects of a new technology;
- Industrial development: this involves learning about the production and maintenance network needed to broaden dissemination; and
- Government policy and regulatory framework: this involves learning about institutional structures and legislation, the government's role in the introduction process, and possible incentives to be provided by public authorities to stimulate adoption.

(Raven 2005:41)

Hoogma et *al.* (2002) use the concept of first and second order learning, based loosely on Argyris & Schön (1974 & 1976) and conclude that other definitions of learning used in the literature on innovation systems describe only incremental innovation, but do not cover all the learning necessary for more radical technological change, such as moving from fossil fuel based transport to sustainable alternatives. Hoogma et *al.* suggest that the demonstration project should be viewed as an arena for learning, a place where engineers can find out if the implicit assumptions built in to the technology are in fact correct, or if they need to be adjusted, but also as a place where users and policymakers can reflect upon the technology and begin to see how they too can make changes in the way technology fits into their lifestyles and into the wider environment.

In order to better understand the basis of this type of first and second order learning, we can go back to the original work of Argyris and Schön (1974) who developed a theory of organizational learning based on action. We find that one of their aims with this theoretical perspective on learning was to move beyond the theories of cognitive learning based on the individual and to look at how whole organisations can learn and change as a result of the activities they participate in. This adaptation of organisations is seen as evidence that the organisation has emerged with new wisdom or knowledge as the result of some kind of collective process it has been through. This is what Argyis and Schön try to conceptualise when they talk of learning occurring in two distinct stages, but the second stage does not occur automatically.

Single loop learning means learning to do something which someone else has done before or learning to do it faster. This kind of learning is deliberate and usually associated with achieving a pre-defined aim. Double loop learning on the other hand is something which occurs in situations where the outcome is not known in advance. It occurs when the actors involved reflect upon what has happened and react to it in some way thus provoking change. When Argyris describes examples of what he means here, it seems to be based on feedback of some sort and he concludes that double loop learning can only occur when an organisation is able to receive and react to feedback and in his own research he observed very few examples of this.

Studies of demonstrations of energy technologies

Sustainable technologies within energy and transport have been regarded as developing slightly differently from many other technologies. The main difference being the active role of policy makers and public sector actors who are interested in using new technologies to achieve political aims and using technology as an instrument of change. Thus we cannot assume that these projects are organised or managed in the same way as other types of technology which have customers eagerly waiting for a new technology to meet their needs. The technologies being developed in the context discussed here are meeting needs which customers did not know they had. A recent analysis of European demonstration projects within sustainable energy and transport was carried out by Hoogma and colleagues (Hoogma et *al.* 2002). They analysed 13 projects and assessed the effects of these projects in terms of learning among participants and effects on the environment. They found that the participants, or rather who they were, influenced the outcome of the project. They also found that increased diversity of participants resulted in wider changes. They found, however, that many projects did not involve users, or if they did they made assumptions about what users knew, what users needed and how users could contribute. They found that projects initiated by users were more successful. They suggest that users need to be involved to such an extent that they are actually finding new ways to use the technology and becoming aware of new possibilities which have not been suggested to them. In most projects they were able to identify learning processes linked to understanding and improving the technology. They also observed that the firms producing the technology were able to indentify the need for changes within their own organisation and adapt. Thus they summarise that first order learning took place, but there were few examples of second order learning where users began to question underlying assumptions about their use of energy and transport. They suggest that demonstration projects should include more "outsiders"; that they should look far beyond the technology perspective, at some of the more difficult problems like getting people to see the potential of new technology and the possibilities it might have for them personally.

One important function of the demonstration project identified by Hoogma et *al*. was the opportunity it provides for interaction between groups of participants who do not normally meet. Typically users and technology designers, but this might also include people from other industries who need to provide part of the solutions and from policy makers at local and national levels. For example one might produce the most perfect, efficient electric vehicle, but that becomes irrelevant if one cannot charge it at regular intervals. What is a "regular interval" has to be decided by users, how the charger works has to be decided by the makers of chargers, while the location of the chargers might be decided by public authorities and yet someone else might have to decide how the power used in charging has to be paid for. The demonstration project is where all these actors come together, often for the first time. Hoogma et *al.* highlight the challenge of interacting as one of translation (Hoogma et *al.* 2002:191) and a process of exchanging and aligning expectations between different groups.

A study of the development of new technology within wind power in Denmark (Kamp et *al.* 2004) highlighted the importance of learning in order to tackle an array of challenges confronting the industry at the time. One of the examples which this paper describes is that the concept of learning about the technology and finding how to make it work, is not in itself enough to bring the technology to the market. It was also necessary to develop an understanding of geographical wind flows in order to know where to place a windmill in order to make it work. This may sound like common sense to the rest of us, but in a new emerging industry this is the kind of challenge which is often overlooked if we limit our understanding to *one* organisation or to *one* industrial sector. In their paper Kamp et *al.* used the concepts of learning-by-searching, by doing etc. as mentioned above and concluded that a variety of different types of learning were necessary to deal with the uncertainties of the a new technology in a new field.

A range of demonstration projects within sustainable energy were studied by Harborne and Hendry (Hendry & Harborn 2011; Hendry, et al., 2010). They studied demonstration projects and field trials in the development of wind power, solar photovoltaics and fuel cells from the 1970s to 2010. Their work was based on interviews with key experts and case studies which they carried out in industrial firms. They studied data from148 programmes and projects at 577 sites in Europe Japan and USA developing various demonstrations of wind power technology and carried out 9 case studies. They also carried out 15 case studies in solar photovoltaics (J. Brown & Hendry, 2009; Hendry, et al., 2010). They found that the presence of a variety of different participants and stakeholders improved the chances of a successful outcome and they were able to indentify different types of learning occurring at different phases and in different situations. This made the projects difficult to compare directly, but strengthened the idea that the demonstration project is an important step on the way to a new working technology.

Learning was also a central theme in the study carried out by Kiss & Neij (2011). In their study they used historical material to study the development of energy efficient windows in Sweden. They used the four types of learning identified within technology studies i.e.

searching, doing, using and interacting. They attempted to identify the relevant conditions for the different types of learning to take place. Suggesting for example that in order for learning by interacting to occur there should be a collaborative network, a closeness among actors and active change agents. In order for learning by using to occur there should be frequent contact and recognised feedback mechanisms. The main value of this paper in our context is that the conditions for the various types of learning are much more easily identifiable than the notoriously abstract concept of learning.

This review of studies strengthens the idea that demonstration projects are a common feature in the development of sustainable technologies and indeed that learning in various forms has been viewed as an important outcome of demonstration projects. It is important that our ongoing study adds to these earlier ones and to this effect we want to do more than just categorise types of learning based on the effects of the projects. We will now look more closely at how the issues revealed from this study of existing literature might be analysed.

Developing an analytical model

One of the most obvious issues arising from the literature study is the *variety* of projects being carried out and the different aims they have. One of the biggest challenges to studying multiple demonstration projects within sustainable energy and transport is that that there is not *one* type of demonstration and not *one* type of technology. It appears that the different technologies are in different stages of their development and that there are different requirements in the different phases. Earlier studies of technology development (Kline & Rosenberg 1986) highlight the role of users in the development process and mention users physically touching the product and making it work. Within sustainable energy the technology can range from windmills on the horizon, to a bio-refinery to a charger for you electric vehicle. Thus we cannot employ a simple one-size-fits-all way of dealing with this issue. It may not be relevant to involve large numbers of users in order to test one piece of technology which will ultimately be part of a larger system. Thus we would expect the aims, the focus and the participants to be different with the different development phases of any technology.

Another feature which becomes visible in this analysis, is that the *context* of a demonstration project is much broader and more diverse than that of an organisation, such as those studied by Argyris and Schön. The context is not as clear-cut as an industrial sector and although there is typically a central industrial actor in a demonstration project, this is not always the case and we cannot assume that projects are organised and steered from an industrial perspective. The context of new sustainable energy technologies includes multiple firms, investors, politicians and users. As we are looking at technologies moving towards a market, a value chain might be an appropriate concept to define the boundaries of the demonstration project. However, although a value chain might include most of the participants, the central role of the political actors would not be evident if we used this concept to identify and link the participants. It is clear that we cannot make assumptions about the context for learning in a demonstration project, even within a limited field, such as sustainable energy and transport. If the context is not fixed or even similar for all projects, then we need to look more closely at who is participating in which project and this should be a central part of our analysis.

Another issue we have is that some technologies are dependent on political decisions in order to function optimally. If the new technology requires changes in rules or new policy decisions, then there is probably a need for some kind of learning among policy makers. This is often seen as the responsibility of the demonstration project. The existing studies only provide limited information on how policy makers are involved, thus it would be interesting if our study could provide an overview of their actual involvement and whether project participants saw this as important or not.

It is not only the participants who constitute the learning context, the way they work together also affects the way learning might occur and the type of learning which might be possible. Certain factors affecting this are the proximity of participants, how frequently they have contact with each other, how often they need to explain things to new and unfamiliar groups of people and how dependent their activities are upon each other. This is the interaction that Lundvall and others have emphasised. The nature of this interaction and what kind of interaction works best for which technologies is still rather unclear. A study which might throw some more light upon the type or types of interaction occurring in technological demonstration projects would be a potentially useful supplement to existing theory.

In spite of the lack of commonality in the phase of technological development or in learning context, one feature which was evident in most of the examples was the need for a systematic way of providing feedback. In order to benefit from all relevant experiences in a demonstration project, there should ideally be feedback from a variety of different participants. For example there is a need for feedback from production environments including the costs and organisation of production. There is the need for feedback from users suppliers where relevant. An analysis should attempt to identify how projects are dealing with multiple or multi-level feedback.

Not only should we be looking for feedback processes or a feedback system, but we should also attempt to find out how this feedback is turned into change. Many of the earlier studies have suggested that this is simply not happening, or as it was described - only first order learning was occurring in all projects, while the second order learning was only identified in a few examples. Studying the effects of feedback in a project is particularly challenging. However there are signs we can look for. We can look for examples of changes in plans and expectations as well as corrections and adjustments to the technology.

Our challenge is therefore to unpack the context for learning in the demonstration project, specifically within sustainable energy and transport. We begin to see that one of the defining features of a demonstration project is that in order to succeed in bringing the technology to the market there really need to be a lot of learners. If they are all to learn and their contributions are to be utilised, then a demonstration project is aiming high.

Based on our analysis of earlier studies and the perceived gaps in our knowledge, we have developed the following framework to analyse the demonstration projects within the Nordic area:

Is the project providing a broad learning environment?	
Diversity of participants	Outsiders Users Environmental groups or organisations Supplier firms Distribution firms Providers of complementary knowledge

	Universities or research institutes Policy makers
Proximity and ways of working	How much contact do participants have with each other? Are their tasks and contributions to the project interdependent? Does the project include negotiations between partners?
Feedback	Do multiple feedback mechanisms exist? How does the project react to different types of feedback?

Figure 1 The Learning Context

Indications of learning:

- Changes in functionality of product or service
- Changes in marketing strategies
- Changes in expectations
- Changes in project scope

From the point of view of the firm we assume that they want to learn about the technology, eliminate faults and tune up their abilities at manufacturing or mass production of their product. They might also want to learn about how customers react to their product on the market. Potential customers can traditionally provide two kinds of feedback: sometimes their comments can help designers to find the source of known problems or weaknesses or they can suggest improvements and new functions which the original designers had not thought of.

From the point of view of policy makers, we assume that they will want to know about the effect the new technology will have upon the environment or on CO2 production. They might also want to learn about possible gaps in the infrastructure which might lead to the failure of the new technology, for example are there other things which the public will need in order to move to the new technology.

Like an organisation, a demonstration project is about learning in collaboration with others, however it is not just others within the firm, it is not just others with the value or within the industrial sector. It is potentially a much broader selection of people with different interests and differing degrees of understanding of the technology being demonstrated.

Data and methods

Our empirical data is based on several studies within a Nordic research project spanning 3 years. We have compiled a database of all demonstration projects within renewable energy and transport, which received public funding between 2002 and 2012. This data has been collected from the various national funding agencies. In addition we have conducted interviews in each country and have sent out a survey to all project managers.

A total of 445 demonstration and trial projects were identified across Denmark (223 projects), Norway (113 projects) and Sweden (109 projects). 97 (22%) of these projects were concerned with transportation. 7 of the Danish projects were funded by the EU, and these 7 projects are not included in all analyses comprised by the InnoDemo project.

During the data collection process, a preliminary analysis was made on the objectives of the projects. This analysis was based on the short descriptions made publicly available by programme authorities or project coordinators. Each project was assessed to have one or more of the following objectives:

- Prove technical feasibility
- Reduce building, operating and maintenance costs
- Prove feasibility in commercial applications
- Prove environmental feasibility
- Contribute to the formation of knowledge networks:
- Improve public acceptance
- Introduce institutional embedding
- Expose system weaknesses
- Facilitate learning
- Others

The result of this preliminary analysis is shown in the figure below.

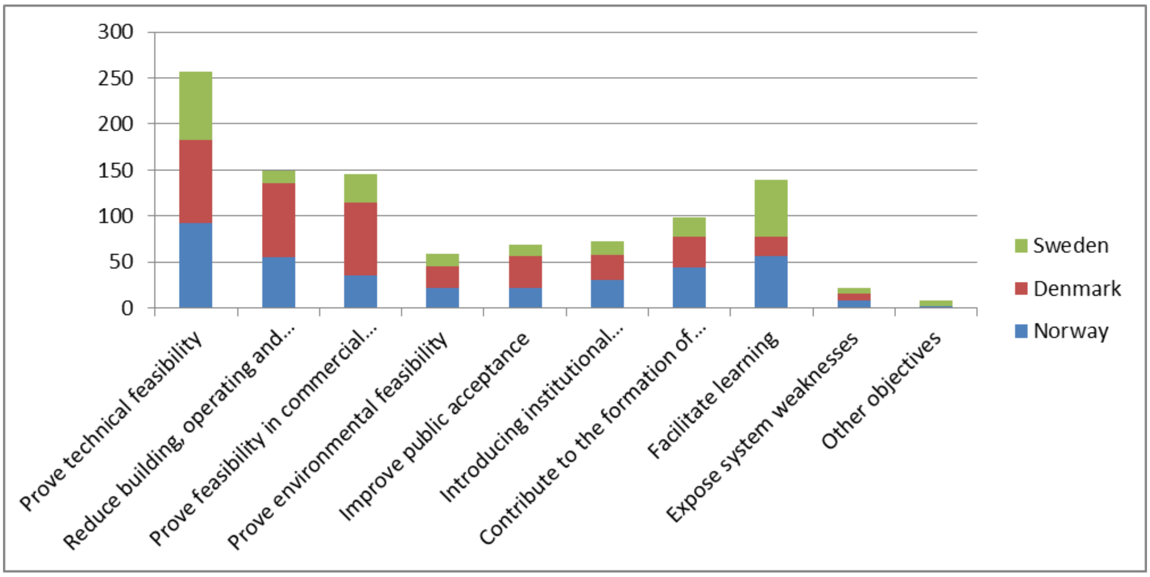

Figure 2. Distribution of the objectives for the projects. Note that each project can have multiple objectives.

The most frequent object of the projects was to prove technical feasibility, appearing in 58% of all projects. Other frequent aims were: reduce building, operating and maintenance cost (33%); prove feasibility in commercial applications (33%) and facilitate learning (31%).

An important outcome of the preliminary analysis is the variety of focus in the projects. Norwegian projects have in average 3.3 objectives whereas the Swedish projects (with 2.3) and the Danish projects (with 1.8) have significantly fewer objectives.

Another outcome of the preliminary analysis is a variation in the objectives across the countries, e.g. reduce building, operating and maintenance cost is relatively low in Sweden and facilitate learning is low in Denmark. However, learning was the second most frequent (57%) objective in the Swedish projects.

Status – database complete and analysed; the survey has a very low response rate and we working to improve this. Some pilot interviews have been carried out however we are currently awaiting approval from the Norwegian authorities for storing of personal data from interviewees.

Based upon this status we have not yet been able to complete our analysis, but hope to have more data to present at the conference.

References:

Argyris, C., & Schon, D. (1974) *Theory in practice: Increasing professional effectiveness*. San Francisco: Jossey Bass.

Argyris, C., & Schon, D. (1978) *Organisational learning: A theory of action perspective*. Reading, Mass: Addison Wesley

Arrow, K. (1962) Economic Welfare and the Allocation of Resources for Invention in Universities National Bureau (eds.), *The Rate and Direction of Inventive Activity: Economic and Social Factors*, UMI, pp. 609 – 626.

Carlsson, B. & Stankiewicz, R. (1991) On the Nature, Function and Composition of Technological systems *Journal of Evolutionary Economics* 1(2) 93-118.

Brown, J., & Hendry, C. (2009). Public demonstration projects and field trials: Accelerating commercialisation of sustainable technology in solar photovoltaics. *Energy Policy, 37*(7), 2560-2573.

Garud, R. (1997) On the distinction between Know How, Know Why and Know What. *Advance in Strategic Management*, Volume 14 81-101.

Hellsmark, H. R. A. (2011). *Unfolding the formative phase of gasified biomass in the European Union: The role of system builders in realising the potential of second-generation transportation fuels from biomass.* Chalmers University of Technology, Göteborg.

Hendry, C., Harborne, P., & Brown, J. (2010). So what do innovating companies really get from publicly funded demonstration projects and trials? innovation lessons from solar photovoltaics and wind. *Energy Policy, 38*(8), 4507-4519.

Hendry, C., & Harborne, P. (2011). Changing the view of wind power development: More than "bricolage". *Research Policy, 40*(5), 778-789.

Hoogma, R. (2000). *Exploiting technological niches, Thesis.* Twente University, Enschede.

Hoogma, R., Kemp, R., Schot, J., & Truffer, B. (2002). *Experimenting for Sustainable Transport Experimenting for Sustainable Transport: the approach of strategic niche management*. London, New York: Routledge.

Jensen, M.B., Johnson, B. Lorenz, E., Lundvall, B-Å (2007) Forms of knowledge and modes of innovation. *Research Policy* 36, 680-693.

Kamp, L.M.; Smits, R.E.H.M; Andriesse, C.D. (2004) Notions on learning applied to wind turbine development in the Netherlands and Denmark. Energy Policy 32, 1625-1637.

Kiss, B., Neij, L. (2011) The importance of learning when supporting emergent technologies for energy efficiency-A case study on policy intervention for learning for development of energy efficient windows in Sweden. Energy Policy 39, 6514-6526).

Kline, S. J. and N. Rosenberg (1986). An overview of innovation in R. Landau and N. R. (Eds) *The Positive Sum Strategy: Harnessing Technology for Economic Growth*. (pp275-305) Washington, DC, National Academy Press.

Klitkou, A., Coenen, Dannemand Andersen, P.,Fevolden, A., Hansen, T., Nikoleris, A., Olsen, D.S. (2013) *The role of demonstration projects in innovation: transition to sustainable energy and transport.* Paper presented at the 4th International Conference on Sustainability Transition, Zurich 18th – 21st June 2013.

Lefevre, S. R. (1984). Using demonstration projects to advance innovation in energy. *Public Administration Review, 44*(6), 483-490.Lundvall, B.-Å., (Ed.), (1992) National

Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, London: Pinter Publishers.
Macey, S. M., & Brown, M. A. (1990). Demonstrations as a policy instrument with energy technology examples. *Knowledge-Creation Diffusion Utilization, 11*(3), 219-236.
Olsen, D. S. (2009) Understanding Interdisciplinary Collaboration in the Creation of New Technology. Paper presented and the OLKC Conference in Amsterdam. April 2009.
Raven, R. (2005). *Strategic Niche Management for Biomass: a comparative study on the experimental introduction of bioenergy technologies in the Netherlands and Denmark. PhD thesis.* Technische Universiteit Eindhoven, Eindhoven.
Rosenberg, N (1982) *Inside the black box: Technology and economics*, Cambridge: Cambridge University Press.
Sagar, A., & Gallagher, K. S. (2004). Energy technology demonstration & deployment. In J. P. Holdren, W. K. Reilly, J. W. Rowe, P. Sharp & J. Grumet (Eds.), *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges* (pp. 20). Washington, DC: National Commission on Energy Policy.
von Hippel, E. (1976). The dominant role of users in the scientific instrument innovation process. *Research Policy* 5, 212-239.

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