Role of demonstration projects in innovation: transition to sustainable energy and transport

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Introduction

Transition towards more sustainability has been on the agenda of politicians, researchers, industry and concerned societal actors for a number of years. The oil crisis in the 1970s, environmental concerns related to decreasing biodiversity, depleted natural resources, cities polluted by emissions from road transport, and climate changes caused by greenhouse gas emissions, all these crises have contributed to a sense of urgency in political statements on the need for transition towards a sustainable society. Politicians have developed different types of instruments to achieve a development towards more sustainability. However, the design and proper mix of such instruments is still to be better developed, as is the knowledge on possible effects of these instruments. This applies also on demonstration projects and programmes.

This paper attempts to review two important strands on literature relevant for our understanding of demonstration projects and trials for the transition towards more sustainability: Firstly, the literature on demonstration projects and trials, applying rather different conceptual frameworks, among others technological innovation systems, and secondly, the broad literature on socio-technical systems and strategic niche management. The analysis of the first shows a focus on technological solutions and to a much lesser degree a focus on institutional embeddedness and societal changes induced by such projects. To prevent such one-sided shift of focus we conclude our review with a short but to our mind relevant account of transition theory.

Our literature review is guided by the research questions for the InnoDemo project:

1. What are the main contributions of Scandinavian demonstration and trial projects and programmes to sustainable energy and transport transitions?
2. How should the governance of such projects and programmes be developed to further support their contribution?

Therefore, we look both at possible outcomes of such projects and at the organisation and governance of the programmes supporting such projects. This paper will serve as a conceptual guidance for compiling a comprehensive database over all relevant demonstration projects and programmes in the three Scandinavian countries, a survey of the identified projects and programmes and interviews with involved stakeholders.

Demonstrations as policy instruments for facilitating learning processes and diffusion of new technologies

The following overview will give a summarizing account of the literature which is addressing specifically demonstration projects as a policy instrument for technology innovation. We distinguish here between two periods: (1) literature about the experiences of US-demonstration projects and programmes in general in the 1970s, 1980s and 1990s (Clark & Guy, 1998; Macey & Brown, 1990; Magill & Rogers, 1981), and (2) literature about demonstration projects for energy technologies, such as wind power, solar photovoltaic energy and fuel cell technology, covering Europe, the US and Japan (J. Brown & Hendry, 2009; Harborne & Hendry, 2009; Harborne, Hendry, & Brown, 2007; Hellsmark, 2011; Hendry & Harborne, 2011; Hendry, Harborne, & Brown, 2010; Lefevre, 1984; Sagar & Gallagher, 2004).

Experiences of US-demonstration projects and programmes in the 1970s, 1980s and 1990s

The US experiences with demonstration projects and programmes refer to federal activities for a broad range of technologies, from agriculture, to education, housing, environmental protection, health, transportation and energy (Baers, Johnson, & Merrow, 1977; Macey & Brown, 1990). According to Magill & Rogers (1981), the US Department of Agriculture supported for over 70 years "demonstrations in diffusing agricultural innovations" (1981:24). Both Magill & Rogers (1981) and Macey & Brown (1990) give reference to work of Baer et al. (1977) and Myers' report on the role of demonstration projects for accelerating the application of new technology (Myers, 1978).

Baers et al. analyse 24 demonstration projects funded by 11 different federal agencies and they state that "a demonstration focuses on market demand, institutional impact, and other non-technological factors, the goal being to provide the basis for well-informed decisions on whether to adopt the technology" (1977:950). Baer et al. distinguish between field trials to prove a technology and demonstrations, and they reduce demonstrations to a test for the market. They emphasise market failure as the main rationale for government support of demonstration projects. Baer et al. (1977) emphasise following attributes for diffusion success: a strong industrial system for commercialisation, low technological uncertainty, and no tight time constraints.

Myers (1978), however, argues that it is necessary to distinguish between two types of demonstration projects: (1) *experimental projects* for "testing the workability of an innovation under operational conditions", and (2) *exemplary projects* "to demonstrate the utility of the innovation to potential adopters (that is, to diffuse the innovation)" (summarised by Magill & Rogers, 1981:27). Magill & Rogers emphasise that by mixing these two types of demonstration projects in prior research it was difficult to determine whether or not a demonstration project can be assessed as successful or not. Projects which are more experimental can by definition not contribute to the diffusion of the technology, but they can have contributed quite successfully to the testing of the technology under operational conditions. According to Magill & Rogers (1981:28), Myers (1978:15) highlighted that these two types of projects differ regarding to audience, design and attitudes of demonstration managers.

Clark and Guy (1998) understand demonstration projects as examples "where public funding is used to sponsor preparation of a facility showing the capabilities of a technology, and its subsequent demonstration to potential users" (1998:387). They refer as well to the study of Baer at al. (1977) and they too do not distinguish between experimental demonstrations and exemplary demonstrations.

Boyd, Borrison and Morris (1983) analyse determinants for success of demonstration projects[1]. They distinguish between three dimensions of success: application success, information success and diffusion success, and single out different conditions relevant for the success. The conditions which

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[1] This paragraph is informed by the information given in the article of Macey & Brown (1990).

lead to these dimensions of success are summarised in the following table. Boyd et al. point out that a new technology has different market values in the early high-value market and in the mature market which include lower-value applications. However, they do not mention the importance of market niches at early stages. For them it is essential to assess how the new technology fits into the existing mix of technologies, that means the existing socio-technical regime, and not how it could overcome this mix.

Table 1: Determinants of successful demonstration projects (adapted from Macey & Brown, 1990, and Boyd et al., 1983)

Attribute of demonstration project	Application success	Information success	Diffusion success
Technology "well in hand"	X	X	X
Well-designed experiment focussed on precise objectives	X	X	X
Significant initiative for demonstration from potential users	X	X	X
Significant cost sharing by participants	X	X	X
Significant risk sharing by participants	X	X	X
Demonstration applicable to variety of sites		X	X
All key parties are involved		X	X
Well-defined high potential initial market			X
Conclusive to decision making on economic basis, minimal impediments			X
Supply and support industry in place			X

Macey & Brown (1990) keep the distinction between the two types of demonstration projects – experimental and exemplary projects, but they distinguish also between *two phases of exemplary demonstration projects*. In the *phase 1 projects* the main goal is "to communicate information and promote the technology primary to opinion leaders and early adopters", while the main goal in *phase 2 projects* is "to reach the broader range of adopters…: it may be periodically adjusted or adapted to meet differing local demands as its application environment extends" (1990:230). Macey & Brown underline that the success of an exemplary demonstration should not necessarily be measured by the adoption of the technology, but by analysing if the project influenced planning and implementation decisions (1990:229). The three different types of demonstration projects have different roles in the innovation process and their success or failure has to be assessed differently. Macey & Brown highlight following reasons for success or failure of demonstration projects: (1) user involvement is crucial at all stages of demonstration projects to facilitate information and learning, (2) project design should not be rigid to allow user input and modifications to improve effectiveness, (3) careful planning to take account of market readiness and user participation, (4) dissemination of results and evaluation information should be included in the project design (1990:234).

Government support for demonstration projects can "influence the diffusion of innovations indirectly by indicating to potential adopters the direction of federal policies and priorities" (Macey & Brown, 1990:231). In terms of functions of technological innovation systems this can be captured with the concept "guidance of the search", one of the main functions of technological innovation systems (i.e. Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007).

Demonstration projects for energy technologies

Lefevre defines demonstration programmes as attempts "to shorten the time within which a specific technology makes its way from development and prototype to widespread availability and adoption by industrial and commercial users" (1984:483). Lefevre shows that the complexity of demonstration projects is caused by two reasons: Firstly, demonstration projects have to serve different objectives, beside technological issues a "variety of economic and environmental considerations" (484) have to be addressed. He lists as non-technical objectives of demonstration projects stimulation of new industries, further training of installers and maintenance personnel, public acceptance and involvement of existent industrial manufacturers (485). Secondly, demonstration projects have to develop a division of administrative responsibilities between governmental or other public agencies and private participants and conflicting interests have to be addressed and settled. Conflicting interests may occur regarding the dissemination of the results of the demonstration because the private partners have an interest to treat the results as proprietary. Lefevre points out that it is necessary to discuss when it is proper to select demonstration projects as a proper policy tool to accomplish political and technological goals. He highlights following issues as relevant:

1. *Allowance for failure:* demonstration projects are experiments and should include the possibility to shift back to technical verification in the case of evidence for technical prematurity;
2. *Cost and risk acceptance:* if the private sector is willing to accept costs and risks this is an indication for near-term or medium-term commercialisation;
3. *Trialability:* prospective adopters can sample the innovation; in the case of modular innovations this may be easier;
4. *Audience identification:* should distinguish between technical (engineers, architects, planners etc.) and non-technical audience (residents, general public);
5. *Audience predisposition toward innovation:* is the intended audience favourable of the innovation or do they have to change their behaviour;
6. *Need for inducements beyond demonstration:* the future commercial success of a demonstrated innovation may depend on other public policy instruments, such as "purchase commitments, tax exemptions and credits, and other incentives for manufacturers and buyers" (Lefevre, 1984:489).

Sagar and Gallagher (2004) give an account of primarily US activities in energy technology demonstration and deployment. Regarding demonstration projects they highlight three roles of such projects helping the demonstrated technologies closer to the market: (1) test a new technology in real-world conditions and gathering technical and economic performance data that can help refine the technology; (2) help in scaling up a technology which is important for technologies which require much larger scale for testing than usual laboratory tests; and (3) demonstrate the feasibility of the technology for the market and therefore enhance their confidence (2004:3). Sagar and Gallagher provide also a review of prominent energy technology demonstration and deployment *programmes*. However, regarding the assessment of demonstration programmes they concentrate on the government budgets for such programmes. In 2006, Gallagher et al. repeat the same argument that demonstration projects "bring technologies closer to the market" in three ways: (1) testing new technologies under almost real-world conditions, including the collection of technical and economic performance data to refine the technology, (2) scaling-up technologies from the laboratory test stage, and (3) demonstrate feasibility under real-world conditions to manufacturers an potential buyers (Gallagher, Holdren, & Sagar, 2006:203).

Aims of demonstration projects and trials

Harborne and Hendry define demonstrations and trials as

> "a government-funded programme or project that has specific technological, operational, and social objectives; with an overall budget and duration; which invites bids with a clear specification of goals; evaluates projects against these, requires a formal management structure; and provides ongoing customer/user support from the manufacturer or operator" (Harborne & Hendry, 2009:3586).

While the MLP stresses the importance of experimentation for sustainability transitions, surprisingly few studies have explicitly focused on and theorized the role of demonstration projects, with the exception of the group around Harborne, Hendry and Brown (Harborne & Hendry, 2009; Harborne, et al., 2007). This group investigates especially the role of demonstration projects for transitions to a low-carbon energy sector, and here especially for complex large-system innovations. Also they highlight combatting 'market failure' as the main rationale of public demonstration interventions, covering "national security, economic opportunities and societal benefits", including mitigating climate change (Hendry, et al., 2010:4507). They understand demonstration projects as an "extension of the prototyping process" to overcome uncertainties. These uncertainties, however, include not just technological or market uncertainties.

The group around Harborne, Hendry and Brown has developed a taxonomy for demonstration and trial projects and programmes according to their *aims* (Harborne & Hendry, 2009:3588; Hendry, et al., 2010):

1. prove technical feasibility,
2. reduce building, materials, components, operating and maintenance costs,
3. prove feasibility in commercial applications, and
4. hybrid projects.

We suggest adding three further categories, (5) prove environmental feasibility, (6) develop public awareness and acceptance, and (7) introduce institutional embedding for societal change. In practice most of the projects and programmes have multiple aims. Therefore the category 'hybrid' will probably dominate.

Hellsmark (2011) applies in his thesis the technological innovation system approach with the focus on the different functions of such systems (Bergek, Hekkert, & Jacobsson, 2008; Bergek, Jacobsson, et al., 2008; Hekkert, et al., 2007) in his analysis of the role of system builders in realising the potential of second-generation transportation fuels from biomass. Following Karlström and Sandén (2004) he identifies demonstration projects as "a particular type of materialisation that is important in the industrialisation of new knowledge fields" (Hellsmark, 2011:34). The function of materialisation has not been so much explored in analyses of technological innovation systems, but this concept captures "the process of strengthening the development and investment in artefacts such as products, production plants and physical infrastructure" (Hellsmark, 2011:33) and in this respect this concept builds on large technical systems of Hughes (Hughes, 1987; Joerges, 1988).

Hellsmark identifies following roles of demonstration projects related to the different functions of technological innovation systems: (1) they contribute to the formation of knowledge networks, (2) they reduce technical uncertainties, (3) they facilitate learning that can be instrumental for decisions on technology choice, (4) “they may also raise public awareness of the technology, strengthen its legitimacy and expose system weaknesses such as various institutional barriers” (2011:34), and, (5) they may form a starting point for advocacy coalitions. Karlström and Sandén list three types of results of demonstration projects: (1) learning which will be fed back into technical development, (2) open up a market by improved public awareness and scrutinizing institutional barriers, and (3) developing a network of actors (2004:288).

Organisational solutions

The group analyses different *organisational solutions* for demonstration and trial projects and programmes (Hendry, et al., 2010:4508f.). They identify following organisational solutions:

1. one-off high profile ‘demonstrations ’and competitions to create public awareness about the potentials of a new technology at an early stage;
2. coordinated ‘programmatic demonstrations ’to systematically measure, test, evaluate and characterise technology for a particular application, often comparing different models and technologies;
3. programmatic ‘field trials’ and tests to improve the performance and reduce costs, in the immediate run-up to commercial roll-out backed by subsidies and incentives, contributing to the development of installation know-how and the establishment of standards; and
4. permanent testing and demonstration facilities (‘test centres’), providing a learning facility and knowledge resource, and supporting manufacturers in many ways, including product certification.

While demonstration projects are considered crucial on a system level for the emergence and diffusion of radical new technology, it remains less clear why and how individual organisations engage with such form of experimentation. On the one hand they provide valuable stimuli to reduce the inherent uncertainty and risk associated with radical new technologies, while on the other they may help incumbents to innovate and/or imitate to prevent new technology to breakthrough (Harborne, et al., 2007). The group has a focus on manufacturers of renewable energy technology because the manufacturers have experience with technological innovation and participate in a large number of such projects.

> This focus “neglects the wider social process of getting ‘buy in’, on which successful innovation depends. While DTs have at times encouraged collaboration to overcome barriers, policy makers have not systematically built socio-political considerations into programmes. Equally, they were rarely mentioned by companies, although apparent to observers. It remains a neglected issue in designing and managing DTs” (Hendry, et al., 2010:4511).

That means that our study should address also the wider social process, not just the technical aims of the projects and programmes. This has percussions on which types of actors will be involved in the interviews and focus groups.

Regarding organisational solutions several themes have been discussed more thoroughly by Hendry et al. (2010): (1) the coordination between technical development and demonstrations and trials, (2) structured steps from technical development via demonstrations and trials to market development, (3) market development before technology advance, (4) learning effects and unintended benefits, and finally (5) capturing and spreading learning. The first two themes address two issues: firstly, problems related to firms’ attempts to use government subsidies for demonstration projects and trial for own R&D activities, which should be finance by them and not be government means. Secondly, the process from R&D via demonstrations and trials towards commercialisation is not a linear one. This means that demonstration projects and trials will naturally lead to loops back to R&D activities. These processes have to be considered and coordinated. The third theme addresses the maturity of the technology deployed – it is also evolving: we can distinguish between different generations of technology – while the first generation can already be commercialised on the market, a second or third generation undergoes refinements in R&D and demonstration and trial projects. And subsidies for demonstration projects and trials of new generations of technology should not be used for the older generation of technology. In the next section we cover mainly theme (4) and (5) related to learning.

Regarding the second theme Karlström and Sandén distinguish between demonstration projects in different phases of the formative period of a technology's life-cycle: In the *experimental phase* demonstration projects should "be designed to maximise learning and novelty" and a variety of projects should be selected. In the *take-off-phase*, where market growth is the aim, consumer awareness and network formation become important and therefore demonstration projects should support the prove of technological and financial feasibility, outreach activities and institutional embedding (Karlström & Sandén, 2004:288). This distinction is important when the timing of certain types of demonstration projects is to be considered. Another important feature to be considered is the size of a project (ibid). Some issues cannot be demonstrated on a small scale and require therefore large projects, especially demonstrations of system innovations fall in this category and require often full-scale demonstrations (see also the section on Large Technical Systems).

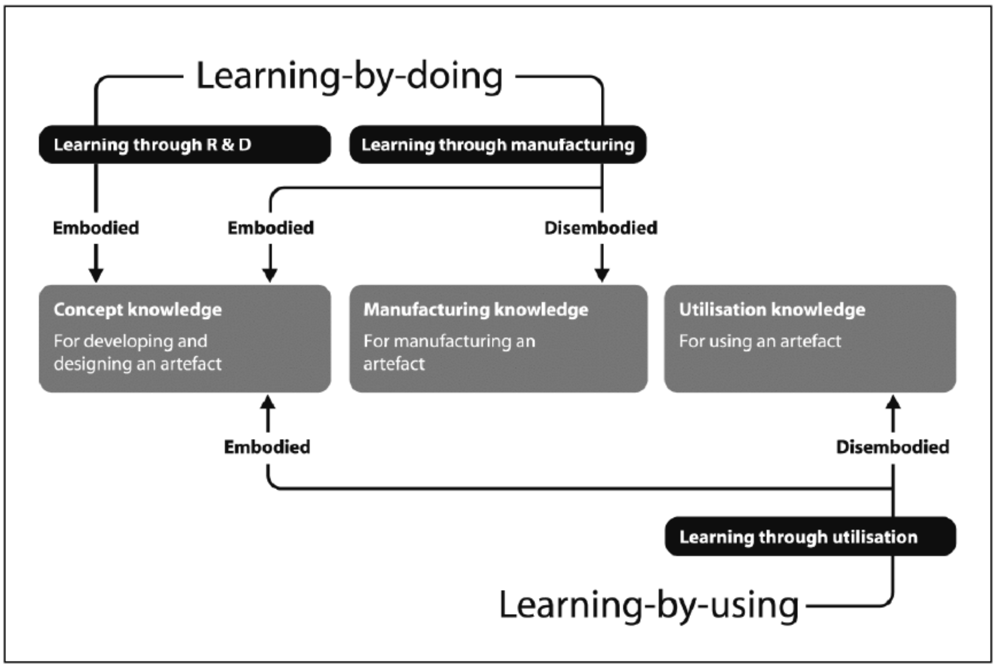
Learning outcomes of demonstration projects and trials

The group around Harborne has developed a database of "demonstration projects and field trials in the development of wind power, solar photovoltaics and fuel cells from the 1970s to the present day", interviewed key experts and performed case studies on a number of organisations (Hendry & Harborne, 2011:779; Hendry, et al., 2010). For wind power there are listed 148 programmes and projects at 577 sites in Europe, Japan and USA (ibid) and nine case studies, and for solar PV 92 programmes and projects and 15 case are studies listed (J. Brown & Hendry, 2009; Hendry, et al., 2010). The database allows them to analyse (1) the "impact of government strategies" on demonstration and trial programmes and their objectives, (2) "stakeholder involvement and location", (3) "evolution in design and technology supported by successive programmes", and (4) "stakeholder learning and the effects on manufacturing capability and competitiveness" (Harborne & Hendry, 2009:3587). Brown and Hendry (2009) apply also the concept "dominant design" when analysing the application of solar photovoltaic technology, distinguishing between a fluid phase with a number of competing solutions and the emergence of a dominant design for grid-connected PV and off-grid PV installations. The emergence of new generations of PV technologies will however contribute to a new "S-curve" (ibid.:2570).

Harborne and Hendry stress the importance of understanding the contribution of demonstration projects for learning processes and the coordination of policy measures in support for the development and deployment of new energy technologies (Harborne & Hendry, 2009:3581). Tax credits and other demand-pull instruments are not to be categorised as trials or demonstrations, but projects supported by such instruments can also include relevant learning and feedback possibilities. Hendry et al. (2010) highlight that demonstration and trial projects should ensure in their budgets performance monitoring, maintenance and trouble-shooting, which are all essential for learning. The group highlights the non-linearity of innovation trajectories and apply a “socio-technical systems approach” (Harborne & Hendry, 2009:3580) stressing the importance of different modes of learning in different phases of these systems (Hendry & Harborne, 2011).

We can distinguish between learning by *searching* (mainly R&D to acquire know-why in the form of formalised knowledge), learning by *doing* (mainly ‘rules of thumb’ and know-how acquired during manufacturing as tacit knowledge), learning by *using* (mainly know-how acquired in the utilisation of technology and especially important for complex, interdependent systems of products and acquired by the users of a technology), and learning by *interacting* (mainly necessary for complex innovations direct interaction between users and producers are necessary) (Kamp, Smits, & Andriesse, 2004).

Figure 1: A model for knowledge and learning (Dannemand Andersen, 2004: 41)



Elaborating further on these types of learning Dannemand Andersen (2004) distinguishes between different types of knowledge: *concept* knowledge, *process* knowledge and *utilisation* knowledge. However, Dannemand Andersen defines learning through R&D as learning by doing (Figure 1), while Kiss and Neij (2011) apply the above introduced the distinction between learning by searching and learning by doing as Kamp et al. (2004). Kiss and Neij highlight that learning by searching and interactive learning have been facilitated through governmental RD&D (2011: 6521). However, they point out that testing and technology certification has supported learning by doing and learning by interacting and they do not address demonstration projects or programmes. “Learning-by-interacting is based on actors’ involvement, interaction and networking, as well as enhanced by mutual interest and change agents” (Kiss & Neij, 2011:6522). The concept of experiential learning has been discussed (Dannemand Andersen, 2004; Rosenberg, 1982) in relation to the type of learning taking place while project participants are collaborating on building new technological solutions and refining them as they are used and the importance of communication across functional boundaries for example between designers and producers (Vincenti, 1990).

The concepts developed by Lundvall and Johnson (Lundvall & Johnson, 1994) on the learning economy are not based on Agyris and Schön (1978), but draw upon on Ryle’s (1949) concepts of know-how, know-what etc. These concepts have been developed into a theory of interactive learning which is relevant for all stages of the demonstration project. The further development of these concepts into the STI/DUI model (Jensen, Johnson, Lorenz, & Lundvall, 2007) is particularly relevant for understanding the combination of scientific knowledge and practical experience necessary for success in a demo project. Some other concepts of learning such as those developed by Lorenz and Lundvall (2011), which include certain aspects such as the freedom individuals have to take decisions and solve problems. This might be particularly relevant for understanding the particular learning processes taking place in a demonstration project.

However, we cannot find evidence for that the science, technology and innovation (STI) mode is dominating totally in demonstration projects and trials in comparison to the doing, using and interacting (DUI) mode (Jensen, et al., 2007). We assume that demonstrations and trials have elements of both modes of innovation: in such projects new technology has to be used to demonstrate their functioning both for the firms, potential customers, and concerned citizens. And we have interactive processes, since such projects mostly are practiced in an interactive setting, especially if they are institutionally embedded. The STI mode is also prevalent, since the assumptions of the demonstrated technology will be verified or modified due to the exposure to real-world-conditions in the experiments. Such results have to be codified in reports and manuals, standards have to be developed and eventually harmonised in cooperation.

In connection to knowledge and learning, the concept of the ‘knowledge base’ might contribute to a better understanding also of demonstration activities. Asheim and Coenen distinguish between two types of knowledge bases, a synthetic and an analytical knowledge base (2005:1176). A *synthetic* knowledge base conceptualises innovation processes dominated by “the application of existing knowledge or through new combinations of knowledge” (ibid), while an *analytical* knowledge base “refers to industrial settings, where scientific knowledge is highly important, and where knowledge creation is often based on cognitive and rational processes, or on formal models” (ibid). Drawing on the concept of knowledge bases, (Moodysson, Coenen, & Asheim, 2008) further refine the distinction for the analysis of innovation biographies. Here innovation is conceptualized as a learning process that involves ‘analysis’ and ‘synthesis’. `Analysis' refers to the understanding and explanation of features of the (natural) world. `Synthesis' refers to the designing or construction of something in order to attain functional goals (Simon, 1969). Analysis typically belongs to the realm of natural science, whereas synthesis typically belongs to engineering. However, these concepts are more or less ideal types. In demonstration projects both knowledge bases often come together since demonstration projects tend to involve not just research collaboration between firms and research organisations, but also interactive learning with customers and suppliers (Asheim & Gertler, 2005). When adding a spatial dimension to the analysis of demonstration projects by introducing territorially embedded regional innovation networks, regionally networked innovation systems, and regionalised national innovation systems (2005:1179f.), this might become still more evident.

Harborne, Hendry and Brown (Harborne & Hendry, 2009; Harborne, et al., 2007) follow Karlström and Andersson in their distinction of different *results of demonstration projects* supported by the government: “(i) learning, (ii) opening a market through increasing customer awareness and clarifying institutional barriers, and (iii) forming a network of actors to drive technology and policy change” (Harborne, et al., 2007:169). They highlight that government policy has to take into account the impact of a range of competing technologies and therefore to consider multiple demonstration projects, not just to pick one winner. Their analysis of demonstration projects for fuel cell technology in public busses reveals that (1) these demonstration projects are purely framed as technological and not as social experiments which explains some of the limited results; (2) alternative technologies complicate a picking winner strategy and therefor they suggest building socio-technical scenarios to establish a social vision (2007).

Hendry et al. addressed an issue related to who has ownership of the learning outcomes of the demonstration projects and trials (2010:4516). How far the learning has been captured only by a single firm or has been disseminated to others remains a question. Different stakeholders have different interests and can act differently in the diffusion of the results of the projects. An issue is also how larger companies and SMEs collaborate in such projects and how the companies retain control of significant intellectual property. Hendry et al. concluded that it may be easier to enable learning "down the supply chain than in promoting technology exchange between partners" (2010:4517).

Multi-level perspective on socio-technical systems

Social scientists have reflected on the above mentioned crises and political agendas and they have developed different theoretical approaches to address the need for transition towards more sustainability. In general, these theories apply a systemic perspective on society. Transition is here understood as shifts or 'system innovations' between distinctive socio-technical configurations encompassing not only new technologies but also corresponding changes in markets, user practices, policy and cultural discourses as well as governing institutions (Geels, Hekkert, & Jacobsson, 2008). Geels and Schot (2010) characterize transitions as following: (1) co-evolution and multiple changes in socio-technical systems or configurations, (2) multi-actor interactions between social groups including firms, user groups, scientific communities, policy makers, social movements and special interest groups, (3) 'radical' change in terms of scope of change (not speed), (4) long-term processes over 40–50 year periods.

A group of Dutch researchers developed the multi-level perspective (MLP) on socio-technical systems which we have chosen as the main conceptual framework for studying the role of demonstration projects. The MLP distinguishes between three levels in a socio-technical system: (1) the socio-technical regime, (2) the socio-technical landscape, and (3) the level of niches (Raven, 2005:31f.). These three levels form a kind of "nested hierarchy", a level of structuration they provide to local practices (Raven, 2005:32).

(1) Rip and Kemp define a technological regime as following:

> "A technological regime is the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artifacts and persons, ways of defining problems – all of them embedded in institutions and infrastructures" (Rip & Kemp, 1998:338).

Geels distinguishes between three kinds of rules: regulative, normative and cognitive rules. Regulative rules constrain behaviour and regulate interactions, such as laws, incentive structures, protocols and standards. Normative rules are for example values, norms and role expectations. Cognitive rules are for example priorities, problem agendas, beliefs and search heuristics of engineers (Geels, 2005:14). Geels develops the concept of technological regimes further and introduces the concept of a *socio-technical regime*. The purpose of this concept is to see that also other social groups incorporate rules beside the engineering community. Geels distinguishes between a user and market regime, a socio-cultural regime, a policy regime, a science regime and a technological regime – and all these regimes are centred on and aligned with a technological system or technological artefact and form the socio-technical regime (Geels, 2005:17).

Raven exemplifies this for the electricity regime as following: “the alignment between the rules upheld by users (e.g. their preferences regarding electricity supply), policy makers (e.g. regulations regarding emissions), engineers (e.g. design heuristics regarding power production), etc.” (Raven, 2005:29).

Raven points out that a “socio-technical regime results in a socio-technical trajectory, the pattern that emerges from dominant practices in engineering, use, policy making, scientific research, etc.” (Raven, 2005:29). This trajectory maintains the dominant regime, secures stability and makes it difficult for new actors to deviate from the proven and incorporated rules.

Hoogma et al. emphasize that most changes in the socio-technical regimes are non-radical: their purpose is the optimization of the regime and not a transformation of the regime; outsiders have an incentive “to develop innovations that can be easily integrated into existing processes and products” and “there are path dependencies that act to contain radically new technologies” (Hoogma, Kemp, Schot, & Truffer, 2002:20).

(2) The *socio-technical landscape* is characterised by deep structural trends and major events which are external to the development of the socio-technical regimes: “Natural resources, infrastructures (electricity, roads, city planning), political cultures and coalitions, lifestyles, macro-economic aspects (oil prices, recessions), demography, and so on are part of this wider context (Geels and Kemp, 2000:18)” (cited by Raven, 2005:31f.). The socio-technical landscape is not influenced directly by the success of local innovation processes, however if a number of regime-shifts succeed, this will also affect the landscape (Hoogma, et al., 2002:27).

(3) The *niche level* is the place were radical innovations which break with the dominant socio-technical regime can be protected and nurtured (Coenen, Benneworth, & Truffer, 2012). “Regime-shifts often start at the periphery of existing dominant technological regimes in small, isolated application domains” – they often first appear in niches (Hoogma, et al., 2002:22). Raven emphasises that niche-activities are characterised by uncertainty: “Actors have to invest time and effort into creating and maintaining structures from which they can derive knowledge or practices (e.g. platforms, participation in conferences, etc.)” (Raven, 2005:32). Hoogma et al. define niches as following:

> “special application domains that are protected from (some of the) rules in the regime, e.g. price/performance ratio, user preferences or regulatory requirements. Protection – for instance, subsidies or regulatory exemptions – from the technological regime can create a proto (temporary) market that provides a testing ground for novel technologies. A technological niche facilitates learning and improves societal embedding; technologies may improve or new functionalities may emerge. In SNM, technological niches are the breeding place for radical innovation.” (Hoogma, et al., 2002:9).

We can distinguish between technological niches and market niches: in market niches the selection criteria are different from the existing regime, while in technological niches “resources are provided by public subsidies or strategic company investments” (Geels & Raven, 2006:377).

Strategic Niche Management

The Strategic Niche Management (SNM) approach has been developed to address niche processes and to some degree to provide policymakers a tool for supporting niche development (Hoogma, et al., 2002:29). Kemp, Schot and Hoogma (1998:186) define Strategic Niche Management as:

> “the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning

> about the desirability of the new technology and (2) enhancing the further development and the rate of application of the new technology."

Policy intervention in socio-technical systems is not only relevant for the selection of niche technologies through experimentation. Policy interventions also include "the articulation of expectations and visions, network formation, resource allocation, favouring open-ended learning processes, and supporting technology diffusion (up-scaling)" (Coenen & Díaz Lopez, 2010:1156).

According to Raven (2005) distinguishes Hoogma (2002:67) between four types of experiments relevant for creating niches: (1) *explorative experiments* at early stages of learning to help define problems, explore user preferences and possibilities for changing the innovation, and learn how future experiments should be set up; (2) *pilot experiments* to raise public and industrial awareness, stimulate debate and open policymaking, test the applicability of innovations in locations with similar conditions or to test the feasibility and acceptability of innovations in new environments; (3) *demonstration experiments* to "show potential adopters how they may benefit from the innovations. They may either be the follow-up of explorative or pilot experiments, or be designed specifically to promote the adoption of an innovation" (Raven, 2005:38); (4) *replication or dissemination experiments* to disseminate tested methods, techniques or models through replication, which involves full-scale implementation of a technology.

Raven emphasises that experiments and niches are not the same. In niches the "local experiments and practices are compared, lessons and expectations are transferred between locations, and delocalised general knowledge of the technology in question is formulated" (Raven, 2005:38). And he highlights that experiments reflect three main evolutionary and sociological aspects of niches:

- Experiments bridge the gap between variation and selection environments: "Interaction between technology actors (firms, research institutes), societal actors (users, environmental groups), and regulating actors (public authorities) may contribute to integrating the concerns of different groups into the design" (Raven, 2005:38);
- Experiments are protected from some of the rules that make up the dominant socio-technical regime: public authorities give subsidies for lowering risks for involved firms and firms may decide to test the feasibility of a technology in a pilot plant because of strategic decisions;
- Experiments are often characterised by limited structuration and high uncertainty, especially in early stages of experimentation.

Rip emphasises that there is no linearity in technological development (Rip, 1995). This has been confirmed by Geels and Raven for a study of Dutch biogas development (Geels & Raven, 2006). Raven shows with a comparative case study approach for biomass technologies in Denmark and The Netherlands that the development of technological niches towards protected market niches and dedicated market niches and eventually regime shifts follows no linear patterns (Raven, 2005:253). Successful niche developments show a more parallel development pattern than unsuccessful developments: instead of one sequential attempt a technology is applied in an increasing number of geographical locations and application domains, by different actors and under different circumstances. These technological variations enable broader and faster learning and the possibility for spill-overs from one trajectory to another. Firms and policy makers are enabled to follow back-up strategies in the case of parallel development patterns (Raven, 2005:253). Beside the technological variations do the varying local context conditions play a major explanatory role (Coenen, et al., 2012).

Instability at the regime level increases opportunities for niche development, which can result in increased niche size. Raven distinguishes between three possible avenues: (1) regime instability can create local opportunities for experiments and niche actors develop expectations linked to regime instability; (2) with a decreasing stability of the regime the regime actors become interested in the niche because of promising options for the future; and (3) in the case of very high instability of the regime a niche can be adopted by the regime as a problem solver, but for this a sense of urgency has to become prominent in political visions and agreements (Raven, 2005:260).

However, the instability of the regime is not sufficient for niches to succeed. The quality of the niche processes is decisive. Following processes have been highlighted in the literature as decisive for successful niche development: facilitating learning processes, the formation of broad and aligned networks and institutional embedding, voicing and shaping of expectations and visions, and the development of complementary technologies and infrastructures (Hoogma, et al., 2002:30; Raven, 2005). In the following we summarize these processes.

Learning processes

Hoogma et al. point out that practical experience is necessary to generate knowledge required to accommodate introduction of new technologies – such knowledge cannot be acquired in house, but it needs to be tested in practice:

> "There is, therefore, always a need for an experimental introduction of novel technologies into use environments with the intend to learn … Often, niche activities are geared towards identifying and testing assumptions about specific advantages. Technological niches come about in the form of experiments, and pilot and demonstration projects" (Hoogma, et al., 2002:30).

Hoogma et al. highlight following aspects of learning as relevant for niches: (1) design specifications of technical development and infrastructure; (2) development of the user context, including user characteristics, their demands and their barriers to use the new technology; (3) the societal, safety and environmental impact of the new technology; (4) required industrial development, including production and maintenance networks to facilitate diffusion of the new technology; and (5) government role and regulatory framework in the introduction process, and possible incentives to stimulate adoption (Hoogma, et al., 2002:28).

Hoogma (2000:58) distinguishes between *first and second order learning*: "First-order learning refers to learning about the effectiveness of a certain technology to achieve a specific goal. First-order learning aims to verify pre-defined goals, to reach goals within a given set of norms and rules. Second-order learning refers to learning about underlying norms and assumptions and is about questioning these norms or changing the rules" (cited by Raven, 2005:42). These theoretical perspectives on first and second order learning base their definitions of learning on the early works of Argyris and Schön (1978) who describe a two stage reflective learning process. Hoogma et al. characterise first order learning in a niche as following: "various actors learn about how to improve the design, which features of the design are acceptable for users, and about ways of creating a set of policy incentives which accommodate adoption" (Hoogma, et al., 2002:28). They highlight that second order learning means to question and explore conceptions about technology, user demands, and regulations. "Opportunity emerges for co-evolutionary dynamics, that is, mutual articulation and interaction of technological choices, demand and possible regulatory options" (Hoogma, et al., 2002:29). While the concept of first and second order learning fits very well with a multilevel perspective, it can be argued that we need a more nuanced concept of learning if we are to understand what is happening in demonstration projects.

Brown, Vergagt, Green and Berchicci (2004) have analysed higher order learning in bounded socio-technical experiments in personal mobility. Bounded socio-technical experiments attempt to "develop and introduce a new technology or service on a scale bounded in space and time" (2004:192). They are driven by long-term and large-scale visions of a more sustainable society. Brown et al. distinguish between two types of learning processes: "the first type occurs among the participants in the experiment and their immediate professional networks; the second type occurs in society at large", but they admitted that their cases did not provide much insight on the second type of learning processes (2004:191).

Raven emphasises the relationship between quality of learning (first order vs. second order learning) and the involved actors: "higher order learning and/or involvement of users and outsiders in the network improved the chances of a technological niche evolving into a market niche or becoming an element in a (new or existing) regime" (Raven, 2005:43).

Learning enables stabilisation at the niche level and is therefore the most crucial process for emergence of a market niche. Beside learning inside an experiment, learning between different locations and between different social groups is a prerequisite for the success of the niche (Raven, 2005).

Institutional embedding and aligned networks

Hoogma et al. identify three aspects of *institutional embedding* in niche development: (1) embedding includes the development of complementary technologies and the necessary infrastructure, (2) institutional embedding produces widely shared, specific and credible expectations which are supported by facts and demonstration successes, and (3) embedding ensures to include a broad array of actors aligned in support of the new technology – aligned network of producers, users, third parties, esp. government agencies (Hoogma, et al., 2002:29).

Coenen et al. emphasise the need for analysing institutional embedding in the geographical context for explaining "the extent to which and in what ways geographically uneven transition processes are shaped and mediated by institutional structures" (Coenen, et al., 2012:973).

Raven highlights that broad social networks include producers, users, regulators, societal groups and that these networks carry expectations and articulate new demands and requirements (Raven, 2005). There are two characteristics of networks which are important for niche development: (1) the composition of the network and (2) the alignment of actors' activities (Raven, 2005:40f.).

Regarding the *composition of the network* actors have to be included who are willing to invest in maintaining or expanding the niche. These may often be large established firms that support the incumbent technology regime and there is therefore a risk for defensive behaviour. A dominance of established firms can lead to dominance of incremental innovations. The network should involve also actors who have no strong ties with the existing regime, but they have often limited resource mobilisation potential and may not be able to maintain the niche over long time. Important is the active involvement of users, both industrial users and costumers, but also the involvement of non-user groups that are affected by the impact of the technology (neighbouring residents, environmental groups, concerned citizens) (Verheul & Vergragt, 1995). Raven points out that traditionally SNM literature has focus on users for generating second order learning processes, but he emphasises that involvement of non-industrial users is not always that relevant for industrial niche projects. Here is might be more relevant to involve environmental organisations or concerned citizens representing the neighbours of an experiment. "Including these groups at an early phase of experimentation can result in the inclusion of their concerns in the innovation process and prevent societal resistance in later phases, through early adjustment of the design" (Raven, 2005:257). It is also a possibility that such actors can participate in the experiments, taking part in the organisation of the plant.

The *alignment of actors' activities* "refers to the degree to which actors' strategies, expectations, beliefs, practices, visions, and so on go in the same direction, run parallel" (Raven, 2005:40). Rip understands alignment as a concept "that indicates the mutual and well-functioning adjustment" of strategies and visions at the network level (Rip, 1995:424). Visions may differ significantly between established firms and new firms and the alignment in a network requires special effort. Rip points out the importance of macro-actors, such as large technology introducers, government agencies and other 'general interest' actors, and relatively independent, and specially constructed macro-actors like 'platforms' or mixed consortia (Rip, 1995:426).

Expectations and visions

Lente (1994) investigates the role of promises and expectations in technological development – how promises about technologies are converted into design specifications. Expectations and visions are constituent for technological development (Borup, Brown, Konrad, & Lente, 2006). However, expectation statements only contribute to the development of technology niches if they become a part of agenda building processes (Lente & Rip, 1998:222). Agenda building processes and expectations influence each other. Expectations get converted into requirements and task divisions at different levels: (1) at the micro level: specific ideas about promising search routes guide solving of specific problems; (2) at the meso-level: visions and expectations about functionality result in functional requirements; and (3) at the macro-level: the cultural level of expectations justifies technological development for achieving sustainable development (Raven, 2005:50).

Expectations change over time, alternating between hypes and disappointment (Borup, et al., 2006:290). When early technological expectations downplay organisational and societal factors the disappointments are inevitable. Expectations can be affected by experiments in three ways: they can become more robust, the quality of the expectations can improve and the expectations can become more specific (Hoogma, 2000). Shifts in expectations have triggered actors to search in different application domains, contributing to niche branching. However, shifts of niche expectations are mainly caused by external changes, e.g. policies, and only to some degree by internal learning processes (Geels & Raven, 2006; Raven, 2005). Raven concludes that "a broad set of expectations is important in the beginning of a niche trajectory (to allow a parallel and continuous pattern), but that expectations should be made concrete and tested in experiments along the innovation journey (expectations should be linked to experimental results)" (Raven, 2005:256). Geels and Raven (2006) summarise the effect of learning outcomes in comparison to initial expectations as following: In the case that learning outcomes validate and accept the initial expectations a new development cycle is initiated that enables further incremental refinement. In the case that learning outcomes are below the initial expectations "faith in the new technology diminishes and expectations decline" (ibid: 380). Eventually, new expectations will be developed and if those come on the agenda non-linearity occurs.

Coenen, Raven and Verbong emphasise that niche-experiments have to be "underpinned by a dynamic set of diverse but complementary expectations that are not fixed but are open to internal and external adjustments while at the same time providing a stable basis for collaboration and coordination within the niche" (Coenen, Raven, & Verbong, 2010:6). While SNM has had a focus on technological expectations, they argue for a broader scope of analysis and to explore the institutional framework which is tied to the locality of the experiments (ibid).

Complementary technologies and infrastructures

SNM aims not just to introduce a new technology but acknowledges also the need for complementary technologies and infrastructures (Hoogma, et al., 2002). Existing infrastructures are not adapted to the needs of the new technology, and complementary technologies often have to be developed or at least to be adapted to the needs of the new technology. Regarding infrastructure, new distribution systems have to be established and maintenance requirements have to be introduced and the work force to be introduced for the new technology (Hoogma, et al., 2002). Investments in the old infrastructure constitute a strong lobby for own, and probably diverging, interests. The value of the new infrastructure and maintenance investments is often rather high and requires therefore decisions and collaboration on cost defraying. This issue is especially important when large technological systems are to be changed, as is the case for energy infrastructure (Hughes, 1987).

Outcomes of SNM

Hoogma et al. summarise four possible outcomes of SNM:

1. “Technological niche remains a technological niche through the set-up of follow-up experiments. This might involve branching to a new application domain and replication in similar domains. Technological niche gestation might lead to expansion and upscaling of the niche.
2. Technological niche becomes a market niche. New experiments are not necessary any longer, but users start to recognize the advantages of the novel technology and suppliers are willing to invest in production on a small scale.
3. Market niche is expanding and branching in new directions leading to the emergence of new market niches.
4. Technological or market niche extinction. The novel technology fails to attract further support and becomes (again) an R&D option (albeit, this time less promising). Niche extinction does not imply that investments are lost. Many spillovers in terms of network development, technical learning and reputation gains can justify the risk of having tried. In addition, learning that a certain technology development is not desirable is also part of SNM” (Hoogma, et al., 2002:31).

Geels and Raven highlight some changes in the analytical core of SNM (Geels & Raven, 2006). They point out three aspects: (1) the distinction between the global and local level of niches, (2) a shift of focus from individual projects to multiple projects, and (3) more attention to the “interactions between the three niche internal processes (learning and articulation processes, building of social networks, articulation of expectations) and how this results in innovation journeys” (ibid: 378).

There exist a number of critiques of the MLP which have been addressed by Smith, Voss and Grin (2010). Here we want to address one of these issues – the interaction of multiple niches and multiple regimes (see also Raven & Verbong, 2007). Niches compete with each other and they are positioned differently in relation to regimes. And a niche can relate to different regimes. Such multiple relations make the system quite complex. In the InnoDemo project this will have some clear importance and requires further reflection. As an example we can take biofuel niches. They have to fight the petroleum industry, but are using often their retail system for selling the biofuel; they have to relate to different sectors providing the resources, such as agriculture, forestry or the waste sector, and they have to relate to the automobile industry, that the produced biofuel can be used in the cars. And the biofuel niches compete with each other: bioethanol, biodiesel or biogas follow rather different avenues.

Large Technical Systems

The MLP framework has taken up important elements of previous work in the field of large technical systems (Hughes, 1987) concerning the interrelatedness of different components, both technical and non-technical, in large technical systems (LTS) as well as its rigidity to change. Joerges defines LTS as:

> "systems of machineries and freestanding structures performing, more or less reliably and predictably, complex standardized operations by virtue of being integrated with other social processes, governed and legitimated by formal, knowledge-intensive, impersonal rationalities" (Joerges, 1988:23f.).

Hughes emphasises that LTS contains a broad range of components which are "both socially constructed and society shaping" (1987:51). LTS include physical artefacts, such as electricity generators and power line systems, organisations, such as utility firms, manufacturing firms, banks, books, articles, research programmes and also legislative artefacts. And if natural resources are socially constructed and adapted, they are also system artefacts.

Hughes has analysed the patterns of evolution of such systems and has identified following phases: invention, development, innovation, transfer, growth, competition and consolidation. However, these phases are not simply sequential. They can overlap and there can be backtracks (1987:56). Radical inventions have started the system, but they are not possible in a mature LTS because they would not contribute to the growth of the existing technical system, but would overthrow it, and "conservative inventions predominate during the phase of competition and system growth" (1987:57).

For the growth of a LTS there are two phenomena important: (1) problems which function as "reverse salient" for the system, and (2) the momentum of the system. For our analysis are reverse salient especially interesting. Reverse salient are system components which have fallen behind and obstruct the system, they have to be addressed in new technology development. This means, that niches could be developed which provide (conservative) solutions for the problem inside the LTS. They could be integrated into the existing system. Alternative, more radical solutions could turn over the existing system if they would succeed. The existing LTS acquires momentum, the involved organisations and people have often "vested interests in the growth and durability of a system" (1987:77). Both reverse salient and the inertia of the system caused by the developed system momentum make niche development inside an existing LTS difficult (Hughes, 1983, 1987).

Hughes has developed the concept of LTS by analysing the history of the electric light and power systems in the U.S., the United Kingdom and Germany, but he also has acknowledged that similar systems, structures, relations and processes can be found in other industries, such as chemical industry, automobile industry or the telecom industry (Hughes, 1987). Analysing the role of demonstration projects for innovation to promote the transition to sustainable energy and transport requires therefore taking into account the specific scale and development patterns of these systems. They are different compared to smaller technical systems which have not amassed momentum in such a high degree as these LTS and which are therefore easier to change.

Joerges distinguished between LTS and major types of subsystems: large technical networks (LTN) and large technical programmes (LTP) (1988:27). For this paper LTP are especially interesting. Joerges sees LTPs as “pre-infrastructural systems oriented towards some quasi-experimental set of technical and economic goals” (ibid:28). LTPs involve multiple government agencies, and they can have a transnational scope. They often are undertaken to radically expand or transform existing LTS and a LTP might be called a “forward salient”, an analogy to Hughes “reverse salient” coined by Joerges.

Conclusions

This paper addresses following three main concerns:
Firstly, it focuses on demonstration and trial projects, targeting core processes and key instruments needed to facilitate the alignment of promising new technologies with societal conditions. Such alignment is necessary for the successful adoption of radical new technology and if the development and diffusion of emergent technologies, in a transition to more sustainable energy and transport systems, is to be sustained and accelerated. Trial and demonstration projects act as ‘market engagement programmes’ which support field tests of new technologies and provide data on their performance in target applications (Grubb, 2004). They have proven to be an important instrument both for policy-makers, researchers and firms in helping to reduce uncertainty and learn about the acceptance, desirability and adaptation of new technology in society. Interaction with societal actors, monitoring experiences with governance of such projects and policy learning are all important issues.
Secondly, it addresses technologies that are promising platforms for a transition to a more sustainable energy system and transport system, such as renewable electricity, hydrogen, and sustainable biofuels. The future development pathways of these technologies are challenged by a high degree of technological, social and economic uncertainty as well as durability of the incumbent fossil-fuel based energy and transport system. It is this ‘systemic lock-in’ that means that the deployment and diffusion of sustainable energy and transport systems is often hampered by market failure, and thus requires policy support.
Thirdly, the measurement of the tangible and intangible outcomes, intended and unintended effects and long-term impacts of trial and demonstration projects can provide important insights for policy makers. Countries have invested heavily in trial and demonstration projects for sustainable energy solutions over recent years. This makes it crucial to understand why certain projects do or do not succeed. Success can be measured by comparing the objectives of the projects and the achieved outcomes of the project. Intangible learning outcomes are important here (Kamp, et al., 2004), and strengthened networking between firms, technology providers, authorities, user groups and other stakeholders (Hoogma, et al., 2002). The understanding of relative failure might also be a first step towards better solutions (Karlström & Sandén, 2004).

This literature review will guide the InnoDemo project answering our research questions:

1. What are the main contributions of Scandinavian demonstration and trial projects and programmes to sustainable energy and transport transitions?
2. How should the governance of such projects and programmes be developed to further support their contribution?

Answering these questions requires a clear understanding of “sustainable energy and transport transitions”. This was the objective of the second part of this literature review positioning this project in the context of Strategic Niche Management theory. SNM has a focus on learning processes, institutional embedding, aligned networking, expectations and visions, and complementary technologies and material infrastructure.

We understand demonstration projects and trials as experiments to overcome uncertainties, while uncertainties can be of different character, such as technological, costs, environmental, social, political etc. Such projects exist at different scale, including a variety of types of actors, and they have different objectives and different types of outcomes. A comparative analysis of demonstration projects and trials has to ensure that projects are comparable according to objectives, organisational solutions, and technologies. We distinguish between following aims of demonstration projects and trials, but most of the projects will have several aims:

- prove technical feasibility,
- contribute to the formation of knowledge networks,
- facilitate learning that can be instrumental for decisions on technology choice and can form a starting point for advocacy coalitions,
- reduce building, materials, components, operating and maintenance costs,
- prove feasibility in commercial applications,
- prove environmental feasibility,
- develop public acceptance and awareness,
- expose system weaknesses such as various institutional barriers, and
- introduce institutional embedding for societal change.

The most important outcome is learning, but here we can distinguish between first and second order learning, and between learning processes related to STI and DUI modes of innovation. The dissemination of the learning outcomes is a major issue for the success of governmental funded demonstration projects and trials. Currently, there is not *one* theory or concept of learning which covers all the potential learning processes in a demonstration project. More work needs to be done in this area in order to make the complex and extensive learning processes occurring in demo projects more visible to participants and stakeholders. Following and expanding Hoogma et al. on learning in niches we will analyse following aspects of learning as relevant for demonstration projects and trials:

- design specifications of technical development and infrastructure,
- development of the user context,
- the societal, safety and environmental impact of the technology,
- required industrial development, including production and maintenance networks to facilitate diffusion of the new technology,
- interactive learning between the partners in the projects,
- policy learning on government role and regulatory framework, and possible incentives to stimulate adoption after the demonstration project.

The literature review revealed following conclusions regarding the governance of demonstration projects and programmes. Here we highlight following issues for programme managers:

- user involvement is crucial at all stages of demonstration projects to facilitate information and learning,
- project design should not be rigid to allow user input and modifications to improve effectiveness,
- careful planning to take account of market readiness and user participation,
- considering the required size of the projects,

- dissemination of results and evaluation information should be included in the project design,
- projects should ensure in their budgets performance monitoring, maintenance and trouble-shooting, which are all essential for learning,
- the programme should be clear about the maturity of the technology to be demonstrated subsidies for demonstration projects and trials of new generations of technology should not be used for the older generation of technology.

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