ENEVATE WP3 Niche Typology

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1. Introduction

Electric vehicles currently operate in two realms. On the one hand, there are niches where they are fully competitive with any alternative driveline technology. Examples are various types of public transport applications such as trams and trolleybuses. Other examples are in certain industrial settings, where products such as electric materials handling equipment are often the norm. In addition, EVs have long been used for certain commercial applications such as milk distribution in the UK and are increasingly used for inner city distribution for their lack of emissions and low noise – this makes them competitive in these settings with conventional IC.

The other EV realm largely relies on subsidies of various kinds. This includes the private EV-as-car-replacement market. In order for EVs to enjoy enhanced penetration in the market, it is these latter areas that need to be stimulated in various ways. However, the question then arises as to what way of stimulating such markets is most effective. Various experiments have taken place and are currently taking place, which may shed some light on this question.

The core task of the ENEVATE project is to collect data from a range of such EV experiments – primarily those based in north-west Europe – and draw lessons from these to inform any future decisions on what type of experiment is likely to succeed and what type is likely to fail, based on previous experience. However, the experiments that are currently taking place, or that have been conducted in the past, are many and varied and in order to extract useful information from these, it was felt that a kind of typology is needed. If experiments can be classified under various types, a more useful set of guiding principles can be devised, thus enhancing the output from the project.

Current and recent experiments and pilot schemes range from electric concept cars, EVs in very limited production, experiments with fleet EVs, shared EVs, localities with a range of EV incentives, etc. Clearly these are all quite different in nature and need to be analysed in different ways. Some of these could be classed as technical experiments or pilots, while others are clearly linked with broader niches of novel technologies combined with new socio-economic, or business models. It is this mixture that may prove challenging to capture. In addition, there are established EV applications, such as trams and trolleybuses that need to be excluded as these have proved viable and have long moved beyond the experimental stage. Yet, where such types are used in novel ways, they still need to be captured in some way.

2. WP3 EV Niche Typology

Table 1 is an initial attempt by the partners contributing to WP3 to establish such a typology. Clearly this can be refined as the project progresses and data from the experiments under consideration begin to flow. Table 1 presents the proposed EV niche typology that will be used to inform the methodological approach in WP3. Nine broad categories are currently identified, as set out in Table 1. We are hoping over time to refine this typology and, ideally reduce the number of categories. This would also help in communicating the concept to stakeholders. Where categories can be fused may become clearer when analysing the ENEVATE pilot schemes.

Table 1: ENEVATE WP3 – EV Niches and Niche Experiments - Typology

TYPE	SUB-TYPE	SUB-SUB TYPE	Examples	*Notes*	Links
1. EV Public Transport	Dedicated Infrastructure needed	i) Rail-based	Train, tram, tram-train, monorail, underground	*Nuremberg has fully automated underground system*	http://www.nwe.siemens.com/denmark/internet/dk/mobility/rullende_materiel/naerbaner/Documents/Metrocar_Rubin_Nuremberg_eng.pdf (Nuremberg specifications)
		ii) MagLev	Shanghai Airport MagLev; Linimo in Aichi Prefecture Japan; Incheon Airport to Seoul (under construction)	*magnetic levitation train*	http://www.maglev.net/ Site for all current and future projects for MagLev rail
		iii) Guided bus	Many examples of IC guided bus; Linie 103 Frankfurt EV guided bus		http://www.transportpolicy.org.uk/PublicTransport/AdvancedBuses/AdvancedBuses.htm
		iv) AGV	Some experiments: ULTRA, Cybus	*AGVs (automated guided vehicles) are normally used in industrial settings guided by cables embedded just below the surface – some commercial passenger carrying examples such as ULTRA in UK (to be used for 2012 Olympics) ; also Cybercar/Cybus in La Rochelle, France*	
		v) Other	e.g. autonomous trolley bus	*Trolley buses in Beijing are disconnected from overhead powerlines and used on battery power alone in certain central shopping streets ;*	http://www.transportpolicy.org.uk/PublicTransport/AdvancedBuses/AdvancedBuses.htm http://www.ebus.com/
	General infrastructure can be used	i) Electric bus/E-Bus	Experiments in Beijing, France, Italy, China, USA		http://www.ebus.com/

		ii) Hybrid bus	Poitiers, Strasbourg; MAN hybrid buses in Munich, Dresden, Bochum, etc.	*OEMs such as MAN are key in providing such vehicles*	http://www.ebus.com/
		iii) EV minibus	Downtown Santa Barbara, Paris Montmartrobus (+ coming soon in the « 17e et 18e arrondissements »)	*All public transport in downtown Santa Barbara, CA carried out by EV minibus*	http://www.eco-rally.org/peugeot-emonarch-electric-minibus-allied-vehicles
		iv) EV taxi	New York + concept developed from Volkswagen	*Charging infrastructure missing – charge at depot; experimental smart grid by Siemens in Wildpoldsried, Germany*	http://www.smartplanet.com/blog/intelligent-energy/nycs-bloomberg-pushes-for-electric-taxis-in-cities/3477
2. Private, consumer-owned EVs			Ranging from electric cars, via electric bicycles, to Segways, etc.		
3. EV Towns	Public incentives, private EVs		Oslo, Mendrisio, project EVUE (Electric Vehicles in Urban Europe); VLOTTE, Austria	*Public sector provides incentives for private buyers and users of EVs*	*Found but no formal website, news sites*
	Public-private partnerships		La Rochelle, Paris (Smart), Strasbourg (Toyota Prius) ; BeMobility Berlin ; Electromobility in evryday life Stuttgart ; Eflott Munich ; MINI E Berlin ; E-Aix in Aachen	*Electric vehicle experiments involving public sector partners (usually to provide infrastructure) and private sector partners (usually to provide vehicles and/or energy)*	http://research.edf.com/pioneering-projects/electric-mobility/experiments/phvs-in-strasbourg-81661.html
	NEV model in the US / quadricycle in Europe		Palm Desert, France (Fam Auto); mia in Mannheim, Aachen, Nuremberg	*The NEV (neighbourhood electric vehicle) model was pioneered as a PPP in Palm Desert, CA. It allows golf cart-derived EVs to share some public roads under special exemption from California state law; EV quadricycles (VSP – voitures sans permis) are available commercially in France; mia in Mannheim, Aachen and Nuremberg*	*USA* http://green.autoblog.com/2011/02/10/smart-car-future-chicago-auto-show-2011/ *Europe* http://www.thechargingpoint.com/tag/quadricycle/

	Promotion of E-bikes?		BeMobility, Berlin; Deutsche Post and private mail services using E-bikes		http://www.levassociation.com/assets/Fact_Sheet_-_Electric_bikes_keep_people_mobile1.pdf
	Promotion of E-scooters?		VLOTTE in Vorarlberg, Austria		http://www.ecitywheels.com/
	Development of EV infrastructure (e.g. charging points)		Electromobile City in Stuttgart; development and testing of charging system in Munich; charging station in Offenbach; NEMo – Nordhessen E-Mobility; Plugged-in-Places, UK	*Projects focussed on developing EV charging infrastructure*	http://www.now-gmbh.de/uploads/media/NOW-FactSheets-ModelRegionsElectromobility_01.pdf
4. EV sharing schemes	Co-operative		Witkar, Amsterdam; several car free communities in Germany and beyond (see www.autofreiwohnen.de/project.html; 'e-car4all' in Bremen and Oldenburg		http://solar-driver.dasreiseprojekt.de/unterkategorie.php?&ok=12&uk=114 *Gives other examples of E-car sharing*
	Public-private partnerships		TULIP, PSA; Kempten, Germany (eE-tour Allgäu – EV car sharing for tourists); BeMobility Berlin	*TULIP (transport urbain, libre, individuel et public) was proposed by PSA Peugeot-Citroën in the 1990s and was to be implemented with the city of Tours.*	http://xa.yimg.com/kq/groups/1088789/1999709807/name/Article+on+EU+carsharing.pdf *Paper*
	Private		Move About, Norway		http://www.moveabout.net/index.php/news/news_article/news_from_move_about1/
5. Depot-based commercial EVs	Food distribution		UK milk floats; supermarket home delivery by Tesco		http://www.smithelectric.com/ *makers of BEV's, they seem to be the market leaders HQ USA but originating in the UK*

	Local parcel distribution		UPS, La Poste; ISOLDE in Nuremberg (since 1997); DHL in Berlin and Stuttgart; DPD in Ludwigsburg; Meyer & Meyer with C&A in Berlin; UPS uses 50 Vito E-Cells in Stuttgart		*http://www.smithelectric.com/ makers of BEV's, they seem to be the market leaders HQ USA but also based here in the UK*
	Repair and maintenance technicians		BT, Milton Keynes and London		
	Fleet experiments		ColognE-Mobil; EVs for commercial use in Hamburg; BT Milton Keynes and London	*Experimental use of EVs by fleet users for different applications*	*http://www.guardian.co.uk/environment/2010/dec/10/hydrogen-bus-london write up of experiment*
	Local authority experiments (e.g. refuse trucks)		*Feasibility study on hybrid refuge trucks*		*http://www.kerstech.com/PDFs/Hybrid%20Refuse%20Truck%20Feasibility%20Study.pdf*
	Research and production		EMKEP - Berlin	*EVs used by firms engaged in research and/or production of relevant products*	*http://www.e-mobil-bb.de/EMKEP.html*
	Pedelecs		Bike + Business 2.0 - Darmstadt	*280 Pedelecs for business trips and commuting by local authority employees and some companies in Rhine-Main region*	*http://www.pedelecs.co.uk/*
6. Industrial EVs	Free-moving EVs on industrial sites		e.g. electric fork-lift trucks; electric pallet moving vehicles		*http://www.taylor-dunn.com/ showcasing different types of*
	AGVs		Electric automated guided vehicles in factories and warehouses		*http://www.gottwald.com/gottwald/site/gottwald/en/products/agv.html*
7. EV integrators	'Better Place' model		Better Place Experiments in Denmark, Israel, Australia		*http://www.betterplace.com/global-progress-israel*

8. Fuel Cell EV experiments	Public transport experiments		CUTE and CHIC fuel cell buses; Hamburg is phasing out diesel buses by 2018, replaced with 60-70 FC buses each year; Chicago, Vancouver		*http://www.dwv-info.de/e/news/mirror/2010/hm1002.html#HamburgnimmtAbschiedvomDieselbus*
	Hydrogen highways		Under development in Germany, Scandinavia, Pacific Coast North Americaetc.		*http://hydrogenhighway.com/*
9. Smart grid + EV	EV as energy stores		Fleet test electromobility – Frankfurt; 4-Sustainelectromobility - Berlin	*EVs integrated into the smart grid as energy stores*	*http://www.evwind.es/noticias.php?id_not=11425*
	Development of smart grids for EV use		'e-SolCar' Berlin		*http://www.smartgridnews.com/*

(source: ENEVATE WP3)

Type 1 in Table 1 contains a number of well established EV applications. However, type 1.a.ii the maglev train still relies on heavy public subsidy for all existing applications. Type 1.a.iii, the electric guided bus is a relatively new application, allowing some of the advantages of rail-based systems without the heavy investment in fixed infrastructure and rail vehicles. 1.a.iv captures the AGV option, which is still relatively new and still largely experimental in urban environments.

Type 2 is the type assumed by many commentators, manufacturers and legislators; the private, consumer- owned EV. As outlined in the table, these may range from conventional car-like EVs such as the Nissan Leaf, or Th!nk, via electric quadricycles such as the Mega and Reva, to electric bicycles, pedelecs (= electric-assisted bicycles, or tricycles such as the Twike) and new types such as Segways.

Type 3 tries to capture a range of situations whereby a local authority in conjunction with other local partners specifically attempts to facilitate the use of EVs in some form. This includes specific EV experiments such as those in La Rochelle, France and Mendrisio, Switzerland, but can also be used to include the situation in Oslo and London whereby public subsidies and infrastructure are used to promote private EV markets. In terms of sub-categorisation we have provisionally classified them according to the role played by public authorities and private actors, respectively. Other categories are attempts to capture the promotion of more specific vehicle types, while one captures infrastructure promotion initiatives. This is probably the most fertile category for research into transitions towards greater acceptance of EVs.

Type 4 is for various types of EV sharing schemes, which have been categorised according to their organisational and ownership characteristics. These too seem likely subjects for research.

Type 5 is for depot-based commercial vehicles, currently probably the most viable application of EV technology, with many examples in daily use throughout NW Europe and beyond. It is clear that this category is already competitive with more traditional technologies, offering specific advantages for a number of operators. However, a number of potential users are still considering whether to opt for EVs for their specific needs and some of these may also be worthy of investigation and will be tracked. Clearly, some of these, once established will move to one of the other categories. A special sub-category, is dedicated to fleet EVs that are used specifically for experimental purposes by technology developers.

Type 6 covers existing and established EV use within industrial environments of various types. These are established applications whereby EV is considered the optimal solution. They are thus fully competitive and do not require support, although it must be recognised that in some cases such applications are driven by existing regulations, particularly those covering in-plant emission and toxin levels under health and safety regimes.

Type 7 has been introduced to cover broader experiments with alternative business models for EVs. On the whole, EV experiments are largely technology-driven, perhaps ignoring the wider business or societal impacts of any move to EVs, which are different enough from IC vehicles to have the potential to force new business models onto the industry. This is an important area of investigation under WP3.

Type 8 is specifically about fuel cell experiments. This is a longer term technology compared with battery EVs and is therefore still more dominated by experimentation. These are important in order to assess their potential viability, as well as to develop further this key technology in more market-like operating environments. We will be keeping a watching brief on FC and track any experiments in this area.

Type 9 has been introduced to capture EV-specific grid experiments, notably ‘smart grids’, whereby a means of communication and energy exchange is created between EVs and the energy generating and distribution grid. Additionally, post EV-use applications of EV batteries for energy storage will also be captured by this category.

We regard this typology very much as a work in progress and expect to refine it during the course of the ENEVATE project and the flow of results from pilots and experiments, as well as further research of existing literatures. In this context, we think the theory of Strategic Niche Management (SNM) is particularly relevant. This is explained below. In the meantime, the WP3 team welcome any comments on this typology.

3. WP3 Academic Content

In addition to the more practical lessons that form the primary aim in this context, it is also important to derive some academic value from the ENEVATE project. It should be noted that this in turn can help in deriving higher level learning from the project, which can lead to more strategic policy advice, thereby producing even more useful outputs from the ENEVATE project as a whole. A useful theoretical framework for capturing some of the findings for WP3 may be provided by the socio-technical regime transitions literature (e.g. Kemp et al., 1998, 2001; Geels, 2002) and particularly the related notion of ‘strategic niche management’. Within this theoretical framework it is argued that a ‘regime shift’ to a new set of technologies and a new set of accompanying social and economic norms can be initiated through the successful establishment of one or more technological niches. In most cases such niches will arise naturally as a result of changes in the operating environment, such as the invention of new technologies. Geels (2002) gives the example of the transition from sail to steam in ships, among others. Learning from different niches can combine and new actors can become supportive and thus gradually, clusters of social and technological factors become more and more powerful, such that they can come to replace an established and hitherto dominant regime. This combination of technological and social factors is essential to bring about such change – technology alone is never sufficient. Changes in the landscape – e.g. the increasing pressure on the use of fossil fuels – weaken the existing regime, thereby opening up windows through which niche technologies and changed social factors can establish themselves.

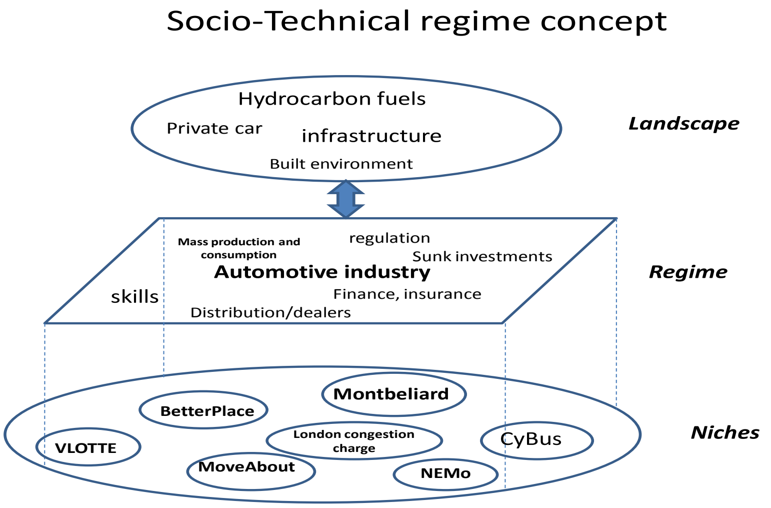

Figure 1: Socio-Technical regime concept overview

However, it is also possible to provide active support for specific niche technologies that are considered particularly desirable. This concept is known as strategic niche management (SNM). Where there is a broader socio-political driver for such a shift – as is the case currently through the desire to reduce carbon emissions from transport – a number of key actors can come together to set up experiments to try and promote such a niche. Such experiments attempt to create a protected market space in order to test the viability of an alternative technology and/or set of accompanying norms. If successful, such a concept can then gradually be exposed to ordinary market forces, thereby helping the niche to move towards replacing the established, but now less desirable regime via a route that offers gradually less protection from prevailing market forces, which in any case do not normally act with foresight. Niches will then benefit from windows that appear in the dominant regime as a result, very often of changes in the landscape – e.g. rapidly rising oil prices. In addition, lessons learned from several such experiments can combine into new niches, thus gradually adapting and strengthening over time.

Thus, for example, in the electric vehicle experiment run in the French city of La Rochelle in the 1990s, the local authority combined forces with Peugeot-Citroën and EDF to create such a niche. Each partner provided key inputs, but inputs from all partners, as well as volunteers to live with the vehicles were all needed to enable the niche experiment to operate. Although now largely dormant, useful lessons were learnt from this experiment which have since informed policy and technology development, as well as informing the more recent Cybercar/Cybus experiment in the same city. This can be contrasted with the Witkar experiment in Amsterdam that ran in the 1970s and 1980s, where only limited protection from market forces was ultimately provided, too few stakeholders became involved, and which therefore ultimately failed, despite offering a number of clear advantages in environmental and social terms (Nieuwenhuis et al. 1992, 113-115). In addition, this experiment is now largely forgotten with few lessons learnt. Figure 1 is an attempt to indicate how niche experiments, or pilots, relevant to ENEVATE can be seen to interact with the existing regime; however it must be pointed out that some of these are mere experiments, while others are potential niches (see point 3, below).

One of the core tasks of ENEVATE is to explore ‘integrated, sustainable, e-mobility concepts’. This aim presupposes ‘sustainability’, which we can interpret as the desire to move towards greater sustainability, as achieving a sustainable transport regime through ENEVATE is clearly overambitious. However, the term ‘integrated’ is also open to several interpretations, and clearly where an experiment or pilot can be integrated with existing transport systems as part of a more integrated transport system, such a concept will be more viable, particularly in the shorter term. It can then expand the nature of such an established niche with a new technology, thereby leading to a degree of ‘stretch’, as outlined under point 4, below. Several niches under consideration as pilots within ENEVATE appear to have this potential. Integrating an EV niche smoothly within an existing transport system is a sure way of gaining credibility for EV technologies and wider public acceptability for this novel technology, which can then be leveraged for the introduction of more radical EV-based technologies by stretching an established niche into a novel niche. This notion requires further analysis under WP3.

However, SNM also contains lessons for how to proceed in ENEVATE. The original thinking about SNM has more recently been refined with certain aspect being actively questioned in the light of more recent findings and experience. It is therefore important for ENEVATE to learn from these experiences and also to build these experiences into its toolkit and learning outcomes. Professor Frank Geels of Sussex University in the UK, one of the key experts in this field, has highlighted for us a number of issues that have arisen in the SNM literature over recent years, as summarised below; these notions will be explored in greater depth in future WP3 outputs.

1) there are limits to what single projects/experiments can do

In more recent SNM work, big policy claims have moved to the background, and more attention has been given to empirical and conceptual analysis. In particular a book based on comparative case studies in an EU research project (Hoogma *et al*., 2002) led to refinements in and nuancing of earlier policy recommendations and ambitions. This book is based on an EU-programme in the late 1990s, which used SNM to study 16 real-life experimental projects with radical technologies in the transport sector (Hoogma *et al*., 2002):

“For one thing, we were certainly over-optimistic about the potential of SNM as a tool for transition. (...) The positive circles of feedback by which a technology comes into its own and escapes a technological niche, are far weaker than expected and appear to take longer than expected (5 years or more). (...) The experiments did not make actors change their strategies and invest in the further major development of a technology. (....). Only occasionally will an experiment be such a big success that it will influence strategic decisions. Experiments may tip the balance of decision-making, but they will not change the world in a direct, visible way” (p. 195).

The authors also noted that:

"(...) In the experimental projects much has been learned about the functioning of technologies at stake and their acceptance. But the contributions of the projects to niche development appear to be small. (...) The experiments were relatively isolated events. It seems difficult for actors to build bridges. (...) There are limits to the power of experimental projects. Only occasionally will an experiment be such a big success that it will influence strategic decisions" (Hoogma *et al*., 2002: 195).

<u>2) problems in design of experiments</u>

This is an issue highlighted in the more recent work on SNM, notably Schot and Geels (2008), and which may usefully inform some of the work in ENEVATE. Experimental results showed that many demonstration projects were organized in an overly contained way. Networks tended to be narrow and projects tended to focus on first-order leaning. Consequently, many demonstration projects followed too much of a technology push approach. The narrow focus came through in the way users were included in the demonstration projects that were studied. They were mainly perceived as consumers with given needs and preferences. Hence, the aim of many demonstration projects was to discover (mis)matches between technology features and these (assumed) needs. Standardized surveys and usability trials and panels were used to investigate these (mis)matches.

Failed niche developments could often be related to either minimal involvement of outsiders in the experiments and a lack of second order learning, or to minimal involvement of regime actors which resulted in lack of resources and institutional embedding. Another recurring finding is that the nature of social networks determined the depth and breadth of learning processes. Networks that were broad and contained outsiders provoked more second-order learning.

With regard to niche-innovation policy, governments tend towards stimulating new technologies, e.g. via R&D and demonstration projects. While this strategy is important, there is a danger of a narrow technical focus. In an evaluation of various sustainable transport demonstration projects, Hoogma et al (2002, p. 192) find recurring characteristics, such as too much focus on technical learning, predominance of first-order learning, minimal involvement of outsiders, and projects that were overly self-contained. We therefore need broader *socio*-technical policies where niche innovation policies also facilitate social learning (e.g. about behaviour and mobility patterns), second-order learning (which enables the questioning of established assumptions about mobility), inclusion of civil society groups, user organizations, different user groups etc.

<u>3) Distinction between experiments and niches.</u>

A niche is carried by a sequence of experiments, as perhaps in the recent example of Cybus in La Rochelle, which could be said to derive from the earlier EV experiment. Importance of portfolio management, and ensuring that knowledge from one project provides input to new projects, which is what ENEVATE has as its primary aim. For this reason, some of this previous experience is likely to be useful to ENEVATE. This could also be used to inform the gradual refinement of the niches as outlined above. Geels and Raven (2006), for example, explain that recent work has expanded the analytical core of SNM in three ways. One addition is to distinguish between concrete local projects and a global niche-level, carried by an emerging field or community (Figure 2).

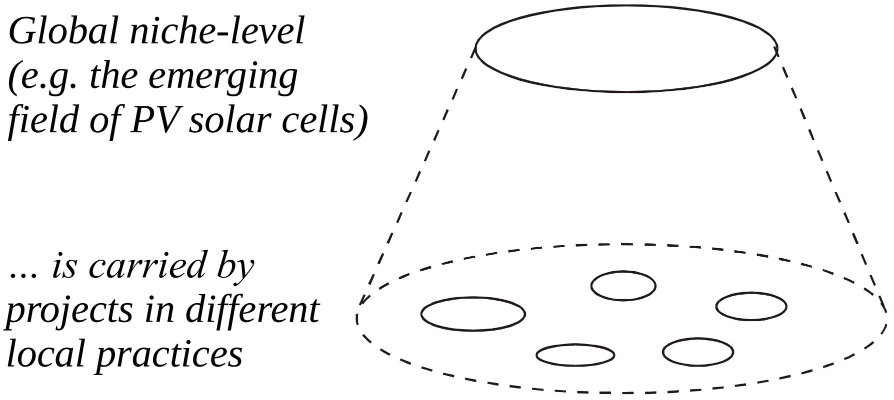

Figure 2: Local projects and global niche-level

It is in this context that the typology outlined earlier may be useful. If different experiments can be identified as belonging to the same niche, the experiences from these can be linked and used in support of such a broader niche. A second addition is that recent SNM work changed the focus from individual to multiple projects. These projects can exist simultaneously and build on each other over time. Sequences of local projects can gradually add up to a technological trajectory at the global level (Figure 3). In this process, global niche rules and expectations, that are initially diffuse, broad and unstable, become more articulated, specific and stable.

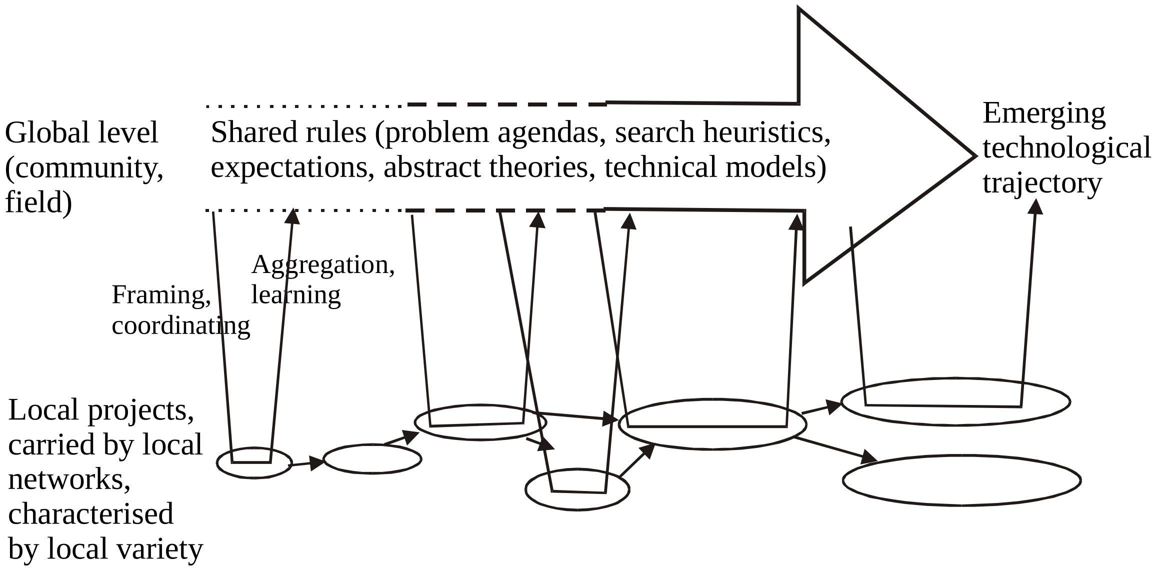

Figure 3: Technical trajectory carried by local projects

The transformation of local outcomes into generic lessons and cognitive rules does not occur automatically, but requires dedicated 'aggregation activities'. Typical aggregation activities include standardization, codification, model building, formulation of best practices, etc. Also circulation of knowledge and actors is important, to enable comparison between local practices and formulation of generic lessons. Conferences, workshops, technical journals, proceedings, newsletters play a role here. It is here that ENEVATE can also provide a key contribution.

Third, recent SNM work shifted the focus to 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. Actors, embedded in networks, are willing to invest resources (money, people) in projects, if they have a shared, positive expectation of a new technology. This shared expectation also provides direction to the projects. Projects, carried by local networks, provide space for local activities. The outcomes give rise to learning processes, that may be aggregated into generic lessons and rules. Outcomes are also used to adjust previous expectations and enroll more actors to expand the social network (see Figure 4).[i]

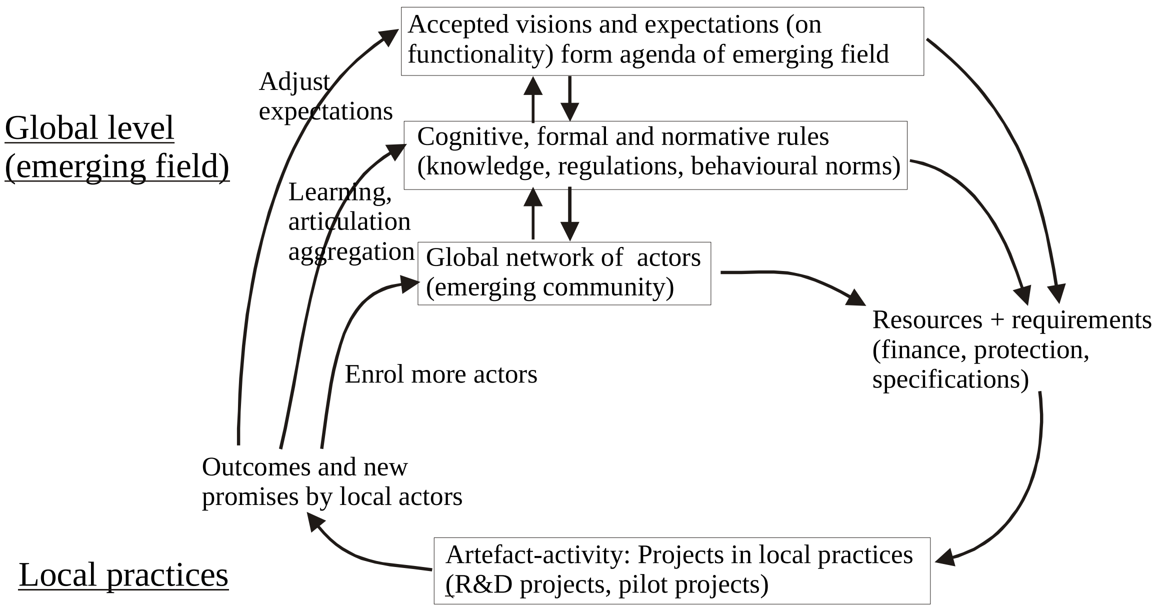

Figure 4: The dynamics of niche development trajectories

The main point is that change and stability in cognitive rules and expectations depend on interactions with learning processes and network building. If outcomes of learning processes are positive (i.e. the initial expectation is validated and accepted as promising for further working) a new development cycle is initiated that enables further refinement within the shared rules. Positive outcomes also make it easier to enroll new actors and expand the social network, resulting in more resources for new projects. If outcomes are much below expectation, faith in the new technology diminishes and expectations decline, followed by shrinking social networks and drying up of resources. In response to these negative outcomes, actors tend to engage in repair work and come up with new expectations that promise better results for search heuristics in other directions. If these redirected promises find their way into the agenda of the field, then non-linearity occurs and the innovation journey changes course.

4) From fit to stretch (long-term co-evolution)

The thinking about the shape and functionality of niche-innovations initially tends to be close to the established regime, i.e. has a *fit* with the established concepts and categories (Geels, 2005b). Historians of technology have commonly found that “When drastically new technologies make their appearance, thinking about their eventual impact is severely handicapped by the tendency to think about them in terms of the old technology – e.g. early EVS are vehicles designed for IC, but fitted with an electric powertrain for which they are not optimized. Technology and use typically co-evolve, both materially and in terms of beliefs and perceptions. Figure 5 provides an analytical generalization of this pattern.

Hoogma (2000) used the fit-stretch pattern to map niche-experiments with electric vehicles over 15 years in several countries: Switzerland, Germany, France, California, Norway, Japan. Hoogma found that experiments in the late 1980s remained close to the existing automobile regime, both in form and use context. In the late 1990s he found more variety in experimentation strategies, some of which moved in stretch directions. Some recent examples, such as the commercially available Renault Twizy and experimental GM EN-V, show even greater deviation from the IC norm.

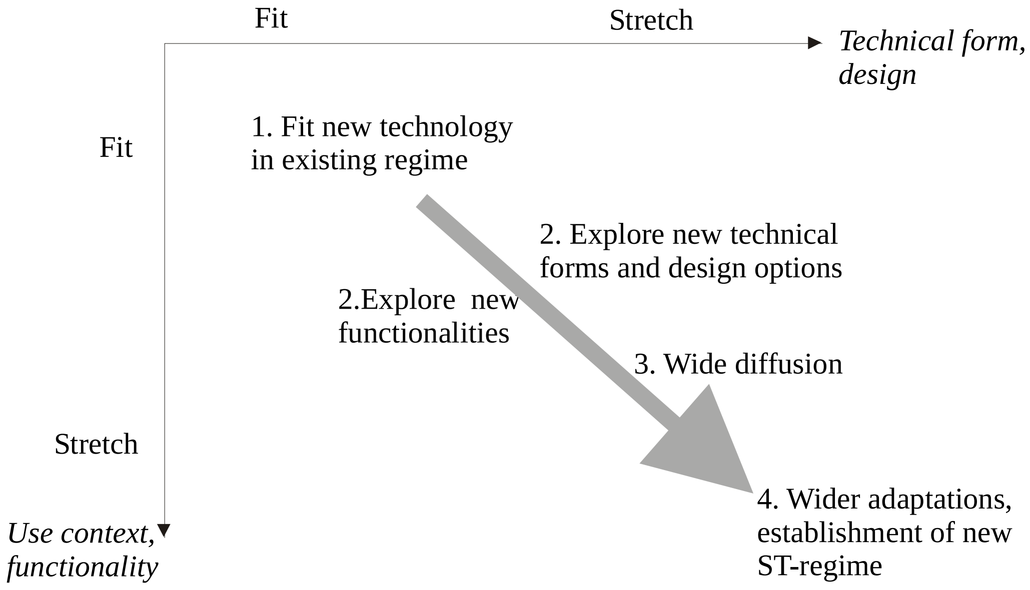

Figure 5: Fit–stretch pattern in the co-evolution of form and function

4. Conclusions

SNM was developed to find ways of coping with the policy challenge of nurturing sustainable innovation journeys and transitions. Building on findings of the last 10 years, SNM scholars concluded that hypotheses about the importance of identified niche internal assumptions are sustained when outcomes of experiments are evaluated ex-post. Building on these findings, SNM research has generated a significant volume of policy advice aimed at creating appropriate processes of network development, learning and visioning. This advice often focuses on generating more appreciation and reflexivity about the ongoing dynamics. It does not result in clear-cut recipes, but helps identify a number of dilemmas. An important contribution of SNM research may thus consist in helping policy makers build competences in recognizing and dealing with these policy dilemmas. SNM is not a silver bullet solution that will bring about transitions towards sustainable development, if only because experimenting will not be sufficient. SNM should be seen as a useful *addition* to existing policy instruments that have neglected the value of experiments. Other more traditional instruments for inducing sustainable innovation, such as market incentives, various forms of regulation, and technology forcing, also have a role to play. For these reasons, SNM seems to be a very suitable model to inform the analysis in WP3.

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[i] Note that Figure 4 not only contains cognitive rules, but also formal and normative rules. Formal rules refer to regulations, standards and formal institutions; normative rules refer to role relationships in networks and behavioural norms. For a more elaborate discussion of these rules see see F.W. Geels, From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory, *Research Policy*, 33, 2004, pp. 897-92.