Infrastructure development for electrical mobility: a Nordic perspective on national and cross-national challenges

Klitkou, Antje; Iversen, Eric ; Borup, Mads

Publication date:
2014

Conference: The future of national infrastructure systems and economic prosperity, 27-28 March 2014, St Catharine's College, Cambridge

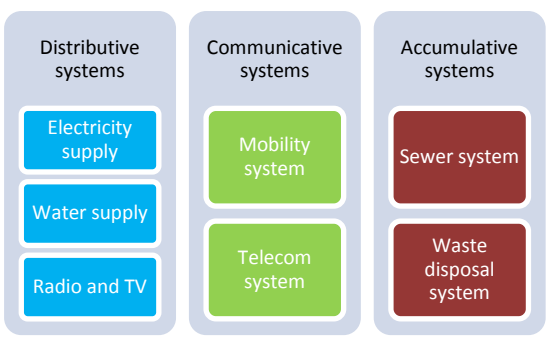
Infrastructure development for electrical mobility: a Nordic perspective on national and cross-national challenges

Antje Klitkou*@, Eric Iversen*£ and Mads Borup**

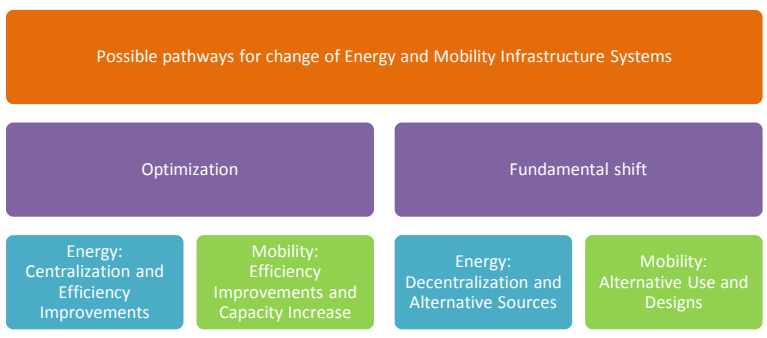
* NIFU Nordic Institute for Studies in Innovation, Research and Education, P.O. Box 5183 Majorstuen, N-0302 Oslo, Norway
** Technical University of Denmark, Department of Management Engineering, Technology and Innovation Management, DK-2800 Lyngby, Denmark
E-mail contacts: @ antje.klitkou@nifu.no £ eric.iversen@nifu.no

Abstract:
The formative EU transport policy focuses on region-wide initiatives to promote more sustainable transportation, including electrical mobility. The vow to integrate or coordinate the ongoing development of electrical mobility into a Europe-wide recharging-infrastructure confronts a number of challenges. As a region, Europe consists of a range of national contexts that differ in most respects that are relevant to realizing this shared aim. In preparation for a transition to standardized regional infrastructure, it is useful to study the implications of what it would mean at the more disaggregated level. This paper studies the national cases of Norway and Denmark within the context of the seemingly homogenous Nordic region.
The paper focuses on the different approaches taken at the national level to build battery electric vehicle (BEV) recharging infrastructure. Norway and Denmark provide apt, contrasting focal points. Despite its position as a large fossil-fuel exporter and its mountainous topography, Norway exhibits high – and rapidly growing – levels of penetration of BEVs. Denmark is developing a connected nation-wide infrastructure. In both countries the integration of the existing infrastructures of electricity systems and road transport/parking systems is part of the challenge.
The paper takes stock of the factors that have contributed to these developments and discusses the implications of further developments in terms of European ambitions and in terms of the role-out of hydrogen-refuelling infrastructure.
Based on domestic endowments, demography, policy contexts, each has pursued different approaches to BEV recharging infrastructure and each has experienced different levels of BEV penetration. We look at a set of factors to explain these differences: the share of electricity from renewable resources, the types of renewable sources, the composition of fleets, public support for infrastructure, public sector incentives for BEV use, etc. This analysis can help inform a discussion of the transition from national to European transportation infrastructure. Implications for the building out of infrastructure for new energy carriers (hydrogen for use in fuel cell vehicles) will also be drawn.

Infrastructure systems architectures

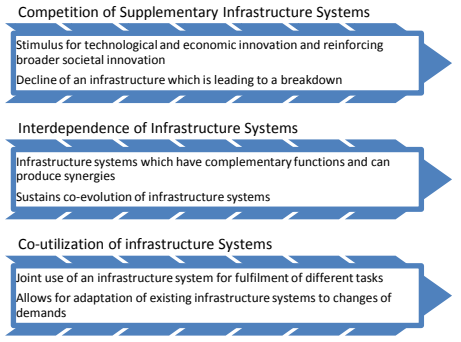


Possible pathways to change of Infrastructure Systems



(Applied from Frantzeskaki & Loorbach, 2010)

Interplay of Infrastructure Systems in Response to Change



- Transition of an infrastructure system is a fundamental change of the institutional components and the design of the physical infrastructure system
- Transition strategies need to be consistent with infrastructure system architecture and the different modes of interplay in response to change: strategies for electrical mobility need to take into account renewable electricity infrastructure system and road transportation infrastructure, incl. charging infrastructure, parking, car pools etc.
- Long-term thinking and 25-years planning horizon require strategies which are adaptive to future generations' demand and flexible in accommodating secondary uses
- Strategies should favour flexible designs and stimulate to joint use of infrastructure systems
- Need for creating protected spaces – niches – for stimulating experiments and learning, such as technological and political pilots/demonstration projects in small scale
- Institutional changes such as deregulation or privatisation of infrastructure systems lead to changes of the architecture of the systems and require careful planning

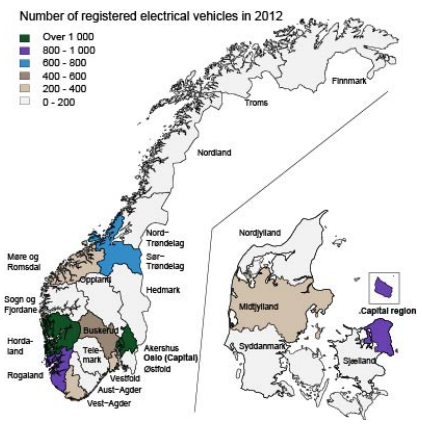
Comparison of Norway and Denmark - rather different starting points and solutions for EVs and charging infrastructure

	Denmark	Norway
Geographies: distances, cities and rural areas	Well-connected and 'compact' country with rather short distances and no mountains	Long distances and many mountains, some more densely populated regions in the South
Renewable electricity production	Wind power – fluctuating In 2011, the share of renewable sources in electricity generation varied from 39%	Hydropower – rather stable, balancing In 2011, the share of renewable sources in electricity generation varied from 98%
Grid	Need for smart grids to exploit fluctuating wind power. Engagement by major energy companies and grid operators	Need for development of central grid and access to surplus of renewable electricity
Political approaches	National strategies and visions for electrical mobility. Considerable, but non-permanent tax-reduction on electric cars Few other incentives for customers to buy EVs. Local authorities supportive, e.g. parking/charging spaces and EVs in public car fleets.	National agency (Transnova) supporting infrastructure development – alignment with environmental NGOs Regional and local authorities supportive Many incentives for customers to buy EVs
Early mover	Early mover for battery switch stations and network operation centre, but one of the two main providers of infrastructure, Better Place, failed because of too high costs, just one car producer applying the switch concept, and too few costumers. Taken over by E.on. Both providers established some fast charging points.	1st stage: Early roll-out of 1st generation of charging points because of Think and Buddy – critical for new generation of EVs 2nd stage: Fast charging infrastructure
Consumer involvement	Full-service subscription based business model including batteries and charging. Ownership of batteries by Better Place might have provoked reluctance by customers	Environmental NGOs and consumer organisations very active
EV producer involvement	Involvement of Renault and Nissan. Moreover, sub suppliers in the car industry, e.g., Continental, A123 (batteries, control systems, etc.	Involvement of Mitsubishi, Nissan and Tesla
Charging points	1.700 charging points in 2013 (BP & Clever)	4.800 in February 2014
Charging infrastructure provider involvement	The two main providers are both in close alliance with energy companies. Better Place came from the outside (Israel). Clever is primarily Danish. Ensuring a degree of competition between providers is part of the policy. Kind of oligopoly situation. A limited number of other (small) infrastructure providers, e.g. car-sharing organisations	Counselling of national projects by different foreign actors (Epyon, ABB, TEPCO etc.) and national electricity providers – building own commercial actors, bottom-up approach
Market penetration of EVs	Ca. 1.300 EVs registered as personal vehicles in 2013	From ca. 1.700 EVs registered in 2008 to 12.000 in 2013. High number compared to other countries. Goal: in 2020 200.000 BEVs and PHEVs
Regional focus	Start with capital region, extended to other cities and main cross-national traffic corridors Goal: Geographical coverage should include not only clusters around a few cities, but be country-wide including also smaller towns, holiday areas, etc. Exception of Tesla due to long range (500 km)	From one-sided domination of capital-region to development of a number of regions with higher market penetration and rollout of charging infrastructure Political shift from charging corridors between larger cities to clusters

Norway – the early mover of electrical mobility

- Early experiments with production of Th!nk and takeover of Buddy from Denmark
- Need for reduction of GHGs in transport sector – biofuels less in the focus
- In several months in 2013 EVs at the top of the list of most sold cars (Tesla, Nissan Leaf)
- Norway a test bed for new EVs of international automobile industry due to very supportive incentives for EVs and higher wages
- Need for charging infrastructure: in February 2014 4.800 charging points
- New ownership models for EVs (car sharing, car renting
- Public procurement for public fleets in municipalities, public agencies and services

Number of registered BEVs in Norway and Denmark in 2012



Norwegian counties	31.12.2012	Danish regions	31.12.2012
Akershus	2908	Hovedstaden	861
Oslo	2774	Midtjylland	227
Hordaland	1089	Syddanmark	165
Rogaland	847	Sjælland	138
Sør-Trøndelag	755	Nordjylland	83
Buskerud	555		
Møre og Romsdal	318		
Vest-Agder	278		
Vestfold	271		
Østfold	192		
Nordland	129		
Aust-Agder	123		
Troms	105		
Nord-Trøndelag	87		
Oppland	77		
Telemark	72		
Hedmark	67		
Sogn og Fjordane	39		
Finnmark	20		

Number of registered electrical vehicles in 2012, incl. private cars, buses, vans, lorries, mopeds, light motor cycles, heavy motor cycles, tractors, special purpose vehicles. Data: Danish Energy Agency and Statistics Norway.

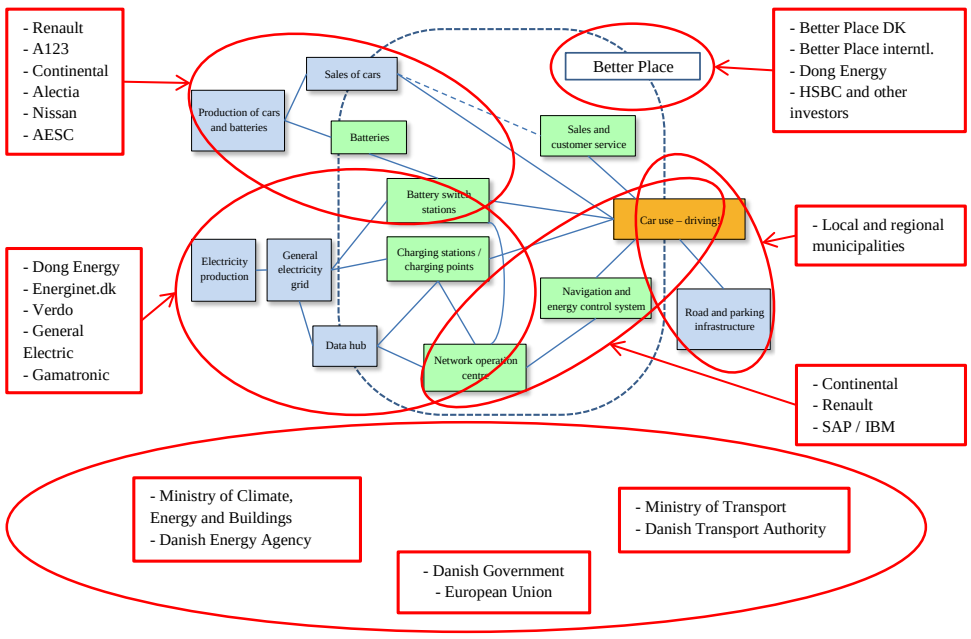
References:
Frantzeskaki, N., & Loorbach, D. (2010). Towards governing infrasystem transitions: reinforcing lock-in or facilitating change? *Technological Forecasting and Social Change*, 77(8), 1292-1301.
Jonsson, D. K. (2005). The Nature of Infrasystem Services. *Journal of Infrastructure Systems*, 11(1), 2-8.

Denmark two larger networks developed over 2010-2013 – 'full scale' networks

- Number of charging points can now be counted in 100s and 1000s, instead of as earlier in 10s
- Better Place: 17 battery switch stations, largest network of charging points (1.400)
- Better Place failed because of bankruptcy in 2013, too few customers, too high costs, Now charging infrastructure taken over by E.ON.
- Clever network: about 300 charging points and 60 fast charging stations established and around 400 cars under its administration

Actors in the different parts of the Better Place value chain – very complex!

Note the integration of the road transport / parking infrastructure (to the right) and the integration with the electricity infrastructure to the left.



Conclusions and Implications

European transport-policy aspirations face a number of challenges on the road towards harmonizing region-wide recharging-infrastructure for electrical mobility. Our work compares the distinct ways in which two Nordic countries have attempted to shape electrical mobility infrastructure up until now.

The Norwegian and Danish cases represent two 'natural experiments' in the dissemination of distributed technological systems. Our approach pairs these two rather small countries in an attempt to control for important country-effects (e.g. population, socio-economic development) that otherwise strongly influence the dissemination process. This allows us to focus on the divergence of pathways that can be attributed to conscious (i.e. policy and technology) choices.

The cases indicate that:

1. Different technological paradigms have been pursued, with Denmark backing a more experimental technology (see chart) with distinct implications for recharging infrastructure.
2. Public support has differed in each country in terms of incentives (tax-breaks, parking, road-access) and of the provision/facilitation of infrastructure in urban areas and in corridors.
3. Each country has experienced different levels—and patterns— of BEV dissemination, with roughly 10 times the number of BEVs on the road in Norway than in its flatter neighbour.

It is important to review the different ways in which BEV technology already are rolled out, and to understand why different choices have been made and the results these have fostered. The distinct trajectories followed – and the different levels of experience –- have implications of further developments in terms of European ambitions towards a Europe-wide recharging-infrastructure.

One implication of the comparison here involves system 'orphans'. European harmonization risks 'orphaning' users of divergent systems that are already in place in different national settings. It is therefore important to take these differences into account and to plan for (e.g. gateway technologies) for users of different technologies.

Further analysis of the interplay between factors can help inform a discussion of the transition from national to European transportation infrastructure. It can also help us draw implications for the building out of infra-structure for new energy carriers, including the potential expansion of hydrogen-refuelling infrastructure.