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Agenda

- Theoretical framework
- Research topics and questions
- Comparative presentation of case studies:
  - E-mobility in Denmark (Borup, 2013)
  - Advanced biofuels in Finland (Wessberg & Eerola, 2013)
  - Hydrogen and fuel cell electrical vehicles in Norway (Scordato & Klitkou, 2014
  - Advanced bioethanol in Sweden (Hansen & Coenen, 2013)
- Conclusions

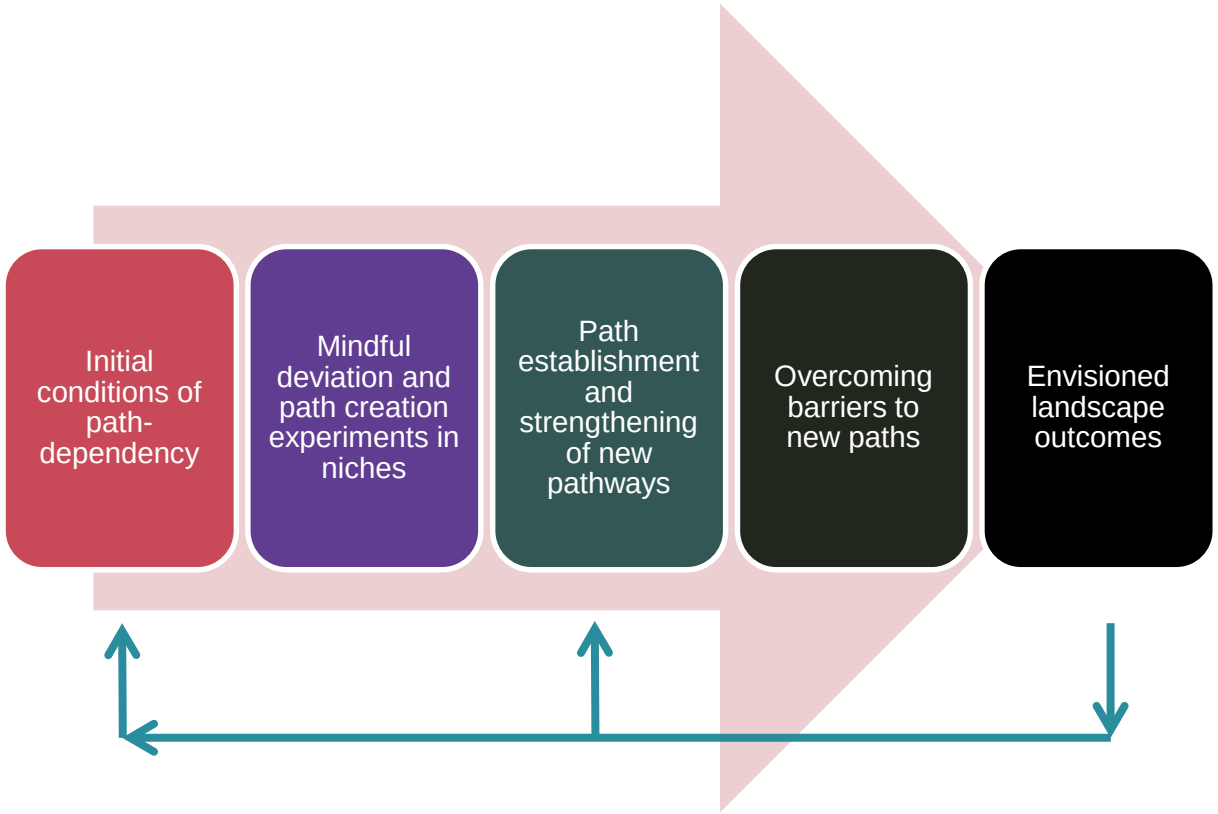
Theoretical framework

- Path creation theory (Garud and Karnøe 2001)

- Multi-level perspective on transition processes (Kemp & Rip, 2001)
  - new and innovative *niches* to overcome incumbent socio-technical regimes
  - *system innovations* (Elzen, Geels and Green, 2004)
  - reconfiguring of *selection environments* (Berkhout, 2008)
  - *institutional embedding* processes in interaction with technological change Foxon (2002)

- Simmie (2012) proposed a hybrid socio-economic theory of new path creation, distinguishing between
  - initial conditions of path-dependency,
  - path creation processes by different agents in a multitude of experiments in niches,
  - new path establishment processes to achieve critical mass and to overcome barriers to new path creation, and
  - landscape change outcomes.

Hybrid socio-economic theory of new path creation (adapted from Simmie, 2012)



Research topics and questions

- Comparison of path-creation processes in Nordic energy and transport systems: Denmark, Finland, Norway and Sweden

- Research questions:

1. How do the Nordic countries develop new paths for sustainable road transport?
2. How do these countries address barriers to the new paths and strengthen the new paths?

Selected case studies

- E-mobility in Denmark (Borup, 2013)
- Advanced biofuels in Finland (Wessberg & Eerola, 2013)
- Hydrogen and fuel cell electrical vehicles in Norway (Scordato & Klitkou, 2014
- Advanced bioethanol in Sweden (Hansen & Coenen, 2013)

Initial conditions of path-dependency

E-mobility in Denmark	Hydrogen and FCEVs in Norway
Road transport system is well developed. Small country. Cars are imported goods. Established net of retailers. Electricity systems well developed, based primarily on fossil fuels, around 1/3 from renewable energy, but fluctuating. Collective memory of EVs in 1980s.	Path-dependencies: hydropower and oil and gas sector. Many possibilities to produce H_2: electrolysis, reforming of natural gas, and by-product hydrogen. Lacking infrastructure for distribution of H_2. Danger of creating lock-in regarding natural gas. Limited connections to global automotive industry and low number of FCEVs produced globally.
Advanced biofuels in Finland	**Advanced bioethanol in Sweden**
Forests a big natural resource in Finland. Wood industry in general developed in Finland producing wood based side-flows. Existing pulp mills producing tall oil as by-product. Municipal and food industry and market based biowaste available. Companies (Neste Oil, St1, UPM) interested in creating a biofuel business.	Vast forest resources. Strong competencies within pulp and paper sector.

Initial conditions of path-dependency – conclusions

- Sustainability of energy mix important for BEVs and hydrogen in FCEVs
- Infrastructure issue for EVs and FCEVs: interaction of two existing systems – distributive system (electricity supply) and communicative system (mobility system)
- Wood-based biofuels: strong competencies in forestry and pulp and paper industry
- Biofuels can rely on existing refuelling infrastructure for fossil fuels (drop-in)

Path creation experiments in niches

E-mobility in Denmark	Hydrogen and FCEVs in Norway
Policy attention to transport as key sustainability challenge. Tax exemption EVs. Fulfilment of EU directive for alternative fuels is a target. Energy companies engaging in e-mobility. Public and private investments. Two alliances developing support and charging infrastructure. Battery switch technology, fast chargers and normal charging. Development of energy management and navigation technology. Public R&D support, experimental scheme for EVs. Experience gathering programme on practical use of EVs. Flexibility new quality parameter in electricity grids (smart grid).	Policy attention to transport as key sustainability challenge. Tax exemption for FCEVs in parallel to EVs. Funding of demonstration projects by public agency Transnova. Subsidies for public procurement of FCEVs. Local projects integrating different H_2 production methods. Regional hydrogen strategy in Oslo-Akershus. Establishment of H_2 refilling infrastructure. Engagement of environmental NGOs, firms and. Fulfilment of EU directive for alternative fuels is a target.
Advanced biofuels in Finland	**Advanced bioethanol in Sweden**
Well planned fulfilment of EU directive for alternative fuels. Legislation for biofuel mixing with fossil fuel. Tax favourable for biofuels. Fulfilment of EU directive for alternative fuels is a target. Existing liquid fuel station infrastructure and vehicles (drop-in solution).	Policies create fuelling infrastructure (on top of fossil fuel infrastructure). Fulfilment of EU directive for alternative fuels is a target. Policy cooperates with Swedish OEMs to secure availability of flexible fuel vehicles. Public funding of research, development and demonstration projects.

Path creation experiments in niches – conclusions

- Diverging experiments positive, also with failure of specific projects
- Policy attention at different levels to transport as key sustainability challenge in interaction with NGOs
- Establishment of new infrastructure, not just optimization of existing but fundamental shift
  - Energy: decentralisation and alternative sources
  - Mobility: alternative use and design
- Transition of an infrastructure system is a fundamental change of the institutional components and the design of the physical infrastructure system
- Need for creating protected spaces – niches – for stimulating experiments and learning, such as technological and political pilots/demonstration projects in small scale

Path establishment and strengthening of new pathways

E-mobility in Denmark

Public funding support for establishment of charging points.
Several hundred charging points established.
Public procurement of EVs by local and regional municipalities.
Increase in number of EVs, but still less than 0.1% of all cars.
Public regulation incl. requirement of open access and roaming between different charging systems.
Data exchange formats and business models developed.
Initiation of work for harmonization and standardization of charging solutions.
Establishment of Nordic test centre for interoperability.

Hydrogen and FCEVs in Norway

Connection of Norwegian H_2 infrastructure with other Nordic countries for travels throughout the Nordic region and Germany.
Strengthening niche markets: busses, scooters, light duty FCEVs.
Public procurement of FC vehicles for car fleets in public services
Market penetration in 2025: 55.000 FCEVs and 30 H_2 refilling stations in greater Oslo area.
Cost of H_2 is calculated to reach a competitive level of 15€/kg by about 2019 and of 8-9 €/kg by 2024-25.
Total investment in H_2 infrastructure: 100-220 million € in greater Oslo area until 2025.

Advanced biofuels in Finland

R&D finding new ways to produce biofuels and new resource options.
New, advanced biofuel production plant investments (St1 and UPM).
Cooperation between Neste and Inbicon.
Authorities support biofuel production with taxes on expense of chemical industry

Advanced bioethanol in Sweden

Policy incentives for owners of flexible fuel vehicles facilitate market growth.

Path establishment and strengthening of new pathways – conclusions

- Incentives for deploying alternative vehicles (tax exemptions, tax reductions, regulations)
- Public support for infrastructure development
- Public procurement of alternative car fleets
- Public strategies to increase number of vehicles using this infrastructure
- Supportive police framework for private investments in new technology

Barriers to new path creation

E-mobility in Denmark

Transport policy and energy policy two independent areas, not fully coordinated
The unsustainability of EV-driving in the present fossil fuel based energy system can get in focus.
Flaws and breakdowns in the operation of the charging networks.
Limited support for battery switch technology.
Manufacturers' prices of EVs are too high.
Variations in wind energy and in charging patterns do not match each other. The flexibility created is still too limited.
Tariff schemes for electricity not sufficient.
Insufficient local grid development.

Hydrogen and FCEVs in Norway

Economic barriers:
- Delivery costs of FCEVs remain high.
- Less developed H_2 refilling infrastructure.
- No strong investors for H_2 refilling infrastructure, first-mover risk.
- High operation and maintenance costs for H_2 refilling stations.
- H_2 costs vary substantially with demand, requires cost levelling.
- Lack of firms investing in this technology in Norway.

Institutional barriers:
- Standards, codes and regulations on hydrogen quality, metering at refilling stations and transports on roads are not harmonised.
- Lack of political leadership by the government.
- Too low funding available for demonstration projects.

Social/cultural barriers:
- Competition between FCEVs and BEVs.
- Lack of knowledge on FCEVs – always in the future.
- Fear for H_2 accidents.

Advanced biofuels in Finland

Competition on resources:
- Scarce tall oil resources are wanted in chemical industry and by biodiesel producers.
- Human resources needed in other sectors.
- Public RD&D resources also needed in other sustainable solutions

Lack of public and private investments.

Advanced bioethanol in Sweden

Initial reliance on first generation bioethanol has created lock-in – renewable targets fulfilled
Lack of long-term advanced bioethanol policies.
Biomass resources are also wanted in other sectors.

Barriers to new path creation – conclusions

- Lack of political coordination between energy and transport policy
- Infrastructure not well enough developed and standardised to allow massive deployment of EVs and FCEVs – especially for crossing borders in the Nordic region to Europe
- High costs of new vehicles
- Need for more involvement of industrial actors, both large players and SMEs
- Lack of private and public investments
- Competition for resources between alternative technologies, both existing fossil-based and new technologies (human capital, RD&D funding, biomass)
- Lock-in on first generation biofuels contributes to more international shipment of resources

Envisioned landscape change outcome

E-mobility in Denmark	Hydrogen and FCEVs in Norway
2020: 10% renewable energy in transport sector 2025: The Capital Region and the network of municipalities in the larger Copenhagen area have a joint climate strategy for 2025 in which the region aims at becoming leading electric car region. 25 per cent of public car fleet will be electric or other alternatives. 12,000 EVs will be deployed in the Capital region. Country wide EV charging infrastructure with more than 1,000 charging points 2050: Fossil free transport sector	2025: H_2 may be cost competitive and subsidies should not be required thereafter. 2040: 1.760,000 FCEVs. 2050: nationwide H_2 infrastructure with 1.100 stations. 2050: total investment in a nation-wide H_2 refilling station infrastructure: 1.5 billion €2005 up to 2050 = 850€ per FCEV. McKinsey study: cost of 1000–2000 € per car or approx. 5% of the overall costs of FCEVs. Domestic renewable fuels (H_2, electricity, biofuels) cover all transportation fuel needs.
Advanced biofuels in Finland	**Advanced bioethanol in Sweden**
Biofuels cover probably the most part of the targeted 20 per cent share of renewable in the transport in the 2020.	Continuing reliance on first generation bioethanol. Increasing focus on other products than advanced bioethanol by key industrial actors.

Envisioned landscape change outcome – conclusions

- Ambitious visions for 2050 have to be backed up by realistic roadmaps
- 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
- Deployment of advanced biofuels in road transport in the longer term (2050) challenged by the need for bio-resources in other sectors

General conclusions

- Both the transport sector and the energy sector are involved in the changes
- Significant differences between the cases: between technology areas and the countries' existing energy and transport systems
- Main issues:

1. Shift from existing path dependency in niche experiments meets problems
2. Addressing uncertainties, learning from errors and avoiding new, sub-optimal lock-ins in new paths
3. Path-creation has to be supported by system innovations and infrastructure changes, embedded in institutional change
4. Process of economic evolution as an interplay of path dependence, path creation and path destruction
5. Concept of 'increasing returns' for analysing energy systems and road transport systems – 'bulk' products (fuels and electricity) vs. technology, machines, components and equipment (fuel cells, batteries, electrolyser, bio-refinery technology)

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Thank you for your attention!

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