

PhD-title: Regions' role in the formative phase of an HFC innovation system

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Abstract

The concept of a *hydrogen economy* captures the high expectations that hydrogen and fuel cell (HFC) technology may bring for the future. According to hydrogen economy supporters, this emerging technology will be able to bring radical changes to all parts of the energy sector through its many application types within transport, stationary and portable devices. If the hydrogen is produced from renewable energy sources, this new energy carrier can help in reducing one of our times' biggest environmental challenges – the emission of CO₂. However, as an emerging and disruptive technology, HFC faces severe challenges on its development path before it will be able to compete with incumbent energy technologies.

The vision of a hydrogen economy is reflected in the political support HFC technology has received in the last decade. Not only from a national (or supra-national) level (in particular USA, Japan, and Europe) but also the regional (sub-national) level seems to play an important role in driving the development (e.g. North-Rhine Westphalia, Germany; Tees Valley, UK; Aragon, Spain; California, USA; Central Jutland, Denmark).

Development activities within HFC technology seem to be embedded in regional economies. Within the last decade, regions throughout Europe and across the world have promoted the HFC technology area by hosting and supporting demonstration activities, and building cluster-like networks in order to strengthen the region's engagement in HFC technologies. Two kinds of actors seem to drive this development.

First, the regional government seem to play an important role in supporting these high-technology development activities. Regional governments' decisions on engaging in hydrogen and fuel cell activities typically are guided by energy and environmental policy concerns but also by industrial and political-economical concerns. It is usually the ambition not only to contribute to the energy supply and environmental achievements but also to the region's overall strategy for economic development – and especially stimulating industrial clusters based on these new technologies. In some regions the development process is typically led by the regional government through different forms of innovation policy. In other cases it has not so much been the regional government who initially took the leading role but companies or already existing network of companies that initiated the development. In these cases, the regional government got involved subsequently.

In any case the regional/local level seems to play an important role in HFC activities.

The objective of my PhD study is to investigate how these regional initiatives contribute to HFC innovation. In other words the project aims to achieve a better understanding of how local/regional governments, regional institutions, and the production structure, in a region, interplay and add to technological development.

Theoretically the PhD project builds on the rich literature on Innovation Systems (IS) (Lundvall 1992, Nelson 1993, Edquist 1997). The IS approach is a systemic approach

that sees innovation as a product of interactive social learning processes. The approach is by most scholars seen as an analytical tool and the choice of the specific branch (national, regional, sectoral or technological) depends on the question asked. In this project I will make use of a combination of the Regional Innovation System (RIS) and the Technological Innovation system (TIS), which I will argue for in the following.

As the focus of the project is set on the interplay between actors, networks, and institutions in a regional context and how this adds to HFC innovation, a natural theoretical perspective to build on is the one of Regional Innovation Systems. This approach offers a systemic and dynamic perspective on innovation. A region is defined as a political-administrative unit at the meso-level between national and local governments (Cooke 2005). Cooke (2004) defines a RIS as two interrelated subsystems: the regional production structure is the sub-system of knowledge exploitation, and the innovation supportive infrastructure is the subsystem of knowledge generation (e.g. universities and research institutions). Furthermore a RIS cannot be seen as an isolated unit. It is strongly dependent on external factors such as other levels of governance, and knowledge flows in and out of the region through knowledge and production channels.

The RIS approach will be the overall analytical perspective by which it is possible to point out factors and prerequisites that might influence the HFC innovation process.

Additionally the technological development can be seen in a broader perspective. For instance, HFC can be seen as an emerging technological innovation system, which is not restricted to any regional or national geographical context. On the contrary the HFC technological innovation system is globally widespread. HFC innovations evolved in one region may be mutually interdependent to HFC innovations evolved in other parts of the world and as for such connected through what we can call a technological innovation system. Regions may therefore be reciprocal connected through knowledge flows in the technological innovation system. (Regions may of course vary, some can be strongly depended on inflow of knowledge to carry out HFC activities others might be characterised by a large outflow of knowledge).

The research question is therefore twofold with the main emphasise on the first part:

- 1. What impact do regional factors and prerequisites have on HFC innovation?**
- 2. How do regional based HFC innovations contribute to the formation of HFC innovation system?**

Analytical strategy

To answer this complex question I plan to carry out a comparative analysis of 3-4 regions in Europe. The analysis will build on both qualitative and quantitative methodologies.

To guide the analysis I intend to develop an analytical model that can capture regional differences and their impact on HFC innovation. The model should point out factors and prerequisites that might influence innovation processes and which I want to compare between the selected regions. A large part of the work in my PhD will be to develop this model and therefore I cannot present a fully developed model here. A combination of explanatory studies, literature studies and courses (e.g. the DIMETIC course) will help me clarify what factors and prerequisites are relevant to include. However, a first outline is showed below.

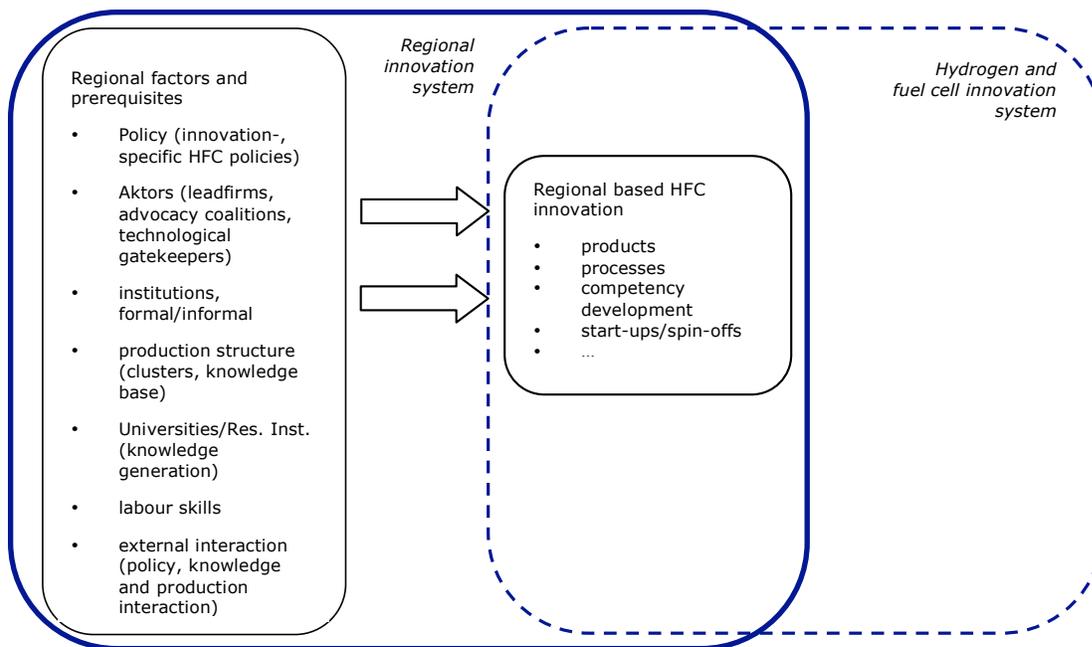


Figure 1: Illustration of the analytical strategy. The left bold box illustrates the Regional IS, inside the box is illustrated which factors and prerequisites that influence HFC innovation. The right box (dashed line) illustrates the HFC IS, which places the regional based HFC innovation in both systems.

'Regional factors and prerequisites' are all those conditions that influence the development. These factors might be numerous and multifaceted. In order to centre focus on some of the many factors, I have chosen to assign greater weight to the impact of regional policies and institutions. That is because my main ambition is to add to the tradition of regional innovation policy.

'HFC Innovation'

Innovation is defined as combination of new and old knowledge that lead to commercialization in respect of new products, processes, services or organizations. Due to the immature character of the technology actual innovation might be seen as a long-term goal. So I find it necessary to measure the impact on more short-term goals that might lead to innovation in the long run. Such short-term goals might include competency development, network-building, demonstration and deployment projects, start-ups or spin-offs companies etc. Moreover the short-term goals should be assessed as viable so they in the future are able to augment the development. In other words the short-term outcome should not be a single one-off project that does not lead anywhere.

'HFC IS'

HFC innovation that happens in one region may be strongly connected to the technological innovation system of HFC that are more global widespread. To measure the contribution to the formation of this system, one option could be to compare the contribution to the sub-functions of the technological innovation systems. Besides the overall function of the system – innovation – the technological innovation system is

often characterized by a number of sub-functions that facilitate the innovation process (Jacobsson and Bergek 2004). These functions count knowledge production and diffusion, entrepreneurship, guidance of the search, market formation, resource mobilization, and creation of legitimacy (Bergek et al. 2008).

Questions:

How can I ascribe the impact to the regional level? Let's say companies located in the region is acting and seeing themselves as global or national actors, their suppliers and customers are equally located in the region as well as outside the region. Are they regional actors just because they are located within the border of a political-administrative unit? The same is the case for regional based HFC-innovation. If all the key innovators that have contributed to a specific innovation located in the region (e.g. a demonstration project or a fuelling station) are external actors, is it then a regional based innovation?

How should I choose the regions I want to analyse in order to be able to compare them? Can I compare regions with different sizes, varying budgetary competence and so on?

References:

Bergek, A., Jacobsson, S., Carlsson, B. Lindmark, S., Rickne, A. (2008): Analyzing the functional dynamics of technological innovation systems: a scheme of analysis. *Research Policy* 37, 407-429.

Cooke, P. (2005): "Regional Knowledge Capabilities and Open Innovation: Regional Innovation Systems and Clusters in the Assymmetric knowledge Economy", in Breschi, S. and Malerba, F. (eds.) *Clusters, Networks and Innovation*, Oxford University Press.

Edquist, Charles 1997: *Systems of Innovation. Technologies, Institutions and Organizations*, London: Pinter

Jacobsson, Staffan & Anna Bergek 2004: Transforming the energy sector, the evolution of technological systems in renewable energy technology, in *Industrial and Corporate Change*, vol. 13, no. 5, pp.815-849

Lundvall, B.Å., (Ed.) (1992): *National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning*. Pinter Publishers, London.

Madsen, A.N. and Andersen, P.D., (forthcoming): Innovative regions and industrial clusters within hydrogen and fuel cell technologies, *Energy Policy special edition on Hydrogen*

Nelson, Richard (ed.) 1993: *National Innovation Systems – A Comparative Analysis*, Oxford University Press