Ten regional RES-FCHS market development plans: Main findings and recommendation

RES FC Market Work package 3 – Deliverable 3.3

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Work package 3: 10 regional RES-FCHS market development plans

The objective of work package 3 is in accordance with the grant agreement page 17 to make market development plans (MDPs) for the 10 potential RES-FCHS markets for the three RES FCHS solutions in the five involved countries.

The work package is split up into three deliverables of which this report contains the third part with the main findings from work package 3.

Deliverable 3.3: Main findings and recommendations

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1. Germany - Biogas, methanol and wind

Being second to only Russia in terms of population, Germany is one of the most important places in Europe as far as energy consumption and climate change mitigation is concerned. The energy system is relatively diverse with the highest installed capacity of wind power in Europe, widespread use of district heating, good biomass resources and a climate that necessitates heating in a large share of the year.

RES FC technologies may thus play a role in Germany.

Regional findings
There are currently producers of both ethanol and methanol in Germany, however within the designated area, there is no methanol production. Methanol from bio-resources is only produced in one area in Germany.

Hydrogen is not yet being produced, however there is a very high degree of wind power being exploited in the Northern and Eastern bunderländer of Germany, so there is a viable source for hydrogen production.

Biogas is being produced in places and may be upgraded and fed into the grid thereby supplying consumers of any kind with a renewable form of methane.

Barriers against the development
A barrier listed by more actors within the energy sector is that that ethanol and hydrogen should not be used for stationary applications, The fuels are too precious for this use and are better used in vehicles where options are more limited in contrast to stationary applications, where much less manageable energy resources may be tapped.

In addition to these barriers, a number of other barriers of a more technical nature are listed where lifetime, robustness and costs are main factors.

Overcoming the barriers
Fuels cells for household use will be competing with other uses of appropriate fuels but German energy plans include a large expansion of RES FC systems in the scale of 72000 units before 2020 and a reduction in the capacity price to 1700 € per kW through economy of scale effects. Also the technical barriers in the form of lack of technical robustness is to be addressed through the German expansion plan.

2. Denmark - Wind power

Denmark holds a very special position in the world in terms of energy as wind power has the highest wind penetration of any places at a current rate of

approximately 20%. In a recent autumn 2007 election campaign, wind power turned out as one of the main policy objectives of all sides of the Danish Parliament indicating a focus on further expansion in the future.

Denmark is also characterised by good wind resources due to a gentle landscape with never more than approximately 50 kilometres to the nearest shore.

Being in the temperate climate zone, Danish dwellings have a considerable heat demand which makes technologies, that supply heat – such as fuel cells – interesting not just for the potential electricity production but also due to the heat production, which hence has a value. Though probably being in the lead in terms of number of dwellings connected to district heating networks, many house are still supplied by individual heating technologies leaving a potential for RES FC household systems.

In the current situation, there are some problems with power balancing due to the large installed capacity of wind power coupled with the large CHP capacity, which production is also determined by climatic conditions. Here fuel cells can serve as a storage system and a power balancing system.

Regional findings

There are currently four different projects in Denmark and the Faroe Islands totalling 421 dwellings where fuels cells systems play a role. The three projects in mainland Denmark totalling 316 dwelling are being planned with fuels cells in mind whereas the last project – on the Faroese Island of Nolsoy, fuels cells may come to play a role.

One of the effects of the high proportion of wind power in the Danish energy system is low spot market prices, at wind power has a tendency to drive these down as the bidding price for wind power typically is zero.

In fact, the prices on the Nordic Spot market (Nordpool) are relatively fluctuating, which improves the feasibility of buying low cost electricity at time of over production and selling back electricity to the grid at time of power deficits.

With the high political focus on wind power, there is an equal understanding that measures must be taken to ensure proper grid integration of substantial amounts of wind power.

The Nordic countries have a market for regulating power which has a higher price variation than the ordinary spot market. This larger band-width improves the economic performance of the RES FC system as they can offer down regulation by picking up power to produce hydrogen and up regulation by turning on the fuel cell. Of course, acting on the regulating market implies that the RES FC system cannot operate on the normal sport market during the same hours (unless some excess capacity is not offered to the spot market).

RES FC systems can furthermore assist the grid stability by rendering ancillary services for frequency and voltage regulation and possibly short-circuit power.

Solar cells in Denmark are operated according to a special tariff system, where electricity meters literally run backwards if production is fed to the grid. This means that consumers are getting a price corresponding to the electricity prince plus all taxes including vat; a total of approximately 1.75 – 2.00 DKK per kWh (up to approximately 25 € cent).

Barriers against the development

In spite of the aforementioned price variations on the spot market, the differences are not sufficiently high to enable an economically feasible operation of the fuel cell system as a storage system.

One has to operate at least 10 MW to operate on the Nordic market for power regulation

The cost of the technology is relatively high.

Overcoming the barriers

Introducing a pricing system corresponding to the system for solar cells will give a much better price for electricity sold to the grid. Buying electricity on the spot market while getting a much higher selling price would give an asymmetrical system though and some price distortion in favour of the RES FC owner.

A favourable framework condition in the Danish context is the existence of The Danish Energy Agency and the Danish TSO Energinet.dk both of whom have both interest, power, organisation, information, access and knowledge of the RES FC technology – thereby making them potential technology carriers. There is also an active fuel-cell industry in Denmark organised in the *Danish Platform for hydrogen and fuel cells* i *the Danish Hydrogen Association*

Identified steps needed to be taken include in the short term
Public support to demonstrate RES FC systems
Appropriate feed-in tariffs
Create cooperation amongst producers of the technologies, energy companies and private consumers through demonstration projects.
Additional R&D
Active incorporation of small-scale plants into the grid
Common conditions for small-scale plants based on different technologies

In the medium term (5-15 years)
Continued public support to development
Demonstration projects including active pool control
Public support to installation and use

In the long term
Large scale projects
Continued but decreasing support for installation and use
Continued support for development

It is currently being investigated how the planned Nakskov project can be implemented with in the current legislation, so this investigation will also play a part in the framework conditions.

3. Denmark - Methanol

The methanol case resembles the wind/Hydrogen case in so far as many of the conditions are the same; the same barriers and the same possibilities exist. Methanol or ethanol production in Denmark could be in the form of biomass fermented and the non-fermented part could be gassified and in a process with hydrogen and oxygen from electrolysers be converted to methanol. This way the available biomass resource is used optimally.

The system will thus provide the same balancing ability in the Danish wind power characterised energy system as the pure hydrogen solution described above.

In addition to there being good wind resources in Denmark, being an agricultural country, there are also available residual biomass resources, though there is also a certain competition from other uses of these – both for energy purposes and for soil improvement / humus build-up especially in organic farming.

Biomass resources however need not only be resources harvested but may also include domestic waste or sewage sludge for that matter, as basically any carbon containing substance may be used.

Denmark already has a well-adapted infrastructure for handling residual resources from agriculture. In addition, there are of course well-functioning handling systems for domestic waste and sewage for that matter. Combined with the good wind resources, from a resource point of view, methanol production thus makes sense in the Danish context. Coupled with the fact that most refineries already have hydrogen production - though not based on wind/electrolyser – all resources are available.

As mentioned previously in the Denmark/Wind case, Danish dwellings also have a considerable heat demand for climatic condition – and electricity demand due to a high economic level

Regional findings

There are a number of relevant stake holders in Denmark including the fuel cells producer IRD Fuel Cells and the systems producer Danterm, both of which are partners in this project.

There are also a number of relevant test sites for the technology. These are the same as listed in the Denmark/wind power description, as these projects have yet to be designed in detail – including fuel use.

One important factor established in the contribution is that market prices on the spot market have been low in e.g. 2007 causing producers of electricity to sell electricity at more of less the marginal cost of producing electricity. *"In such a situation the entire contribution margin, is made up by selling regulating power, which makes the electrolyser concept very interesting."*

Denmark has a producer of methanol reformers. The company Haldor Topsoe A/S have commercially available in sizes suitable for clusters of houses of 150-300 houses.

Barriers against the development

Barriers against the option are mainly economic. See also the section on Denmark/Wind

Overcoming the barriers

With Denmark's expansion of wind power, ways of integrating wind power is required. This opens a door for fuel cells and electrolysers, however it is a market that needs to be developed though various measures – see the section on Denmark/wind.

It may be added that Danish consumers are already accustomed to having communal heat supply systems, so solutions need not even be in form of totally decentralised solutions in each dwelling. It may also include solutions for clusters of houses, which may bring the fuel cell and reformer costs down – at the expense of having to install a district heating network though.

Such central plants will bring the cost down and make the systems more economically feasible though economy of scale and may also make accessing the power spot market and the regulating market more reachable, however some special incentives will still be required.

4. Denmark - Biogas

The biogas case resembles the two previous Danish cases in so far as many of the conditions are the same; the same barriers and the same possibilities exist.

Denmark already uses biogas to a high degree and thus has a large knowledge base on this technology. Due to the high penetration of wind power in Denmark, Denmark has a need for both up and down regulating capacity, and while hydrogen and methanol can supply both of these as standard, biogas can mainly supply up-regulation as no electricity is used in the production of biogas. Down regulation may of course be supplied when biogas-fueled RES FC systems are operating. The system will thus provide some of the balancing

ability in the Danish wind power characterised energy system as the previous solutions described above.

Being an agricultural country, there are many bio-digestible residual resources available. This being solid biomass or what is more often the case in Denmark. Manure. In contrast to the competition for biomass resources, there is little competition for e.g. manure as de-gassed manure actually has favourable properties both in terms of chemical composition of nutrients and in terms of handling. The degassed manure contains its nutrients in a more accessible way and the liquid is more homogenous and less smelly than the raw manure.

Denmark already has a well-adapted infrastructure for handling manure from agriculture. Combined with the good wind resources, from a resource point of view, biogas production thus makes sense in the Danish context.

As mentioned previously in the Denmark/Wind case, Danish dwellings also have a considerable heat demand for climatic condition – and electricity demand due to a high economic level

Regional findings

Existing Danish biogas plants utilize approximately one third of the energy produced on site for advancing the process in the digester leaving two thirds of the energy available for other uses. While this to a large extent is in the form of piston-engine or gas-turbine-based CHP-plants,

Apart from anaerobic digestion, gasification is also an option given the added benefit that the fuel will be so pure that is can be utilised in fuel cells without further fuel processing. Biogas from digesters is still a possibility though. Upgrading the biogas to natural gas quality and injecting into the natural gas grid may also be beneficial as the grid is already existing. Odorants added to natural gas in the grid may pose a problem though as it typically contains sulphur which is not appropriate in fuel cells.

Barriers against the development

Main barriers are economic.

On a European scale there are also other barriers listed in the contribution, however some of these have already been overcome in Denmark during its gradual transition from a central energy system to a de-central energy system. This relates to issues like building permits and grid access which are not universally readily accessible.

As opposed to the hydrogen cases, the low cycle efficiency is not an issue here as fuel cells are at least comparable to alternative engines and gas turbines in terms of efficiency – and will most likely in the future reach higher efficiencies than these

Overcoming the barriers

Feed-in tariffs are required to overcome the barriers.

Lower VAT on renewable energy would favour biogas.

Demonstration projects would show-case the technology and maybe through further implementation drive down costs.

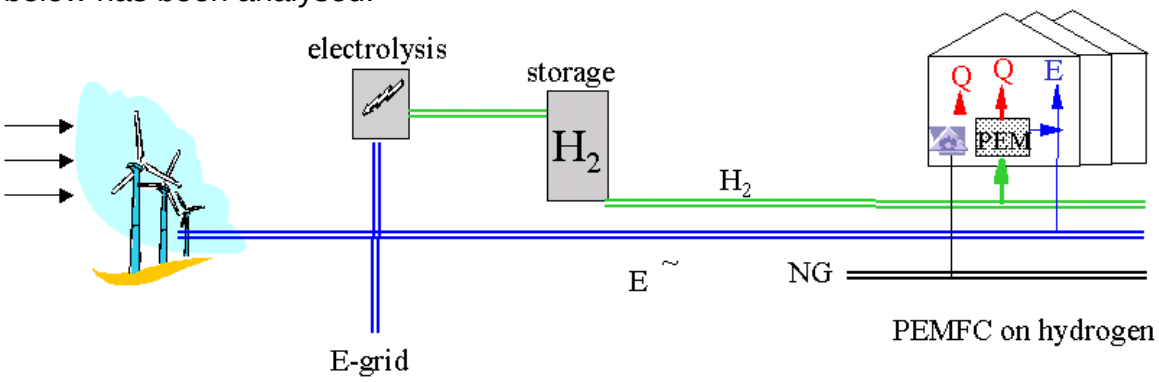
Mandatory targets would also further the technology

5. Netherlands - Wind

As in Denmark, the Netherlands is also a country of good wind resources and is thus experiencing a growth in wind power capacity with the load balancing problems this may give.

It is also a country with a certain heat demand, so fuel cell units would have a market for the inescapable heat production. It is furthermore a country not completely unaccustomed to communal energy infrastructures.

There is thus a potential for a hydrogen solution, and a system as depicted below has been analysed.



Regional findings

Eergy systems analyses have been conducted for a 1 kW fuel cell. Due to the cost of the unit, it has not been over-sized to allow for additional capacity to be utilised for supplying spot market or regulating power market. In this configuration, it supplied 81 % of the electricity demand in the houses, leaving 7% peaks and 12% low loads non-covered as the system is only assumed to be operated between 20 and 100% nominal load for efficiency reasons. Due to the assumed load following operation, the unit will operate in partial load most of the time.
This indicates that there will be both an up and a down regulating capability most of the time if the Netherlands were to open a regulating power market for small scale plants like this.

As indicated in the figure, the hydrogen production facility is assumed modelled as a unit supplying a cluster, so here possibilities of entering the market are most likely better.

In the Netherlands three regions for the development of fuel cell systems and hydrogen applications are foreseen:

1. The Rijnmond area
2. Arnhem area
3. Friesland/Petten area

Two specific communities have furthermore been identified

Leeuwarden
Here it has been proposed that a maximum of 20 houses are to be supplied with fuel cell systems

Arnhem
Here it has been proposed that a maximum of 20 houses are to be supplied with fuel cell systems

Arnhem - De Stoere Houtman
Here a citizen initiative for renewable energy with hydrogen as buffer/energy carrier is started for 138 existing dwellings and 150 new dwellings.

Barriers against the development

The study finds that the production cost for electricity based on small-scale RES FC systems will be in the order of 0.31 € per kWh which is higher than the electricity cost for normal consumers including all taxes etc. So as in the other country/technology combination, costs are the main barrier against the development.

The costs are closely linked to the low cycle efficiency and unit costs.

Overcoming the barriers

In the report it is concluded that it will not be possible to install RES FC systems within the next decade in the Netherlands as the costs are simply too high and the system too inefficient.

In spite of this, there is some movement going on as indicated in the proposed activities in Leeuwarden and Arnhem.

6. Spain - Wind

The region of Navarra is located in the corner of the Biscay bordering to France and is by Spanish – and any other context for that matter – supplied by a very high degree of wind power. At 51.7% of the electricity demand, wind power is

the most important power source in this region. It is also considered that he region is nearing its maximum capacity of wind power – seen from a grid perspective. There has thus also been put a moratorium on further expansion of wind power in the region.

A wind/hydrogen/fuel cell solution is therefore called for to allow further integration of wind power in the region – for the same reasons as discussed in Denmark and the Netherlands.

With heat demands in dwellings being more modest than in Northern Europe, heat demands are not as high a concern as in countries further north, however there is still a heating need to be covered.

Regional findings

Spain has established some framework conditions aimed at promoting the RES FC technology. A feed in tariff of 12 Euro cent per kWh from RE fuel cells has thus been introduced.

Two areas have been identified which are of interest for the development of the technology:

a) Sarriguren.
This area is 5 Km from the city of Pamplona. This location has been chosen due to the special characteristics as being an “eco city”. All the households are built based of the principles of bioclimatic architecture, energy saving, integration of renewable energy and application of the “healthy building”

b) Tudela
This region is located 90 km south of the city of Pamplona. It has been selected because Tudela is one of the participating ECO-City demonstration communities. The target of this project is to reduce energy demands and to provide energy efficient solutions to integrating the maximum use of renewable energy sources.

Barriers against the development

Costs are the main barrier in the Spanish case as with the other cases due to high investment costs and low cycle efficiency.

As the plant is not sufficient to supply all the energy needs of the dwellings, additional heat production capacity is needed as well as grid access for electricity deficits. This will naturally be an additional cost. The grid access is of course also required for being able to supply electricity to the grid and thus making money by selling electricity to the grid.

Yet an identified barrier is the short guaranties of the fuel cell causing lack of confidence among potential users

Another important problem is the lack of legislation related to the use of hydrogen in residential sector, which difficult the installation and maintenance.

Lack of knowledge about the technology.

Overcoming the barriers

If hydrogen and fuel cell could offer to the manufactures a market niche in the not too distant future, maybe they began to manufacture mass production components to reduce the cost through economy of scale.

It is necessary to make an effort in R&D to improve efficiencies, reliability, lifetime, and materials performance. Thereby this technology could be more competitive with the technologies that are used nowadays. Lack of confidence in the technology among consumers could also require setting minimum standards for fuel cell technology and/or establishing warranty requirements for producers of the technology.

According to the households promoters, in Navarra would be more interesting to use a 1 kW_e + 3 kW_{th} CHP fuel cell. If this type of fuel cell is used into the house it wouldn't be necessary an extra systems to cover thermal needs.

If the house is connected to the grid the end user could feed into the grid the surplus electricity to obtain a feed in tariff, making this system more economical.

Increased Government support both in terms of legislative reform and financial support is necessary to enable hydrogen technologies to reach commercialisation and to establish a sustainable position in the market. Subsidies for demonstration models could be one way forward.

It will be necessary a lot of dissemination activities about hydrogen technologies to encourage the concept of clean energy among the general public and to increase the knowledge about the hydrogen economy. Thereby the end user will be interested in using fuel cells in their households. However it must be added that in Eco cities as the one proposed, residents are bound to be more favourable and informed than in other areas.

7. Portugal - Wind and Biogas

Portugal is planning a strong expansion of wind power, and within three years it is planned to have an installed capacity of 5100 MW bringing the country to a second or third place in Europe in terms of wind power exploitation. Currently approximately 2MW is installed every day in Portugal. With very good wind conditions in the country, this is a very appropriate move on the path to sustainability.

This also necessitates a flexible system energy system to accommodate such large quantities of wind power, and this is where RES FC household systems may have a role to play.

However, the Portuguese government is actively pursuing a policy of exploiting pumped hydro storage for accommodating large scale wind power integration.

A better option in Portugal is therefore biogas, as biogas is only exploited to a limited extent in Portugal with an installed electricity capacity of 8.2 MW – though the number of anaerobic digesters at 100 suggest a higher exploitation.

Heat demands in Portugal are however lower than in Northern Europe giving fuel cells a limited heat demand they can cover. The inevitable heat production from fuel cells will hence not have a high value in the Portuguese context.

Regional findings

A potential site for development of residential RES FC systems has been located in Coimbra. These could run on biogas from urban solid waste, agricultural residues or from sewage sludge.

Portugal operates with a TSO must-buy system, where prices are determined by the size of the plant

- up to 10 MVA, it is index-linked to one option of the regulated retail prices modulated by the time of the day;
- for the part of the electricity sold over 10MVA, it is based on avoided costs, plus remuneration for the environmental externalities avoided.

For fuel cells run on renewable energy sources, this translates to a feed-in tariff of 0.2 € per kWh

Barriers against the development

As for all the other markets, the price is the main barrier to overcome – particularly combined with the low cycle efficiency and lack of heat demand.

With the Portuguese Government's decision to promote pumped hydro storage, there is also no excess wind power to be utilised and the public support is also not sufficient to make the solution economically viable. Public support schemes focuses on other technologies.

Overcoming the barriers

The largest construction company in the central region of Portugal has shown some interest in the project and in the RES FC technology, albeit, costs have been an issue. The importance of having an important market player being interested in the technology however should not be underestimated.

Government incentives are hence required to overcome the economic barrier met by private consumers or by building constructors.

It is also required that it is demonstrated to fuel-cell producers that residences are in fact a large market in Europe. Tapping into this potentially very large

market however requires improvements in the fuel-cell technology in terms of costs, efficiency, reliability and life time.

8. Iceland - Methanol

Iceland is pursuing an active energy policy aimed at lowering it's (imported) fossil fuel dependency. While this is already modest due to extensive use of geothermal energy for heating purposes and hydro for electricity generation, this in fact means that it is all the more interesting in the Icelandic case as there is a tendency that the closer one is to reaching a full renewable energy system, the more complex it becomes. At high levels of renewable energy in the system, there no more low-hanging fruits to be plucked and hard-to-address areas of the energy system such as transportation have to be addressed. In the Icelandic context, this also includes the large fishing fleet, which the country has an ambition of converting to renewable energy.

Regional findings
As the main part of Iceland is supplied with heating from geothermal sources, there is little need for any heat produced by RES FC fuel cells. Electricity is furthermore also of little concern as the country has good hydro electric resources to the extent that the sparsely populated country even attracts foreign electricity intensive industries such as aluminium smelters using low cost electricity as a bargaining chip.

However, there are also areas outside the good geothermal areas and due to the low population density, there are even houses outside the electricity grid. The project has identified an area with leisure houses where the RES FC technology could be appropriate

Barriers against the development
The main barrier in the Icelandic case is the cost of the RES FC system

Overcoming the barriers
While there is a barrier in the form of cost, there are in fact more potential in Iceland than in many other places.

The national ambition of lowering fossil fuel dependency gives the impetus to actually implement fuel-cells in the proposed dwellings. While the policy is largely targeted at transport (vehicles and the fishing fleet) the policy will also create the infrastructure that will be a pre-requisite for using RES-FC systems.

Analyses already show that hydrogen from electrolysis is feasible in Iceland.

There is furthermore already a dedicated company - Carbon Recycling International – with the core business of producing methanol from mainly carbon dioxide and hydrogen. This company will have an inherent interest in expanding its target group to include also residential consumers.

9. Final words

The main barrier against the development of RES FC systems are costs and/or low efficiencies. If costs and efficiencies were improved, the system could reach a level where no substantial further particular adjustments would be needed for the technologies in question to be market ready.

One recurring recommendation from the individual contribution is thus a certain level of subsidy for the introduction of the technology – also coupled with set minimum tariffs for delivery of electricity to the grid (or a system where electricity metres count backwards when dwellings are net-producers thus giving a good price as it includes various taxes and fees).

One must naturally also look at some the advantages of the fuel cell technology and the ability to supply regulating power – upwards in case of all fuel types and also downwards in case of electrolytic hydrogen – could improve the economy of the plants. This would require that local regulation should permit that very small units participate in the regulating power market. Additionally, some level of automation would be required as local house owners cannot be expected to make bidding as well as control the unit according to concluded deals. Of course – if operated by a common operator, at least the typical minimum physical size requirement for market operators may be overcome. It would however require low-cost systems for remote controlling of the units as well as low costs systems to monitor the exact timing of production and demand to demonstrate that obligations are met.

Both the Icelandic case and the Danish wind case point towards un-conventional users. This can be for off-grid summer cottages or for futuristic dwellings. Both of these are aimed at consumers that might be willing to pay a premium for an unconventional energy source with a certain appeal for the technologically interested.

Many contributors in the project refer to the importance of national or EU policy within the area. Importance is e.g. attached to the EU directive 2003/30 on liquid bio-fuels. Also important is the establishment of ambitious goals on both national as well as EU levels. This would demonstrate to technology producers that there is an emerging market to address and will function as a leverage to get utilities to adopt the technology. Ambitious EU goals would also compel member countries to create setting that will favour the introduction of the technology.