HyWays

The Netherlands Hydrogen Energy Vision

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Development of the energy system (excluding hydrogen)

In general the present energy flows in the Netherlands show the significance of the Dutch oil refinery industry (mainly for export purposes), the importance of natural gas for household and industrial use, and the importance of transit trade in the Netherlands (oil, gas).

In 2004, the total primary energy supply (TPES) in the Netherlands was 82.3 Mtoe. The share of renewables was 2.9%. Natural gas accounted for 44.6%, oil for 38.4%, coal for 11.2%, combustible renewables and waste for 2.6%, nuclear 1.2% and non-combustible renewables for 0.2%. Domestic energy production was 67.9 Mtoe in 2004, accounting for 82.5% of the TPES. The most important domestic source is natural gas, accounting for 90.7% of domestic energy production.[1]

In present forecasts for 2010 the total primary energy supply is expected to be 86 Mtoe. The share of renewables in TPES will be 3.7% in 2010 (3.2 Mtoe). For 2020 the expectation is that the TPES will be 97.5 Mtoe, with a share of 6, 7% for renewables without new policy measures. [2]

The formal Dutch policy objective for the development of sustainable energy is that 5% of total energy will be delivered by sustainable sources in 2010 (uitvoeringsnota Klimaat) and 10% in 2020 (Energy Report 1999). There are various scenarios for the post-2010 period. Vision and policy directions for the long term are being developed in public-private collaboration for "Energy Transition". These visions have been incorporated in the HyWays MS workshop discussions.

Development of the energy system until 2050 and beyond

The present situation is characterised by a strong dependence on fossil fuels; this will gradually develop into a clean fossil system (here referred to as "sustainable") based on CO_2 capture and sequestration (CCS), possibly in combination with nuclear energy (not renewable, but "sustainable" from CO_2 and Air Quality perspective). Around 2050 the energy system is expected to be "sustainable" according to these definitions.

Next to this "sustainable" development, the share of "renewable" energy sources will grow continuously, and will become more important than fossil sources (and nuclear) after 2050. This will be due to the expected strong rise in fossil fuel cost on the global market in combination with the rising cost of CO_2.

The nature of the fossil sources will change as well. Domestic produced natural gas will gradually be replaced by import by pipeline from Russia and Norway, and the import of LNG by ship from sources further away. In combination with the expected rise in oil prices this will lead

[1] Eurostat (2006), yearly statistics data 2004
[2] WLO GE scenario (2006)

to gas becoming more expensive. Coal, most likely imported by inland and sea shipping, will become more important. Due to logistic reasons power plants will be situated along waterways.

As coal is a more polluting feedstock than gas, a scenario in which coal becomes the dominant energy source without CCS would impede seriously on the success of CO_2 reduction policies. The use of coal will have to be combined with CCS or with the re-use of CO_2 in chemical plants and horticulture glass houses. There are excellent opportunities for CCS in the Netherlands through the nearby presence of large depleted oil and gas fields. On the other hand there are still barriers for actual implementation of CCS, and more research is necessary to solve these. Also there are alternative uses for the depleted gas fields, particularly storage of imported natural gas.

For the same reasons as above it will become increasingly economically attractive to use renewable feedstocks. It is expected that biomass and wind will be the most important ones. There are excellent opportunities for biogas in the Netherlands, due to the existing dense natural gas pipeline grid, and the presence of large amounts of natural waste (sewage, animal manure etc).

More important in transport than biogas will be ethanol. Ethanol will initially be imported from South America (Brazil), but there are risks involved like competition with local food production and ecological concerns. An alternative is domestic (especially sugar beet cultivation) and European production. Besides ethanol there is an (smaller) interest in bio diesel, and much is expected from the development of the future generations of bio fuels (such as lignocelluloses ethanol and Fischer-Tropsch diesel).

Formal policies have clear and ambitious targets for wind energy. A number of large fields are planned (some already under construction) in the North Sea. However, other renewable sources may turn out to become more important. Solar energy is often mentioned as having this potential, based on the expected huge drops in the cost of solar cells, and the expected progress in using concentrated solar power.

The nuclear share in the Dutch electricity mix is considerable due to the (partly) liberalised EU energy market (imports from France), but the Dutch formal policy aims at closing down the last nuclear plant in the Netherlands. The share may grow when fossil fuel prices rise further and the French nuclear electricity will become relatively cheaper. The political debate on the use of nuclear power is back under the influence of global warming, air quality and security of supply considerations, but this will not lead to new nuclear plants in the short term.

Long-term contribution of hydrogen: 2050 and beyond

Strong determinants for the introduction path of hydrogen in The Netherlands are the availability of industrial hydrogen in Rijnmond area; the extensive natural gas grid in the country and the important share of natural gas in the energy mix; the strong logistics and transport capabilities (for import of feedstock's like coal and biomass); the promotion of off-shore wind energy; the availability of huge carbon storage locations; and the population and transport densities in the country.

By 2050 (and probably decades sooner) oil production will have peaked, resulting in high prices and insecurity of supply. As described above coal will become a much more important fossil energy source. The geographic spread of the scarce fossil sources will strengthen the need to use renewable sources such as wind and biomass. Important energy carriers will be electricity and hydrogen, which can both be produced from a range of primary sources.

Hydrogen will be the energy carrier of choice for light duty vehicles and buses as no breakthroughs are expected in electric storage technology for pure electric vehicles. Heavy trucks are more likely to run on advanced bio fuels. Also inland and short sea vessels can run well on hydrogen, but synthetic fuels will be used as well. For stationary applications the competition with both the natural gas and the electric infrastructure is too stiff for hydrogen. Using electricity directly is more efficient and therefore economically sound than converting electricity to hydrogen and then back to electricity in micro-grids. Exceptions can be edifices in areas without electric grid but near a hydrogen pipeline.

Based on the HyWays hypotheses regarding hydrogen penetration rates, hydrogen will be available by 2050 throughout the country, with the main user centres in the densely populated western part of the country ("Randstad": Amsterdam, Rotterdam, The Hague, Utrecht and other towns, comprising some 10 million inhabitants). Smaller centres are the Brabant towns in the mid-south, Arnhem/Nijmegen and Enschede/Hengelo regions in the east, the Limburg towns in the deep south, and Groningen in the north. These centres are also linked across the borders to the nearby Ruhr area and Flanders.

The hydrogen will be produced from a mix of energy sources, dominated by coal (gasification), natural gas (SMR), biomass (gasification) and wind energy (percentages: 45, 30, 20, 5). Production from fossil sources will be combined with CCS and the re-use of CO_2. Electricity from the wind farms will be put in the grid in most cases but imbalances will be used for hydrogen production through electrolysis. In the longer future also dedicated hydrogen production from wind can be feasible. Natural gas and coal will eventually (by end century) be fully replaced by renewable sources, and The Netherlands may by then be importing hydrogen from e.g. Norway, Iceland or North-Africa.

The widespread use of hydrogen will have justified, and be possible thanks to, the construction of a national pipeline grid for hydrogen. This grid will have grown over the decades by integration of regional pipelines that link up decentralised production plants and fuel stations as well as clusters of stationary users (micro-CHP in newly constructed residential areas and business parks). There will also still be on-site production for small demand or remote users.

The technology used to convert hydrogen in 2050 will be fuel cells, which gives zero emissions and has high efficiency. The modular design is a benefit especially for stationary applications as installed power can be increased when energy demand grows. Gas turbines may be preferred for very large installations, possibly combined with high temperature fuel cells.

Hydrogen in the intermediate period: 2020-2030

This period sees a steep growth of hydrogen demand, mostly as a fuel for road-based passenger transport, i.e. buses, taxis, passenger cars, vans and lorries in urban use. Fuel cell propulsion using hydrogen will have become cost-competitive with conventional and hybrid propulsion systems for passenger vehicles running on fossil or bio fuels. The growth in hydrogen demand in transport calls for an increasing number of fuelling stations along main roads and in urban centres, starting from the Randstad. The first user centres for hydrogen vehicles will be the Rotterdam area, Amsterdam area and Arnhem/Nijmegen area. Where hydrogen is available for vehicles, combinations will be sought with stationary uses.

The energy mix for hydrogen production will be dominated by natural gas (mostly with CCS), followed by coal (only acceptable with CCS), biomass and wind energy (percentages: 50, 30, 15, 5). In this period distribution of liquefied hydrogen will make way for pipeline distribution and on-site production technology starts being replaced by larger-scale production plants in the user centres. The existing central SMR installations in Rotterdam will be adapted for carbon capture. The plants will feed regional pipeline networks which will evolve from the existing industrial pipeline infrastructures or originate from the new plants. In this build-up period the natural gas grid functions as "overflow" for hydrogen when hydrogen supply exceeds demand. This fits in the policy for "greening of gas" by admixture of biogas and later synthetic natural gas from biomass as well as hydrogen.

In this period the potential for CCS will become clearer. If the promises cannot be fulfilled then policy will push stronger for biomass at the expense of coal, giving impetus to new processes for hydrogen production from biomass like fermentation.

Short-term period: by 2010

In the start-up period the urban implementation of hydrogen will contribute strongest to environmental policy objectives. A number of pilot projects will be ongoing both in transport, creating a basic hydrogen infrastructure of fuelling stations that mainly serve regional fleets of buses, vans and urban lorries. They receive hydrogen from existing pipelines: fossil hydrogen with partial carbon capture recycled for greenhouses in the Westland region. Also small-scale on-site SMR will be reasonably affordable. Other fuelling stations will be supplied with liquefied hydrogen from existing liquefaction units.

H_2 -Internal Combustion Engines will probably play a role in the start up phase. Shortly after 2010 the hydrogen fuel price will become competitive per EUR/km in the case of FCV's compared to petrol vehicles. The FCV's are however still more costly in this period than conventional vehicles.

There is very little demand for stationary applications in 2010. A few experiments in Rijnmond use hydrogen from the industrial pipeline (specific project: retirement home Zwijndrecht), and some by-product hydrogen will be used in a few locations (specific project: fuel cell electricity plant).

Policy support

The policy framework needed should address three main barriers.

- Economics: lack of incentive for hydrogen introduction. Solutions to be implemented by government (starting today):

    - National: inclusion of hydrogen in the support frameworks for renewable energy; inclusion of hydrogen in fuel tax framework; reduced vehicle tax for hydrogen vehicles; inclusion of hydrogen in the Bio fuels obligation; grant/soft loan scheme for fuelling station investments; requirement to offer hydrogen at fuelling stations.
    - Local: market creation for zero-emission vehicles in urban areas (zoning); use of privileges like free parking.
    - EU: introduction of generic instruments for pricing CO_2 and other external costs, CO_2 standards, inclusion of transport sector in emission trade system
- Technology: fuel cell and hydrogen technology and carbon capture and storage are not commercially available. Solution to be implemented by government (until 2025):
    - EU, national: RD&D programme for development of fuel cells, hydrogen storage
    - EU, national: RD&D programme for CCS.
    - EU, national, local: organise demand in public procurement, launching customer ship
- Infrastructure: development of pipeline infrastructure and fuelling stations require large investments and orchestration. Solution to be implemented by government (until 2025):
    - EU, national: public-private investment schemes
    - National: master plan for infrastructure development and management
- Institutional, public acceptance, safety and regulations. Solutions to be implemented by government (starting today):
    - EU, national: experimentation programme to provide experience and insight in hydrogen introduction pathways
    - National, local: create learning environments with flexible regulation, licensing etc.
    - National: education and training.

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