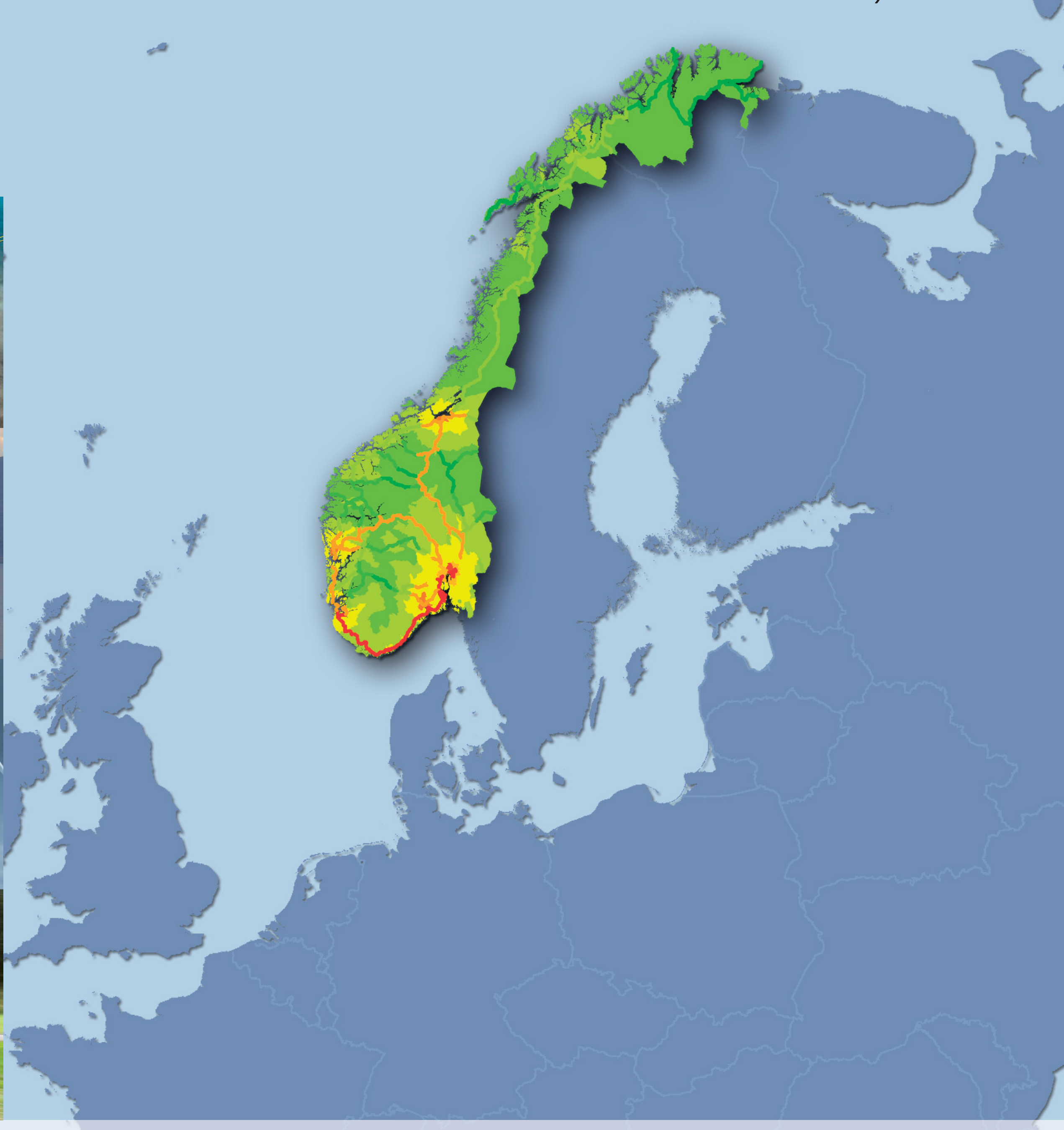
NorWays

Core Message and Executive Summary

May 2009



Recommendations to the Norwegian Government for the implementation of hydrogen as transportation fuel in Norway

NTNU

IFE

SINTEF

Core message to the Norwegian Government

The global challenge of sustainable transportation

Global climate challenges impose both legislative and ethical obligations on all nations. Norway's fortunate energy situation with access to abundant renewable, as well as fossil fuel energy resources imposes special responsibilities for active engagement in the transition towards more sustainable energy systems.

Transportation contributes to Norway's greenhouse gas (GHG) emissions by 38%, considerably higher than the global average. Road transportation alone is responsible for two thirds of these emissions. In addition to the environmental aspects, dwindling crude oil reserves (as basis for production of conventional fuels) and the low efficiency of the internal combustion engine (ICE) have become major drivers for change.

A robust approach to obtain sustainable transportation in Norway

Based on the results from a 3 year national and cross disciplinary research effort involving key Norwegian stakeholders from industry and academia, a set of statements has been formulated pinpointing actions needed to be taken by the Norwegian Government in order to comply with national GHG-emission targets by 2050:

1. Business as usual will not lead to sustainable road transportation

Results from this study have confirmed that business as usual will not lead to the required transition to an environmentally sound transportation sector. In agreement with statements from the European Commission, substantial political engagement and intervention is required.

2. Crude oil needs to be replaced by *future proof* energy carriers for road transportation

Second generation biofuels and hydrogen have been identified as true, *future proof* fuels for road transportation in a recent European strategy report, which would enable the efficient utilisation of a wide range of energy sources. In addition electrification of transportation may contribute significantly to emission reductions, especially when based on renewable energy. Pursuing these three options: ***2nd generation biofuels, hydrogen and electricity***, will ensure a robust approach towards sustainable road transportation.

3. Introduction of hydrogen as fuel for road transportation is a prerequisite for success

Thorough assessment of technologies, available energy resources and their environmental impact, clearly shows that hydrogen and fuel cell technology is a prerequisite for reaching national GHG emission targets for road transportation by 2050. Due to the limitations in biomass resources available for energy applications, we recommend that biofuels are reserved for segments of transport where liquid fuels are the only practical alternative e.g., heavy duty trucks, ships and aircraft. Converting domestically available unused biomass resources (20TWh) into biofuels may cover 70% of the fuel demand for heavy duty vehicles by 2030. Battery electric vehicles may cover around 25 % of the passenger kilometres travelled in Norway. Plug-in hybrids may contribute up to another 25% (depending on the all-electric driving range), so that altogether, up to half the emissions from passenger road transportation may be eliminated by the utilisation of renewable electricity. Efficient utilisation of hydrogen in fuel cell vehicles constitutes the best solution for covering the remaining (at least) 50% of passenger transportation. The only alternative is massive import of biofuels, but this will not contribute to the reduction of global GHG emissions, due to the limited availability of biomass resources. Other drawbacks of the dependence upon extensive import of biofuels are security of supply and ethical issues related to the production.

4. Norway possesses energy resources suited for large scale hydrogen production

Norway's abundant natural gas resources and suitable formations for CO_2-storage in the North Sea bed, along with high untapped potentials for wind power represent the two most viable sources for the large-scale production of CO_2-lean hydrogen.

5. Hydrogen fuel can become competitive by 2025

The assessment of production and distribution of hydrogen as a vehicle fuel shows that by 2025 hydrogen may be cost competitive and subsidies should not be required thereafter. Yet, hydrogen costs vary substantially with demand, hence cost levelling measures will be required to ensure competitive costs particularly in areas of low population density. Furthermore, the overall investment needed for a nationwide hydrogen infrastructure (comprising of 1,100 refuelling stations) is estimated at 1.5 billion $€_{2005}$ until 2050. This is three times the cost of the new Oslo opera house. To put this number in a 40 year time perspective: allocating ½ % of the annual yearly income from taxes on vehicles (currently 50 bill NOK), will cover the required investments for a hydrogen refuelling infrastructure until 2050. Financial stimuli for infrastructure establishment are a pre-requisite to stimulate sufficient investments in the early phase.

6. Hydrogen technologies and hydrogen energy export represent market opportunities

The transition towards sustainable transportation also represents opportunities for the development of new industries. Considerable competence and skills are present both in academia and industry, especially within petro- and electrochemistry as a basis for substantial value creation. Currently, Norway's fossil energy production is one order of magnitude larger than the domestic consumption. Substantial export of oil and gas with the future potential to export renewable electric energy (primarily in terms of offshore wind) render Norway in a key position as part of Europe's energy future. Norway could thus continue its role as a large contributor to the security of the energy supply in Europe in a sustainable way. This study has shown that the export of hydrogen to the European fuel market constitutes an economically interesting option. It is recommended that this option should be considered as an integral part of policy discussions with the European Commission.

7. Cost reduction of key technologies is needed

The low efficiency of the internal combustion engine is a major hurdle towards reducing the environmental footprint of transportation. A more efficient utilisation of energy in fuel cells as well as advanced battery technologies is required. Both technologies are ready for early market applications. Costs and performance can be improved most efficiently by ramping up production capacity through a market roll-out and at the same time performing further research on materials, configurations and production methods. Political support for market introduction as well as R&D is therefore needed. Furthermore, the development of more efficient and affordable 2^{nd} generation biofuel and hydrogen production processes is necessary.

8. Substantial intervention from government is required

Energy and climate policies represent powerful cross disciplinary measures to ensure the rapid transition to sustainable transportation. This includes legislation as well as taxation. Active use and development of the governmental body TRANSNOVA – in close cooperation with industry - should assure support to alternative fuels and propulsion technologies covering both short and longer term solutions, i.e., biofuels, electricity and hydrogen. Today's high tax levels on new vehicles and transportation fuels render the Norwegian Government with an extra degree of freedom when dealing with greenhouse gas emission reductions from transport. Thus, the continual implementation and further development of powerful policy measures may significantly accelerate the transition process towards more environmentally sound fuels and more efficient propulsion technologies.

Norway's profitable engagement in hydrogen

Based on the 8 points above we conclude that Norway can profit from an introduction of hydrogen energy for transport in three ways;

- *first by becoming an early adopter of hydrogen as transportation fuel and* ***reducing GHG emissions from road transportation****;*
- *secondly by becoming an industrial and research pioneer in sustainable hydrogen production, supply and infrastructure technologies, and thereby* ***developing a hydrogen technology based industry****;*
- *thirdly by* ***utilising abundant natural gas resources as well as the huge wind energy potential for large scale hydrogen production*** *and exporting GHG neutral, hydrogen to central Europe thereby maintaining Norway's key role as a European energy provider.*

Today Norway is perceived as one of the World's key players in hydrogen energy and has gained credibility for its commitment in strategy formulation/road-mapping, R&D and industrial developments along with demonstration activities towards the commercialisation of hydrogen energy.

To fully utilise its potential role to maintain and consolidate Norway's key position in the European energy future a major pre-requisite will be that the Norwegian Government takes a proactive role in pursuing the introduction of hydrogen by applying current and new policy measures.

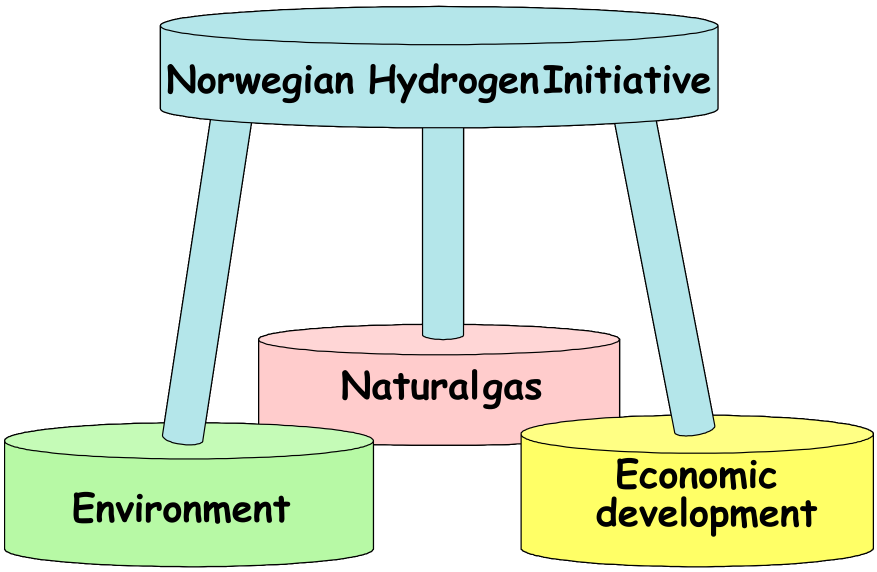


Figure 1. The recommendations given in this document consolidate the three arguments constituting the rational for the Norwegian Hydrogen Initiative provided by the Norwegian Hydrogen Commission in 2004 [NoU 2004:11].

Executive Summary of the NorWays-project

High energy use and emissions from Norwegian road transportation

The geography and demography of the Norwegian mainland renders the transportation demand considerably higher than the global average. The annual energy consumption of around 60 TWh for transporting people and freight contribute to Norway's domestic emissions of greenhouse gases (GHG) by 38%, the global average being 26%. Among the various forms of transportation, road transport is by far the dominating source contributing to two thirds of the emissions.

The transportation demand is expected to increase by approximately 40% from 2010 to 2050, thus with a targeted reduction in GHG emissions of 50-80%, it is evident that cleaner fuels and new, more efficient propulsion technologies need to be introduced.

In agreement with international and European strategy efforts it has been concluded that 2nd generation biofuels, hydrogen and electricity constitute the three most viable alternatives for future sustainable mobility throughout the world.

The role of biofuels, hydrogen and electricity for road transportation in Norway

In the EU, the CONCAWE-EUCAR-JRC study estimates that domestic 2nd generation biofuels can replace about 10% of the fuel demand for transportation. In addition globally, biomass resources will be inadequate to cover more than a fraction of the steadily increasing demand. This valuable energy source should therefore primarily be utilised locally or regionally to prevent the inevitable losses and corresponding environmental impact from long distance transportation of biomass or biofuels. We therefore recommend that biofuels are reserved for segments of transport where liquid fuels are the only practical alternative e.g., heavy duty trucks, ships and aircraft. Norway possesses unused biomass resources, estimated at 20 TWh annually, which may be converted to around 1.3 billion litres of biofuel utilising 2nd generation conversion processes. Currently, Norway has upwards of 440 000 heavy duty vehicles on the road. If utilised for road freight transportation, this will correspond to about 70% of the projected fuel demand in this transportation segment by 2030 (Figure 2) when converted in Internal Combustion Engines (ICEs).

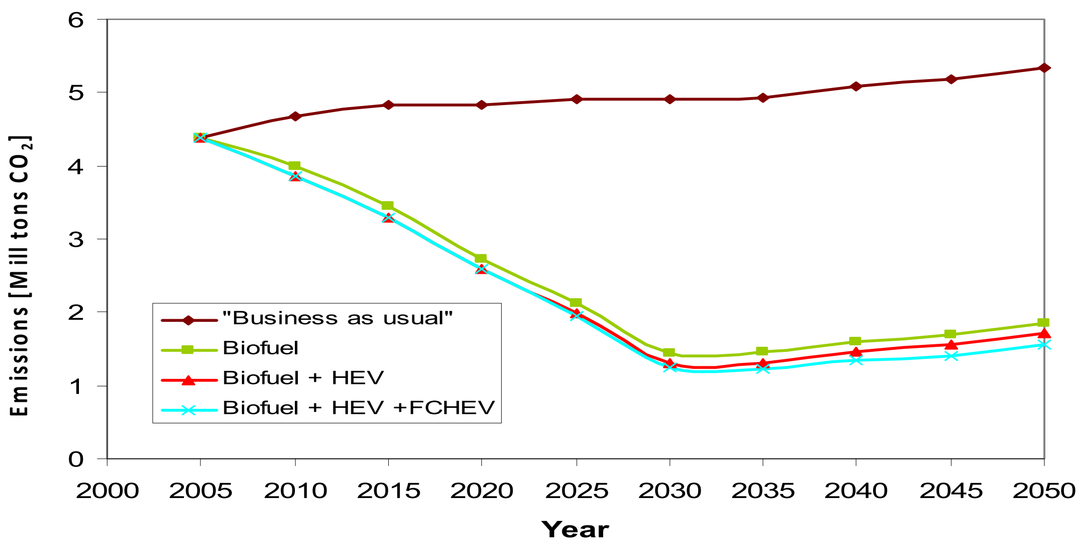


Figure 2. Estimated potential for reduction of CO_2-emissions from freight transport by the introduction of (domestic) biofuel (converted in ICEs) in heavy duty vehicles, and introduction of hybrid technology (HEV), as well as hydrogen fuel cells (FCHEV from 2020) in light duty vehicles.

Hybrid electric vehicles (HEVs), which combine ICEs with electric motors and batteries, became commercially available in 1997. Electric propulsion power trains are expected to become an integral part of most future vehicles, initially utilising conventional and biomass based fuels in ICEs and eventually hydrogen converted in fuel cells. Hybridising an ICE-based propulsion system is reducing fuel consumption by typically 30-40% for city driving. However, for highway driving patterns the fuel savings are minor. Plug-in hybrid electrical vehicles (PHEVs) are expected to enter the market in 2010 and battery electric vehicles (BEVs) are commercially available although currently sold in very low numbers.

Given the dominance of renewable electricity in the domestic power production, electric vehicles (BEVs and PHEVs) charged from the grid will constitute an attractive option for Norway to reduce GHG emissions. However, the contribution to emission reductions from electrical vehicles is subject to customer convenience and will therefore depend on breakthroughs in battery technology for extended range and low temperature characteristics as well as on the development of a fast recharge infrastructure.

Hydrogen constitutes a zero emission fuel when produced from renewable sources or natural gas with carbon capture and storage (CCS). Direct utilisation of renewable electricity in electrical vehicles (in BEVs and PHEVs) is, however, by a factor of 2 more energy efficient than the hydrogen alternative on a *well-to-wheel* basis. On the other hand, using fossil resources such as natural gas, the *well-to-wheel* efficiency of a hydrogen powered fuel cell vehicle is similar to that of electrical vehicles. While the range of BEVs is limited to ca 200 km due to the weight of the batteries, with hydrogen powered fuel cell vehicles a range of more than 800 km has already been demonstrated for a full size recreational vehicle with no compromise in personal comforts. Thus, these vehicles will comply with different needs and dominate in various segments of transportation.

Passenger transport was then assessed, substituting electricity and hydrogen for conventional fuels (diesel and gasoline), biofuels being reserved for freight transportation (Figure 2). Assuming utilisation of pure battery electric vehicles (BEVs) in all Norwegian households which have 2 or more cars (≈ 39%), and the all electric range of PHEVs to be 10 miles (16 km) from 2010 (PHEV10), increasing to 40 miles (64 km) in 2020 (PHEV40), it was concluded that ***hydrogen powered fuel cell vehicles are needed to comply with national GHG emission reduction targets for road transportation (Figure 3).***

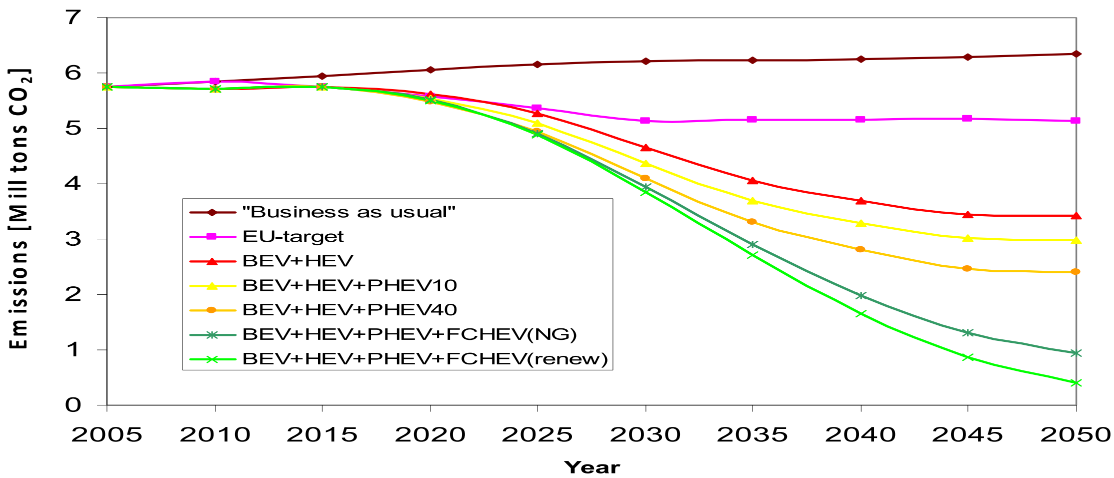


Figure 3. Estimated potential for reduction of CO_2-emissions for personal vehicles when BEVs are introduced in every household with 2 or more cars, and conventional ICE powered cars are gradually replaced by HEVs, PHEVs, or FCHEVs. NG=natural gas (with CCS), and renew=renewable electricity.

Transition to hydrogen as fuel for road transportation

Utilisation of hydrogen as fuel for road transportation requires the establishment of a nation-wide refuelling infrastructure. In agreement with European strategy as well as road-mapping activities, this transition is foreseen to take around 4 decades, ending up with a fully developed infrastructure by 2050. To facilitate the most economically favourable development, hydrogen demand and supply in Norway was analyzed up to 2050 using two models: A hydrogen infrastructure build-up simulation model (H2INVEST) treating all Norwegian municipalities simultaneously and an energy market model covering three Norwegian counties separately (MARKAL). The MARKAL model captured specific regional aspects in order to understand the impact of local conditions and policies on the choice of vehicle fuel and drive trains. In contrast, the H2INVEST model assumed a certain overall penetration of hydrogen fuel and applied an all-Norwegian approach to assess the impacts on the Norwegian demography, topology and infrastructure on the development of hydrogen supply infrastructure and costs. Iteration between the models assured the consistency of the supply infrastructure assumptions of MARKAL with the hydrogen demand development assumed for H2INVEST. The results provided insights into the possible energy market development patterns from complementary techno- and socio-economic perspectives.

From the techno-economic optimization of MARKAL, it is clearly seen that for new car technologies to be competitive in the mid-term, a differentiation of taxes between fossil fuels and alternative fuels, such as hydrogen and biomass, is required. In the case of hydrogen production, the cost of the energy source dominates the fuel cost. This implies that higher oil and gas prices result in a delay in the introduction of hydrogen, as production from natural gas is the cheapest option in the short and mid-term. In order for hydrogen production by biomass gasification to become competitive, significant reduction of the investment costs and improved efficiency are required.

By means of the H2INVEST model developed during the project, realistic distribution of hydrogen demand, and lowest-cost hydrogen supply to a set of refuelling stations was calculated based on the above mentioned “BEV + HEV + PHEV + FCHEV”-scenario (Figure 3). The complete national coverage was deemed attainable by 2040, and by 2050 hydrogen was assumed available at 1,100 of today’s conventional refuelling stations, each station serving an average of 1,600 vehicles. The regional deployment of hydrogen is depicted in Figure 4, showing the early user centres and development of corridors eventually connecting densely populated regions.

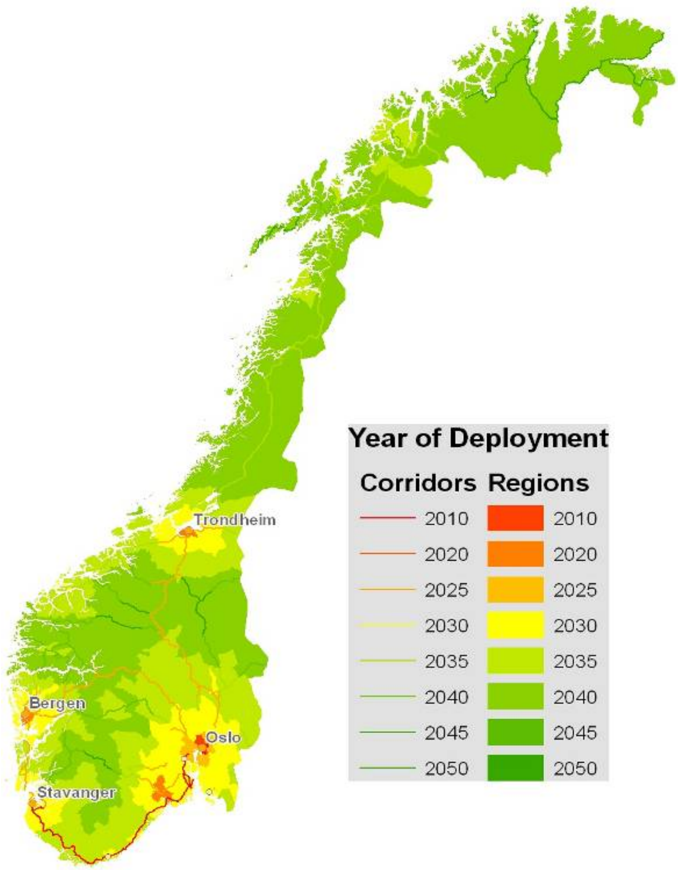


Figure 4. The municipal deployment of hydrogen towards full coverage in 2040.

NorWays

www.ntnu.no/norways

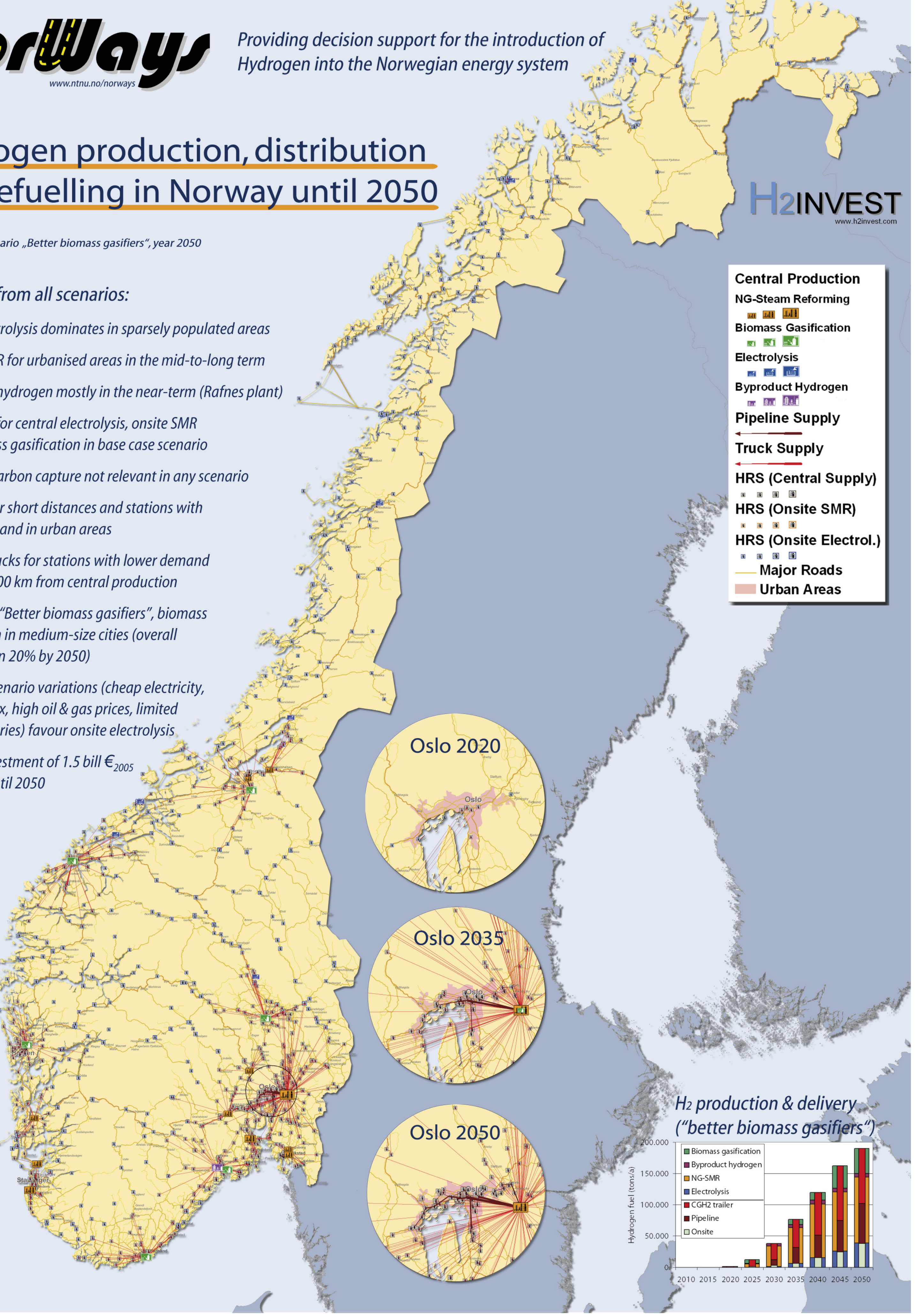
Providing decision support for the introduction of Hydrogen into the Norwegian energy system

Hydrogen production, distribution and refuelling in Norway until 2050

Map shows scenario „Better biomass gasifiers", year 2050

Learnings from all scenarios:

- *Onsite electrolysis dominates in sparsely populated areas*
- *Central SMR for urbanised areas in the mid-to-long term*
- *Byproduct hydrogen mostly in the near-term (Rafnes plant)*
- *Minor role for central electrolysis, onsite SMR and biomass gasification in base case scenario*
- *SMR with carbon capture not relevant in any scenario*
- *Pipelines for short distances and stations with higher demand in urban areas*
- *Gaseous trucks for stations with lower demand located <100 km from central production*
- *In scenario "Better biomass gasifiers", biomass gasification in medium-size cities (overall contribution 20% by 2050)*
- *All other scenario variations (cheap electricity, high CO_2 tax, high oil & gas prices, limited truck deliveries) favour onsite electrolysis*
- *Overall investment of 1.5 bill €$_{2005}$ required until 2050*



NTNU Norwegian University of Science and Technology · SINTEF · IFE Institute for Energy Technology · Statkraft · StatoilHydro · HEXAGON COMPOSITES · The Research Council of Norway

Hydrogen supply

Given the demand, timely and geographical distributed deployment described in the section above (Figure 4), the supply side was assessed. The supply optimisation considered techno-economic data of central production processes, distribution types and hydrogen refuelling stations (HRS) with and without onsite electrolysis or steam methane reforming (SMR) production as shown in Figure 5. Together with timely variable inputs on the demand of refuelling station locations, energy prices, and locations where central production is feasible, the model created a least cost integrated supply solution of all hydrogen refuelling stations over time. The resulting aggregated production and distribution shares are shown in Figure 5, and the supply to the various refuelling stations throughout Norway up to the year 2050 is depicted on pages 8 and 9 of this document.

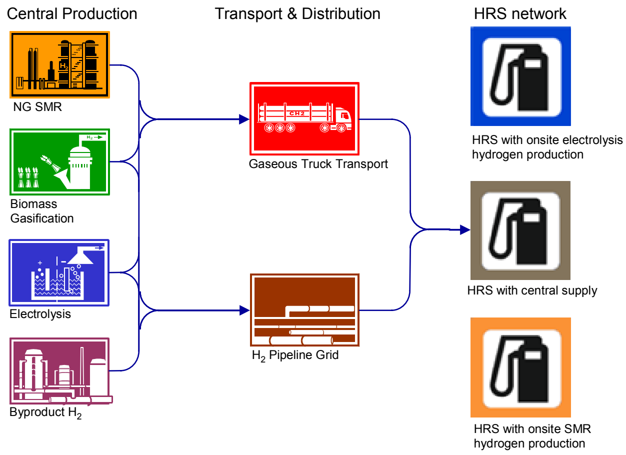


Figure 5: Options for production and distribution of hydrogen considered in the H2Invest modelling work.

Decentralised hydrogen production technologies, especially electrolysis, play a crucial role in the initial phase, but also in the later phase in rural areas. By-product hydrogen, especially from the Rafnes plant (Telemark), is a low cost supply option for the transition phase (also to Oslo). In the long run, central technologies (SMR and possibly biomass gasification) with truck or pipeline distribution become dominant for medium to large cities.

Somewhat surprisingly, for scenarios with high CO_2 taxes, the realisation of large-scale Carbon Capture and Storage (CCS) schemes cannot compete with small-scale distributed electrolysis technology in terms of costs. This may be due to the fact that distribution of liquid hydrogen, which for remote large-scale production such as SMR with CCS would be the most cost efficient solution, was not considered an option in this study (Figure 5).

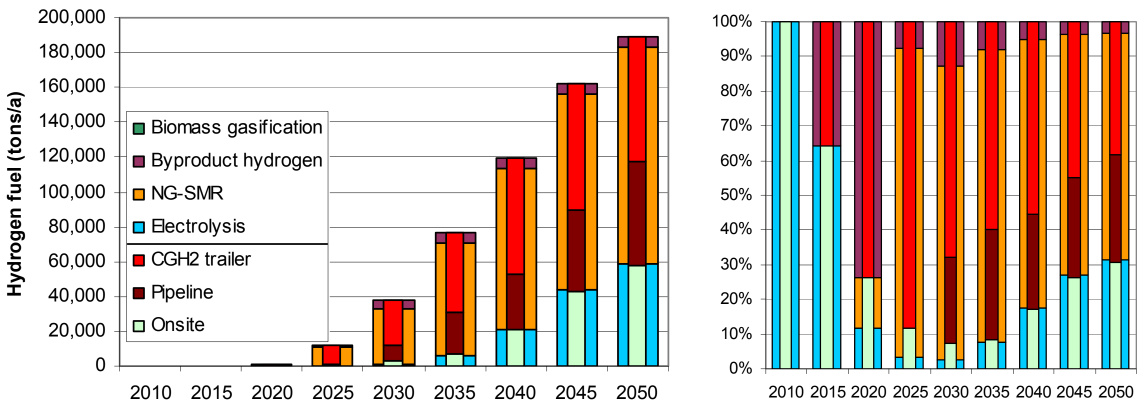


Figure 6: Aggregated shares of production and distribution options in the base case scenario of H2Invest.

The cost of hydrogen

The costs of hydrogen can be at a competitive level of below 5 €/kg from a penetration rate of approximately 5% (anticipated for 2025) if a regionally concerted vehicle roll-out and infrastructure build-up is implemented. Still, the costs of hydrogen at the refuelling stations vary significantly between regions and municipalities. This is due to the significant variation in demand density and hence utilisation of refuelling station and distribution infrastructure, further due to the limited regional availability of energy resources (e.g., biomass, natural gas). Delivery cost variations will have to be compensated for by specific cost-levelling policy measures to ensure high consumer attractiveness also in less densely populated areas. The total estimated investment of a nation-wide hydrogen refuelling station infrastructure was estimated at 1.5 billion $€_{2005}$ up to 2050.

GHG emissions from hydrogen production depend on the production mix and will, depending on the framework conditions, result in 10 to 70 g CO_2 equivalent per km driven in a FCHEV. Scenario studies have shown that the emission level can be influenced effectively by political measures such as a high CO_2 taxes, subsidies on renewable electricity, or development and investment subsidies for CO_2-lean production technologies such as biomass gasification.

Regional variations between Oslo, Telemark and Rogaland

These three regions were selected for more detailed energy system studies in the NorWays project, because they represent a variation in both population density and the local energy sources available for hydrogen production. Energy system modelling utilising MARKAL constitutes a powerful tool to identify the impact of individual technological, economic or structural parameters in regions. Furthermore, it facilitates studying likely developments under open competition between hydrogen and fuel cells and other alternative fuel and technology options.

For the base case assumptions, (bio)diesel and hydrogen cars have been found to be the most economic favourable solutions by 2020 to 2030 in the regions of Rogaland and Telemark (Figure 7). The introduction of hydrogen cars would first be expected in the urban areas. The available by-product hydrogen from Rafnes (at a relatively low cost) was found especially attractive for an early introduction of hydrogen in Telemark. Hydrogen combustion engine vehicles (with lower investment cost and lower efficiency) are selected in Telemark. In contrast, in Rogaland fuel cell cars would be a cost optimum solution for the customer; because hydrogen is somewhat more expensive here, where central SMR is the dominating hydrogen production process. In this scenario, the gasoline cars of today (depicted for year 2005 in Figure 7) would first be replaced by diesel cars with a high share of biodiesel in all regions as there are no import restrictions on biodiesel assumed in the model.

In Oslo, however, production of hydrogen from natural gas is more expensive, since there are no other big consumers of natural gas, and hence the NG transport costs are high. Import of hydrogen from other regions was furthermore not permitted in the MARKAL model. Hence, from 2020 biodiesel and plug-in hybrid cars appear to become the most economic choice in Oslo. This is linked to the plug-in hybrid's high efficiency and lower energy cost. However, if constraints are put on CO_2-emissions as assumed for the scenario shown in Figure 8, a significant share of the cars sold in Oslo already from 2020 will be hydrogen fuelled.

It can, furthermore, be concluded from Figures 7 and 8 that a significant reduction in energy use for road transportation may be achieved, despite a 40% increase in transport demand from 2010 to 2050. These dramatic energy savings are obtained from the introduction of far more energy efficient propulsion technologies.

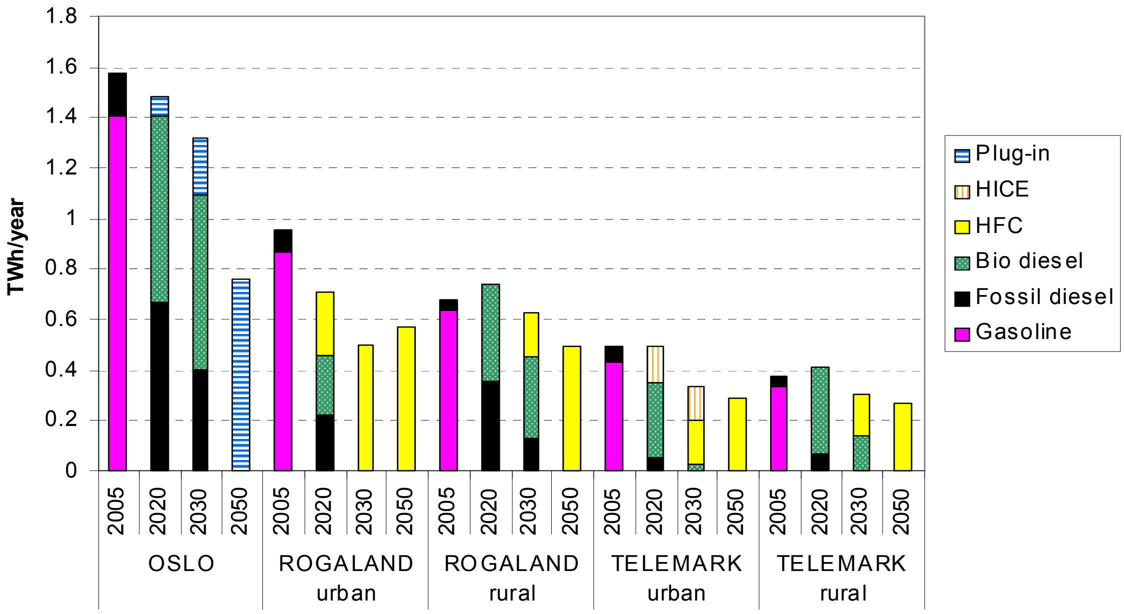


Figure 7. Estimated energy use for competitive vehicles in the selected regions in the period 2005-2050, with the base case assumptions of the MARKAL modeling.

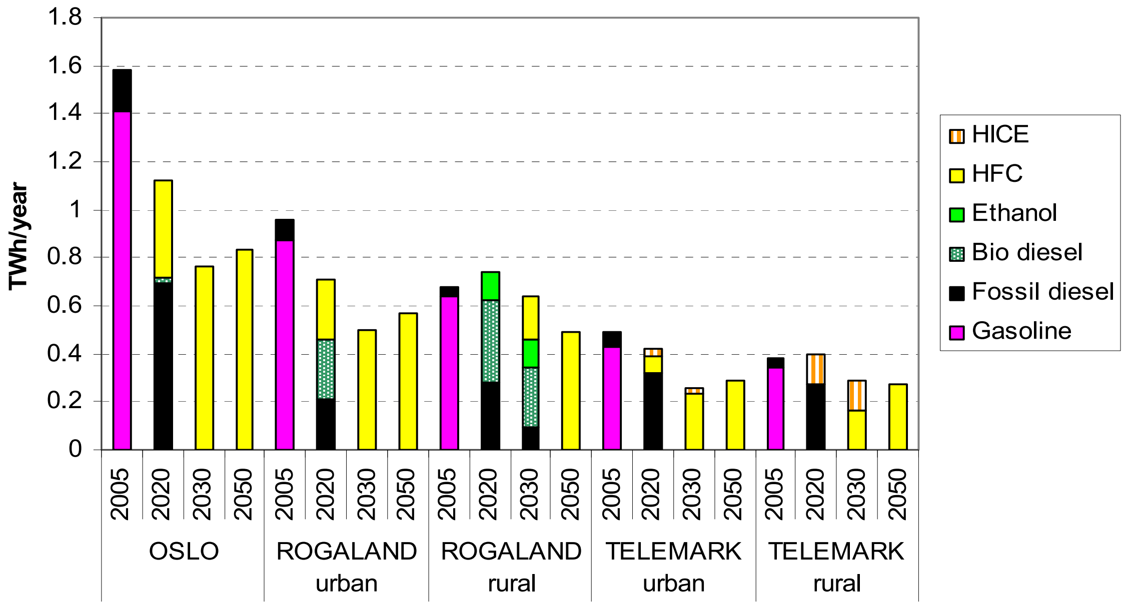


Figure 8. Estimated energy use for competitive vehicles in the selected regions in the period 2005-2050, assuming 20% reduction in national CO_2-emissions by 2020, 66% by 2030, and 75% by 2050, respectively.

From the infrastructure and energy system analyses it can be jointly concluded that: ***Leaving the transition to alternative fuels and new propulsion technologies purely to market forces, the transportation sector will not comply with national emission reduction targets.***

Enforcing stringent CO_2-reduction constraints applying consistent and coherent policies are required to smoothly shape the transition towards sustainable and *future-proof* alternatives: ***Biofuels, hydrogen and electricity.*** Policy support should comprise both active measures such as the application of end-use taxes to favour the most environmentally sound vehicles as well as support the development of infrastructure for these solutions, along robust strategic guidelines. To take full advantage of this transition phase, public support for R&D activities is a prerequisite.

Export of Hydrogen to the growing European transportation fuel market

Norway has built its wealth on exploiting natural energy resources, from the start of building hydropower plants more than a century ago, to substantial production and export of oil and gas since the late 1970s. By mid 1990, a third energy related pioneer activity was initiated, rendering Norway the World's largest producer of solar cell wafers today.

Based on the untapped renewable offshore wind resources and abundant natural gas reserves, Norway has the opportunity to become a net exporter of renewable energy as well as environmentally sound hydrogen.

Various supply options to the European transportation fuel market have been assessed, utilising on- and offshore wind resources as well as natural gas with carbon capture and storage. Transport options included hydrogen pipelines, liquid hydrogen ships and HVDC cables. A plausible customer is central Europe due to its proximity, high population density and lack of domestic energy resources. Eight CO_2-lean energy export chains were evaluated with respect to efficiency, environmental impacts and costs. These are schematically depicted in Figure 9.

In a scenario where hydrogen is used as fuel for transportation, export of hydrogen from renewable electricity by hydrogen pipelines and ships appeared energetically and economically interesting against the direct export of electricity through HVDC lines. Export of hydrogen made from NG by SMR appears slightly more expensive than the direct export of NG with SMR in the destination country, but more efficient if hydrogen is the end product. Furthermore, hydrogen export offers higher flexibility of feedstock choice and increased utilisation of Norwegian R&D experience and higher value creation is anticipated by the export of a higher refined product. On the other hand, the direct export of the feedstock offers a higher flexibility of use in the destination country.

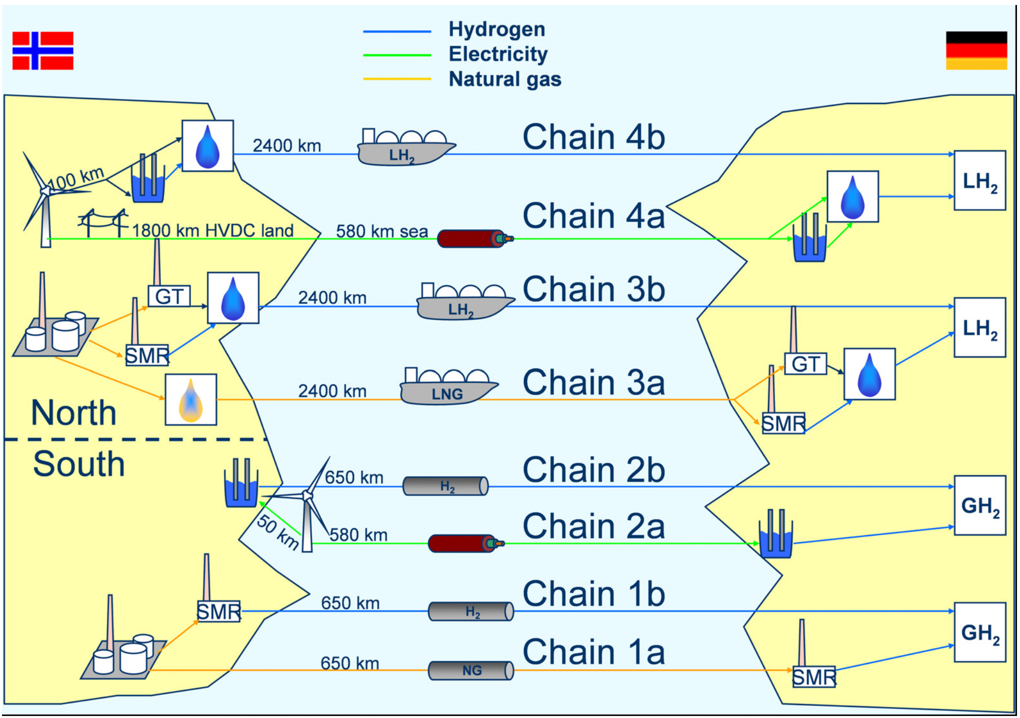


Figure 9. Comparison of energy chains for export of CO_2 lean energy from Norway to Germany assessed in the NorWays-project for the European transportation fuel market.

NorWays

Key information about the NorWays-project:

The NorWays-project was established upon request from industrial partners, Statkraft and Norsk Hydro in early summer 2005. The application submitted in September 2005 was successfully evaluated and supported with a grant from the Research Council of Norway in January 2006. The project commenced late March 2006 and lasted until May 2009.

This three year national hydrogen energy roadmap project has been carried out with the objective of

> ***providing decision support for the introduction of hydrogen into the Norwegian energy system.***

The NorWays project has been conducted as a knowledge building project with user involvement. Financial support has been provided by the Research Council of Norway, as well as from the industrial participants of the project: Statkraft, Statoil and Norsk Hydro (now StatoilHydro), Hexagon Composites, and "Næringslivets Idefond for NTNU". Work has been conducted in collaboration between the research partners involved, SINTEF, IFE and NTNU in dialogue and under the guidance of industrial partners. The project was coordinated and managed by SINTEF.

The organisation of the project is illustrated in Figure 10. A series of 6 workshops have been arranged and held biannually, to ensure close dialogue with the involved industrial partners.

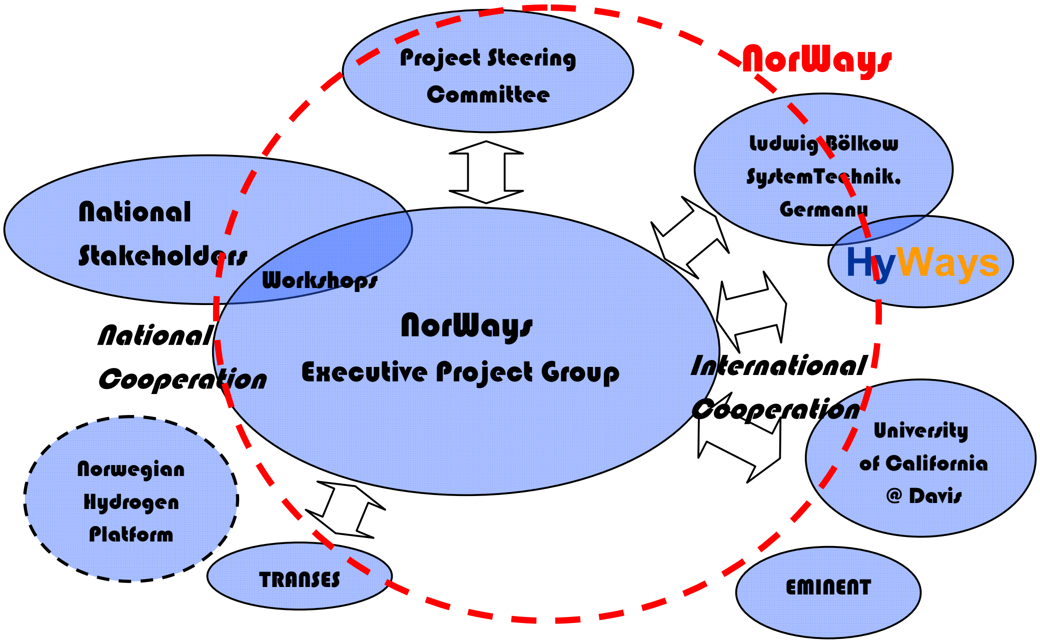


Figure 10: Illustration of the NorWays project organisation.

NorWays

The NorWays project has included modelling activities at national, regional and local (municipal) levels (Figure 11) as well as biannual stakeholders' workshops for discussions and consensus building. Modelling has included model developments both in terms of regional models for MARKAL, but also development of the hydrogen infrastructure build-up simulation model H2Invest in collaboration between the Norwegian University of Science and Technology (NTNU) and Ludwig-Bölkow-Systemtechnik (LBST GmbH), Munich, Germany. The MARKAL modelling was carried out at the Institute for energy technology (IFE). In addition case studies using *Well-to-wheel* analysis have been carried out primarily by SINTEF and NTNU. The work was carried out in continuation of the EU hydrogen roadmap project HyWays (www.HyWays.de).

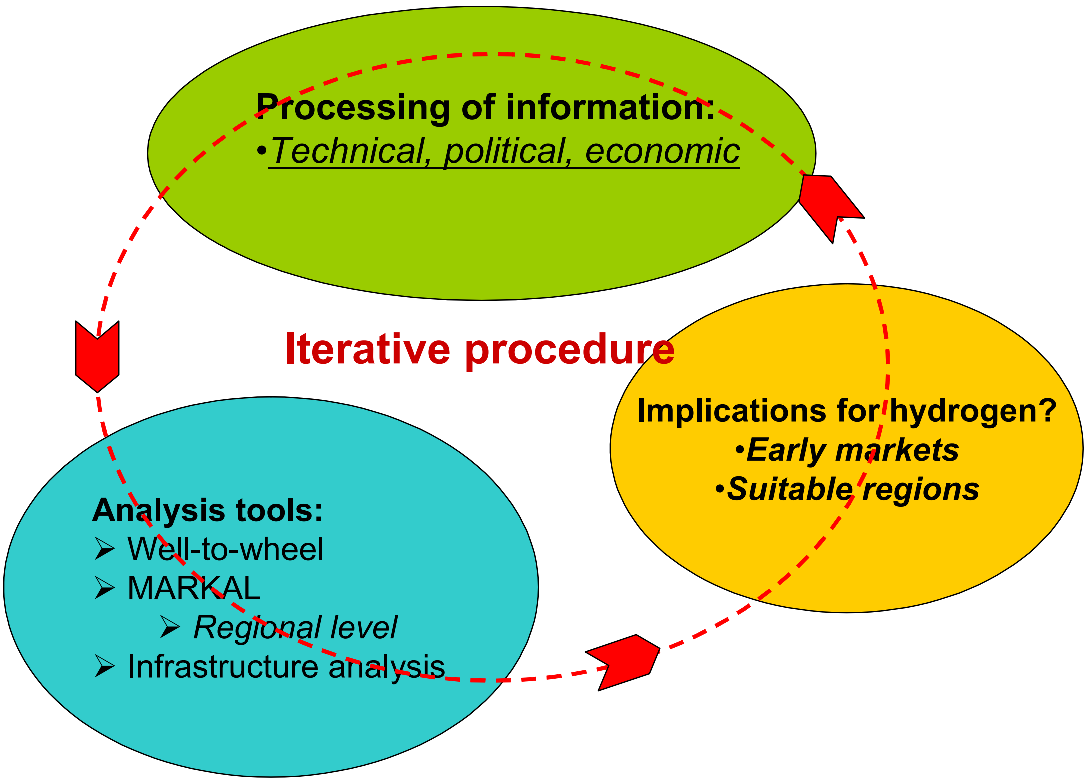


Figure 11: Modelling efforts in the NorWays project were carried out in an iterative way, to ensure consistency in results and robust recommendations.

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NorWays

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173045/S30 (Research Council of Norway)
URL: www.ntnu.no/norways
Coordinated by:
SINTEF Materials and Chemistry
Dr. S. Møller-Holst
Duration: March 2006 - May 2009
Total budget: 6.9 mill NOK

The work was conducted by the research institutions:

NTNU

IFE

SINTEF

Financial support provided by:

The Research Council of Norway

Statkraft

StatoilHydro

HEXAGON COMPOSITES

Disclaimer:
The result from the NorWays-project is the outcome of a collaborative effort between NorWays' industrial and institute/university partners. Extensive stakeholder consultation facilitating feedback from NorWays' industrial partners was ensured by arranging bi-annual workshops. This document represents a synthesis of the project results summarised by NorWays academic project partners. The Core Message and Executive Summary is in broad general agreement with NorWays' principal findings and perspectives. However, while a commendable level of consensus has been achieved, this does not mean that every consulted stakeholder or NorWays' Industry Partner necessarily endorses or agrees with every finding and statement in this document. The academic partners are solely responsible for its content and recommendations.