Arena H2Cluster
The Norweigan Hydrogen Cluster

Cross-Sectoral - Value Chain

THE NORWEGIAN HYDROGEN CLUSTER - H2CLUSTER

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ABOUT H2CLUSTER

What We Do

H2Cluster – The Norwegian Hydrogen Cluster is a national cluster. The aim is to strengthen the position for our partners by facilitating collaboration

- amongst our partners
- across sectors/ market segments
- through the entire value chain
- with regional/ international clusters and organizations

H2Cluster is working on several projects aiming to accelerate the development of new business opportunities within the hydrogen industry.

WORLD LEADER

Vision

The Norwegian hydrogen industry is a world leader in technology, business models and solutions for the production, transport, storage, application and export of hydrogen.

INNOVATION ARENA

Mission

The hydrogen cluster's mission is to create a national innovation arena where companies collaborate on innovation, competence building, market development and positioning.

INCREASED VALUE CREATION

Our Main Goals

Increased value creation among the companies in the Hydrogen cluster, through intensified cooperation on R&D, competence enhancement, business models, market development and positioning nationally and internationally.

Air Liquide Norway AS

Air Liquide is one of the main players behind the rapidly growing part of the energy sector that uses hydrogen as an energy source.

They have expertise in the entire hydrogen supply chain, i.e., production, distribution, and storage of hydrogen, as well as fuel cells and filling stations. Hydrogen in combination with oxygen in the air can be converted into electricity using fuel cells, and with clean water as the only residual product.

Air Liquide Norway AS is a member of the Air Liquide group. Together with sister companies in Denmark, Sweden, and Finland as a part of a joint Nordic organization.

Air Liquide is the world's leading supplier of gas, technology and services for industry and the healthcare sector.

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AGA AS

Linde is the only company that covers every step of the hydrogen value chain, from production and processing through distribution and storage to daily applications in industry and consumer. Linde's hydrogen expertise is based on decades of research and many completed projects and shows innovative strength and documented expertise in delivering functional, economically viable hydrogen technologies that are suitable for mass distribution.

They also provide:

- Know-how and technology in gas related processes
- Gases, gas mixtures and equipment for tests and pilot plants
- Gas system inspections, condition monitoring as well as maintenance and repair services

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Akershus County Council

In Viken, efforts are being made to get a significant part of the transport to more environmentally friendly vehicles. The relevant fuel types are biogas, hydrogen, and electricity. The county municipality is actively working on the development of charging infrastructure for electric cars and filling stations for biogas and hydrogen.

A network of fast chargers is now being built, both in the cities and along the E18 and E6. In addition, many municipalities have developed strategies for charging infrastructure.

The county municipality takes responsibility for reducing greenhouse gas emissions.

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Bellona

The Bellona Foundation is an independent non-profit organisation that aims to meet and fight the climate challenges, by identifying and implementing sustainable environmental solutions. They work towards reaching a greater ecological understanding, protection of nature, the environment and health. Bellona is engaged in a broad range of current national and international environmental questions and issues around the world.

After “digging for barrels of toxic waste” for several years, the Bellona Foundation turned its focus to larger projects with an emphasis on finding realistic and manageable solutions to the environmental, resource, transport, and energy problems in the world today.

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Bertel O. Steen AS/ Mercedes-Benz

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Since 1994, Daimler/Mercedes-Benz has actively been working on the development of hydrogen fuel-cell vehicles (FCEVs). Several test projects have been held, among these an extensive program which started in 2010 in Norway, Germany, and USA. As the Norwegian official importer of Mercedes-Benz to Norway they are proud to participate in this test, where 10 Mercedes-Benz B-Class F-Cell have been leased to different users in Oslo area.

The Experience from the test shows that the fuel cell technology is high level of quality and reliability, and Daimler/Mercedes-Benz Foresees to begin series production of fuel cell vehicles within the next few years.

Bilimport Renes Landsforening

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Bilimportorenes Landsforening (BIL) is the Norwegian Association of car importers representing the international car industry in Norway. BIL has Recently become a member of NHF (The Norwegian Hydrogen Forum) as they recognize their important role in this growing industry. The process of commercializing the hydrogen technology for vehicles is in progress, and BIL has already established its own project group together with the manufacturers developing hydrogen technology, as they see huge possibilities in joining forces working for a cleaner global environment.

BIL's main purpose is to engage in government dialogue to influence the automotive industry's framework conditions. In the broadest sense, this concerns everything from technical and traffic regulations to taxes and duties on vehicles.

CerPoTech

CerPoTech portfolio includes state-of-the-art ceramic materials for electrodes and electrolytes of Solid-oxide cells, as well as ceramic materials that are employed in stack production. In addition, they can provide many novel and beyond state-of-the-art materials. CerPoTech has a proven track record in synthesising lead-free electro ceramic materials for R&D purposes. they can supply materials of the BTO/BZO as well as the KN/NN-system.

CerPoTech can offer fine complex ceramic oxide powders of tailored compositions with high phase purity, high chemical purity, very high homogeneity, narrow particle distribution, offering excellent properties for further processing at competitive prices.

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Bilimport Renes Landsforening

Christian Michelsen research AS (CMR) is a technology research company that focuses on commercial research and development.

CMR Computing focuses on IT-R&D, with emphasis on advanced visualization and analysis of data. The goal is to develop new program modules and program system that contribute to increased value creation for clients in four solution areas: visual communication, data analysis, simulation, and decision- making support.

They offer expertise on a wide range of sensor technologies including acoustic, electromagnetic, optic, and nuclear technologies as well as application knowledge within their three main market areas: Oil and gas, Fisheries and Aquaculture and Environment and geophysics. Metering Solutions for Hydrogen quality and flow is one of the application areas where CMR Instrumentation is involved.

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DNV GL

DNV GL has invested heavily in hydrogen R&D through active participation in national and international project and networks (e.g., EU and IEA activities).

DNV GL became a pioneer in developing fuel cell technology for ships through the fellowSHIP project, successfully testing the world's first industrial size marine fuel cell in the offshore support vessel Viking Lady. DNV GL is also leading the Norwegian Green Coastal Shipping Program. Which is Currently exploring environmentally shipping, including the use of fuel cells.

DNV GL has also undertaken several studies related to hydrogen market and commercial aspects, as well as hydrogen safety and process risk studies.

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Energy Norway

The main purpose of Energy Norway is to deal with industry-related economic, political, and R&D issues on, behalf of its members, to provide as good framework conditions for the industry as possible with respect to financial, legal, and technical issues. Internationally Energy Norway represents Norway in EURELECTRIC – The Union of the Electric Industry.

The main activities to hydrogen are theoretical R&D projects.

Part of Energy Norway's Strategy is to increase competence and knowledge related to new energy and strategic sources for the future environment-friendly energy system.

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Enova SF

Enova SF is a public enterprise owned by the Norwegian Ministry of Petroleum & Energy. Enova SF contributes to reduced greenhouse gas emissions, development of energy and climate technology and a strengthened security of supply for energy in addition to the development of energy and climate technologies. Enova supports projects mainly through the granting of investment aid with an aim to reducing barriers and stimulating lasting market development.

Since 2015, transport has been included in Enova's mandate. One of the main aims is the reductions of green house gas emissions from transport. This includes hydrogen projects.

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GexCon

Gexcon is a world-leading company in the field of safety and risk management and advanced dispersion, explosion, and fire modelling. GexCon Provides Services in the following areas of hydrogen safety:

- Sale, lease, and consulting services of FLACS CFD-software for H2 & LNG consequence assessments: dispersion, fire, explosion scenario & ventilation and studies thereof, incl. Quantitative Risk Assessments.
- State-of-the-art test facilities for dispersion and explosion experiments with hydrogen, other gaseous fuels, dust, and sprays/mists.
- Equipment testing, hazardous area classification, and explosion protection documents within the framework of the ATEX directives.
- Safety training courses, including live demonstrations.

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Greenstat

Greenstat is working towards the sustainable production of hydrogen becoming a reality in all of Norway, first and foremost in transport, naval, industrial and export markets.

They are primarily focusing on:

- **Transportation**
- **Maritime**
- **Industry**
- **Export**

Greenstat desires to be both owner and operator of hydrogen energy plants, either independently or cooperatively. The company is working closely with partners and has joint efforts with Nel Hydrogen and Hy2gen.

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Hexagon Composites

Hexagon Agility is the leading global provider of highly engineered and cost-effective compressed natural gas, liquid natural gas, propane, and hydrogen fuel systems and Type 4 composite cylinders for medium- and heavy-duty commercial vehicles.

Their solutions enable the safe and effective use of natural gas, propane, and hydrogen as a transportation fuel. These clean fuels reduce greenhouse gas and other air emissions and save money for fleet operators and their customers.

Hexagon Agility is the most recognized brand for performance, reliability, durability, and safety of their fuel systems as well as their engineering capabilities and superior end-to-end customer service.

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Hordaland County Council

Hordaland County Municipality shall contribute to less emissions of greenhouse gases and contribute to a climate-friendly and more efficient energy use.

Transport is the sector in which the county municipality has the greatest impact when it comes to emissions. In addition to public transport, they promote carpooling and low-emission solutions on the road.

They are also the driving force behind establishing charging stations for electric cars throughout the county.

The county municipality is the water region authority for Hordaland and is responsible for the regional plan for water management.

HORDALAND FYLKESKOMMUNE

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Hynor Lillestrøm AS

Hynor Lillestrøm AS is responsible for the overall design, construction, and operation of a hydrogen refuelling station with on-site hydrogen production based on renewable energy sources. The station is in Akershus Energy Park in Lillestrøm, ca. Hynor Lillestrøm Is currently the host for fuel cell and hydrogen (FCH) systems operated by research institutes and companies, such as institute for Energy Technology (IFE), ZEG Power, Hystorsys, and HYOP.

The Hynor Lillestrøm test centre now being developed by IFE to become the Systems Laboratory for the Norwegian FCH Centre, a collaboration between SINTEF, IFE and NTNU.

Hynor Lillestrøm

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Hyundai Motor Norway AS

Hyundai is the world's first auto company offering all powertrains, including fuel cell, electric, hybrids, and plug-in hybrids. The world of the consumer is not one dimensional, and Hyundai is striving to provide alternatives that work for everyone on their way towards zero emission society.

Hyundai was the first manufacturer to mass produce their ix35 Fuel Cell, starting in 2013, a natural progression of the ground-breaking R&D done over the last 15 years.

Hydrogen vehicles are a major step in a green direction, and Hyundai is focused on commercialising the technology to be used for longer distances, while battery-electric vehicles are so far somewhat better suited for inner city driving and day to day commute.

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Hystorsys AS

Hystorsys AS is a spin-off company from the Norwegian Institute for Energy Technology (IFE) at Kjeller, Norway. Their focus is on the use of metal hydrides for compression and storage of hydrogen.

Hystorsys is a provider of high purity compressors for hydrogen with no moving parts and practically no noise and vibrations. Using waste heat, amongst others commonly available from a range of industrial processes, the compressor may be operated at almost no energy cost. The metal hydride compressors have a very low maintenance level, and hence also low maintenance cost.

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Innovation Norway

By financing projects and raising the competence of companies with ambitions for growth and exports, they are helping to create the jobs of the future. They offer services within financing, consulting, expertise, networking, and profiling. Daily, they work with several different tasks, initiatives, programs, initiatives, and events. It is about making Norwegian business better.

In context of hydrogen and fuel cells a relevant financial support service is their industrial Research and Development contracts. These require an agreement between two or more companies to cooperate in developing a new "state-of-the-art" product, an innovative process, or services which one or more of the participants need. Through their international offices, they have access to relevant network and cooperation related to hydrogen and fuel cells market developments internationally.

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Institute for Energy Technology (IFE)

IFE is the host for MoZEES, one of the main ambitions in MoZEES is therefore to show how zero emission technologies can be a viable technical and economical alternative for the maritime sector, both in Norway and abroad. MoZEES will also support R&D performed by the commercial User Partners that intend to participate in the international battery and hydrogen technology value chains.

The Institute for Energy Technology (IFE) conducts research for a better future. They have contributed to the development of ground-breaking cancer medicine, new solutions in renewable energy, more energy-efficient industrial processes, zero-emission transport solutions and future-oriented energy systems.

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Lillestrøm Centre of Expertise

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Lillestrøm Centre of Expertise (Kunnskapsbyen Lillestrøm) is a driving force for improved framework conditions and increased interaction between members. LCE stimulates innovation and works to create a growing, competitive, and attractive business region. LCE is an initiator, facilitator, driving force challenging members and other social actors.

The following three focus areas are prioritized by LCE's members:

- Renewable Energy and Environment Technology
- Civil Protection and Security
- Urban and Regional Development

NAF – Norwegian Automotive Federation

Safer and more environmentally friendly mobility is a major goal for NAF & making alternative fuels and technology available and attractive for their members is important.

NAF wants to work purposefully to take responsibility for the environment through their social and advocacy work and through their daily operations.

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NAF takes social responsibility related to the environment by:

- Active work with / prioritize socio-political advocacy work related to climate and the environmental challenge.
- Have products and services in the "portfolio" that have a positive environmental profile.
- Emphasize the environment in agreements with their partners and alliances.

NEL Hydrogen

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Nel is a global, dedicated hydrogen company, delivering optimal solutions to produce, store and distribute hydrogen from renewable energy. They serve industries, energy, and gas companies with leading hydrogen technology.

Their hydrogen solutions cover the entire value chain from hydrogen production technologies to hydrogen fuelling stations, enabling industries to transition to green hydrogen, and providing all fuel cell electric vehicles with the same fast fuelling and long range as fossil-fuelled vehicles – without the emissions.

Norwegian Defence research Establishment (FFI)

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FFI is the prime institution responsible for defence-related research in Norway and is the chief advisor on defence-related science and technology to the Ministry of Defence and the Norwegian Armed Forces' Military organization.

NAF wants to work purposefully to take responsibility for the environment through their social and advocacy work and through their daily operations.

Reforming of liquid fuels to hydrogen is an important field for FFI, also due to military community's interest in power generation form auxiliary power units based on diesel reforming and fuel cells for use on military vehicles. FFI has also tested commercially available fuel cell systems for soldiers.

Norwegian Maritime Authority (NMA)

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The Norwegian Maritime Authority (NMA) is the administrative and supervisory authority in matters related to safety of life, health, material values, and the environment on vessels flying the Norwegian flag and foreign ships in Norwegian waters.

Hydrogen could play an important role in the green shift. It is important for the NMA to be involved when the new technology is developed, to ensure that the technology is safe, reliable, and ready for marine use.

Hydrogen challenges existing prescriptive regulations, and vessels fuelled by hydrogen will therefore need approval through a risk-based design approval process.

Norwegian Small Hydropower Association

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Web: www.smakraftforeninga.no

Småkraftforeninga is the organization for the small power industry and represents those who own small power resources, have developed, or want to expand, or have a special interest in the small power industry.

The association's members have around 400 power plants in operation. In addition, approx. 200 members in planning phase. The power plants cover the entire spectrum of small-scale hydropower plants, from micro power of 20 kW to large, small power plants with an installed capacity of 10 MW.

The association operates this website, publishes the trade magazine Småkraftnytt four times a year and arranges one of the world's largest regular small power fairs, Småkraftdagene, in March every year.

National University of Life Sciences (NMBU)

Norwegian University of Life Sciences

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The study program of M.Sc. Renewable Energy gives students a combination of qualifications in both the natural sciences and technology, qualifications which are required by society for operation and innovation with businesses, management, and research. The study program emphasizes topics which are ventral to the maintenance and development of sustainable society.

The program encompasses courses chosen according to preferred knowledge and the topic for the Master thesis. Several students at NMBU have completed a hydrogen related Master thesis at Institute Energy Technology (IFE).

NTNU- Department of Chemical Engineering

NTNU
Department of Chemical Engineering

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Research activities are mainly related to hydrogen production, membrane separation and CO2 Sorbent technologies, and some activities within fuel cells. Catalysis is important in the production of hydrogen from hydrocarbons. The conversion of transportable hydrogen carriers such as natural gas, biomass, propane and (bio)alcohols are studied.

Separation technology also includes membranes for selective CO2 capture. CO2 and/ or H2 separation technologies in hydrogen production processes are targeted through CO2 sorption enhanced reaction concepts, chemical looping and membrane reactors based on novel Pd thin film technology as well as high temperature oxygen membranes.

NTNU- Department of Chemistry

The Department of Chemistry offers both theoretical and practical disciplines. Chemistry affects the environment, industry, schools, research, and management. Chemistry is also basic requirements for medicine, biology, and technology.

The facilities at the department of chemistry relevant for hydrogen and fuel cells include:

- Several test stations to test PEM fuel cell performance.
- Equipment to measure the thermal conductivity of materials.
- Apparatus to measure transport numbers of ions and water.
- A calorimeter to measure electrochemical heat effects.

NTNU
Department of Chemistry

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NTNU- Department of Materials Science and Engineering

The Department of Materials Science and Engineering is Norway's leading educational and research institution in materials science and technology.

They teach and do research on the manufacture of new and the improvement of existing materials in chemistry, electrochemistry, and metallurgy. They look at how we use and recycle materials and material resources, and how we can reduce energy consumption and emissions during production and recycling.

The Department of Materials Science and Engineering is one of eight departments at the Faculty of Natural Sciences.

NTNU
Department of Materials Technology

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Paraxair Norge AS

Nippon Gases is the fourth- largest industrial gas company in Europe with an overall market share close to 9% in the continent.

The main products supplied by Nippon Gases in various physical forms and purities are oxygen, nitrogen, argon, carbon dioxide, hydrogen, helium, carbon monoxide, gas mixtures, electronic gases, specialty gases and the services and technologies associated with the use of these gases and mixtures.

Nippon Gases has a very balanced situation regarding mode of supply and enjoys an open portfolio in terms of markets served.

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Prototech AS

Prototech is a provider of technology development, engineering, product design and manufacturing services covering a broad spectrum of areas including space applications, new energy systems, offshore technology as well as industrial and consumer products. Prototech is supplying its customers in these sectors with designs, calculations, prototypes, and custom-made hardware for operation in demanding environments, from the depths of the ocean floor to the International Space Station (ISS) and beyond.

Their core areas of expertise are:

- Experimental modules for unmanned and manned space flights
- Thermal & mechanical analysis (FEM) and Aero- & hydrodynamic analysis (CFD)
- Special equipment and tools to client specifications for the oil & gas and offshore industry
- Concept studies of energy conversion processes
- Development and demonstration of fuel-cell-based energy processes
- Extensive expertise in developing advanced and special tools for pipeline inspection.

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Research Council of Norway

Research Council of Norway Provides funding for fundamental, strategic, and applied research on the hydrogen area. This is both in terms of technologies for production, storage, distribution/ transport, and the use of hydrogen. Support for commercialisation, testing and demonstration of hydrogen technologies in the transport sector is mainly covered by Enova.

The Council supports both Researcher Projects, Competence projects (with research institutions as contracting parties), and innovation projects, where industry companies are contracting parties.
The Research Council also support Centre for Environmentally Friendly Energy Research (CEER, or FME in Norwegian). For 2017-2021, 8 new centres are established, amongst them the FME MooZEES, covering environmentally friendly transport based on hydrogen and batteries.

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RotoBoost AS

RotoBoost AS was started in 2009 as the result of Age Skomsvolds ideas for different energy technology devices and systems. After patenting and years of research and development, the company is currently prioritizing two of its products, namely the RotoReformer for Hydrogen production through Steam Methane Reforming, and RotoHeatPump for heating and cooling devices.

Their rotating water electrolyser for hydrogen production is designed for FCEV refuelling stations, funded by Trans nova. The rotation removes the gas-bubbles from the electrodes, circulates the liquid (lye) and compresses the gasses (H2 and O2) in one single, ultra-compact device. The technology is licensed to NEL ASA.

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Ruter AS

Ruter AS is the public transport authority for the city of Oslo and the surroundings county of Akershus. Ruter plans, procures, and markets the public transport in this area, providing over 300 Million travels a year.

Fuel cell (FC) buses with hydrogen are also being tested. Ruter has been operating five FC buses been since 2012 as a part of the EU project CHIC-project (Clean Hydrogen in European Cities). A hydrogen production and refuelling station has been constructed for the buses at the bus depot at Rosenholm.

Ruter Targets to reduce local air pollution and noise and to use only renewable energy to power all public transport in the region from 2020. This transition is well under way, including the use of biofuels, electric trains, metro and trams, and hybrid diesel electric buses.

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SINTEF

SINTEF is the largest independent contract research organization in Scandinavia. SINTEF Develops and implements technological solutions in society and thereby creates value through knowledge generation, research, and innovation.

SINTEF research important areas within the entire value chain for pure hydrogen from production to transport and storage, and end use. Knowledge in these areas gives Norway a golden chance to develop a new green industry that the world will need to overcome the climate crisis.

SINTEF operates significant “open-access” laboratory infrastructure facilities for:

- Materials synthesis and characterisation
- Fuel cell and electrolyser single cell and stack testing
- Determination of degradation mechanisms for extended lifetime.

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Sogn og Fjordane Co

SFC supports several local H2 value chain projects. One of them is in Hoyanger Monicipality, where a small-scale hydropower system can be adapted to supply the local fish farm Osland Havbruk with hydrogen, oxygen, and thermal energy. SFC is also involved in a pilot project with Flora Municipality, Brodrene Aa, Maritime association Sogn or Fjordane, DNV GL and other to develop and test hydrogen-fuel cell technology for passenger vessels.

SFC has initiated a two-year development project (2016-2018) to establish a H2 network of businesses, municipalities, and R&D institutions in the region.

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University of Agder

They are primarily doing Materials Research on materials applied for sustainable energy systems. Materials used in Renewable Energy Technology is of special interest. Main areas:

- **Thermo Electric Materials. Can generate electricity when two different temperature zones are available.**
- **Fuel Cells. Generate electricity by chemical reactions.**
- **Solar Cells. Generate electricity from solar radiation. They are cooperating with the Norwegian Catapult Centre "Future Materials".**

Projects and programmes:

- Fuel cells – Solid Oxide, PEM and Alkaline – focus on cell testing and new materials.
- Thermoelectric – focus on materials testing, degradation, and electrical measurements.
- High temperature material synthesis – Titanium metal, novel conducting oxides, polymer membranes.
- Metallurgical Scale up – in collaboration with NORCE. Theoretical studies of new solar cell concepts.

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University of Bergen

Research in hydrogen-related technology is within the field of fuel cells, particularly solid fuel cells:

Material Research
A range of oxide nanoparticles relevant for ceramic fuel cells have been produced using a new, patented concept of sol-gel process. These particles have been sintered to produce functional materials, specifically electrolytes and anodes. Work is now in progress to produce thin layers for a new concept of planar solid oxide fuel cells.

Modeling of fuel cells
A comprehensive numerical model for a SOFC combining CFD with modelling of the chemical reactions that heat flows has been built.

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University of Oslo

There are several strong and relevant activities at UiO for hydrogen technologies, all organized within Centre for Materials Science and Nanotechnology (SMN) with participating groups from the Departments of Physics & Chemistry.

Topics include petroleum chemistry and catalysis; solid electrolysers; hydrogen storage materials; semiconductors for solar energy conversion; high temperature sensors; and fundamental research in materials science and nanotechnology. The university partakes in several national and international projects within or related to hydrogen technology.

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ZEG Power AS

ZEG Power's value proposition is efficient production of clean hydrogen from hydrocarbon gases with integrated CO2 capture, based on the patented ZEG-technology.

The ZEG technology is a modular platform technology for different sizes and applications; both fossil and bio-based gas resources can be used. The technology can be integrated in industrial processes or be used in stand-alone energy plants of increasing size and complexity. ZEG plants can be delivered as

- ZEG-H2 plants (stand-alone hydrogen production from gas with integrated CO2 capture),
- ZEG-EL plants (electric power production from gas with integrated CO2 capture), or
- ZEG-HYBRID plants (where the amount of electric power and hydrogen produced can be adapted to customer and market needs)

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ZERO

ZERO is an independent, non-profit organization that was founded in 2002 by a group of former active and employees in Nature and Youth and Bellona. They have only one client: the climate issue

ZERO works for:

- A CO2 fund for the business community with enhanced support for the purchase of commercial vehicles
- Improvements in ENOVA's programs to accelerate vehicle roll-out and renewable fuel infrastructure.
- Continued full exemption from all purchase and use taxes including tolls for emission-free vans, trucks, and buses.
- Zero-emission zones - ZERO worked to ensure that Norwegian cities adopt zero-emission zones in the city centre, and with a decision to gradually expand the zone.
- ZERO works to gradually increase the CO2 tax on fossil fuels from the current level of approx. NOK 500 per tonne to NOK 1500 / tonne.

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