Bergen Energy Lab

SPRING 2018

The spring semester has been full of highlights. In this edition of the Bergen Energy Lab newsletter, you can read about them all.

By looking at the diversity of the topics we have touched upon this spring, we can see that renewable energy is truly interdisciplinary and there is a lot of knowledge spread across different institutions in and around Bergen.

The person in charge of coordinating the many activities within renewable energy at the University of Bergen and responsible for the University's initiative within energy transition, is the new Energy director and our very own programme committee leader, Kristin Guldbrandsen Frøysa. Many congratulations to Kristin, and best of luck in her new position.

Thank you very much to all the speakers, and those of you who have attended our events this spring. We are looking forward to see you again after the summer!

Enjoy reading!
Hans-Kristian Ringkjøb

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CONTACT US

www.uib.no/energy

energylab@uib.no

facebook.com/bergenenergylab

Language and climate action - expressions of responsibility and obligation

In a joint DIGSSCORE & Bergen Energy Lab lunch meeting, professor Kjersti Fløttum from the department of foreign languages spoke about "Language and climate action - conceptions and expressions of responsibility and obligation"

In order to tackle climate change, both political measures and individual action are needed. But how does the public view climate change, what actions do they think are needed, and how do they use language to express their associations, attitudes and responses?

Professor Kjersti Fløttum (Photo: Bergen Energy Lab)

Professor Kjersti Fløttum from the department of foreign languages gave an answer to these questions on a joint lunch seminar between DIGSSCORE and Bergen Energy Lab on the 23rd of January. She presented results from a study conducted through the Norwegian Citizen Panel, where open-ended survey questions were used. By using open-ended questions, rather than close-ended questions, respondents are able to freely formulate their attitude and opinions giving more valuable answers with rich and nuanced data.

In the survey-study, 4634 respondents answered to the question: "Concerning climate change, what do you think should be done?"

By applying a technique called Structural Topic Modelling (STM), Kjersti and her colleagues were able to define distinct topics based on the frequencies of words used in the open-question answers. Seven topics were induced; Transportation, energy transition, attribution of climate change, emission reduction, the international dimension, lifestyle/consumption and government measures, suggesting that Norwegians put emphasis on mitigation rather than adaptation.

The majority of respondents are clear about that something should be done to tackle climate change. Generally, they claim that something must be done, and that all should contribute and take responsibility. However, many of the survey's respondents do not provide further specifications about who is responsible for what; the expressed willingness thus becomes quite vague. The citizens' answers suggest a willingness to accept stronger mitigation action (quasi-absence of adaptation), but claim that authorities and politicians at both local and national level should facilitate "green" choices (and contribute to bridging policy and individual action).

The study has provided new knowledge on constraints on and opportunities for climate action, which are fundamental to decision-making. If you want to read more about this, Endre Tvinnereim, Kjersi Fløttum, Øyvind Gjerstad, Mikael Poul Johannesson and Åsta Dyrnes Nordø have published a paper on this, and see Kjersti's presentation here.

An Update on Renewable Energy and Technology

On the 30th of January, Karoline Ullaland Hove from Greensight gave an update for the Bergen Energy Lab on the status of renewable energy and technology on a global and a local scale.

Karoline has a master's degree in Renewable Energy Development from the Heriot-Watt University on the Orkney Islands, where she wrote her master thesis on the commercialisation of wave and tidal energy. Currently she works as an energy analyst for the company Greensight, an analysis/consultancy company working for a faster green transformation of the society.

Costs of renewable power generation are falling, much of it driven by technological improvements, competitive procurement and experienced project developers. In 2016, investments in renewable generation capacity were 241.6 billion US dollars, falling from 312.2 billion USD in 2015. Despite the lower investments, the reduced costs of renewables means more capacity is added for each dollar invested. Solar and wind have had a massive growth in recent years, and stood for the majority of investments in 2016. Despite this growth, renewable electricity (including hydropower) accounts for only about 25 % of the global electricity production and even less when talking about final energy consumption.

Batteries are cheaper than ever, dropping from about 1000 $/kWh in 2010 to 209 $/kWh in 2017, and quickly approaching the tipping point of 100 $/kWh. In Australia, Tesla installed the world's largest battery last year with a charge/discharge capacity of 100 MW and the possibility to store 129 MWh. The battery has already proved valuable, and responded in record time to restore the frequency in the grid after a failure in a coal-fired power plant. Even though the coal-fired power plant was about 1000 kilometres away, the battery responded in only 140 milliseconds. With the falling battery prices, one might see batteries in the European power system in the coming years, especially as the share of variable renewables as solar and wind are increasing.

Karoline then shifted focus to Norway, and what is happening on a local scale. Norway has unique hydropower resources, and the power system is already almost fully renewable. However, the share of renewable energy in gross final energy consumption in Norway was 69.4% in 2016. This is of course already very good, but there is potential to do more.

A lot of effort is put into the transport sector. The uptake of electric vehicles is increasing, a hydrogen filling station was officially opened in Åsane last month, and electric and hydrogen ferries are soon coming to Norwegian fjords.

If you would like to stay updated on what is happening within renewable energy, please subscribe to Greensight's series of reports called "Grønn Innsikt". The report, written in Norwegian, is published every quarter and aims to keep people updated on the most important trends in the "green shift".

Karoline Ullaland Hove (Greensight) (Photo: Greensight)

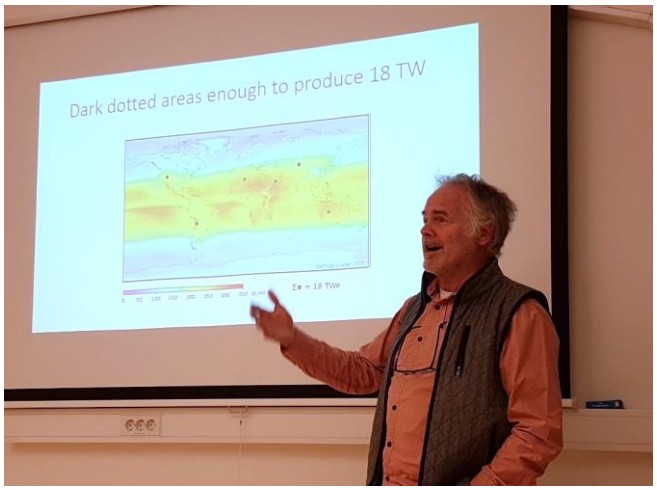
Global perspective on energy support and demand (and food)

Can we really get rid of "all" fossil fuels within 2050?

In his presentation at the Bergen Energy Lab lunch meeting on the 6th of February, Einar Svendsen spoke about observed and modelled global development of new renewable energy and the probable effects on the demands for fossil fuel.

The United Nations have defined 17 sustainable development goals to eradicate poverty, protect the planet and ensure that all people live in prosperity and peace. The access to clean and affordable energy is described in SDG 7, and energy is crucial to almost all challenges we are facing in the world today. An increasing population with a higher standard of living calls for more energy. In his presentation, Einar predicted that the energy demand will rise from 16 TW today to 30 TW in 2050, but where will this energy come from?

Enormous amounts of clean energy is available; the six black dots on the picture above is enough to produce 18 TW from solar energy, and additional wind energy resources are available. With the historical development of solar and wind power between 2000 and 2016 as basis, Einar has developed a model for future global solar and wind power production. By his modelling, Einar finds that the global demand for fossil fuels will crash during the period 2030-2040, and in 2050 almost all power (in addition to hydro and nuclear power) will be supplied by solar and wind. However, the development of solar and wind is slowed down by a number of resistances/breaks/inertia such as politics, human



Einar Svendsen (Photo: Bergen Energy Lab)

tradition, presence of fossil fuelled based technology, the challenge of energy storage and so on.

Einar Svendsen also talked briefly about climate change's evil twin, ocean acidification. Ocean acidification is directly linked to the use of fossil fuels, and a sneaking threat to marine ecosystem functioning. Norway is the world's second largest exporter of fish and fish products, it is Norway's second largest export product after fossil fuel and by far the largest based on renewable resources. The risk of ocean acidification is uncertain, and depends on the ecosystem's ability to adapt to acidification and human's ability to adapt to changes in marine life; meaning that the precautionary principle should be applied.

Read more in Einar's presentation here

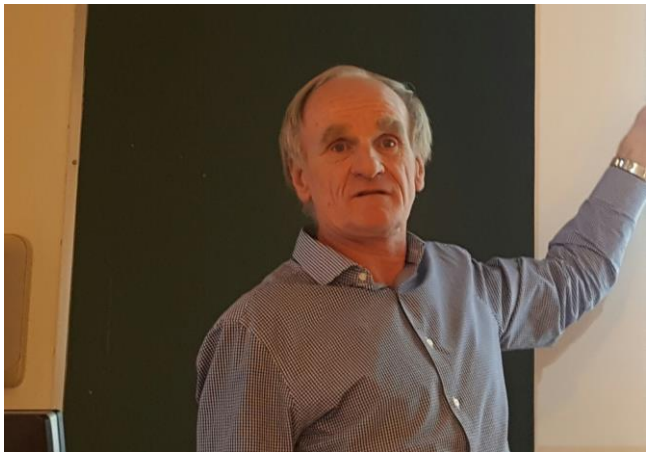
Does the world really need more energy?

Access to clean and affordable energy is essential to eradicate poverty, end hunger and combat climate change, but do we need to change the way we think about energy?

The demand for energy is increasing

The growth in primary energy demand has gone hand in hand with economic growth in the last decades. This trend is expected to continue, as the world population increases and more and more countries are lifted out of poverty and increase their standard of living.

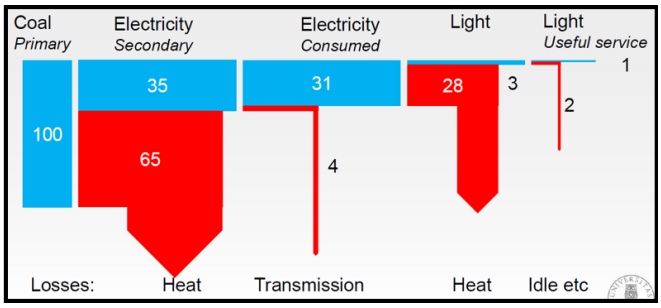
In their World Energy Outlook (WEO) new policies scenario, the International Energy Agency (IEA) projects a 30 % increase in the world's primary energy demand by 2040. Others, such as DNV GL in their Energy Transition Outlook (ETO), claim that the demand for primary energy will peak already in 2030, largely driven by electrification and increased energy efficiency.



Professor Finn Gunnar Nielsen (Photo: Stian Backe)

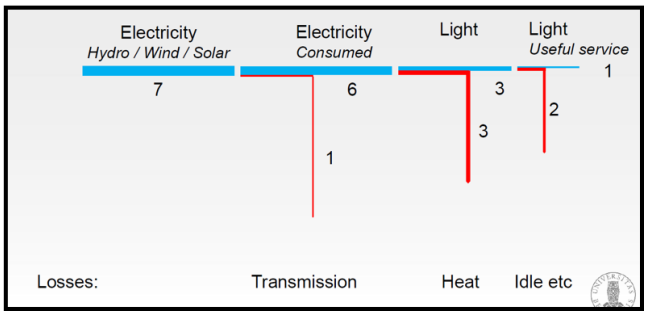
Primary energy vs energy services

Professor Finn Gunnar Nielsen showed how reducing the demand for primary energy is possible with a very powerful example: the ordinary service of providing light. The Sankey diagrams to the right illustrate how providing light from a coal-fired power plant via an incandescent light bulb to useful light needs an energy ratio of 100:1 from primary energy to a useful service. Achieving the same service using renewables and a LED light bulb only requires an energy ratio of 7:1.



From coal via an incandescent light bulb to useful light service (Figure: Finn Gunnar Nielsen)

This shows that by switching from coal to renewables and by applying a more effective end-use technology, the primary energy demand is reduced 14-fold!



From renewables via a LED light bulb to useful light service (Figure: Finn Gunnar Nielsen)

The unlimited potential of renewable energies

Installed capacities of solar and wind are growing every year. Through the year of 2017 about 75 GW of solar and 54 GW of wind capacity was installed worldwide. At the same time, costs are dropping and renewable energy technologies are increasingly competitive with fossil fuels. Solar and wind are becoming the cheapest generation technology alternative in more and more countries, even without subsidies.

Finn Gunnar also showed the massive potential for various renewable energy technologies, which exceeds the demand for energy multiple times.

The intermittent nature of the solar and wind resource is, however, a challenge that needs to be resolved, possibly by the application of various energy storage technologies.

"150 000 wind turbines are needed to replace the energy in Norwegian gas export"

Finally, Finn Gunnar had also taken a closer look into some of the statements made by the CEO of Norwegian Oil and Gas, Karl Eirik Schjøtt Pedersen, at the conference "*Vi må snakke om i morgen*".

Firstly, Schjøtt Pedersen claimed that Norway's export of gas to the EU corresponds to ten times the Norwegian electric energy production. Second, we would need 150 000 wind turbines to replace the energy in this gas.

The statement in itself is correct. The energy content in the gas amounts to about 1250 TWh, which is about 10 times larger than the Norwegian power generation of 140 TWh. However, this is like comparing apples and oranges; we need to look where the gas is used to be able to compare it to electricity.

Using gas to generate electricity has an efficiency of maximum 50 – 60 %, whereas using gas for house heating has an efficiency of about 80 %. On the other hand, renewables (hydro, wind and solar PV), generate electricity directly (efficiency of 100 %), and through heat pumps they achieve house heating efficiencies of about 300 %. This results in a so-called primary energy factor of 2.5, i.e. we need 502 TWh of electricity to replace the 1254 TWh of energy embedded in the gas.

This brings us to the second statement. Assuming wind turbines have an average capacity factor of 0.4, 143 GW of installed wind power is needed to produce the 502 TWh/year of the electricity required to replace the gas exported from Norway each year. The next generation of wind turbines are at a size of approximately 10 MW – i.e. 14 300 wind turbines would be needed. This is 1/10 of what Schjøtt Pedersen claimed! With the present installation rate in the EU of 15 GW of wind capacity added per year; wind energy could replace Norwegian gas export as fast as in ten years.

Read more in Finn Gunnar's presentation here.

Reducing Cost of Energy for Tidal Stream Turbines through Co-location

Can placing wind turbines on top of tidal turbines help reduce the cost of energy from marine renewables?

Dr. David Lande-Sudall is a Research Fellow at the Western Norway University of Applied Sciences (HVL), working with marine engineering research in the 50m-long MarinLab towing tank. In a joint Bergen Energy Lab and Maritime Bergen lunch meeting, David talked about how co-location of offshore wind and tidal stream turbines can reduce the cost of energy from marine renewables. David also gave a guided tour to the MarinLab towing tank, where both industry and academia can test new ship designs, maritime equipment or marine renewable energy technologies concepts.

Levelised Cost of Energy

Cost is one of the main drivers for the commercialisation of renewable energy technologies. A frequently used term is the levelised cost of energy (LCOE), often used as a measure to compare the competitiveness between various energy generating technologies. The LCOE is a measure of the cost per kilowatt-hour to build and operate a plant over its financial lifetime, discounted to its present value.

David Lande-Sudall (Photo: Bergen Energy Lab)

In his presentation, David focused on two ways of improving the LCOE of tidal stream arrays; reducing the investment cost (CAPEX) or maximising the energy yield.

Reducing cost of energy by co-location

In his presentation, David focused mainly on two ways of improving the LCOE of tidal stream arrays; reducing the investment cost (CAPEX) and maximising the energy yield. According to David, placing a wind turbine on top of a tidal stream array could achieve both. This would increase the power output of the structure and at the same time make it less variable. It would also reduce the complexity, allowing shared support- and infrastructure with the aim to reduce the capital cost of investment.

In his work, David modelled both the energy yield and the extreme loads on the structure. He looked at three main configurations: a tidal turbine on its own with a very small tower, a tidal turbine with a large tower, and finally multiple rotors on a shared support structure.

David's results show that co-location results in a lower LCOE in comparison to a tidal array alone. One could achieve cost savings of more than 10 % compared to installing tidal turbines only, and increase the energy yield by at least 12 %. However, co-location will also increase the peak loads significantly. In the case of using a two-rotor configuration with a shared support structure, the peak loads increased by as much as 65 %. Although the load is much larger, a support structure to withstand those loads could be manufactured.

MarinLab towing tank

The MarinLab towing tank is a 50-meter long laboratory for testing marine vessels and

renewable energy devices. It has an Edinburgh Designs force-feedback wave maker, and a towing carriage with a maximum speed of 5 m/s. In addition, HVL also has a lot of infrastructure for in-house model manufacturing, such as a 3D-printer for quickly making prototypes to test in the tank.

Students on the joint UiB/HVL energy master have the opportunity to work in the MarinLab through their master thesis projects. The tank is also available for commercial hire. If you are interested in accessing the MarinLab, contact either Dr David Lande-Sudall or Dr Glora Stenfelt. You can find their contact information on the website of the MarinLab here.

Read more and watch David's presentation here

The Winter Package and the Agency for Cooperation of Energy Regulators (ACER)

An agency with 'lots of power' and no teeth?

The Agency for Cooperation of Energy Regulators (ACER) and the Winter Package has been the centre of a heated debate in Norwegian media lately. On March 6 as part of the Bergen Energy Lab lunch seminars, Ignacio Herrera Anchustegui spoke about the content of the new proposal, what kind of powers ACER could have in the future, what it means for the future of energy, and the impact of such decisions for both the EU and for Norway.

Ignacio Herrera Anchustegui (Photo: Dragefjellet Lærings- og Formidlingssenter)

The Agency for Cooperation of Energy Regulators (ACER) was established in the EU in 2009 as a part of the 'Third Energy Package', a set of rules enacted in the EU that aim to create a single EU gas and electricity market. Norway is already a part of the second energy package, but is currently discussing the contents of the third one, particularly the establishment of ACER.

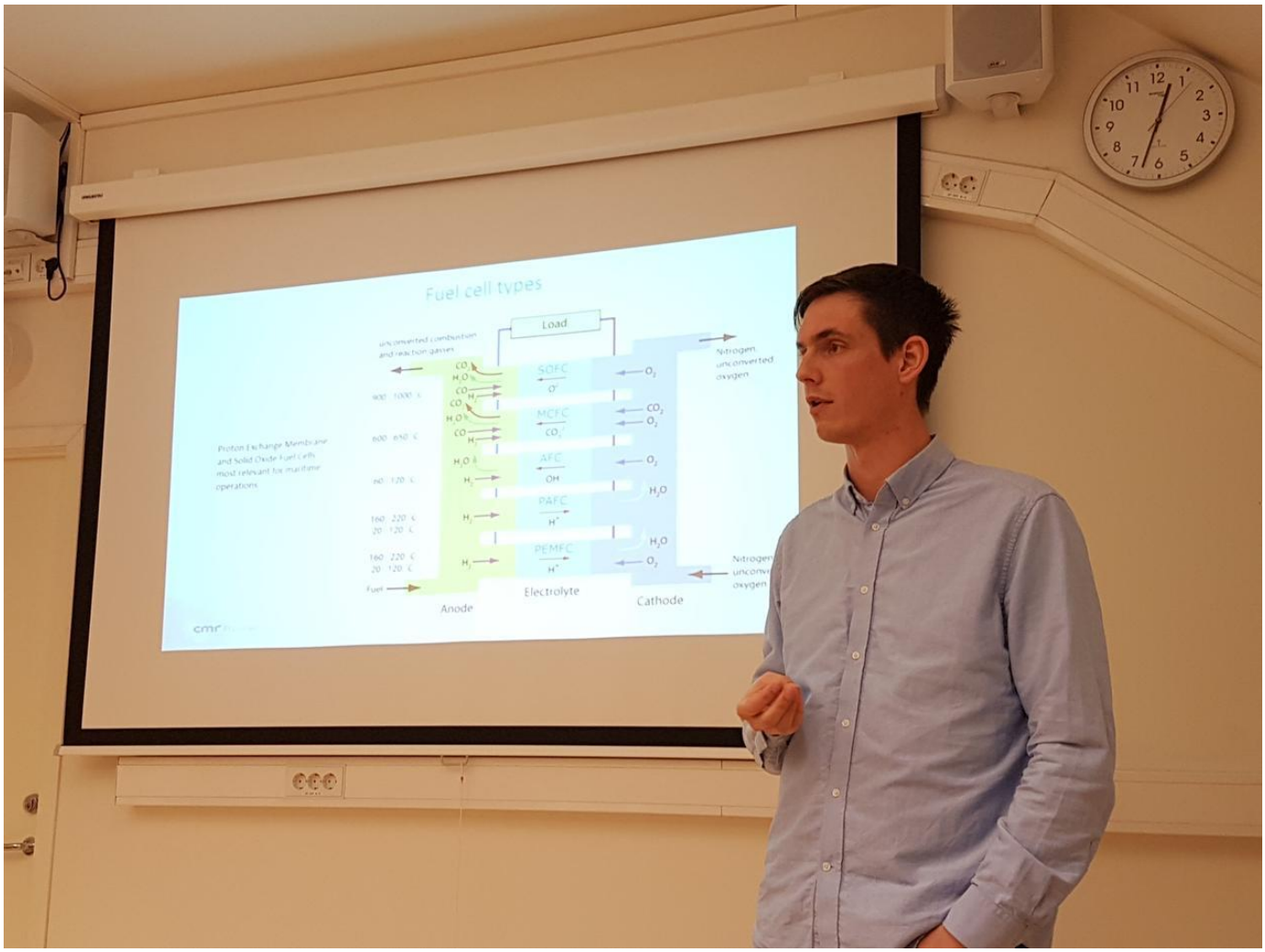
ACER's current role is to help the cooperation between different national regulators, enhance competition, review network development plans and monitor the functioning of the internal market including work to secure fair retail power prices. The Agency can also take binding individual decisions in specific cases and under certain conditions on cross-border infrastructure issues.

In the EU Commission's Winter Package from 2016, currently being negotiated, the EU seeks to further develop the Energy Union, which aims to create a common energy market for the EU, to improve security of supply, promote renewables and to reach ambitious climate targets. Among many other measures, it also proposes to grant further competences to ACER. This includes a strengthening of ACER's power regarding decision making on cross-border issues, monitoring national market's performance, wholesale market supervision and a stronger role in developing network codes.

These proposed rules which are likely to be adopted in the EU in the second half of 2018 will shape the energy future in Europe and Norway. While they do not radically change the current regime, the rules will have an impact on how and what kind of energy is produced, the way that it is transported, the role of end consumers and, particularly, a stronger focus concerning renewable sources. What seems clear is that the energy future in Europe looks more and more green and electric. See Ignacio's presentation here.

Fuel Cells and Hydrogen in Maritime Applications

Tjalve Magnusson Svendsen is a researcher at Prototech AS, a company in the Christian Michelsen Research group focusing on prototype development and with 25 years of experience within research, development and testing of hydrogen and fuel cell technology. On the 13th of March, Tjalve held a presentation for the Bergen Energy Lab on fuel cells and hydrogen in maritime applications.



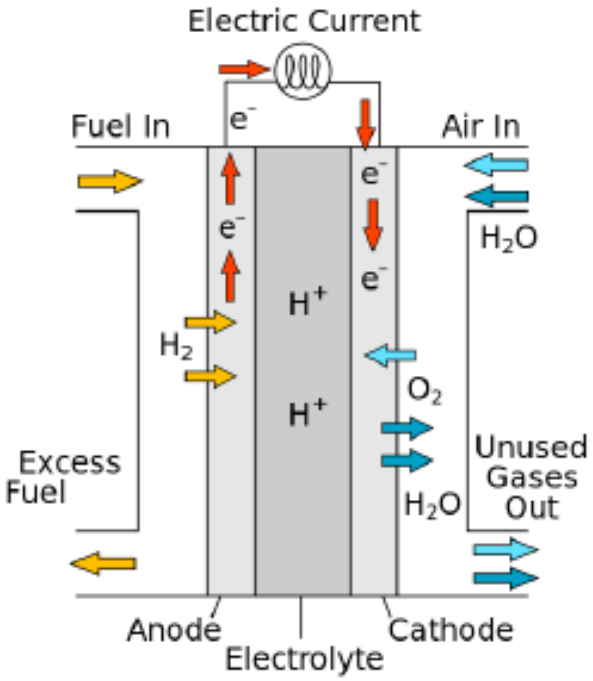
Tjalve Magnusson Svendsen (Photo: Bergen Energy Lab)

What is a fuel cell?

A hydrogen fuel cell is an electrochemical unit that produces electricity from hydrogen and oxygen. There are several types of fuel cells capable of operating with various fuels, and for various applications. Common to them all is that they consist of an anode, electrolyte and a cathode.

The general operating principle of a fuel cell is rather simple (see figure below of a Proton Exchange Membrane (PEM) fuel Cell), and consists mainly of two chemical reactions. Hydrogen (H_2) enters the fuel cell at the anode, where it is oxidised by a catalyst. This turns the hydrogen molecule into positively charged hydrogen ions (H^+) and negatively charged electrons (e^-). The ions then travel through the electrolyte, which is designed so that the ions can go through it, but not the electrons. The electrons are therefore forced to take the route through an external wire, thus generating an electric current. Finally, the electrons and hydrogen ions meet

each other at the cathode, where they react with oxygen to create water.



Schematic of fuel cell operation (Copyright: R.Dervisoglu)

Among the many fuel cell technologies available, Proton Exchange Membrane (PEM) and Solid Oxide Fuel Cells are the most relevant for maritime applications.

Anode side reaction:

$$2H_2 \rightarrow 4H^+ + 4e^-$$

Cathode side reaction:

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

Net reaction:

$$2H_2 + O_2 \rightarrow 2H_2O$$

Maritime Applications

According to Tjalve, the maritime sector is an obvious case for electrification and one that has a huge potential to significantly reduce energy consumption, emissions and total cost of ownership. This “electric revolution” has already started in Norway, represented by the world’s first battery-powered ferry, Ampere, being launched as early as in 2015. Furthermore, through a successful ferry-tender in 2016, the Hordaland county council was able to cut CO_2 emissions by about 90 % and reduce energy consumption by about 65 % on 17 ferry connections.

The same development approach has now been initiated for hydrogen car ferries. The Norwegian Public Road Administration has launched a contract for use of minimum 50% hydrogen for a car ferry in the Hjelmeland-Nesvik-Skipavik crossing, to be set in operation from 2021. In addition there are several ongoing pilot projects under development in Norway.

Fuel cells and batteries are complementary technologies, and are both needed to achieve an emission free maritime sector. For example can fuel cells be able to provide a zero emission alternative for energy intensive applications where there is a limited time or access to charging facilities for batteries.

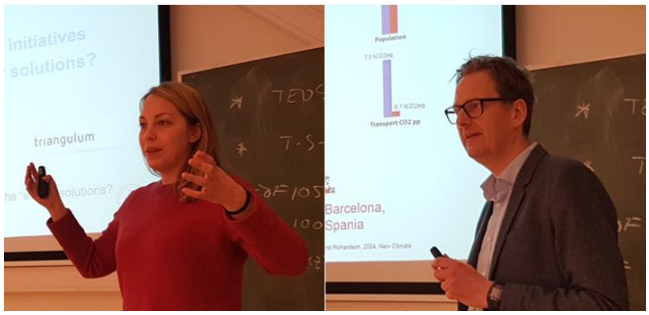
The advantages of using fuel cells are many, including low weight, fast "charging", no significant noise or vibrations, low complexity, high level of redundancy, high part-load efficiency and a low energy consumption with electrical efficiencies of about 50-65 % and the possibility of utilising rest heat to further improve the overall efficiency. However, the cost and lack of infrastructure for hydrogen as a fuel remains a barrier for widespread implementation. In addition, the fuel cell technology has to be optimised and further adapted to maritime applications.

Read and learn more about hydrogen and fuel cells for maritime applications in Tjalve’s presentation here, including the very interesting Hydrogen Viking project where the world’s first luxury yacht powered by hydrogen is developed.

The role of smart cities in promoting energy transitions

- Do smart city projects make cities more sustainable?

On March 21, Marikken W. Wathne and Håvard Haarstad from SpaceLab held a presentation on the role of smart cities in promoting energy transitions. A wave of "smart cities" is washing over Europe, with more than half of European cities with over 100,000 residents currently having implemented or proposed smart city initiatives. These initiatives are characterised by a strong focus on technology, innovation and entrepreneurship, but the concept of sustainability seems to be missing as an important driver.



Marikken W. Wathne & Håvard Haarstad (Photo: Bergen Energy Lab)

The "Smart City" has a flexible framing and no precise definition. It is usually associated with the implementation of technology in order to solve urban problems with a holistic and interdisciplinary approach to urban planning. This involves smarter and more efficient ways to use energy, to create better public services for the inhabitants and to generate economic and social prosperity in a sustainable way. The use of information and communication technology (ICT) is often referred to as the key enabler for making cities "smart".

More than half of the world's population are living in cities today, a number believed to increase to about 66 % by 2050. Cities keep getting bigger, and Smart Cities is very much a large city phenomenon. In Europe, 51 % of cities with over 100 000 inhabitants and more than 90 % of cities with over 500 000 inhabitants are Smart Cities.

In their presentation, Marikken and Håvard presented results from fieldwork carried out in three EU Horizon 2020 Smart Cities: Nottingham, Stockholm and Stavanger, and tried to answer how environmental concerns are integrated into the "smart" solutions.

As an example, the Smart City project in Stavanger was very much about filling the void from the petroleum industry. The need for Stavanger to find new business opportunities and a new niche was combined with the need of improving local transport systems. It built on already existing projects and focused on small improvements or adoption of familiar technologies, rather than innovation through new technological solutions. A similar story was told by an informant in Nottingham when asked why they were doing a smart city project, "We are looking for the next steps. We know what we want to do, we haven't always got the funding for it, so we are actively looking for funding."

Read more in Marikken's and Håvard's presentation here. Also check out the book "Grønn omstilling – norske veivalg", edited by Håvard Haarstad and Grete Rusten, kindly given as a gift to the Bergen Energy Lab after the presentation.

Energy, measurement and society

Read about our recent half-day seminar on the measurement of energy, its infrastructure and its implications for the society.

Energy drives everything around us. Everything you do, the car you drive, the phone you use, the food you eat, the light in your home, everything requires energy. But how, and why do we measure energy? What infrastructure do we have, how will we measure energy in the future, and can measuring energy impact social and environmental aims? On April 10th, four experts from around the world came together to discuss these questions.

For those who could not attend the seminar, and for those who want to see it again, a recording of the full seminar, except the closing discussion, is available here.

Professor Steven Wolf (Copyright: Bergen Energy Lab)

Professor Steven Wolf from Cornell University opened the seminar with a talk on the multi-faceted challenge of measurement from an analytical perspective. According to Steven, measurement is an input to management that through tracking and monitoring allows us to understand and perhaps control things. He also warned that in the question of sustainability, elected officials, bankers and consumers could use science, technology and measurement as a substitute for action. We already know what is needed, but instead of action, we are over-studying things.

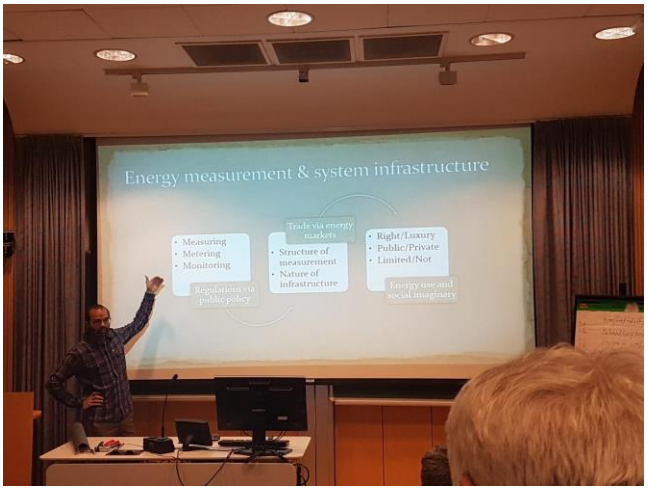
BKK is a power company providing electricity to about 213 000 consumers in western Norway. Measurement is crucial in their everyday business, enabling them to monitor the grid, operate it in an effective and reliable manner, comply with regulatory requirements, and of course invoice their customers. Hans-Terje Ylvisåker is the programme director of BKK SmartNett. In his presentation, he introduced measurement in BKK today and in the future. New sensor technologies will be available, such as Radio Frequency Identification Neurons or Universal Wireless Sensors, which are able to measure temperature, pressure and other factors that might affect the operation of the power system. Tomorrow's grid will be smarter, affected by digitalisation, automation, more sensors and an increased interaction with the customers. According to Hans-Terje, the change happening now is disruptive; the change for the last 100 years has been incremental.

More than 50 million households in the EU are struggling to attain adequate heating and cooling, to pay their utility bills on time, and to live in homes free of damp and mould. In Portugal, nearly 30 % of the population is potentially under energy poverty conditions, especially related to space heating and cooling. Dr. João Pedro Gouveia and colleagues from the NOVA University of Lisbon have developed an index to map energy poverty and applied it to a case-study of Portugal. This index tries to map energy poor regions, and to identify hotspots for action by combining socio-economic details of the population with building characteristics and energy performance. This mapping of energy poverty could be useful to identify local actions, to support the definition of

tailor-made policies and could be applied to other countries in the European Union.

João Pedro Gouveia from the NOVA University of Lisbon (Photo: Bergen Energy Lab)

COST (Cooperation in science and technology) is a European framework that supports international cooperation between researchers, engineers and scholars across Europe. Dr. Siddharth Sareen, who also organized and chaired this half-day seminar, is the co-chair of the working group on indicators in the "COST Action ENGAGER: European Energy Poverty". The COST Action aims to change and improve the major societal challenge that household-level energy poverty is in Europe through multidimensional research and policy. Specifically, Dr. Siddharth's working group is trying to develop an operational European energy poverty framework, by formulating indicators and including toolkits that use available and emerging data sources to identify and measure energy poverty on a wide European scale.



Dr. Siddharth Sareen, who also organised and chaired this seminar (Photo: Bergen Energy Lab)

Vehicles for a sustainable future

Norway is leading the way towards a sustainable transport sector. In March, as much as 54 % of cars sold in Hordaland were electric. Read about our recent half day seminar, where we put the spotlight on vehicles for a sustainable future.

Vegard Frihammer from Greenstat showing his hydrogen powered car (Photo: Anne-Kathrine Torvund)

Longer range, better batteries, wider selection of car models and significant tax exemptions have spurred a massive growth of electric passenger cars in Norway. But how do we get to a 100 % share of low-carbon vehicles? How does the transition to a sustainable transport sector look for other vehicle types, and can hydrogen be the solution for long-distance transport? In this joint half-day seminar organized in cooperation between Klimapartnere Hordaland, the Western Norway University of Applied Sciences (HVL) and Bergen Energy Lab, we put the spotlight on vehicles for a sustainable future.

Following a networking lunch, the dean of the Faculty of Engineering and Science at HVL, Geir Anton Johansen, officially opened the seminar by stressing the importance of collaboration in developing the vehicles of tomorrow. By bringing together actors from both the automotive and energy industry, the authorities as well as academics, we hope seminars like this might lead to more collaboration across entities and perhaps even inspire new projects.

Materials for a more sustainable automotive future

International cooperation is just as important, and the first speaker of the day was an expert on lightweight materials from Germany. Dr. Robert Schneider from Aalen University demonstrated how weight reductions in vehicles could save fuel and reduce emissions, and thus improve the sustainability of automotive structures. He gave an example of using aluminum instead of steel, which would lead to a weight saving of about 40 % and by that reduce fuel consumption. However, we also need to consider the whole lifecycle of the car and take into account the production of the material. Producing one kilogram of aluminum requires about 10 times as much energy and emits about 10 times as much CO_2 as producing one kilogram of steel. Choosing aluminum would therefore only make sense if the car is going to be driven a significant distance (more than 100 000 kilometers to reach break-even), and the aluminum is recycled.

The status of Green Transport

Torfinn Belbo from ZERO gave an overview of the status of green transport in Norway today. The government has decided to prolong the very important tax exemptions for electric vehicles at least until 2021, and there is a new ruling from the parliament that says that electric vehicles should pay max 50 % of toll, parking and ferry costs. These are two extremely important policies, which are necessary if we are going to reach the very ambitious long-term goals in the national transport plan. The goals say that from 2025, all new passenger cars and light vans should be emission free. In addition, all new heavy vans should be emission free and commercial transport in the largest cities should be close to emission free by 2030.

A Sustainable Drive

Many new technologies are coming to market in the next couple of years, both in terms of passenger vehicles, light vans, heavy-duty trucks and construction machines. Scania has the ambition to lead the shift to a sustainable transport system, and base their approach on three pillars: energy efficiency, alternative fuels and electrification, and smart and safe transport. Ulf Christiansen, marketing manager at Scania, focused mainly on the pillar concerning alternative fuels and electrification in his presentation. Scania has the broadest range of trucks and buses for alternative fuels, with the potential of reducing CO_2 emissions by up to 90 %. Scania is also working a lot on electrification, including efforts on hybrid buses and trucks, battery development & production as well as building electric roads.

Torfinn Belbo from ZERO presented the status of green transport in Norway (Photo: Anne-Kathrine Torvund)

Charging Forwards

Electrification is also important for the regional power company in Bergen, BKK. Henrik Håkonsen told about BKK's internal goal of switching their about 500 vehicles to fossil-free alternatives by 2030. They have also built a lot of charging infrastructure in western Norway so far, including 115 superchargers. There is no doubt that BKK has played a big part in western Norway having the largest share of electric vehicles per capita in Norway.

Hydrogen Possibilities

Electric vehicles are excellent in many cases, but faces limitations in terms of range, charging time and battery weight. Hydrogen could be a good

alternative to overcome these challenges, and according to Vegard Frihammer from Greenstat, hydrogen vehicles could complement electric vehicles rather than compete with them. Together, hydrogen and electric vehicles can work towards a fossil-free transport sector. The important thing is that we achieve our goals of zero-emission transport, and hydrogen can be a big part of that.

Green Transport

Norway's largest grocery wholesaler, ASKO, is a company in the forefront of the green shift. Rune Listhaug, marketing and logistics manager in ASKO VEST presented their efforts on becoming sustainable and climate neutral. The company has a national goal of reducing their energy use by 20 % by 2020, produce their own renewable energy equivalent to 100 % of their energy use, and run their vehicles on 100 % renewable fuel. Not only are they an early adopter of new and climate friendly transport technologies, but they have also already installed large amounts of solar photovoltaic panels and wind turbines as well as a facility producing hydrogen from solar cells for use in their vehicles. ASKO will make use of electric- and hydrogen powered distribution vehicles in the next few years.

Panel Discussion

The seminar was rounded off with a panel discussion on the main challenges and opportunities for the transport sector going forward, featuring Sølve Sondbø from the Hordaland County Council, Morten Woldseth from Skedsmo Municipality, Tomas Fiksdal from Greenstat and Jon Gaute Kvinge from BIR.

Low Carbon Vehicle Display & Test Drive

After completion of the program, the participants moved outside in the Bergen sun for a display and test-drive of several low-carbon vehicles. Both hydrogen and electric cars were present, in addition to a new electric bicycle used by DB Schenker for distributing packages within the city of Bergen. The bicycle can carry up to 300 kg of goods, and has a range of about 80 kilometers. Currently one bicycle is in operation in Bergen, but 15 to 20 more are coming to Norwegian cities in the near future. Innovative solutions like this are needed if we are going to make the transition to a sustainable transport sector.

Read more in the presentations below, and see recordings of all the talks in the menu to the right!

Kårstein Måseide from the Centre for climate and energy transformation tested the new electric bicycle used by DB Schenker. (Photo: Anne-Kathrine Torvund)

Riders on the Storm - Investors' Fiduciary Duty and Liability in Climate Change Matters

With climate change cases topping number 1000 around the world, who is next? Is there a long leap from companies to investors and pension funds? Should we expect, or plan against, a (further) climate case against Statoil and a climate case against "Oljefondet"?

Esmeralda Colombo is a PhD candidate who does research on climate lawsuits at the Faculty of Law at the University of Bergen. On April 24th, she held a presentation at the Bergen Energy Lab about investors' fiduciary duty and liability in climate change matters.

The costs of renewable energy technologies are falling rapidly, and every year since 2015, more renewable energy has been added globally to the energy mix than all other sources combined. Electric vehicles might reach global cost parity in 2024-2025, and there are almost 10 million people employed in the renewable sector worldwide today.

Still, traditional oil companies are investing heavily in the petroleum sector. In fact, the Carbon Tracker Initiative has estimated that some oil and gas companies have planned investments, even 20%-30% of their investments that are not needed in a two-degree scenario. This poses a significant financial risk, but oil and gas companies are also increasingly facing the risk of climate lawsuits.

Last summer, San Mateo County and other counties and cities in California filed a lawsuit against 29 fossil fuel companies, including Statoil, over their responsibility for contributing to climate change and causing millions of damages to the cities and counties in California bringing the lawsuit. According to Esmeralda, this is just one of the possible ways for holding companies accountable and nudge a change in their corporate strategy.

A fiduciary duty is the legal responsibility of acting in the best interests of another party. Investors who do not take into account the risks related to climate change could be found liable for breaching their fiduciary duty This could potentially lead to cases against not only companies, but also investment funds such as the Norwegian Government Pension Fund – Global ('Oljefond').

Esmeralda Colombo (Photo: Bergen Energy Lab)

. Last week, Esmeralda arranged a lawsuit simulation at NHH involving students in the Economics of Climate Change course. In this case, Nature and Youth and the Republic of Palau sued the Norwegian Government Pension Fund - Global ('Oljefond') demanding the fund to divest and to cover damages for the republic of Palau. Endre Nåmdal, a former judge and former assistant professor at UiB, played the role as the judge during the simulation. He decided that the duty of care was not fleshed out enough, and the claims against the Oljefond were dismissed.

However, in a real lawsuit in the future the outcome could be different. Companies, and the Norwegian Government Pension Fund - Global need to work towards preventing their Liability Risk.

Read more in Esmeralda's presentation here.

Renewable energy and the climate science

Jan Wohland is a visiting PhD student from the Forschungszentrum Jülich in Germany. On May 8, he spoke about the coupling between climate sciences and renewable energy.

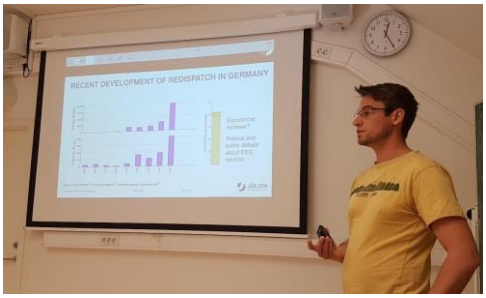
The carbon budget is shrinking. We only have about 9 years left at current emission levels to have a 50 % chance of limiting global warming to 1.5 °C. Emission cuts are urgent, and transitioning to the use of renewable energy sources is a good way to mitigate climate change.

Challenges of system integration

While the economic competitiveness of wind and solar power has dramatically increased in the recent past, the integration of high shares of volatile renewables in the power system remains a challenge. In the first part of Jan's presentation, he looked at the example case of Germany, who have seen a large growth in variable renewables in the latest years. In 2017, the share of renewable energy in the electricity mix reached almost 40 %.

Despite the increase in renewables in Germany, the country has also seen an increased cost due to "redispatch" in the latest years. The dispatch process is designed to minimize the costs of power generation, but it does not necessarily ensure physical feasibility in the grid. In Germany, this can result in a situation where cheap renewable and coal-fired generators are scheduled in the north of Germany, but with lacking transmission capacity to transfer the power to the load centres in the south. This leads to a redispatch process, in which generation is shifted in space to meet the demand. In this case, this means that the more expensive generators in the south have to be switched on, while the unused generators in the north are still being paid

In 2016, the cost of redispatch in Germany decreased, and the underlying causes have been heavily debated. Jan and his colleagues looked into the wind generation in Germany since about 1980, and figured out that natural wind variability triggered the drop in redispatch costs in 2016. They found that 2016 was a rather weak year in terms of wind power generation, and that less variable renewable power generation lead to a reduction of redispatch costs in the order of hundreds of millions of euros. An improved understanding of wind variability is essential to optimize system design & operation.



Jan Wohland (Photo: Bergen Energy Lab)

Robustness of a fully renewable system

Several studies have shown the effect of transmission grids to smoothen the variability from fluctuating renewables. In the second part of his presentation, Jan looked at the robustness of a fully-renewable European power system and how it may be affected by climate change in the future.

Using wind fields from high-resolution climate models and a simple model of the European power system, Jan and his colleagues showed that climate change will have significant impacts on a future power system driven by wind energy. Their results led to a robust increase of backup energy, increased spatial correlation of the wind time series across Europe (leading to countries being more likely to experience generation shortfall at the same time), and finally an increase in circulation weather types usually associated with low Europe-wide wind generation.

This shows that planning and operation of renewable power systems need targeted climatic information.

Read more in Jan's presentation here.

Hydrogen from waste

Ferries and fast passenger boats in Western Norway could run on hydrogen produced from waste in the future!

Norbert Lümmen is an associate professor at the Department of Mechanical and Marine Engineering at the Western Norway University of Applied Sciences (HVL). On May 15, he spoke about hydrogen production from waste.

The Transport Sector

The transport sector in Norway has a lot of potential to contribute to the reduction of fossil fuel use. Many companies and public transport operators have plans to make a transition from mainly Diesel-powered vehicles to the use of either electric, hybrid or hydrogen-powered vehicles in the near future.

In addition, a company could choose to only use hydrogen that has been produced from renewable sources. This puts electrolysis driven by electricity produced from renewable energy sources and the gasification of biomass in focus among the existing methods for hydrogen production. Both can be conducted without the use of fossil fuels.

With regard to the desired implementation of a circular economy, where use of new materials and primary energy should be reduced to a minimum and sourced locally, the question arises, how much of the hydrogen needed for future transport solutions in Western Norway can be produced from available sources in the Bergen region?

Hydrogen production potential in Bergen

In his presentation, Norbert looked into the potential of hydrogen production from municipal solid bio-waste by gasification and from electrolysis driven by energy recovered from waste heat available at BIR's local waste incineration plant in Rådalen, Bergen.

Norbert Lümmen (Photo: Norbert Lümmen)

BIR's incineration plant has a capacity for 210 000 tonne of waste per year. The energy released in this combustion is used to produce high temperature and pressure steam, which is run through a turbine to generate electricity. The rejected heat can then be fed to the district heating network. During winter mode the plant generates 8 MW of electricity and 55 MW of district heat, while in the summer the plant generates 16 MW of electricity and 15 MW of district heat. Due to the lower demand of district heat in the summer, 32 MW of useful energy is wasted.

Norbert explained two different processes from which hydrogen could be produced using excess heat and waste in the incineration plant. Further details on these two processes can be found in Norbert's presentation below.

1. Use excess heat to produce electricity for hydrogen production by electrolysis

    - Electricity from waste heat during summer mode by means of an organic Rankine cycle

- Use of auxiliary electricity during winter mode to have year-round hydrogen production

2. Use wet organic waste fraction as fuel for hydrogen production by gasification

- The total amount of waste that can be handled by the incineration facility increases with new process for organic waste
- The heating value of incinerated waste improves when wet organic fraction is removed

Through the bio-waste-gasification up to 2700 tonne of hydrogen could be produced, while the waste-heat driven electrolysis could yield up to 345 tonne. This could prove to make a considerable contribution to fossil fuel reduction in the transport sector in Hordaland, and several hydrogen ferries and fast passengers boats could be supplied with hydrogen from waste. The costs of producing this hydrogen is comparable to known costs for the different methods, but with high total capital investments especially for biomass gasification.¨

Learn more in Norbert's presentation here.

Sustainable Finance

Can the financial sector be a powerful force in tackling climate change?

Berte-Elen R. Konow is a professor at the Faculty of Law, University of Bergen. On the 22nd of May, she held a presentation at the Bergen Energy Lab about Sustainable Finance.

Berte-Elen Konow (Photo: UIB)

Sustainable finance involves taking into account environmental, social and governance aspects in investments. This includes having a low carbon footprint, promoting the growth of renewable energy, the application of a circular economy and the more efficient use of available resources.

In her presentation, Berte-Elen talked about international as well as national initiatives on sustainable finance. She talked about the connection between sustainable finance and the UN sustainable development goals, initiatives from the European Union, World Bank and branch initiatives from national banks such as Finans Norge and Nordea. Two days after Berte's presentation, the European Commision published a press release on their efforts on sustainable finance. Read it here.

If you want to learn more about sustainable finance, take a look at Berte-Elen's presentation here.

Bergen Energy Lab