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## Welcome to the 3rd edition of the Energy Lab newsletter!

It is hard to pick winners in the ongoing transition to renewable energy and modern energy services. It seems a fairly safe bet that hydropower will continue to play an important although perhaps changing role both in Norway and abroad. Wind, including offshore wind that we focussed on last month, is rapidly increasing globally. This month we have some coverage of solar power, which we know is cost competitive in sunny low latitudes, but it is now coming also to Bergen! Our main focus this time however is on hydrogen, in particular hydrogen produced from renewable electricity with industrial as well as consumer applications.

I found the recent Energy Lab event run by first year energy master students with contributions from BKK, Statoil and Greenstat particularly interesting and stimulating. Sunney Fotedar, Estee Vermeulen and Rouzbeh Siavashi had put together an intriguing program inviting contributors to discuss nothing less than The Future of Energy. Read all about it on page 2 and do not miss the later articles including the interview with second year energy master student Tore Solheimslid on page 8. He is doing his master thesis precisely on industrial applications of hydrogen. Students are our future!

Peter Haugan

Editor: Hans-Kristian Ringkjøb.
Thanks to Meng-Chieh Yang and Ingvild Øijorden for their contributions

# The Future of Energy

**A mini-conference organized and run by students from the UiB/HiB energy master for the Energy Lab was held Thursday the 3rd of November. During this conference three keynote speakers from BKK, Statoil and Greenstat presented their views on the future of energy.**

Professor Peter M Haugan started the mini-conference by presenting the Energy Lab and the UiB/HiB energy master. He also reminded the master students about five 10 000 NOK grants that will be awarded by the Hordaland County Council to those who want to write a master thesis related to their climate action plan.


**Professor Peter M Haugan (Photo: UiB Energy Lab)**

Asgeir Thorsteinsson is the head of the section "Strategic asset management of BKK power plants" in BKK. BKK is a nearly 100-year old power company, with their core business in hydropower and deep roots in western Norway. In later years BKK has also engaged in other activities, such as contracting services, district heating, metering of energy and internet, TV and telecom.

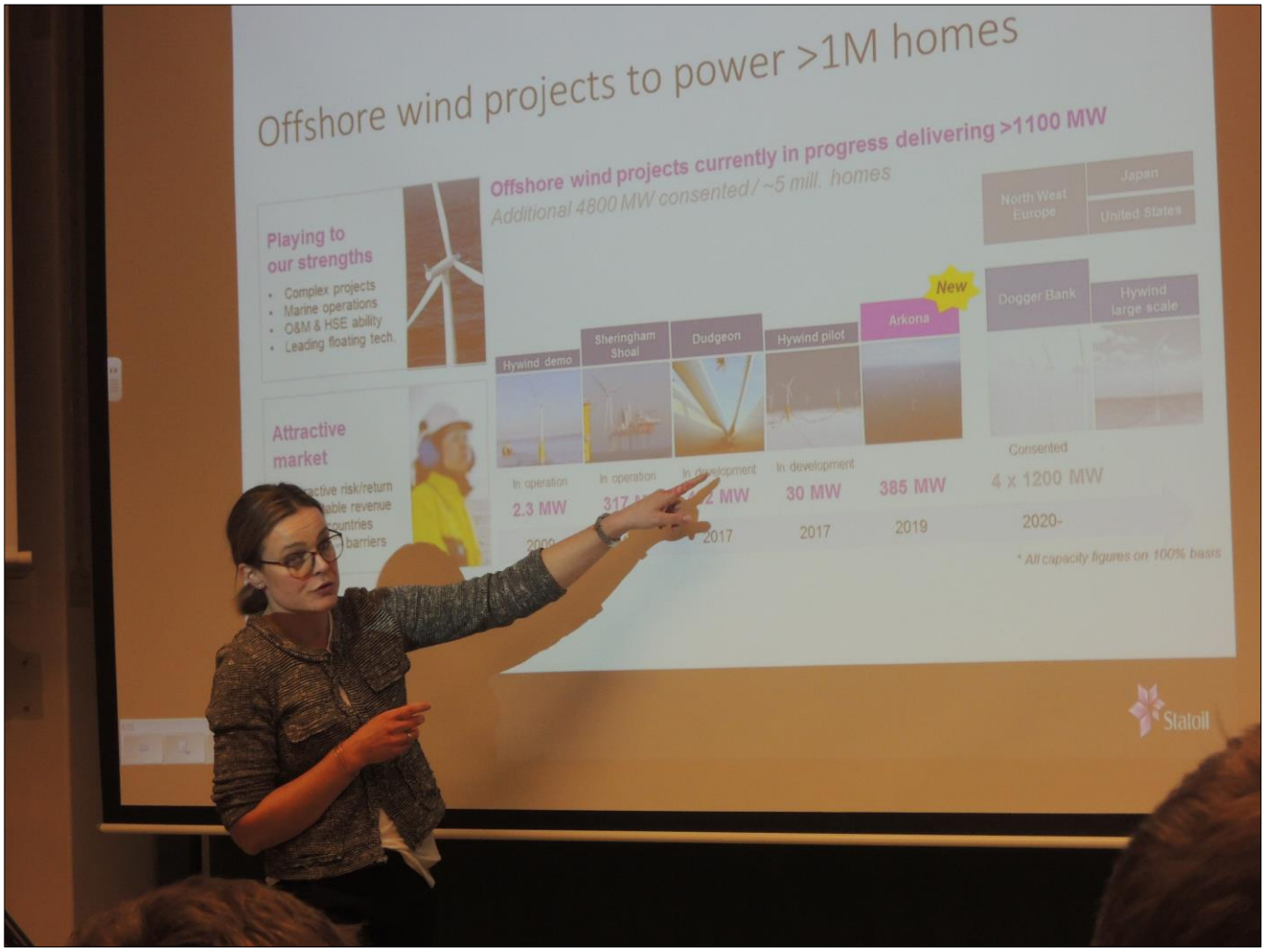
According to Asgeir, the future is happening right now. Alternative energies such as wind and solar are increasing, investors are withdrawing from coal and large global companies such as Google and Apple are positioning for renewable energies. We are moving towards a more decentralized energy system, but hydropower will remain a central part of it. Hydropower can be stored for prolonged periods, produced on demand, easily adjusted and can also be used to decrease flood peaks. Therefore, as the core competency of BKK, hydropower will also be very important for the company in the future.

BKK is also thinking new, and will target other segments than hydropower. For example through new focus areas such as local energy solutions, design of energy systems and charging stations.

**Asgeir Thorsteinsson (Photo: UiB Energy Lab)**

Marte Godvik is a principal researcher at Statoil, and is working mainly on modelling and simulation of loads and responses for both bottom-fixed and floating offshore wind turbines.

Statoil is a large multinational oil and gas company. In 2015 they announced a new business area called New Energy Solutions, which aims to build a portfolio of new, non- oil and gas options. Their focus is primarily on offshore wind and carbon capture and storage (CCS).




**Marte Godvik (Photo: UiB Energy Lab)**

Statoil installed the world's first full scale floating turbine about ten kilometres off the south-west coast of Norway. The turbine has had an overall capacity factor of 40 %, and the installed active motion controller has helped the floater to have no negative impacts on the performance of the turbine.

The Hywind concept has now been further developed, and in 2017 a pilot wind park consisting of five turbines will start producing electricity from the wind outside Scotland.

Statoil is also involved in several other offshore wind projects. All their wind projects currently in progress, including Sheringham Shoal and Dudgeon, will in total deliver 1100 MW enough to power more than a million homes.

The final presentation was held by Vegard Frihammer, the founder of Greenstat. Greenstat is a relatively new company, originally created as the "new green Statoil". It was officially founded the 18th of September 2014, on the same date as Statoil was founded in 1972.

Greenstat focuses on mainly three areas, green insight, local energy and hydrogen. Their vision is to develop and run projects related to sustainable energy and technology, and also projects that help the transition from fossil to renewable energy production and consumption.

In the green insight area, Greenstat makes fact-based future scenarios and investigates which technologies will be the winners in the "green shift". Through local energy, Greenstat believes that through the large price reductions we see on solar, wind and energy storage today we will soon reach "socket parity", i.e. the local energy solutions can produce power at a lower price than the electricity from your sockets.

Vegard Frihammer (Photo: UiB Energy Lab)

Finally, and maybe the area that has received the most focus, is hydrogen. Greenstat aims to be a large-scale producer of hydrogen, to be used as fuel to ships, personal vehicles, for industrial use, back-up and storage and also for export. A colleague of Vegard, Tomas Fiksdal visited the Energy Lab lunch-meeting the 1st of November. He gave a talk entirely about Greenstat's efforts on hydrogen. You can read more about this on page 7.

Finally, big thanks to Estee Vermeulen, Sunney Fotedar and Rouzbeh Siavashi for organizing and running the very successful event!

Sunney Fotedar, Estee Vermeulen and Rouzbeh Siavashi (Photo: UiB Energy Lab)

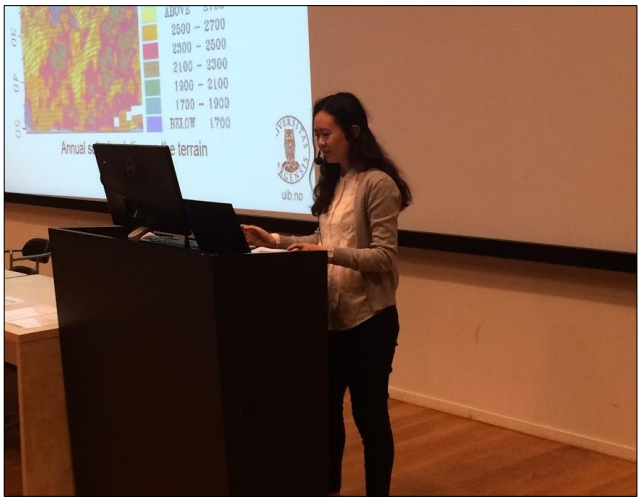
## Solar Resources and solar facilities - What is happening in Bergen?

**The 1st of November 2016, the Norwegian Solar Association (NSF) and Norwegian VVS-Association together held exciting lectures on measurement of solar radiation and photovoltaic systems for commercial buildings in Bergen. In addition, the tour of the new GC Rieber solar facilities on the top of its office here in Bergen was guided and illustrated by the project director from GC Rieber, Gunnar Hernborg.**

PV system on "Basen" (Photo: Meng-Chieh Yang)

Hilde Skeie, the chair of the Norwegian VVS-Association in Bergen, together with Simona Petroncini, the chair of the Norwegian Solar Energy Association in Bergen and the CEO of Solbære AS, held a welcoming introduction talk which was continued by project manager in BKK and the former chairman in NSF Bergen, Alexander Svanbring. The solar energy resources and utilization of solar energy in Bergen were discussed.

Meng-Chieh Yang from the Geophysical Institute at UiB analysed and presented the work she has done with Professor Jan Asle Olseth about solar radiation data from Flesland and Florida and also the energy production of two solar module facilities in Ulsmåg and Haakonsvern.




Meng-Chieh Yang (Photo: Simona Petroncini)

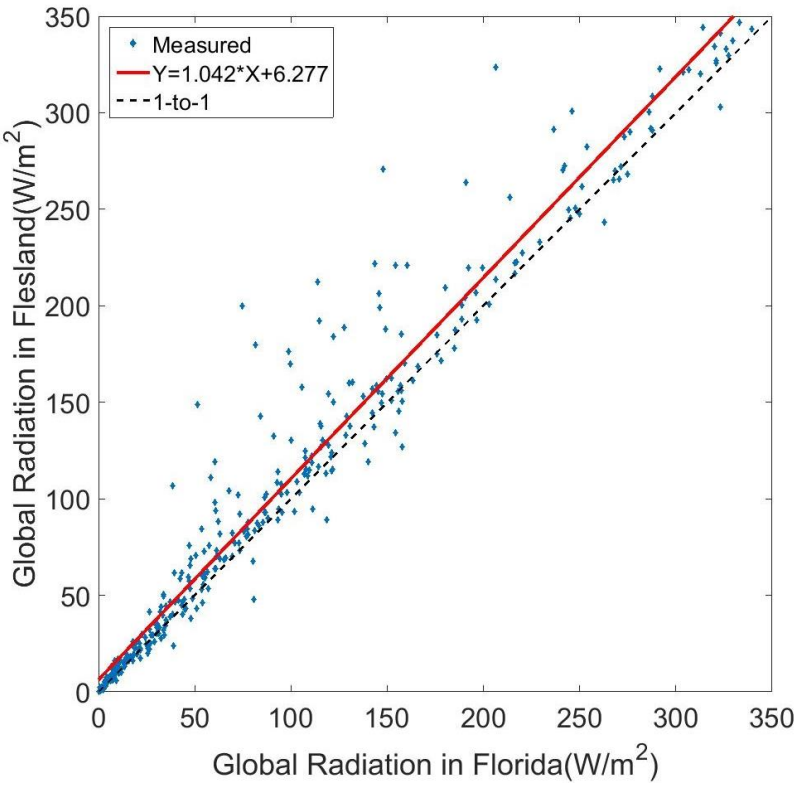
During the last 1 year period, between 01/08/2015 and 31/08/2016, the solar radiation in Flesland has been 11.1 % higher than in Bergen Florida. This is because of the influence of terrain and different weather conditions.

The production from the two solar module facilities has also been correlated with the solar radiation data (see figure below). In the last part of her presentation, Meng-Chieh also discussed the different orientations of solar panels and how it can influence the production, and the optimal tilt angles for solar panels in Bergen in each month and for the whole year.

The second presentation was held by Gunnar Hernborg. He talked about the new plans and possibilities of Marineholmen Research Park in the future. In addition, the new building «Basen» opened at the 12th of September 2016, which has been built by GC Rieber Eiendom AS for DNV-GL. It has solar panels on the roof and is environmentally certified with BREEAM Excellent, which is the second highest level in the environmental certification of buildings completed by BREEAM-NOR.

Gunnar Hernborg (Photo: Meng-Chieh Yang)

One of the features that ensured GC Rieber new top classification in Bergen is the use of solar cells on the roof. Gunnar Hernborg mentioned that solar cells are predicted to produce approximately 80,000 kWh in a year. This corresponds to one-eighth of the building's energy consumption.




Correlation between global radiation in Flesland and Florida for 1 year from 01/08/2015 to 31/08/2016. Flesland receives 11.1 % more radiation than Florida.

# Large-scale production of hydrogen

**On the same day as the event on solar energy in Bergen, the UiB Energy Lab was visited by Tomas Fiksdal from Greenstat during the weekly lunch-meeting. Tomas is the project manager for Greenstat's efforts on hydrogen, and showed us the many exciting projects they are working on.**


Tomas Fiksdal (Photo: UiB Energy Lab)

With the slogan "Making Green Hydrogen Happen", Greenstat is aiming to develop several projects related to production of green hydrogen.

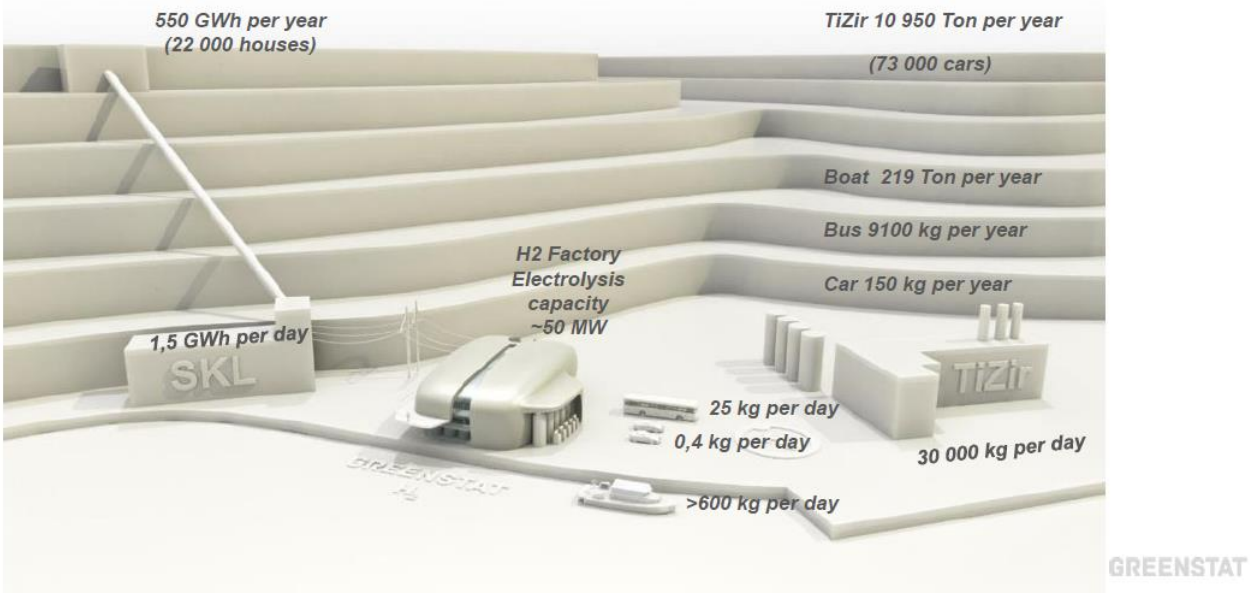
There are two major ways to produce hydrogen today, by steam reformation or by electrolysis. In steam reformation methane is used together with water in order to produce hydrogen and $CO_2$. More than 90 % of the hydrogen produced in the world today is made from fossil input. Although being cheap, this involves both energy loss and emissions.

Electrolysis on the other hand uses electricity to separate water into hydrogen and oxygen. Greenstat wants to use excess clean electricity from Norwegian hydropower to produce Hydrogen.

Greenstat has signed a letter of intent with the Titanium and Iron producer TiZir in Tyssedal, who currently uses coal as an oxidant in their production. The aim is to use hydrogen instead, reducing their $CO_2$ emissions by 90 %.

The idea is to set up a hydrogen production factory in Tyssedal with a capacity of 50 MW, which will deliver about 30 tons of hydrogen to TiZir every day. See the illustration below for some interesting additional numbers.

In addition to the TiZir project, Greenstat is also looking into large-scale production of hydrogen at Statoil Mongstad, smaller scale hydrogen production from run-of-river hydropower as well as developing a fuelling station in Bergen for hydrogen vehicles.




Hydrogen production factory in Tyssedal (Illustration: Greenstat)

# Optimising Hydrogen production facilities

**Tore Solheimslid is on his second year of the energy master program with specialization within energy technology and thermal machinery. He writes his master thesis for Greenstat about optimization of hydrogen production facilities. He hopes his research can help to get hydrogen onto the market to replace fossil fuels and reduce global warming.**

***Why did you choose to study the master in energy at UiB/HiB and why did you choose energy technology?***

At some point during my life it was natural for me to study something within renewable energy. I have a bachelor's degree in energy technology from HiB, and I felt that I needed a master's degree to be better suited for getting a job. I also wanted to know more and have more competence.

***What do you think about the master in energy at UiB/HiB?***

When I first started my master I chose the topic of optimization. After a year I figured out that it didn't suit me very well, as it was very heavy on programming and mathematics. However, if I had the right background, optimization would have been really interesting. Particularly due to its focus on energy efficiency, which is a really hot topic today.

I felt like I had to switch topic to thermal machinery. However, the specialization topic wasn't the most important for me, but the master thesis that I want to write on optimization of hydrogen production.

The topics in thermal machinery are mostly focused on combustion engines. This is a little bit heavy on the fossil fuel topics for me, but it's interesting as it's beneficial to know every side of a topic, so nothing is irrelevant.

***Tell us about your master thesis***.

The basis is that I work part time for a company called Greenstat which in short terms is the renewable energy's answer to Statoil. Greenstat has written a letter of intent together with TiZir Titanium & Iron who produce iron and titanium by using coal as oxidant in their production. They have the option of using hydrogen instead, a relatively new method. So that's how they got in contact with Greenstat. The plan is that Greenstat sets up a production facility and delivers the hydrogen that TiZir needs. If we can produce this hydrogen with the least amount of expenses and the highest efficiency, we would earn more money which is always relevant. So my thesis will be on optimizing the production facility in regard to economy and energy efficiency.

***How did you build the connection with Greenstat?***

Since I already had a part time job at Greenstat, I could write my master thesis in cooperation with them. When I first heard about Greenstat I thought to myself that this had to be the place for me.


Tore Solheimslid (Photo: Private)

Then, I started attending the talks Vegard Frihammer [Founder and GEO of Greenstat] held and I simply spoke to him about my views and asked him questions on various topics. Eventually he asked me to take a summer position at Greenstat and it just escalated from there. So if you have a goal, go for it, don't be lazy.

***How do you and Greenstat benefit each other in relation to your master thesis?***

Hopefully, if I do everything that I'm supposed to do with my master thesis, Greenstat will be able to use my work when we

are going to establish new hydrogen production facilities. If everything goes according to the plan, I will probably have a job for life.

There are a lot of people in the office, especially from Christian Michelsen Research and Prototech, which have a lot of experience with production and consumption of hydrogen. They have agreed to let me bug them with a lot of questions, so I'm quite privileged.

***How do you think your research can influence the world?***

Well, the goal has to be to save the world right? That's a difficult challenge, but let's say that my master thesis gets as perfect as I want it to be. Then Greenstat will have an easier way to establish hydrogen production facilities. As such, Norway will have a greater energy hungry industry and potentially becoming world leading in that sense. The economy of Norway could benefit a lot from that. Everything is relative, my contribution may not mean that much, but it could mean something. On the global scale it would mean less, but it could help to some extent to get hydrogen onto the market, replace the fossil fuels and get a zero emission society which we need in order to limit the global warming to 2 degrees or less.

***How do you think this education can be used in your future career?***

My master thesis will hopefully be used. I learn a lot about various components in the combustion cycles, which is relevant for many other processes. In addition it is good to have knowledge on the details of the components, and that will help me to understand what limits specific processes.

***How do you picture the energy future? What is your vision or hope?***

Hydrogen on the market can make Norway an energy hungry nation. We have so much renewable energy in form of hydropower that the incentive for establishing more new renewable energy is lacking.

Since solar and wind will be very hot topics in the future, we need to be a part of that. We could be exporters rather than importers of such technology, and we could live of that. A lot of other countries really need a lot of solar and wind power in order to sustain themselves in the future.

In Norway I picture an energy hungry industry with less fossil fuel, more hydrogen, more wind, solar and some more hydropower. Globally pretty much the same, but it's more critical that the global emissions go down. We need to reach the zero emission world as quickly as possible in order to be as safe as possible and do it as cheap as possible.

# Energy news from around the world

### There's no way around it: Donald Trump is going to be a disaster for the planet

From VOX (Click here for the original news article)

Brad Plumer has written an interesting albeit worrying blog post about what we can expect from the new president of the United States regarding climate. Trump's view on climate is very clear, calling global warming a hoax created by the Chinese. He has said that he wants to scrap all regulations to reduce $CO_2$ emissions put forward by Obama, including the clean power plan. Trump has also hinted that he wants to get rid of the Environmental Protection Agency, stop all spending on clean energy and even pull the US out of the Paris agreement.

Read also: http://energiogklima.no/kommentar/klimapolitisk-jordskjelv-usa/ (In Norwegian)

### Florida voters say no to misleading solar amendment

From Miami Herald: (Click here for the original news article)

Another important election took place in Florida on the 8th of November. The solar-energy related amendment 1, which has been a devious attempt by local utilities to monopolise the solar-energy market in Florida. The utilities have tried to take advantage of the popularity of solar to pass an amendment that could have been used as a legal barrier to raise fees on solar users and keep out companies that want to compete with the utilities to provide solar energy generation.

Luckily, the amendment was defeated.

### Landmark Paris Climate Agreement Takes Formal Effect. It's Not Nearly Enough

From TIME: (Click here for the original news article)

3rd of November the Paris Agreement came into force, after countries representing more than 55 % of global emissions have ratified the deal. COP 22 in Marrakech from 7th to 18th of November will be the first opportunity for the parties to decide how to implement the deal.

Also read this blog by Jeremy Legget

### Dong Energy confirms oil and gas exit (In Norwegian)

From Dagens Næringsliv: (Click here for the original news article)

### Your feet can be the next source of renewable energy (In Norwegian)

From TU: (Click here for the original news article)

### IEA raises its five-year renewable growth forecast as 2015 marks record year

From IEA: (Click here for the original news article)