

ENERGY18

Energy research increases competitiveness and exports of green technologies



RESEARCH - DEVELOPMENT - DEMONSTRATION

Faster commercialisation of new energy technology

Prices of wind power, photovoltaic solar modules and batteries are tumbling, and digitisation and the Internet of Things are sweeping across the world's technologically most advanced countries – including Denmark. The global green transition provides new opportunities for Denmark, Danish businesses and world-class Danish research, but Denmark is not the only country that can see jobs and exports in the green transition. Continued strong efforts within research, development and demonstration of new energy solutions are therefore vital to maintain and strengthen market share for Danish exporters, develop new strongholds, and to implement a cost-effective green transition in Denmark.

China, the USA, Japan, Germany and many other countries are investing heavily in the green transition. If Denmark is to maintain its leading position, our research, development and demonstration must be ambitious, far-sighted and targeted, as there is a long road from research to a mature-for-market solution. We must be able to deliver high-quality research and remain an attractive hub for innovation, development and demonstration of green solutions. Danish enterprises must also be faster to commercialise their solutions, because time-to-market is becoming ever more important for businesses competing on the global market.

The backdrop for our research, development and demonstration work is

that the market for climate-friendly solutions will grow dramatically in the years to come. There is powerful global demand for more energy, but at the same time the fight against irreversible climate change and for more sustainable development will become even stronger in the wake of the Paris climate agreement and the 17 UN Sustainable Development Goals.

Innovation Fund Denmark, the Energy Technology Development and Demonstration Programme (EUDP) and ELFORSK complement each other well with regard to supporting research, development and demonstration of new green solutions that can be used in both the short and long terms. Together, we will ensure that Danish enterprises reap the full potential of the public efforts within research, development and demonstration and thereby bring the new solutions safely through the valley of death and out into the light as mature-for-market solutions.

Research, development and demonstration should underpin Danish energy and climate targets and develop future export successes in close cooperation with Nordic, European and other international partners, for example in the context of Mission Innovation. The new solutions must promote the green transition and establish the basis for growth and jobs throughout Denmark.

Around 45 percent of the Danish electricity system is now covered by wind energy. In a few years, up to 60-70 per-

cent of electricity production will come from fluctuating sources, so we will need new technologies and solutions to ensure utilisation across sectors, and for energy storage and flexible demand.

Innovation Fund Denmark, the EUDP and ELFORSK are ready to contribute funds to enterprises and knowledge institutions to develop the green solutions of the future. With targeted and coordinated work, we will help develop and maintain the Danish strongholds within green technology; we will pave the way for the green transition, and we will increase Danish exports of energy technology.



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EUDP BOARD

Thea Larsen



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EXECUTIVE VICE PRESIDENT
INNOVATION FUND DENMARK

Tore Duvold



ANDERS STOUGE
DEPUTY DIRECTOR GENERAL
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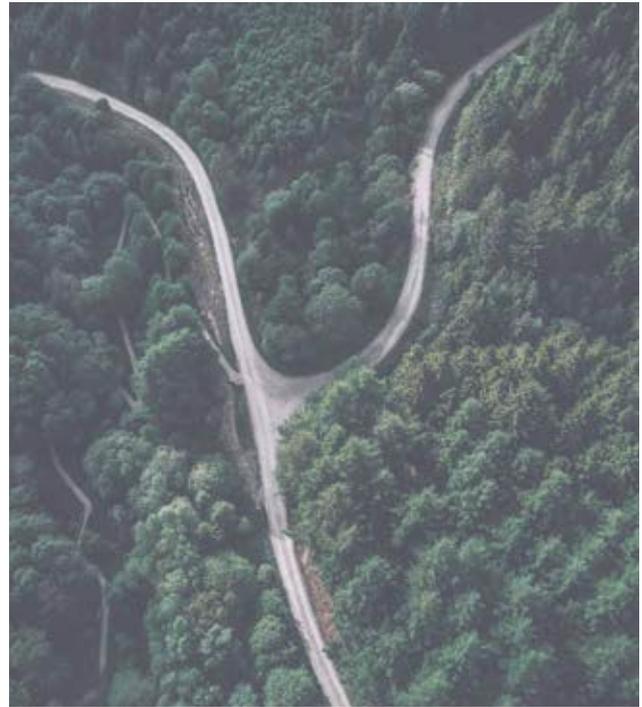
Anders Stouge

We must be able to deliver high-quality research and remain an attractive hub for innovation, development and demonstration of green solutions.

THEA LARSEN, TORE DUVOLD AND ANDERS STOUGE

Synergy from idea to market

Innovation Fund Denmark, the EUDP and ELFORSK work together to develop Danish energy technology. Each of the three programmes has its own focus to support research, development and demonstration at different stages and with different risk profiles to create synergies along the development chain from initial idea to market.



The shared web portal, energiforskning.dk, helps stakeholders to keep track of what the three public programmes are supporting, and what they are contributing to with regard to development of new solutions and technologies. Evaluations show that the initiative has raised the level of knowledge at enterprises and knowledge houses and it has established new collaboration relationships with derived benefits of new jobs and exports of environmental technologies.

Public subsidies cover many areas, from testing related concepts, for example in the EUDP "EnergyLab Nordhavn" project, which has a budget of around DKK 100 million, to technology projects and more research-focussed Innovation Fund Denmark projects like the Centre for IT-intelligent energy systems in cities, with a budget of more than DKK 70 million. ELFORSK supports technology projects with budgets of one or two million DKK in which enterprises develop technologies for efficient use of energy.

Development of new knowledge that can enhance the competitiveness of Danish businesses is key for all three programmes. Among other things, this is through industrial

researcher projects and help for SMEs and entrepreneurs via InnoBooster and InnoFounder under Innovation Fund Denmark, which also supports more comprehensive projects through the Grand Solutions scheme.

The development chain from idea to market needs both small and large projects, just as an ever-more globalised world needs international collaboration, for example Nordic Energy Research and the EU Horizon 2020. The need for green solutions will increase in the years to come, and a massive effort is required throughout the entire value chain if Danish businesses and researchers are to remain at the forefront.

Innovation Fund Denmark, the EUDP and ELFORSK work together to convert promising research results in commercially sustainable solutions.

Through cohesive efforts throughout the development chain, we will ensure that Danish enterprises retain their market share, that Denmark remains an attractive hub for green innovation, and that the green transition in Denmark is cost effective.



The Danish energy research programmes



Energy Technology Development and Demonstration Programme

The EUDP supports development and demonstration of new energy technology, as well as research, inasmuch as the EUDP also supports preparation for development and demonstration. The objective of the EUDP is to create growth and jobs, increase the security of supply, and contribute to the green transition that will make Denmark independent of fossil energy by 2050.

The EUDP also finances Danish participation in international collaboration and knowledge-sharing on energy technologies. The EUDP supports participation in the IEA Technology Collaboration Programmes and Danish membership of Nordic Energy Research. The EUDP also supports projects within several areas of the EU ERA-NET collaboration.

The EUDP can support development and demonstration up to market within all types of energy technology. Demonstration projects in particular can

be difficult to finance, partly because they typically demand large financial resources, and partly because they demand a high risk tolerance. By contributing to financing, the EUDP ensures results from research and development projects are brought closer to market.

The EUDP board's strategy for 2017-19 was presented in early 2017. The strategy places special priority on ensuring that funds are granted in focus areas in which there is a particularly good match between the global demand for energy technology on the one hand, and Danish strongholds and commercial potentials on the other. Furthermore, the strategy establishes assessment criteria and impact targets. The strategy is available (in Danish) at: ens.dk/sites/ens.dk/files/Forskning_og_udvikling/final_strategi_praesentation.pdf

In 2017, the EUDP granted DKK 310 million to 78 projects. Furthermore, the EUDP contributed around DKK 10 million in connection with participation in the IEA Technology Collaboration Programmes and Nordic Energy Research.

Read more about the EUDP (in Danish) at ens.dk/eudp. You can also read more about all the projects supported by the EUDP (in Danish) at energiteknologi.dk



Energy is a major investment area

Innovation Fund Denmark grants funding for research, development and innovation as one of the thematic main areas.

Innovation Fund Denmark's 2016 strategy for energy investment was revised during 2017 and published in January 2018.

The outset for Innovation Fund Denmark's investment strategy for 2018 to 2020 is that the transition of the energy sector provides good opportunities for radical new solutions, and that major technological breakthroughs will typically be based on new knowledge and new competences obtained through strong research and strong public-private cooperation. Therefore, Innovation Fund Denmark will strengthen strategic research in the energy area, increase the momentum of innovation in the Danish energy sector, and help develop radical new solutions for the energy systems of the future.



Moreover, the Fund will invest across sectors in new energy technologies with a high content of material technology, as well as new services and business models with a high ICT content.

Investments should generate economic and social value in Danish enterprises or in public customers in central government, regions and municipalities. Innovation Fund Denmark's investment strategy therefore supports companies' existing strongholds and new innovative solutions.

In 2017, Innovation Fund Denmark invested around DKK 100 million in seven Grand Solutions energy projects within wind, energy efficiency, storage and systems integration. Furthermore, the Fund has made smaller energy investments in research talents/ industrial researchers, business startups (InnoFounder) and innovation in small and medium-sized enterprises (InnoBooster) totalling about DKK 35 million. In 2017, the Fund drew up an international strategy, and the international activities in the energy area for 2017 encompass four Eurostars projects and four projects with approximately DKK 8 million for the six Danish partners in EU Cofund Electromobility Europe. In 2017, the Fund entered into an agreement with the Chinese Ministry of

Science and Technology, MoST, for annual bilateral calls on energy in 2018, 2019 and 2020. In 2018, an agreement was established with India on bilateral calls in the energy area. Innovation Fund Denmark also joined the EU Cofund Smart Energy Systems with calls in 2018. Visit innovationsfonden.dk



**Efficient
energy use**

With its annual DKK 25 million, the Danish Energy Association's research and development programme, ELFORSK, has achieved good results for Danish enterprises looking to use energy efficiently and increase their competitiveness. Entrepreneurs, SMEs, large enterprises, municipalities, GTS institutes (approved technological service providers) and universities apply for funds every year to research into and develop efficient use of electricity and energy within construction and industry. Smart use of data is particularly interesting to make buildings intelligent and flexible. There are still huge

potentials in industry, and a natural development is to use data for efficiency improvements, flexibility and interaction options, and to determine when heat pumps or new processes can replace the use of fossil fuels.

Project results only provide value for Danish society, businesses and consumers when they are applied. Therefore, it is important that project partners help disseminate results and make sure that they are made use of by the correct target groups. In this context, the ELFORSK team helps projects to gain knowledge about the use of their results.

The deadline for submission of applications to ELFORSK is 19 September 2018. We support smaller projects lasting for about two years with average funding of about DKK 1 million, with enterprises contributing a corresponding amount themselves. It is very important that the users of the expected results are involved in projects as active partners.

For more information and to subscribe to our newsletter, visit elforsk.dk.

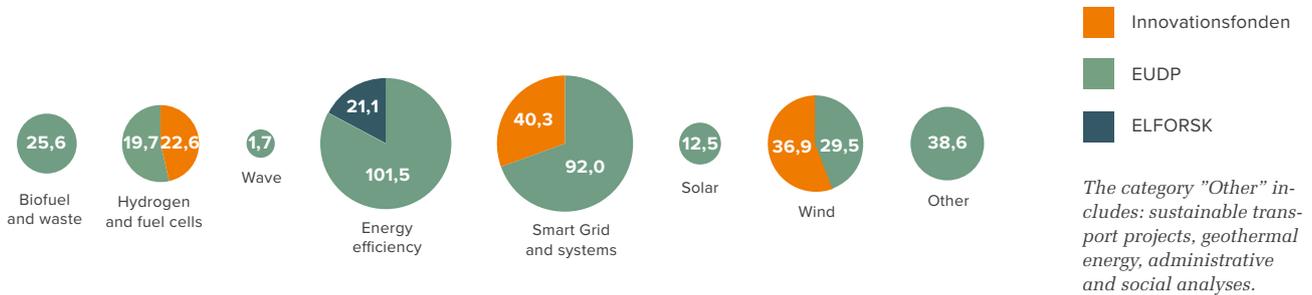
Programme grants

In 2017, DKK 494 million was granted to projects to research, develop and demonstrate the green solutions for the future. Funding went in particular to: energy efficiency, Smart Grid and systems (systems integration) and wind. Systems integration projects include storage, smart energy

and interaction between technologies. Over the past 10 years, funding for research, development and demonstration in the energy area has changed focus. In recent years, technologies such as biomass, hydrogen and fuel cells have become less dominant.

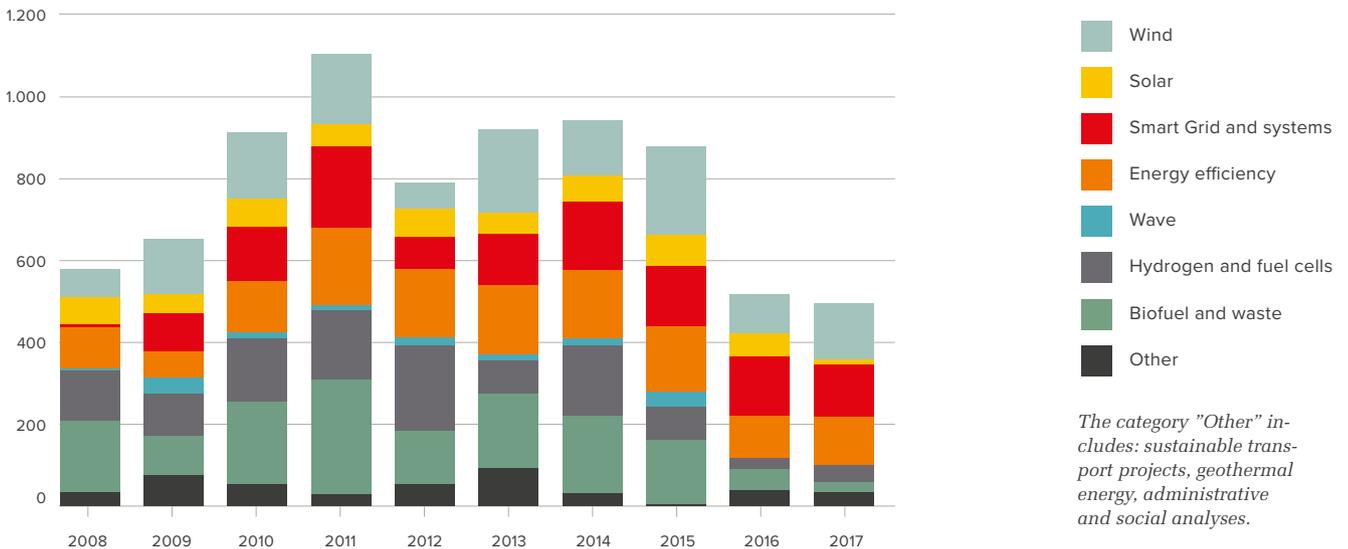
PROGRAMME GRANTS BY TECHNOLOGY - 2017 (DKK MILL.)

Source: Energiforskning.dk



PROGRAMME GRANTS FOR TECHNOLOGIES OVER 10 YEARS (DKK MILL.)

Source: Energiforskning.dk



The graphs on this page are based on data from energiforskning.dk and show how the grants have been used specifically. Therefore, to a certain extent, the figures refer to grants that were not fully utilised by all projects. The figures shown can therefore include reutilisation of grants not initially fully utilised. The graphs include all the energy projects that received grants, irrespective of whether the grants were from the Finance Act and earmarked for energy, or the grants were for a broader objective that just energy.

764 projects in progress

There are currently 764 projects in progress with overall funding of more than DKK 4 bn. The projects are self-financed at between 30-50% of the total project costs. Descriptions of all the projects are available on energiforskning.dk.



Bioenergy and waste

DKK 641 mill.



Hydrogen and fuel cells

DKK 541 mill.



Wave

DKK 45 mill.



Energy efficiency

DKK 954 mill.



Smart Grid and systems

DKK 718 mill.



Solar

DKK 255 mill.



Wind

DKK 953 mill.



Other

DKK 265 mill.

Developments in Danish energy research funding

Public funding for research, development and demonstration in the energy area, administered by different programmes.

During the period, several programmes have been PSO-financed, but this changed with the political agreement on 17 November 2016 to discontinue the PSO tax. ForskEL closed down at the end of 2016 and the projects in progress on 1 January 2018 were transferred to the EUDP. In the years up to 2021, PSO funds for ELFORSK will be transferred to the Finance Act.

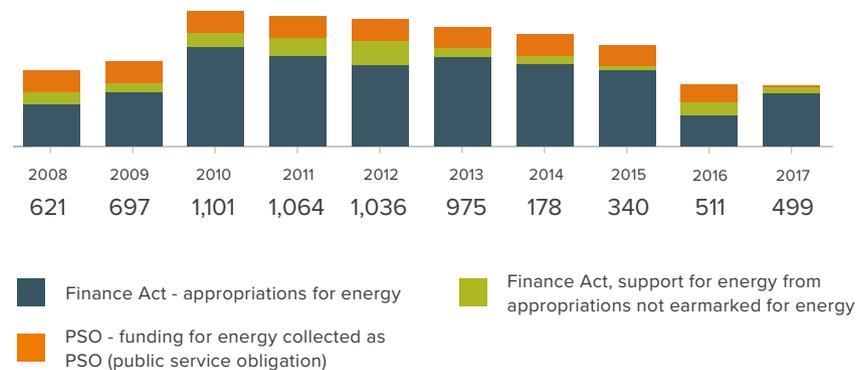
Since 2017, three programmes in particular have supported research, development and demonstration in the energy area. The EUDP and ELFORSK are targeted towards the energy area, while Innovation Fund Denmark covers energy and other areas such as Big Data and material technology. Some of Innovation Fund Denmark's funds are earmarked for energy purposes. In addition, Innovation Fund Denmark invests varying amounts year to year, in energy projects, with grants stemming primarily from Grand Solutions that are not earmarked specifically for energy.

Finance Act and PSO funding for research, development and demonstration in the energy area has also varied over the years. The total public funding is shown for three categories: 1) Finance Act appropriations earmarked for energy 2) Finance Act appropriations not earmarked for energy, and 3) PSO financing.

TOTAL PUBLIC FUNDING FOR ENERGY RESEARCH (DKK MILL.)

Excl. EU grants

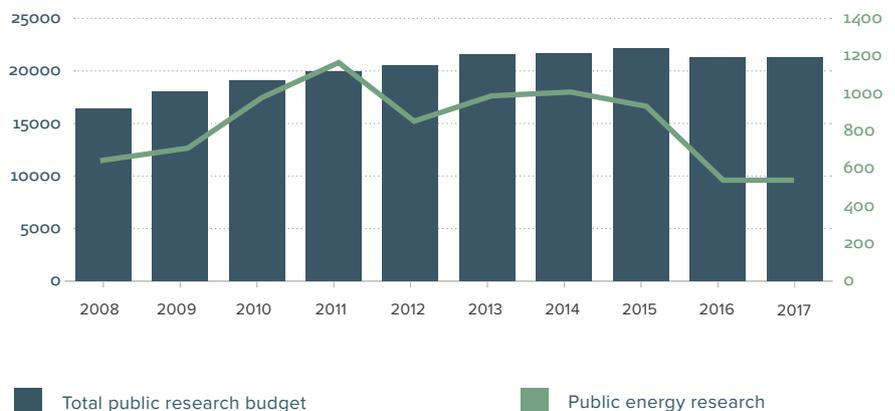
Source: Finance Act, Danish Energy Agency and Innovation Fund Denmark



The graph does not include non-earmarked funds from Innovation Fund Denmark that have been utilised for energy purposes. In 2016, DKK 50 million of non-earmarked funds were included.

ENERGY RESEARCH'S SHARE IN RELATION TO THE PUBLIC RESEARCH BUDGET (DKK MILL.)

Source: Statistics Denmark and energiforskning.dk

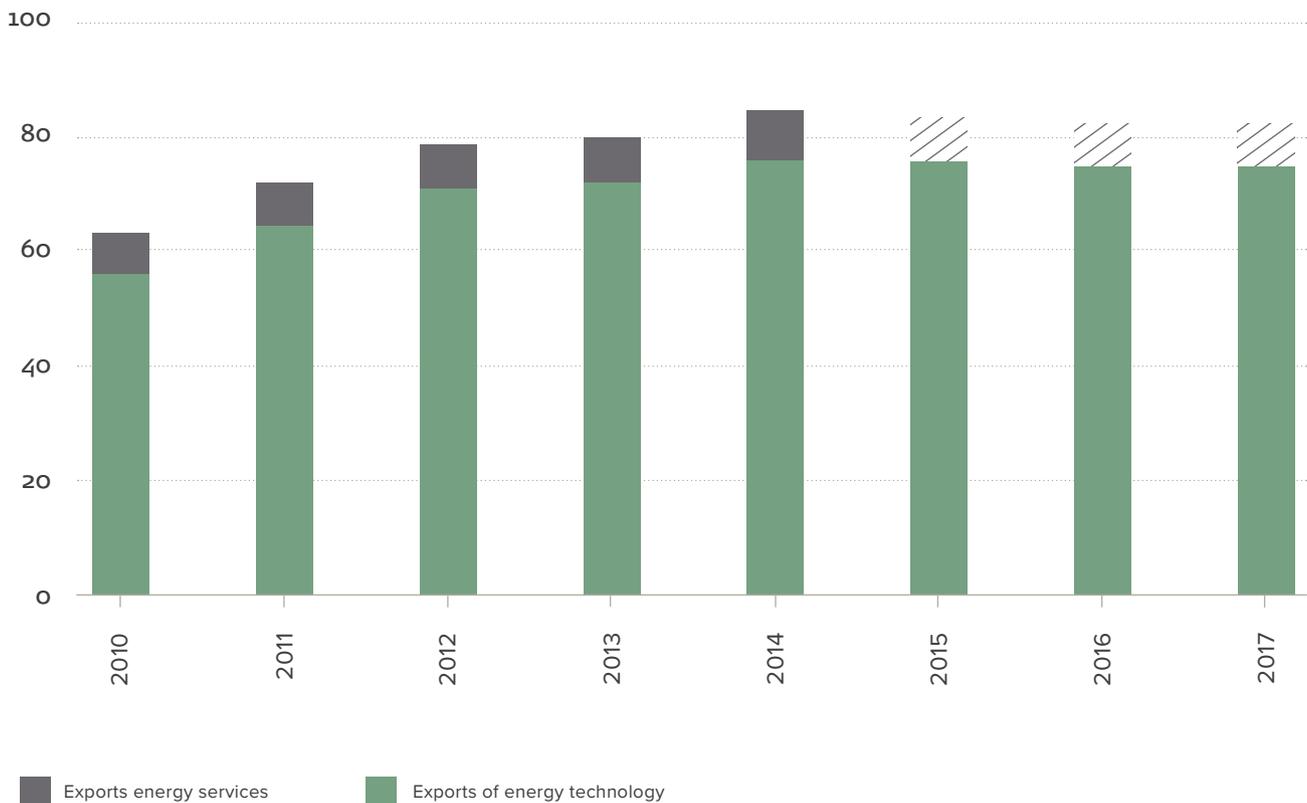


Danish exports of energy technology lose momentum

In 2017, Danish exports of energy technology and services amounted to DKK 85 bn. This is an increase of 1.5% compared with 2016. Exports of energy technology amounted to 11.1% of total Danish goods exports in 2017. Half of the exports of energy technology come from green technologies,

but exports in this context fell for the third consecutive year. Energy research, development and demonstration should help increase Danish exports of energy technology to benefit the competitiveness of Danish enterprises.

DANISH EXPORTS OF ENERGY TECHNOLOGY AND SERVICES (DKK BN.)



Exports are in current prices. The data was revised in 2018. Exports of services at enterprise level in 2015-2017 have been projected on the basis of developments in the sectors' total exports and share of service exports.

Source: Confederation of Danish Industries, Danish Energy Association and Danish Energy Agency.

Lithium Balance sets course for the global market

At its own address in Smørum, Lithium Balance has installed a facility with a battery plant for housing associations with solar installations, for example. The test plant is being used in several of the funded projects Lithium Balance is participating in.

Photo: Lithium Balance

Joint efforts by Innovation Fund Denmark, the EUDP and ELFORSK are supporting Danish development of a key component for global markets for electric vehicles and photovoltaic solar modules: battery management systems.

Production of electric vehicles is now beginning to grow exponentially, closely following trends in battery production. Denmark manufactures neither electric cars nor batteries, but a small company in Smørum is busy developing a key component for electric transport in the future: battery management systems.

“I’m convinced that we’re on the right track technologically, because you simply can’t use lithium-ion-batteries without a management system,” says CEO Lars Barkler from Lithium Balance, which was established in 2005 and which includes Ørsted among its investors.

As part of its journey towards global markets, Lithium Balance is drawing on a number of public subsidy schemes including Innovation Fund Denmark, the EUDP and ELFORSK. Initially, Lithium Balance was involved in projects run by universities and knowledge centres, and according to Lars Barkler this provided a good network for the small company, which had just two employees when he was appointed as CEO in December 2007.

Commercial perspective

By being at the right at the right time, and by offering researchers a commercial perspective, Lithium Balance has made itself felt and now things are snowballing. Lithium Balance has grown in strength, and in recent years the company has placed itself at the forefront of a number of research and development projects. Today, Lithium Balance has more than 30 employees, revenues counting tens of millions of DKK and annual growth on 30-40 percent.

“Support from the research programmes has been crucial for us. When we started, there was almost no market for electric vehicles, and with the financial crisis, it was difficult to raise funding from investors. With support, we could continue our development and take the lead with a technology that is very much needed by the major global players,” says Lars Barkler.

Further investment in technology development

Lithium Balance is now selling its battery management systems and has started earning money, but if companies are to stay ahead and continue to grow, according to Lars Barkler

it is vital to invest further in technology development and new products. Therefore, Lithium Balance is refining its management technology with support from the EUDP. The company is working on management of flow-batteries with support from Innovation Fund Denmark, and it is developing solar-cell/battery-management systems with support from ELFORSK. This means that Lithium Balance is taking advantage of the different entrances to the programmes, among other things with regard to technological maturity at the time of its application for funding.

“We’re not earning fortunes yet, but it is vital to keep up the momentum. Everyone’s talking about electric cars and storage, and the winner technologies are being defined even as we speak. We’re still a small business, so we have to stay in front of technology,” says Lars Barkler, who together with new and old investors - including himself – is developing full battery packs. They hope to launch these next year.

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LARS BARKLER

Important partner in China

On the investor side, the Chinese battery manufacturer, Suzhou Zenlead, which also works with Toyota, has put money into Lithium Balance. China is extremely interesting, partly because China is scaling-up its production of batteries dramatically, and partly because the

Chinese market for electric cars and electric buses is really getting into gear.

“Zenlead will be using our battery management system in the future,” says Lars Barkler. Battery management is also interesting in relation to another growth market: energy storage.

Driven by the remarkable developments in China, prices of photovoltaic solar modules and batteries are tumbling dramatically, and the combination of photovoltaics and batteries will therefore become ever more attractive for homeowners in many places in the world. Battery management systems can help reduce energy loss and optimise the cost-efficiency of these local systems, which typically interact with energy companies’ grids and can probably provide more services for the various electricity markets.

“A lot’s going on right now with energy storage, so here too it’s all about being in front technologically,” says Lars Barkler.

Ten-year journey towards the light



Filament bulb

LED lighting goes from standard goods to design by function, and 3D printing provides a new degree of freedom for future design. These two points will change our perception of lighting, but “it’s a tremendous task because we’re fundamentally changing the way you design products,” says CEO Jacob Willer Tryde from AT Lighting. The company has received financing from Innovation Fund Denmark, the EUDP and ELFORSK to build up networks, develop products and submit documentation that the products work.

The Danish start-up company AT Lighting is gathering partners so that it can fully realise the technology behind an LED bulb the company has developed and send an innovative and energy-saving lighting technology to consumers. With all the benefits of the light source, with the right people on board, AT Lighting hopes to be able to compete for market share, despite the fierce competition from China and established companies.

“We’re finding partners and working to launch our LED bulb in 2019. So yes ... we’re taking up the fight up with the Chinese on the consumer lighting market,” says CEO and industrial designer Jacob Willer Tryde from AT Lighting, as he drives with Alexandra Alexiou, a product designer and ceramicist.

Behind this courageous decision is a world patent and an almost decade-long development process, during which AT Lighting has received support from the EUDP (and ELFORSK and Innovation Fund Denmark for related projects), and during which the start-up company has worked closely with the Technical University of Denmark (DTU), the Danish Technological Institute, and Force Technology, as well as Louis Poulsen, Philips and Osram.

An obstacle course

Jacob Willer Tryde describes the development process as an “obstacle course”, where support from the public programmes has been crucial to develop the knowledge and products, document concepts and establish networks.



AT Lighting has 3D-printed an aluminium cooler core with a powerful 2000 lumen LED module as a part of the HYPERCOOL project funded by Innovation Fund Denmark. The cooler core will be a visible part of the finished lamp. Two prototypes of AT Lighting’s CoolLED bulb from the EUDP CoolLED project on a “bed” of old E27 fittings.



Halogen bulb



LED bulb



LED spot

“Without this support, we would have had a technology we believed in ourselves, but which no one else knew about,” says Jacob Willer Tryde, who in 2009 with Alexandra Alexiou, as part of a final project at the School of Architecture (KADK) at the Royal Danish Academy of Fine Arts, designed LED concepts.

The pair are good at getting ideas, and there is competition for the knowledge they have built up with their network. The LED bulbs with built-in cooling have inspired others to look at cooling for other types of equipment; everything from computers to batteries and engines.

The LED bulbs have also led to further study of cooling, and how 3D printing in aluminium, coupled with advanced computer calculations, can provide new design opportunities. ELFORSK and Innovation Fund Denmark have contributed financing for this line of development. AT Lighting has also worked with engineers from Force Technology, who examined the quality of 3D-printed aluminium cooling cores and tested the effects of chemical-coated surfaces, for example, gold and black nickel.

“This means, for example, we can explain faults and provide advice on the surface treatment that can provide the best heat discharge, the greatest strength and the lowest risk of corrosion,” says Jacob Willer Tryde, who has supplemented his creative talents with business competencies from an MBA at DTU Business.

Commercial philosophy

One of the challenges during the process has been to understand what motivates partners to take the good ideas further and out into the global market:

“We’re ideas people and we’ve been in dialogue with the world’s leading researchers in the area, but navigating in a commercial world is a whole new learning process. Developing our company has taught us that the idea is only



We’re ideas people and we’ve been in dialogue with the world’s leading researchers in the area, but navigating in a commercial world is a whole new learning process. Developing our company has taught us that the idea is only five percent of the work. Jacob Willer Tryde.

JACOB WILLER TRYDE

five percent of the work. If we want to live by the values we’re driven by, we have to be able to do much more. It’s a tremendous task because we’re fundamentally changing the way you design products,” says Jacob Willer Tryde.

With its work on 3D printing, AT Lighting has been a long way ahead of most other Danish companies, but Jacob Willer Tryde thinks that now the method is gaining ground. AT Lighting has patents and ideas for specific products for the processing industry and a number of up-market 3D-printed aluminium products.

Break with Edison’s design

Initially, however, it is primarily about getting a long-awaited profitable business out of the new energy-efficient LED solution, which will break with the format heralded by Edison’s filament bulb more than a 100 years ago, and which LED light bulb manufacturers are copying.

“For a little time yet, lighting will be about buying a lamp with a fitting and putting in a bulb. However, the problem is that the bulb is a “one-size-fits-all solution”, and that the bulb is rarely appropriate for the lamp, as these two things are never designed precisely for each other,” Jacob Willer Tryde points out.

If it were up to AT Lighting, in future LED light bulbs would be designed for a specific lamp, and therefore it would be easy for the consumer to choose the best system without light waste,

with low energy consumption and with attractive lighting.

Jacob Willer Tryde points out that this is not always easy, because designers of future LED lighting solutions have to decide on the number of LEDs, the directions of light, colour temperatures, optics, electronics and cooling. LED means lighting has moved on from basic filament bulbs to a much more complicated outset.

“Our ambition is to make formats that allow us to return to a simple outset for the designer and not least for the consumer,” says Jacob Willer Tryde.

Projects in 2017

List of grants by technologies, and a status on the number of new, completed and ongoing projects in 2017. Descriptions of all the projects are available on energiforskning.dk.





Bioenergy and waste

Grants in 2017: DKK 26 million

NUMBER OF PROJECTS

New in 2017: **8**

Completed in 2017: **15**

Ongoing: **92**



Hydrogen and fuel cells

Grants in 2017: DKK 42 million

NUMBER OF PROJECTS

New in 2017: **6**

Completed in 2017: **8**

Ongoing: **59**



Wave

Grants in 2017: DKK 53 million

NUMBER OF PROJECTS

New in 2017: **1**

Completed in 2017: **5**

Ongoing: **18**



Energy efficiency

Grants in 2017: DKK 123 million

NUMBER OF PROJECTS

New in 2017: **59**

Completed in 2017: **32**

Ongoing: **240**



Smart grid and systems

Grants in 2017: DKK 132 million

NUMBER OF PROJECTS

New in 2017: **21**

Completed in 2017: **12**

Ongoing: **105**



Solar

Grants in 2017: DKK 13 million

NUMBER OF PROJECTS

New in 2017: **7**

Completed in 2017: **7**

Ongoing: **78**



Wind

Grants in 2017: DKK 66 million

NUMBER OF PROJECTS

New in 2017: **12**

Completed in 2017: **6**

Ongoing: **112**



Other

Grants in 2017: DKK 39 million

NUMBER OF PROJECTS

New in 2017: **11**

Completed in 2017: **16**

Ongoing: **60**

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More information about all Danish energy projects is available in the database at energiforskning.dk

Apply for support for research, development and demonstration of the green energy projects of the future



Energy18

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