New and Ongoing Wind Power Research in Sweden 2018

A compilation of Swedish research programs and new scientific publications on wind energy

UPPSALA UNIVERSITET

The National Network for Wind Utilization

March 2019

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Front page: Kiteboarder at Varbosviken, Gotland. In the background, the wind park in Klintehamn.
Photographer: Ulrika Ridbäck

Publications from the National Network for Wind Utilization are available for download
www.natverketforvindbruk.se

This is a publication from the Node for Education and Competence in the National Network for Wind Utilization. The project is funded by the Swedish Energy Agency.

Contents

1. Introduction

Uppsala University Campus Gotland annually publishes a summary of *New and Ongoing Wind Power Research* in Sweden. The summary is published on the website of the National Network for Wind Utilization, Nätverket för Vindbruk, where both the English and Swedish versions are available.

The aim of this summary is to provide an easily accessible overview of what is happening annually in wind power research for interested parties. This report is the seventh edition in the series.

This compilation is divided into two sections. The first is a presentation of the research centres and research programmes active in wind power research in Sweden. Then a topic-based list of the wind power research published in 2018 follows where at least one of the authors is active at a Swedish university. Here one also can find doctoral and licentiate theses as well as theses at bachelor and master levels that have been published during the year. All have direct online links to the publications. This report also includes tables which compile the new publications.

The data for this report is taken from various databases and websites, and also from direct contact with universities, researchers and representatives of the various programs. We would like to take this opportunity to thank everyone for your contributions and help. To complete this report for the coming year, we will gladly accept more information!

Uppsala University Campus Gotland is the node with responsibility for education and competence development within the National Network for Wind Utilization which is financed by the Swedish Energy Agency. The 2018 summary of current wind power research is a part of this task.

All editions of *New and Ongoing Wind Power Research* are published on the website of the National Network for Wind Utilization.

2. Research programs and research centres

In Sweden, several universities and colleges conduct research in a number of areas linked to wind power both on and offshore. The research is extensive and includes technical development, operational solutions, environmental impacts, acceptance and other issues. This summary describes activities during 2018 at research centres and programs that grant funding for research on wind power.

2.1. VindEL

VindEL is the Swedish Energy Agency's research and innovation program for wind power. The program goal is to contribute to the wind energy impact targets that the Energy Agency points out in its wind power strategy:

• Wind power is a significant part of the Swedish electricity supply.

• Wind power contributes to climate change mitigation, business development and the stability of the power system.

• The installation and operation of wind power takes place with regard to social, economic and ecological sustainability.

Since 2017, the Vindval program aims to distribute a large part of its funding to projects through a continuous annual call. The current program period runs until the end of December 2021. The Energy Agency plans to extend the program period until 2024, a decision that will be made in spring 2019. The direction of the research calls are prioritised areas of action in accordance with the wind power strategy: (1) Resource-efficient wind power in Swedish conditions, (2) Wind power as part of society and environment (3) Integration into the electrical system. In 2018, a new research call was announced within the prioritised research areas. The next research call will preliminary be in April 2019.

More about VindEL

The second announcement within VindEL 2018

The first announcement within VindEL 2017

Granted projects within VindEL 2017 pdf

Swedish Energy Agency strategy for wind power

Projects accepted within the 2018 VindEL- research call

Detection and modeling of frost, snow and ice on wind power blades
The purpose of the project is to develop solutions for reducing the production loss for wind power in a cold climate. The focus is on improving the efficiency of the ice detection system through image analysis and modeling of ice formation, as well as examination of the effect of frost on ice and snow accumulation. Luleå Technical University, Johan Casselgren.

Icing map for Sweden

This project aims to create new icing maps with high-resolution data on icing climate for the hub heights of today and the future in entire Sweden. The goal is to make these icing maps available on the web through an open and interactive visualization system. In addition to icing on the exact hub height, the ice charting will include the swept rotor area in the calculations and will be based on another project on icing (IceLoss 2.0, started 2017). Kjeller Vindteknikk AB, Hanna Sabelström.

Chemical recycling of glass fiber composite from wind turbine blades

The lack of recycling of glass fiber composites from wind turbine blades is a growing problem in Sweden today. This project will investigate the possibility of recovering these composites through chemical recycling, so-called solvolys / HTL. By separating fiber and thermosets from the glass composite, these parts can be converted and reused; the thermosets in, for example, plastics and fiberglass fractions to new composites. RISE SICOMP AB, Cecilia Mattsson.

Sound from wind turbines - Development and validation of control methods

There is a major need for revising current verification methods for wind turbine noise in Sweden. This also includes the validation of proposed verification methods through measurements and sound calculations. The goal of the project is that the results will be used in future guidance on noise from wind power. Akustikverkstan i Skaraborg Holding AB, Pontus Thorsson.

Meteorological effects on the offshore wind resource – forecasting and climatology

Offshore wind power is more attractive because the wind resource is larger at sea than on land. The purpose of the project is to improve the assessment of the wind resource over the Baltic Sea's inland sea and intends to propose a better model set-up for wind resource calculations over inland waters. The ability of current operational models to forecast low-level jets within 12 to 24 hours will be evaluated based on the most suitable configuration. Uppsala University, Erik Sahlée.

Optimal electricity trading of wind power using probabilistic forecasts

Wind power is a weather-dependent resource and therefore both variable and uncertain. By developing advanced computational methods based on machine learning for probabilistic forecast, the prediction accuracy for wind power production can be improved. Quantification of uncertainty information will be used as input in order to perform optimal electricity trading in the Nordic countries. Greenlytics AB, Sebastian Haglund El Gaidi.

Turbulence Measurements in the wake of a Wind power plant

This project intends to develop and test a measurement method for wind speeds and turbulence parameters in the flow field behind the rotor blades. Measurement data will be used to verify the flow simulations performed with commercial programs. A drone-(UAV-) carried anemometer will be used to provide higher spatial resolution, and the drone's stability and the anemometer's resolution will also be analyzed. Lund University, Jens Klingmann.

Windpower in Swedish conditions

Conditions for wind power in Swedish forest landscapes are very complex due to variations in landscape and topography. The purpose of the project is to study wind and turbulence conditions over forest landscapes in Sweden. The study includes turbulence measurements, development of Sodar and Lidar measurement techniques, and development of models dedicated to forest in open source platforms. Uppsala University, Stefan Ivanell.

Wind power in Swedish climate - A complete modelling chain
The project intends to study everything from meteorological conditions to detailed computations of how turbines' aerodynamic properties are affected by ice. Based on this, the production and load variations of the turbines will be calculated, as well as how different types of ice build-up cause these variations. The project's results can be applied to investigate how anti-defrosting systems can be adjusted for optimal function. Lund University, Johan Revstedt.

Wind turbines in Swedish conditions - optimization of loads and power production
Complex forested areas and beach-close positions are characterized by different wind conditions that affect the location of wind turbines. The project goal is to quantify differences in energy production and fatigue loads for wind turbines in these environments, as well as to compare with wind power plants located in flat terrain and offshore. The results will be applied in proposals for the most optimal location and operation of wind turbines, which also requires the development of a new turbine model that takes into account transient wind conditions in these areas. Uppsala University, Karl Nilsson.

2.2. Vindforsk IV

Vindforsk IV is an collaborative program that ran during the years 2013–2017 through collaboration between the Swedish Energy Agency and Elforsk AB, since 2015 Energiforsk AB. The program ran until April 2018 to report and disseminate results from finished projects, among other objectives, through a compilation report published in June 2018. The research within the program has been divided into three areas: (1) The wind resource, design and establishment; (2) Operation and maintenance; (3) Wind power in the electricity system.

Projects in the Vindforsk IV-program that were finished in 2018

Nordic Consortium: Optimization of large wind farms
The project is a continuation of two doctoral projects from Vindforsk III and divided into two parts. The first part has enabled optimization and control of turbines in wind farms, with respect to performance and loads. The second part facilitates modelling on a large scale by studying how large parks affect the wind field and thus also nearby parks, so-called park-park interaction. This is something that increasingly needs to be taken into account in the expansion of wind power. Uppsala University, Stefan Ivanell.

Wind power in forest II
Through wind measurements and model simulations, the project has produced new knowledge about wind conditions over forests. The results lead to more reliable

calculations of the winds over forests, which is important in order to be able to assess the energy production and the load on the turbines and to gain knowledge to evaluate the location of wind turbines and wind farms in the forest environment. The project has also clarified the effect the forest has on energy production and proposed methods for increasing the energy exchange over forest terrain. The final report is called Wind power in forests II, Energy Research Report 2018: 499, Uppsala University, Matthias Mohr.

The collaboration between the Swedish Energy Agency and knowledge company Energiforsk was meant to contribute to more collaboration and funding between industry and research in wind power. Since 2018, Energiforsk has established the industry network Vindforsk which gathers and disseminates knowledge and facilitates industrial collaboration in research projects.

Reports from the interaction program Vindforsk IV are available at Vindforsk industry network's website.

These reports were also published in 2018:

Deicing systems for wind turbines (*Avisningssystem för vindkraftverk)*, 2018:467 Vindforsk. Lindskog Innovation AB, project leader Sven-Erik Thor.

Inertial support from variable speed wind turbines, 2018:468 Vindforsk. Chalmers University of Technology, project leader Peiyuan Chen.

Harmonics and wind power, 2018:469 Vindforsk. Luleå Technical University, project leader Math Bollen.

Load monitor 1, 2018:482 Vindforsk. Kjeller Vindteknikk, Uppsala University Campus Gotland och Teknikgruppen med stöd av Stena Renewable.

Load monitor 2, 2018:483 Vindforsk. Kjeller Vindteknikk, Uppsala University Campus Gotland och Teknikgruppen med stöd av Stena Renewable.

Bayesian methods for preventive maintenance, 2018:484 Vindforsk. Uppsala University, project leader Bahri Uzunoglu.

Analysis of sub-synchronous oscillations in wind power plants, 2018:498 Vindforsk. KTH, project leader Mehrdad Ghandhari.

Dynamic rating of power lines and transformers for wind energy integration, 2018:500 Vindforsk. KTH, project leader Patrik Hilber.

Analysis of vacuum breaker generated transients in a 36kV wind farm cable grid, 2018:502 Vindforsk. Chalmers University of Technology, project leader Talrik Abdulahovic.

Brushless wind power generator for limited speed range, 2018:503 Vindforsk. KTH, project leader Chandur Sadarangi.

2.3. Wind Power in cold climate

The research and development program Wind power in cold climate ran between 2013 and 2016. The last projects with funding from this program were finished in 2018. Since

2017, funding for research on wind power in cold climate can be sought through VindEL (read more in chapter 2.1.).

The main goal of the program was to encourage and simplify a conversion of the Swedish energy system as well asto help Swedish research take a leading position and develop special knowledge regarding wind power in cold climates. In the long run, the aim is to facilitate the establishment of larger wind parks in northern Sweden during the next decade by researching the challenges associated with wind power in cold climate.

The program also aimed at promoting the development of appropriate academic competence in wind power in cold climate. This competence will contribute to a necessary knowledge base for continued progress in primarily research and development where academia and industry collaborate. The aim has also been to promote the development of technical solutions that correspond to the areas of need that impede and delay the establishment of wind power in cold climate

More about Wind power in cold climate

Projects which were finished in 2018 in the program Wind power in cold climate

Wind-turbines in cold climate: Flow dynamics, ice accretion and terrain effects
Cold climate affects the expansion of wind power in the Barents region. The purpose of the project was to increase knowledge about how icing affects wind turbine noise and how sound dispersion is affected by snow or ice formation on the ground, the nature of the terrain and temperature variations. It was also investigated whether acoustic measurements can be used to detect the degree of icing. Lund University, Johan Revstedt.

Wind power in cold climate - modelling of icing and production losses
The Swedish Meteorological and Hydrological Institute (SMHI), WeatherTech Scandinavian AB (WT) and Uppsala University use weather models that will be specified with a focus on parameterization of cloud physics and turbulence. The purpose of the project is to optimize the models' ability to calculate icing and production loss in wind turbines that operate under icing conditions. Uppsala University, Anna Rutgersson.

2.4. Vindval

Vindval is collaboration between the Swedish Energy Agency and the Swedish Environmental Protection Agency with the task of developing and communicating scientifically based facts about the effects of wind power on humans, nature and the environment. The program’s reference group is represented by users that apply results from Vindval’s projects. The reference group’s mission is to carry out analyses on needs, propose initiatives based on needs and to follow Vindval's projects in more detail.

Vindval started in 2005 and is now in its fourth stage (Vindval IV) that continues until the 31st of December 2021. The programme's impact goals are that the research results will contribute to a sustainable expansion of wind power in Sweden and that environmental effects should be placed in relation to the environmental impact of other activities.

The research calls for 2018 were aimed at projects in Wind power and planning, as well as on Reindeer and wind power.

Projects in Vindval that were finished in 2018

Northern bat and Western barbastelle – consideration when establishing and operating wind turbines

The project has investigated how Northern bat (*Eptesicus nilssonii*) and Western barbastelle (*Barbastella barbastellus*) are affected by wind power and how this should be handled. The conclusion of the study is that the direct effect of wind power on the two species is probably small. However, negative effects can arise secondary to the destruction of the habitat of the bats, for example if making new access roads for forestry in previously intact forest. Forestry is of crucial importance for both Western barbastelle in southern Sweden and Northern bat in the north. The recommendation from the authors is that nature conservation efforts should focus on protecting forests with nature-like qualities that constitute the bats' habitat. Authors: Jens Rydell (Lund University), Stefan Pettersson (Enviroplanning AB) and Martin Green (Lund University). Report no 6827 (2018).

Wind power and reindeers - a knowledge compilation

Several studies have been conducted on wind power, reindeers and reindeer husbandry in Norway and Sweden. The results of the studies are partly different. In the Vindval report *Vindkraft och renar - en kunskapssammanställning*, the researchers explain why. The report summarises eleven different studies that have investigated the effects of wind power and power lines on reindeers. Authors: Olav Strand (Norwegian Institute for Natural Research NINA), Jonathan E. Colman (University of Oslo UiO), Sindre Eftestøl (UiO), Per Sandström (Swedish Agricultural University SLU), Anna Skarin (SLU) and Jørn Thomassen (NINA). Report no. 6799, (2018) from Vindval is a translation of the Norwegian report *Vindkraft og reinsdyr – en kunnskapssyntese* (originally published in NINA's report series).

Population modeling for eagles: relative importance of mortality factors and possibility of compensatory measures

The purpose of the study was to try to understand what impact a wind power expansion can be expected on Sweden's eagle populations and how this impact can be compensated.. Författare: Jan Olof Helldin (Calluna AB). Link to report at Calluna's website.

Capercaillie and Wind Energy – an international research project

The project goal is to assess risks associated with wind power for the threatened Capercaillie (*Tetrao urogallus*) in Central Europe. The project has been carried out in collaboration with a five-year research program run by the Forest Research Institute of Baden-Württemberg (Germany) and the University of Natural Resources and Life Sciences (Austria). The Swedish project has marked and made inventories of Capercaillie in areas where wind power is current and is based on data from forest landscape in Sweden where Capercaillie is not threatened. The Swedish project's reporting to Vindval has been approved and the report from the project will be published when the international research program is completed. The project has been granted continued funding from the

Swedish Environmental Protection Agency until 31 December 2019. Project leader: Henrik Andrén (Swedish Agricultural University SLU, Uppsala).

People's experiences of noise from wind power in hilly terrain related to sound measurement
The aim of the project was to investigate how people perceive noise from wind turbines related to the sound level that prevails in a place at a specific time. The goal has not been achieved, because too few of the respondents reported interest in participating in the study. Parts of the project are reworked and will provide the basis for scientific articles, but this is beyond the mission of Vindval. The project report will not be published as a Vindval report. Project leader: Anna Rutgersson (Uppsala University).

Explanation models for disturbing noise from wind turbines
The project goal was to investigate factors that dominate when experiencing interference of wind power noise. The goal has not been achieved. The part of the study that has been carried out consists of listening tests where one examines which sound aspects that dominate the experience and how they affect the degree of disturbance. The part of the study concerning non-acoustic factors has not been implemented. Because the project has not been completed in all parts, it has not been possible to compare the results in the different parts. The project report will not be published as a wind selection report. Project leader: Dag Glebe (RISE - Research Institutes of Sweden).

Ongoing projects in Vindval that finishes in 2019

Factors that affect the presence of insects and bats at high height
The project aims to investigate which factors that contribute to the high presence of insects and bats at wind turbines. The presence of these animals is measured with great precision at the ground and at hub height. It also includes mapping of a number of external factors. Insect attraction is measured through experiments with varying light intensity and colours. Swedish Agricultural University SLU, Johnny de Jong.

Insect distribution around wind turbines and its impact on insect-eating bats and birds
The purpose is to study the accumulation of insects at wind turbines in different weather conditions and whether the occurrence of insects attracts food-seeking bats and birds, such as European Nightjar (*Caprimulgus europaeus*), Common Swift (*Apus apus*) and swallows . The project is based on new technology where laser-based remote sensing technology registers insects, vertical radar is used to study movements of insect-eating birds and through GPS logging techniques movements of nesting nightcaps are followed. Lund University, Susanne Åkesson.

Vindval IV projects that started in 2018

Tool for strategic planning by assessing the cumulative environmental impact of wind power
In the case of large-scale expansion of wind power, new areas are being used and locations of new establishments depend on the landscapes' physical and infrastructure conditions, as well as how it affects other activities, plans, local residents and natural environment. The purpose is to develop a tool for assessing and comparing the overall environmental impact on land and offshore for different development scenarios, nationally, regionally

and from a landscape perspective. The project ends on December 19, 2020. Chalmers University of Technology, Sverker Molander.

Impact and mitigating measures for wind power within reindeer winter grazing areas
There is a lack of knowledge about how wind turbines and human activities associated with wind power affect reindeers, with emphasis on behaviour and avoidance reactions of reindeer in winter grazing areas. The goal is to gather knowledge about which measures can mitigate and minimize negative effects on visibility, noise and human activity. The project ends on December 31, 2020. The University of Oslo, Jonathan E. Colman.

Reindeer and wind power in the winter grazing area
A large proportion of wind power establishments in Sweden occur in reindeer husbandry areas, which requires knowledge of how it affects the reindeer and reindeer herding. This project therefore intends to collect and analyse more data to develop and strengthen the knowledge that has emerged through previous studies on wind power and reindeer. The project ends on December 31, 2020. Swedish Agricultural University SLU, Anna Skarin.

Land-use synergy, integration or conflict in sustainable land-based wind power
The project will contribute to the sustainable expansion of land-based wind power by developing knowledge, planning conditions and possible scenarios in relation to other national interests on local, regional and national scale. Through analyses of various factors, wind power expansion is set in relation to the impact on and effects of other land use, current planning themes, environmental goals, ecosystem services and green infrastructure. The project ends on December 31, 2021. Swedish Agricultural University SLU, Johan Svensson.

Regional wind power planning
In order to find good places for expansion of wind power, regional planning needs to be developed, which includes coordination of various knowledge bases, competencies and actors. The project aims, among other things, to identify which factors have been included in wind farm plans and rulings related to wind power expansion and how these have been dealt with, and what trade-offs between sustainability goals have been made. Furthermore, scenarios will be created for different identified approaches, for which an impact assessment shall be performed in a selected region by GIS-based multi-objective analysis. The project ends on December 31, 2021. The Royal Institute of Technology, Ulla Mörtberg.

Research reports published in 2018

Northern bat and Western barbastelle - consideration when establishing and operating wind turbines [Nordfladdermus och barbastell - hänsyn vid etablering och drift av vindkraftverk] (Jens Rydell, et al., 2018)

Wind power and reindeers – a knowledge compilation [Vindkraft och renar – en kunskapssammanställning] (Olav Strand, et al., 2018)

Vindval website

More about Vindval stage IV - increased knowledge about wind power's environmental impact

The call for funding for research on how wind power affects reindeers (Vindval IV)

More about Vindval's research program on wind power's environmental impact 2005–2021

2.5. RISE

RISE, Research Institutes of Sweden, is an independent, state research institute which runs and supports all kinds of business-related research projects and innovation processes for technologies, products and services within many areas, of which wind power is one. RISE has been an institute since 2016 and collaborates internationally with companies, academia and the public sector to contribute to a competitive business community and a sustainable society.

Research and innovation in the field of wind power has grown at RISE for several years. There is a targeted investment in wind power research, which expands in line with the Swedish government's goal of a 100% renewable electricity generation by the year 2040.

In 2018 RISE expanded the European research collaboration through a greater involvement in the wind power portion of EERA, European Energy Research Alliance, and similar research networks in order to strengthen Sweden's role as a knowledge centre in wind power.

Selected priority areas for the coming years are:

- Testing and verification in cold climate as well as technology and materials for de-icing
- Sea-based wind power in Swedish conditions
- More efficient methods of operation and maintenance for increased technical life span, additional cost reductions and increased durability
- Increased contribution/benefit from wind power for the stability of the electrical system
- Fire technical issues and fire protection for wind turbines and electric power equipment

RISE website

Current projects in 2018 with relevance for wind power

Floating wind power at sea
The company SeaTwirl strives to become leading in the marine wind power market and their patented wind turbines have already received a lot of attention. To develop a new wind turbine, SeaTwirl collaborates with RISE and Chalmers to calculate how the construction is affected by the wind. The turbine S2, with a power of 1 megawatt, will be ready for use in 2020. Contact person: Gabriel Strängberg.

Cold climate test

In 2018, RISE led the establishment of a new test centre for wind power under icy conditions. The test centre's proposed location is Uljabuouda in Arjeplog, 780 meters above sea level, where testing of new wind turbine models will be carried out in an authentic cold climate environment. Collaboration partners include Skellefteå Kraft, Wind Power Center, Vinnova, Swedish Wind Power Technology Center (SWPTC), Vattenfall and the Energy Research Center of the Netherlands (ECN). Contact person: Stefan Ivarsson.

Design of cost effective DC-based collection-network for inland-sea wind-farm using series high-frequency transformers
The project is based on a collaboration between RISE and Chalmers and the goal is to determine what power can be achieved at different frequencies and output voltages. The research object is a special wind farm configuration for inland sea environment with intermediate frequency transformer, with focus on high voltage isolation at medium frequency levels. Thermal properties are also examined to ensure optimal operating temperature. Contact person: Mohammad Kharezy. .

Offshore Väst
The project Offshore Väst aims to contribute to the development of offshore industrial activities. The purpose is to build a strategic collaboration between the business sector, authorities, researchers and politicians, which will create better conditions for a developable innovation system in the offshore area. With a focus on the potential of member companies in offshore wind power, a number of preliminary studies have been conducted in accordance with Swedish conditions. Contact person: Tanja Tränkle.

Lasting concretes for energy infrastructure under severe operating conditions (LORCENIS)
The project LORCENIS aims to optimize concrete used in energy infrastructure and to withstand extreme environments. As a foundation for, among others, wind turbines, concrete is required which can be exposed to cold climate, soft water and other harsh conditions. Contact person: Urs Mueller.

Flexible heat and power (FHP)
The challenge with renewable energy sources, including wind power, is that the asset cannot be controlled. The main goal of the FHP project is to increase the share of renewable energy in the power systems. By increasing flexibility for electricity-to-heat solutions, electric louds can be controlled for periods with plenty of renewable electricity in relation to the demand. Contact person: Markus Lindahl.

New projects that started in 2018 and are led/coordinated by RISE

ReComp – Circular streams from fiberglass composite
This project is funded by Vinnova and examines how fibreglass composite waste from wind power, boat, vehicle and construction industries can be recycled through solvolysis/HTL process. The project starts on January 1, 2019 and extends over three years. Contact person: Cecilia Mattson.

Rekovind – Chemical recycling of glass fibre composites from wind turbine blades
This project is funded by the Swedish Energy Agency and EnergiForsk and investigates the possibility of recycling fiberglass components and chemical building blocks from wind turbine blades on a chemical basis (solvolys/HTL). The idea is to contribute to a circular

economy where the recycled materials can be reused in other products (see chapter VindEl 2.1, *Chemical recycling of glass fiber composite from wind turbine blades*). The project started on January 1, 2019. Contact person: Cecilia Mattson.

2.6. SamspEL – Research and innovation for the future electricity grid

The program SamspEL is run by the Swedish Energy Agency and started in 2016 to support research, development and innovation in the area of electricity networks. SamspEL aims to contribute to the development of a flexible, resource-efficient and robust electrical system, which includes collaboration within a completely renewable electricity system which includes the socio-technical system, its actors and regulations. Several projects relevant to wind power are financed by SamspEL.

More about the research program SamspEL

The Swedish Energy Agency has a support project linked to SamspEL in the form of the interactive knowledge portal framtidenselsystem.se [Future power systems], which is used for dissemination of results and communication regarding research, development and current seminars and research calls. More about Framtidenselsystem.se

Ongoing projects relevant for wind power in SamspEL 2018

Grid strength metrics and evaluation in converter-dominated grids
The project aims to re-evaluate classical metrics and propose new suitable metrics in order to evaluate the grid voltage and frequency strength of a power system dominated by power electronics. This can contribute to a functioning system and increased understanding for the grid strength. Chalmers University of Technology, Peiyuan Chen.

New prediction services to enable resource efficient grids
The project will develop forecasting tools for electricity grid companies of different sizes with emphasis on accuracy, working hours and costs. This means knowledge, method and prototype development in order to create the conditions for efficient use of existing electricity resources, for predicting energy and power demands and weather-dependent electricity production, including wind power. Expektra AB, Niclas Ehn.

Power electronic based dc transformer for off-shore wind energy installations
A new concept for DC/DC converters is investigated for the collection of wind energy from offshore wind turbines. The overall goal of the project is to develop the dc/dc converter to reduce its weight and installation cost and to improve the energy efficiency. Chalmers University of Technology, Torbjörn Thiringer.

Energy storages for regional and local integration of heat and power systems
The purpose is to study how the integration of renewable and variable electricity production with a changed need for electricity and heat can be optimized through district heating production and thermal energy storage. It includes case studies with simulations

and calculations of energy balance in, among other things, solar and wind power production. Uppsala University, Magnus Åberg.

Minimizing of curtailments in power systems with high share of wind and solar power
If there is no possibility of storing energy surplus from renewable power production in batteries or through export, it will be an energy loss. The purpose of this project is to develop methods for estimating when disconnection is necessary and that its implementation minimizes the energy loss while maintaining power system stability. Royal Institute of Technology, Lennart Söder.

Replacement inertia for a power system dominated by renewable sources
A continuously active synthetic inertia will be developed and demonstrated through this project. This means developing new hardware that can deliver the inertia that corresponds to what is needed in the power system. Uppsala University, Claes Urban Lundin.

Efficient control of the power balance in systems with a large share of renewable production
The project aims to improve the efficiency of power balance control in power systems, first and foremost by developing optimal trading strategies on the regulating market. The result is expected to contribute to increased competitiveness in terms of renewable electricity production. Linnaeus University, Magnus Perninge.

2.7. STandUP for Wind

The research center STandUP for Wind is collaboration between the Royal Institute of Technology KTH, Uppsala University, Luleå Technical University and the Swedish University of Agricultural Sciences SLU.

STandUP for Energy was formed in 2009, following a government decision to allocate funding to universities and colleges for the development of 24 research areas that were considered strategically important. One of these areas was renewable electricity on a larger scale and its integration into the power grid. Research within wind power are gathered in the center STandUP for Wind, where the intention is to facilitate the development towards a larger proportion of electricity from wind power in the grid through interdisciplinary working methods.

More about STandUP for Wind

Ongoing research 2018 within the following areas:

Wind surveying and cold climates

NEWA - New European Wind Atlas. Uppsala University, Stefan Ivanell.

Meteorological effects on wind resource calculation over inland sea - forecasts and climatology, Uppsala University, Erik Sahlée.

Improved icing forecasts through better representation of local meteorological processes, SMHI and Uppsala University, Anna Rutgersson.

Ice detection via image analysis of blades, Luleå Technical University, Lavan Kumpar Eppanapelli.

Probabilistic forecasts of icing on wind turbines, SMHI and Uppsala University, Anna Rutgersson.

Fluid dynamics for wind turbines in parks and forests

Wake physics and farm control. KTH and Uppsala University, Stefan Ivanell.

Vindforsk IV - Nordic Consortium; Optimization of large wind farms. Uppsala University and KTH, Stefan Ivanell.

Wakes and farm control in nordic conditions. Uppsala University, Karl Nilsson.

Wind condtitions in Swedish forested landscapes. Uppsala University, Stefan Ivanell.

Wind Farm aerodynamics : Experiments and simulations to study the flow over wind farms, assess their power production over simple and complex terrains and how the power production can be enhanced through turbulence manipulation. KTH, Antonio Segalini.

Wind Farm Blockage: Experiments and simulations to calculate blockage losses in wind farms. KTH, Antonio Segalini and Vattenfall, Jan-Åke Dahlberg.

Theoretical description of the aerodynamics of wind turbines with simplified methods. KTH, Antonio Segalini.

Electrical systems

System modelling for a 100% renewable power system. KTH, Lennart Söder.

Subsynchronous resonance in power systems wind wind power. KTH, Mehrdad Ghandhari.

Balancing methods for power systems with large amounts of wind and solar power. KTH, Mikael Amelin.

Evaluation methods of risk of capacity deficit in multi-area systems with large amounts of wind power. KTH, Lennart Söder.

Flex4RES, KTH, Lennart Söder.

Using wind power on lower voltage for voltage control on higher voltage. KTH, Lennart Söder.

Weekly planning of hydropower in systems with large volumes varying power generation. KTH, Mikael Amelin.

Weekly planning of hydropower in systems with large volumes varying power generation. KTH, Mikael Amelin.

Efficient hydro power modelling in presence of volatile wind power. KTH, Lennart Söder.

Efficient handling of wind power curtailments. KTH, Lennart Söder.

New market design impact on hydro power operation in presence of large scale wind power. KTH, Lennart Söder.

Sound

Improved modelling of sound propagation through the use of synthetic turbulence. Uppsala University and KTH, Johan Arnqvist.

Ljudoptimering runt vindkraftsparker. KTH and Uppsala University, Karl Bolin.

Vertical axis wind turbine development

Generators and control systems

Dynamic rating with applications to renewable energy. KTH, Patrik Hilber.

Landscape and participatory planning

Operation and maintenance

2.8. Swedish Wind Power Technology Centre - SWPTC

The Swedish Wind Power Technical Centre, SWPTC, was established in 2010 with the purpose to strengthen the expertise of wind power technology in Sweden and to meet the demands of the rapidly expanding global wind power industry. The goal is for the research to lead to an increased life expectancy of wind power plants by means of better load prediction, optimum operation and preventive maintenance and cost-effective electrical system integration.

The current focus of SWPTC is the development of wind turbines, which optimizes the cost of manufacturing and maintenance. The objective is to build up component and system knowledge that enables the development and production of subsystems and wind turbines in Sweden.

SWPTC is led by Chalmers University of Technology and is run in collaboration with Luleå University of Technology, RISE, Lund University and companies in the wind power industry.

The research at SWPTC focuses first and foremost on the individual wind turbine, as it is of the utmost importance to first understand how its individual parts interact to become an optimal converter of wind energy to electrical energy. Today's view, that a group of wind turbines is to equate to an electricity production plant, shows the importance of having good knowledge of the interaction between wind turbines in a wind farm and how these are controlled and linked together in the best way for maximum energy production and best life span. The research will focus on larger wind turbines and parks for placement in forest, alpine and marine environments.

Stage 2 was completed in 2018 and Stage 3 starts in January 2019 to address the following research areas: Bearing structure, Electric drivetrain and DC power grid, Life span and maintenance, Deicing and ice detection, Forest/complex terrain and regulation, Network services from wind turbines.

More about SWPTC (via Chalmers)

Ongoing projects during 2018:

ISEAWIND – Innovative structural engineering approaches for design of offshore wind power plant foundations

Models of electrical drives for wind turbines

Optimal maintenance of wind power plants

Wind power in forest - impact of forest clearings

Wind turbines in difficult operating conditions

Increased reliability of heating systems on wind turbine blades

Chalmers' wind turbines are put into operation for research

Analysis methodology for fatigue loads in wind turbines

2.9. Summary

The various research programs and research centres presented here provide a picture of what is happening in wind power research in Sweden. The Swedish Energy Agency is a main financier for VindEL and Vindval, and also part financier of Vindforsk IV.

Vindval is collaboration between the Swedish Energy Agency and the Swedish Environmental Protection Agency, with focus on the impact of wind power on humans, nature and the environment, with forthcoming research projects on large scale planning and impacts on reindeer. Vindforsk IV has had a technical focus and was financed by the Energy Agency and the wind power industry through Energiforsk.

SamspEL is run by the Swedish Energy Agency and supports research, development and innovation in the power system, with particular emphasis on a completely renewable electricity system, which also includes wind power.

In 2018, the Swedish Energy Agency has gathered support for wind power research within the programs VindEL, Vindval and SamspEL. Thereby creating a comprehensive approach to the continuation of the previous research programs Vindforsk III-IV and Vindkraft i kallt klimat (Wind power in cold climate).

Since the completion of Vindforsk IV, Energiforsk has established the program Vindforsk, an industry network that collects and disseminates knowledge and facilitates research projects where industry and academia collaborate.

The research centre STandUP for Wind is a collaboration between the Royal Institute of Technology KTH, Uppsala University, Luleå University of Technology and the Swedish University of Agricultural Sciences SLU. Here, research is gathered on how the wind is generated and how it is integrated into the Swedish electrical system, with research on design and planning of wind power as well.

The Swedish Wind Power Technical Centre SWPTC is run by Chalmers in collaboration with Luleå University of Technology. At SWPTC, expertise in wind power technology is strengthened to meet demands of the rapidly growing global wind power industry. The focus is on development of wind turbine construction which optimizes the cost of manufacturing and maintenance.

Since 2018, the research institute RISE is also included in this compilation. At RISE, research and innovation in the wind power area has grown over several years, mainly focusing on testing and certification services.

In addition to the above research programs and centres, there are also international collaboration projects for wind power. One example is the New European Wind Atlas (see Chapter 2.7. STANDUP for Wind) which is a European collaboration in wind power research.

3. Published scientific articles and reports

In this listing, scientific articles are listed according to the subject. This includes articles that have been published during or in connection with conferences.

Some of the links below require login into Scopus. When you open the link, you are free to open and read the document.

3.1. Financing, electricity market, cost accounting

The marginal system LCOE of variable renewables – Evaluating high penetration levels of wind and solar in Europe
Reichenberg, Lina, et al., Energy, vol. 152, pp. 914-924, 2018

3.2. Wind resources, energy calculations

Evaluating anemometer drift: A statistical approach to correct biases in wind speed measurement
Azorin-Molina, Cesar, et al., Atmospheric Research, vol. 203, pp. 175-188, 2018

From Lidar scans to roughness maps for wind resource modelling in forested areas
Floors, Rogier, et al., Wind Energy Science, vol. 3, nr. 1, pp. 353–370, 2018

Monte Carlo methods to include the effect of asymmetrical uncertainty sources in wind farm yield assessment
Gleim, Alexander, et al., Wind Engineering, vol. 42, pp. 624-632, 2018

Analysis of wind power intermittency based on historical wind power data
Guorui, Ren, et al., Energy, vol. 150, pp. 482-492, 2018

Feasibility study about using a stand-alone wind power driven heat pump for space heating
Hailong, Li, et al., Applied Energy, vol. 228, pp. 1486-1498, 2018

A wind-tunnel study of the wake development behind wind turbines over sinusoidal hills
Hyvärinen, Ann, et al., Wind Energy, vol. 21, pp. 605-617, 2018

Micro-scale model comparison (benchmark) at the moderately complex forested site Ryningsnäs
Ivanell, Stefan, et al., Wind Energy Science, vol. 3, nr. 2, pp. 929-946, 2018

Probabilistic forecasting of wind power production losses in cold climates: a case study
Molinder, Jennie, et al., Wind Energy Science, vol. 3, pp. 667–680, 2018

ERA5: The new champion of wind power modelling?
Olauson, Jon, Renewable energy, vol. 126, pp. 322–331, 2018

Assessment of turbulence modelling in the wake of an actuator disk with a decaying turbulence inflow
Olivares-Espinosa, Hugo, et al., Applied Sciences, vol. 8, nr. 9, doi: 10.3390/app8091530, 2018

Wind farm power production assessment: a comparative analysis of two actuator disc methods and two analytical wake models
Simisiroglou, Nikolaos, et al., Wind Energy Science, doi: 10.5194/wes-2018-8, 2018

3.2.1. Conference proceedings

Operational regions of a multi-kite AWE system
Leuthold, Rachel, et al., 2018 European Control Conference, ECC 2018, IEEE, 2018, pp. 52-57

A Quantification of the Performance Loss of Power Averaging in Airborne Wind Energy Farms
Malz, Elena, et al., 2018 European Control Conference, ECC, 2018, pp. 58-63

Kinetic energy estimation in the Nordic system
Persson, Mattias; Chen, Peiyuan, Proceedings of the 20th Power Systems Computation Conference, PSCC'18, 2018

3.3. Technical development, wind turbine design and loads

The analysis of turbulence intensity based on wind speed data in onshore wind farms
Guorui, Ren, et al., Renewable Energy, vol. 123, pp. 756-766, 2018

Performance and wake comparison of horizontal and vertical axis wind turbines under varying surface roughness conditions
Mendoza, Victor, et al., Wind Energy, doi: 10.1002/we.2299

Multiple vertical axis wind turbines with passive rectification to a common DC-link
Rossander, Morgan, et al., Renewable energy, vol. 127, pp. 1101-1110, 2018

Stability analysis of newly developed polygonal cross-sections for lattice wind towers
Sabău, Gabriel, et al., Wind Engineering, vol. 42, nr. 4, pp. 353-363, 2018

A comparative study of three onshore wind turbine foundation solutions
Wael, Mohamed; Austrell, Per-Erik, Computers and Geotechnics, vol. 94, pp. 46-57, 2018

A new and reusable foundation solution for onshore windmills
Wael, Mohamed, et al., Computers and Geotechnics, vol. 99, pp. 14-30, 2018

3.3.1. Conference proceedings

CFD and control analysis of a smart hybrid vertical axis wind turbine
Hosseini, Arian, American Society of Mechanical Engineers, Power Division, vol. 1, ASME 2018 Power Conference, POWER 2018

Large-eddy simulation study of effects of clearing in forest on wind turbines
Matsfelt, Johanna; Davidson, Lars, 6th Symposium on OpenFOAM in Wind Energy, Svensk Vindkraftstekniskt Centrum (SWPTC), 2018, doi:
https://research.chalmers.se/publication/507001/file/507001_Fulltext.pdf

REDWIN - REDucing cost in offshore WINd by integrated structural and geotechnical design
Skau, Kristoffer S, et al., Journal of Physics: Conference Series, vol. 1104, nr. 1, EERA DeepWind' 2018

3.4. Manufacturing, operation and maintenance

Condition monitoring of wind turbine pitch controller: A maintenance approach
Asier González-González, et al., Measurement, vol. 123, pp. 80-93, 2018

Analysis of SCADA data for early fault detection, with application to the maintenance management of wind turbines
Bangalore, Pramod; Patriksson, Michael, Renewable Energy, vol. 115, pp. 521-532, 2018

Global metal flows in the renewable energy transition: Exploring the effects of substitutes, technological mix and development
Månberger, André; Stenqvist, Björn, Energy Policy, vol. 119, pp. 226-241, 2018
Maintenance optimization of power systems with renewable energy sources integrated
Shayesteh, Ebrahim, et al., Energy, vol. 149, pp. 577-586, 2018

Bayesian approach with subjective opinion fusions for wind turbine maintenance
Uzunoğlu, Bahri, Journal of Physics, Conference Series, vol. 1037, nr. 6, doi: 10.1088/1742-6596/1037/6/062021, 2018

3.5. Electrical grids, electrical grid integration, electrical power and power systems

Optimization of short-term overproduction response of variable speed wind turbines
Altin, Müfit, et al., IEEE Transactions on Sustainable Energy, vol. 9, nr.4, pp. 1732-1739, 2018

Energy storage coupling in a high efficiency household scenario: A real life experimental application
Falabretti, Davide, et al., Journal of Energy Storage, vol. 17, pp. 496-506, 2018

Validation of a coupled electrical and hydrodynamic simulation model for a vertical axis marine current energy converter
Forslund, Johan, et al., Energies, vol. 11, 3067, doi: 10.3390/en11113067, 2018

A comparison of variation management strategies for wind power integration in different electricity system contexts
Göransson, Lisa; Johnsson, Filip, Wind Energy, vol. 21, nr. 10, pp. 837-854, 2018

Economic and environmental costs of replacing nuclear fission with solar and wind energy in Sweden

Hong, Sanghyun, et al., Energy Policy, vol. 112, pp. 56–66, 2018

Power and methanol production from biomass combined with solar and wind energy: analysis and comparison

Husni, Firmansyah, et al., Energy Procedia, vol. 145, pp. 576-581, 2018

Tailoring large-scale electricity production from variable renewable energy sources to accommodate baseload generation in Europe

Reichenberg, Lina, et al., Renewable Energy, vol. 129, pp. 334-346, 2018

A review of demand side flexibility potential in Northern Europe

Söder, Lennart, et al., Renewable and Sustainable Energy Reviews, vol. 91, pp. 645-664, 2018

11: Analysis of the future power systems's ability to enable sustainable energy—Using the case system of Smart Grid Gotland

Wallnerström, Carl J.; Bertling Tjernberg, Lina, Application of Smart Grid Technologies, pp. 373-393, 2018

Economical flexibility options for integrating fluctuating wind energy in power systems: The case of China

Yi, Ding, et al., Applied Energy, vol. 228, pp. 426-426.

Modeling the impacts of deep decarbonization in California and the Western US: Focus on the transportation and electricity sectors

Zakerinia, Saleh, et al., Limiting Global Warming to Well Below 2 °C: Energy System Modelling and Policy Development, pp. 245-259, doi: 10.1007/978-3-319-74424-7_15, 2018

3.5.1. Conference proceedings

System stability of a small island's network with different levels of wind power penetration

Favuzza, S., et al., 2018 IEEE 4th International Forum on Research and Technology for Society and Industry (RTSI), RTSI, 2018, doi: 10.1109/RTSI.2018.8548355

Hybrid auxiliary power supply system for offshore wind farm

Huang, Xing; Chen, Yao, Journal of Physics: Conference Series, vol. 1102, nr. 1, Global Wind Summit 2018, 2018

3.6. Planning and Policy

Improving the flexibility of coal-fired power generators: Impact on the composition of a cost-optimal electricity system

Garðarsdóttir, Stefanía Ó., et al., Applied energy, vol. 209, pp. 277-289, 2018

Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands

Kooji, Henk-Jan, et al., Energy Research & Social Science, vol. 37, pp. 52-64, 2018

Implementing wind power policy – Institutional frameworks and the beliefs of sovereigns
Newell, David, Land Use Policy, vol. 72, pp.16-26, 2018

Uses of the word 'landskap' in Swedish municipalities' comprehensive plans: Does the European Landscape Convention require a modified understanding?
Sandström, Ulf; Hedfors, Per, Land Use Policy, vol. 70, pp. 52-62, 2018

3.7. Impact on animals

Effect of an offshore wind farm on the viviparous eelpout: Biometrics, brood development and population studies in Lillgrund, Sweden
Langhamer, Olivia, et al., Ecological Indicators, vol. 84, pp. 1-6, 2018

Out of sight of wind turbines—Reindeer response to wind farms in operation
Skarin, Anna, et al., Ecology and Evolution, vol. 8, nr. 19, pp. 9906-9919, 2018

3.8. Sound, noise and vibrations of wind turbines

Impact of snow on sound propagating from wind turbines
Conrady, Kristina, et al., Wind Energy, vol. 21, nr. 12, doi: 10.1002/we.2254, 2018

3.9. Risk assessment, lightning damages

On the estimation of the lightning incidence to offshore wind farms
Marley, Becerra, et al., Electric Power Systems Research, vol. 157, s. 211-226, 2018

3.10. Summary of published articles and conference proceedings

In comparison with 2017, the number of scientific articles published in wind power research has decreased by half (Table 1). Just as in the last three years, it is mainly articles within the categories of *Wind resources, energy calculations*, and *Electrical grids, electrical grid integration, electrical power and power systems* that dominate.

One new category, *Risk assessment, lightning damage*, has been added for 2018. The former title of the category *Influence on birds* has been changed to *Influence on animals*, which in 2018 includes new research on how wind power affects reindeer and viviparous eelpout (fish).

The categories *Financing, electricity market* and *Operation and maintenance* have been expanded to *Financing, electricity market, cost accounting* and *Manufacturing, operation and maintenance*. The category *Design and loads on wind turbines* has also been broadened to *Technical development, wind turbine design and loads*.

There are no publications in *Resource management of renewable energy sources* and *Regional development, social benefit*, nor in *Acceptance* and *Climate and environmental impact*.

Table 1. **The number of scientific articles published in 2018 compared to previous years.**

Category	2015	2016	2017	2018
Financing, electricity market, cost accounting	5	4	10	1
Wind resources, energy calculations	5	5	28	14
Technical development, wind turbine design and loads	4	9	8	9
Manufacturing, operation and maintenance	4	11	16	5
Electricity grid, electrical grid integration, electric power	7	14	27	13
Resource management of renewable energy sources	2	-	6	-
Planning and policy	2	3	9	4
Regional development, public benefits	5	4	5	-
Acceptance	1	1	-	-
Impact on animals	1	-	2	2
Climate and environmental impact	3	3	1	-
Sound, noise and vibrations of wind turbines	1	-	2	1
Risk assessments, lightning damages	-	-	-	1
Others	-	7	8	-
Reviews	2	3	1	-
Total	**42**	**64**	**123**	**50**

This summary is based on this report and also *New and ongoing wind power research 2015, 2016 and 2017.*

4. Academic dissertations and theses

4.1. Doctoral dissertations

Wind turbine drive train system dynamics; multibody dynamic modelling and global sensitivity analysis
Asadi, Saeed, Chalmers University of Technology, Mekanik och maritima vetenskaper, Dynamik, 2018

Subsynchronous resonance in doubly fed induction generator based wind farms
Chernet, Selam, Chalmers University of Technology, Elnät och komponenter, 2018

Energilandskap i förändring: Inramningar av kontroversiella lokaliseringar på norra Gotland
Edberg, Karin, Södertörns högskola, Institutionen för samhällsvetenskaper, Sociologi; Södertörns högskola, Centrum för Östersjö- och Östeuropaforskning (CBEES), 2018

Design of rare earth free permanent magnet generators

Eklund, Peter, Uppsala University, Institutionen för teknikvetenskaper, Elektricitetslära, 2018

Adapting sonar systems for monitoring ocean energy technologies

Francisco, Francisco, Uppsala University, Institutionen för teknikvetenskaper, Elektricitetslära, 2018

Expansion governance of the integrated North Seas offshore grid

Gorenstein Dedecca, João, Royal Institute of Technology KTH, Skolan för elektroteknik och datavetenskap (EECS), 2018

From condition monitoring to maintenance management in electric power system Generation with focus on Wind Turbines

Mazidi, Peyman, Royal Institute of Technology KTH, Skolan för elektroteknik och datavetenskap (EECS), Elkraftteknik, 2018

Aerodynamic studies of vertical axis wind turbines using the Actuator Line model

Mendoza, Victor, Uppsala University, Institutionen för teknikvetenskaper, Elektricitetslära, 2018

Wind power wake modelling: Development and application of an actuator disc method for industrial utilization

Simisiroglou, Nikolaos, Uppsala University, Institutionen för geovetenskaper, Luft-, vatten och landskapslära, 2018

Mesoscale processes over the Baltic Sea

Svensson, Nina, Uppsala University, Institutionen för geovetenskaper, Luft-, vatten och landskapslära, 2018

Impact of icing on wind turbines aerodynamic

Tabatabaei, Narges, Luleå Technical University, Institutionen för teknikvetenskap och matematik, Strömningslära och experimentell mekanik, 2018

Convex optimal power flow based on second-order cone programming: Models, algorithms and applications

Yuan, Zhao, Royal Institute of Technology KTH, Skolan för elektroteknik och datavetenskap (EECS), Elkraftteknik, 2018

4.2. Licentiate dissertations

Wind turbines over a hilly terrain: performance and wake evolution

Hyvärinen, Ann, University, Royal Institute of Technology KTH, Skolan för teknikvetenskap (SCI), Mekanik, Strömningsfysik, 2018

Dynamic rating of power lines and transformers for wind energy integration

Morozovska, Kateryna, Royal Institute of Technology KTH, Skolan för elektroteknik och datavetenskap (EECS), Elektroteknisk teori och konstruktion, 2018

High-performance finite element methods: with application to simulation of diffusion MRI and vertical axis wind turbines

Nguyen, Van-Dang, Royal Institute of Technology KTH, Skolan för elektroteknik och datavetenskap (EECS), Beräkningsvetenskap och beräkningsteknik (CST), 2018

Condition monitoring of wind turbine drivetrains using wavelet analysis
Strömbergsson, Daniel, Luleå Technical University, Institutionen för teknikvetenskap och matematik, Maskinelement, 2018

4.3. Master theses (two years)

Capacity utilization for Power-to-Heat in Swedish district heating systems: A study with existing power plants in future energy systems
Bolander, Dan-Axel, Uppsala University, Institutionen för teknikvetenskaper, Fasta tillståndets fysik, 2018

CFD modeling of a neutral atmospheric boundary layer over complex terrain
Brekason, Kári, Chalmers University of Technology, Institutionen för mekanik och maritima vetenskaper, Strömningslära, 2018

Gotland as a microgrid - Energy storage systems frequency response in grids with high level of renewable energy penetration
Daraiseh, Firas, Uppsala University, Institutionen för teknikvetenskaper, Elektricitetslära, 2018

Joining solution for a wooden wind turbine tower
Ekblad, Oskar; Strömblad, Oskar, Chalmers University of Technology, Institutionen för industri- och materialvetenskap, Produktutveckling, 2018

Development of an electricity spot market model based on aggregated supply and demand functions for future solar and wind power deployment
Fachrizal, Reza Fachrizal, Uppsala University, Institutionen för teknikvetenskaper, 2018

Can Mexico meet the renewable energy targets under the emission trading scheme?: An analysis of the Mexican electricity framework
Govea Buendia, Jose Agustin, Royal Institute of Technology KTH, Skolan för industriell teknik och management (ITM), Energiteknik, 2018

Partially parabolic wind turbine flow modelling
Haglund El Gaidi, Sebastian, Royal Institute of Technology KTH, Skolan för teknikvetenskap (SCI), Mekanik, 2018

Analyzing the simplified model of the DFIG wind turbine under short circuit faults
Heidarzad Pahlaviani, Kasra, Chalmers University of Technology, Institutionen för elektroteknik, Elkraftteknik, Strömningslära, 2018

The effect of soil-structure interaction on the behaviour of onshore wind turbines with a gravity-based foundation
Isaksson, Jonathan; Tenenbaum, David, Chalmers University of Technology, Institutionen för arkitektur och samhällsbyggnadsteknik, 2018

Concept study and design of floating offshore wind turbine support structure
Johannessen, Markus, Royal Institute of Technology KTH, Skolan för teknikvetenskap (SCI), Farkost och flyg, Marina system, 2018

Integrering av Savonius-vindturbiner och solpaneler
Kihlberg, Kristofer, Uppsala University, Institutionen för teknikvetenskaper, 2018

Landscape effect of wind turbines on farmland and forest birds in Sweden
Kost, Carsten, Lunds universitet, Biologiska institutionen, 2018

Validation of a vortex panel method for aerodynamics and aero-elasticity of wind turbine
Thibierge, Antoine, Royal Institute of Technology KTH, Skolan för industriell teknik och management (ITM), Energiteknik, Kraft- och värmeteknologi, 2018

Reactive power management capabilities of Swedish sub-transmission and medium voltage level grid. Öland's case
Tomaszewski, Michal, Royal Institute of Technology KTH, Skolan för elektroteknik och datavetenskap (EECS), 2018

Geotechnical considerations of shallow wind turbine foundations on onshore locations in Sweden - An evaluation of the conventional method
Tunander, Elin; Jonsson, Erik, Chalmers University of Technology, Institutionen för arkitektur och samhällsbyggnadsteknik, 2018

Investigating the energy demand and supply of a residential neighborhood in Malmö
Wang, Tianqi, Lunds universitet, Institutionen för arkitektur och byggd miljö, 2018

Comparison between active and passive rectification for different types of permanent magnet synchronous machines
Örnkloo, Johannes, Uppsala University, Institutionen för teknikvetenskaper, Elektricitetslära, 2018

4.4. Master theses (one year)

Business development: Market research & feasibility study of a PV-wind hybrid system for commercial use
Abuzohri, Ahmed, Uppsala University, Institutionen för teknikvetenskaper, Industriell teknik, 2018

Detection and removal of wind turbine ice: Method review and a CFD simulation test
Bravo Jimenez, Ismael, Högskolan i Gävle, Akademin för teknik och miljö, Avdelningen för bygg- energi- och miljöteknik, 2018

Design of an off-grid renewable-energy hybrid system for a grocery store: a case study in Malmö, Sweden
Ghadirinejad, Nickyar, Högskolan i Halmstad, Akademin för ekonomi, teknik och naturvetenskap, 2018

The impact of wind energy development on Swedish elspot day-ahead prices
Kasimoglu, Ata, Uppsala University, Institutionen för geovetenskaper, Vindenergi, 2018

Multi-actor multi-criteria decision analysis of wind power community benefit schemes
Leach, Christopher, Uppsala University, Institutionen för geovetenskaper, Vindenergi, 2018

Community benefit funds and wind power: A Scottish case study
Mathers, Adam, Uppsala University, Institutionen för geovetenskaper, Vindenergi, 2018

Wind resource assessment for posibel wind farm development in Dekemhare and Assab, Eritrea
Negash, Teklebrhan, Högskolan i Halmstad, Akademin för ekonomi, teknik och naturvetenskap, 2018

Wind turbine foundations in clay: Technical and economic considerations for proposals for wind turbine foundations
Papagiannis, Michail, Uppsala University, Institutionen för geovetenskaper, Vindenergi, 2018

Comparison between wind turbines in forestall and flat areas of Sweden
Rathinasamy, Sethupathy, Högskolan i Halmstad, Akademin för ekonomi, teknik och naturvetenskap, 2018

A simulated comparison of linear and rans based CFD modeling in regard to critical slope
Robinson, Jeffrey, Uppsala University, Institutionen för geovetenskaper, Vindenergi, 2018

Analysis of hybrid offshore floating wind and marine power
Sai Varun, Kollappillai Murugan, Högskolan i Halmstad, Akademin för ekonomi, teknik och naturvetenskap, 2018

A GIS-based multicriteria decision analysis approach on wind power development: The case study of Nova Scotia, Canada
Senteles, Athanasios, Uppsala University, Institutionen för geovetenskaper, Vindenergi, 2018

Wake induced power deficit analysis on wind turbines in forested moderately complex terrain using Scada Data
Öztürk, Esma, Uppsala University, Institutionen för geovetenskaper, Vindenergi, 2018

4.5. Bachelor theses

Energy conversion Gotland: Alternatives to reach a renewable energy system
Ahlvin, Martin; Arrigata, Yasmine; Bauman, Elise; Berglund, Hanna; Magnusson, Clara och Wiklund, Sofia, Uppsala University, Institutionen för geovetenskaper, 2018

Bearing arrangement for offshore vertical axis wind turbine
Doneski, Darko**;** William, Alaa, Chalmers University of Technology, Institutionen för industri- och materialvetenskap, Produktutveckling, 2018

Construction of a T-joint for a vertical axis wind turbine
Götvall, Anders; Hällgren, Jacob, Chalmers University of Technology, Institutionen för industri- och materialvetenskap, Konstruktionsmaterial, 2018

Is there any limit?: - About increased use of urban roofs in Uppsala
Nordwall, Anders, Uppsala University, Kulturgeografiska institutionen, 2018

Is small-scale wind power profitable for villas in Sweden?

Putkonen, Markus, Uppsala University, Institutionen för teknikvetenskaper, Systemteknik, 2018

Does positive attitudes towards wind power increase the establishment of new wind turbines?: A quantitative analysis of attitudes to wind power

Walan, Jonas, Uppsala University, Nationalekonomiska institutionen, 2018

The development potentiality of wind power: A study on collaboration and technological leap

Wansulin, Linnéa, Umeå University, Teknisk-naturvetenskapliga fakulteten, Institutionen för tillämpad fysik och elektronik, 2018

Comparison of different machine learning models for wind turbine power predictions

Werngren, Simon, Uppsala University, Institutionen för teknikvetenskaper, Systemteknik, 2018

4.6. Summary of academic dissertations and theses

Table 2 below shows the number of academic dissertations and essays during the years 2015–2018. The amount of doctoral and licentiate theses are roughly the same as in previous years. The number of master's theses (30/60 credits) and bachelor theses has declined since 2017, while master's theses (15 credits) are relatively the same number over the past three years.

Here it should be mentioned that a master's thesis of 30 or 60 credits must be completed for a two year Master and a master's thesis of 15 credits is required for the one year Master.

Table 2. Number of doctoral, licentiate, master and bachelor theses 2015–2018.

Nivå	2015	2016	2017	2018
Doctoral theses	11	13	12	12
Licentiate theses	3	4	3	4
Master theses (30/60 hp credits)	17	22	46	17
Master theses (15 hp credits)	16	11	16	13
Bachelors theses	10	10	17	8
Total	**57**	**60**	**94**	**54**

The summary is based on this report and *New and ongoing wind power research in Sweden* 2015, 2016 and 2017.