

PhD Projects 2026

Department of Electric Energy

March 2026

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Electric Energy



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At the Department of Electric Energy (IEL), the mission is to contribute to the fundamental and applied knowledge of electric power engineering, and to develop technology and systems for the planning, operation, and maintenance of efficient, sustainable energy systems. Both research and research-based education at the Department of Electric Energy cover the broad interdisciplinary aspects of power engineering from generation, transmission, distribution, conversion, to the use of electric energy, including the accompanying techno-economic aspects.

The Department works in close collaboration with industry partners and public administration to develop technology for production of electric energy from renewable energy sources and contribute to research that leads to solutions for the future power grid, with high relevance for the society, addressing industrial needs and global challenges.

The Department has four research groups that are each responsible for research and education within their respective areas:

- Electricity Markets and Energy System Planning (EMESP)
- High Voltage Technology (HVT)
- Power Electronics and Electrical Machines (PEM)
- Power System Operation and Analysis (PSOA)

PhD Studies

In this booklet we are presenting ongoing research within all four areas by highlighting the work performed by our PhD candidates. The PhD programme in Electric Power Engineering is standardized to 180 credits (3 years). The final plan for the PhD programme is designed in consultation with the candidate, the supervisor and the Department, depending on the subject area of the thesis and the candidate's needs and preferences.

Usually, the PhD studies are integrated as part of larger research and development projects that are carried out in collaboration with national or international research and industry partners.

We hope you will enjoy reading about our research!

NTNU, March 2026,

Frank Mauseth
Professor
Coordinator of the IEL PhD programme

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Electricity Markets and Energy System Planning (EMESP)

The main research areas of the group are related to the integration of renewable energy sources, energy storage and consumption in the electricity market, and how to optimize the integration of the power system with other parts of the energy system, e.g., heating and transport.

Alexandra Sheppard

Home Country: Australia

Year of Birth: 1998

Email: alexandra.sheppard@ntnu.no

Home Page: [Alexandra Sheppard | NTNU](#)

Master's degree

MSc. Innovative Sustainable Energy Engineering

University: DTU & NTNU

Graduation Year: 2021

Main supervisor: Gro Klæboe

Research Group: EMESP

Co-Supervisors: Magnus Korpås (NTNU), Magnus Moe Nygård (IFE)

Project: HydroSun



Market integration of hybridised solar PV and energy storage power plants in different energy markets

The Norwegian HydroSun project aims to capitalise on technological diversification between hydropower and solar PV by using existing hydropower plants to accelerate integration of solar PV. The project captures the benefits of physical co-location of hydropower and FPV, such as shared electrical infrastructure and costs, reduced reservoir evaporation, and seasonal complementarity of resource availabilities between inflow and solar irradiance.

The PhD investigates the case of market entry and participation for hybridised power plants, in different market structures, through multi-market optimisation modelling. Linear programming models are used to optimise operation of the hydropower plant, solar PV dispatch, and in some cases battery operation, over different time resolutions. Sub-hour solar fluctuation mitigation is balanced against seasonal storage decisions under uncertainty of solar irradiance forecasts, day-ahead market prices, and balancing market prices.

Innovation potential and possible applications

Hybridised renewable power plants provide an opportunity for to integrate greater shares of renewable energy into the power market. The PhD aim is to identify the market levers which greatly impact profit and market integration of hybridised power plants. This can be used by asset owners, power contract designers, and policy makers to inform future decisions regarding hybridised power plants and accelerate market acceptance.

Ali Kaboli

Home Country: Iran

Year of Birth: 1997

Email: ali.kaboli@ntnu.no

Home Page: <https://www.ntnu.edu/employees/ali.kaboli>



Master's degree: Energy Engineering

University: Politecnico di Milano

Graduation Year: 2024

Supervisor: Jayaprakash Rajasekharan

Research Group: Electricity Markets and Energy System Planning (EMESP)

Co-Supervisor(s): Magnus Korpås, Gro Klæboe

Project: FME NTRANS

Advanced Informatics for Distributed Grid Balancing Through Flexibility Aggregation

Description of the research

The increasing integration of renewable energy sources, such as solar and wind, poses challenges due to their unavoidable uncertainty and variability. Additionally, energy decarbonization efforts, such as the retirement of thermal power plants, have decreased the availability of grid inertia traditionally provided by these plants. Consequently, the power system operation requires an increase in its capacity to respond to unexpected fluctuations in generation or transmission. In this regard, demand-side flexibility could maintain the balance between generation and demand in electrical grids.

Different sources of demand-side flexibility can be combined to form innovative solutions for power system operation. Considering current regulations in Norway, small and medium consumers on the demand side cannot participate directly in the balancing markets to provide their flexibilities due to the low tradable volumes, engagement cost, and reliability issues. This has led to the rise of a new player, the 'aggregator,' who aggregates these flexible loads and participates in the balancing markets on behalf of end-users to support the security of supply considering network, generation, and consumer constraints.

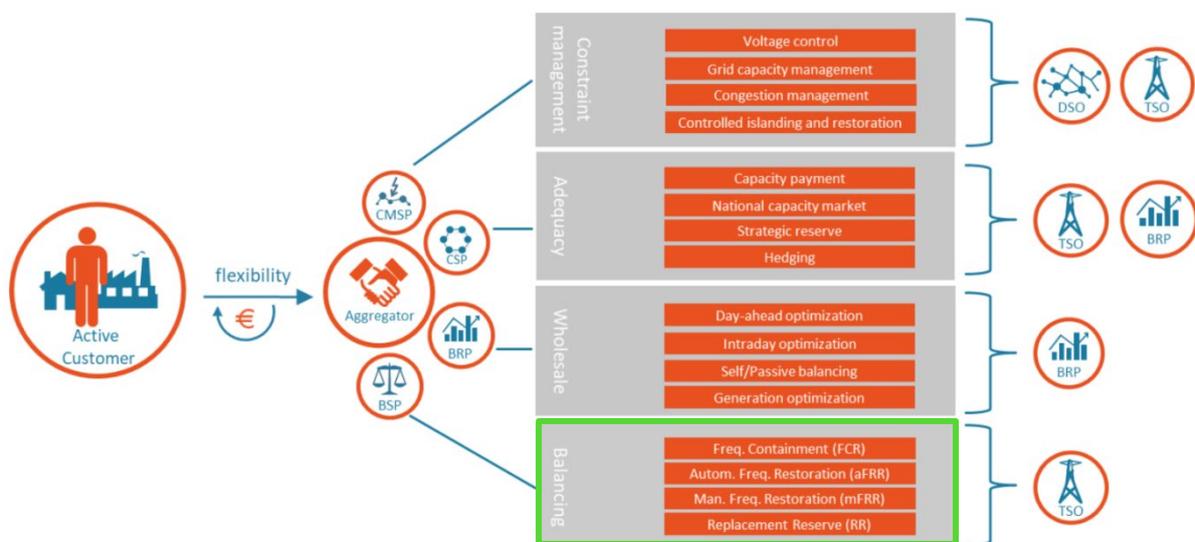


Figure 1: Overview of demand-side flexibility and active parties.

Recently, there has been a growing interest in providing flexibility services from distributed resources, such as Electric Water Heaters (EWHs), to transmission grid operators through aggregated demand response. EWHs have significant potential for offering demand-side flexibility, as they are power-intensive devices with thermal storage capabilities. To effectively integrate EWHs into the balancing markets, aggregators must estimate available flexibility values, optimize market bids, schedule and monitor distributed resources, enhance their operations, deliver the promised flexibility, and validate its delivery. The technologies and tools employed for these tasks should be low-cost, reliable, robust, scalable, and highly accurate.

The main research question to be answered in this project is: How can we address the challenges and issues that hinder the aggregator's effective integration of EWHs into the balancing markets?

Innovation potential and possible applications

The main objective of this project is to develop, validate, and assess advanced operational tools designed to assist aggregators in integrating small and medium-sized distributed energy resources, particularly EWHs, into the balancing markets. This integration supports grid balancing and offers financial benefits to end users, enabling them to profit from flexibility extraction while contributing to the overall stability and sustainability of the Nordic power system.

Aslan Eqbal

Home Country: Germany

Email: aslan.eqbal@ntnu.no

Home Page: ntnu.no/ansatte/aslan.eqbal



Master's degree:

Renewable Energy Systems Engineering

University: Technische Universität Berlin

Main supervisor: Steve Völler

Research Group: Electricity Markets and Energy System Planning (EMESP)

Co-supervision: Industrial secondment at Pixii AS

Project: IDEAL4GREEN (Horizon MSCA)

Energy hubs with multi-port advanced power converters and control for hybrid microgrids

Description of the research

The research aims to advance the global green energy transition by contributing to decentralized, flexible, and efficient energy systems. Central to this are local *energy hubs*, distributed units that combine battery storage, PV generation, and grid or local load connections through multi-port converters. Major challenges to be investigated are managing complex dynamic interactions among multiple converters and integrating diverse energy assets while ensuring reliable, scalable, and autonomous operation across interconnected microgrids. The methodology involves developing and validating a multi-layer control architecture through both simulations and experimental testing to achieve robust performance under varying operational conditions, such as grid-connected and islanded modes. The collaboration with Pixii bridges academic research and industrial application, supporting practical implementation and real-world impact.

Innovation potential and possible applications

The research holds high potential for impact across multiple domains: it advances academic knowledge in control strategies and integration of hybrid microgrids, supports industrial innovation by streamlining microgrid deployment, provides grid operators with more flexible and resilient system resources, and contributes to the broader societal goals of energy security and decarbonization. By fostering closer collaboration between research and industry, the work enhances its overall impact and accelerates the translation of innovation into sustainable energy infrastructure.

Erik Seeger Bjørnerem

Home Country: Norway

Year of Birth: 1995

Email: erik.bjornerem@ntnu.no

Home Page: <https://www.ntnu.no/ansatte/erik.bjornerem>



Master Degree: Energi og Miljø

University: NTNU

Graduation Year: 2021

Supervisor: Magnus Korpås

Research Group: Electricity Markets and Energy System Planning

Co-Supervisor(s): Christian Naversen (SINTEF)

Project: HydroConnect

System Impacts of Connecting Norwegian Hydropower to the European Power System

Description of the research

European countries are phasing out fossil power generation to achieve ever more ambitious climate change mitigation targets. Simultaneously, the share of capacity from variable renewable generation such as wind and solar is increasing. The intermittency of these technologies needs to be balanced by flexible technologies, such as hydropower.

During periods of surplus variable renewable generation, hydropower production can be withheld, and stored for a later occasion. Additional pump capacity may further utilize the variations from wind and solar generation and reduce curtailment, while supplying power in peak demand hours. However, pumped hydropower storage upgrades feature large investment costs, and current investment models overestimate the flexibility of hydropower through aggregation and simplification.

This PhD aims to improve the representation of hydropower in capacity expansion models to accurately compare the allocation of flexible resources from hydropower storage to other technologies such as battery or hydrogen storage. This is then applied to various policy scenarios for CO₂-emissions to investigate how the 85 TWh of reservoir capacity in Norway can contribute to decarbonizing the European power sector, as well as quantifying the impacts for Norway.

Innovation potential and possible applications

This work will provide new insights into capacity expansion modelling of hydropower storage and high shares of variable renewable generation on a European scale.

Jarand Hole

Home Country: Norway

Year of Birth: 1994

Email: jarand.hole@ntnu.no

Home Page: [Jarand Hole - NTNU](#)



Master's degree: Electrical engineering

University: NTNU

Graduation Year: 2018

Main supervisor: Magnus Korpås

Research Group: EMESP

Co-Supervisor(s): Harald Endresen, Steve Völler

PhD work title: Capacity expansion in stochastic dual dynamic programming

Description of the research

More renewable and zero emission energy is needed for decarbonization and new industrial activities. My research is focused on Norway's future electricity supply, understanding how different types of regulations like subsidy schemes and methods for permitting affect this, but most of all understanding how different technologies can play together to make efficient power systems.

The main activity in this research is the work with investment models based on stochastic dual dynamic programming (SDDP). Using the open source SDDP.jl, we can make use of the policy graph concept to structure the decision problems, and by using a non-standard policy graph like the one shown below, optimal investment decisions can be integrated with optimal dispatch decisions.

J. Hole et al.

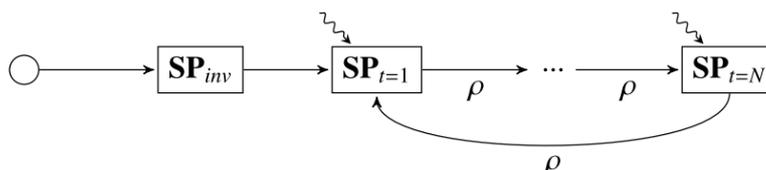


Fig. 3. The policy graph structure for **INV – HTP – ∞** .

Including risk measures and reserve markets in these types of models are necessary to represent the highly complicated and dynamic power markets of today. By integrating

investment decisions into models like these, we ensure that resulting investments also consider that the legacy system operates differently with different capacities.

Innovation potential and possible applications

The models developed in this project will be of interest to actors who are interested in energy system planning. The work is connected to The Norwegian Water Resources and Energy Directorates modelling framework FRAM. The results produced throughout the research will hopefully provide a better knowledge base for decision makers.

Jens Kruse-Hansen

Home Country: Denmark

Year of Birth: 1996

Email: Jens.Kruse-Hansen@ntnu.no

Home Page:

<https://www.ntnu.no/ansatte/jens.kruse-hansen>



Master's degree: Electrical Engineering, Wind Energy

University: TU Delft, NTNU

Graduation Year: 2024

Main supervisor: Jayaprakash Rajasekharan

Research Group: Electricity Markets and Energy Systems Planning

Co-Supervisor(s): Kasper Emil Thorvaldsen & Sébastien Gros

Project: FME NTRANS (Research area 3 - Future energy markets)

PhD work title: Multi-market Decision-making under Uncertainty Using Distributed Heterogeneous Flexible Resources

Description of the research

This PhD research explores strategies for optimising the integration and utilisation of distributed, heterogeneous energy resources in evolving energy markets. It focuses on developing decision-making frameworks that enable aggregators to effectively manage portfolios of distributed heterogeneous flexible resources and engage across multiple energy markets, including balancing markets. The research aims to address challenges related to market dynamics, uncertainty, and risk management.

A key objective is to ensure compliance with emerging regulations while maximising value through multi-market participation. The underlying hypothesis fuelling the research is that decentralised flexible resources can contribute to grid stability, congestion management, and renewable energy integration, thus supporting a transition to more sustainable and resilient energy systems.

Statnett, the Norwegian TSO, expresses a clear desire for more flexibility in the energy sector, as it is a viable alternative to constant grid reinforcements and will help stabilise the grid in a time where intermittent production accounts for more of the total supply. Making sure, the

energy mix is in alignment with the Paris agreement is imperative, and creating a framework that incentivises end-user participation will be key to accelerating this transition.

Innovation potential and possible applications

An expected result of the research conducted will be the novelty that is the application of reinforcement learning (RL) based model predictive control (MPC) on electricity markets. This will yield an RL-MPC framework, that can give insight into and quantify the value of value stacking and of heterogeneous portfolios.

Hopefully this can result in a model that European aggregators can use to maximise profits when bidding in multiple short-term markets, such as the day-ahead, intra-day and balancing markets with a focus on the upcoming market structures resulting from the collaboration between the Norwegian, Swedish, Finnish and Danish TSOs (The Nordic Balancing Model).

Kristine Schüller

Home Country: Norway

Year of Birth: 1998

Email: kristine.schuller@ntnu.no

Home Page:

<https://www.ntnu.no/ansatte/kristine.schuller>

Master's degree: Applied physics and mathematics

University: NTNU

Graduation Year: 2023



Main supervisor: Arild Helseth

Research Group: Electricity Markets and Energy System Planning (EMESP)

Co-Supervisor(s): Hossein Farahmand and Hongyu Zhang (University of Southampton)

Project: RES100 - Modelling a 100% Renewable Electricity System

New Methods for Analyzing a 100% Renewable Nordic Electricity System

Description of the research

The Nordic countries—and Norway in particular—have a large share of hydropower, which can serve as an important flexible resource for balancing renewable energy production. The increasing share of variable renewable energy sources introduces greater short-term uncertainty and variability, which must be accounted for in long-term hydropower scheduling. However, incorporating these effects quickly leads to very large and computationally complex optimization problems.

This PhD uses the ReSDDP model, a research prototype model for long-term hydropower scheduling that applies advanced spatial decomposition techniques to capture both long- and short-term uncertainties. The PhD work will investigate new methods for aggregating hydropower systems by representing detailed system dynamics through feasibility spaces, expressed as linear inequalities referred to as feasibility cuts. Finally, the impact of this improved representation of the Nordic region will be assessed within the context of a fully renewable European electricity system.

Innovation potential and possible applications

The PhD work will contribute to the RES100 project in establishing a new prototype power market model tailored to a fully renewable energy system. New methodologies and algorithms will be developed and built upon the existing framework. The prototype models

will provide a useful tool for planning and decision making that can complement or replace existing models.

Levi M. Larsen

Home Country: United States of America

Year of Birth: 1994

Email: Levi.larsen@ntnu.no

Home Page: [linkedin.com/in/levimlarsen](https://www.linkedin.com/in/levimlarsen)

Master's degree: Economics

University: The University of Edinburgh

Graduation Year: 2021



Main supervisor: Magnus Korpås

Research Group: Electricity Markets and Energy System Planning

Co-supervisor(s): Gro Klæboe (NTNU), Audun Botterud (MIT), John Parsons (MIT),

Project: Markets for Zero-Carbon Energy Systems

Markets for Zero-Carbon Energy Systems

Decarbonizing electricity systems is fundamentally changing how power markets operate. Liberalized market structures were developed for dispatchable thermal fleets with predictable costs and operating behavior. Today's systems are increasingly dominated by variable renewable energy technologies, creating steep ramping needs, price volatility, and new reliability challenges. This is demonstrated by phenomena such as the duck curve observed in the CAISO US market, shown in Figure 1.

California's duck curve is getting deeper

CAISO lowest net load day each spring (March–May, 2015–2023), gigawatts

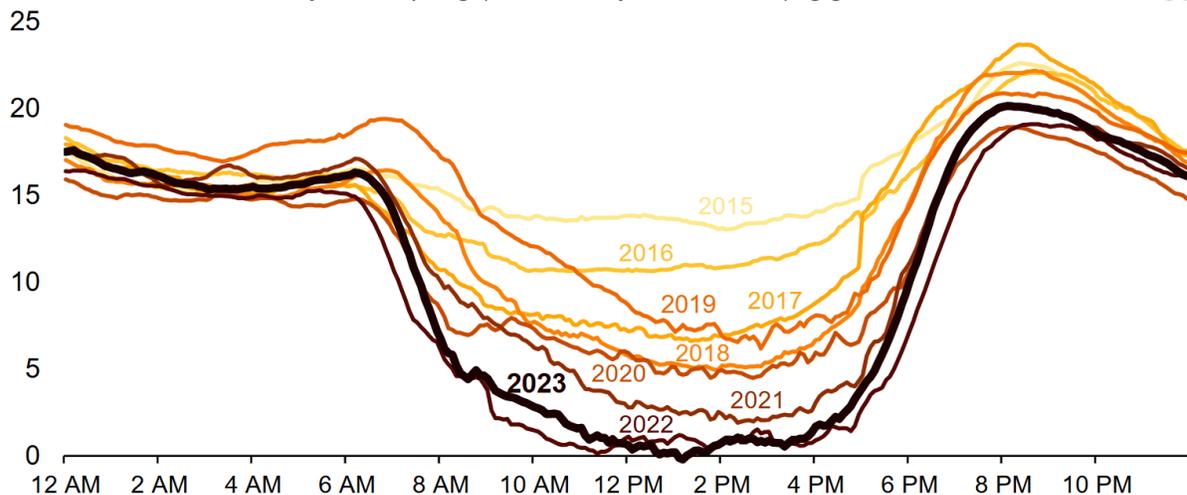


Figure 1. Duck curve formation between 2015 and 2023 in the USA CAISO market. Image credit: EIA.

At the same time that these markets are shifting, many planning tools still rely on simplified financial and structural assumptions that do not reflect technology specific financing or risk. This leads to systematic gaps between theory and practice, including inaccurate investment forecasts, weak investment incentives in market design, and incomplete representations of long run system constraints. This PhD addresses these gaps through three integrated research focuses that connects project finance, market design, and equilibrium modeling.

First, the project develops improved capital cost estimation methods for energy system models. Existing approaches typically apply static discount rates and capital recovery factors that ignore how financing risk evolves over real project lifetimes. This research proposes a Timing and Risk Adjusted Capital Cost Estimation (TRACE) framework that incorporates phase specific risk and financing structures into discounting and annuity calculations. This enables more realistic valuation of capital intensive, long-lived technologies such as nuclear, hydro, and offshore wind, and can be integrated into widely used capacity expansion and LCOE models with minimal structural changes.

Second, the research evaluates market design mechanisms that improves market signaling for investment without additional institutional intervention. Building on the literature on scarcity pricing and the missing money problem, it studies downward sloping demand curves in reserve and capacity markets. By testing alternative demand curve formulations within expansion models, the work assesses how pricing rules influence both the quantity and timing of new investment, with the goal of achieving resource adequacy without institutional intervention.

Third, the project extends long-run equilibrium models developed by Korpås and Botterud by introducing rampability and secondary service constraints. These additions capture operational limitations that become critical in high renewable systems and help explain how requirements for fast response, inertia, and reserves shape optimal supply portfolios.

Together, these contributions provide a more rigorous foundation for predicting investment, designing markets that incentivize it efficiently, and understanding the long run structure of deeply decarbonized power systems.

LIAM DAUCHAT

Home Country: Belgium

Year of Birth: 2003

Email: liamd@ntnu.no

Home Page: <https://www.ntnu.no/ansatte/liam.dauchat>



Master's degree: Energy engineer

University: UCLouvain, Belgium

Graduation Year: 2025

Main supervisor: Magnus Korpås

Research Group: EMESP

Co-supervisor(s): Stine Fleischer Myhre (IFE), Matias Vistnes (SINTEF), Asgeir Tomasgard (NTNU)

Project: SecurEL

PhD work title: Power Grid Modelling for Net-Zero Energy Systems

Description of the research

In my thesis I will investigate how distribution grid constraints and flexibility can be integrated into large-scale energy system planning and market models, with the overall objective of developing scalable modelling methods that improve the representation of distribution networks in net-zero transition pathways.

As electrification accelerates through EVs, heat pumps, and distributed renewables, operational bottlenecks are shifting from transmission to distribution networks. Yet most long-term energy system models aggregate or omit distribution-level constraints such as voltage limits, local congestion, and losses—even though these increasingly shape system-wide costs, curtailment, and investment decisions toward 2050. This creates a gap between the technical realities of modern power systems and the models used to plan their decarbonization. My research addresses this by developing tractable formulations that embed key distribution constraints into planning and market-clearing models, while maintaining computational feasibility at national scale.

Innovation potential and possible applications

This work will produce methodological frameworks and open-source tools that bridge distribution network engineering with energy system economics. I will quantify when and

how distribution-level detail changes welfare outcomes, renewable curtailment, and optimal investment portfolios. Through analytical interpretation of price signals (Distribution Locational Marginal Prices), the research will inform market design and DSO–TSO coordination mechanisms. The results will be validated using Norwegian case studies and disseminated through peer-reviewed publications, open datasets, and policy briefs.

Energy system modelers, transmission and distribution system operators, regulators, and policymakers will be able to use these methods and insights to design more credible, cost-effective pathways toward reliable net-zero electricity systems.

Mari Haugen

Home Country: Norway

Year of Birth: 1987

Email: mari.haugen@ntnu.no

Home Page:

<https://www.ntnu.edu/employees/mari.haugen>



Master's degree: Environmental Physics and Renewable Energy

University: Norwegian University of Life Sciences

Graduation Year: 2012

Main supervisor: Hossein Farahmand

Research Group: Electricity Markets and Energy System Planning (EMESP)

Co-Supervisors: Stein-Erik Felten (Industrial Economy NTNU) and Stefan Jaehnert (SINTEF Energy Research)

Project: Next-generation market models

PhD work title: Advanced modeling techniques for power markets with a large share of hydropower

Description of the research

The main challenge when planning hydropower operations has traditionally been to balance the uncertainty in future inflow and power demand with the risk of emptying or spilling from the reservoirs. In future decarbonized power systems, the level of uncertainty in planning will increase and flexible generation from hydropower resources are expected to become increasingly important. This necessitates modifications or even redesign of the planning tools used.

To properly evaluate hydropower flexibility, a detailed description of the hydropower assets and short-term variations, in addition to the long-term uncertainty in hydro inflows, will become more important when modelling hydropower operations. Formulating the long-term hydrothermal scheduling problem as a two-stage stochastic linear problem solved in a rolling horizon using Benders' decomposition has been demonstrated to be well suited to value the flexibility in the hydropower system.

However, the approaches based on stochastic programming operate under the premise that the underlying probability distributions are accurately identified, even though future scenarios themselves are inherently uncertain. In addition, hydropower scheduling based on

stochastic optimization models that focus on maximizing social welfare, may result in reservoirs being managed quite aggressively. Both aspects can result in operational strategies that are vulnerable to unexpected events in an increasingly uncertain future.

Distributionally Robust Optimization (DRO) does not rely on precise probability distributions; instead, it identifies the worst possible probability distribution within a family of distributions and performs optimization within this set called ambiguity set. Hence, DRO formulation will be more risk averse as the worst-case average cost over all distributions is optimized. The objective of this work is to explore how a DRO formulation of the long-term hydropower scheduling problem affects the long-term strategy for hydropower reservoirs.

Innovation potential and possible applications

We will evaluate if adding some robustness to the hydropower scheduling problem by using DRO can improve the strategy and give more realistic operation of hydropower reservoirs. The results from the DRO formulation are compared to the results from a stochastic formulation to demonstrate the benefits and weaknesses of our method. This will give valuable insights in the development of the next generation market models used for long-term hydropower operation in Norway.

Mikias Hailu Kebede

Home Country: Ethiopia

Year of Birth: 1990

Email: mikias.h.kebede@ntnu.no

Home Page: <https://www.ntnu.edu/employees/mikias.h.kebed>



Master's degree: Electrical Engineering (Power Engineering)

University: Addis Ababa University

Graduation Year: 2014

Main supervisor: Steve Völler

Research Group: Electricity Markets and Energy System Planning (EMESP)

Co-Supervisor(s): Magnus Korpås, and Irina Oleinikova

Project: HYDROGENi

PhD work title: Adaption of the Electric Energy System for Large-scale Hydrogen Production in Norway

Description of the research

Large-scale hydrogen production can be achieved via electrolysis – a process whereby water is split into hydrogen and oxygen using electricity generated from entirely renewable energy sources. This process demands the installation of energy-intensive hydrogen production facilities (electrolyzers, compressors, storage, fuel cells, power electronic converters, and other auxiliary components) that interact with the existing power grid.

Such grid-tied hydrogen production facilities do have opportunities in line with their flexible operation like grid congestion management, voltage and frequency variation adjustment, grid balancing services, seasonal, long-term energy storage provision, combined heat and power (CHP)-cogeneration offer, and power curtailment reduction. On the other hand, increased power/energy demand, grid integration difficulty, system optimization and feasibility study, project spatial allocation, and the need for massive investment are among the challenges of the same facilities.

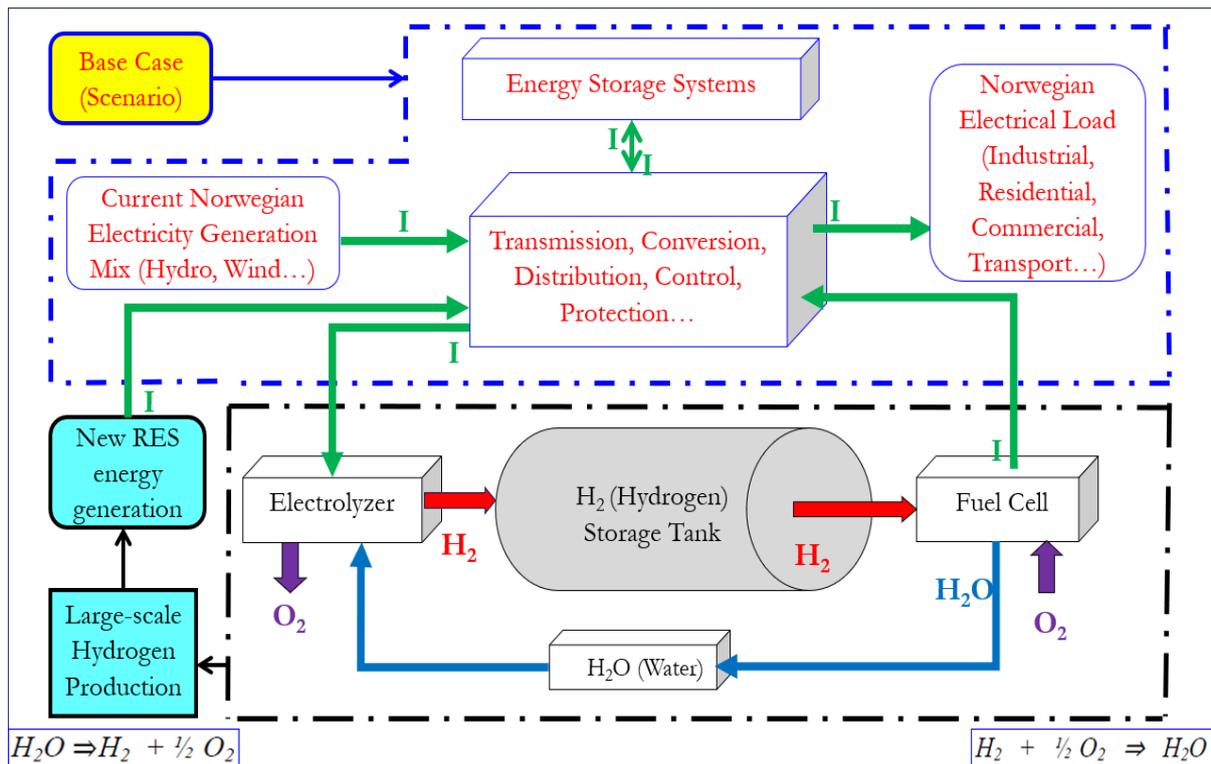


Figure 1: Large-scale Hydrogen Production Conceptualization in Norwegian Power Grid

Hence, to address these challenges and opportunities, my research revolves around the following objectives:

- ✎ Study the need for new renewable energy generation and grids to support new hydrogen installations.
- ✎ Assessment of the technical ability of hydrogen systems to provide flexibility/grid services to the energy system.
- ✎ Conduct a techno-economic analysis of the economic benefits of providing grid services versus normal operation.
- ✎ Evaluation of different energy storage technologies (H_2 and/or electrical) for flexibility in production and cost containment.
- ✎ To work with actual use cases to assess e.g. the local grid constraints and operation modes of the hydrogen systems.

Innovation potential and possible applications

Ultimately, it is anticipated that the findings of this research will be highly significant for energy firms and hydrogen producers, by expanding knowledge on how green hydrogen production can be included in the energy system in a technically sound and financially viable way.

Noah Monz

Home Country: Germany

Year of Birth: 1999

Email: noah.l.monz@ntnu.no

Home Page: -



Master's degree: Industrial Engineering
University: Karlsruhe Institute of Technology
Graduation Year: 2024

Main supervisor: Hossein Farahmand

Research Group: EMESP

Co-Supervisor(s): Kasper Thorvaldsen, Magnus Korpås, Tomas Skjølsvold

Project: NTRANS

PhD work title: Decentralized Transmission Expansion Planning for a resilient and just Energy Transition

Description of the research

This PhD thesis focuses on developing a decentralized transmission expansion planning model designed for the Norwegian electricity grid, with broader applications to the European power system. The model prioritizes resilience, self-sufficiency, and just transitions by integrating local perspectives and addressing distributional effects.

Innovation potential and possible applications

The optimization model developed in the context of this thesis presents a novel decentralized approach to transmission expansion planning that integrates local perspectives, resilience, and fairness. The research addresses significant challenges in energy systems, such as increasing energy demand, the integration of variable renewable energy sources, and the need for just transitions. The model represents a major contribution to the field, providing a practical framework for balancing technical optimization with societal needs and contributing to a sustainable and equitable energy future.

Rahmathulla Madathi Parambath

Home Country: India

Year of Birth: 1998

Email: madathi.p.rahmathulla@ntnu.no

Home Page:

<https://www.ntnu.edu/employees/madathi.p.rahmathulla>



Master's degree: Data science

University: IISER Pune, India

Graduation Year: 2022

Supervisor: Jayaprakash Rajasekharan

Research Group: EMESP

Co-Supervisor: Hossein Farahmand

Project: IntHydro

Hybrid Machine Learning Approaches for Explainable Reservoir Inflow Forecasting

Description of the research

Hydropower is the main source of electricity production in Norway, accounting for over 90% of the total electricity generation. With over 1600 hydropower plants in operation, it produces around 153TWh of electricity per year. Hydropower is a renewable, clean and flexible source of energy with a low carbon footprint. However, hydropower production is highly dependent on weather and environmental conditions, which leads to uncertainty in production levels. To overcome this production uncertainty, it is important to effectively estimate the future water inflow into the reservoirs. There are many existing methods to achieve this, including physical models, machine learning models and hybrid models. Even though there are high-performing machine learning models, explainable models are few. To improve the reliability of water inflow prediction, model explainability is crucial, and this project aims to address it.

The main research questions to be answered in this project are:

1. How to improve the interpretability and transparency of inflow forecasting models by integrating physical principles with machine learning approaches?
2. How can spatial and temporal factors be effectively integrated into explainable inflow forecasting models?

Hybrid machine learning-physical models present a favourable strategy for improving inflow forecasting. The ability to experiment with diverse model architectures enables a careful balancing of predictive performance and model explainability. In a recent work, I developed physics-guided deep learning frameworks that combine the structure of a conceptual hydrological model (HBV) with neural networks, so the model can provide not only accurate inflow predictions but also meaningful intermediate variables that help explain *why* it makes a certain forecast. I also investigate how allowing selected model parameters to vary over time, rather than being fixed, can improve performance under seasonal changes and nonstationary conditions. To do this in a controlled way, I use sensitivity-based analysis to identify which parameters benefit most from being time varying and then learn their temporal patterns from meteorological inputs. Overall, the goal is to achieve forecasting models that are both highly performing and practically interpretable for operational decision-making.

Innovation potential and possible applications

Explainable inflow forecasting models can be useful for hydropower plant operators. Which helps them in better decision-making and optimal hydropower scheduling.

Shivaraj Chandrakant Patil

Home Country: India
Year of Birth: 1994
Email: Shivaraj.c.patil@ntnu.no
Home Page: <https://www.ntnu.edu/employees/shivaraj.c.patil>



Master's degree: Renewable Energy Technologies. Water & Waste Management
University: SRH Berlin, TU Berlin

PhD Project Future Renewable Energy Systems
Research Group Electricity Markets and Energy Systems Planning
Supervisor Magnus Korpås
Co-Supervisor Corinna Schulze-Netzer
Department of Energy and Process Engineering

The potential of waste-to-energy technologies for integrating with other forms of renewable energy systems, to create a more diverse and resilient energy system towards a future Renewable Energy Mix

Descriptions of the research

Under the Future Renewable Energy Systems project, the Waste-to-Energy (WtE) domain and its role will be studied. The following are the objectives of the study.

- To investigate and gain a comprehensive understanding of the existing WtE systems along with biofuel production and their role in the future energy mix.
- To access the key operational and technical challenges that arise during the integration modelling alongside evaluating the limitations of using WtE technologies.
- To model a hybrid WtE system combined with other forms of renewable energy systems and analyse the potential performance and benefits, the Trondheim Municipal Council, Norway case.
- To assess the environmental, economic, and social impact of implementing the WtE technologies, and identify potential mitigation measures to minimise negative impacts.

To fulfil the objectives, the study will answer the following research questions.

- What are the current WtE technologies and their potential to generate electricity, heat, and biofuels in Norway?
- What are the current operational and technical challenges of integrating WtE systems with variable renewable energy sources such as wind and solar, and how can they be addressed to improve the flexibility of the overall energy systems in Norway?
- How can the integration of energy storage systems with WtE systems improve the flexibility and reliability of the overall energy system in Norway?
- What is the potential of WtE systems in producing biofuels in Norway, and how can they be maximised to contribute to the renewable energy mix?

Innovation potential and possible applications

- The study during the Phd period aims to provide a diverse decision-making tool (Multi-criteria Decision Analysis) for selection of the best waste-to-energy technology combinations to improve the municipal solid waste management and maximise the use of energy content from waste streams
- Furthermore, the innovation lies in applying a structured, multi-criteria AHP methodology to simultaneously optimize technological performance, economic feasibility, environmental sustainability, and socio-cultural acceptance in retrofitting CCS units to waste incineration plants.

Synne Krekling Lien

Home Country: Norway

Year of Birth: 1992

Email: synne.k.lien@ntnu.no

Home Page:

<https://www.ntnu.edu/employees/synne.k.lien>



Master's degree: Energy and environment

University: NTNU

Graduation Year: 2016

Main supervisor: Jayaprakash Rajasekharan

Research Group: Electricity Markets and Energy System Planning (EMESP)

Co-Supervisor(s): Karen Byskov Lindberg

Project: COFACTOR

PhD work title: Data-driven Load Disaggregation and Building Load Profile Classification.

Description of the research

The focus of the Ph.D.-project is disaggregation and classification of HVAC-loads (domestic hot water, space heating, other appliances, etc.) and EV-charging from the AMS-meter data of buildings. The main research questions are;

R1. How can aggregated energy metering be disaggregated into typical load profiles per energy service?

R2. How can building load profiles be classified based on disaggregated load data?

Innovation potential and possible applications

The methods developed in the project could be used to improve the methodology for calculating the peak load of buildings, improve the commercial standard NS3032, and the methodology for calculating the peak load element in the energy label of buildings. The methods could also be used for improving commercial products for load disaggregation and classification of building energy loads

Vegard Viken Kallset

Home Country: Norway

Year of Birth: 1996

Email: vegard.v.kallset@ntnu.no

Home Page: <https://www.ntnu.no/ansatte/vegard.v.kallset>

Master's degree: Energy and Environmental Engineering

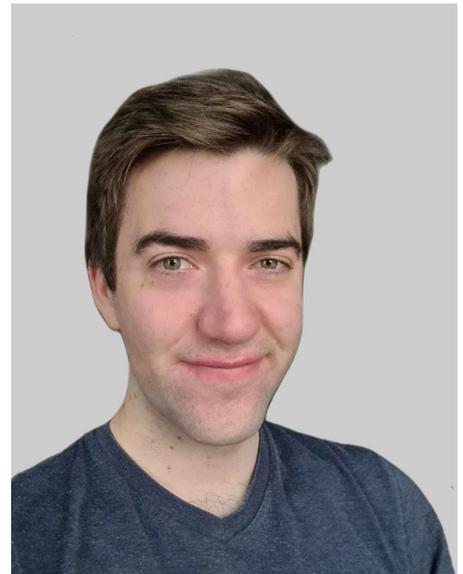
University: NTNU

Graduation Year: 2020

Supervisor: Hossein Farahmand

Research Group: EMESP

Co-Supervisor: Christian Naversen

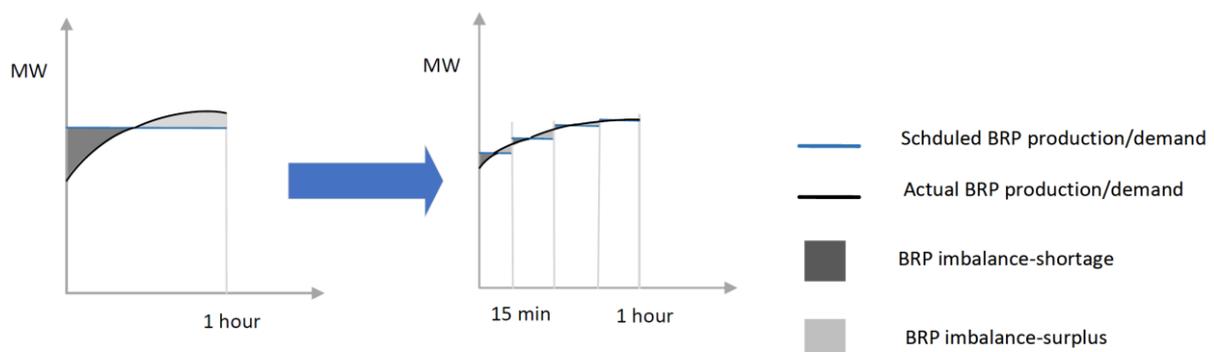


Flexibility Coordination in Sub-Hourly Power Systems Balancing

Description of the research

In the transition towards a low-carbon future, massive amounts of variable renewable energy sources are expected to enter the power system. However, the intermittent nature of RES challenges the system-security the flexibility of conventional generators is pushed to its limits.

Currently the Nordic system operators are working on establishing a new Nordic Balancing Model. Among other things, the new Nordic Balancing Model changes the the day-ahead market resolution from hourly to a 15-minute time resolution. This helps reduce the need for balancing, as shown in the figure below, but also poses challenges to the established process of conducting balancing coordination manually. The system operators must handle these challenges by digitizing and increasing automation.



The purpose of this PhD project is to develop model tools that can aid decision-makers in coordinating balancing of the interconnected North European power system. A promising method for examining and reducing structural imbalances in a system with hydropower and thermal generation is using a continuous-time commitment model. Continuous-time optimization represents parameters and variables as polynomials by expressing them as a linear combination of Bernstein basis-polynomials, thus eliminating the need for instantaneous jumps from one timestep to the next. This approach is computationally demanding, so one of the objectives in the PhD is to employ decomposition-techniques and scale it to a realistic Nordic system.

Additional objectives in the PhD will be:

- Reflecting sub-hourly balancing in the system dispatch (day-ahead market clearing). This will allow the day-ahead dispatch to efficiently manage power system flexibility by adequately utilizing ramping resources.
- Investigating the impact of power grid bottlenecks in sub-hourly system balancing and estimating optimal flow-reliability margins on transmission corridors.
- Incorporating short-term uncertainty in a fundamental continuous-time power market model.

Innovation potential and possible applications

This research could help reduce the cost of balancing the power system by reducing the structural imbalances resulting from discrete time resolution in the in the day-ahead market. This will directly benefit Transmission System Operators, but it could also benefit other market participants in the day-ahead, intraday, or balancing markets by informing better bidding strategies and increasing income.

Viviane Aubin

Home Country: Canada

Year of Birth: 1995

Email: viviane.aubin@ntnu.no

Home Page:

<https://www.ntnu.edu/employees/vivianau>

Master's degree: Energy Engineering

University: Polytechnique Montréal

Graduation Year: 2020 Electricity Markets and Energy System Planning (EMESP)

Main supervisor: Magnus Korpås

Research Group: Electricity Markets and Energy System Planning (EMESP)

Co-Supervisor(s): Arild Helseth (SINTEF Energy), Stein-Erik Fleten (IndØk), Francesca Verones (IndEco)

Project: SusHydro



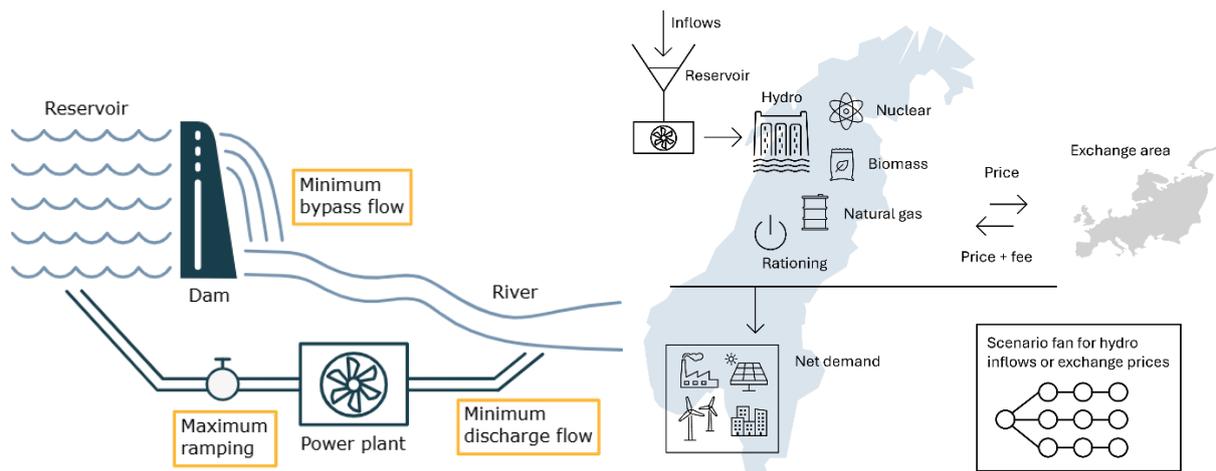
Hydropower in future power systems: challenges and opportunities for policy

Description of the research

In the face of both the climate and biodiversity crises, power systems are undergoing significant transformations. Extreme events induced by climate change amplify the pressure on its infrastructure and the uncertainty in its planning. Meanwhile, policies aimed at mitigating the environmental crises impact power plant operations. They also accelerate the economically induced shift of power mixes towards renewable energy sources and away from fossil fuels.

Hydropower, typically a cheap technology with low GHG emissions, can play an essential role in these future power systems. Its storage and flexibility potential are gaining value with the decommissioning of dispatchable thermal plants and the rise in intermittent VRE generation. However, hydropower is vulnerable to floods and droughts, the frequency of which is set to increase with climate change. This may compromise the reliability services that we hope it can offer.

But what role exactly should hydropower play in future power systems? Is the current power market design fostering the most efficient use of hydropower? What policies and market design should be put in place to ensure hydropower achieves its potential in supporting future power systems in a sustainable way? This Ph.D. tries to contribute to answering those difficult questions through the angle of reconciling society's and private producers' interests in liberalized markets.



More specifically, I look at how hydropower plants and the power system respond to stricter environmental constraints in the context of the transition to high shares of variable renewable energy sources. I also investigate how rising uncertainty in power systems impacts hydropower management and energy security in hydropower-rich regions. Finally, I explore the implications of different policies targeting energy security when applied in those regions.

Innovation potential and possible applications

We should ensure that an institutional framework and economic incentives are present for sustainable, reliable, and affordable hydropower operation, within environmental constraints. This PhD hopes to give policymakers and relevant authorities insights on policy and market design that would foster efficient use of existing hydropower in future power systems.

High Voltage Technology (HVT)

The main research activities of the group are related to the design, modeling and operation of electric power components. With close working links with industry, research into better insulation materials, both for ac and dc, is being conducted. There is ongoing research and development of new technology and expertise in the following fields:

- Insulation Materials
- Analysis of Stresses
- Component Designs
- Smartgrid

Amar Abideen

Home Country: Saudi Arabia
Year of Birth: 1992
Email: Amar.abideen@ntnu.no
Home Page: ntnu.no/employees/amar.abideen



Master Degree: Electric Power Engineering
University: Kungliga Tekniska Högskolan (KTH)
Graduation Year: 2020

Supervisor: Frank Mauseth
Research Group: High Voltage Technology
Co-Supervisor(s): Øystein Hestad
Project: LowEmission center - SP3

Wet Design of AC Power Cables for Future Offshore Power Grids

Description of the research

The main aim of the PhD project is to examine and determine critical ageing mechanisms for a wet design AC power cables with aluminum conductor, which is a project carried out under the umbrella of the LowEmission Centre. The scope of the project covers the investigation of wet design cables influenced by the corrosion of aluminum conductor.

This an extended investigation to what has been previously reported that the corrosion of outer aluminum strands in direct contact with a cable screen can cause the growth of microcracks within the cable screen. Later, some of these microcracks can expand and bridge the entire screen to be a potential site for the inception of vented water trees growing from the inner conductor screen. In severe cases, the growth of vented water trees can lead to a breakdown of the insulation system.

The work consists of experimental characterization of service aged and laboratory aged wet cable design insulation systems under conditions i.e. salinity of strand filling, post extrusion thermal relaxation. It is within the interest to implement different material characterization techniques e.g. scanning electron microscopy and atomic force microscopy to detect different changes caused by the aging.

Innovation potential and possible applications

This project will contribute in developing new technologies and concepts for offshore energy systems, energy efficiency and integration with renewable power production technologies for application on the Norwegian Continental Shelf (NCS). This will help the industry to meet their 2030 and 2050 emission reduction goals, as well as paving the way for zero-emission petroleum production by 2050.

Arik Subhana

Home Country: Bangladesh

Year of Birth: 1995

Email: arik.subhana@ntnu.no

Home Page:

<https://www.ntnu.edu/employees/arik.subhana>



Master's degree: Electrical and Electronic Engineering

University: Bangladesh University of Engineering and Technology (BUET)

Graduation Year: 2021

Supervisor: Frank Mauseth

Research Group: High Voltage Technology

Co-Supervisor: Nina Sasaki Støa-Aanensen

Project: New Gases for GIS

Ageing of New Environmentally Friendly Insulation Gases

Description of the research

SF₆ has been used as the preferred insulation medium in most of the gas insulated switchgear (GIS) in operation since 1960s. However, being an extremely stable compound, SF₆ molecules have an atmospheric lifetime of 3200 years and a global warming potential (GWP) 24,300 times higher than that of CO₂ over a 100-year time horizon. Due to its high GWP, alternative gases are being investigated to replace SF₆ in electric power applications. C5-fluoroketone (C5-FK) and C4-fluoronitrile (C4-FN) are found to be very promising in this regard in addition to natural origin gases like nitrogen (N₂), oxygen (O₂) and carbon dioxide (CO₂).

The insulation gas in a GIS may experience partial discharges (PD), dielectric breakdowns and electric arcing which may lead to decomposition and ionization of the gas. Unlike SF₆, the new insulation gases may not recombine and the dielectric properties may change over time, resulting in gas degradation and ageing.

'New Gases for GIS – long-term reliability and fundamental understanding of insulation properties' is a project led and coordinated by SINTEF Energy Research, where NTNU is one of the research partners along with other international research institutions, gas and switchgear producers, and grid operators. The fundamental characteristics and long-term dielectric performance of the new environmentally friendly insulation gases for medium and high voltage GIS are being investigated in this project for future assurance of a safe and sustainable

power grid. This PhD research lies within the scope of this project where the impact of different types of electrical discharges leading to ageing is investigated on long term dielectric performance and chemical decomposition to develop a knowledgebase for condition assessment and safe operation. The main scopes of the PhD research can be summarized as follows.

- Investigation of ageing of C5-FK and C4-FN gas mixtures in addition to natural origin gases (e.g., dry air and CO₂) by means of medium voltage (MV) and high voltage (HV) arcing and PD tests simulating real-life scenarios.
- Evaluation of the effect of ageing on the long-term dielectric performance by conducting AC, positive lightning impulse (LI+) and negative lightning impulse (LI-) breakdown tests before and after the ageing process.
- Investigating gas decomposition via gas chromatography coupled with mass-spectrometry (GC-MS) and spectroscopic method, namely, Fourier Transform-Infrared Spectroscopy (FTIR). In case of solid byproduct formation, scanning electron microscope (SEM) coupled with energy-dispersive X-ray spectroscopy (EDS) is employed to examine the composition.

Innovation potential and possible applications

The expected lifespan of a typical GIS is several decades, and early degradation of the equipment would entail considerable risks to the grid operators. Therefore, extensive research is needed to investigate the effect of ageing while introducing the new environmentally friendly insulation gases to the electric grid. Based on the findings of this PhD project, it will be possible to anticipate the change in gas density or insulation performance as the composition changes when exposed to electric discharges. This can serve as a useful tool for condition assessment of the gases and the findings will help in establishing guidelines for design and development of new SF₆-free GIS.

Arvin Pourebrahim Shishavan

Home Country: Iran

Year of Birth: 1994

Email: arvin.p.shishavan@ntnu.no

Home Page:

<https://www.ntnu.edu/employees/arvin.p.shishavan>



Master's degree: Power Systems Engineering

University: K. N. Toosi University of Technology,

Tehran, Iran

Graduation Year: 2019

Main supervisor: Kaveh Niayesh

Research Group: High Voltage Technology

Co-Supervisors: Inge Madshaven, Lars Esben Lundgaard (SINTEF)

Project: LiPe

PhD work title: Experimental Investigation of Electrical Breakdown of Alternative Insulating Liquids

Description of the research

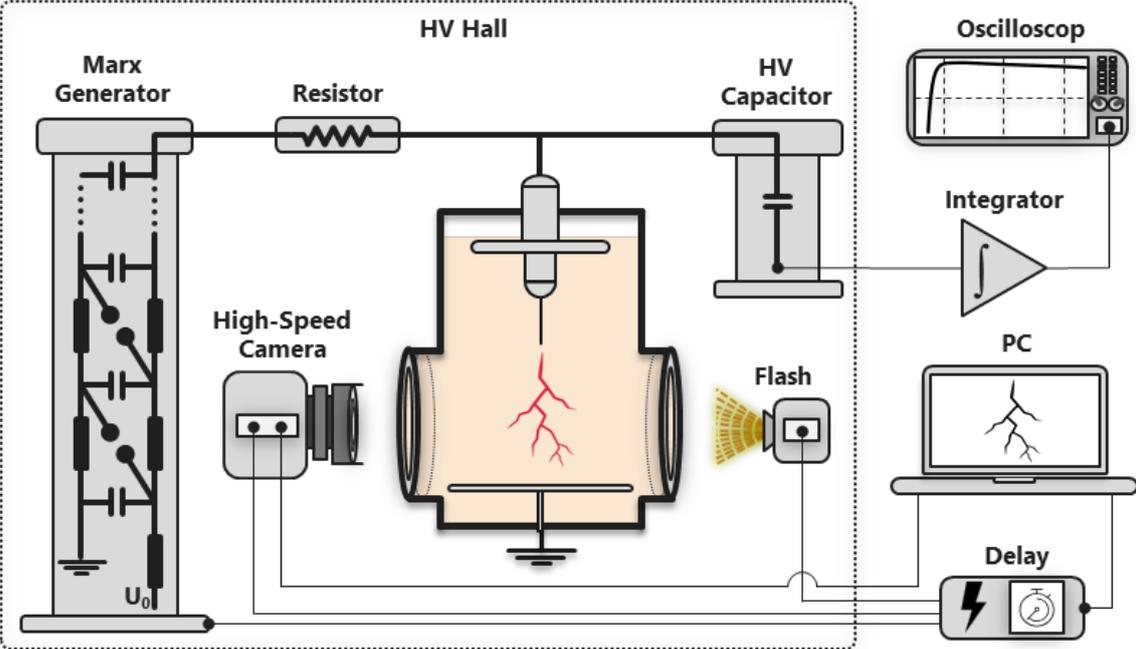
The dielectric liquid is the key component of the transformer insulation system, expected to withstand the electrical stresses it may be exposed to (lightning, switching, and temporary over-voltages), while providing proper cooling, and reduced risk of fire. Mineral oils have been used in transformers for years due to their proven electrical withstand, cooling capability, and reasonable cost. However, their low flash point, flammability, explosion risk, and, more importantly, lack of biodegradability motivate the transition to safer and more environmentally friendly options. Nowadays, new insulating liquids (such as natural and synthetic esters) are being introduced for use in transformers, offering reduced fire risk, and improved cooling properties. Nonetheless, many behavioral aspects of these liquids remain largely unknown. So, further studies are required to ensure their reliable application as a milestone in further electrification of society.

Reports on alternative liquids (e.g. natural and synthetic esters) indicate that, under certain conditions and geometries, they can exhibit lower withstand voltages and faster streamer propagation than mineral oils in positive and negative impulses. Consequently, replacing mineral oils is feasible only if electrical withstand of candidate liquids is adequately characterized and, if possible, improved. Achieving this requires identifying and quantifying the breakdown mechanisms governing streamer initiation and propagation in liquids. My PhD experimentally investigates streamer inception and propagation in various insulating liquids, such as mineral oils and esters, to clarify breakdown governing processes and

possible differences between different liquids across well-controlled conditions (e.g., electrode geometry, electrode distance, and voltage waveform).

Innovation potential and possible applications

The outcome of this work is a more comprehensive understanding of streamer phenomena, which can support improving the performance of alternative insulating liquids and help select suitable liquids for future safe and environmentally friendly transformers. In addition, the experiments and the resulting data will contribute to the development of a more standardized testing procedure for future insulating liquids.



Experimental setup used to investigate streamer discharges in liquids

Ingrid Gunheim Folkestad

Home Country: Norway

Year of Birth: 1997

Email: ingrid.g.folkestad@ntnu.no

Home Page: <https://www.ntnu.edu/employees/ingrid.g.folkestad>



Master's degree: Energy and Environmental Engineering

University: NTNU

Graduation Year: 2022

Main supervisor: Frank Mauseth

Research Group: High Voltage Technology

Co-Supervisor: Hans Kristian Hygen Meyer (SINTEF)

Project: FreeSwitch

PhD work title: Pre-breakdown and breakdown mechanisms in natural origin gas insulation systems

Description of the research

Gas-insulated switchgear (GIS) are used in the electrical grid for interrupting the current during faults and maintenance. For decades, sulfur hexafluoride (SF₆) has been the state-of-the-art insulation gas for high and medium voltage GIS. However, it is known for being the most potent greenhouse gas known to date. Consequently, the EU has decided to strictly regulate the use of SF₆ and other F-gases in medium-voltage switchgear, effective from January 1, 2026. Among the most promising alternatives are high-pressure natural origin gases (NOG) such as air.

Traditionally, the pressure range used for high-voltage applications has been more explored than that relevant for medium-voltage applications. There is a knowledge gap concerning the dominant mechanisms in the pressure range of 1-3 bar absolute for air. It is expected that several discharge mechanisms scale with the product of distance times pressure. Another knowledge gap pertains to critical design areas found in switchgear such as triple junctions, where gas, dielectric material and metal meet. How discharge phenomena in triple junctions scale with pressure has yet to be fully understood. The aim of my PhD is to address some of these questions through experiments and simulations.

Innovation potential and possible applications

The findings of the PhD project are expected to enhance our understanding of the insulation system used in the new eco-friendly product portfolio for medium-voltage GIS.

Manufacturers can leverage this knowledge to develop future products, making the grid more reliable and safe without relying on SF₆.

Martin Hovde

Home Country: Norway

Year of Birth: 1991

Email: martin.hovde@ntnu.no / martin.hovde@nexans.com

Home Page: <https://www.ntnu.no/ansatte/martin.hovde>



Master's degree: Energy Physics

University: Norwegian University of Life Sciences

Graduation Year: 2017

Main supervisor: Bjørn A. Gustavsen

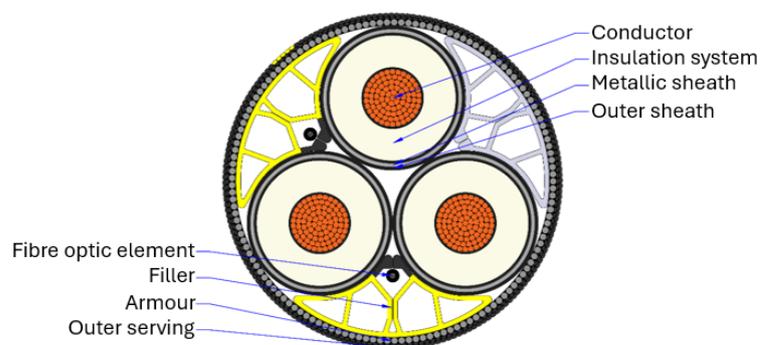
Research Group: High Voltage Technology

Project: NFR Industrial PhD – Electromagnetic modelling of high-voltage power cables

PhD work title: Electromagnetic modelling of high-voltage power cables

Description of the research

Since the early 2010s significant improvements have been made in electromagnetic modelling of armoured three-core cables, with the aim of improving the accuracy of current rating calculations. The cross-section of such a cable is depicted to the right.



The avalanche of activity on this topic was initiated by an industry realization that the IEC 60287 standard tends to overestimate armour losses, in some cases quite drastically. Various methods have been proposed, and in 2023 a recommendation by CIGRE in the form of Technical Brochure (TB) 908 was published.

However, TB 908 and other published work on the topic have revolved around current rating calculations, i.e. power frequency and positive sequence operation. In addition, the published work has almost exclusively focused on cables with a single layer of round wire armour. Other common armour designs include a single layer of flat or rectangular wire, and two layers of either round wires or flat wires.

A few knowledge gaps can immediately be identified:

- Modelling armour consisting of a single layer of flat wires, two layers of round wires or two layers of flat wires for current rating applications.
- Methods for modelling cable armour that are applicable for both positive-/negative- and zero sequence excitation.
- Wideband models applicable for all four armour combinations and any excitation.

Some of these gaps forms the research questions for the project.

The project is an industrial PhD-project funded by Nexans Norway AS and The Research Council of Norway.

Innovation potential and possible applications

It is expected that if objectives are reached, the PhD-work will contribute to an improvement of the state-of-the-art model representation for armoured three-core cables. Specifically, improvements will be made in the calculations of series impedance and loss calculations. The work may broaden the range of cable designs that can be accurately modelled.

Mohamed Hassan Abdelsamea Hassan

Home Country: Egypt

Year of Birth: 1995

Email: mohamed.hassan@ntnu.no



Master's degree:

University: Faculty of Engineering at Shoubra – Benha University - Egypt

Graduation Year: 2024

Main supervisor: Prof. Øystein Hestad

Research Group: High Voltage Technology (HVT)

Co-Supervisor: Prof. Kaveh Niayesh

Project: New Liquids for Transformers (NewLift)

PhD work title: Investigating Different Properties of New Insulating Liquids for Power Transformers

Description of the research

The research aims to enhance the knowledge and decision-making processes of manufacturers and users of transformers that utilize the new environmentally friendly “Biodegradable” insulating liquids as alternatives to the non-biodegradable mineral oil. The research will focus on studying the thermal properties of these fluids and their performance.

Innovation potential and possible applications

The research will provide knowledge and fit-for-purpose models to accurately assess the thermal performance of the alternative dielectric liquids for power transformers, which will mitigate risks and uncertainties and facilitate the utilization of the next-generation functionally improved insulating liquids.

Nafees Ahmad

Home Country: Pakistan

Year of Birth: 1997

Email: nafees.ahmad@ntnu.no

Home Page: <https://www.ntnu.edu/employees/nafees.ahmad>



Master's degree: Master of Science in Electrical Engineering Power

University: National University of Sciences and Technology (NUST), Islamabad, Pakistan

Graduation Year: 2023

Main supervisor: Øystein Leif Gurandsrud Hestad

Research Group: High Voltage Technology (HVT)

Co-supervisor(s): Frank Mauseth, Torbjørn Andersen Ve

Project: LowEmission

PhD work title: Ageing Models and Reliability of Extruded HVDC Cables for Offshore Power

Description of the research

Extruded XLPE HVDC cables are a better alternative to mass-impregnated cables for long-distance transmission and subsea applications. Their advantages include lighter weight, better thermal performance, lower cost and no oil leakage. In subsea environments, they are exposed to high water pressure, water ingress and thermal cycling. Water can enter the micro voids left during the manufacturing process such as scorch spots, crosslinking byproducts and semiconductive protrusions. In wet and semi-wet cable designs, moisture eventually reaches the insulation, which leads to degradation of dielectric properties and chemical deterioration. Ageing models are important for estimating the lifetime of these systems. Established physics-based ageing models for HVDC insulation are lacking since models derived from AC systems cannot include DC phenomena such as space-charge accumulation and electrochemical processes induced by DC stress. It is important to understand these complex ageing mechanisms to accurately estimate the service life of 30 to 40 years and ensure system reliability.

This project investigates extruded XLPE HVDC samples under wet conditions at the High Voltage Laboratory. Combined temperature and humidity stresses are applied to accelerate ageing. Accelerated ageing tests are performed on cup-shaped XLPE samples at 90 °C and 100 % relative humidity. We measure space charge (using PEA), conductivity, and dielectric properties to understand the intrinsic ageing mechanisms. For modelling, COMSOL Multiphysics is used to simulate electro-

thermal-moisture transport inside the samples, and MATLAB for statistical analysis and lifetime prediction. The work supports the LowEmission Research Centre’s targets for reducing offshore GHG emissions. The project stays at early technology readiness levels, TRL 1 to 3. The following images show the cup shaped samples and the accelerated ageing chamber for this research study.



Innovation potential and possible applications

The study will analyze and interpret the main ageing mechanisms in XLPE insulation under DC stress. PEA space charge analysis, polarization/depolarization currents, DSC and other analysis techniques will be employed. The multiphysics models, fitted to data from the accelerated tests, will directly connect electric field, temperature, and humidity to insulation degradation, failure probability, and expected lifetime. That gives clear acceleration factors for qualifying cables under IEC 62067 and accurate 30 to 40 year forecasts for subsea use. For offshore wind farms and platform electrification, these models can reduce unexpected failures and replacements, thereby cutting material waste and repair costs.

RICCARDO FACCHINI

Home Country: Italy

Year of Birth: 1998

Email: riccardo.facchini@ntnu.no

Home Page: <https://www.ntnu.edu/employees/riccardo.facchini>



Master's degree: Electrical Energy Engineering

University: UNIBO - University of Bologna

Graduation Year: 2025

Main supervisor: Øystein Leif Gurandsrud Hestad

Research Group: HVT - High Voltage Technology

Co-supervisor(s): Frank Mausteh, Torbjørn Andersen Ve

Project: AMPRExDC

PhD work title: Numerical Modelling of Ageing Mechanisms, Performance, and Reliability of Extruded XLPE Cables

Description of the research

The research investigates the ageing mechanisms, performance, and long term reliability of extruded HVDC cables insulated with cross linked polyethylene (XLPE). As HVDC transmission becomes increasingly important for offshore wind integration and long distance power exchange, ensuring reliable cable operation is essential due to the very high installation costs and the significant consequences associated with failures. Although recent work has improved understanding of DC insulation behaviour, existing HVDC qualification procedures still rely partly on assumptions originating from AC based testing and on empirical acceleration factors, which create uncertainty in lifetime prediction for modern 525 kV insulation systems.

The project focuses on the development of a physics based numerical modelling framework that emphasises charge transport and electrothermal ageing. The fundamental processes of injection, drift, trapping, de trapping, and recombination are studied to understand how they govern the evolution of space charge distributions under long duration DC stress and varying load cycles. The Bipolar Charge Transport (BCT) model provides the main structure for this work, and the project seeks to refine, stabilise, and validate it using controlled experimental datasets. While the central emphasis is placed on electrical and electrothermal mechanisms, selected chemical changes may be included when they provide necessary information on trap state evolution or broader trends in material behaviour.

The work is carried out within the AMPRExDC research consortium and is integrated with experiments performed on peelings and model cables. Experimental datasets include PEA space charge measurements performed by the candidate, and DC conductivity and polarization-depolarisation current results from partners. When beneficial, additional results from partners obtained with characterisation tools such as FTIR, DSC and TGA, and DMA will be used to support interpretation of material changes. Multiphysics simulations implemented in COMSOL and or Elmer FEM with MATLAB will be used to connect microscopic charge transport mechanisms with macroscopic electric field distributions and operational behaviour during long term operation, transient events, and realistic load cycling.

The overall objective is to produce a validated modelling framework capable of predicting the long-term behaviour of extruded HVDC insulation under conditions representative of actual operation. The results will support improved lifetime estimation, strengthen the physical basis of qualification procedures, and provide insight into the electrical degradation mechanisms that ultimately determine cable reliability.

Innovation potential and possible applications

The research aims to introduce an advanced, physics-driven modelling framework to improve understanding and prediction of HVDC cable ageing by focusing on charge dynamics and electrothermal stress. This enables more accurate lifetime estimation and offers a valuable tool for manufacturers and grid operators seeking to design, qualify, and maintain reliable HVDC assets. The modelling approach can be applied to support improved HVDC testing protocols, optimise insulation design, and enhance condition assessment methodologies for both subsea and land-based systems. By linking measurement-based ageing indicators to predictive simulations, the framework contributes to more robust and cost-effective planning of cable operation and maintenance, supporting the expansion of HVDC infrastructures critical for renewable-energy transmission.

Rizwan Rafique Syed

Home Country: Pakistan

Year of Birth: 1981

Email: rizwan.r.syed@ntnu.no

Home Page: <https://www.ntnu.edu/employees/rizwan.r.syed>



Master's degree: European Wind Energy Masters

University: DTU, Denmark; TU Delft, Netherlands; and NTNU, Norway

Graduation Year: 2015

Supervisor: Hans Kristian Høidalen

Research Group: High Voltage Group

Co-Supervisor: Bruce Mork

Project: WP5 of ProDig project

Dependability and Performance Analysis of Digital Substation Automation System (DSAS)

Description of the research

Substations constitute critical nodes within modern electrical power systems. The ongoing transition towards smart grids, supported by advancements in computing and communication technologies, has accelerated the digitalization of substation infrastructure. The IEC 61850 standard plays a central role in enabling interoperability and communication within digital substations. In parallel, virtualization technologies, widely adopted in the information technology sector, are increasingly being considered for deployment in power system applications. However, their integration into safety-critical infrastructures such as electrical power grids require careful and comprehensive assessment prior to large-scale adoption.

The scope of Digital Substation Automation Systems (DSAS) spans multiple stages, from design and engineering to operation and maintenance. Among the most significant challenges associated with this transition are issues related to system dependability and performance. These challenges raise important research questions, including:

- Are existing reliability and dependability models sufficient to capture the architectural and technological changes introduced by digital and virtualized substations?
- Are the performance of Virtual Protection, Automation, and Control (VPAC) solutions comparable to that of conventional physical Intelligent Electronic Devices (IEDs)?

Work Package 5 (WP5) of the ProDig project addresses these challenges with a particular focus on performance and reliability assessment. The research aims to develop methodologies for reliability evaluation of substations with and without VPAC-based DSAS implementations. Such methodologies support informed decision-making during the design and engineering stages by enabling the selection of system architectures that meet desired reliability targets. Performance assessment of virtualized PAC solutions is conducted using a dedicated laboratory setup comprising commercial VPAC platforms, physical IEDs from multiple vendors, and an in-house developed Virtual Protection Relay (VPR). This approach enables systematic evaluation under controlled conditions, thereby increasing confidence in the performance and suitability of virtualized solutions prior to deployment in critical infrastructure environments.

Innovation potential and possible applications

The research aims to develop novel tools, methods, and evaluation techniques applicable across the lifecycle of a DSAS, including design, engineering, commissioning, and operational phases. The outcomes are expected to support all stakeholders, especially utilities and system integrators, in making informed decisions regarding the adoption of digital and virtualized substation technologies while maintaining high standards of reliability and performance.

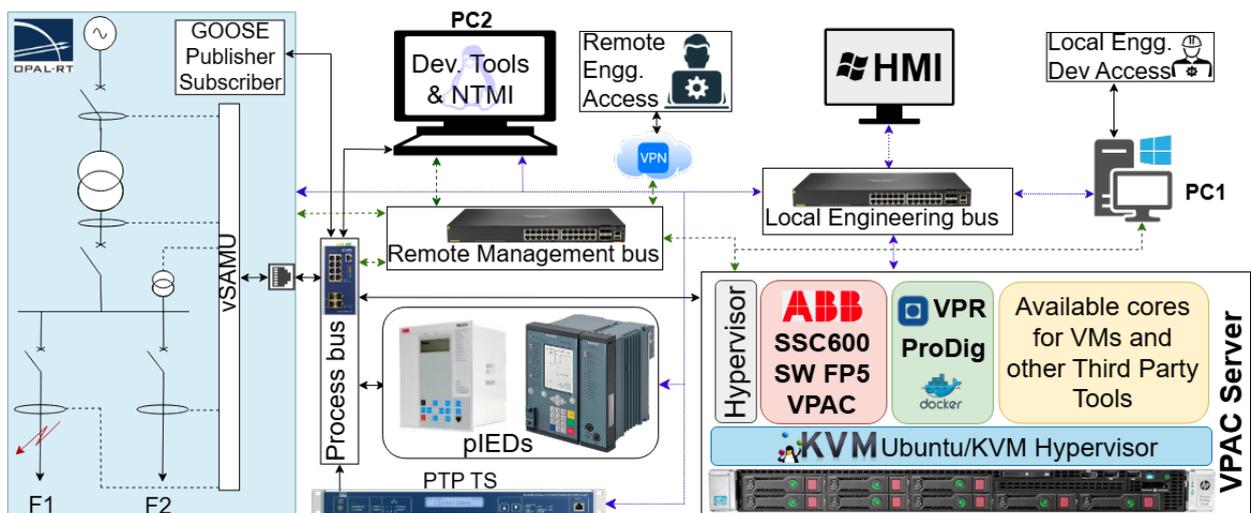


Fig. 1: VPAC testbed lab setup

Salman Khan

Home Country: Pakistan

Year of Birth: 1997

Email: salman.khan@ntnu.no

Home Page: [Salman Khan - NTNU](#)

(<https://www.ntnu.edu/employees/salmak>)



Master's degree: Electrical Engineering Power

University: National University of Sciences and Technology, Pakistan

Graduation Year: 2023

Main supervisor: Frank Mauseth

Research Group: HVT

Co-supervisor(s): Øystein Leif Gurandsrud Hestad, Caterina Elena Lesaint Rusu

Project: Ageing Mechanisms, Performance and Reliability of Extruded HVDC Cables (AMPRExDC)

PhD work title: Material Characterizations of Aged HVDC Cable Insulations

Description of the research

Extruded high-voltage direct current (HVDC) cables represent a critical technology for the long-distance transmission of renewable energy, particularly from offshore wind farms. The insulation system in modern HVDC cables typically utilizes cross-linked polyethylene (XLPE), which must withstand sustained electrical and thermal stresses. These combined electro-thermal conditions progressively degrade the insulation, altering dielectric behavior and ultimately constraining cable lifetime and reliability. Although various electrical and material characterization methods are available to investigate insulation ageing, the fundamental degradation mechanisms and their relationship to electrical performance remain insufficiently understood, particularly under electro-thermal stress. To enhance ageing assessment and lifetime prediction of HVDC cable insulation, a systematic and integrated characterization approach is necessary. This project seeks to address this critical research gap.

The primary research questions addressed in this project are as follows:

1. In what ways does electro-thermal ageing affect the dielectric properties and charge dynamics of XLPE-based HVDC cable insulation?
2. How can electrical ageing indicators be correlated with material degradation to enhance reliability assessment and lifetime prediction of HVDC cables?

Innovation potential and possible applications

HVDC cables are critical for the introduction of **renewable energy sources**, such as offshore wind power. Furthermore, the environmental impact of repairing or replacing the cables can be kept to a minimum with better lifetime and condition assessments. Extruded cable insulation also offers environmental benefits, such as reduced material usage, compared to traditional mass-impregnated insulation. The project will directly contribute to **UN Sustainable Development Goals (UNSDG) 7** "Affordable and clean energy for all" and "Industry, Innovation and Infrastructure", while also laying an important foundation for reaching goal 13, "Climate Action".

Silas Merlin Gerhard

Home Country: Germany / Norway

Year of Birth: 2000

Email: silas.m.gerhard@ntnu.no

Home Page: <https://www.ntnu.edu/employees/silas.m.gerhard>



Master's degree: Electrical Engineering and Information Technology

University: Technical University of Munich (TUM)

Graduation Year: 2024

Main supervisor: Kaveh Niayesh

Research Group: High Voltage Technology (HVT)

Co-Supervisor: Nina Sasaki Støa-Aanensen

Project: MISSION - eMISSion-free HV and MV transmissSION switchgear for AC and DC

PhD work title: Characterization of Short and Rapidly Elongating Arcs for Fast Current Commutation in MVDC Circuit Breakers

Description of the research

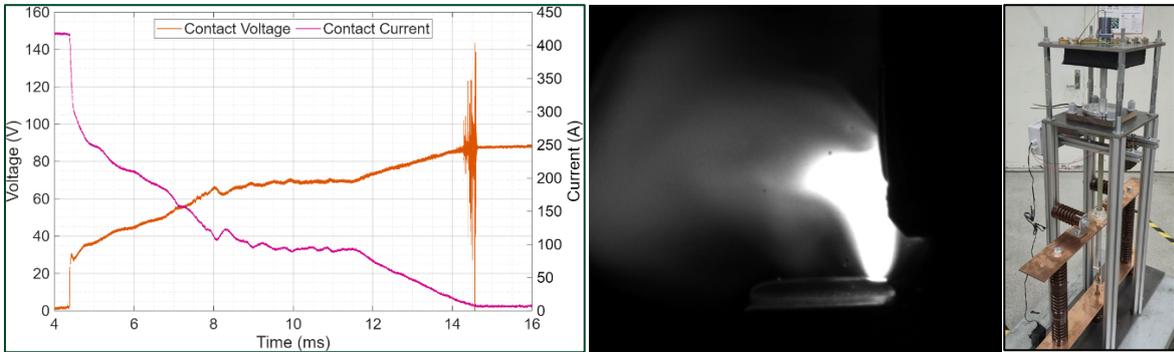
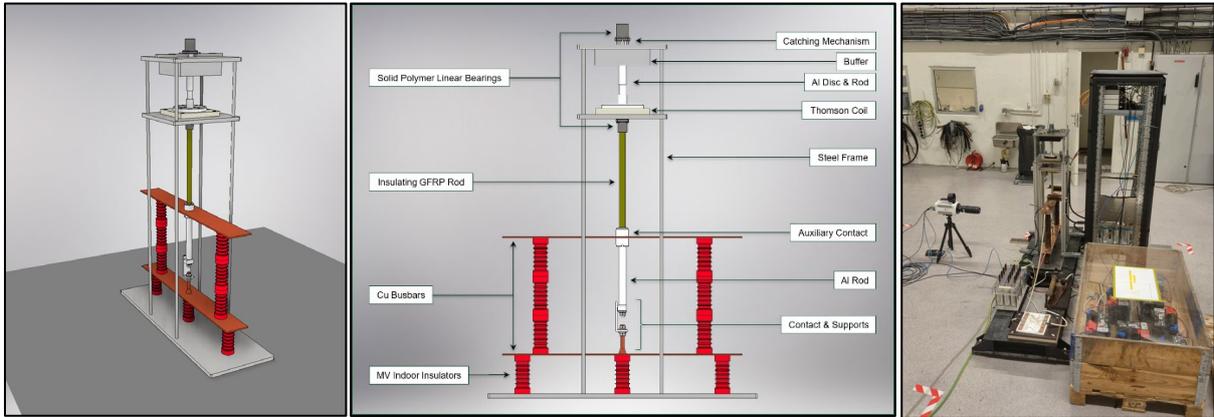
MVDC grids are part of the future power distribution system and have the potential to collect renewable energy sources more effectively and cost-efficiently. However, circuit breakers for DC are demanding faster switching because of high fault current rise rates and they are more complex to develop because of the missing zero current crossing in DC systems. Recent concepts are using an ultra-fast mechanical switch in form of a Thomson coil actuator (TCA) to commutate the current into a parallel capacitor to break the circuit. The success of the commutation is strongly dependent on the voltage of the arc forming between the contacts of the switch. To understand and optimize the switch and the commutation process, a thorough understanding and characterization of the arcs that occur is necessary. This includes the dielectric recovery of the switching gap as well.

Experiments will be carried out in the high current laboratory in order to characterize short and rapidly elongating arcs by means of different measurements. The research also includes the development of arc models to determine the arc voltage as a function of interruption current. The influence of current, contact material, contact velocity and other influential factors is investigated.

The following specific objectives apply to the PhD project:

- Physical characterization of the arcs and the previous metal vapor discharge
- Evaluation of the dielectric recovery of the electrode gap after arc extinction
- Development of models to describe the arcing, the dielectric recovery and the influence on the commutation process

Lately, the revamp of NTNU's Thomson coil actuator (TCA) and preliminary experiments with low voltage are in the focus of my work. The following pictures show the mechanical design of the new drive.



This PhD research is expected to provide new knowledge about the to date little researched rapidly elongating arcs and, thus, enable a more effective and cost-efficient circuit breaker technology for the power market.

Innovation potential and possible applications

MVDC grids are not established in the power system of today and MVDC circuit breakers are not yet commercially available. However, in the future MVDC could be used for the collection of offshore wind energy, local solar power systems, onboard systems of ships, rails systems, gas and oil rigs, mines urban areas with a lot of DC consumers (e.g. university campuses) and local networks for huge data centers. Therefore, MVDC circuit breakers are interesting for the operators of future MVDC power grids. Standards for MVDC grids are on their way now while research on MVDC circuit breakers has been conducted over many decades. MVDC circuit breakers have been developed under utilization of SF₆, vacuum or power electronics in the past. The MVDC circuit breaker based on current commutation by an ultra-fast mechanical switch aims to get by without these and thereby saving costs (OpEx as well as CapEx) and space. The research conducted in the PhD project is supposed to be useful for the design and development of this type of circuit breakers for research organizations and circuit breaker manufacturers, while at the same time providing general knowledge about switching arcs and electrical contacts.

Tina Mirzaamin

Home Country: Iran

Year of Birth: 1996

Email: tina.mirzaamin@ntnu.no

Home Page: <https://www.ntnu.no/ansatte/tina.mirzaamin>



Master's degree: MSc in Physics

University: NTNU

Graduation Year: 2022

Main supervisor: Kaveh Niayesh

Research Group: HVT

Co-supervisor(s): Espen Eberg (SINTEF)

Project: SWoP

PhD work title: Characterization of Nonlinear Electric Field Grading in Insulation Systems Exposed to Power Electronic Converter Stresses

Description of the research

My research investigates the electric field and temperature distribution in insulation systems subjected to fast, high frequency voltage pulses generated by modern power electronic converters. As switching speeds increase, traditional insulation designs (50/60Hz) face significant challenges due to rapid voltage transitions. In this project, I evaluate the performance of nonlinear field-grading technique, which is a method of controlling the electric field, by integrating experimental work with data analysis. The current step of the work is to look at sinusoidal voltages in 50Hz - 9KHz frequency range, and in the later steps I will focus on square wave voltages.

Innovation potential and possible applications

My project can help researchers who work with high voltage insulation systems in power electronic converters. It is relevant for industries in renewable energy, electric transport, and modern power grids, where strong insulation is essential. Manufacturers developing materials and components that must handle fast electrical stresses may also find it useful.

Power Electronic and Electrical Machines (PEM)

The main research areas of the group are related to electrical machines and to power electronics. More specifically, for power electronics, development, design, optimization, and control of power electronic converters and systems. And specifically for electrical machines, modelling and optimization, design of electric machinery.

The goal is to provide innovative high efficiency environmentally friendly solutions within the production, distribution, and use of renewable energy. This includes application areas such as energy production, onshore and offshore power systems, marine, oil & gas.

Andrew Macmillan Smith

Home Country: USA

Year of Birth: 1994

Email: andrew.smith@ntnu.no

Home Page: <https://www.linkedin.com/in/andrew-smith-61bb1464/>



Master's degree: Renewable Energy in the Marine Environment (REM)

University: University of Strathclyde (UoS), University of the Basque Country (UPV), Norwegian University of Science and Technology (NTNU)
Graduation Year: 2022

Main supervisor: Elisabetta Tedeschi

Research Group: Power Electronics and Electrical Machines (PEM)

Co-Supervisor(s): Gilbert Joseph Bergna Diaz

Project: SAFER collaboration

PhD work title: Stability and control of large offshore power plants

Description of the research

The offshore wind energy industry has grown rapidly in recent years, with projections for further expansion. For instance, the European Network of Transmission System Operators for Electricity (ENSOE) nearly doubled its offshore wind capacity from 2015 to 2023. Floating offshore wind, following the success of Hywind Scotland, has opened new markets. The Norwegian government plans to install 30 GW of offshore wind by 2040, much of it floating installations. The sector will play a key role in a decarbonized energy future.

Most modern offshore wind turbines are Type IV, with full power electronics interfaces that decouple grid and generator frequencies. However, these converters have low electrical inertia, which can cause stability issues. As inverter-based generation increases, grid stability may be compromised. Several real-world instability events have been observed, such as harmonic oscillations in Europe and subsynchronous oscillations in Germany due to converter interactions. These issues are expected to persist as converter-based generation grows.

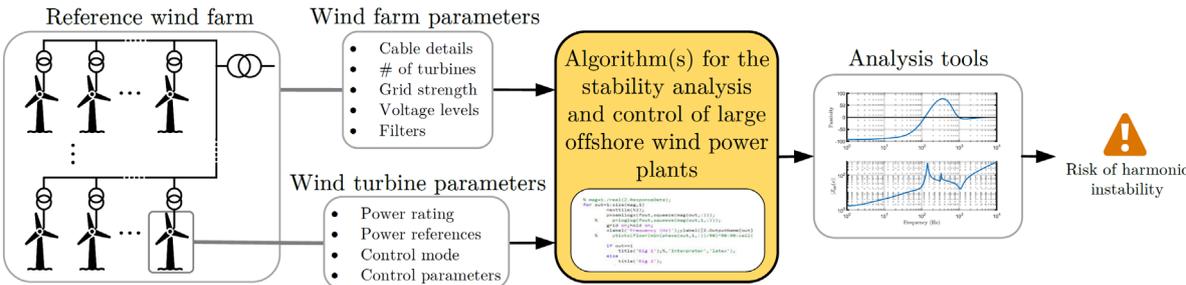
Instabilities can occur across a wide range of frequencies, from subsynchronous to supersynchronous, due to factors like control loop interactions, nonlinear functions, and resonances. Variations in topologies, control strategies, and grid conditions complicate

stability, especially as control strategies shift during operation. Assessing potential stability issues and the impact of grid changes is crucial for further renewable energy integration.

This PhD work aims to develop methods for modeling harmonic instabilities and identifying critical parameters that may lead to instability, providing insights into prevention and mitigation strategies.

Innovation potential and possible applications

By developing methods to model and mitigate harmonic instabilities, the research can be applied to the design and operation of future offshore wind installations, ensuring their integration into the power grid without compromising stability. It will be valuable for wind farm developers or operators and grid operators looking to expand renewable energy capacity. Additionally, the findings could help policymakers and engineers optimize grid infrastructure and control strategies to support large-scale offshore wind adoption, contributing to a more stable and decarbonized energy system. Some of the innovations may be applicable to wider converter-based grid-connection such as solar PV or HVDC applications.



Chirag Ramgopal Shah

Home country India
Year of Birth 1993
Email chirag.shah@ntnu.no
Homepage <https://www.ntnu.no/ansatte/chirag.shah>



Master's degree M.Sc., Electrical Power Engineering
University RWTH Aachen University, Germany
Graduation Year 2021

Supervisors Prof. Roy Nilsen (Main Supervisor)
Prof. Marta Molinas
Dr. Mohammad Amin (external)
Research group Power Electronics and Electrical
Machines (PEM)

Working title: Impedance-based analysis to understand the underlying mechanism leading to small-signal instability in a system dominated by IBRs.

Description of the research:

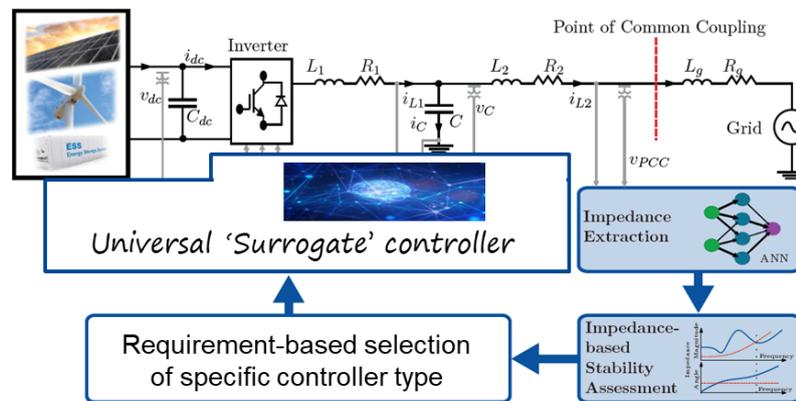


Figure 1

In this PhD project, from the broad perspective, focus will be on improving small-signal stability of grid-tied converters under varying operation points. The overall system consideration for this research work is shown in Figure 1. Each of the blocks is being studied, analysed, and enhanced to improve system performance.

For the impedance extraction, different data-driven methods will be studied and analysed. Based on the impedance extraction, small-signal stability analyses will be performed. During the stability analysis, particular focus is given to a coupling between impedances in the synchronous reference frame. Based on the stability analysis results, suitable controller will be selected to satisfy grid functionality requirements with stable operation.

Innovative potential and application:

Combining data-driven methods with stability enhancement can enable fast response of power electronics converter to any unforeseen unstable operation. A part of this work is useful for the transmission as well distribution service provider and other part is useful for converter manufacturers.

Eljesan Ibrahim

Home Country: Kosovo

Year of Birth: 1997

Email: eljesan.ibrahimi@ntnu.no

Home Page: <https://www.ntnu.edu/employees/eljesan.ibrahimi>



Master's degree: Electrical Engineering

University: Polytechnic University of Tirana

Graduation Year: 2023

Main supervisor: Arne Nysveen

Research Group: Power Electronics and Electrical Machines (PEM)

Co-supervisor(s): Zhaoqiang Zhang, Subhadra Tiwari

Project: FME RenewHydro, RP-2.2 Sustainable upgrading and expansion of the hydropower system

PhD work title: Investigation of Losses in Converter-fed Synchronous Machines for Pumped Storage Hydropower

Description of the research

Variable-speed operation in pumped-storage hydropower plants offers numerous benefits regarding the plant's efficiency, stability, and power adjustability in both generating and pumping mode. A synchronous machine has been traditionally used as means of electro-mechanical conversion in such plants. Variable-speed operation is only achieved by using a power frequency converter which generates higher-order harmonics due to switching. This, in turn, will generate extra losses in the synchronous machine in terms of copper and iron losses which heat up the machine and reduce its lifespan. Therefore, it is important to understand, quantify, and mitigate these effects.

The challenge lies in the accuracy, comprehensiveness, and scalability of the models used to calculate the losses. This is primarily due to the complex non-linear magnetization nature of soft magnetic materials which becomes even more complex when the magnetic field is rotating. High-computational burden is another limiting factor when calculating these losses. This research aims to better understand the mechanisms of extra losses and accurately measure them by means of advanced laboratory setups, analytical models and computer models using Finite Element Method (FEM).

Innovation potential and possible applications

Potential innovation includes machine winding modifications, advanced low-cost harmonic filters, advanced converter control methods within pumped-storage applications.

Erlend Redi Haga

Home Country: Norway

Year of Birth: 2000

Email: erlenrh@ntnu.no

Home Page: <https://www.ntnu.no/ansatte/erlend.r.haga>



Master's degree: Electric Power Engineering

University: NTNU

Graduation Year: 2025

Main supervisor: Dimosthenis Peftitsis

Research Group: Power Electronics and Electrical Machines (PEM)

Co-supervisor(s): Roy Nilsen, Subhadra Tiwari

Project: MarTrans

PhD work title: Galvanically isolated DC/DC converters using WBG semiconductors for marine applications

Description of the research

The research aims to develop galvanically isolated, modular DC/DC converters employing wide-bandgap (WBG) semiconductors to be used in MVDC grids for marine applications. The converters will be developed to interface batteries and fuel cells with an onboard MVDC grid, while shielding the energy storage unit from grid faults. The use of WBG semiconductor technology also permits compact converter designs, meeting the strict space requirements in marine vessels.

Innovation potential and possible applications

Power electronic converters play a key role when integrating environmentally friendly energy carriers into utility grids. The successful development of DC/DC converters in this project can enable such energy carriers to be utilized in marine vessels, significantly reducing the emissions of new ships in the marine industry.

Niccolò Andreetta

Home Country: Italy

Year of Birth: 1999

Email: niccolo.andreetta@ntnu.no

Home Page:

<https://www.ntnu.edu/employees/niccolo.andreetta>

www.linkedin.com/in/niccolò-andreetta-7aab551a1



Master's degree: Mechatronics Engineering

University: Università di Trento (Italy)

Graduation Year: 2023



Supervisor: Tedeschi Elisabetta

Research Group: Power Electronics and Electrical Machines (PEM)

Energy Storage Sizing/Control for 100% Renewable Supplied Isolated Grids

Description of the Research

The objective of this PhD project is to study the potential benefits brought by a suitably selected combination of different Renewable Energy Sources (RESs) and Energy Storage Systems (ESSs) in meeting the local power needs of a target Isolated Power System (IPS).

The use of RESs is commonly considered one of the possible solutions for meeting the growing energy demand sustainably since it is expected that their use will contribute to reducing the reliance on traditional fossil fuels in certain applications. However, this technological shift also presents challenges related to the intermittency of primary resources and grid stability. Among the possible solutions, one approach is the simultaneous use of different primary energy sources (i.e., hybridization) and various ESSs. This allows for the exploitation of the temporal and spatial complementarity of different resources and energy storage technologies to ensure a stable power supply to the grid.

A key novelty of this study is the simultaneous consideration of both well-established energy sources, such as wind and solar power, alongside emerging ones, such as wave and tidal energy. The latter, in particular, offer valuable advantages in terms of predictability and availability.

The research is divided into two main parts. The first part focuses on the development of a data-driven tool to support investment decisions for an optimal power generation mix that best matches the

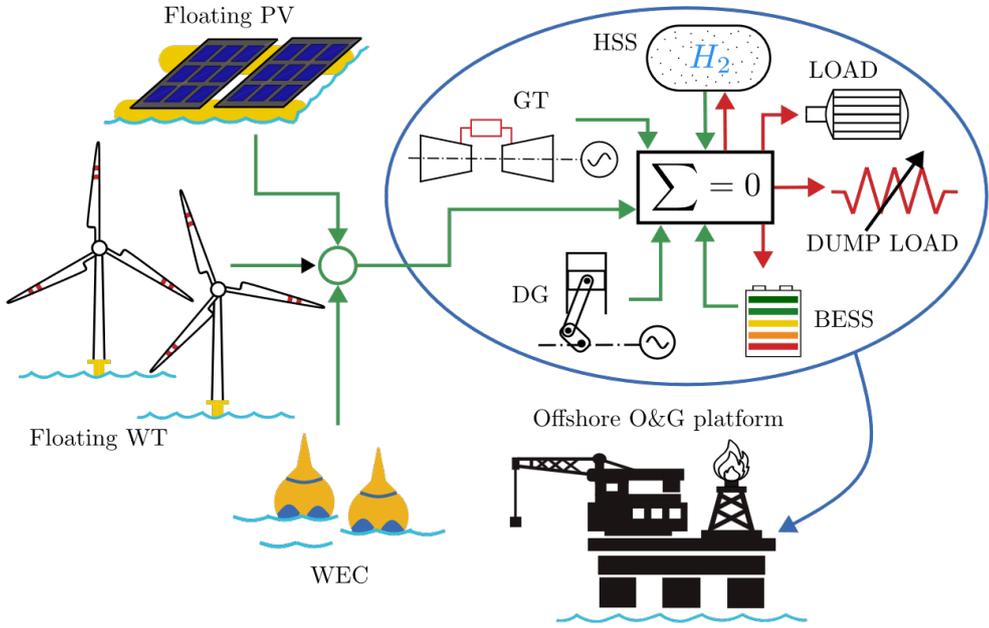
demand patterns of a specific use case. The second part aims to identify the most cost-efficient way to operate the proposed system, ensuring that the target grid is supplied exclusively with renewable energy sources.

In summary, this study will investigate how an ESS should be sized and controlled to enable the smooth integration of multiple RESs into isolated power systems. The goal is to create systems that are completely independent of fossil fuels while remaining resilient under various environmental and operational conditions.

Innovation Potential and Possible Applications

This research will generate new knowledge on the optimal and safe operation of fully RES-based IPSs. The findings will contribute to the development of guidelines and algorithms for the sizing, control, and operation of such systems. In particular, decision-support tools for the sizing and control of RESs and ESSs in IPSs will be developed. These tools will assist decision-makers in optimizing investments and accelerating the green transition of polluting power systems.

Although the research will initially focus on specific IPS test cases, such as an offshore oil rig, the proposed methodology is expected to be general enough to be applied to any IPS.



Srinivas Lakshmi Narayana Gudi

Home Country: India

Year of Birth: 1993

Email: srinivas.l.n.gudi@ntnu.no

Home Page: <https://www.ntnu.edu/employees/srinivas.l.n.gudi>



Master's degree: Electrical Power Engineering

University: RWTH Aachen University

Graduation Year: 2021

Main supervisor: Pål Stabel Keim

Research Group: Power Electronics and Electrical Machines (PEM)

Co-Supervisor(s): Kaveh Niayesh

Project: Clean Aviation

PhD work title: Electrical insulation systems in superconductive power trains for aircraft propulsion

Description of the research

Electrification of aviation can result in reduction of emissions related to it. The main hurdle in aviation electrification is weight. This can be overcome by using motors based on superconductors. Powertrains based on cryogenic technologies can be applied to significantly reduce weight without compromise in powertrain efficiency. These powertrains still need to be insulated for use and a suitable insulating material need to be employed during the operation in cryogenic temperatures.

The insulation system of superconducting rotating machines must satisfy the thermal and mechanical requirements as well as electrical specifications. These specifications include: "high dielectric strength, low dielectric losses in the case of AC voltage, high heat conductance in the internal electrical insulation for heat diffusion reasons, low heat conductance in the bushing, especially high mechanical strength in large superconducting magnets, and high radiation resistance in magnet coils for fusion reactors and accelerators".

Organic insulation materials deteriorate at a faster rate compared to metallic and ceramic elements due to the cryogenic temperatures of these systems. Electron avalanches (partial discharges) caused due to breakdown mechanisms of the material used for insulation accelerate the deterioration of the insulation material. AC losses due to superconducting windings are a predominant cause for insulation degradation and windings need to be cooled with a suitable coolant, usually liquid hydrogen at 20 K.

Insulation materials also experience additional mechanical stresses at cryogenic temperatures due to microstructural changes at these temperatures. Harmonics from PWM fed systems cause additional degradation and accelerate ageing of the insulation materials due to thermal and mechanical stress on the insulation.

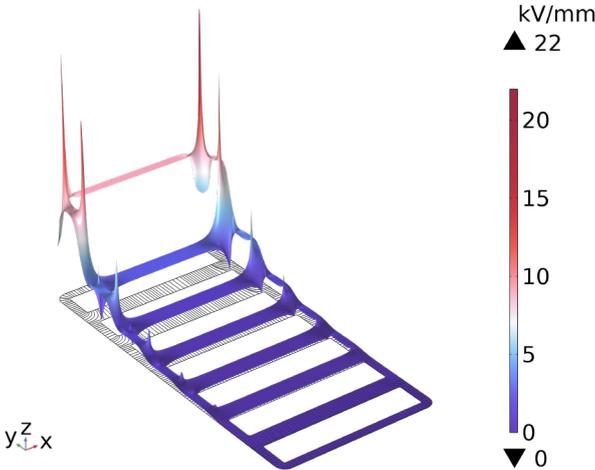


Fig: Electric field distribution in machine slot showing field enhancement at corners of the turn due to sharp corners created by the geometry of HTS tapes.

The materials used as insulation in these machines should be able to withstand electrical, mechanical, and thermal stresses during operation and protect the superconductors from damage due to these stresses. There is a lot of information available on the materials used for conventional machines and the stresses experienced during their operation but not much information on the insulation materials in cryogenic temperatures and the response of these materials in cryogenic temperatures. There are also additional challenges of not being able to extrude the insulation material on the conductor to encapsulate it as the temperatures in the process of extrusion may damage the superconductors.

Thus, the main scope of this PhD study is to investigate insulation materials used in cryogenic temperatures and to provide suitable design options of electrical insulation systems for the power dense aviation motor considering the typical stresses involved in operation.

Innovation potential and possible applications

This project will contribute to the development of clean aviation and the reduction of emissions created by flight propulsion. This will help the aviation industry to meet the 2030 and 2050 emission reduction goals as well as paving the way for net zero emissions and carbon neutrality.

Power System Operation and Analysis (PSOA)

The main research areas of the group are related to the planning, operation, control, and analysis of power systems, with applications in smart grids, transmission, and distribution grids, microgrids and HVDC systems.

Cornelia Skaga

Home Country: Norway

Year of Birth: 1997

Email: cornelia.skaga@ntnu.no

Home Page:

<https://www.ntnu.no/ansatte/cornelia.skaga>



Master's degree: Energi og Miljø

University: NTNU

Graduation Year: 2022

Supervisor: Gilberg Bergna-Diaz

Research Group: PSOA

Co-Supervisor: Babak Abdolmaleki

Distributed Resilient Control of DC Microgrids under Scalable Stability Guarantees

Description of the research

Modern power grids are evolving into multi-agent converter-dominated grids, emerging as a strategic solution for the profitable and effective integration and management of renewable energy sources (RES). DC power systems are both compatible with the DC nature of RES and modern electric generations and loads, and offer simpler dynamics, control and management. From a control perspective, it is crucial to develop new control schemes that are suitable for a rapidly and continuously expanding RES grid, and thus able to safely scale with the grid without risking unstable operations. Hence, multi-agent DC electrical systems with communication-reliant control strategies, also referred to as cyber-physical microgrids (MGs), have gained significant attention as a solution to enhance the flexibility, scalability and reliability of modern power grids. This research project aims to optimize a distributed control framework for DC cyber-physical MGs to always guarantee scalable stability conditions, while providing reliable and optimal power utilization.

Proportional load sharing (current or power-sharing) among the distributed generators (DGs) and voltage containment are often considered the two main objectives in DC MGs. Therefore, this project's primal research objective is to design a distributed controller that ensures both control objectives in steady state operations. Our stability analysis, based on time-scale separation and Lyapunov theory, aims to establish scalable stability conditions that guarantees all energized units to contribute an equal amount of power relative to their rated power while operating dynamically within predefined voltage limits when the system converges to the optimal equilibrium.

Despite the operational advantages of including communication technologies in the control system, this implementation increases the cyber-physical system's vulnerability to cyber-attacks. Accordingly, the controllers robustness against cyber-attacks is examined. Specifically, nonlinear observers are embedded within the distributed controllers to identify abnormal behaviour induced by malicious threats.

Innovation potential and possible applications

With the increased focus on sustainable energy and digitalization of modern power grids, this research enhances the scalability, reliability and stability of future networked power grids interfacing RES through power-electronic converters. The integration of information and communication technologies (ICTs) in the control of electrical systems, establishes a seamless connection between the power and energy industries and the evolving fields of digitalization and cybernetics. Moreover, in today's global landscape, the rise in cyber threats targeting electrical power systems is a growing concern. This underscores the imperative for a resilient control system capable of maintaining grid stability and optimal performance in the face of these cyber-attacks.

Denys Mishchenko

Home Country: Ukraine

Year of Birth: 1989

Email: denys.mishchenko@ntnu.no

Home Page:

<https://www.ntnu.edu/employees/denys.mishchenko>



Master's degree: Electrical Engineering Systems of Power Supply

University: National Technical University of Ukraine "Kyiv Polytechnic Institute", Kyiv, Ukraine

Graduation Year: 2012

Supervisor: Irina Oleinikova

Research Group: PSOA

Co-Supervisors: Hans Kristian Høidalen, Laszlo Erdodi

Cyber-Physical Security and Resilience of Digital Substations in Modern Power Systems

Description of the Research

The digital transformation of power systems has led to the widespread deployment of digital substations and advanced monitoring, protection, and control solutions based on standards such as IEC 61850 and WAMPAC. These technologies improve efficiency, observability, and automation, but they also create strong dependencies between cyber and physical domains. Disturbances affecting communication, data integrity, or time synchronization can directly influence protection functions and system stability.

This PhD project investigates hybrid cyber-physical threats to digital substations from a power-system perspective, with a focus on preparedness and resilience. Rather than analyzing isolated vulnerabilities, the research examines how coordinated and stealthy disturbances propagate through digital substation architectures and affect operational behavior, protection reliability, and system observability.

A key element of the work is the development and use of cyber-physical testbeds that realistically reproduce the interaction between physical power system dynamics and digital substation communication. These testbeds integrate real-time power system simulation, industrial protection and monitoring devices, and standardized protocols, including IEC 61850

Sampled Values and IEEE C37.118 synchrophasors. This enables controlled, repeatable experiments that reveal system-level effects of cyber-physical stress.

Using these platforms, the research evaluates advanced threat scenarios such as stealthy data integrity distortions, coordinated disturbances across multiple protocols, and hybrid cyber-physical stress conditions. These scenarios are treated as resilience stress tests, exposing structural weaknesses and limitations of existing protection and monitoring mechanisms.

The outcomes contribute to a lifecycle-oriented protection concept for digital substations, addressing deterrence, prevention, detection, mitigation, and resilience. The research emphasizes independent verification mechanisms, cross-domain monitoring, and testbed-based validation as key enablers for trustworthy operation of future digital substations.

Innovation Potential and Possible Applications

The project's innovation lies in its integrated cyber-physical and power-system-centric approach, combining realistic experimental infrastructures with resilience-focused security analysis.

- **Academia and research institutions** benefit from the identification and experimental validation of a previously underexplored class of stealthy false data integrity disturbances affecting digital substations and WAMPAC systems.
- **Transmission and Distribution System Operators** gain insights into how cyber-physical disturbances affect protection and monitoring functions, supporting risk-informed operation and preparedness.
- **Regulators and standardization bodies** benefit from experimental evidence on the behavior of standardized technologies under hybrid threat conditions.
- **Engineering consultants and security experts** can apply the scenario-based testbed methodology for realistic risk and resilience assessment.
- **Equipment and solution vendors** obtain guidance on resilience-oriented design and validation of digital substation technologies.

ERIK-ANANT STEDJAN NARAYAN

Home Country: Norway

Year of Birth: 1995

Email: erik-anant.s.narayan@ntnu.no

Home Page: <https://www.ntnu.edu/employees/eanaraya>



Master's degree: Energy and Environmental Engineering

University: NTNU

Graduation Year: 2020

Main supervisor: Kjetil Obstfelder Uhlen

Research Group: Power System Operation and Analysis (PSOA)

Co-Supervisor: Sigurd Hofsmo Jakobsen (SINTEF Energy Research)

Project: The Research Council of Norway's Industrial PhD Scheme

PhD work title: Data-Driven Modeling of Frequency Reserves

Description of the research

The power system is undergoing a never-before-seen change driven by sustainability concerns. The well-known dynamics of synchronous generators are increasingly being replaced by novel converter-interfaced generation (CIG) like solar and wind power, increasing uncertainty and variability in the system. These changes present new challenges of how to control the system, how to model it, and how to properly analyze it.

Of special interest in this project, is how to balance the power system in the form of frequency reserves, amid varying inertia and system conditions. Particularly the tuning of controllers for frequency containment reserves (FCR), and to some extent fast frequency reserves (FFR), becomes increasingly important when reduced inertia levels in effect make the power system take on the characteristics of a smaller, more volatile system. The challenge is therefore twofold. It consists of adequately modeling the reserve providing units, and properly controlling them.

Increased system complexity challenges conventional physics-based modeling (PBM) approaches. At the same time, the advances in data generation and processing, as well as machine learning methods for system modeling and control offer exciting opportunities.

However, data-driven modeling (DDM) approaches are not without their weaknesses. DDM methods, e.g., based on (deep) neural networks, are often presented as black boxes, offering little to no information on their inner workings. They often require large amounts of data

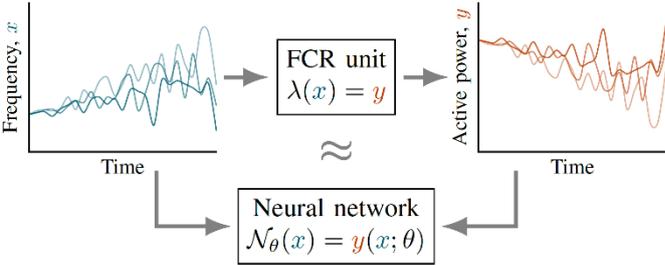
and tend to perform poorly on test cases not present in the training data. This is potentially problematic for critical infrastructure like the power system.

PBM methods, on the other hand, are transparent, but can suffer from a lack of fidelity, as they often rely on simplifications and assumptions in order to create a computationally feasible solution. Based on this, a growing interest in combining the two paradigms has emerged, enabling the leveraging of each of their strengths, like moment-matching artificial neural networks and complex Gaussian process regression.

Innovation potential and possible applications

The main objective of the project is to explore and further develop methods of data-driven modeling of frequency reserves, employing a combined physics- and data-based approach focusing on the faster frequency reserve types.

The overarching aim of the project is to contribute to the transition to a future net zero emissions power system dominated by renewables by improving power system control and frequency reserve provisions. The project focuses on power systems containing both conventional and emerging production and consumption units.



The goal of the project is to develop proof-of-concept methods which can be used further in research and further refined into deployable tools by power system actors.

Fernanda Braga

Home Country: Brazil

Year of Birth: 1993

Email: fernanda.c.braga@ntnu.no

Home Page:

<https://www.ntnu.edu/employees/fernanda.c.braga>



Master's degree: MSc in Renewable Energy in the Marine Environment

University: University of Cork, UPV/EHU & NTNU

Graduation Year: 2023

Main supervisor: Irina Oleinilova

Research Group: PSOA

PhD work title:

Resilient and Reliable Power Exchange Promoting Flexibility Solutions

The project looks into the role of Energy Communities as a strategic solution to the systemic challenges posed by the global transition toward a power grid dominated by variable Renewable Energy Sources. As fossil-fuel-based generation, characterized by predictable, centralized, and high-inertia synchronous machines, is replaced by weather-dependent sources like solar and wind, the power system faces significant risks regarding frequency stability, voltage control, and overall reliability. These challenges are largely driven by the inherent variability of renewables and the technical limitations of inverter-based resources, which often lack the natural inertia and fault-current capabilities of conventional plants. Consequently, ensuring a stable and resilient energy transition requires a fundamental shift toward decentralized flexibility solutions that can effectively manage local fluctuations while supporting the broader grid infrastructure.

The integration of Energy Communities, acting as organized networks of consumers and prosumers, offers a methodology to leverage Distributed Energy Resources and Energy Storage Systems against systemic stability issues. By coordinating local generation through community-level management strategies, these entities can provide essential ancillary services, such as synthetic inertia and demand response, which are necessary to maintain system balance in high-renewable scenarios. This approach aligns with modern legislative frameworks, like the European Clean Energy Package, which positions Renewable and Citizen Energy Communities as key actors in a decentralized energy landscape. By transforming

passive consumers into active market participants, these communities not only enhance grid efficiency but also improve local energy access and resilience in the face of increasingly frequent extreme weather events.

A rigorous comparative analysis of distribution systems reveals the technical and economic advantages of this decentralized coordination. By evaluating scenarios where distributed generation is unorganized against those where resources are structured into formal communities with integrated storage, it becomes possible to quantify the benefits of collective energy management. This analysis examines various operational philosophies and their impact on grid response during fault conditions and periods of high volatility.

The goal of this project is to demonstrate how the organizational structure of energy communities can mitigate the negative consequences of decentralized generation, providing a scalable pathway toward a sustainable, carbon-neutral, and resilient power system that meets global sustainability goals.

Innovation potential and possible applications

The innovation potential of this research lies in its transition from viewing decentralized energy as a grid challenge to utilizing it as a sophisticated provider of stability and flexibility. By developing advanced energy management philosophies for Energy Communities, the project creates a framework where local storage and prosumer coordination can replace the missing inertia of traditional power plants. These applications are particularly valuable for distribution system operators seeking to defer costly infrastructure upgrades and for policy-makers designing regulatory incentives for citizen-led energy transitions. Furthermore, the findings are directly applicable to the development of resilient microgrids in isolated or climate-vulnerable regions, providing a scalable model for autonomous and reliable energy access.

Fredrik Ege Abrahamsen

Home Country: Norway

Year of Birth: 1988

Email: fredrik.e.abrahamsen@ntnu.no

Home Page: <https://www.ntnu.no/ansatte/fredrik.e.abrahamsen>

Master's degree: Sustainable Manufacturing

University: NTNU

Graduation Year: 2016

Main supervisor: Ian Norheim

Research Group: Power System Operation and Analysis (PSOA)

Co-Supervisor: Kjetil Obstfelder Uhlen

Flexibility and controllability of distribution grids with a large degree of distributed energy sources

Description of the research

The increasing integration of solar PV into distribution grids can create technical challenges, including reverse power flow, voltage rise, and grid congestion. These issues can lead to operational inefficiencies, increased wear on grid components, and disruptions in power quality. In weaker networks that are not designed to accommodate high levels of decentralised generation, these challenges become even more pronounced. Addressing them requires a combination of technical solutions and improved grid management strategies. This research explores how flexibility measures can help mitigate these challenges while reducing the need for costly infrastructure upgrades. As part of the study, simulations based on real distribution grids and case studies will be considered in collaboration with a distribution system operator (DSO). By analysing operational challenges in such grids, the study aims to identify practical approaches to improving system efficiency and reliability.

Innovation potential and possible applications

The study is relevant for grid operators and policymakers responsible for maintaining a stable and efficient distribution network in areas with a high share of solar PV. It provides insights into how flexibility can be integrated into weaker grids to enhance stability and efficiency, supporting investment decisions and operational strategies. The results may also contribute to the development of new methods for managing voltage stability, alleviating grid constraints, and facilitating a higher share of renewable energy in the system.

Hugo Rodrigues de Brito

Home Country: Brazil

Year of Birth: 1993

Email: hugo.r.de.brito@ntnu.no

Home Page: www.ntnu.edu/employees/hugo.r.de.brito



Master's degree: Electric Power Engineering

University: Federal University of Pará (UFPA)

Graduation Year: 2019

Main Supervisor: Kjetil Obstfelder Uhlen

Research Group: Power System Operation and Analysis (PSOA)

Co-Supervisor: Thomas Øyvang

Project: System Optimization between power producer and grid owners for more efficient system services (SysOpt)

Secondary voltage regulation for long-term reactive power management and minimization of network losses

Description of the research

Modern power transmission networks are facing significant changes related to the current trends of electrification and massive integration of renewables-based generation. The resulting increase in bidirectional power flows leads to bottlenecks with limited transfer capacity, lower net export margins and intensification of overall system losses. In addition, TSOs are progressively more overburdened by labor-intensive manual operations within regional control centers (RCCs), particularly in connection with long-term management of voltage quality and reactive power source (RPS) devices.

A mitigation strategy for simplified RCC routines with successful real-life implementations consists of automatic and coordinated voltage regulation through hierarchical control layers. This framework is typically divided into three time-decoupled levels: primary voltage regulation (PVR), on a power plant level; secondary voltage regulation (SVR), on a regional grid level; and tertiary voltage regulation (TVR), on a power system level.

Among the three, the intermediate SVR layer has been the focus of renewed research interest due to its twofold contribution to flatter voltage profiles and fairer reactive power sharing within a predefined control area. These objectives are attained, respectively, by the selection of a pilot bus representative of the area voltage behavior and by the assignment of participation factors to RPS devices involved in the SVR scheme.

Lawal Ibrahim Okikiola

Home Country: Nigeria

Year of Birth: 1993

Email: ibrahim.o.lawal@ntnu.no

Home Page: [Ibrahim Okikiola Lawal - NTNU](#)



Master's degree: Dynamics of Renewable-based Power Systems (Erasmus Mundus DREAM)

University: HTW Berlin / UPC Barcelona / École Centrale de Nantes

Graduation Year: 2025

Main supervisor: Sjur Føyen (Department of Electric Energy, NTNU)

Research Group: Power System Operation and Analysis (PSOA)

Co-Supervisor: Gilbert Joseph Bergna Diaz (Department of Electric Energy, NTNU), Raymundo E. Torres Olguin (SINTEF)

Project: SecurEL

Enhancing Grid Stability In Converter Dominated Grid

Description of the research

Power systems are entering a phase where stability is no longer shaped primarily by the electromechanical behavior of synchronous machines, but increasingly by the embedded control of power-electronic converters. As inverter-based resources (IBRs) displace conventional generation, the grid loses several stabilizing features that previously came inherently: inertia, synchronizing torque, strong fault current contribution, and the natural voltage–frequency coupling of synchronous machines. The outcome is not simply less inertia; it is a qualitative shift in the dominant dynamics and in the mechanisms that can trigger instability.

Most renewable converters deployed over the last decade operate in grid-following (GFL) mode, behaving as controlled current sources that lock to the grid voltage angle through a phase-locked loop (PLL). This architecture works well in stiff grids but becomes fragile as the network weakens. The PLL and outer power/voltage loops introduce dynamics that can interact adversely with grid impedance and other converters, potentially leading to sub-synchronous oscillations and instability.

In response, grid-forming (GFM) control has emerged as a serious candidate for maintaining stability in converter-dominated grids. Instead of following an external voltage reference, a GFM converter behaves as a controlled voltage source with internal angle and frequency dynamics, enabling it to form a local grid and provide essential grid-support functions. However, the future grid will be mixed: many installed assets remain PLL-based GFL, while new installations increasingly adopt GFM functions. This mixed environment raises system-level questions that are not resolved by local controller tuning alone.

A further barrier is that converter models are frequently proprietary, limiting visibility into internal control implementations. Without credible models, it becomes difficult to define robust stability margins or interoperability boundaries. This motivates approaches that combine physics-based understanding with uncertainty-aware modelling strategies.

This PhD addresses these challenges through five interconnected tasks. First, a reproducible benchmark distribution feeder (IEEE 13-node) with mixed synchronous generation, PV, and grid-forming resources is established, together with an impedance-based stability workflow linking time-domain events to mechanism-level explanations. Second, current limiting in grid-forming converters is investigated as a stability-critical control function rather than a pure protection mechanism, comparing strategies such as circular limiting, virtual impedance, and voltage-aware approaches. Third, Unified Integral Control (UIC) is implemented for PV systems as a PLL-less alternative, and its stability implications are assessed relative to conventional approaches. Fourth, direct transformer energization by grid-forming converters is studied as a demanding large-disturbance scenario relevant to system restoration. Fifth, an AI-enhanced stability assessment framework explores whether machine learning can complement traditional impedance-based and eigenvalue methods for faster stability screening across large parameter spaces.

Innovation potential and possible applications

The main objective of this project is to develop systematic, explainable, and scalable strategies for enhancing stability margins in converter-dominated grids, with particular emphasis on converter–network interactions and mixed grid-forming and grid-following operation. The research employs a combined physics-based and data-driven approach, focusing on impedance-based stability methods complemented by time-domain validation.

The overarching aim is to contribute to the transition to a future net zero emissions power system dominated by renewables, by improving power system control and stability assessment in networks with high penetration of inverter-based resources. The project is grounded in the Norwegian grid context, where the hydropower-dominated generation system, planned offshore wind integration, and extensive HVDC interconnections create a particularly relevant and challenging environment for studying converter–network interactions.

The expected innovations include: a validated benchmark system and impedance-based workflow for mixed-resource distribution networks; practical guidance on current-limiting design that preserves grid-forming stability; stability characterization of Unified Integral Control as a scalable PLL-less framework for PV integration; identification of control requirements for stable transformer energization in converter-dominated grids; and an AI-enhanced screening tool that accelerates stability assessment across large parameter spaces while traditional physics-based methods remain essential for detailed mechanism understanding.

The goal is to develop proof-of-concept methods and tools which can be used further in research and refined into deployable solutions by power system operators and equipment manufacturers. The results are expected to provide clear design guidance for converter control coordination in weak and mixed-resource networks, supporting the reliable integration of renewable energy at both distribution and transmission levels.

Maiken Borud Omtveit

Home Country: Norway

Year of Birth: 1996

Email: maiken.omtveit@no.abb.com

Home Page:

<https://www.ntnu.no/ansatte/maiken.omtveit>



Master's degree: Energy and Environmental

Engineering

University: NTNU

Graduation Year: 2022

Main supervisor: Kjetil Uhlen

Research Group: PSOA

Co-Supervisor(s): Charlotte Skourup (ABB)

Project: The Research Council of Norway's Industrial PhD Scheme

PhD work title: Coordinated control of industrial processes and power systems for enhanced flexibility and resilience of operation

Description of the research

The concept to be explored in this PhD project is resilient industrial power system management by means of flexible process control. The *resilience* of a system refers here to its ability to withstand disturbances, and *flexibility* refers to its ability to change operating point. The goal is to ensure security of supply and flexibility to maximise the utilisation of the available resources and the industrial processes that require electric power.

Utilising the operating range of industrial processes suited for variable operation can significantly improve the stability of the power supply during contingencies. Moreover, industrial system owners may want to vary process production rate based on factors such as market mechanisms, degradation of equipment or total system efficiency. To meet the demands in these circumstances, plant control systems can be designed to balance the available power and the operating point of the process, actively utilising the total operational envelope of the process and power system.

Because of international goals to reduce greenhouse gas emissions, there is an increased interest in processes that can operate with varying power supply from renewable energy sources (RESs), for example green hydrogen production. Such plants that have not yet been realised present an opportunity to design the system topology taking the coordinated

control of process and power systems into account, saving costs of reducing the need for expensive equipment such as battery energy storage systems.

Innovation potential and possible applications

The research topic is particularly relevant with an increasing share of RESs introduced into the energy mix, plans to electrify offshore platforms and plans to introduce large power consuming industrial sites to the grid, all of it making the national grid more prone to unwanted dynamics. It is expected that the research of this PhD will be a contribution to tackling these challenges.

Tarikua Mekashaw Zenebe

Home Country: Ethiopia

Year of Birth: 1991

Email: tarikua.zenebe@ntnu.no

Home Page: <http://www.ntnu.edu/employees/tarikua.zenebe>



Master's degree: Postgraduate Programme-
Renewable Energy

University: University of Oldenburg, Germany

Graduation Year: 2020

Main supervisor: Prof. Ole-Morten Midtgård

Research Group: Power System Operation and Analysis (PSOA)

Co-Supervisor(s): Assoc. Prof. Steve Völler

Project: Digital Solar Electricity

Machine Learning for Solar Photovoltaic (PV) System Performance and Operational Fault Analysis

Description of the research

The adoption of photovoltaic (PV) systems has been rising rapidly due to declining system costs and supportive policies. According to the IEA report [1], by 2030, renewable energy sources are expected to account for 46% of global electricity generation, with PV alone contributing 16%. Given this anticipated high reliance on PV electricity generation, an efficient and cost-effective protection and monitoring system, suitable even for small-scale residential PV installations, is essential to maintain the lifespan, energy yield, security, and reliability of PV systems.

Recently, several fire incidents linked to PV systems have been reported. Additionally, studies indicate that annual energy losses due to various faults can reach up to 18.9% [2]. Consequently, fault detection and diagnosis in PV systems have gained significant attention in recent years, leading to the development of various techniques. However, existing fault detection and diagnosis methods are primarily constrained by the non-linear nature of PV arrays, the need for remote monitoring, and the presence of faults with similar signatures. Moreover, standard protective devices often fail to detect faults under conditions such as low irradiance or low impedance. As a result, many researchers have been studying data-driven approaches, particularly machine learning (ML). Nevertheless, most machine learning (ML) studies for PV fault detection and diagnosis focus on evaluating algorithm performance, with fewer studies on integrating these methods into real PV systems. Additionally, several new ML algorithms have recently been introduced to improve model robustness and accuracy. Assessing the suitability of these models is essential to fully leverage their benefits for PV systems. Therefore, this Ph.D. research project aims to address the following research questions:

1. What are the state-of-the-art machine learning techniques for PV performance and fault analysis? What are the existing gaps, challenges, and future perspectives?
2. How can transfer learning be utilized in PV system performance and fault analysis? What is the performance of less-explored algorithms?
3. How can we develop a modular, flexible, and scalable fault management system (FMS) for PV using machine learning techniques?
4. How can an ML-based PV FMS be integrated into existing protection systems?

Figure 1 provides a simplified illustration of the focus of this Ph.D. project.

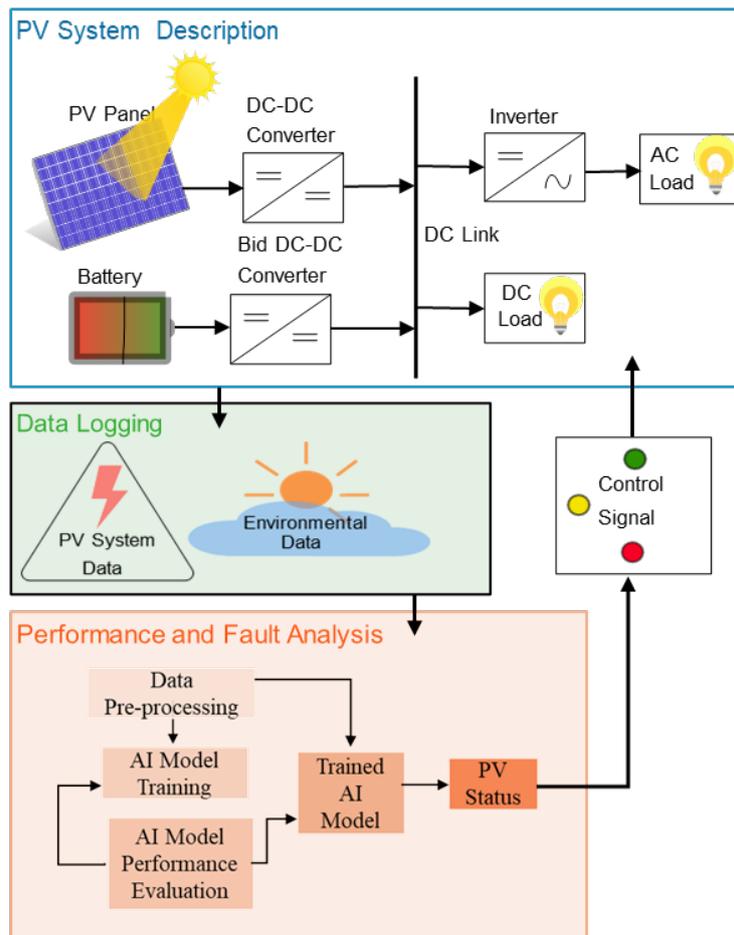


Figure 1: The simplified illustration of the Ph.D. project

Innovation potential and possible applications

The Ph.D. work's results can be used for any PV system, but the focus is on standalone small-scale PV systems, where predictive maintenance is not often practiced and less costly protection and monitoring systems are required.

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Zenebe, T. M., Midtgård, O. M., Völler, S., & Cali, Ü. (2021). Machine Learning for PV System Operational Fault Analysis: Literature Review. https://easychair.org/publications/preprint_download/5msl

Valéria Monteiro de Souza

Home Country: Brazil

Year of Birth: 1992

Email: valeria.m.de.souza@ntnu.no

Home Page: www.ntnu.edu/employees/valeria.m.de.souza



Master's degree: Electric Power Engineering

University: Federal University of Pará (UFPA)

Graduation Year: 2019

Supervisor: Kjetil Obstfelder Uhlen

Research Group: Power System Operation and Analysis (PSOA)

Project: Nordic Early Warning Early Prevention System (NEWEPS)

Early Warning Early Prevention Strategy for Voltage Instability Phenomena

Description of the research

Several factors have been contributing to the challenges observed in power systems worldwide such as the progressive growth in load demand, the lack of investment in grid infrastructure, and the increasing penetration of power electronics-interfaced technologies. Furthermore, weather disruption events are happening more frequently due to climate change, making the monitoring and operation of these systems even more demanding. Under these conditions, risks of voltage instability events are bound to escalate unless proactive actions are implemented.

A measure of particular importance for Transmission System Operators (TSOs) to effectively tackle the complexities inherent to power system dynamic behavior is to accurately estimate the voltage stability margin in real time. Literature on this research topic is extensive, and several Voltage Stability Indicators (VSIs) suitable for real-time monitoring have been proposed. Synchronized Phasor Measurement Units (PMUs) are commonly used in these methods due to their high sampling rate and widespread presence throughout electrical power systems.

Different approaches might be adopted to the development of VSIs, such as: Thévenin equivalent, sensitivity analysis, machine learning techniques, etc. Regardless of the adopted algorithm, it is paramount to strive for an effective and optimized performance within control centers, aimed at improving daily voltage control routines. The ability to issue early alarms when detecting a rapid decline in voltage stability margin can be decisive for whether corrective actions (automatic or operator-initiated) can be taken fast enough to restore the

stability of the system and avoid collapse. Thus, the VSI should be able to identify in advance, without giving false alarms, the onset of voltage stability rather than detect its consequences.

VSIs based solely on PMU measurements and already proposed in the literature had their performance assessed considering placement of monitoring device, different types of loads, line disconnections events, presence of noise in the measurements, and on-load tap changer and over-excitation limiter actions. Moreover, it was of particular interest to test their ability to detect shorter-term events, since they are understandably expected to work best in long-term stability events due to the need for computations and filtering. For this intent, tests with PMU measurements from a real event that occurred in the Nordic power grid were conducted.

Innovation potential and possible applications

The results obtained highlighted the advantages and disadvantages of each index and served as a basis for the development of a new VSI. This novel approach is thought to respond faster and more accurately to the dynamics of the renewables-rich and interconnected power systems of the future, providing real-time information on voltage stability margins. Further research can cover the investigation of its applicability in determining optimal dispatch of reactive power, optimal allocation of distributed energy resources, development of load shedding schemes, among other topics of interest.

Victor Andreu Banuls Ramirez

Home Country: Spain

Year of Birth: 1997

Email: victor.a.b.ramirez@ntnu.no

Home Page:

<https://www.ntnu.no/ansatte/victor.a.b.ramirez>



Master's degree:

University: Polytechnical University of Valencia

Graduation Year: 2022

Main supervisor: Vijay Venu Vadlamudi

Research Group: PSOA

Co-Supervisor(s): Iver Bakken Sperstad

Project: Development of coupled offshore and onshore grids

PhD work title: Development of coupled offshore and onshore grids

The project responds to the ambitious target set by the Norwegian government of achieving 30 GW offshore wind capacity by 2040, necessitating substantial infrastructure development that parallels existing onshore systems. It aims to advance research methodologies and generate comprehensive insights to enable the socio-economically optimal integration of offshore and onshore electrical grids. The scope specifically addresses critical gaps in understanding grid interdependencies, economic implications, and robustness amidst rapidly changing energy landscapes.

Building on current knowledge primarily centered around isolated offshore installations, the project will explore advanced methodologies for coordinated offshore-onshore grid development. This includes sophisticated optimization and simulation strategies to evaluate hybrid connections, energy islands, and meshed AC/DC grids. The research will rigorously examine the socio-economic impacts of diverse grid development scenarios, emphasizing holistic integration rather than isolated enhancements.

A significant research dimension involves ensuring the reliability and resilience of the integrated system. Emphasis will be placed on assessing vulnerabilities, particularly concerning the increased deployment of HVDC technologies and resilience against extreme weather conditions. To facilitate robust scenario analysis, the project will develop reduced, computationally efficient grid models that accurately reflect system interactions while remaining manageable for extensive computational studies.

The project team comprises SINTEF, Statnett, Aker Solutions, GE Grid Solutions, NTNU, and international collaborators from KU Leuven, representing a multidisciplinary consortium that bridges academia, industry, and grid operation expertise. Outcomes will include the provision of open-source datasets, research tools, and methodological frameworks. These contributions will support informed strategic planning and decision-making, reducing uncertainties and promoting sustainable, secure, and economically sound investments in offshore wind infrastructure development.

PhD graduates at the Department of Electric Energy

2026 (by the end of February)

Name	Title
Surya Venkatesh Padiyan	Electric water heater modeling for optimal bidding of aggregated flexibility
Fanny Skirbekk	Streamer inception mechanisms in air - Polarity and pressure dependence in strongly nonuniform fields

2025

Name	Title
Bwandakassy Elenga Banningobera	Design and Implementation of an ASIPS for Frequency Stability in Low-Inertia Power Systems
Christian Magnus Hartmann	Design of Next-Generation Cryo-Electric Aircraft with Superconducting Powertrains
Joseph Kiran Banda	Converter Interfaced Devices for Power Quality Enhancement in Offshore Oil and Gas Platforms
Berhane Darsene Dimd	Digital Solar Electricity: The Role of Artificial Intelligence, Machine Learning, and Energy Optimization
Runar Mellerud	Design of Low-Loss Superconducting Armatures for Lightweight Electric Machines
Ayotunde Adekunle Adeyemo	Optimization of Energy Storage Systems for Offshore Oil and Gas Platforms: Technology Assessment, Sizing, and Deployment Strategies
Babak Abdolmaleki	Networked Control of Converter-Based Power Systems
Matias Vistnes	Probabilistic Short-Term Operational Planning of Large-Scale Power Systems using Security-Constrained Optimal Power Flow
Mohammad Khalili Katoulai	Experimental analysis and development of Process Bus IEDs in digital substations
Sverre Stefanussen Foslie	The Role of Process Flexibility for Faster Decarbonization of Industrial Energy Demands
Jordon Ashley Grant	The Impact of High-Voltage Circuit Breaker Condition on Power System Reliability
Ida Fuchs	Solar Home Systems and Swarm Electrification: Decentralized Power Systems for Energy Access

2024

Name	Title
Marthe Fogstad Dynge	Local Electricity Markets: Evaluating Pricing Mechanisms, Fairness and Privacy
Emil Dimanchev	Decarbonization of Energy Systems Under Risk
Matthias Hofmann	Implicit Demand Side Flexibility as an Alternative to Investments in the Transmission Grid
Paul Monceyron Røren	Ablation-Assisted Load Switching at Medium Voltage in an Alternative Gas to Sulphur Hexafluoride
Ugur Halden	Advancing Power Systems: Harnessing the Potential of Artificial Intelligence and Disturbed Ledger Technology
Yannick Cyiza Karekezi	Assessing the Impacts of Flexible Operation Strategies on Classic Hydropower Generators for Advancing the Energy Transition
Prabhat Ranjan Bana	Advanced Control Design for Grid-Connected Converters in Renewable Energy Applications
Gard Lyng Rødal	Real-time Simulation and Adaptive Gate Driving of SiC MOSFETs
Kjersti Berg	Local Energy Communities: Member Benefits and Grid Impact Under Various Regulatory Frameworks
Sjur Føyen	Modelling of Frequency-Coupled Power Electronics Systems: Automated Model Generation and Chirp Frequency Scanning, Applied to Single-Phase VSCs
Thomas Treider	Earth Fault Location in Non-Radial Resonant Grounded Networks – Theory, analysis and methods
Atousa Elahidoost	Stability Improvement of MMC-Based Multiterminal HVDC Grids

2023

Name	Title
Daniel dos Santos Mota	Control and Stability of Isolated Grids with Synchronous and Non-Synchronous Generation
Raghendra Tiwari	Frequency Converter Solutions and Control Methods for Variable Speed Operation of Pumped Storage Plants
Krister Leonart Haugen	Scalable Regenerative Power Converters for Accelerator Magnets
Daniel Simon Baltensperger	Optimal and Adaptive Arming of System Protection Schemes
Daniel Alexander Philipps	On Dynamic Characterization Evaluation and Control of Active Gate Drivers for SiC power MOSFETs
Matteo Leandro	Framework for Analytical-based Digital Twin Development of Electric Drive Using Slotless PM Machines
Linn Emelie Schäffer	Environmental constraints in stochastic hydropower scheduling for long planning horizons
Aravinda Perera	Enhanced Sensorless Control of Electric Drivetrains for Deep-Sea Mining Vehicles
Mostafa Barani	Reliability Studies in Information and Communication Technology (ICT)-dominated Distribution Systems: Adequacy Assessment of Cyber-Physical Distribution Networks Including Microgrids
Stine Fleischer Myhre	Reliability Assessment Tool for Modern Electrical Distribution Systems – A Monte Carlo Simulation Approach
Erick Fernando Alves	Optimization of Energy Storage for Frequency Control in Autonomous AC Power Systems – Frameworks for Planning and Operation
Spyridon Chapaloglou	Data-driven sizing and control of energy storage for wind-powered offshore platforms – Energy Management and Control of Offshore Platforms Integrating Renewable Energy

2022

Name	Title
Wei Wang	Electromagnetic field calculation and power loss evaluation in power transformers –Analysis of Leakage Fields and Stray Losses under Special Operation Conditions
Sigurd Bjarghov	Designing grid tariffs and local electricity markets for peak demand reduction in distribution grids
Kasper Emil Thorvaldsen	A Long-term Strategy Framework for Flexible Energy Operation of Residential Buildings
Hossein Ehya	A Novel Health Monitoring System for Synchronous Generators using Magnetic Signatures
Magnus Askeland	Policy issues for distributed energy resources as a part of larger energy systems
Hallvar Haugdal	Application of Phasor Measurements for Online Monitoring and Adaptive Damping Control of Electromechanical Oscillations
Naghme Dorraki	Investigation on Fault Current Making in Medium Voltage Switchgear in Air
Per Aaslid	Optimal coordination of renewable sources and storage in energy-constrained power systems
Andreas Giannakis	Design of High-Performance Solid-State Circuit Breakers for LVDC and MVDC Applications
Espen Flo Bødal	Hydrogen Production from Wind and Hydro Power in Constrained Transmission Grids

PhD graduates at the Department of Electric Power Engineering (2005 – 2021)

Year	Name	Title
2021	Torbjørn Andersen Ve	Effect of absorbed water and teperature on charge transport and accumulation in XLPE cable insulation
	Tor Inge Reigstad	Optimal control of variable speed hydropower-Utilising model predicitive control and virtual inertia for delivering power system services
	Erlend Sandø Kiel	Methods for quantifying and communicating risks and uncertainties related to extraordinary events in power systems
	Hans Ole Riddervold	Automated short-term production planning process for hydro- and windpower
	Fredrik Tomas Bjørndalen Wergeland Göthner	Stability and Power Quality Improvements to Facilitate Wide-Scale Deployment of Future Microgrids
	Dimitri Pinel	Optimal Investment in the Energy System of Zero Emission Neighborhoods
	Augusto Matheus dos Santos Alonso	Multi-purpose Coordinated Control of Distributed Energy Resources in Transactive AC Microgrids
	Christian Øyn Naversen	Modelling Approaches for Hydro-Dominated System Balancing
2020	Ole Chr. Spro	Design and Optimisation of an auxiliary power supply with medium-voltage isolation using GaN HEMT's
	Gunnar Håkonseth	Transient Electric Field Distribution Estimates for Layered Paper-Oil High Voltage Direct Current Insulation
	Salman Zaferanlouei	"Integration of Electric Vehicles into Power Distribution Systems - The Norwegian Case Study; Using High-Performance Multi-Period AC Optima
	Pål Keim Olsen	Inertial Partial Discharges at High DC Voltage and the Effect of Superimposed AC Voltage
	Abid Fahim	Characteristics of Switching Arc in Ultrahigh-pressure Nitrogen
	Torstein Grav Aakre	Partial Discharges in voids at Variable Voltage Frequency and Temperature – Diagnostic Testing of Stator Mainwall Insulation
	Abbas Lotfi	Off-core magnetic flux paths in power transformers - Modeling ans applications
2019	Sigurd Hofsmo Jakobsen	Frequency control and stability requirement on Hydro plants
	Martin Håberg	Activation Optimization and Congestion Management in the European Balancing Energy Market
	Subhadra Tiwari	SiC MOSFETs and Diodes: Characterization, Applications and Low- Inductive Converter Design Considerations
	Hans Ivar Skjelbred	Unit-based Short-term Hydro Scheduling in Competitive Electricity Markets
	Anirudh Budnar Acharya	Evaluation Modeling and Control of Modular Multilevel Converter for Photovoltaic Applications
	Erlend Løklingholm Engevik	Design and Operation Investigations for large Converter-Fed Synchronous Machines in Hydropower Applications

	Markus Löschenbrand	Dynamic Electricity Market Games – Modeling Competition under Large- scale Storage
	Emre Kantar	Longitudinal AC Electric Breakdown Strength of polymer Interfaces
	Martin Kristiansen	Multinational transmission expansion planning: Exploring engineering- economic decision support for a future North Sea Offshore Grid
	Martin Hjelmeland	Medium-Term Hydro power scheduling in a Multi-Market Setting
	Hans Kristian Hygen Meyer	Dielectric barrier under lightning impulse stress: Breakdown and discharge – dielectric interaction in short non-uniform air gaps
	Henning Taxt	Ablation-assisted load current interruption in medium voltage switchgear
	Iromi Udumbara Ranaweera Kuruwe Mudiyanselage	Energy storage for Control of Distributed Photovoltaic Power Systems
2018	Konstantin Pandakov	Improvements in protection of medium voltage resonant grounded networks with distributed sources
	Ingeborg Graabak	Balancing og wind and solar power production in Northern Europe with Norwegian hydropower
2017	Erling Tønne	Planning of the Future Smart and Active Distribution Grids
	Atsede Gualu Endegnanew	Stability Analysis of High Voltage Hybrid AC/DC Power Systems
	Lester Kalemba	Multi-variable control systems and analysis Techniques applied to power systems
	Edris Agheb	Medium frequency high power transformer for All-DC wind parks – Design, modeling and optimization
	Amir Hayati Soloot	Resonant overvoltages in offshore wind farms. Analysis modeling and measurement
	Karen Byskov Lindberg	Impact of Zero Energy buildings on the Power System
	Astrid Røkke	Permanent Magnet Generators for Marine current Tidal Turbines
2016	Seyed Majid Hasheminezhad	Tangential electric breakdown strength and PD inception voltage of Solid- Solid interface
	Bjarte Hoff	Model predictive control of voltage source converter with LCL filter
	Ravindra Babu Ummaneni	Design and modelling of a linear permanent magnet actuator with gas springs for offshore application
	Dinh Thuc Duong	Online voltage stability monitoring and coordinated secondary voltage control
	Christian Skar	Modeling low emission scenarios for the European power sector

	Emil Hillberg	Perception, prediction and prevention of extraordinary events in the power system
	Traian Nicolae Preda	Modelling of active distribution grids for stability analysis
	Mehdi Karbalaye Zadeh	Stability analysis methods and tools for power-electronics based DC distribution systems, applicable to on-board electric power systems and smart microgrids
	Nathalie Holtsmark	Investigation of the matrix converter application in a DC series-connected wind farm modulation, control and efficiency
2015	Yonas Tesfay Gebrekiros	Analysis of Integrated Balancing Markets in Northern Europe under Different Market Design Options
	Mustafa Valavi	Magnetic Forces and Vibration in Wind Power Generators
	Nina Sasaki Støa-Aanensen	Air Load Break Switch Design Parameters
	Gro Klæboe	Stochastic Short-term Bidding Optimisation for Hydro Power Producers
	Zhaoqiang Zhang	Ironless Permanent Magnet Generators for Direct-Driven Offshore Wind Turbines
	Rene Alexander Barrera Cardenas	Meta-parametrised metamodeling approach for optimal design of power electronics conversion systems. Application to offshore wind energy conversion systems
	Gilbert Bergna Diaz	Modular Multilevel Converter - Control for HVDC Operation
	Santiago Sanchez Acevedo	Stability Investigation of Power Electronics Systems A Microgrid Case
2014	Bijan Zahedi	Shipboard DC Hybrid Power Systems - Modelling, Efficiency Analysis and Stability Control
	Chuen Ling Toh	Communication Network for Internal Monitoring and Control in Multilevel Power Electronics Converter
	Hamed Nademi	Advanced Control of Power Converters: Modular Multilevel Converter
	Håkon Kile	Evaluation and Grouping of Power Market Scenarios in Security of Electricity Supply Analysis
	Jonas Sjolte	Marine renewable energy conversion: Grid and off-grid modeling, design and operation
	Nadeem Jelani	Investigating the Role of Active Loads in the Future Electrical Grid Dominated by Power Electronics
	Erik Jonsson	Load Current Interruption in Air for Medium Voltage Ratings
2013	Sverre Skalleberg Gjerde	Analysis and Control of a Modular Series Connected Converter for a Transformerless Offshore Wind Turbine

	Vrana, Til Kristian	System Design and Balancing Control of the North Sea Super Grid
	Larsen, Pål Johannes	Energy Savings in Road Lighting Correct Lighting at all times and every condition
	Aigner, Tobias	System Impacts from Large Scale Wind Power
	Nguyen, Dung van	Experimental studies for streamer phenomena in log oil gaps
	Jafar, Muhammad	Transformer-Less Series Compensation of Line-Commutated Converters for Integration of Offshore Wind Power
	Torres Olguin, Raymundo	Grid Integration of Offshore Wind Farms using Hybrid HVDC Transmission Control and Operational Characteristics
	Wei, Yingkang	Propagation of Electromagnetic Signal along a Metal Well in an Inhomogeneous Medium
2012	Yordanov, Georgi Hristov	Characterization and Analysis of Photovoltaic Modules and the Solar Resource Based on In-Situ Measurements in Southern Norway
	Haileselassie, Temesgen Mulugeta	Control, Dynamics and Operation of Multi-terminal VSC-HVDC Transmission Systems
	Abuishmais, Ibrahim	SiC Power Diodes and Junction Field-Effect Transistors
	Zhang, Shujun	Percussive Drilling Application of Translation Motion Permanent Magnet Machine
	Ruiz, Alejandro Garces	Design, Operation and Control of Series-connected Power Converters for Offshore Wind Parks
	Jaehnert, Stefan	Integration of Regulating Power Markets in Northern Europe Offshore Wind
	Tesfahunegn, Samson G.	Fuel Cell Assisted Photo Voltaic Power Systems
	Farahmand, Hossein	Integrated Power System Balancing in Northern Europe Models and Case Studies
	Suul, Jon Are	Control of Grid Integrated Voltage Source Converters under Unbalanced Conditions – Development of an On-line Frequency-adaptive Virtual Flux-based Approach
2011	Marvik, Jorun Irene	Fault localization in medium voltage distribution networks with distributed generation
	Krøvel, Øystein	Design of Large Permanent Magnetized Synchronous Electric Machines – Low Speed, High Torque Machines – Generator for Direct Driven Wind Turbine – Motor or Rim Driven Thruster
	Chen, Anyuan	Investigation of PM machines for downhole applications
2010	Chiesa, Nicola	Power Transformer Modeling for Inrush Current Calculation
	Danielsen, Steinar	Electric Traction Power System Stability Low-frequency interaction between advanced rail vehicles and a rotary frequency converter

	Nordgård, Dag Eirik	Risk Analysis for Decision Support in Electricity Distribution System Asset Management
	Greiner, Christopher J.	Sizing and Operation of Wind-Hydrogen Energy Systems
2009	EEK, Jarle	Power System Integration and Control of Variable Speed Wind Turbines
	Kulka, Arkadiusz	Sensorless Digital Control of Grid Connected Three Phase Converters for Renewable sources
	Guidi, Giuseppe	Energy Management Systems on Board of Electric Vehicles, Based on Power Electronics
2008	Pedersen, Per Atle	Forces Acting on Water Droplets in Electrically Energized Oil Emulsions; Observations and Modelling of Droplet Movement Leading to Electrocoalescence
	Østrem, Trond	Reliable Electric Power Conversion for Connecting Renewables to the Distribution Network
	Skjellnes, Tore	Digital Control of Grid Connected Converters for Distributed Power Generation
	Næss, Bjarne Iidsøe	Operation of Wind Turbines with Doubly Fed Induction Generators During and After Line Voltage Distortions
	Belsnes, Michael Martin	Optimal Utilization of the Norwegian Hydropower System
	Helseth, Arild	Modelling Reliability of Supply and Infrastructural Dependency in Energy Distribution systems
2007	Di Marzio, Giuseppe	Secure Operation of Regional Electricity Grids in Presence of Wind Power Generation
	Gullvik, William	Modeling, Analysis and Control of Active Front End (AFE) Converter
	Andreassen, Pål	Digital Control of a Zero Voltage Switching Inverter for distributed Generation of Electrical Energy
	Hoff, Erik Stjernholm	Status and Trends in Variable Speed Wind Generation Topologies
	Løken, Espen	Multi-Criteria Planning of Local Energy Systems with Multiple Energy Carriers
	Ericson, Torgeir	Short-term electricity demand response
	Mauseth, Frank	Charge accumulation in rod-plane air gap with covered rod
2006	Maribu, Karl Magnus	Modeling the Economics and Market Adoption of Distributed Power Generation
	Catrinu, Maria	Decision-Aid for Planning Local Energy Systems. □ Application of Multi-Criteria Decision Analysis
2005	Hellesø, Svein Magne	Dynamic analysis and monitoring of power transmission cables using fibre optic sensors
	Lund, Richard	Multilevel Power Electronic Converters for Electrical Motor Drives
	Bjerkan, Eilert	High Frequency Modeling of Power Transformers - Stresses and Diagnostics
	Vogstad, Klaus-Ole	A system dynamics analysis of the Nordic electricity Market: The transition from fossil fuelled toward a renewable supply within a liberalised electricity market