Master's Thesis Topics at the DLR Institute of Maritime Energy Systems

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Master's Theses: Reduced order modelling of energy conversion and storage technologies for incorporation and simulation within a maritime energy system

The newly founded DLR Institute of Maritime Energy Systems in Geesthacht researches and develops innovative solutions for enabling increased utilization of renewable energy in waterborne transport, towards decarbonization and emissions reduction of shipping. The institute is building a large-scale infrastructure to test and trial the new energy systems to be developed in a standardized laboratory environment as well as under real conditions on a research vessel. Through ongoing collaborations with industrial and touristic ship operators, energy system data is obtained from practical use in different vessel types. Based on all data sources, a comprehensive energy system simulation model is developed to assess various energy converter and distribution technologies. The overall target is to optimize performance, efficiency and reliability for different use-cases, especially when integrating renewable energy sources.

Through these Master´s theses, we seek to develop an energy system or subsystem model to investigate and optimise the energy distribution onboard of ships. One or more of the following key questions may be addressed within the scope of a one Master's thesis:

Analysis and simplification of load profile data of complex marine energy systems or subsystems for the optimal design of renewable energy integration and new types of converters.

- Based on literature and measured data - how can consumers and load profiles be modelled in a simplified way (0D/1D) to integrate and assess converters and energy storages?
- What is the potential for emission savings in existing systems, e.g. based on future fuels?

Integration of fuel cells and electrical/heat storages for low-emission operation

- What differences must be considered with integration of energy storages and advanced converters like fuel cells regarding the provision of heat, electricity and mechanical power?
- How energy storages can support an emission-free operation in ports?

Optimisation algorithms for the steady-state or dynamic design of marine energy systems based on novel converters and storage systems

- How can technical parameters be optimised when using new converters, heat storages or batteries?
- How to make use of multi-objective optimisation (e.g. for storage size, durability, system emissions)

Utilisation of future fuels in new and existing ship energy systems

- What is the potential for emission savings in existing systems using ammonia, methanol, hydrogen?
- What is the Impact of fuels based on renewable energy on system performance and energy density?

The exact scope of a thesis can be defined based on the interests and skill-set of the candidate. We also welcome own proposals by students, should their interest lie outside the scope of the described questions.

Qualifications sought:

- Study in the fields of electrical-/ mechanical-/ naval-/ civil-/ renewable-/ energy system- -engineering/-technology, physics, or any comparable degree program.
- Knowledge of energy converters (combustion engines/ fuels cells/ batteries) or thermodynamics
- Good programming skills in MATLAB/Simulink (preferred), or any other system simulation software
- Interest in teamwork and collaborative model development for simulation environments.
- High affinity for solving interdisciplinary problems with self-made algorithms.
- Ability to work independently, enthusiasm, and thirst for knowledge.
- Good English language skills

Compensation: Students will be compensated up to TVöD 5 scale for 15 hours/week, following an initial review of the project plan

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Master's Thesis: System-level Assessment and Comparison of Fast Charging and Battery Swapping Technologies to Enable Full Electrification of Ships

The newly founded DLR Institute of Maritime Energy Systems in Geesthacht researches and develops innovative solutions for enabling increased utilization of renewable energy in waterborne transport, towards decarbonization and emissions reduction of shipping. Electricity obtained from renewable sources is, in principle, the most efficient means to convert renewable energy to work. Electrification has shown great promise in land-based vehicles, however, challenges around energy storage and requirements of shore-side charging infrastructure currently limits their scope in waterborne transport.

We are looking for enthusiastic and motivated students to contribute to electric shipping, and through this thesis, we seek to quantify and address technical challenges of battery electric vessels, by comparing two battery replenishment technologies – fast charging, and battery swapping. The following key questions may be addressed within the scope of this Master's thesis:

- What maritime applications and routes are best suited for full electric propulsion? What are the typical chemistries and energy densities of modern maritime batteries?
- How do fast charging and battery swapping technologies compare in enabling efficient full electric propulsion?
- What are the trade-offs between vessel range (onboard battery size, chemistry, etc.) and shore-side charging infrastructure requirements (number of chargers, power level of charger, etc.) for each scenario?
- What is the impact of any selected infrastructure on ship scheduling?
- How does battery swapping technology complement shore-side energy storage systems?

The exact scope of this thesis can be defined based on the skill-set and interests of the candidate. We also welcome own proposals by students, should their interest lie outside the scope of the described questions.

Qualifications sought:

- Study in the fields of electrical-/ mechanical-/ renewable-/ energy system- -engineering/-technology, physics, or any comparable degree program.
- Good programming skills in MATLAB/Simulink (preferred), or any other system simulation software
- Interest in teamwork and collaborative model development for simulation environments.
- High affinity for solving interdisciplinary problems with self-made algorithms.
- Ability to work independently, enthusiasm, and thirst for knowledge.
- Good English language skills
- Knowledge of batteries and vehicle electrical charging systems is beneficial.

Compensation: Students will be compensated up to TVöD 5 scale for 15 hours/week, following an initial review of the project plan

Contact: Dr. Dheeraj Gosala, dheeraj.gosala@dlr.de, +49 4152-8488102

Master's Thesis: Investigation of deep learning-based fault detection algorithms for shipboard power system

The newly founded Institute of Maritime Energy Systems in Geesthacht researches and develops innovative solutions for decarbonization and emission reduction in shipping and transfers them into practice by cooperation with industry. One of the research areas at DLR Institute of Maritime Energy Systems is "Electrical Systems and Infrastructure" as electrification is one of the key factors to decarbonize the energy system. With the development of distributed energy resources and high voltage and current semiconductors, DC distribution becomes a potentially competitive alternative to conventional AC distribution. One of the main challenges encountered in the designing of DC shipboard Microgrids is the lack of comprehensive protection strategies. Especially the fault detection schemes in shipboard power systems (SPS) are still in the early development stage. In recent years, the emergence of Industry 4.0 and the use of artificial intelligence methods, such as machine learning (ML) or deep learning (DL) have led to the development of data-driven Fault detection techniques.

The goal of this thesis is to investigate deep learning-based fault detection strategies for the DC shipboard distribution system. The following key questions may be addressed within the scope of this Master's thesis:

- What are the DC fault features (transient behavior) and protection requirements?
- How effective the deep learning-based approaches is for detecting the type of fault and location with the transient information contained in the fault voltage and current waveform?
- How do deep learning-based approaches complement conventional fault detection approaches?

Qualifications sought:

- You study in the fields of electrical/ renewable/ energy systems - engineering/ technology, physics, or any comparable degree program.
- Good programming skills in MATLAB/Simulink (preferably power systems analysis and design), python
- Prior experience in machine learning tools such as PyTorch and Tensorflow
- Prior experience in time-frequency signal analysis and processing
- Knowledge in machine learning techniques
- Determined to reach goals in time, ability to work independently
- Open-minded, quick learner interested in new topics.
- Good English language skills

Compensation: Students will be compensated up to TVöD 5 scale for 15 hours/week, following an initial review of the project plan

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Master's Thesis: System-level analysis of various wind-assisted ship propulsion technologies over given ship routes and applications

The newly founded DLR Institute of Maritime Energy Systems in Geesthacht researches and develops innovative solutions for enabling increased utilization of renewable energy in waterborne transport, towards decarbonization and emissions reduction of shipping. The use of renewable energy onboard, in particular through wind-assisted ship propulsion (WASP), has potential to substantially reduce the ship's energy demands and consequently fuel consumption. Various technologies for wind-assisted propulsion are being evaluated today, including Flettner rotor, kites, sails, and wings.

Through this thesis, we seek to develop a methodology to quantify the benefits of various WASP technologies and identify the most suitable technology for a given maritime route and application. The following key questions may be addressed within the scope of this Master's thesis:

- What are the key WASP technologies of relevance to the maritime industry?
- In what maritime applications, and over what maritime corridors, does WASP play a major role?
- What fuel savings can be expected from various WASP technologies?
- How does the load profile of the base energy system change in the presence of wind-assistance?
- What is the trade-off between fuel savings and "quantity" of wind assistance, for various WASP technologies and different ship applications?

The exact scope of this thesis can be defined based on the skill-set and interests of the candidate. We also welcome own proposals by students, should their interest lie outside the scope of the described questions.

Qualifications sought:

- Study in the fields of electrical-/ mechanical-/ naval-/ civil-/ renewable-/ energy system- -engineering/-technology, physics, or any comparable degree program.
- Good programming skills in MATLAB/Simulink (preferred), or any other system simulation software
- Interest in teamwork and collaborative model development for simulation environments.
- High affinity for solving interdisciplinary problems with self-made algorithms.
- Ability to work independently, enthusiasm, and thirst for knowledge.
- Good English language skills
- Knowledge of wind-assisted ship propulsion technologies is beneficial.
- Skills to obtain AIS, wind profiles through databases is beneficial

Compensation: Students will be compensated up to TVöD 5 scale for 15 hours/week, following an initial review of the project plan

Contact: Dr. Dheeraj Gosala, dheeraj.gosala@dlr.de , +49 4152-8488102

Master's Thesis: Analysis of the impact of wind-assisted propulsion on ship design

The newly founded DLR Institute of Maritime Energy Systems in Geesthacht researches and develops innovative solutions for enabling increased utilization of renewable energy in waterborne transport, towards decarbonization and emissions reduction of shipping. The use of renewable energy onboard, in particular through wind-assisted ship propulsion (WASP), has potential to substantially reduce the ship's energy demands and consequently fuel consumption. WASP technologies convert the available wind forces into sail forces. These split up into beneficial additional thrust and side forces, which influence the hydrodynamics, structure and manoeuvrability of the ship.

Through this Master's thesis, we seek to quantify the additional forces and reactions experienced in the presence of WASP technologies, to enable their full and optimal integration of into design of future ships. The following key questions may be addressed within the scope of this Master's thesis:

- What is the hydrodynamic impact of various WASP technologies on different ship applications?
- What additional forces and loads are experienced by the ship in the presence of WASP, as well as the sails, during a typical voyage? What is their impact on the structural integrity?
- How do the additional forces affect the fuel savings expected from WASP technologies?
- How can WASP technologies be integrated into the design of newbuild ships?
- Is there a trade-off between system efficiency and structural robustness, for various technologies?

The exact scope of this thesis can be defined based on the skill-set and interests of the candidate. We also welcome own proposals by students, should their interest lie outside the scope of the described questions.

Qualifications sought:

- Study in the fields of mechanical engineering, naval architecture, civil engineering, applied mechanics, applied physics, or any comparable degree program.
- Experience in CAD modelling and FEM / CFD analysis, depending on the exact scope of the thesis
- Interest in teamwork and collaborative model development for simulation environments.
- High affinity for solving interdisciplinary problems with self-made algorithms.
- Ability to work independently, enthusiasm, and thirst for knowledge.
- Good English language skills
- Knowledge of wind-assisted ship propulsion technologies is beneficial.
- Knowledge in at least one of hydrodynamics or structural mechanics is beneficial.
- Good knowledge in classification societies' rulesets to obtain loads and accelerations is beneficial.

Compensation: Students will be compensated up to TVöD 5 scale for 15 hours/week, following an initial review of the project plan

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Master's thesis: Route-optimization algorithm using wind patterns for a ship equipped with wind-assisted propulsion technology

The newly founded DLR Institute of Maritime Energy Systems in Geesthacht researches and develops innovative solutions for enabling increased utilization of renewable energy in waterborne transport, towards decarbonization and emissions reduction of shipping. The use of renewable energy onboard, in particular through wind-assisted ship propulsion (WASP), has potential to substantially reduce the ship's energy demands and consequently fuel consumption.

As wind energy is harnessed through the use of onboard WASP technologies, wind patterns across oceans and waterways play an important role in determining the optimal route of the ship. In the presence of wind-assistance, the shortest distance between two ports may no longer be the most efficient or fastest route. Through this Master's thesis, we seek to develop an algorithm to optimize the route of a ship in the presence of wind-assistance. The following questions may be addressed within the scope of this thesis:

- How can the optimal route between two ports be determined for a ship harnessing wind energy via WASP technology?
- How does the optimal route vary for different voyage objectives (e.g. maximizing fuel efficiency, minimizing time, increasing robustness to changing wind patterns etc.)?
- What additional data would be required to enable robust real-time implementation of this algorithm?

The exact scope of this thesis can be defined based on the skill-set and interests of the candidate. We also welcome own proposals by students, should their interest lie outside the scope of the described questions.

Qualifications sought:

- Study in the fields of electrical-/ mechanical-/ controls-/ system-/ energy system- -engineering/-technology, physics, or any comparable degree program.
- Good programming skills in MATLAB/Simulink (preferred), or any other system simulation software
- Interest in teamwork and collaborative model development for simulation environments.
- High affinity for solving interdisciplinary problems with self-made algorithms.
- Ability to work independently, enthusiasm, and thirst for knowledge.
- Good English language skills
- Knowledge of wind-assisted ship propulsion technologies is beneficial.
- Knowledge in conceptualizing cost functions and solving optimization algorithms through numerical solvers is beneficial.

Compensation: Students will be compensated up to TVöD 5 scale for 15 hours/week, following an initial review of the project plan

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Master's Thesis: Assessment of the benefits of onboard photovoltaic power generation over various ship routes and applications

The newly founded DLR Institute of Maritime Energy Systems in Geesthacht researches and develops innovative solutions for enabling increased utilization of renewable energy in waterborne transport, towards decarbonization and emissions reduction of shipping. The use of renewable energy onboard, in particular through photovoltaic (PV)-based power generation, has potential to substantially reduce the ship's energy demands and consequently fuel consumption. Solar energy provides a predictable energy source that can be used for hotel loads and propulsion in ports as well as during voyages.

Through this Master's thesis, we seek to determine the various impacts of using solar power generation for a given maritime route and application. Some key questions that may be addressed within the scope of this thesis include:

- What are the latest advancements in solar panel technology, and what kind of solar panels can be used for various maritime applications?
- What fuel savings can be expected by harnessing solar energy, for a given application and ship route?
- How is the loading of the onboard energy grid affected by the intermittencies of onboard PV power?
- What is the trade-off between deck-area and fuel savings for various panel configurations?
- What structural integrity concerns and constraints must be considered for the onboard integration of solar panels across various ship applications?

The exact scope of this thesis can be defined based on the skill-set and interests of the candidate. We also welcome own proposals by students, should their interest lie outside the scope of the described questions.

Qualifications sought:

- Study in the fields of electrical-/ mechanical-/ naval-/ civil-/ renewable-/ energy system- -engineering/-technology, physics, or any comparable degree program.
- Good programming skills in MATLAB/Simulink (preferred), or any other system simulation software
- Interest in teamwork and collaborative model development for simulation environments.
- High affinity for solving interdisciplinary problems with self-made algorithms.
- Ability to work independently, enthusiasm, and thirst for knowledge.
- Good English language skills
- Knowledge of solar panels, and PV power generation technologies is beneficial.
- Knowledge of onboard microgrids is beneficial
- Skills to obtain AIS and solar irradiation profiles through databases is beneficial

Compensation: Students will be compensated up to TVöD 5 scale for 15 hours/week, following an initial review of the project plan

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