Summer jobs at ENERSENSE 2021

This summer we are offering the chance to be involved in one of our exciting research projects within ENERSENSE. The ENERSENSE research group focuses on energy storage, energy efficiency, and sensor technology in an interdisciplinary way. There are 12-15 summer positions available, and the different topics of these are listed and described below. All projects are under the supervision of our Ph.D. candidates, postdocs and researcher. If you have any questions about the projects, please contact the responsible person. We especially encourage students that might be interested to continue with a master project, to apply.

Practical information:

- Five weeks of full-time work, with pay rate 22 (student assistant salary system).
- Start-up in early June with some flexibility towards the student's availability.
- Specific requirements are listed under the positions.
- Delivery of a poster is required at the end of 5 weeks.

How to apply?

If you are interested in one or more of the summer jobs, please send in your motivation letter, CV (including relevant skills and competencies), and a grades-overview. In case you want to apply for multiple positions, send your top three preferred projects.
Please send this information to enersense.ntnu@gmail.com with the email-subject "summer2021_firstname_lastname" before the **deadline on 13.03.2021 at 23:59.**

List of topics

ESS2101 Lithium-Ion Battery Production for Electrical Vehicles.
ESS2102 Sustainable Lithium-Ion Battery value chain
ESS2103 Lithium-ion Battery SOC estimation
ESS2104 Thermal Conductivities of Lithium-Ion Batteries.
ESS2105 Fiber Optic Sensors for Measuring Temperature of Lithium-Ion Batteries.
ESS2106 Distributed Fiber Optic Sensing in a PEM fuel cell.
ESS2107 Electrochemical fluorescence sensing at the tip of an optical fiber
ESS2108 Sensors for Biogas Production.
ESS2109 Photosynthetic Wastewater Treatment.
ESS2110 Feasibility analysis of pre-trained “LSTM based Seq2Seq neural nets” for Indoor Air Temperature Prediction in Buildings
ESS2111 Membrane properties for Reverse Electrodialysis
ESS2112 Electrodialysis as a Recycling Tool in Norway’s Metal-producing Industry
ESS2113 Sonochemical synthesis of noble metal nanoparticles

#ESS2101: Lithium-Ion Battery Production for Electrical Vehicles.

Supervisor: Silje Nornes Bryntesen and Asanthi Jinasena

Overview: Today, one of the hottest topics within scientific communities are lithium-ion batteries (LIBs) for electrical vehicles. Innovative technologies need to be introduced to excel in the expected large-scale battery production. The most energy requiring step in battery production is the drying of the electrode. The determination of drying kinetics is therefore of immense importance to assure an energy efficient battery production.

Goals and tasks: The students will get an experimental and theoretical background in battery manufacturing, drying kinetics, and electrochemical properties of the LIB technology. Experiments will focus on synthesis of electrodes, coin cell assembly and electrochemical analysis. Based on the students' preferences, a variation of the materials within the battery cell can also be tested investigated.

After the project, the students will be able to:

- Give a brief overview of the Lithium-ion battery manufacturing process.
- Give a brief overview of material compositions, solvents, and drying methods of electrode drying.
- Understand and explain the drying process and kinetics.
- Perform experiments at the laboratory.
- Document the work in the thesis/report.

Desired skills and competencies: Skills within renewable energy storage, or chemistry is a bonus, but not required.

Any student who has a shared interest in the abovementioned project is most welcome to apply.

Important info: For more details or questions about the summer job, please contact silje.n.bryntesen@ntnu.no.

ESS2102: Sustainable Lithium-Ion Battery value chain

Supervisor: Nelson Manjong and Asanthi Jinasena

Overview: Sustainable battery materials are of high interest within the research community with the increasing demand of electric vehicle batteries. The material flow from mining to the battery are widely used in life cycle assessments (LCA). However, the available data on such materials on the conversion of purified base materials to battery grade materials (e.g $LiCO_3$, LiOH, $NiSO_4$, $MnSO_4$, $CoSO_4$) is not complete or has very low resolution. Therefore, most studies often rely on datasets that are based on estimates and has high variance. Also, battery grade materials are key drivers of impacts, and their production routes have not been appropriately mapped out and documented nor thoroughly investigated under an LCA perspective yet. Lack of high-resolution data for battery grade materials contributes to high variabilities in the overall footprints of the Li-ion battery. Therefore, profound understanding in the various production processes of the battery grade materials and their footprints will contribute to transparency in reporting the impacts of battery value chains and contribute to sustainable battery production research.

Goals and tasks: The aim of the summer job is to carefully map out all existing production routes for a given battery grade material from base materials, and further gather available data on the material and energy used to produce this battery grade material.

Desired skills and competencies:

- Ability to do structured literature survey and reporting,

- Ability to work independently with high levels of initiative with some guidance from the supervisor,
- Good problem-solving skills,
- Enjoy working in a research environment with many other researchers.
- Knowledge on production processes and LCA is an advantage.

Important info: For questions about the summer job, contact nelson.manjong@ntnu.no or asanthi.jinasena@ntnu.no

 # ESS2103: Lithium-ion battery SOC estimation
Supervisor: Jacob J. Lamb
Overview: The estimation of battery state-of-charge (SOC) is a vital parameter when Li-ion batteries are used in electric transport. Although current methods are able to give some indication of the SOC, they are not precise enough for accurate estimates. In order to improve SOC estimates, new and specific machine learning algorithms need to be designed in order to learn the characteristics of battery SOC and reduce estimation error. A promising route is the incorporation of recurrent neural networks (RNNs) to estimate SOC using battery charge and discharge datasets. Improvements to the RNN model and adaptation of the algorithms to battery SOC will improve its use in the modern transport sector.
Goals and tasks: The task will be to use test datasets to carry out machine learning of the SOC in Li-ion batteries. Focus will be on improving the model to decrease the estimation error in SOC.
Desired skills and Characteristics: Students must have:
- Basic knowledge of electrochemistry, Li-ion batteries and machine learning approaches;
- be able to work independently with high levels of initiative with some guidance from their supervisor;
- have good problem-solving skills;
- enjoy working in a research environment with many other researchers; and, interesting in a renewable, clean future.

Important Information: If you have any further questions, please email Jacob: jacob.j.lamb@ntnu.no

 # ESS2104: Thermal Conductivities of Lithium-Ion Batteries
Supervisor: Lena Spitthoff
Overview: Electric vehicles require safe, long-lasting Lithium-ion batteries that can be charged within a short period of time. When increasing the size of Lithium-ion batteries, particularly during intense charging, large amounts of heat will be generated. This results in increased temperatures which has an accelerating effect on most degradation mechanisms and can lead to sever safety problems. Therefore, an understanding of the thermal behavior of Li-ion batteries for different operation strategies and the effects of the internal temperature distribution on the performance and safety of the battery are of upmost importance. The determination of thermal conductivity of battery materials allows modelling of internal temperature profiles.

Goals and tasks: The aim of the summer job is to measure thermal conductivities of different battery materials with a thermal conductivity meter. The results will be used to investigate internal temperature profiles using an existing model.

Desired skills and competencies:

- Combination of practical lab skills and Matlab programming experience,
- Ability to work independently with high levels of initiative with some guidance from the supervisor,
- Good problem-solving skills,
- Enjoy working in a research environment with many other researchers.

Important info: For questions about the summer job, contact lena.spitthoff@ntnu.no.

#ESS2105: **Fiber Optic Sensors for Measuring Temperature of Lithium-Ion Batteries**

Supervisor: Lena Spitthoff, Markus Wahl and Jacob Lamb

Overview When increasing the size of Lithium-ion batteries, particularly during intense charging, large amounts of heat will be generated. This results in increased temperatures which has an accelerating effect on most degradation mechanisms and can lead to sever safety problems. Fiber optic sensor offer the opportunity to measure internal temperature of Lithium-ion batteries due to their extremely small size and being chemically inert to reactive environments.

Goals and tasks: This project will investigate the practical aspects of using fiber optic sensors for temperature measurements in Lithium-ion batteries. The aim of the summer job is the implementation of a fiber optic sensor in a working lithium-ion battery.

The following tasks are part of the summer project:

- Implementation of optical fibre into commercial lithium-ion battery.
- Characterize sensor performance and perform measurements of an operating battery.

Desired skills and competencies:

- Combination of practical lab skills and Matlab programming experience,
- Ability to work independently with high levels of initiative with some guidance from the supervisor,
- Good problem-solving skills,
- Enjoy working in a research environment with many other researchers.

Important info: For questions about the summer job, contact lena.spitthoff@ntnu.no.

#ESS2106: Distributed Fiber Optic Sensing in a PEM fuel cell.

Supervisor: Michael Fried

Overview: Proton exchange membranes fuel cells allow for the generation of electricity from stored hydrogen gas. This is an important technology for the transition to renewable energy and a 'hydrogen economy'. So far, there have been few methods to perform measurements inside of a fuel cell, and therefore, no way to validate current fuel cell models. The aim of this project is to perform distributed temperature and humidity measurements in a PEM fuel cell gas diffusion layer using OFDR techniques. This project will include the practical aspects of inserting the fibers in the fuel cell, as well as designing an experiment to test the sensors during fuel cell operation.

Goals and tasks: The following tasks are part of the summer project:

- Investigate methods of incorporating optical fibers in the fuel cell.
- Perform optical measurements to determine the integrity of the fibers.
- Operation of the fuel cell to determine the sensors impact on the fuel cell performance.
- Use of optical frequency domain reflectometry to perform distributed measurements and determine sensor performance.

Desired skills and characteristics:

- Previous lab experience is a plus.
- The student can collect and analyze experimental data.
- The optical fibers are small and delicate, so some patience and mechanical intuition is beneficial.

Important info: For questions about the summer job, contact michael.fried@ntnu.no.

ESS2107: Electrochemical fluorescence sensing at the tip of an optical fiber

Supervisors: Michael Aaron Fried, Markus Solberg Wahl

Overview: The limited lifetime of electrochemical energy storage solutions (batteries, fuel cells) is one of the main factors currently holding back the necessary transition into a more sustainable society. Understanding the ageing mechanisms of batteries and fuel cells is therefore important. What changes inside these systems that weakens performance over time? A micro-sensor placed on the tip of an optical fiber may give the answer.

Goals and tasks: This project will work with fluorescence sensing with optical fibers, aimed at measuring the chemical environment inside batteries and fuel cells. This will include:

- Lab work (optical/chemical)
- An understanding of optical systems
- An understanding of light-matter interactions
- An understanding of chemical reaction kinetics

Desired skills and competencies:

- Experience within optics/chemistry/electrochemistry/fluorescence always good, but everyone interested is encouraged to apply.
- Experience with plotting and analysis in Matlab
- Ability to work independently with some guidance from the supervisor,
- Enjoy working in a research environment with many other researchers.

Important info: For questions about the summer job, contact michael.fried@ntnu.no or markus.s.wahl@ntnu.no.

#ESS2108: Sensors for biogas production

Supervisor: Jacob J. Lamb

Overview: The production of biogas through anaerobic digestion can result in the accumulation of biological compounds known as volatile fatty acids (e.g., acetic acid / edikksyre). In order to improve the production of biogas, these acids must be monitored. A promising new approach is to use colorimetric sensors in order to sense the acids. The Trondheim bogas company Biokraft is interested in assessing the sensor technology for acid detection in biogas production.

Goals and tasks: The task will be to use a small test facility for this, and carry out measurements of biogas production with the custom sensor system and compare to traditional sensing. The technology would also be assessed in the industry to see how it functions in the "real world."

Desired skills and Characteristics: There is one summer studentship position available to progress this work.

Students must have:

- Basic knowledge of bioenergy and digital technology;
- be able to work independently with high levels of initiative with some guidance from their supervisor;
- have good problem-solving skills;
- enjoy working in a research environment with many other researchers; and,
- interesting in a renewable, clean future.

Important Information:

If you have any further questions, please email Jacob: jacob.j.lamb@ntnu.no.

#ESS2109: Photosynthetic Wastewater Treatment

Supervisor: Jacob J. Lamb

Overview: The production of fish in recirculating aquaculture systems (RAS) can result in the accumulation of biological compounds containing high amounts of P and N. In order to improve the recirculation of the water used in RAS, these nutrients need to be reduced to avoid becoming toxic to the fish. A promising new French technology developed by the company **Inalve** may have potential for such mediation of N and P by growing microalgae. The Trondheim RAS company **Nofitech** is interested in assessing the **Inalve** technology for wastewater treatment of its RAS.

Goals and tasks: The task will be to use a small test facility for this, and carry out measurements of the degree of purification that can be achieved for this, and how the technology can be optimised for RAS in Norway.

Desired skills and Characteristics:

There is one summer studentship position available to progress this work.

Students must have:

- knowledge of mass-balance analysis, chemistry, process engineering and photosynthetic growth;
- be able to work independently with high levels of initiative with some guidance from their supervisor;
- have good problem-solving skills;
- enjoy working in a research environment with many other researchers; and, interesting in a renewable, clean future.

Important Information: If you have any further questions, please email Jacob: jacob.j.lamb@ntnu.no

 # ESS2110: Feasibility analysis of pre-trained "LSTM based Seq2Seq neural nets" for Indoor Air Temperature Prediction in Buildings

Supervisor: Gaurav Chaudhary

Overview: Transfer learning is a subfield of machine learning and artificial intelligence, aiming to apply the knowledge gained from one task (source task) to a different but similar task (target task). This is done by using a pre-trained model. For example, in the field of image classification, a pre-trained model is a saved neural network that was previously trained on a large dataset, typically on a large-scale image-classification task. The intuition behind transfer learning for image classification is that if a model is trained on a large and general enough dataset, this model will effectively serve as a generic model of the visual world.
The same intuition can be applied to buildings where the indoor air temperature is predicted using a pre-trained model trained using data gathered from another building of almost the same usage, location, and type.
Goals and tasks: The summer job aims to statistically evaluate the feasibility of pre-trained **"Long Short-Term Memory (LSTM) based Sequence-to-Sequence (Seq2Seq) Recurrent Neural Networks"** when used in a different building. The feasibility will be evaluated in terms of error metrics and the rate of increase in prediction accuracy in the new building. The student will be using pre-trained models provided by the supervisor.
Desired skills and competencies:

- Python programming skills + any building simulation tool like IDA ICE or Energy Plus,
- Ability to work independently with high levels of initiative with some guidance from the supervisor,
- Good problem-solving skills,
- Enjoy working in a research environment with many other researchers.

Important info: For questions about the summer job, contact gaurav.chaudhary@ntnu.no

#ESS2111: Membrane properties for Reverse Electrodialysis
Supervisor: Simon Solberg
Overview: Low temperature waste heat from e.g. industrial processes constitutes a large amount of energy which is typically difficult to utilize efficiently. HeatToH$_2$ is the concept where hydrogen gas is produced using a reverse electrodialysis stack, and the spent electrolyte solutions are regenerated to the initial concentrations using waste heat. The properties of the ion-exchange membranes involved in the reverse electrodialysis process are key to this system's ability to produce hydrogen efficiently. Electrolyte properties and its interaction with the membranes is also of interest.
Goal: The aim of this summer job is to measure the electric potential of an electrochemical cell with an ion-exchange membrane, and to conduct electrochemical impedance spectroscopy to determine membrane resistance.
Desired skills and competencies:

- Combination of practical lab skills and Matlab programming experience,
- Ability to work independently with high levels of initiative with some guidance from the supervisor,
- Good problem-solving skills,
- Enjoy working in a research environment with many other researchers.

Important info: For questions about the summer job, contact simon.b.b.solberg@ntnu.no

#ESS2112: Electrodialysis as a Recycling Tool in Norway's Metal-producing Industry

Supervisor: Pauline Zimmermann

Overview: Due to readily available hydropower and a great amount of raw material in the ground, Norway has a leading position in the world's metal production. However, raw materials become depleted and the focus on sustainable use of resources is ever increasing. Norway's metal industry is facing the challenge of implementing circular economy in their process cycle. Electrodialysis is a promising technology for metal recycling from aqueous streams. It is a separation process based on ion-selective membranes that uses an electric potential to drive the separation. This practically oriented summer job focusses on laboratory studies on an Electrodialysis setup, with the aim to describe ionic transport processes and evaluate the energy efficiency of the application.

Goal: Ultimately, the goal is to find out if Electrodialysis is feasible to be used as recycling method in Norway's metal industry to increase circular economy.

Desired skills and competencies:

- Experience with lab work.
- Basic understanding of chemistry and energy engineering.
- Basic understanding of transport phenomena.
- Be able to work independently with high levels of initiative with some guidance from their supervisor.
- Enjoy working in a research environment with many other researchers.
- Interest in a renewable, clean future.

Important info: For questions about the summer job, contact pauline.zimmermann@ntnu.no.

#ESS2113: Sonochemical synthesis of noble metal nanoparticles

Supervisor: Henrik Erring Hansen

Goals and tasks: The aim of this summer project is to synthesize a range of noble metal nanoparticles such as Au, Ag, Pd, and Pt using high power ultrasound. The student will perform the sonochemical synthesis, and analyze the resulting nanoparticles using UV-Vis spectroscopy and electrochemical techniques. As we will investigate nanoparticles, it is required that the student is familiar with nanotechnology and characterization of nanomaterials. A background in nanotechnology, materials science or chemistry is therefore an advantage. The following tasks are part of the summer project:

- Synthesize noble metal nanoparticles using ultrasound
- Characterize nanoparticles using physical and electrochemical techniques

Desired skills and characteristics:

- The student is structured, disciplined and organized in their work.
- The student has knowledge about nanomaterial synthesis.
- The student is interested in nano science.
- Experience with NTNU Nanolab is preferred.

Important info: For questions about the summer job, contact henrik.e.hansen@ntnu.no.