Summer jobs at ENERSENSE 2022

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 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 "summer2022_firstname_lastname" before the **deadline on 06.03.2022 at 23:59.**

List of topics

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ESS2208	Optimizing flow-cell batteries for H_2-production
ESS2209	Efficient Silver Recycling through Electrodialysis
ESS2210	Development of Monovalent Selective Ion Exchange Membranes for the Separation of Silver Ions from Multivalent Metal Ion Solution
ESS2211	Sonochemical synthesis of catalysts for water electrolysis
ESS2212	Algorithm development for linking biomethane production potential (BMP) to near-infrared (NIR) spectroscopy analysis of feedstock

#ESS2201: Lithium-ion battery digital twin
Supervisor: Jacob J. Lamb

Overview: Li-ion batteries have become the cornerstone of energy storage in the green shift for use in mobility, stationary storage and technological devices. This is because of their ability to store large amounts of chemical energy produced by intermittent renewable energy sources. In order to advance Li-ion battery technologies, significant research and development in the laboratory is required. This is a process that takes large amounts of time and does not always yield positive results. With the urgent need for energy storage solutions, new approaches to research and development are required. One promising route is to develop a Li-ion battery digital twin. This would allow the development of robust theories and hypotheses before conducting laboratory research, in turn reducing the time for research and development.

Goals and tasks: The task will be to assess modelling routes for developing a digital twin. Focus will be on selecting and developing pre-existing models of Li-ion battery characteristics.

Desired skills and Characteristics:
Students must have:

- Basic knowledge of electrochemistry, Li-ion batteries and modelling approaches (e.g., matlab and/or python);
- be able to work independently with high levels of initiative with 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.

#ESS2202: Solid state battery production systems, review and analysis of existing processes and inventory
PhD Candidate: Sina Orangi, Nelson Manjong

Overview: Solid-state battery shows outstanding advantages for the next generation of battery technology with higher energy density at lower cost of production comparing with the current state-of-the-art lithium-ion technology. Since this sort of battery technology is still at the development stage, there does not exist a general valid process chain. Driven by this, the process chain for solid-state technology can be formed by different possible process alternatives. More importantly, a successful outcome of the current project bases a solid-state battery production model to demonstrate the material and energy flow is an essential base for life cycle assessments (LCA).

Goals and tasks: We are seeking candidates with strong interest in battery industry. This project mainly aims to collect data from recent relevant publications and reports in order to classify the possible process chains and material. The following tasks are part of the summer project:

- Investigation for the possible (or available) solid-state battery production models in the recent publications and relevant reports
- Presenting an explicit classifications of the collected data through a final report.
- Presenting the results for a poster.

Desired skills and characteristics:

- Highly motivated in battery industry
- Ability to work and think independently and in group
- Background in modelling of production models
- Excellent written and oral English language skills

Important info: For questions about the summer job, contact sina.orangi@ntnu.no and nelson.manjong@ntnu.no.

#ESS2204: Lithium-ion batteries: measuring the internal temperature using fiber-optic sensors
Supervisor: Markus Solberg Wahl, Jacob Joseph Lamb

Overview: The most important factor for battery life is temperature. When increasing the size of lithium-ion batteries (LIBs), particularly during intense charging and discharging, large amounts of heat will be generated. The increased temperatures within the LiB accelerate the degradation processes which reduce the capacity of the batteries. This leads to shortened lifetimes of LiBs, and in extreme cases can result in thermal run-away, which is a severe safety issue. To determine the changes in the thermal profile of LiBs, temperature measurements must be taken within an operating LiB. Since traditional thermocouple sensors have electrical components, they are not suitable for inserting within a LiB cell and may also react with the chemical environment. *Fiber-optic sensors* provide a method for measuring internal temperatures without affecting battery operation.

Goals and tasks: This project will work with temperature sensitive optical fibers, aimed at measuring the dynamic temperature variations 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 always good, but everyone interested is encouraged to apply.
- Experience with plotting and analysis in Matlab/Python.

- 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 markus.s.wahl@ntnu.no

#ESS2205: Tilted Fiber Bragg Grating Plasmonic Hydrogen Sensors
Supervisor: Michael Fried

Overview: The increase in interest in hydrogen as a renewable fuel source has created a demand for hydrogen sensors. Optical fiber sensors are inherently safe in an explosive environment, and thus provide an advantage over electrical sensors. A promising sensing method is the use of plasmonics to sense small changes in the refractive index of metals as they form metal-hydrides under hydrogen exposure. Tilted Fiber Bragg Gratings (TFBGs) have gained attention as a sensing platform due to their simple fabrication, small size, self-referencing for strain and temperature, and remote sensing capabilities. Phase matching between the core and cladding modes occurs at discrete wavelengths, and thus a spectral 'comb' of cladding modes is excited. These cladding modes can excite surface plasmons in a metal layer coated on the fiber cladding. By tracking small shifts in wavelength or change in power of specific cladding modes, the change in refractive index can be detected. This project aims to build a low cost method of interrogating the fiber sensors that doesn't rely on an expensive optical spectrum analyzer.

Goals and tasks: The first goal is to assemble an interrogation system composed of a chirped laser diode, photo-detector and digital oscilloscope. The second task is to write a program to determine the peak position from the data. Finally tests to determine the capabilities of the system, and tune the setup for optimal performance.

Skills:
- knowledge in optics and electronics.
- ability to analyze the data with programming language of your choice.
- ability to work and problem solve independently.
- students interested in continuing with a master project on optical fiber hydrogen sensors in the fall may be given priority.

#ESS2206: Sensing Strategies for Supercapacitors
Supervisor: Steven Boles
Goals and tasks: Quantification of the mechanical changes associated with the charging and discharging of supercapacitors can provide important insights into the electrochemistry of these devices. For example, the competition between faradaic and non-faradaic reactions may have associated mechanical signatures that have important implications for their long term health and reliability. Similarly, catastrophic failure of electrochemical devices may be evidence by irreversible swelling and package deformation. The goal of this project is to

implement sensing methods to effectively observe such changes. In the pursuit of this, the following tasks are envisioned to be part of the summer project:

- Assess fiber-based sensing methods suitable for measuring package strain.
- Assist with the design and execution of experiments to measure deformation during charge and discharge of supercapacitors
- Conduct materials characterization
- Collect and analyze relevant data to identify critical indicators

Desired skills and characteristics:
The student must:

- Have basic knowledge of optics, mechanics (stress/strain), and/or electrochemistry;
- Be able to work well with others and independently depending on the situation;
- Have good problem-solving skills;
- Be an effective communicator

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Important info: For questions about the summer job, contact steven.boles@ntnu.no.

#ESS2207: Super Activated Carbon Supercapacitors
Supervisor: Steven Boles

Goals and tasks: The process of super-activating carbon is essential for enabling electrochemical capacitors to rapidly store and release a large number of charges with each charge and discharge. This process typically involves a thermal treatment to increase the surface area of the carbon, thereby increasing the number of sites on the carbon surface for ion adsorption.
The aim of this summer project is to improve the super activation process. Therefore, it is required that the student has an eager interest in the link between materials, electrochemistry, and energy storage. The following tasks are part of the summer project:

- Assist with the assembly of thermal treatment equipment
- Assist with the design and execution of experiments targeting different carbon activation conditions
- Conduct materials characterization
- Assemble electrochemical capacitors to verify energy storage capabilities.

Desired skills and characteristics:
The student must:

- Have basic knowledge of pyrolysis, thermal treatments, and/or electrochemistry;
- Be able to work well with others and independently depending on the situation;
- Have good problem-solving skills;
- Be an effective communicator

Important info: For questions about the summer job, contact steven.boles@ntnu.no

#ESS2208: Optimizing flow-cell batteries for H_2-production
Supervisor: Simon B. B. Solberg

Overview: Hydrogen as a green energy carrier is more relevant than ever. At ENERSENSE we are developing a salinity gradient flow-cell battery that only needs an input of industrial waste heat to produce H_2. This can help utilize the large amounts of heat which is otherwise released into the environment, as well as the shift toward a greener society. We need to test key features of the flow-cell to optimize the system, such as resistance and power output under operation.

Goals and tasks: Test the power output of an early "prototype" flow-cell for H_2 production and measure the resistance of components of the flow-cell using EIS. This task is largely practical laboratory work.

Desired skills and Characteristics:

- Basic knowledge and understanding of electrochemistry;
- be able to work independently with high levels of initiative with guidance from their supervisor;
- have good problem-solving skills;
- enjoy working in a systematic manner in a research environment with many other researchers.

Important Information: If you have any further questions, please contact:
simon.b.b.solberg@ntnu.no

#ESS2209: Efficient Silver Recycling through Electrodialysis
Supervisor: Pauline Zimmermann

Overview: Due to readily available hydropower, Norway has a leading position in the world's metal production. Recovery of precious metals from End-of-Life products is essential to cover the increasing demand for those rare resources. For example, solar panels contain vast amounts of silver. Silver is usually used in alloys with other metals. For recycling, the alloys are dissolved in acid, and silver is recovered from aqueous solution by electrolysis. The other metals present in the solution are impurities that accumulate and decrease the efficiency of silver recycling. This project is about investigating an electrochemical process to remove impurities like Cu, Zn, and Fe from the silver solution. In Electrodialysis, ion-selective membranes are used to separate the monovalent silver ions from the divalent impurities (Cu, Zn, Fe). In this practically oriented summer job, you will perform experiments on a lab-scale Electrodialysis setup, with the aim to investigate ionic transport processes, find the most promising process conditions (current, flow rate, etc.) and evaluate the energy efficiency of the application.

Goal: Investigate if Electrodialysis is a feasible separation method to remove impurities from silver electrowinning solution and to increase circular economy in Norway's metal producing industry.

Desired skills and competencies:

- Experience with lab work.
- Basic understanding of chemistry and transport phenomena.
- work independently.
- 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

#ESS2210: Development of Monovalent Selective Ion Exchange Membranes for the Separation of Silver Ions from Multivalent Metal Ion Solution
Supervisor: Önder Tekinalp

Goals and tasks: This project is one of the tasks of PRICE (PRocess Industries in the Circular Economy) Project. The main objective of PRICE is to increase the recovery of metals and minerals from hydrometallurgical process streams. Within the scope of this project, there is close collaboration with industry partner KA Rasmussen (KAR). KAR recycles silver from collected scrap (jewelry, cutlery etc) in Hamar. However, unwanted compounds accumulate with silver during recycling process. Therefore, silver should be removed from these impurities. As those impurities are divalent cations (copper, zinc and iron) while silver is monovalent cation. Monovalent selective ion exchange membranes (MSIEMs) are of special utility for the separation of monovalent ions from multivalent ions using electrodialysis. One way of developing MSIEMs is the surface modification of commercially available IEMs via layer-by-layer (LbL) deposition of polyelectrolytes. LbL method controls membrane's final surface properties (i.e. surface charge, toplayer tightness) to improve selectivity between monovalent and multivalent ions.

Student Activity:

- Surface modification of commercially available IEMs via LbL method using polyelectrolytes
- at different deposition conditions,
- Characterization of deposited layers,
- Monovalent ion selectivity tests of surface modified IEMs using laboratory scale electrodialysis unit with model and real metal solutions found at the industrial sites.

Desired skills and characteristics:

- Experience with lab work.
- Basic understanding of chemistry and transport phenomena.
- Be able to work independently.

Important info: For questions about the summer job, contact onder.tekinalp@ntnu.no.

#ESS2211: Sonochemical synthesis of catalysts for water electrolysis
Supervisor: Henrik Erring Hansen

Goals and tasks: The aim of this summer project is to synthesize inexpensive catalysts for water electrolysis by a novel ultrasound technique called sonochemistry. The student will perform the ultrasound 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. Previous experience with laboratory work is also needed.

- Synthesize nickel 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.

#ESS2212: Algorithm development for linking biomethane production potential (BMP) to near-infrared (NIR) spectroscopy analysis of feedstock

PhD Candidate: Seyedbehnam Hashemi

Goals and tasks: Biogas is a mixture of gases, mostly methane and carbon dioxide, which can be considered as alternative fuel. Biogas can be produced by serving different organic matters (i.e., known as feedstocks or substrate) including fish silage, manure, and food waste in the absence of oxygen (i.e. anaerobic digestion (AD)). One way of assessing the maximum biogas produced by a substrate is BMP test, a small-scale batch test; however, this is a very slow process and can take up to 40 days to evaluate the feedstock for biogas production.

NIR spectrophotometer can virtualize the presence of different organic material as transmittance percentage in different wavelengths (i.e., generally between 1000 to 2500 nm). It might be possible to predict the biogas production potential of different feedstock by NIR spectroscopy analyses. The main objective of this summer project is to conduct laboratory analysis in other to develop a mathematical algorithm for predicting biomethane production potential of fish silage. We have laboratory that students can test and produce biogas. In this position, we will focus on the methods related to Freeze drying of substrate, BMP tests, NIR spectroscopy and mathematical modeling. Students can have a half-day trip to Biokraft biogas plant at Skogen. The following tasks can be part of summer project:

- Literature review
- Freeze dry of substrate
- Batch BMT tests
- NIR spectroscopy
- Mathematic modeling

Desired skills and characteristics:

- Students at master and bachelor level within chemical engineering, biological engineering, process engineering or energy and environmental technology.
- Willing to work in the laboratory
- Interested in research and writing reports
- Solution-oriented
- Experience with conducting laboratory tests relative to anaerobic digestion process is considered as positive point

Important info: Preferable for start-up in early June. Candidate should deliver a poster and a report at the end of the five weeks. For more information, you can contact me: seyedbehnam.hashemi@ntnu.no