DENSYS

MASTER ERASMUS MUNDUS | DECENTRALISED SMART ENERGY SYSTEMS

MASTER'S THESES 2022-2024

With the support of the Erasmus+ Programme of the European Union

UNIVERSITÉ DE LORRAINE

KTH VETENSKAP OCH KONST

Politecnico di Torino

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Internships and Master Theses of the cohort 2022-2024:

Fabrice Lemoine,
Chair of DENSYS

To combat global warming, a transition to low-carbon energy is essential. This involves integrating renewable energy sources, producing decarbonized energy carriers, and decarbonizing end-uses of energy to achieve the ambitious goal of a carbon-neutral world by 2050. These technological advancements must be supported by a political framework that enables large-scale deployment within a just transition, a key objective of the European Green Deal, ensuring no one is left behind.

Decentralized smart energy systems are increasingly important for integrating renewable energy sources. This is the vision of DENSYS. The overall goal of DENSYS is to educate highly skilled engineers with a multiphysics approach (including electrical, mechanical, and chemical engineering) who can design, size, optimize, and operate decentralized smart energy systems while maintaining a holistic understanding of citizens' needs.

DENSYS is a European Union-funded program, coordinated by the University of Lorraine (UL, France), and jointly developed with the Royal Institute of Technology (KTH in Stockholm, Sweden), the Polytechnic Institute of Torino (PoliTo, Italy), and the Universitat Politècnica de Catalunya (UPC in Barcelona, Spain).

DENSYS follows a "T-shaped" education profile. The vertical bar of the T represents core engineering competencies (mechanical, electrical, and chemical engineering), while the horizontal bar includes complementary competencies necessary for a holistic vision and the ability to engage with various stakeholders.

DENSYS provides solid engineering training as well as competencies in economics and humanities, which are crucial because the energy transition is primarily a human and societal issue.

DENSYS is also an intercultural experience, allowing students to share local contexts, which are vital for developing relevant and efficient energy solutions.

DENSYS aims to train responsible engineers and researchers who will become ambassadors of new energy technologies and the energy transition, and citizens of a world that urgently needs to shift towards climate neutrality.

As part of their training, DENSYS students complete long-term internships and master theses in top research labs, companies, or global international organizations. The diversity of internship subjects reflects the students' open-mindedness, intellectual agility, and ability to engage in advanced technologies for heat and cold management and engineering, integration of renewables into networks, renewable energies, implementation of cross-sectoral key enablers like the hydrogen sector (fuel cells, electrolysers), power-to-X, energy storage (including batteries), digitalization of energy systems and production processes, energy use in energy-intensive industrial sectors, energy-intensive processes, and global-scale energy policy making.

Among the **24** students, internships are carried out in the following sectors:

- Energy systems, management, and modelling: **7**
- Renewable energies: **2**
- Heat and cold: **4**
- Batteries: **3**
- Decarbonization of energy-intensive sectors: **2**
- Digitalization of energy systems production: **1**
- Hydrogen: **1**
- Fluid flows, experimental and computational approaches: **2**
- Global-scale energy policy making: **2**

They are involved in large international groups, SMEs, global international organizations, or research laboratories across European countries. Discover our students and their master thesis topics.

DENSYS

MASTER ERASMUS MUNDUS | DECENTRALISED SMART ENERGY SYSTEMS

Cohort 2022-2024:

Fllanza
AHMETAJ

Blessing
AKINPELU

Ali Mohamed
ALI

Paula
ALTIMIR

Perizat
AMIRZHAN

Abed Al Wahab
ANIS

Hazem
ASHOUR

Timon
BENZ

Charls
CHRISLE

Greco Gervin
CRUZ

Nethmini Kolambage
DAHAMUNA KOLAMBAGE

Joy Surjy
DEB

Vishnu
DHINAKARAN

Delight
EZEH

Kainat
FATIMA

Alejandro Andres
FLORES CHACON

Ahmed
HARBI

Nuril
HIDAYATI

Mohammad
HOSSAIN

Hasibuzzaman
MAHMUD

Seyed MohammadAmin
TALEGHANI

Marlo Angelo
TITO

Fiorella Cristina
VASQUEZ DIAZ

Larissa Stella
YANGA TOFEUN

Fllanza AHMETAJ

www.linkedin.com/in/fllanza123/

Bach. in Electrical Engineering, University of Prishtina, Kosovo

Mobility scheme

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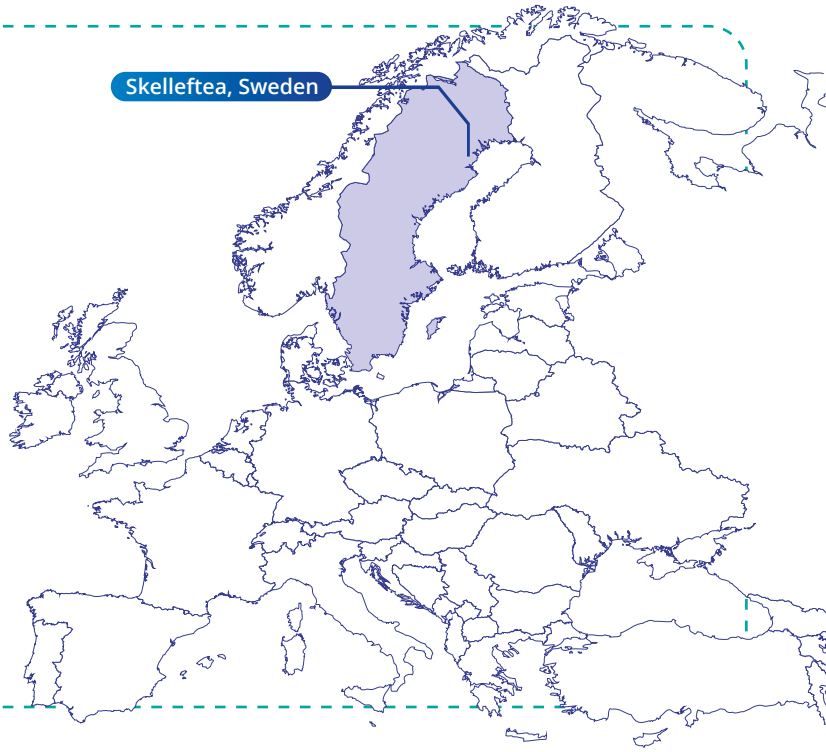
“The world’s best batteries, fresh and frosty from the North Pole!”

Company

northvolt®

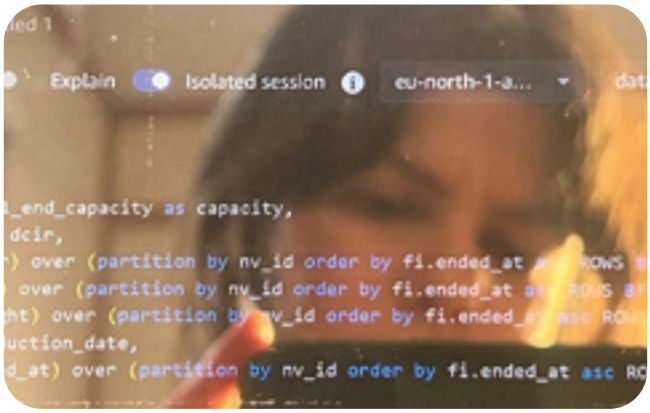
Northvolt Ett

Northvolt Ett is a gigafactory in Skellefteå, Sweden which produces lithium-ion batteries for electric vehicles and energy storage. Hosting both active material and cell production from the battery value chain, Northvolt Ett has assembled a team of >5,000 employees from 120 countries, aiming for market leadership, cost competitiveness, and scalability to meet growing demand.



Master's thesis title

Combining novel and existing process data for cell defect detection



Cell defects pose a significant challenge for battery cell manufacturers. In the context of Northvolt Ett, a gigafactory aiming to produce 60GWh per year, and engaged in partnerships with leading European automotive manufacturers and industry players, effective defect detection is crucial both for maintaining high product quality and managing costs.

Therefore, the implementation of viable and efficient testing solutions is imperative to guarantee that only products meeting high quality standards are released from the factory.

This thesis aims to describe the implementation process of a novel AI-based cell diagnostic technology at Northvolt's facility. Furthermore, it focuses on combining the output from the new technology with existing company process data to optimize the ability to predict battery cell defects.

The implementation process of a new technology at the lab consists of a set of steps and factors to be considered and in this thesis is developed a framework for the evaluation of the technology prior to its industrialization, including elements such as technology training, test experiment design, risk assessment and project management. The data results from the tests are complemented by process data to refine the predictive model for defect detection. For the development of this model and data analysis, AWS Redshift and Minitab software serve as the primary tools.

Blessing AKINPELU

linkedin.com/in/akinpelu-blessing

Bach. in Mechanical Engineering, Federal University of Technology, Akure, Nigeria

Mobility scheme

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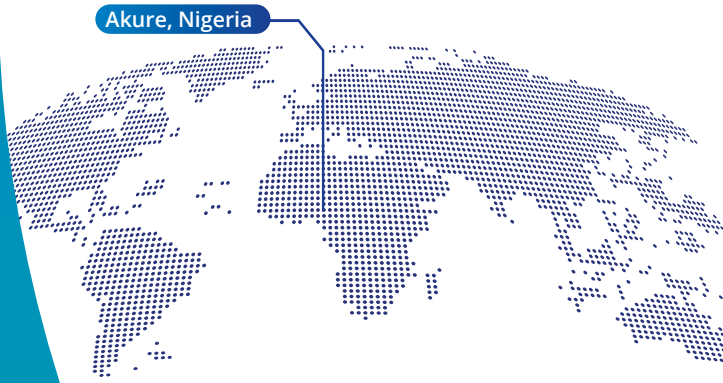
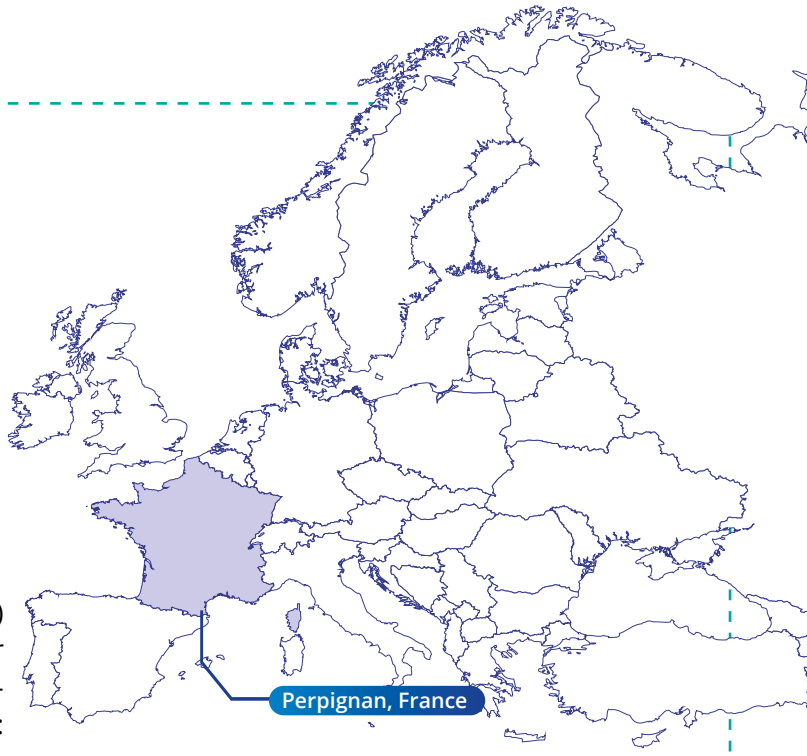


“Turbulence Science for a Sustainable Future!”

Company

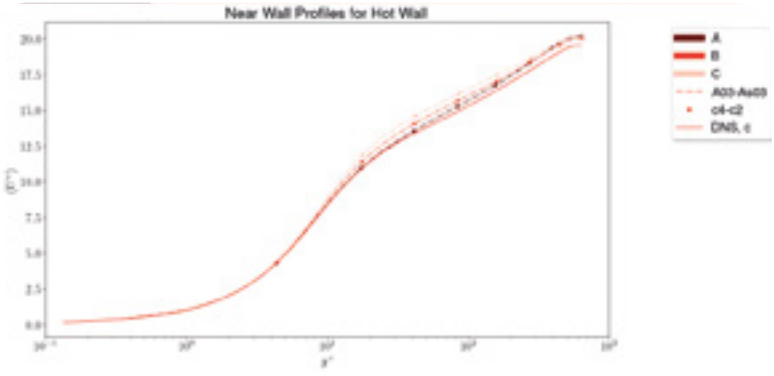


PROMES Research Institute

PROMES laboratory is a CNRS Proper Unit (UPR 8521) attached to the CNRS Engineering Institute under agreement with the University of Perpignan via Domitia (UPVD). The laboratory is located on three sites: Odeillo-Font Romeu (CNRS 1 MW solar oven), Targasonne (Thémis, 5 MW tower power plant, site of the Departmental Council of PO) and Perpignan, Tecnosud. The laboratory brings together around 150 people from the CNRS and the UPVD around a unifying subject, solar energy and its use as a source of energy and high temperatures. PROMES runs the laboratory of excellence (Labex) SOLSTICE (SOLaire: Sciences, Technologies, Innovations for Energy Conversion)

Master's thesis title

Parametric Study of Thermal-Large Eddy Simulation (T-LES) Models in Turbulent Anisothermal Channel Flow



Concentrated solar power (CSP) plants utilize concentrated sunlight to heat a transfer fluid for electricity generation. However, achieving high operating temperatures, a critical factor for efficiency, remains a challenge. This study investigates pressurized gas as a potential heat transfer fluid, exploiting the observed velocity-temperature correlation within turbulent flows. Large Eddy Simulation (LES) is employed for turbulence modeling due to its favorable balance between accuracy and computational cost compared to Direct Numerical Simulation (DNS) and Reynolds-Averaged Navier-Stokes (RANS). A three-pronged approach was undertaken: comprehensive bibliography study, LES models sensitivity analysis, and statistical evaluation: Closure models within LES are evaluated to assess their impact on near-wall turbulence predictions, comparing them to DNS. Through this approach, the study identified several mixed models effective for different meshes for near-wall turbulence. This finding has significant implications for optimizing heat transfer efficiency in CSP plants by leveraging pressurized gas and turbulence modeling with the two-layer mixed closure models within LES.

Ali Mohamed ALI

www.linkedin.com/in/fozi/

Bach. in Electrical Engineering and Electronics, Abdullah Gul University, Turkey

Mobility scheme

UNIVERSITÉ DE LORRAINE

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Kayseri, Turkey

“From Nomad to Renewable Maverick: Charging Across Continents for a Greener Future!”

Company

GridLab - HES-SO Valais-Wallis

The GridLab platform of the HES-SO Valais-Wallis allows the study of the integration of renewable en- ergies and energy storage for tomorrow's electricity grids. Research and training activities take place in a state-of-the-art laboratory equipped with transmission grid, a distribution grid, and converter-interfaced batteries and photovoltaics. The latest communication control completes these Smart Grid Installations. GridLab is also the Swiss representative of the European Distributed Energy Resources Laboratory (DerLAB) network.

Master's thesis title

Optimal Siting and Sizing of Energy Storage for Distribution Grids.

The stability, reliability, and correct operations of electricity distribution grids are critical, as they represent the final stage in delivering power to residential, industrial, and other end-users. Integrating distributed energy resources, such as photovoltaics and electric vehicles, introduces significant challenges to maintaining correct operations of distribution grids. This thesis investigates the optimal siting and sizing of battery storage systems as a non-wire solution for voltage magnitude control, in contrast to traditional wire solutions of cable and transformer upgrades. The objective is to perform a comprehensive techno-economic analysis aligned with Switzerland's 2050 Zero Net Carbon goals.

The primary challenge lies in the computational complexity of large networks due to the non-linear nature of load flow equations. To address this, these are linearized using sensitivity coefficients to produce a tractable model and linear optimal power flow. Future scenarios for the penetration of photovoltaics and electric vehicles are considered based on Switzerland's carbon neutrality targets. Preliminary results indicate that battery storage systems can effectively control distribution grid voltage magnitude, making them a viable alternative to traditional grid reinforcements. Further assessments of battery storage technology applications are in progress in collaboration with OIKEN, a distribution system operator in Sion and Sierre, Canton Valais, Switzerland. These evaluations aim to ensure that battery storage systems can meet the required grid operations and reliability standards in line with Switzerland's 2050 sustainability goals

Paula ALTIMIR MATAIX

www.linkedin.com/in/paulaaltimir

Bach. in Energy Engineering, UPC, Spain

Mobility scheme

UNIVERSITÉ DE LORRAINE

Politecnico di Torino

“Empowering the Future with Wind: Driving Efficiency and Innovation in Technical Performance Analysis team at RWE”

Company

RWE

RWE RENEWABLES

With more than 125 years of successful history behind them, RWE has undergone fundamental change and is now a leading supplier of renewables worldwide. They have wind farms, solar power, and battery storage facilities in many countries. Even today, most of their core business is green electricity.

RWE aims to continuously improve, investing in renewables and fully embracing promising hydrogen technology. Together, they have achieved a lot and will continue on their path: for a sustainable future, for achieving net zero emissions by 2040 - to become the best energy company they can be!

Master's thesis title

Technical Performance Analysis and SCADA System Integration for Eolic Turbines

Make RWE wind farms operated more efficient and reliable—focus on making turbines perform better through detailed analysis of SCADA data. The primary difficulties revolve around the identification and elimination of technical problems to further enhance the turbine's efficiency and, accordingly, the overall productivity of the wind farm.

New software tools and processes were developed for the quantification, analysis, and tracking of wind farm performance. These tools facilitate routine analysis by enabling side-by-side comparisons of turbines to pinpoint discrepancies and improve overall efficiency. Furthermore, reliability and power curve tests are carried out to evaluate and improve new operational positions.

Significant achievements in the creation of robust data analysis frameworks will streamline the process of monitoring turbine performance for early detection of possible component failures. Prospective further development of these tools to provide even more precise and actionable insights is in progress.

The research is pushing the frontiers of sustainable management in renewable energy. Technical performance analysis is being combined with advanced software solutions to enable empowering the future with wind. More data-driven improvements with proactive maintenance will set new standards in efficiency and reliability in the operation of the wind farm.

Perizat AMIRZHAN

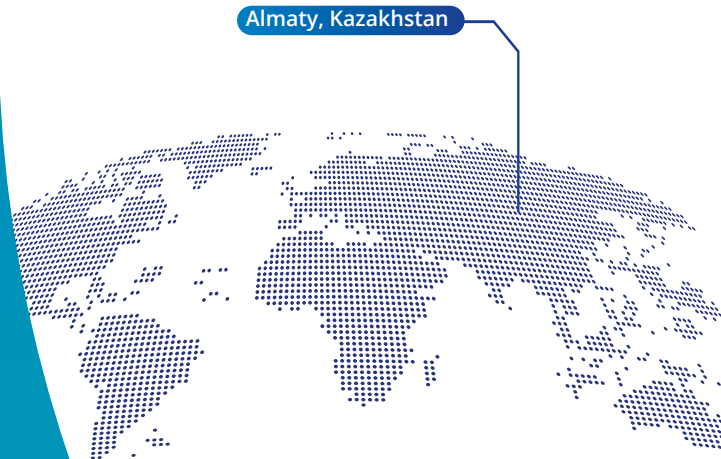
www.linkedin.com/in/perizat-amirzhan-69779520a/

Bach. in Electrical Engineering, aL Farabi Kazakh National University, Kazakhstan

Mobility scheme

UNIVERSITÉ DE LORRAINE

Politecnico di Torino



“Steel the future!”

Company

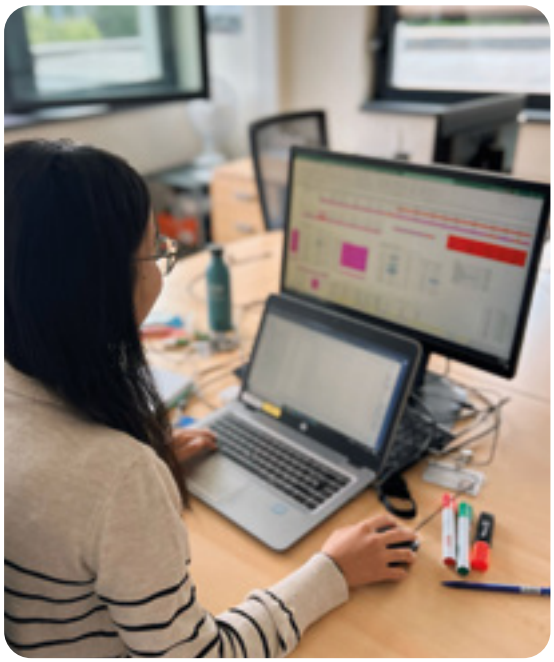
ArcelorMittal

ArcelorMittal Maizières – Global Research and Development

ArcelorMittal is the largest steel producer in the world, employing 126 756 people across more than 60 countries and an industrial footprint in 27 countries. ArcelorMittal dominates leading industries including automotive, building, home appliances, and packaging. ArcelorMittal Global R&D expands its global presence with 14 research sites located in 9 countries and employees from more than 25 different nationalities.

Master's thesis title

Roll out of an energy Savings and Decarbonization tool for Iron and Steel plants



Steelmaking is a resource-intensive industry. Thus, ArcelorMittal is looking for ways to save energy and materials in its plants. To achieve this, the company uses various advanced tools to predict potential results and compare them with the actual plant operations. This approach optimizes work, minimizes resource consumption, and increases overall efficiency.

The objective of this thesis was to roll out an existing tool for energy saving and decarbonization of iron and steel processes using advanced Python programming. Initially, the tool was developed using Microsoft Excel, it computes mass and energy balances at every step of the steelmaking process, from the coking plant to secondary metallurgy. The key tasks were to understand the steelmaking process, analyze the structure and functionality of the tool, and translate the tool into a Python environment. This transition used object-oriented programming to ensure code reuse and scalability. The Python-based tool has demonstrated significant improvements in computational efficiency and operational flexibility, closely matching the data from the previous tool. The introduction of a new tool in a new environment highlights its ability to optimize the use of resources and contribute to the implementation of ArcelorMittal's sustainable development goals. This thesis demonstrates how advanced programming approaches may be used to enhance industrial processes, resulting in considerable increases in material and energy efficiency and contributing to the company's decarbonization efforts.

Abed Al Wahab ANIS

www.linkedin.com/in/abed-al-wahab-anis-3327831b4

Bach. in Electric Power and Machines, Beirut Arab University, Lebanon

Mobility scheme

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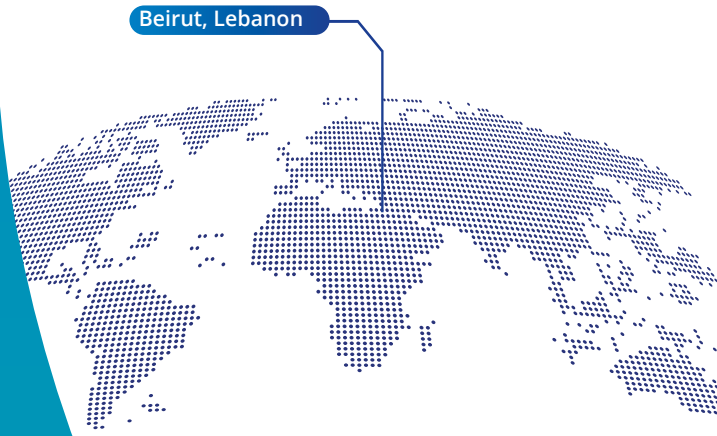
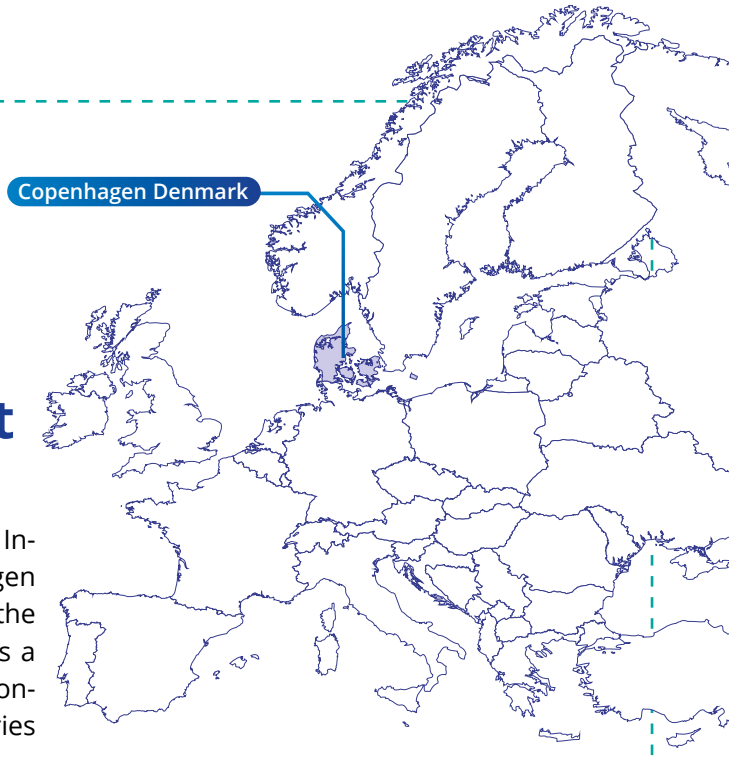


“Create the Impact. Be the change”

Company



United Nations development Program (UNDP) , UN City

The United Nations Development Program (UNDP) Unit of Information Technology and Management (ITM) in Copenhagen is responsible for supporting UNDP Country Offices around the world with ICT and Green Energy solutions. Our Unit offers a stimulating and versatile internship in an international environment with contact to various partners from some 166 countries with UNDP presence.

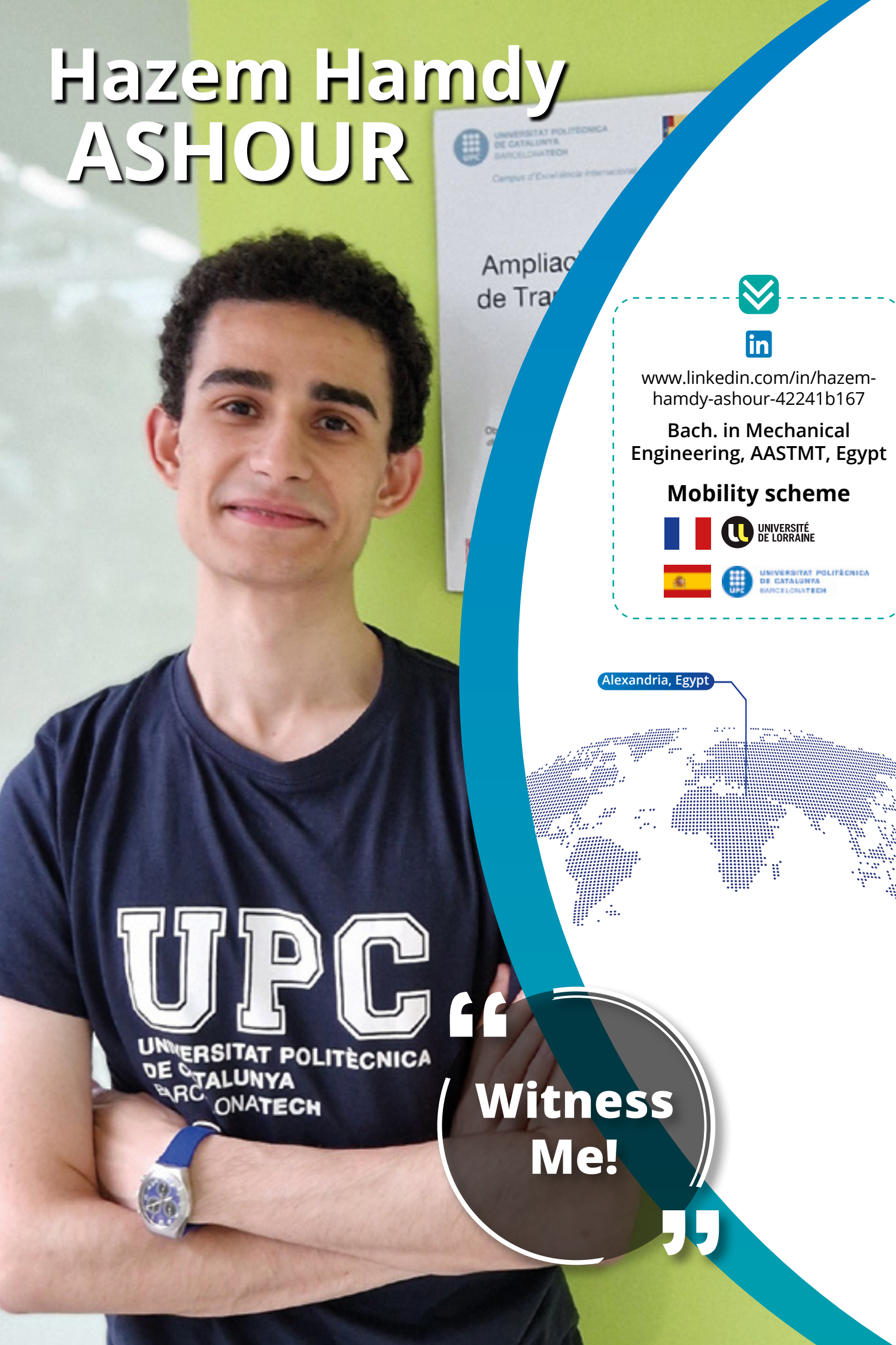
Master's thesis title

Data-driven improvement for solar system design

The transition to sustainable energy is imperative due to the urgency of global warming, with the United Nations aiming to lead by example through the United Nations Development Program (UNDP) Moonshot initiative. This program targets the shift from fossil fuel dependence to renewable energy across transportation, power consumption, energy efficiency, and waste management in UNDP's country offices. Despite significant efforts by the UNDP ITM Green Energy team (GET), which has implemented over 150 solar PV projects globally, performance often falls short of the targets set in the business case documents prepared by GET. This research aims to understand the discrepancies between theoretical projections and real-world performance, focusing on solar PV systems.

The study will perform a technical and environmental analysis, comparing theoretical designs and practical implementations. Methodologically, it will analyze performance data from implemented solar PV systems commissioned before May 2023, assessing factors like uptime, annual output, and specific yield. The findings will highlight patterns of underperformance, differences between business case projections and vendor designs, and root causes such as downtime, load discrepancies, and technical malfunctions. By identifying these issues, the research will propose recommendations to improve the initial project planning and design processes, ensuring more accurate and reliable renewable energy implementations aligned with the Moonshot 2030 targets.

Hazem Hamdy ASHOUR



www.linkedin.com/in/hazem-hamdy-ashour-42241b167

Bach. in Mechanical Engineering, AASTMT, Egypt

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“Witness Me!”

Company

Centre Tecnològic de Transferència de Calor
UNIVERSITAT POLITÈCNICA DE CATALUNYA

Heat and Mass Transfer Technological Center (CTTC)

The Heat and Mass Transfer Technological Center (CTTC) is a renowned worldwide research group in Solar and Renewable Energy, Thermal Systems and Equipment, Aerodynamics, Computational Fluid Dynamics & HeatTransfer, and High Performance Computing

Master's thesis title

Numerical resolution of mass, momentum and energy equations in 0-1D transient models. Application to next generation of HVAC&R components and equipment.

Climate change caused by emission from human activity is a great threat to humanity. Road transportation is a major source of these emissions threatening our planet. The electric vehicle is one of the solutions for reducing road emissions when powered by renewable energy sources due to its zero emissions on the road. One of the important design elements of the electric vehicle is the thermal management system, because of the major differences of the thermal requirements of the vehicle compared to a traditional internal combustion vehicle. This thesis provides the basics on the design of an electric vehicle thermal management system. It discusses the main layouts features of the system such as the battery loop, VCC & cabin loop, and the motor and power electronics loops. It takes a benchmark patent system and compares it to other systems from three systems from literature and to three other patents to identify key modes of operation for the thermal systems such as different modes of heating or cooling. Lastly the thesis provides the basic required knowledge in heat transfer and CFD in order to approach the building of 0-1 D model of individual component or entire system design through the study of some known cases of 1D conduction heat transfer in a rod, 2D conduction heat transfer in a rod of 4 materials, Smith-Hutton, and Lid Driven Cavity.

Timon BENZ

www.linkedin.com/in/timon-benz-5570b4267/

B.Sc. in Energy and Environmental Engineering, HRW Bottrop, Germany

Mobility scheme

UNIVERSITÉ DE LORRAINE

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

“Striving for top research in down under”

Company

Australian National University

Australian National University (ANU) Group of Thermal Energy Research

The Thermal Energy group is focused on industrial decarbonization, thermal energy storage and solar-thermal energy collection. Industrial decarbonization is supported via involvement in the Heavy Industry Low-Carbon Transition CRC (HILTCRC) with a range of leading heavy industry companies, and includes work on green iron and steel production, cement production, and alternative sources of industrial process heat. Work is also conducted on gasification of biomass and synthesis of biomass-derived liquid fuels. Experimental facilities include furnaces, solar concentrators, a sodium heat transfer 'loop', and thermal energy storage components.

Master's thesis title

Variability of high-temperature industrial heat supply for optimal sizing and operation of integrated renewable energy and thermal energy storage systems

The decarbonisation of heavy industry processes is challenging as continuous supply of large amounts of high-temperature heat is needed. When considering a switch to heat supply from renewables (solar and wind), their intermittency stands in conflict with the continuous heat demand. As a result, system designs for completely continuous heat supply each hour of the year are oversized in their renewables and the storage capacities. Such an oversizing causes high levelized cost of product (LCOP) and therefore lack of cost-competitiveness.

This work analyses and shows to which degree the heat supply can be allowed to vary; reducing the oversizing and increasing cost-competitiveness of the renewable system. As variations in the heat supply cause additional costs, e.g. damage to equipment or lost production; these costs are categorized, quantified, and balanced with the cost reduction thanks to the reduced oversizing. Another research objective is to see how the planning of operation and maintenance can be adapted to the variability and availability of the renewables.

The methodology is based on optimization in Pyomo using a mixed integer linear programming (MILP) approach. The sizing and operational planning for a full year is optimised. In a sensitivity analysis, different variable heat load models are applied and the impact on costs, system sizing, design and operation are observed.

Chrisle CHARLS

linkedin.com/in/beacon0

Bach. in Technology, APJ Abdul Kalam Technological University, India

Mobility scheme

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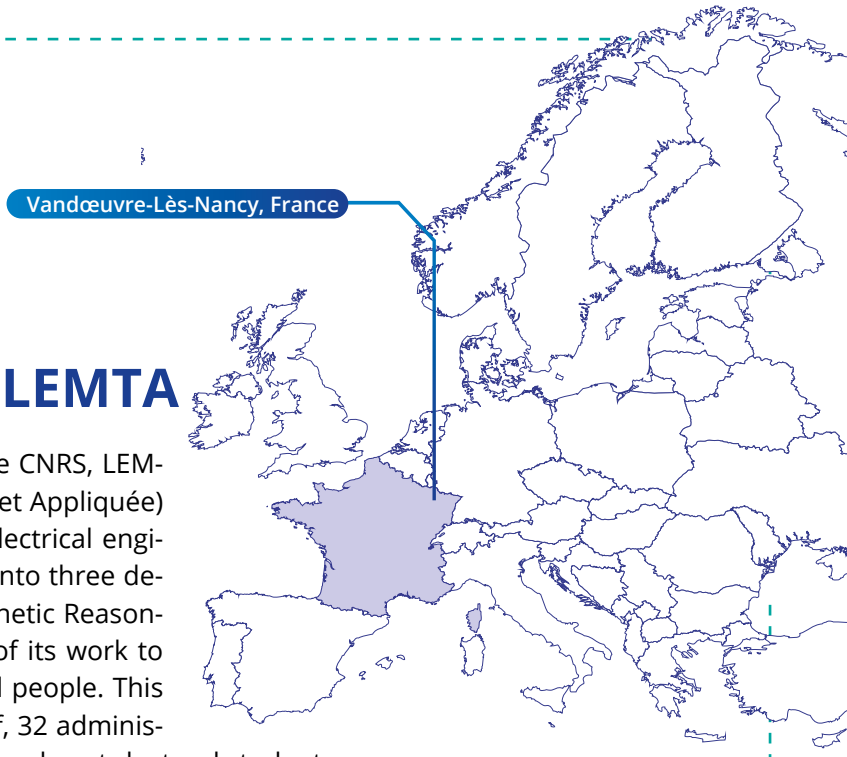
“There is always room to be better under the tides of time... And yet, let’s not forget to appreciate what’s good while we pursue what’s better.”

Company

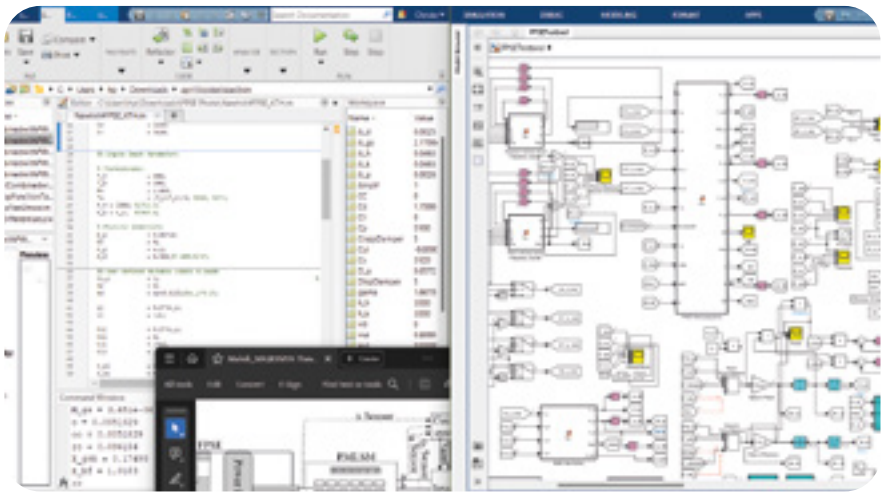


Vecteurs Energétiques, LEMTA

A laboratory of the Université de Lorraine and the CNRS, LEMTA (Laboratoire Énergies & Mécanique Théorique et Appliquée) focuses on mechanics, heat and mass transfer, electrical engineering and electrochemical systems. Organized into three departments and a cross-disciplinary group on Magnetic Reasoning Imaging (MRI), the Laboratory devotes most of its work to the energy transition and the safety of goods and people. This research is carried out by some 80 academic staff, 32 administrative and technical staff and around 80 doctoral and post-doctoral students.

Master's thesis title

Numerical Modeling and Sensitivity Analysis of Free Piston Stirling Engines coupled to Linear Alternators for Power Conversion Applications



The study investigates the combination of Free Piston Stirling Engines (FPSE) and Permanent Magnet Linear Synchronous Motors (PMLSM) to explore their potential in Combined Heat and Power applications due to their omnivorous and reversible natures. The external combustion characteristic of the Stirling cycle-based FPSE makes it particularly suitable for low to medium temperature waste heat recovery. It can also be integrated into systems for co or trigeneration (heat, cold, electricity) or combined with Solid Oxide Fuel Cells (SOFC) or biomass boilers.

The primary objective of the study is to determine the most efficient and maximum thermal power extractable using a given FPSE-PMLSM coupled system when running in heat engine mode. Multiple simplified numerical models based on previous research are developed and tested for accurate prediction in distinct linear and non-linear cases for transient and steady state operation. The model's improvements further the understanding about the system behavior and reduce the necessary model inputs for the system control.

Greco Gervin Lumabas CRUZ

www.linkedin.com/in/grecogervincruz

Bach. of Science in Electronics and Communications Engineering, University of the Philippines Diliman

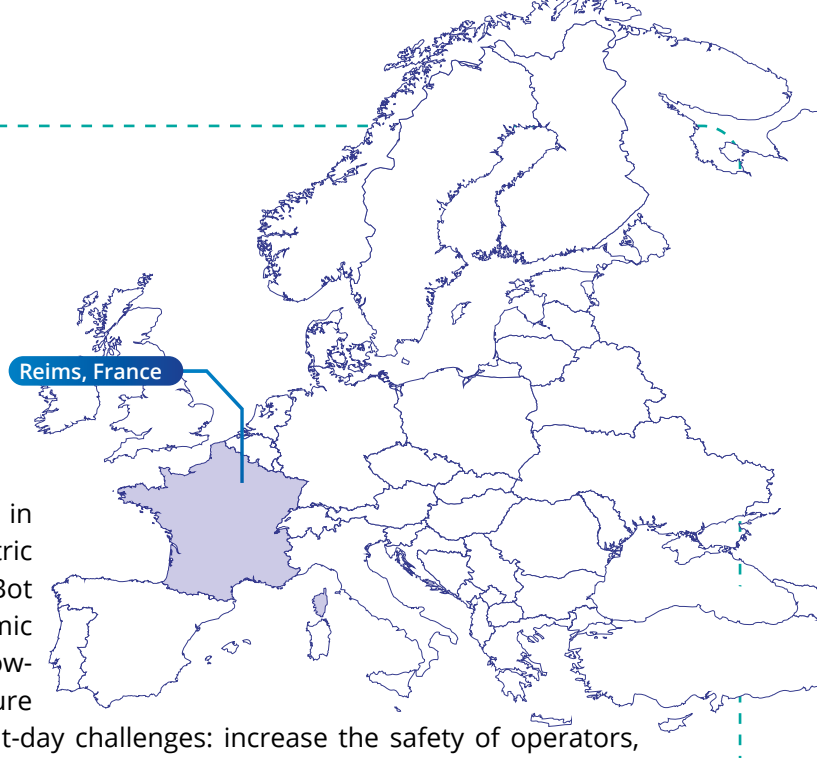
Mobility scheme

UNIVERSITÉ DE LORRAINE

KTH VETENSKAP OCH KONST

“MabuHEY! DEN-Seize the moment and watt-ch out for the energy transition! Ener-G!”

Company

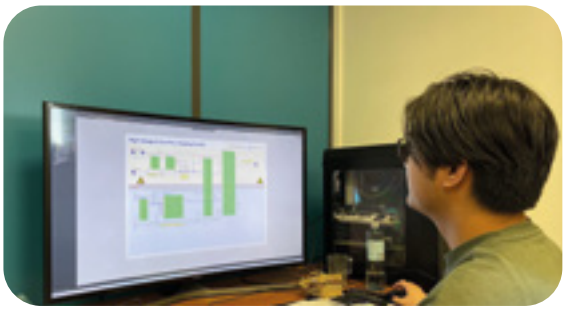


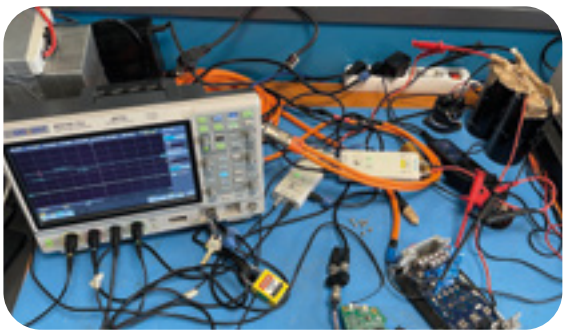
VitiBot and Université de Lorraine

VitiBot is a French industrial company established in 2015 and is in the market of autonomous and electric vineyard robots. By offering a driverless solution, VitiBot reconciles contemporary environmental and economic issues. The company's ambition is to make wine-growing practices evolve towards a sustainable viticulture with practical and concrete solutions to the present-day challenges: increase the safety of operators, protect the vineyard and biodiversity, and reduce the environmental carbon footprint of viticulture.

Master's thesis title

High Voltage Active Pre-charging System for Electric Robot "BAKUS"





In the electric machine and automotive sector, pre-charge circuits are widely employed in various industrial applications. Pre-charge systems serve the purpose of minimizing the inrush current, effectively prolonging the equipment's lifetime, boosting reliability, and guarding against damage due to unavoidable current surges. VitiBot's trademark product - the Bakus robot, makes use of multiple high-voltage inverters, which include DC/DC converters and motor controllers integrated with large decoupling capacitors. The main goal of this project is to create a pre-charging system specifically suited for Bakus that actively manages the initial inrush current during pre-charging, allowing the control of important parameters such as pre-charging time and maximum in-rush current. These include the selection of an appropriate pre-charge architecture, verification of the performance using computer simulations and preliminary testing, creation of a Printed Circuit Board (PCB) prototype, and the validation of this solution once integrated with the Bakus robot.

Through the implementation of such active pre-charging systems, the Bakus robot starting sequence becomes more efficient, improving the smoothness and reliability of the robot's operation. This boosts the robustness of the electric robot itself, as there is a lesser need for frequent maintenance. Ultimately, this can help achieve a less carbon intensive electric machine manufacturing sector in the long run, as it would reduce the need to produce and outsource new manufactured components as a result of fewer repairs throughout the robot's lifetime, thereby minimizing GHG emissions and material usage in the manufacturing sector.

Nethmini KOLAMBAGE

www.linkedin.com/in/nethmini-kolambage/

Bach. in Engineering (Hons), University of Moratuwa, Sri Lanka

Mobility scheme

UNIVERSITÉ DE LORRAINE

KTH VETENSKAP OCH KONST

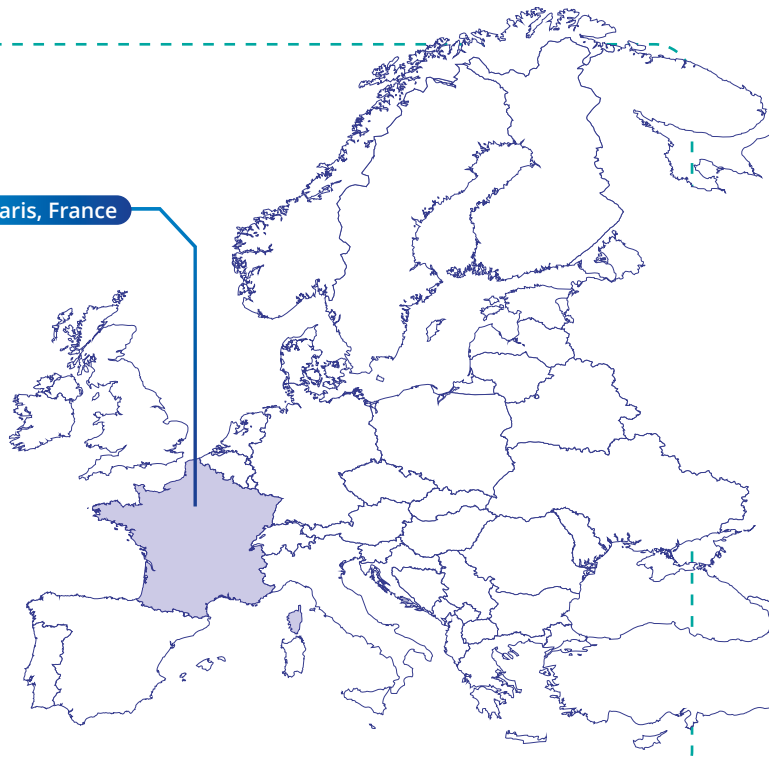
> **Lead the charge against climate change with a Marathoner's Mindset and a Sprinter's Focus**

Company

GE VERNOVA

GE Vernova

GE Vernova, a global leader in energy transformation, is dedicated to electrifying the world and decarbonizing it through advanced technologies and services in power generation, renewable energy, and energy storage. Headquartered in Cambridge, Massachusetts, their influence is profound, contributing to about 30% of the world's electricity generation. Their comprehensive approach also includes consulting services to aid companies in transitioning to cleaner energy, ensuring efficient energy delivery, and spearheading research into new energy technologies.



Master's thesis title

Battery Modeling in Energy Systems

The integration of renewable energy sources presents a challenge: maintaining grid stability with fluctuating power generation. Battery storage offers a solution, but accurately determining its optimal capacity in long-term capacity expansion (CEP) models remains complex. This project investigates these challenges and explores solutions.

The research analyzes the limitations in capturing the value of battery storage. It then justifies the selection of PLEXOS, a prominent commercially available software. A sample model will be deployed and key inputs, outputs, and underlying assumptions will be discussed with a specific focus on how battery storage systems can be effectively modeled to replicate energy arbitrage.

This project contributes to a more comprehensive understanding of the challenges and opportunities associated with optimizing battery storage deployment through long-term capacity expansion planning.

Joy Surjy DEB

www.linkedin.com/in/joy-surjy-deb-7763181b3/

Bach. in Nuclear Eng., University of Dhaka, Dhaka, Bangladesh

Mobility scheme

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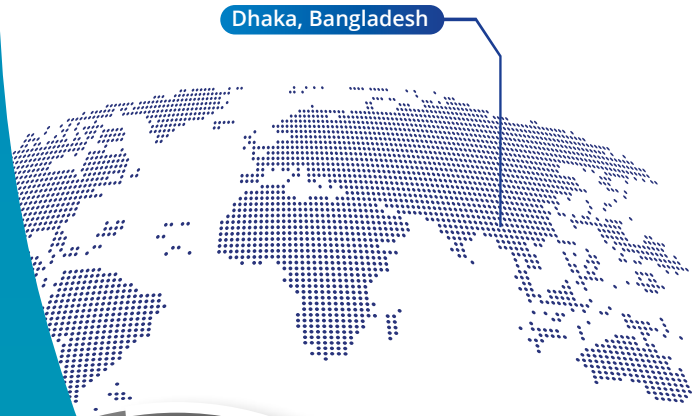
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH



“Radiant Gravity Current is my Model: Capturing the Flow behind the Lens”

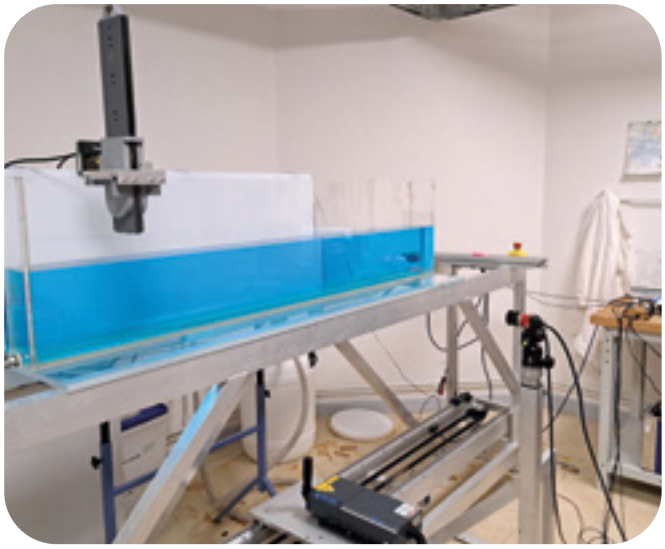
Company

LEMTA

A laboratory of the Université de Lorraine and the CNRS, LEMTA (Laboratoire Énergies & Mécanique Théorique et Appliquée) focuses on mechanics, heat and mass transfer, electrical engineering and electrochemical systems. Organized into three departments and a cross-disciplinary group on Magnetic Reasoning Imaging (MRI), the Laboratory devotes most of its work to the energy transition and the safety of goods and people. This research is carried out by some 80 academic staff, 32 administrative and technical staff and around 80 doctoral and post-doctoral students.

Master's thesis title

Gravity currents in a stratified environment: an experimental study



Gravity currents are important in both natural contexts, such as ocean currents and avalanches, and industrial situations, such as wastewater treatment and tunnel fires. Studying these currents is critical for tackling major health and environmental issues. This research effort seeks to investigate the dynamics of gravity currents such as their movement and mixing with the environment as they flow through locations of varied densities.

At LEMTA, with cutting-edge experimental facilities and novel measuring methodologies, like PIV, LED panel and LAT, numerous experiments have been conducted to track the progression of gravity currents, to comprehend how these fluxes convey materials. During the experiment heavier or more dense fluid and lighter fluid in the experimental tank have been separated by a lock. By employing LAT and PIV technology images have been captured during the real-time experiment. One of the most challenging part was to extract detailed and realistic information on physical values like density, velocity, and buoyancy from the pixel information of the camera. Simultaneously capturing the event with proper measurement was significant as well. The result also shows us the lobe and cleft flow and vortices generated during the progression of the current which is important to analyze the energy transportation and behavior of the heavier fluid. These improvements have the potential to inform mitigation methods for gravity currents' effects on the environment and human health.

Vishnu DHINAKARAN

www.linkedin.com/in/vishnu-dhinakaran/

Bach. in Electrical and Electronics Eng., National Institute of Technology, India

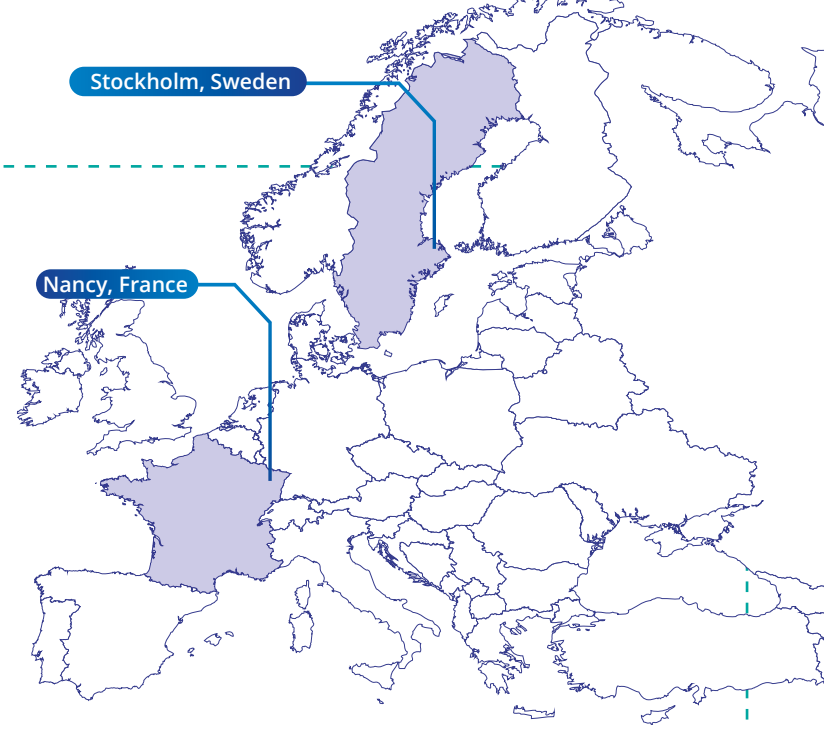
Mobility scheme

UNIVERSITÉ DE LORRAINE

KTH VETENSKAP OCH KONST

Chennai, India

“Circularity is an option today, but will be a necessity tomorrow - it’s better to get ahead of the curve.”



Company

INSTITUT JEAN LAMOUR

KTH

Materiaux Carbonés, IJL | Applied Electrochemistry Division, KTH

The Carbon-based Materials group in IJL conducts research on carbon materials and their strong application potential in a wide variety of fields. The group is more specifically interested in low dimensional crystalline materials: graphite and related structures, graphene and its derivatives, carbon nanotubes, etc.

In the Applied Electrochemistry Division at KTH, the research is directed mainly towards electrochemical power sources (lithium-ion batteries, molten carbonate fuel cells, polymer electrolyte fuel cells and redox flow batteries) and electrolytic processes (polymer electrolyte water electrolysis and chlorate electrolysis).

Master's thesis title

Revitalising Graphite: Optimisation of recycling parameters for graphite from end-of-life Li-ion batteries

The global effort for a paradigm shift in the energy sector is a Herculean task that requires attention from multiple points of view. A heavy focus has been given to decarbonising the energy sector by introducing storage options for the transport sector - especially Li-ion batteries. An increase in demand for devices like Li-ion batteries will be reflected by an increase in demand in critical materials that are used in them. Due to the higher cost and more urgent need for cathode materials (like Lithium, Nickel, and Cobalt) in Li-ion batteries, significant research has gone into methods for their effective recycling.

However, one of the main disadvantages with the current recycling techniques is that all of them at the industrial scale tend to discard the graphite present in the battery. Not only is this an unfortunate side-effect of current battery recycling techniques, but has also resulted in a gap that prevents complete circular economy of batteries. The goal of this thesis is to bridge this gap by finding optimal recycling parameters that will yield the best physical and electrochemical performance of graphite taken from the end-of-life batteries.

Delight EZEH

www.linkedin.com/in/delightezeh

Bach. in Mechanical Engineering, Owerri, Nigeria

Mobility scheme

UNIVERSITÉ DE LORRAINE

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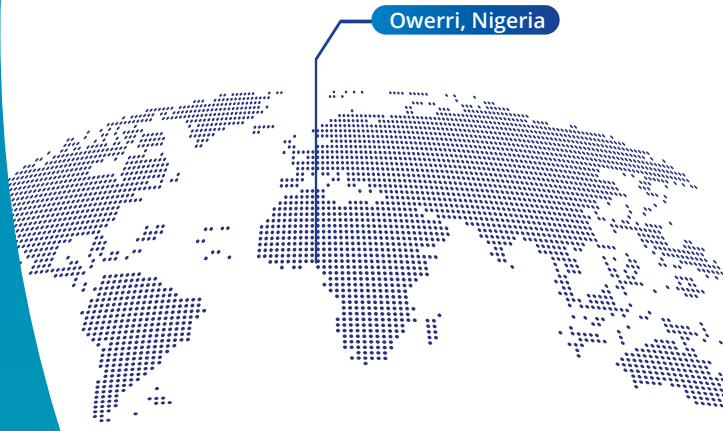


> **“It rocks to save energy!”**

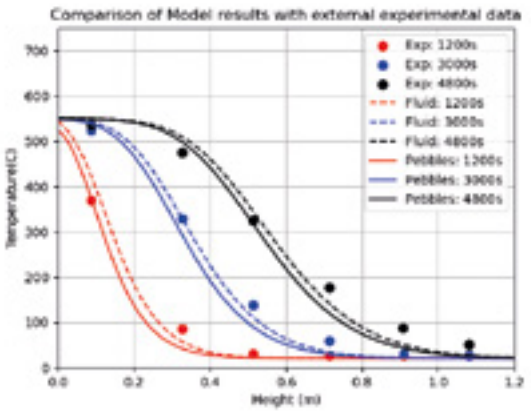
Company

ArcelorMittal Maizières Research SA, Metz, France

ArcelorMittal is the world's number one steel company, with 127,000 employees in more than 25 countries. It has led the consolidation of the world steel industry and today ranks as the only truly global steelmaker with an industrial presence in 27 countries. ArcelorMittal is the leader in all major global markets, including automotive, construction, household appliances and packaging. ArcelorMittal's Global R&D spans the Globe with 14 sites dedicated to research (operating in process, products, application and steel solutions) within 9 countries and with employees from more than 25 countries.

Master's thesis title

Development of a simulation tool for pebble heaters as part of energy savings and decarbonization for steel plants.



Steel production is a very energy-and-emission-intensive process, and with its projected increase in the future, due to steel's vitality in the operation, sustenance, and development of modern economies, there is a huge need for solutions, pathways, and methodologies to increase the sustainability of steel making processes across all production facets to meet global energy and climate goals.

Pebble bed heaters/ Thermal Energy Storage (TES) systems possess great potential to be used as regenerators to recover waste heat across all facets of steel plants. Thus, this thesis focuses on the development of a simulation tool for pebble heaters via numerical modeling of heat transfer and its paraphernalia within packed bed TES systems, as a preliminary instrument for testing use cases and optimizing design decisions for their incorporation in steel production processes, to ultimately enable energy savings and decarbonization. The project was carried out by: executing a thorough literature review and survey on heat transfer modeling techniques of packed-bed heat storage devices used in heavy industries, improving and developing algorithms, numerical models, and corresponding codes for existing and novel packed bed TES systems, analyzing model results and comparing with experimental results where available and testing the developed model on semi-industrial and industrial size scenarios.

Kainat FATIMA

www.linkedin.com/in/engr-kainat-fatima-675a8715a/

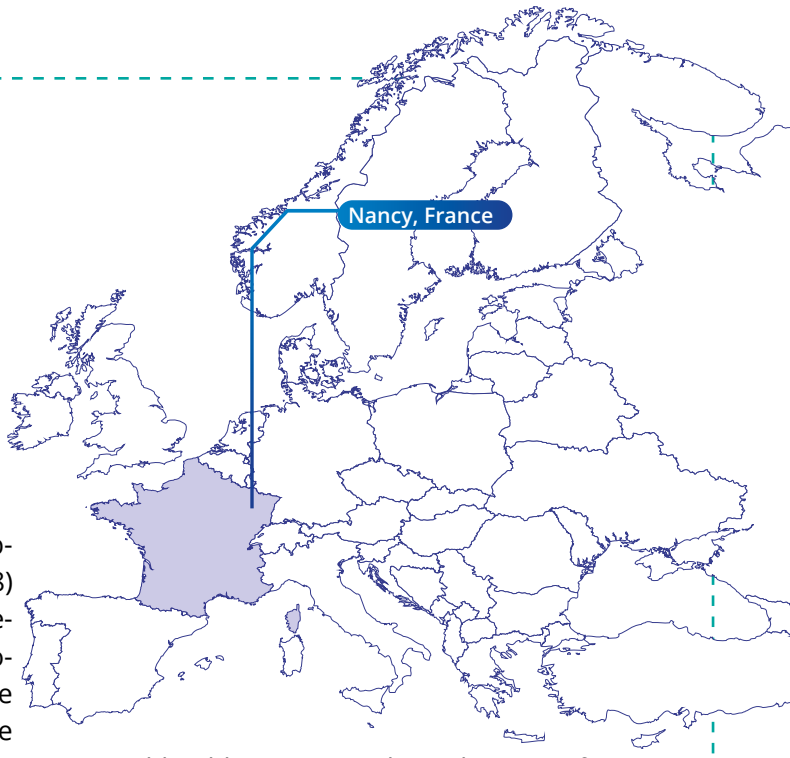
Bach. in Electrical Engineering,
NED University,
Pakistan

Mobility scheme

UNIVERSITÉ DE LORRAINE

“Even Small Innovations Can Make a Big Impact!”

Company



Université de Lorraine – Institut Jean Lamour (IJL) UMR CNRS 7198

The Institut Jean Lamour (IJL) is a fundamental and applied research laboratory. It is a joint unit (UMR 7198) of the CNRS and Université de Lorraine. It is a multi-thematic laboratory covering materials, metallurgy, nanosciences, plasmas, surfaces and electronics in response to societal challenges such as energy, environment, the industry of the future, mobility, the preservation of resources and health. Its research work ranges from the design of devices to their industrial applications. The IJL is mainly based in Nancy, in the Artem campus.

Master's thesis title

DPP approach to solve current mismatch issue in hybrid PV-TEG energy harvesting system for low power applications

Based on the state of the art in DPP techniques for PV and TEG modules under unbalanced conditions, the first objective of this internship is to make a review of the possible differential power converter topologies and associated control that can be used for series connected Photovoltaic-Thermoelectric sources in hybrid energy harvesting systems. The advantages and drawbacks of each topology will be highlighted and a comparison will be made between all of them. The small case applications will be targeted, and similar areas for PV and TEG will be considered, in the spirit of the ANR HYDRES project.

Then, this internship will be dedicated to select one of the studied DPP-based energy harvesting approach for a TEG module connected in series with a PV cell. The increase in efficiency by implementing DPP will be theoretically studied for the selected differential power conversion, and compared with the use of a single centralized converter or with the use of two separated MPPT converters (optimal case in terms of harvested energy, if power losses, cost, and size are not considered – one MPPT converter for each PV and TEG source).

Finally, the energy harvesting systems based on two series-connected TEG modules with and without DPP will be simulated in the Matlab environment.

Alejandro Andres FLORES CHACÓN

www.linkedin.com/in/alejandro-flores-chacon

Bach. in Mechanical Engineering, Universidad Metropolitana de Caracas, Venezuela

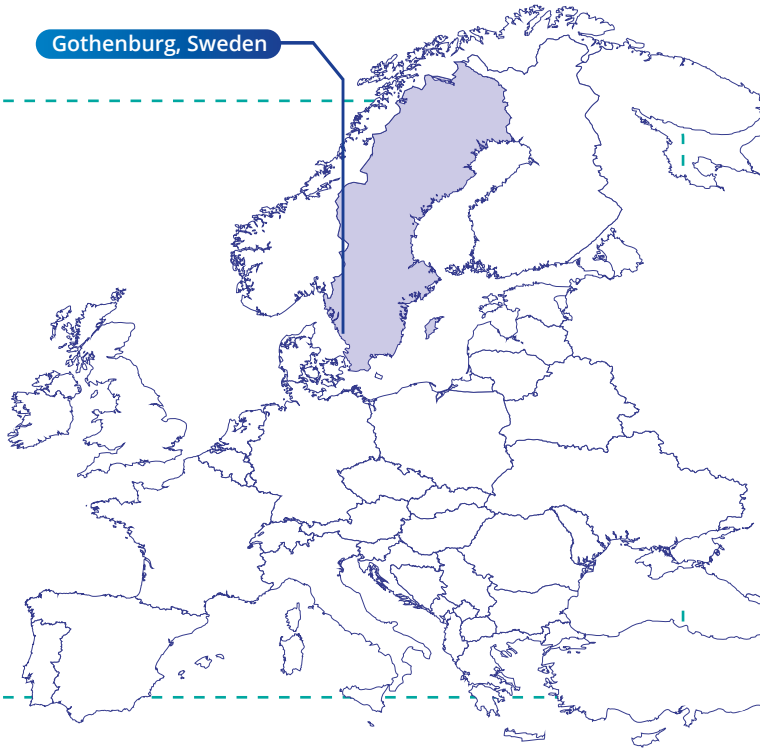
Mobility scheme

UNIVERSITÉ DE LORRAINE

Politecnico di Torino

“Making batteries last longer and fossil fuels last less”

Company

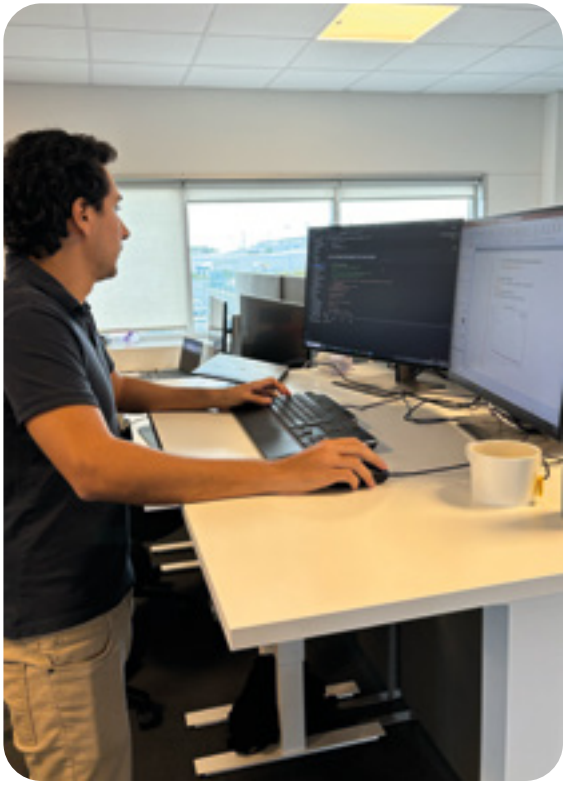


Polestar Performance AB

The Swedish electric performance car brand determined to improve society by using design and technology to accelerate the shift to sustainable mobility. Headquartered in Gothenburg, its cars are available online in 27 markets globally across North America, Europe and Asia Pacific.

Master's thesis title

Li-ion Cell modeling & machine learning based diagnosis



With the current energy transition and the rise of Electric Vehicles, optimizing battery use and improving our understanding of batteries are becoming increasingly important. This thesis focuses on the modeling and diagnosis of Li-ion cells, specifically on designing and training a machine learning (ML) model capable of quantifying and characterizing degradation modes within the cell. The model aims to quantify the loss of active material (anode and cathode) and the loss of cyclable lithium throughout the battery's life, using the cell's voltage response during low C-rate charging as the only input. This measurement can be carried out in electric vehicles without the need for extra sensors or complex equipment, utilizing the already installed voltage and current sensors.

One of the main challenges in using ML is the need for large datasets to train the models effectively. In this case, synthetic data is generated based on digital twins of the cell, which replicate the cell's behavior under certain degradation conditions. Additionally, the final model is applied to real-life cells aged under different drive cycles and conditions to capture the various types of degradation experienced by each tested group.

Ahmed HARBI

www.linkedin.com/in/iharbijr/

Bach. in Mechanical Power Engineering, Mansoura University, Egypt

Mobility scheme

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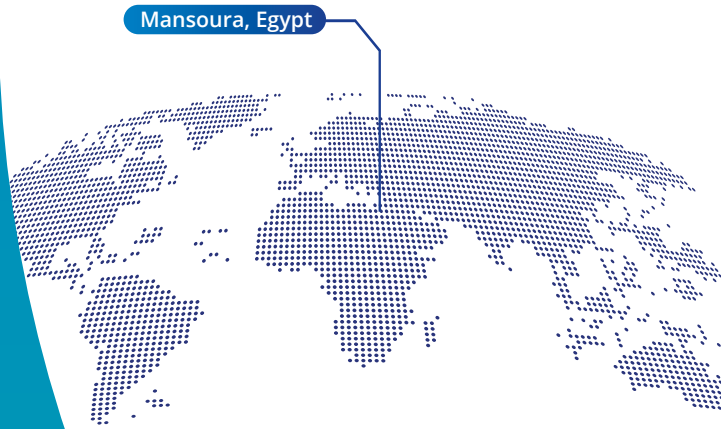


> **In theory, coding CFD solvers appears seamless, but in practice, turbulence arises.**

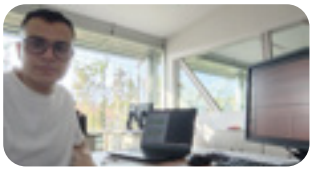
Company

Heat and Mass Transfer Technological Center (CTTC)

The Heat and Mass Transfer Laboratory, Laboratori de Termotècnia i Energètica, of the Universitat Politècnica de Catalunya·BarcelonaTech (UPC), is situated in Terrassa, Barcelona. The research activities are focused on two main lines. The first one is dedicated to the mathematical formulation, numerical resolution and experimental validation of fluid dynamics and heat and mass transfer phenomena. Some issues in this line are: natural and forced convection, turbulence modelling, combustion, two-phase flow, solid-liquid phase change, radiation, porous media, numerical algorithms and solvers, high performance computing (parallelisation), etc. The second line involves the application of the acquired know-how from the basic studies mentioned above to the thermal and fluid dynamic optimisation of thermal system and equipment.

Master's thesis title

Numerical resolution of mass, momentum and energy equations in a 3D steady state and transient models. Application to the next generation of HVAC&R components and equipment.



This thesis comprises two primary components: firstly, a comprehensive review of advanced computational methods employed in the field of computational fluid dynamics (CFD), and secondly, the development and validation of bespoke CFD and heat transfer (HT) codes through canonical test cases.

In the theoretical component, the focus is on spatial symmetry-preserving discretization of the Navier-Stokes equations, examining both staggered and collocated grid arrangements. Special emphasis is placed on collocated arrangements due to their versatility and suitability for complex geometries. The computational expense of Direct Numerical Simulation (DNS) scales with the Reynolds Number, presenting significant challenges for turbulent flow simulations. To address this, an introduction to spatial filtering is provided, establishing the groundwork for Large-Eddy Simulations (LES). Further attention is dedicated to Eddy-viscosity models, with a novel approach involving the reformulation of these models using appropriate tensor invariants, culminating in a five-dimensional phase-space of invariants.

The practical component of this thesis involves the development of a customized CFD/HT code. Utilizing staggered formulations on non-uniform Cartesian grids ensures computational efficiency without compromising precision, thus offering a robust framework for accurate fluid dynamics simulations. Object-oriented programming (OOP) techniques are employed to develop these codes, which are then tested on canonical cases including laminar and turbulent flows such as lid-driven cavities and differentially heated cavities with an aspect ratio of 4. Rigorous validation against academic benchmarks demonstrates the accuracy, reliability, and capability of these codes to effectively capture complex fluid and thermal dynamics within computational frameworks.

Nuril HIDAYATI

www.linkedin.com/in/nurilhidayati/

Bach in Engineering Physics, Institut Teknologi Sepuluh Nopember, Indonesia

Mobility scheme

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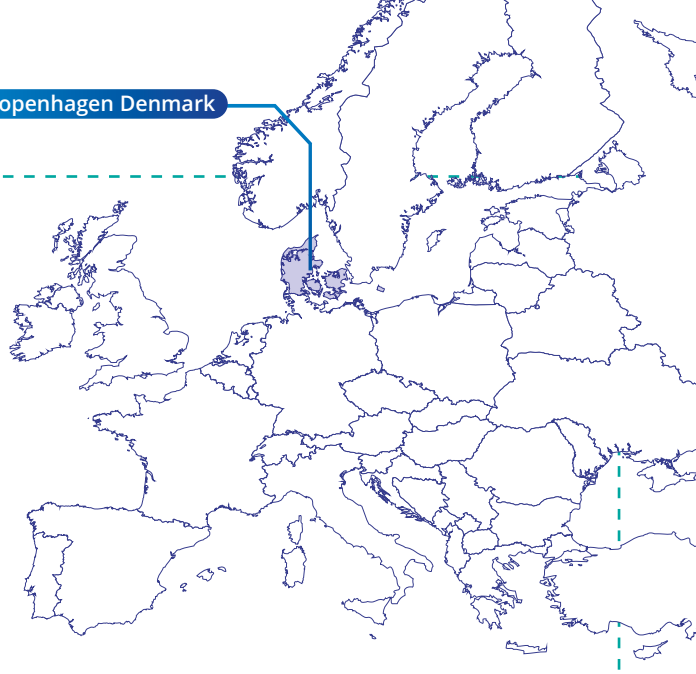
KTH VETENSKAP OCH KONST

"Where Profess-ionalism, Passion, and Purpose Align"



Company

Information and Technology Management (ITM) Unit of United Nations Development Programme (UNDP)

UNDP Unit of Information and Technology Management (ITM) is responsible for supporting UNDP Country Offices around the world with ICT and Green Energy solutions. Their vision is to develop smart UN facilities which are: Optimal and efficient, Efficient in management and Sustainable, implemented to build modern age UNDP facilities around the globe that are fully aligned with Sustainable Development Goals (SDGs).

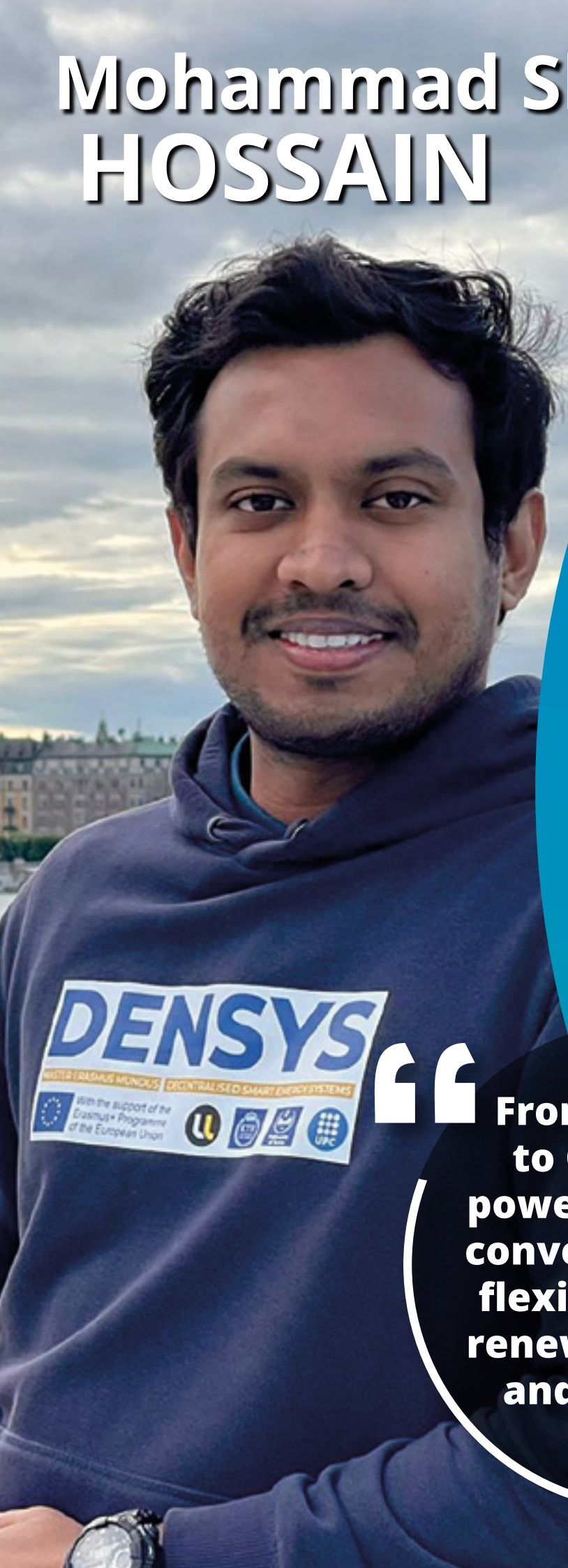
Master's thesis title

Propelling Green Energy: A process Improvement Study on Capacity Building & Partnership and Country-Based Case Study of Solar PV projects

In implementing their Green Energy Solutions, the Green Energy Team (GET) of the UNDP ITM unit utilizes a standardized method called the "Seven Steps Method," which covers the end-to-end process from preparing the business case, procurement, and installation to the operation and maintenance phases. Various stakeholders are involved in this work, primarily the ITM team, the client, and the supplier. Among the procurement strategies is one that involves an international supplier partnered with a local vendor to provide the green energy solution. The objective of this partnership is to enable knowledge and skill transfer, as well as to enhance the capacity of the local vendor.

One of the main objectives of this thesis is to conduct a process improvement study to gain insights into possible improvements in capacity building and the partnership dynamic between these stakeholders. Furthermore, this thesis will also address the country-specific context and examine how implementing these green energy technology solutions synergizes with other SDGs.

Mohammad Shafayet HOSSAIN



www.linkedin.com/in/shafayethossain957/

Bach. in Electrical Engineering, North South University, Bangladesh

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Dhaka, Bangladesh

“From kilowatts to Gigawatts, power electronics converts anything flexibly between renewable energy and the power grid.”

Company

Supergrid Institute

SuperGrid Institute is a privately owned company with expertise in high and medium voltage direct current (HVDC and MVDC) systems and technologies – key components of the energy networks of the future. It is an independent innovation and research company dedicated to the development of technologies for the future system of power transmission.

Master's thesis title

Power converters for hydrogen electrolysis in the frame of renewable energy sources integration

The primary objective of this master's thesis is to explore and evaluate various AC-DC converter topologies for hydrogen electrolysis applications, with a focus on their reliability in hydrogen production while ensuring power quality. This includes a comparative analysis of existing technologies such as 12-pulse diodes, thyristor bridge rectifiers and potentially newer options like two-level voltage source converters. The main challenge lies in identifying a topology that supports hydrogen electrolysis while effectively addressing power quality requirements, including reducing harmonics and ripples in the supplied dc power along with managing reactive power. Achieving an ideal balance between efficiency, cost, and performance, while ensuring compliance with stringent power quality standards, adds complexity to the research. Significant probable outcomes include designing AC-DC converters that ensures the efficiency and reliability of hydrogen electrolysis, improved power quality through superior reactive power compensation and harmonics reduction, and providing industry stakeholders with detailed insights for informed decision-making. Additionally, the research aims to ensure that chosen topologies meet regulatory requirements for power quality, facilitating smoother integration into existing and future energy systems.

Hasibuzzaman MAHMUD

www.linkedin.com/in/hasibmahmud01

Bach. in Mechanical Eng., Ahsanullah University of Science & Technology, Dhaka, Bangladesh

Mobility scheme

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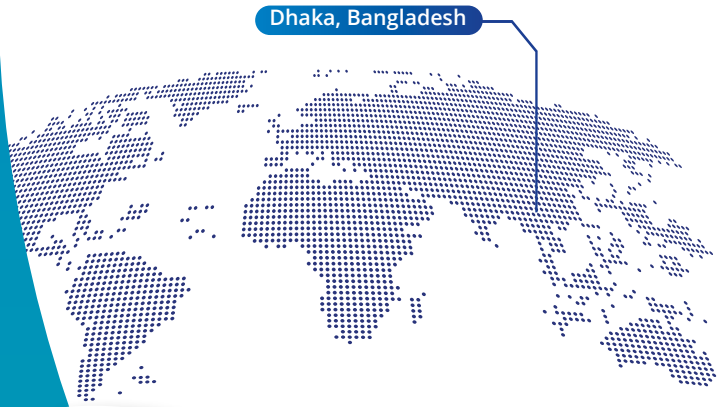


“Everything is cool when you’re part of a team!”

Company

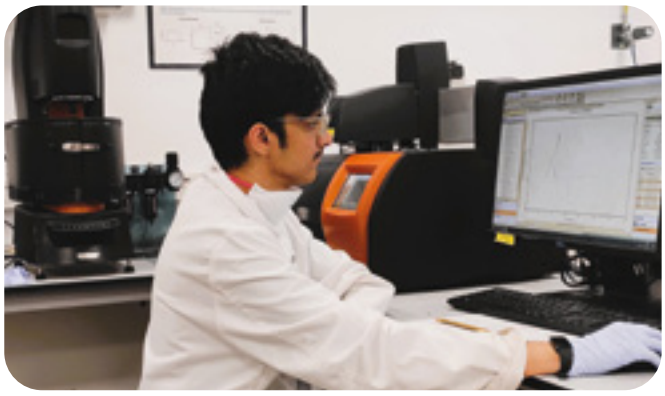
CIC energiGUNE
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

CIC EnergiGUNE

CIC energiGUNE is the research center of electrochemical and thermal energy storage, a strategic initiative of the Basque Government. CIC energiGUNE was born in 2011 to generate excellent research in materials and systems for energy storage. The goal of CIC energiGUNE is to maximize the impact on results to the Basque business network through collaboration with universities, research centers, and companies.

Master's thesis title

Enhancement of Solid-Solid Phase Change Materials: Effect of Carboxylic Functional Groups and Nanoparticles



Solid-solid phase change materials (PCMs) are poised to revolutionize the next generation of thermal storage systems by merging the affordability and simplicity of solid storage materials (such as rocks, bricks, and sand) with the high energy density of solid-liquid PCMs like paraffin, fatty acids, and molten salts. Organic plastic crystals (OPCs), exhibiting solid-solid transitions between 40°C and 200°C, offer promising applications in both building and industrial sectors. However, they face significant challenges like low thermal conductivity, sublimation, and thermal hysteresis.

To address these challenges, the addition of functionalized nanoparticles presents a promising solution. To understand the interaction between the carboxylic acid functional group and the neo pentyl glycol (NPG) molecules, one of the OPCs, different molar fraction of NPG mixture with Lauric acid is selected, and the properties related to phase transition are measured using differential scanning calorimetry (DSC). Additionally, thermogravimetric analysis (TGA) is performed to provide insights into thermal stability and sublimation tendencies.

Furthermore, the optimal preparation method for different nanoparticles with NPG was identified and the composite material was characterized. Finally, a numerical validation with the data from the DSC test was done, which may provide a glimpse into the interaction between NPG and the nanoparticles.

Seyed MohammadAmin TALEGHANI

www.linkedin.com/in/sma-taleghani/

Bach. in Mechanical Engineering, Shahid Chamran University, Iran

Mobility scheme

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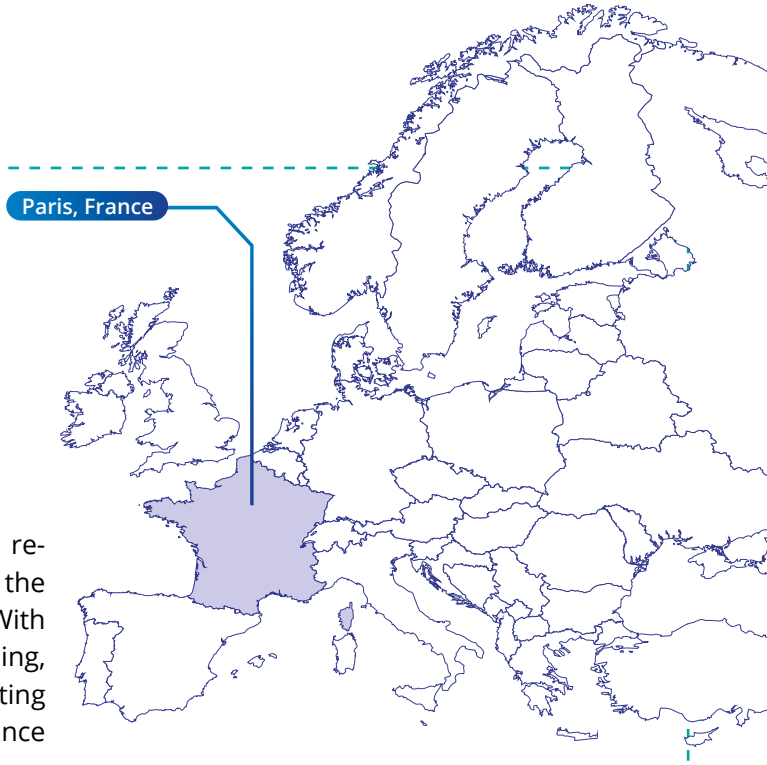
“Turning Methane into Magic: CFD Unveils the Secrets of Methane Pyrolysis!”

Company

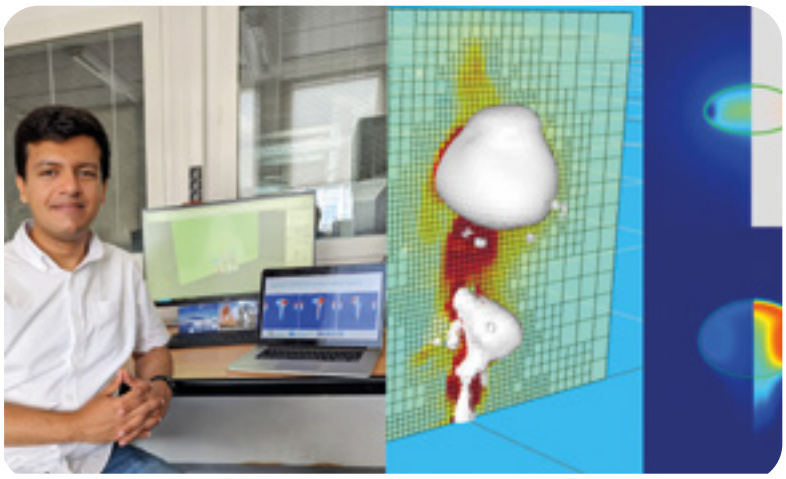


Institut Jean Le Rond d'Alembert

The Jean Le Rond d'Alembert Institute (∂'Alembert) is a research laboratory affiliated with Sorbonne University and the CNRS, specializing in Mechanics, Acoustics, and Energy. With nearly 170 members, ∂'Alembert excels in theory, modeling, and interdisciplinary experiments, significantly contributing to scientific and technological innovation in the Île-de-France region.

Master's thesis title

Numerical Simulation of Methane Pyrolysis in Molten Metal Baths



Global warming, driven by the increasing concentration of greenhouse gases in the Earth's atmosphere, necessitates the transition towards cleaner energy sources. Hydrogen, a versatile and environmentally friendly energy carrier, offers a promising alternative to traditional fossil fuels. This research project explores methane pyrolysis as a cost-effective and sustainable method for hydrogen production, addressing the challenge of carbon dioxide (CO2) emissions.

The primary objectives are to investigate the dynamics of methane pyrolysis in liquid metal, optimize hydrogen production efficiency, and gain insights into the thermal and chemical processes involved. The study employs advanced numerical simulations using the Basilisk platform to model the complex multiphase flow and thermal dynamics. Initial results include the successful simulation of a single reacting bubble and the formation of bubbles from a single orifice. One of the significant challenges is the high temperature and opaque nature of the liquid metal, which complicates the direct observation of the pyrolysis process. Numerical simulations play a crucial role in overcoming these challenges, providing detailed insights that are otherwise difficult to achieve experimentally. The expected outcomes include a comprehensive understanding of methane pyrolysis dynamics, strategies for process optimization, and potential pathways for industrial-scale hydrogen production, contributing to a cleaner and more sustainable energy future.

Marlo Angelo TITO

https://www.linkedin.com/in/tmarloangelo/

B.Sc. in Chemical Engineering, University of the Philippines, Los Baños

Mobility scheme

UNIVERSITÉ DE LORRAINE

Politecnico di Torino

“Rethink Reduce Reuse Recycle”

Company

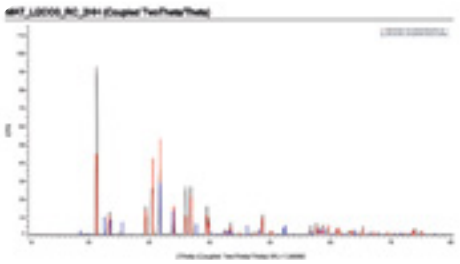
CIC energiGUNE
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

CIC EnergiGUNE

CIC EnergiGUNE is the research center of electrochemical and thermal energy storage, a strategic initiative of the Basque Government. CIC energiGUNE was born in 2011 to generate excellent research in materials and systems for energy storage. The goal of CIC energiGUNE is to maximize the impact on results to the Basque business network through collaboration with universities, research centers, and companies.

Master's thesis title

Developing a hydrometallurgical process to integrate a Cathode Active Materials (CAM) synthesis step into the recycling process of spent Li-ion batteries containing nickel, cobalt, and manganese.



The demand for lithium-ion batteries (LiB) is expected to exponentially increase in the coming years with the need to store energy to accommodate the energy transition movement. The most used raw materials for cathodic materials for LiBs are nickel, manganese, and cobalt. These metals, along with lithium, are now considered critical due to their exhausted usage and increasing economic importance. Recycling methods are established to alleviate the pressure on the demand for these materials. Hydrometallurgical methods recover the cathode active materials (CAM) in their precursor form, while lithium is recovered with low yield and purity. This study aims to integrate a lithium-recovery step in the hydrometallurgical recovery process of spent LiBs by increasing the yield and purity of lithium. This can be done using two ways: precipitation with sodium carbonate or with carbon dioxide gas to obtain lithium carbonate. Optimal reaction parameters were noted with respect to the yield and purity of the lithium carbonate. The recovered Li2CO3 was relithiated with the recycled CAM to synthesize a NMC battery. To validate the integration of this recovery step to the hydrometallurgical process, electrochemical testing was done to assess the performance of the recycled battery. Lastly, the energy and chemical costs were determined to evaluate the economic viability of the lithium recovery step.

Fiorella Cristina VASQUEZ DIAZ

www.linkedin.com/in/fiorellavasquezdiaz/

Bach. in Mechanical and electrical engineering, Universidad de Piura, Peru

Mobility scheme

UNIVERSITÉ DE LORRAINE

KTH VETENSKAP OCH KONST

> **Sweden: Greener and steadier with wind farms diving into FCR-D**

Company

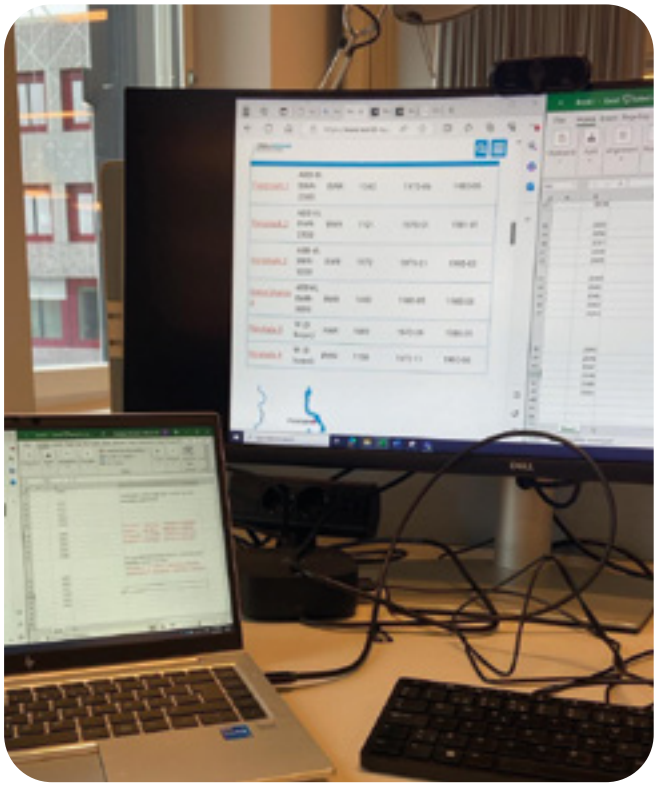
VATTENFALL

Vattenfall

Vattenfall is a major European energy company headquartered in Sweden. They are a leading producer of fossil-free electricity, committed to helping society transition away from fossil fuels. They also invest in wind farms, develop charging stations for electric vehicles, and manage electricity grids.

Master's thesis title

Methodology for Adding Ancillary Services to Onshore Wind Farm Bussiness Cases



This study investigates the methodology for integrating Frequency Containment Reserve Down (FCR-D down) capability into onshore wind farm business cases in Sweden, a market with recently introduced and highly attractive FCR-D down prices. FCR-D is a new ancillary service that helps maintain grid stability by rapidly reducing power output from participating resources in response to frequency deviations.

The key challenge lies in the market's nascent stage. While current FCR-D down prices are higher than the day-ahead market, the limited volume raises concerns about saturation as more wind farms participate. This study addresses this by constructing multiple scenarios and calculating potential revenue streams based on various price forecasts. Despite its smaller size, the FCR-D down market presents a unique opportunity for wind farms to generate additional revenue. Unlike the day-ahead market, FCR-D down requires short-term reductions in power output upon request. However, wind farms can potentially participate in both markets simultaneously, essentially offering their capacity as an "add-on" service for additional income.

Larissa Stella YANGA TOFEUN

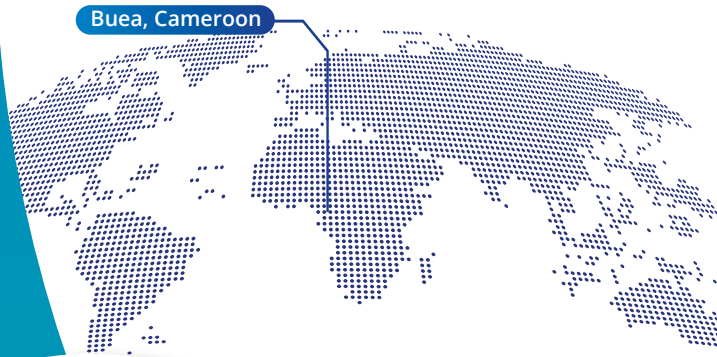
www.linkedin.com/in/yanga-tofeun-larissa-stella/

Bach. in Electrical and Electronic Engineering, University of Buea, Cameroon

Mobility scheme

UNIVERSITÉ DE LORRAINE

Politecnico di Torino



“Open data, IoT, flexibility, resilience, and energy savings.”

Company

G2ELab (Grenoble Electrical Engineering Laboratory)

G2Elab is a top lab in Grenoble focused on Energy and Electrical Engineering. It works closely with industries and is connected to CNRS, UGA, and Grenoble INP. In 2010, it got an A+ rating, one of only two in France for Electrical Engineering. The lab has five research teams and two groups working on power electronics, materials, smart electricity, and more. G2Elab aims to improve energy efficiency in service of energy transition, making significant contributions to science and industry.

Master's thesis title

Design of a User Interface(UI) for Participatory Science Experiment in an Energy Environment.

Energy efficiency in the building sector necessitates innovative technologies and active occupant engagement. Achieving these goals requires a user-centric approach to visualize energy metrics, encouraging energy-saving habits. This master's thesis focuses on designing a user interface (UI) for participatory science experiments in energy environments, bridging the gap between technology and user engagement.

The primary objective is to develop an intuitive, accessible dynamic dashboard, enabling users to monitor, understand, and manage energy consumption effectively. Key challenges include ease of use, providing clear insights, and motivating user participation in energy-saving initiatives.

Significant realizations include creating a prototype dynamic dashboard integrating real-time energy data visualization, personalized feedback, and interactive features to enhance engagement. Prospective achievements involve deploying this dashboard in real-world settings, evaluating its impact on energy behaviors, and refining the design based on feedback.

Additionally, this thesis underscores the importance of regulatory frameworks for robust energy management systems and incentives to encourage demand response participation in the electricity market. By fostering user engagement and participatory science, the ultimate goal is to contribute to sustainable energy efficiency in the building sector. This work aims to make a meaningful impact on energy efficiency approaches and implementations.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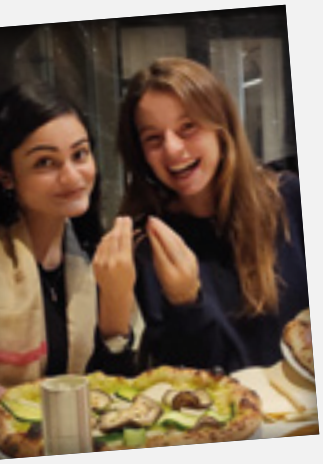

https://densys.univ-lorraine.fr/

densys-contact@univ-lorraine.fr

@DENSYS_em

Conception graphique/Direction artistique: Laetitia Martin - Laetmartin@gmail.com