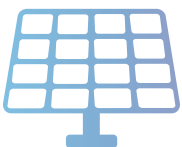


MASTER'S THESES 2023-2025



Internships and Master Theses of the cohort 2023-2025:



Fabrice Lemoine,
Chair of DENSYS

The fight against global warming calls for an urgent and profound transformation of our energy systems. Achieving carbon neutrality by 2050 requires not only the deployment of renewable energy sources and decarbonized energy carriers, but also the rethinking of energy consumption across all sectors. This transformation must take place within a just transition—one that is fair, inclusive, and leaves no one behind—at the heart of the European Green Deal.

This is precisely the vision of **DENSYS**: to shape a new generation of engineers capable of leading this transition through the design and operation of **decentralized smart energy systems**. DENSYS equips students with a **multiphysics engineering education**—spanning electrical, mechanical, and chemical disciplines—while fostering a **holistic understanding** of societal needs and challenges.

Funded by the European Union and coordinated by the **University of Lorraine (France)**, DENSYS is delivered in partnership with the **Royal Institute of Technology (KTH, Sweden)**, the **Polytechnic Institute of Torino (PoliTo, Italy)**, and the **Universitat Politècnica de Catalunya (UPC, Spain)**. It offers a unique “T-shaped” education: deep technical expertise in multiphysics and digital engineering combined with cross-cutting skills in economics, humanities, and stakeholder engagement. Because the energy transition is not only a technical issue—it is fundamentally a human and societal challenge.

At DENSYS, we place a strong emphasis on **problem-solving skills, interdisciplinarity**, and an **intercultural mindset**. Our students benefit from diverse learning environments and local contexts, which are essential to developing impactful and sustainable energy solutions.

Above all, we aim to train **responsible engineers and researchers**, future ambassadors of clean energy technologies and climate neutrality.

As part of their final year, our students undertake extensive internships and Master theses within **leading research institutions, companies, international organizations, and NGOs** across Europe. Their projects cover a wide range of topics critical to the energy transition:

- Renewable energy integration into networks
- Heat management
- Heat and fluid flows
- Hydrogen technologies
- Batteries
- Power-to-X and energy storage
- Decarbonisation of the energy-intensive industries
- Digitalization of energy systems
- Energy efficiency in industrial processes
- Global energy policy design and implementation

This booklet showcases the achievements of our 24 students, who have demonstrated outstanding creativity and a strong commitment to shaping a more sustainable future.

Cohort 2023-2025:



**Omnia Ali
ABDULRAHEIM**



**Haseeb
AHMED**



**Daniel
CRUZ**



**Anamta
FAROOQUE**



**Keith
GUMBO**



**Anjan
KARMAKAR**



**Adoos
KHALID**



**Rajnesh
KUMAR**



**Denise Faye
LENSOCO**



**Michelle
LOZANO JIMENEZ**



**Emilio
MACIAS**



**Dilafruz
MAVLANOVA**



**Oluwanifemi Blessing
OJO**



**Andrea
PUTRI**



**Amin
ROOBERAHAN**



**Abir
SAHA**



**Diella
SALIHU**



**Jose Andrés
SANTAMARÍA CORDERO**



**Sara-Medina
ŠEHOVIĆ**



**Irisa
SEVDARI**



**Gandharva
SHELAR**



**Avtandil
SVIANADZE**



**Giang Ngoc Huong
VU**



**Kira
ZHMUD**

Omnia Ali ABDULRAHEIM



www.linkedin.com/in/omnia-ali-abdulraheim/

Bach. in Chemical Engineering
University of Khartoum, Sudan

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Khartoum, Sudan



“

Planning
energy today
is shaping
the world of
tomorrow

”



Company



GET.transform / GIZ GmbH

GET.transform is a technical assistance programme supporting national and regional partners and institutions in advancing their energy sector transformations. The programme focuses on long-term energy planning, on- and off-grid regulation, market development, and renewable energy grid integration. GET.transform is being implemented by GIZ and co-funded by the European Union, Germany, Norway, the Netherlands, Sweden and Austria.



Master's thesis title

Scenario Development for Long-Term Energy Planning in Zimbabwe using PyPSA-Earth



Through the development of energy scenarios using PyPSA, an open-source energy system modeling tool, this research aims to provide actionable insights and recommendations to inform policy, investment, and the energy transition decisions in Zimbabwe.

Zimbabwe's current electricity system is heavily reliant on coal and hydropower, both of which face growing sustainability and reliability challenges due to climate change and aging infrastructure. The country also experiences prolonged power outages and remains dependent on electric-

ity imports. With only 62% of the population having access to electricity and rising demand, there is an urgent need to diversify the energy mix and plan for a resilient, low-carbon future.

The research aims to simulate the Zimbabwean power system in PyPSA-Earth, to address critical issues such as renewable energy integration, and energy security. Key challenges included data collection and adapting PyPSA to Zimbabwe's context. The core scenarios analyzed included reducing dependency on coal and hydro and enhancing renewable deployment with storage solutions.

The project contributes to Zimbabwe's long-term strategic energy planning and highlights the country's potential role in strengthening regional energy security given its interconnection with four countries in the Southern African Power Pool: South Africa, Zambia, Mozambique, and Botswana.

Haseeb AHMED



www.linkedin.com/in/haseebahm985/

BSc Electrical Engineering,
Hungary

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Politecnico
di Torino

Rawalpindi, Pakistan



“

Exploring
smart
solutions for
next-generation
thermal
control

”



Company



Laboratory of Energies and Theoretical and Applied Mechanics,

The Laboratory of Energies and Theoretical and Applied Mechanics (LEMTA) at the University of Lorraine is a renowned research center focused on energy systems, fluid dynamics, heat transfer, and rheophysics.

It promotes interdisciplinary collaboration, cutting-edge experimentation, and innovation to address complex challenges in theoretical and applied mechanics and sustainable energy technologies.



Master's thesis title

Master's Thesis Proposal: Energy Evaluation and Optimization of Building-Integrated Photovoltaic Panels: Simulation and Experimental Application on Residential Configurations.



This thesis investigates the energy evaluation and optimization of Building-Integrated Photovoltaic (BIPV) panels, focusing on their simulation and experimental application in residential settings. The motivation lies in addressing the increasing energy demands in urban areas through sustainable solar solutions while minimizing their thermal impacts on buildings. A core challenge is the complex interaction between photovoltaic modules and building thermal behavior, including shading effects, airflow disruption, and dynamic heat exchanges. To address this, we apply advanced numerical techniques such as Monte Carlo simulations and Particle Swarm Optimization (PSO) to evaluate PV system performance under various configurations. The study analyzes how key design parameters—orientation, tilt, and density—influence both electricity production and thermal comfort across varied climatic contexts. Experimental validation, supported by LEMTA's infrastructure and the CNRS EDStAR platform, complements the simulations. The goal is to derive actionable guidelines for optimizing BIPV systems, improving overall building energy efficiency, and supporting energy-positive building strategies. Simulations will be calibrated using real-world data and weather conditions from regions like Nancy, Las Vegas,

and Búzios to ensure global relevance. Outcomes are expected to contribute toward the standardization of BAPV/BIPV installation practices, offering a practical framework for energy modeling, optimization, and sustainable integration of photovoltaic technologies in building envelopes.

Daniel CRUZ



www.linkedin.com/in/daniel-andre-cruz/

Bach. in Electrical
Engineering, National
Autonomous University of
Honduras (UNAH), Honduras

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Politecnico
di Torino

Tegucigalpa, Honduras



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**Power
grids don't
fail in silence-
they fail in
millions.**

”

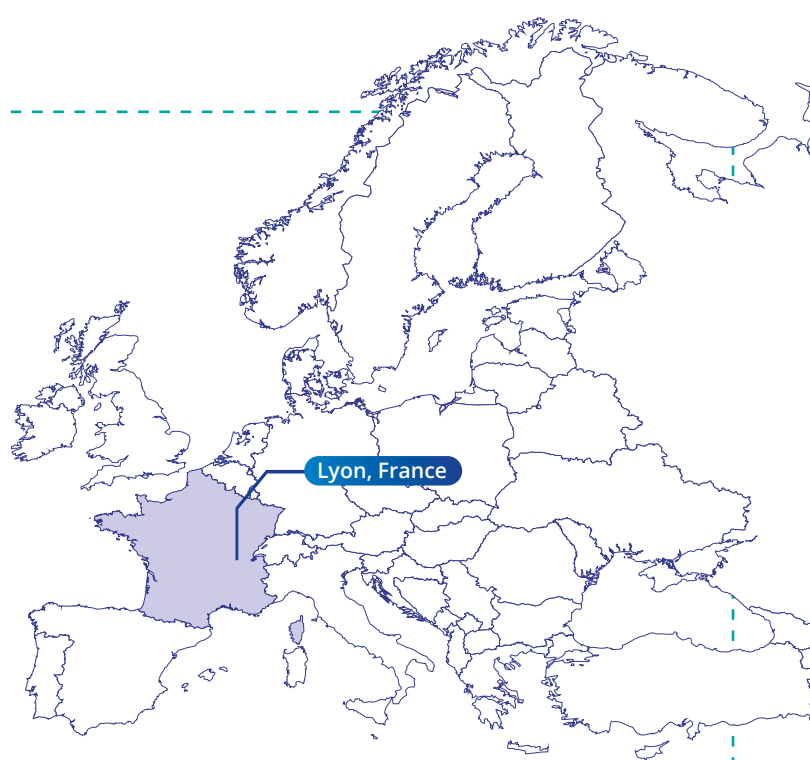


Company

Nexans

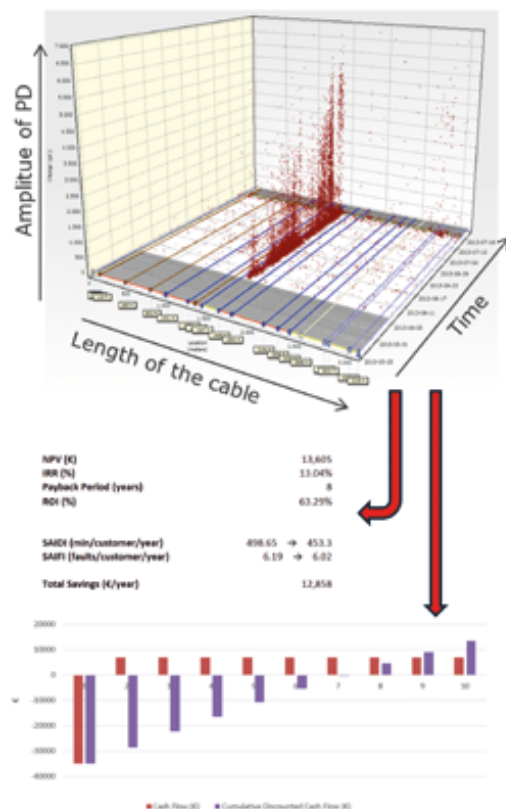
Nexans

Nexans is a global leader in cable systems and services, dedicated to advancing electrification worldwide. With over a century of expertise, it provides innovative solutions across power generation, transmission, distribution, and industry sectors. Committed to sustainability, Nexans aims for net-zero emissions by 2050, supporting a more connected and sustainable energy future.



Master's thesis title

Economic and Reliability Assessment Tool for Smart Monitoring Solutions in MV Cable Networks



With distributed energy resources proliferating, power flows in medium-voltage grids have become more diverse and less predictable. This shift degrades the accuracy of existing fault-location methods and raises power-quality concerns, creating a critical need for faster, more reliable fault-detection systems. Although smart monitoring solutions deliver real-time cable-health data and early fault warnings, grid operators often lack a clear business case to justify adoption.

This internship focuses on bridging that gap by developing an assessment tool to evaluate the value of smart monitoring solutions in MV cable networks. The main goals are to estimate financial benefits (such as reduced outage costs, improved maintenance planning, and return on investment) and to assess reliability improvements through key indicators like SAIDI and SAIFI. Key challenges included identifying the main KPIs that drive decision-making for grid operators, integrating technical performance models with cash-flow analysis, and adapting cost calculations to country-specific markets and regulatory environments.

Major achievements include a prototype decision-support interface that translates monitoring data into actionable economic and reliability indicators, and a "Direct Cost of Reliability" metric adapted to MV cable networks. Future work will refine scenario analyses across countries, expand the tool's applicability to transport and industrial hubs, and validate outcomes with field data.

Anamta FAROOQUE



www.linkedin.com/in/anamta-farooque-17005/

Bachelor in Electrical
Engineering, NED University
of Engineering and
Technology, Pakistan

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Politecnica
di Torino

Karachi, Pakistan



**Who
needs the
spin of tradition
when the global
energy transition is
unfolding in linear
precision and
elegant control!**





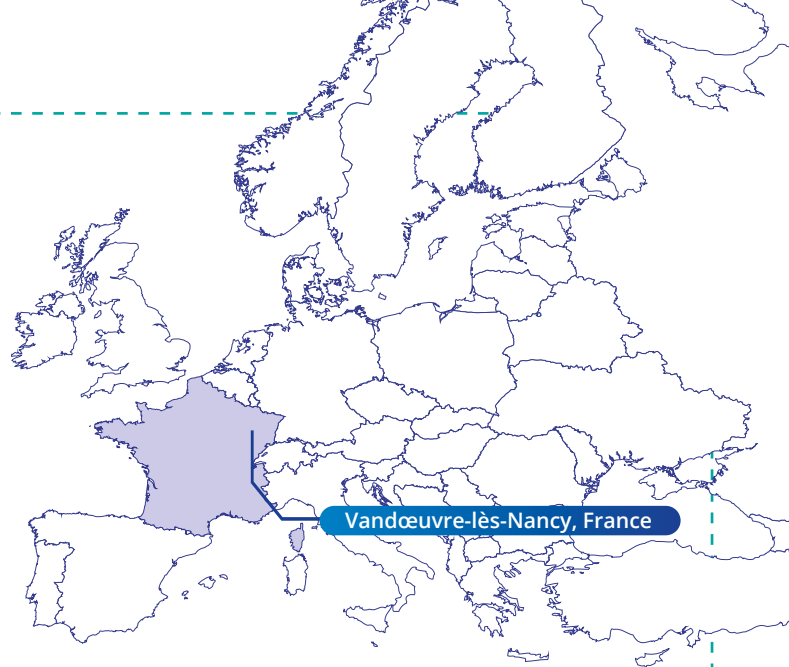
Company



LEMTA

LEMTA is a joint research unit of the University of Lorraine and CNRS, dedicated to advancing research in energy, mechanics, electricity, and thermal sciences. It comprises approximately 70 researchers and teacher-researchers, supported by 31 technical and administrative staff, along with around 79 PhD and post-doctoral researchers.

The laboratory is structured into three departments: Energy Carriers, Energy and Transfer, and Fluid Matter & Rheology. Within the Energy Vectors group, the "Electrical Energy Management" team focuses on the modeling, control, and optimization of electrical systems. LEMTA's research spans a broad spectrum of energy topics, with particular strengths in electrical energy management, system modeling, and control strategies.



Master's thesis title

Design and Control of a Permanent Magnet Linear Synchronous Machine Coupled with a free Piston Stirling Engine to maximize the energy recovery"



One of the central challenges of the global energy transition is not only generating clean energy, but also ensuring that existing energy resources are utilized with maximum efficiency. Across industries, a significant portion of energy is lost as process heat, particularly at low temperatures, which often goes unutilized due to the lack of efficient recovery technologies. While high-temperature waste heat has been harnessed through various means, low-grade thermal energy remains largely untapped. In response to this gap, the Stirling engine emerges as a promising solution due to its ability to operate over a wide temperature range - including low-temperature differentials - making it uniquely suited for converting

waste heat into usable power. When coupled with a reliable and efficient Permanent Magnet Linear Synchronous Machine (PMLSM), the system becomes capable of generating electricity with minimal mechanical losses and high precision.

This thesis investigates the behavior of a PMLSM integrated with a Free Piston Stirling Engine (FPSE), using a simplified spring-damper model to represent its reciprocating motion and internal friction. To gain comprehensive insight into this hybrid system, three different PMLSM topologies are examined and evaluated for their performance and suitability in energy harvesting applications.

A key objective was to maintain desired system speed, achieved through both conventional sensor-based and advanced sensor less control methods. To ensure precise and stable operation, three modern controllers were tested, each evaluated across multiple PMLSM configurations. The integration of sensor-less control with PMLSM offers independence from costly, noise-prone position sensors while keeping the system control precise.

Overall, this work contributes a detailed foundation for future experimental validation and offers insight into a promising energy conversion system aligned with the goals of sustainable energy innovation.

Anjan KARMAKAR



www.linkedin.com/in/anjan-karmakar-70256b103/

**Bachelor of Technology in
Mechanical Engineering
National Institute of
Technology (NIT) Mizoram,
India**

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Mizoram, India

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**From
Waste Heat
to Power—
One Optimized
Interface at a
Time!**

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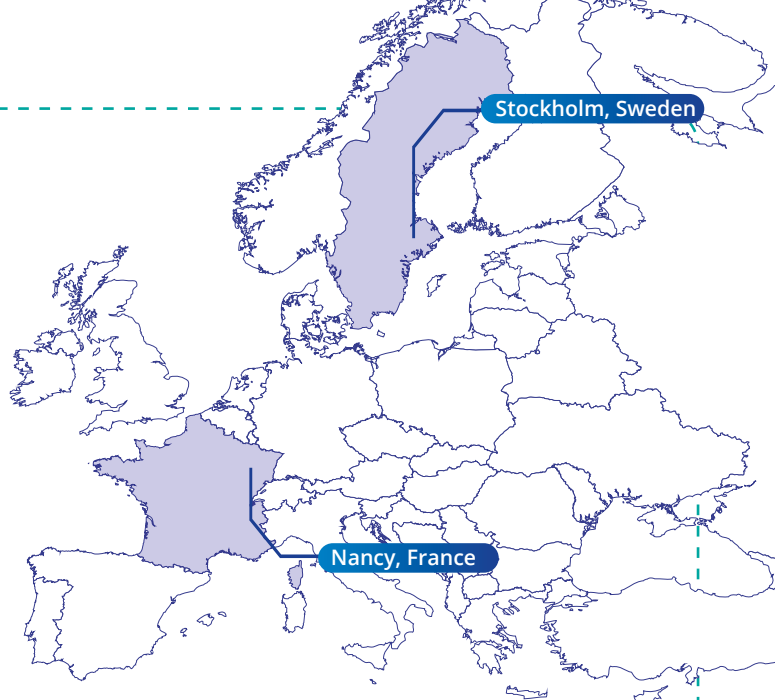
Company



Institut Jean Lamour (IJL) with RISE

The Materials with Thermoelectric Properties group at Institut Jean Lamour (Université de Lorraine, CNRS) specializes in the synthesis, structural analysis, and characterization of thermoelectric materials and modules. The group's research focuses on enhancing energy conversion efficiency through advanced interface engineering and transport property optimization, contributing to the development of sustainable power technologies.

RISE is Sweden's state-owned research institute, advancing sustainable innovation across materials, energy, and digital systems. With expertise in thermoelectrics, materials science, and reliability testing, RISE bridges academia and industry, supporting scalable solutions for energy harvesting and conversion through EU-funded collaborations and cutting-edge applied research.



Master's thesis title

Optimization of Contact Elements in Bismuth Telluride and Half-Heusler Based Segmented Thermoelectric Generators



Segmented thermoelectric generators (TEGs) offer a promising route for efficient thermal-to-electrical energy conversion across broad temperature gradients. However, their performance is often limited by contact degradation at the interfaces between segments. This study addresses this critical challenge by developing and integrating advanced contact materials specifically engineered for compatibility with bismuth telluride (Bi_2Te_3)-based compounds and Half-Heusler alloys. These materials are designed to withstand thermal cycling and mechanical stress while minimizing interfacial resistance.

To enhance structural cohesion, we employ flash sintering as a rapid densification technique. The interfaces are thoroughly characterized using scanning electron microscopy (SEM), X-ray diffraction (XRD), thermoelectric property measurements (ZEM, LFA), and custom-built contact resistance tests. These methods provide detailed insights into microstructure, thermal and electrical behavior, and mechanical integrity under simulated operating conditions.

In parallel, Multiphysics simulations conducted with COMSOL Multiphysics® model heat and current distribution across the contact regions, enabling prediction of failure modes and optimization of material combinations and interface geometries.

Our results demonstrate a significant reduction in contact resistance, along with improved thermal and mechanical stability. These enhancements translate into a measurable increase in the overall efficiency and reliability of segmented TEGs. The findings support the integration of optimized contact designs in practical energy recovery and waste heat harvesting systems, contributing to the advancement of sustainable energy technologies.

Keith Kudakwashe GUMBO



www.linkedin.com/in/keith-gumbo-b53386149/

BEng in Aeronautical
Engineering (China)

Mobility scheme



UNIVERSITÉ
DE LORRAINE



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

“

**Cool
Power,
Hot
Performance.**

”



Nanjing, China



Company



Huawei Technologies

The Huawei Nuremberg Research Center was founded in 2011 with the focus on advanced technologies for the Digital Power Business of Huawei. It focuses on the development of innovative power converter topologies, power devices in the application and reliability area, control algorithms, and overall system architecture. The business focuses on clean power generation, energy digitalization, green ICT power infrastructure, transportation electrification and power converter testing, devices reliability, static and dynamic device testing.



Master's thesis title

Passive Immersion Cooling as an Alternative to Thermal Interface Materials for Thermal Management of Electric Vehicle Power Converters



This thesis investigates the thermal performance of thermal Interface materials (TIMs) for EV power converters. These glues and TIMs pose challenges in maintenance and are failure prone after several cycles leading to thermal runaway. A one-dimensional lumped parameter model was first developed using Simscape to analyze temperature distributions and quantify thermal resistance contributions across key components. The results showed that TIM cooling led to higher maximum temperatures and greater thermal resistance, compared to the novel approach. The simulation results confirmed the superior

thermal performance of the novel approach (oil immersion cooling), demonstrating lower hotspot temperatures and more uniform heat distribution. The solution also allows for easier maintenance of power converters. This work highlights the importance of interfacial resistance and fluid domain definition in power converter thermal management and offers guidance for the design EV power converter thermal management. It shows that, by minimizing oil bond layer thickness across the main heat dissipation path, oil can have comparable performance to TIMs.

Adoos KHALID



www.linkedin.com/in/adoos-khalid

Bach. In Electrical
Engineering, Pakistan

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Karachi, Pakistan



**Disconnect
to Reconnect
- Inverter
Dynamics for
Resilient
Grids**



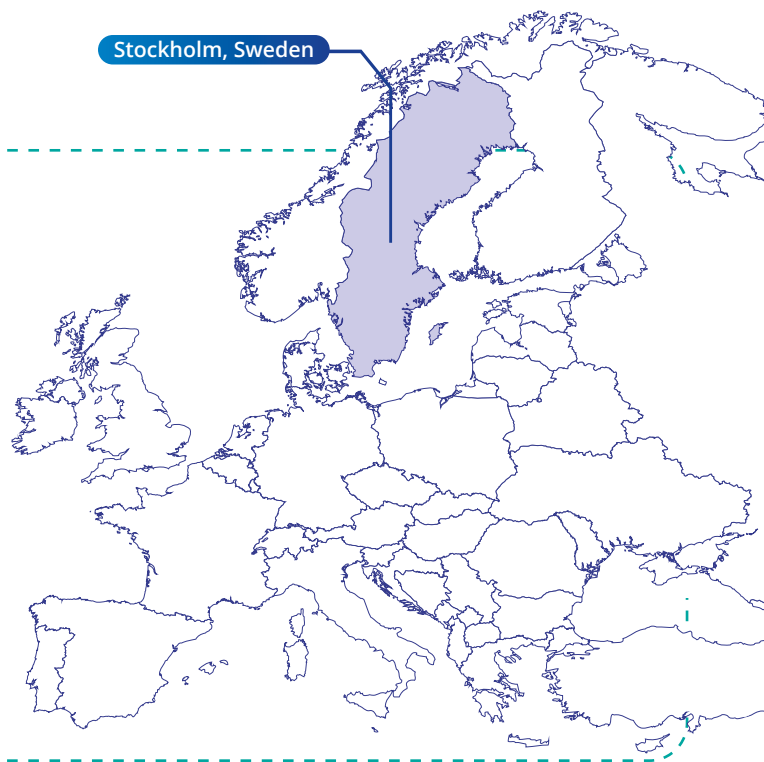


Company

VATTENFALL

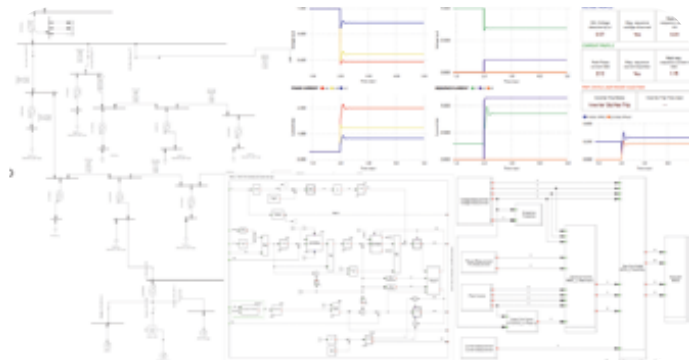
Vattenfall

Vattenfall is one of Europe's largest producers and retailers of electricity and heat. With a mission to enable fossil-free living within one generation, Vattenfall leads the energy transition by investing heavily in renewable energy, smart grids, and innovative energy technologies. Its R&D division plays a key role in developing reliable, efficient, and sustainable energy solutions.



Master's thesis title

Anti-Islanding Protection for Renewable Energy Systems (RES) during Medium Voltage (MV) Faults



The growing integration of inverter-based renewable energy systems (RES) into distribution networks introduces complex protection challenges, particularly the risk of unintentional islanding, where a segment of the grid remains energized by distributed generation after disconnection from the utility, creating safety hazards and potential equipment damage. This thesis focuses on understanding the dynamic behavior of converter-based renewable energy systems (RES) under medium-voltage fault conditions by

analyzing anti-islanding protection strategies through detailed dynamic modeling and scenario-based simulations.

A comprehensive simulation environment is developed in DigSILENT PowerFactory, incorporating network topology, equipment modelling, grounding techniques, and inverter dynamic behavior, focusing on controller dynamics and operational strategies. Root Mean Square (RMS) simulations are performed across a range of symmetrical and asymmetrical fault scenarios, at different locations, by varying control strategies and energy storage system capacity. Sequence component analysis is used to evaluate system response and fault propagation.

Major challenges addressed include capturing accurate inverter behavior under fault conditions and analyzing fault propagation through sequence component methods. The model is validated against analytical calculations and existing literature. The results highlight critical factors affecting protection performance and provide benchmarks for optimizing protection settings in alignment with grid regulations and standards.

Overall, this research offers practical insights into inverter-based RES fault dynamics, contributing towards a more resilient grid for the evolving energy landscape.

Rajnish KUMAR



www.linkedin.com/in/rajnish-kumar-07b731186

Bachelor's in Mechanical
Engineering, Mehran
University of Engineering &
Technology, Pakistan

Mobility scheme



UNIVERSITÉ
DE LORRAINE



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

Chuhar Jamali, Pakistan



**Warm
Homes,
Cool Planet:
Redefining Heat
for a Low-Carbon
Tomorrow**





Company



Fraunhofer
ISE

Fraunhofer Institute for Solar Energy System

Fraunhofer ISE (Institute for Solar Energy Systems) is Europe's largest solar research institute. Based in Freiburg, Germany, it develops sustainable energy technologies, including photovoltaics, energy-efficient buildings, and smart grids. The institute partners globally with academia and industry, advancing innovations for a climate-neutral energy supply and shaping the renewable energy future.

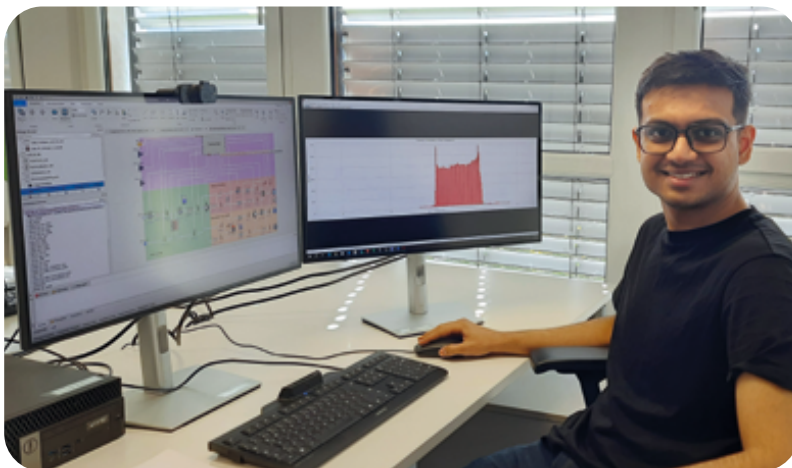


Freiburg im Breisgau, Germany



Master's thesis title

Simulation-based Investigation of Decentralized Heat Pump System in an Existing Multi-Family Building



The building sector is responsible for nearly one-third of global energy consumption and CO₂ emissions, underscoring the urgent need for its decarbonization. Replacing fossil fuel-based heating systems with efficient, low-emission alternatives is critical to achieving climate targets. Propane heat pumps, offering high energy efficiency based on a future-proof natural refrigerant, constitute a promising solution for transitioning existing buildings toward carbon neutrality.

This thesis presents a simulation-based investigation of a decentralized propane heat

pump system designed to meet both space heating and domestic hot water demands in an existing multi-family building. A co-simulation framework is developed by coupling a building energy model created in EnergyPlus with a detailed heat pump system modeled in Modelica/Dymola. Various system configurations and control strategies are evaluated to assess their impact on energy performance and occupant comfort.

The analysis focuses on four key performance indicators: energy consumption, Seasonal Performance Factor (SPF), thermal comfort, and heat pump cycling behavior. These metrics are used to identify efficient and robust combinations of system design and control logic. The findings aim at supporting the deployment of propane heat pumps in building retrofits and thus fostering the spread of efficient, scalable heating solutions aligned with global energy transition goals.

Denise Faye LENSOCO



www.linkedin.com/in/denisefayelensoco/

Bachelors of Science in
Chemical Engineering - 2015:
University of the Philippines
- Diliman

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Politecnico
di Torino



Diliman, Philippines

“

I tried
so hard, and
got so far in
the end carbon
credits make
it matter

”



Company
riverse

Riverse

Riverse is a carbon crediting platform designed for technology-based carbon projects, focused on issuing high-quality credits closely aligned with the value chains and geographies of corporate buyers.

Our current methodologies span biomass carbon removal and storage, biobased construction materials, electronics refurbishing, battery second life, and bio-gas from anaerobic digestion.



Master's thesis title

Sensitivity Analysis on the Life Cycle Assessment (LCA) Model of the Electronics Refurbishing Methodology



This study conducts a sensitivity analysis on key parameters within the Life Cycle Assessment (LCA) model of Riverse's Electronics Refurbishing Methodology. With growing environmental concerns surrounding electronic waste, refurbishing offers a sustainable alternative to recycling and disposal by extending product lifespans and reducing demand for raw materials. Riverse supports this solution by integrating electronics refurbishing into its portfolio of methodologies for carbon credit issuance. As LCA forms the backbone of emissions quantification in greentech projects, project developers often face challenges

due to the complexity of models and the extensive data requirements involved. This study aims to identify which parameters most significantly influence the total greenhouse gas (GHG) emissions results of the model, thereby providing insight into where data precision is most critical. It also seeks to reassess the uncertainty imposed by literature-driven data used in the calculations. Key variables include recycling rates, percentage of lightly and fully refurbished devices, device collection distances, device lifetime, market mix, and residual values.

Michelle LOZANO JIMENEZ



www.linkedin.com/in/mlozanojimenez

Bach. in Electrical
Engineering, Colombia

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Cali, Colombia

“

**Engineering
resilient
grids, powered
by resilient
minds.**

”



Company



Fraunhofer
IWES

Fraunhofer Institute of Wind Energy Systems

Fraunhofer IWES is a leading German research institute specializing in wind energy and hydrogen technologies. It supports energy transition by reducing costs, minimizing development risks, and accelerating product certification. With strong expertise and infrastructure, IWES drives innovation, promotes sustainability, and advances wind-hydrogen integration for future energy systems.



Master's thesis title

Topology optimization of Meshed Offshore HVDC Grids with integrated reliability and contingency analysis



Europe's transition to a low-carbon energy system is driven by the urgent need to address climate change and rising electricity demand. Offshore wind energy, particularly in the North Sea and Baltic Sea, plays a central role in this transition. The European Union's goal of installing 300 GW of offshore wind capacity by 2050 reflects this strategic focus.

Achieving this target requires more than expanding generation capacity; it demands a transmission network capable of integrating variable renewable energy and enabling efficient cross-border electricity exchange. To meet these requirements, grid infrastructure must evolve beyond traditional radial configurations, which lack the flexibility and reliability

needed for large-scale offshore integration. Higher redundancy and increased transmission capacity are essential to match the pace of offshore wind deployment.

This thesis proposes a reliability-optimized planning framework for meshed offshore wind transmission networks. The framework is aligned with Transmission Network Expansion Planning (TNEP) principles and supports long-term infrastructure development. It models transmission systems and identifies optimal topologies using graph theory-based optimization. Contingency analysis is used to evaluate the performance of each candidate topology under various failure scenarios, quantifying overall system reliability.

A case study in the North Sea demonstrates the framework's application. Results highlight the potential of reliability-informed planning to reduce disruptions and improve grid resilience, supporting Europe's energy transition goals.

Emilio MACIAS AMADOR



www.linkedin.com/in/emilio-macias/

Bach. in Mechatronics
Engineering, Mexico

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Monterrey, Mexico



We can't
direct the
wind, but we
can adjust
the sails.





Company



Fraunhofer
IWES

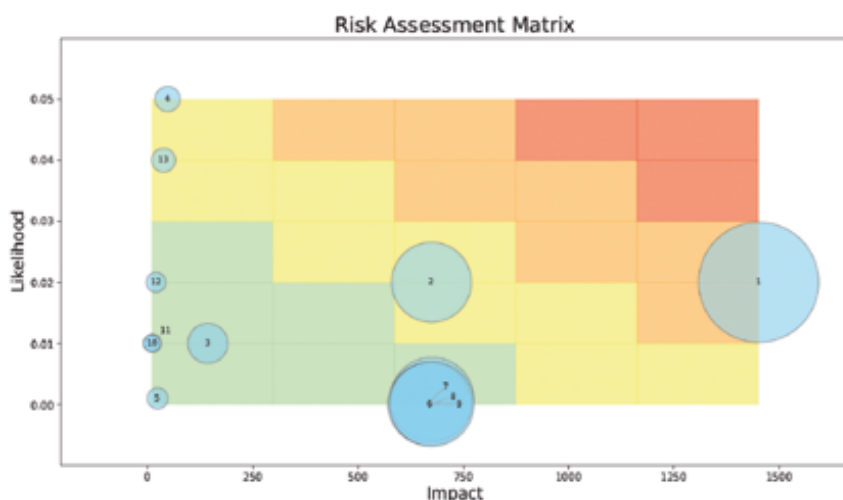
Fraunhofer Institute of Wind Energy Systems

Fraunhofer IWES is continuously working on optimizing wind energy and hydrogen technologies. With its research services, IWES makes a significant contribution to advancing the energy transition and substantially decreasing the associated costs. The institute's expertise and unique test infrastructure allow them to systematically identify and minimize development risks in new products and systems.



Master's thesis title

Model-Based Tool for Optimal Offshore Wind Farm Decommissioning: Weather and Operation-Related Risk Assessment



With the ambitious goal of becoming climate neutral by 2050, the EU anticipates a significant expansion of offshore wind energy capacity. An offshore wind farm (OWF) has an average lifespan of 20-25 years; therefore, the yearly number of turbines in need of decommissioning in the North and Baltic Sea will increase significantly starting in 2035. However, research on this phase is still being carried out and experience is limited. For this reason, this research work enables the development of a comprehensive risk analysis tool that simulates differ-

ent OWF decommissioning strategies, focusing on critical cost and risk drivers. The methodology is focused on applying quantitative risk analysis to decommissioning project plans. Paired with Monte-Carlo simulations, this method can accurately assess the potential impact of various uncertainties, including logistical and weather-related challenges. By enhancing the understanding of decommissioning risks, the tool seeks to support smart planning and execution, ultimately contributing to cost reduction and improved viability of offshore wind energy. The preliminary findings show that port and vessel availability risks are among the most significant in the final project duration, together with adverse weather conditions. This work not only fills in a significant research gap, but also provides actionable insights for industry stakeholders engaged in offshore wind energy projects.

Dilafruz MAVLANOVA



www.linkedin.com/in/dilafruz-mavlanova/

Automation and Control
Engineering
Tashkent Chemical-
Technological Institute
Tashkent, Uzbekistan

Mobility scheme



Tashkent, Uzbekistan



“

**Smart
flows,
green
growth**

”



Company



Laboratoire de Génie Chimique

The Laboratoire de Génie Chimique (LGC) is a leading French research center in chemical and process engineering. As part of the national ACT-4-IE project on industrial decarbonization, LGC contributes expertise in modeling and analyzing energy and resource flows to support the development of sustainable eco-industrial systems.



Master's thesis title

Definition and modeling of network components for resource exchange to support the implementation of industrial ecology



The transition toward sustainable and circular industrial systems has driven increasing interest in the development of eco-industrial parks (EIPs), where resource exchanges between companies can reduce waste, optimize energy use, and lower environmental impacts. This thesis contributes to this objective by developing a methodology to define and model the components of resource exchange networks, with a particular focus on parks in France. The objective is to identify potential

synergies—such as waste heat reuse or material by-product exchanges—between industrial actors by representing each company as a black-box model based on input and output flows. Key challenges include collecting reliable data, simplifying complex processes, and accounting for diverse industrial profiles within the park. The work involves mapping the industrial landscape, characterizing flow types, and creating a preliminary structure for network modeling. While full simulation is identified as future work, significant progress has been made in developing a database of company profiles and matching criteria for exchange opportunities. The outcomes of this research support the design of resource-efficient and decarbonized industrial ecosystems and lay the groundwork for future integration with simulation tools and optimization algorithms.

Oluwanifemi BLESSING OJO



www.linkedin.com/in/oluwanifemi-ojo/

Bachelor's in Electrical and
Electronics Engineering

Nigeria

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Politecnico
di Torino



Kwara state, Nigéria



**Bridging
data and
innovation to
power smarter
energy
solutions**



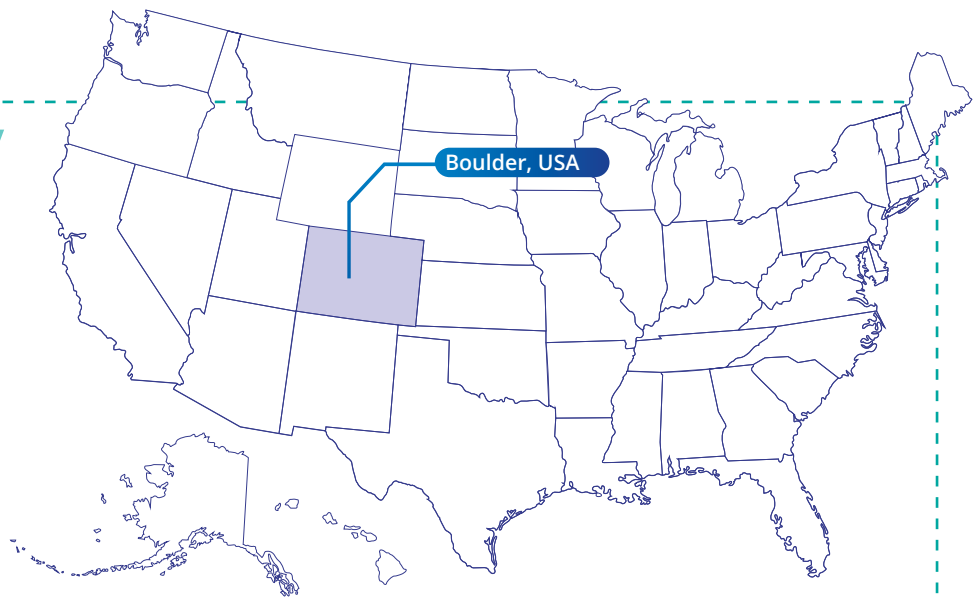


Company



Rocky Mountain Institute

Rocky Mountain Institute (RMI) is a globally recognized, independent nonprofit organization which focuses on transforming global energy systems through market-driven solutions to secure a prosperous, resilient, clean energy future for all. RMI works with businesses, policymakers, and communities to scale renewable energy solutions, reduce energy waste, and boost access to affordable clean energy.



Master's thesis title

Demand Flexibility in Interconnected Minigrids: Operational and Economic Implications for Developers, DisCos, and Customers



This master's thesis investigates the potential for performance optimization in interconnected minigrids in Nigeria through demand-side flexibility, quantifying the operational and economic implications for developers, Distribution Companies (DisCos), and end-users.

Using empirical consumption data from over 800 customers, the study categorizes users by consumption level to identify high-demand households with realistic potential for load shifting. Energy use for each appliance was estimated based on common household appliances and their typical usage durations. This analysis identified which appliance loads could be shifted to different

times of day. A Time-of-Use (ToU) pricing model was implemented to encourage the redistribution of shiftable loads to off-peak hours, aligning consumption with periods of higher solar PV availability. A key challenge addressed is evaluating the extent to which residential customers can participate in structured load-shifting programs and the associated system-level benefits. The results demonstrate that demand flexibility can lead to reductions in customer energy costs and lower reliance on diesel generation during peak hours for developers. Also, solar PV usage improves through better demand alignment, and energy curtailment is minimised. These findings highlight the potential of demand-side management as a scalable strategy to enhance the efficiency, sustainability, and economic viability of distributed energy resources.

Andrea Eka PUTRI



www.linkedin.com/in/andreaekaputri/

Aerospace Engineering,
Bandung Institute of
Technology, Indonesia

Mobility scheme



UNIVERSITÉ
DE LORRAINE



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

Jakarta, Indonesia



**Reducing
doesn't mean
simplifying.**





Company

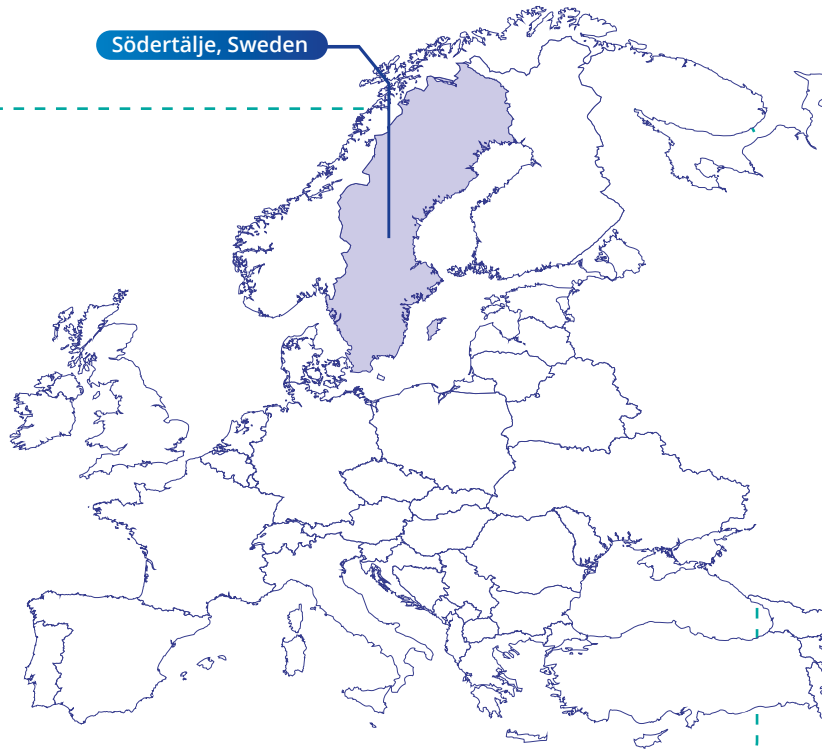


SCANIA

Scania

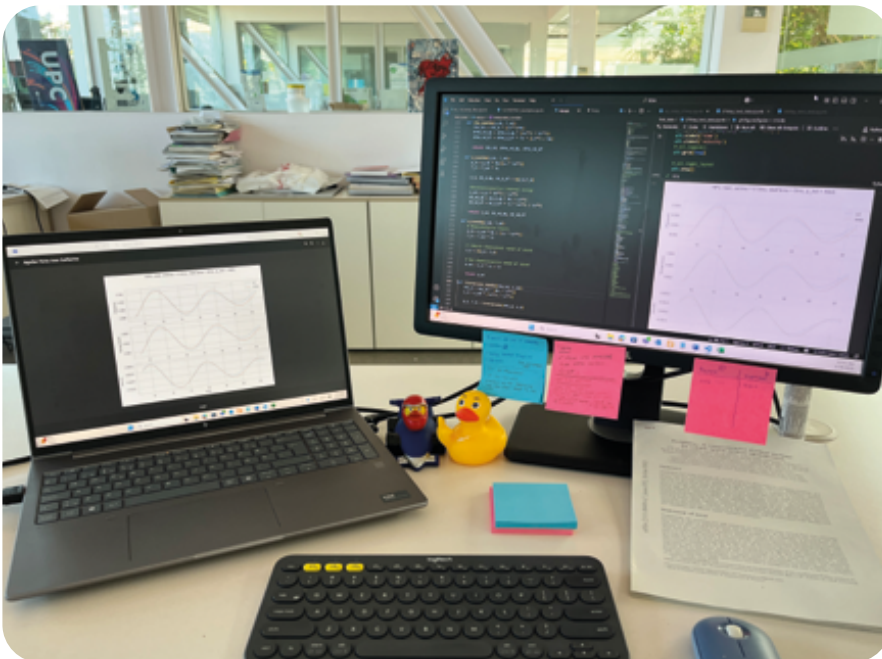
Scania is a leading global manufacturer of heavy trucks, buses, and industrial and marine engines, headquartered in Södertälje, Sweden. Scania collaborates with Cummins through Cummins Scania XPI Engineering Sweden to develop advanced fuel injection systems, enhancing engine performance and delivering excellent fuel efficiency across its products.

Södertälje, Sweden



Master's thesis title

Data Driven Modelling of Fluid Mechanical Systems for Fuel Injection Control



Stringent emission regulations, such as Euro 7, are driving the automotive industry to enhance the precision of their fuel management systems. Achieving accurate fuel injection is critical to meeting these standards, which requires advanced and computationally efficient modelling of injection dynamics. This thesis focuses on simplifying the complex fuel injection process by developing a one-dimensional model of the fuel system that balances accuracy with computational efficiency.

Building on this, the project applies Sparse Identification of Nonlinear Dynamics (SINDy) to extract reduced

order models (ROMs) from simulation data. These ROMs, which are essentially 0D, capture the essential fluid mechanical behavior of the injection system at a fraction of the computational cost, enabling faster simulations while retaining key dynamics. By combining physics-based modeling with data-driven methods, the work highlights the potential of ROMs for real-time control and system optimization.

The thesis was carried out at Scania in Södertälje, Sweden, and contributes to ongoing efforts to integrate accurate yet lightweight models into embedded automotive applications.

Amin ROOBERAHAN



www.linkedin.com/in/amin-rooberahan

B.Sc. in Mechanical
Engineering, Iran

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Politecnico
di Torino

Mashhad, Iran

“

**Energy
+ Motion =
Emotion**

”



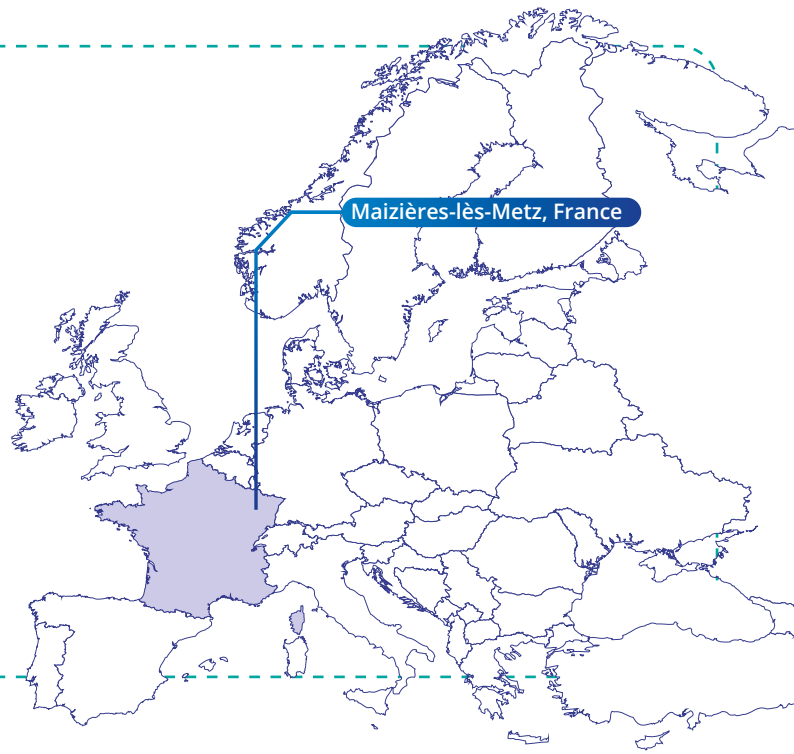
Company



ArcelorMittal

ArcelorMittal

ArcelorMittal is the world's number one steel company, with 260,000 employees in more than 60 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.



Master's thesis title

Advanced Physical Modeling of the Direct Iron Reduction Process in a Steel Plant



the decarbonization roadmap of the steel industry but also provides hands-on experience in industrial process modeling, project management, and collaborative research within a global enterprise.

In response to the pressing need for decarbonizing the steel industry, this Master's thesis internship at ArcelorMittal focuses on modeling the Direct Reduced Iron (DRI) process—an essential pathway to achieving the company's 2050 carbon neutrality objective. Hosted at the Maizières Process R&D site in France, and embedded within the Process Energy team, the internship involves developing a comprehensive digital twin of the DRI process to capture the key physical and chemical phenomena, including solid-gas interactions, reaction kinetics, energy consumption, and CO₂ emissions.

The project began with an extensive literature review to assess the current state-of-the-art in DRI process modeling. It then transitioned into building and validating simulation tools using AVEVA, MATLAB, and Python. Existing models were adapted and integrated, while missing elements were developed to simulate the plant in a stepwise manner—from simplified subsystems (e.g., gas compression) to the complete multiphase reactor environment.

Key challenges include achieving a balance between model accuracy and computational efficiency, and ensuring alignment with real plant data. This internship not only contributes to

Abir SAHA



www.linkedin.com/in/abir-saha-me16/

Bachelor's in Mechanical
Engineering, Chittagong
University of Engineering
and Technology, Bangladesh

Mobility scheme



UNIVERSITÉ
DE LORRAINE



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

Dhaka, Bangladesh

“
Illuminating
the future
with
Concentrated
Solar
Innovation
”



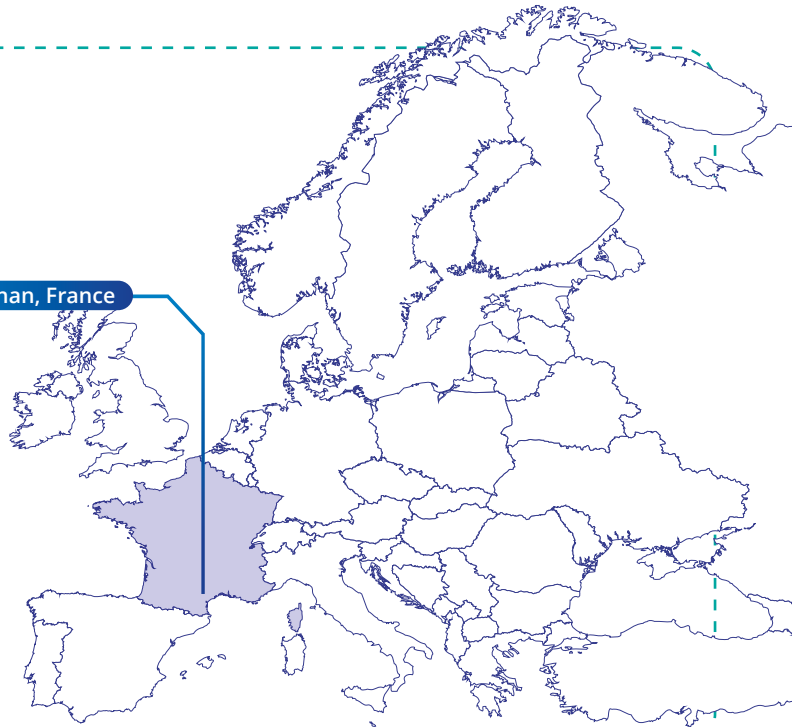
Company



PROMES-CNRS

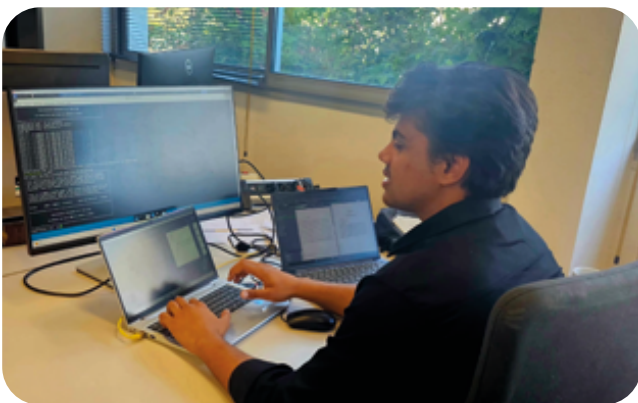
PROMES-CNRS (Processes, Materials and Solar Energy) is a leading French research laboratory specialising in solar energy technologies. Its research focuses on concentrated solar power, high-temperature processes, energy storage, and advanced materials. The lab combines experimental and numerical approaches to develop innovative solutions for sustainable energy and climate-resilient technologies.

Perpignan, France



Master's thesis title

Numerical Investigation of Turbulent Two-phase Flow in Direct Steam Generation Solar Receiver



The urgent global transition towards a sustainable and carbon-free society demands efficient and innovative thermal technologies. Concentrated Solar Power (CSP) with Direct steam Generation (DSG) system offers a promising solution by enabling higher thermal efficiency and eliminating the need for an intermediate heat transfer fluid.

This thesis numerically investigates the turbulent two-phase flow behaviour inside a horizontal solar receiver. This work is motivated by the urgent need to understand complex phenomena such as flow instability, pressure

fluctuation, and thermal stress inside the receiver through numerical modelling and experimental validation. Accurately capturing these effects is essential for the design and operational stability of solar receivers.

The study employs Neptune_cfd and Syrthes software for solid-fluid conjugated thermal modelling. The numerical results are validated by the PROMES-CNRS novel experimental setup. Moreover, the study analyses the influence of key parameters such as tilt angle, mass flow rate, and heat flux on the flow pattern, steam generation, and wall temperature distribution. Finally, this work contributes to the broader effort to develop more reliable and cost-effective solar thermal power systems by advancing understanding of flow behaviour and heat transfer mechanisms in the DSG system.

Diella SALIHU



www.linkedin.com/in/diella-salihu/

Bach. in Energy Engineering,
Republic of Kosovo

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Gjilan, Kosovo

“

**Reverse-
engineering
human behaviour
from voltage
spikes**

”



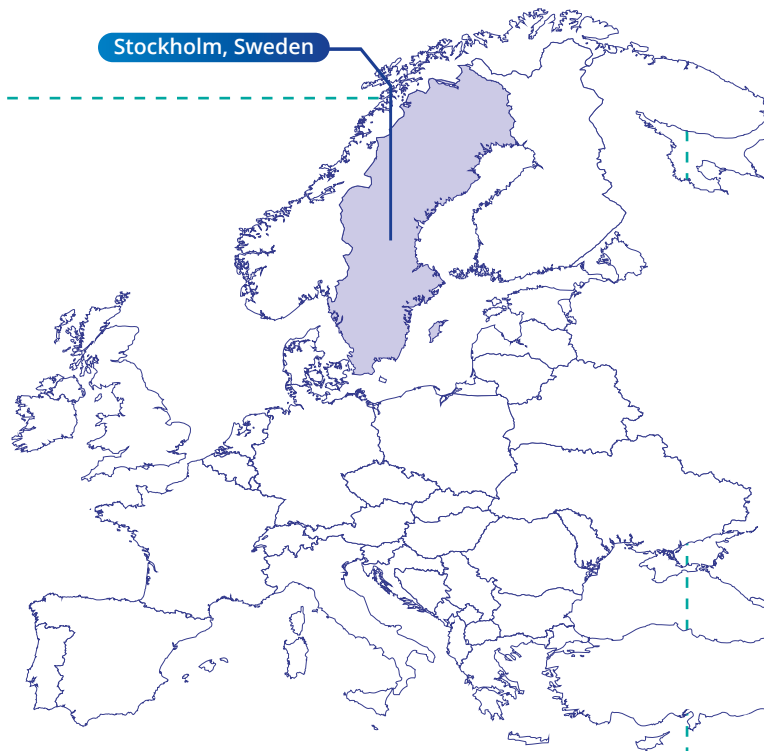
Company

H HYPERGRYD



HYPERGRYD, KTH Royal Institute of Technology

HYPERGRYD is an EU-funded project developing scalable, cost-effective solutions to integrate renewables into hybrid thermal-electric grids, advancing 4th–5th generation district heating and cooling (DHC) through ICT tools and real-time energy management. As a project partner, KTH Royal Institute of Technology contributes with research on demand response, data-driven optimization, and IoT-based control for building- and Local Energy Communities (LEC)-integrated DHC systems.



Master's thesis title

Machine Learning-based Non-Intrusive Load Monitoring (NILM) using Data from Smart Sensors in a Live-in Lab Environment



Non-Intrusive Load Monitoring (NILM) is a technique that disaggregates the total electrical load of a building into individual appliance contributions without the need for separate sub-metering devices. This approach offers valuable insights for optimizing energy use, enhancing system efficiency, and fostering better demand-side management.

Nevertheless, several challenges limit its effectiveness, such as the varying time resolutions of smart meter data, the wide diversity of appliances, and the similarity in their consumption patterns complicate the creation of a universal solution. These factors hinder the development of generalized disaggregation models and necessitate context-specific methodological adaptations.

This thesis investigates a NILM framework that operates on low-frequency time-series data, ensuring compatibility with standard data acquisition protocols employed by most Distribution System Operators (DSOs). This design choice reduces computational overhead and facilitates easier scalability across different deployment scenarios.

In order to improve disaggregation performance, particularly for HVAC loads, we introduce preprocessing steps that among others incorporate ambient temperature data as an external variable. This aids in isolating heating and cooling demand from the rest of the consumption, thereby enabling more accurate load disaggregation. Such differentiation is particularly valuable for energy management and planning, as it allows for targeted control strategies, better forecasting of thermal loads, and more effective integration of demand-side flexibility measures.

Jose Andrés SANTAMARÍA CORDERO



www.linkedin.com/in/jose-santacor

Bach. in Chemical Engineering,
Costa Rica

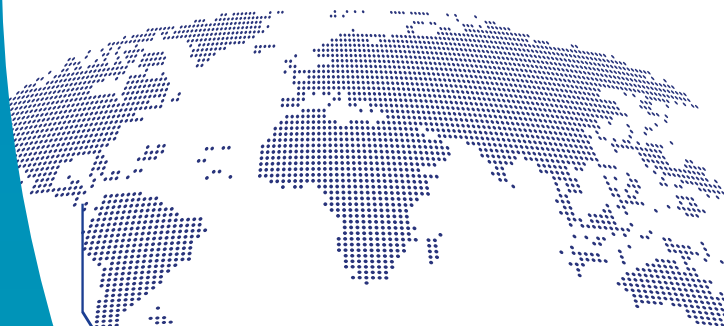
Mobility scheme



UNIVERSITÉ
DE LORRAINE



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH



Cartago, Costa Rica

“ It's not
just what
we simulate
- it's what we
choose to
stand for. ”



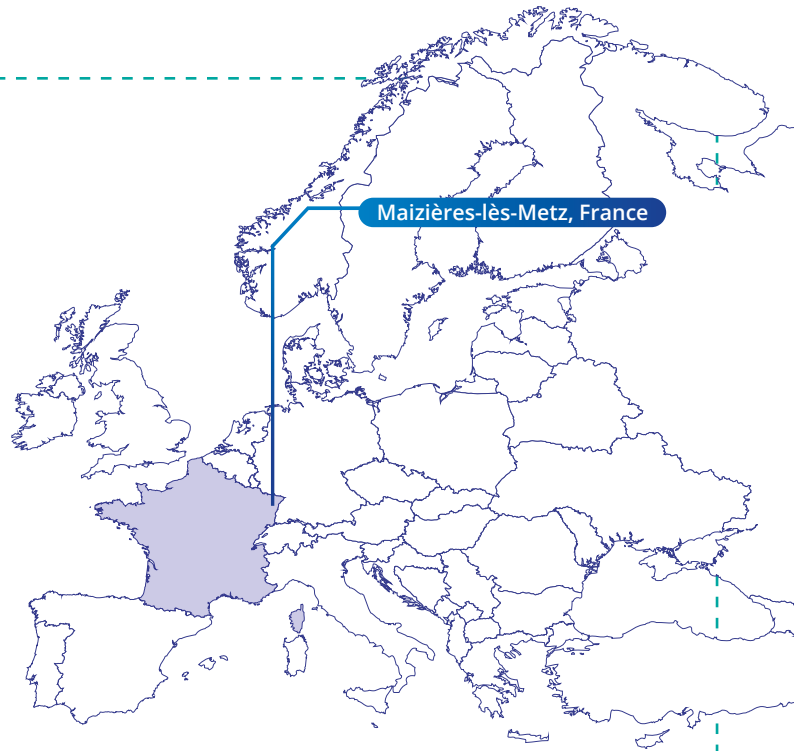
Company



ArcelorMittal

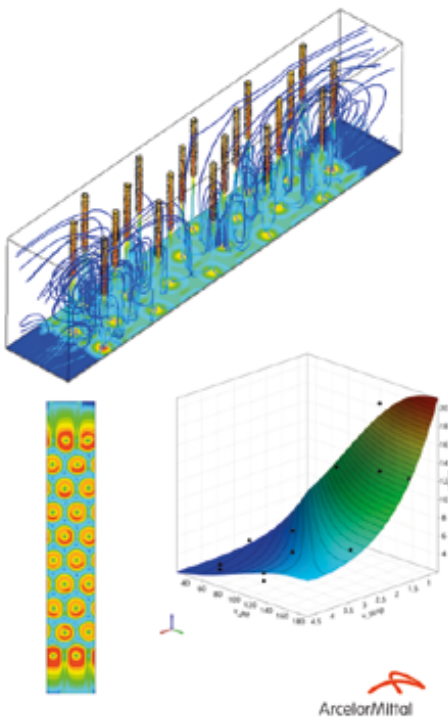
Arcelormittal

ArcelorMittal is the world's largest steel producer with presence in 129 countries and manufacturing in 15 of them. Within the company, ArcelorMittal Research and Development (R&D) center drives innovation in steelmaking through advanced research in materials, processes, and sustainability. With a strong focus on decarbonization, digitalization, and performance, its global network supports cutting-edge projects in one of the biggest industries.



Master's thesis title

Development of a Digital Twin workflow for ArcelorMittal R&D - Jet cooling study case



This thesis was developed within THEMEF, a team at ArcelorMittal R&D focused on developing and improving steelmaking processes through computer-aided engineering tools such as Computational Fluid Dynamics (CFD) and addresses the emerging field of digital twins. The main objective is to develop a workflow that enables ArcelorMittal R&D to create digital twins based on high-fidelity CFD models.

The jet cooling unit operation, situated downstream of the galvanization bath in the steel making process, was selected as a case study. A detailed CFD model was first developed using drawings and process data from one of ArcelorMittal's production facilities, with the main output being the predicted steel strip temperature at the cooling unit's exit. This simulation served as the foundation for a Reduced Order Model (ROM), built using data-driven techniques and tools like Ansys OptiSLang and Twin Builder. The ROM's predictions were compared to the existing in-house models employed today by the company, differences of less than 1 % were detected on the estimation of the exit temperature of the steel strip. The final ROM was exported to create a digital twin, able to be consumed in different formats

like python codes or dynamic simulation software where real-time control can be applied.

This project delivers a proof of concept for integrating digital twins into ArcelorMittal's workflows, enhancing process optimization and supporting broader R&D goals such as decarbonization.

Sara-Medina SEHOVIC



www.linkedin.com/in/sara-medina-s-8038aa221

BSc in Mechanical Engineering, University of Sarajevo, Bosnia and Herzegovina

Mobility scheme



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UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH



Sarajevo, Bosnia and Herzegovina



**If
you can't
convince
them, confuse
them-with
turbulence.**





Company



Centre Tecnològic de Transferència de Calor
UNIVERSITAT POLITÈCNICA DE CATALUNYA

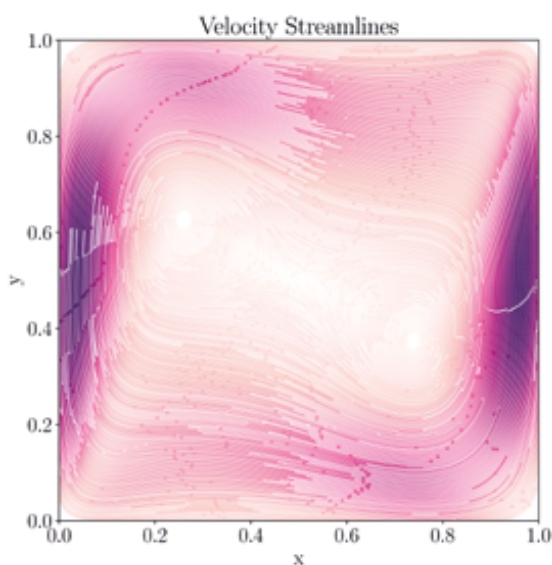
Centre Tecnològic de Transferència de Calor

The Heat and Mass Transfer Laboratory (Laboratori de Termodinàmica i Energètica, CTTC) at the Universitat Politècnica de Catalunya - BarcelonaTech (UPC), located in Terrassa near Barcelona, conducts advanced research in fluid dynamics and heat and mass transfer. Key activities include mathematical modeling, numerical simulation, and experimental validation of phenomena such as convection, turbulence, combustion, two-phase flow, phase change, radiation, porous media, and high-performance computing. The laboratory also applies this expertise to optimize thermal systems and equipment, with ongoing projects in refrigeration, HVAC, solar energy, heat exchangers, thermal storage, aerodynamics, and wind energy.



Master's thesis title

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



This thesis addresses the numerical modeling and simulation of fluid flow and heat transfer phenomena, with a focus on applications relevant to next-generation thermal systems. The work combines advanced techniques in Computational Fluid Dynamics (CFD) and Heat Transfer (HT) to solve the governing equations of mass, momentum, and energy conservation in both steady and transient regimes. Emphasis is placed on the integrated treatment of convection, conduction, and radiation to capture the complex interactions present in climate control and refrigeration equipment. High-performance computing resources and modern discretization strategies are employed to develop efficient and accurate computational frameworks. The implementation and validation of these numerical methods are carried out through well-established benchmark problems, including Lid-driven and Differentially heated cavities, which serve to assess the reliability of the developed codes in both

laminar and turbulent flow regimes. The results offer insights into the physical behavior of thermal systems and inform optimization strategies for HVAC&R applications. This study contributes to the ongoing development of robust simulation tools and highlights the challenges and opportunities in the computational analysis of complex energy systems.

entsoe Irisa SEVDARI



www.linkedin.com/in/irisa-sevdari-bb6b1416a/

Bach. in Electrical
Engineering (Power Systems),
Polytechnic University of
Tirana, Albania

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Tirana, Albania

“ Standard
by standard,
building the
backbone
of energy
flexibility. ”



Company

entsoe
ELECTRIFYING EUROPE

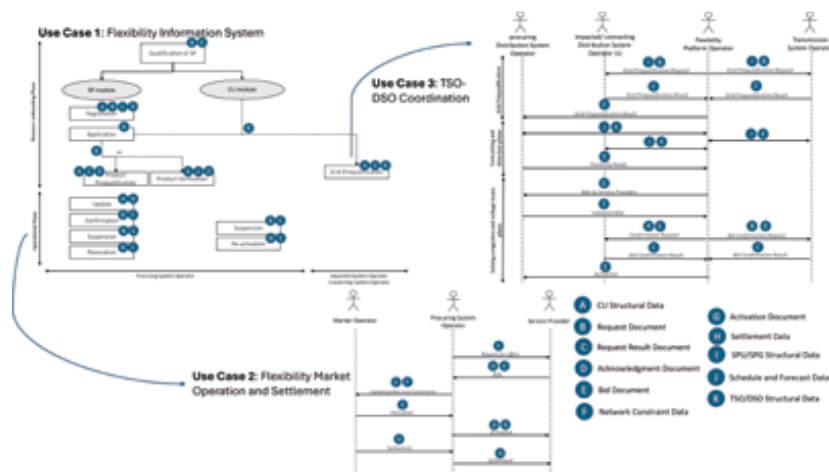
ENTSO-E

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the association for the cooperation of the European transmission system operators (TSOs). The 40 member TSOs representing 36 countries are responsible for the secure and coordinated operation of Europe's electricity system, the largest interconnected electrical grid in the world.



Master's thesis title

Standardizing Data Exchange for Demand Response: A TSO-Centric Approach



This thesis investigates how standardized data exchange can enable the scalable and interoperable integration of demand response into electricity markets, focusing on the role of Transmission System Operators (TSOs). Conducted in conjunction with my internship at ENTSO-E, the work contributes to ongoing efforts to implement the upcoming Network Code and Implementing Act on Demand Response (NC DR and IA DR). These regulatory instruments aim to remove barriers to demand-side flexibility procurement and ensure interoperability

across system operators, service providers, and market platforms.

The thesis defines and analyzes three high-level business use cases: (1) Flexibility Information Systems, (2) Flexibility Market Operation and Settlement, and (3) TSO-DSO Coordination, based on regulatory texts, expert consultations, and pilot projects. Each use case is mapped to relevant standards (e.g., IEC 62325, 61970/61968, 62746-4) and assessed using the Smart Grid Architecture Model (SGAM) focused on the TSO level.

A structured methodology is developed to identify gaps between legal requirements and current standard coverage, highlighting where technical or semantic interoperability is at risk. The findings support targeted standardization and implementation efforts to ensure that demand response services can be reliably qualified, activated, and settled across Europe's evolving electricity system.

Gandharva SHELAR



www.linkedin.com/in/gandharvashelar

Bachelors of Engineering,
Chemical Engineering (India)

Mobility scheme



Mumbai, India



“ When
economics
meets
electrons,
the planet gets
a fighting
chance. ”



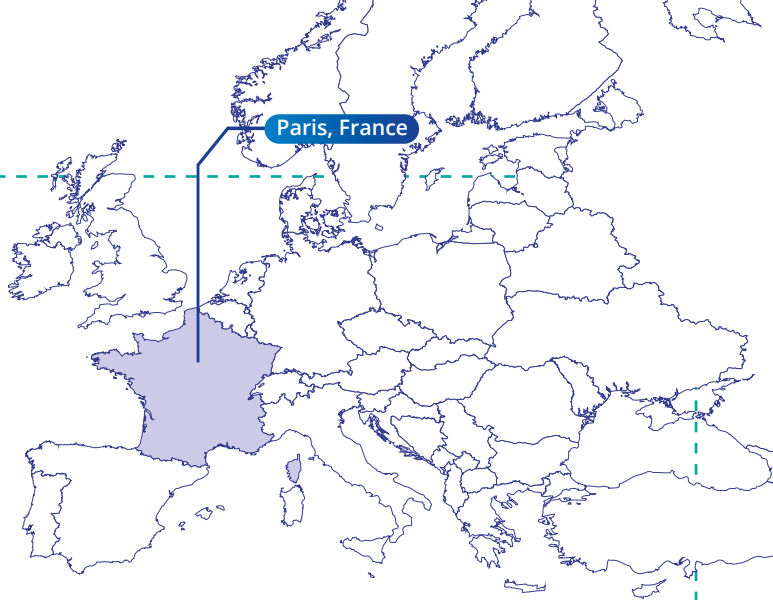
iea

International
Energy Agency

Company

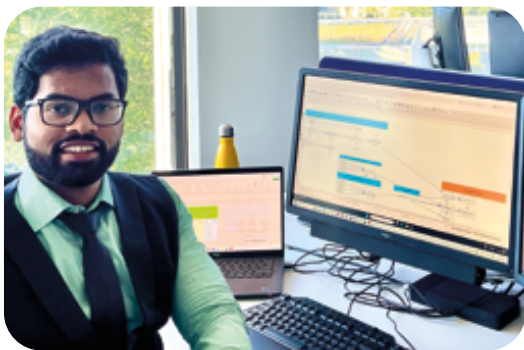
International Energy Agency

The International Energy Agency (IEA) is a global authority on energy policy, providing data-driven insights and actionable policy recommendations to support a secure, affordable, and sustainable energy future. As an inter-governmental organization, the IEA supports countries in their efforts to achieve net-zero emissions and enhance energy security, while fostering international collaboration across clean technologies, including hydrogen, renewables, and energy efficiency. Through a unique combination of robust technical analysis and socio-economic policy evaluation, the IEA plays a decisive role in shaping the global energy transition. Its work informs high-level decision-making across governments, industry, and international institutions, fostering collaboration and aligning efforts toward a more resilient and low-carbon global energy system.



Master's thesis title

Techno-Economic Modeling of Hydrogen Costs: Assessing Electrolyser Supply Scenarios and Policy Impacts



As part of my internship at the International Energy Agency (IEA), I am contributing to the IEA's analytical work on the cost competitiveness of hydrogen by developing and refining advanced techno-economic models using system dynamics modeling platform. My primary objective is to model the evolution of hydrogen pricing—both current and projected—to support informed policy and investment decisions in the global energy transition.

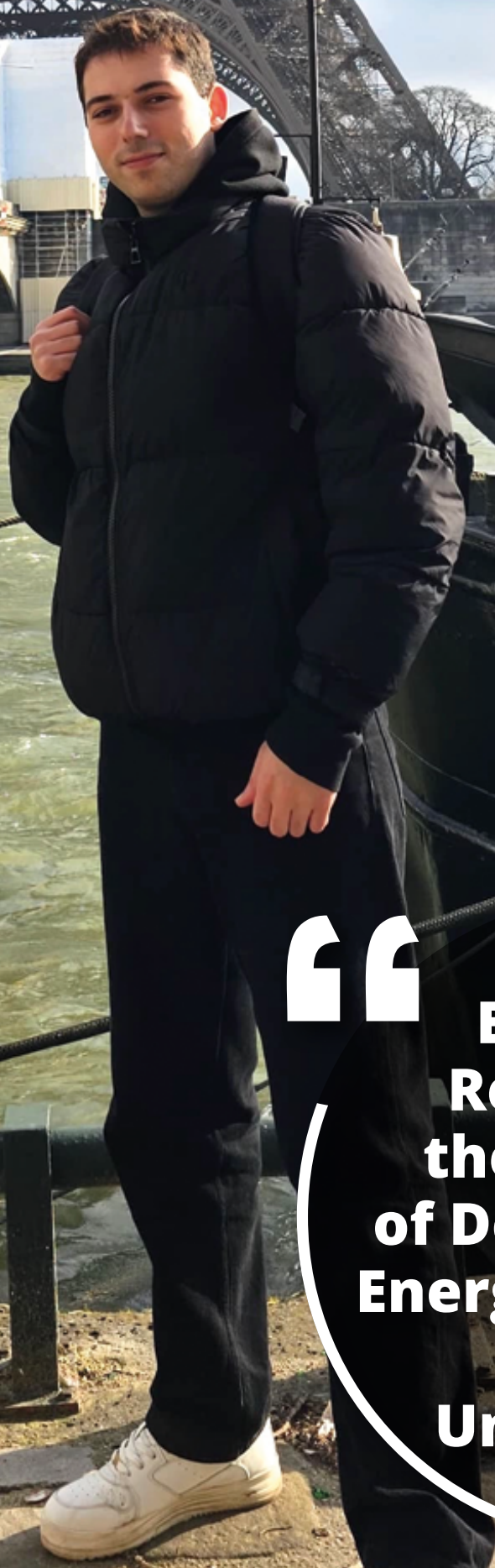
This work centers on calculating the Levelized Cost of Hydrogen (LCOH) through data-driven methodologies that integrate technical parameters with economic and policy variables. These models

simulate a range of scenarios, accounting socio-economic contexts, such as existing policy frameworks, net-zero pathways, to generate precise and actionable cost estimates for hydrogen deployment.

Currently, I'm evaluating the impact of Chinese-sourced electrolyser components on the LCOH in European production contexts. This involves building dynamic cost structures that incorporate diverse datasets, such as import/export records, component-level cost breakdowns, shipping tariffs, and trade policy mechanisms.

In addition to technical data analysis and policy research, I use these models to simulate supply chain scenarios and perform sensitivity analyses to identify key cost drivers and potential leverage points for reducing hydrogen production costs in Europe. The modeled outcomes are benchmarked against current hydrogen prices, followed by a comprehensive assessment of industry standards, global subsidy schemes, and policy support frameworks.

Avtandil SVIANADZE



www.linkedin.com/in/avtandilsvianadze/

**Bachelor's Degree in
Aeronautical Engineering**

Mobility scheme



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DE LORRAINE



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

xiix xiix ixix

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**Without
Economic
Regulation,
the Potential
of Decentralised
Energy Resources
Is Left
Unexploited**

”

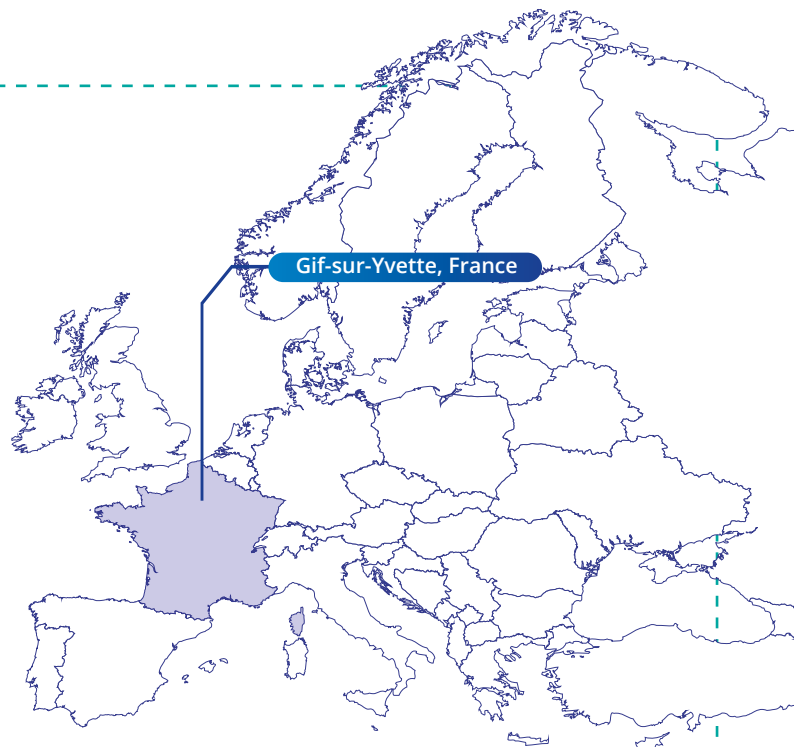


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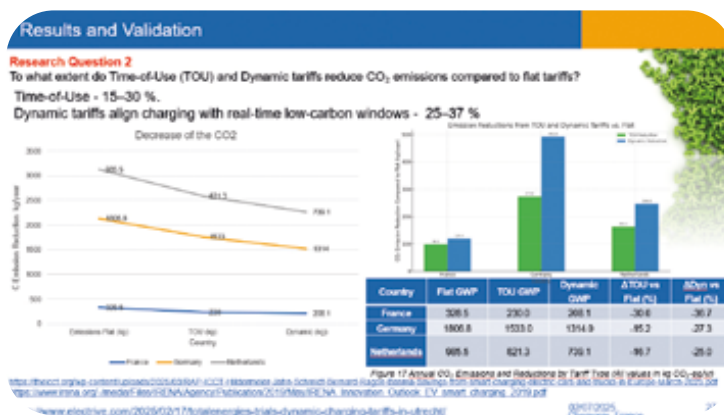


CentraleSupélec of Université Paris-Saclay

The CentraleSupélec Paris-Saclay University in France operates within the Industrial Engineering Department (LGI), bridging economics, management and engineering. Specialising in eco-innovations for energy and mobility, it evaluates environmental and socio-economic impacts through interdisciplinary techno-economic and strategic analyses, collaborating with industry, regulators and academic partners worldwide.



Master's thesis title Economic Regulation of Decentralised Energy Resources



This thesis explores how economic regulation influences the value distribution between electric vehicle (EV) owners and aggregators in Vehicle-to-Grid (V2G) systems. A detailed simulation framework, based on a Virtual Power Plant (VPP) of EVs, is developed and applied to France, Germany, and the Netherlands.

The framework comprises five interlinked modules: (i) EV mobility patterns and charging station availability, (ii) EV owner plug-in behaviour based on state of charge (SOC), (iii) national electricity tariffs and regulatory rules, (iv) electricity market

dynamics including wholesale and imbalance prices, and (v) aggregator-retailer optimisation. The analysis focuses on how tariffs, taxes, and discharge compensation affect participation incentives. Results reveal that regulatory design strongly shapes who captures V2G value. Without proper discharge remuneration or tax incentives, EV owners avoid grid services, limiting aggregator flexibility. Conversely, certain policy mixes improve value-sharing and grid responsiveness.

Results show that without regulations for discharged energy or targeted tax incentives, EV owners tend to avoid grid services, constraining aggregator flexibility. In contrast, well-designed combinations of flat, Time-of-Use and dynamic tariffs can show equitable value sharing, reduce use-phase CO₂ emissions by 37%, and sustain positive aggregator margins. The study can be a transparent, policy-testing tool and offers practical guidance for aligning private incentives with public decarbonisation goals.

Giang Ngoc Huong VU



www.linkedin.com/in/giang-ngoc-huong-vu/

BSc. Energy in Vietnam

Mobility scheme



UNIVERSITÉ
DE LORRAINE



Hanoi, Vietnam



Data scouting
- Run the
simulation - Not
know why it doesn't
work - Struggle to
debug - Clueless on
why it works -
Repeat





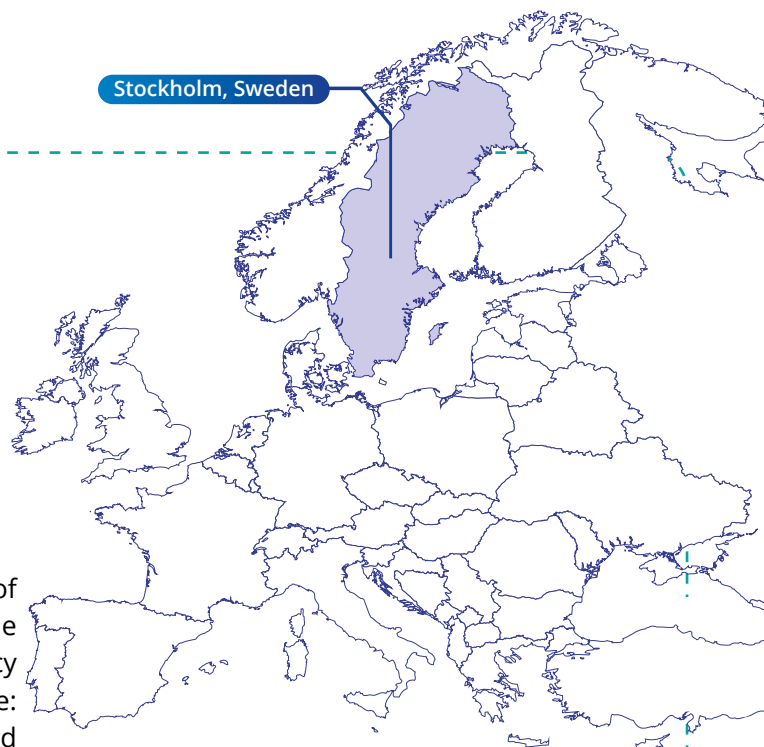
Company



KTH Department of Energy Technology

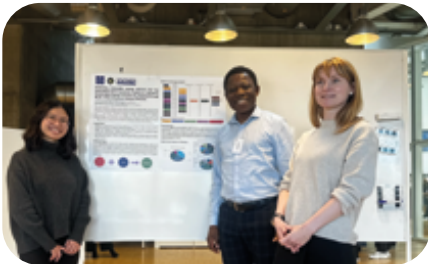
The Division of Energy Systems - KTH Royal Institute of Technology focuses on broad system perspective and the interlinkage between technology, innovation, and policy to sustainable development. Its research areas include: energy access and development, energy system and innovation, circular economy & resource efficiency, open tools for systems science, etc.

Stockholm, Sweden



Master's thesis title

Assessing renewable energy policies and the associated socio-economic impacts in Vietnam's Sustainable Energy Transition.



Vietnam's renewable energy sector has experienced remarkable growth since 2017, transforming the country into a regional leader in solar and wind energy deployment within ASEAN. Solar generation increased from negligible levels in 2017 to 28,400 GWh in 2022, representing 10% of total electricity generation, driven by attractive feed-in tariffs and ambitious national targets. However, rapid expansion has created systemic challenges including electricity shortages despite renewable curtailment, insufficient grid infrastructure, and market uncertainty from expired FIT schemes, threatening energy

security. The Vietnamese government responded with Power Development Plan 8 (PDP VIII) in March 2023, revised in April 2025, establishing frameworks for energy development towards 2050. While emphasizing renewable targets and grid improvements, PDP VIII inadequately addresses just energy transition measures and potential social impacts on affected communities. This study evaluates Vietnam's energy transition policies through a comprehensive multi-method approach, integrating energy system modelling with OSeMOSYS and multi-criteria decision analysis (MCDA) framework. Three scenarios are examined: Baseline, Revised PDP8, and NDC commitments, assessing both techno-economic feasibility and socio-economic considerations including energy security, environmental impacts, and social acceptance. Key findings reveal that the revised PDP8 scenario achieves significant diversification with new technologies including offshore wind, geothermal, nuclear, liquefied natural gas, hydrogen, and pumped hydro and battery energy storage. Total installed capacity reaches over 880GW by 2050 compared to 277GW in the baseline scenario. Carbon emissions are reduced by over 1.5 billion tons of CO₂ by 2050, with emissions peaking at 207 million tons in 2029 before declining to zero by 2050. However, achieving these targets requires substantial investment of 875.5 billion USD for technology infrastructure and 24.2 billion USD for transmission and distribution systems. The study provides policymakers with practical recommendations for achieving a just and sustainable energy transition that aligns national targets with global climate commitments while ensuring socio-economic benefits.

Kira ZHMUD



www.linkedin.com/in/kira-zhmud/

Bach. in Nuclear Power
and Thermal Physics, ITMO
University, Russia

Mobility scheme

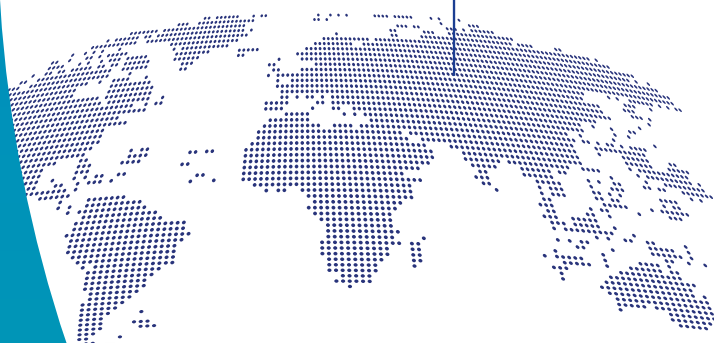


UNIVERSITÉ
DE LORRAINE



Politecnico
di Torino

Saint Petersburg, Russia



“

Training
algorithms
to feel the
heat.

”



Company

CIC
energi
GUNE

MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

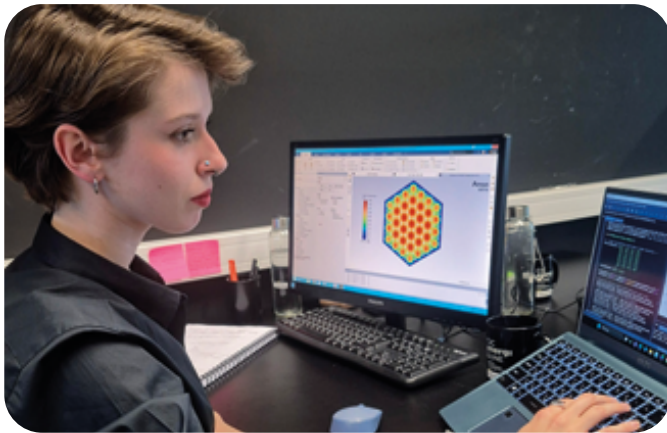
CIC EnergiGUNE

CIC energiGUNE is a leading energy storage research center in the Basque Country, Spain, working in electrochemical and thermal energy storage and conversion. The thermal energy storage unit specializes in advanced materials and system-level solutions for efficient heat storage and management. The collaborative and dynamic environment at CIC fosters a genuinely welcoming and supportive team culture.



Master's thesis title

Machine learning application for the analysis of a hybrid battery thermal management system with shape-stabilized phase change material



This thesis presents the development of a machine learning-based reduced-order model (ROM) for battery thermal management systems (BTMS) incorporating shape-stabilized phase change materials (SS-PCMs). The goal is to predict the temperature evolution of lithium-ion cells under dynamic operating conditions with significantly reduced computational time.

To achieve this, a recurrent neural network (RNN) model is trained using data from high-fidelity simulations. The simulations integrate electrochemical estimations based on Coulomb Counting and the Bern

nardi heat generation model with a transient computational fluid dynamics (CFD) model built in Ansys Fluent. This coupled approach ensures an accurate representation of the system's transient thermal behavior.

A fully automated workflow was developed to generate a comprehensive dataset spanning a wide range of C-rate profiles and thermal boundary conditions. The resulting RNN-based ROM acts as a lightweight, data-driven surrogate capable of approximating thermal responses with substantial reductions in computational cost compared to full-scale CFD runs.

Beyond model development, this work proposes a systematic methodology for applying transient thermal engineering principles to battery systems using simulation-enhanced machine learning. This methodology lays the foundation for the creation of cost-effective digital twins and can support the design, evaluation, and potential real-time control of advanced BTMS architectures, particularly those leveraging materials such as SS-PCMs.



2022 COHORT







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



densys-contact@univ-lorraine.fr



@DENSYS_em