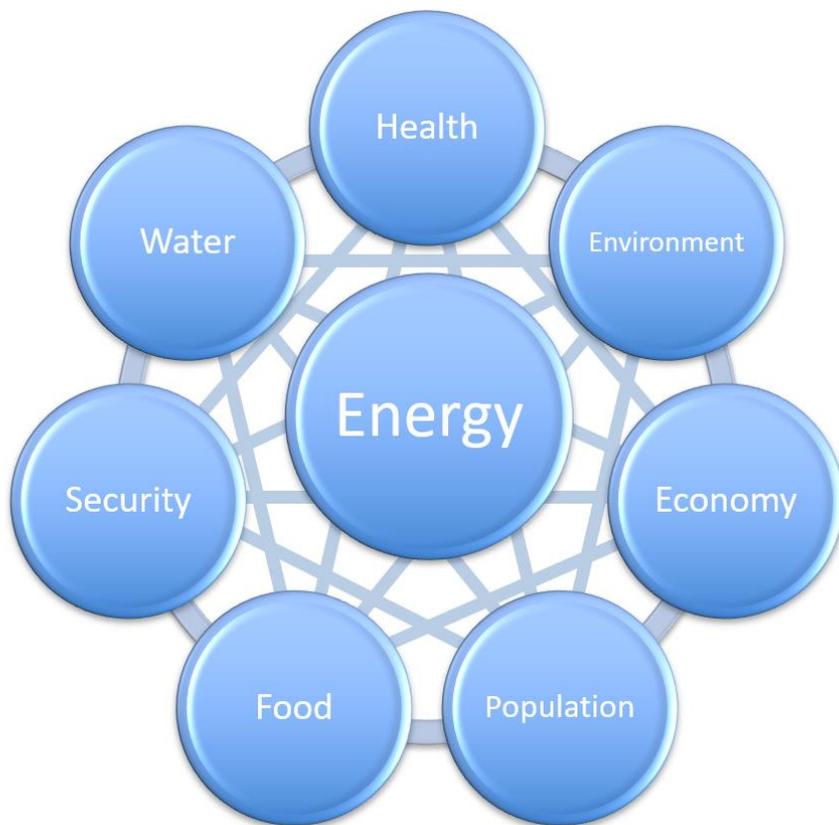


ENGINEERING FOR THE ENERGY TRANSITION



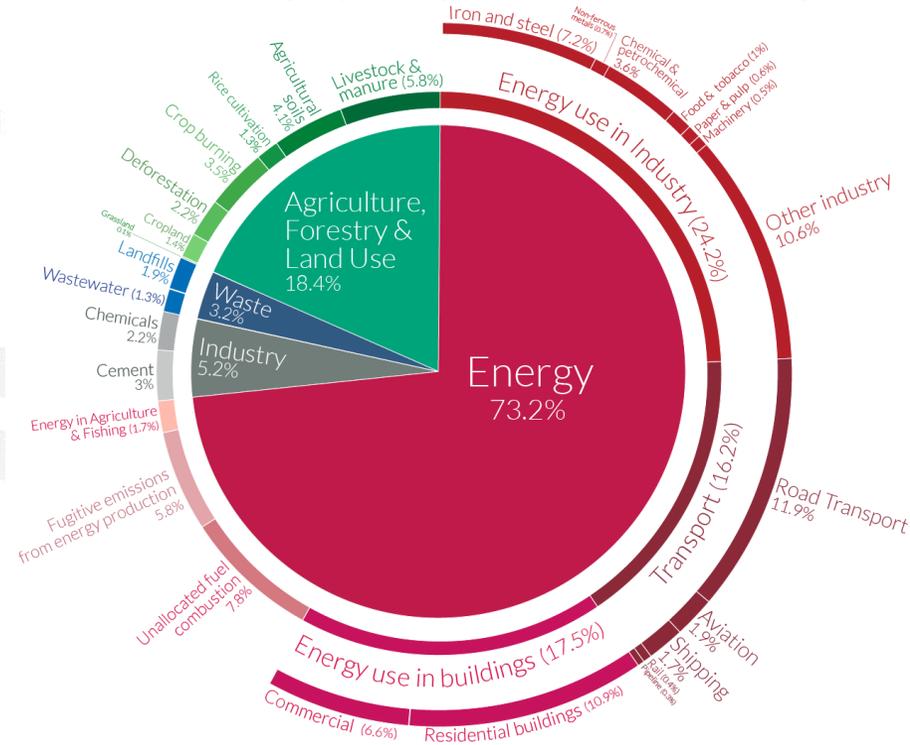
To begin with ... the fossil fuel-based-energy sector is complex and represents the biggest contribution to global warming due to greenhouse gas emissions



Global greenhouse gas emissions by sector



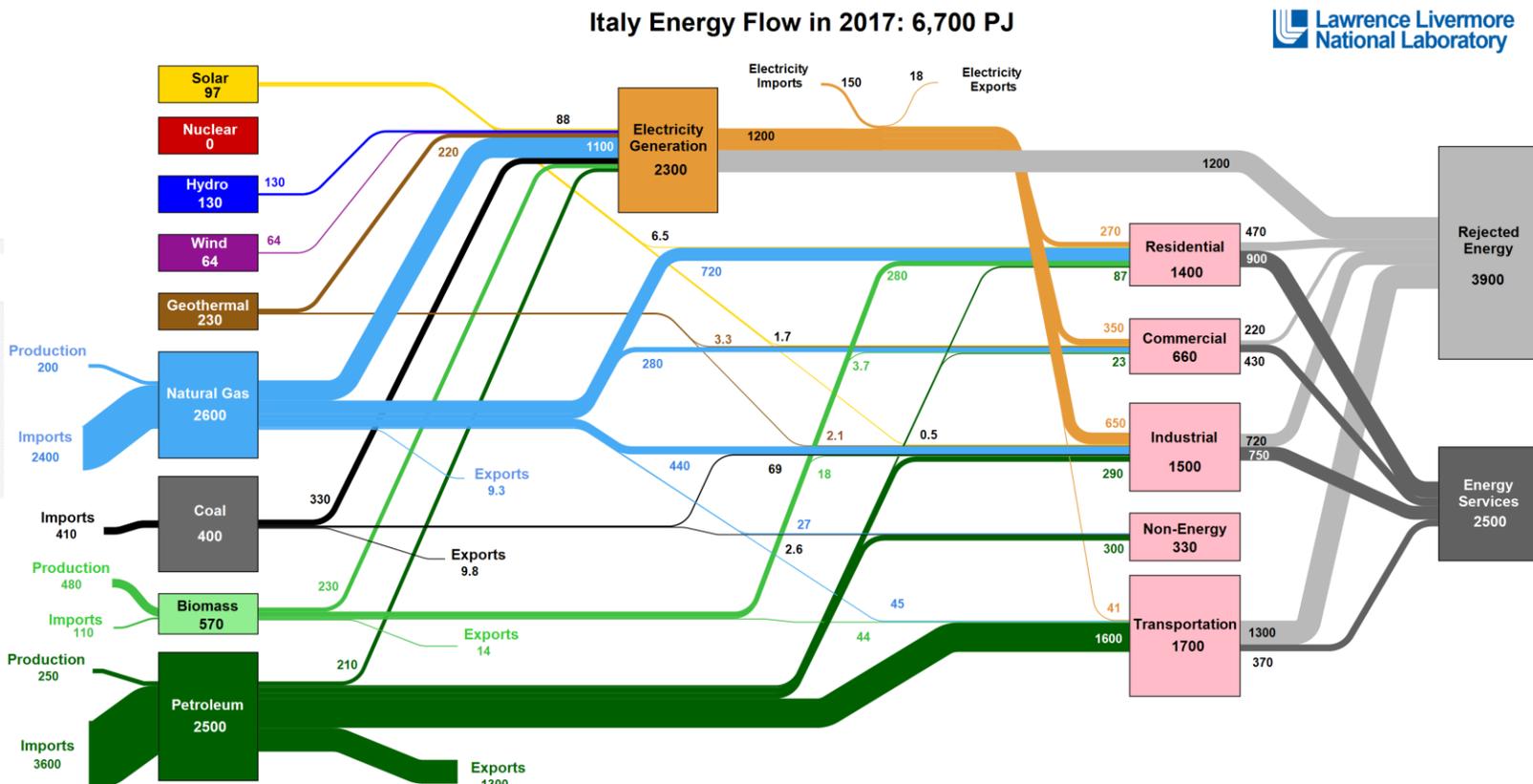
This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂eq.



OurWorldinData.org – Research and data to make progress against the world's largest problems. Source: Climate Watch, the World Resources Institute (2020). Licensed under CC-BY by the author Hannah Ritchie (2020).



And why is that? The fossil fuel-based-energy sector is inefficient!



We waste **50%** of fossil fuels to produce power & **75%** of fossil fuels to move cars

Source: LLNL 2021. Data is based on IEA's Detailed World Energy Balances (2019 Edition). If this information, or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the U.S. Department of Energy, under whose auspices this work was performed. All quantities are rounded to 2 significant digits and annual flows of less than 0.10 PJ are not included. Total energy supply (top of chart) and energy resource statistics (left-side boxes) represent national energy use which is the sum of production and imports minus exports. Totals may not equal sum of flows due to independent rounding, stock changes, statistical difference and reporting inconsistencies. Further information can be accessed at <https://flowcharts.llnl.gov>. LLNL-MI-410527

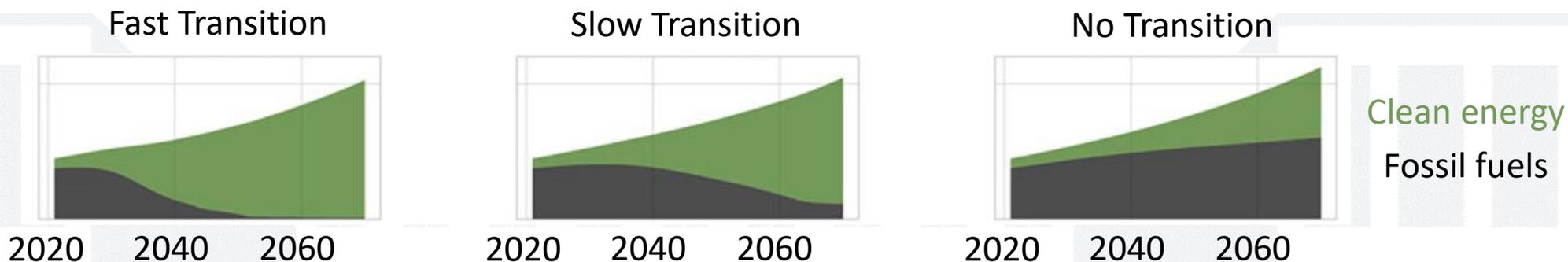
Overall we waste **61%** of the primary resources!



In addition to that ...

The fossil fuel-based-energy sector is too expensive!

Three energy system scenarios



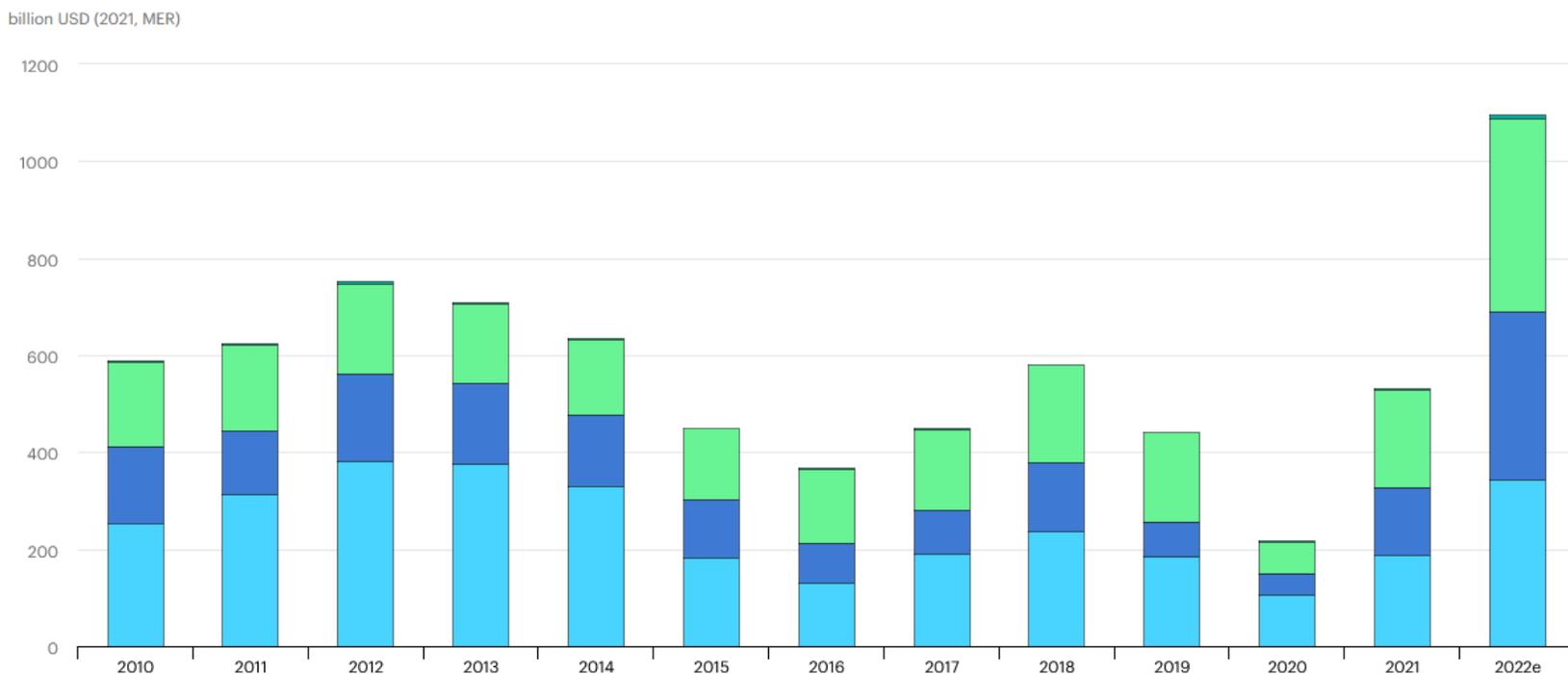
Joule 2022 62057-2082DOI: (10.1016/j.joule.2022.08.009)

A rapid green energy transition is likely to result **in trillions of net savings!!!**





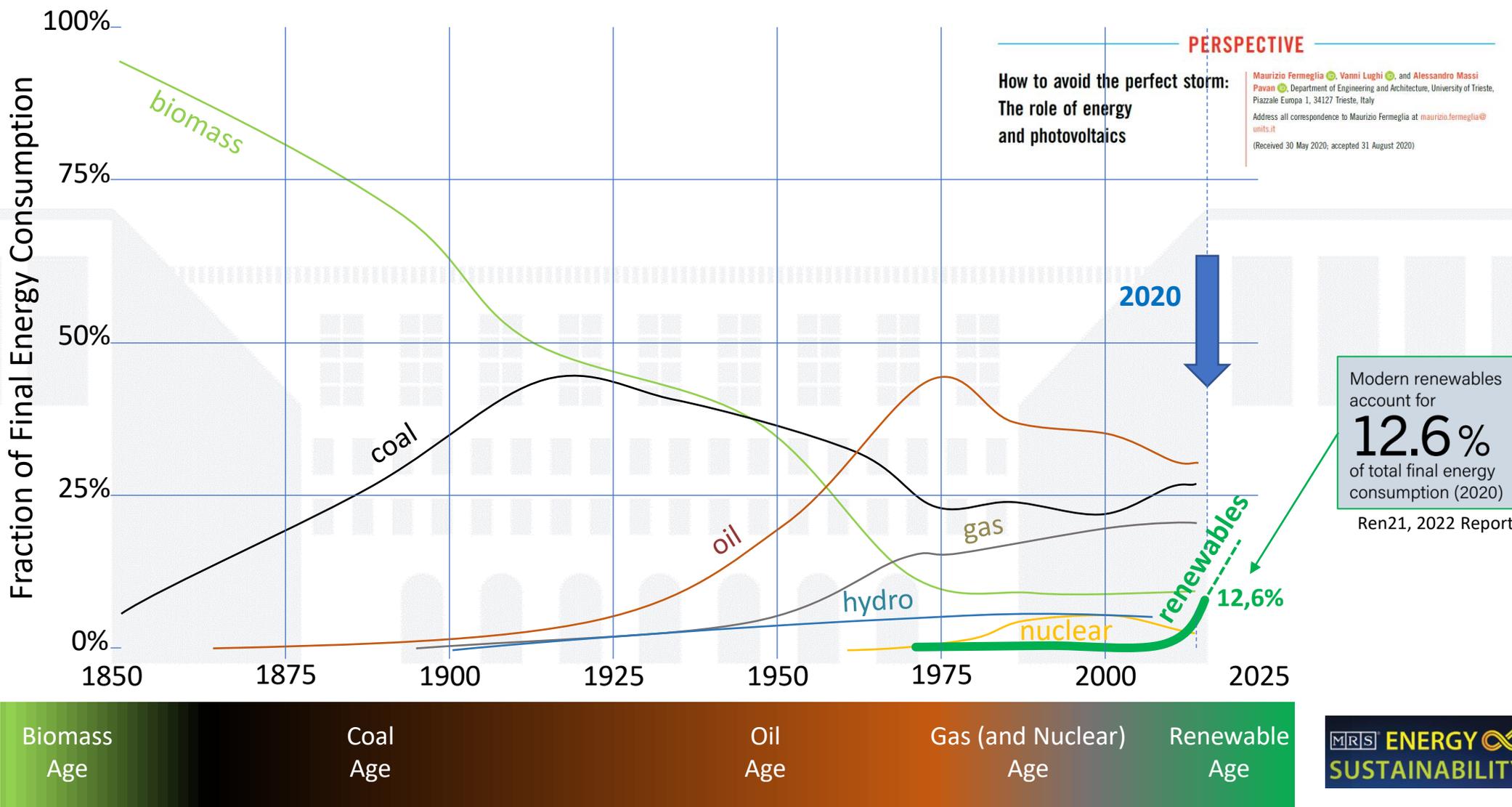
As well as the waste ... global fossil fuels subsidies are rapidly growing and almost double than the renewables subsidies!



● Oil ● Natural gas ● Electricity ● Coal



It's clear that the energy transition is the way forward to solve all the issues



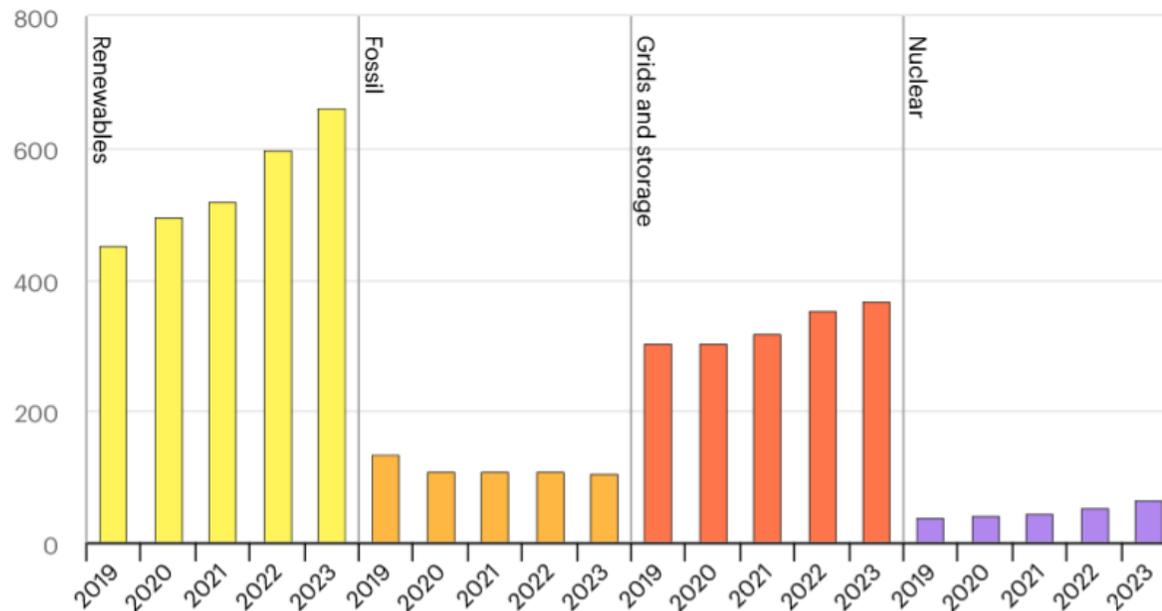


Thankfully, global investments are already moving in the right direction

Power investment, 2019-2023



billion USD (2022)



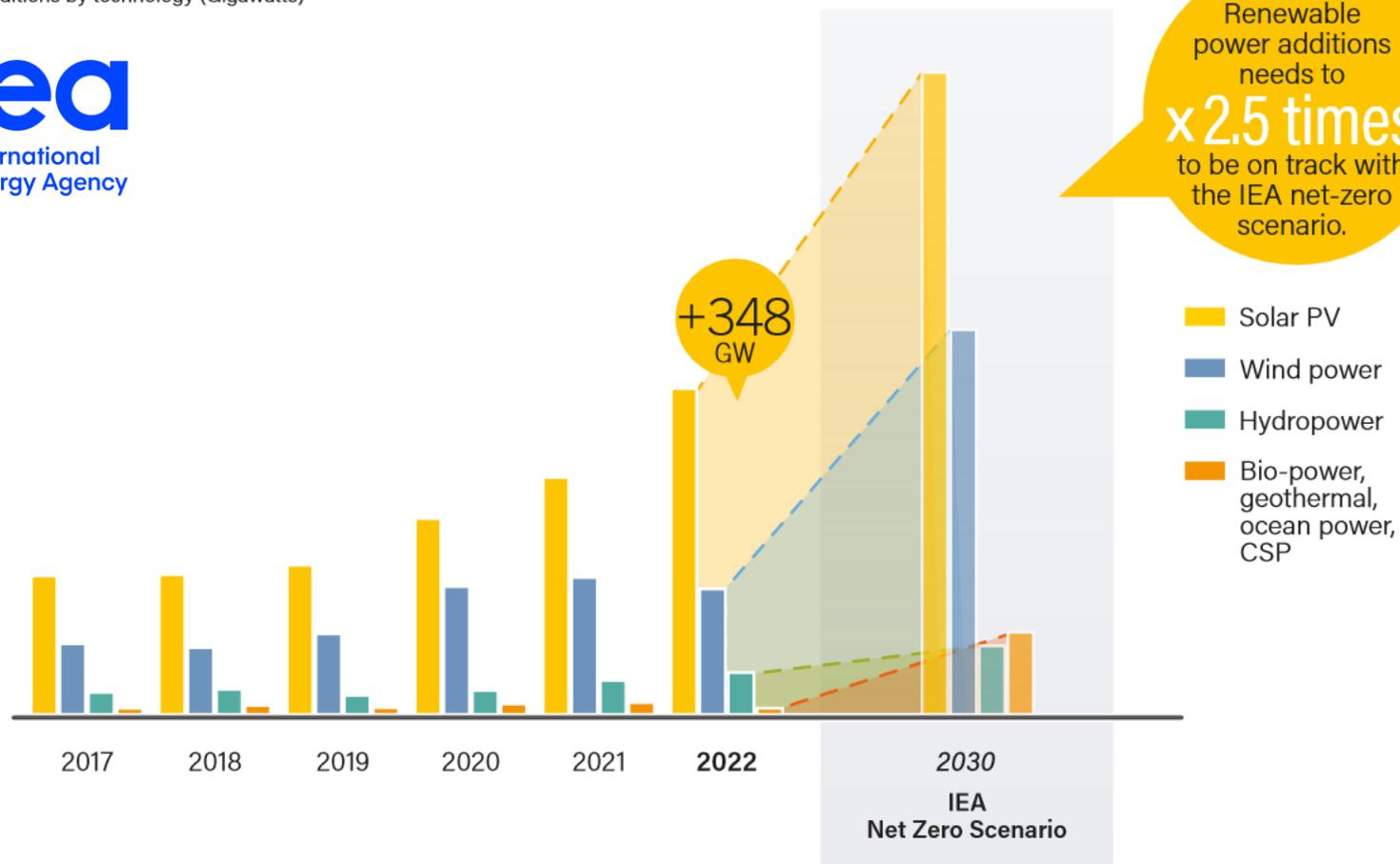
IEA. Licence: CC BY 4.0

● Renewables ● Fossil ● Grids and storage ● Nuclear



However ... there's still a lot of road to cover!

Additions by technology (Gigawatts)





Looking ahead

Industries in the EU will play a key role in the green transition

shaping new types of jobs that will require new skills to perform them



EUROPEAN
**GREEN
DEAL**

The Master's Degree in **Engineering for the Energy Transition** is the answer to the European call!



UNIVERSITÀ
DEGLI STUDI
DI TRIESTE

A common vision: the Italian Government

In Italy

A decisive acceleration is required to implement **the energy transition**

To achieve this, Italy will require an extreme effort, which will necessitate new educational courses

The Master's Degree in **Engineering for the Energy Transition** is the answer to Italy's needs!





**UNIVERSITÀ
DEGLI STUDI
DI TRIESTE**

A common vision globally



**The importance of focusing on jobs
and fairness in clean energy
transitions**



Renewable energy jobs rise by 700,000 in a year, to nearly 13 million

**The students at the heart of the
green jobs boom**



**EUROPEAN
COMMISSION**

**The renewable energy transition is
creating a green jobs boom**



**JOBS AND SKILLS
IN THE ENERGY
TRANSITION**



What we offer

The Master's Degree in **Engineering for the Energy Transition** is an interclass Program, offered **entirely in English**, and includes **Building Systems Engineering** and **Energy Engineering** classes



The Program aims to **equip students with advanced skills to address the energy transition**

both in the field of building systems and in the industrial sector, through two specific curricula: **Sustainable Building Design and Technology** and **Sustainable Industrial Systems**



What we offer

The Program is based on a **strongly multidisciplinary experimental approach** characterized by laboratory activities



The Master provides the tools to comprehend both **technical & technological aspects** related to materials, components and the complex building/energy plants systems. This includes their interaction and integration with the **environment** and the contextual aspects of the transition relating to **administrative, economic and social issues**



What we offer

The Program therefore **trains professionals** capable of operating in the field of **energy design and management of building systems** and in the **industrial sector**

The Master offers a set of skills that are useful for acquiring the **technical and cultural expertise** necessary to **occupy positions of responsibility in different fields** such as design, coordination and management both as freelancers and at companies and public or private entities



1 st Year		
Course	Modules	CFU
Fundamentals of the Energy Sector and Renewables	Fundamentals of the Energy Sector	3
	Renewable Energy Technologies	6
Economics, Evaluations, Legislation, and Social Aspects for the Energy Transition	Environmental Economics	3
	Economic Evaluation of Projects for the Energy Transition	3
	Legislation and Social Change	3
Building HVAC Systems	HVAC System Design	6
	HVAC Load Calculation	3
Environmental Hydraulics: Pollutants, Emissions and Global Warming		6
Industrial Energy Management		6
Fundamentals of modern Power Systems		9
Elective Courses		6

2 nd Year		
Course	Modules	CFU
Building Envelopes and Structural Integration	Technologies for Building Skins	3
	Structural Design	9
Materials and Systems for the Energy Transition	Materials for the Energy Transition	3
	Electrical Systems for the Energy Transition	3
Photovoltaics and E-Mobility	Photovoltaic Systems	3
	E-Mobility	3
Integrated Ecosystem Design	Regenerative and Smart Building Technologies	6
	Regulatory Framework and Building Energy Design	3
	Informative 3D Modeling for Project Design and Management	3
Building Energy Simulation		6
Elective Courses		6
Other Activities		6
Final Thesis		12



1st Year

Course	Modules	CFU
Fundamentals of the Energy Sector, Renewables and Energy Systems	Fundamentals of the Energy Sector	3
	Renewable Energy Technologies	6
	Elements of Fluidmachinery and Energy Systems	6
Economics and Evaluations for the Energy Transition	Environmental Economics	3
	Economic Evaluation of Industrial Projects	3
Design and Simulation of HVAC Systems	HVAC System Design	6
	HVAC Load Calculation	3
	Introduction to Computational Fluid Dynamics	3
Environmental Hydraulics: Pollutants, Emissions and Global Warming		6
Industrial Energy Management		6
Fundamentals of modern Power Systems		9
Elective Course		9

2nd Year

Course	Modules	CFU
Alternative Energy Technologies 1	Electrical Energy Storage	3
	Materials for the Energy Transition	3
	Electrical Systems for the Energy Transition	3
Alternative Energy Technologies 2	Wind Energy and Fundamentals of Nuclear Energy	3
	Wave and Tidal Power Plants	3
	Hydrogen and Fuel Cells	6
Integrated Spatial and Energy Planning	Spatial Planning for Photovoltaic Systems	3
	E-Mobility	3
Design for Sustainability of Products and Processes	Design for Sustainability of Processes	3
	Sustainable Materials: Selection and Design	3
Models and Data for the Electricity Market	Electricity Market Modeling	3
	Data Analytics in the Electricity Market	3
Other Activities		6
Final Thesis		12



Renewables and battery energy storage systems integration



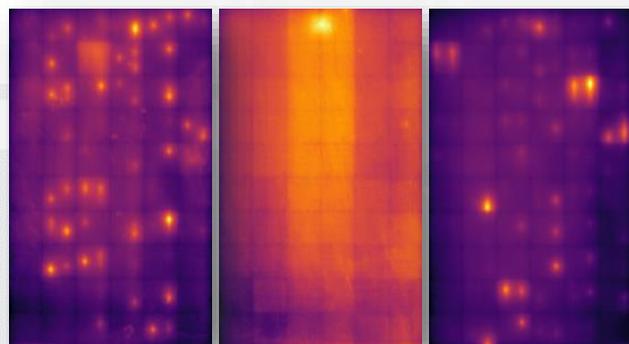
Integration of smart grids and e-vehicles



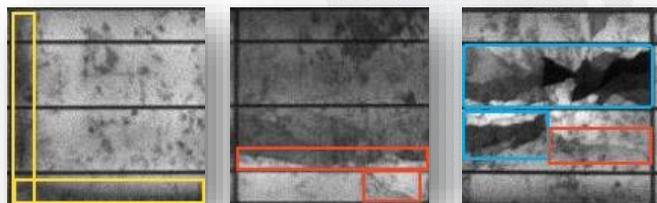


Artificial intelligence-based faults detection and classification

Modeling and forecasting

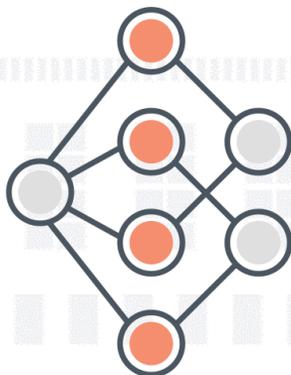


Thermography



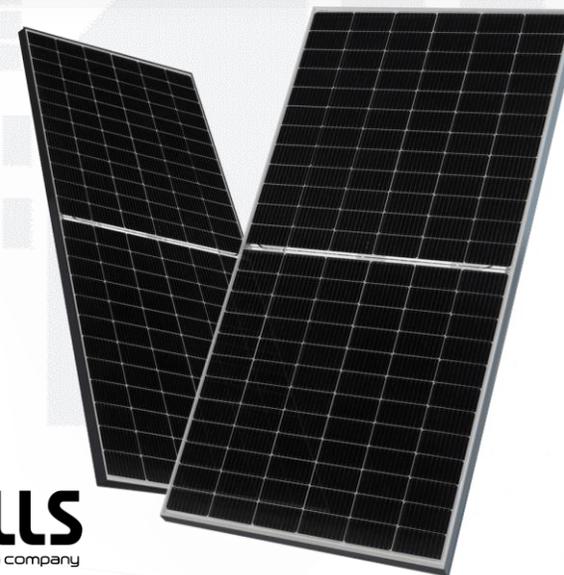
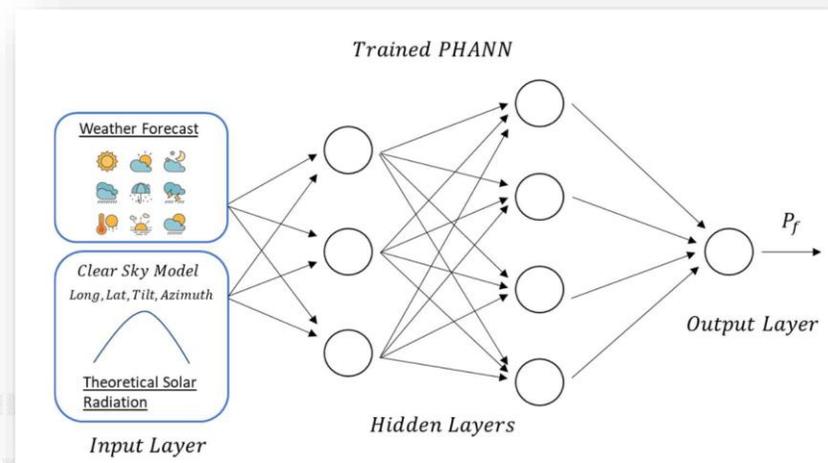
Electroluminescence

Artificial Neural Network

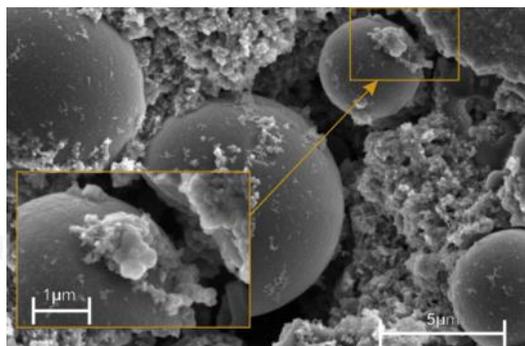
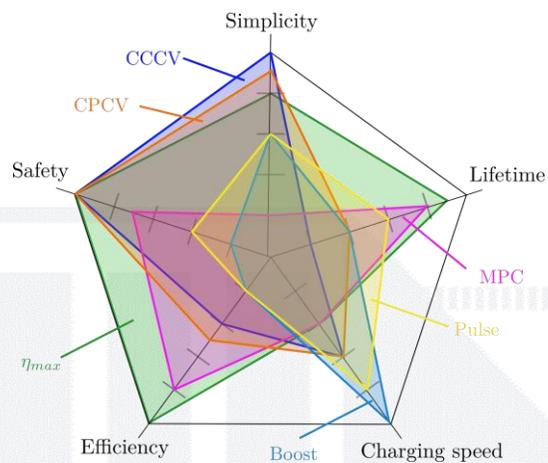


Faulty
class

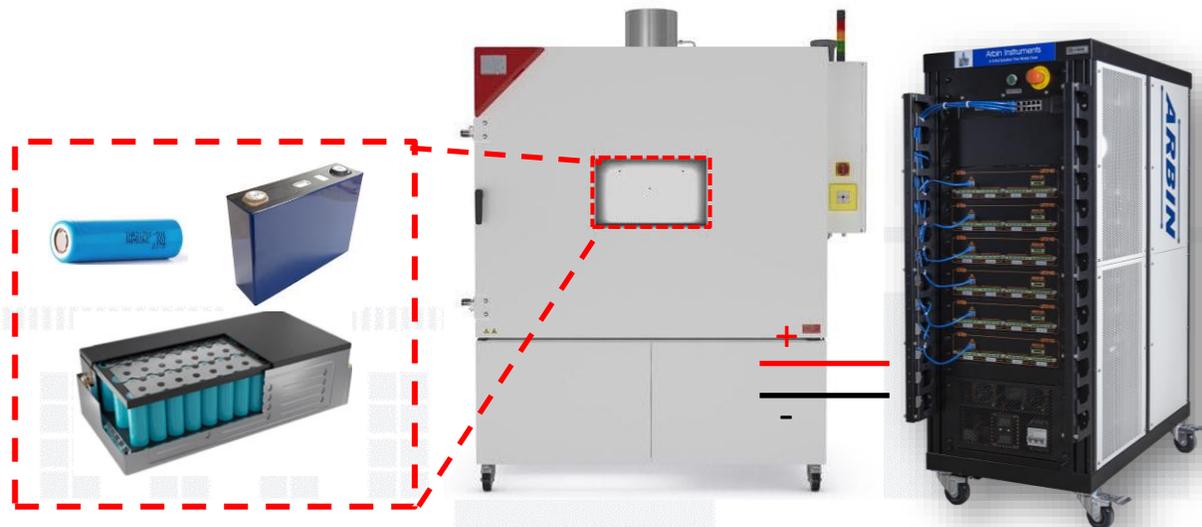
IoT integration



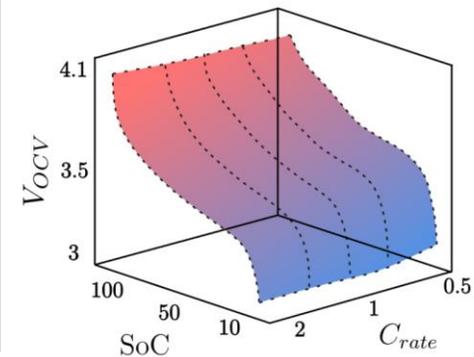
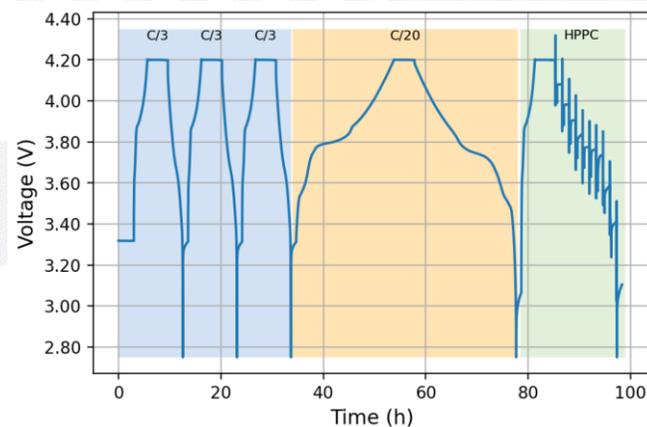
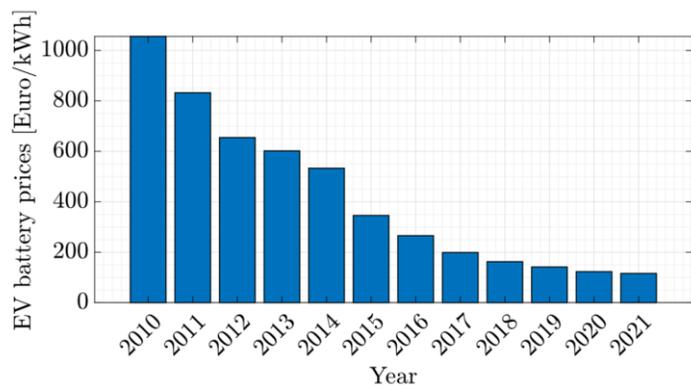
Operation mechanisms and materials



Aging models and cell characterization

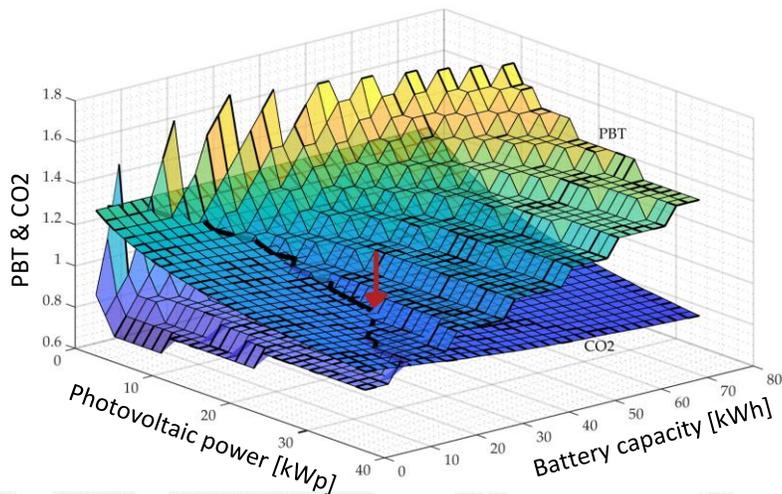


Economic evaluation and social acceptability





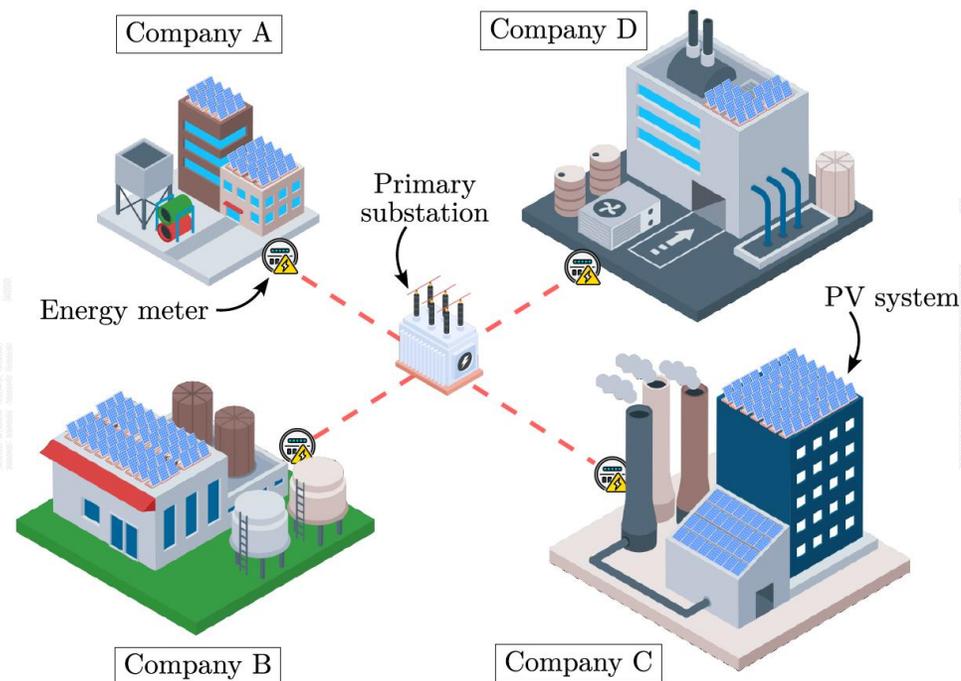
Optimal design of PV-BESS systems



Energy democracy and poverty



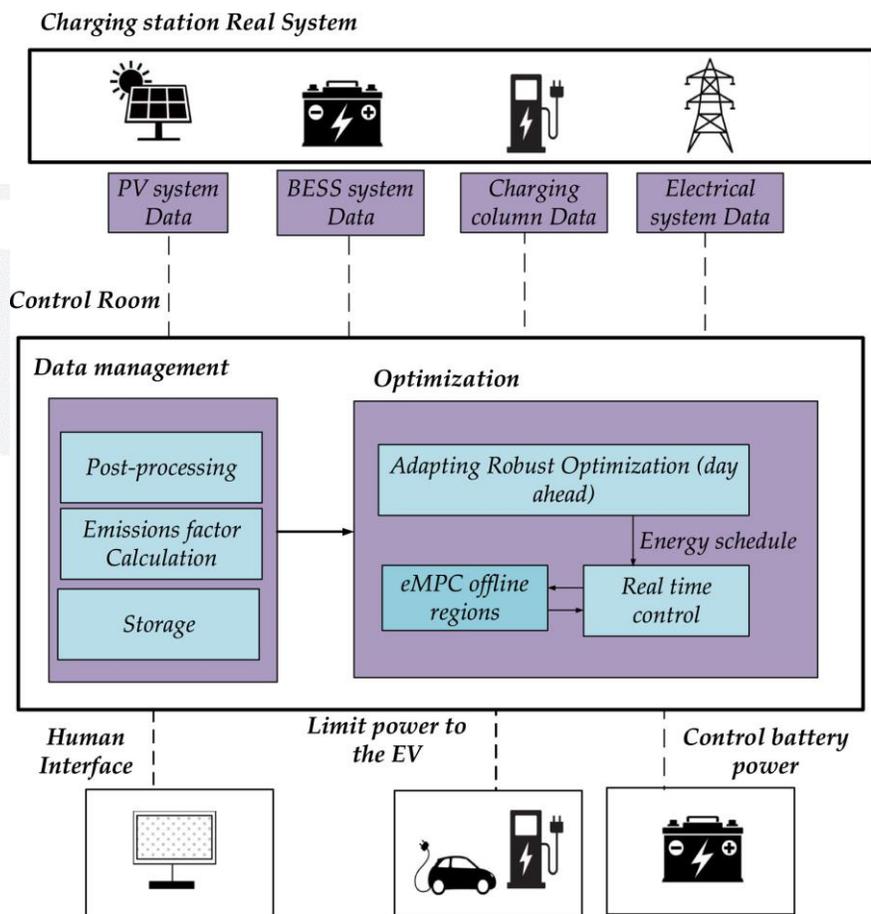
Simulation and modeling



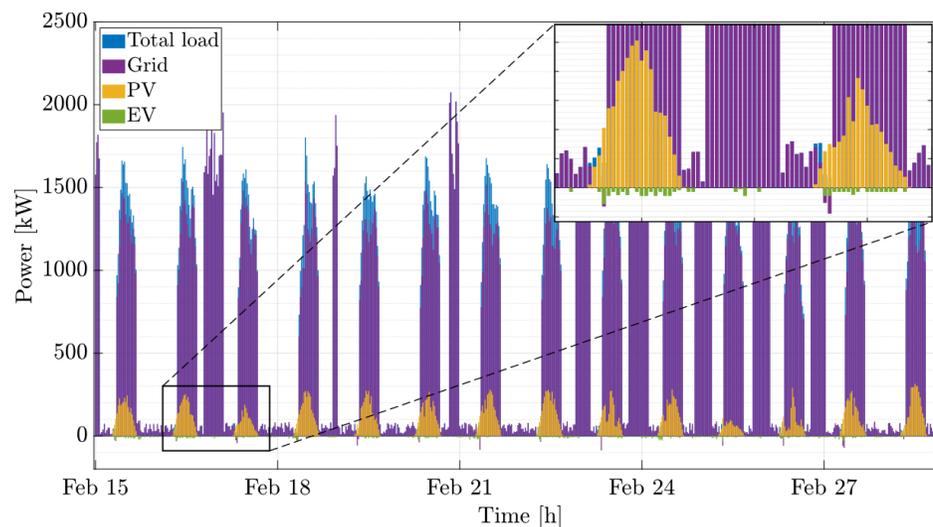
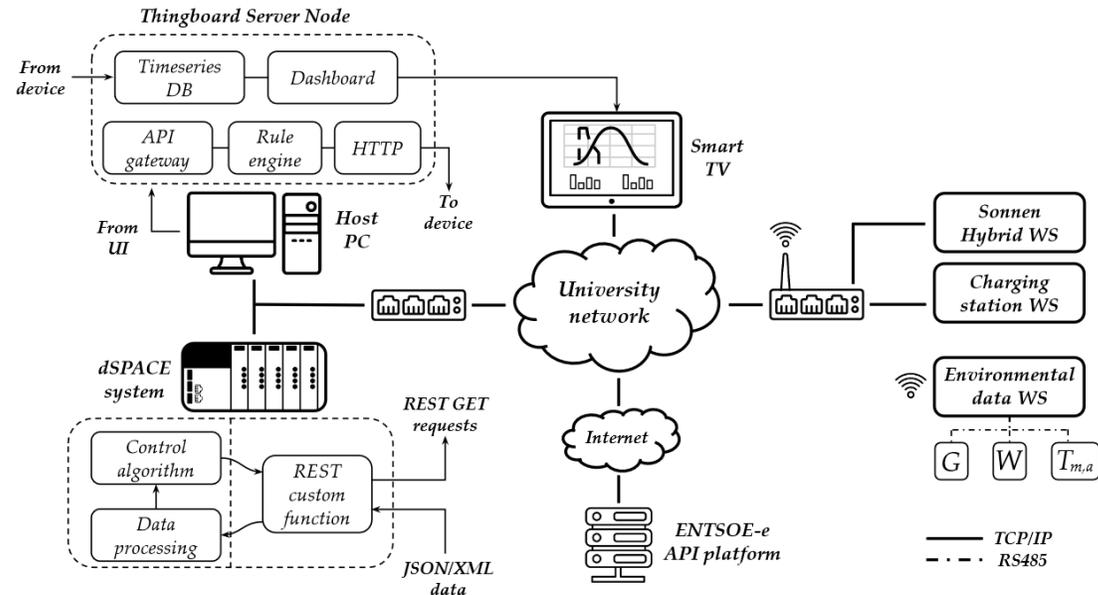
Energy, economic and environmental analysis and evaluation



Demand Response

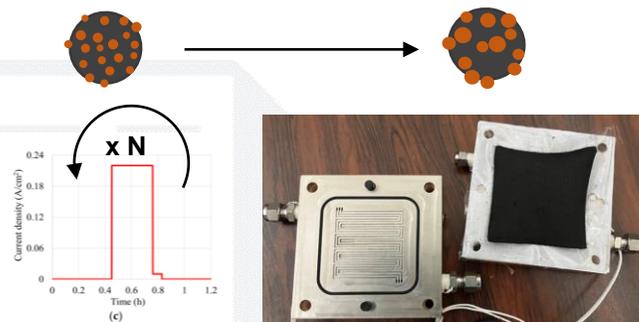


Renewable energy integration and optimization

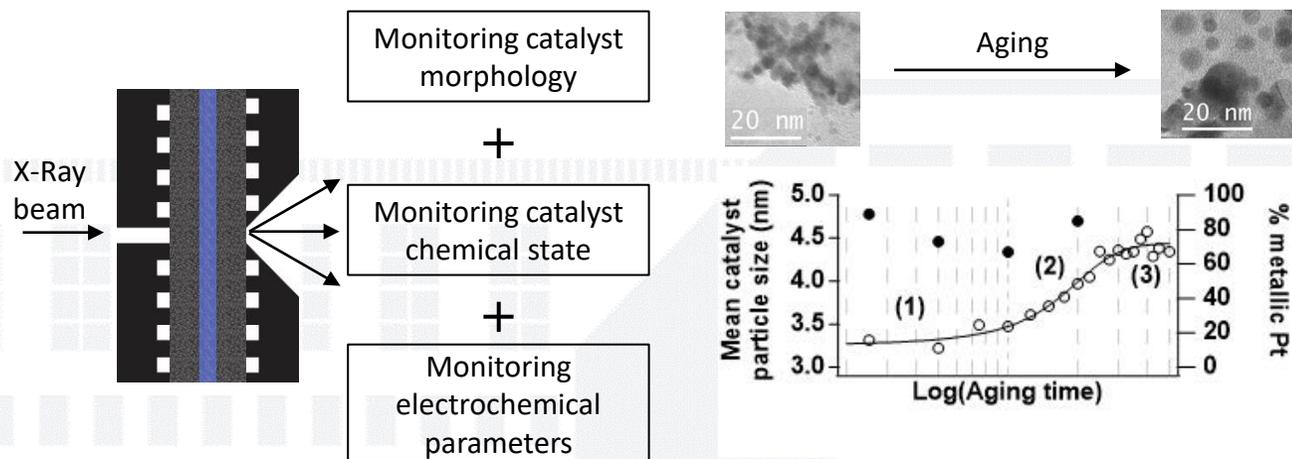


Fuel cells and hydrogen generators based on water electrolyzers

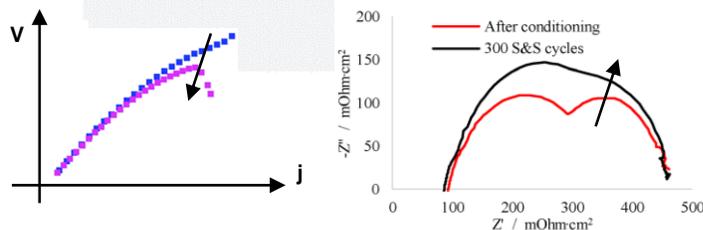
Test of degradation protocols for enhancing aging of components in fuel cells and electrolyzers



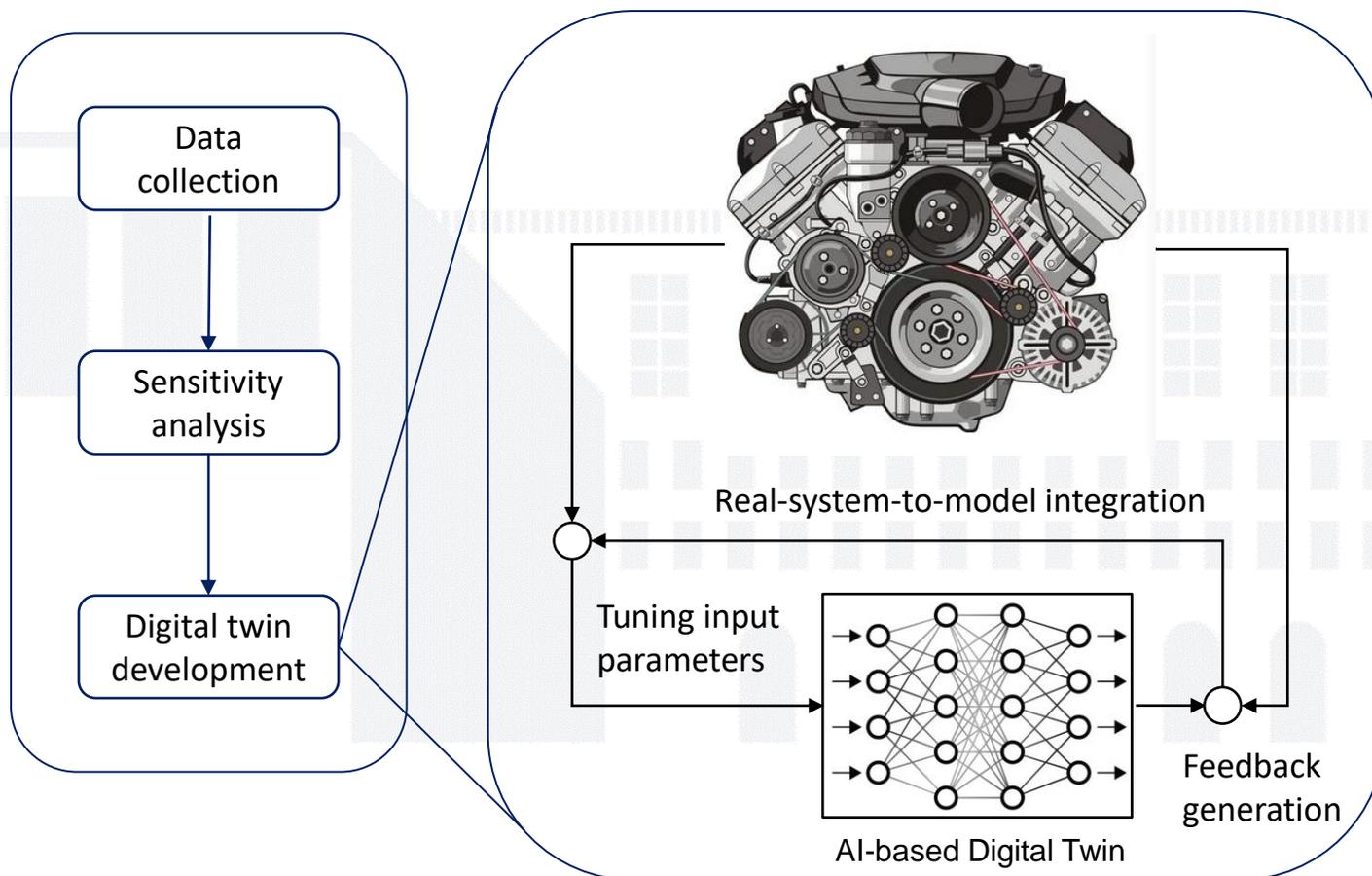
In-depth multi-technique-based investigation for fuel cells and water electrolyzers



Characterization of performance drop



Development of Artificial-Intelligence-based Digital Twins for industrial application



GUI control development

OUTPUT VARIABLES	Model	Engine
t Temp a Cyl Mean	32.77	42.69
t Temp b Turbine	32.77	42.69
t Temp a Turbine	32.77	42.69
p Press b Turbine	841.13	1224.25
TC Speed	93.27	96.22
Firing Pressure Avg Mean	1.48	1.64
IMEP	42.22	41.97
NO Emissions	0.87	0.94
THC Emissions	0.87	0.94
Gas + PFO Engine Efficiency	42.22	41.97
Combustion	507.27	480.68

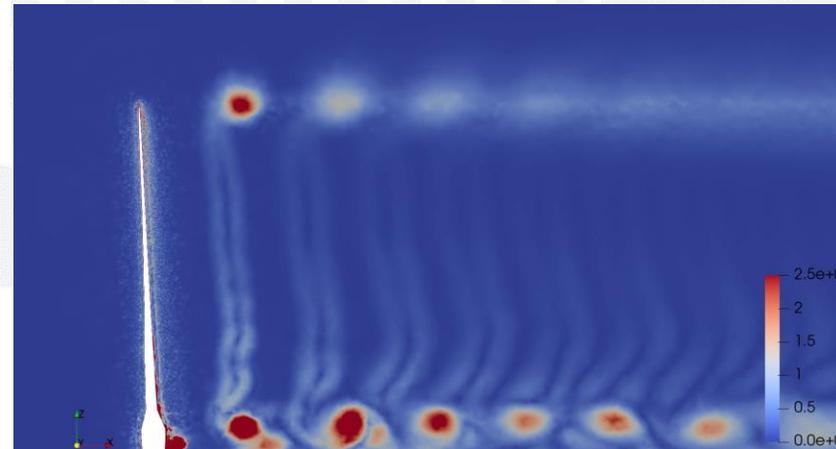
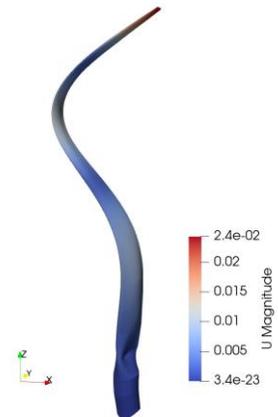
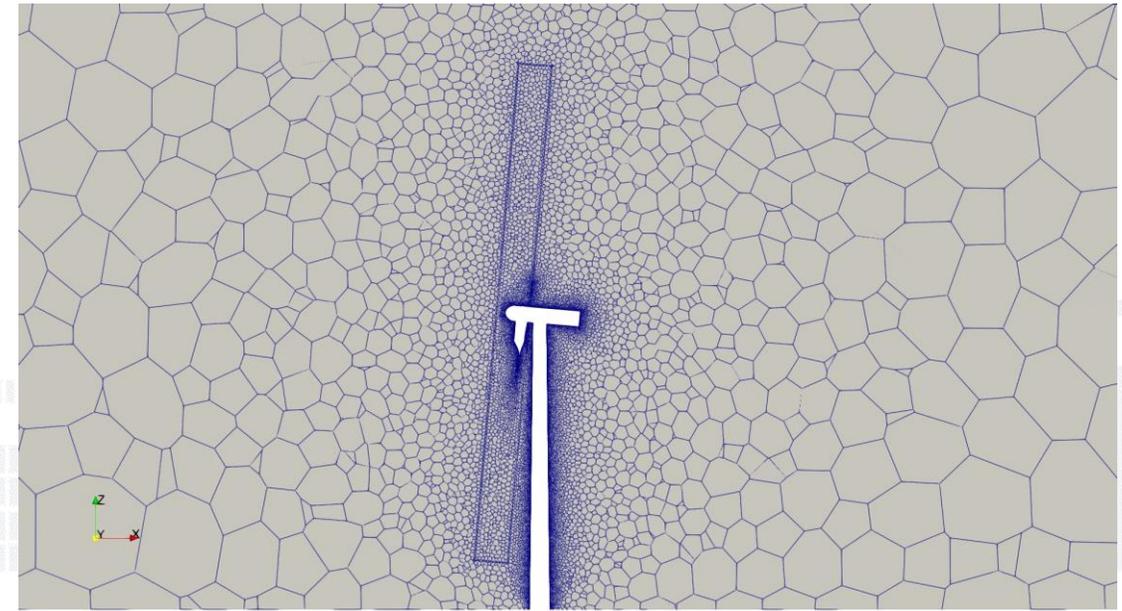
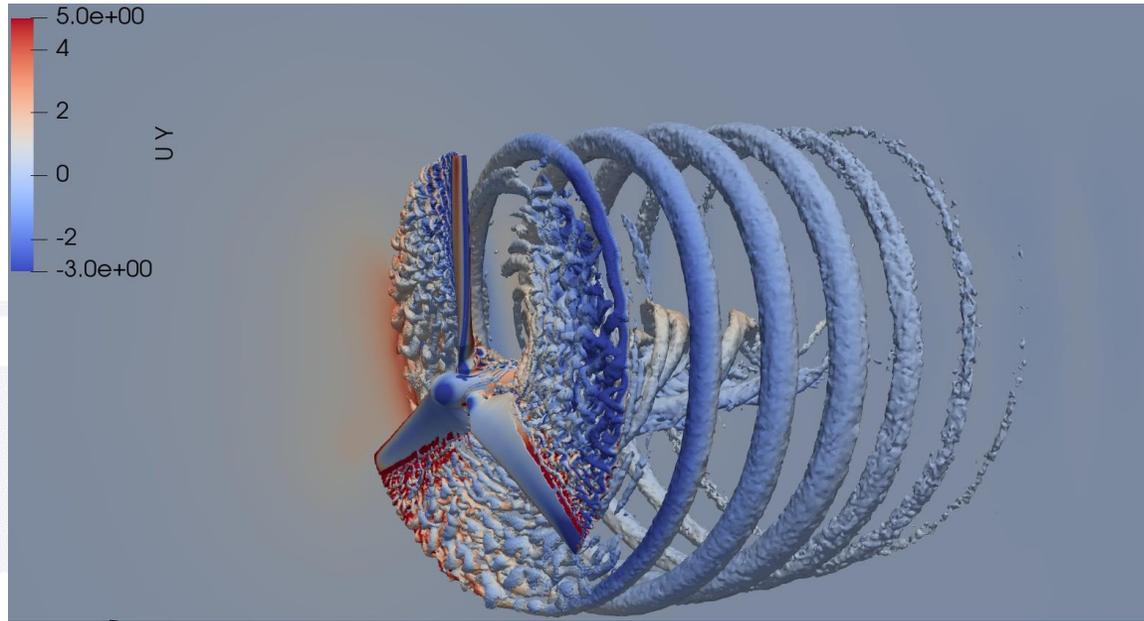
TEST TYPE
 Steady State
 Real-Time

TEST FEATURE
 Real-Time Testing
 Test Evaluation

ENGINE SPEED [rpm]

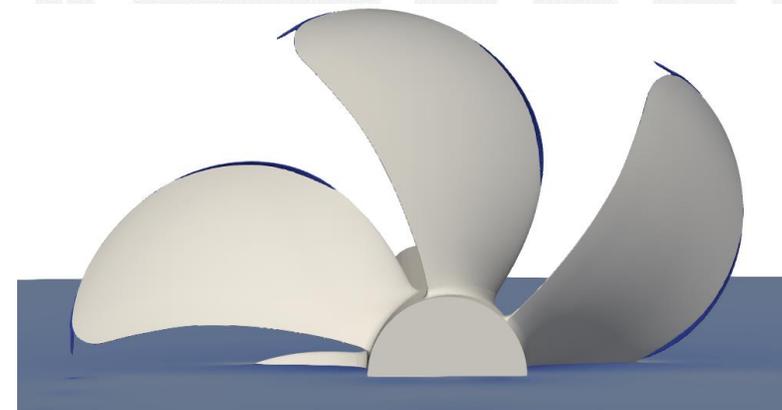
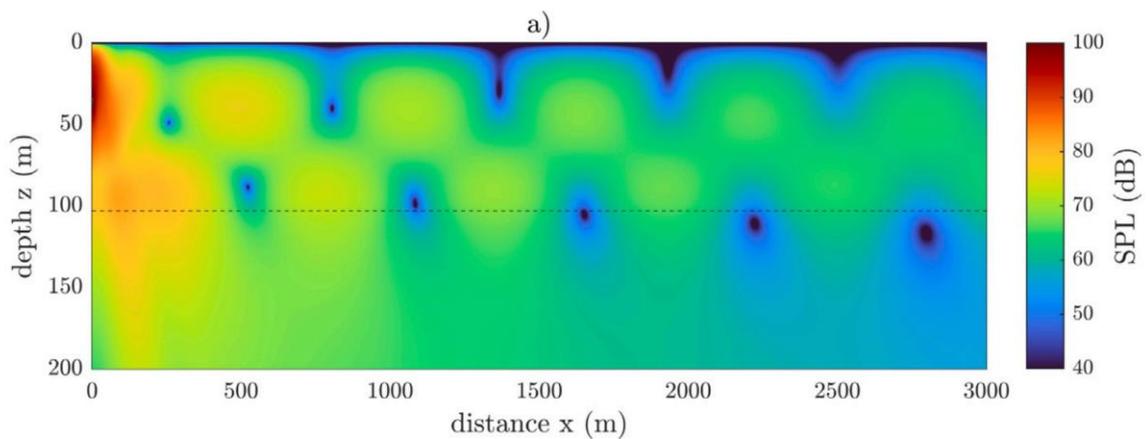
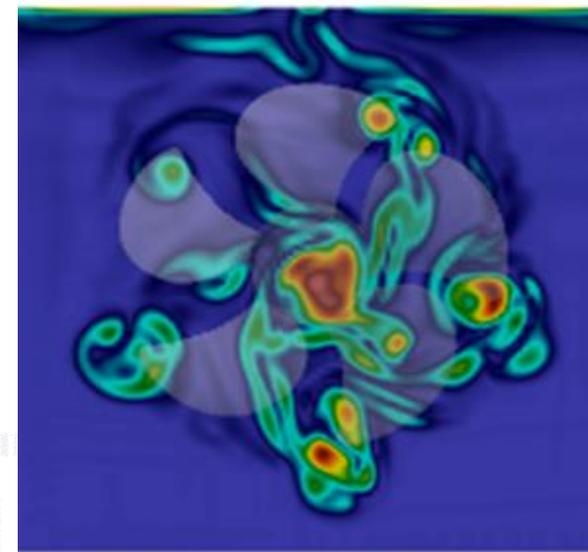
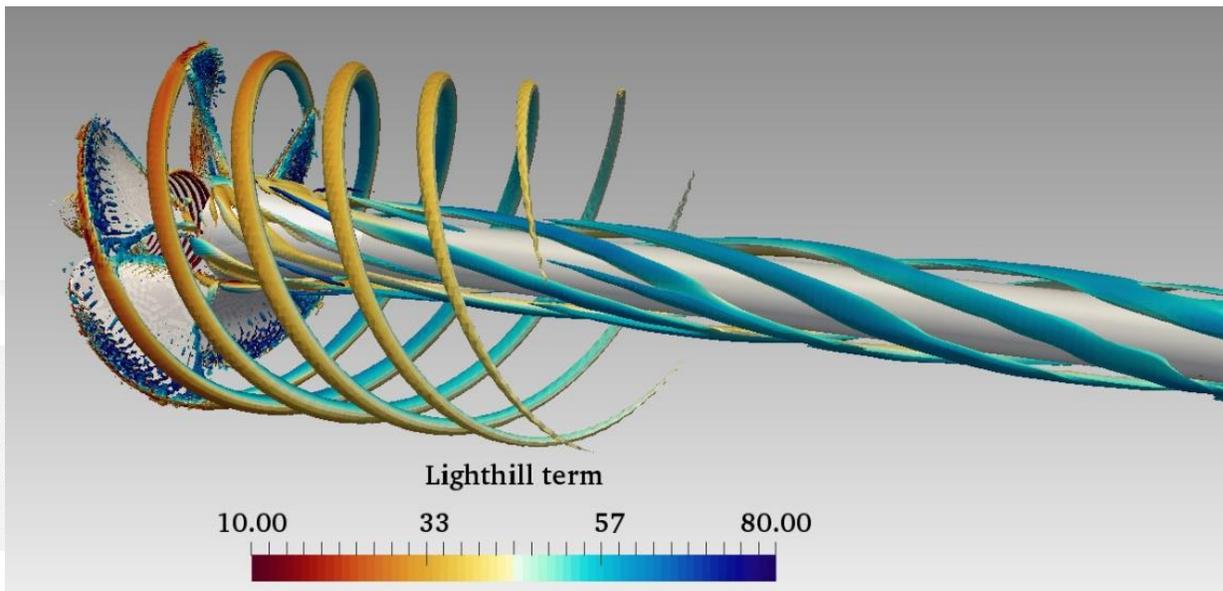


Blade/tower interaction



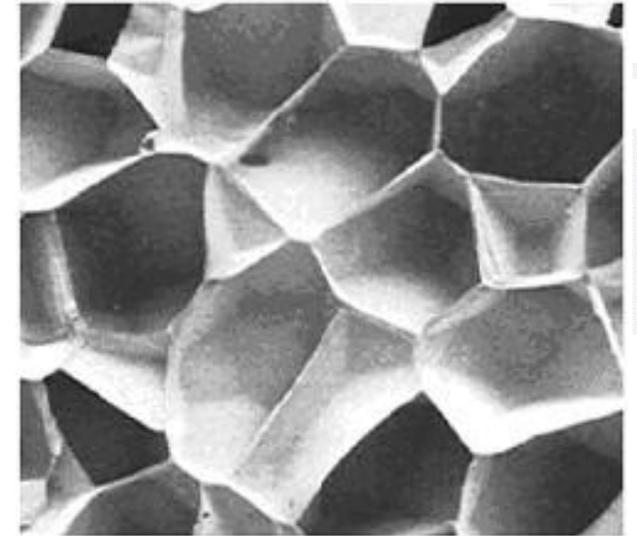
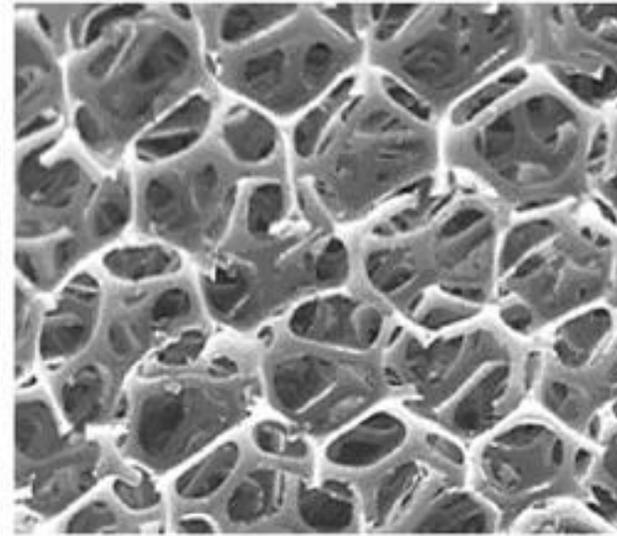


Noise and cavitation



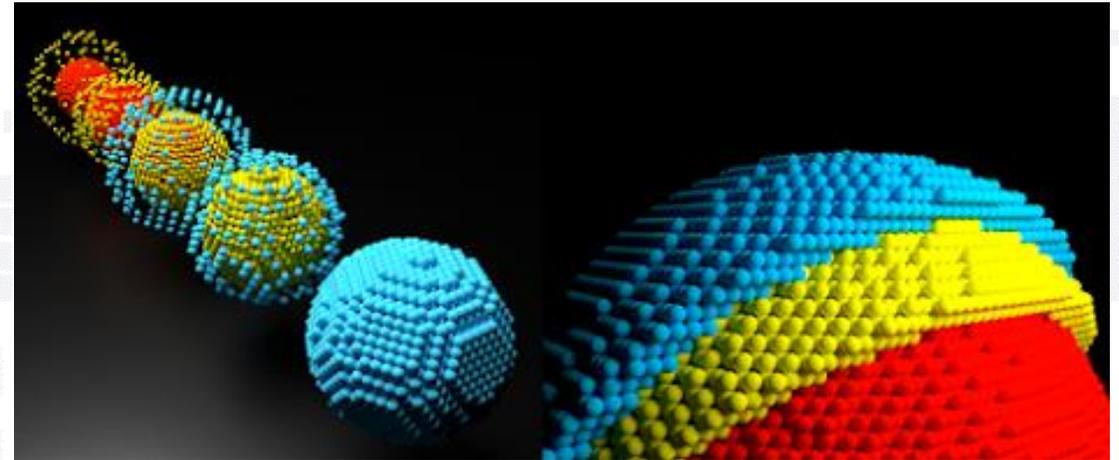
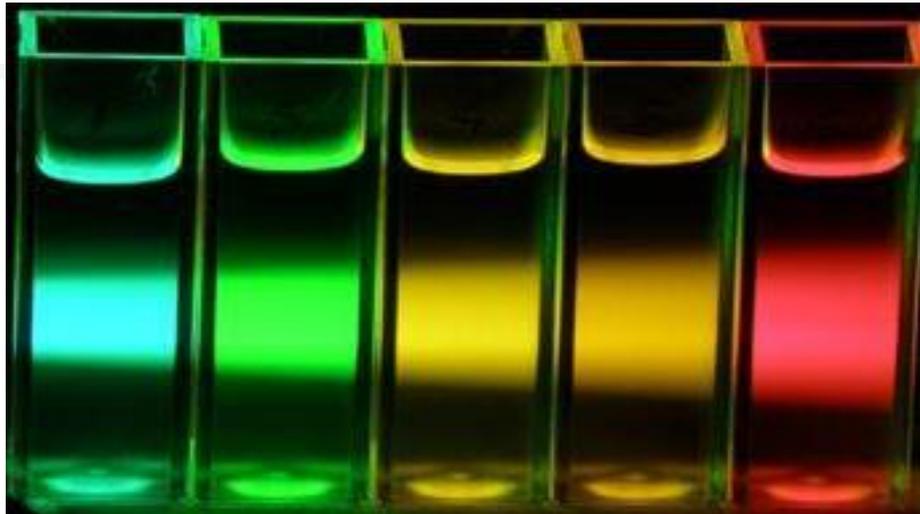


Recyclable natural composite materials for thermal insulation



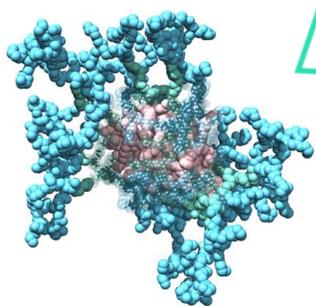
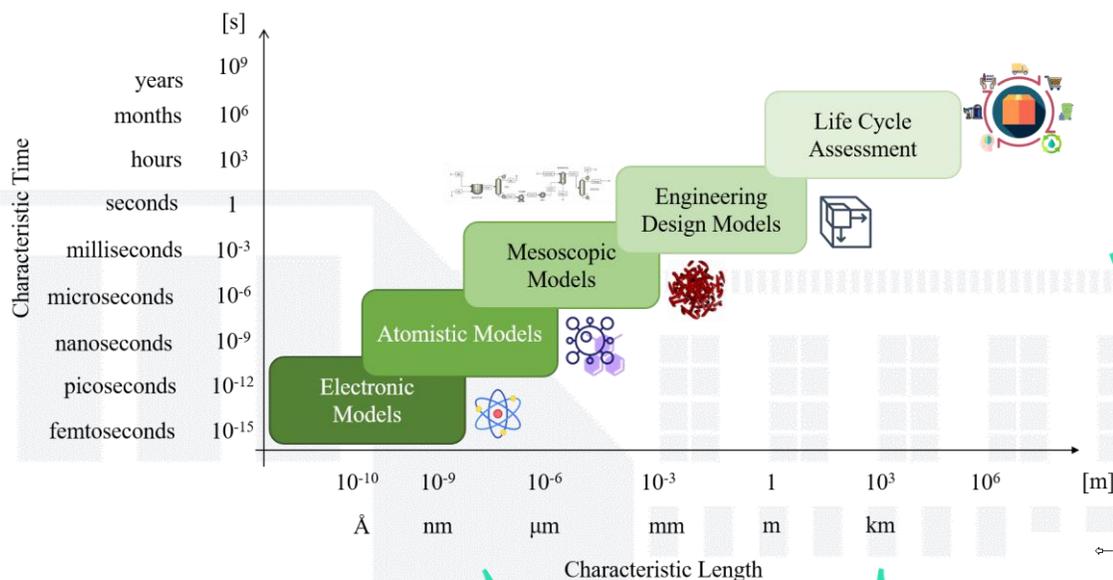


Nanostructures for photovoltaics and photocatalysis

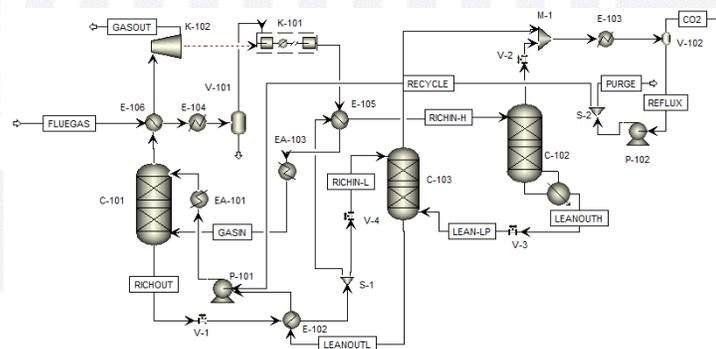




Multiscale modelling for eco-design

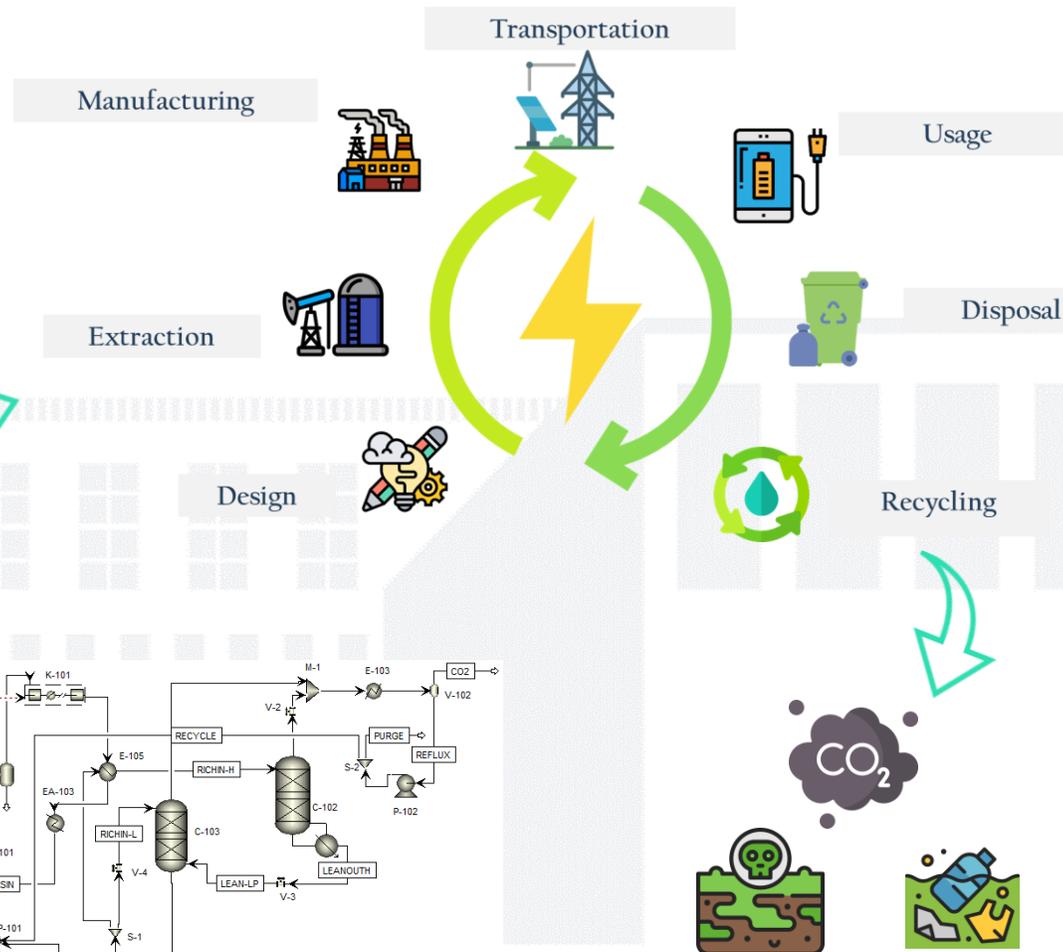


Molecular Dynamics



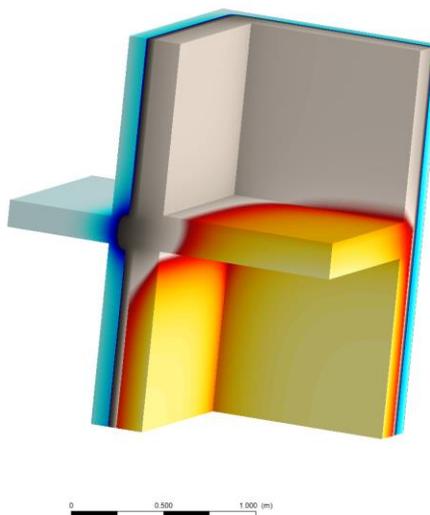
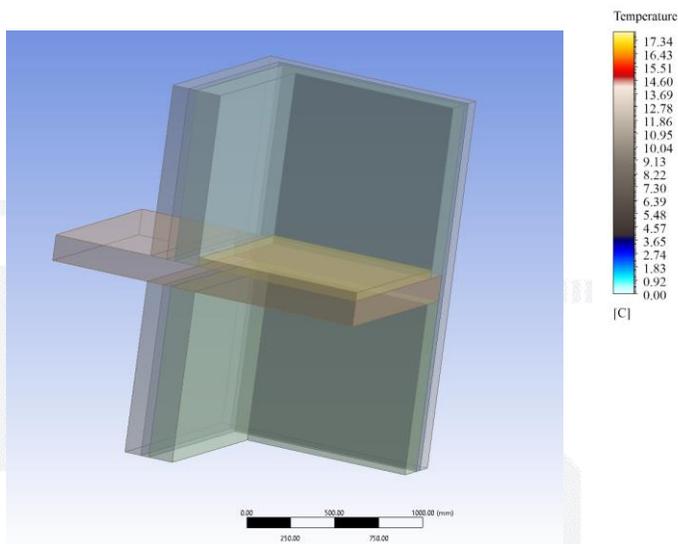
Process simulation of production
of chemical and materials

Life Cycle Assessment

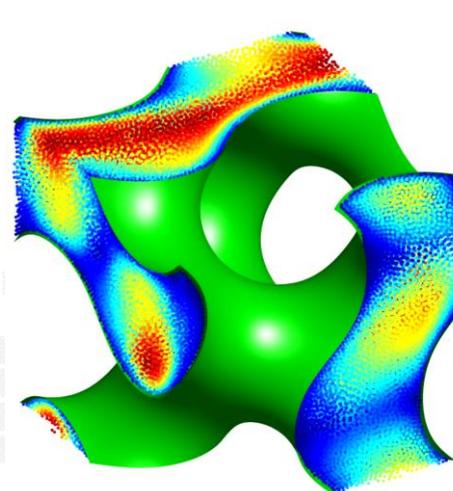


Environmental evaluation

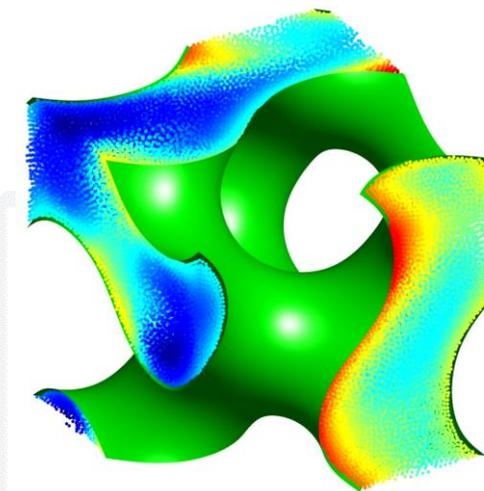
Modelling thermal bridges using the EU Standard ISO 10211: 2017



Forced convection heat transfer in a gyroid heat exchanger

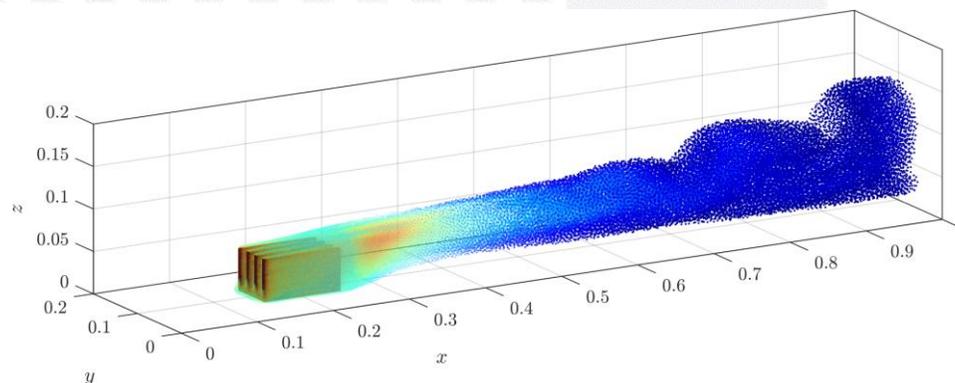
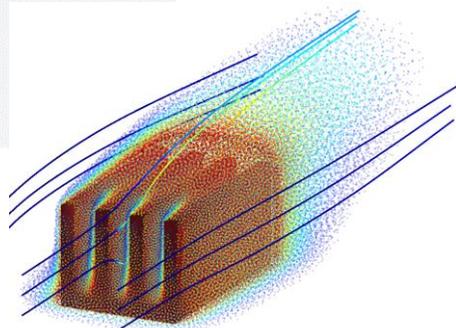


Velocity



Temperature

Forced convection heat transfer over a heat sink

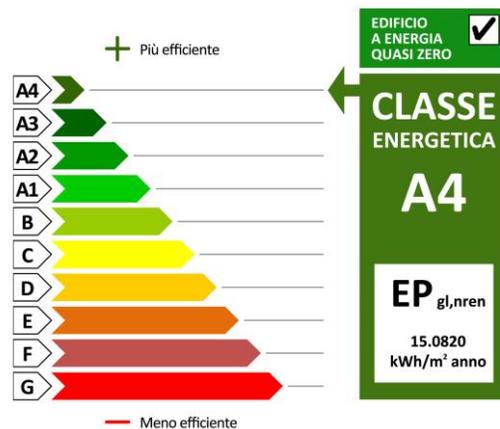




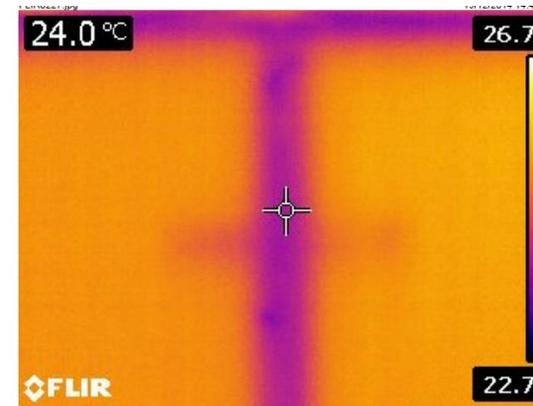
Building energy simulation Revoltella Museum in Trieste



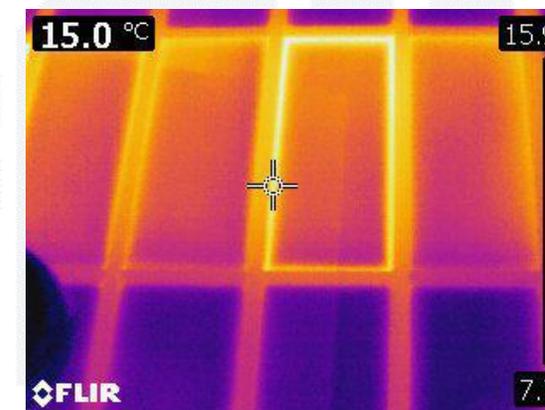
PRESTAZIONE ENERGETICA



Infrared analysis



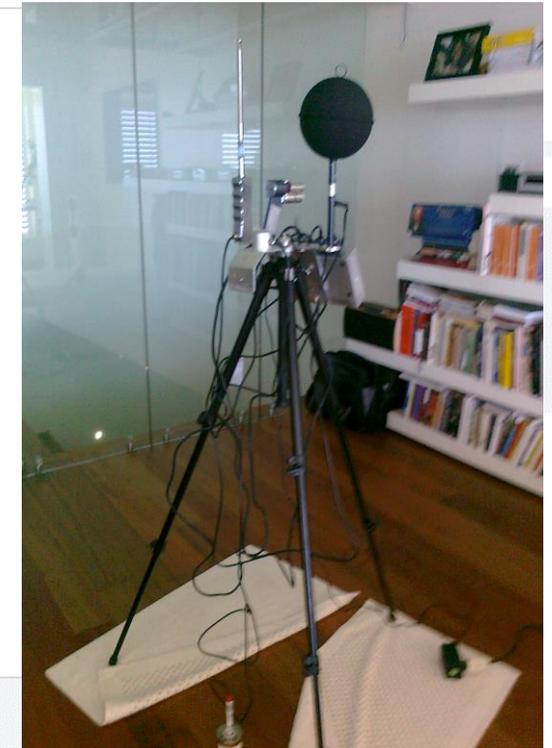
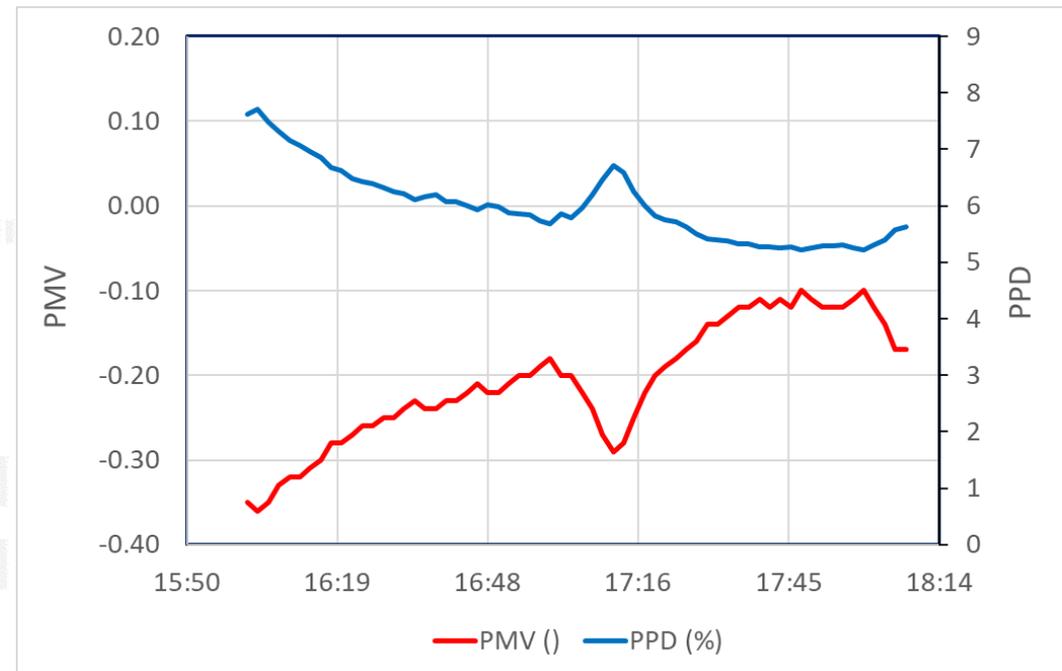
Thermal bridge due to metal studs in plasterboard internal insulation



Thermal bridge due to window frame

Thermal comfort simulation and measurements

PMV	Thermal Sensation
+3	Hot
+2	Warm
+1	Slightly Warm
0	Neutral
-1	Slightly Cool
-2	Cool
-3	Cold





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Advanced Applied Research
Sustainable Buildings

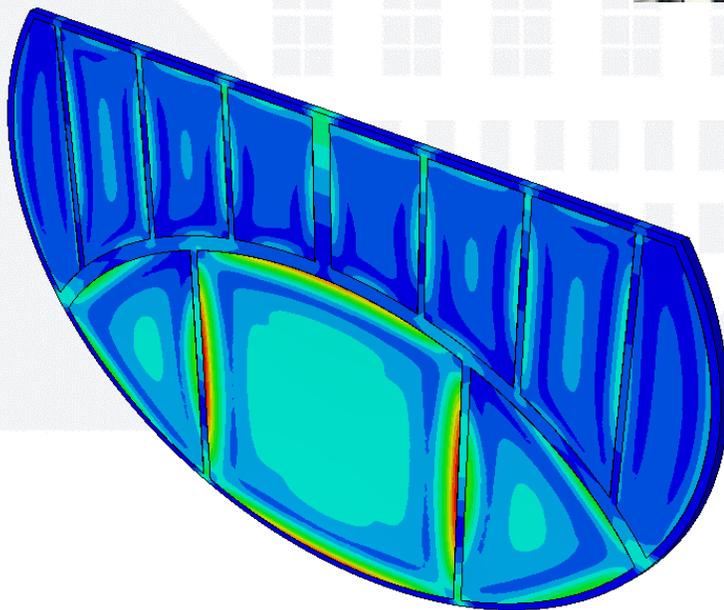
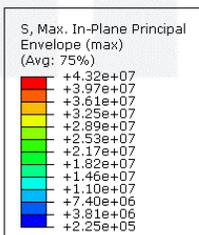
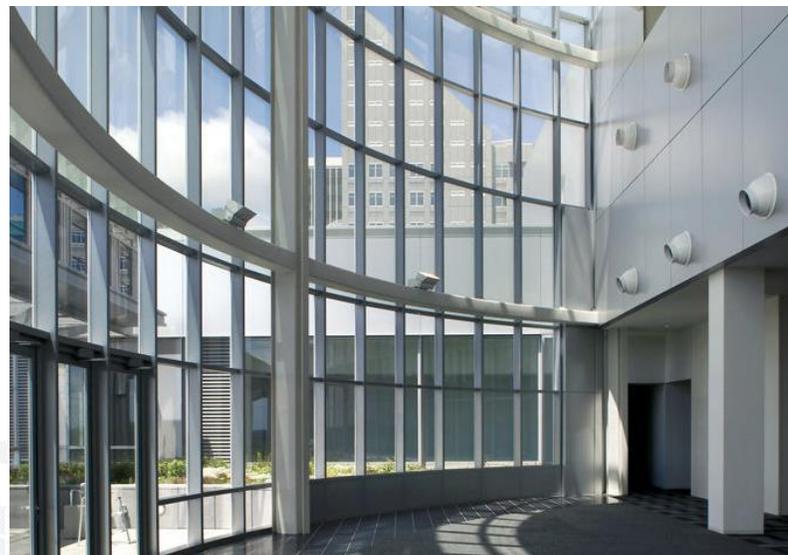
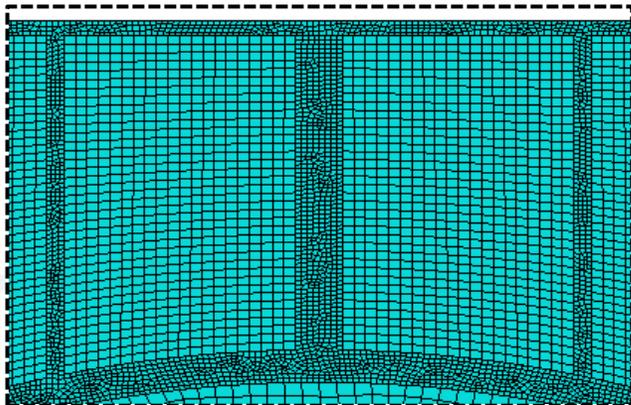
Sustainable Building Design and Technology

- Building envelopes
- Structural integration
- Construction materials
- Methods of analysis
- Design standards and requirements
- Performance indicators
- ...





Testing and modelling





Sustainability

- Concepts and strategies
- Green buildings
- Innovative materials
- Reuse and recycle





Structural needs

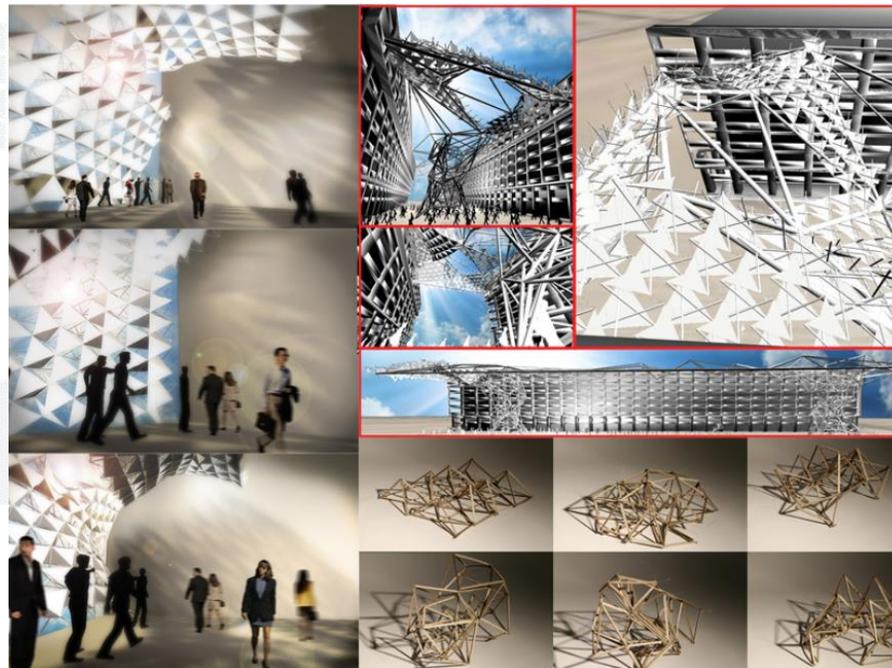
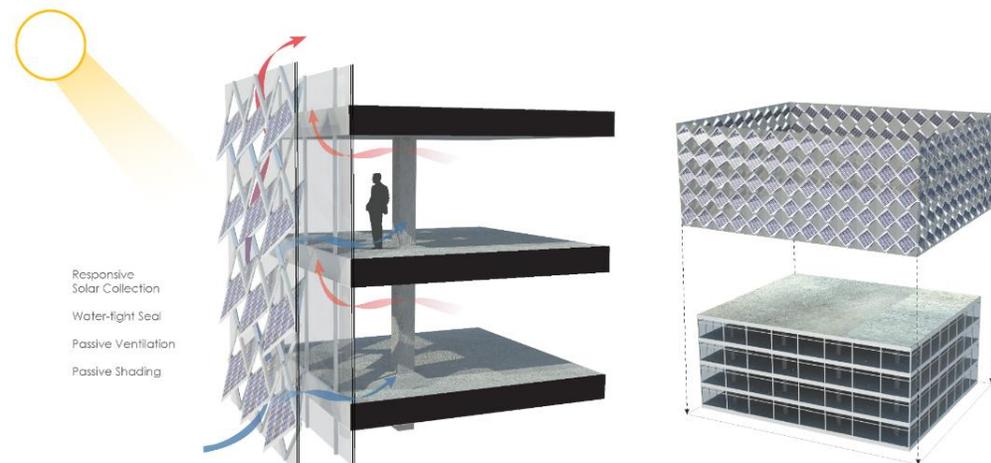
- Standards and regulations
- Design actions
- Experimental protocols
- Performance requirements





Smart / Adaptive systems

- Adaptive building skins
- Technologies
- Performances





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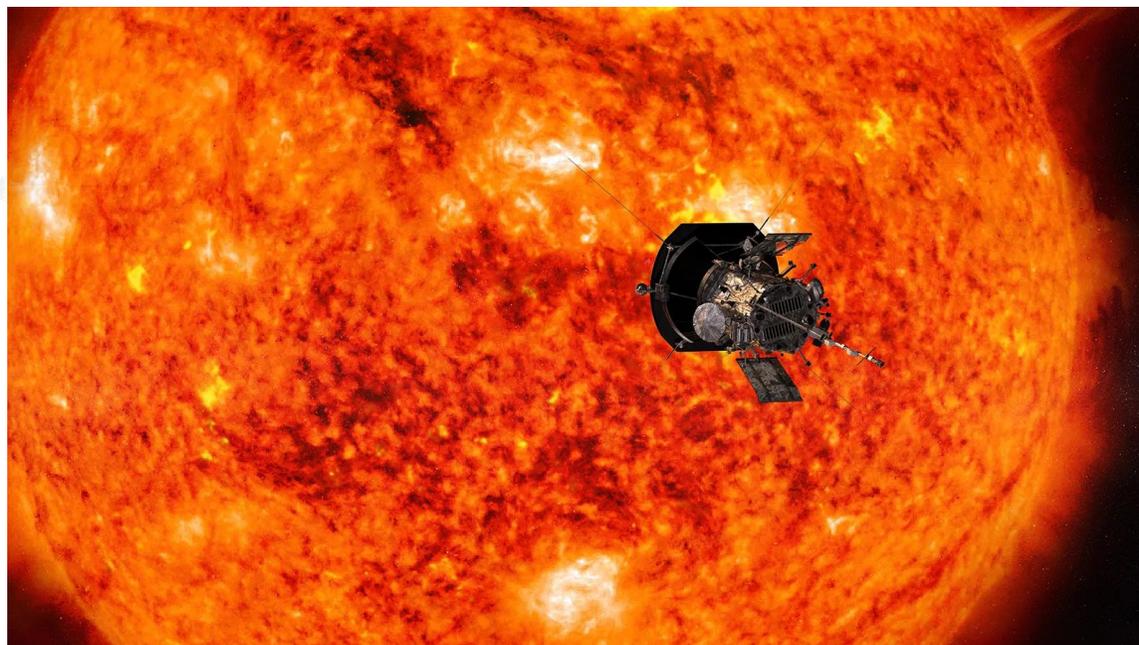
Organizations involved
in the Master's creation



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