Investigação e ensino: Contributos para a transição energética

Centro de Excelência de Formação de Formadores para o Gás Natural

Universidade Lúrio

18 de julho 2023

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Departamento de Engenharia Mecânica, FCTUC

01

Breve apresentação da UC e da ADAI

A Universidade de Coimbra

Fundada em 1290 e classificada em **2013** como **património mundial pela UNESCO**, a Universidade de Coimbra tem vindo a reforçar a sua posição singular, reunindo **tradição**, **atualidade** e **inovação**.

A Universidade acolhe **25.200 alunos**, **1.750 docentes** e **1.200 Investigadores**

Organizada em **11 faculdades**, oferece todos os níveis académicos em Arquitetura, Engenharia, Ciências Exatas, Ciências Naturais, Ciências Médicas, Psicologia, Ciências Sociais, Humanas, Direito e Desporto

Organização das Nações Unidas para a Educação, a Ciência e a Cultura

Universidade de Coimbra – Alta e Sofia inscrita na Lista do Património Mundial em 2013

A NOSSA HISTÓRIA

- **ADAI** - Associação para o Desenvolvimento da Aerodinâmica Industrial é uma instituição privada de interesse público, fundada em 1990

- Está ligada ao **DEMUC** - Departamento de Engenharia Mecânica da UC, área de energia e ambiente

- Unidade de gestão do **LAETA** – Laboratório associado em Energia, Transportes e Aeroespacial (avaliado com **Excelente** pela FCT)

ÁREAS DE INVESTIGAÇÃO E DESENVOLVIMENTO

Energia, Ambiente e Conforto

Incêndios Florestais e Detónica

CENTROS ADAI

A ADAI encontra-se estruturada em quatro centros de investigação :

CEIF

CEI

CSBE

CED

INFRAESTRUTURAS

Maioritariamente, a ADAI desenvolve a sua atividade nas seguintes infraestruturas:

LEDAP - Laboratório de Energética e Detónica (Condeixa)

LEIF - Laboratório de Estudos sobre Incêndios Florestais (Lousã)

LAI - Laboratório de Aerodinâmica Industrial (Coimbra)

ATIVIDADE da ADAI 2022

- 123 PUBLICAÇÕES
- 135 INVESTIGADOR@S
- 61 PROJETOS E PRESTAÇÕES DE SERVIÇOS
- 147 COMUNICAÇÕES
- 40 FORMAÇÃO AVANÇADA
- 17 ORGANIZAÇÃO DE SEMINÁRIOS E CONFERÊNCIAS
- 33 RELATÓRIOS
- 13 APLICAÇÕES COMPUTACIONAIS E INSTALAÇÕES PILOTO

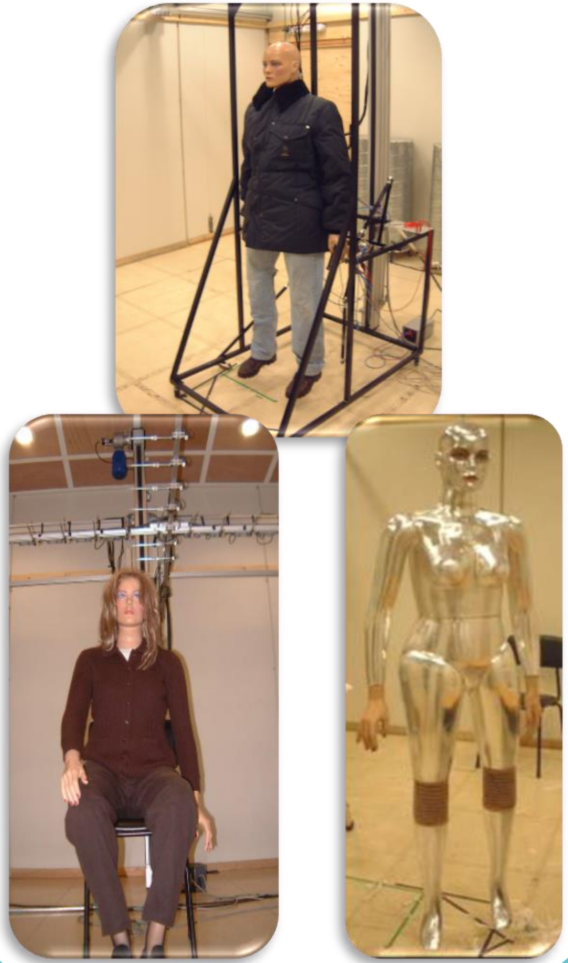
ADAI – Associação para o Desenvolvimento da Aerodinâmica Industrial

Aerodinâmica – Estudos em túnel e CFD

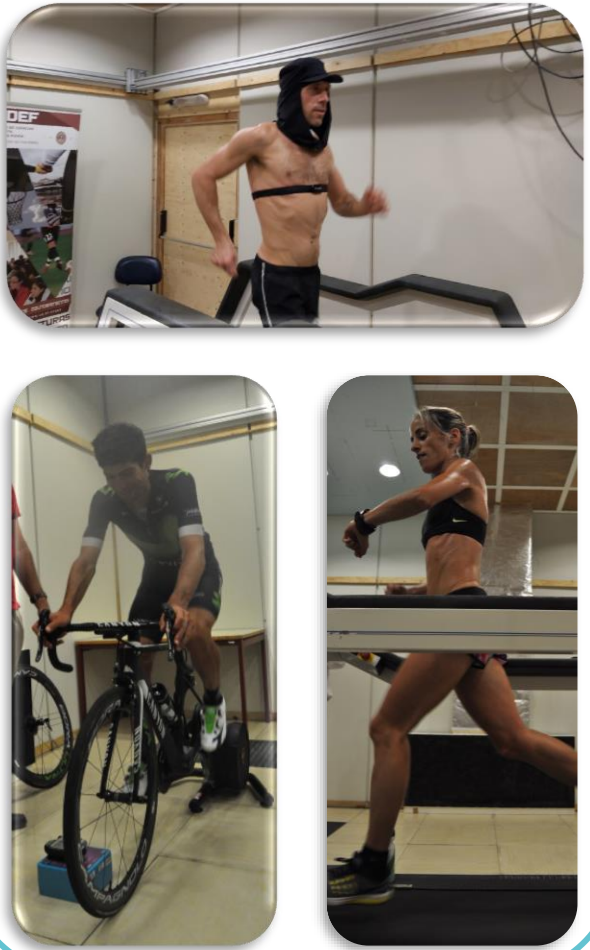
Câmara Climática – Ambientes térmicos

Câmara Climática

Manequim de térmico



Atletas em treino de aclimatação

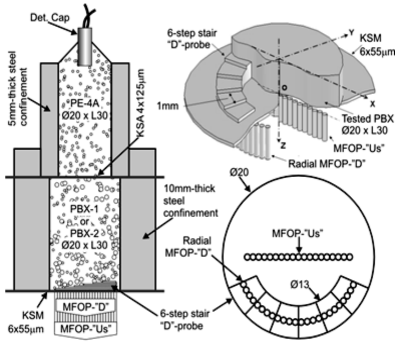


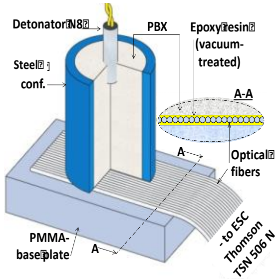
Laboratório de Estudos em Incêndios Florestais

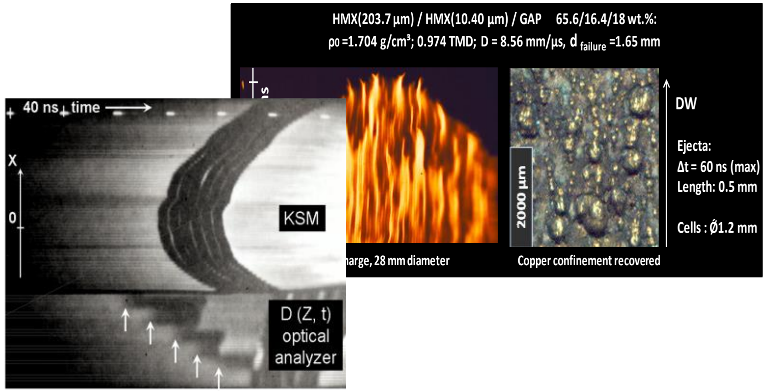
Equipamento laboratorial para estudo e formação sobre o comportamento de incêndios

LEDAP– produtos energéticos e detónica

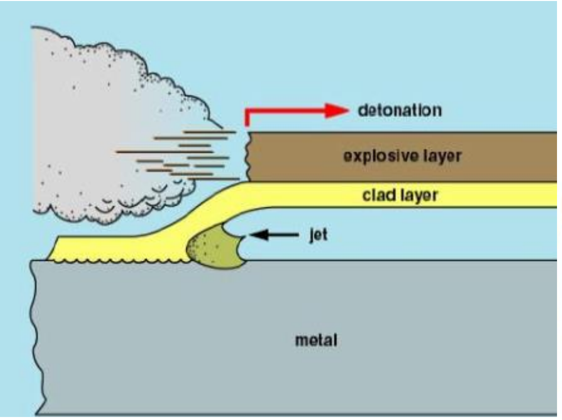
Ondas de Choque e Detonação

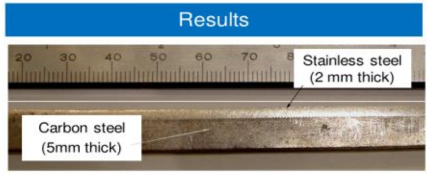


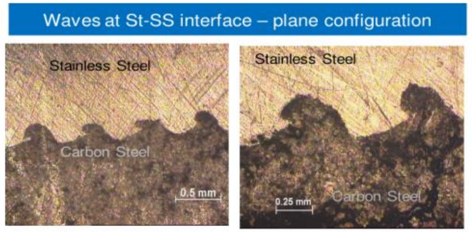




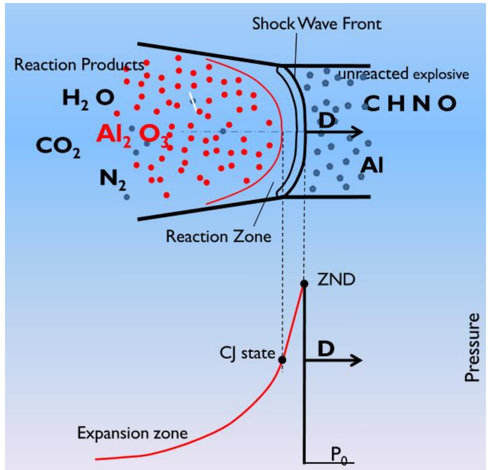
Soldadura por Detonação

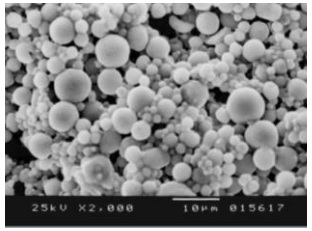


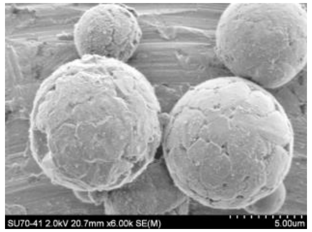




Síntese de micro, nano partículas cerâmicas







02

Alterações climáticas

Situação energética e emissões de CO_2 em números

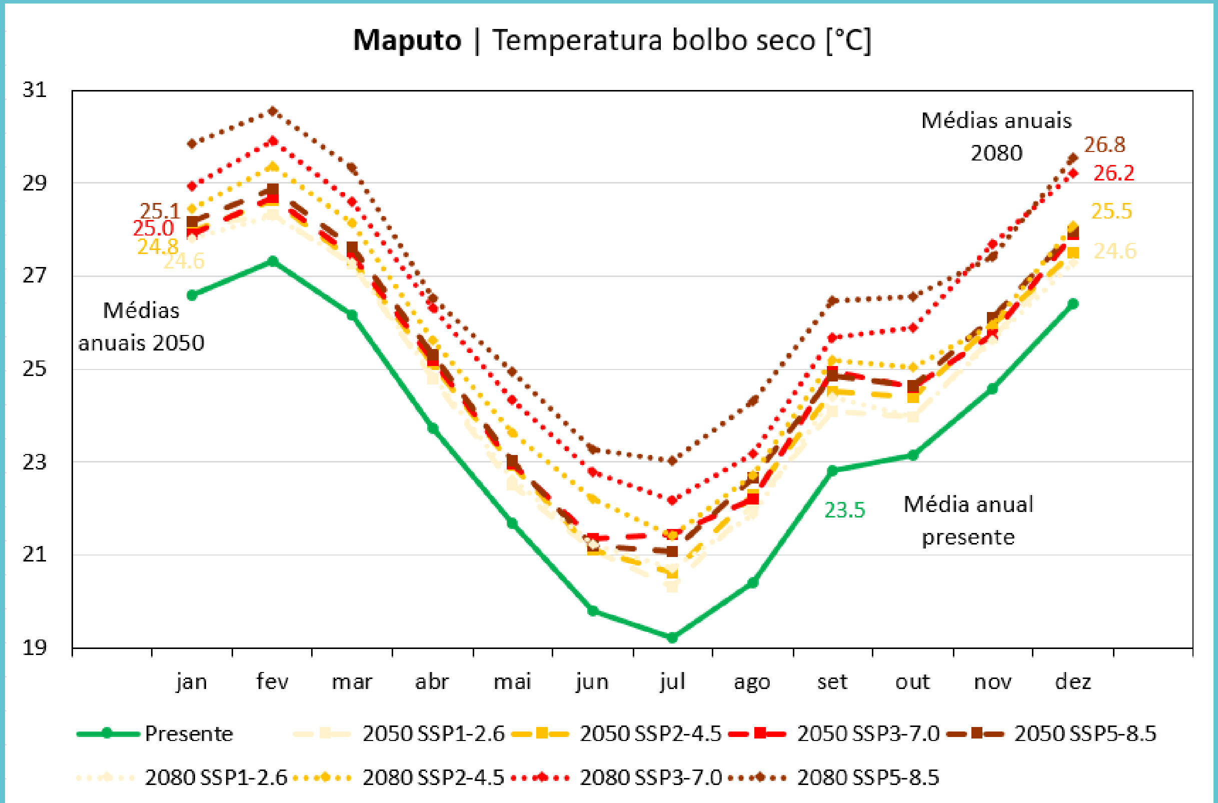
SSP - Shared Socioeconomic Pathways

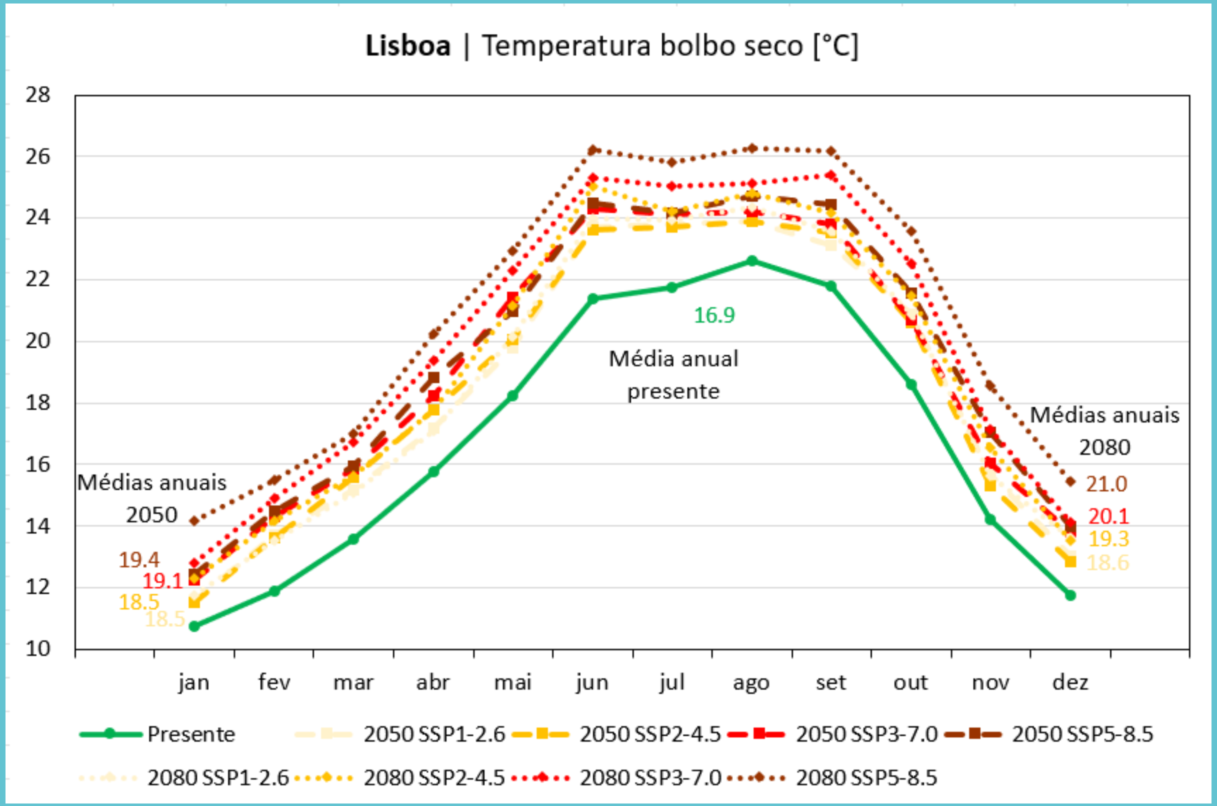
SSP	Cenário	Aquecimento estimado (2041-2060)	Aquecimento estimado (2081-2100)
SSP1-2.6	Baixas emissões de GEE: emissões de CO_2 reduzidas a zero em 2075	1.7 °C	1.8 °C
SSP2-4.5	Emissões intermediárias de GEE: emissões de CO_2 em torno dos níveis actuais até 2050, decaindo depois, mas não atingindo zero até 2100	2.0 °C	2.7 °C
SSP3-7.0	Altas emissões de GEE: emissões de CO_2 duplicam até 2100	2.1 °C	3.6 °C
SSP5-8.5	Emissões muito altas de GEE: emissões de CO_2 triplicam até 2075	2.4 °C	4.4 °C

IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.
https://web.archive.org/web/20210819125401/https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

IPCC - Intergovernmental Panel on Climate Change

Variação da temperatura ambiente média mensal



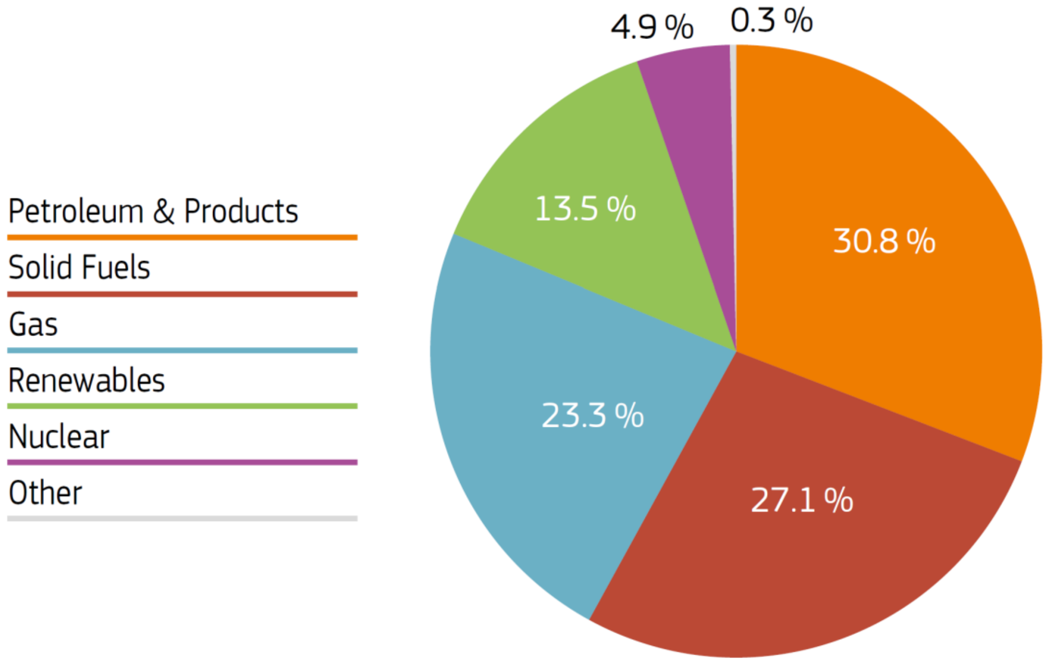


Resultados obtidos com 'Future Weather Generator' v0.5.4 (https://adai.pt/future-weather-generator/)

Ficheiros climáticos de base em https://climate.onebuilding.org/:
MOZ_MC_Maputo.Intl.AP.673410_TMYx.2004-2018.epw
PRT_LB_Lisboa.Portela.AP.085360_TMYx.2004-2018.epw

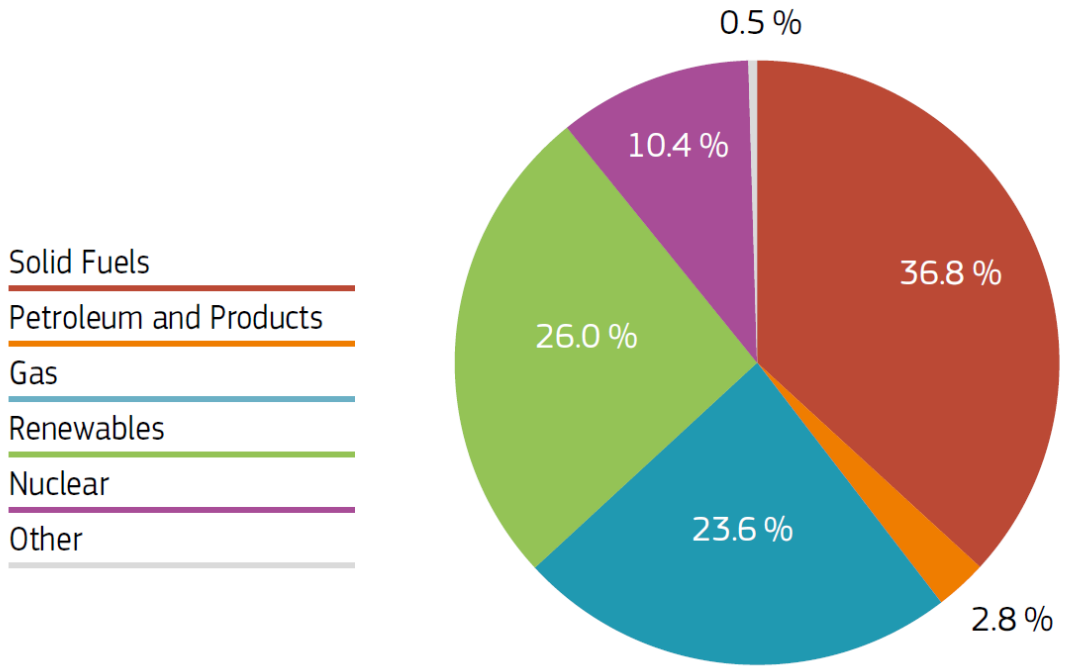
World Energy Production by Fuel

TOTAL 2019 = 14745 Mtoe

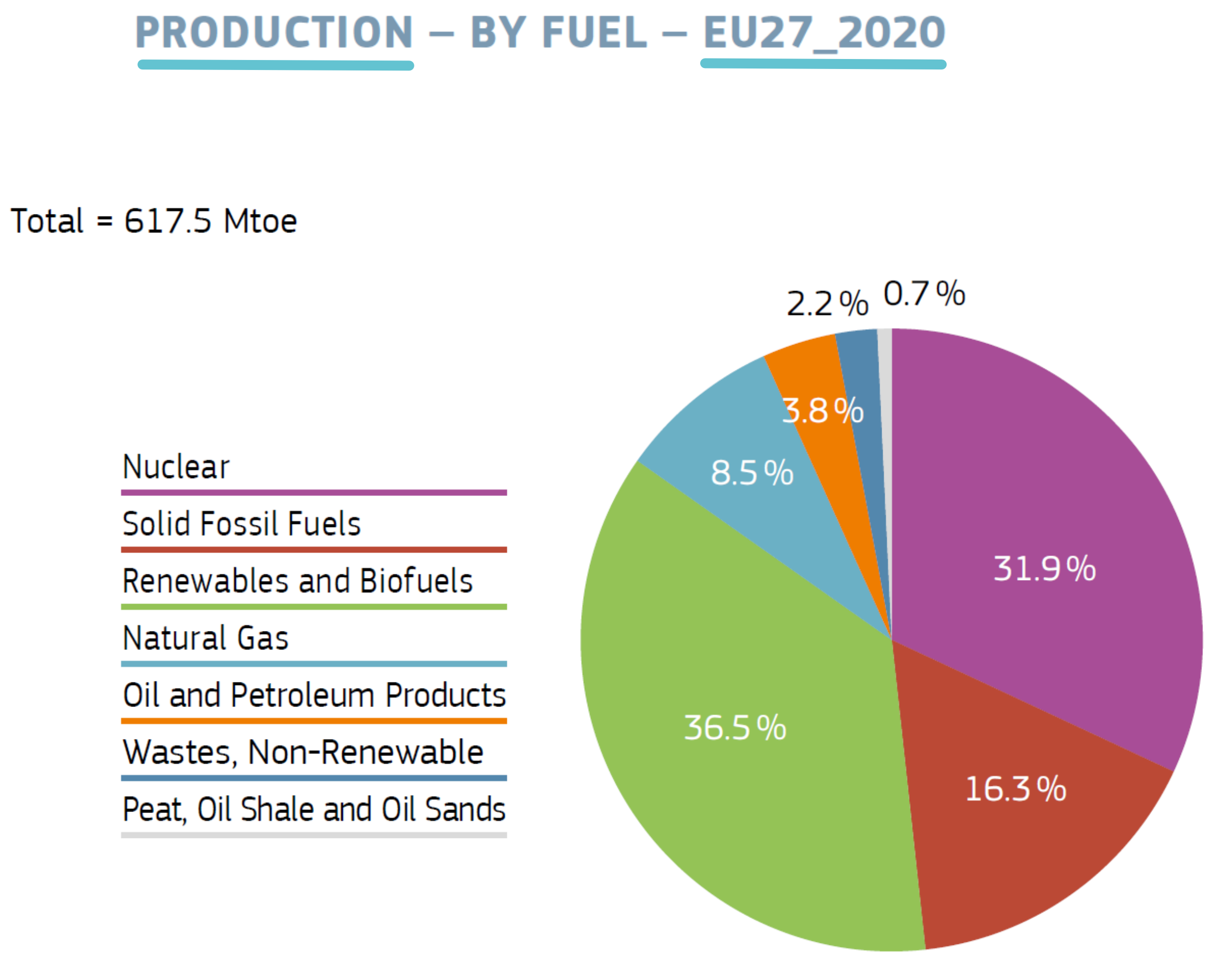


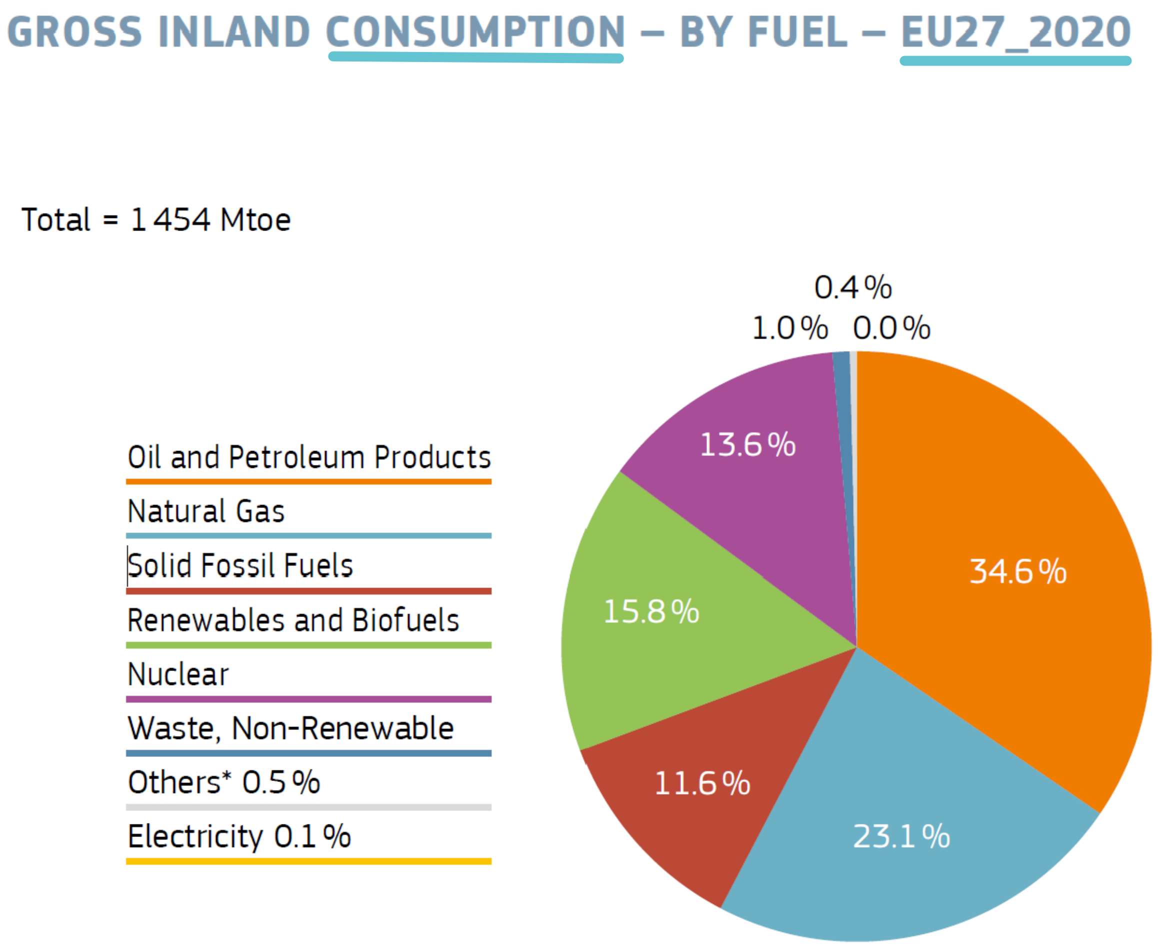
World Electricity Generation by Fuel

TOTAL 2019 = 26936 TWh



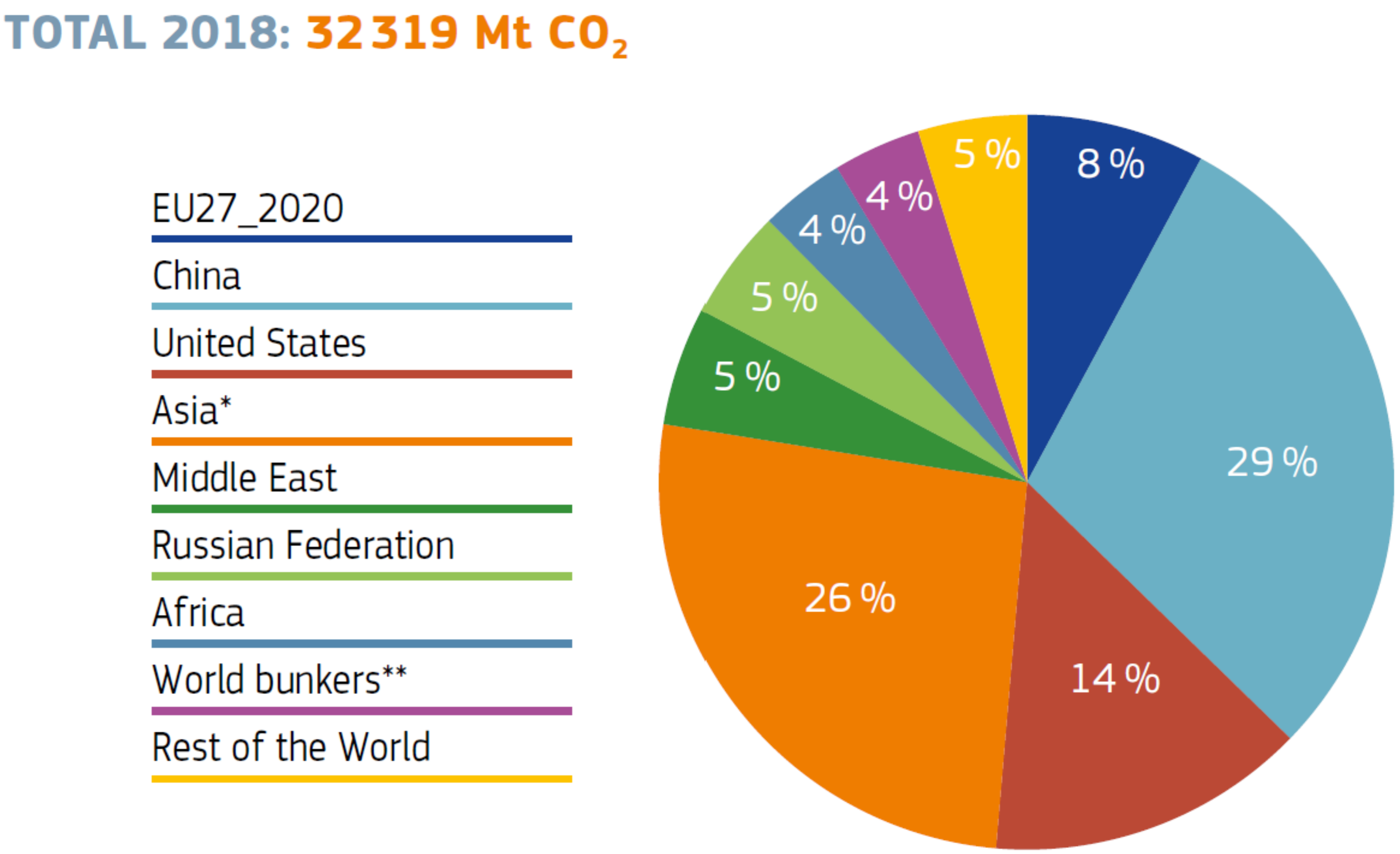
European Commission, Directorate-General for Energy, *EU energy in figures : statistical pocketbook 2021*, Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2833/511498





European Commission, Directorate-General for Energy, *EU energy in figures : statistical pocketbook 2021*, Publications Office of the European Union, 2021, **https://data.europa.eu/doi/10.2833/511498**

World CO_2 Emissions by Region

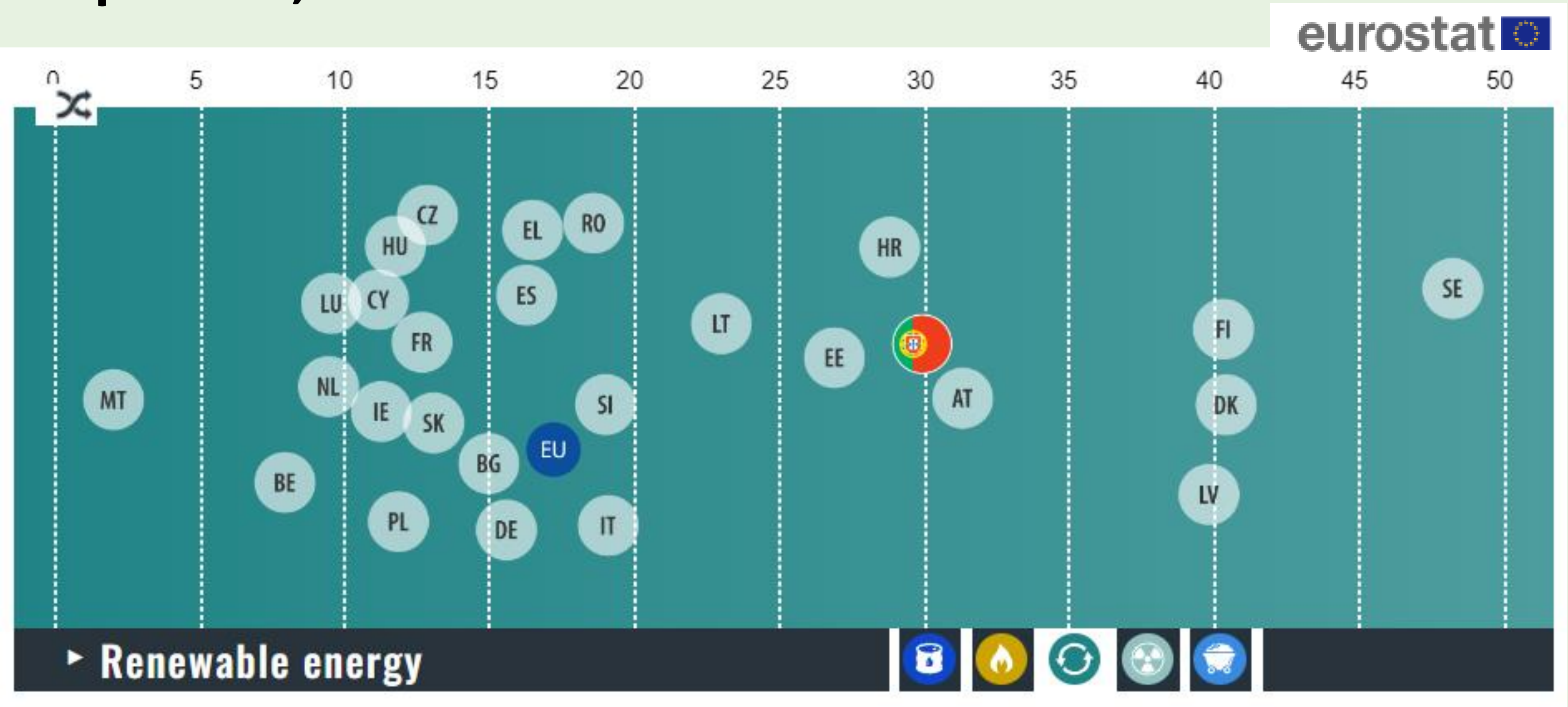


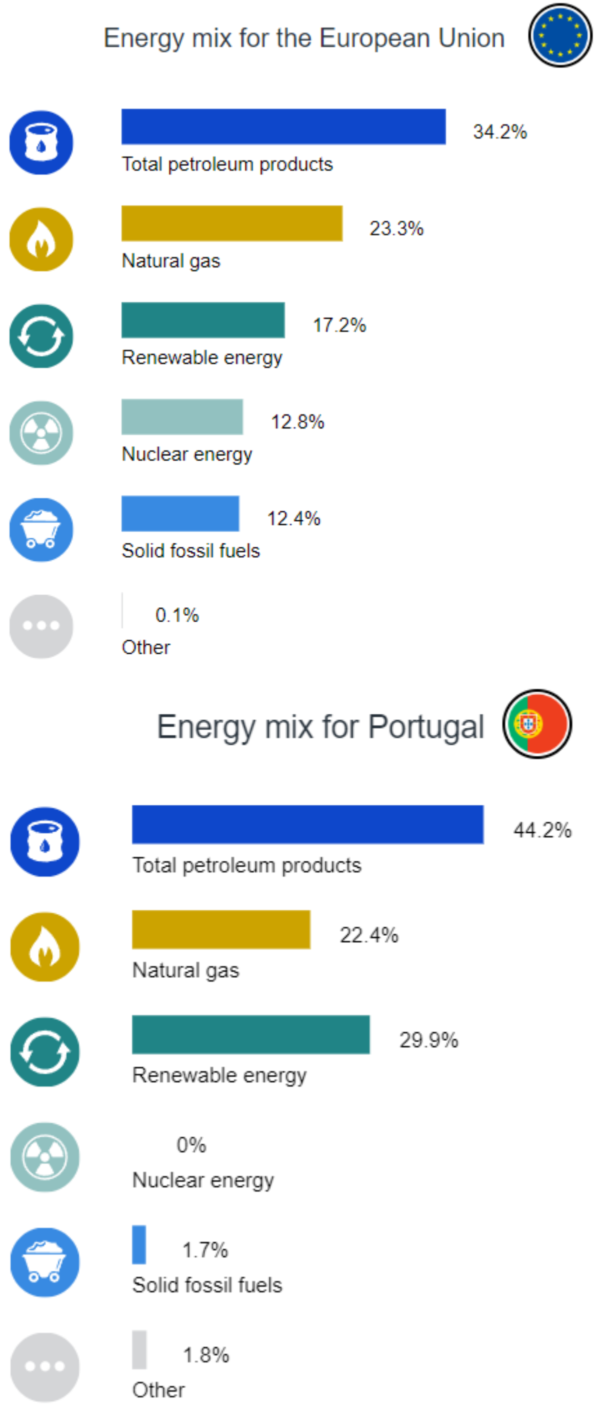
European Commission, Directorate-General for Energy, *EU energy in figures : statistical pocketbook 2021*, Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2833/511498

03

Estratégia na Europa (e em Portugal) para a transição energética

Percentagem de energias renováveis no total de energia disponível, 2021





Em 2021, a UE produziu apenas cerca de **44%** da sua própria energia, importando **56%**.

Os **produtos petrolíferos** têm a maior quota do **mix energético** europeu (5 fontes principais).

As **energias renováveis** têm apenas uma quota de **17%** do mix energético europeu.

Em **Portugal**, as energias renováveis representam cerca de **30%** do seu mix energético.

Consumo de eletricidade na UE

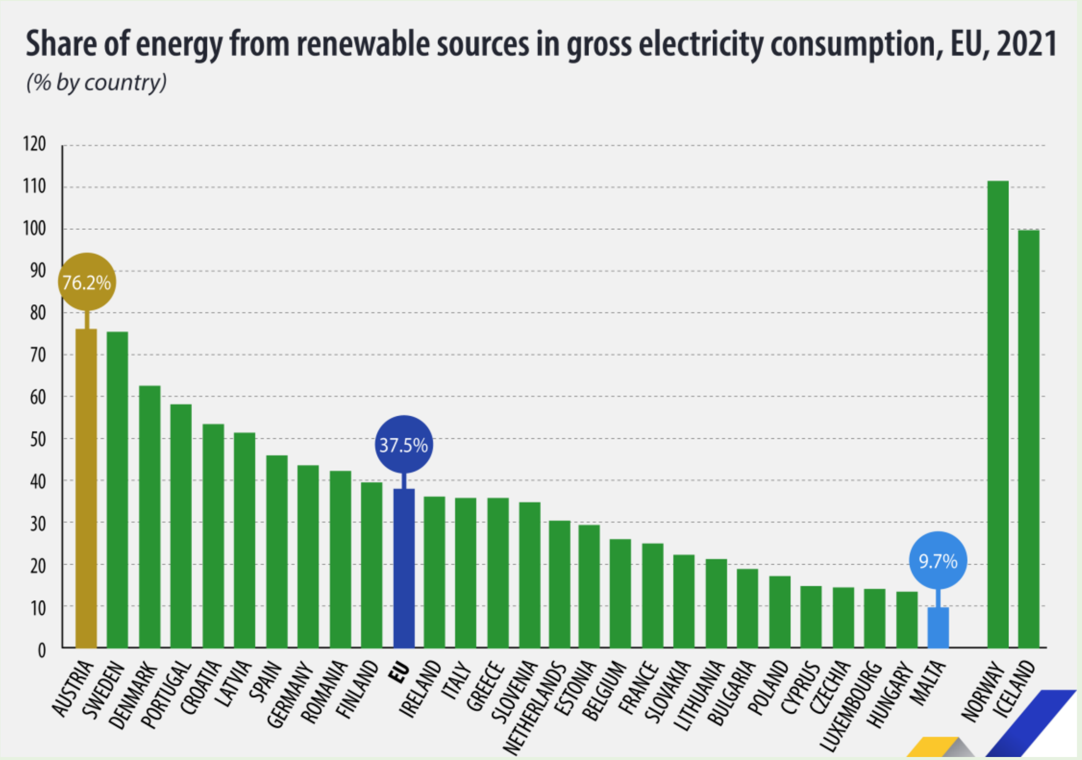
A percentagem de energias renováveis no consumo bruto de eletricidade dos países europeus **varia bastante**.

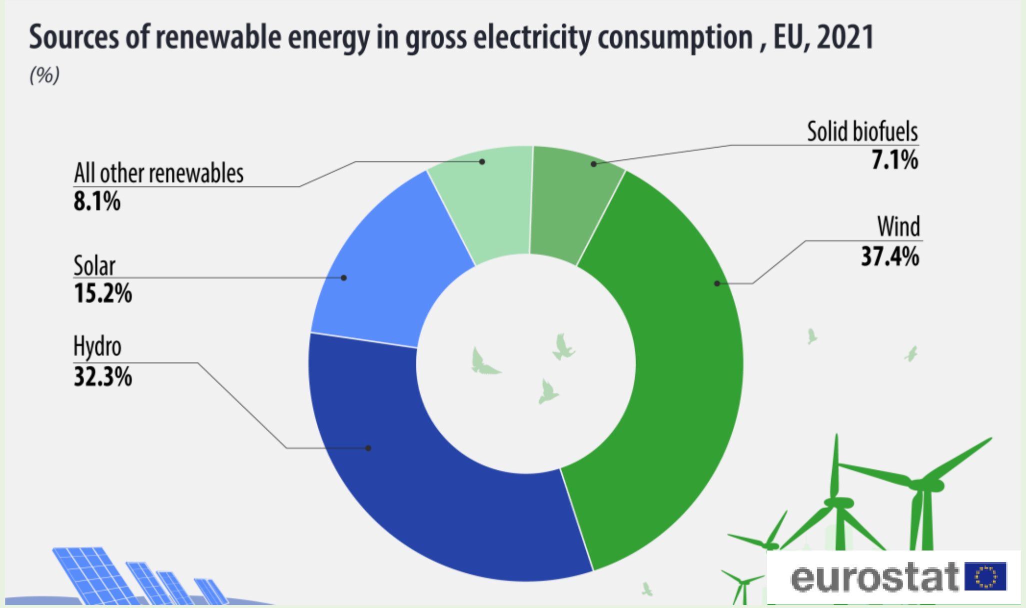
Exemplos como a **Áustria** (76.2%, maioritariamente hídrica) e a **Suécia** (75.7%, sobretudo hídrica e eólica).

Até exemplos como **Malta** (9.7%), **Hungria** (13.7%) e **Luxemburgo** (14.2%).

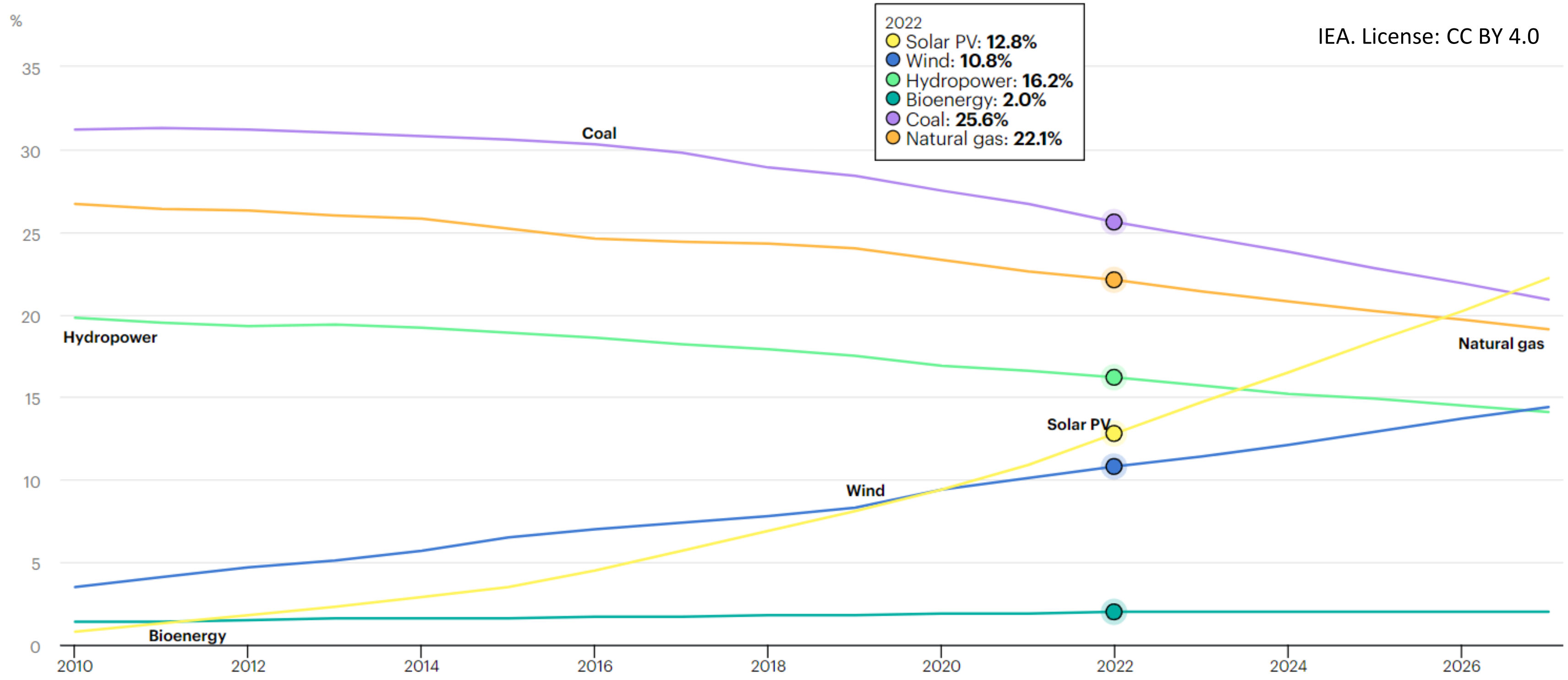
Em 2021, a **energia eólica** e a **energia hidroelétrica** representaram mais de **dois terços** da eletricidade total produzida a partir de fontes renováveis.

A **energia solar** é a fonte em **crescimento mais rápido**. Em 2008, representava apenas 1% da eletricidade consumida na UE.





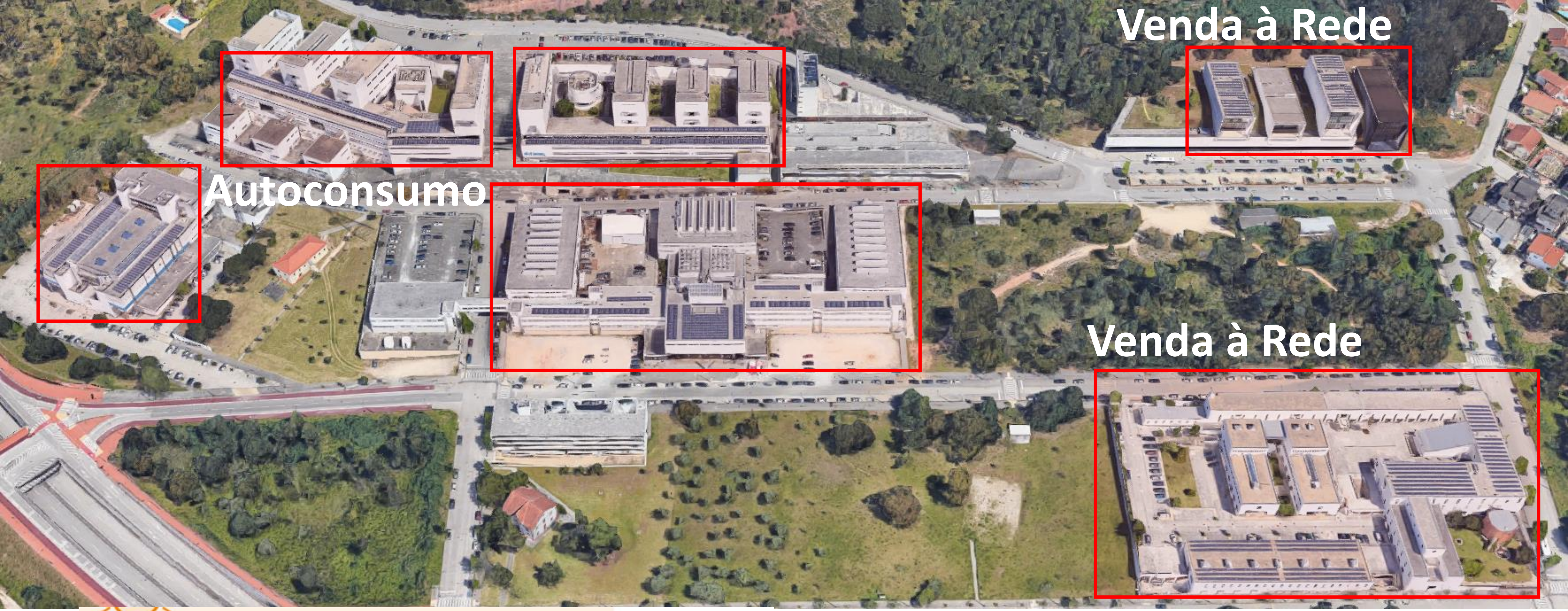
Percentagem da capacidade energética instalada acumulada por tecnologia, 2010-2027



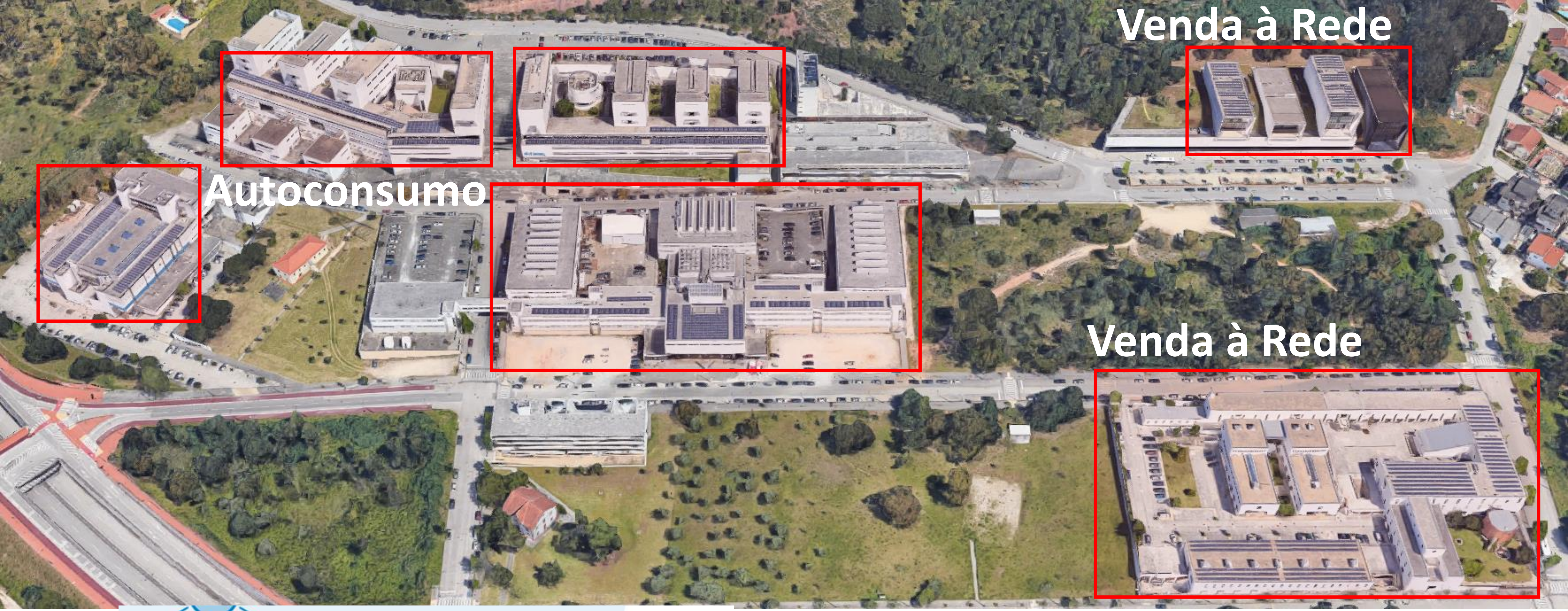
A **Agência Internacional de Energia** prevê que a capacidade solar fotovoltaica acumulada quase triplique, ultrapassando o **gás natural** em 2026 e o **carvão** em 2027.

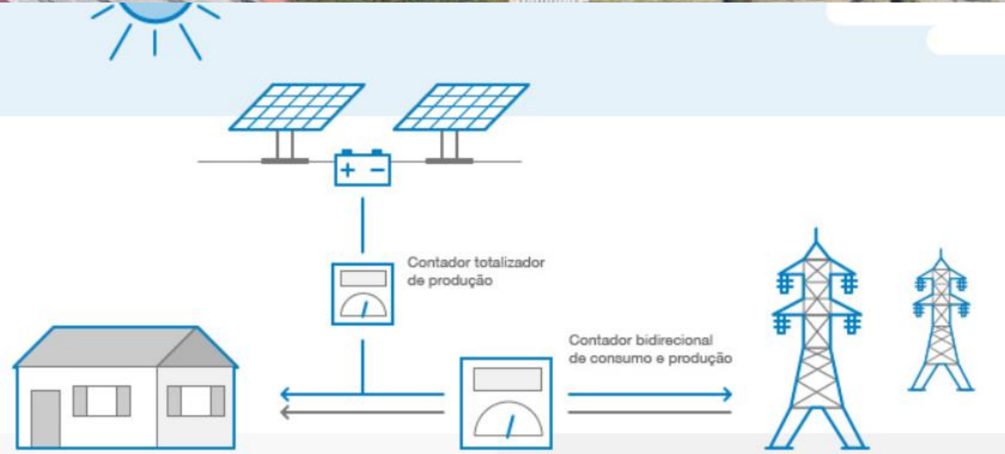
Para este **aumento** contribuirá o aumento dos preços de retalho da eletricidade e do crescente apoio político, bem como ser a opção menos dispendiosa.

A capacidade eólica quase duplicará, motivada pela aumento dos projetos offshore.

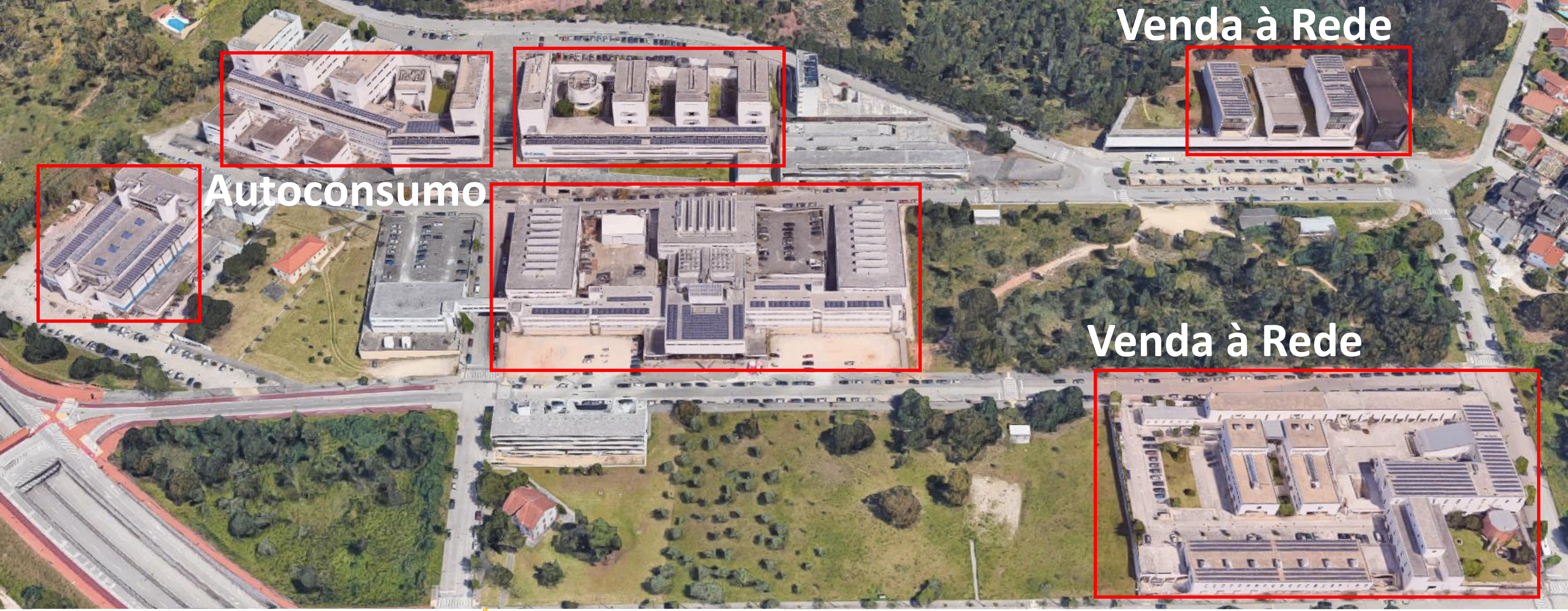


A **produção fotovoltaica** iniciou com a instalação de sistemas em modalidade de **Venda à Rede**, com tarifa fixa e duração de contrato de mais de uma década.





Numa **segunda fase**, a instalação de sistemas foi realizada na modalidade de **autoconsumo**.



Atualmente, está a ser estudado o aumento da capacidade instalada de produção fotovoltaica, estando a ser analisada a criação de uma **Comunidade de Energia Renovável**, para partilha com outras instalações da Universidade de Coimbra e consumidores na **proximidade**.

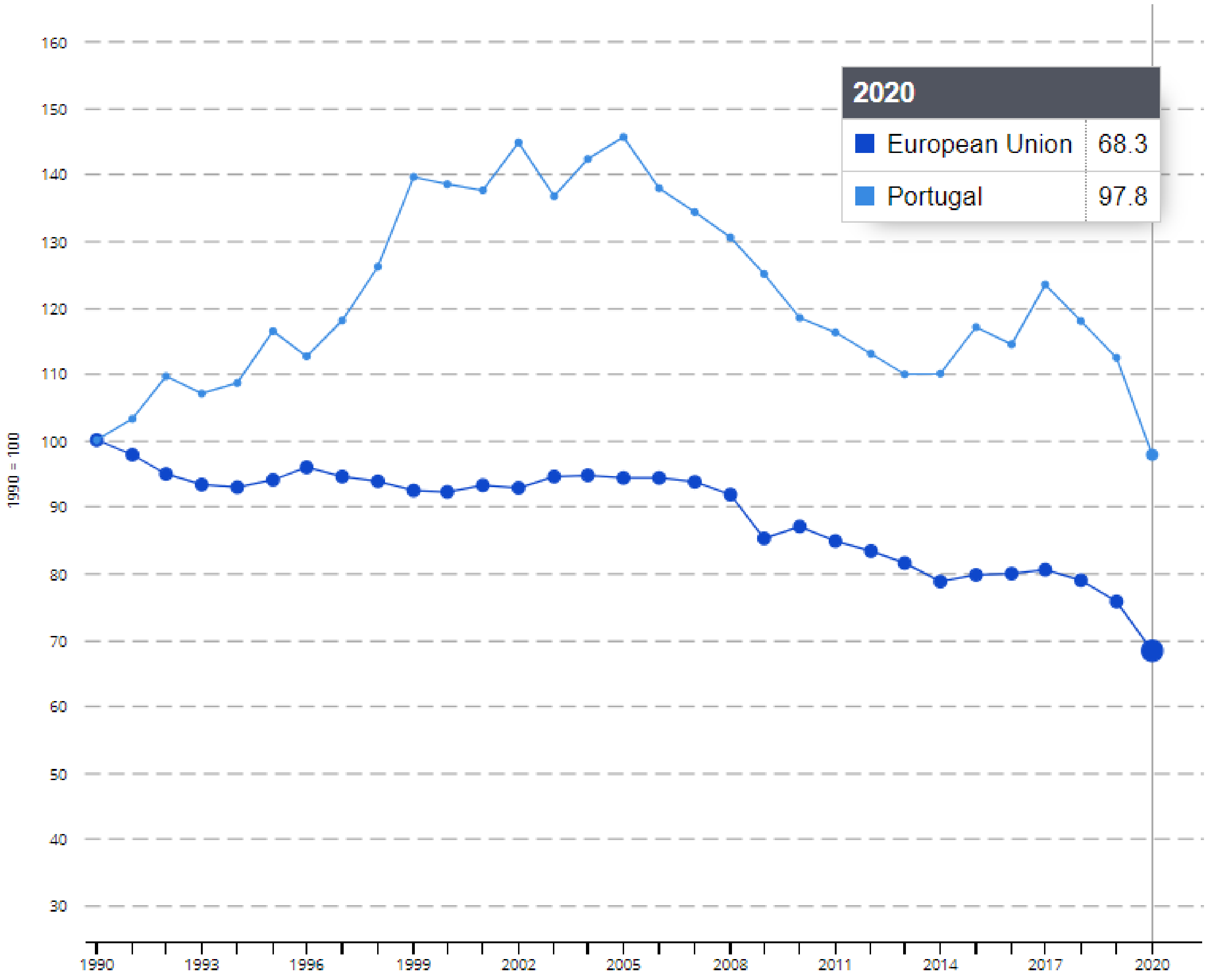
Emissões de gases de efeito de estufa

A **penetração de energias renováveis** e a **melhoria da eficiência energética** dos processos e sectores começam a ter efeito claro na redução de gases com efeito de estufa da UE.

Em **2022**, as emissões de gases com efeito de estufa (GEE) da UE situaram-se **32%** abaixo dos valores de 1990, **excedendo o objetivo** da EU de redução de **20%** até 2020.

O novo objetivo da UE para **2030** passa por **reduzir em 55%** as emissões de GEE em relação a 1990.

Outro objetivo da UE é tornar-se o primeiro continente **climaticamente neutro** até **2050**.



O Pacto Ecológico Europeu (**EU Green Deal**) tem por objetivo criar **487 000** novos postos de trabalho na UE até **2030**.

A **mão-de-obra** precisará de **reorientar-se** dos empregos em indústrias baseadas nos combustíveis fósseis para os **sectores verdes emergentes** e para os sectores que apresentem escassez de competências.

É necessário mapear os requisitos de **competências verdes** e **melhorar a requalificação** e o reemprego para o sucesso futuro na economia circular e de baixo carbono em **todos os sectores**.

Objetivo: Melhorar o desenvolvimento de tecnologias sustentáveis de energias renováveis e de combustíveis nas cidades, promovendo a sustentabilidade e a circularidade e implementando um programas educativos inovadores, concebido em conjunto com as partes interessadas, para desenvolver capital humano altamente qualificado, a fim de permitir resultados com elevada replicabilidade em diferentes sistemas educativos.

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- Sustainable Energy Technologies and Strategies in **Urban Environment**
- Decarbonization Strategies and Social Innovation for Cities and Communities
- Advanced Design of Sustainable Cities
- Business Strategies for a Sustainable Urban Transition
- Sustainability by Design: Developing a Resilient Built Environment
- Innovation in the Urban Energy Sector: Strategies & Management

Micro-Programme

Advanced Design of Sustainable Cities

Includes the following micro-credential courses

- Introduction to Sustainable Finance
- Data Analytics for the Energy Sector
- Energy Management and Smart Communities
- Decarbonisation of Thermal Energy
- Analysis of Energy Consumption
- Advanced Modelling of Buildings and Energy Systems

Plus a choice of 2 from these micro-credentials

- Economics and Physics of Energy Storages
- Positive Energy Districts
- Biogas Systems for Climate Transition
- Enacting a Circular Economy
- Small Scale Wind Power

Programme and courses developed by:

Maynooth University · Universitat Politècnica de València · Universidade de Coimbra · Università di Genova · UGA Université Grenoble Alpes · Halmstad University

04

Abastecimento de água e tratamento de águas residuais

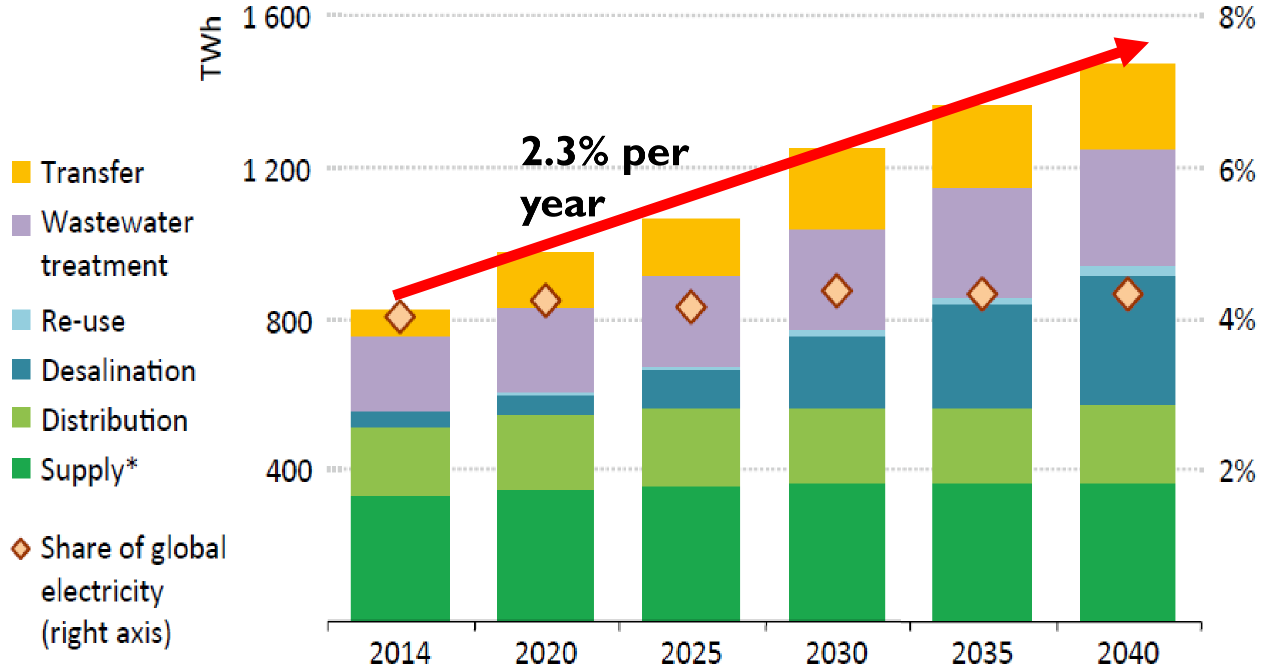
Abastecimento de água e tratamento de águas residuais

Este sector é **energeticamente intensivo**.

Metade do consumo é sob a forma de eletricidade, representando cerca de **4% da eletricidade total consumida mundialmente**.

Prevê-se que o consumo energético do sector **aumente rapidamente**, mais que duplicando entre 2014 e 2040, devido:

- Aumento das captações de água municipais e industriais;
- Maior recurso a fontes de água não tradicionais;
- Maiores quantidades de águas residuais a serem tratadas a níveis mais rigorosos.



Source: IEA, 2016

Abastecimento de água e tratamento de águas residuais

- **Desafios:**
  - melhorar a eficiência energética;
  - aumentar a penetração de energias renováveis.

A instalação de **sistemas de produção fotovoltaica** são uma excelente opção para aumentar a produção de energia renovável no sector.

Auditorias energéticas poderão ser importantes a promover e disseminar a eficiência energética dado que são essenciais para **avaliar e melhorar** a eficiência das **instalações e processos**.

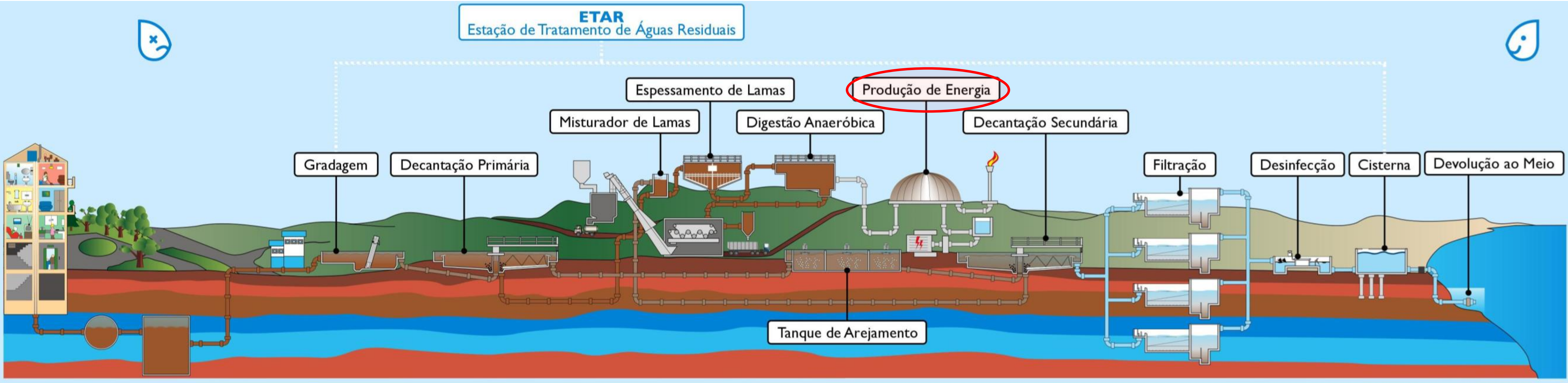
	Savings		
	%	kWh	€
WWTP1			
Change the operating profile of the submersible mixers (oxidation ditch)	2.5	16421	1576
Change the operating profile of the submersible mixers (anoxic tank)	3.5	22989	2207
Change the operating profile of the recirculation pumps	0.2	1278	123
Replace the existing coarse bubble diffusers	6.8	44509	4273
WWTP2			
Change the operating profile of the agitators (digesters)	7.0	53283	5081
Change the operating profile of the submersible mixers (anoxic tank)	11.2	85287	8188
Replace the existing coarse bubble diffusers	3.8	29233	2806

Permitem identificar medidas de implementação **simples**, que podem ser facilmente identificadas e implementadas pelos membros das empresas **sem necessitar de recorrer a empresas especializadas**.

Essas medidas permitem alcançar **poupanças de energia significativas** sem comprometer o processo de tratamento.

Abastecimento de água e tratamento de águas residuais

Além da instalação de sistemas fotovoltaicos, o **aproveitamento das lamas** nas Estações de Tratamento de Águas Residuais para **produção de biogás** poderá contribuir significativamente para o **aumento da autossuficiência energética** através da geração de energia (calor e eletricidade) no local.



Exemplos de Sucesso

Em **2021**, a energia elétrica produzida a partir do biogás para **autoconsumo** representou **19,7%** (**18 GWh**) do consumo de energia da Águas do Tejo Atlântico.

O **aumento** da produção de energia elétrica resultou da aquisição de **novos cogeradores** em conjunto com a otimização dos processos, como por exemplo a **melhoria a nível de espessamento das lamas**.

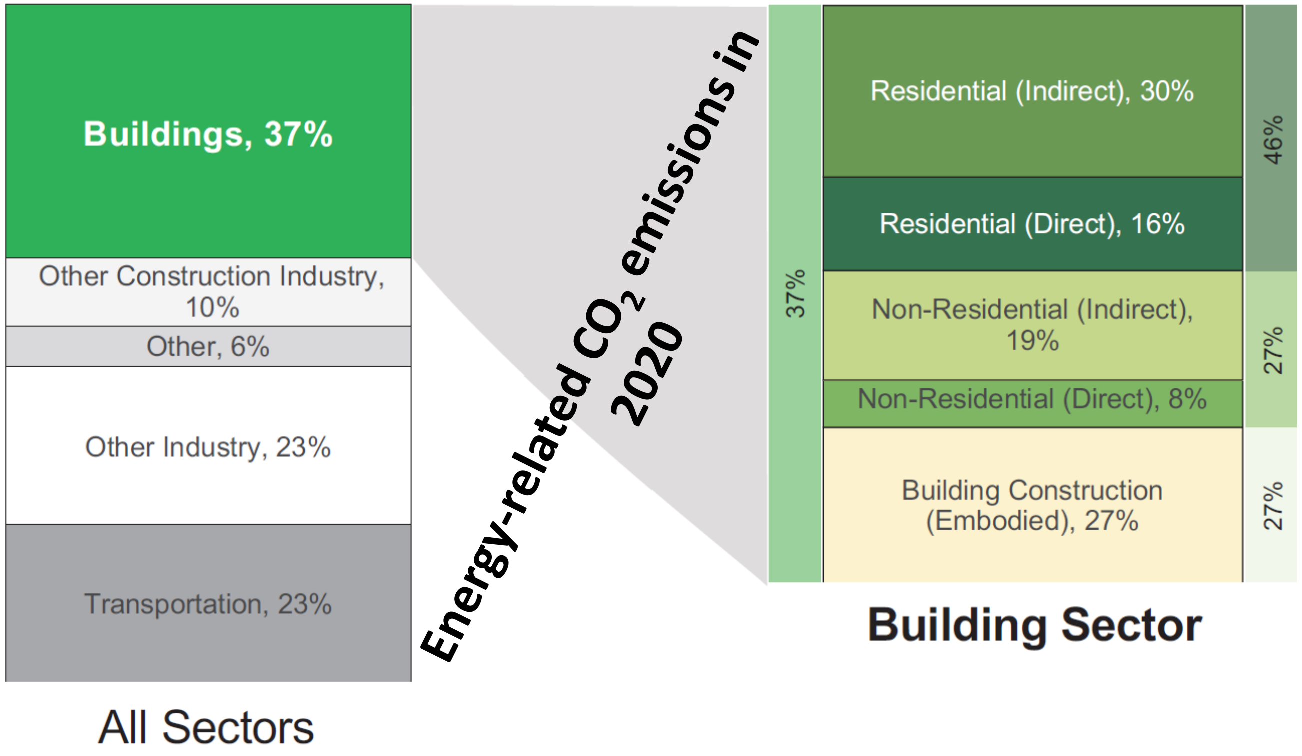
Fonte: Águas do Tejo Atlântico, ADP

Fonte: Águas do Tejo Atlântico, ADP

05

Descarbonização no sector dos edifícios

Decarbonization of the building sector

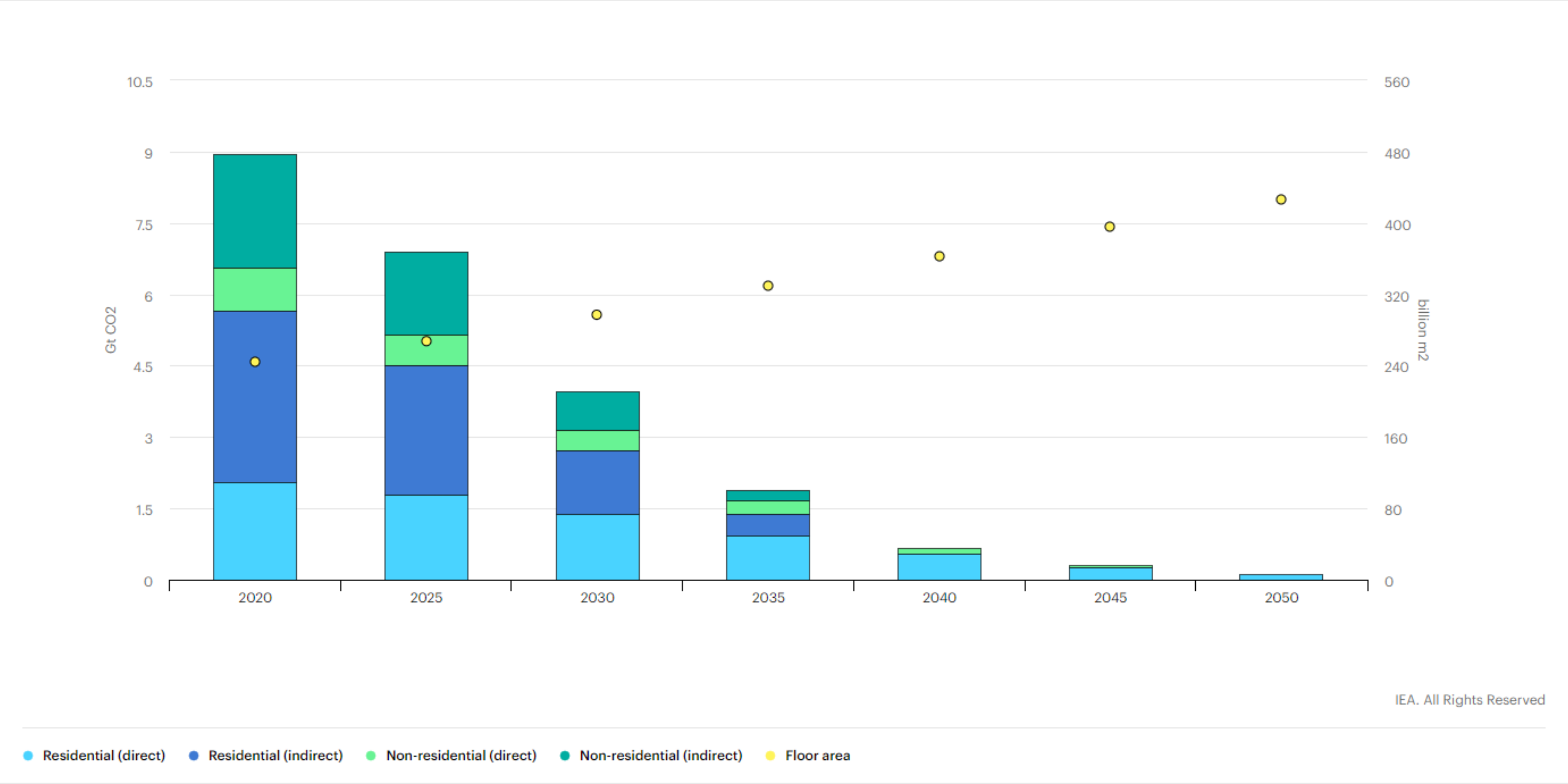


Sources:
IEA 2021
ASHRAE Position Document on Building Decarbonization

- **Buildings** provide many **benefits to society** but have a significant worldwide **environmental impact** due to their GHG emissions:
  - The building industry accounts for roughly **40% of global GHGs**
  - and the global **building stock** is expected to **double by 2060**
- **Decarbonization** of buildings and their systems must be based on a **holistic analysis** including:
  - healthy, safe, and comfortable environments
  - energy efficiency
  - environmental impacts
  - sustainability
  - operational security
  - and economics

Reaching a zero-carbon buildings stock by 2050

Mandatory **zero-carbon-ready codes** for the residential and commercial sectors **by 2030**



Sources: IEA 2021

How can the buildings energy performance be improved?

A

Building <u>design and construction</u>

- Architecture
- Construction solutions
- HVAC, lighting, miscellaneous equipment, …
- Incorporation of new and renewable technologies

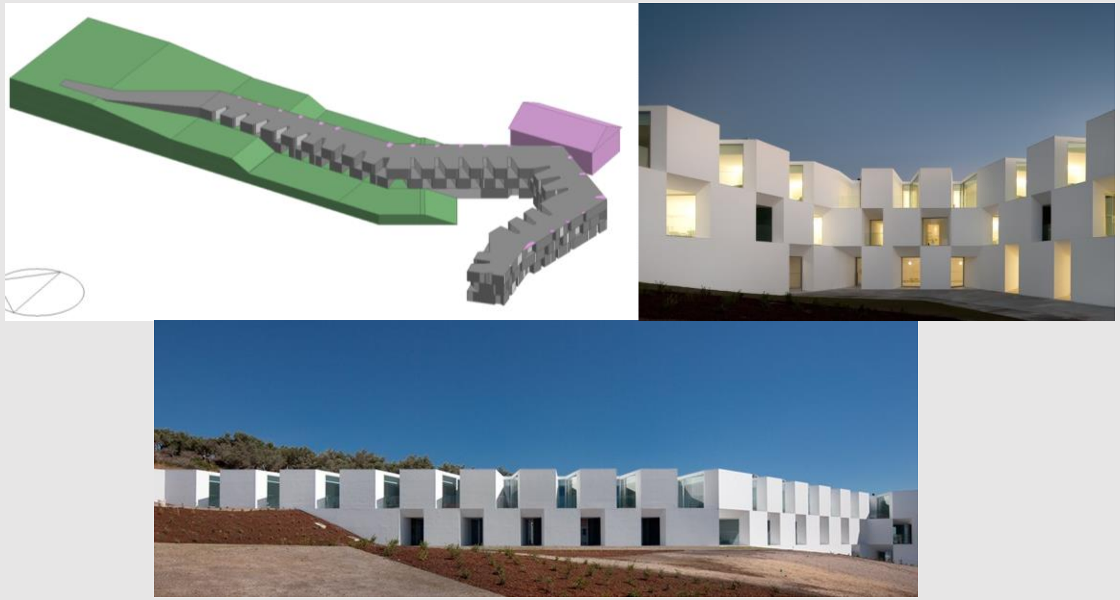
B

Building and systems <u>operation and maintenance</u>

- Envelope maintenance and **renovation**;
- Daily operation (Occupant's behavior, **control** of setpoints, IAQ, …)
- Energy systems **maintenance** and **renovation**

Dynamic energy simulation tools for buildings and systems

A complex building shape



Simulation tools

- Simulation is the **"imitation of the operation of a real-world process or system over time"**

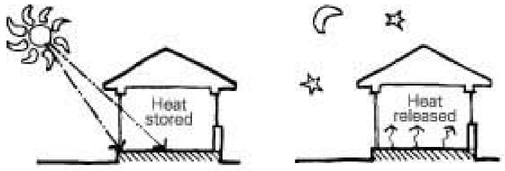
- The model represents:
  - the **key characteristics or behaviors** of the selected physical or abstract system or process.
  - the **system itself**, whereas the simulation represents the operation of the system over time. […]

- Simulation can be used for the evaluation of different solutions:
  - From an **energy** and/or **indoor ambient** conditions perspective
  - **Architectural** aspects (shape, …)
  - **Windows** positions and dimensions
  - **Solar** obstructions/shadings
  - **Passive or bioclimatic** (Trombe wall, green roofs, natural ventilation, passive cooling, …)
  - Building **materials and elements** (glazing type, thermal insulation, new materials, ...);
  - **Site** (façades orientation, exterior shading, ground characteristics,...)

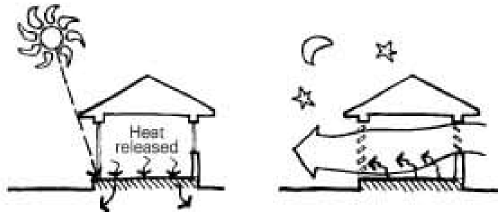
Lightweight Buildings' Construction

Wood

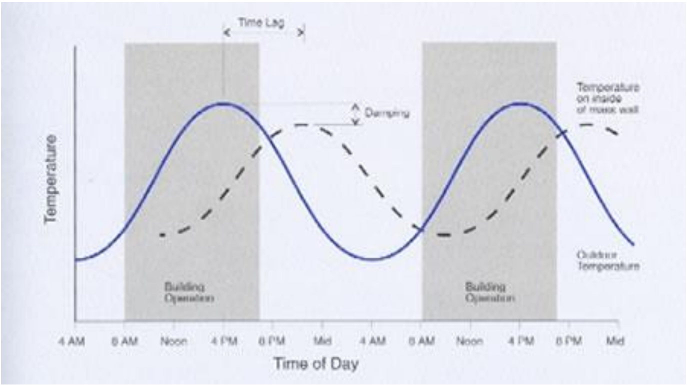
Steel



Winter



Summer



- **New Buildings**
- **Rehabilitation and rebuild**

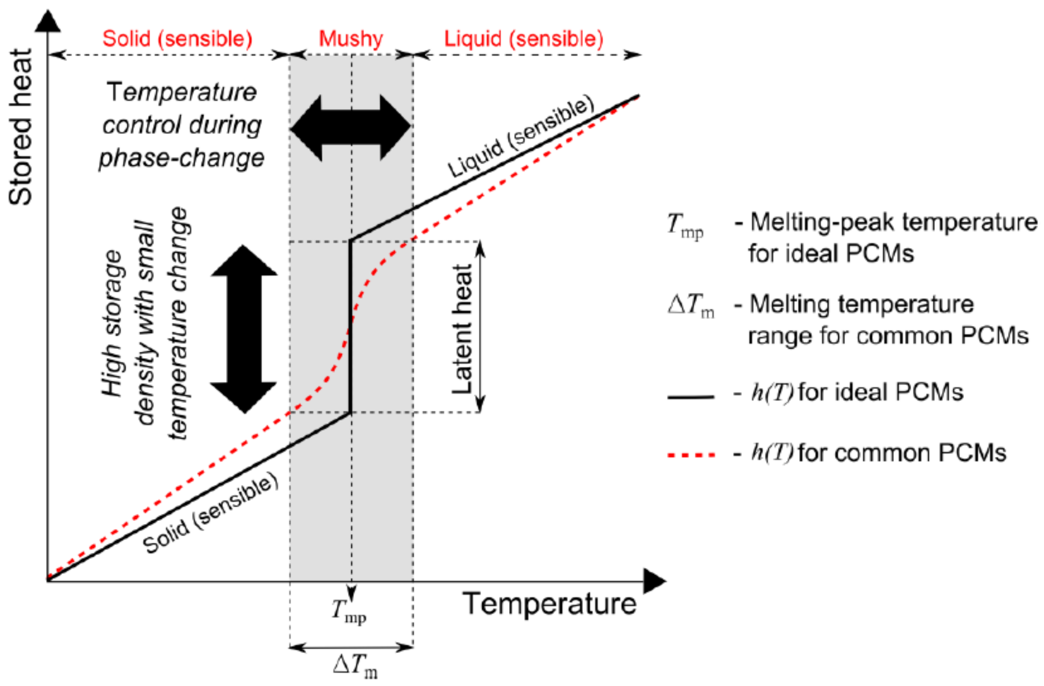
Advantages

- Construction time;
- Costs
- Material embodied;
- Energy embodied
- modularity;
- …

Disadvantages

- Thermal bridges
- Thermal mass (Mediterranean climates)

Phase change materials (PCM)



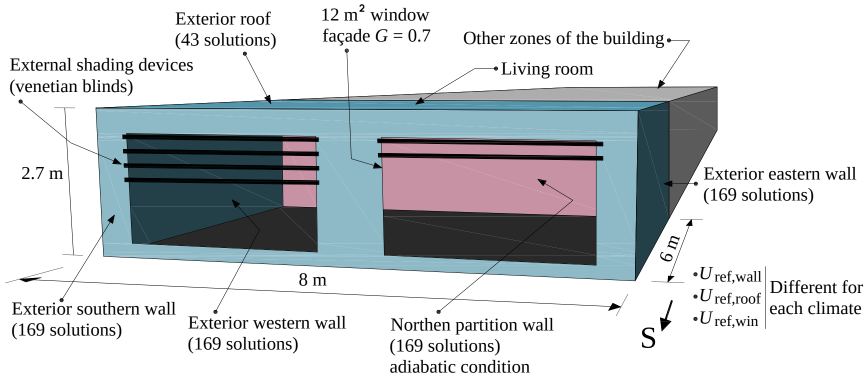
Free-form *vs.* Microencapsulated PCMs

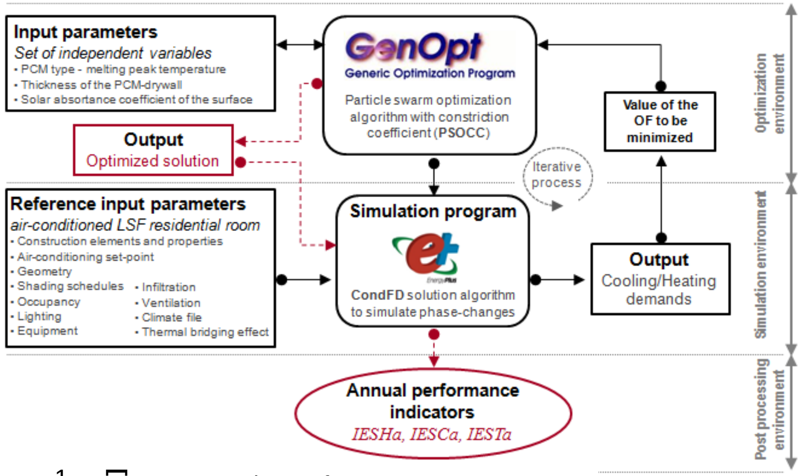
Techniques to incorporate PCMs in construction elements avoiding liquid leakage: **micro-** and **macro-encapsulation**.

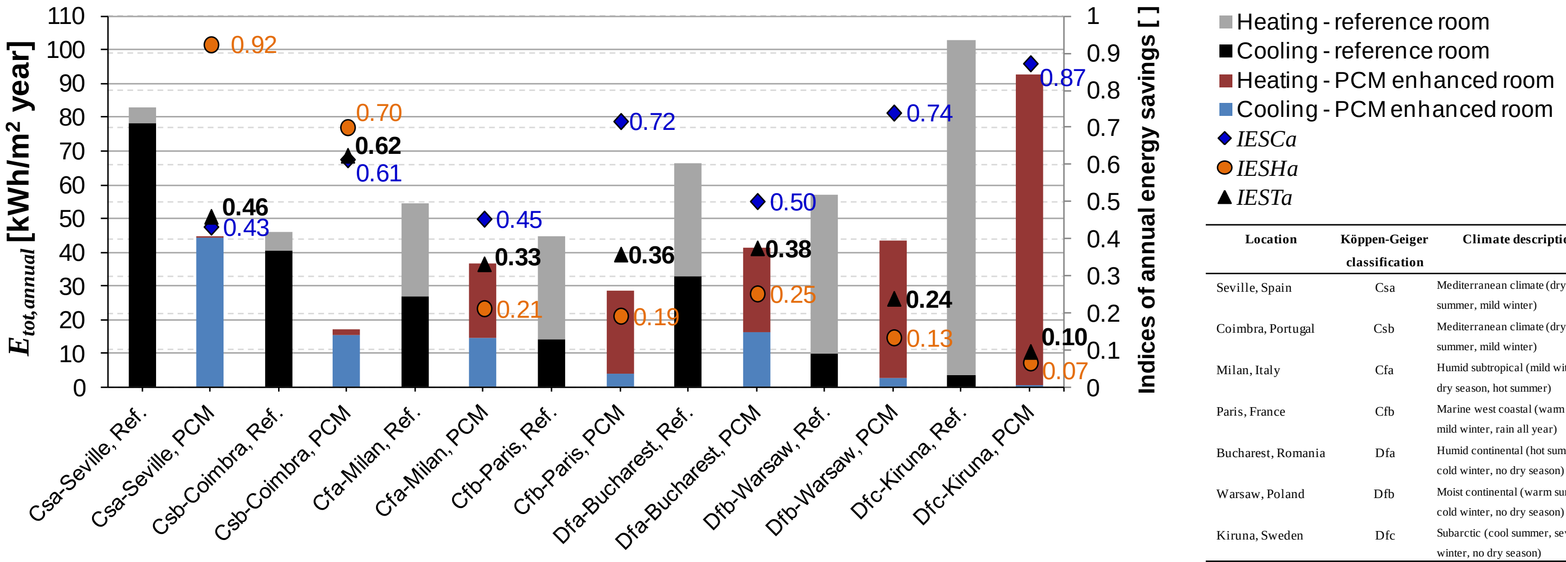
Potential fields of application:

- temperature control ;
- storage and supply of heat with high storage density and small temperature change.

Phase change materials (PCM) for the improvement of lightweight buildings' energy efficiency



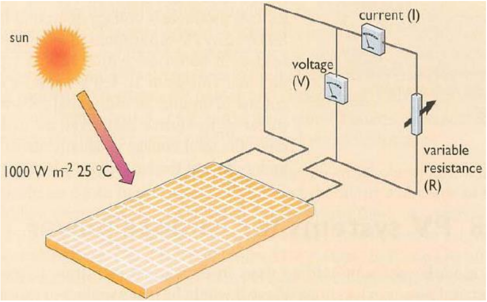


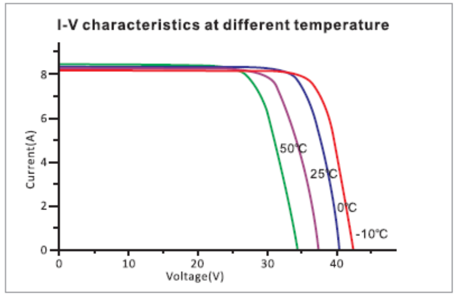


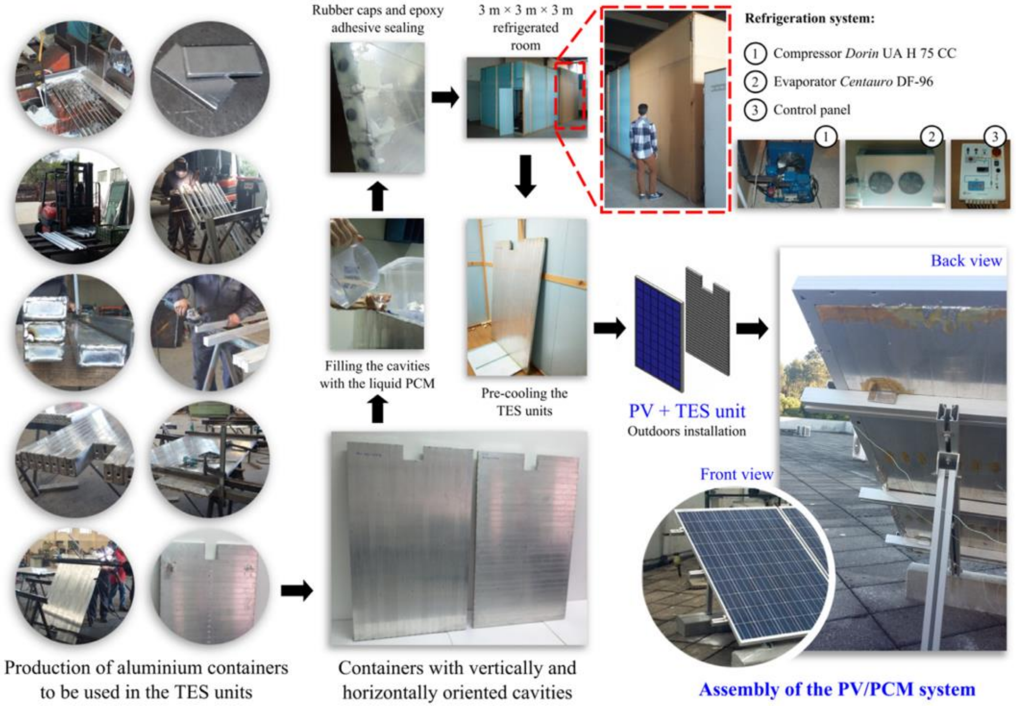
Location	Köppen-Geiger classification	Climate description
Seville, Spain	Csa	Mediterranean climate (dry hot summer, mild winter)
Coimbra, Portugal	Csb	Mediterranean climate (dry warm summer, mild winter)
Milan, Italy	Cfa	Humid subtropical (mild with no dry season, hot summer)
Paris, France	Cfb	Marine west coastal (warm summer, mild winter, rain all year)
Bucharest, Romania	Dfa	Humid continental (hot summer, cold winter, no dry season)
Warsaw, Poland	Dfb	Moist continental (warm summer, cold winter, no dry season)
Kiruna, Sweden	Dfc	Subarctic (cool summer, severe winter, no dry season)

Soares, N.; Gaspar, Adélio R; Santos, P.; Costa, J.J.. 2014. "Multi-dimensional optimization of the incorporation of PCM-drywalls in lightweight steel framed residential buildings in different climates", Energy and Buildings, 70: 411 - 421. doi: 10.1016/j.enbuild.2013.11.072.

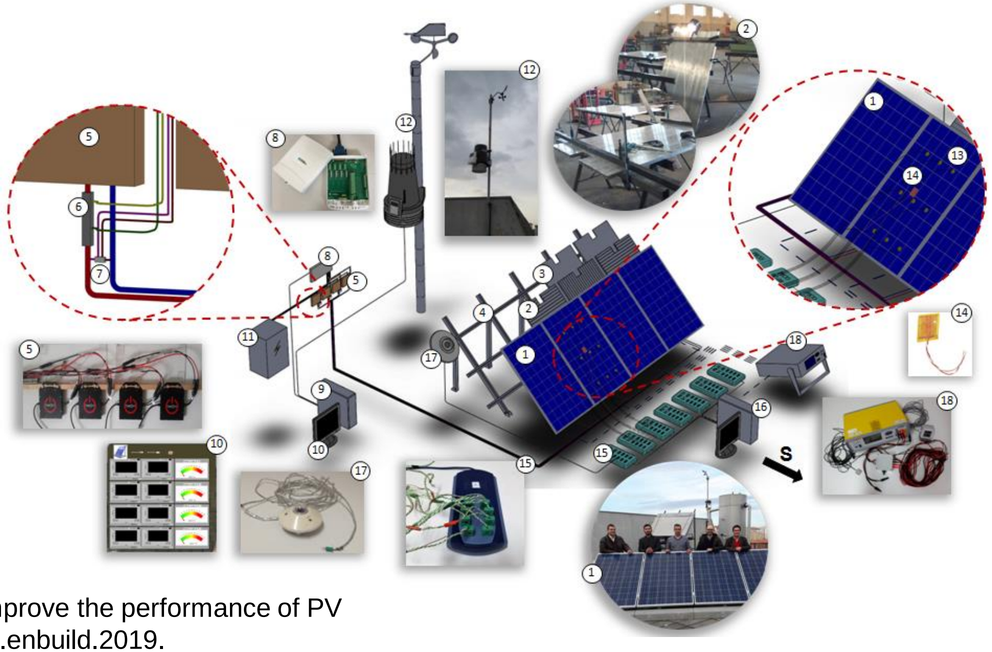
Thermal regulation of photovoltaic modules using thermal energy storage units with PCMs





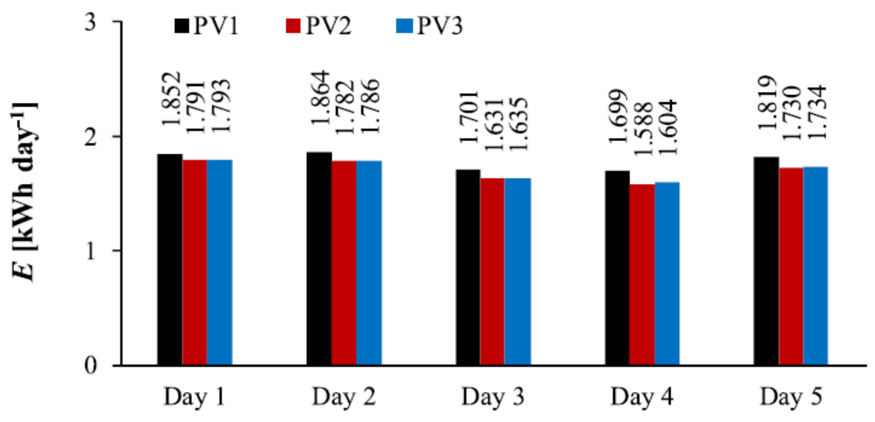


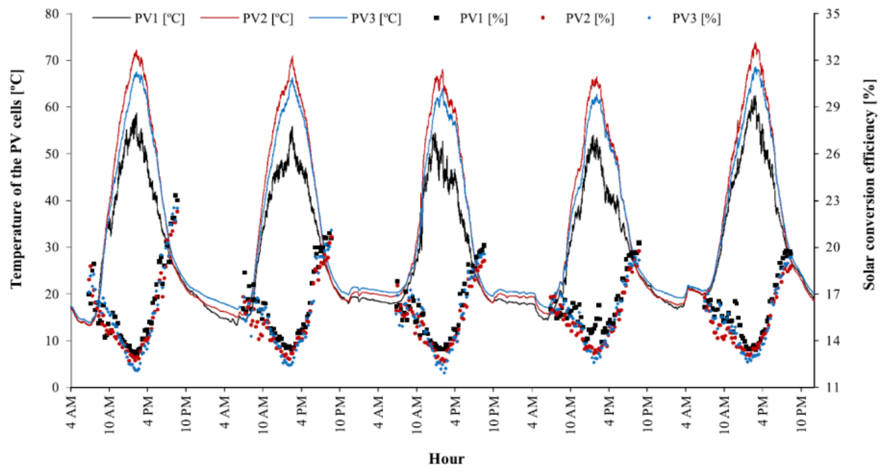
- **High operating temperatures reduce** the **performance** of commercial polycrystalline silicon photovoltaic (PV) devices
- Experimental Apparatus
  - 250 W STC-rated commercial polycrystalline silicon PV panels
  - Horizontally and vertically oriented cavities, with PCM RT 22 HC on the panels' back



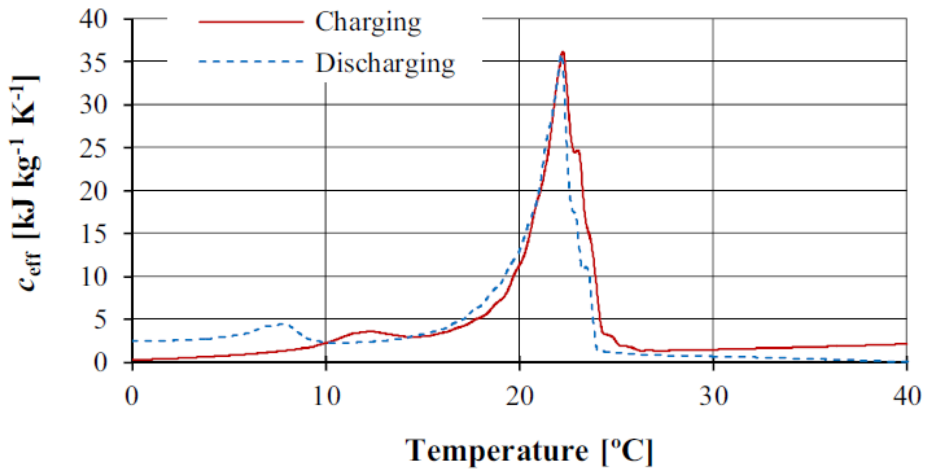
Soares, N.; Costa, J.J.; Gaspar, A.R.; Matias, T.; Simões, P.N.; Durães, L. Can movable PCM-filled TES units be used to improve the performance of PV panels? Overview and experimental case-study, Energy & Buildings 210 (March 2020) 109743, doi: https://doi.org/10.1016/j.enbuild.2019.

Thermal regulation of photovoltaic modules using thermal energy storage units with PCMs





- Results
  - Characterization of effective heat capacity (*Ceff*)
  - PV operating temperature has increased (at peak time)
  - the daily energy produced by the PV panel reduced
- Conclusion
  - PCM movable TES units **have a negative impact** on the performance of the PV/PCM systems



Soares, N.; Costa, J.J.; Gaspar, A.R.; Matias, T.; Simões, P.N.; Durães, L. Can movable PCM-filled TES units be used to improve the performance of PV panels? Overview and experimental case-study, Energy & Buildings 210 (March 2020) 109743, doi: https://doi.org/10.1016/j.enbuild.2019.

Automated generation of Floor plan designs with thermal performance optimization

Authors: Eugénio Rodrigues, Adélio Gaspar, Álvaro Gomes
Research project 2011-2014

- **Evolutionary Program for Space Allocation Problem (EPSAP)** is an algorithm developed for automated generation of floor plans.
- EPSAP uses a **hybrid evolutionary approach** (evolutionary strategy enhanced with a local search technique).
- **Genetic operators perform geometric transformation** to the floor plans during the evolving process.
- Takes several **architect preferences and constraints** into account such as spaces dimensions, multi-levels with stairs and elevators, window view orientation, maximum areas, adjacencies, interior connectivity, exterior openings, multi openings per space, building boundary etc..
- The architect may screen the final **generated solutions and compare designs** and choose which to be further developed in latter stages.

Rodrigues, E., Gaspar, A., and Gomes, A´. (2013). An evolutionary strategy enhanced with a local search technique for the space allocation problem in architecture, part 1: Methodology. Computer Aided-Design, 45(5):887–897. doi: 10.1016/j.cad.2013.01.001.

Rodrigues, E., Gaspar, A., and Gomes, A´. (2013). An evolutionary strategy enhanced with a local search technique for the space allocation problem in architecture, part 2: Validation and performance tests. Computer Aided-Design, 45(5):898–910. doi: 10.1016/j.cad.2013.01.003.

Rodrigues, E., Gaspar, A., and Gomes, A´. (2013). An approach to the multi- level space allocation problem in architecture using a hybrid evolutionary technique. Automation in Construction, 35:482–498. doi: 10.1016/j.autcon.2013.06.005.

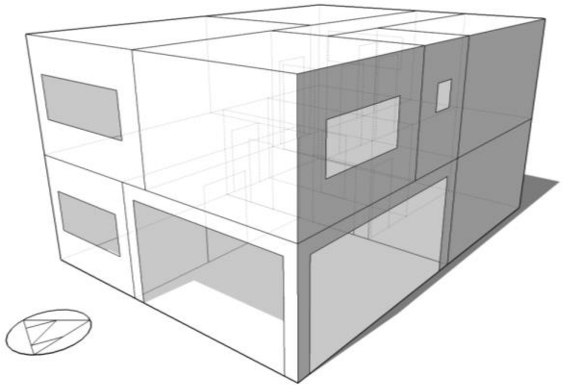
Automated generation of Floor plan designs with thermal performance optimization

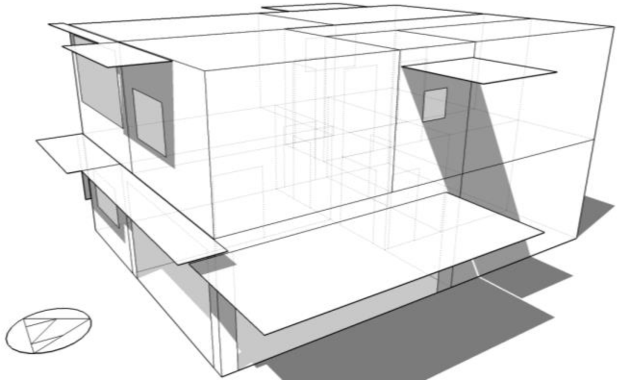
Authors: Eugénio Rodrigues, Adélio Gaspar, Álvaro Gomes
Research project 2011-2014

- The use of **EPSAP** and **FPOP** will benefit the architectural design process by **reducing time and associated costs**.

- The **architect may benefit from an enlarged number of generated alternative designs**, automated procedure to improve thermal comfort, and detailed reports on each design solution.

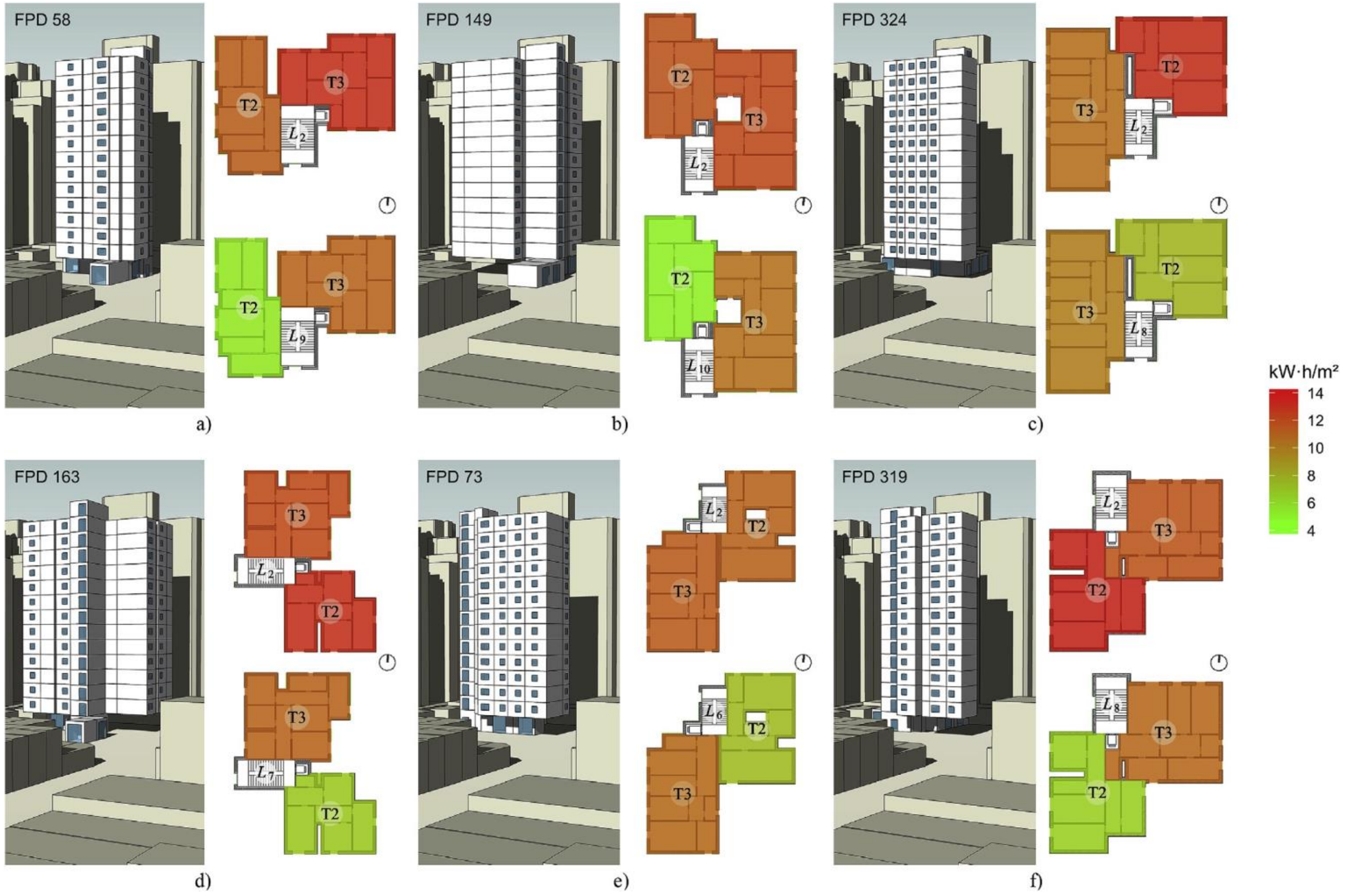
- It is expected that such programs may **help the architect in designing better buildings** by incorporating energy efficiency and thermal comfort measures from the early design stages (space planning phase).

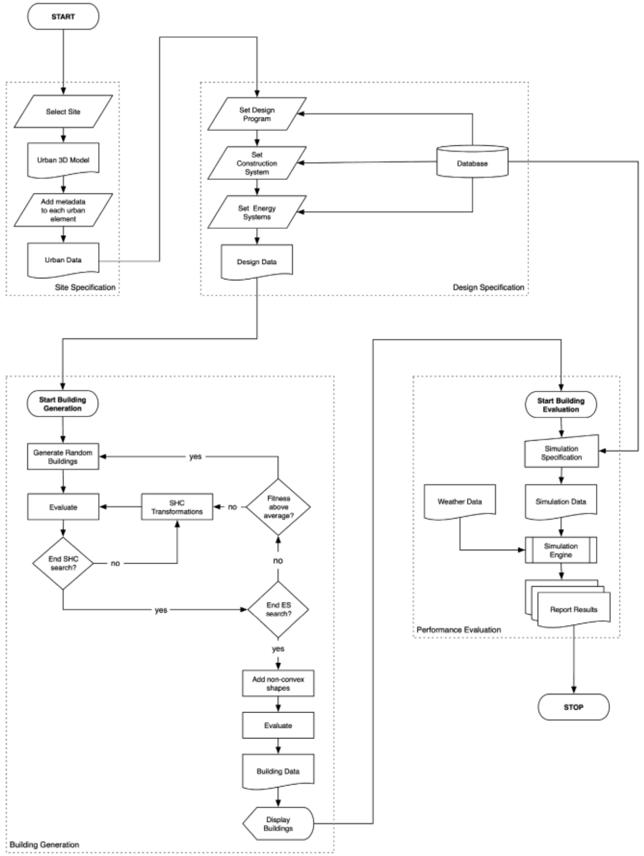




Rodrigues, E., Gaspar, A., and Gomes, Á. (2013). A gradient descent technique coupled with a dynamic simulation to determine the near optimum orientation of floor plan designs. In Kabele, K., Urban, M., Suchý, K., and Lain, M., editors, Proceedings of CLIMA 2013, Prague, Czech Republic. Society of Environmental Engineering (STP).

Application - Large buildings with complex surroundings

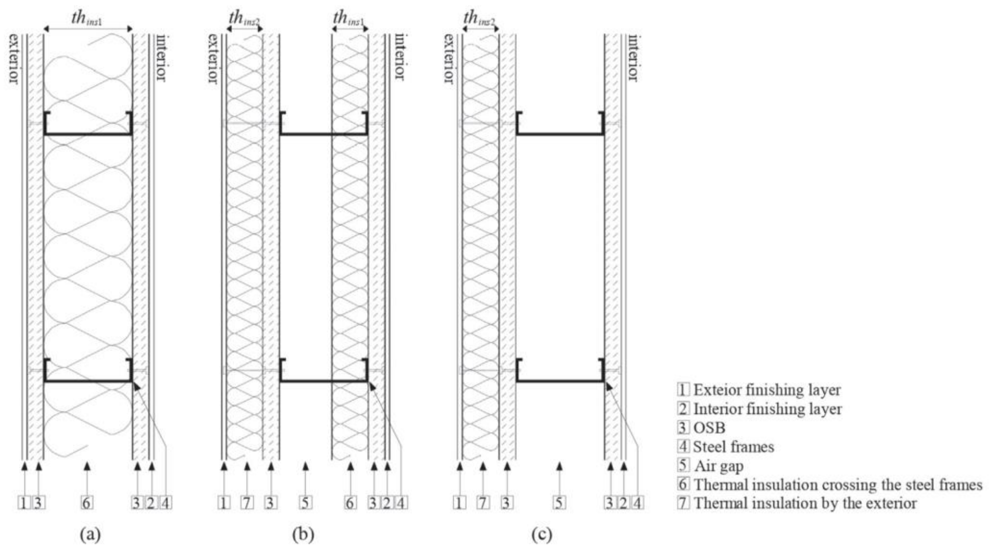


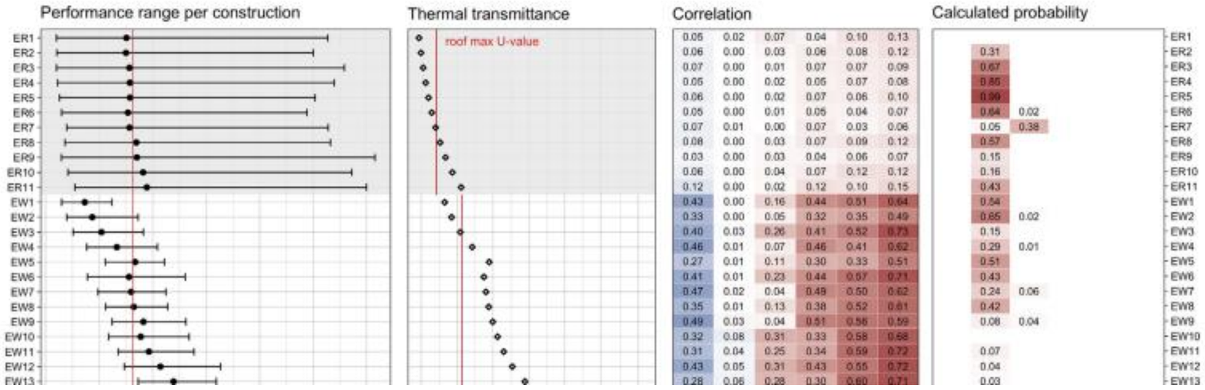


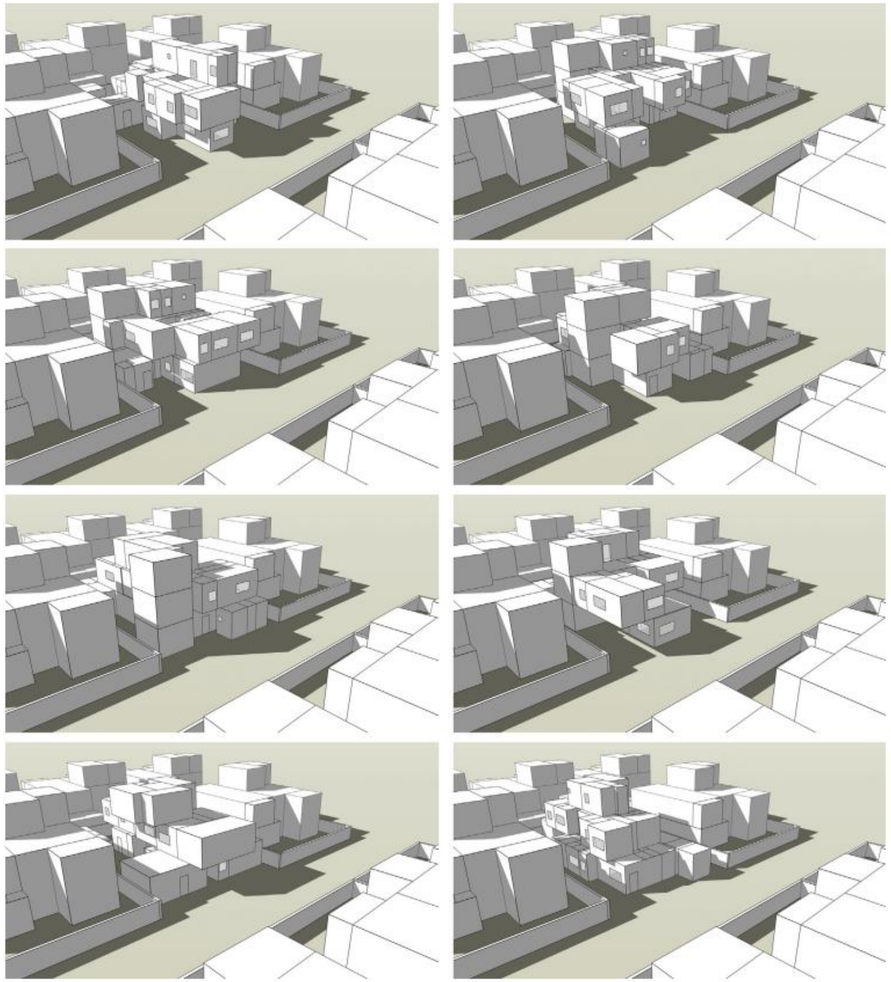
Energy consumption, thermal comfort, and visual comfort analysis

Rodrigues, E., Fernandes, M. S., Gomes, Á., Gaspar, A. R., & Costa, J. J. (2019). Performance-based design of multi-story buildings for a sustainable urban environment: A case study. Renewable and Sustainable Energy Reviews, 113, 109243. https://doi.org/10.1016/j.rser.2019.109243.

Application - modular lightweight steel framed dwellings in hot climates



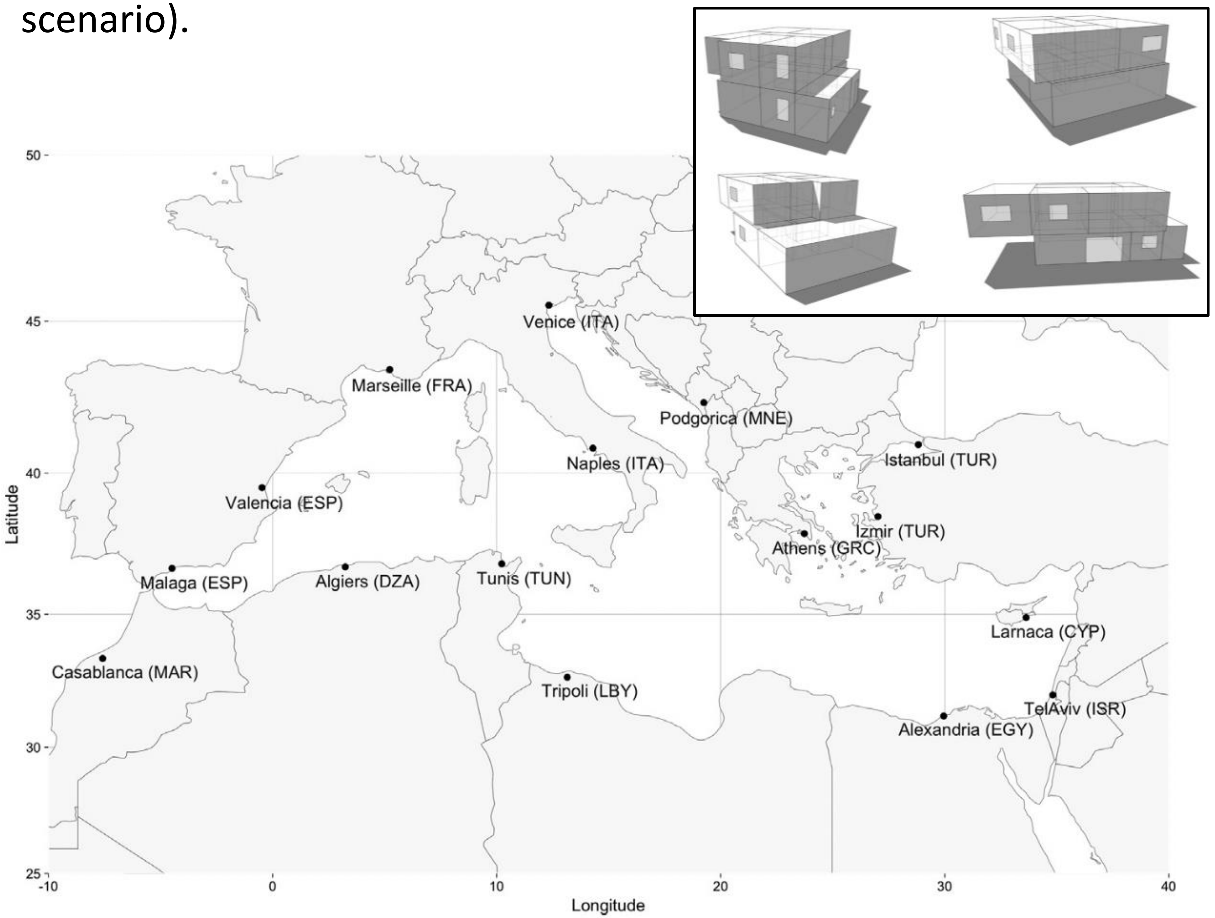


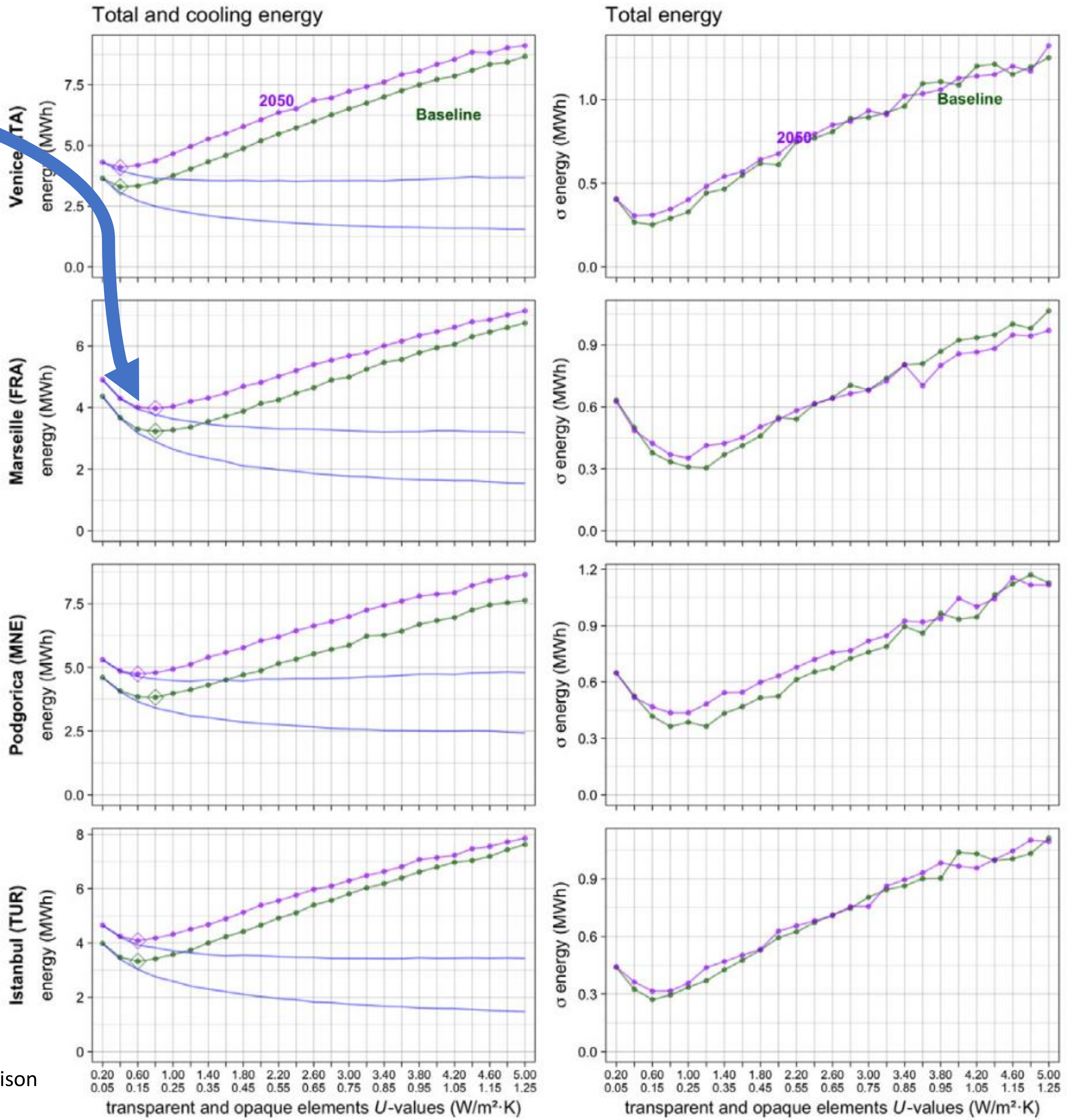


Rodrigues, Eugénio; Soares, N.; Fernandes, Marco; Gaspar, Adélio R; Gomes, Álvaro; Costa, J.J.. 2018. "An integrated energy performance-driven generative design methodology to foster modular lightweight steel framed dwellings in hot climates", Energy for Sustainable Development, 44: 21 - 36. doi: 10.1016/j.esd.2018.02.006.

<u>Today's</u> optimal thermal transmittance values <u>will be similar to</u> <u>future</u> optimal thermal transmittance values.

Study analyzed coastal locations in the Mediterranean region using a large dataset of virtual buildings (**192 000**) simulated with morphed weather data to match one of the IPCC's 3rd Assessment Report climate model (HadCM3 model, 2050 A2 climate change scenario).





Rodrigues, E., & Fernandes, M. S. (2020). Overheating risk in Mediterranean residential buildings: Comparison of current and future climate scenarios. Applied Energy, 259, 114110. https://doi.org/10.1016/j.apenergy.2019.114110

The effectiveness of the Iranian building code in mitigating climate change (case study: Bandar Abbas, a coastal city in the south of Iran)

Reference building in Bandar Abbas

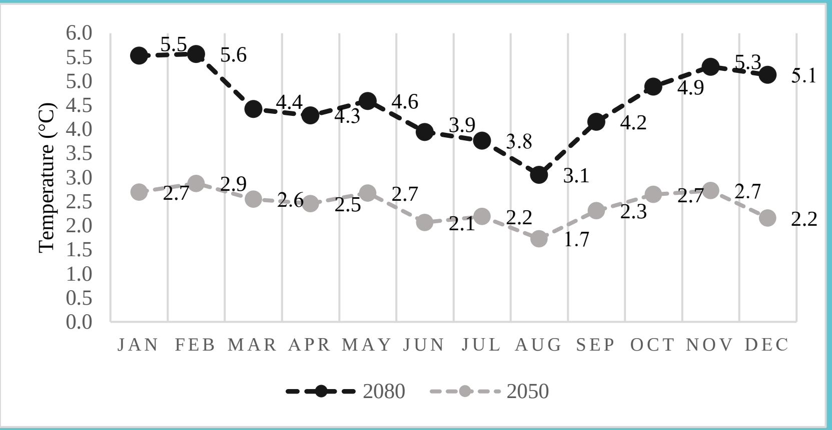


Figure1- Monthly values of average temperatures (°C) differences between 2050, 2080 and baseline climate.

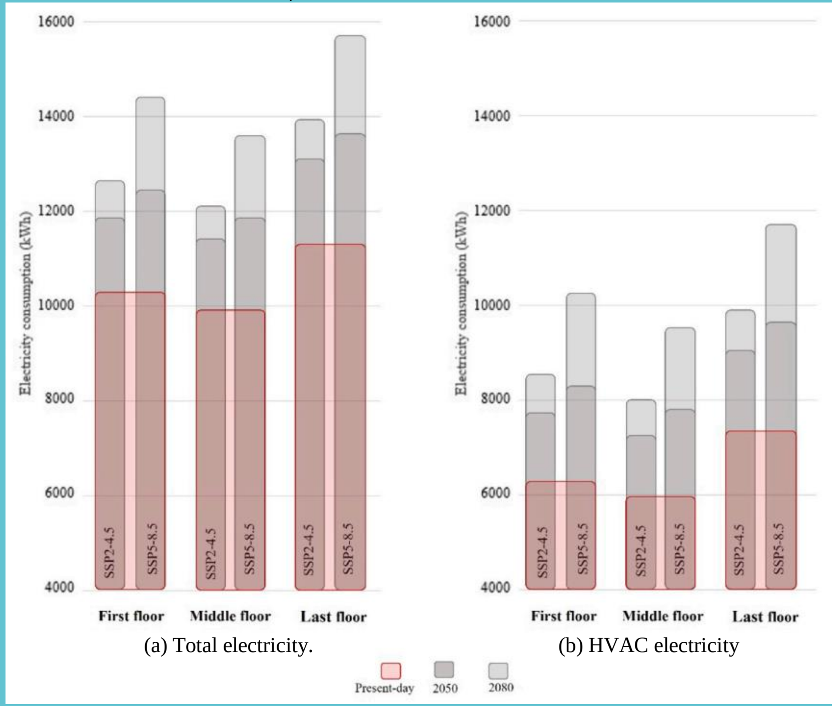


Figure 2- Building's annual and HVAC electricity consumptions for 2050and 2080

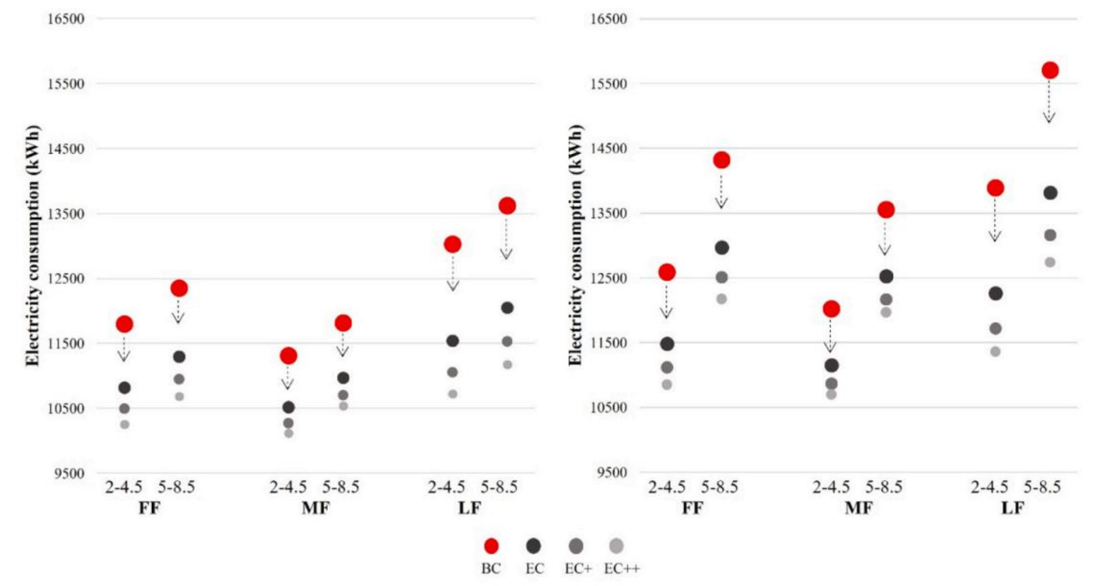
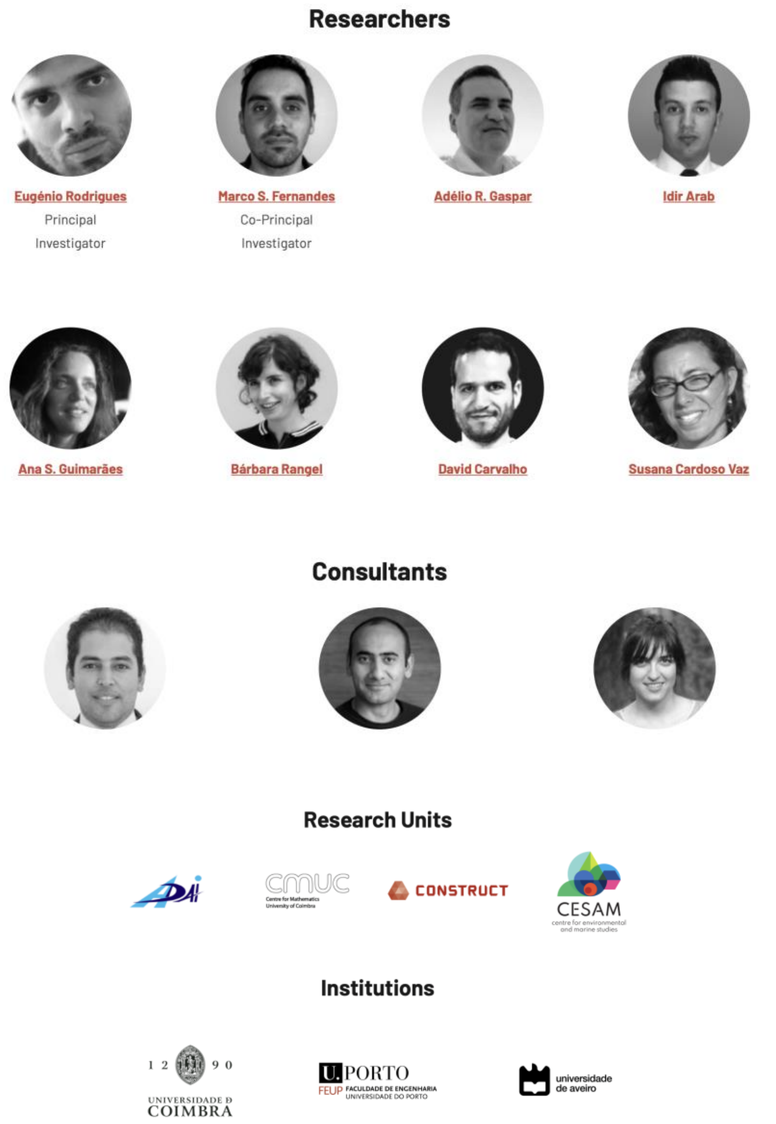


Figure 3- Comparison between total annual electricity consumption for the base case (BC) and Iranian building code energy levels under scenario SSP2-4.5 and SSP5-8.5 for the 2050 and 2080 timeframes.

- Average air temperatures in Bandar Abbas will rise 4.5 °C for SSP5-8.5 by 2080 (Fig.1)
- Multi-apartment buildings' electricity demand will increase by up to 40 % (Fig.2)
- Building code's highest energy-efficiency requirement mitigates the increase (Fig.3)
- **Stringent code requirements are needed to meet the carbon neutrality target.**

Project CLING - Climate change-based building design guidelines



How future buildings should be designed?

http://adai.pt/future-weather-generator/

06

Monitorização e simulação da qualidade do ambiente interior

BACKGROUND

Museu da Ciência (MCUC)
Museum

Biblioteca Joanina (BJUC)
Historic

Casa-Forte (BGUC)
Archives

Dep. Eng.ª Mecânica (DEM-UC)
Scholar/Academic

Gabinetes Técnicos (FMUC)
Offices

Biblioteca Ciências Saúde (BCS-UC)
Libraries

Experimental

Simulation

EnergyPlus

DesignBuilder

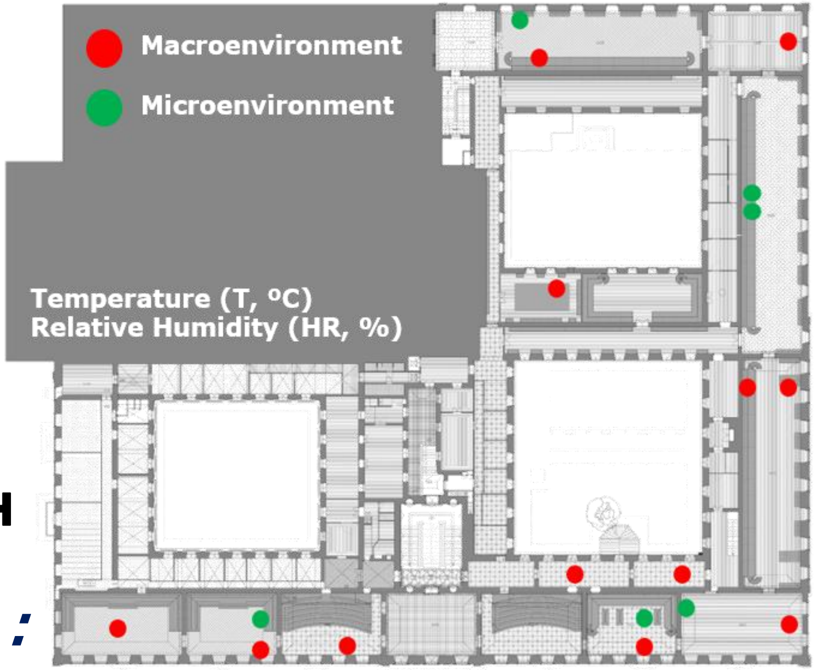
Radiance

MONITORING

Distribution of equipment

Temp & RH

Science Museum :



Joanina Library :

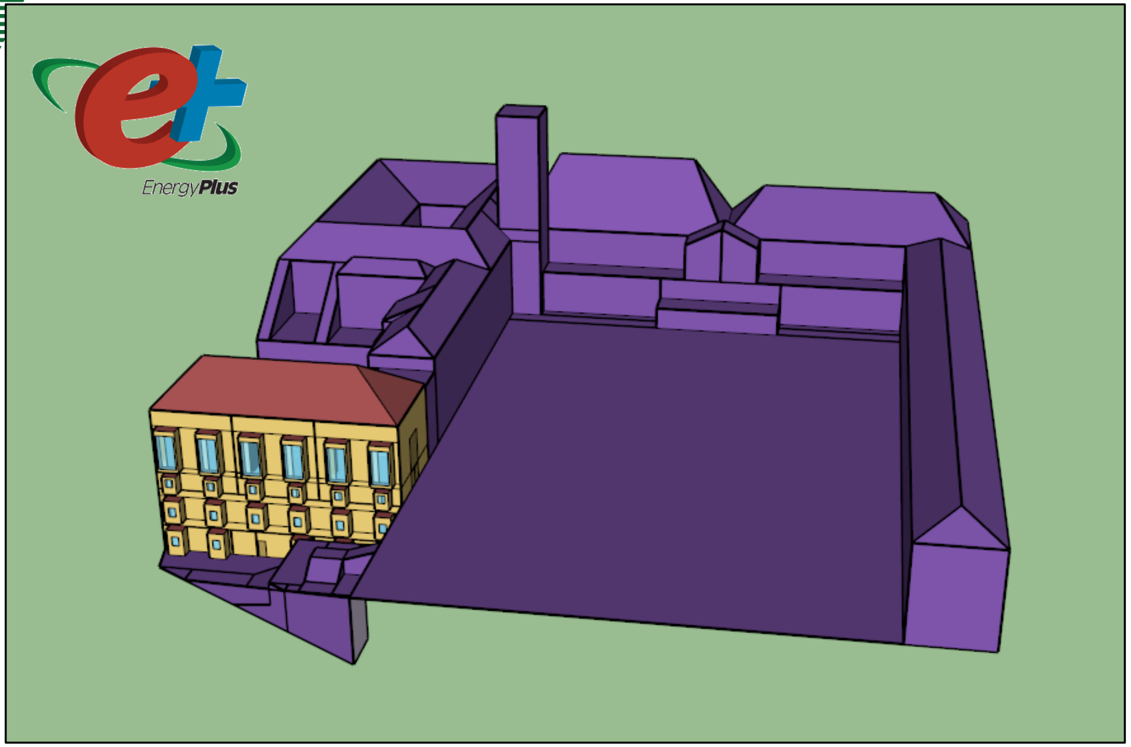
a) Noble floor - balcony; b) Noble floor - ground; c) Intermediate floor; d) Prison floor.

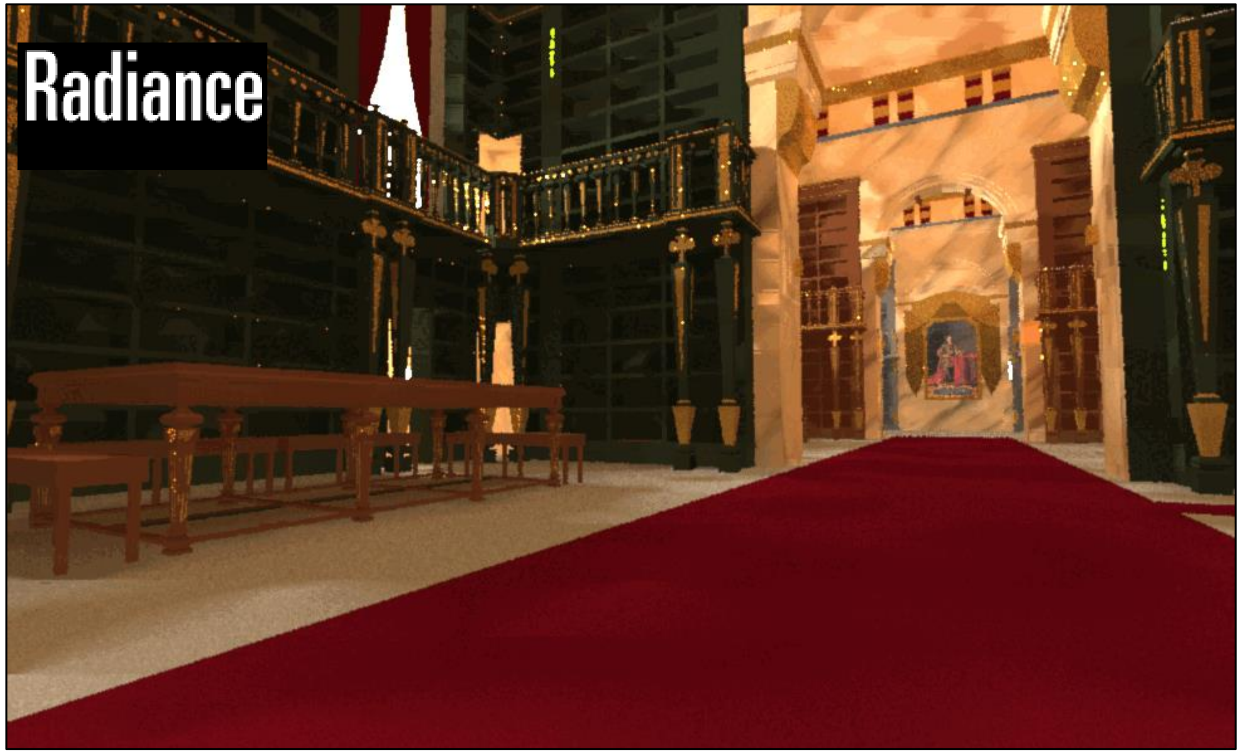
Indoor Environmental Parameters	
Continuous	Temperature (T, ºC)
	Relative Humidity (HR, %)
	Carbon Dioxide (CO_2, ppm)
	Particulate Matter (PM, µg/m^3)
	Illuminance (lux)
Punctual	Other Pollutants (Radon, etc.)
	Microbiological (UFC/m^3)
	Noise (dB)

- Temp & RH
- Temp & RH & CO_2
- Particulate Matter
- Illuminance

SIMULATION

Joanina Library





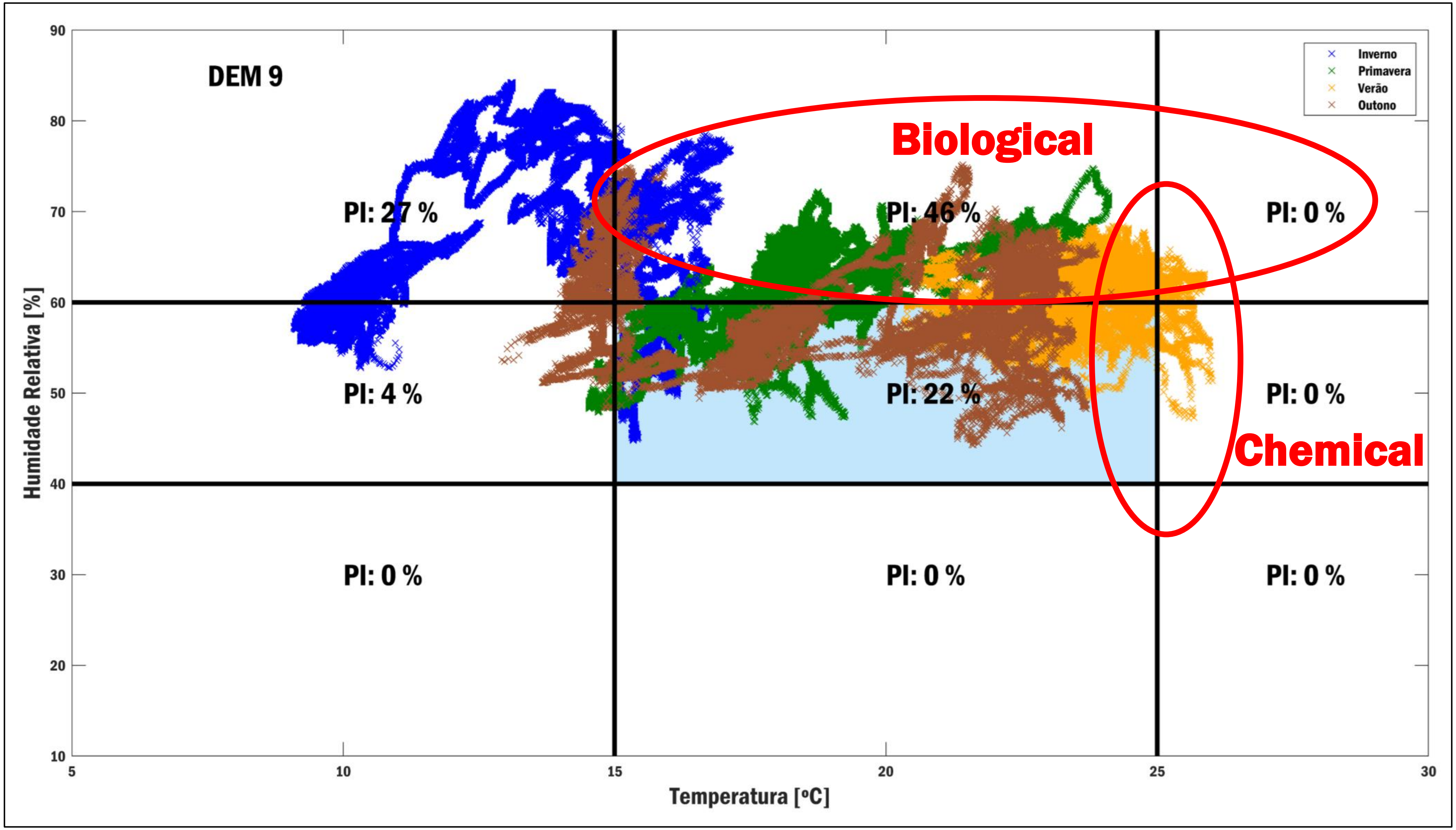
Hygrothermal Simulation using **Airflow Network model** in *EnergyPlus.*

Lighting Simulation using **Matrix-based methods** in *Radiance.*

MONITORING

Hygrothermal

Understand when a bigger risk of degradation occurs.

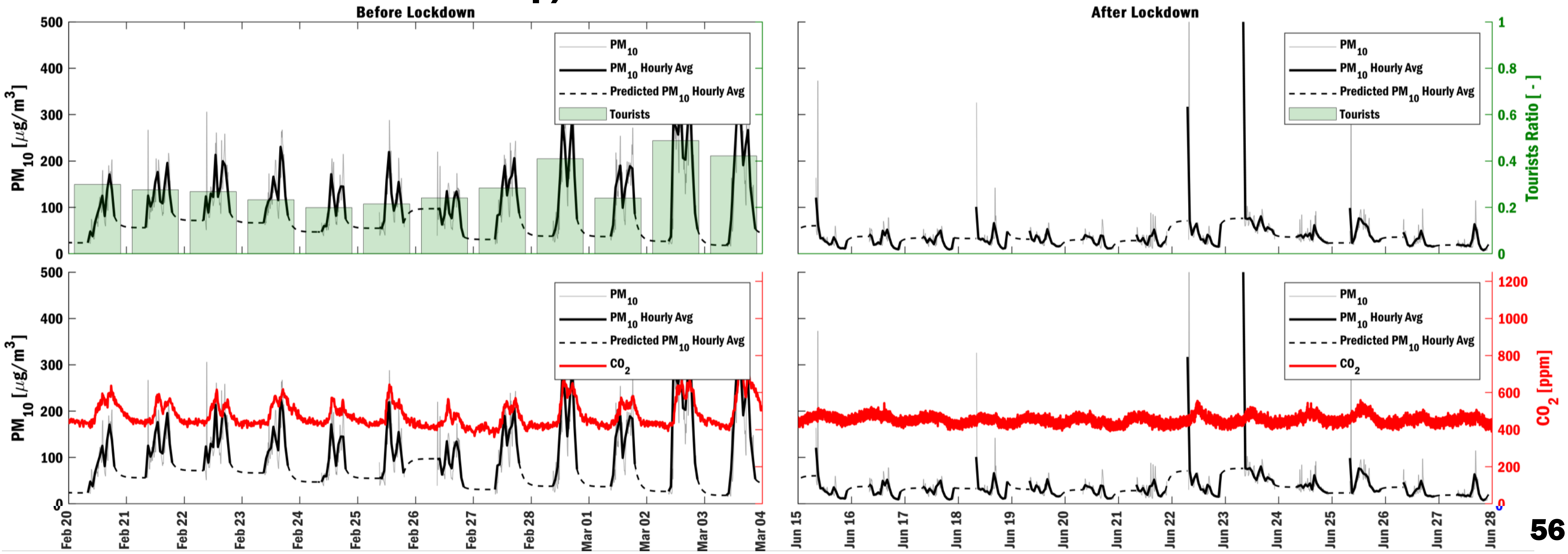


MONITORING

Particulate Matter

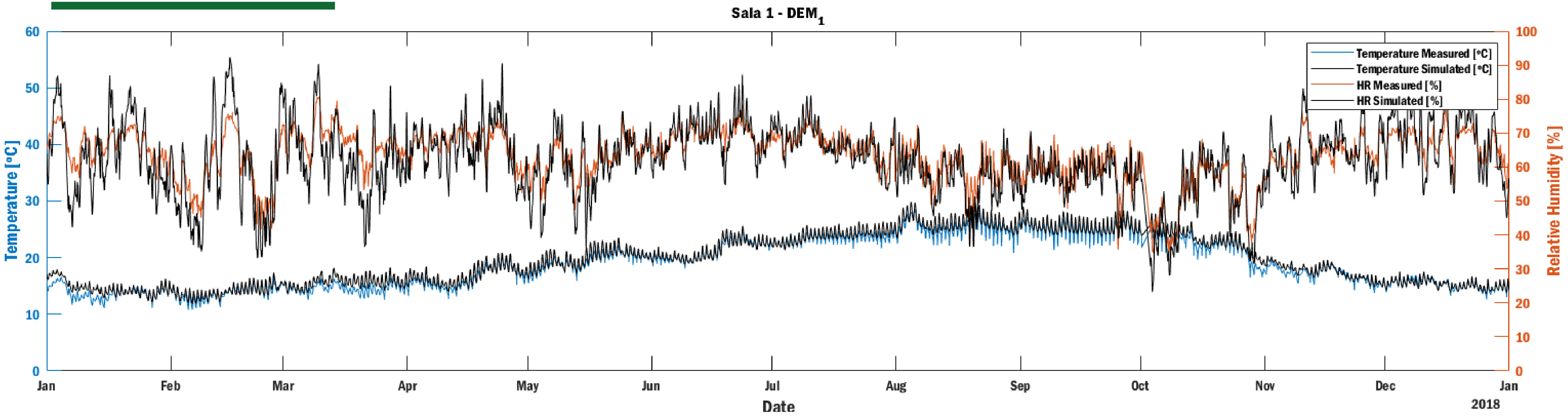
The **large dust** loads result from the transport of particles adhering to **visitors, deposition on the carpet, and** resuspension of particles deposited on the carpet.

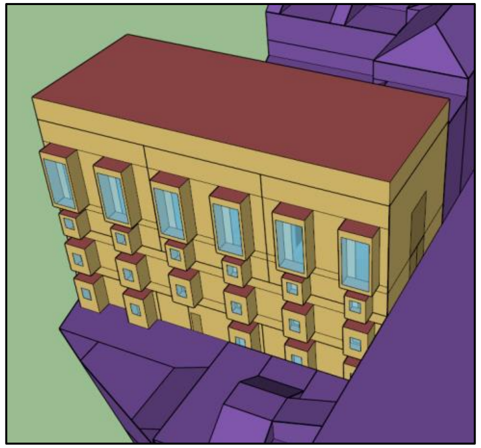
A seasonal pattern was identified due to the correlation between particulate matter in indoor air and **precipitation (rainfall → particle drop).**



SIMULATION

Hygrothermal





Validated Thermal Model

USED TO SUPPORT DECISION-MAKING PROCESS:

- Study the impact of having an alternative entrance
- Design an HVAC system
- Evaluate the positive outcome of insulating the roof of the building
- Assess the tourism impact
- Simulate the thermal performance in case of climate change

Project **AfroEnergy** - **Sustainable energy** for **health** promotion in African households (2022-2024)

Faculdade de Engenharia, Univ. Lúrio, Pemba, Moçambique

Missão de formação em Pemba, Moçambique, 2019

Fonte de energia da população baseada em biomassa e carvão vegetal

AKDN
AGA KHAN DEVELOPMENT NETWORK

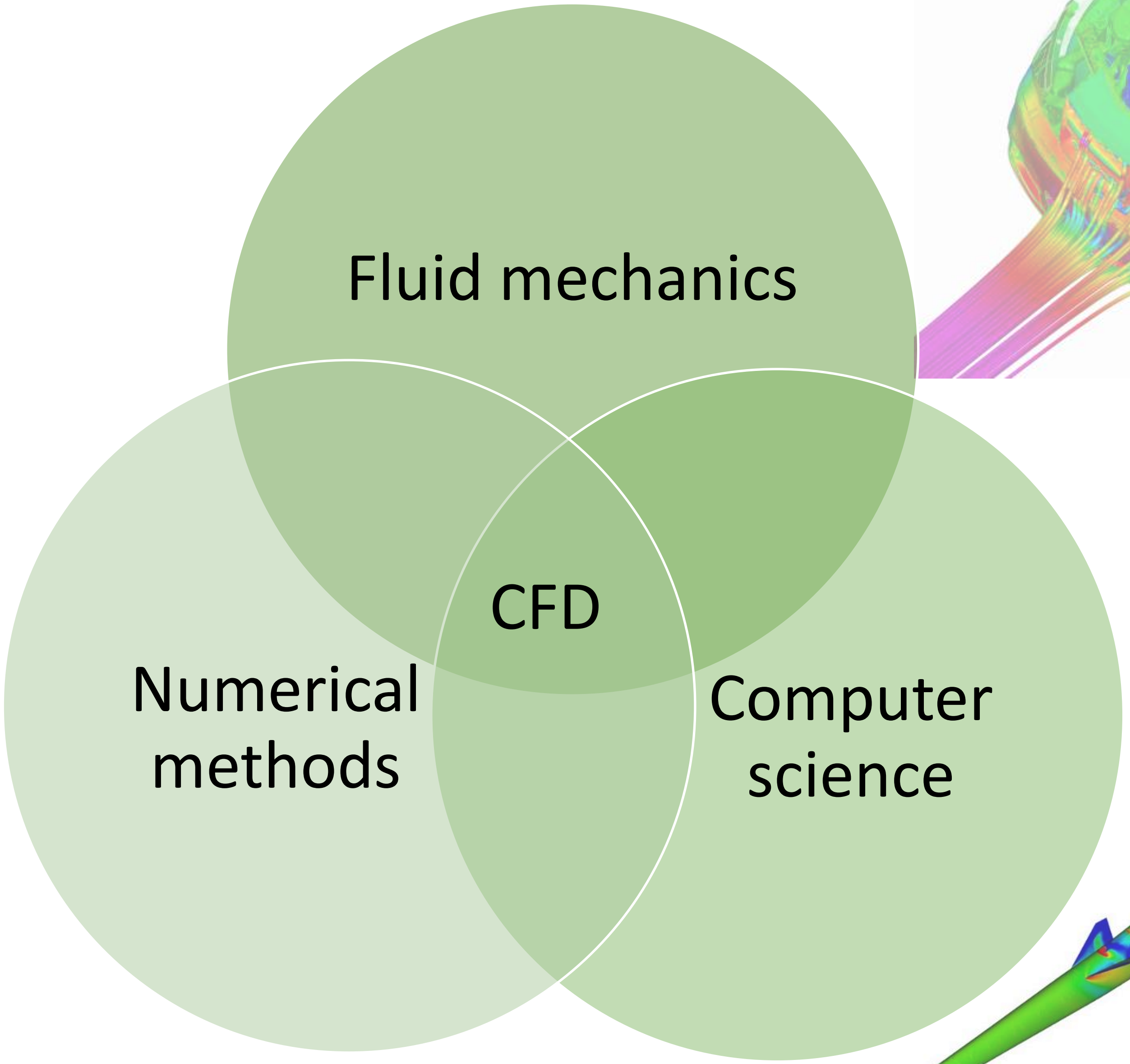
FCT Fundação para a Ciência e a Tecnologia

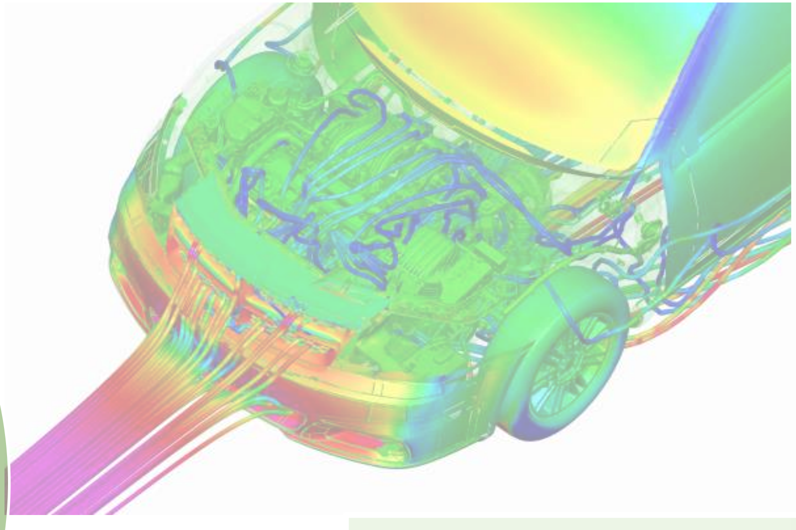
1290 UNIVERSIDADE D COIMBRA

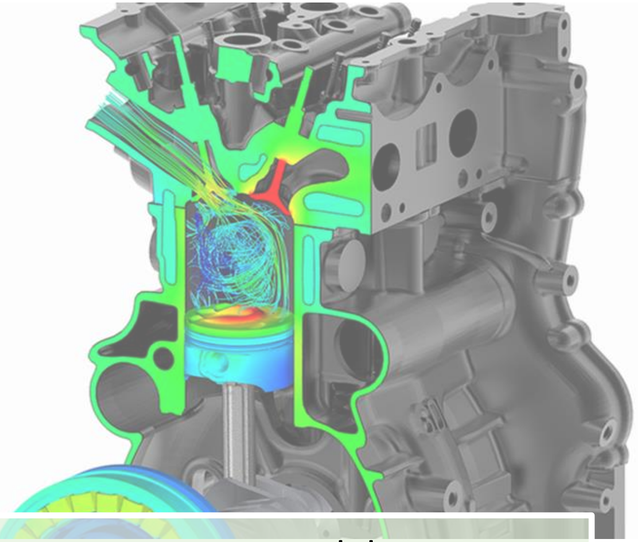
UNIVERSIDADE LÚRIO Scientia · Cretum · Fides

07

CFD-modelação numérica de escoamentos





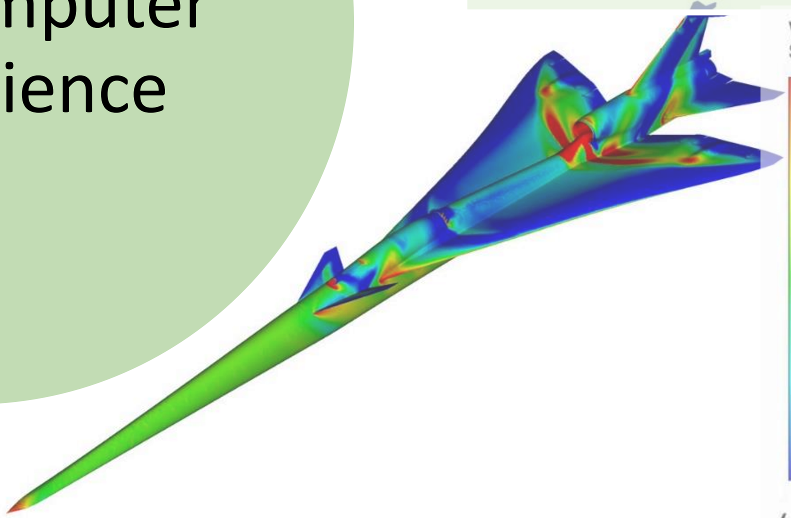


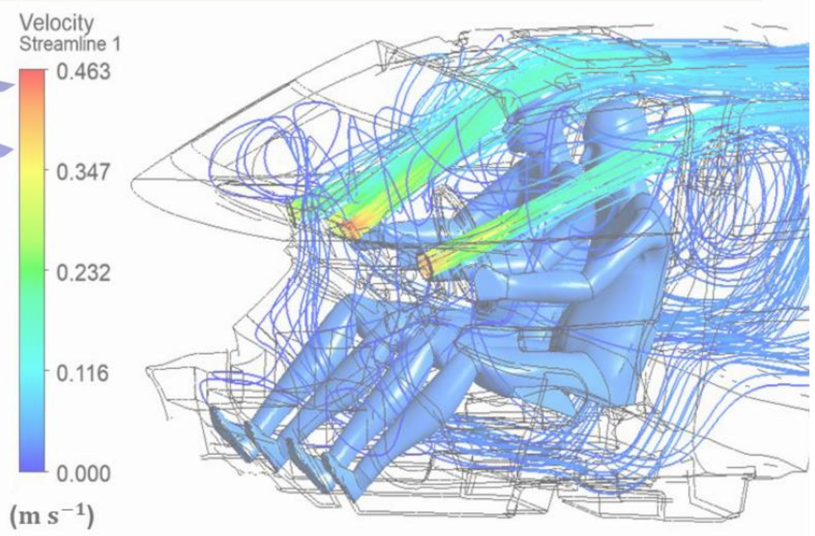
Resolution of engineering problems

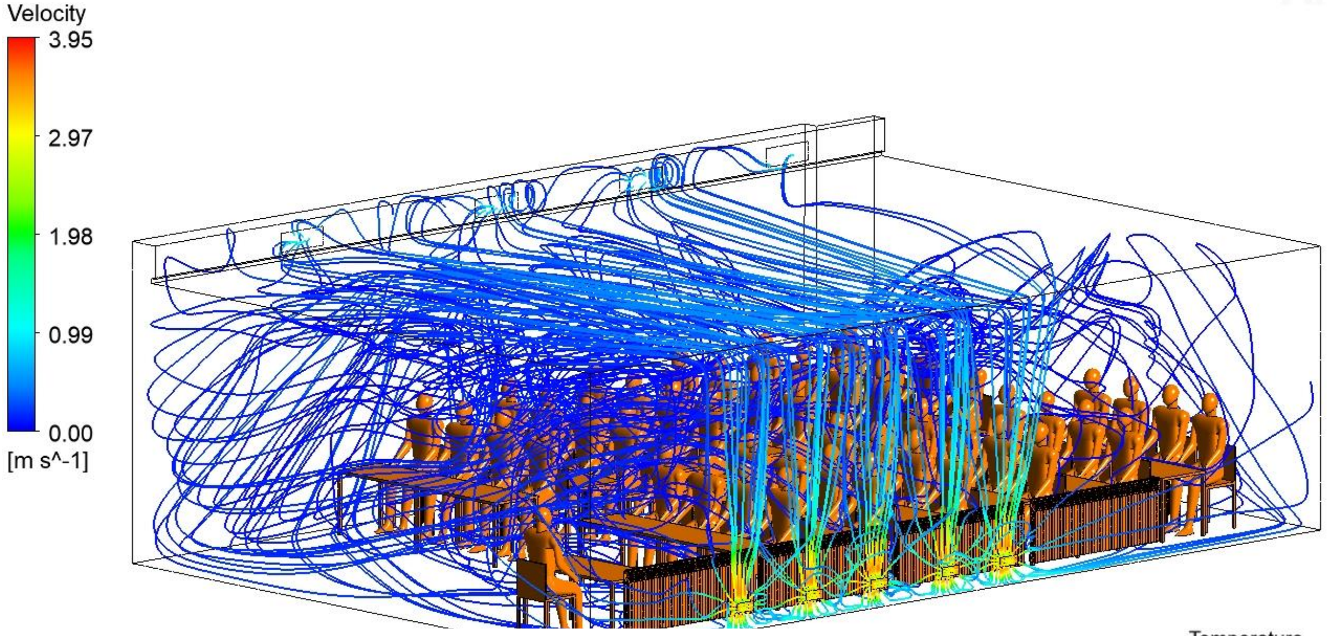
Design/redesign and conception

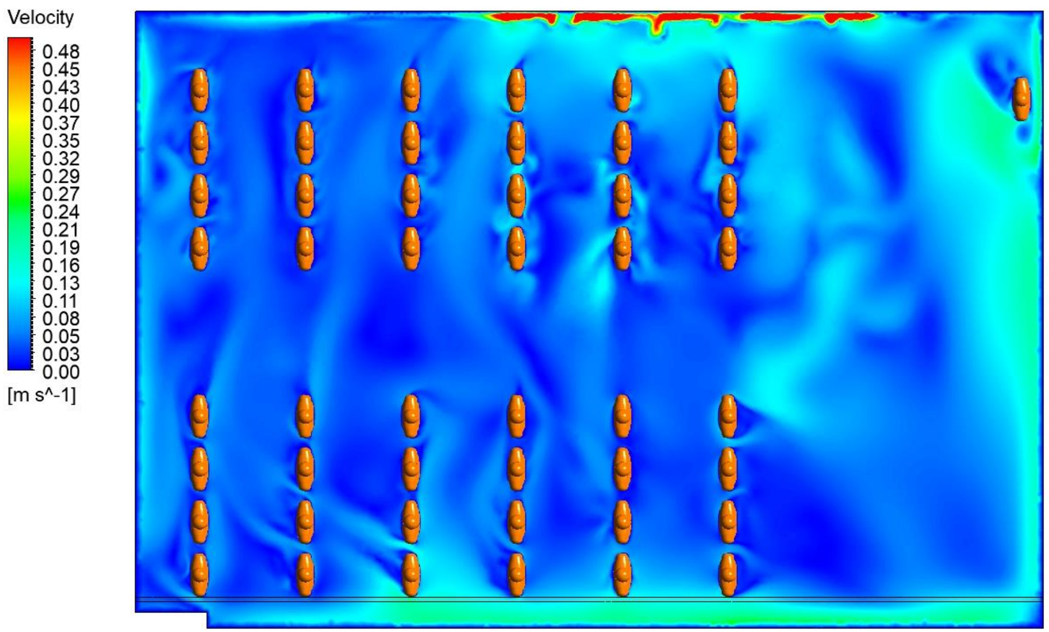
Research

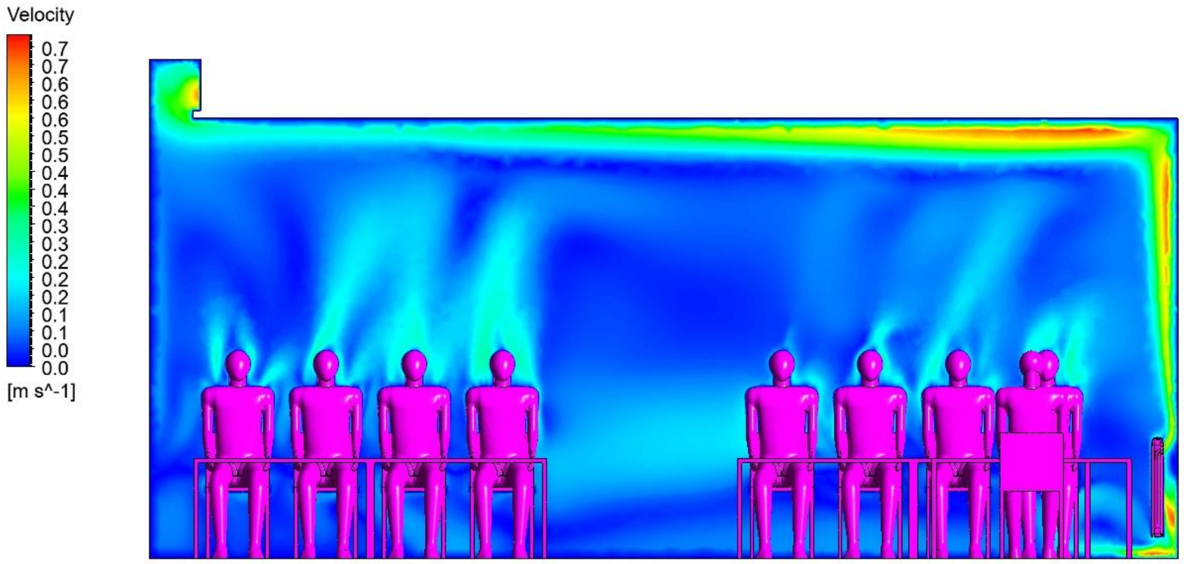
Product development

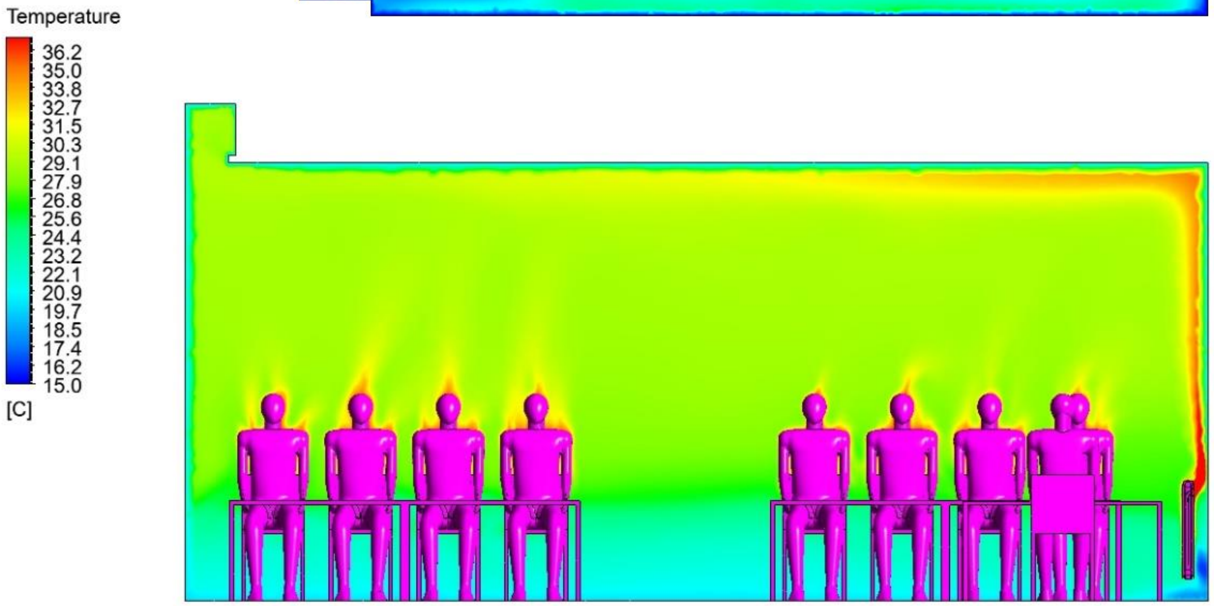





Velocity
3.95
2.97
1.98
0.99
0.00
[m s^-1]


Velocity
0.48
0.45
0.43
0.40
0.37
0.35
0.32
0.29
0.27
0.24
0.21
0.19
0.16
0.13
0.11
0.08
0.05
0.03
0.00
[m s^-1]

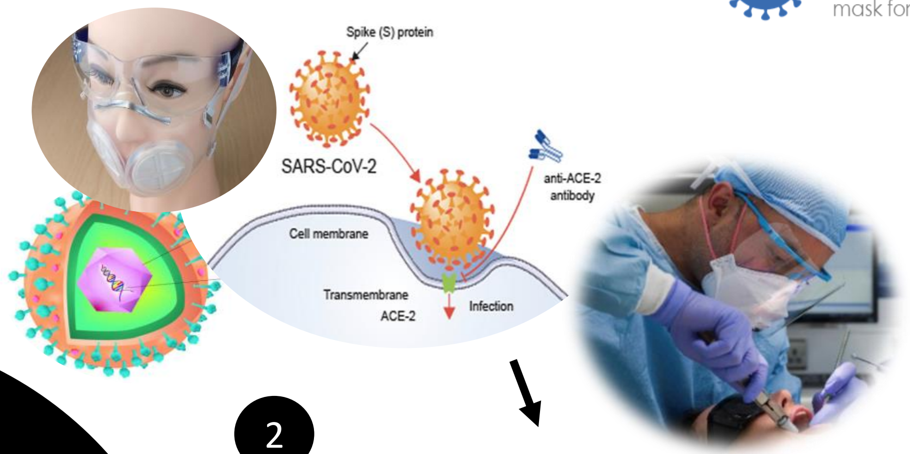

Velocity
0.7
0.7
0.6
0.6
0.6
0.5
0.5
0.4
0.4
0.4
0.3
0.3
0.2
0.2
0.2
0.1
0.1
0.0
0.0
[m s^-1]


Temperature
36.2
35.0
33.8
32.7
31.5
30.3
29.1
27.9
26.8
25.6
24.4
23.2
22.1
20.9
19.7
18.5
17.4
16.2
15.0
[C]

1. Framework

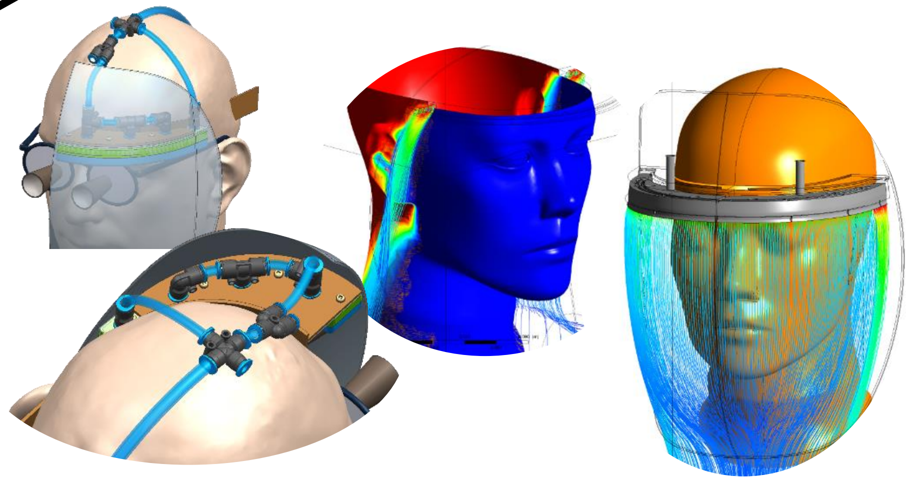
MASK4MC
mask for medical care

1 Preliminary studies



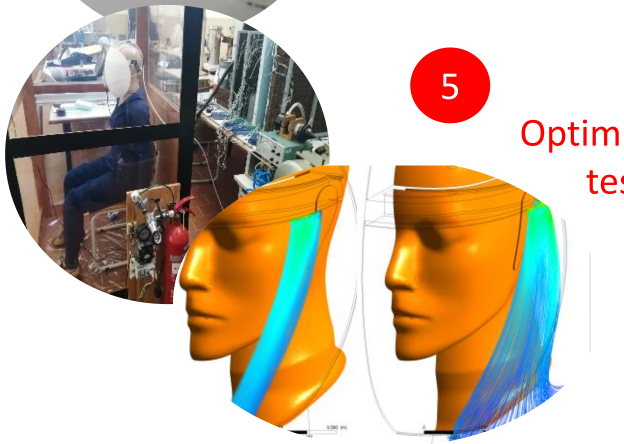
2 Definition of the requirements and specifications

3 Design and numerical simulations



4 Production of prototypes

5 Optimization tests



6 Final model

7 Technical seminars and workshops

MASK4MC

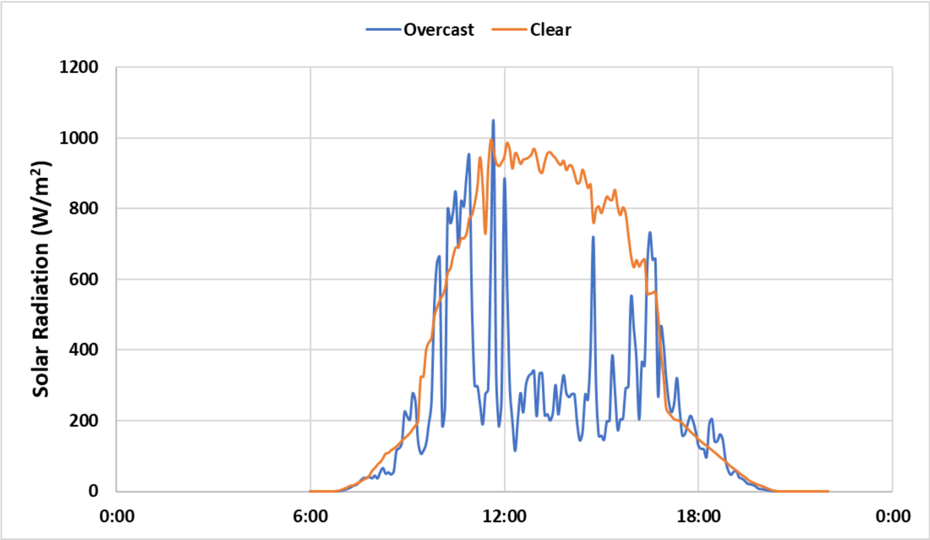
MAIN TASKS

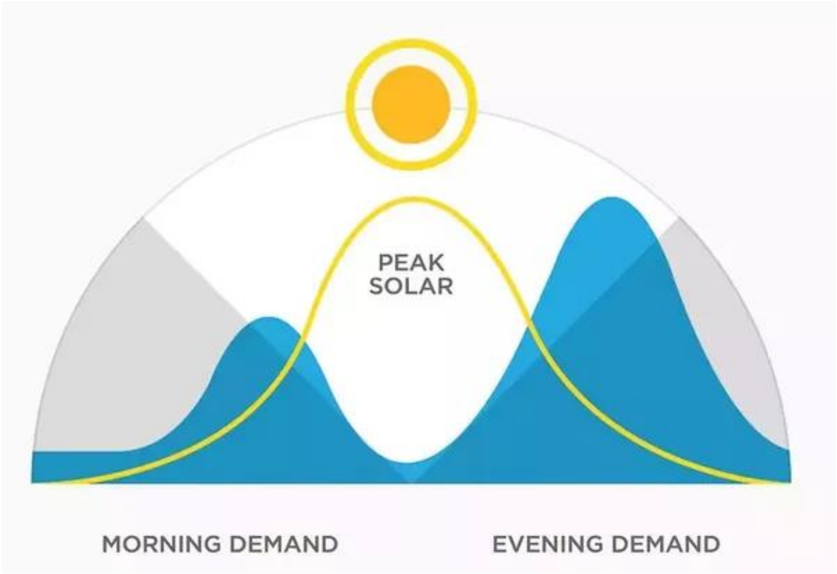
Air-curtain seals in a newly designed visor developed to significantly reduce the risk in the breathing zone of inhaling droplets and aerosols with a potential viral load

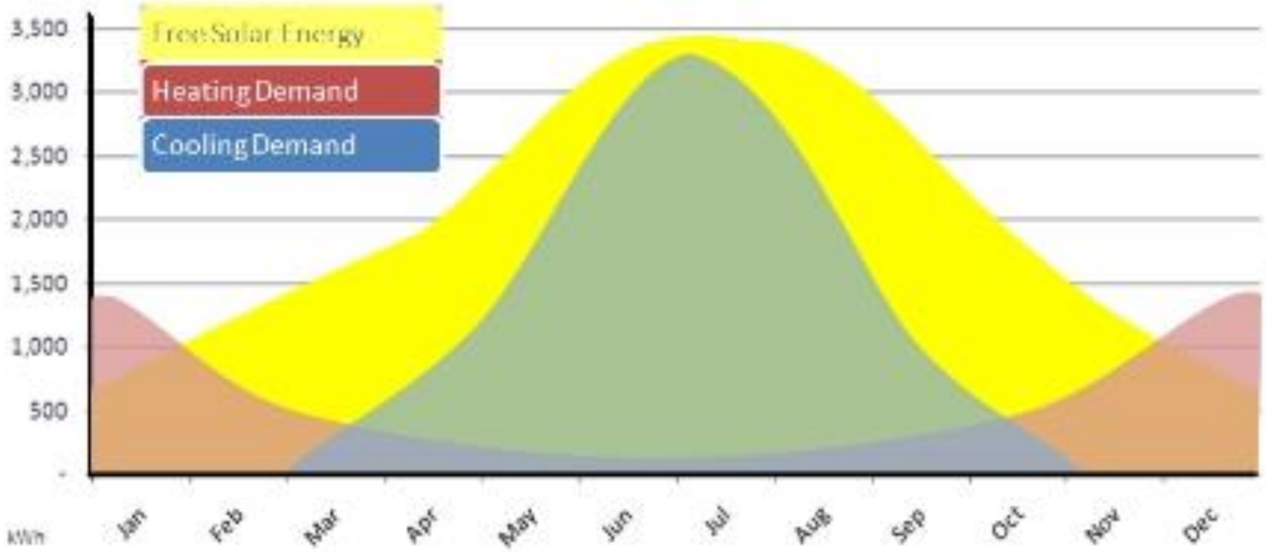
08

Estudos sobre arrefecimento com energia solar térmica e armazenamento de energia térmica

Solar energy intermittence nature and daily and annual mismatch with thermal demand







Solar Adsorption cooling system

Authors: Gonçalo Brites, José Costa, Vítor Costa

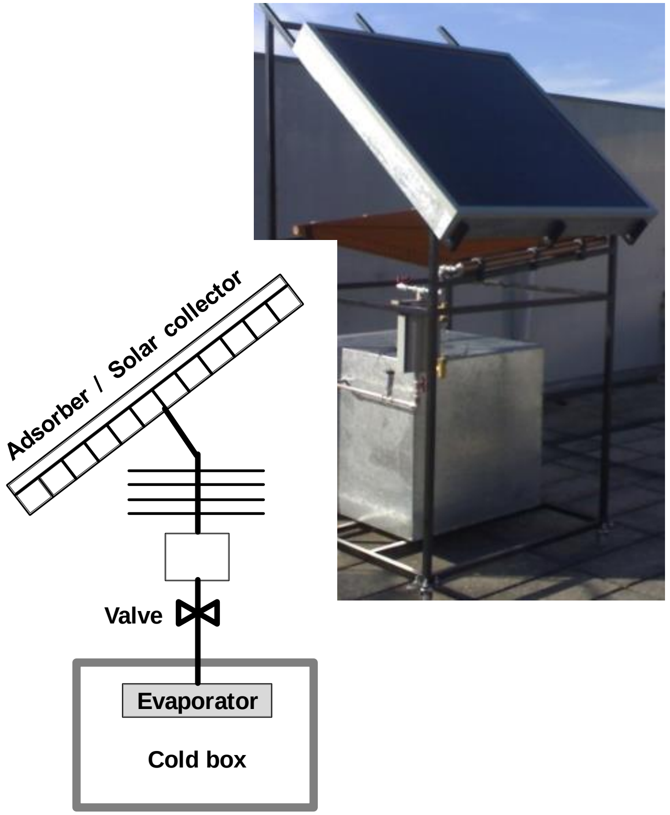
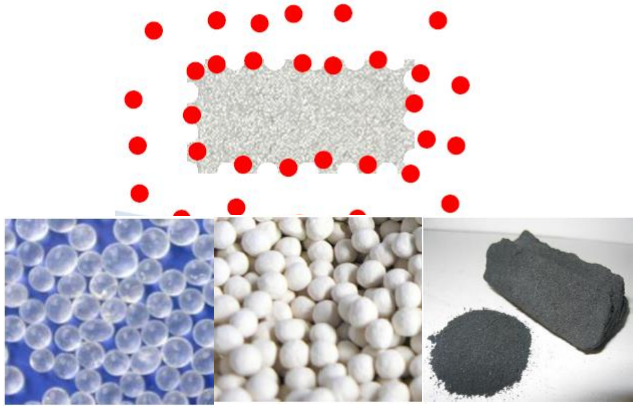
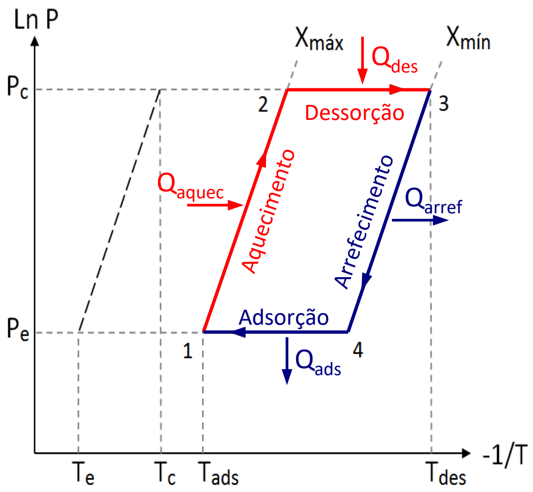


Fig. 2 – Solar refrigerator.

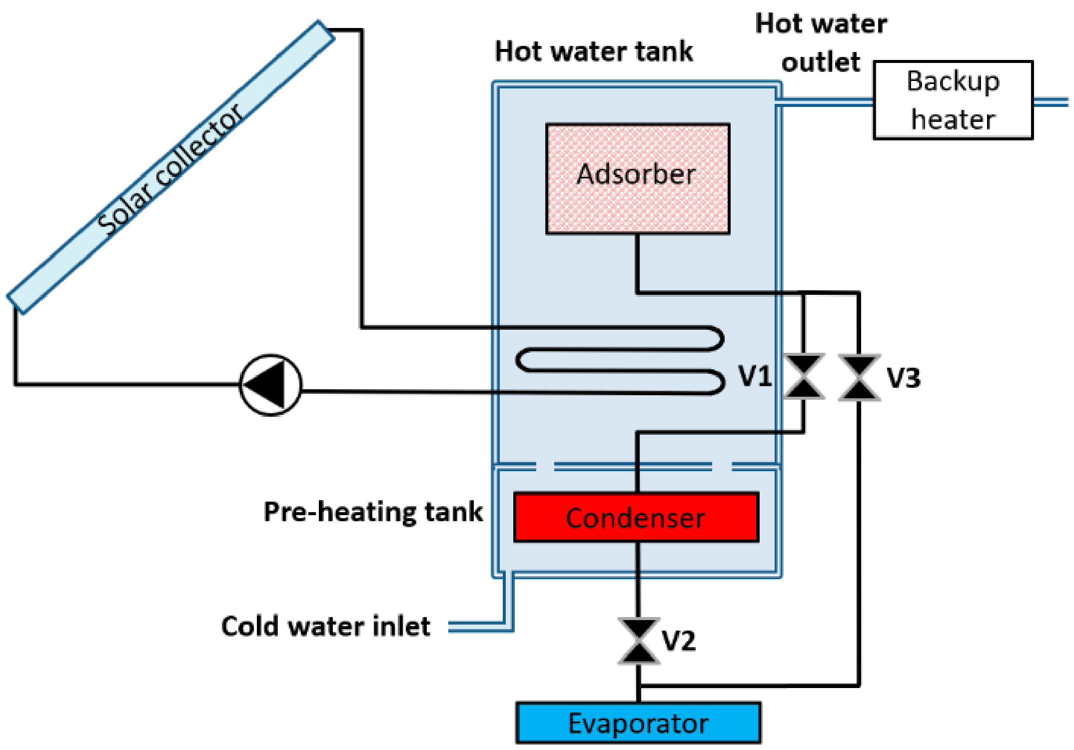


Adsorption materials: Silica gel; Zeolite; Activated carbon, …



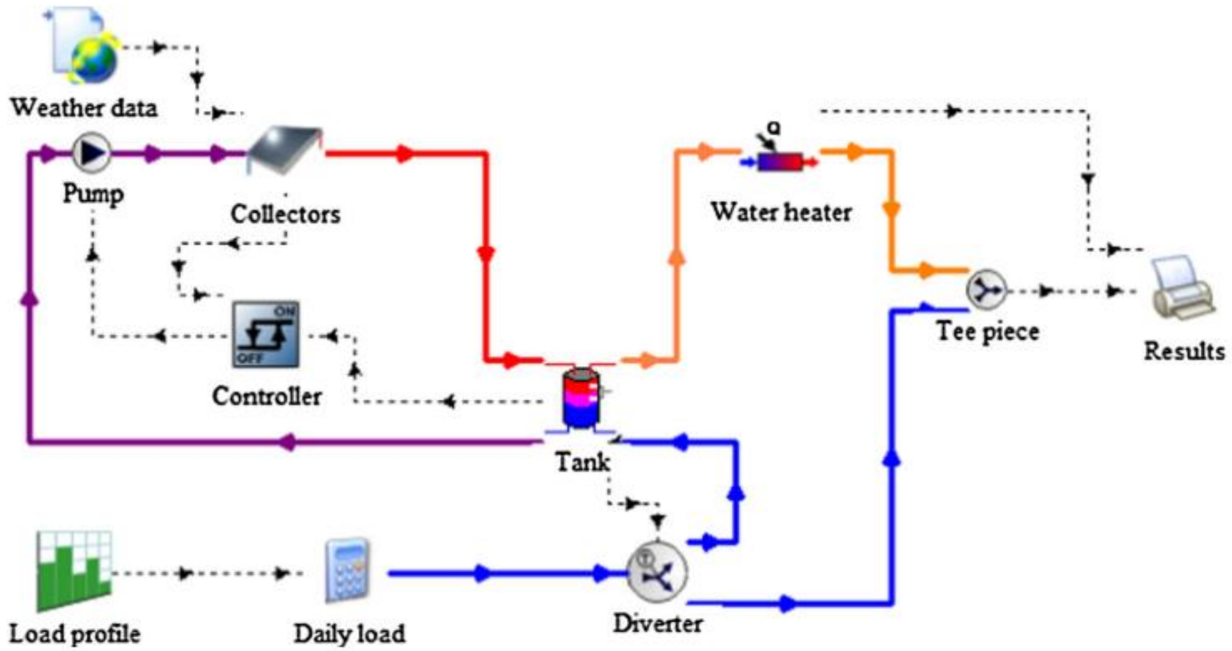
Working principle

Hot water solar system + Adsorption module



- **Advantages:**
- Increases the overall efficiency of Domestic Hot Water (DHW) systems
- Increases the thermal energy storage capacity (higher energy density)
- Decreases the thermal losses in DHW tanks
- Decreases the solar energy waste in solar thermal systems
- Decreases the backup heating energy

Simulation model



- The system was simulated in TRNSYS+MATLAB
- A new hot water storage + adsorption module type was developed
- The results for a typical 4 people family dwelling in Coimbra (water tank of 250 L, and 3.7 m^2 of solar collectors) point to a **16%** annual reduction of backup energy consumption [155 MJ reduction: 822 MJ → 667 MJ]

TRNSYS18

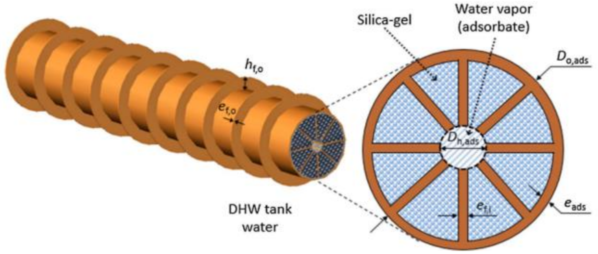
MATLAB

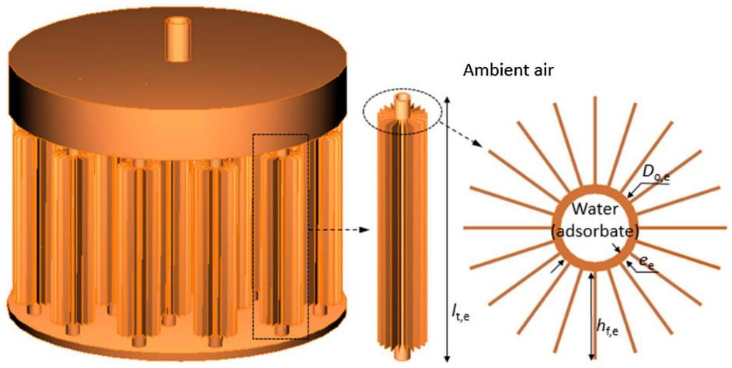
Adsorption Technology for Supplementary Storage of Thermal Energy[2020-2023]

RD project with a hot water tanks manufacturer company to design, dimension, assemble, test, and improve the system, encompassing 2 prototypes:

- Enhancement of the system's configuration/operation
- Improvement of the simulation model
- Validation of the numerical model
- Testing of the system in different operation modes
- Proof of concept

AdsorTech





TANKPOR RESERVATÓRIOS, LDA

1 2 9 0 UNIVERSIDADE D COIMBRA

CTCV

Cofinanciado por:

COMPETE 2020

PORTUGAL 2020

UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

AdsorSeason - Long-term adsorption solar-thermal energy storage [2023-2025]

Just starting

- **Objectives:**
  - **new configuration** of a **long-term** solar thermal energy storage system with **high energy density** and **reduced thermal losses**
  - **new numerical model**
  - evaluate the **performance** in **different climatic** conditions, **dimensional scales,** and **profiles** of thermal energy

09

Programas multi e Interdisciplinares para a Sustentabilidade e Transição Energética

ENERGY FOR SUSTAINABILITY

1 2 9 0

INSTITUTO DE INVESTIGAÇÃO INTERDISCIPLINAR
UNIVERSIDADE D COIMBRA

EfS Initiative

To organize, in the energy and sustainable development area, **interdisciplinary answers to the challenges** presented by the study, conception, operation and regulation of:

- **Energy efficiency**
- **Power generation, distribution and storage**
- **Cities, buildings and industry**
- **Mobility and territory**

In the following three-pronged approach**:**

- **Research & Development**
- **Educational programs**
- **Transfer of knowledge and technology**

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Master study plan

1st SEM

Choose one in the branch color

- Indoor Environmental Quality
- Energy Conversion, Production & Storage
- Dissertation Project
- Energy Management in Buildings
- Energy Economics and Energy Markets

Optional (choose one in the branch color):

- Computational Fluid Mechanics
- Energy Simulation in Buildings
- Optative Course
- Building Envelopes
- Indoor Environmental Quality
- Industrial Ecology
- Sustainable Mobility
- Energy Management in Industry

2nd SEM

Choose one in the branch color

- HVAC Systems
- Energy Planning & Sustainable Develop.
- Dissertation Project
- Buildings & Environment
- Renewable Energy Systems

Optional (choose one in the branch color):

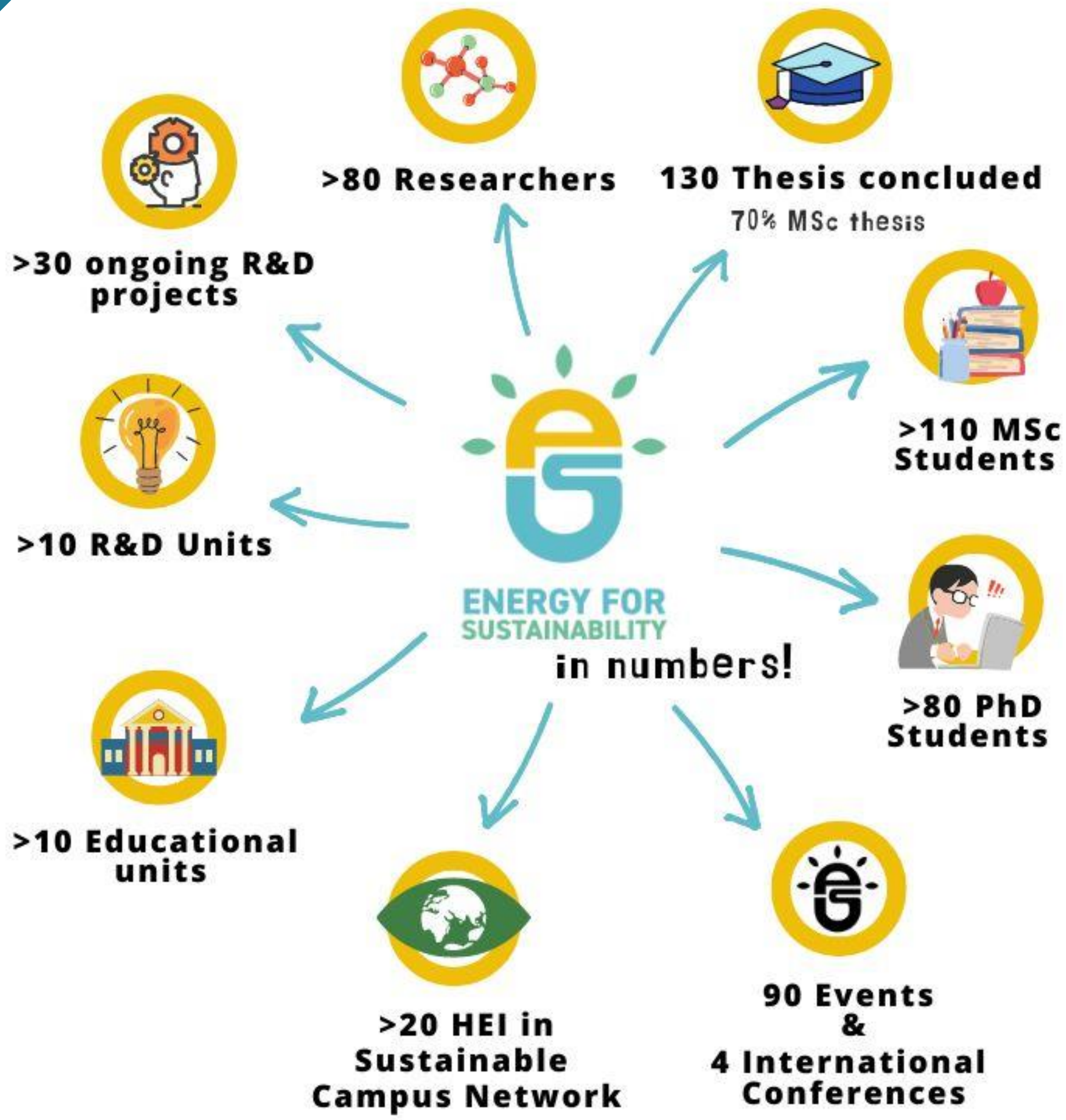
- Energy and Comfort Audits
- Buildings & Environment
- Optative Course
- Space Organization and Environment
- Building Technology for Façades & Roofs
- Policies for Energy Markets Transformat.

Indoor Climate and Comfort

Buildings and Urban Environment

Energy Systems and Policies

External Advisory and Assessment Board


>80 Researchers
130 Thesis concluded
70% MSc thesis
>30 ongoing R&D projects
>110 MSc Students
>10 R&D Units
ENERGY FOR SUSTAINABILITY
in numbers!
>80 PhD Students
>10 Educational units
>20 HEI in Sustainable Campus Network
90 Events & 4 International Conferences

Co-funded by the
Erasmus+ Programme
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The European Campus of City-Universities EC2U

A pan-European multi-cultural and multi-lingual Alliance

Selected by the European Commission in the pilot phase of European Universities initiative (2020-2023)

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Full Partner Universities: 7

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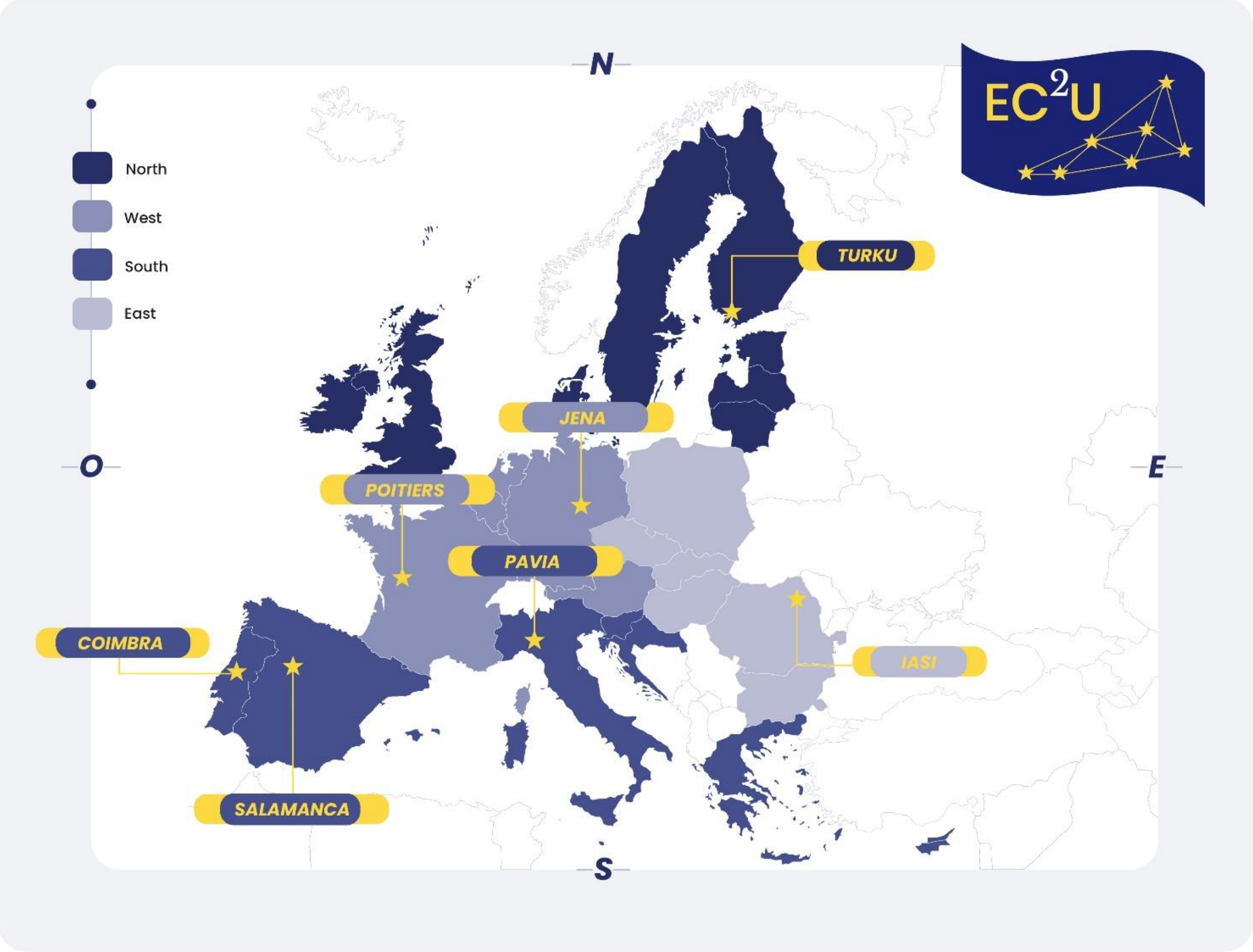
Coimbra (PT)
Alexandru Ioan Cuza, Iasi (RO)
Friedrich Schiller, Jena (GE)
Pavia (IT)
Salamanca (SP)
Turku (FI)

Total number of Students: 160 000
Total number of Staff: 20 000
Total number of Citizens: 1 600 000



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Addressing all missions of the Knowledge Square

3 Virtual Institutes (WP4-5-6)

- Education
- Research
- Innovation
- Service to society
- Interdisciplinarity

3 EC2U Joint Master Programmes

- **“Health & well-being”:** prevention, ageing, imaging, cancer
- **“Quality education”:** multilingualism, interculturality
- **“Sustainable cities & communities”:** quality of air and water, energy, public policies

3 GOOD HEALTH AND WELL-BEING

4 QUALITY EDUCATION

11 SUSTAINABLE CITIES AND COMMUNITIES

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Investigação e ensino: Contributos para a transição energética

Centro de Excelência de Formação de Formadores para o Gás Natural
Universidade Lúrio

18 de julho 2023

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