



# CLIMATE CHANGE: CAUSES & CONSEQUENCES

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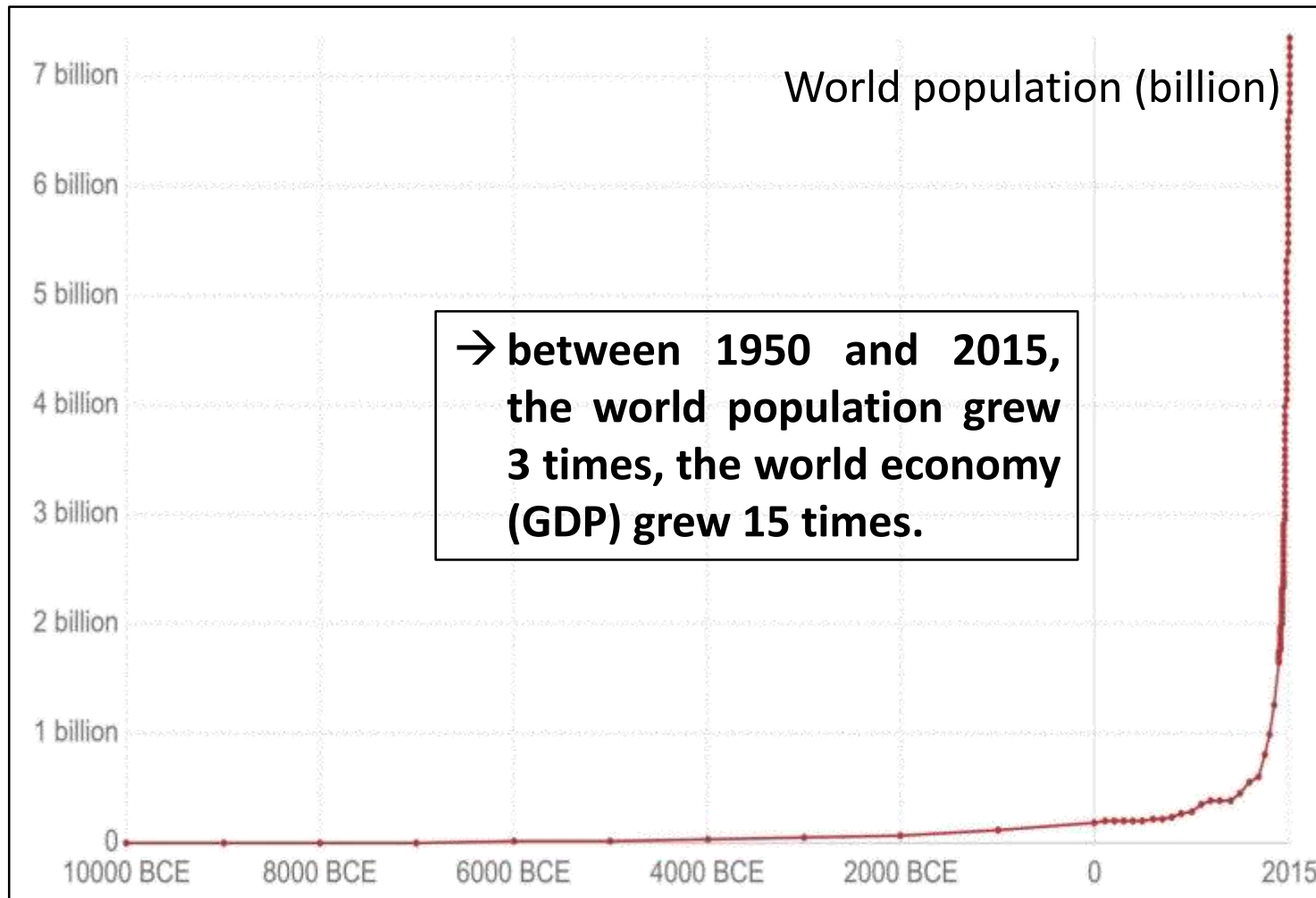


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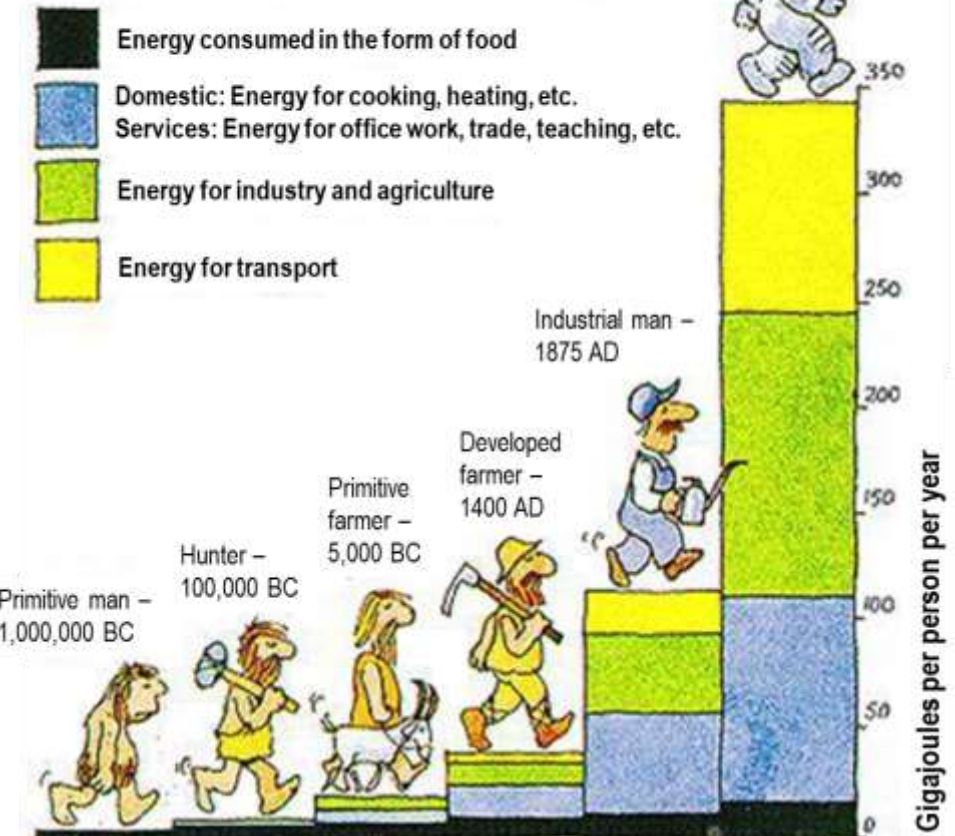
## Causes of climate change: population grow and energy



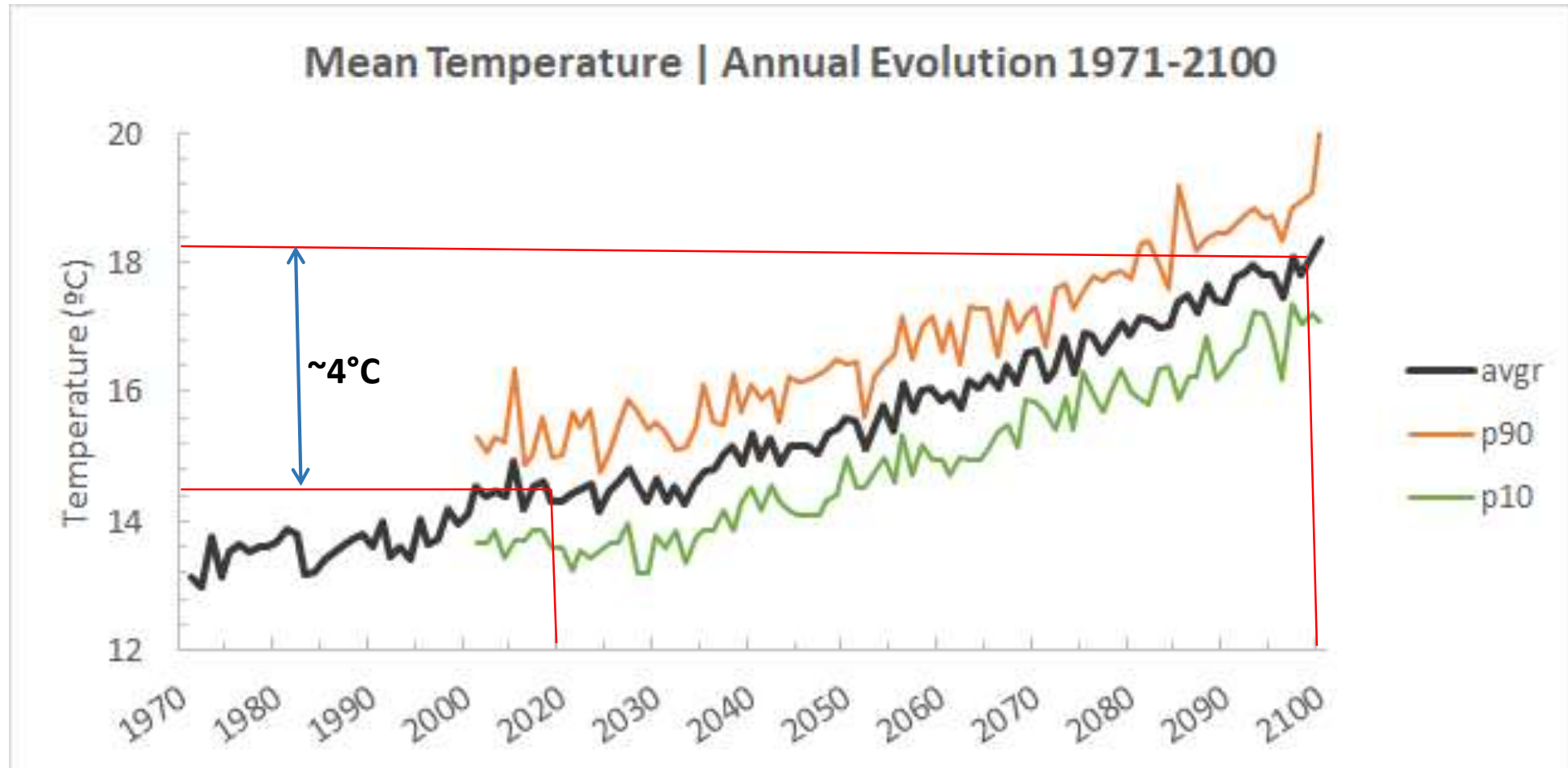
## Individual energy consumption

Adapted from Unesco Courier

Technological man - 2010 AD

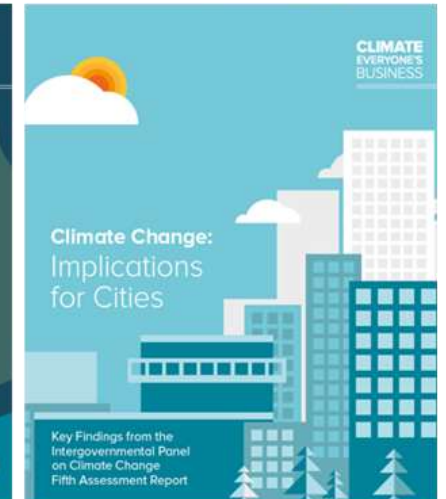
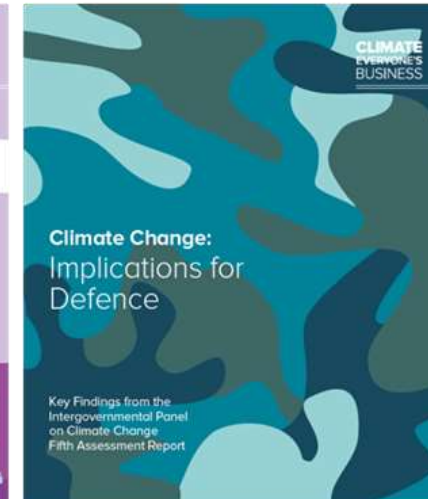
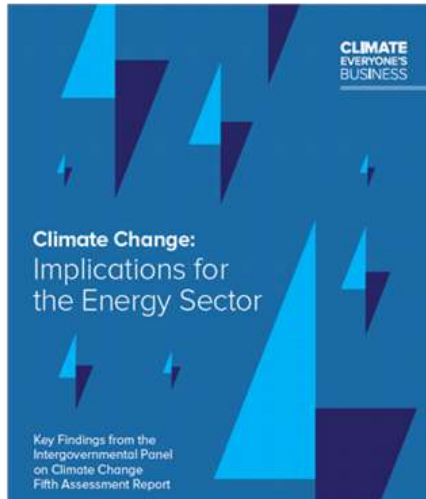
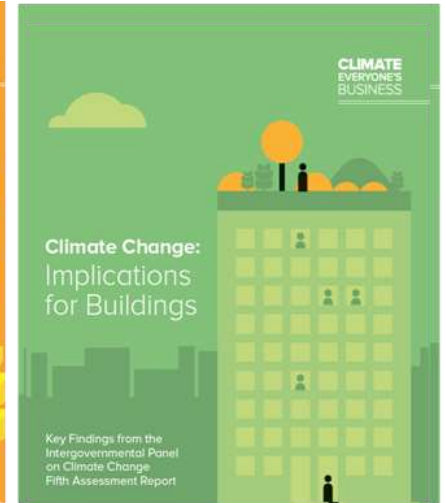
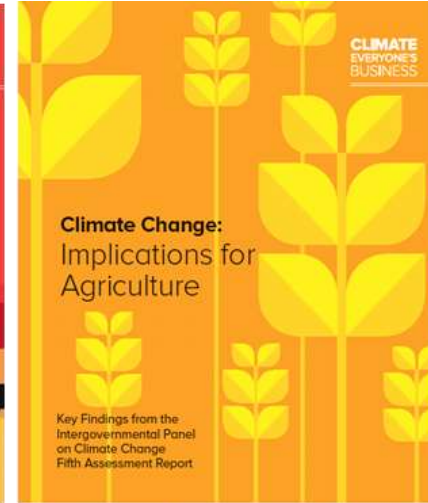


## Climate change in Portugal





## Implications of climate change (5<sup>th</sup> IPCC Report)



## Climate change & Built Environment

Significant  
contributions to  
GHG emissions!

**32%**  
of all energy in EU  
is used for transport



**28%**  
of all energy in EU  
is used for industry



**40%**  
of all energy in EU  
is used for buildings



2/3 of energy consumption in  
buildings is used for heating  
and cooling

80% of energy consumption  
is used in small buildings  
< 1000 m<sup>2</sup>



## Climate change: the need for adaptation

Climate change → Increase in the air temperature → Temperature rise in buildings → Increase in energy consumption (cooling) → Increase in costs → Reduction in thermal comfort → Need for adaptation

**40%**

of the world's energy use  
is due to buildings

**90%**

of the total energy of buildings  
is consumed during building lifetime

**10%**

of consumption is linked to the materials  
and construction of buildings



## Building and construction sector: the key for sustainable development



## The numbers in the construction sector

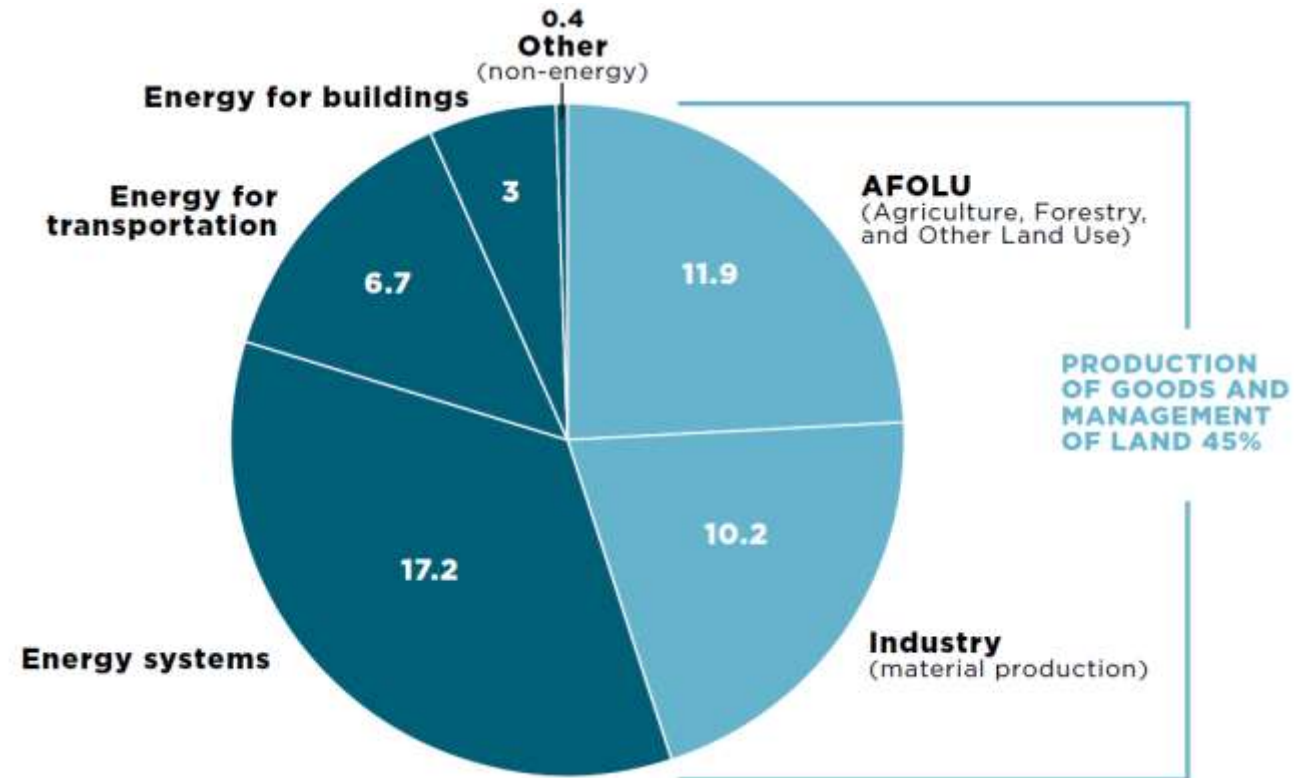
Did you know that a **shift to renewable energy** can only tackle **55% of greenhouse gas emissions**? So, we need to look further.

From a global perspective, the **building and construction sector** accounts for the **largest share in the use of natural resources, land use and material extraction**.

In Portugal **73% of material extracted** is used in the **building sector**.

**A smart way of using materials → circular economy**

Global GHG emissions (billion tonnes of CO<sub>2e</sub> per year, 2010)





## Circular economy

*Circular Economy is a strategic concept inspired by nature-based solutions founded on extension of life cycle of products by sharing, leasing, reusing, repairing, refurbishing and recycling of materials and energy ...*

**More efficient and productive: do “more with less” and increase in value. The “less” can be shared, designed to “go back home” and be repaired, reused, remanufactured and recycled.**

Linear  
economy



Recycling  
economy



Circular  
economy



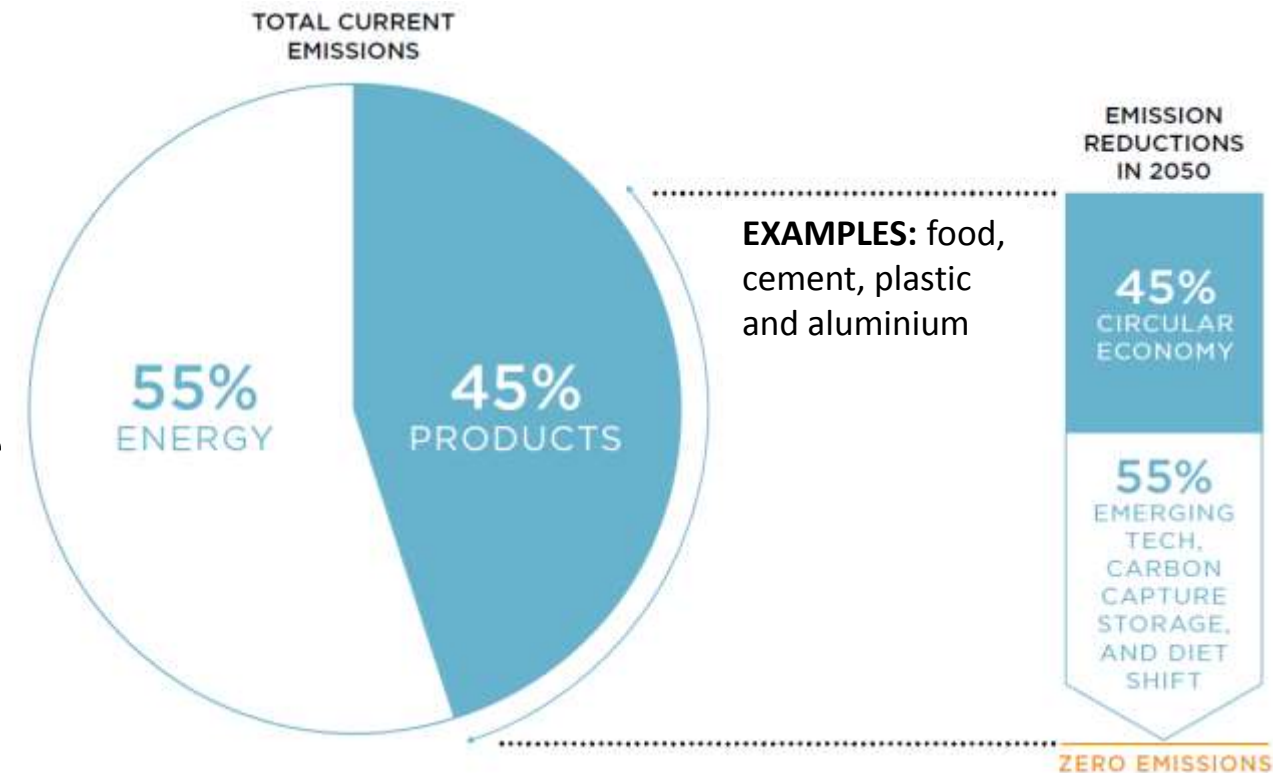
## Circular economy: tackling the overlooked emissions

- Today's efforts have focused on the **critical role of renewable and energy-efficient measures** in the transition to a **net-zero economy**.

- Meeting **climate targets** will also require tackling the remaining **45% harder-to-abate global emissions**, which are associated with the **production of goods and materials**.

- **Circular economy** offers a systems-level and cost effective approach to tackling this challenge. When applied to the **food system and industry** – cement, steel, plastic and aluminium production – circular economy strategies help **reduce global emissions** by 9.3 Gt CO<sub>2e</sub> in 2050.

- This is **equivalent** to removing all forms of **GHG-emitting transport** from the planet.





## Circular economy in the building sector: example in Portugal

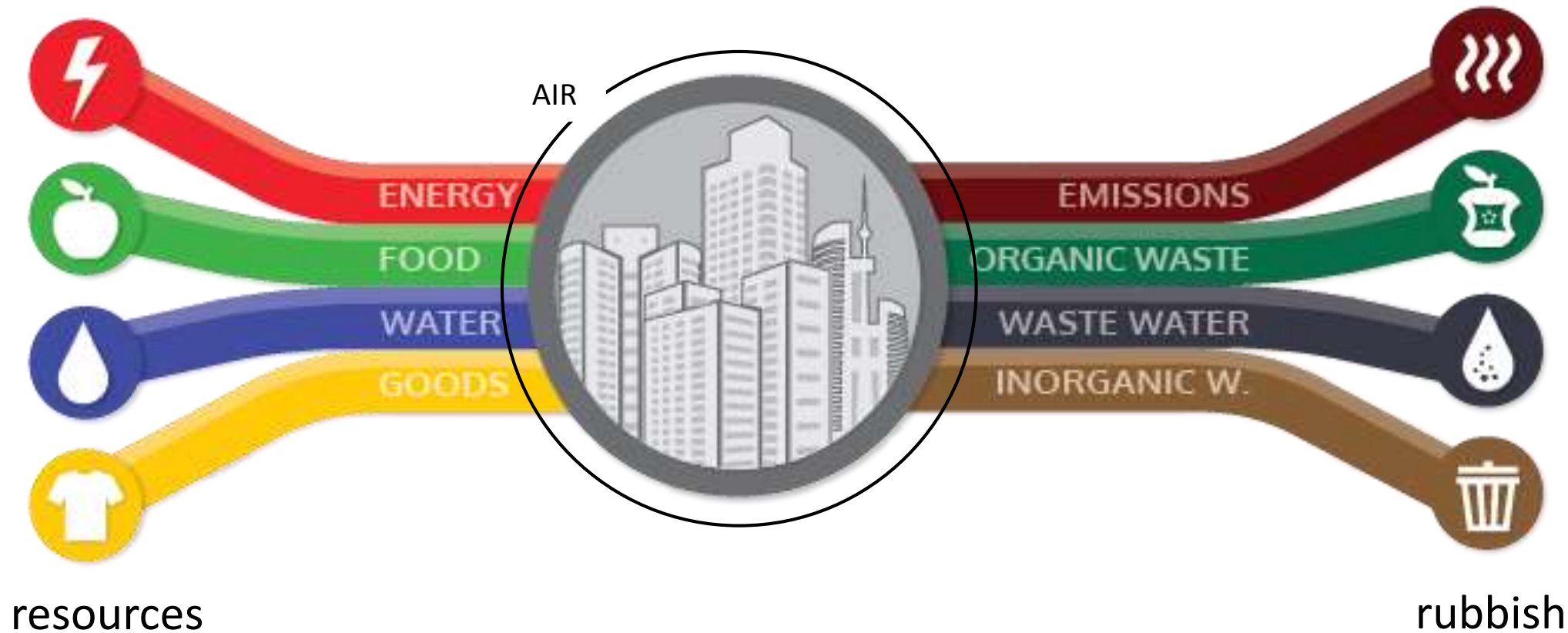


*The Portuguese company Tailored Tile has been using plastic wastes to build tiles that can be shredded and remoulded more than once*



<https://eco.nomia.pt/pt/exemplos/tailored-tile>

## Urban Metabolism with Linear Economy





## Urban Metabolism with Circular Economy



**New perspective of urban metabolism**

**Buildings and infrastructures**  
are a significant part of what is  
stocked in the urban area

... the main weapon is:

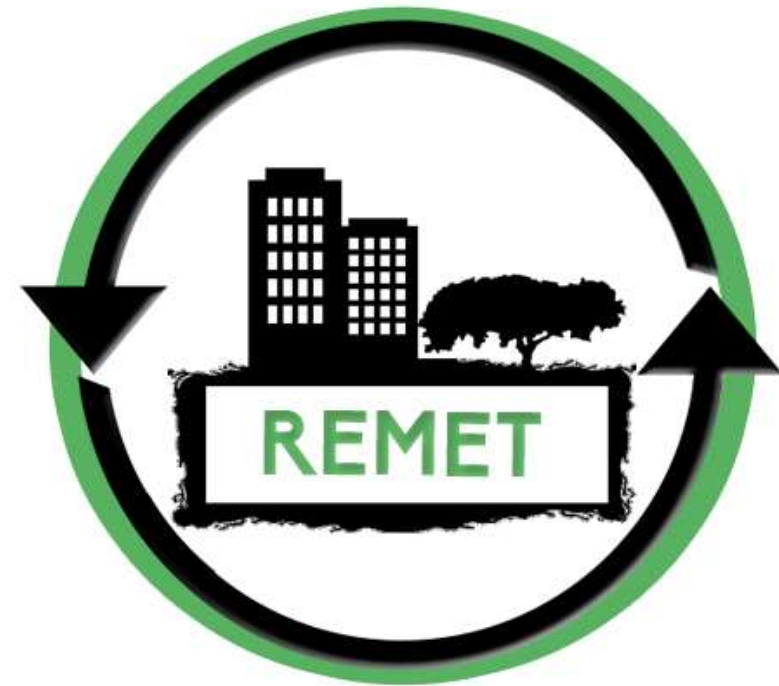
**CIRCULAR ECONOMY → CIRCULAR CITIES**

## REMET-UA: Regional Metabolism model

The REMET-UA (REgional METabolism) model was developed to assess the urban metabolism of the Alentejo Region

REMET-UA allows to identify business opportunities and circularity potential within a region

Represents connections between different regions



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## Urban Resilience

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... is the capacity of a city to absorb perturbations and to reorganise itself in order to essentially maintain the same function, structure, identity and feedbacks, **continually adapting through cycles of change**



## Nature-Based Solutions – NBS

Solutions that bring more **nature and natural features and processes** into cities, landscapes and seascapes, through **locally adapted, resource-efficient and systemic interventions**. The use of **nature-based solutions (NBS)** will increase society's economic, social and environmental **resilience**.



Urban  
regeneration



Increasing  
carbon  
sequestration



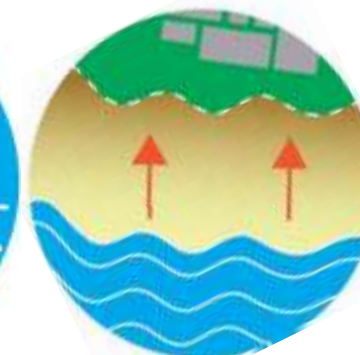
Enhancing the  
insurance  
value of  
ecosystems



Increasing the  
sustainable  
use of matter  
and energy



Multi-functional  
watershed  
management and  
ecosystem restoration



Coastal  
resilience



Improving well-  
being in urban  
areas



## Green Areas

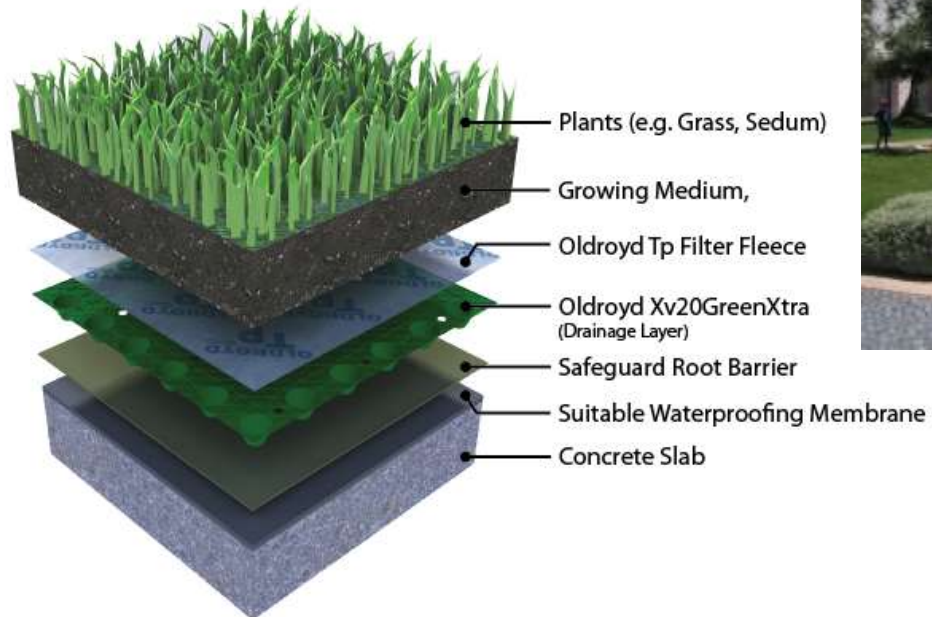
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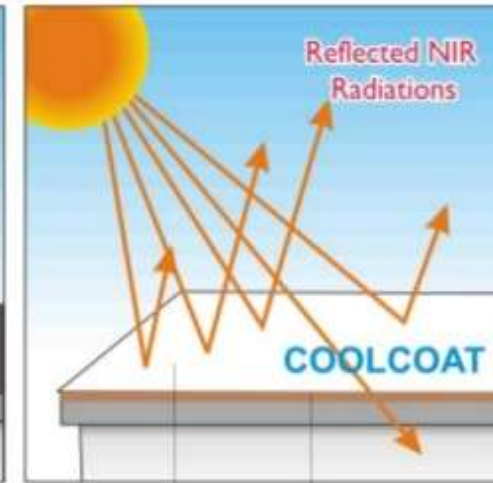
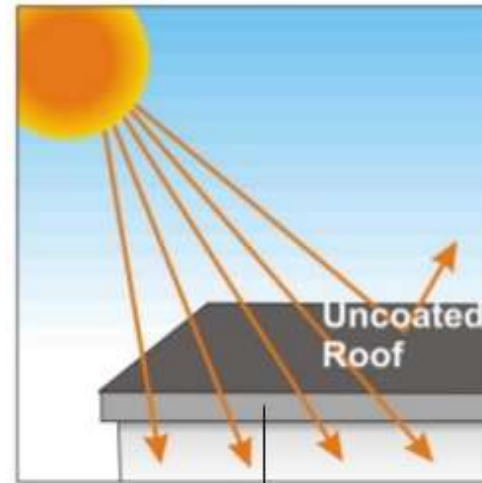


## Green Roofs

BS EN 13707:2004+A2:2009, EN 13948:2007



## White Roofs

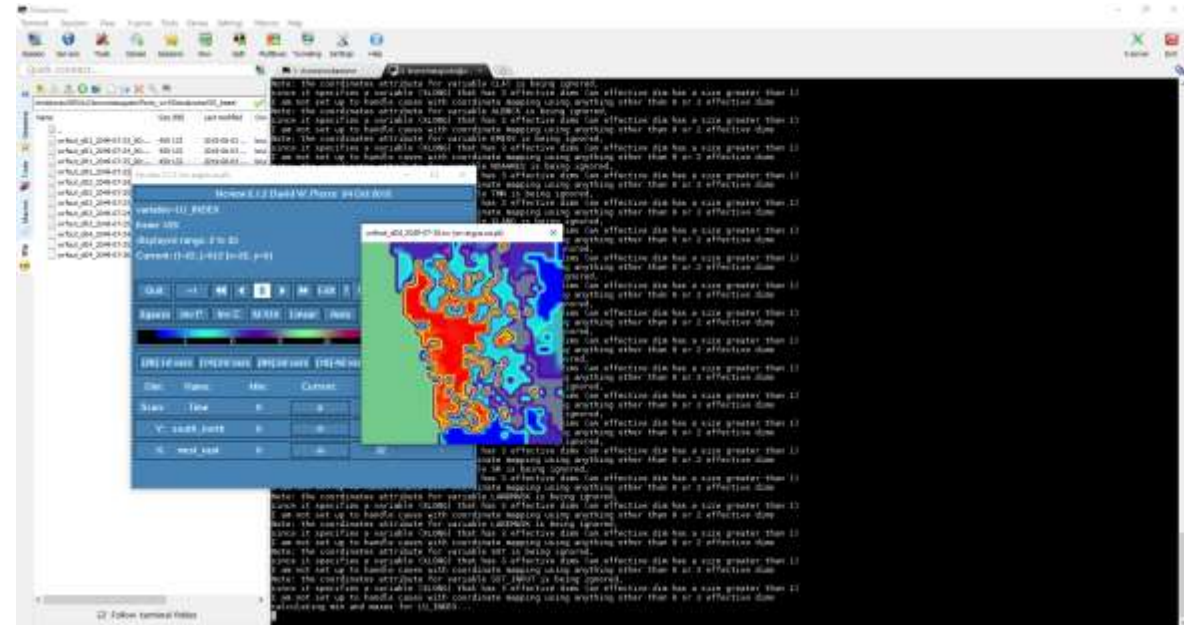




## How to quantify NBS impacts?



Physical modelling (Wind Tunnel)



Numerical modelling



*...a case study...*  
*...innovation in services!*



## Case study | Porto urban area: cooling down the city



### The **city of Porto**

- is one of the European areas with a higher index of sprawling
- has air quality problems
- warming is expected in a near future
- heat wave in 2003

### Average temperature increase



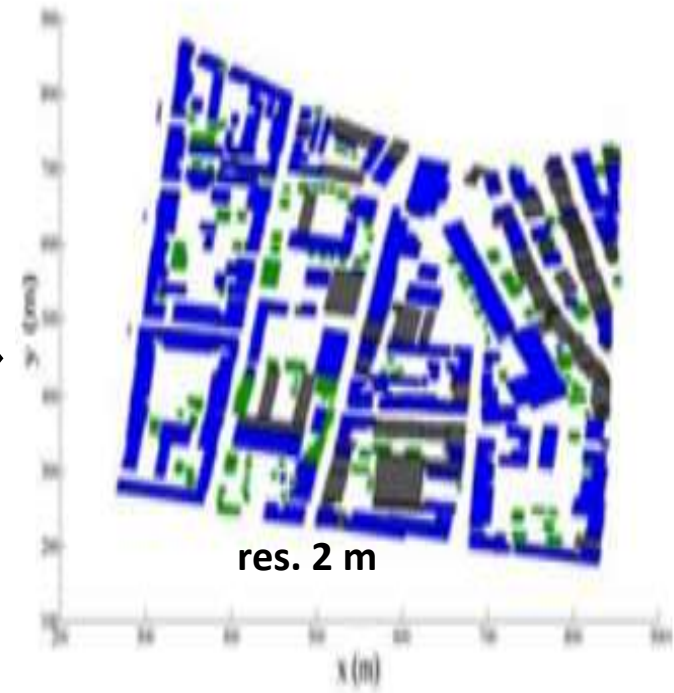
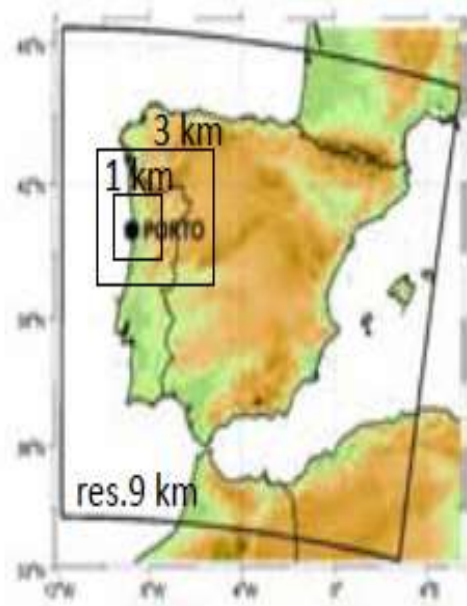
1,9°C (2050)

3,7°C (2100)





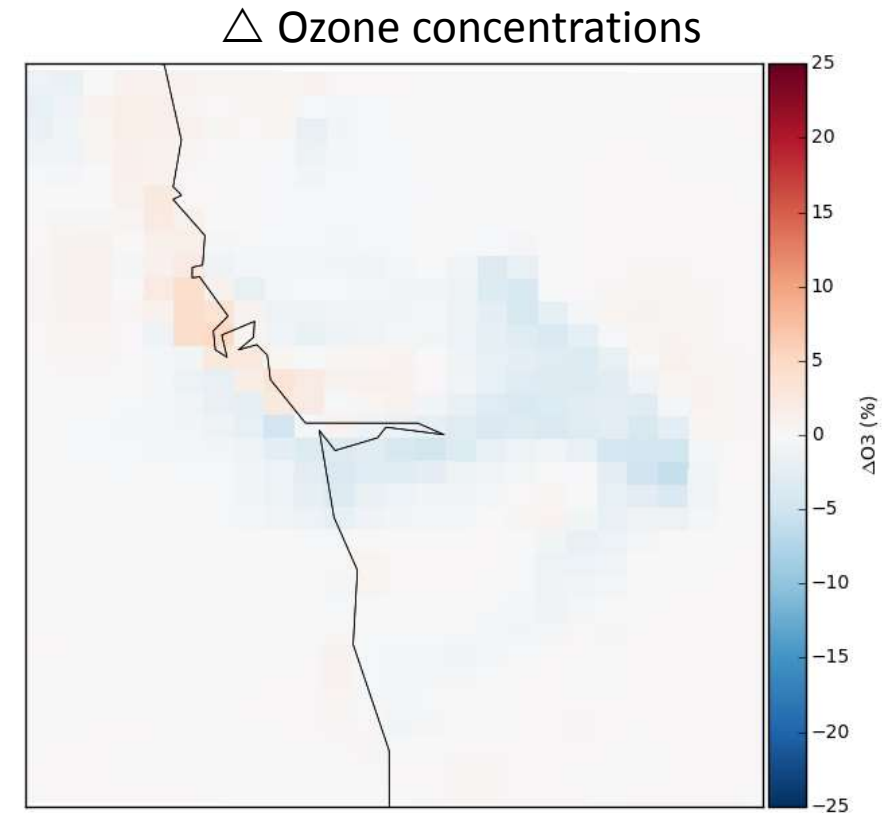
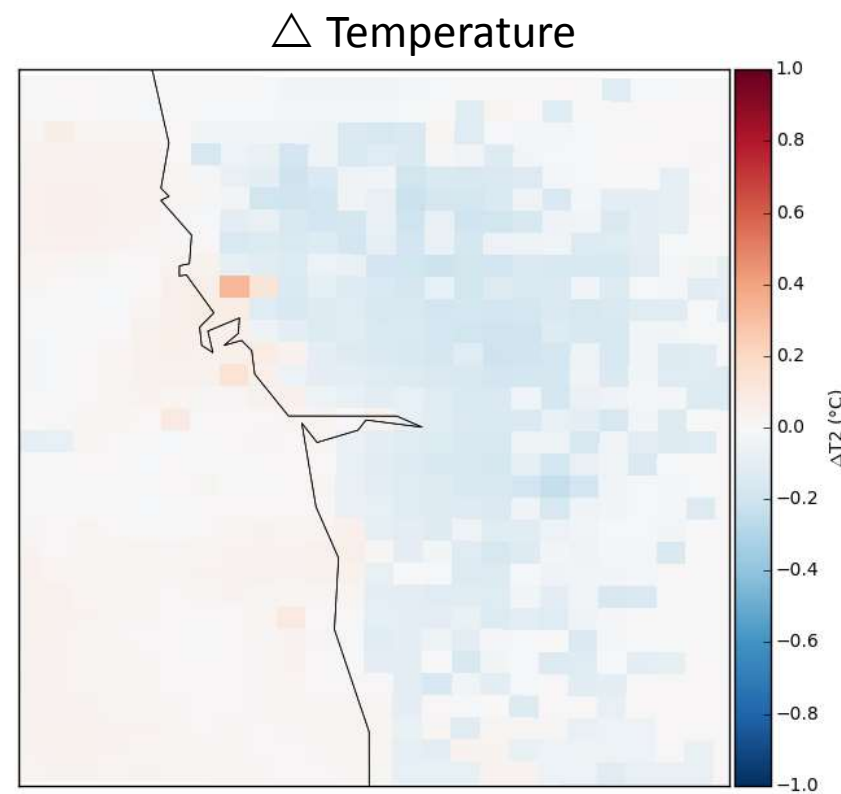
## Case study | Porto urban area: numerical models, from regional to local scale





## Case study | Porto urban area: cooling the city and improving air quality

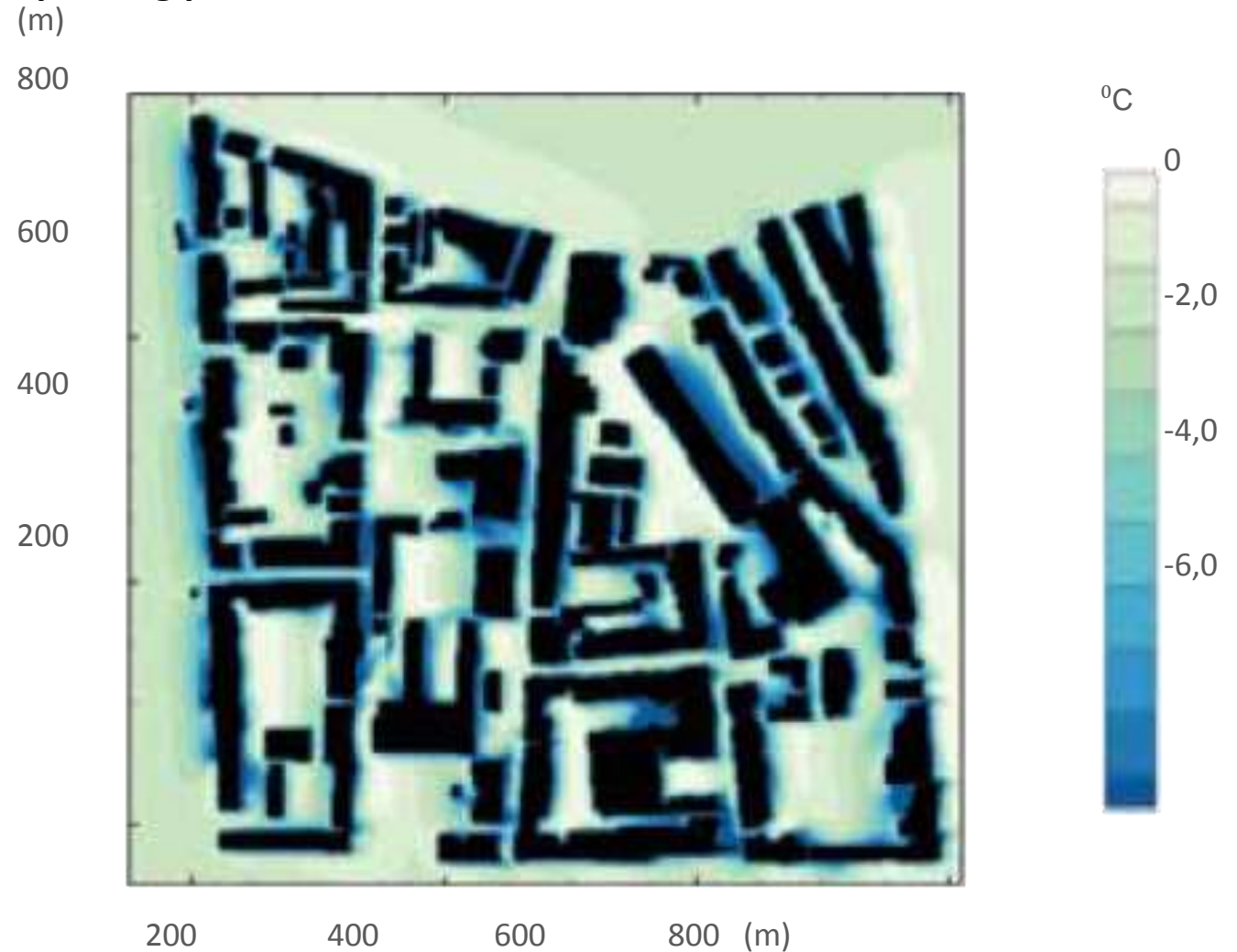
Spatial distribution of the absolute differences between implementation of green areas and green roofs, and baseline scenario, under a future heat wave (2050)



Green areas and roofs promotes an average air temperature reduction of  $-0.5^{\circ}\text{C}$ ; promotes a reduction on  $\text{O}_3$  concentrations, with maximum decreases varying between  $-2.3\%$  and  $-5.8\%$ .

## Case study | Porto urban area: cooling the city and improving pedestrian comfort

The application of **green roofs** results in the reduction of temperature between 0 and  $-2^{\circ}\text{C}$ , in the majority of the domain, and reaching maxima of  $-6^{\circ}\text{C}$  next to the buildings.



## Notes... and Challenges



- **Population** is increasing, urban problems persist and **extreme weather events** are more frequent and intense.
- **Construction sector** faces the challenge of **designing and constructing buildings and infrastructure** that can withstand more stress from a changing climate.
- **Citizens should be part of the solution** and play an active role in defining development policies and projects for their neighbourhood, city and region.

### The challenge?

bring together the **scientific knowledge, companies and citizens** by a way of circular economy and holistic solutions (NBS) to **promote sustainable, systemic, energy and resource efficient solutions,**

and

**to develop business models and innovative financing modalities for integrated solutions.**





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Thank you!



Grupo de  
Emissões,  
Modelação e  
Alterações

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universidade de aveiro  
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e ordenamento