The Heating and Cooling Gap in Southern European cities: A Challenge for Climate Mitigation

Júlia Seixas*, João Pedro Gouveia*, Pedro Palma*, Sofia G. Simoes*

mjs@fct.unl.pt; jplg@fct.unl.pt; p.palma@campus.fct.unl.pt; sgcs@fct.unl.pt

*CENSE – Center for Environmental and Sustainability Research. NOVA School of Science and Technology, NOVA University Lisbon, Portugal.

Questions

- What is the **energy performance gap** for space heating and cooling in Portuguese dwellings, at very high spatial scale?
- How do **climatization patterns** affect the gap?
- What is the impact of **bridging the energy gap on CO_2 emissions**?

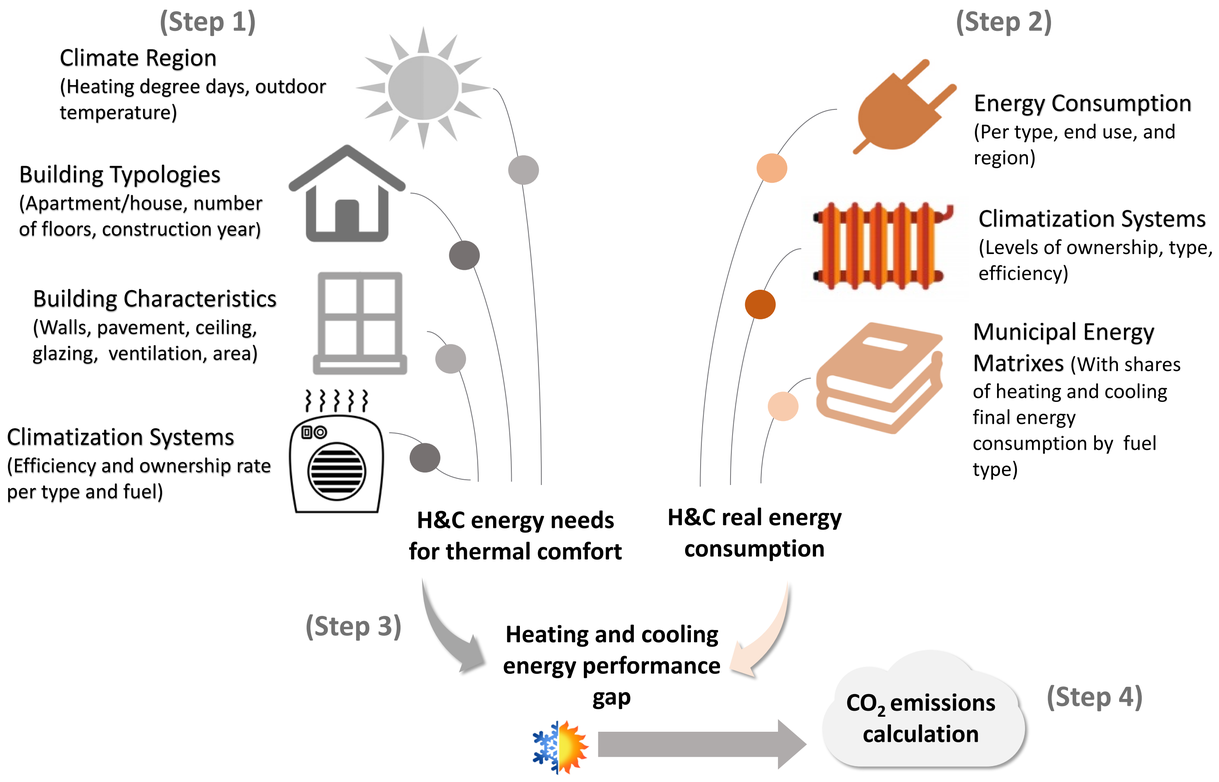
Context

- People spend about 90% of their time inside buildings [1], mostly in their own homes.
- In European Union, low income households, poor building construction and high energy costs: **50 to 125 million people are not able to ensure indoor thermal comfort (heating & cooling, H&C) in their households** [2]. Thermal comfort affects people's health, welfare and ability to function.
- **Heatwaves** put in risk populations' health [3,4,5], and require increasing energy need for cooling. Future climate change scenarios carry an increase in the number and intensity of heat waves for this region [5,6].
- **Portugal is a good case study:**
  - located at Southern Europe, targeted as one of the **most likely climate impacted regions** [7].
  - **ageing building stock with low energy performance, decentralized low efficiency climatization systems** and **low rates of climatization systems**, mainly cooling.
  - **high levels of energy poverty** [8,9]: 24% of the population are unable to keep their homes warm during winter, whilst during summer, 36% cannot keep their homes cool [10]. Most residential buildings rely solely on natural ventilation for cooling [4].

Methodology

Energy performance gap acts as a proxy for thermal comfort and energy efficiency assessment.

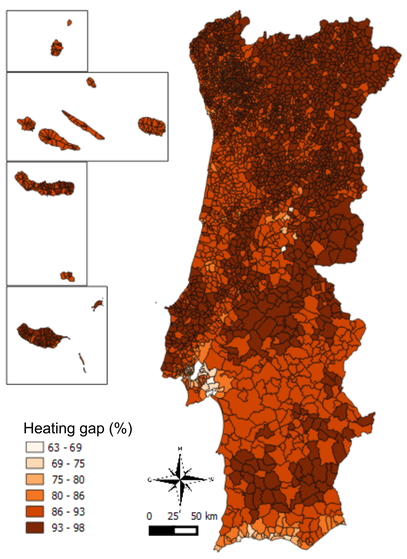
- ***Step 1*** **– Nominal final energy** needs for space H&C estimated from **191 different building typologies** (e.g. buildings' area, walls types, bearing structure). **Geographical explicitness:** 18 different climatic regions, and all **3092 Portuguese civil parishes** (administrative territorial units smaller than a city).
- ***Step 2*** **– Real energy consumption** for H&C estimated from climatization systems ownership data, municipal statistics on energy consumption and data from energy matrixes per type of end use for different Portuguese geographic regions.
- ***Step 3*** **– Energy performance gap (%)** estimated from the difference between **Nominal** and **Real** final energy consumption. Alternative **Conservative case** assessed, assuming more realistic regional average cooled/heated areas and climatization equipment operating hours.
- ***Step 4*** **– CO_2 emissions related to energy consumption increase** for bridging the performance gap are computed for both cases and compared to current energy consumption associated emissions.



Results

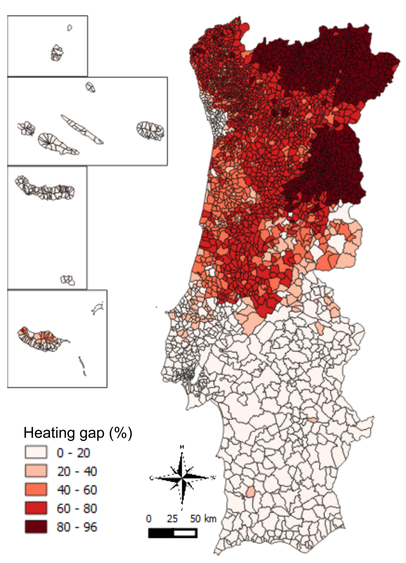
Real case: 600 kWh per capita; **Nominal case:** 7415 kWh per capita; **Conservative case:** 1375 kWh per capita

Heating Gap: Nominal case
[24h/day & 100% area]

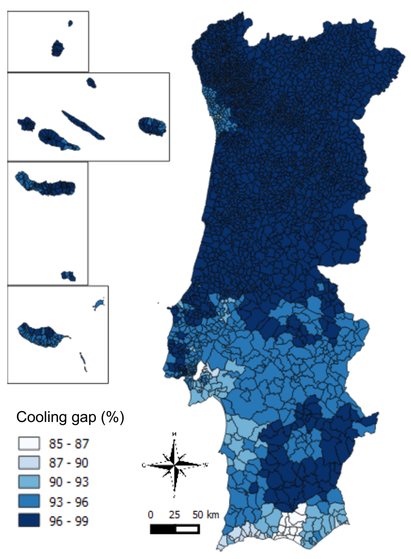


- 20% of spatial units with no gap.
- Average national heating gap reduced from **93%** to **52%.**

Heating Gap: Conservative case
[11h/day & 50% area]

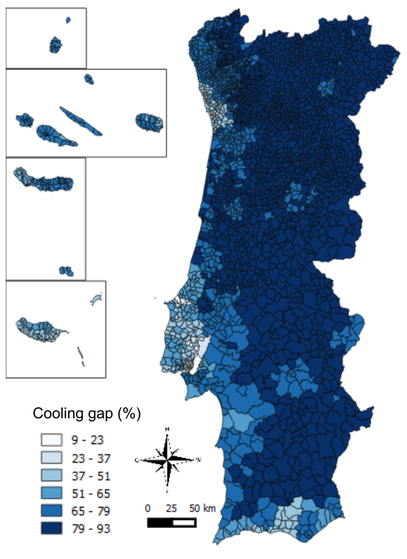


Cooling Gap: Nominal case
[24h/day & 100% area]

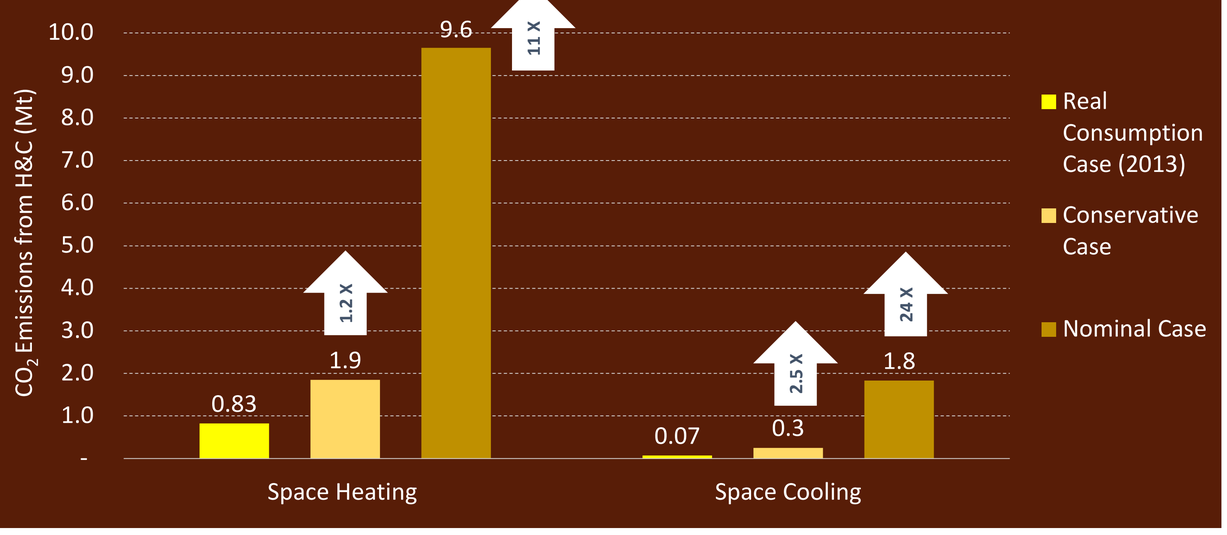


- No cooling gaps are offset.
- Average national cooling gap reduced from **97%** to **76%.**

Cooling Gap: Conservative case
[10h/day & 38% area]



CO_2 Emissions from H&C – comparison between Cases



Discussion and Conclusions

- Energy performance gap results from behavioral climatization patterns, occupants' habits and schedules, **without jeopardizing indoor thermal comfort, and** also from **energy poverty levels** of population groups.
- The potential increase of energy consumption (and emissions) for adequate indoor thermal comfort, red flags a **problem for climate mitigation goals.**
- **Energy efficiency increase in both buildings and equipment and the increased use of passive measures (shading and insulation)** for southern European countries are key to reduce energy needs.
- Thermal comfort requires investment in **local renewable energy sources** to prevent impacts on CO_2 emissions.
- Results combined with socio economic data of the building occupants can be further developed to track **vulnerable consumers** and to support national and local energy efficiency policies and instruments.

References:

[1] Sookchaiya, T., Monyakul, V., Thepa, S. (2010). Assessment of the thermal environment effects on human comfort and health for the development of novel air conditioning system in tropical regions. *Energy and Buildings 42, pp 1692–1702*

[2] WHO (2012). *Environmental Health Inequalities in Europe*. World Health Organization.

[3] Vandentorren, S., Bretin, P., Zeghnoun, A., Mandereau-Bruno, L., Croisier, A., Cochet, C., Ribéron, J., Siberan, I., Declercq, B., Ledrans, M. (2006). August 2003 heat wave in France: risk factors for death of elderly people living at home. *Eur J Public Health 16, pp 583-591.*

[4] Barbosa, R.; Vicente, R., Santos, R. (2015). Climate change and thermal comfort in Southern Europe housing: A case study from Lisbon. *Building and Environment 92, 440-451*

[5] Sánchez, C. S., Mavrogianni, A., González, F. J. N. (2017). On the minimal thermal habitability conditions in low income dwellings in Spain for a new definition of fuel poverty. *Building and Environment 114, pp 344-356.*

[6] Gualdi et al. (2013). *Future Climate Projections*. In Regional Assessment of Climate Change in the Mediterranean. Volume 1: Air, Sea and Precipitation and Water. Navarra, A., Tubiana, L. (eds). Advances in Global Change Research 50. Springer Netherlands.

[7] Santos, F.D., Miranda, P. (2006). *Climate change in Portugal: scenarios, impacts, and adaptation measures.* SIAM II Project. Gradiva. Portugal.

[8] Simões, G. S., Gregório, V., Seixas, J. (2016). Mapping fuel poverty in Portugal. *Energy Procedia 106, pp 155 – 165*

[9] Gouveia, J. P., Seixas, J. Long, G. (2018). Mining households' energy data to disclose fuel poverty: Lessons for Southern Europe. *Journal of Cleaner Production 178, pp 534-550*

[10] Eurostat (2017). EU Statistics on income and living conditions. Available at: [http://ec.europa.eu/eurostat/statistics-explained/index.php/Main_Page]

FCT FACULDADE DE CIÊNCIAS E TECNOLOGIA UNIVERSIDADE NOVA DE LISBOA

CENSE center for environmental and sustainability research

Scan me