



LARSyS
Laboratory of Robotics
and Engineering Systems



MARETEC
MARINE ENVIRONMENT & TECHNOLOGY CENTER

Energy and Economic Growth

Tiago Domingos

with João Santos, Marco Vittorio Ecclesia, Laura Felício, Ricardo Pinto and Tânia Sousa

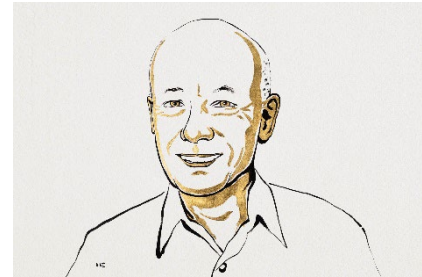
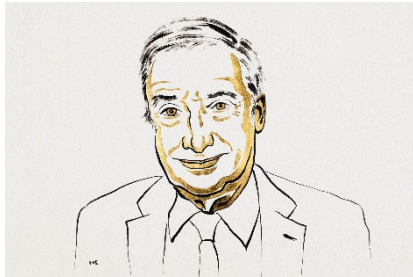
MARETEC, LARSyS, Instituto Superior Técnico, Universidade de Lisboa, Portugal

FCT

Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

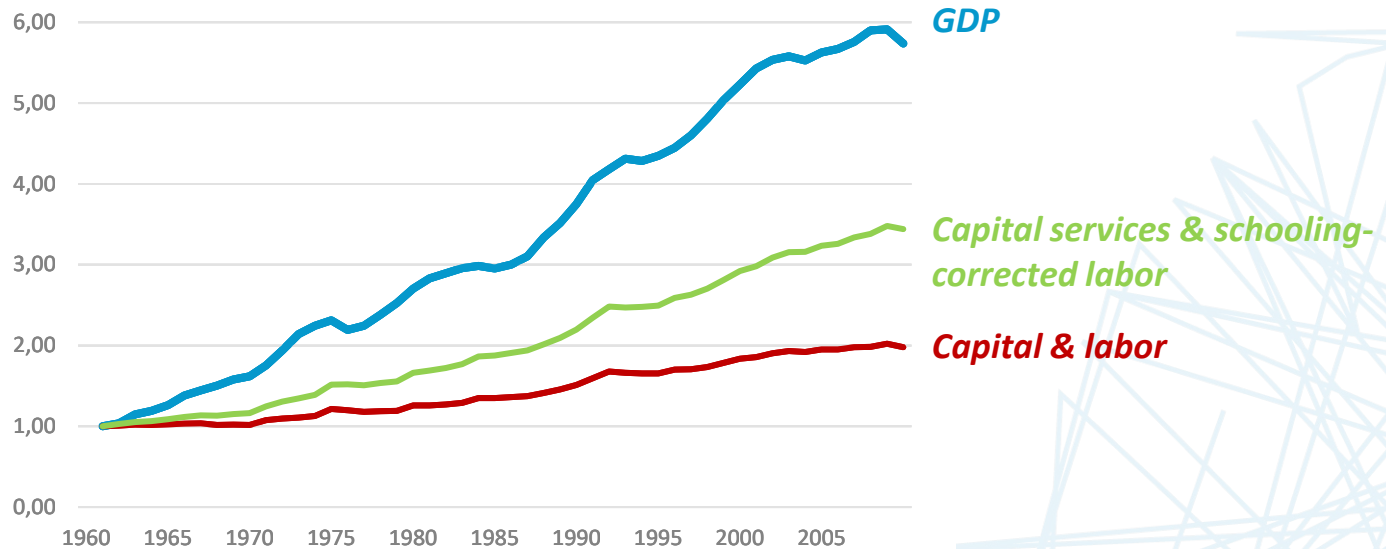


Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2025



“Over the last two centuries, for the first time in history, the world has seen sustained economic growth. This has lifted vast numbers of people out of poverty and laid the foundation of our prosperity. This year’s laureates in economic sciences, Joel Mokyr, Philippe Aghion and Peter Howitt, explain how innovation provides the impetus for further progress.”

GDP, production factors and the Solow residual Portugal 1960-2009





Exergy

- **The statement “a lamp consumes energy” is WRONG**
- **Energy is conserved, so a lamp cannot consume energy**
- **A lamp degrades energy, reducing its quality**
 - **We can do much more with electricity than with heat and light**
- **So, electricity has a higher exergy than heat and light**
- **The statement a “lamp consumes exergy” is RIGHT**



Primary, final and useful exergy



Coal (30 g)
0.27 kWh



Power station



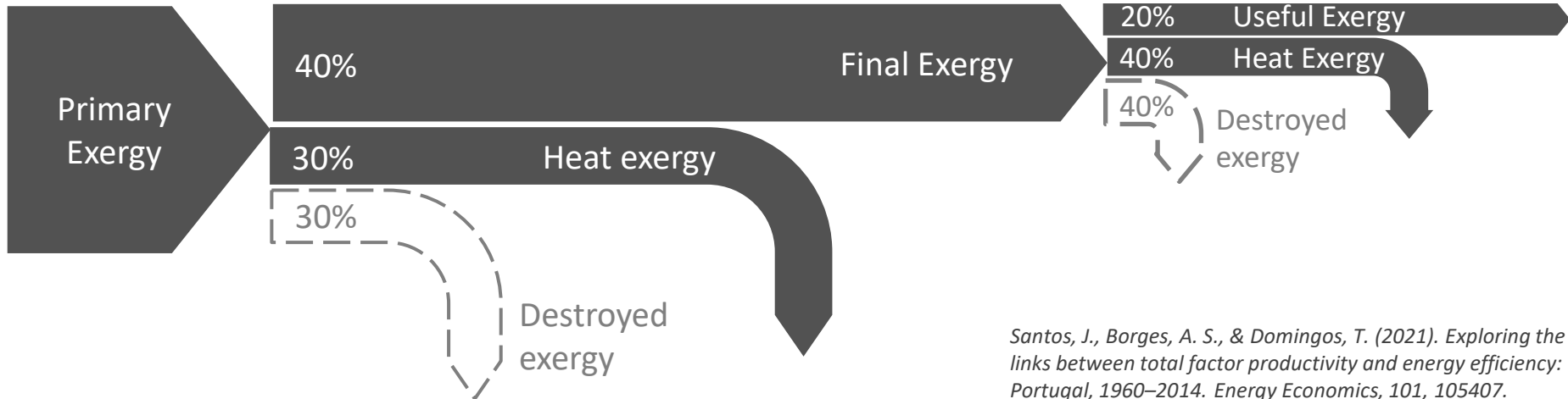
Electricity
0.08 kWh



Lightbulb

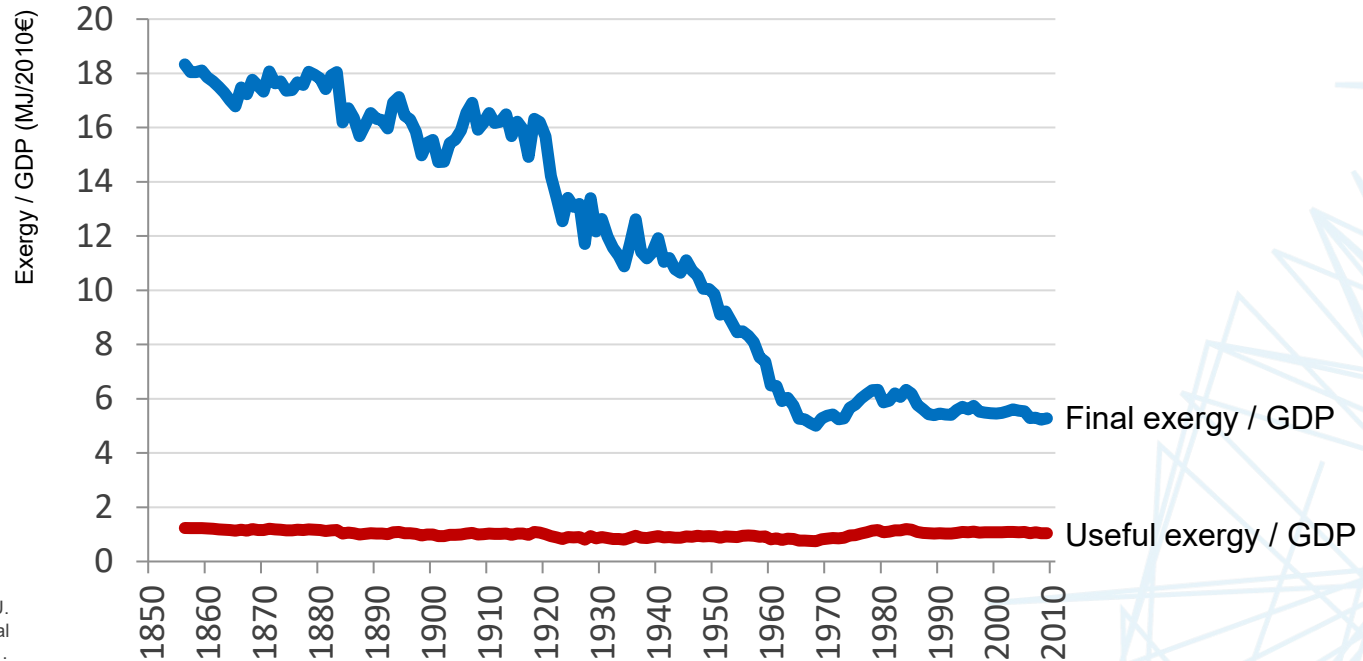


Light
0.02 kWh



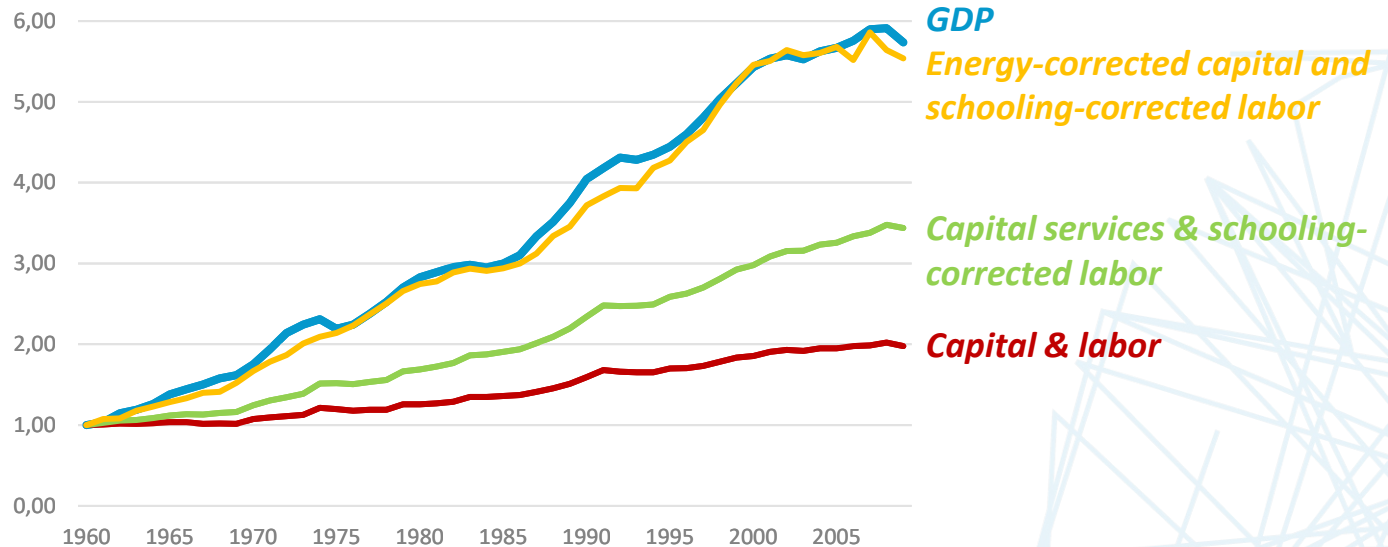
Santos, J., Borges, A. S., & Domingos, T. (2021). Exploring the links between total factor productivity and energy efficiency: Portugal, 1960–2014. *Energy Economics*, 101, 105407.

Final and useful exergy intensities



Energy-corrected capital explains the Solow residual

Santos, J., Domingos, T.,
Sousa, T., & Aubyn, M. S.
(2018). Useful exergy is key
in obtaining plausible
aggregate production
functions and recognizing
the role of energy in
economic growth: Portugal
1960–2009. *Ecological
Economics*, 148, 103-120.



The Parable of the English Farmer





Summing Up

- **Energy is a central but overlooked factor in economic growth**
- **Development and climate policies must necessarily recognize this**

