upna
Inarbe
Institute for Advanced Research in Business and Economics

Observatoire Hommes Milieux Fessenheim

Energy transitions of the past, the present and the future: beyond technological change

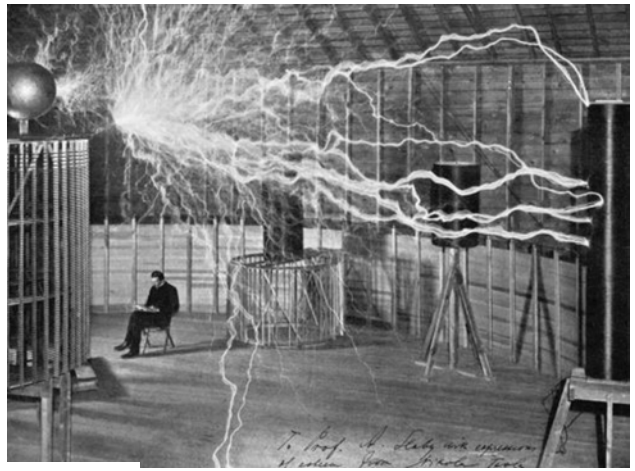
Mar Rubio-Varas

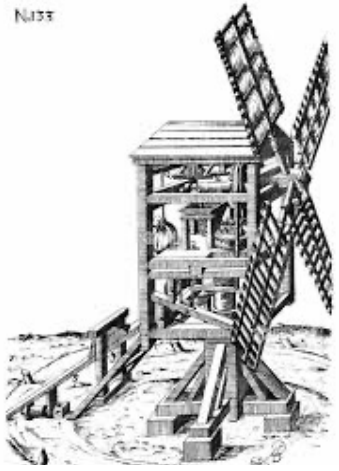
Department of Economics
Universidad Pública de Navarra (UPNA)
Pamplona, Spain

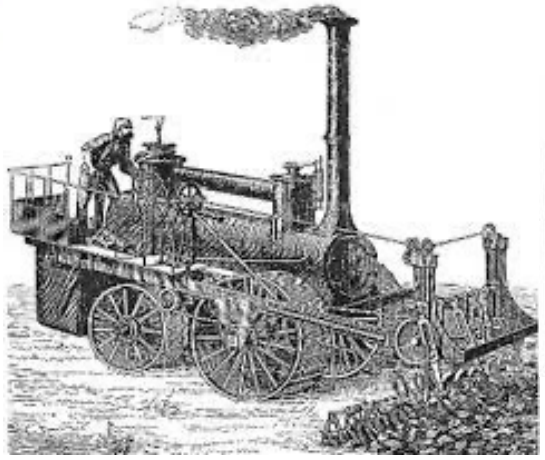
upna
Universidad Pública de Navarra
Nafarroako Unibertsitate Publikoa

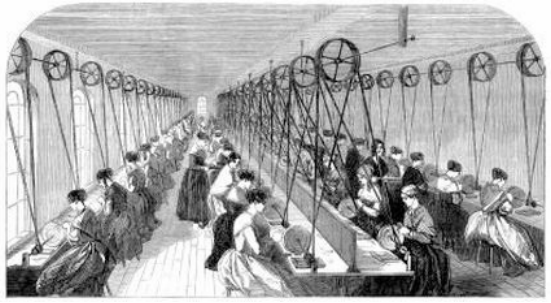
upna
Inarbe
Institute for Advanced Research in Business and Economics

Energy transitions of the past, the present and the future









upna
Inarbe
Institute for Advanced Research in Business and Economics

Transition:

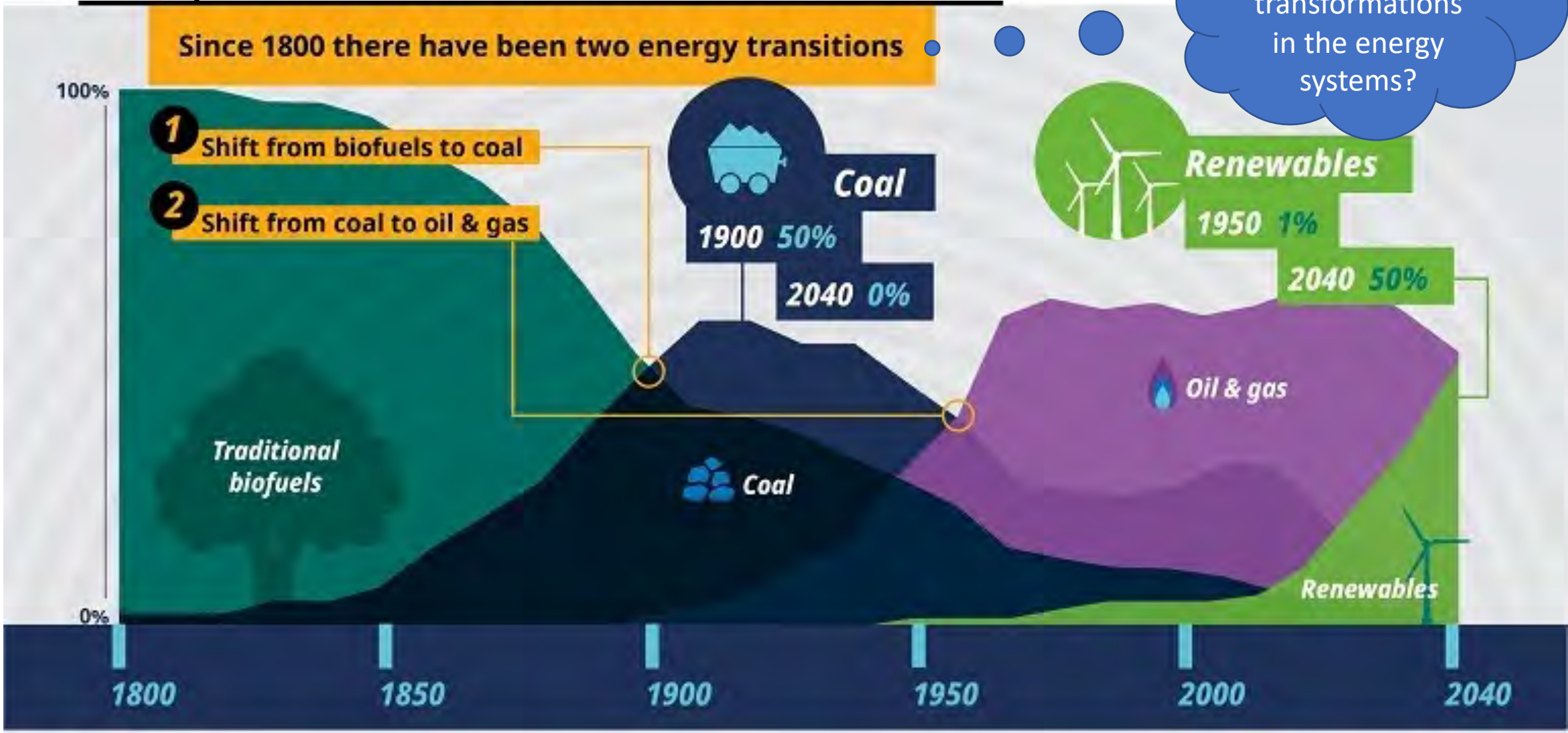
the process (or a period)of changing from one state or condition to another.

Past energy transitions	**Present energy transitions**	**Future energy transitions**
Understanding the processes of change within the energy systems through time.	A fast pathway to a low carbon energy system (away from fossils)	? Will depend on how the present one comes about.

upna
Inarbe
Institute for Advanced Research in Business and Economics

Stylized view

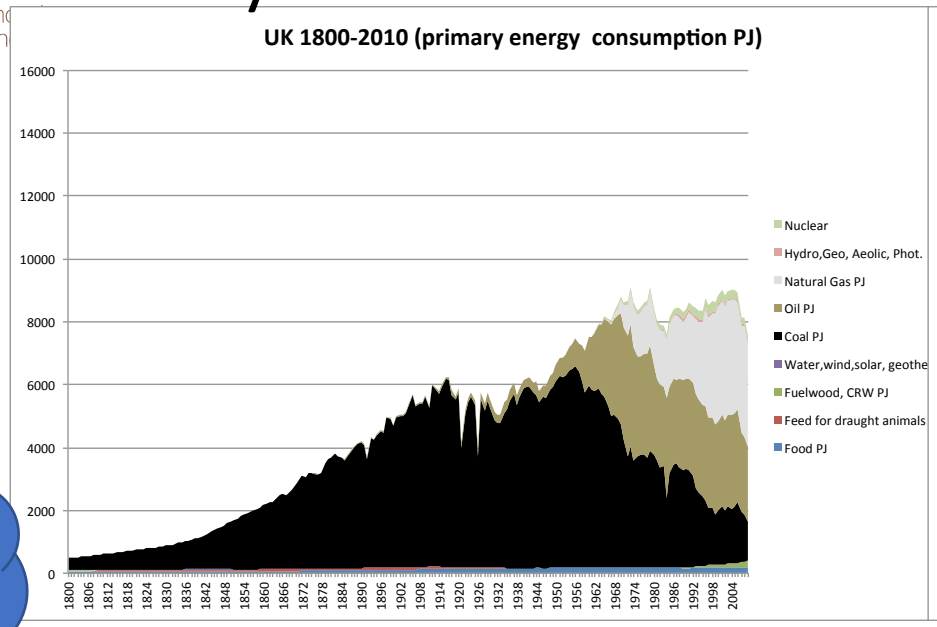
Are these the only transformations in the energy systems?

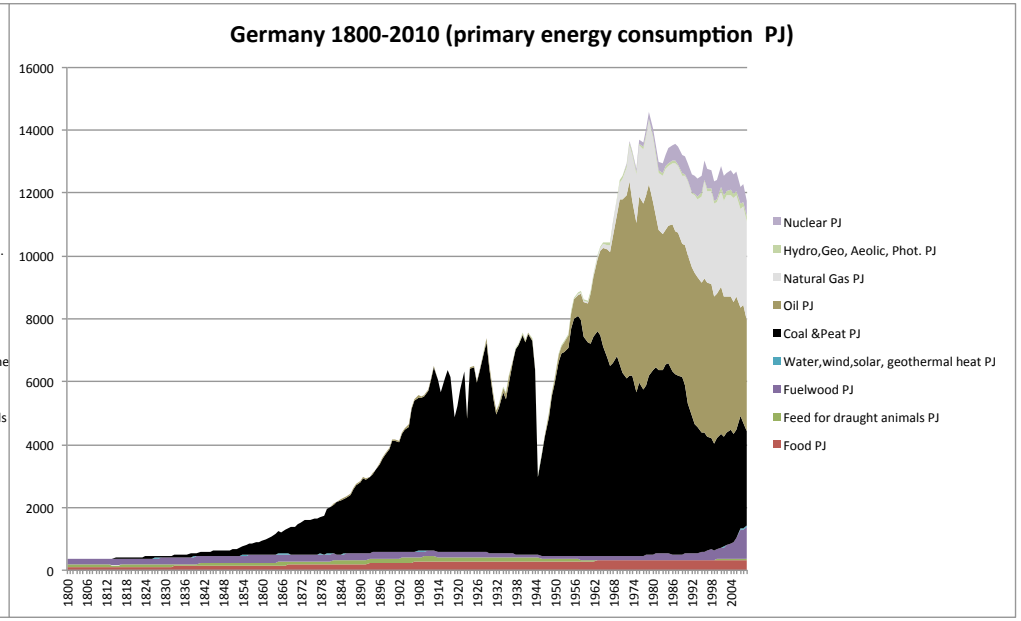


Source: Bloomberg New Energy Finance, IEA, World Bank, Schroders – 31 October 2021.
Read more: https://www.schroders.com/en/insights/economics/climate-change-tracker-hits-record-low-as-progress-gathers-pace/

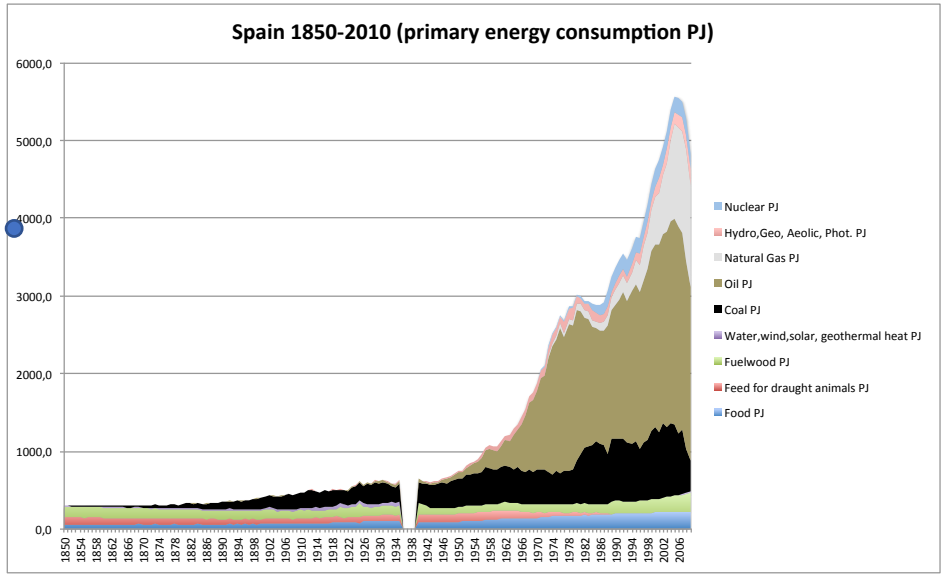
upna
Inarbe
Institute for Advanc
Research in Busin
and Economics

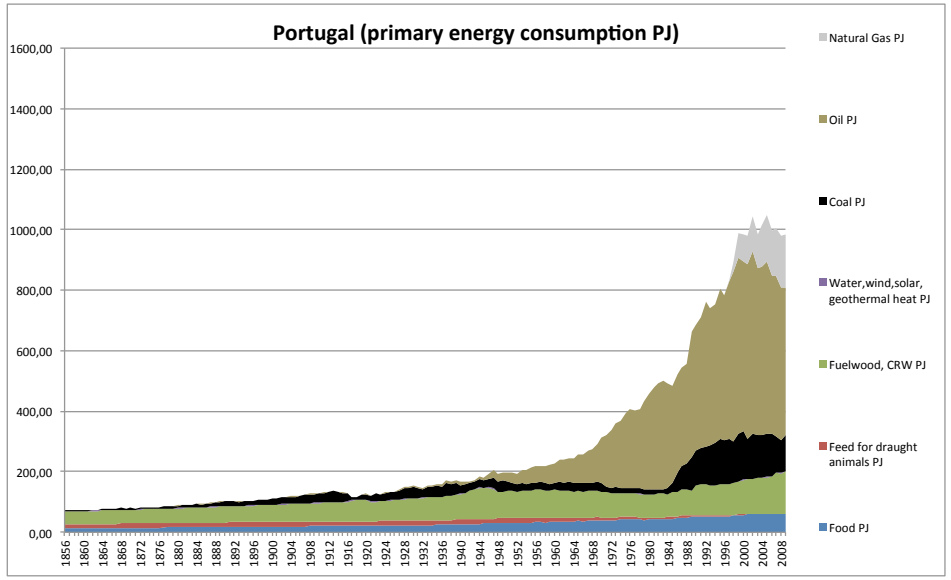
Can you tell which one was more diversified?





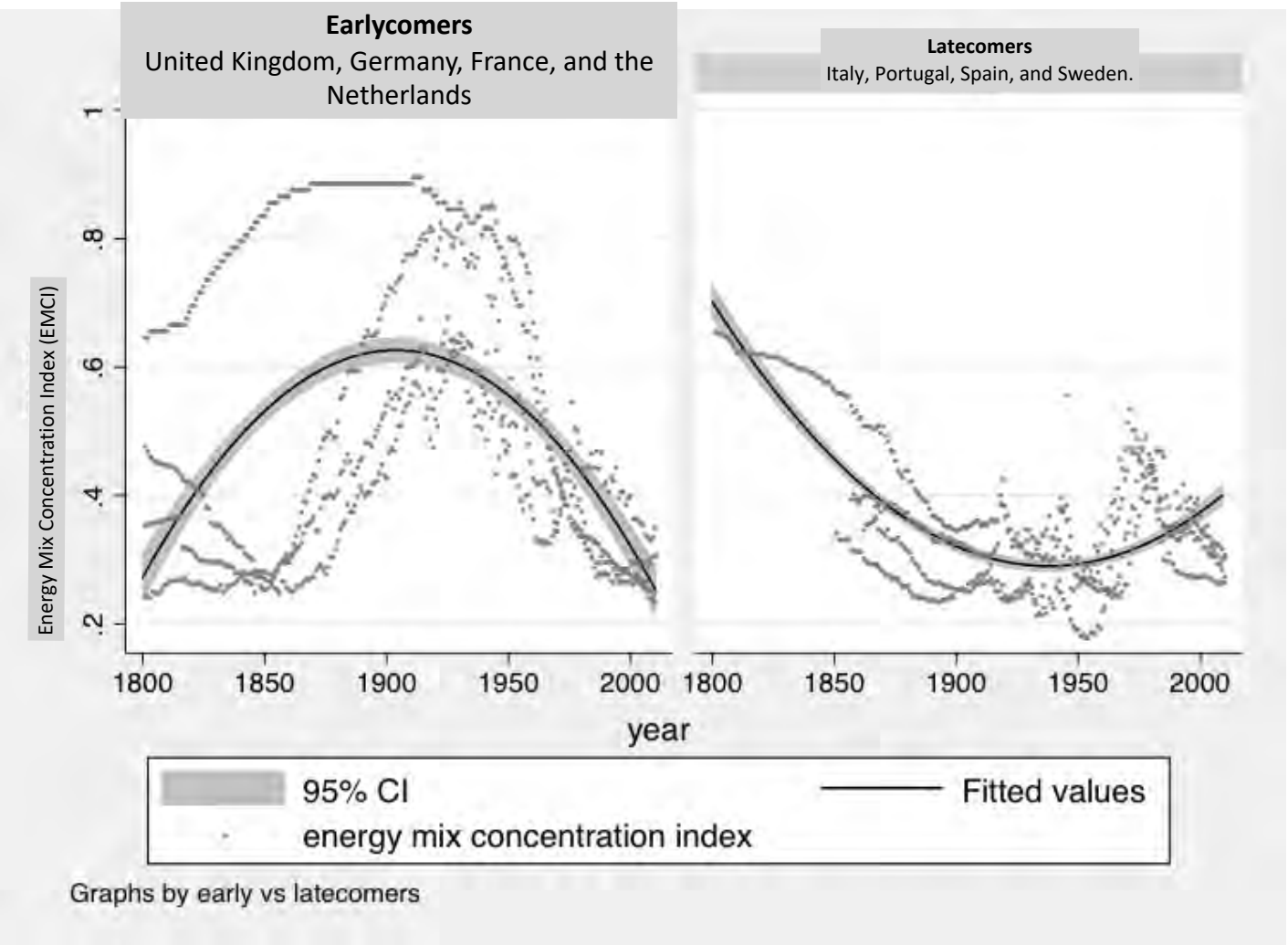
Note:
scales are
different





upna Inarbe Institute for Advanced Research in Business and Economics

Large vs small:Energy diversification paths of European countries last 200 years



Rubio-Varas & Muñoz-Delgado (2019)

The alteration of the energy basket:

- Was slower in the 19th century
- Was slower for larger energy consumers
- It accelerates over time

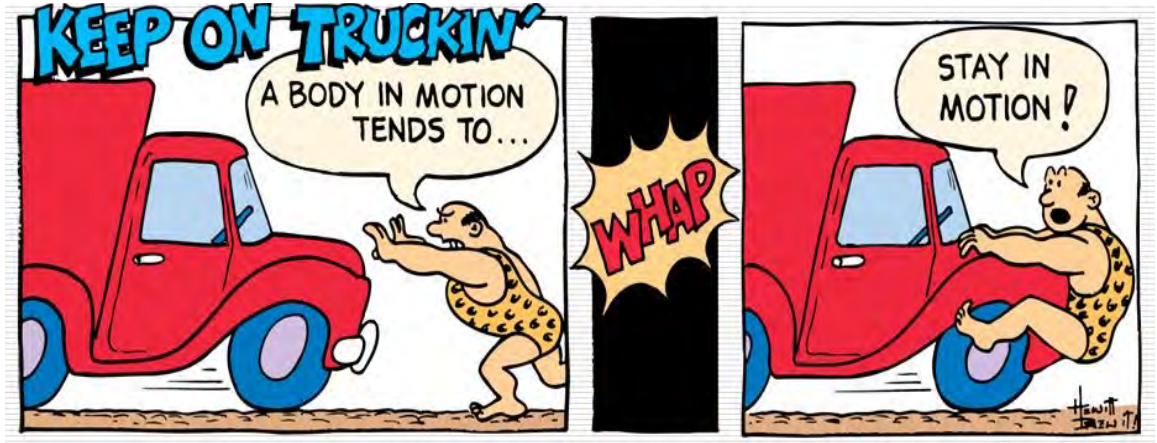
In this sample, energy transitions always occur at mid-to-low concentration levels.

Latecomers enjoyed far more diversified energy baskets

upna Inarbe Institute for Advanced Research in Business and Economics

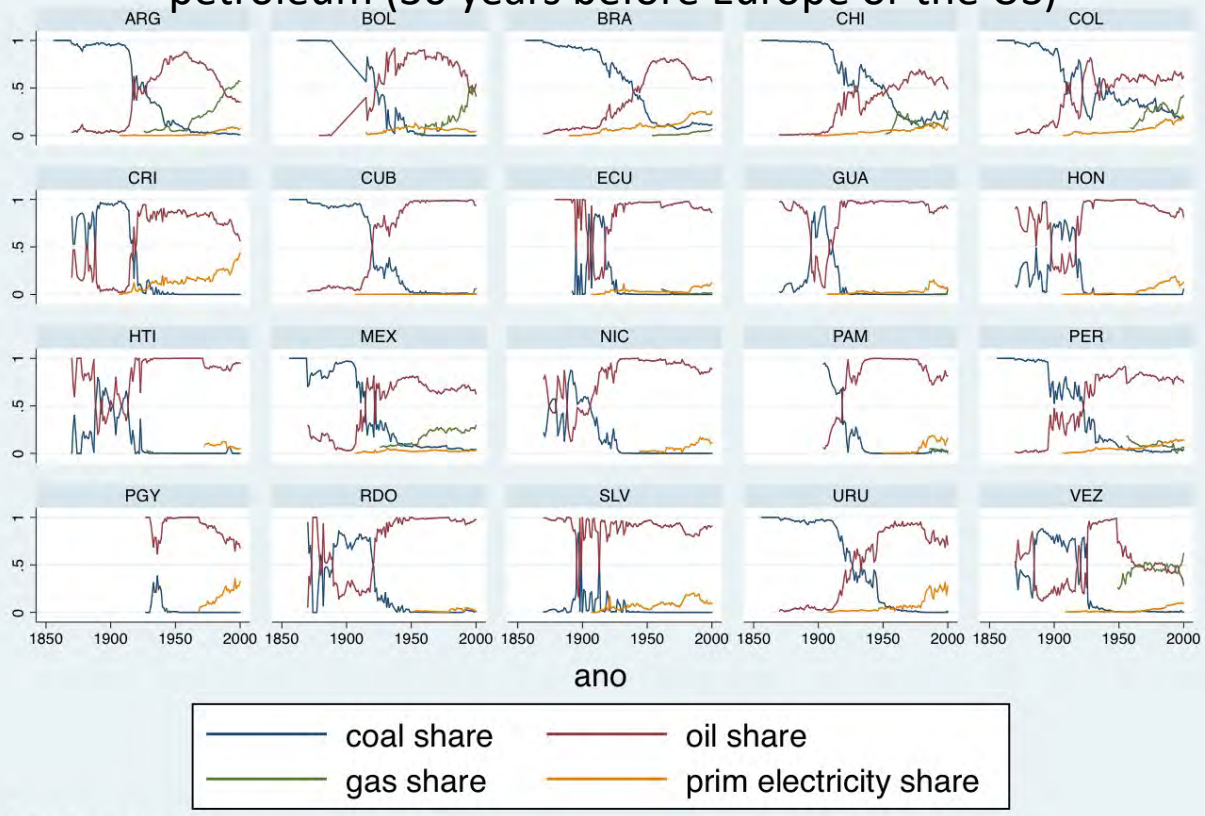
Large vs small: the inertia of the energy systems

Experts in energy transition refer to the "inertia of energy systems" when trying to explain how difficult, painful, and slow is to alter a given course



Evidence suggests that large and small energy consumers follow different paths in the process of altering their energy mixes

By 1929 Latin America had completed the transition to petroleum (30 years before Europe or the US)

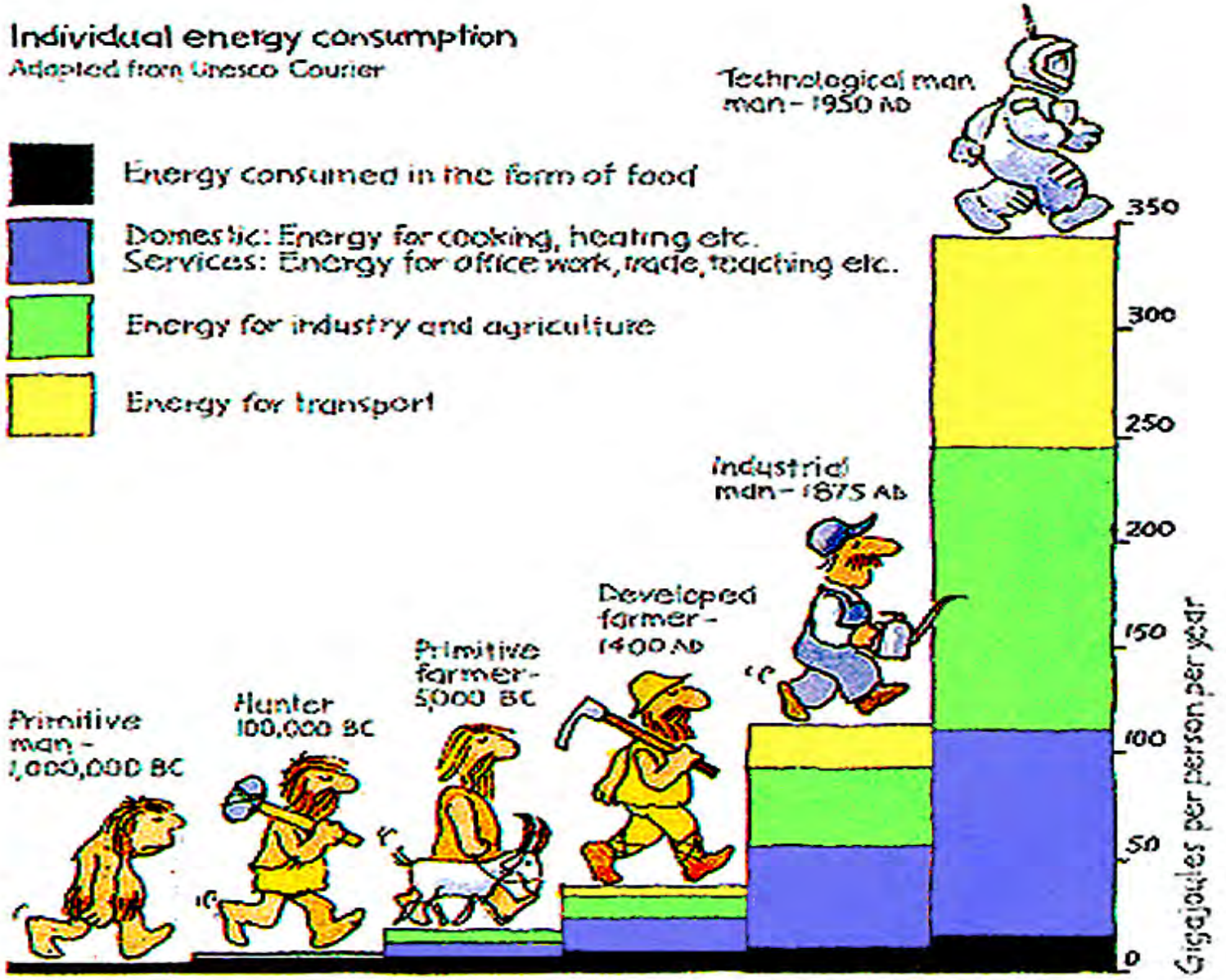


Rubio & Folchi, 2012

upna
Inarbe
Institute for Advanced Research in Business and Economics

The **amount** of energy & **what do we use it for** also changed

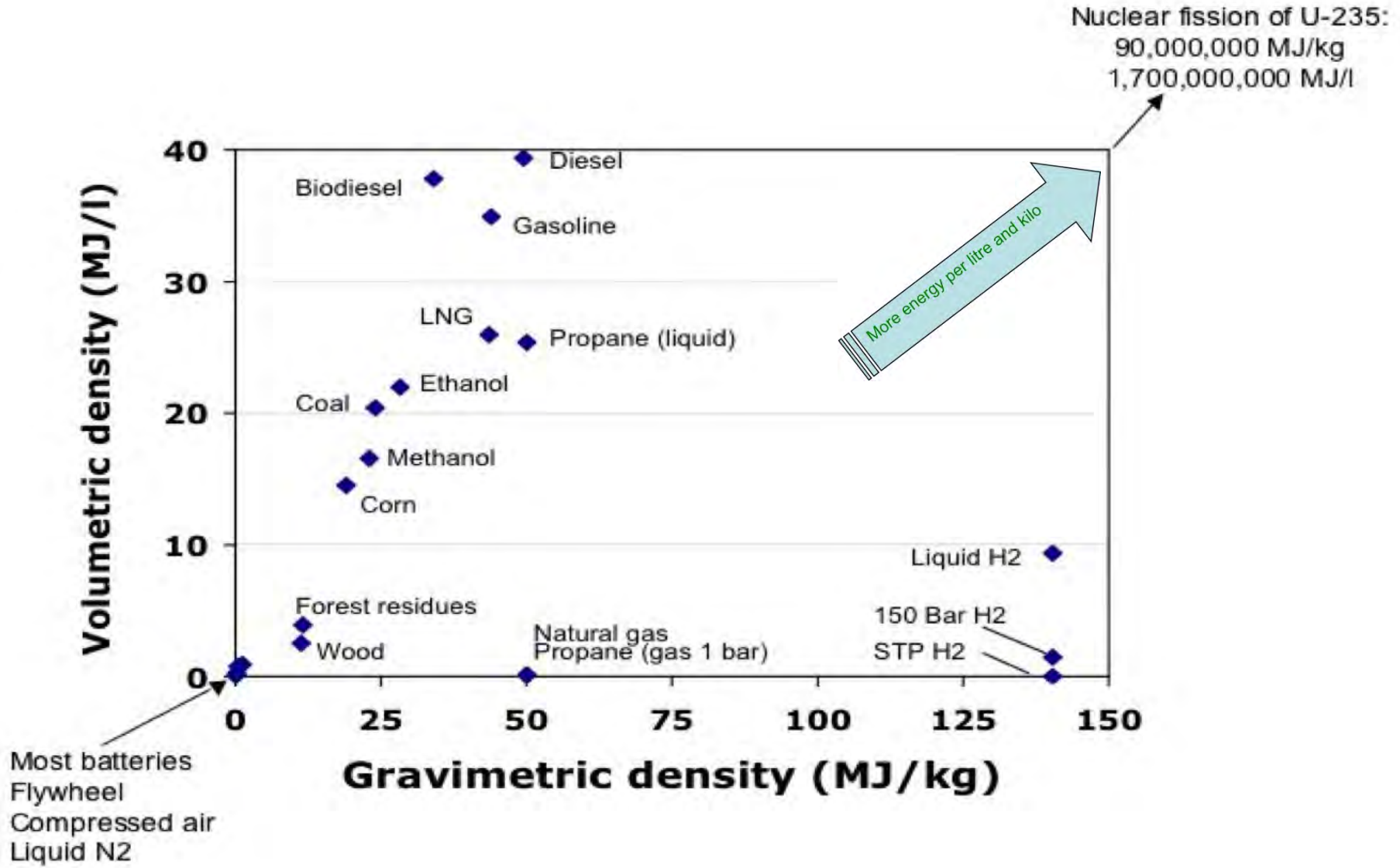
Energy is the ability to do work.



upna
Inarbe
Institute for Advanced Research in Business and Economics

Transition to **higher quality** energy carriers (I)

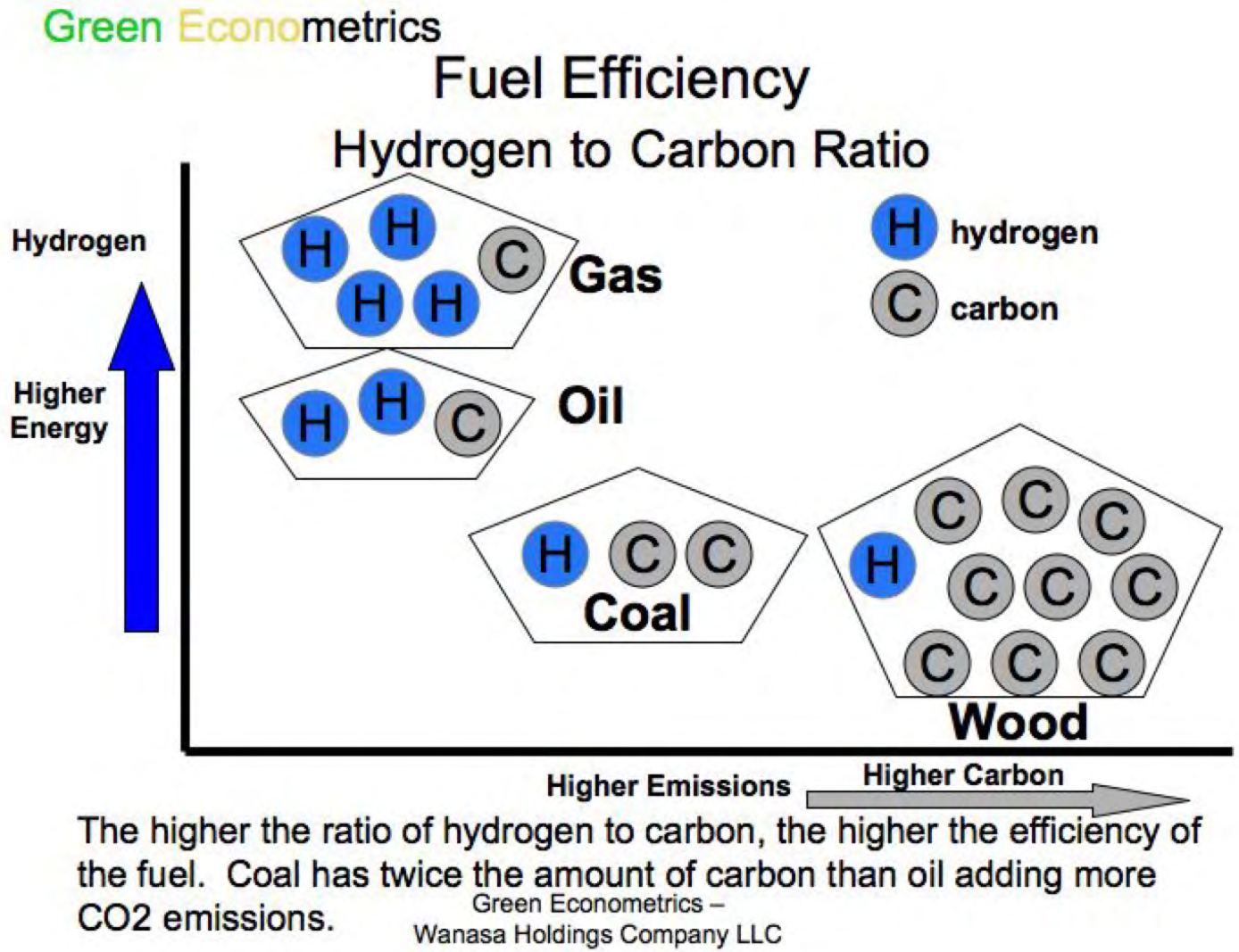
(More energy per unit of volume and weight, capacity to do useful work, flexibility, density, etc)



upna
Inarbe
Institute for Advanced Research in Business and Economics

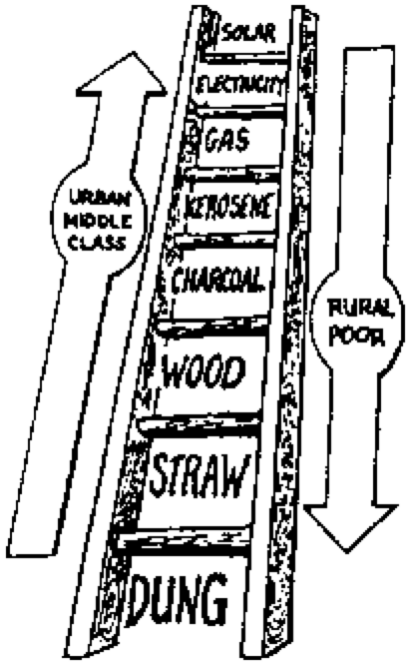
Transition to **higher quality** energy carriers (II)

(less CO2 per unit of energy- the definition of de-carbonization)



upna
Inarbe
Institute for Advanced Research in Business and Economics

Energy transitions and income:
The energy ladder



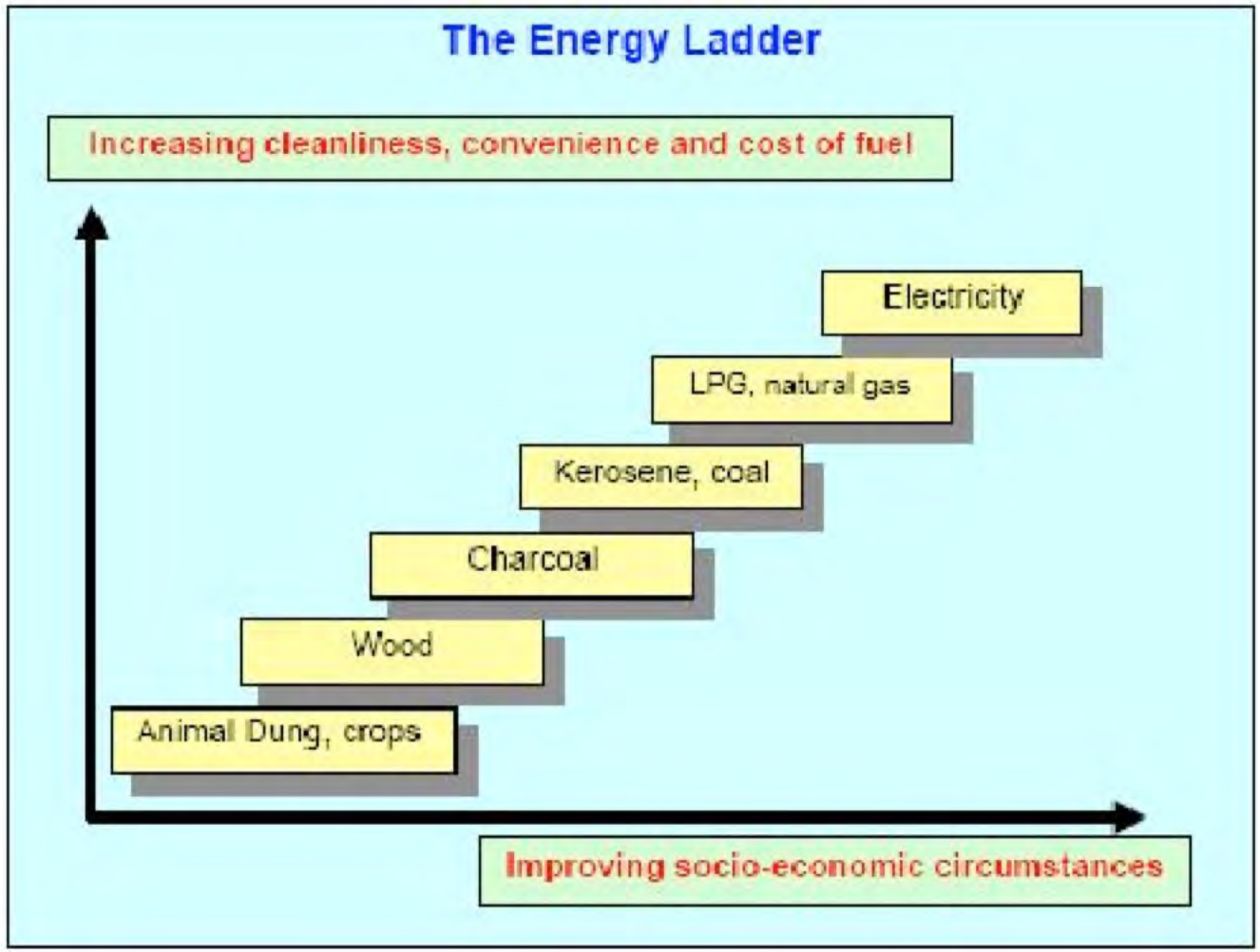
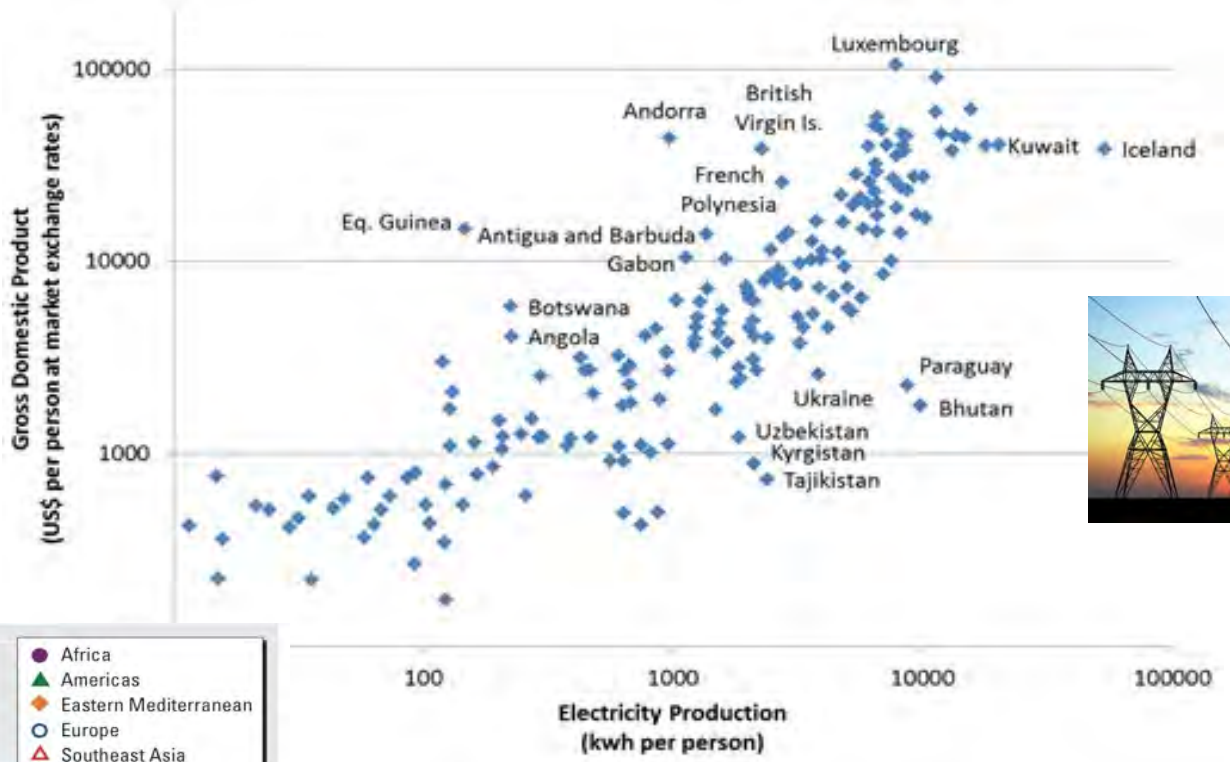
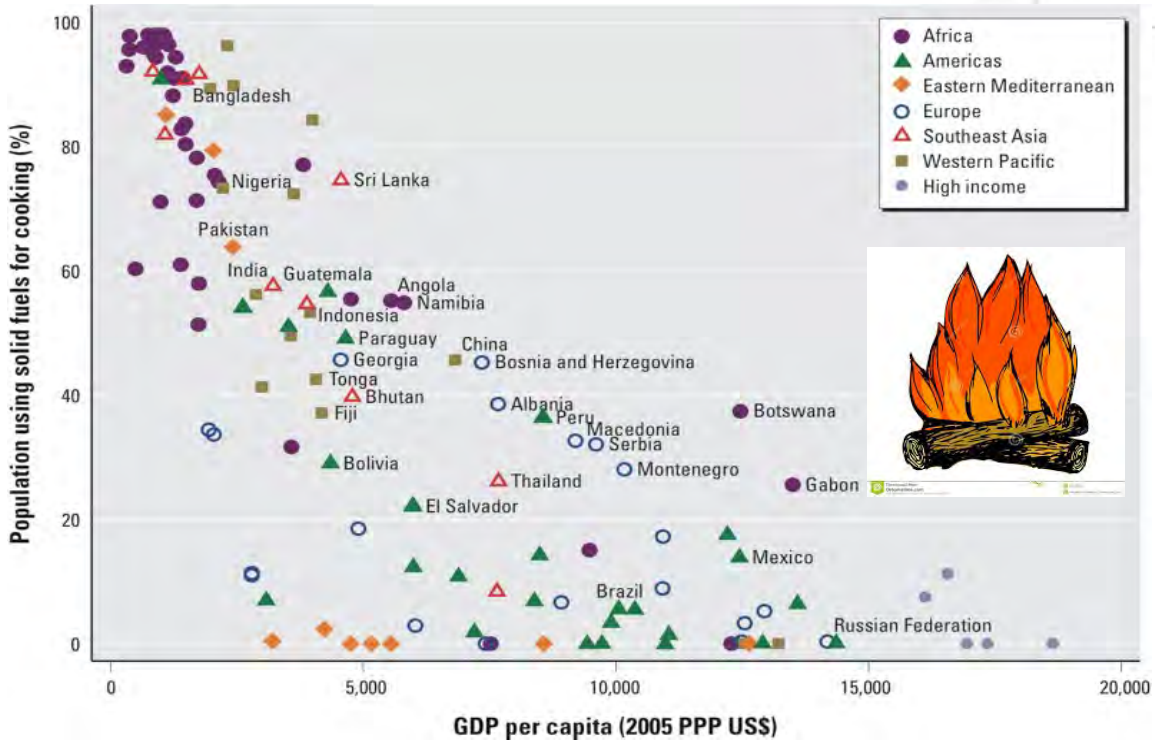


Figure 2: The Energy Ladder (adapted from Smith et al., 1994)

upna
Inarbe
Institute for Advanced Research in Business and Economics

Not all forms of energy have the same impact on economic output

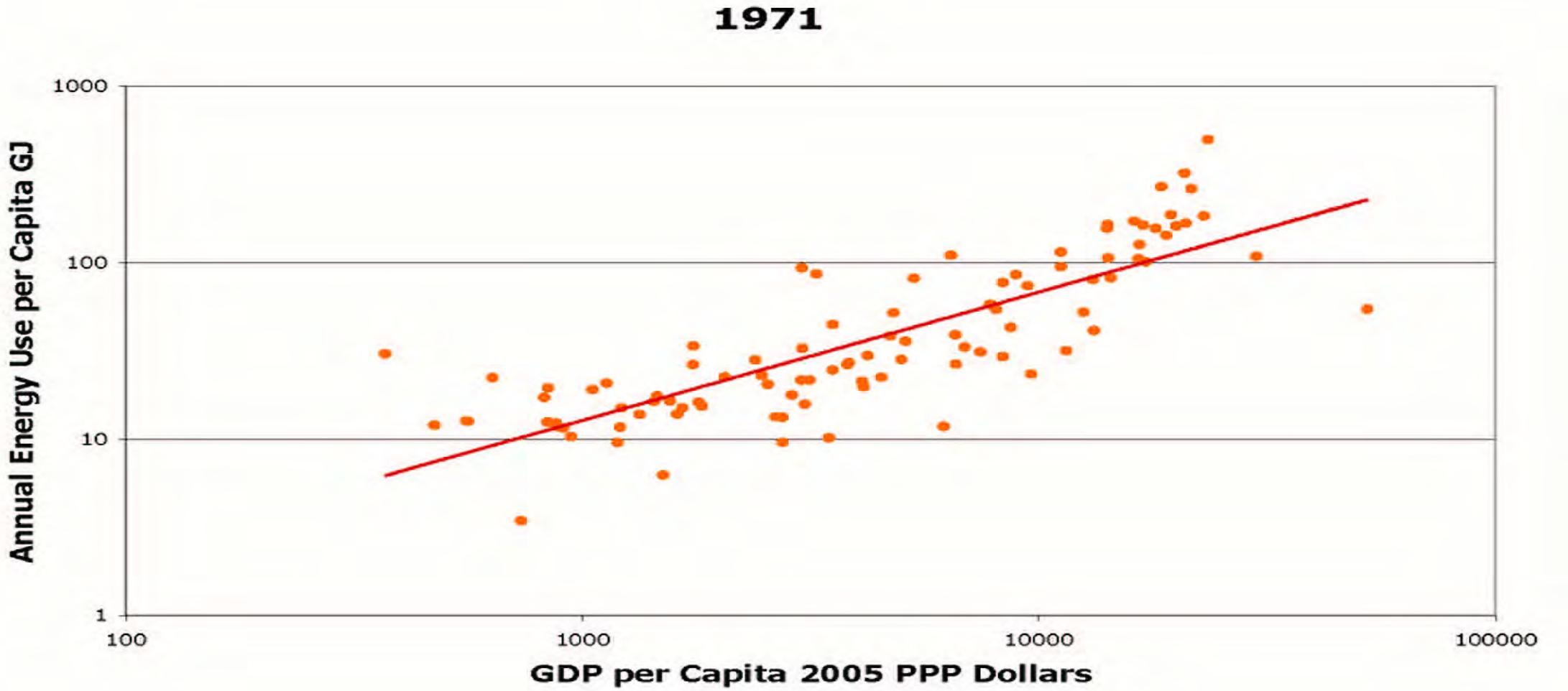




Higer quality energy carriers tend to have larger impact in economic output (GDP)

upna
Inarbe
Institute for Advanced Research in Business and Economics

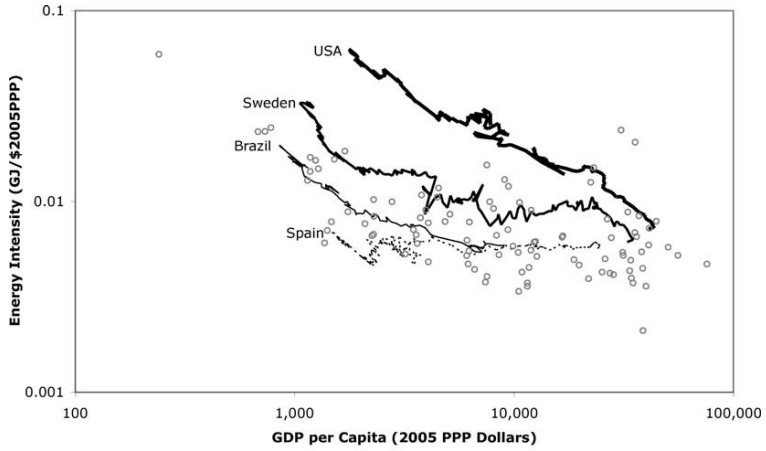
GDP and energy (I):
More production requires more energy

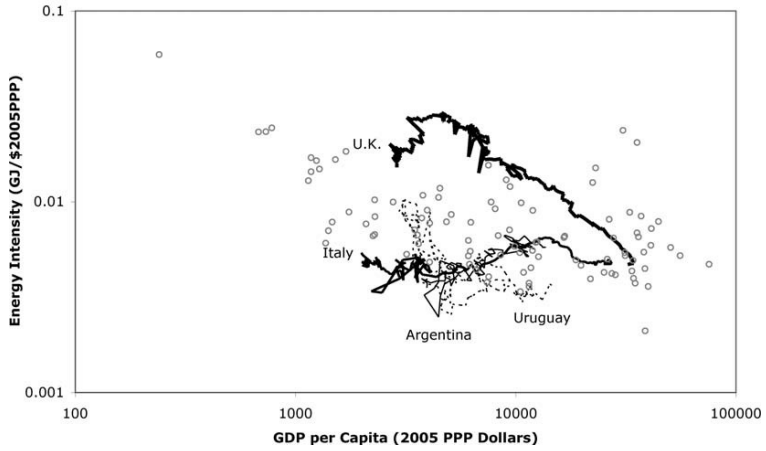


upna
Inarbe
Institute for Advanced Research in Business and Economics

But…
the economy (GDP) growths faster than the energy consumption (decoupling)

Energy intensity vs income per capita 1800-2010





Energy intensity of economy falls

Some countries have expanded GDP per capita significantly:

Without increasing energy use per capita

Or even while energy use per capita has fallen

e.g. UK's energy use per capita is the same as it was in the 1960s, down 12% from peak year (1996)

Evidence is that causality flows both ways

GDP causes higher energy demand

Greater energy availability is good for the economy

upna
Inarbe
Institute for Advanced Research in Business and Economics

Some lessons

Do this help with **the present energy transition to a low carbon economy?**

- Past energy transitions:
- affected all aspects of the energy systems: mix, quantity, quality, uses, etc
- accelerated over time
- always occurred at mid-to-low concentration levels.
- Most energy carriers did not decline in actual use when their share decreased (but eventually did!)

- Increasing energy quality with income.
- More income requires more energy, but
  - There exist a long term trend for decoupling (less energy per unit of output) –partly due to higher energy quality over time

upna
Inarbe
Institute for Advanced Research in Business and Economics

Transition:

the process (or a period)of changing from one state or condition to another.

Past energy transitions

Understanding the processes of change within the energy systems through time.

Present energy transitions

A fast pathway to a low carbon energy system (away from fossils)

Future energy transitions

?

Will depend on how the present one comes about.

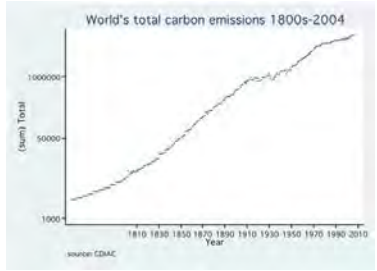
upna Inarbe Institute for Advanced Research in Business and Economics

The transition to a low carbon economy

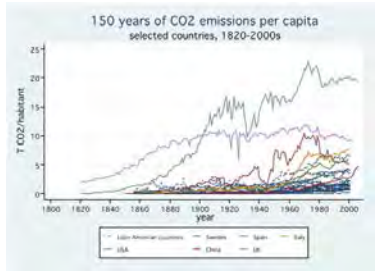
Which carbon indicator?

- (1) total?
- (2) Per capita?
- (3) Per dollar?
- (4) Per unit of energy?

(1)

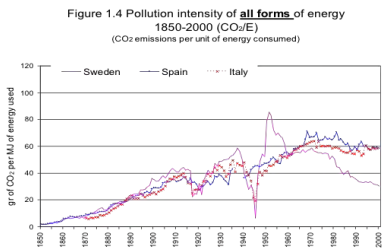


(2)



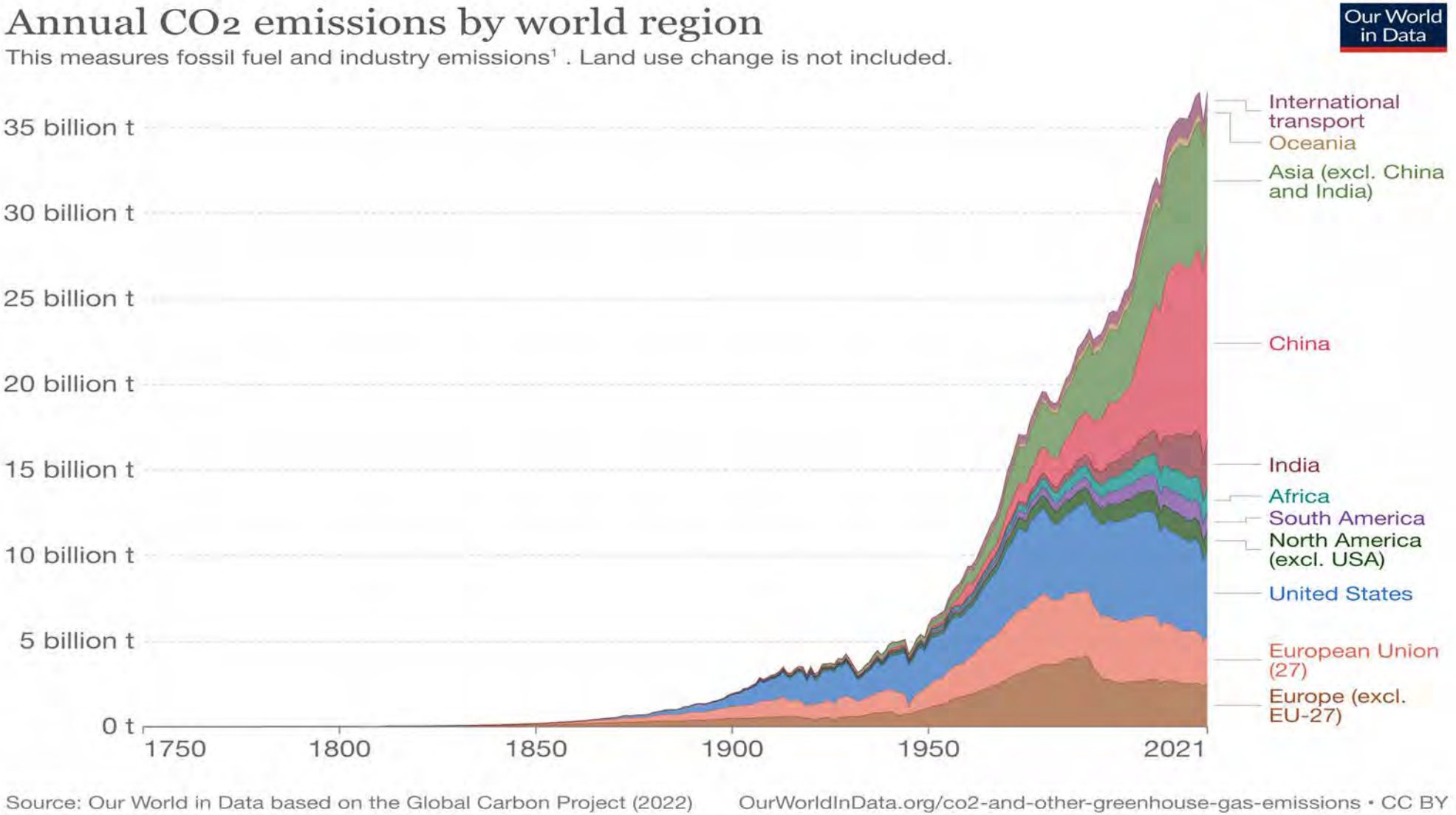
(3)

(4)



upna
Inarbe
Institute for Advanced Research in Business and Economics

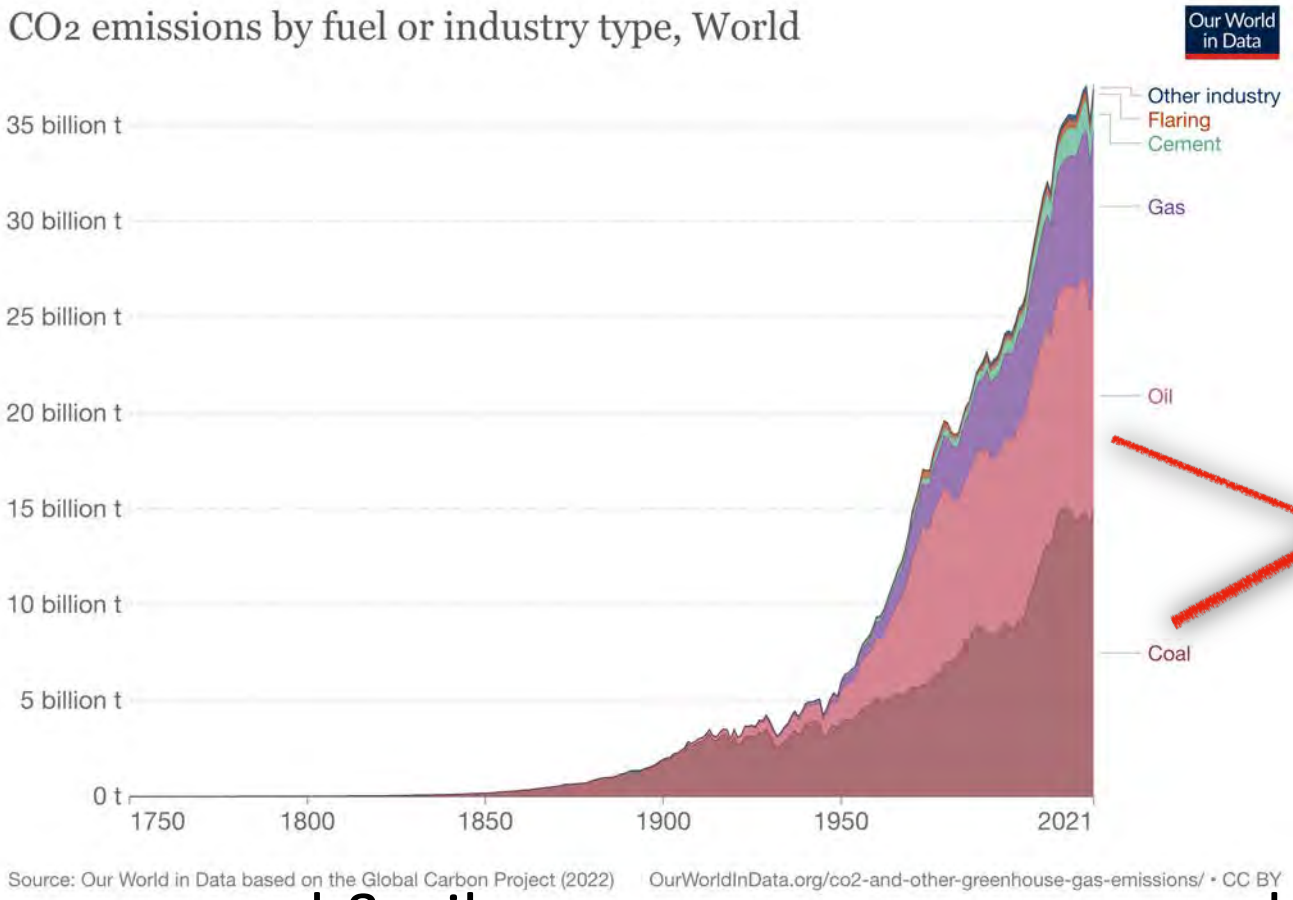
(1)Total emissions



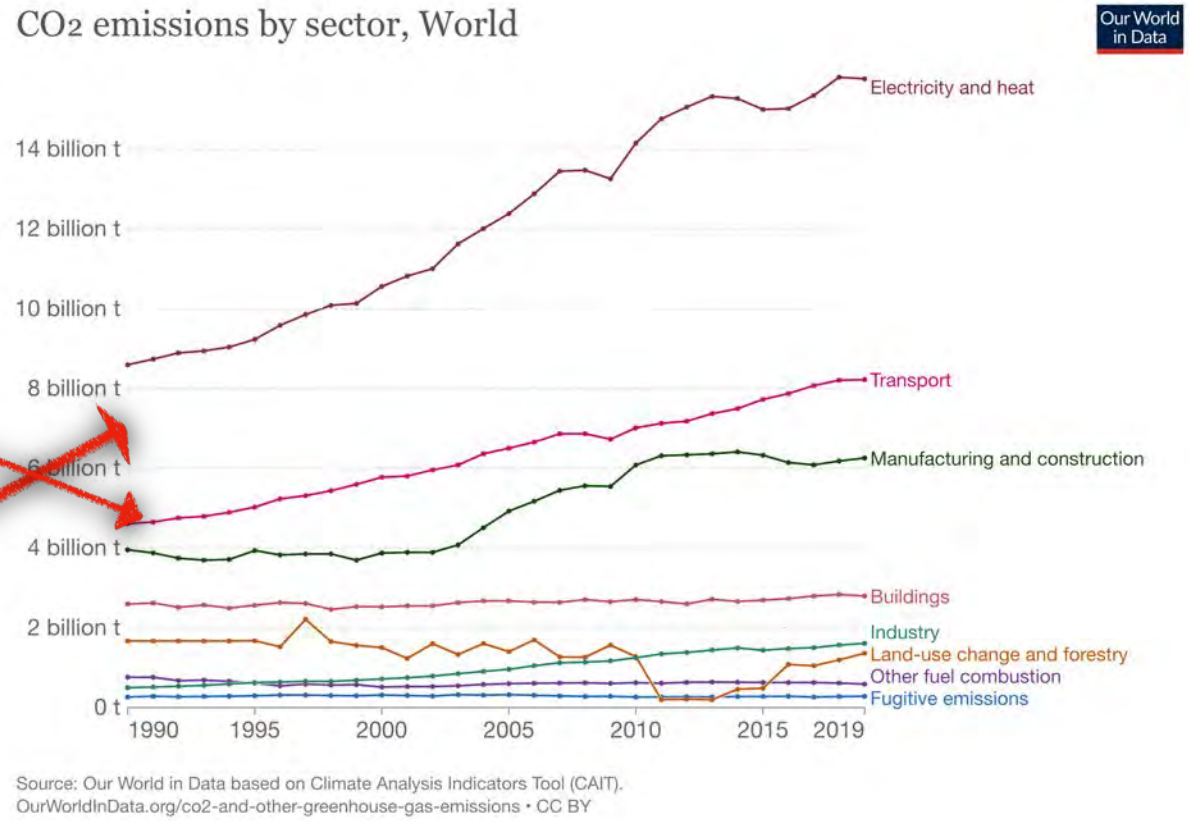
1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

upna
Inarbe
Institute for Advanced Research in Business and Economics

Key emissors



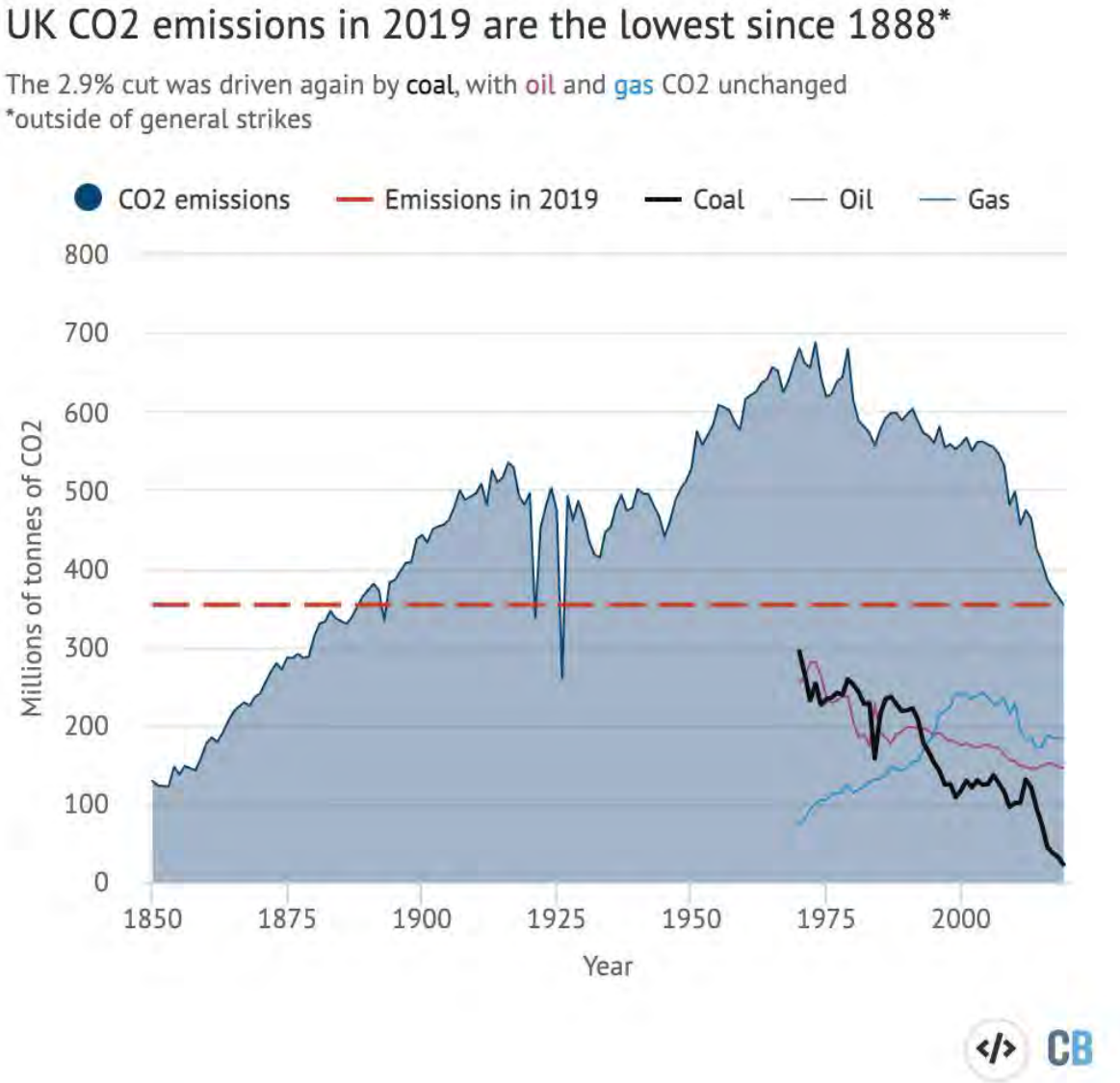
coal & oil



electricity, heat and transport (>70%)

upna
Inarbe
Institute for Advanced Research in Business and Economics

Some (very recent) good news



The UK's CO2 emissions 1850-2019, millions of tonnes (blue area) and the level in 2019 (dashed red line). Emissions from coal, oil and gas are shown from 1970 onwards. Source: BEIS, Carbon Brief analysis and the World Resources Institute CAIT data explorer. The CAIT data has been adjusted because it excludes emissions from land use and forestry. Chart by Carbon Brief using Highcharts.

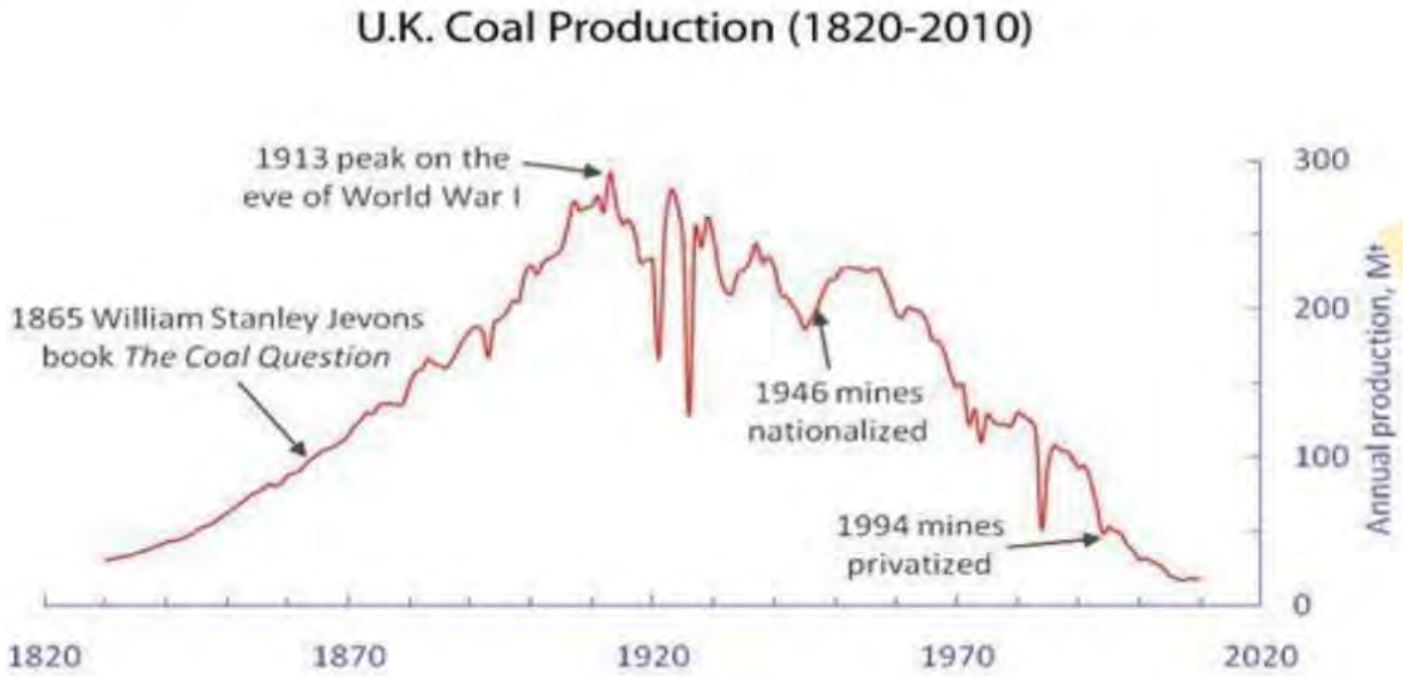
upna
Inarbe
Institute for Advanced Research in Business and Economics

The Coal Question;

An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of Our Coal Mines (1865)

W. S. Jevons(1835-1882)

1. He drew attention to the **gradual depletion** of coal in Britain
2. He explained that the increase in the efficiency of energy production and consumption paradoxically leads to **more energy consumption.**



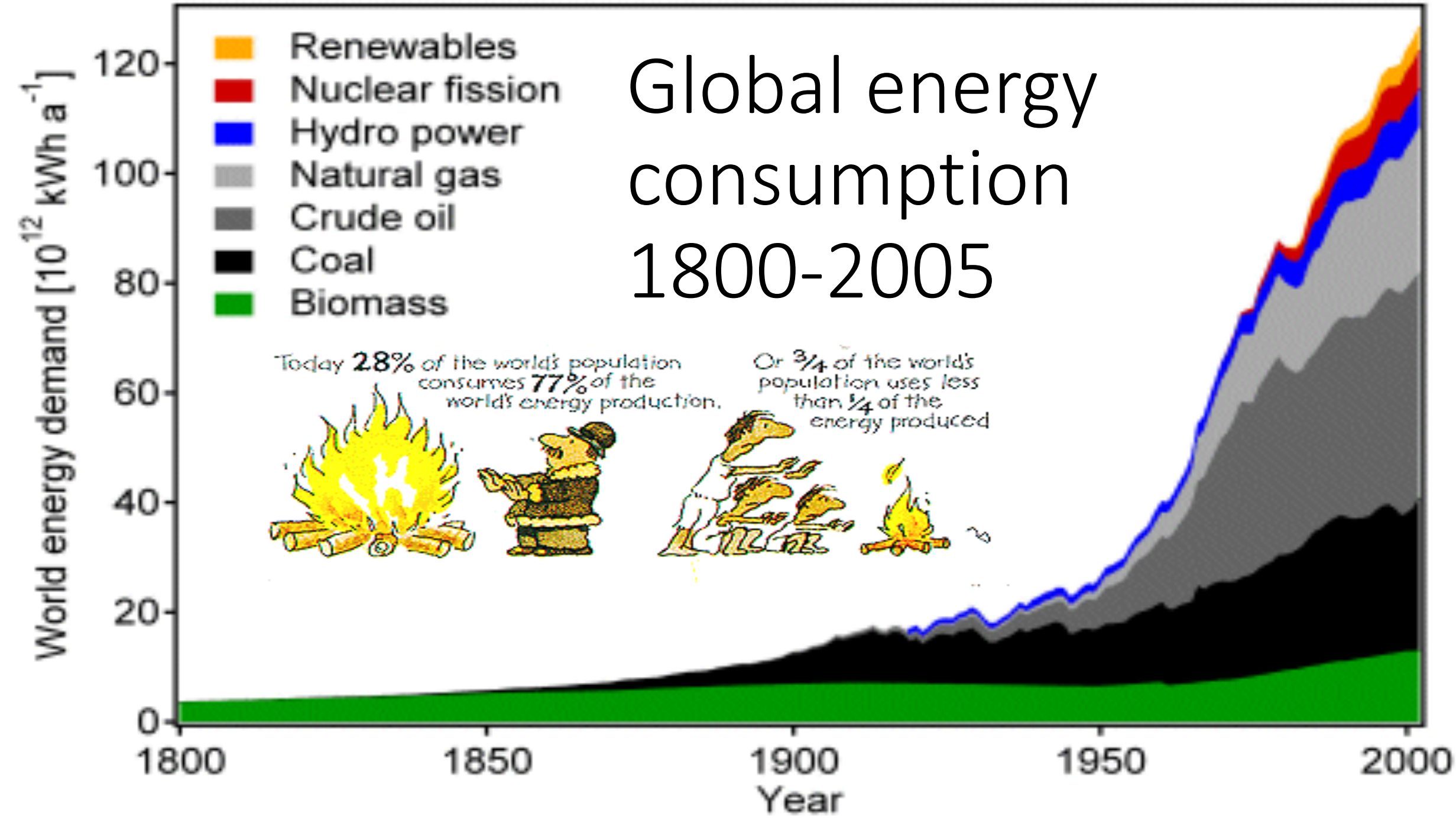
GB tripled coal production; **physical exhaustion did not chappen**; the economic did (found oil&gas in the 1970s)

upna
Inarbe
Institute for Advanced Research in Business and Economics

Beyond the technology : some of the socio-technical challenges for the ongoing energy transitions

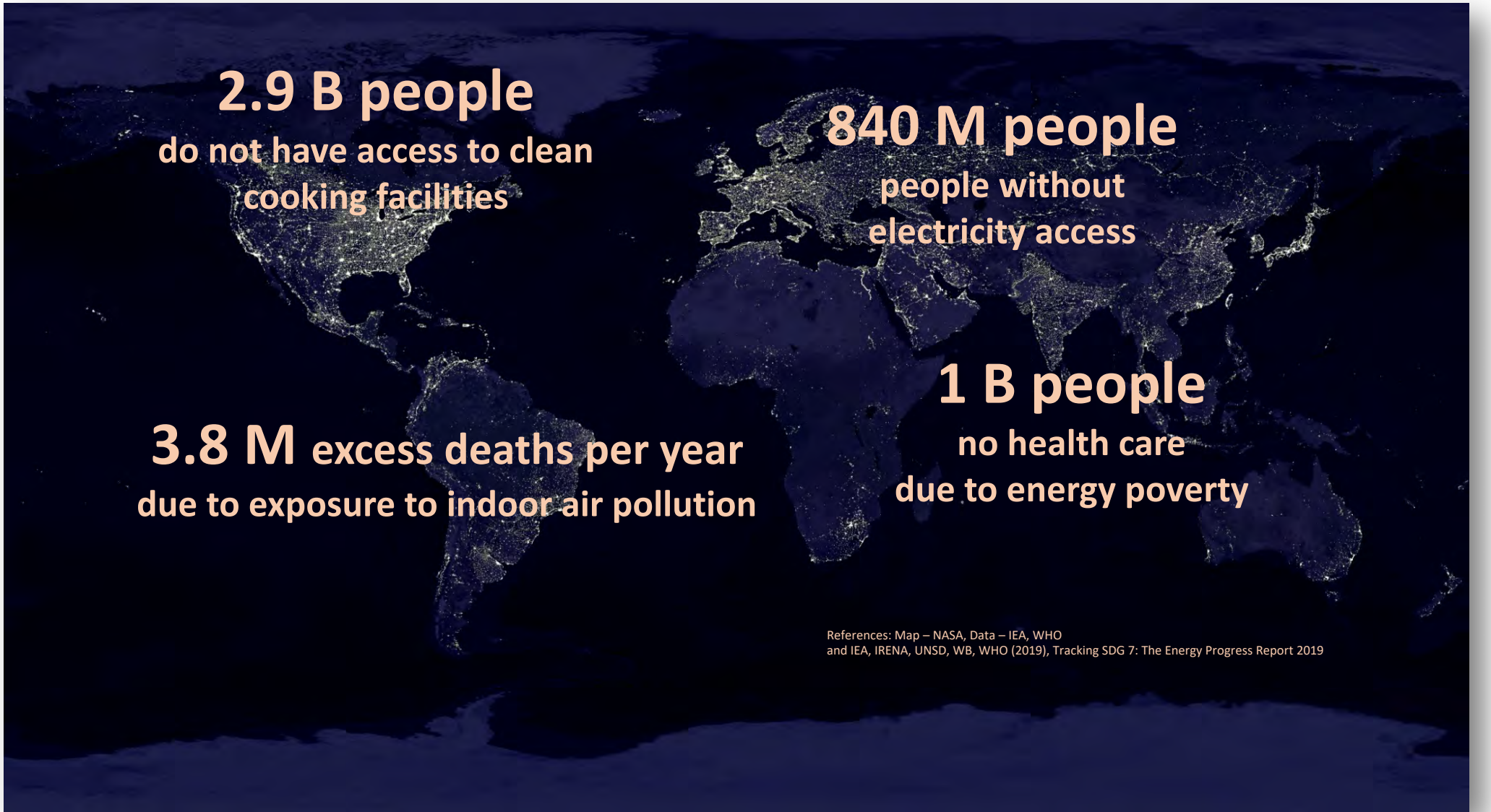
- Energy inequality (energy justice)
- Governance of the transition
- Changing habits (and other challenges for technology adoption)
- Billion machines

Global energy consumption 1800-2005



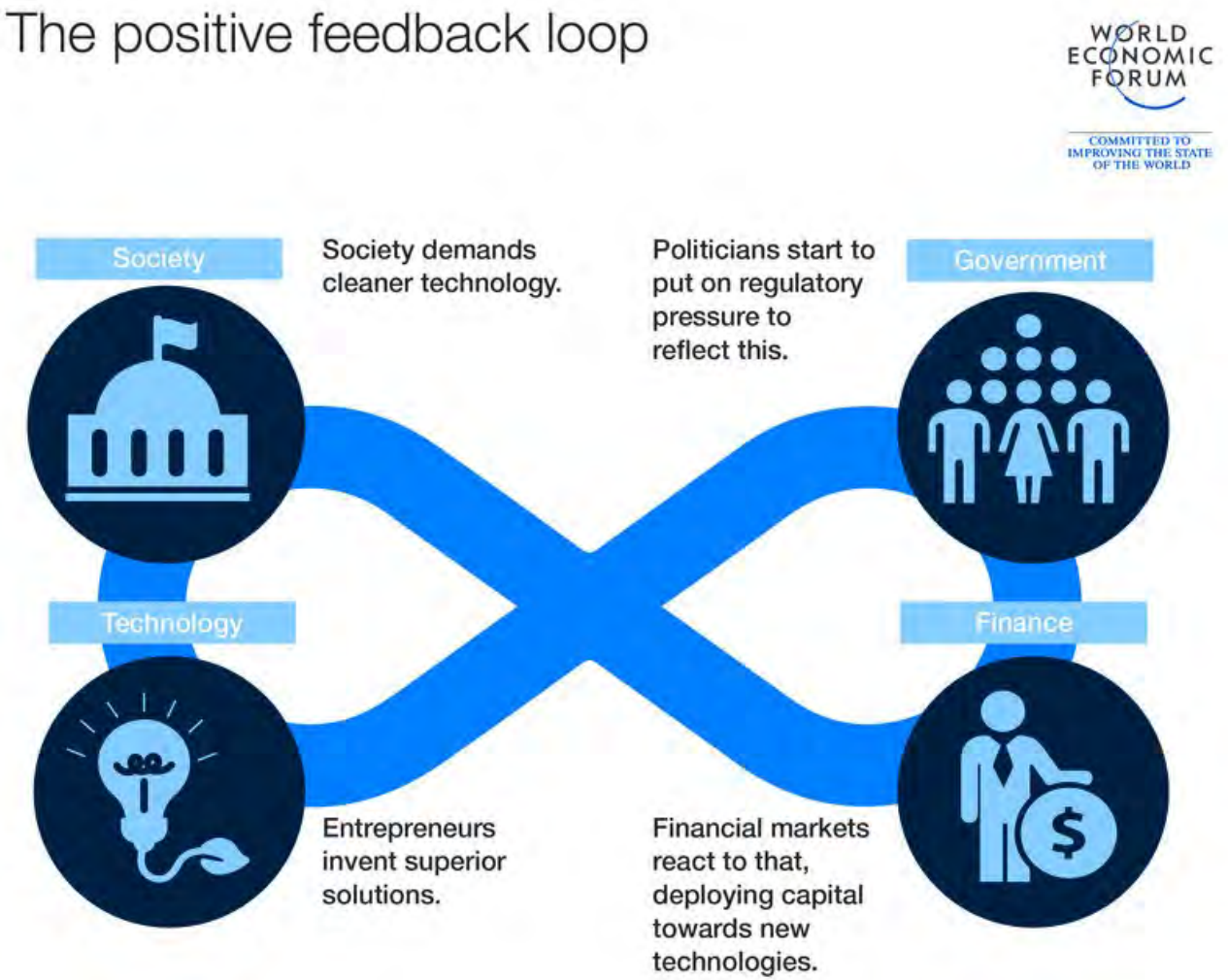
upna
Inarbe
Institute for Advanced Research in Business and Economics

Global Access to Energy



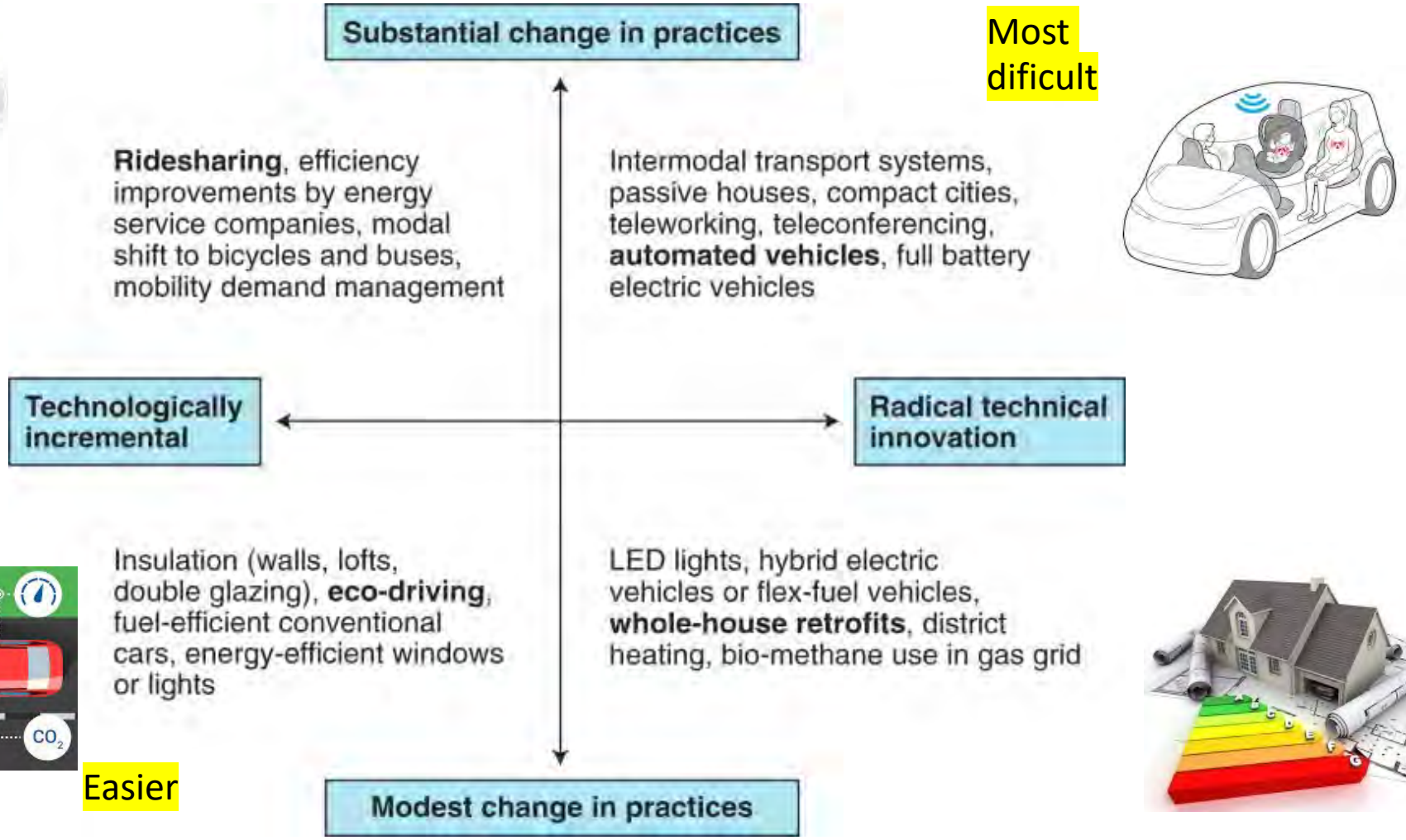
upna
Inarbe
Institute for Advanced Research in Business and Economics

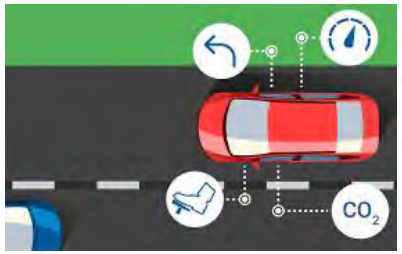
Governance of the transition:
society, policy and markets



Source: Speed of the Energy Transition whitepaper 2019, World Economic Forum

Changing habits/practices is difficult (both for societies & individuals)



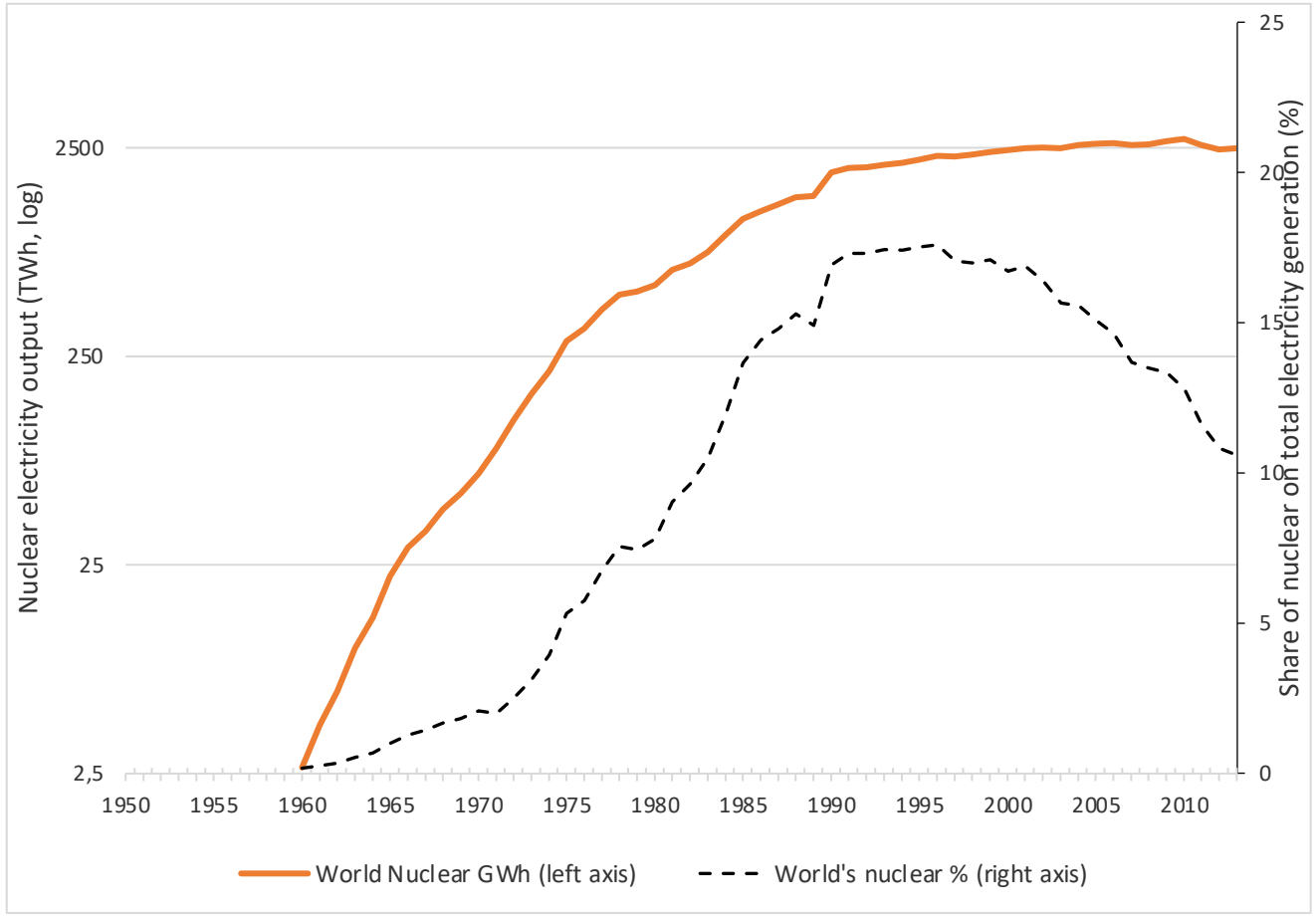


Slource:Sovacool, B.K., Griffiths, S. Culture and low-carbon energy transitions. *Nat Sustain* **3**, 685–693 (2020). https://doi.org/10.1038/s41893-020-0519-4

upna Inarbe Institute for Advanced Research in Business and Economics

Technology may exist but…may not be adopted

(because of social, economic, political, ethical, philosophical reasons…)



Source: Rubio-Varas, M. 'The Changing Economic Context Influencing Nuclear Decisions', in Kaijser, A., Lehtonen, M., Meyer, J.-H. & Rubio Varas, M. (eds.) (2021) *Engaging the Atom: The History of Nuclear Energy and Society in Europe from the 1950s to the Present.* West Virginia University Press.

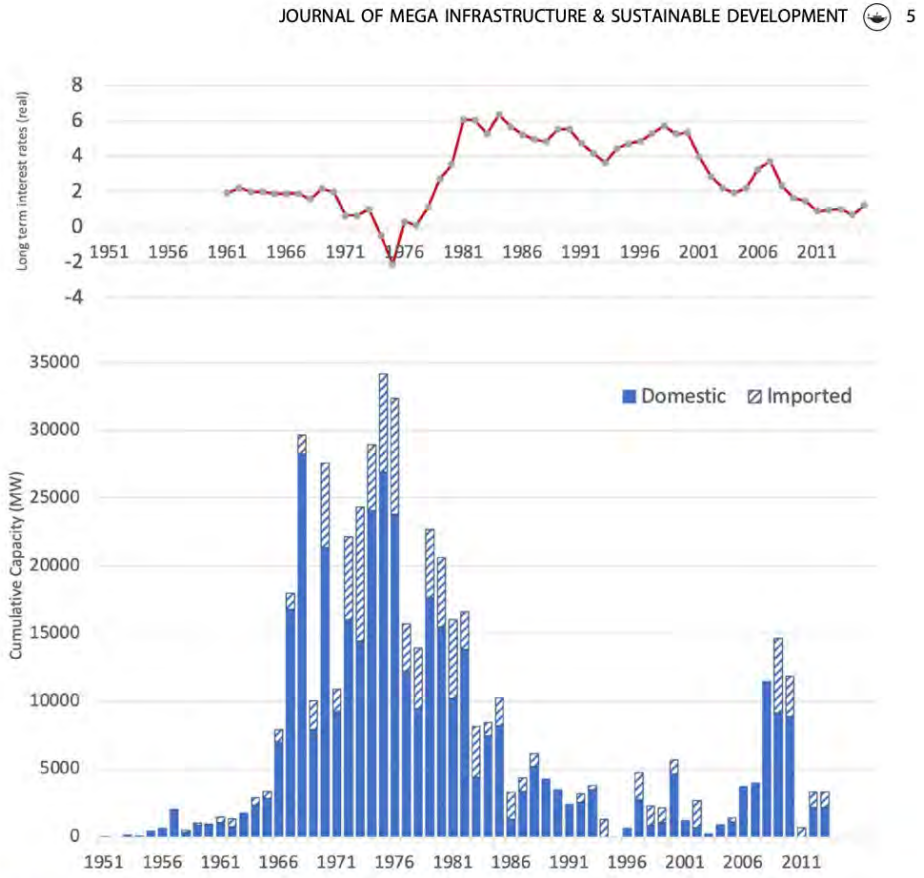


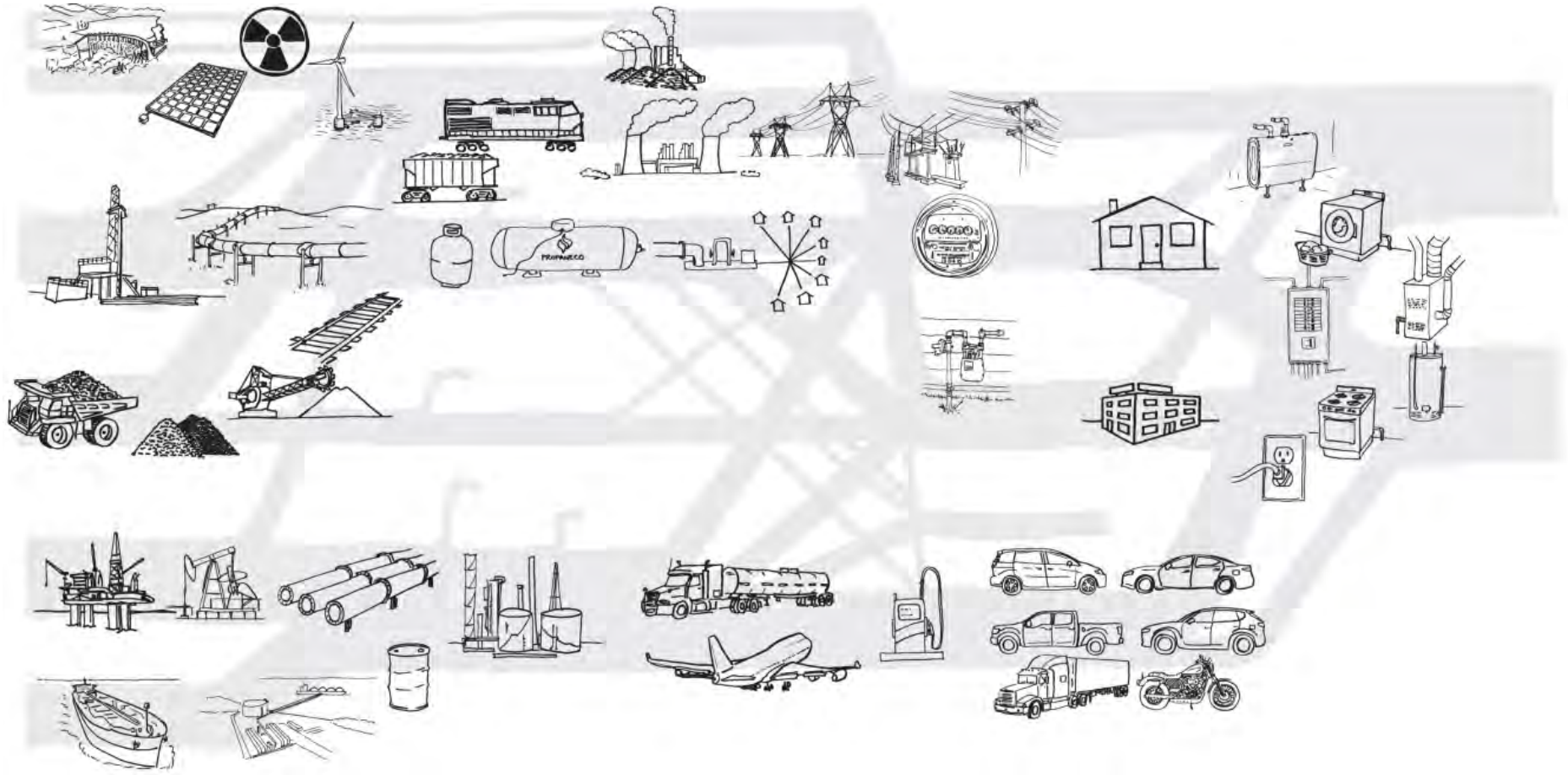
Figure 2. Financing costs vs new nuclear projects initiated yearly 1950–2013.
Sources and notes: Own elaboration from the compilation of the IAEA PRIS databases. The year refers to the construction start. Completed reactors only, thus those connected by 2020 began construction in 2013 at the latest. Domestic built refers to those projects where the reactor manufacturing takes place in the country in which the reactor is located. Imported reactor denotes a reactor coming from a different country where it is located. World Development Indicators, World Bank for real interest rates (blended for the US, Japan, the UK and France). Note that real interest rate is the lending interest rate adjusted for inflation. Rates are representative interest rates offered by banks to resident customers. A negative real interest rate indicates a loss in the purchasing power of the principal as inflation was above the nominal interest rate. DOI: 10.1080/24724718.2022.2092993

upna
Inarbe
Institute for Advanced Research in Business and Economics

Billions of machines to be replaced all over the world

(fewer in the supply than in the demand side)

Energy supply
(about 1 million machines)



Energy Demand
(about 1 BILLION machines)

Adapted from: https://saulgriffith.medium.com/one-billion-machines-48a7c3cf0694

upna
Inarbe
Institute for Advanced Research in Business and Economics

Transition:

the process (or a period)of changing from one state or condition to another.

Past energy transitions

Understanding the processes of change within the energy systems through time.

Present energy transitions

A fast pathway to a low carbon energy system (away from fossils)

Future energy transitions

?

Will depend on how the present one comes about.

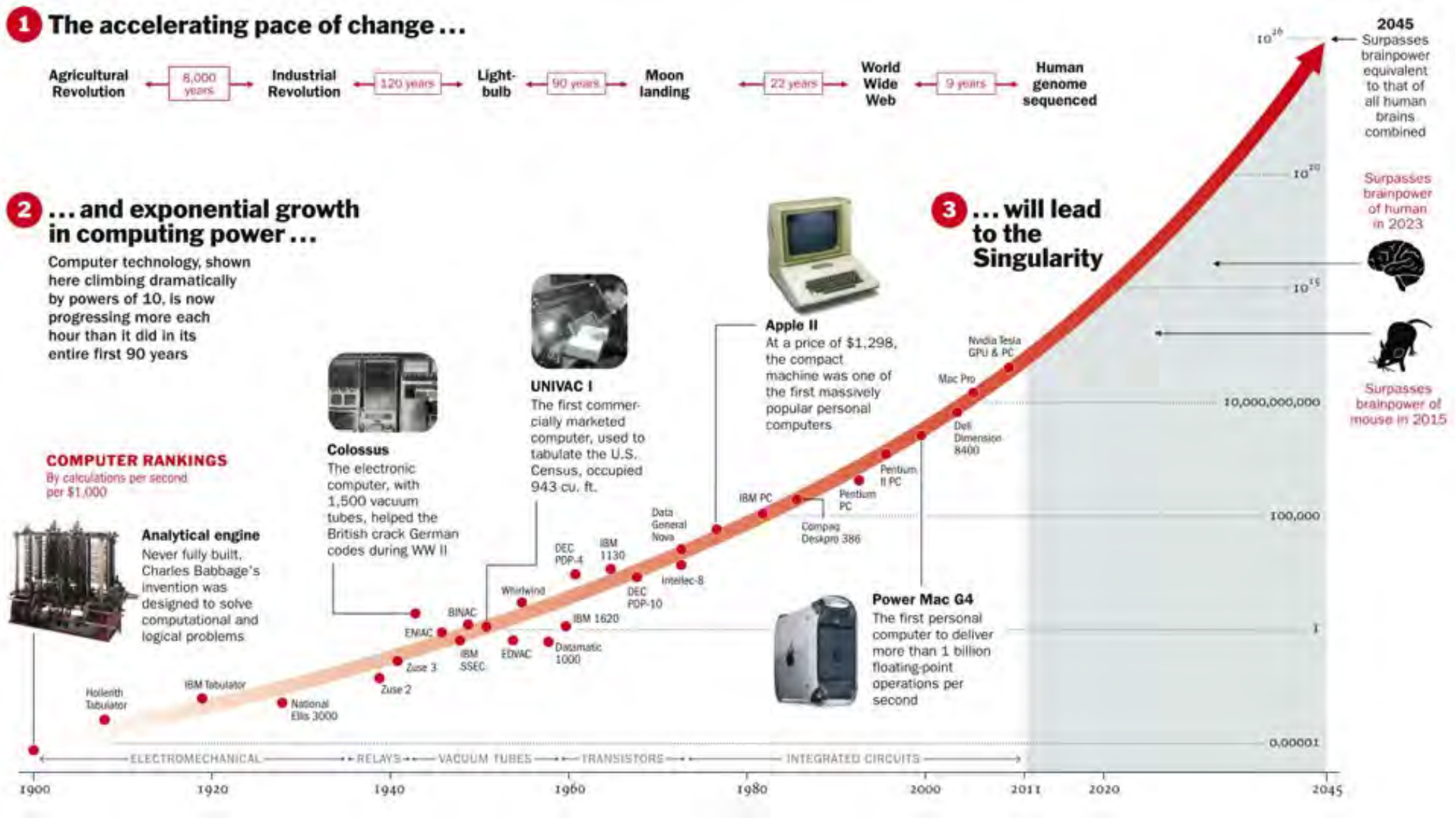
upna
Inarbe
Institute for Advanced Research in Business and Economics

Cornucopians vs Degrothwers

two radically different views of the present energy transition (and the future ahead)

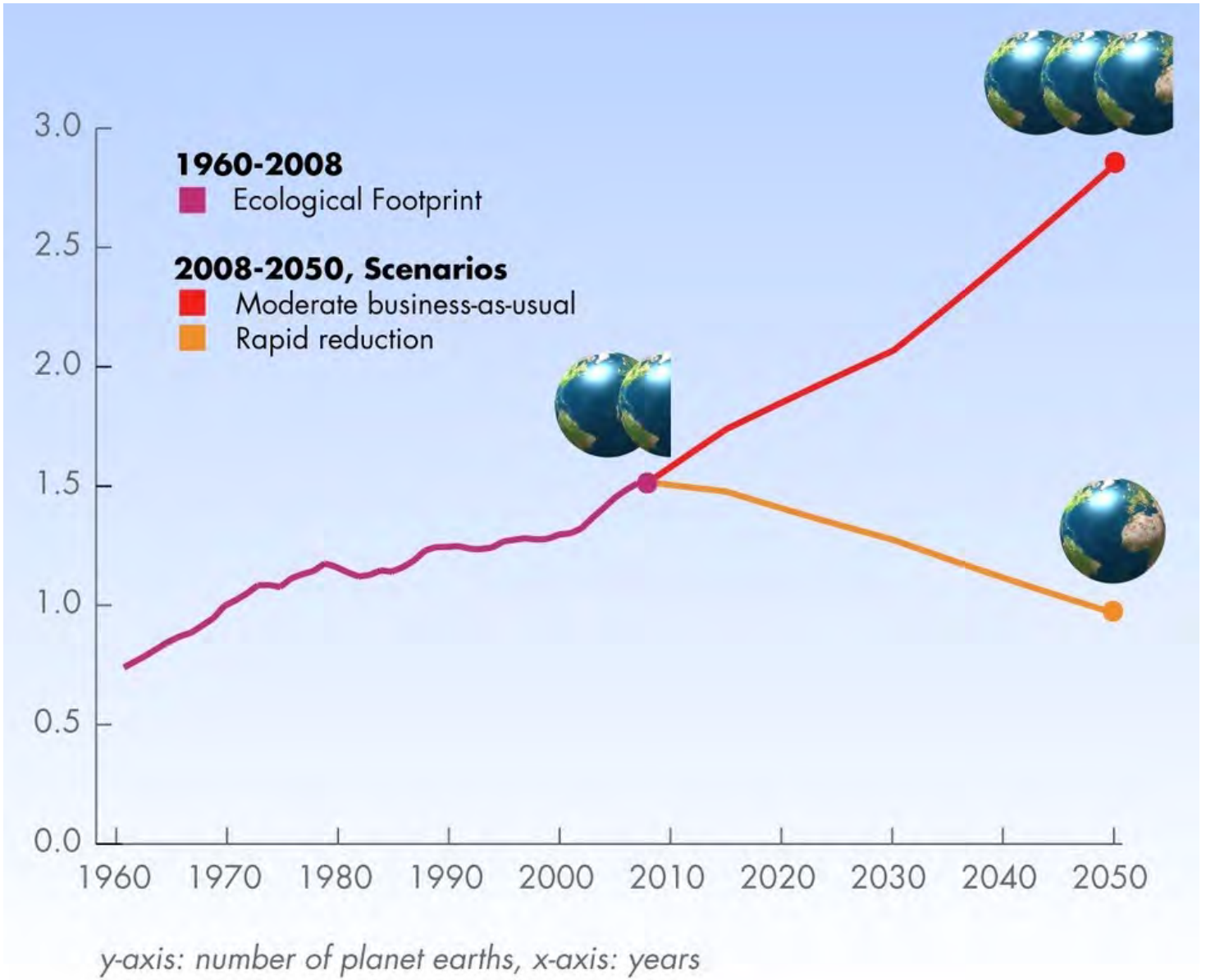
upna
Inarbe
Institute for Advanced Research in Business and Economics

Cornucopians vs Degrothwers



upna
Inarbe
Institute for Advanced Research in Business and Economics

Cornucopians vs Degrowthers

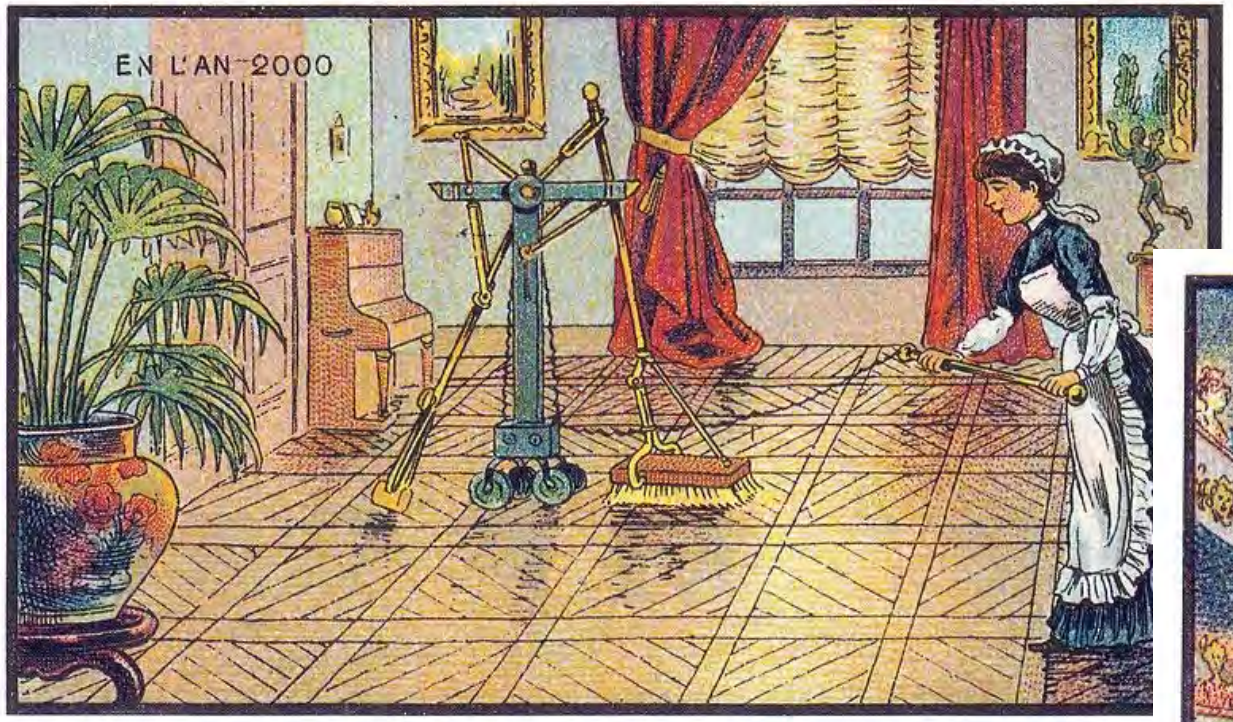


upna
Inarbe
Institute for Advanced
Research in Busi
and Econ

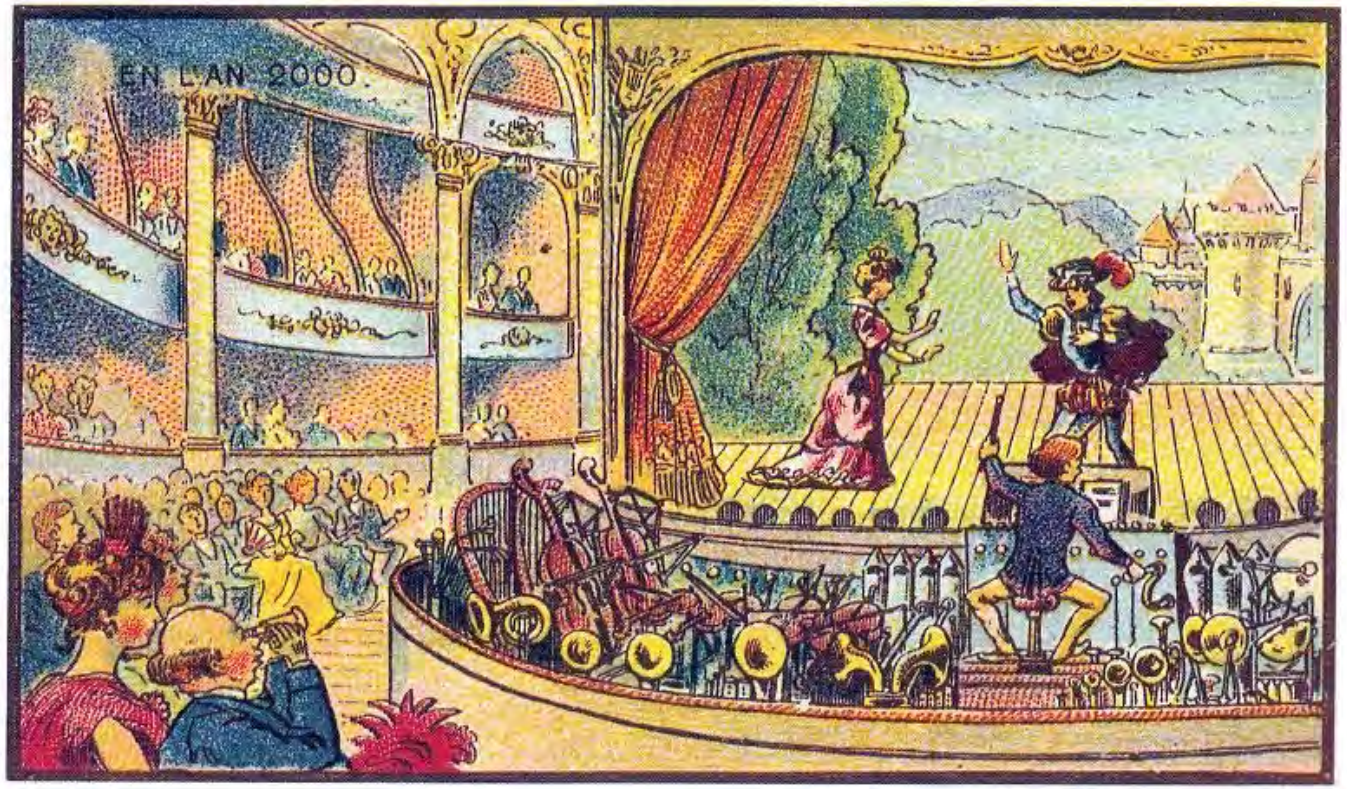
The limits to imagine futures: our fears

upna
Inarbe
Institute for Advanced Research in Business and Economics

The limits to our ability to imagine futures: precognitions and prejudism



Electric Scrubbing



A Well-Trained Orchestra

upna
Inarbe
Institute for Advanced Research in Business and Economics

In the past, visions of the future tended to be too pessimistic

(but they helped us in the search for solutions).

Social sciences and humanities are central to understand energy transitions

upna
Inarbe
Institute for Advanced Research in Business and Economics

Mar Rubio-Varas
Director
Institute for Advanced Research in Business and Economics (INARBE)
Universidad Pública de Navarra (UPNA)
Campus de Arrosadía, 31006 Pamplona, Spain
+34 948 16 9706
mar.rubio@unavarra.es

upna Inarbe Institute for Advanced Research in Business and Economics

Further readings…

Csereklyei, Z. Stern, D.I. and, Rubio-Varas, M.d.M , 'Energy and Economic Growth: the stylized facts, *Energy Journal*, April 2016, 37,2, pp.223-256

Ducoing, C., Gales, B, Hölsgens, R & Rubio-Varas, MdM (2019) 'Machines and Energy. Energy Capital ratios in Europe and Latin America 1875 - 1970' *Scandinavian Economic History Review*. 67:1, 31-46: 10.1080/03585522.2018.1503968

Fouquet, R. (2014), "Long run demand for energy services: income and price elasticities over 200 years.' Review of Environmental Economics and Policy 8(2) 186-207.

Fouquet, R. (2016). "Historical energy transitions: Speed, prices and system transformation". Energy Research & Social Science, 22: 7–12.

Fouquet, R., Pearson, P.J.G. (2012). "Past and prospective energy transitions: Insights from history". Energy Policy 50: 1–7.

Gales, B., Kander, A., Malanima, P., Rubio, M.d.M. (2007). "North versus South: energy transition and energy intensity in Europe over 200 years". European Review of Economic History 11 (2): 219–253.

Grübler, A. (2004). Transitions in energy use. Encyclopedia of Energy 6, 163–177. Elsevier

Kander, A., Stern, D.I. and Rubio-Varas, M. (2020) 'Energy Intensity: The Roles of Rebound, Capital Stocks, and Trade' in Ruth, M. (ed) *A Research Agenda for Environmental Economics*, (Edward Elgar: MA) pp.122-141 ISBN978 1789900 40

Marchetti C. (1977). "Primary Energy Substitution Models: On the Interaction between Energy and Society". Technological Forecasting and Social Change 10: 345–356.

Marcotullio, P. J., Schulz, N. B. (2007). "Comparison of energy transitions in the United States and developing and industrializing economies". World Development 35 (10): 1650–1683.

Rubio, M.d.M., Folchi, M. (2012). "Will small energy consumers be faster in transition? Evidence from the early shift from coal to oil in Latin America". Energy Policy 50: 50–61.

Rubio-Varas, M. and Muñoz-Delgado, B. (2019), Long-term diversification paths and energy transitions in Europe, Ecological Economics, vol.163, pp.158-168 https://doi.org/10.1016/j.ecolecon.2019.04.025

Rubio-Varas, M. and Muñoz-Delgado, B. (2019), The Energy Mix Concentration Index (EMCI): Methodological considerations for implementation, MethodsX, Vol.6, pp.1228-1237 https://doi.org/10.1016/j.mex.2019.05.023

Rubio-Varas, M.d.M, 'The First World War and the Latin American transition from coal to petroleum',Environmental Innovation and Societal Transitions, (2019, in press) https://doi.org/10.1016/j.eist.2018.03.002