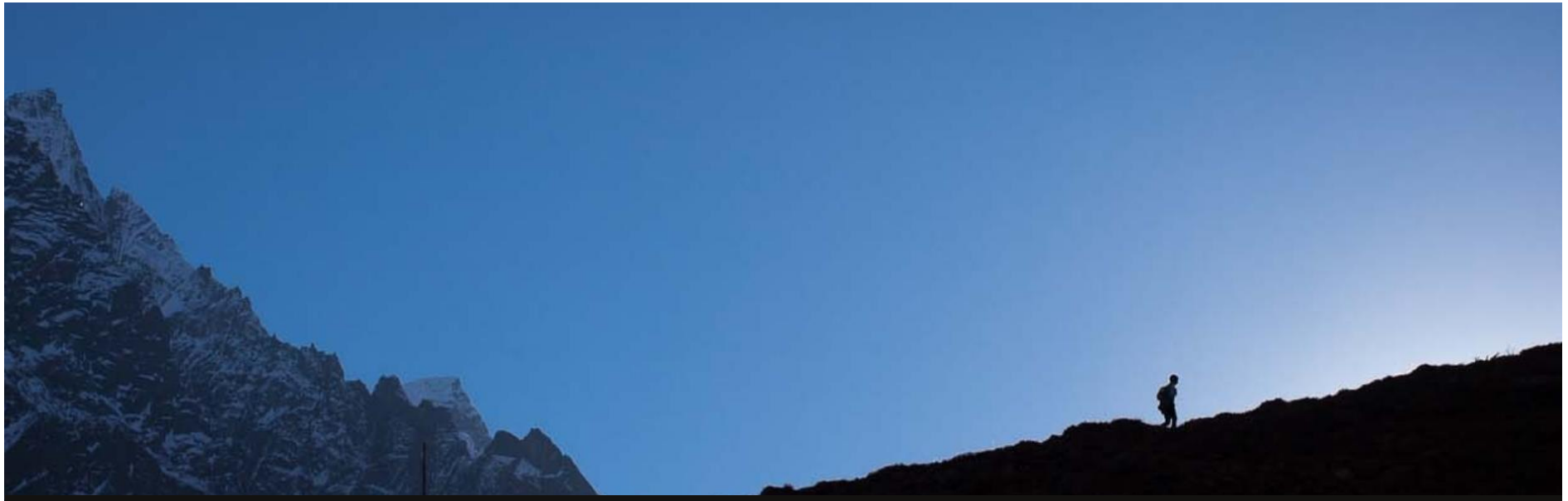
Doutoramento em Alterações Climáticas e Políticas de Desenvolvimento Sustentável



Class 2 18th March 2022 | Global energy and climate

Sofia G. Simoes

SEMINAR ENERGY & CLIMATE CHANGE

Climate Change and Sustainable Development Policies

LNEG

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

CENSE center for environmental and sustainability research

1	04/03 6ª Feira	16h-18h	Session reserved for students meeting with the Scientific Committee on practical aspects of the PhD Program, and choice of tutors.	Comissão Científica
2	11/03 6ª Feira	16h-18h	ENERGY & CLIMATE CHANGE: A COMPLEX RELATION, PERENE AND INTERDISCIPLINARY. Framework and purpose of the course in the PDACPDS. Practicalities and seminar program. Basic concepts of the energy systems.	J. Seixas, FCT NOVA
3	18/03 6ª Feira	16h-18h	**Current state of the global energy system :** main energy carriers, energy production and consumption regions; energy access; concepts of energy and carbon intensity.	S. Simões
4	25/03 6ª Feira	14h-16h	**Global balance of CO_2 emissions** associated with energy and industrial processes. Estimates of the Global Carbon Budget (http://www.globalcarbonproject.org/) and its relationship to the global energy system and changes in land use. Future scenarios for greenhouse gas emissions: RCPs (Representative Concentration Pathways). Global emissions based on consumption vs. production.	S. Simões
5	02/04 Sábado	09h-11h	**Renewables:** Economic, environmental and energy security of endogenous vs. imported resources. Renewable technologies. Sustainability issues related with renewables. Land & water use, critical raw materials. Discussion: Where to place 7GW of solar PV in Portugal till 2030?	S. Simões
6	08/04 6ª Feira	16h-18h	**Energy concepts:** Primary/final energy; Sankey diagrams; energy efficiency; Energy services; Energy carriers; Final energy supply cost curves; learning curves of energy technologies. Definition and usefulness of LCOE. System value of Renewables. Global renewables' market.	S. Simões
7	22/04 6ª Feira	16h-18h	**Drawdown** - Climate Solutions for a New Decade	João P. Gouveia, FCT NOVA
8	30/04 Sábado	09h-11h	**Green hydrogen:** technological options, costs and the role for a carbon neutral energy system	P. Fortes, FCT NOVA
9	06/05 6ª Feira	18h-20h	**CARBON PRICING.** Regulatory framework in the European Union: 2020 - 2030 targets. Fit for 55. European low-carbon Roadmap 2050. Paris Agreement, and its implications.	S. Simões
10	13/05 6ª Feira	16h-18h	**Debate Como perspetivar o futuro da energia e alterações climáticas?** Baseado no artigo *An energy vision: the transformation towards sustainability — interconnected challenges and solution s*	students / S. Simões
11	21/05 Sábado	11h-13h	**Hands-on energy data:** access to energy databases, Portuguese and European (PORDATA, DGEG, EUROSTAT). i) How to find and explore energy statistics and emissions of greenhouse gas (GHG) emissions for Europe and Portugal; ii) How to make energy conversions; iii) How to build indicators and charts with added value; iii) How to analyze economic sectors, and interpret their performance in terms of energy consumption and greenhouse gas emissions.	S. Simões
12	27/05 6ª Feira	16h-18h	**Integrated assessment of energy systems:** The energy system addressed by the systems analysis approach. How to envisage the future energy system? Implications for the decision making in the medium and long term. Concept and formulation of cost-effectiveness within the integrated energy systems. Hands on Climate Mitigation Simulation	S. Simões
13	03/06 6ª Feira	16h-18h	Mentoring with each students' group : discussion on the approach and methods adopted by the students, expected results to be obtained with the final work; assessing preliminary results, if any.	S. Simões
14	17/06 6ª feira	18h-20h	**Smart and Sustainable cities:** concept, components and implications for the energy systems. The concept of Postive Energy Districts, and implications for future planning at the city level.	João P. Gouveia, FCT NOVA
	2 julho, 14h	14h-16h	Avaliações: apresentação dos trabalhos pelos alunos.	S. Simões / J. Seixas

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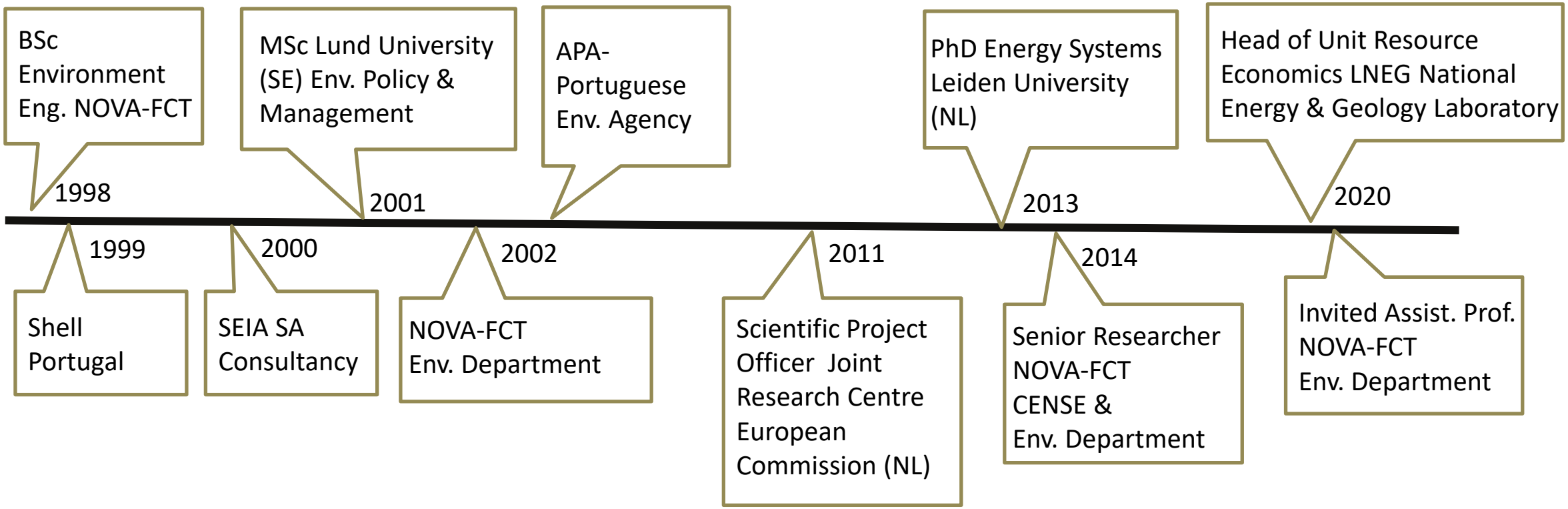

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LNEG Resource Economics Unit

The unit is **crosscutting the Energy and Geology areas** of LNEG
Develops I&D&D activities and decision-support for both public policy-makers and the private sector on **energy and geology resource economics, towards carbon neutrality and sustainable resource exploitation and use**

The unit applies techno-economic & social analytical approaches in the following I&D fields:

1

Sustainable energy systems

2

Resource use for energy production and consumption

3

Classification of geological deposits in a global economy

4

Economic and social impact of the energy transition

5

Circular economy, including design of products, services, systems and business models

6

Sustainable public circular procurement

https://www.lneg.pt/en/unit/resource-economics-unit/

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If you need to discuss topics related to the course, including the assignment, I am available on Fridays 10h-11h – send me an e-mail to book this slot at least 4 days before

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REPÚBLICA PORTUGUESA
AMBIENTE E AÇÃO CLIMÁTICA

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86% OF CAR JOURNEYS TO WORK ARE DRIVER ONLY

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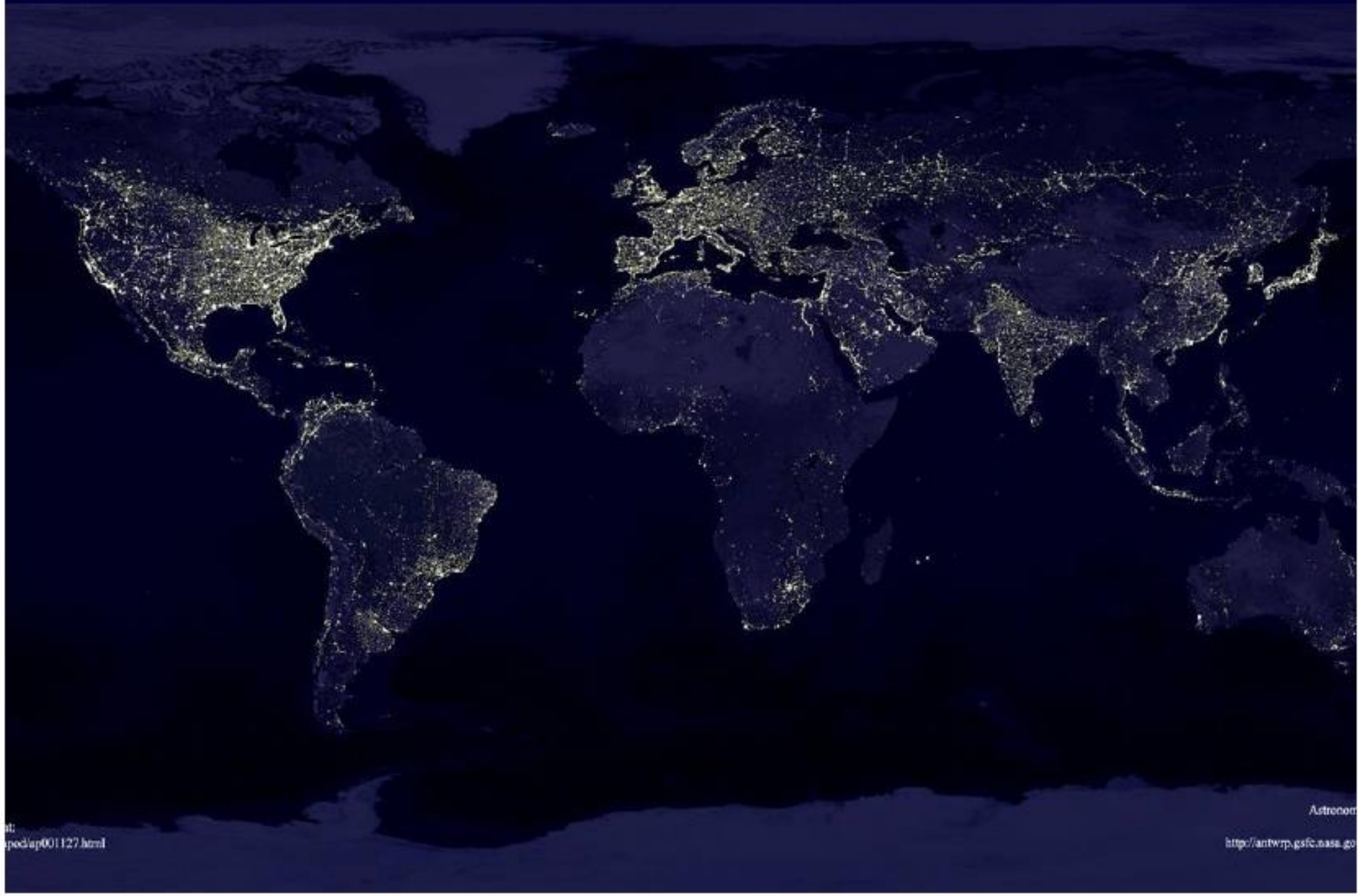
Energy Demand & Prosperity



Outline

- Some energy concepts
- Historic trends in energy consumption & Energy access
- A new energy era?

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Outline

- Some Energy concepts

Darling Harbour, Sydney, Australia

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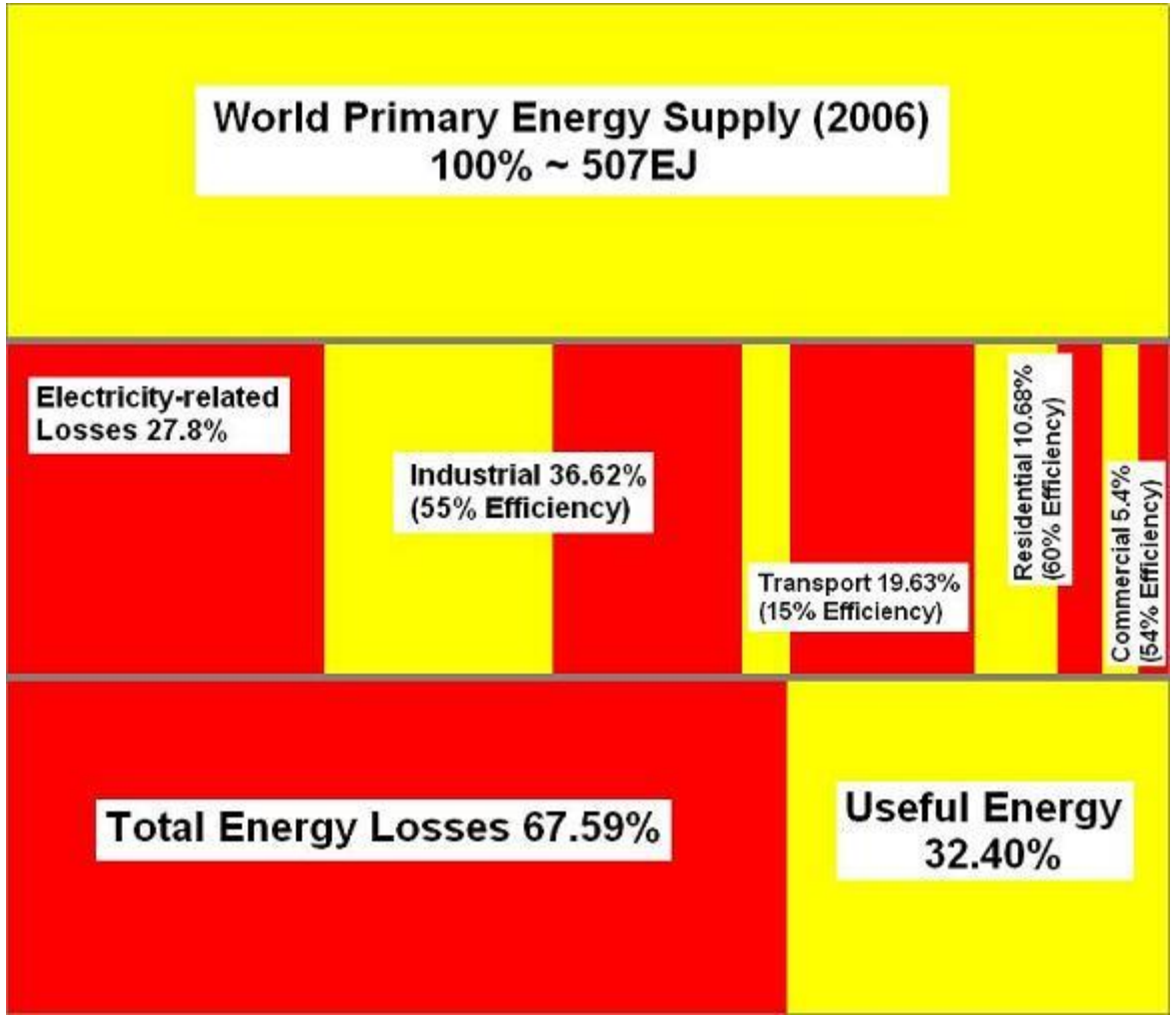
Primary energy *versus* Final and useful energy



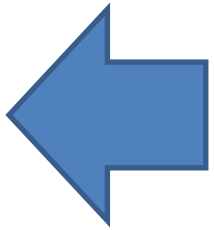
Energy services

- Lighting
- Cooking
- Clothes washing, drying
- Dishwashing
- Space heating
- Space cooling
- Hot water
- Recreation

- Mobility

- Process heat
- Machine drive in industry

- (…)



ENERGY

Energy units

toe/tep tonne of oil equivalent (Mtoe, ktoe)

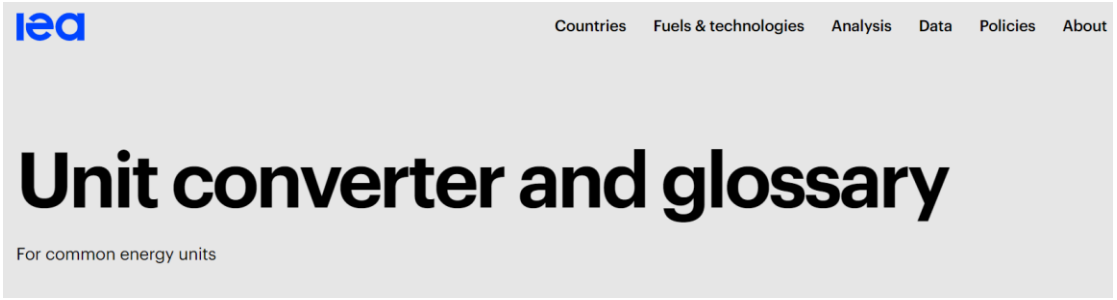
Wh watt hour (TWh, GWh, MWh, kWh)

J joule (PJ, TJ, GJ)

Btu British thermal units

cal calorie

tce tonne of coal equivalent



https://www.iea.org/reports/unit-converter-and-glossary

[Installed capacity in GW, TW, MW]

Capacity (MW) x operation hours (no. hours) x capacity factor (non dimensional) = energy production (MWh)

Solar PV plant with a capacity of 1.5 MW that is operating at its maximum capacity for 2 hours - at the end of the 2nd hour, the PV generates 1.5 MW x 2 hours = 3 MWh energy

If same solar PV plant, because of maintenance stops, orders from the grid operator, or lack of solar irradiation during those 2 hrs period operates only 1hr, then at the end of the 2nd hour, the PV generates 1.5 MW x 1 hours = 1.5 MWh energy

capacity factor (non dimensional) = actual operation hours / maximum possible working hours at full capacity (normally in an year, i.e. 8760 hrs)

WHICH IS THE AVERAGE CAPACITY FACTOR OF SOLAR PV IN PORTUGAL? And of a gas power plant?

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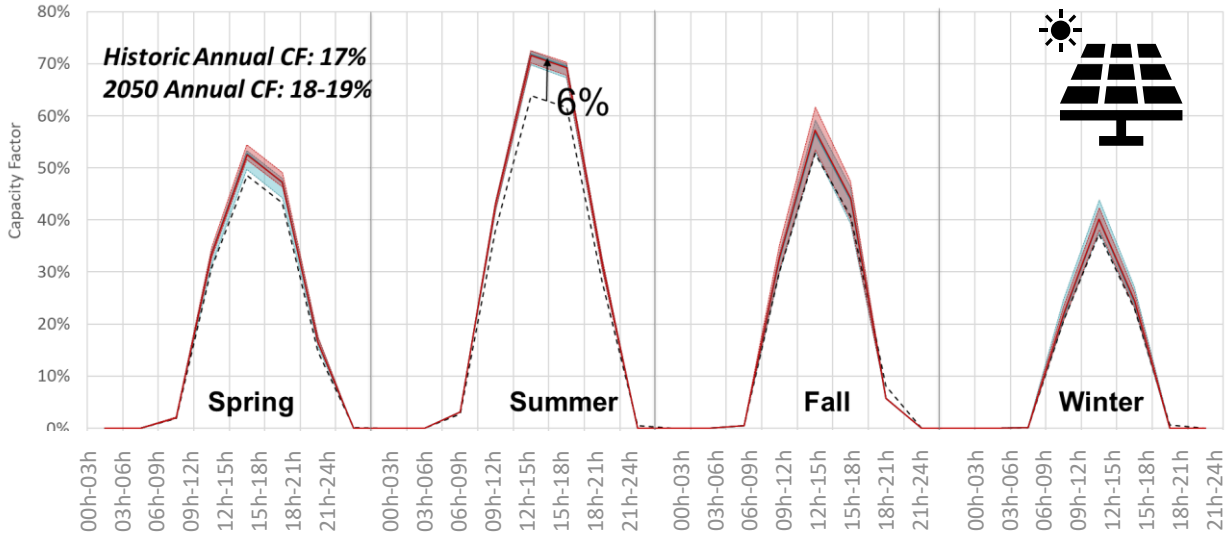

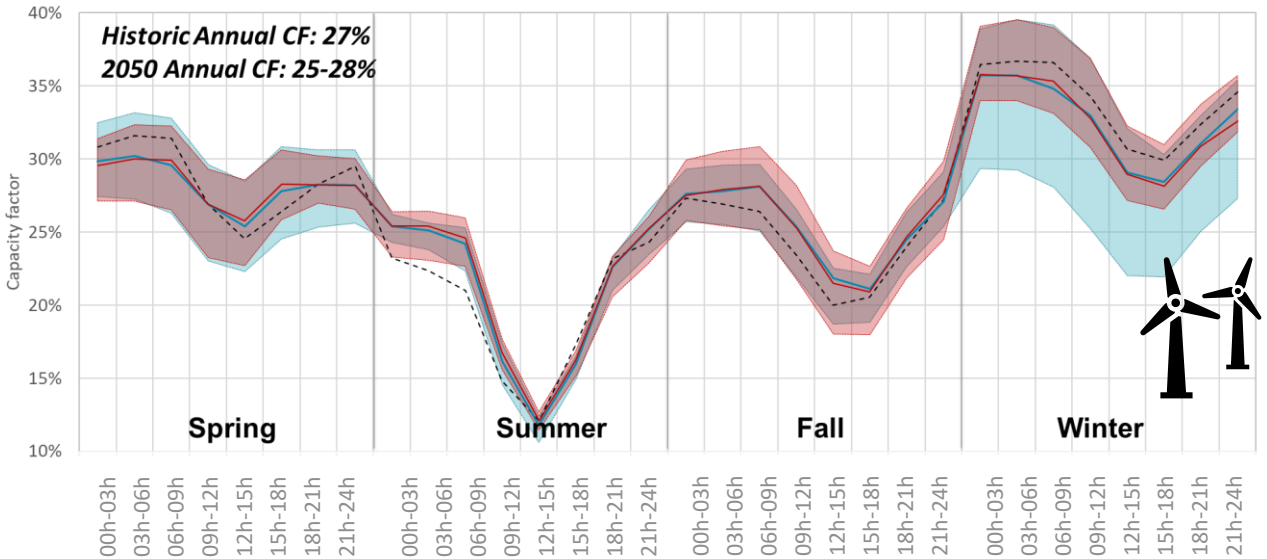

CLIM2POWER PROJECT

https://clim2power.com/

Project CLIM2POWER is part of ERA4CS, an ERA-NET initiated by JPI Climate, and funded by FORMAS (SE), DLR (DE), BMWFW (AT), FCT (PT), EPA (IE), ANR (FR) with co-funding by the European Union (Grant 690462).

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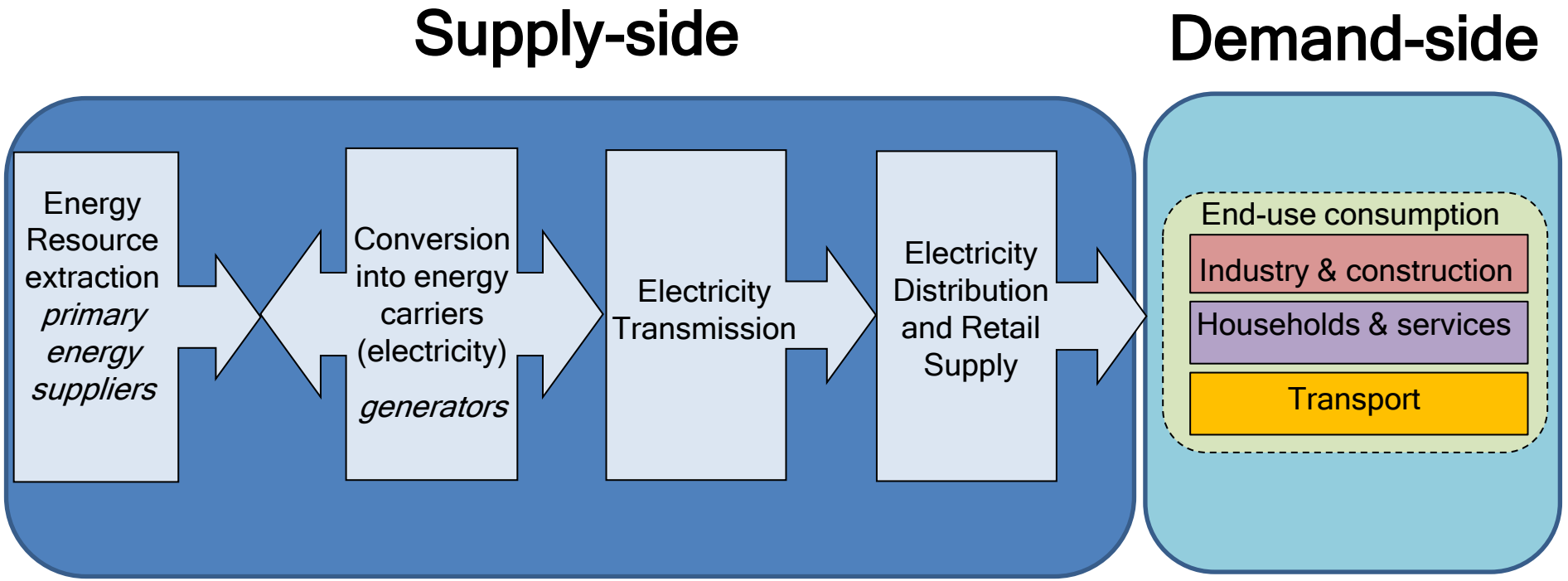
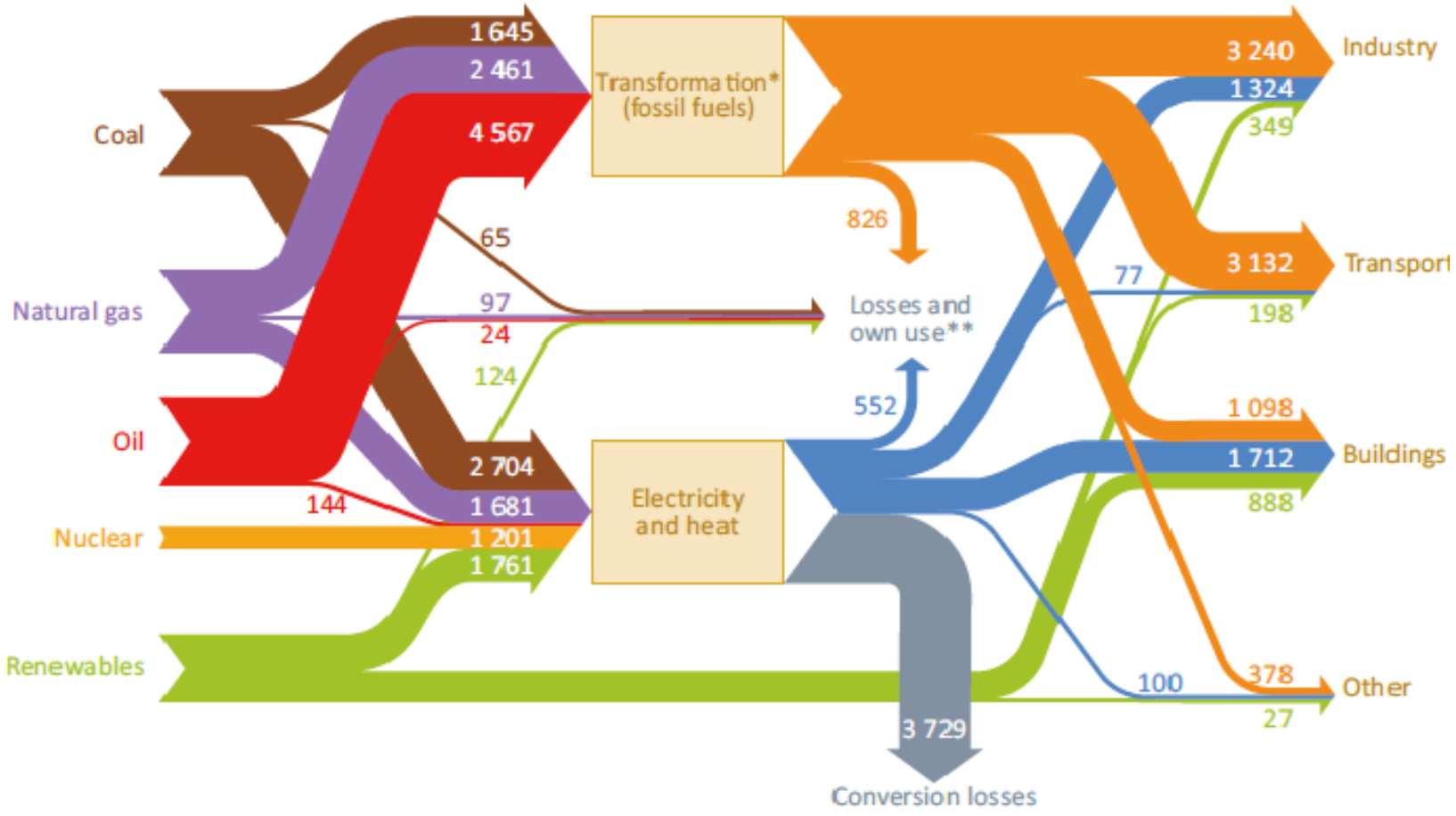
Energy System



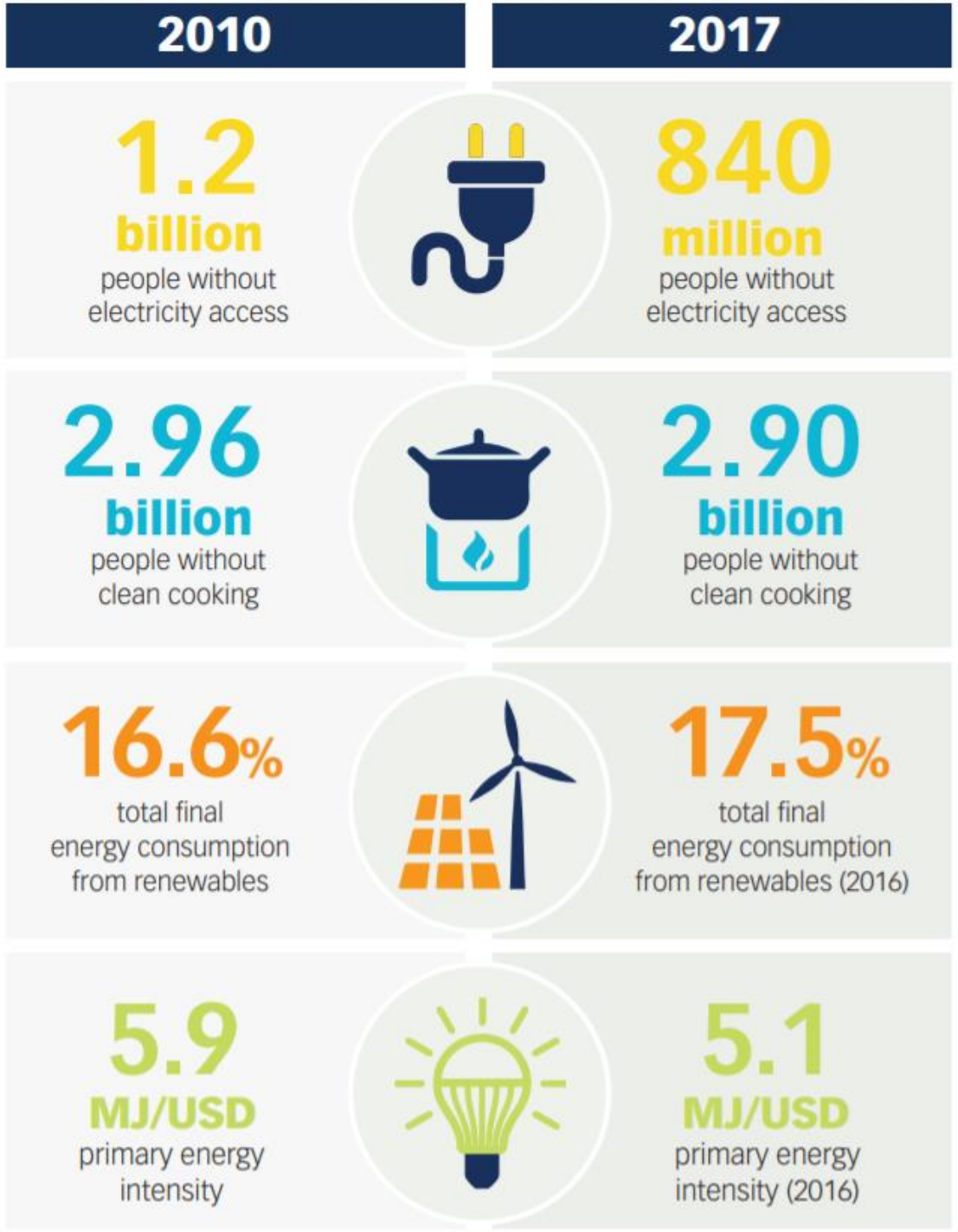
Energy Balance – example for 2040

Figure 2.11 ▷ World energy demand by fuel and sector in the New Policies Scenario, 2040 (Mtoe)



© OECD/IEA 2015 – World Energy Outlook 2015

What is Sustainable Energy?



https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/2019-Tracking-SDG7-Report.pdf

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Outline

- Historic trends in energy consumption & Energy access

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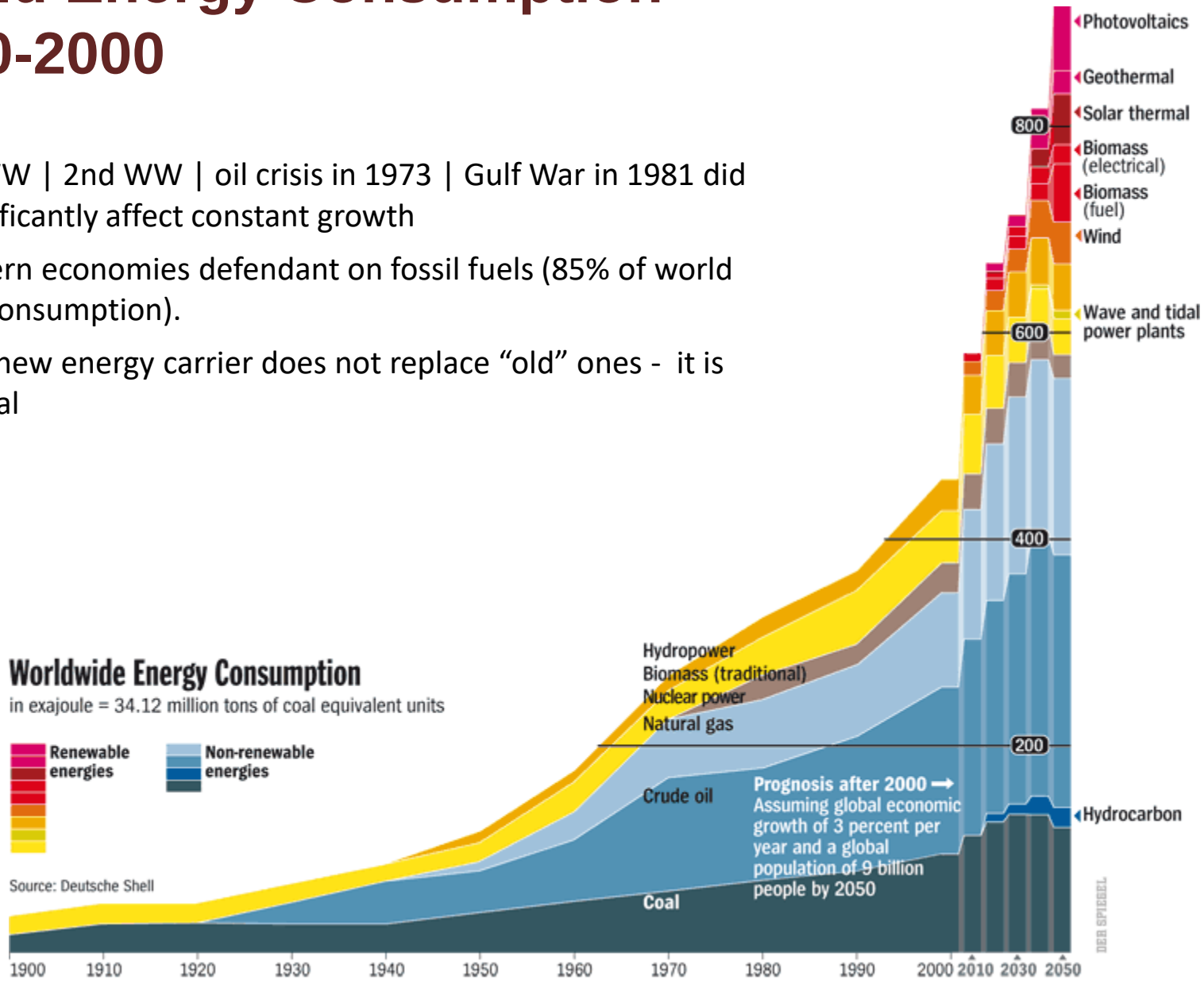
World Energy Consumption 1860-2000

→ 1st WW | 2nd WW | oil crisis in 1973 | Gulf War in 1981 did not significantly affect constant growth

→ Modern economies defendant on fossil fuels (85% of world energy consumption).

→ Each new energy carrier does not replace “old” ones - it is additional

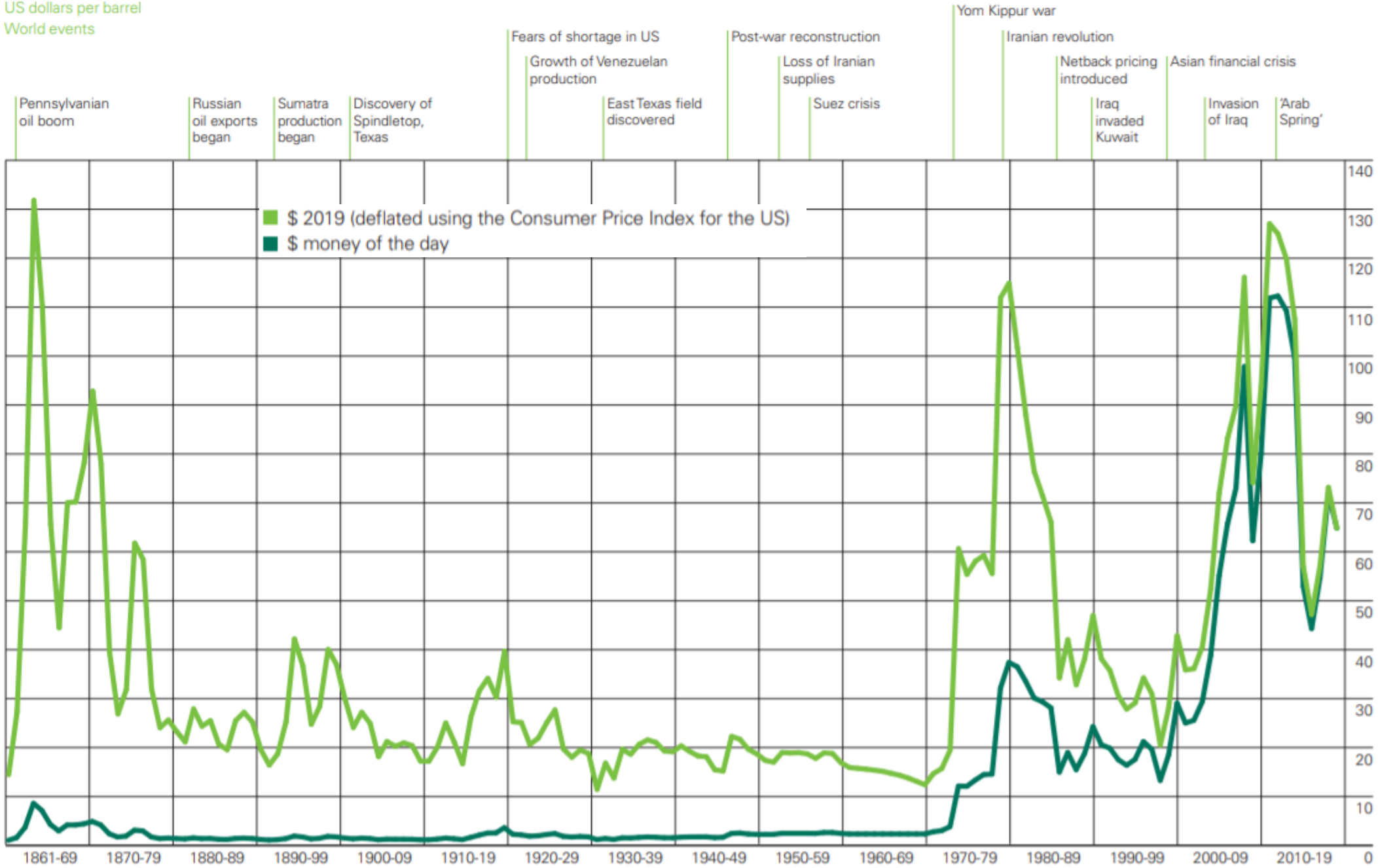


Fonte: Deutsche Shell

Crude oil prices 1861-2019

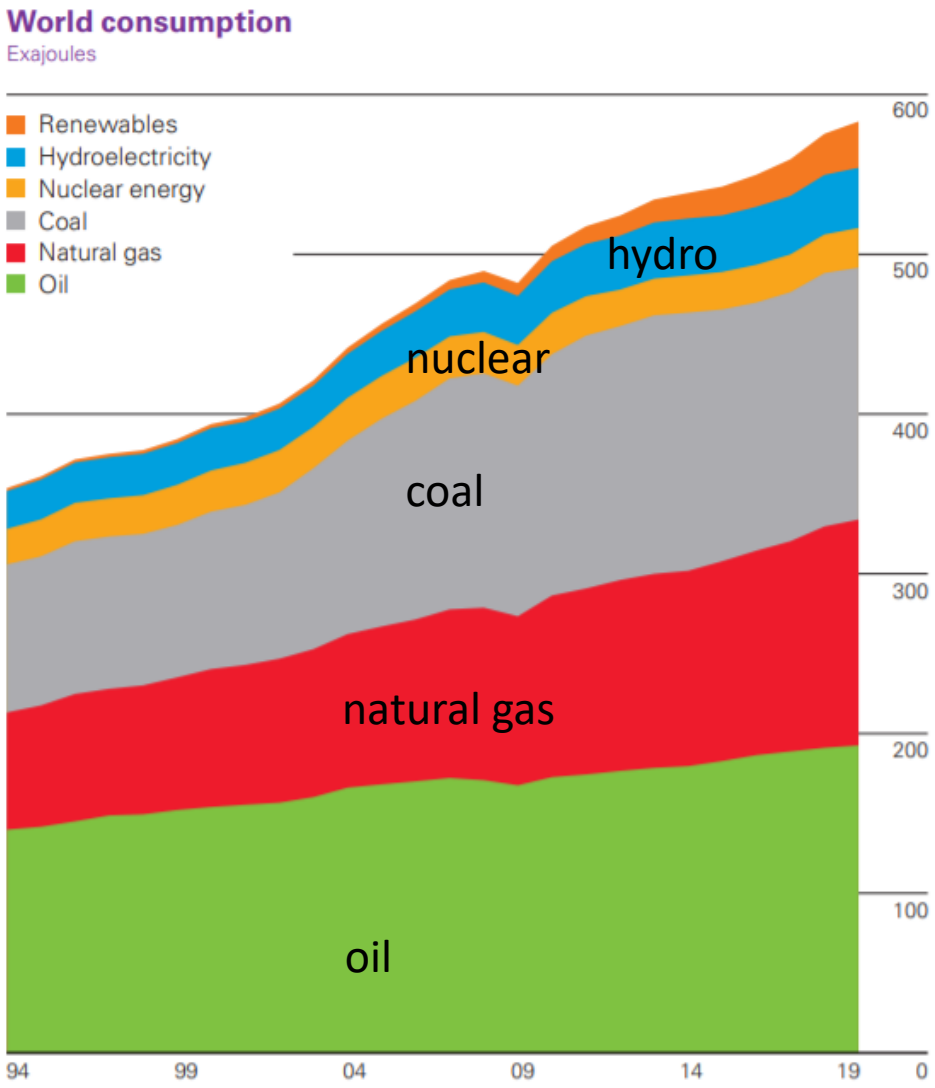
US dollars per barrel

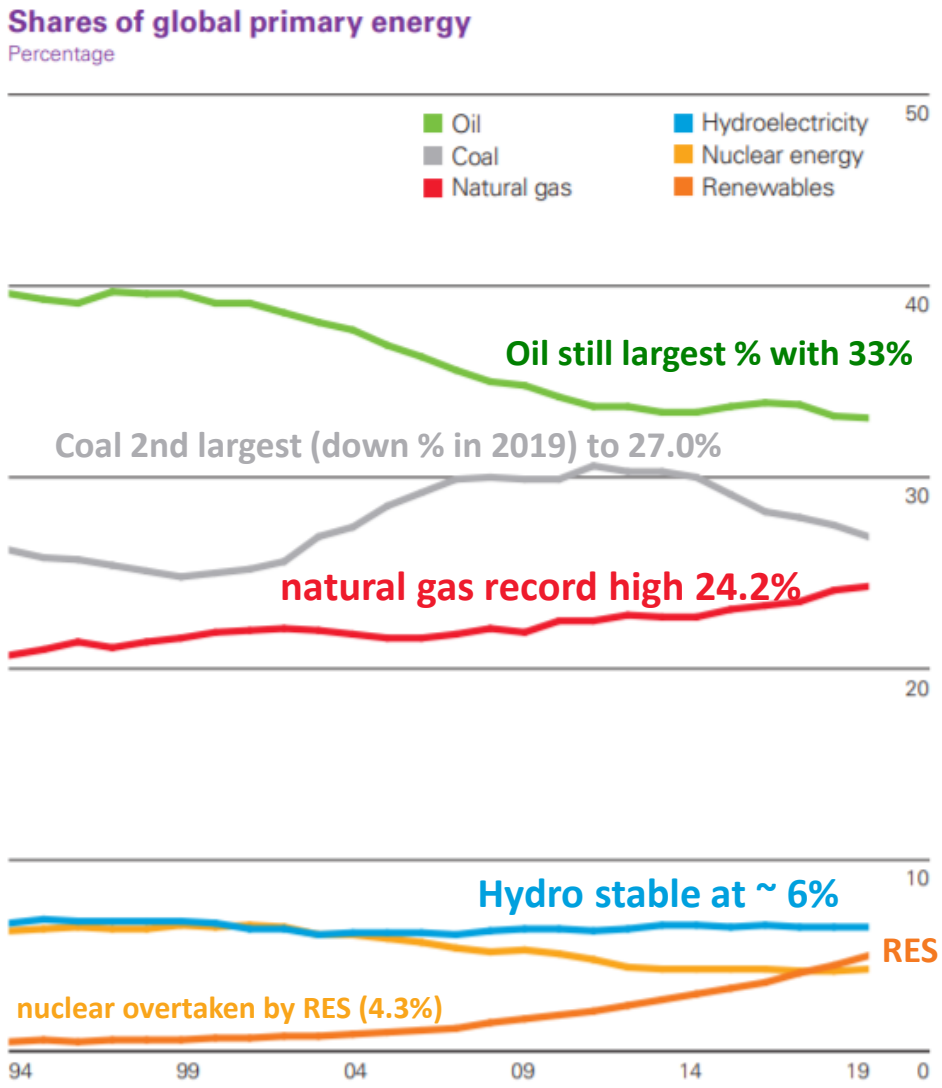
World events



BP Statistical Review of World Energy 2020, © BP p.l.c. 2020
https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf

Primary energy world consumption 1994-2020





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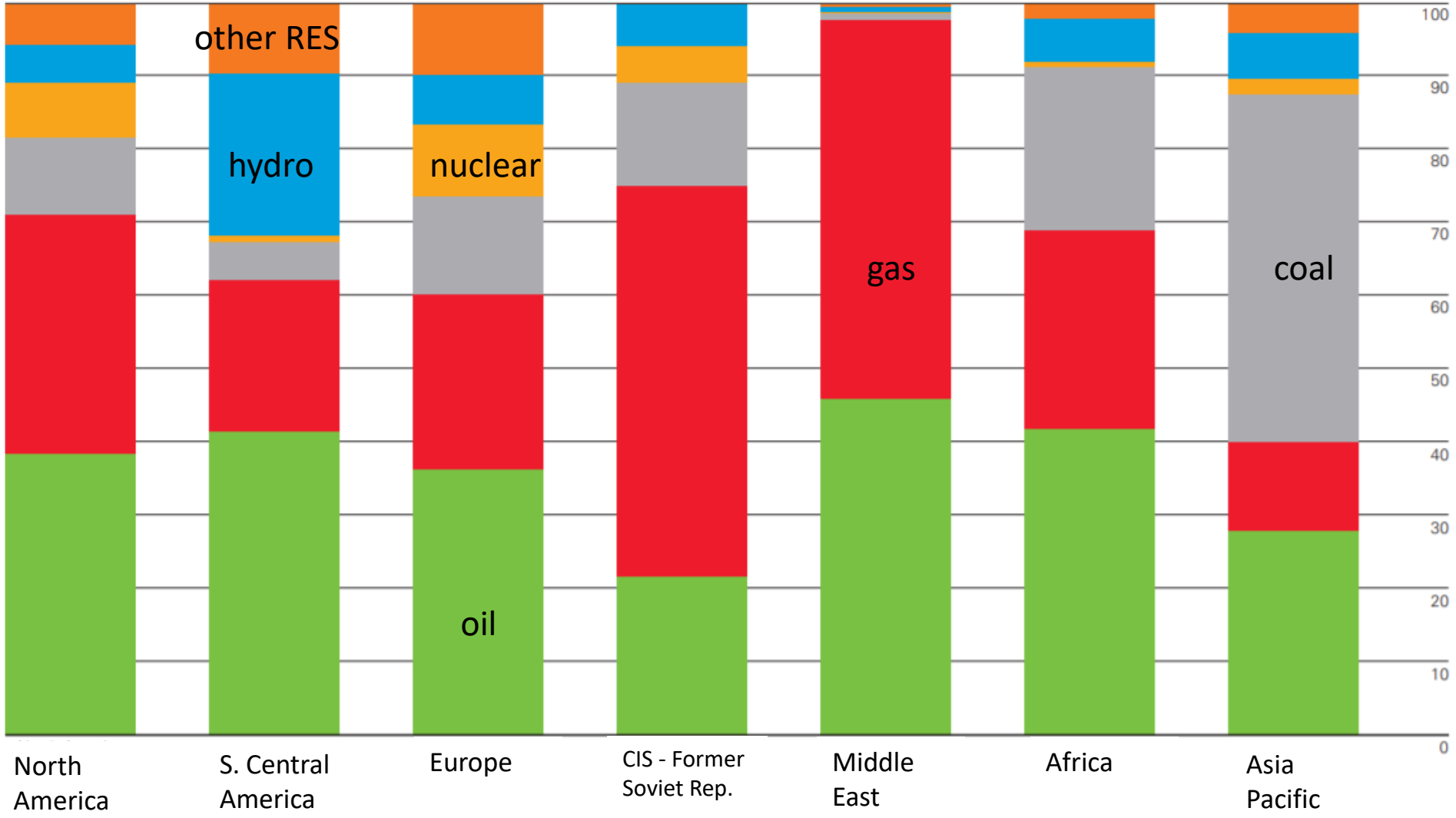
Primary energy regional consumption pattern 2020



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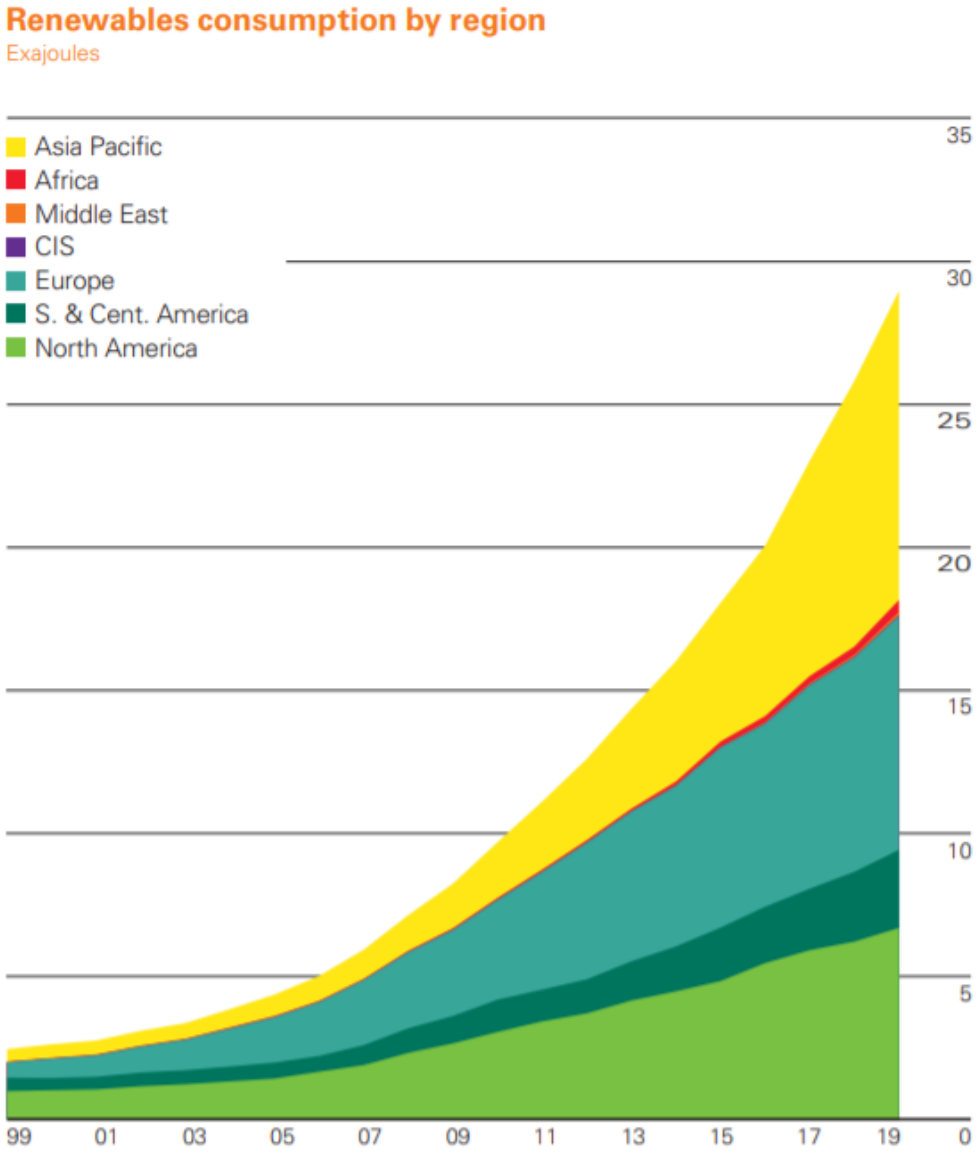
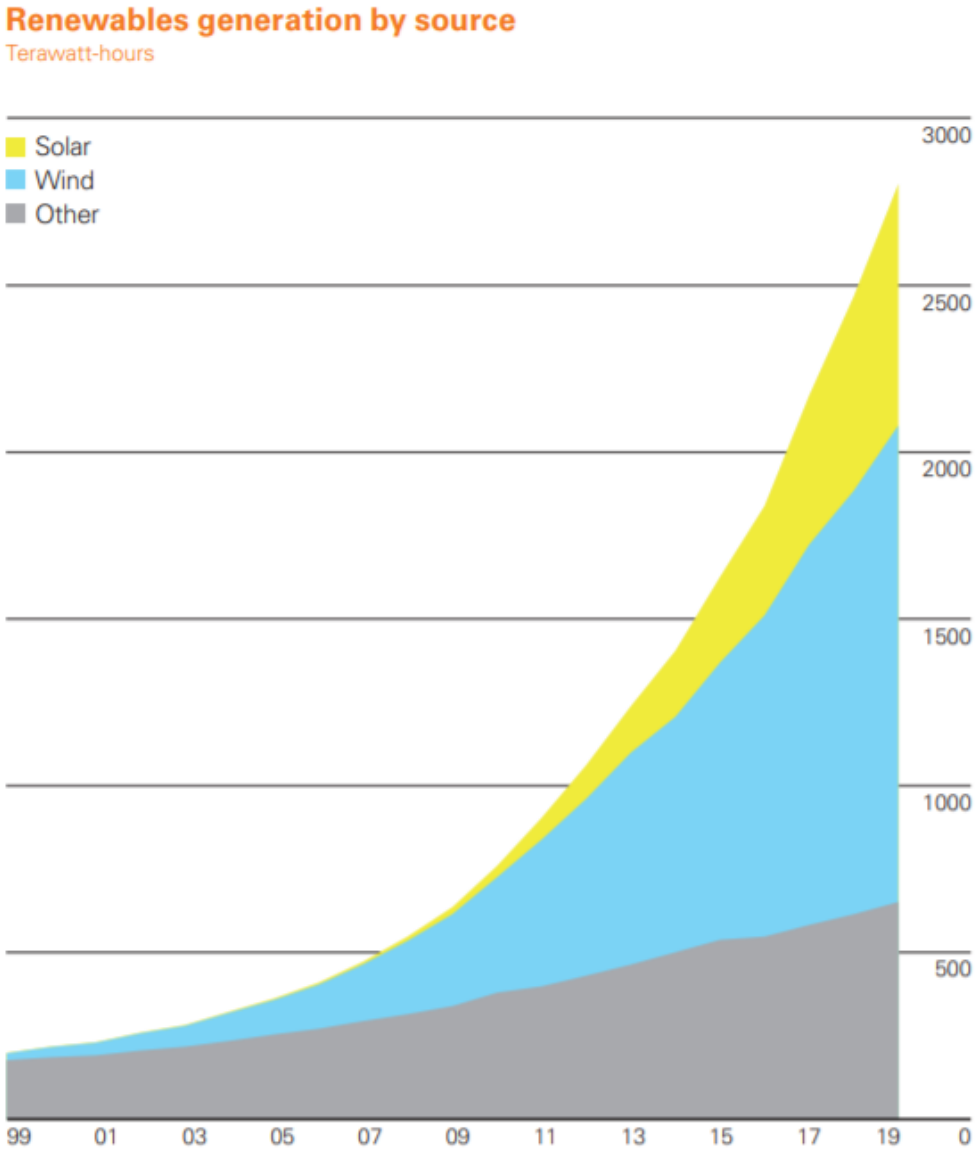
Global renewable energy evolution 1999-2020





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Primary energy consumption per capita 2014

Tonnes oil equivalent


Somewhere in Southern Europe

0-1.5
1.5-3.0
3.0-4.5
4.5-6.0
> 6.0

BP Statistical Review of World Energy 2015

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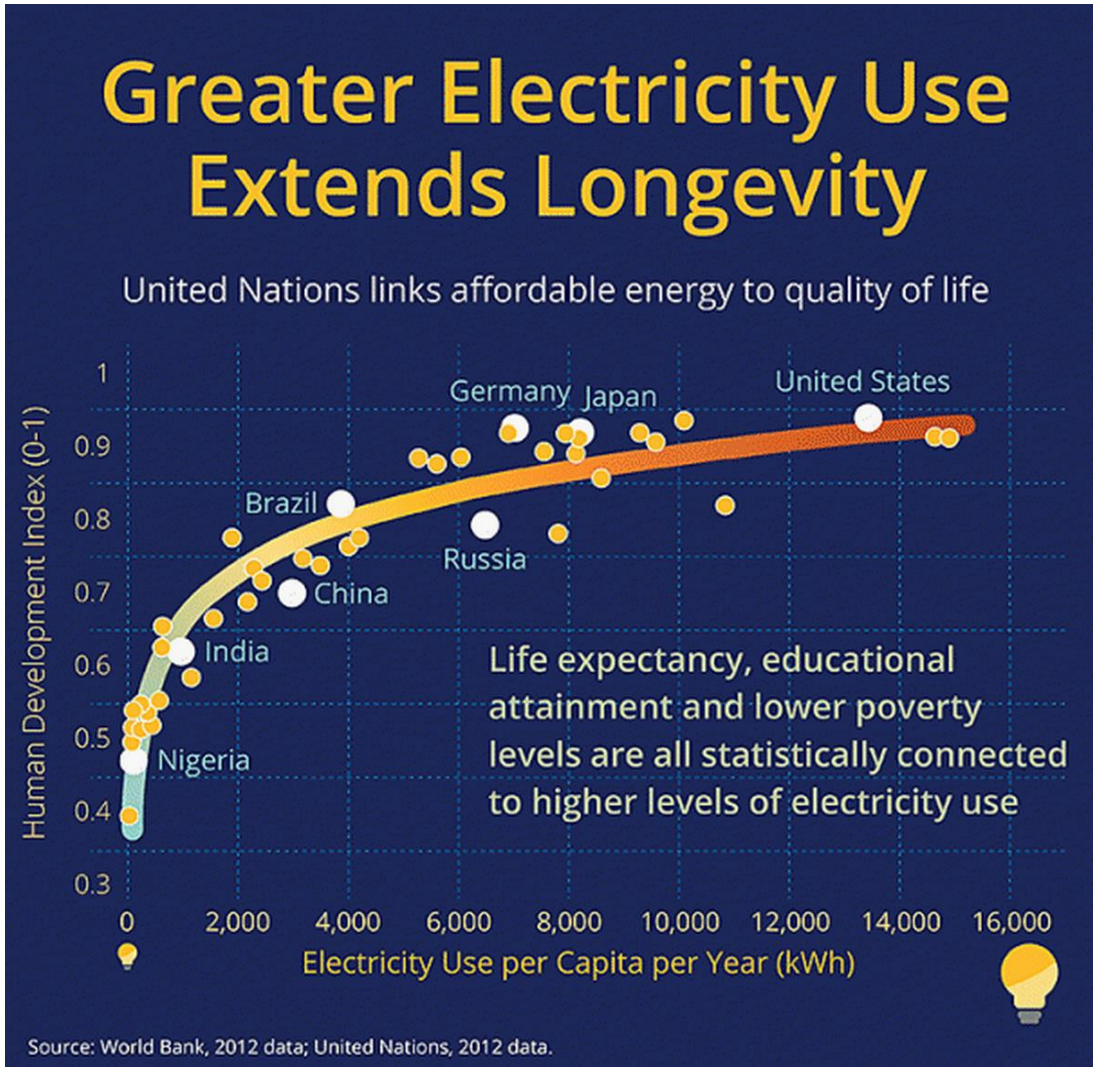
Energy Access



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Energy Access

How can we provide the benefits of energy to the population of the globe without damaging the environment, negatively affecting social stability, or threatening the well-being of future generations?

in Sustainable Energy, MIT 2005

One-Quarter of World's Population Lacks Electricity

Replacing wood and coal with electricity could help reduce poverty and pollution

By Nathanial Gronewold | November 24, 2009 | 1

The total number of individuals without electric power is put at about 1.5 billion, or a quarter of the world's population, concentrated mostly in Africa and southern Asia.

Ler o artigo em: http://www.scientificamerican.com/article.cfm?id=electricity-gap-developing-countries-energy-wood-charcoal

PRIMITIVE ENERGY: With no electricity, many people in Third World countries cook their food over wood fires. Image: ISTOCKPHOTO/DORINS

In 2018 it was "only" one-tenth of world's population lacking access to electricity

A woman dries cassava paste by a natural gas flare in Nigeria. Millions of people in Nigeria lack access to modern energy, even though the African nation is a major oil producer.

PHOTOGRAPH BY ED KASHI, NATIONAL GEOGRAPHIC

Energy Access

Source: IEA, *World Energy Outlook -2019*

Electricity Access, Summary by Region

	Proportion of the population with access to electricity						
	National					Urban	Rural
	2000	2005	2010	2015	2018	2018	2018
WORLD	**73%**	**77%**	**80%**	**85%**	**89%**	**96%**	**79%**
Developing Countries	**64%**	**69%**	**74%**	**80%**	**86%**	**95%**	**77%**
Africa	**36%**	**39%**	**43%**	**49%**	**54%**	**79%**	**35%**
North Africa	91%	96%	>99%	>99%	>99%	>99%	>99%
Sub-Saharan Africa	24%	28%	33%	40%	45%	74%	26%
Developing Asia	**67%**	**74%**	**79%**	**87%**	**94%**	**98%**	**91%**
China	99%	>99%	>99%	>99%	>99%	>99%	>99%
India	43%	58%	68%	79%	95%	>99%	92%
Indonesia	53%	56%	67%	88%	98%	>99%	96%
Other Southeast Asia	65%	76%	79%	85%	90%	97%	83%
Other Developing Asia	38%	46%	57%	74%	79%	89%	73%
Central and South America	**88%**	**91%**	**94%**	**96%**	**97%**	**99%**	**88%**
Middle East	**91%**	**90%**	**91%**	**92%**	**93%**	**98%**	**78%**

- **89% world population has access to electricity (only 45% of Sub-Saharan African population)**
- **huge difference in rural *vs* urban**
- **very quickly improving but mostly due to India**

IEA (2019), SDG7: Data and Projections, IEA, Paris
https://www.iea.org/reports/sdg7-data-and-projections

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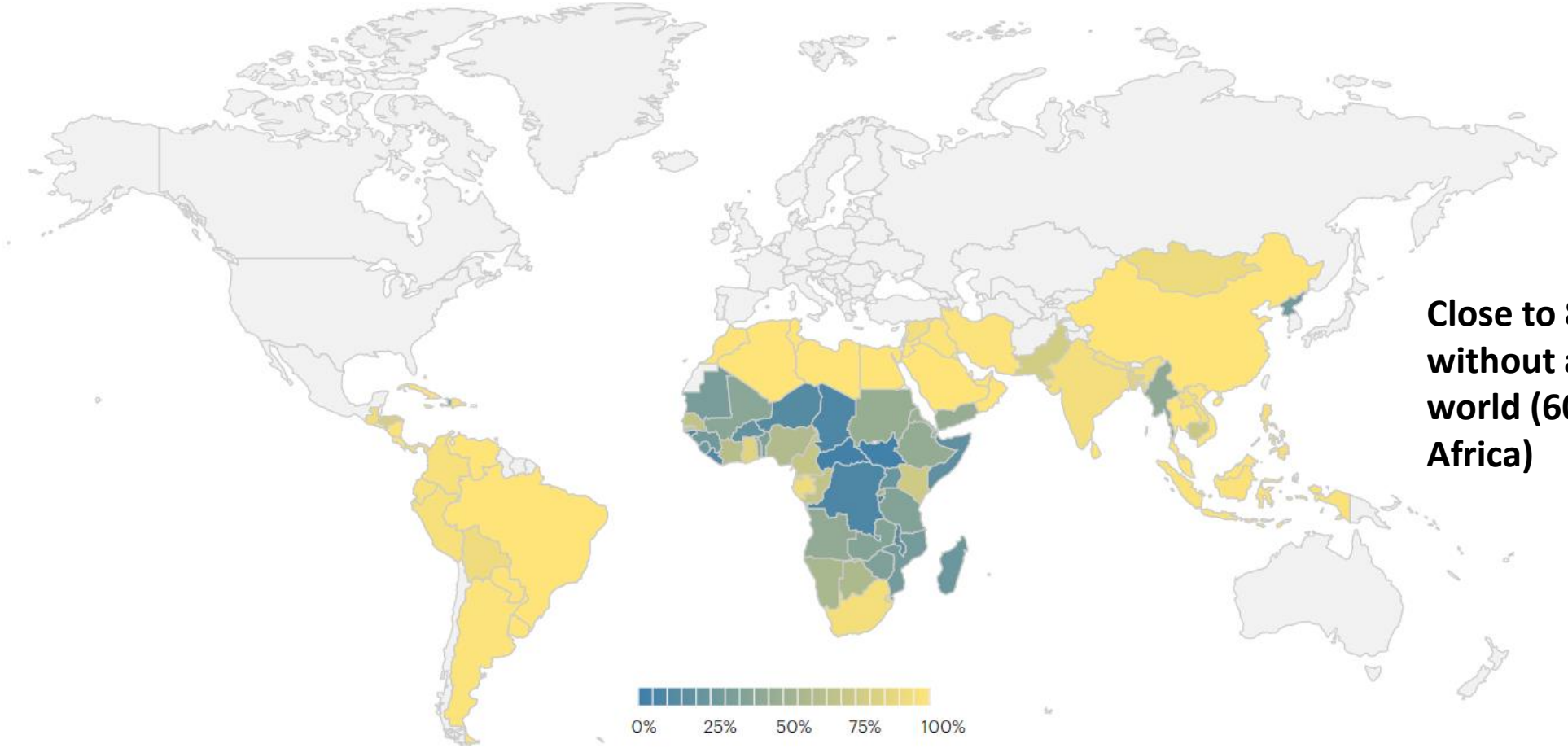
Energy access in south hemisphere

% of population with access to electricity



Close to 860 million people are still without access to electricity in the world (600 million in sub-Saharan Africa)

Most access gained in Ethiopia, Kenya and Tanzania mainly via grid connections & via solar home systems – countries with less access are Nigeria, DR Congo, Ethiopia, Tanzania and Uganda

IEA (2019), SDG7: Data and Projections, IEA, Paris
https://www.iea.org/reports/sdg7-data-and-projections

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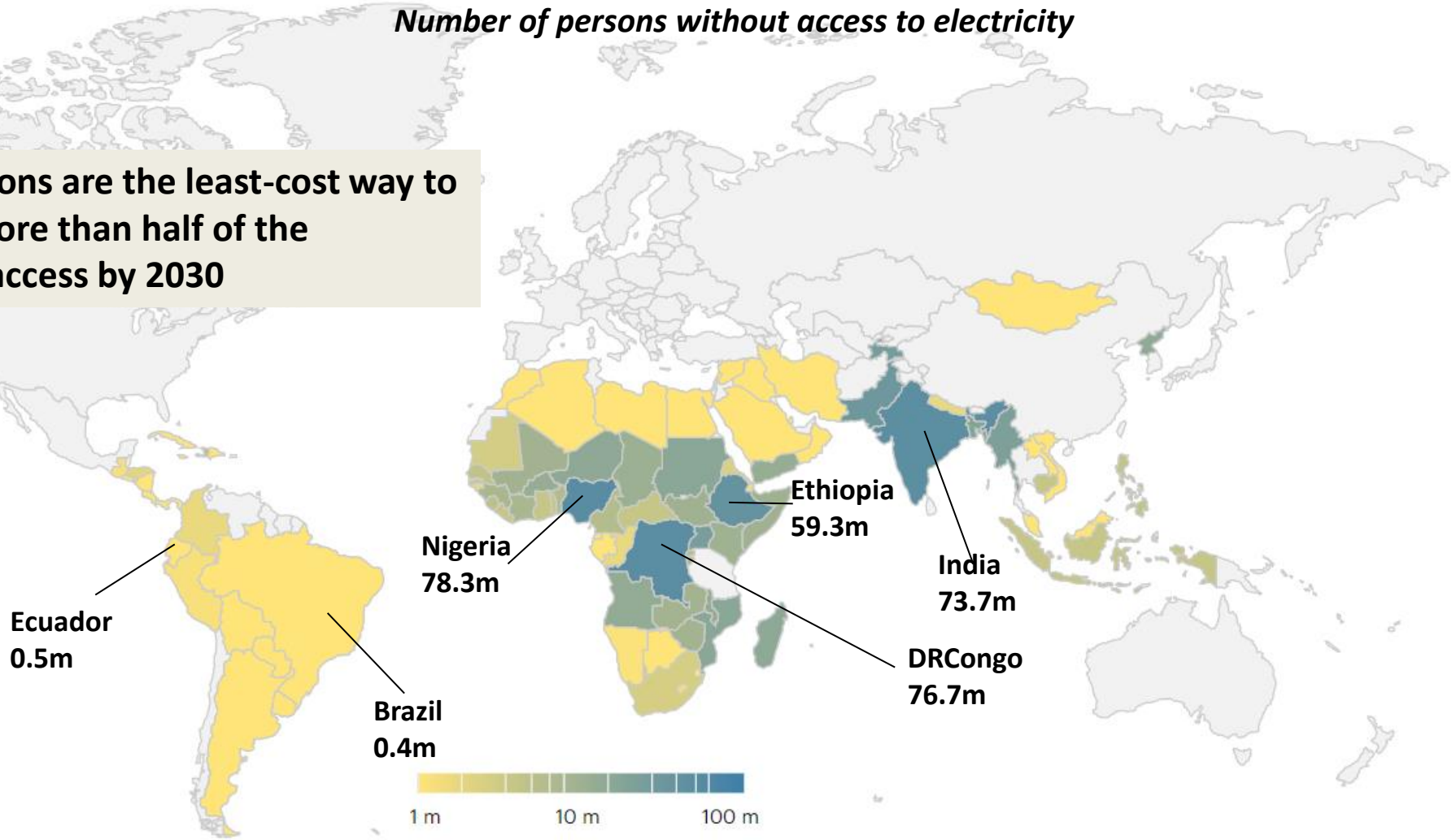
Energy access in south hemisphere

Decentralised solutions are the least-cost way to provide power to more than half of the population gaining access by 2030



IEA (2019), SDG7: Data and Projections, IEA, Paris
https://www.iea.org/reports/sdg7-data-and-projections

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Hands-on!

Fast facts

17%
of global population lack access to electricity, despite modest improvements

38%
of global population lack clean cooking facilities

International Energy Agency
Secure Sustainable Together

Go to https://trackingsdg7.esmap.org/
Pick a country and report back:
- % population access to electricity
- % population access to modern cooking

YOU HAVE 5 MINUTES

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Energy Access

IRENA
International Renewable Energy Agency

ABOUT OUR WORK RENEWABLES NEWSROOM

More People Have Access to Electricity, but World Is Falling Short of Sustainable Energy Goals

22 May 2019 | Press Release

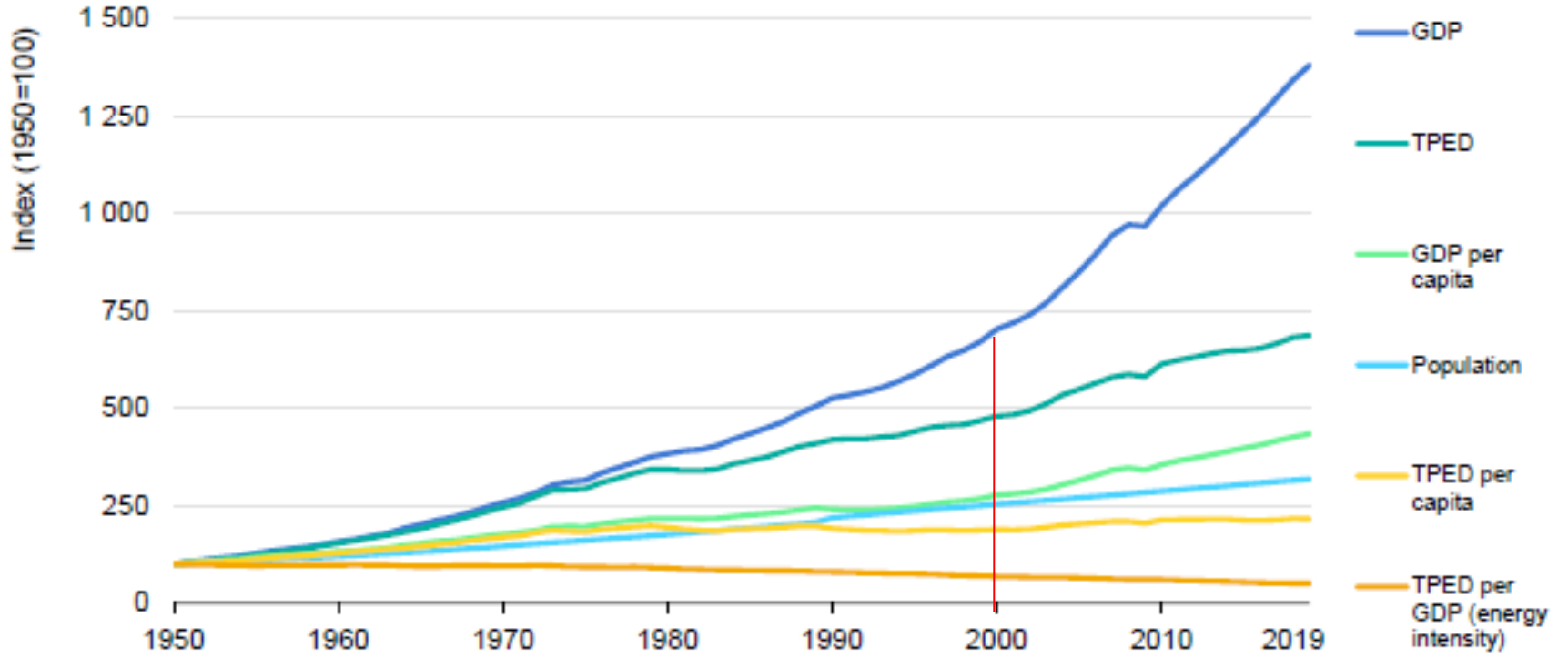
https://www.irena.org/newsroom/pressreleases/2019/May/More-People-Have-Access-to-Electricity-Than-Ever-Before

Evolution of primary energy and GDP

Since 2000, energy intensity (energy consumption per unit of GDP) has been declining.

"Today, the world needs 20% less energy to produce one dollar of economic output than it did only 19 years ago"

Figure 1.1 Global total primary energy demand, population and GDP, 1950-2019



IEA 2020. All rights reserved.

Note: TPED = total primary energy demand.

Energy demand has historically been driven by GDP and population, reaching a sevenfold increase from 1950.

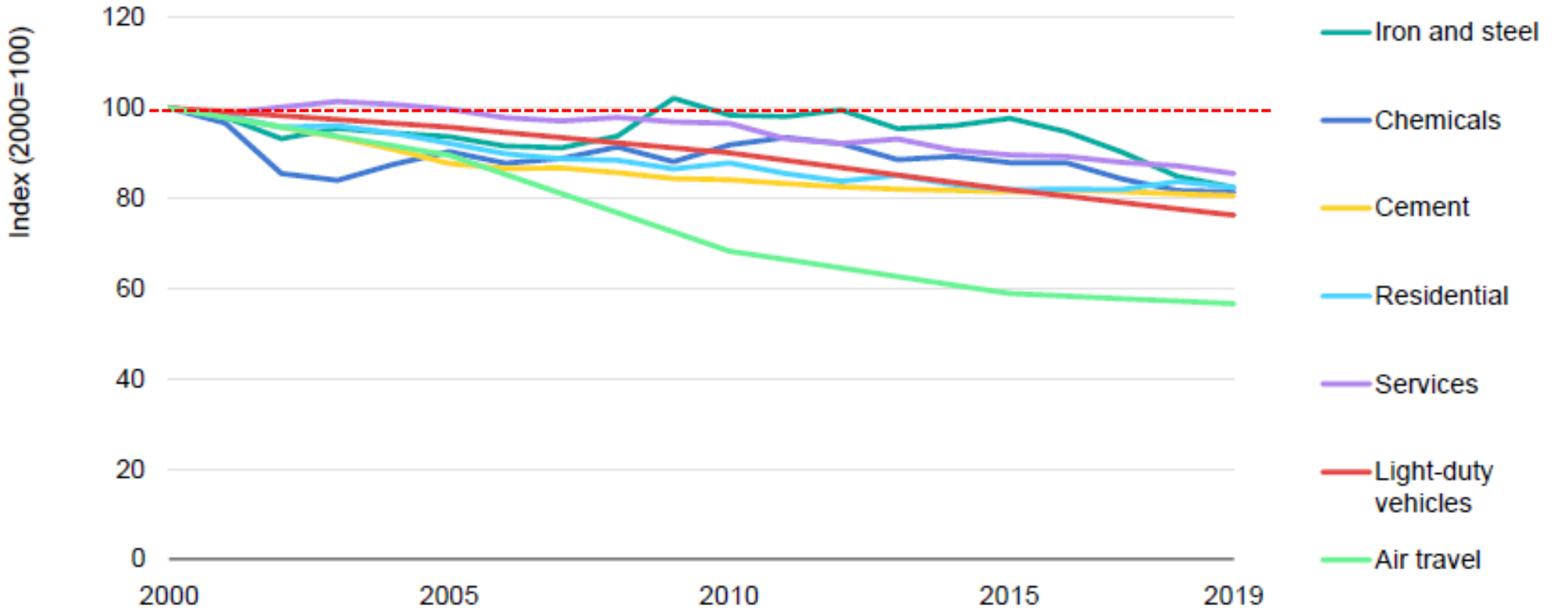
Energy Services drivers

Energy demand drivers for human consumption:

- Energy services: food, comfort, hygiene, health, culture
- Population and households
- Wealth
- Consumption profiles: preferences in expenditures with goods and services

Energy intensity everywhere (from 2000)

Figure 1.6 Global average energy intensity in selected end-use sectors, 2000-19



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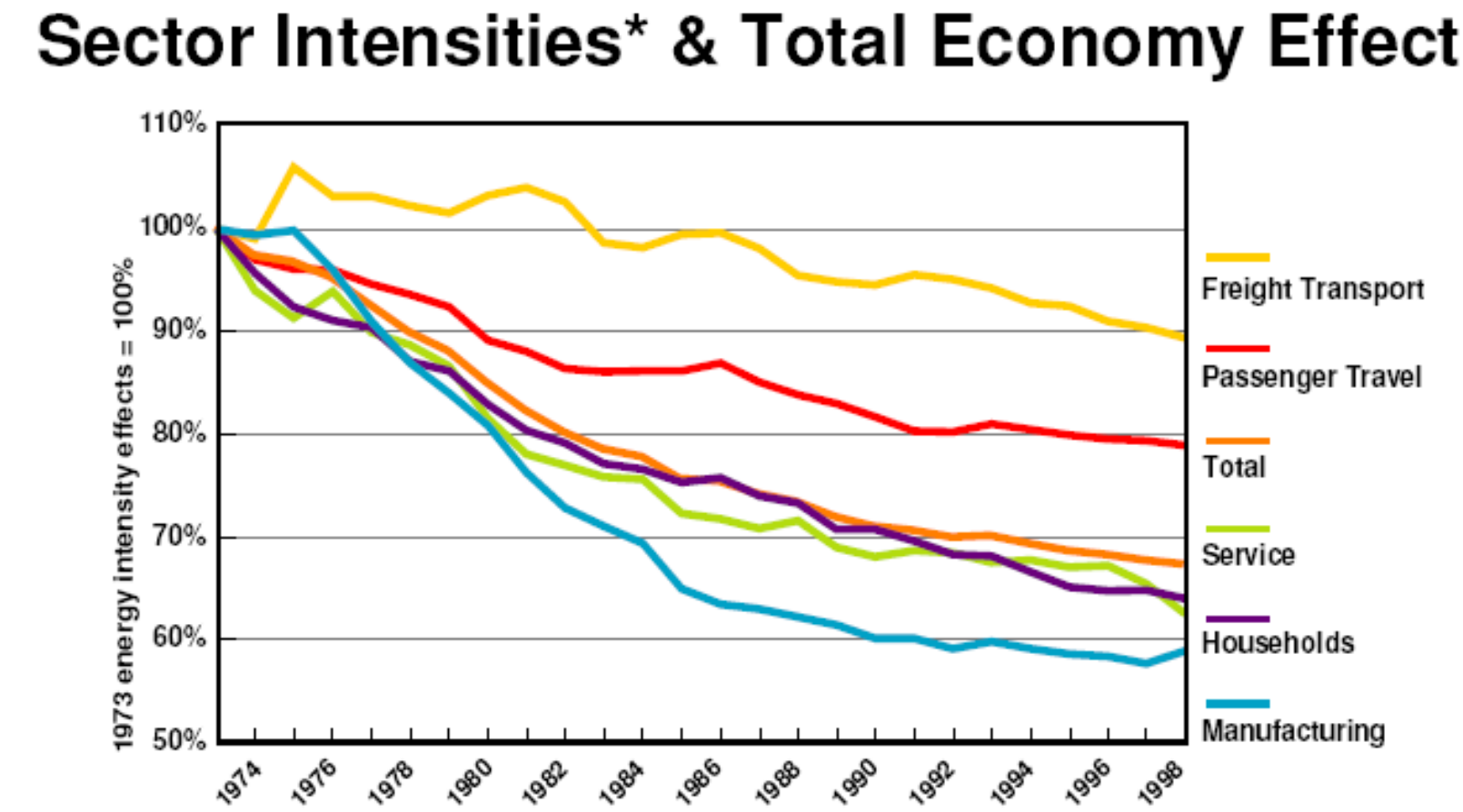
Energy intensity in wealthy countries



Energy intensity declines have slowed in all sectors since the late 1980s

*Note: Data for IEA-11 (Australia, Denmark, Finland, France, Germany, Italy, Japan, Norway, Sweden, the United Kingdom and the United States)

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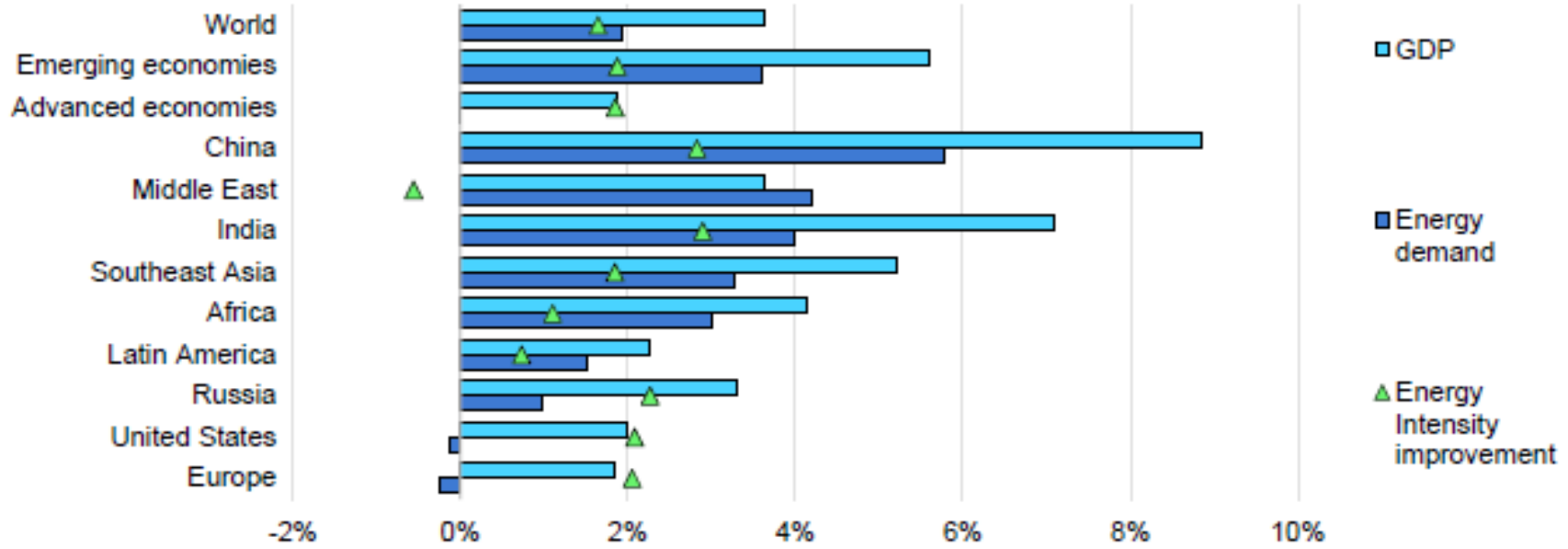
Energy intensity in all countries

Figure 1.2 Annual change in GDP, total primary energy demand and energy intensity in selected countries/regions, 2000-19



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Note: Energy intensity is measured as total primary energy demand per unit of GDP. GDP is measured in PPP terms.

Energy intensity of the global economy improved on average by 1.6% per year due to structural changes, saturation effects and efficiency gains.

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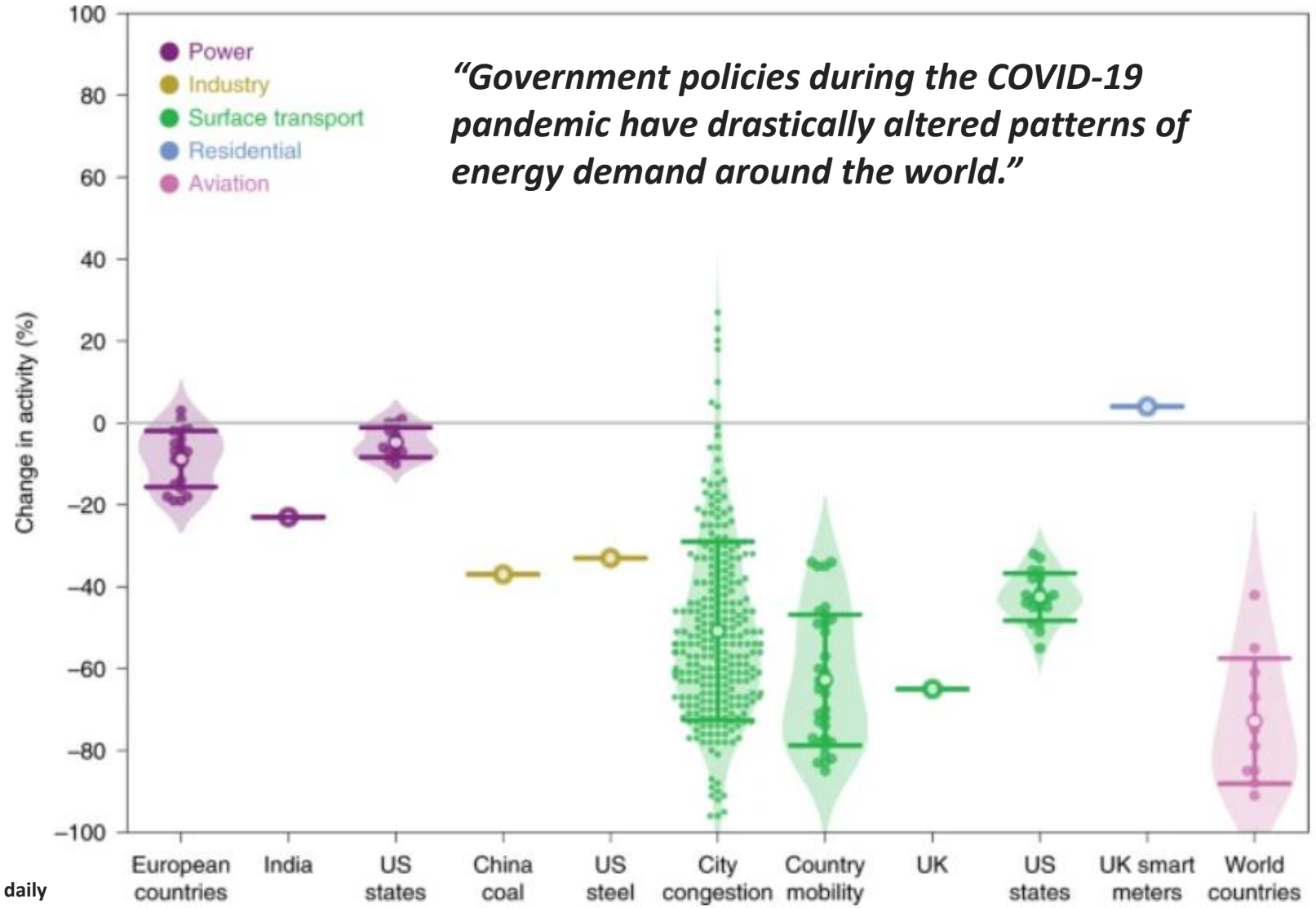
Change in activity by sector during COVID-19 confinement (%)



"Government policies during the COVID-19 pandemic have drastically altered patterns of energy demand around the world."

"The data includes: for the power sector, temperature-adjusted electricity trends in Europe[10], India[38] and the US[11]; for the industry sector, coal use in industry in China[22] and US steel production[39]; for the surface transport sector, city congestion[40], country mobility[41], UK[42] and US state[43] traffic data; for the residential sector, UK smart meter data[44]; and for aviation, aircraft departures[45].
Each data point (filled circles) represents the analysis of a full time series and shows the changes in activity compared to typical activity levels prior to COVID-19, corrected for seasonal and weekly biases. "

Le Quéré, C., Jackson, R.B., Jones, M.W. *et al.* **Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement**. *Nat. Clim. Chang.* **10,** 647–653 (2020). https://doi.org/10.1038/s41558-020-0797-x

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Hands on!

- https://ourworldindata.org/energy
- Check your country primary energy consumption
- Check your country energy intensity evolution

Do it for next class

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Key information you should have apprehended after the class

- Differences between primary energy, final energy and useful energy
- What are energy services
- Main energy units for energy flows
- Main energy units for installed capacity of power plants
- Going from installed capacity to generated electricity
- What is a capacity factor for a power plant and why is it important for solar PV and wind
- What is the “energy system”
- How to read an energy balance
- Grab how multidimensional and systemic is the transition to a low-carbon economy (and energy system)