



# CZ-AT WINTER-SUMMER SCHOOL 2025

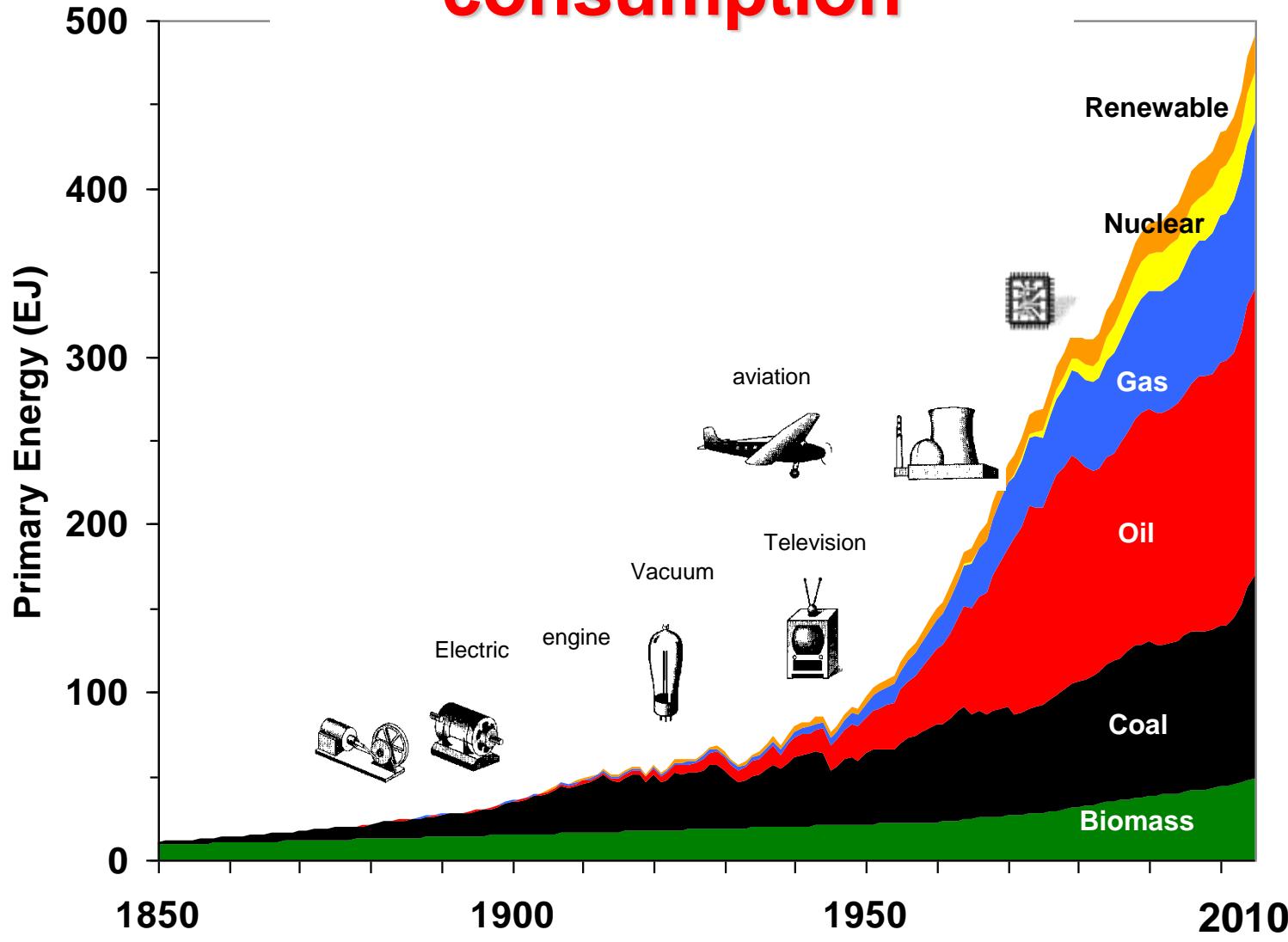
# THE WORLD ENERGY SYSTEM

## – AN INTRODUCTION

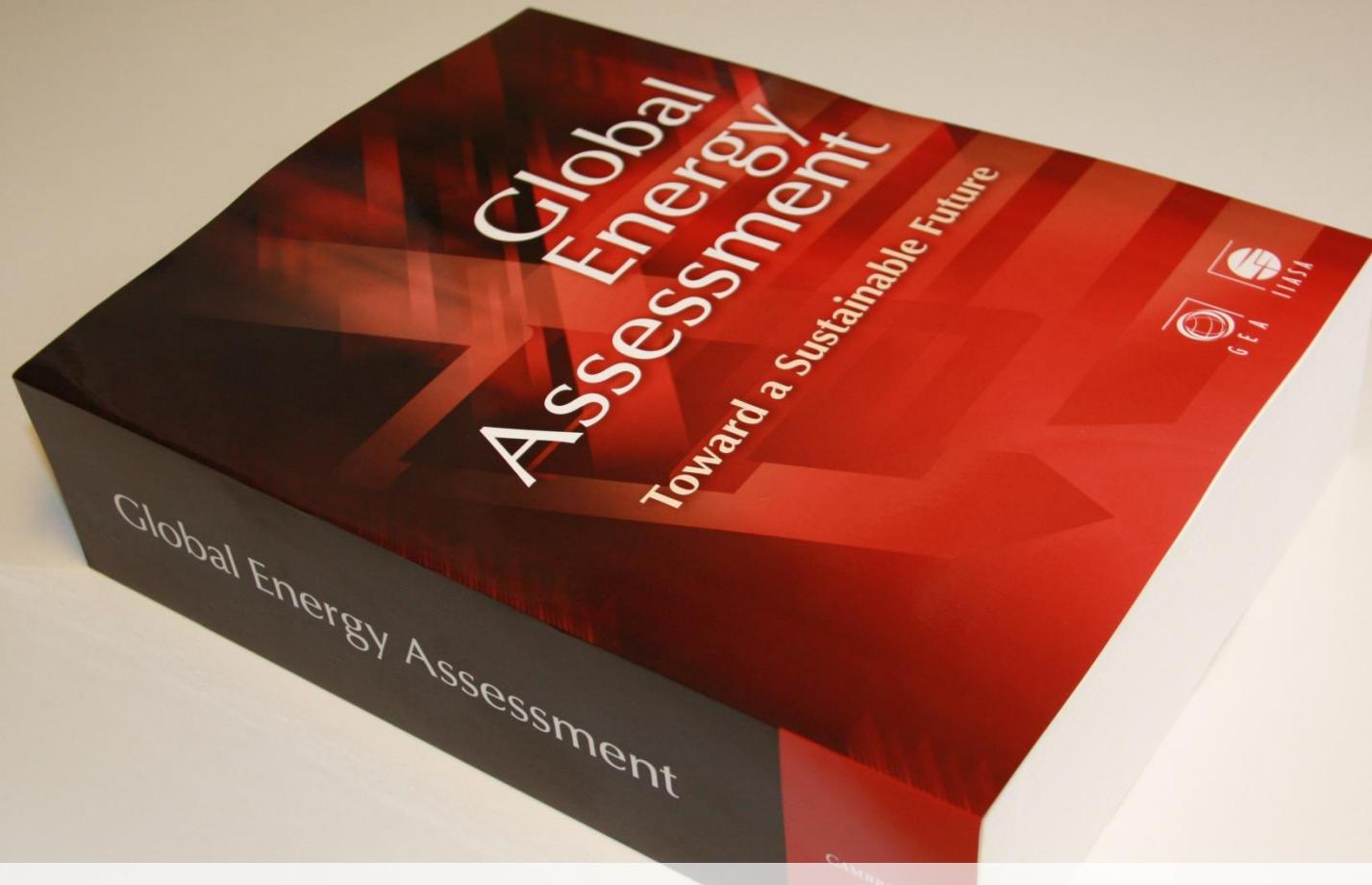
Reinhard Haas  
Amela Ajanovic

Energy Economics Group (EEG), TU Wien

# World Primary Energy consumption

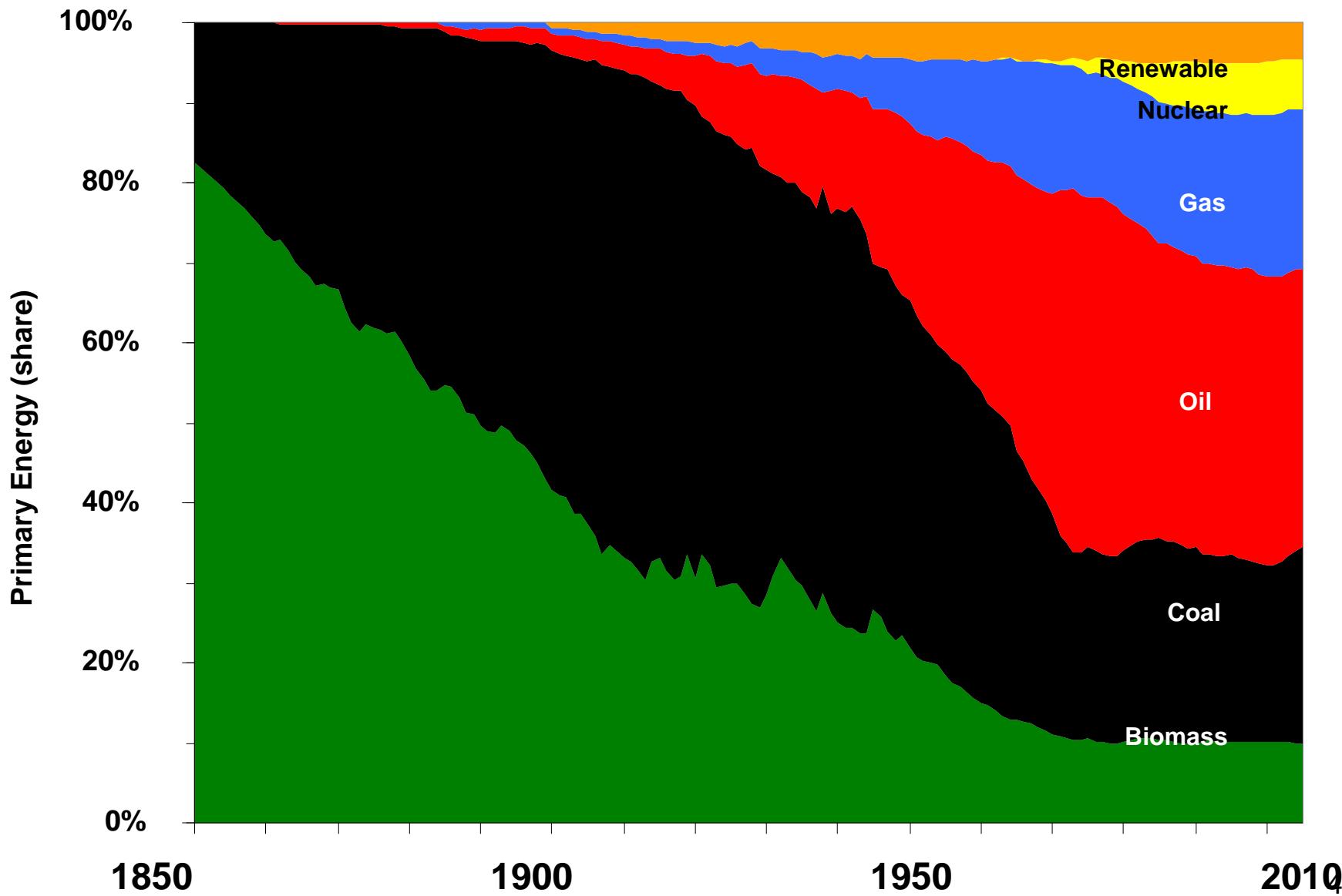


Source: GEA (2012)

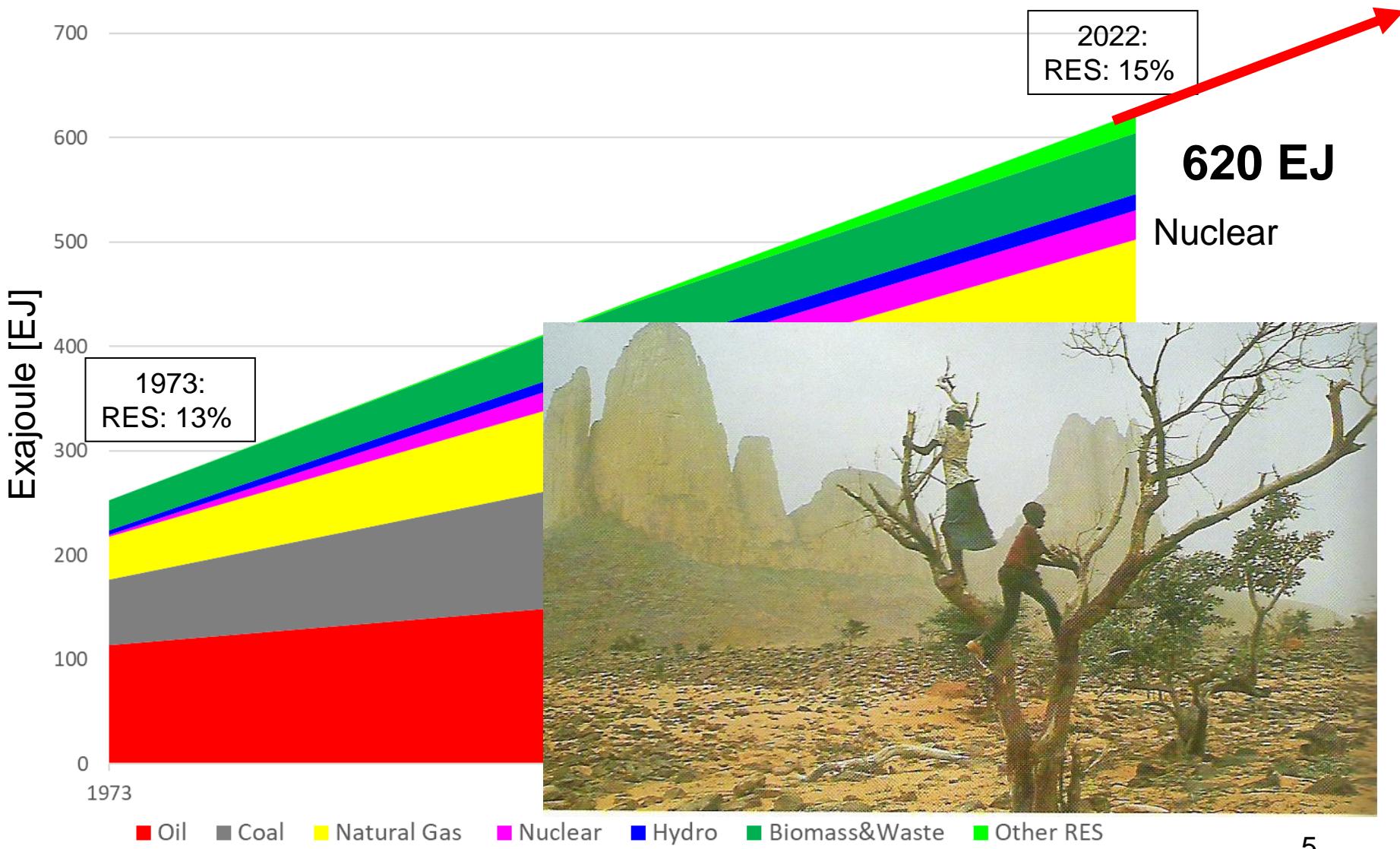


- **Total Effort: 300 Authors; 200 Reviewers  
> 6 years >> 6m € and >> 100 p-years**

# Shares of PE world-wide



# WORLD-WIDE TREND IN PRIMARY ENERGY



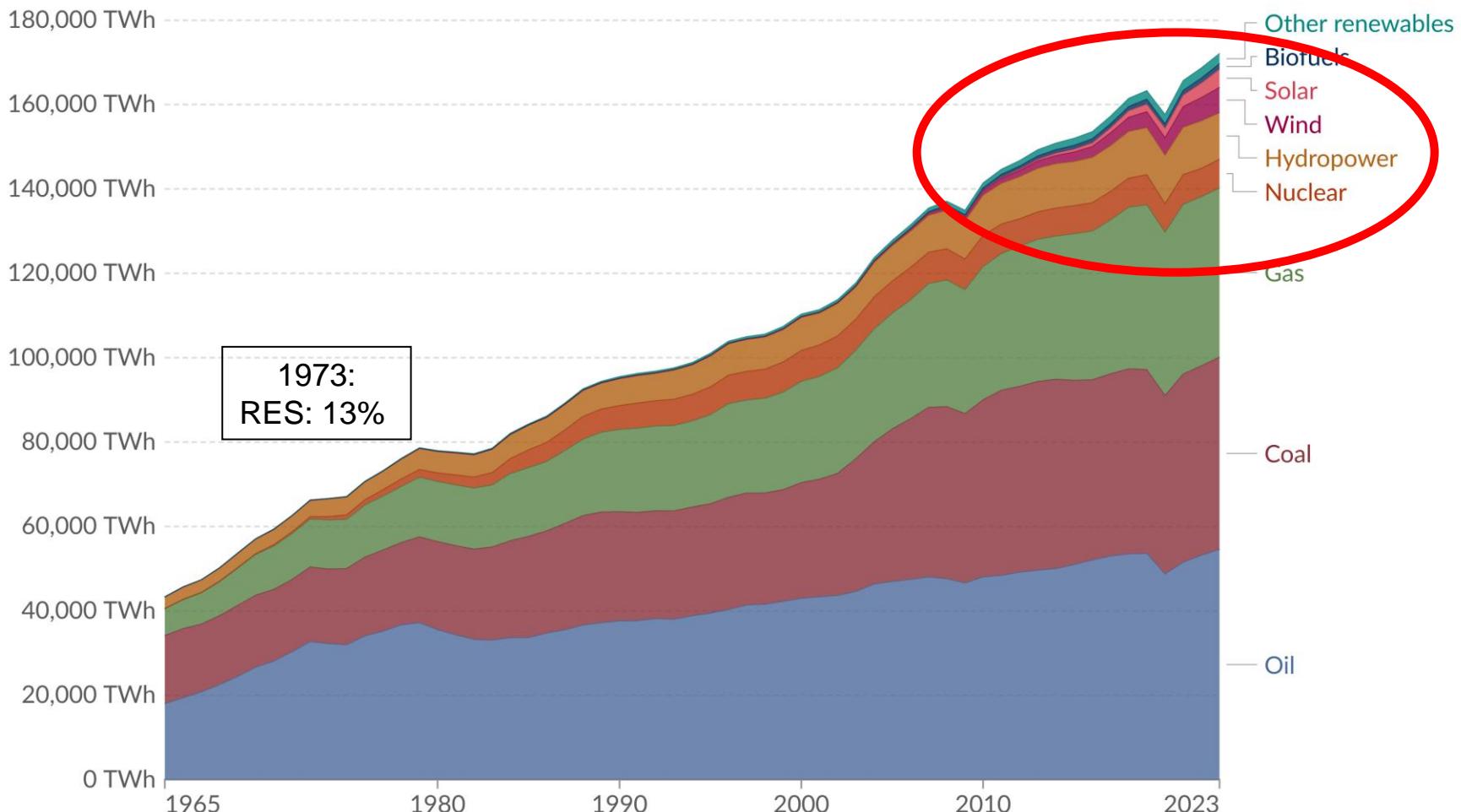
# WORLD-WIDE TREND IN PRIMARY ENERGY

## Energy consumption by source, world

Measured in terms of primary energy<sup>1</sup> using the substitution method<sup>2</sup>.

2023:  
RES: 21%

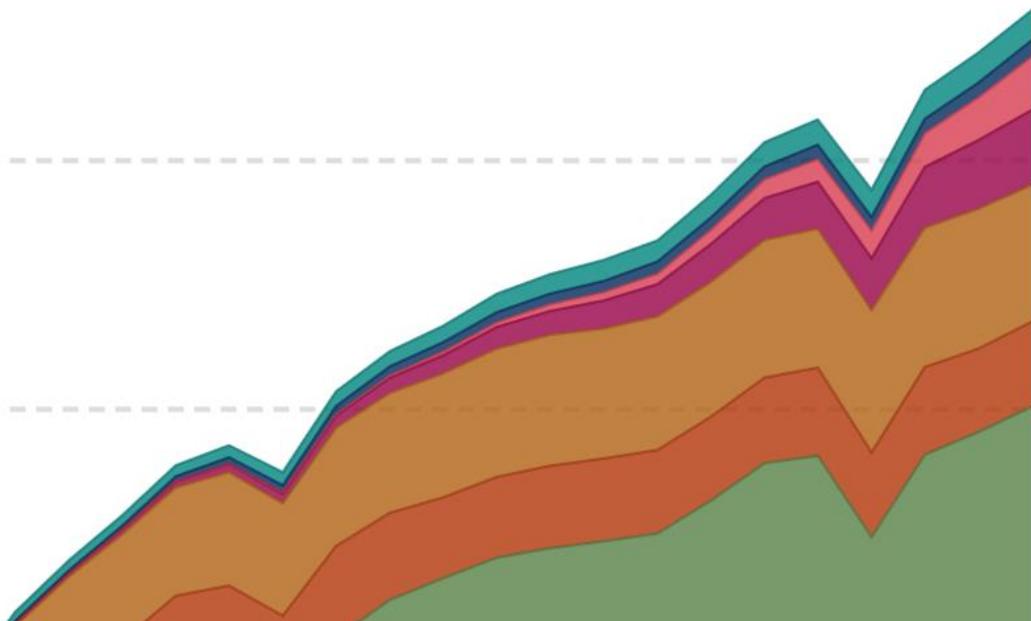
Our World  
in Data



Data source: Energy Institute - Statistical Review of World Energy (2024)

Note: "Other renewables" include geothermal, biomass, and waste energy.

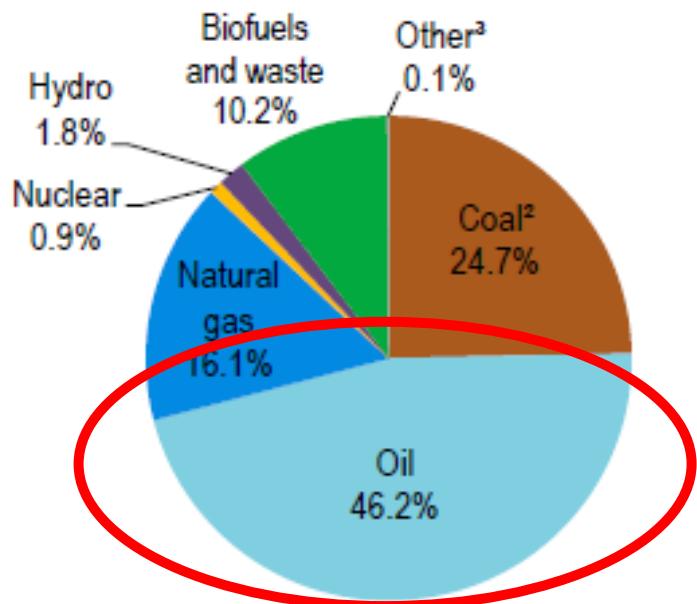
OurWorldinData.org/energy | CC BY



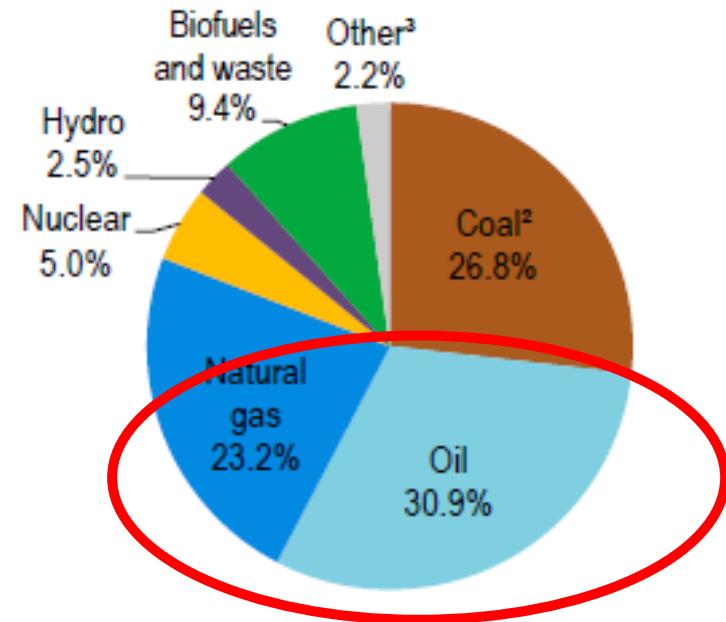
- Other renewables
- Biofuels
- Solar
- Wind
- Hydropower
- Nuclear

# World: Primary energy

1973



2021



254 EJ

618 EJ

- *Total primary energy demand more than doubled between 1973 and 2021;*
- *Share Oil down (more than -30%!), Gas up, Coal up!*

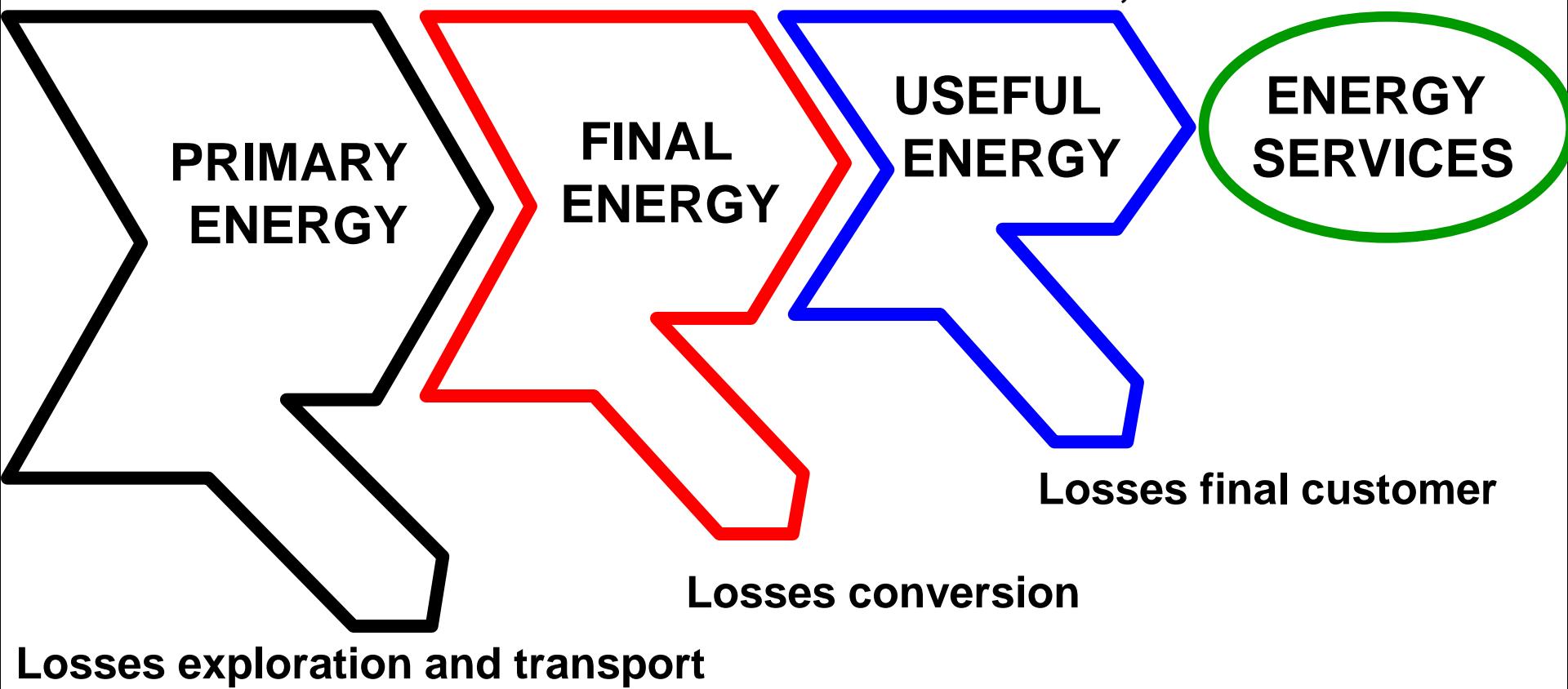
## Categories of energy:

Crude oil, wood,  
coal, natural gas,  
solar, hydro, nuclear

Gasoline,  
electricity,  
pellets, district heat

Heat, light,  
mechanical  
work,

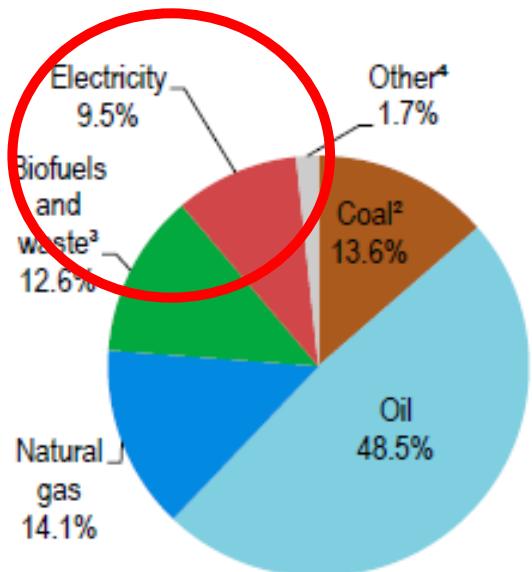
Warm and bright  
rooms, mobility  
....



# World: Final energy

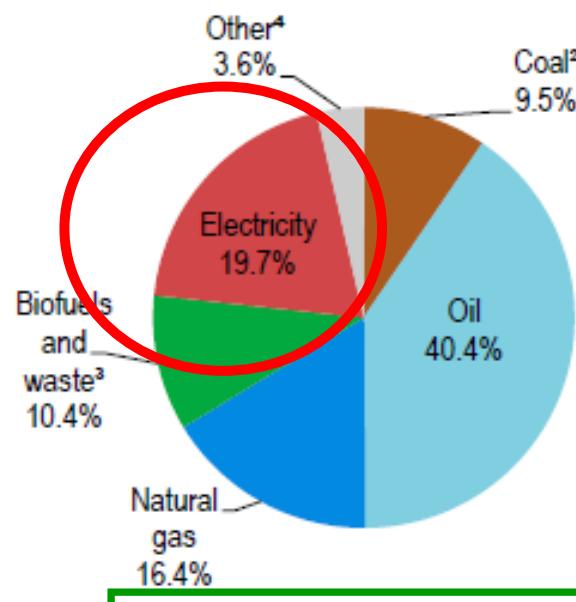
Share of world total final consumption by source, 1973 and 2021

1973



194 EJ

2021



418 EJ

- The **share of electricity increases continuously:**  
In 2021 twice of 1973
  - **Share of oil decreased from 48% to 40%**

\*\* Other includes Solar, Geothermal, Wind

**LIMITED  
RESOURCES:**  
Renewable,  
Fossile,  
nuclear,

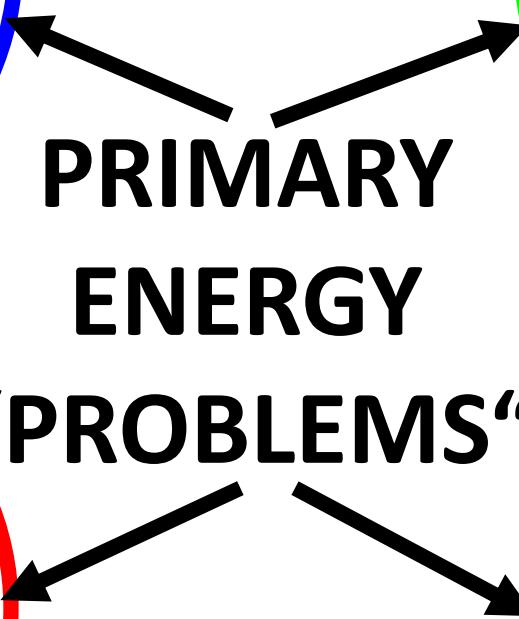
**ENVIRONM.  
EXTERNALI-  
TIES (CO<sub>2</sub>,  
SO<sub>2</sub> radiation)**

**PRIMARY  
ENERGY**

**“PROBLEMS”**

**SOCIAL:  
UNEVEN  
CONSUMP-  
TION**

**SUPPLY  
SECURITY:  
NATURAL  
GAS, OIL**



# The Key Energy Challenges



**Energy  
Access**



**Climate Change**



**Energy  
Security**



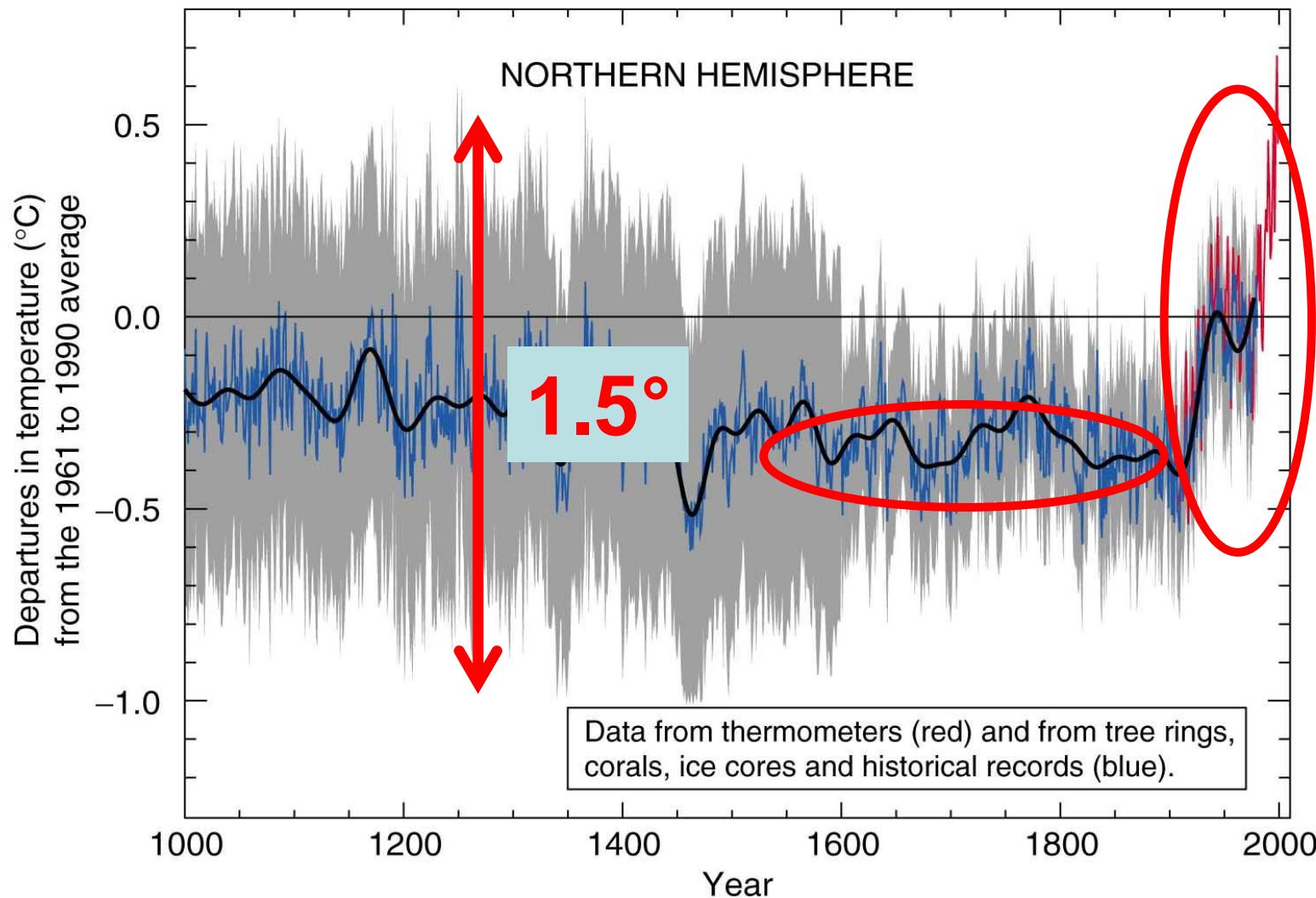
**Air Pollution  
Health Impacts**

# Wood for Cooking



Source: Modi, 2011 and Yumkella, 2013

# Long-term Variations of Earth's Surface temperature in the past 1000 years

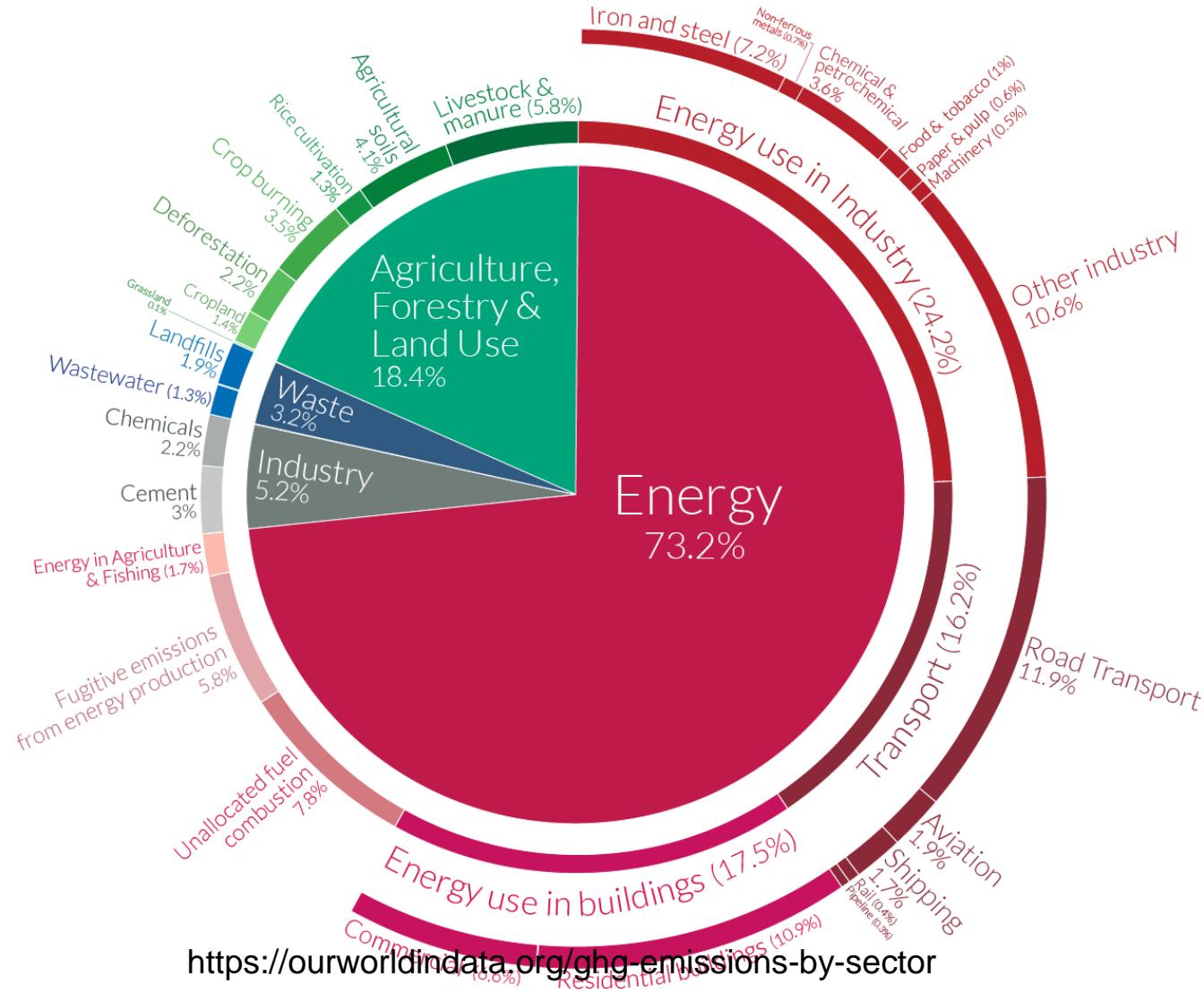


# What does energy contribute to Global Warming?

## Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO<sub>2</sub>eq.

Our World  
in Data



## Annual greenhouse gas emissions by world region, 1850 to 2023

Greenhouse gas emissions<sup>1</sup> include carbon dioxide, methane and nitrous oxide from all sources, including land-use change. They are measured in tonnes of carbon dioxide-equivalents<sup>2</sup> over a 100-year timescale.

60 billion t

50 billion t

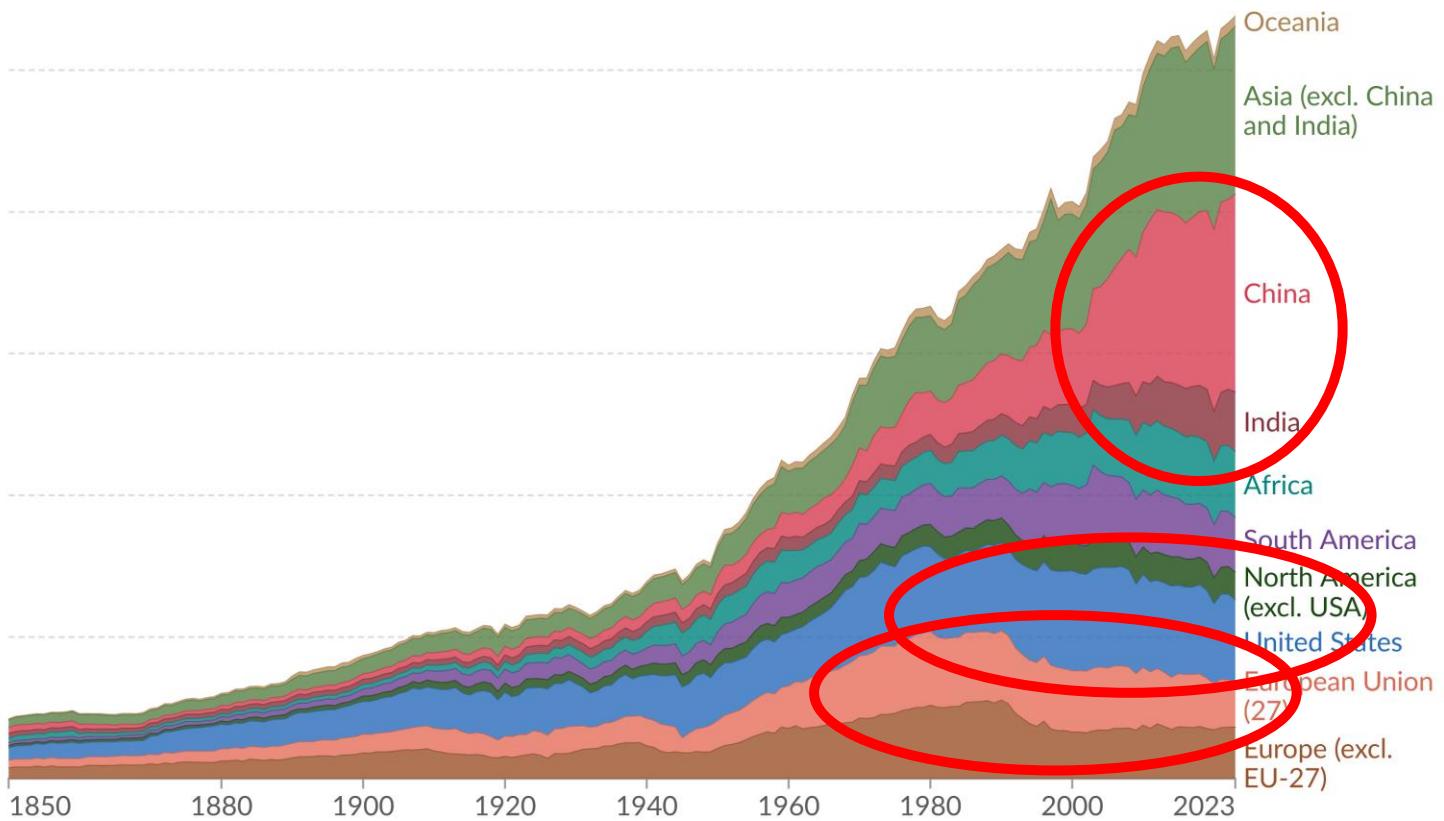
40 billion t

30 billion t

20 billion t

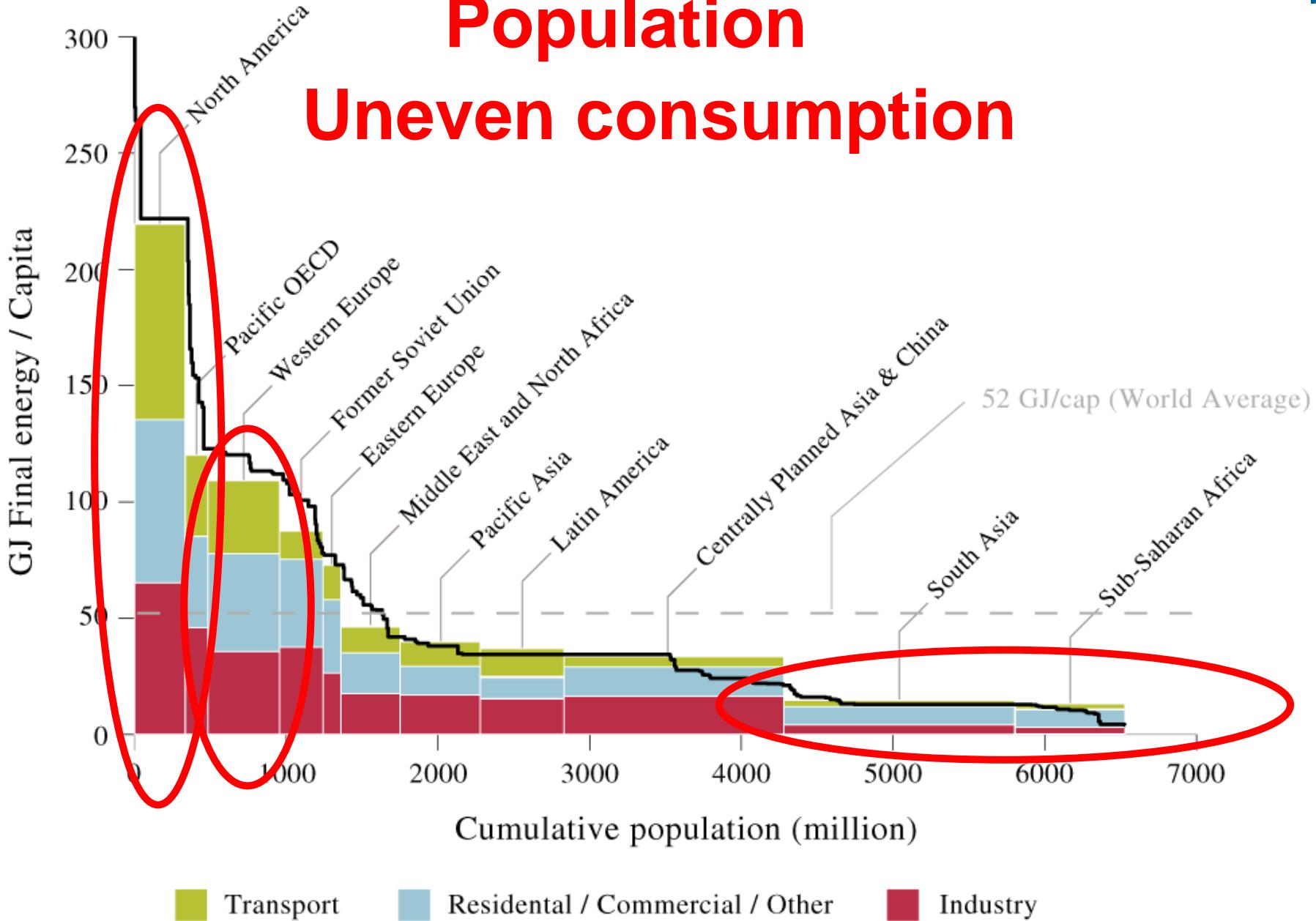
10 billion t

0 t



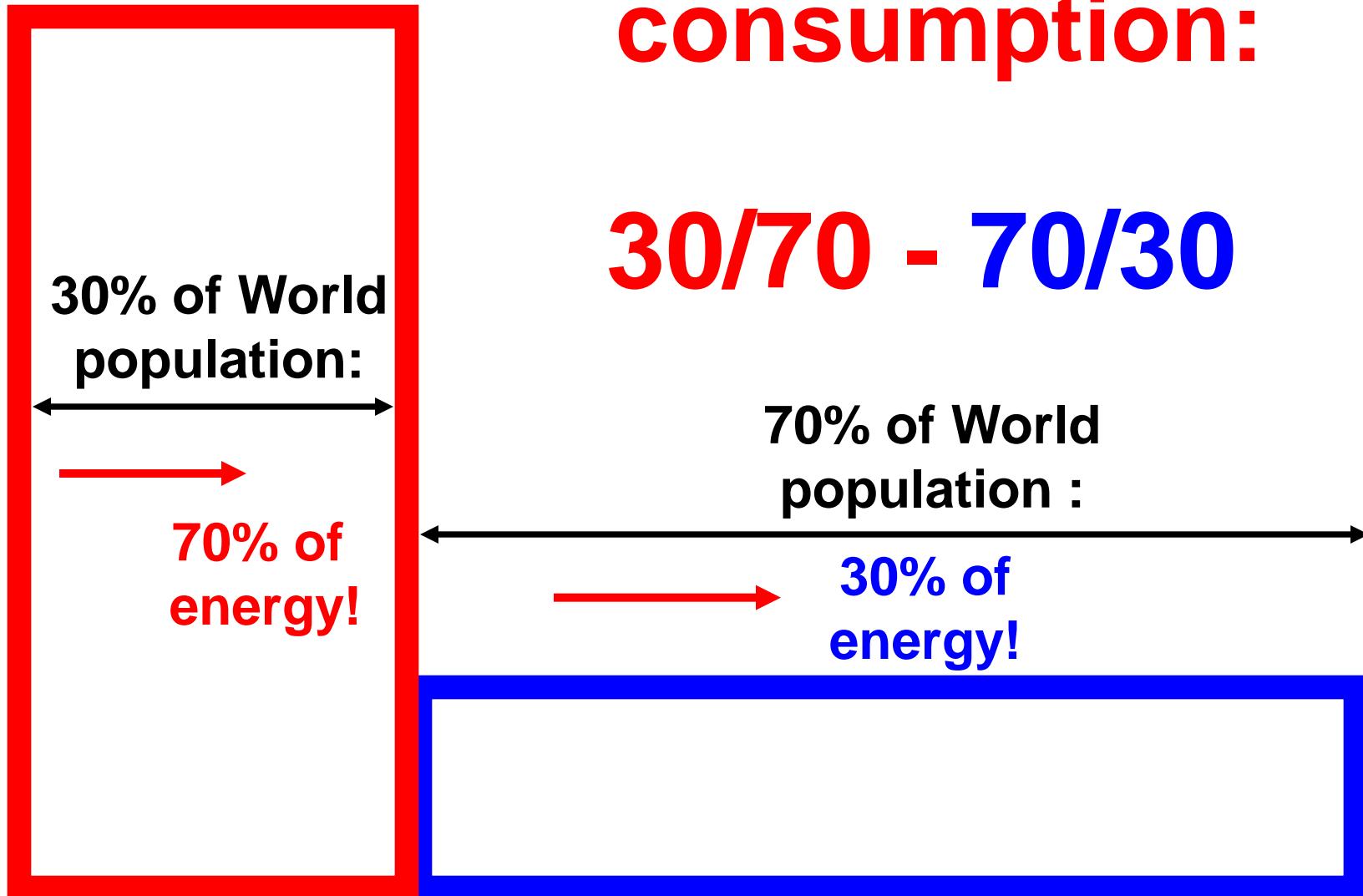
# Per Capita Final Energy & Population

## Uneven consumption



# Uneven consumption:

**30/70 - 70/30**



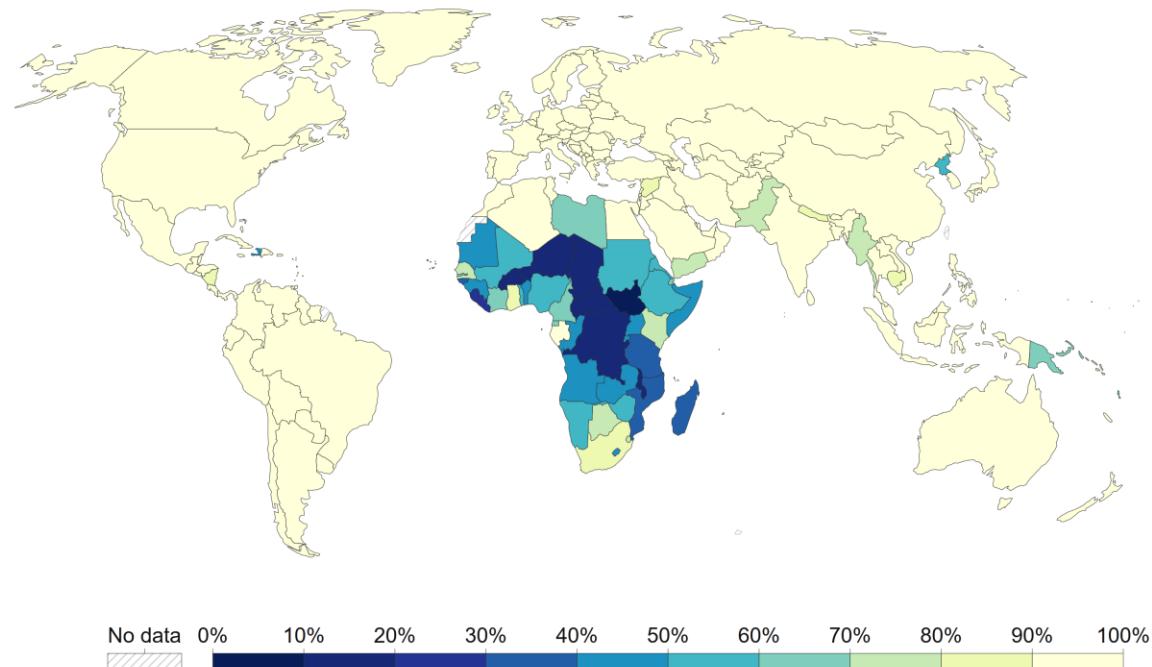
- **The issue of SEA: Sustainable energy access for all ? SDG ... ?**

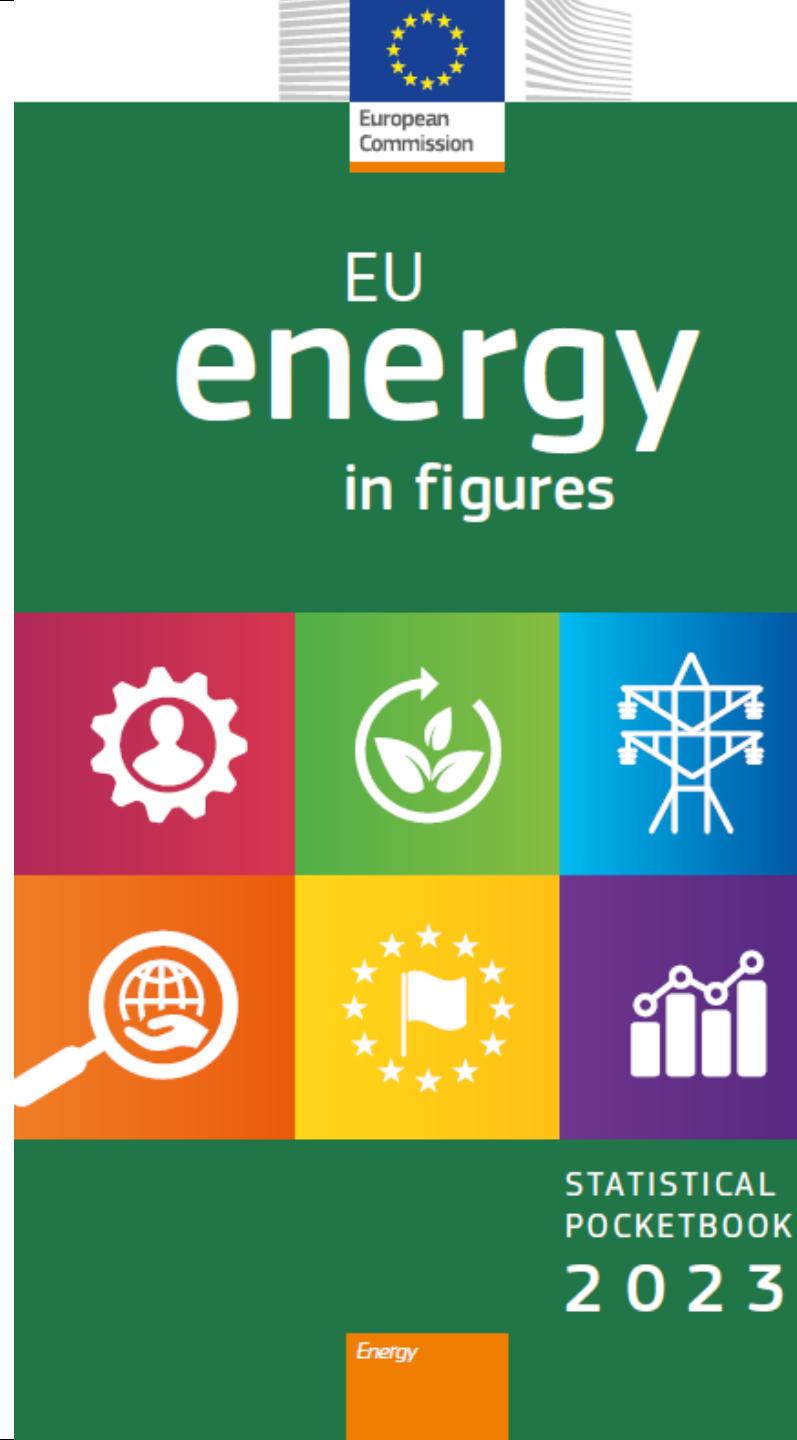
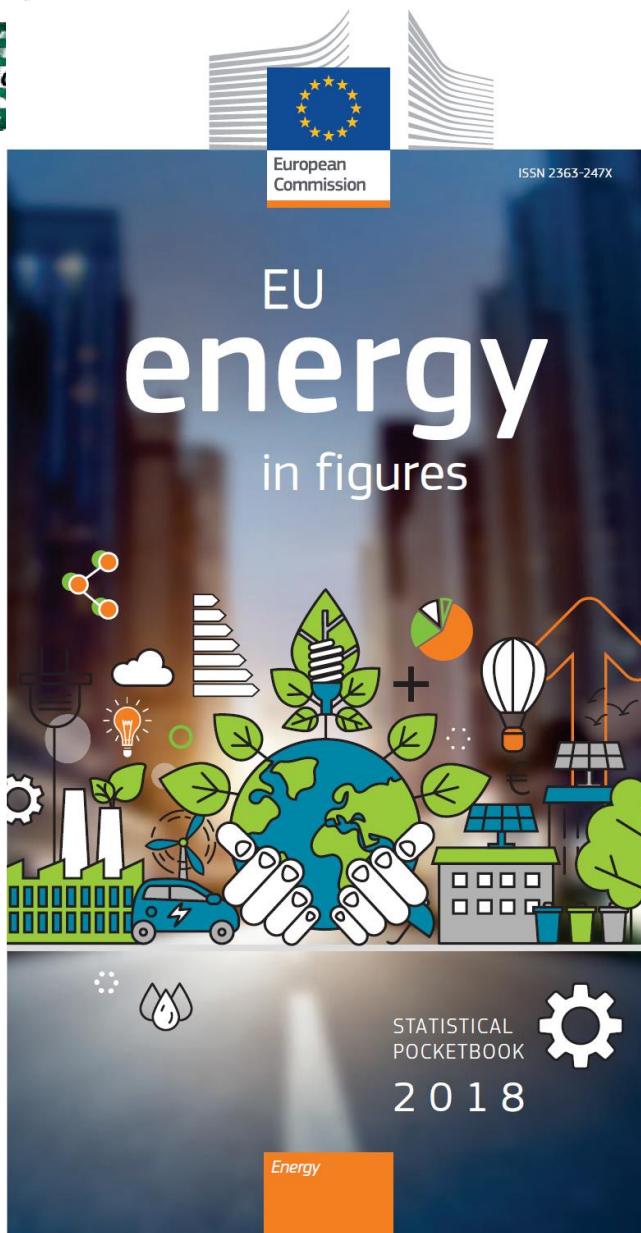


### Electricity access, 2020

Share of the population with access to electricity. The definition used in international statistics adopts a very low cutoff for what it means to 'have access to electricity'. It is defined as having an electricity source that can provide very basic lighting, and charge a phone or power a radio for 4 hours per day.

Our World  
in Data



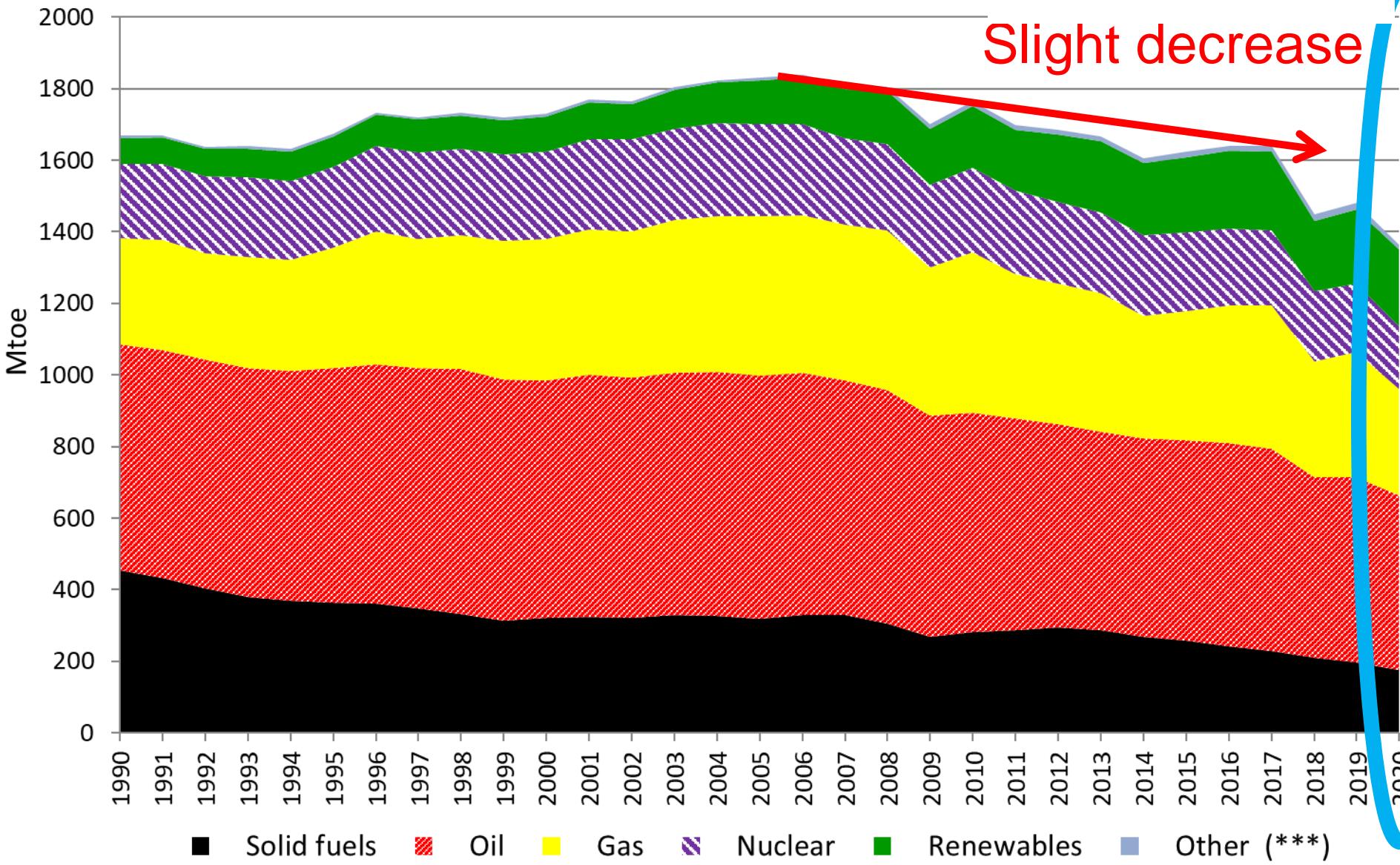


# Primary energy in Europe

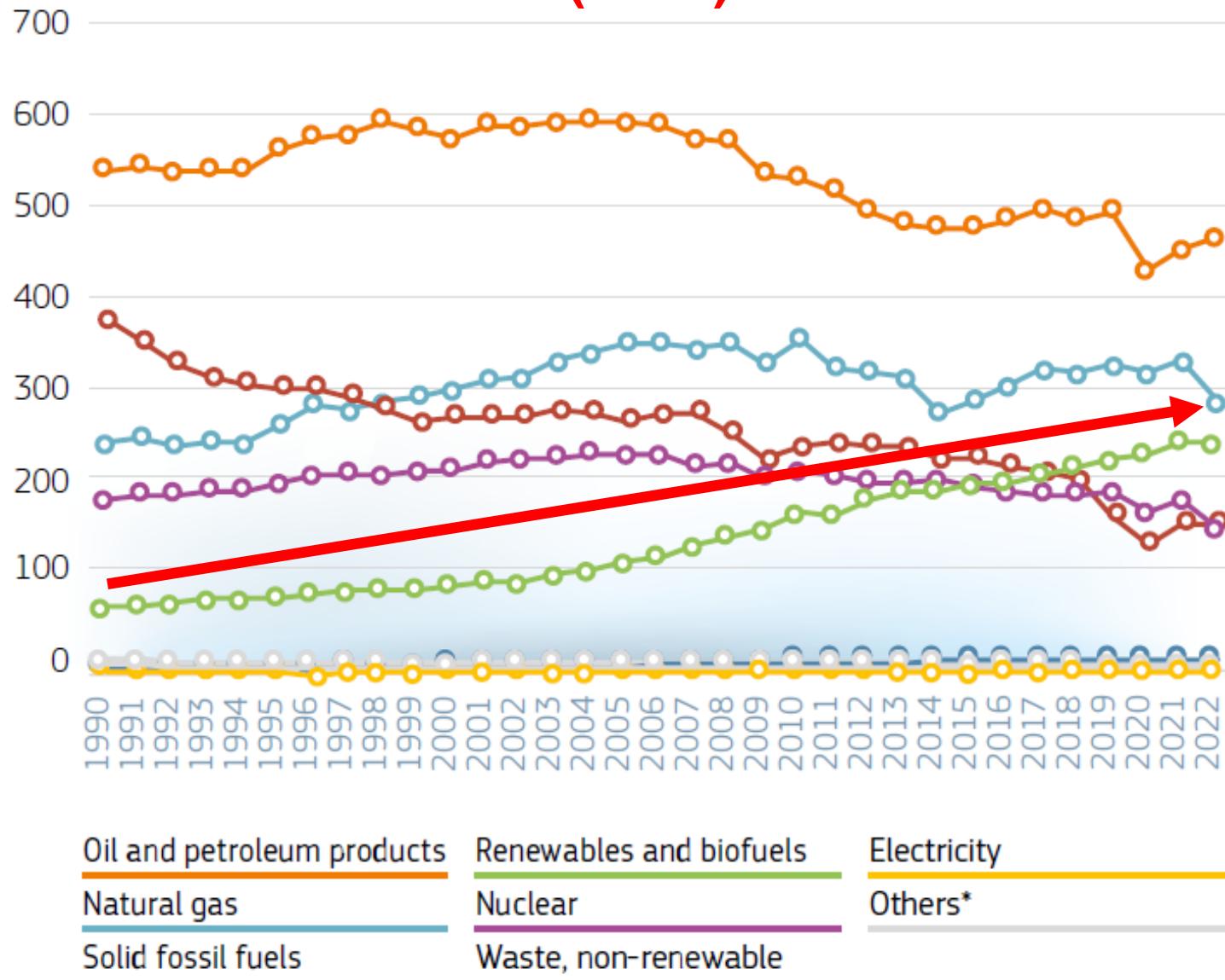
Primary energy consumption EU-28

2020: Corona?

Slight decrease



# EU-27: Gross inland energy consumption (Mtoe)



Oil and petroleum products

Natural gas

Solid fossil fuels

Renewables and biofuels

Nuclear

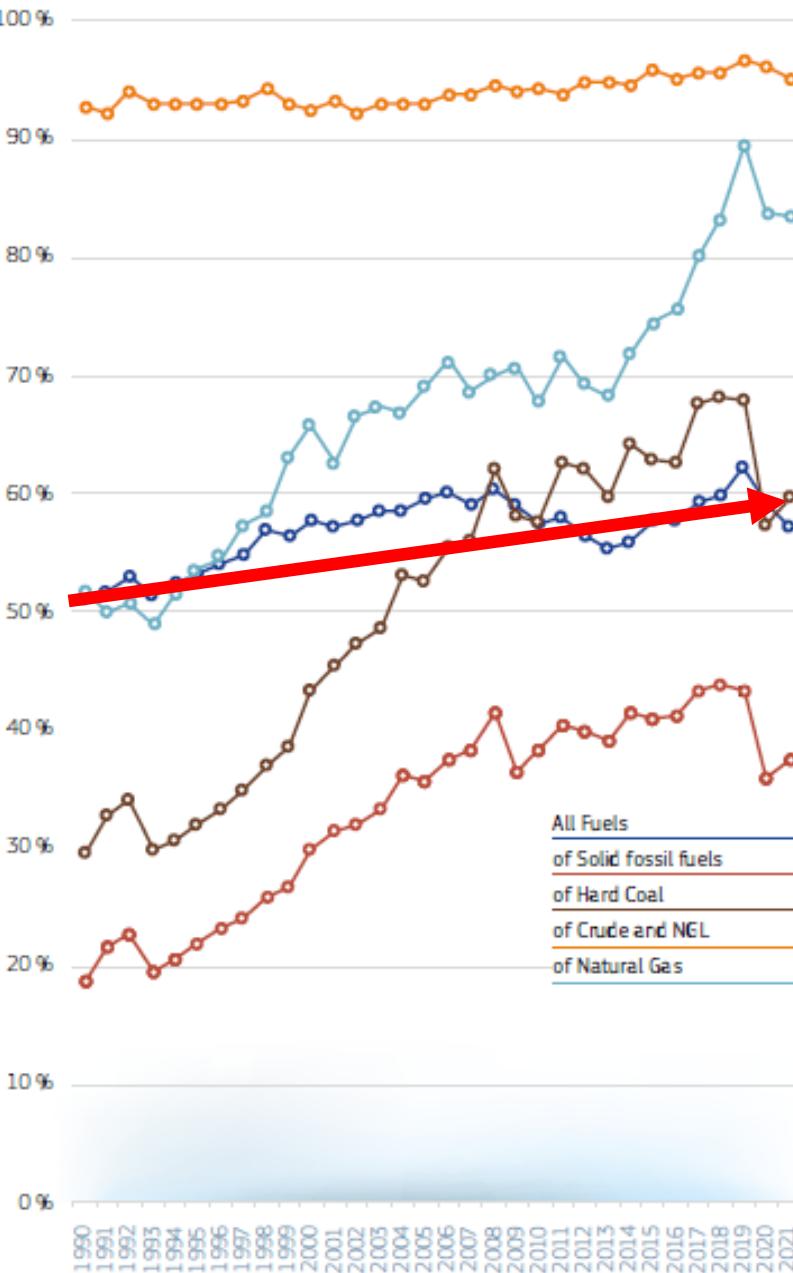
Waste, non-renewable

Electricity

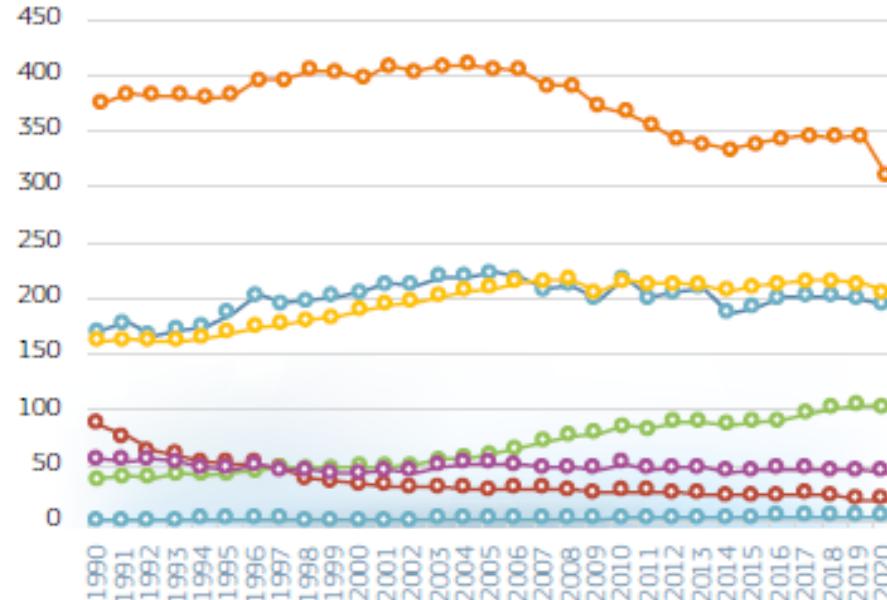
Others\*

## 2.3.2 Import Dependency by Fuel

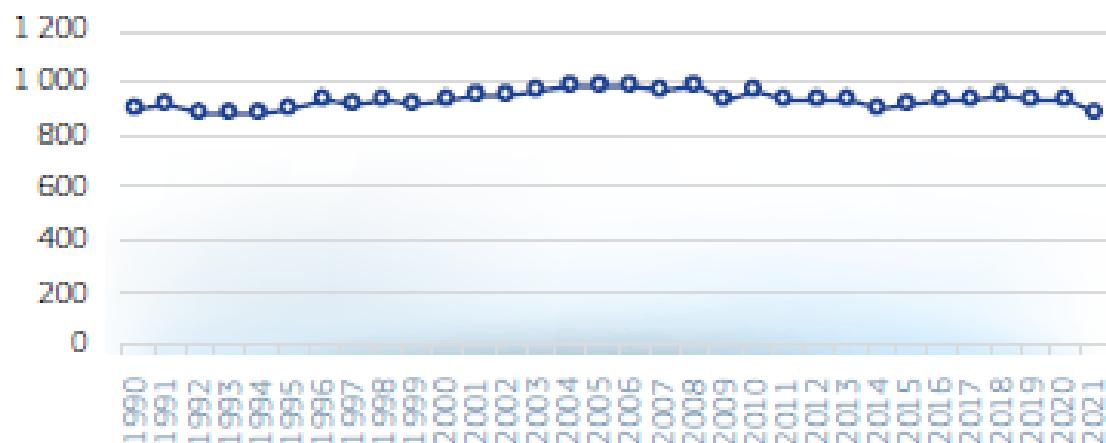
EU27\_2020 – IMPORTS FROM EXTRA-EU – 1990-2021 (%)



# Final energy EU-27

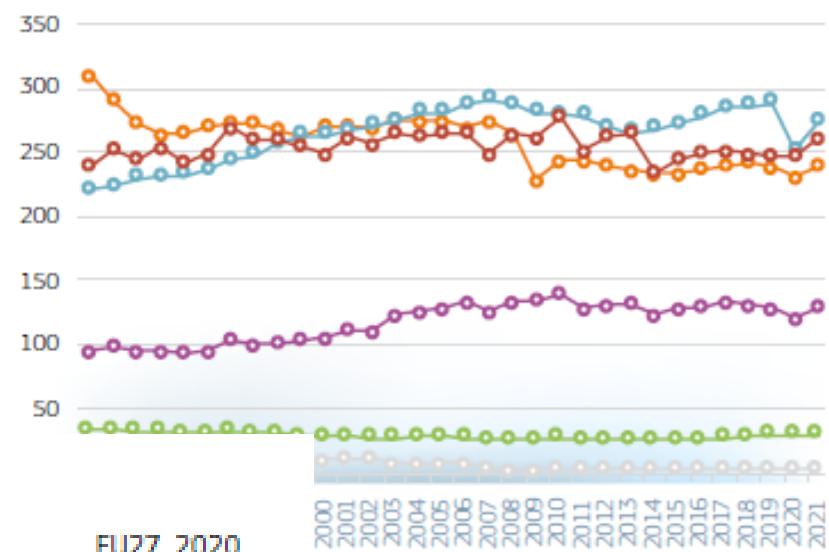


FINAL ENERGY CONSUMPTION – TOTAL –  
1990-2021 (Mtoe)



## 2.5.3 Final Energy Consumption

BY SECTOR – EU27\_2020 – 1990-2021 (Mtoe)



EU27\_2020

Agriculture and Fishing  
Transport

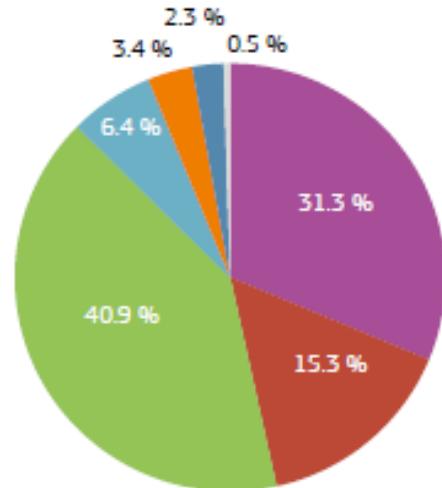
Services  
Others

# Primary Energy EU-28: origin of resources

## Indigenous:

Total = 597.6 Mtoe

- Nuclear
- Solid fossil fuels
- Renewables and biofuels
- Natural gas
- Oil and petroleum products
- Wastes, non-renewable
- Peat, oil shale and oil sands



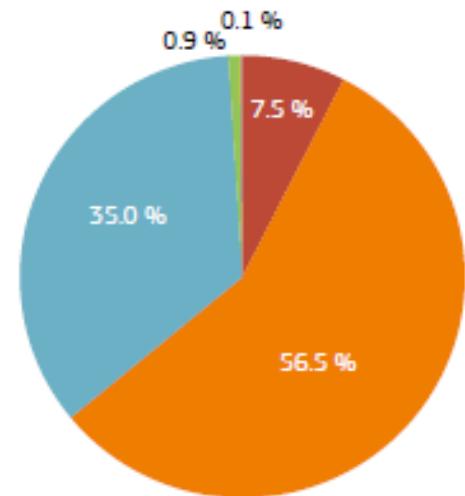
Total 2021: ca. 600 Mtoe

## Imports:

BY FUEL – EU27\_2020 – 2021

Total = 793 Mtoe

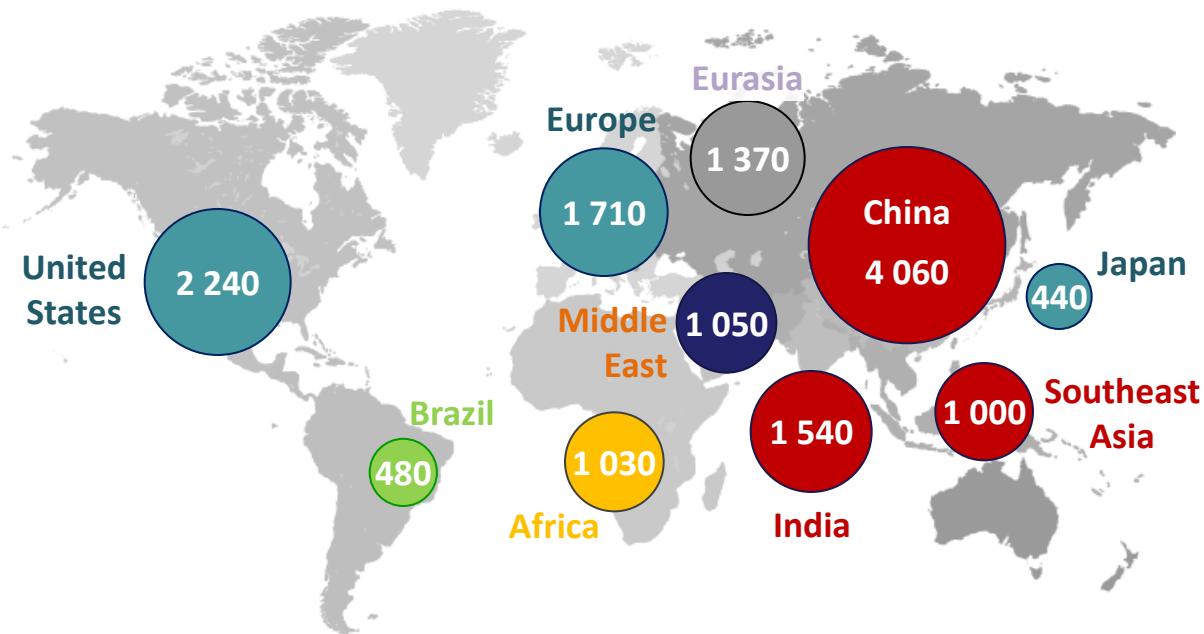
- Solid fossil fuels
- Oil and petroleum products
- Natural gas
- Renewables and biofuels
- Electricity
- Heat
- Waste, non-renewable



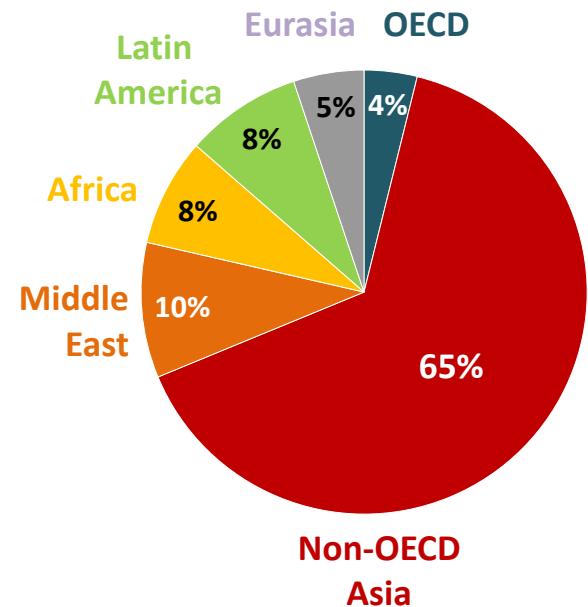
Total 2021: ca. 800 Mtoe

# WEO: The engine of energy demand growth moves to South Asia

Primary energy demand, 2035 (Mtoe)

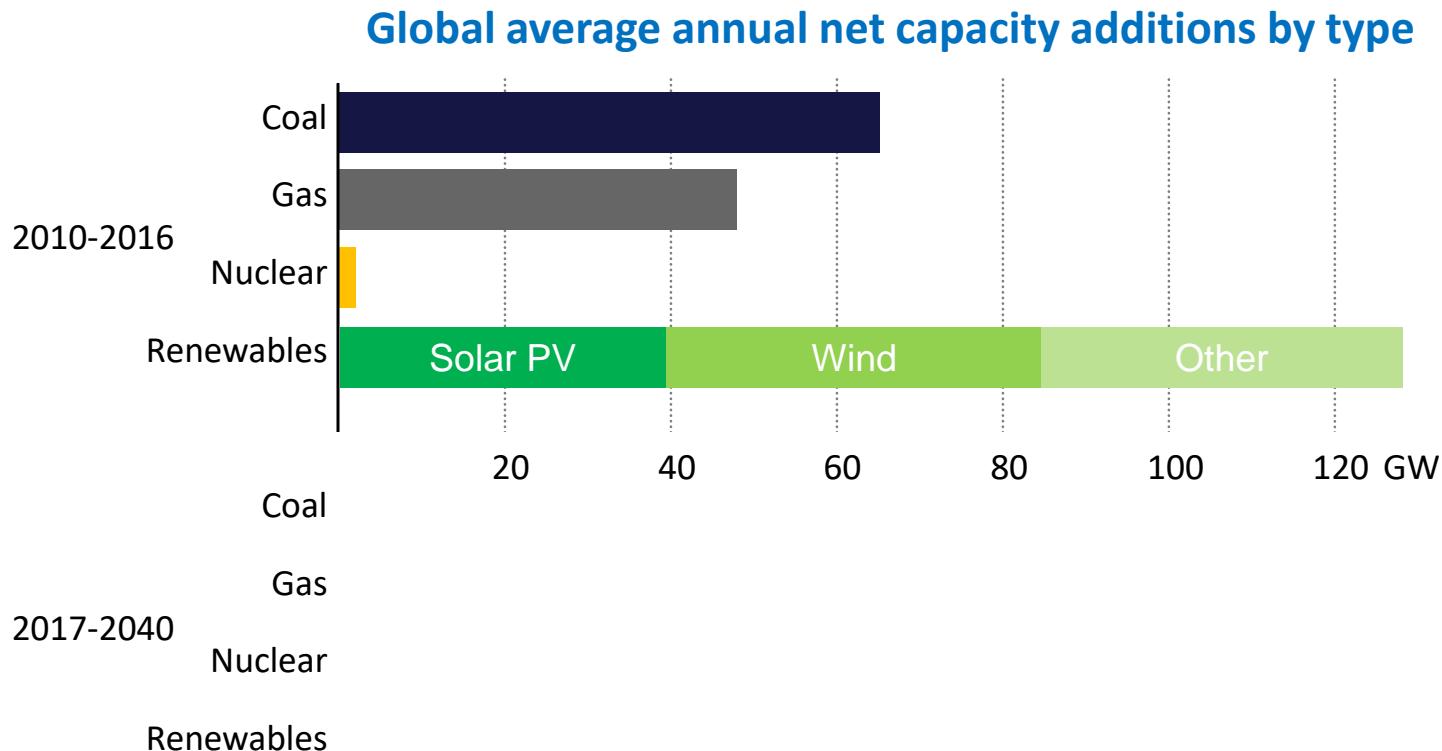


Share of global growth  
2012-2035



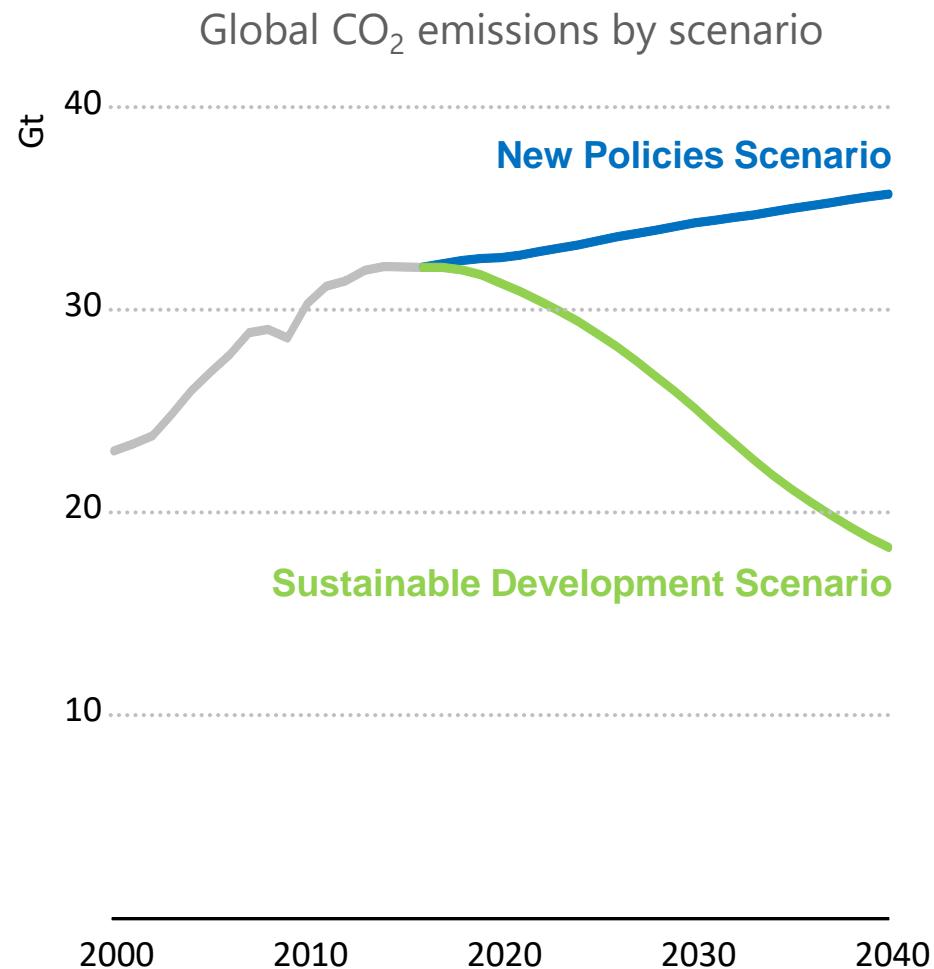
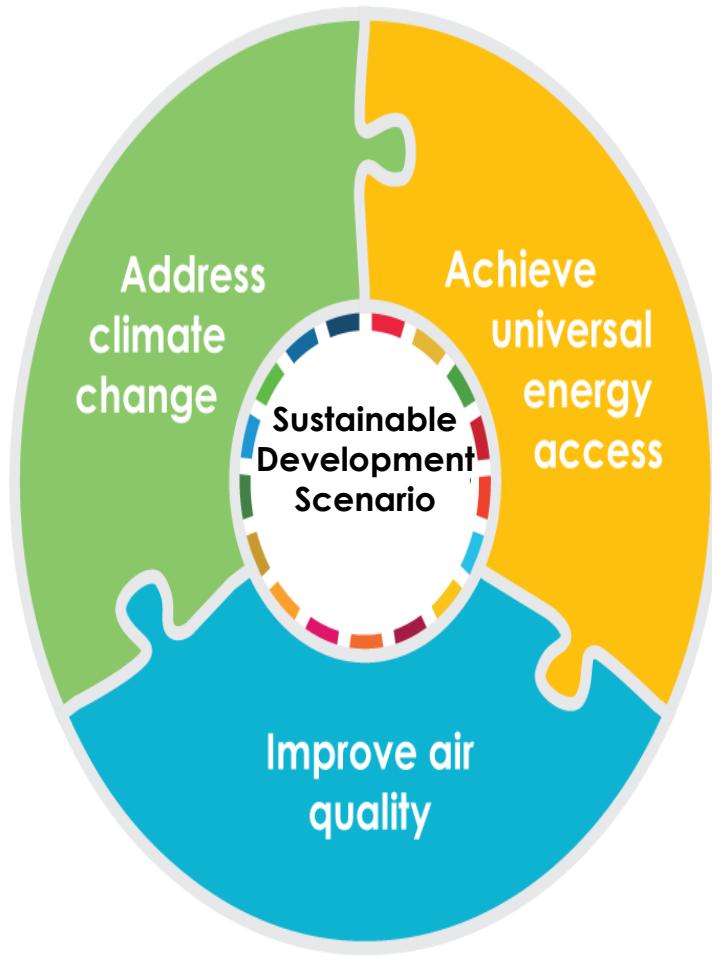
*China is the main driver of increasing energy demand in the current decade, but India takes over in the 2020s as the principal source of growth*

# Solar PV forges ahead in the global power mix



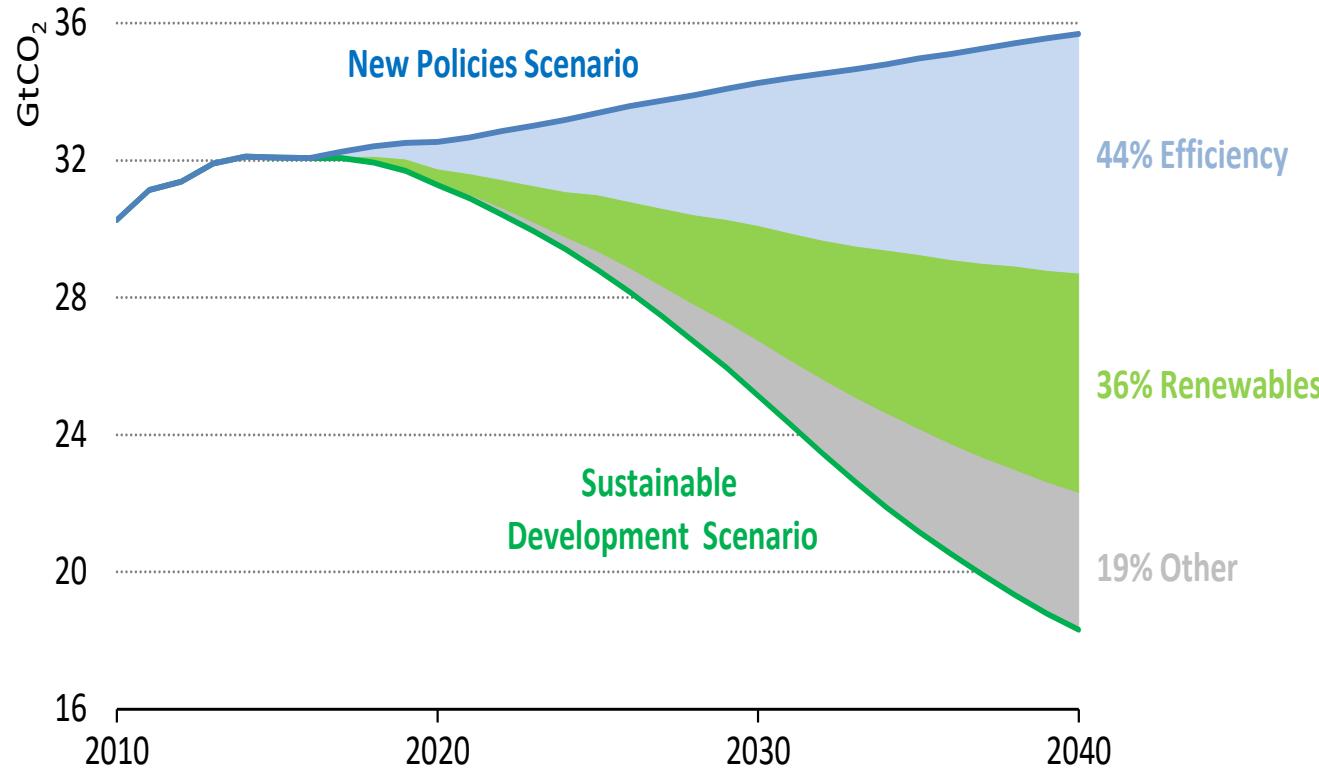
*China, India & the US lead the charge for solar PV, while Europe is a frontrunner for onshore & offshore wind: rising shares of solar & wind require more flexibility to match power demand & supply*

# A new strategy for energy & sustainable development



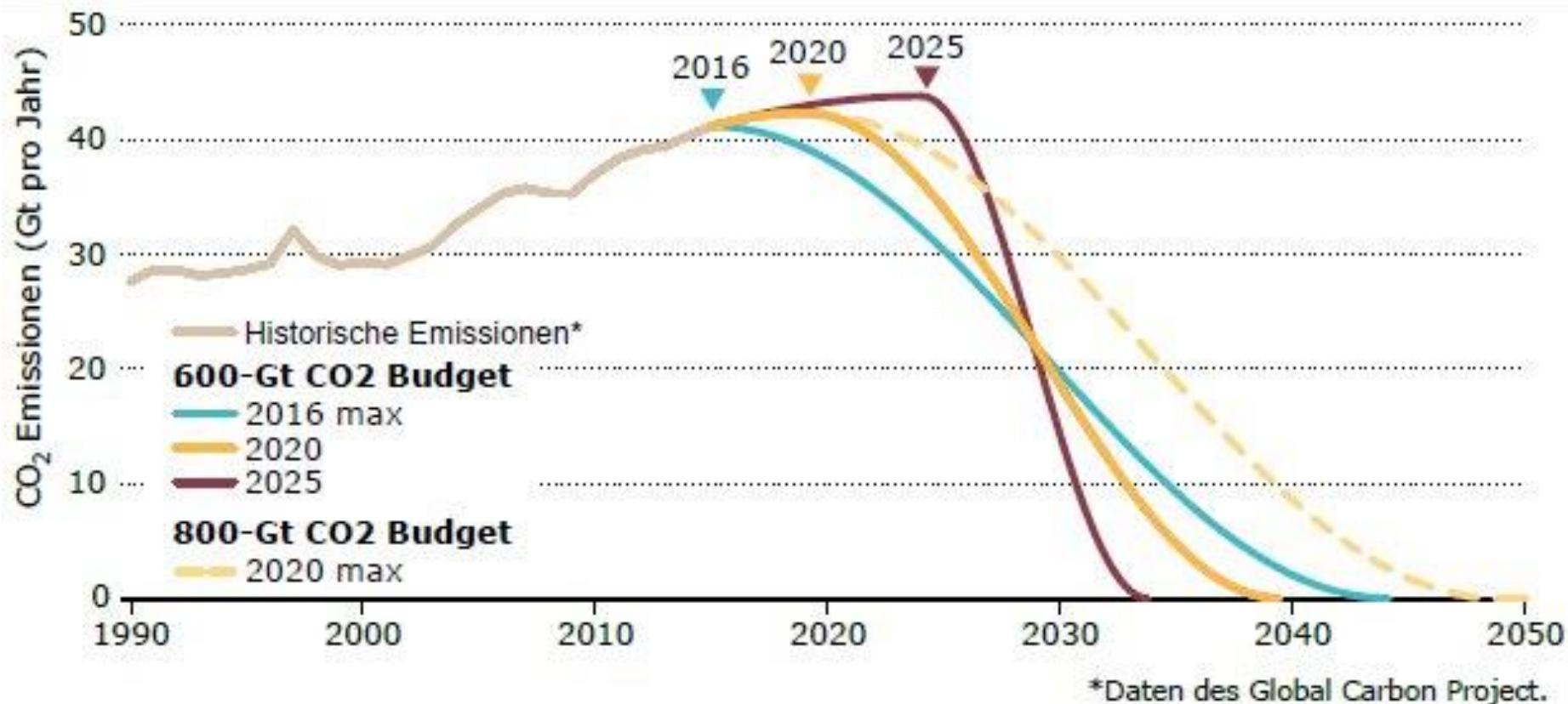
*The Sustainable Development Scenario reduces CO<sub>2</sub> emissions in line with the objectives of the Paris Agreement, while also tackling air pollution and achieving universal energy access*

# Global energy-related CO<sub>2</sub> emissions abatement and key contributions in the SDS



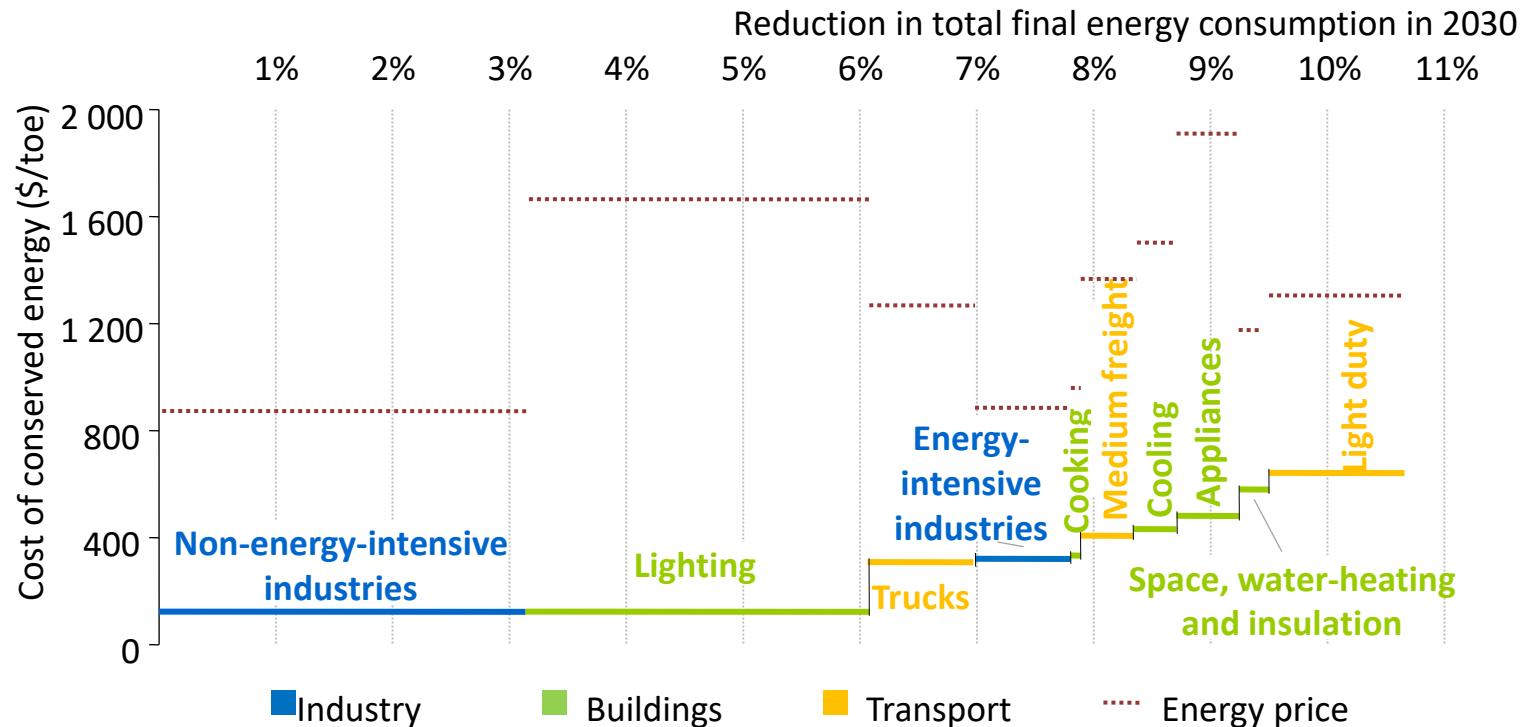
**Energy efficiency and renewables are the two key abatement measures in the New Policies and Sustainable Development Scenarios**

# Scenarios CO2 budgets



# Saving more energy is not necessarily expensive

Cost of conserved energy of the untapped global energy efficiency potential, 2030



*On average, the cost of conserved energy of efficiency measures beyond the New Policies Scenario is only one-fifth of the respective energy price*