

CZ-AT WINTER-SUMMER SCHOOL 2021



**INTRODUCTION TO
“ENERGY SYSTEMS”**

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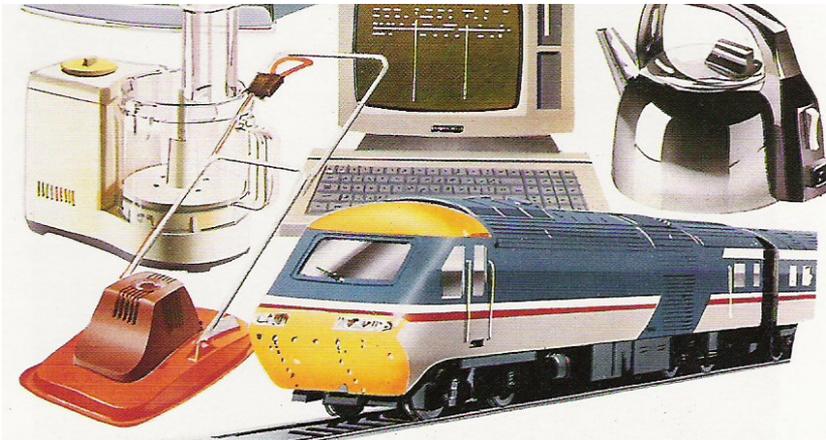
CONTENT:

- 1. Motivation: Energy problems**
- 2. Basic principle: Providing energy services – not consumption of energy !**
- 3. Energy chains and energy systems**
- 4. Dynamics: Why history is important**
- 5. Visions of future energy systems**

1. Motivation

Why are we here today?

- Energy is the fundament of our standard of life today
- Every second of our life – even in deep sleep – we „consume“ energy
- Dramatic increase in energy consumption in recent years!
- Dramatic increase in **electricity** consumption in the next decades expected!



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

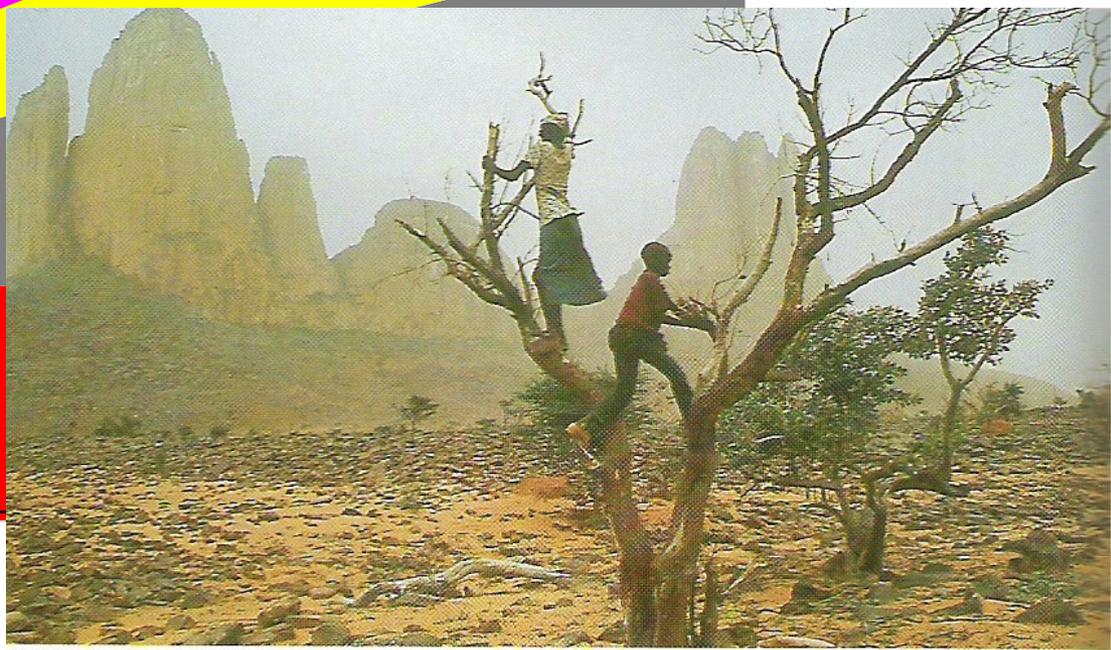
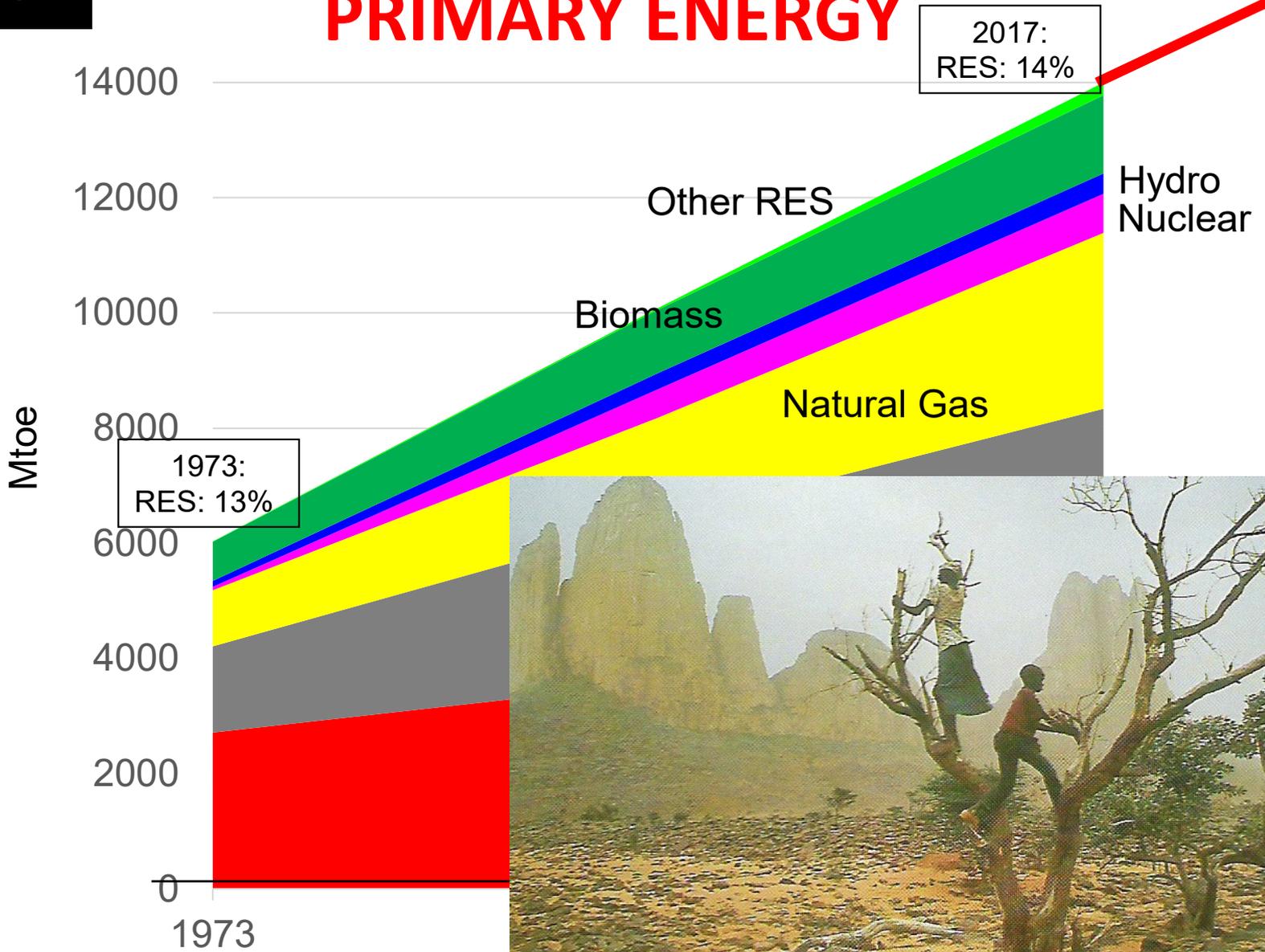
**ENVIRONM.
EXTERNALI-
TIES (CO₂,
SO₂ radiation)**

**ENERGY
“PROBLEMS”**

**SOCIAL:
UNEVEN
CONSUMP-
TION**

**SUPPLY
SECURITY:
NATURAL
GAS, OIL**

WORLD-WIDE TREND IN PRIMARY ENERGY



The Key Energy Challenges



**Energy
Access**



Climate Change



**Energy
Security**



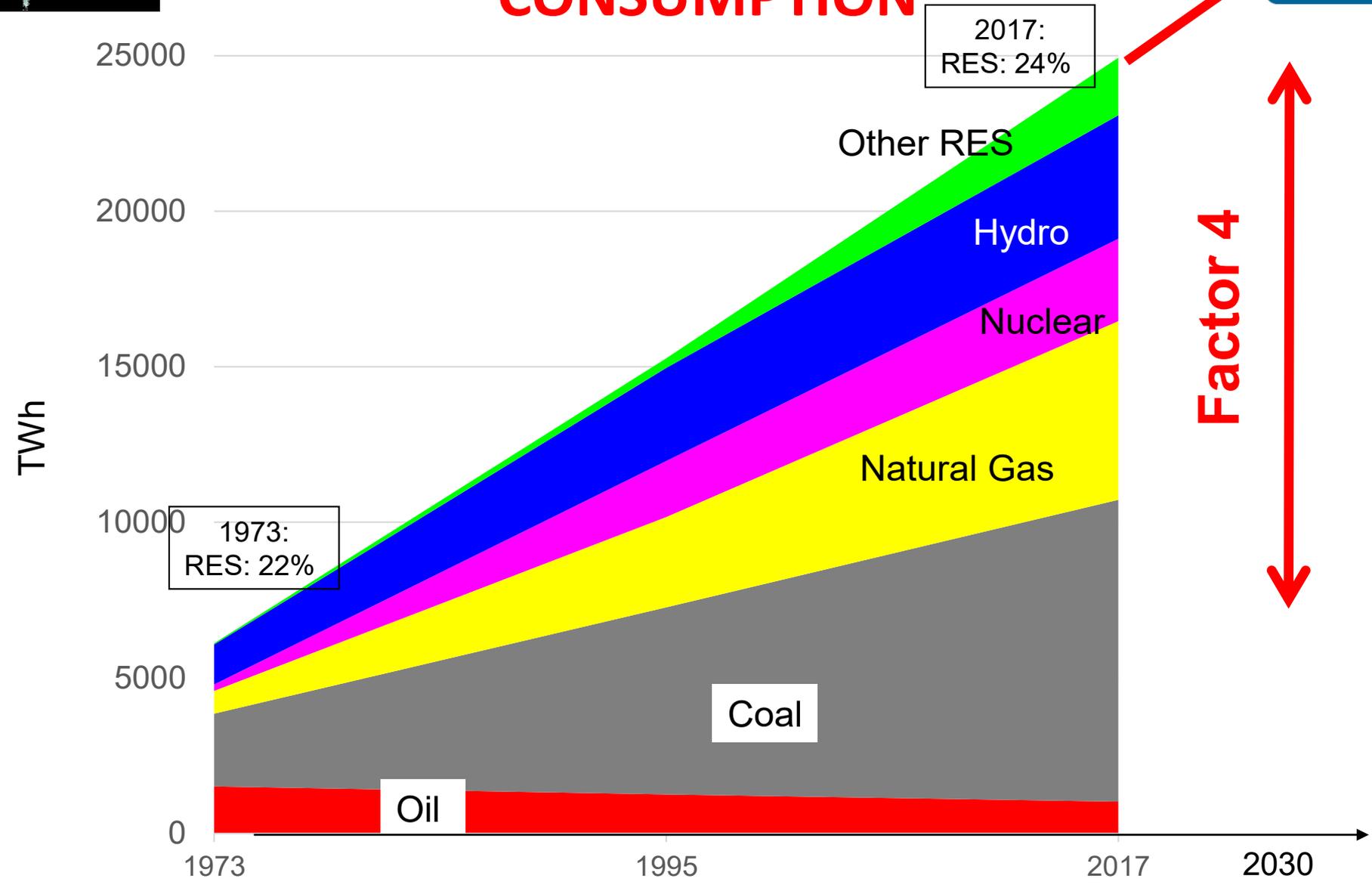
**Air Pollution
Health Impacts**

Wood for Cooking



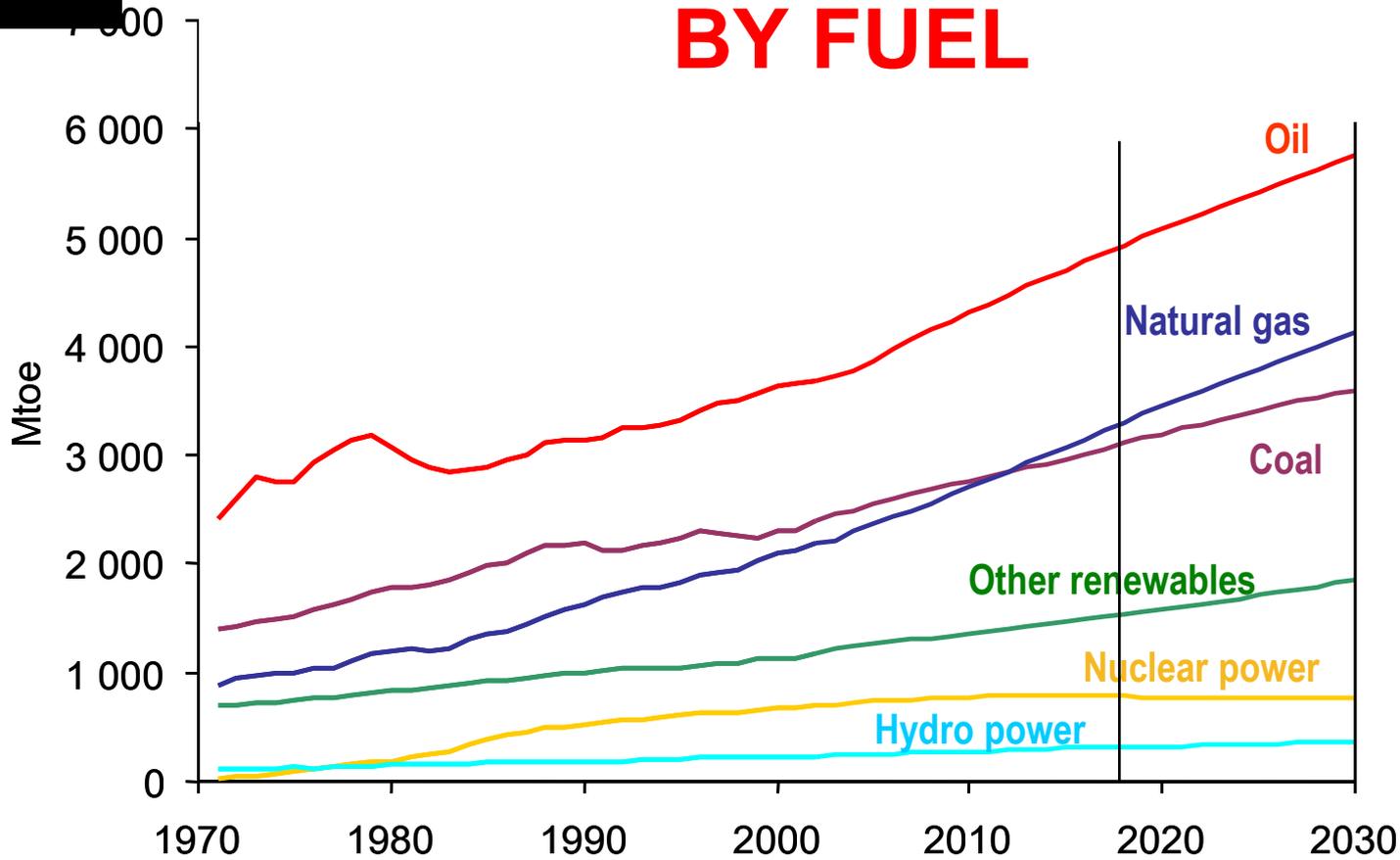
Source: Modi, 2011 and Yumkella, 2013

WORLD-WIDE TREND IN ELECTRICITY CONSUMPTION



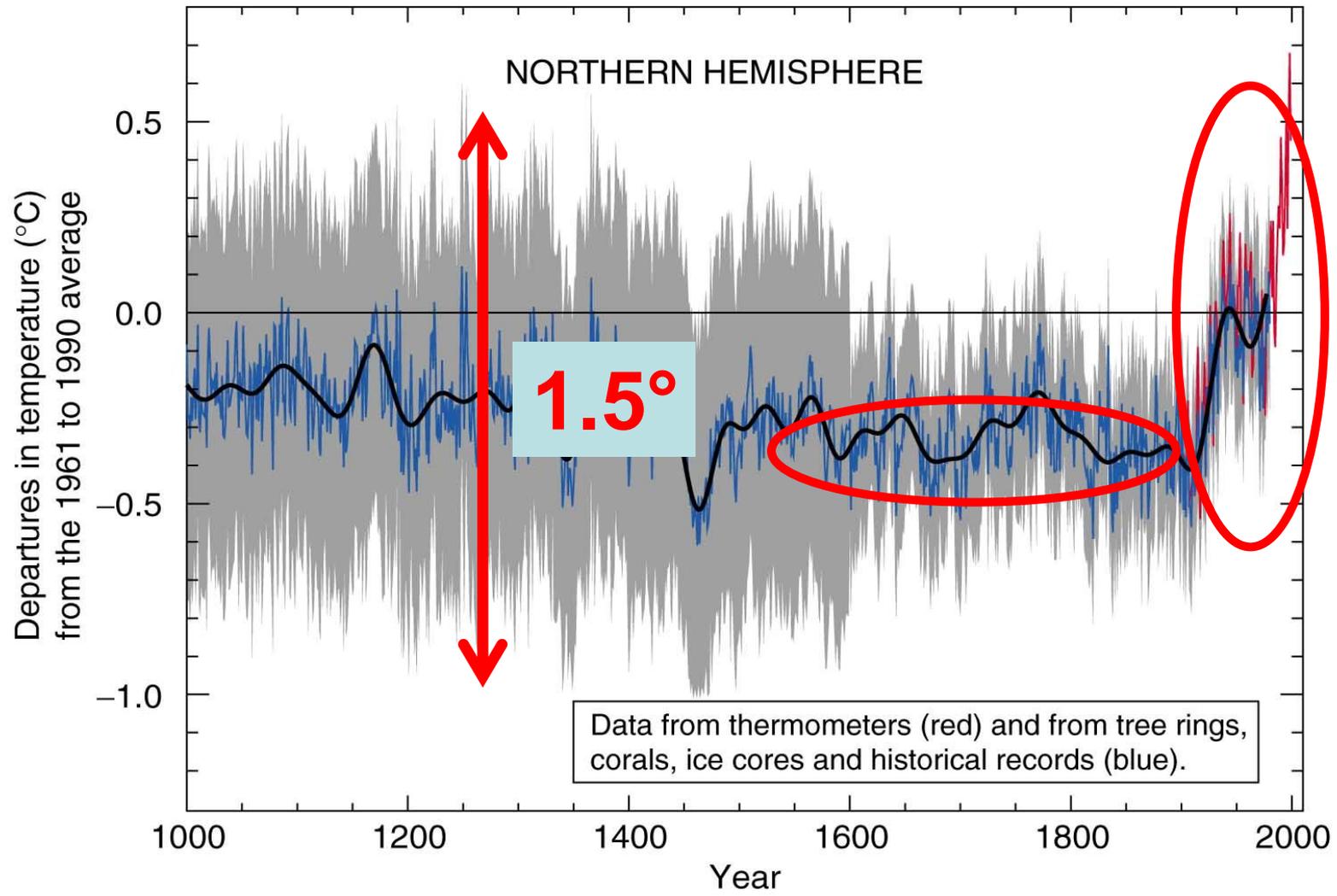
Source: IEA (2018)

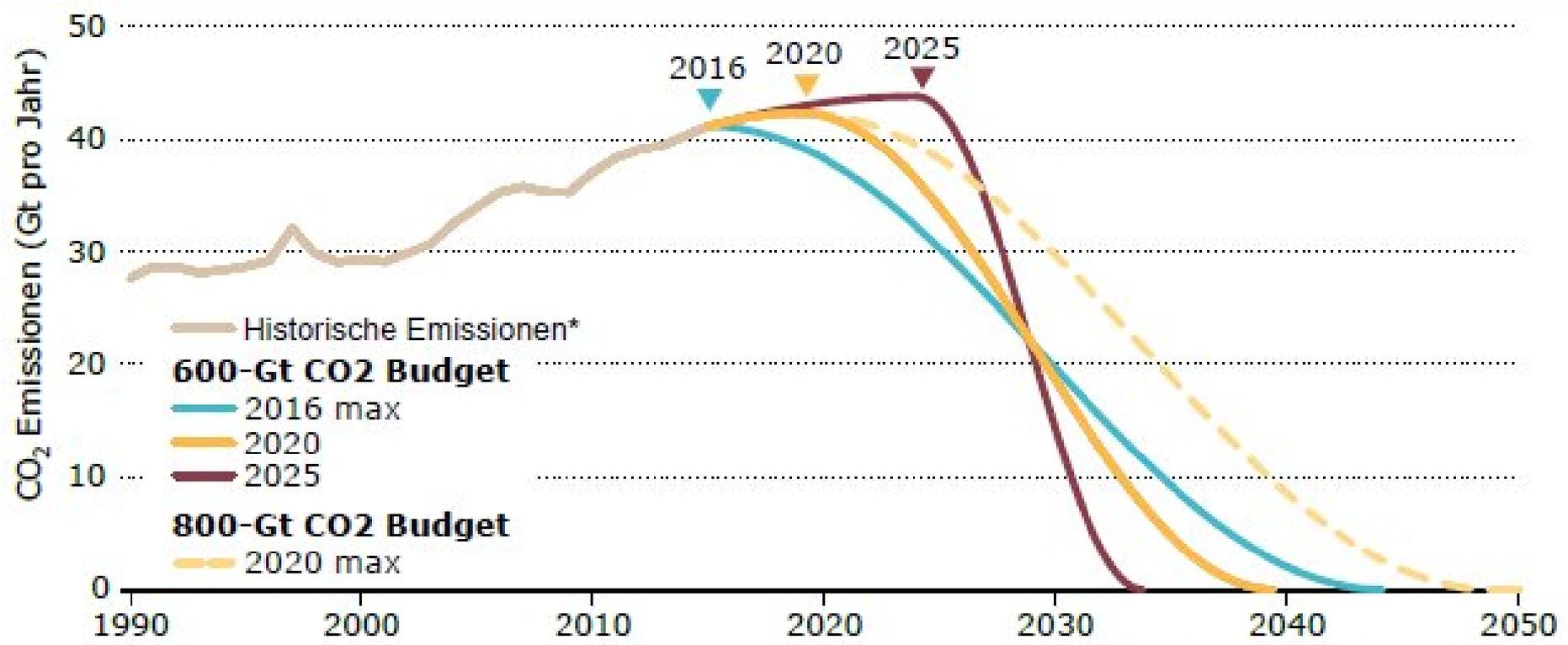
PRIMARY ENERGY: TRENDS BY FUEL



IEA: Fossil fuels will continue to dominate the global energy mix, while oil remains the leading fuel!

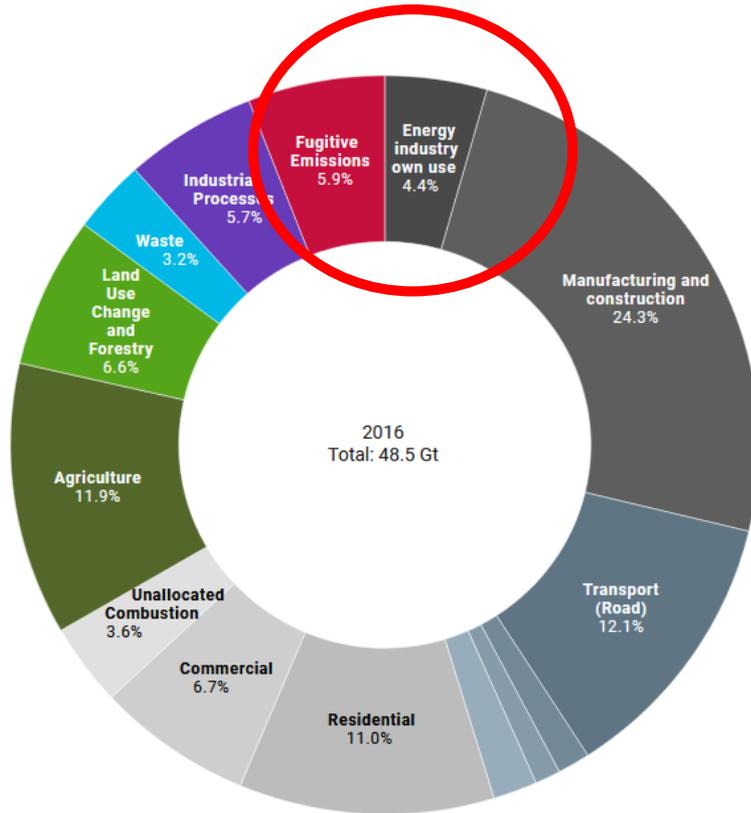
Long-term Variations of Earth's Surface temperature in the past 1000 years





*Daten des Global Carbon Project.

What does energy contribute to Global Warming?



Global GHG Emissions by Sector

2016 global emissions of greenhouse gases
(fuel combustion emissions attributed to energy consumers)

- Energy industry own use (4.4%)
- Manufacturing and construction (24.3%)
- Transport (Road) (12.1%)
- Transport (Int. Shipping) (1.4%)
- Transport (Int. Aviation) (1.1%)
- Transport (Other) (1.9%)
- Residential (11.0%)
- Commercial (6.7%)
- Unallocated Combustion (3.6%)
- Agriculture (11.9%)
- Land Use Change and Forestry (6.6%)
- Waste (3.2%)
- Industrial Processes (5.7%)
- Fugitive Emissions (5.9%)

Data

Emissions from combustion of fuels: IEA¹.
Other emissions: Climate Watch².

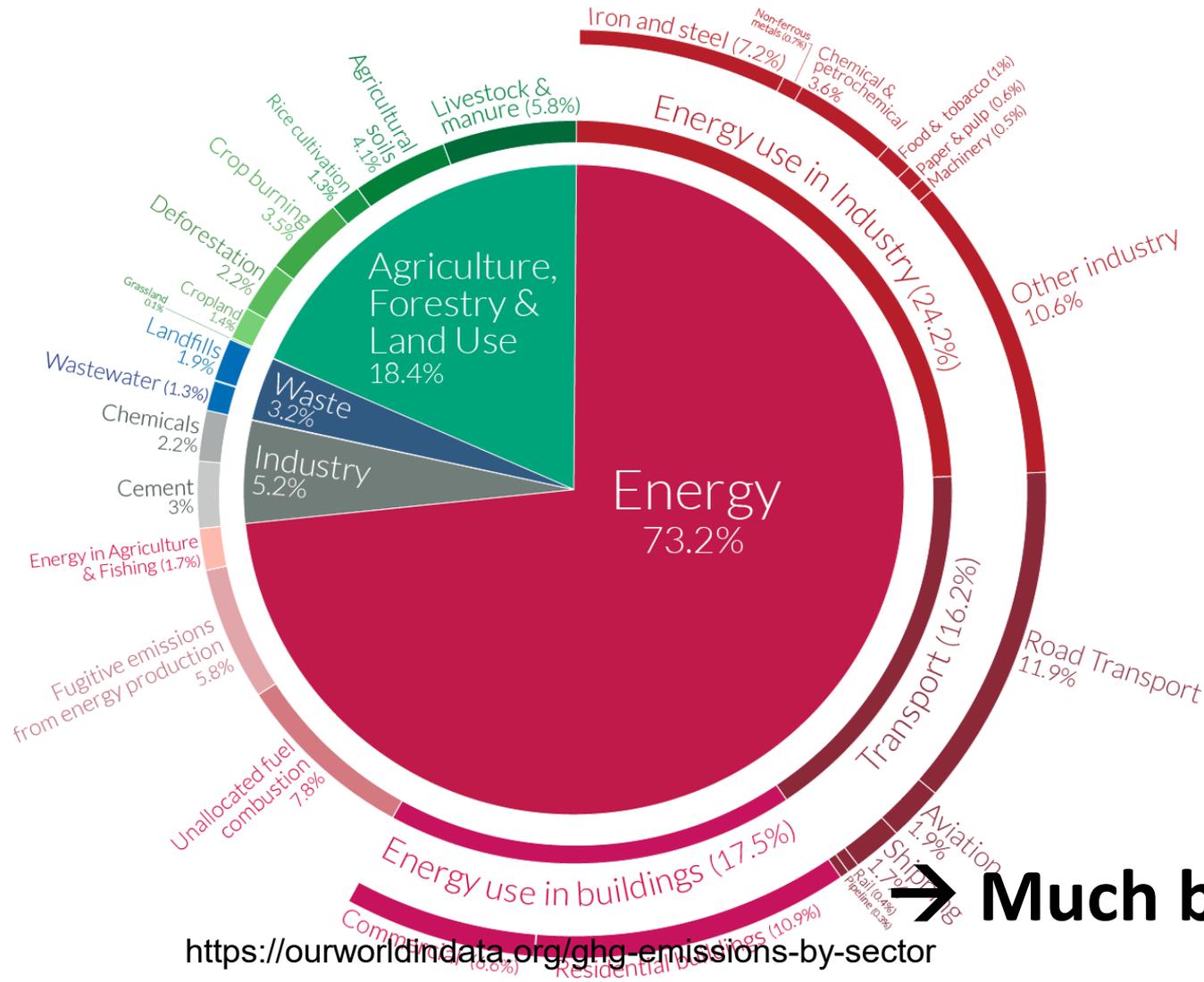
→ Not a very good approach

What does energy contribute to Global Warming?

Global greenhouse gas emissions by sector

Our World in Data

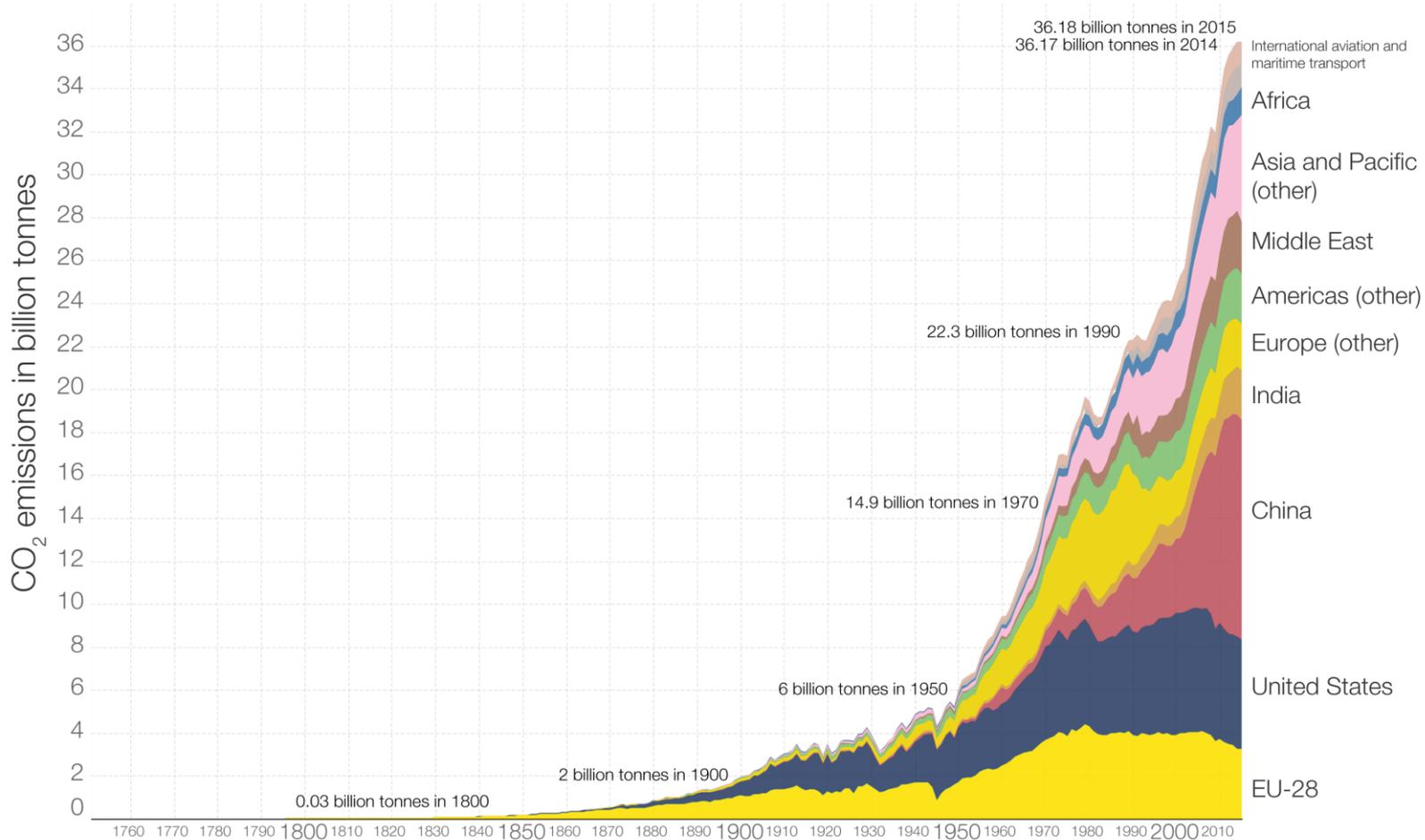
This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂e.



➔ **Much better!**

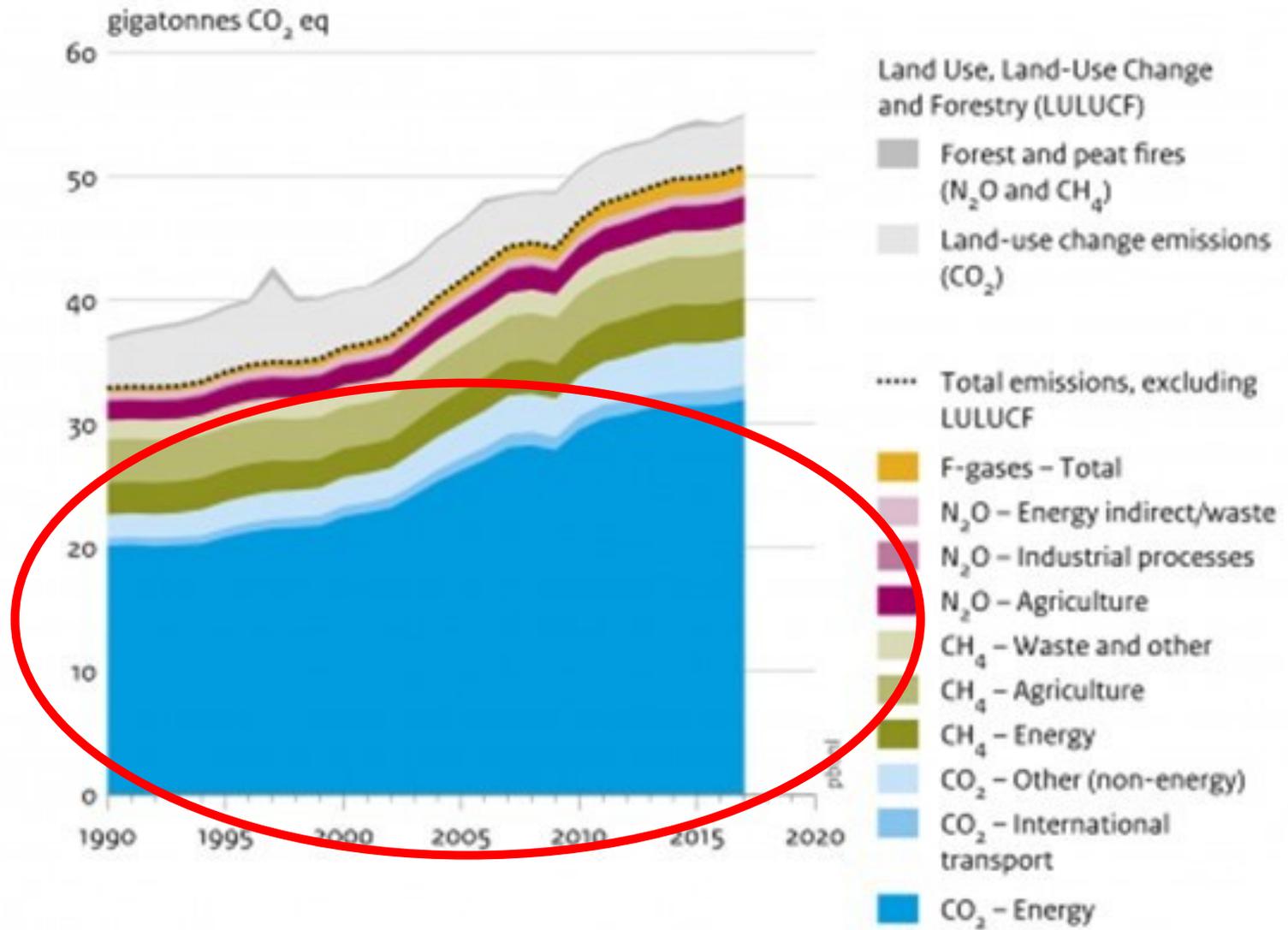
Global CO₂ emissions by world region, 1751 to 2015

Annual carbon dioxide emissions in billion tonnes (Gt).



Data source: Carbon Dioxide Information Analysis Center (CDIAC); aggregation by world region by Our World In Data. The interactive data visualization is available at OurWorldInData.org. There you find the raw data and more visualizations on this topic.

Global greenhouse gas emissions, per type of gas and source, including LULUCF

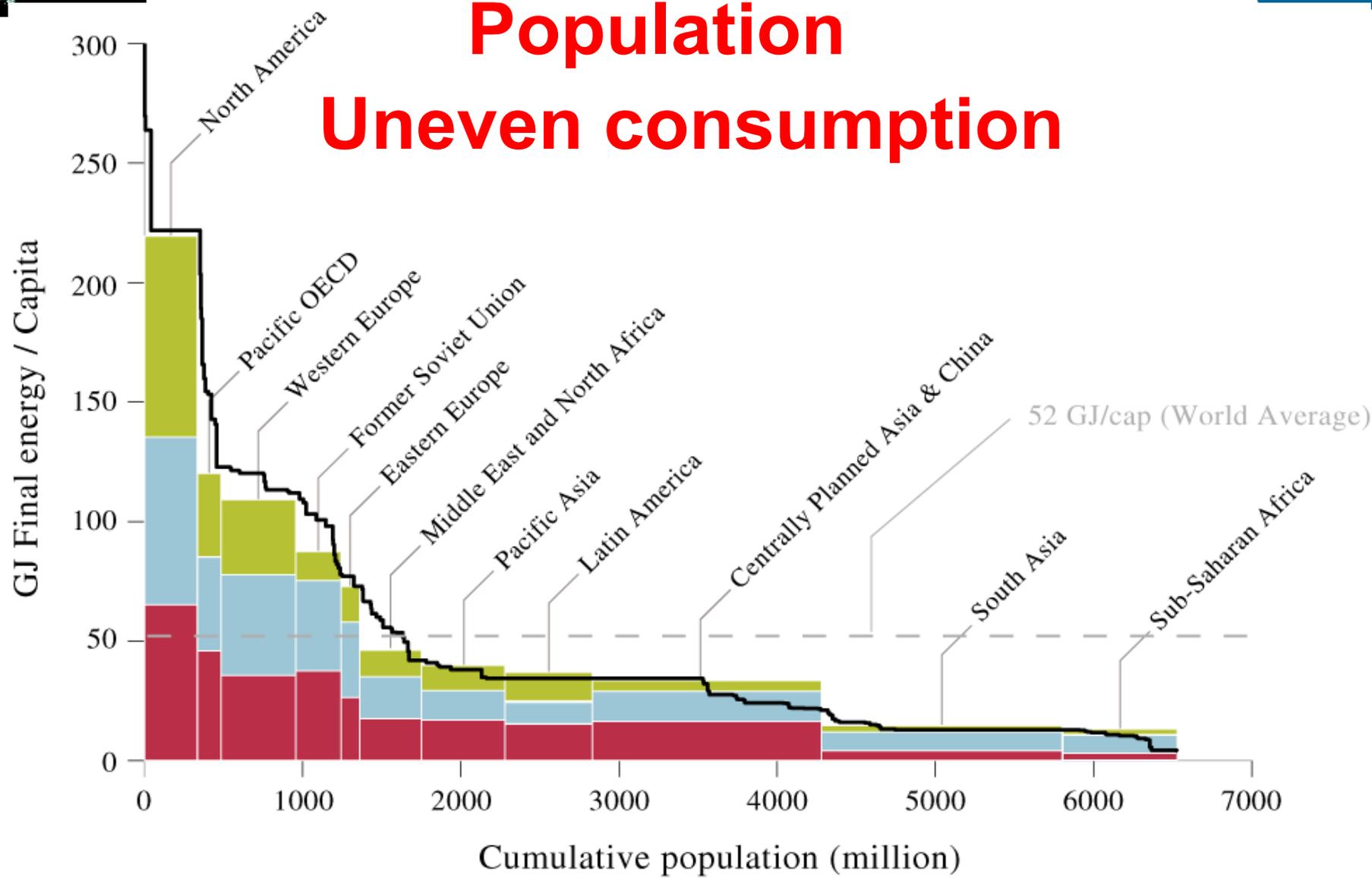


<https://www.pbl.nl/en/publications/trends-in-global-co2-and-total-greenhouse-gas-emissions-2018-report>

Source: EDGAR v5.0/v4.3.2 FT 2017 (EC-JRC/PBL, 2018); Houghton and Nassikas (2017)

Per Capita Final Energy & Population

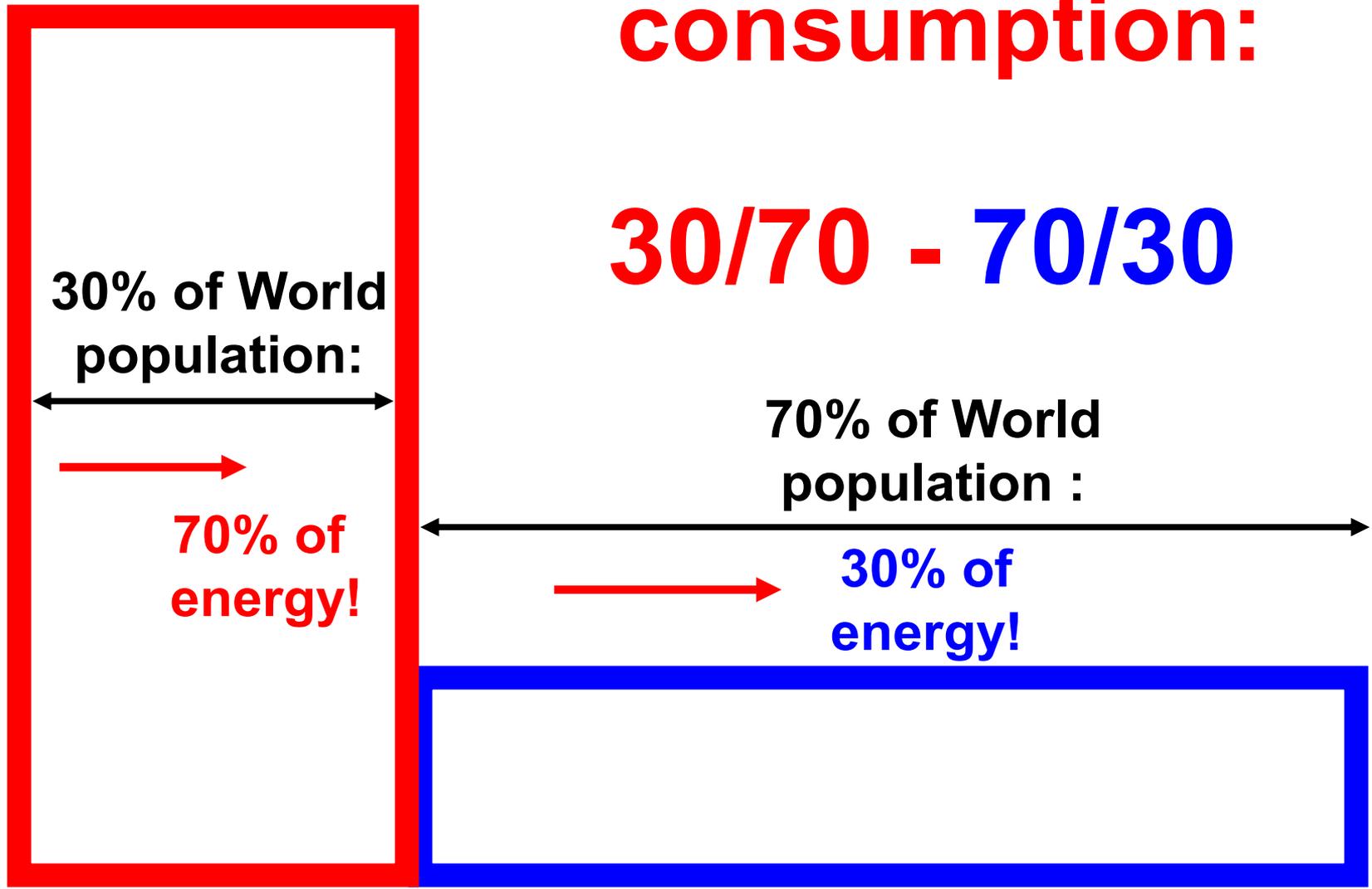
Uneven consumption



■ Transport
 ■ Residential / Commercial / Other
 ■ Industry

Uneven consumption:

30/70 - 70/30



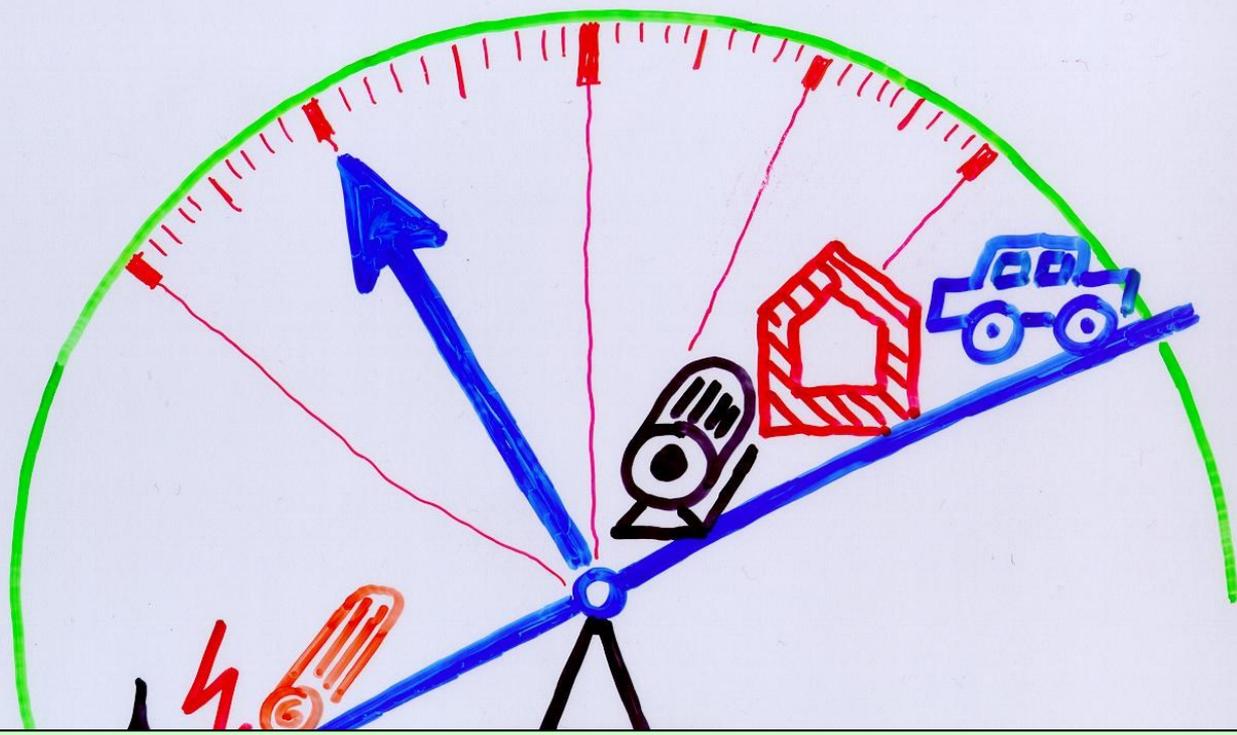
What is an energy service?

2. The basic concept of providing energy services

- There is no interest to consume energy. There is a demand for energy services: clean shirts, warm and bright rooms, cold beer, hot coffee.
- Inputs: Energy, Technology, human capital, environment
- Energy services are produced :

$$S = E \eta (T)$$

Service = Energy x Technology !



***• But currently the balance is biased tremendously:
To much energy, far to less technical efficiency!***

What are energy services?

Direct energy services:

- Lighting
- Heating, cooking
- Mobility, Transport
- ...

Indirect energy services:

- Food
- Shoes, Shirts
- Communication
- What you can buy in a super market!

3. Energy chains and energy systems

Categories of energy:

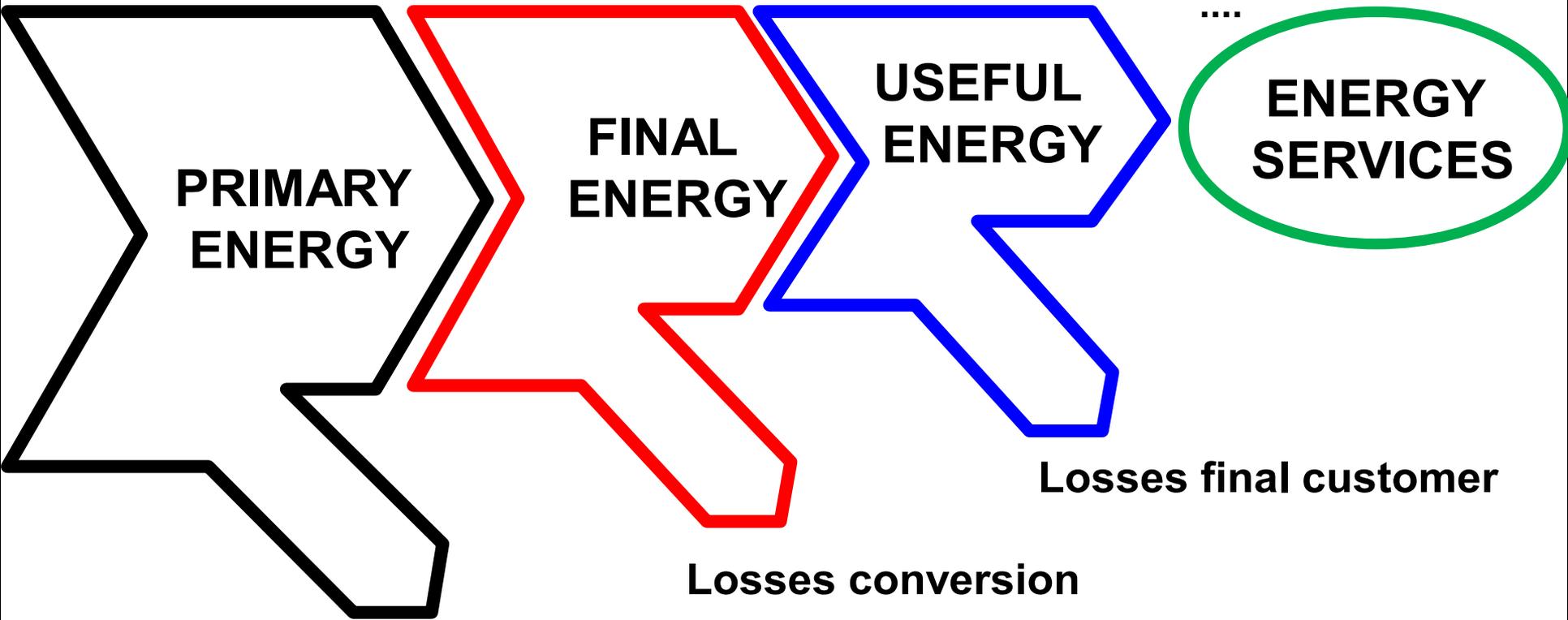
Crude oil, wood, coal, natural gas, solar, hydro, nuclear

Gasoline, electricity, pellets, district heat

Heat, light, mechanical work,

Warm and bright rooms, mobility

....



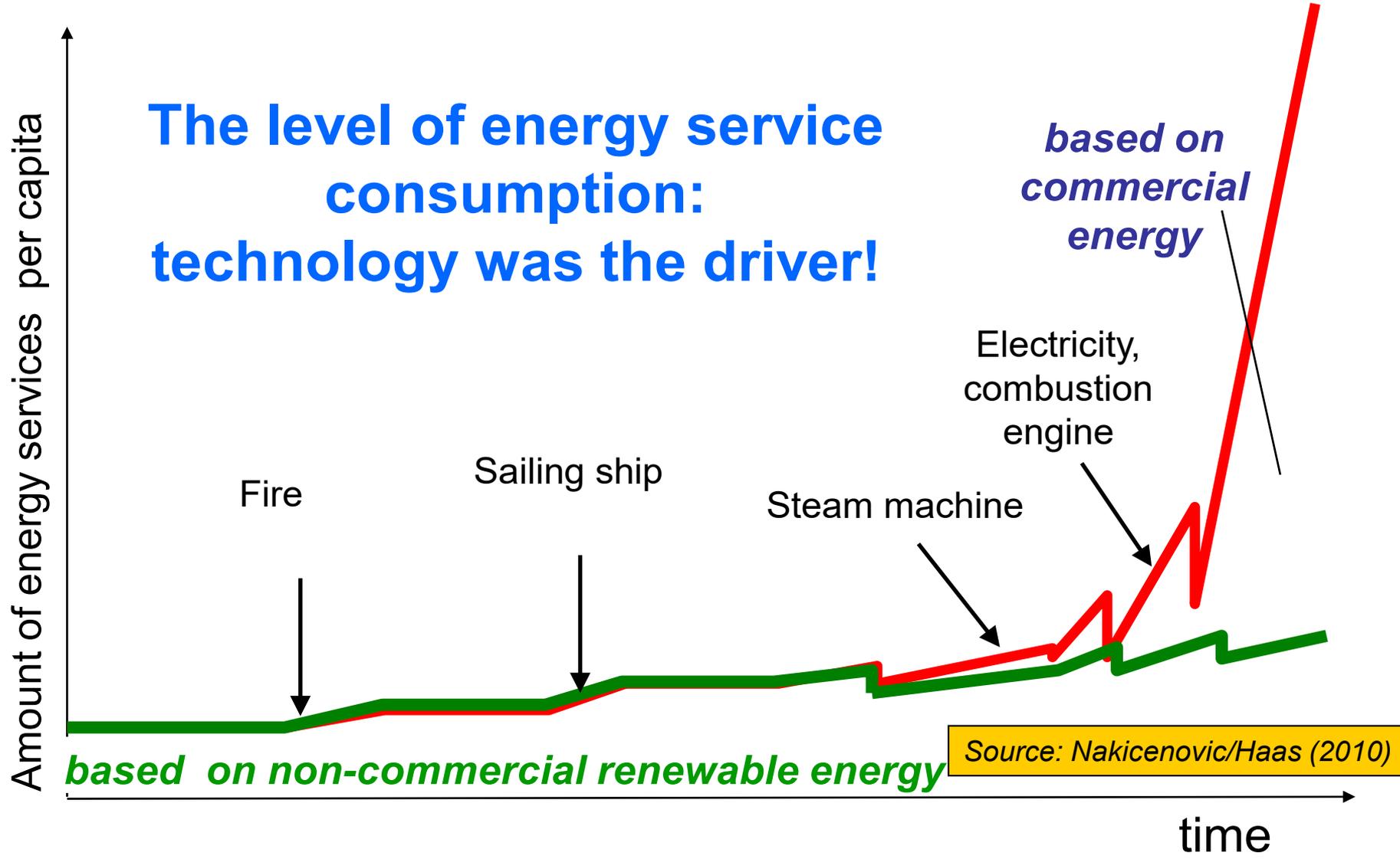
Losses exploration and transport

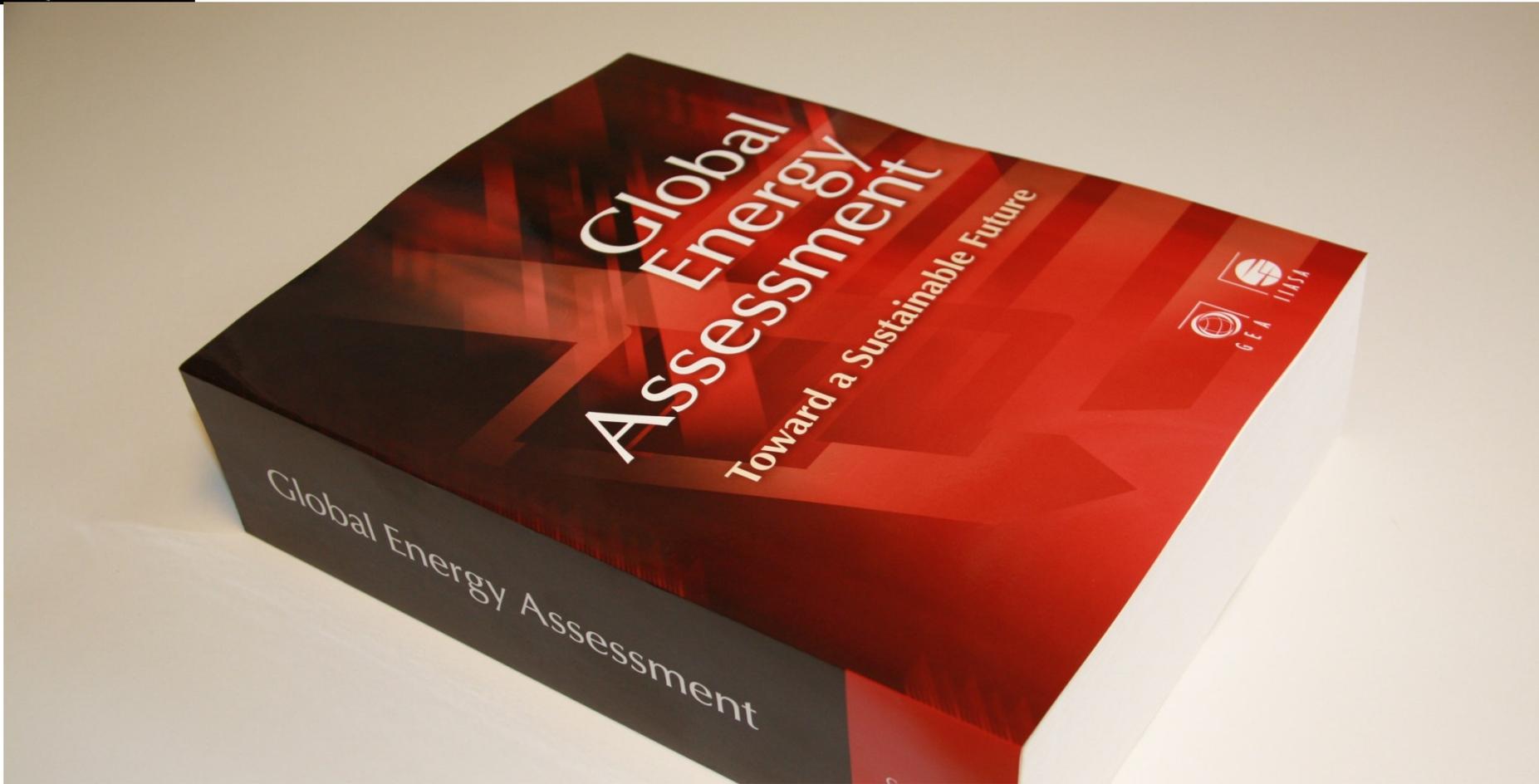
Losses conversion

Losses final customer

4. Dynamics: Why history is important

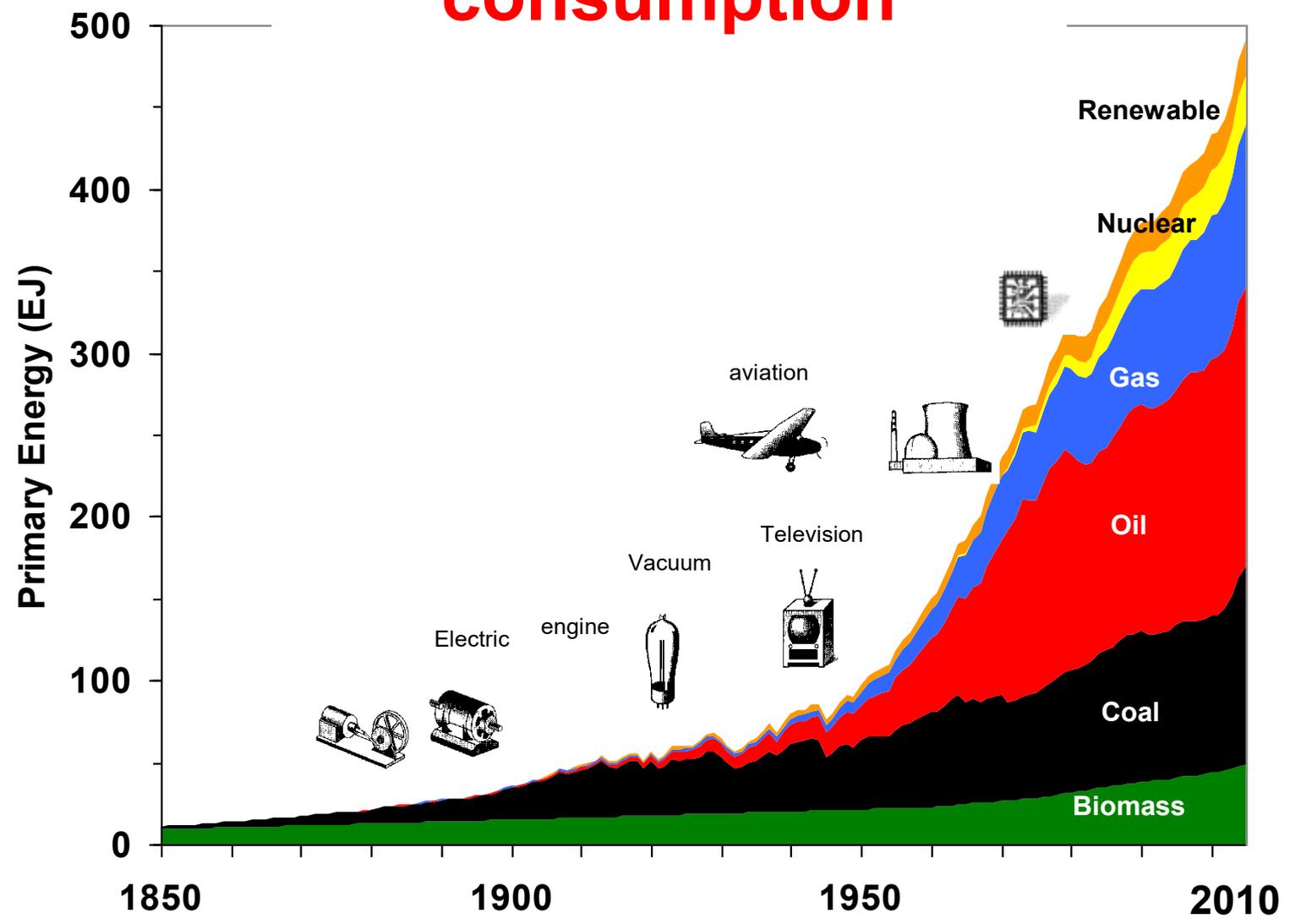
The level of energy service consumption:
technology was the driver!





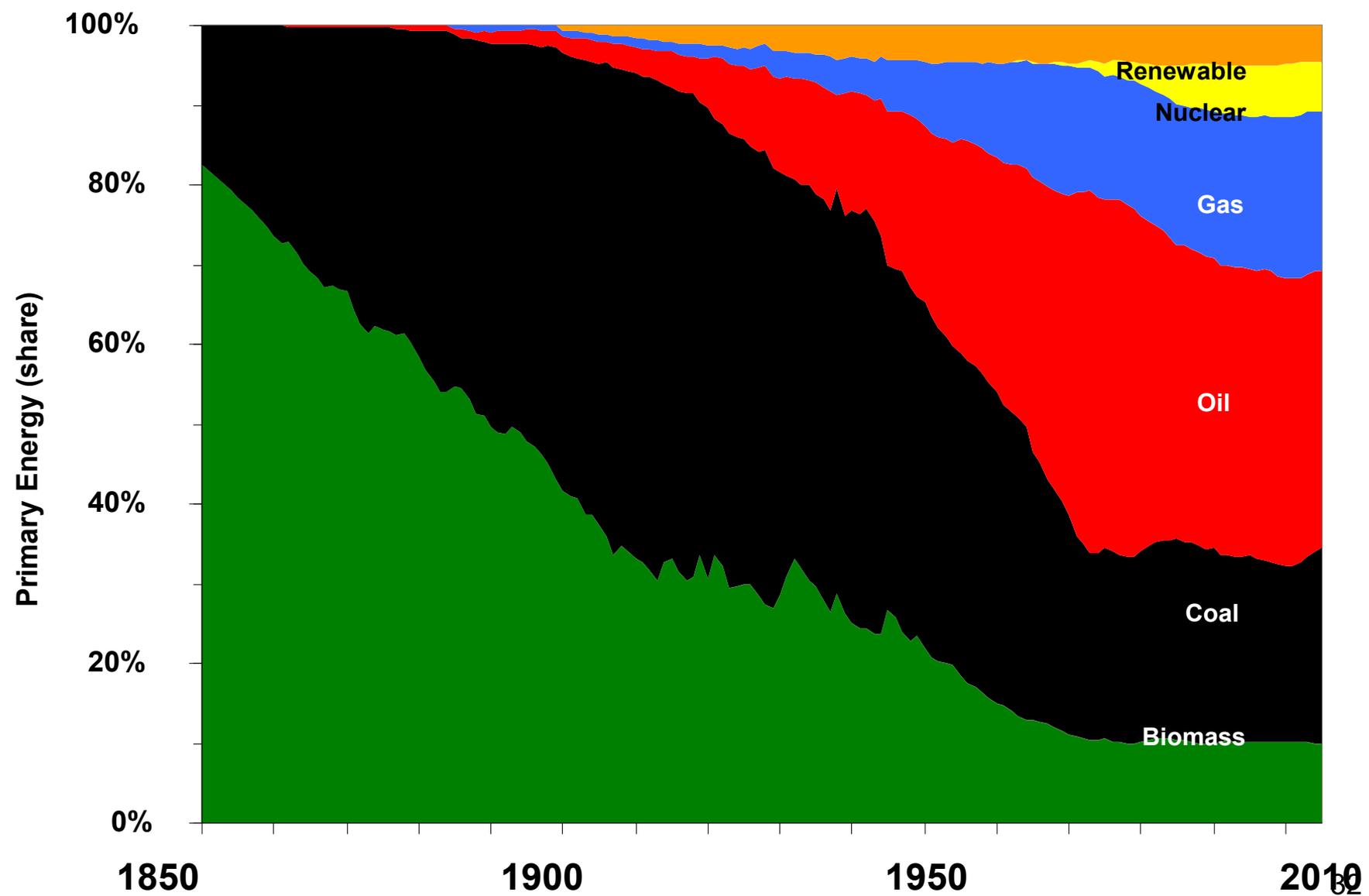
- **Total Effort: 300 Authors; 200 Reviewers
> 6 years >> 6m € and >> 100 p-years**

World Primary Energy consumption



Source: GEA (2012)

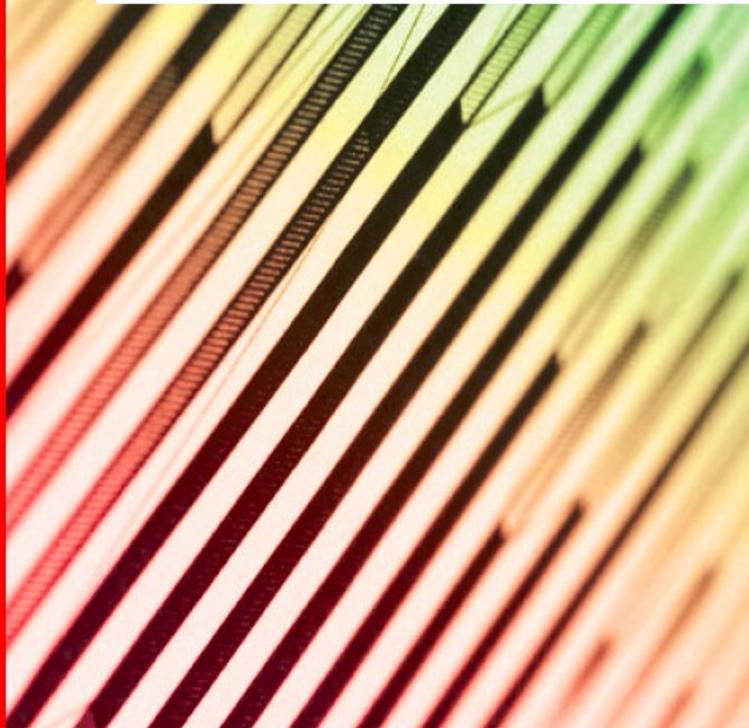
Shares of PE world-wide



Source: GEA (2012)

Key world energy statistics

Also available on smartphones and tablets



Statistics report

Key World Energy Statistics 2020

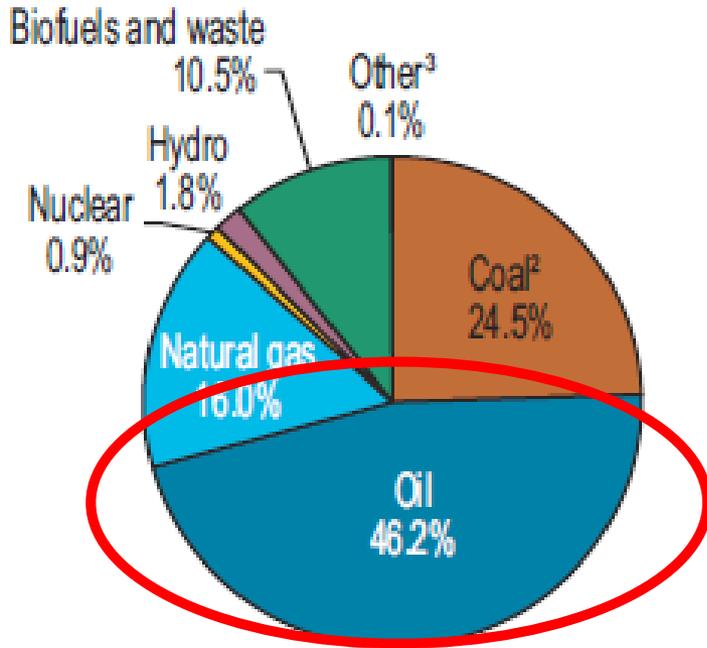
August 2020



iea

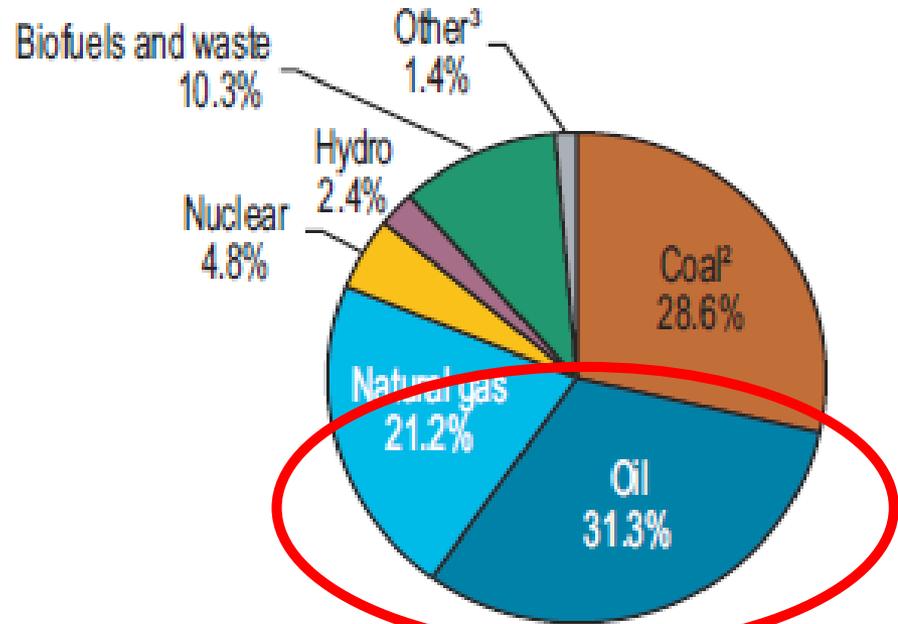
World: Primary energy

1973



6 101 Mtoe

2017

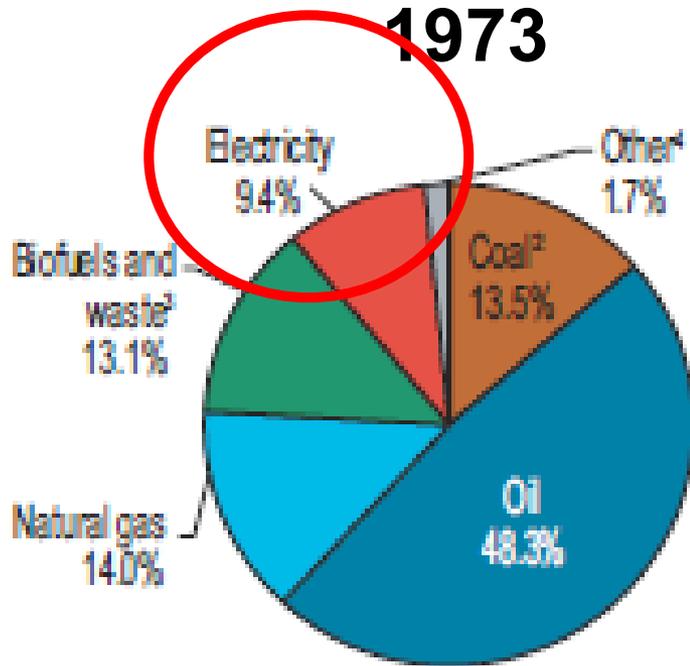


13 699 Mtoe

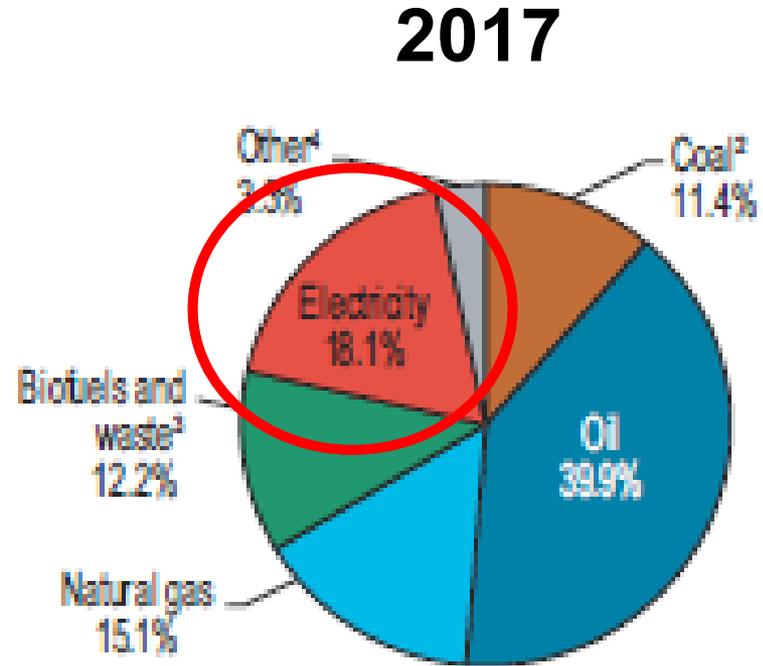
Source: IEA 2019

- **Total primary energy demand more than doubled between 1973 and 2017;**
- **Oil down (more than -30%!), Gas up, Coal up!**³⁴

World: Final energy



4674 Mtoe

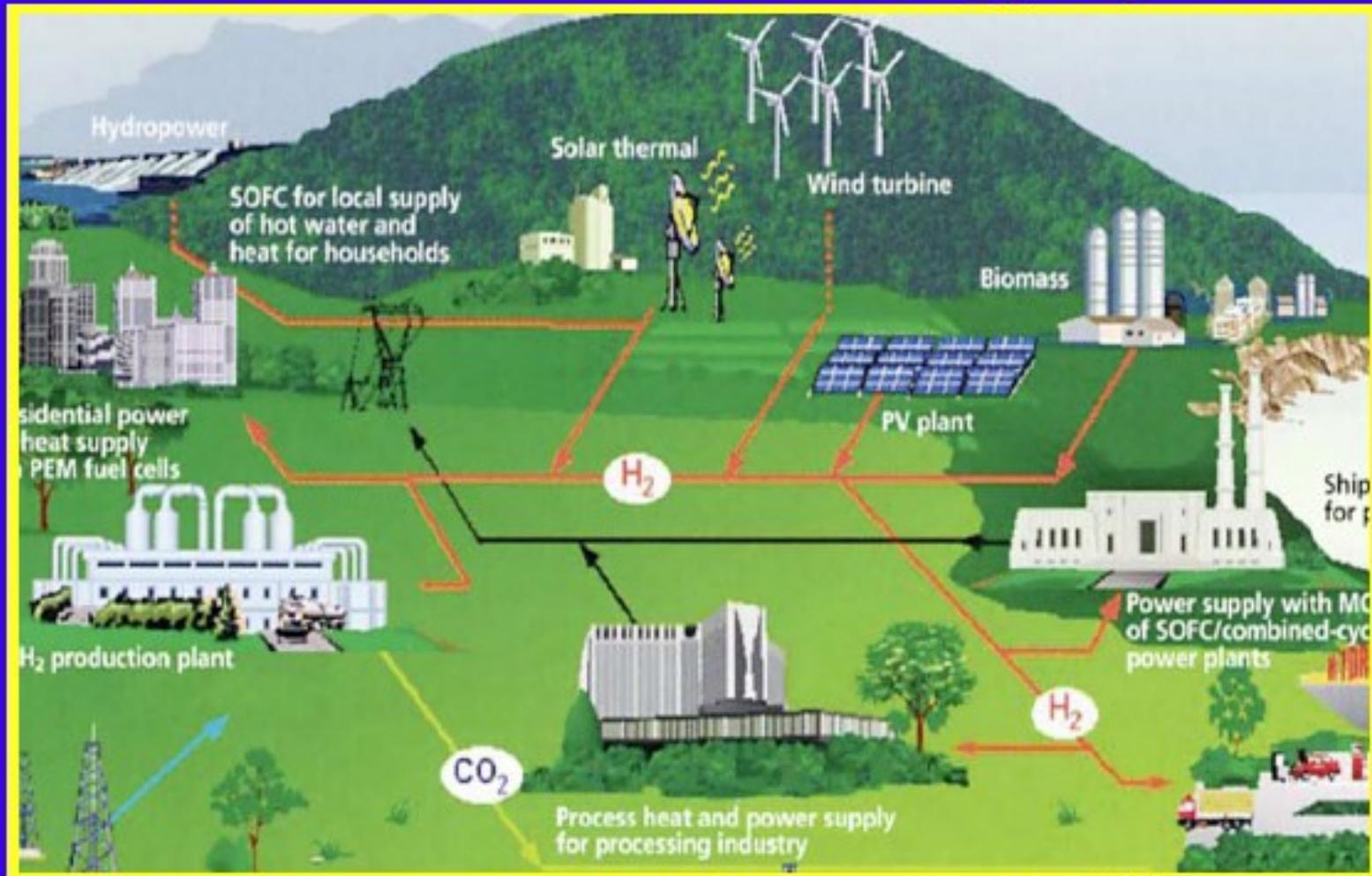


9425 Mtoe

- The **share** of electricity increases continuously:
In 2017 twice of 1973
- Share of oil decreased from 48% to 40%

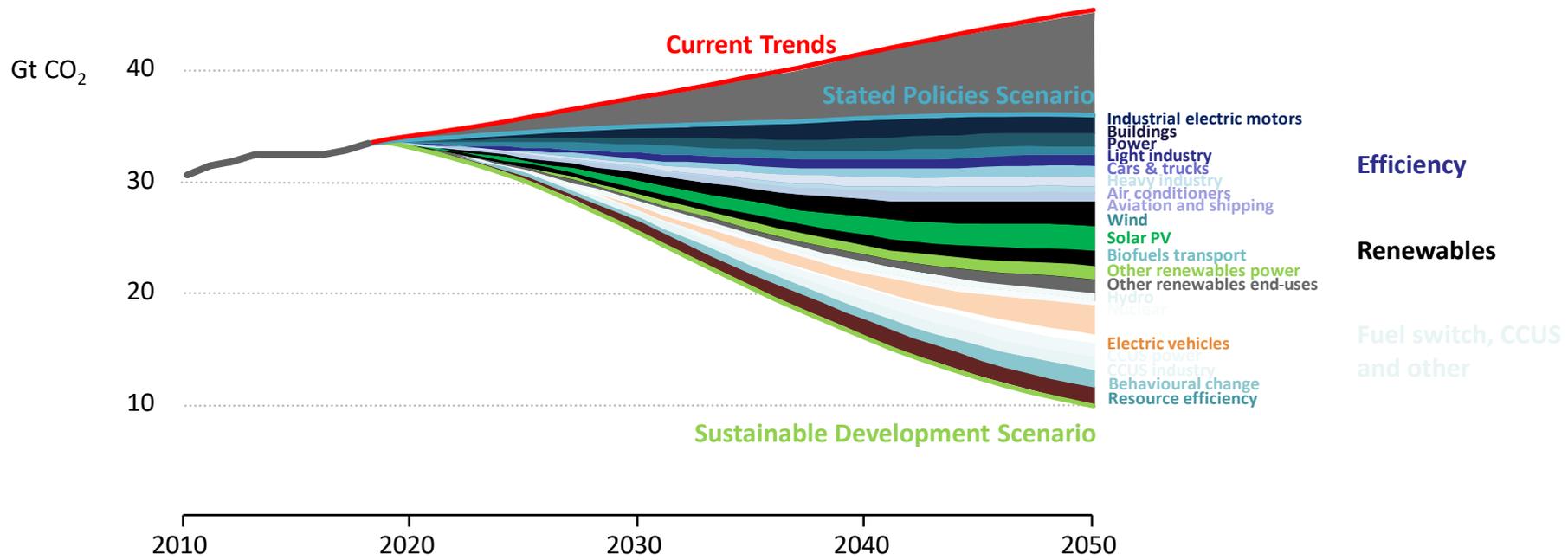
** Other includes Solar, Geothermal, Wind

5. VISIONS OF FUTURE ENERGY SYSTEM



No single or simple solutions to reach sustainable energy goals

Energy-related CO₂ emissions and reductions in the Sustainable Development Scenario by source



A host of policies and technologies will be needed across every sector to keep climate targets within reach, and further technology innovation will be essential to aid the pursuit of a 1.5°C stabilisation



FOR FURTHER INFORMATION:

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