CZ-AT WINTER-SUMMER SCHOOL 2020

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

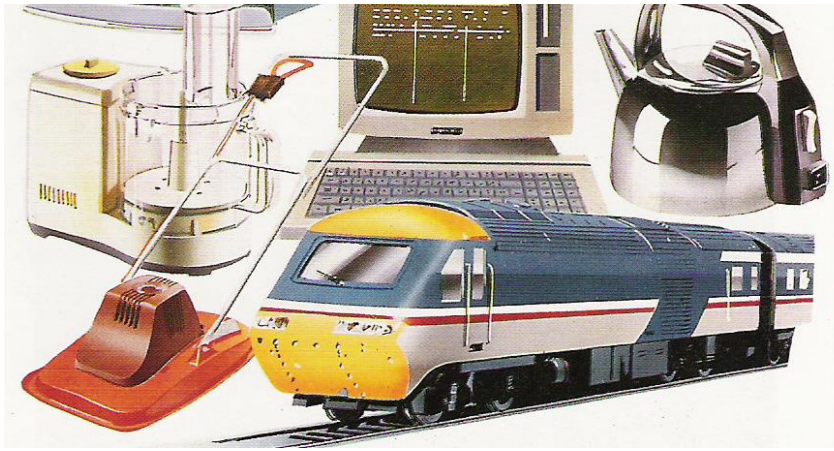
5. Visions of future energy systems

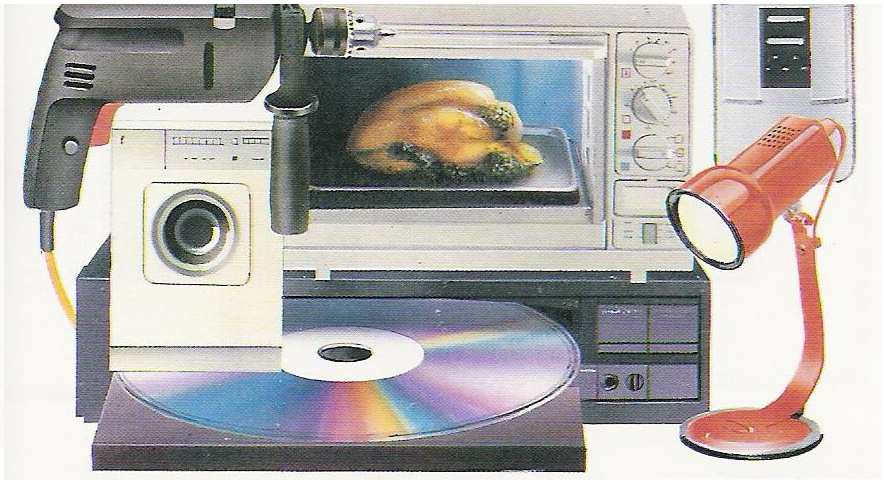
1. Motivation

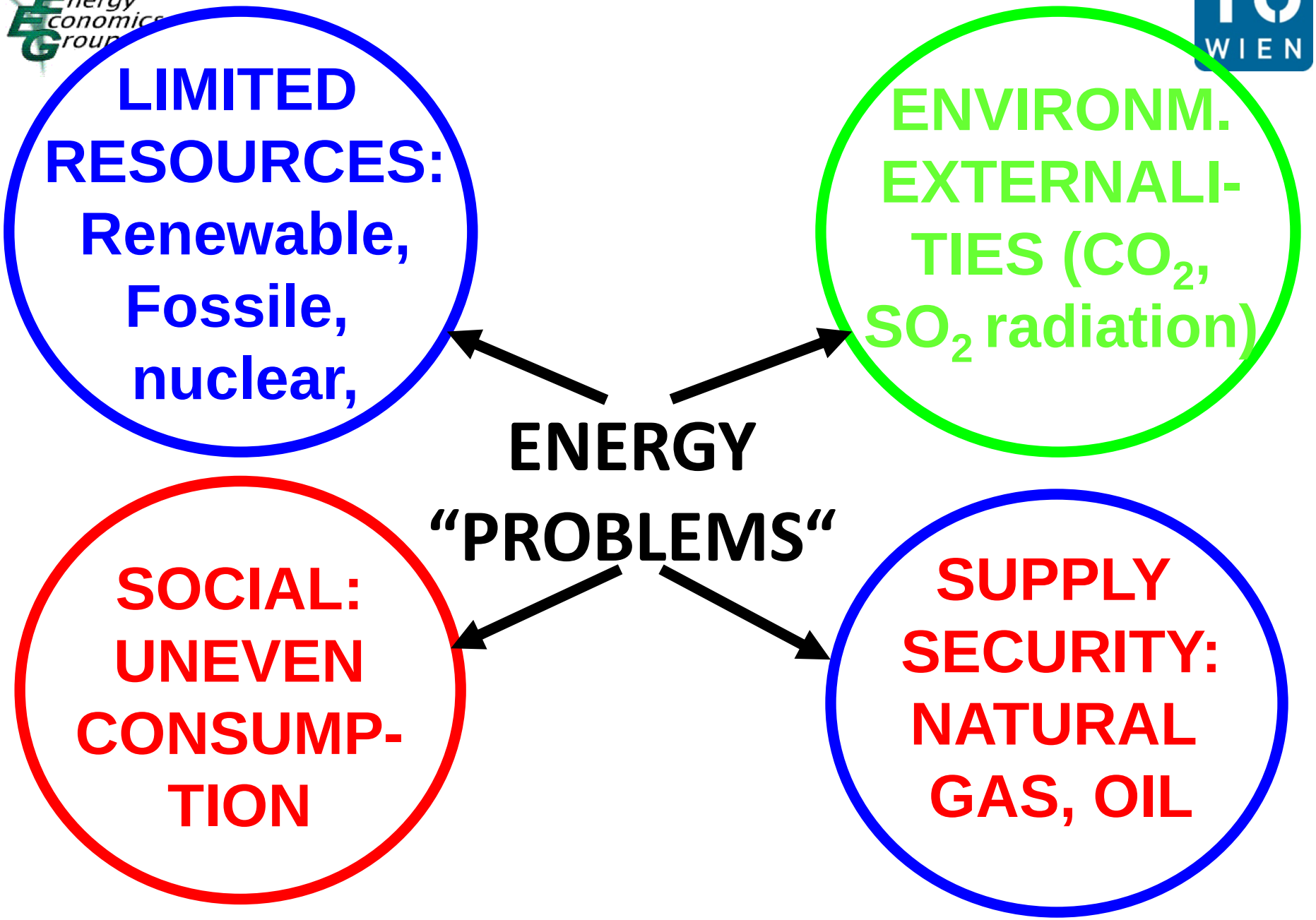
Why are we here today?

- Energy is the fundament of our standard of life today
- Every second of our life – even in deep sleep – we „consume“ energy

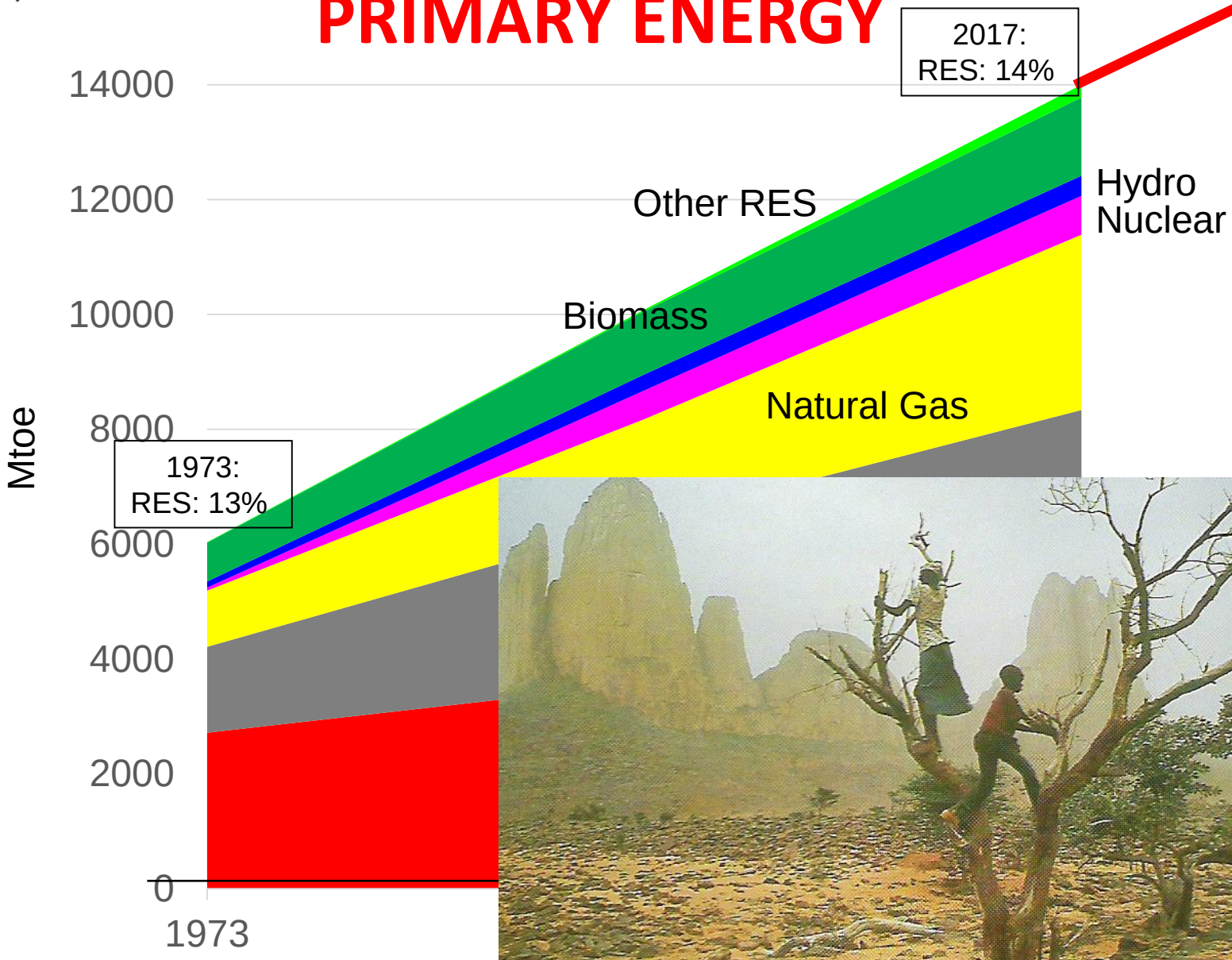
- Dramatic increase in energy consumption in recent years!
- Dramatic increase in **electricity** consumption in the next decades expected!






LIMITED RESOURCES: Renewable, Fossile, nuclear,
ENVIRONM. EXTERNALI-TIES (CO_2, SO_2 radiation)
ENERGY "PROBLEMS"
SOCIAL: UNEVEN CONSUMP-TION
SUPPLY SECURITY: NATURAL GAS, OIL

WORLD-WIDE TREND IN PRIMARY ENERGY



Source: IEA (2019)

The Key Energy Challenges

Energy Access

Climate Change

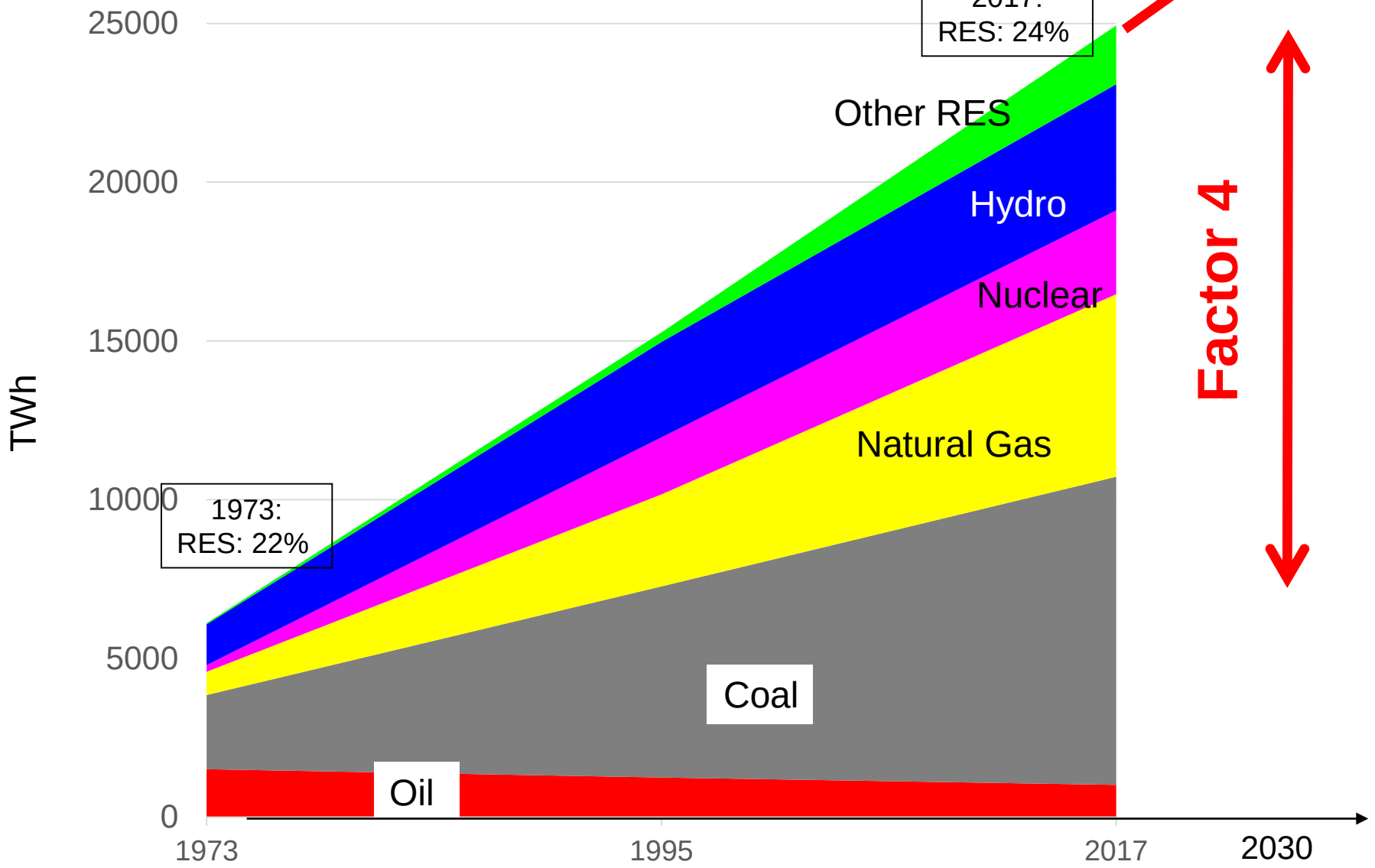
Air Pollution Health Impacts

Energy Security

Wood for Cooking

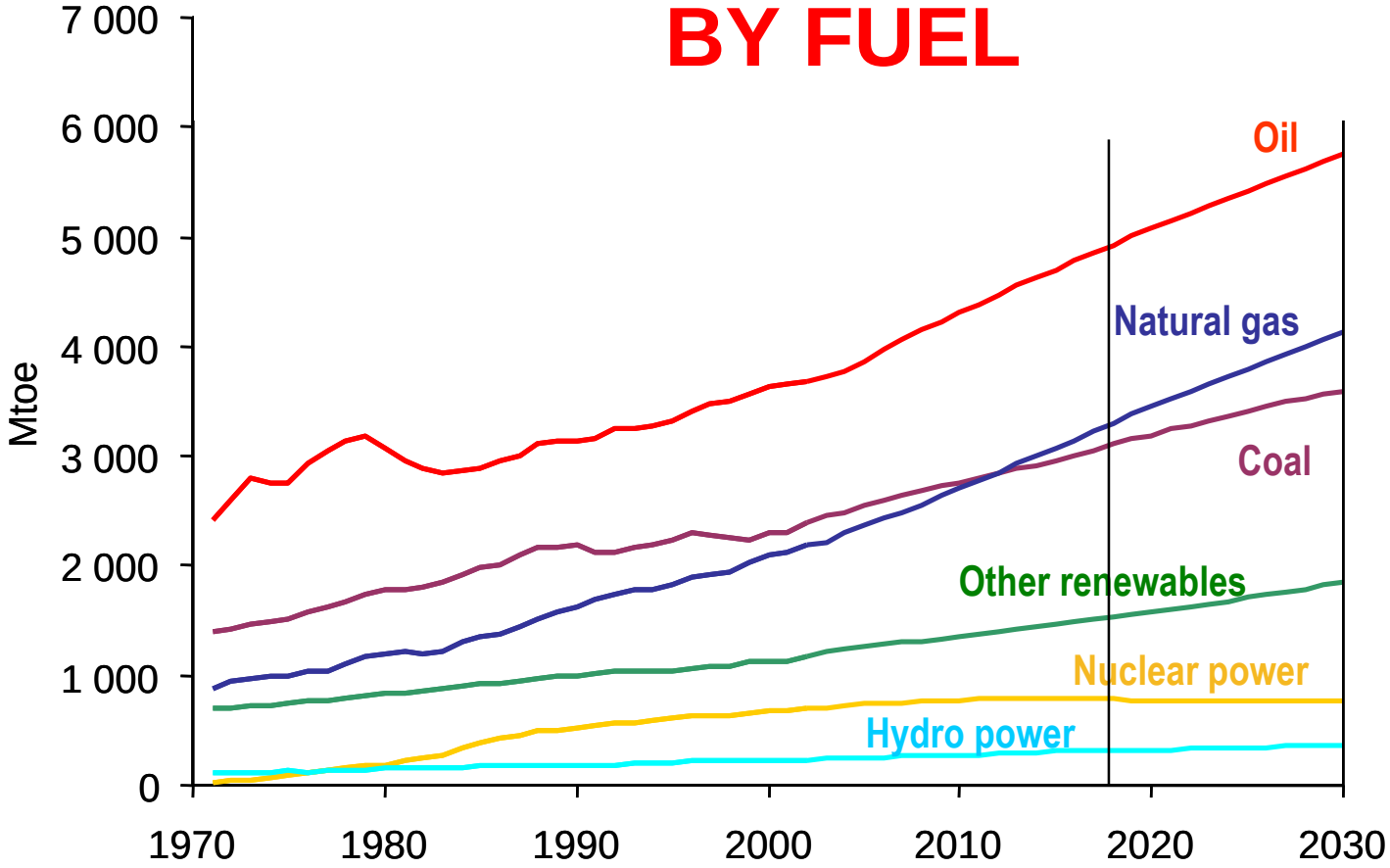
Source: Modi, 2011 and Yumkella, 2013

WORLD-WIDE TREND IN ELECTRICITY CONSUMPTION



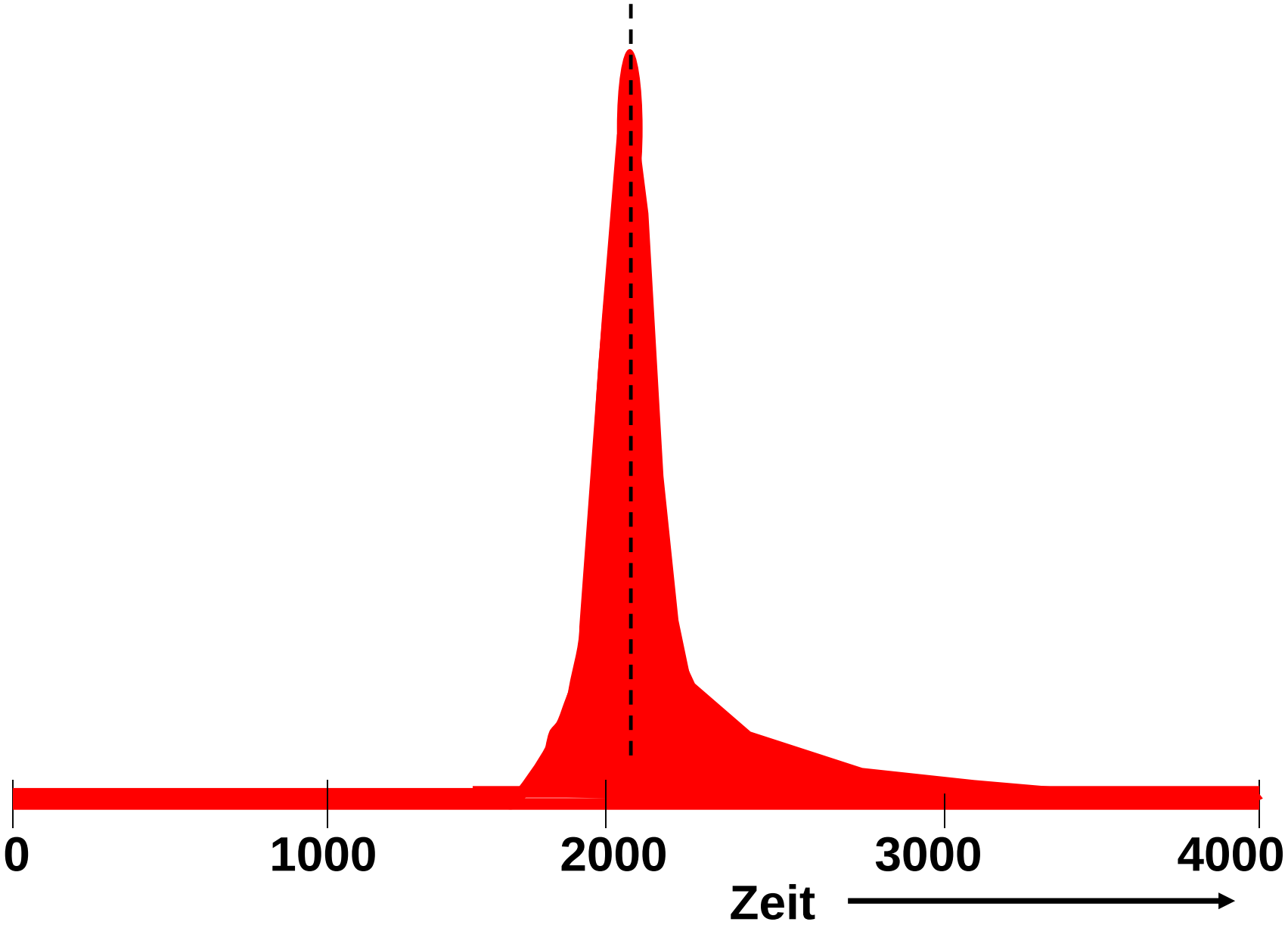
Source: IEA (2018)

PRIMARY ENERGY: TRENDS BY FUEL



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

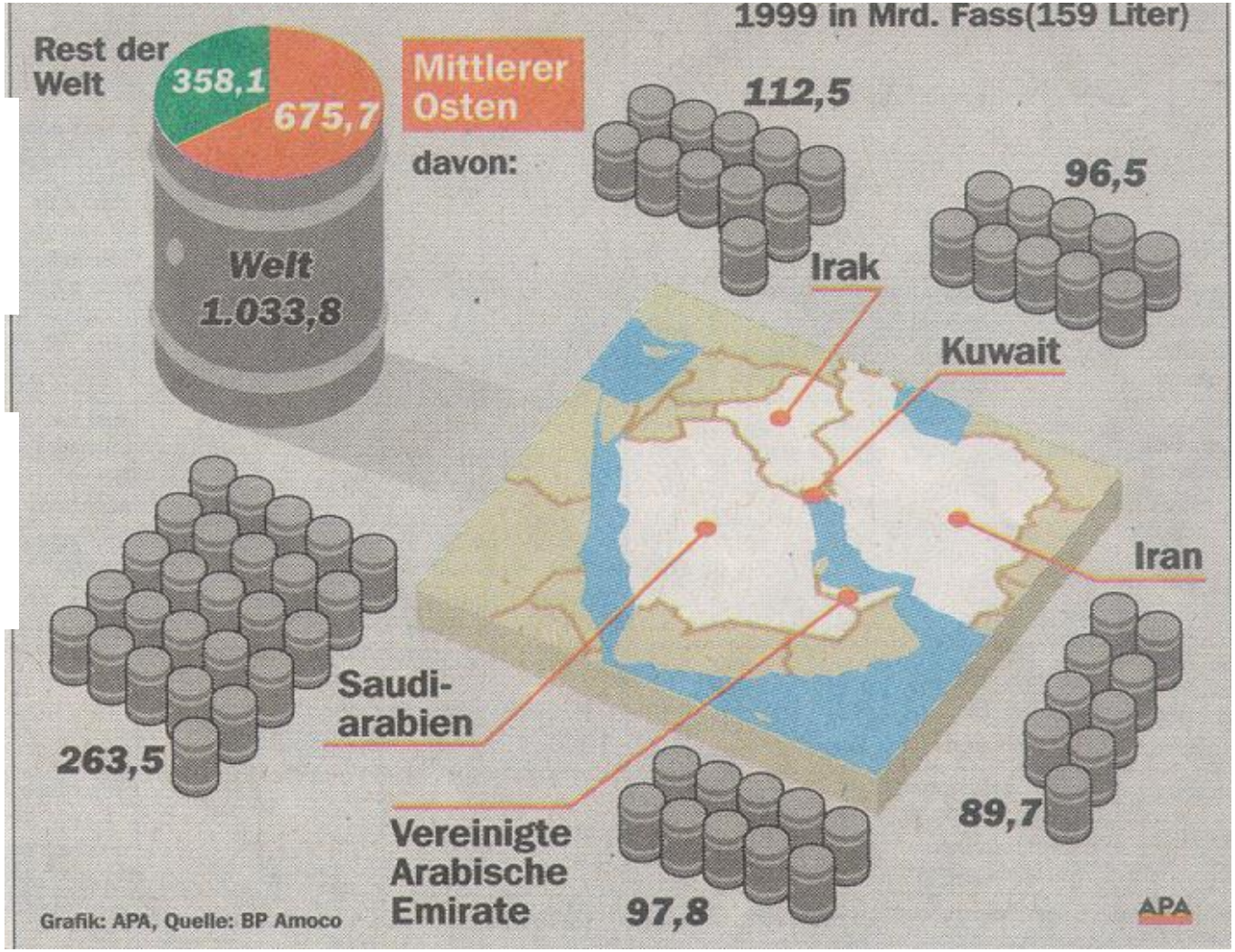
Oil consumption over time



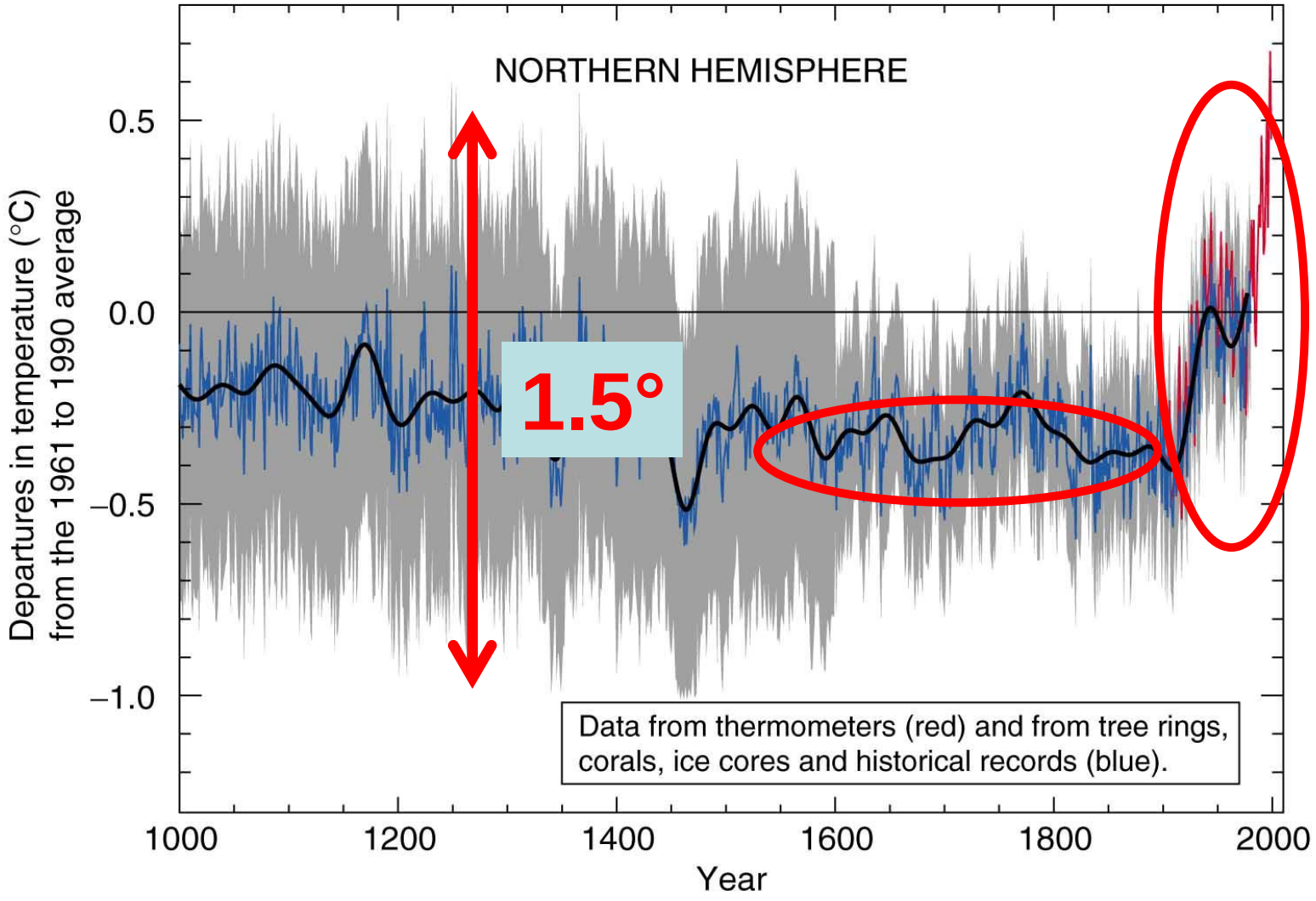
Oil reserves in the Middle East

Middle East: 2/3

Rest of world: 1/3

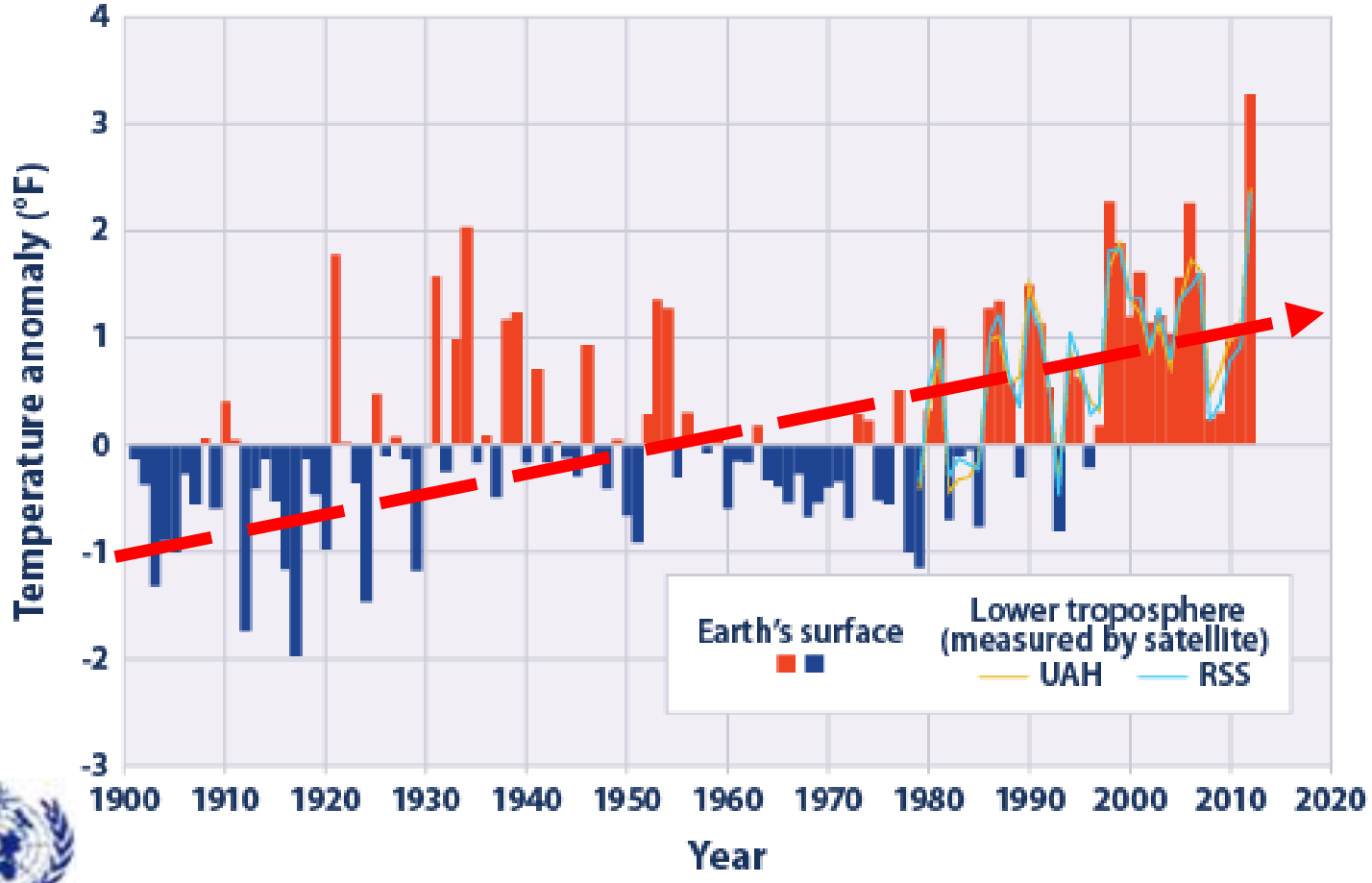


Long-term Variations of Earth's Surface temperature in the past 1000 years

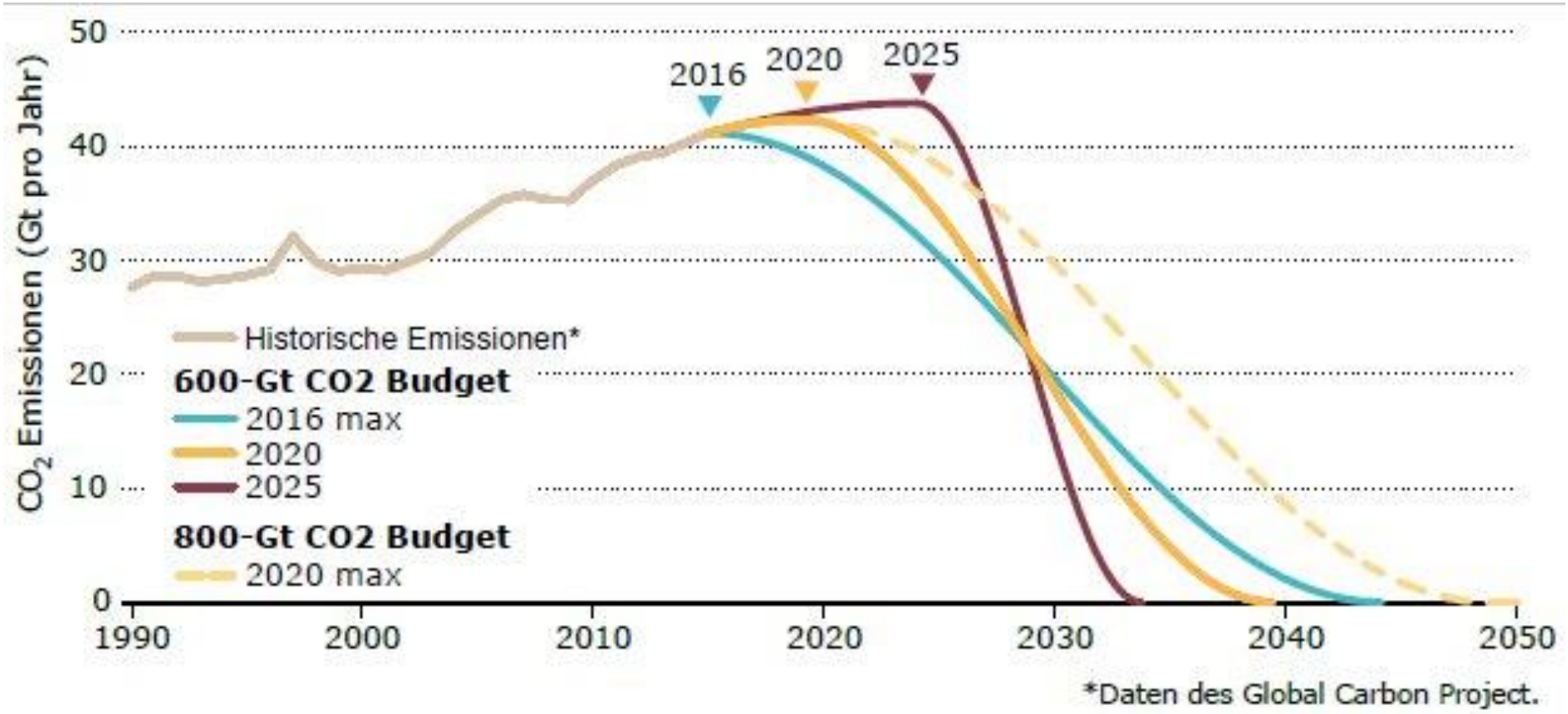


Source: IPCC, 2001a

Variations of Earth's Surface temperature in the past 110 years

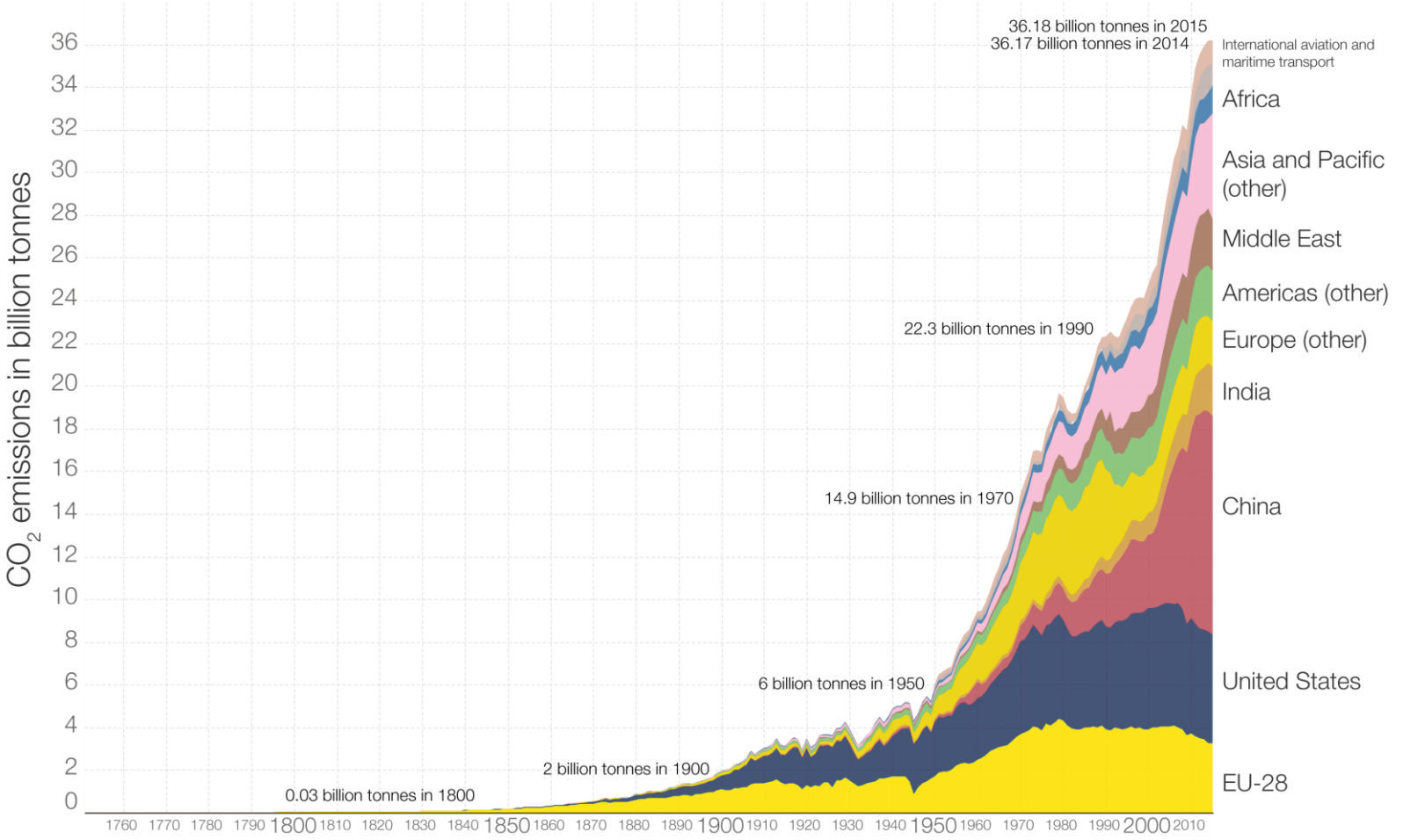


WMO


50
40
30
20
10
0
CO_2 Emissionen (Gt pro Jahr)
2016
2020
2025
Historische Emissionen*
600-Gt CO2 Budget
2016 max
2020
2025
800-Gt CO2 Budget
2020 max
1990
2000
2010
2020
2030
2040
2050
*Daten des Global Carbon Project.

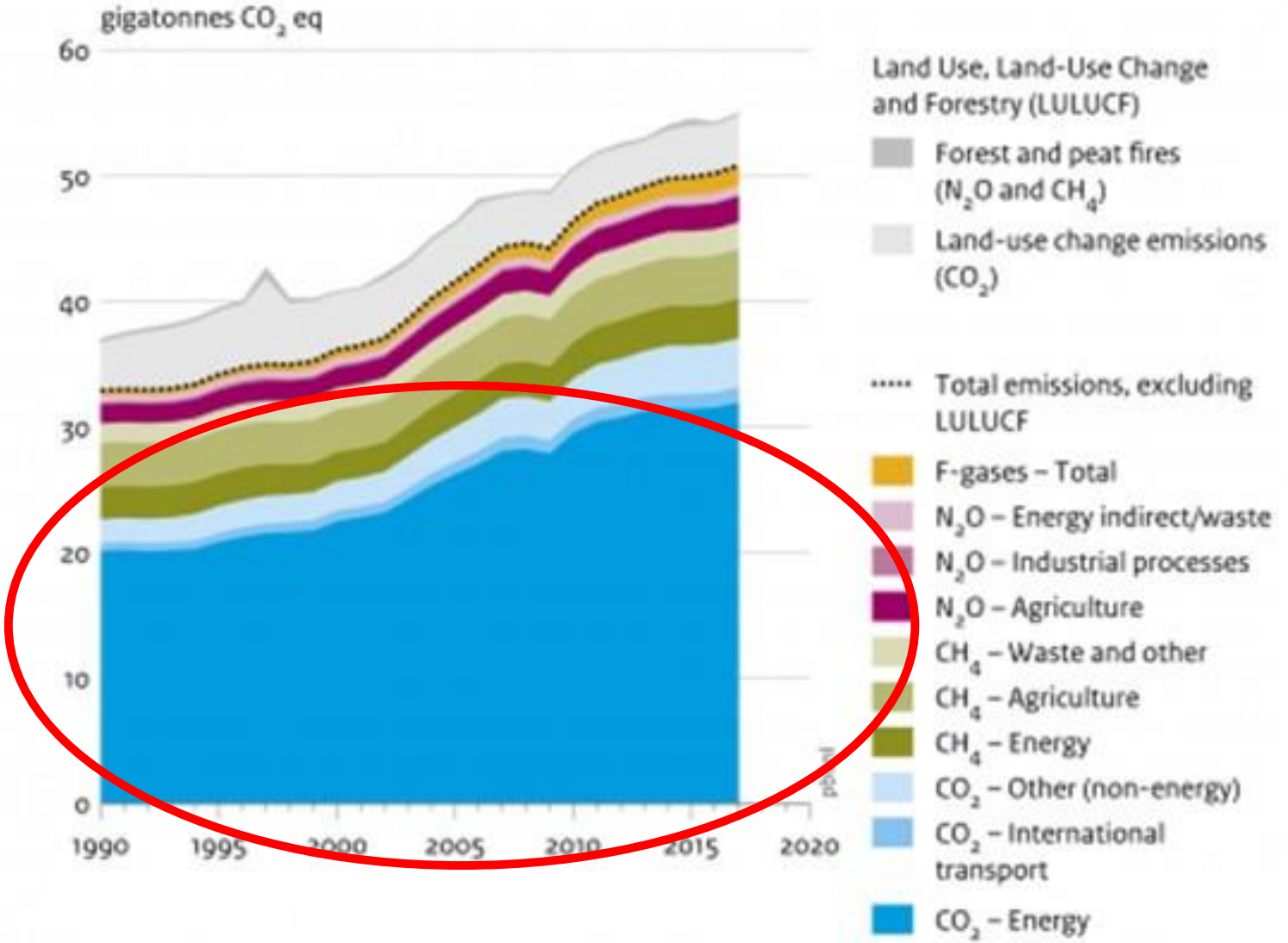
Global CO_2 emissions by world region, 1751 to 2015

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.

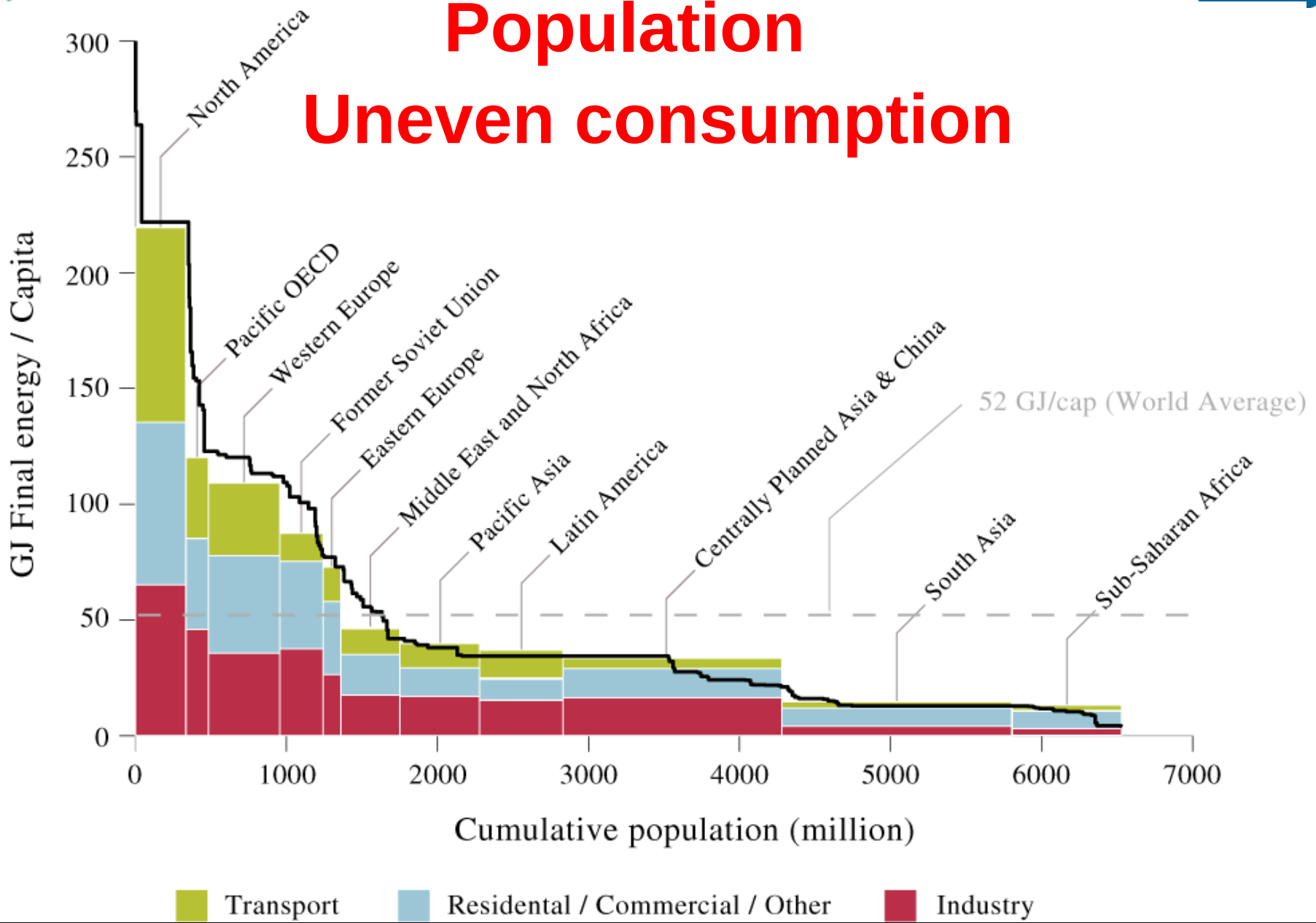
Global greenhouse gas emissions, per type of gas and source, including LULUCF



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

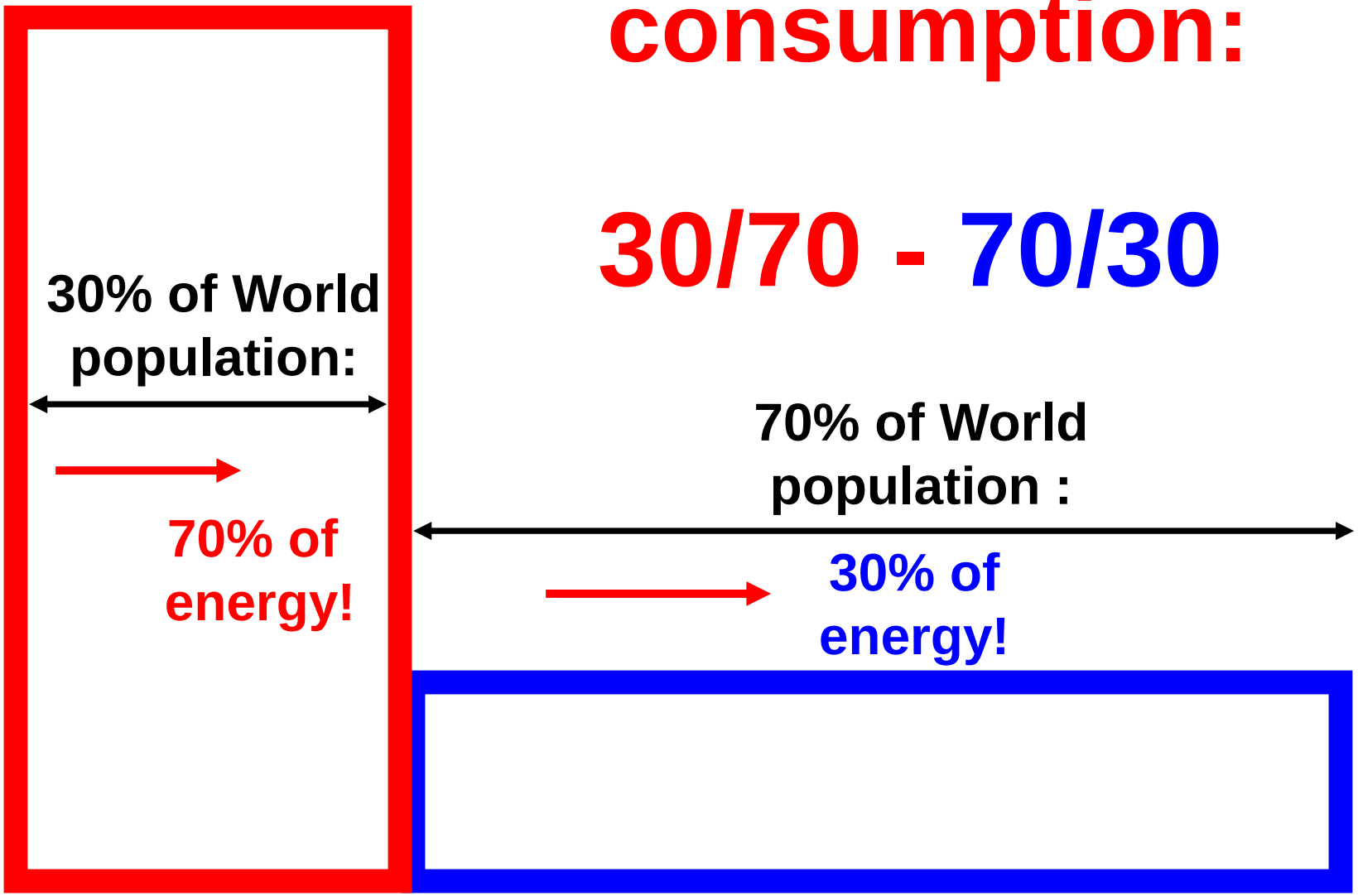
Source: EDGAR v5.0/v4.3.2 FT 2017 (EC-JRC/PBL, 2018); Houghton and Nassikas (2017)

Per Capita Final Energy & Population
Uneven consumption



Uneven consumption:

30/70 - 70/30

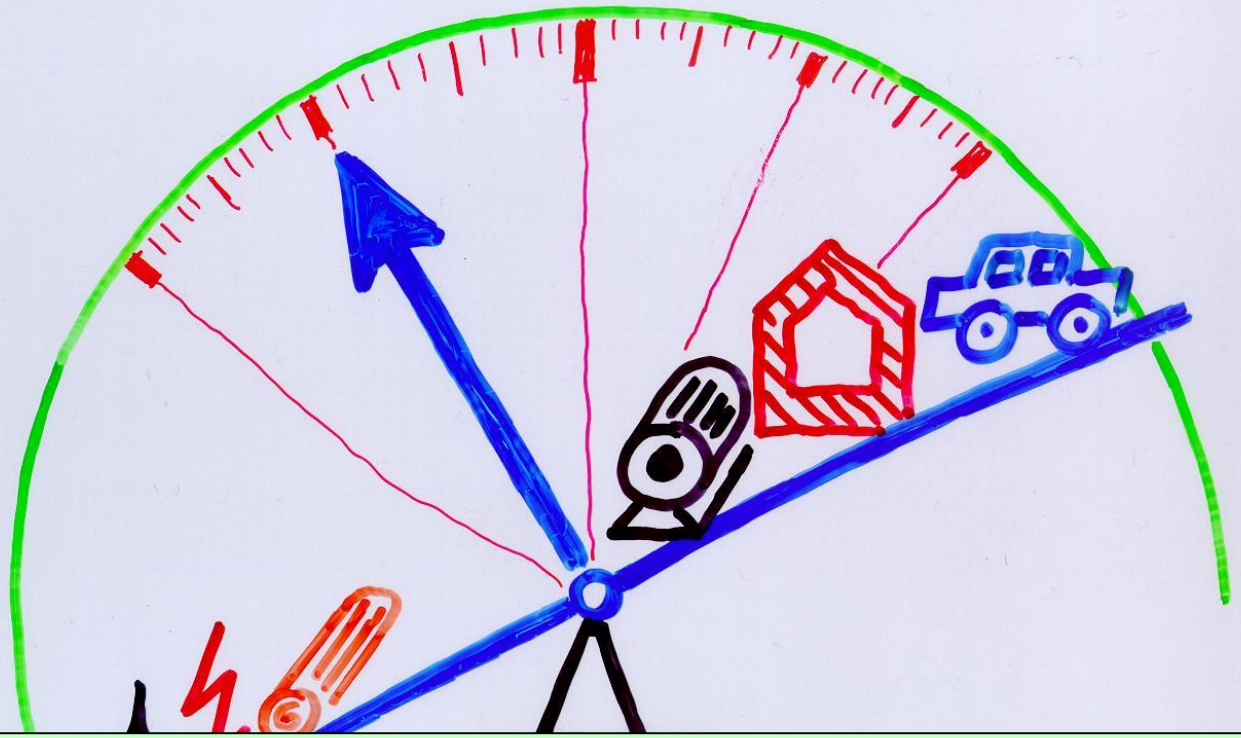


2. The basic concept of providing energy services

- 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:

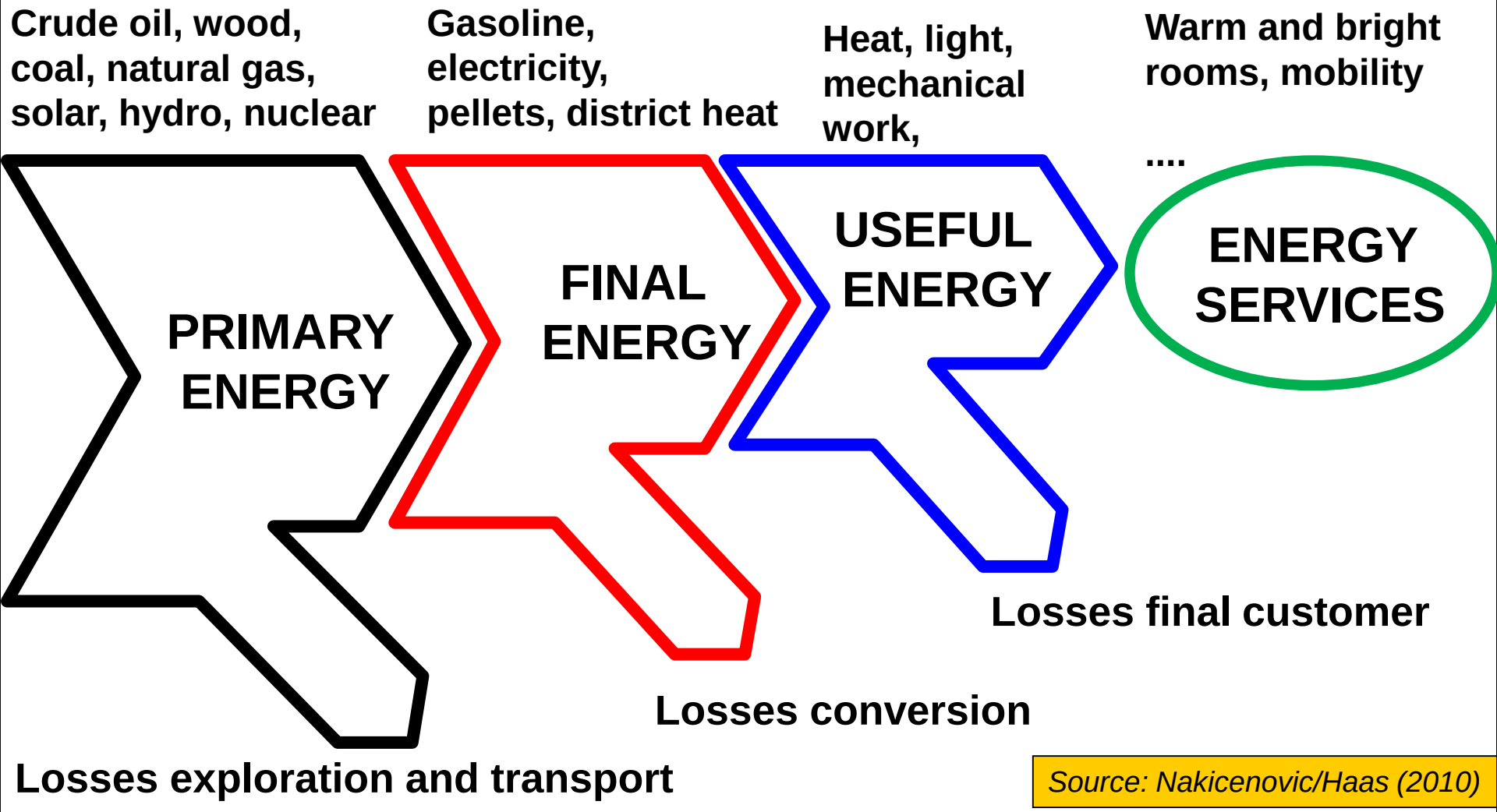
- Lighting
- Heating, cooking
- Mobility, Transport
- …

Indirect energy services:

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

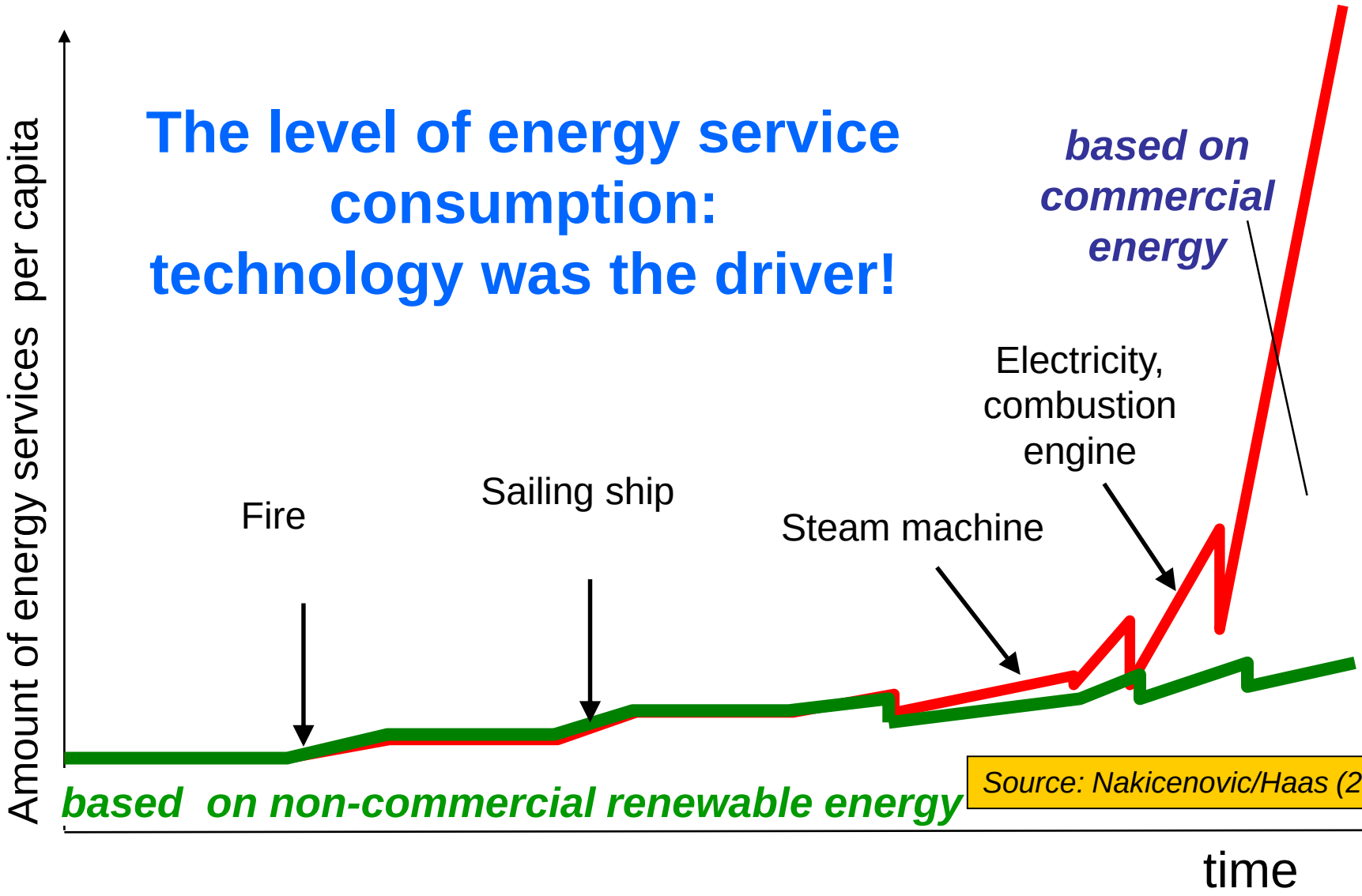
3. Energy chains and energy systems

Categories of energy:



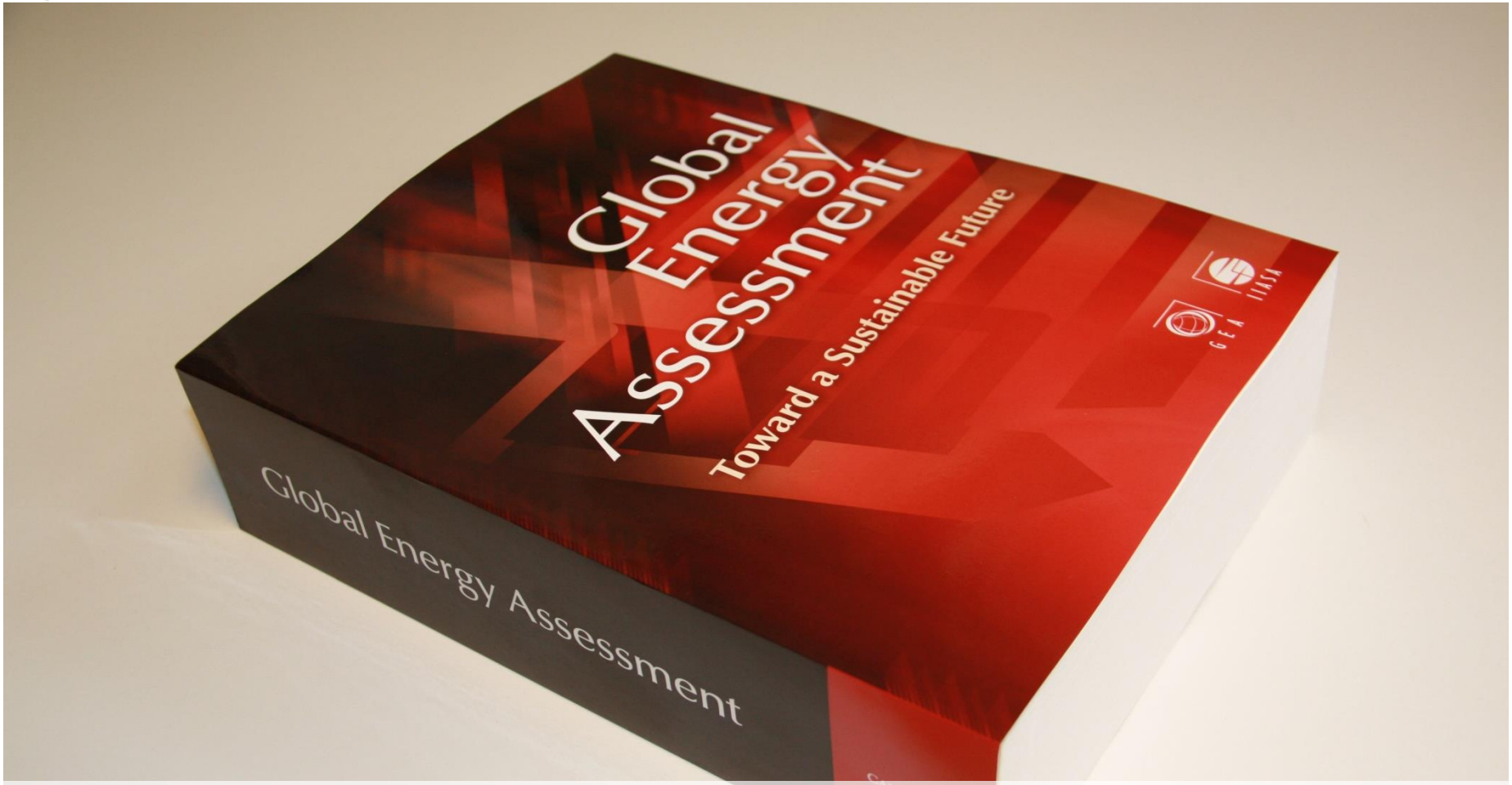
Source: Nakicenovic/Haas (2010)

4. Dynamics: Why history is important



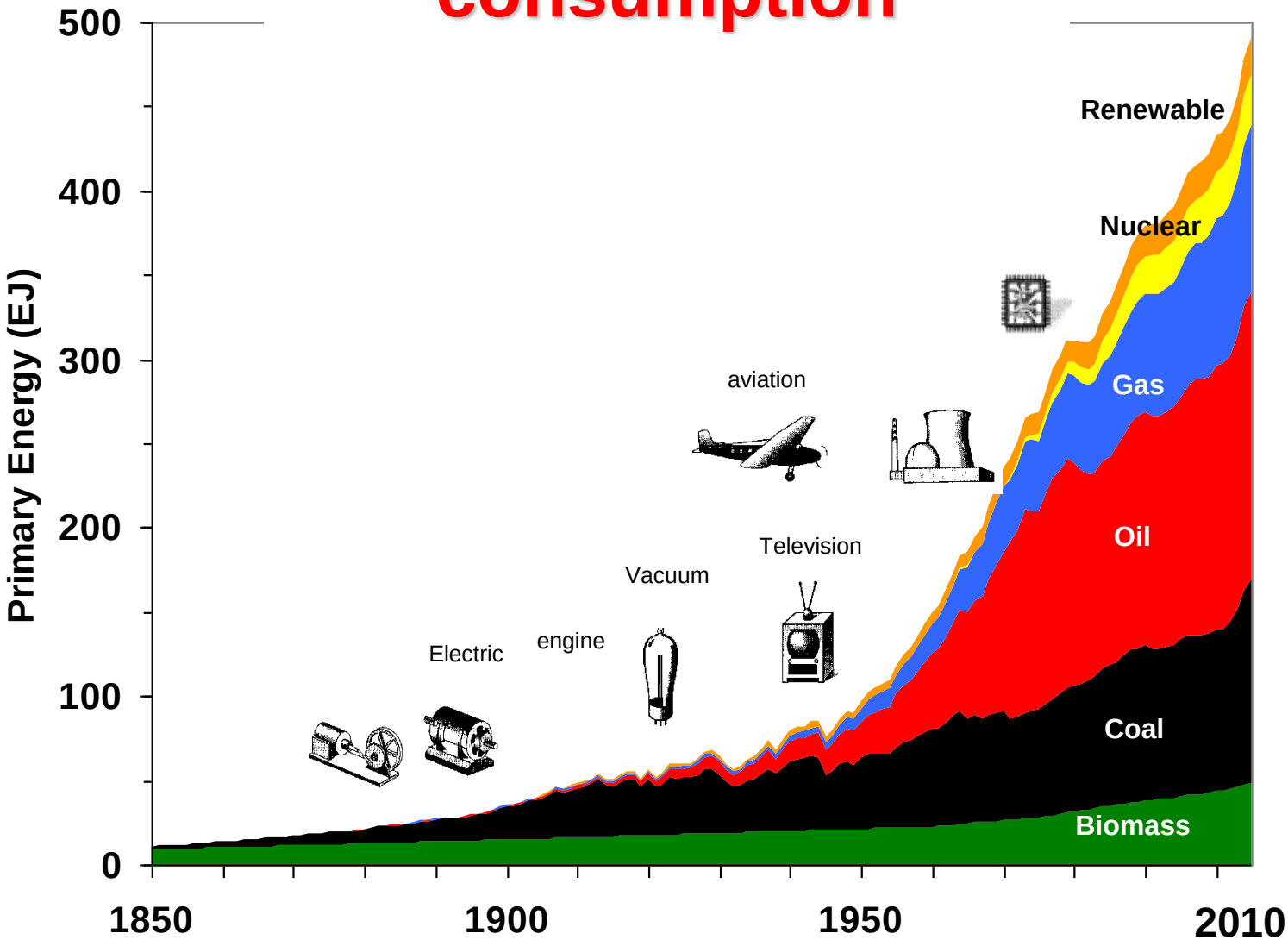
Source: Nakicenovic/Haas (2010)

www.GlobalEnergyAssessment.org



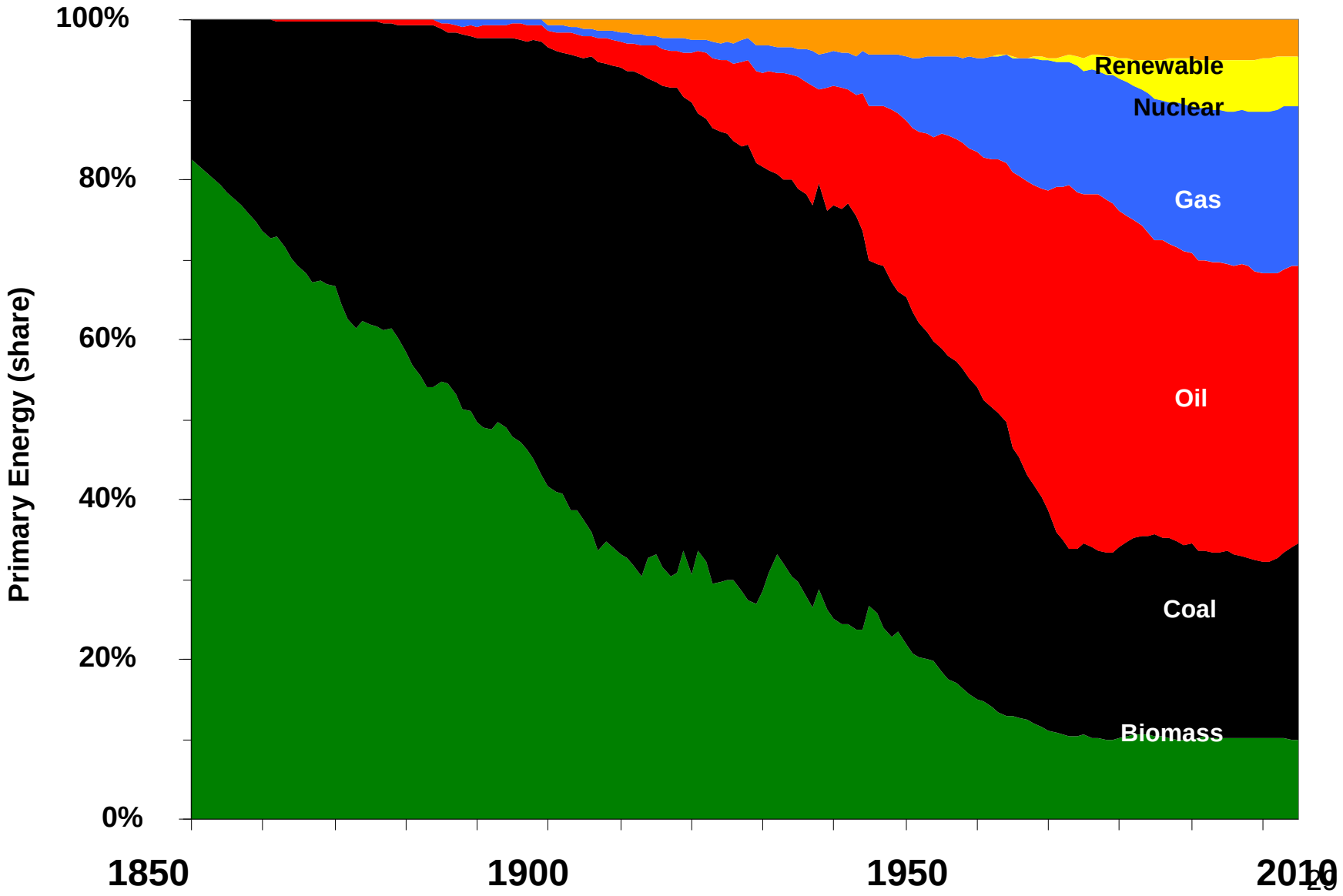
- **Total Effort: 300 Authors; 200 Reviewers**
  > 6 years >> 6m € and >> 100 p-years

World Primary Energy consumption

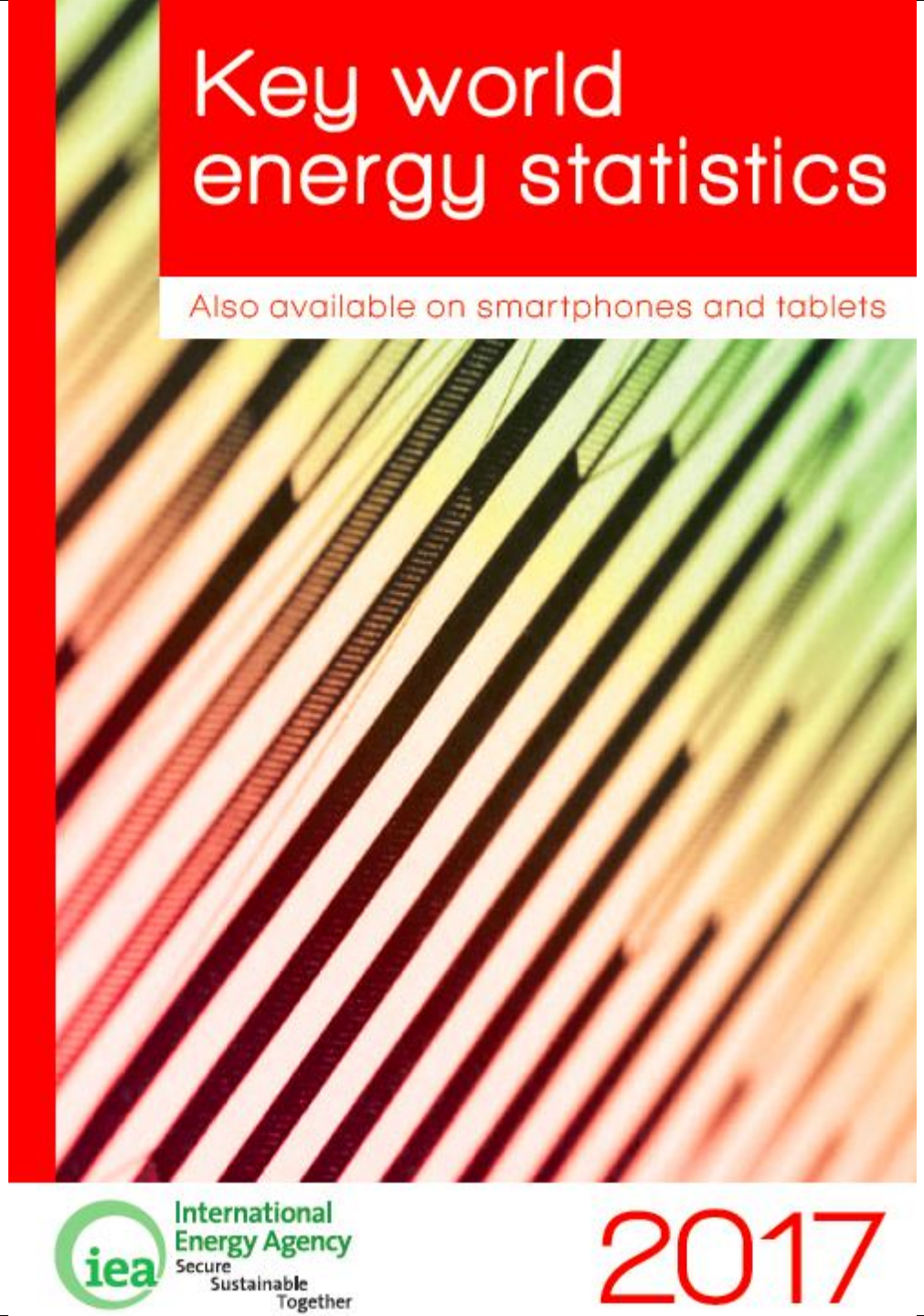


Source: GEA (2012)

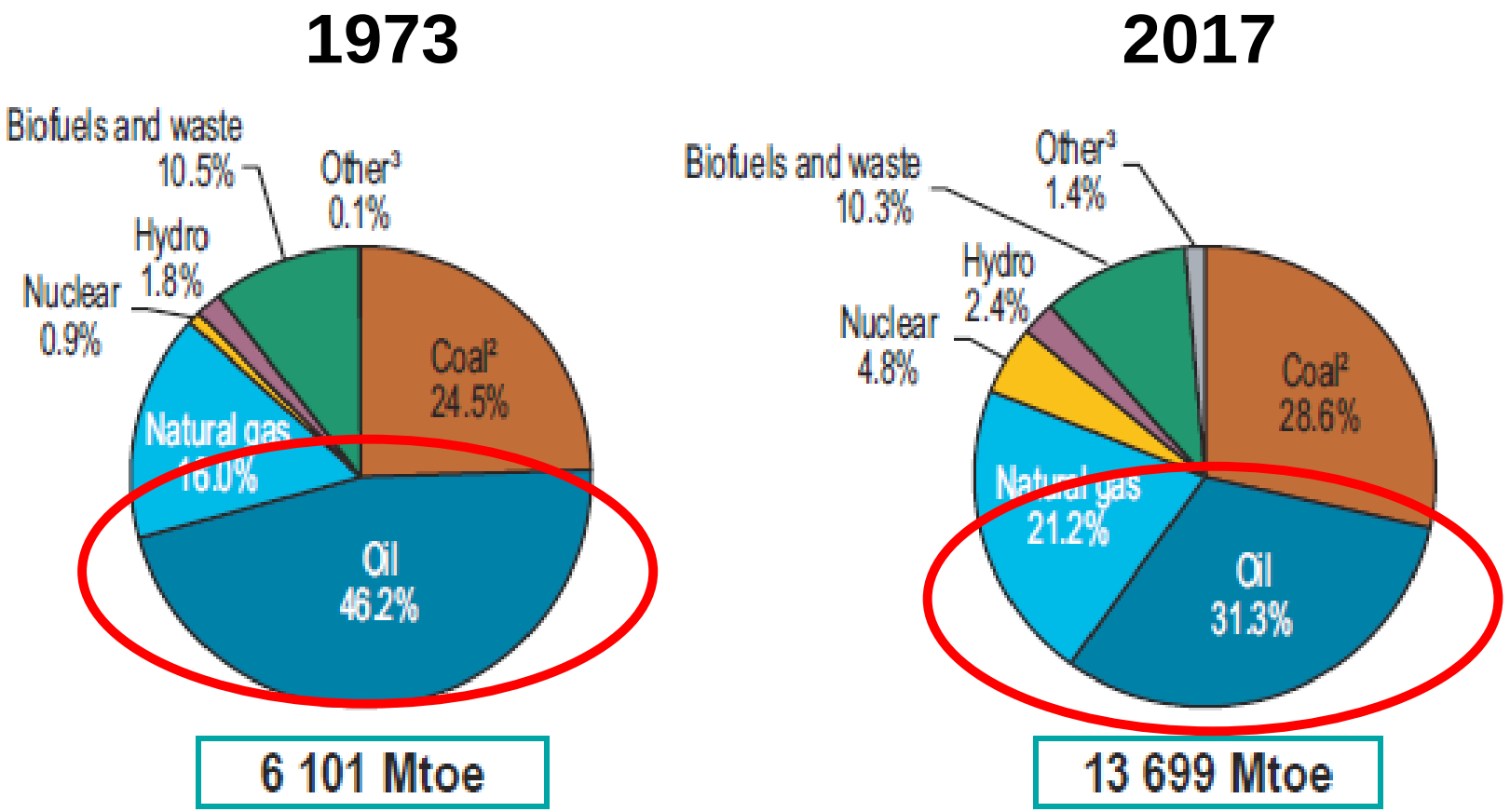
Shares of PE world-wide



Source: GEA (2012)


Key world energy statistics
Also available on smartphones and tablets
International Energy Agency
Secure Sustainable Together
2017

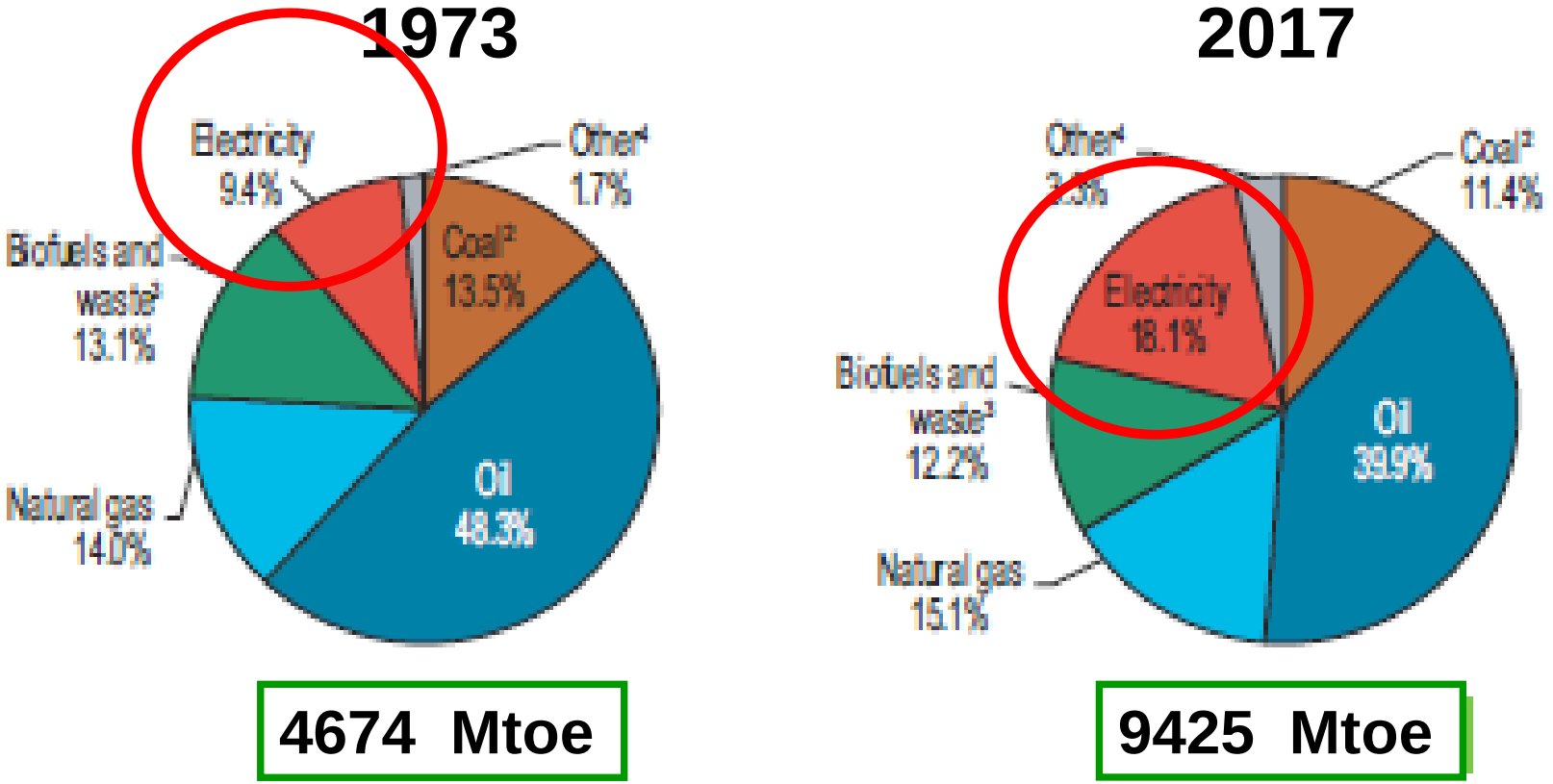
World: Primary energy



Source: IEA 2019

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

World: Final energy



4674 Mtoe

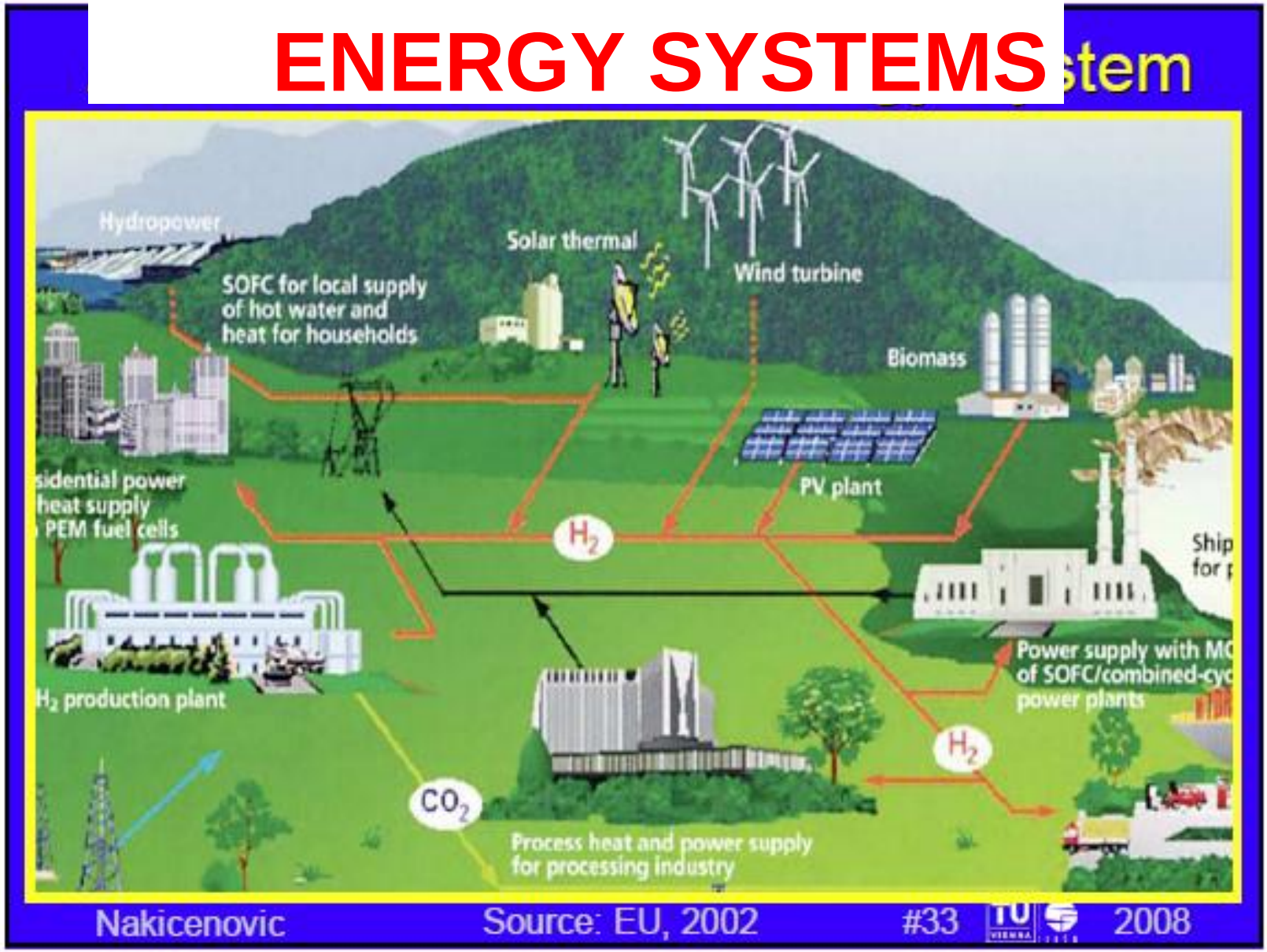
9425 Mtoe

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

** Other includes Solar, Geothermal, Wind

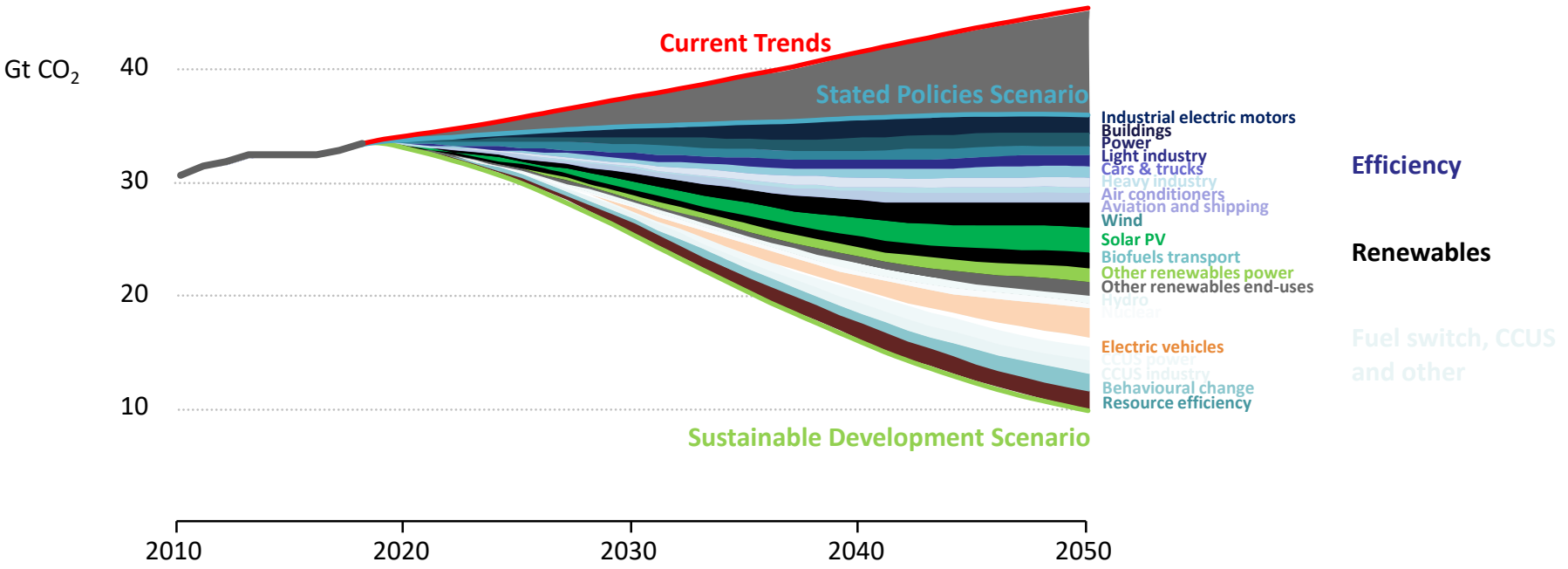
Source: IEA 2019

5. VISIONS OF FUTURE ENERGY SYSTEMS



No single or simple solutions to reach sustainable energy goals

Energy-related CO_2 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

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