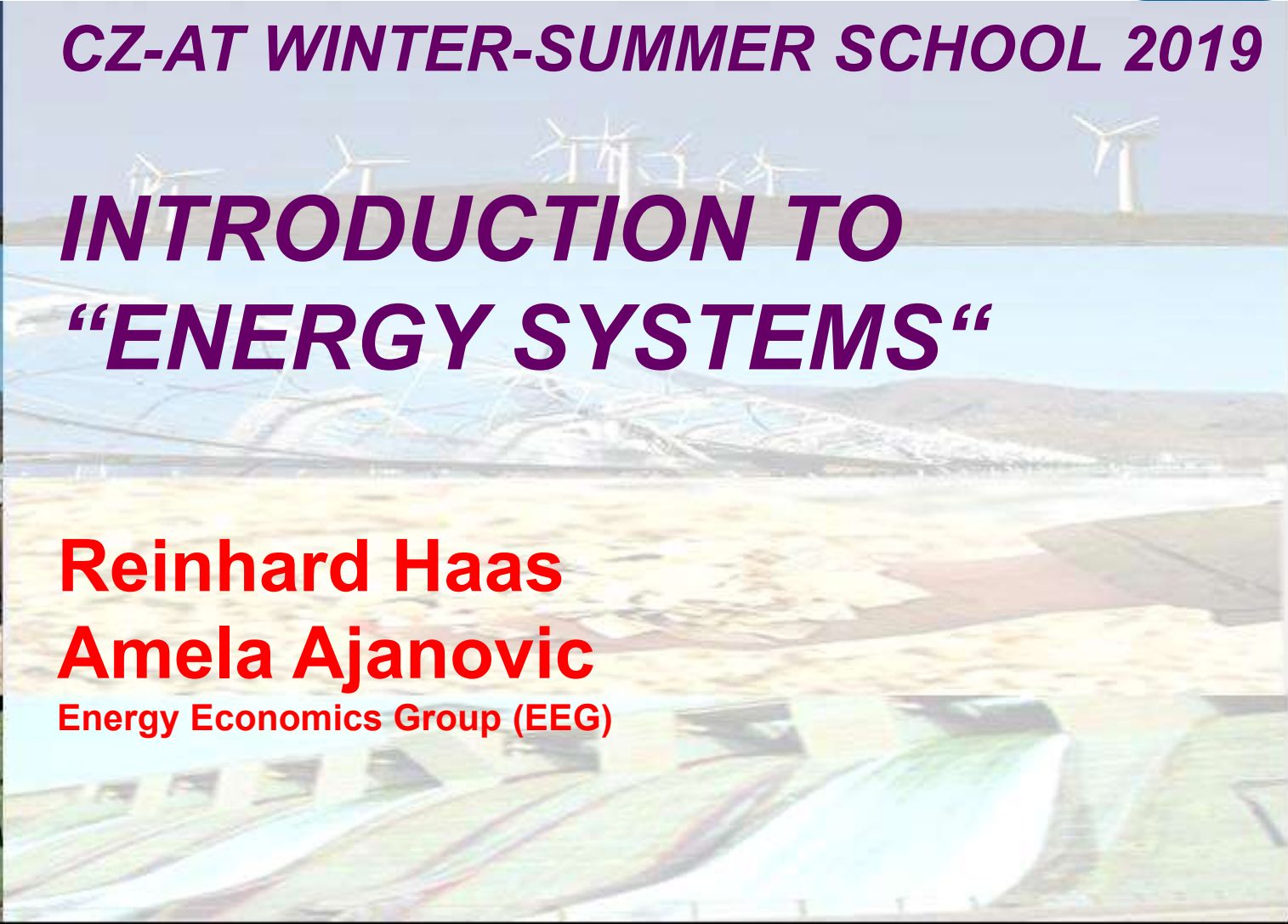


CZ-AT WINTER-SUMMER SCHOOL 2019

INTRODUCTION TO “ENERGY SYSTEMS“

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Amela Ajanovic
Energy Economics Group (EEG)





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

The Key Energy Challenges



**Energy
Access**



Climate Change



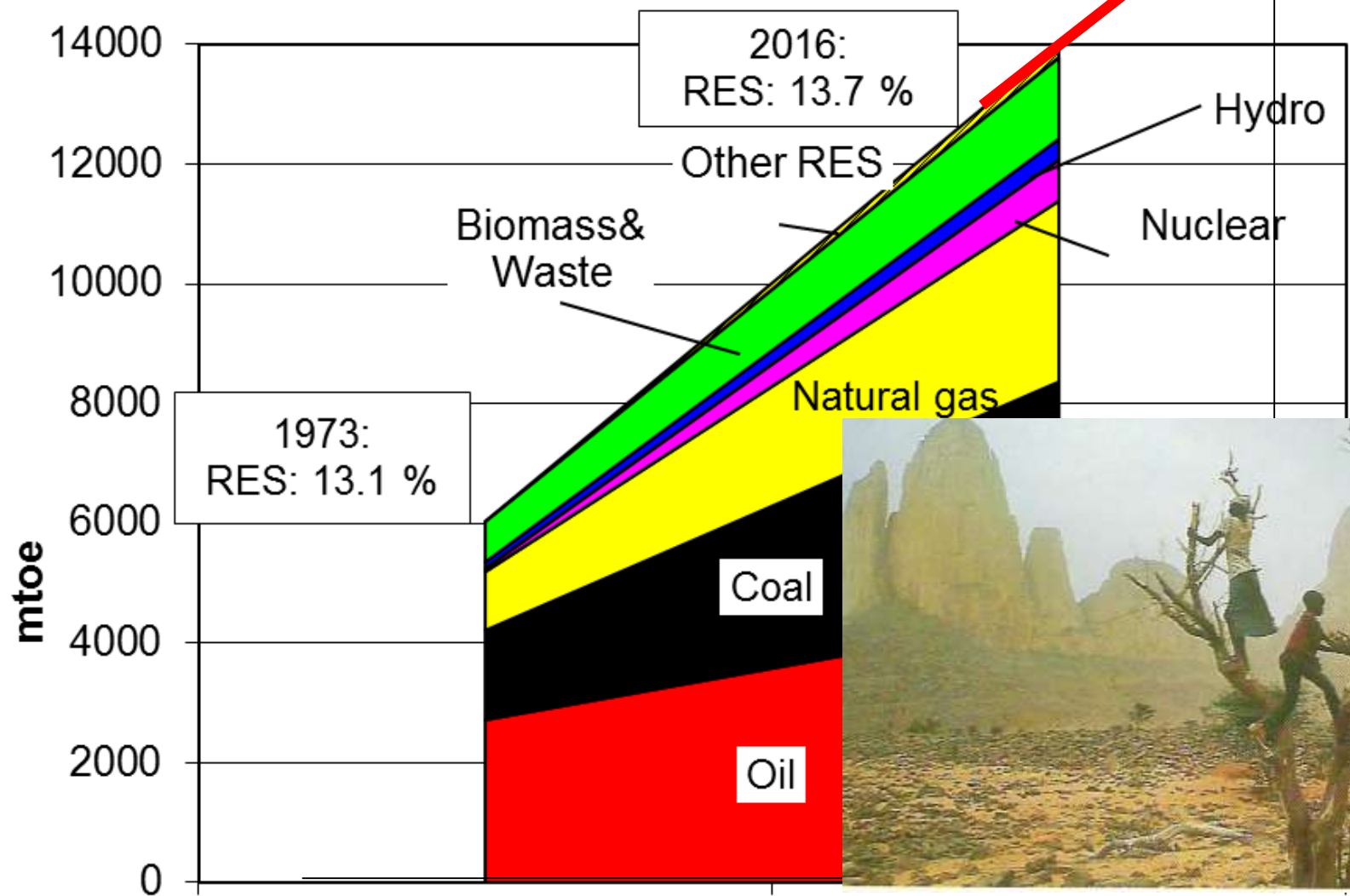
**Energy
Security**



**Air Pollution
Health Impacts**



WORLD-WIDE TREND IN PRIMARY ENERGY



Source: IEA (2017)

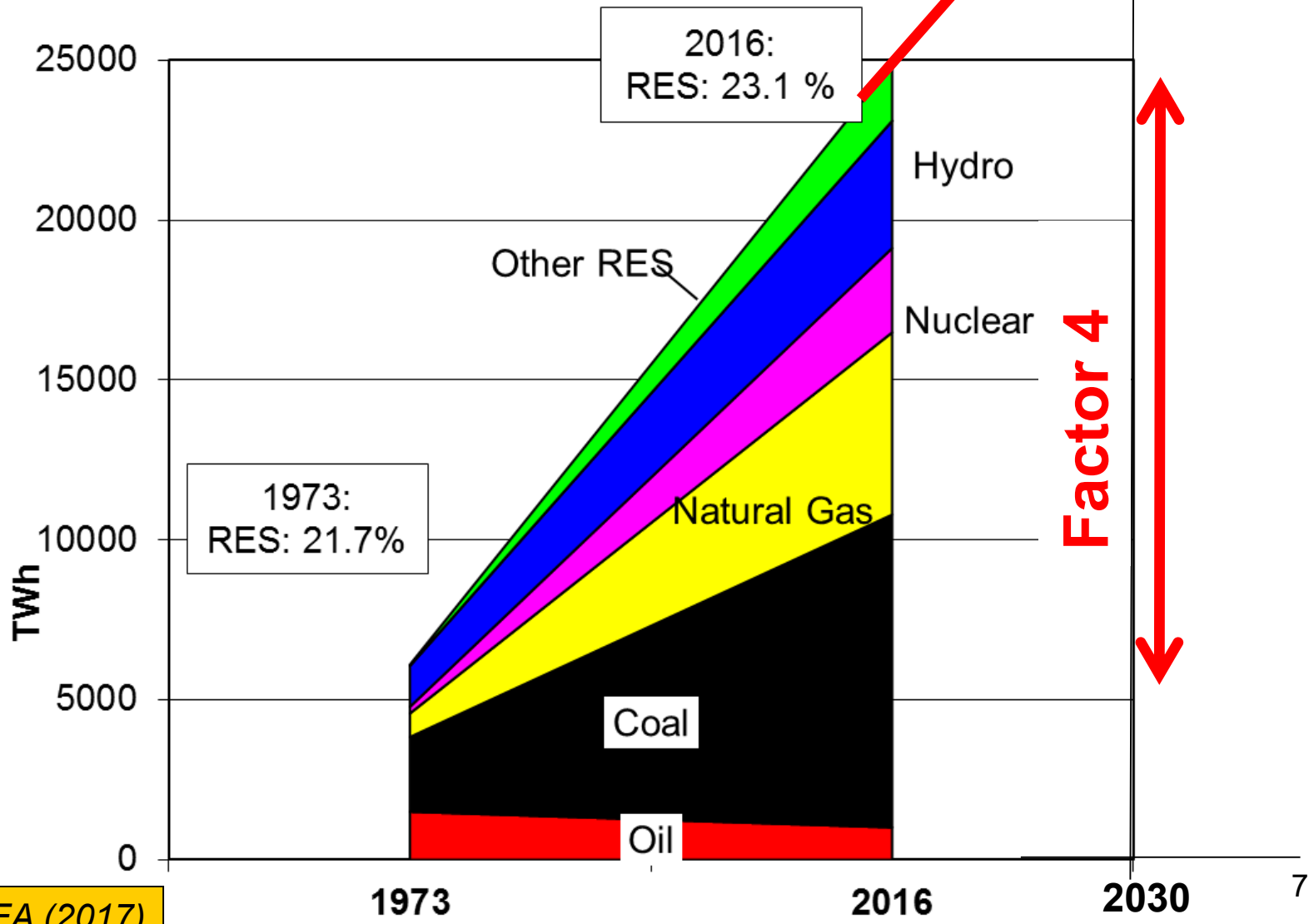
1973

2016

2030



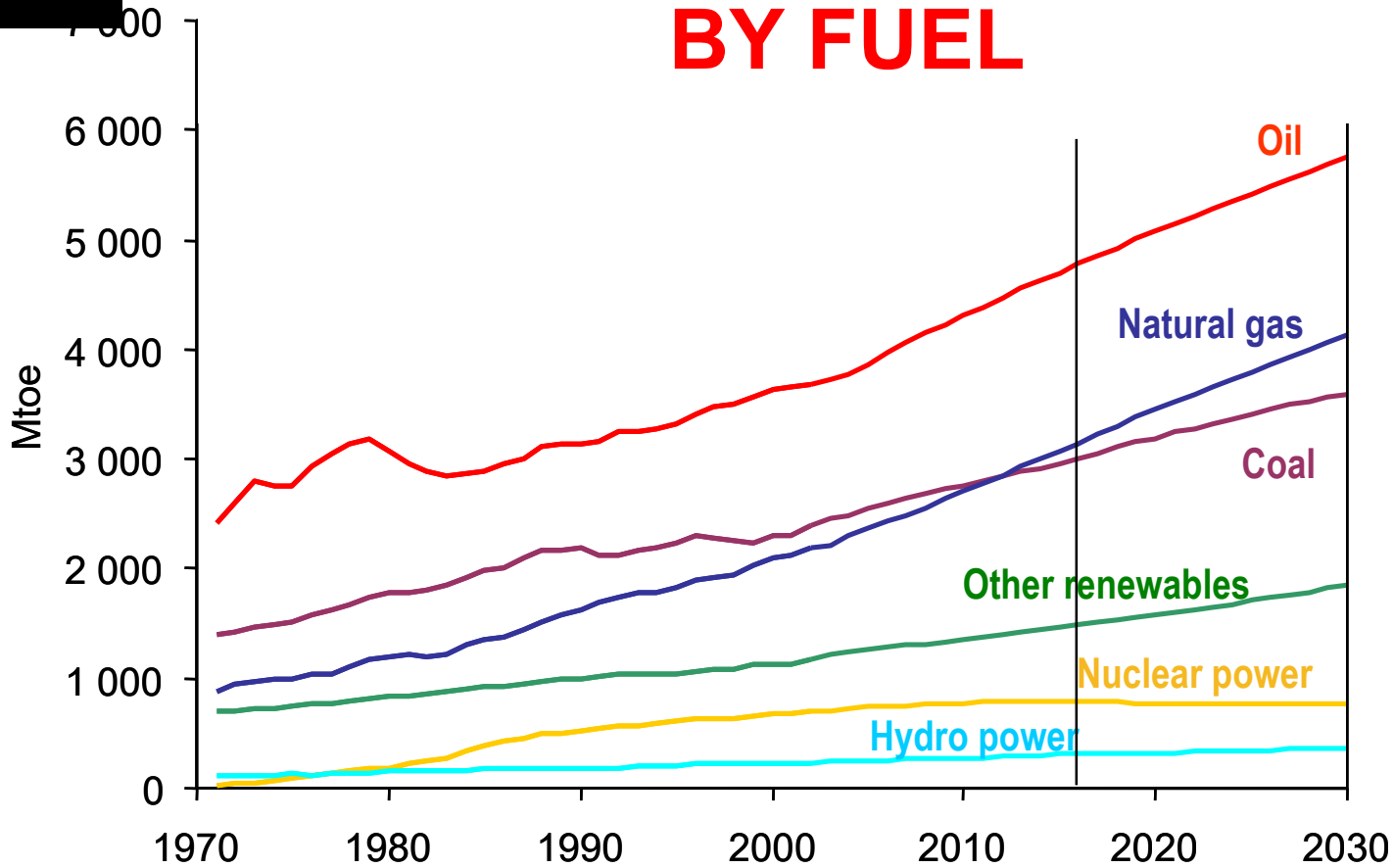
WORLD-WIDE TREND ELECTRICITY CONSUMPTION



Source: IEA (2017)



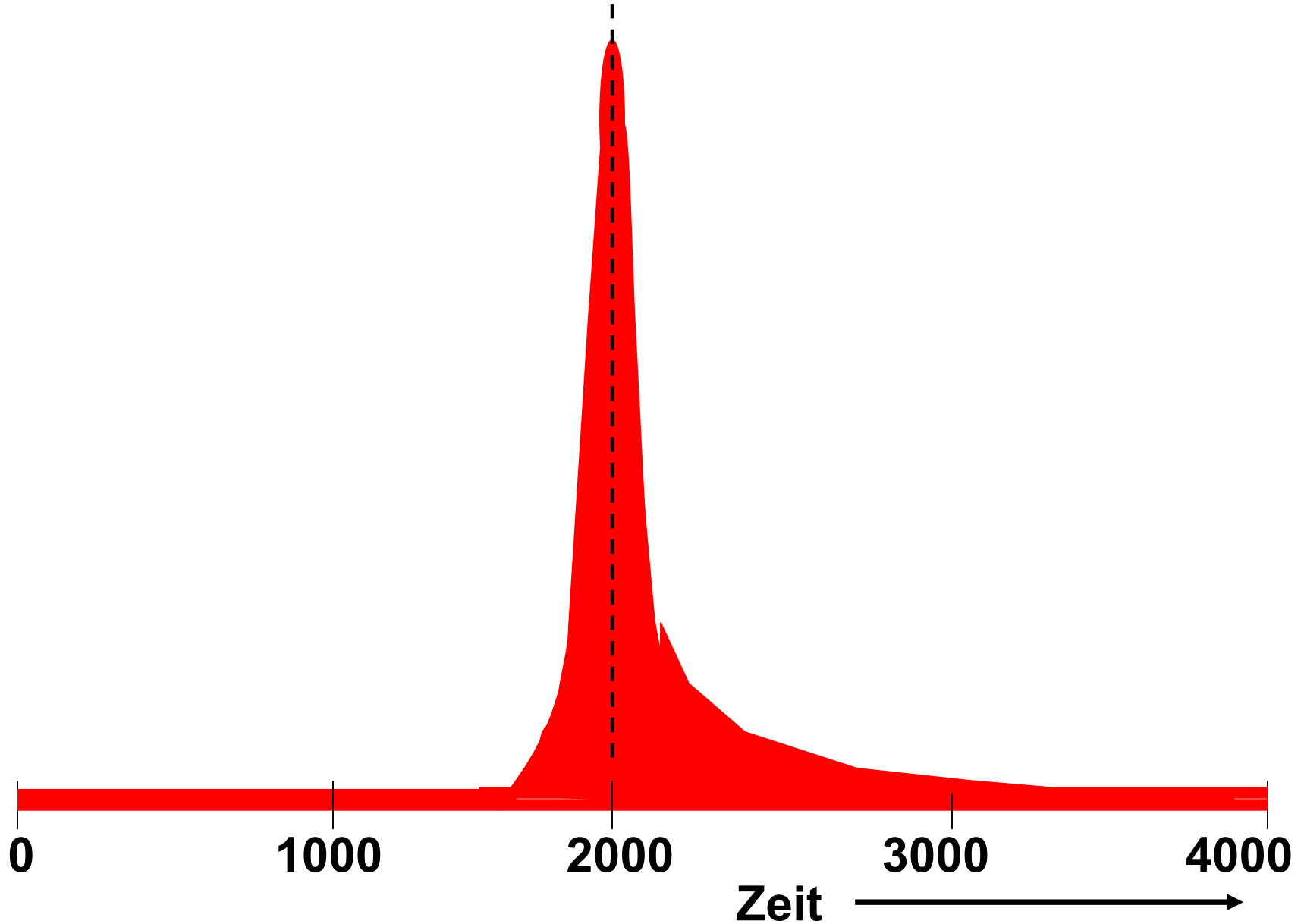
PRIMARY ENERGY: TRENDS BY FUEL



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



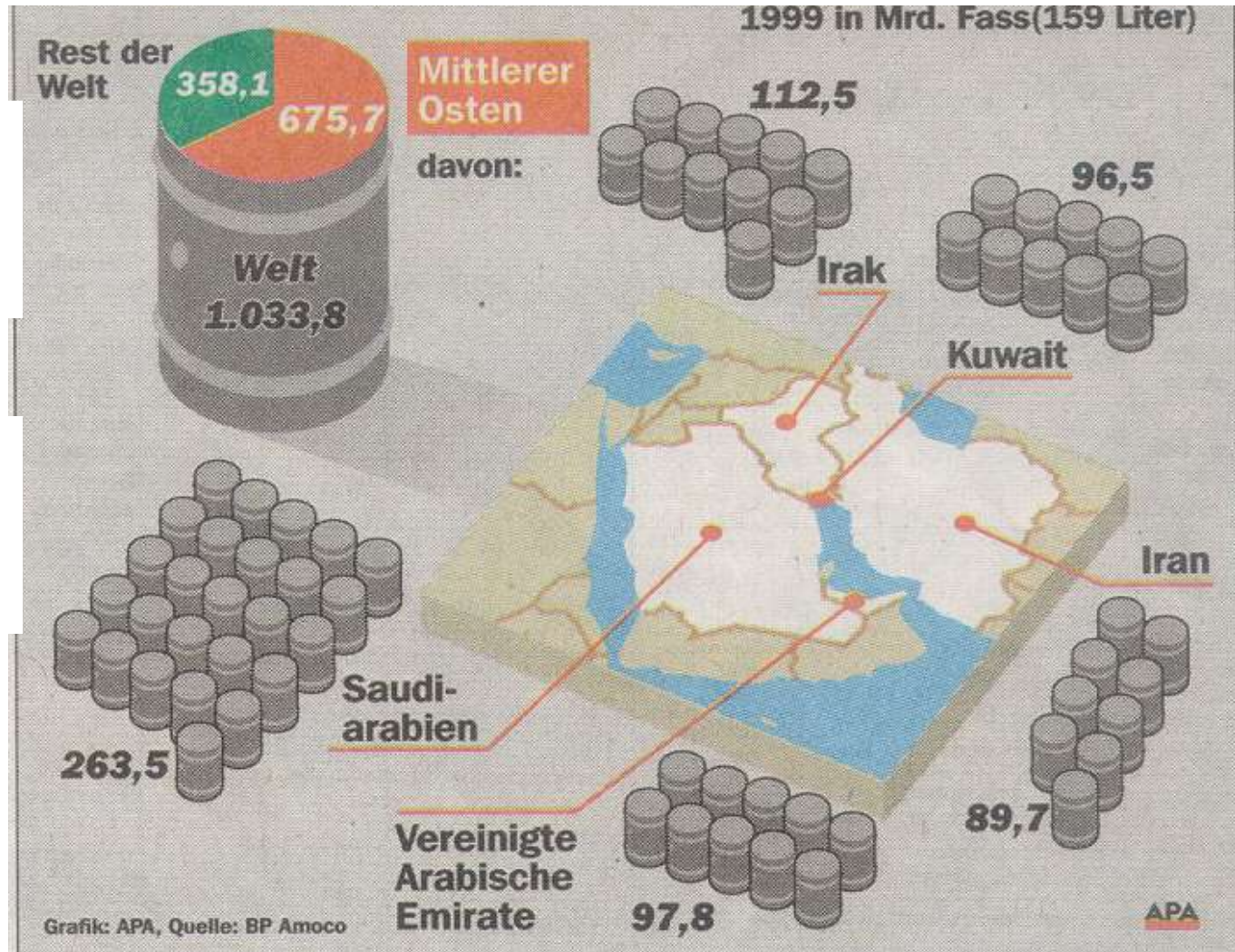
Oil consumption over time



Oil reserves in the Middle East

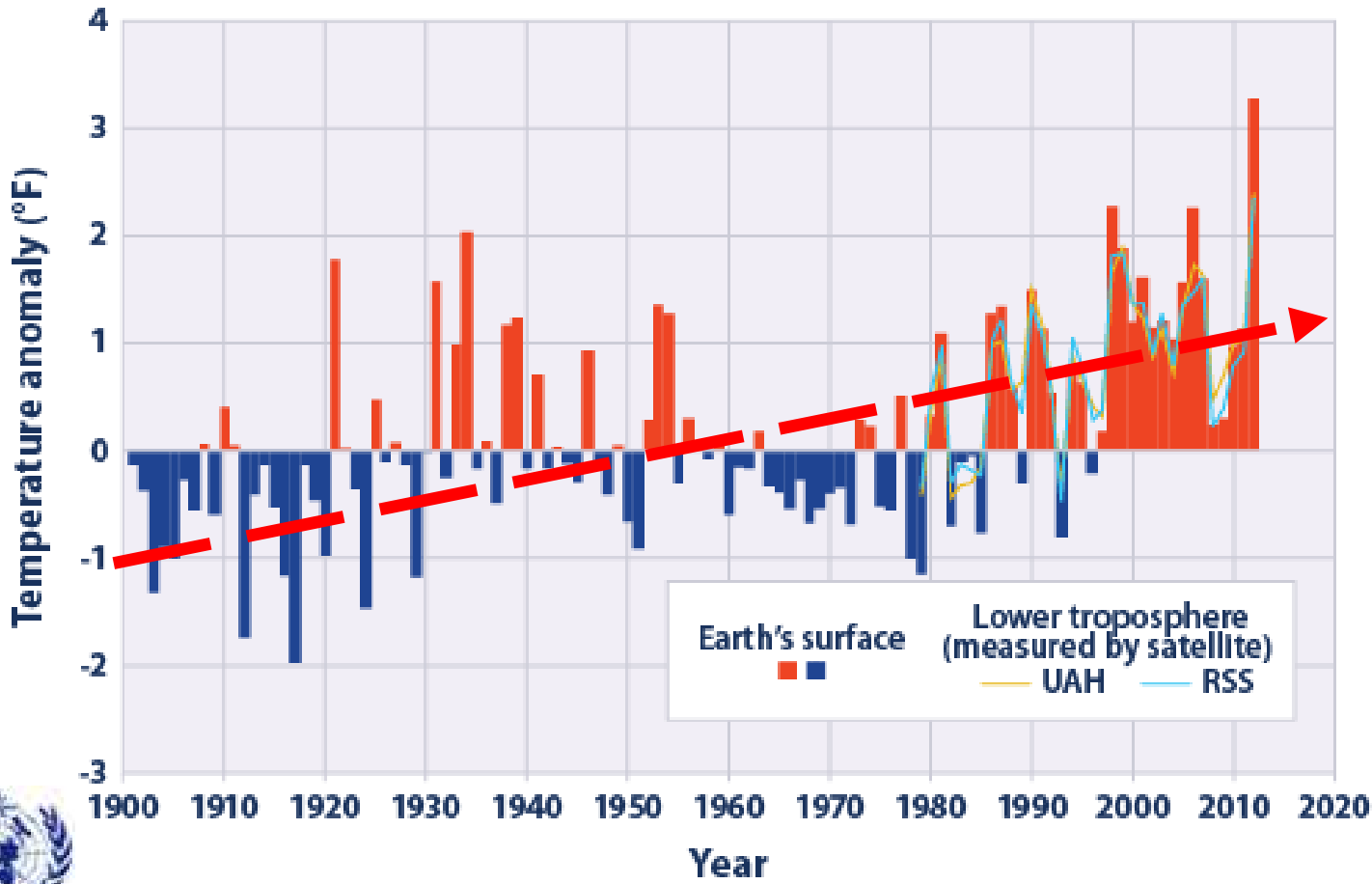
Middle East: 2/3

Rest of world: 1/3





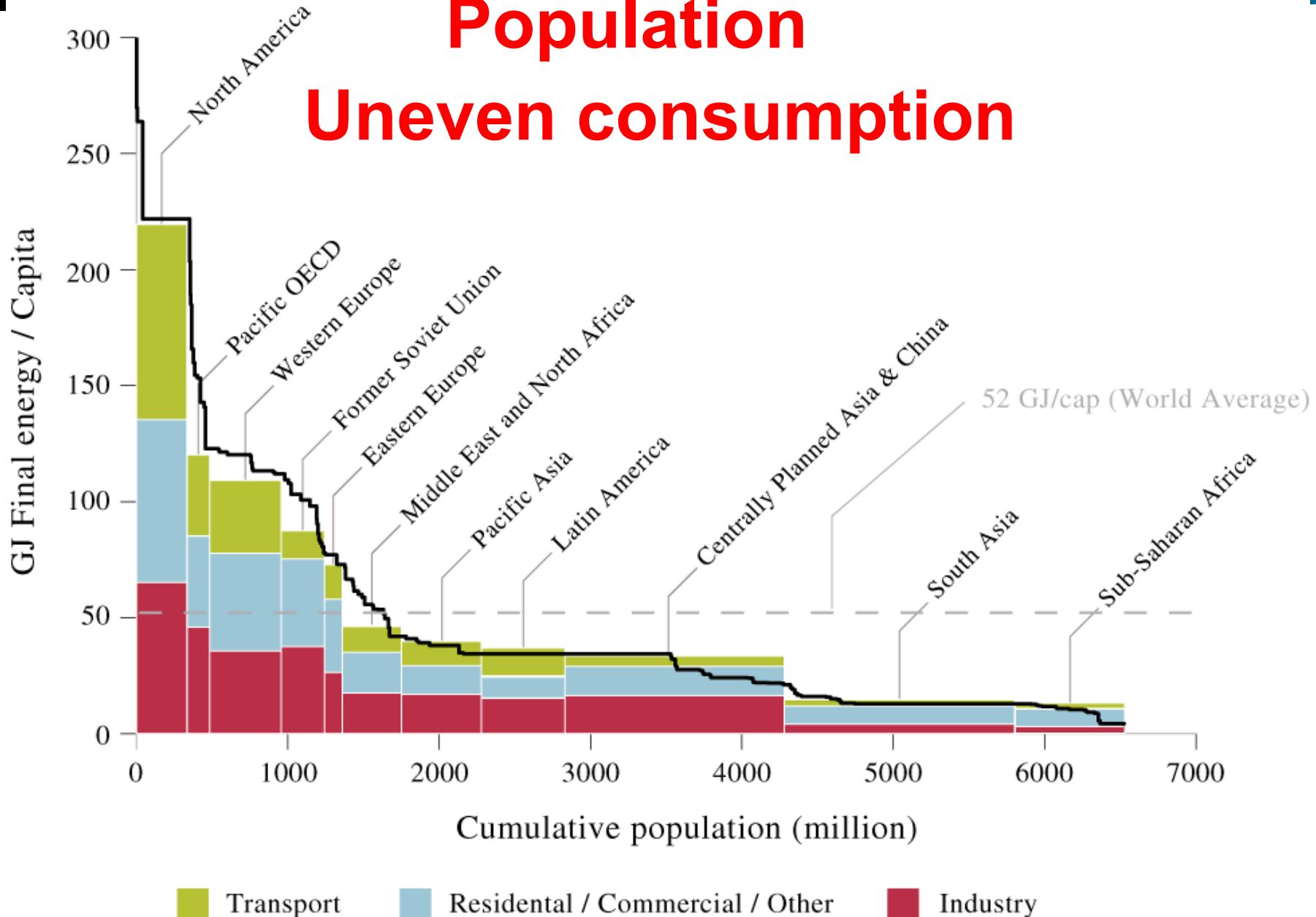
Variations of Earth's Surface temperature in the past 110 years



+ 2° !

Per Capita Final Energy & Population

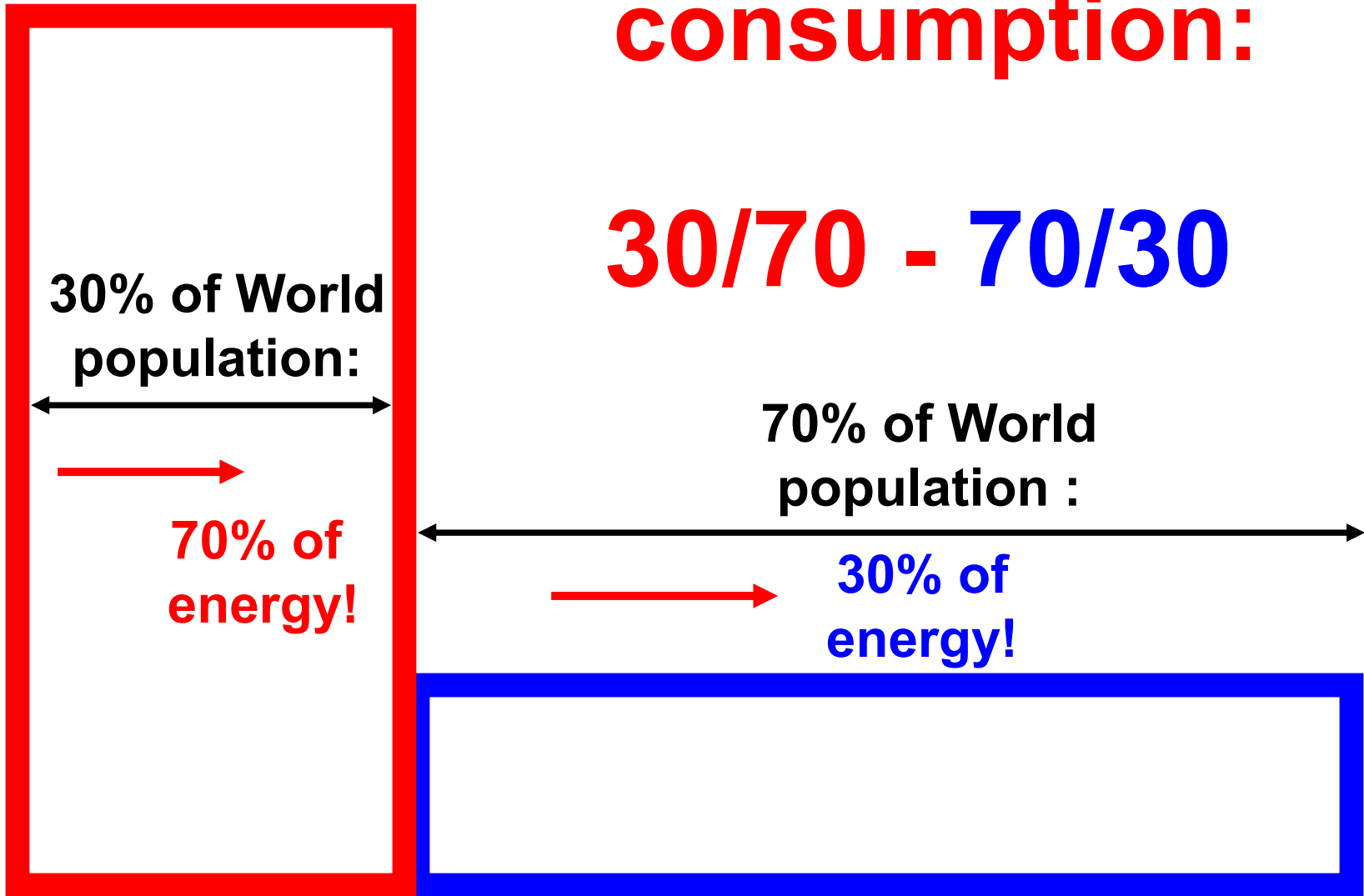
Uneven consumption





Uneven consumption:

30/70 - 70/30



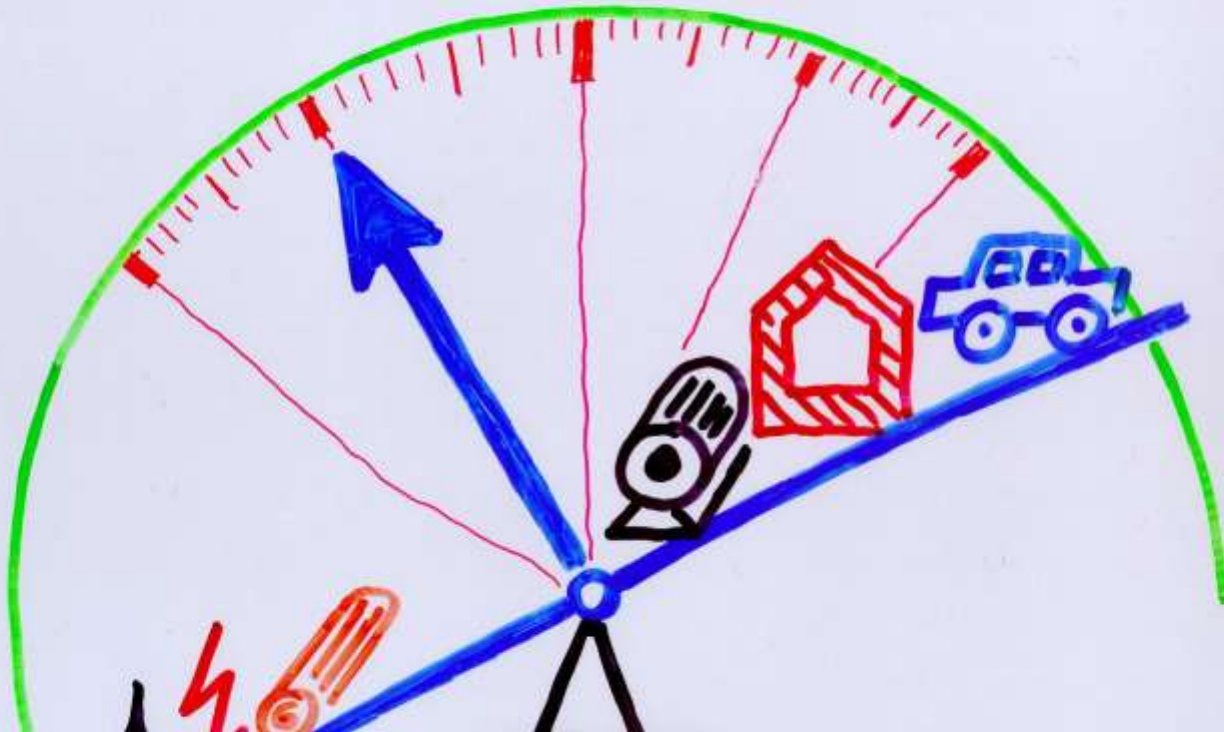


2. The basic concept of providing energy services

- 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

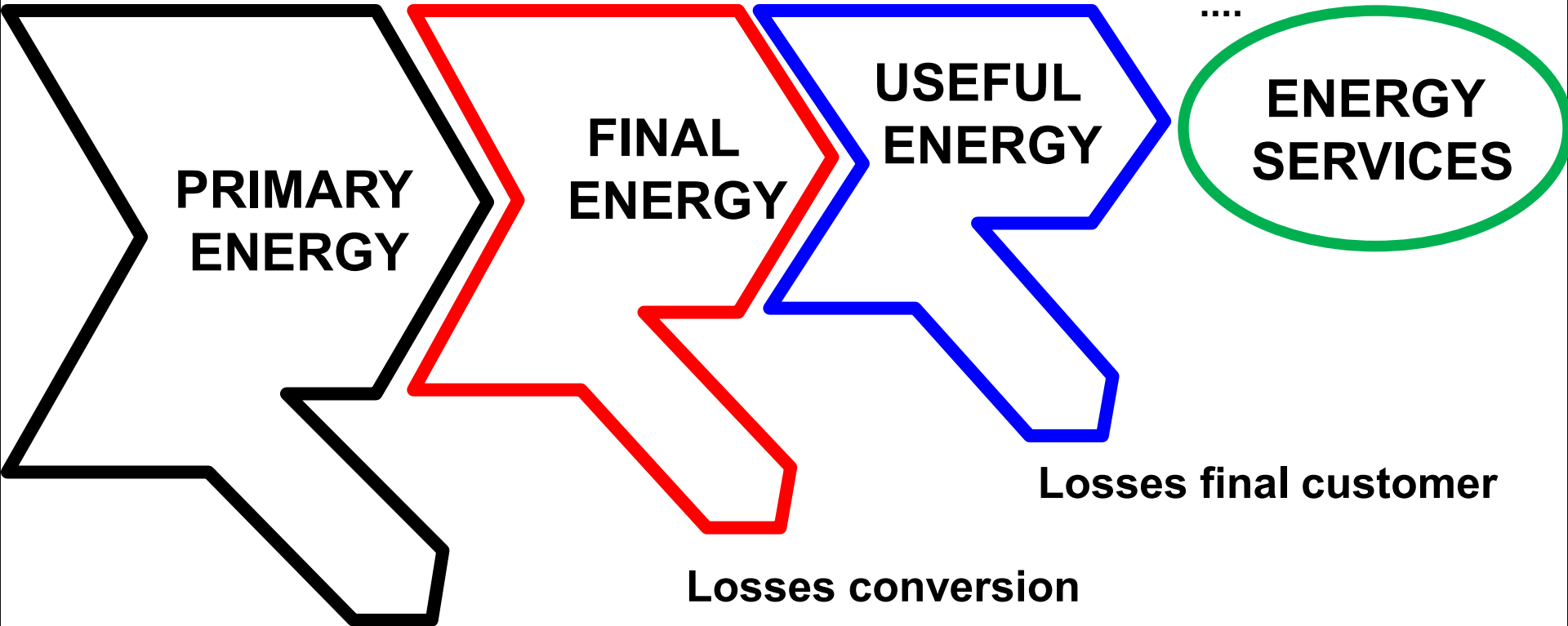
Categories of energy:

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

Gasoline, electricity, pellets, district heat

Heat, light, mechanical work,

Warm and bright rooms, mobility
....



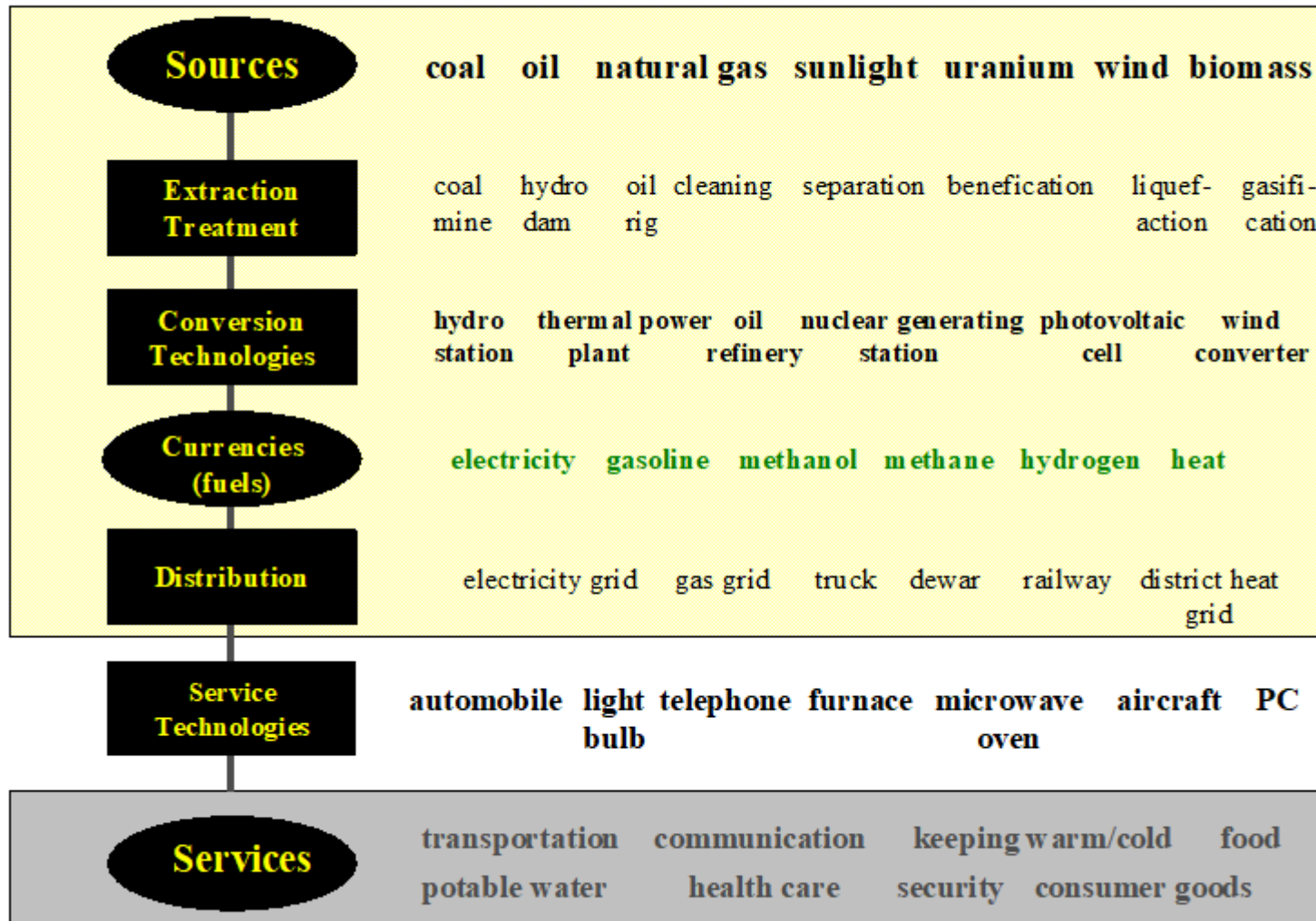
Losses exploration and transport

Losses conversion

Losses final customer

What is an energy system?

Architecture of the Energy System



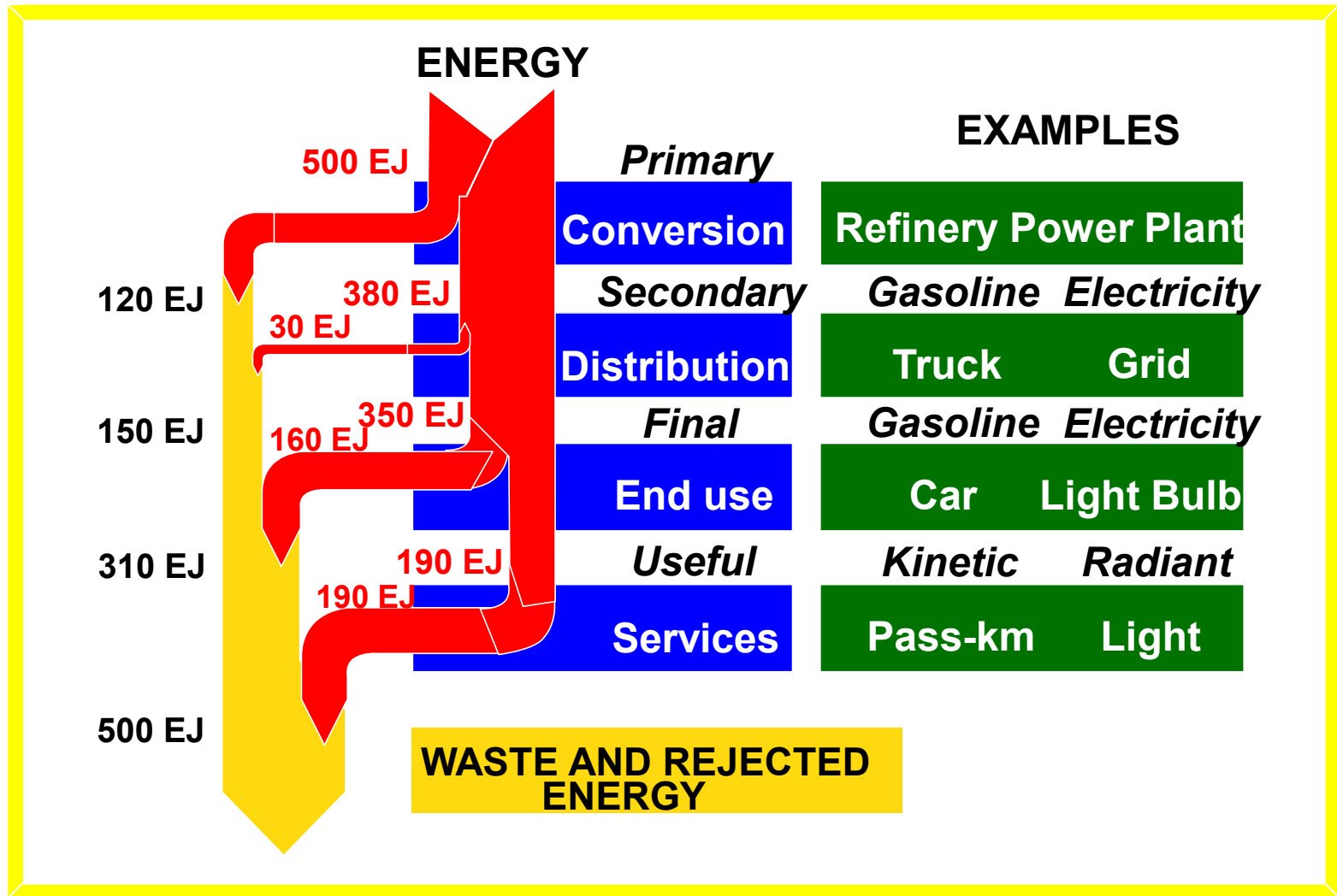
What Nature Provides

Energy Sector

What People Want



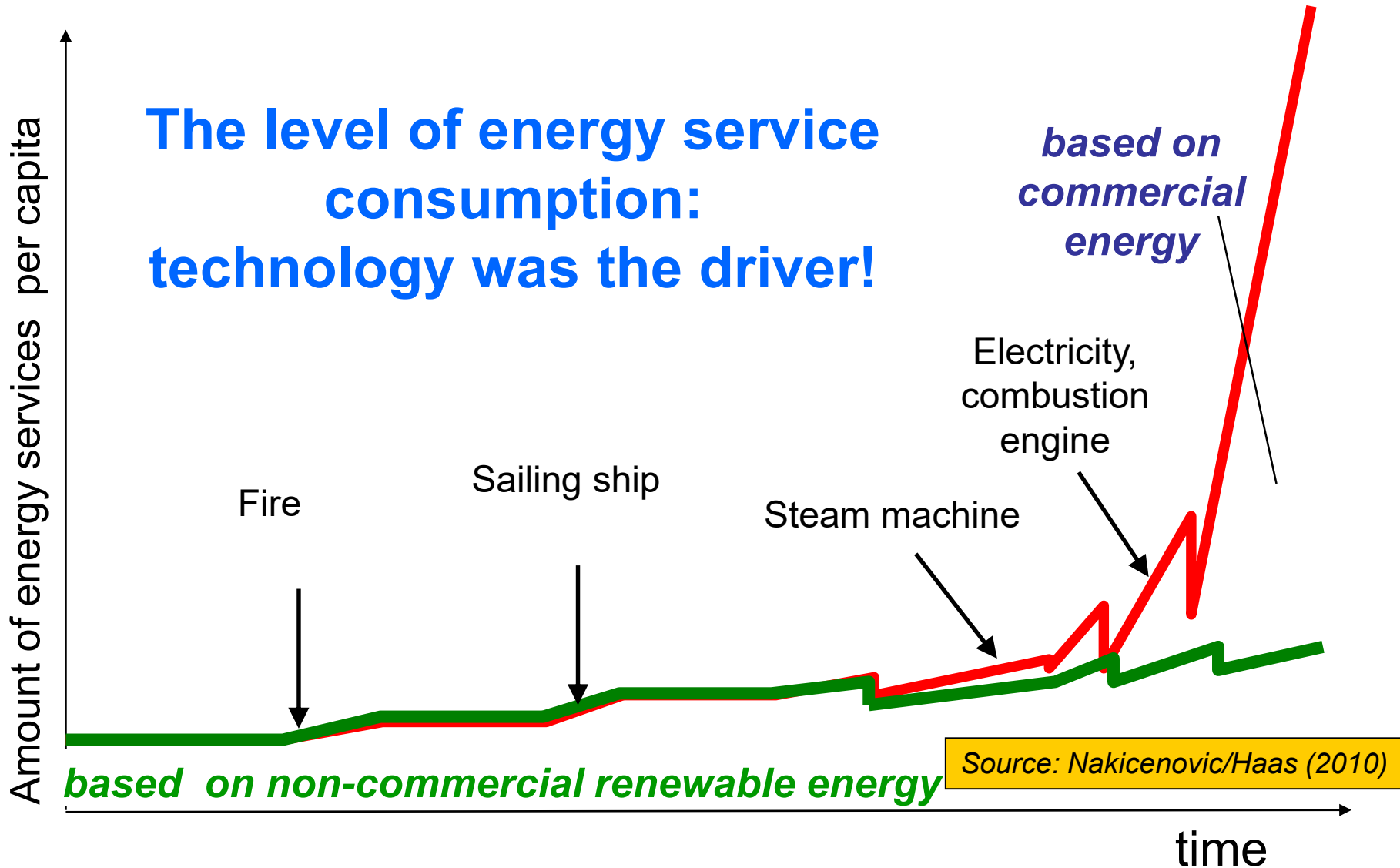
Global Energy Flows

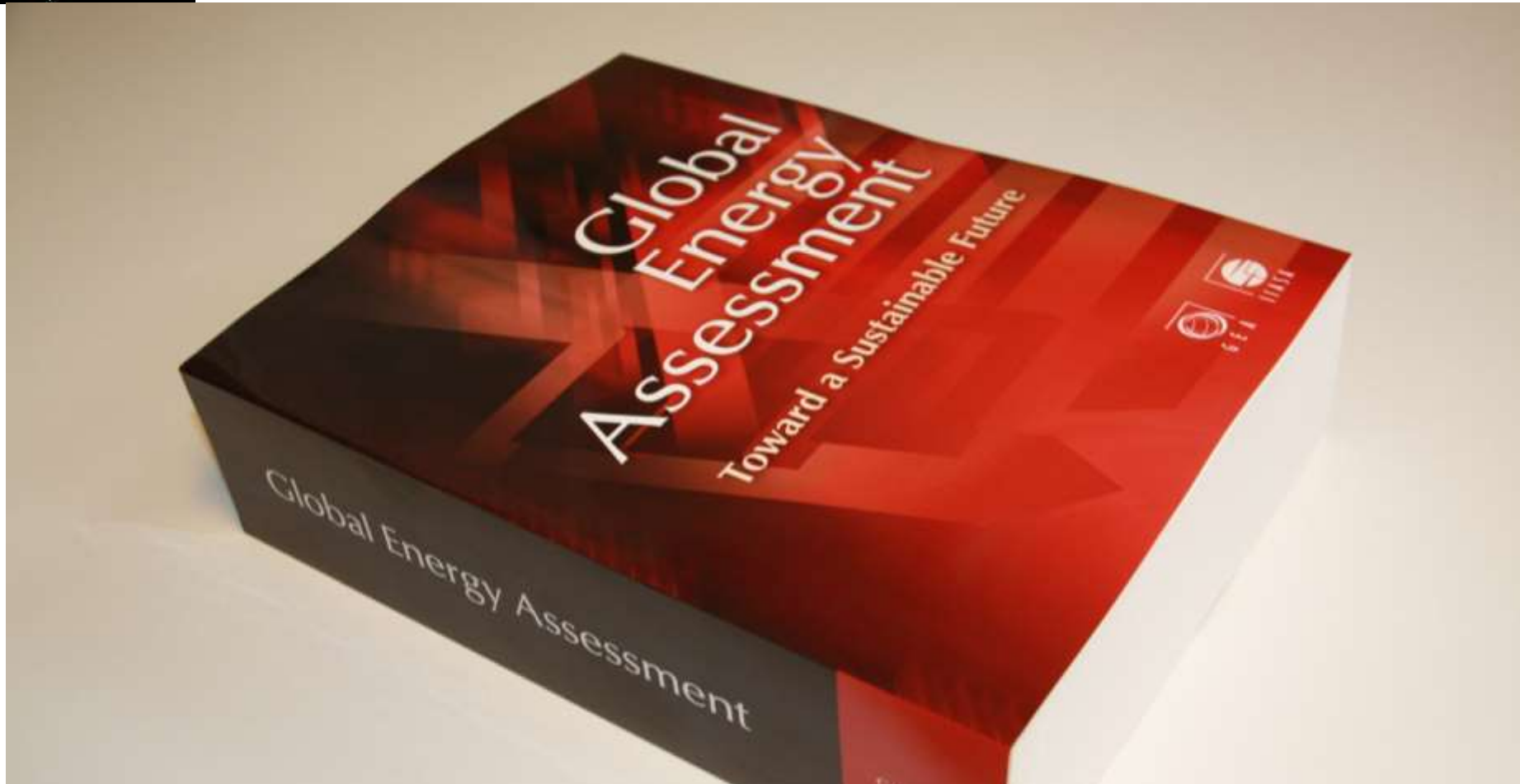




4. Dynamics: Why history is important

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

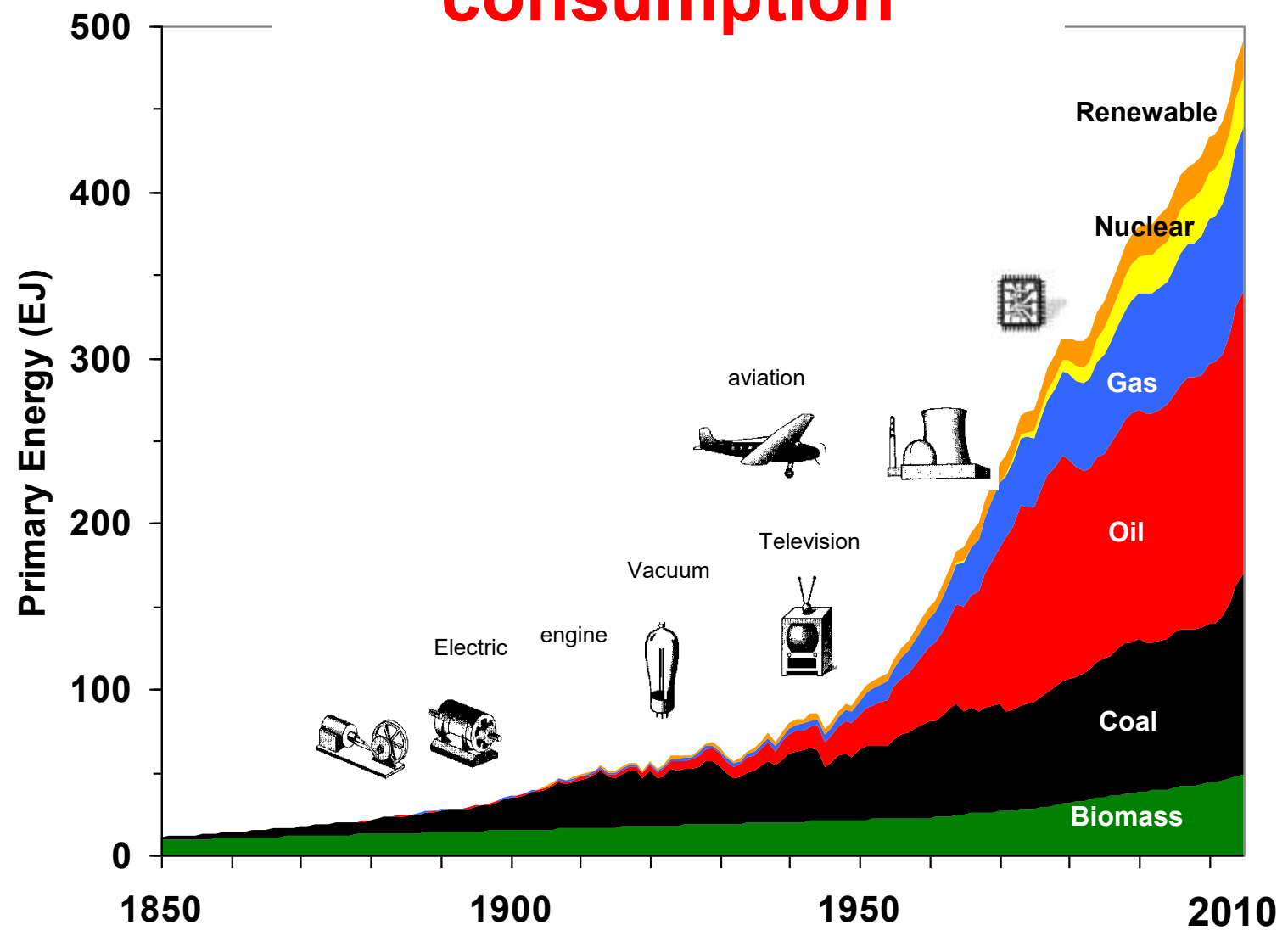




- **Total Effort: 300 Authors; 200 Reviewers
> 6 years >> 6m € and >> 100 p-years**



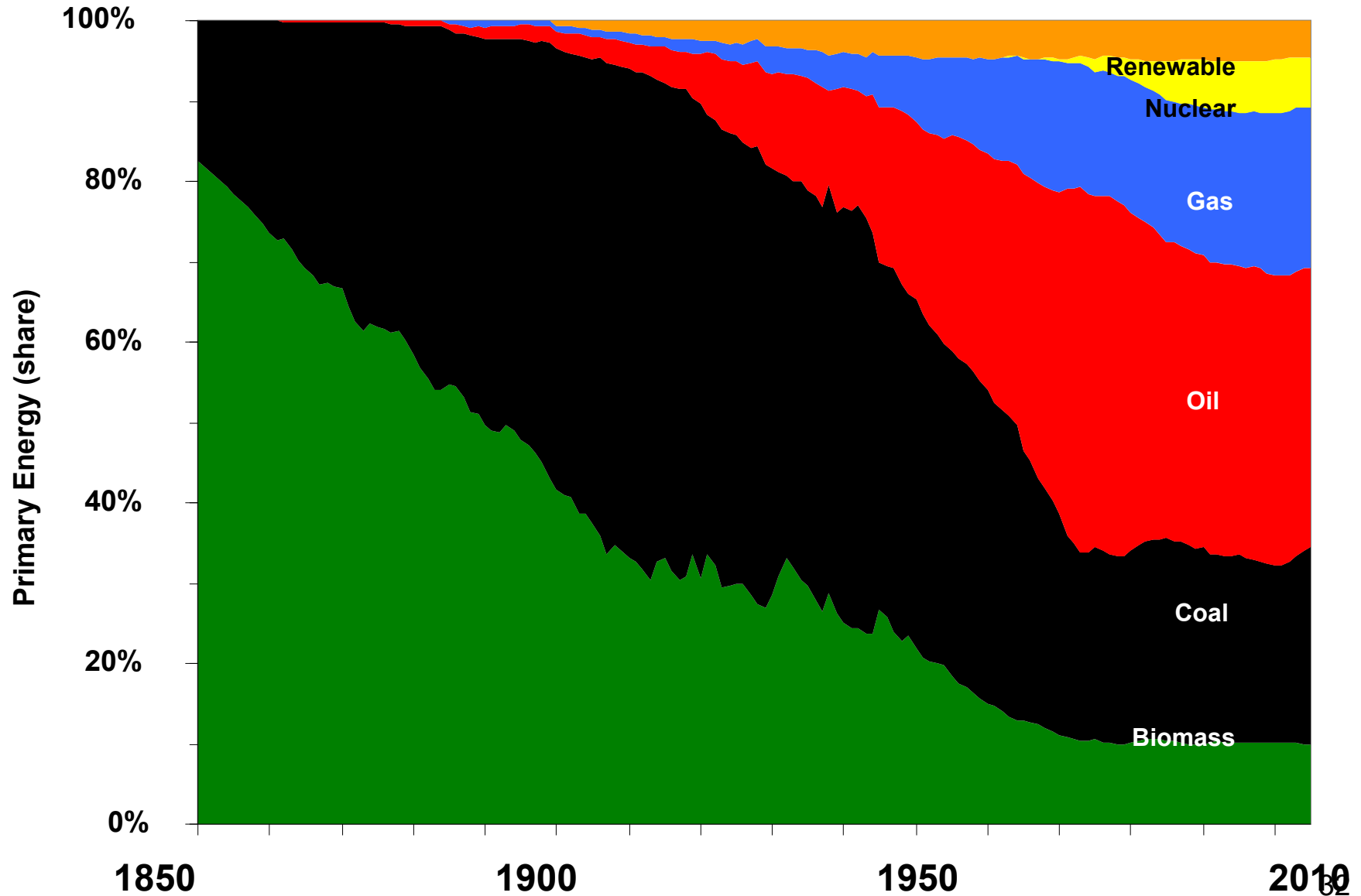
World Primary Energy consumption



Source: GEA (2012)



Shares of PE world-wide



Source: GEA (2012)



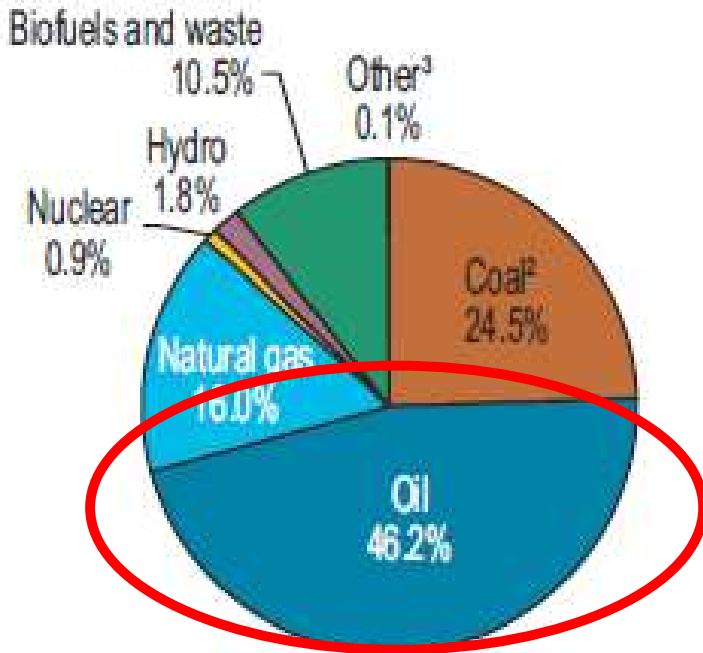
Key world energy statistics



Also available on smartphones and tablets

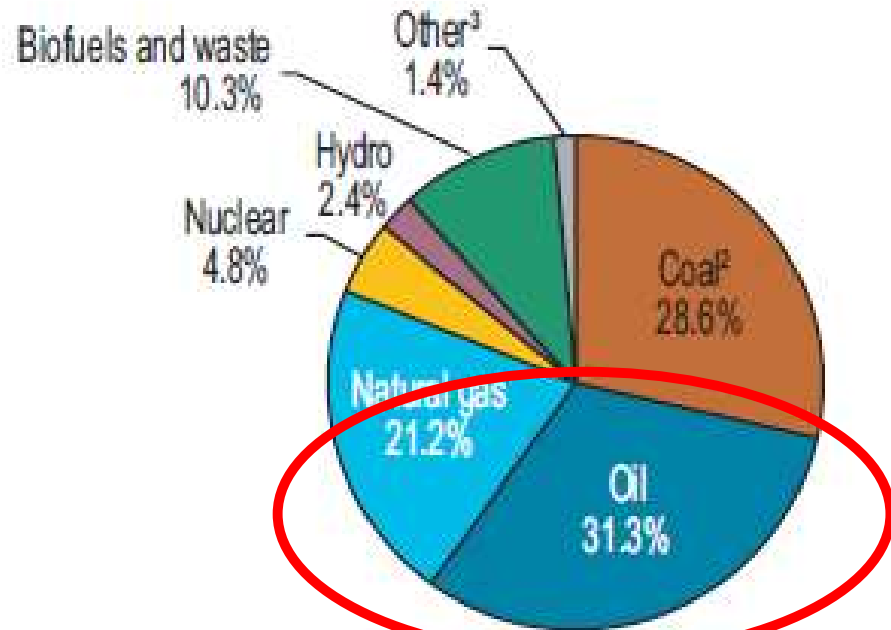
World: Primary energy

1973



6 101 Mtoe

2016

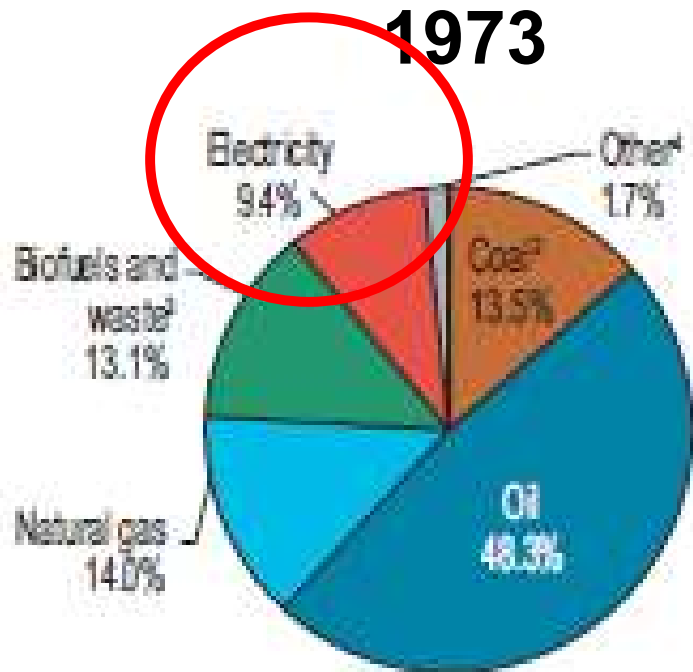


13 699 Mtoe

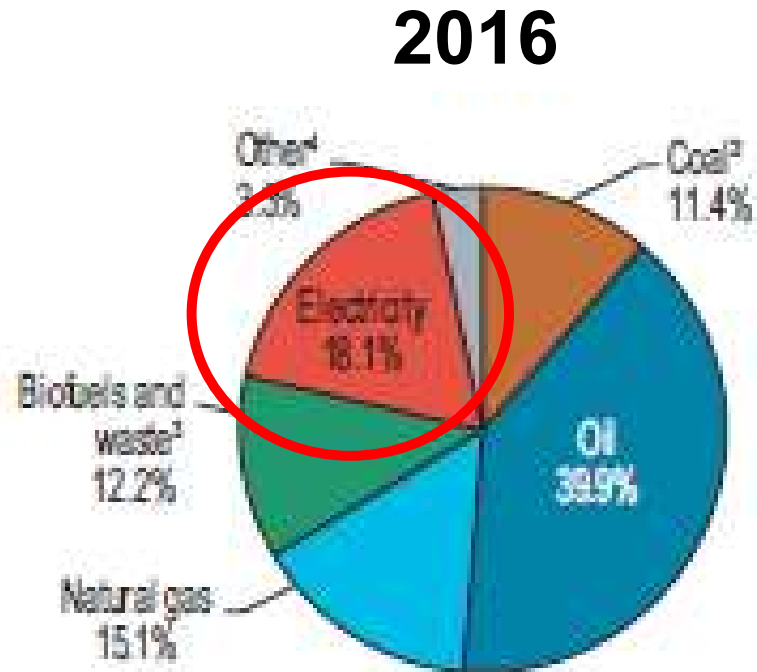
Source: IEA 2017

- **Total primary energy demand more than doubled between 1973 and 2016;**
- **Oil down (more than -30%!), Gas up, Coal up!**³⁴

World: Final energy



4674 Mtoe



9425 Mtoe

- The **share** of electricity increases continuously:
In 2016 twice of 1973
- Share of oil decreased from 48% to 40%

** Other includes Solar, Geothermal, Wind



FOR FURTHER INFORMATION:

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**A small Seminar work on:
Czech Republic, Austria, EU-28, USA, China:**

- 1. What are major primary sources?**
- 2. What are major sources for electricity generation?**
- 3. How did greenhouse gas emissions develop over the last decades ?**
- 4. How did energy and electricity consumption develop over the last decades?**
- 5. Is the country net importer of energy (oil, gas) and electricity?**
- 6. What are major cornerstones of national energy and climate policy?**