

**CZ-AT WINTER-SUMMER SCHOOL 2023**

# **THE WORLD ENERGY SYSTEM – AN INTRODUCTION**

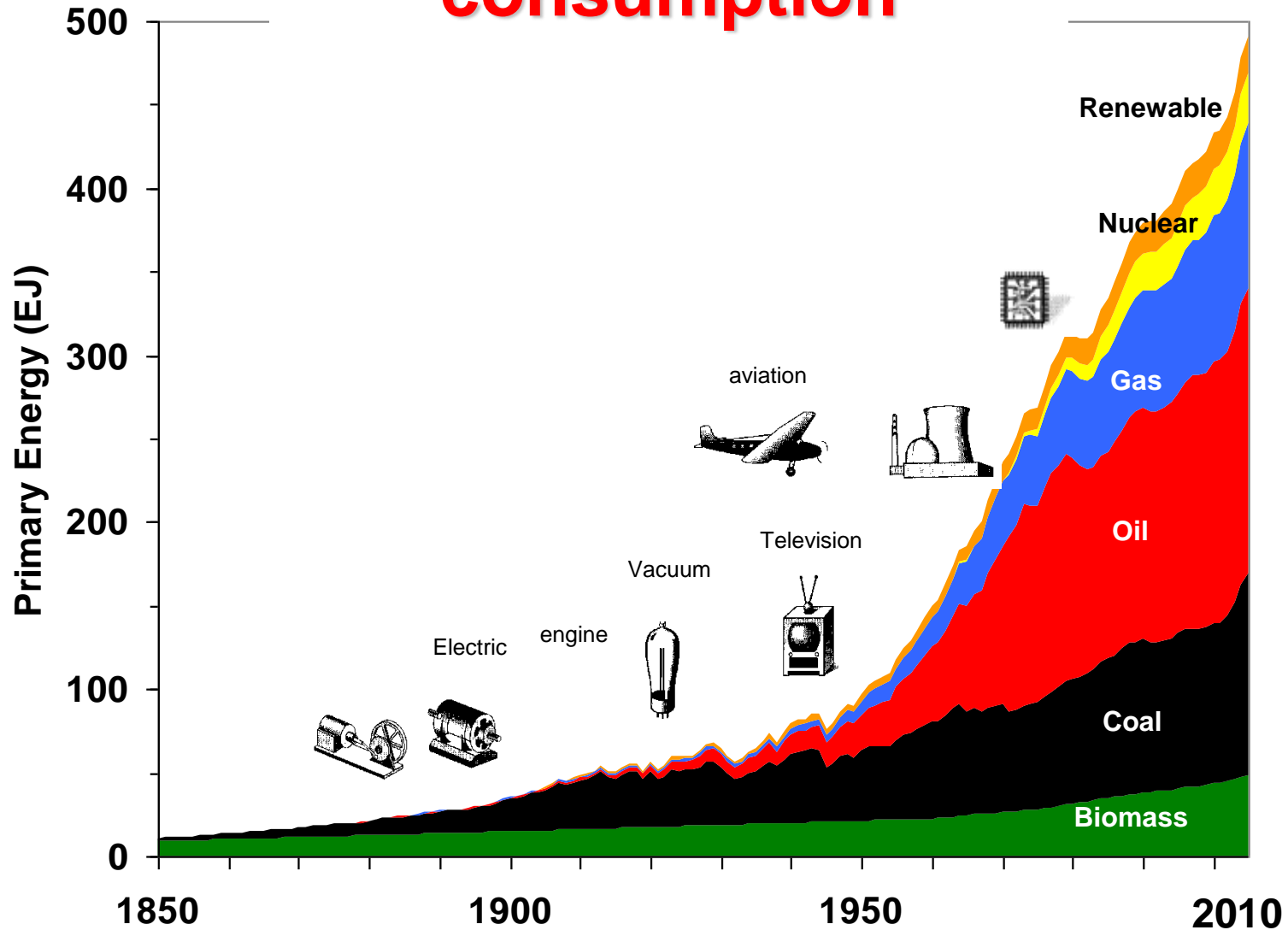
**Reinhard Haas**

**Amela Ajanovic**

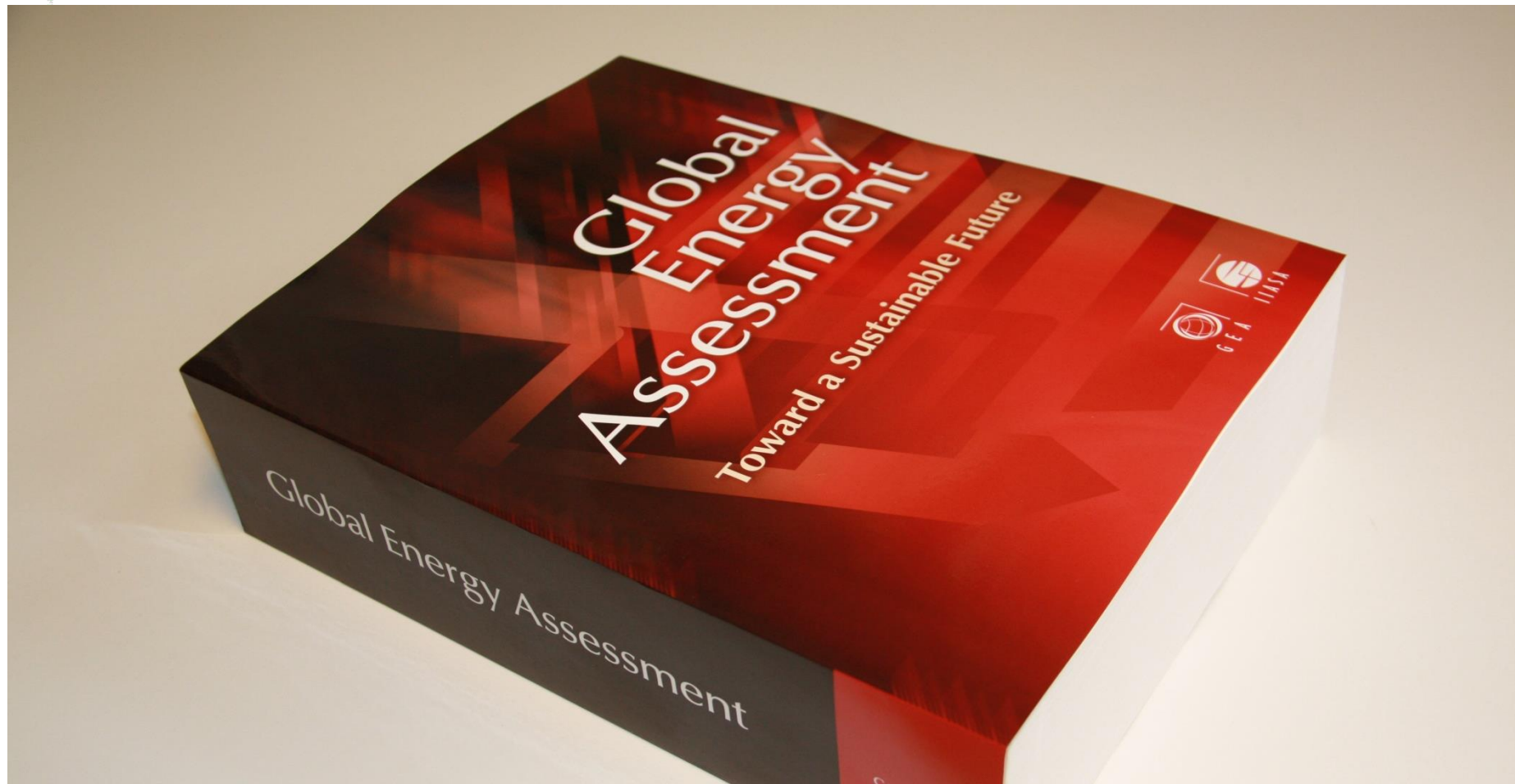
**Energy Economics Group (EEG), TU Wien**



# World Primary Energy consumption

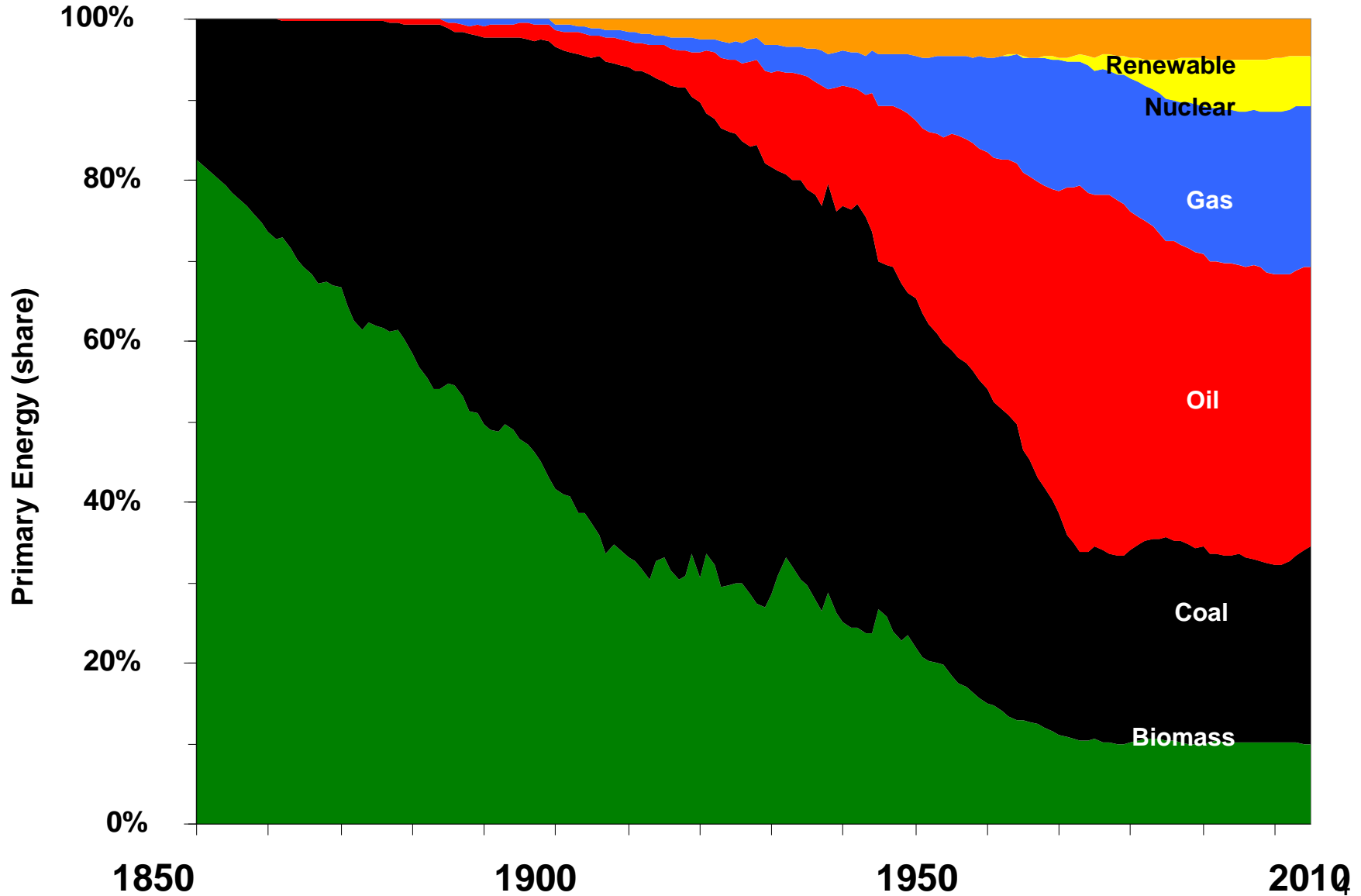


Source: GEA (2012)



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

# Shares of PE world-wide

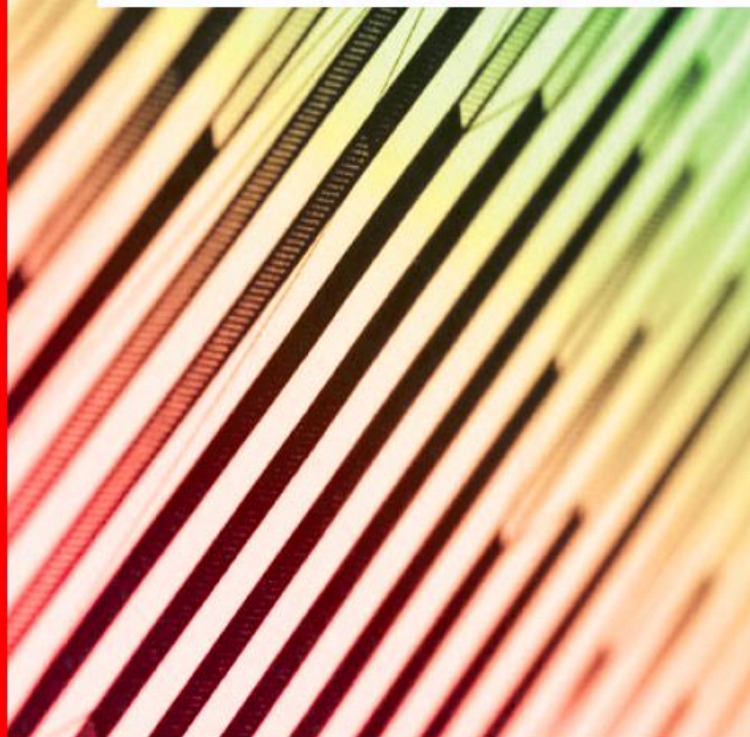


Source: GEA (2012)



# Key world energy statistics

Also available on smartphones and tablets

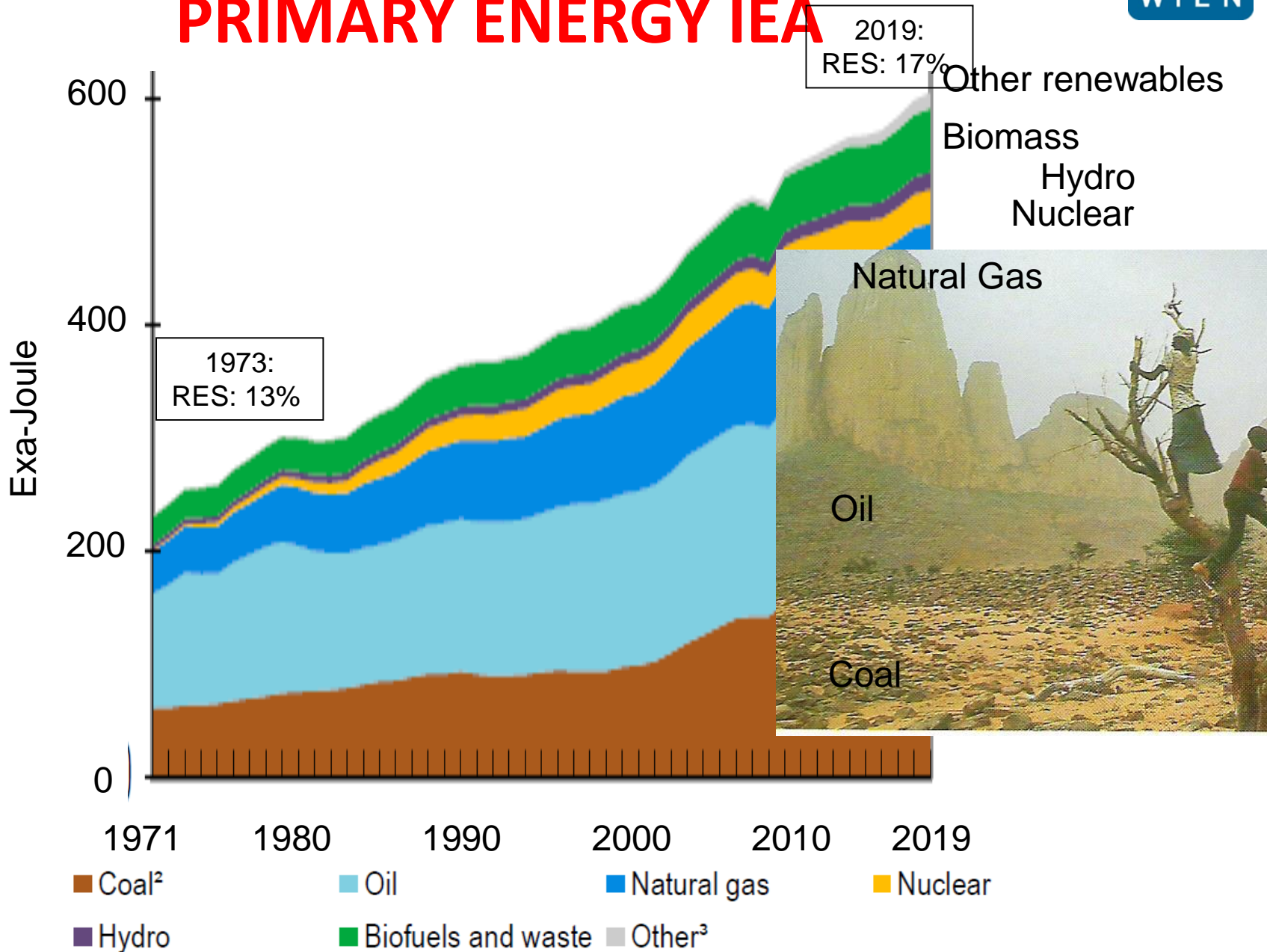


Statistics report

# Key World Energy Statistics 2021

September 2021

# WORLD-WIDE TREND IN PRIMARY ENERGY IEA





# Wood for Cooking

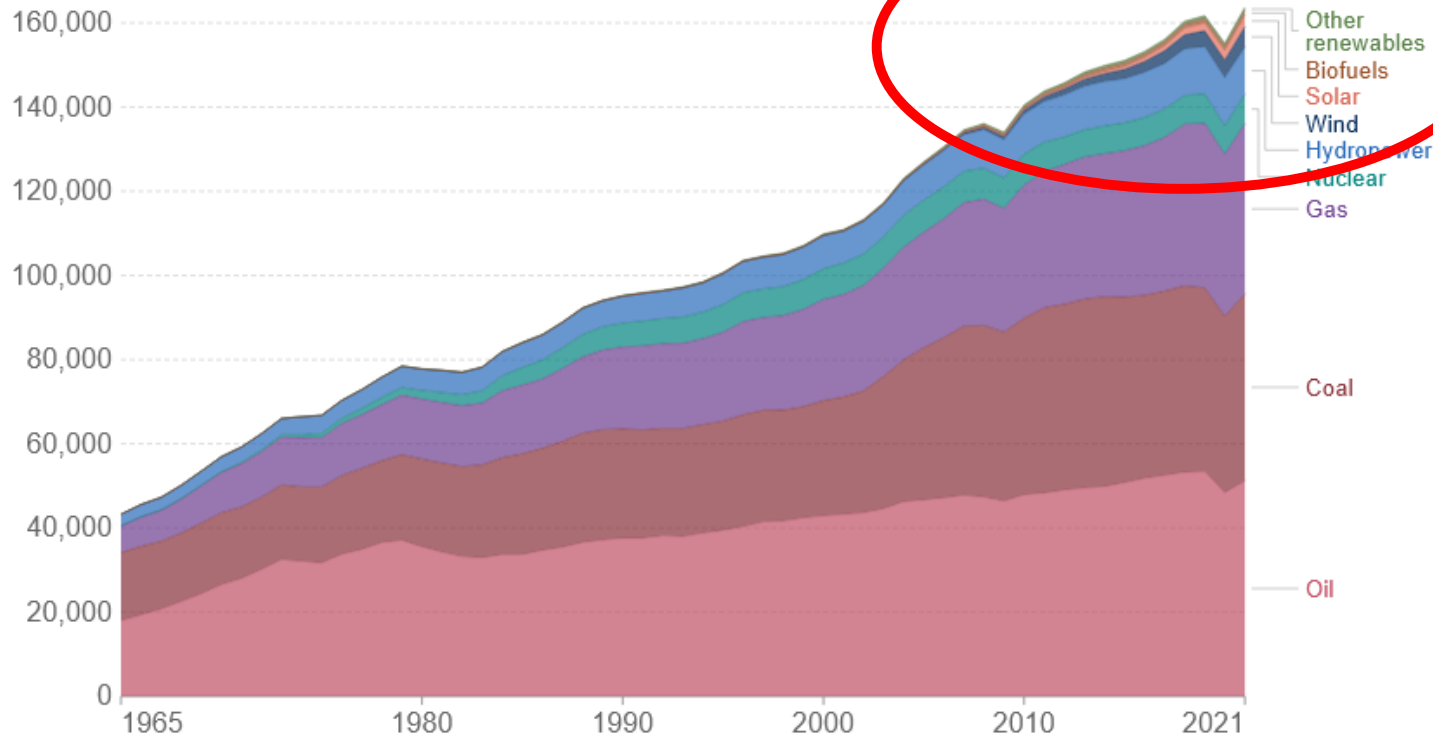


Source: Modi, 2011 and Yumkella, 2013

# WORLD-WIDE TREND IN PRIMARY ENERGY

## Energy consumption by source, World

Primary energy consumption is measured in terawatt-hours (TWh). Here an inefficiency factor (the 'substitution' method) has been applied for fossil fuels, meaning the shares by each energy source give a better approximation of final energy consumption.

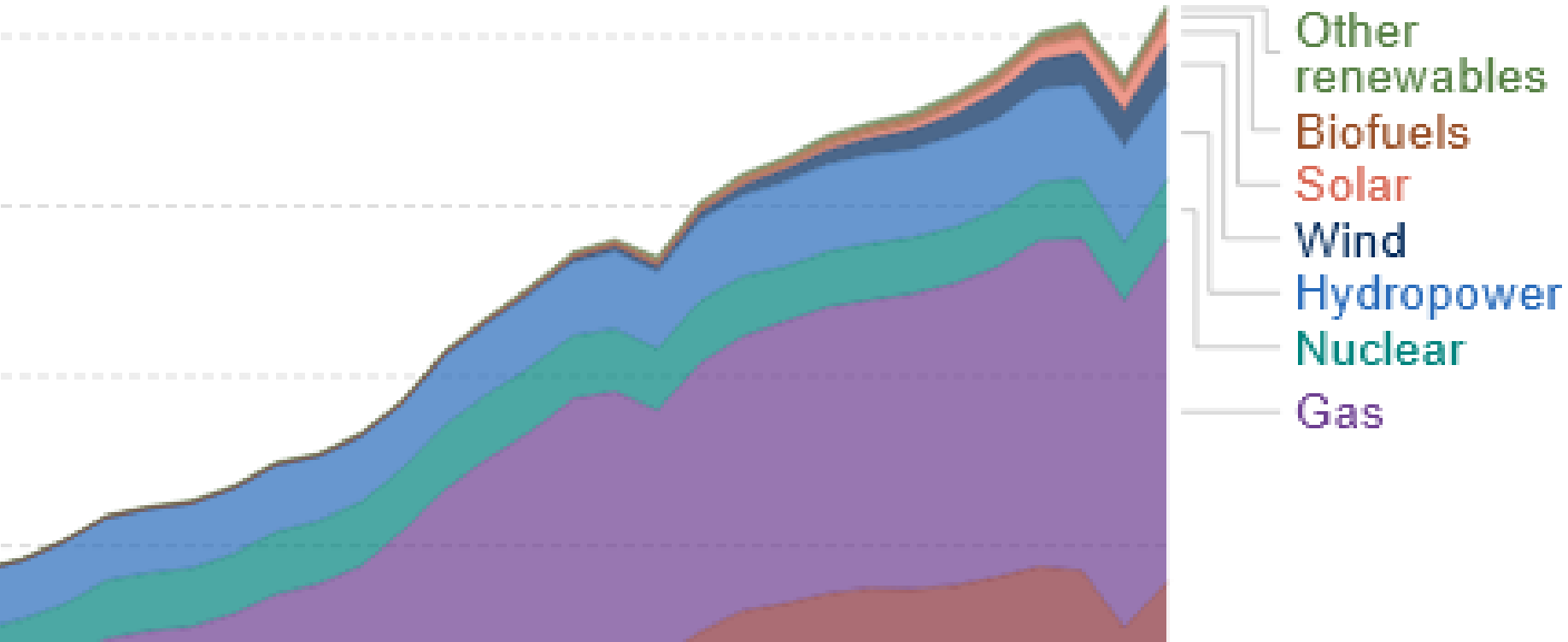


Source: BP Statistical Review of World Energy  
 Note: 'Other renewables' includes geothermal, biomass and waste energy.



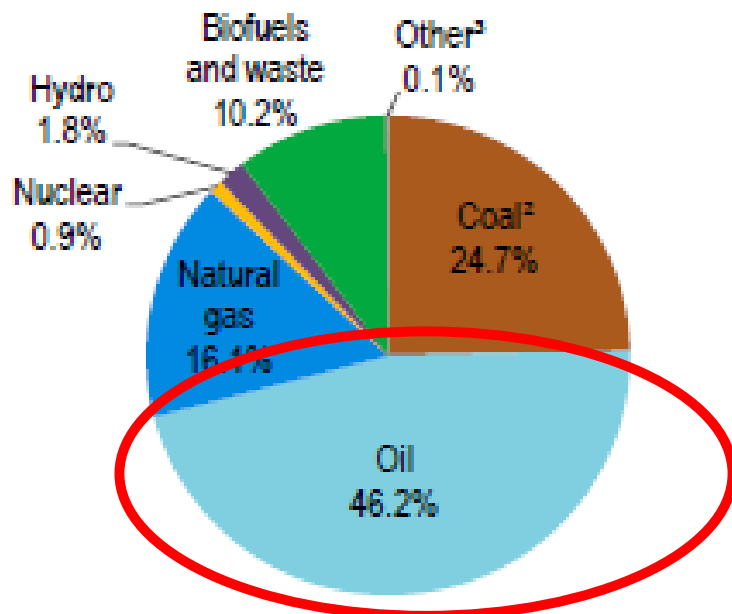
rld

Wh). Here an inefficiency factor (the 'substitution' by each energy source give a better approximation of



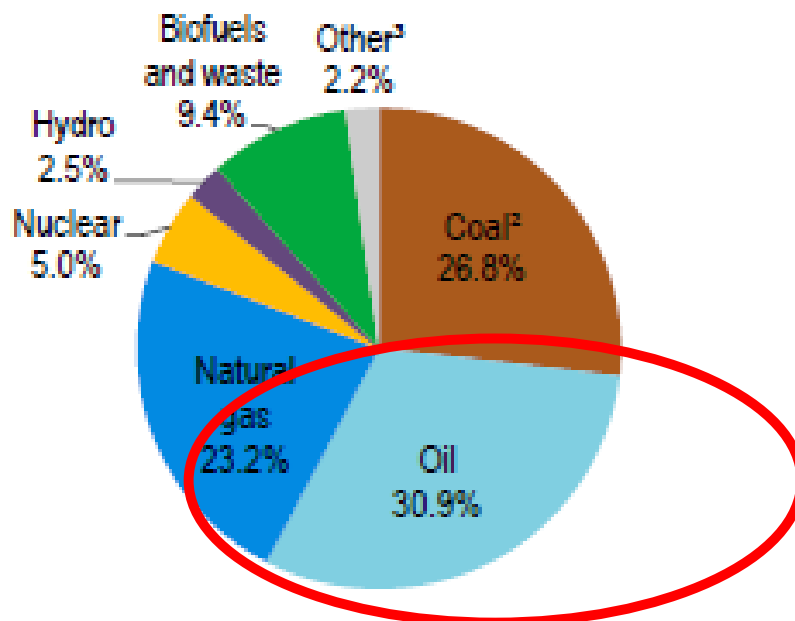
# World: Primary energy

1973



254 EJ

2019



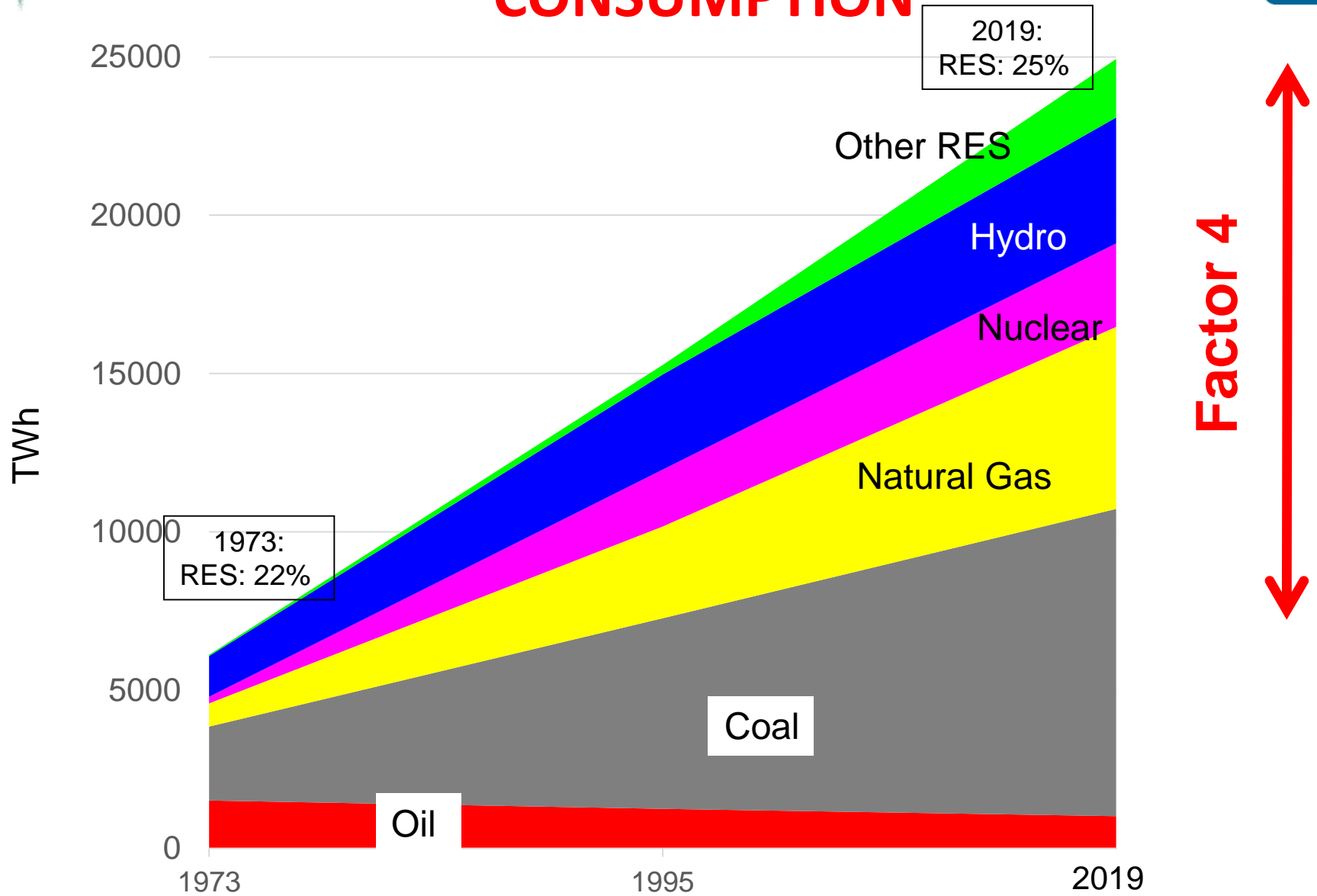
606 EJ

Source: IEA 2021

• **Total primary energy demand more than doubled between 1973 and 2019;**

• **Oil down (more than -30%!), natural gas up (+45%)!**

# WORLD-WIDE TREND IN ELECTRICITY CONSUMPTION

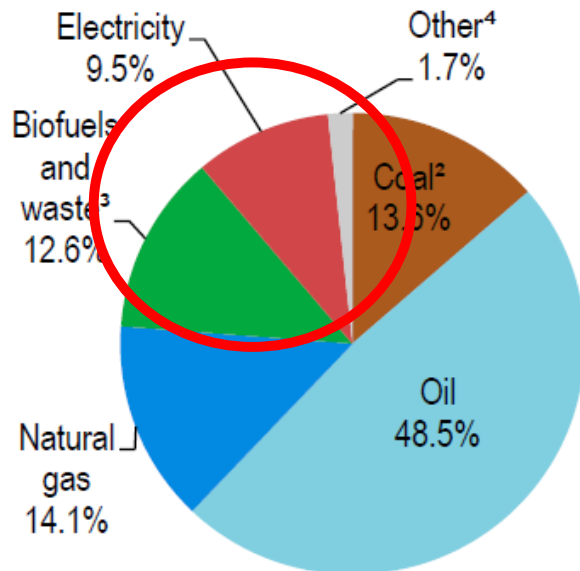




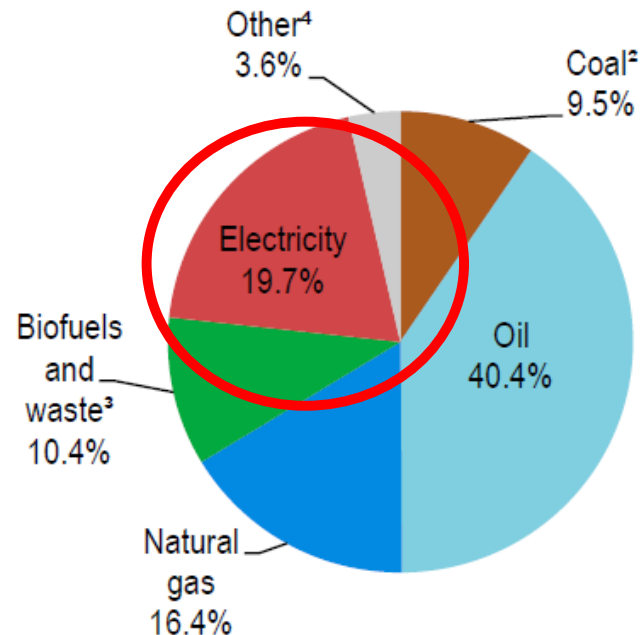
# World: Final energy

1973

2019



194 EJ



418 EJ

- The **share** of electricity increases continuously:  
In 2019 twice of 1973
- Share of oil decreased from 48% to 40%

\*\* Other includes Solar, Geothermal, Wind

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

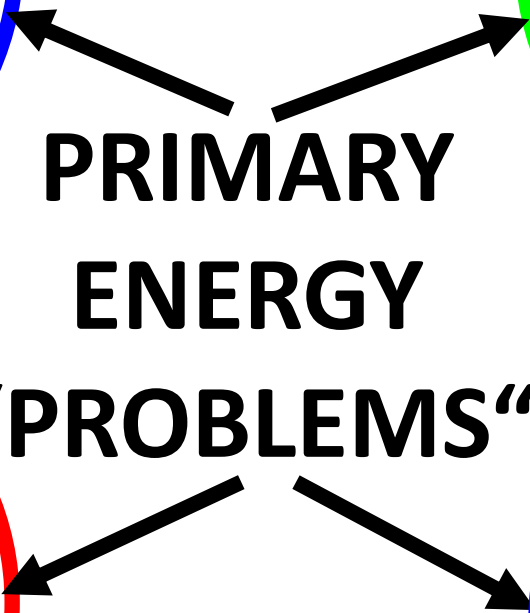
**ENVIRONM.  
EXTERNALI-  
TIES (CO<sub>2</sub>,  
SO<sub>2</sub> radiation)**

**PRIMARY  
ENERGY**

**“PROBLEMS”**

**SOCIAL:  
UNEVEN  
CONSUMP-  
TION**

**SUPPLY  
SECURITY:  
NATURAL  
GAS, OIL**



# The Key Energy Challenges



**Energy  
Access**



**Climate Change**



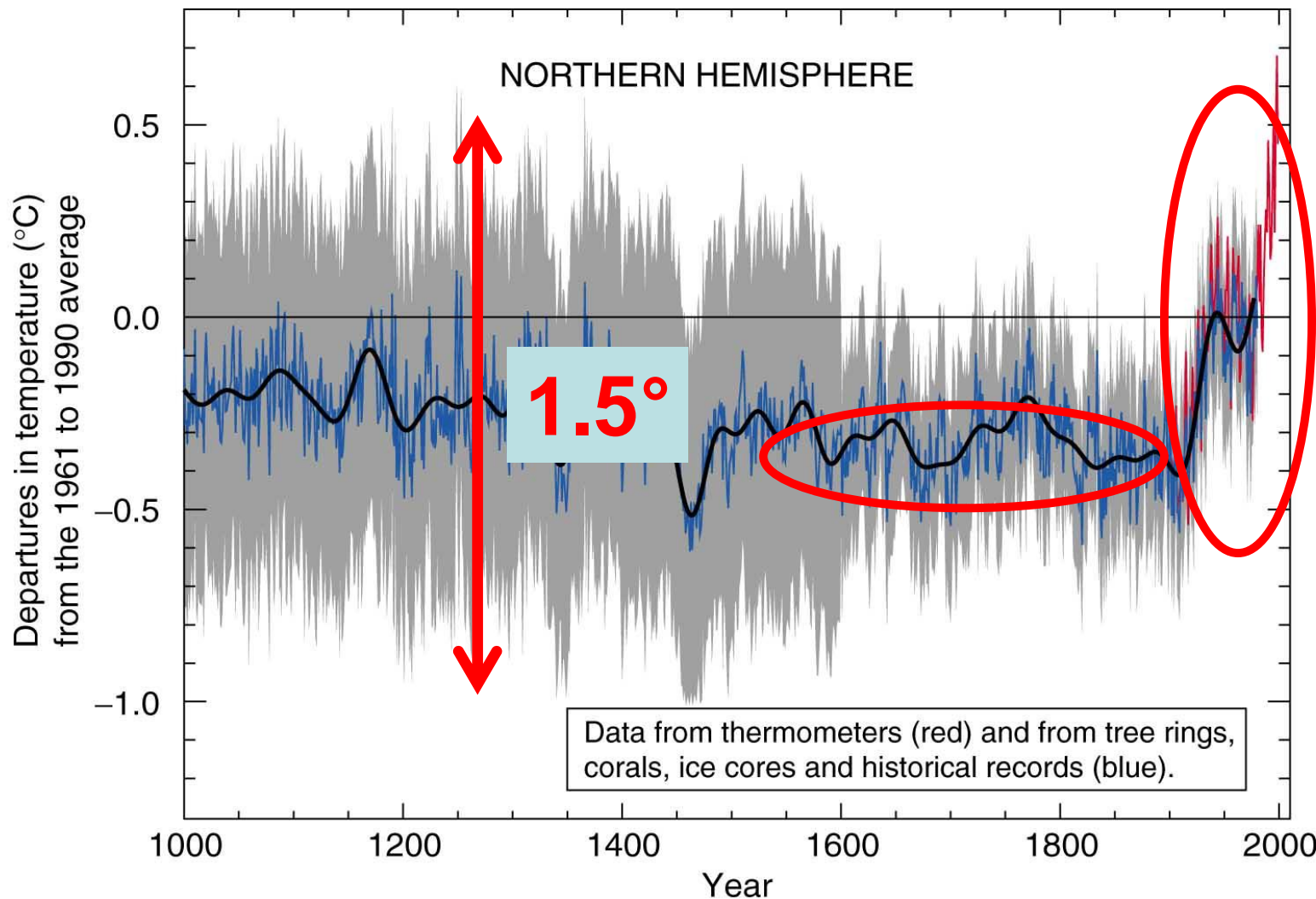
**Energy  
Security**



**Air Pollution  
Health Impacts**



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

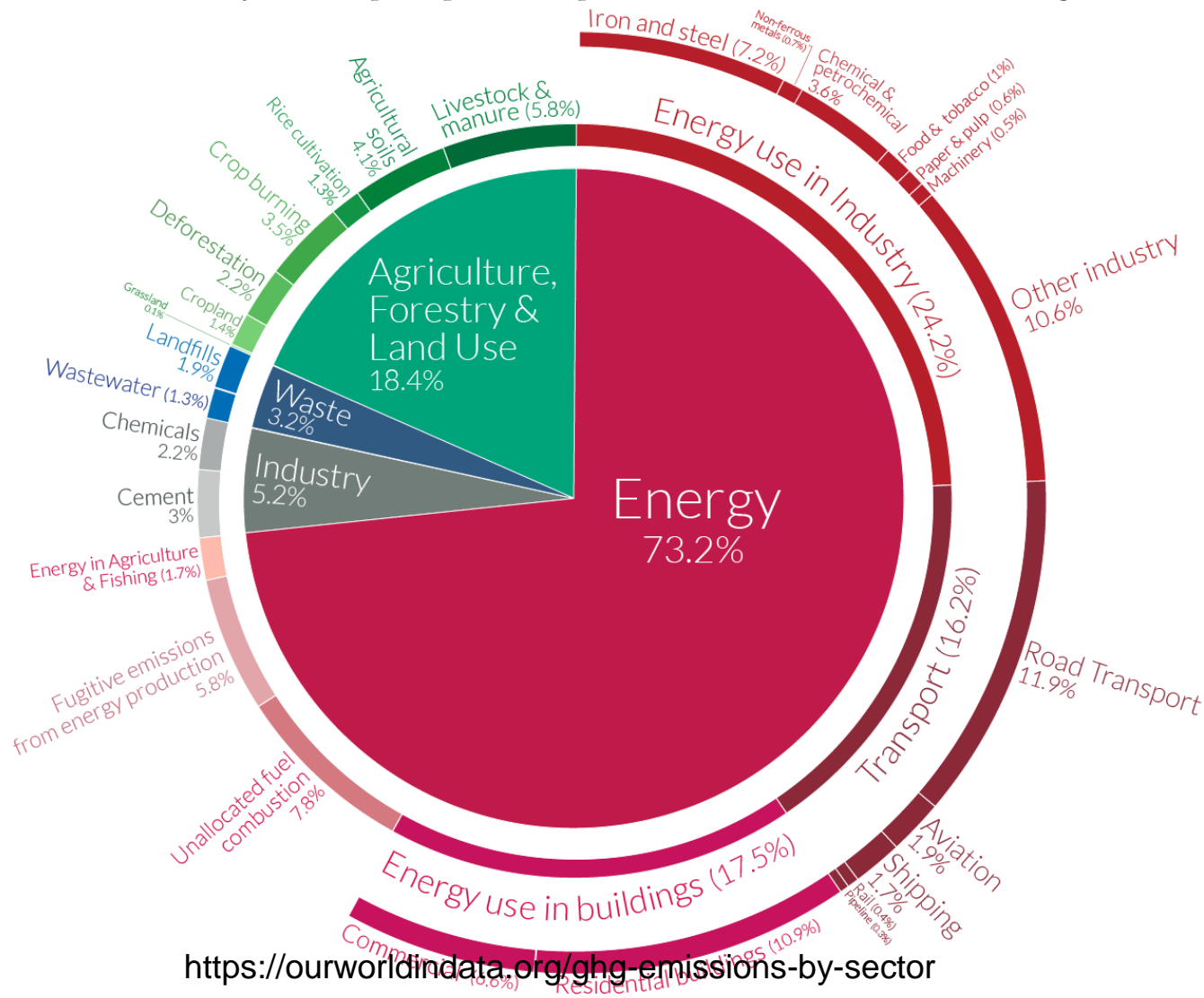


# What does energy contribute to Global Warming?

## Global greenhouse gas emissions by sector

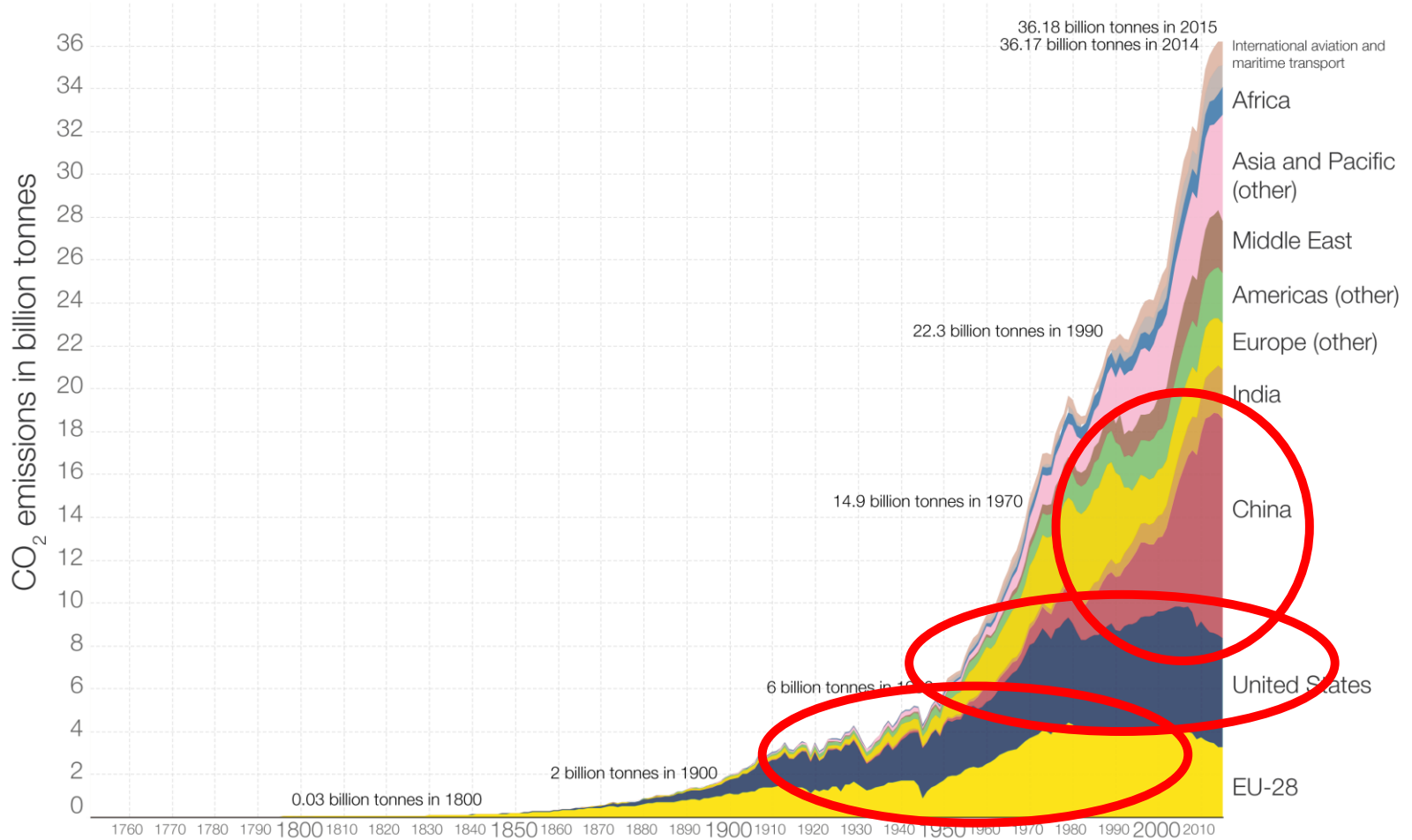
Our World in Data

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



# Global CO<sub>2</sub> emissions by world region, 1751 to 2015

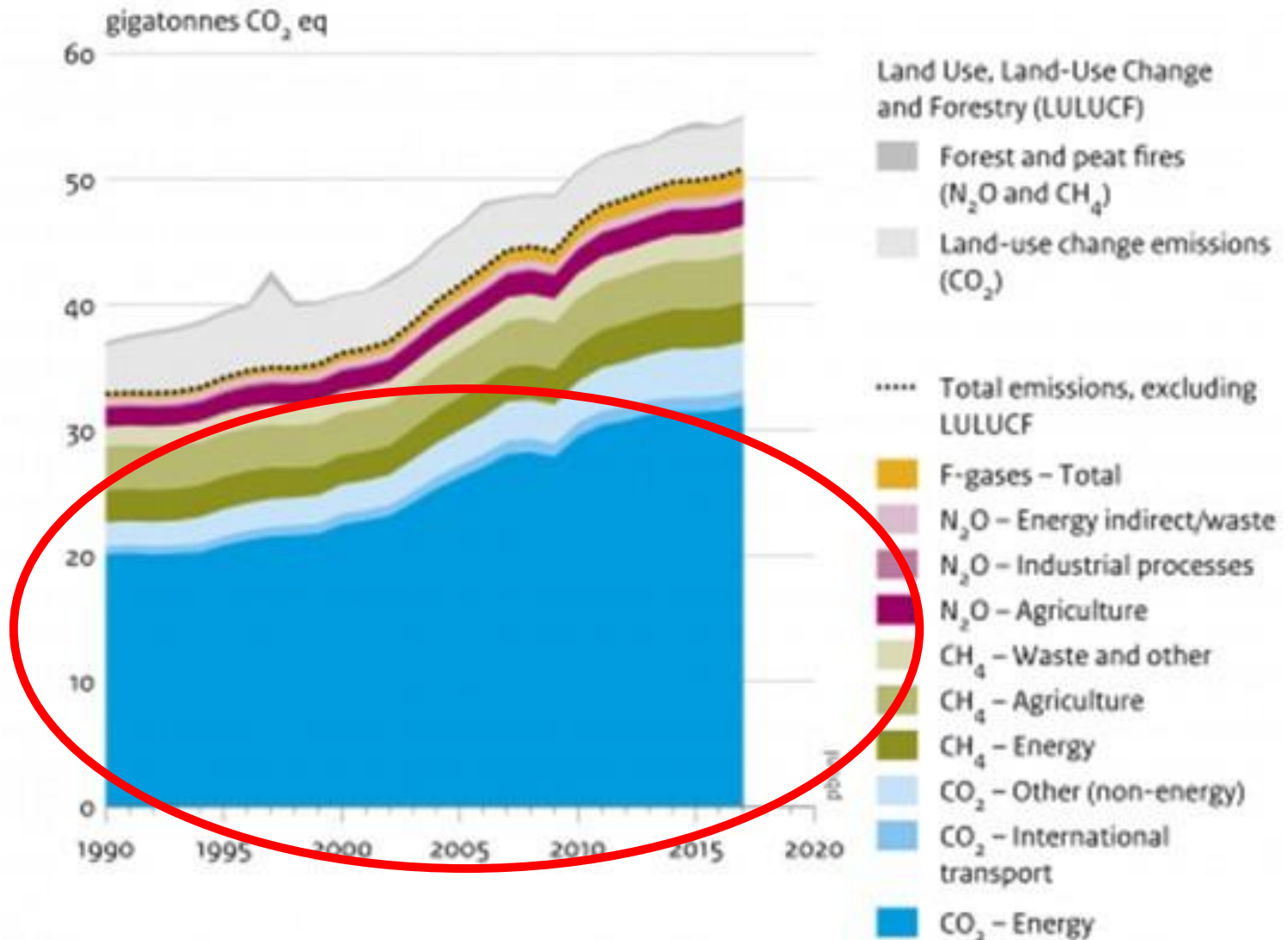
Annual carbon dioxide emissions in billion tonnes (Gt).



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](http://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

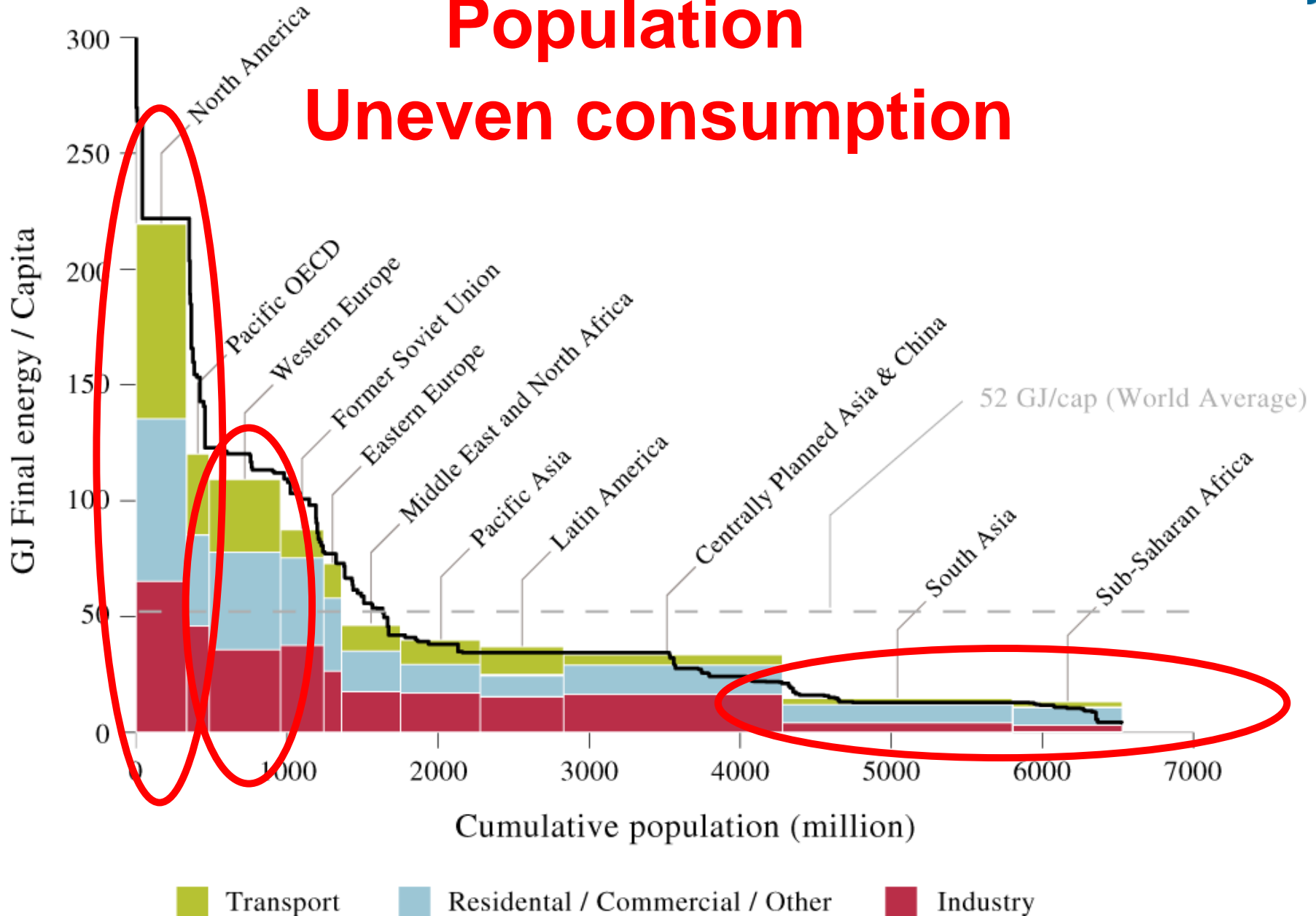


<https://www.pbl.nl/en/publications/trends-in-global-co2-and-total-greenhouse-gas-emissions-2018-report>

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

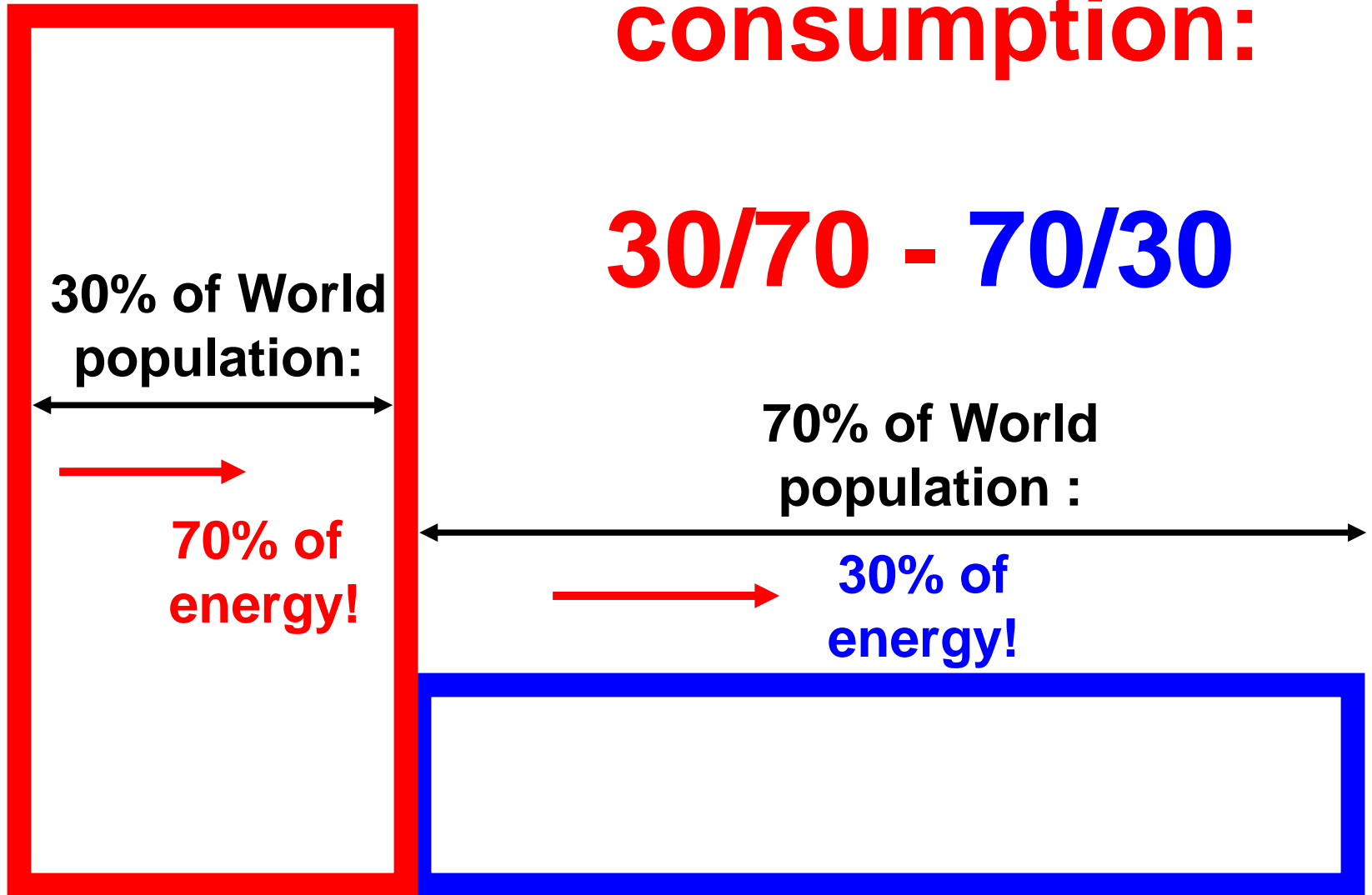
# Per Capita Final Energy & Population

## Uneven consumption



# Uneven consumption:

**30/70 - 70/30**





European  
Commission

ISSN 2363-247X

# EU energy in figures



STATISTICAL  
POCKETBOOK  
2018



Energy

## Energy, transport and environment statistics | 2020 edition



STATISTICAL  
BOOKS

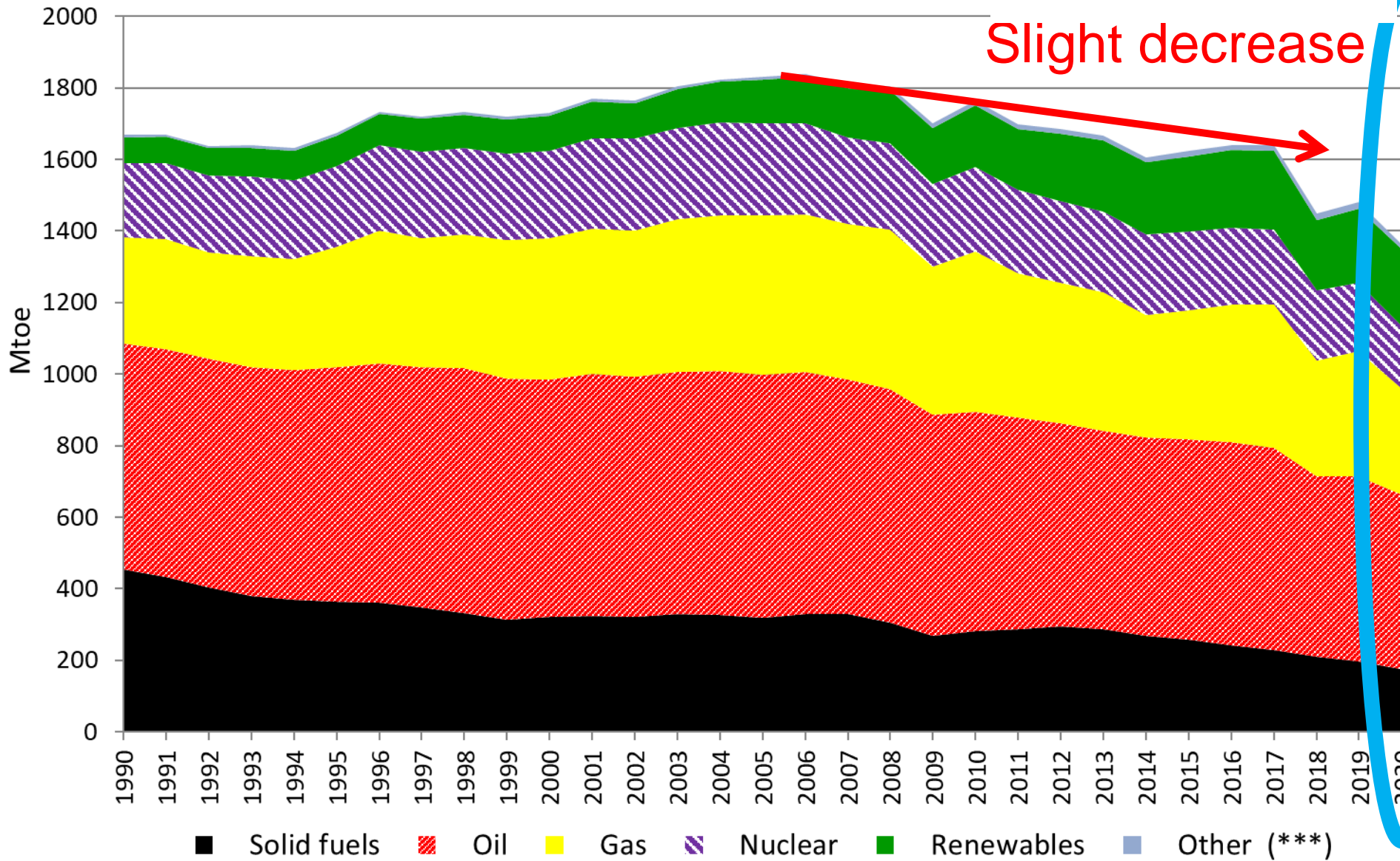
eurostat



# Primary energy in Europe

Primary energy consumption EU-28 2020: Corona?

Slight decrease

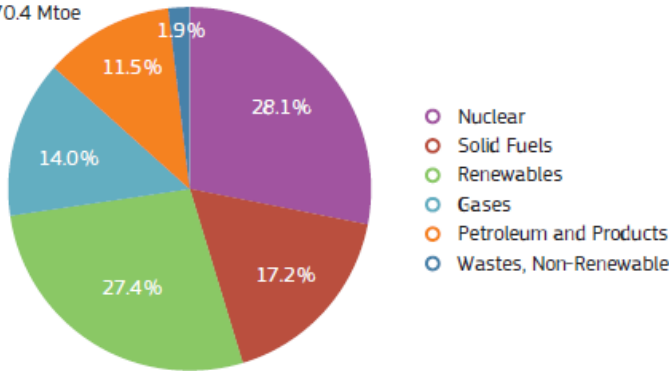


# Primary Energy EU-28: origin of resources

## Indigenous:

PRODUCTION – BY FUEL – EU-28 – 1990-2016 (% OF TOTAL)

Total = 770.4 Mtoe

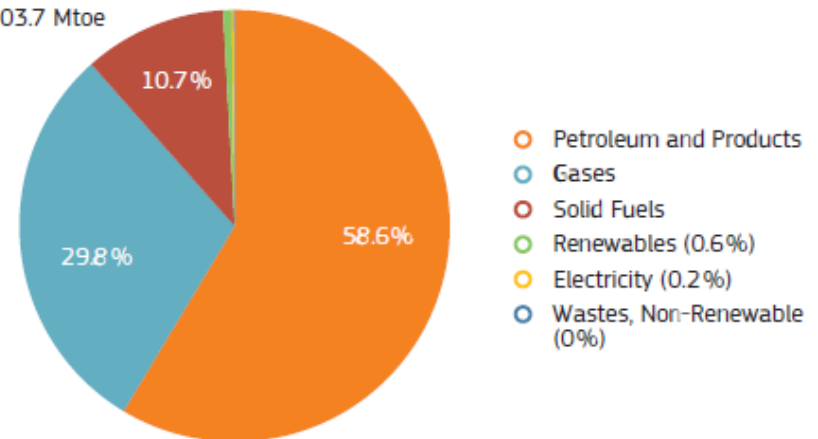


**Total 2019: ca. 770 Mtoe**

## Imports:

NET IMPORTS – BY FUEL – EU-28 – 2016 (% TOTAL)

Total = 903.7 Mtoe



**Total 2019: ca. 904 Mtoe**

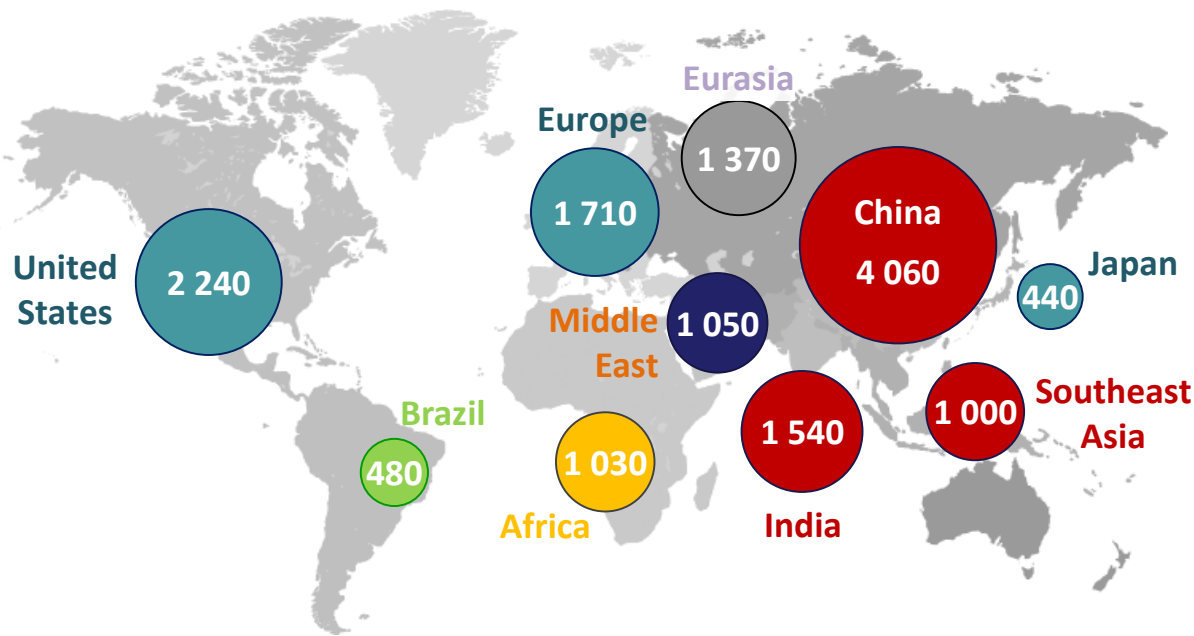
# World Energy Outlook

2017-2022

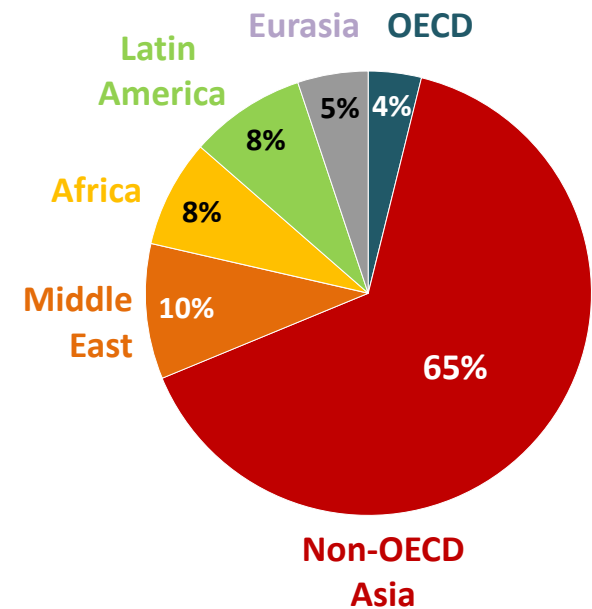
- Four large-scale upheavals in global energy set the scene for the new *Outlook*:
  - The **United States** is turning into the undisputed global leader for oil & gas
  - **Solar PV is on track to be the cheapest source of new electricity in many countries**
  - **China's** new drive to “make the skies blue again” is recasting its role in energy
  - The future is **electrifying**, spurred by cooling, electric vehicles & digitalisation
- These changes brighten the prospects for affordable, sustainable energy & require a reappraisal of approaches to energy security
- There are many possible pathways ahead & many potential pitfalls if governments or industry misread the signs of change

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

Primary energy demand, 2035 (Mtoe)



Share of global growth 2012-2035

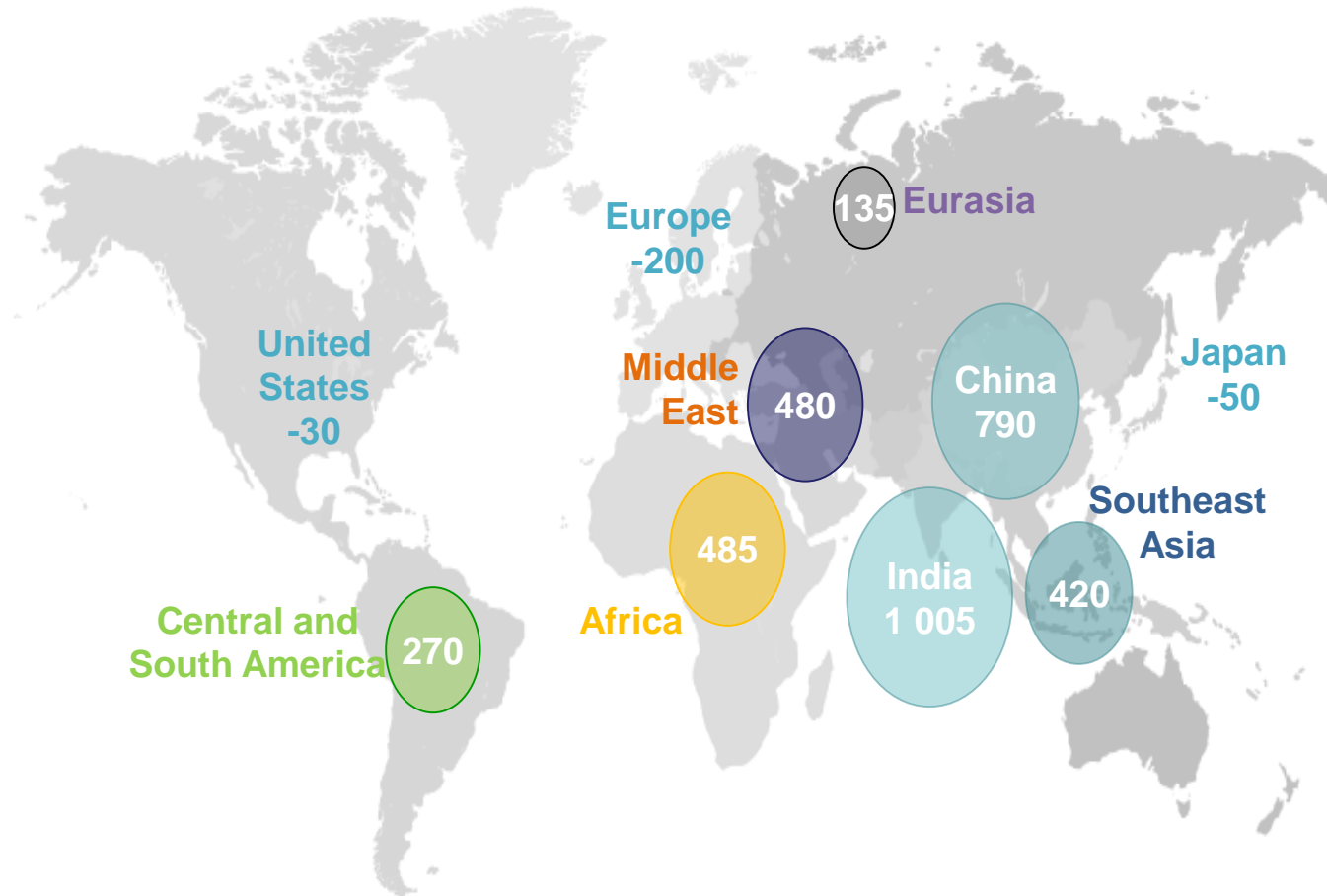


***China is the main driver of increasing energy demand in the current decade, but India takes over in the 2020s as the principal source of growth***



# WEO 2017: India takes the lead, as China energy growth slows

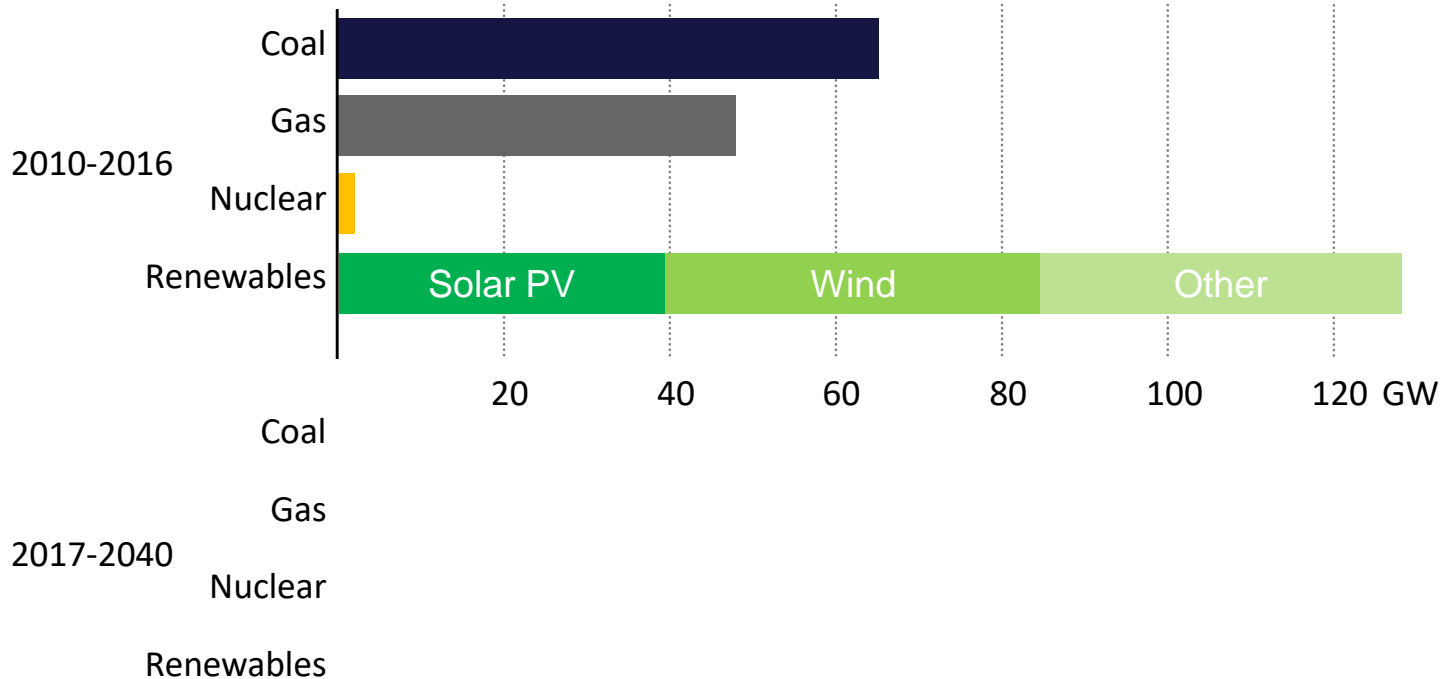
Change in energy demand, 2016-40 (Mtoe)



*Old ways of understanding the world of energy are losing value as countries change roles: the Middle East is fast becoming a major energy consumer & the United States a major exporter*

# Solar PV forges ahead in the global power mix

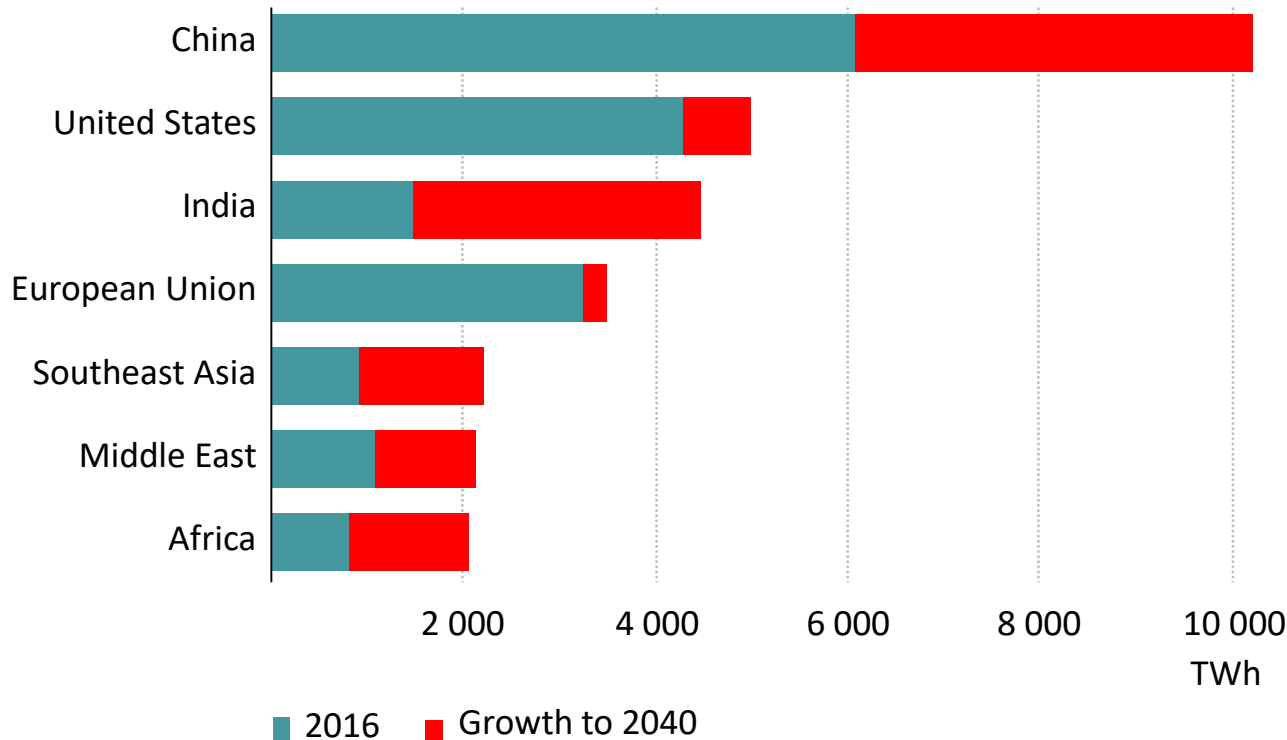
Global average annual net capacity additions by type



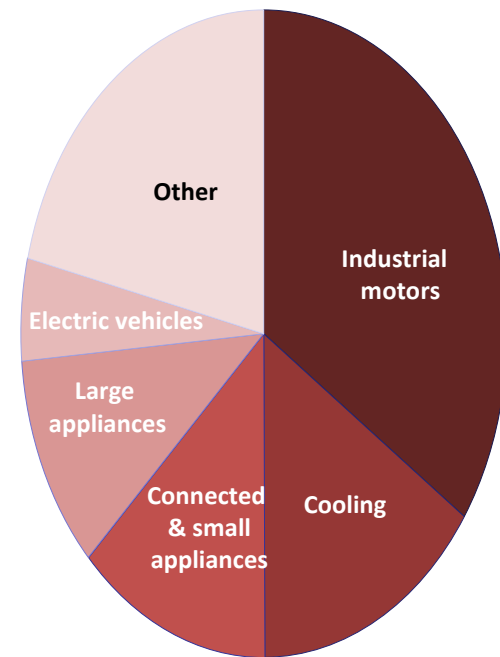
*China, India & the US lead the charge for solar PV, while Europe is a frontrunner for onshore & offshore wind: rising shares of solar & wind require more flexibility to match power demand & supply*

# The future is electrifying

Electricity generation by selected region



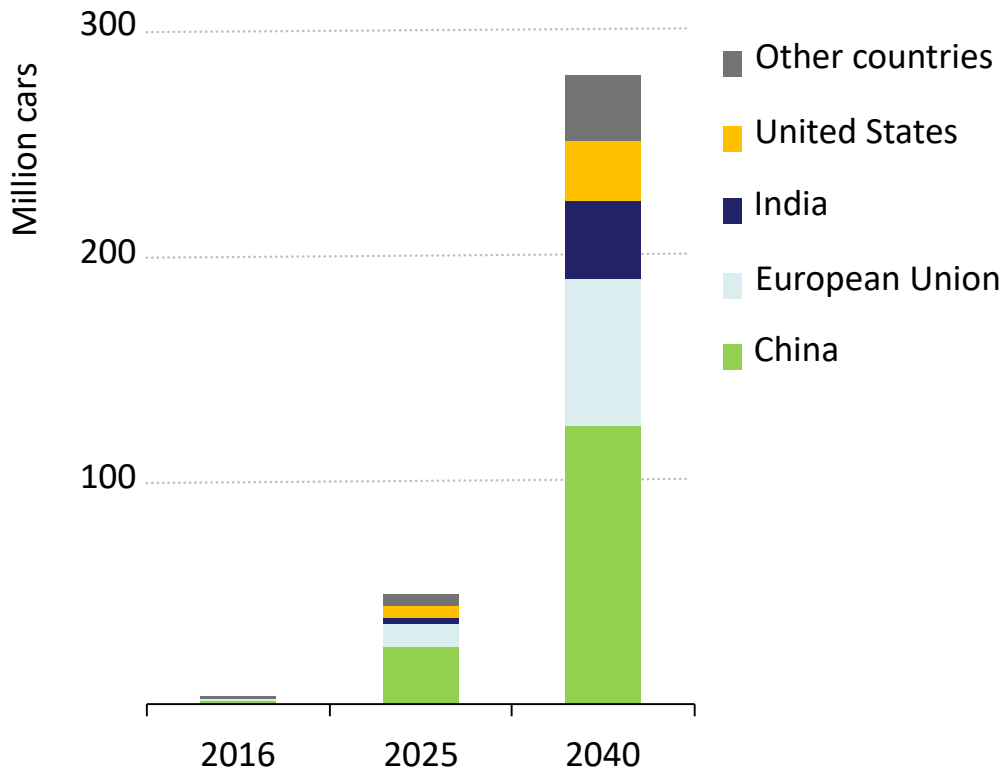
Sources of global electricity demand growth



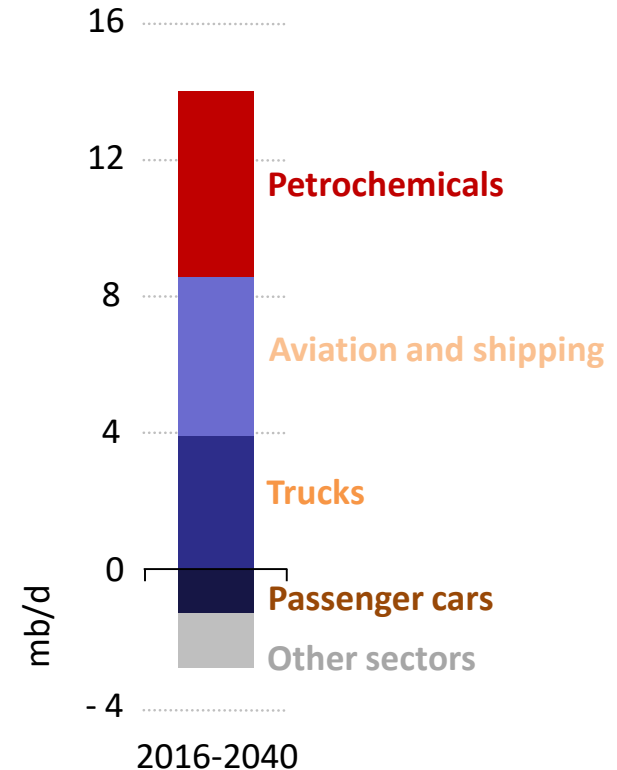
*India adds the equivalent of today's European Union to its electricity generation by 2040, while China adds the equivalent of today's United States*

# EVs are on the way, but oil demand still keeps rising

Electric car fleet

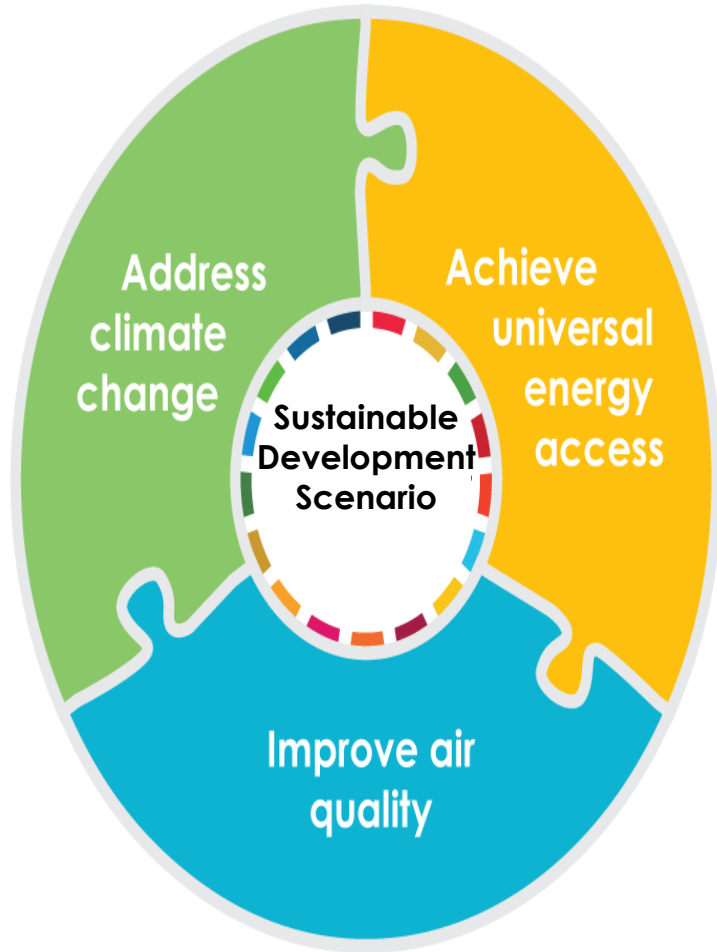


Change in global oil demand

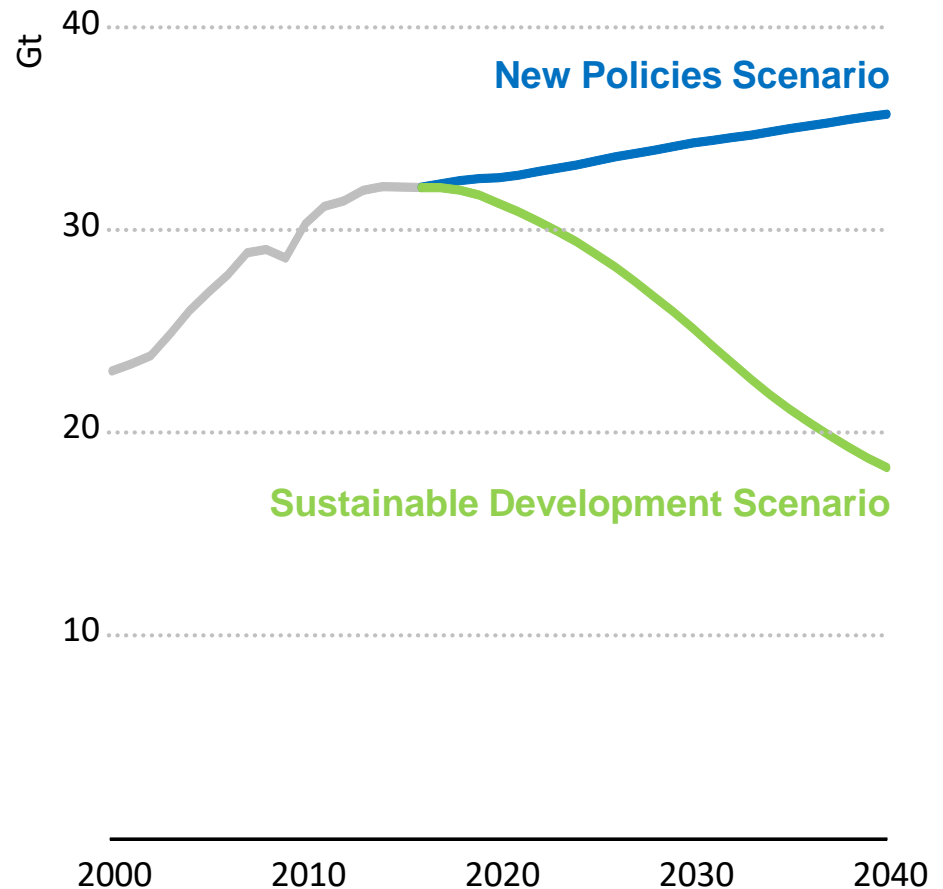


*Electric cars are helping to transform energy use for passenger cars, slowing the pace of growth in global oil demand: however, trucks, aviation, shipping & petrochemicals keep oil on a rising trend*

# A new strategy for energy & sustainable development



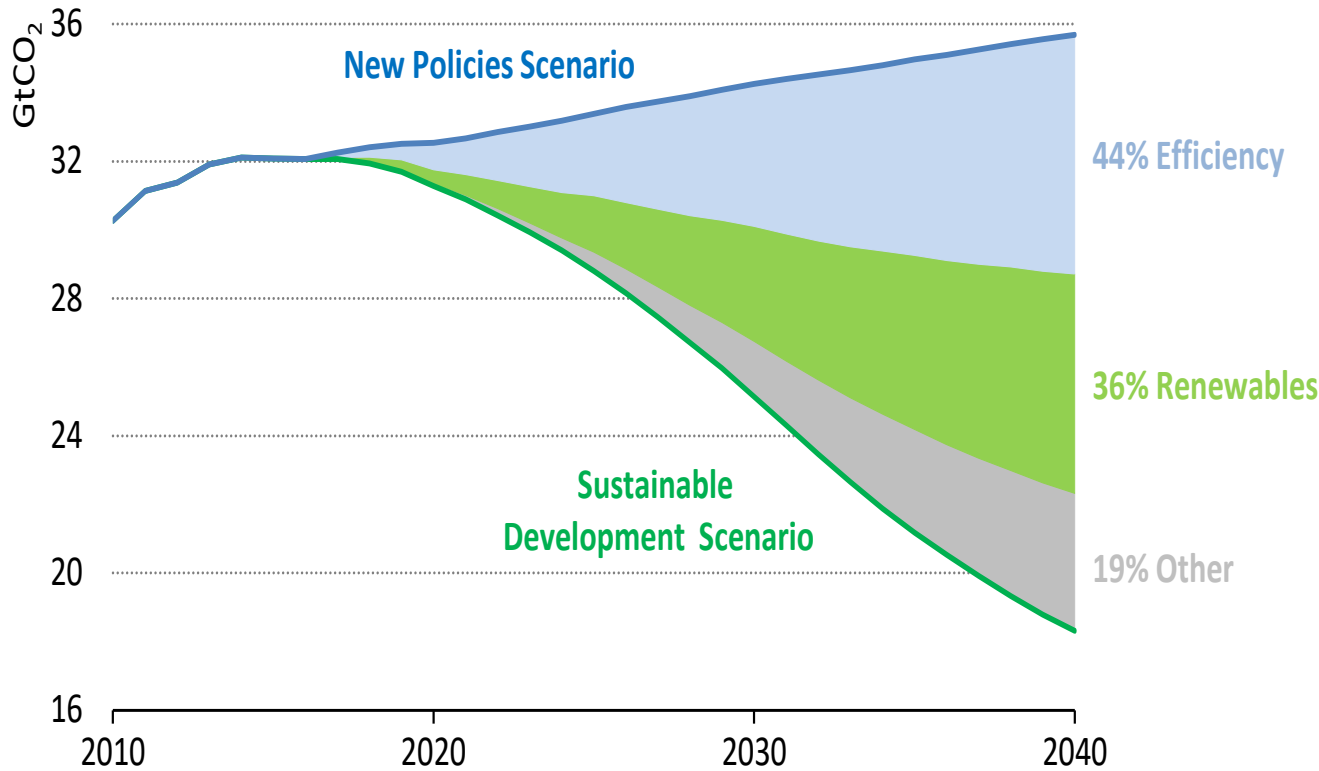
Global CO<sub>2</sub> emissions by scenario



*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*

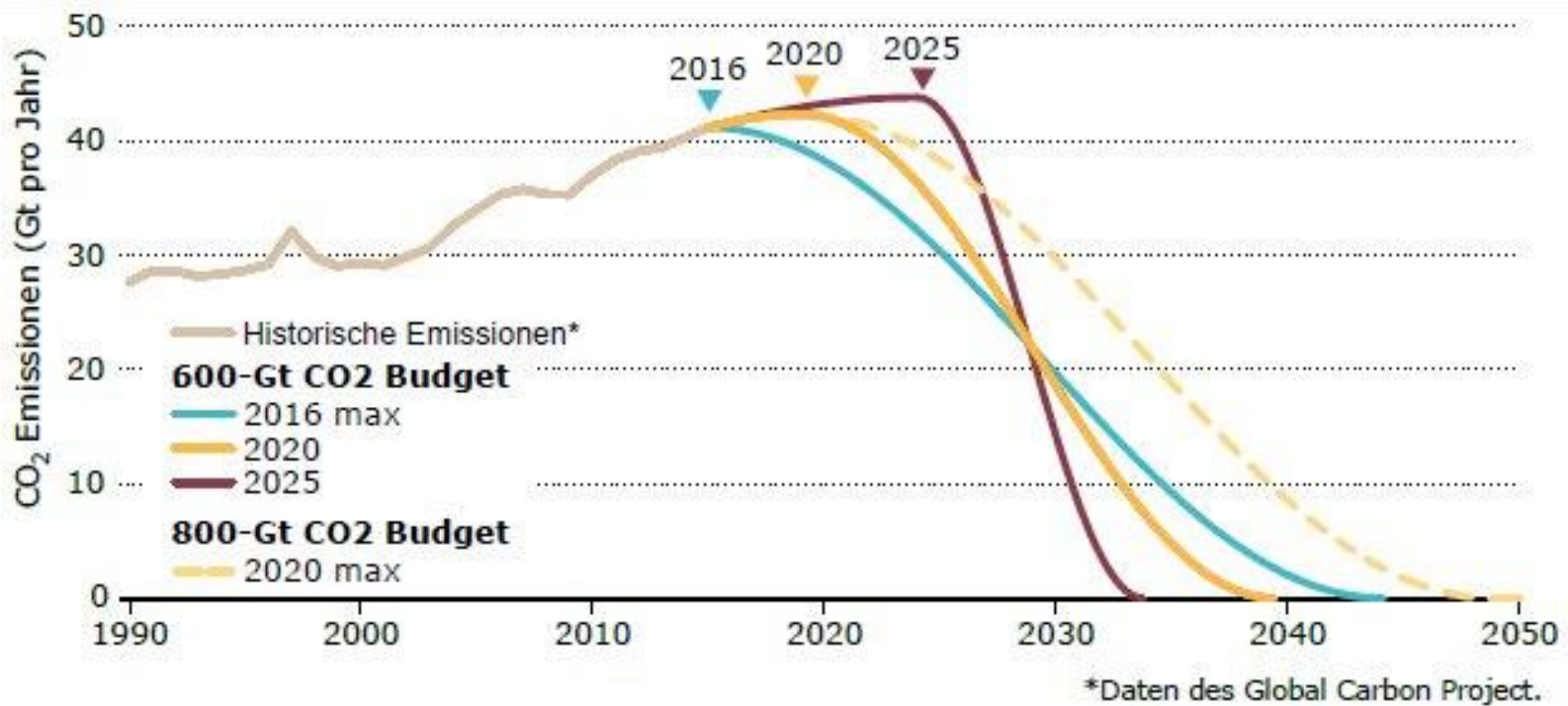


# Global energy-related CO<sub>2</sub> emissions abatement and key contributions in the SDS



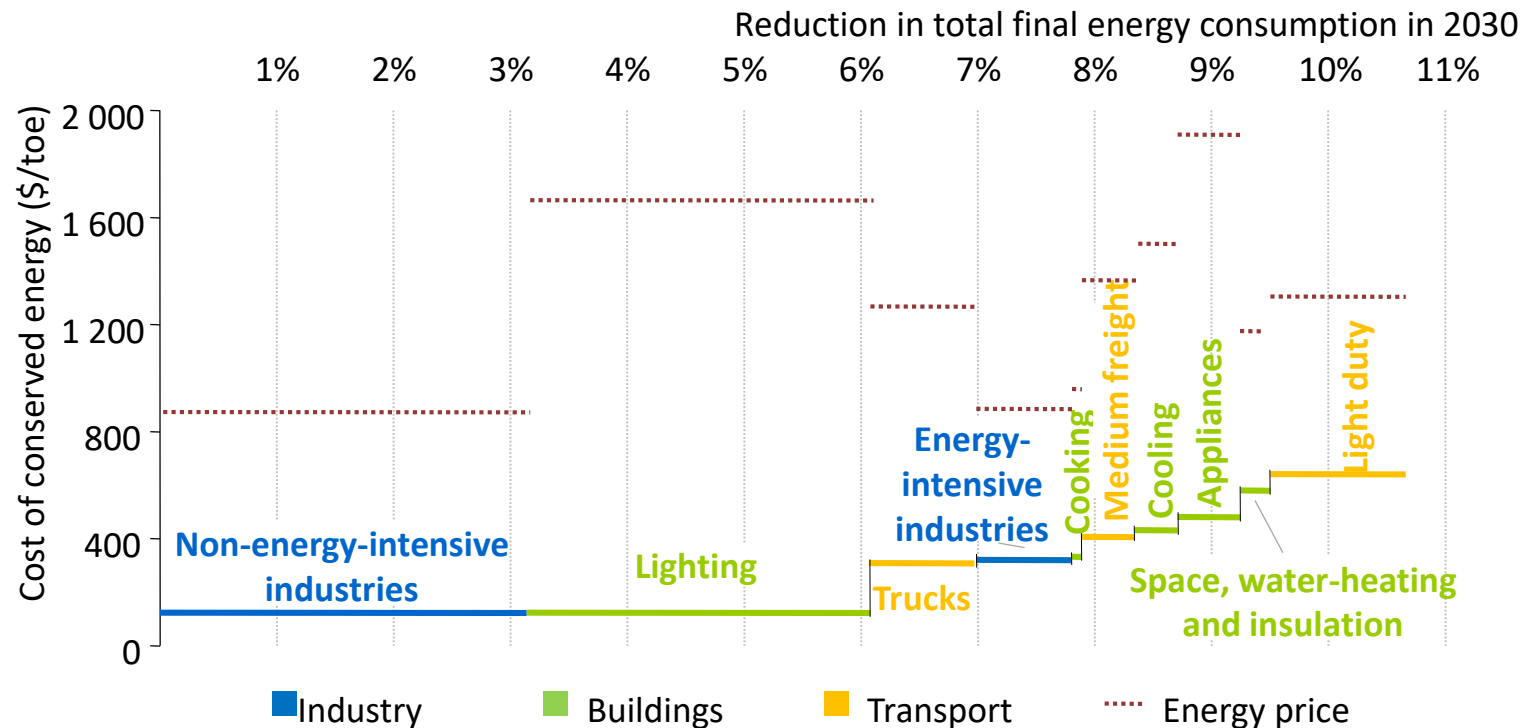
***Energy efficiency and renewables are the two key abatement measures in the New Policies and Sustainable Development Scenarios***

# 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***

# FOR FURTHER INFORMATION:

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