

Energy in Sweden

Monitor Lodge, VASA Order of America

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With thanks to Eric Swanson, Bobbie Watson, Christer Axelsson, and Geir Vollsæter

For What is Energy Important?

- Industry
- Transportation
- Environment & health
- Water use
- Agriculture
- Mineral resources
- Science & engineering
- Military technology & use
- Housing
- Communities
- The economy
- International trade & relations
- ***Our future***

Topics Today

1. Sources
2. Uses
3. Efficiency
4. Transmission
5. Trends
6. Public opinion
7. Comparisons to U.S.
8. Policies
9. Recent news
10. Take aways

Energy sources: Energikällor

- Nuclear energy

- Fossil energy

Coal

Oil

Natural gas

- Renewable

Bioenergy

Ground source heating

Hydropower

Solar energy / Photovoltaic

Wind & offshore wind

- Kärnenergi

- Fossil energi

Kol

Olja

Naturgas

- Förnybar energi

Bioenergi

Bergvärme

Vattenkraft

Solenergi / Solceller

Vindkraft & vindkraft till havs

Kärnenergi: Nuclear Energy

Oskarshamn plant



Nuclear Power Plants at Forsmark, Ringhals, & Oskarshamn.

Barsebäck closed.

Vattenfall studying small reactor concept for Ringhals.



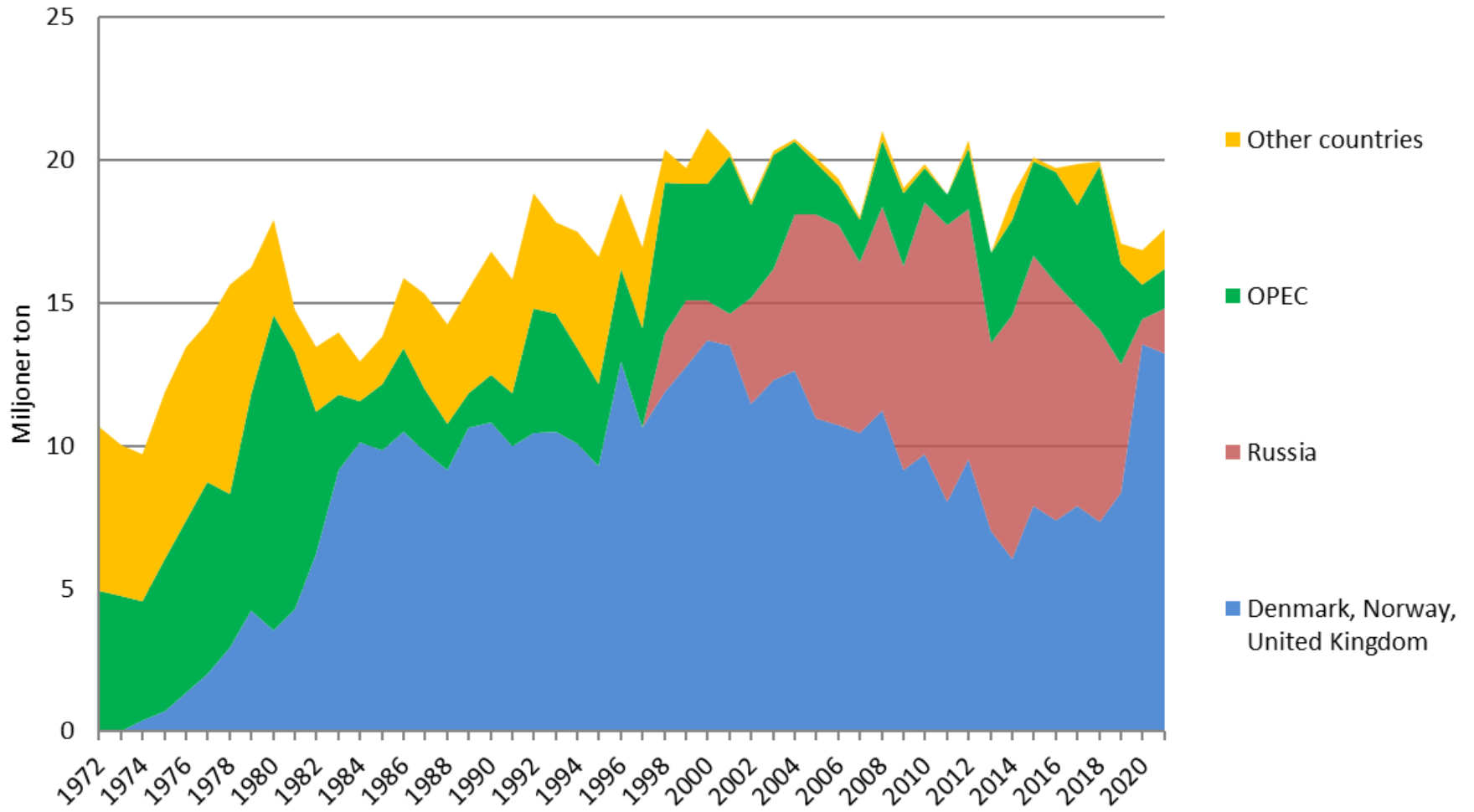
Kol



Olja, Refinery Owned by Preem at Lysekil, West Coast



Swedish import of crude oil, by country of origin, from 1972, million tonnes



Naturgas: Natural gas used for truck fuel in Östersund, Jämtland



Natural Gas Network



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Bioenergie: Bioenergy

Kalix heat power plant



Vattenkraft: Hydroelectricity at Svängsta



Solarenergie: Solar energy at Port of Stockholm



Vindkraft: Wind power

Lehtirova plant near Gällivare and Pajala

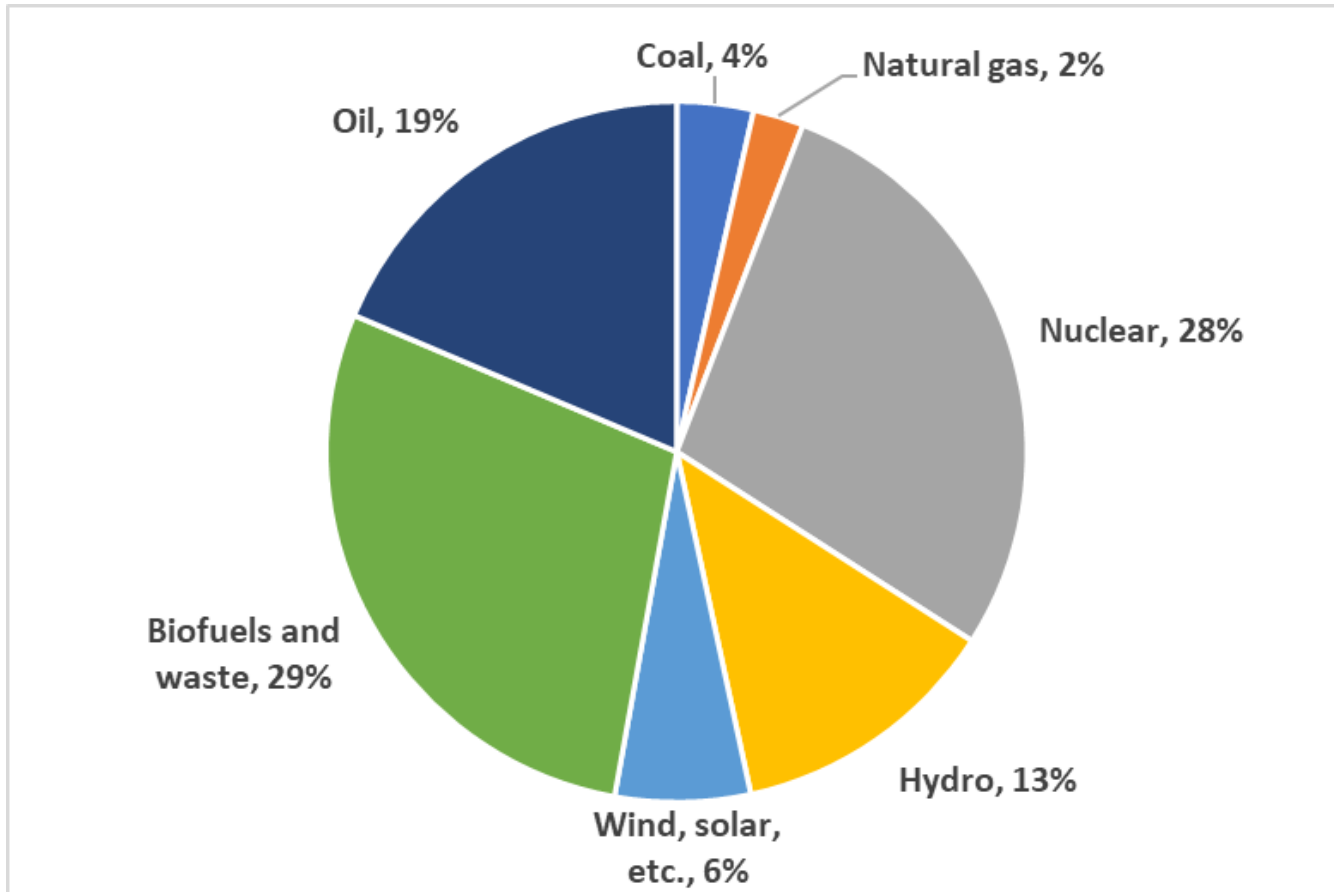


Vindkraft till havs: Offshore wind power Near Kalmarsund

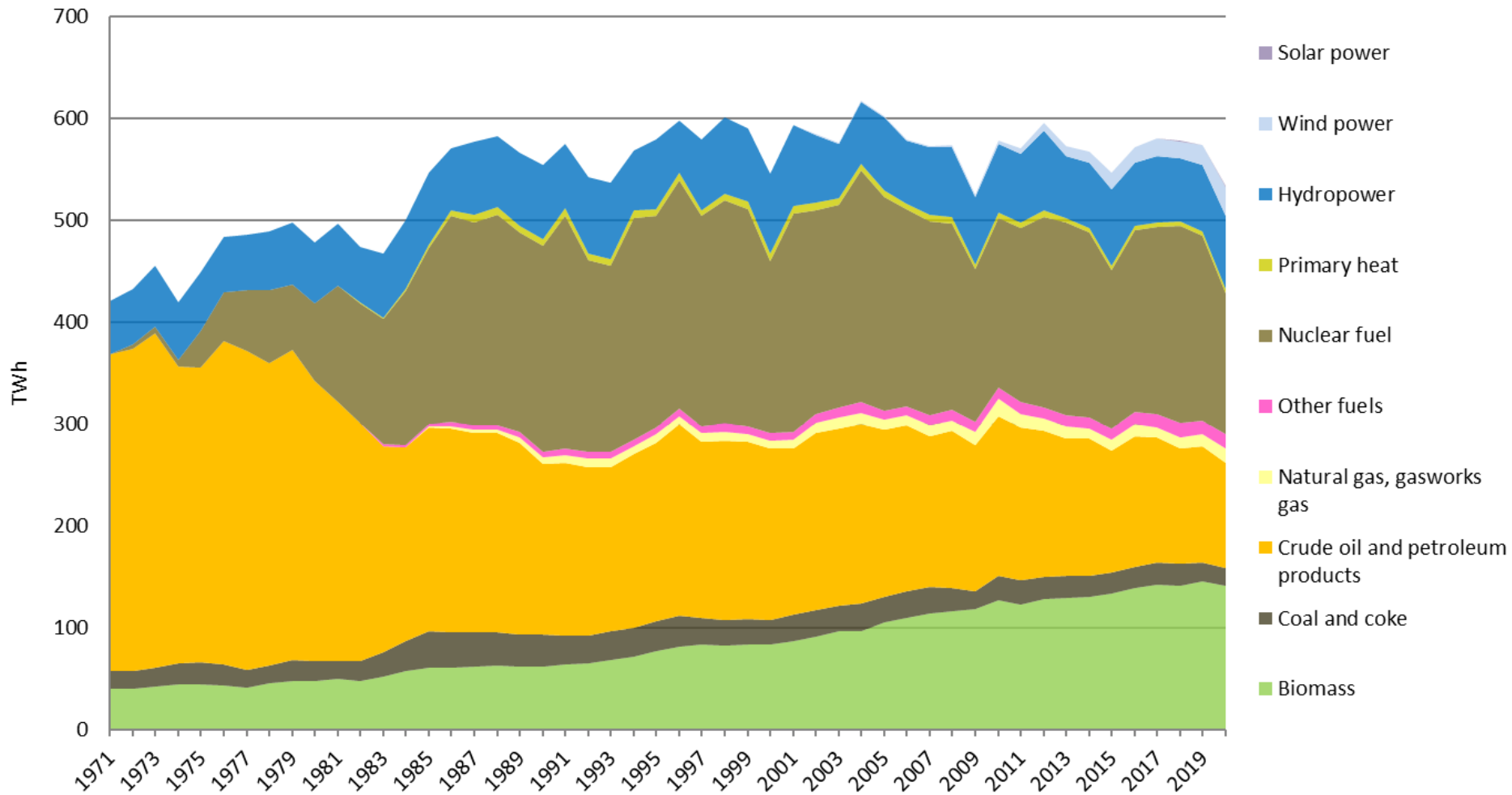


© Gunnar Britse

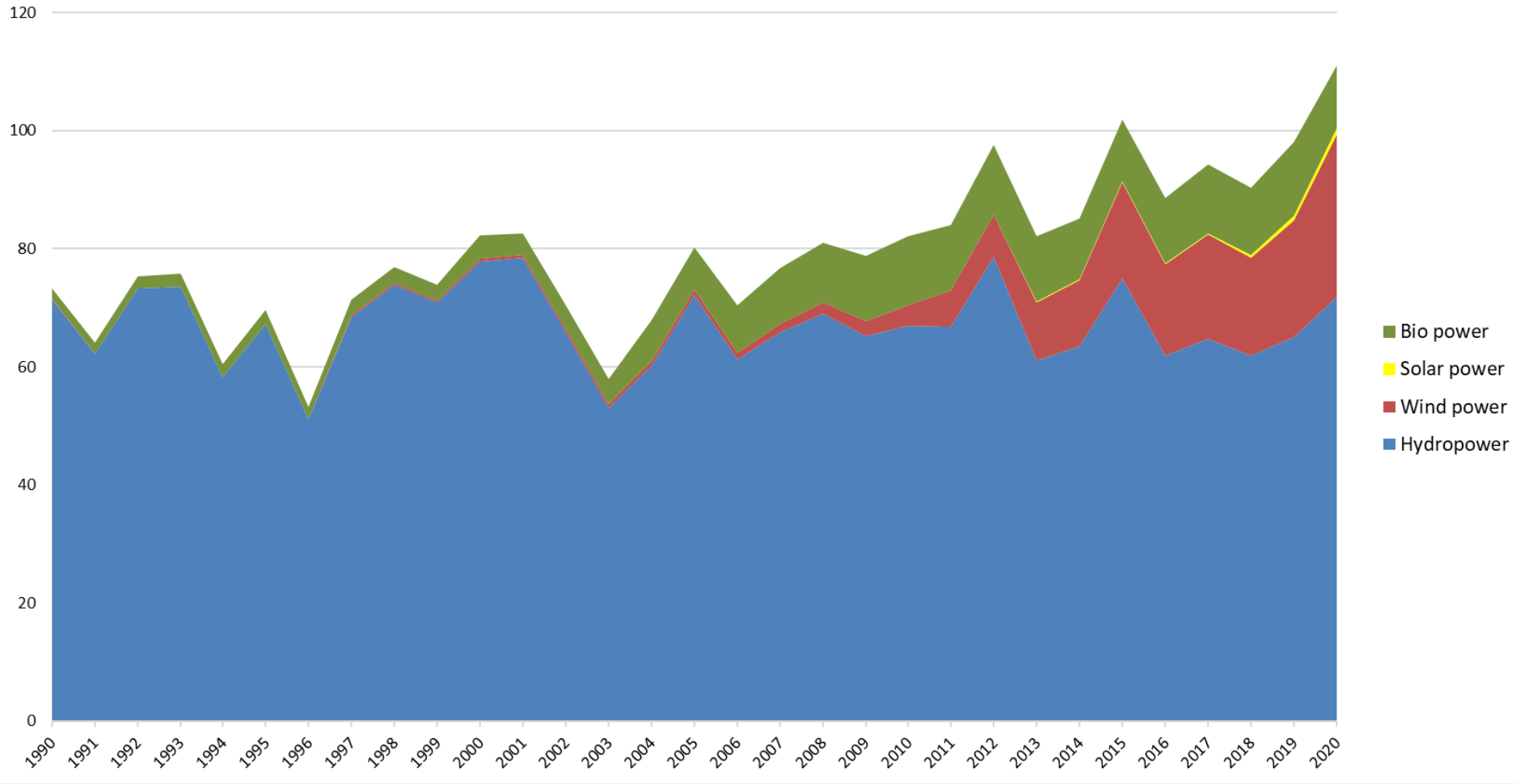
Energy Supply Sources for Sweden in 2021



Total energy supply by energy commodity, from 1970, TWh

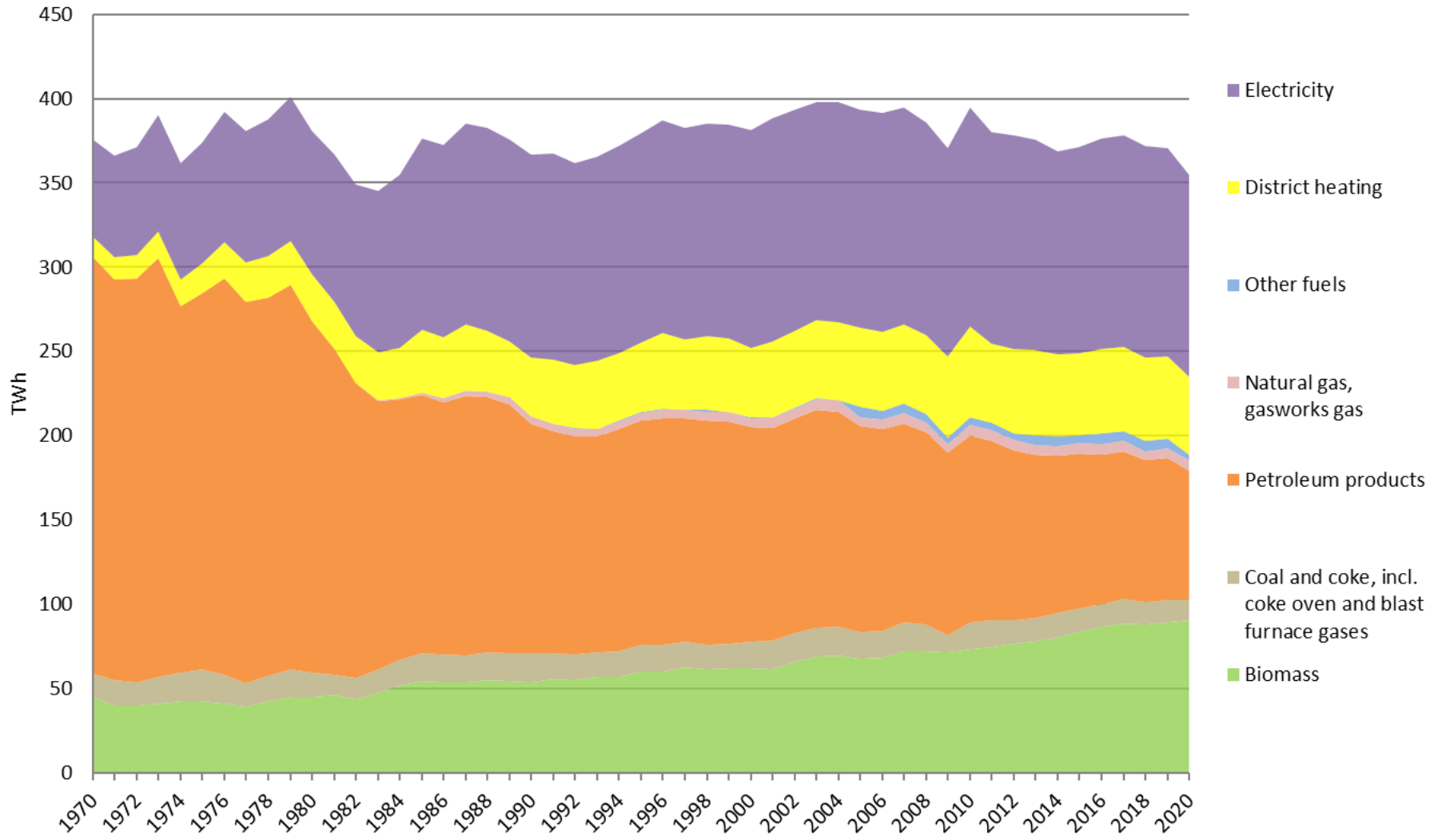


Net production of renewable electricity, from 1990, TWh

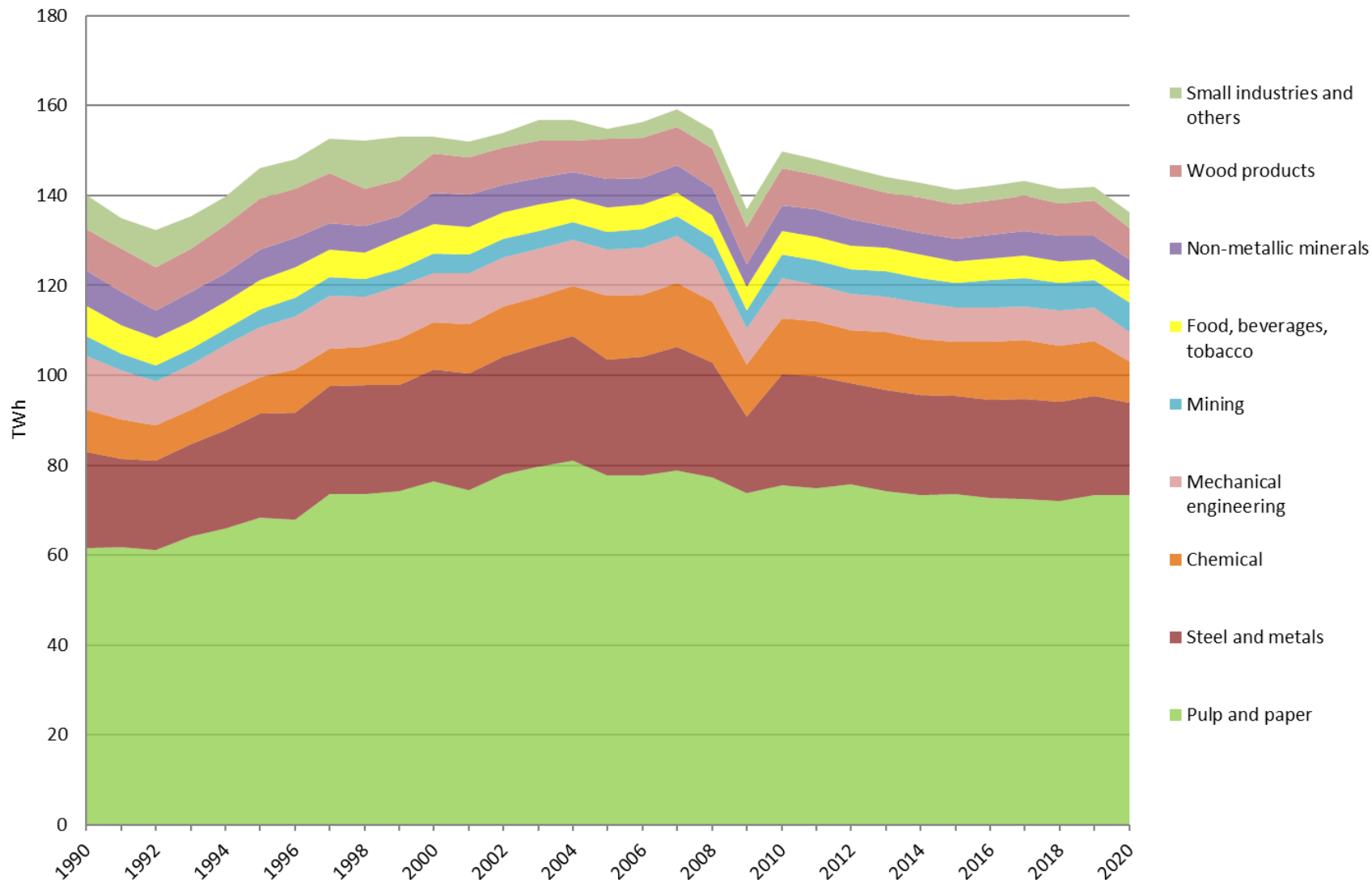


Energiförbrukning: Energy Use

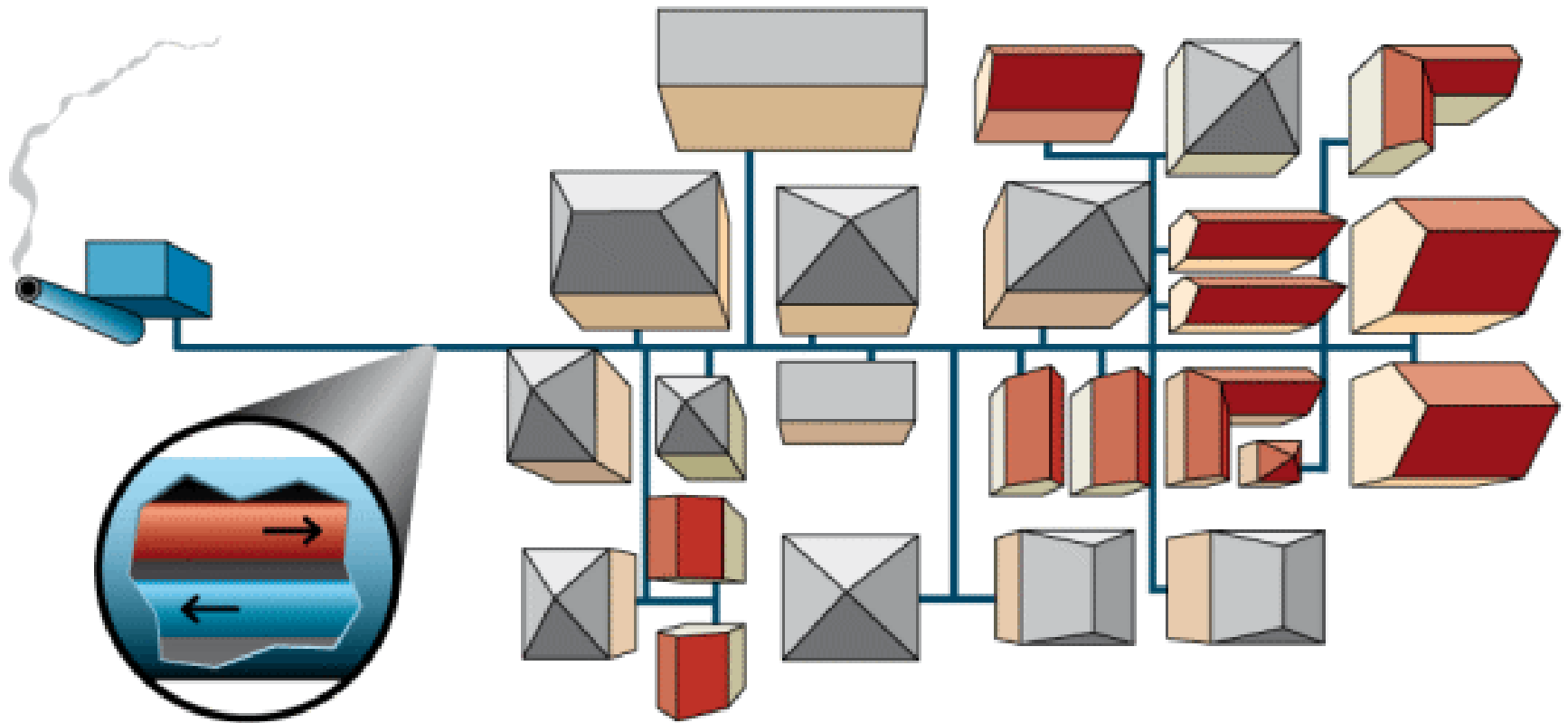
Total final energy use, by energy carrier, from 1970, TWh



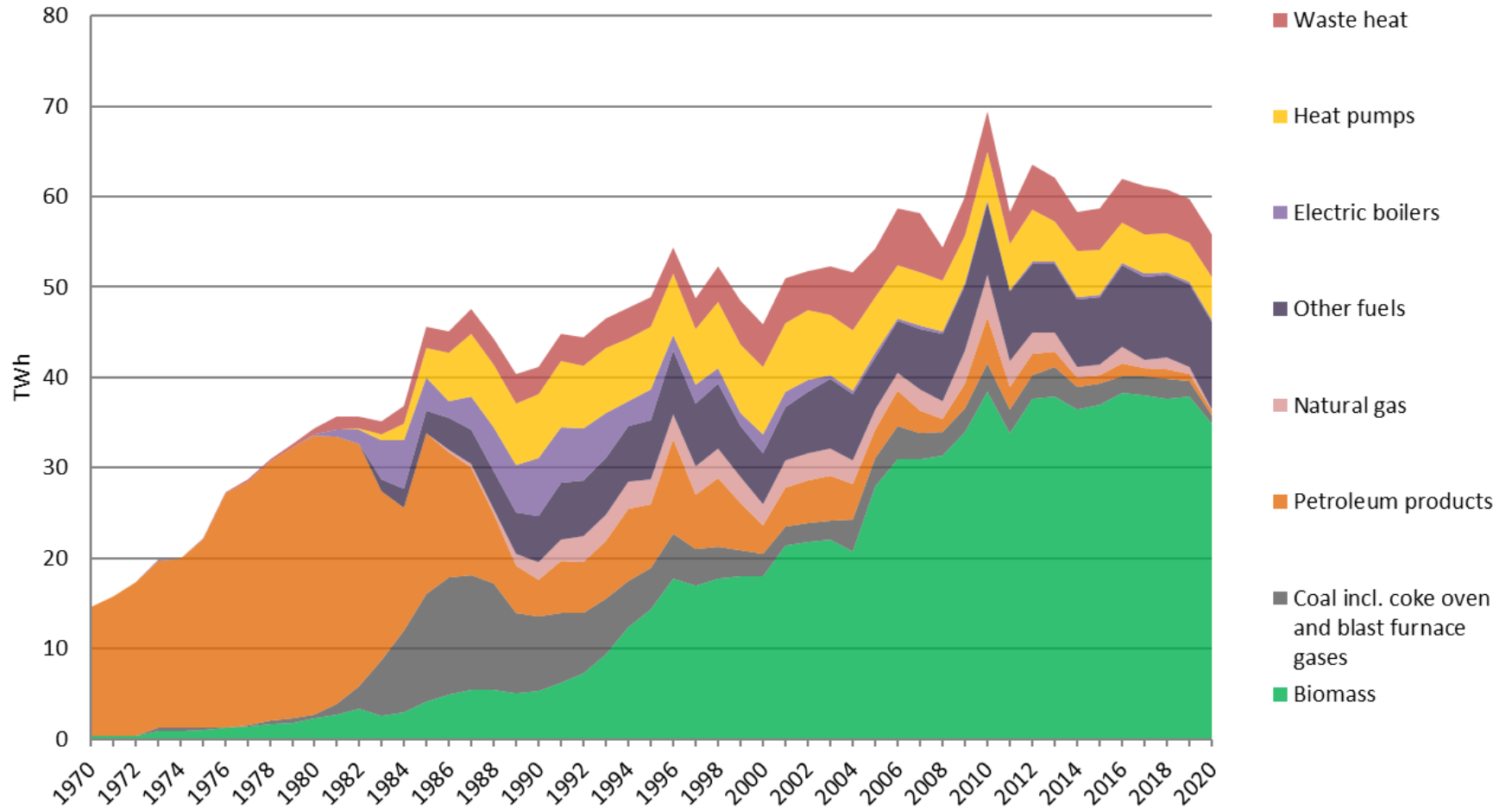
Final energy use in the industrial sector, by industry, from 1990, TWh



District Heating



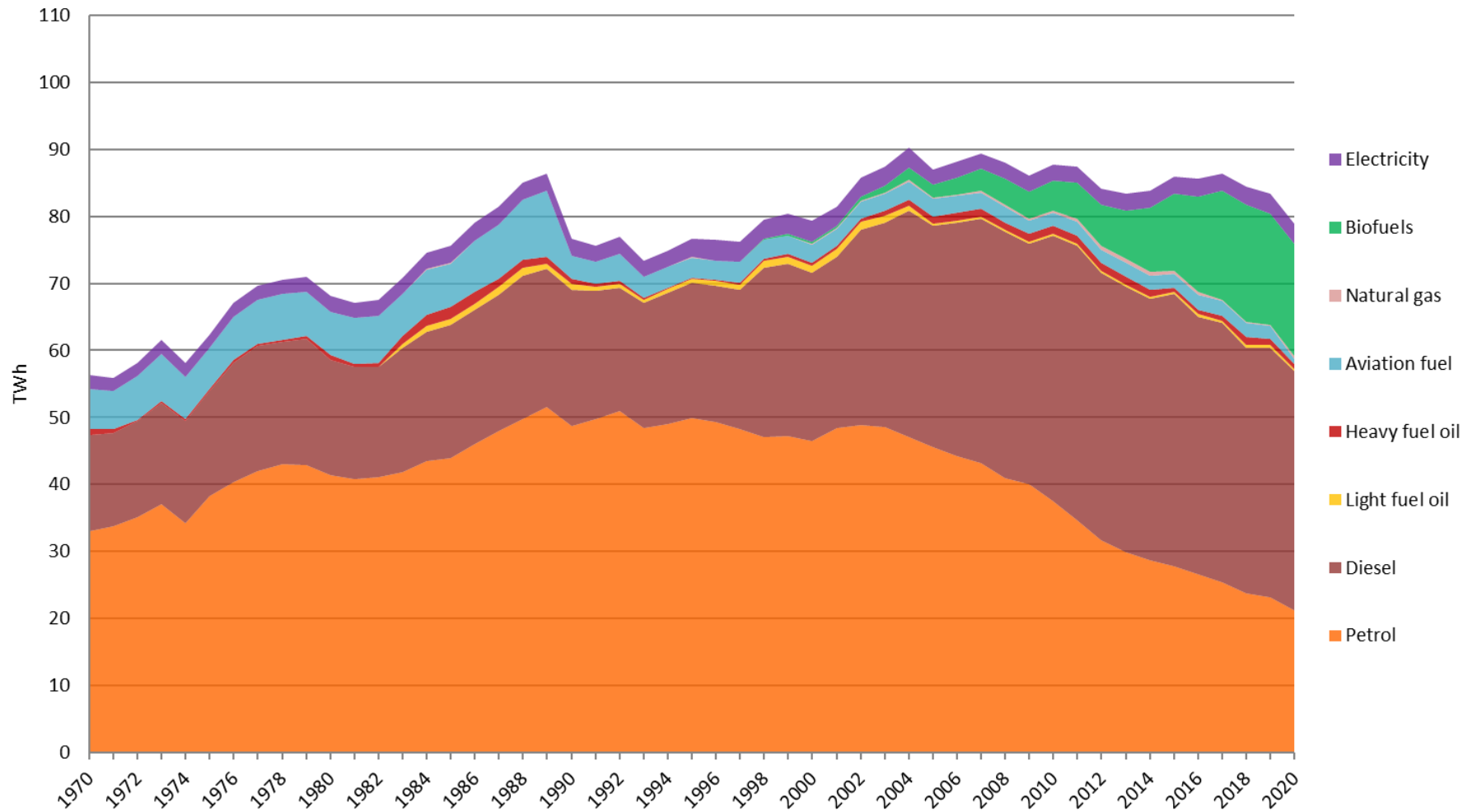
Input energy used in the production of district heating, from 1970, TWh



Transport Energy

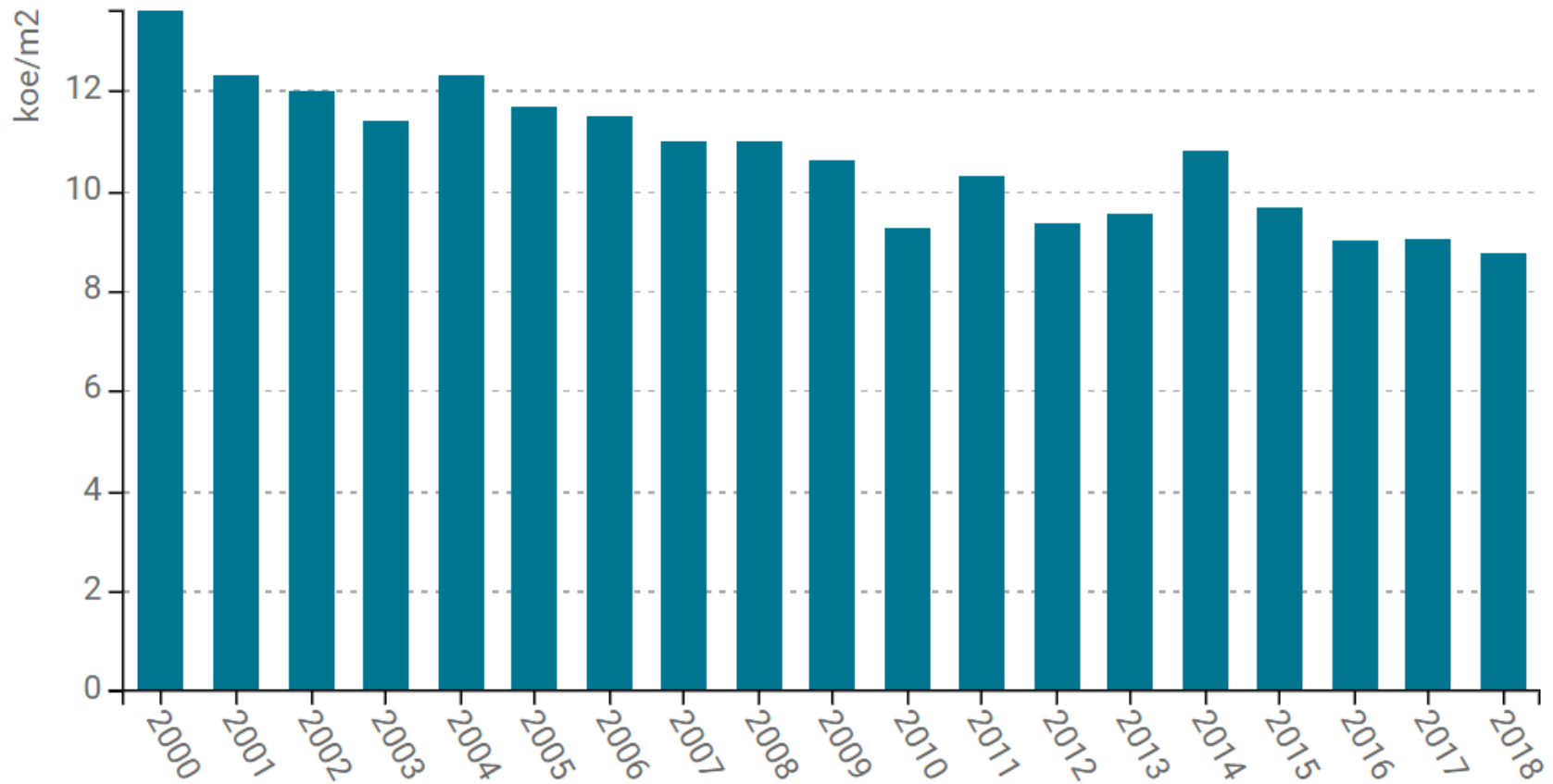


Final energy use in the transport sector (domestic), from 1970, TWh

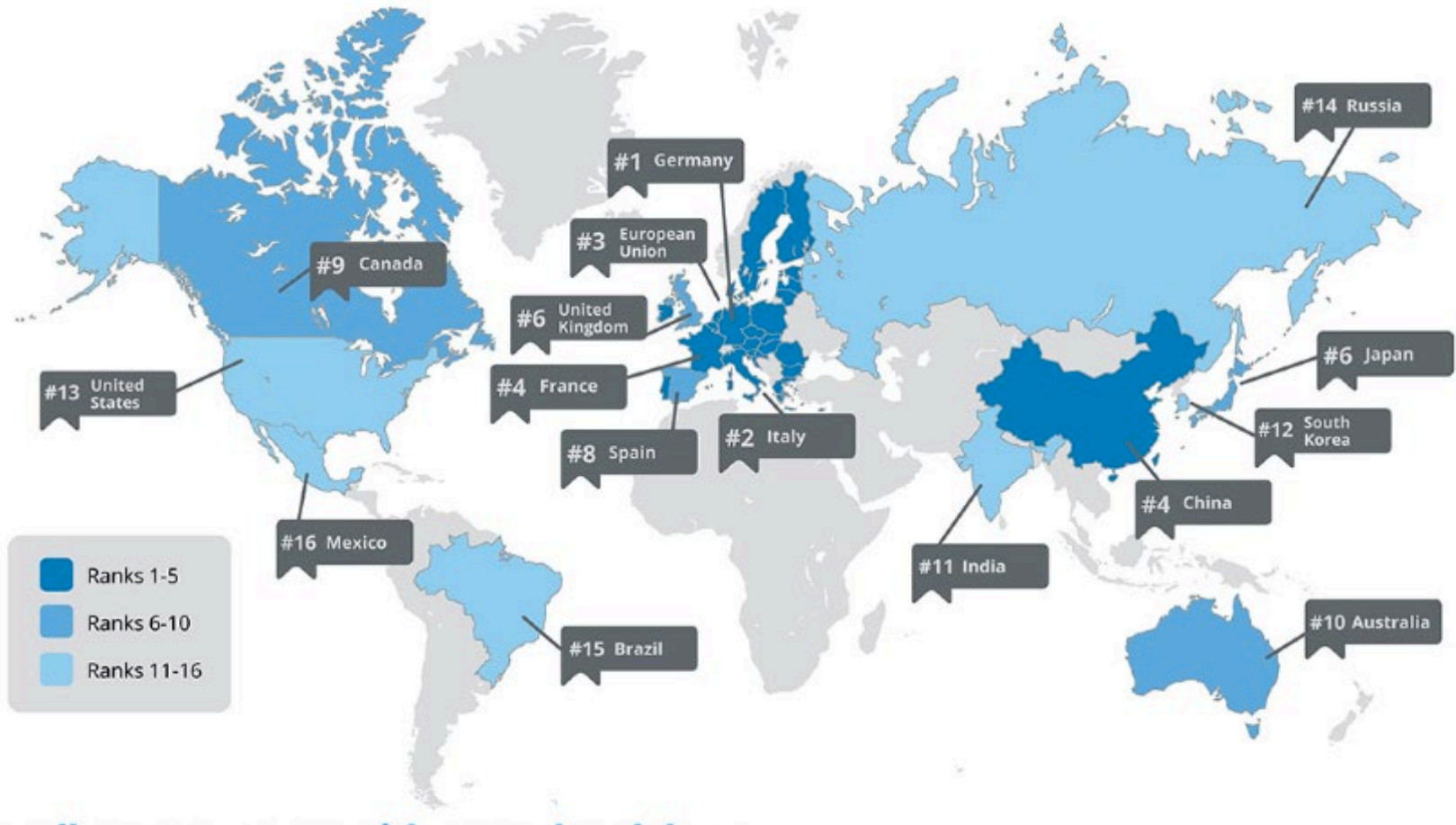


Effektivitet: Efficiency

Energy Consumption of Space Heating per Sq. m



2014 International Energy Efficiency Scorecard



Electricity Transmission

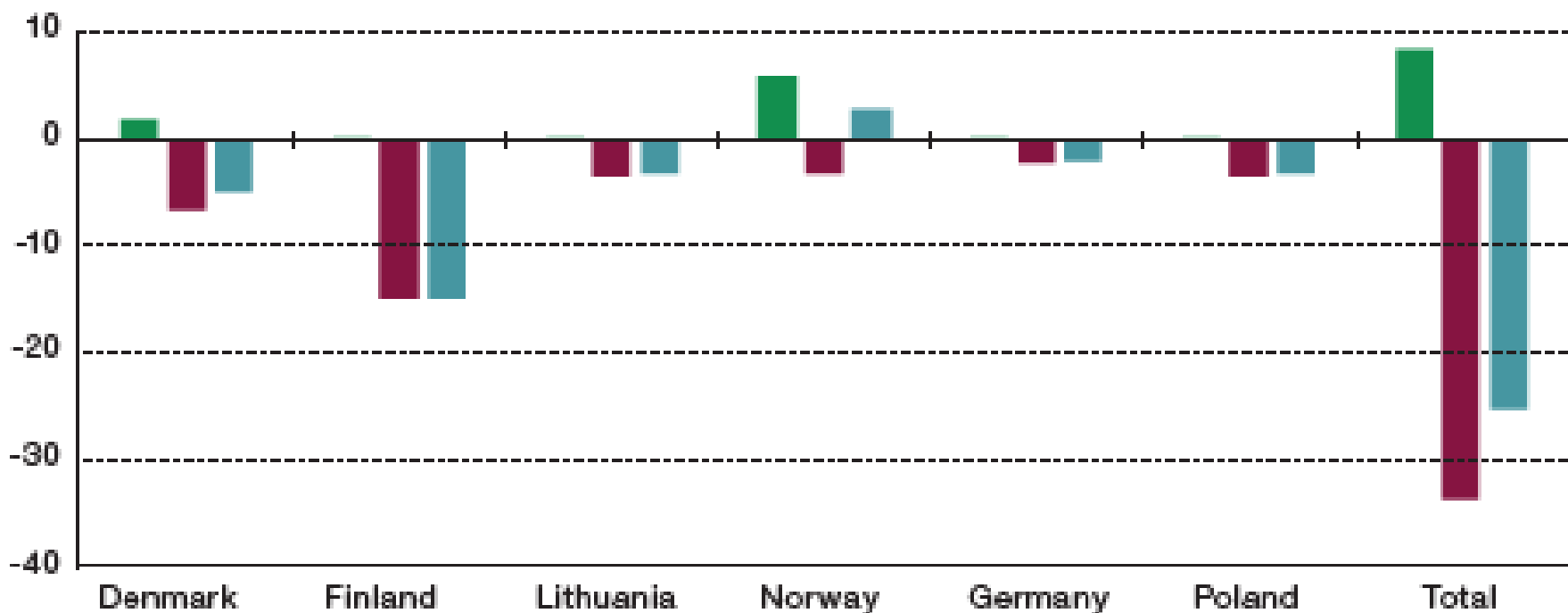
Electric Grid with Connections to Other Countries

Svenska Kraftnät



Import and export of electricity 2021, TWh

■ Import ■ Export ■ Net export



Major Trends-All Energy

- **Total energy use** has remained **stable** over time, with population growth.
- **Energy prices** had a **stable** period in the 1980s and 1990s, but have **increased in the 2000s and later** due to **increasing fuel prices and taxes**
- **Crude oil and petroleum** supply has **decreased** by more than half.
- **Growth in wind and solar power** has made energy supply more decentralized.
- **Biofuels** supply has **tripled** over last 40 years.

Major Trends-Consumption

- The **pulp and paper** industry accounts for **over half** the energy used in **industry**.
- **Petroleum** used mainly in **agriculture, forestry, fishing, and construction**.
- **Fossil fuel** use in industry **decreasing, but still** extensive, especially in **iron and steel industry**.
- **Residential** buildings and facilities are **rarely heated by oil** now.
- In **houses, electricity** is **most common carrier** used, followed by biofuel, and district heating.
- In **multi-building dwelling and non-residential facilities, district heating** is the most used carrier.

Major Trends-Electricity

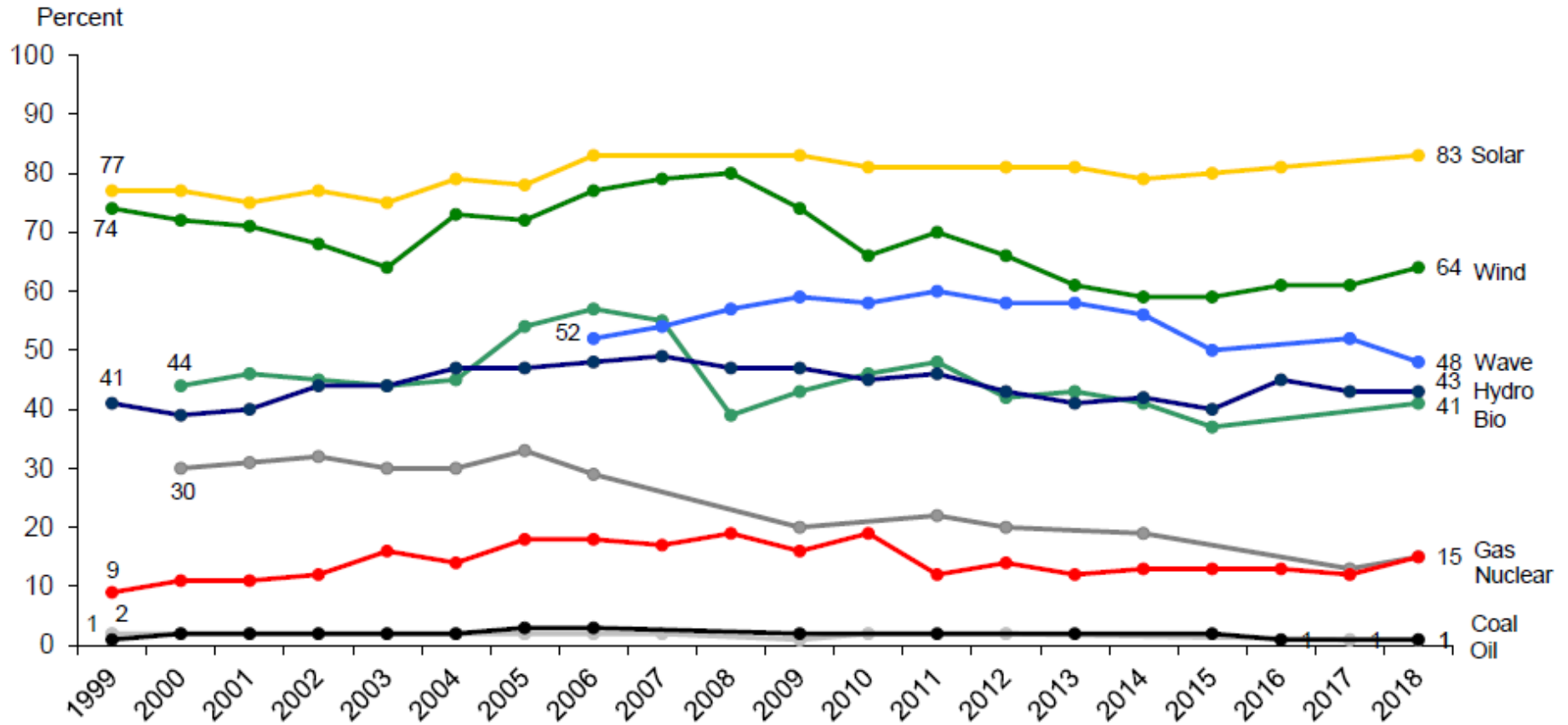
- **Electricity** use was **highest in 2001** and has since declined.
- In 2020, **electricity** came from **hydropower** (45%), **nuclear** power (29%), **wind** power (17%), **combustion** power (8%), and **solar** power (1%).
- **Most** of the **electricity** is used by the **residential and service** sector, then industrial sector, and then transport sector.
- From 2020 to 2021, grid-connected **PV systems** increased 46%.
- **Energy trading** with neighboring countries **varies** through the year and between years, due to **price differences**.

Major Trends-Transport

- In the **transport** sector, **biofuels have increased** significantly over last 15 years.

Public opinion

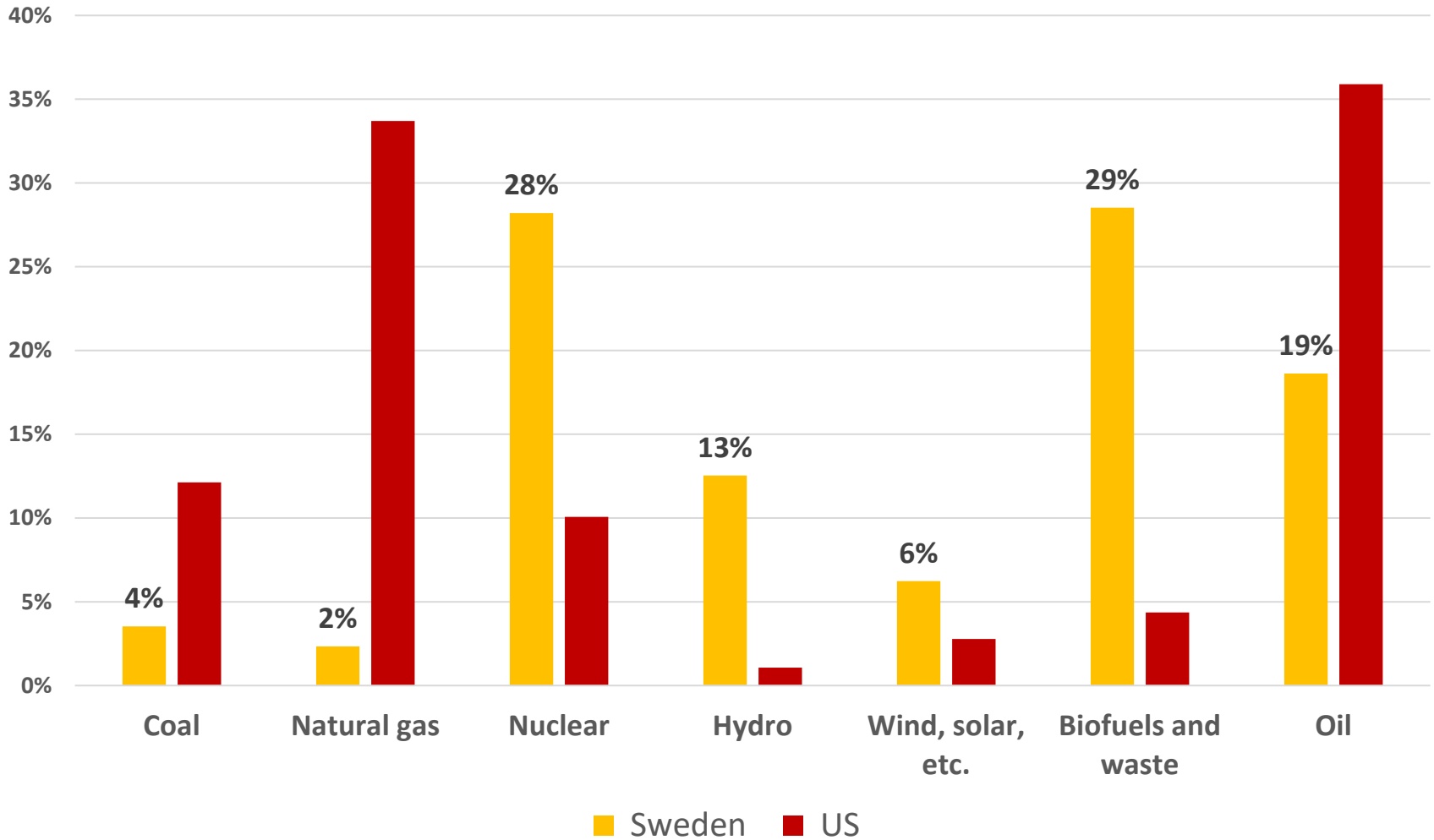
Percent Swedes Who Think Sweden - More than Today - Should Go For Different Energy Sources



2019, U. of Gothenburg, et al.

Comparisons- Sweden to U.S.

Sources of Total Energy Supply in 2021

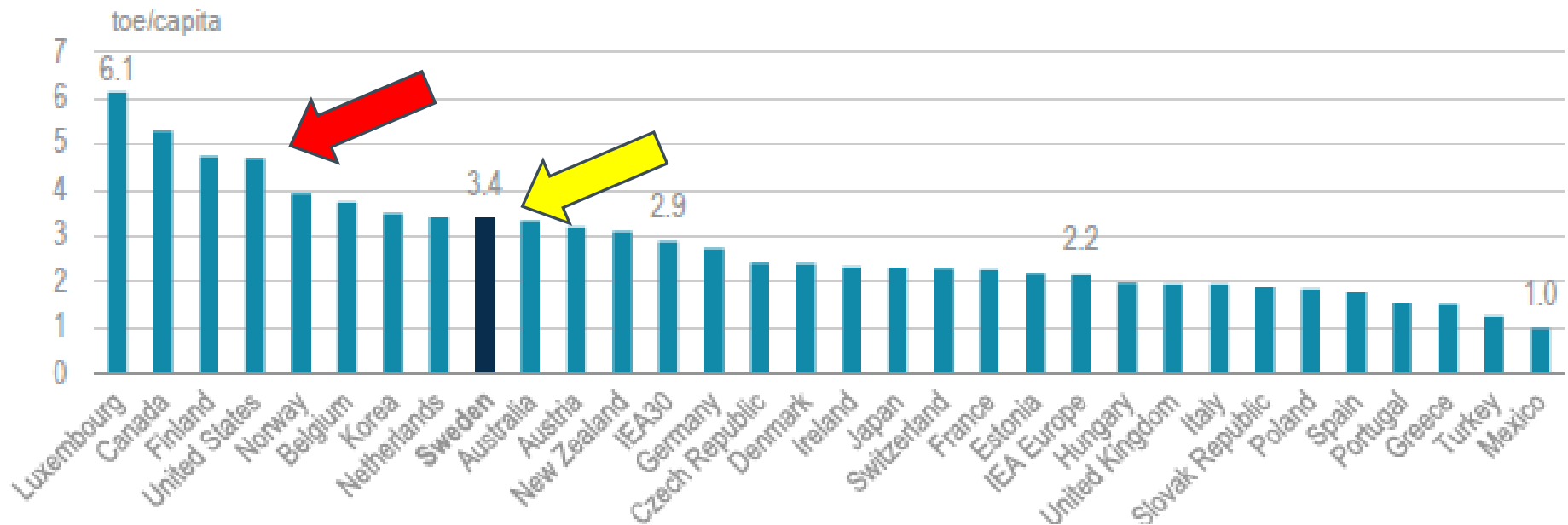


Consumer Energy Prices

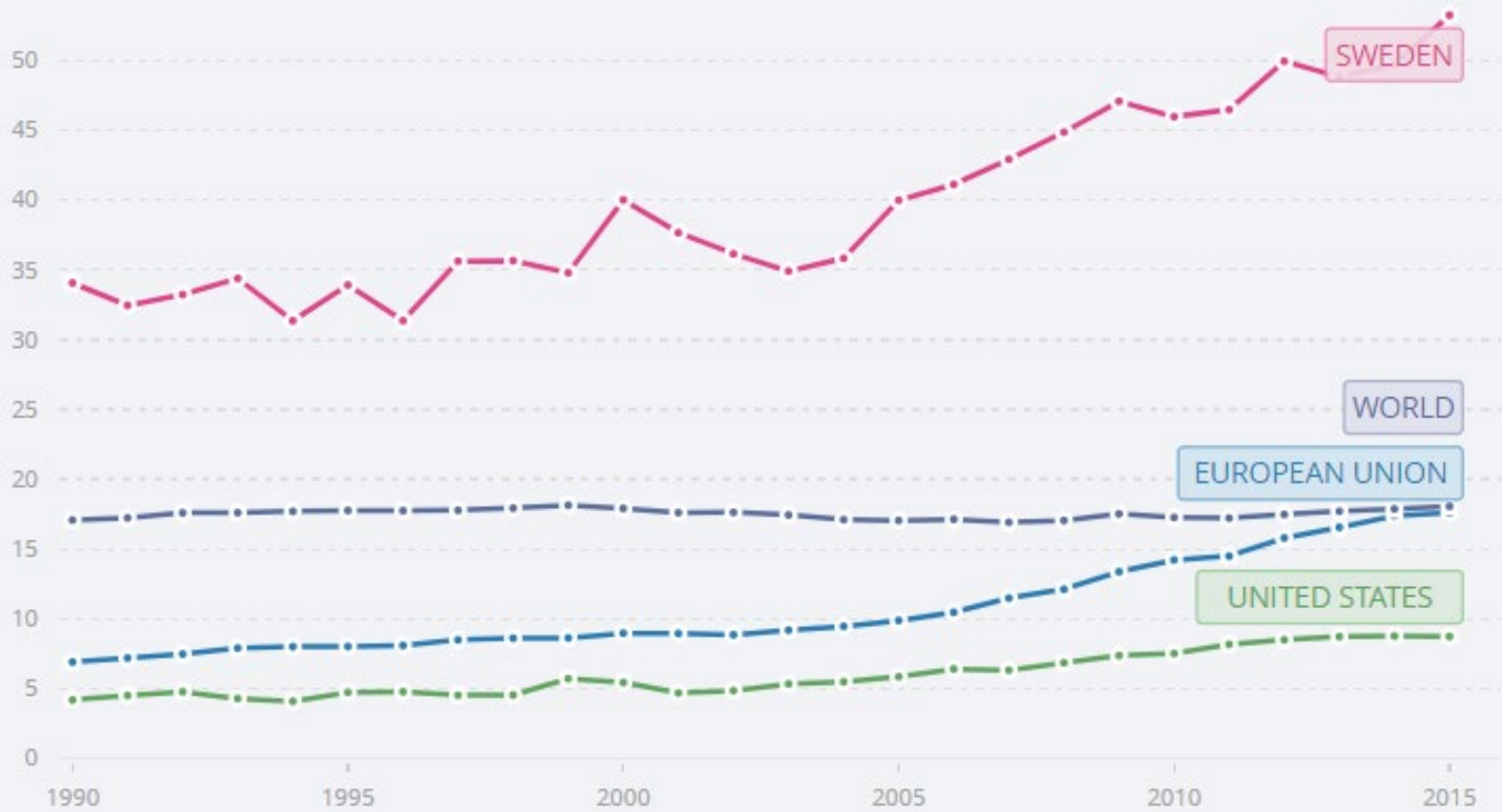
	Household electricity, per kWh, Dec. '22		Gasoline, per gallon, Sep. 4, '23	
Sweden	\$	0.42	\$	7.25
U.S. average	\$	0.17	\$	4.13
Ratio		240%		176%

Comparing Energy Use per Person in the U.S. and Sweden

Energy consumption per capita (TFC/CAP)

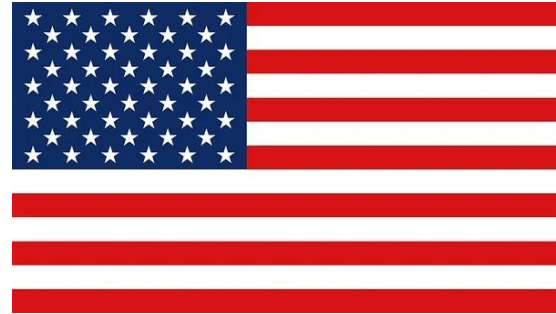


Renewable energy consumption (% of total final energy consumption)



Data from World Bank

Energipolitik: Energy Policies



European vs U.S. Policy Context

Them

- Climate change + energy security urgency
- Mandated national & EU targets
- Heavy subsidies/ revenue guarantees
- Leasing process tied to a guaranteed market

US

- Climate change ambivalence; new sources of domestic fossil fuel
- No National Renewable Energy Policy; states driving market development
- Inconsistent, short-term policy support
- disconnect between the leasing process (site control) and the market

Swedish Targets Achieved as of 2020

- **Consumption 20% more efficient** compared to 2008
- **Energy intensity** down 31% from 2005
- **Renewable energy** in relation to final energy consumption **increased** each year since 2011.
- High share of **renewable energy** due to use of **biofuels** in industrial sector and **district heating**, plus large share of electric generation from **hydropower**
- Share of **renewable energy for domestic transportation** was 24% in 2020, exceeding target of 20%.

Swedish Targets Remaining, as of 2020

- Consume 50% less by 2030
- Obtain 100% of electricity from renewable sources by 2040
- Make consumption 50% more efficient by 2030 cf. 2005
- Balance sources with load variations

Recent News Stories

New Battery Maker near Skelleftea, on Bay of Bothnia



- Startup company, Northvolt, to make batteries
- To be used in electric vehicles
- Domestic alternative to Chinese sources
- Factory powered by local hydropower

Photo from NPR

New Large Resource at Kiruna for Rare-earth Metals, Needed in Electric Vehicles, Turbines, etc.

Per Geijer Deposit



 Eiffel Tower for scale at 330 m tall

Take Away Points-1/3

- **Total supply** in order: bioenergy, nuclear, oil, hydro, wind & solar, coal, and natural gas
- In supply, **oil and petroleum** are **decreasing**, while **biomass and wind** are **increasing**.
- **Most crude oil** imported from **Denmark, Norway, and UK**, with decreasing share from Russia
- **Pulp and paper** industry makes up **largest share of industrial** use, followed by steel and metals.
- **District heating** important at **residential** level- **increasing** from **biomass** and **decreasing** from **petroleum**
- **Transportation** use **increasing** from **biofuels** and **decreasing** from **gasoline**
- **Sweden one of the most energy efficient nations** in the world

Take Away Points- 2/3

- Sweden is a **net exporter of electricity**, especially to Denmark and Finland
- **Swedes support solar** power the **most** and coal and oil sources the least
- Compared to US, **Sweden relies more heavily** on nuclear, hydro, wind & solar, and bioenergy
- Compared to US, **Sweden relies less heavily** on coal, natural gas, and oil
- Swedish **consumers pay about twice as much** per unit for **electricity and gasoline** as American
- Sweden **ranks near the top** globally in **consumption per capita**
- Sweden ranks far **above US in renewable** energy as % of consumption

Take Away Points- 3/3

- National **policy in Sweden is more comprehensive** than in US
- **Targets** to date in **efficiency, intensity, and renewables** have been **achieved**
- Goals:
 - **Consume 50% less** by 2030
 - Make **consumption 50% more efficient** by 2040 compared to 2005
 - Obtain **100% of electricity from renewable sources** by 2040
- **Battery making** is a developing industry
- Large **new resource of rare earth** metals could be transformative

Afterword

Questions & answers

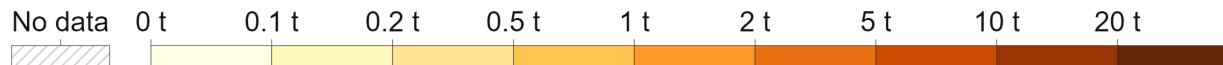
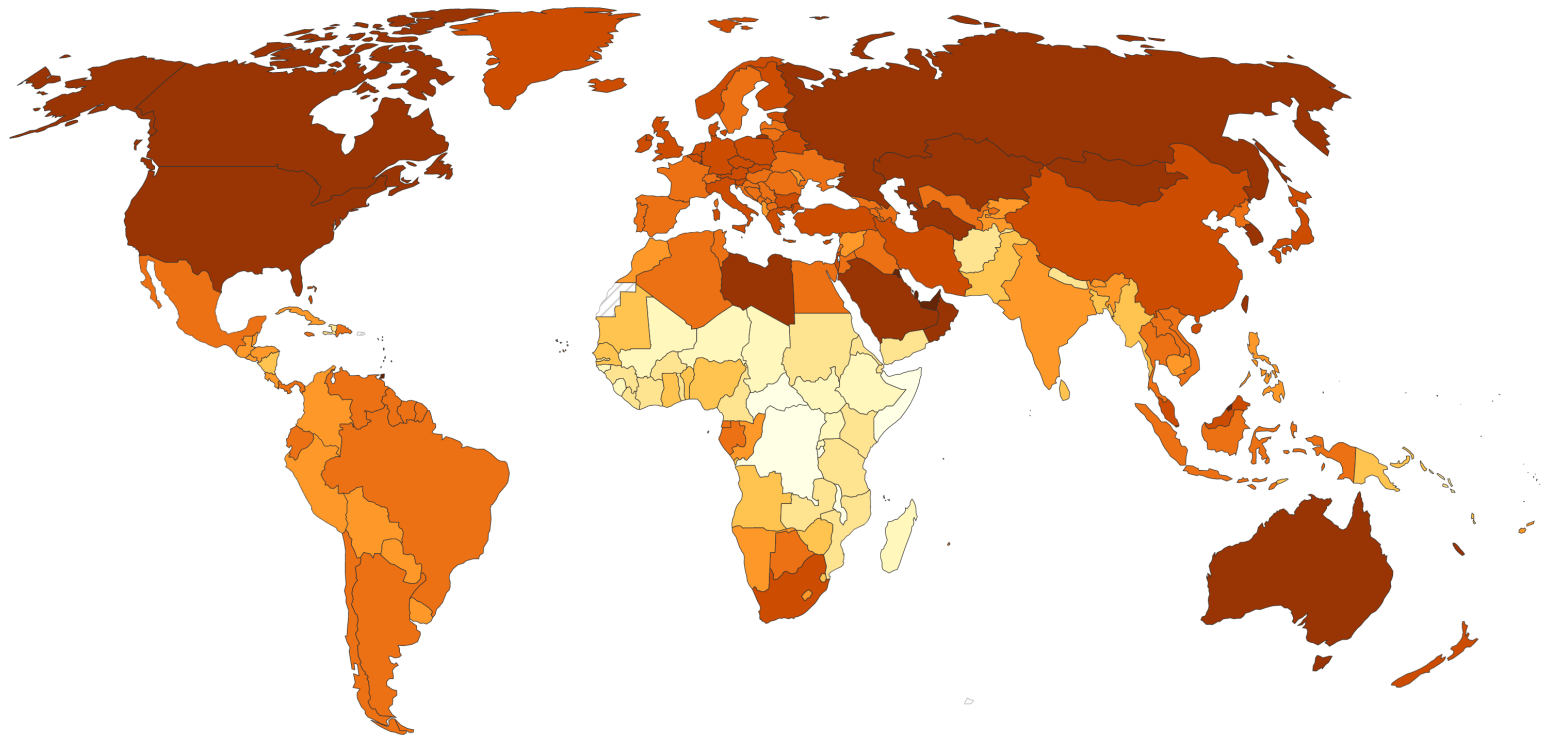
Discussion

Supplemental as Time Allows

Carbon Dioxide Emissions

Per capita CO₂ emissions, 2021

Carbon dioxide (CO₂) emissions from fossil fuels and industry¹. Land use change is not included.



Source: Our World in Data based on the Global Carbon Project (2022)

OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO₂) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO₂ includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

CO₂ Emissions for Vattenfall

Goal is to cut in half by 2030

CO₂ emissions intensity

