SVENSKA ARALSJÖSÄLLSKAPET

Swedish Aral Sea Society

3. Energy

Lars Rydén
Professor Emeritus
Uppsala University

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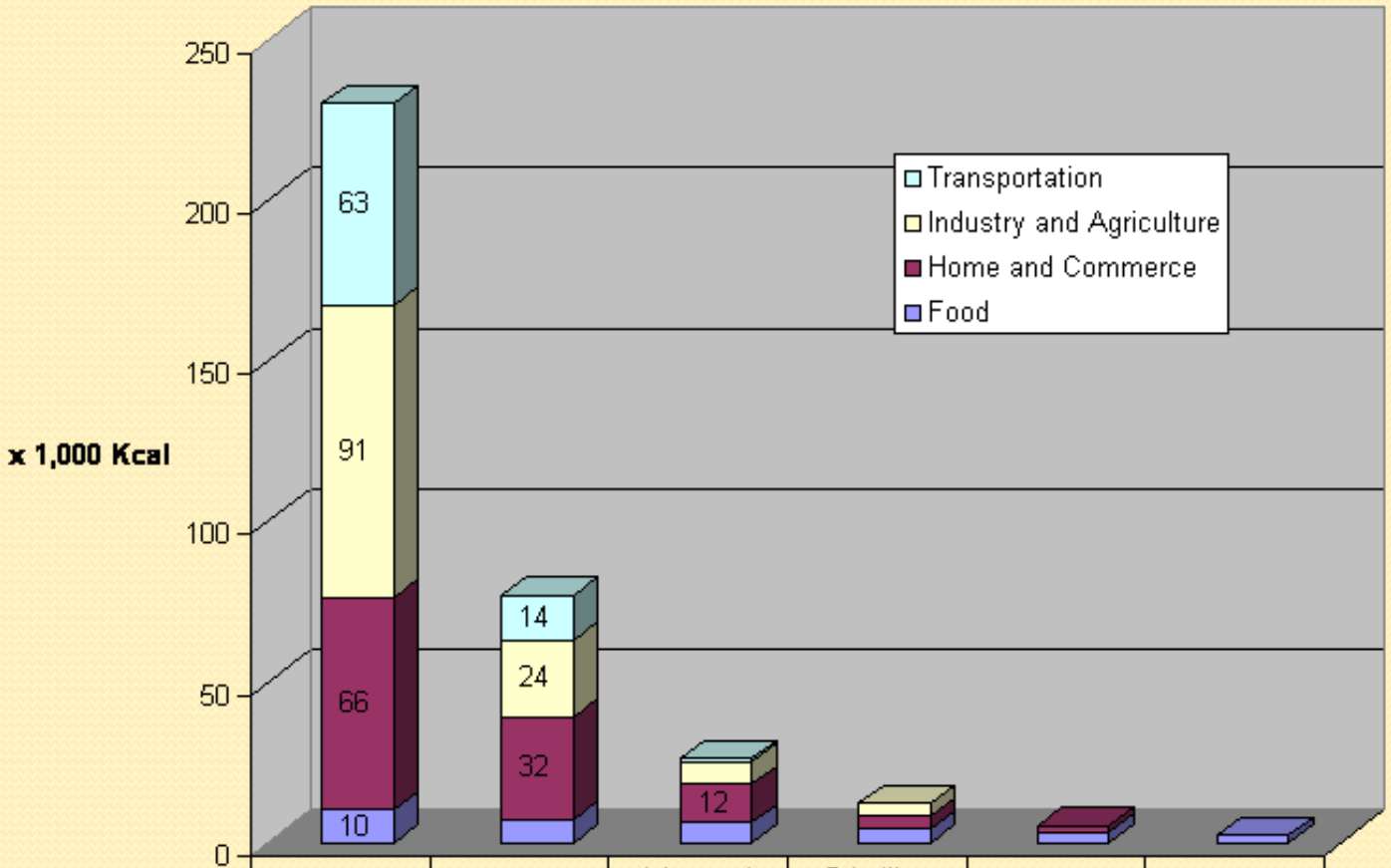
Energy supply and use

Energy use per capita in different societies

• Biological	2.4	kWh/day
• Gatherers, hunters	10	kWh/day
• Agriculture	25-50	kWh/day
• Industrial society	50-100	kWh/day
• Contemporary	250	kWh/day

Daily Consumption of Energy Per Capita



	Technological Man	Industrial Man	Advanced Agricultural Man	Primitive Agricultural Man	Hunting Man	Primitive Man
Transportation	63	14	1			
Industry and Agriculture	91	24	7	4		
Home and Commerce	66	32	12	4	2	
Food	10	7	6	4	3	2

Two different kinds of energy

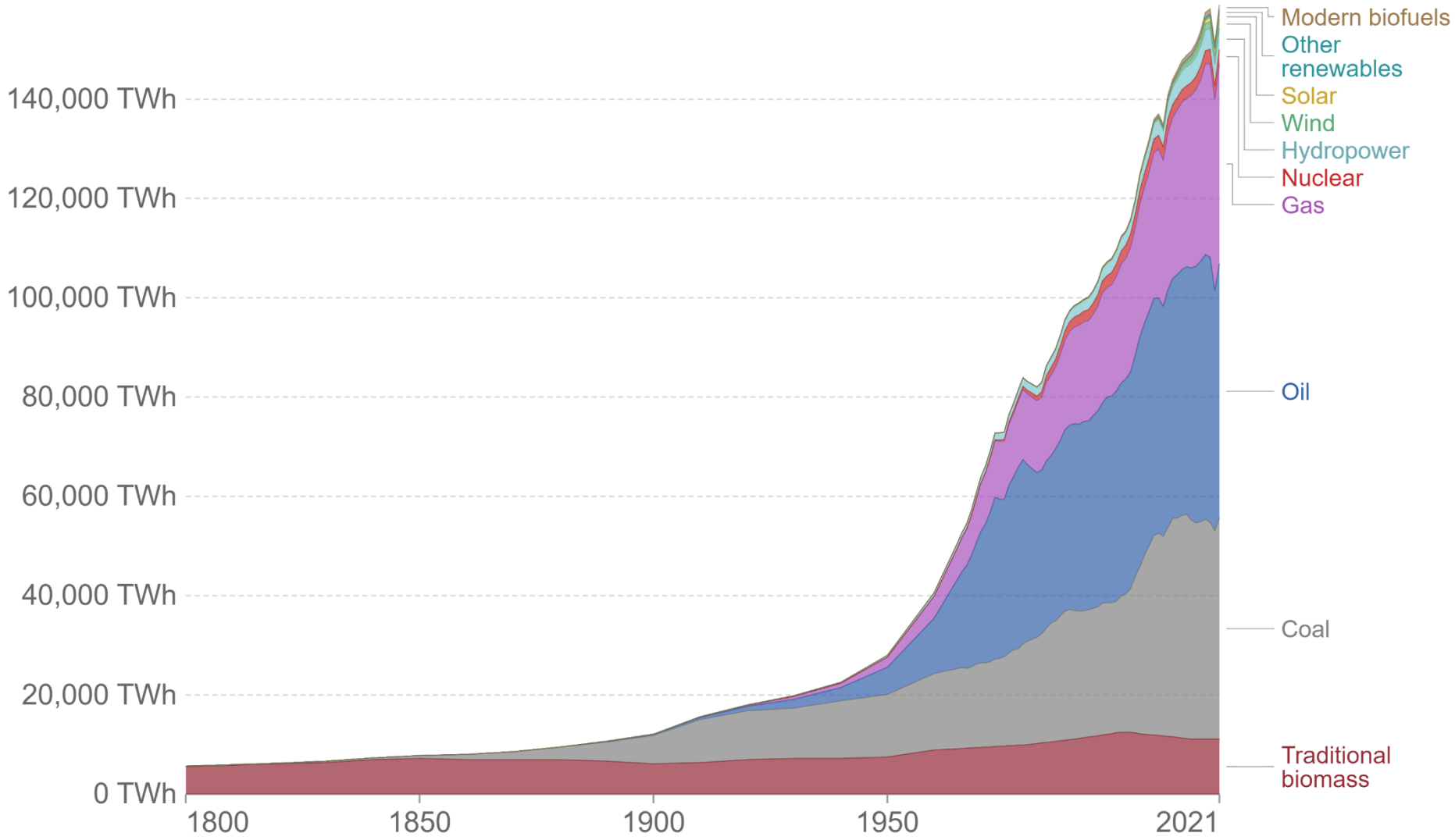
- **Non-renewable (fossil) energy resources**
  - Coal
  - Oil
  - Gas

- **Renewable – flowing - energy resources**
  - Biomass and other forms of bioenergy
  - Hydropower
  - Wind power
  - Sun

Global direct primary energy consumption

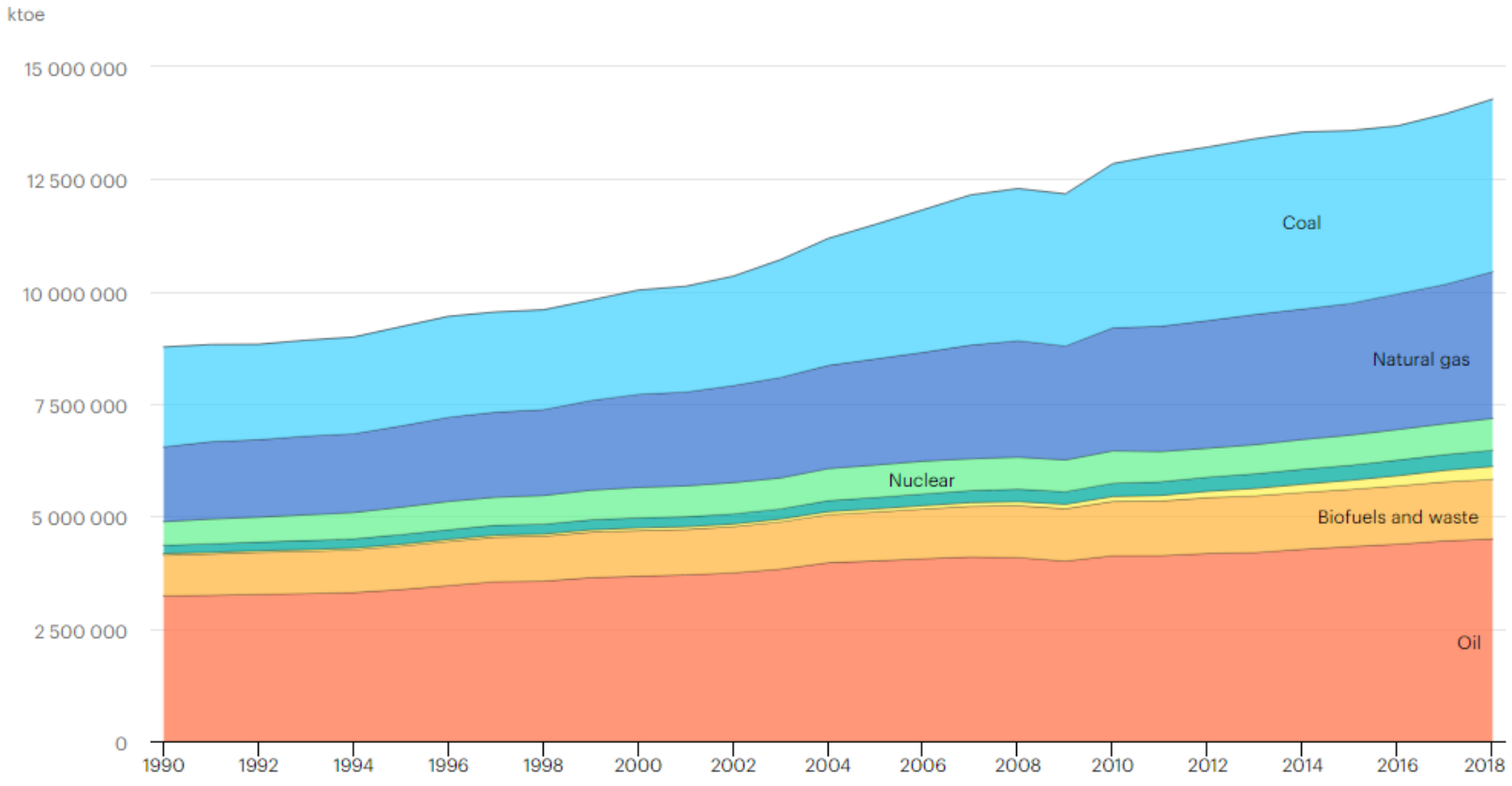
Direct primary energy consumption does not take account of inefficiencies in fossil fuel production.

Our World in Data

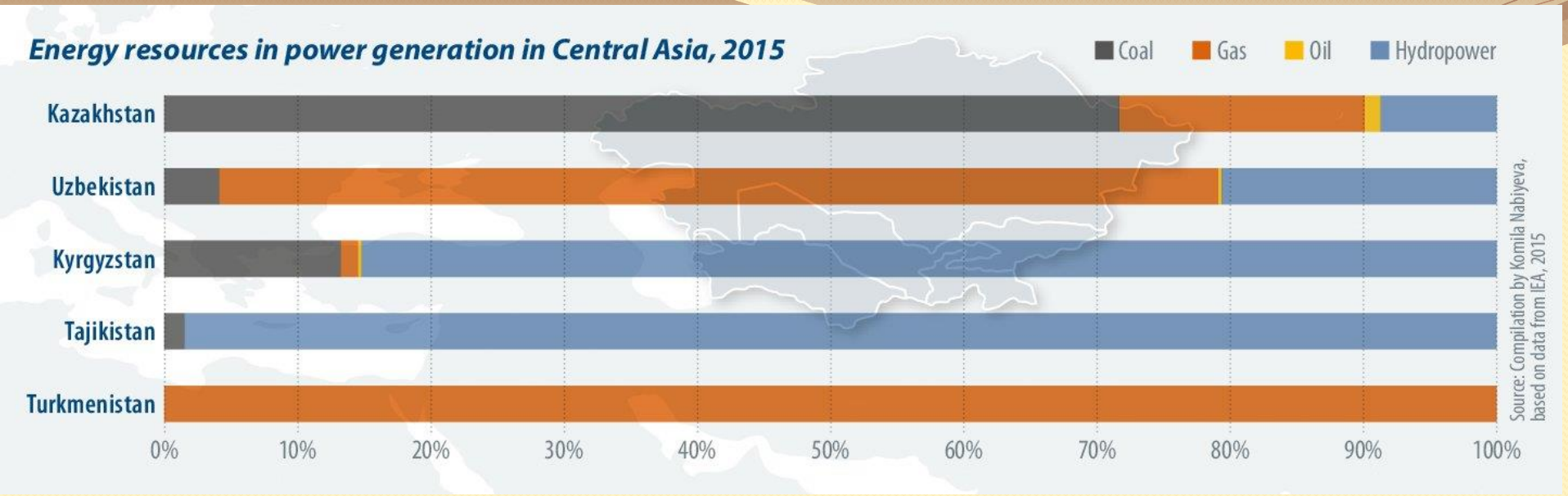


Source: Our World in Data based on Vaclav Smil (2017) and BP Statistical Review of World Energy

World Energy Outlook 2020 – Analysis – International Energy Agency, IEA



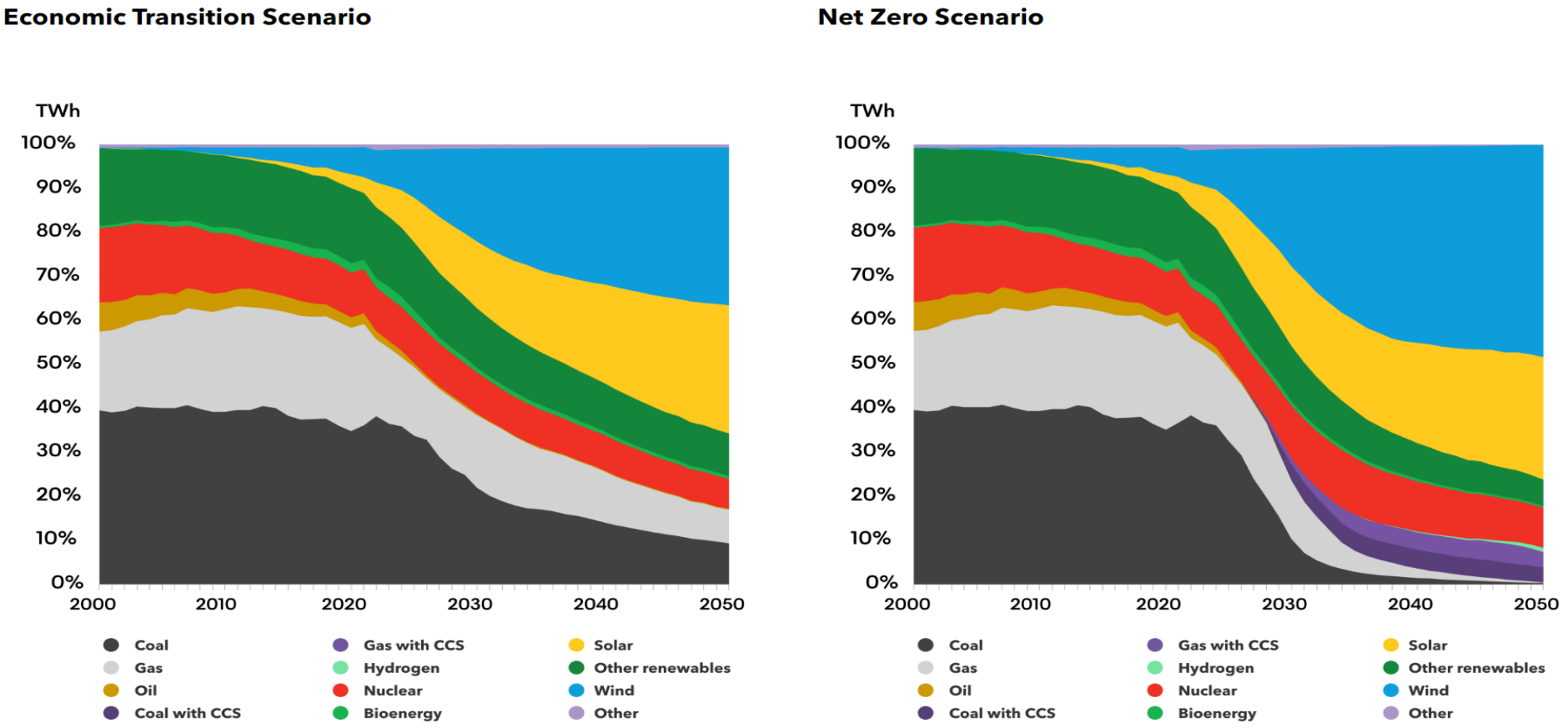
https://www.iea.org/data-and-statistics?country=WORLD&fuel=Energy%20supply&indicator=TPESbySource



https://energytransition.org/2018/06/central-asias-green-horizons/

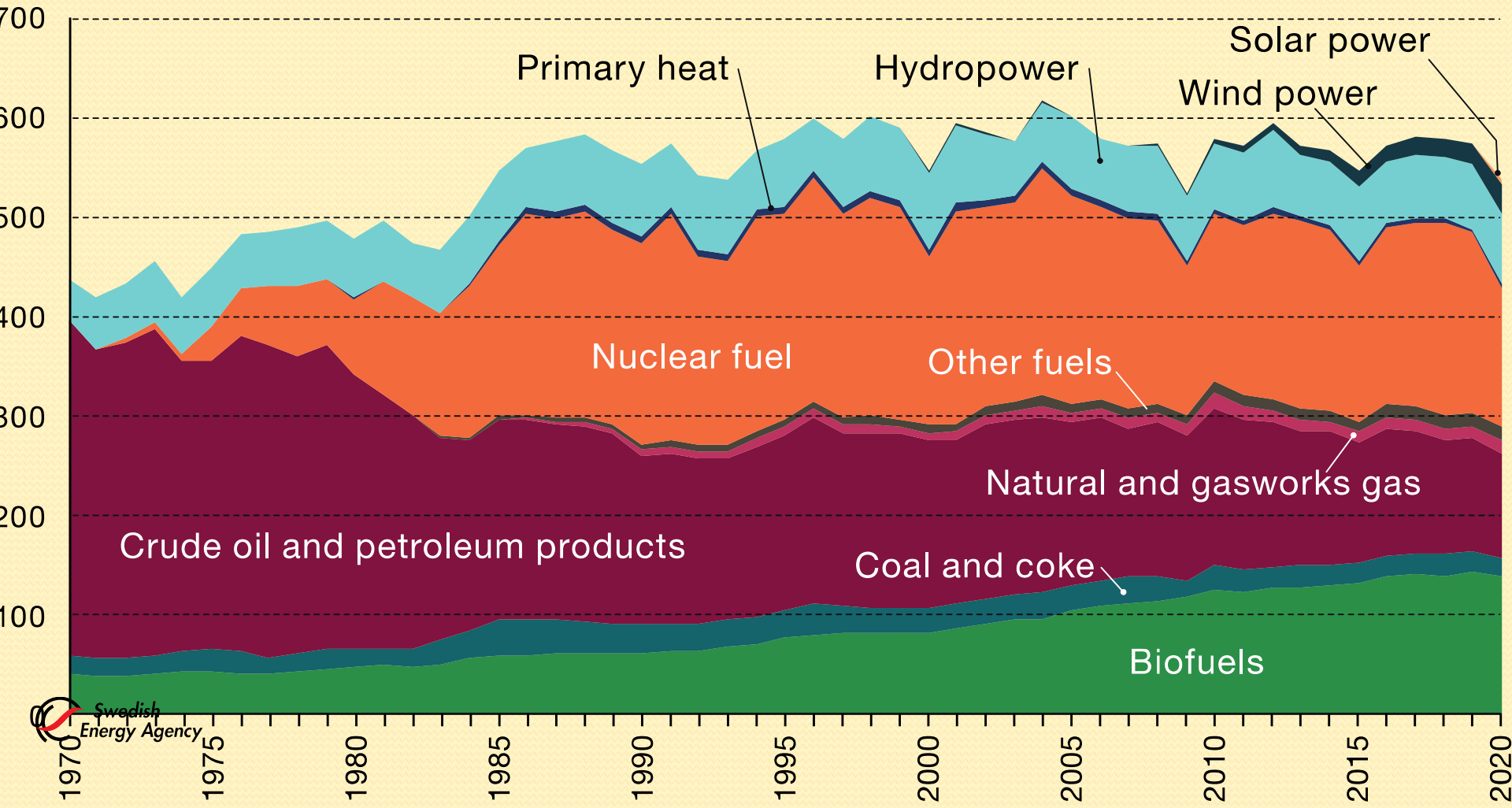
Sun and wind power dominates investments today, and will dominate in the future

Electricity generation by technology, by scenario



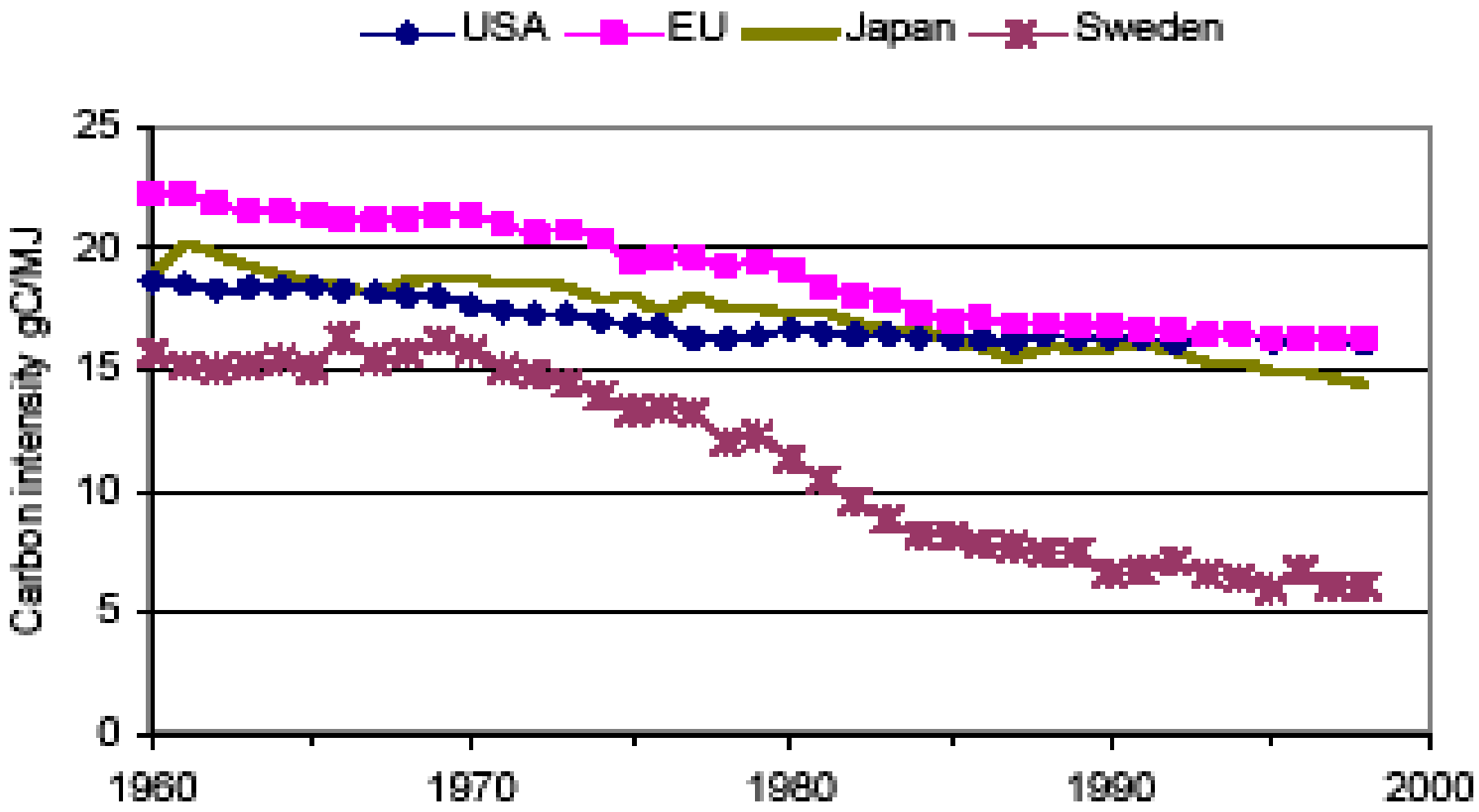
Source: The 2022 New Energy Outlook (NEO) Bloomberg New Energy Finance

Sweden - Total supplied energy 1970–2020, TWh

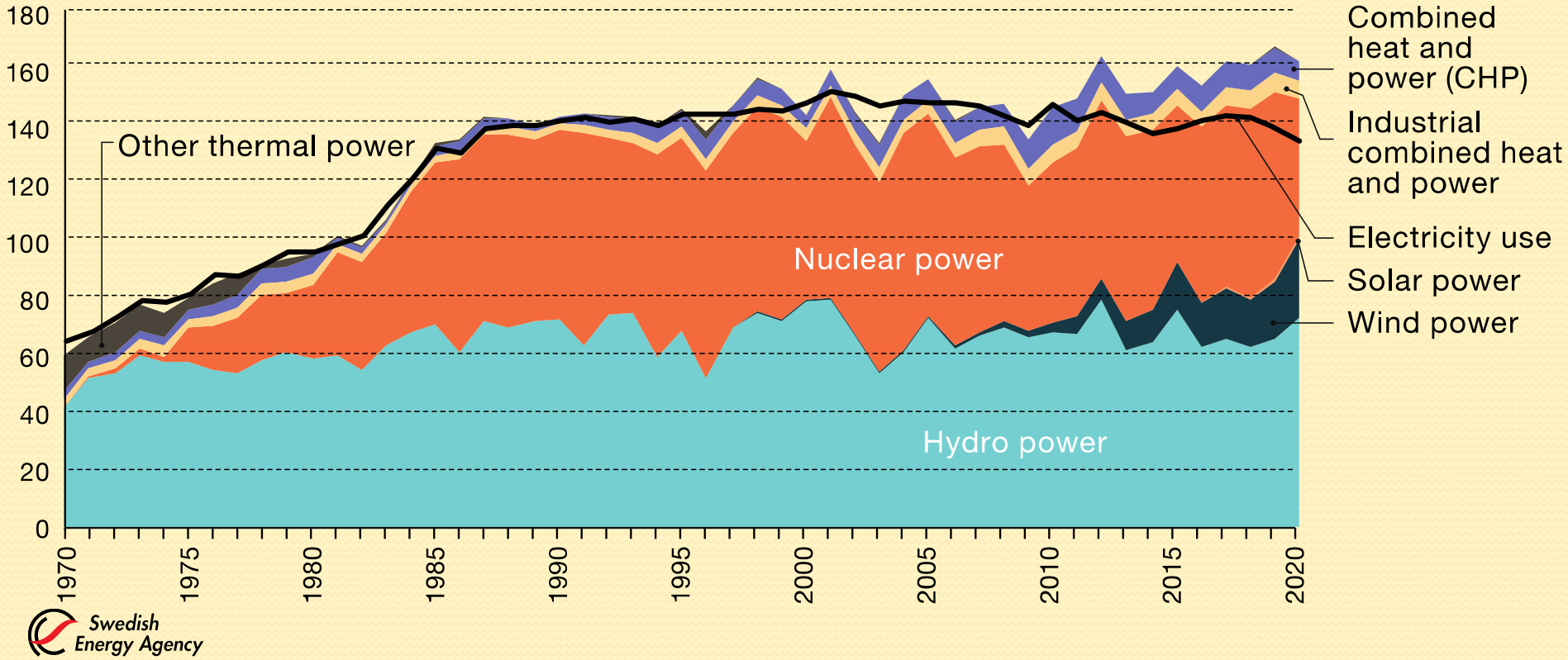


Carbon content of energy

From *Decoupling*, Azar, Holmberg and Karlsson, Chalmers University of Technology, 2002 based on IEA statistics

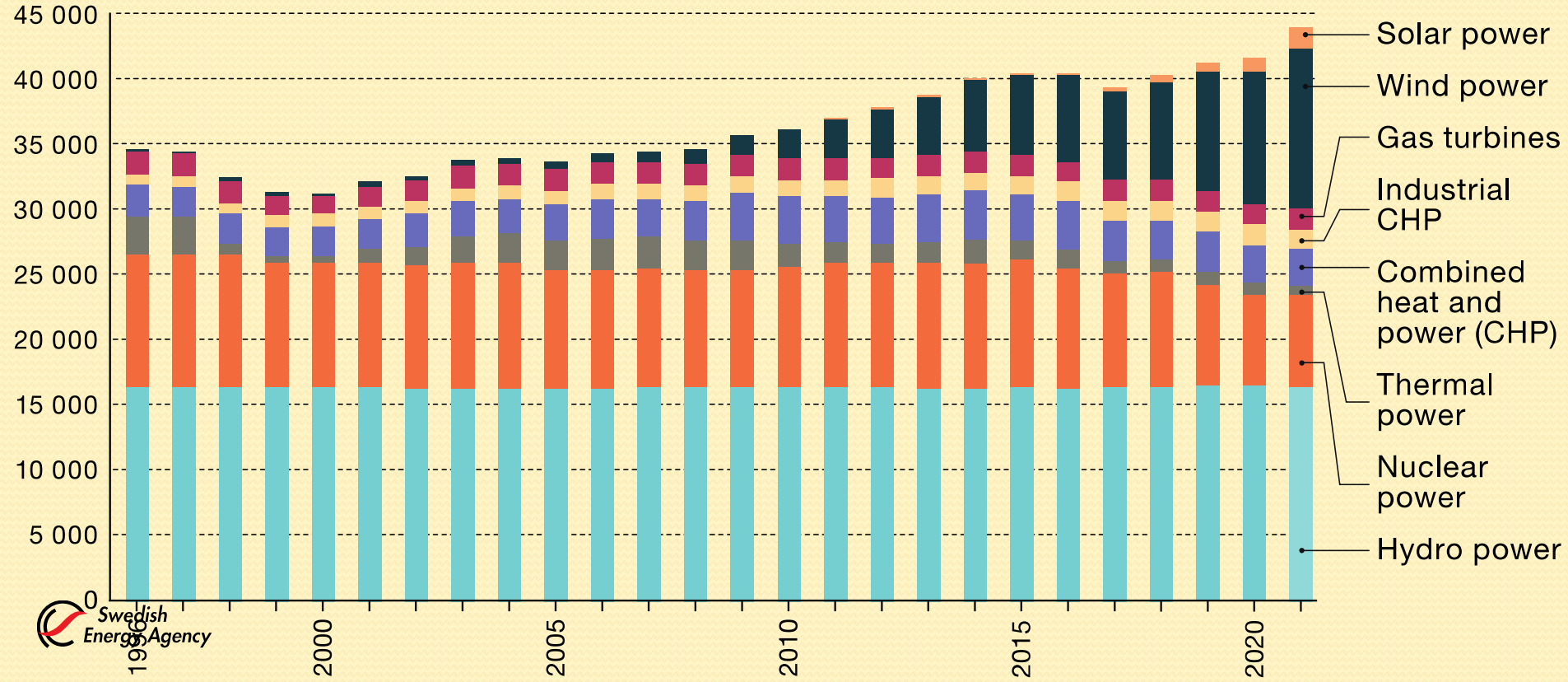


Electricity use and electricity generation per type of power 1970–2020, TWh

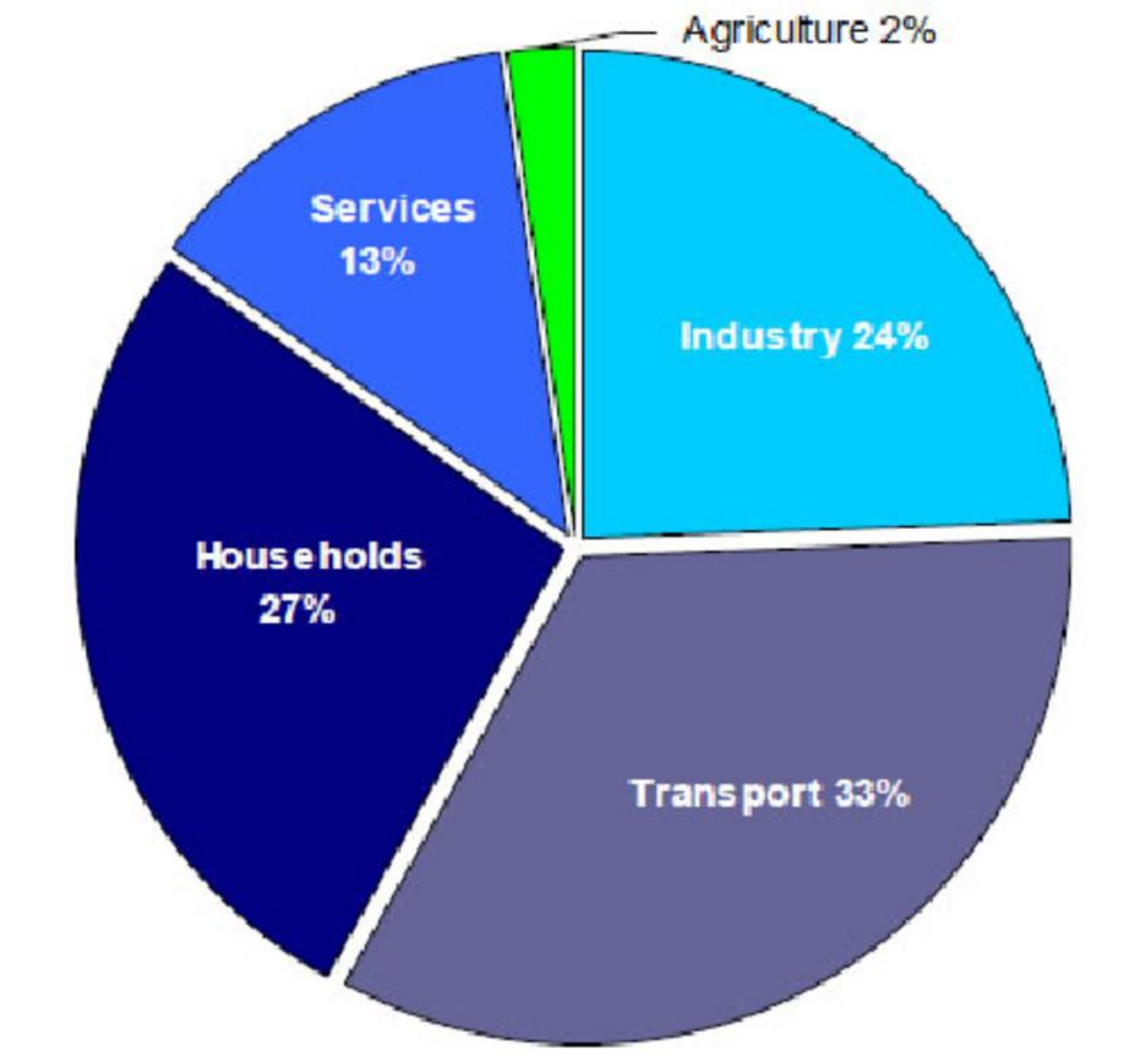


Swedish Energy Agency

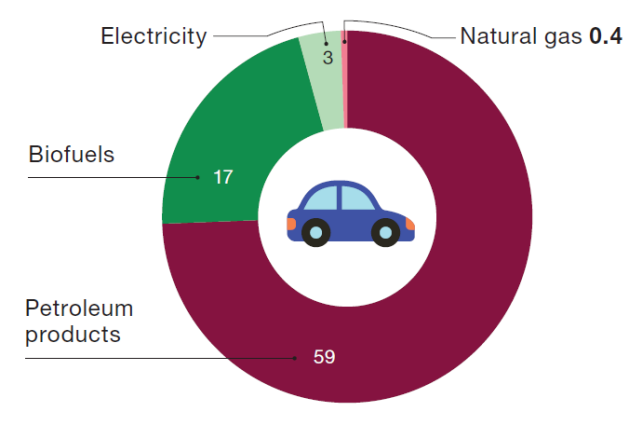
Installed electricity generation capacity by type of power 1996–2021, MW

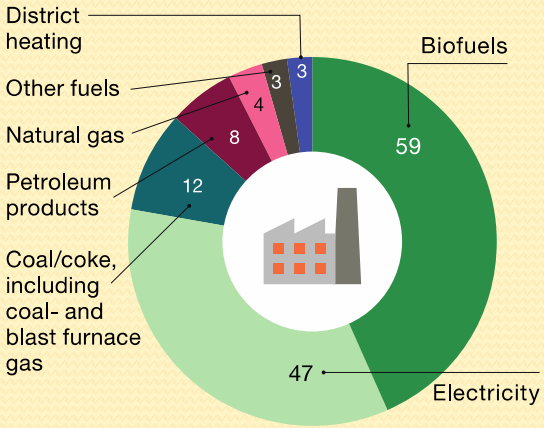


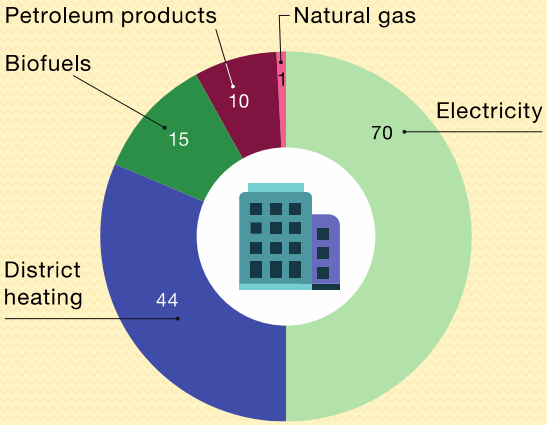
Energy use


Agriculture 2%
Services 13%
Industry 24%
Households 27%
Transport 33%

Final energy use in the different sectors 2020, TWh

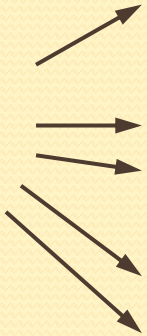






Swedish Energy Agency

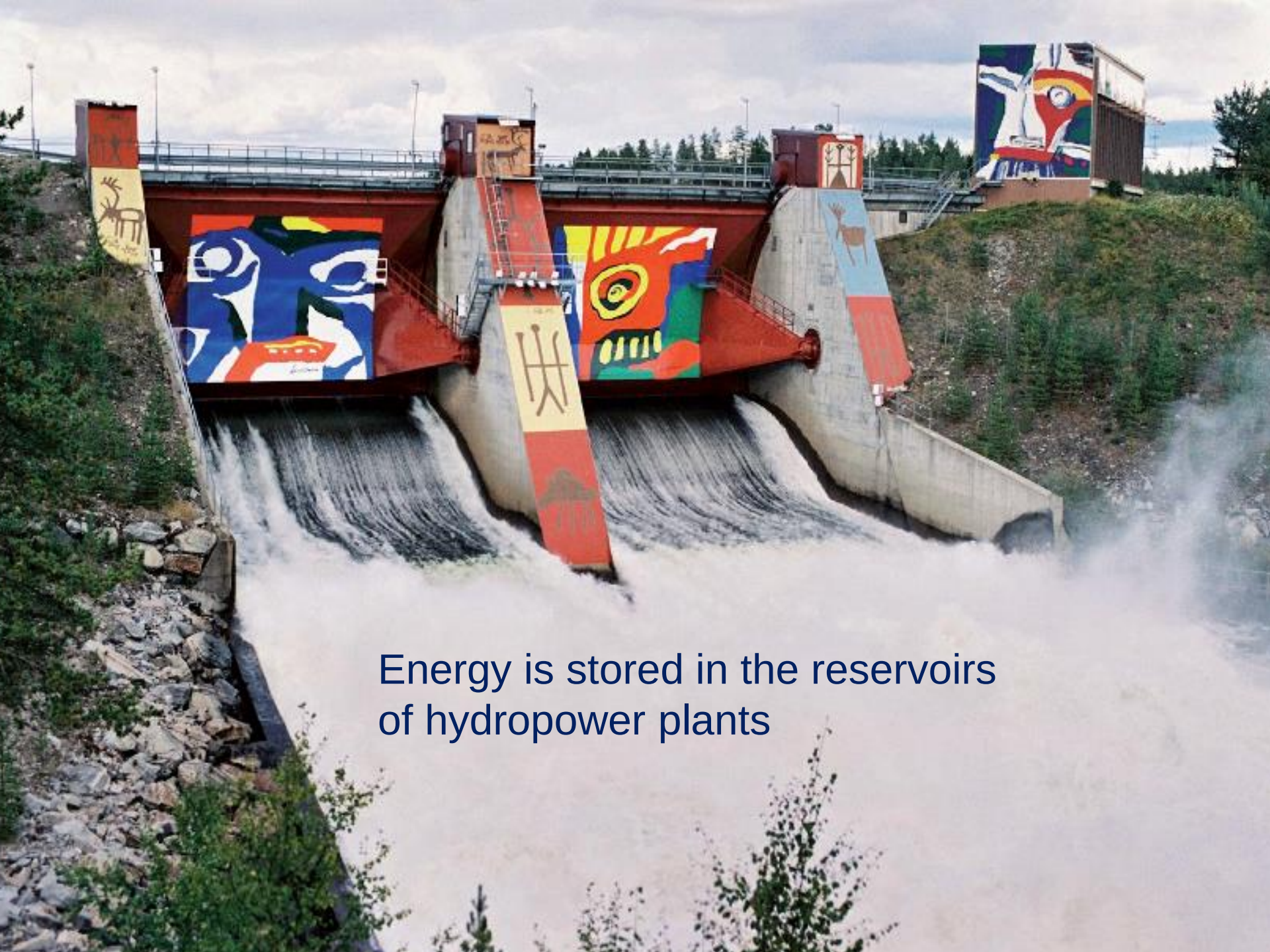
Energy intensity (J/h)	Activity	Happiness
Very low (zero)	Sex	4,7
	Socialising	4,0
	Relaxing	3,9
	Praying/meditating	3,8
	Eating	3,8
	Exercising	3,8
	Watching TV	3,6
Use of appliances: medium high	Shopping	3,2
	Preparing food	3,2
	Talking in phone	3,1
	Taking care of children	3,0
	Computer/internet	3,0
	Housework	3,0
	Working	2,7
Commuting: high	Commuting	2,6



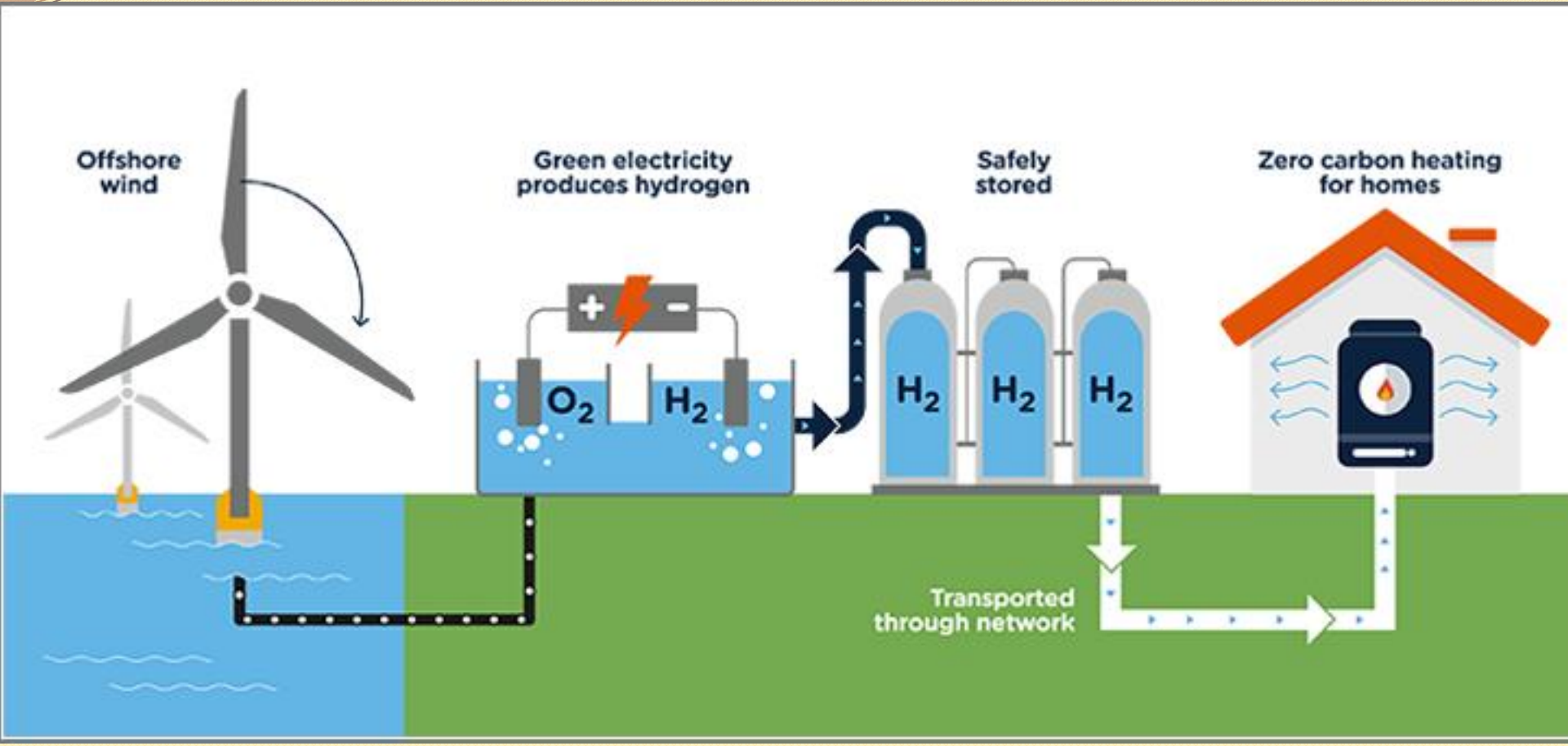
Storage of energy

Enormous amounts of energy is stored in biomass

How can we best harvest the biomass?

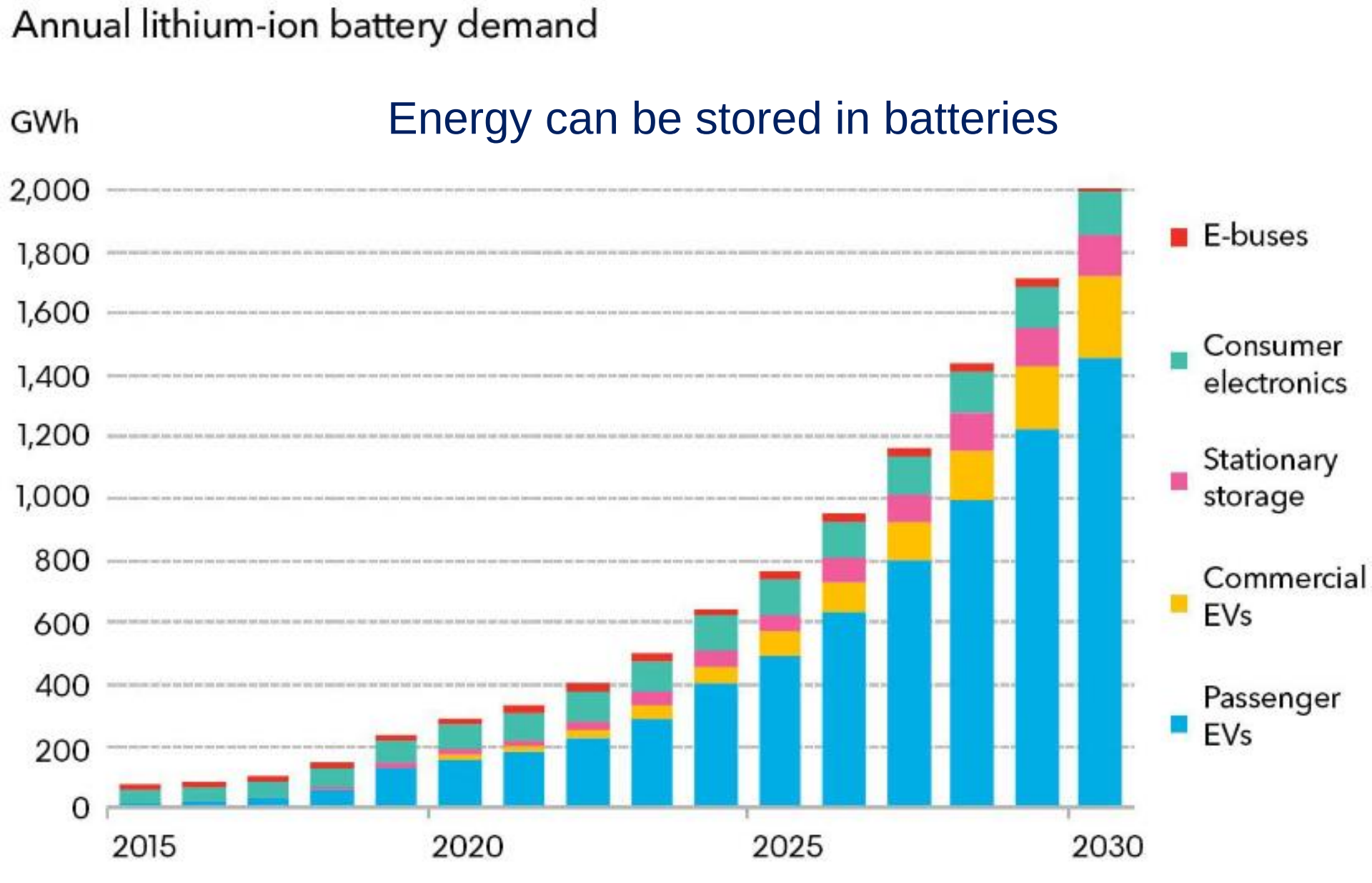


Energy is stored in the reservoirs of hydropower plants



Energy can be stored as hydrogen gas

Energy can be stored in batteries



Source: Bloomberg NEF 2019 Electric Vehicle Outlook

Energy efficiency

Energy conservation: Insulation of pipes and covers on containers

Building a passive energy house

A passive energy house

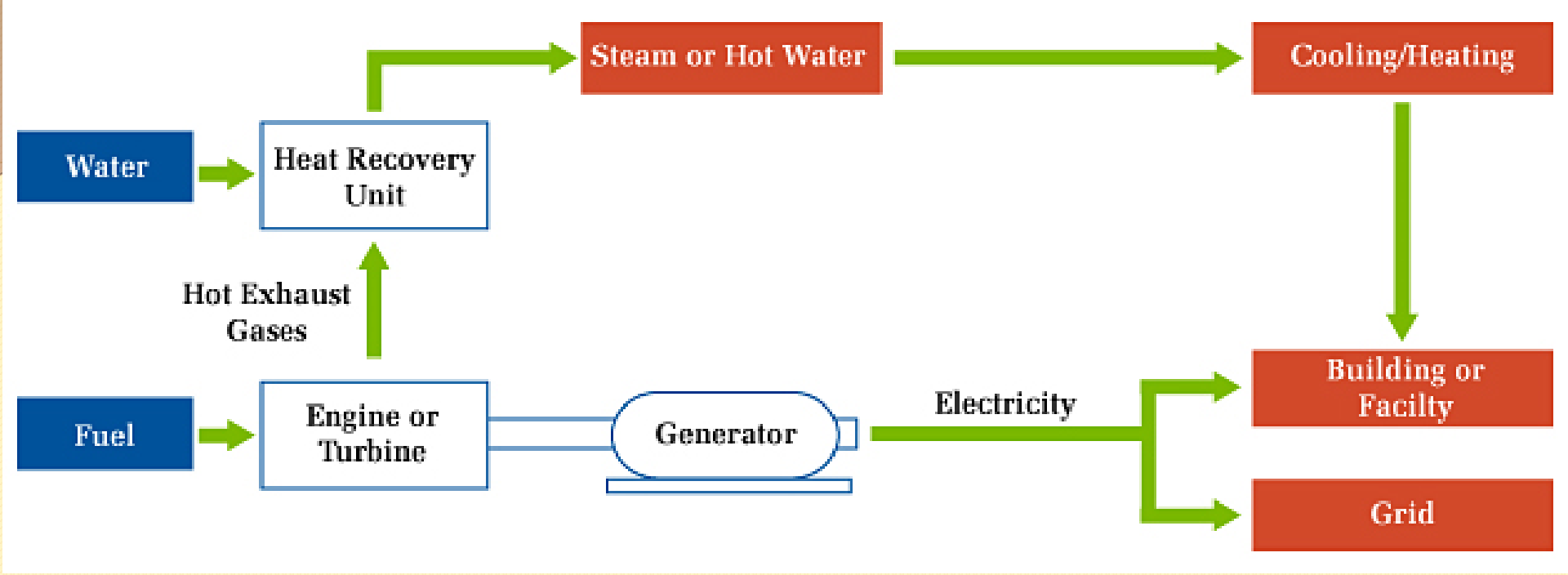
Improved technology

Torraca, Italy, has LED for all street lights

Improved technology

Electric cars

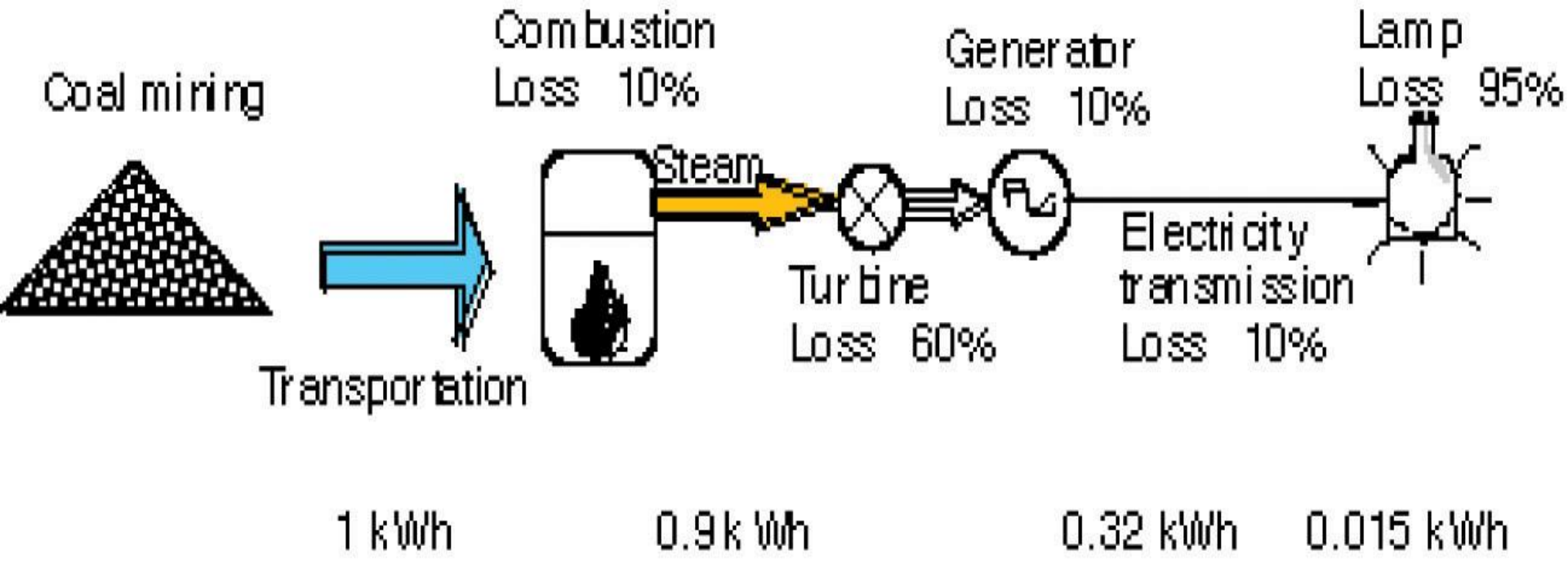
Combustion engine: 15 % of energy comes to the wheels
Electric engine: 90 % of the energy comes to the wheels



Power stations

Careful use of energy:
Combined heat and power - cogeneration

Why demand management is better than increased production



PFE - Energy Efficiency in Large Companies

Swedish Energy Authority

- 100 companies took part
- All made a complete energy use mapping
- All introduced a certified energy management system
- 1247 projects and 1.47 TWh less electricity annually
- 708 MSEK in investments
- 400 MSEK less energy costs annually
- Average return of investments 1.5 year
- Tax reductions 150 MSEK annually

Mapping Energy use, project proposals

1. Background
2. Photos
3. Energy efficiency proposals
4. Drawbacks of each
5. Calculations – kWh, Investments, Return on investements

52 projects during 2 years

Primary improvements

- Temperature adjustments
- Heat recovery
- New valves
- Insulation
- Changed routines
- New lighting
- Toilets

Secondary improvements

- Reduced water use
- Decreased fire risks
- Less air pollutants
- Less noise

Results after 2 years

- Accomplished 19 304 MWh /year
- Under planning 32 942 MWh /year

Increased use of renewable resources

- promoting local development
- creates new jobs
- combats climate change
- requires competence
- creates social capital
- promotes sustainable development


The power plant in Enköping produces heat and electricity to the town using forest rest Products.
Yield: ca 90 %
Emissions: 2,99 g CO2/kwh
https://www.enae.se/
© Henrik von Klopp

Biofuel - waste

Uppsala biogas station use organic waste, including food waste from households etc to produce biogas, methane.

All citybuses in Uppsala are running on locally produced Biogas.

Similar in many Swedish cities.

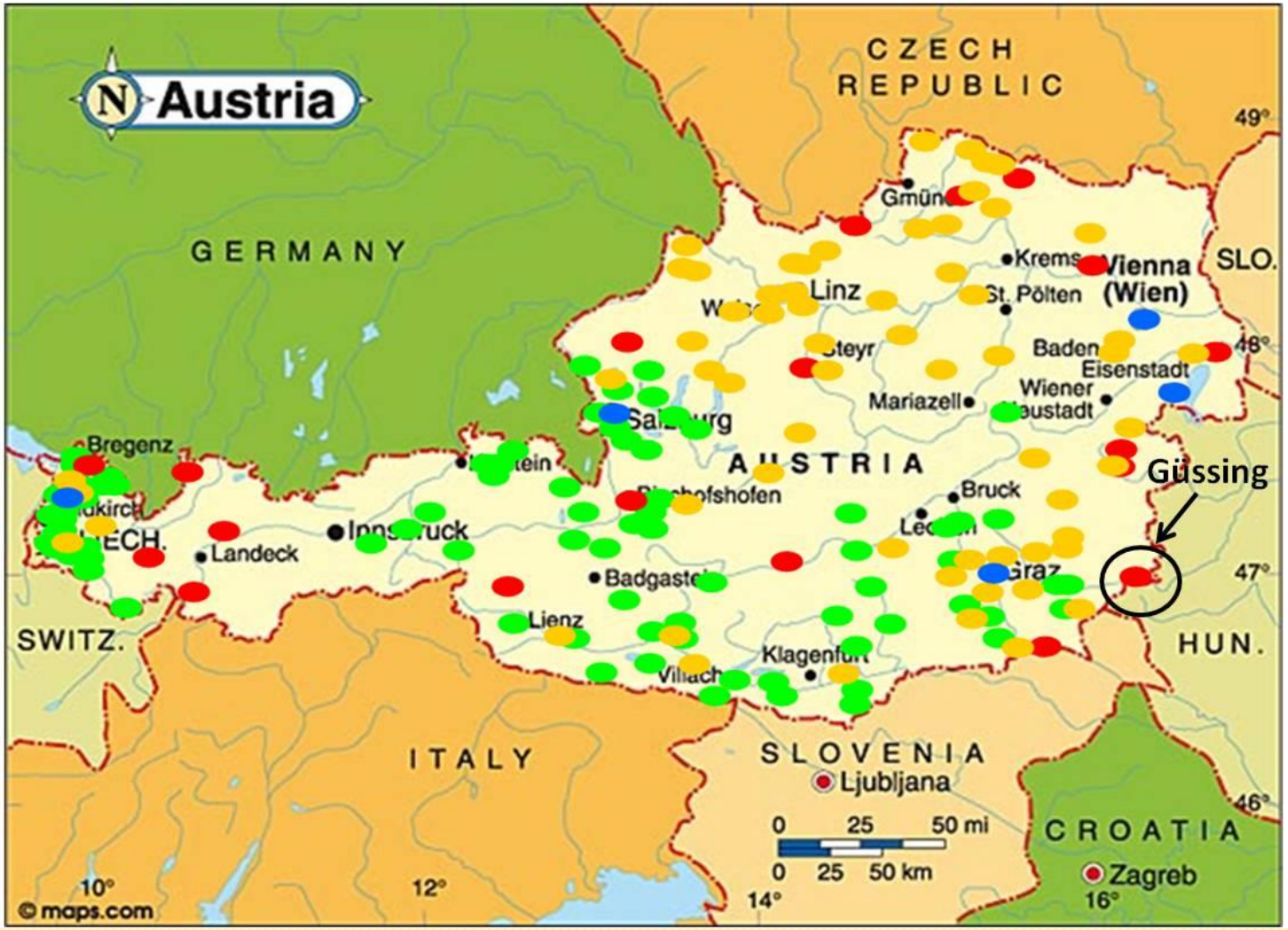
Güssing, Austria

From 1992 and in 11 years, Güssing became self-sufficient in electricity, heating, and transports. In the process 60 new companies with more than 1,500 new "green jobs" were created and commuting decreased to 40 %. On top of this Güssing now sells green energy outside the municipality to $28 million yearly and emissions of CO2 decreased by more than 80%.

https://www.100-percent.org/gussing-austria/

Energy Independence
Growing on Regional Level

Regions Independent in Electricity, Heat and/or Transportation **E-Mobility Pilot Projects**
Regions with growing Energy Independence **Regions with high Energy Efficiency standards**



Networks of fossil-free municipalities in the world

- ***Post carbon cities***, USA based
- ***Local Renewables Initiative*** run by ICLEI (local authorities for sustainability)
- ***Solar Cities*** network Australia
- ***52 cities in Japan*** develops energy autonomy
- ***Transition Towns*** A network for munciplities with local transition initiatives to tackle the double challenge of peak oil and climate change.
- And many more!

30 minutes

- Discuss which kind of energy you use
- Discuss which kind of energy your university uses
- Discuss how can you save energy

After 10 minutes we meet and talk together!

II. How to work with energy supply on the local scale

Policy choice

1. The reasons

- increases energy security
- reduces financial risks
- improves ecological profile

2. Adopting a policy of local energy supply

- several islands
- many muncipalities
- households

3. Economic incentives

- Feed-in tariffs in Germany
- Governmental support for investments in Sweden
- Small energy companies promote local initiatives

Rescaling as a strategy

Both *upscaling* (e.g. from individual heating of houses to district heating) and *downscaling* (e.g. from district heating to heat pumps).

Rescaling seems to be the most common strategy for improving sustainability in municipalities.

Technology choice

The technical development makes renewable energy production increasingly realistic

1. Electricity/Heat - Sun/Wind/Streaming water

- Solar panels
- Solar cells for PV electricity
- Wind power
- New technologies

2. Fuels

- Biodiesel, ethanol
- Wood chips, pellets
- Biogas
- Green hydrogen

Case 2 Samsö, Denmark

Samsø 114 km2 with 4,000 people, as a model of sustainability changed daily lives for greater energy efficiency. 11 wind turbines generating 28,000 MWh annually meet the community's electricity demands and public transportation system, with 10 percent to sell.

The community experiments with electric cars as distances are very short, less than 50 kilometres. Farmers have adapted their tractors and other vehicles to consume ethanol or other fuels distilled from locally grown plants, like canola.

In 2007, Samsø's inhabitants were able to declare their island 100% energy self-sufficient based on wind, solar and biomass energy.

https://www.visitsamsoe.dk/en/inspiration/20-years-denmarks-renewable-energy-island/


Samsö Denmark

Samsö Wind farm

Case 3 El Hierro, Canary islands

The project was created by a local consortium with EU money to supply electricity for 11,000 residents, tourists, and three water desalination facilities.

2014, El Hierro opened its hydro-wind power plant - a complex of 5 wind turbines and 2 artificial reservoirs at a height of 650 meters of 380,000 m^3.

The wind turbines can run fully most of the time generating 11.5 MW – more enough to meet the electricity needs of the island of some 8 MW.

The electricity surplus is used to pump water to the upper basin. When the wind drops the water is released to activates 4 hydraulic turbines producing 11.3 MW of electricity.

https://www.livingcircular.veolia.com/en/city/canary-islands-first-100-green-energy-island

CANARY ISLANDS

Case 4 Vauban, Freiburg, Germany

- The city is working to grow its **green economy**. The green city initiatives are seen as a factor in attracting green businesses to locate in Freiburg. There are about 1,500 green businesses employing about 10,000 people. Of those ten thousand, about 1,500 people are employed in the solar energy sector.
- About 50 % of electricity is produced by **co-generation units** that also provide heat through district heating systems. In addition to larger co-generation units, there are about 90 small CHP units around the city.
- Solar energy is very visible around Freiburg. Currently **12.3 MW of solar capacity** is in place, producing over 10 million kilowatt-hours annually.
- There are 5 medium sized **wind turbines** installed on the hills around the city. They produce **14 million kwh** every year, more than produced by all the solar PV panels.

- Freiburg remains at the forefront of **green building** technologies. All new construction uses only the latest **energy efficiency** passive house standards. **Energy conservation** is central and energy efficient retrofits are being applied to existing structures. Residential **recycling** is mandatory as **compost** is also collected in the form of kitchen and garden waste.
- Freiburg promotes **biking and walking**, and has a pedestrian-only zone in the city center, where no cars are allowed. Biking accounts for over 1/4 of all transportation. Over 300 miles of **bike paths** in the city help to reduce automobile use.
- All roads in Freiburg, other than major roads, have a **max speed** limit of 50 km/h. A region card enables residents full access to all of Freiburg's trams, streetcars, trains, and buses.

https://www.greencitytimes.com/freiburg/


Rostock
Hamburg
Berlin
Hannover
Dortmund
Leipzig
Köln
Bonn
D
Frankfurt
Stuttgart
F
Freiburg
München
Basel
CH

Four steps for renewable energy

1. Energy mapping
2. Energy sufficiency
3. Energy efficiency
4. Energy projects

Mapping renewable energy resources
I. Electricity

A. Solar

A1 Direct sunlight to electricity

A2 CSP combination panels for electricity and hot water

B. Water

B1 Water flows in streams

B2Water flows from reservoirs and lakes (hydropower)

C. Wind and wave

C1 average wind speed according to map

C2Wave at the coast

Mapping renewable energy resources

III. Fuels

F. Solid Biomass (to power plants)

F1 Direct solid biomass as wood or forest residues

F2 Energy forests

F3 Peat

F4 Household waste

G. Ethanol or Biogas (fuel to filling stations)

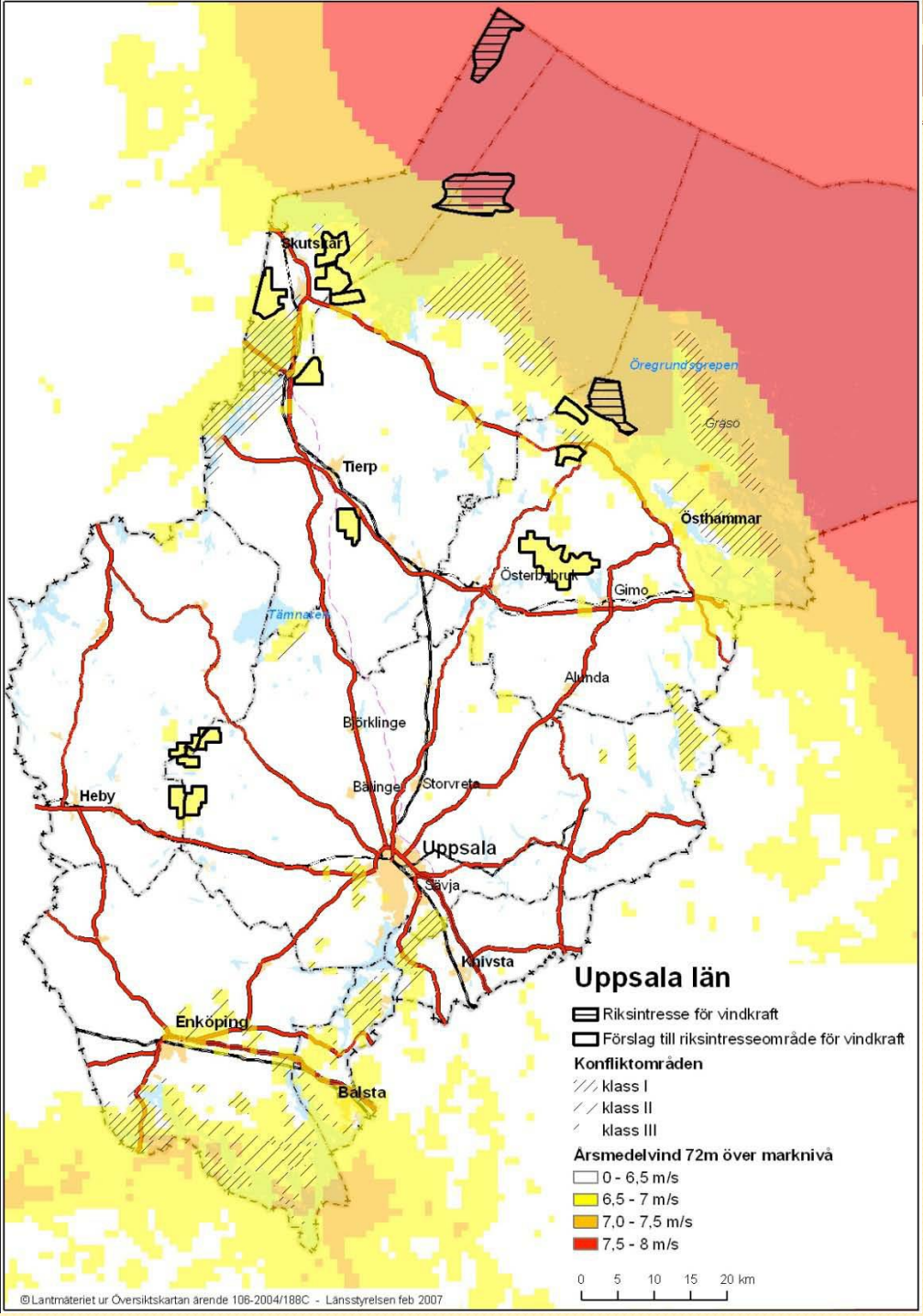
F1 Slaughter waste to biogas

F2 Conversion of harvest to ethanol

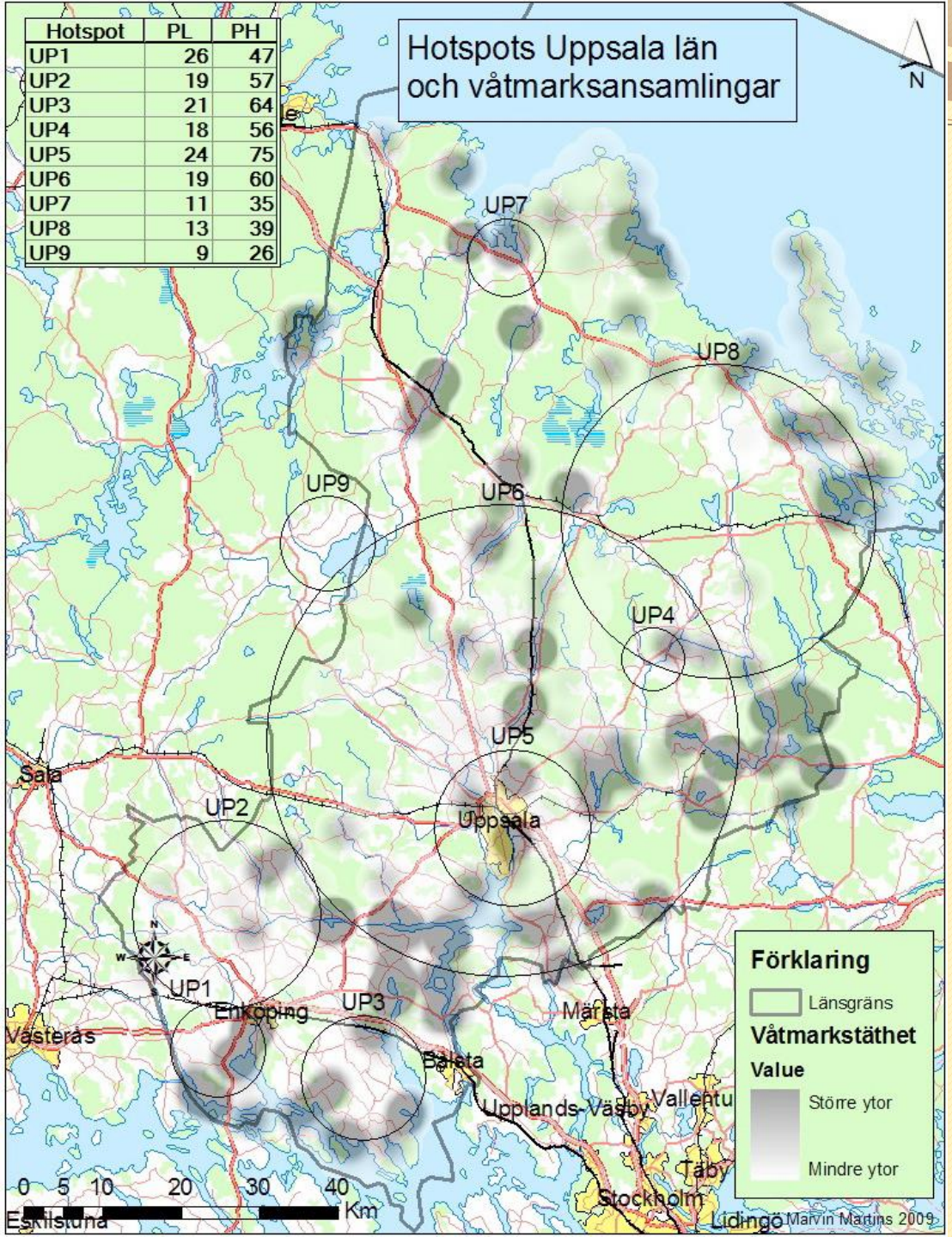
F3 Conversion of e.g. reed or residuals from farms to biogas

F4 Indirect biomass from manure to biogas

F5 Indirect biomass from sludge to biogas



Wind speed in Uppsala County
(yearly average at 72 meters above ground level)



Hotspot	PL	PH
UP1	26	47
UP2	19	57
UP3	21	64
UP4	18	56
UP5	24	75
UP6	19	60
UP7	11	35
UP8	13	39
UP9	9	26

Hotspots wetland for biogas production

Solar electricity Heby

Heat pumps

Sweden has today (2019) some 1.9 million heat pumps in households and other facilities, of which about 500 000 takes heat from the ground. It makes Sweden the No 2 country in the world in geothermal heating (after Iceland). A modern heat pump may reduce energy use by up to 80 %.


Energy forest – Salix – is
grown using wastewater

Collecting food waste

Scharnhausen light rail tramways. Running on rail is much more energy efficient than on road.

To read

- Energy and Climate. Chapter 1 *Energy and Sustainable Development*. pp 11-22.
- Energy and Climate. Chapter 2 *How much energy do we use – energy statistics*. pp 23-34.
- Renewable Energy Policy Network for the 21st Century (REN21). *Renewables 2020 Global Status Report. Executive summary* pp. 15-26 (*reference literature*).