Energy Economics and Environment

Lecture 5

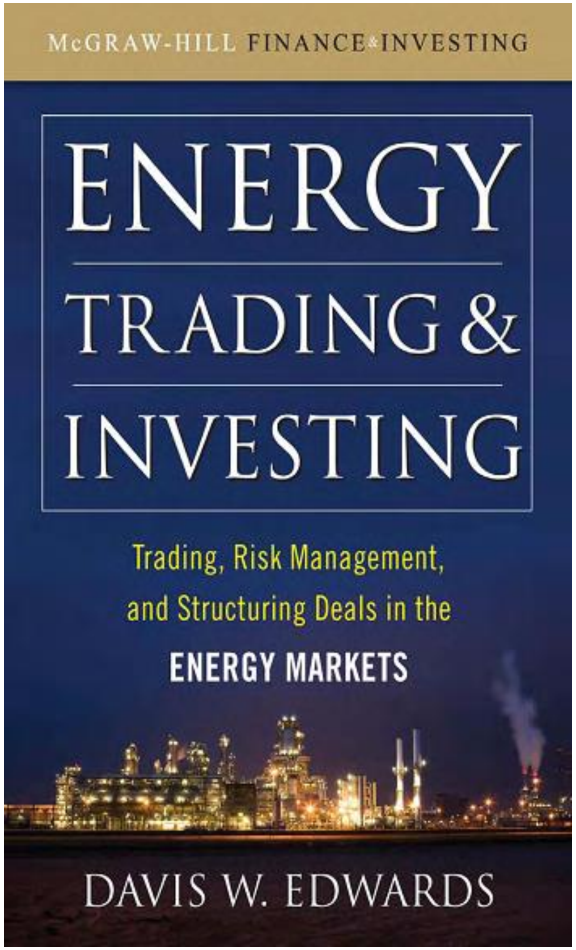
EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

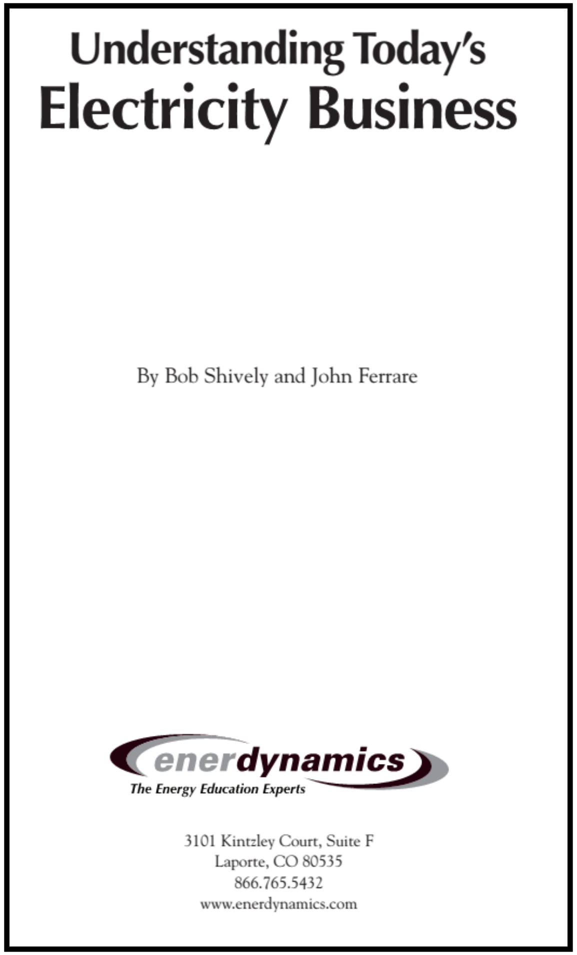
MINISTERSTVO ŠKOLSTVÍ,
MLÁDEŽE A TĚLOVÝCHOVY

The electrical system 2

Generation (power stations)

Literature for today





p.93-112 +117 (California)

Shively Ch. 4.

Terminology

(Electricity) Generator

=

Power Plant

Terminology

What is the difference between power and energy?

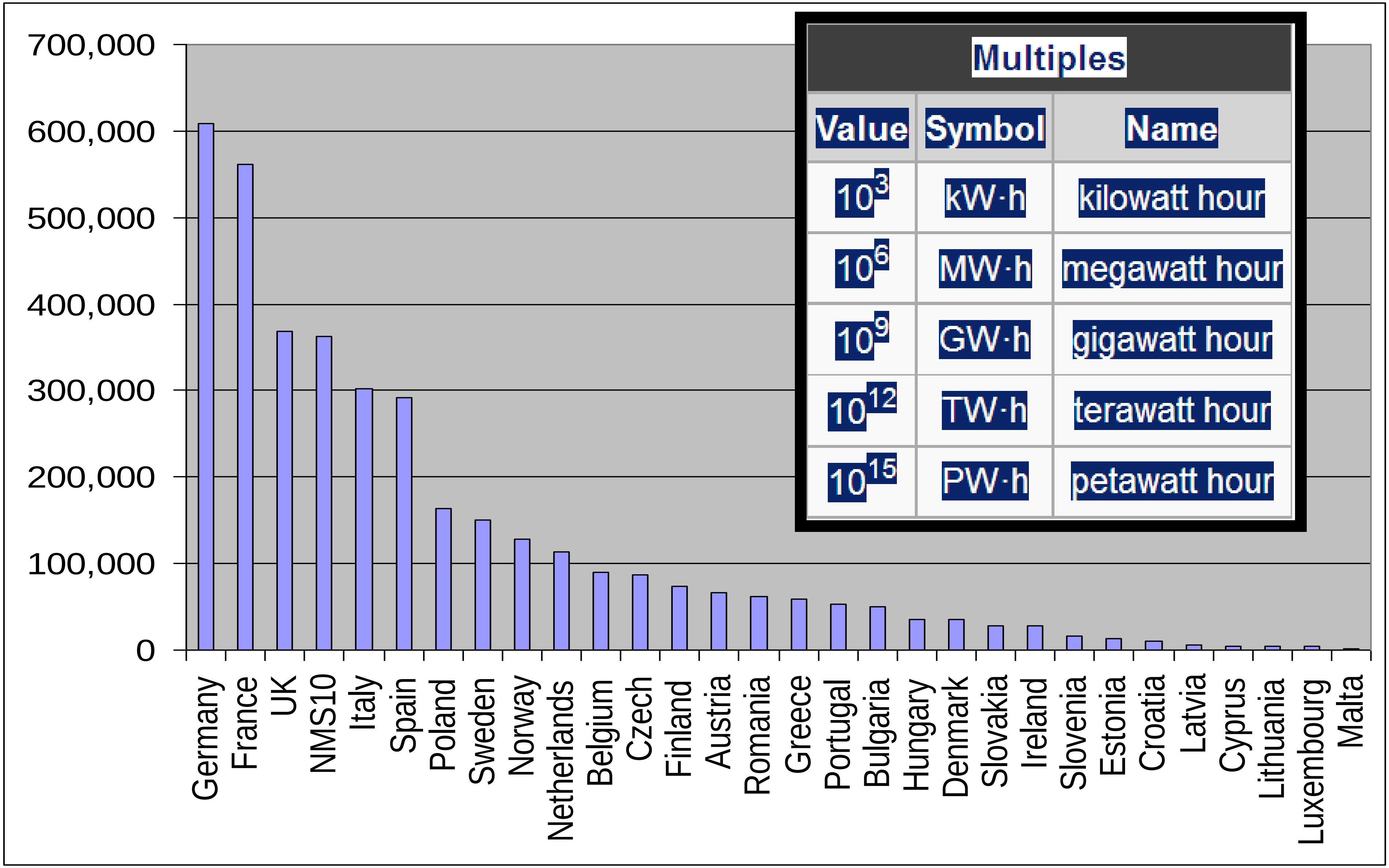
Terminology

Speed & Distance	Speed (KM/Hr)	Hours (Hr)	Distance (KM)
	12 KM/Hr		
	12 KM/Hr		
Power & Energy	Power (MW)	Hours (Hr)	Energy (MWh)
	200MW		
	200MW		

Speed & Distance	KM/hr	Hr	KM
Power & Energy			

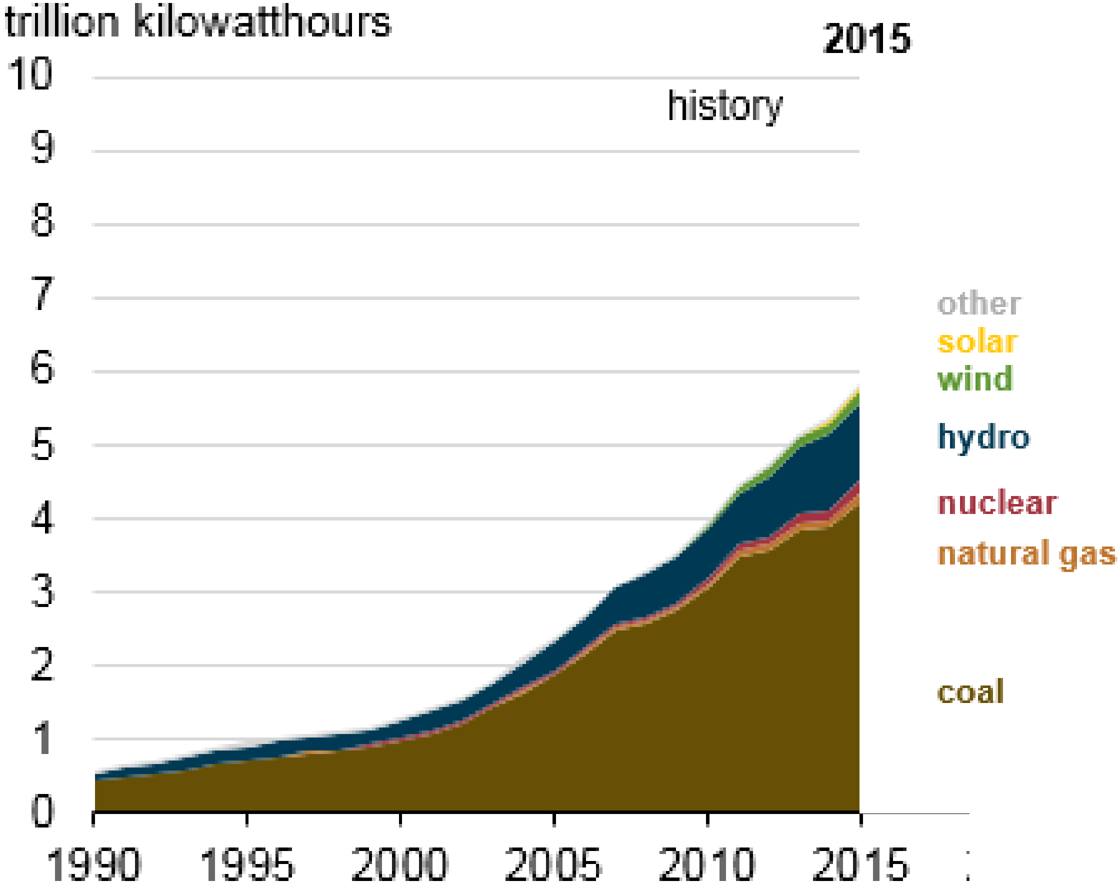
=MW

Annual consumption in 2011 in GWh

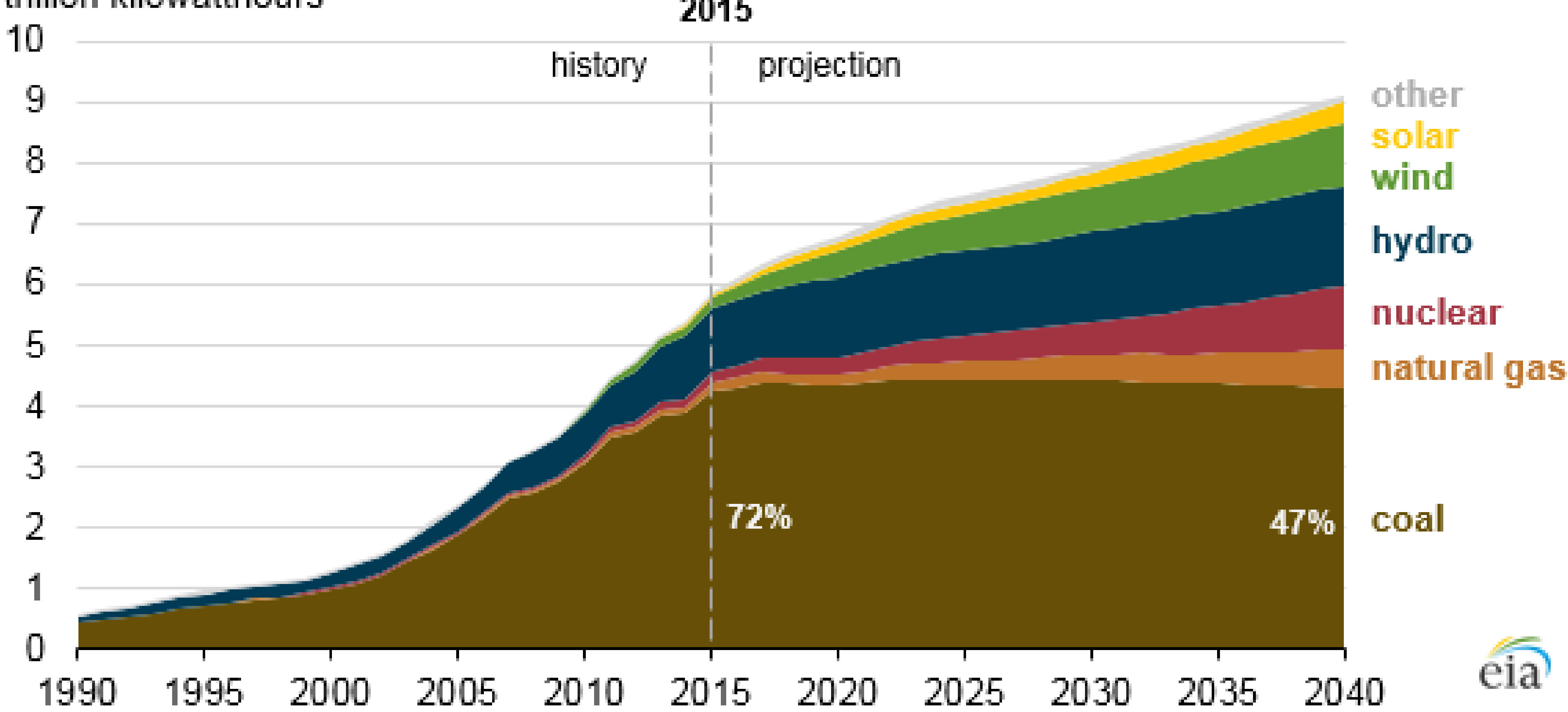


Multiples		
Value	Symbol	Name
10^3	kW·h	kilowatt hour
10^6	MW·h	megawatt hour
10^9	GW·h	gigawatt hour
10^{12}	TW·h	terawatt hour
10^{15}	PW·h	petawatt hour

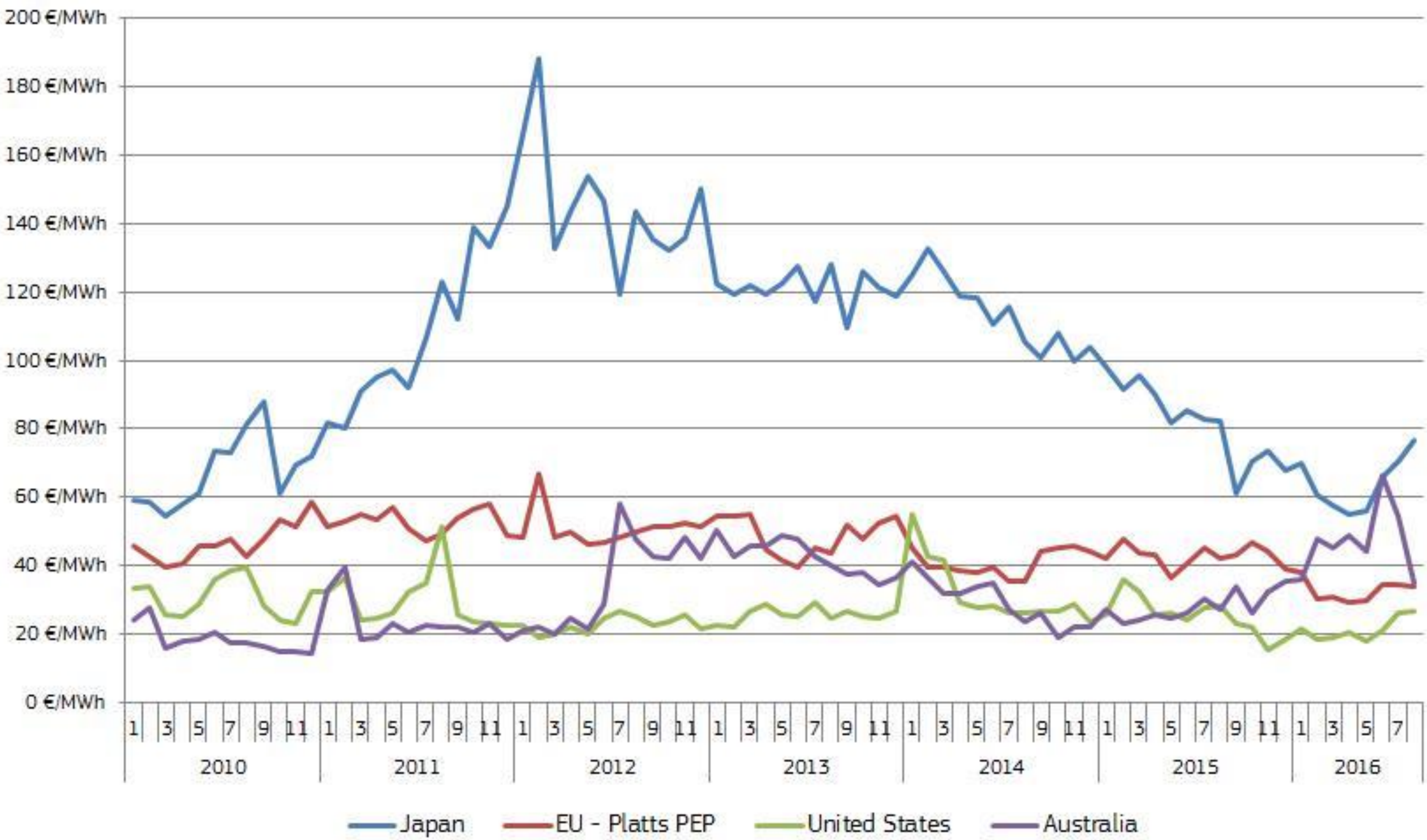
Annual electricity generation in China, IEO2017 Reference case (2005-2040)



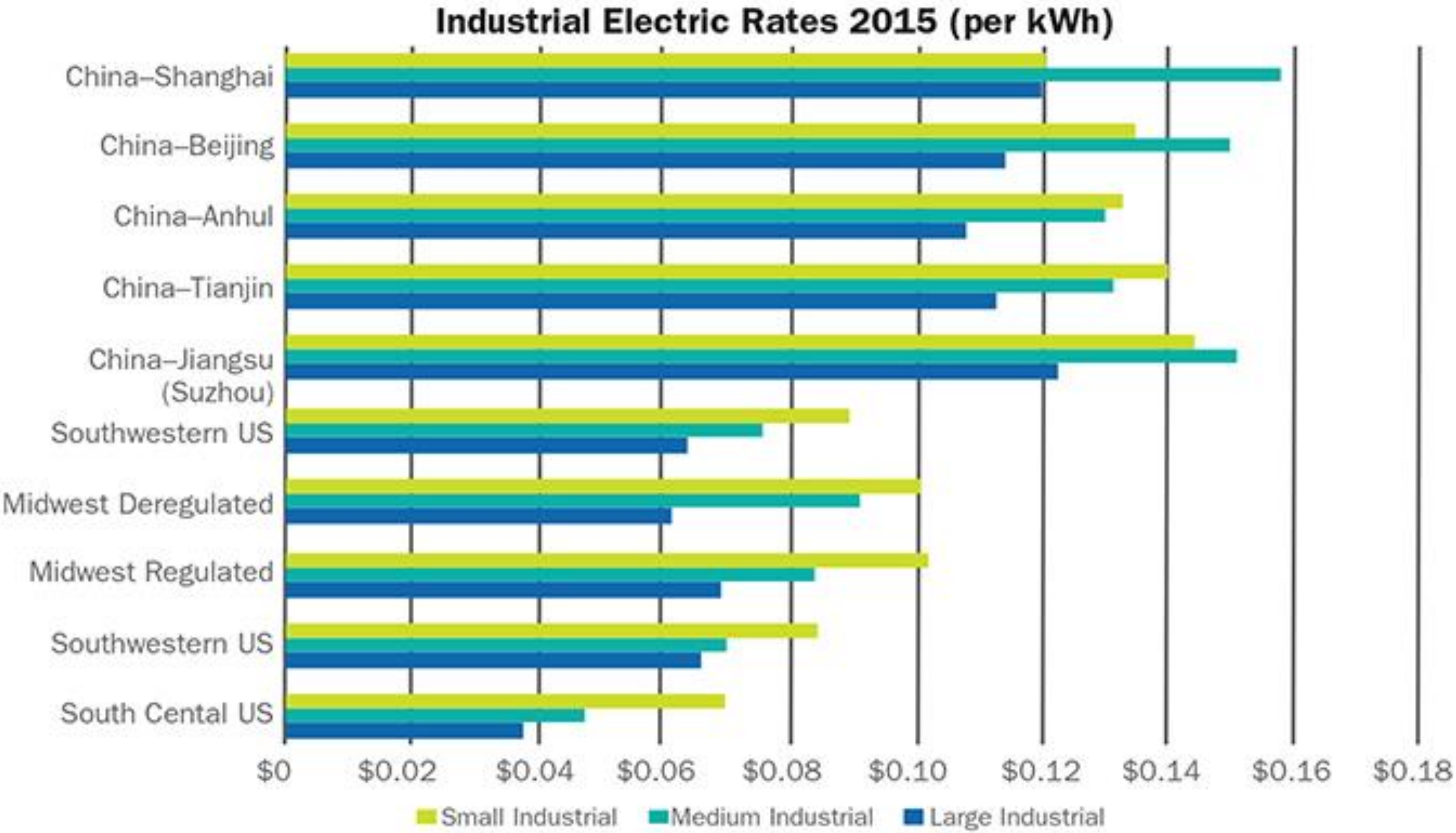
Annual electricity generation in China, IEO2017 Reference case (2005-2040)
trillion kilowatthours



EU: 3 €cent/KWh | **= 0.03€/ KWh** | **= 30€/ MWh**



13 $cent/KWh	= 0.13$/ KWh	= 130$/ MWh



I have a nuclear with a capacity of 500MW (power).

How much energy can this power plant produce in a year?

How many hours are in a year?

24*365= 8760

(Q&D, +/- 10.000 minus 12%)

≈500MW * 10.000 hours

≈ 5.000.000MWh

≈ 5.000GWh

≈ 5 TWh

=4.4 TWh

In the EU in 2012 there was a capacity of 120GW (power) in solar. This produced 100TWh in 2012.

What is approximately the capacity factor of EU solar?

How many hours are in a year?

10.000 minus 12%

If it ran at full capacity (100% c.f.) it would have produced about 120 * 10.000GWh

≈1.200.000 GWh

≈1.200 TWh

≈1.000 TWh (minus the 12%)

But it produced 10 times less…

Thus c.f. is ≈ 10%

INTRO

Overview of generation types

Hydro-plant

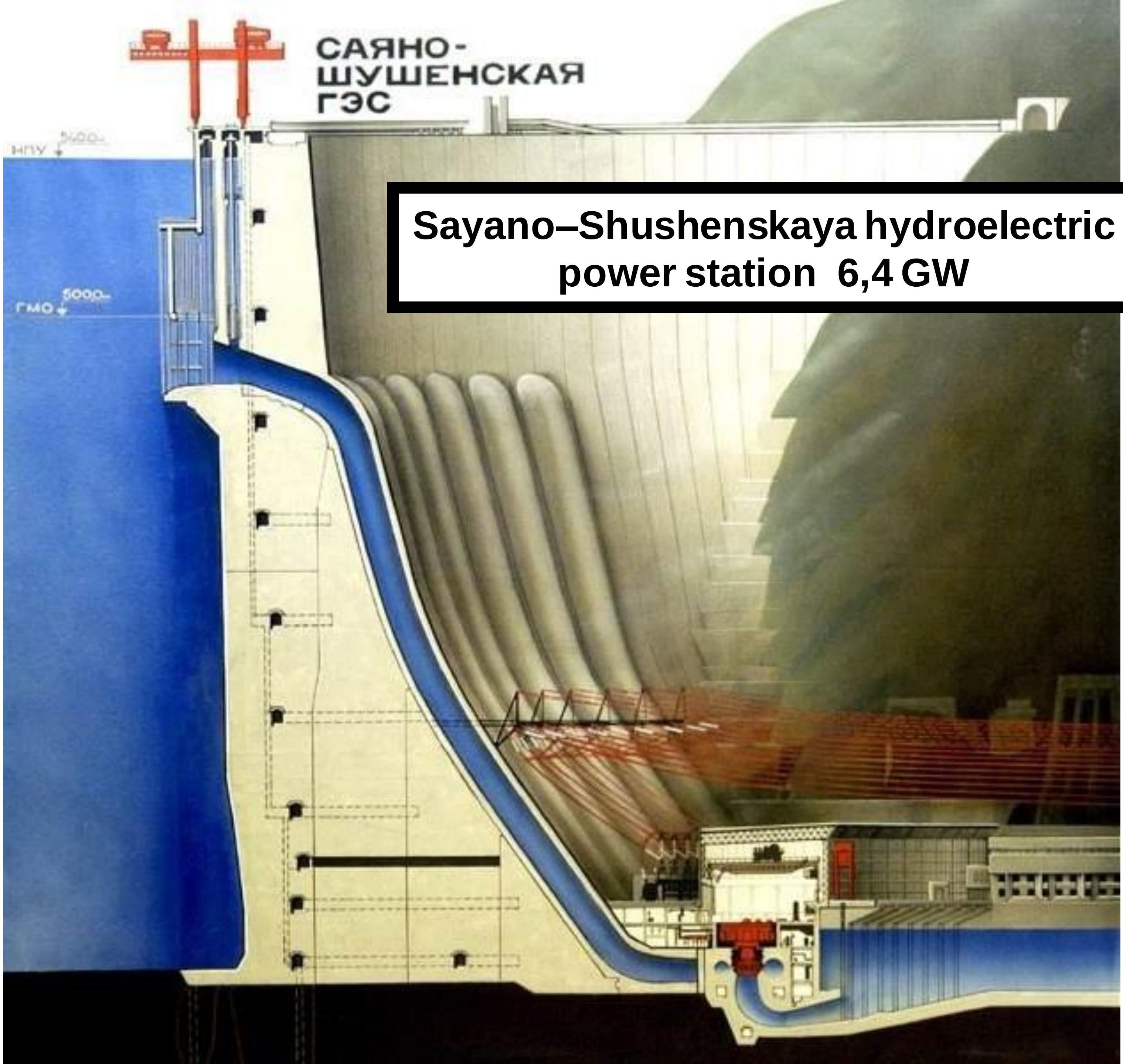
Hydro comes in three variants

1. With dams (reservoir)
2. Pumped storage
3. Run-of-River

Hydro with dams (reservoir)

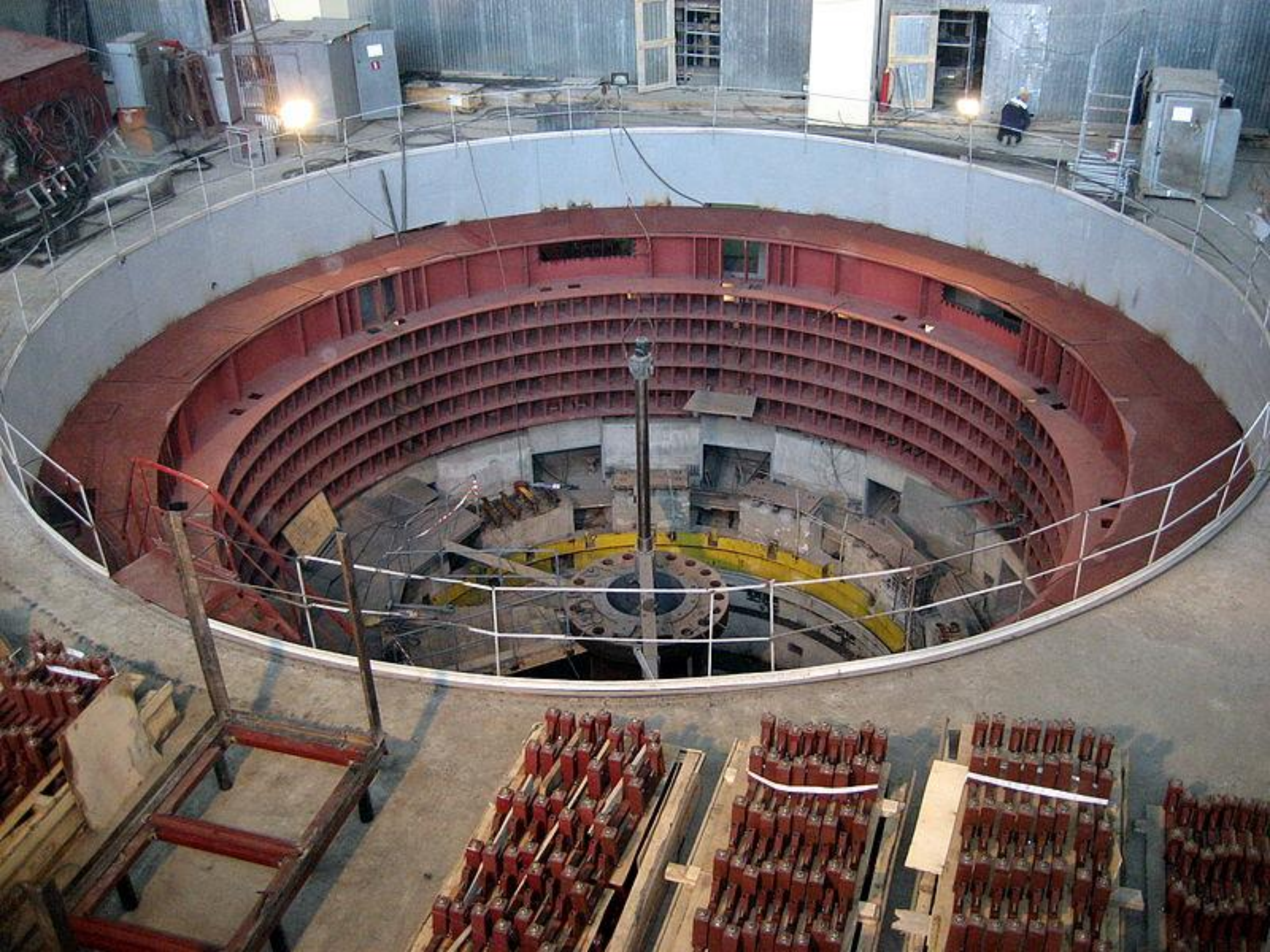
VID

Wednesday 2_ Hydroelectic Power - How it Works (hq).mp4



Sayano–Shushenskaya hydroelectric power station 6,4 GW

Отм. 320
Отм. 315
Отм. 310

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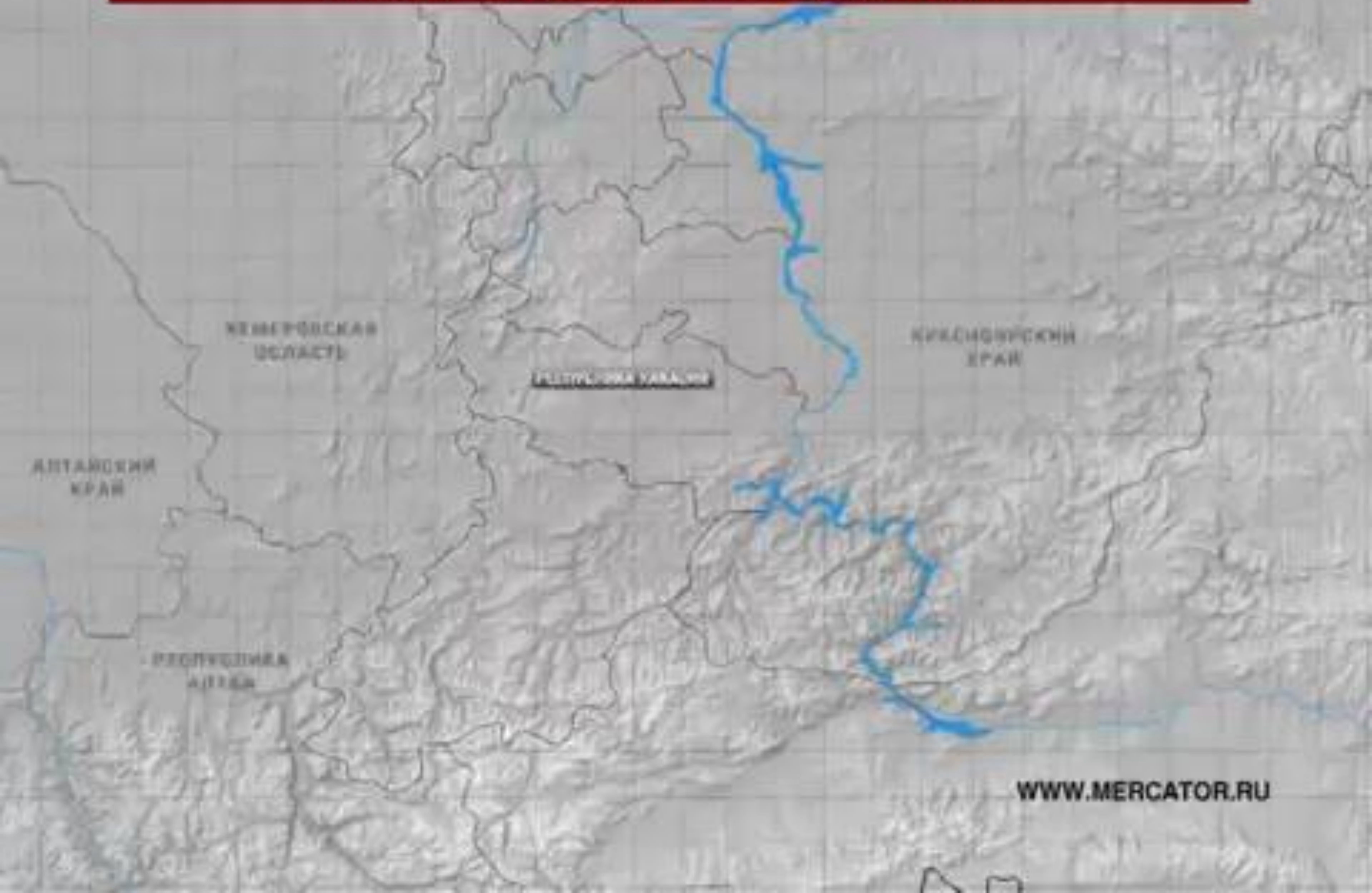
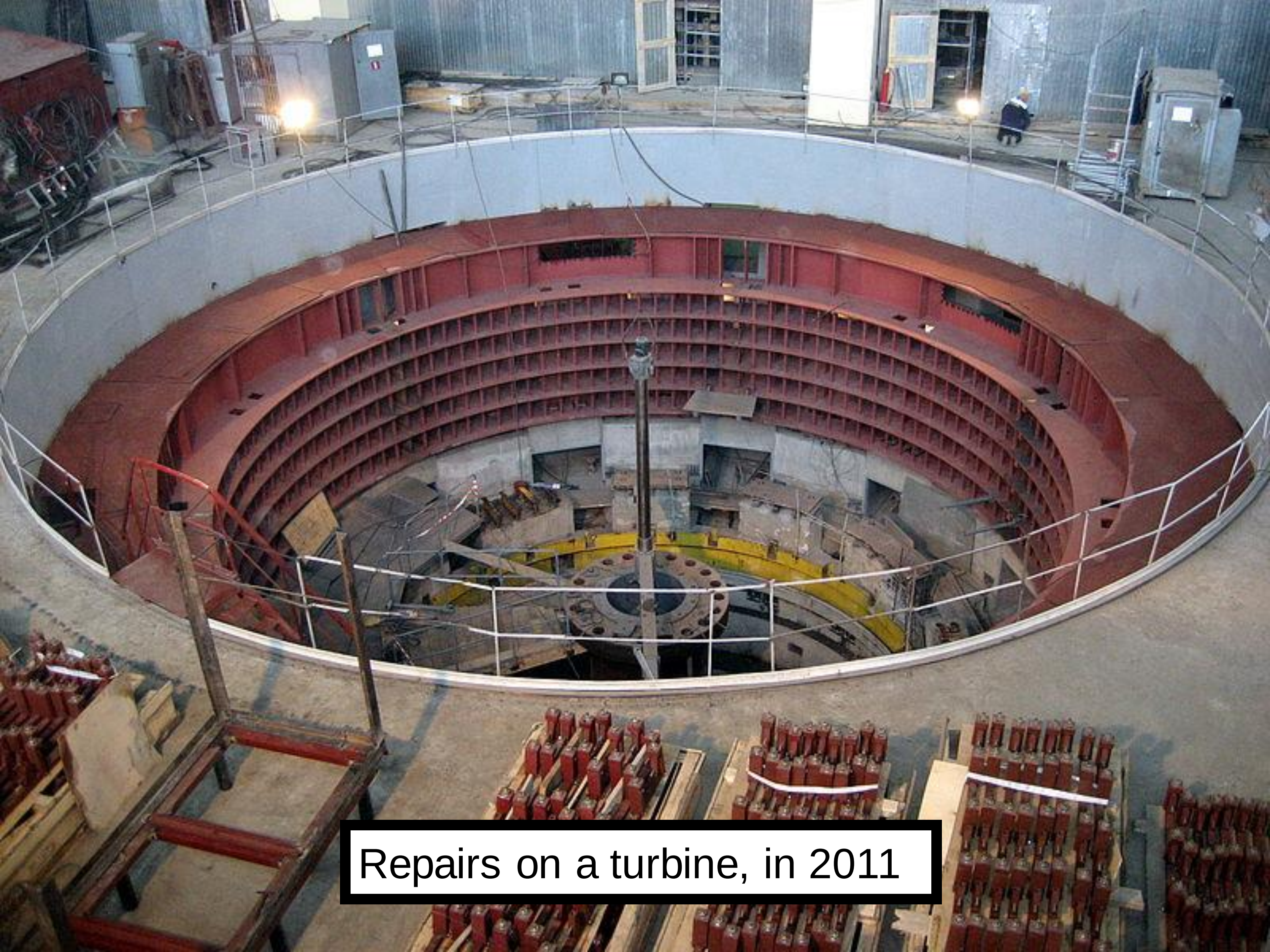
АВАРИЯ НА САЯНО-ШУШЕНСКОЙ ГЭС

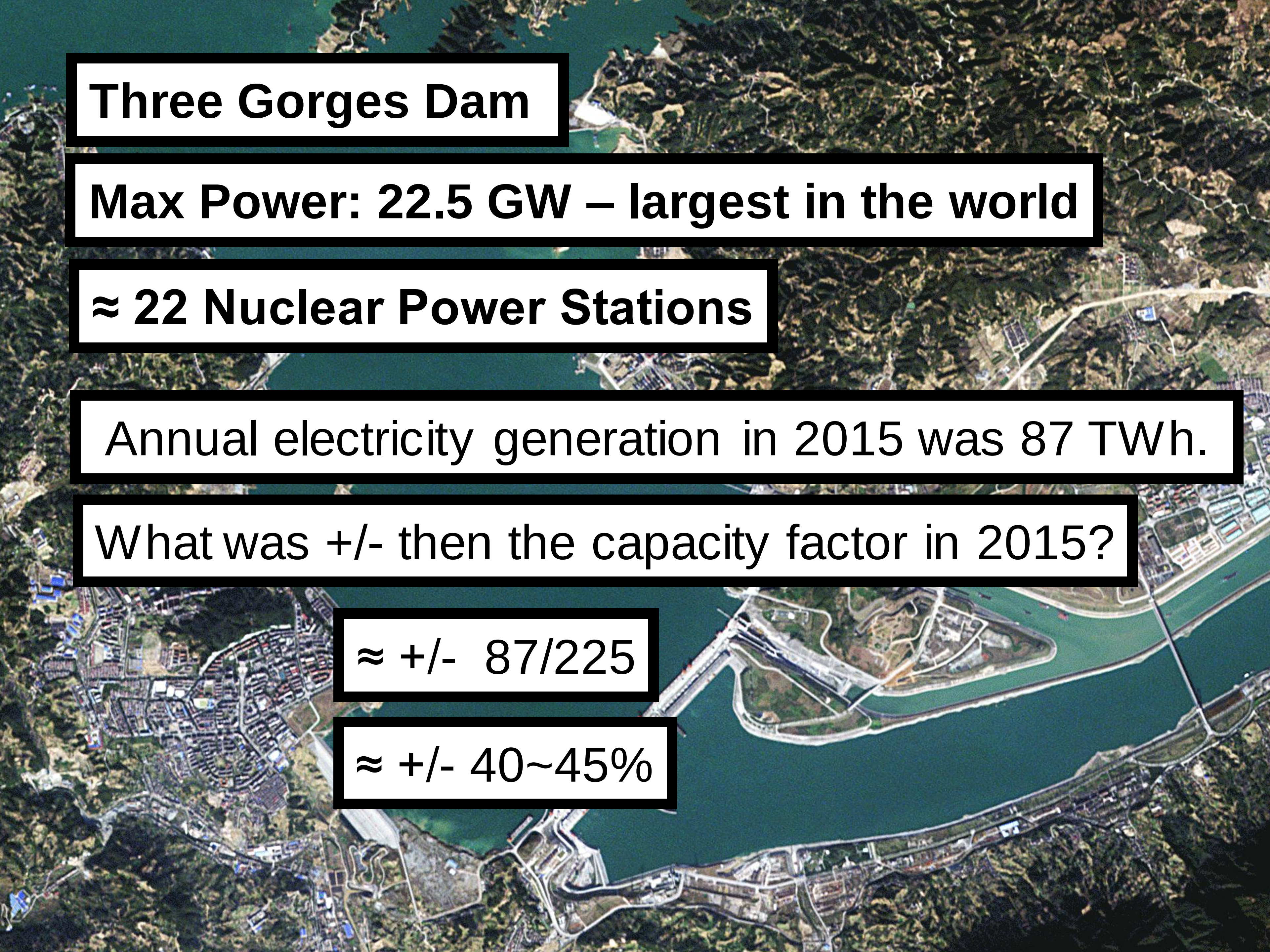




Repairs on a turbine, in 2011

Sayano-Shushenskaya hydropower station accident


华云旅游 www.tao5166.com



Three Gorges Dam

Max Power: 22.5 GW – largest in the world

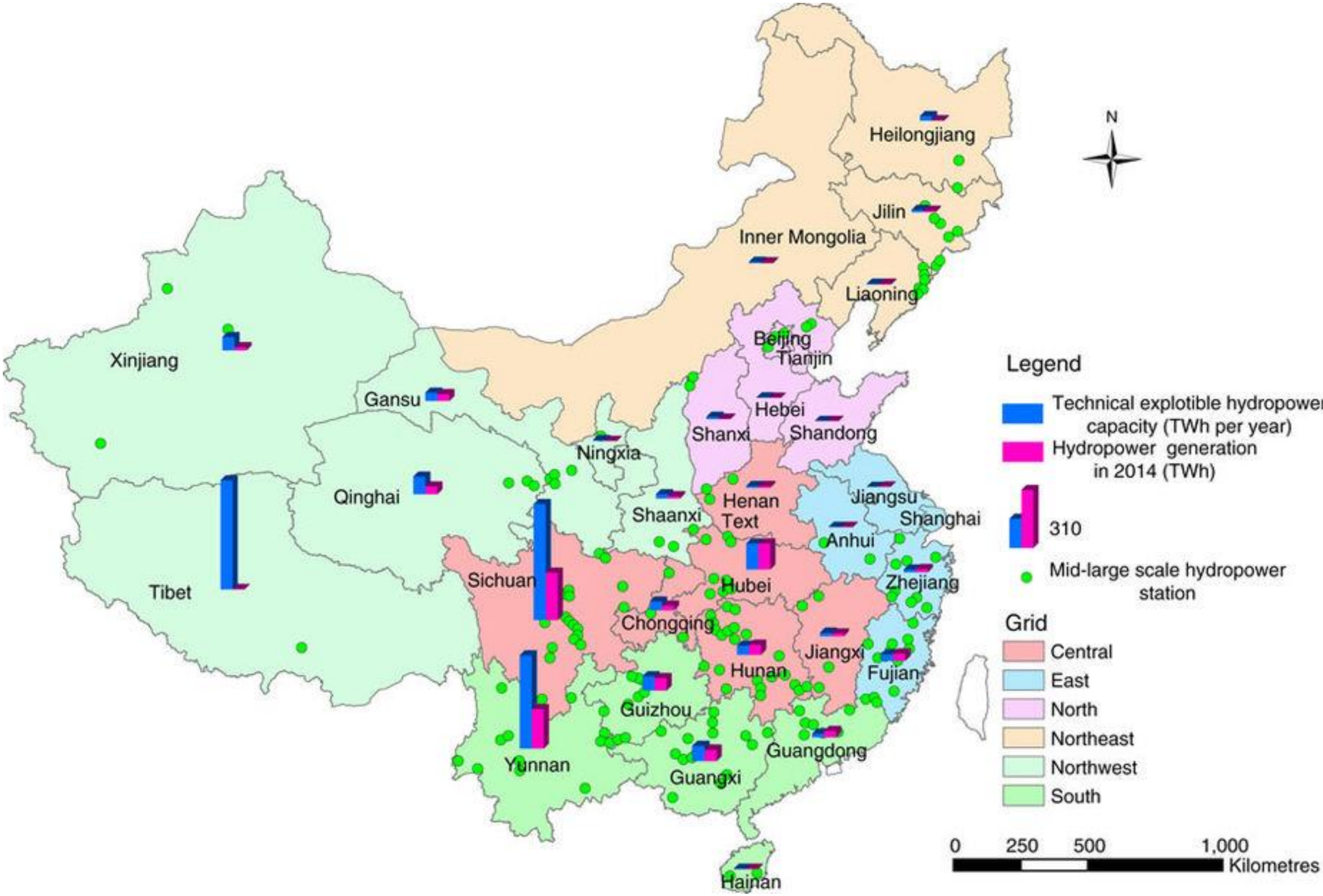
≈ 22 Nuclear Power Stations

Annual electricity generation in 2015 was 87 TWh.

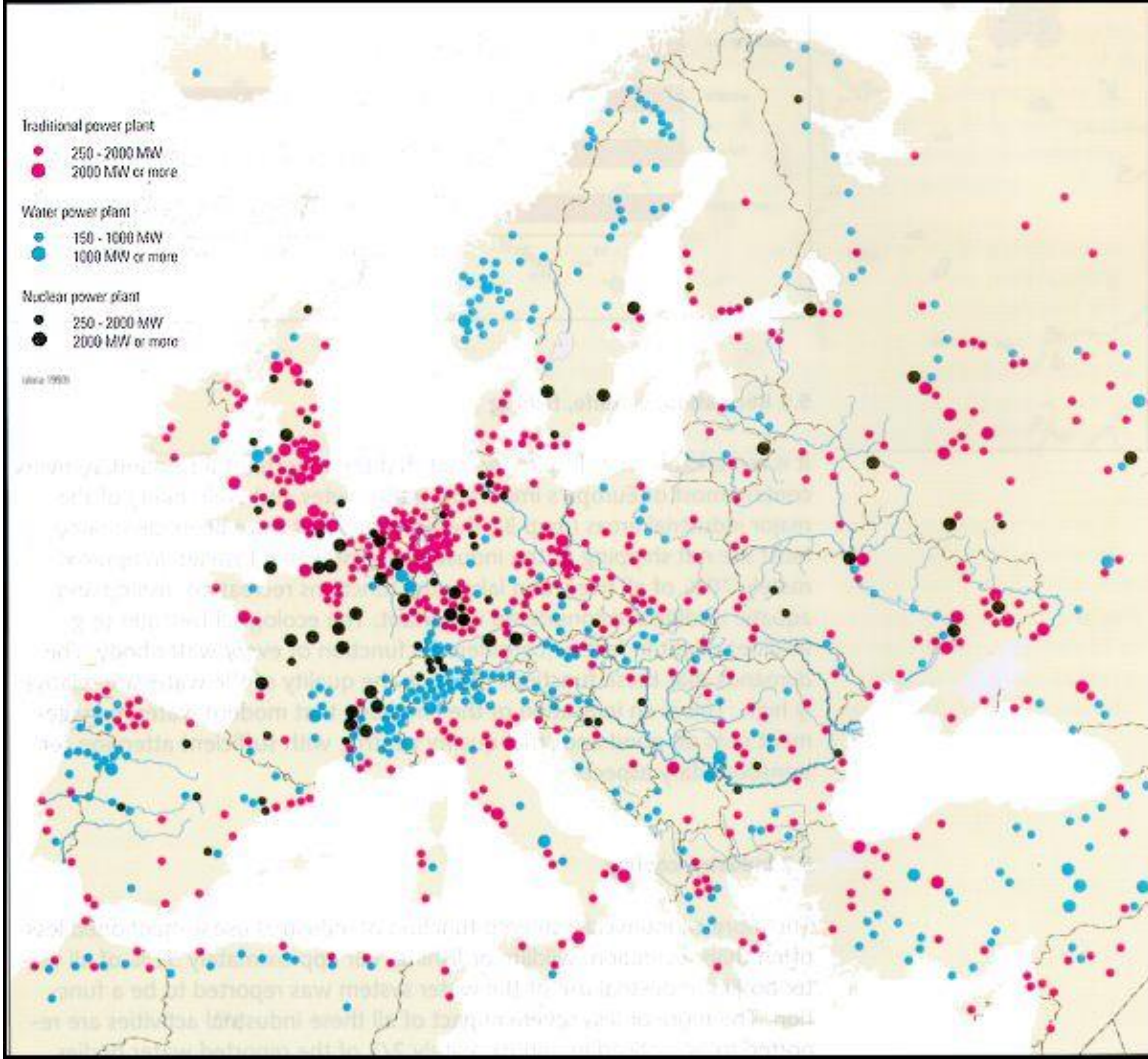
What was +/- then the capacity factor in 2015?

≈ +/- 87/225

≈ +/- 40~45%



N
Heilongjiang
Jilin
Inner Mongolia
Liaoning
Beijing
Tianjin
Xinjiang
Gansu
Hebei
Shanxi
Shandong
Ningxia
Qinghai
Henan
Text
Jiangsu
Shaanxi
Shanghai
Anhui
Tibet
Sichuan
Hubei
Zhejiang
Chongqing
Jiangxi
Hunan
Fujian
Guizhou
Guangdong
Yunnan
Guangxi
Hainan
Legend
Technical explotible hydropower capacity (TWh per year)
Hydropower generation in 2014 (TWh)
310
Mid-large scale hydropower station
Grid
Central
East
North
Northeast
Northwest
South
0 250 500 1,000
Kilometres

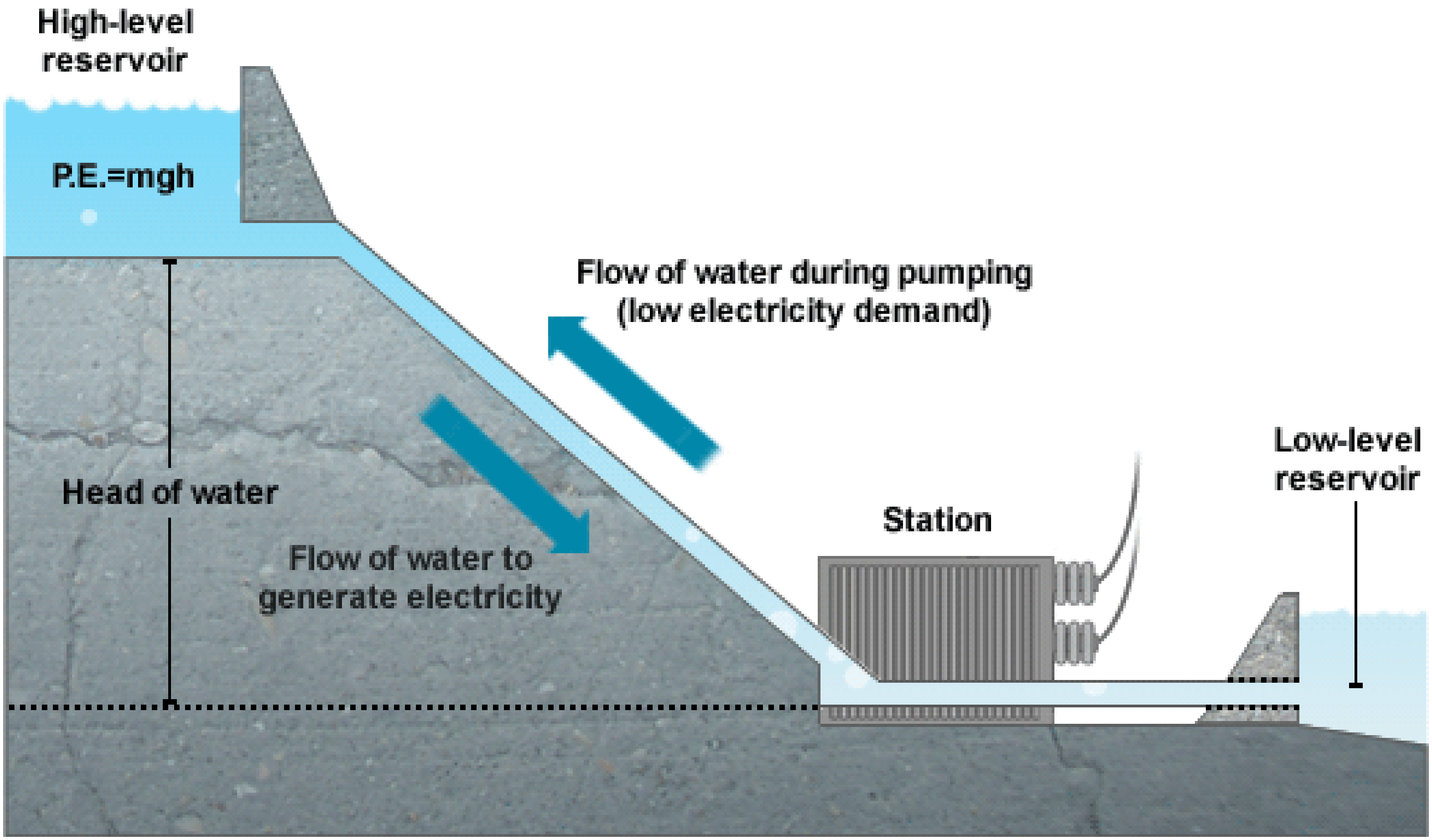


Traditional power plant
250 - 2000 MW
2000 MW or more
Water power plant
150 - 1000 MW
1000 MW or more
Nuclear power plant
250 - 2000 MW
2000 MW or more

Hydro and Storage?

Hydro and Storage?

Pumped Storage Hydro


High-level reservoir
P.E.=mgh
Flow of water during pumping (low electricity demand)
Head of water
Flow of water to generate electricity
Station
Low-level reservoir

Pumped storage

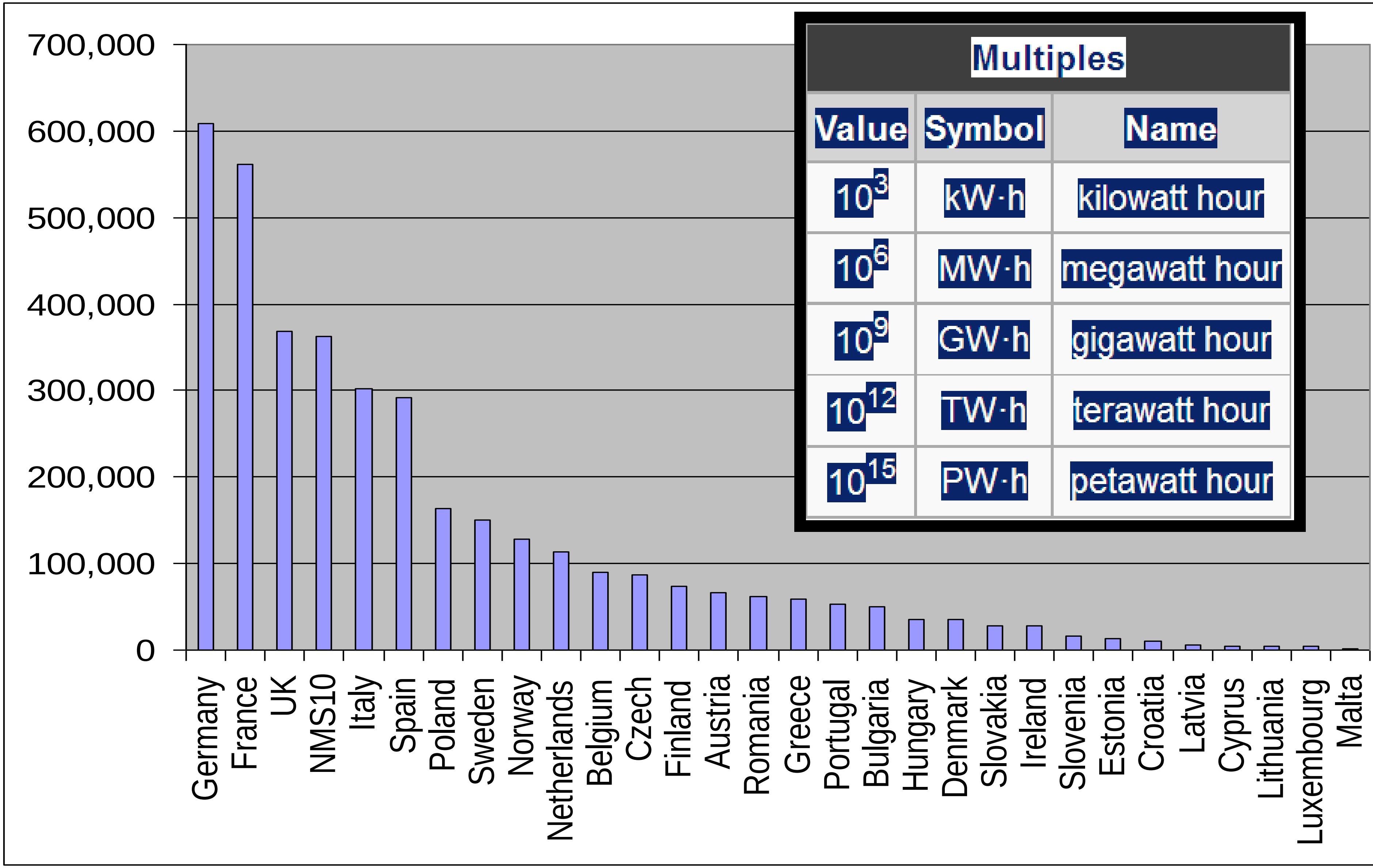
Dinorwig - 10 GWh energy; 2 GW maximum power

- **That is THE storage technology for electricity!**

- **Is it a lot?**

- **No, is tiny.**

Annual consumption in 2011 in GWh



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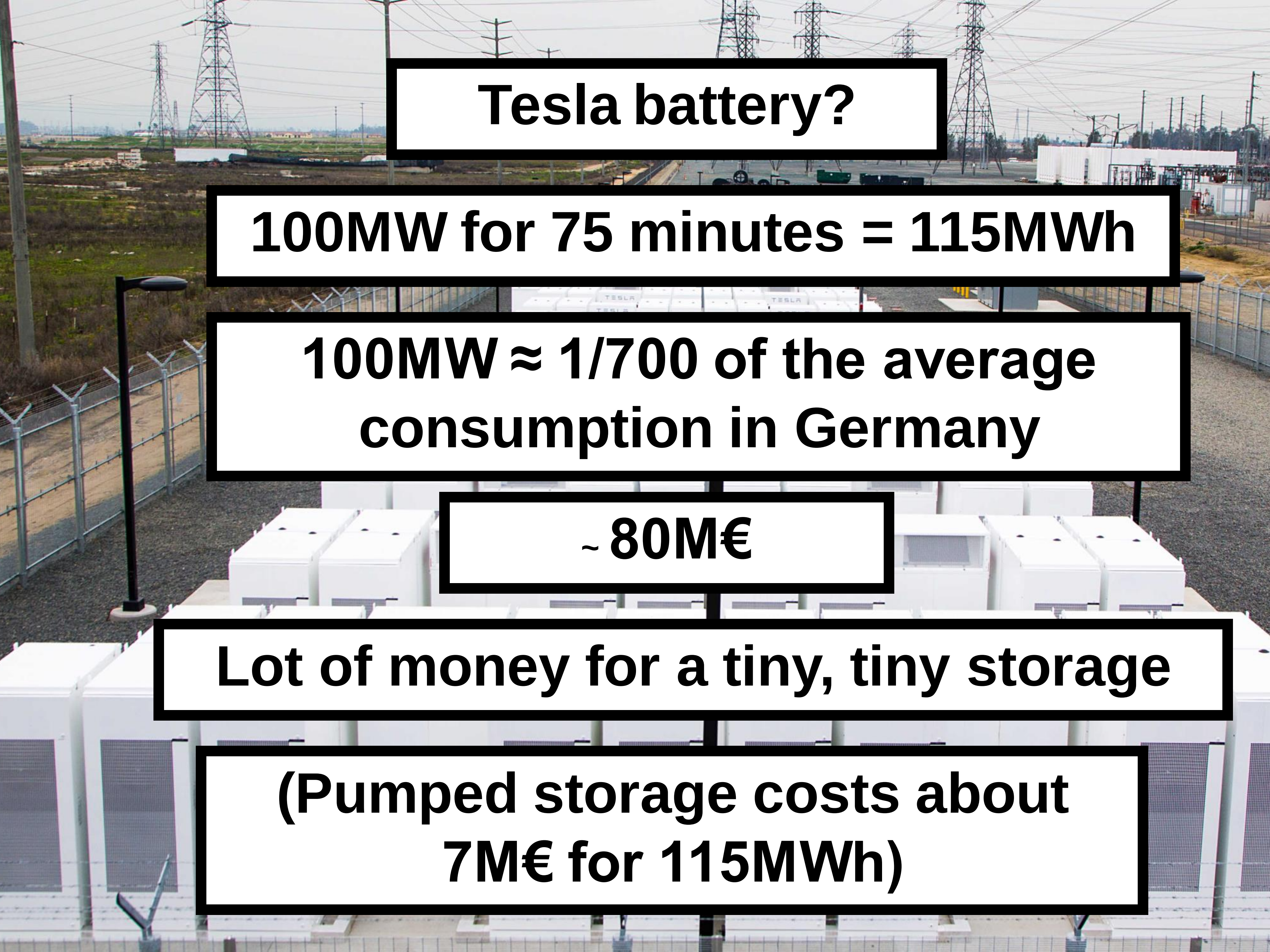
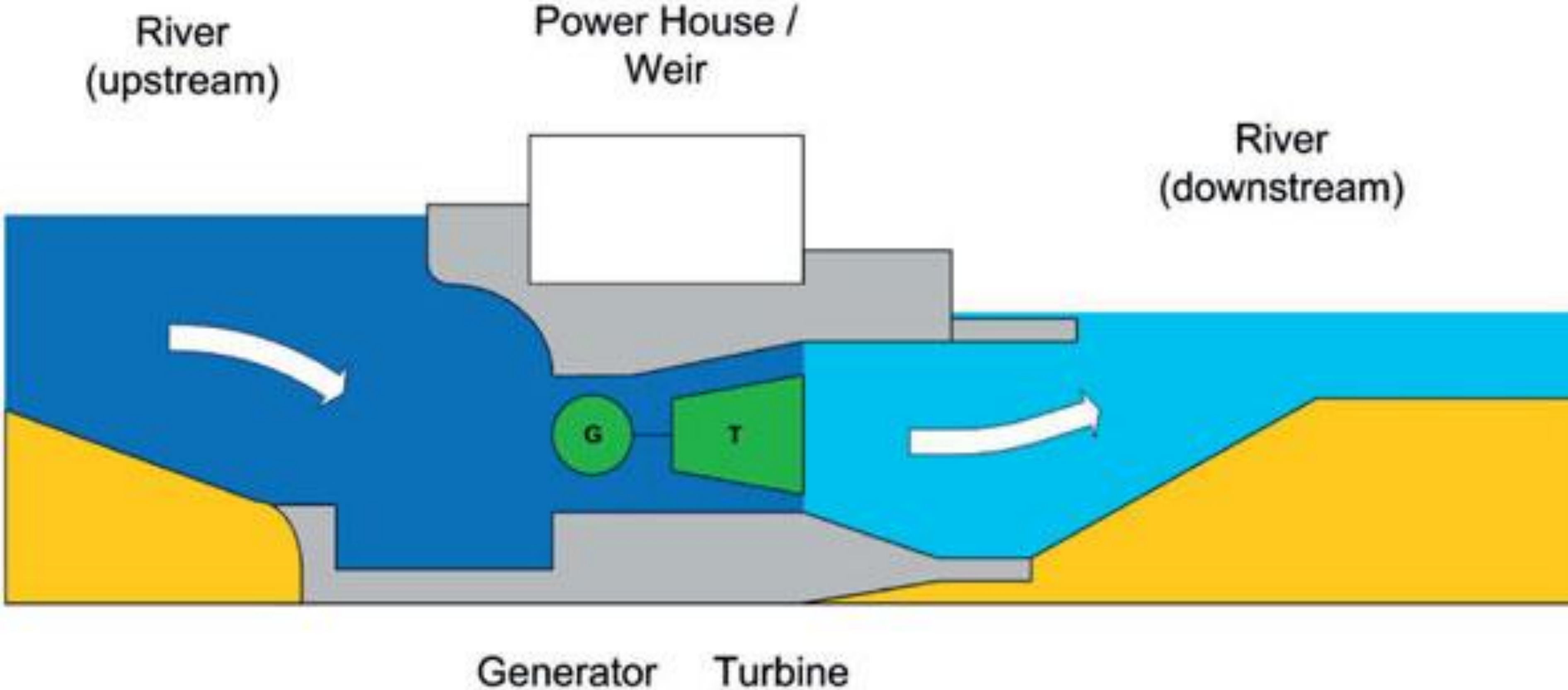

Tesla battery?
100MW for 75 minutes = 115MWh
100MW ≈ 1/700 of the average consumption in Germany
~ 80M€
Lot of money for a tiny, tiny storage
(Pumped storage costs about 7M€ for 115MWh)

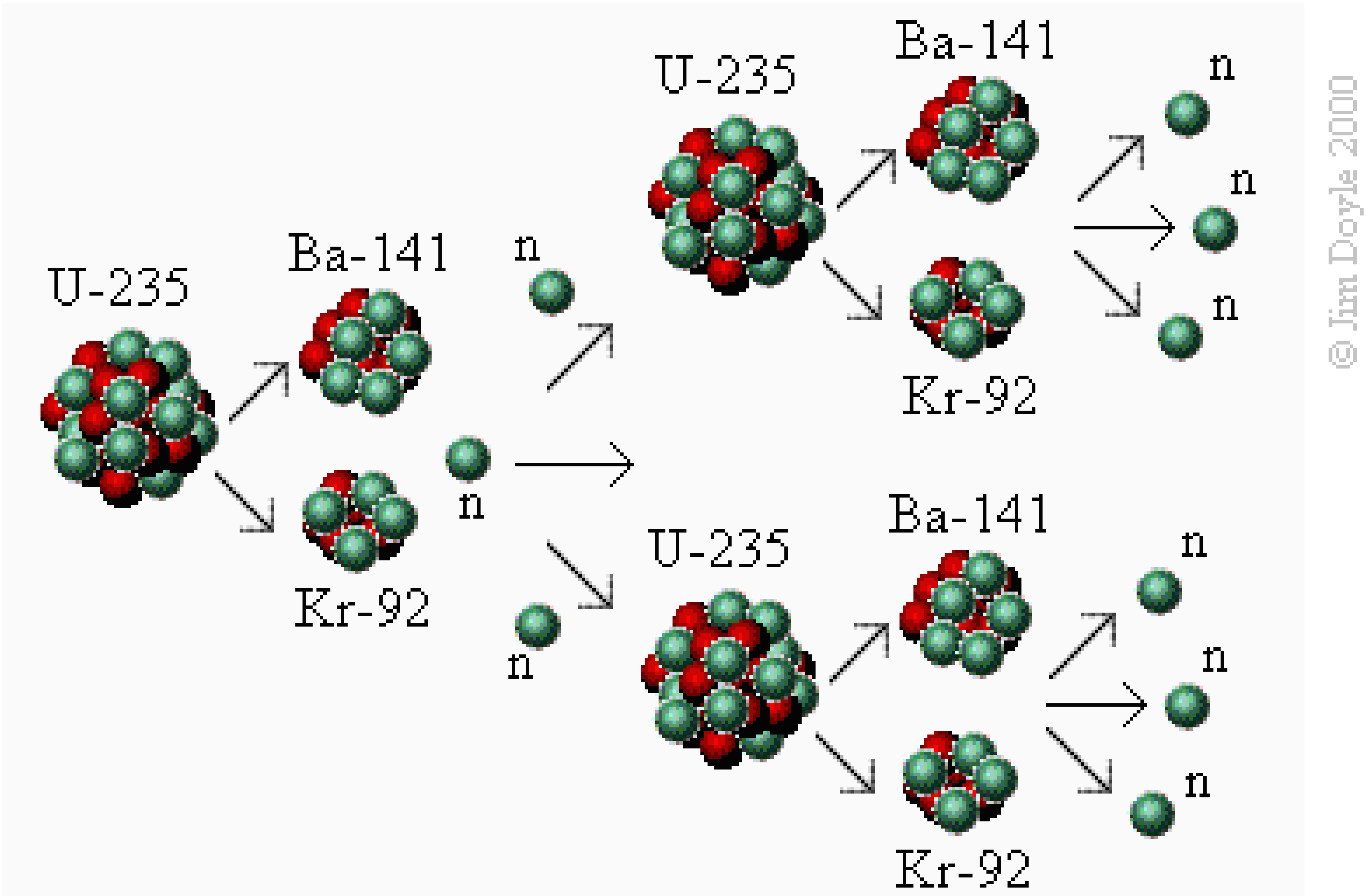
Run-of-river Hydro


River
(upstream)
Power House /
Weir
River
(downstream)
G
T
Generator
Turbine

Baseload

Nuclear plants

Nuclear Fission



Cost escalation curse

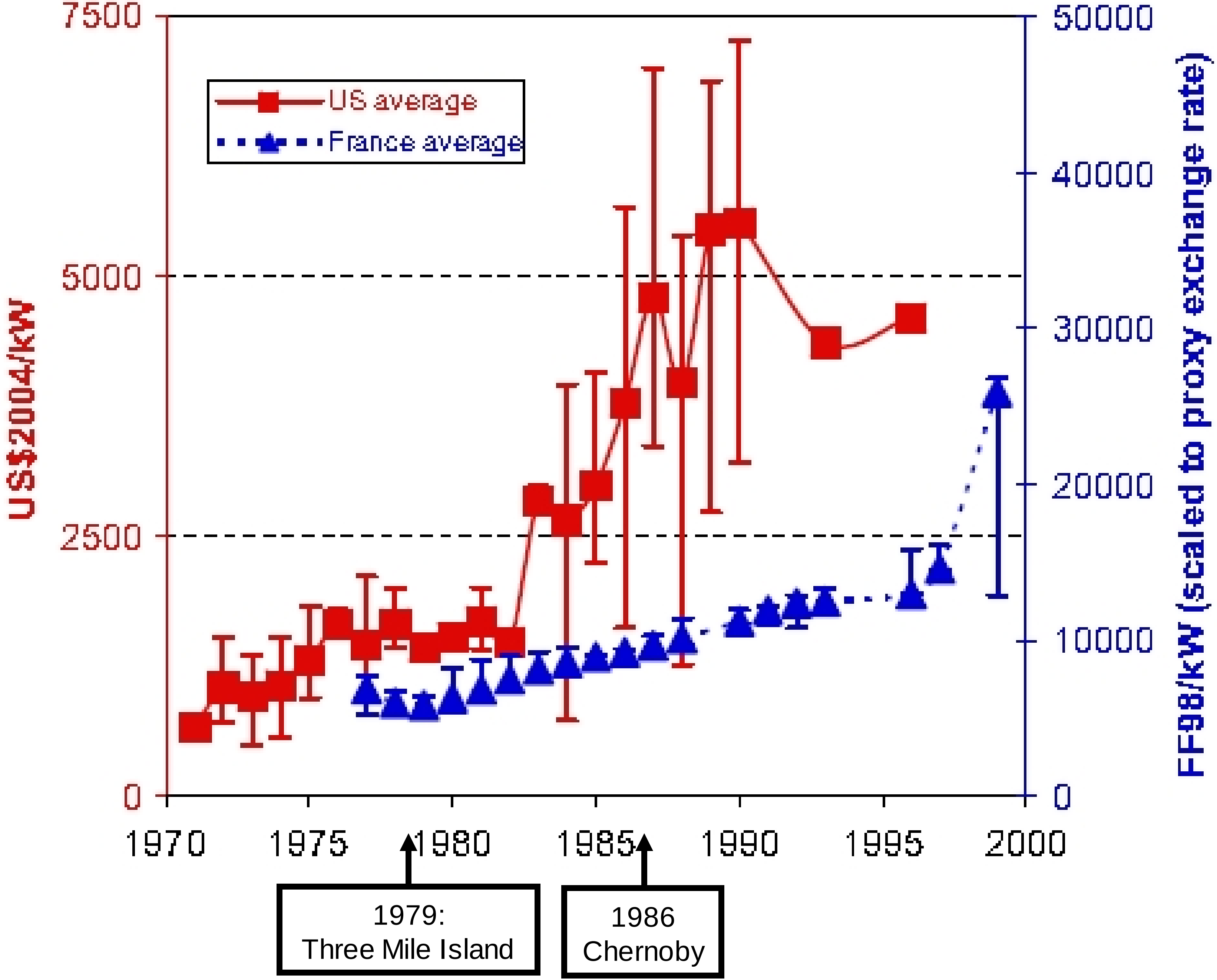
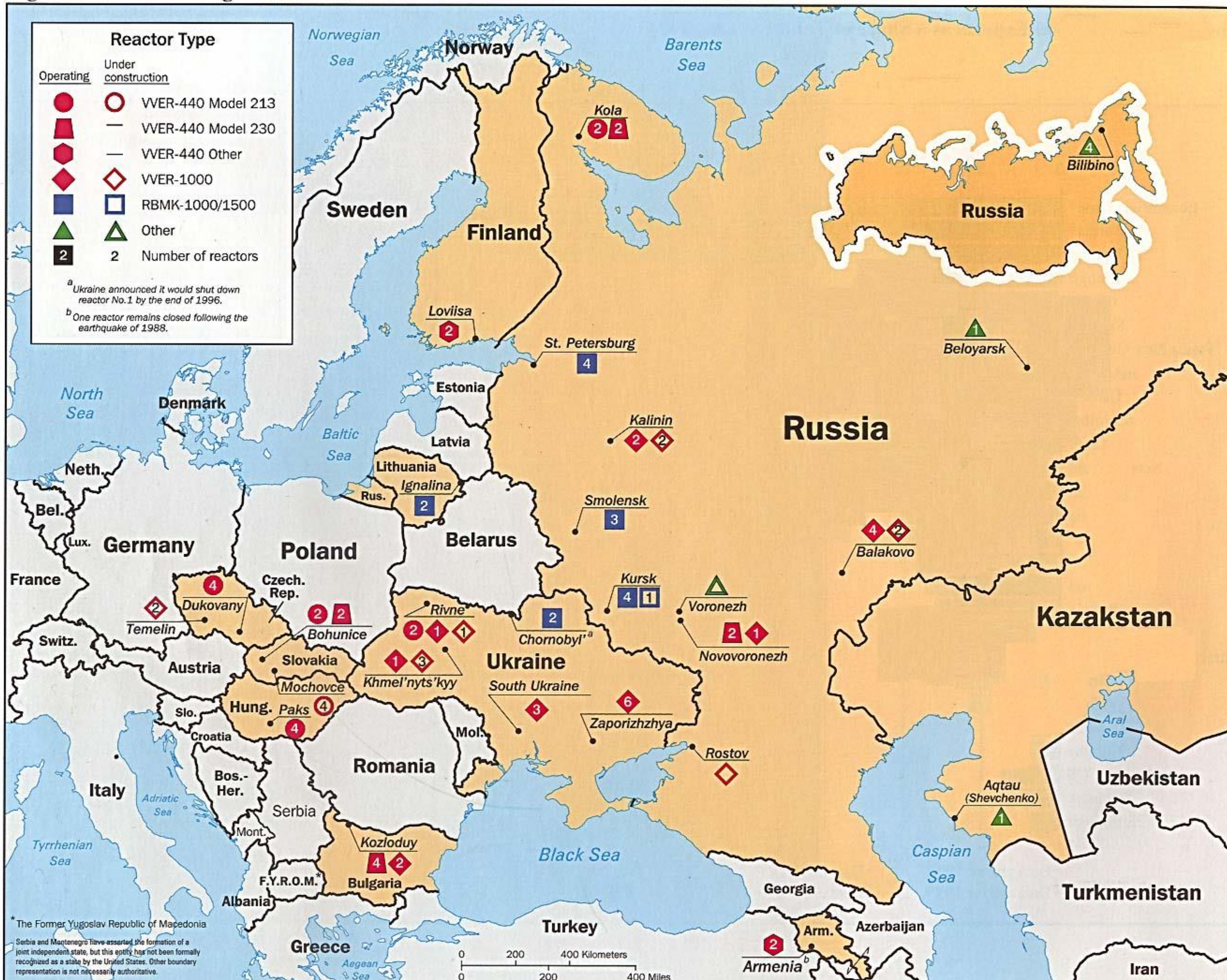


Figure 30. Soviet-Designed Nuclear Power Plants

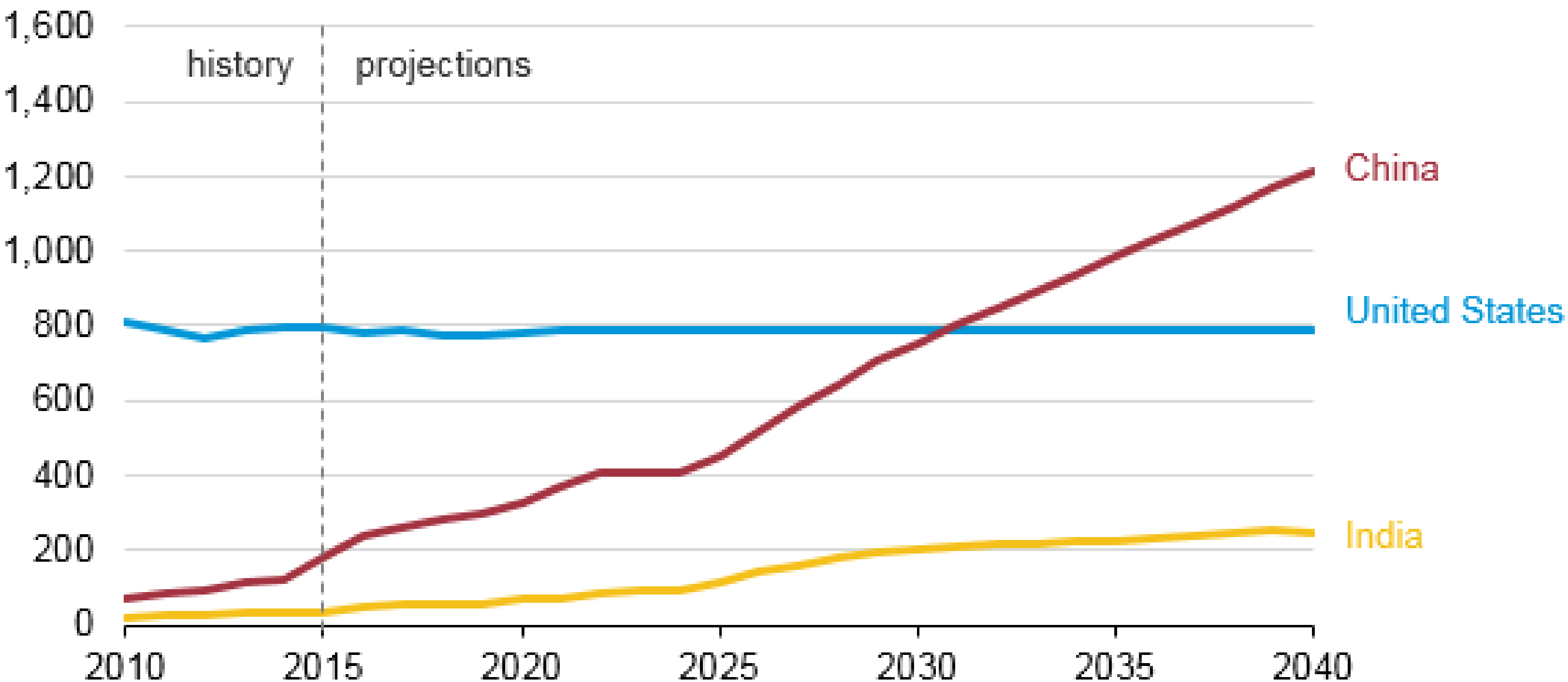


739927 (R00564) 9-96

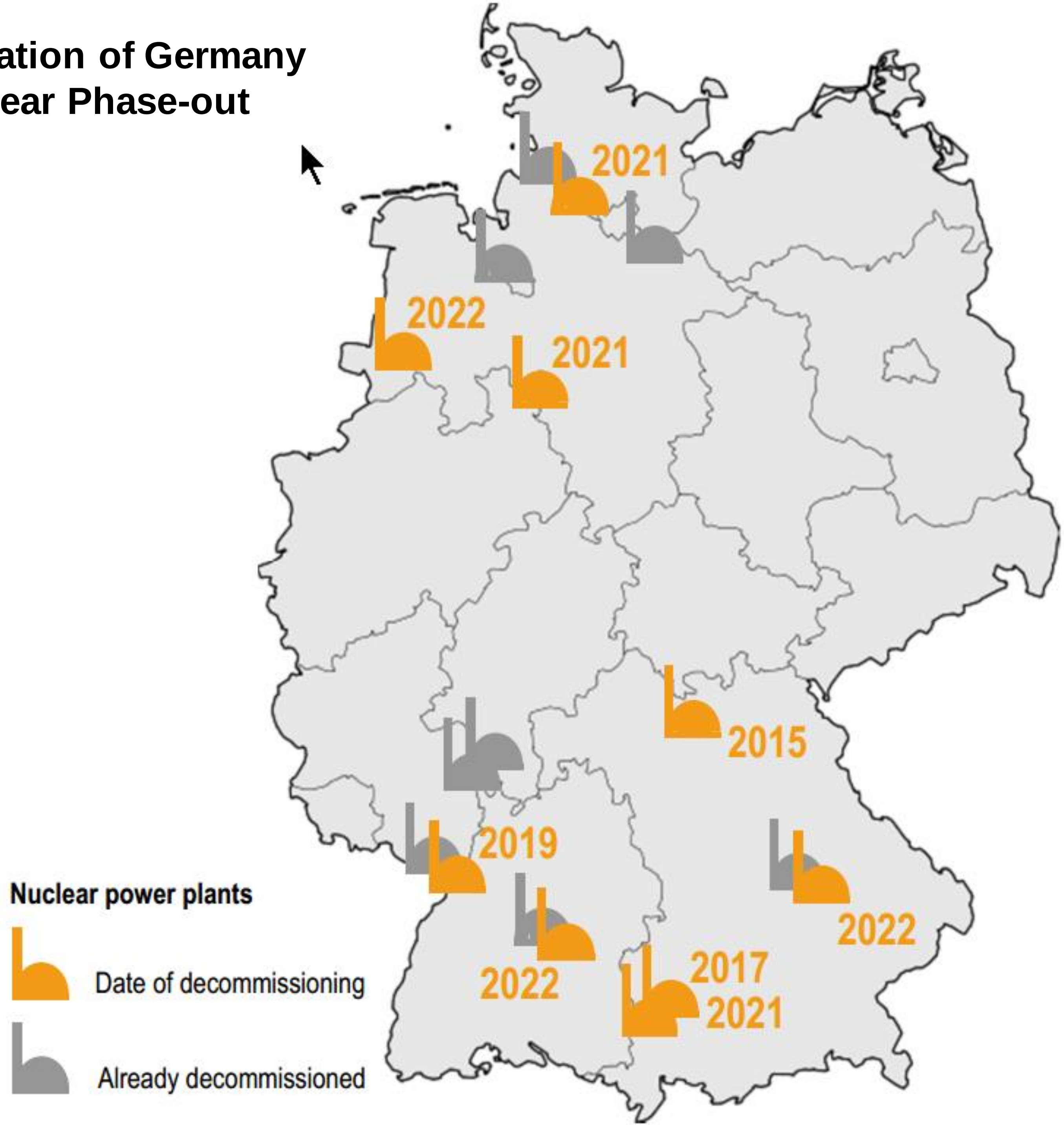
Nuclear Power Plants in China

Source: World Nuclear Association

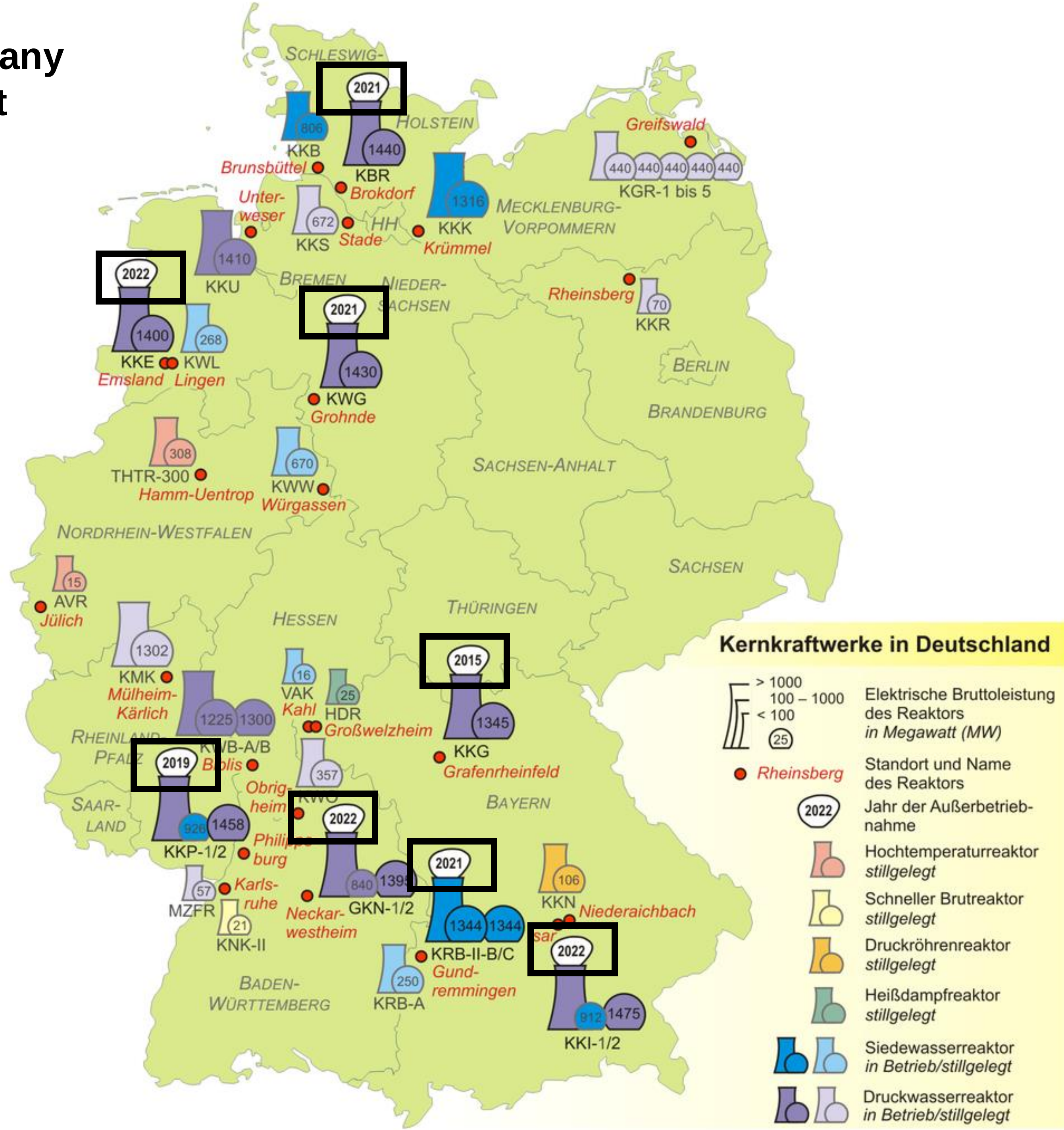
Projected nuclear electricity generation in selected countries (2010-40)
trillion kilowatthours



Acceleration of Germany Nuclear Phase-out

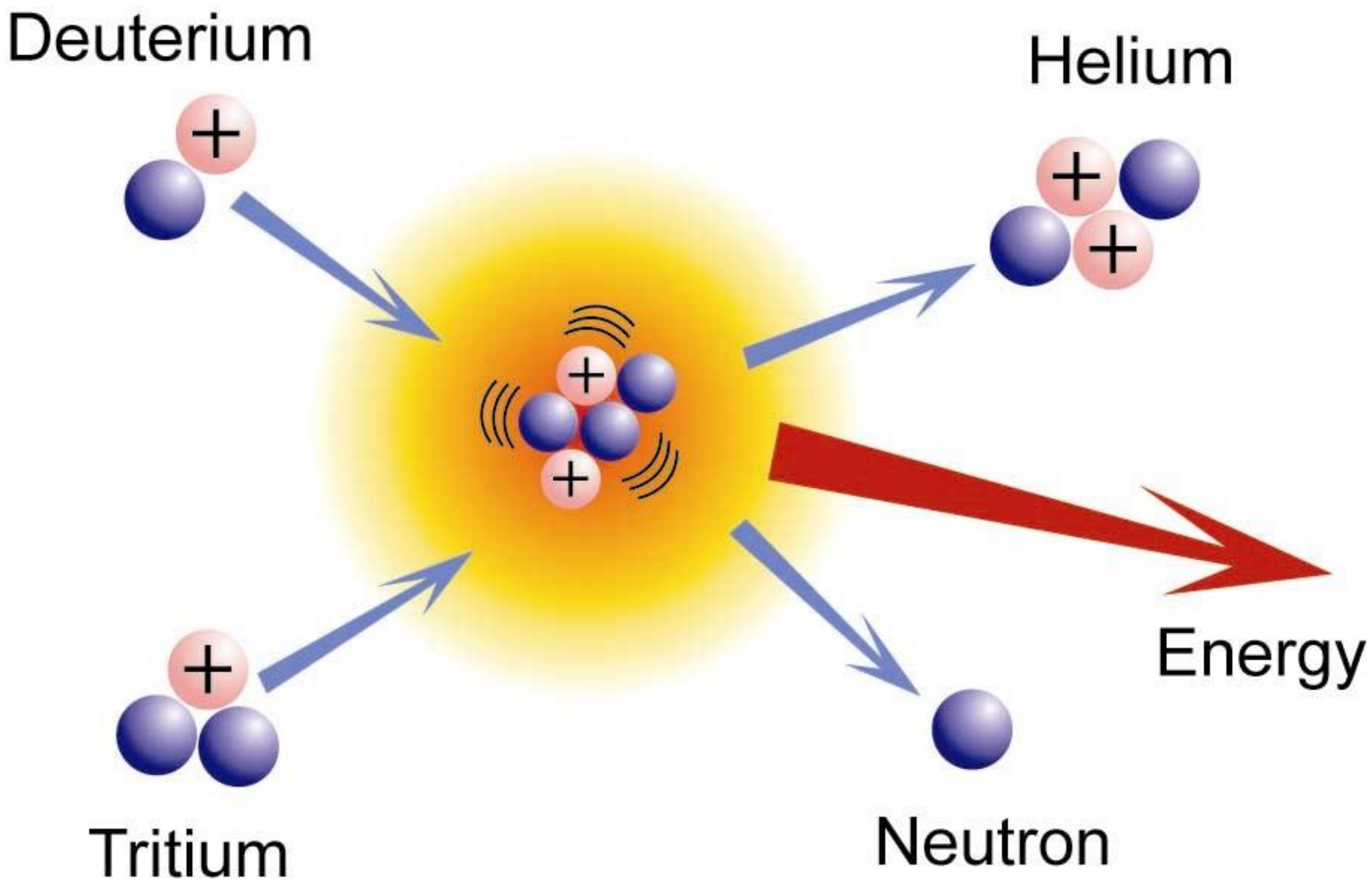


Acceleration of Germany Nuclear Phase-out



Nuclear *Fusion*

Experimental but breakthrough is imminent (since 1954)



"Our children will enjoy in their homes electrical **energy too cheap to meter**...

“famines will be known as matters of history”

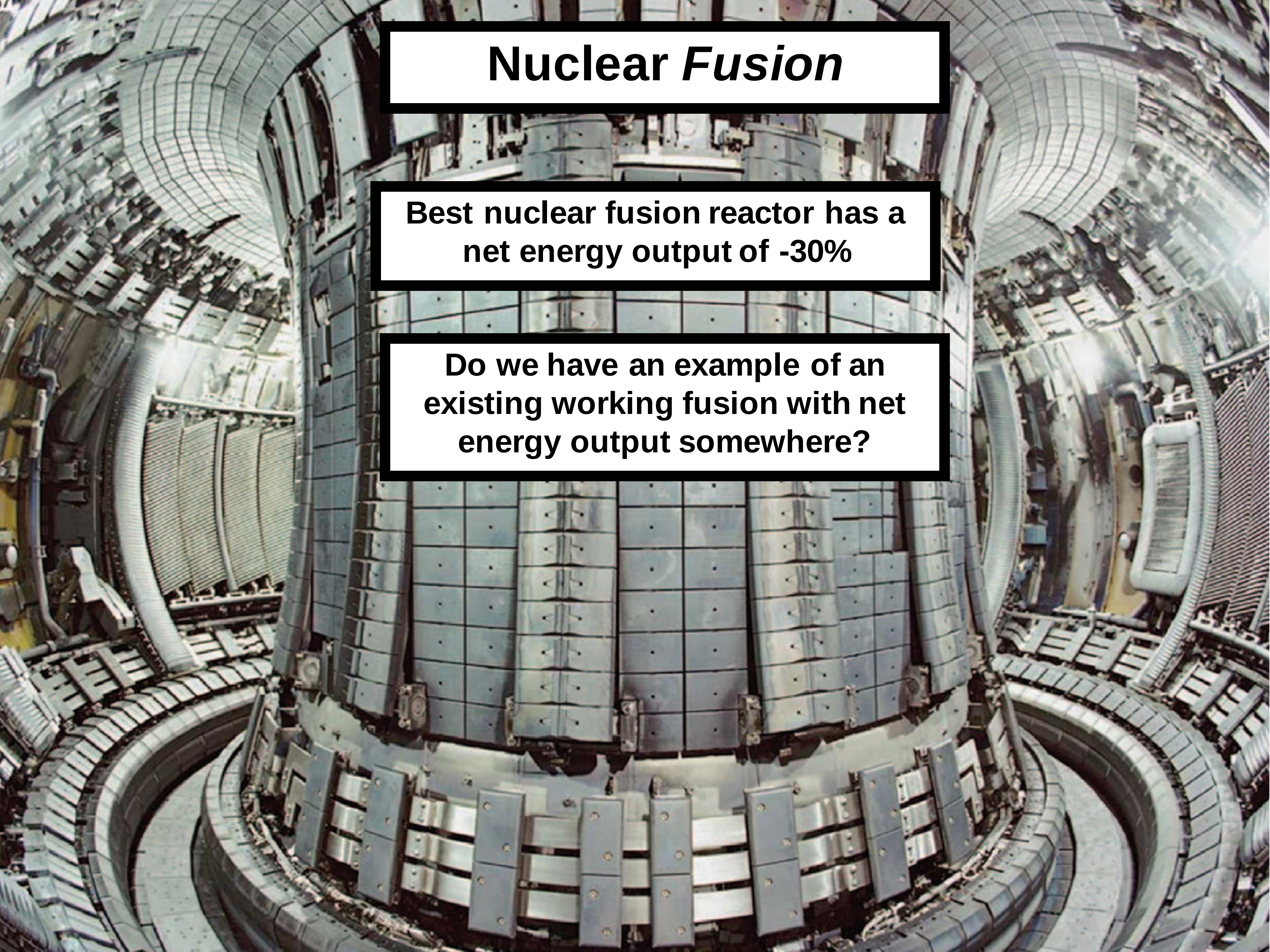
Lewis Strauss, 1954
Chairman of the US Atomic Energy Commission

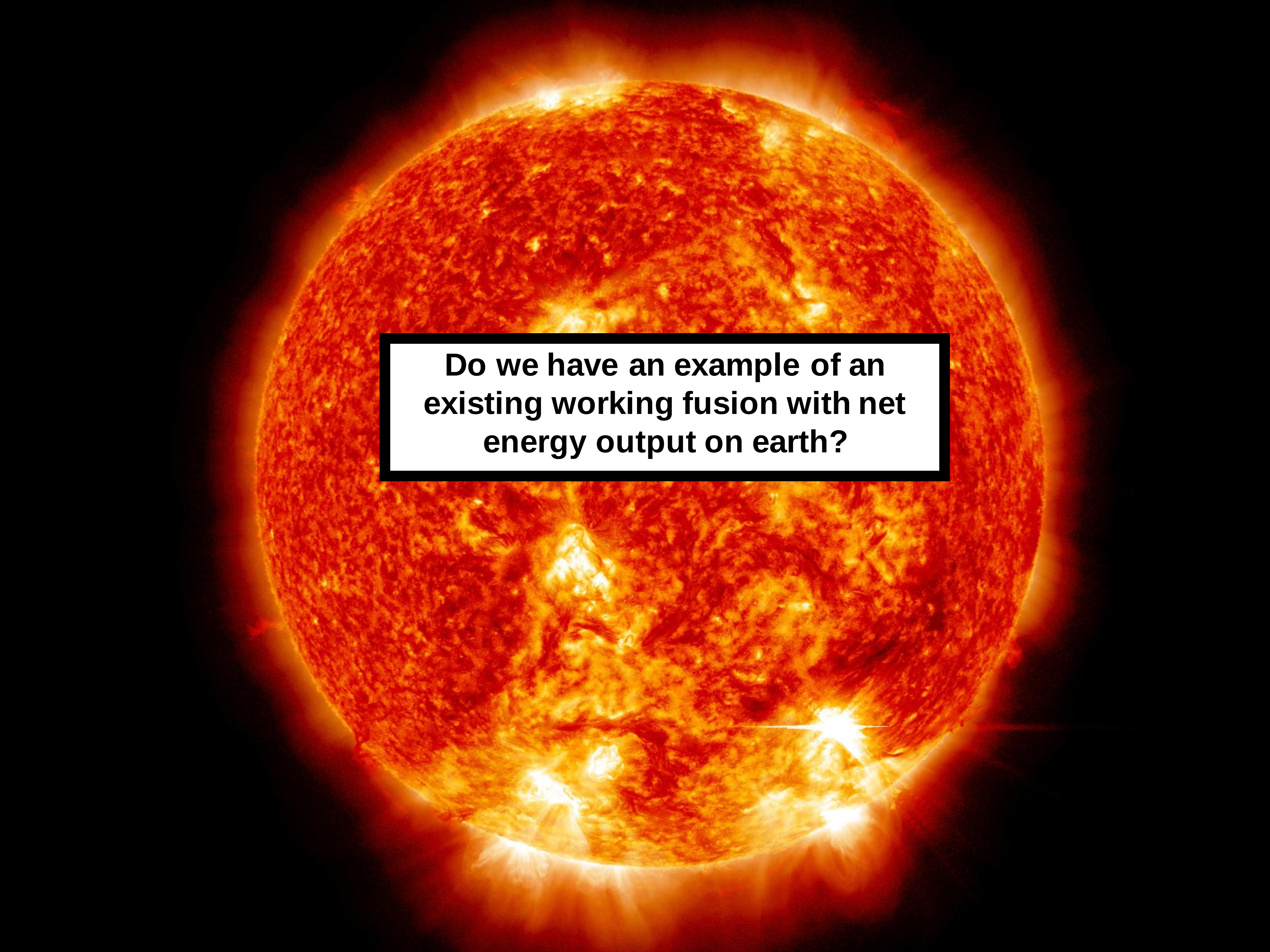
referring to the prospects of nuclear ***fusion*** (not fission).

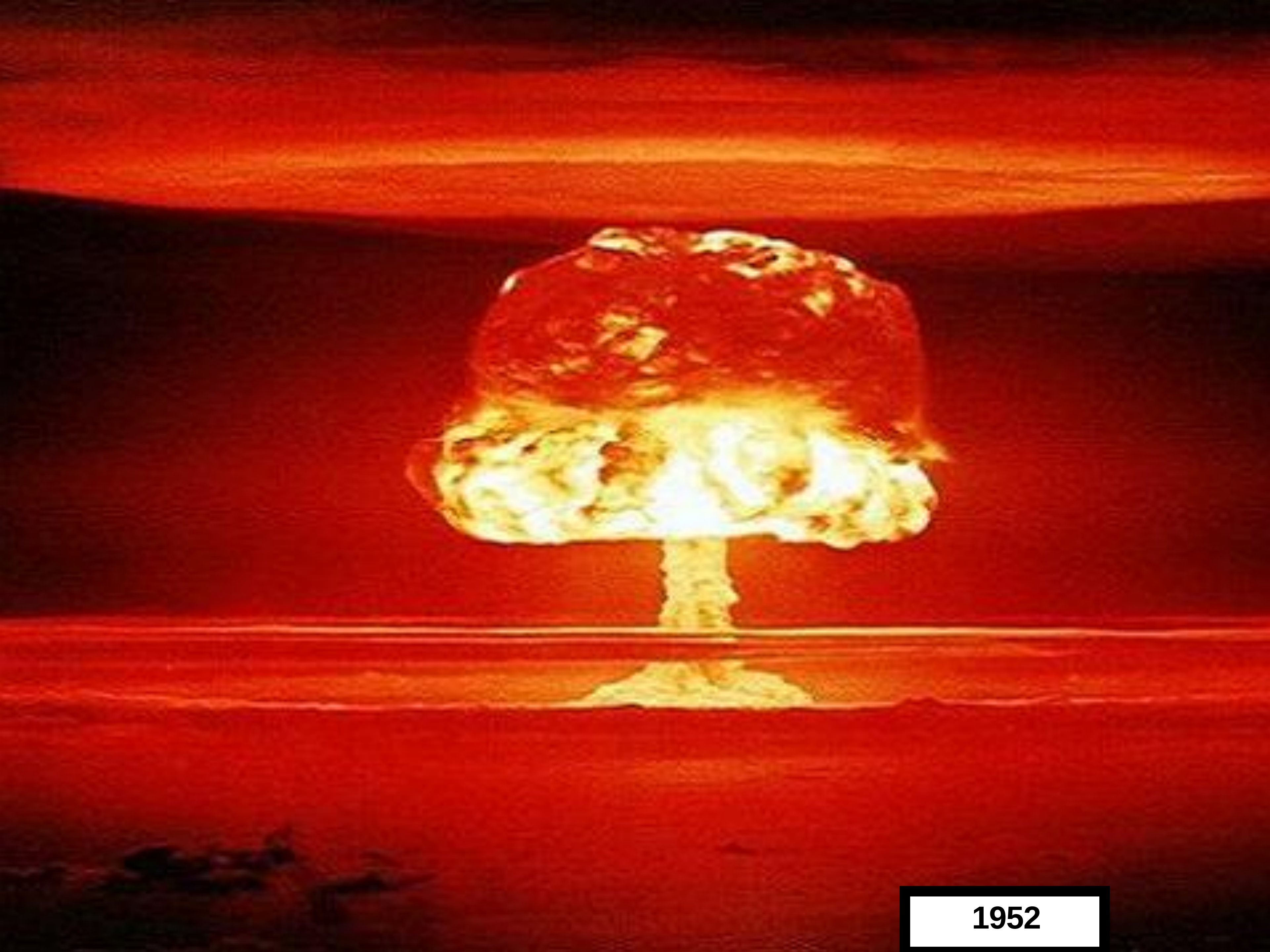
Nuclear *Fusion*

Best nuclear fusion reactor has a net energy output of -30%

Do we have an example of an existing working fusion with net energy output somewhere?

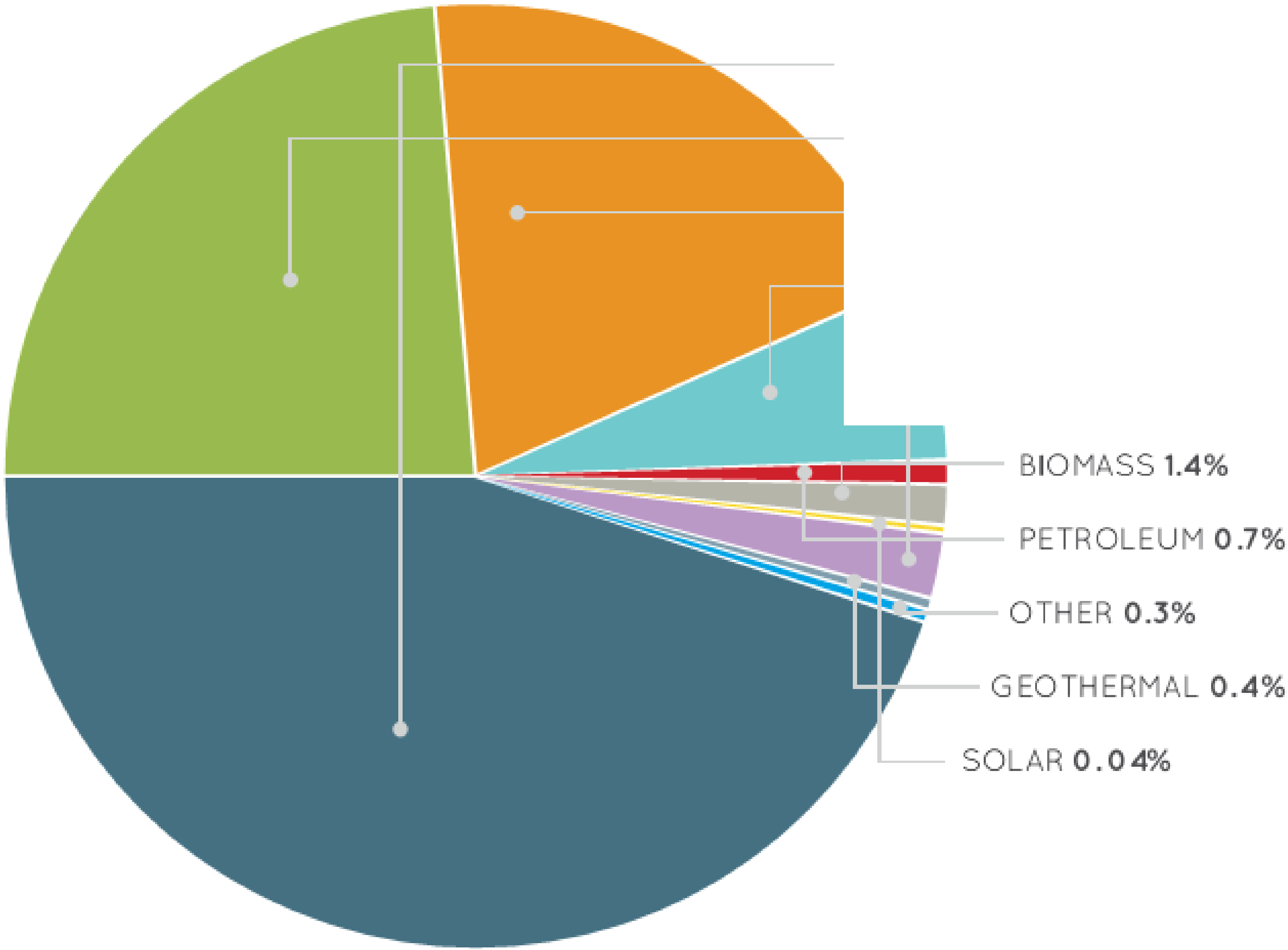



Do we have an example of an existing working fusion with net energy output on earth?


1952

2018.03.14 previous lecture

U.S. ELECTRIC POWER INDUSTRY NET GENERATION 2011




Baseload
Large coal plants

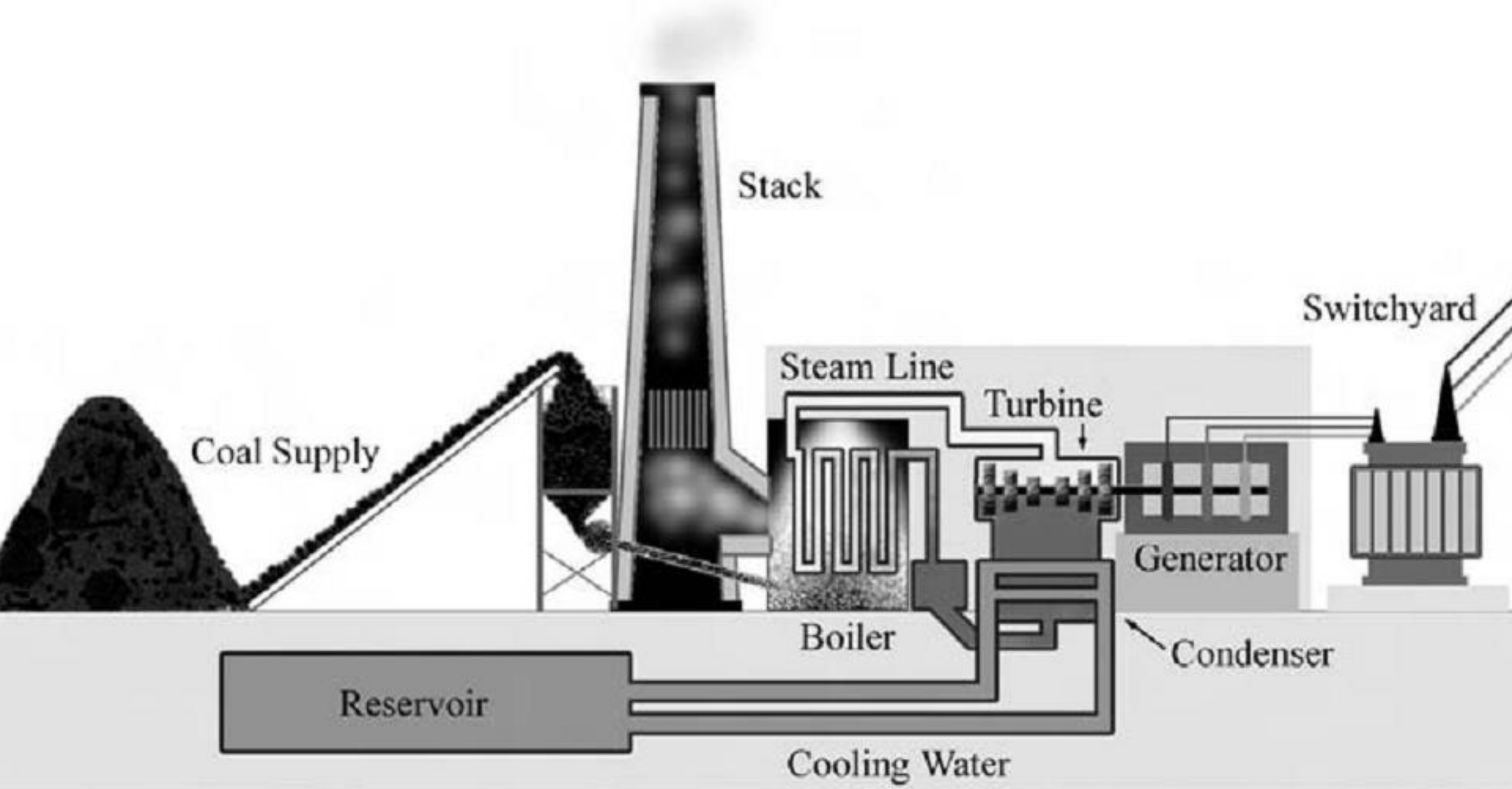
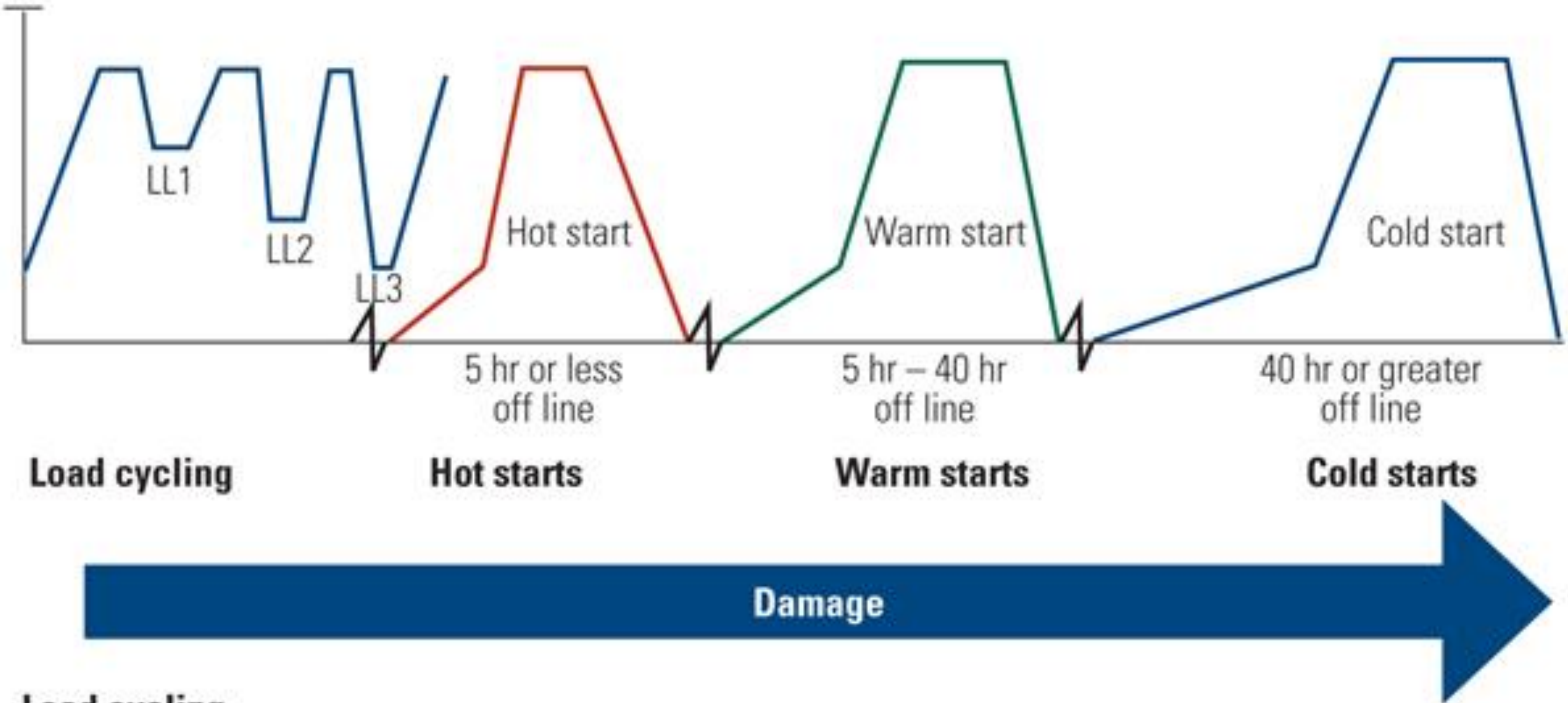


Figure 2-10. Steam power plant.

Turning off can be very costly



Load cycling

LL1–lowest load at which design SH/RH temperatures can be maintained

LL2–current "advertised" low load

LL3–lowest load at which the unit can remain online


Germany to start up more coal-fired power stations than at any time in the past 20 years


New coal-fired power stations
Planned locations, output in megawatts
Black coal
Lignite
1 x 1,600 / 2 x 800
Brunsbüttel
800 to 1,100
Kiel
Wilhelmshaven 800
1,640
Hamburg
2 x 800
Lubmin
800
Emden
900
Dörpen
800/800/1,000 Stade
800
Berlin
750
Duisburg
1,100
Datteln
each 820
Hamm
750 / 900
Lünen
660
Profen
670
Boxberg
750
Krefeld
400 Düsseldorf
2,200
Neurath
1,100
Staudinger (Hanau)
Source: Friends of the Earth Germany (BUND)
2,200
Niederaussem
750
Mainz
900
Mannheim
800
Karlsruhe

Combined heat & power (must-run)

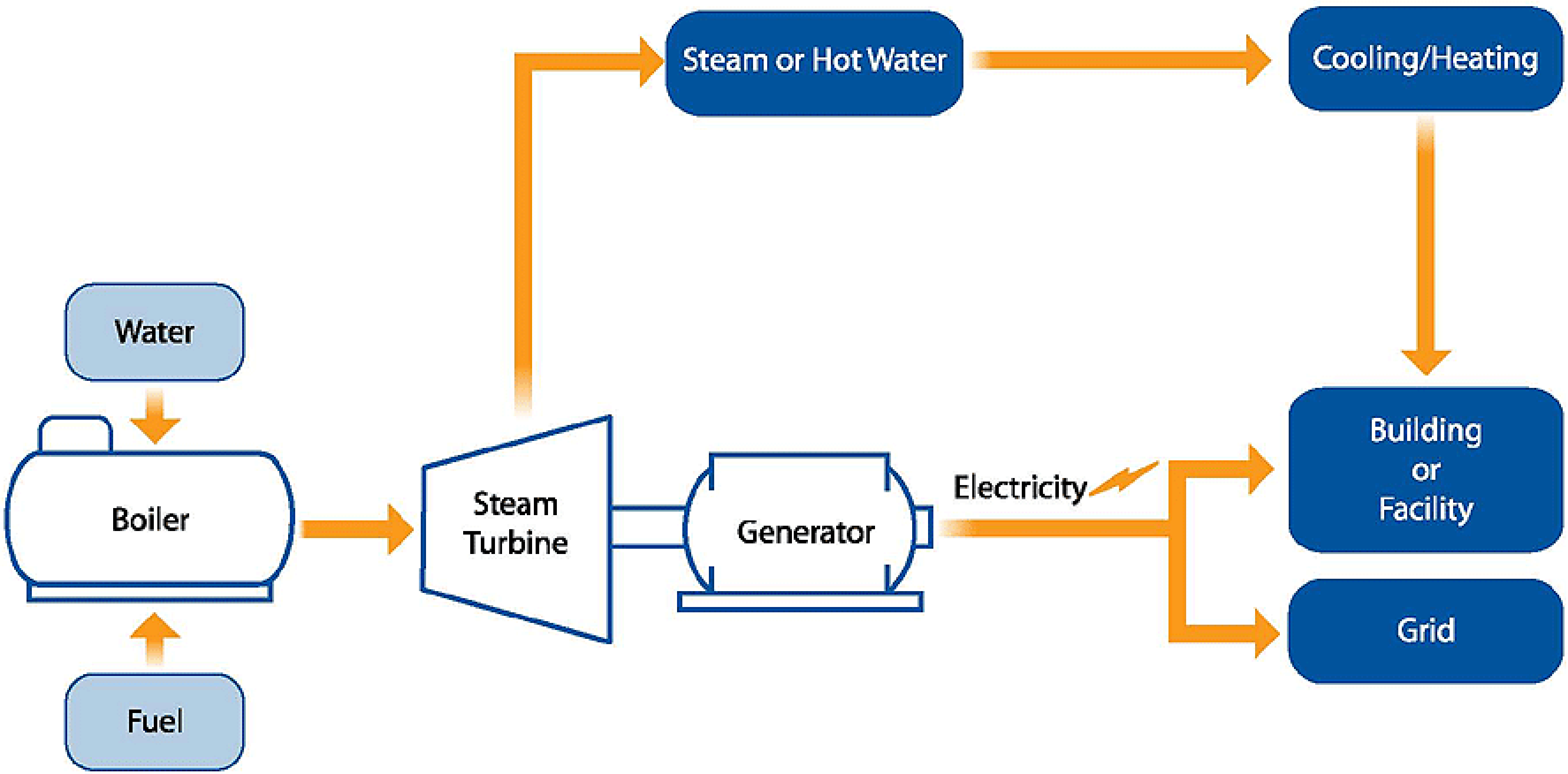
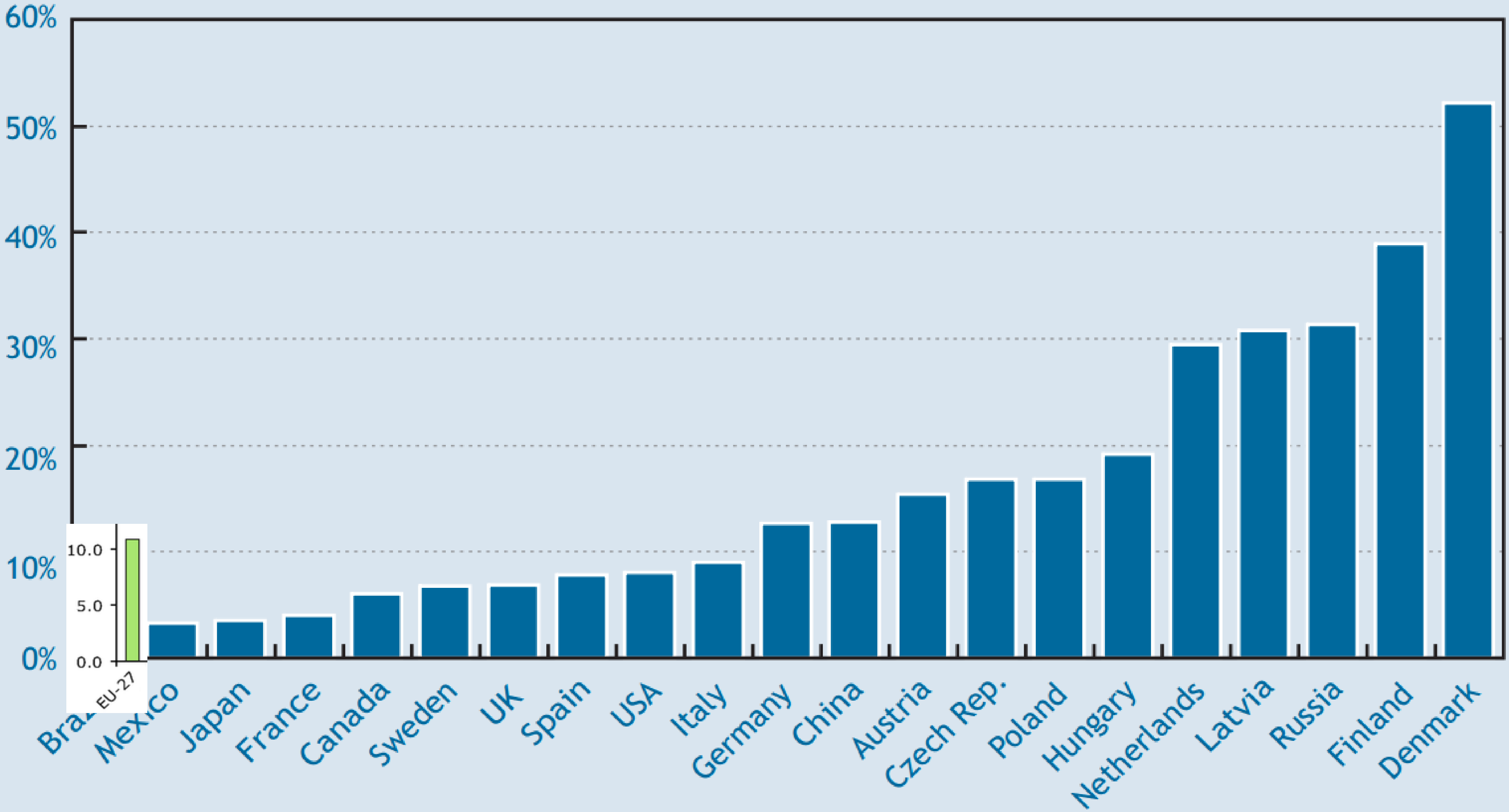
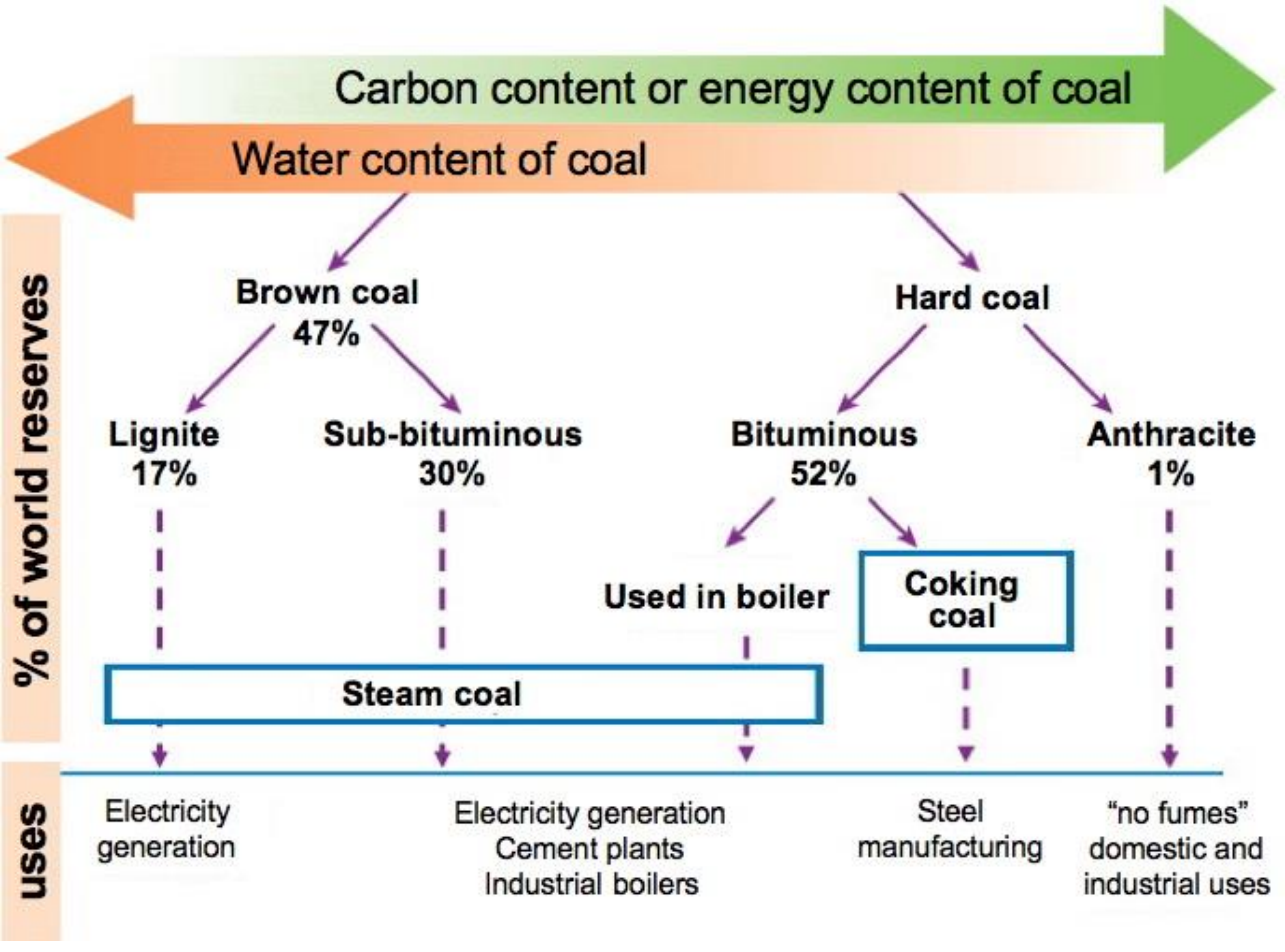


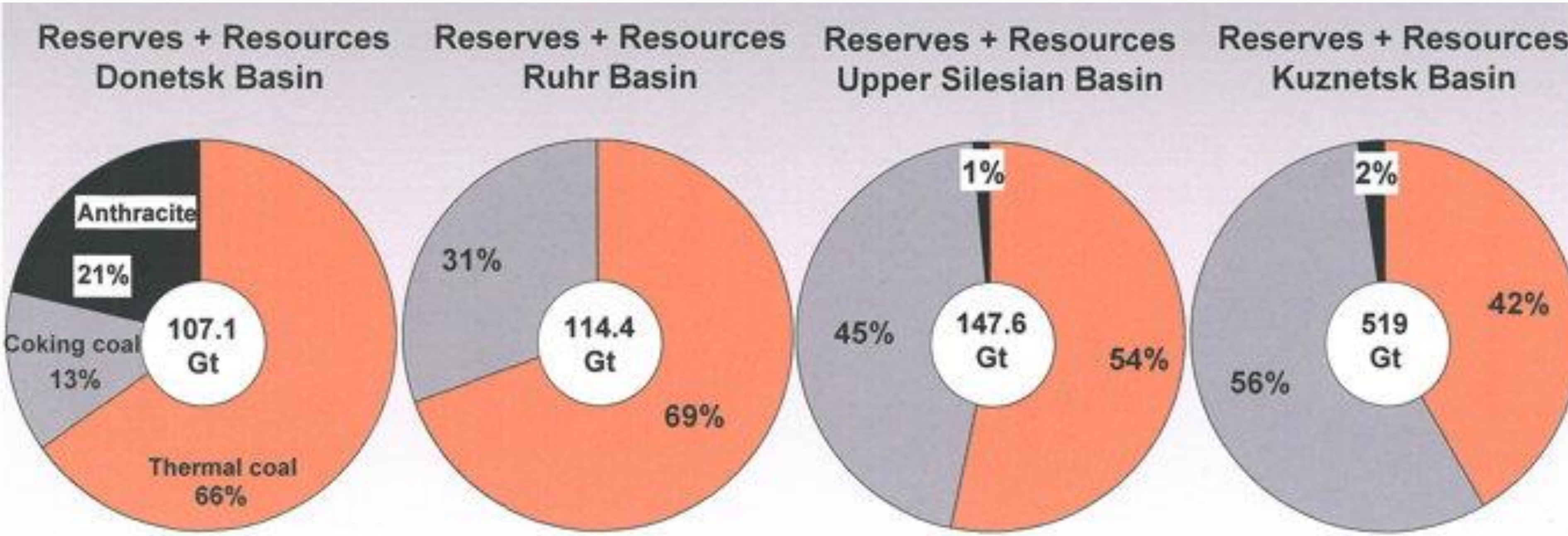
Figure 5 • CHP share of total national power production



- Hard coal
- Brown coal
- Peat

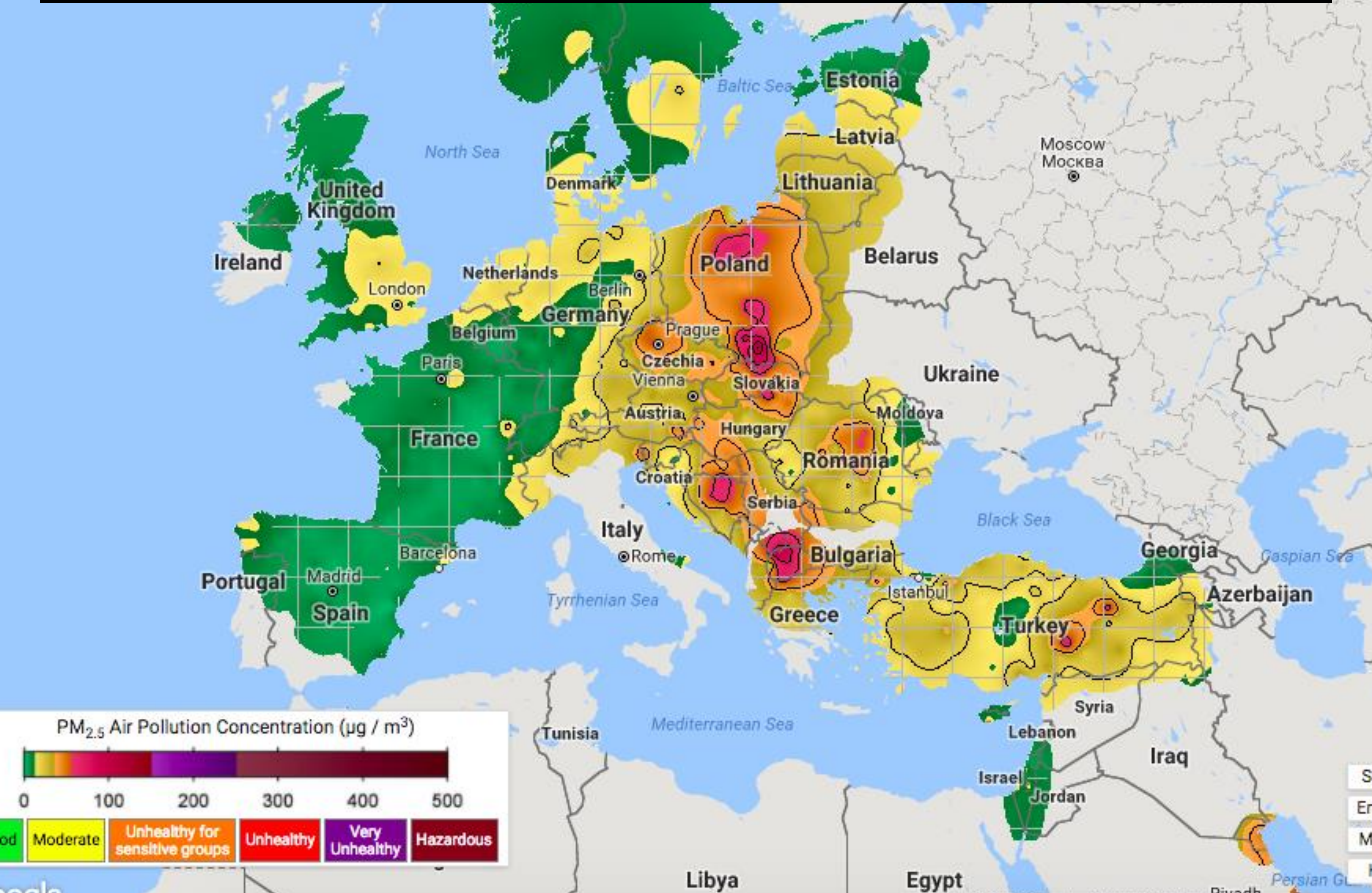

Carbon content or energy content of coal
Water content of coal
% of world reserves
Brown coal
47%
Hard coal
Lignite
17%
Sub-bituminous
30%
Bituminous
52%
Anthracite
1%
Used in boiler
Coking coal
Steam coal
uses
Electricity generation
Electricity generation
Cement plants
Industrial boilers
Steel manufacturing
"no fumes" domestic and industrial uses

- Internationally traded
  - Hard coal
- Not internationally traded:
  - Brown coal
  - Peat


Reserves + Resources
Donetsk Basin
Anthracite
21%
Coking coal
13%
107.1
Gt
Thermal coal
66%
Reserves + Resources
Ruhr Basin
31%
114.4
Gt
69%
Reserves + Resources
Upper Silesian Basin
1%
45%
147.6
Gt
54%
Reserves + Resources
Kuznetsk Basin
2%
42%
519
Gt
56%

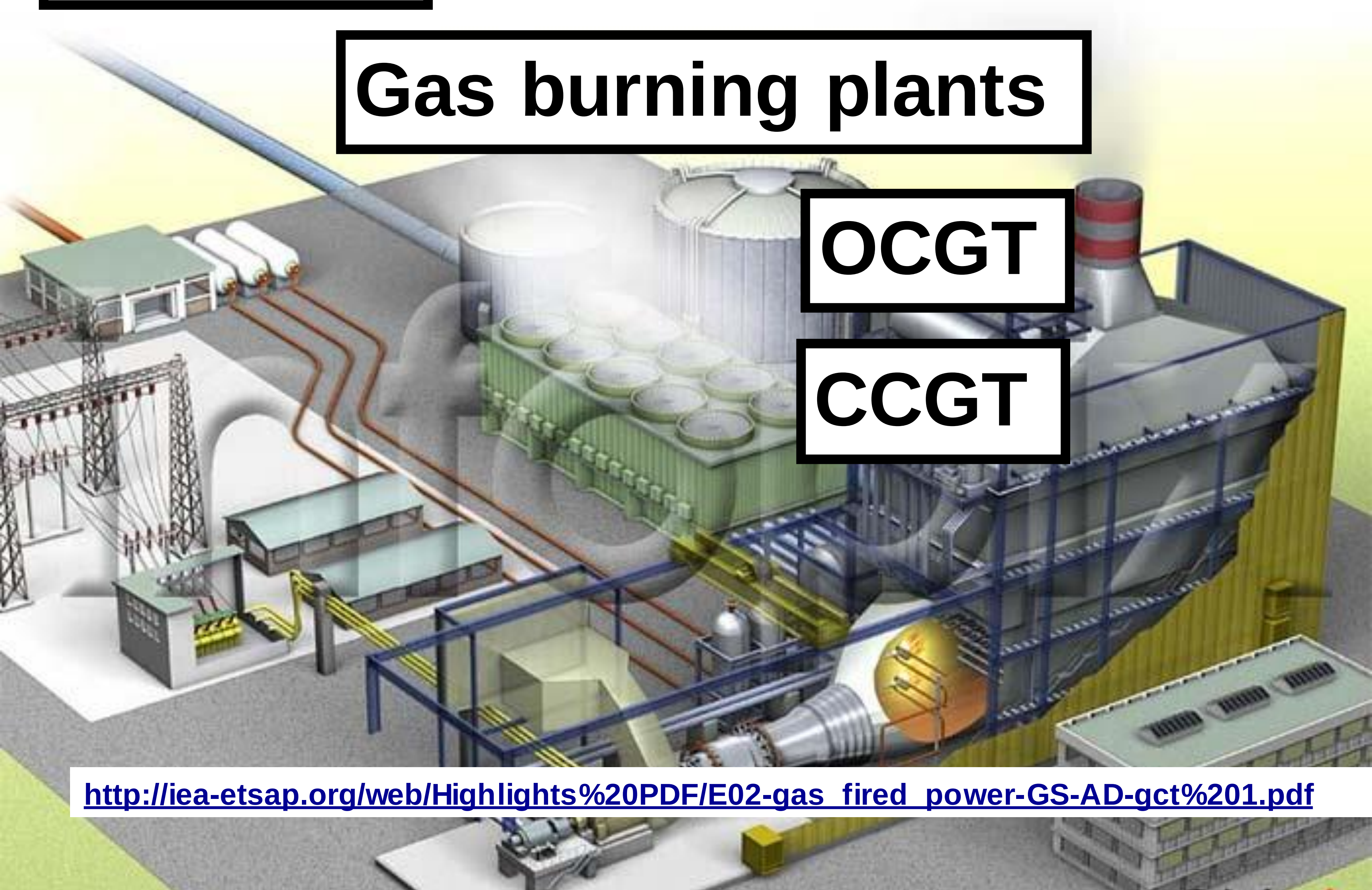
Coal pollutes the air and emits a lot of CO_2

Coal pollutes the air and emits a lot of CO_2



Peaker

Gas burning plants

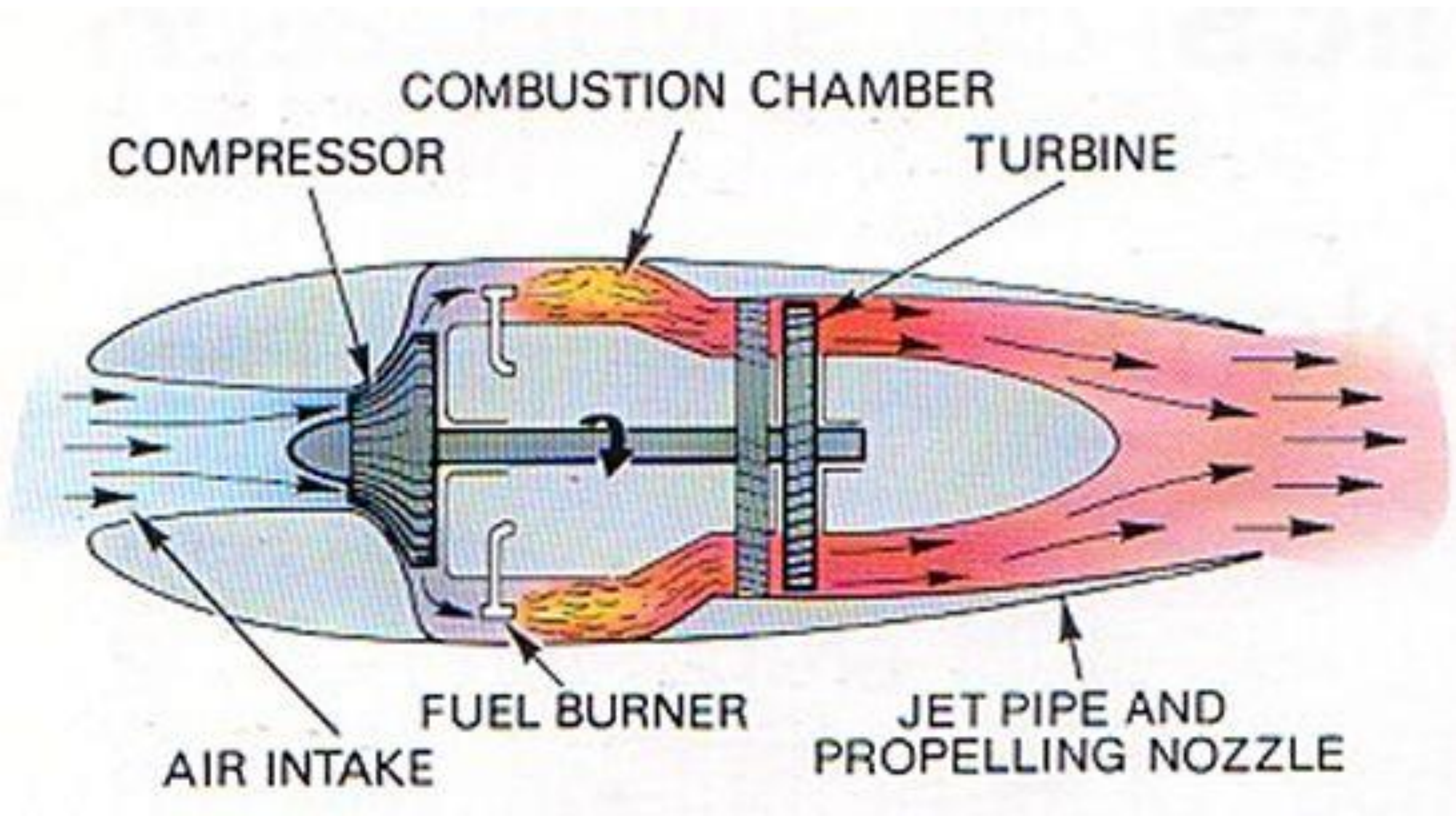


OCGT

CCGT

http://iea-etsap.org/web/Highlights%20PDF/E02-gas_fired_power-GS-AD-gct%201.pdf

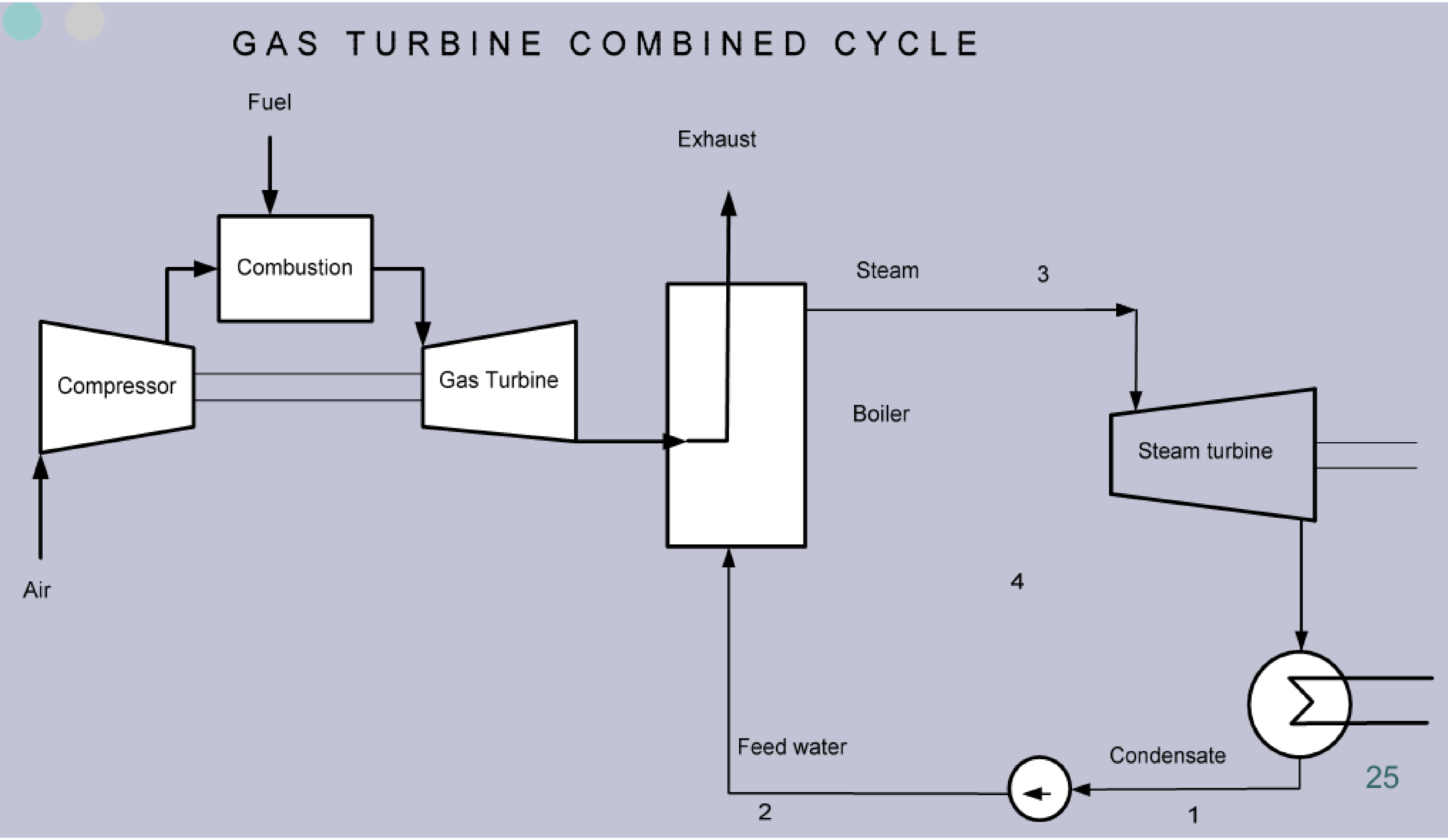
OCGT

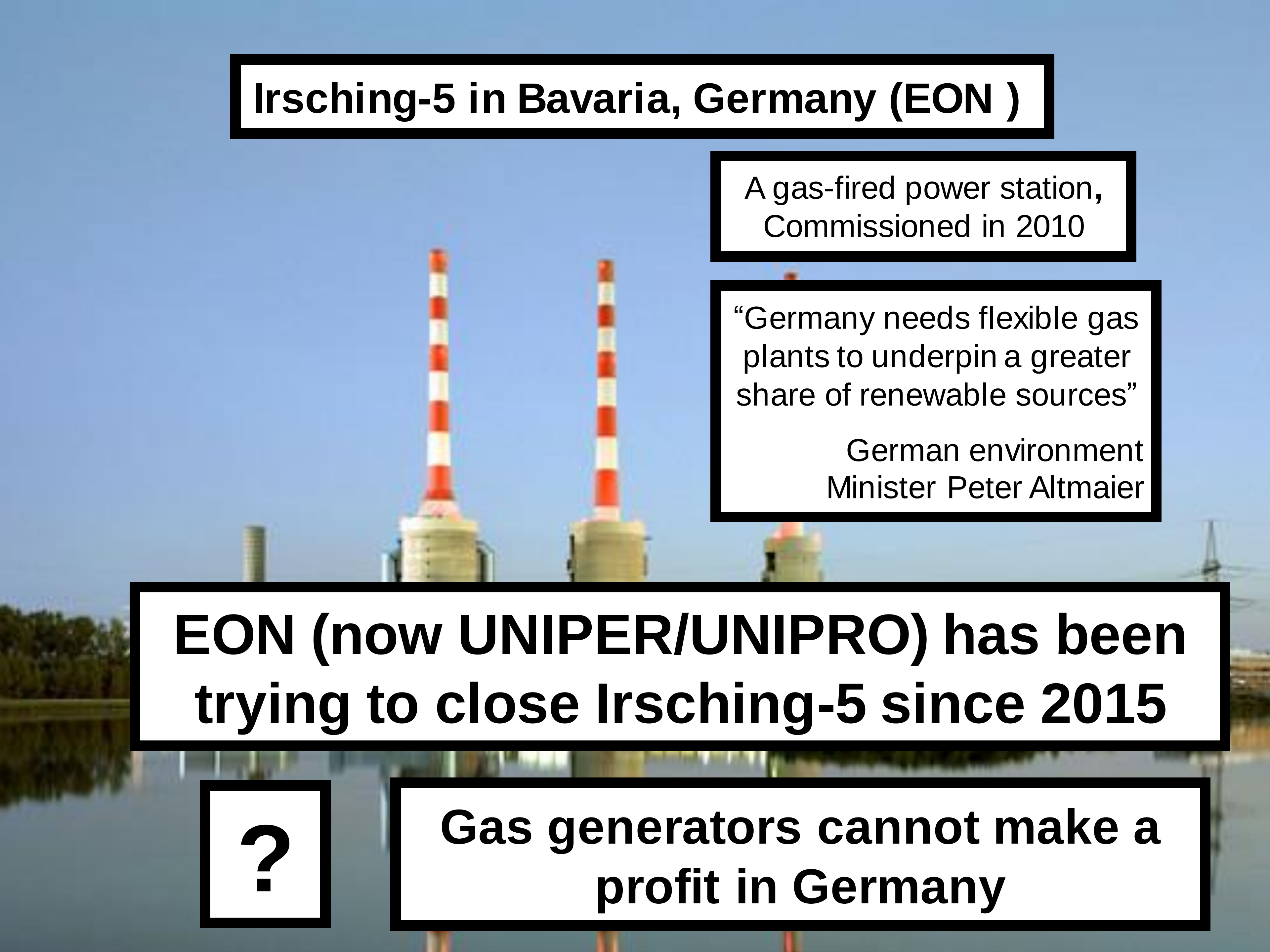

COMBUSTION CHAMBER
COMPRESSOR
TURBINE
FUEL BURNER
JET PIPE AND
PROPELLING NOZZLE
AIR INTAKE

VID

Wednesday 2_ Gas Turbine Basics (hq).mp4

CCGT


GAS TURBINE COMBINED CYCLE
Fuel
Exhaust
Combustion
Steam
3
Compressor
Gas Turbine
Boiler
Steam turbine
Air
4
Feed water
Condensate
2
1

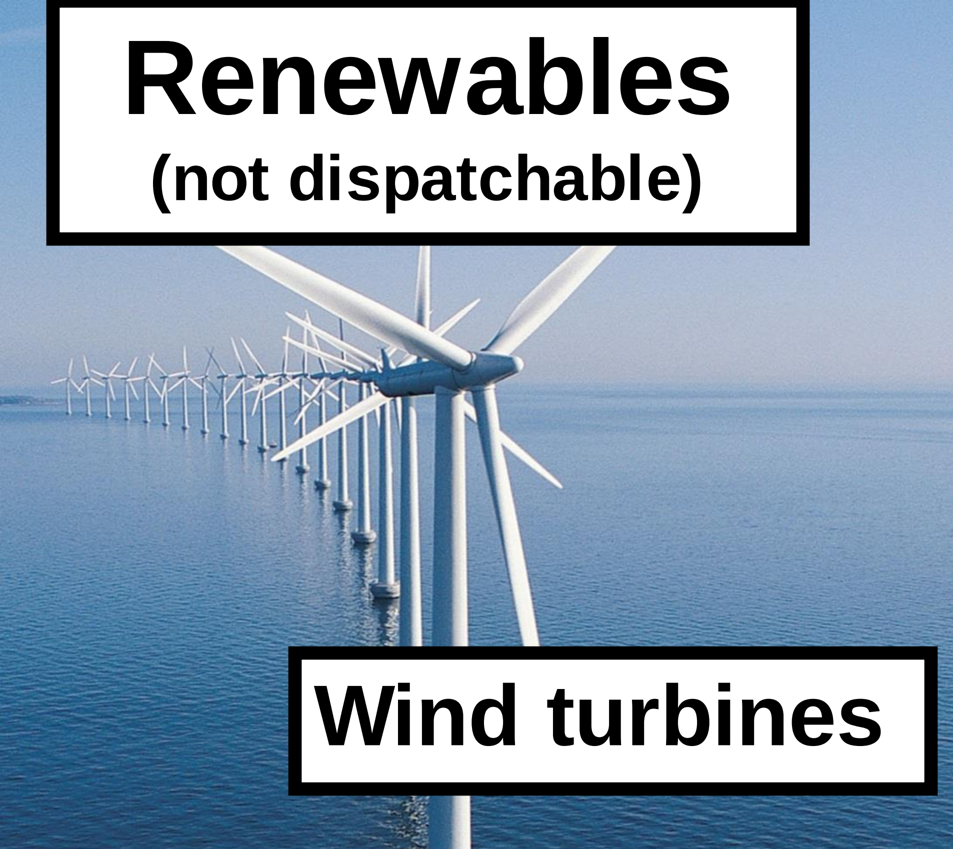


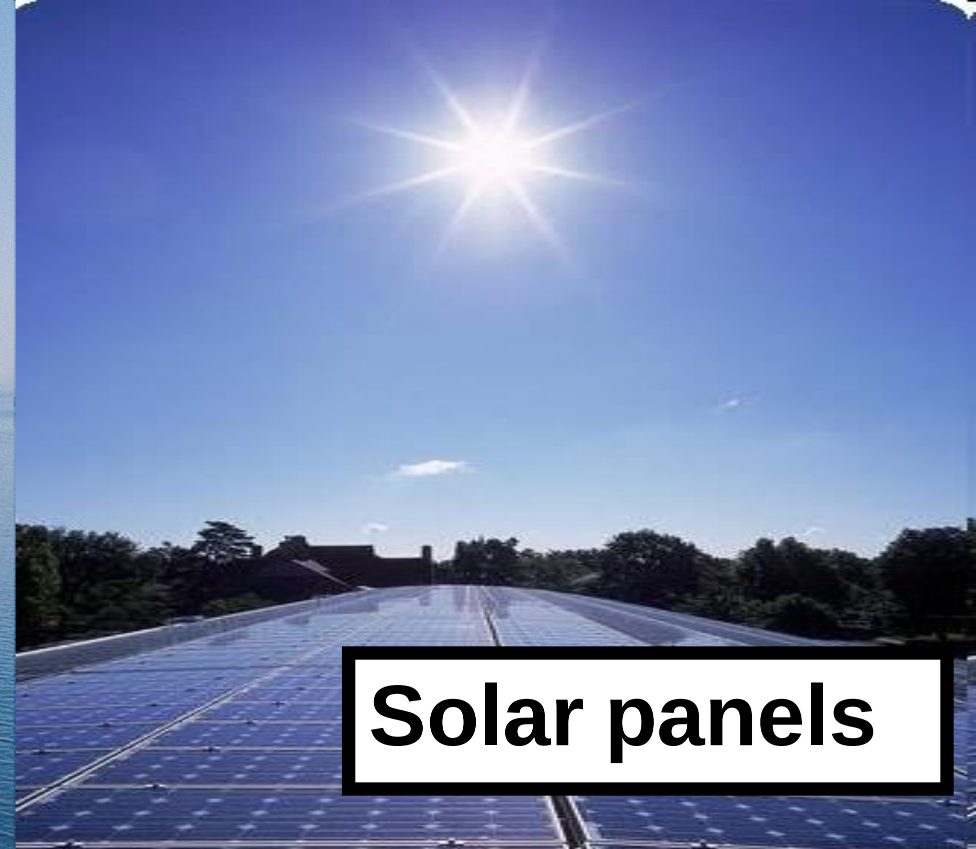
Irsching-5 in Bavaria, Germany (EON)
A gas-fired power station, Commissioned in 2010
"Germany needs flexible gas plants to underpin a greater share of renewable sources"
German environment Minister Peter Altmaier
EON (now UNIPER/UNIPRO) has been trying to close Irsching-5 since 2015
?
Gas generators cannot make a profit in Germany

Malženice 430 MW CCGT, Slovakia
Commissioned in January 2011

On July 15, 2013 EON (UNIPER) announced to mothball its CCGT in Malženice effective October 2013


Peaker
Oil burning plants

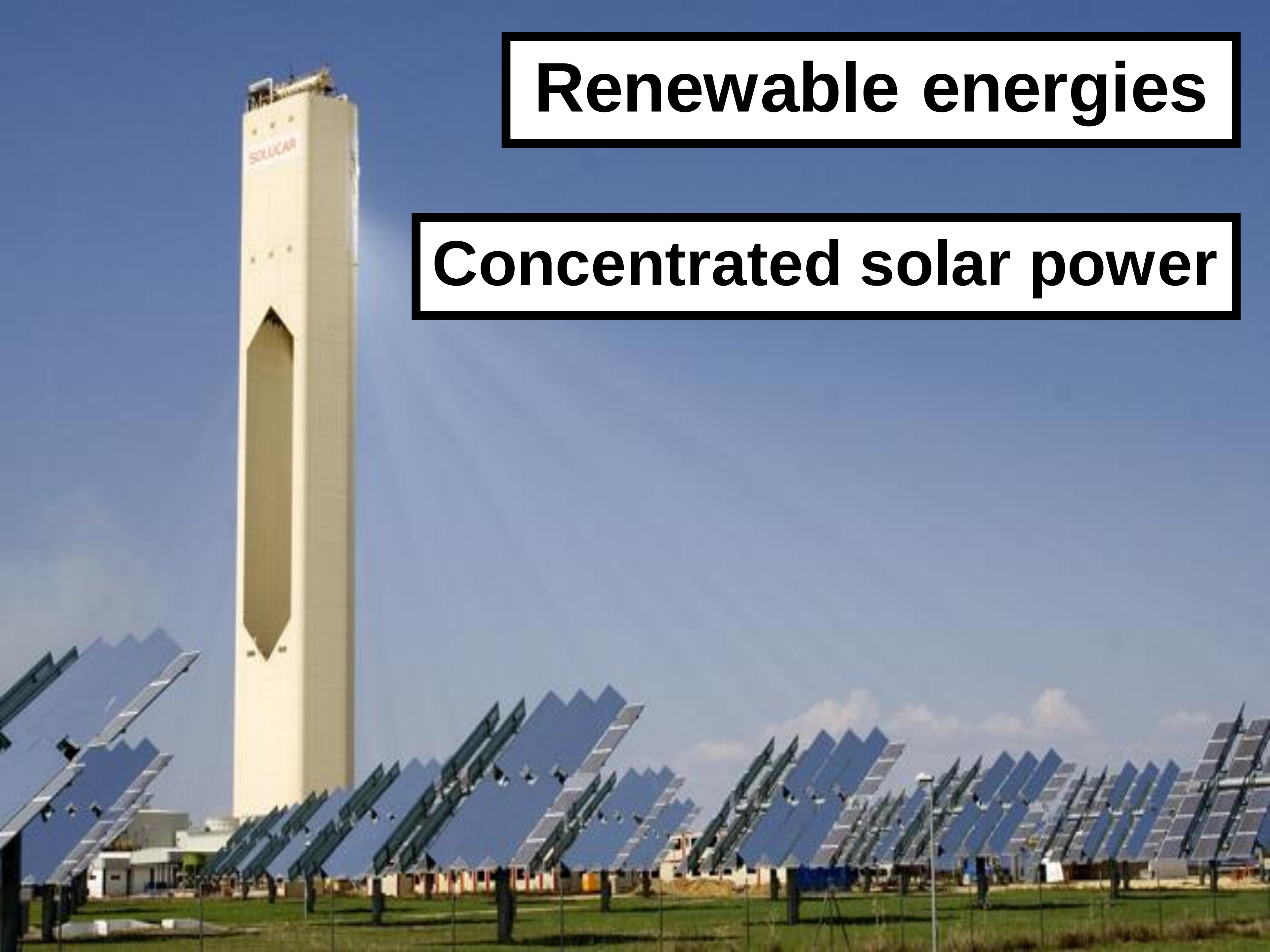

Renewables
(not dispatchable)
Wind turbines

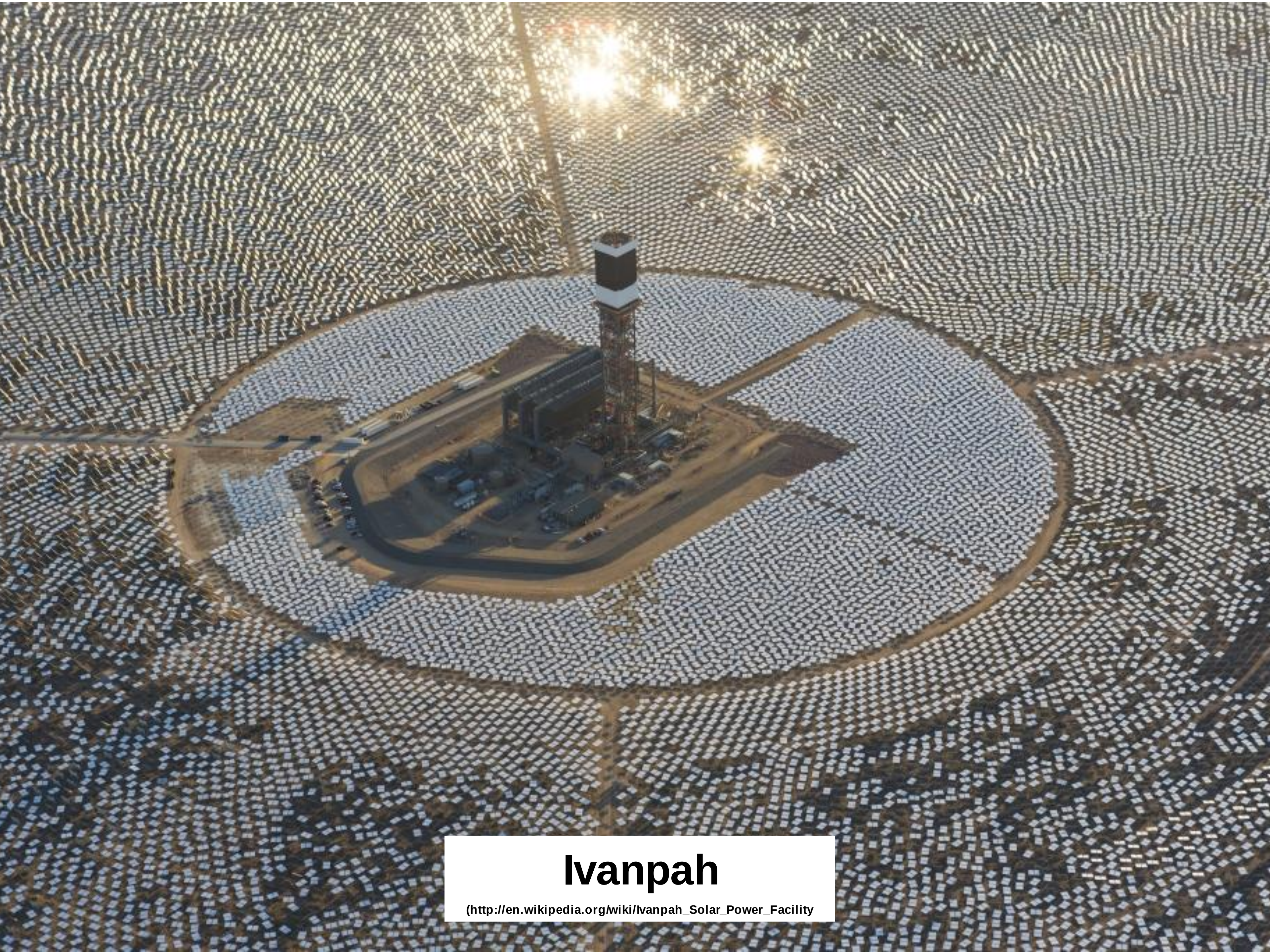

Solar panels


Renewables
(dispatchable)
Biomass

Renewable energies

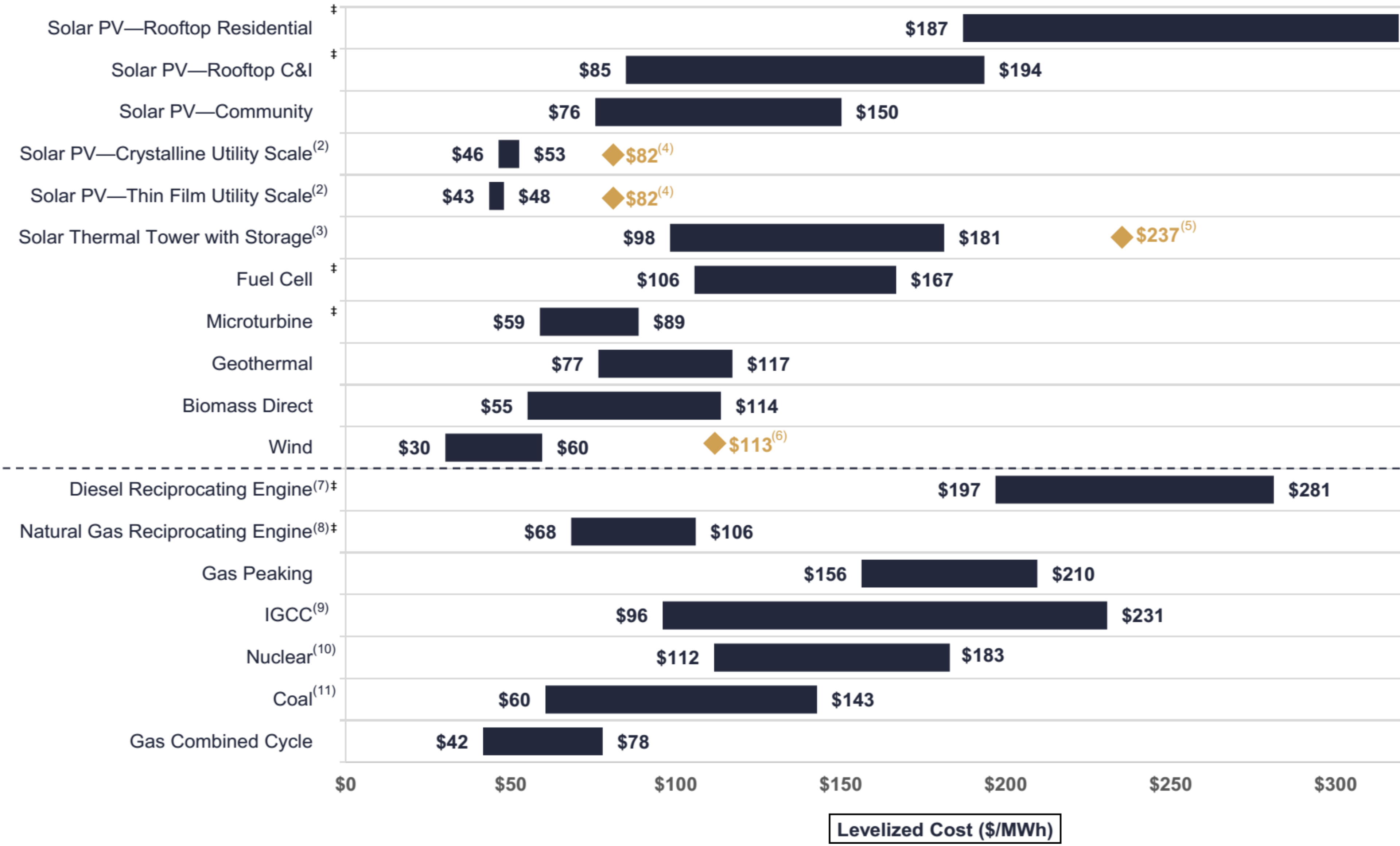
Concentrated solar power





Ivanpah

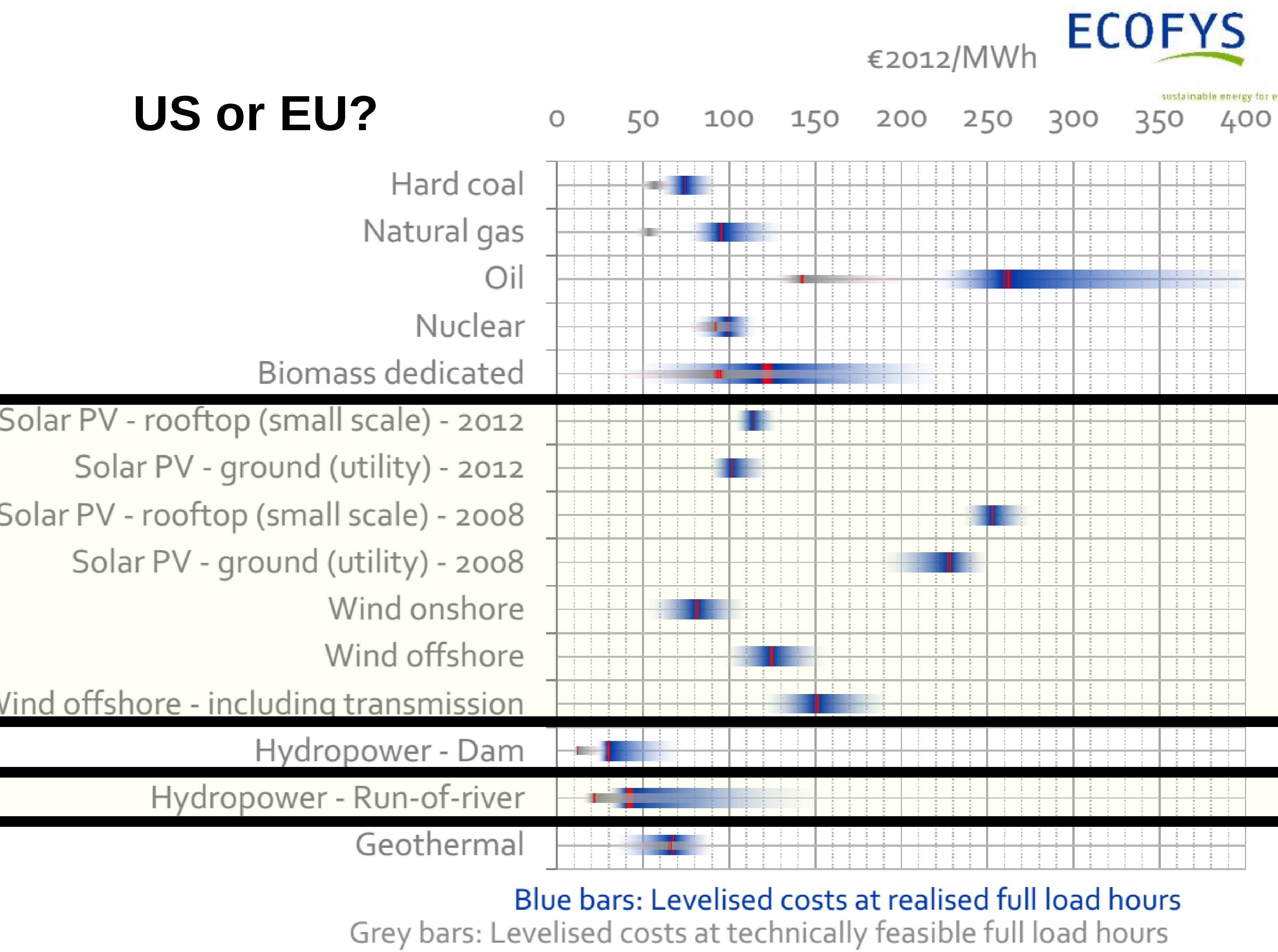
(http://en.wikipedia.org/wiki/Ivanpah_Solar_Power_Facility



US or EU?

https://www.lazard.com/perspective/levelized-cost-of-energy-2017/

US or EU?



ECOFYS
sustainable energy for e
€2012/MWh
0
50
100
150
200
250
300
350
400
Hard coal
Natural gas
Oil
Nuclear
Biomass dedicated
Solar PV - rooftop (small scale) - 2012
Solar PV - ground (utility) - 2012
Solar PV - rooftop (small scale) - 2008
Solar PV - ground (utility) - 2008
Wind onshore
Wind offshore
Vind offshore - including transmission
Hydropower - Dam
Hydropower - Run-of-river
Geothermal
Blue bars: Levelised costs at realised full load hours
Grey bars: Levelised costs at technically feasible full load hours

(1) Analysis excludes integration (e.g., grid and conventional generation investment to overcome system intermittency) costs for intermittent technologies.

(2) Low end represents single-axis tracking system. High end represents fixed-tilt design. Assumes 30 MW system in a high insolation jurisdiction (e.g., Southwest U.S.). Does not account for differences in heat coefficients within technologies, balance-of-system costs or other potential factors which may differ across select solar technologies or more specific geographies.

(3) Low and high end represent a concentrating solar tower with 10-hour storage capability. Low end represents an illustrative concentrating solar tower built in South Australia.

(4) Illustrative "PV Plus Storage" unit. PV and battery system (and related bi-directional inverter, power control electronics, etc.) sized to compare with solar thermal with 10-hour storage on capacity factor basis (52%). Assumes storage nameplate "usable energy" capacity of ~400 MWhdc, storage power rating of 110 MWac and ~200 MWac PV system. Implied output degradation of ~0.40%/year (assumes PV degradation of 0.5%/year and battery energy degradation of 1.5%/year, which includes calendar and cycling degradation). Battery round trip DC efficiency of 90% (including auxiliary losses). Storage opex of ~$8/kWh-year and PV O&M expense of ~$9.2/kW DC-year, with 20% discount applied to total opex as a result of synergies (e.g., fewer truck rolls, single team, etc.). Total capital costs of ~$3,456/kW include PV plus battery energy storage system and selected other development c osts. Assumes 20-year useful life, although in practice the unit may perform longer. Illustrative system located in Southwest U.S.

(5) Diamond represents an illustrative solar thermal facility without storage capability.

(6) Represents estimated implied midpoint of levelized cost of energy for offshore wind, assuming a capital cost range of $2.36 – $4.50 per watt.

(7) Represents distributed diesel generator with reciprocating engine. Low end represents 95% capacity factor (i.e., baseload generation in poor grid quality geographies or remote locations). High end represents 10% capacity factor (i.e., to overcome periodic blackouts). Assumes replacement capital cost of 65% of initial total capital cost every 25,000 operating hours.

(8) Represents distributed natural gas generator with reciprocating engine. Low end represents 95% capacity factor (i.e., baseload generation in poor grid quality geographies or remote locations). High end represents 30% capacity factor (i.e., to overcome periodic blackouts). Assumes replacement capital cost of 65% of initial total capital cost every 60,000 operating hours.

(9) Does not include cost of transportation and storage. Low and high end depicts an illustrative recent IGCC facility located in the U.S.

(10) Does not reflect decommissioning costs or potential economic impact of federal loan guarantees or other subsidies. Low and high end depicts an illustrative nuclear plant using the AP1000 design.

(11) Reflects average of Northern Appalachian Upper Ohio River Barge and Pittsburgh Seam Rail coal. High end incorporates 90% carbon capture and compression. Does not include cost of transportation and storage.

.greentechmedia.com/articles/read/germany-briefly-hit-new-record-for-renewable-energy-generation

Pwn PwnYouTube conv buk8 MZDA vse Dict EZp slow Py

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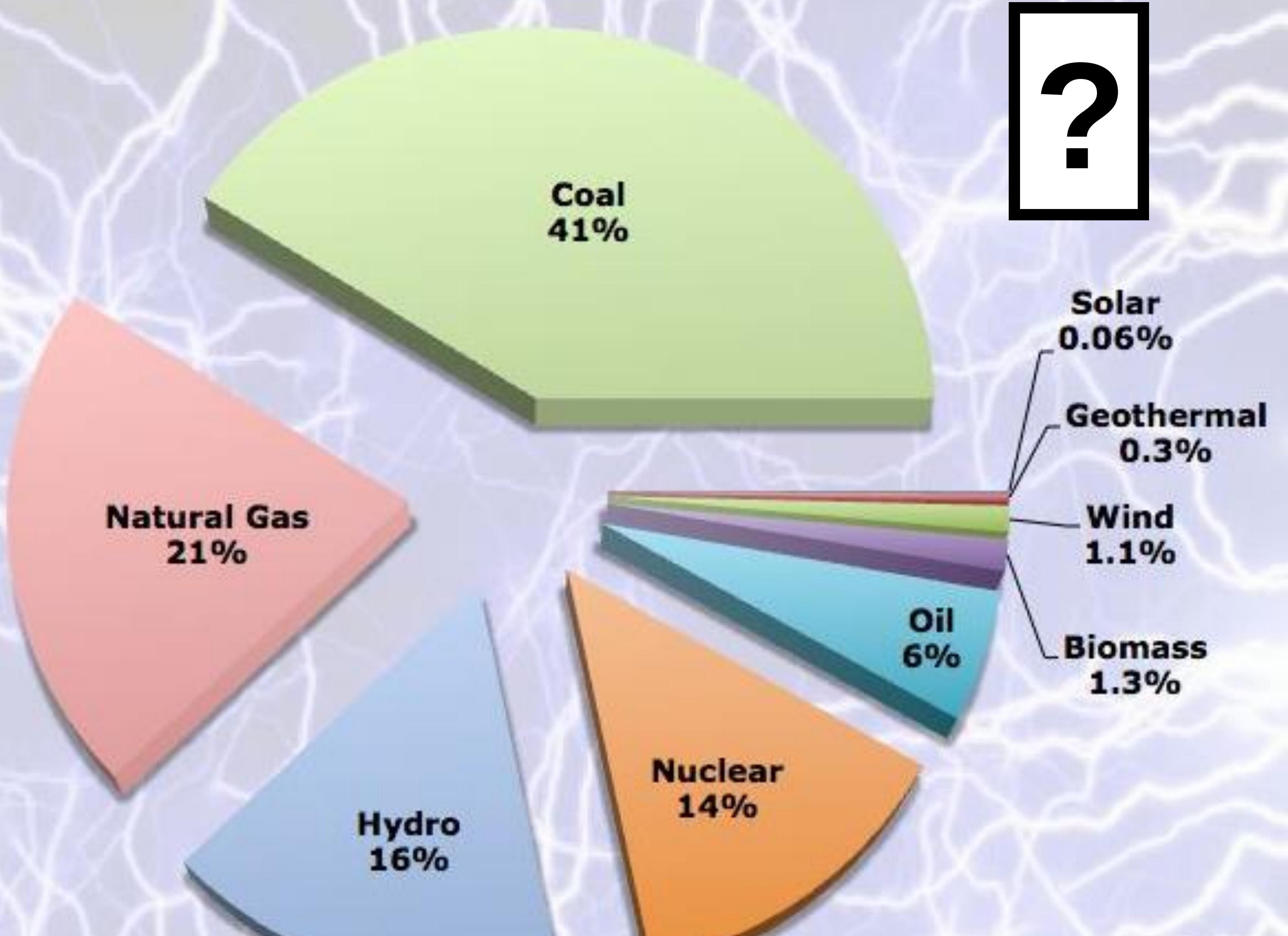
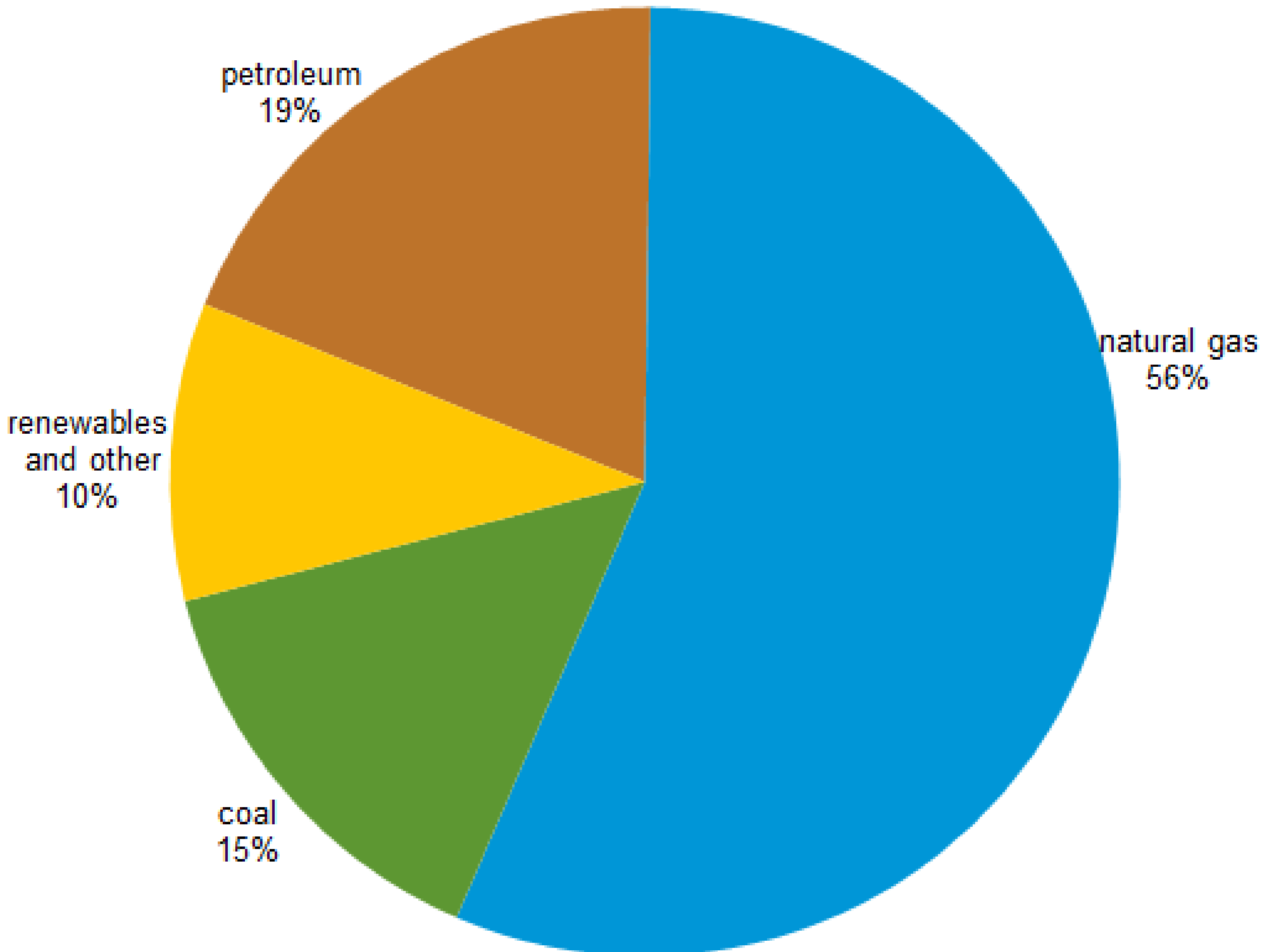
Where the world gets its energy

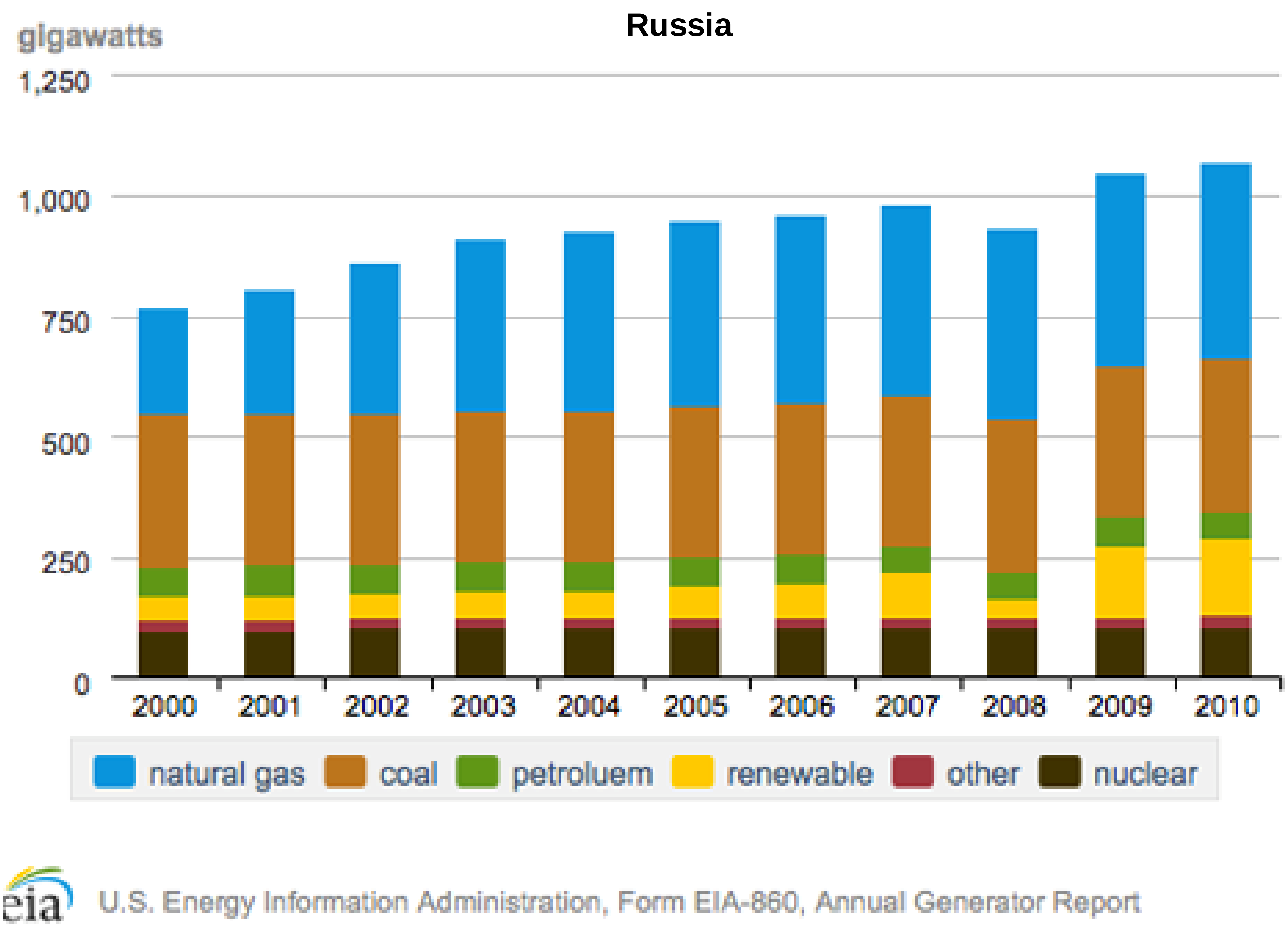
Where the World Gets Its Electricity



Russia's primary energy consumption, 2011



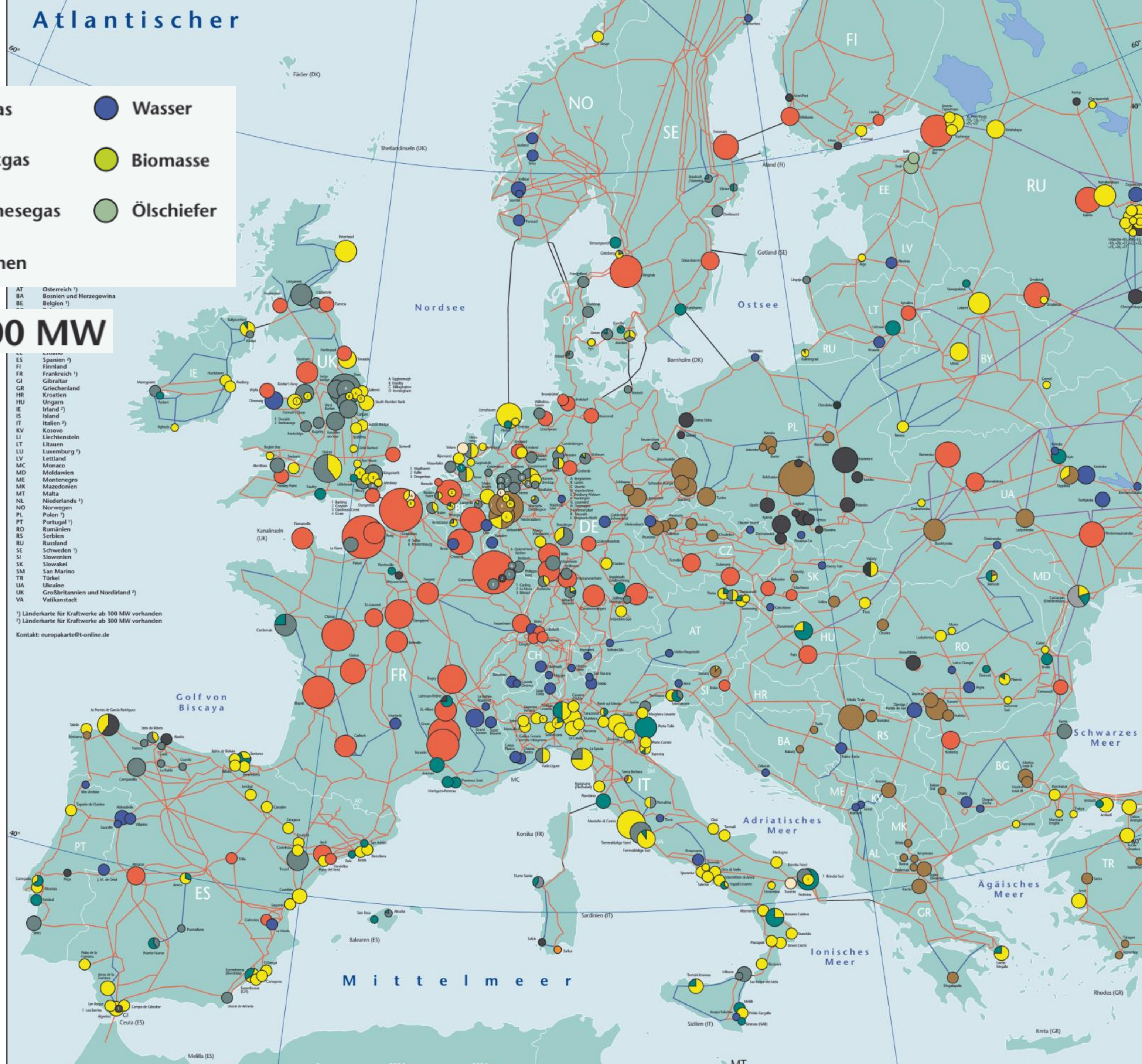
Source: U.S. Energy Information Administration, International Energy Statistics Database


Russia
gigawatts
1,250
1,000
750
500
250
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
natural gas
coal
petroluem
renewable
other
nuclear
U.S. Energy Information Administration, Form EIA-860, Annual Generator Report

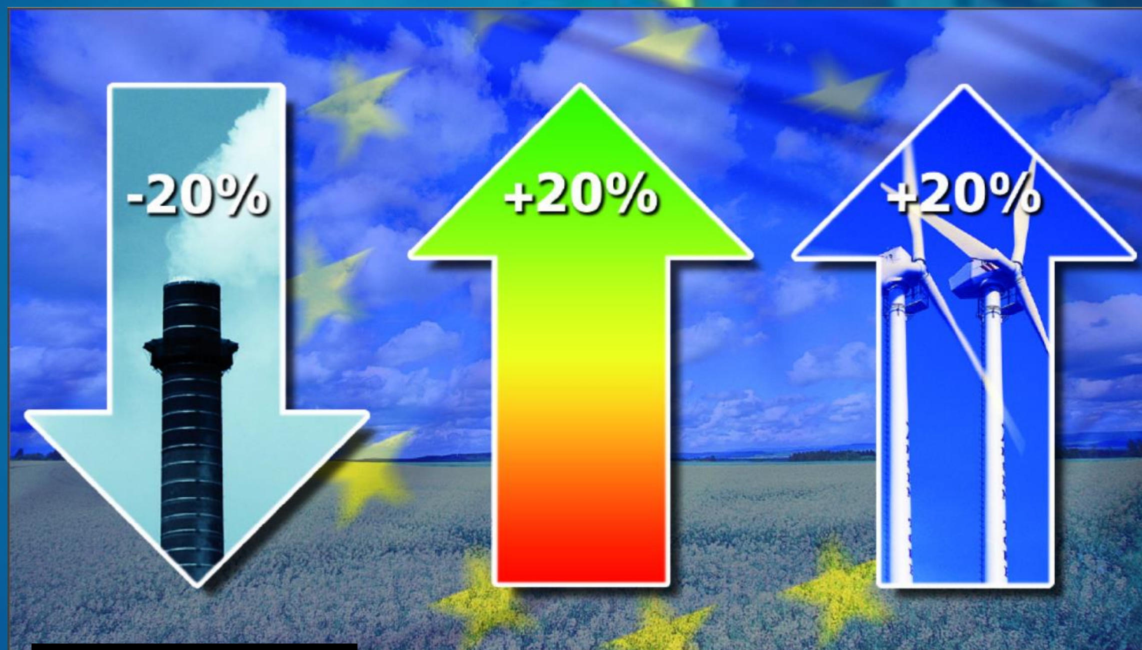
Kraftwerke ≥ 500 MW

Stand: April 2009

- Steinkohle
- Braunkohle
- Heizöl
- Kernenergie
- Erdgas
- Gichtgas
- Synthesegas
- Bitumen
- Wasser
- Biomasse
- Ölschiefer



EU's 20-20-20 strategy for 2020



Carbon emissions

Renewables

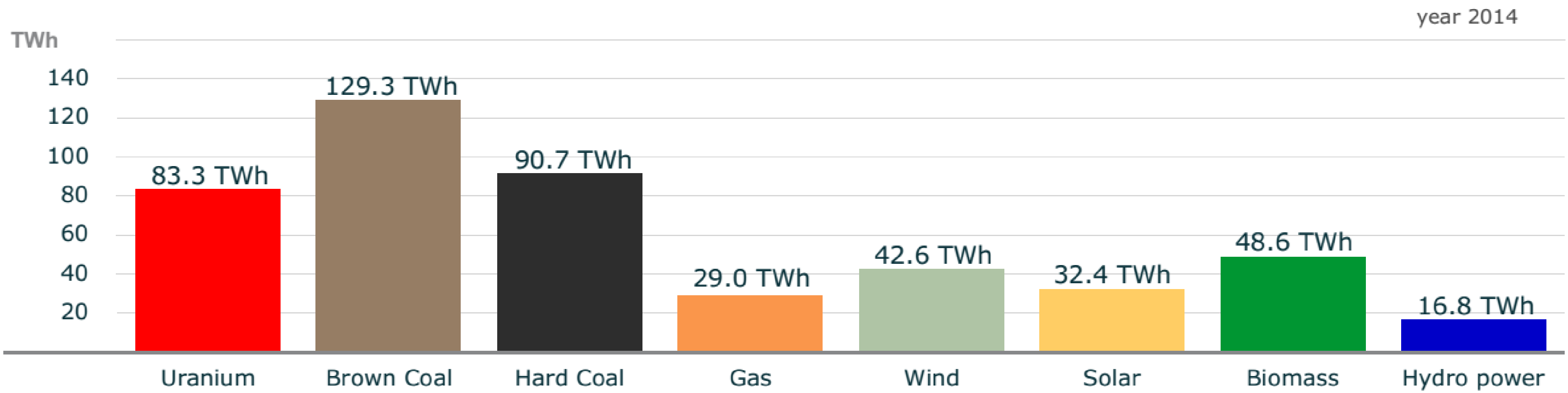
Efficiency

Regarding the question:

- “how much electricity or energy Germany produces by renewables/ zero-carbon sources?”
- Newest data: first 11 months of 2014
- Eurostats gives good data but with quite late (+/- 14 months)
- ISE Frauenhofer gives good up to date data on Germaney (http://www.ise.fraunhofer.de/en/)
  - **Fraunhofer Institute for Solar Energy Systems**
  - **Number of politicized, questionable analyses (strongly promoting solar)**

2014

Electricity production: first eleven months 2014

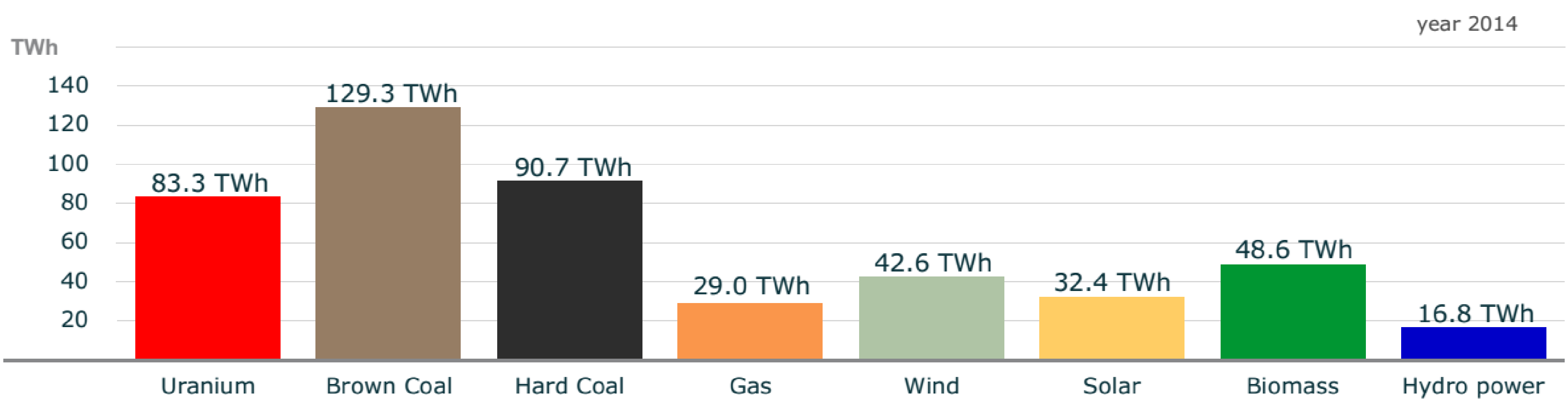


Source: Bruno Burger, Fraunhofer ISE, Data: Bundesnetzagentur

http://www.ise.fraunhofer.de/en/renewable-energy-data/data-and-facts-about-pv

	Energy in TWh				
Uranium	83.3				
Lignite (BC)	129.3				
Hard Coal	90.7				
Gas	29.0				
Wind	42.6				
Solar	32.4				
Biomass	48.6				
Hydro	16.8				
	472.7				

Electricity production: first eleven months 2014

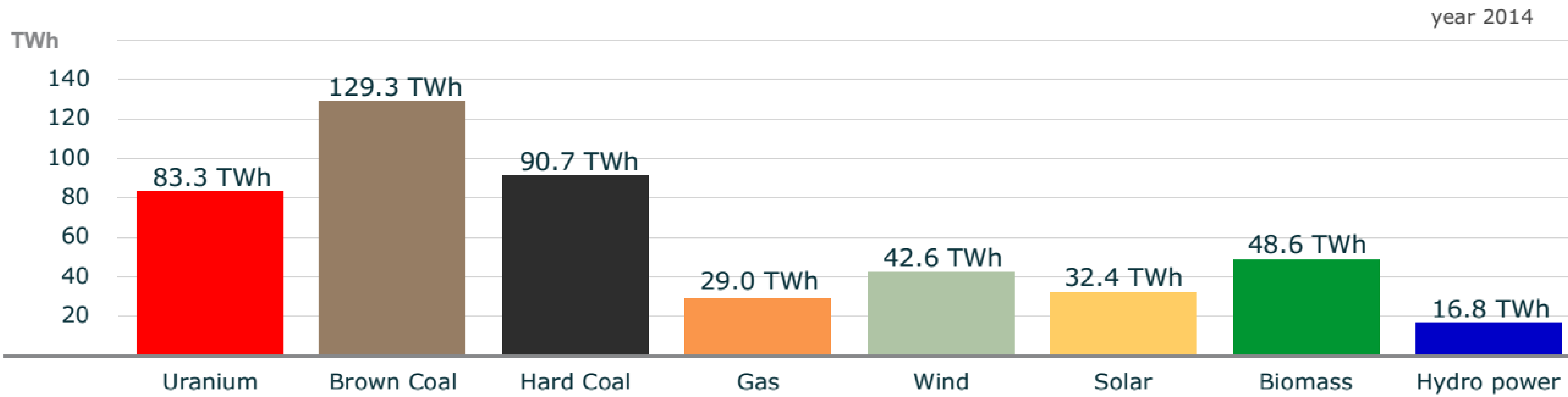


Source: Bruno Burger, Fraunhofer ISE, Data: Bundesnetzagentur

http://www.ise.fraunhofer.de/en/renewable-energy-data/data-and-facts-about-pv

	Energy in TWh				
Uranium	83.3	18%			
Lignite (BC)	129.3	27%			
Hard Coal	90.7	19%			
Gas	29	6%			
Wind	42.6	9%			
Solar	32.4	7%			
Biomass	48.6	10%			
Hydro	16.8	4%			
	472.7	**100%**			

Electricity production: first eleven months 2014

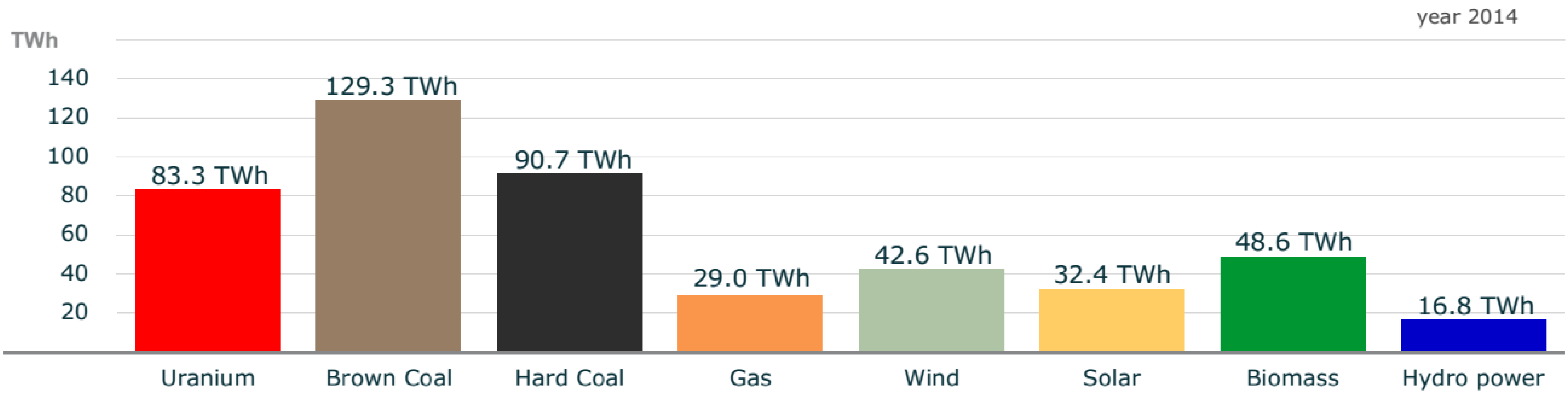


Source: Bruno Burger, Fraunhofer ISE, Data: Bundesnetzagentur

http://www.ise.fraunhofer.de/en/renewable-energy-data/data-and-facts-about-pv

	Energy in TWh		All renewables		
Uranium	83.3	18%			
Lignite (BC)	129.3	27%			
Hard Coal	90.7	19%			
Gas	29	6%			
Wind	42.6	9%	9%		
Solar	32.4	7%	7%		
Biomass	48.6	10%	10%		
Hydro	16.8	4%	4%		
	472.7	**100%**	**30%**		

Electricity production: first eleven months 2014

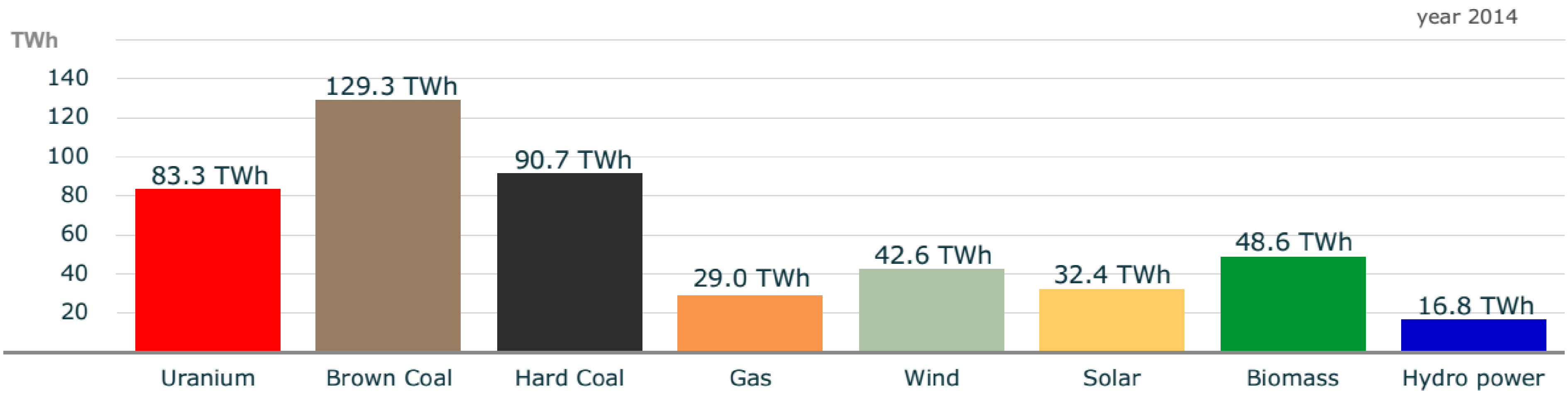


Source: Bruno Burger, Fraunhofer ISE, Data: Bundesnetzagentur

http://www.ise.fraunhofer.de/en/renewable-energy-data/data-and-facts-about-pv

	Energy in TWh		All renewables	New renewables	
Uranium	83.3	18%			
Lignite (BC)	129.3	27%			
Hard Coal	90.7	19%			
Gas	29	6%			
Wind	42.6	9%	9%	9%	
Solar	32.4	7%	7%	7%	
Biomass	48.6	10%	10%	10%	
Hydro	16.8	4%	4%		
	472.7	**100%**	**30%**	**26%**	

Electricity production: first eleven months 2014

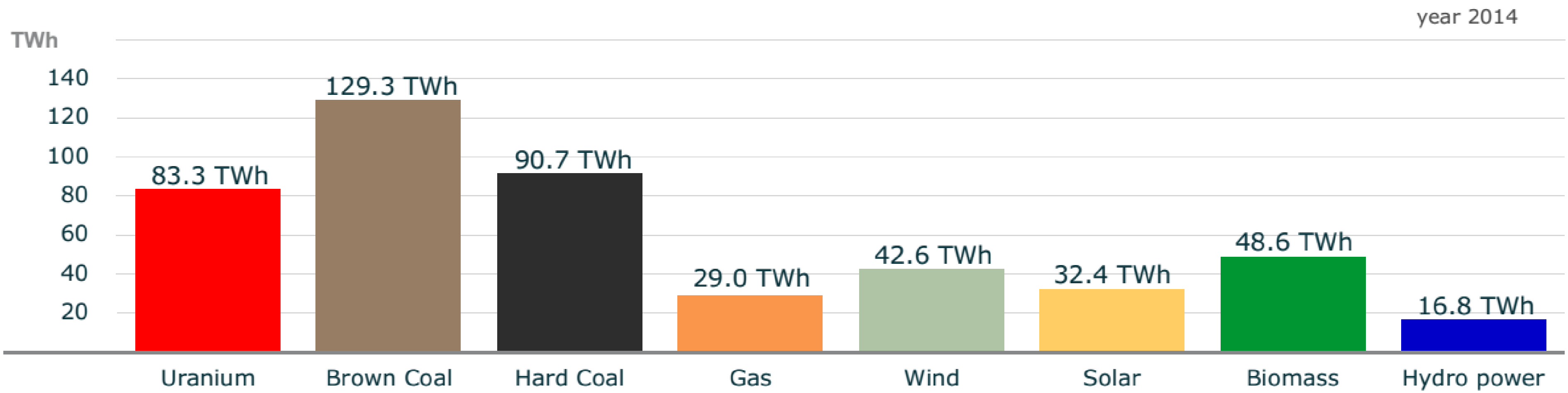


Source: Bruno Burger, Fraunhofer ISE, Data: Bundesnetzagentur

http://www.ise.fraunhofer.de/en/renewable-energy-data/data-and-facts-about-pv

	Energy in TWh		All renewables	New renewables	Solar+Wind
Uranium	83.3	18%			
Lignite (BC)	129.3	27%			
Hard Coal	90.7	19%			
Gas	29	6%			
Wind	42.6	9%	9%	9%	9%
Solar	32.4	7%	7%	7%	7%
Biomass	48.6	10%	10%	10%	
Hydro	16.8	4%	4%		
	472.7	**100%**	**30%**	**26%**	**16%**

Electricity production: first eleven months 2014



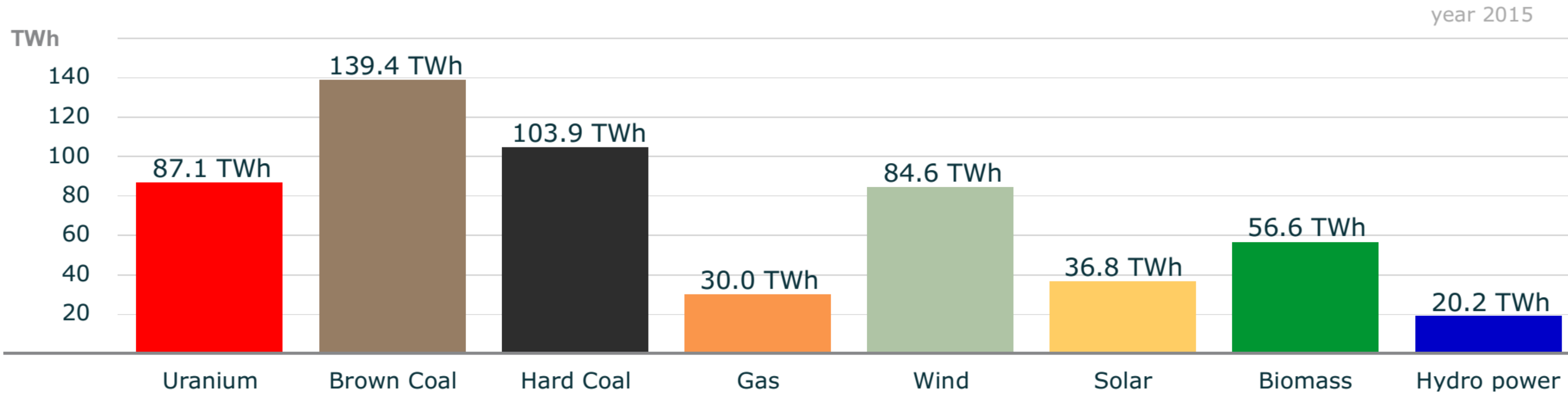
Source: Bruno Burger, Fraunhofer ISE, Data: Bundesnetzagentur

http://www.ise.fraunhofer.de/en/renewable-energy-data/data-and-facts-about-pv

	Energy in TWh		All renewables	New renewables	Solar+Wind	*Coal*
Uranium	83.3	18%				
Lignite (BC)	129.3	27%				*27%*
Hard Coal	90.7	19%				*19%*
Gas	29	6%				
Wind	42.6	9%	9%	9%	9%	
Solar	32.4	7%	7%	7%	7%	
Biomass	48.6	10%	10%	10%		
Hydro	16.8	4%	4%			
	472.7	**100%**	**30%**	**26%**	**16%**	***47%***

2015-2017

Electricity production in 2015

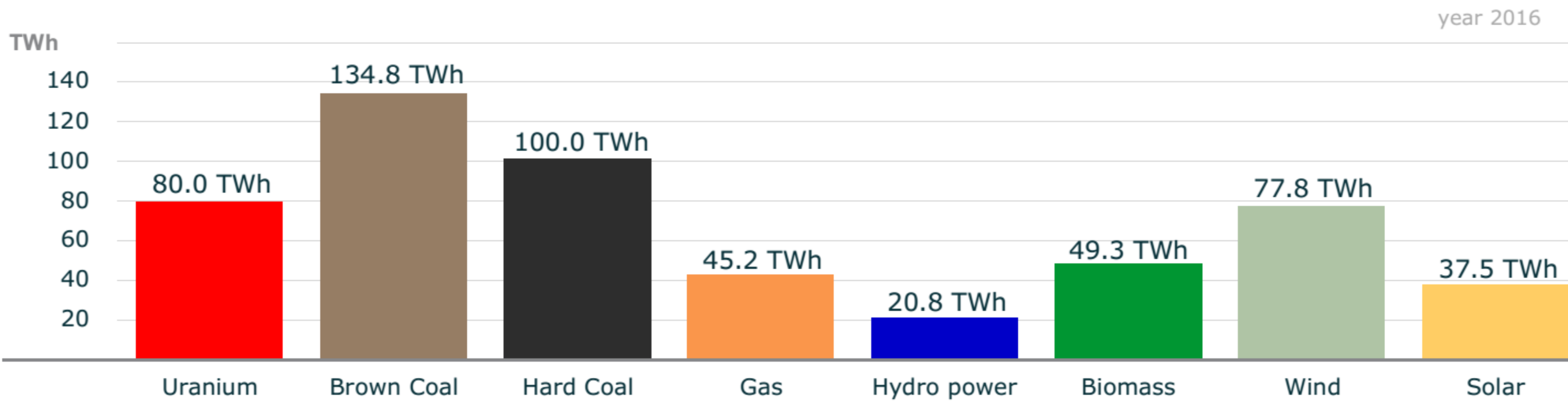


Source: Bruno Burger, Fraunhofer ISE, Data: Bundesnetzagentur

http://www.ise.fraunhofer.de/en/renewable-energy-data/data-and-facts-about-pv

	Energy in TWh		All renewables	New renewables	Solar+Wind	*Coal*
Uranium	87.1	16%				
Lignite (BC)	139.4	25%				*25%*
Hard Coal	103.9	19%				*19%*
Gas	30	5%				
Wind	84.6	15%	15%	15%	15%	
Solar	36.8	7%	7%	7%	7%	
Biomass	56.6	10%	10%	10%		
Hydro	20.2	4%	4%			
	558.6	**100%**	**35%**	**32%**	**22%**	*44%*

Electricity production in 2016

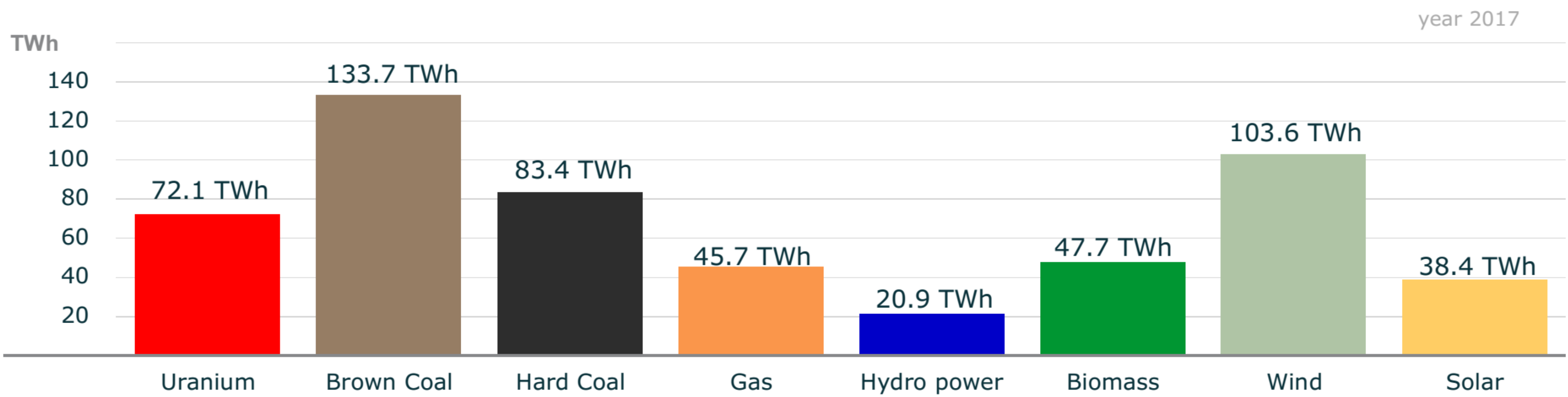


Source: Bruno Burger, Fraunhofer ISE, Data: Bundesnetzagentur

http://www.ise.fraunhofer.de/en/renewable-energy-data/data-and-facts-about-pv

	Energy in TWh		All renewables	New renewables	Solar+Wind	***Coal***
Uranium	80	15%				
Lignite (BC)	134.8	25%				***25%***
Hard Coal	100	18%				***18%***
Gas	45.2	8%				
Wind	77.8	14%	14%	14%	14%	
Solar	37.5	7%	7%	7%	7%	
Biomass	49.3	9%	9%	9%		
Hydro	20.8	4%	4%			
	545.4	**100%**	**34%**	**30%**	**21%**	***43%***

Electricity production in 2017



Source: Bruno Burger, Fraunhofer ISE, Data: Bundesnetzagentur

http://www.ise.fraunhofer.de/en/renewable-energy-data/data-and-facts-about-pv

	Energy in TWh		All renewables	New renewables	Solar+Wind	*Coal*
Uranium	27.1	5%				
Lignite (BC)	133.7	27%				*27%*
Hard Coal	83.4	17%				*17%*
Gas	45.7	9%				
Wind	103.6	21%	21%	21%	21%	
Solar	38.4	8%	8%	8%	8%	
Biomass	47.7	10%	10%	10%		
Hydro	20.9	4%	4%			
	500.5	**100%**	**42%**	**38%**	**28%**	***43%***

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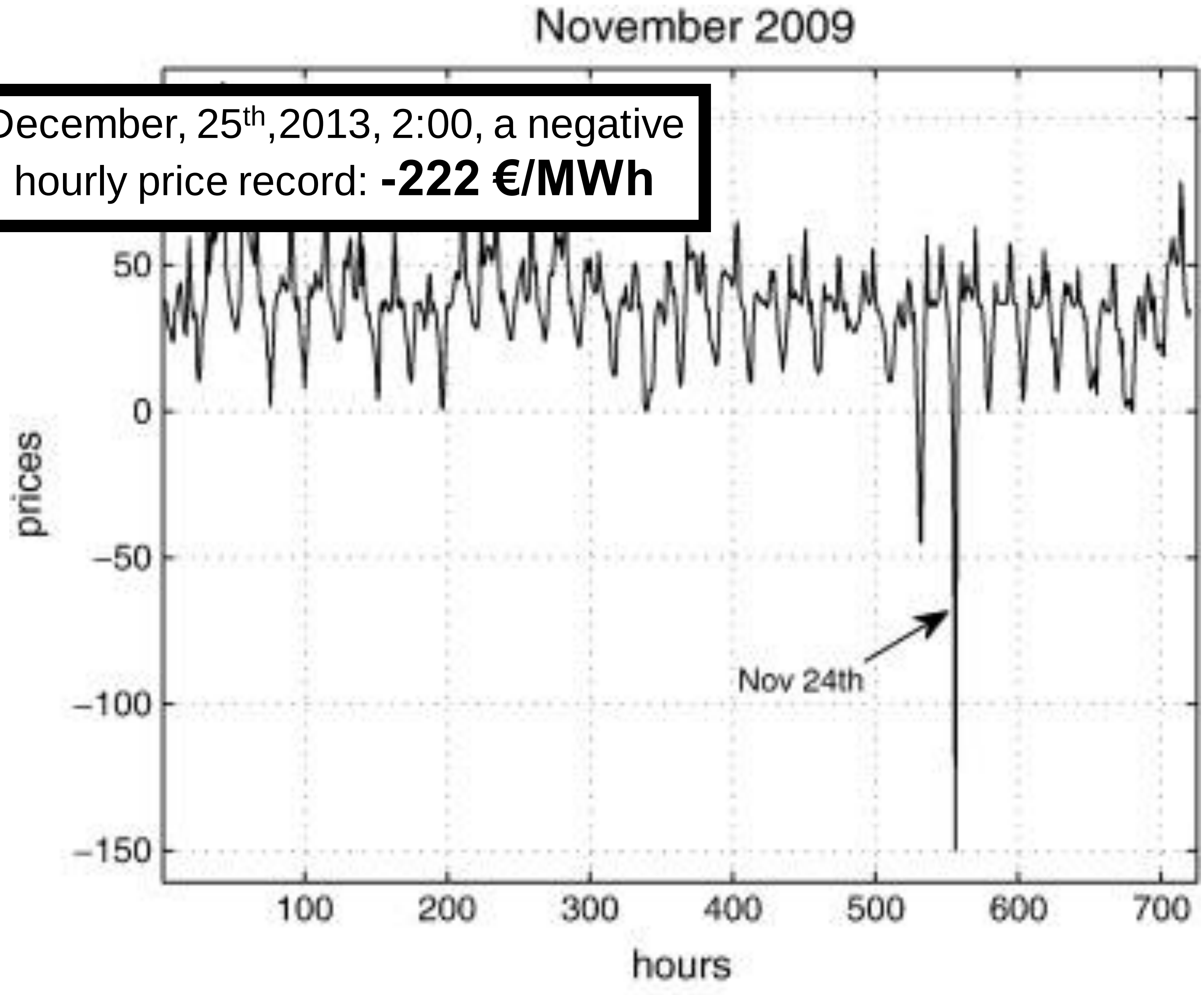
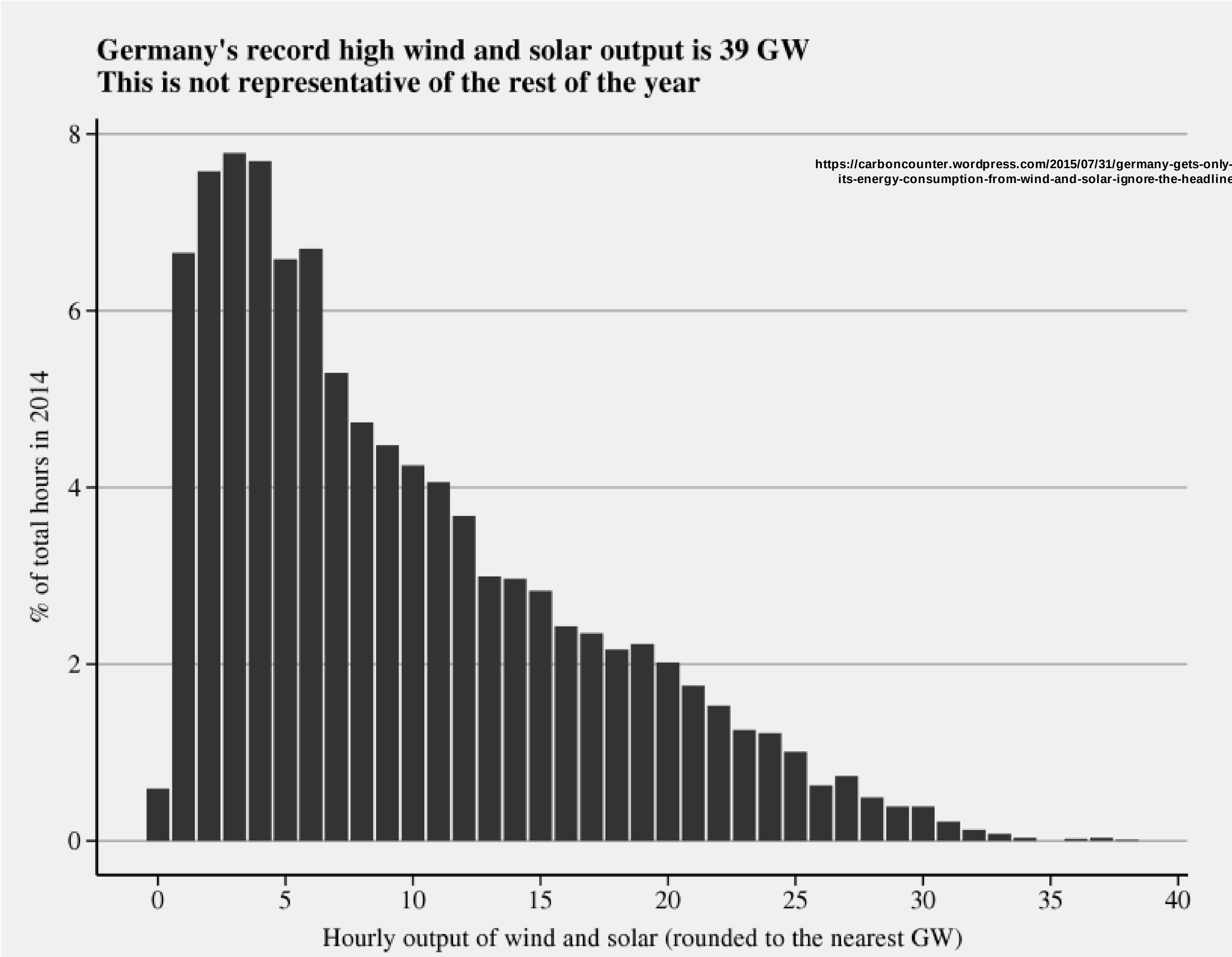
German electricity wholesale market

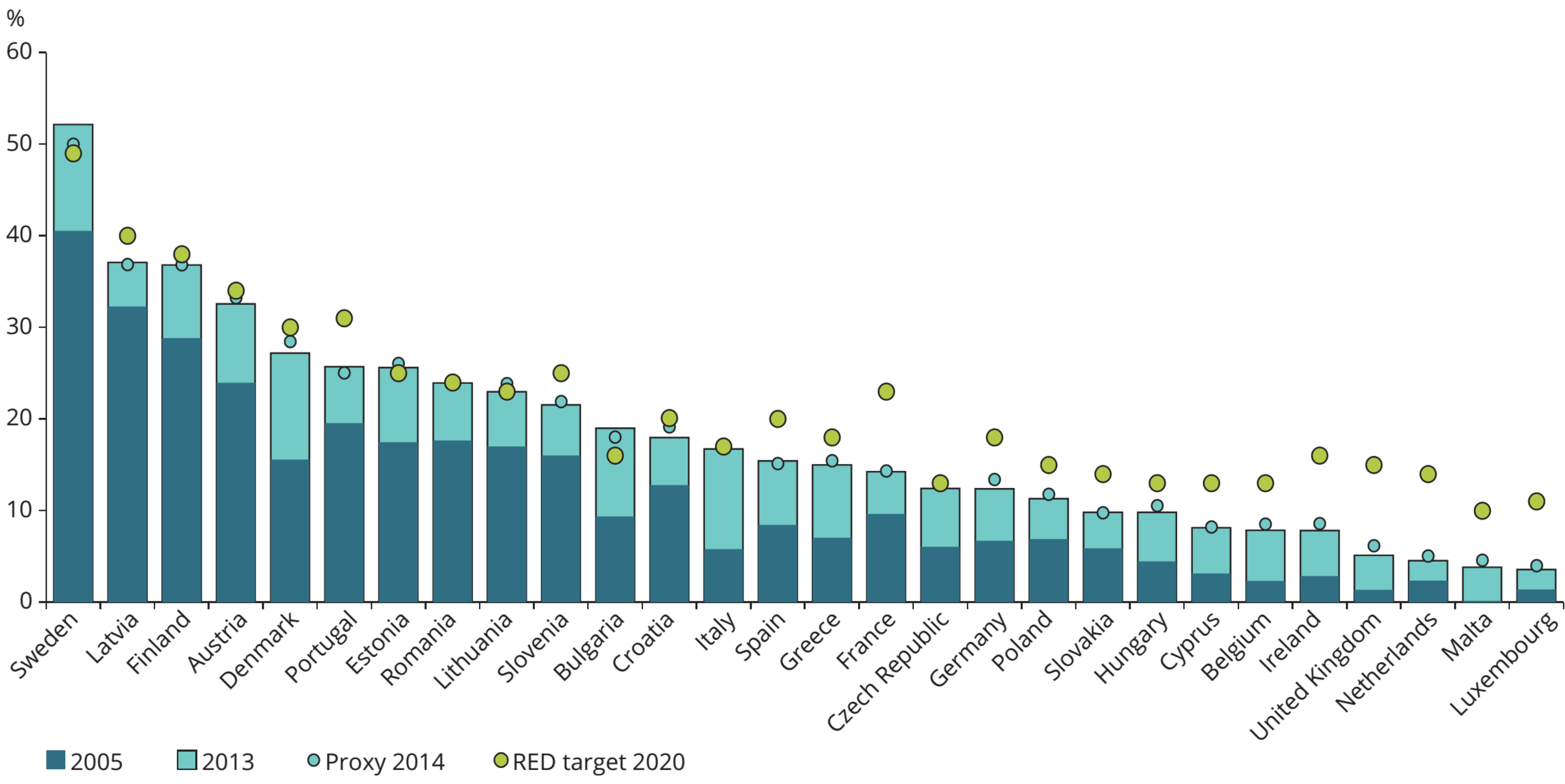
December, 25th,2013, 2:00, a negative hourly price record: **-222 €/MWh**

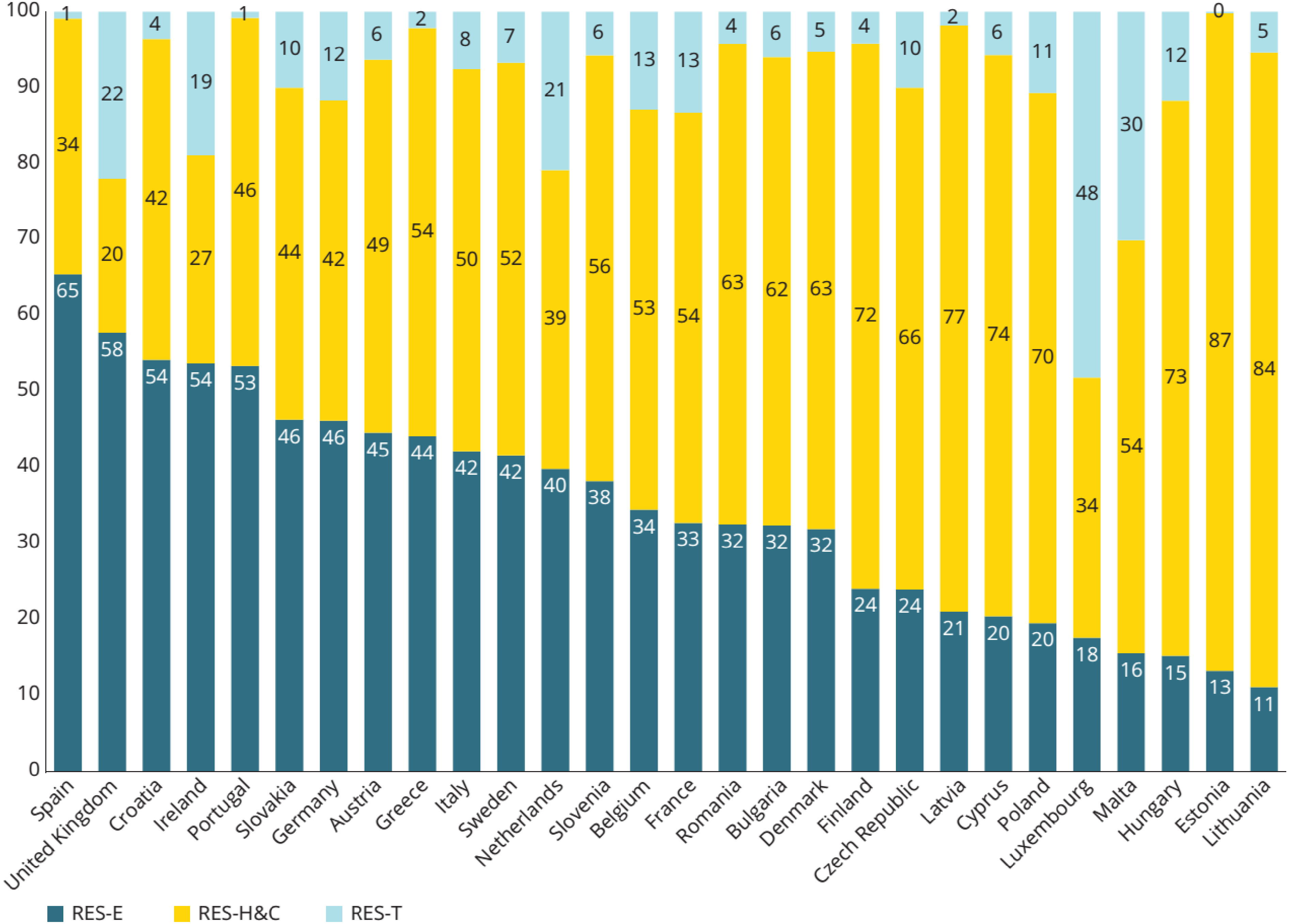




Germany's record high wind and solar output is 39 GW
This is not representative of the rest of the year
https://carboncounter.wordpress.com/2015/07/31/germany-gets-only-3-3-of-its-energy-consumption-from-wind-and-solar-ignore-the-headlines/
% of total hours in 2014
0
2
4
6
8
0
5
10
15
20
25
30
35
40
Hourly output of wind and solar (rounded to the nearest GW)

RES shares in the EU-28 Member States





Source: EEA (based on Eurostat, 2015b)

http://www.eea.europa.eu/publications/renewable-energy-in-europe-2016

Renewable electricity in the EU-28: breakdown by RES technologies

Technology	Final energy (ktoe)				
	2005	2012	2013	Proxy 2014	NREAP 2020
Hydropower excl. pumping (normalised)	29 582	29 822	29 987	30 171	31 786
Onshore wind (normalised)	5 784	16 110	18 189	20 110	30 303
Solid biomass	4 773	8 488	8 610	8 446	13 460
Solar photovoltaic	126	5 796	6 953	7 849	7 062
Biogas	1 101	3 994	4 550	4 627	5 493
Offshore wind (normalised)	174	966	1 201	1 377	11 740
Geothermal	464	496	510	535	943
Concentrated solar power	0	325	378	378	1 633
Bioliquids (compliant)	0	290	346	290	1 096
Tidal, wave and ocean energy	41	40	36	45	559
Total renewable electricity (normalised, compliant biofuels)	42 044	66 326	70 761	73 828	104 075
Total renewable electricity (normalised, including non-compliant biofuels)	42 196	66 348	70 784	73 906	104 075

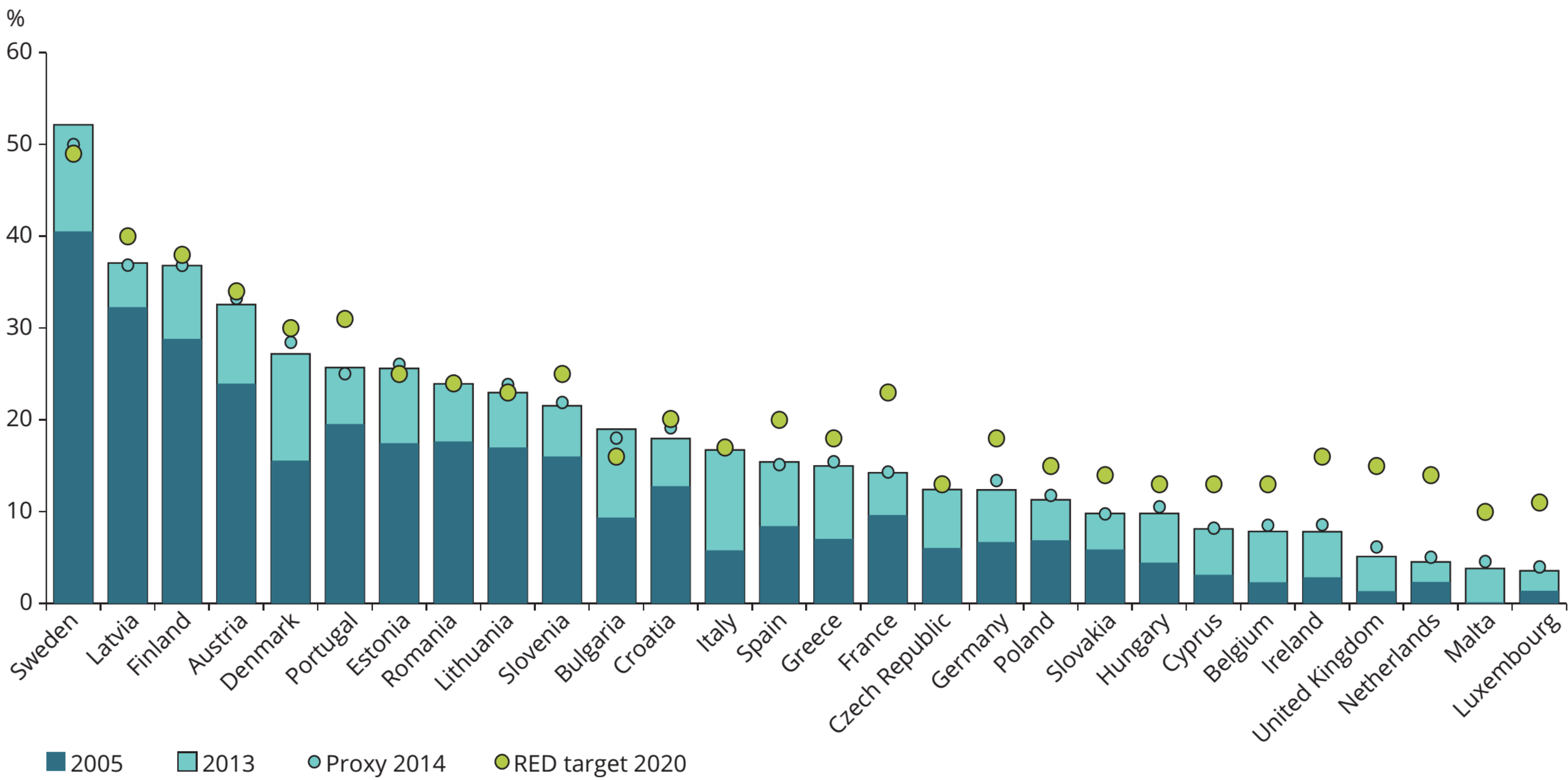
Renewable heating and cooling in the EU-28

Technology	Final energy (ktoe)				
	2005	2012	2013	Proxy 2014	NREAP 2020
Solid biomass	56 609	73 331	75 548	71 012	80 886
Renewable energy from heat pumps	2 239	6 897	7 385	8 134	12 289
Biogas	714	2 154	2 525	2 595	5 108
Solar thermal	702	1 833	1 947	2 045	6 455
Geothermal	559	609	658	697	2 646
Bioliquids (compliant)	0	239	228	228	4 416
Total renewable heat (compliant biofuels)	60 824	85 063	88 292	84 710	111 801
Total renewable heat (including non-compliant biofuels)	60 990	85 251	88 478	84 897	111 801

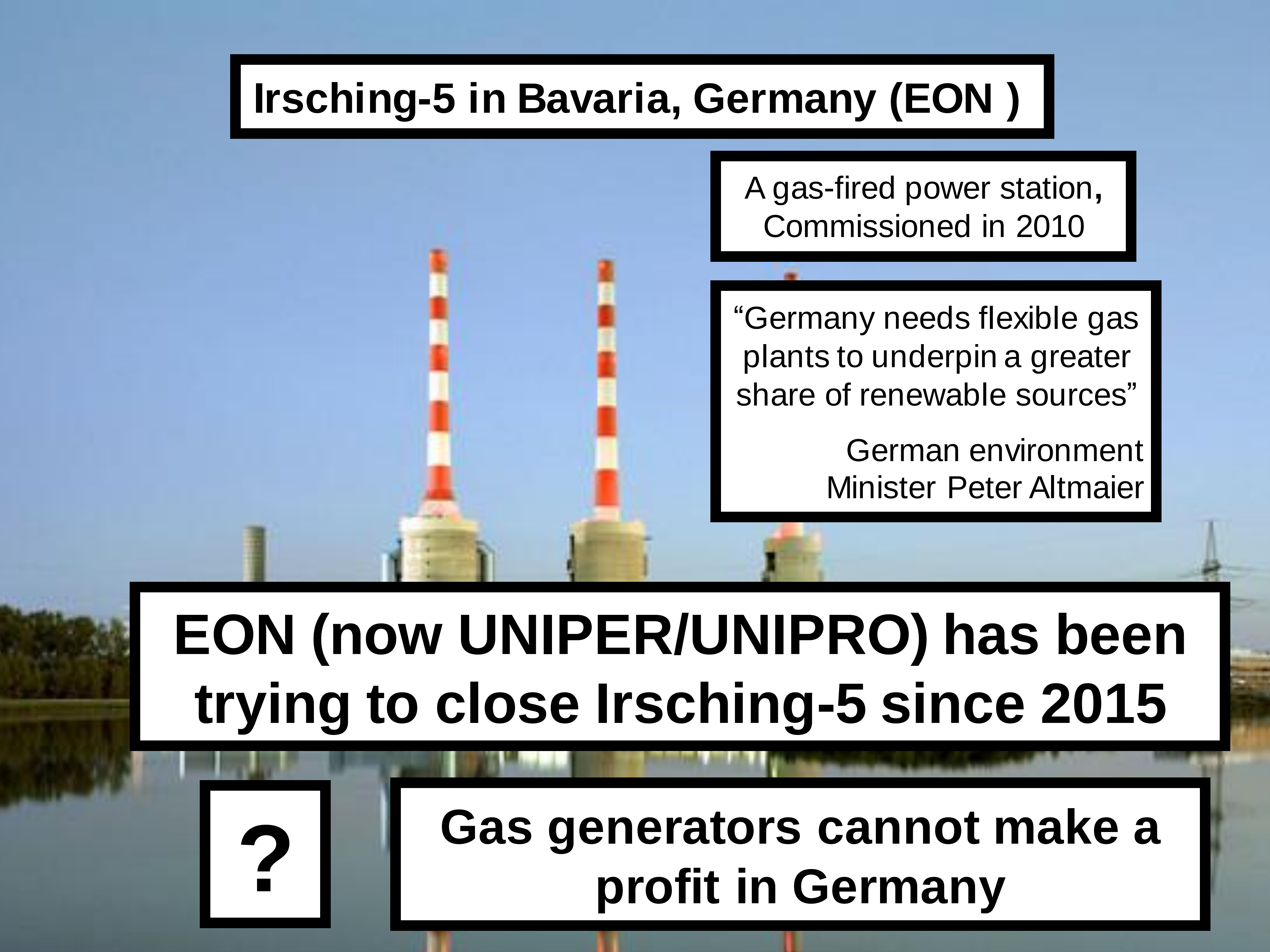
Renewable transport in the EU-28: biofuels

Technology	Final energy (ktoe)				
	2005	2012	2013	Proxy 2014	NREAP 2020
Biodiesels (all)	2 565	11 492	10 293	11 076	20 920
Biogasoline (all)	560	2 858	2 717	2 700	7 324
Other biofuels (all)	155	117	126	357	746
Compliant biofuels	3 240	11 595	11 932	12 841	28 989
All biofuels	3 279	14 467	13 135	14 133	28 989

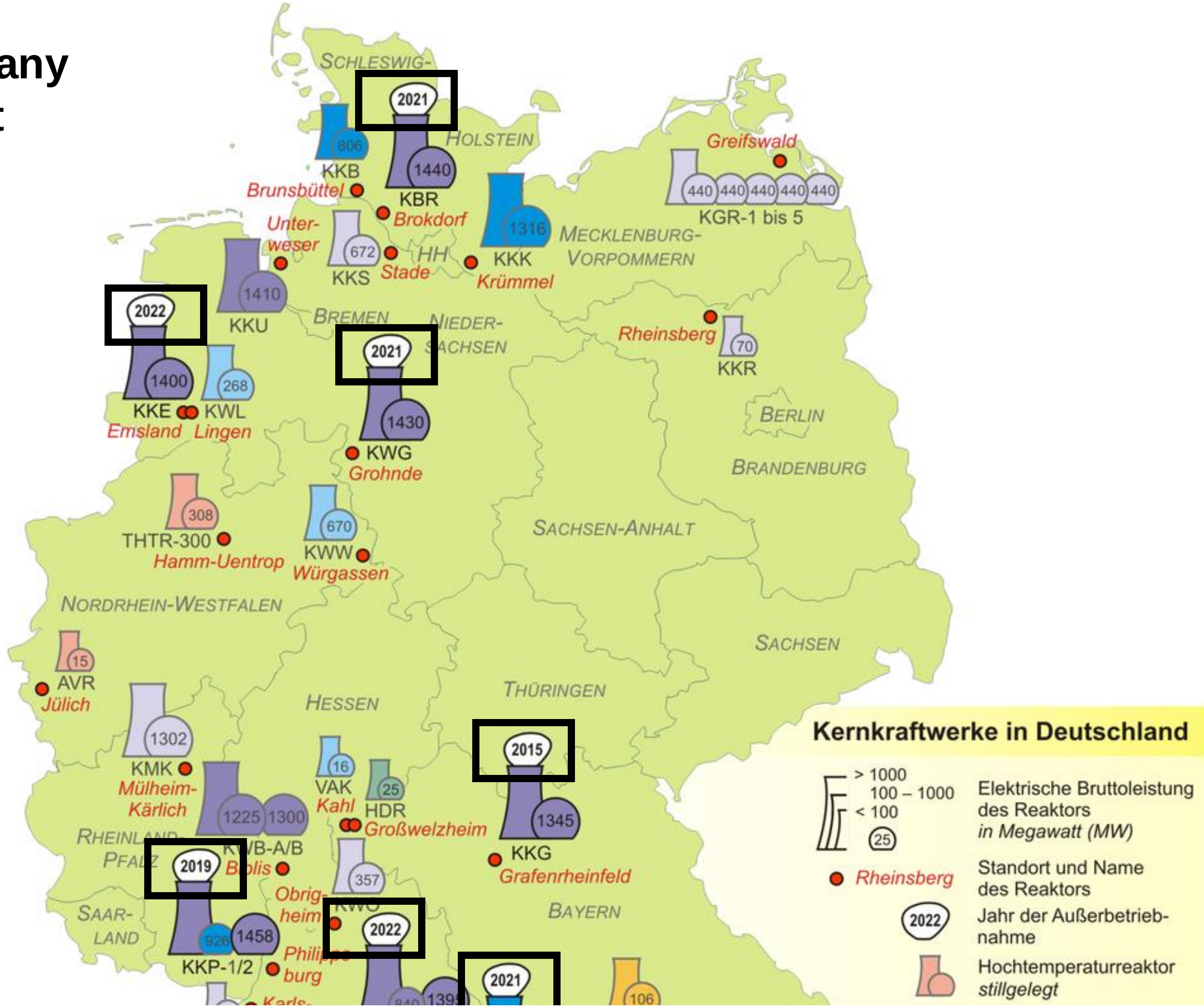
RES shares in the EU-28 Member States



Germany to start up more coal-fired power stations than at any time in the past 20 years


Irsching-5 in Bavaria, Germany (EON)
A gas-fired power station, Commissioned in 2010
“Germany needs flexible gas plants to underpin a greater share of renewable sources”
German environment Minister Peter Altmaier
EON (now UNIPER/UNIPRO) has been trying to close Irsching-5 since 2015
?
Gas generators cannot make a profit in Germany

Acceleration of Germany Nuclear Phase-out



EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

MINISTERSTVO ŠKOLSTVÍ,
MLÁDEŽE A TĚLOVÝCHOVY

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MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

Národohospodářská fakulta VŠE v Praze