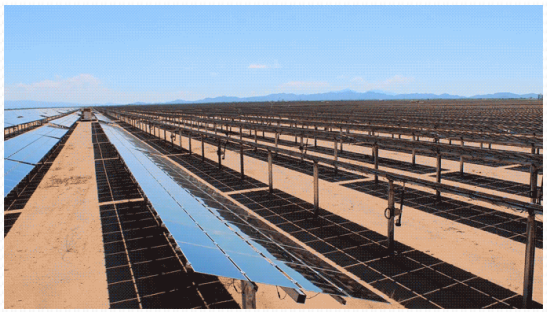
Gas, Galvanizing and Greenwashing – furnace technology?

Rob White and Lan Tian
Wedone Thermo

Intergalva 2022, Rome, Italy

Electric heating is the best for galvanizing tanks, but unfortunately it is not always possible to use it because of the high cost of electrical energy (H Bablik 1926)



Some numbers

- Heating steel ~**55 kWh per tonne**
- Melting zinc ~**82 kWh per tonne**

So theoretically we need around 66kWh per tonne galvanized, but

- Evaporating water ~**1.1 kWh per tonne** (20g water/m²).
- In addition we also have **heat losses by radiation and convection** which could be up to 17kW/h per m² of kettle surface and say 1kW/h per m² kettle wall surface. Ash removal adds another heat loss.
- In total around **70 kWh is required per tonne of steel galvanized**.

Carbon Energy sources

- Coal, Coke
- Oil
- Diesel
- Gas

CO_2 emissions from combustion of common fuels

Fuel	Liquid density	Specific carbon content	Specific Energy content		Specific CO_2 emission (amount of fuel basis)			Specific CO_2 emission (amount of energy basis)		
	kg/l	kg_C/kg_{fuel}	kWh/kg_{fuel}	Btu/lb_{fuel}	Kg_{CO2}/kg_{fuel}	Kg_{CO2}/gal_{fuel}	lb_{CO2}/gal_{fuel}	kg_{CO2}/kWh	kg_{CO2}/GJ	lb_{CO2}/mill Btu
Methane (natural gas)		0.75	15.4	23900	2.75			0.18	50	115
Propane	0.510	0.82	13.8	21300	2.99	5.78	12.7	0.22	60	140
Butane	0.564	0.83	13.6	21100	3.03	6.47	14.3	0.22	62	144
LPG (wt of C3=C4)	0.537	0.82	13.7	21200	3.01	6.12	13.5	0.22	61	142
Gasoline	0.737	0.90	12.9	19900	3.30	9.20	20.3	0.26	71	165.3
Kerosene (Jet)	0.821	0.82	12.0	18500	3.00	9.33	20.6	0.25	70	162.5
Diesel	0.846	0.86	12.7	19605	3.15	10.1	22.3	0.25	69	160.8
Heavy fuel oil (No.6/Bunker C)	0.980	0.85	11.6	18000	3.11	11.6	25.5	0.27	75	173.3
Petroleum coke		0.89	9.4	14500	3.26	14.7	32.4	0.35	97	225.1
Coal:										227.3
Anthracite		0.92	9.0	14000	3.37			0.37	104	229.5

Relying on Carbon Combustion

- The calorific value of the various fuels available is determined by the ease and nature of the energy release in burning carbon with oxygen
- The greater the surface area in contact with the oxidizing agent the more efficient it will be (Temperature, Turbulence, Time).
- Gas should be better than liquid should be better than solid.

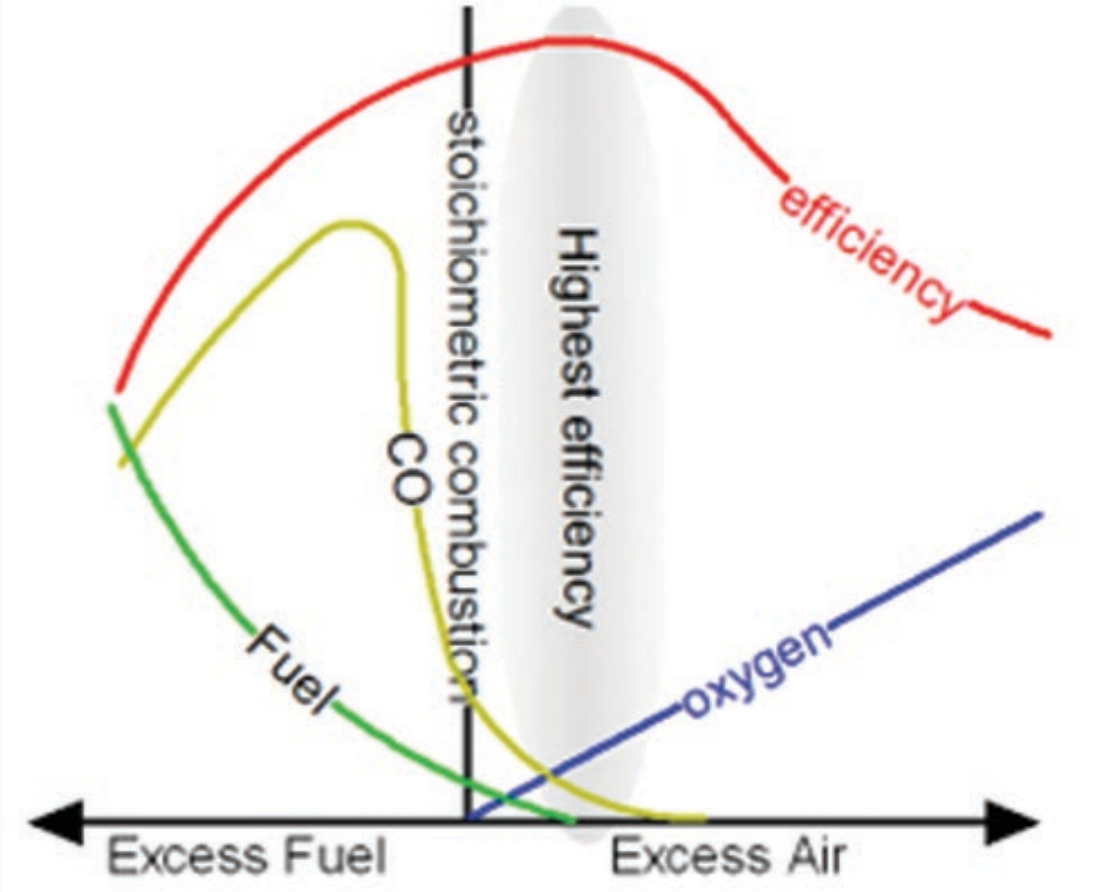
Fuel	Particulates	SOx	NOx
Natural Gas			√
LPG			√
Light Fuel Oil		√	√
Heavy Fuel Oil	√	√	√
Coal	√	√	√

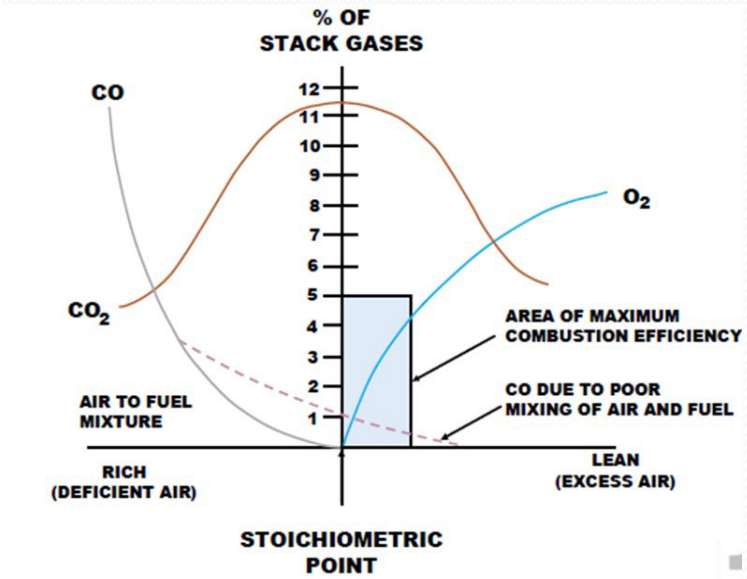
Combustion with natural gas

$$C_mH_n + (m+n/4)O_2 \rightarrow mCO_2 + (n/2)H_2O$$

For example:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + heat$$



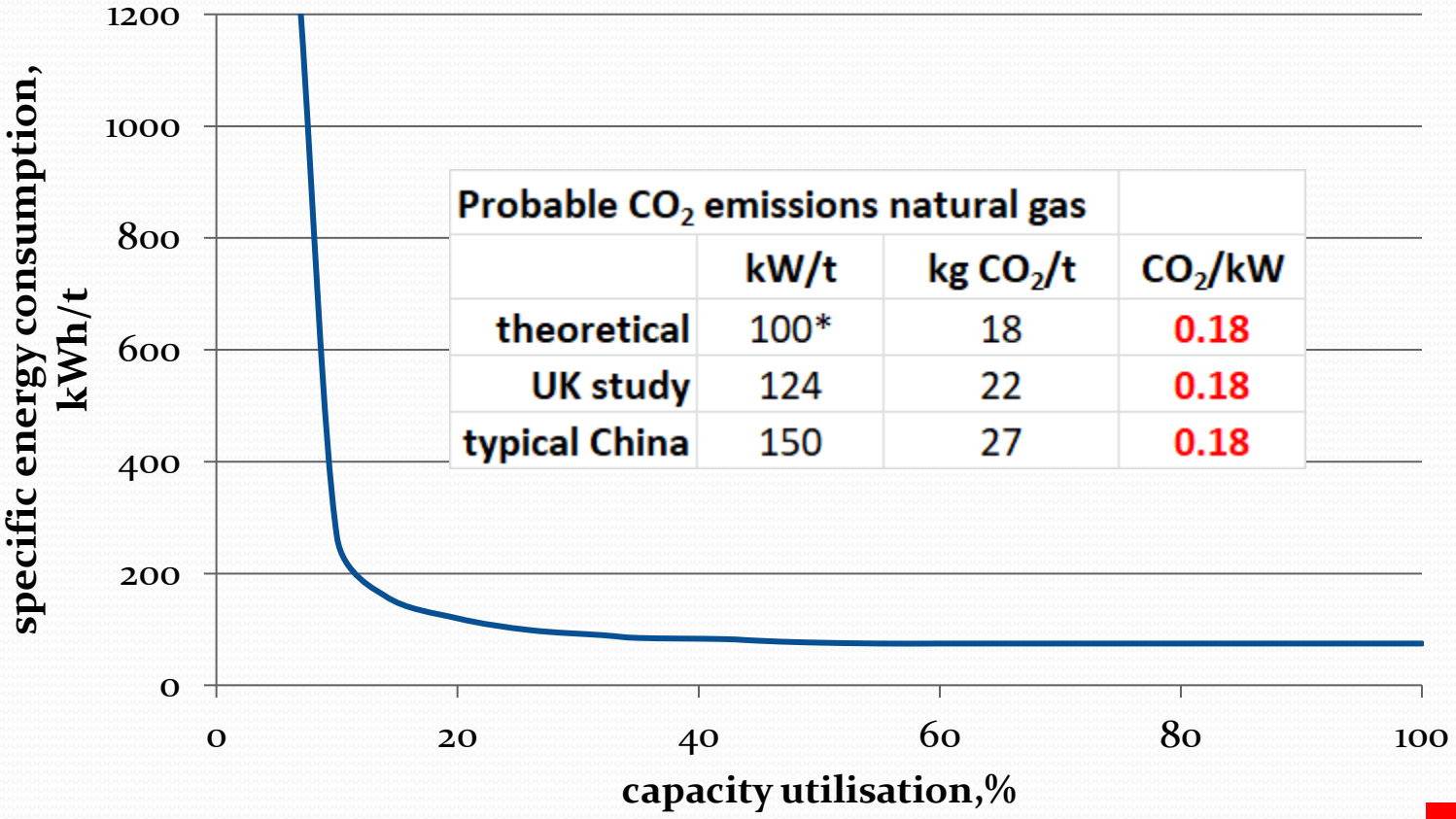


The CO_2 load with gas

- Nm^3(normal cubic metres) CO_2 produced ≅ 50% O_2 used.
- Studies confirm that the CO2 produced is dependant upon the input gas composition.
- Study in Turkey -

	INPUT GASES (Nm^3)			FLUE GAS (Nm^3)		
Fuel Analysis	% Ob	O_2	N_2	CO_2	H_20	N_2
Methane	94,1	1,882	7,07632	0,941	1,882	7,07632
Ethane	0,1	0,0035	0,01316	0,002	0,003	0,01316
Propane	1,2	0,06	0,2256	0,036	0,048	0,2256
Butane	0,12	0,0078	0,029328	0,0048	0,006	0,029328
Pentane	2,71	0,2168	0,815168	0,1355	0,1626	0,815168
Nitrogen	1,66	-	1,66	-	-	1,66
Carbon dioxide	0,11	-	0,11	-	-	0,11
Total	100	2,1701	9,929576	1,1193	2,1016	9,929576
		13,099676			13,150476	

Relationship between energy consumption per tonne steel galvanized and utilisation



Probable CO_2 emissions natural gas			
	kW/t	kg CO_2/t	CO_2/kW
theoretical	100*	18	0.18
UK study	124	22	0.18
typical China	150	27	0.18

* working on 70% gas efficiency

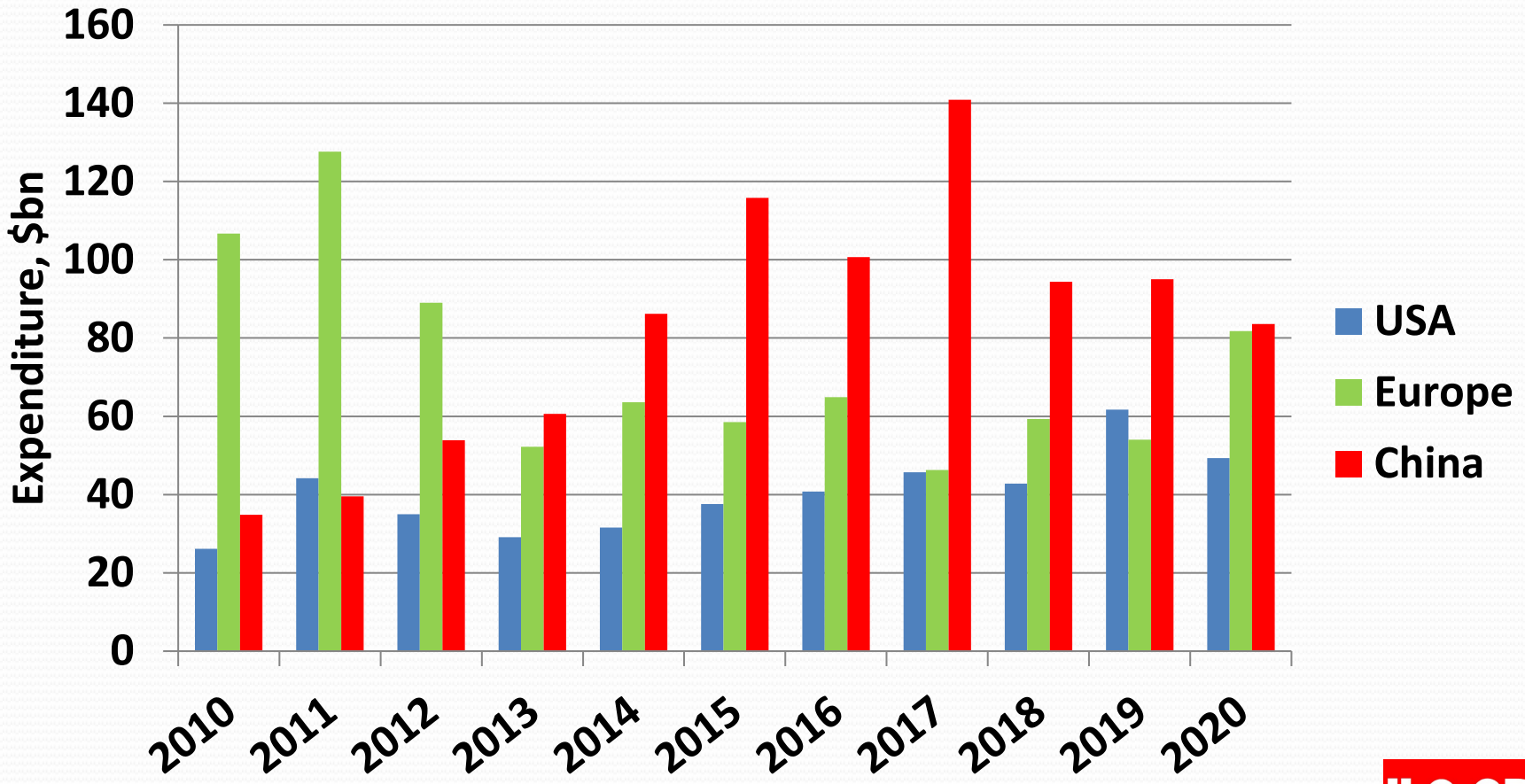
The Chinese situation

- Early 5-year plans focused upon productivity (using people) and industrialisation – more, faster, better, cheaper
- 8th 5-year plan under Deng Xiaoping in 1991 accelerated the trading process which was catapulted forward again with the joining of the WTO in 2001.
- Cleaner Production Promotion Law – 2002, Environmental Protection Law 2015, Only really enforced in 2017 – many galvanizing plants closed!

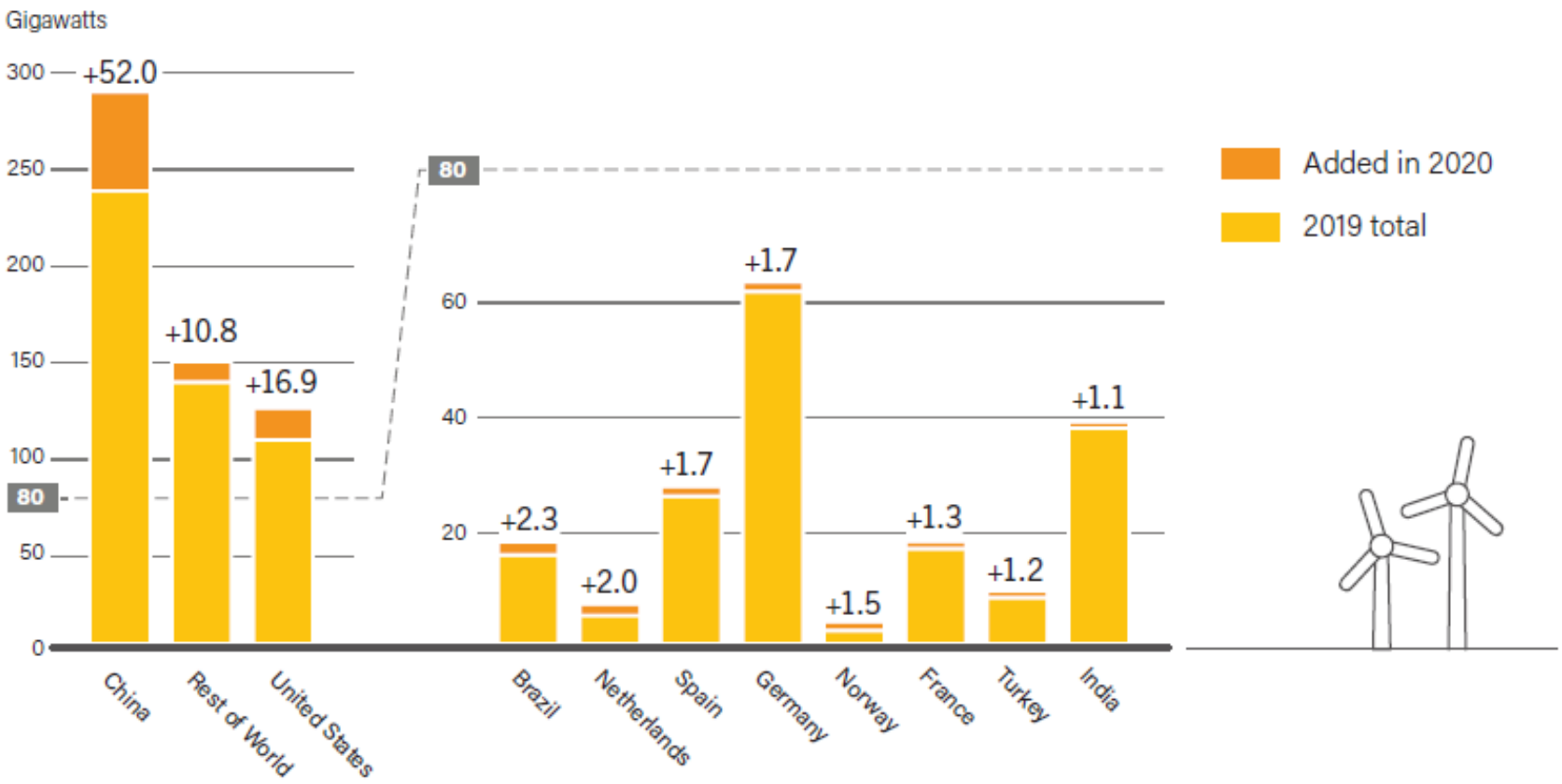
Addressing the low carbon economy in China (14th 5-year Plan 2021-2025)

- Carbon emissions will peak in 2030 – action plan
- Cut energy intensity by 13.5% and carbon intensity by 18%
- Non-fossil fuels to be 20% of energy source
- Focus on energy security to support ongoing economic growth (common prosperity, etc.)
- Carbon neutrality by 2060

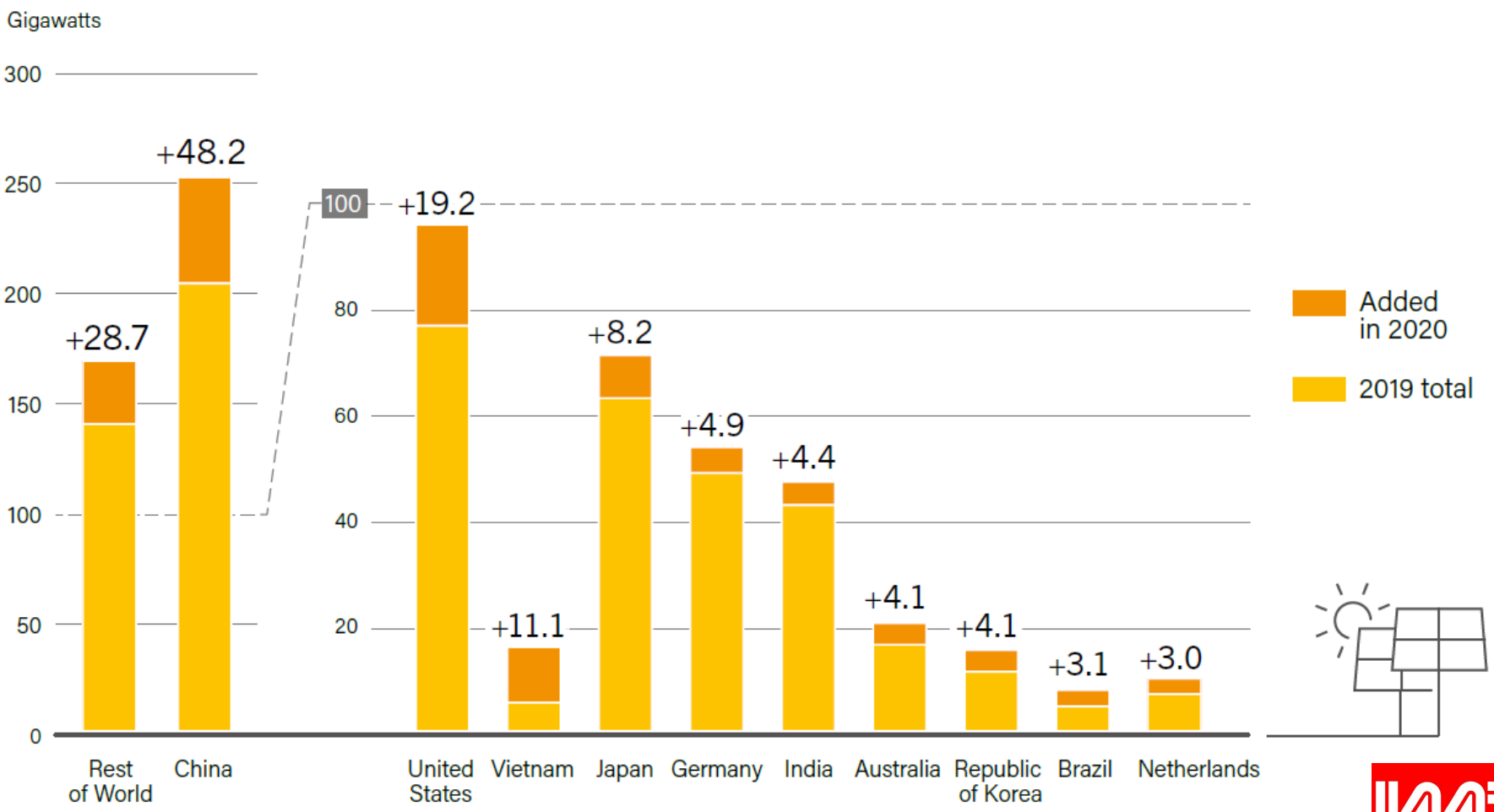
Expenditure on renewables



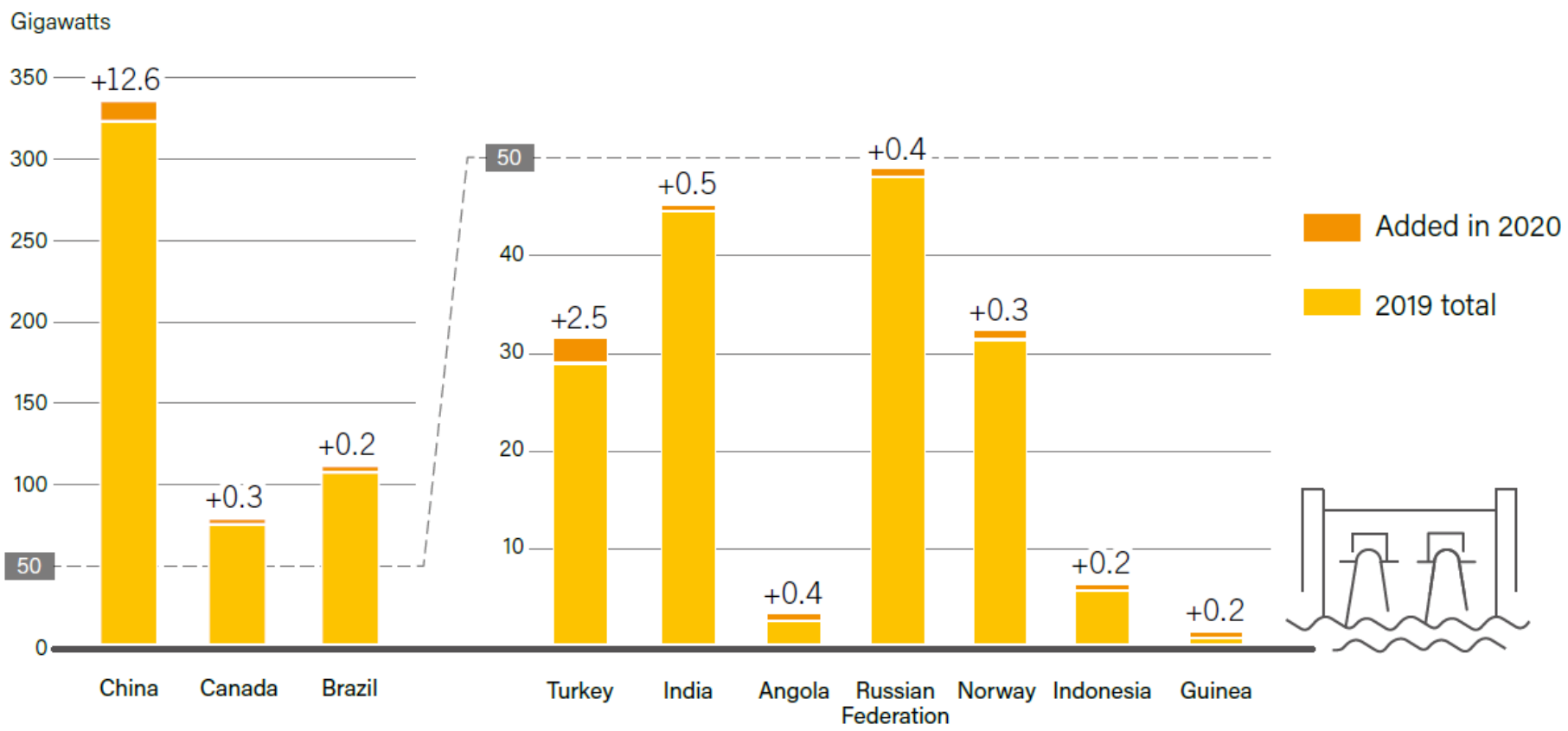
Renewables – wind



Renewables – Solar PV



Renewables – hydropower

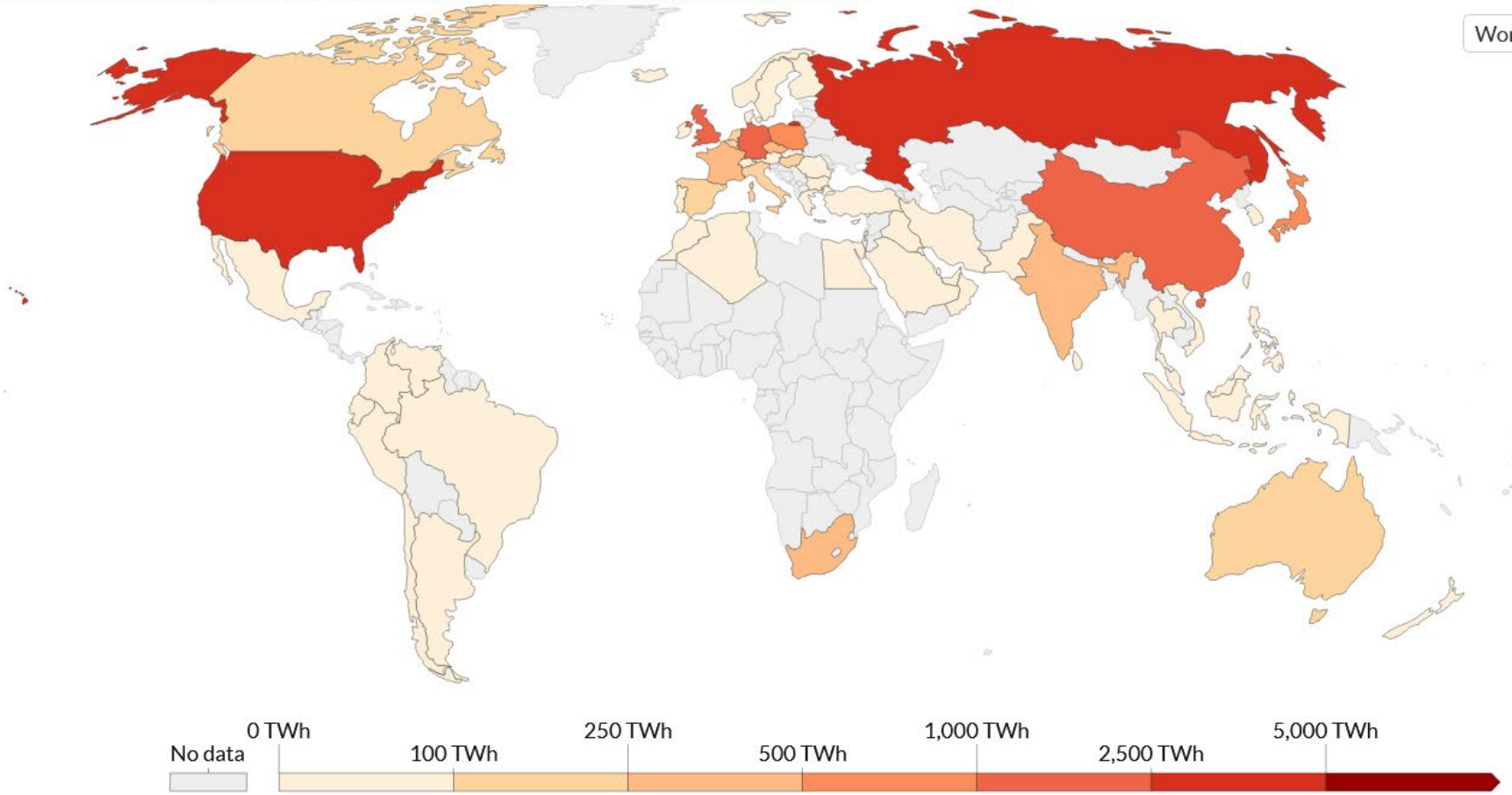


Coal consumption, 1965

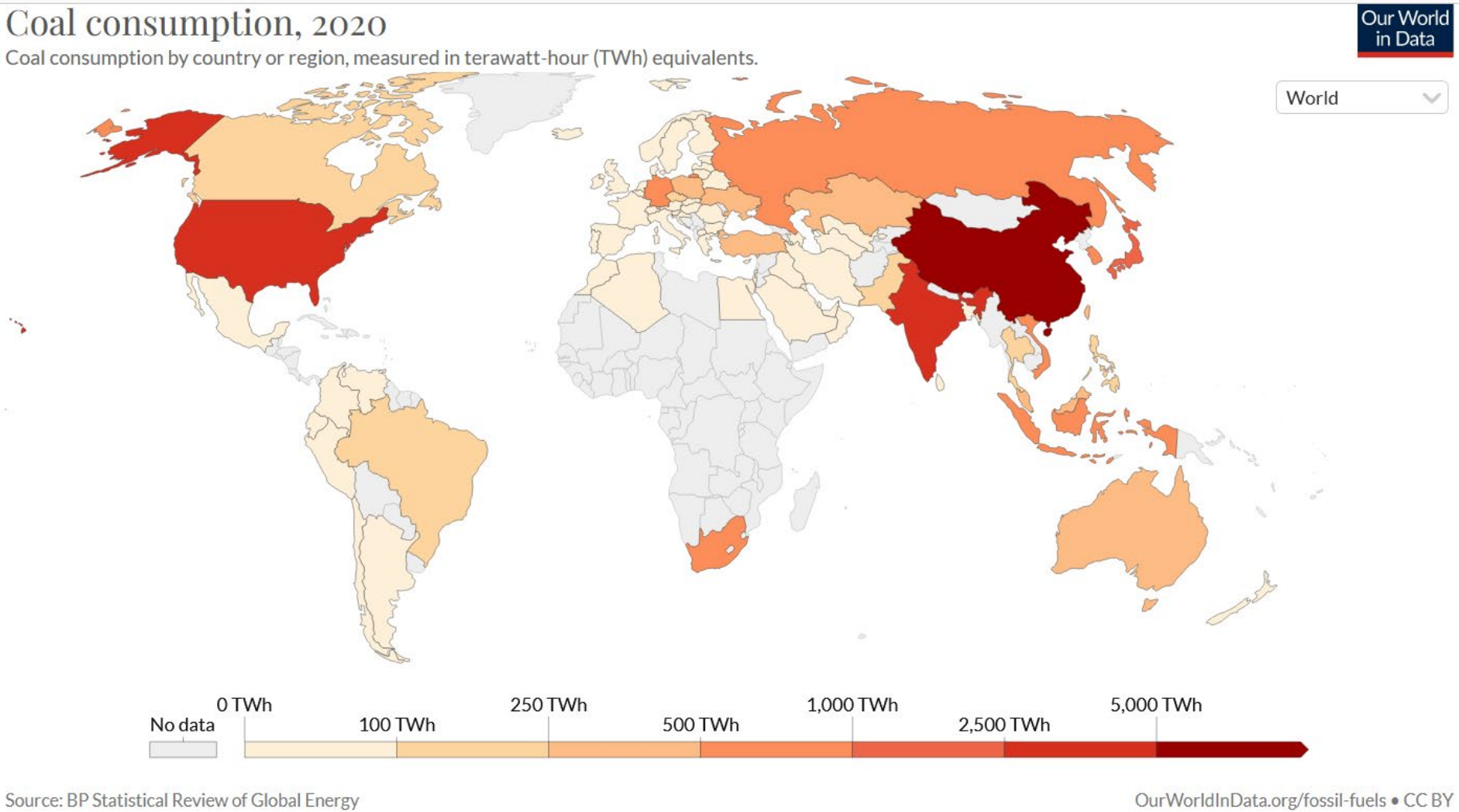
Coal consumption by country or region, measured in terawatt-hour (TWh) equivalents.

Our World in Data

World



Source: BP Statistical Review of Global Energy



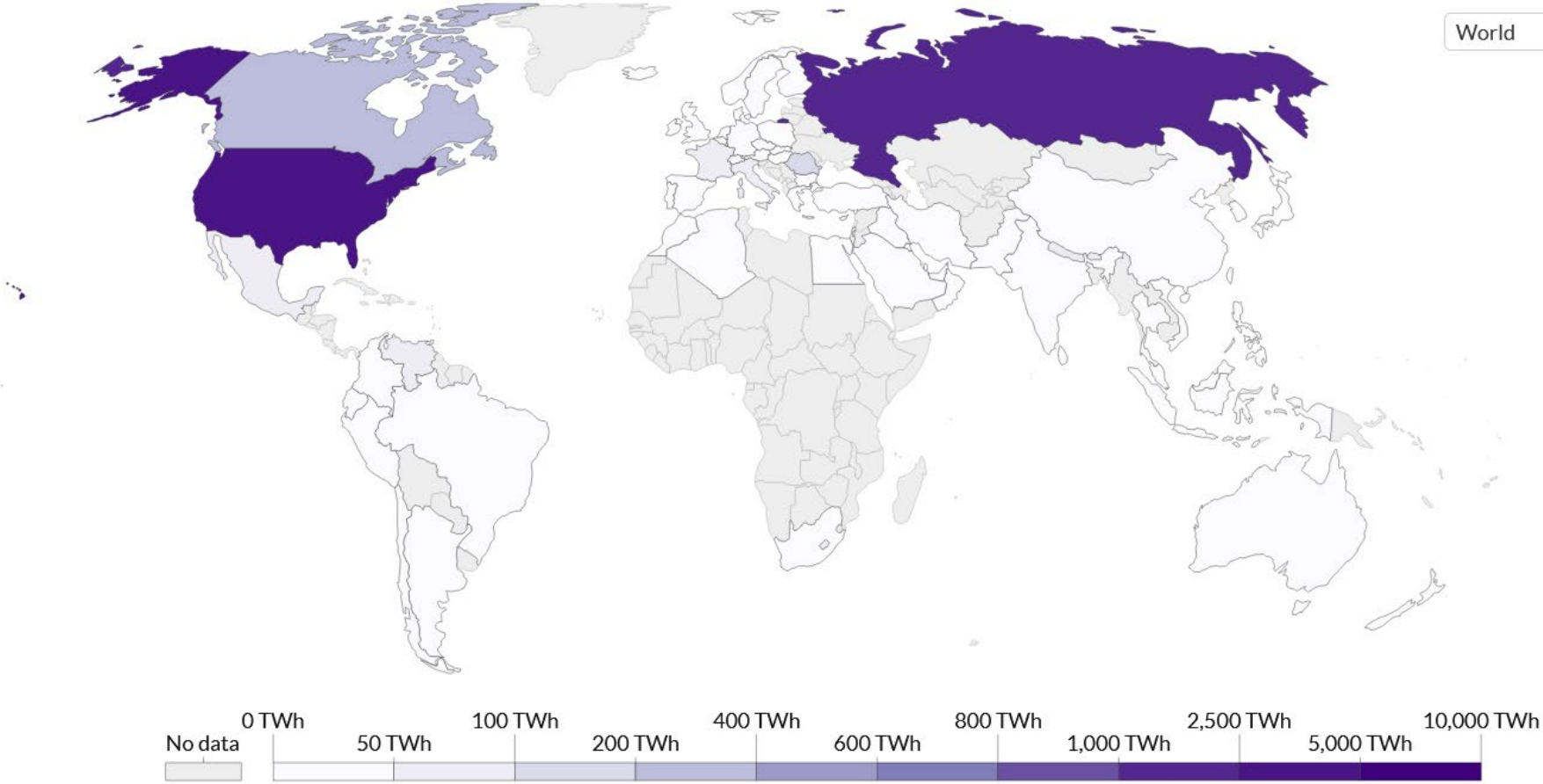
Internationally, coal is the most widely used primary fuel, accounting for about 36% of the total fuel consumption of the world's electricity production.

Gas consumption, 1965

Natural gas consumption is measured in terawatt-hour (TWh) equivalents per year.

Our World in Data

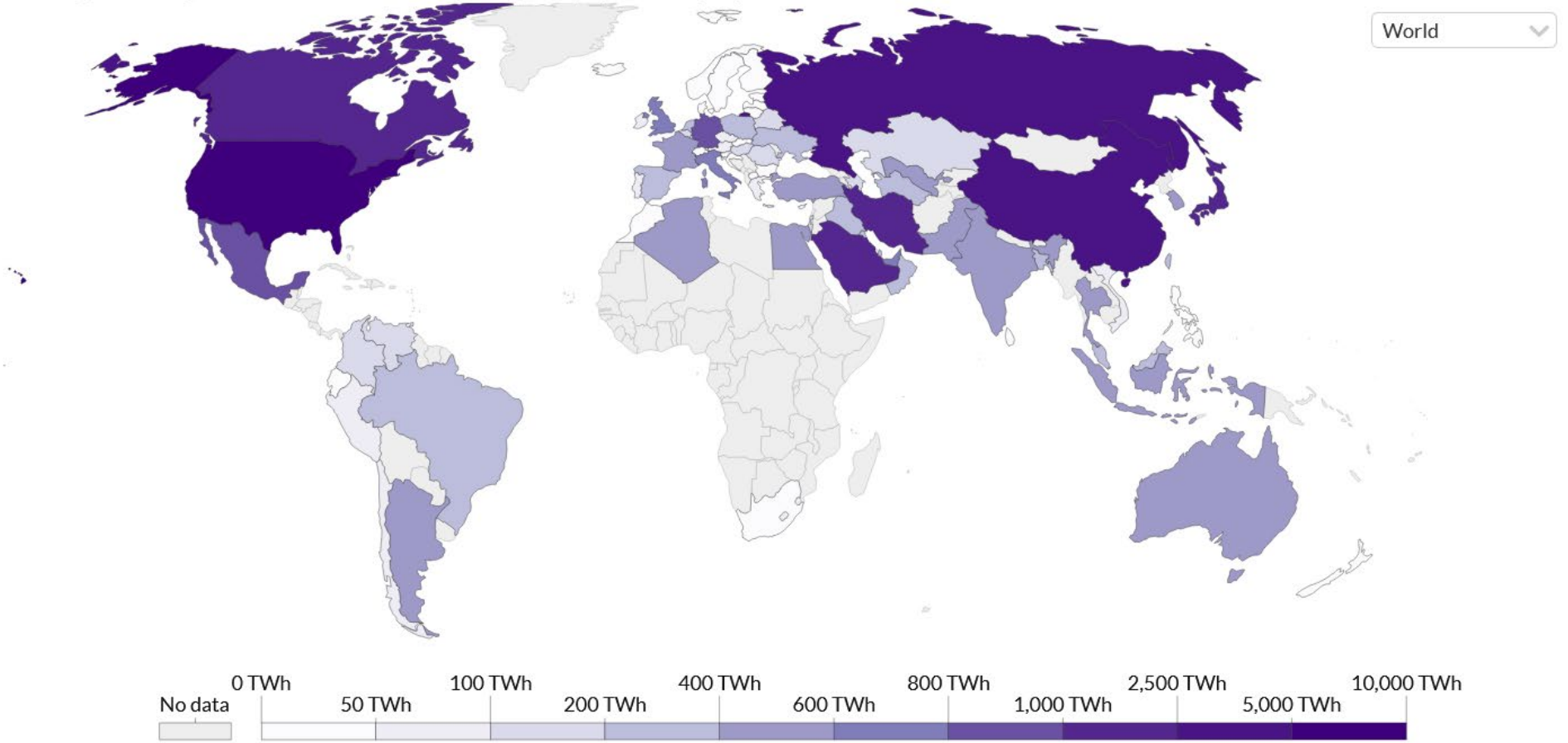
World



Source: BP Statistical Review of Global Energy

Gas consumption, 2020

Natural gas consumption is measured in terawatt-hour (TWh) equivalents per year.



Source: BP Statistical Review of Global Energy

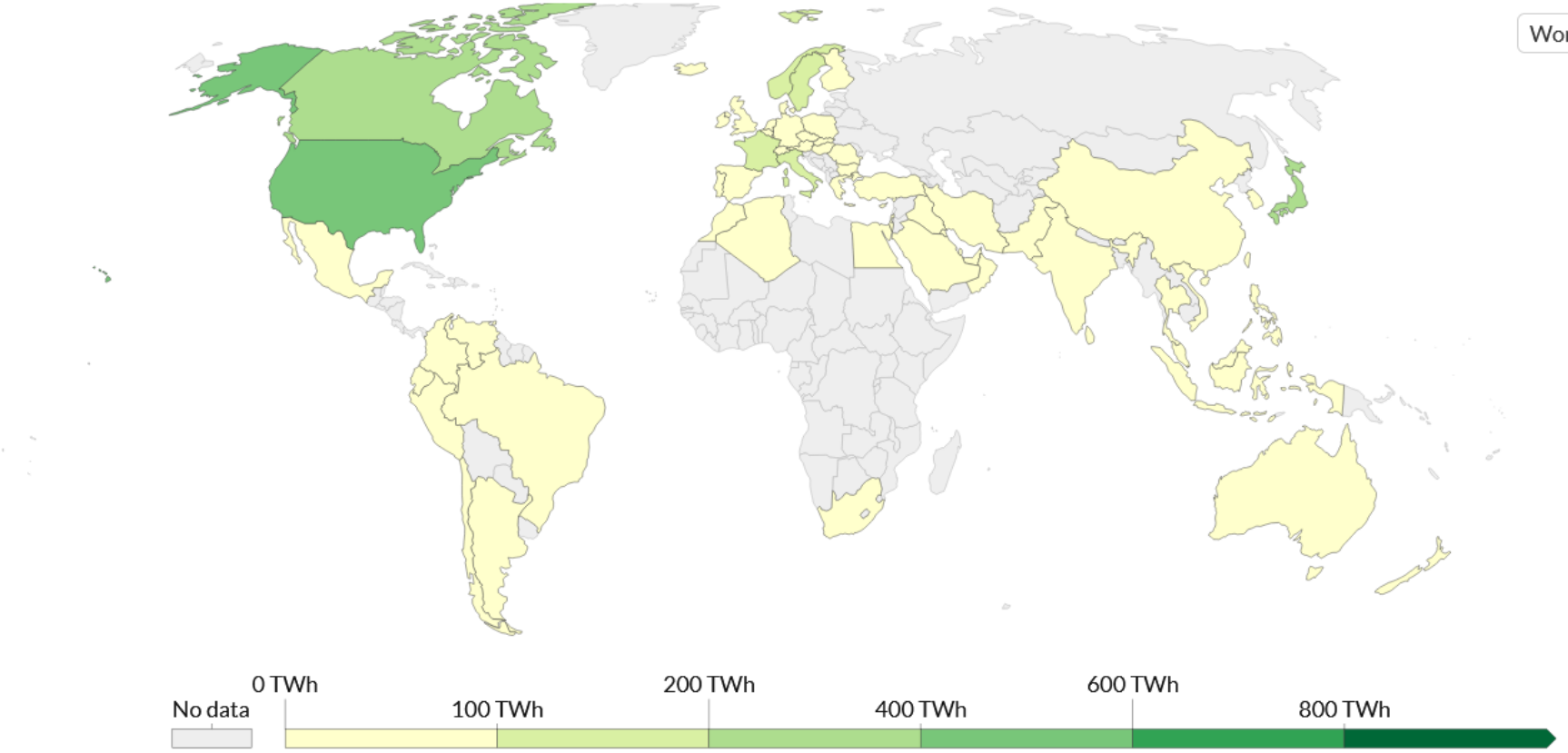
OurWorldInData.org/fossil-fuels • CC BY

Primary energy consumption from renewables, 1965

Our World in Data

Renewable energy includes hydropower, solar, wind, geothermal, wave and tidal and bioenergy. Traditional biofuels are not included. Energy consumption is based on primary energy equivalents, rather than final electricity use.

World



Source: Our World in Data based on BP Statistical Review of World Energy

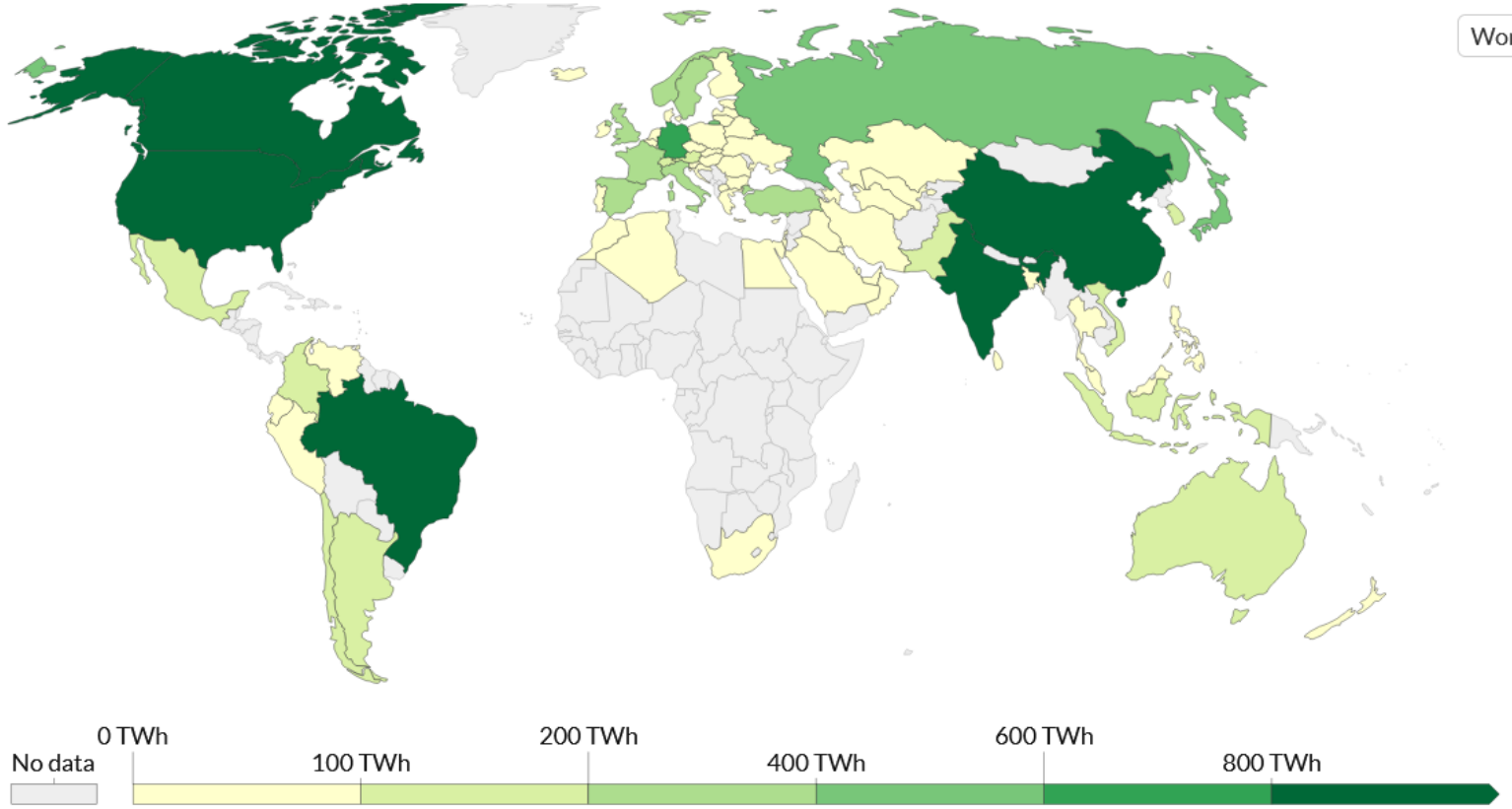
Note: 'Primary energy' refers to energy in its raw form, before conversion into electricity, heat or transport fuels. It is here measured in terms of 'input equivalents' via the substitution method: the amount of primary energy that would be required from fossil fuels to generate the same amount of electricity from renewables.

Primary energy consumption from renewables, 2020

Our World in Data

Renewable energy includes hydropower, solar, wind, geothermal, wave and tidal and bioenergy. Traditional biofuels are not included. Energy consumption is based on primary energy equivalents, rather than final electricity use.

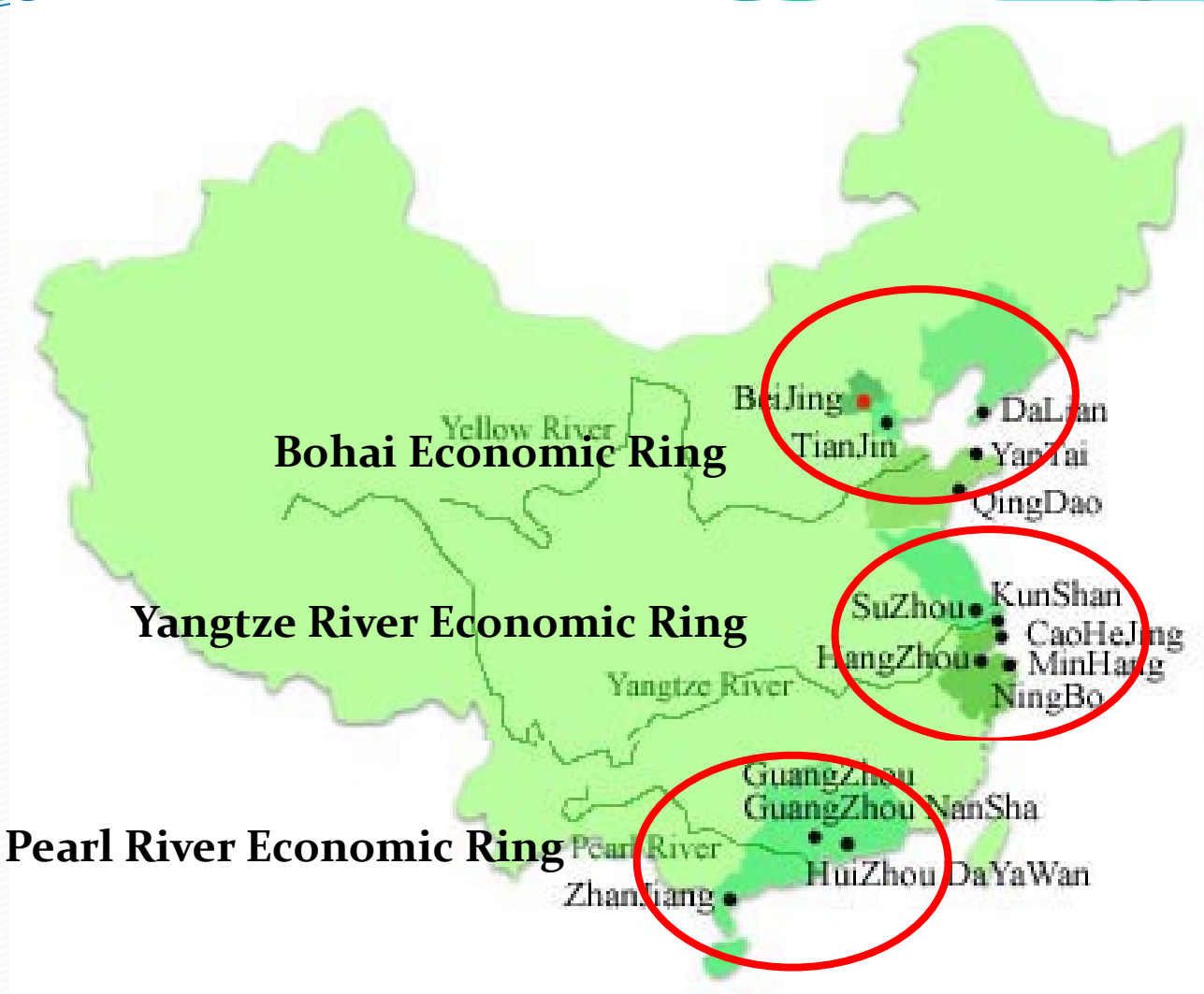
World



Source: Our World in Data based on BP Statistical Review of World Energy

OurWorldInData.org/energy • CC BY

Note: 'Primary energy' refers to energy in its raw form, before conversion into electricity, heat or transport fuels. It is here measured in terms of 'input equivalents' via the substitution method: the amount of primary energy that would be required from fossil fuels to generate the same amount of electricity from renewables.



> 500 plants

> 500 plants

> 100 plants

Galvanizing industry in China, 2020

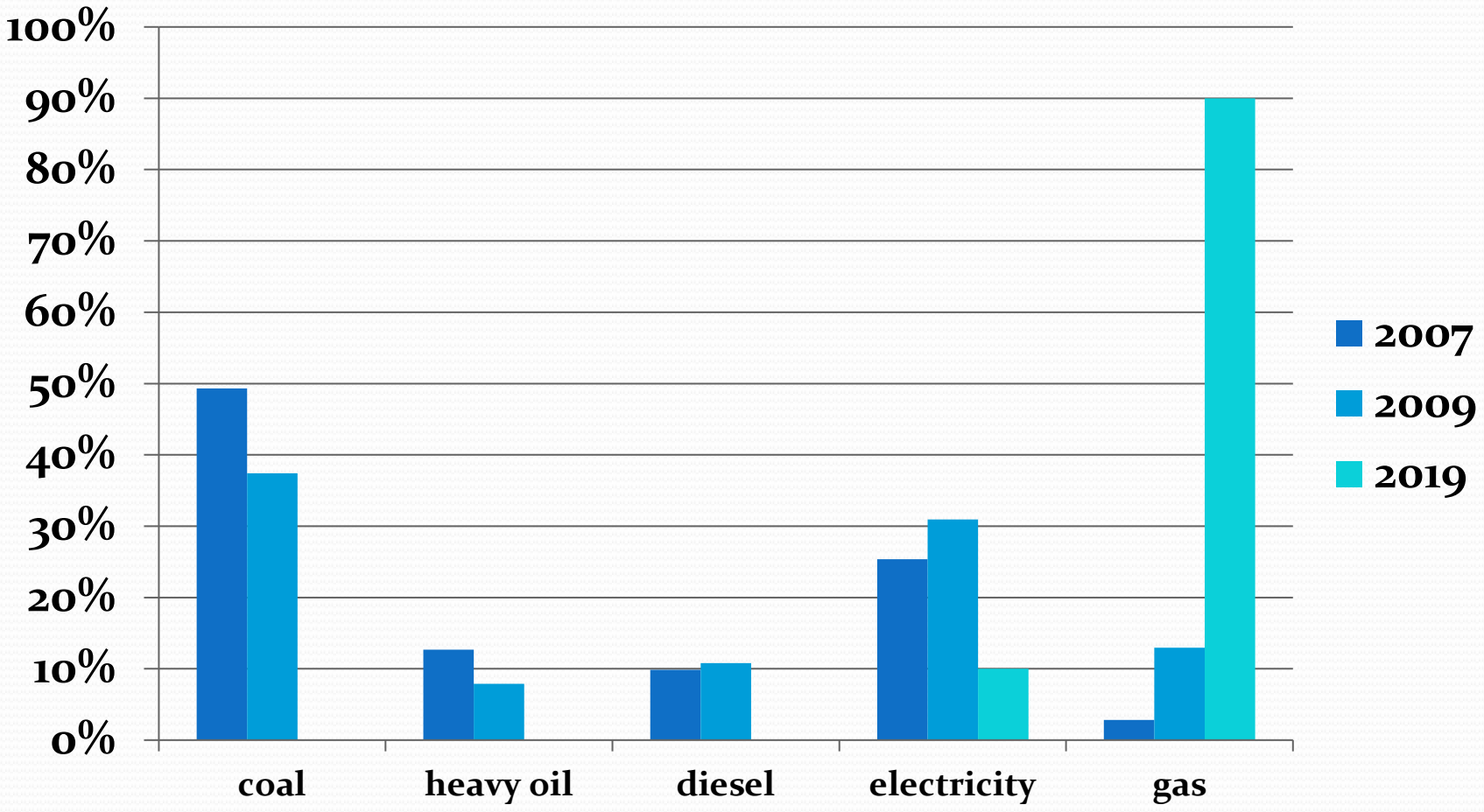
Galvanized steel	Capacity (million tonnes)	Production (million tonnes)	Average Zn pick-up (kg/tonne)	Zn consumption (million tonnes)
Sheet and coil	120	66	22	1.45
Steel structures	50	38	43	1.63
Pipe and tube	20	16	40	0.64
wire/mesh/ hardware	8	5	40	0.2

Some 55 million tonnes of fabricated steel was galvanized in China in 2020.
Overall, the consumption of Zn for all galvanizing = 3.92mt, nearly 60% of total Zn consumption.

What drove the move to gas?
(2010 numbers)

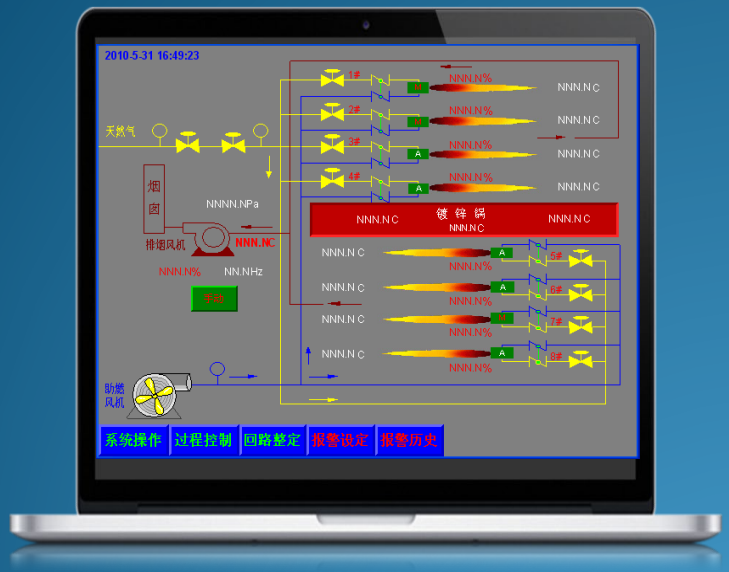
燃料类型 Fuel Type	温控/燃烧系统 Temperature / Combustion System	能耗（/吨镀件） Energy Consumption (/tons (galvanized pieces))	单价（元/吨或Nm³或KWh） Unit Price (Yuan/ton or Nm3 or KWh)	能源成本（元/吨镀件） Energy Cost (Yuan/ton (galvanized pieces))
煤 Coal	人工 Manual	100-130kg	800	80-104
水煤气 Water gas	人工 Manual	70-100kg	800	56-80
柴油 Diesel oil	自动/平焰 Automatic / flat flame	20-25kg	5000	100-125
重油 Heavy oil	人工 Manual	30-40kg	3000	90-120
天然气Natural gas	自动/高速脉冲燃烧 Automatic / high-speed pulse combustion	20-25Nm³	2.5	50-62.5
电 Electricity	自动 Automatic	110-130kWh	0.7	77-91

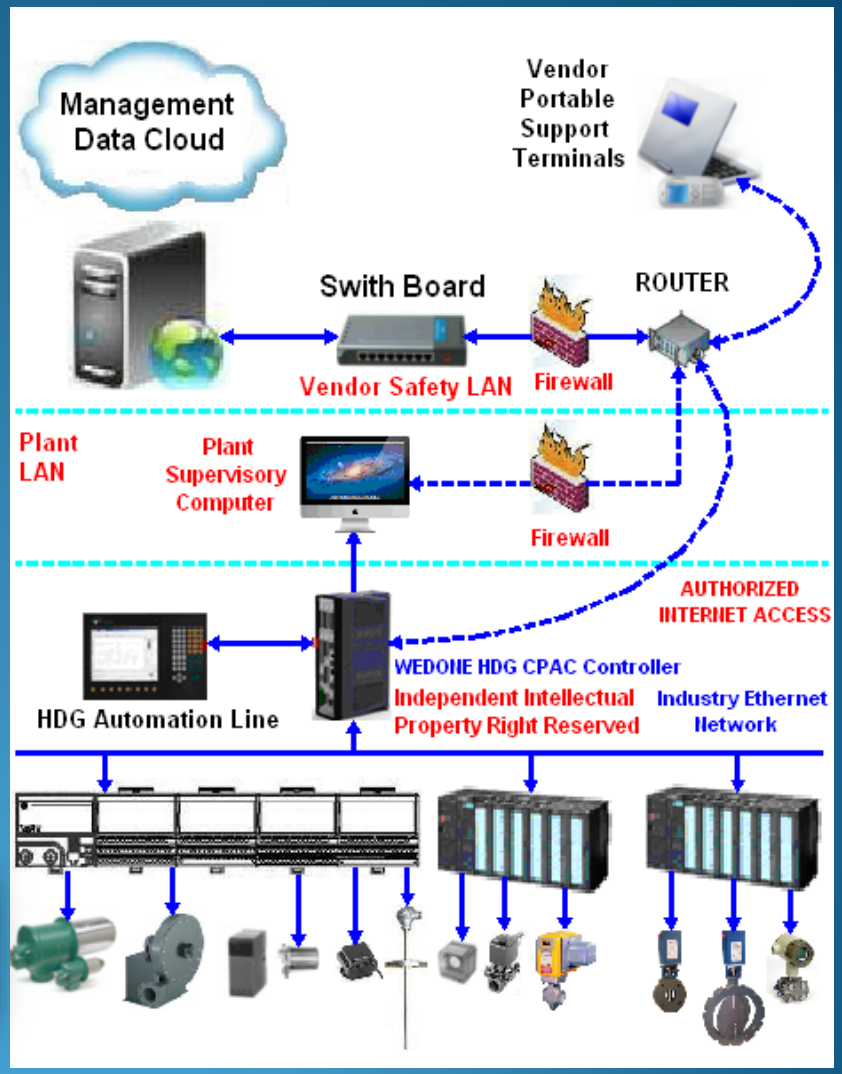
Changes in energy source HDG plants – China



The evolution of gas furnace technology in China since 2010

- **Before 2010, most furnaces:**
  - had no recirculation heat systems
  - used flat flame burners
  - used impulse burner heating
- **After 2010, the introduction of high velocity pulse fired (hvpf) burners enabled industry development and adoption of modern control systems.**





Smart Control System

City energy prices, average Jan-March 2022

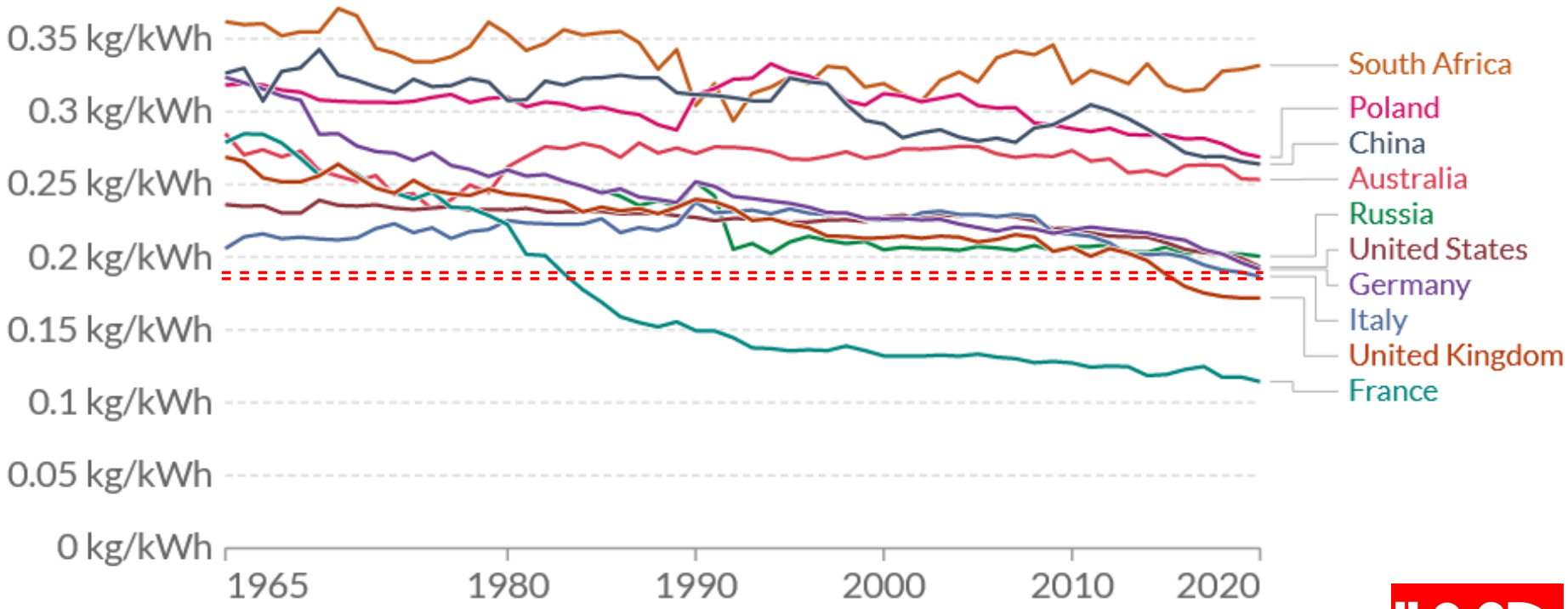
REGION	CITY	Natural gas price		Electricity price	
		￥/Nm³	$/KWh	￥/KWh	$/KWh
North West China	Xian	2.67	0.0403	0.608	0.092
	Yinchuan	1.95	0.0295	0.55	0.083
	Xining	1.95	0.0295	0.52	0.079
	Urumqi	2.25	0.0339	0.65	0.103
North East China	Shenyang	3.63	0.0548	0.665	0.1
	Changchun	3.06	0.0462	0.684	0.103
	Harbin	3.67	0.0554	0.632	0.955
North China	Beijing	3.22	0.049	0.7	0.105
	Tianjin	3.72	0.056	0.733	0.11
	Shijiazhuang	3.95	0.059	0.633	0.096
	Qingdao	3.42	0.0517	0.76	0.115
	Jinan	4.24	0.0641	0.72	0.109
	Houlhot	2.25	0.0339	0.65	0.098
Central China	Zhengzhou	2.6	0.0393	0.68	0.103
	Wuhan	3.09	0.0467	0.755	0.114
	Changsha	2.73	0.0412	0.81	0.122
East China	Shanghai	3.65	0.0551	0.86	0.13
	Hangzhou	4.82	0.0728	0.87	0.131
	Nanjing	3.56	0.0538	0.875	0.132
	Hefei	3.16	0.0477	0.73	0.11
	Xiamen	3.76	0.0568	0.76	0.115
South West	Chengdu	3.65	0.0551	0.6	0.091
	Chongqing	2.58	0.0389	0.71	0.107
South China	Guangzhou	4.36	0.0659	0.824	0.124
	Shenzhen	4.49	0.0678	0.8	0.121
	Nanning	3.55	0.0536	0.685	0.103
	Haikou	3.32	0.0501	0.69	0.104

Galvanizing Furnace Energy Consumption & Operation Cost

Energy Type	Energy Consumption per tonne	Energy Cost Per tone in $USD
Natural Gas Fired Furnace	15 ~ 20 Nm^3/tonne	7.5 ~ 10.0
	(Including flux heating)	
Electricity Heated Furnace	120 ~ 175 KWh/tonne	16.68 ~ 24.33
	(Including flux heating)	
Note:		
1. Energy Consumption included the heat required for flux heating		
Average price of natural gas:	0.499 USD/Nm^3	
Average price of industrial electricity:	0.139 USD/KWh	
2. Energy cost is based on average price of natural gas and industrial electricity in the end of last year in China		

Carbon intensity of energy production

Carbon intensity of energy production is measured as the quantity of carbon dioxide emitted per unit of energy production. This is measured in kilograms of CO_2 per kilowatt-hour.

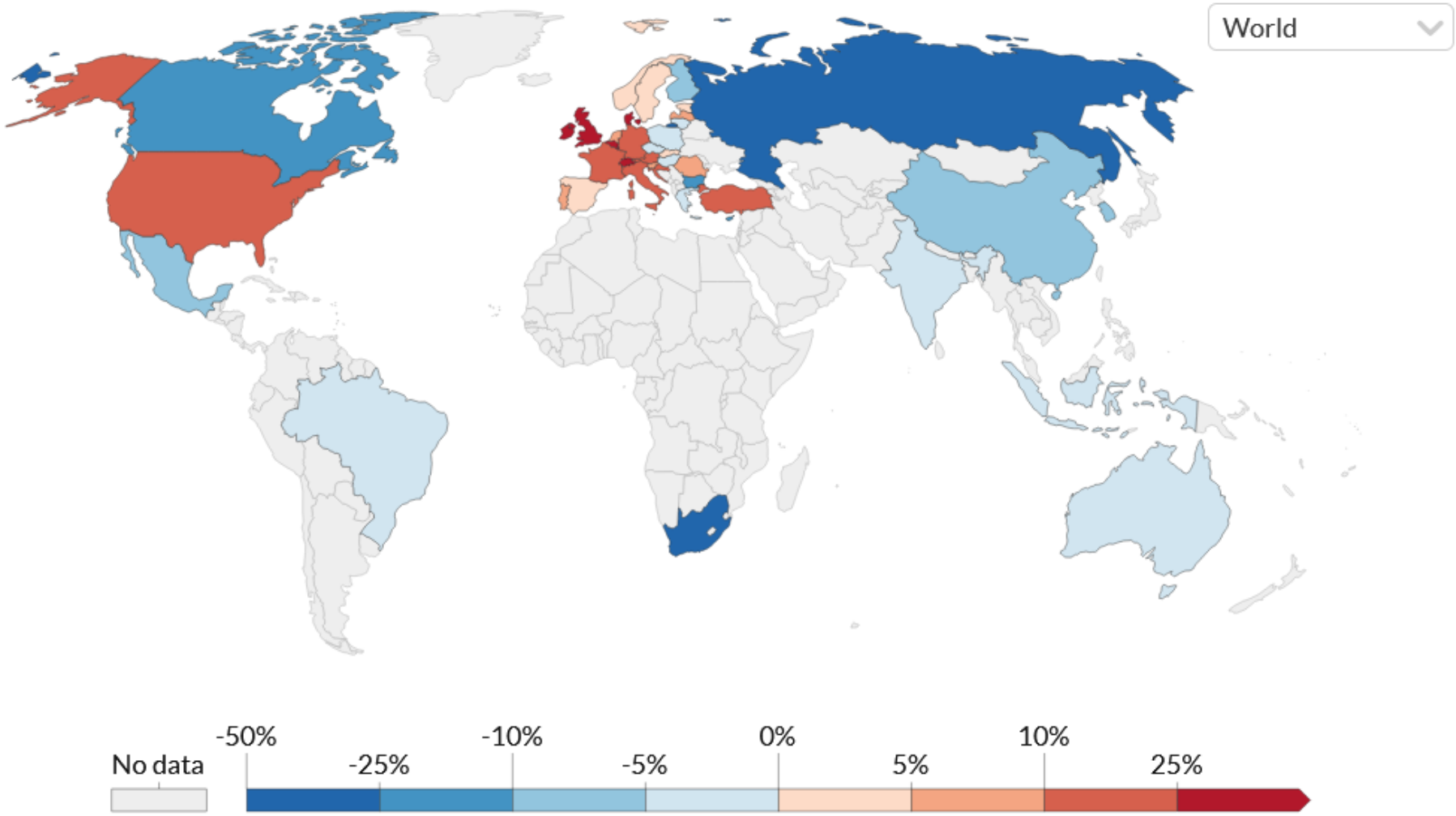


Source: Our World in Data based on the Global Carbon Project, BP and Shift Energy Data Portal

Energy embedded in traded goods as a share of domestic energy, 2020

Our World in Data

Net energy embedded in traded goods is the difference in energy embedded in exported goods, and imported goods. A positive value means that a country is a net importer; a negative means it's a net exporter. This is given as a percentage of a country's domestic energy use.



Source: Calculated by Viktoras Kulionis, based on the EXIOBASE v3.8.2 database

Conclusions

- The move to gas has significantly reduced the HDG CO_2 footprint in China and will continue to do so.
- Electrical energy usage will increase but gas will remain cost-effective and used for some time.
- The use of grid power does not necessarily reduce the carbon footprint of the galvanizing industry in China (and maybe some other countries), whereas ongoing improvements in gas furnace technology will.

Thankyou for listening!

Add: 上海浦东新区金新路58号银桥大厦701室
Apt.701, Yinqiao Building, No 58 Jinxin Road,
Pudong District, Shanghai, P. R. China
Tel: +86 21 5835 6625
Fax: +86 21 5102 6063
Email: info@wedonethermo.com
www.wedonethermo.com