UK Energy – a route to Net Zero?

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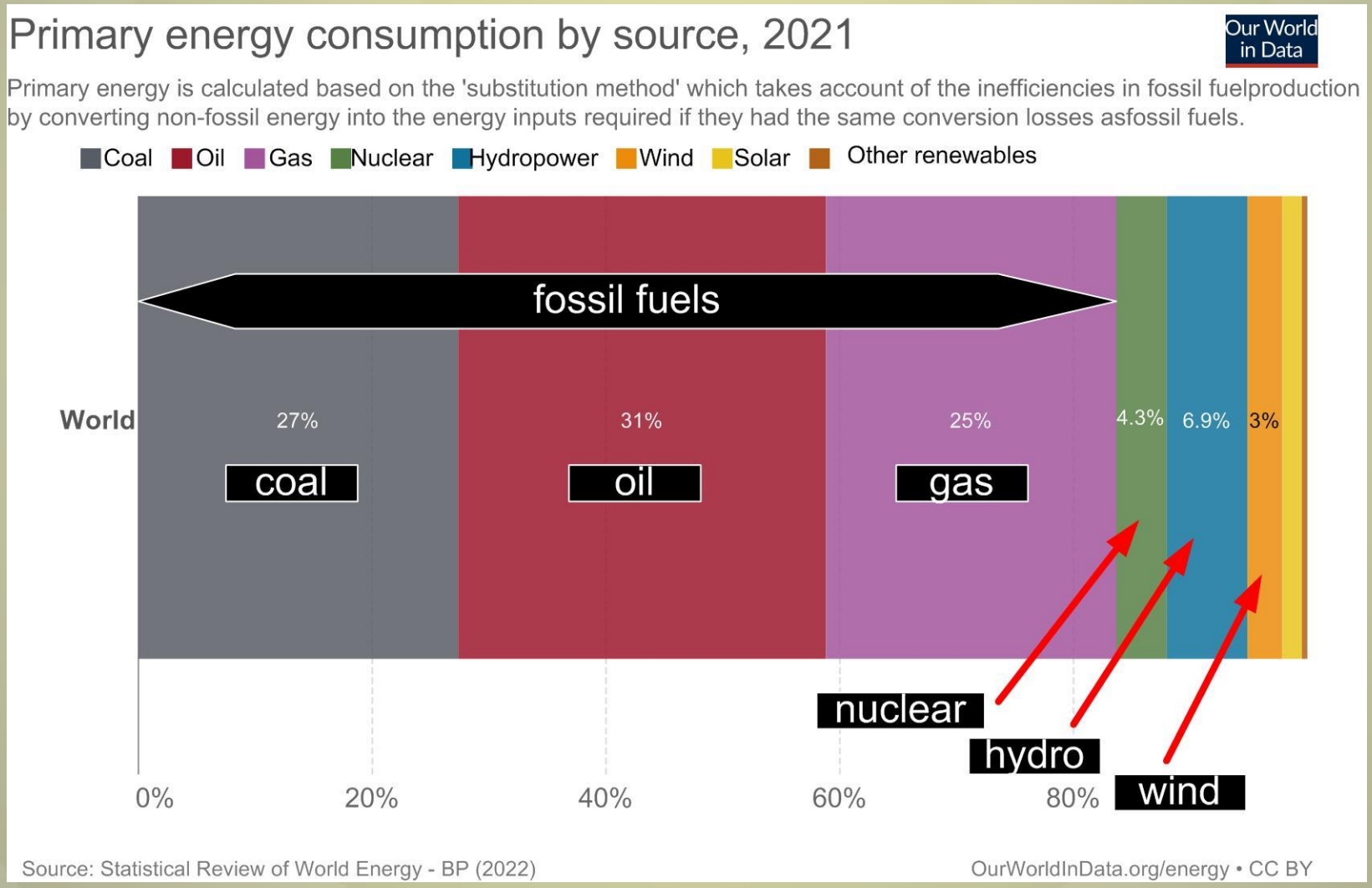
Context

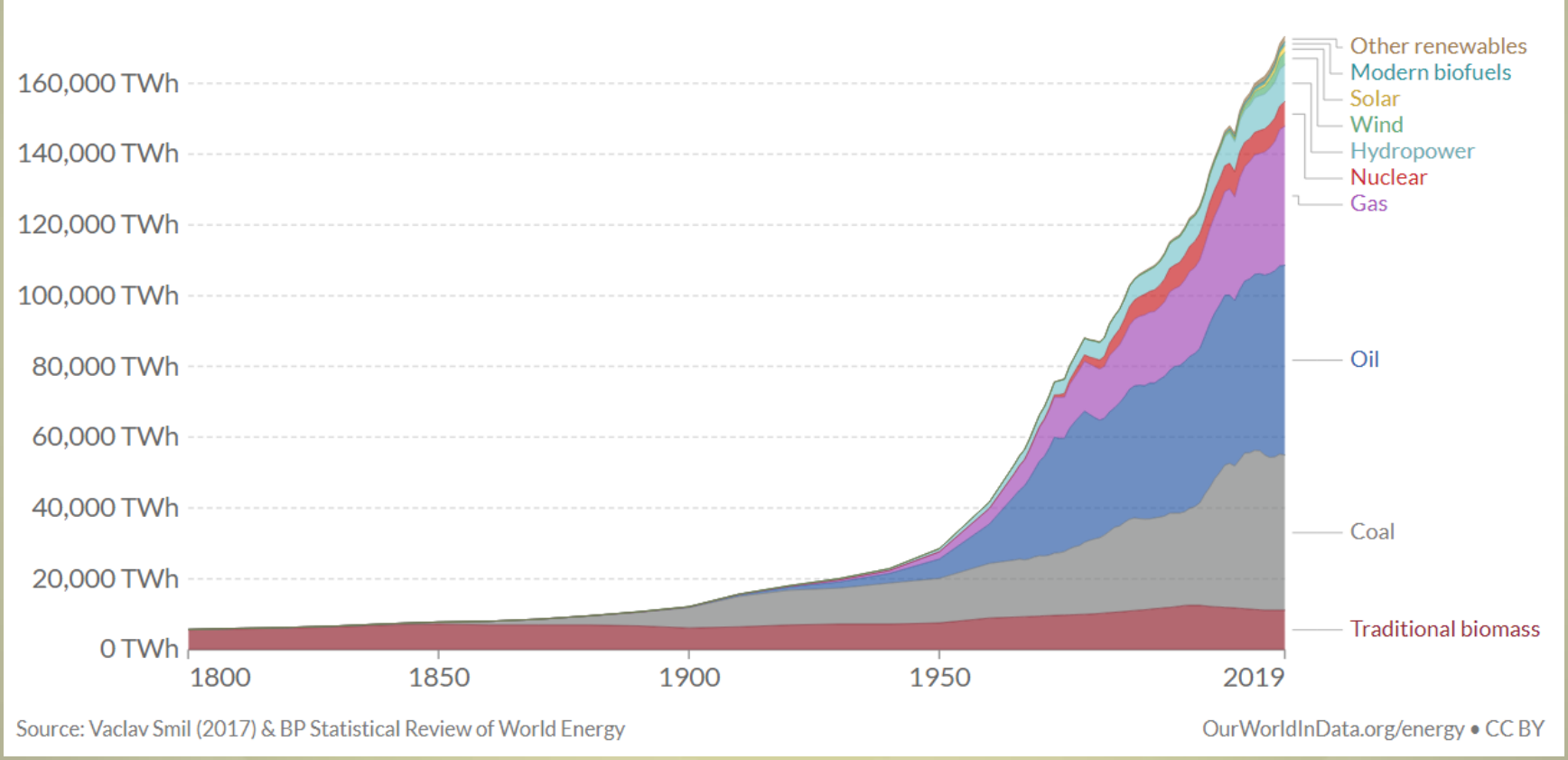
- Net Zero CO_2 emissions by 2050
  - Climate Change Act of 2008 modified in 2019
  - legally binding
- since 2019:-
  - 10 Point Plan
  - Net Zero Strategy
  - British Energy Security Strategy
- July 2022 High Court ruling:
  - the government's strategy for getting to net zero is inadequate and unlawful.

- **Climate & Energy**
- **UK Energy**
- **Energy Transition 2030**
- **Energy Transition 2040**
- **Nuclear Power**

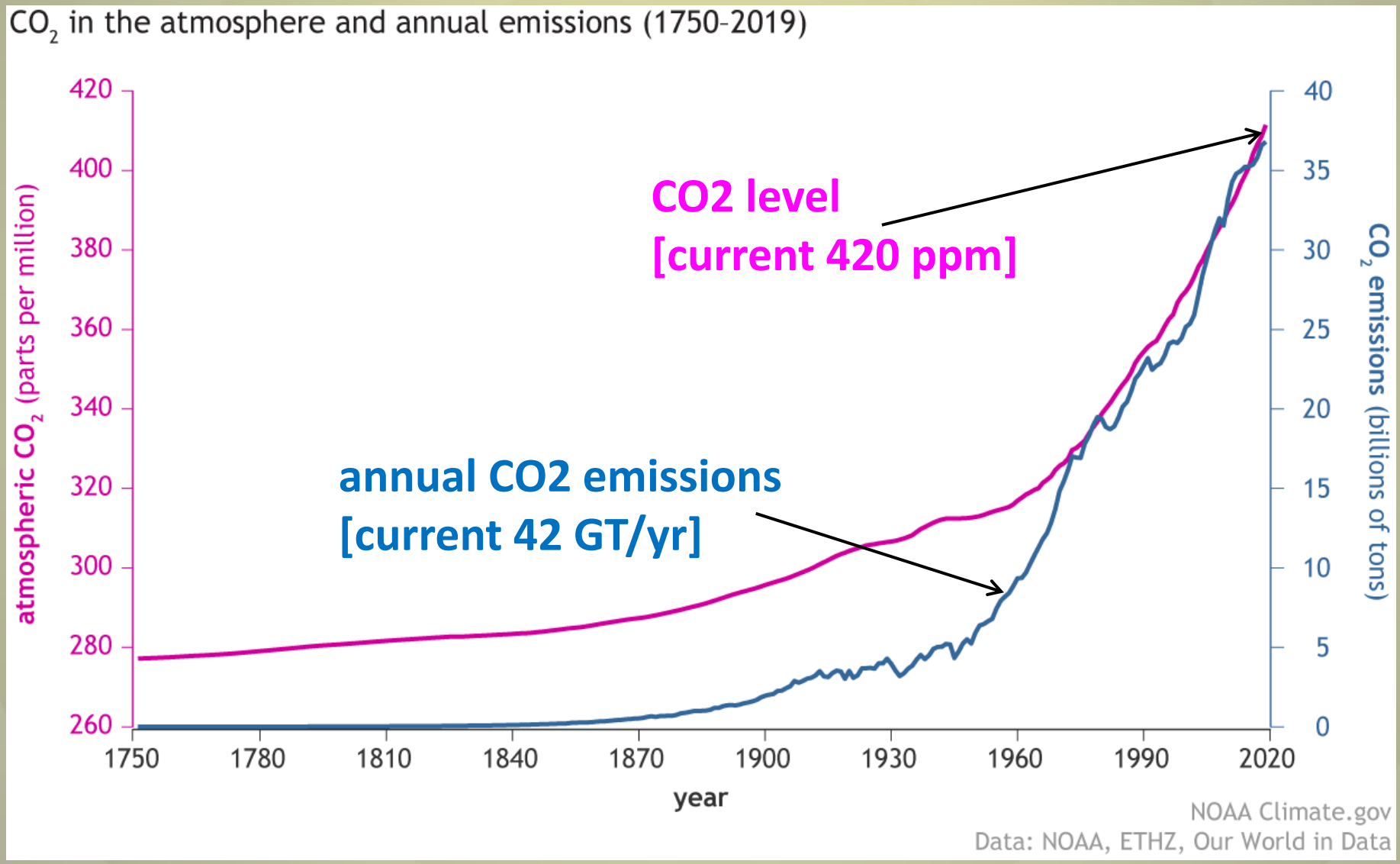
83% of world energy comes from **fossil fuels**



. . . and it's rising

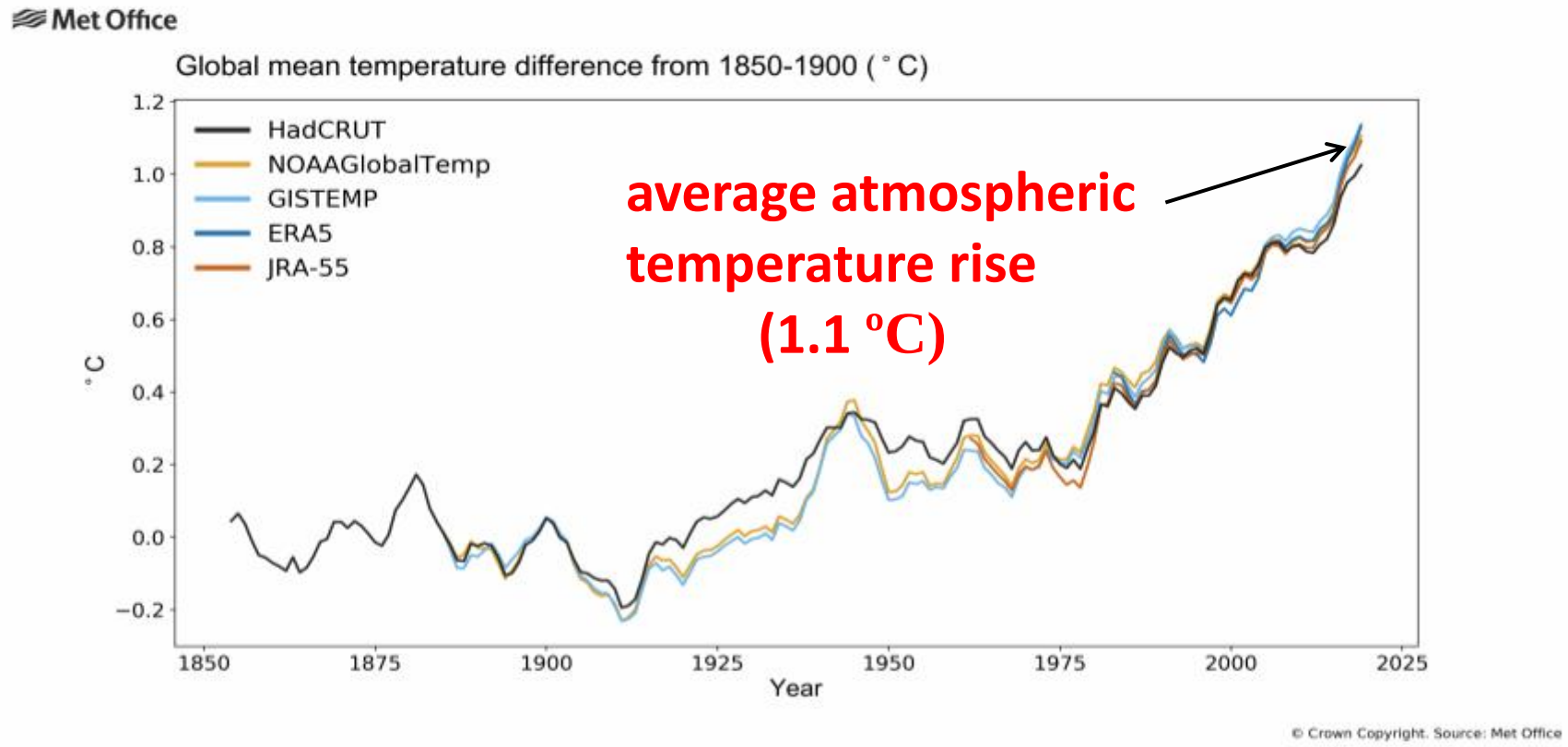


. . . and the resulting emissions



The Atmosphere

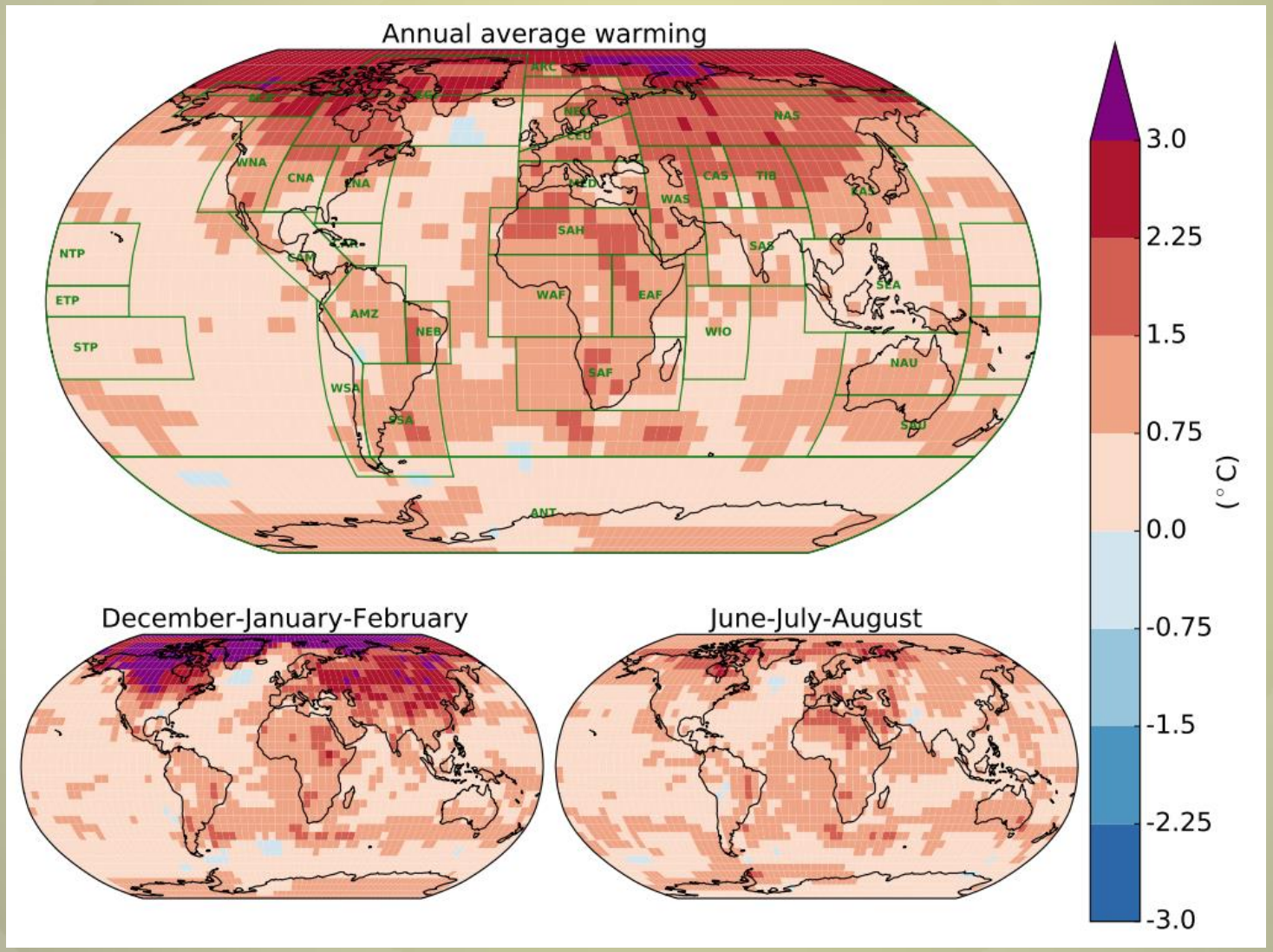
. . . leading to global heating



Five-year running average of global temperature anomalies (relative to pre-industrial) from 1854 to 2019 for five data sets: HadCRUT.4.6.0.0, NOAAGlobalTemp v5, GISTEMP v4, ERA5, and JRA-55. Data for 2019 to June

1ºC is not very much ??

- rise is not uniform – arctic heat



Tipping Points

- Polar icecaps + Greenland melting -> less reflection -> more heat -> more melting. Glacier foundations loosening.

  Antarctic currently losing 500,000 tonnes / minute
  Greenland averaging loss at 1,000,000 tonnes/min

- Siberian permafrost melting -> methane release -> zombie fires -> less reflection -> more heat.

- Rain forest loss -> less rain -> more heat -> dying forest -> fire -> savannah -> desert.

- Conveyor (Gulf Stream) collapse -> huge changes in climate distribution.

➢ tipping points linked -> could lead to cascade

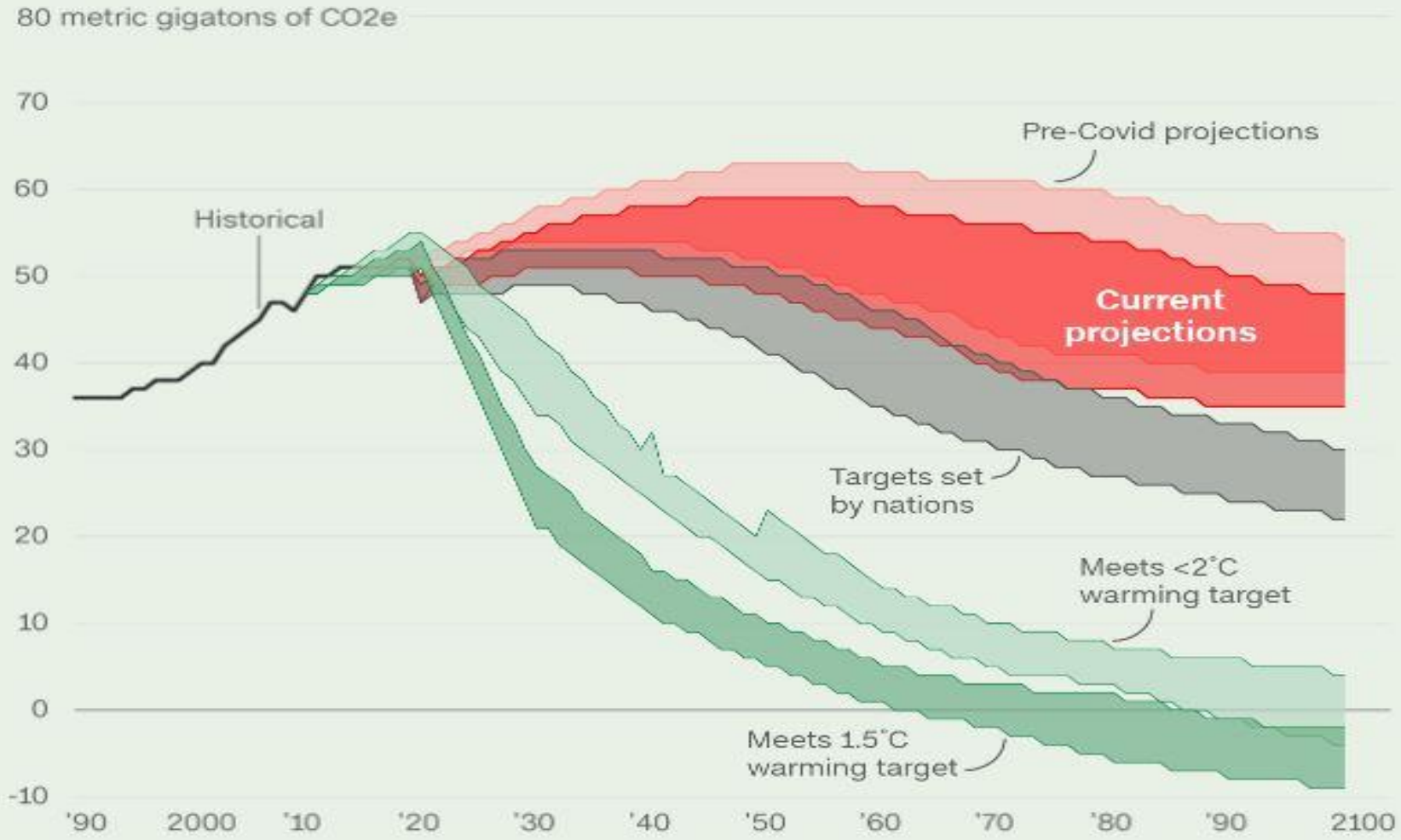
IPCC 2018 - 1.5ºC Report

[International Panel on Climate Change]

- to avoid uncontrolled run away we must limit temperature rise to less than 1.5ºC
- to have even a 2/3 probability of achieving this we must limit our TOTAL AND FOREVER global CO_2 emissions to less than **570 Gigatonnes** (from 2018)
- yet we are currently emitting at **42** GT per year and rising (UK emits 0.4 GT per year)
- **to achieve this we have to drop our global emissions by 10% every year**
  - **we are required to drop emission by 60% by 2030**
  - **and to net zero by 2050**

Global greenhouse gas emissions

Projected CO2 emissions are still much higher than they need to be to limit warming to below 2°C above pre-industrial levels.



Note: Historical emissions and current projections exclude land use, land use change and forestry.
More information on methodology can be found at climateactiontracker.org

Source: Climate Action Tracker

CNN article Sept 2020

Fossil Fuels have allowed humans to grossly overreach environmental sustainability

- we must de-carbonise
- we must rein in profligate consumption
- we must reverse environmental degradation

  - BUT, we still need ENERGY for:
    - heating/cooling/cooking
    - food production, storage, distribution
    - water and waste treatment and transmission
    - essential services
    - manufacturing & transport : including:
    - transition to low carbon infrastructure
    - leisure & pleasure (the arts; culture; love-miles)

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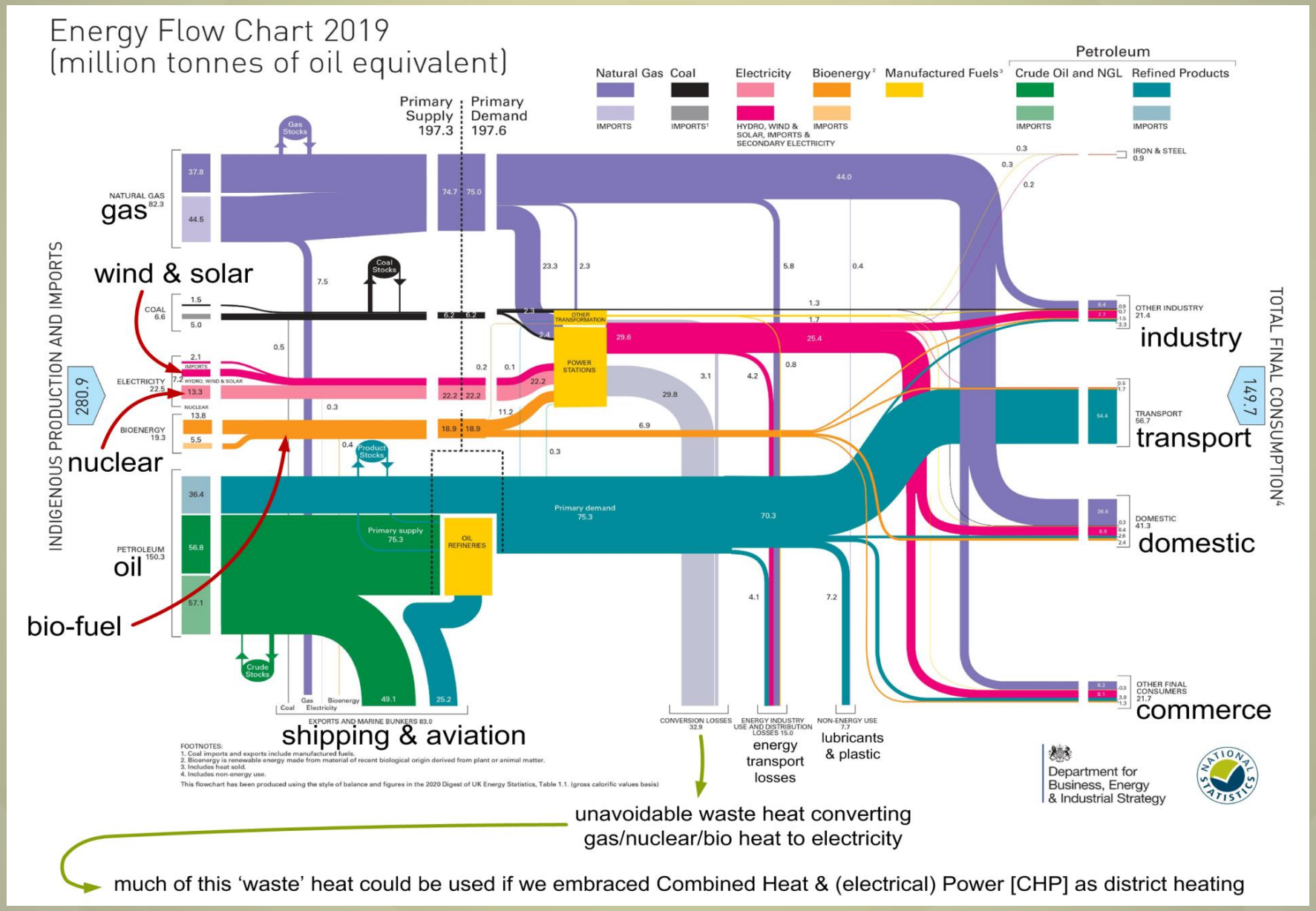
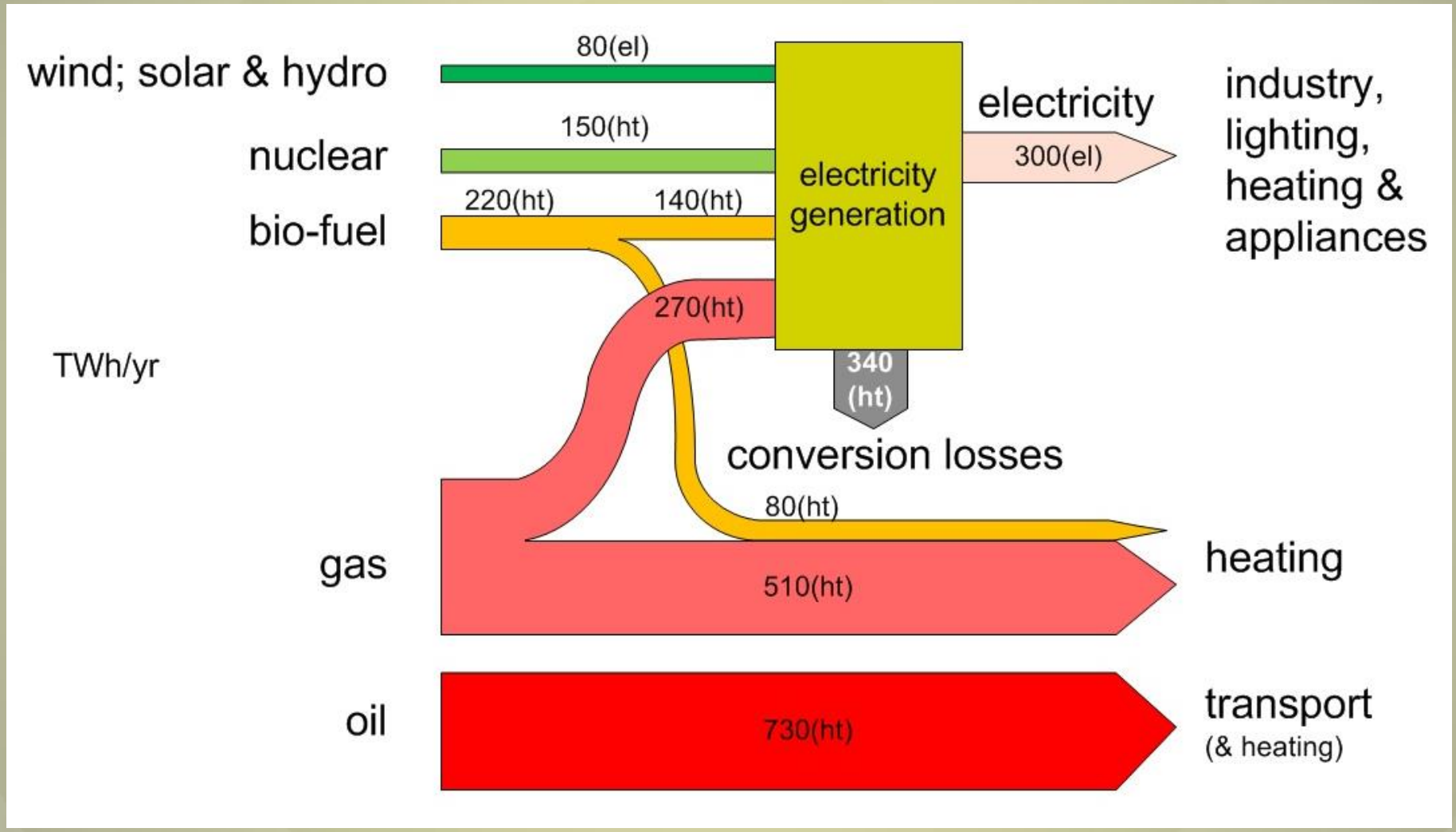
UK Energy Use



unavoidable waste heat converting gas/nuclear/bio heat to electricity

much of this 'waste' heat could be used if we embraced Combined Heat & (electrical) Power [CHP] as district heating

UK Current Energy Use (simplified)



UK Oil ; Gas ; Bio-mass use currently emits **370 MTonne** CO_2 per year

UK Energy transition since 1990

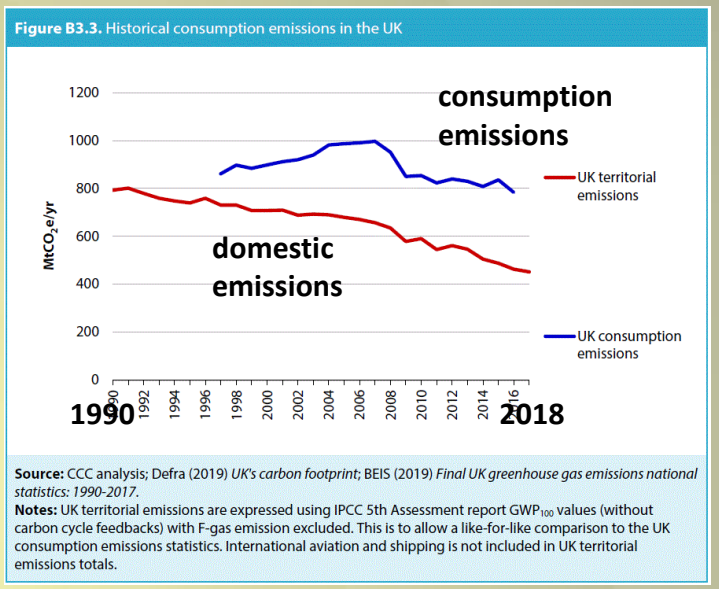
	1990	2019
• oil	40%	37%
• gas	22%	36%
• coal	30%	1%
• solar/wind/hydro	1%	9%*
• nuclear	7%	7%
• bio-mass/fuel	0%	10%
➢ energy use [TWh/yr]	2500	2200 [-13%]

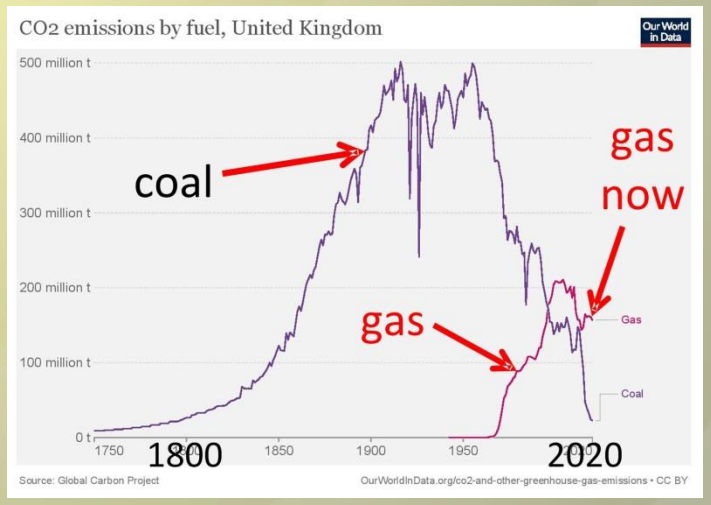
* uplifted for electricity being higher energy value

UK CO_2 Reductions - Claims v. Reality

- Claim : 48% reduction since 1990
  - but this ignores off-shoring of industry & increase in imports
- Reality : 22% reduction since 1990

- this 22% reduction is mainly due to transition Coal –> Gas
  - gas has lower emissions for same energy (CH_4)
  - gas is used at higher efficiency





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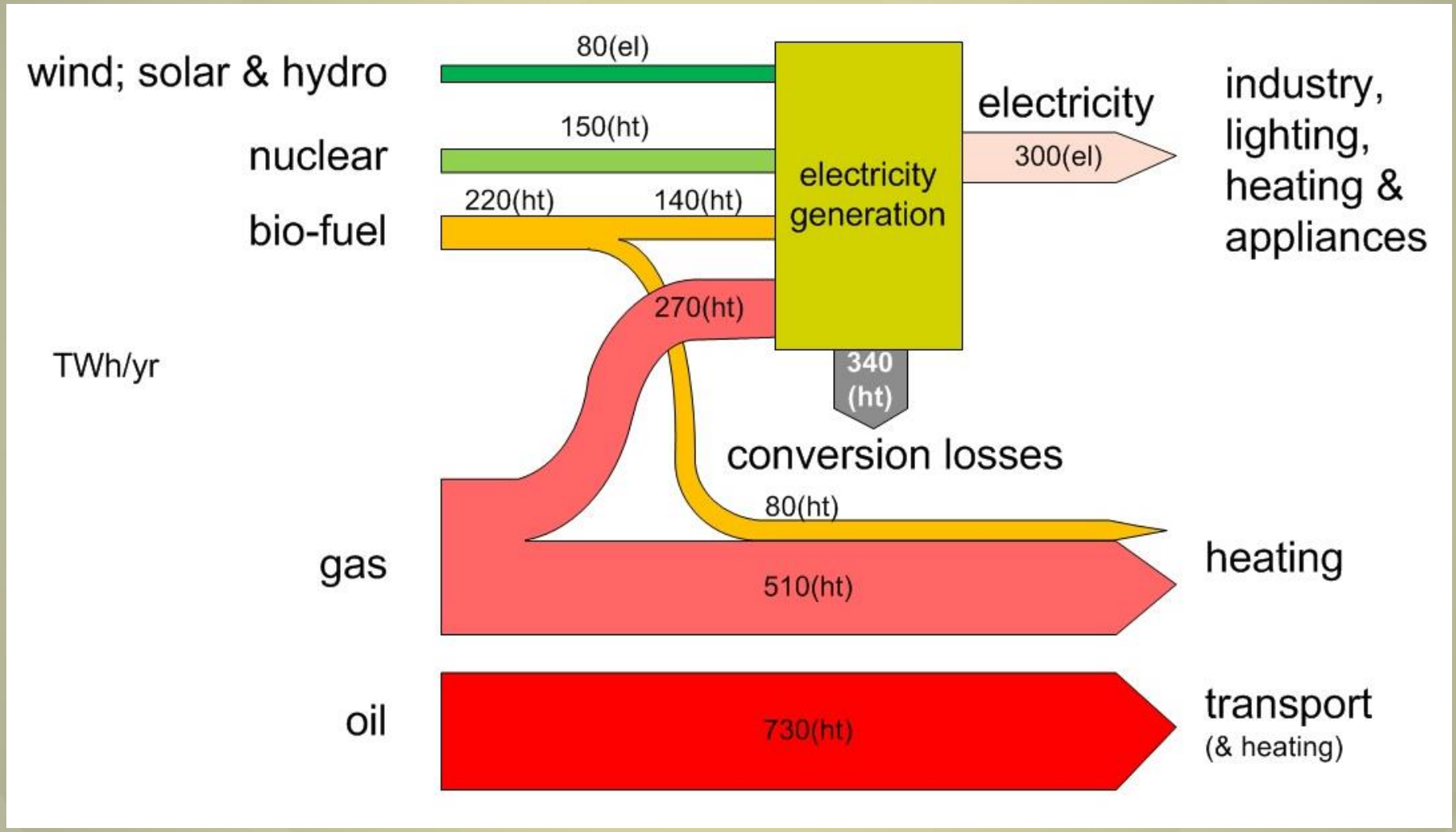

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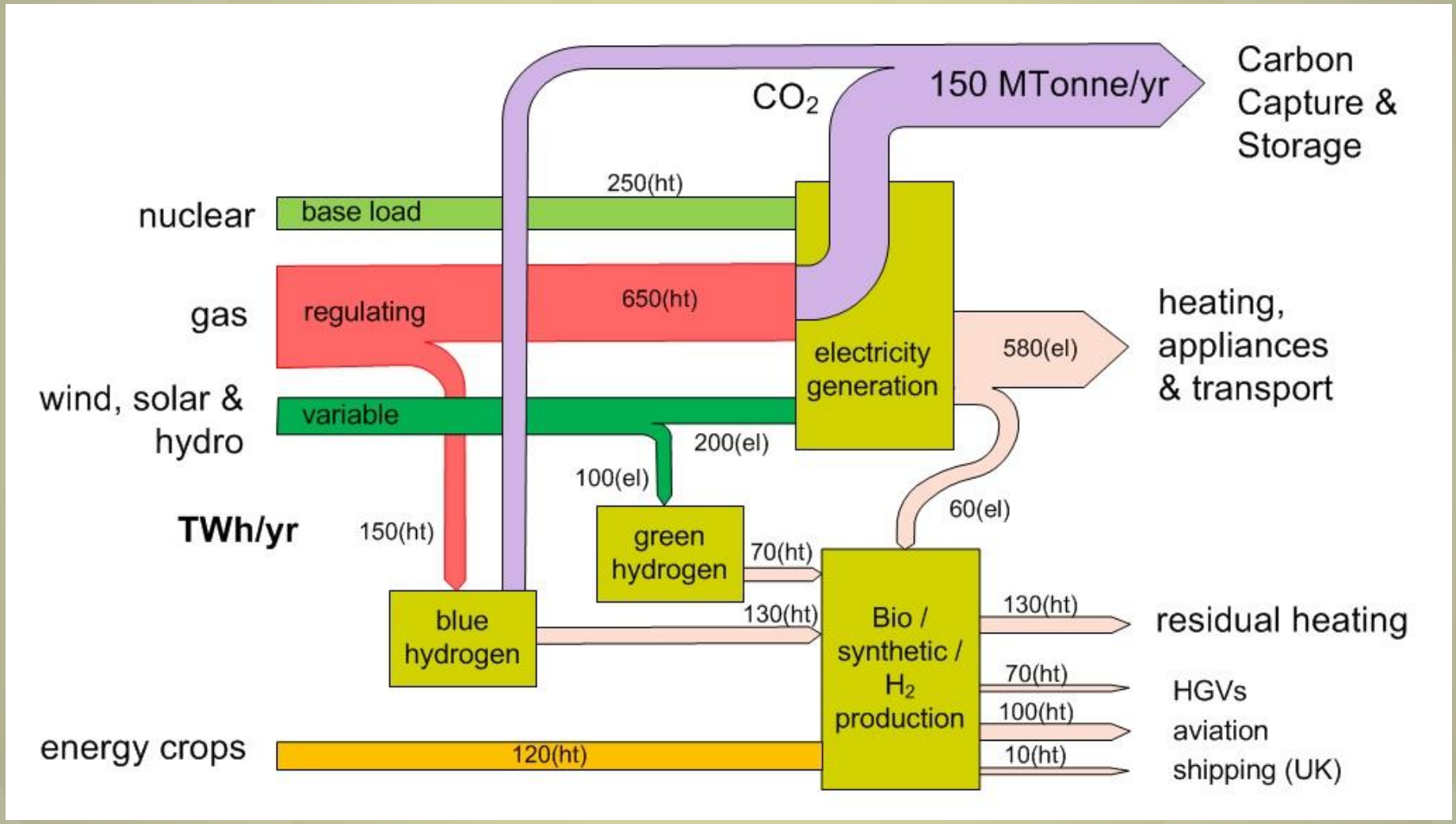
Energy Transition Scenario

Sector	CURRENT		TRANSITIONED		TRANSITIONED + SAVINGS	
	Fossil/bio fuels TWh(ht)/yr	Electricity TWh(el)/yr	Synthetic / bio / H2 direct fuels TWh(ht)/yr	Electricity TWh(el)/yr	Synthetic / bio / H2 direct fuels TWh(ht)/yr	Electricity TWh(el)/yr
Domestic	375	103	112	275	79	192
Industrial	167	92	38	365	23	219
Commercial	158	94	47	166	28	100
Transport						
Cars	272		0	67	0	47
LGV/bus	89		0	26	0	26
HGV	97		97	19	68	14
Rail	9	6	13	10	13	17
UK Sea	11		11	2	8	2
UK Air	173		173	35	95	19
Totals	**1,350**	**295**	**492**	**966**	**314**	**636**
			63% drop cf. current	**triple electricity use**	**77% drop cf. current**	**double electricity use**

Energy Transition

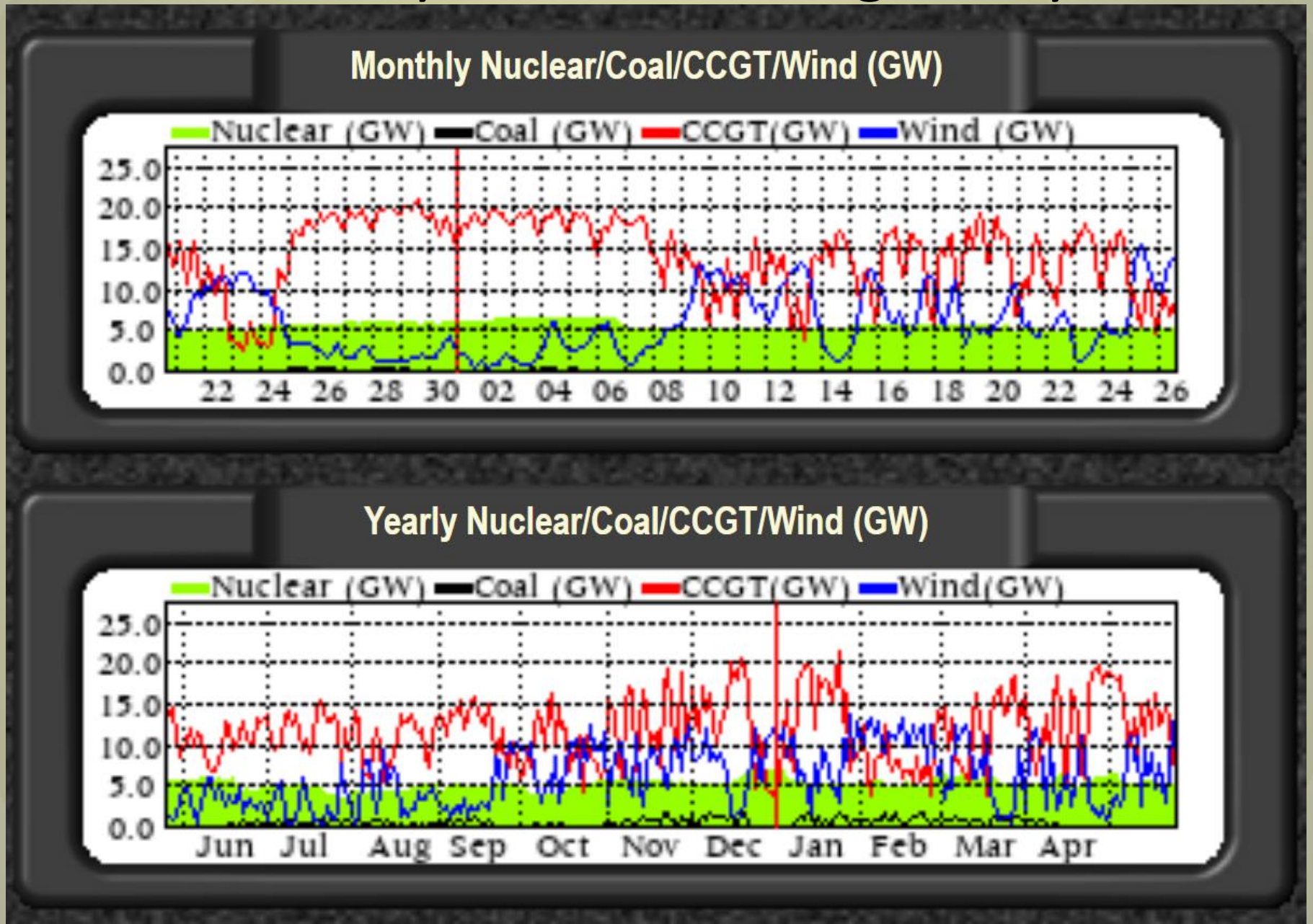
- **transfer 70% to Electricity**
  - **electric vehicles ; heat pumps**
- remaining 30% energy to come from fuels:
  - synthetic ; bio-fuel ; hydrogen
- and apply energy saving { say -30% }
  - INSULATE ; travel less & slower ; smaller, more efficient cars ; buy local ; repair & re-use ; public transport

Short Term Transition



UK currently emits **370 MTonne** $C0_2$ per year

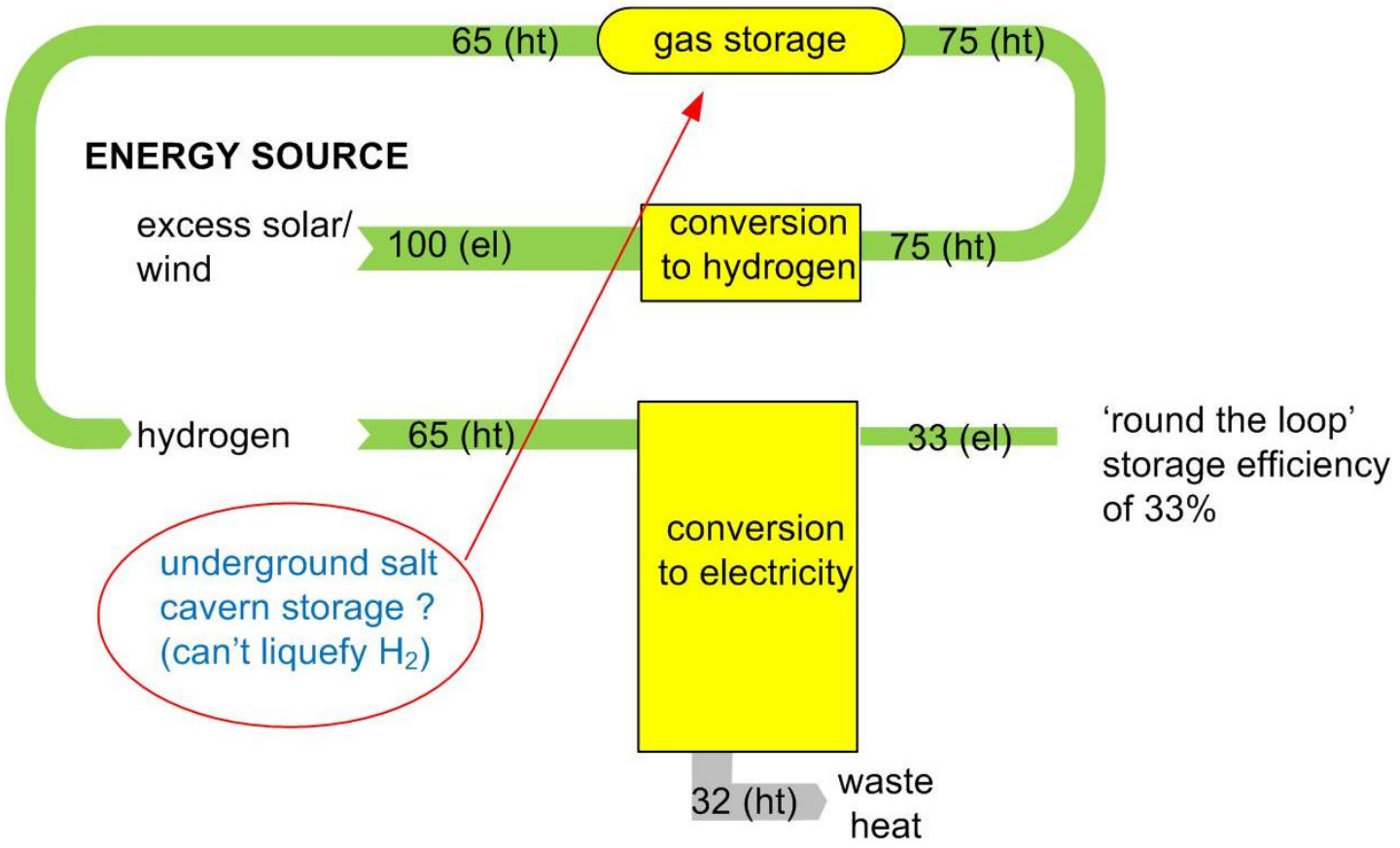
UK Electricity Generation Log – May 2022



Storing Electricity?

- **generation must match demand at all times**
- there is no energy storage in the grid
- can we convert & store:-
  - hydro pumped storage - ‘peak shaving’
  - batteries - minutes
  - synthetic fuels - use for heat/transport
  - hydrogen - use for heat (difficult to store)

Electricity ‘Storage’ Efficiencies



Notes: 1. arbitrary units of energy used ; 2. (el) = electrical energy ; (ht) = heat energy

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Longer Term Transition

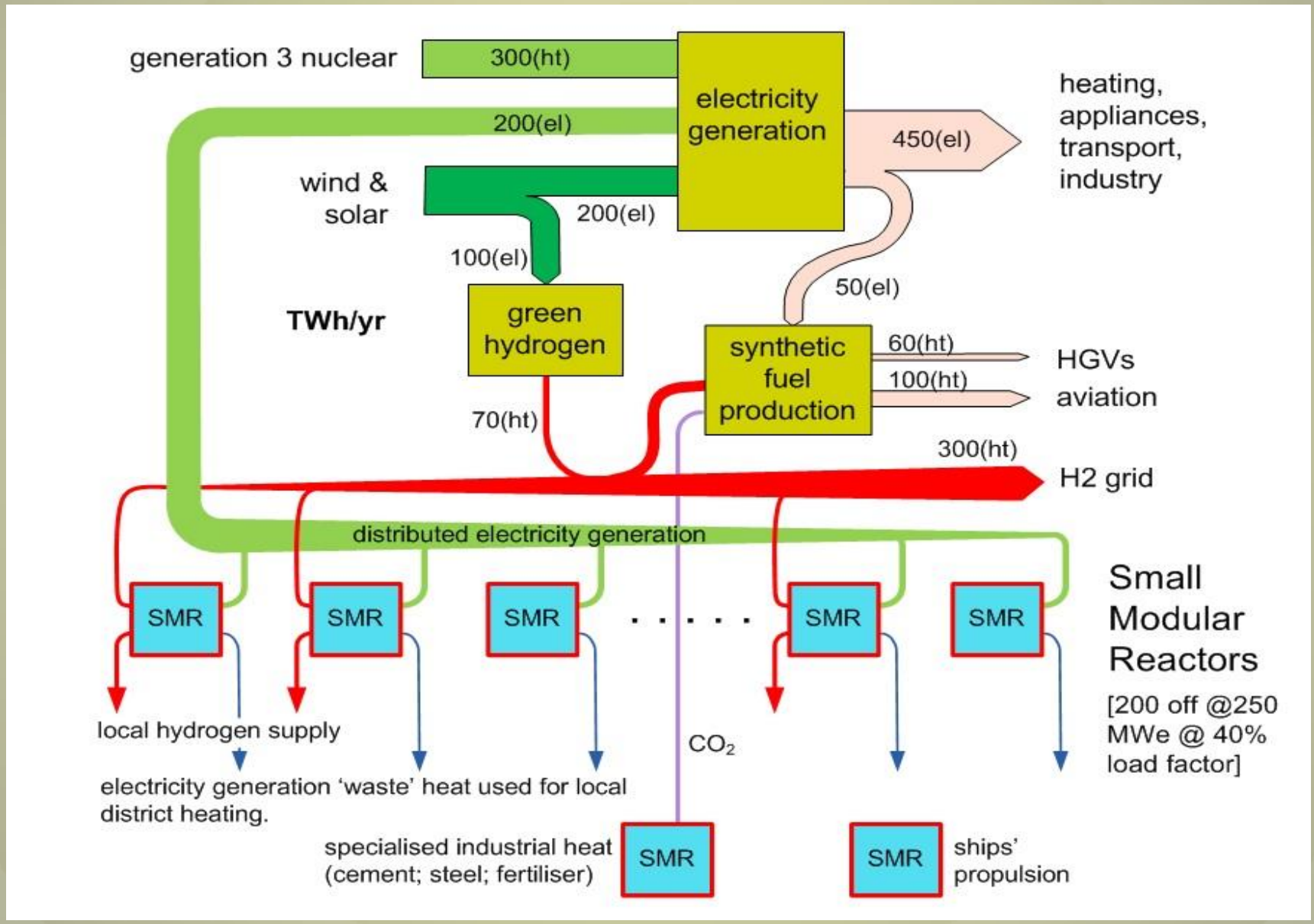
In addition to:

- increasing wind capacity by 4 X from current
- doubling conventional nuclear
- smart grid

Develop, manufacture & roll out in bulk

- Small Modular Reactors (SMRs)
  - intrinsically safe
  - factory built
  - fast breeder type
  - waste consuming
  - CHP (combined heat & power)
  - hydrogen producing

Longer Term Transition



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Main Reactor Types

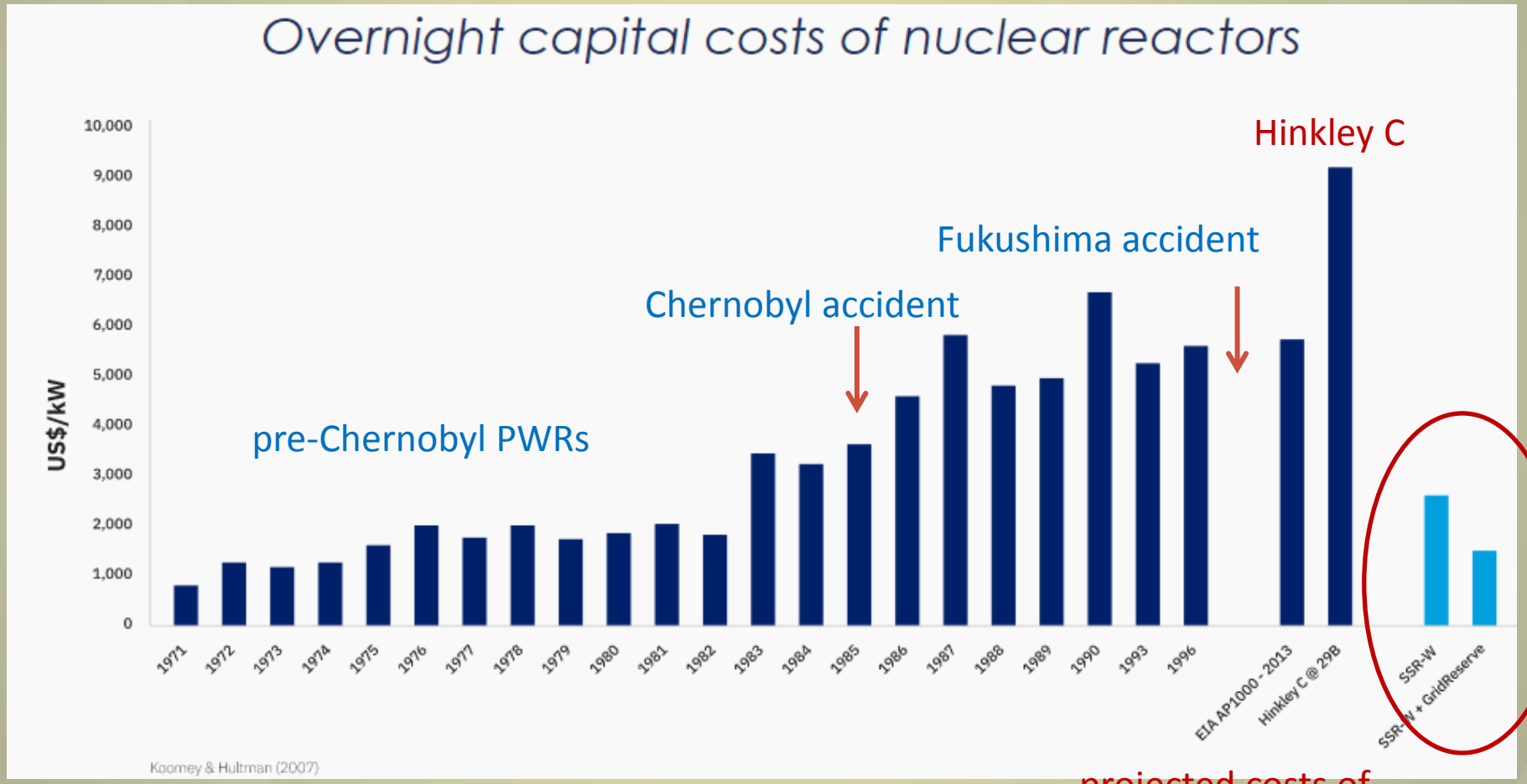
- AGR (Advanced Gas Reactor)
  - graphite moderated ; CO_2 cooled ; medium pressure ; high thermal efficiency ; U_{235} ; active safety systems
- PWR (Pressurised Water Reactor)
  - water moderated ; water cooled ; high pressure ; low thermal efficiency ; U_{235} ; active safety systems
- SMR (Small Modular Reactor)
  - several types: factory built and serviced cassette reactors ; low cost ; fast delivery
  - particular interest : Molten Salt Reactors

Molten Salt SMR Characteristics

- intrinsically safe
  - passive safety : i.e. does **not** require active safety systems.
  - uses passive residual heat removal : i.e. does **not** requiring electrical supplies.
  - self power regulating: i.e. does **not** requiring control rods.
  - fuel unusable for military purposes (anti-proliferation).
- wide fuel range
  - uses (plentiful) 'depleted' U_{238} or plutonium or thorium
  - 'burns up' old stored high level waste
- high temperature
  - high thermal efficiency
  - direct conversion of water to H_2

- fast modulating
  - can react quickly to load demand changes
  - (may use thermal salt store)
- low cost
  - factory built
  - cost effective even at low load factor (thermal store)
- fast delivery
  - factory built ; simple, low pressure fabrication
  - BUT, only after a lengthy licensing and prototype cycle
- Examples
  - Moltex – New Brunswick Power, Canada https://www.youtube.com/watch?v=V8ApH-0YHkA
  - Thorcon – Indonesia project https://www.youtube.com/watch?v=oB1IrzDDI9g

Capital Cost of Nuclear



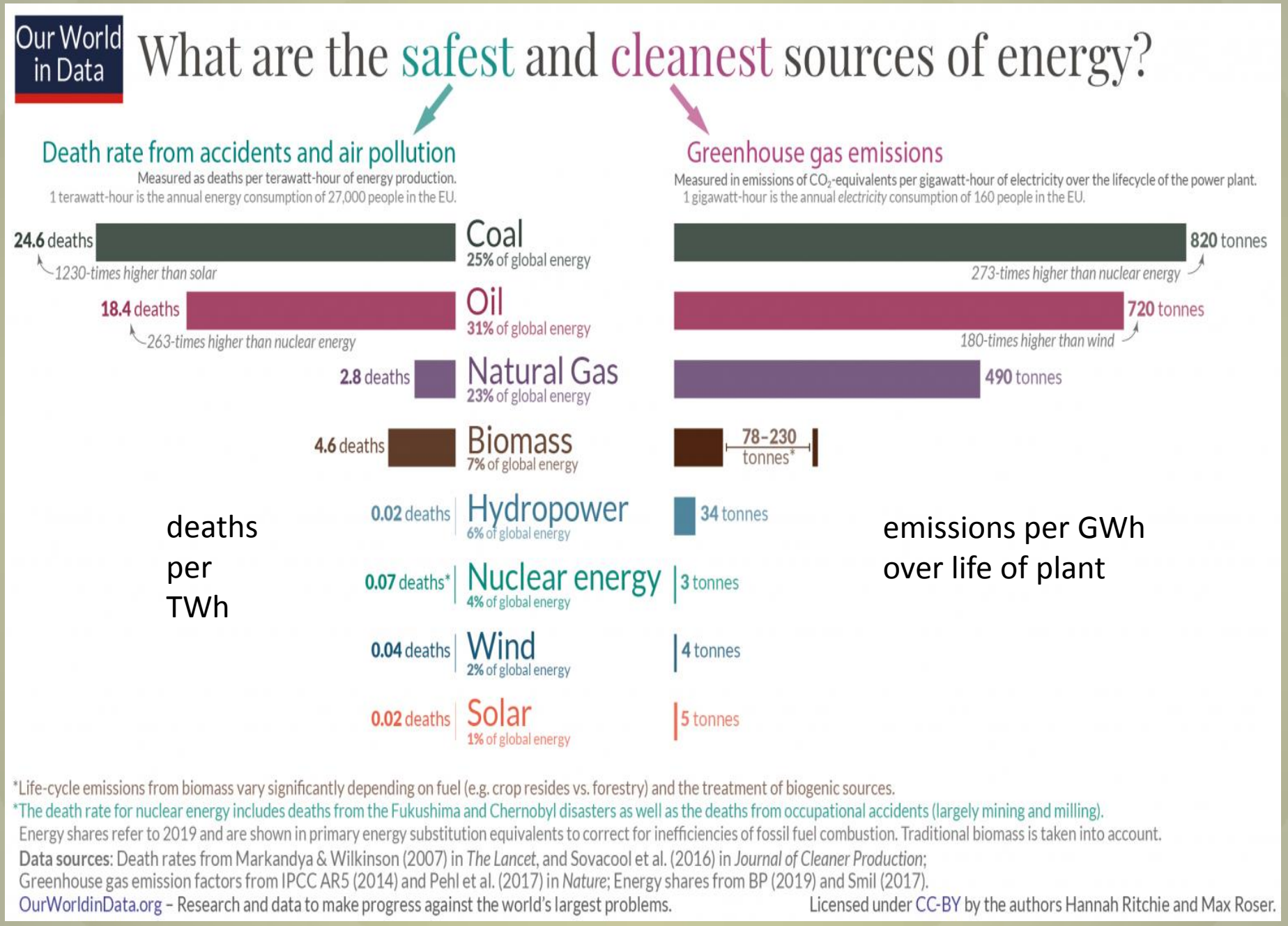
projected costs of SMR

courtesy of Moltex Energy

Nuclear Waste

- UK waste at Sellafield
  - mainly legacy military program waste (badly managed).
  - modern reactors have less waste and it's priced in.
  - Sellafield site is 260 ha (double size of average Galloway farm).
  - material is contained and we know where it is.

- Handle with respect but consider relative risks:
  - nuclear ionising radiation – alpha ; beta ; gamma and neutrons part of our natural environment since earth began.
  - 40 GT/yr CO_2 + 500 MT/yr CH_4 into atmosphere;
  - 300MT/yr plastics produced of which > 10MT/yr into the oceans
  - 2000 new chemical compounds registered each year
  - micro and nano particles now pervading atmosphere; oceans and all living organisms
  - "pollution blamed for one in six deaths worldwide" [2019 Global Burden of Disease project]

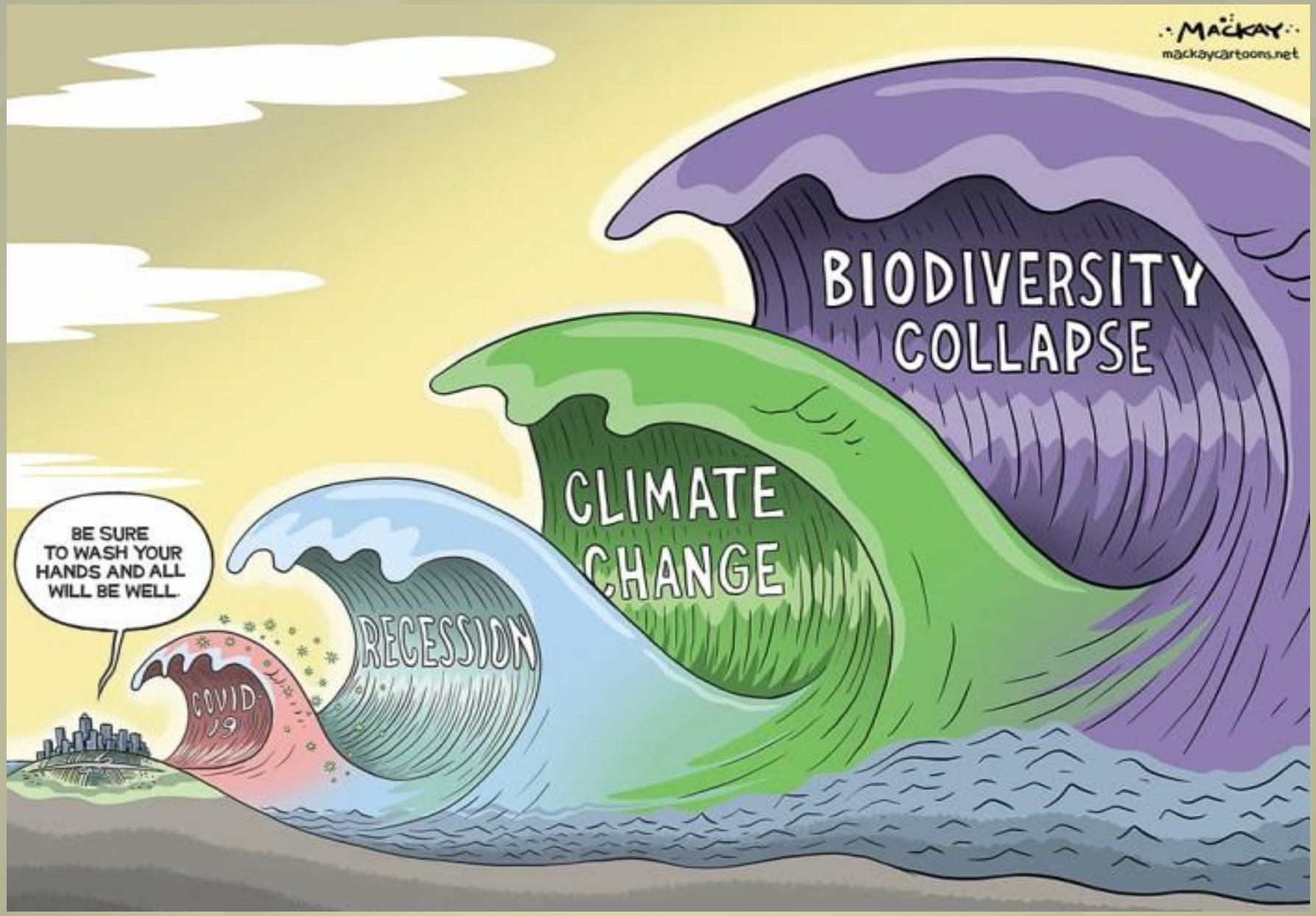

Our World in Data
What are the safest and cleanest sources of energy?
Death rate from accidents and air pollution
Measured as deaths per terawatt-hour of energy production.
1 terawatt-hour is the annual energy consumption of 27,000 people in the EU.
Greenhouse gas emissions
Measured in emissions of CO_2-equivalents per gigawatt-hour of electricity over the lifecycle of the power plant.
1 gigawatt-hour is the annual electricity consumption of 160 people in the EU.
24.6 deaths
1230-times higher than solar
Coal
25% of global energy
820 tonnes
273-times higher than nuclear energy
18.4 deaths
263-times higher than nuclear energy
Oil
31% of global energy
720 tonnes
180-times higher than wind
2.8 deaths
Natural Gas
23% of global energy
490 tonnes
4.6 deaths
Biomass
7% of global energy
78–230 tonnes*
0.02 deaths
Hydropower
6% of global energy
34 tonnes
0.07 deaths*
Nuclear energy
4% of global energy
3 tonnes
0.04 deaths
Wind
2% of global energy
4 tonnes
0.02 deaths
Solar
1% of global energy
5 tonnes
deaths per TWh
emissions per GWh over life of plant
*Life-cycle emissions from biomass vary significantly depending on fuel (e.g. crop resides vs. forestry) and the treatment of biogenic sources.
*The death rate for nuclear energy includes deaths from the Fukushima and Chernobyl disasters as well as the deaths from occupational accidents (largely mining and milling).
Energy shares refer to 2019 and are shown in primary energy substitution equivalents to correct for inefficiencies of fossil fuel combustion. Traditional biomass is taken into account.
Data sources: Death rates from Markandya & Wilkinson (2007) in The Lancet, and Sovacool et al. (2016) in Journal of Cleaner Production;
Greenhouse gas emission factors from IPCC AR5 (2014) and Pehl et al. (2017) in Nature; Energy shares from BP (2019) and Smil (2017).
OurWorldinData.org – Research and data to make progress against the world's largest problems.
Licensed under CC-BY by the authors Hannah Ritchie and Max Roser.

Decarbonisation can be done !

it needs

- vision ; courage ; commitment & resolve
- government & media to **TELL the TRUTH** about the level of existential threat
- strong leadership, legislation and incentives to drive industry to implement solutions (rather than greenwash)

individuals can make savings, but most important is pressurising government to act.



"We are on a highway to climate hell with our foot still on the accelerator" Antonio Guterres