U3AC SCE 05

Climate change: How catastrophic is it?

Session 6

Electricity

February 2019

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What we will cover

A Policy drivers

B UK Power generation

C Renewables

D Electric vehicles

E Other countries

Why talk about electricity? - climate change drives policy

Climate change activists say “we must take action”

Politicians have become convinced that CO2 drives climate change

Must therefore reduce (or eliminate) CO2 emissions from power generation

⇨ 2008 UK Climate Change Act

Policy: 2008 Climate Change Act

Defines six so-called greenhouse gases

Recommends 57% reduction by 2030

Requires 80% reduction in emissions by 2050

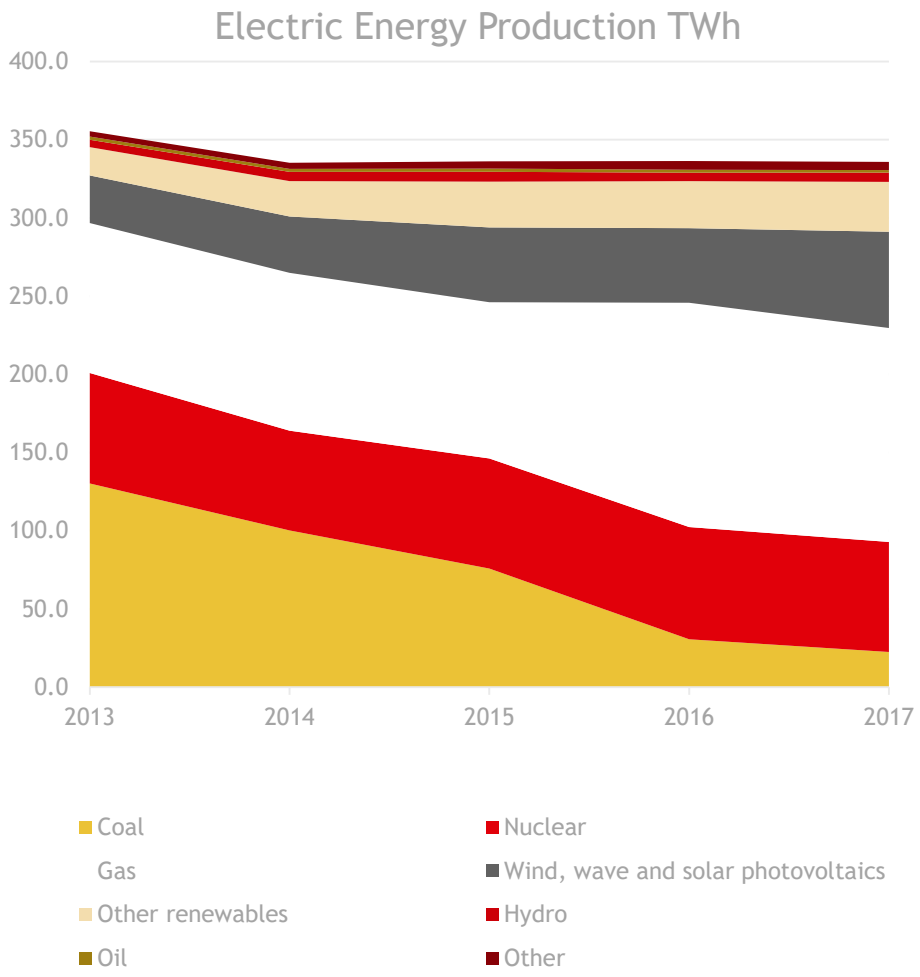
UK first country to adopt these stringent requirements although others have emissions reduction targets

Q: How?

A: Stop burning fossil fuels in power stations

UK contributes about ~1% to global emissions of CO2
Of which energy accounts for ~25%

What fuels generate our electrical energy today?



	2013	2014	2015	2016	2017
Coal	37%	30%	23%	9%	7%
Nuclear	20%	19%	21%	21%	21%
Gas	27%	30%	30%	43%	41%
Wind, wave and solar photovoltaics	9%	11%	14%	14%	18%
Other renewables	5%	7%	9%	9%	9%
Hydro	1%	2%	2%	2%	2%
Oil	1%	1%	1%	1%	0%
Other	1%	1%	1%	2%	2%
Total production	100%	100%	100%	100%	100%

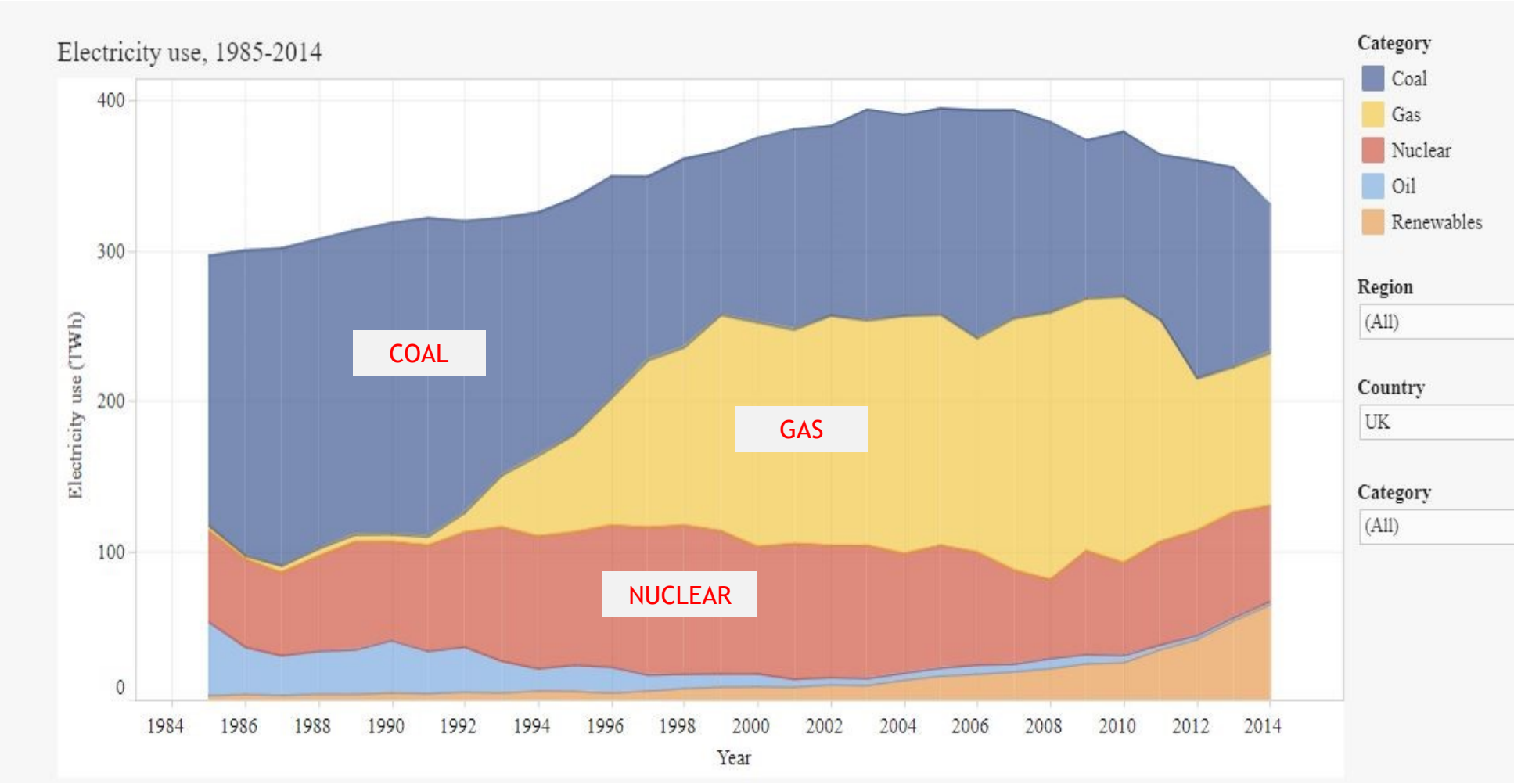
Coal virtually phased out

Significant nuclear but uncertain future

Gas important

About 70% of energy production is not from renewables

A longer perspective: UK Energy mix from 1984-2014



The key question

70% of our electricity still comes from “non-renewable” resources
Can renewables sources replace this 70%?

If not, and if fossil sources are phased out, we will have energy shortages

“Renewables” are:

- Wind: onshore and offshore
- Solar (PV)
- Biomass (mainly wood pellets – Drax burns 7.3 millions tonnes p.a.)
- Hydro
- Tidal, wave, ground source

Renewables have some fundamental shortcomings….

- Intermittent, hard to predict, and hence not controllable
- Low energy density compared to coal, gas, nuclear

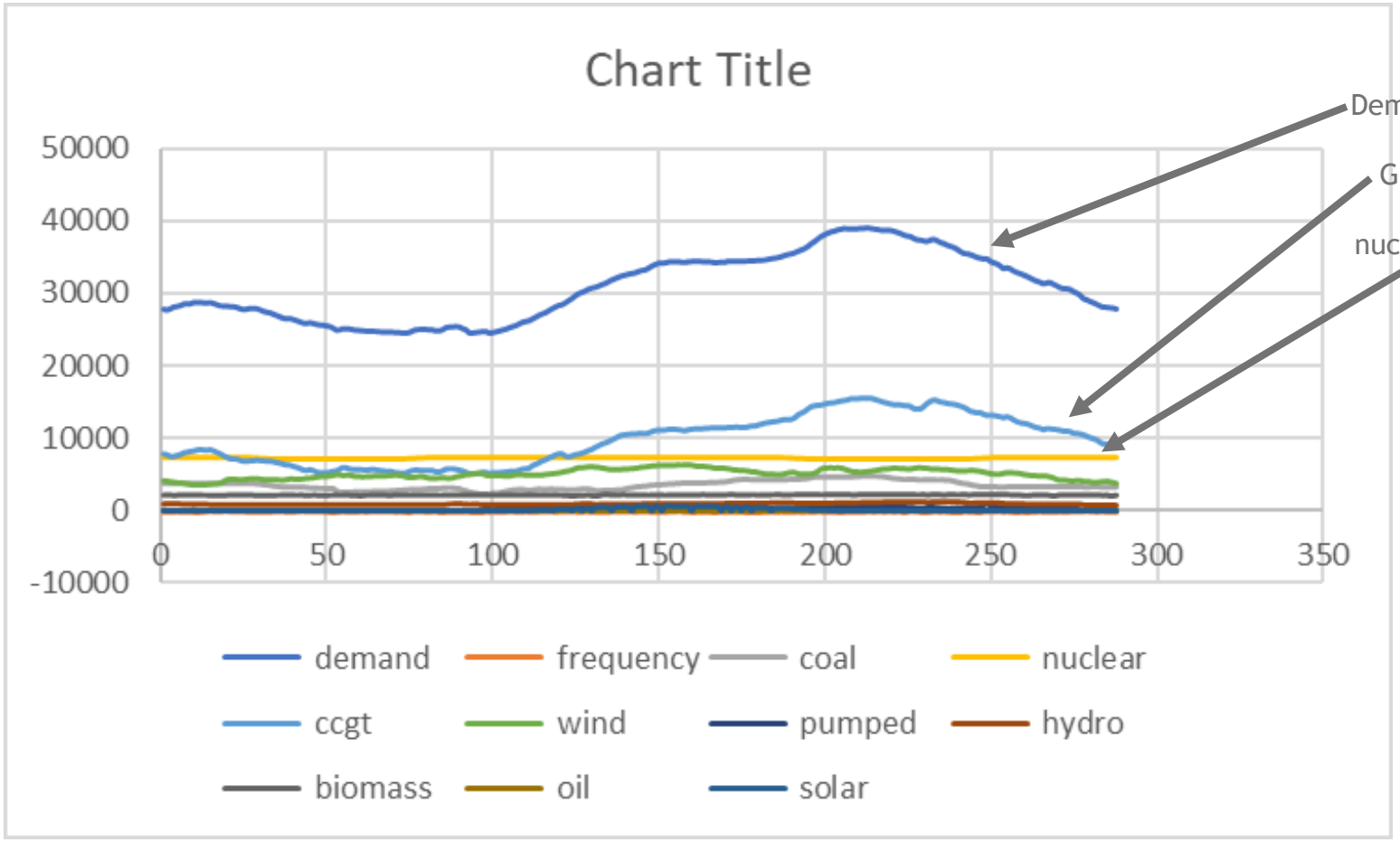
Energy demand varies

Demand varies on a minute by minute basis

You cannot store electricity
- apart from small amounts in pumped storage
- even smaller amounts in batteries

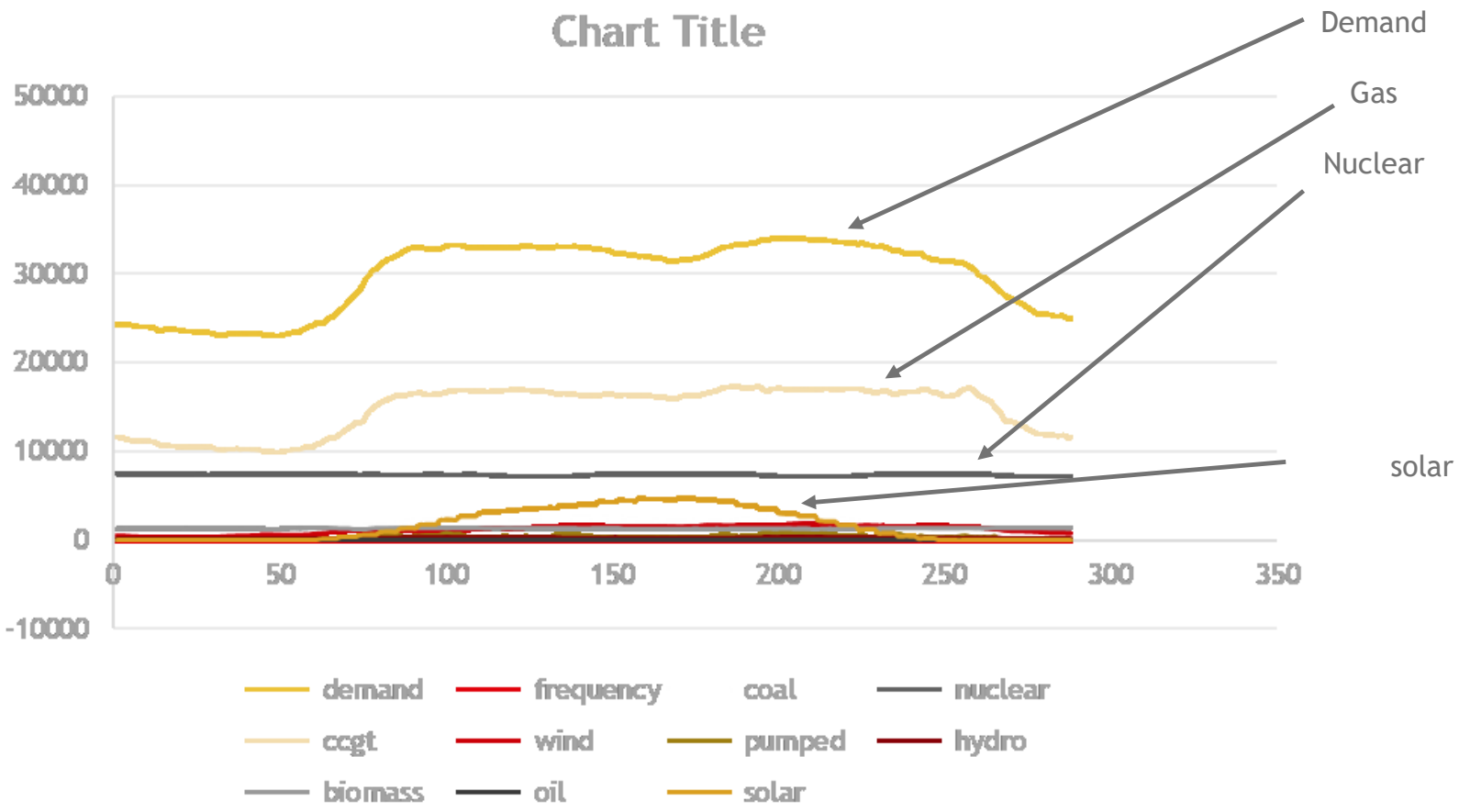
UK has grid and grid control to match (instantaneously) demand with production: dynamic control of power stations

Demand through the day: 01 Jan 2017: WINTER



Vertical axis: MW Horizontal axis shows 5-min samples for 24 hour period from 00:00

Demand through the day: 04 Jul 2017: SUMMER



Vertical axis: MW Horizontal axis shows 5-min samples for 24 hour period from 00:00

Power and energy

POWER is rate of energy production or consumption

ENERGY produced or consumed over a period of time is POWER * TIME

We pay for ENERGY. POWER relates to how quickly we use or generate it

On a winters day the peak rate of power consumption is about 40GW
This reduces to about 25GW at night

In summer, the peak is about 33GW, reducing to a low of about 22GW

UK annual electricity production is ~280TWh

What is a Terra Watt hour ?

		days		year		
Demand	Power	period	Energy	period	Energy	Energy
	GW	Hrs	GWh	days	GWh	TWh
max	40.0					
min	25.0					
avg	32.5	24	780	365	284700	284.7
				Energy production per year		
				Terra Watt hours		

Watts and Giga Watts

A watt is a unit of power, energy per second
A watt is quite small so domestically we often talk in kilo watts, = 1000 Watts
An electric kettle is usually rated at 2.4kW

An electric kettle running for 1 hour consumes energy of 2.4kWh (kilo watt hours)
We pay for energy, not power (kWh not kW) What is the cost of 1 kWh ?

Megawatt (MW) = 1,000,000 Watts Gigawatt = 1000 MW Terawatt = 1000 GW
UK annual demand ~280TWh

UK power generation of 30GW will power about 12 million kettles
Fortunately they are not all on at the same time

The UK plan for energy

Close down coal and oil burning power stations

Replace with renewables: wind and solar
(Hydro considered part of renewables)

Massive increased reliance on gas (47%)

Nuclear still major contributor (21%)
Replace ageing nuclear reactors
Build some new ones, eg Hinckley, maybe

Promote use of electric cars (but no new generation to power them)

The issues with climate policy

Half of nuclear capacity scheduled for closure by 2025
Plans for new nuclear delayed and long term
Hydro capacity only about 2% of requirement

Wind is considered a major input to our energy supply
But it is intermittent and low energy density

Solar is guaranteed intermittent and low energy density in northern Europe

Electricity storage is virtually impossible at large scale
(Batteries have tiny capacities relative to demand)

Other forms of energy such as tidal are harder to introduce than might be expected, still on horizon

Wind and solar generation

Installed capacity does not equate to energy produced

Installed capacity is sometimes called “nameplate capacity”
It refers to what would be produced in ideal conditions

Wind installed capacity (2016) is 17.2 GW from 8135 turbines, 3480 km
Estimated total generating capacity per year is 206 TWh

Actual output was 48TWh = 23% of capacity
This is a typical figure for renewables, an average figure over a year
There are many extended periods during the year when wind output is 0% of capacity

Wind farms are built with back up generators powered by fossil fuels

Solar installed capacity (2016) is 12.5 GW

Good and bad news

Biggest offshore windfarm to start UK supply this week

High hopes for Hornsea One as developer says its output could fill the gap left by nuclear

11th February 2019

This offshore windfarm on the Yorkshire coast, that will dwarf the world's largest when completed, is to supply its first power to the UK electricity grid this week.

The Danish developer Ørsted, which will be installing the first of 174 turbines at Hornsea One, said it was ready to step up its plans and fill the gap left by failed nuclear power schemes.

The size of the project takes the burgeoning offshore wind power sector to a new scale, on a par with conventional fossil fuel-fired power stations. Hornsea One will cover 407 sq km, five times the size of the nearby city of Hull. At 1.2GW of capacity it will power 1m homes, making it about twice as powerful as today's biggest offshore windfarm once it is completed in the second half of this year.

Price - £155.53/MWh, triple the market price (the bit they don't tell you)

UK beat CO2 emissions target for 2020 (Compared to 1990 levels)

BUT….

Renewables output dominated by wind

Intermittent and unknown generating capacity of wind will lead to major power outages unless backed up by other fuels. It requires STOR, large diesel generators installed on permanent standby, which supply energy at cost premium

Energy subsidies for wind estimated at £7bn by 2021
Cost to every household £265/year
UK electricity prices amongst highest in Europe

Safety margin is tiny due to reduced base load generation from closure of coal and old nuclear

Smart meters being installed at cost of £11bn to £14bn (£374 - £476 per household)
Will be used for demand control?

You can view real time UK power production

http://www.gridwatch.templar.co.uk/

Total demand

Sources of power production

Import and export via interconnectors

Daily, monthly, annual statistics

Updated every 5 minutes

China and Germany

China INCREASES its CO2 output every year by more than the UK's TOTAL output

This is in accordance with its Paris Climate change agreement

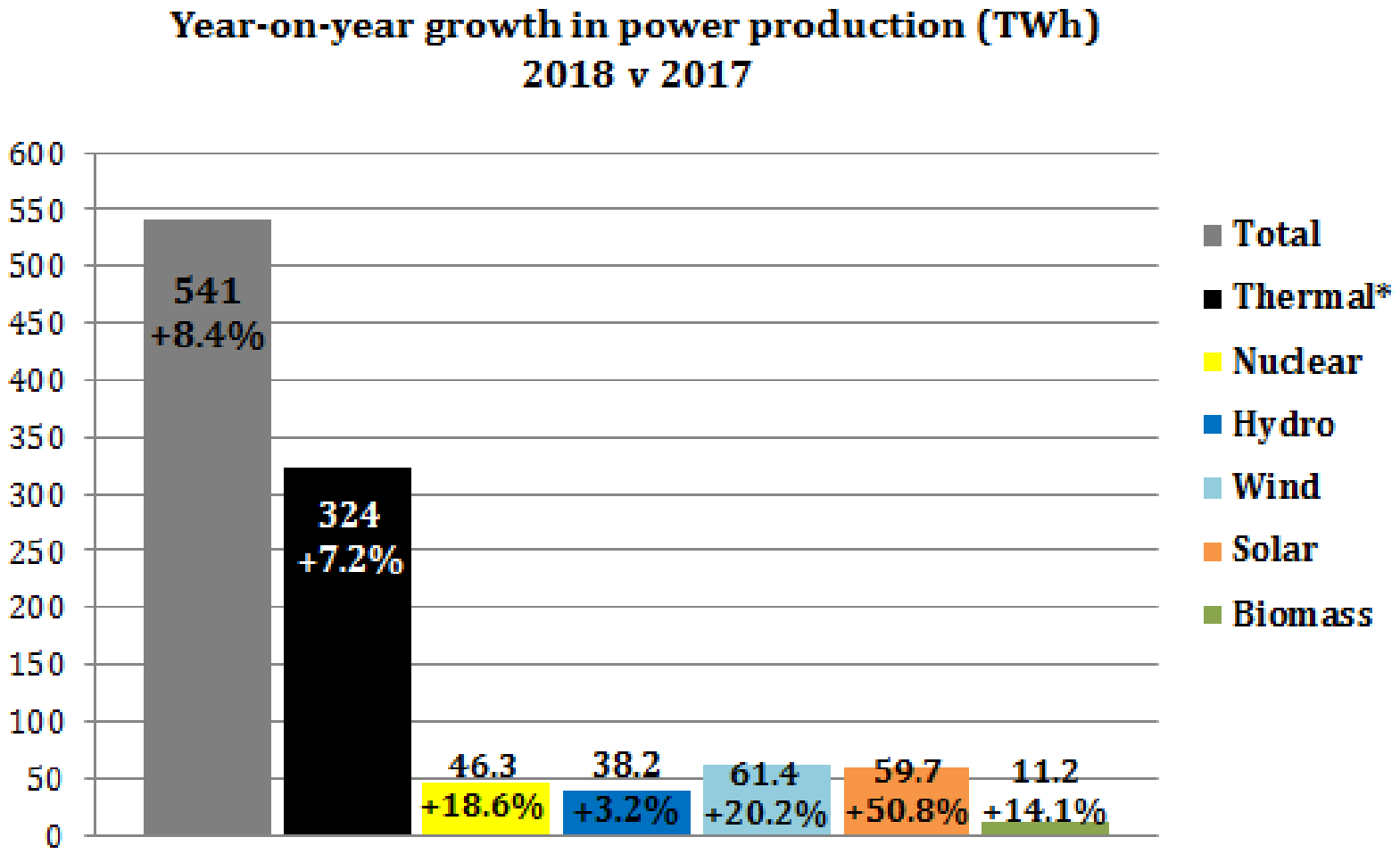
Germany has abandoned its nuclear generating programme following Fukushima accident
It sometimes imports energy from France (generated by nuclear)

It relies heavily on coal fired power stations, with the majority using brown (lignite) coal

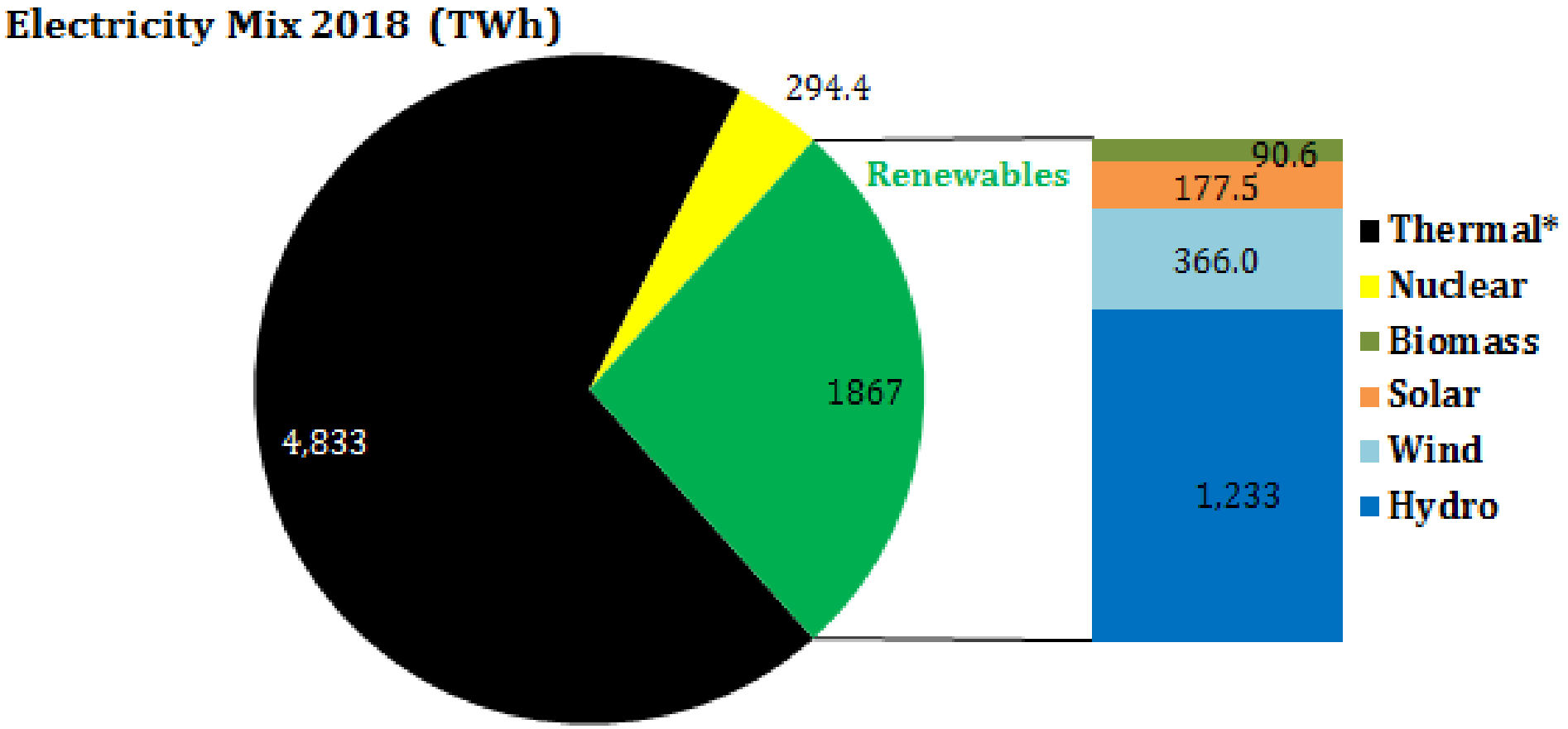
It will miss its climate change target for CO2 reduction in 2020

It has the highest energy costs in the EU

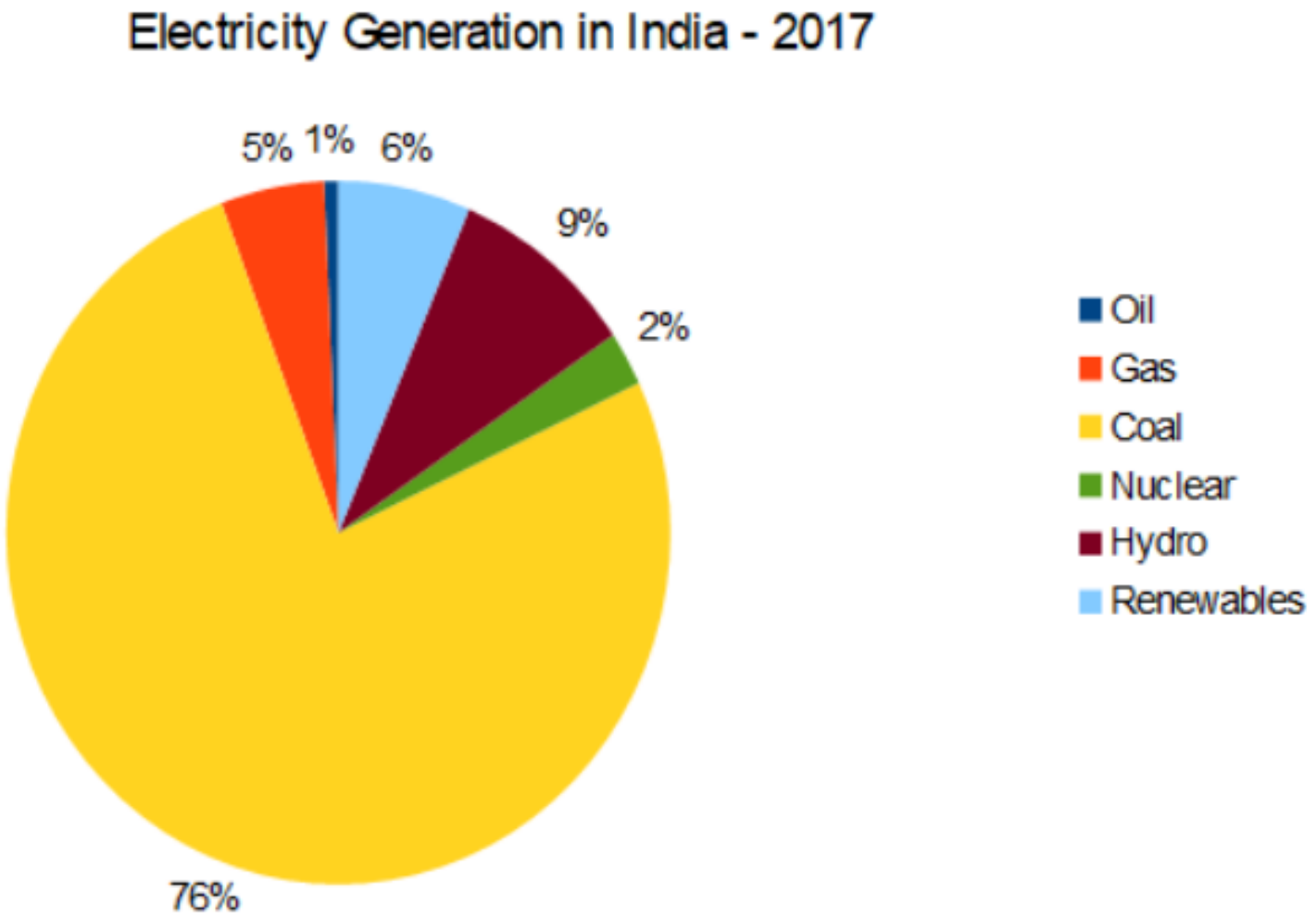
China


Year-on-year growth in power production (TWh)
2018 v 2017
600
550
500
450
400
350
300
250
200
150
100
50
0
541
+8.4%
324
+7.2%
46.3
+18.6%
38.2
+3.2%
61.4
+20.2%
59.7
+50.8%
11.2
+14.1%
Total
Thermal*
Nuclear
Hydro
Wind
Solar
Biomass

China


Electricity Mix 2018 (TWh)
294.4
Renewables
1867
4,833
90.6
177.5
366.0
1,233
Thermal*
Nuclear
Biomass
Solar
Wind
Hydro

India


Electricity Generation in India - 2017
5%
1%
6%
9%
2%
76%
Oil
Gas
Coal
Nuclear
Hydro
Renewables

EU Commission Study Reveals International Competitive Disadvantage of Climate Policies

EU 28 household electricity prices are now more than double those in the G20, while industrial electricity prices are now nearly 50% higher.

The only G20 states with higher industrial electricity prices are those with heavy commitments to renewables.

One has to free oneself from the illusion that international climate policy is environmental policy… We redistribute de facto the world's wealth by climate policy.

Ottar Edenhofer, Co-chair UN's Intergovernmental Panel on Climate Change working group on Mitigation of Climate Change from 2008 to 2015

3. All India yearly Coal Consumption for Power Generation (Utilities)

YEAR	Coal Consumption Million Tonnes
2004-05	278.00
2005-06	281.00
2006-07	302.00
2007-08	330.00
2008-09	355.00
2009-10	367.00
2010-11	387.00
2011-12	417.56
2012-13	454.60
2013-14	489.40
2014-15	530.40
2015-16	545.90
2016-17	574.30
2017-18	608.00