BECCS
Biomass Energy with CCS

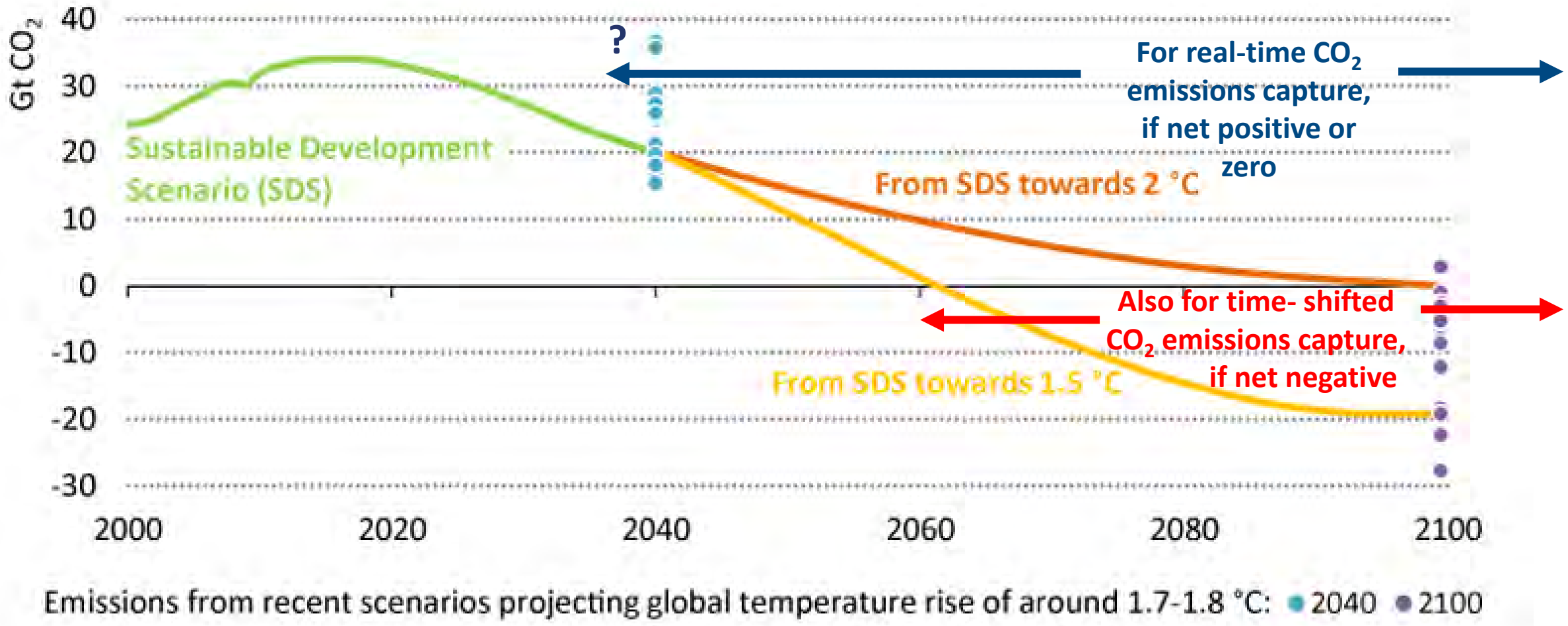
Jon Gibbins
Director, UK CCS Research Centre
Professor of CCS, University of Sheffield

UKERC
UK Energy Research Centre

UKCCS
RESEARCH CENTRE

The University Of Sheffield.

IEA World Energy Outlook 2017 Scenarios
What do negative emissions technologies get used for?



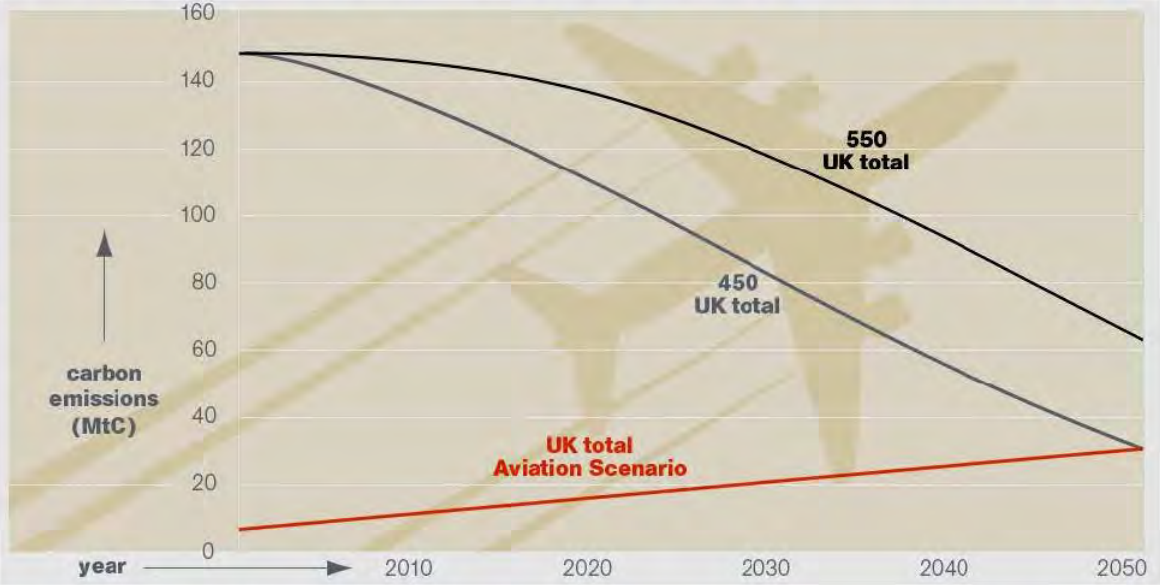
UKERC
UK Energy Research Centre

UKCCS
RESEARCH CENTRE

The University Of Sheffield.

LONGER TERM POTENTIAL FOR BIOMASS WITH CCS?

Tyndall Centre
'Decarbonising the UK'
http://www.tyndall.ac.uk



Cambridge Energy Forum
Carbon Capture & Storage: the impact on UK Nuclear Policy?
26 October 2005

Carbon capture and storage

Dr Jon Gibbins
Energy Technology for Sustainable Development Group
Mechanical Engineering Department, Imperial College London
j.gibbins@imperial.ac.uk

Principal Investigator, TSEC programme, UK CCS Consortium
www.ukccsc.co.uk

Tyndall UK aviation emissions projections for 2050	~ 30 MtC
RCEP estimates for max UK biomass production by 2050	~ 60 Mt
Carbon content of biomass	~ 24 MtC
Carbon captured using biomass with CCS	~ 90%
Energy recovered compared to use without CCS	~ 75%
Oil price equivalent of $50/tonne CO2	$22/barrel

Transport Atmosphere carries CO2 from plane to plant for free!
But need to supply biomass to CCS plants

UKCCS RESEARCH CENTRE

The University Of Sheffield.

BECCS Overview

- Doable technically, Drax is examining possibilities in UK
- Not the same as coal CCS, biomass has unique properties
- Carbon capture probably more important than energy
- Need a baseload way to convert biomass to CO_2 – combustion is easiest, gasification still not demonstrated at necessary scale
- MUST leave space in the energy system for BECCS
- Just as bad not to capture CO_2 from biomass as from fossil – and biomass generates a lot more CO_2 than natural gas when used
- So better to use biomass with CCS and replace unabated biomass by gas without CCS – generally wasteful to use biomass to decarbonise heat (or transport)
- **But always limited biomass, especially when climate change adds water and food stresses.**
- **BECCS is good to use for biomass but cannot be a backstop.**

* http://www.aps.org/policy/reports/assessments/upload/dac2011.pdf

Group of Experts on Cleaner Electricity Systems

15th session

Geneva, 5-6 November 2019, Palais des Nations, Salle XI

Towards a solid strategy for the Group of Experts: The role of coal/fossil fuels in sustainable energy and meeting climate goals

Background data on coal use, overall CO_2 emissions from fossil fuels and using CCS to deliver net-zero GHG emissions

Personal comments by

Jon Gibbins

University of Sheffield

UK CCS Research Centre

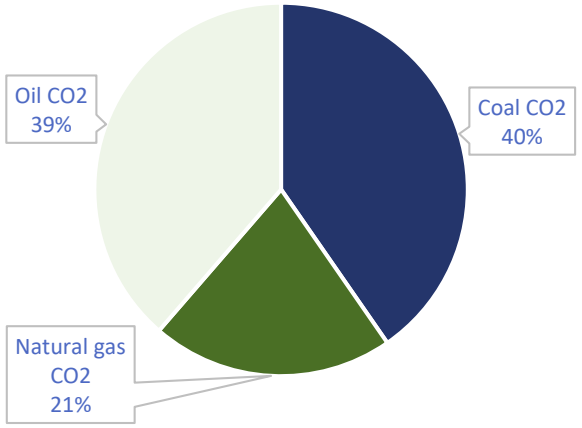
www.ukccsrc.ac.uk

j.gibbins@sheffield.ac.uk

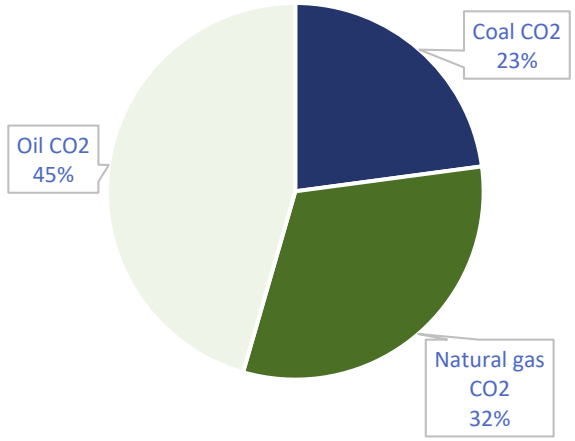
UNECE countries emit around a third of global fossil CO_2 emissions, coal is a relatively small part of UNECE fossil CO_2, less than 25%

Estimates based on BP Statistical Review of World Energy 2019

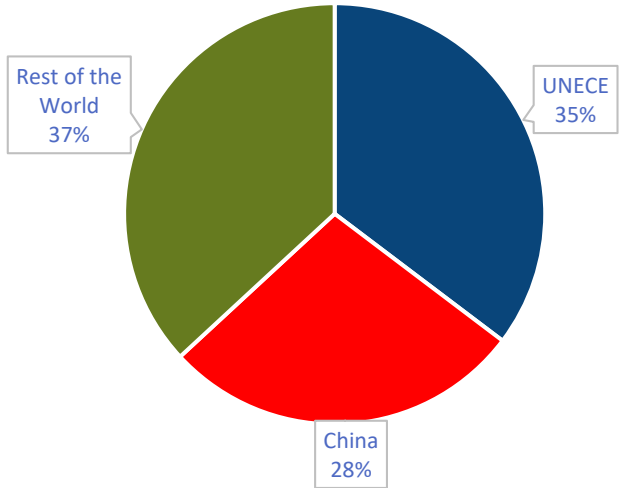
Approximate estimated global CO_2 emissions by fuel



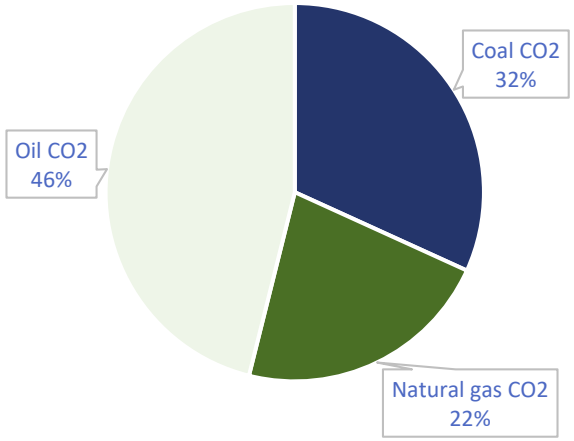
Approximate estimated UNECE CO_2 emissions by fuel



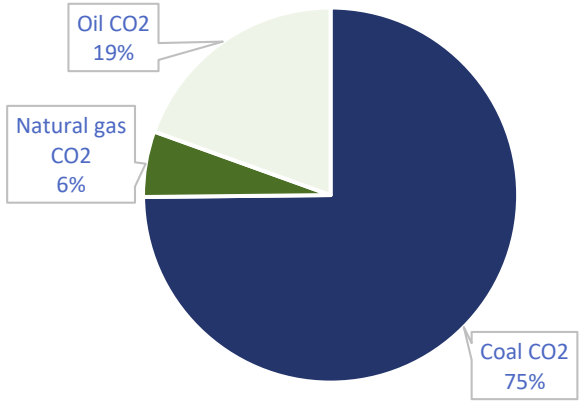
Fossil fuel CO_2 emissions



Approximate estimated Rest of the World CO_2 emissions by fuel



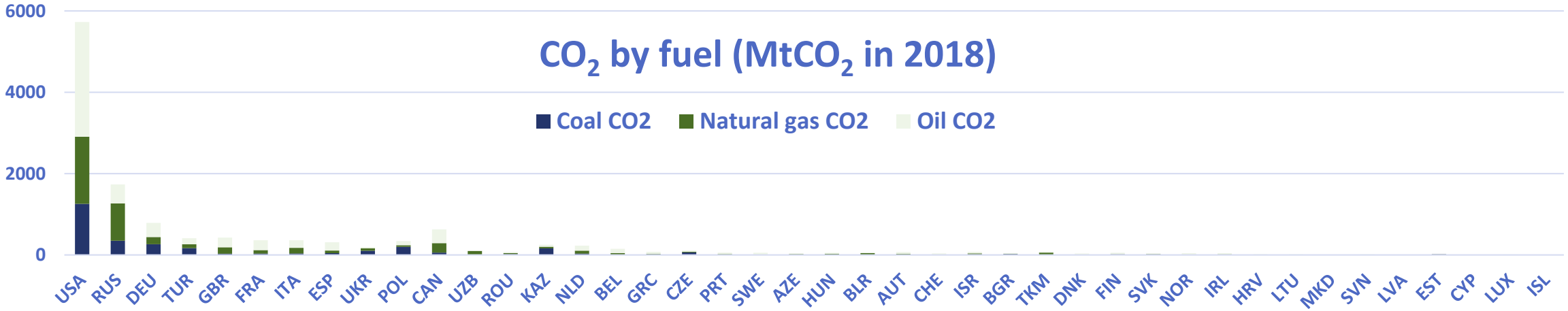
Approximate estimated China CO_2 emissions by fuel

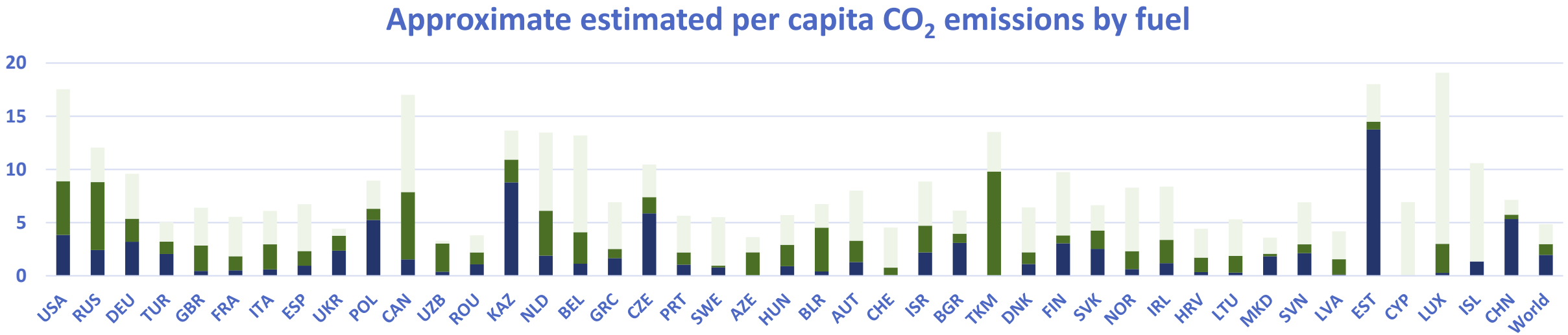


PRELIMINARY AND PERSONAL COMMENTS

Bulk of UNECE coal CO_2 emissions are concentrated in a small number of countries, but locally some countries are very dependent on coal

Estimates based on BP Statistical Review of World Energy 2019



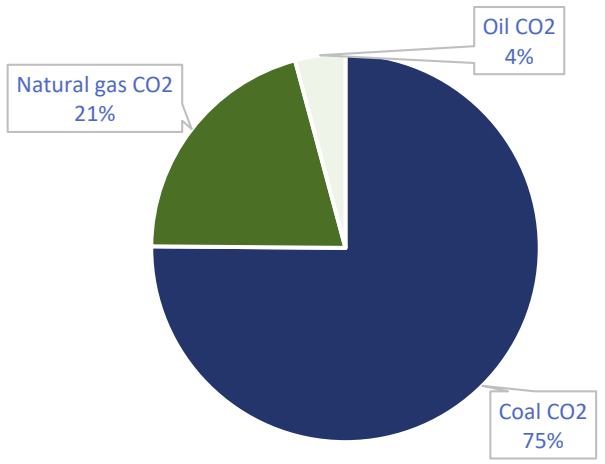


PRELIMINARY AND PERSONAL COMMENTS

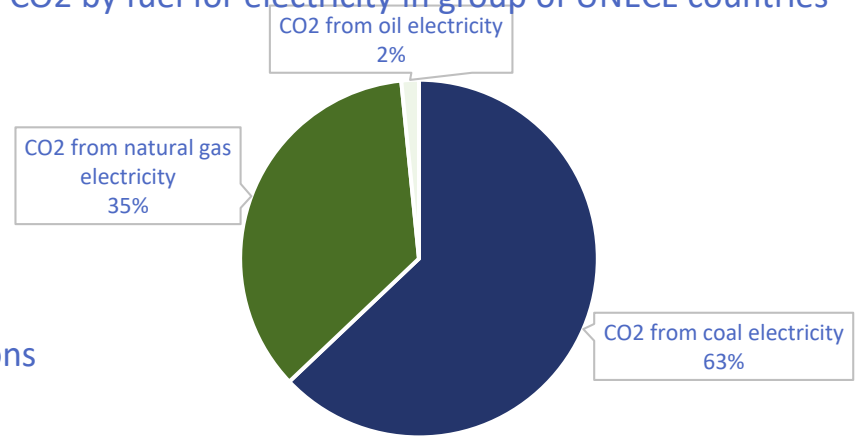
UNECE countries average ~65% of electricity sector fossil emissions from coal, slightly below the world average of ~75%

Estimates based on BP Statistical Review of World Energy 2019

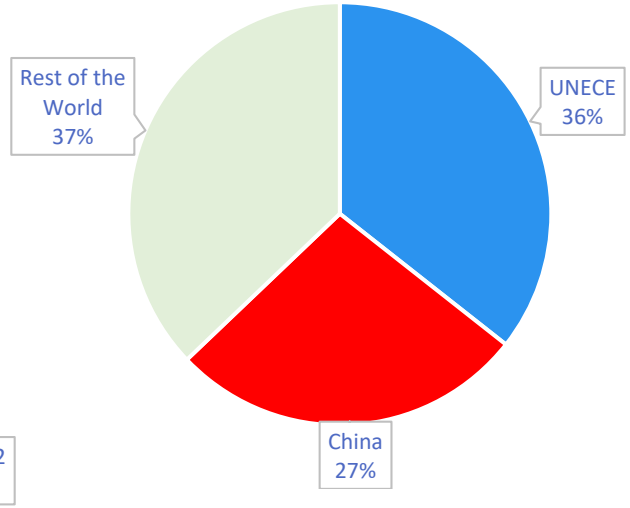
CO2 by fuel for electricity globally



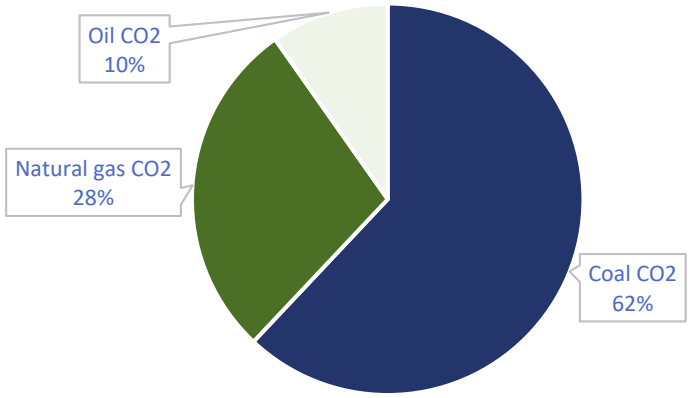
CO2 by fuel for electricity in group of UNECE countries



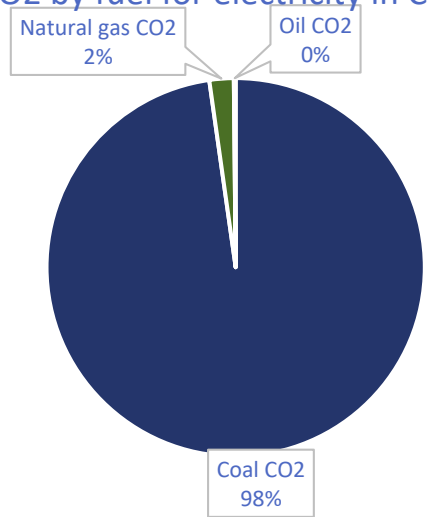
Electricity CO2 emissions



CO2 by fuel for electricity in the Rest of the World



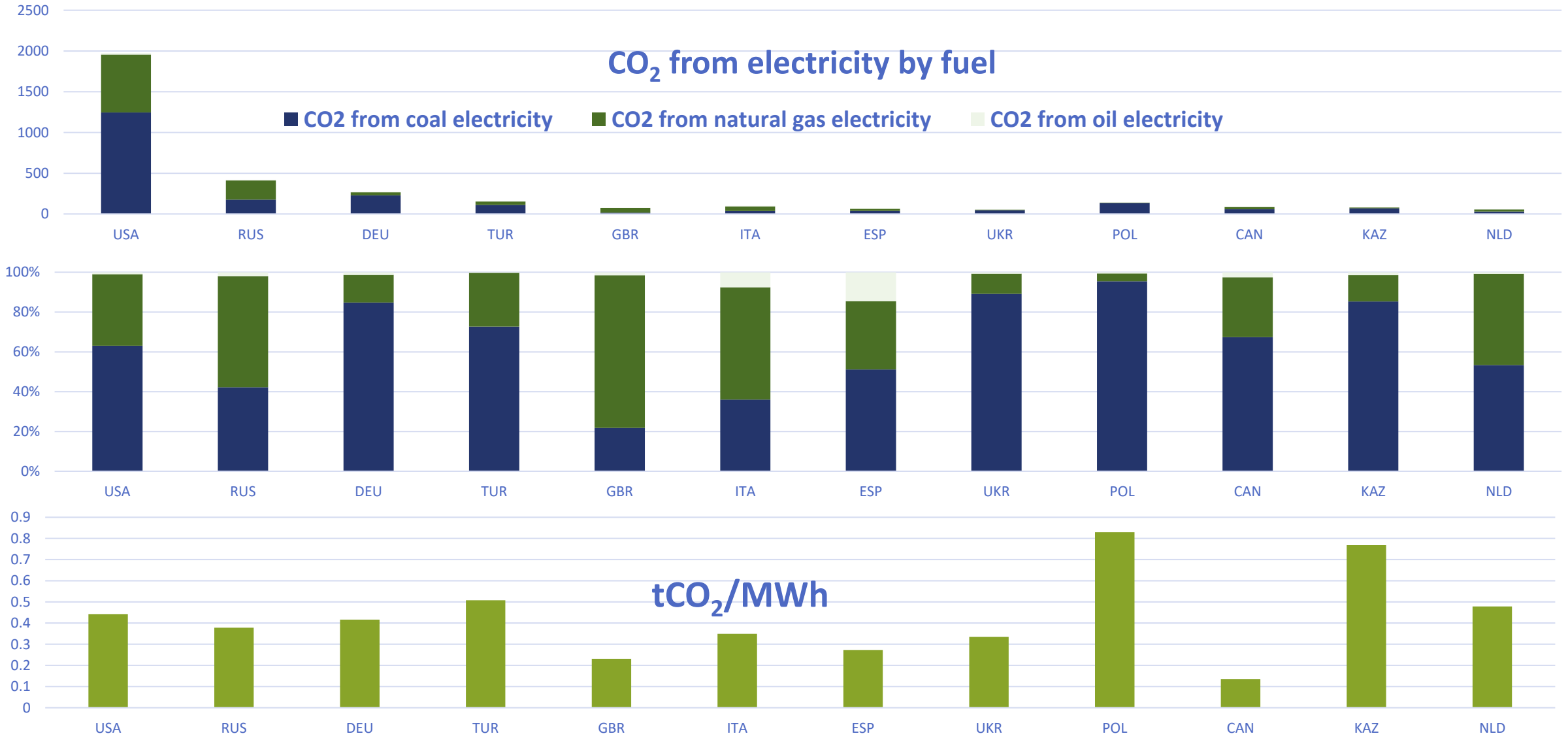
CO2 by fuel for electricity in China



PRELIMINARY AND PERSONAL COMMENTS

UNECE electricity coal CO_2 emissions are concentrated in a small number of countries, but locally some countries are very dependent on coal

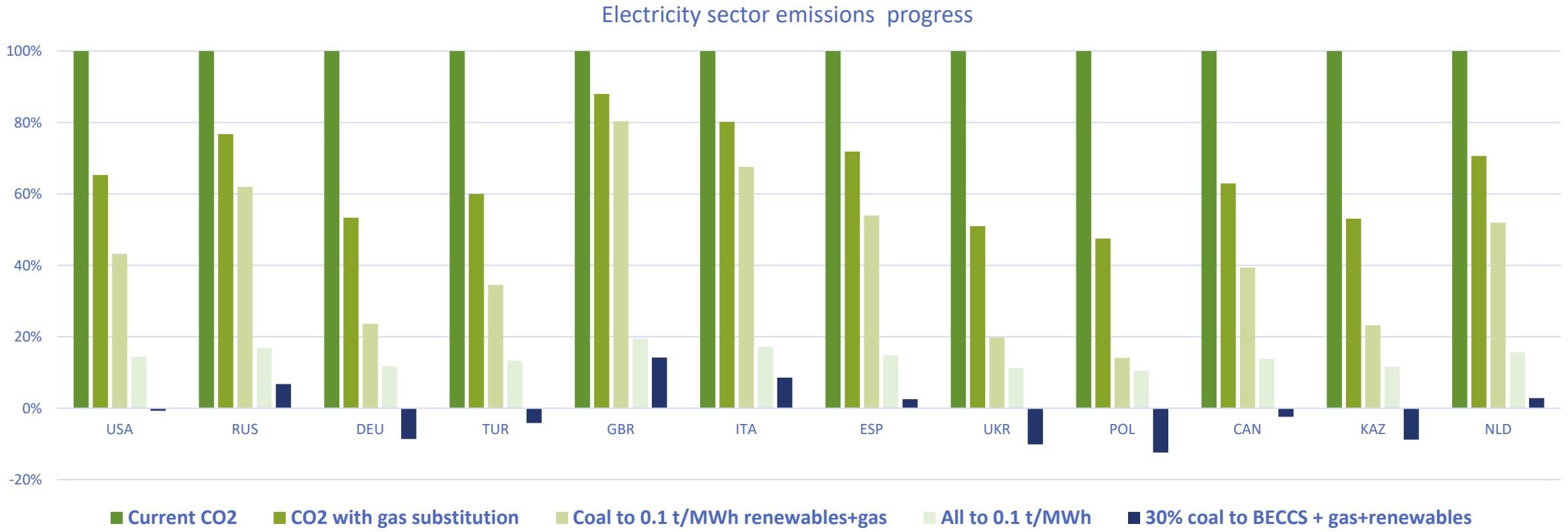
Estimates based on BP Statistical Review of World Energy 2019



PRELIMINARY AND PERSONAL COMMENTS

Cutting electricity sector emissions in UNECE countries via different scenarios for replacing existing coal generation - just getting rid of coal will not solve climate change!

- Switching from coal to gas has a limited effect
- Also cutting coal generation by 90% (or replacing with gas) and using renewables for the rest to average 0.1tCO_2/MWh
- Need to cut <u>all</u> fossil generation to get low levels of emission – but this would not be sufficient for net-zero
- Converting ~30% of coal generation to BECCS get to net-zero CO_2 emissions or below



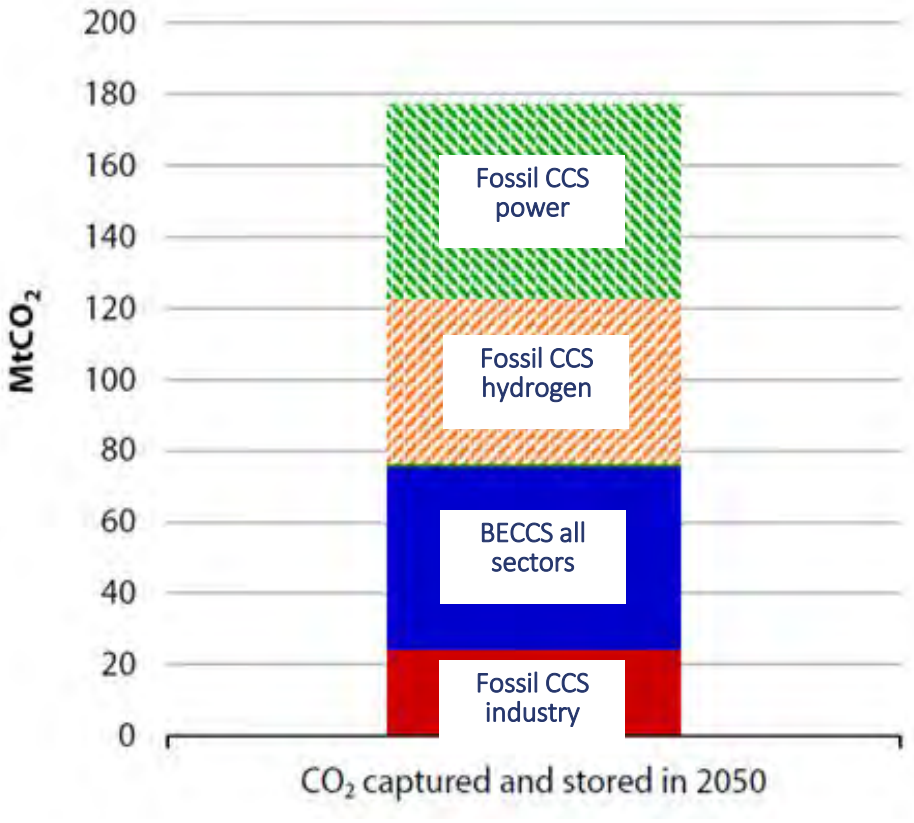
PRELIMINARY AND PERSONAL COMMENTS

CCS in Net-Negative Electricity Systems for Net-Zero GHG Emission Societies

https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

- UK Committee on Climate Change has scenarios for achieving net-zero GHG emissions nationally in 2050
- "CCS in not an option, it's a necessity"
- Negative emissions are a key requirement to get to net-zero and BECCS is limited only by biomass availability
- Most BECCS expected via combustion for electricity, may be in old or new power plants
- Also significant CCS on power from natural gas , with a limited amount of this via hydrogen

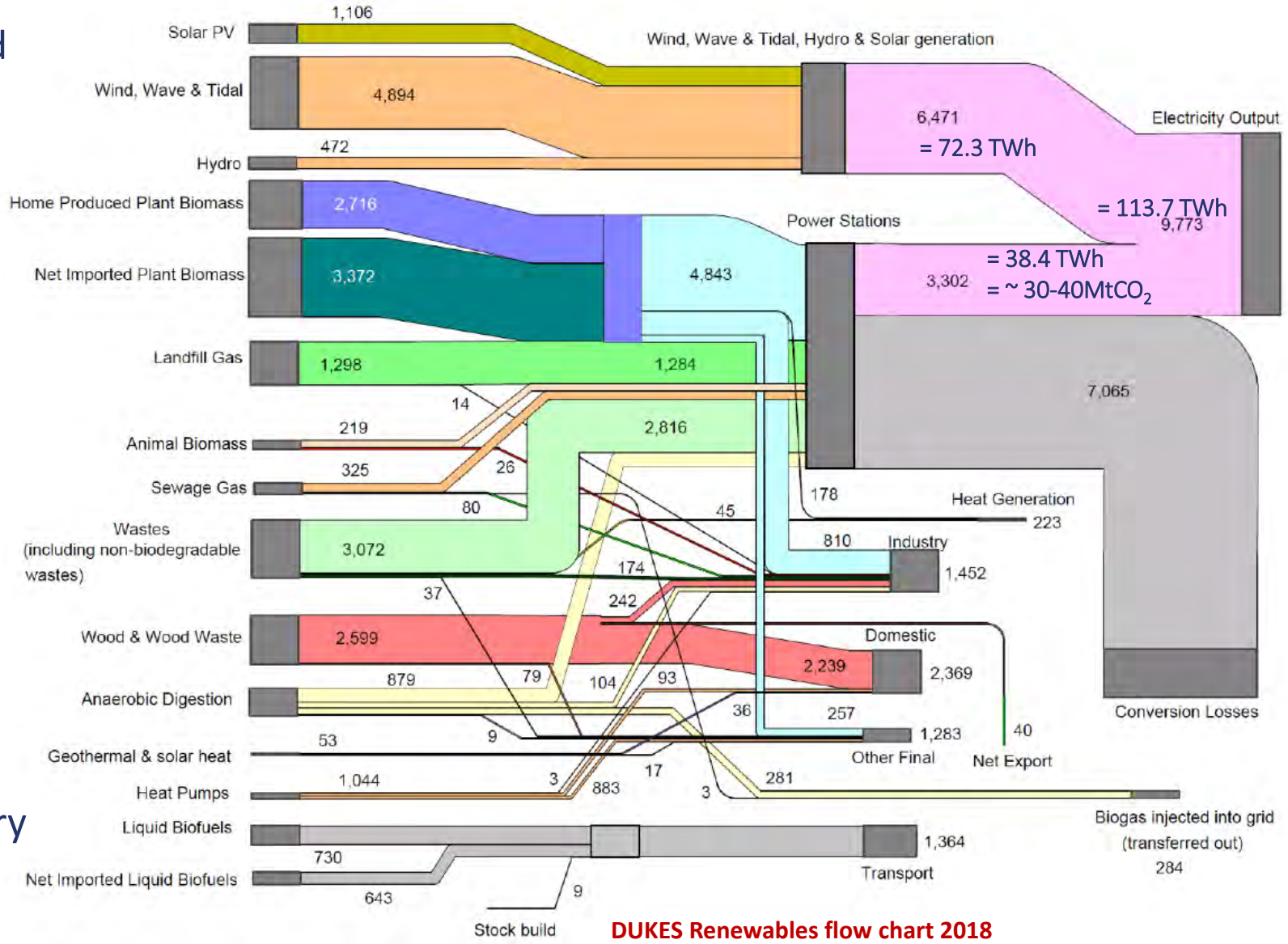
Emission source	$MtCO_2$ in 2017/2018	2050 CCC Further Ambition Scenario for CO_2 captured and stored vs 2018
Natural gas for power	50.2	~50 $MtCO_2$; ~100% of current
Hydrogen, for natural gas substitution and 'new' applications		~45$MtCO_2$; equivalent to~45% of current total direct natural gas use, or >100% of current industry and commercial natural gas use
Direct Air Capture		Yet to be determined
Biomass and wastes into power only (but CO_2 not reported)	30-40	~50 $MtCO_2$; ~ 150% of current, but current is a mix of large and dispersed sources with domestic and imported biomass
Industry, fossil and process above	~35	~25 $MtCO_2$; ~70% of current, some extra reductions could be via H_2



PRELIMINARY AND PERSONAL COMMENTS

UK renewables – large role for biomass in coal plants - but CO_2 emissions from biomass are largely invisible

- If CO_2 from <u>any</u> source is captured and stored and prevented from going into the atmosphere then the result is the same
- Biomass flue gases have high concentrations of CO_2 so the electricity output penalty for capturing them is low
- Drax in the UK has converted 3 x 660MW coal units to 100% biomass firing, with derate
- Drax is now examining possibility for CCS
- But full conversion is not necessary to get the benefits of BECCS; co-firing gives flexibility



DUKES Renewables flow chart 2018

PRELIMINARY AND PERSONAL COMMENTS

https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2019

The role of all fuels – fossil, biomass and hydrogen - in delivering net-negative electricity to support net-zero societies

- Just getting rid of coal power generation won't solve climate change
- In the short term just cutting coal can give marginal changes in electricity CO_2 emissions but delays essential developments on CCS
- Emissions from low-efficiency peaking plants likely to be locked in – hard to address with CCS
- When CCS is needed on both coal and natural gas then there will be much closer competition between these two fossil fuels
- But there is also a major requirement for BECCS to deliver net-zero societies - electricity will have to be net-negative to compensate for more challenging sectors
- Co-firing in coal plants and 100% conversion to biomass has been widely demonstrated
- Amounts of biomass could be limiting for BECCS – but there may be more than is obvious
- Big waste if coal plants are closed and then new solid fuel power plants have to be built again for BECCS - CCS also provides scope for additional coal use alongside BECCS

PRELIMINARY AND PERSONAL COMMENTS