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Środowiskowe aspekty implementacji innowacyjnych technologii energetycznych

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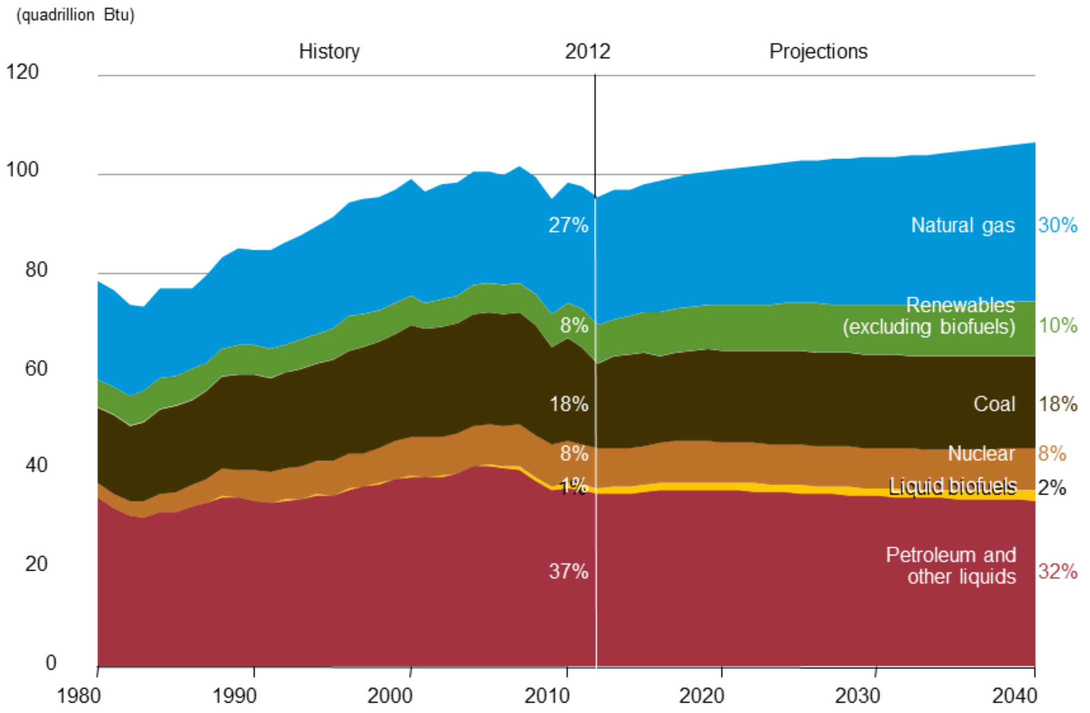
Background

- Fossil fuels will remain important in the future
- CCS will aid the global transition to a sustainable low-carbon economy by capturing CO_2 and reducing carbon footprint

Source: The Telegraph, 21th of April, 2009. Photo: GETTY

US Primary energy consumption by fuel type

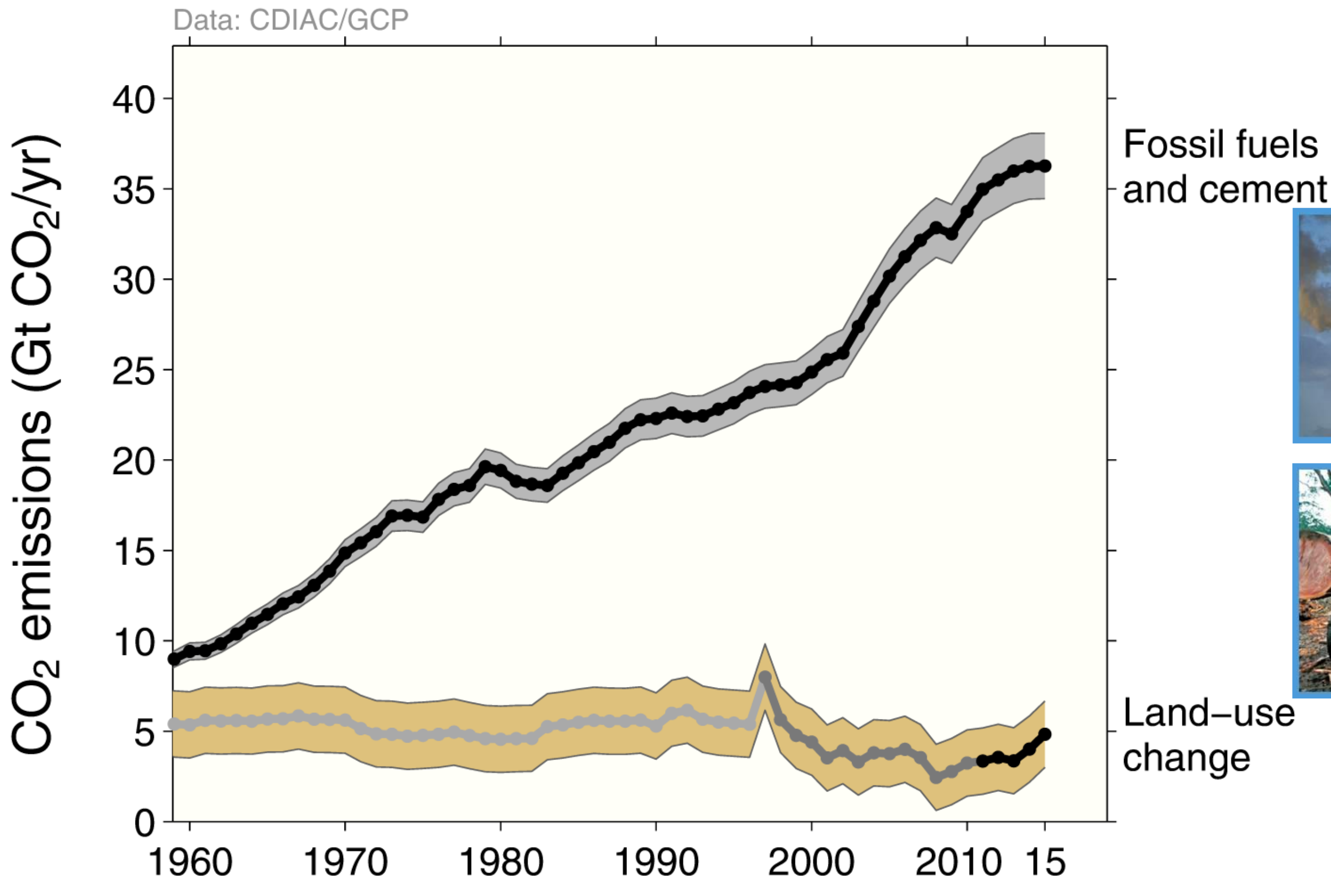


Source: IEA

Total global emissions

Total global emissions: 41.9 ± 2.8 $GtCO_2$ in 2015, 49% over 1990

Percentage land-use change: 36% in 1960, 9% averaged 2006-2015



Three different methods have been used to estimate land-use change emissions, indicated here by different shades of grey

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Source: [CDIAC]; [Houghton et al 2012]; [Giglio et al 2013]; [Le Quéré et al 2016]; [Global Carbon Budget 2016]

Fate of anthropogenic CO_2 emissions (2006-2015)

34.1 $GtCO_2$/yr

91%

9%

3.5 $GtCO_2$/yr

Sources = Sinks

16.4 $GtCO_2$/yr

44%

31%

11.6 $GtCO_2$/yr

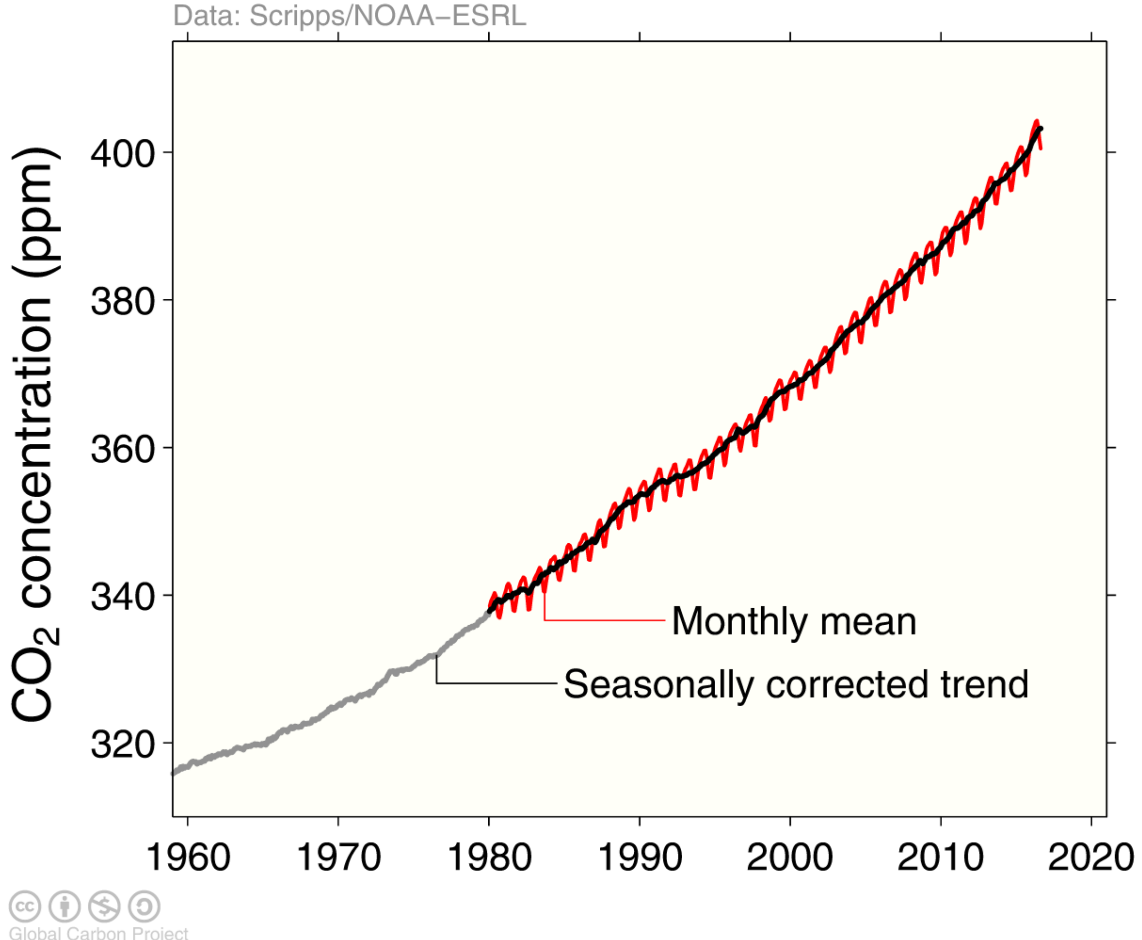
26%

9.7 $GtCO_2$/yr

Source: CDIAC; NOAA-ESRL; Houghton et al 2012; Giglio et al 2013; Le Quéré et al 2016; Global Carbon Budget 2016

Atmospheric concentration

The global CO_2 concentration increased from ~277ppm in 1750 to 399ppm in 2015 (up 44%)
2016 will be the first full year with concentration above 400ppm



Globally averaged surface atmospheric CO_2 concentration. Data from: NOAA-ESRL after 1980; the Scripps Institution of Oceanography before 1980 (harmonised to recent data by adding 0.542ppm)

Source: NOAA-ESRL; Scripps Institution of Oceanography; Le Quéré et al 2016; Global Carbon Budget 2016

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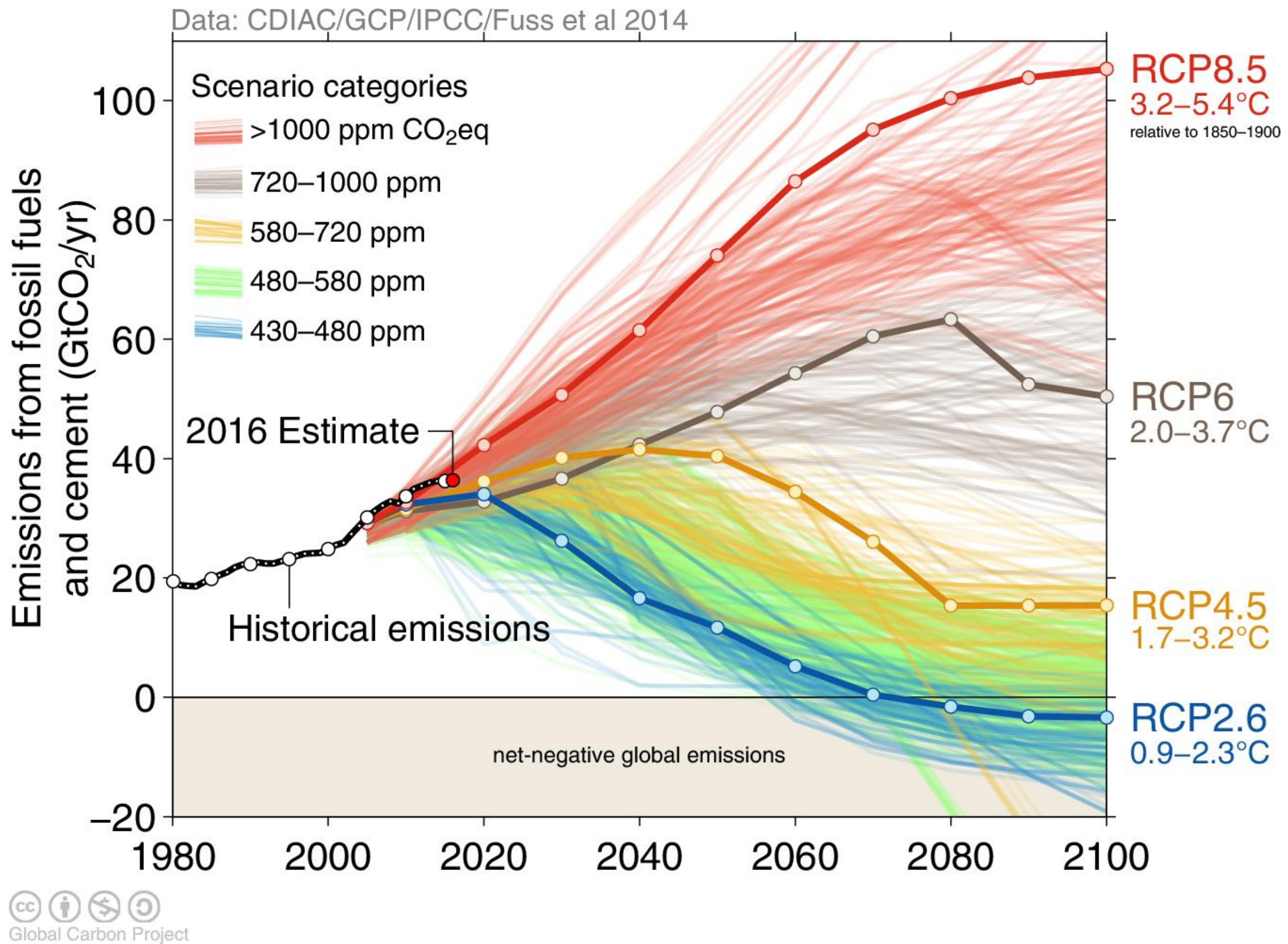
Observed emissions and emissions scenarios

The emission pledges to the Paris Agreement avoid the worst effects of climate change (4-5°C)
Most studies suggest the pledges give a likely temperature increase of about 3°C in 2100



The IPCC Fifth Assessment Report assessed about 1200 scenarios with detailed climate modelling on four Representative Concentration Pathways (RCPs)

Source: [Fuss et al 2014]; [CDIAC]; [IIASA AR5 Scenario Database]; [Global Carbon Budget 2016]

Emission reduction options

Main approaches:

- Pre-combustion measures: improved efficiency of energy production, coal washing, substitution of fuels,
- Post-combustion measures: CCS
- Co-control of climate gases and air pollutants (GHGs, PM, SO_2, NOx)
- Wider use of renewable energy sources

Selection of appropriate measures depend on:

- Current technology (different measures may be most cost efficient in different regions)
- Rules, regulations etc.
- Economic and social factors

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Coal use in China, India and South Africa

Power generation:

	Subcrit PCC	*SC/USC PCC*	*FBC*	*IGCC*
China	X	X	X	X
India	X	(X)	X	X
South Africa	X	(X)		

- Shanghai, 900 MW SC units
- Fuyang Huaren, 660 MW SC units

Sipat power plant, India

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Nordjylland 3, Denmark – highlights

USC, tower boiler, tangential corner firing, int. bituminous coals, cold sea water

Most efficient coal-fired plant

Operating net efficiency 47% LHV, power only mode/44.9% HHV (not annual)

High steam conditions 29 MPa/582°C/580°C/580°C at boiler by early use of new materials (P91)

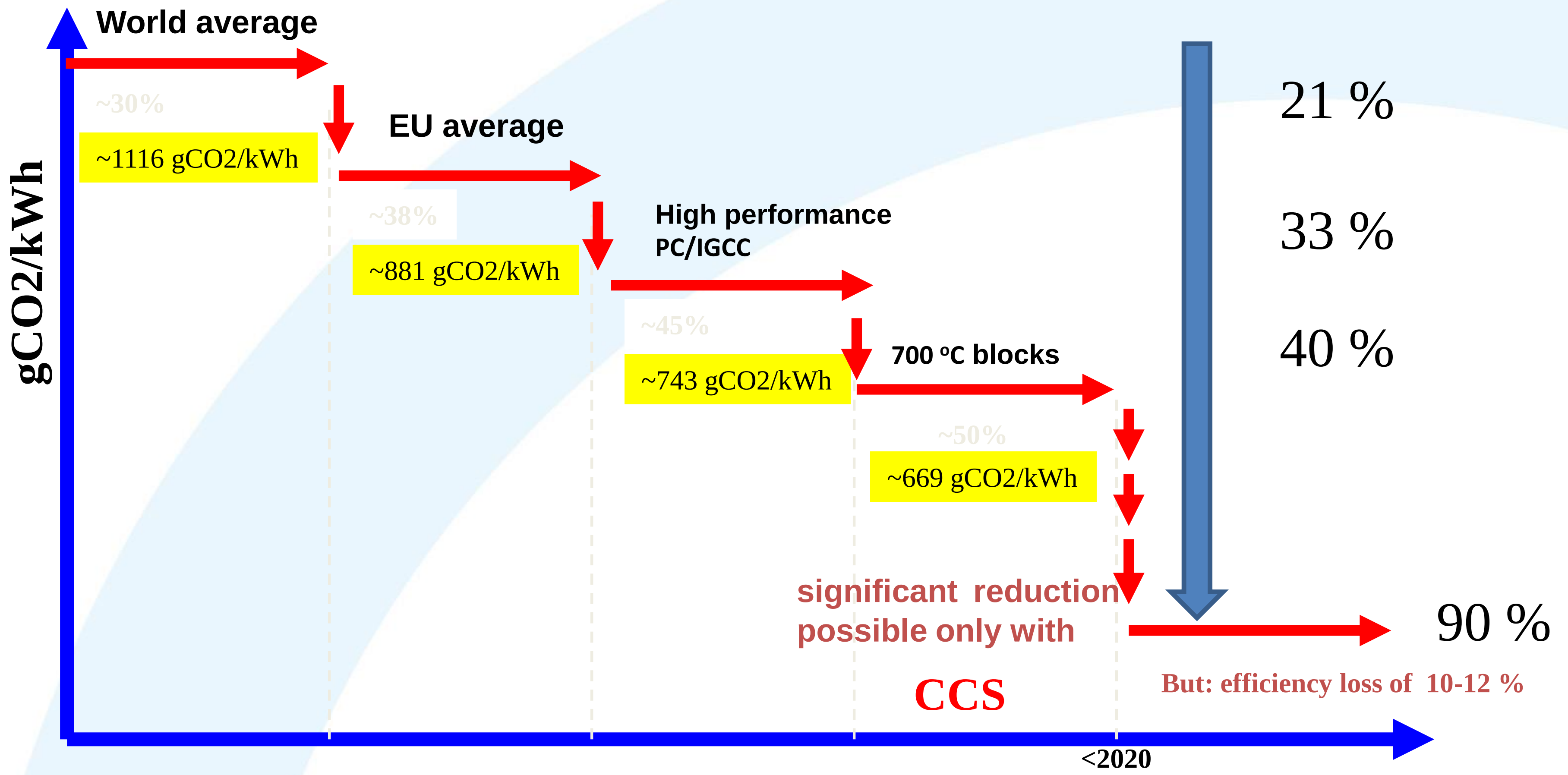
Large number of feedwater heating stages

Double reheat has prevented LP blade erosion

Very low emissions and full waste utilisation

NOx abatement	Combustion measures and SCR
Particulates removal	ESP
Desulphurisation	Wet FGD

CO_2 emission reduction as a result of technological changes



Increase of efficiency results in significant effects, but only CCS leads to real CO_2 emission reduction.

adapted from VGB 2007; efficiency – HHV,net

Sorbent based on ash from coal power station

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Applying LCA to CCS
Some initial observations…

- CCS has substantial potential to reduce point emissions of CO_2 and thus human induced climate change.
- CO_2 capture requires energy, chemicals and technical infrastructure. The capturing process also leads to air emissions and waste which needs to be compared to the benefits of reducing climate gases and other emissions.
- Technologies designed to reduce close to 90% of the CO2 from flue gas, reduces in reality 74-84 % for coal combustion plants.

Three parameters have been identified as having significant impacts on CCS:

- Power plant efficiency and energy penalty of the capture process
- CO_2 capture efficiency and purity
- Fuel origin and composition

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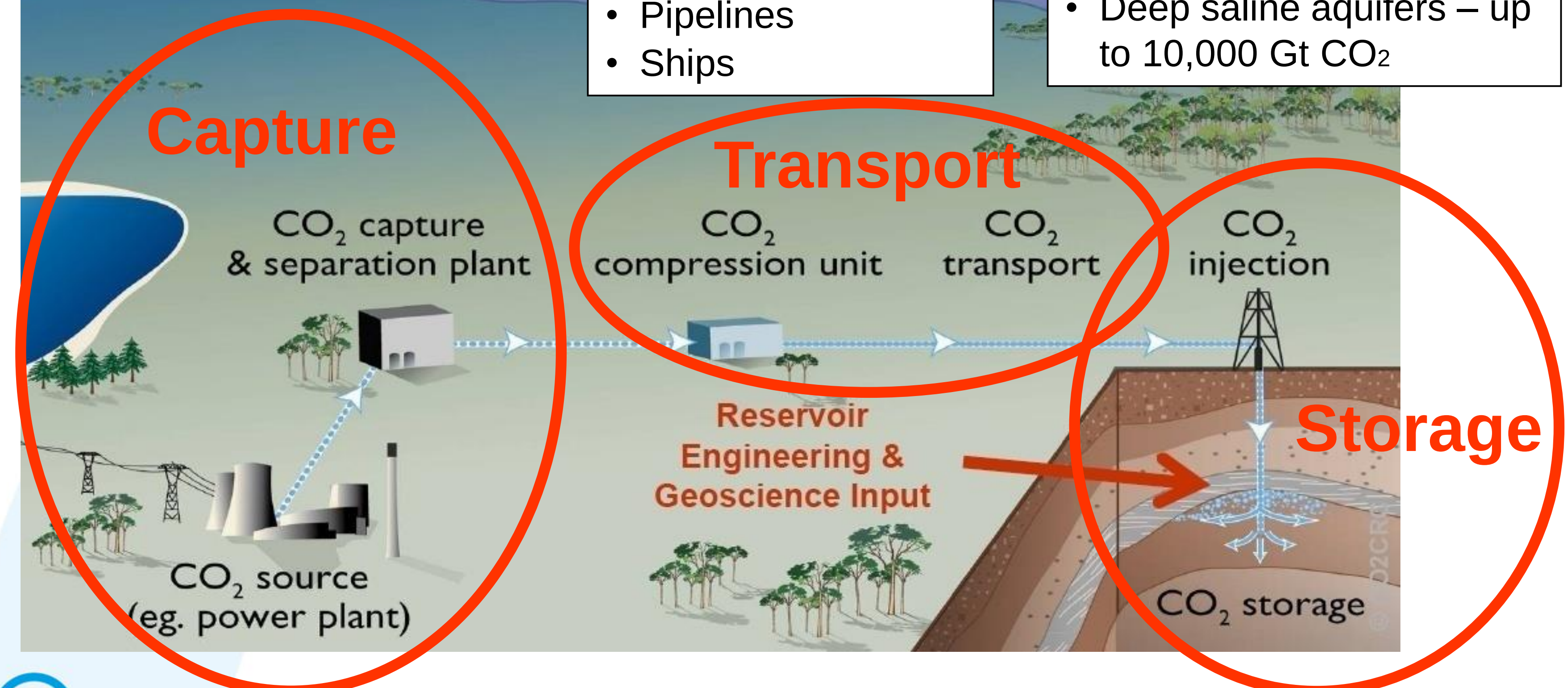
Carbon capture and storage

Three Options;
- Post-combustion
- Pre-combustion
- Oxyfuel

Two Options;
- Pipelines
- Ships

Three Options;
- Coal seams, 40 Gt CO_2
- Oil and gas fields, 1,000 Gt CO_2
- Deep saline aquifers – up to 10,000 Gt CO_2



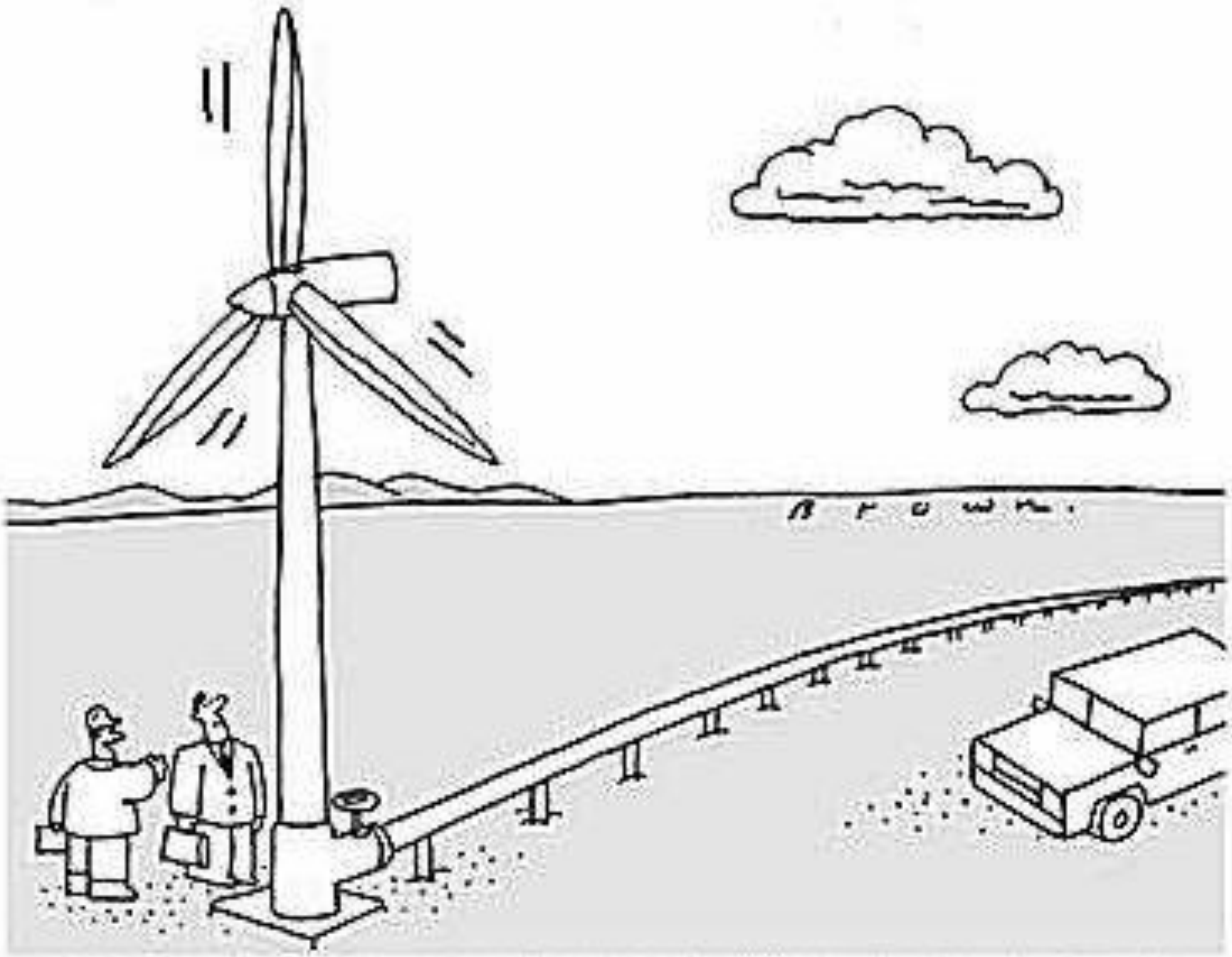
PRO_CCS:
Economically efficient and socially accepted CCS/EOR processes

Source:Bellona.org

Source:subseaworldnews.com

LCA will focus on the comparison between shipping and pipelines for CO_2 transport to storage sites

LCA will also compare post-combustion carbon capture in CHP/PC power plant or an industrial installation, and without CO_2 capture



"This is our most successful project. When we dug the footing for the wind turbine, we struck oil."

Background

http://www.undeerc.org/pcor/household-energy/electricity/

http://www.fires-gas.com/energy-ideas/different-types-of-fossil-fuels.html

http://www.economiccalendar.com/2016/08/06/crude-oil-prices-stabilize-after-worst-month-in-a-year/

2020 Climate and Energy Package
20 % share renewables by 2020

2030 Climate and Energy Framework
At least 27 % share renewables by 2030

http://www.iea.org/topics/renewables/subtopics/wind/

http://www.ieapower.com/solar-power-installation/

https://www.iea.org/topics/renewables/subtopics/hydropower/

Table 9.4 Cost comparison of electricity generating technologies. Adapted from the U.S. EIA, Annual Energy Outlook (2015)

Energy source	Plant type		Range for total system LCOE ($\$_{2013}$ per MWh) Minimum	Average	Maximum
Fossil fuels	Coal	Conventional	87.1	95.1	119.0
		Advanced	106.1	115.7	136.1
		Advanced with CCS	132.9	144.4	160.4
	Natural gas	Conventional combined cycle	70.4	75.2	85.5
		Advanced combined cycle	68.6	72.6	81.7
		Advanced with CCS	93.3	100.2	110.8
	Nuclear	Advanced	91.8	95.2	101.0
Renewable	Geothermal		43.8	47.8	52.1
	Biomass		90.0	100.5	117.4
	Wind	Onshore	65.6	73.6	81.6
		Offshore	169.5	196.9	269.8
	Solar	PV	97.8	125.3	193.3
		Thermal	174.4	239.7	382.5
	Hydroelectric		69.3	83.5	107.2

Note: The values for each source are given for a different capacity factor

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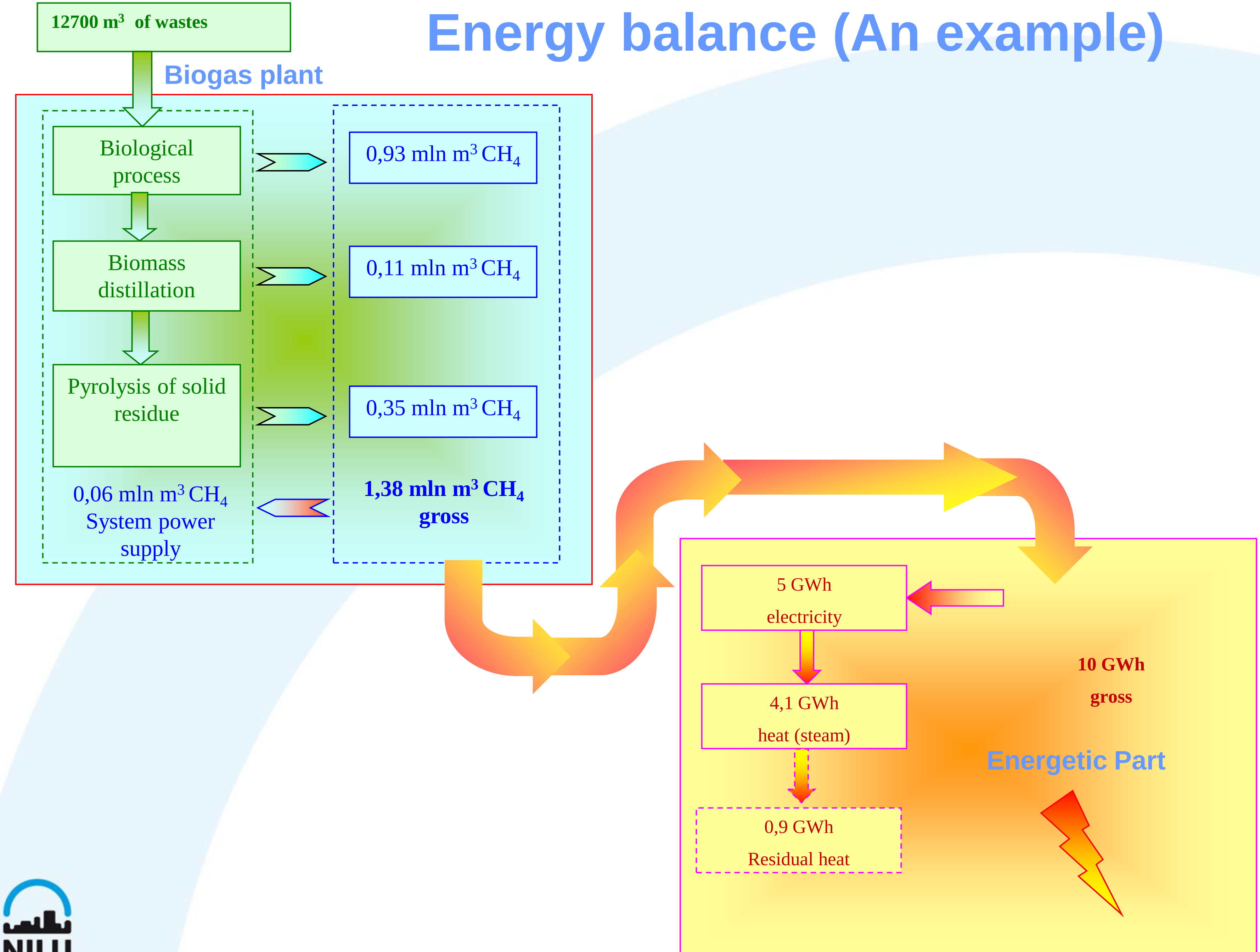
Energy balance (An example)



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Can coal combustion be environment friendly?

YES, it can, BUT:

- New, highly efficient combustion technologies are needed to produce electricity and heat (new blocks with supercritical vapor conditions, co-generation, hybrid systems, etc).
- Carbon dioxide emissions should be reduced through the implementation of pre-combustion, post-combustion methods, or combustion in oxygen.
- CCS technologies should be implemented mainly in new power stations (storage of carbon monoxide should be resolved).
- Co-control technologies should be employed to reduce emissions of various contaminants, such as mercury (e.g. various adsorbers).
- Cost of the above technologies should not lead to deterioration of competitivness and relocation of energy production outside EU, where standards are less restrictive.

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Emission reductions are achievable

Thank you for your attention