Technologies Carbon Capture and Storage (CCS)

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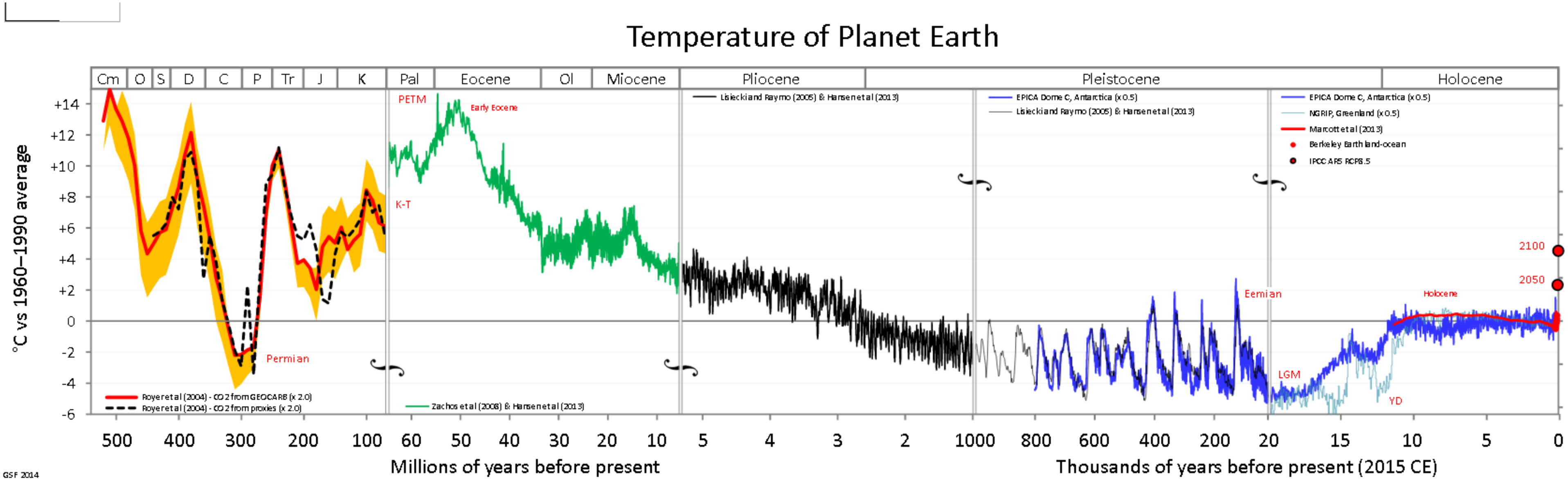
WHY CAPTURE AND STORAGE OF CO_2?

- there is an opinion that humankind-produced CO_2 (and increase of its atmospheric concentration) is a cause of so-called global climate change or global warming
- major CO_2 sources: fossil fuel combustion, industry (steel, cement), crude oil refining
- 1860-2010 atmospheric concentration has risen from 300 to 400 ppm
- CCS currently does not belong into priorities of energy and climatic policy
- Actual State Energy Conception expects a role for CCS after 2040 and recommends a support for CCS research



CCS technologies in general

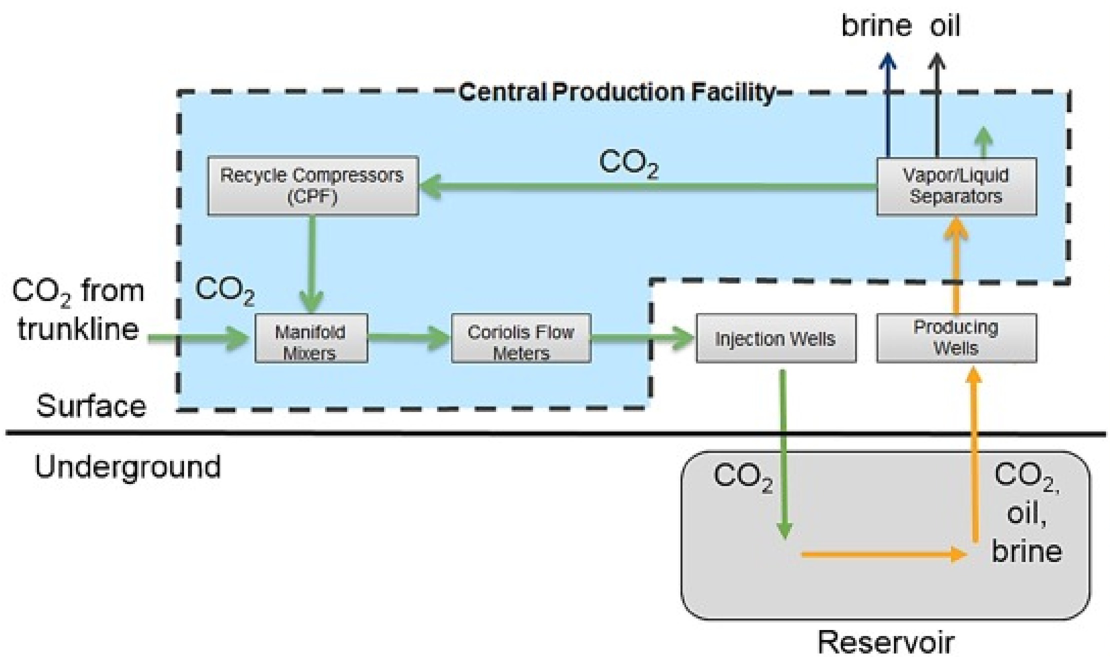
- **3 TECHNOLOGIC PARTS:** capture, transport, storage (alternatively CCU – utilization)
- **CAPTURE:** 3 main technology groups – post-combustion, pre-combustion and oxyfuel combustion
- **TRANSPORT:** gaseous or liquid, different pressures and temperatures according to economic effectiveness; <u>longer distances</u> – pipeline transport in gas phase, ship transport in liquid phase; <u>shorter distances</u> – railway transport in liquid phase
- **STORAGE:** <u>saline aquifers</u> – porous rocks containing saline water; <u>exploited oil and gas fields</u> – EOR; alternative options – deep sea hydrates, some specific rocks (e.g. basalt)

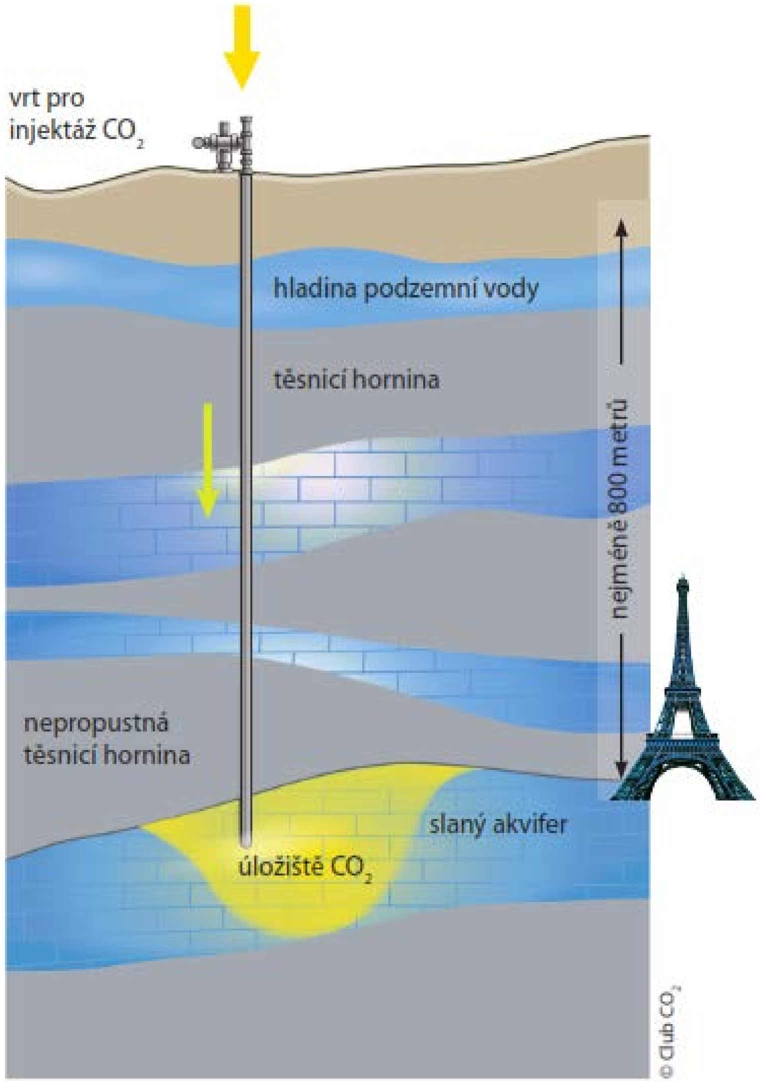
CCS technologies in general

- **STORAGE:** CO_2 in time (100-1000 years) reacts with surrounding environment to form new minerals

- **UTILIZATION:**

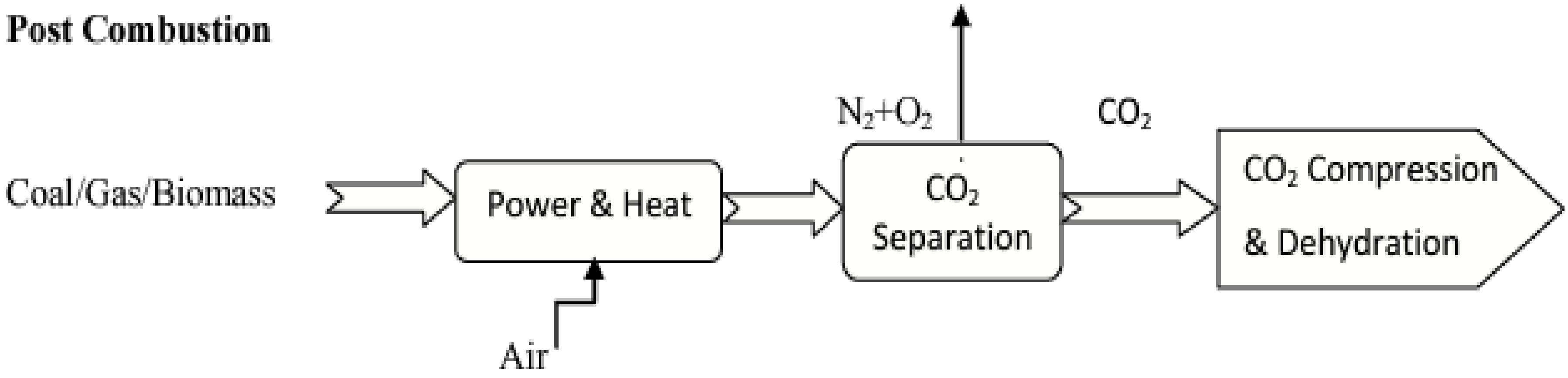
- EOR – enhanced oil recovery (and simultaneous storage)





POST-COMBUSTION CAPTURE

- = separation of CO_2 after a combustion process has been completed = capture of CO_2 in a low concentration from large gas flows
- 250 MWe unit (NW Bohemian lignite coal) produces approx. 770 thousand Nm^3/h of flue gas with CO_2 concentration approx. 14 %



POST-COMBUSTION separation processes

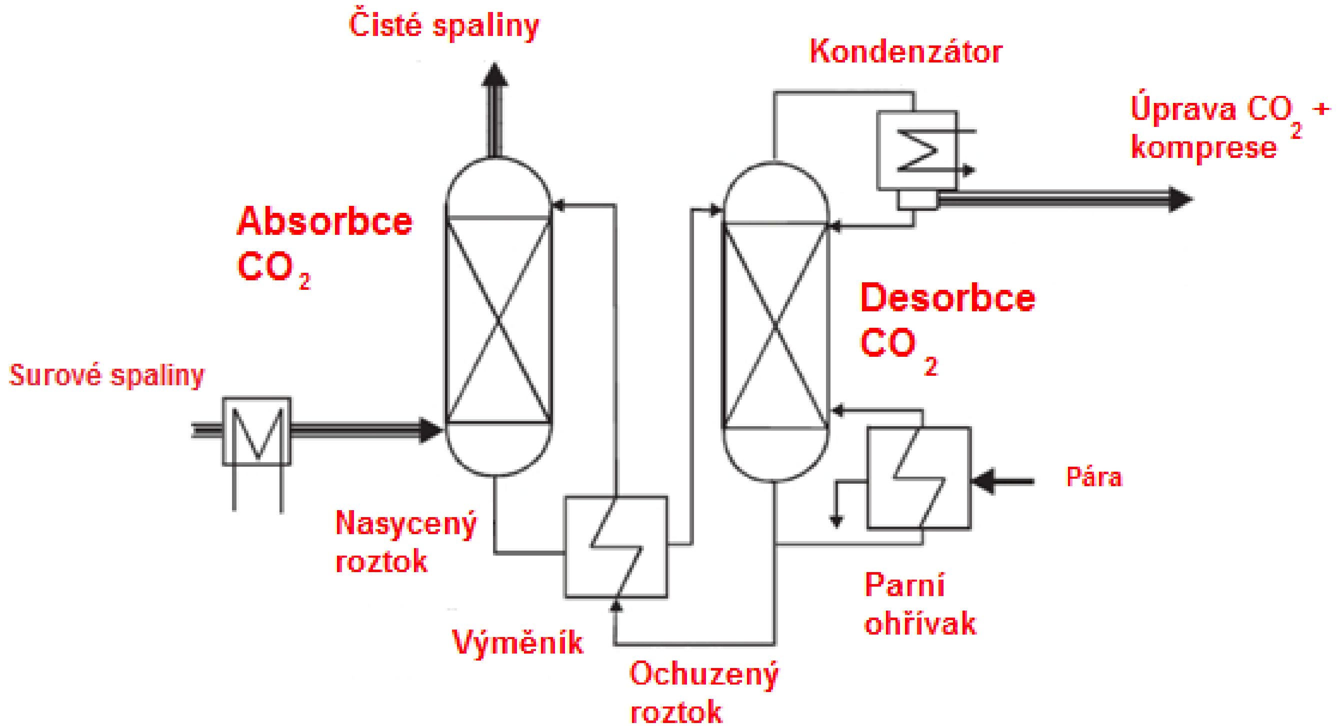
Technology	Principle
Absorption	1) Amine scrubbing, e.g. MEA or DEA 2) NH_3 – ammonia scrubbing 3) Alkaline solvents, e.g. NaOH
Adsorption	1) Ca-based sorbents, e.g. limestone – Ca-looping 2) Alkaline carbonates, e.g. Na_2CO_3 3) Special sorbents and molecular sieves, e.g. zeolites or active carbon
Membrane separation	1) Polymeric membranes 2) Inorganic and hybrid membranes
Cryogenic separation	Separation of CO_2 by freezing

MEA SCRUBBING

- demo unit SaskPower – Boundary Dam power plant, Canada

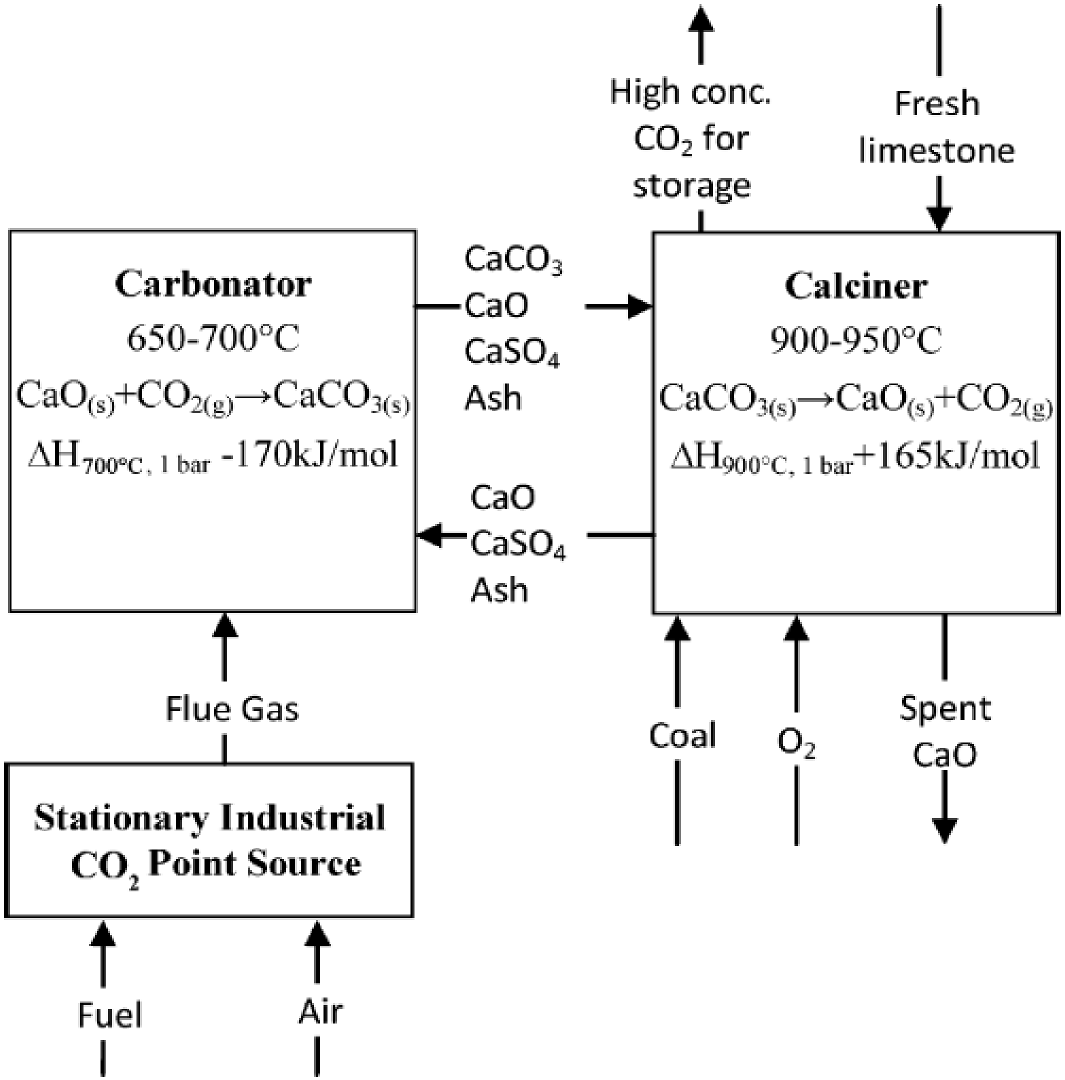
- flue gas after deNOx and deSOx, regeneration in desorber; compared to ammonia: (+) higher absorption temperature (15°C); (-) lower capacity, solvent degradation

$$HOCH_2CH_2-NH_2+CO_2+H_2O \rightarrow HOCH_2CH_2-NH_3^+ + HCO_3^-$$



Ca-looping

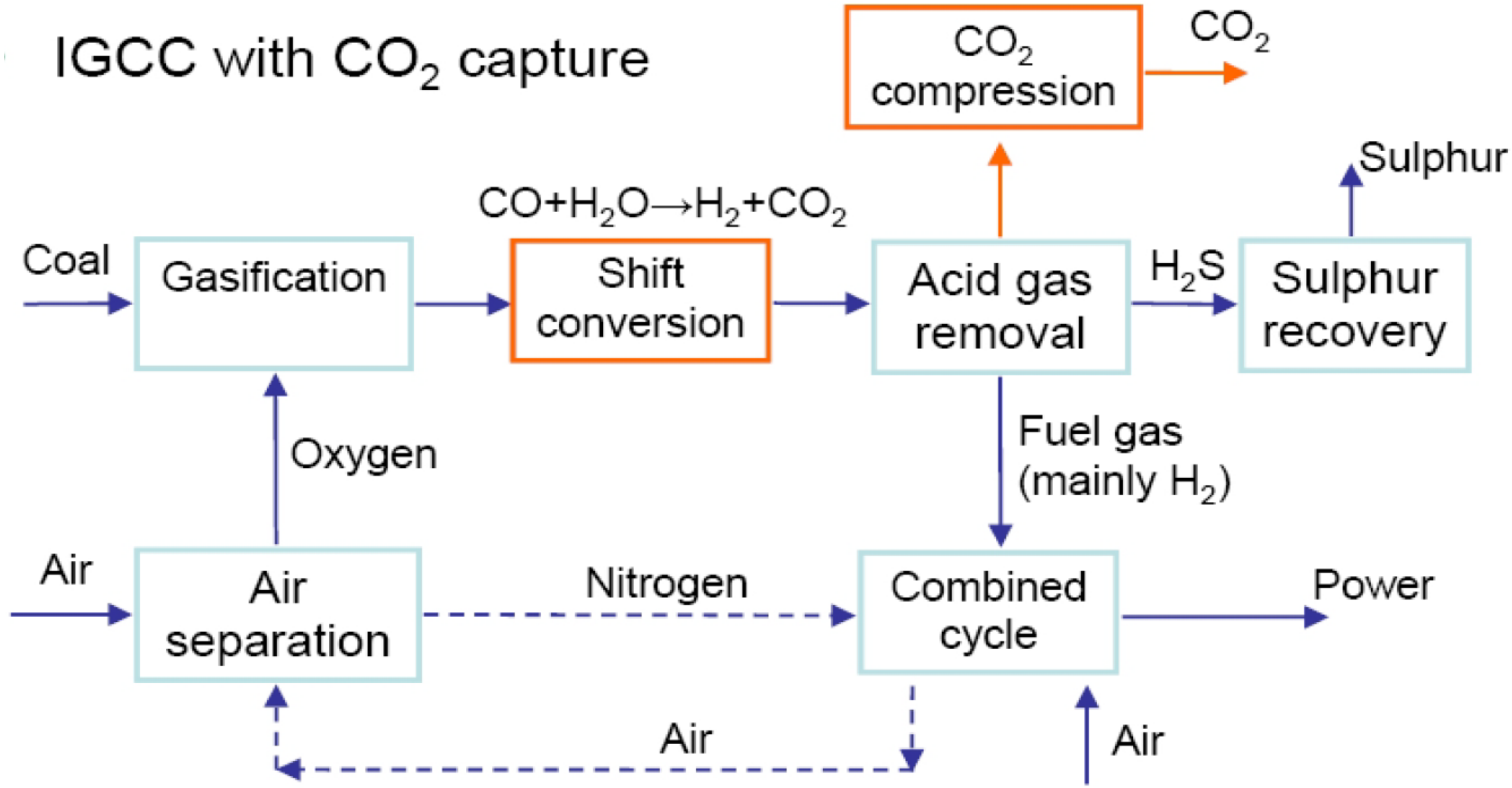
- dual CFB principle



- Ca-looping application in a conventional power plant means **building a new source of about half thermal input in oxyfuel mode**
- (+) proven CFB techno-logy, cheap sorbent, recoverable energy;
- (-) oxygen consumption, plant size, lower capture ratio, electricity need for driving the circulation of solids

PRE-COMBUSTION capture

- based on fuel gasification, conversion of CO to CO_2 and subsequent separation, product is H_2
- hydrogen is used in conventional IGCC



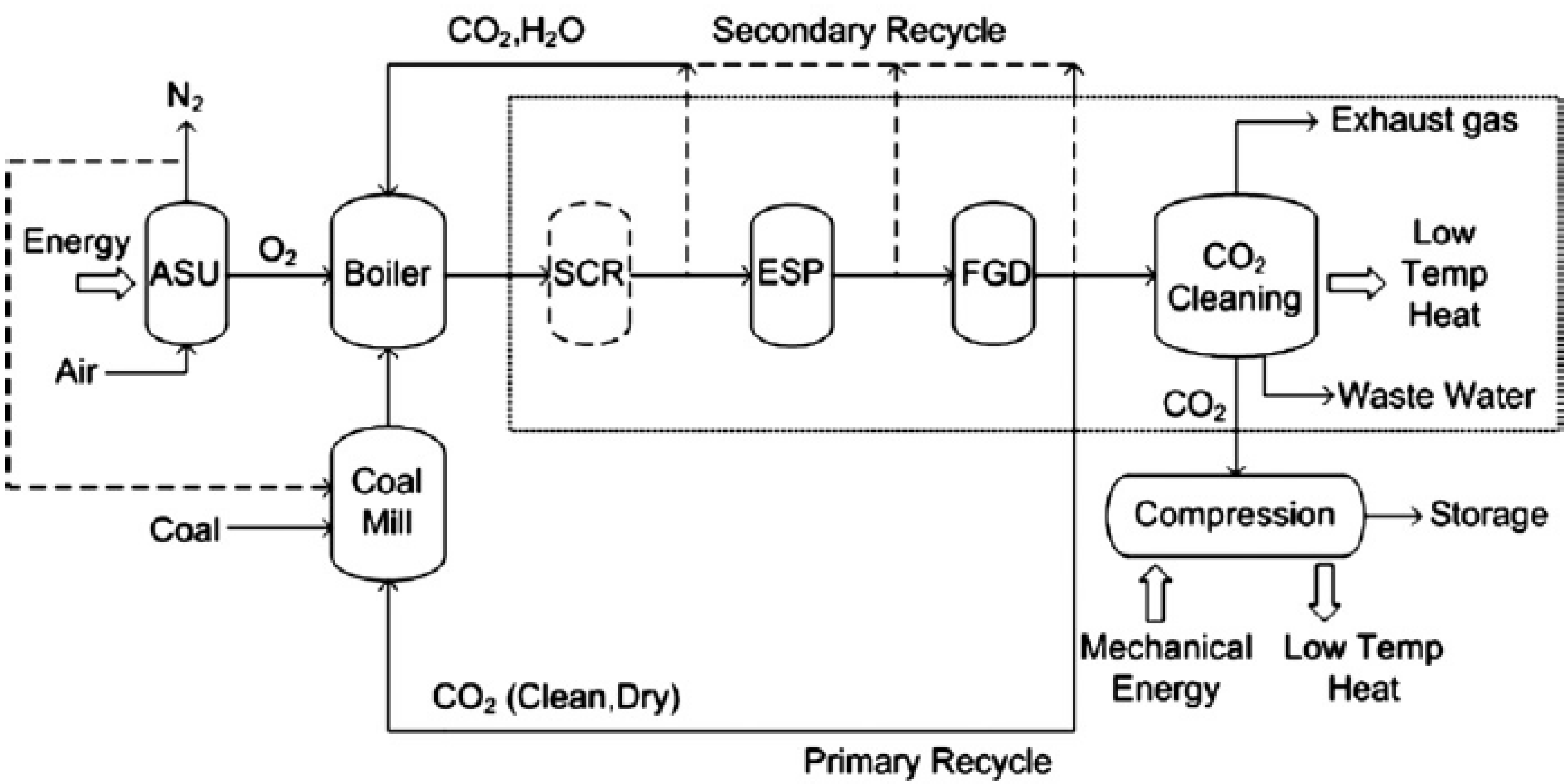
PRE-COMBUSTION capture

- Water-gas shift: two-step conversion of CO to CO_2; catalytic process (ZnO/Al_2O_3), LTS 150-300°C, HTS 350-600°C
- CO_2 is separated using an AGR (acid gas removal) technology – either with acid gases (WGS before separation) or stand-alone (WGS after separation)

Procedure	Process name	Specification
Absorption (no chemical reaction)	Selexol/Coastal AGR	Solvent mixture of dimethyl ethers and propylene glycol (DEPG); temperature 20°C
	Rectisol/Ifpexol	Solvent methanol, sub-cooled -20 to -60°C (IGCC Vřesová)
	Purisol	Solvent N-methyl-pyrollidon (NMP), chilled to-15°C
	FluorSolvent	Solvent propylen-carbonate; chilled to -18°C
Absorption with chemical reaction	MEA	Solvent mono-etanolamine

OXYFUEL COMBUSTION

- technologically most simple capture – combustion of a fuel with pure oxygen, output is concentrated CO_2+H_2O vapor (+minor pollutants)
- (+) simple technology, requires „only“ ASU construction; (-) purity of output CO_2, concentration lowered by false air intake and oxygen excess; corrosion and deposits; different dimensioning of heat exchanging surfaces



COMPARISON OF CCS TECHNOLOGIES – 250 MWe reference, 9.5 MJ/kg, 90 % capture

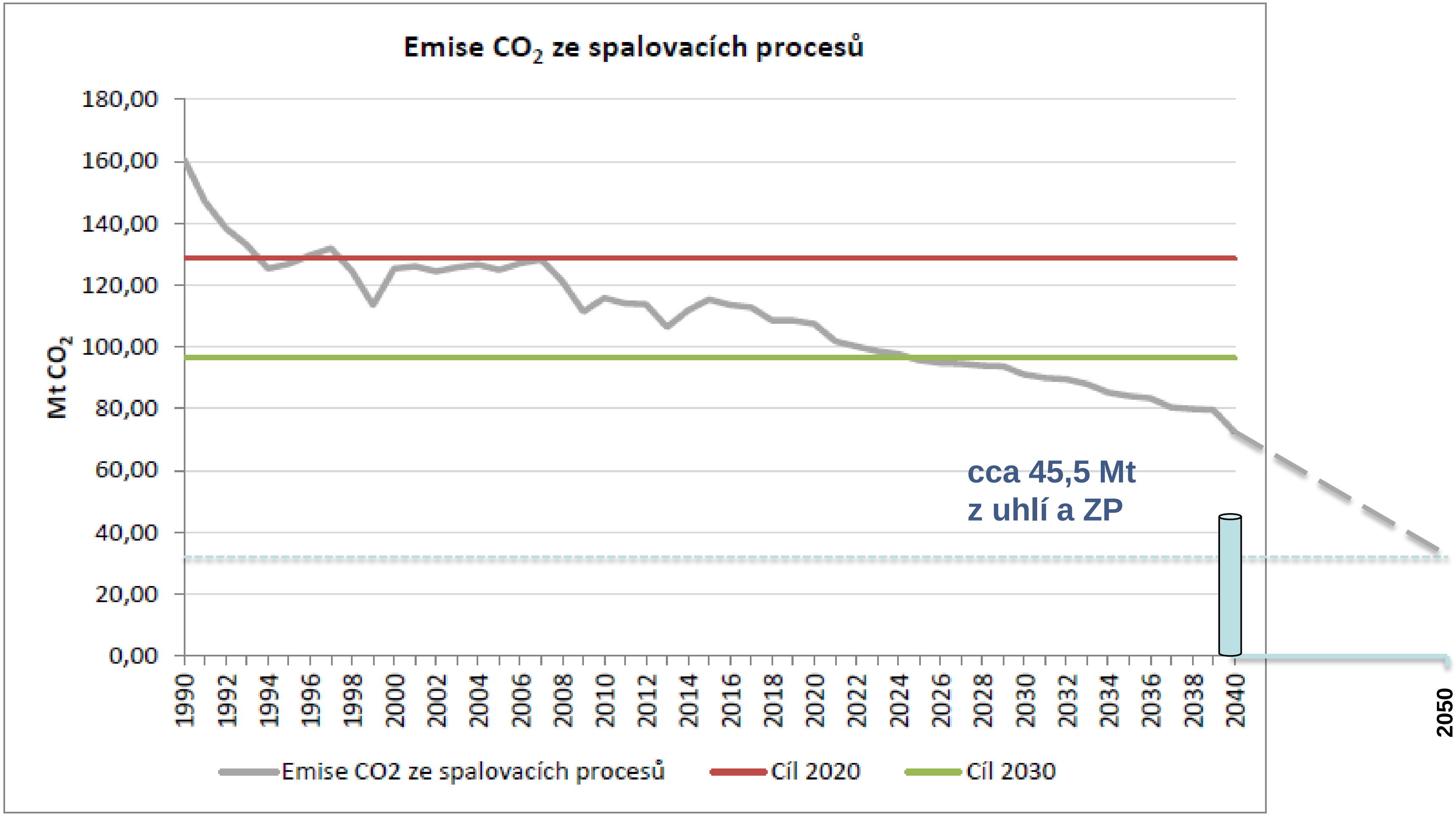
Parameter		Current plant	NH_3 scrub	Oxyfuel	Solid adsorbent/ zeolite	Ca-looping *)	Pre-combustion/ Rectisol*)
El. out brutto	MWe	250	238	262 **)	245	354	272
Fuel consumption	t/h	214	214	217	214	369	99**)
Internal consumption	MWe	24	75	94	47	123	41
CO_2 production	t/h	211	211	216	211	211+113	211
CO_2 capture	t/h	0	190	190	158	297	201
CO_2 to air	t/h	211	21	26	53	27	10
El. out netto	MWe	226	163	168	198	231	231
Electric efficiency	**%**	**38.4**	**28.12**	**28.53**	**33.73**	**23.01**	**39.75**
Efficiency decrease	**p.b.**	**0**	**10.87**	**10.46**	**4.77**	**15.39**	**-----**

*) coal SD, calorific value 16,5 MJ/kg **) fuel pre-dried to 11% - WTA drier

Thank you for your attention!

CCS in the Czech Republic

Graf č. 33: Emise CO_2 ze spalovacích procesů



Pozn.: Pro emise CO_2 nejsou stanoveny cíle pro jednotlivé země EU, ale pouze cíl pro EU jako celek. Uvedené linie jsou tedy vypočteny z hodnot cíle EU snížení emisí do roku 2020 o 20 % oproti roku 1990 a cíle EU snížení emisí do roku 2030 o 40 % oproti roku 1990 vztažených k hodnotě emisí ze spalovacích procesů na území České republiky.