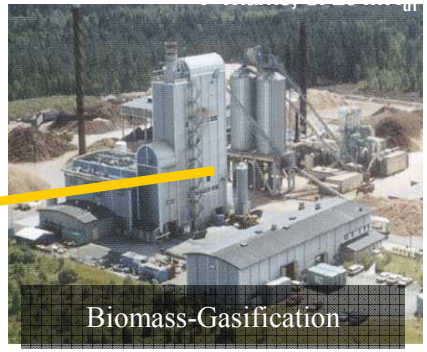
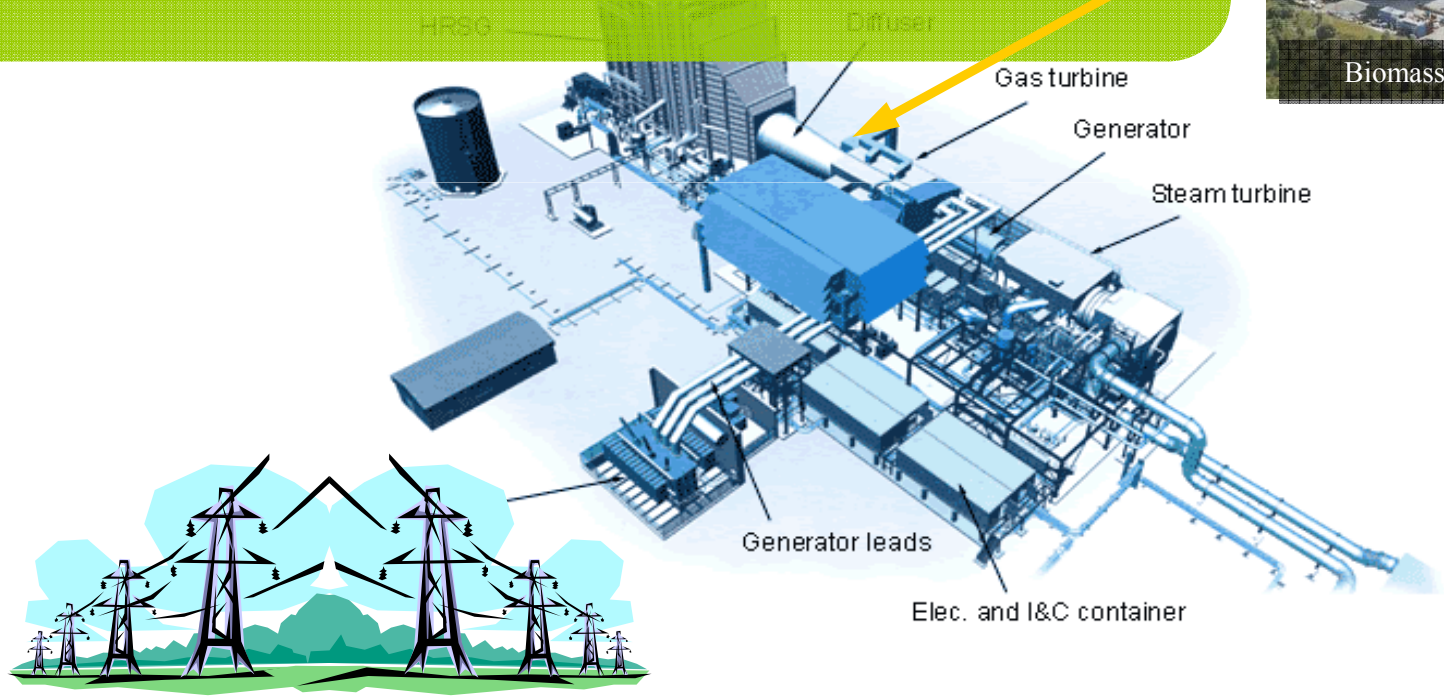
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Energie BFE
Swiss Federal Office of Energy SFOE

ZEP (Technology Platform Zero Emission Power Plants) - R & D activities in Europe



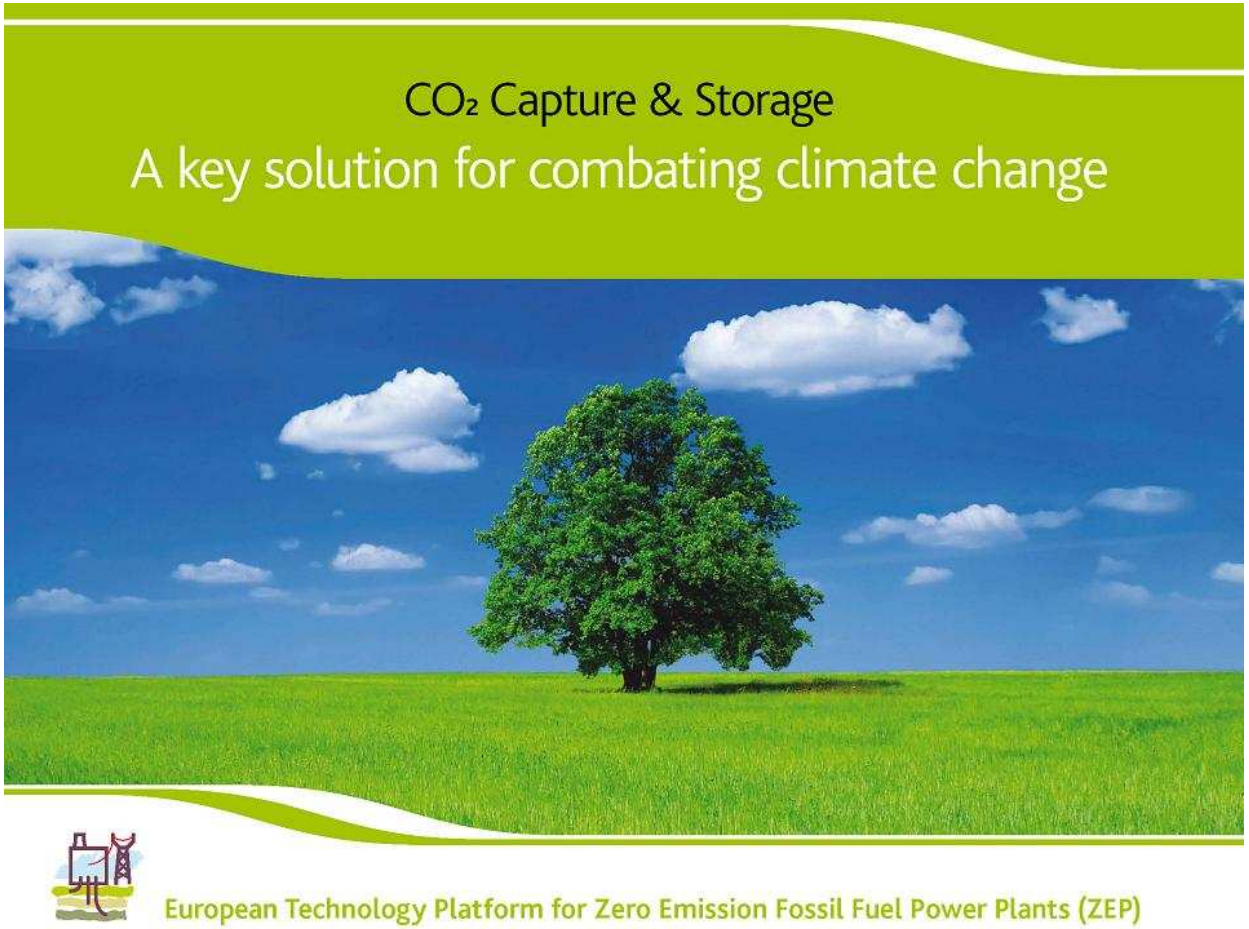


Overview

- European networks:
  Technology Platform Zero Emission Power Plants
  The European CCS Demonstration Project Network
- European Research Framework Program ***(FP7):***
  - Integrated research Projects, e.g. H2-IGCC
  - European Energy Research Alliance (EERA) CO_2 Capture and Storage
  - European Carbon Dioxide Capture and Storage Laboratory Infrastructure (ECCSEL)
- European Industrial Initiative ***(EII)***
  - Carbon Capture & Storage CCS

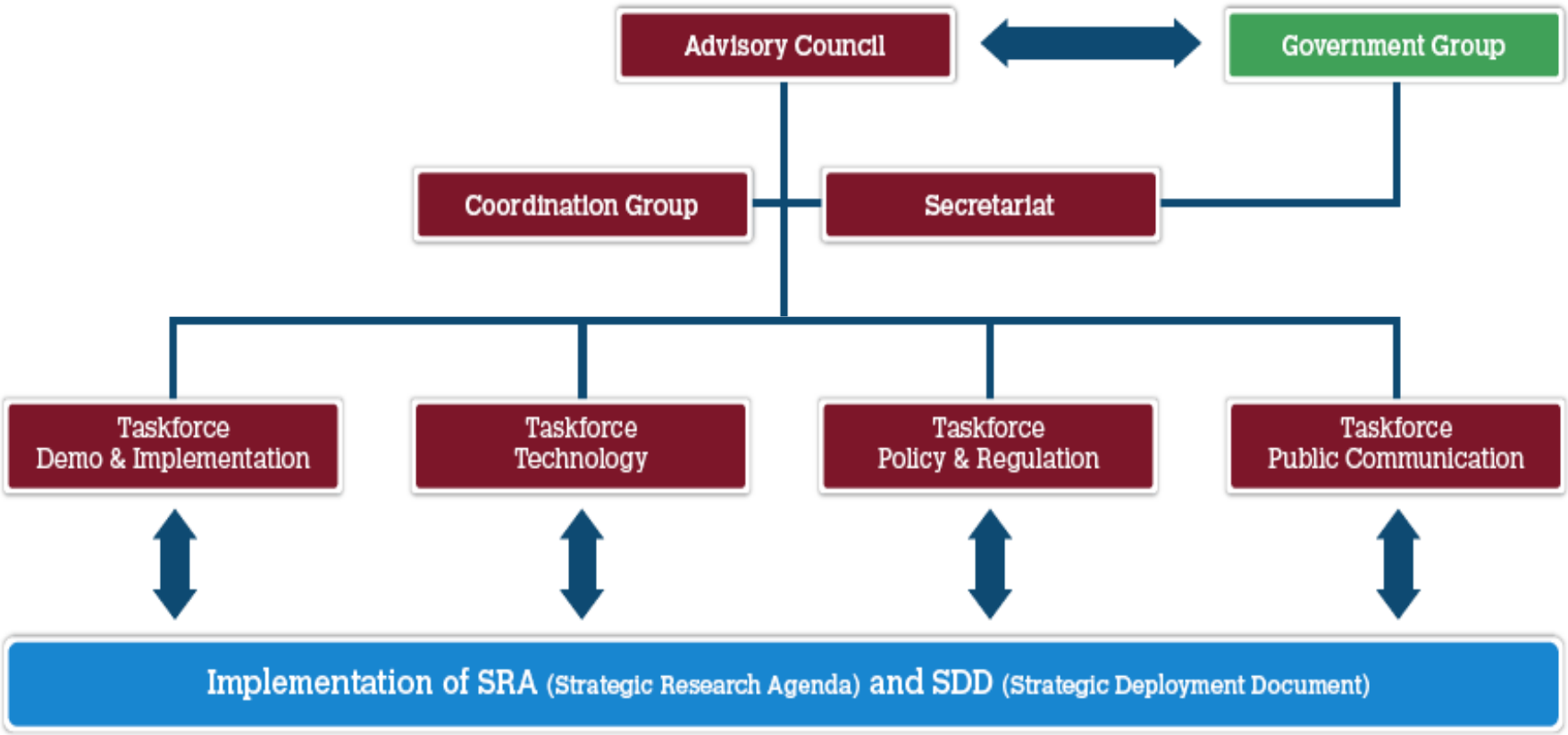
with participants like

European Technology Platform for Zero Emission Fossil Fuel Power Plants



www.zeroemissionsplatform.eu

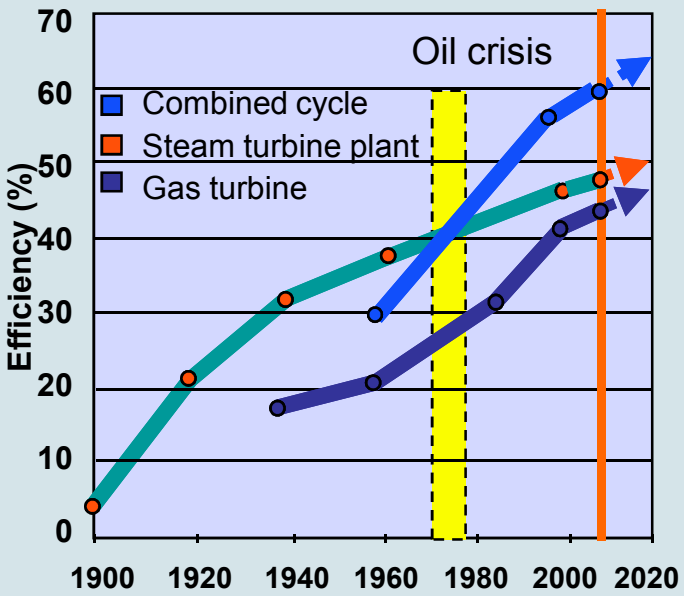
European Technology Platform for Zero Emission Fossil Fuel Power Plants

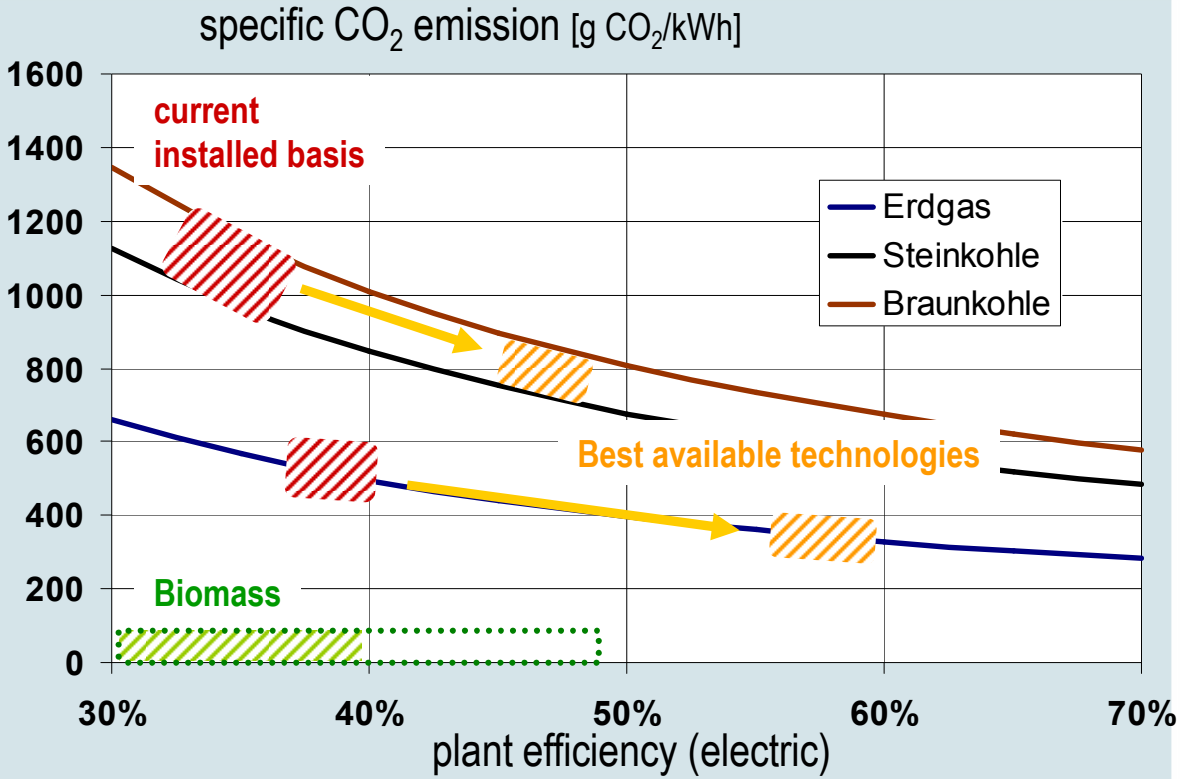


www.zeroemissionsplatform.eu

CO_2 MITIGATION VIA INCREASE OF EFFICIENCY

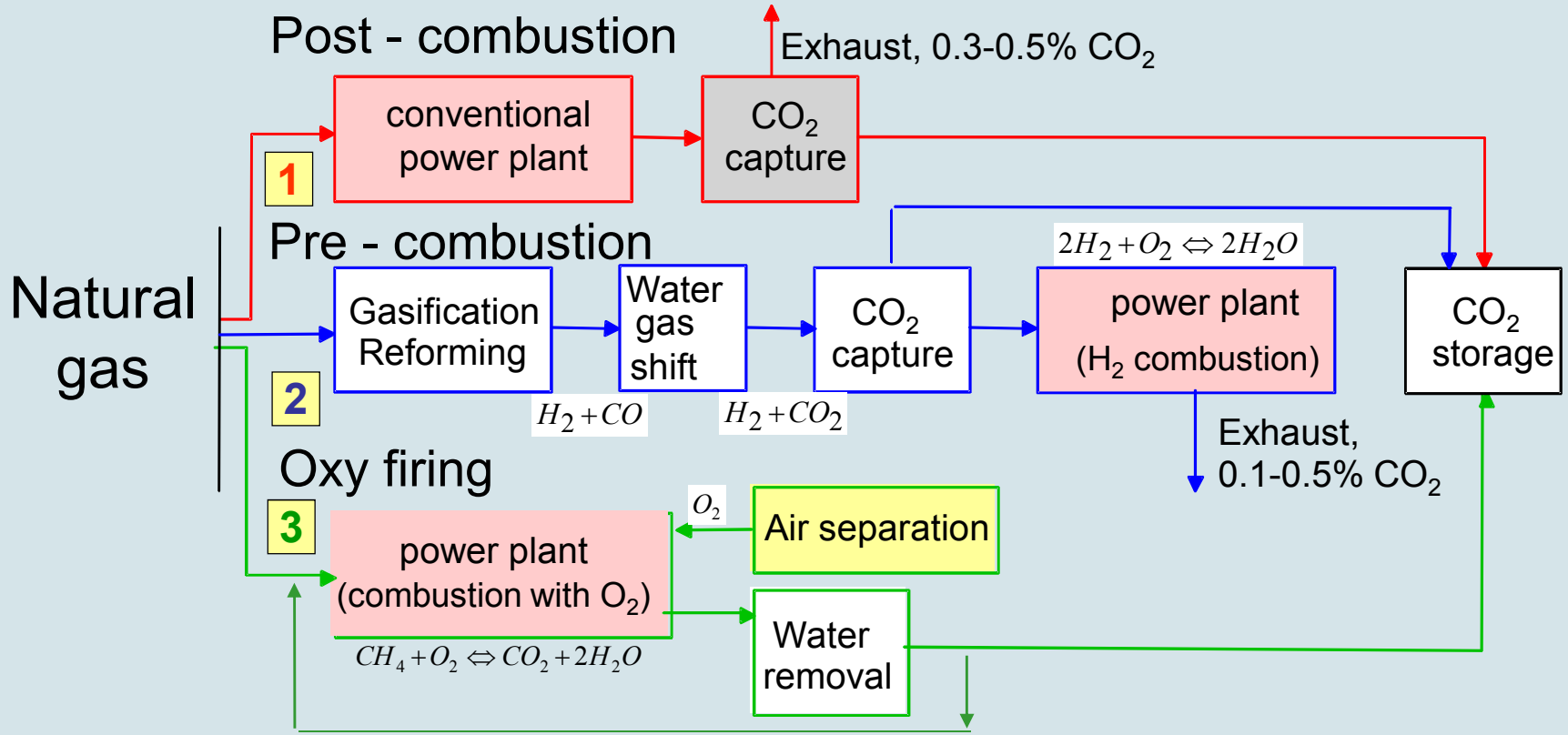
⇒ impressive history in efficiency improvements





⇒ significant reduction (-35%) in CO_2 emissions by introduction of high efficiency plants

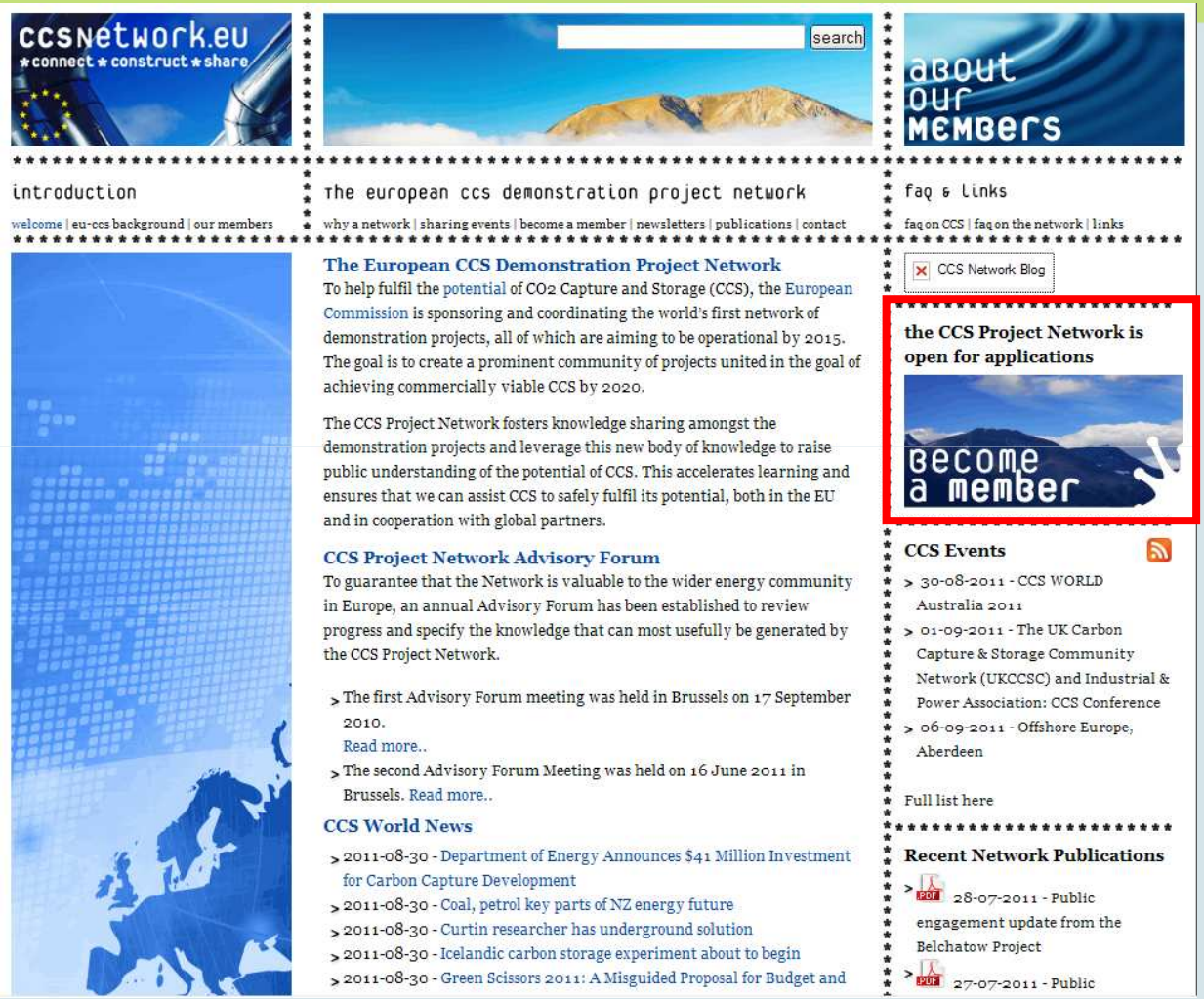
CO_2 MITIGATION VIA CARBON CAPTURE & STORAGE (CCS)



European Technology Platform for Zero Emission Fossil Fuel Power Plants

The European CCS Demonstration Project Network

www.ccsnetwork.eu



The European CCS Demonstration Project Network

www.ccsnetwork.eu

Project title	Storage location
1 Porto Tolle	Adriatic Sea
2 Jänschwalde	Natural gas field "Altmark", saline...
3 Bełchatów CCS Project	Three potential storage sites have been...
4 Hatfield CCS Demonstration Project	South North Sea, hydrocarbon reservoir or...
5 Rotterdam ROAD	North Sea, near the Dutch coast
6 Compostilla Oxy CFB 300	Duero basin

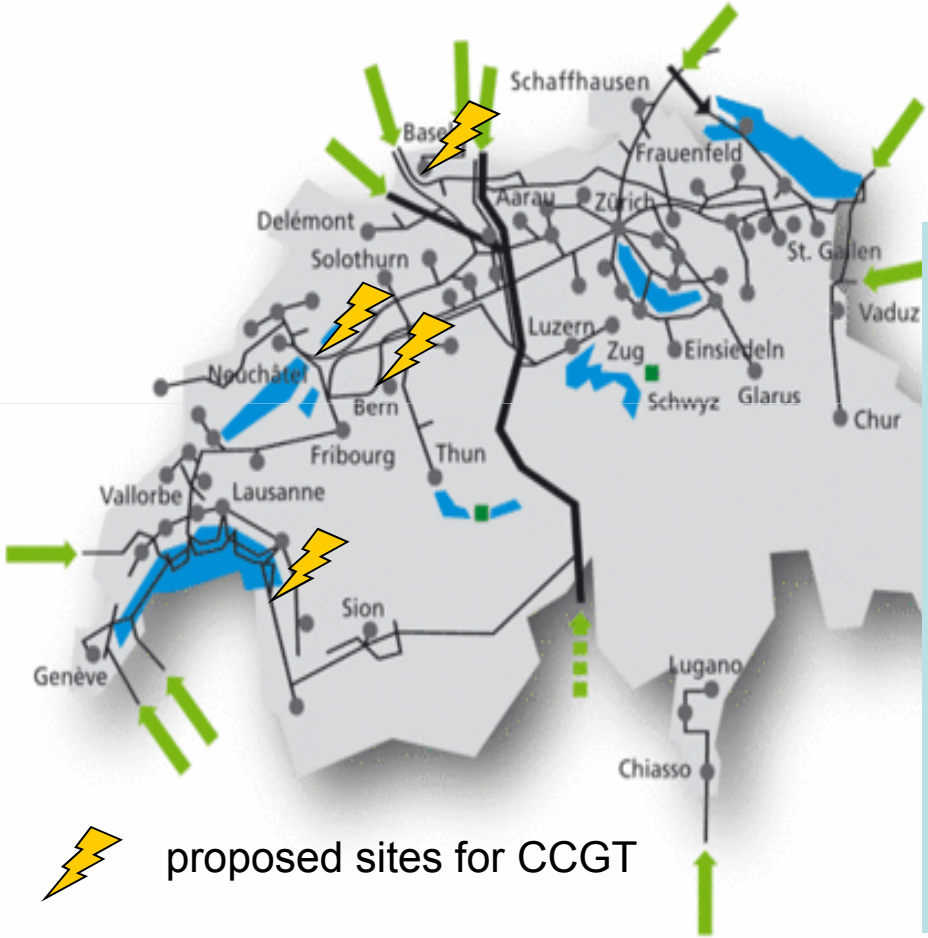
The European CCS Demonstration Project Network

www.ccsnetwork.eu

Eligibility Criteria

Projects in the Network shall have sound plans to
demonstrate the full CCS value chain by 2015
and shall fulfil the following ***technical criteria***:
The CCS project shall for a fossil fuel-fired power plant have a
minimum gross production of 250MWe
before CO2 capture and compression.
The CCS project shall for an industrial plant realise a
minimum of 500kt per year of stored CO2.
The **CO2 capture rate shall not be less than 85%**
of the treated flue gas stream.
The project, i.e. the plant to which CCS is applied, shall be
located within the European Economic Area (EEA)

Swiss Options for participation in the ZEP Flagship Programme



Swiss Natural Gas Pipeline Network

concerted effort needed

- ***political boundary conditions in CH*** *(& France)*
- ***commitment of project developer(s)***
- ***funding of Flagship Programme*** *(7-12 Bln€)*

Alstom's CCS development programs

Presented to Swiss Electric

Dr. Andreas Brautsch

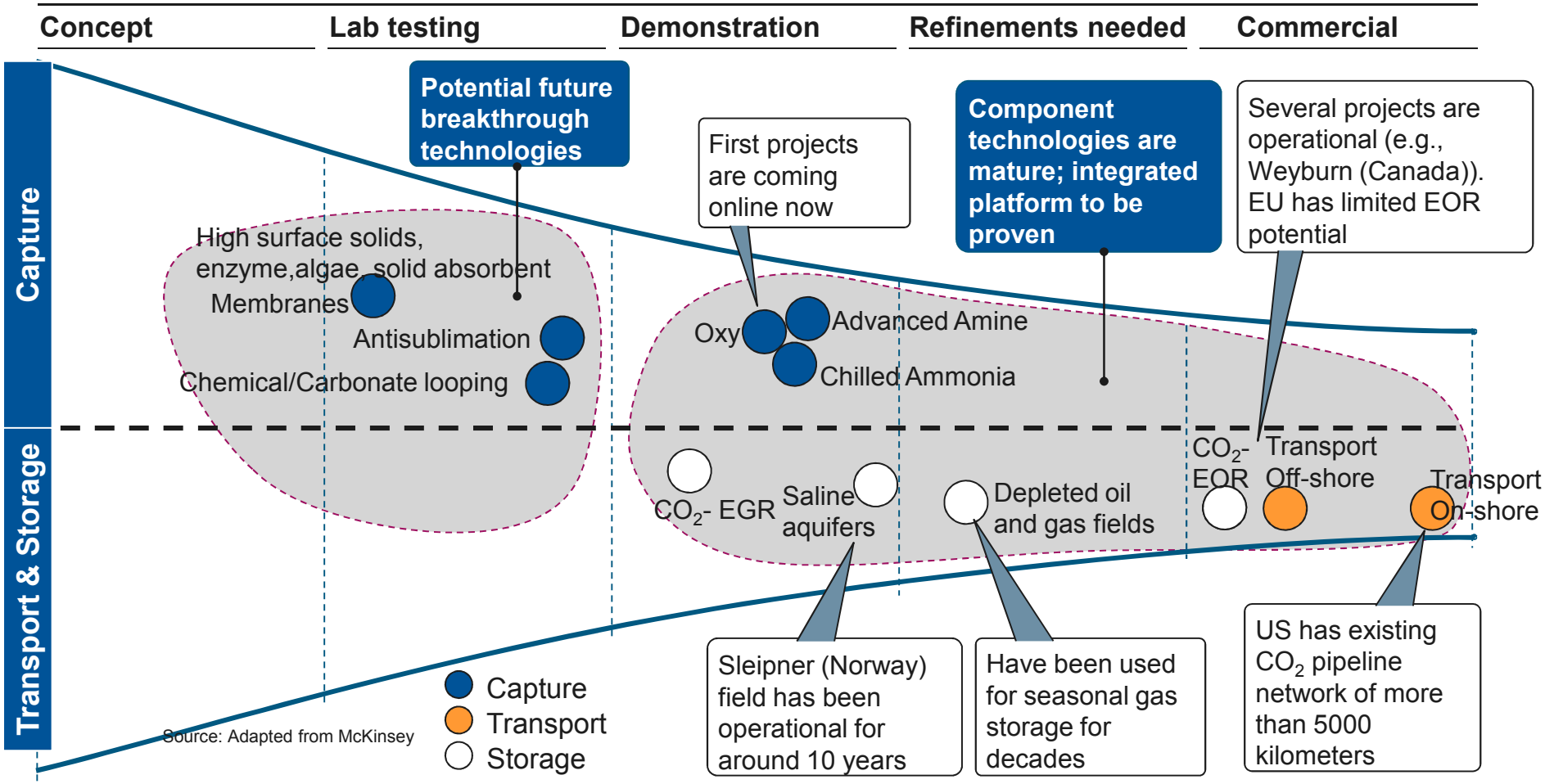
Director R&D Programs CCS

Bern, Aug 31st 2011

ALSTOM

Status of CCS development

ALSTOM

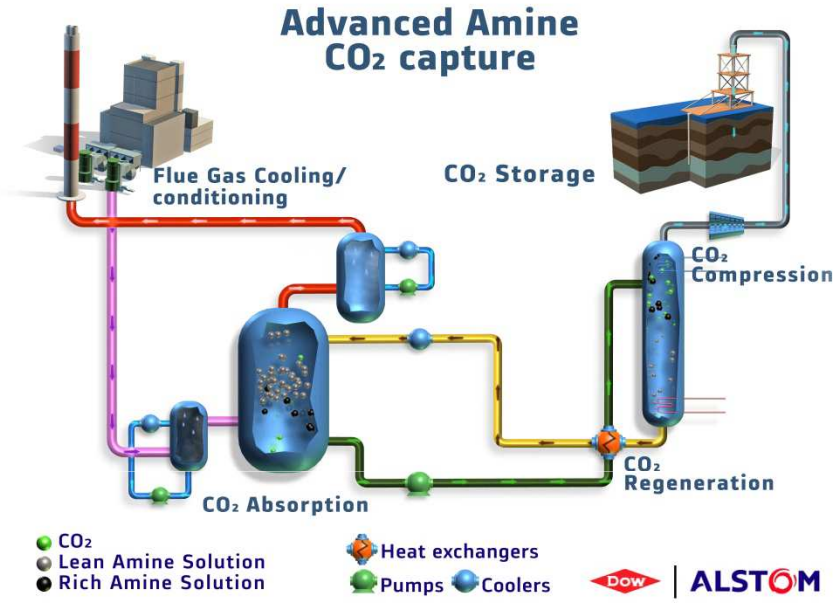


1st CCS Generation in Demo phase, 2nd Generation at pilot level

Advanced Amine Process (AAP)

Principle

- Flue gas is treated with aqueous amine solution, which reacts with CO_2
- Raising the temperatures reverses the above step – releasing CO_2 and recycling the solution for re-use



Key features AAP

- Proven in natural gas & syngas purification
- Carbon capture from flue gas is a new application with new challenges
- More efficient capture of CO_2 than MEA process
- Higher tolerance against oxygen & trace contaminants than MEA
- Lower solvent degradation rates than MEA

Advanced Amine Process (AAP) Alstom roadmap

2007 — **2009** — **2011** — **2014-2015** — **from 2015**

Pilot → **Industrial / Validation** → **Large-scale demonstration** → **Commercial**

University of Texas
USA

Dow Chemical Co.
USA - 2MWth, Coal

EdF Le Havre
France - 4 MWth, Coal

PGE Belchatow
Poland - 260 MWe, Lignite
(FEED completed)

Selected for receiving EEPR funding

In operation **Tests completed** **In construction** **Coming**

Chilled Ammonia Process (CAP)

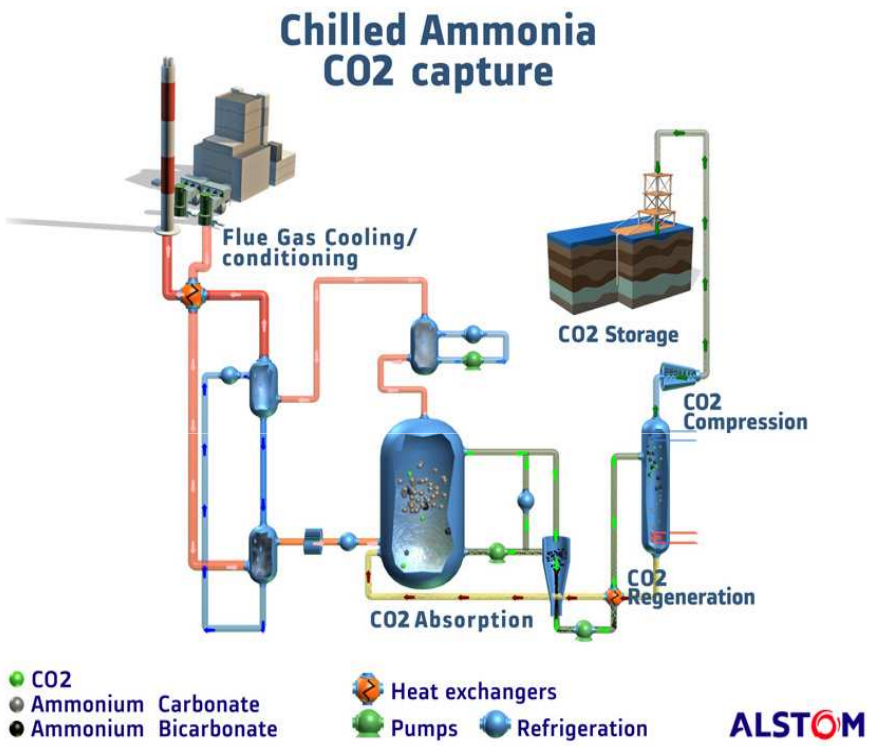
ALSTOM

Principle

- Cooled flue gas is treated with ammonium carbonate in solution, which reacts with CO_2 to form ammonium bicarbonate
- Raising the temperatures reverses the above reactions – releasing pressurized CO_2

Advantages

- Energy-efficient capture of CO_2
- High CO_2 purity
- Tolerant to oxygen and flue gas impurities
- Stable reagent, no degradation possible, no emission of trace contaminants
- Low-cost, globally available reagent



Source: Alstom

Chilled Ammonia Process (CAP)
Alstom roadmap

2006 — **Test Rigs**

2008 — **Industrial Pilots**

2009 — **Validation Pilots**

2015 — **Large-scale demonstration** → **Commercial** from 2016

Alstom Vaxjö
Sweden
0.25 MWth

We Energies
Pleasant Prairie
USA - 5 MWth, Coal

EoN Karlshamn
Sweden - 5 MWth, Oil

AEP Mountaineer
USA - 58 MWth, Coal

Statoil Mongstad
Norway - 40 MWth, Gas

AEP Mountaineer
US - >200 MWe, Coal
(FEED ongoing)

Transalta
Canada - >200 MWe, Coal
(FEED ongoing)

Selected by Alberta CCS fund and the Canada Clean Energy Fund and ecoENERGY Technology Initiative

Selected by US DOE to receive CCPI Round 3 funding

In operation **Tests completed** **In construction** **Coming**

Oxy-Combustion Process
Technology Overview

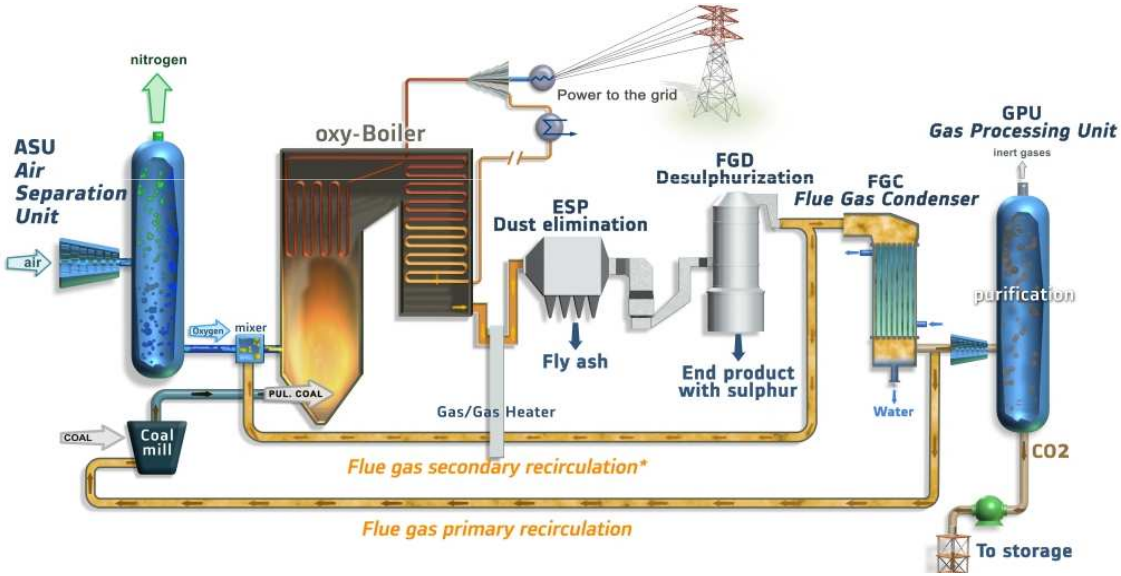
ALSTOM

Principle

- Fuel is burned in a mixture of oxygen and re-circulated flue-gas. Due to the absence of Nitrogen, the resulting flue gas is enriched in CO_2
- After water condensing and purification, CO_2 is compressed and send for storage or re-use.

Advantages

- Reliability: main components exist, only adaptation required
- All types of boilers / firing systems adaptable to oxy to cover complete fuel range
- Rapid scale-up to large size (1,000 MWe range) possible after large demos. Retrofit in Oxy can be addressed
- High efficiency and competitiveness of supercritical/ultra-supercritical cycles and large unit size will be key benefits



Update on Alstom roadmap
Oxy-Combustion Process

ALSTOM

2004 — **Lab Scale**

2008 — **Pilots**

2009 — **Pilots**

2014-2015 — **Large-scale demonstration** → **Commercial**

Up to 500 kW_{th}
Germany (U. Stuttgart, U. Cottbus, U. Hamburg-Harburg, U. Dresden)

Vattenfall Schwarze Pumpe
Germany - 30 MWth, Lignite & Bit. Coal

Total Lacq
France - 30 MWth, Natural Gas

Alstom Boiler Simulation Facility
USA - 15 MWth, Coals

300 – 600 MW_{th} Oxyfuel Coal
e.g. Alstom's Feasibility Study for
Vattenfall Jänschwalde
(Demo Tender out)

Selected for receiving EEPR funding

Tests completed | In construction
In operation | Coming

Moving forward to scale-up the technology

Alstom activity on demonstrations

ALSTOM

Operating

Vattenfall Schwarze Pumpe
Germany - 30 MWth
Oxy - Lignite

AEP Mountaineer
USA - 58 MWth
Chilled Ammonia - Coal

EoN Karlshamn
Sweden - 5 MWth
Chilled Ammonia - Fuel

Total Lacq
France - 30 MWth
Oxy - Gas

Dow Chemical Co.
USA, West Virginia
Advanced Amines - Coal

Alstom BSF Windsor
US - 15 MWth
Oxy - Coals

Coming

RFCS EU - Darmstad
Germany – 1 MWth
Chemical looping - Coal

EdF – Le Havre
France – 5 MWth Adv.
Amines - Coal

Statoil Mongstad
Norway - 40 MWth
Chilled Ammonia - Gas

Pre-commercial

PGE Belchatow
Poland – 260 MWe
Adv. Amines - Lignite

Vattenfall Jänschwalde
Germany - 250 MWe
Oxy - Lignite

Transalta
Canada - >200 MWe
Chilled Ammonia - Coal

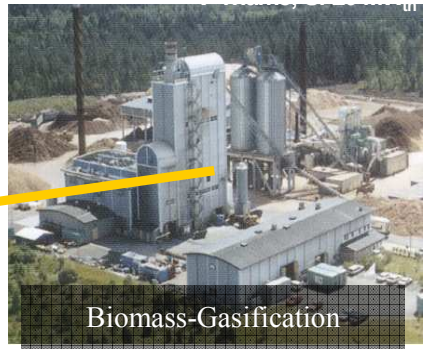
AEP Mountaineer
USA – 235MWe
Chilled Ammonia - Coal

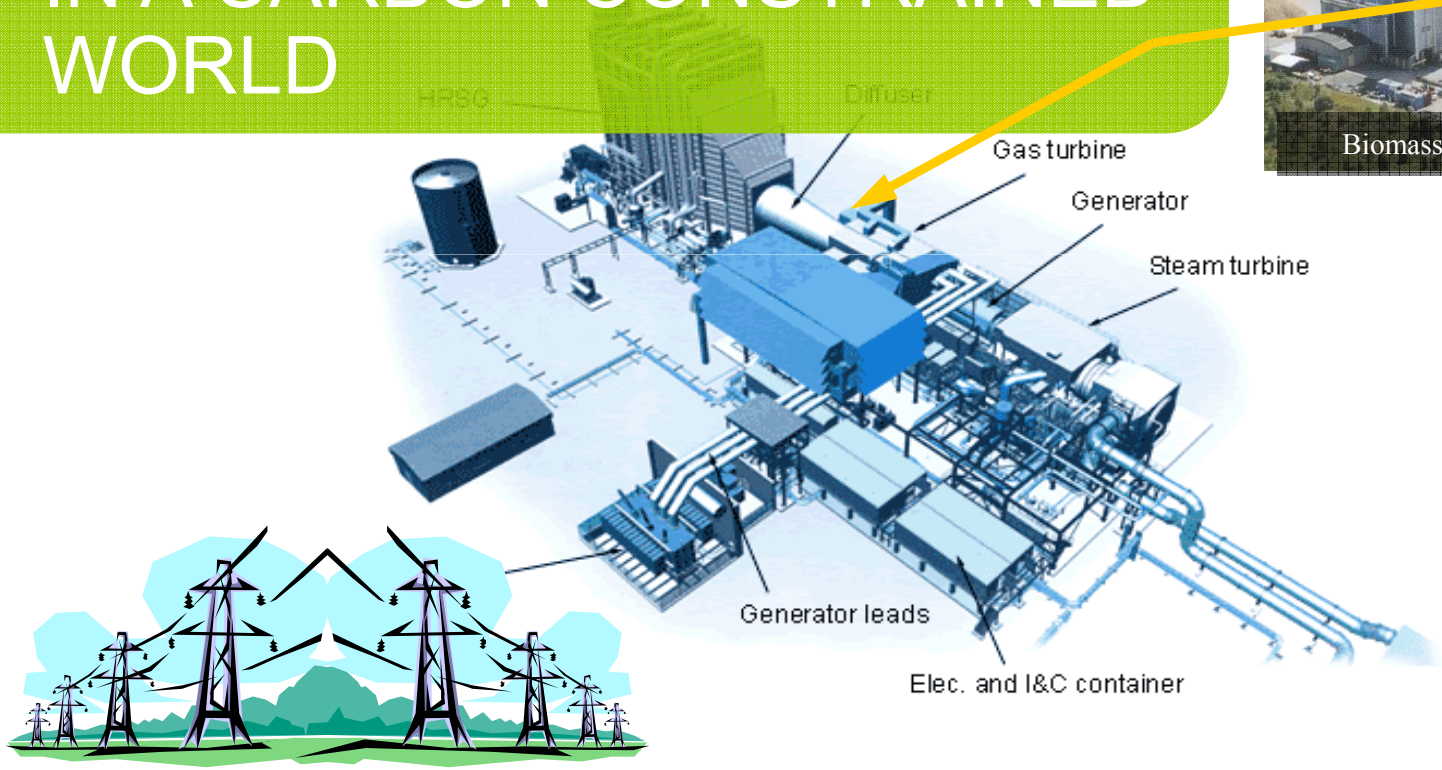
Selected for receiving EEPR funding

Selected by Alberta and Federal Canadian funding

Selected by US DOE to receive CCPI Round 3 funding

KRAFTWERK 2020 – SWISS POWER GENERATION IN A CARBON CONSTRAINED WORLD





Programm-Partner "Kraftwerk 2020"