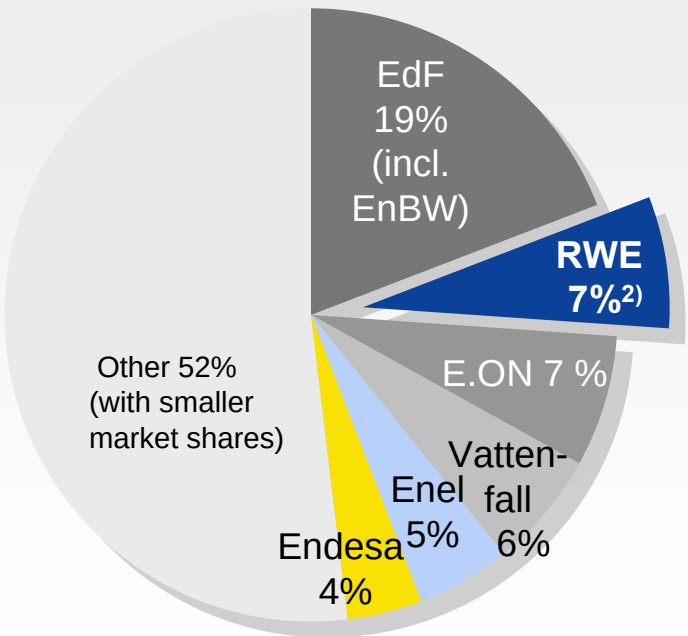
Future Power Generation Concepts: In which direction is Europe prone to go?

Case Study RWE Power

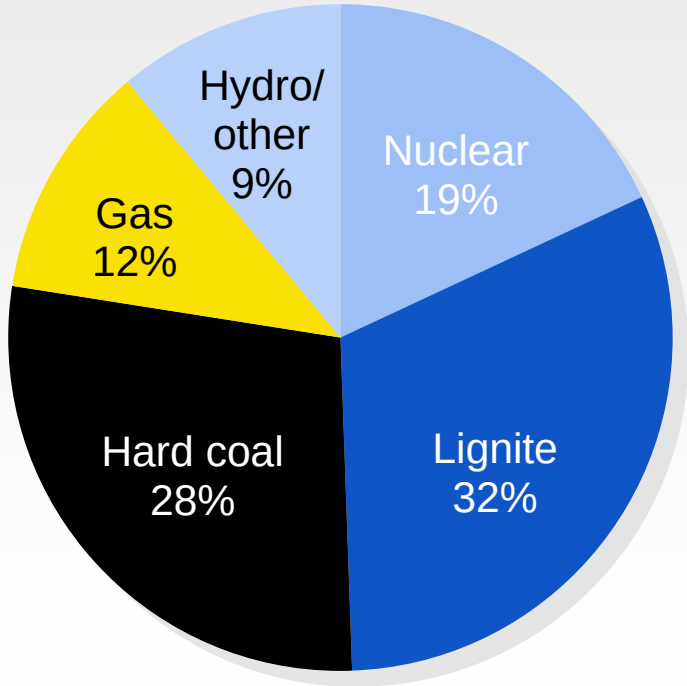
Werner Renzenbrink
Synergies between HYPOGEN and the Hydrogen Economy
Expert Workshop - Brussels, 18th January 2007

Power generation at RWE Power

Market shares in European power generation[1)]



Power generation capacity of RWE Power* (34 GW)



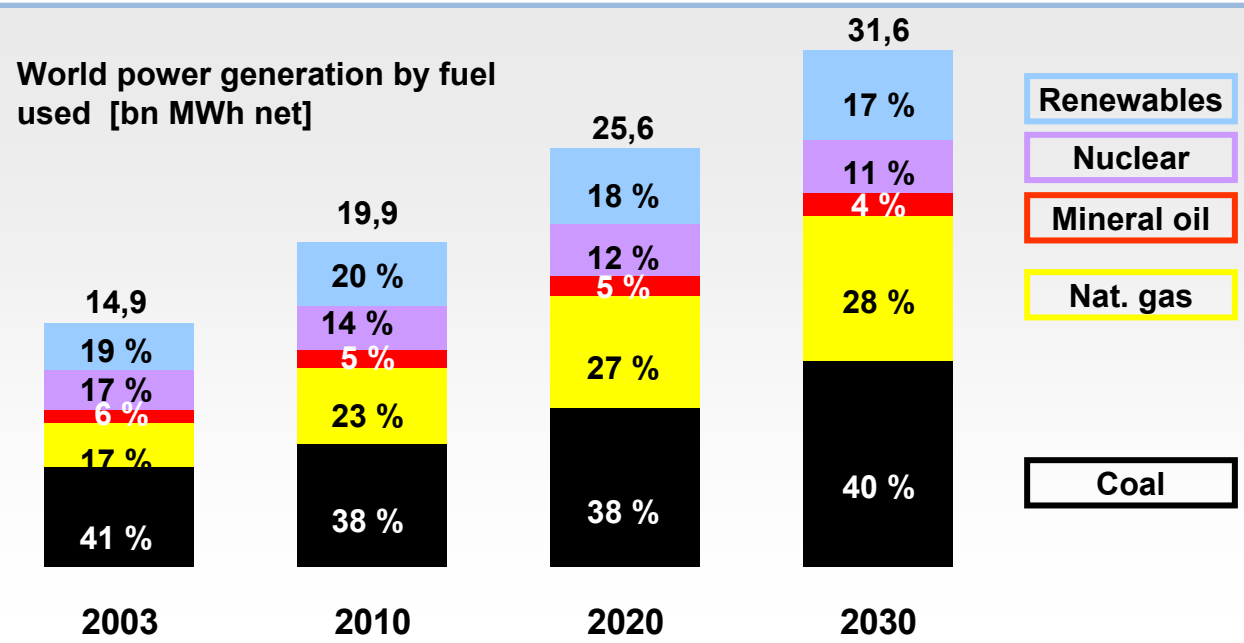
1) Own generation and purchases
2) RWE Power 6%; RWE npower 1%

incl. purchases from third parties; *as of 31/12/2005

RWE is one of the leading power generating companies in Europe with a broad energy mix

Future perspectives of coal-based power generation

The energy source's indispensability



New requirements

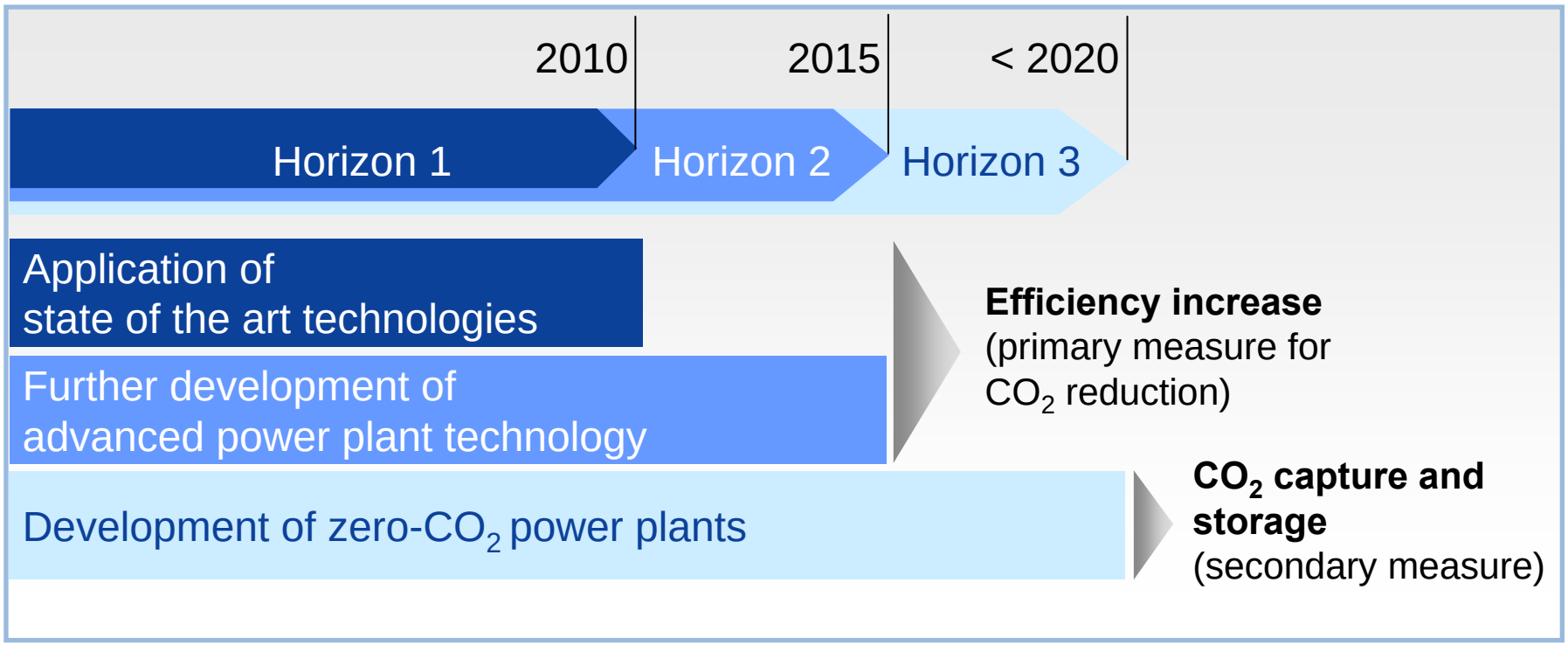
Increasing fossil energy needs for power generation and the simultaneous demand for climate protection involve a strong conflict of goals.

CO_2 emissions have become an additional significant cost factor.

Conflict of goals can only be resolved by using low- or zero-CO_2 technologies!

Source: Department of Energy/Energy Information Administration, Washington 2006 (Reference case)

RWE Power's CO_2 reduction strategy in fossil-fired power generation



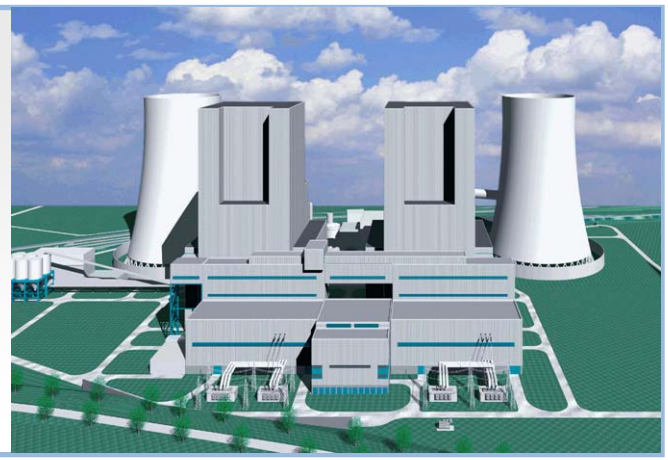
Horizon 1 example of lignite: RWE puts focus on state-of-the-art power plant technology

Niederaußem power plant

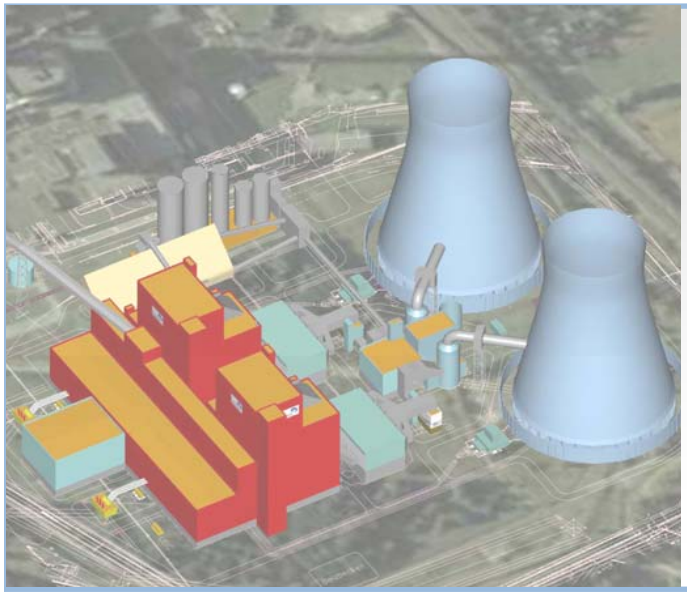
Commercial operation	since 2003
Capacity:	1,012 MW
Efficiency:	> 43 % LHV
Main steam:	275 bar/580 °C
Reheater:	60 bar/600 °C

Neurath power plant

Under construction, planned commercial operation:	2009/10
Capacity:	2 x 1,100 MW
Efficiency:	> 43 % LHV
Main steam:	272 bar/600 °C
Reheater:	55.5 bar/605 °C



Horizon 1 example of hard coal: RWE puts focus on state-of-the-art power plant technology



- **Westfalen power plant**

Status: Procurement prepared

Commercial Operation: 2011/12

Capacity:	**2 x 800 MW**
Efficiency:	**> 45 % LHV**

Moreover, bids have been invited for four additional 800 MW units, two are located in the Netherlands and two in the Saar area (commercial operation: 2012).

Horizon 1 example of natural gas: RWE puts focus on state-of-the-art power plant technology

- **Lingen power plant**

Status: Procurement prepared

Commercial Operation: 2009

Capacity: 876 MW
Efficiency: > 59 % LHV

Altogether, RWE Power will spend some €11 billion on highly efficient technology in the generation field until 2012.

Horizon 2: RWE Power actively involved in further efficiency increase

2015

Dry lignite-fired power plant
η: + 4% points

RWE project: **WTA prototype**

1:1 prototype of the drying plant connected to the new 1000 MW unit at Niederaußem

- **Developed by RWE**
- **Groundbreaking in June 2006**
- **Budget: €50 mill.**

2020

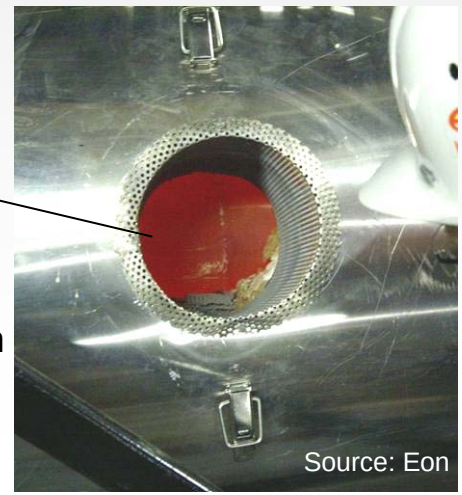
700°C power plant (L + HC)
η: + 4% points

Joint **COMTES700** project of operator and supplier industry:

All components for 700°C tested in Scholven power plant

Red-hot main steam line

- **Budget: €24 mill.**
- **Start of operation June 2005**



The initiated measures will enable coal-fired power plants to pass the 50% efficiency threshold in the medium term.

RWE's decisions on CCS

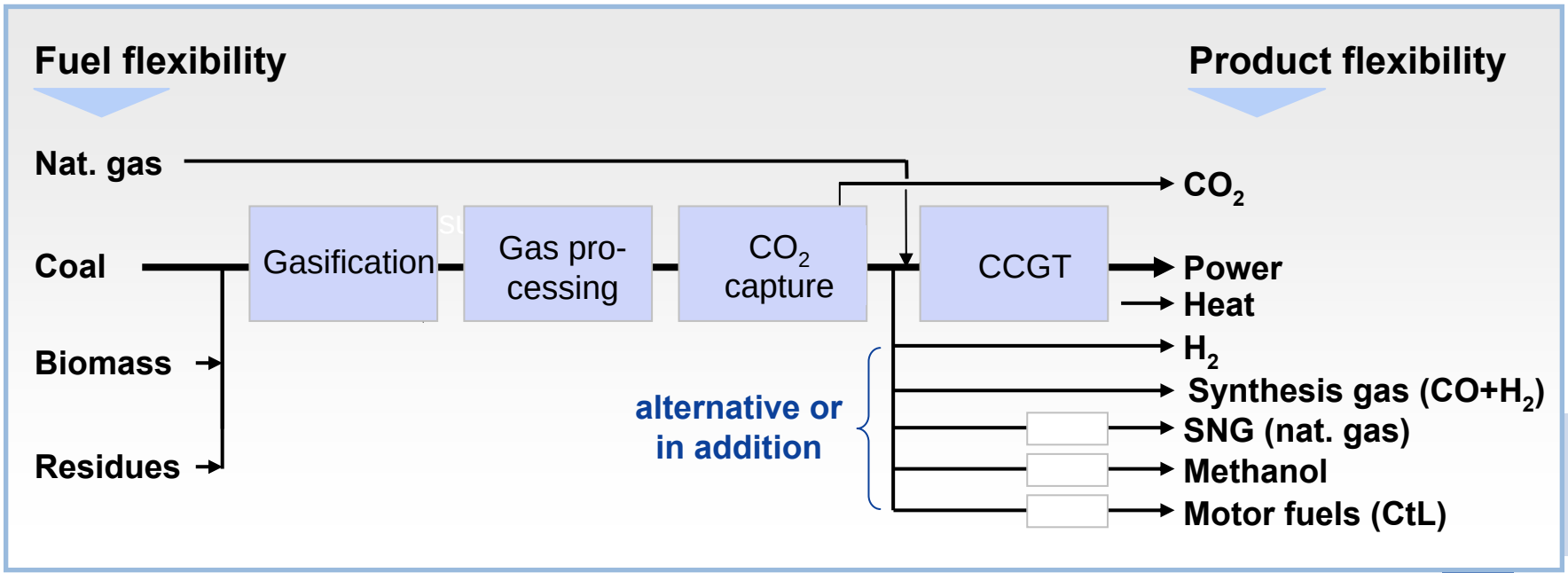
1. RWE Power develops and builds a **zero-CO_2 450 MW coal-fired power plant** based on IGCC technology incl. CO_2 transport and storage

2. In parallel, RWE will develop the technology of **CO_2 scrubbing** for future advanced coal-fired steam power plants and as a retrofit option for modern installations.

RWE Power thus makes its generation business more future-proof.

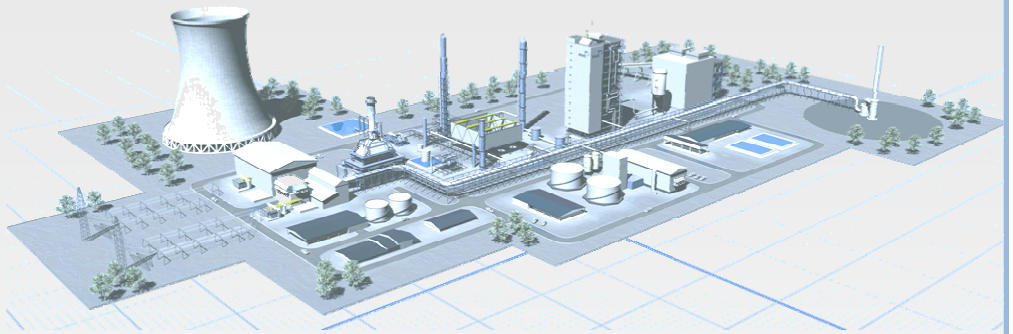
IGCC offers favourable preconditions as zero-CO_2 power plant technology

- All process steps are commercially available
- Technical and economic statements are robust
- Power plant can also be operated efficiently without capture
- IGCC has reserves for further reducing classic emissions
- High fuel flexibility
- High product flexibility



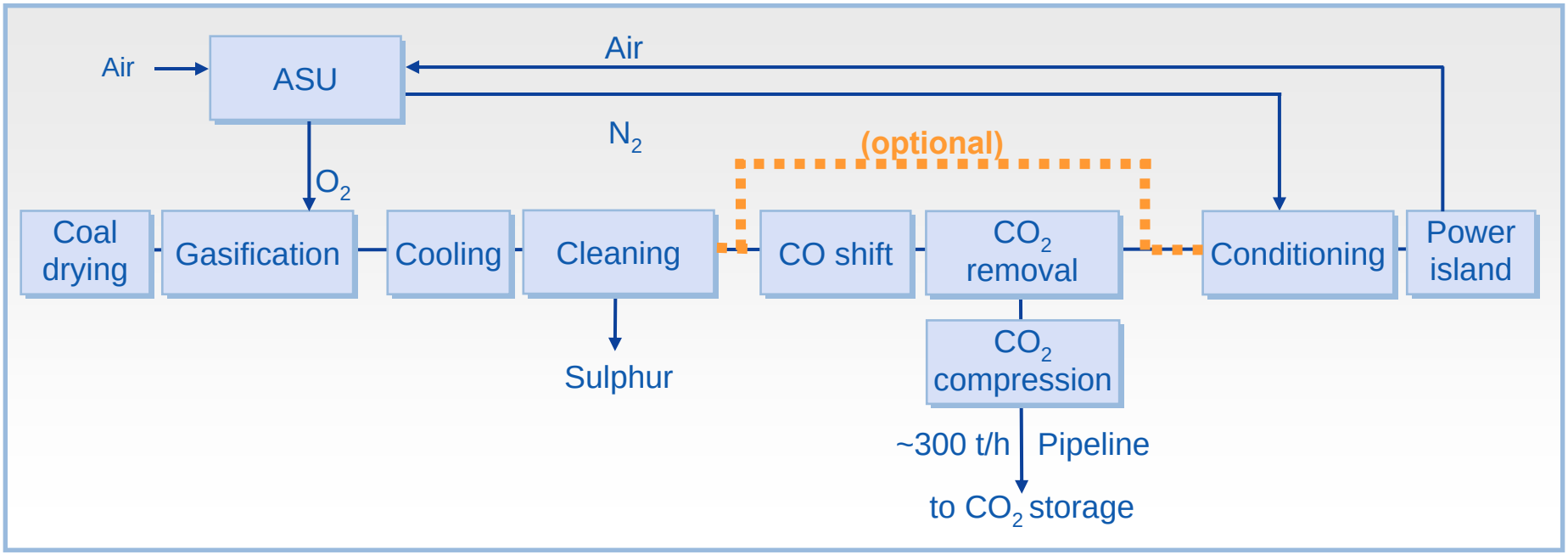
The RWE project of a zero-CO_2 450 MW power plant with CO_2 storage (IGCC-CCS)

- **Basic technology: IGCC**
- **El. capacity: 450 MW_{gross}**
  360 MW_{net}
- **Net efficiency: 40%**
- **CO_2 storage: 2.3 mill. t/a**
- **CO_2 storage in depleted gas reservoir or saline aquifer**
- **Commissioning: 2014**
- **RWE budget: approx. €1 billion**



In RWE Power, RWE has inhouse power plant and gasification know-how and, in RWE Dea, it has basic inhouse CO_2 storage know-how.

RWE's IGCC-CCS Project - Overall concept



Gasification technology options:

- **Entrained flow gasification**
  - **Shell or**
  - **Siemens Fuel Gasification (SFG, former Future Energy)**

  allow the use of one technology for both hard coal and lignite

- **HTW fluidized bed**
  - **process represents well proven back-up option**

Development of CO_2 storage site
Tasks and current status of work

- **Phase 1: Selection of storage site (2006-2008)**
  - Setting up the storage site portfolio
  - Analysing basic methods for evaluating storage potentials
  - Detailed feasibility study for 2-3 selected sites
- **Phase 2: Evaluation of storage sites (2008-2010)**
  - 3D seismics of potential storage sites
  - Exploration, drilling, formation tests
  - Selection of a storage site, application + approval
- **Phase 3: Construction of storage facility (2011-2014)**
  - Production drilling
  - Trial operation, if appropriate
  - Surface facilities, pipeline

CO_2 storage is the critical element of CCS success

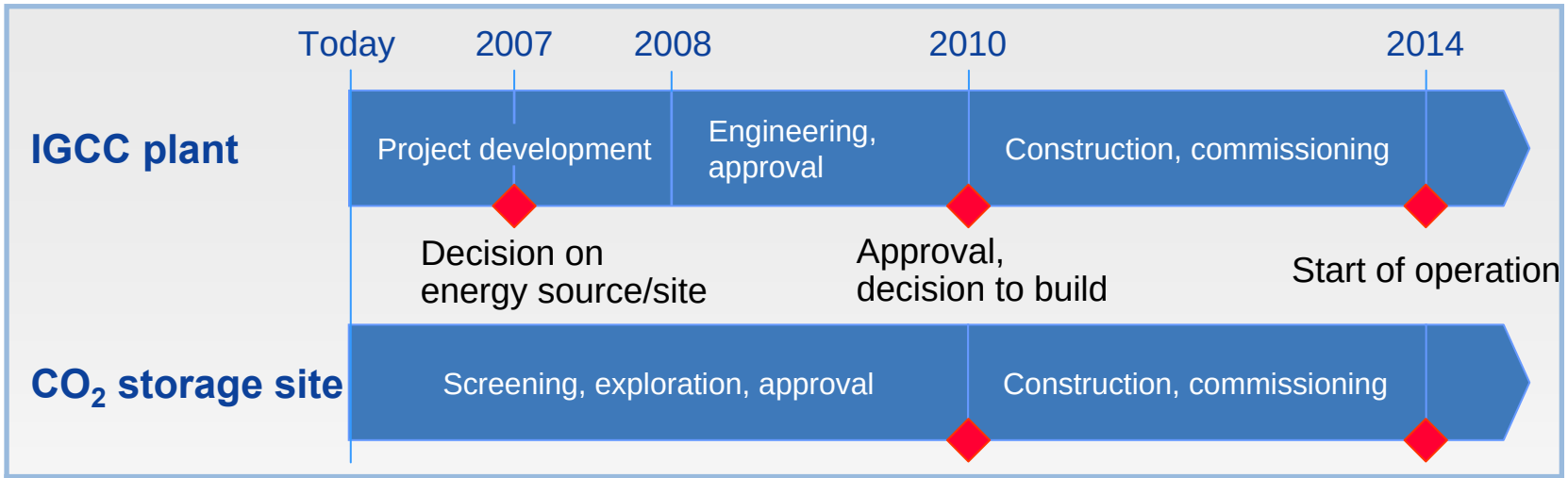
- **Technical challenges**
  - No recognized methods for the identification and suitability evaluation of storage sites and, in particular, their long-term tightness.
  - High uncertainty as regards costs and time needs due to geological imponderabilities.
  - Injection of 2 mill. t CO_2/a would currently be the largest volume world-wide.

- **No legal bases for CO_2 storage**
  - Applicable rule of law is unclear and regulatory framework below the law level is lacking.
  - Fundamental rules are open, e.g. right of access to storage site, liability issue.
  - Consideration of CCS in the CO_2 regulatory framework required after 2012.

- **Public acceptance must be reached**

The storage task will not be a simple one. But we think it can be tackled if all those involved cooperate!

Work on the zero-CO_2 coal-fired power plant has gained momentum



Current activities:

- **Power plant:**
  - Gasification tests in external plants using Rhenish lignite
  - Concept development with Siemens, Uhde, Lurgi, Linde
  - Screening of potential partners and research funding
- **Storage site:**
  - Screening of potential storage sites (depleted gas reservoirs, closed and open aquifers)
- **Law:**
  - Development of a legal framework with policy-makers
  - Talks with Federal Economics Ministry and EU Commission