Brussels, 29. November 2011

CO_2 Capture and Use (CCU)

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> What are the possible routes for CCU

> How much CO_2 can be mitigated by CCU

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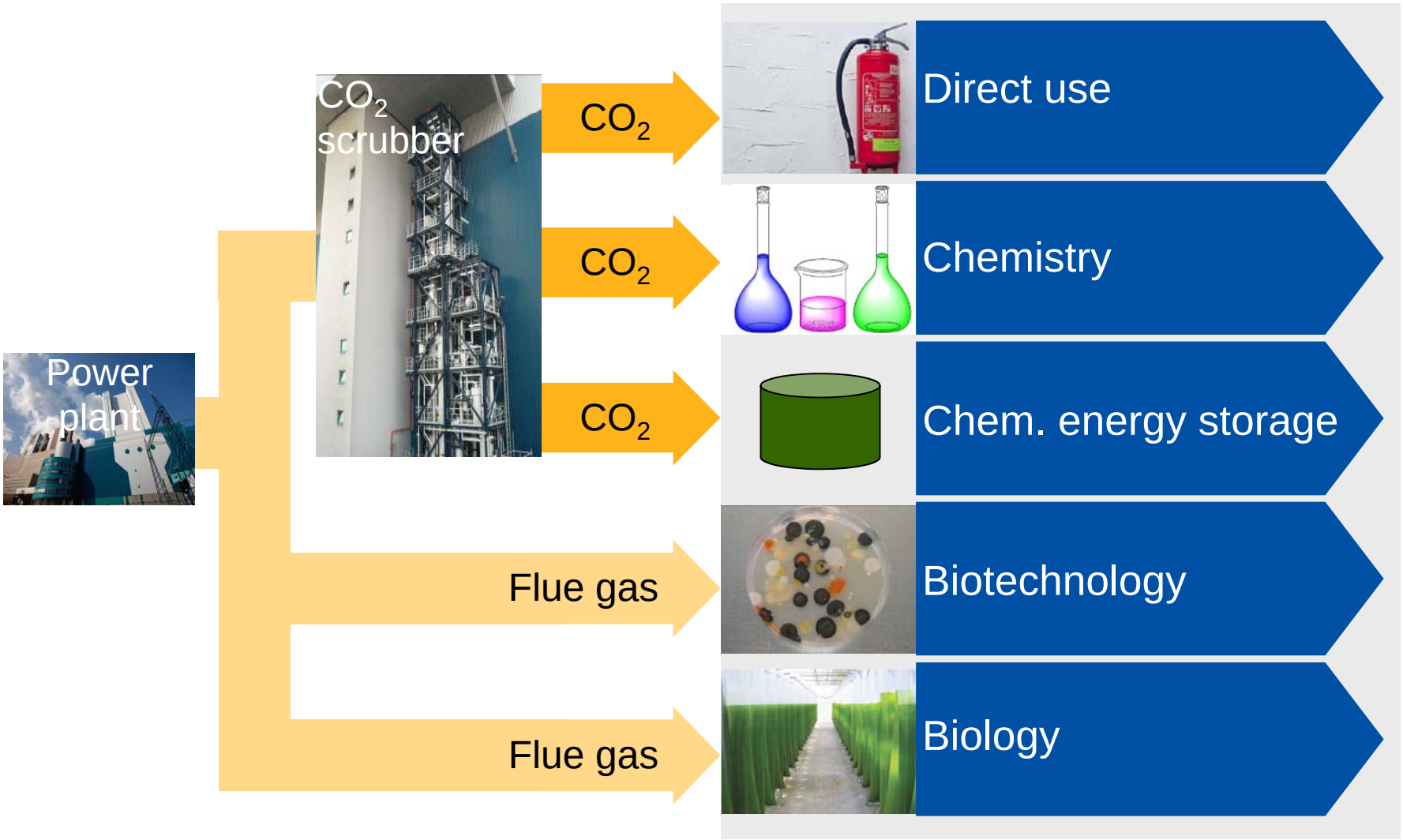
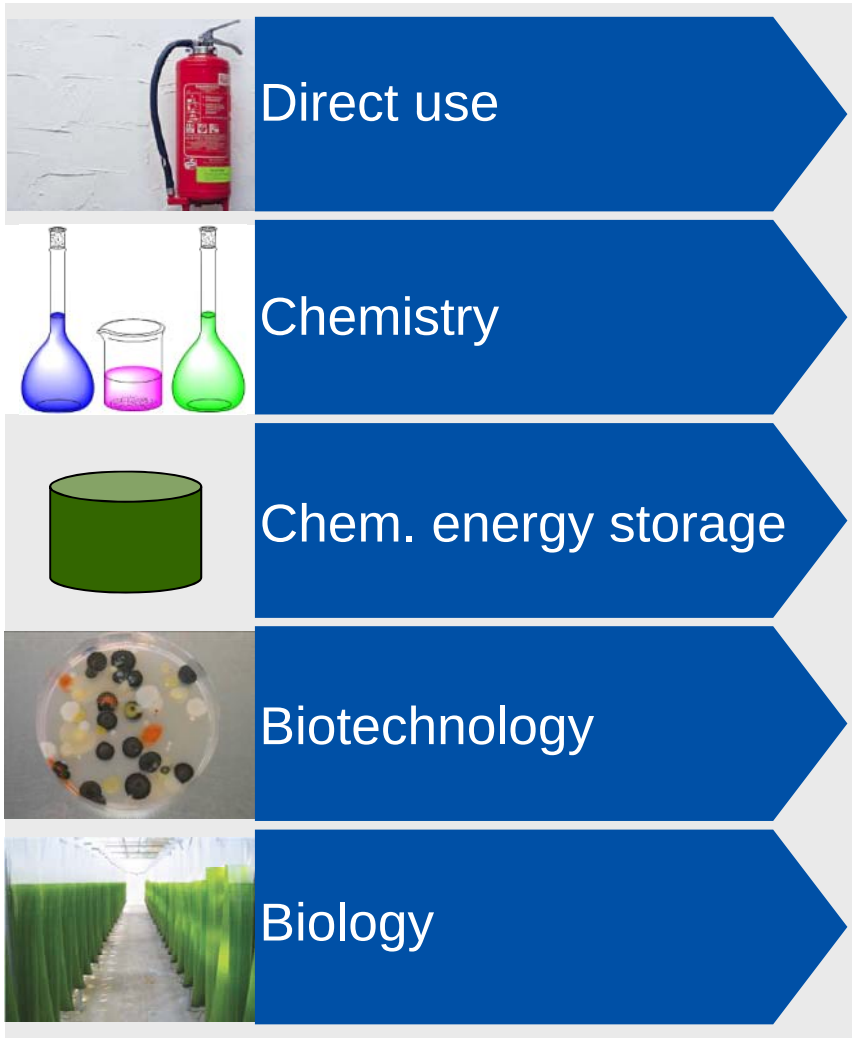
> What boundary conditions must be fulfilled

Basic routes of CO_2 utilization



These basic technologies can open up numerous product lines



Product lines

- technical gas
- synthetic gas
- basic chemicals
- plastics
- specialty chemistry
- fuels
- synthetic natural gas
- biogas

A scenario of a possible future CO_2 utilization reveals a potential up to 10 Mio. t/a in Germany

CO_2

- Industrial gas
- Synthetic gas
- Basic chemicals
- Plastics
- Special chemicals
- Fuels
- Natural gas/biogas

Market: **1 Mio. t CO_2/a**

C-Input from fossil fuels: ~ 15 Mio. t
(CO_2-equivalent: 50-60 Mio. t)
possible C-Input via CO_2: **5-10 Mio. t CO_2/a**

Scale analog to biodiesel: 2,5 Mio t. (2008)
CO_2-based fuels: **7 Mio. t CO_2/a**

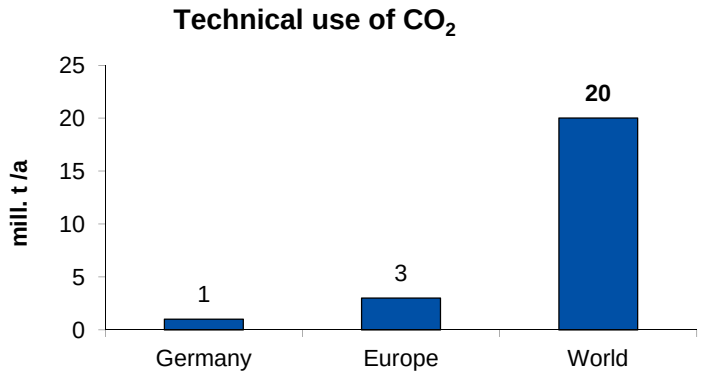
Scale analog to biogas generation: 2 Mrd. m^3 CH_4
CO_2-based CH_4: **3,5 Mio. t CO_2/a**

Basic potential limitations:

- Natural gas und chemical products: product market
- Particularly fuels and gas: enough regenerative energy (CO_2-Footprint)

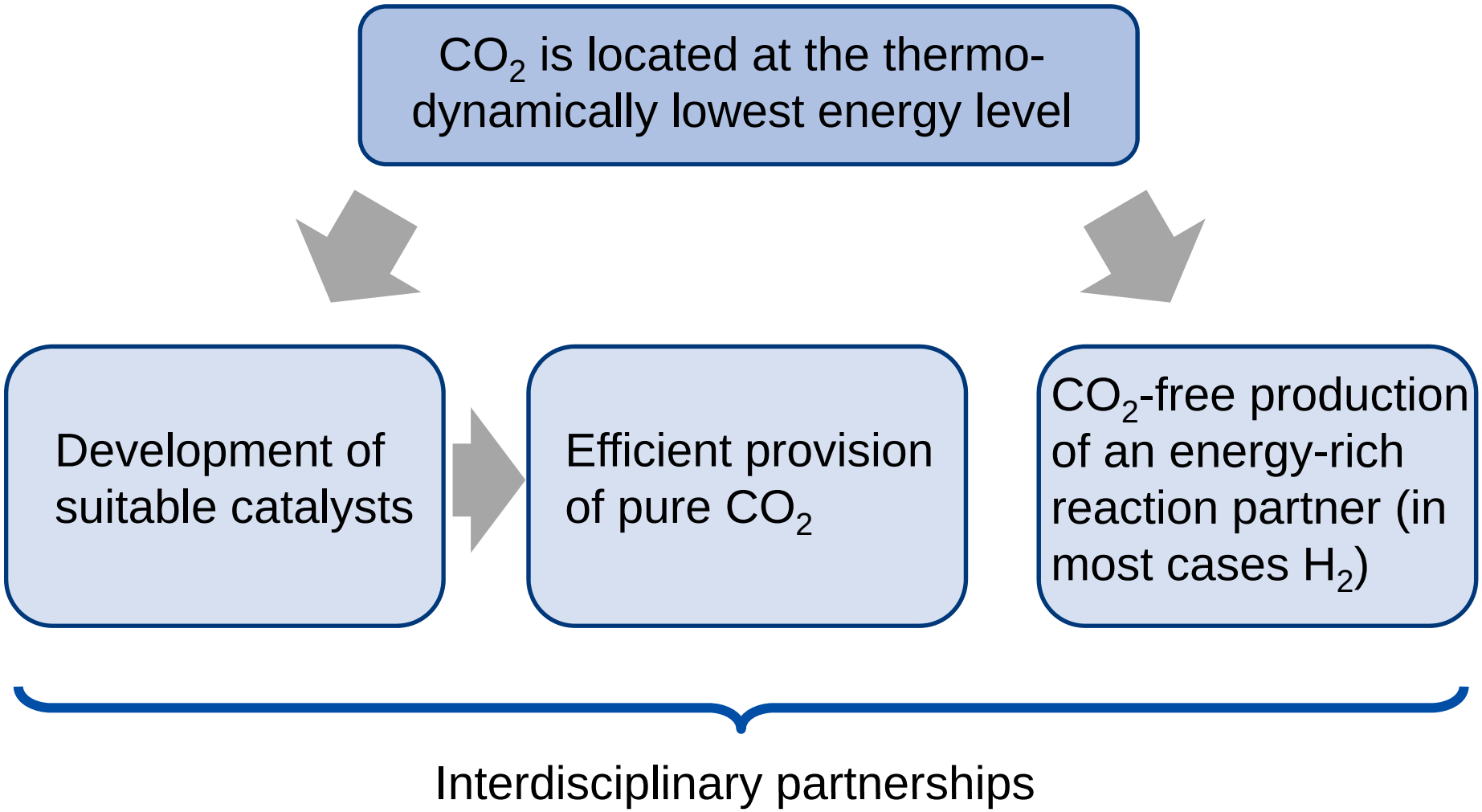
Market for industrial CO_2

- CO_2 used as:
  Dry ice for cooling or cleaning, fertilizer in greenhouses, carbonation of drinks, refrigerant, solvent, EOR, fire extinguisher, …
- Usually high purity CO_2 exhaust streams are sources for supplying the market
- Technical gas market limited in comparison to power plant emissions



Power plant operators have the capability to supply the market with CO_2

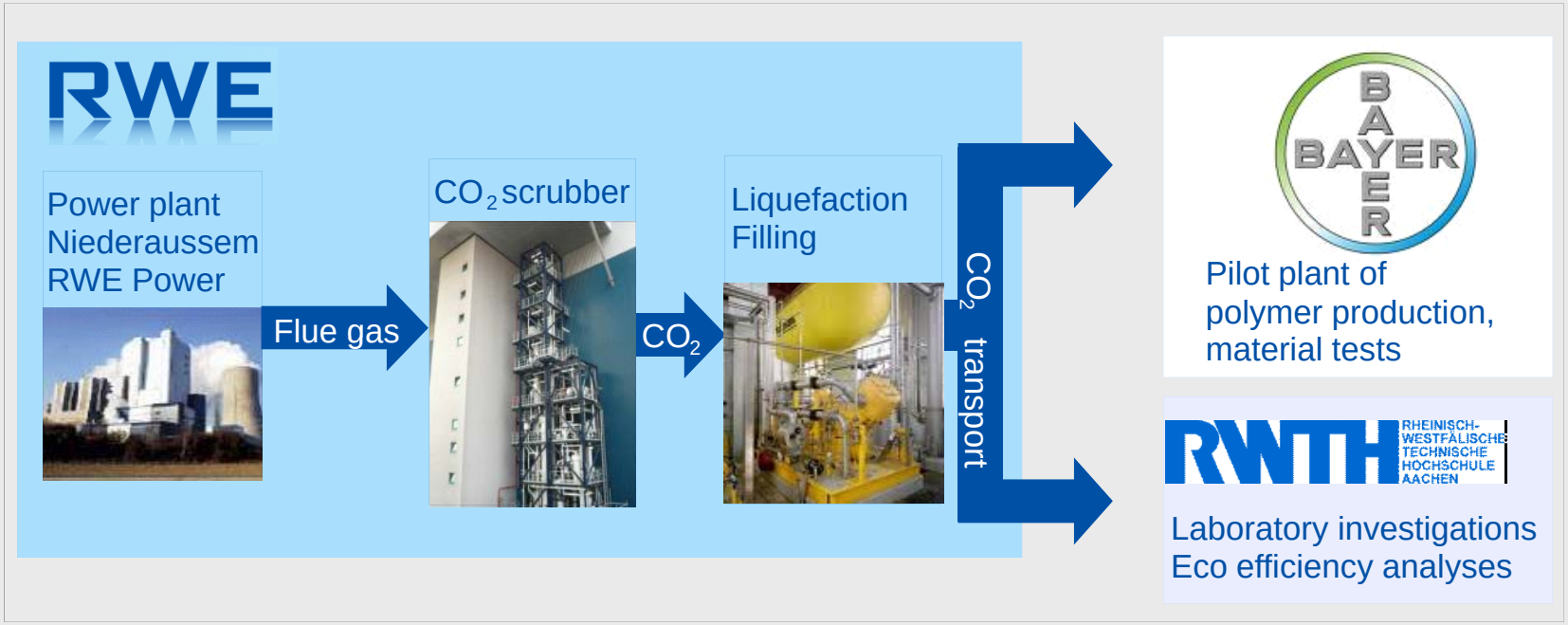
What are the technological challenges for use of CO_2 in chemical processes



Role of power plant operator

Example: R&D project ”DreamProduction“

Lignite-CO_2 as a resource for the production of polyurethane



- Efficient capture of CO_2 out of flue gas
- Conditioning of CO_2 in order to provide high CO_2 purity for catalytic reactions

Applications for polyurethane

Hard foams

- construction foam
- thermal insulation of buildings
- ...

Soft foams

- mattresses
- car seats
- ...

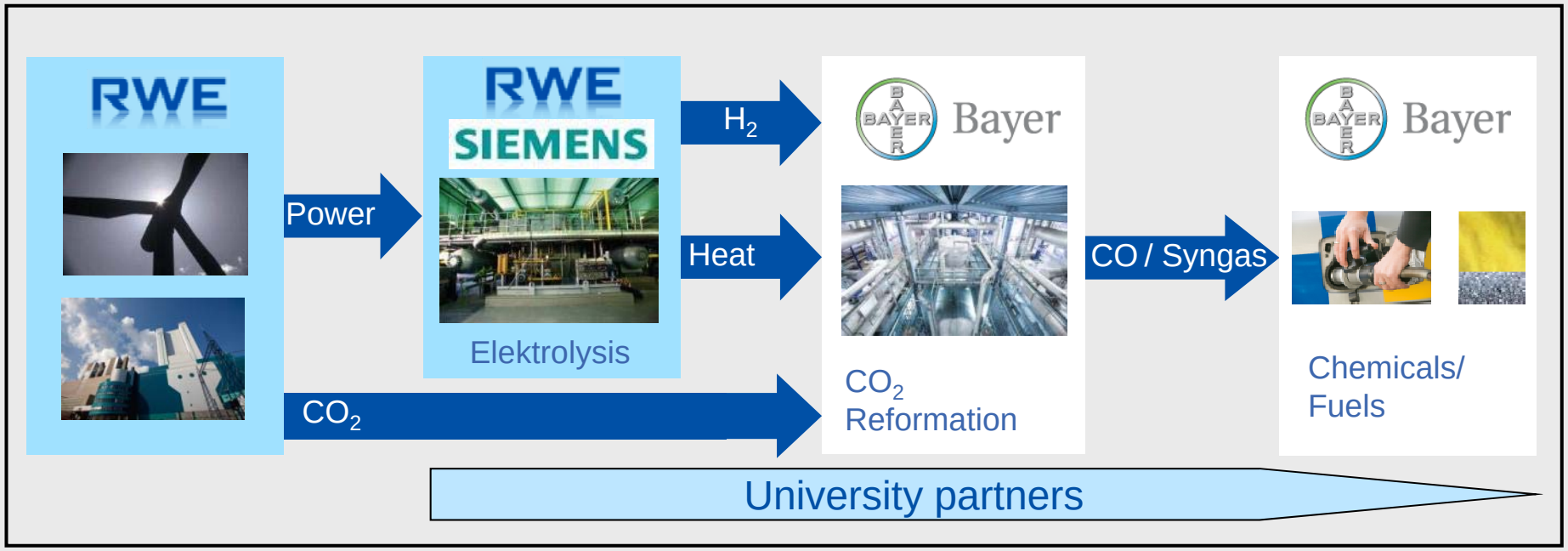
Specials

- household goods
- footballs
- ...

Role of power plant operator

Example: R&D project " CO_2RRECT"

Lignite-CO_2 and renewable power for the chemical production



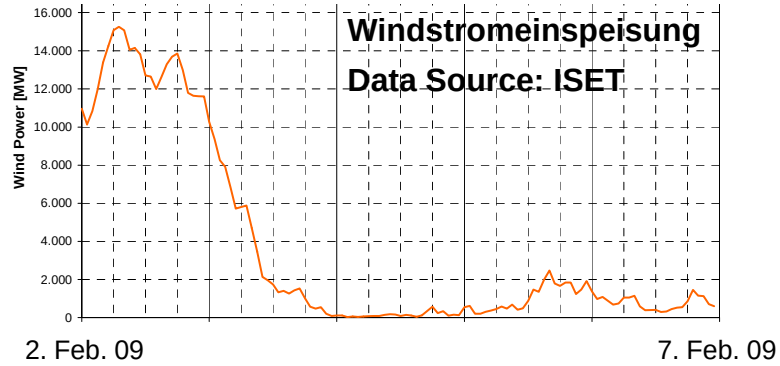
Consortium led by Bayer (BTS)

- Provision of electricity/hydrogen based on fluctuating renewable electricity feed-in

Electricity industry:
CO_2 is a component to enable long-term storage of renewable excess energy

In the future temporarily over-supply of wind and solar power

Use of stored energy in windless times

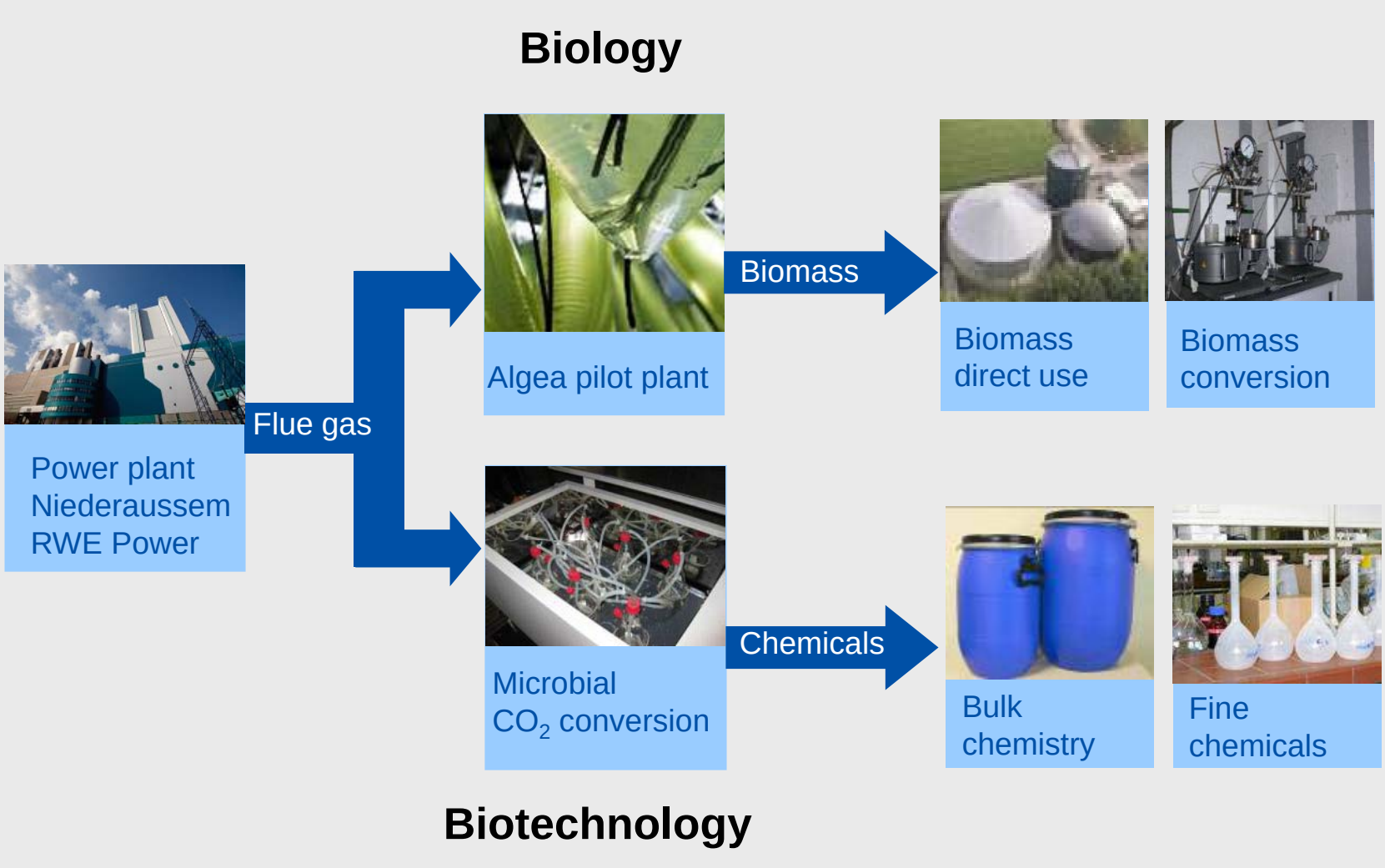


H_2

CO_2

Simple, in large quantities and permanently storable energy source: methanol, methane (synthetic natural gas), …

Biology und Biotechnology for CO_2 utilization



Microbial CO_2 conversion
(R&D cooperation with B•R•A•I•N)

R&D cooperation to study CO_2 conversion from power plant flue gas using micro-organisms

> Project goal: Development of "carbon capture bacteria" to produce biomass and chemicals onthe basis of coal-derived CO_2

> Product examples: Bio-polymers / bio-plastics for
- food packages
- consumer products
- automotive industry (car interior)

Selection of bacteria

Cultivation in culture medium

Products

Also for CO_2 utilization, the CO_2 must be transported

Pipeline

- standard for large quantities of CO_2 (e. g. > 2 mill. t/a)
- in case of short distances also for smaller quantities of CO_2

Rail

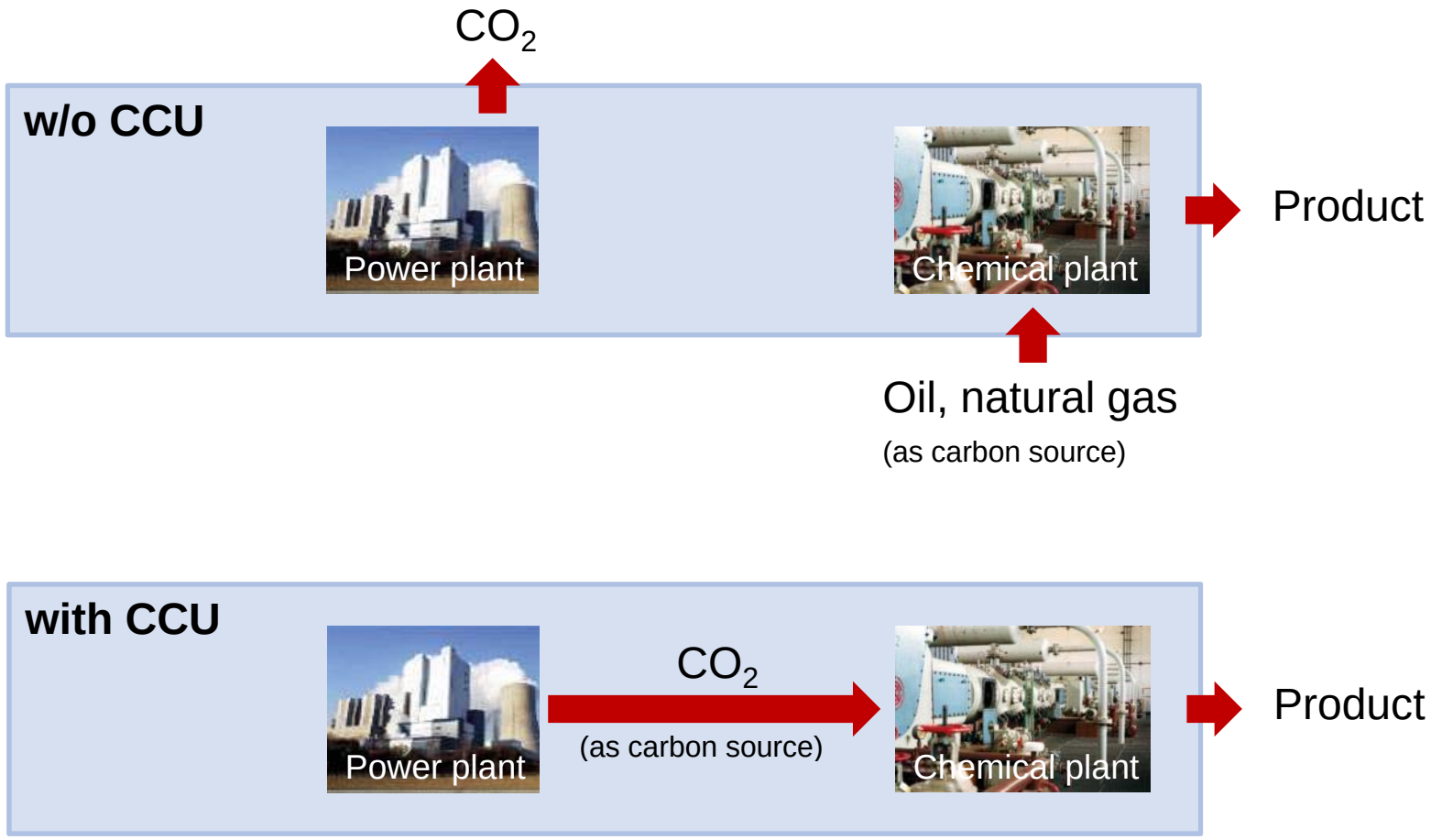
- standard for medium quantities of CO_2 (e. g. < 1 mill. t/a)

Truck

- small quantities of CO_2
- short distances
- short period

The economical choice of transport option depends on the amount of CO_2 and the transport distance

CCU is a technology to reduce CO_2 emissions



EU ETS must recognize CCU as CO_2 reduction

The utilization of CO_2 as a carbon source is a very promising approach because it combines a new source of raw material with CO_2 reduction and substitutes oil- and natural gas-based production.

But, the current EU ETS legislation (EU ETS monitoring regulation[1)]) does not recognize CCU as CO_2 reduction technology:

Only CO_2 captured for the purpose of long-term geological storage can be subtracted from the overall CO_2 emissions for which CO_2 certificates need to be purchased.

(whereas the EU monitoring guidelines[2)] still define CCU as CO_2 reduction like CCS)

1) 4th draft of the Commission Regulation on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council

2) Commission Decision of 8 June 2010 amending Decision 2007/589/EC as regards the inclusion of monitoring and reporting guidelines for greenhouse gas emissions from the capture, transport and geological storage of carbon dioxide

The development and implementation of CCU is impeded by the current EU ETS legislation

Conclusions

- The utilization of CO_2 as a carbon source is a very promising approach because it combines a new source of raw material with CO_2 reduction
- Research and development focus on
  - new CO_2-based production routes
  - new products based on CO_2
- Support programs for research and development
- Interdisciplinary collaborations are indispensable
- In view of the realistic potential is to be noted:
  In terms of CO_2 emissions, CCS is the main approach for CO_2 reduction
- Establishment of acceptance in the implementation (CO_2 transport)
  => Ensure positive public communication for CO_2
- Recognition of CCU as an emissions reduction
  (CO_2 emissions trading, consideration in TEHG)
- Successful examples: - gypsum from flue gas desulfurization
  - ash as building material for road construction