Federal Ministry
of Education
and Research

SIEMENS

Joint Seminar of BMBF and Siemens "CO_2 Utilization Potential"

22/23 September 2009, Steigenberger Grandhotel Petersberg, Bonn

22 September 2009

General introductory talk

▶ Dr. Johannes Ewers, RWE Power AG

Keynote presentations on "CO_2 utilization on the basis of biological processes"
Dr. Ulrich Schurr, Forschungszentrum Jülich GmbH
Dr. Martin Kerner, SSC Strategic Science Consult GmbH

Keynote presentations on "Inorganic CO_2 utilization, mineralization"
Prof. Hans Geerlings, TU Delft, DelftChemTech
Prof. Ron Zevenhoven, Åbo Akademi University

Keynote presentations on "Alternative fuels and energy sources for industry and transport"
Prof. Dr.-Ing. Kai Sundmacher, Max-Planck-Institut Dynamics of Complex Technical Systems
Prof. Dr. Eckhard Dinjus, Forschungszentrum Karlsruhe

"CO_2 Utilization Potential"

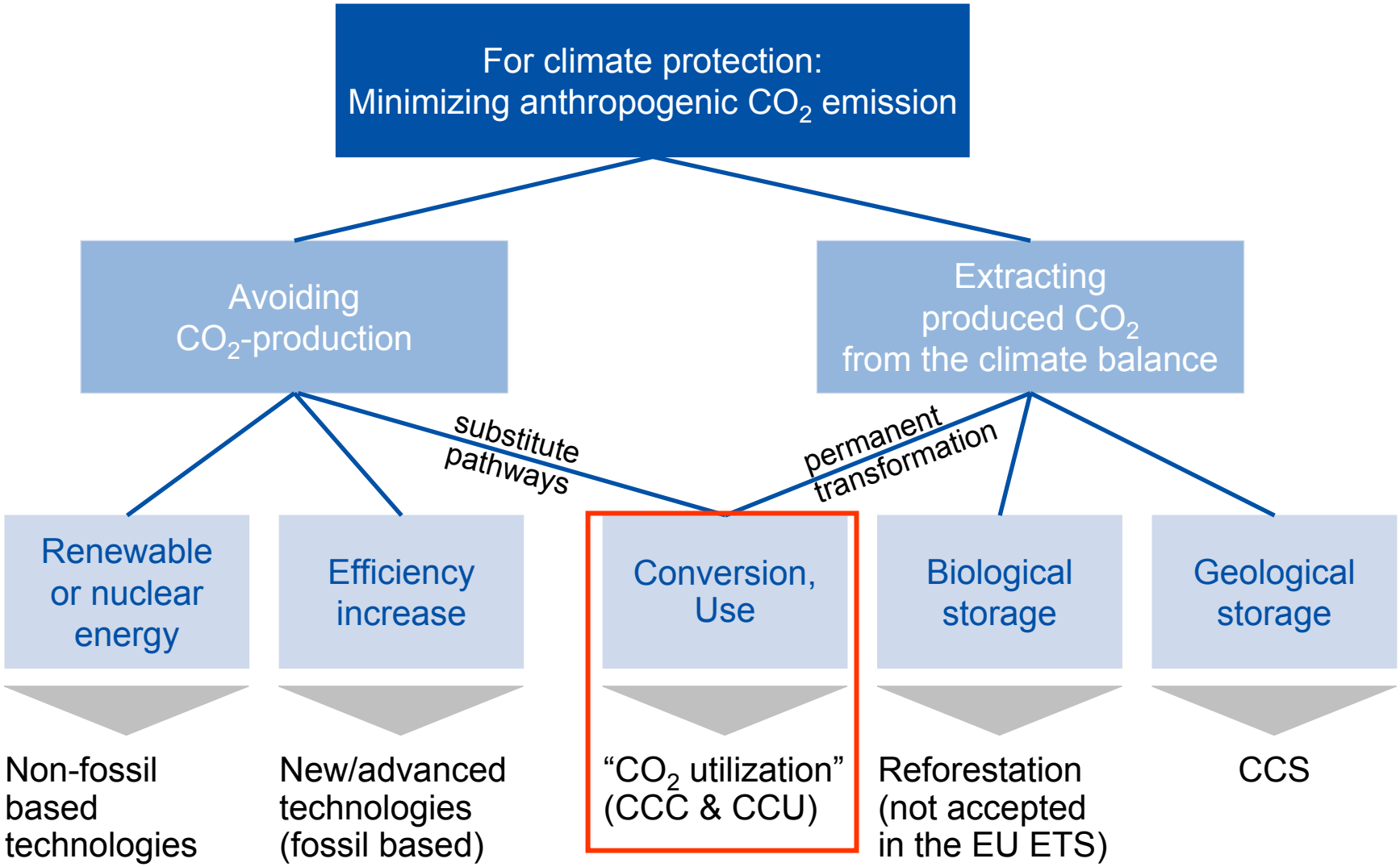
Joint Seminar of BMBF and Siemens
Bonn, 22-23 September 2009

Potential of CO_2 Utilization

Dr. Johannes Ewers – RWE Power AG

RWE
The energy to lead

Why do we think about CO_2 utilization?



CO_2 utilization: general ideas

CO_2 direct use

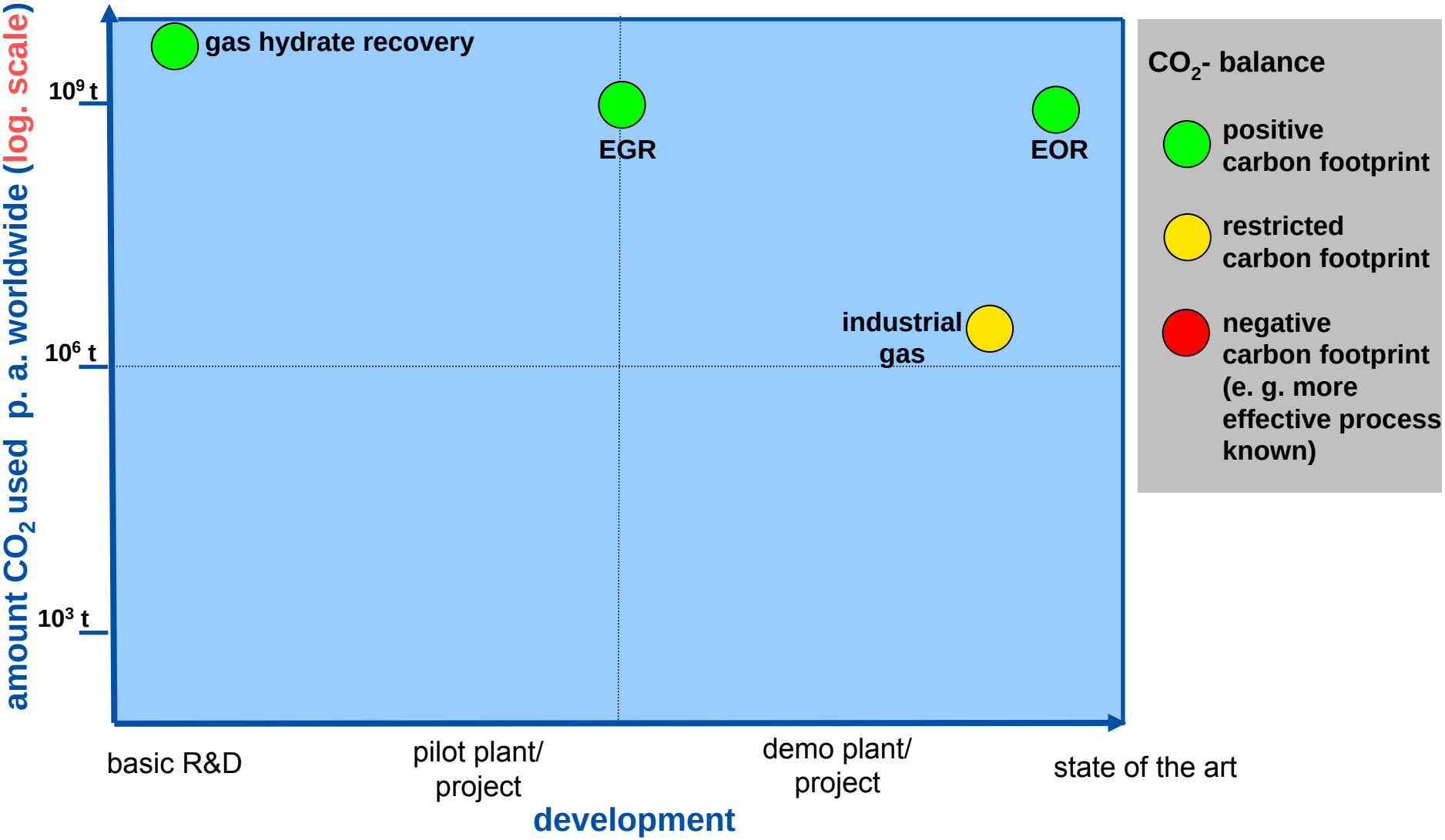
CO_2 use for recovery of hydrocarbons

- enhanced oil recovery (EOR),
- enhanced gas recovery (EGR),
  (special interest for EOR and EGR: new possibility of connection with LNG-transport chain)
- gas hydrate recovery

CO_2 use as industrial gas

- cleaning agent (e. g. for textiles)
- CO_2 = refrigerant R-744, replacement of refrigerants with high GWP in automotive air conditioning (e. g. R134a)
- carbon dioxide based cooling in refrigerated containers (shipping containers)

CO_2 utilization: technology map



CO_2 utilization: general ideas

Chemical Processing of CO_2

Chemical products

- bulk chemicals (e. g. state of the art urea)
- fine chemicals, state of the art: salicylic acid
- fine chemicals, new developments: hydrogenation products of CO_2 (e. g. formic acid)
- polymers (e. g. polycarbonates)

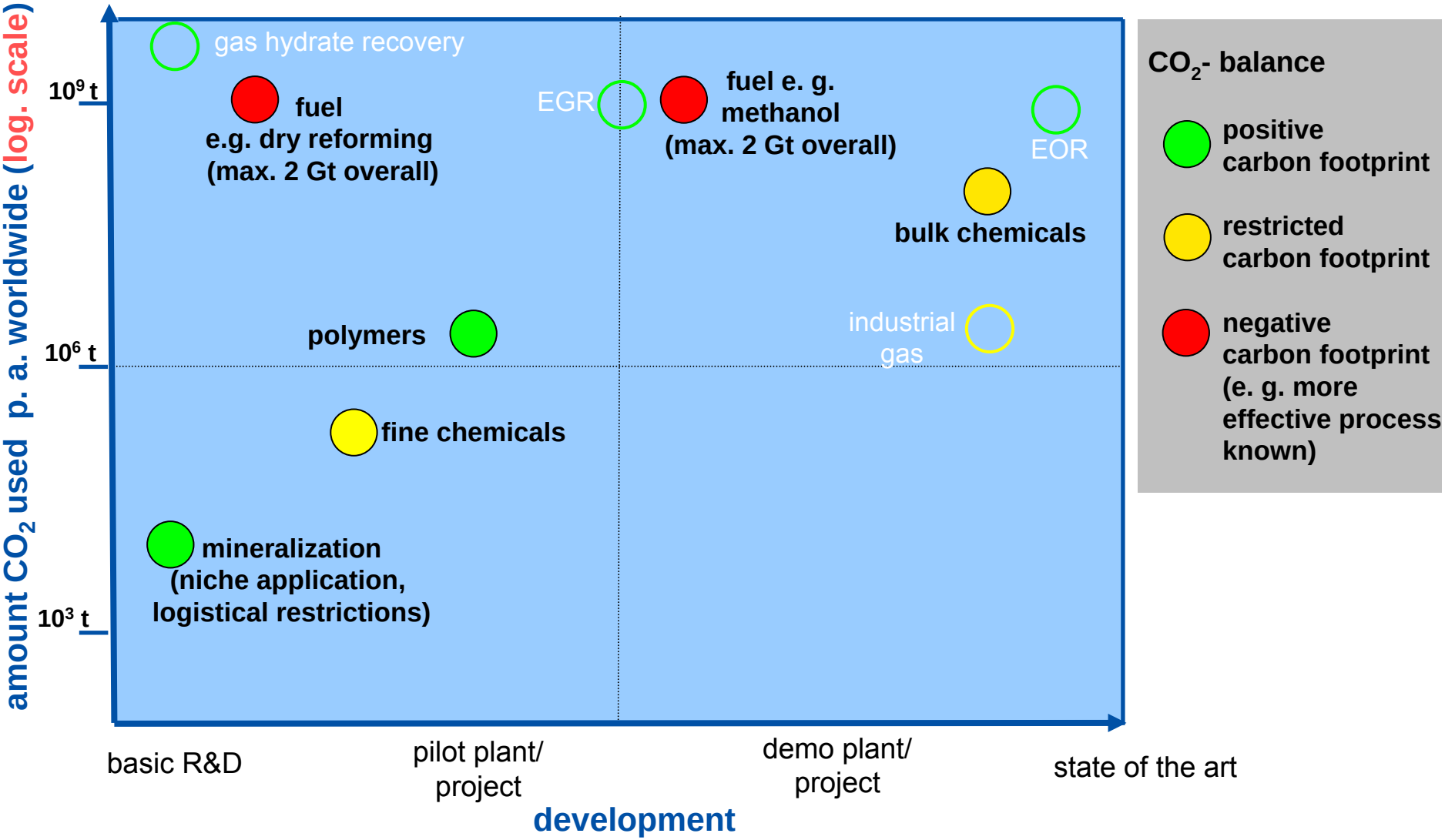
Syngas and fuel production

- e. g. dry reforming (instead of steam reforming) ($CH_4 + CO_2 \rightarrow 2\ CO + 2\ H_2$)
- e. g. methanol ($CO_2 + 3\ H_2 \rightarrow CH_3OH + H_2O$)

Inorganic CO_2 utilization

- mineralization by carbonization via silicates (e. g. with olivine, serpentine or wollastonite)

CO_2 utilization: technology map



CO_2 utilization: general ideas

Biological conversion

- industrial biomass production and biomass conversion
- biotechnology (microorganisms)
- permanent storage by reforestation of primeval / rain forest

Agriculture

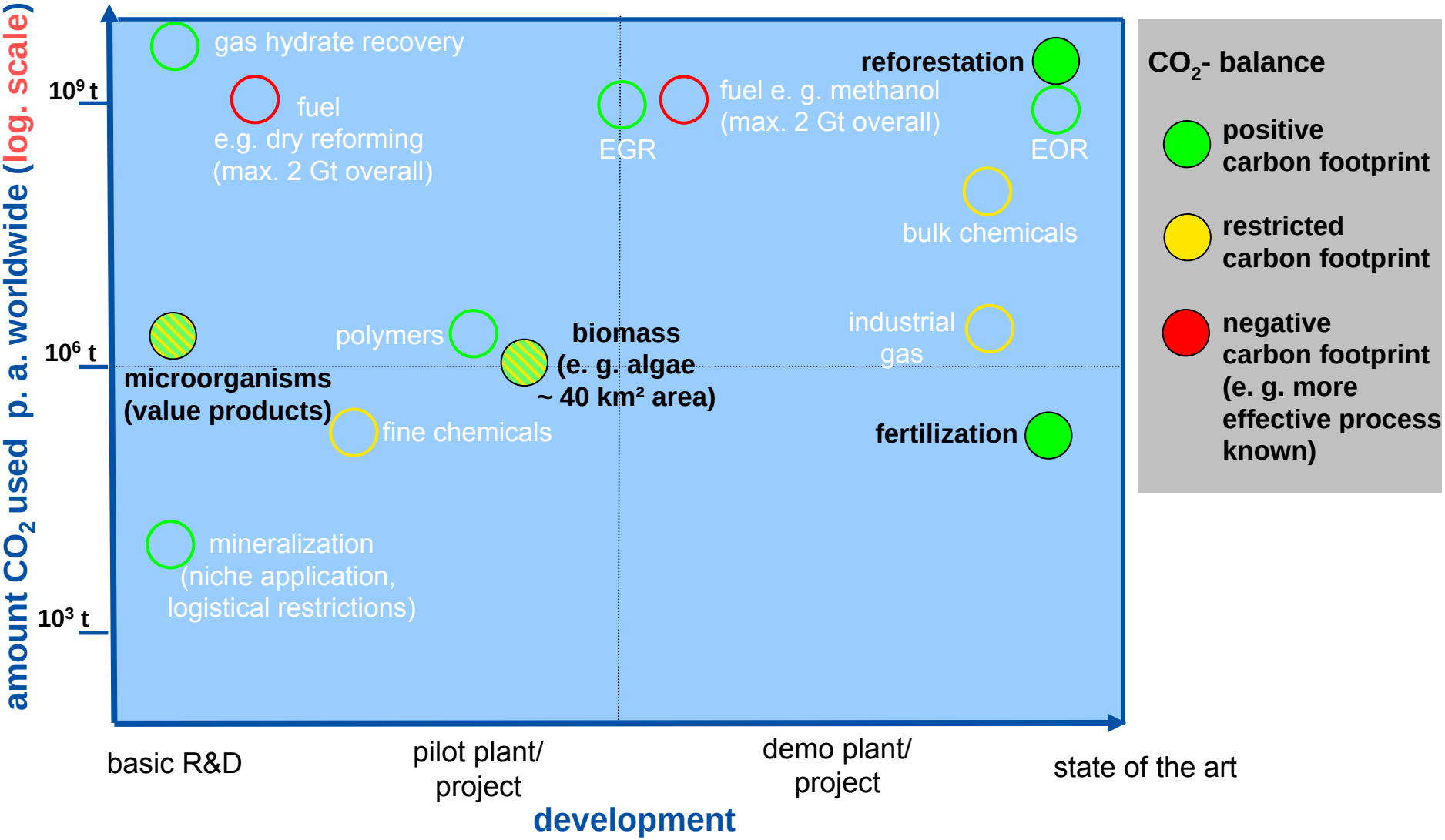
- fertilization (green houses & outdoor)
- soil conditioning
- acid mine drainage

Additional technical options

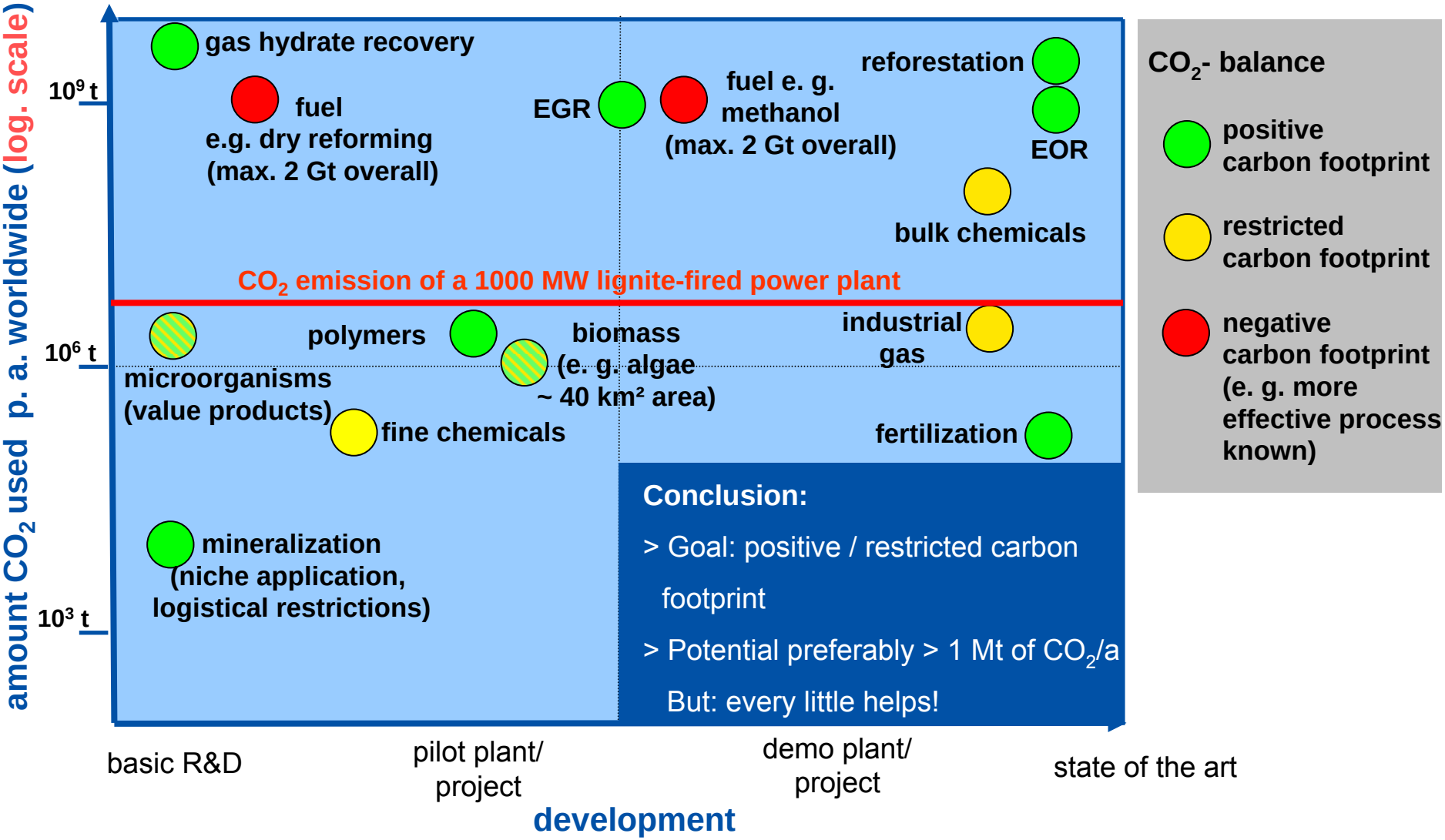
Artifical photosynthesis

- photocatalytical: water decomposition and hydrogen production, CO_2 activation
- dye-sensitized solar cells / Grätzel cells
- conversion of CO_2 to hydrocarbons

CO_2 utilization: technology map



CO_2 utilization: technology map



RWE Power R&D activity
Algae Pilot Project in Niederaussem

Why algae?

> Fast growth with high rate of photosynthesis (10x higher than land plants)
> Algae absorb CO_2 directly from flue gas
> No competition: food vs. fuel

Goals of the algae project

1. Direct CO_2-absorption from power plant flue gas and use of waste heat from cooling tower
2. Use of algae with consideration of their special properties (biogas, fuels, building materials,…) among others via fermentation or HTC

RWE‘s Algae Pilot Project

- area: 600m²,
- 1720 V-Reaktoren
- Overall volume 55.000 L
- expected crop: 6000 $kg_{biomass}$/a
- expected CO_2 mitigation: 12000 kg_{CO2}/a
- Continuation of project with further partners from academia and industry

Considerable development along all steps of the process chain required

Crucial: proof of positive carbon footprint and value added chain

RWE Power R&D activity
Chemical Conversion of CO_2

RWE‘s Carbon Capture Pilot Plant

Polymer production with carbon dioxide from coal power plant

> Joint venture of chemical industry, power-producing industry and academic researchers

> Goals

- supply of carbon dioxide from power plants in a quality suitable for chemical synthesis
- carbon dioxide as C1-building block for production of plastics
- long term: process development for implementation of carbon dioxide as main raw material for certain polymer brands

> mitigation potential: 2-3 Mio t/a CO_2 (estimation chemical industry)

> Challenges for future chemical production:

- CO_2 mitigation via increase in efficiency of production process
- CO_2-mitigation by embedding captured carbon dioxide (e. g. from coal power plants) and substitution of fossil based carbon (e. g. from oil)

RWE Power R&D activity
Microbiological conversion of CO_2

Study of biological conversion of CO_2 with bacteria or other microorganisms

Why bacteria and microorganisms ?

> no competition food vs. fuel

> required space comparatively small

> direct production of chemical products possible

Focused goals

> feed microorganisms with flue gas or carbon dioxide from coal power plant

> production of biomass, fine or bulk chemicals

> neutral or positive carbon footprint

> integration in power plant environment

RWE strategy for Power Production: CO_2 mitigation also by CO_2 utilization

For today

Efficiency increase by renewal

Power plant portfolio: continous renewal

For tomorrow

Efficiency improvement by new technologies

Commercial use

For the future

Carbon Capture &

– Storage (CCS)
– Conversion (CCC)
– Use (CCU)

RWE is willing to promote the climate relevant R & D on CCC and CCU and to put forward new processes to large-scale application

Development of CO_2 utilization is an important contribution to climate protection

- CO_2 capture will be of growing importance in numerous processes and thus CO_2 will be available as a raw material in large amounts
- CO_2 is easy to handle: it is (nearly) non-toxic, non-flammable and logistics are convenient
- Today the amount of CO_2 produced is several orders of magnitude of CO_2 used

→ There is a need for extensive R&D on CO_2 utilization, especially with regard to industrial scale-up

→ CO_2 utilization can create added value and preserves fossile resources. CO_2 mitigation will not necessarily be the main achievement

→ CO_2 utilization will only lead to limited CO_2 mitigation and cannot replace Carbon Capture and Storage (CCS)

Conclusion: Challenges for CO_2 utilization

Possibilities for CO_2 utilization are plenty,
but the following questions have to be answered for each route:

- Is additional potential of CO_2 mitigation created?
- Is the use of resources superior or equal to a reference process without CO_2 utilization (energy balance, costs, time, required space…) ?
- Is added value created?
- What is the result of the benefit-cost analysis?

1

A holistic evaluation of the entire CO_2 process chain is always required!

Conclusion: Further actions

- CO_2 utilization has a potential for CO_2 mitigation as additional measure to CCS
- CO_2 utilization offers an alternative carbon source

2 **Financial support for R & D necessary**

- CO_2 utilization shows, that CO_2 is also a valuable resource

3 **Ensure positive public communication for CO_2**

THANK YOU VERY MUCH FOR YOUR ATTENTION AND LET´S JOIN OUR FORCES TO LEAD THE WAY

RWE
The energy to lead