

PAUL SCHERRER INSTITUT



Wir schaffen Wissen – heute für morgen

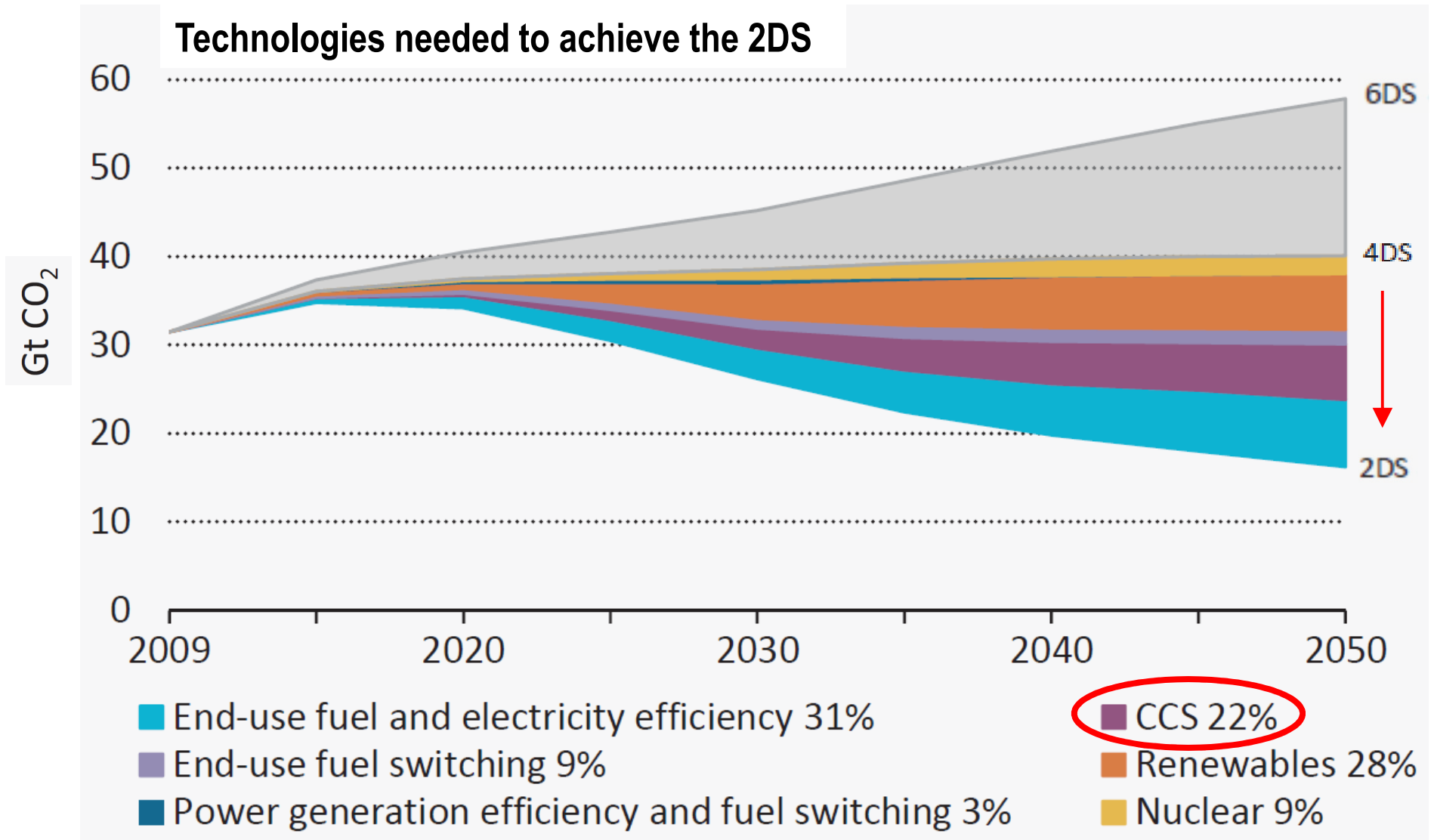
Paul Scherrer Institut

Kathrin Volkart

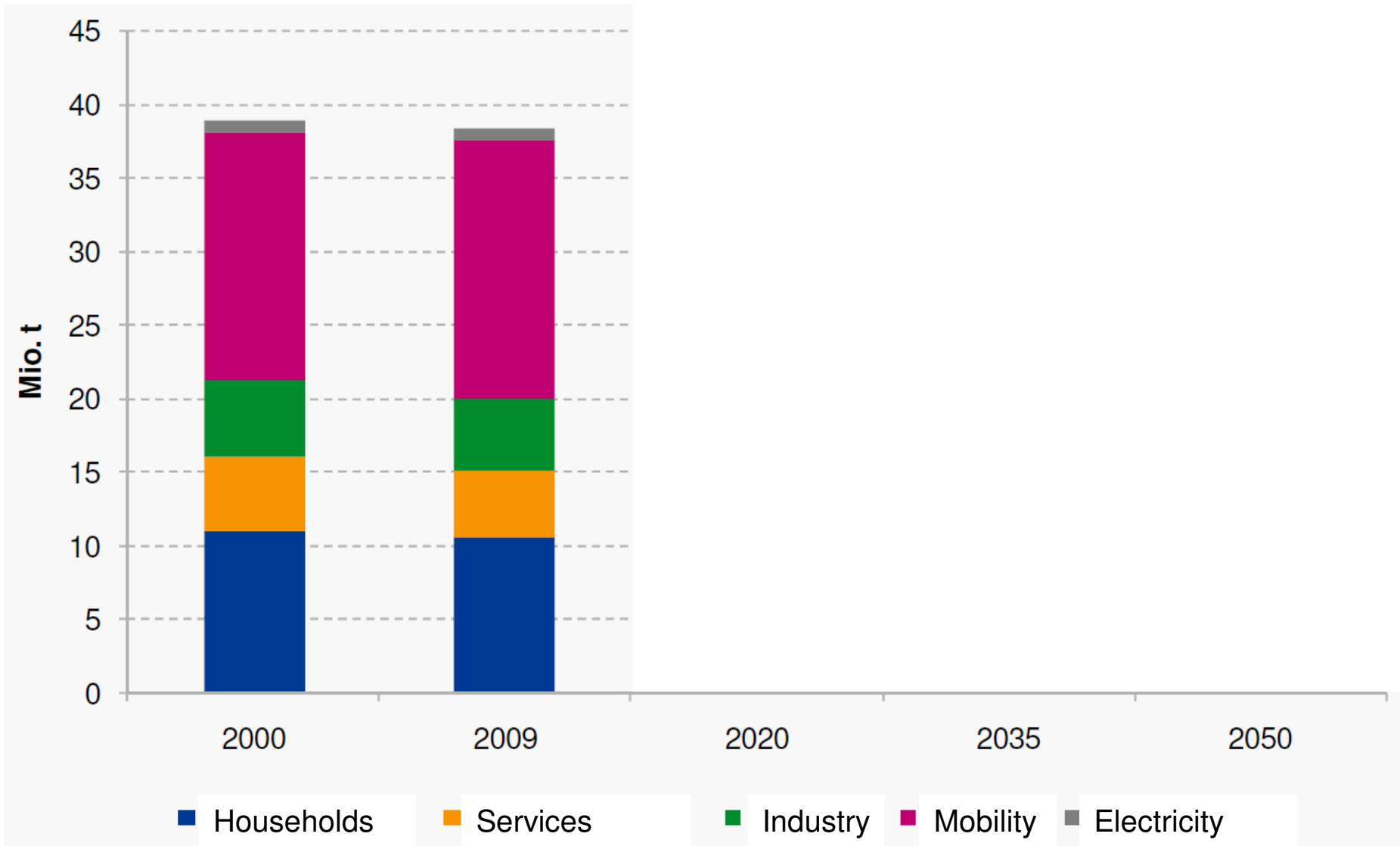
Carbon Capture and Storage –

A future option for Switzerland?

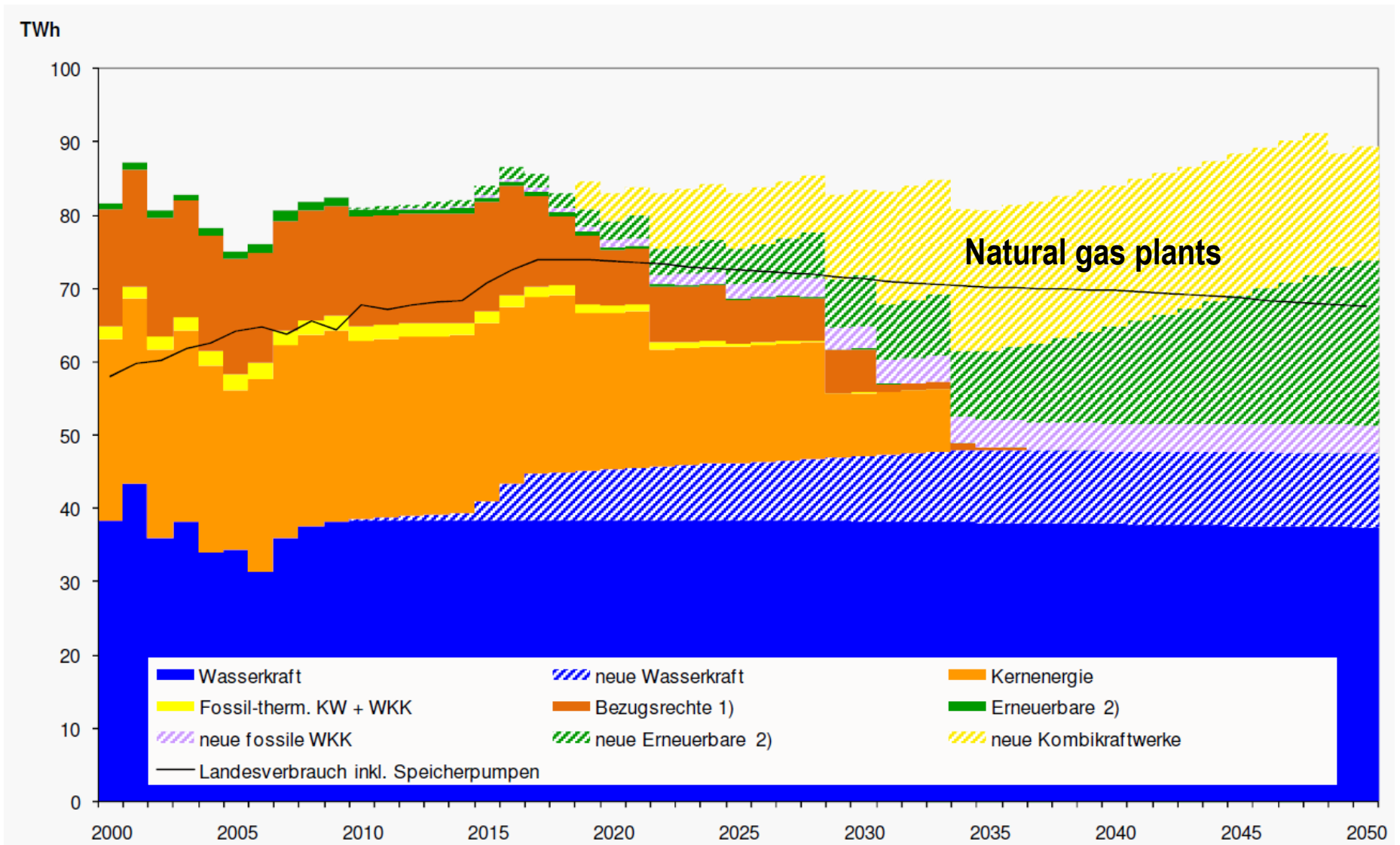
- Introduction
- CCS technology
- Life cycle assessment of CCS
- Conclusions
- Roadmap and CCS pilot project for Switzerland



Source: IEA Energy Technology Perspectives 2012

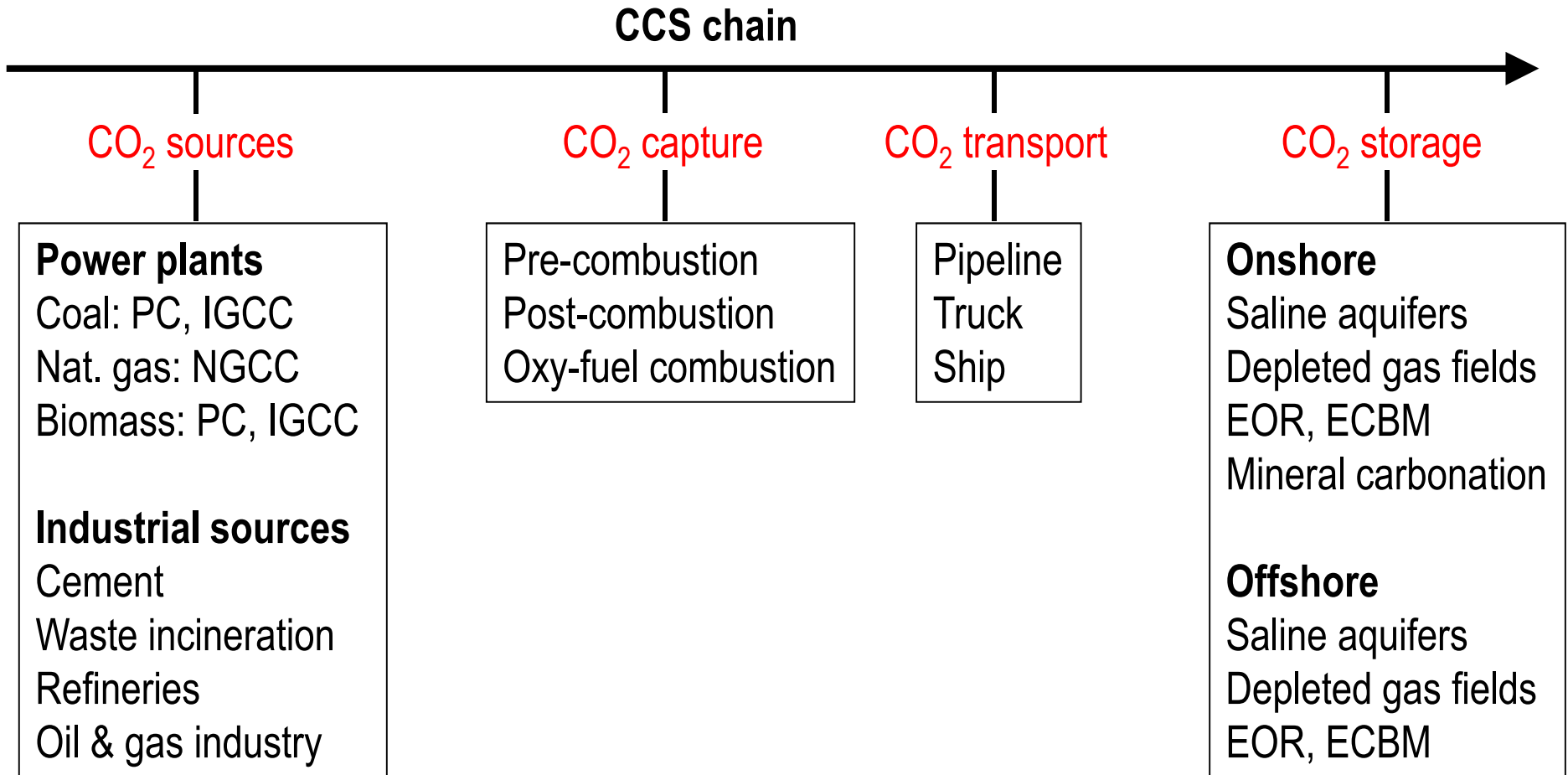


Source: Prognos 2011 (new energy policy, supply 2, option C&E)

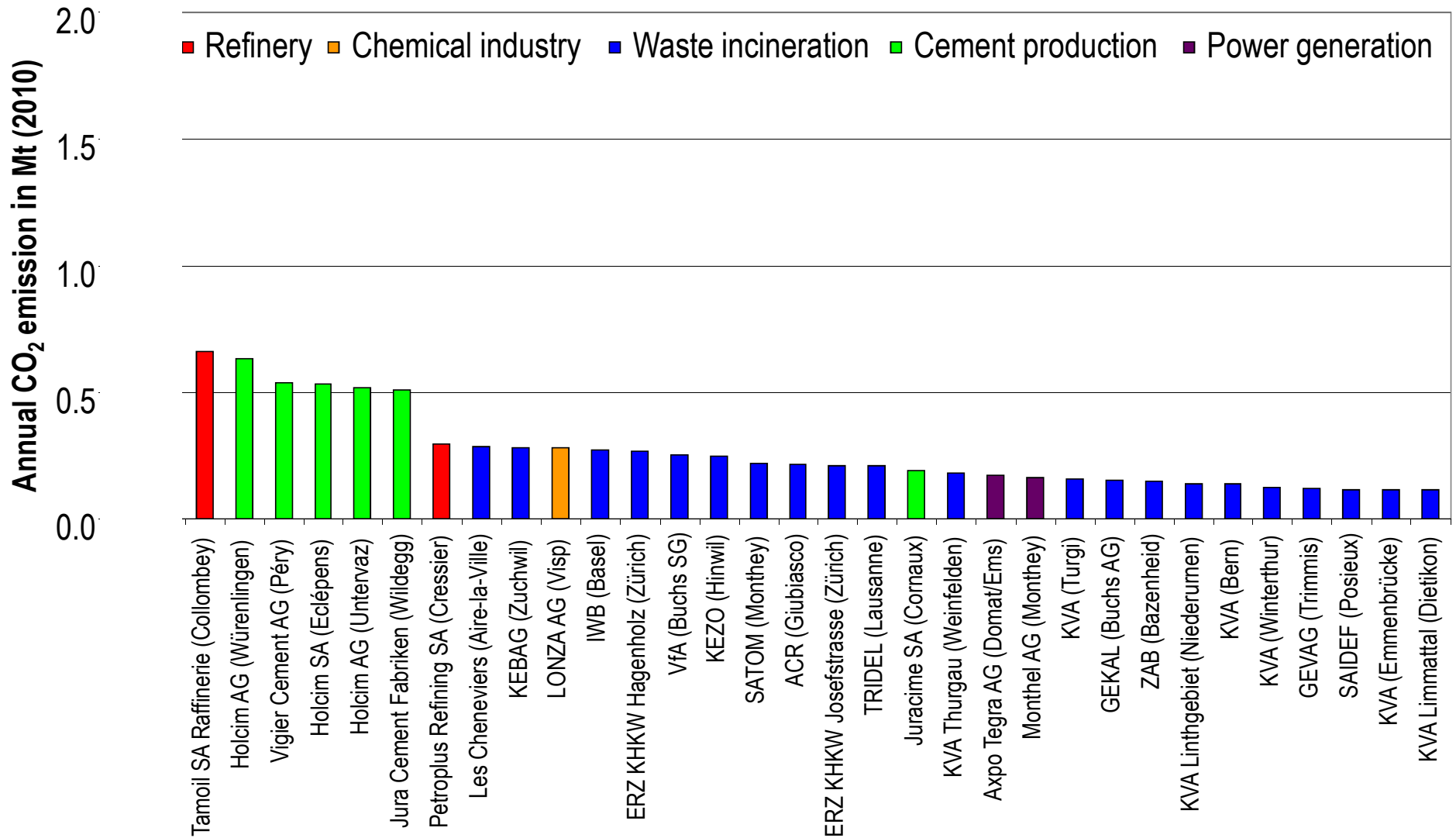


Source: Prognos 2011 (new energy policy, supply 2, option C&E)

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Large Swiss CO₂ point sources (2010)

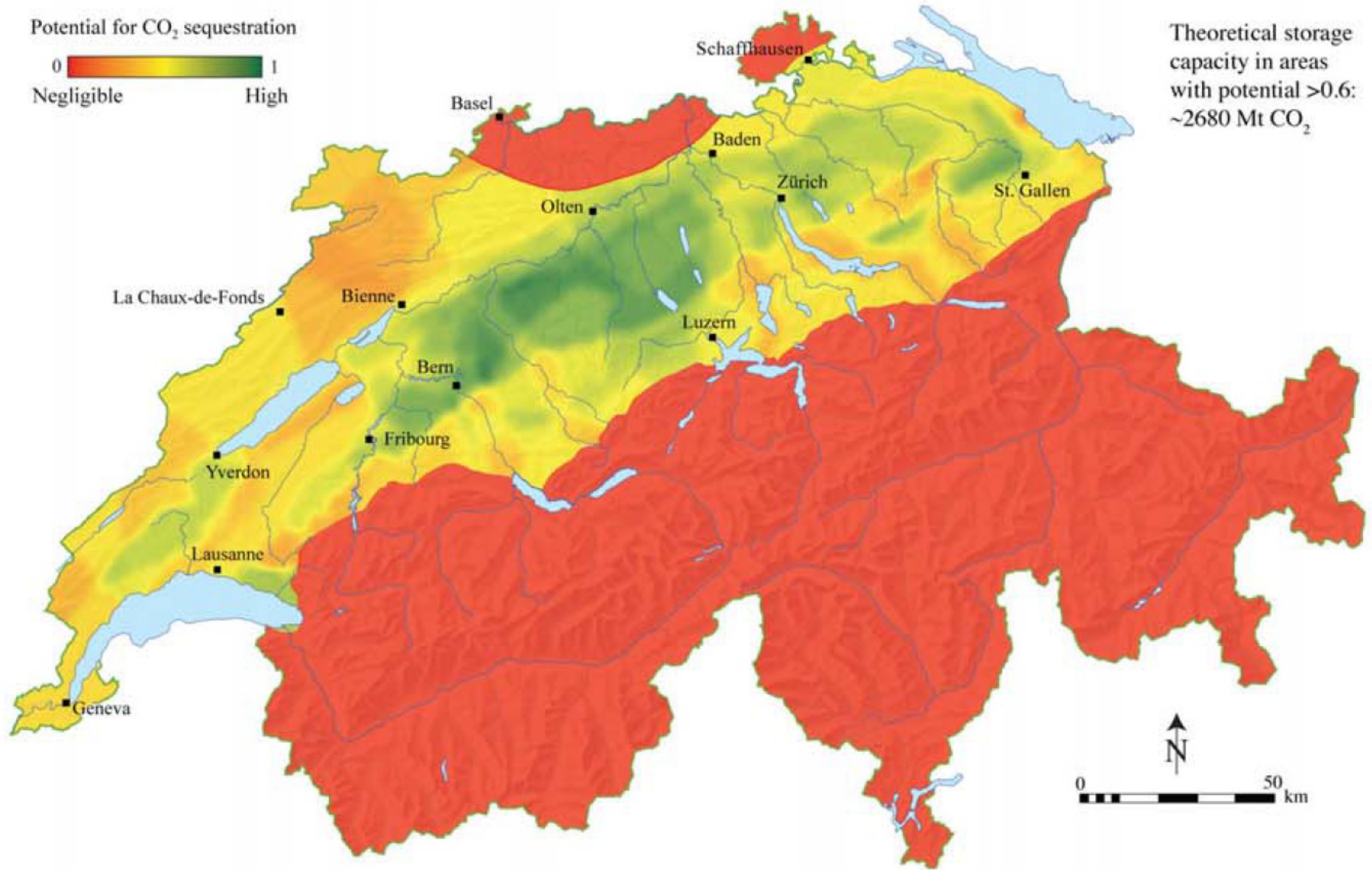


Source: E-PRTR (2012)

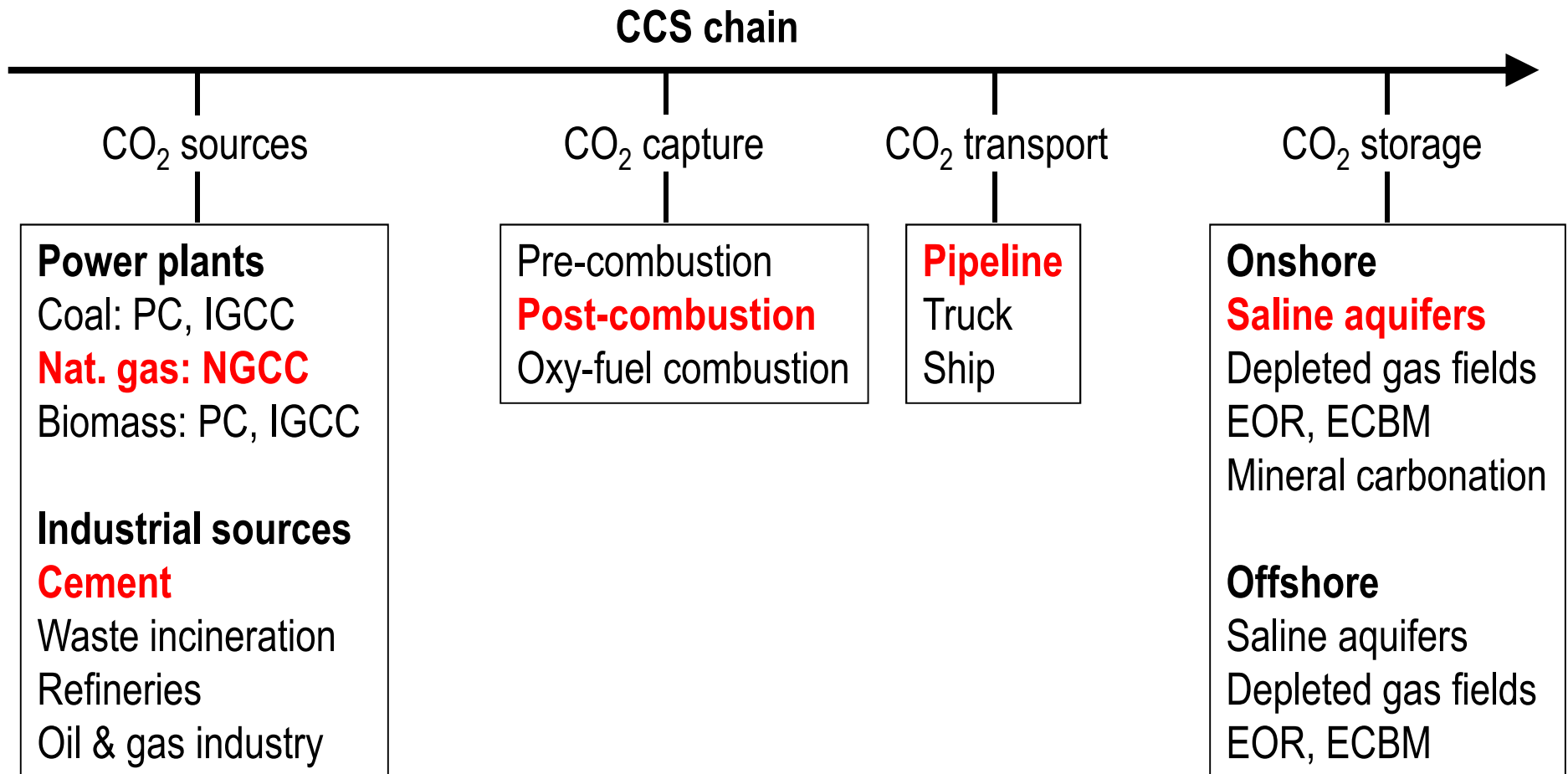
Large Swiss CO₂ point sources (2010)



Potential for geological CO₂ storage in Switzerland

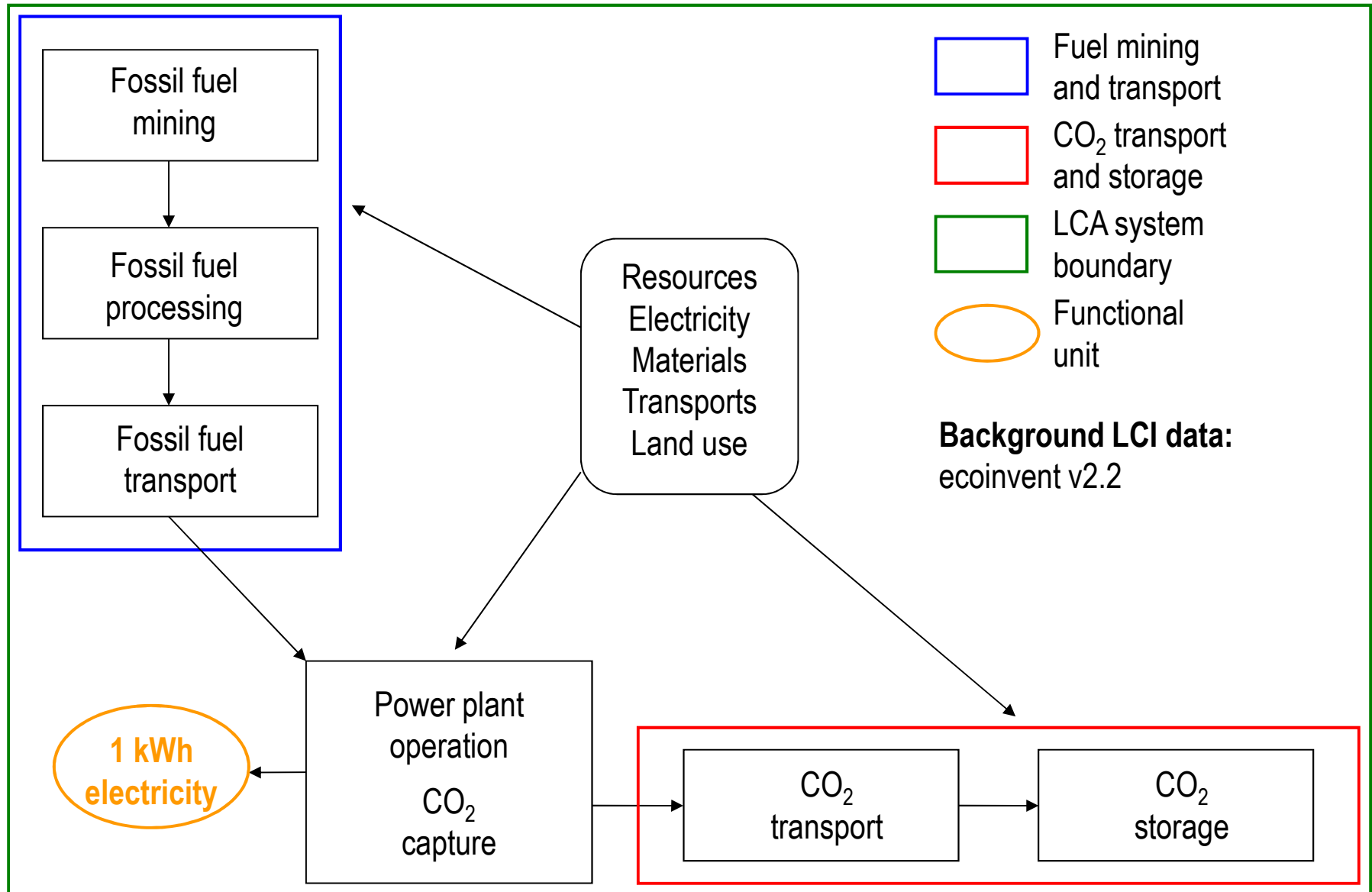


Source: Diamond, Leu et al. (2010)



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LCA of power generation with CCS: Goal and scope

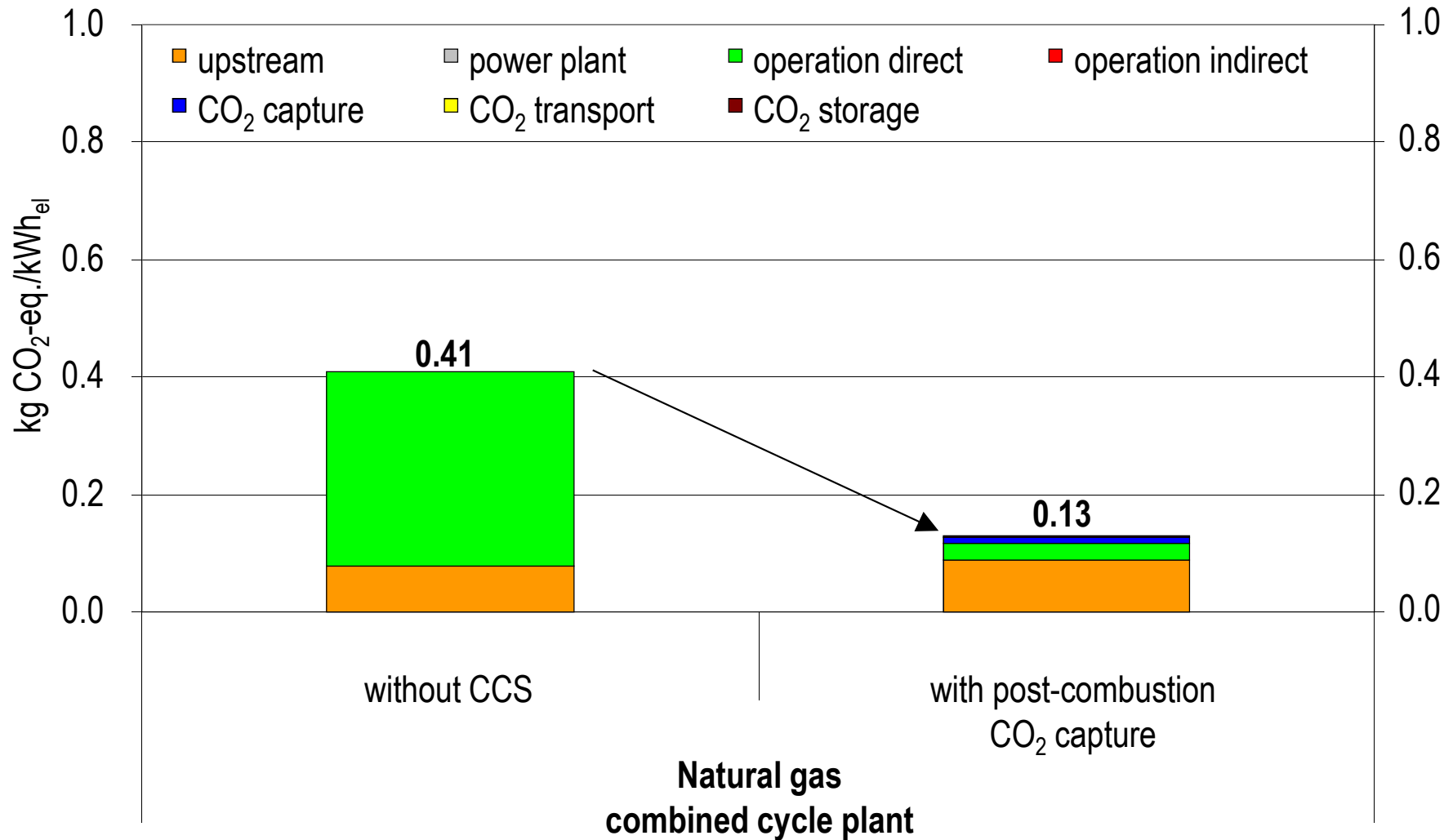


Source: Volkart, Bauer et al. (2013)

LCA of natural gas plants (2025)

Method: IPCC 2007

Assumption: 200km pipeline transport, 1000m storage depth

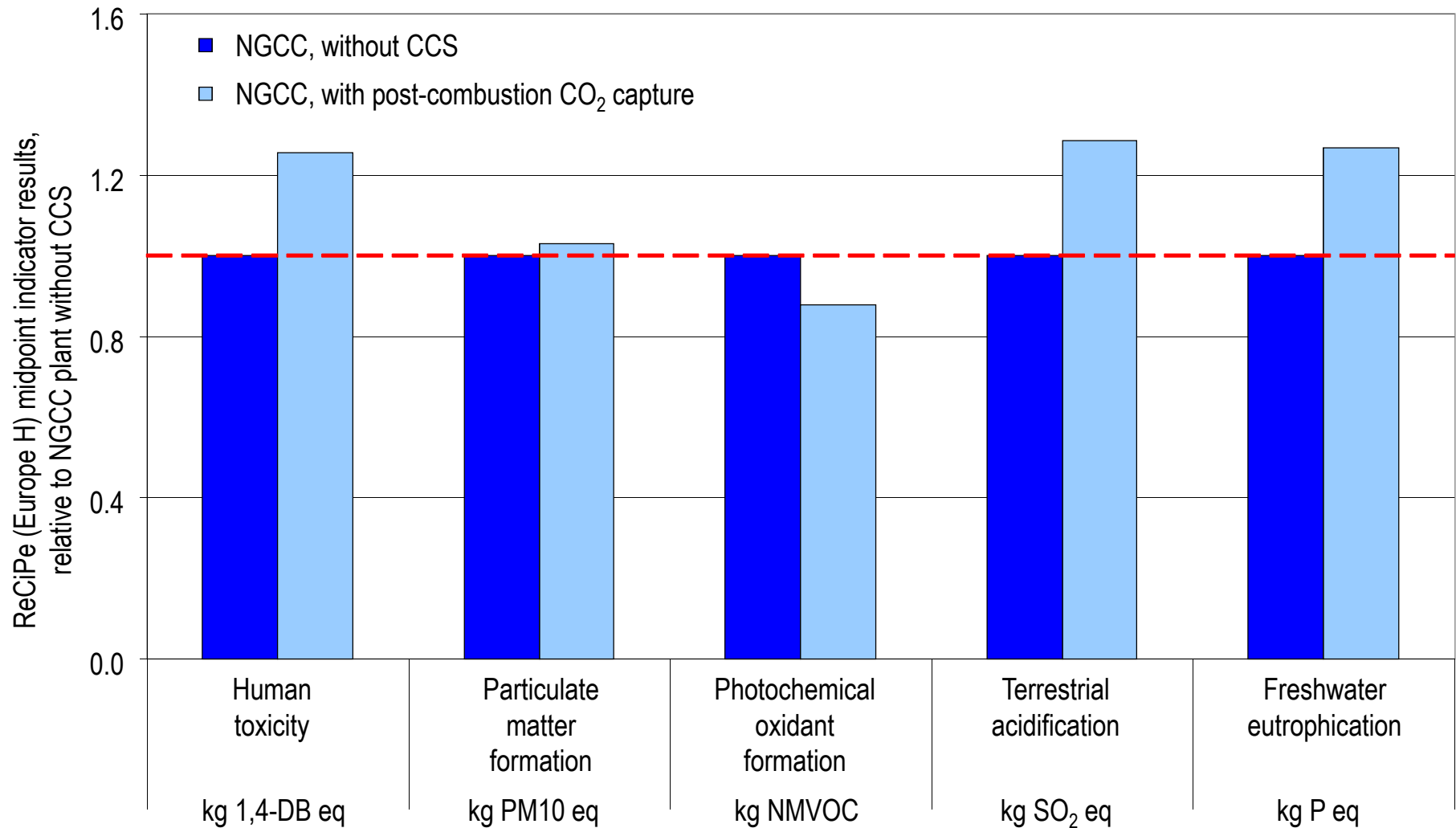


Source: Volkart, Bauer et al. (2013)

LCA of natural gas plants (2025)

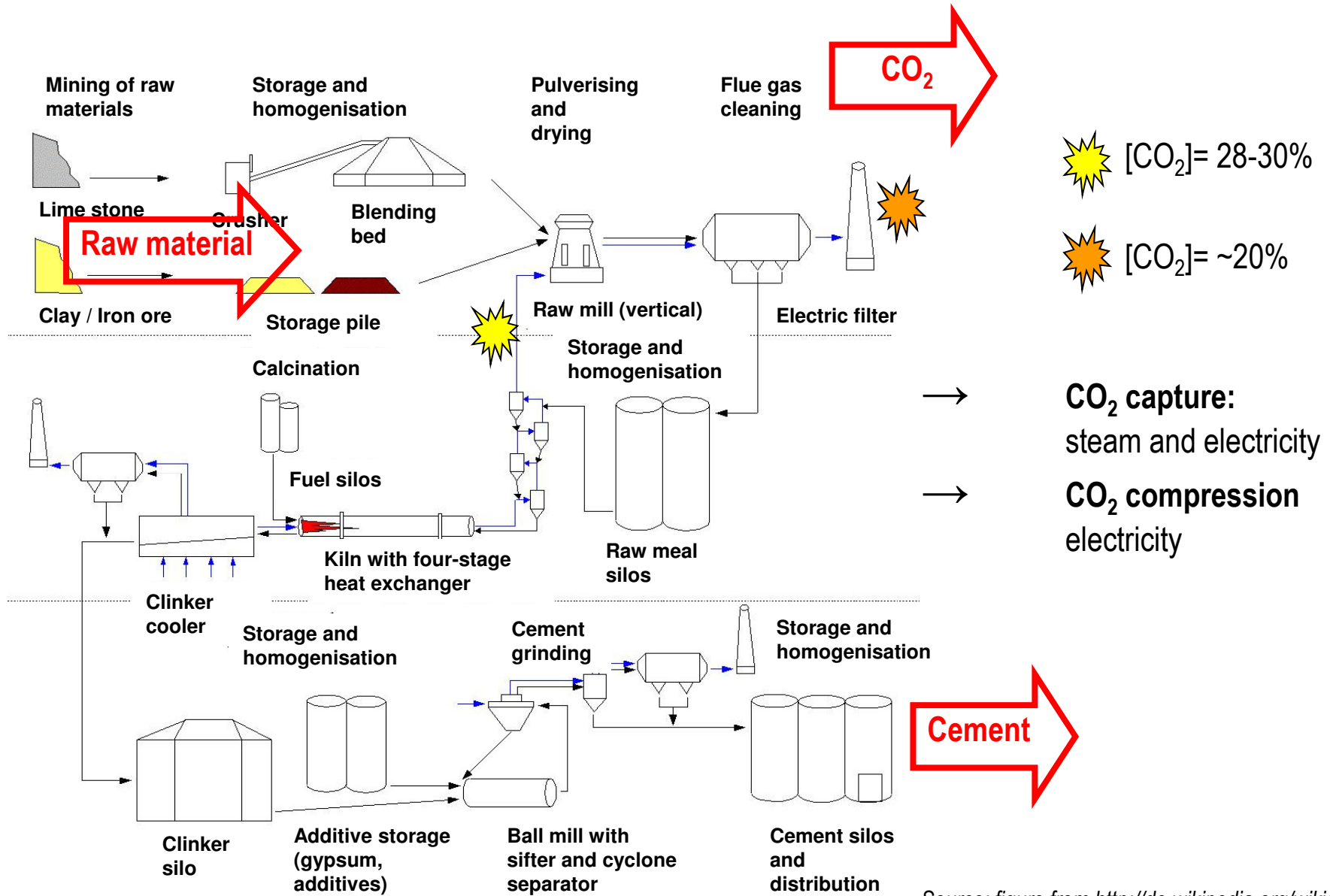
Method: ReCiPe (Europe H) midpoint

Assumption: 200km pipeline transport, 1000m storage depth



Source: Volkart, Bauer et al. (2013)

LCA of cement production with CCS: Goal and scope



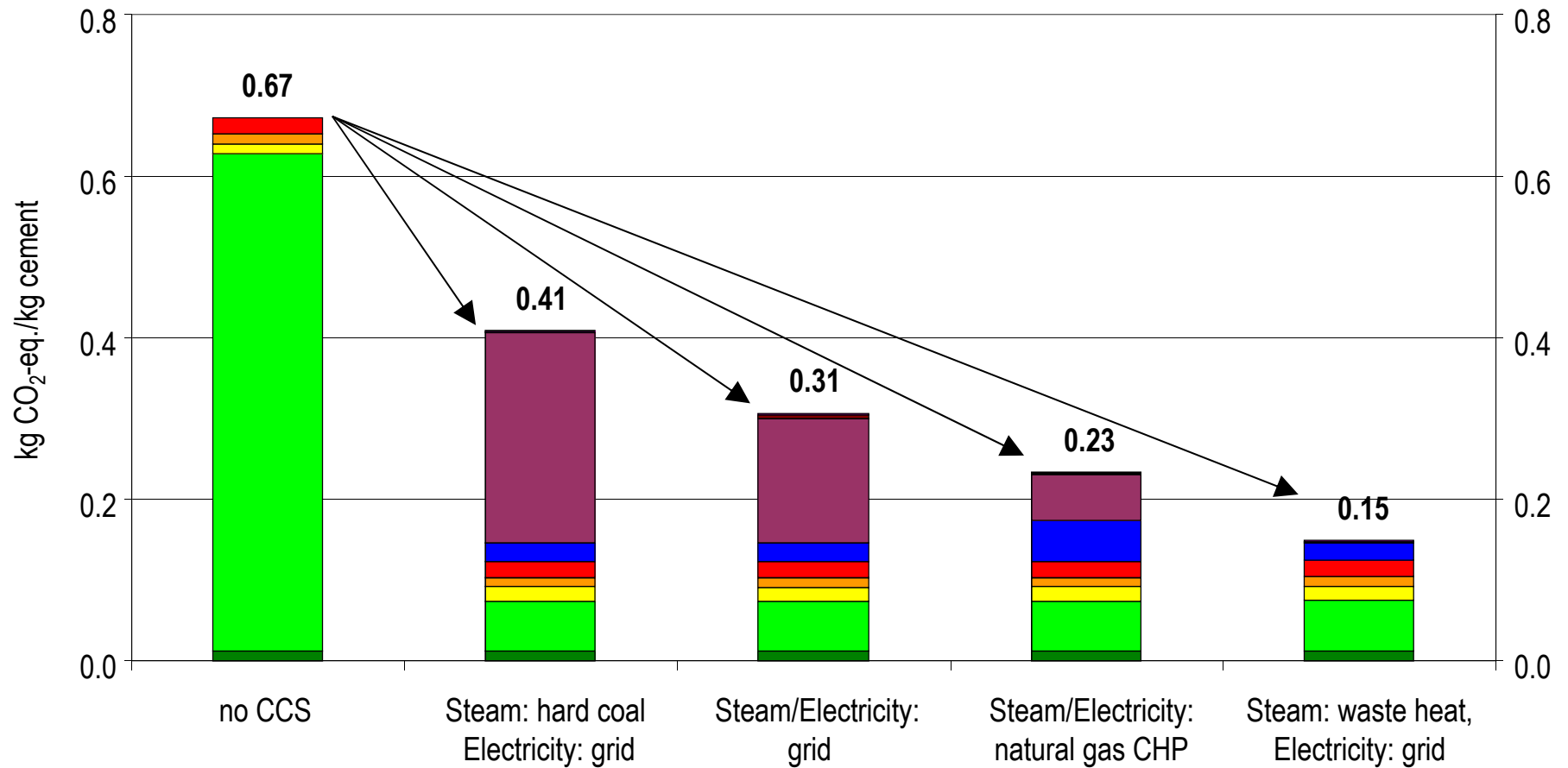
Source: figure from <http://de.wikipedia.org/wiki/Zement>

LCA of cement plants (2025)

Method: IPCC 2007

Assumption: 200km pipeline transport, 1000m storage depth

- Cement production
- Clinker: primary fuels
- CO₂ capture: indirect
- Clinker: direct
- CO₂ capture: electricity
- CO₂ transport
- Clinker: indirect
- CO₂ capture: heat
- Clinker: primary raw material
- CO₂ storage

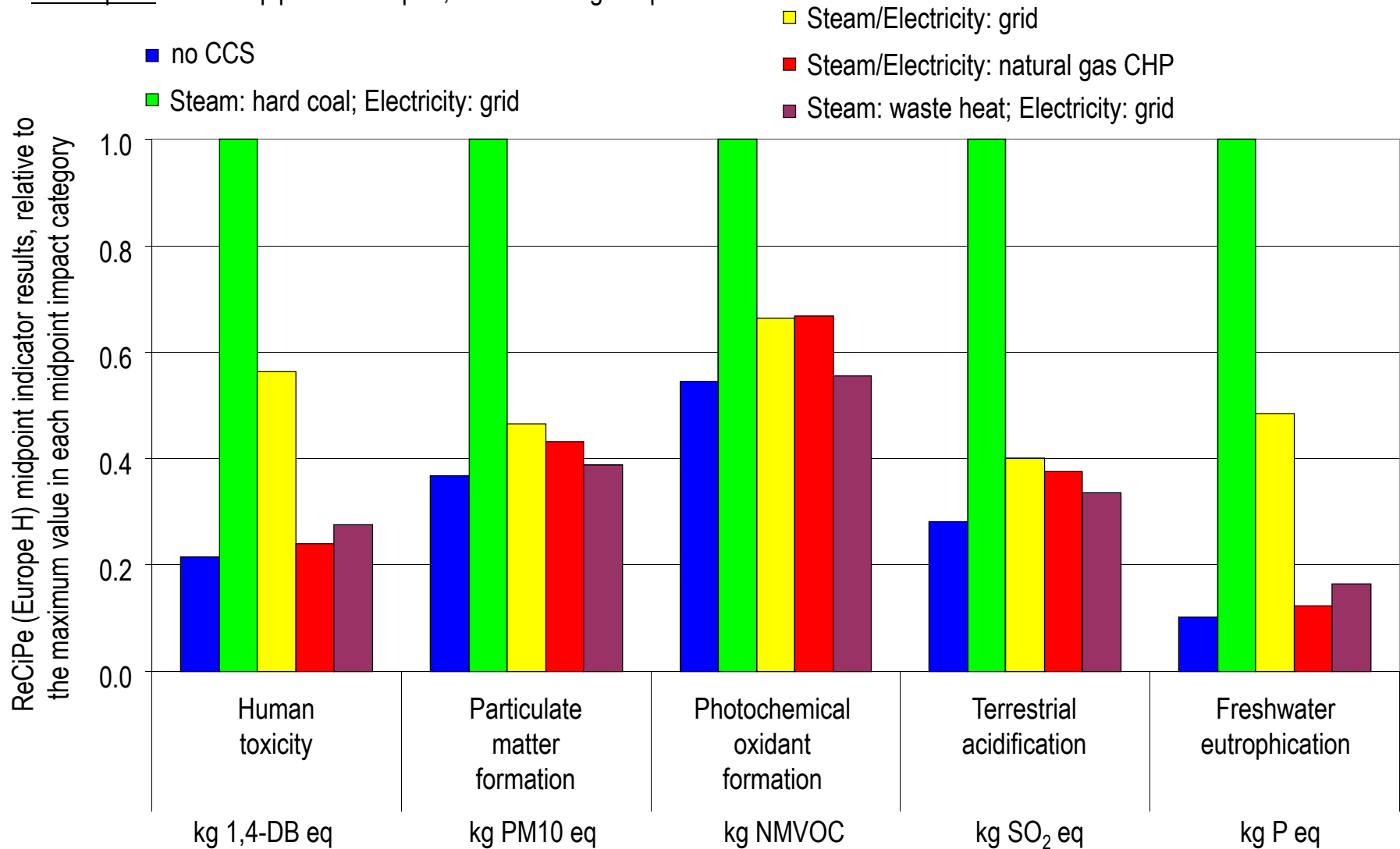


Source: Volkart, Bauer et al. (2013)

LCA of cement plants (2025)

Method: ReCiPe (Europe H) midpoint

Assumption: 200km pipeline transport, 1000m storage depth



Source: Volkart, Bauer et al. (2013)

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- **Conclusions on the life cycle assessment results**

- CCS has the potential to strongly reduce **life cycle GHG-emissions** from natural gas electricity generation (by ~70%) and cement production (by ~40-80%).
- CCS can thus significantly contribute to both, **low carbon electricity and low carbon cement** production.
- **Trade-offs** related to other environmental aspects have to be kept in mind.

- **Conclusions on CCS in Switzerland**

- **Future developments** may lead to the need for CCS in Switzerland.
- The legal situation (**CO₂ Gesetz**) is – among other criteria – decisive.
- CO₂ capture and transport are proven technologies. CO₂ storage instead is subject to considerable **uncertainties**.
- To prove the feasibility of CCS in Switzerland a **full cycle pilot project** including an injection site is required.

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- **Key issues for a CCS pilot project**

CO₂ storage site, legal aspects (mining, waste, water protection, ...), costs and acceptance

- **Objectives of the CCS roadmap**

- Adequacy of the target formations for CO₂ storage, demonstration of the safety of the CO₂ injection and storage, testing of predictive modelling results
- Assessment of the economics
- Knowledge transfer to the public, policy makers and licensing authorities
 - Provision of specific knowledge for a later planning & construction of a full CCS chain

- **Tentative timeline**

- Risk dialogue with authorities and public 2013/14
- Seismic exploration 2014/15
- Site acquisition & Drilling Permit 2015-17
- Drilling & Installation Operations 2017-19
- CO₂ Injection Operations 2019-22
- Monitoring 2022-min. 2032

I would like to thank

Christian Bauer (PSI), Ernst Bucher and Christian Zipper (Holcim)

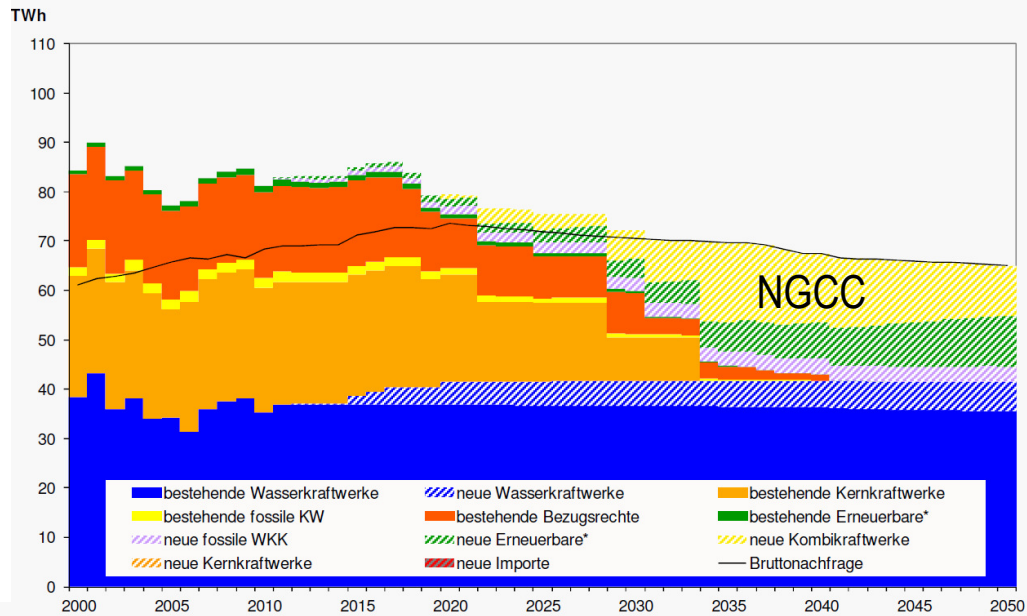
This work was carried out as part of the project CARMA and funded by

Competence Centers of Environment and Sustainability (CCES) and Energy and Mobility (CEM), the Swiss Federal Office of Energy (SFOE) and Alstom Power Service.

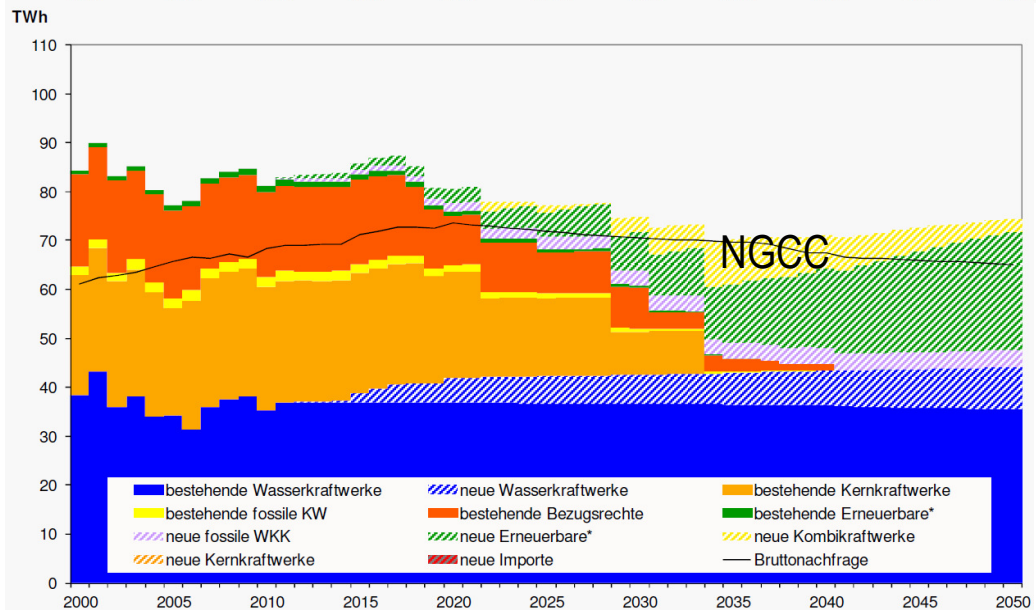


Questions?



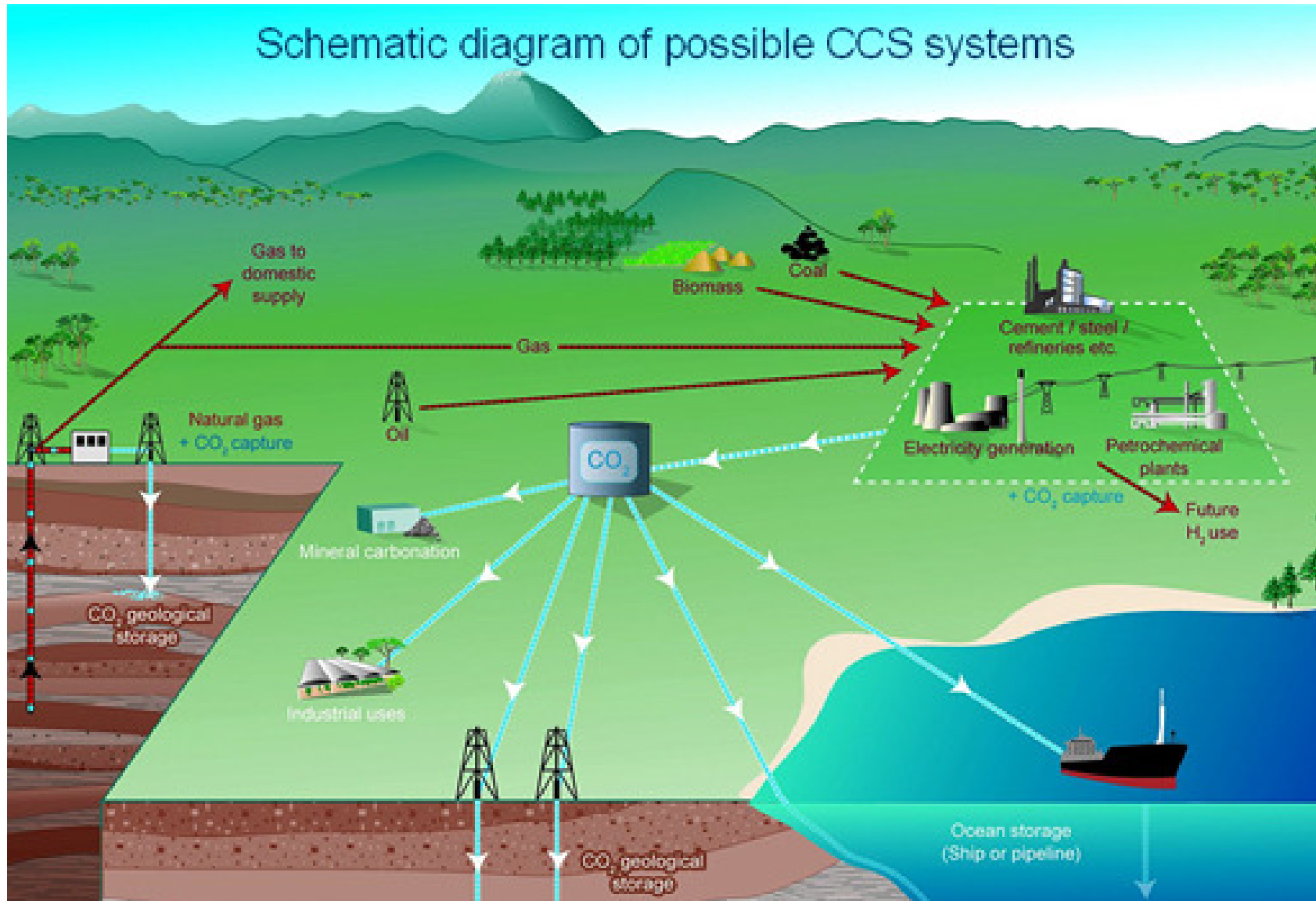


- Hydrological year
- „New energy policy“
- Central fossil supply (C)



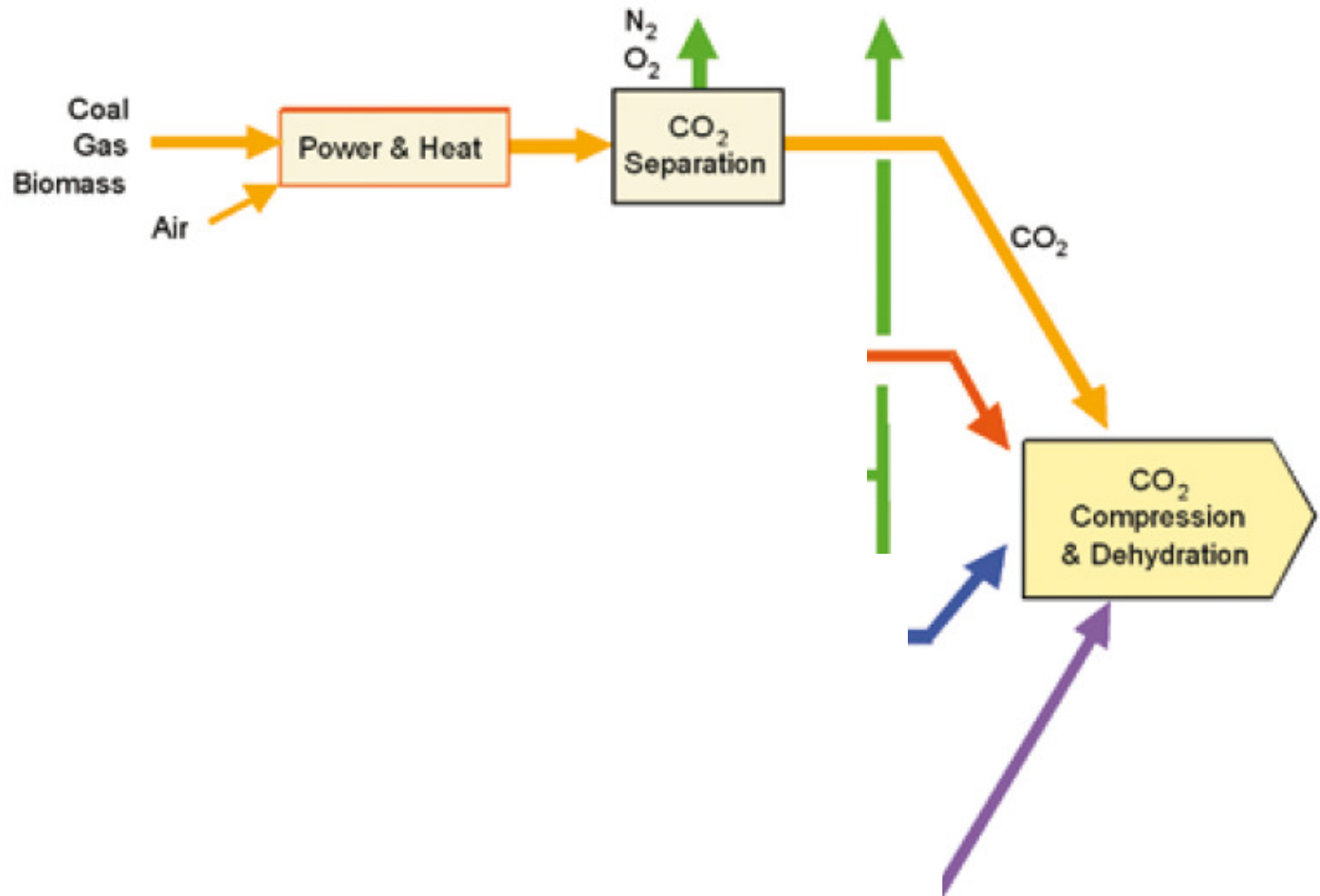
- Hydrological year
- „New energy policy“
- Central fossil and renewable supply (C&E)

Source: „Die Energieperspektiven für die Schweiz bis 2050“, Prognos AG (2012) for SFOE

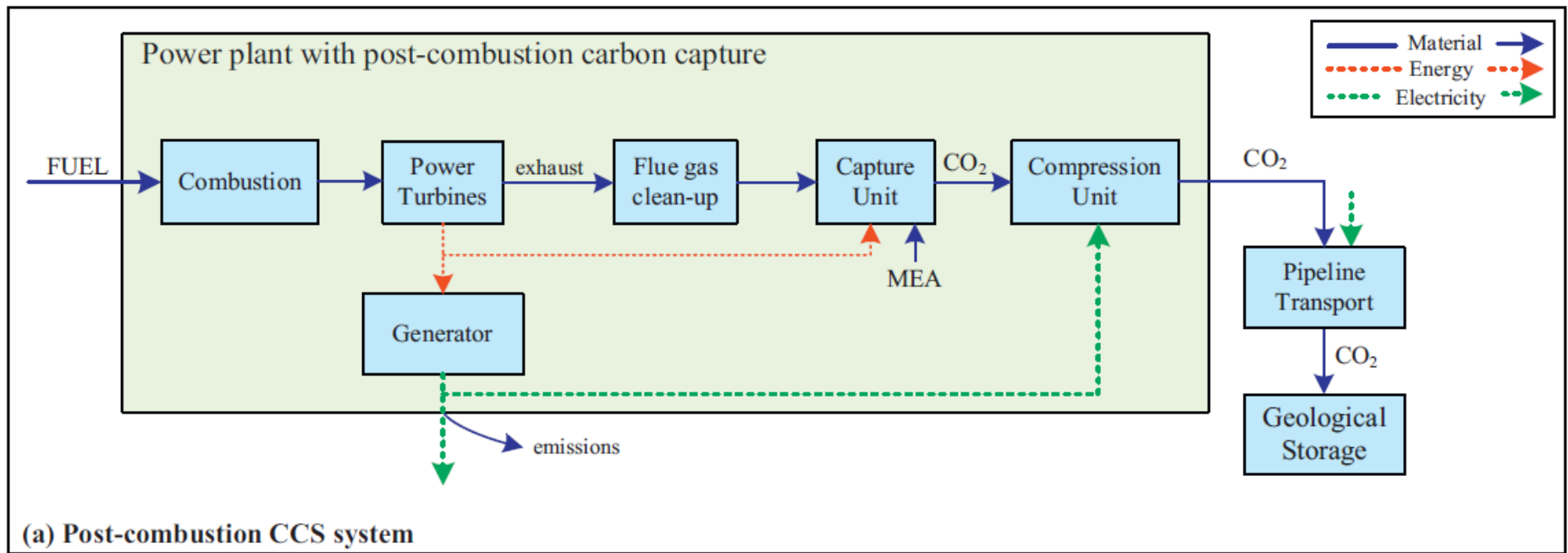


Source: IPCC 2005

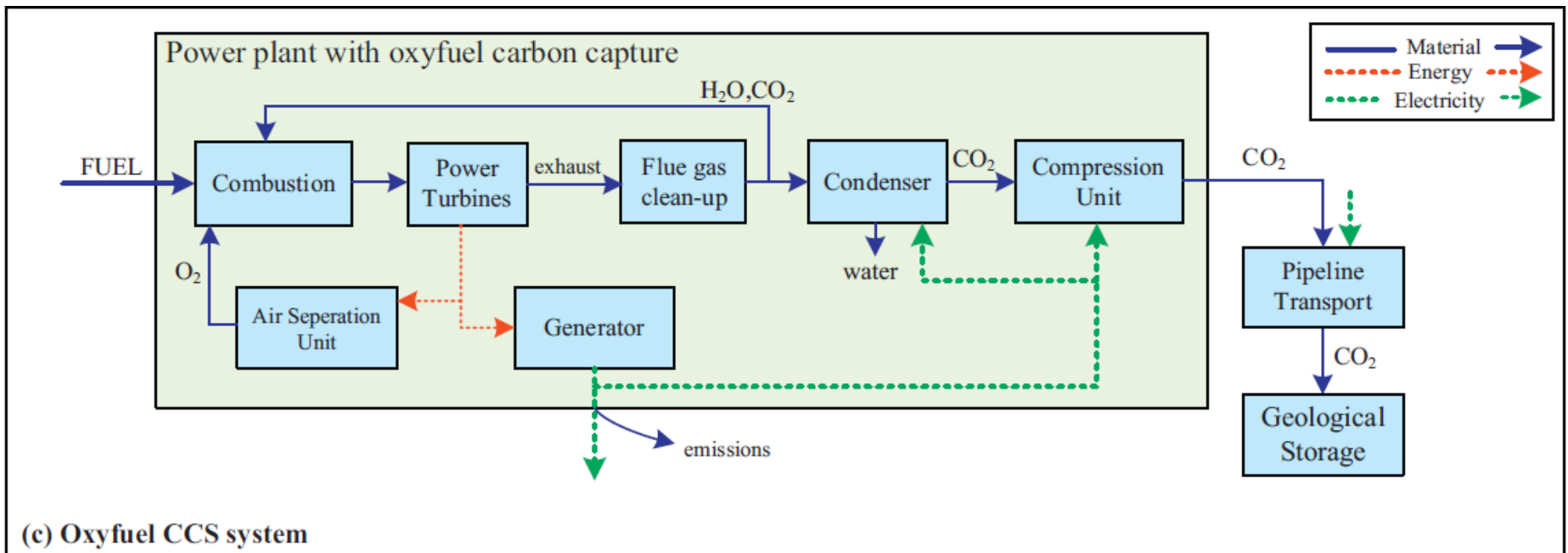
Post combustion



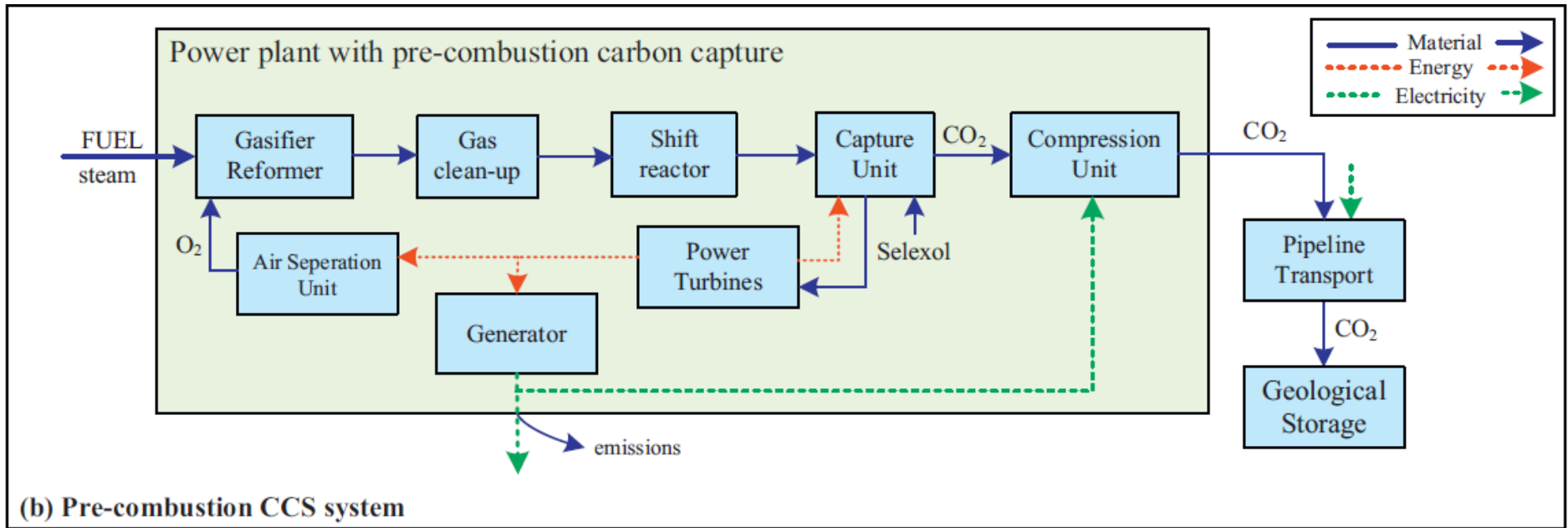
Source: IPCC 2005



Source: Singh Strömman et al. (2011)



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Potential pipeline network for CO₂ transport (2008)



IPCC 2007 focuses on greenhouse gases (GHG) according to the definition by the Intergovernmental Panel on Climate Change (IPCC)

Unit: kg CO₂-equivalent

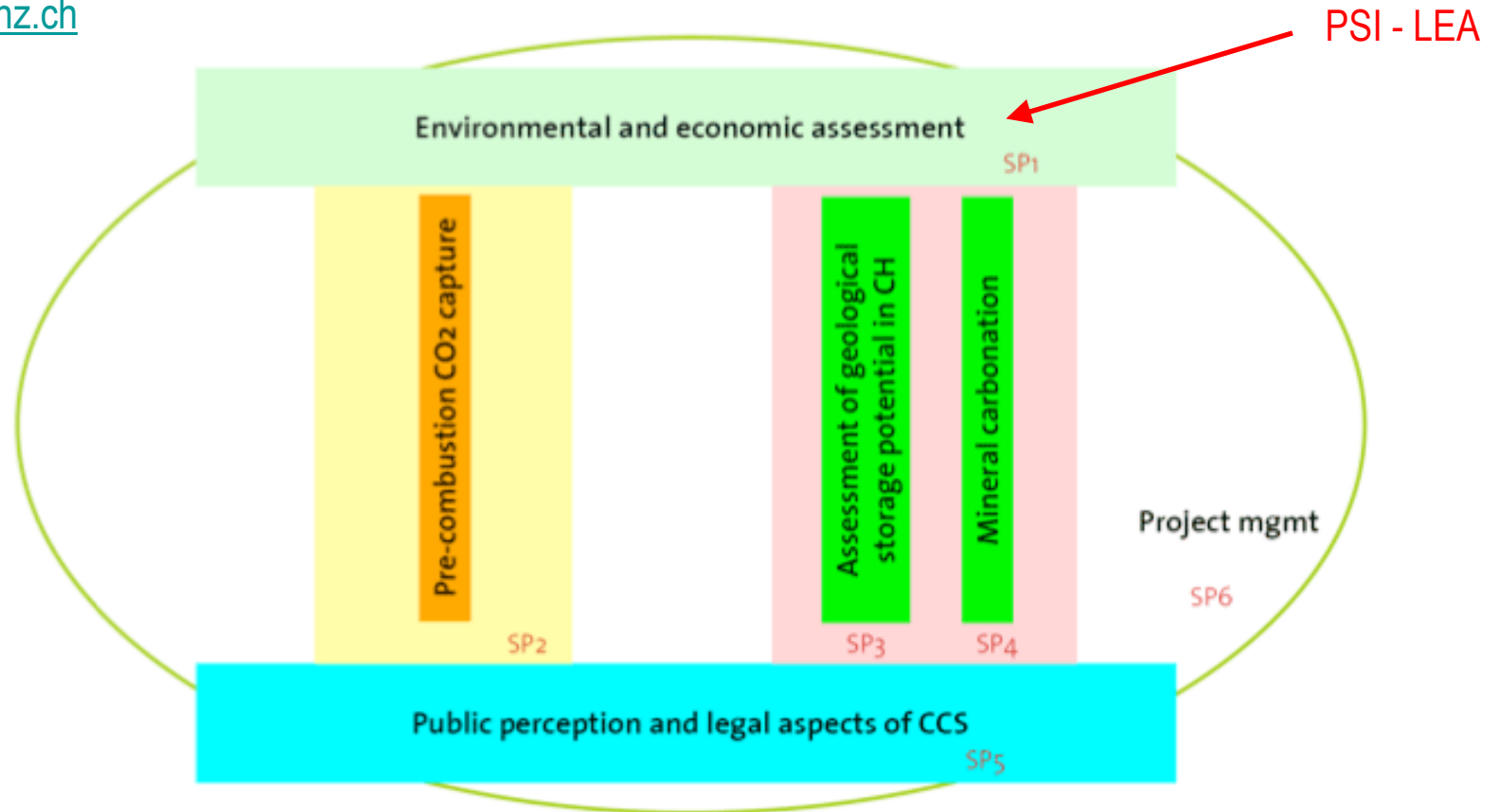


Source: <http://www.eere.energy.gov/>

“Swiss research project that aims to explore the potential and feasibility of Carbon dioxide Capture and Storage (CCS) systems deployment in Switzerland, within the framework of future energy scenarios.”

www.carma.ethz.ch

2009-2012



Funded by CCES, CCEM, SFOE, swisselectric research and ALSTOM.

Source: www.carma.ethz.ch