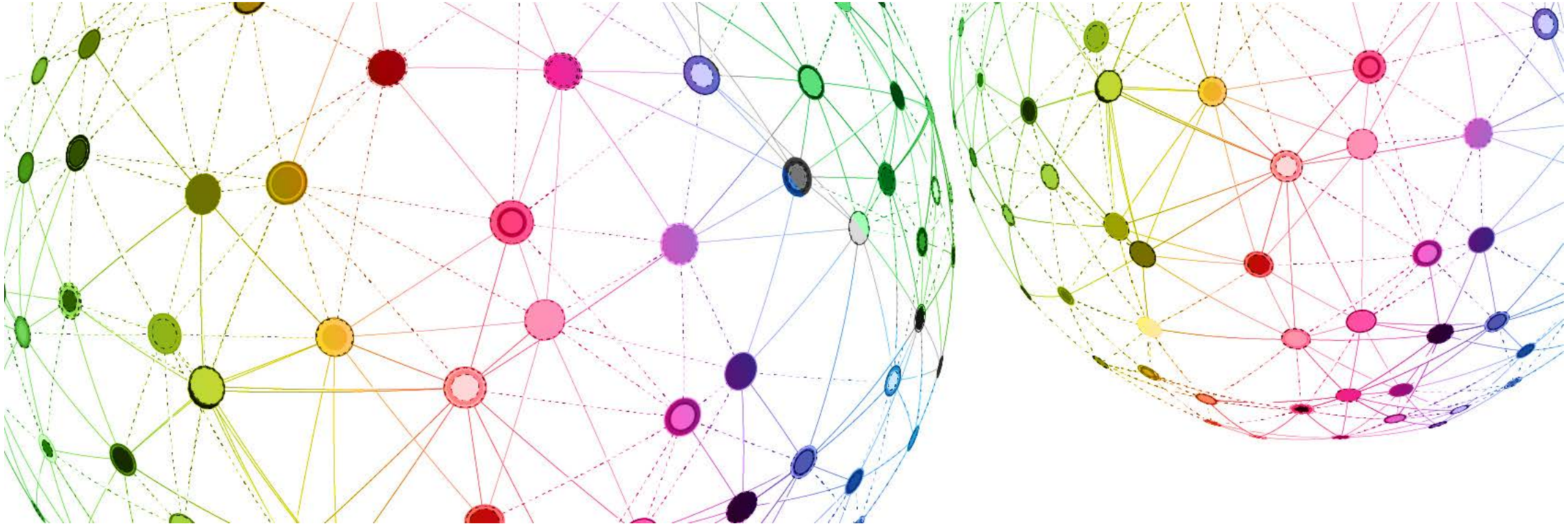
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Energie BFE
Office fédéral de l'énergie OFEN
Ufficio federale dell'energia UFE
Swiss Federal Office of Energy SFOE



INTERNATIONALE PERSPEKTIVE ZU CARBON CAPTURE AND USAGE (CCU)

GUNTER SIDDIQI, BUNDESAMT FÜR ENERGIE / SCHWEIZ & CHAIR DER IEA RENEWABLE ENERGY WORKING PARTY – 8.OKTOBER 2019

CONTENTS

1. Perspective (IEA Technology Collaboration Programs dealing directly with CCUS)
2. Perspective European Research Area Network – Accelerating CCUS (ERA-NET ACT)
3. If time permits, a short perspective on Switzerland

IEAGHG – “the” CCS Technology Collaboration Program

Who is the IEAGHG?

Our internationally recognised name is the IEA Greenhouse Gas R&D Programme (IEAGHG). IEAGHG is a Technology Collaboration Programme (TCP) and part of the International Energy Agency’s (IEA’s) Energy Technology Network.

Disclaimer

The IEA Greenhouse Gas R&D Programme (IEAGHG) is organised under the auspices of the International Energy Agency (IEA) but is functionally and legally autonomous. Views, findings and publications of the IEA Greenhouse Gas R&D Programme do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

https://ieaghg.org/ and for CCU work contact: jasmin.kemper@ieaghg.org

IEA Greenhouse Gas R&D Programme (IEAGHG)

- A collaborative international research program founded in 1991
- Aims:
  - To evaluate technology options for greenhouse gas mitigation from energy and industrial systems
  - To facilitate implementation of potential mitigation options,
  - To facilitate international collaborative activities,
  - To widely disseminate our results.
- Focus is on Carbon Dioxide Capture and Storage (CCS)
- Producing information that is:
  - ✓ Objective, trustworthy, independent
  - ✓ Policy relevant but NOT policy prescriptive
  - ✓ Reviewed by external Expert Reviewers

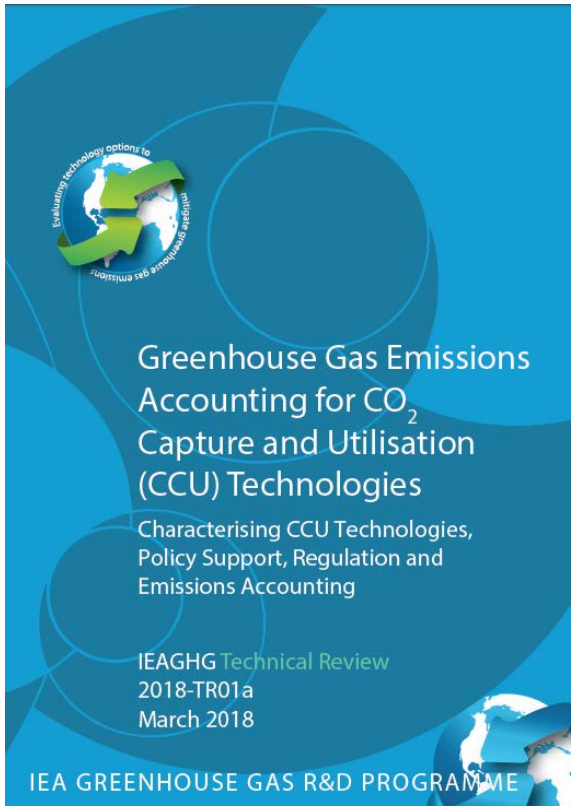
IEA Greenhouse Gas R&D Programme (IEAGHG)

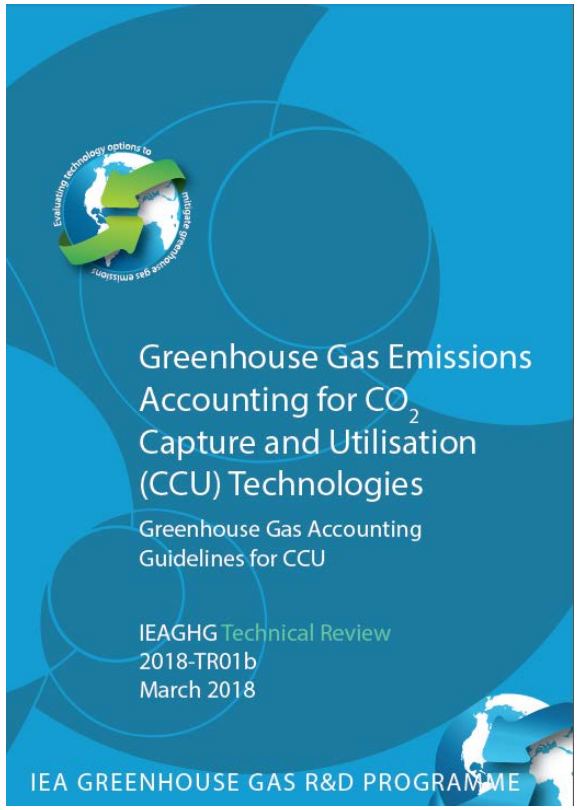
- Technical Studies
  - >320 reports published on all aspects of CCS
- International Research Networks
  - Risk Assessment/Management
  - Monitoring
  - Modelling
  - Environmental Research
  - Social Research
  - Oxy-combustion
  - Post-combustion Capture
  - Solid Looping
- GHGT conferences
  - GHGT-13, Lausanne, Switzerland, 13-18 Nov 2016
  - GHGT-14, Melbourne, Australia, 22-26 Oct 2018
  - GHGT-15, Abu Dhabi, UAE, 5-8 Oct 2020
- PCCC conferences
  - PCCC4, Sep 2017, Birmingham, Alabama
  - PCCC5, Sep 2019, Kyoto, Japan
- International CCS Summer School
  - 550 alumni from 50 countries
  - 2019 at International CCS Knowledge Centre, Regina, Canada
  - 2018 at SINTEF, Trondheim, Norway
- Reviewing activities
  - US DOE
  - US EPA
  - CO2CRC etc.
- Active in international regulatory developments
  - UNFCCC
  - London Convention
  - ISO TC265 etc.
- Collaborations with other organisations
  - IEA
  - CSLF
  - CCSA
  - EU ZEP etc.

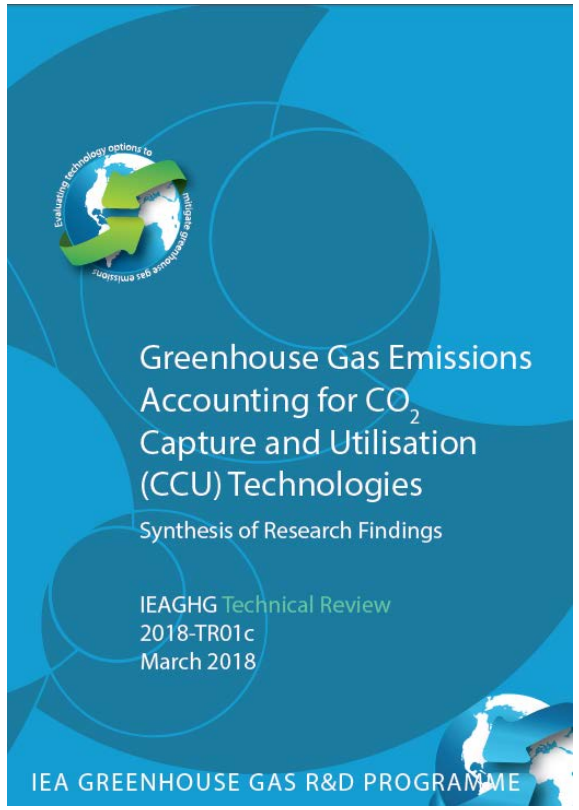
IEAGHG: WORK ON GHG ACCOUNTING FOR CCU – PHASE I

Published as a trilogy:

https://ieaghg.org/publications/technical-reports







QJ Science

CARBON COUNTS

九州大学
KYUSHU UNIVERSITY

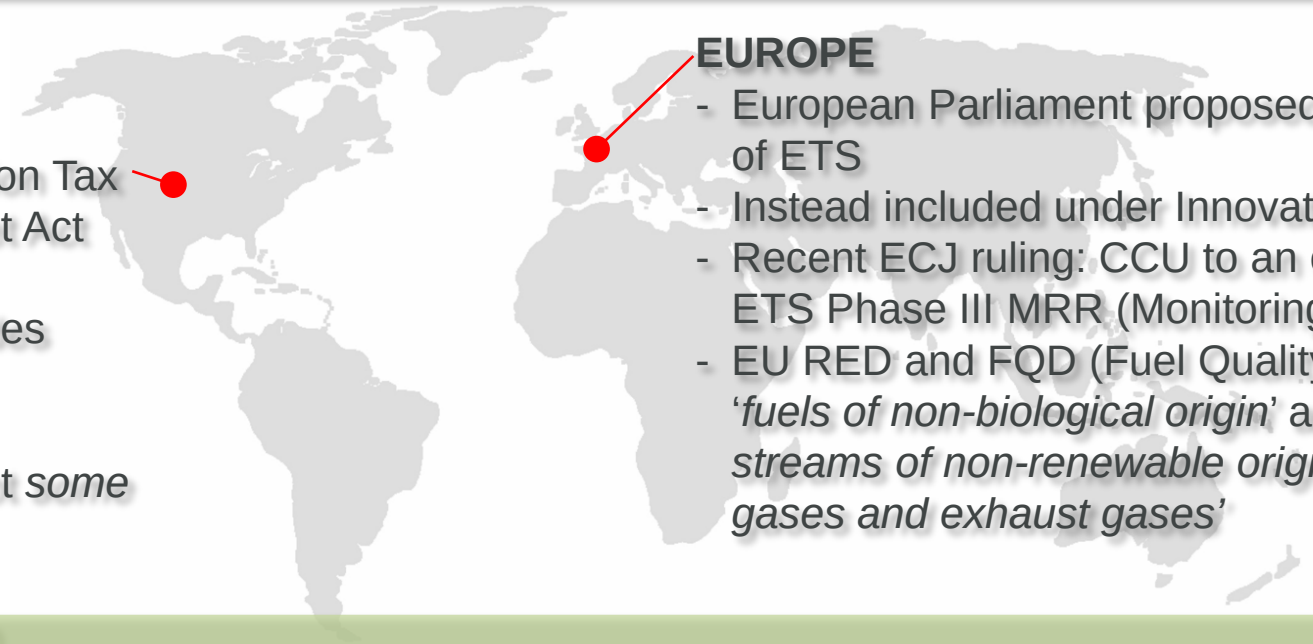
IEAGHG: WORK ON GHG ACCOUNTING FOR CCU – PHASE I

Background:

- Interest in CO_2 capture and utilisation (CCU) has increased significantly over recent years
- Uncertainties remain regarding CCU's potential for climate change mitigation
- Views from various stakeholders exist
- Detailed studies have only been partially carried out and rely heavily on assumptions (e.g. low-carbon H_2)
- Need to assess the overall energy and carbon balance for different CCU pathways

IEAGHG: WORK ON GHG ACCOUNTING FOR CCU – PHASE I

GLOBAL
- Main products could utilise ~7 $GtCO_2$/yr with market of >US$800 billion by 2030 (Global CO_2 Initiative)
- CO_2 as possible signature 'rough diamond' material in circular economy (WEF/McKinsey)



UNITED STATES
- CCU in 45Q Sequestration Tax Credit (Bipartisan Budget Act 2018)
- Clean Power Plan includes CCU technologies
- Various renewable fuel standards already accept *some* CO_2 derived fuels

EUROPE
- European Parliament proposed to include CCU in Phase IV of ETS
- Instead included under Innovation Fund/"NER400" from 2021
- Recent ECJ ruling: CCU to an extent will be integrated into ETS Phase III MRR (Monitoring and Reporting Regulation)
- EU RED and FQD (Fuel Quality Directive) to include both '*fuels of non-biological origin*' and *'fuels produced from waste streams of non-renewable origin, including waste processing gases and exhaust gases*'

REST OF THE WORLD
- Will be interested to see how rules evolve in e.g. Japan, China, Korea, India.
- Could influence treatment of future carbon finance initiatives under UN Convention on Climate Change

IEAGHG: WORK ON GHG ACCOUNTING FOR CCU – PHASE I

Scope of the study:

1) Characterising CCU technologies and emissions reductions pathways
2) Determining CCU facility-level greenhouse gas (GHG) emissions
3) Developing a composite life-cycle GHG emissions profile for CCU activities
4) Assessing GHG accounting options

Methodology

- Two components:
  - A. Lifecycle (LC) GHG inventory for different CCU processes/products
  - B. GHG benefits assessment by comparative analysis of CCU processes/products against conventional products
- LC GHG Inventory Method (A) provides basis for estimating GHG benefits in Method (B)
- Cradle-to-gate assessment, but including end use where relevant to reflect permanence concerns
- Choice of reference case is key issue for assessing GHG benefits
- Development based on facility data collected from variety of operators

IEAGHG: WORK ON GHG ACCOUNTING FOR CCU – PHASE I

- CCU accounting guidelines v1.0 developed based on a GHG emissions assessment of 4 different CCU case studies
- CO_2 benefit factor offers some advantages as allows direct product comparisons. Improves transparency of analysis/results.
- Guidelines v1.0: further feedback on the method welcome to improve them
- Towards Guidelines v2.0: refine approach, methods for functional equivalence and substitution effects

IEAGHG: WORK ON INTEGRATED GHG ACCOUNTING FOR CCU & CCS – PHASE II

Awaiting publication:

- Report sets out accounting guidelines for GHG emissions and emissions reduction effects from CCUS
- Applies both a project- and product-based approach
- Modular approach:
  - Calculate the GHG effects arising from the capture (and transport) of CO_2 based on the avoided emissions from providing the same service or product as output from the CO_2 source facility, but without CO_2 capture.

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IEAGHG: WORK ON INTEGRATED GHG ACCOUNTING FOR CCS & CCS – PHASE III

- The purpose of new work programme is to:
  - Translate the current product- and project-based accounting methods into a framework consistent with national GHG accounting and national GHG inventory compilation and reporting
  - Take a scenario driven-approach and consult with stakeholders to better inform the possible relevant outcomes from such analysis

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IEAGHG: FURTHER WORK ON CCU

- Reality check: Climate mitigation through CO_2 conversion routes
- CO_2 as alternative feedstock: Identification of the most promising CO_2 conversion pathways gathering environmental and economic benefits
- From carbon dioxide to cement – improving process efficiency

IEAGHG: STAY TUNED FOR GHGT-15

- Deadline to submit an abstract – Monday 6th January 2020
- Early Bird registration opens March 2020
- Draft Technical programme announced online May 2020
- Visit https://ghgt.info/ for all conference information and abstract submission

HOSTED BY KHALIFA UNIVERSITY,

ABU DHABI, UAE

5-8 OCTOBER 2020

European Research Area Network – Accelerating CCUS Technologies

ACT aligns with SET-Plan Action 9:

- International cooperation – the tool for accelerating implementation of CCS/CCU in power and energy-intensive industries
- Fund research and innovation projects that can lead to safe and cost effective technology
- **Cooperating on 2 joint calls (probably a 3rd one in 2020) and knowledge sharing**
- Duration of EC support for ACT: February 2016 - January 2021

ACT has launched 2 joint calls

1st Call for proposals, June 2016

- 10 partners from 9 countries cooperate
- 8 new projects decided for funding in 2017
- Project period 3 years
- 36 mln € from ACT
  - of which ~11.9 mln € from the EC

Co-funded by the European Commission within the Horizon 2020

2nd call for proposals, June 2018

- 13 partners from 11 countries
- Budget of 22-30 M€
- 47 pre-proposals, requesting 112 mln €
- 26 full proposals were notified on 1 July 2019
- Once contract negotiations completed, official announcement

ACT's 1st call

Co-funded by the European Commission within the Horizon 2020

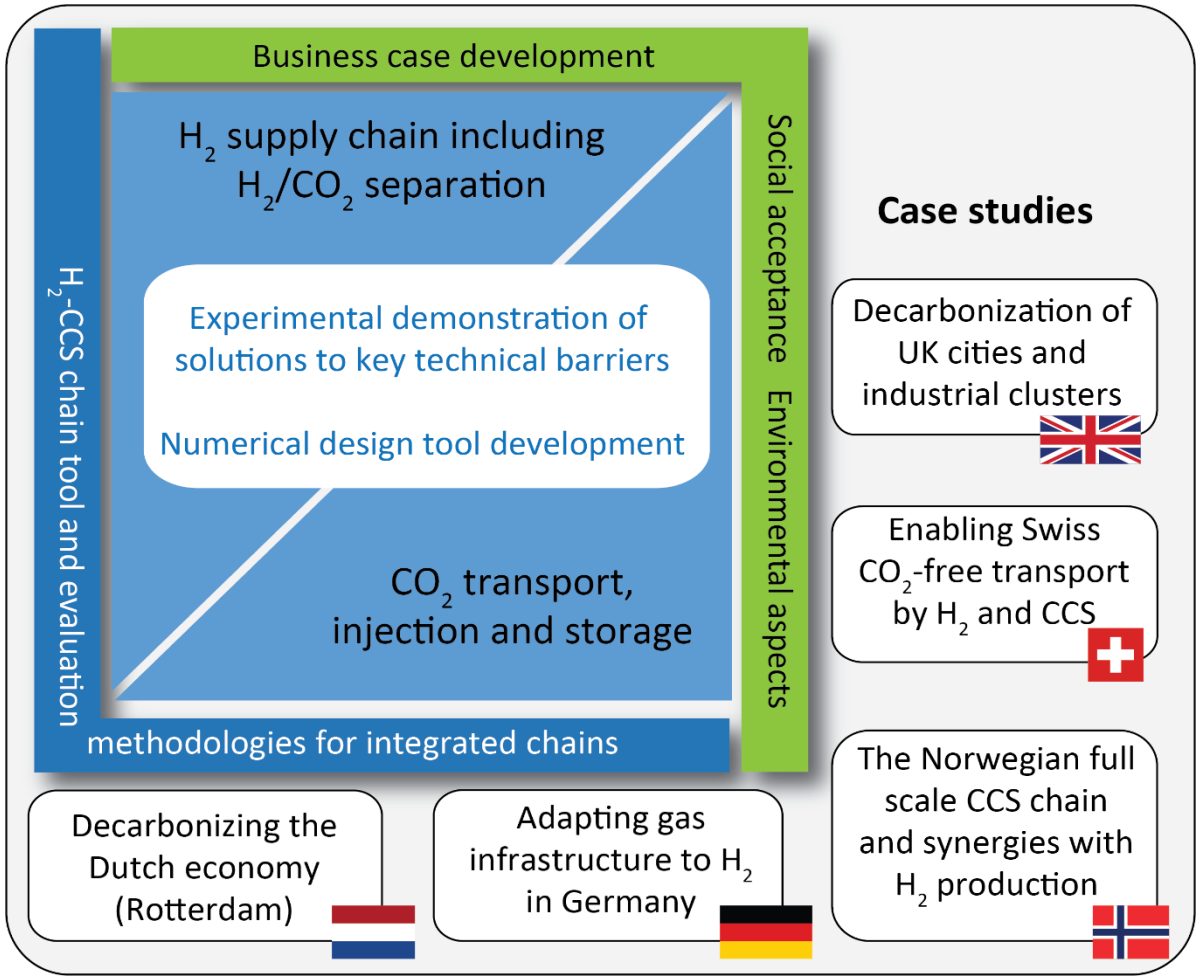
Project	Activities	ACT, M €	Norway	Netherlands	UK	Germany	Romania	Switzerland	Spain	Turkey
ALIGN	Chain integration, clusters	14,5	x	**X**	x	X	X			
ELEGANCY	Chain integration, hydrogen	8,9	**X**	x	x	X		x		
PRE-ACT	CO2 storage, pressure handling	4,5	**X**	x	x	X				
ACORN	Full chain CCS / infrastructure	2,0	x	x	**X**					
DETECT	CO2 storage, risk assessment	2,0		**X**	X	X				
ECOBASE	CO2-EOR SouthEast Europe	1,2	**X**	x			x			x
GASTECH	Gas switching technology	1,7	**X**	x			x	x	x	x
3D-CAPS	3D printed sorbents	1,5	X	**X**			x			

- Total budget for 8 projects: € 50 M
- ACT supporting: € 36 M

bold X = lead country

more info at www.act-ccs.eu

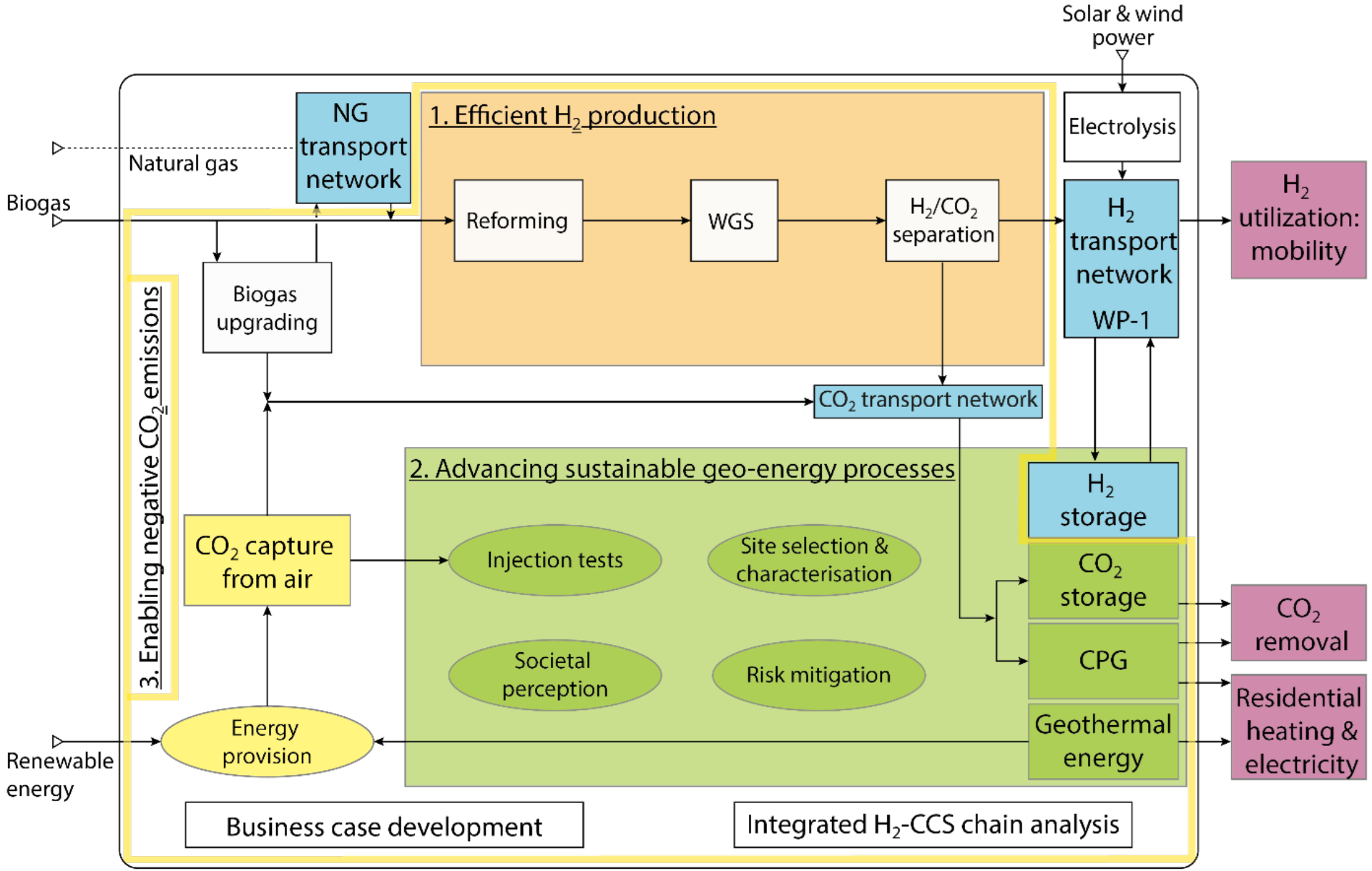
ELEGANCY – ENABLING A LOW-CARBON ECONOMY VIA H_2 AND CCS BY…



1. improving the Life Cycle Analysis performance of hydrogen production with CCS;
2. enhancing our understanding of CO_2 storage, particularly stemming from H_2 production;
3. enabling low carbon H_2 production with fossil-carbon or biomass via new market models;
4. designing cost-optimal and carbon footprint-optimal H_2 and CO_2 networks;
5. assessing country-specific challenges and opportunities, and identifying feasible country-specific pathways towards a H_2 economy coupled with CCS;
6. educating the next generation of European engineers and scientists on H_2 and CCS.

Publications and news at www.elegancy.no

ELEGANCY (SWITZERLAND) IN A GRAPH:



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ELEGANCY – ENABLES A LOW-CARBON ECONOMY VIA H_2 AND CCS BECAUSE:

1. Advanced CO_2 capture technologies coupled with Steam Methane Reforming or Auto-Thermal Reforming (using nat. gas or biomass feedstock) improve the Life Cycle Analysis of H_2 production with CCS.
2. New thermodynamic modelling tools & new CO_2 transport experiments, demonstrated in in surface and underground laboratories, corroborate safe storage of CO_2, particularly in connection with H_2 production.
3. Tools can model technical and economic interdependencies and allow for the design of business models and market mechanisms to enable a low-carbon hydrogen economy based on fossil-carbon and biomass.
4. New network modelling tools account for nature of feedstock, the design of H_2 and CO_2 networks, the distribution of H_2 demand and CO_2 storage sites, lead to optimal choices between C footprint and costs.
5. Technology and tools are bases for case studies of a wide range of differing technology chains in five European countries that allow the identification of pathways and opportunities.
6. Elegancy educates scores of European scientists and engineers and students, in the science and technology related to the hydrogen economy and to the sustainable implementation of CCS.

MEANWHILE BACK IN SWITZERLAND

Advanced CCU technologies being researched and developed in Switzerland:

- Enhanced Carbon Uptake via Cement
  (e.g. Sika Technologies AG or Neustark GmbH)
- Direct Air Capture
- A range of power-to-X pilot applications (e.g. solar fuels)

https://www.bafu.admin.ch/dam/bafu/en/dokumente/klima/externe-studien-berichte/the-role-of-atmospheric-carbon-dioxide-removal-in-swiss-climate-policy.pdf.download.pdf/The_Role_of_Atmospheric_Carbon_Dioxide_Removal_in_Swiss_Climate_Policy.pdf

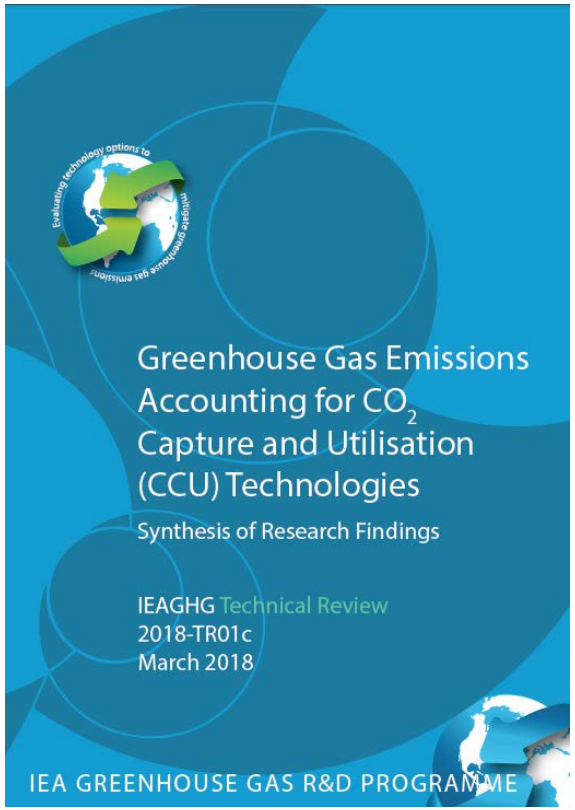
THANK YOU FOR YOUR ATTENTION

Questions now or later
gunter.siddiqi@bfe.admin.ch

IEAGHG: WORK ON GHG ACCOUNTING FOR CCU – PHASE I

CCU accounting guidelines v1.0 developed,
based on a GHG emissions assessment of 4 different CCU case studies

- *Carbon8 Aggregates (UK)* – carbonate mineralisation from CO_2 and industrial waste residues to produce aggregates
- *Carbon Recycling International, CRI (Iceland)* – methanol production from CO_2 and hydrogen produced from water electrolysis; 'renewable methanol'
- *Algenol Biofuels (US)* – ethanol production from cyanobacteria algal production utilising CO_2
- *Weyburn-Midale EOR project (Canada/US)* – enhanced oil recovery (EOR) utilising CO_2 from coal-fired power generation and coal gasification plants



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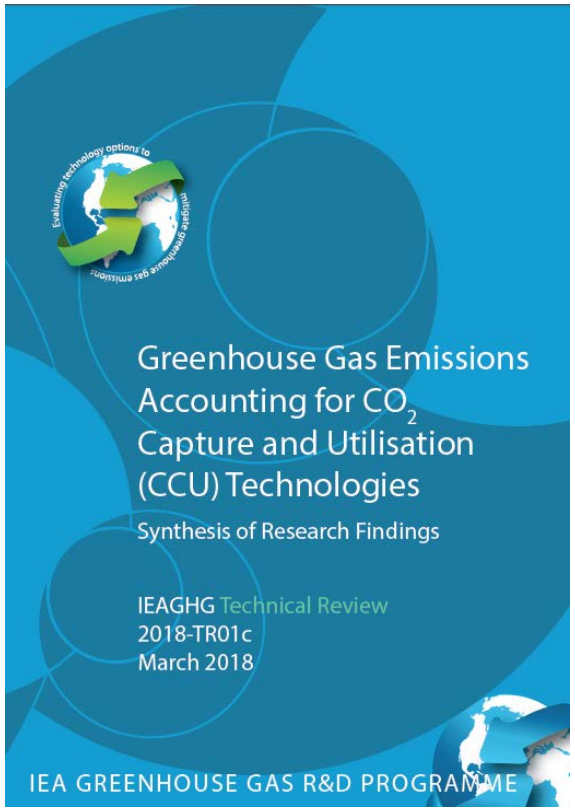
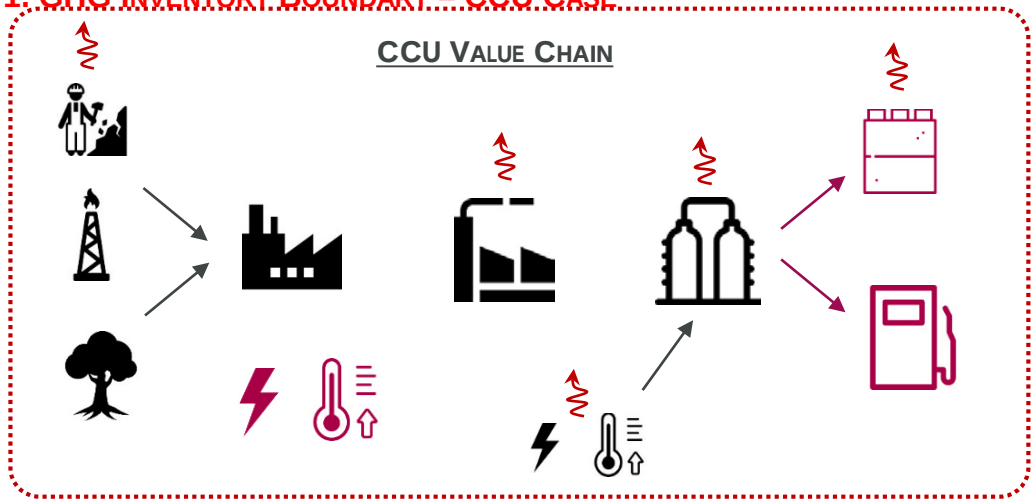
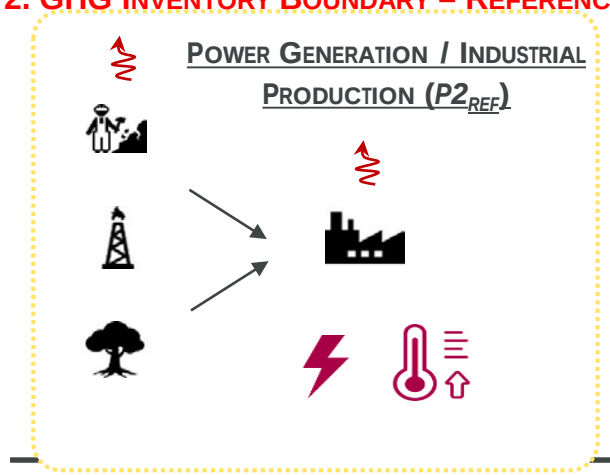


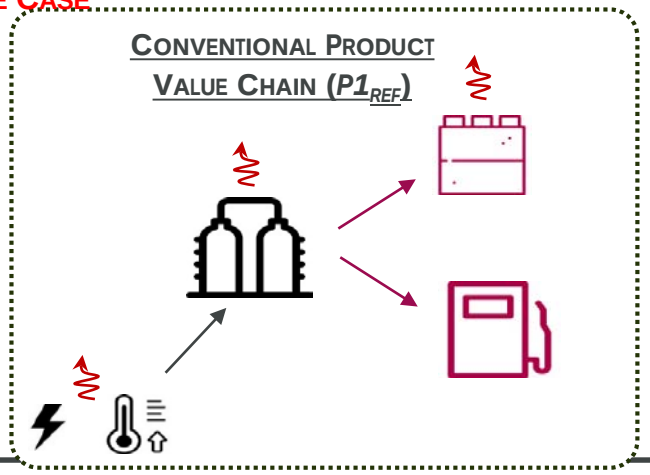
GHG BENEFITS ASSESSMENT BY COMPARATIVE ANALYSIS OF CCU PROCESSES/PRODUCTS AGAINST CONVENTIONAL PRODUCTS

1. GHG INVENTORY BOUNDARY – CCU CASE



2. GHG INVENTORY BOUNDARY – REFERENCE CASE





Comparative LCA

Two **reference cases**:

1. Primary Product *(functional equivalence of CCU product; P1)*
2. Secondary product *(functional equivalence of CO_2 source plant product; P2)*

Only way to make *fair comparison*

Analysis often assumes utilisation = -1 tCO_2

EXAMPLE: CCU FUEL

FUEL PRODUCTION USING CAPTURED CO_2

'Company A' uses CO_2 captured from a subcritical pulverised coal-fired power plant to produce a light volatile chemical product that can be used as a petroleum substitute either directly or via blending.

The plant requires various process inputs, including the following:

- Electricity and heat to run various production processes;
- Water as a major input to the process;
- Other chemical inputs, which it buys in from various suppliers;
- 13,000 tonnes of CO_2 per year.

EXAMPLE: CCU FUEL

GHG BENEFITS: 2550 – (2466 + -1391) = 1475 $kgCO_2e$ per tonne fuel substitute