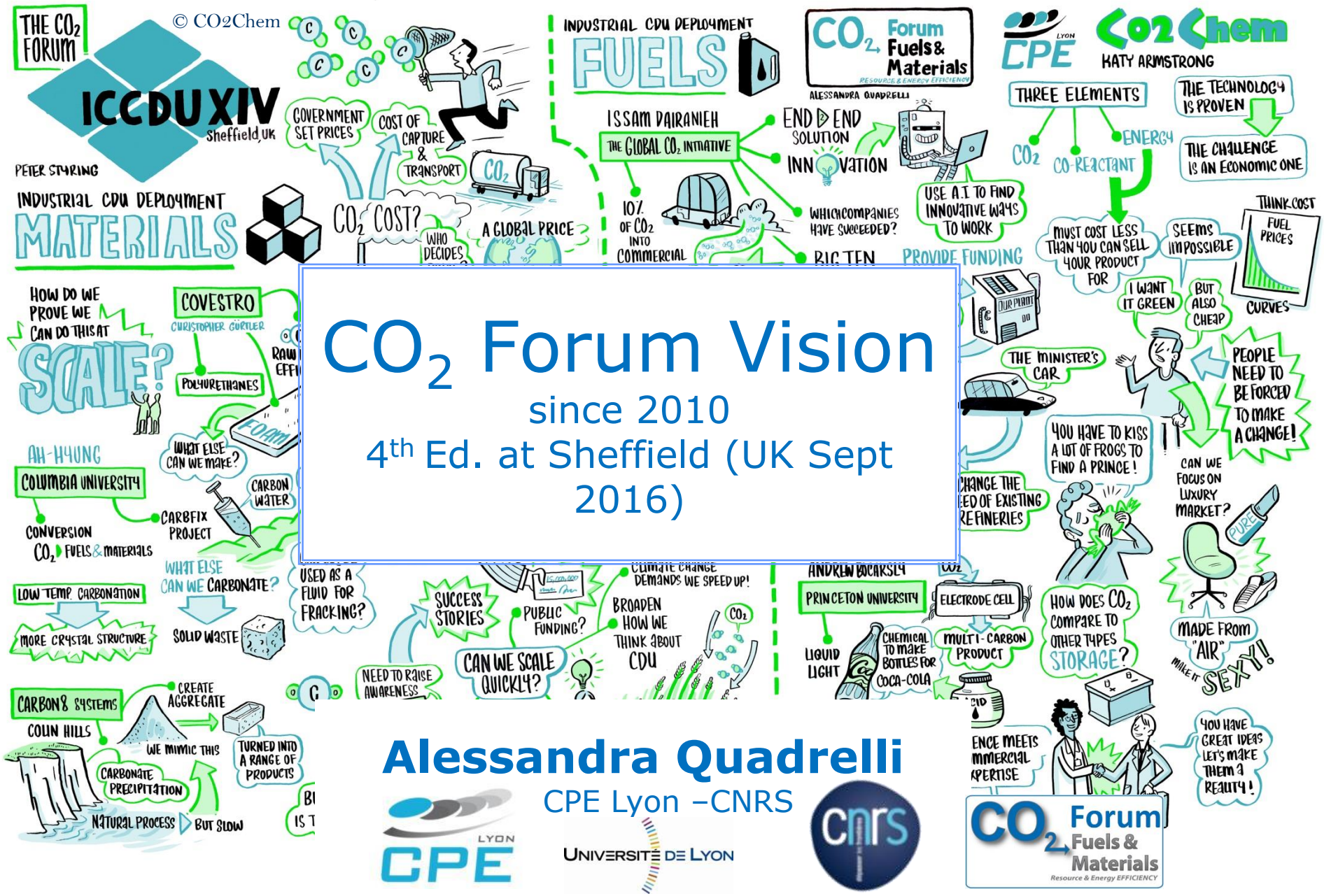


CO_2 Forum Vision

since 2010

4th Ed. at Sheffield (UK Sept 2016)

Alessandra Quadrelli

CPE Lyon –CNRS

Engineering school of Chemistry Physics and Engineering -Lyon

- An « Ecole d'Ingénieur » (French Higher Education system) in Chemistry, Process Engineering or Information Technology
- Master of Science & Engineering + Business skills + International working experience
- Continuous relations with leading companies
- High level embedded research centre

1,600 students
6.3 m€ turnover with industrial partners
9 research labs (organic, analytic, catalysis, process engineering, nanotechnologies)

- Part of Federative University of Lyon (120,000 students)
- Lyon is France's largest city after Paris (and Marseille); fastest growing, rising European ranking
- The only chemistry/environment competitive cluster in France -AXELERA-housed in Lyon

Define SERA
Attract
Propose

Reference

www.cpe.fr

Train our engineers

Sustainable Development Chair

Tool to promote Coherent deployment of Sustainable development oriented actions

Since June 2009

Sustainable Development Chair

To become

Vision

- Aware of capacities and limitations of science & technologies.
- At the service of society's needs and expectations.
- Able to face the increasingly more complex challenges.

To be able to

Challenges

- Save resources, contribute to economic development.
- Combine long and short term, local and global.
- Satisfy increasing and increasingly demanding stakeholders.

To be

Values

- Ambitious.
- Competent. Capable of distinguishing facts from opinions.
- Proactive. Pragmatic. Team worker.
- Humanist and modest.

« Example is not the main thing in influencing others. It is the only thing. »
Albert Schweitzer

Reference

www.cpe.fr

CO_2 Forum Fuels & Materials
Resource & Energy EFFICIENCY

An event of the Sustainable Development Chair of

CPE LYON ÉCOLE SUPÉRIEURE DE CHIMIE PHYSIQUE ÉLECTRONIQUE DE LYON

Conference Vice Chair

Claude Fussler

Clean tech advisor

"Why not CO_2?" *July 2009*

Sustainable Development Chair

Reference

Session 1

Environmental, Social & Economic awareness

Global Context

Climate mitigation Issues, International policies, CO_2 finance

Sessions 2-5

Quest for Scientific Solutions

State-or-the art large volume CO_2 recycling options

Inorganic Materials, Chemicals, Polymers, Fuels, Biochemical materials

Session 6

Creativity and Innovation

Enabling technologies

Business, Funding Groups

Session 7

Drive

Outlook

Techno-economic Analysis, business opportunities, SWOT anaylis

1st Edition

CO_2 Fuels & Materials

Sept. 2010

1st CO_2 Forum Conference-2010

Examples of 2010 sponsors and participants affiliations :

Lyon, Sept 27-28th, 2010

Reference

CO2forum.cpe.fr

Examples of 2012 speakers

2nd CO_2 Forum Conference-2012

09:30 -09:40	Participants welcome and Introduction Gérard PIGNAULT, CPE Lyon
SESSION 1	CO_2 : the context Chair: Claude FUSSLER, Cleantech and Innovation advisor
09:40 – 10:00	Climate mitigation – the scientific context Rajendra PACHAURI, IPCC.
10:00-10:20	Carbon capture – technology and economic perspectives Juho LIPPONEN, International Energy Agency
10:20 – 10:40	CO_2 markets, taxes and quotas Olivier SARTOR, CDC Climat Research (F)
10:40 – 11:40	Questions to speakers' round table and Chair's conclusions

Reference

CO2forum.cpe.fr

Examples of 2014 session

Session 1 - Materials from capture

Chair: Simon BENNETT, International Energy Agency

Keynote Lectures:

Donald DE PAOLO, Lawrence Berkeley Nat Lab (US)

Pre-recorded : Current Research on Atmospheric and Captured CO_2 Utilization

Michel GIMENEZ, Lafarge (F)

Postcombustion, oxycombustion and other CO_2 capture technologies

Colin HILLS, University of Greenwich (UK)

Virgin stone replacement from agregates manufactured from hazardous waste and CO_2 gas

3rd CO_2 Forum Conference-2014

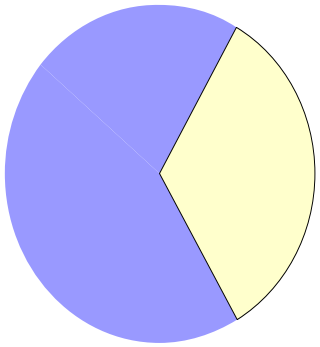
Reference

CO2forum.cpe.fr

Examples of 2014 figures

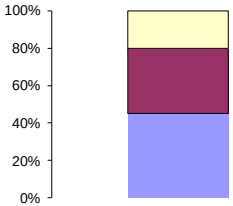
3rd CO_2 Forum Conference-2014

- *272 Participants (°+CPE engineers)*



2/3 Established professionals

1/3 Ms. students, Ph.D. Candidates, Post doc



20 % Policy Orienter
35% Company
45% Academia

- *29 Countries*
- *27 Plenary speakers*
- *67 posters with 5 flash presentations*
- *4 round tables*
- *2 associated workshops*

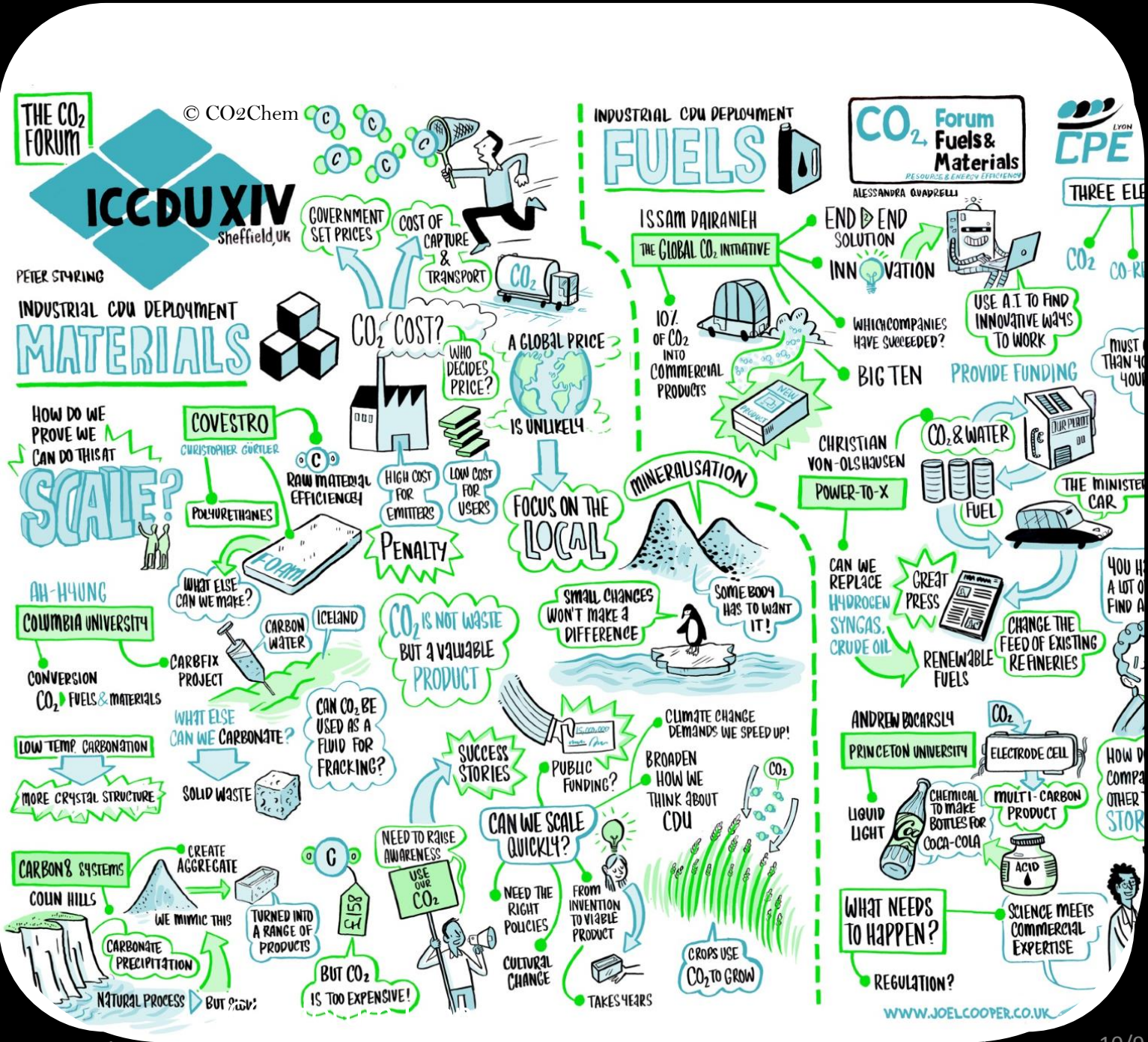
BIO-TIC

SCT Smart CO_2 Transformation

Reference

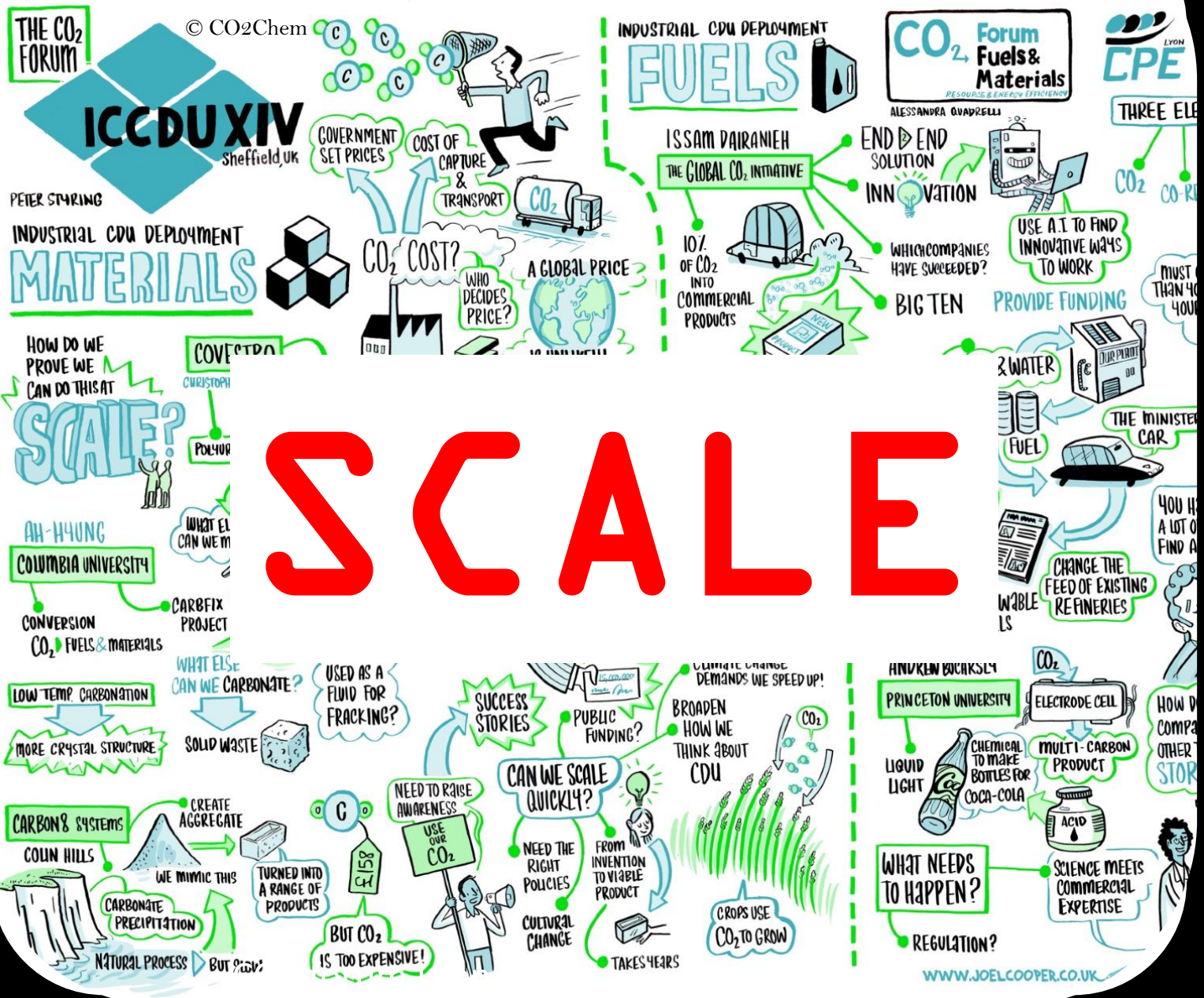
CO2forum.cpe.fr

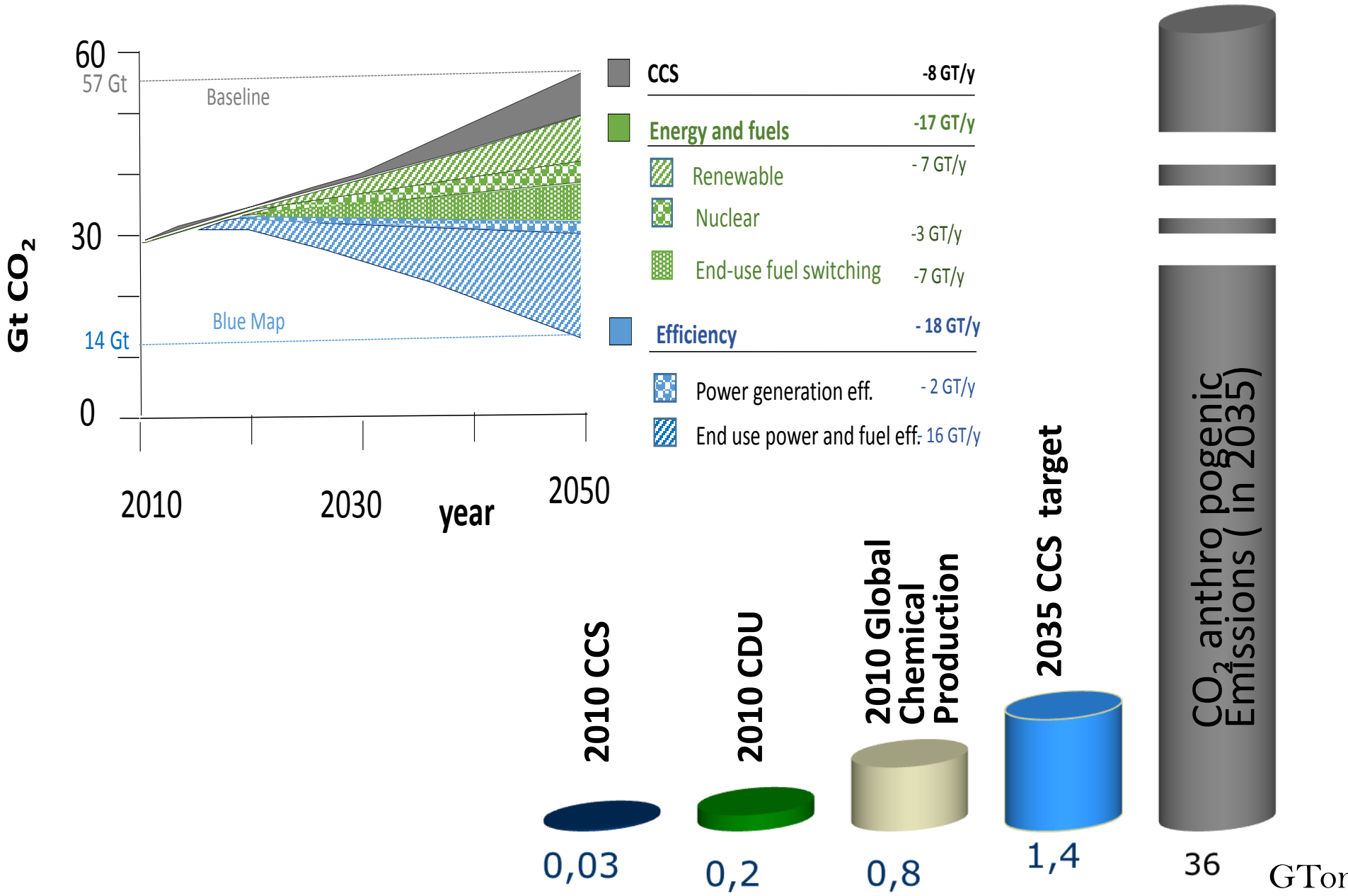
4th CO_2 Forum Conference-2016



4th CO_2 Forum Conference-2016

Examples of 2016 open questions

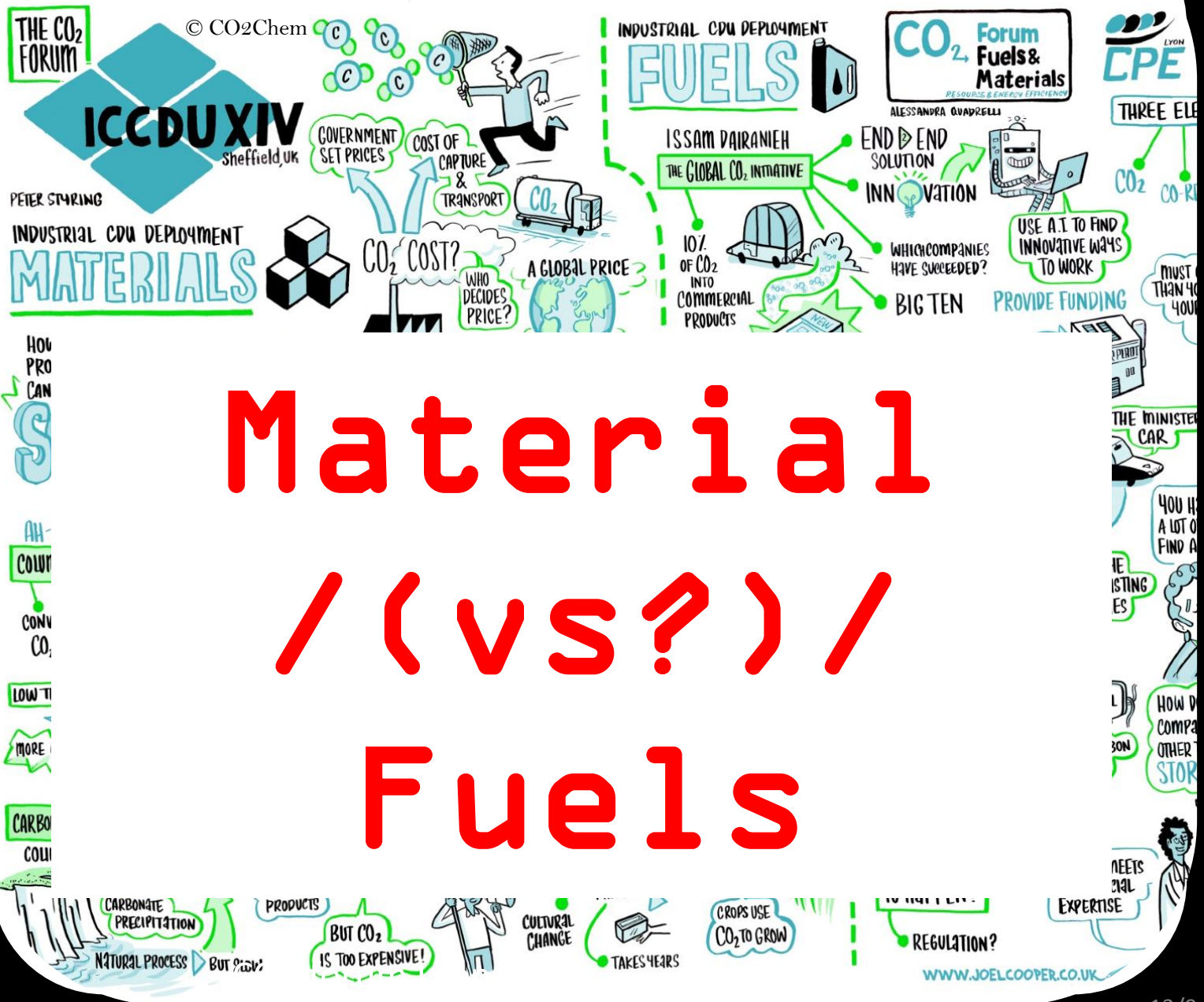




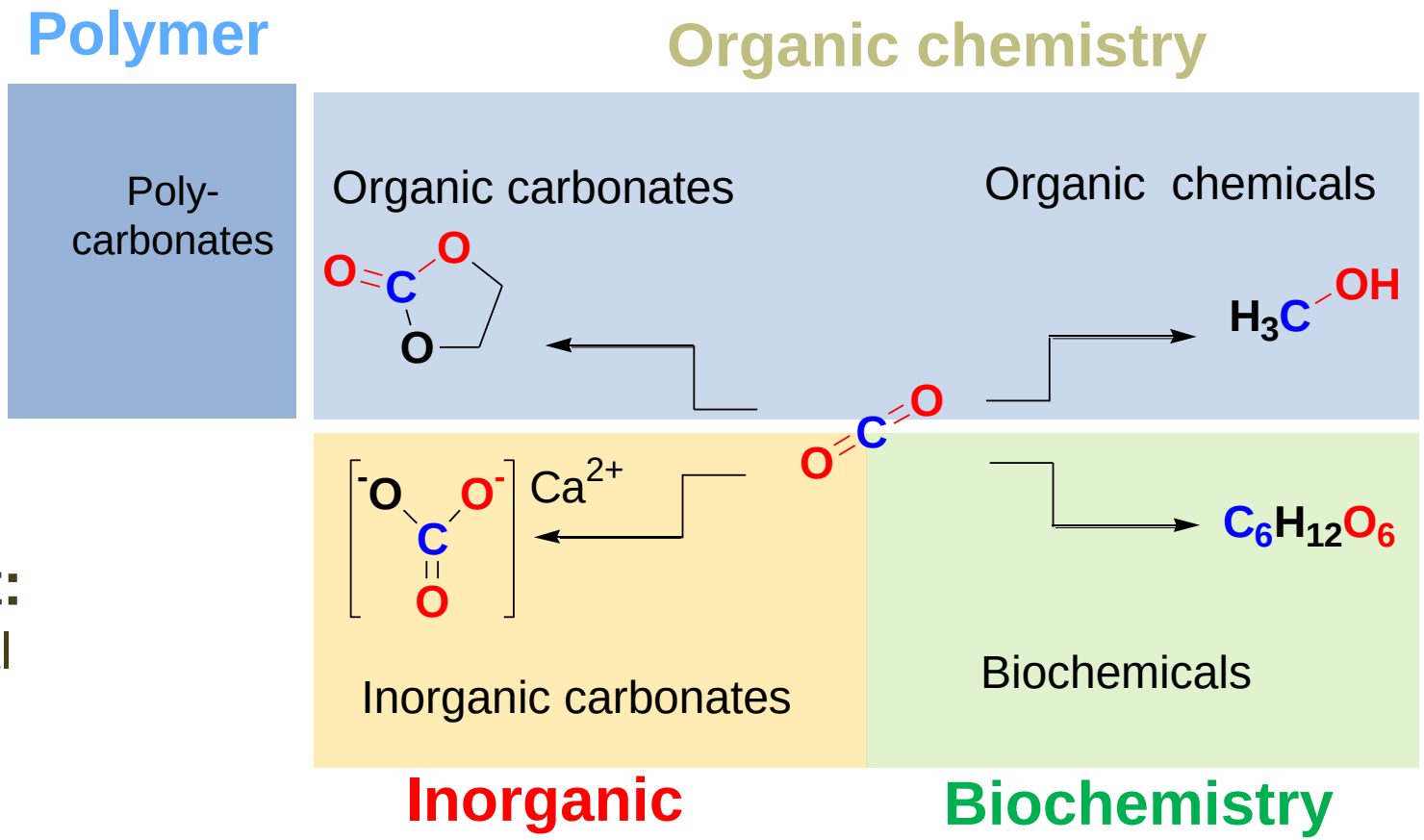
E. A. Quadrelli, G. Centi, J.-L. Duplan and S. Perathoner *ChemSusChem*, **4**,1183 (2011)

4th CO_2 Forum Conference-2016

Examples of 2016 open questions



Material /(vs?)/ Fuels

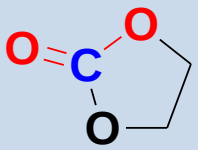


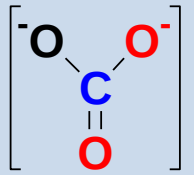
Context:
Traditional
Fields

E.A. Quadrelli and G. Centi, "Green Carbon Dioxide" (edit.) ChemSusChem, ***4****,1179-1180 (2011).*

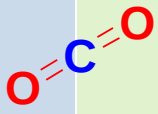
Carboxylations Carbonylations

Organic (poly)carbonates

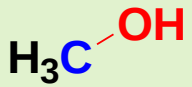


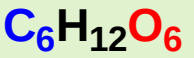


Inorganic carbonates



Organic chemicals





Biochemicals

Not excessively
energy intensive
Long lasting products

Reduction
Strongly
energy demanding

MATERIALS

CHEMICALS for ENERGY

*E.A. Quadrelli and G. Centi, "Green Carbon Dioxide" (edit.) ChemSusChem,**4**,1179-1180 (2011).*

→ CO_2 STORAGE or FUELS

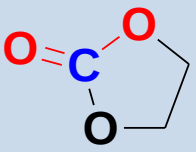
Not necessarily Climate-related

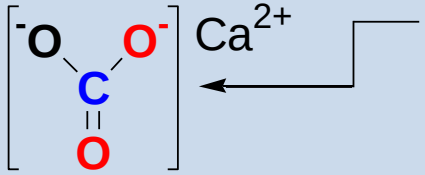
→ Size of markets
→ Overall LCA

Ex.
Carboxylic acids
Carboxylic esters
Methylated amines

Carboxylations

Organic (poly)carbonates

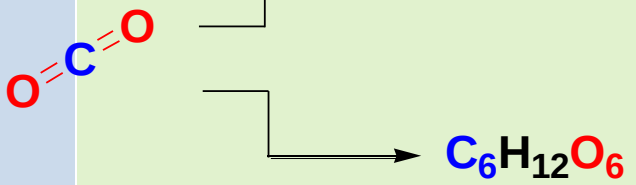




Inorganic carbonates

Carbonylations

Organic chemicals



Biochemicals

Expanding the feedstocks

Not excessively energy intensive
Long lasting products

Reduction
Strongly energy demanding

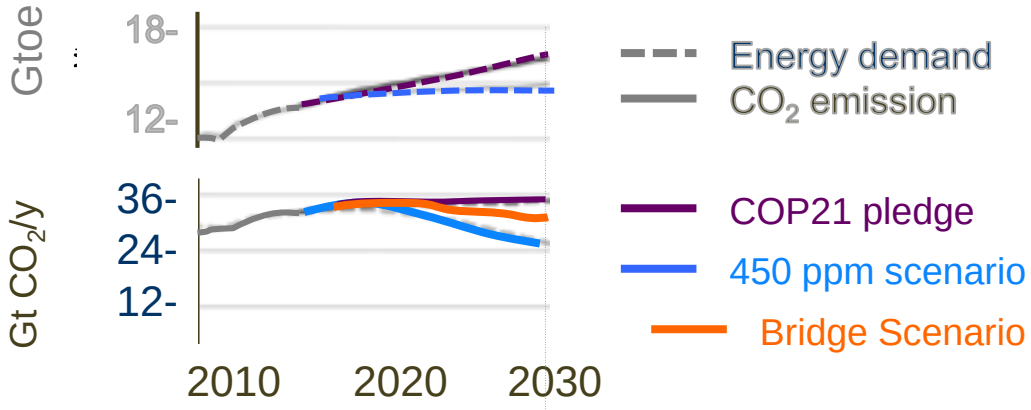
« new (?) » C1 source (available and abundant (?))

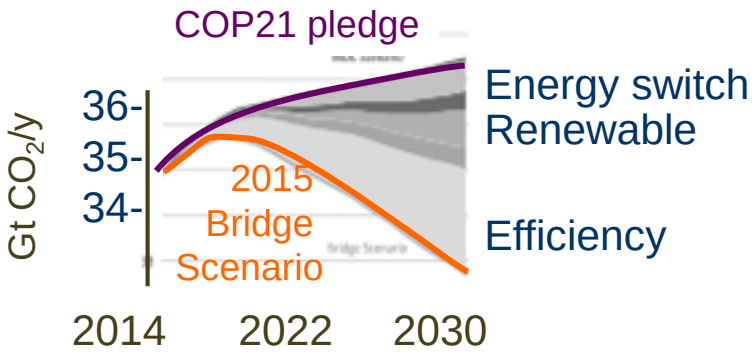
MATERIALS

CHEMICALS for ENERGY

Short-to-medium term	*Medium-to-long term*
Carboxylations **Organic carbonates** **Inorganic carbonates** •continue progression as a raw material (ex. phosgene-free organic carbonate) • Question on costruction waterials/waste disposal •substantial contribution to portfolio strategy to curb CO_2-emission	**Carbonylations** **Organic chemicals** **Biochemicals** •Strategic molecule for introduction of renewable energy into energy chain •Drop-in option possible • impact on chemical industry (methanol-to-olefins)
Potential reduction of 250-350 Mt per year (i.e. ca. 10% of objectives)	Not a storage option Yet Potential in Gt /y for energy efficiency
MATERIALS	CHEMICALS for ENERGY
(Potentially) **Relevant** to CCS-alternative	**Not Relevant** to CCS-alternative

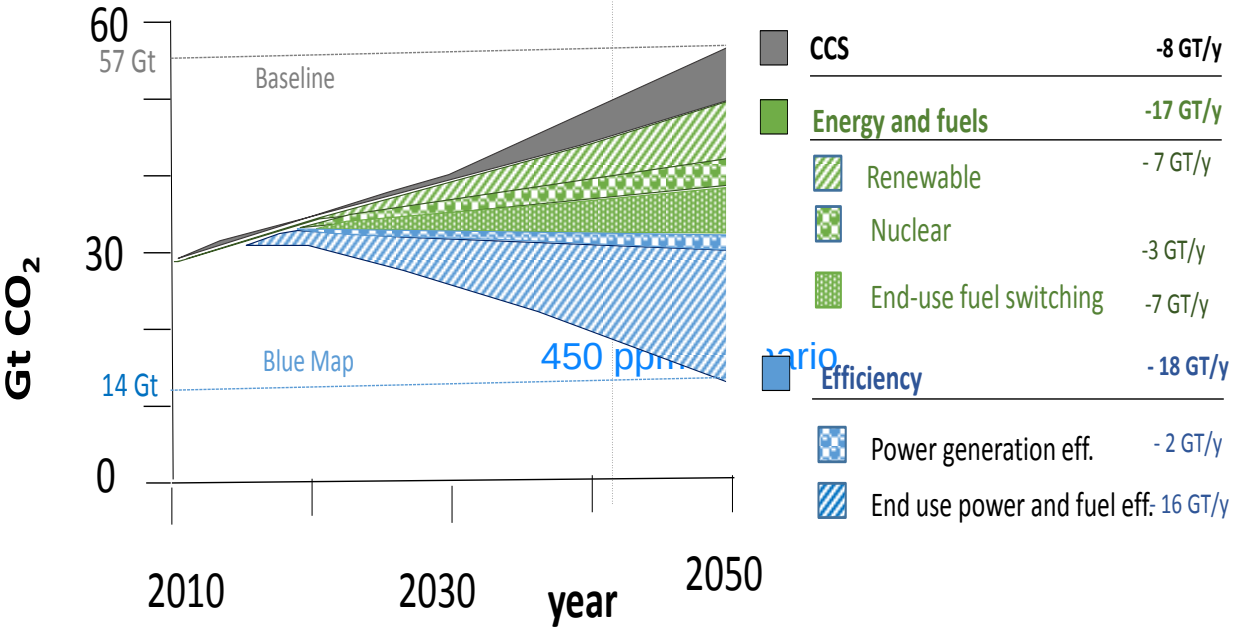
"Global Energy-related demand and CO_2 emissions pledges in WEO 2015"





Source: IEA World Energy Outlook 2015

"Global Energy-related CO_2 emissions abatement in the 450ppm scenario (2008)"



World Energy Outlook, **International Energy Agency** (2008)

CDU role

Entrapment

Energy

Efficieny

« Carbon Dioxide Utilisation, Closing the Carbon Cycle » P. Styring, E. A. Quadrelli and K. Armstrong Eds. Elsvier (2014))

CO2 Forum Fuels & Materials
Resource & Energy EFFICIENCY

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CPE LYON ÉCOLE SUPÉRIEURE DE CHIMIE PHYSIQUE ÉLECTRONIQUE DE LYON

CDU role

Entrapment

Energy

Efficieny

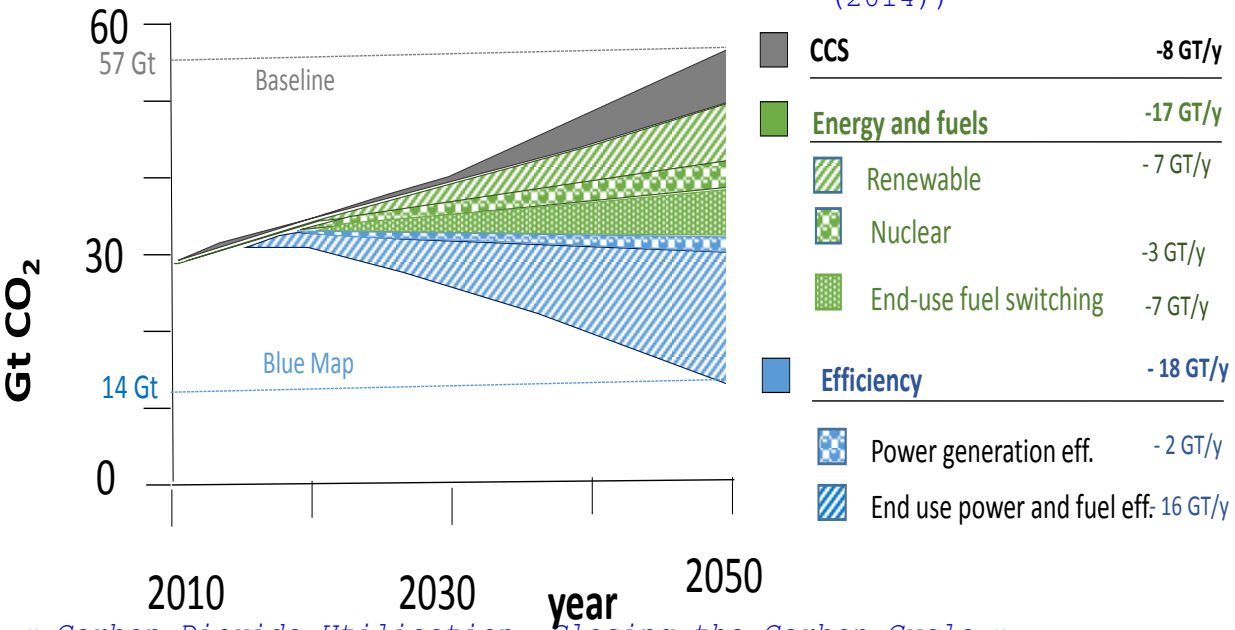
« Carbon Dioxide Utilisation, Closing the Carbon Cycle » P. Styring, E. A. Quadrelli and K. Armstrong Eds. Elsvier (2014))

Carbon8 Acc. Carbonation (1GT!)

Covestro Polycarbonate (PU)

CRI SOEC co-electrolysis « vulcanol »

Aether Lafarge (30%of 2GT)
Haldor Topsoe CO_2 in current MEOH



« Carbon Dioxide Utilisation, Closing the Carbon Cycle »
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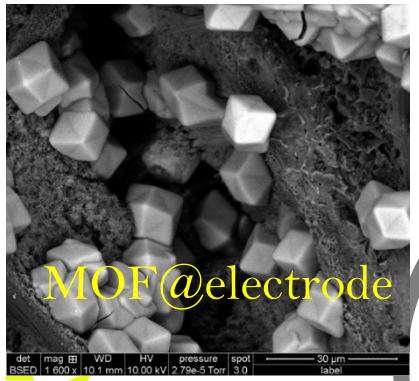
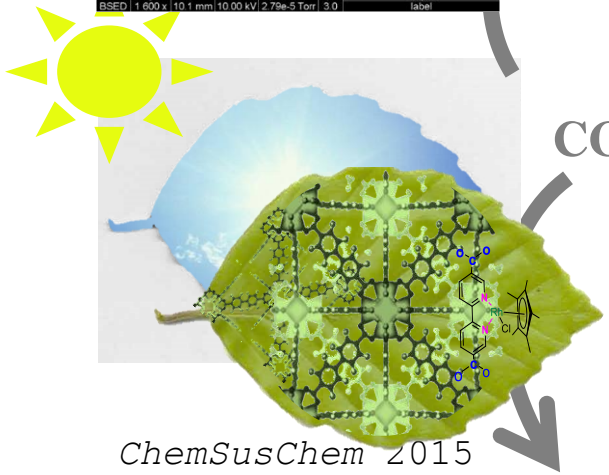


Solar fuels

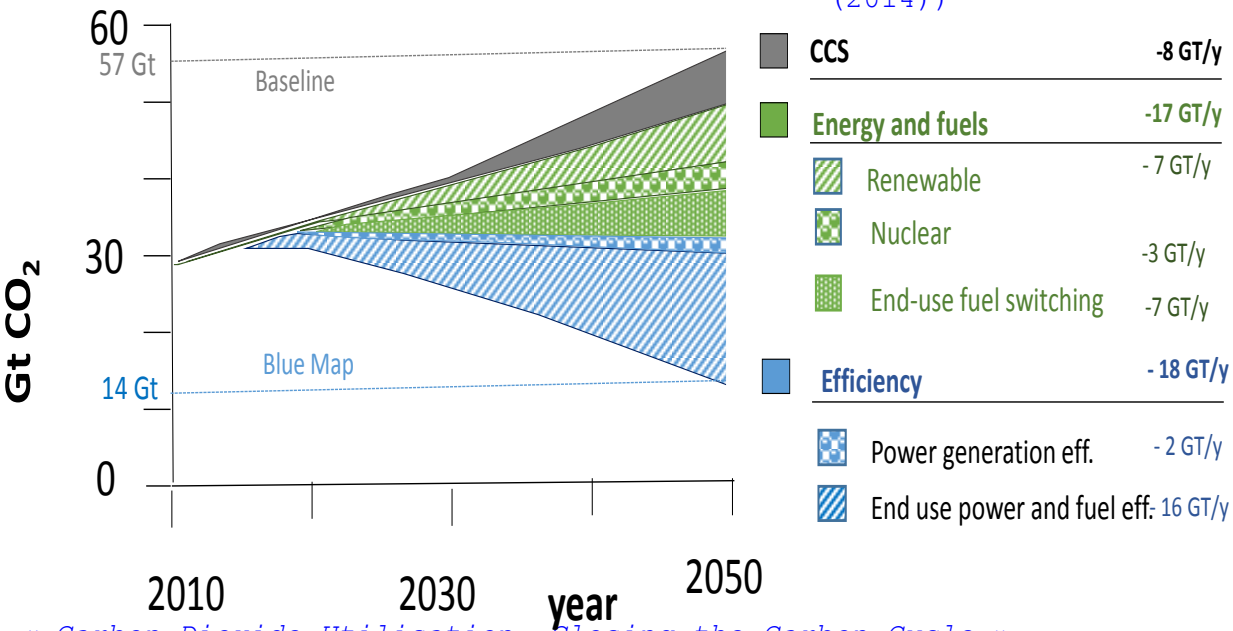


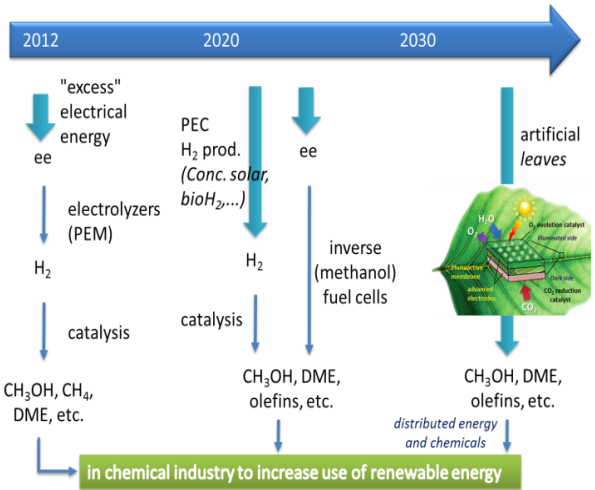
CO_2

ChemSusChem 2015

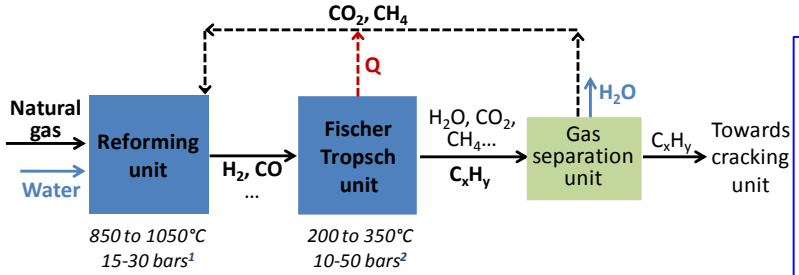
EES 2013

Solar fuels





« *Carbon Dioxide Utilisation, Closing the Carbon Cycle* »
P. Styring, E. A. Quadrelli and K. Armstrong Eds. Elsvier (2014))



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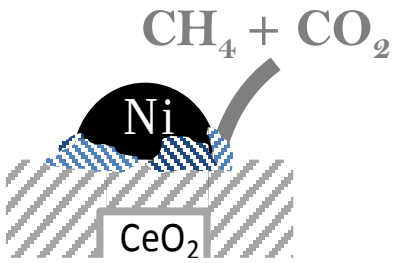


Thieuleux et al.JACS 2012

$H_2 + CO$

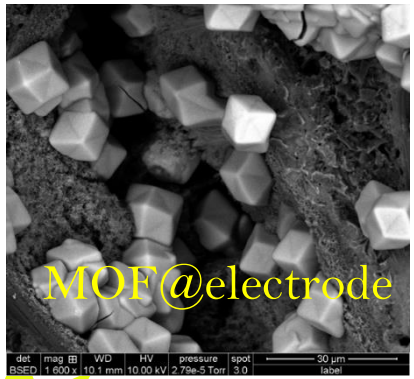
CDU role

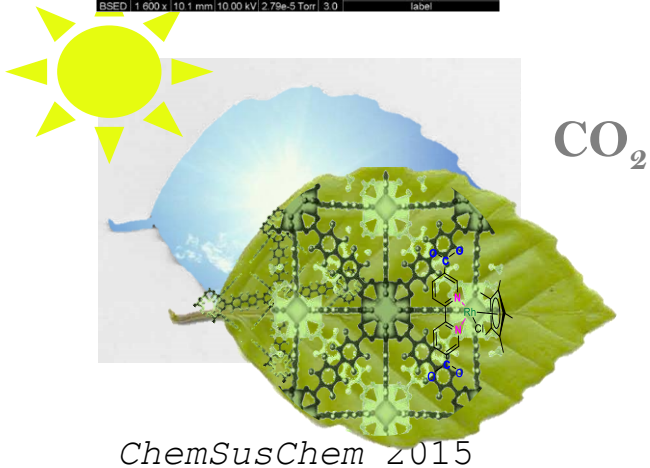
Entrapment

Energy

Efficieny

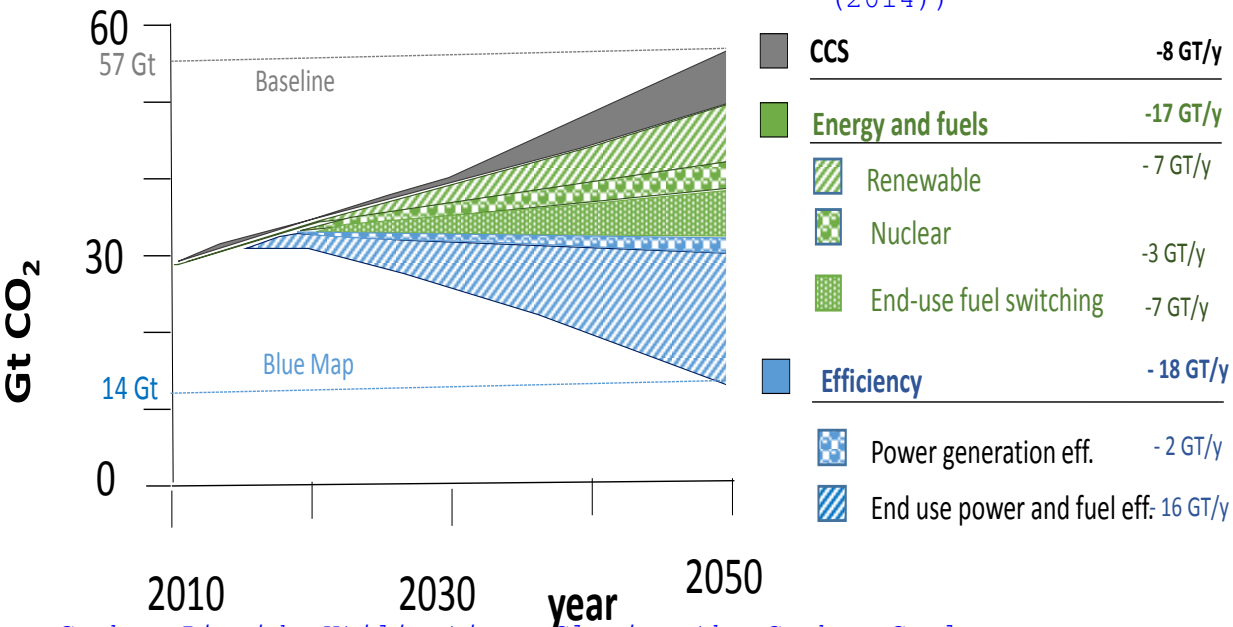
« Carbon Dioxide Utilisation, Closing the Carbon Cycle » P. Styring, E. A. Quadrelli and K. Armstrong Eds. Elsvier (2014))



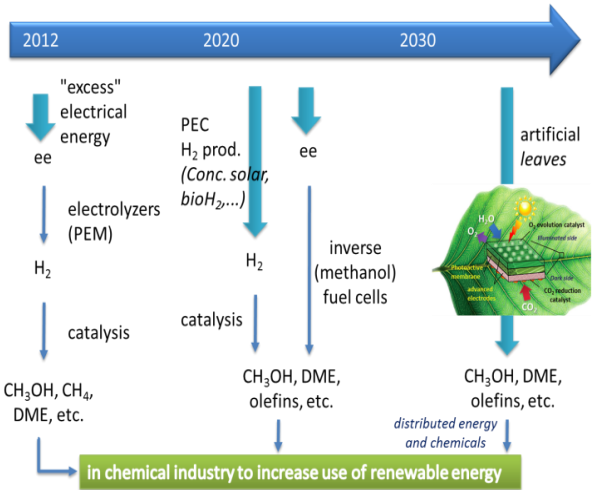


ChemSusChem 2015

EES 2013



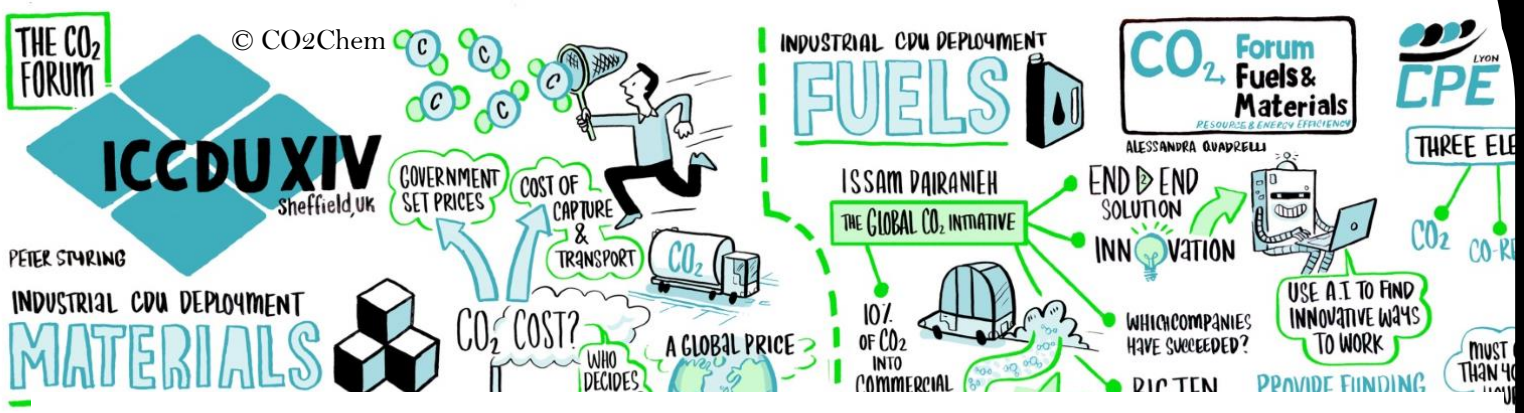
CCS	-8 GT/y
Energy and fuels	-17 GT/y
Renewable	- 7 GT/y
Nuclear	-3 GT/y
End-use fuel switching	-7 GT/y
Efficiency	- 18 GT/y
Power generation eff.	- 2 GT/y
End use power and fuel eff.	- 16 GT/y



« Carbon Dioxide Utilisation, Closing the Carbon Cycle »
P. Styring, E. A. Quadrelli and K. Armstrong Eds. Elsvier (2014))

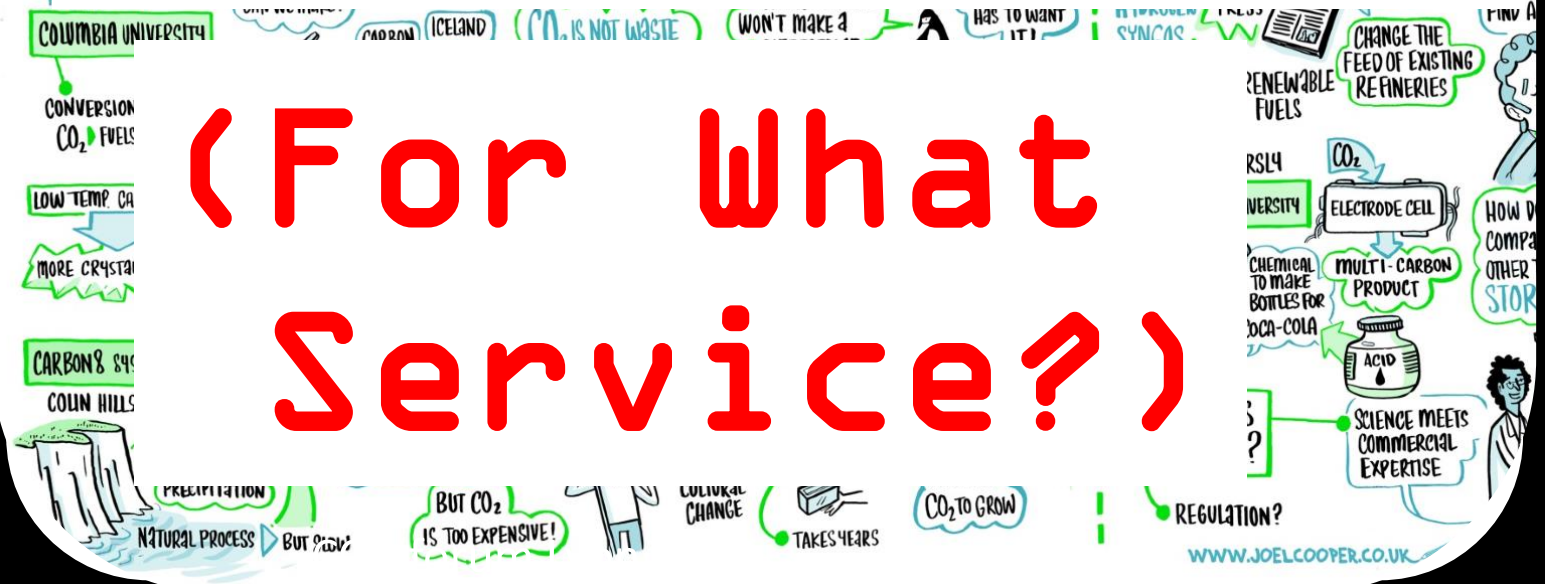
4th CO_2 Forum Conference-2016

Examples of 2016 open questions

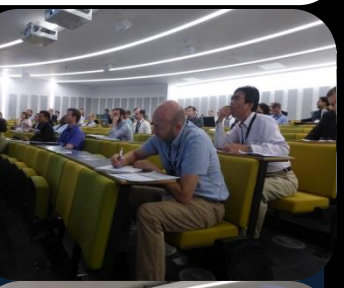


COST/PRICE

(For What Service?)



4th CO_2 Forum Conference-2016



Examples of 2016 open questions

SERVICE: Store REN (not « just » produce fuel)

Renewable Energy (REN)

chemistry

Energy Vector Molecule [oxidized form]

Energy Vector Molecule [reduced form] + **Stored Energy** (in chemical bond)

chemistry

Energy On demand

Examples of possible CO_2 roles:

REN

CO_2 → MeOH, DME, …

Energy On demand

REN

CO_2

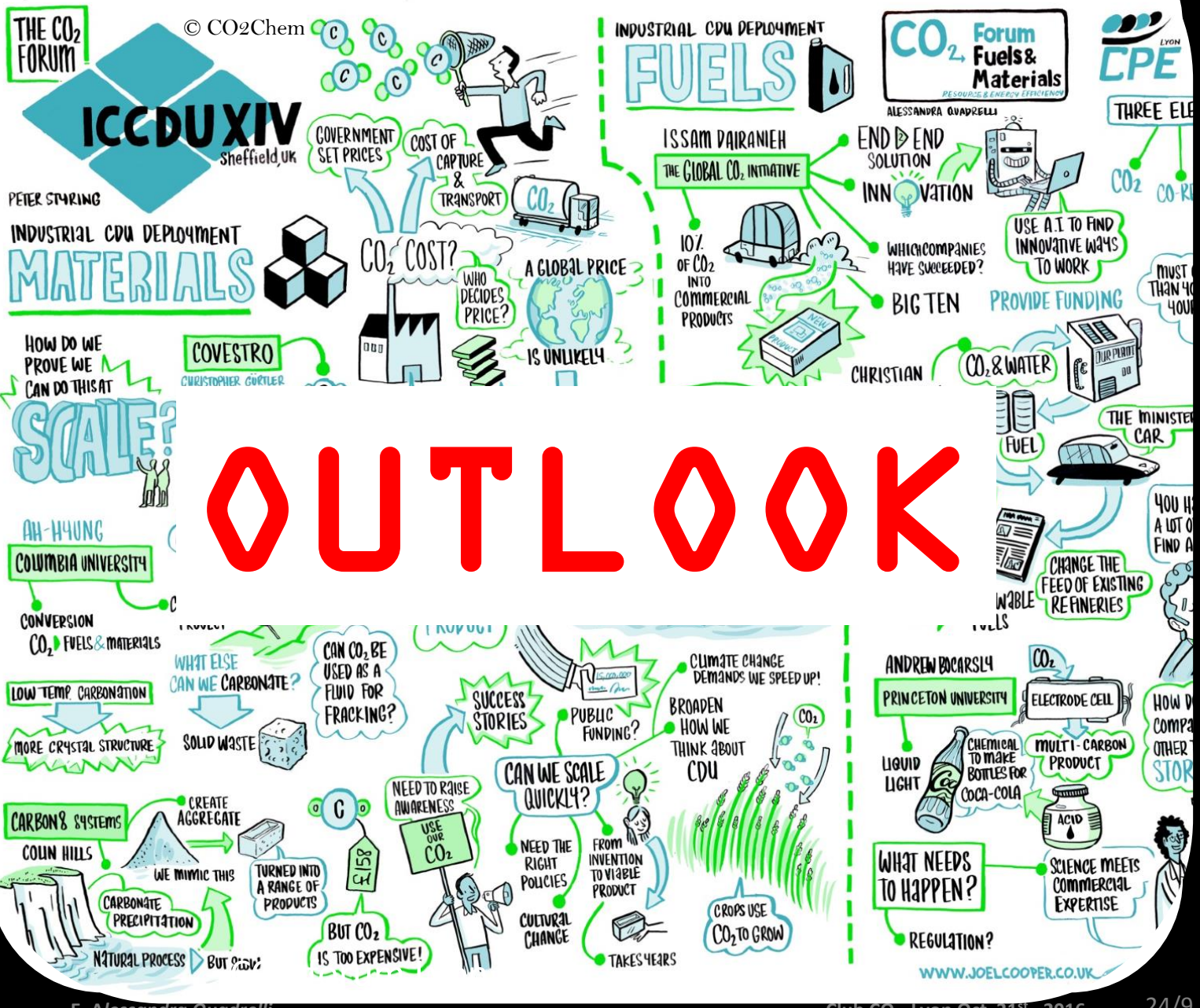
H^+ → H_2 → HCOOH, CH_3OH

CO_2

Energy On demand

4th CO_2 Forum Conference-2016

Examples of 2016 open questions



OUTLOOK

CO2 Forum Fuels & Materials
Resource & Energy EFFICIENCY

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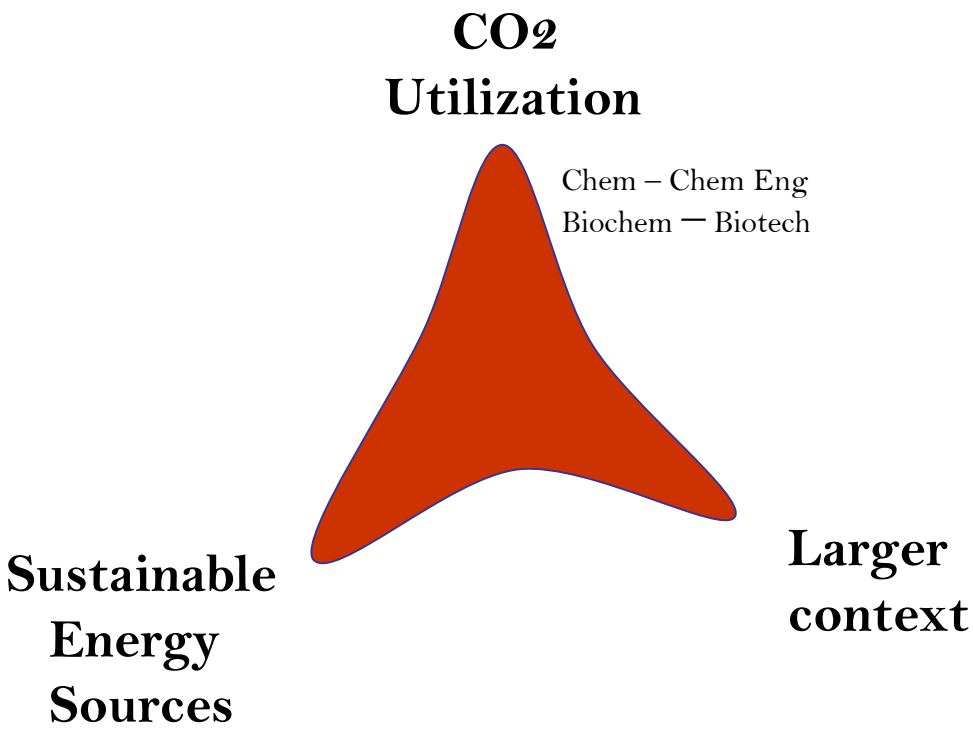
LYON CPE ÉCOLE SUPÉRIEURE DE CHIMIE PHYSIQUE ÉLECTRONIQUE DE LYON

3 Pillars



3 Pillars

An event of the Sustainable Development Chair of CPE LYON

Mineralisation

CO2 Utilization

General Context

Chem – Chem Eng
Biochem – Biotech

Polycarb

PtL -PtG

Policy

Sustainable Energy Sources

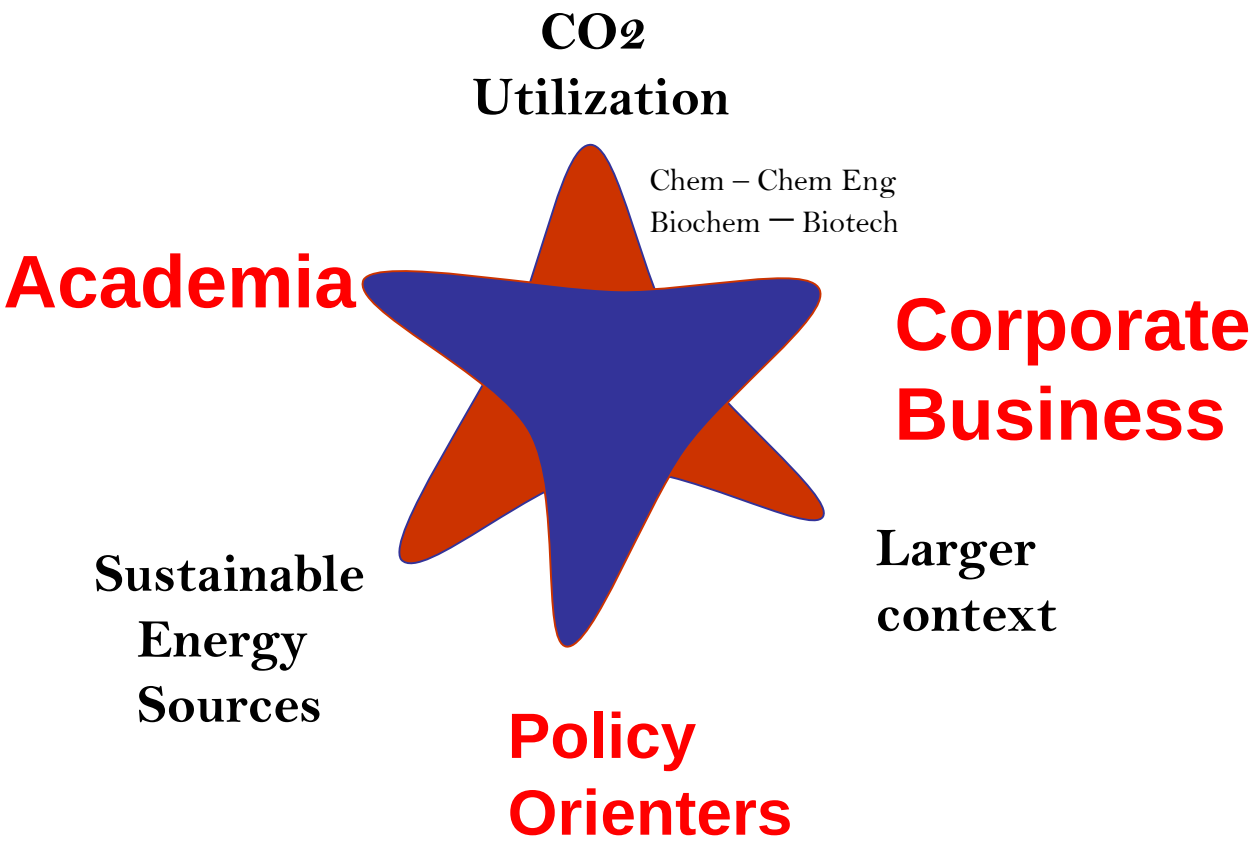
Larger context

Energy Source

Bio+Photo

Triple Helix Approach

An event of the Sustainable Development Chair of CPE LYON

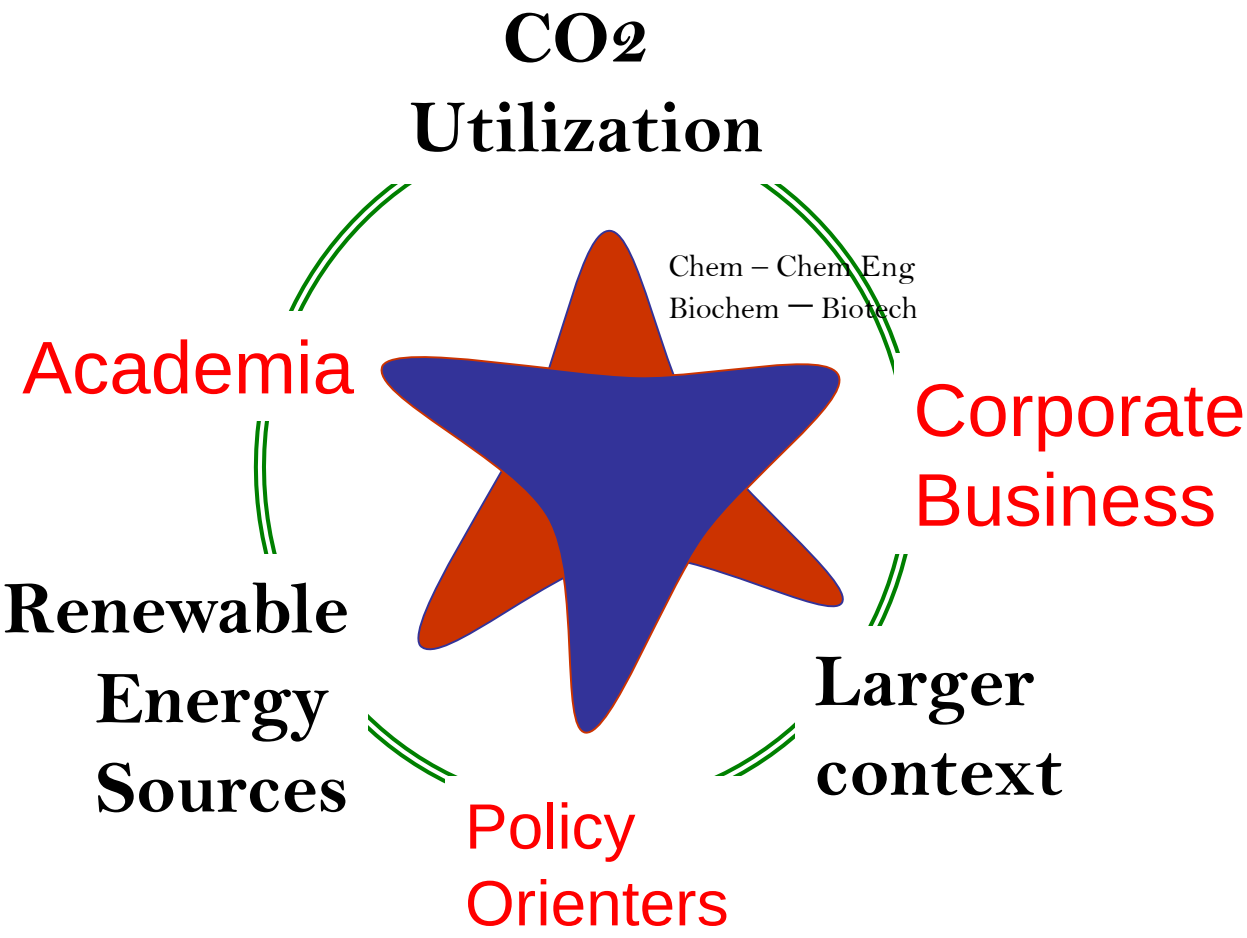


CO2 Forum Fuels & Materials
Resource & Energy EFFICIENCY

An event of the Sustainable Development Chair of

CPE LYON ÉCOLE SUPÉRIEURE DE CHIMIE PHYSIQUE ÉLECTRONIQUE DE LYON

Third Level: Territories



Slide adapted form T. Kotancheck (DOW)

CO_2 Forum

http://co2forum.cpe.fr

co2forum@cpe.fr

Large-Volume CO_2 Utilization

Enabling Technologies for
Energy and Resource Efficiency

membre de UNIVERSITÉ DE LYON

CPE LYON
ÉCOLE SUPÉRIEURE DE CHIMIE PHYSIQUE ÉLECTRONIQUE

SUSTAINABLE DEVELOPMENT CHAIR