Technology Collaboration Programme
by iea

Clean and Efficient Combustion

Hydrogen and other low-carbon fuels

Yuri M. Wright – IEA combustion TCP

IEA Networking event, Berne

May 24th 2022

COMBUSTION TCP

Outline

The relevance of combustion – now and in the future

Renewable fuels: which options for which sectors

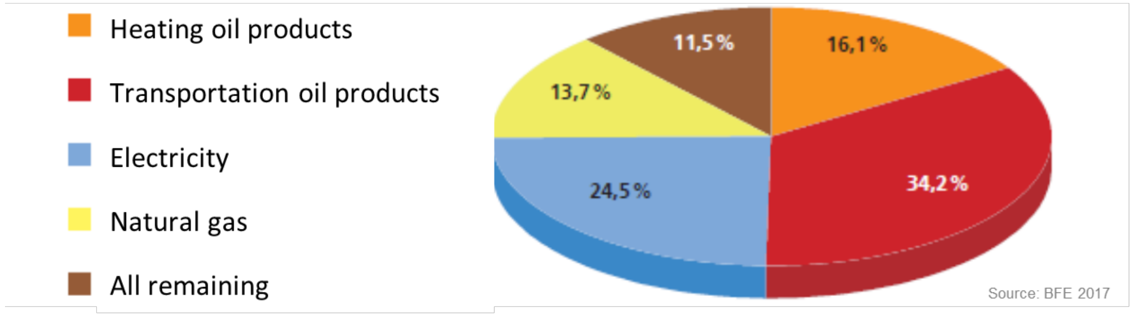
Challenges for combustion research and the TCP

- Multi-scale physics in IC engines, but also gas turbines and solid fuels!
- Diagnostics, modelling and understanding imperative for advances
- Aside CO2 and other GHG (CH4 etc.), emissions a persistent topic
- How to translate insights to policy messages? → systems analysis/cross-cutting tasks
- Opportunities for interaction with other TCPs

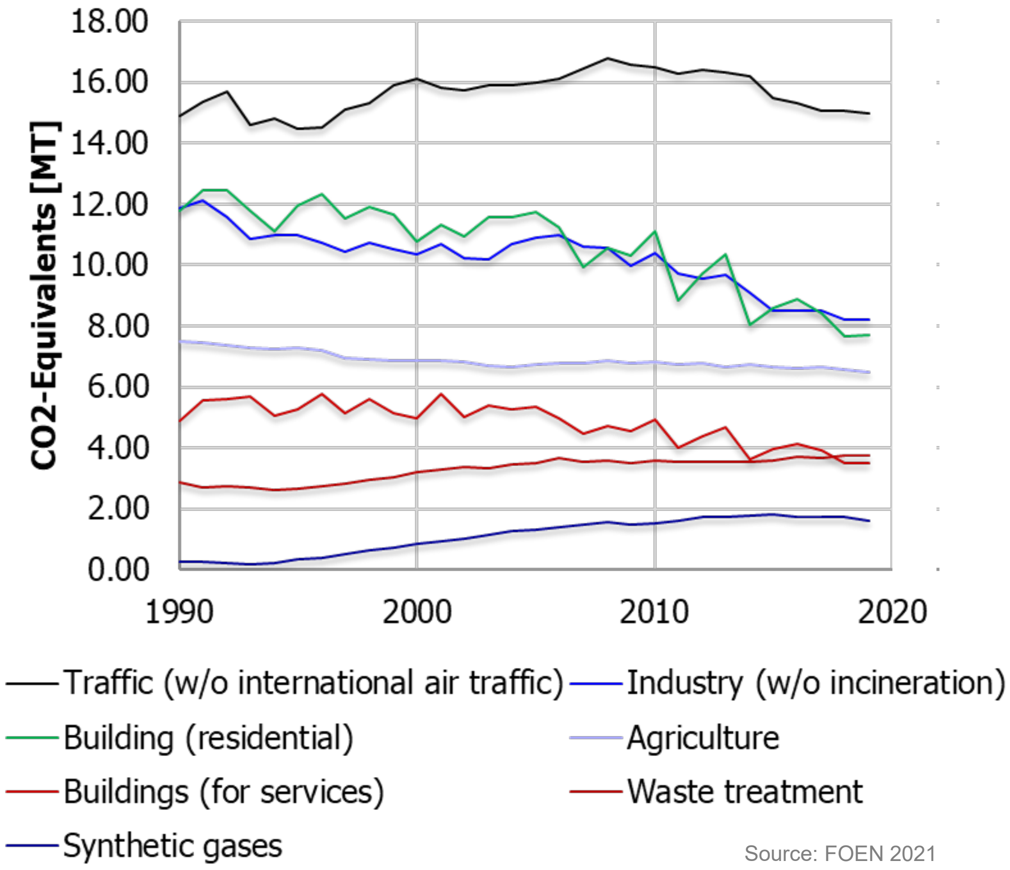
Conclusions

Energy demand and GHG emissions – breakdown by sectors in Switzerland

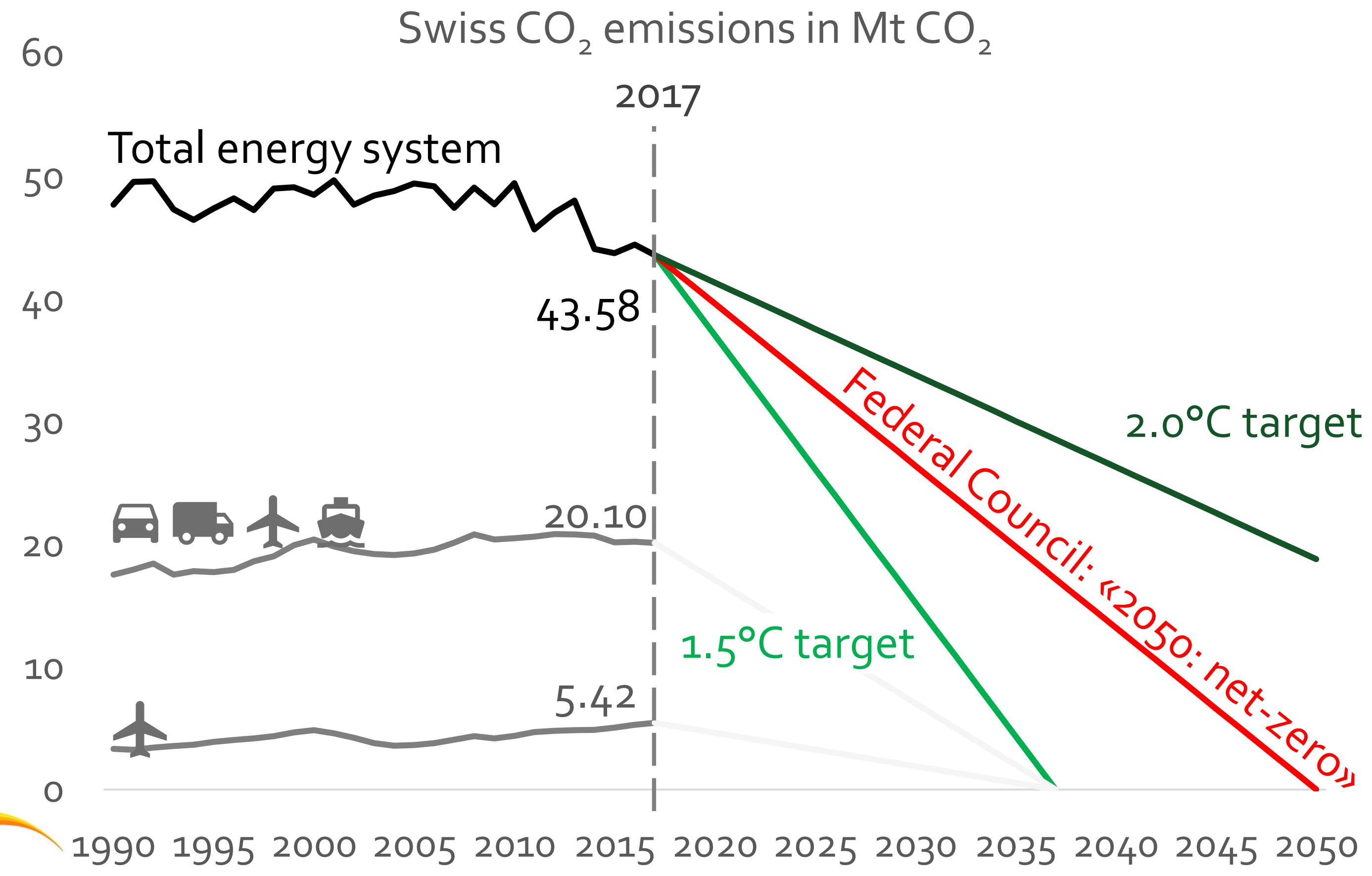
- 36% energy demand for transportation



- CO_2 reductions apparent in some sectors
  - Buildings: heat pumps, insulation, BIM, …
  - Transport remains an issue (still largely fossil)
  - Power (co-) generation needs chem. energy carriers, too!



The CO2 budget – global and national



Target	World	Switzerland
2.0°C (66%)	1170 Gt CO_2	1290 Mt CO_2
1.5°C (66%)	420 Gt CO_2	460 Mt CO_2

Per-capita distribution

Discrepancy between the resolution of the Federal Council and the 1.5°C target

	CO_2 emissions* (2018-2050)	Net zero
2.0°C (66%)	1290 Mt CO_2	~2076
Fed. Council	700 Mt CO_2	2050
1.5°C (66%)	460 Mt CO_2	~2038

*) Figures are based on the assumption of a linear decrease in emissions between 2018 and 2050, see graph on the left.

Reference: BAFU (2019): «Entwicklung der Treibhausgasemissionen der Schweiz seit 1990», IPCC (2018): «Global warming of 1.5°C.", Alle Zahlen inklusive internationalem Flug- und Schiffsverkehr (und ohne IPCC-Subsektoren 4 (LULUCF) und 6 (Others))

Renewable fuels – some options

Production efficiency (renewable electricity + DAC)

- Hydrogen and short-chain HC fuels highly beneficial
- Liquid "drop-in" fuels → aviation and shipping (existing assets with long fleet replacement times)

Distribution infrastructure

- Hydrogen ??? → fuel cell or ICE?
- rLNG, rDME, rNH3: use established LNG framework
- rMeOH ideal "short-chain" liquid candidate
- Longer-chain liquids: OME, (FT-)Diesel, Jet-X

Handling issues

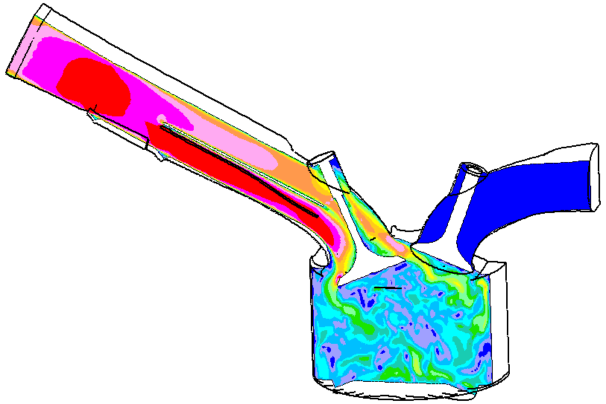
- Toxicity, ease of refueling, compatibility with engine components
- volatility, reactivity (flame speed, ignition propensity)

e-fuel	efficiency
cgH2 LH2	0.56-0.60 0.48-0.55
NH3	0.49-0.55
MeOH	0.41-0.48
LNG	0.43-0.46
DME OME3-5	0.45-0.48 0.33-0.36
Diesel (FT) Via MeOH	0.33 0.37

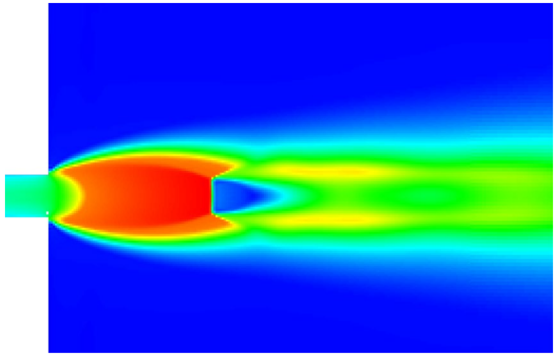
Held, PhD thesis ETH Zurich
Held et al., Energy Environ. Sci., 2019
Stolz, Held et al, Nature Energy 2022

Combustion – fundamental challenges

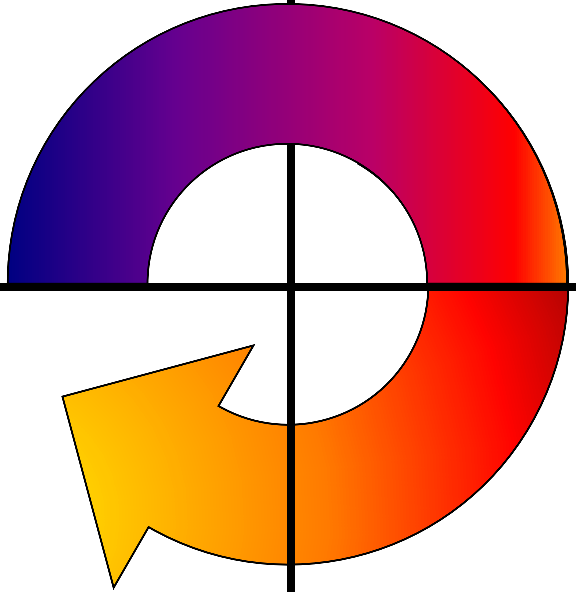
Turbulence

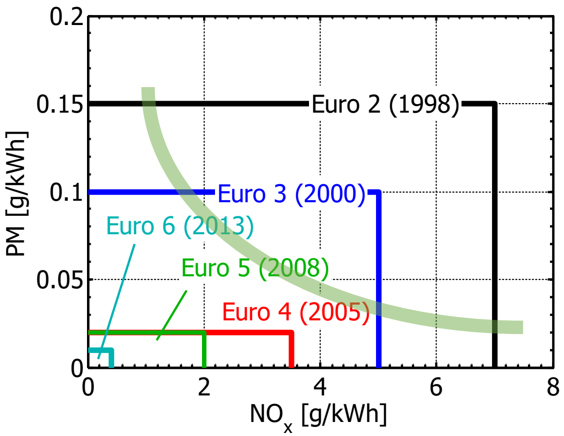


High pressure fuel injection

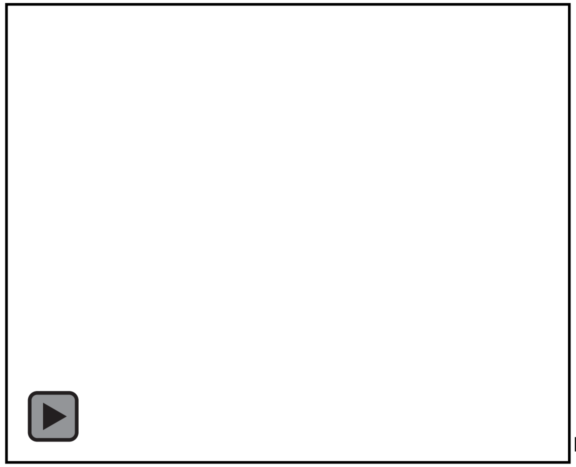


Martin Schmitt, LAV





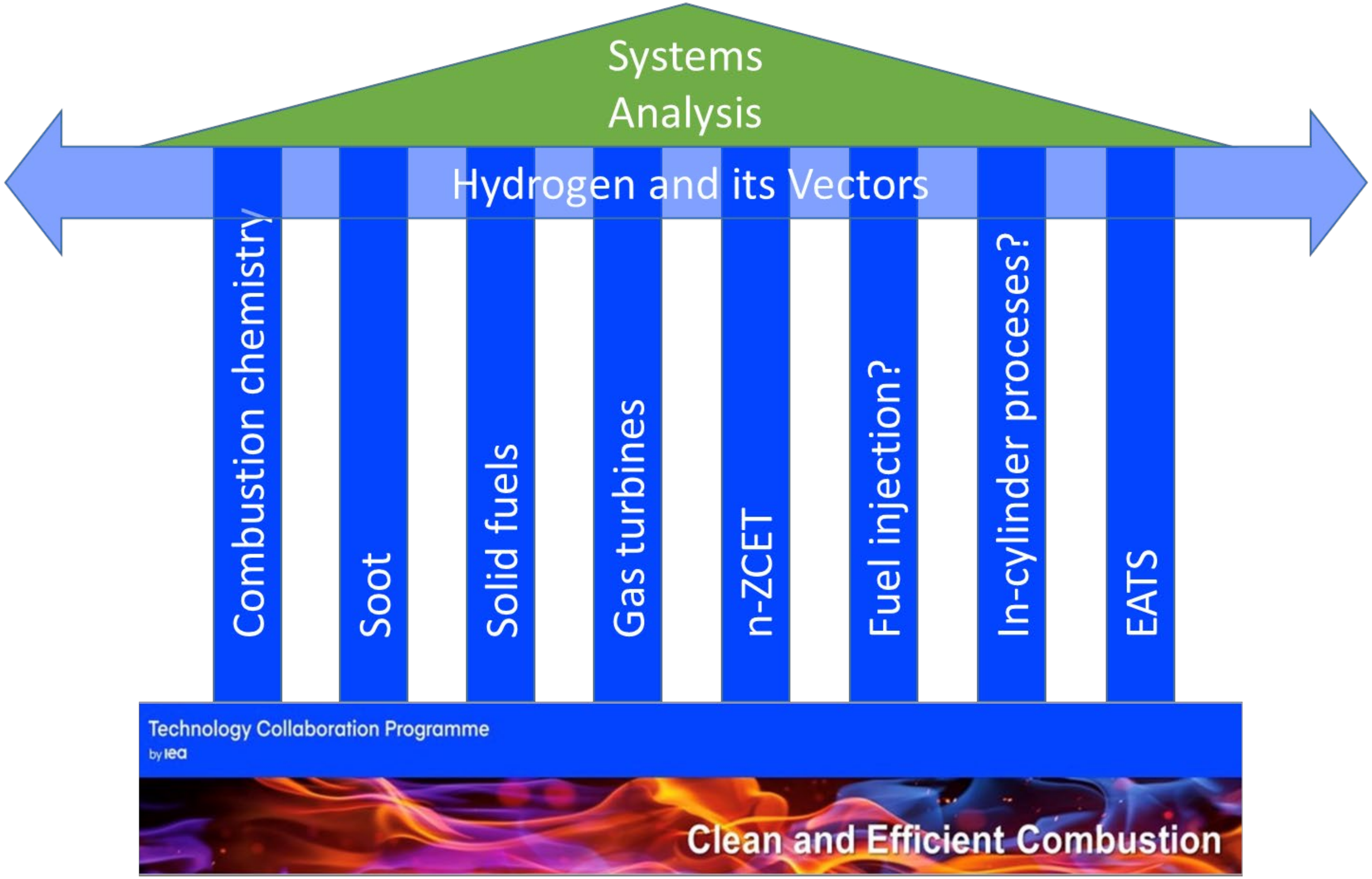
emissions



LAV

combustion

How to evolve the combustion TCP ?



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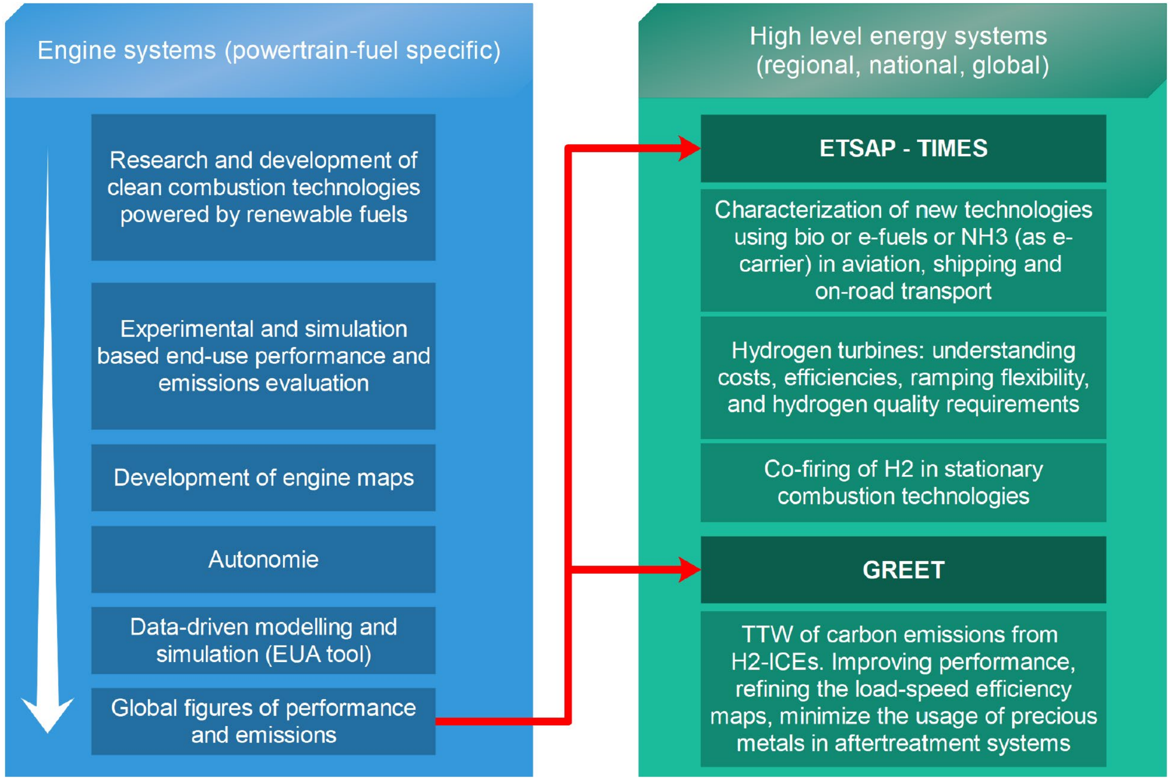
System Analysis Task

31 Members · 10 Countries · 16 Institutes



Kroyan & Larmi, combustion TCP strategy meeting April 2022, Berlin

GREET+

- Striving to inform and improve comparisons of fuels and technologies in a well-to-wheel perspective across transport-related TCPs.
- Technological expertise from the TCPs will be used in
  - Regionalization beyond the U.S.
  - Integration of new fuel cycle / vehicle cycle pathways
- Results shall inform
  - System analyses in the TCPs
  - IEA scenario modelling

Miles., combustion TCP strategy meeting April 2022, Berlin

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Interactions with other TCPs

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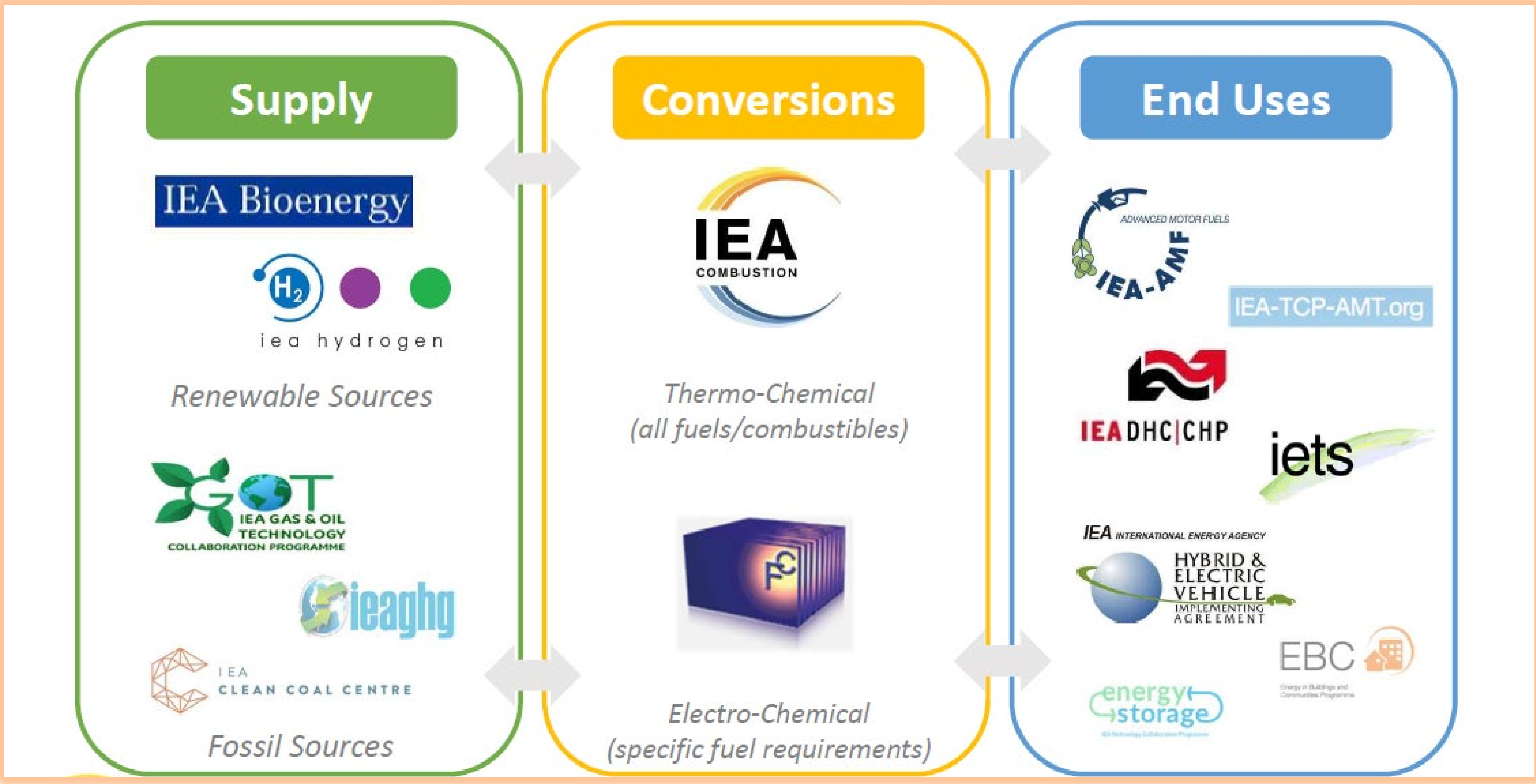

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Miles., combustion TCP strategy meeting April 2022, Berlin

Conclusions

- Overarching goals
  - Net zero CO2 by 2050
  - Electrification wherever possible *undisputable*
  - Various sectors will nonetheless need to rely on combustion
  - Technology neutrality important and "bang for the buck" should be kept in mind
  - Security of supply: seasonal availability of renewables (and current geopolitical considerations!)
  - Long-term storage options essential in this respect → chemical energy carriers, CHP, …

- Implications
  - Synthetic (net) zero carbon fuels at scale required
  - Understanding combustion physics of H2 and low-/net zero carbon fuels mandatory
  - Evolve task to reflect changes in fuels availability, technology, regulations, energy security
  - Improve interactions with other TCPs and EUWP

Thank you!