



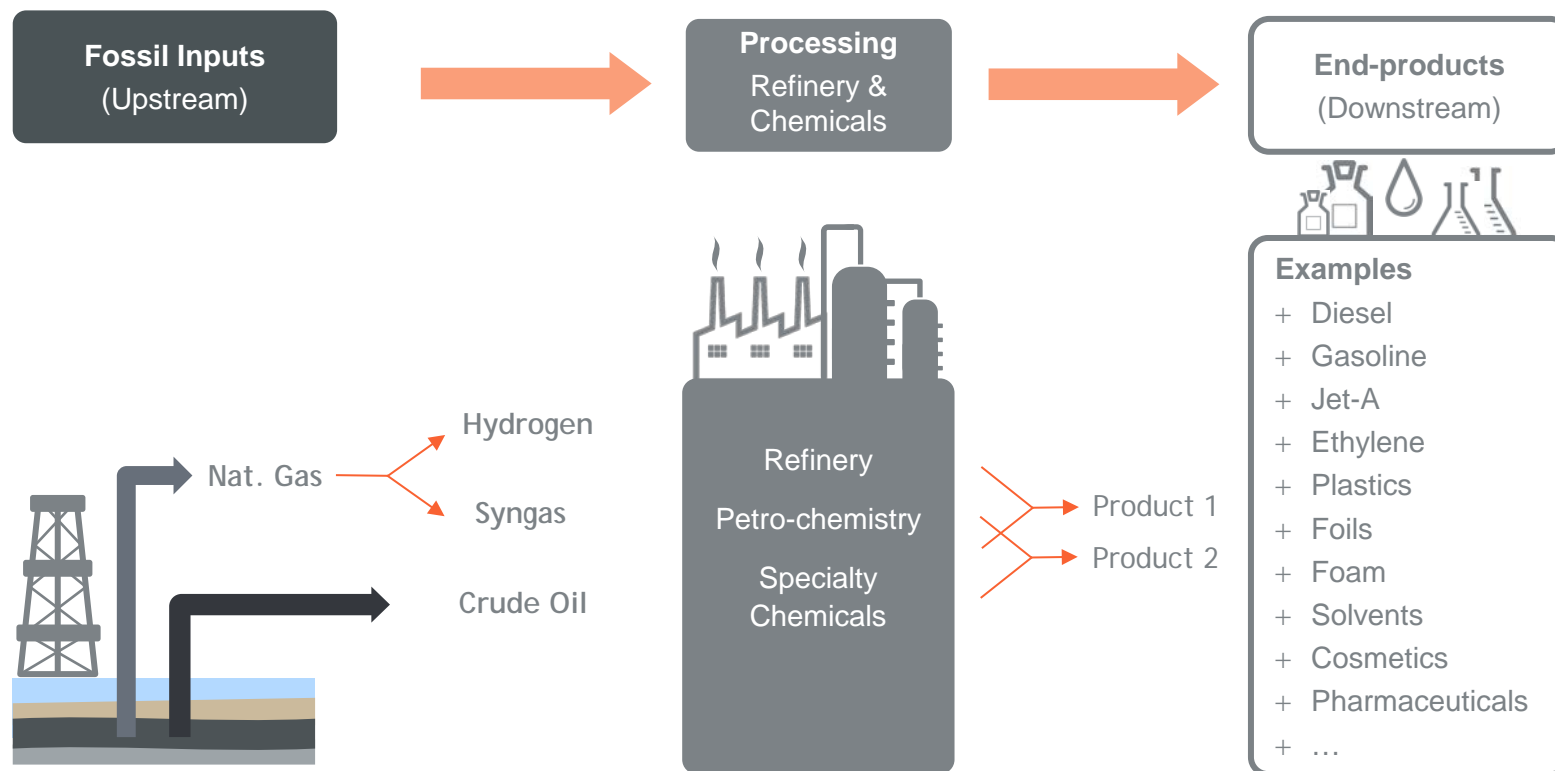
Connecting Energy Sectors

Solid Oxide Electrolysis

08.12.2016 — Christian von Olshausen / CTO

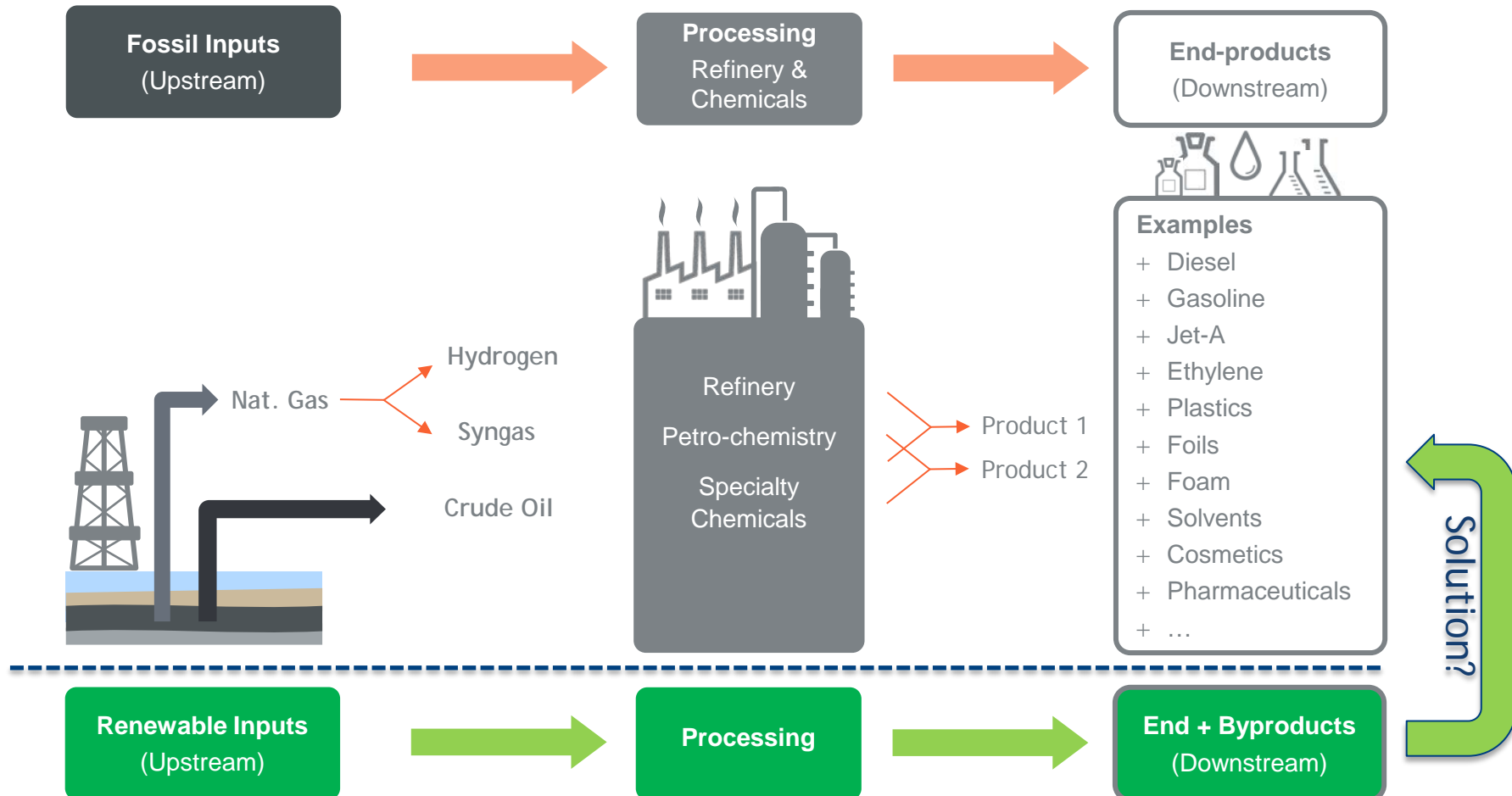


Existing Value Chain for Oil and Gas

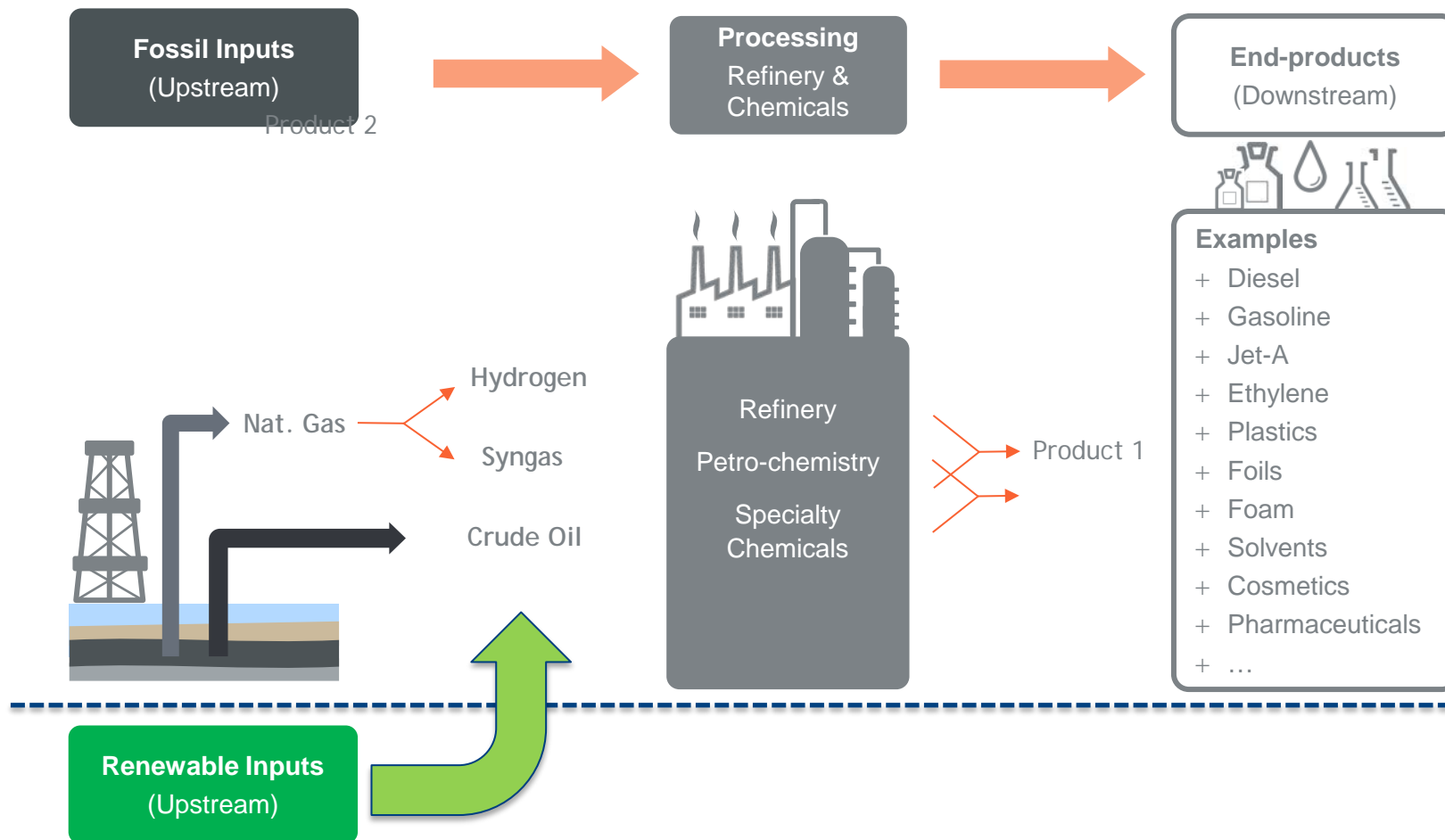


Large assets already in place using fossil natural gas and oil as a feedstock.

Existing Value Chain for Oil and Gas

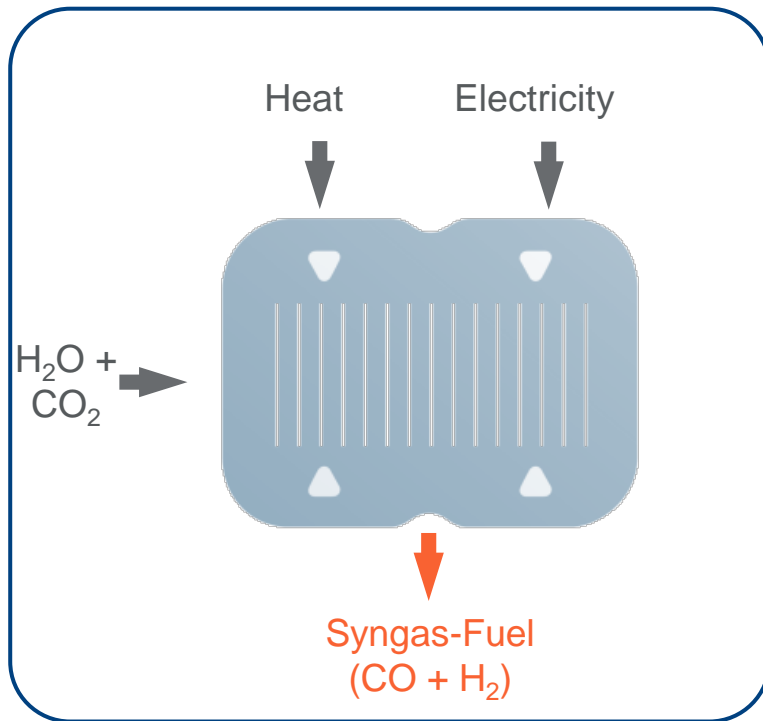


Existing Value Chain for Oil and Gas

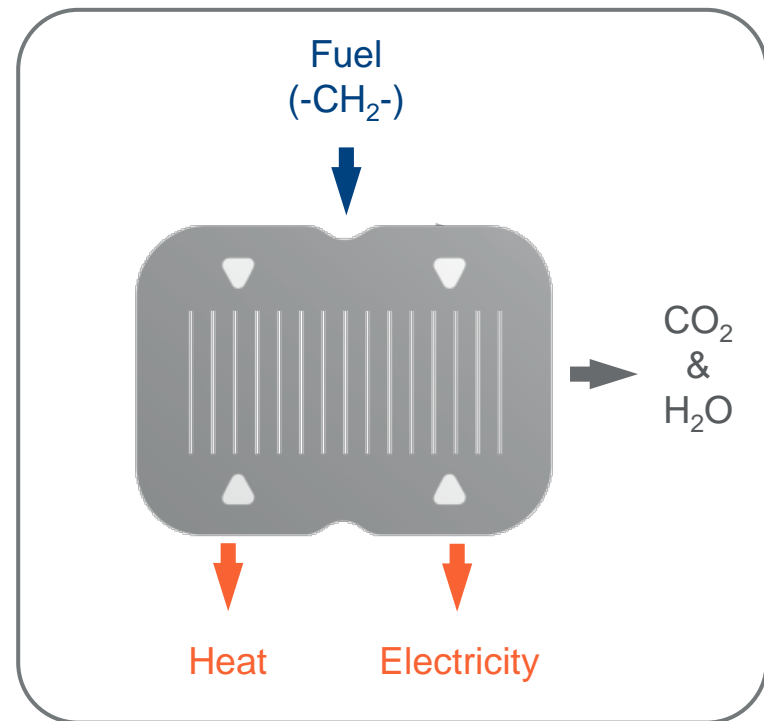


Solid Oxide Cells convert...

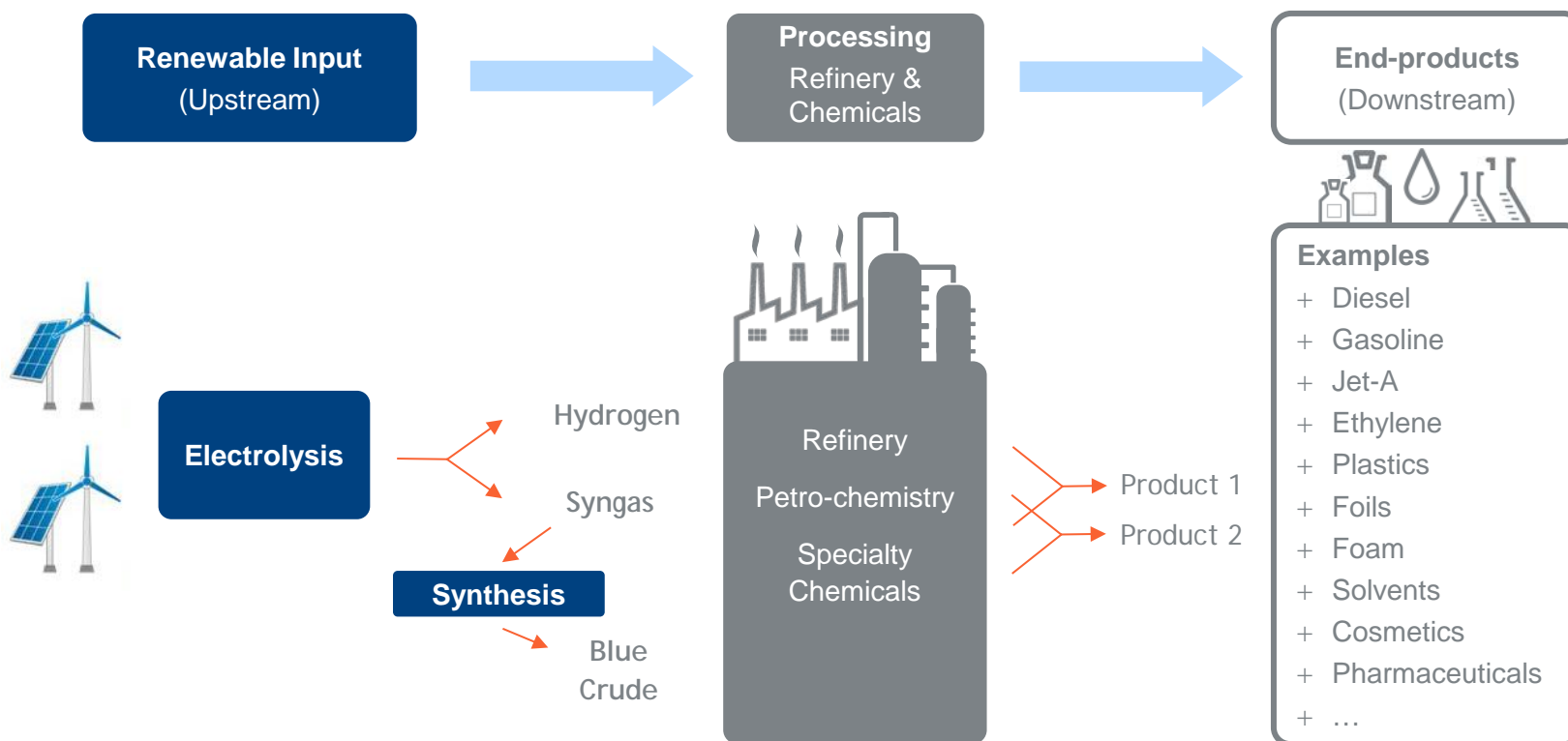
...electricity into **Fuels**



...Fuels into **electricity and heat**



Sector Coupling using Existing Value Chain



Sunfire makes use of existing assets instead of changing each processes individually (no disinvest)

H2 Potential in German Refineries (Fuel only)

Assumptions:

- + Current H2 requirement in German refineries: 136 kt/a (globally = 20,150 kt/a)
- + Ren. fuel quota to increase from 3.5 to 6% GHG emission reduction in 2020 (biofuels not sufficient to fill gap)

H2 demand	t/a	136,000
Nominal installed power (SOEC)	MW	1,100
Electricity consumption	GWh/a	5,782
Percentage of fuel quota	% GHG	0.50

-> 1,100 MW at 60% utilization rate

-> 0.5% GHG reduction is the exact advanced fuel required

Reference Projects



- + 1x 150 kW SOEC power input and 30 kW SOFC power output
- + SOEC efficiency of $>80\%_{LHV}$
- + Reaching a lifetime of greater 10,000 h with a degradation rate below 1 %/1,000 h
- + Meeting the H₂ quality standards of steel industry



- + 2x 100 kW SOEC power input and 40 kW SOFC power output
- + Roundtrip efficiency ca. 45%
- + Electricity storage for autonomous electricity supply during day and night (PV connected)



150 kW SOEC unit in Dresden, Germany



200 kW SOEC unit in Los Angeles, USA

Reference project PtL



Audi
Vorsprung durch Technik



Federal Ministry
of Education
and Research

- + Plant produces synthetic diesel, waxes, naphtha (drop-in fuel)
- + High efficiency of ca. η_{el} =60% (electricity to fuel)
- + Renewable electricity, CO₂ from various sources (i.e. ambient air), no biomass required
- + Audi confirms the fuel's eco-friendliness
- + Gamechanger technology for renewable liquids
- + Long term operation and production of > 3 tons blue crude successful



Extreme Value Comparison



Three Pillars required for CO₂-Valorization Business

CO₂ Valorization Business

T echnology

- ✓ Efficiency potentials almost leveraged
- TRL to be increased
- CAPEX to be reduced

E conomics

- Develop effective model that stops externalization of CO₂ - costs in fossil economies.
- Prevent early mover Economies from becoming uncompetitive.

L egal

- Establish legal framework for renewable sector coupling.
- Adapt fee and tax scheme to WtP for renewable products
- Allow technology independent competition.

Legal Framework Details

LEGAL

- Establish legal framework for renewable sector coupling
 - Treat *CO from CO₂* and *H₂ from H₂O* or any *derivative (C_xH_yO_z)* equally.
Current framework prefers H₂ over CO.
 - Treat *electric based molecules* equally to *electric energy*.
Current framework prefers electric cars over electric fuel driven cars (EU 443)
 - Treat renewable *feeds* and *products* equally.
Current framework prefers renewable products (biofuels) over renewable feeds (H₂ for refineries).

Equal treatment includes LCA value comparison!
- Adapt fee and tax scheme to WtP for renewable products
 - Reduce fees and taxes on e.g. electricity if operation supports grid stability.
 - Do not charge energy tax on renewable electricity or renewable chemicals as their cost level is already higher than their fossil alternative.
 - Do not charge grid cost on consumption but on maximum supply capacity.
- Allow technology independent competition
 - Do not ban fuel using technologies if they can use renewable fuels. Ban fossil fuels, not flexible technologies.
 - Do not prescribe which technologies to use but prescribe efficiency and CO₂ reduction targets.



+ **VIELEN DANK**

ENERGY
EVERYWHERE