

Industrial Solutions for CO₂ Capture and Utilization

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SOCIETY

ENVIRONMENT

BUSINESS



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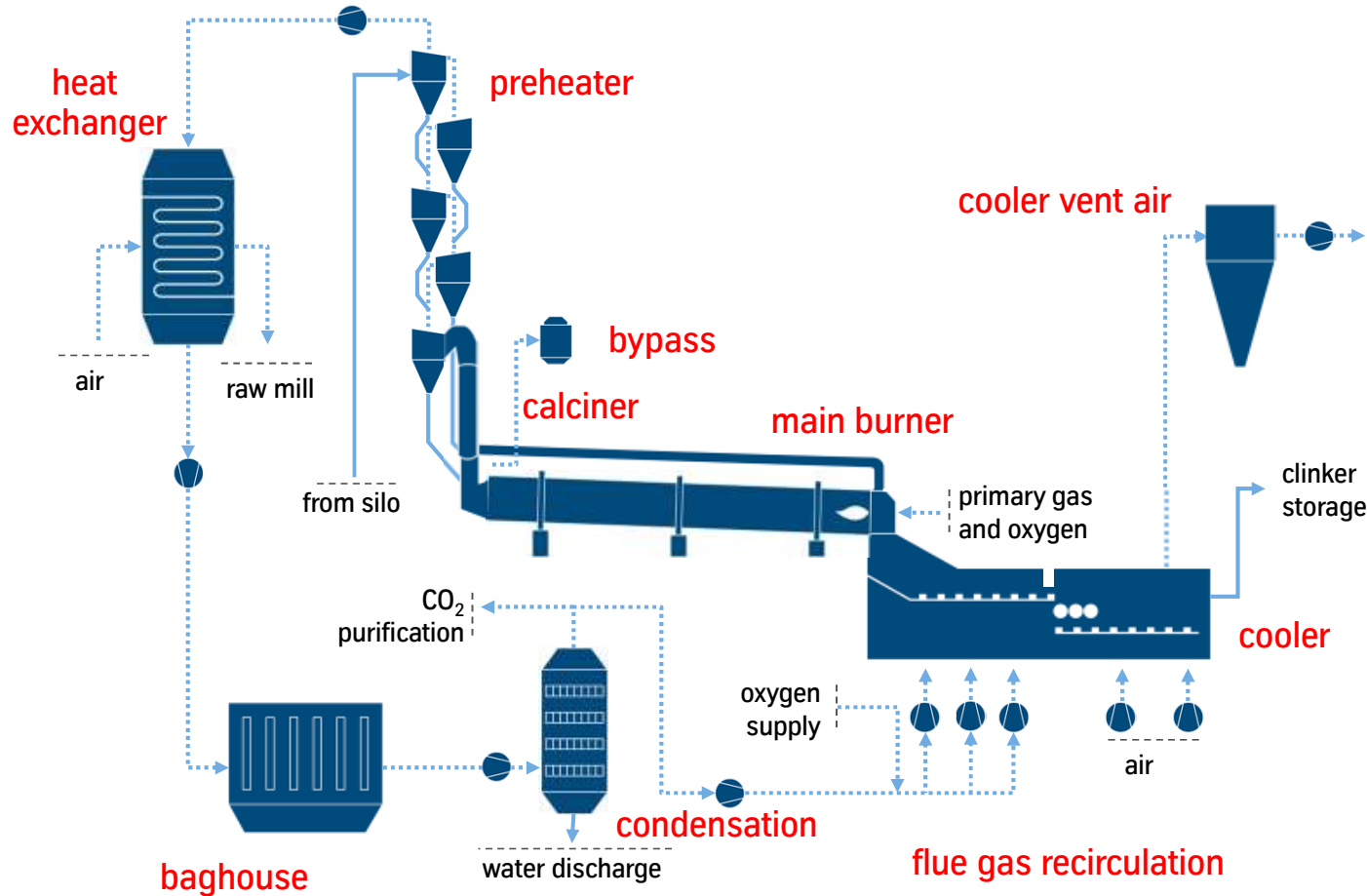
Cement industry in changing times

The sustainability concept - United Nations global agenda for change



Oxyfuel technology

"Standard Oxyfuel" for retrofit of existing plants



Benefits

Technically developed up to industrial scale, i. e. "ready to market"

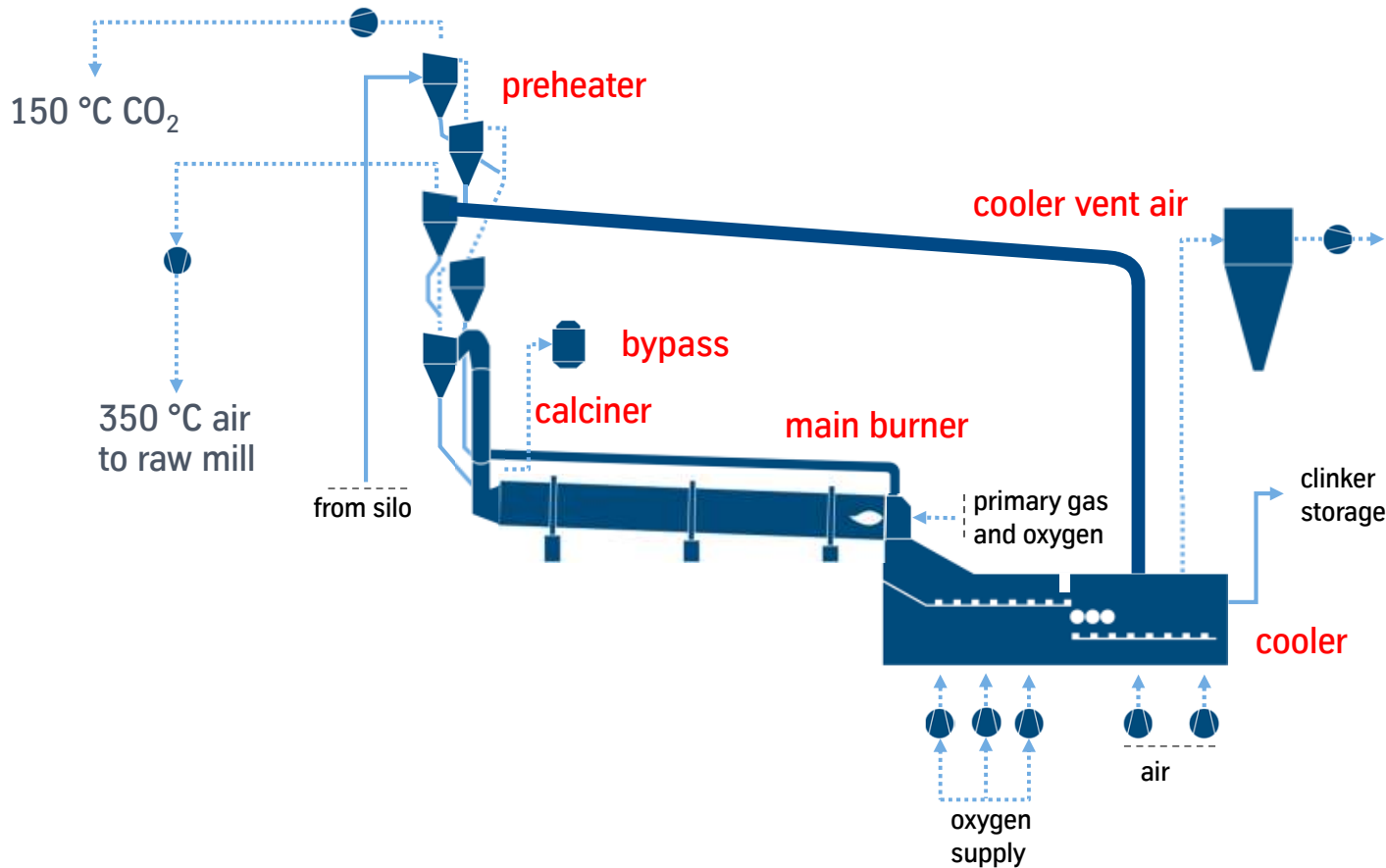
Designed with focus on retrofits of existing plants

Oxyfuel technology retrofit technically feasible with a high degree of maturity



Oxyfuel technology

"Pure Oxyfuel" for new plants



Benefits

Decreased investment costs, compared to "Standard Oxyfuel"

- Size reduction of preheater tower
- Size reduction of kiln line (~2,5 x smaller)
- Less expenses for auxiliaries
- Waste heat recovery not necessary

Decreased operational costs

- Less volume flow (combustion gases)
- No recirculation

Oxyfuel technology for new plants under development



Oxyfuel market

Scenarios for market assessments

Scenarios

Expected implementation order of CO₂-saving measures

First (and ongoing) steps of customers

1. Clinker factor reductions
2. Thermal efficiency improvements
3. Maximization of fossil fuel substitution

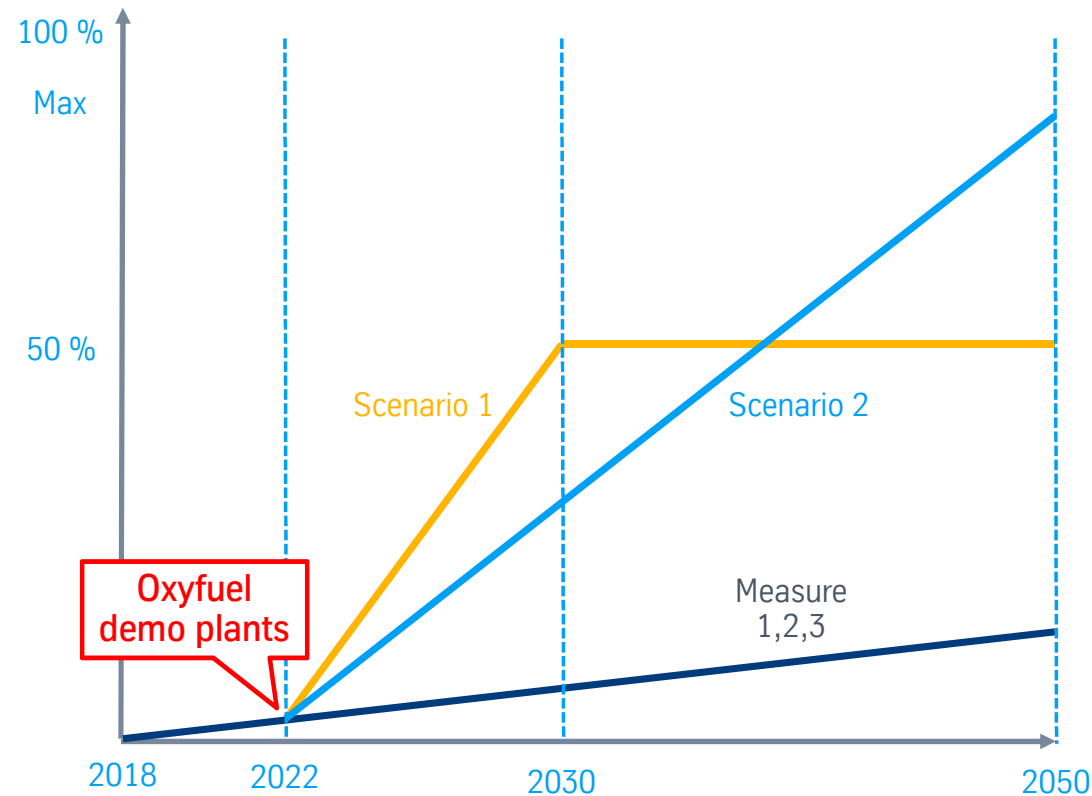
➞ Limited contribution to CO₂ savings

Second step for customers

4. Application of Oxyfuel process

➞ 2 potential scenarios (out of many)

CO₂ reduction



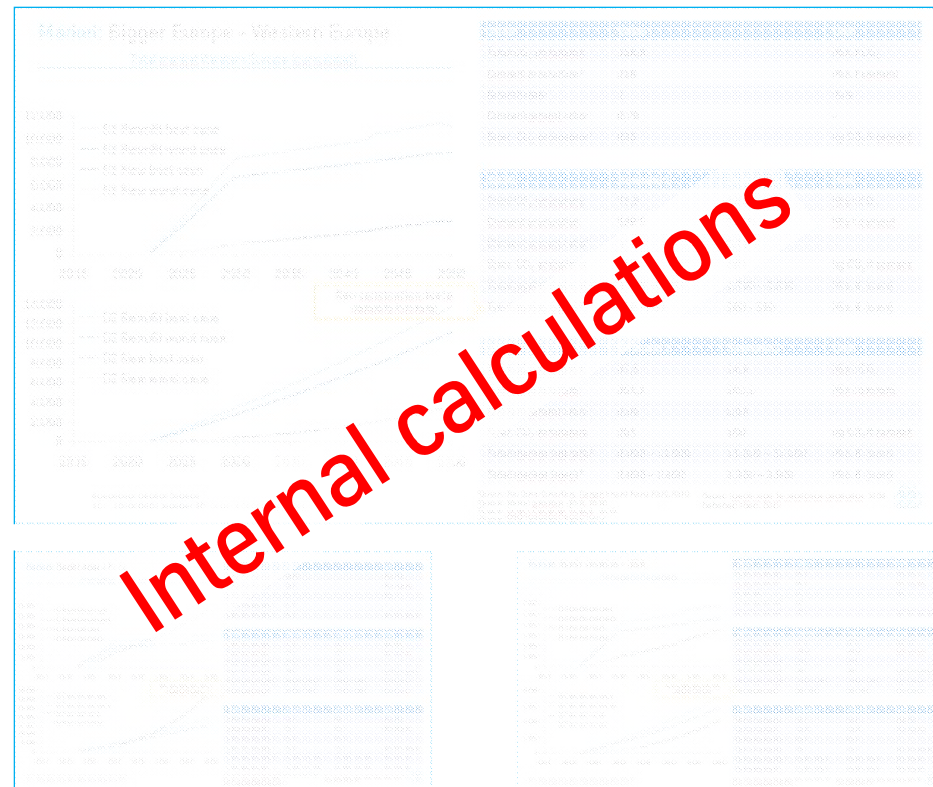
Oxyfuel market depending on society, i. e. legislation



Oxyfuel market

Total market for selected countries

Overview: Western Europe, USA & India



Key messages

Markets¹

- Industrialized countries Focus on retrofit
- Developing countries Focus on new plants

Total Market (cumulated until 2030):

- Europe 5,000 - 10,000 Mio. €
- USA 2,500 - 5,000 Mio. €
- India 5,000 - 20,000 Mio. €

Total Market (cumulated until 2050):

- Europe 10,000 - 20,000 Mio. €
- USA 8,000 - 12,000 Mio. €
- India 40,000 - 60,000 Mio. €

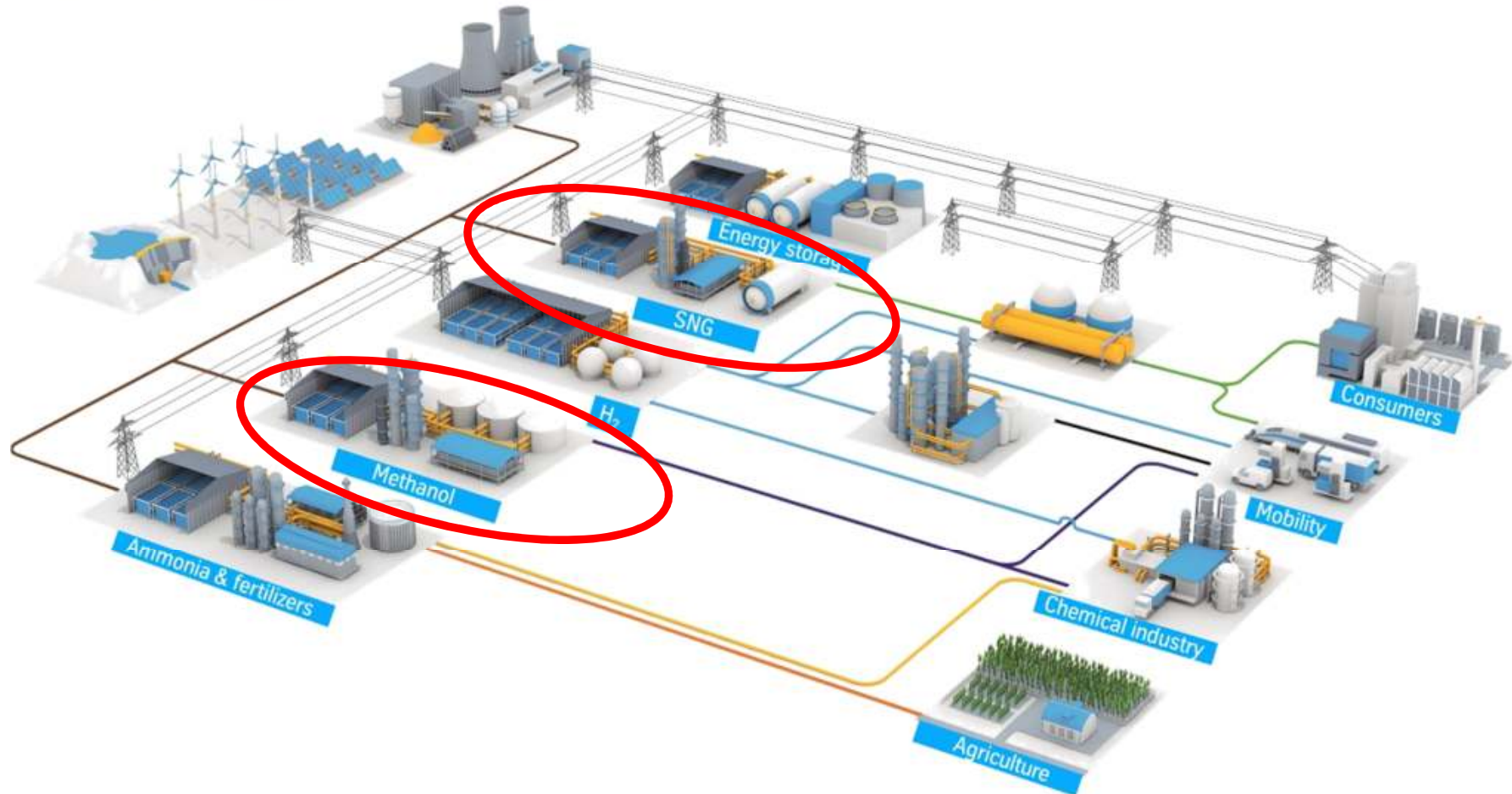
Significant Oxyfuel market, however, depending almost completely on society, i. e. legislation

¹Internal calculations based on ECRA Technology Papers, 2017



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Power-to-X Strategy – Several Options for CCU application



Carbon usage technologies technically feasible with a high degree of maturity

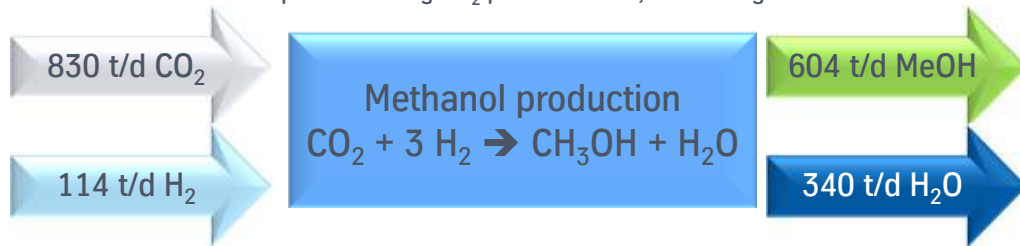


Methanol and Synthetic Natural Gas (SNG) synthesis

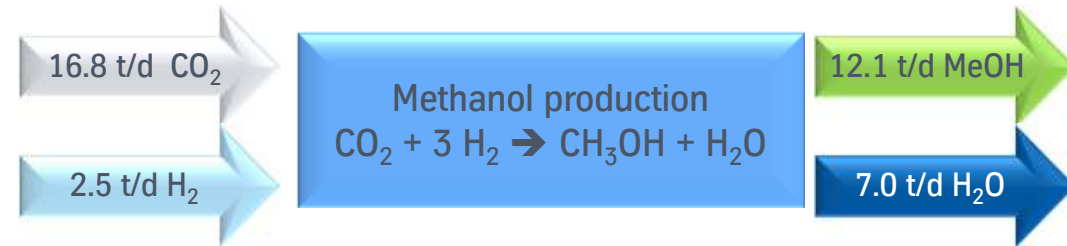
Application to the cement industry

Gross potentials for a small (e. g. 1,000 t/d) cement plant

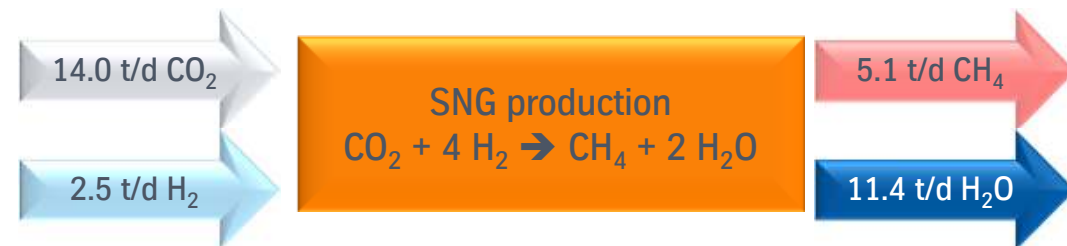
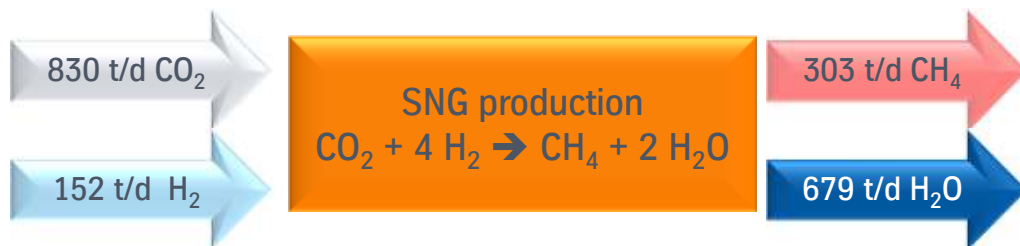
Assumptions: 830 kg CO₂ per ton clinker, losses neglected



Capacities for a 5 MW electrolysis plant for H₂-supply



H₂-supply for Methanol production covers the requirement to convert 2 % of the CO₂ production of a 1,000 t/d cement plant



H₂-supply for SNG production covers the requirement to convert 1.5 % of the CO₂ production of a 1,000 t/d cement plant

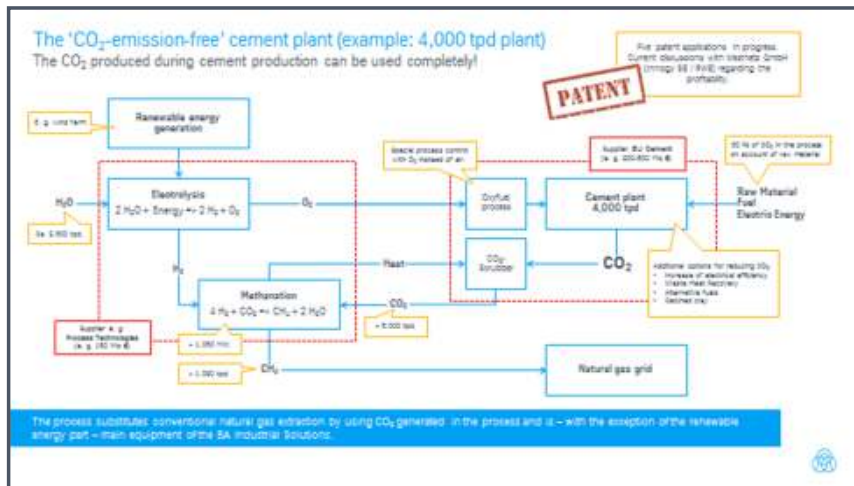
CO₂-conversion into Methanol and SNG is highly energy-intensive



CO₂-utilization and Renewable Energies supply

Sample estimations for Germany

Energy demand and SNG production



- Clinker production rate 23 Mio. [t_{cl}/a]
- Energy demand 200.000.000 [MWh/a]
- **Average power consumption 22 [GW]**
- **CH₄ production (methanation) 2,300 Mio. [m³ CH₄/a] (stp)**

Renewable energy potentials Germany

Photovoltaics (900 load hours per year)

- Currently installed 45 GW¹
- Currently exploited 5 GW¹
- Potential roof and facade areas 290 GW_{peak}²
- Potential brownfield areas 280 GW_{peak}²



Wind onshore (2,400 load hours per year)

- Currently installed 53 GW¹
- Currently exploited 16 GW¹
- Potential (conservative) 200 GW³
- Potential (maximum) 1,200 GW⁴

Wind offshore (4,000 load hours per year)

- Currently installed 6 GW¹
- Currently exploited 3 GW¹
- Potential (optimistic) 30 - 50 GW⁵

Total renewable energy potential for Germany
500 GW - 2,000 GW



¹Fraunhofer Energy Charts 2018, ²Fraunhofer IWES 2012, ³Fraunhofer IWES 2011, ⁴Umweltbundesamt 2013, ⁵ECN 2011

CO₂-conversion into Methanol and SNG is highly energy-intensive



Fake news!

Fake News!

But may be real news soon!

Frankfurter Allgemeine Nov. 12, 2018
European Cement producer under public pressure after China's market introduction of CO₂-neutral cement.

CORRIERE DELLA SERA Nov. 10, 2018
Stock prices of European cement producers plunge downward after China's market introduction of CO₂-free cement.

THE TIMES Nov. 1, 2018
Climate Change Europe debating - US denying - China acting
China starts with the production of the first CO₂-free cement.

CHINADAILY 中國日報
深圳市 Shenzhen: First CO₂-neutral Cement Plant in Operation, ten to follow soon. Nov. 13, 2018

The Washington Post Oct. 18, 2018
China taking the lead in environmental protection!
First Zero CO₂-Emissions Cement Plant operating in China

The Telegraph May 5, 2021
Large Chinese Cement manufacturer starts up first new CO₂-free cement plant based on thyssenkrupp technology.

Greenhous gases
World is grinning about Europe's helpless reaction on China's first CO₂-free cement production. Nov. 22, 2018

THE WORLD NEWS Nov. 8, 2018
Climate Change
European Parliament under pressure after first CO₂-free cement is produced in China. Funding of the European Cement industry's two CO₂-free cement demonstration plants got stuck for years in EU bureaucracy.

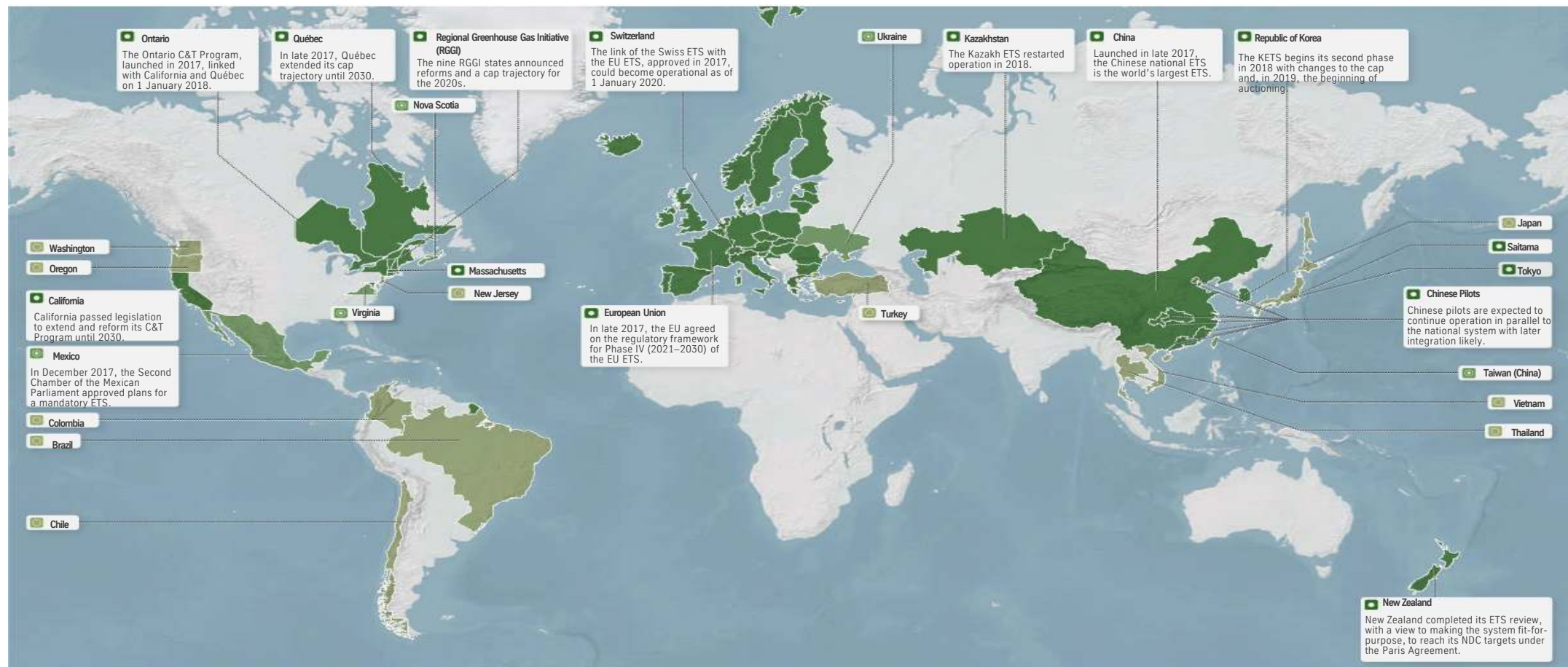
arab news The Middle East's Leading English Language Daily
China's answer on climate change - first buildings under construction based on CO₂-neutral cement. Nov. 24, 2018

Europe risks losing out on the leadership in environmental protection



Emission Trading Systems emerging world-wide

21 trading systems in force (end of 2017), covering 28 jurisdictions representing 50 % of the Gross Domestic Product



China launched an Emission Trading system in late 2017



Cement industry in changing times

Conclusions

Carbon Capture and Carbon Usage for cement plants in Europe

- allow for a sustainable development and require now primarily for adoption from Society (i. e. public and politics)
- are technically feasible with a high degree of maturity
- underline the necessity to speed up with the development of renewable energies
- show the obligation of searching for other CO₂-sinks, e. g. Carbon Storage techniques
- should underline the European claim for leadership in climate protection

