Power and CO_2 emissions to methanol

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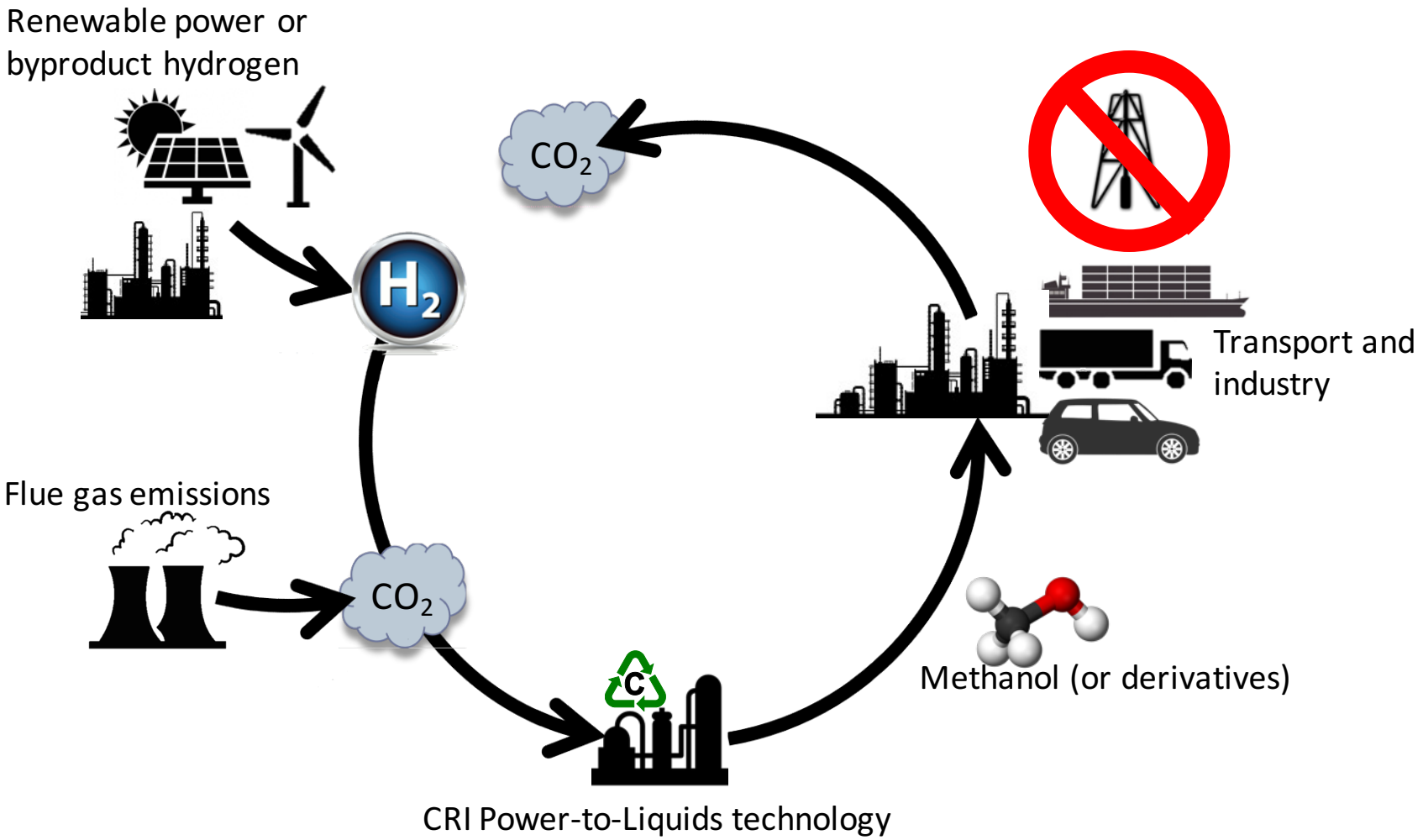
Brief history of CRI



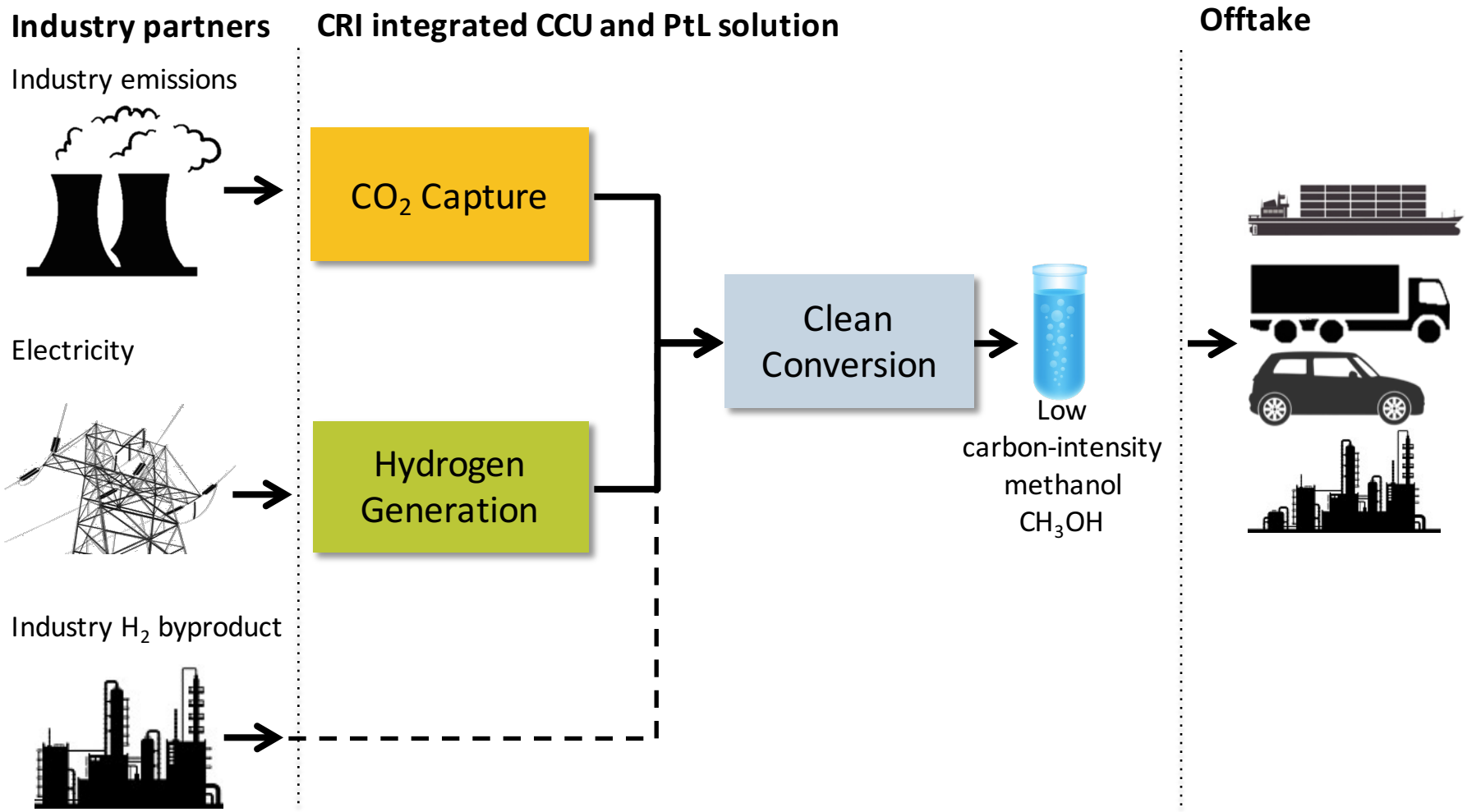



2007	2008	2009	2010	2011	2012	2013	2014	2015
Company launched in Reykjavik	Technology development	Pilot plant production	Plant engineering	Plant construction	**Plant opening** with 1,300 t/yr capacity	**First sales** (exports and domestic) **Methanex invests**	**Plant expanded** to 4,000 t/yr capacity	Marketing of technology & partnerships **Geely (owner of Volvo Cars) invests**

Low carbon intensity methanol: energy carrier

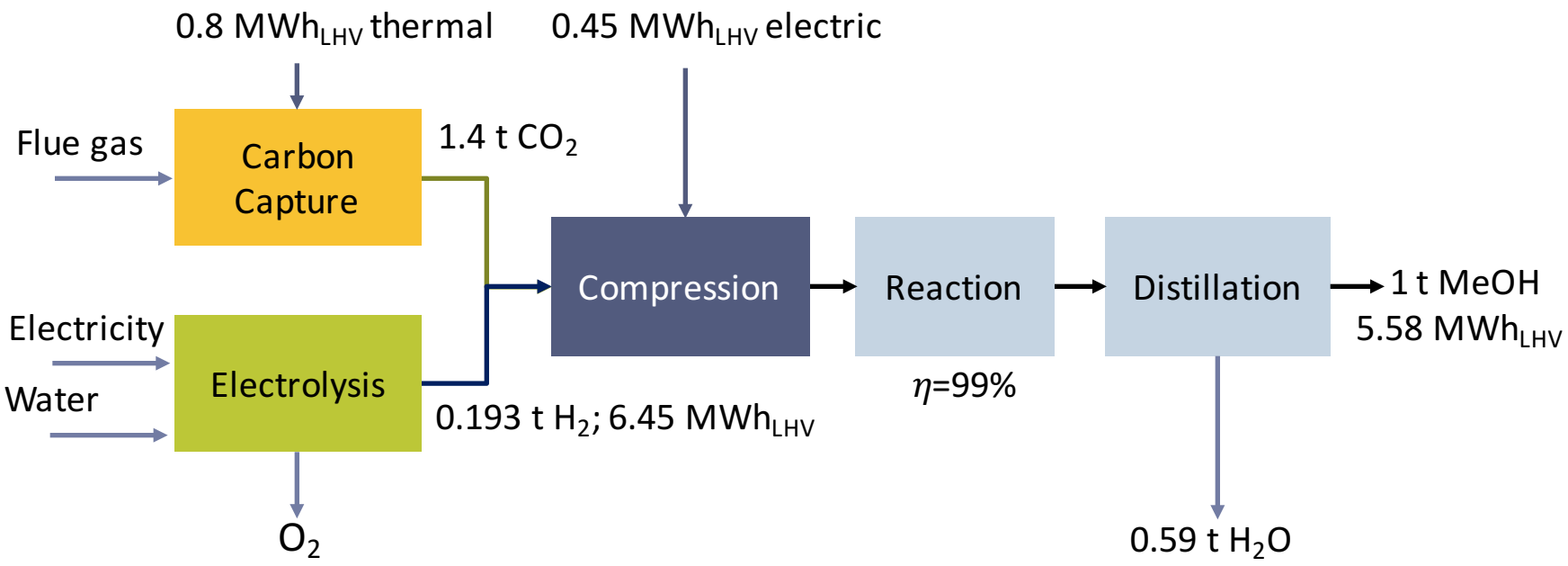


CRI's Power-to-Liquids platform

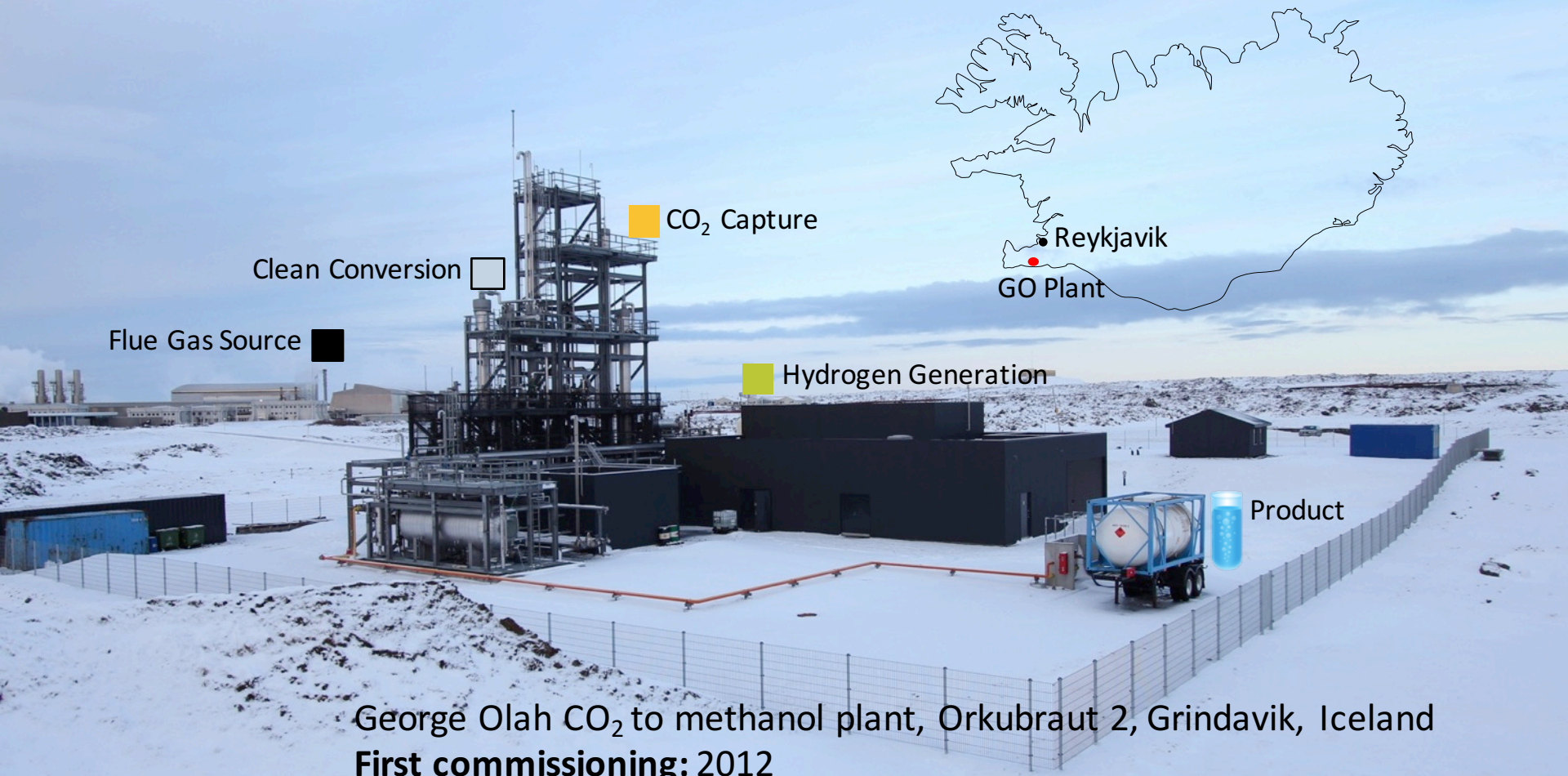


ETL mass energy balance and efficiency: electrolysis

Total electrical energy 9.5 MWh/t methanol with overall efficiency of 60%



CRI first of its kind Power-to-Liquids facility in Iceland



George Olah CO_2 to methanol plant, Orkubraut 2, Grindavik, Iceland

First commissioning: 2012

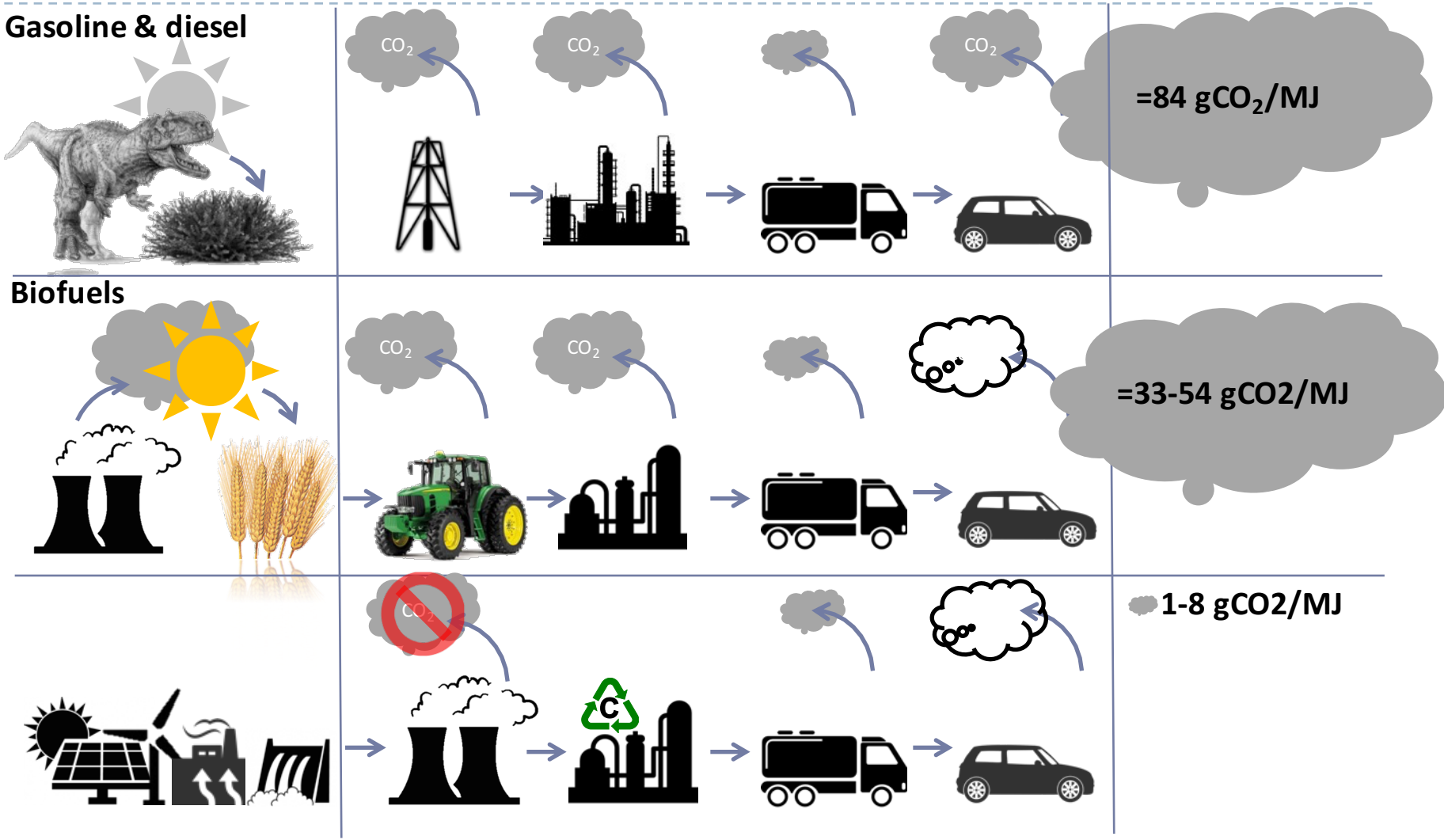
Capacity expansion: 2015

CCU throughput: 5,600 t/yr CO_2

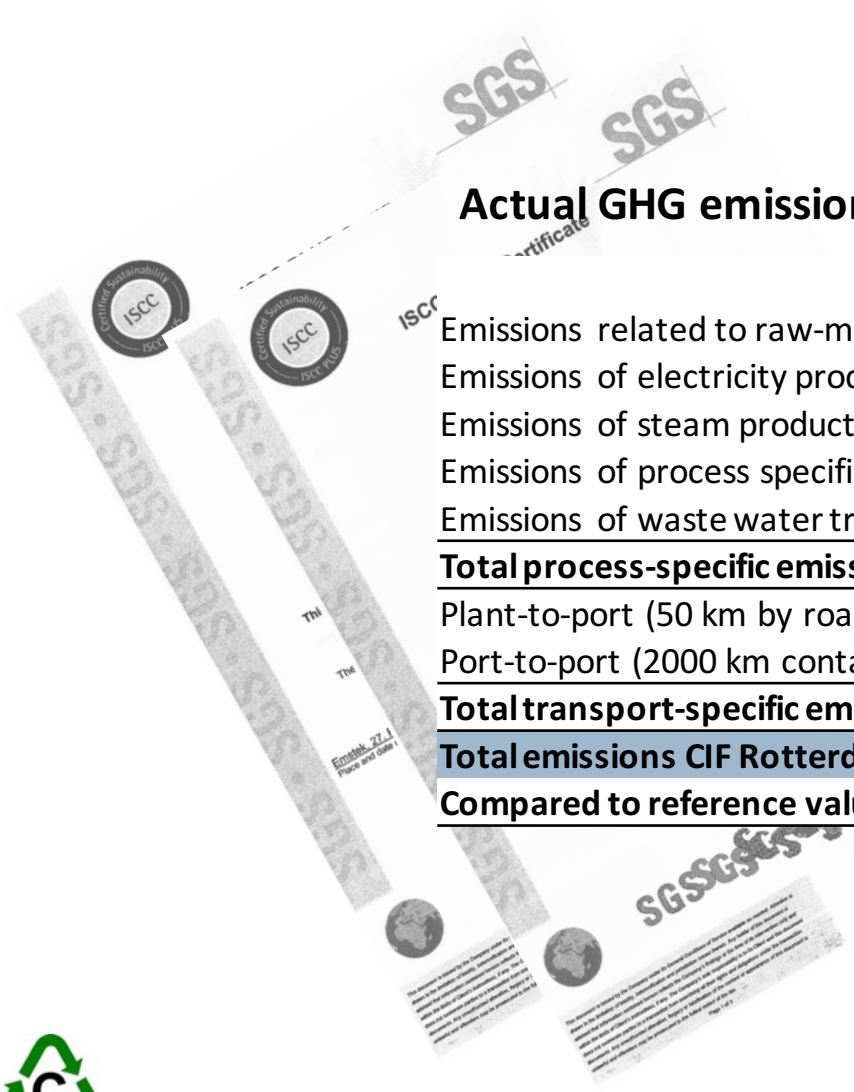
Electrolyzer capacity: 800 t/yr H_2 (1200 Nm^3/hr)

Production capacity: 4,000 t/yr methanol

Framework to compare CO_2 life cycle emissions of fuels



First PtL plant with ISCC+ certification of sustainability



Actual GHG emission values using ISCC EU GHG module*

	kgCO2e/t RM	gCO2e/MJ RM LHV
Emissions related to raw-material:	0	0
Emissions of electricity production (grid)	134	**6.71**
Emissions of steam production	4	0.22
Emissions of process specific inputs:	4	0.21
Emissions of waste water treatment:	1	0.06
Total process-specific emissions:	143	**7.2**
Plant-to-port (50 km by road)	7	0.34
Port-to-port (2000 km container ship)	20	1.00
Total transport-specific emissions	**27**	**1.3**
Total emissions CIF Rotterdam	**170**	**8.5**
Compared to reference value of 83.8 gCO2e/MJ fossil		**>90% reduction**

***Based on EU directive 2009/30/EC (FQD)**

Streams of innovation

CRI firsts	Achievement
Used CO_2 capture from industrial sources to make transport fuel	▶ Processes 15 mt CO_2 / day into transport fuel
Implemented large-scale electrolysis for power-to-liquids applications	▶ Installed capacity of multi-MW alkaline electrolyzers for hydrogen production
Delivered renewable fuel of non-biological origin to EU market	▶ Gasoline blending and in biodiesel in Netherlands, Sweden and Iceland
Received certification for renewable fuel of non-biological origin	▶ Certification of 90% reduction of CO_2 according to EU Renewable Energy Directive

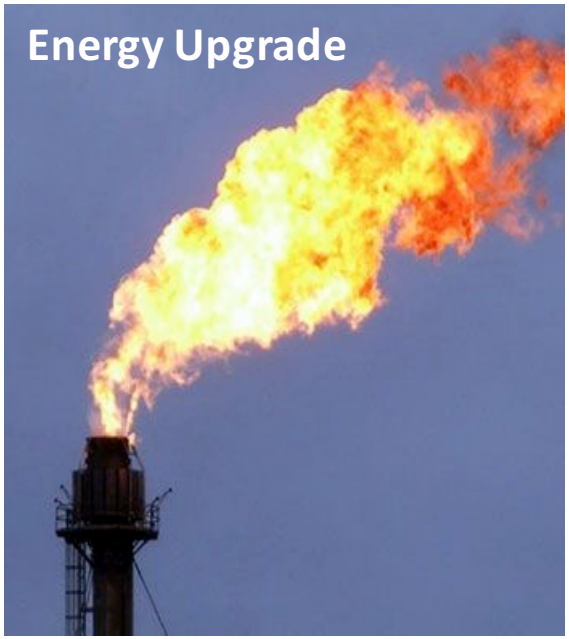
The MHPSE CRI Partnership

Mitsubishi-Hitachi Power Systems Europe (MHPSE) and CRI have combined their resources to offer integrated industrial solutions for carbon capture and power-to-methanol production.

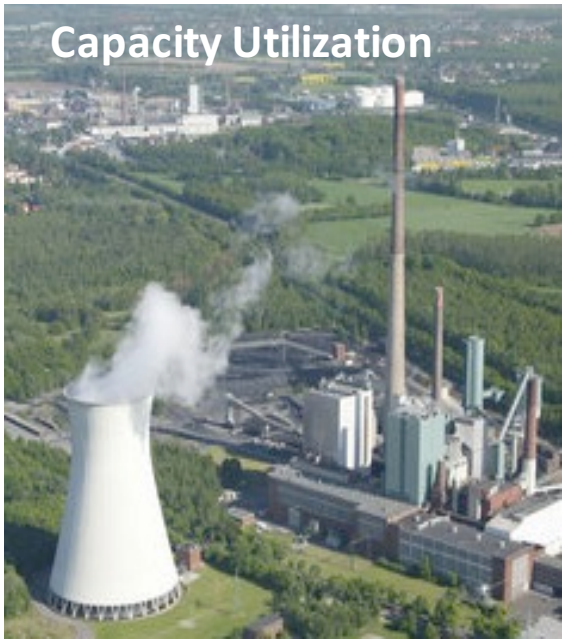
By joining forces, the two companies can offer clients a complete suite of services from:

- Feasibility studies;
- Turn-key contracts, including design, construction of modularized systems
- Pre-commissioning, erection, on-site commissioning, operator training;
- Post-purchase services and off-take contracts

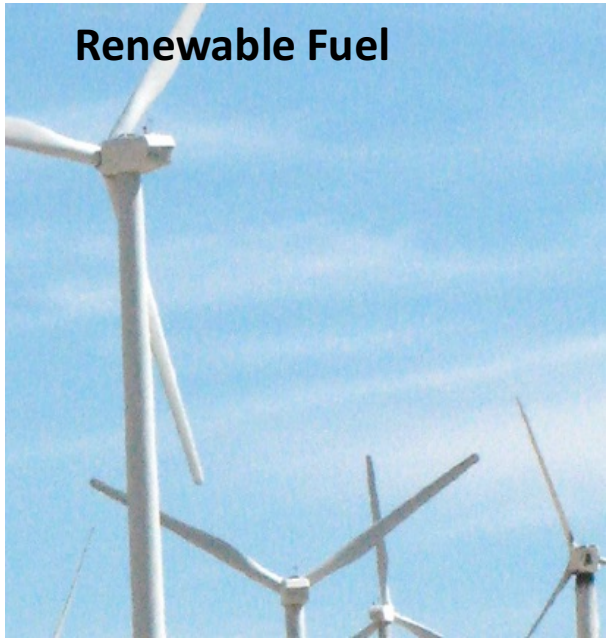
Three applications of CRI PtL platform



Recover hydrogen released by chemical and steel plants



Use **excess thermal capacity** to make hydrogen



Use **renewable energy** to make hydrogen

Project at Steag Lünen coal-power plant, Germany

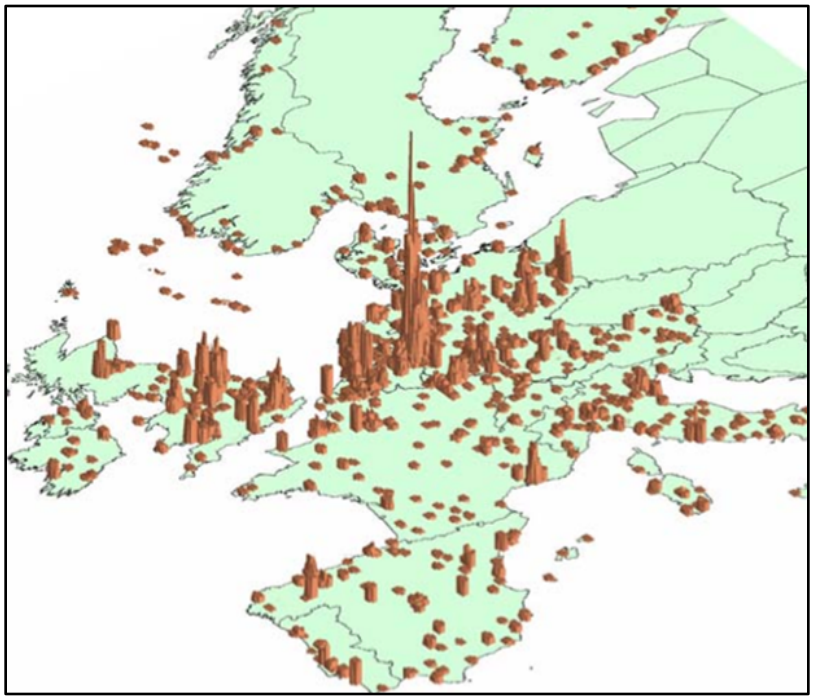
Input: 1 MW electric + 500 t/yr CO_2
Output: 400 t/yr methanol
Capacity: 1 t/day

$MethCO_2$ Horizon 2020 (€8.6/m)
Collaboration with STEAG, MHPSE, Hydrogenics and EU universities

Sources of Carbon Dioxide

Capturing carbon dioxide from flue gas with concentration >15%

Locations of concentrated CO_2



Concentrated CO_2 in EU: >1.3 billion tons

Equivalent to >27000 sites with 100 t/day capacity

	CO_2 Mt/year	Number of sources	CO_2 percent in flue-gas
Power plants	1033	795	15%
Steel	153	62	15-30%
Cement	125	215	15-30%
Ammonia	17	42	100%
	1328	**1114**	

Sources of hydrogen

Focusing on locations with concentrated sources of H_2 in Europe

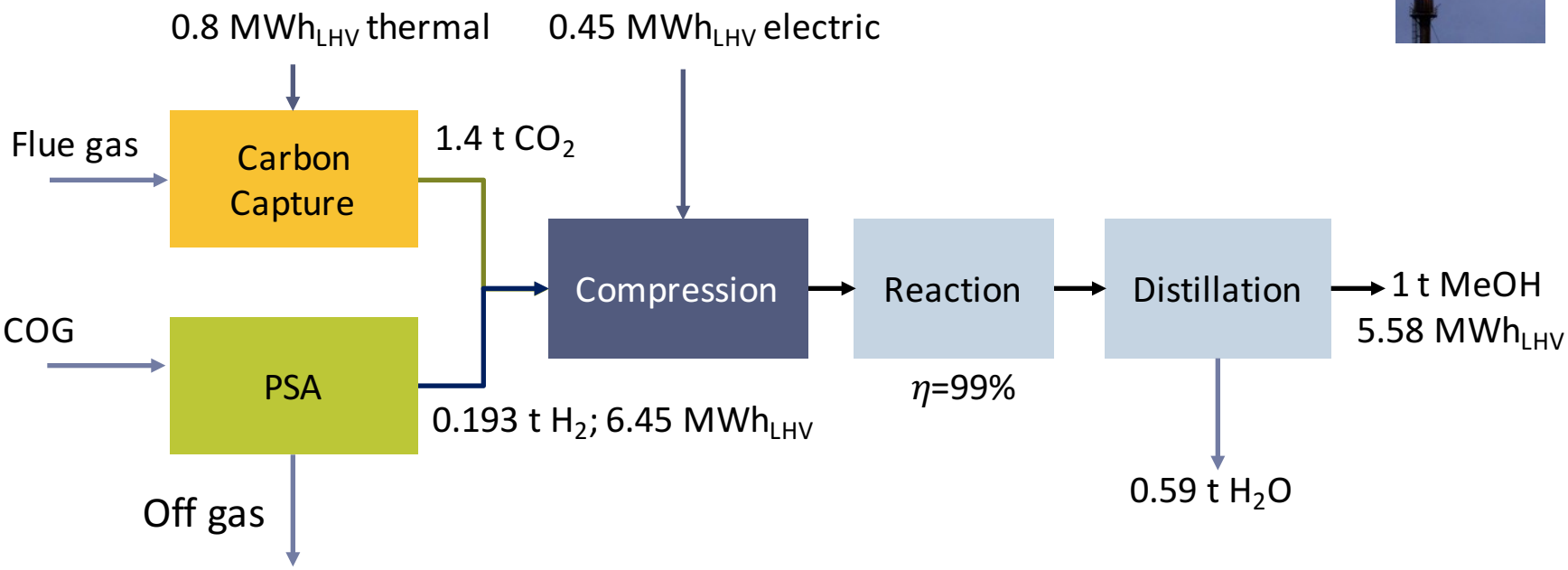
Chemical production sites with H_2 as a by-product and concentrated CO_2

Equivalent to >100 sites with 100 t/day capacity

Long term total production of methanol 6 million tons per year

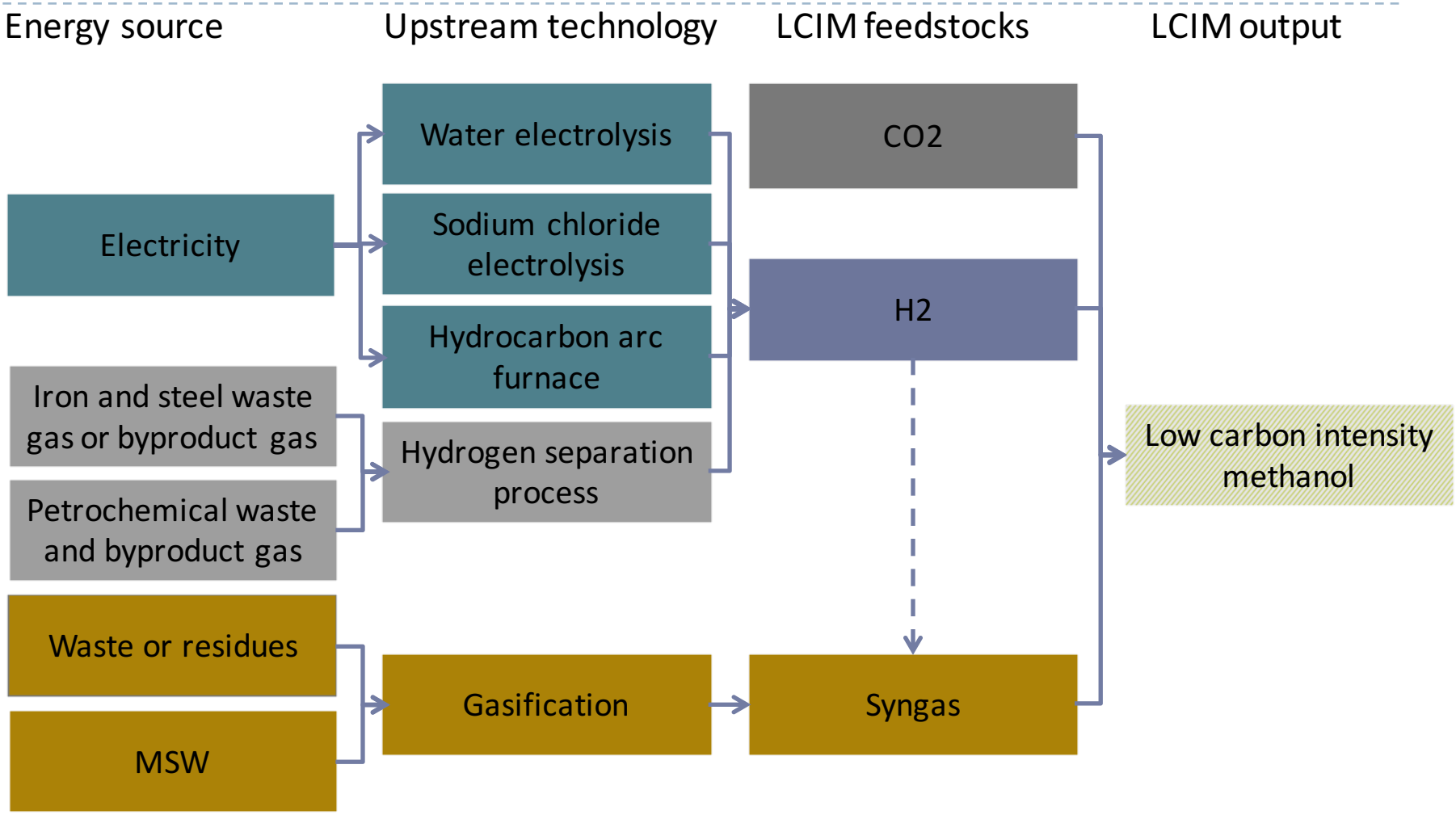
ETL mass energy balance and efficiency: captured H_2

Total energy input: 7.7 MWh/t methanol with overall efficiency >70%



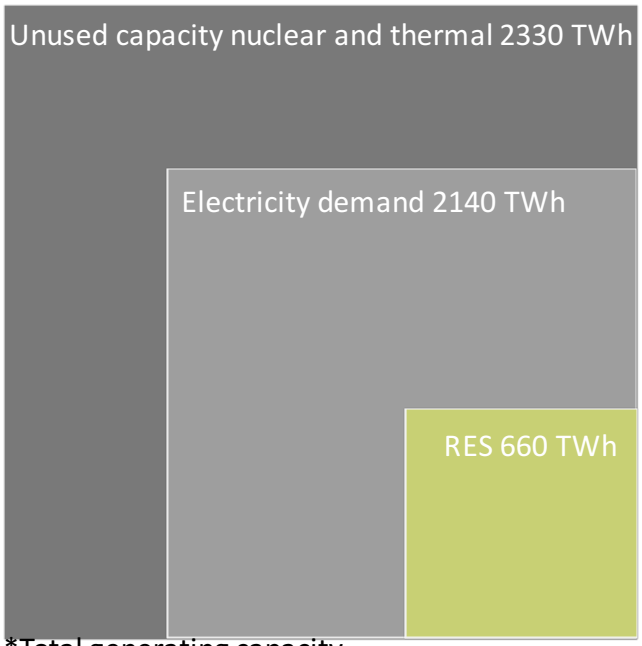
*Not including PSA

Low Carbon Intensity Methanol production processes



Opportunities for power-to-methanol in EU-28

Electricity market 5120 TWh*

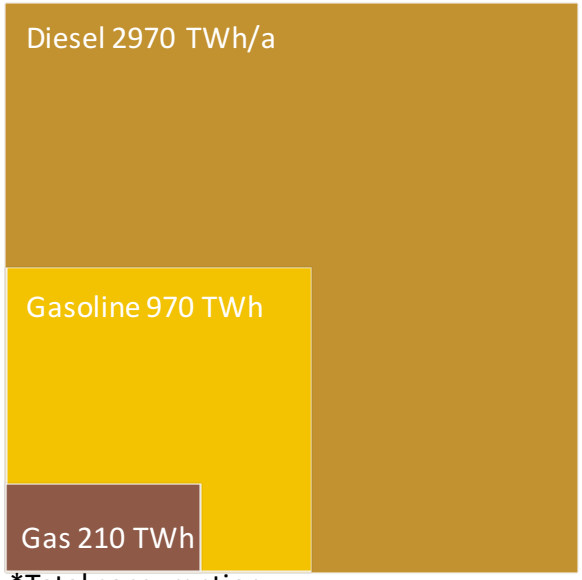


*Total generating capacity

20%

20%

Road fuel market 4157 TWh*



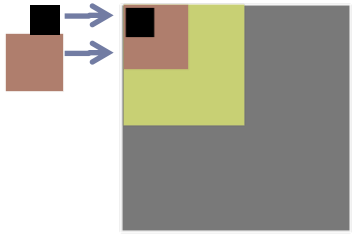
*Total consumption

Energy recovery

Hydrogen from chlor-alkali process 9 TWh

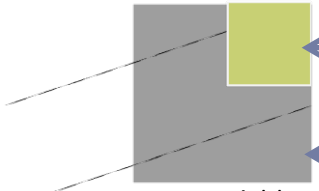
Hydrogen from coke-oven gas 37 TWh

Power-to-liquids



640 TWh

Supply of PtL methanol



"Green" methanol 80 TWh

Low CO_2 methanol 310 TWh

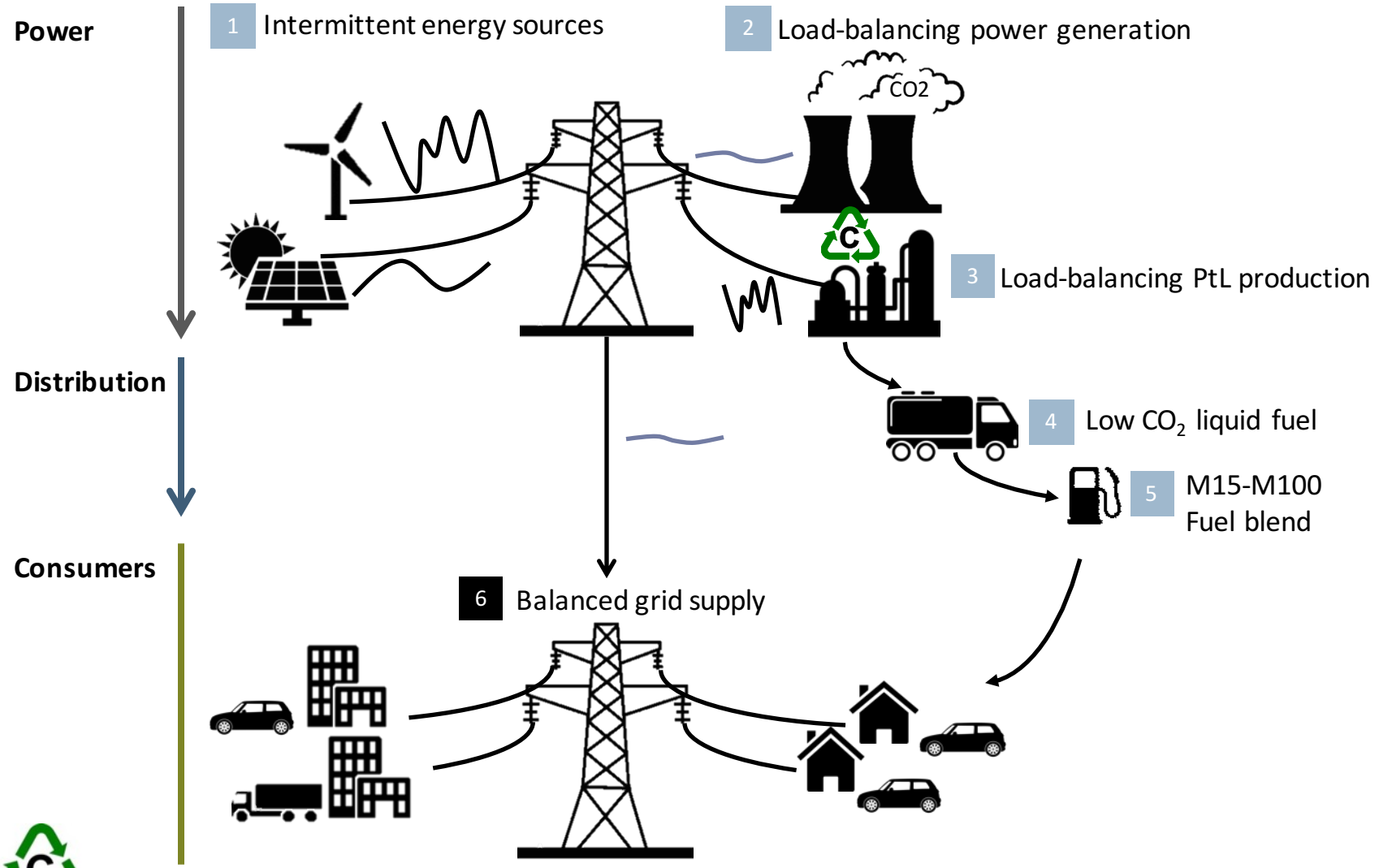
390 TWh**

Current gasoline cons.

**33 million metric tons of oil equivalent

Source: Eurostat 2012, Eurochlor 2013, Eurocoal 2011

Methanol from CO2 and electricity for transition to renewable power and clean fuel



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