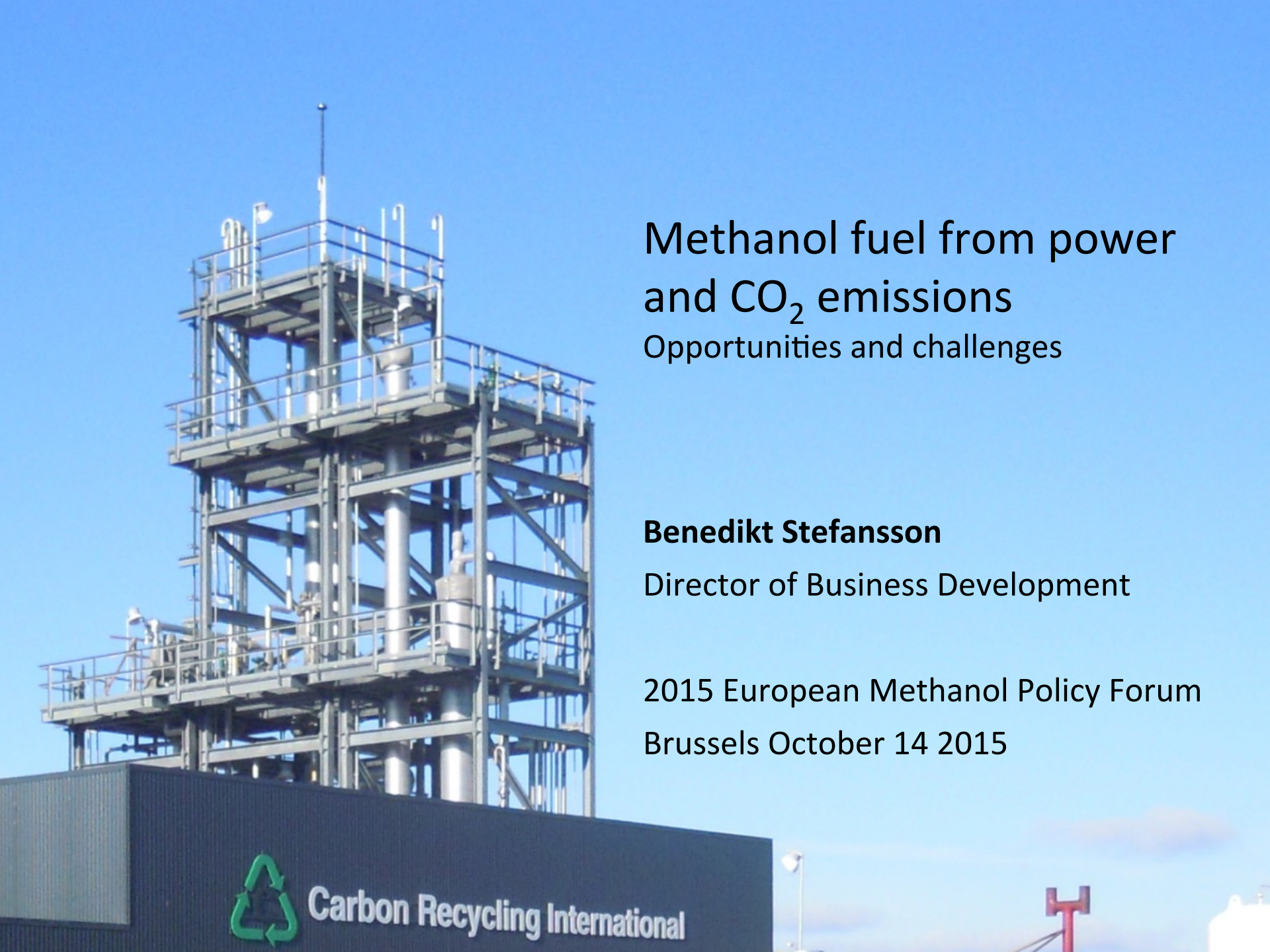


Methanol fuel from power and CO_2 emissions

Opportunities and challenges

Benedikt Stefansson

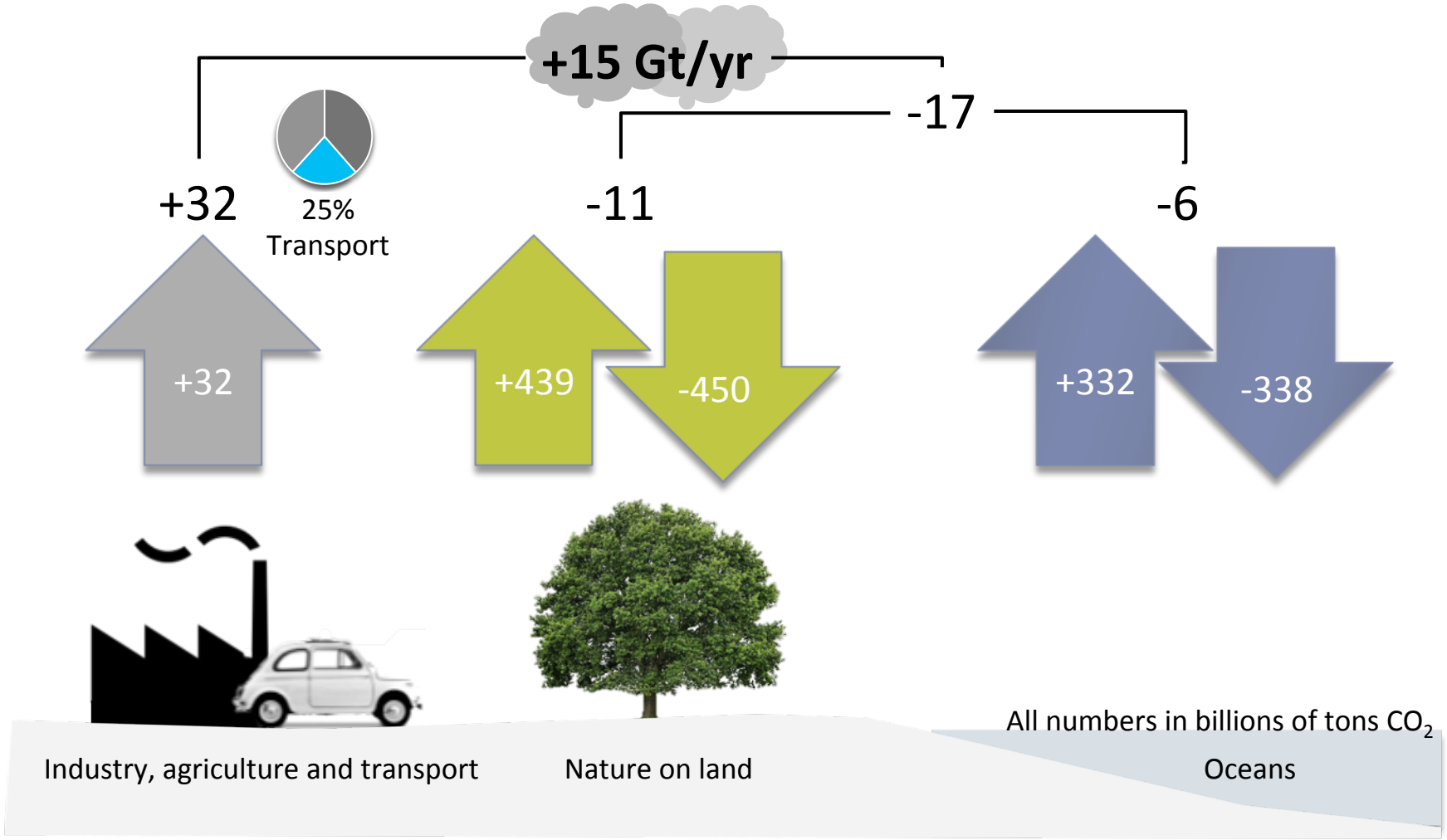
Director of Business Development

2015 European Methanol Policy Forum

Brussels October 14 2015

Our imperative

Global GHG impact from human and natural activity



Source: UN IPCC / IEA

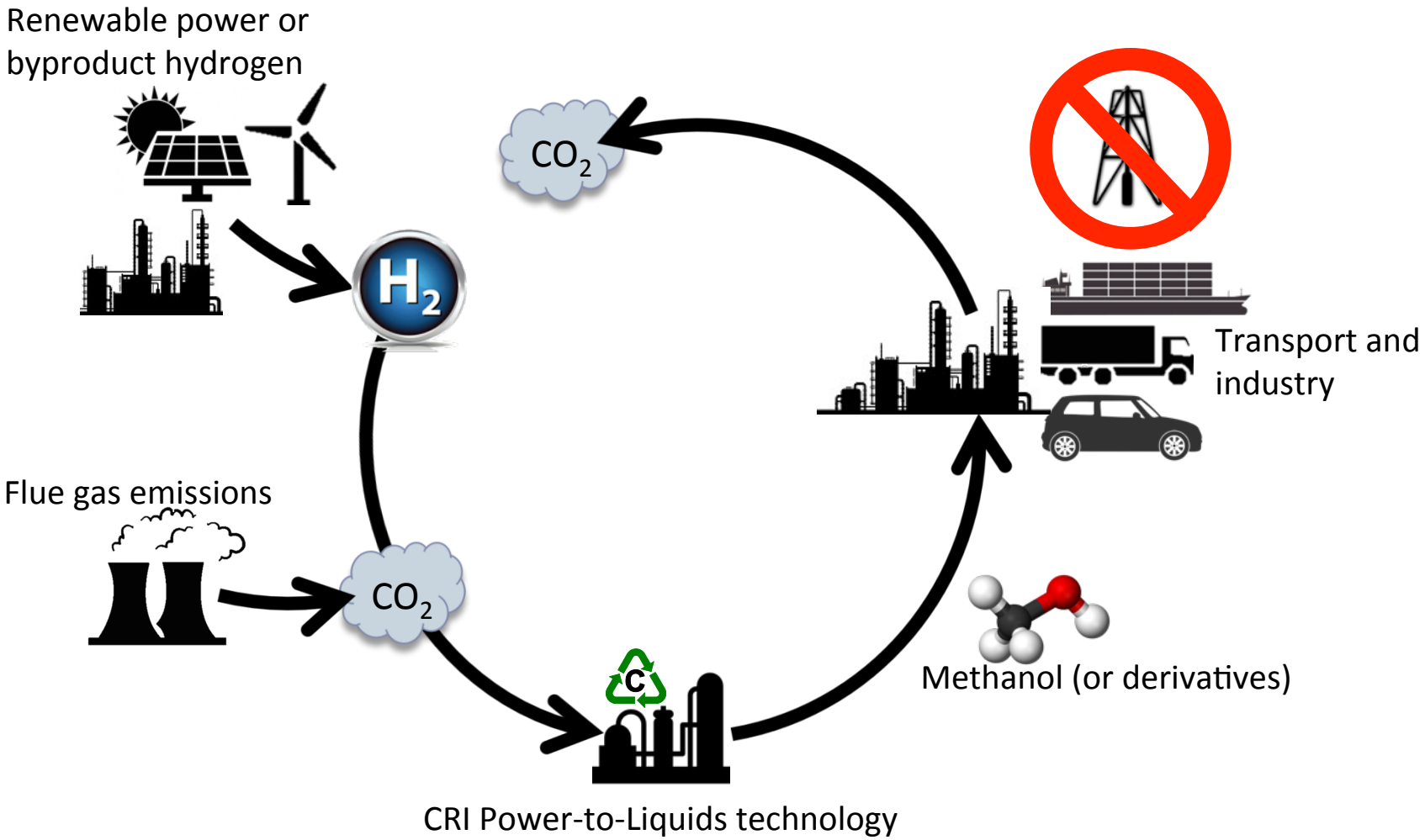
Drivers for GHG emissions intensity 1990 - 2012

GHG Emissions = Population × Affluence × Efficiency

Region	CO_2	Population	GDP / Population	Energy / GDP	CO_2 / Energy
World	+51%	**+33%**	**+57%**	-27%	-1%
EU-28	-14%	+6%	+37%	-31%	-14%
US	+4%	+26%	+38%	-35%	-7%
China	+262%	+19%	+579%	-59%	+9%
India	+237%	+42%	+179%	-37%	+35%

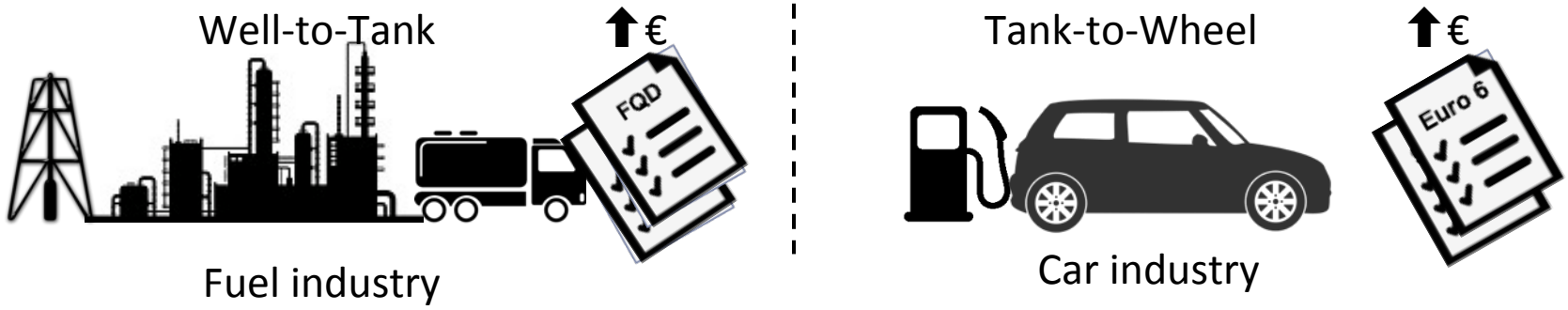
Source: IEA CO2 Emissions From Fuel Combustion 2014

Low carbon intensity methanol: energy carrier in a circular economy

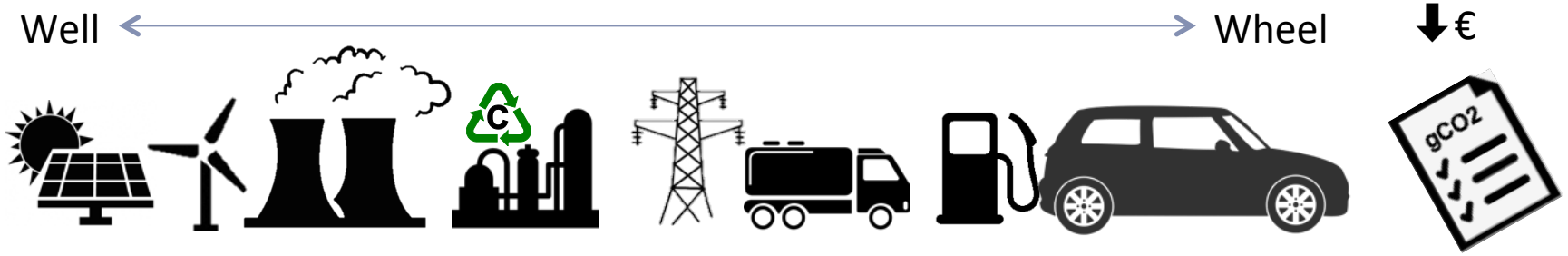


Cleaner future by reducing pollution on **Well-to-Wheels** basis

Currently: Separate activities to meet targets for reduced pollution



Future: Integrated approach to reduce pollution on Well-to-Wheels basis

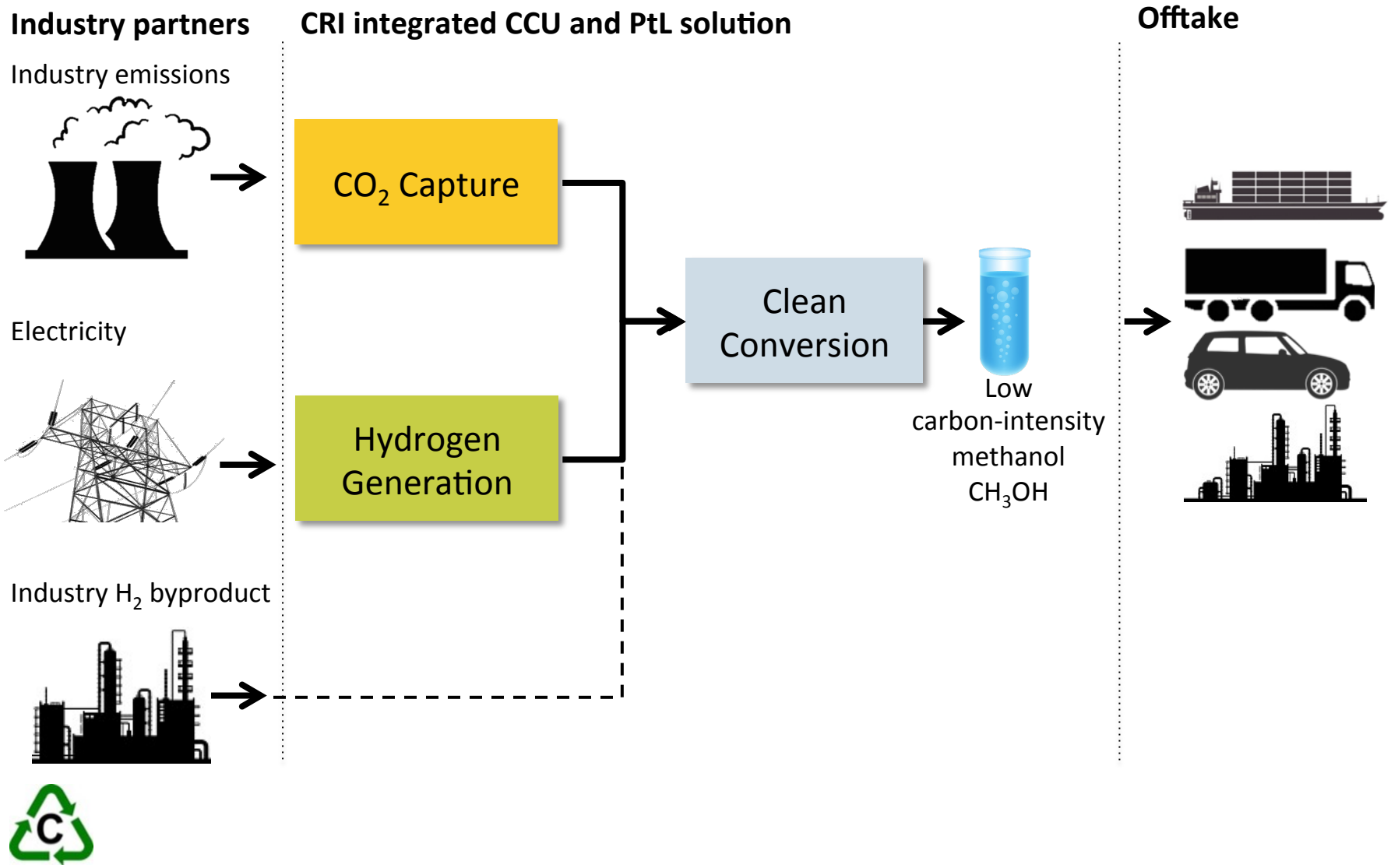


From problem to solution (one bite at a time)

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 largest methanol provider invests**	**Plant expanded** to 4,000 t/yr capacity	Marketing of technology & partnerships **Investment by Geely owner of Volvo Cars**

CRI's Power-to-Liquids platform



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

Customers

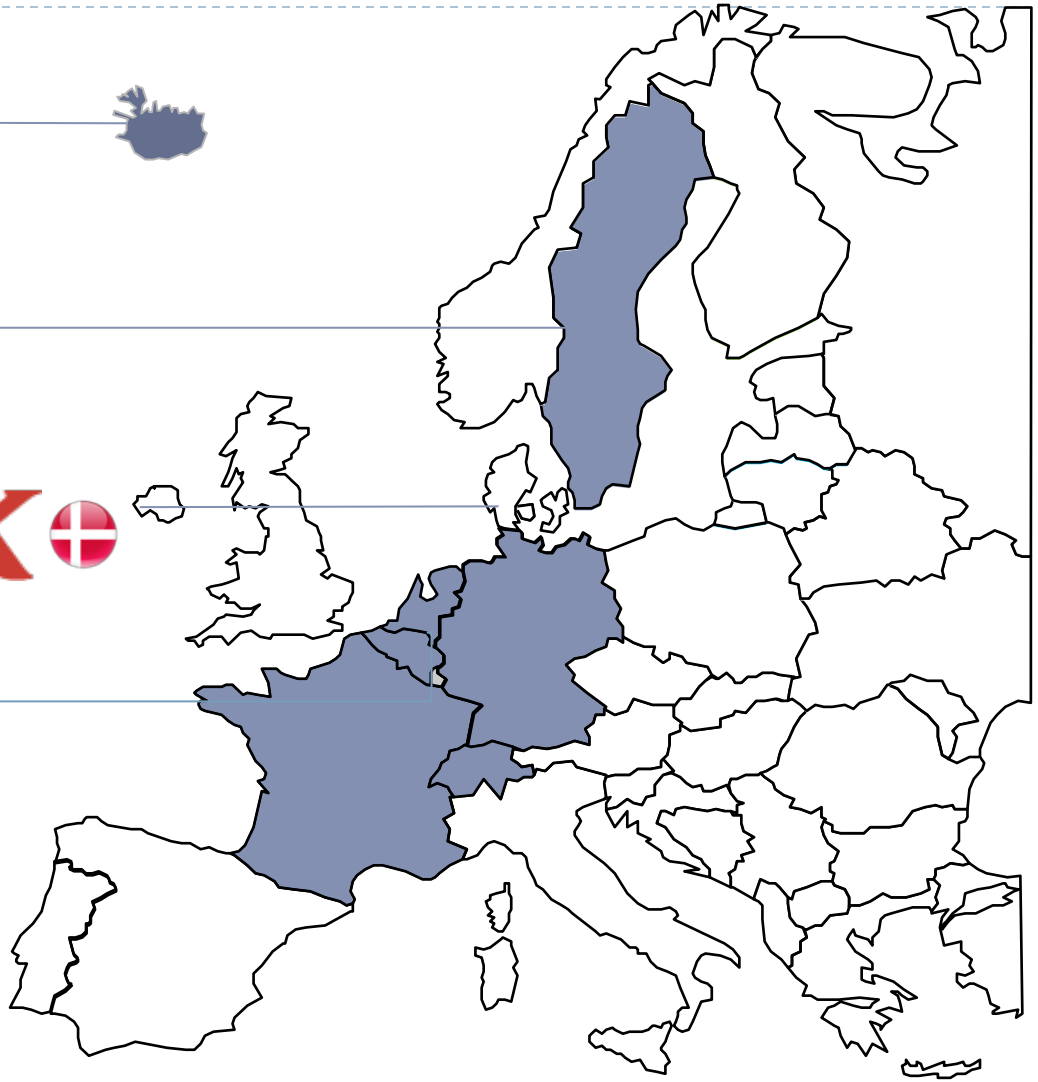
Perstorp

Ser energy®
The Power of Simplicity

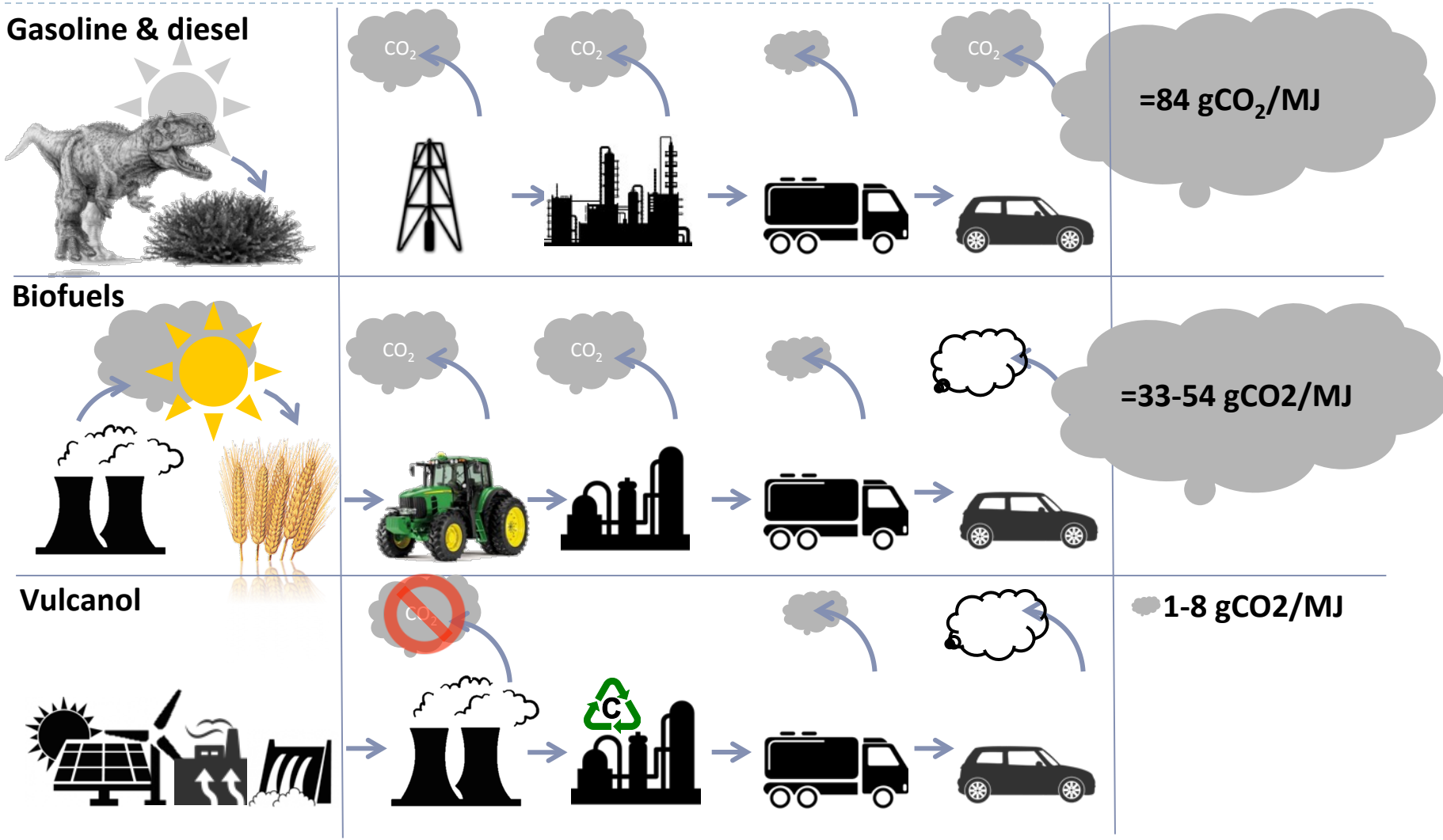
OK

Argos

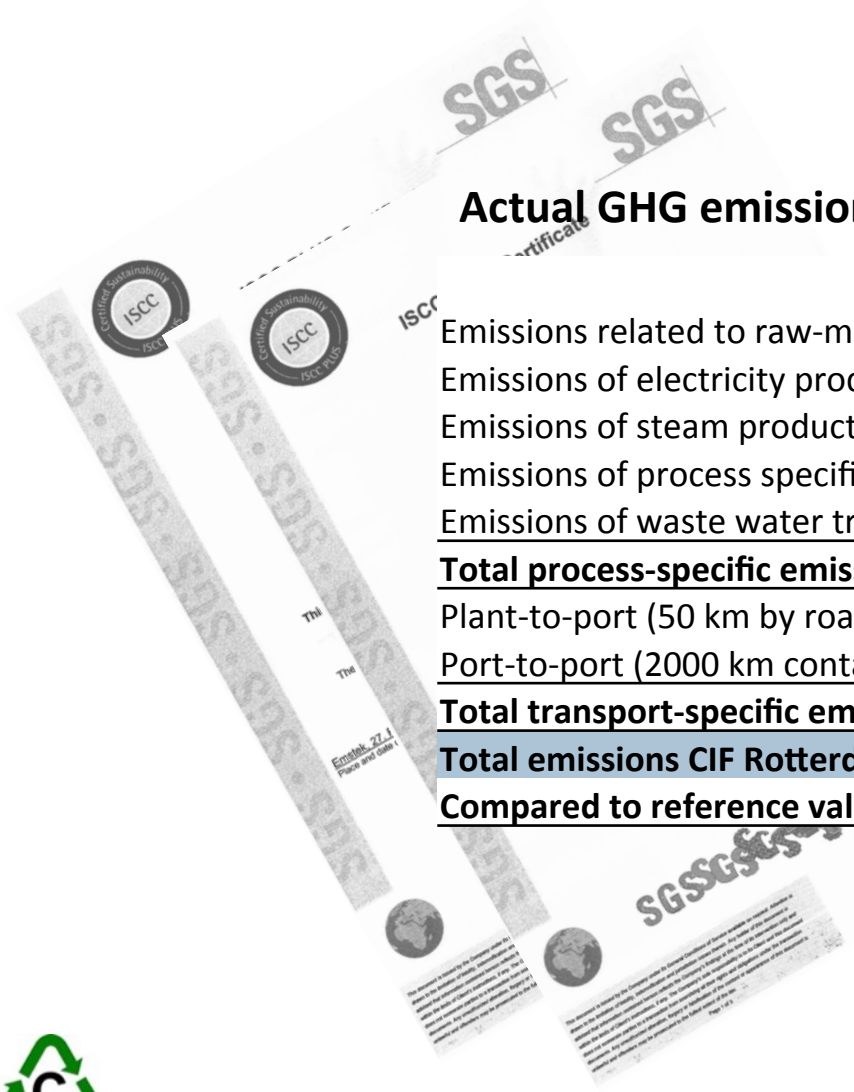
GUTTS®



Framework to compare CO_2 life cycle emissions of fuels



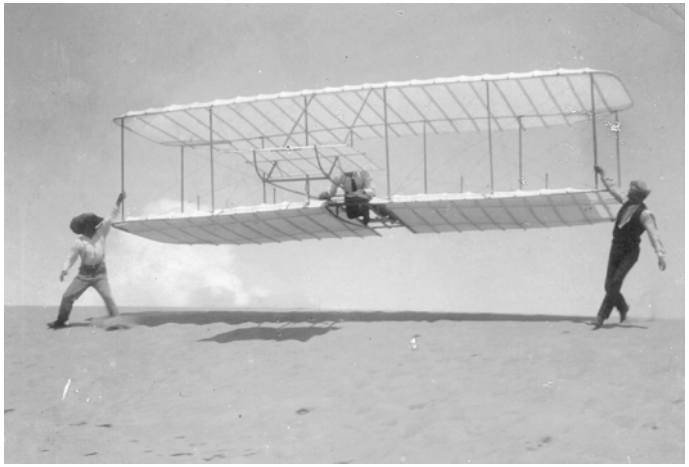
First PtL plant with ISCC+ certification of sustainability



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)**



Towards a sustainable business

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

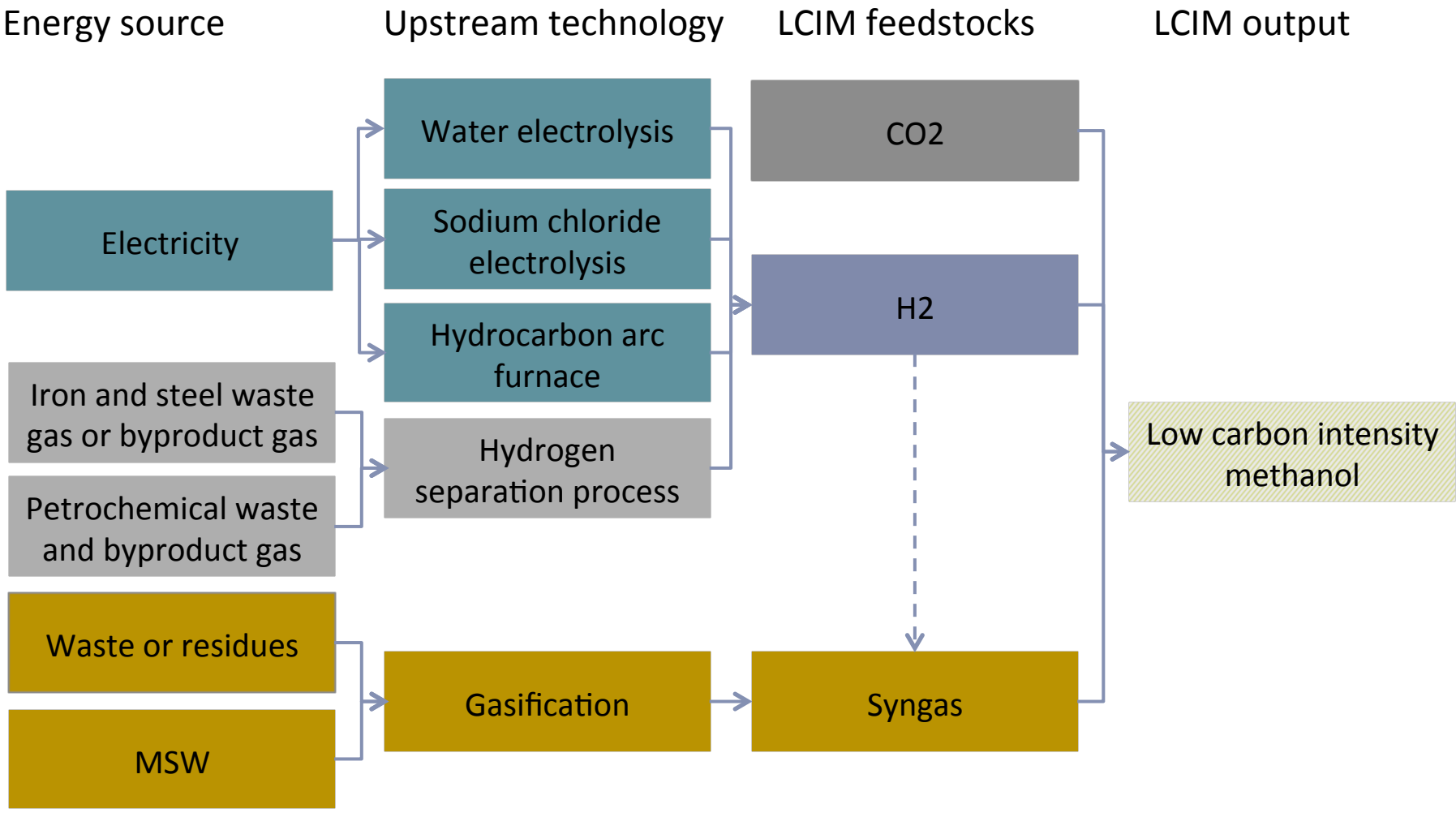
The MHPSE CRI Partnership

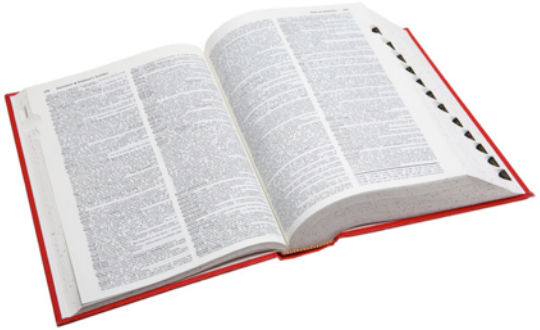
Mitsubishi-Hitachi Power Systems Europe (MHPSE) and CRI have combined their resources to offer integrated industrial solutions for carbon capture and power-to-methanol production.

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

Low Carbon Intensity Methanol production processes





The impact of regulation

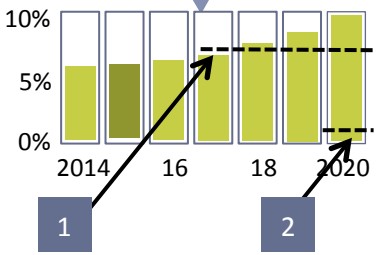
EU fuel regulatory framework: moving from agricultural policy to sustainability focus

EU 2009: 20% GHG reduction/20% efficiency improvement/20% renewable share)

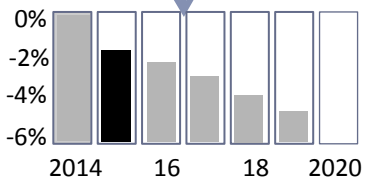
Renewable Energy Directive (2009/28;RED)

Renewable energy in transport:
10% minimum share by 2020

3

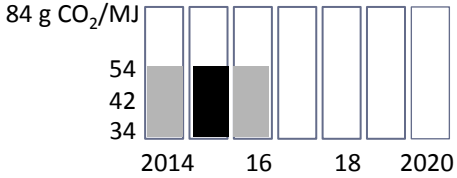


Fuel Quality Directive (2009/30; FQD)



CO_2 footprint of all fuel:
Minimum 6% reduction by 2020

4



Biofuel CO_2 footprint:
Maximum 34 gCO2/MJ after 2017

4

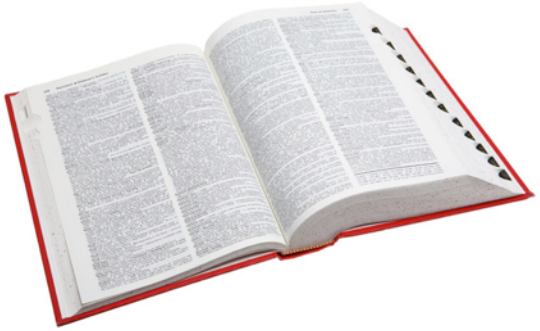
2015 ILUC amendment (to RED and FQD)

1 **Maximum 7% from crop based fuel**	3 **Double counting energy from advanced fuels**
2 **Minimum 0.5% from advanced fuel**	4 **CO2 release because of land use change reported**

Transposed by EEA Member States before July 2017

The three pillars of EU policy for renewable transport fuels of non-biological origin

Inclusive terminology

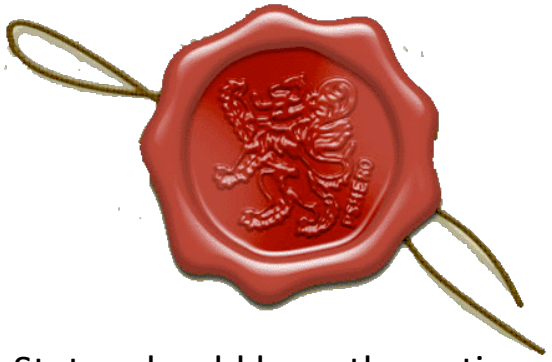


Define the term **renewable gaseous or liquid fuel of non-biological origin**

Sustainability criteria

Provide **sustainability criteria and a methodology to verify the green-house gas footprint**

Guarantees of Origin



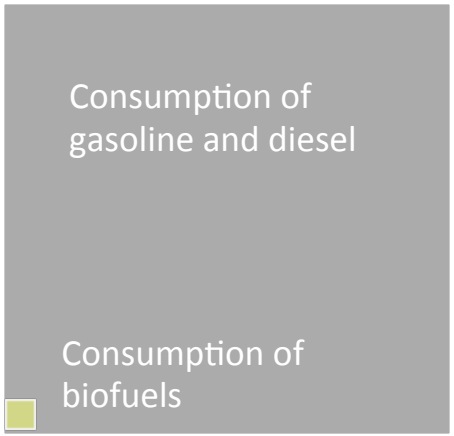
States should have the option to use **Guarantees of Origin** for energy to meet transport target

We urge the Council, Parliament and Commission to implement policy which allows us to power transport with low carbon intensity fuels from renewable energy today

cri.is etogas.com eu.mhps.com nel-hydrogen.com hydrogenics.com argos.nl

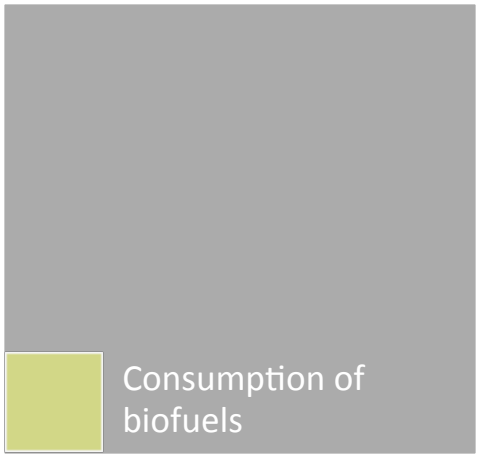
Share of renewable fuels in EU-28 road transport until 2020

2002: 0.4% of energy



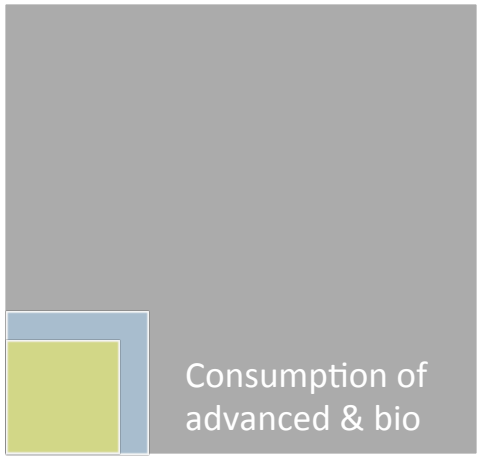
Biofuels	(0.4%)	1.1
Advanced		
Gasoline		97.0
Diesel		168.7
Total Mtoe		**266.9**

2013: 4.7% of energy



Biofuels	(4.7%)	13.6
Advanced	(0.0%)	
Gasoline		69.1
Diesel		196.8
Total Mtoe		**279.4**

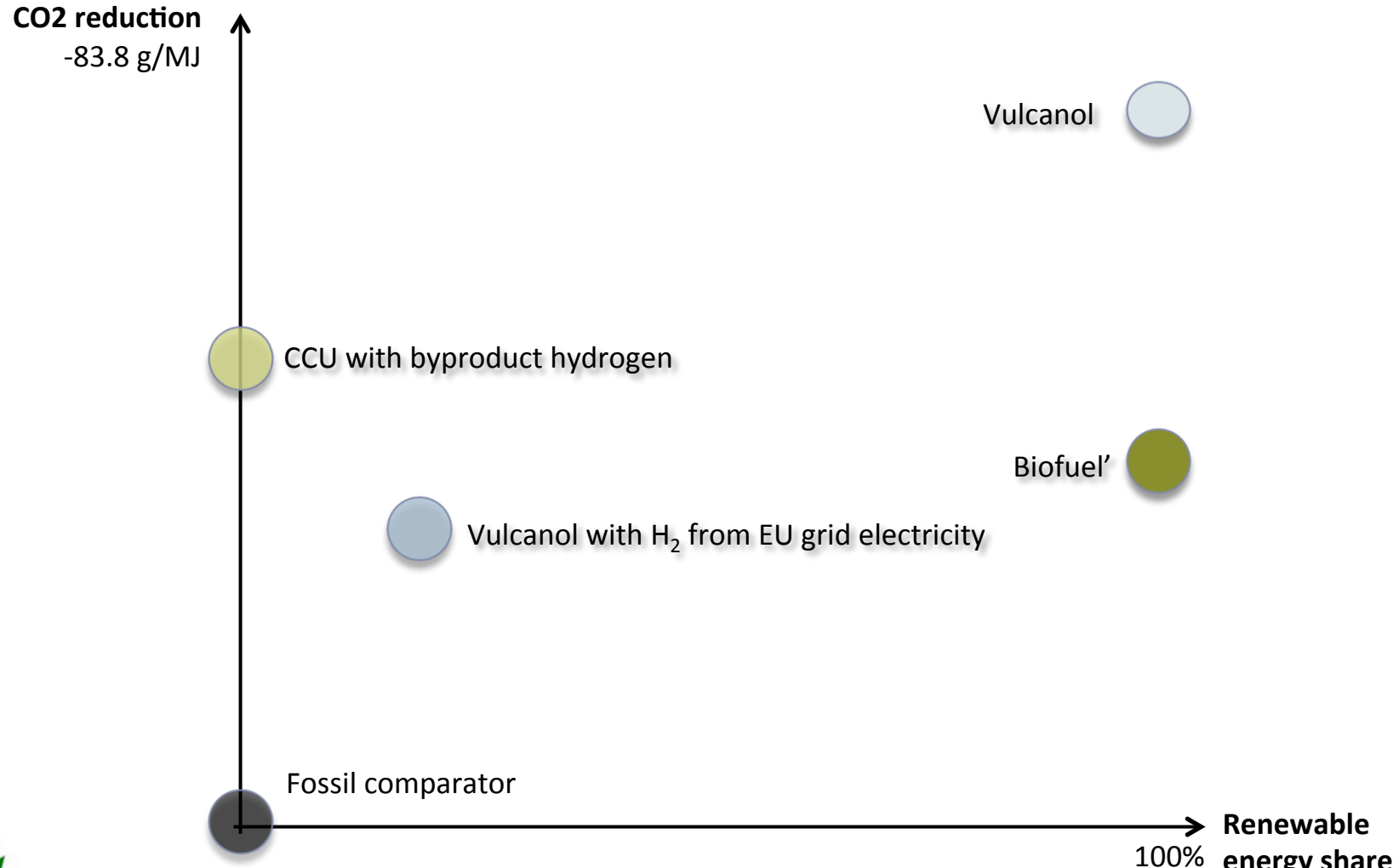
2020: 10% of energy
Biofuels 7% maximum
Advanced 0.5% minimum



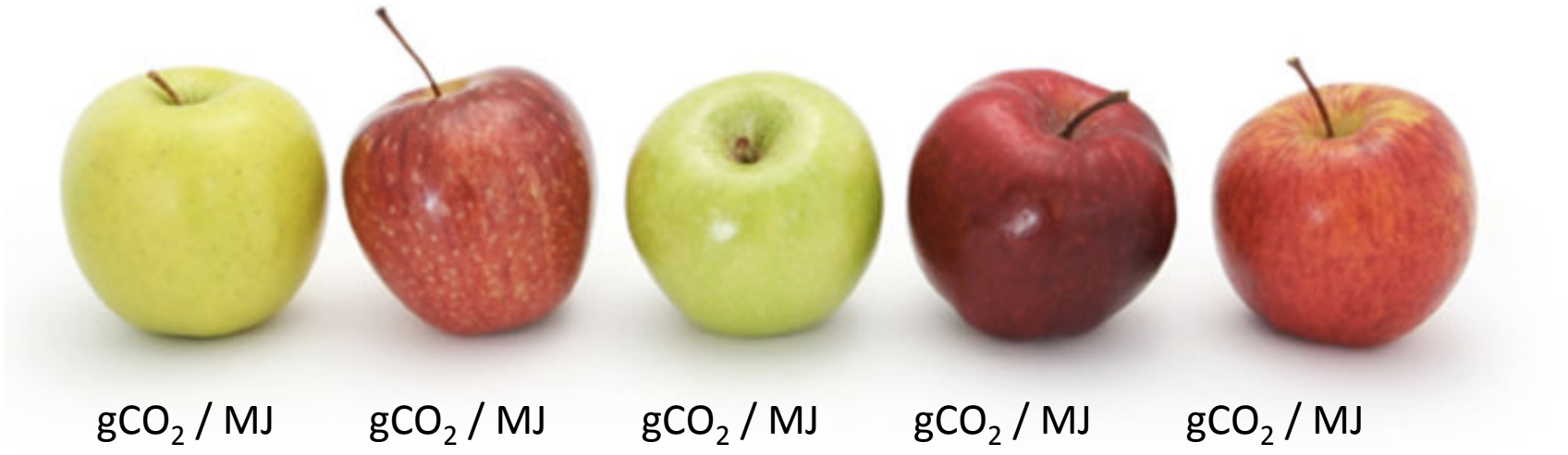
Biofuels	(6%)	18.5
Advanced	(4%)	11.0
Gasoline		64.0
Diesel		185.9
Total Mtoe		**279.4**

Source: Eurostat, EurObserver, European Commission

EU framework mixes two metrics: CO_2 reduction per unit energy and overall share of renewable energy

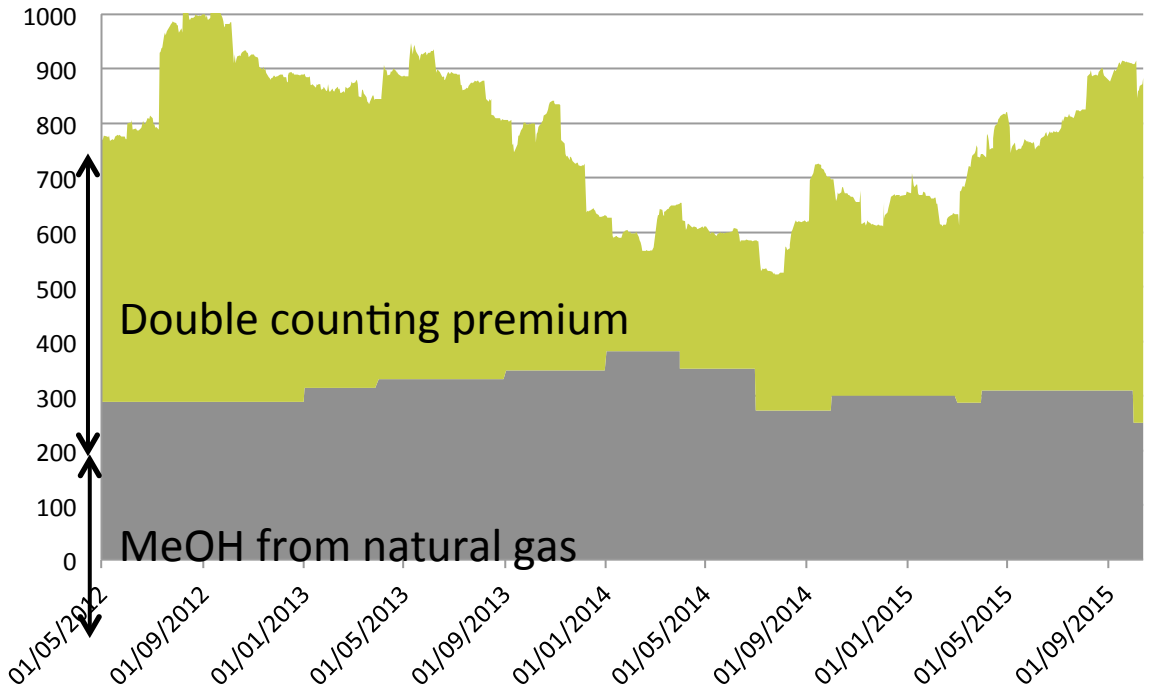


CO_2 reduction is the relevant metric

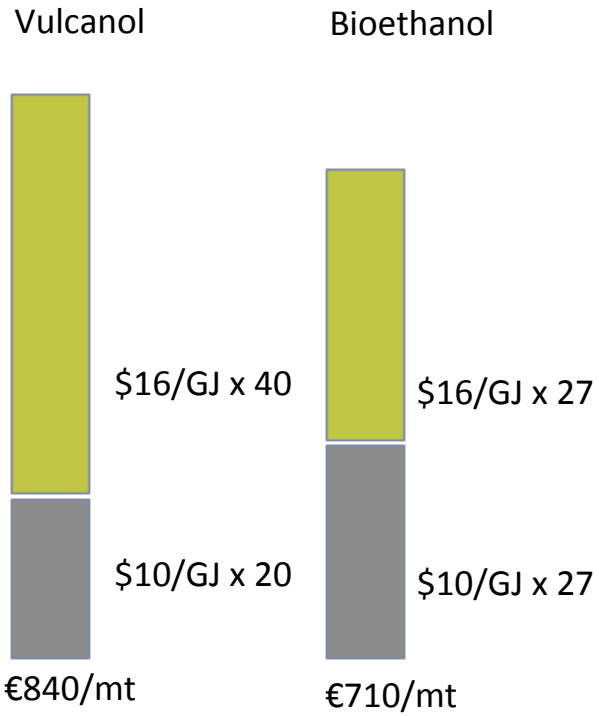


Market value of renewable methanol in Europe

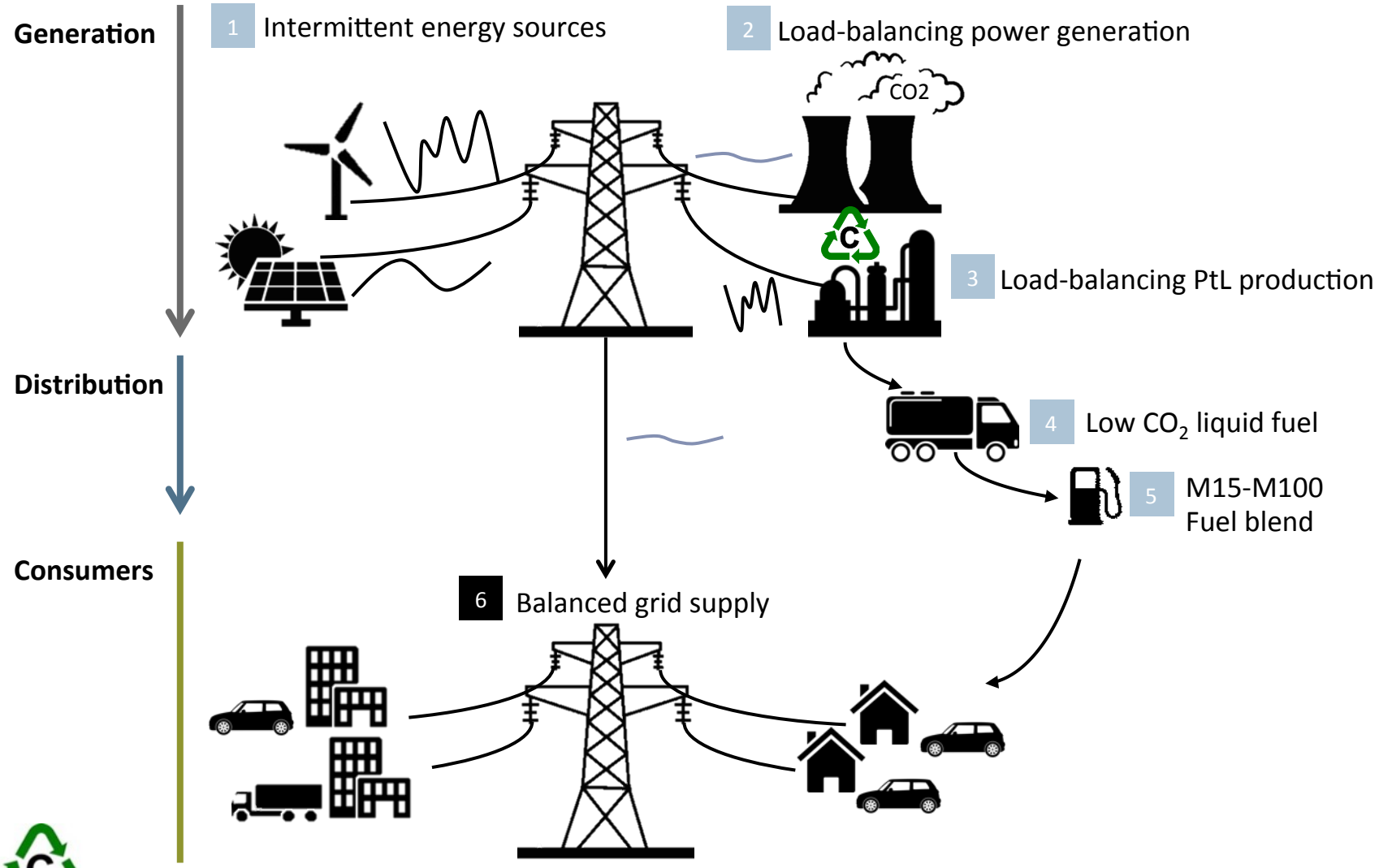
Market prices (€/mt)



Market premia



Methanol from CO2 and electricity: energy carrier and storage for renewable transition

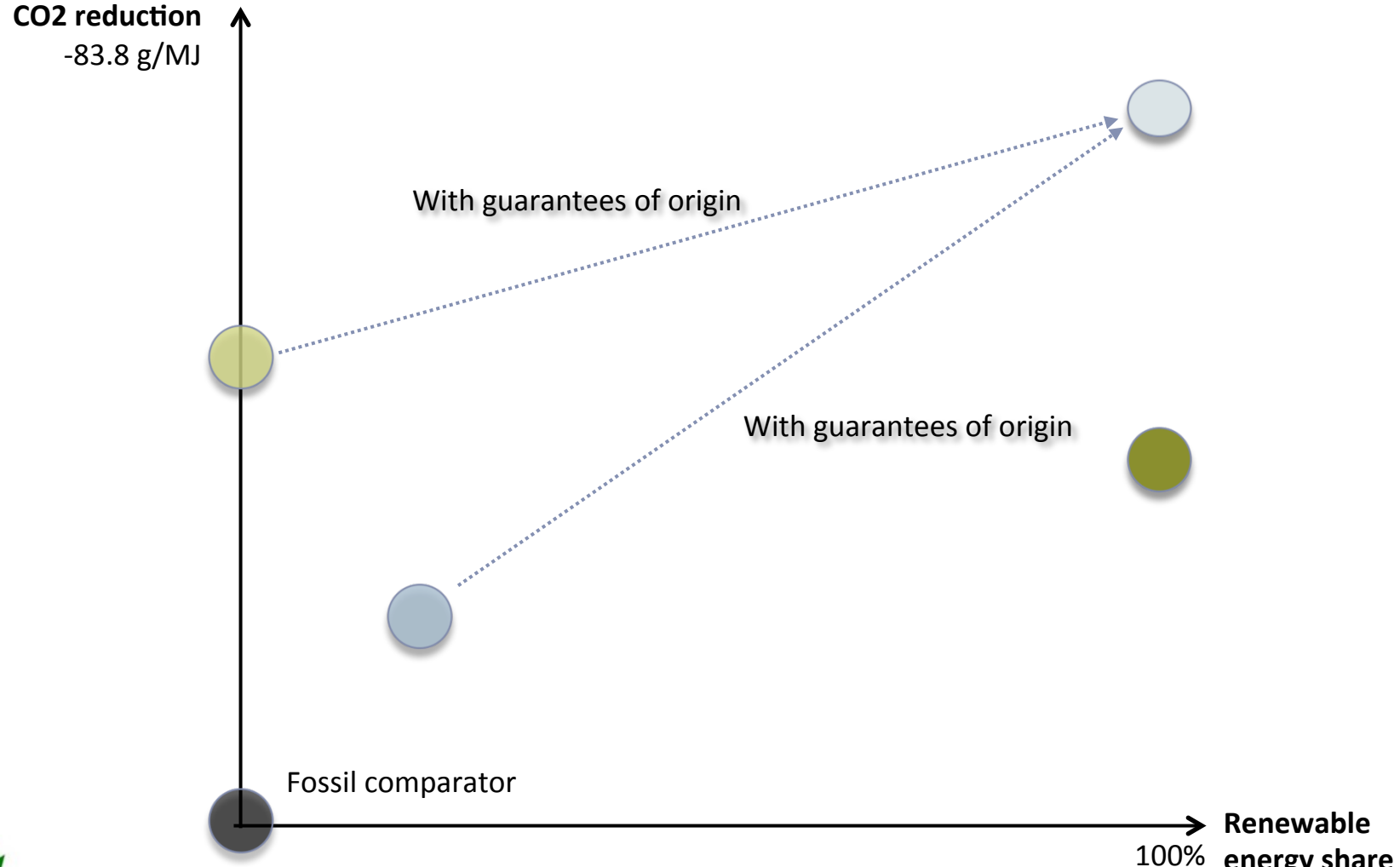


Two birds with one stone

Power to fuel

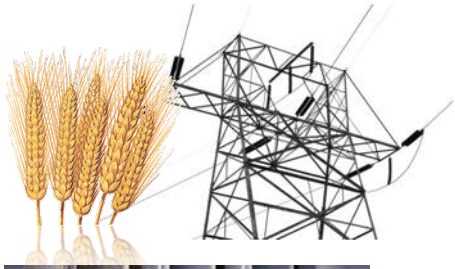
Demand side management

Guarantees of origin are missing instrument for transport target problem of double dipping can be addressed and eliminated



Summary

- Current RED finally provides roadmap to non-bio renewable fuels and CCU fuels



Non-bio renewable fuels will play vital role as a scalable and sustainable solution

- Level playing field a necessary condition for the development of advanced fuels

- PtL technology demonstrated at scale and addresses upstream and downstream issues

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