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# Market power in Power-to-Gas and related markets? Preliminary insights for the upcoming interrelated power, gas, and hydrogen industries.

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### Motivation

#### POWER-TO-GAS?

Currently produced from gas, hydrogen can be **produced from renewable electricity by electrolysis of water**. This technology, called Power-to-Gas (PTG), is one solution considered to:

- Provide flexibility to the electricity system
- Replace coal, oil, natural gas, and conventional hydrogen for uses where energy needs cannot economically be met by electricity
- Contribute to the energy security by decreasing dependency on fossil fuels

icons are from Flaticon

PTG is an early technology with high investment costs. First movers in PTG are firms with a strong oligopolistic presence in either the power, gas, or H2 markets

#### Do Industrial Organization considerations matter for the operation of Power-to-Gas?

This study aims at comparing the market outcomes obtained under different asset-ownership structures for PTG in an imperfect power, gas and hydrogen system.

### Model

Our analysis is based on a stylized partial equilibrium model that simulates **the interactions between the markets for natural gas, power and hydrogen**.

The model is formulated as a deterministic, discrete-time, finite-horizon oligopoly model that explicitly considers the imperfectly competitive structures prevailing in these three sectors.

The model is **solved as an instance of a Mixed Complementarity Model (MCP)**

#### Agents' maximization problems

Max. Profits

s.t. constraints (capacity, efficiency, ramp-up constraints...)

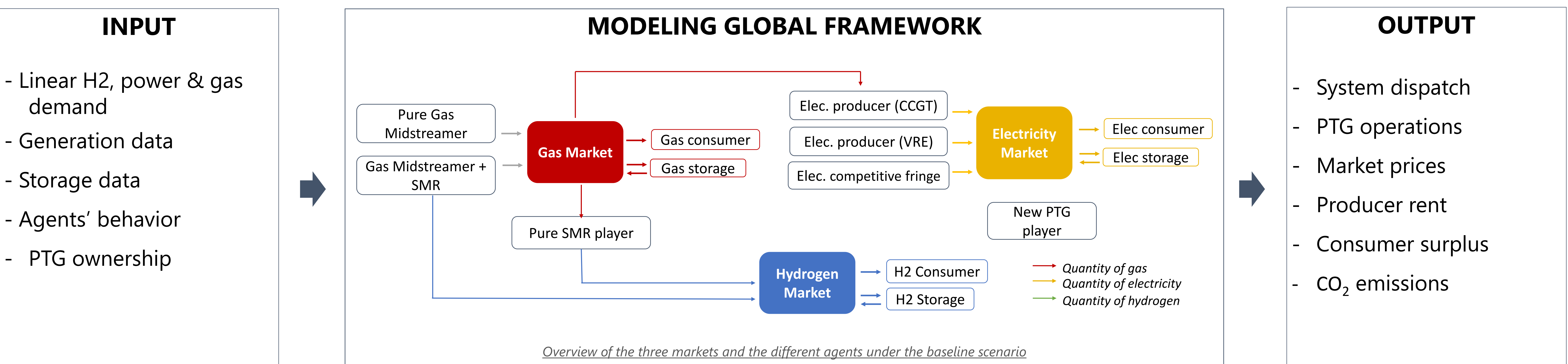
#### Market Clearing condition

#### Scenarios

Alongside our baseline scenario without PTG, we define a series of **alternative scenarios that represent various PTG-ownership structures**.

Scenario	PTG ownership
No PTG (Base case)	No PTG
H-New Prod	New PTG player
H-SMR	Pure SMR player
G-Gas	Pure Gas midstreamer
G-Gas+SMR	Gas midstreamer + SMR
E-CCGT	Elec. Producer (CCGT)
E-VRE	Elec. Producer (VRE)

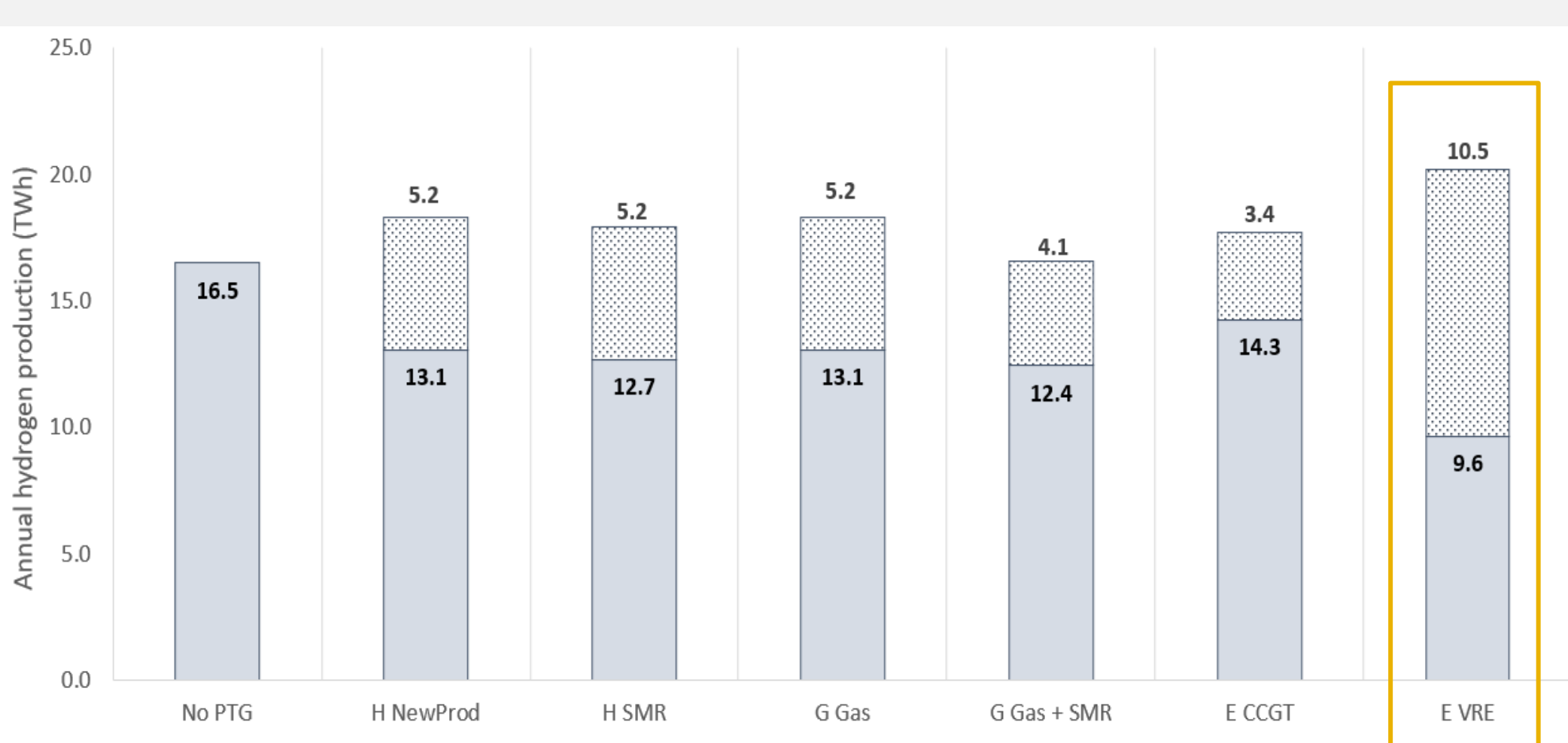
SMR : Steam Methane Reforming / CCGT : Combine Cycle Gas Turbine / VRE : Variable Renewable Electricity



### Key Findings

#### PTG ownership structure matters

VRE-electricity producers tend to use PTG more than other agents as they own the VRE capacities needed to produce renewable-based hydrogen



Annual hydrogen production per scenario (TWh)

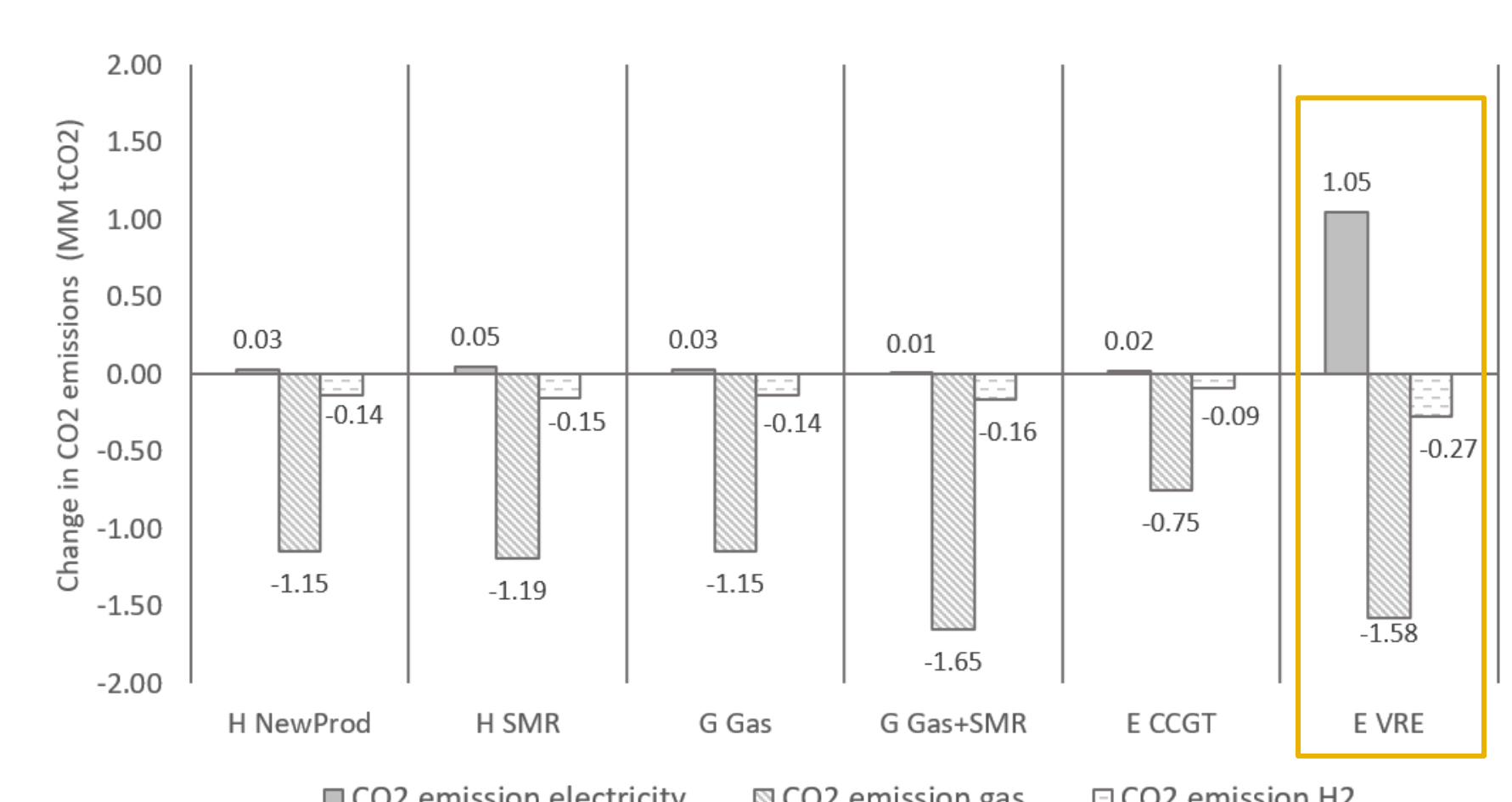
#### An extensive use of PTG may raise social and environmental concerns

**Social**, because even if, the change in **short-term welfare** associated with the addition of PTG is positive, its **distribution is unequal**.

	No PTG	H NewProd	H SMR	G Gas	G Gas+SMR	E CCGT	E VRE
<b>Elec</b>							
E-VRE	/	+0.55	+0.56	+0.55	+0.44	+0.36	+0.84
E-CCGT	/	+0.00	+0.00	+0.00	+0.00	+0.17	+0.00
E-Fringe	/	+0.45	+0.45	+0.45	+0.34	+0.27	+0.73
<b>Gas</b>							
G-Full Gas	/	-0.04	-0.05	+0.13	-0.01	-0.02	-0.01
G-Gas+SMR	/	-0.17	-0.15	-0.17	+0.03	-0.11	-0.26
<b>H2</b>							
H-Full SMR	/	-0.02	+0.14	-0.02	-0.00	-0.02	-0.03
H-NewProd	/	+0.17	/	/	/	/	/
<b>Total Producer rent change</b>	/	<b>+0.95</b>	<b>+0.95</b>	<b>+0.95</b>	<b>+0.79</b>	<b>+0.65</b>	<b>+1.27</b>
<b>Electricity welfare</b>	/	-0.81	-0.81	-0.81	-0.61	-0.50	-1.39
<b>Gas Welfare</b>	/	+0.03	+0.05	+0.03	+0.01	+0.02	+0.01
<b>H2 Welfare</b>	/	+0.10	+0.08	+0.10	+0.00	+0.06	+0.21
<b>Total Consumer welfare change</b>	/	<b>-0.68</b>	<b>-0.68</b>	<b>-0.68</b>	<b>-0.60</b>	<b>-0.42</b>	<b>-1.17</b>
<b>Overall Welfare change</b>	/	<b>+0.27</b>	<b>+0.26</b>	<b>+0.27</b>	<b>+0.20</b>	<b>+0.23</b>	<b>+0.09</b>

Impact of PTG on welfare (Bn €)

**Environmental**, because PTG use could **indirectly lead to an increase in carbon-based electricity generation**



Change in CO2 emissions by sector compared to the "No PTG" case (MM tCO2)