Power to gas and decarbonisation pathways

Direzione Centrale Strategia, Regolazione ed Enti Locali
Pianificazione Strategica e Policy Making
11.06.2020

Gruppo Hera and its main businesses and figures

ENVIRONMENTAL SERVICES
7,2 mln/ton OF WASTE HANDLED
3,2 mln CITIZEN SERVED

INTEGRATED WATER CYCLE
289,3 mln/m³ OF WATER SOLD
3,6 mln CITIZEN SERVED

GAS DISTRIBUTION
3,0 mld/m³ OF GAS DISTRIBUTED
2 mln CITIZEN SERVED

SALE OF ELECTRICITY
12,8 TWh OF ELECTRICITY SOLD
1,3 mln CUSTORMER SERVED

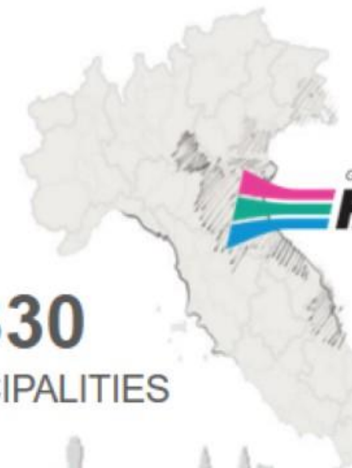
7,4 mld € Revenues
1,1 mld € EBITDA

2 mln/ton OF URBAN WASTE COLLECTED

35,359 km OF WATER NETWORK

20,901 km OF GAS NETWORK

12,602 km OF ELECTRICITY NETWORK



9,079 WORKERS

330 MUNICIPALITIES

CE100 · UN Global Compact · The CEO Water Mandate

Who are we? And what do we know?

Stefano Verde

Strategy and Policy Making Manager

Previous working experience

- 2009 – 2012, Head of Power and Environmental Markets Trading Desk @ **Hera Trading S.r.l.**, Imola
- 2008 – 2009, Policy Officer @ **Italian Energy Regulatory Authority** (ARERA), Milan
- 2006 – 2008, Consultant and Researcher @ **Ricerche Industriali ed Energetiche**, Bologna
- 2005 – 2006, Intern & Policy Officer @ **European Commission**, DG Enterprise, Brussels

Academic background

- **Ph.D** in Law and Economics, LUISS University (Rome)
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- **BA + Master** degree in Economics, Alma Mater Studiorum Bologna

Filippo Reggiannini

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Previous working experience

- 2017 – 2018 Senior Regulatory Affairs Specialist @ **2i RETE GAS S.p.A.**, Milan
- 2015 – 2016 Energy Economist / Consultant @ **Studio Commerciale Zucchini,** Bologna
- 2013 – 2014 Energy and Regulatory Affairs Analyst @ **REF-e Ricerca e consulenza energetica,** Milan
- 2009 – 2011 Project financing Junior Analyst @ **Sinloc Spa** – Advisory and equity investment, Padua

Academic background

- **MA** in Energy and Environmental management, @ Business School Il Sole 24 Ore, Milan
- **BA + Master degree** in Law & Economics, Alma Mater Studiorum

Structure of this lecture

Presentation Structure

- Decarbonisation Policies & Needs
- What can be considered Clean gas
- How and why gas supply chain will change
- Regulatory needs for new gases uptake

SECTION I – Decarbonisation Policies & Needs; What can be considered Clean gas

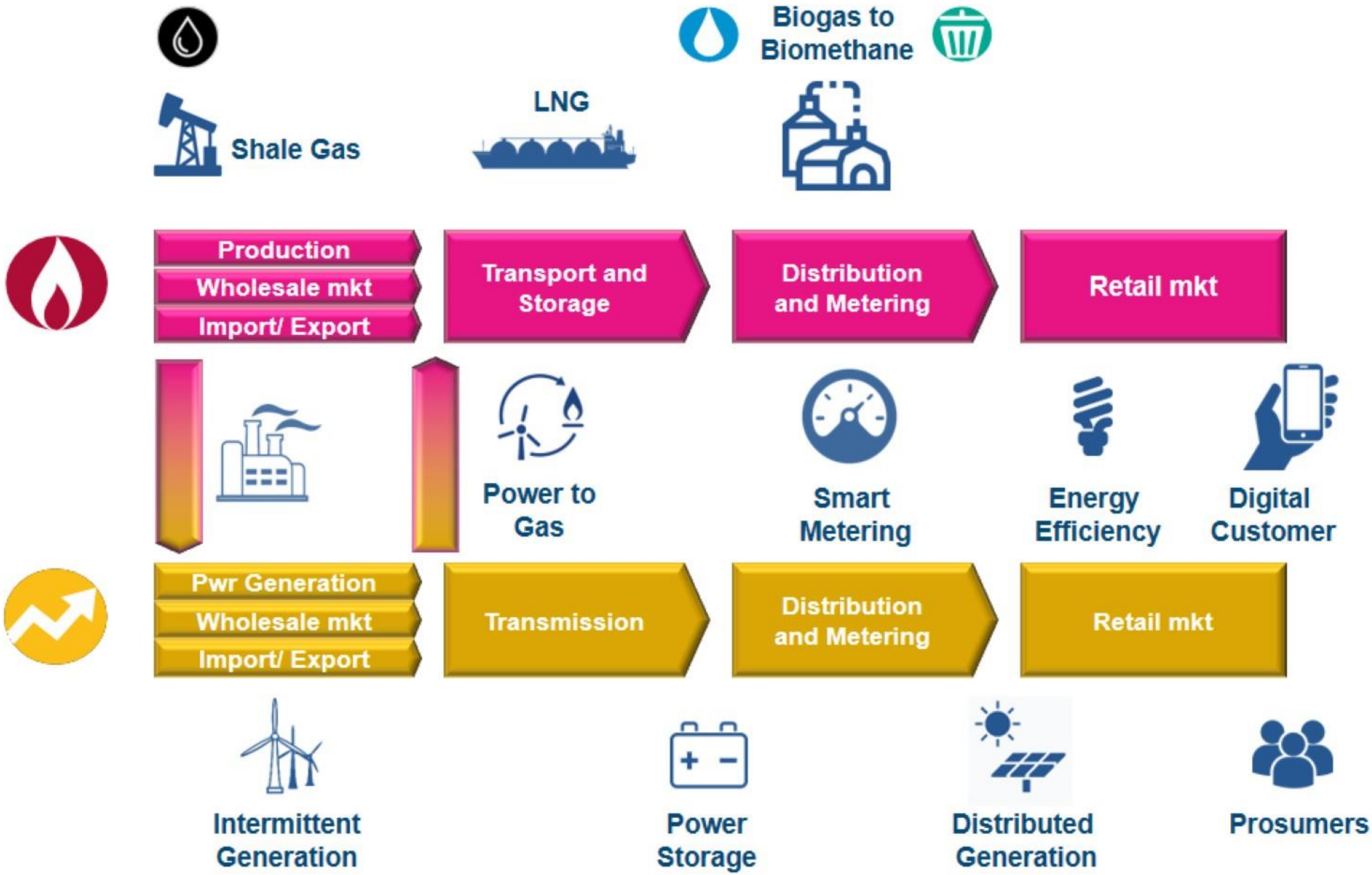
SECTION II – How and why gas supply chain will change; Regulatory needs for new gases uptake

01

Pathways to decarbonization and the role of “clean gases”

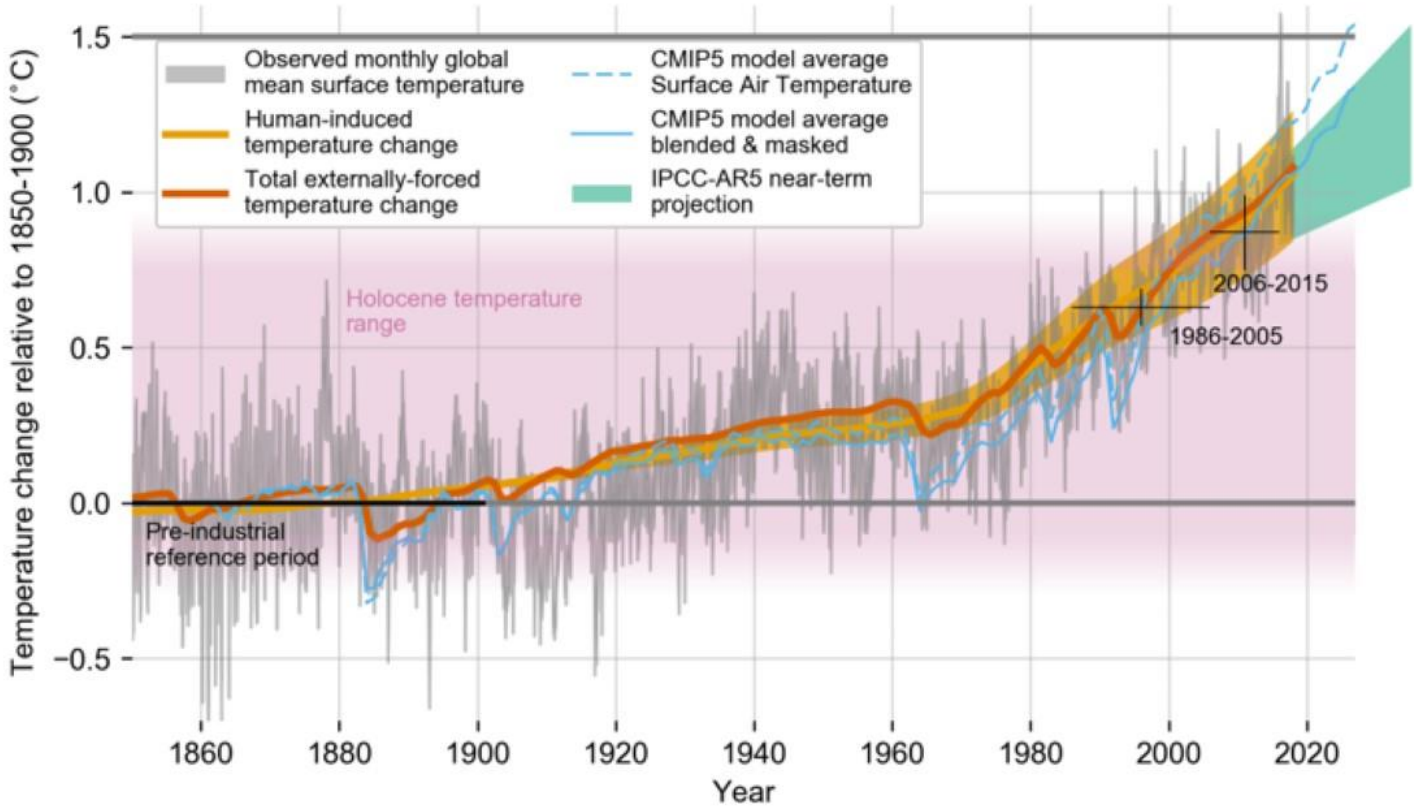
Stefano Verde

The continuous evolution of power and gas markets… so far!



Climate change is THE challenge ahead and policies need to address at least 2 targets to be effective

Evolution of global mean surface temperature (GMST) over the period of instrumental observations – source: IPCC

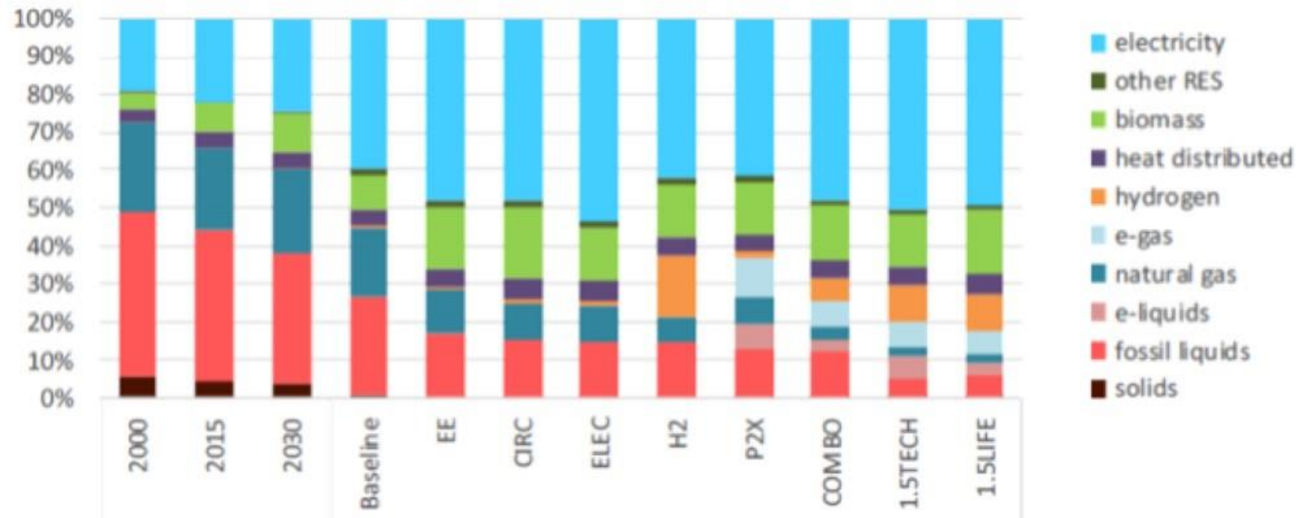


1 **Decarbonization**

2 **Carbon Peak**

The first target (carbon neutrality) can be reached following a number of different paths in terms of energy industry mix: there is «no silver bullet»

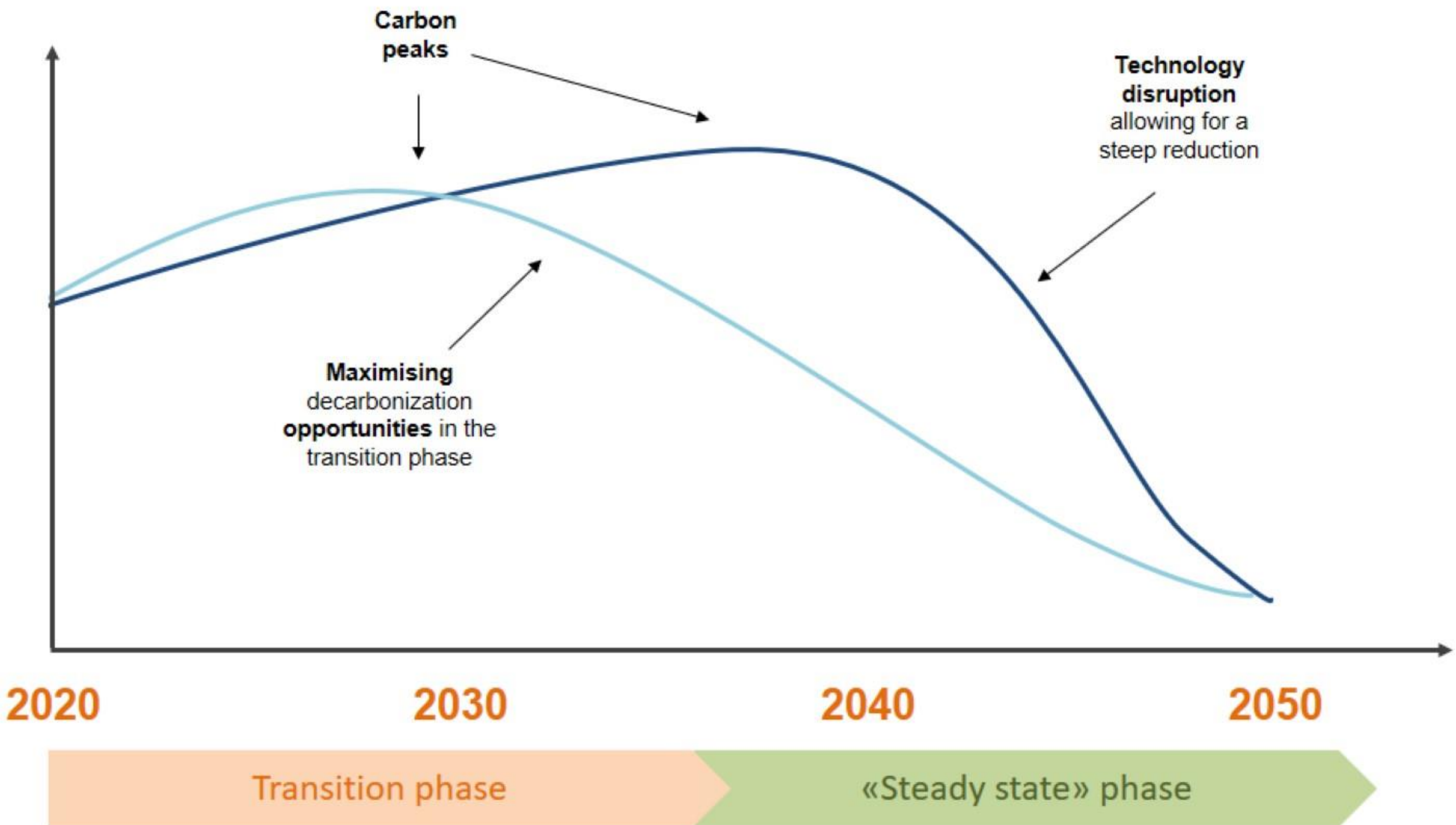
Energy mix by 2050 (%)
According to different scenarios



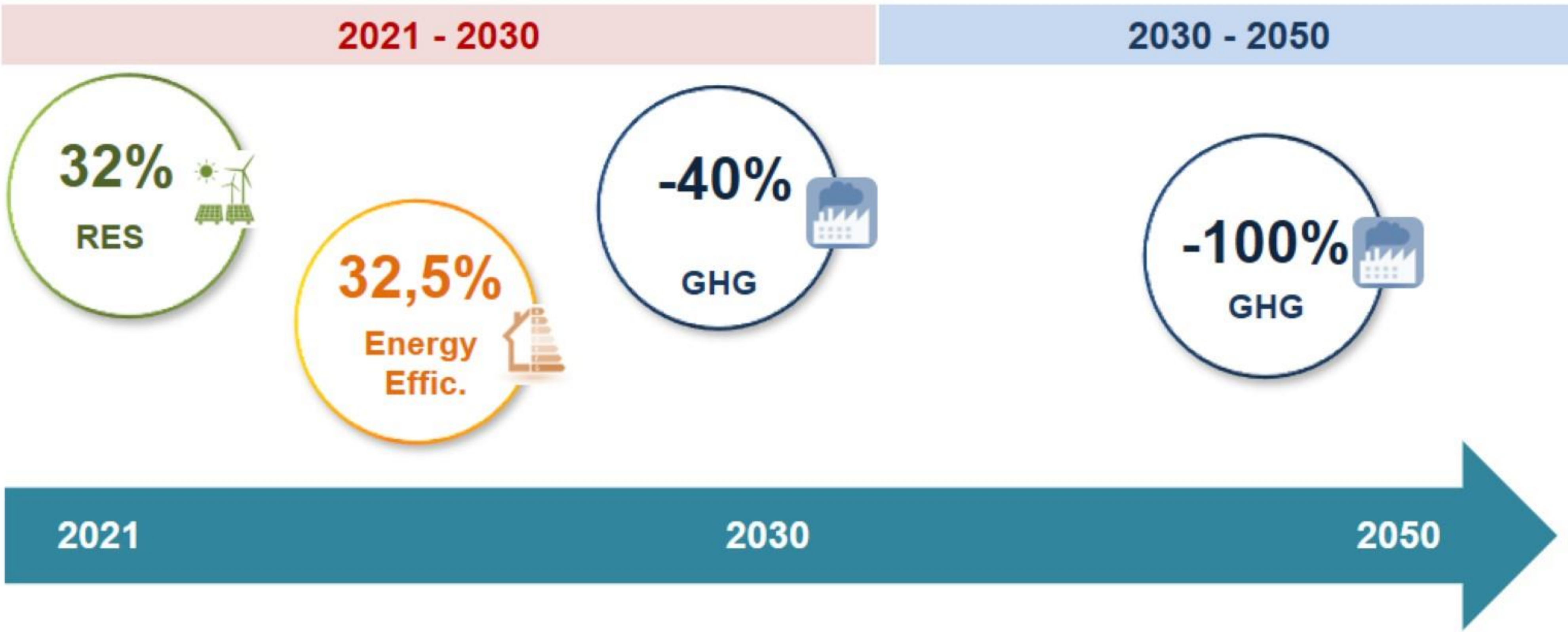
- Several institutions are drawing up **scenarios** leading to decarbonizing the energy sector. Each of them is based on **different assumptions** characterized by a different role to for many energy vectors towards carbon neutrality
- As the goal of **carbon neutrality is set at 2050**, a big play will be left to the **technology evolution** we will witness in the coming years

Source: European Commission, 2019 - A Clean Planet for all A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy

The second target requires EU policy makers to anticipate carbon peak at the earliest: any opportunity to decarbonize has to be actioned



EU energy and climate policy has been drawing a path towards decarbonization since 2007: this decade will be key for its success



- The European institutions are currently discussing an **update of 2030 GHG targets**, so to make them more compliant with the final goal in 2050
- The **current decade to 2030** will be **pivotal** to start an effective decarbonization path leading to reach the carbon peak as soon as possible

Energy decarbonization is going to be addressed from a wider perspective, moving from power to power and gas opportunities to scale it up

European Commission

2018 — 2019 — 2020 — 2021

Clean Energy Package

- **Targets 2030**
- **Governance** of the Energy Union

A Clean Planet for all by 2050

- **Large scale electrification** of the energy system **coupled** with biofuel H_2 and power to gas (P2G)
- Smart network infrastructure and interconnections
- Tackling remaining CO_2 with carbon capture and storage (CCS)

Green Deal 2050

- **Climate Law** with 2050 binding targets: new GHG reduction target set at **-50%**
- **Emission Trading Scheme Reform** and **Carbon Border Tax**
- **Sustainable EU investments** 1.000 €/mln in 10y

Strategy on energy Sector Integration

Expected at the **end of June 2020**

New Gas Directive

?

Under the "Green Deal for Europe" the Commission is expected to deliver some important actions on decarbonization in the next 18 months

2020 – 2021

Circular strategy

- EU **Industrial Strategy** UE
- Circular Economy Action Plan
- Market incentives for circular products
- Waste legislation revision proposal

Energy

- **National Energy and Climate Plan** assessment
- **Smart sector integration Strategy**
- Review of Trans EU Networks **Energy**

Climate

- Climate Law
- 2030 target review on **GHGs**
- EU Climate Change adaption strategy
- **ETS review**
- Carbon Border Tax

Green Finance

- EU **Sustainable investment Plan**
- **Just Transition Fund**
- Renewed Sustainable Finance Strategy
- Review of the Non-Financial Reporting Directive

Decarbonization paths: the support coming from electrification

Why electrification?

1. **RES-E production avoids** emissions from fossil fuels

2. **More efficient solutions** (electricity heat pumps are 4X more performant than a gas boiler)

3. **Higher energy security of supply,** because of **lower gas import** from non EU member State

Energy sector will be

Decentralized

Decarbonised

Electric

Electricity demand by 2050 (*)

63%

63%

50%

60%

Electricity demand **4.800-6.000 TWh**

Source: Eurelectric Decarbonization pathways, 2018

(*) Eurelectric scenario number 3

Decarbonization paths: the support coming from green gases

Why gas is important to tackle decarbonisation?

1. Full decarbonisation requires **high volumes of RES-E**, there will be need to store energy

2. Clean gases and/or hydrogen can better accommodate **needs from some customers** (i.e.: long-haul transport, high temperature industries, …)

3. **Green and Synthetic gases** allow for the use of current gas network. **No stranded assets** means a cheaper transition for the system as whole

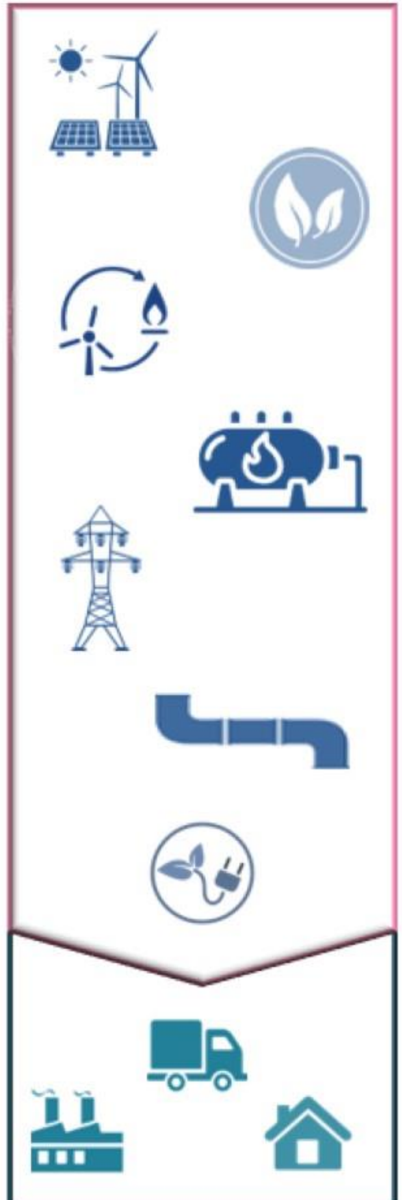
Energy sources	% Tot (9.012 TWh)
Biomethane	13%
Hydrogen	19%
Power	50%
Biofuels	11%
Heating	4%
Other	3%

Source Navigant – Gas For Climate «The optimal role for gas in net-zero emissions energy system», 2019

Decarbonization paths: strenghts of an integrated approach

Electricity-only model

- **+** **Lower energy losses**
- **+** **End user safety**
- **+** **Higher energy independence** (but what about supply chain?)
- **−** High electrification costs for some end user (i.e. **industry**)
- **−** Challenges when electrifying specific **transport sectors** (aviation, shipping)



Electricity-and-gases model

- **+** **Maximization of decarbonization opportunities**
- **+** **Seasonal storage** and **peak handling**
- **+** Gas/power according to a **least cost approach** for end users
- **+** Better use of **existing gas assets** (no stranded costs)
- **−** Existence of n networks resulting in **lower network economies**
- **−** Higher **energy losses** due to **low efficiencies**

Source: The Value of gas infrastructure in a climate-neutral Europe, Frontier

What are “Renewable Gases”? A definition issue

RED II Directive definitions...

1. **Energy from renewable sources** means energy from renewable non-fossil sources, namely wind, solar and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and **biogas**

2. **Biogas** means **gaseous fuels** produced from biomass

..RED II takes also into account...

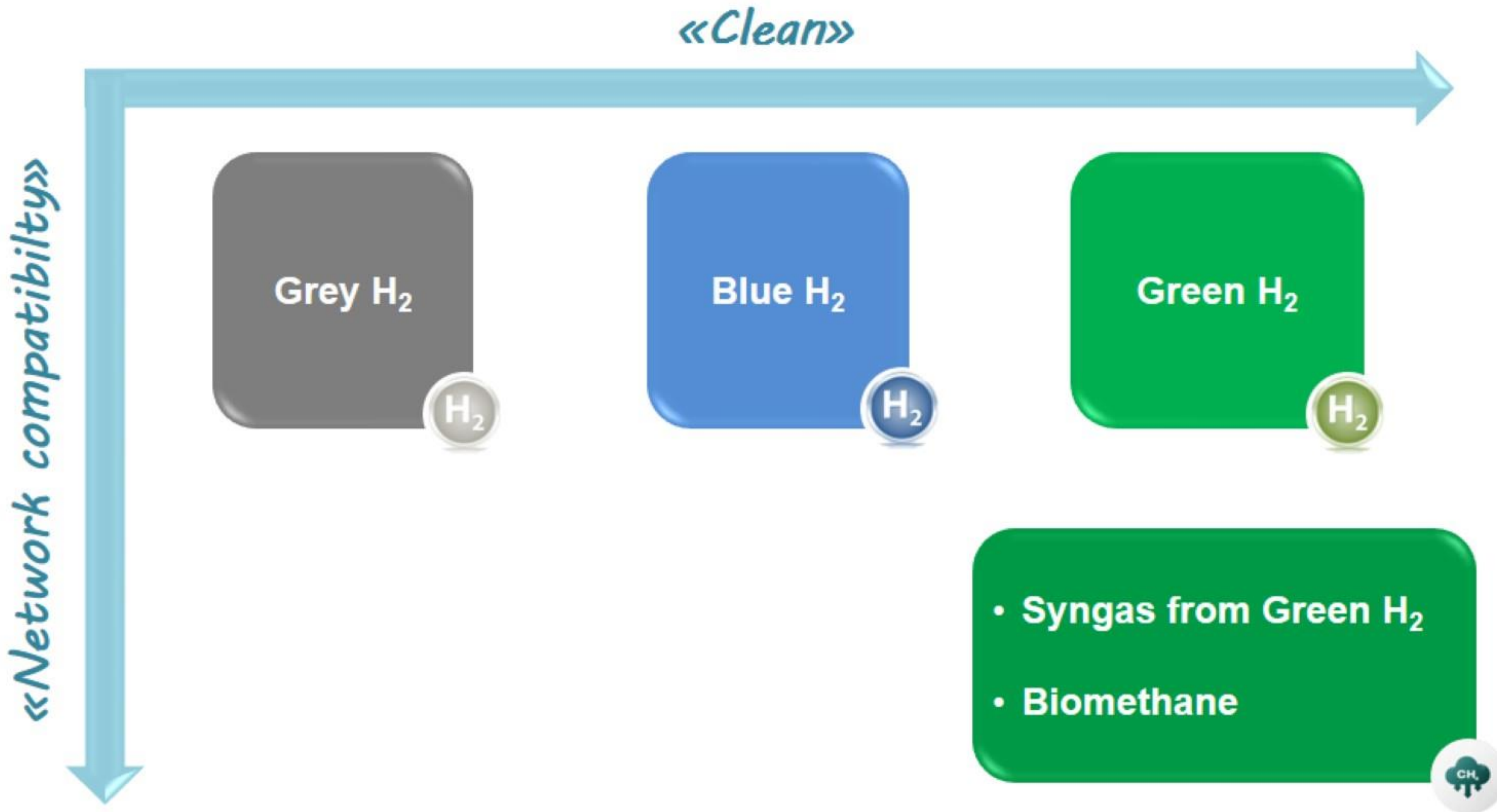
..BIOGAS upgrading

..into BIOMETHANE

Why do we need a clear definition?

- There is an increasing scope for the development and **flexible use** of different types of gases
- Moreover an **unambiguous definition** is required for the **upcoming regulatory measures** and **support schemes**

Despite the lack of a definition, (green) gases can be clustered according to 2 features: their "carbon footprint" and their "usability" on a large scale



Source: own elaboration on Florence School of Regulation (2020)

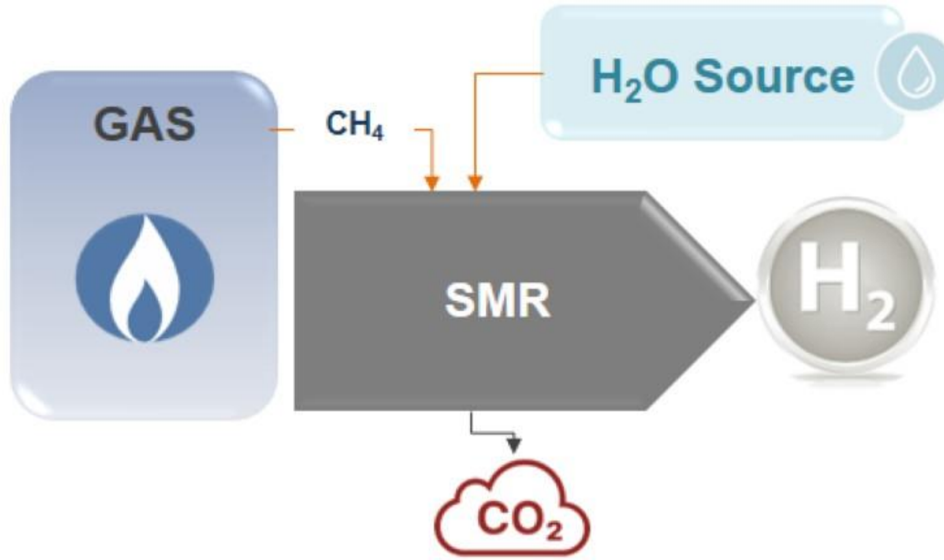
Grey hydrogen: a definition and key features

Taxonomy and definition

Grey hydrogen is gas produced by thermochemical conversion (such as steam methane reforming) of **fossil fuels without carbon capture**

Example of technological process

- In the **Steam Methane Reforming** process, a **hydrocarbon feedstock** (i.e. gas) is pre-heated, mixed with **steam** before passing through a **catalyst** in a top-fired steam reformer **to produce H_2, CO** and **CO_2**
- **Grey hydrogen** is currently most consumed **as feedstock** for **chemical** and **refining processes**



Technological maturity/scalability

Carbon footprint 10 to 19 tCo2eq/tH_2

Source: Carbon footprint from IEA (2019)

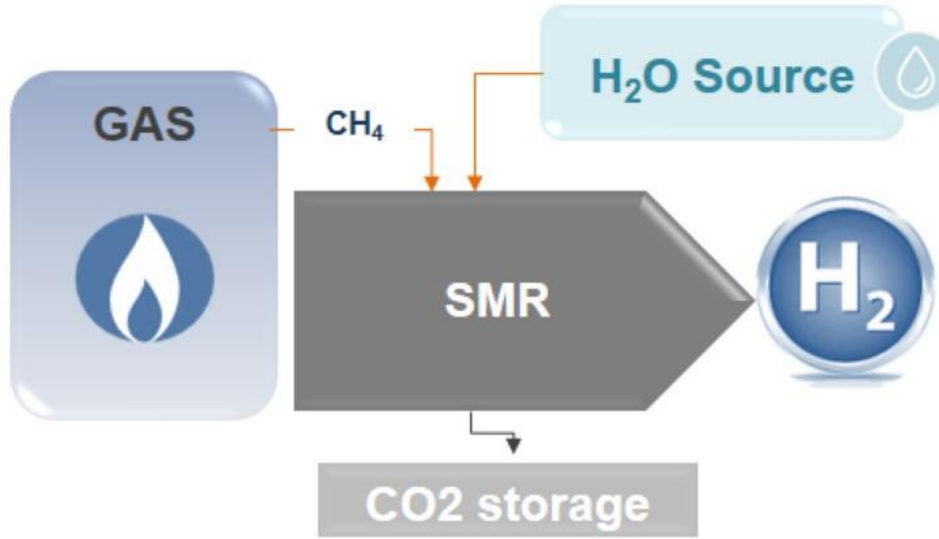
Blue hydrogen: a definition and key features

Taxonomy and definition

Blue hydrogen is a low-carbon gas produced by thermochemical conversion (i.e. grey hydrogen) of fossil fuels (i.e. natural gas) with carbon capture and storage (CCS*)

Example of technological process

- The **SMR process** allows the extraction of hydrogen and carbon dioxide from natural gas and water steam
- CCS system allows to stock CO_2 and so to avoid emissions
- SMR is currently optimized to capture **90% of the GHGs**



Technological maturity/scalability

Carbon footprint

1 to 1,9 tCo2eq/tH_2

Source: Carbon footprint from IEA (2019)

Blue hydrogen: which role in the decarbonization process?

State of play and opportunities ahead

- **Blue hydrogen** can be considered a valuable **temporary fuel** allowing faster decarbonization
- Blue hydrogen based on **applying CCS** can be **scaled up** to very large quantities within a relatively short timeframe to **58 bcm** natural gas equivalent by 2050(*)
- It could be a solution for the development of a market from the **early 2020s**, awaiting green H_2 cost competitiveness. **Policymakers** can ensure that blue H_2 plays a role as a bridge fuel to achieve net-zero emissions
- To play a role in the "steady state" phase, blue H_2 **needs to be net-zero** emissions by engineering efforts or by compensating negative emissions

Expected development

58 bcm

2050E

=

2018 EU gas demand

Decarbonization role

Ready for early stage

Transition phase → «Steady state» phase

Source: Gas for Climate Gas Decarbonisation Pathways 2020–2050

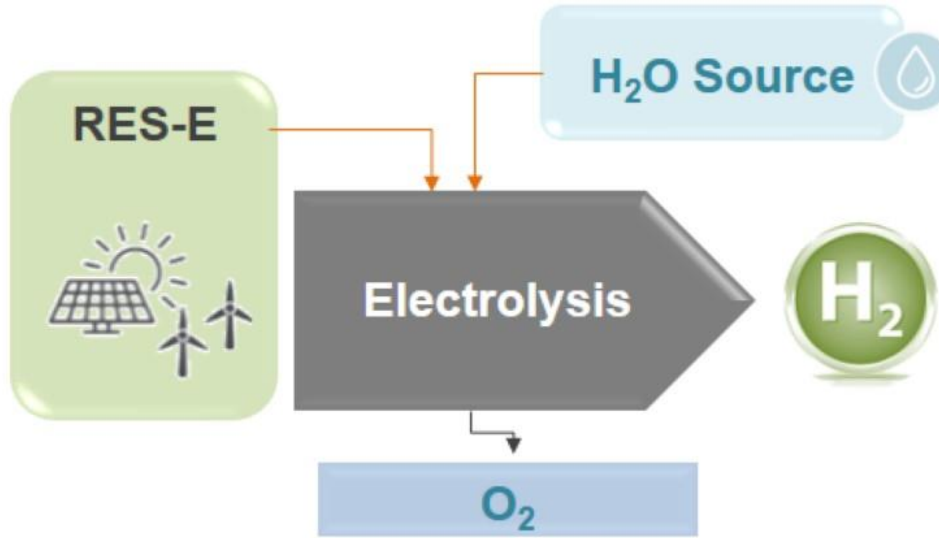
Green hydrogen: a definition and key features

Taxonomy and definition

Green hydrogen is produced through an electrolytical process, fuelled by renewable energy only so to have no emissions

Example of technological process

- Power from **RES-E is** used to feed the electrolysis process
- Through the electrolytical process **water** molecule is splitted in $\mathbf{H_2}$ and $\mathbf{O_2}$ molecules



Technological maturity/scalability

Carbon footprint

Towards 0 $tCo2eq/tH_2$

Source: Carbon footprint from IEA (2019)

Green hydrogen: which role in the decarbonization process?

State of play and opportunities ahead

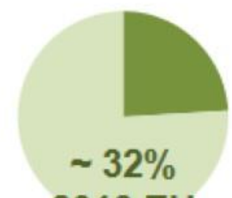
- Hydrogen can address **several end uses** (industrials, transports on the top of the list)
- Green hydrogen needs a massive scale up of **RES-E**, so to use and optimize excess power generation from **intermittent sources**
- Green hydrogen can be efficenty **stored** and it can allow thus a **long-term storage** for power excess
- It is the feedstock for the production of «**syngas**» in a Power-to-Gas system (see infra)

Expected development

149 bcm

2050E

=



2018 EU gas demand

Decarbonization role

Need for further development to scale up RES-E and tech

Transition phase → **«Steady state» phase**

Source: Gas for Climate Gas Decarbonisation Pathways 2020–2050

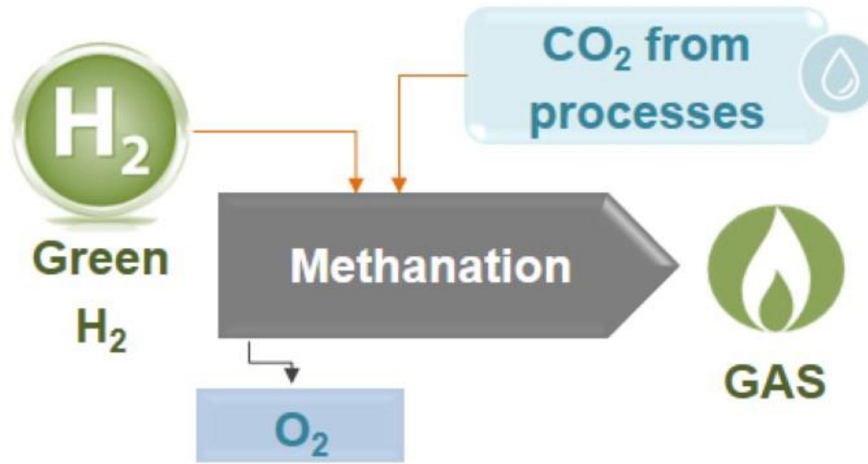
Power to Gas: a definition and key features

Taxonomy and definition

Power to Gas leads to the production of **synthetic gas,** starting from the green hydrogen as a feedstock

Example of technological process

- **Green hydrogen** and carbon dioxide undergo a hydrogenation process (methanation) the result of which is **synthetic gas**
- Syngas shows a **methanation degree very high** (96% - 99%) so it can be fed directly into the **natural gas network**



Technological maturity/scalability

Carbon footprint

Power to Gas: which role in the decarbonization process?

State of play and opportunities ahead

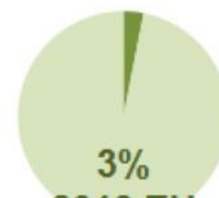
- As green hydrogen, P2G needs a massive scale up of **RES-E**, so to use and optimize excess power generation from **intermittent sources**
- P2G allows for «**storage**» **of intermittent power** produced in excess under the natural gas vector, using **existing natural gas infrastructures**
- P2G solutions also allows for developing **circular opportunities** among industries, one of which being the water depuration business

Expected development

15 bcm

2050E

=



2018 EU gas demand

Decarbonization role

Need for further development to scale up RES-E and tech

▼

Transition phase → **«Steady state» phase**

Source: Gas for Climate Gas Decarbonisation Pathways 2020–2050

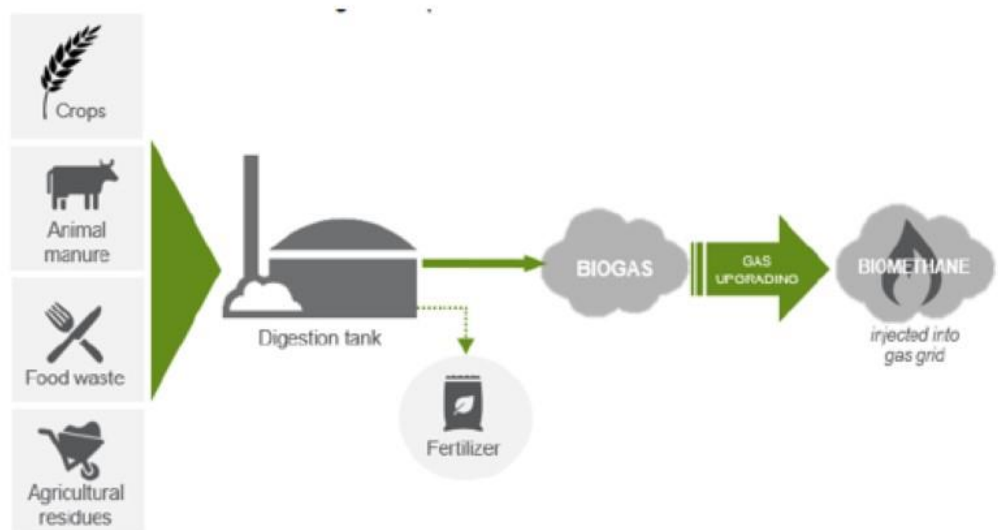
Biomethane: a definition and key features

Taxonomy and definition

Biomethane can be produced from a number of feedstock, ranging from agricultural manures, sludge, prunings/wood biomasses or urban organic waste (food)

Example of technological process

- Feedstocks (crops, animal manure, organic waste, …) are collected into a **biodigestion tank** and exposed to a «fermentation» process.
- Outputs from the biodigestion phase are **biogas** and **fertilizers**
- Biogas has a methanation degree around 55%, and it needs to be **upgraded** to **biomethane** able to be fed into the grid



Technological maturity/scalability

Carbon footprint

Biomethane: which role in the decarbonization process?

State of play and opportunities ahead

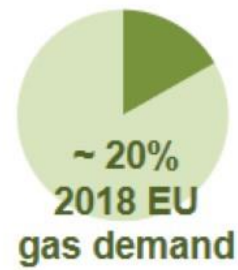
- Biomethane is chemically identical to natural gas, so it can be **fed into natural gas** existing networks and existing end-user appliances
- Biomethane production also support some **circular business models**, integrating waste and agricultural business with the energy sector
- According to the feedstock used, biomethane exhibits a different **carbon footprint,** with an emissions saving ranging from -70% (crops) to -100% (manure, agricultural specific crops)

Expected development

95 bcm

2050E

=



Decarbonization role

Ready for early stage

Transition phase → **«Steady state» phase**

Source: Gas for Climate Gas Decarbonisation Pathways 2020–2050

Wrapping up on «clean gases»

	Grey H_2	Blue H_2	Green H_2	Syngas	Biomethane
Feedstock	Fossil fuel and water	Fossil fuel and water	Water	Green H_2	Organic waste Agricultural waste
Features	-	With CCS systems	With RES-E	With CO_2 from processes	With CO_2 from processes
Technol. maturity	High scale	Medium scale (on CCS)	Low scale	Low (Green H_2) High (methanation)	High scale
Carbon footprint	High emissions	Low emissions	Low emissions	Low emissions	Low emissions
Targeted STAGE	OUT OF SCOPE	TRANSITION READY	LATE TRANSITION	LATE TRANSITION	TRANSITION READY

Key takeaways

Decarbonisation is THE challenge: time matters!

There is no silver bullet to decarbonise, but many alternative solutions

New renewable gases will play a key role in decarbonization pathways

Different clean gases address different stages of the path

02

Changes and evolutions in the gas supply chain

Filippo Reggiannini

New gases deployment implies an evolution for the energy sector: in this section we are going to discuss some questions on future gas supply chain

How does today's gas supply chain work?

Which are the key factors for the change?

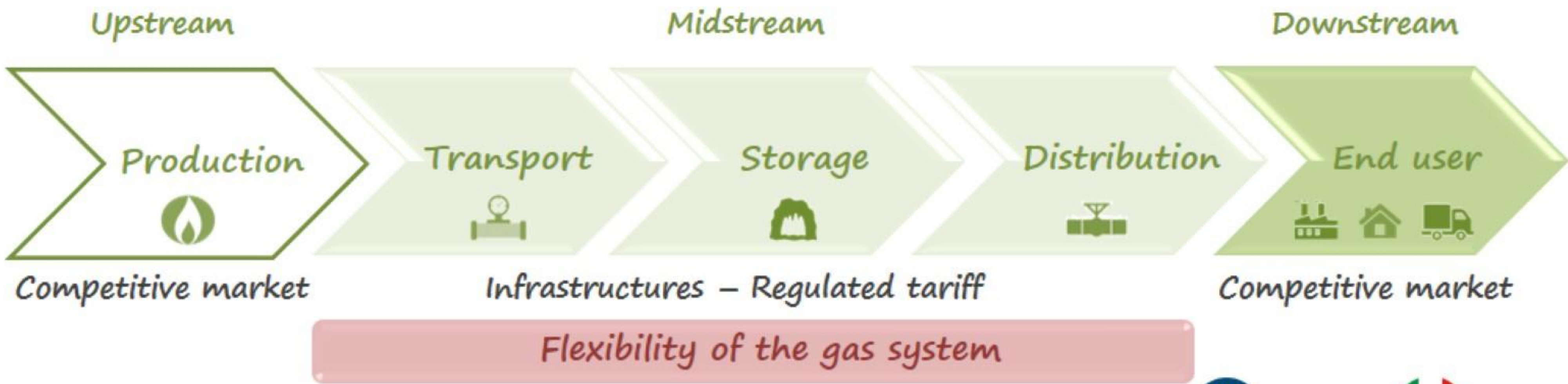
Do we need a new regulatory framework for a "Clean gases market" development?

Some topics are still under stakeholders debate because of technology infancy and regulatory lacks.
Therefore, for some issues there isn't yet a decisive answer

Source: own elaboration

How does today's gas value chain work

Today's Gas Value Chain(*)



- Today **gas supply chain is «one way» from upstream** to **retail market**
- **Stability** and **flexibility** of the system are guaranteed by natural gas infrastructure, in particular by **underground storage** (*see the following slide*)

TSOs Networks (Km)	270 K	35 K
TSOs Number	45	9 *
DSOs Networks (Km)	1.4 Mln	260 K
DSOs Number	2 K	~200

*(*) Hereinafter the acronym **TSO** (Transport System Operator) identifies the legal subject who operates the natural gas transport network , while **DSO** refers to the Distribution System Operator*

Source: Navigant 2019 and ARERA (convenient round numbers)

(*) Snam Rete Gas operates about 93% of italian infrastructures

Energy system stability and security today are guaranteed by the flexibility of the gas infrastructures

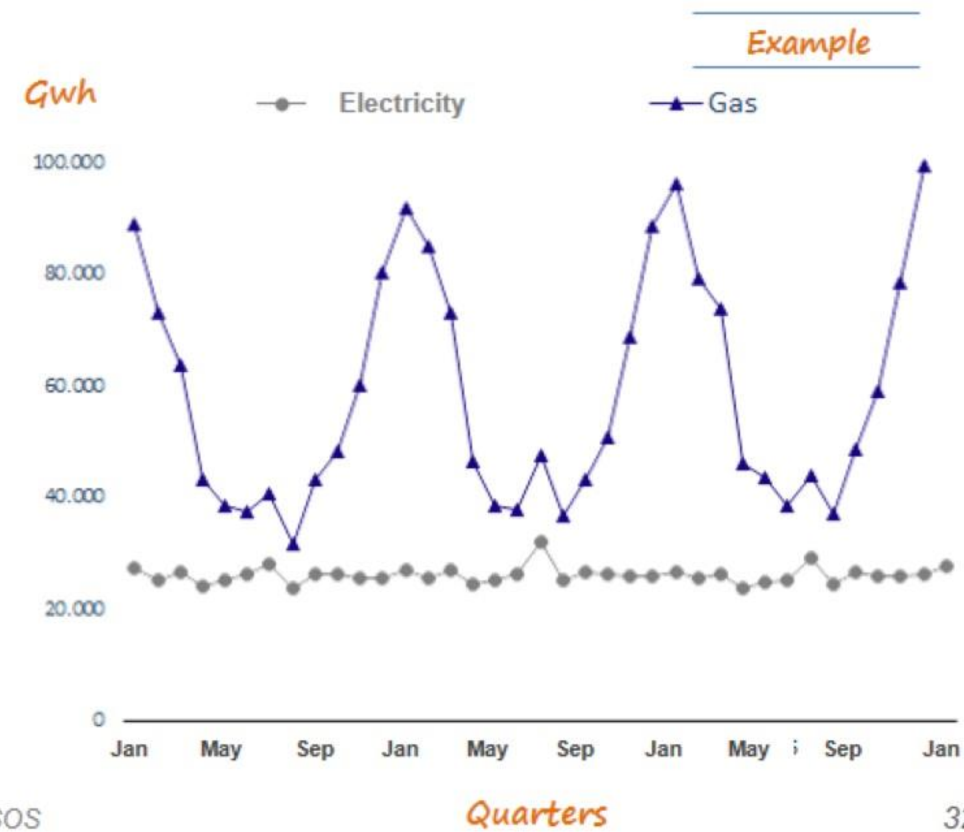
What is Flexibility?

Flexibility can be defined as the **capacity to adapt** the energy system in reaction **to an external situation**: peak demand or low supply of energy. The objective of flexibility is to guarantee the safety and the continuity of the service to the benefit of consumers

Why is Flexibility important?

- Today electricity and gas demand curves present different trends and gas represents around 45% of EU heating demand
- Electricity demand EE is pretty stable (except a low peak on summer) during the whole year, while **gas curve** features **seasonal peak on winter**
- **Electricity infrastructure** today is **not able** to **absorb winter peaks** in order to satisfy **heat demand** (especially households), unless large investments on the grid extension are provided
- **Gas grids**, through **storages,** are **naturally capable** of **managing energy demand fluctuation** related to **seasonality**

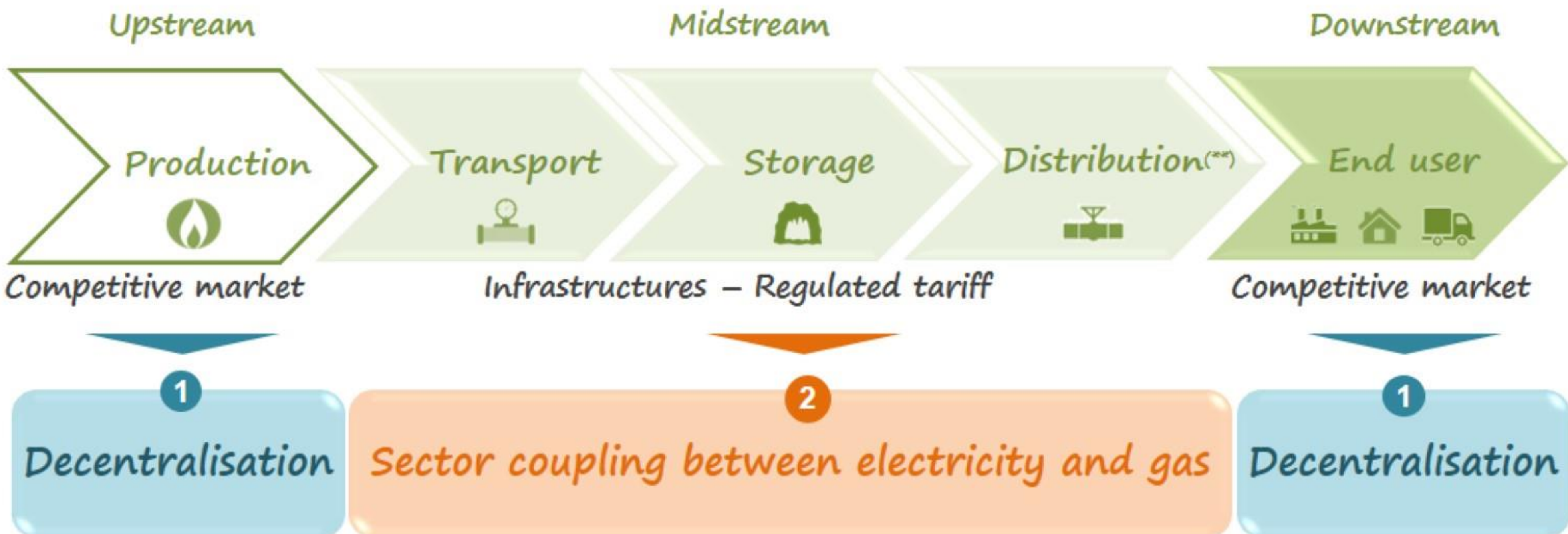
Seasonal energy trends



Source: own elaboration on Flexibility in the energy transition a toolbox for gas DSOS

Why gas supply chain is bound to change?

The (r)evolution is based on 2 key factors



Flexibility needs have to be reviewed

Decentralised production of clean gas has an impact, at least, on three aspects of infrastructures flexibility

New aspects to consider in a decentralised gas supply chain

1 — New business models

Renewable gases injection into the **grid** will depend on the **distance between** the production **plant** and the grid itself and/or the **electrolyser unit**

2 — Gas reverse flow from DSOs to TSOs

- **The gas "reverse flow" is crucial to maximise new gases injection** into the **grid**
- **DSOs networks are more capillary than** TSOs ones, however they don't have the same transport capacity so they are not able to deliver high volumes of green gases. Thanks to **reverse flow** into **TSOs networks**, **green gases** can potentially **be delivered everywhere** in EU

3 — New storage needs

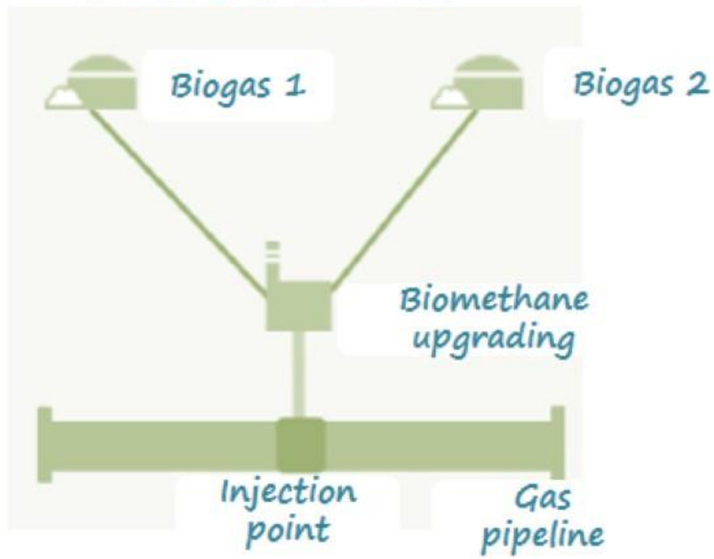
- **New renewable sources** require **new storage technologies**
- **Electricity storages** today are able to absorb only **short term peaks**, while **syngas is storable** in long term handling **seasonal peaks**

Source own elaboration on Navigant 2019

Most interesting new business models regard biomethane and green H_2 produced by RES-E

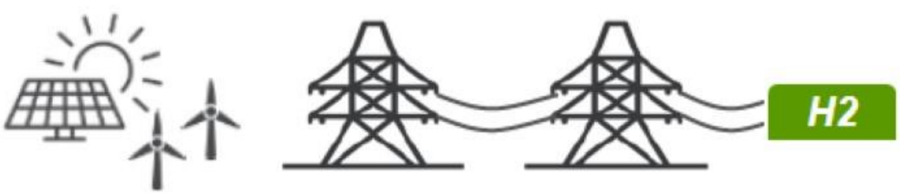
1

Decentralised biogas plants connected to a biomethane hub



- The first solution analyzed involves the **connection** of **two** (or more) **raw biogas digesters** to a **biomethane upgrading plant** that **works** as **hub**
- **Raw biogas** is **delivered via PVC pipe** and the **biomethane plant** is **connected** to **gas grid**
- **Isolated raw gas producers bear** lower investments costs by **avoiding capex** for a new biomethane upgrading plant

Green H2 by RES-E surplus



- Many business models are related to Green H_2 produced by **renewable electricity surplus.** They **depend on** where **electrolyser units** are **located**
- RES-E are converted **into H_2** far away **from** the **production plant.** They are **transmitted through electricity grid**

Source: Navigant – Gas For Climate 2019

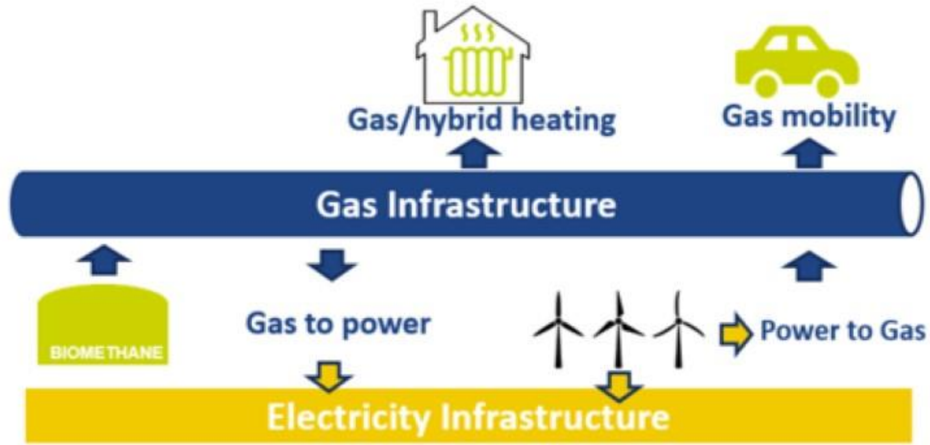
Sector coupling creates a link between electricity and gas networks in order to guarantee both the system flexibility and decarbonisation needs

2

What is sector coupling?

Sector coupling can be defined **as co-production, combined use** and **conversion** of **different energy forms (i.e. electricity, gas, heat and fuels).** A typical **example** is provided by **power to gas (P2G)**

- The crucial aspect of sector coupling consists in creating **new links between energy carriers** and the **respective infrastructure** (both at TSO and DSO level)
- Seasonal **demand peaks** are handled by employing the **most proper energy vector** according to the single need of each different end user device (i.e. **gas intensive** industrial processes)



Source: Image from ENTSO-G

\+
- RES-E surplus stored
- **Avoids switching costs** for those **gas intensive end users**

−
- **Technology infancy**
- **Regulatory** and **subsidize schemes lack**

Source: Sector Coupling the New EU Climate-and Energy Paradigm? Florence School of Regulation, 2018

How to make gas grids ready for the decarbonisation? Many industrial associations are contributing to the debate

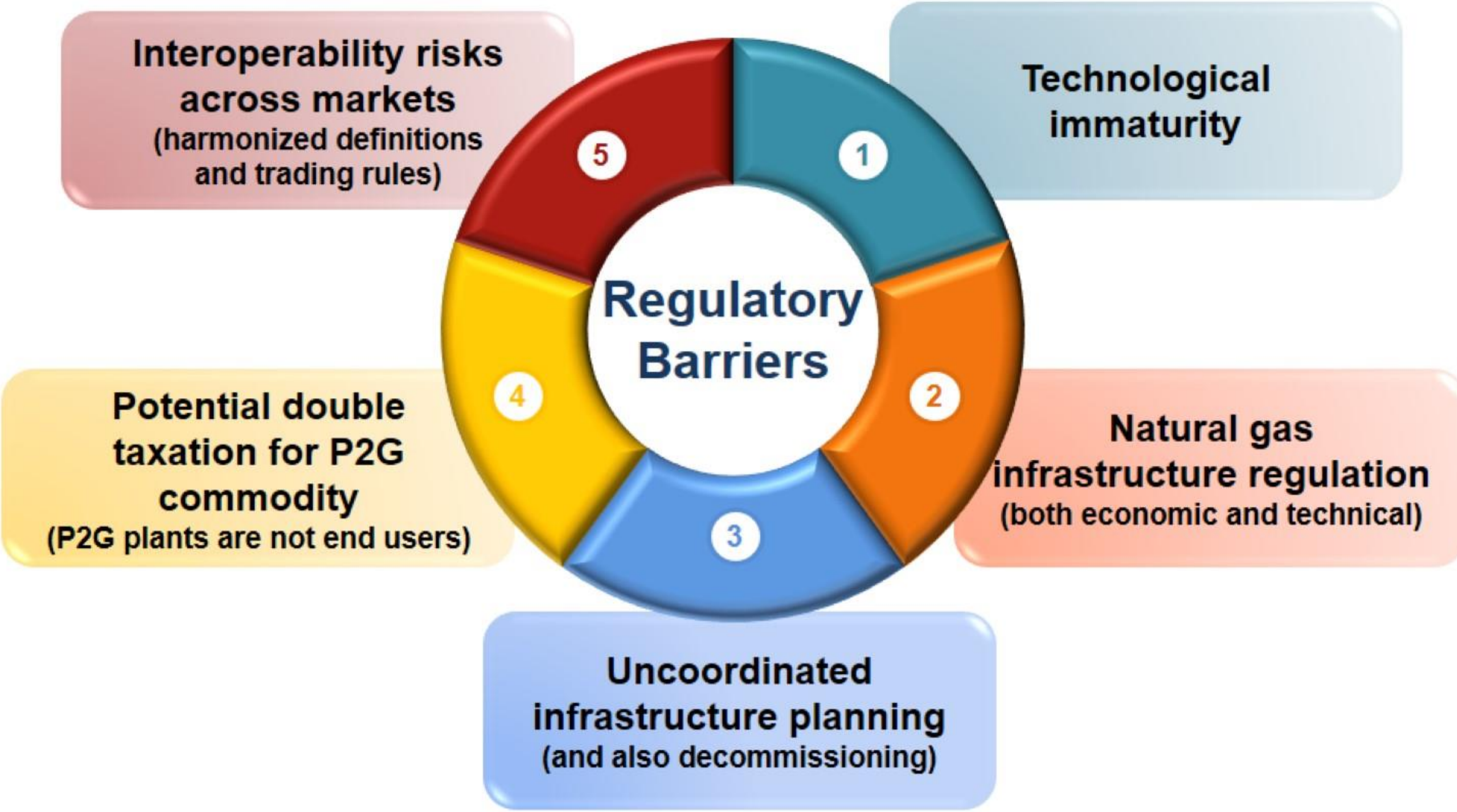
The TSOs perspective

Key principles

1. **New technical layers imply** also **remuneration** for TSOs new services
2. **Interoperability** and **security of supply** must be preserved
3. **Syn CH_4** must be classified **as renewable energy**
4. **Avoiding** potential **distortions on taxes/levies** on P2G in the context of sector coupling
5. Encouraging **pilot projects** with regulatory **flexibility** for **TSOs**
6. **Cost recovery for gas quality handling**
7. Introduce a **regulatory** approach to **CO_2 infrastructure**

Source: ENTSOG 2050 Roadmap for gas grids

Regulatory Barriers in linking Gas and Electricity Sector – State of play



Source own elaboration on «Potentials of sector coupling for decarbonisation – Assessing regulatory barriers in linking the gas and electricity sectors in the EU",2019 – Consortium composed by Frontier economics, CE Delf, Thema Consulting Group

Which is the end game? Clean gases and RES-E a holistic partnership for tomorrow energy system?

Key Takeaways

1 **Decentralised production** of **clean gases** and **sector coupling will change** the **gas supply chain**

2 **P2X technologies** permit variable **RES-E** long term **storage (peaks handling)**

3 **Sector coupling allows end users** to **choose** the most **proper green energy carrier** for **each different need**

Open points

1 There is a **regulatory lack on: green gases definition, new asset ownership** and **related investments remuneration**

2 **Will be sector coupling another step towards smart grid?**

Source: image from Gas For Climate 2020