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POLICY BRIEF

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How Many Shades of Green? An FSR Proposal for a Taxonomy of 'Renewable' Gases

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Highlights

- The role of gas in the future of the EU energy sector has been one of the most debated topics in the last few years. As natural gas (NG) makes up less and less of Europe's energy mix (according to several studies), there is an increasing scope for the development and flexible use of a number of different types of gases (namely *biogas, biomethane, synthetic methane* (or *syngas* or *renewable methane*) and *hydrogen*.
- Some of these 'new gases' (as we will call them in this paper) may be generated from renewable sources, or from hydrocarbons. A few of these gases are carbon neutral by process; others are responsible for the emissions of greenhouse gases (GHG)[1], despite being of 100% biological origin. Some of them are almost identical in chemical terms, but their carbon footprint may vary quite significantly.
- This complex scenario makes it difficult (and very confusing) to refer to the new gases with non-univocal adjectives such as 'renewable', 'green' or 'no-carbon/low carbon'.
- Therefore, there is a strong need – widely recognised by all the parties in the sector – to agree on a common terminology which could help prevent any misunderstanding when referring to a specific gas; this is even more important in the public debate since the 'new gases' are going to be the subject of upcoming EU regulatory measures.

1. GHG covered by the Kyoto Protocol are the following: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6), nitrogen trifluoride (NF3).

1. The Rationale for a Fair Taxonomy

In order to guarantee a balanced approach, our proposal is founded on four main proposals or papers elaborating a new taxonomy/terminology for 'renewable gases'. Two of them come from the civil society[2]; the other two respectively come from an international electricity company[3] and from seven main associations operating in the gas sector[4].

The taxonomy we propose uses a scientific approach and aims to classify a 'new gas' according to:

- its *green value*: the environmental impact, in terms of GHG emissions, of their origin and generation process
- its *usability* : the possibility for this gas to access the existing infrastructure at the injection phase.

In order to attribute values to these two parameters we utilise a binary code (0 or 1).

The two main parameters we identified are the Green Value (GV) and Usability (U).

1.1 Green Value (GV)

In our analysis, the Green Value of a gas can be defined as *the GHG impact of a gas' source and process* and it is composed of two sub-parameters: **Origin** and **Lifecycle GHG emissions**.

Indeed, we trace the impact that new gas has on the environment depending on its *origin* (fossil or non-fossil) and on the GHG emissions it releases, starting to count from its extraction/generation until injection into the transmission grid or into a storage facility. Our study does not take into account the ex-post usage of gas (distribution and consumption); it only focuses on the gas status when it enters the gas infrastructure. Also, other types of environmental impact (water pollution, water scarcity, etc) are not considered in this study.

1.1.1 Origin: Fossil vs Non Fossil

Gas can be sourced from either biological/organic (water, biomass, wind) origins or non-biological feedstock (hydrocarbons or various types of chemicals commonly used as feedstock). In this study, we distinguish between the *fossil* and *non-fossil* origins of a gas and attribute different values to each.

In the case of the new gases, this very first differentiation is particularly important, to distinguish cases in which the same resulting gas (i.e. hydrogen) is green by source or not.

Biogas, for instance, is typically produced from the decomposition of organic matter (animal manure, food waste, sewage) in the absence of oxygen[5].

Some type of hydrogen is also produced from non-fossil origin (the so-called 'green hydrogen'), because it can be generated (through different processes) starting from natural biomass or from water. Other types of hydrogen (the so-called 'blue' or 'grey' hydrogen) are instead produced from gas or coal.

Coal, natural gas and oil are the typical fossil fuels that make up the most traditional sources of energy generation.

We attribute 0 if a gas has "non-fossil origin" and 1 if it has "fossil origin".

2. GHG covered by the Kyoto Protocol are the following: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6), nitrogen trifluoride (NF3).

3. ICCT *'Gas definitions for the European Union'* and E3G's *'Renewable and decarbonised gas options for a zero-emissions society'*

4. Iberdrola, *'Align gas terminology'*

5. At the same time, it is also possible to produce biogas from different feedstock such as rubber, and in that case the biogas produced would have a different green value at origin in our classification.

1.1.2 Lifecycle GHG Emissions: Offset vs Non Offset

Under this sub-parameter, we aim at identifying and counting all emissions of those gases that have a detrimental impact on climate, emissions which might be released or leak during the lifecycle of a new gas, from extraction/sourcing to injection.

One of the proposals we considered - the gas associations' - attempts to classify each gas based on the percentage of reduction of GHG emissions that its presence would allow.

In an effort to provide a taxonomy that takes the entire process into effect, from gas sourcing through transport and injection in the transmission network, our approach employs a binary code, that evaluates whether each process allows for a complete offset of greenhouse gases emissions, regardless of the gas' fossil or non-fossil origin. If GHGs emitted (if any) during the process are fully compensated, we can consider the whole lifecycle as a carbon-neutral process, thus we attribute to this sub-parameter ('GHG offset', in *Table 1*) the value 0.

If at any point in time GHG emissions are released and non-compensated, the process cannot be considered carbon neutral, hence we would assign the value 1.

1.2 Classification According to Green Value: Some Considerations

Based on the Green Value parameter only, we may conclude that a gas can be *green by source* (if it scores

Table 1: Classification of New Gases

PROCESS	GAS	GREEN VALUE		USABILITY	SCORE
		ORIGIN	GHG offset		
Anaerobic digestion / gasification	**Biogas**	0	1	0	**GV1, U0**
	Biomethane	0	1	0	**GV1, U0**
Methanation of green H2 + atm CO2	**Synthetic methane**	0	0 / (-1)	0	**GV0, U0**
Methanation of green H2 + NON atm CO2		0	1	0	**GV1, U0**
Electrolysis	**«Green» H2**	0	0	1	**GV0, U1**
Pyrolysis/gasification of natural biomass		0	0	1	**GV0, U1**
Photo catalysis		0	0	1	**GV0, U1**
Pyrolysis of gas	**«Blue» H2**	1	0	1	**GV1, U1**
SMR with CCUS		1	0	1	**GV1, U1**
Pyrolysis of coal	**«Grey» H2**	1	1	1	**GV1, U1**
SMR without CCUS		1	1	1	**GV1, U1**

0 in Origin) or *green by process* (if it scores 0 in Lifecycle GHG emissions offset).

Biogas, biomethane, synthetic methane and the so-called 'green hydrogen' are gases *green by source;* whereas 'blue' and 'grey' hydrogen, because of their hydrocarbon origin, are not.

On the other hand, among the gases that are *green by process* we find 'green' hydrogen and even 'blue' hydrogen.

In some cases, the production of gases that are typically *green by source* – such as biogas – generate significant GHG emissions: *high levels of methane are produced when manure is stored under anaerobic conditions. During storage and when manure has been applied to the land, nitrous oxide is also produced as a by-product of the denitrification process. Nitrous oxide (N2O) is 320 times more aggressive as a greenhouse gas than carbon dioxide (CO2), and methane 20-28 times more than carbon dioxide*[6].

According to our classification, the only gases whose GHG emissions can be considered as offset are:

- synthetic methane (that is, gas generated from green hydrogen and methanised with CO2 coming from air capture)[7]
- hydrogen produced via photo catalysis, electrolysis (with renewable electricity), gas or biomass pyrolysis and via Steam Methane Reforming (SMR), with the addition of Carbon Capture and Storage or Carbon Capture and Usage (CCUS)[8].

Biogas and biomethane, as previously explained, emit GHG emissions that can be limited or controlled only with additional technological instruments and therefore cannot currently be classified as carbon neutral by process. Finally, hydrogen produced via SMR without CCUS releases CO2 in the atmosphere and so does coal pyrolysis.

1.3 Usability (U)

The Usability parameter in our analysis aims at measuring homogeneity in operational, market and usage terms.

We attribute 0 to gases which can access and be transported through the current infrastructure and to gases whose "transportability" would require instead changes to the current infrastructure. By making an artificial simplification of current facts, we assume that any change that would be required - from the smallest adjustment to the most expensive refurbishing - has an equal weight.

Based on these considerations, the only gases which can make use of existing gas infrastructure are currently biogas, biomethane and synthetic methane – either pure or mixed/blended among themselves. Moreover, they can all be mixed with Natural Gas (NG)[9] and therefore can be transported, traded and used as homogeneous products.

On the other side of the usability scale, we find hydrogen – regardless of its green value or the process by which it is produced. The hydrogen molecule, indeed, cannot be injected into current gas infrastructure unless it is first blended with a different type of gas; it therefore requires a dedicated infrastructure.

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6. https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf
7. To some extent, when green hydrogen's feedstock is biomass, which contain the naturally captured atmospheric CO2, this particular process could be considered carbon negative.
8. Although the known technology does not allow 100% of CO2 emissions to be captured at this stage.
9. Natural Gas is not included in this analysis as it is not a 'new gas'. However, if classified according to our parameters, it would rank Green Value 1 and Usability 0.

2. Categorisation and Evaluation and of Results

After having attributed values 0 or 1 to Origin, Life-cycle GHG emissions and Usability, we proceed to summarise the results. The combination of these two sub-parameters constituting the Green Value produce the following results:

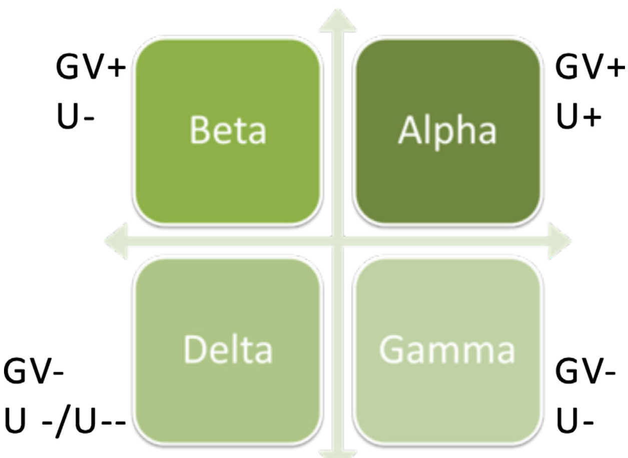
GREEN VALUE	GHG offset	GHG non offset
Non-fossil	GV 0	GV 1
Fossil	GV 1	GV 1+1

This methodology suggests that for a gas to have a Green Value (GV)=0, both sub-parameters must also be 0.

By combining the GV with the Usability score, each gas ends up being 'described' by the combination of two binary values.

By grouping the results obtained, we obtain **four major categories** – which we will name *Alpha, Beta, Gamma and Delta.*

Figure 1: The Four Categories



GV: *Green Value;* **U:** *Usability*

Based on their features:

- *Alpha Gases* have high or very high GV (they are either green by origin or by process, or both) and have high usability. These are: biogas and biomethane produced via anaerobic digestion or gasification and synthetic methane (or syngas) produced via the methanation of green hydrogen.
- *Beta Gases* have high or very high GV (even though they may be green by origin or by process, or both) and have low usability. Currently, the so-called 'green hydrogen' falls in this category, regardless of the process used to produce it (electrolysis, pyrolysis or gasification of natural biomass or photo catalysis)
- *Gamma Gases* have low GV (they can be green by origin or by process) and they have low usability. Hydrogen produced via pyrolysis of gas or via steam methane reforming, with the presence of CCS or CCUS, is an example of a Gamma gas.
- *Delta Gases* have low or very low GV (they are not green by origin or process) and low usability. Only the so-called 'grey hydrogen' belongs to this category, as it is generated via pyrolysis of coal or via SMR without CCUS technology.

2.1 Considerations

- Alpha gases can be mixed among themselves and transported or traded as homogenous products. Additionally, as explained in section 2.3, Alpha gases can also be mixed with natural gas since they all include methane and their chemical composition is compatible. Of course, while these gases are green by origin and NG is not, it has to be taken into account that such a mixture would impact on the Green Value of the final gas delivered/transported/traded.
- Depending on the process by which it is produced, hydrogen may belong to the Beta, Gamma or even Delta category. Green hydrogen is the only type of hydrogen which is both green by origin and by process. In the case of genera-

tion via electrolysis, this happens only when the electricity used to split water is produced from renewable sources; in the other cases, the resulting gas is of gamma or delta type.

- Across the four studies analysed, there seems to be a general agreement that – in addition to the 'green hydrogen' produced from (curtailed) renewable electricity via electrolysis - also hydrogen produced from "fossil gas" (as defined in the ICCT paper) can be accounted as 'green' or 'GHG neutral'. As a double condition, however, CO2 must be sequestrated all along the lifecycle, via CCS, and GHGs upstream emissions are also to be captured. ICCT warns that this double condition "would likely require exceptional efforts", particularly because at present no known technology is yet able to ensure that 100% of GHG emissions are captured. Iberdrola instead rejects *a priori* the idea that hydrogen produced this way (from natural gas) can be accounted as renewable or carbon neutral.

- Beta, Gamma and Delta gases can be mixed with NG. Usability might vary depending on their percentage and on the type of infrastructure used. Blending percentages of hydrogen with natural gas and injecting this mix into the transmission network is technically feasible; however, the maximum percentage of hydrogen that can be injected into a certain pipeline may vary quite significantly across Europe (from 0.01 to 20%).

- Technology and infrastructure evolution are due to play a significant role in the classification of gases as per our taxonomy. With technological progress, some options may become more interesting than others (air capture technologies, CCS or pyrolysis); with changes in technology infrastructure, gases might change category: green hydrogen might, for instance, become an Alpha gas soon, since some EU countries are already developing dedicated hydrogen pipelines.

3. Conclusions

The Value of a Taxonomy of the New Gases

- The main scope of our taxonomy consists in providing a scientific classification of the most promising new gases, with the primary goal of providing a correct terminology, a common language for the relevant policy and regulatory debate.

- Moreover, it has the ultimate ambition of clarifying a rather complex and interlinked scenario, hence providing policy makers and regulators who are considering the opportunity to support certain categories of 'new gases' with a clear picture and the most relevant information for their final choice.

- What our table distinctly displays is, in fact, that it is fundamental to distinguish between gases that are "green by source" from those that are "green by process" because, as ICCT correctly points out, "*renewable gas does not always mean low-carbon*". Some new gases that are intuitively conceived as environmentally neutral, such as biogas and biomethane, have a very strong carbon and methane footprint, despite their non-fossil origin. On the other hand, it is possible to obtain forms of clean gas such as hydrogen from fossil fuels (natural gas) through processes having negligible or no impact in terms of GHG emissions (such as pyrolysis).

- As hydrogen is emerging as one of the most promising additions to the future EU energy mix, it is fundamental to track its whole lifecycle process. Depending on the type of electricity used to produce hydrogen via power-to-gas installations, on the feedstock used for pyrolysis and on the presence/absence of CCUS technology – the green value of hydrogen may vary significantly from very high to very low.

- Due to the complexity of this classification exercise, and in order to avoid unwanted references to the definitions already included in the existing regulation, we believe that naming the four categories with neutral terms such as Alpha, Beta, Gamma and Delta will help avoid misunderstandings. For each gas, these four categories describe the *GHG impact in terms of origin and process* and the *homogeneity in operational, market and usage terms.*

Regulatory and Policy Challenges Ahead

It is important to remember that our taxonomy proposal is a *model* which, by definition, - to use Albert Einstein's words - is '*a selective reproduction of reality*'. For instance, the usability parameter levels any differences between biogas and natural gas in terms of accessibility to gas infrastructure; similarly, CCUS technology is, by approximation, deemed able to fully compensate for CO2 emissions in SMR.

Such simplifications, or large approximations, are needed in order to move the discussion forward at this stage. Otherwise, the risk is for the debate to keep revolving around percentages and statistics which are going to evolve with time and progress in research anyway.

The role of technological innovation is indeed an element that cannot be neglected. An efficient taxonomy for the new gases should be able to accommodate progress in the technology used to obtain them, which is in continuous evolution. Air capture technology, pyrolysis and photo catalysis are three areas where investments in R&D could be particularly interesting.

Regarding efforts to define the green value of a gas, while our proposal gives prominent importance to the environmental impact of 'new gases', it is discretionary *where* to start measuring the impact of the 'lifecycle GHG emissions' concerning the production of a green gas, and "which kind of environmental effect" should be prioritised. As an example, decision makers might have to deliberate whether favouring power to gas technology, with the noble scope to incentivise generation of beta gas (=clean hydrogen), could lead to water scarcity issues. Similarly, if production of biogas and biomethane are to grow significantly in the next years, it is fundamental to ensure that this acceleration does not create distortions on market rules, price and use of other markets' products (such as food and agriculture).

Moreover, a non-negligible challenge for regulators and policy makers lays in the fact that the taxonomy debate fro green gases doesn't take place in a regulatory void and any new terminology proposal might therefore have immediate consequences at the regulatory and therefore at the commercial level. For instance, referring to some of the new gases as 'renewables' immediately raises questions about their relation with the definition of "renewable energy" included in the Directive 2018/2001 (RED II) at art.2 (1).[10]

At the same time as this proposal for taxonomy is being presented, the European Commission is developing an EU Taxonomy for Sustainable Finance[11], setting out criteria to determine the environmental sustainability of an economic activity. While in definition and scope, at least, the two Taxonomies seems to have different purposes and focus, we recommend that they be developed in a consistent and compatible manner.

All the above mentioned challenges (and others) should not discourage the work in searching for a common, understandable and unequivocal taxonomy, which would ultimately allow an overarching classification and reference base to gases in all parts of the globe. The highest ambition of a fair taxonomy indeed is managing to provide a "universal green energy dictionary", which is robust to geography or structural contingencies and can be understood by everyone.

10. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN

11. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0097

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