Annex 1

Barriers to gas and power sectors coupling

1. Introduction and objectives of this note

1.1 There is currently much discussion in Europe regarding the need to foster greater sector coupling in the electricity and gas sectors to drive an efficient energy transition. However, sector coupling remains an ill-defined concept and the barriers to sector coupling have not been thoroughly documented to date.

1.2 Against this background, FTI-CL Energy has been commissioned by GIE to conduct a review of some of the key barriers to sector coupling based on personal interviews with market participants. This paper is an Annex to the GIE paper on policy recommendations on Sector Coupling and includes the results of this survey.

1.3 There are many definitions of sector coupling. In general, it refers to the interconnection of the energy consuming sectors with power producing sectors at large. In this note we will focus on the Gas-to-Power and Power-to-Gas elements. Gas can be easily stored and burnt to produce electricity– "Gas-to-Power" – and used as a storage of excess decarbonised electricity in the form of methane or hydrogen – "Power-to-Gas".

Drivers of electricity and gas coupling

1.4 The evolution of the electricity system and technology changes are driving a greater need for flexible and dependable resources. At the same time, in some countries the electricity grid is facing growing congestion issues and the gas grid encountering difficulties in managing the system due to falling demand.

1.5 Through sector coupling, gas infrastructures to transport and store gas could potentially be leveraged to provide flexibility to the power system and transport green gas produced from carbon free electricity through the gas network. Alternative options are also being discussed, including options that do not require continued use of the gas network, such as electricity storage via batteries. Flexible sources of electricity will be increasingly valuable in the future as the growth of variable renewable generation in the power sector will increase the need for power sector flexibility, and as the power network may face increasing congestion challenges.

1.6 Sector coupling would however lead to gas being used differently than it was when the network was built, and the market designed. In the past two decades the European regulatory and market framework for gas and electricity has been developed without necessarily fully considering the need to ensure an efficient interaction between of these two energy carriers. As a result, there is a need to reconsider the market and regulatory framework and identify potential enhancement that would promote better gas and electricity coupling.

1.7 In addition, power and gas sector coupling will compete with a range of other options to provide the different services to the energy system. For instance, the flexibility of the gas system will compete with other short-term flexibility options in the power system such as electricity storage (batteries), or demand response. Similarly, gas power plants dependability will compete with other dependable resources.

Core principles for efficient sector coupling

1.8 It follows that an efficient sector coupling will require a regulatory and market framework that relies on a **number of core principles**:

- **Recognise the different sources of value provided to the energy system by different energy sources and infrastructures in a holistic perspective** – in particular some of the externalities not valued today in the current market and regulatory framework will need to be explicitly taken into account;
- **Establish a level playing field for different energy sources and infrastructures to provide / access these different services**;
- **Re-examine the market and regulatory framework to stimulate competition and innovation between energy sources and infrastructures** to provide the different services needed by the energy system;
- **Revisit the governance of the energy sector and the indicative planning mechanisms to foster a holistic approach** to infrastructure development.

1.9 It is beyond the scope of this note to explore in details the potential approaches to revisit the current market and regulatory framework in Europe. We instead focus on identifying barriers to sector coupling, using a literature review and interviews with sector experts.

1.10 As a disclaimer we stress that this list does not aim to provide a comprehensive review of all barriers, but instead provide an overview of the main barriers identified, presenting concrete examples which may be specific to some countries, and giving some general directions and recommendations to address the barriers identified.

Categories of barriers identified

1.11 One difficulty in mapping the different barriers to sector coupling is that some of these originate in electricity or gas market or regulatory failures, whilst other barriers focus on the interaction across the electricity and gas market and regulatory frameworks. In what follows we have not attempted to distinguish between these different types of barriers but leave this for further work.

1.12 Our interviews and survey of the literature led us to identify a range of barriers to sector coupling which we classify in the following categories: regulatory, market design, technical and governance barriers.

1.13 Based on interviews and review of the literature, we group the barriers into four categories:

- **Market design barriers** relate to the internalising of the scarcity and dependability value in both gas and electricity markets. Without recognising the value gas adds to the energy system in this new role under sector coupling, it will be difficult to attract the investment required for its progression. There are also barriers with the interplay between the gas and electricity markets, such as the alignment of time frames and products.
- **Regulatory barriers** include the conditions of usage and access of networks and infrastructures as well as fiscal and taxation issues. There is also more generally a degree of uncertainty of the regulatory and market arrangements, and this lack of clarity can inhibit investment in sector coupling.
- **Technical barriers** come with the greater use of renewable energy sources, in particular green gas such as hydrogen or methane. There is currently no common approach for defining technical standards on a number of operational issues. This can prevent different parts of the energy sector and different countries collaborating with each other if technical standards are uncertain.
- **Governance barriers** are predominantly impediments to planning and collaboration across different parts of the energy sector that need to work closer together in sector coupling.

1.14 The rest of this note is organised as follows: Section 2 explores these barriers in Gas-to-Power and Section 3 in Power-to-Gas.

2. Gas-to-Power

2.1 The below table sets out examples of barriers to Gas-to-Power in each of the four categories.

Barrier category	Barrier	Description	Potential solution
Regulatory	Network charging	The required responsiveness of gas power plants in some countries may be hindered by the lack of gas network transport products tailored for a more volatile operation of gas plants. Gas transport products remain long term in a number of countries and operators of power plants may therefore not be available for some extended periods of time if they make the decision to not subscribe to these products. Under long-term contracts, operators need to buy network capacity 'just in case' it is needed, which increases the costs of energy generation. There are some concerns over how feasible these short-term contracts may be, since this would not reflect the underlying characteristics and costs of the network that need to be recovered. Short-term capacity trading between network users, subject to technical requirements on substitutability, could have a similar effect, without incurring the complications from moving away from long-term contracts. Recently, some progress has been made thanks to the European network codes. However, there remain barriers to the availability of short-term transportation contracts in a number of countries.	Evaluation of effects on expanding the transport capacity products to include more short-term products. Possibly incentivise network operators to innovate in the design of products best suited to the needs of users such as power generators having a role in sector coupling. For example, Italy has recently started incentivising gas DNOs to have more short-term network capacity. Look at amending EU regulation 715/2009 to require ENTSOs to develop a Network Code on sector coupling to specify the technical and operational details.

Barrier category	Barrier	Description	Potential solution
	Uncoordinated approach to crisis management / joint scarcity in the power and gas sectors	Some countries apply the European gas security of supply regulation in a way which can distort market outcomes through interventions. At times of joint scarcity in both the gas and electricity sectors, the electricity sector will seek to use gas as its reliable source of energy generation. However, security of gas supply regulations may be applied to prevent the use of Gas-to-Power in these situations – instead domestic customers may be prioritised. This could result in a lack of availability of gas, which could make gas a less reliable and flexible source of electricity.	Need to move away from separate approaches to crisis management to avoid situations in which an intervention in one sector has adverse side effects on the other sector. A joint approach for crisis management in both the gas and electricity sectors at times of scarcity could help ensure that there are no barriers / inconsistencies.

Barrier category	Barrier	Description	Potential solution
Market design	Liquidity in the gas market	With gas acting as the flexible source of energy, the gas market for power generators will have increasingly volatile and short notice demands for gas volumes. There are concerns in some countries over the extent that the current design of the gas market can facilitate this, in particular the gas balancing regime. One of these components of the gas market design is the gas balancing zone. Larger gas balancing zones can provide more flexibility – but many countries' gas markets were designed with several small gas balancing zones. Given this greater need for liquidity, several European countries that had multiple zones have merged them over the past decade, including France. However, for some of the geographically smaller European countries, even merging into one zone can still result in a small gas balancing area. The gas balancing timeframe also influences liquidity. Whilst electricity market imbalances are typically dealt with within an hour to real time, in the gas sector longer balancing timeframes allow within day flexibility, as gas buyers and sellers can respond to short-notice demands for Gas-to-Power and still have time to ensure they balance intake and offtake by the end of the period. A short balancing timeframe limiting liquidity could make gas plant less flexible compared to other types of energy.	Foster liquidity of gas market particularly in the short term, by e.g. encouraging the continuation of merging gas balancing zones and/or avoiding too short time frames for gas balancing. Re-examine the balancing timeframe to ensure that it is sufficient to ensure liquidity to serve the needs of the power sector, and balance this against other drivers of the choice of this timeframe intrinsic to the gas system such as the valuation of short-term flexibility through more granular balancing.

Barrier category	Barrier	Description	Potential solution
Taxation	Taxation does not always apply to the end consumer	Taxation in several countries may not be following the principle of taxing the end consumers. Taxing other part of the energy system can result in an unlevel playing field. This can particularly affect sector coupling, because Gas-to-Power is classed as and end consumer in some countries and so incurs tax.	In the specific case of infrastructures having a sector coupling function, could consider having a separate approach with tax exemptions / reductions.
	Lack of harmonised national taxation regimes and policies	There may be a lack of harmonisation of national taxation regimes, which can create barriers to cross-border exchange of some energy services such as flexibility. Trade can also be distorted if countries' energy subsidies are not aligned. For example, if some countries provide consumption-side support and others producer-side support, some gas may receive both subsidies if it originates in a country with the later and is imported to a country with the former support.	Harmonisation of national taxation regimes.

Barrier category	Barrier	Description	Potential solution
Governance	Planning and regulators' approach	Without joint planning for key infrastructures across electricity and gas, there could be a risk of inefficient investments as gas and electricity networks could duplicate investment to meet future demand including P2G locations. Given the long time to implement changes in asset-heavy networks, it is crucial that this planning is proactive and a holistic approach is used. One barrier to this being done is the separate process for indicative planning of gas and electricity network development, with network operators being required to submit plans to different regulatory bodies. Some countries have started this joint planning, but more progress is needed. Another barrier is lack of information sharing, including of wind and solar generation forecasts and actual output. Greater information sharing will allow the gas and power sectors to plan better and be more proactive in managing the energy system as a whole.	Ensure regulation of gas and electricity infrastructure operators does not create adverse incentives to have a narrow sectoral approach. Define guidelines and a common methodology for the TSOs network plans in gas and electricity can / should be coordinated. In addition, investment approval could be subject to a cost benefit analysis comparing options across sectors as opposed to options within sectors.

Barrier category	Barrier	Description	Potential solution
	Obligations and incentives having a narrow sectoral focus	Obligations put on market participants and /or infrastructure operators often narrowly focus on either electricity or gas. In some countries for instance, there are legal obligations to supply electricity or gas irrespective of what is happening in the other sector. Some of these obligations can be linked to the EU security of supply regulations. Financially, infrastructure operators are incentivised to minimise costs and maximise use of their own sector. These incentives usually form the basis of the regulatory framework and can result in difficulties exploring solutions than span across the two sectors – for instance building a gas-fired plant to alleviate an electricity network constraint.	Address legal obligations preventing a joined approach across sectors. Define a regulatory framework for network and storage operators in electricity and gas that allows a level playing field.

3. Power-to-Gas

3.1 Power-to-Gas allows the energy system to store electricity in the form of gas. This technology is not as mature as Gas-to-Power, which brings several additional barriers to expanding its use.

Barrier category	Barrier	Description	Solution
Regulatory	Gas network charges	Operators pay to use networks, with charges structured to prevent congestion to some extent. Power-to-Gas is classified as a generation asset in several countries, and as such it incurs double Transmission Network Use of System (TNUoS) charges. However, under sector coupling, Power-to-Gas might help relieve congestion on the gas network (depending on use and location on the network), implying it may be more appropriate for it to incur lower network charges recognizing its system value. In addition, infrastructure tariffs designed to incentivise the long-term use of the gas system can be inappropriate for those who want to use gas spare capacities through short-term flexibility. Such tariffs do not reflect the nature of Power-to-Gas's interruptible use: network use is not driving expansion of the grid and not creating congestion, so should incur a lower price.	Differentiated network charges for storage and / or activities with a sector coupling function such as Power-to-Gas.
	Electricity network charges	Electricity operators that can have their network use interrupted could also be charged to reflect their flexibility and their role in alleviating congestion. Power-to-Gas and storage operators can often be flexible in their network use. Some countries are looking into creating a different electricity network tariff for such flexible / interruptible users. This takes into account that these users' supply can be interrupted more easily, with a lower tariff to reflect this (e.g. Norway).	Differentiated network charges for storage and / or activities with a sector coupling function that can interrupt their consumption when needed to relax constraints on the electricity grid.

Barrier category	Barrier	Description	Solution
	Ownership of Power-to-Gas	The lack of clarity on the type of regulatory and business model that should support the development of Power-to-Gas has been a barrier to its progression in Europe. Under unbundling rules, designed to ensure there is enough separation to ensure competition in the sector, Power-to-Gas is classified as energy storage, which is categorised as generation. Therefore, transmission and distribution operators cannot own, develop, manage or operate energy Power-to-Gas facilities. This does, however, vary by country, with exceptions to this rule: in Italy and Belgium, for example, TSOs can build and operate Power-to-Gas. In the end, the lack of business model clarity may prevent the development of Power-to-Gas businesses on a European scale.	A clear guidance on the regulatory framework for Power to Gas should be developed. One option to address the potential competition concerns, commercial market players could be invited to invest in Power-to-Gas, and, if there is no commercial interest, then TSOs/DSOs allowed to invest themselves. In such case, the TSO/ DSOs would be limited to the conversion, not owning the commodity.
Market design	Low cost of fossil fuels no internalizing the value of environmental externalities	Fossil fuels' use of carbon is not fully internalised[1], resulting in inefficient energy prices for decarbonisation, and in practice in low cost fossil fuels that are harder to displace with low carbon alternatives.	Internalise the price of externalities of high carbon energy, such as through CO_2 prices[2].
	Uncertainty around the	Since use of hydrogen and biogases is relatively new, there is a large amount of uncertainty over how these fit into the regulatory framework and market design	Provide greater regulatory and market design certainty on hydrogen and

[1] http://www.europarl.europa.eu/RegData/etudes/STUD/2018/626091/IPOL_STU(2018)626091_EN.pdf

[2] https://www.cleanenergywire.org/factsheets/sector-coupling-shaping-integrated-renewable-power-system

Barrier category	Barrier	Description	Solution
	regulatory framework for hydrogen and biogases	and what changes may be made to accommodate them. This is exacerbated by concerns that hydrogen and biogases may not be the chosen solution; there are many options being considered to provide flexibility. This uncertainty includes questions on how the currently unregulated hydrogen value chain may be regulated and whether hydrogen will be available under third party obligations. This uncertainty can reduce investment. Investors seek to avoid the risk of committing money to projects that may have their financial model fundamentally altered if there are changes to regulation and market design.	biogases.
	High upfront costs and financeability issues	The upfront costs of expanding or refurbishing the existing infrastructure and constructing new infrastructure needed for sector coupling can be high. Combined with the uncertain regulatory environment generating lower investment, there may be difficulties in financing these high upfront costs. Power-to-gas technology (electrolysers) is only financially viable if used continuously, and so can incur a long period of investment without returns while the energy sector transitions.	Consider intervention in the market in the early stages of sector coupling to ensure the investment requirements are met.
	No common definition / tracing system for guarantees of origin for clean gas	There are inconsistent uses of Guarantees of Origin (GoO) certificates for gases. Countries including Denmark, Sweden, Germany, Holland and Belgium use them, but there are still barriers to trading with countries that have not yet adopted GoO certificates. For example, hydrogen from wind energy is defined as a “biogas” in Germany, but users have reported difficulties trading with Switzerland, as it is treated as a natural gas there.	Develop Europe-wide common definitions for different types of gases (including hydrogen) and incentivise greater take-up of GoO.
	Calculation	The calculation of renewable energy shares in electricity for transport is based on	Allow Gurantees of Origin to

Barrier category	Barrier	Description	Solution
	rules on the share of renewable energy in the transport sector (EU Directive 2018/2001 Art. 27)	the average share in the electricity in the country of production in the two years before. This can inhibit large investments in Power-to-Gas, as the return on investment will have a two-year lag. Alternatively, electricity obtained from a direct connection to renewable electricity generation can be counted as fully renewable energy provided it is used to produce renewable liquid and gaseous transport fuels. Electricity that is taken from the grid can be counted as fully renewable provided it has documentation proving it was produced exclusively from renewable sources. However, this documented proof is not currently easy to achieve.	transverse sectors so renewable energy can be acknowledged.
Technical	Technical standards and solutions differ across countries	The injection of hydrogen into gas grids does not yet have consistent technical standards[3]. Only a low amount of hydrogen can be mixed in the current gas network, as the network has not been designed to withstand the specific properties of hydrogen, which could lead to higher permeation and corrosion. There are also concern around the hydrogen tolerance of end user appliances. There is still ongoing research into the best blending limits of hydrogen into the natural gas network. This has created barriers to progressing projects to produce hydrogen, which find it difficult to obtain permits. In the Netherlands for instance the Gas Act determines the mix of gas allowed in the network, stipulating that gas must be over half methane. This prevents hydrogen being injected into the network.	Increase research in understanding the capabilities of gas networks and appliances. Remove the legislative barriers – such as that in the Netherlands – to changes in gas quality to allow experimentation.

[3] European power to Gas Platform: Power-to-gas in a decarbonised European energy system based on renewable energy sources.

Barrier category	Barrier	Description	Solution
	Lack of cross sector qualified human resources	Given the large amount of technical knowledge needed for planning and operating across the energy networks, greater integration between gas and electricity results in network operators needing to have expertise in both. The lack of skilled workforce that can work across the sectors can be a barrier to sector coupling.	Support multi-energy qualifications. For example, DSOs in Germany have started to require their Chief Engineers to be dual qualified in gas and electricity.
Taxation	Power-to-Gas is taxed as an end user	End users of energy incur taxes. Since Power-to-Gas results in electricity being 'used' it is taxed as an end user, even though this is providing a service in sector coupling by storing excess electricity. For example, this happens in the Netherlands. In Germany for instance, the financial case for Power-to-Gas is hindered by a range of additional fees – including grid fees, taxes and renewable charges – because storage is treated as an end consumer.	Remove taxes from the Power-to-Gas process, e.g. by classifying storage as a separate element in the energy system, distinct from end users. In Denmark for instance, Power-to-Gas is considered a process energy and so is not subject to tax.
	Favourable taxation for fossil fuels	In some countries there are anti-decarbonisation tax and subsidies systems[4]. If decarbonised energy is not financially competitive with fossil fuels it will be difficult for sector coupling to progress without regulatory intervention.	Ensure tax and levies incentivise low carbon energy sources.
Governance	Impediments to combined electricity and gas infrastructure companies	There are legal and regulatory barriers to having more infrastructure companies doing both gas and electricity as an integrated energy company. These often derive from unbundling regulations, designed to ensure competition in the energy sector through separation. This creates a barrier to electricity and gas infrastructure companies proceeding with projects that incorporate both electricity and gas, which would help promote sector coupling.	Incentivise closer working between local electricity and gas DSOs where it creates value, and allow them to operate in both sectors. ENTSOs could be incentivised to work towards increasingly integrated

[4] https://blog.energybrainpool.com/en/sector-coupling-how-far-is-germany/

Barrier category	Barrier	Description	Solution
		Electricity and gas operational synergies are likely to be strongest at local level, which may support more combination of electricity and gas DSOs.	TYNDPs. Moreover, CEF arrangements could be opened to investments into sector coupling technologies such as P2G.