FLEXIBILITY IN THE ENERGY TRANSITION

A Toolbox for Gas DSOs

February 2018

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The biggest challenge facing the EU energy sector is to pave an effective and cost-efficient road towards decarbonisation

A. BACKGROUND

With the European energy transition demanding closer inter-DSO cooperation in the interest of customers and society at large, the European associations representing DSOs (distribution system operators) - CEDEC, EDSO for Smart Grids, eurelectric, Eurogas and GEODE - have been working together constructively now for several years.

In recognition of the fact that DSO issues are becoming of increasing interest and importance to European energy policy, the European Commission has repeatedly expressed its desire to receive trusted, expert level advice on a range of matters affecting DSOs. These include market design, DSO/TSO cooperation, flexibility patterns and procedures, integration of renewable energy sources, deployment of smart grids, demand response, digitalisation and cyber security.

With this in mind, the above associations have agreed to deepen their cooperation and are prioritising the issue of flexibility. They have established a programme of work and a committee of experts covering flexibility for both electricity and gas.

The work of both focus areas, which has run in parallel over the past year, resulted in two reports, one for electricity and another for gas. Both reports together provide a holistic overview of how DSOs can use flexibility and thus contribute to the transition towards a more decarbonised and sustainable European energy sector. They present a set of solutions to enable DSOs to use flexibility as a tool to operate their grids in a cost-efficient way.

The reports also provide clear recommendations to policymakers on how the regulatory framework should evolve to make better use of flexibility, both by the DSOs as well as by other stakeholders.

An improved regulatory framework should reward the use of flexibility – also by DSOs – and must take into account the growing role of the DSO as an active system operator and neutral market facilitator. These reports present solutions for DSOs to cope with the challenges of flexibility, an analysis of the various technologies available to provide the required flexibility services to system operators, as well as alternative ways to acquire such services.

B. EXECUTIVE SUMMARY

An integrated approach between electricity and gas

The European Union is looking at cost-efficient ways to make the European economy more climate-friendly and less energy-consuming. Energy related emissions account for almost 80% of the EU's total greenhouse gas emissions.

The energy challenge is therefore one of the greatest tests which Europe has to face. The EU energy system needs a transition to carbon neutral and sustainable energy sources. Many of these energy sources, in particular renewables tend to be volatile e.g. solar and wind energy.

Furthermore, the new generation sites using these more distributed energy sources are to a large extent connected directly to the distribution system, as opposed to traditional centralised power generation units which are usually connected to the transmission system. As a result, electricity generation is gradually moving from a centralised to a largely decentralised perspective.

On the customers' side, the demand for mobility and heating is also shifting. Traditionally, fuel for transport has been derived from oil, but this sector also has its own specific decarbonisation targets. It is highly likely that in coming years, road transport will significantly change its energy source from oil to electricity, gas and hydrogen.

The heating and cooling sector for buildings is also set to undergo important changes in the near future. Whereas heating is now achieved mostly through classic energy sources (often with natural gas) alternative technological solutions such as heat pumps and micro-cogeneration are rising.

It is therefore evident that the energy transition will not only see profound changes in the way energy is produced, but also in the way energy is used, stored and consumed. This is set to increase in the future and will have a huge impact on distribution grids.

This is where flexibility will have a critical role to play. Besides the technical grid solutions, flexibility is needed both on the generation and on the demand side. In order to benefit from the storage capabilities of natural and renewables gas it is important that the electricity and gas sectors cooperate in order to develop integrated solutions, such as power-to-gas.

The unique features of both energy systems can be complementary to each other and can contribute towards developing cost-efficient technological solutions. Gas can be an important flexibility solution for electricity. The EU DSOs in electricity and gas have agreed to collaborate and share their competencies and knowledge. This partnership will contribute towards the development of an adequate and coherent regulatory framework to improve the development and exploitation of flexibility's potential in the European energy system.

The large diversity of DSOs in the EU in terms of size, activities or organisational structure will not be able to cope with a "one size fits all" future model. However all DSOs face the same challenge: connecting more than 90% of customers and ever growing numbers of local renewable generators in a fast-changing, more decentralised and digital energy world.

The gas flexibility report

Already today gas grids are a powerful tool to manage flexibility of the energy system in the European Union. EU energy demand for heating depends on seasonality and therefore is very fluctuant during the year, with a winter peak load several times higher than in summer. Gas grids, through storages and linepack, are naturally capable of managing high energy demand fluctuation.

Gas technologies can also provide flexibility solutions to electricity grids: by storing excess of electricity supply via Power-to-Gas and by lowering demands via (micro/mini) combined heat and power (CHP).

Flexibility can be brought to the electricity system by the gas infrastructure which can balance fluctuations (surplus and shortages) in the power grid on the upstream side through the use of the power-to-gas technology; and on the downstream side through the use of flexible production units such as (micro/mini) CHP.

The optimal and cost-efficient use of all existing infrastructures should be a goal for both the energy industry and politics. Hybrid applications in the heating sector or the conversion of excess electricity into hydrogen are just two examples where the combination of both energy systems can lead to a win-win situation. Decarbonisation, decentralization and digitalisation will turn also gas DSOs into key actors of energy flexibility.

Achieving decarbonisation of the heating needs in the EU exclusively through electrification of heating would require a massive build-up of electricity grids and additional renewable and back-up generation capacity for a low number of utilisation hours. To address this challenge, the greening of gas grids through the development of biomethane shall be privileged: biomethane is a predictable and storable sustainable energy that can be injected in flexible gas grids. By 2030 thousands of decentralized biomethane production units are expected to be connected to DSO grids, and this will require a more active role of the gas DSO vis-à-vis the gas TSO regarding network planning and reverse flows.

The development of smart grids – in the fields of metering, maintenance and operation - in gas and electricity will provide more detailed data that will further improve flexibility management and enable synergies both between energies (electricity, gas) and usages (heating, mobility).

To achieve the ambitious EU energy and climate goals and to contribute to a stable and efficient energy system, the gas DSOs are calling on policymakers and regulators to integrate these new elements and roles for DSOs in flexibility in all future gas market legislation:

- Further develop Research & Innovation on gas-related technologies that provide flexibility to the overall energy system (biomethane, hydrogen, micro-CHP, reverse flows and others);
- Encourage renewable and smart gas producers as flexibility providers (P2G, micro/mini CHP);
- Take into account the more active role of gas DSOs in managing flexibility on their grids (Ten-Year Network Development Plan (TYNDP), reverse flows, connections for renewable gas producers).

C. KEY RECOMMENDATIONS

1. Develop gas technologies and gas DSO Research & Innovation (H2020[1] , SET- Plan[2]…) focused on promoting energy flexibility

- **Renewable gas technologies to diversify renewable energies with more predictable and storable energy:**
  > Develop, test and improve technologies associated to the production of these new renewable gases (purification & injection, biomass gasification…)

- **Gas technologies to lower electricity peak demand or to store renewable excess electricity:**
  > Optimise hybrid heating solutions such as solar with gas
  > Optimise CHP, Micro-CHP, Fuel Cells and gas heat pumps
  > Develop power-to-gas technology to use excess variable renewable electricity to produce synthetic gas, distributed and stored in gas infrastructure
  > Test capacity of gas grids and gas appliances to use more H2

- **Promote incentive regulation for gas DSO in research and innovation projects**

2. Set up an appropriate legal/regulatory framework to accelerate the development of gas technologies providing flexibility for the overall energy system

- **P2G producers shall be recognised as flexibility providers**
  > The production of hydrogen from surplus electricity can avoid the installation of fossil/renewable generation capacity and replace electricity network expansion. These avoided costs need to be monetised and the H2 producers shall be financially rewarded accordingly.
  > The operator of the electricity network should be allowed to buy flexibility from power-to-gas plants. And if there are capacity markets in place, the power-to-gas plant should be allowed to take part in the auction.
  > Taxes and levies for electricity have to be revised as powers-to-gas plants are not end users but energy storages.
  > Technical rules have to be adapted to increase the percentage of H2 in gas grids.

1. Horizon 2020 programme
2. The European Strategic Energy Technology Plan

- **Biomethane producers shall be rewarded for all the positive externalities**
  - > Support schemes shall be developed taking into account all the positive externalities: contribution to energy flexibility, decarbonisation of agriculture, waste treatment…

- **Gas prosumers using smart gas flexible solutions such as micro-CHP shall be incentivised**
  - > Building codes and energy labelling should fully reflect the benefits for consumers and at energy system level which is not the case today.
  - > Recognition of renewable gas share used in micro CHP in the energy efficiency performance of the building

3. Set up an updated legal & regulatory framework to take into account the more active role of Gas DSO to manage flexibility

- **Gas TSO shall partner with Gas DSO to build the Ten Year Network Development Plan to take better into account:**
  - > decentralized production forecast
  - > new usages development such as gas mobility

- **Gas TSO shall make a cost benefits analysis to assess if local reverse flow can meet better flexibility issues than extension of TSO networks**

- **Member States shall be allowed to implement support schemes for renewable gas producers**

1. INTRODUCTION

Renewable & natural gas can contribute to EU decarbonisation objectives

Gas is of paramount importance in the EU energy system. EU gas consumption represents around 4500 TWh (terawatt hour) per year[3] compared to 3000 TWh for electricity[4]. To deliver that energy, the EU gas industry represents more than 2 million km of pipelines and 100 million delivery points, managed by 45 Transmission System Operators (TSOs) and 2000 Distribution System Operators (DSOs).

EU ambitions to decarbonise the economy should consider natural gas as a key contributor for two reasons: it is the cleanest fossil fuel, and it can become renewable. Gas is a clear enabler of energy transition. It can complement intermittent renewable electricity and meet peaks in demand as a predictable and storable energy vector. Moreover, gas can be decarbonised – which means that the EU can continue to benefit from the attributes of gas as the energy system becomes greener.

Gas DSO role will evolve in a decarbonised and digitalised energy system

The CEER (Council of European Energy Regulators) elaborated a paper on “Future role of DSOs” dated 13th of July 2015, which stated that “higher levels of distribution-connected generation and the deployment of smart technologies will require DSOs to be responsive and innovative to ensure efficient network development and operation”.

The large diversity of EU DSOs with regards to numbers, size, activities or organisational structure means there cannot be a “one size fits all” future model. However all DSOs face the same challenge: connecting more than 90% of the customers and ever growing numbers of renewable gas producers in a fast-changing energy world.

3. http://ec.europa.eu/eurostat/statistics-explained/index.php/Natural_gas_consumption_statistics or Eurogas press release “Gas demand in EU rises for the first time in four years, according to new Eurogas data”: http://www.eurogas.org/uploads/media/Eurogas_Press_Release_-_Gas_demand_in_EU_rises_for_the_first_time_in_four_years_according_to_new_Eurogas_data_01.pdf
4. http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_production,_consumption_and_market_overview


80
100
120
140
160
4
5
6
7
8
9
10
0
GAS
PRESSURE
bar
psi

2. PROBLEM DESCRIPTION

Flexibility can be defined as the capacity to adapt the supply or the demand of energy in reaction to an external situation: peak demand or low supply. The objective of flexibility is to maintain a constant balance between supply and demand that guarantee the safety and the continuity of the energy system, to the benefit of consumers.

Flexibility can be quantified through the amount of supply/demand that can be adapted and qualified through the ease, the speed and the duration of the response.

Flexibility has always been a key topic of both gas and electricity sectors, but it has become critical as a result of the increase of renewable intermittent electricity, namely wind and solar generation. This trend has two major consequences: reduced predictability of the electricity supply, and the transfer of flexibility and system management from the TSO to the DSO; whereas traditional generators tend to be connected to the TSO, 90% of renewable energy producers are connected to the DSO. With the ongoing increase of production of renewable gas, gas DSOs also face the challenge of managing a network with increasing generation at the distribution level.

Finding solutions to address appropriately flexibility problems is mandatory to maintain and accelerate the development of renewable gas and electricity in Europe.

OBJECTIVES OF THE REPORT: REVIEWING TECHNOLOGICAL SOLUTIONS AND RELEVANCE OF REGULATORY FRAMEWORK

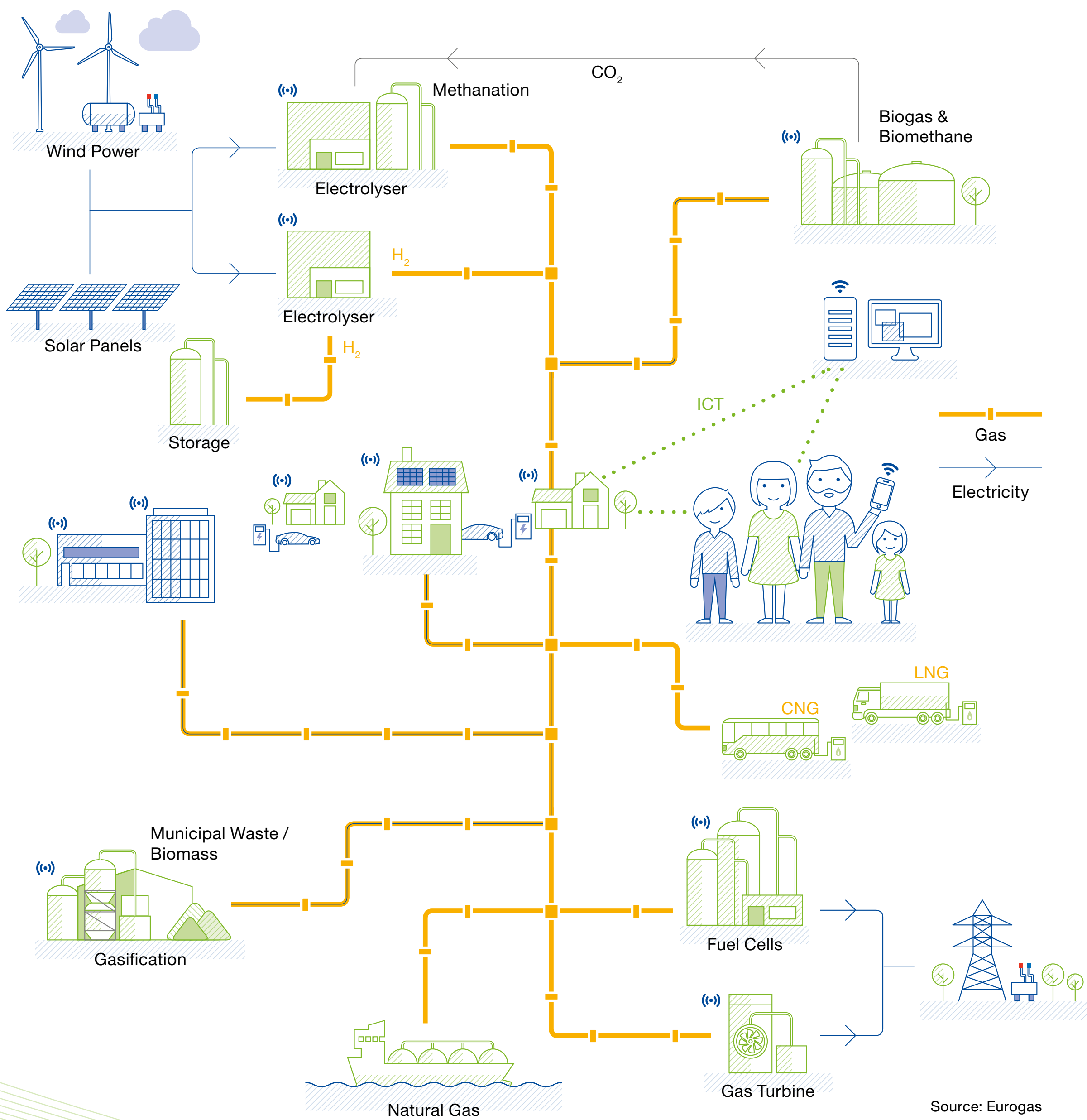
To meet this increasing energy flexibility challenge, gas DSOs and European associations have gathered together internal expertise to identify potential technological and regulatory solutions. This report will address, review and discuss identified solutions to increase the capacity of DSOs to adapt supply and demand in order to ensure safety and continuity of the energy system. Gas and DSOs can contribute to increase flexibility of the energy system in several ways:

Part 1 - Gas grids are naturally flexible.
Gas and existing gas infrastructure are naturally flexible, and it is necessary to recall the added value of the gas grid to handle peak demands.

Part 2 – Gas technologies can provide flexibility for electricity sector.
The ability of the gas grid to balance the fluctuations in the power grid can be increased via Power-to-Gas (P2G) and Micro-Cogeneration technologies.

Part 3 – Gas DSO are becoming key actors of flexibility as a result of decarbonisation and digitalisation.
The role of gas DSO shall be updated to the upcoming more decentralised and renewable gas system, while continuing to supply a reliable, cost-effective source of energy when consumers need it. We will explore how gas and electricity synergies can be further developed to contribute to solve electricity flexibility issues and move into a more holistic and smart energy system.

INTEGRATING RENEWABLE GAS IN A SART & CLEAN ENERGY SYSTEM



Source: Eurogas


£ 0.05
per hour
£ 0.06
per hour
£
kW
CO2

3. GAS GRID IS NATURALLY FLEXIBLE

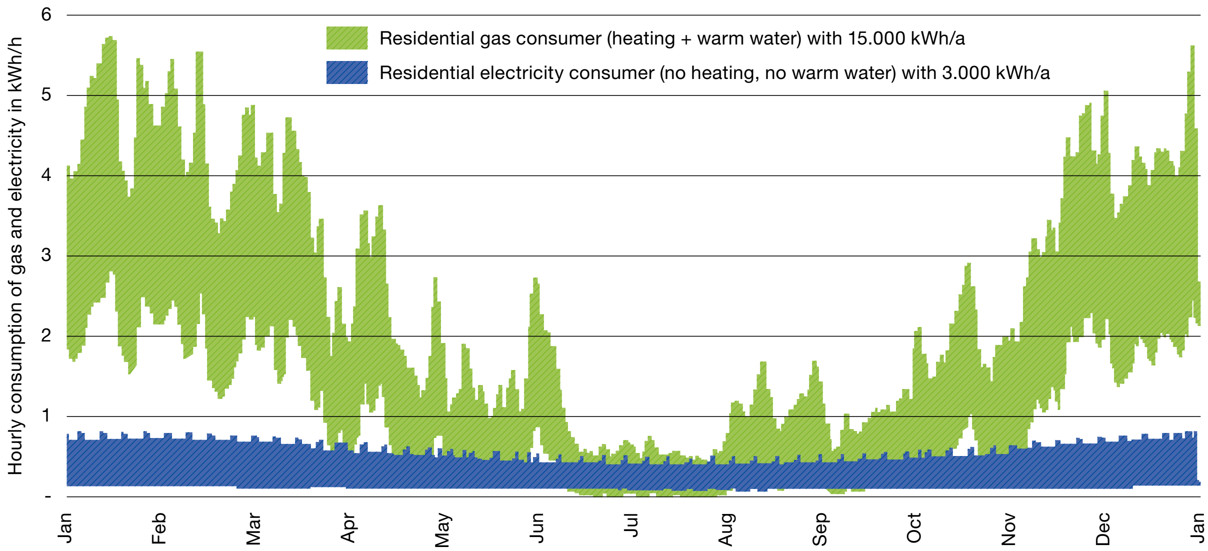
Gas is by nature flexible. Its physical properties make it easy to store, in pipes or in dedicated gas storage. Moreover, gas infrastructure has been designed since its very beginning to handle winter peak demands. This means that networks have been scaled to meet peaks, and gas interruptible contracts have been established to allow a 'demand lever' to be activated easily where necessary. Gas is therefore by nature and by design fully compatible to a flexibility focused energy world.

In addition, the increasing ambition of EU Member States to develop the volume of renewable gas they produce is changing the gas scene. The vast majority of biomethane - or hydrogen - producers are connected to the gas distribution grid. Distributors are no longer solely gas receivers and distributors but have to manage local production alongside local consumption. The role of DSO to ensure the flexibility of gas systems will continue to increase.

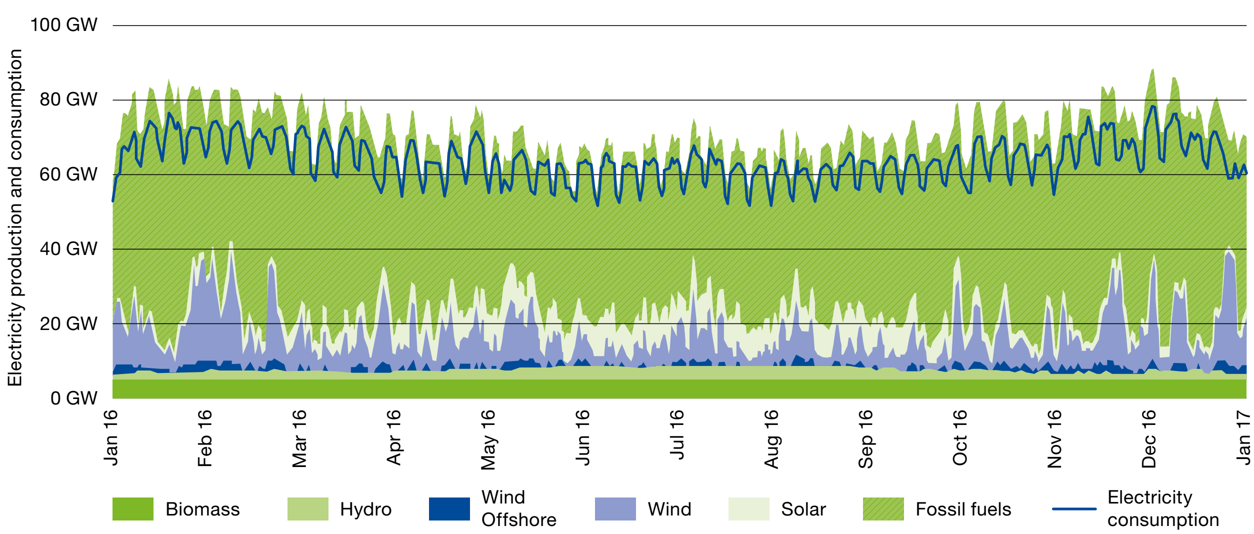
GAS GRID PROVEN CAPACITY TO HANDLE PEAK DEMAND IS UNIQUE

Heating demand is seasonal, and gas represents 46% of heating demand in the EU. Gas is already largely contributing to manage the fluctuations of the energy demand in the EU.

Example 1: Germany - In Germany, peak load for heating is 7 times higher than for normal electricity usage



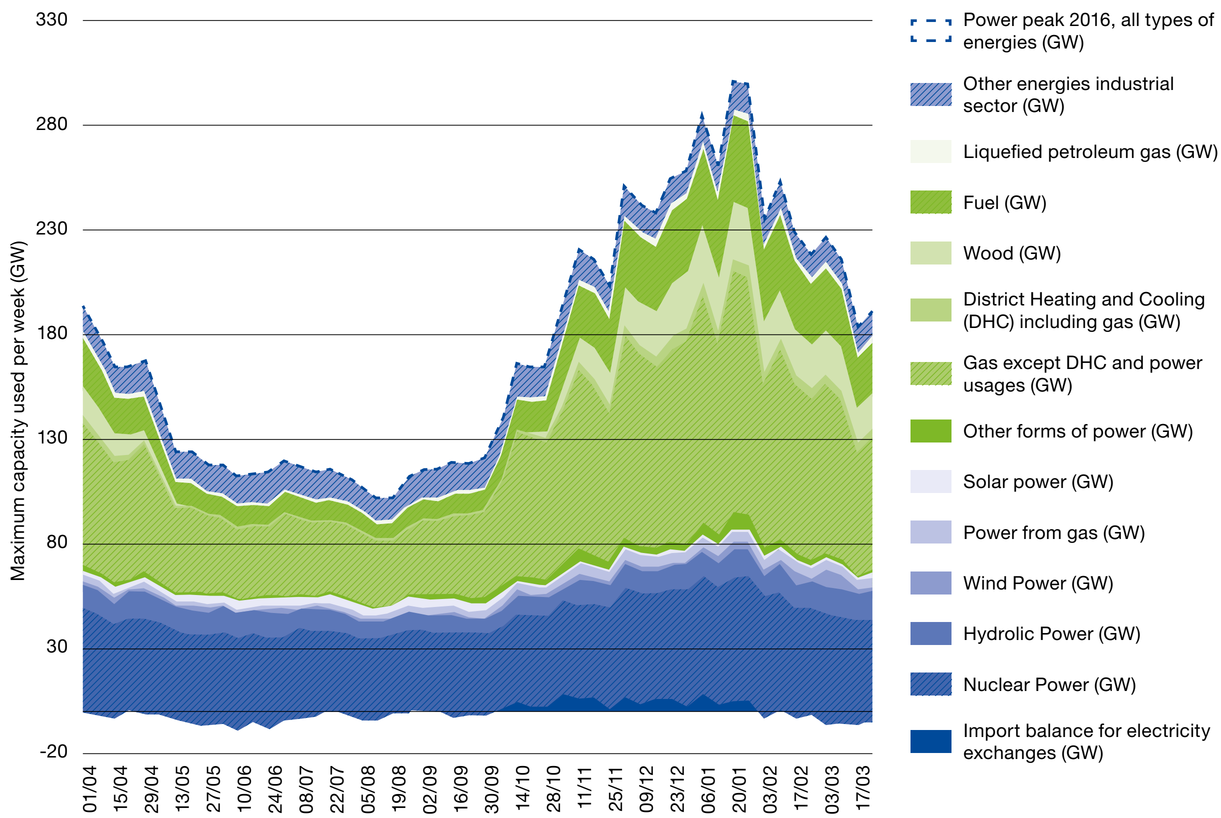
Source: Thüga



Source: Agora Energiewende

Example 2: France - The French energy peak demand for all combined energies over the year shows that the energy system requires at least three times more energy in winter compared to the summer. This is due to heating needs. The electric facilities represent an actual available capacity bellow 100 gigawatt (GW) for a theoretical installed capacity of 120 GW. The gas network, represents an available capacity ranged between 200 and 220 GW, which accounts for more than 3 times of the nuclear fleet. When the temperature drops, electric heating saturates the electricity infrastructures. This leads to the reduction of consumption or load shedding (example from January 2017).

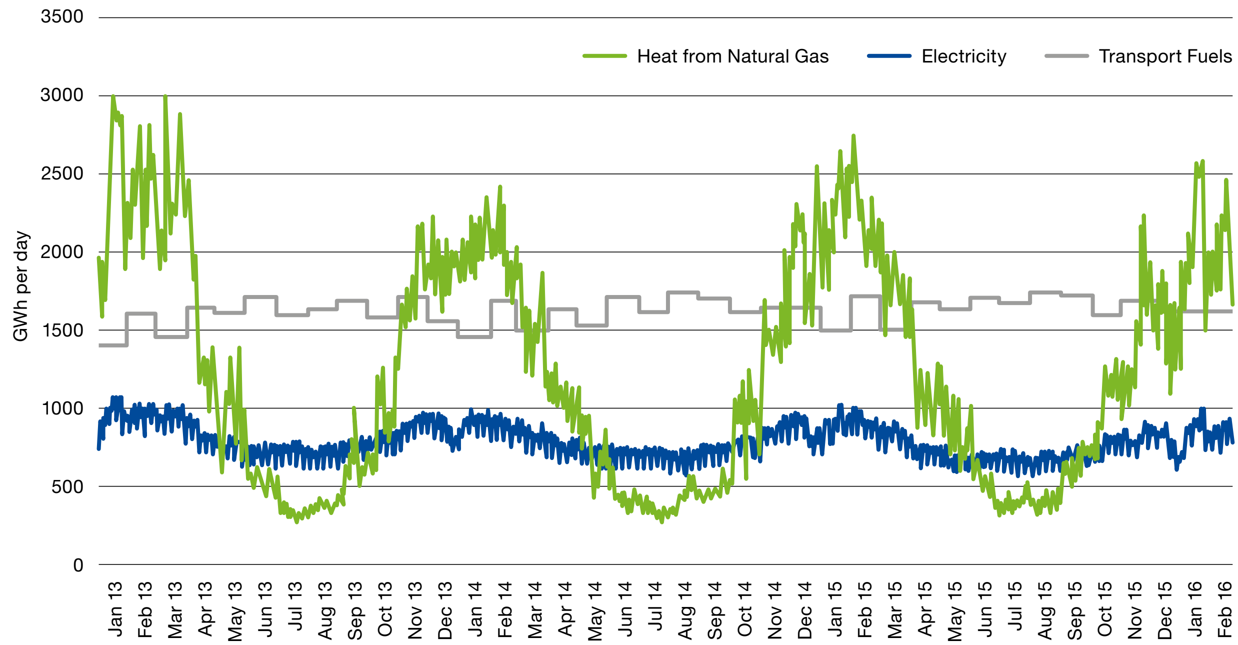
Energy peak per week over the period from 01.04.2016 to 31.03.17 in France



Source: GDRF

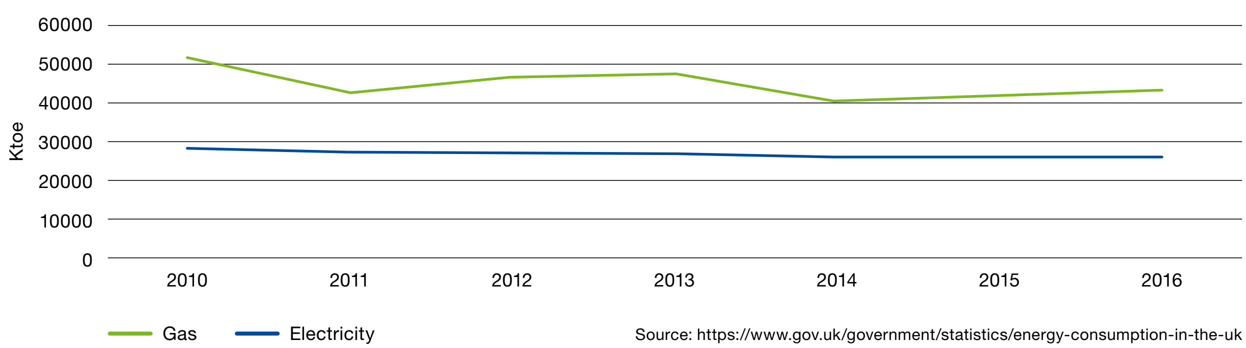
Example 3: United Kingdom (UK) - With 83% of households using gas as their main source of heat, the peak demand for gas is extremely high – up to six times higher than peak demand on the electricity network. Gas plays a vital role across the UK energy system: in energy terms total consumption is around four times higher than electricity per year, and the share of electricity generated from gas rose from 29% to 42% from 2015 to 2016 as the generation of electricity from coal has reduced and the need to balance intermittent renewable sources has increased.

Daily Gas, Transport and Electricity demand in Great Britain, 2013-15



Source: https://www.frontiersin.org/articles/10.3389/fenrg.2016.00033/full

Chart derived from UK Government "Energy Consumption in the UK" statistics, 2017



Source: https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

Example 4: Italy

Figure. Hourly breakdown of power generation by source – spring week 2015

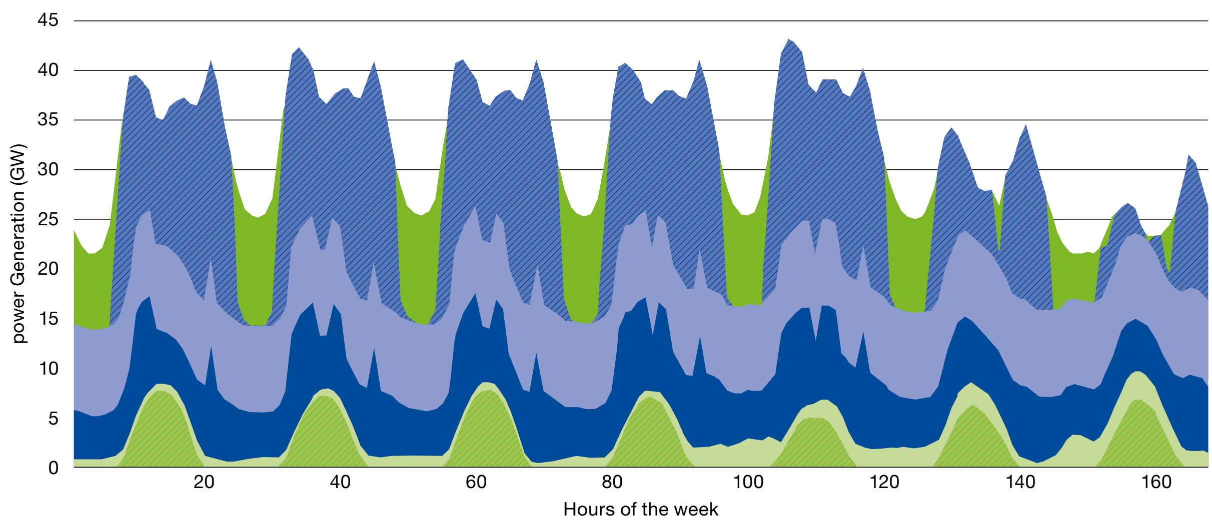
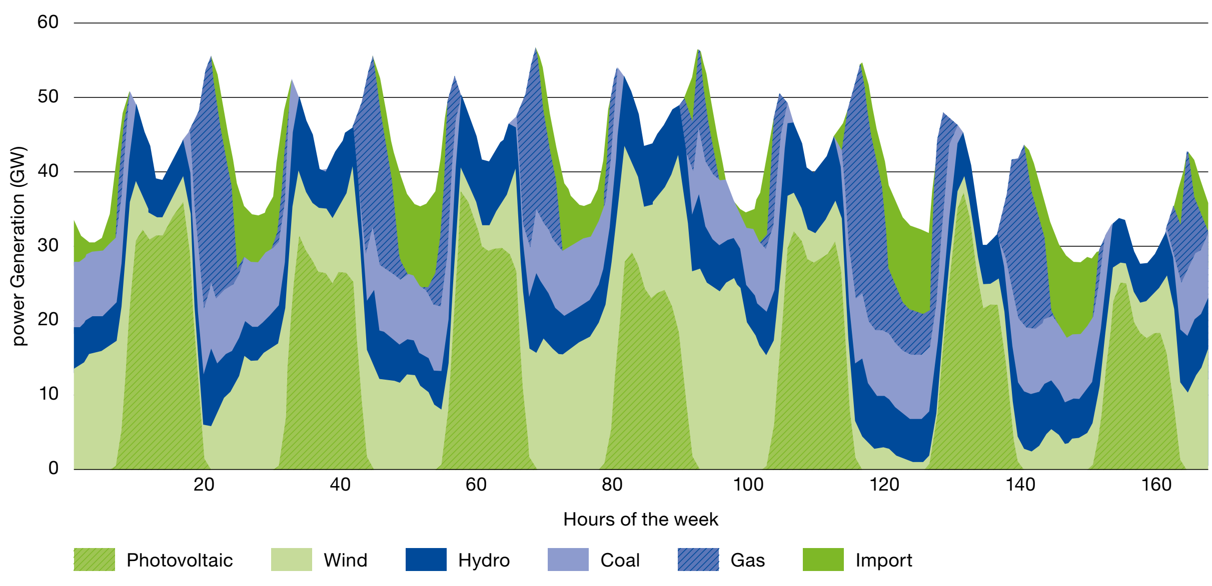


Figure. Hourly breakdown of power generation by source – spring week 2050



Source: E. Vaccariello, M. Cavana, P. Leone, Impact of Renewable Power Generation on Back-Up Thermal Power Plants and Storage Capacity, XIII Research and Development in Power Engineering Conference, Warsaw 2017.

Key findings:
- In absence of additional storage capacity, up to 20% of the yearly generation from renewables will be subjected to curtailment by 2050;
- Around 95 GW of storage should be installed in Italy to achieve zero renewables curtailment;

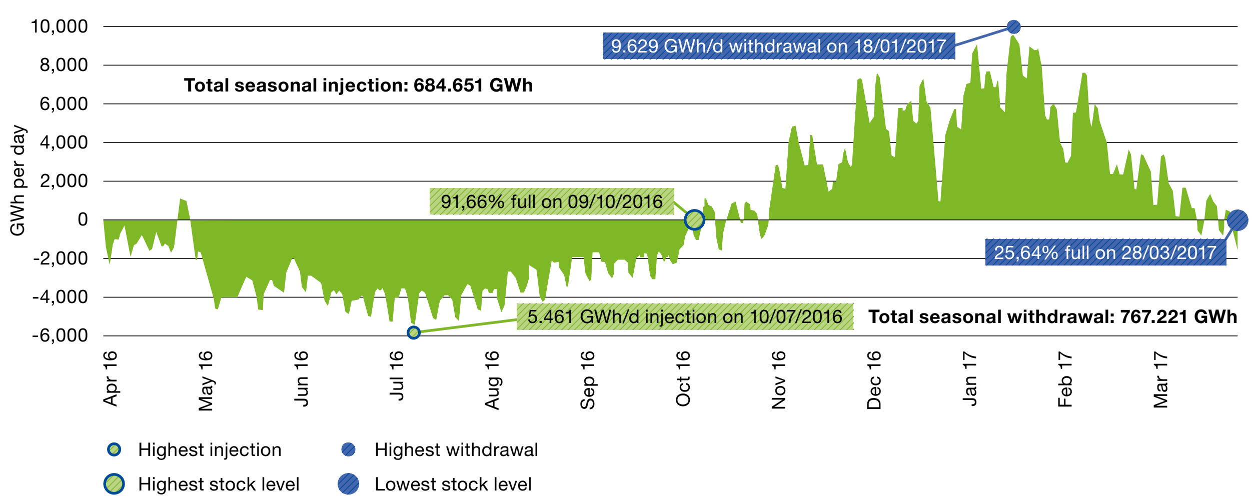
As these cases show, putting all loads on a single infrastructure, e.g. electricity, would require a massive build-up of grids and additional renewable and back-up generation capacity for a relatively low number of utilisation hours.

GAS GRID ABILITY TO STORE EXCESS SUPPLY AND LOWER DEMAND

Gas supply that exceeds demand can be stored in underground storage or LNG terminals

Total European capacity of underground gas storage and LNG terminals represent about 27.000 GWh/d or 1.125 GWh/h, corresponding roughly to the total installed electricity capacity in Europe.

EU Storage / injection / withdrawal



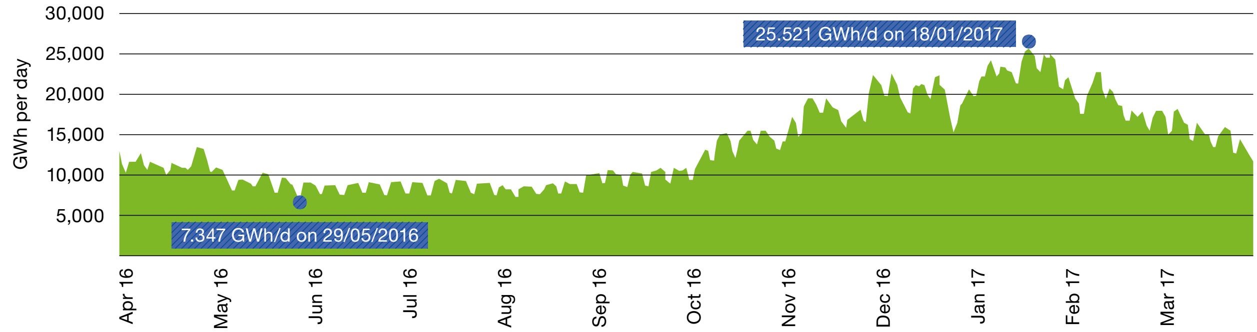
Withdrawal max: 9.629 GWh/d / Injection max: 5.461 GWh/d

Source: ENTSOG/GIE: System Development Map 2016 / 2017

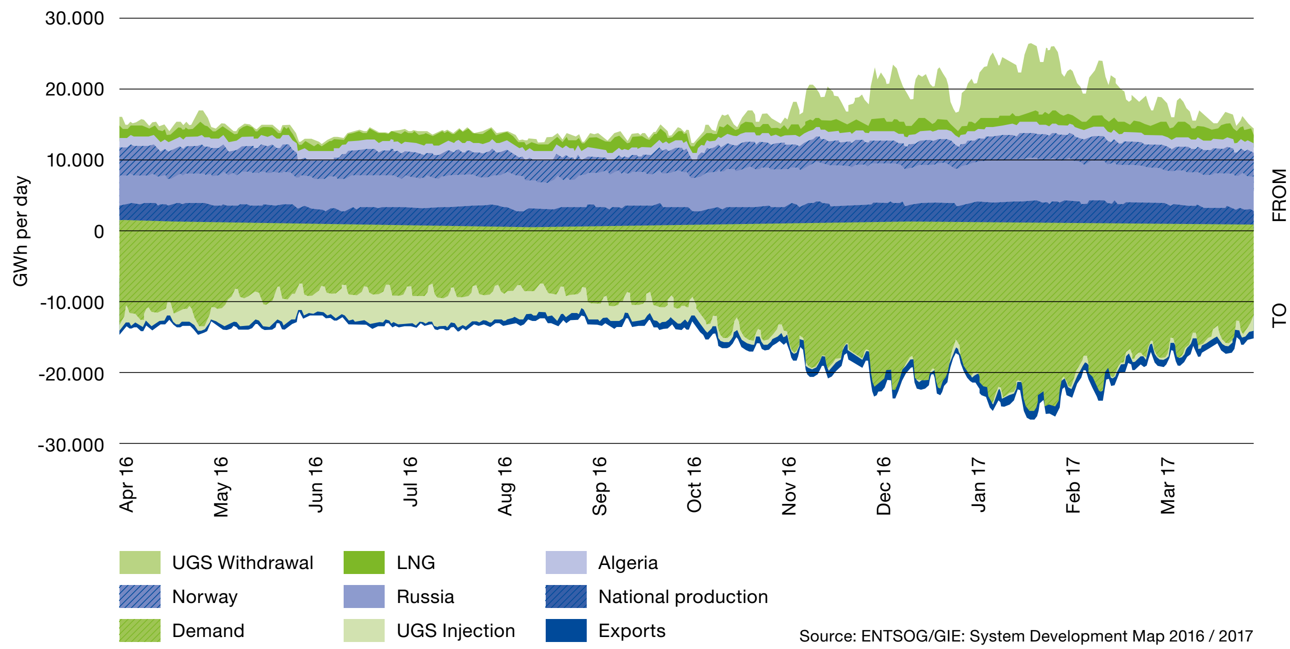
European demand: EU Total 2016 4.903.339 GWh

EU Apr 2016 - Sep 2016 (summer)	1.722.470 GWh	EU Oct 2016 - Mar 2017 (winter)	3.286.078 GWh
EU min. day (29/05/2016)	7.347 GWh/d	EU max. day (18/01/2017)	25.521 GWh/d

EU Daily gas demand profile: seasonal profile / GWh/d



European supply:



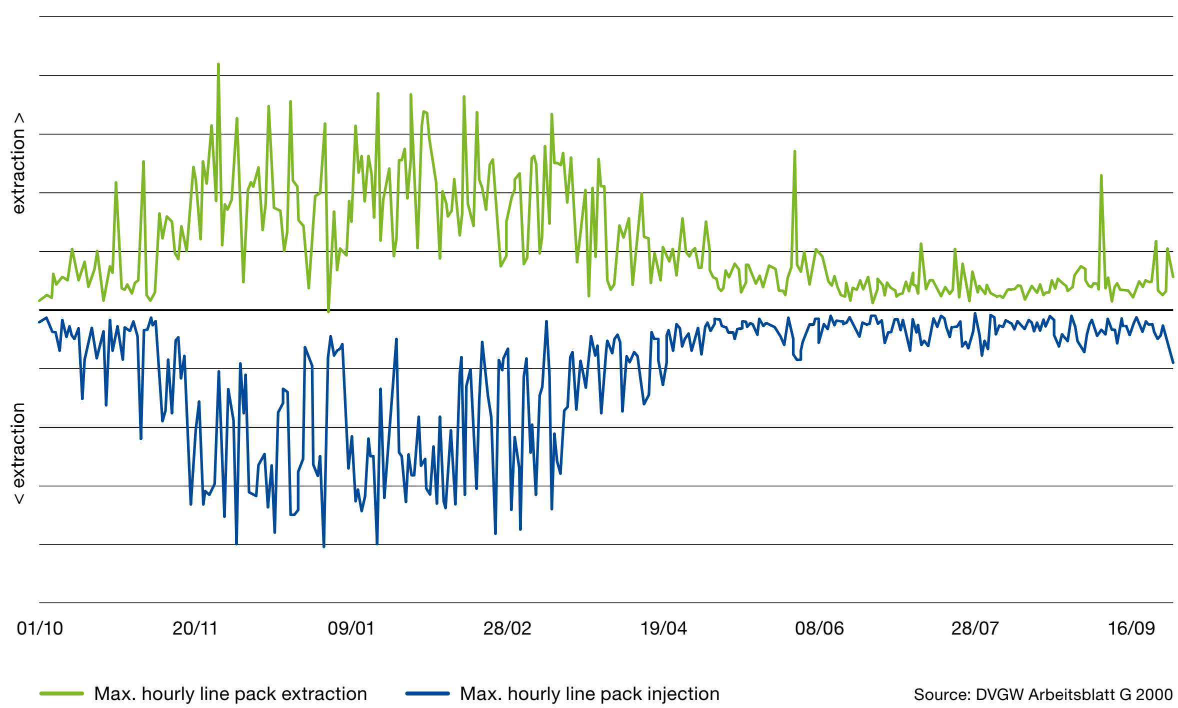
Source: ENTSOG/GIE: System Development Map 2016 / 2017

Gas supply that exceeds demand can be stored in the grid

“Linepack” is the ability of any gas grid to store gas through changes of the pressure in the pipe. Every pipe of a TSO or DSO has a maximum pressure, under which it may be operated. This pressure depends on the material, diameter and thickness of the material of the pipe. Typical maximum pressures in DSO pipes are 100 millibar (mbar), 1 bar, 4 bar or 16 bar systems. Most commonly, German DSOs operate 1 bar systems. The operating pressure in these systems can vary considerably between 20 mbar up to 900 mbar. For the delivery to commercial and industrial consumers and also for the transport of gas between different cities high pressure pipelines are operated up to 84 bar. TSOs only operate high pressure pipeline systems, usually above 16 or 25 bar. It depends on the ruling of the member state which pressure level is operated by the DSO and which by the TSO.

The usage of the line pack depends very much on customers connected to the grid and – at least for the DSO – on the pressure at the connection point. To optimize the volume the TSO and DSO can work together. E.g. in summer some of the pipelines are operated at lower pressure levels as the throughput is lower and therefore a lower pressure is sufficient.

Example 1: Germany - A DSO operates a regional 16 bar high pressure grid. In the diagram below the maximum extraction and injection rates are shown. Usually, the linepack is filled up at night and emptied during the day. As the consumption is low on the weekend, the linepack is at the highest volume on Sunday night.

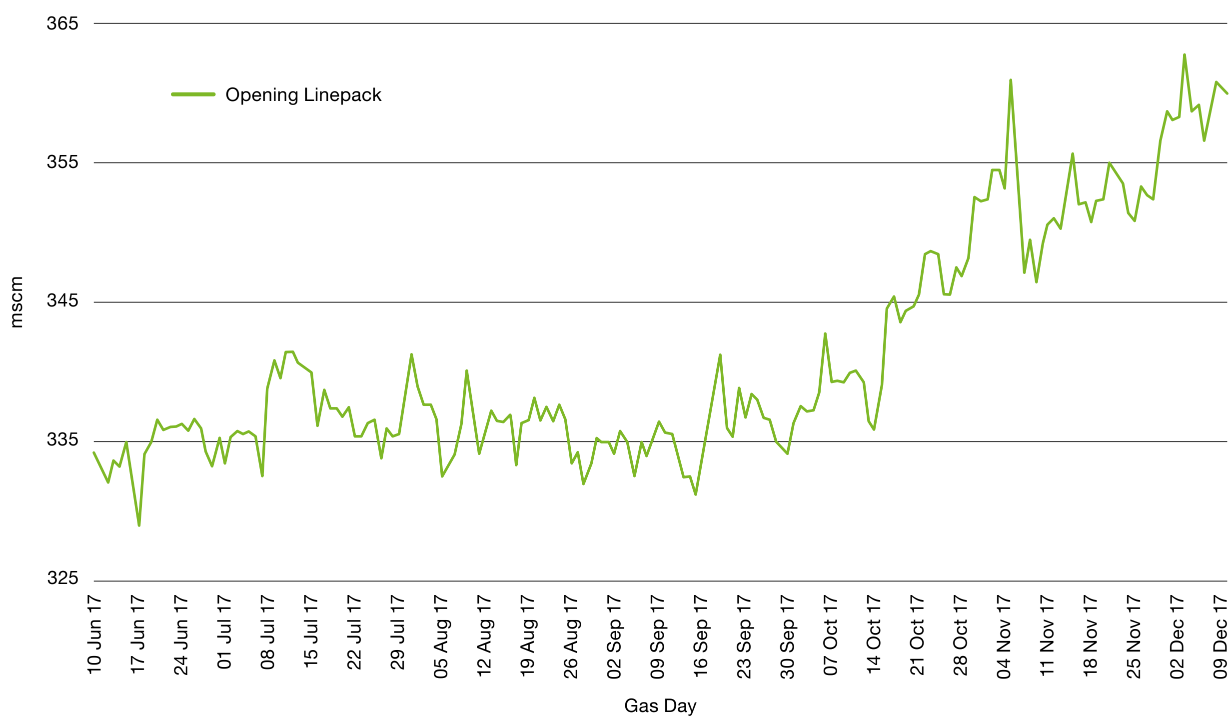


Source: DVGW Arbeitsblatt G 2000

This typical example of linepack usage is driven by the need to lower the maximum transport capacity booked by the DSO from the TSO. In southern Germany transport capacity is scarce in cold winters and therefore the linepack is needed to lower the input. With new biomethane or H2/SNG (Synthetic Natural Gas) injections the linepack could be used in various ways. In summer the limit is clearly the pressure of the maximum of the TSO grid and the offtake from the DSO grid. With low consumption the pressure differences are lower than in the summer.

A rough estimate for various diameters and pressure levels shows that already in **10 km of a DSO grid, with a pressure up to 4 bar, the electricity of a 5 Megawatt (MW) windmill can be stored for 18 minutes.** In high pressure grids this amount increases considerably. 16 bar pipes are operated in several countries by the DSO. They could store up to 3 hours or a 5 MW windmill. On the TSO level the pipelines are operated on even higher pressure levels going up to 100 bar. The energy content of these pipelines due to the larger diameter and the possible pressure differences 10 times higher.

Example 2: UK - Linepack is used by National Grid, the TSO, and the four gas DSOs, to meet manage demand across the UK. As the following graph of daily linepack in the Transmission System (June – December 2017) shows, the volume stored is generally increased in colder months to meet higher demands anticipated. This is crucial for the UK energy system as a whole, which relies on gas to meet around 80% of peak heat and power demand.



Source: National Grid Prevailing View, http://mip-prod-web.azurewebsites.net/PrevailingView/Index, accessed 10 December 2017

Gas Grid capacity to lower demand: interruptibility contracts for Large Customers

Interruptibility means that customers may choose to enter a contractual agreement to stop their gas procurement in certain situations. Often, these customers have another energy source, e.g. oil at hand.

Interruptible contracts with customers connected to the DSO grids can have a positive effect on the overall system. In the case of transport capacity restrictions in the TSO grid the interruption of large consumers can be a cost effective way to reduce new investments in both the TSO and DSO grids. With the development of higher volumes of renewables gas injection, flexible consumers that can increase their uptake of gas (e.g. for their CHP plant or switching between electricity and gas in their industrial production processes) may make a higher injection rate possible. Otherwise excess gas can be cleaned from odorant, compressed and injected into the TSO level.

Example 1: Germany - Network operators in Germany may conclude interruptible contracts with their connected customers. Network operators may offer these contracts at a reduced network fee. Such a contract can be interesting for big commercial or industrial consumers and power plants. They either can adjust their demand to a certain extent by reducing production or switching to another fuel, or in some cases use their own storage facilities. The network operator, the supplier and the connected customer negotiate the terms and conditions of the interruptible contract, but it relies on the control of the NRA. Until now the NRA only grants low network fee reductions which make interruptible contracts unattractive for the market.

Additionally, in October 2016, a new balancing product for interruptible balancing energy was introduced for industrial customers > 10 MW connected to the DSO grid. Since then, balancing responsible parties have been allowed to offer interruptible balancing energy at the virtual trading point in “critical” situations (merit order list 4). That for, network users may conclude specific agreements with large industrial customers.

Example 2: France - French regulation refers to two types of interruptibility between network operators and gas customers:

Warranty interruptibility: large industrial customers with an interruptible capacity greater than 1000 MWh / day and under a contractual agreement with network operators agree with 2 hours' notice to stop their gas procurement, with agreed financial compensation. This compensation consists of an annual remuneration, an exemption from the obligation to pay the price of storage in the price of natural gas (2 to 4 € per MWh) as well as an exemption from their participation in the authorized income of the storer.

Flexible interruptibility: industrial customers consuming more than 5 000 MWh / year of natural gas and under a contractual agreement with network operators agree with 24 hours' notice to stop their gas procurement. No minimum interruptible capacity is required for these clients and no annual compensation is paid for service rendered. However, these customers will benefit from an exemption from the obligation to pay the price of storage in the price of natural gas (2 to 4 € per MWh) as well as an exemption from their participation in the authorized income of the storage operator.

4. GAS TECHNOLOGIES CAN PROVIDE FLEXIBILITY TO ELECTRICITY SYSTEM

Flexibility for electricity is defined as a temporary increase or decrease of the energy exchanged with the electricity grid, managed in real time depending on the needs of the distribution system operator and on the situation.

Flexibility answers to the needs of the electricity system which are:
- Management of the consumption/production peak. These peak periods appear mainly in winter due to heating consumption peak. This need can appear both at national and local level.
- Short term balancing of the national grid managed by the electricity transmission system operator which aims at matching demand and supply at any time.
- An adjustment of the load and the local transit managed by the distribution system operator in order to contain the characteristics of the local grid.

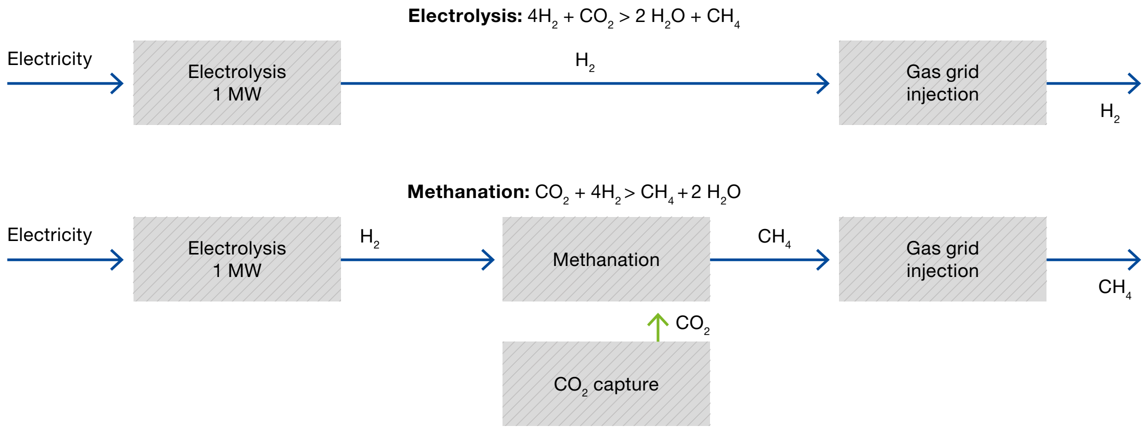
Fluctuations (surplus and shortages) in the power grid on the upstream side through the use of the power-to-gas technology and on the downstream side, through the use of flexible production units such as combined heat and power systems.

POWER-TO-GAS CAPACITY TO STORE EXCESS ELECTRICITY SUPPLY

Description of the technology

Power-to-gas technology provides an innovative solution by transforming surplus supplies of electricity from wind and solar sources into synthesized gas, a carbon-neutral fuel that can be injected into the natural gas network.

Indeed, the Power–to-Gas process uses electricity to transform water into hydrogen via electrolysis. The hydrogen can then be combined with carbon dioxide (CO_2) to obtain synthesized methane, via a methanation step. This operation is all the more useful in that it enables capture and recycling of CO_2 from industrial emissions. The hydrogen or synthesized methane thus produced can then be injected in the transmission network.



Source: IGU

Benefits of the technology

The Power–to-Gas technology contributes to the transition of energy systems by:

- Transforming electric power into hydrogen or SNG allows to use the energy at any time and space – independent from its production – by using the well-developed gas infrastructure.
- Using the gas network as large energy storage. The transformed energy (hydrogen and SNG) can be stored in the grid and be transported when and where it is needed. This allows an efficient usage of the infrastructure and of generation capacities.
- Methane and hydrogen have a wide range of potential applications, including industrial use and fuelling heavy goods transport, which can be supported by distributing them through existing gas infrastructure.
- The gas network in Europe is well-developed and highly meshed. The need for network development measures is low compared to the electricity network.

- Investments costs arrive for the employment of the technology itself, not for infrastructural needs.
- Peaks in RES-production (renewable energy source) can efficiently and sustainably be used by transforming this energy into SNG and hydrogen. RES-curtailment becomes unnecessary and system stability is strengthened.
- Troughs in power production can be balanced by generating electric power from power-to-gas plants.

In 2016, 154 GW of wind power were installed and produced 300 TWh. If you convert this amount of electricity into hydrogen via P2G, 210 TWh of hydrogen could be produced. In comparison to the 4500 TWh of gas transported in the European gas grid this amount to 5%. If in all 2 Mio. km of gas grid would only use the linepack with 1 bar pressure difference all wind energy could be stored for 8,6 hours. In addition all European underground gas storages have a working volume of 1000 TWh. These numbers shall showcase the incredible amount of energy storage possibilities that are already available today.

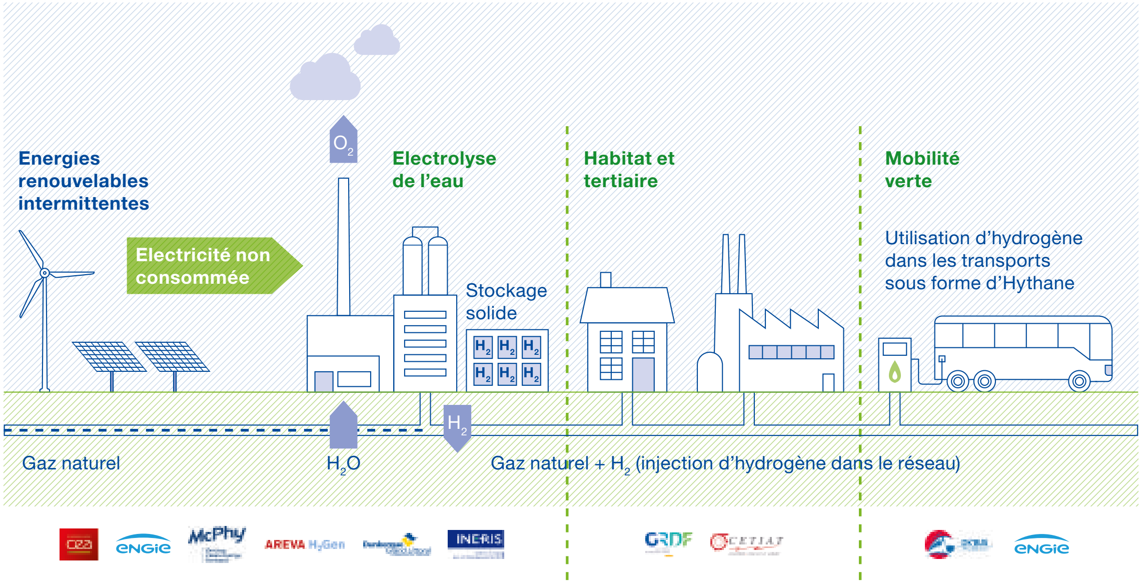
Current barriers

Deployment of synthetic methane/hydrogen in the energy mix, as a storage solution for green/carbon free electricity is hindered by technical and economic barriers:

- Demonstrators around Europe are proving the technical and economic relevance of the power-to-gas technology. There is a need to continue moving forward on the learning curve and thereby bring costs down.
- Advantages of the technology for the whole energy system should be rewarded. The transformation of electricity surplus into hydrogen allows the renewable energy to be stored; the already installed capacities do not have to be interrupted, but to run and produce more electricity; this reduces their specific costs and makes them run more efficiently. As a consequence, their production of hydrogen from surplus electricity can avoid the installation of fossil/renewable generation capacity. Electricity grids are relieved and network expansion can be reduced or avoided.

Example 1: Germany - Germany has implemented a special curtailment regulation that ensures the safe operation of the electricity grid in times of oversupply of RES plants which is called “EinsMan”. The operator of the RES plant is reimbursed for the curtailed electricity by the grid operator. The costs are allocated into the national RES fee. In 2015 the curtailed production amounted to 4,72 TWh with an associated cost of 478 Mio €. 2016 saw a 20 % decrease of the curtailed production to 3,7 TWh and 373 Mio. €. It is to be expected that the curtailments will increase in the future with growing injection of RES electricity. DSO and TSO Grid expansion and the installation of batteries could reduce the curtailment as long as the oversupply periods are short and the battery can be discharged later on. Windy and sunny week-ends prove to be critical as consumption drops due to the lower industrial usage. To store several days of surplus electricity a very high capacity of batteries would have to be installed. If this curtailed renewable electricity was converted to hydrogen or SNG it could be saved. With the use of seasonal underground gas storages the energy can be used in future months.

Example 2: France - GRHYD - the first power-to-gas project linked to the French gas distribution network. GRHYD stands for “Gestion des Réseaux par l’injection d’hydrogène pour décarboner les énergies” – network management by injecting hydrogen to decarbonize energy. The objective of the project is to evaluate and validate the technical and economical relevancy of blending Hydrogen with natural gas for both transport and heating sectors.

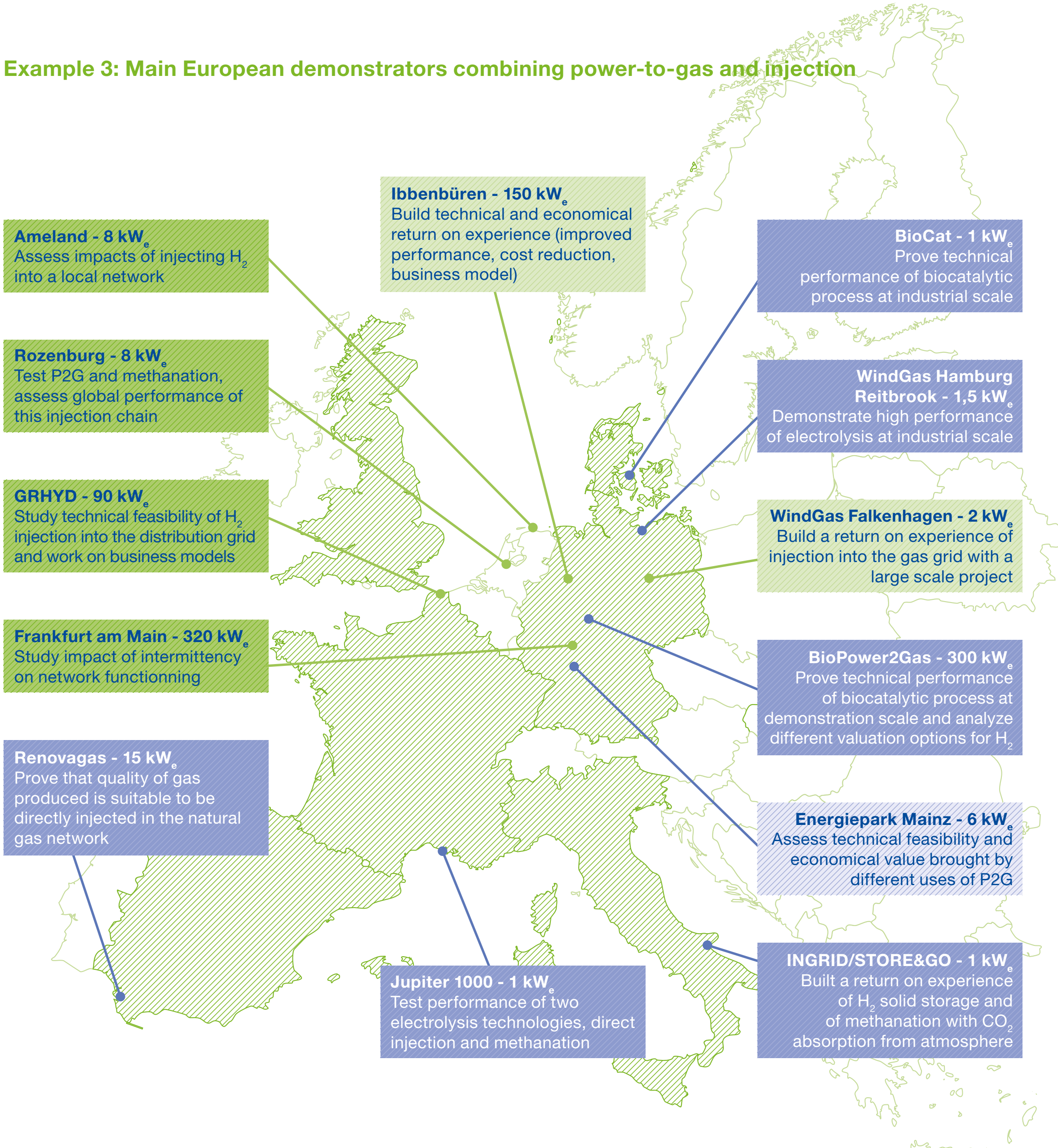


Source: GRHYD

The projects consists in two demonstrators in Dunkerque (North of France):

- A project of injection of hydrogen into the gas distribution network. A new built neighborhood of 100 homes in Cappelle-la-Grande will be fed by a blend of natural gas and up to 20% of hydrogen.
- A project of Hythane® production at industrial scale. A refueling station for buses will provide a fuel made of natural gas and 6 % of hydrogen, proportion that will be increased up to 20%.

Example 3: Main European demonstrators combining power-to-gas and injection



Main objectives of the demonstrators / pilots:

- Test performance and viability of technologies in real condition
- Build a return on experience, work on business model
- Study impact of H_2 injection on network infra and/or end-user equipments
- Compare different valuation options of H_2 (technically and economically)

Source: "Gas Bridges: the natural gas network as key partner of energy transition" dec 2017 Marcogaz, Eurogas, Gerg

- Legal/regulatory framework evolution needed to exploit the potential and to serve the overall energy system
- Power-to-Gas R&I and deployment should be encouraged
- Fees and levies for the input-electricity have to be revised as power-to-gas plants are no end users but storages
- Support schemes should be implemented as the market is at an emerging phase
- Producers of excess renewable intermittent electricity should be incentivized to avoid curtailment and use power-to-gas technologies.
- The operator of the electricity network should be allowed to buy flexibility from power-to-gas plants. So the offer of flexibility through power-to-gas would be adequately priced. If there are capacity markets in place, the power-to-gas plant should be allowed to take part in the auction.
- It is important to make market players, politicians and the public aware of the benefits of power-to-gas. Public acceptance should be encouraged through explanations and information dissemination to energy consumers.

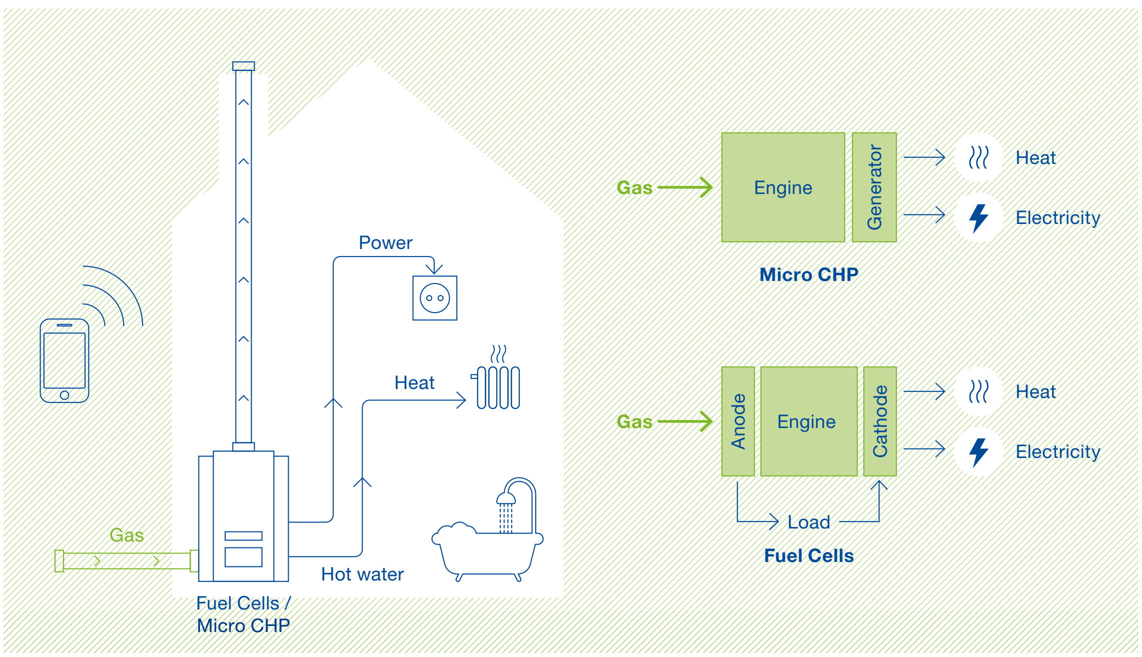
MICRO CHP CAPACITY TO LOWER ELECTRICITY DEMAND

Description of the technology

Cogeneration is the simultaneous production of electricity and useful heat (combined heat and power "CHP"-systems). Usually, in other typical power plants, the heat produced in the generation of electricity is lost, often through the chimneys. Cogeneration plants, however, use this heat and can achieve energy efficiency levels of around 90 percent.

Large gas-fired CHP plants, typically located in the load centers (where electricity and heat are required), have the potential to be an important puzzle stone of the energy supply of the future. They can be a relevant source of supply for district heating grids of metropolitan areas and contribute to safeguard security of supply of the electricity grid. They are the ideal supplement to fluctuating renewable energies and therefore play a role in facilitating their integration in the electricity grid. Producing reliable clean heat and electricity for home – at home. Micro-CHPs and Fuel Cells produce heat and electricity at home and can sell the excess power back to grid with smart combination with distributed renewable sources.

The European Cogeneration Directive (2004/8/EC) defines small-scale CHP as all units with an electrical capacity: micro CHP is below 50kW and mini-CHP is below 1MW. The Micro-CHP systems are currently powered by natural gas, biogas, biomethane, bio-fuels or liquefied petroleum gas (LPG). Micro-CHP appliances are similar in size and shape to ordinary, domestic boilers, so they can be wall-hung or floor-standing. The major difference to a standard boiler is that they are able to generate electricity while they are heating water. First experiments on flexibility were focused on power solutions (e.g. batteries and curtailment) but new cases are currently investigated based on gas solutions. Indeed, recent and smart gas solutions like micro-CHP, hybrid systems or fuel cells can be used to offer flexibility services to the power network: micro or mini-CHP solutions can be monitored to offer local electricity production, hybrid solutions allow to trade-off between gas and power consumption depending on technical or price signals. The deployment of these solutions is relatively recent in Europe (50 000 micro CHP, mainly Internal Combustion Engine) compared to Japan (which has round 200 000 fuel cells and 130 000 Internal Combustion Engine already installed).



Source: Eurogas

Benefits of the technology

Mini/micro-CHP-systems allow a greater interaction between the electricity and gas systems and bring efficiency and flexibility to the energy system:

- Micro- and mini-CHP are highly efficient solutions for shifting load between the electricity and the gas network. They incorporate local storage via heat storage, which allows for an efficient utilization of the gas and power grids. They also empower the consumer to actively take part in the energy supply market according to the capacity ranges of the CHP-systems.
- A substantial volume of fuel is saved by avoiding exhaust heat losses, which often occur on many large power generation stations. These fuel savings together with the clean combustion in the micro turbine lead to a significant reduction of CO_2-emissions (some 3 to 6 tons of CO_2 emissions annually), as well as low emissions of NOx and CO_2. This helps to achieve the EU climate goals.
- The energy in the fuel is almost fully utilised. Moreover, micro-CHP save transmission and distribution losses of electricity from power stations to end-users.
- Electricity DSOs/TSOs avoid investments in excessive cross border-flows and excessive reinforcement of the electricity grid to prepare for down time of intermittent sources.
- The need for additional investment in the gas network is low, as the grid is already there and highly meshed.
- Micro-CHP combined with smart electricity meters (consumption and generation) and supplier services, link the gas and electricity networks effectively creating high interoperability.

Current barriers

- Permissions and approvals hinder the potential of micro-CHP.
- Capital and maintenance costs are a major challenge. There is a need for larger production volume to drive the costs down.
- Environmental and system benefits of micro-CHP are not rewarded by policy.
- There is a lack of a regulatory framework for local flexibility (some projects in the UK, experimentation framework recently introduced in France by the energy transition law – LTECV).
- There is a need to increase confidence of customers in the product by raising awareness on the product.

Case studies

There are just a small number of flexibility experiments with smart gas products and in most cases they focus on technical aspects. The experiments with fuel cells focus on demonstrating their performance and reliability rather than the integration in the total energy system or the market implications. Other experiments are focused on the ability to combine and remotely controlled gas solutions (e.g. Dresden project testing micro-CHP VPP[5] feasibility - ~20 micro-CHP aggregated or Ameland Island with 45 fuel cells and hybrid systems remotely operated with PV and biomethane supply).

5. Virtual Power Plant

Example 1: France - Interflex project (INTERactions between automatic energy systems and FLEXibilities provided by actors of energy markets) is a H2020 project aiming at inventing the future DSO. Officially launched in January 2017 for 3 years, the demonstrator in France is under the supervision of Enedis (electricity DSO), and represent a key innovation: ~150 kilowatt electric (kWe) of flexibility generated by smart gas solutions will be deployed and managed by aggregators to deal with local distribution flexibility needs. The project will thus advance both technical and economic aspects with an evaluation of the cost and value brought by the different flexibility assets integrated into the demonstration.

Example 2: Wales - The FREEDOM (Flexible Residential Energy Efficiency Demand Optimisation and Management) Project, a joint Wales & West Utilities and WPD £5m innovation project in the Bridgend 'living heat laboratory' in South Wales, is a real example of a 'whole systems' approach to the future of heat. Using an air-source heat pump and high-efficiency gas boiler hybrid system in 75 residential properties, the project clearly demonstrates the value that an integrated approach to deploying low-carbon smart technologies can deliver. Project estimates suggest that a hybrid approach to decarbonising our heating that is combined with green gas growth could lead to as much as an 80% reduction in carbon emissions from domestic heat.

Smart switching between the two technologies through a control panel enables the buying of fuel and the sale of heat simultaneously, creating value for both the consumer and enabling the system to offer heat and power flexibility services to the wider network. The project simulates a residential demand side response service, with an aggregator buying gas and electricity on live wholesale markets on behalf of the consumer to meet their chosen settings.

- Legal/regulatory evolution needed to ease the development of an efficient energy system that fits today's and tomorrow's needs
- A coherent, steady and predictable policy framework is the key for the European heating sector to invest in new products and develop new business models
- Building codes and energy labelling should fully reflect the benefits for consumers and at energy system level which is not the case today. This will be an important driver for the micro CHP to reach the mass market
- Energy and climate policy should take a whole system approach, looking at the energy system as a whole and exploring decarbonization and energy efficiency opportunities across the electricity and gas network alike.

5. GAS DSOs WILL BECOME KEY ACTORS OF FLEXIBILITY AS A RESULT OF DECARBONISATION AND DIGITALISATION

RENEWABLE GAS DEVELOPMENT INCREASES GAS DSO ACTIVE ROLE IN FLEXIBILITY MANAGEMENT VIS-À-VIS GAS TSO

Renewable gases contribute to diversification of renewable energies and higher flexibility of the EU energy system

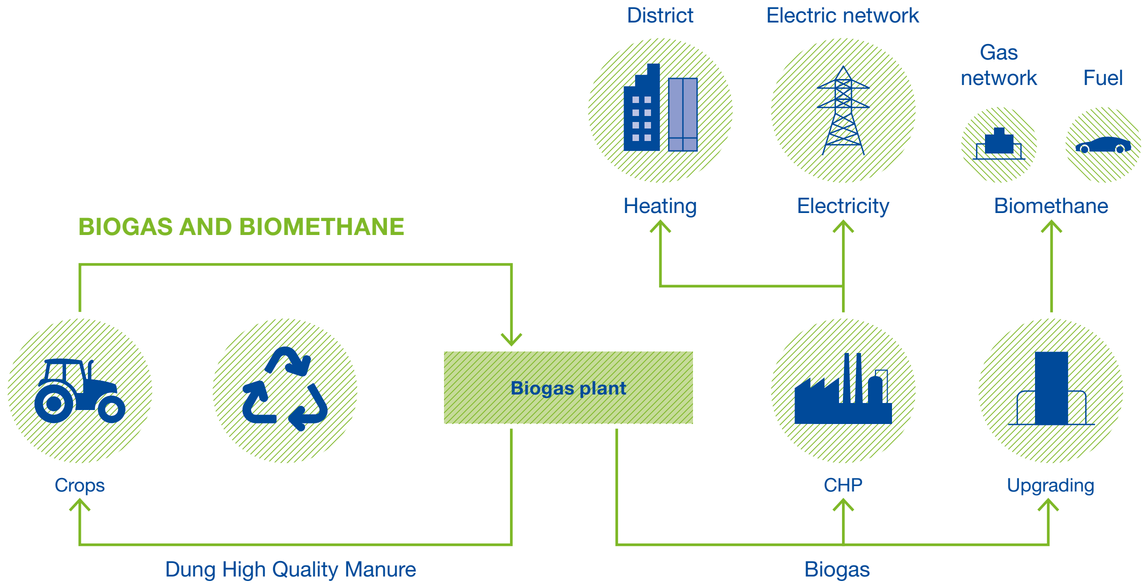
Biomethane is produced and consumed locally and thus is anchored in local areas, by contrast with natural gas extracted from gas fields and mainly imported in many European countries. By valorising local organic waste through anaerobic digestion, biomethane production is a tool supporting the development of the circular economy, positive environmental outcomes and local employment.

By collecting organic and agricultural waste to produce biomethane, the environmental impact of municipalities, businesses and farmers is reduced by avoiding GHG atmospheric emissions and by increasing renewable energy production. Biogas production also produces a co-product called digestate. This is a natural organic fertiliser and it can be used on agricultural land in place of mineral fertilisers of fossil origin.

Injecting biomethane has the added value of producing a renewable gas, replacing natural gas without any changes to the traditional end consumption sectors. Once injected the biomethane can be used where it is needed either for heating or mobility needs. It provides an environmental friendly alternative in the mobility sector thanks to “biomethane fuel” or “bio-natural gas vehicle (bio-NGV)”. It is then a solution to reduce GHG (greenhouse gas) emissions of both heating and mobility sectors.

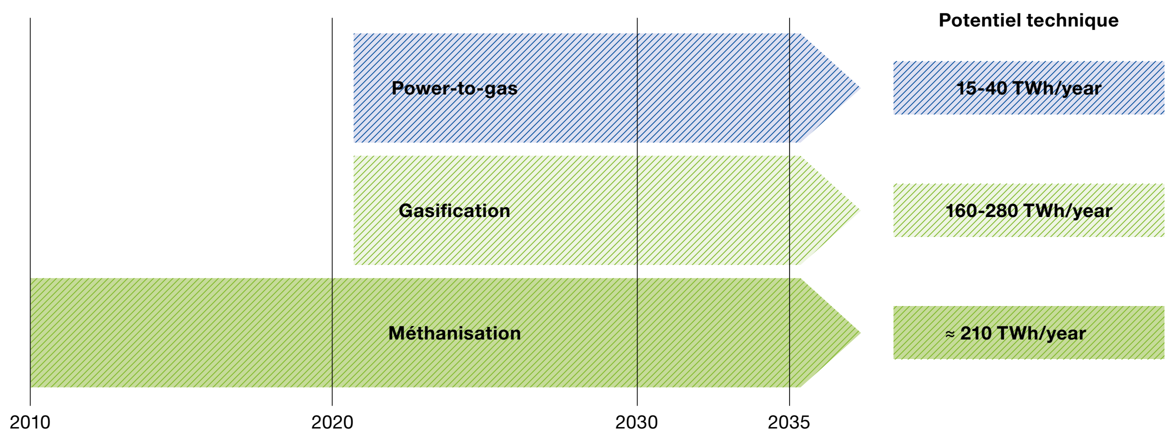
Biomethane can be produced throughout the whole year and thus is able to contribute to winter peak demand in contrast to intermittent photovoltaic and wind power plants. In France, for example, the load factor of PV and Wind production is respectively 24% and 15%.

Biomethane can contribute to diversification of renewable energies and its production is predictable and storable, increasing the flexibility of the energy system.



Source: Snam Global Gas Report- http://www.snam.it/it/gas-naturale/global-gas-report/index.html

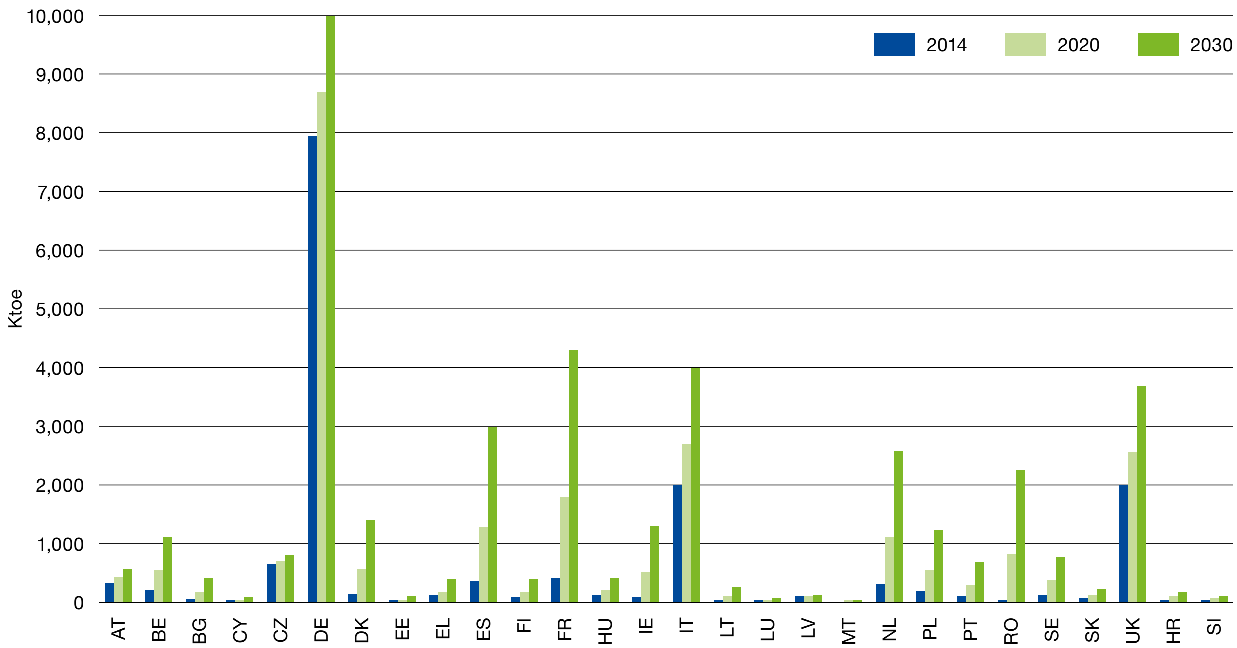
Example 1: France - The technical potential to produce biomethane in France is 210 TWh per year by 2035. Several thousands of biomethane sites are expected to be built and connected to gas DSO grids in the by that date.



Source: ADEME-SOLAGRO Anaerobic Digestion Potential Study 2013 - GRDF/MEDDE/MAAF/MEF Gasification study - ADEME/GRT gaz Power-to-gas study

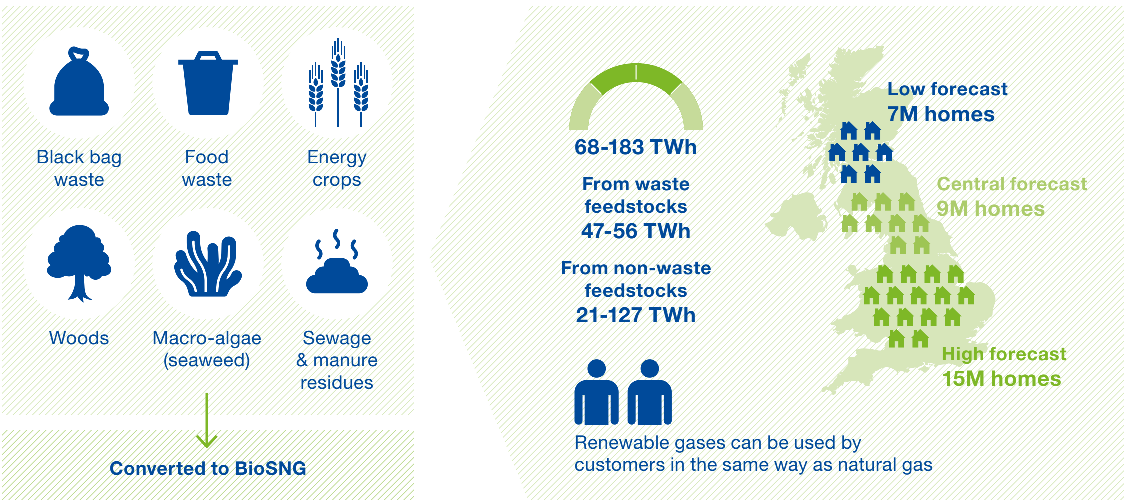
Example 2: EU - CE Delft did a first assessment of biomethane potential production in Europe by 2030 that identifies France, Spain, Italy, Romania, Ireland, Netherlands and the UK as potential leaders in this renewable energy.

Growth of biogas production per member State in Scenarios 2 and 4 (accelerated growth) in ktoe



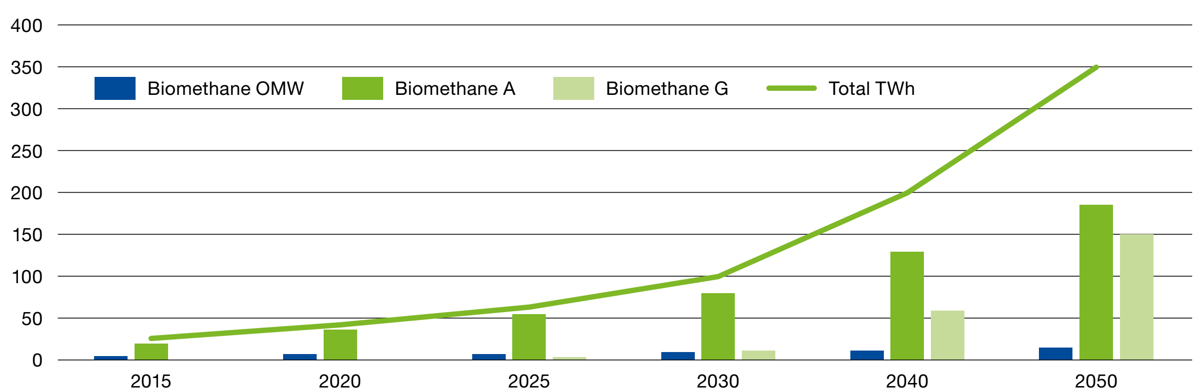
Source: "Optimal use of biogas from waste streams. An assessment of the potential of biogas from digestion in the EU beyond 2020"
http://www.cedelft.eu/publicatie/optimal_use_of_biogas_from_waste_streams/1925

Example 3: UK - Cadent, the gas distribution network for North London, East Anglia, the Midlands and the North West, have produced the following analysis of the potential of renewable gas across the UK:



Source: https://cadentgas.com/About-us/The-future-role-of-gas/Renewable-gas-potential

Example 4: Italy - The cost structure of biomethane may be competitive with solar and wind renewables when considering the cost of intermittency. Here below a summary of renewable gas potential for Italy in 2050 relate for the various kinds of renewable methane (Organic Municipal Waste [OMW], Agricultural [A] and renewable from gasification or biogenic [G]).



Source CIB Feb 2017 Report: https://www.consorziobiogas.it/wp-content/uploads/2017/05/LA-BIOGAS-REFINERY-ENG-2017-FINAL.pdf

Renewable gases decentralized production creates a more active role of the gas distributors vis-à-vis the gas TSO in managing flexibility

In order to fully benefit from the flexibility potential for the gas system, good cooperation is required between the DSO-level and TSO-level. The grid operators need to communicate about changing behaviours at entry and exit points, demand and production patterns and to react correspondingly.

In every member state the TSOs have to develop a network development plan containing measures for the next ten years. They have to make reasonable assumptions about the evolution of the production, supply, consumption and exchanges with other countries, taking into account investment plans for regional and Community-wide networks (…).[6] Correspondingly, DSOs and TSOs have a stake in an exchange of assumptions about future development: this is a precondition for an efficient state of the gas infrastructure providing flexibility.

Best practice 1 – Inclusion of Gas DSO in the TSO Networks Planning in Germany:

German DSOs yearly elaborate a 10-year-forecast for their capacity needs, which they forward to the TSOs. This forecast is one parameter for the network development plan of the TSOs and is considered in the TSOs' network planning.

According to the EU directive and to German law, national TSOs consult their network development plan with the interested parties and hand it over to the national regulatory authority. Before its confirmation, the national regulatory authority also consults the market and can request changes of the planning.

Recommendation: Gas TSOs shall partner with Gas DSOs at national and EU levels to build the Ten-Year Network Development Plan to take better into account:
- decentralized production forecast
- new demand development such as gas mobility

6. Cf. Directive 2009/73/EC Article 22 (3)

Best practice 2 – Encourage reverse flows from DSO to TSO networks to facilitate the development of renewable gases:

Implementing reverse flow installations towards higher-pressure level in order to access wider consumption areas and higher storage capacities would facilitate the development of renewable gases production. There are more than 10 installations working in Germany while some experiments will be launched in the coming year in France.

Recommendation:
- Gas TSO shall make a cost benefits analysis to assess if local reverse flow can meet better flexibility issues than extension of TSO networks
- Gas DSO & TSO shall be allowed to take in charge part of the grid connection costs of renewable gas producers.

SMART ENERGY NETWORKS DEVELOPMENT REQUIRES A HOLISTIC APPROACH TO ENERGY SYSTEM

To tackle the EU energy challenges it is important to develop smart and integrated networks which function as components of a holistic energy system, including gas, electricity, heat, transport and information technologies.

This needs active networks with interactive functionalities to integrate multiple energy sources and services, and empower consumers to use and produce energy more efficiently. Such active gas networks, or smart gas grids, are beginning to be developed in tandem with smart electricity grids to facilitate smart energy utilization.

Whereas electricity networks require real-time responses to changes in demand, peak load reduction or load control, gas networks are more inherently flexible since they can store large amounts of energy.

As uncertainties on the future development of efficient and large scale electricity storage technologies remain, gas will increasingly become a key provider of both heating and electricity balancing services.

The Expert Group 3 of the Smart Grids Task Force[7] concluded that the flexibility can be provided by both (electricity and gas) supply and demand on a large scale, for example by CCGT (Combined Cycle Gas Turbine) plants, industrial and commercial consumers, aggregated smaller household load, distributed generation (natural gas and green gases), energy storage, ancillary services (all services necessary for the operation of transmission system and distribution networks, including LNG facilities, and/or storage facilities for gas, these services include load balancing, blending and injection of inert gases and do not include facilities reserved exclusively for transmission system operators carrying out their functions), peak shifting/shaving (the flattening of a gas consumption load curve: the gas peak demand e.g. in the morning is shifted to a different time of the day e.g. early afternoon; or the peak demand is satisfied through an LNG satellite storage).

However, it has been stated that the gas network and gas utilization will play a major role in achieving the efficiency goals and will enable cost saving solutions for many problems encountered in the electricity networks[8].

The major benefits of gas and smart gas grids show its essential role in an overall energy mix program.
The benefits are:
- reducing greenhouse gas emissions,
- increasing the share of renewable energy (biomethane, syngas, injection of H2,..),
- optimising the intermittent production of renewable energy,
- contributing to improve the security of supply,
- improving energy efficiency by enabling the active participation of the end users,
- creating the conditions for efficient use of energy networks, giving consumers the ability to choose the most economic energy source in real-time, and at the same time save energy,
- avoiding costly investments in electricity grids by using gas networks and gas appliances, supporting economic development,
- enabling consumers to become “prosumers” by using gas to lower the ‘peaks’ in the electricity network and to reduce energy losses in the electricity transmission and distribution networks;
- enabling synergies between gas and electricity networks through the encouragement of distributed generation,
- comparing with electricity, gas can be stored more cost-efficiently - for example in networks - and the scope for local production is limited to the feed-in of alternative gases such as biogas.

7. SGTF – EG3 report January 2015 – Regulatory Recommendations for the Deployment of Flexibility.
8. Gas for energy issue 3/2015 Gas grids for a smart energy system by Jos Dehaeseleer, Tim Cayford, Benjamin de Ville de Goyet and Ilir Kas.

ANNEX 1

TERMS OF REFERENCE OF THE GAS FLEXIBILITY WORKING GROUP

European associations representing DSOs (CEDEC, EDSO, eurelectric, Eurogas and GEODE) have initiated a DSO committee on flexibility markets.

It was set up to continue the cooperation and to provide quality expertise on DSO issues. The aim is to provide the public at large with reports on findings and insights, to provide assistance to the European Commission.

Two sub groups were founded working in parallel on gas and electricity flexibility issues, ensuring to cover the overlaps.

Terms of Reference – Committee on flexibility for gas

1. Problem definition

Assess whether current flexibility arrangements under the European Balancing Network Code are sufficient for the system with increasing penetration of renewable gasses at local level.

2. Solution Space

Given the above, what is the definition or specification of the services and / or technologies that could assist the gas DSO when addressing the issues set out in response to Q1 (above)? What are the factors affecting the choice of option and the regulatory environment necessary to accommodate it?

3. Technologies

What is the range of known gas-based technologies or resources that might be candidates to offer flexibility services to the system, for example demand-side response; local gas-based generation like micro-CHP and fuel cells; power-to-gas plants; plants which inject hydrogen; biomethane ('green gas"); grid storage; or heat storage? What is the catalogue of potential supply? What does technological advance hold for this catalogue?

4. Modes of Service Acquisition

In recognition that in business-as-usual, the gas DSOs acquire a wide range of services and products (under regulatory supervision), what are the possibilities open to the gas DSOs to acquire these services for example by arms-length commercial procurement or otherwise? What are the prospects of organised liquid markets developing for these services (for example through EU-certified biogas) and what might be the 'footprint' of these markets (local or regional or other)? What are the consequences or remedies open to the gas DSO in the event of non-performance by any of the service providers?

ANNEX 2

MEMBERS OF THE GAS FLEXIBILITY WORKING GROUP

Guillaume Virmaux (Chair)	GRDF
Isabel Orland (Vice-Chair)	VKU
Luciano Baratto	Anigas
Ana Belen Rubio De Santos	Nedgia
Isabelle Diversy	GRDF
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Matthew Hindle	ENA
Michael Mollner	EVN
Andrès Olmo Jimenez	Nedgia
Julie Pinel	GRDF
Rene Pollaschak	Wiener Netze GmbH

ANNEX 3

DEFINITIONS

Smart gas grids

The smart gas grid-concept is based on maximising the efficiency of overall energy usage and taking full advantage of flexibility and all the opportunities that gas and the gas grid can offer.

As pointed out in the EG4-report[9], smart gas grids will support the ability of gas to play a major role in the energy mix while meeting the carbon targets via the enabling of renewable energy and the enabling of active participation of the end-users in the energy market.

The concept of smart gas grids is different from that of smart electricity grids. The key difference is the much larger possibility of storing energy in smart gas grids, notably through linepack (for further information cf. excursus on linepack). Another important difference is that the potential for the future development of decentralised gas production is relatively small. Nonetheless, the operation and management of gas grids could be enhanced by a smart gas grid and the smart end-use of gas. Furthermore, also the smart gas grid shows potential related to energy efficiency services and the development of new types of services[10].

While electrons cannot be stored in wires, gas molecules are easily stored in pipes. Further, electrons can be converted to molecules in a process of what is referred to as power-to-gas. These gas molecules can also be converted to electrons via various power-to-gas technologies (combined heat and power (CHP), micro-CHP, fuel cells, dual-fuelled appliances, etc.). Gas can come from an array of sources, from the traditional natural gas to the renewable forms, such as biogas, bio-methane, synthetic gas and hydrogen[11].

The gas grids then become reservoirs of sustainable energy for intake and throughput in a continuous, flexible manner, able to handle short- and long-term intervals (for daily and seasonal variations), as well as geographic transfer. These technical characteristics must be borne in mind when considering legislation that undergirds renewable energy deployment. Gaseous energy becomes a basis for sector coupling in a sustainable energy system. Taking these technologies into consideration in a holistic way, it is clear that gas is needed not just as a flexible and reliable supporter, but as an integral part of the transition towards a decarbonised energy system where the renewable energy deployment happens within a diversified and sustainable energy mix.

The gas system also has a unique feature in that it is also complementary to the electricity energy system: if too much electricity is generated (for instance wind or solar farms), the surplus of electricity could be transformed into natural gas (SNG and hydrogen).

9. EU Commission Task Force for Smart Grids - Expert Group 4 (EG4) - Smart Grid aspects related to Gas 06/06/2011.
10. ECORYS- ECN "The role of DSOs in a Smart Grid environment" Client: European Commission, DG ENER Final report Amsterdam Rotterdam, 23 April 2014.
11. Eurogas views on the Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources (Recast) May 2017.

Renewable gas

Renewable gas comprises biomethane and hydrogen and SNG from power-to-gas process.

Biomethane is the first generation of decentralized renewable gases. It is produced by anaerobic digestion of animal and/or organic materials followed by a purification/upgrading process before being injected into the natural gas networks.

Anaerobic digestion produces a gaseous mixture that is saturated with water and composed of 50-70% of methane. Organic material can come from various sectors: agricultural, industrial, catering waste, municipal waste, gas from non-hazardous waste storage facilities, etc. Once collected and transported to the anaerobic digestion site, the organic matter is sorted, stirred and heated for a few weeks in a digester (oxygen-free enclosure). The biogas, which contains between 40 to 60% of methane, is then purified/upgraded in order to reach the same quality as natural gas (at least 95% of methane).

Biomass gasification & methanation

Biomethane, derived from anaerobic digestion, is the first renewable gas production technology which is already mature. In the medium and long-term, new renewable gases production processes will develop:
- Gasification of dry biomass; it relies on a thermochemical process at high temperature to produce mainly CO and H2. After combination of those compounds by methanation and purification, we obtain synthetic methane (SNG) that can be injected into the natural gas grid.
- Valuation of microalgae.

Synthetic Natural Gas (SNG) is produced from ligno-cellulosic biomass or wastes by gasification:
- Forestry products such as wood,
- Agricultural by-products like straw,
- Forestry management by-products,
- Waste from the wood and paper industries
- Sludge from treatment plants

These processes are still at R&D stage.

Hydrogen can be produced by splitting water (h2o) into its components hydrogen (h2) and oxygen (o2). This can be done through an electrolysis process. The electricity needed for this process can come from renewable or fossil sources. The efficiency factor amounts to about 2/3. With further developments or more sophisticated electrolysis plants higher efficiencies can be expected. A further increase in efficiency can be reached if the heat, which is produced in certain electrolysis plants, can be delivered to heating consumers or injected into a heating grid. Besides the electrolysis process, the methane reformation process has been applied for many years by usage of natural gas and water to produce hydrogen.

Hydrogen is an additive gas and differs in its components and combustion characteristics from the commonly distributed gases in the grid. Adding hydrogen leads to significantly changed parameters of the gas and can affect the combustion behavior. Hence, hydrogen may only be added to the gas in the grid up to a certain percentage level. Some appliances as e.g. gas turbines are more affected than residential heating systems. There have been successful tests carried out in Germany to show that appliances can work properly with a hydrogen level of up to 20 percent without exchanging them. Furthermore, pore storage facilities limit the percentage of hydrogen in the gas grid. Germany, France, the UK and Austria currently launch research projects in order to specify the limits of the hydrogen level and to test appliances and storages working with hydrogen percentages of up to 100 percent.

The power-to-gas technology makes local surplus electricity from renewable chemically storable. In the first step of the power-to-gas technology electric power is transformed into hydrogen via electrolysis. This means that electricity is used to split water into its components hydrogen and oxygen. In a possible second step of the process the hydrogen can be transformed by the reaction with carbon dioxide into synthetic natural gas (SNG). This SNG is chemically identical with conventional natural gas and can be injected into the grid up to 100 volume percent. Hence, the power-to-gas technology makes local surplus electricity from renewables chemically storable.

CHP (combined heat and power)

In a combined heat and power “CHP”-systems electricity and useful heat are produced simultaneously. Usually, in other typical power plants, the heat produced in the generation of electricity is lost, often through the chimneys. CHP-plants, however, use this heat and can achieve energy efficiency levels of around 90%.

LNG (liquefied natural gas)

LNG (liquefied natural gas) is natural gas that has been converted to liquid form by cooling it to approximately –162 °C. It is storable and can be transported by ships and does not need a pipeline infrastructure.

ANNEX 4

EU REGULATORY FRAMEWORK

The relevant EU directives and regulations for natural gas are:
- Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC (“Gas Directive”).
- Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 775/2005 (“Gas Regulation”).
- Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 stablishing an Agency for the Cooperation of Energy Regulators (“ACER Regulation”).
- Regulation (EU) No 1227/2011 of the European Parliament and of the Council on wholesale energy market integrity and transparency (“REMIT Regulation”).
- The Network Code on Interoperability and Data Exchange Rules (INT NC) was developed by ENTSOG (European Network of Transmission System Operators for Gas) on the basis of a draft developed by ENTSOG and recommended by the Agency, in accordance with the procedure set out in Article 6 of Regulation (EC) No 715/2009. Its aim is to encourage and facilitate efficient gas trading and transmission across gas transmission systems within the Union, and thereby to move towards greater internal market integration.

That Network Code was approved by the EU Gas Committee on 5 April 2015 as Commission Regulation (EU) No 2015/703. The implementation date was 1 May 2016 with the exception of Article 5.

The EU Regulation on Energy Market Integrity and Transparency (REMIT) requires that information related to the capacity and use of facilities for storage of natural gas and use of LNG facilities, including planned or unplanned unavailability of these facilities (’fundamental data’) is to be reported to ACER, the Agency for the Cooperation of Energy Regulators (www.acer.europa.eu).

ACER acts as governing body to monitor the reporting regime and to ensure greater transparency in markets by helping to reduce the risk of manipulation.

Transmission system operators shall publish, per balancing zone, the amount of gas in the transmission system at the start of each gas day and the forecast of the amount of gas in the transmission system at the end of each gas day. The forecast amount of gas for the end of the gas day shall be updated on an hourly basis throughout the gas day. If imbalance charges are calculated on an hourly basis, the transmission system operator shall publish the amount of gas in the transmission system on an hourly basis. Alternatively, transmission system operators shall publish, per balancing zone, the aggregate imbalance position of all users at the start of each balancing period and the forecast of the aggregated imbalance position of all users at the end of each gas day. If the national regulatory authority is satisfied that such information could give room to potential abuse by network users, it may decide to exempt the transmission system operator from this obligation.

The relevant EU directives and regulations for **smart power and gas grids** are:

- 2012/148/EU: Commission Recommendation of 9 March 2012 on preparations for the roll-out of smart metering systems (Power & Gas).
- Commission Recommendation 2014/724/EU for Data Protection Impact Assessment Template for Smart Grid and Smart Metering Systems (Power & Gas).
- M/441 Standardisation Mandate to CEN, CENELEC and ETSI in the field of measuring instruments for the development of an open architecture for utility meters involving communication protocols enabling interoperability (Power & Gas).
- M/490 Smart Grid Mandate Standardisation Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment Regulation 347/2013 for infrastructure (Power & Gas).

Until now, the regulatory framework on **biomethane** remains very limited at EU-level.

- Biomethane (bio-CNG) has been introduced in the first Renewable Energy Directive (2009/28/EC) – RED I – as a relevant option to decarbonize the transportation sector. RED I defines sustainability criteria for biofuels and bio-liquids including bio-CNG. Biogas/biomethane produced from waste streams may count double towards the transport target, providing an additional incentive above biogas and biofuels produced from energy crops.
- The RED II Directive currently under discussion takes into consideration biomethane as a renewable gas capable to contribute to achieve EU objectives on renewable energies and security of supply. RED II also plans to extend the Guarantees of Origin system to renewable gases improving its traceability. There is still a need to precise benefits brought by biomethane to the heating sector (the role of biomethane in renewable heating shall be more explicit). RED II defines specific sustainability criteria..
- The European Committee for Standardization (CEN) developed two standards to harmonize the quality of biomethane to be injected into the grid:
  - > The EN 16726 [12] standard published in 2016 deals with main parameters common to natural gas and biomethane;
  - > The EN 16723-1[13] standard published in 2017 deals with parameters specific to biomethane.

The Injection of biomethane is authorized in an increasing number of European countries: UK, France, Germany, Austria, Italy, Sweden, etc.

12. EN 16726 – Gas Infrastructure – Quality of gas – Group H
13. EN 16723-1 – Natural gas and biomethane for use in transport and biomethane for injection in natural gas network – Part 1: Specifications for biomethane for injection in the natural gas network

Biomass gasification & methanation: There is currently no regulation on these new renewable gases. Several working groups are working on technical and standardisation aspects, especially for hydrogen combined with natural gas. Sustainability criteria currently discussed in RED II could apply to these renewable gases. SNG quality is also defined if injected in the natural gas grid (EN 16726 and EN 16723-1).

Currently, there is no specific legal framework on the injection of hydrogen. National law or technical ruling in the Member States varies broadly. Technical parameters for the injection and transportation are under development by the TC6 and TC 234 hydrogen (technical committees of CEN).

In Germany, up to 5 volume percent of hydrogen may be added. In case of a natural gas filling station connected to the grid, only 2 volume percent of hydrogen may be added. It is conceivable that the limit for the hydrogen injection will increase in the future. There are studies ongoing on reactions of the grid and gas appliances to higher hydrogen concentrations. On the basis of current information available, cavern and pore storages, above-ground facilities and fuel tanks in gas cars are the major critical components. Assuming that hydrogen is injected into the distribution net without gas fuel stations or complex industry, a compatibility of 10 volume percent can be presumed for the future.

The EU-framework for power-to-gas is very imprecise. There are provisions for power-to-gas and its uses in the different sectors. Some member states have set up further specifying provisions, e.g. in Germany and France.

The European Framework does not provide any specific rules on interruption demand response is done on a contractual basis in the member states.

ANNEX 5

BIBLIOGRAPHY

- CEER - Status Review on European Regulatory Approaches Enabling Smart Grids Solutions (Smart Regulation) – 2014
- Dehaeseleer, Cayford, de Ville de Goyet, Kas – Gas Grids for a smart energy system – 2015
- EG3 – SMART GRID TASK FORCE – Regulatory Recommendations for the Deployment of Flexibility (Refinement of Recommendations) - 2015
- Eurogas, Marcogaz, GERG Task Force on Smart Gas Grid - Gas Bridge: the natural gas network as key partner on the energy transition – 2017
- Bozzetto, Curlisi, Fabbri, Pezzaglia, Rossi, Sibilla – The development of biomethane: a sustainable choice for the economy and environment – 2017

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