Smart Energy Grid aspects related to Gas

IGU World Gas Congress 2015 – Paris

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1. Scope and purpose of this report

Greenhouse gas emissions, EU energy import dependency, increasing energy demand, affordability and many other factors cause decision makers to rethink energy use, production, transportation and storage.

In order to achieve the energy efficiency goals, the European Commission supports strongly the development of smart energy grids.

In this context, in a lot of minds, only electricity grids are considered. However, this report will make it clear that the gas network and gas utilisation will play a major role in achieving the efficiency goals and will enable cost saving solutions for many problems encountered in the electricity networks.

The major benefits of gas and smart gas grids show its essential role in an overall energy mix program. The benefits described in this report are:

- lowering greenhouse gas emissions,
- increasing the share of renewable energy (biomethane, Syngas, injection of H_2,..),
- optimising the intermittent production of renewable energy,
- contributing to improve the security of supply,
- improving energy efficiency by enabling 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,
- enabling consumers to become "prosumers" by using gas to lower the 'peaks' in the electricity network and to reduce energy loss in the electricity transmission and distribution networks;
- enabling synergies between gas and electricity networks through the encouragement of distributed generation.

Clean and efficient energy emphasizes the need for a modernised, smart and flexible energy infrastructure at all levels to allow more flexible back-up and balancing power capacity, storage systems, new energy usages such as CNG vehicles and demand-response programs. This stresses the need to ensure greater cooperation between all stakeholders with the end-user as a "central player".

This status report is a further building upon the report 'EU Commission Task Force for Smart Grids - Expert Group 4 - Smart Grid aspects related to Gas' published by the EU Commission in 2011.

This report gives insights on products, opportunities and benefits of gas grids as an enabler and an integral part of a smarter energy system.

It describes the actual status of implementation by a sampling of on-going projects, some of which were presented in the 2011 report. Some complementary cases are also presented in this report. The list of projects attached to this report is non-exhaustive and only given to provide some illustrations.

2. Introduction

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

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

Further, uncertainties around the future development of efficient and large scale electricity storage technologies means that gas will increasingly become a key provider of both heating and electricity balancing services.

As pointed out in the EG4 report[1], smart gas grids will support the ability of gas to play a major ongoing 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.

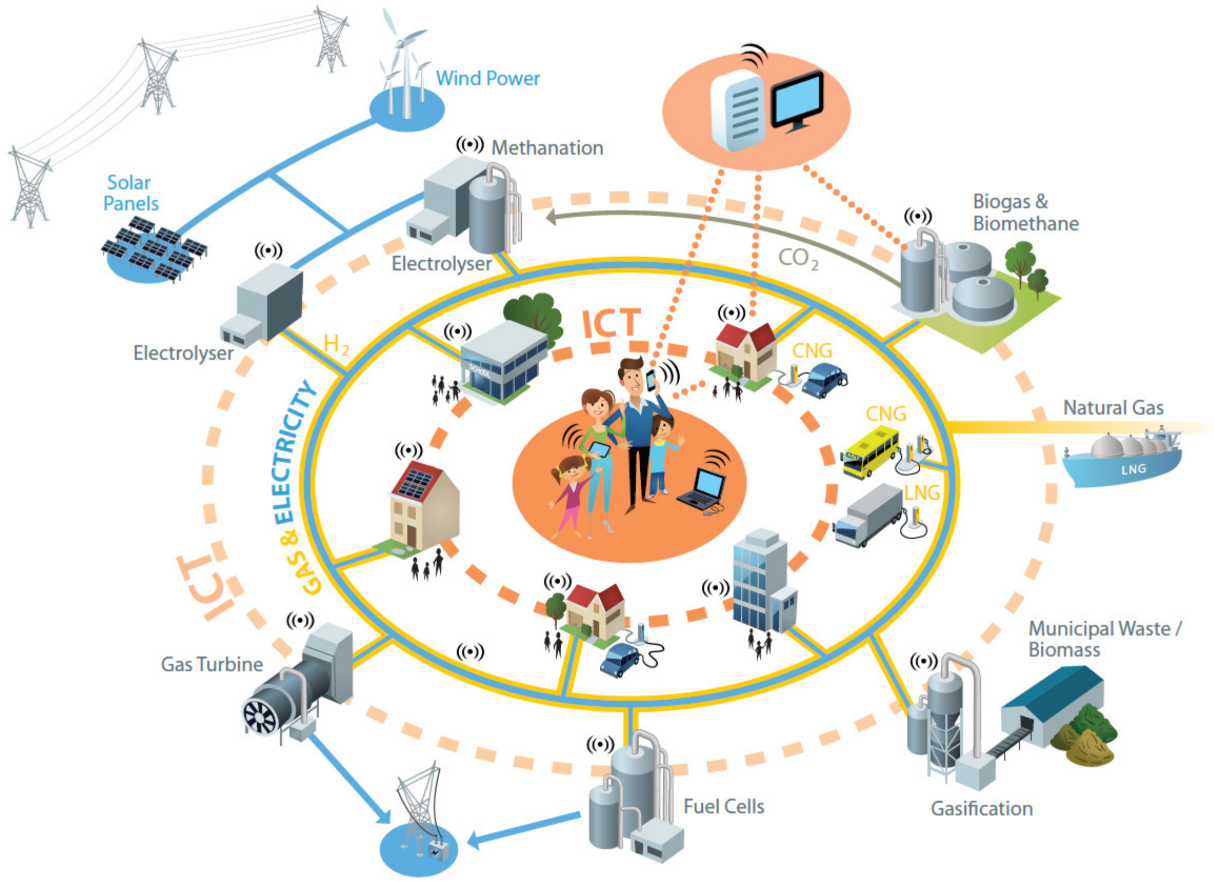
The smart gas grid concept is based on maximizing the efficiency of overall energy usage and taking full advantage of the flexibility and all the opportunities that gas and the gas grid can offer.

In this paper, we will illustrate the functionalities, services, opportunities and products of the gas smart grid, and their related benefits.

The next three sections are focused on the role that a smarter infrastructure could play to mitigate the misalignments between renewable energy production and energy use.

In particular, in clause 3.2, the challenges and opportunities of intermittent renewable energy are discussed.

[1] EU Commission Task Force for Smart Grids - Expert Group 4 - Smart Grid aspects related to Gas http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group4.pdf



Source: Eurogas, 2014

Figure 1: smart energy networks

3. Sustainable energy prospects

3.1 Energy use evolution

If we focus on the network related energy use, a major trend can be recognized toward increasing sustainable resources which would be more decentralized compared with today. The more frequently discussed options for decentralized energy production are wind and solar energy. Because these resources can provide electricity one may tend to assume that an all-electric energy system would be obvious. However, the transition towards an energy system entirely based on electricity will likely be an insurmountable challenge.

As an example, the graph below shows the heat and electricity demand in the domestic and commercial sector in the UK. The peak heat demand is far greater than the present electricity demand, and therefore even if very ambitious savings are achieved, prohibitively expensive investments in electricity production and transport capacity are needed to cover the heat demand.

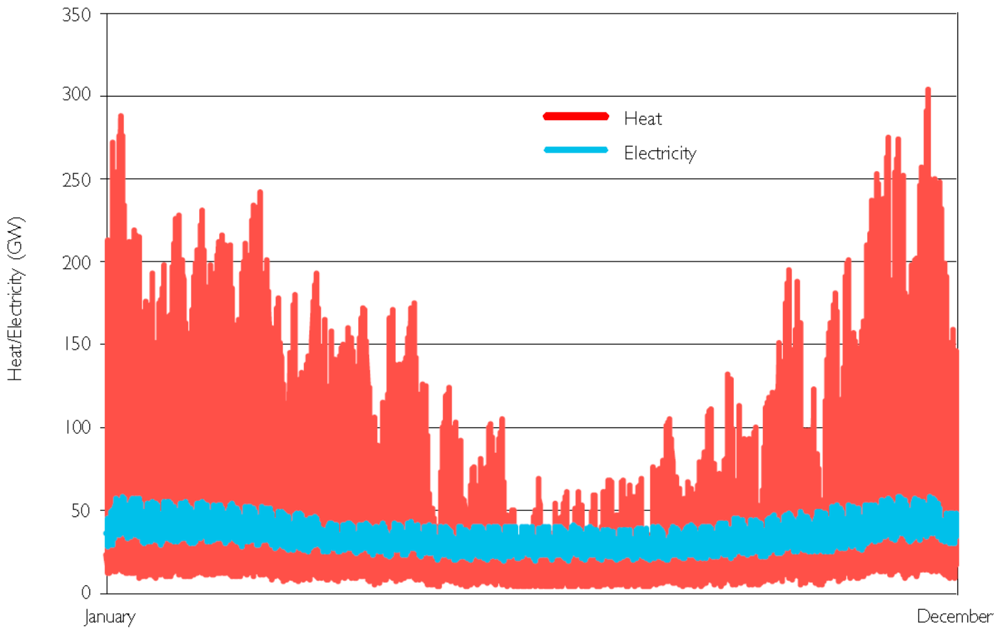


Figure 2: Heat and electricity demand variability across a year (UK 2010) [2]

The challenge of a transition toward an energy system entirely based on electricity lies not only in the difference between the peak demands of heat versus electricity (figure 2 above). Besides capacity, the flexibility needed is a serious obstacle to overcome.

Figures 3 through 5 below show the modelled daily power generation for the UK[3]. The figure on the left shows the situation in 2009 where the wind capacity is about 4 GW. In

[2] The Future of Heating:A strategic framework for low carbon heat in the UK (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48574/4805-future-heating-strategic-framework.pdf)

[3] Source: Rogers, H.V., The impact of import dependence and wind generation on UK gas demand and security of supply to 2025. The Oxford institute for energy studies, August 2011

the figure on the right (scaled down to make comparison easier) the capacity of wind is almost 44 GW (2025). Gas powered generation seems to provide the necessary flexibility. On an hourly basis the need for flexibility is even starker, and storage will be needed to secure base load for coal and nuclear power generation. Power to Gas can help to solve these problems. Looking at the installed wind capacity in Germany compared with the UK (figure 5) it is not surprising that power-to-gas pilot projects can be found in Germany, while the UK is still in the planning stages of development.

Figure 3 . 2009 UK Modelled Daily Wind Power Generation in Generation Stack

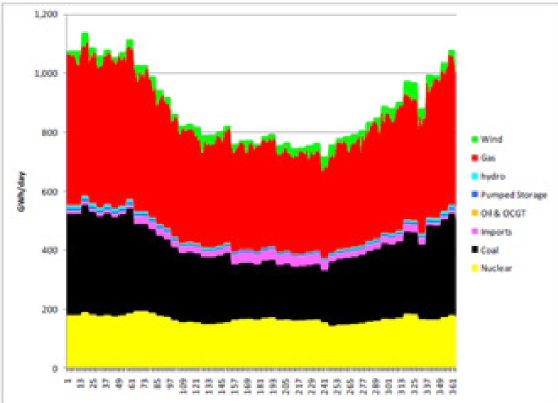


Figure 4 . 2025UK Modelled Daily Wind Power Generation in Generation Stack

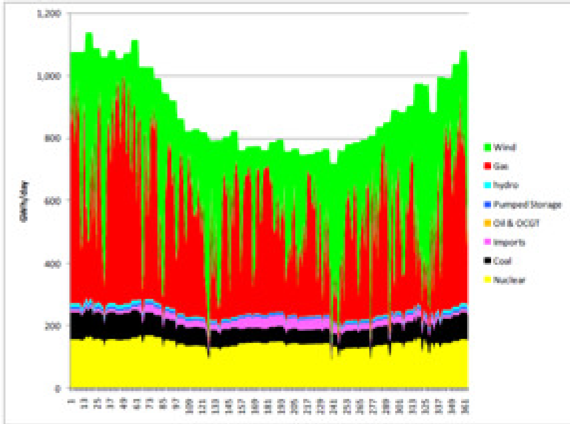
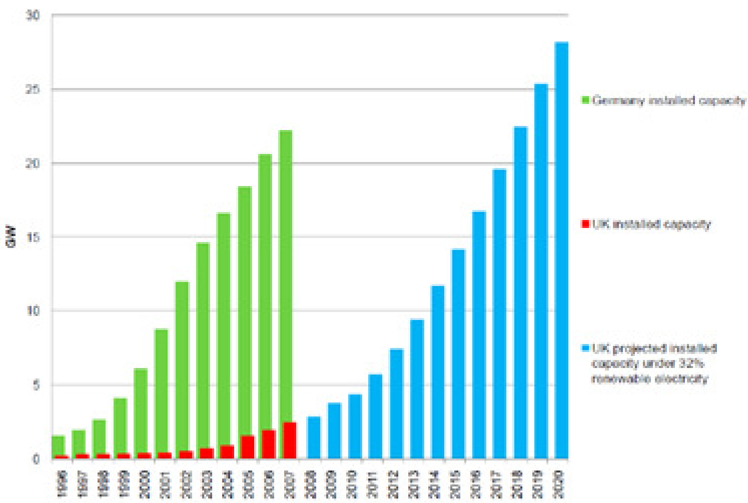


Figure 5 Cumulative installed wind capacity in UK and Germany 1996 – 2007 and projected UK 2008 – 2020 in the Committee on Climate Change 2008 Report.



Towards renewables and dual-fuel appliances

Smart gas utilisation such as "dual fuel" appliances (electricity & gas), fuel cells, an increased use of Natural Gas Vehicles (NGV) for transport, and biomethane injection into the gas grid, together with extensive use of cogeneration (CHP), offer solutions to manage greenhouse gas emissions, the efficiency of the networks and to empower the end-users to optimize their energy use and to allow them to participate actively in the energy market.

Modern gas boilers are very efficient for space heating and hot water production. The efficiency can be further increased by using renewables. At present this is commonly done by using condensing gas boilers in combination with solar (thermal) panels, mainly for hot water production. The next generation of gas appliances will be even more efficient by using the energy from air, ground or water in gas heat pumps. This technology is available but not yet common in Europe.

A hybrid heating system combines a heat pump (typically air-to-water) with a condensing gas boiler and thus it is a dual-fuel appliance. The heat pump will supply energy to the house at moderate temperatures (depending on the heating system and the costs of electricity vs. gas) and the condensing gas boiler supplies energy at lower outside temperature. When properly integrated in a smart energy system the network operator can choose the optimum fuel to balance the energy system and the customer can choose the energy form of his choice depending on price and/or sustainability gradient.

Hybrid heat pumps are available today from boiler manufacturers and also from other suppliers. The available products range from add-on heat pumps for existing installation to combined heat pump / boiler systems for new installations or the replacement market.

Hybrid heat pumps have lower running costs and lower CO_2 emissions than condensing boilers, but the installation and equipment costs are higher. Manufacturers have reduced the equipment costs by optimizing the size of the heat pump. It is therefore expected that the market share of hybrid heat pumps will significantly increase over the next years, making it an important part of smart energy grids.

Gas for local electricity production

The IPPC's Fifth Assessment Report [4] concludes that near-term greenhouse gas emissions from energy supply can be reduced by replacing coal-fired power plants with highly efficient natural gas combined cycle (NGCC) power plants or CHP plants. Many CHP units exist already across Europe and there is a substantial potential for further development. In 2009, 11.4 % of the electricity in the EU was produced by CHP; of which 39.4 % based on natural gas[5].

In spite of the potential, there is only limited growth in the use of CHPs in many countries. According to COGEN Europe[6] there are signs of CO_2 mitigation delay and loss of opportunity. Large-scale industrial CHP is facing difficulties in several European countries due to a combination of circumstances. COGEN Europe states that "European member states must take steps now to give confidence to stakeholders so that at least their installed capacities will be maintained, through what is an exceptionally difficult time for the larger players in the sector".

The future appears to be potentially brighter on the other end of the size range. Micro- or mini-CHP units provide energy to commercial and residential buildings. Appliances based

[4] http://report.mitigation2014.org/drafts/final-draft-postplenary/ipcc_wg3_ar5_final-draft_postplenary_chapter7.pdf

[5] http://www.eea.europa.eu/data-and-maps/indicators/combined-heat-and-power-chp-1/combined-heat-and-power-chp-2

[6] http://www.cogeneurope.eu/medialibrary/2014/04/18/786b6c1c/220414%20IPCC%20confirms%20role%20of%20CHP%20in%20long-term%20CO2%20reduction.pdf

on Sterling engine or internal combustion engine with an output of 1 kWe, for use in single family houses, are being commercialized. Up to 1000 residential fuel cell micro-CHP appliances from 9 European manufacturers will be demonstrated in the ene.field project[7] across 12 key member states.

Micro-CHP appliances produce electricity when there is a heat demand. As such they may play an important role in a future smart energy grid where the electricity demand also may be heat-driven.

Gas for mobility

Compressed natural gas (CNG) can replace gasoline in vehicle engines after minor modifications to fuel and control systems. As the CO_2 emissions from natural gas are much lower than the emissions from oil, the use of CNG results in emission reductions up to 25 %. The technologies for gas-driven cars are far more advanced than for electric cars and emission reductions therefore come at a much lower cost.

The CO_2 emissions from natural gas vehicles (NGVs) can be further reduced by using biomethane as a fuel. Biomethane has a significant market share in Finland, Germany, the Netherlands and Sweden[8].

More than 3000 NGV filling stations are in operation within EU, which, together with home compressors, supply fuel to 1.1 million NGVs[9]. Some of these stations supply L-CNG or LNG to heavy duty vehicles. The LNG Blue Corridors project aims to improve knowledge and awareness of LNG as an alternative fuel for medium and long distance road transport by the roll out and demonstration of four LNG corridors across Europe. This will include building 14 new LNG or L-CNG stations and building up a fleet of about 100 LNG Heavy Duty Vehicles which will operate along the corridors[10].

There is also the possibility to use compressed e-gas based on H_2 and recycled CO_2[11].

In conclusion, in the long run an increasing production of unpredictable solar and wind energy benefits from the presence of a gas infrastructure. Smart appliances can make a huge contribution towards sustainability even in the short and medium-term. The needed technology for dual-fuel appliances, fuel-cells, micro and mini CHP, gas fired cooling systems and gas fired heat pumps is developed and available but not yet common in the European market.

The technologies for gas-driven cars are far more advanced than for electric cars and have considerable advantages in relation to efficiency. Increasing the efficiency of energy usage is a fundamental objective of the European energy strategy. Smart gas utilisation will support this objective and should be encouraged.

[7] http://enefield.eu/
[8] http://www.ngvaeurope.eu/european-ngv-statistics (status September 2013)
[9] http://www.ngvaeurope.eu/european-ngv-statistics (status September 2013)
[10] http://www.lngbluecorridors.eu/
[11] http://www.audi.com/com/brand/en/vorsprung_durch_technik/content/2013/10/energy-turnaround-in-the-tank.html

3.2 Renewable resources

Towards increasing integration of green gas in the natural gas networks

Now produced from waste and, in the longer term produced from wood, straw or microalgae, biomethane gas is a green, 100% renewable gas, injected into the natural gas network. The multiplication of injection points involving various gas qualities becomes a reality requiring improved performance indicators of the distribution network: In the past, the gas came from centralized geological sources; in the future the gas system will provide increasing network access to many local producers of biomethane.

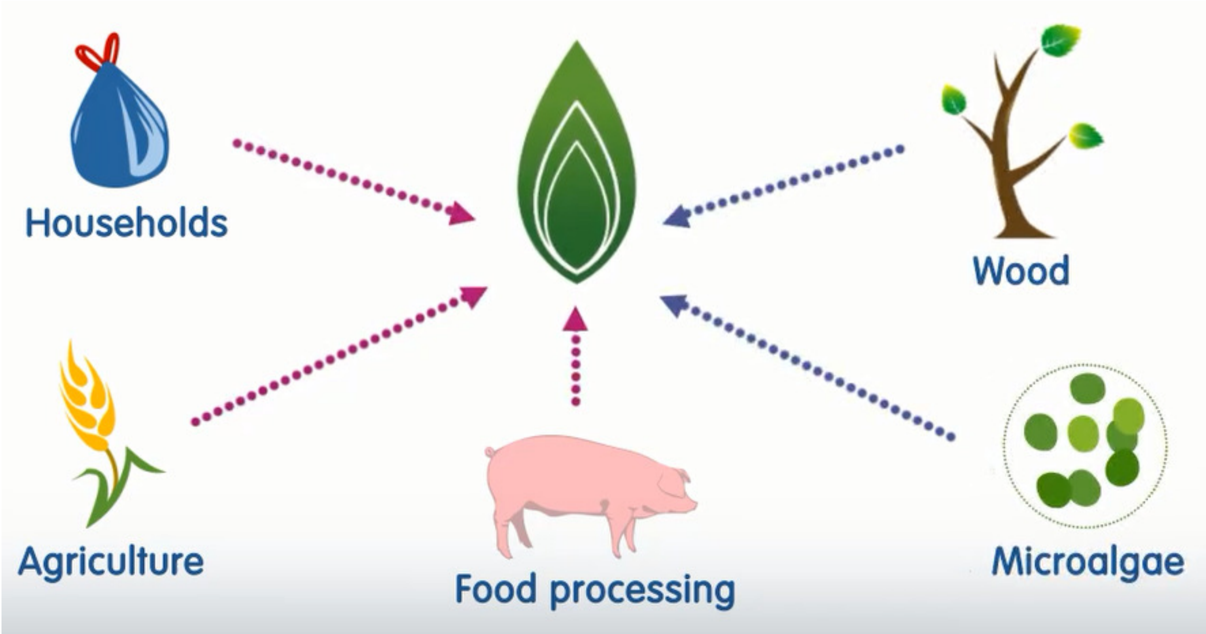


Figure 6: Origins of the feedstock for producing biogas.

On top of the potential of anaerobic digestion of waste, technical and economic study of gasification of solid biomass and biogas from microalgae is on-going. As all these additional potentials are complementary, a large share of the gas could be supplied from renewable sources in the future (e.g. in France, 100% green gas mix is deemed technically feasible.)

Towards increasing integration of energy networks

The development of electric intermittent renewable sources such as wind and photovoltaic raises questions about their integration into networks. A low level of production requires having flexible production capacity for back-up support. Moreover, large production requires developing storage capacity or conversion of surplus electricity to other energy carriers such as hydrogen or methane.

In response to these issues, technologies enabling electricity conversion towards gas - principle called "power-to-gas" - are sometimes called upon. Based on the large storage capacity of gas infrastructure (linepack and underground storage), they aim to convert renewable electricity into hydrogen by electrolysis of water. This hydrogen can be injected into the network of natural gas in the natural state, or after a step of methanation, which comprises the associate H_2 with CO_2 to convert it to methane. As hydrogen cannot be stored in underground storage for technical reasons, power-to-methane enables access to the full scope of gas infrastructures.

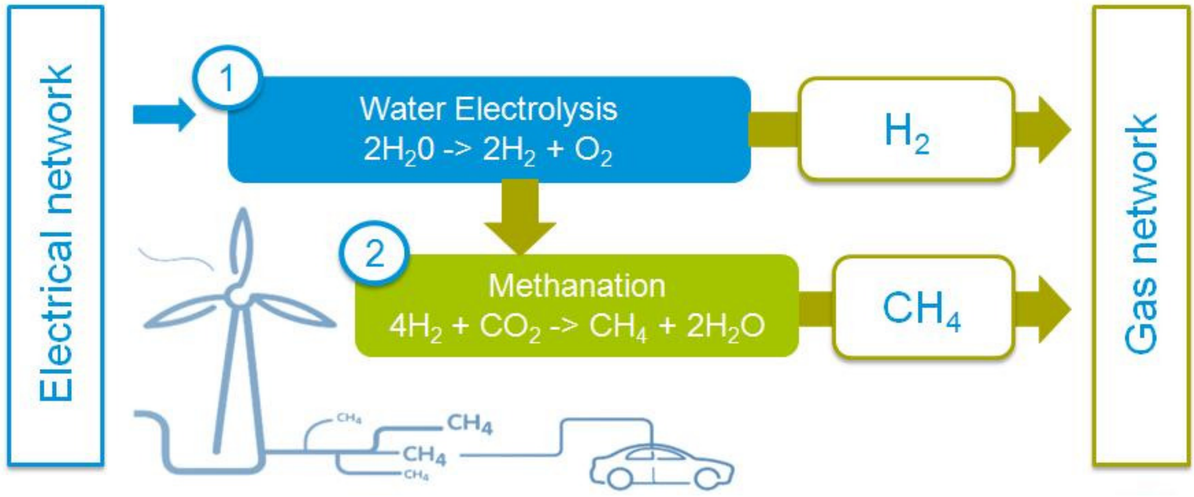


Figure 7: Power to gas.

The injection of non-conventional gases, like biomethane or hydrogen, insofar as it is produced from a carbon free source, reduces the carbon intensity of the gas grid. Manufacturing biomethane by upgrading biogas produced by methanation is available and already injected in the gas network in more than 200 places in Europe, mainly in Germany.

Other gases could be injected directly, or by using a blending facility in the gas networks. Since there are only a small number of pilots going on for the moment, there is less experience available.

These new sources have different characteristics which require smart functionalities:

- Decentralized and numerous, in the long term
- Predictable and stable for biogas production but intermittent for renewable electricity (electricity at low cost, maintenance, grid capacity, quality)
- Sources of gases of different qualities

In order to monitor and manage the different gas qualities and flows, a growing number of communicating devices at crucial points of the network will have to be deployed and monitored for a faster and a more accurate fault diagnoses. Remote control of key infrastructure components could allow implementation of innovative strategies such as dynamic pressure adjustment to maximize green gas integration.

Like other renewable sources, manufacturing non-conventional gases for injection in the gas network is not yet a mature technology which is widespread on the market. It requires cost-effective incentives taking into account the greenhouse gas emission benefits.

European legislation/standards concerning the required quality of injected non-conventional gas are in the final stage. For the safe use of the gas by the end-users and for correct billing, the quality has to be monitored. In the case of off-spec gas, necessary and in-time actions have to be taken to stop such gas entering the network.

3.3 Smarter infrastructures

With the injection of different kinds of gases like biomethane, H_2, Syngas, etc., new techniques and more 'active' control of the gas distribution system will be necessary and can lead to a more efficient network.

Storage

A key existing feature of the gas grid is its ability to store energy. This storage provides flexibility in use of gas between day and night, between summer and winter and gives flexibility in relation to the use of other energy carriers. In addition to the provision of discrete storage on a seasonal basis in dedicated facilities (depleted gas reservoirs, salt cavities and using Liquefied Natural Gas), gas holders and the gas network itself (by cycling of pressure in the network) may be used on a diurnal basis to store energy when gas is not directly consumed. Flexible grids will enable the integration of electricity, gas, heating and cooling with the result that the overall efficiency of the grid(s) is optimized. The result will be a sustainable, economic and reliable future energy system. Peaks in electricity consumption could be reduced / removed by the use of dual fuel applications, or even more by using combined heat and power (CHP) or cogeneration at local or even residential level.

A highly promising possibility of storing power from renewable sources is the conversion of wind or solar power into hydrogen or into other non-conventional gases. These gases could be stored or fed into gas networks. When required, power could be generated from gas using gas-fired power plants, cogeneration (CHP, mini and micro CHP) or fuel cells.

Monitoring

In order to monitor and manage the different gas qualities and flows, a growing number of communicating and measuring devices and critical control points will have to be deployed for faster and more accurate diagnoses. Remote control of key infrastructure components will allow implementation of innovative strategies such as dynamic pressure adjustment, blending… to maximize green gas integration.

This would optimize the operation of all distribution assets and improve the efficiency of the energy networks through enhanced automation, monitoring, protection and real time operation.

Today gas quality is monitored upstream or at entry points into the gas distribution network. When gases from different sources are injected into the distribution network at new entry points, additional monitoring of the gas quality should be undertaken in order to ensure the safe use of the gas appliances and accurate billing.

This will require analyzers of gas quality to be placed at the injection points in the network in order to ensure the quality of gas injected is acceptable. If the gas becomes off-spec, active control of gas flow (shut down), buffering, propane injection, or blending with other gases will be required.

As a general principle, regardless of the developments that can be implemented in a smart gas grid, gas injected into the gas network must meet predetermined quality specifications. At present, these specifications are being defined at Member State level but European specifications are under development.

Gas systems are located in an increasingly complex environment with increased safety consequences when its integrity is compromised. Smart (self) monitoring (and in the future maybe even self-healing) of the system could be a cost effective solution.

Safety

Safety related issues and management of the networks could be improved by the smart gas grid concept. The use of smart tools in the field of pressure regulation, traceability, internal pipe inspection, odorisation, and cathodic protection could improve the integrity of the network.

This functionally could optimize the operation of all distribution assets and improve the efficiency of the energy networks through enhanced automation, monitoring, protection and real time operation.

Balancing

A smart gas grid can supply centralized and detailed information about crucial points which are representative of the network. This allows correct balancing of the network both from a physical as well as a commercial point of view.

The distribution and transmission system management should guarantee optimal and flexible configuration of the gas flows. The main benefits are related to:

- Energy savings (reduction of fuel gas for compressor station utilization)
- Reduction of pressure losses
- Reduction of gas storage utilization (in/out)
- Network efficiency
- Security and emergency management:
    - in time detection of anomalies or breakdowns,
    - management of a critical path to guarantee constant flows,
    - data management about the possibility to switch with other energy sources.

In the long term, monitoring of pressure and flow will allow more efficient investment planning.

Automated component quality and integrity surveillance enables the prediction of failures in order to avoid gas losses and supply interruptions.
New sensors are being developed which can measure stresses on pipeline and the strength of materials in situ. Combined with modern communication, methods and/or state of the art mobile and autonomous robotic sensor platforms, information can be gathered about the status of the grid. This can be used to optimize 'just in time' maintenance and replacement and to minimize cost and disruption to network services and other networks (traffic).

Improved asset management, replacement and extension strategies should be based on monitored information of the quality of network components and by information on actual flows and pressure patterns.
The use of smart pressure regulators, would allow indirect flow measurement, remote outlet pressure control, flow limitation and remote monitoring. The pressure in the network could be continuously adapted as functions of the demand, taking into account both consumption and injection. In case of incidents on the network, the pressure and flow could be reduced remotely.

4. Conclusions and further recommendations

The importance of gas and gas smart grids in the future energy use, production and transportation in Europe should not be under estimated. Gas grids play a central role in the overall energy usage, production and transport thanks to its flexibility and compatibility with renewables. Storage abilities of gas and energy convertibility to gas will solve many of problems already identified in order to attain to future energy efficiency in a sustainable way.

Although gas and gas smart grids are actually not the first priority in a lot of European debates concerning energy efficiency and smart grids, the gas industry has been an increasingly active contributor toward a smarter energy system. This report gives an overview of some projects towards a smarter gas grid as part of a smart energy system.

Gas networks allow for cutting edge innovative solutions for renewable energy implementation. For instance, power-to-gas projects show that gas networks can be used to store and transport the excess production of green power. Already, non-conventional green gases like biomethane are injected in the existing gas grids. New distribution networks which allow gases from renewable sources are currently being tested.

In addition, gas networks have the ability to store a large amount of energy and thus are much more flexible than electricity networks. Local electricity production by CHP, combined heat and power… can be used to lower down the peaks in the electricity network.

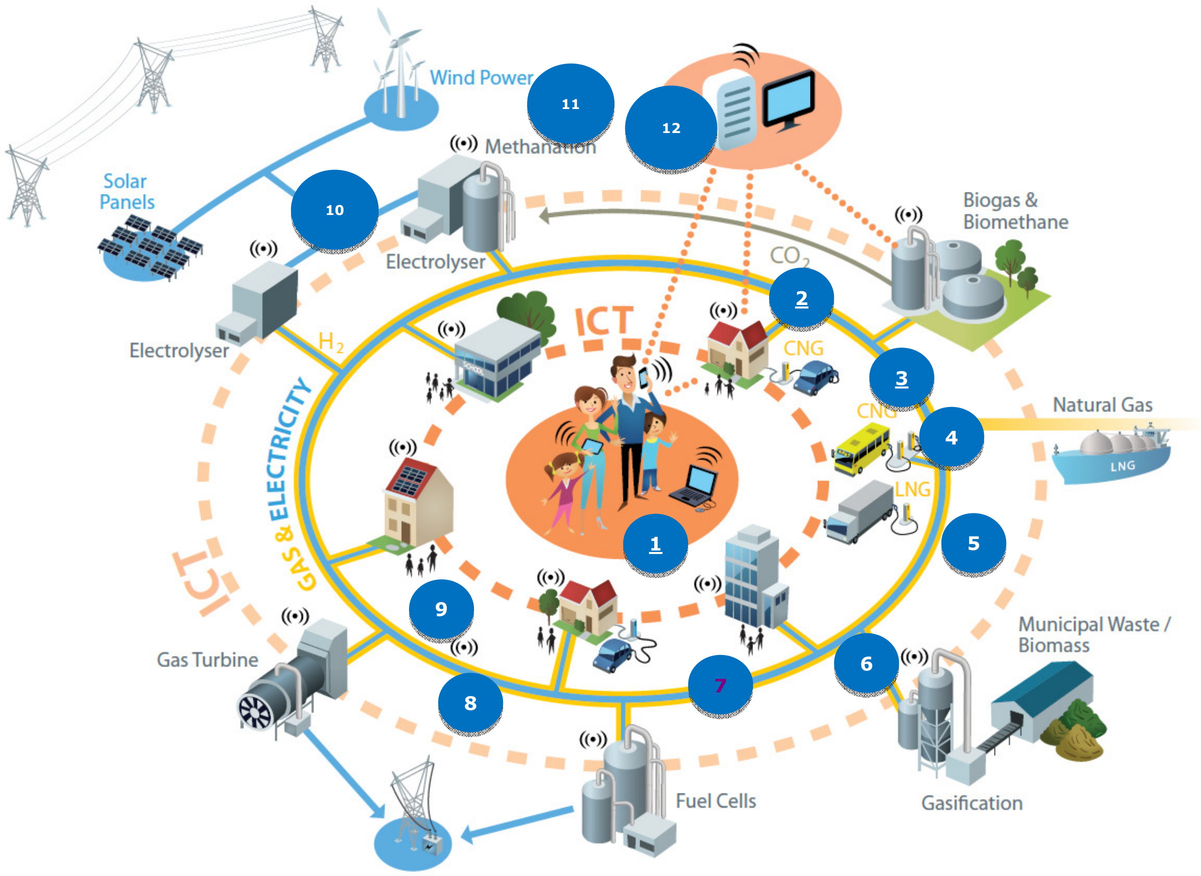
The use of dual fuel appliances, fuel cells, gas for transport (CNG, LNG) allows the consumers to manage their own energy use and to choose the most efficient one. At the same time the CO_2 emission will be reduced.

Gas systems are located in an increasingly complex environment with increased safety consequences when its integrity is compromised. Smart (self) monitoring and more active control of the system will lead to a more safe and reliable network.

The European gas networks are active and crucial components toward realizing smarter future energy system that the coming generations need. To fully achieve such an integrated, balanced, and sustainable system is challenging and will only be realized with the continued engagement of all stakeholders.

5. Ongoing projects in relation to smart gas grids

(Ctrl+Click on the blue tags to get more details on existing projects).



Source: Eurogas, 2014

Diagram reference n°1

Project Name	Opower E.ON
Website	http://www.eonenergy.com/for-your-home/help-and-support/saving-energy-toolkit

Diagram reference n°2

Project Name	BioNGV in France
Website	http://www.marcogaz.org/egatec2011/PS2/PS2D_Bordelanne_egatec2011.pdf

Diagram reference n°3

Project Name	Biomethane from biowaste: BIOMETHAIR
Introduction / scope	ACEA is a modern Italian multi-utility company, which currently provides services for Municipalities, private companies and citizens in three main fields – environment, water and energy, also trough natural gas distribution grid. Thanks to its waste treatment facilities managing biowaste from source separate collection through Anaerobic Digestion and composting, ACEA is developing an integrated approach from biowaste to biomethane and beyond. We are currently running two projects; one is called GREEN NG and the second one BIOMETHAIR.
Benefits / purpose	ACEA is involved in BIOMETHAIR as a supplier of biomethane and hydrogen for a small hybrid car with a low to zero expected impact on environment. We will develop a pilot scale fermentation system in order to produce hydrogen via a mesophillic fermentation. The bio hydrogen will then upgraded to be mixed with the biomethane coming from GREEN NG with different ratio as it will be asked from car manufacturer.
Roll-out / planning	BIOMETHAIR will develop a pilot scale plant for producing biohydrogen via a mesophillic fermentation and it is expected running from the beginning of 2015.
Budget / Cost and challenges / State of development	BIOMETHAIR is based on a total budget of 10.2 M€. The project is developed on a preview timeline from 03/2013 to 06/2015. ACEA is working on the design and authorization phase of the pilot plant. BIOMETHAIR, it is mostly oriented on automotive sector, ACEA will start the construction phase late in October 2014 in order to be in operation for the beginning of February 2015.
Company + logo	BIOMETHAIR project is divided in three main topics: • *BIOMASS conversion process* • CNG dedicated mini hybrid powertrain • Advanced CNG storage technologies
Country(ies)	Italia
Website	BIOMETHAIR: www.biomethair.it

Project Name	Biomether LIFE+
Introduction / scope	The availability of residual biomass in Emilia-Romagna amounts to about 16.000.000 t/year, and the natural gas grid is significantly widespread and a leading industrial sector on methane fueling station components is present. These factors make the potential for biomethane production for grid injection significant in order to contribute to the EU2020 targets.
Benefits / purpose	Biomether aims at developing the biomethane value chain in Emilia-Romagna using two demonstrative plants for biogas upgrading. One plant will be located at a wastewater treatment plant, and will upgrade the produced biogas to biomethane to be used for transport. The other plant will be located at a waste disposal site, where biomethane will be used for direct grid injection. The data obtained from these two demonstrative plants will allow to draw guidelines for the development of a regional biomethane value chain in Emilia-Romagna.
Roll-out / planning	The project started in October 2013 and will end in march 2018. After design, construction and installation of the upgrading prototypes, biomethane will be produced for at least a two years period. The quality of the input biogas, of the produced biomethane, its uses, and the environmental benefits will be monitored.
Budget / Cost and challenges / State of development	The total budget is 3.375.465 € with an EU contribution equal to 45%. The project is at the initial state of development (technical preparatory actions ongoing).
Company + logo	ASTER S.cons.p.a.(Coordinating beneficiary), CRPA SpA, IREN Rinnovabili SpA, HERAmbiente SpA, SAFE SpA
Country(ies)	Italy
Website	www.biomether.it www.biomether.eu

Project Name	Gontrand
Introduction / scope	Accompanying profound changes in the energy landscape, networks that allow energy delivery to the consumption point is preparing an unprecedented modernization. The number of injection points of green gas is increasing and the gas infrastructure are facing challenges around gas quality and flow management.
Benefits / purpose	Study and development of a platform and SCADA allowing near-real time feedback and monitoring of the network as well as control of the injection of green gas.
Roll-out / planning	Start : 06.02.2014, duration : 36 months
Budget / Cost and challenges / State of development	Total cost: 4.900 k€ (to be confirmed)
Company + logo	GrDF
Country(ies)	France
Website	N/A

Project Name	Bionet: raw biogas injection in to the low CV-gas grid;
Introduction / scope	The Bionet project takes a major step forward, as we consider the gas supply chain in all its aspects. In the BioGrid project, modifications to accommodate biogas in the gas chain are not carried out within the gas production and distribution itself, but on the equipment of the end-user. The pilot project will apply development and practice towards building a dedicated biogas grid and modifying the relevant household appliances. The project will experiment with a mix of natural gas and biogas.
Benefits / purpose	1. The first target is to reduce the cost of gas supply in gas delivery chain. 2. The second objective is to contribute to renewable energy supply in an efficient way. 3. The third objective is the contribution towards a lower EPC norm in housing which is a EU obligation in 2020
Roll-out / planning	Start 2013
Budget / Cost and challenges / State of development	In progress. Boiler manufacturer ATAG has a multi gas boiler available.
Company + logo	
Country(ies)	The Netherlands
Website	http://www.atagverwarming.nl/home https://www.liander.nl/

Project Name	Designing the Bio methane supply chain through automated synthesis
Introduction / scope	A Decision Support Tool (DST) has been developed that will aid Distribution Service Operators (DSOs) in their decision making process on which investments to make in the gas distribution grid in order to facilitate the use of bio methane
Benefits / purpose	Decision support to optimize investments in the complete value chain including the distribution network
Roll-out / planning	PH.D. Thesis finished in April 2014
Budget / Cost and challenges / State of development	Thesis is available
Company + logo	UNIVERSITEIT TWENTE.
Country(ies)	The Netherlands
Website	http://doc.utwente.nl/78889/

Diagram reference n°4

Project Name	Biomethane from biowaste: GREEN NG
Introduction / scope	ACEA is a modern Italian multi-utility company, which currently provides services for Municipalities, private companies and citizens in three main fields – environment, water and energy, also trough natural gas distribution grid. Thanks to it's waste treatment facilities managing biowaste from source separate collection through Anaerobic Digestion and composting, ACEA is developing an integrated approach from biowaste to biomethane and beyond. We are currently running two projects; one is called GREEN NG and the second one BIOMETHAIR.
Benefits / purpose	The purpose of the GREEN NG project is to develop an upgrading plant from biogas to biomethane in order to distribute it in the natural gas grid.
Roll-out / planning	The GREEN NG plant it is expected running from end of May 2014 with a testing operation phase from 3 to 4 months not feeding the grid. After that period, the plant will potentially run feeding the grid. It will depend on the national technical standard under development.
Budget / Cost and challenges / State of development	GREEN NG, based on an original budget of 1.2 M€. The plant will be in operation from late of May and the project will be ended in October 2014. GREEN NG, is nearly to be concluded.
Company + logo	GREEN NG project: • Hysytech srl • ACEA Pinerolese Industriale SpA • Proplast srl • AdMil srl
Country(ies)	Italia
Website	BIOMETHAIR: www.biomethair.it

Diagram reference n°5

Project Name	STIGS, Short Term Infrastructure for Gas Storage
Introduction / scope	Natural gas and bio methane filling stations have compressors and storage facilities. How can this contribute as an "extended line pack to manage the difference between supply of bio methane and demand of customers connected to the distribution network?
Benefits / purpose	To increase the possibility for producers of bio methane to inject into the distribution network.
Roll-out / planning	Pilot started in 2014. Results expected by the end on 2014
Budget / Cost and challenges / State of development	The budget of the pilot is approximately € 100.000,-. One of the challenges is to define the cooperation between the different actors like Filling station and network operators.
Company + logo	ORANGEgas, Liander
Country(ies)	The Netherlands
Website	http://www.orangegas.nl/ http://www.liander.nl

Diagram reference n°6

Project Name	Gothenburg gasification project SE
Website	http://www.goteborgenergi.se/English/Projects/GoBiGas__Gothenburg_Biomass_Gasification_Project

Diagram reference n°7

Project Name	Greenlys for piloting bi-energy services
Website	http://www.greenlys.fr/

Diagram reference n°8

Project Name	TEX
Introduction / scope	At GrDF, we have three main uses of remote monitoring : First : remote monitoring of pressure reduction stations in order to fix a station breakdown before gas is cut off Second : remote monitoring of corrosion protection stations to ensure permanent protection of steel networks Third: remote control of valves to prevent a gas supply interruption for isolated cities and to monitor low-pressure networks within big cities. TEX is an organizational, hardware and software evolution. Current situation is the following: operational devices only for remote monitoring, local information systems, thirty area operational management centers The target is the following : • Industrialization and remote monitoring implementation: remote monitoring of medium and low pressure pipelines, cathodic protection monitoring, centralized information system. AOM centers are in charge of supervision • Building a unique monitoring and management tool. It means the update and convergence of the decision making tools and development and implementation of a SCADA (Supervisory Control and Data Acquisition)
Benefits / purpose	The TEX project aims at: • Replacing obsolete constituents • Increase the number of technology providers • Improve reliability of tools and processes • Improve efficiency by new data-driven network management strategies implementation.
Roll-out / planning	2013 - 2018
Budget / Cost and challenges / State of development	30MEUR
Company + logo	GrDF
Country(ies)	France
Website	N/A

Project Name	Pilot Zuthpen sensoring Pressure, Flow and temperature
Introduction / scope	Measurearing flow, pressure and temperature in 10 distribution stations and collect data real-time.
Benefits / purpose	Validation of net design criteria. Insight of energy flows is a first step to an active controlled network and optimizing network and station replacement and investment
Roll-out / planning	finished
Budget / Cost and challenges / State of development	Result of the pilot were used to define Overall program "Digitalizing the gas network"
Company + logo	Liander
Country(ies)	The Netherlands
Website	http://www.liander.nl/liander/

Project Name	Micro Wobbe meter
Introduction / scope	the first step towards an on-chip energy content measurement system
Benefits / purpose	The introduction of biogas in national gas grids is hindered by the absence of a cheap, reliable and miniature device for the energy content measurement of fuel gases. The integrated micro Wobbe index meter will provide a point-of-use solution for this and other applications, e.g. burner control, where constant gas quality is required.
Roll-out / planning	PhD program: First measurement have indicated the feasibility of the concept
Budget / Cost and challenges / State of development	Ongoing development
Company + logo	Bronkhorst High-Tech BV, MESA+ Institute for Nanotechnology, University of Twente, Hobré Instruments BV
Country(ies)	The Netherlands
Website	http://doc.utwente.nl/83633/

Project Name	Dynamic Pressure Control
Introduction / scope	A network with 5 regulation stations feeding 3000 customers is provided with electronic pressure controls. The network pressure will be adjusted real time in accordance with the demand.
Benefits / purpose	Two objectives: 1. create short term storage 2. reduce gas leakages
Roll-out / planning	Pilot to be finished end 2014
Budget / Cost and challenges / State of development	Cost of the pilot approximately € 250.000 All components like electronic regulator, RTU, GPRS communication are available. The challenge lies in system integration and validation.
Company + logo	Liander
Country(ies)	The Netherlands
Website	http://www.liander.nl/liander/index.htm

Project Name	Study of bi directional city gate
Introduction / scope	If a lot of bio methane is produced over a long period storing the gas in the network will not be sufficient. The local surplus can be transported to areas with sufficient gas demand through the transmission network. Unlike electricity, gas does not flow just from the regional to the national grid. This requires a compressor station. The traditional one-way street of a gas city gate must change into a bi-directional gate. Enexis, jointly with the national network operator Gasunie Transport Services works out a pilot to shape both the technical aspects and the associated regulations.
Benefits / purpose	Enables more bio methane to enter the distribution network.
Roll-out / planning	2014/2015
Budget / Cost and challenges / State of development	Required budgets are part of the study. Challenges lies in grid operation, ownership and business case.
Company + logo	ENEXIS, gasunie transport services
Country(ies)	The Netherlands
Website	http://www.enexisinnovatie.nl/ http://www.gasunietransportservices.nl/

Project Name	Pirate robot
Introduction / scope	This project is devoted to design an energy efficient robot system, capable of autonomous navigation in low-pressure gas distribution network. Furthermore this projects aims to develop innovative network sensor systems and sensing methodologies which can be integrated in the robotic device for data acquisition on the gas distribution network. This system could eventually replace the current practice of leak survey and improve the assessment of the quality of the mains, being able to investigate the mains very closely from inside.
Benefits / purpose	Improved safety and reliability of the network
Roll-out / planning	The project started in 2006. The first prototype was developed in 2008. A second prototype is now being tested in a test-track consisting of a wide range of materials and a selection of bends and joints. A field test is in preparation
Budget / Cost and challenges / State of development	Ongoing development
Company + logo	UNIVERSITEIT TWENTE. kiwa Partner for progress
Country(ies)	The Netherlands
Website	http://www.ce.utwente.nl/e13/pirate/index.php

Project Name	Use of radar satellite to observe ground settlement
Introduction / scope	The topic of this project is the observation and analysis of satellite radar data, in order to estimate surface motion, particularly close to buildings in the urban environment. This is of importance due to the risk of differential motion between buildings/infrastructure and the Surrounding grounds, related to potentially induced strain on gas pipes. Such differential motion may lead to hazardous (explosive) situations if the gas pipes are overstressed and break.
Benefits / purpose	Improve safety
Roll-out / planning	PHD-program to be finished mid-2014.
Budget / Cost and challenges / State of development	Now available to be incorporated with GIS systems
Company + logo	TU Delft Delft University of Technology; Hansje Brinker Infrastructure Monitoring
Country(ies)	The Netherlands
Website	http://www.citg.tudelft.nl/en/about-faculty/departments/geoscience-and-remote-sensing/ http://hansjebrinker.com/en/

Project Name	**Cooperation of DSOs and TSOs to optimize the usage of linepack**
Introduction / scope	Since the 2008 cooperation agreement gas (KoV III) between all German DSO and TSO line pack is used as internal balancing energy between the grid operators and for the capacity management. Line pack exists in many of the 700 DSO grids in Germany. The volumes differ considerably depending on the length of the grid, the diameter of the pipes and the pressure levels. Distribution grids may go up to 84 bar. The DSO can reduce his capacity booking to the TSO through the usage of linepack therefore lowering the needed capacity at TSO level. In certain areas in Germany e.g. Baden-Württemberg, Upper Bavaria or Swabia this is crucial as TSO capacity is scarce. Line pack is crucial for congestion management as has been seen in Feb 2012.
Benefits / purpose	• Optimal use of existing local line pack • Congestion management between TSO and DSO • Lesser interruptions for industrial customers in case of congestion in the grid
Roll-out / planning	No specific roll-out. The rules of the Cooperation Aggreement 3 started 1.10.2008 and are still in use. The rules are updated regularly, the new cooperation agreement 7 will be published end of join and come into force 1.10.2014
Budget / Cost and challenges / State of development	rules and processes are established
Company + logo	all TSOs, DSOs and the two market area operators have to sign the cooperation agreement (KOV) in Germany. It is a binding contract.
Country(ies)	Germany
Website	http://www.bdew.de/internet.nsf/id/DE_Kooperationsvereinbaru-Gas

Diagram reference n°9

Project Name	DEVO, Sustainable energy Veenendaal-Oost
Introduction / scope	Energy hub consisting of combination of heat pump, CHP, boiler and buffer supply heat and cold to customers.
Benefits / purpose	Lower costs for the customers and a CO_2 reduction of 60%
Roll-out / planning	Energy hub in operation since 2011.
Budget / Cost and challenges / State of development	Tariff reduction for the customers 15% compared with gas heating. About 400 of in total 1250 houses are connected
Company + logo	DEVO
Country(ies)	The Netherlands
Website	http://www.devo-veenendaal.nl/energiesysteem/hoe-werkt-het/#

Project Name	Smart Power City Apeldoorn
Introduction / scope	Up until now only small scale tests with micro CHPs have been undertaken. A large scalefield test has not been carried out. In Apeldoorn, the Netherlands, a large field test with 172 micro CHPs is finished. A micro CHP is a new energy system that combines the function of a boiler with the production of electricity.
Benefits / purpose	Field test of 72 micro CHPs and extensive measurements on 8 installations. Results after 16 month recording: • Energy saving 3% • Cost saving 11% • CO_2 reduction 7% • No negative effect on LV system
Roll-out / planning	Field test have been completed.
Budget / Cost and challenges / State of development	
Company + logo	Smart Power City Apeldoorn is an initiative of Liander, GasTerra, province of Gelderland, Nuon, boiler manufacturer Remeha, city of Apeldoorn and housing associations de Woonmensen and Ons Huis.
Country(ies)	The Netherlands
Website	http://www.liander.nl/liander/overheid/smart_power_city_apeldoorn.htm

Project Name	PowerMatching City
Introduction / scope	PowerMatching City is an internationally recognized lighthouse project that demonstrates our future energy system in an existing neighborhood in Groningen, the Netherlands, using both the natural gas and electricity infrastructure. By engaging and empowering the forty participants in becoming active energy prosumers, this project is a typical example of what democratizing the energy market looks like in real life. Using a state-of-the art smart energy system, they can control where and when they want to use or produce energy. Central and local energy systems are equally important in this smart city. Multiple stakeholders, including energy suppliers, network operators and consumers, cooperate to actively balance the demand for and supply of energy in the grid. Together they have created a sustainable, reliable and future-proof energy system.
Benefits / purpose	The goal of PowerMatching city is to demonstrate the energy system of the future with related smart energy services, as well as the validation of costs and benefits of this system in practice in order to enable the energy transition.
Roll-out / planning	PowerMatching City started in 2007 as part of the EU research programme, FP6 INTEGRAL. The first households were connected to this smart grid in 2009. Phase I ended in the first half of 2011. The second phase started in September 2011 as part of the Dutch smart grid pilot projects programme, IPIN, and will last three years. The extension to 40 households started in June 2013.
Budget / Cost and challenges / State of development	Budget (phase 1+2): approx. 10M€ / Pilot project
Company + logo	Enexis, RWE/Essent, Gasunie, ICT Automatisering, TNO and DNV GL
Country(ies)	The Netherlands
Website	www.powermatchingcity.nl

Diagram reference n°10

Project Name	GRHYD
Introduction / scope	Power-to-gas is a system solution designed to store large quantities of electricity produced from renewable sources on a long-term basis and subsequently make it available wherever it is needed without being connected to high-voltage power lines.
Benefits / purpose	The project aims at studying the impact of hydrogen on the existing gas infrastructure, equipments and acceptability of the consumers. Hydrogen is to be injected in the form of HENG - hydrogen enriched natural gas - with a 2 to 20% H2 content.
Roll-out / planning	Quick off on 1.1.2014. 5-year project
Budget / Cost and challenges / State of development	16MEUR
Company + logo	GrDF + 11 companies
Country(ies)	France
Website	N/A

Project Name	**Power to Gas plant of the Thüga group**
Introduction / scope	Production of hydrogen with a PEM (Polymer Electrolyse Membrane) – Electrolyseur. Nominal electrical load 315 kW, hydrogen output 60 m³N/h. Mixture of hydrogen with natural gas, injection of 3000 m³/h mixed gas into the local gas grid. Pressure 3,5 bar. Percentage of hydrogen in the mix is less than 2 %.
Benefits / purpose	• Long term operational test of PEM under dynamic and flexible conditions • Energy efficiency calculations at various loads • Participation of plant in the 3 balancing markets and possibly in a gas/electricity flexibility market for Demand Side manegement
Roll-out / planning	First test injection started in Nov 2013. Regular operation started in May 2014. The project is planned for 3 years.
Budget / Cost and challenges / State of development	1,5 Mio. €.
Company + logo	13 partners of the Thüga Group jointly developed, built and operate a power to gas demonstration plant in Frankfurt/Main
Country(ies)	Germany
Website	http://www.energie-und-wende.de/energie-wende/energie-speicher/power-to-gas-anlage.html http://www.powertogas.info/power-to-gas/interaktive-projektkarte/demonstrationsanlage-der-thuega-gruppe.html

Project Name	Smart Country Bitburg-Prüm in Rheinland-Pfalz, Germany
Introduction / scope	Interlinking between Biogas, Wind energy and photovoltaic energy to supply 125 km medium-high-voltage system and 100 local distribution stations
Benefits / purpose	Biogas will be used for CHP if wind and photvoltaic energy is not available.
Roll-out / planning	2012
Budget / Cost and challenges / State of development	In progress.
Company + logo	Gefördert durch: Bundesministerium für Wirtschaft und Technologie aufgrund eines Beschlusses des Deutschen Bundestages ABB CONSENTEC technische universität dortmund RWE
Country(ies)	Germany
Website	https://www.rwe.com/web/cms/de/683556/smart-country/

Project Name	P2G (Power-to-Gas) Ibbenbüren
Introduction / scope	Installation of an innovative 100 kW PEM-Elektrolyser (production of hydrogen for injection at 13 bar in a high pressure natural gas grid)
Benefits / purpose	Buildup of knowhow concerning the operational performance of an electrolyser in the context of regenerative energy production (analysis of possible load variations, intermitting operation, possible overload, development of efficiencies over lifetime etc.) Demonstration of the complete energy chain (electricity from renewable resources to hydrogen and back to "green electricity" using CHPs linked to the RWE gas-grid and a RWE-district heating grid
Roll-out / planning	2013-2016
Budget / Cost and challenges / State of development	Under construction / first performance tests finalized
Company + logo	RWE Deutschland AG VORWEG GEHEN
Country(ies)	Germany
Website	http://www.rwe.com/web/cms/de/2258232/rwe-deutschland-ag/energiewende/intelligente-netze/smart-stations/power-to-gas/

Diagram reference n°11

Project Name	P2G (Power-to-Gas) Rozenburg
Introduction / scope	Demonstrating small scale P2G (via hydrogen to methane, pipeline quality)
Benefits / purpose	Expanding already existing hydrogen experience, finding out more about gas quality issues from Sabatier process, tackling balancing issues electricity grid, in next phase hydrogen generation using plasma physics and reuse of carbon dioxide.
Roll-out / planning	2014-2018
Budget / Cost and challenges / State of development	1M
Company + logo	Stedin
Country(ies)	The Netherlands
Website	http://www.stedin.net/Informatie_voor/Pers/Persberichten/Pages/Praktijkproef_elektriciteit_wordt_aardgas_in_Rozenburg.aspx

Diagram reference n°12

Project Name	Energy in the Picture (Energie in Beeld)
Introduction / scope	Energy in the Picture is an application that gives a visual representation of the energy consumption in a municipality or neighbourhood. In a map you can see exactly which areas uses a lot of energy and what areas are energy efficient. Due to privacy, we show no data at the individual level, but only by zip code and neighbourhood level.
Benefits / purpose	To help municipalities and neighbourhoods with their climate and sustainability goals and targets by giving insight in energy consumption.
Roll-out / planning	live
Budget / Cost and challenges / State of development	The service is provided to municipalities free of charge.
Company + logo	Liander, Enexis and Stedin
Country(ies)	The Netherlands
Website	http://www.energieinbeeld.nl/