Approach for the implementation of AMR system for gas meters in France – GrDF AMR Project

Isabelle DROCHON: GrDF, Project Manager, Automated Gas Meter Reading Project
Pascal VERCAMER: GDF SUEZ, Research and Innovation Division, Research Program Manager for distribution and gas networks – member of Working Operating Committee 4 of IGU triennium 2010-2012

Executive Summary

This paper deals with the preliminary studies and experimental roll out of Automatic Meter Reading (AMR) for gas consumption which is being studied and performed by GrDF in France since 2008, involving all the stakeholders concerned by gas metering for end users.

It presents insights on the French gas market and presents Gaz Réseau Distribution France (GrDF), the main French DSO. GrDF worked closely with the French Authorities and the stakeholders to set up technical experiments and customer tests to define the main functionalities of the future French gas smart metering system.

The paper then sums up the main results and feedback on the Experimental Phase, and explains what are the next steps for GrDF and the AMR Project now the Construction Phase has been approved by the French Energy Regulator and supported by the Authorities and the stakeholders.

It examines also the possible applications regarding the operation of networks, new services in relation with the development of such a system, and how GrDF strives to contribute to help customers make energy savings and improve networks' efficiency.

Table of contents

Executive Summary 1

1. Background: Current position of gas metering for French consumers 3

France's gas distribution market 3

GrDF, an expert in natural gas distribution...3

GrDF, a reference in gas Smart Metering since 2004 4

2. The definition of functionalities of a future AMR system 8

The starting point : working closely with the Authorities and the stakeholders.....................8

The definition of the main functionalities of the future AMR system....................................9

Main functionalities of the future AMR system...10

Abandoned functionalities for the future AMR system 10

3. The experimentation of the roll out of AMR in four French towns and their feedback on technical, operational and organisational aspects...................................12

Features of technical experiments 12

Description of customer tests...13

Information obtained and technical recommendations on the target solution 15

Information obtained on the design of the experiments..15

Information obtained on the deployment of the experiments 17

Information following the network optimisation phase 19

Lessons derived from the operation of the experiments 20

Accompaniment of end customers...22

Accompaniment of stakeholders...23

Main information on customer services..24

4. The planning of future operations..26

Recommendations from the French Energy Regulator...26

Objectives and planning of the AMR Project 26

Challenges of the AMR Project 27

5. Future developments around automatic metering of gas consumptions 29

New services for the end consumer? 29

Optimisation of gas network operations 29

Automatic meter reading in the town of tomorrow 30

Questions for the future 31

6. Conclusions...33

1. Background: Current position of gas metering for French consumers

France's gas distribution market

France comprises about 11,300,000 gas consumers. There are 27 active energy suppliers and more than 95% of consumers are supplied through the network operated by the main Distribution System Operator (DSO) GrDF, Gas distribution affiliate. According to French law, Gas DSOs are in charge of

- Delivering natural gas on behalf of suppliers without discrimination and in full independence,
- meter reading on behalf of the suppliers,
- design, build, operate, and maintain the natural gas distribution network by ensuring the safety of goods and people, and the quality of service,
- connect new customers and develop the natural gas network in a sustainable and profitable way to allow access to natural gas to the greater number of people,
- ensure management of public service gas distribution through concession contracts.

Gas distribution is ruled by the French Gas Regulator implemented by the national law of 2004. The regulator proposes tariffs, examines the investment plans of network operators and is now a major player for defining rules to be applied in gas markets.

GrDF, an expert in natural gas distribution

Gaz Réseau Distribution France, known as GrDF, is the principal distributor of natural gas in France. It is a fully owned subsidiary of the Group GDF SUEZ, the number one independent power producer in the world.
GrDF was created in 2007 following the full deregulation of the energy market in France. The company develops the natural gas network with a twofold objective as it targets both economic performance and equal access to natural gas. In all its roles and at the heart of its industrial activities, GrDF focuses on the safety of people and property. An active player in sustainable development and public service, the Company is committed to its customers and its employees in a responsible approach that promotes dialogue and discussion.

GrDF enables all its suppliers to access the network freely and on a non-discriminatory basis. A Code of Good Conduct that applies to all company employees defines best practices and describes the measures taken in this regard. The distributor's impartiality also reflects its independence, which is guaranteed by private sector decision-making bodies.
GrDF ambition is to distribute natural gas to 11 million customers, while ensuring everyone's safety. The company invests 1 million euros per day in safety.
To develop its network, pursue its policy of innovation, and assure its consumers of the best quality of service, GrDF relies on the expertise of 12,000 employees. To develop its employees' skills, GrDF invests 5.4% of its total payroll in training programs. The company also strives to procure the expertise it will need in the future by implementing an ambitious recruitment policy that respects its values of diversity and equal opportunity.

GrDF is a recognized expert in energy efficiency and makes its know-how available to local players. Whether it is a question of using the latest technologies, combining natural gas and renewable energy, or finding the best way to boost energy efficiency, GrDF consultants propose the most efficient and environmentally-friendly energy solutions. To meet the new energy challenges, the teams work with the full gamut of local partners to develop low-energy buildings and create ecological neighbourhoods. GrDF's commitment is also local, in particular with ecological work sites that involve the use of noninvasive techniques like the vacuum digging.

Performance is at the heart of GrDF's corporate project, which encourages entrepreneurship as the road to success. To meet the expectations of users of natural gas and ensure impeccable quality in customer service, GrDF multiplies initiatives. It has introduced a new version of the gas access Information System (IS) tool know as SIAG to better inform customers on access to natural gas. It has modernized the metering system to improve the quality of service when meters are read or consumption is imported via the Internet (www.grdf.fr). Already, 25,000 Parisians have used their computers and telephones to enter their meter read-outs. In a simple and transparent operation, this tool allows customers to convert the volume of gas on their meter and the consumption indicated on the supplier's bill.
To meet the challenges of the Grenelle Environmental Round and satisfy the new thermal insulation regulations, natural gas has a prime role to play. In this area, GrDF take an active part in designing the energy solutions of tomorrow, by supporting the players in the energy industry. The objective is to develop sustainable and innovative technologies to boost the energy performance of buildings. GrDF engineers make their expertise available to help manufacturers develop the ecogenerator. This technological advance produces up to 80% of dwelling's electricity. GrDF also provides consulting and advisory services. In particular, it supports local government initiatives in the development of the bio-gas segment. In the future, this renewable energy will be carried in the natural gas network.

GrDF, a reference in gas Smart Metering since 2004

Customers and suppliers have been expressing a need for an improved billing for several years : no more estimated billing, more frequent read-outs, easier changes to contract when moving in or out, and new services around energy savings. French laws and European Directives start giving more and more importance to those requests and encourage distributors to roll-out smart metering system. In particular, the law n°2010-1022 of the 31st of August 2010 makes electric smart meter mandatory in France. Regarding the gas market, the Energy Regulator is the main actor defining the rules for gas smart metering at the moment.

In this context, GrDF aims at becoming a reference in gas smart metering. Automatic Metering for gas consumptions has been implemented by GrDF from 2004 to 2006 for the 4,000 major industrial customers consuming more than 5,000,000 Kilo-Watts hour per year (KWh/year). Those customers represent approximately 20% of the gas delivered, and they benefit from daily read-out of their gas meter.

In 2010, GrDF started the T3MM Project aiming at deploying smart gas meters to its 100,000 Industrial and Commercial customers consuming more than 300,000 KWh/year (about 27,000 cubic meters per year). Those customers represent approximately 30% of the gas delivered and they will benefit from a monthly read-out of their meter.
The technology adopted involves the installation of remote metering equipment on the meter's low-frequency outlet, directly connected via GSM/GPRS to the T3MM national host Information System.
Following experiments in 2007-2008, which particularly served to validate the technical solution and define the deployment process, GrDF's teams took a census of company meters. In 2009, a tender for general deployment was launched: TECHNOLOG won the contract for the supply of the T3MM Information System, the supply and installation of the equipment and the maintenance of the system. The equipment installed comprises Cello smart meters made by TECHNOLOG and Colibri smart meters produced by SIS. The ten-year contract notably provides for the following:

- the supply and the installation of the equipment, which carries a ten-year warranty;
- maintenance;
- the development and assurance of operational conditions for the host IS;
- the availability of the data read.

Over the period 2009-2011, GrDF teams worked to standardize meters that couldn't be equipped (to make them compatible with remote meter-reading systems that will be installed). General deployment throughout France was organized in two stages: from mid-2010 to mid-2011, and then from mid-2011 to mid-2012. The project is expected to end in June 2012, as initially planned.

Next page :
Figure 1 - Picture of a TECHNOLOG GPRS Module
Figure 2 - Picture of a SIS GPRS Module


Cello


SIS

The main results are :

- 85,000 meters read monthly have been equipped at the end of 2011, within the framework of the general roll-out since March 2010.
- Since September 2010, the pace of installation was up to 4,000 installations/month.
- The rate of success of the production of read-outs is over 99% for customers whose meters are read on a monthly basis and also for customers with daily read-outs.

Beyond these big customers, GrDF is conducting a new project to examine the technical and economical feasibility of the implementation of an AMR system for all consumers, including domestic ones, whose gas meter reading are still made by operators at a 6-months frequency, jointly with electricity meter. In 2007, gas DSOs started to examined various technological options to implement remote automatic reading on gas meters.

This project, called the AMR project, started after the French Authorities asked GrDF to define the specifications of an AMR system for gas metering that could be deployed to 11 millions of French residential consumers in its deliberation of the 3rd of September 2009.

Following this request, between February 2010 and June 2011 GrDF tested 4 different AMR system for gas meters with 4 different manufacturers to assess existing AMR technologies for gas meters and define the most suitable one for a potential mass roll-out.

2. The definition of functionalities of a future AMR system

The starting point : working closely with the Authorities and the stakeholders

In 2007 the French Gas Distributor (*Gaz reseau Distribution France* - GrDF) began initial studies on the advisability of developing smart metering for the mass market, under the supervision of the French Energy Regulator (*Commission de régulation de l'énergie* – CRE) and French Authorities, and with the help of all the stakeholders impacted by smart metering (energy suppliers, meter manufacturers, consumer associations...)

Following a request by the CRE, in the first half year of 2008 the subject of advanced metering systems was discussed in working groups in order to specify:

- The appropriate features to be integrated in a future metering system
- The architectures that would meet the requirements. To this end a consulting cabinet was asked to conduct the initial technical/economic survey.

At the stakeholders' request, in late 2008 a survey was launched on the possible synergies between the advanced gas and electricity metering systems. The objectives were to determine to what extent it would be possible to pool infrastructures and resources in the deployment phase. The results of the survey were presented to the CRE working group in 2009. Following the analysis of existing solutions on the French energy market, the gas advanced gas metering system has to be based on a fixed radio network and its deployment could not be pooled with that of an advanced electricity metering system. This choice is justified by required services regarding gas smart metering, costs, and reliability of the technologies.

In June 2009 the CRE launched a public consultation on advanced gas metering systems for the retail market, and work continued to define precisely, with all the stakeholders, expected functionalities of the future gas smart meters.

On 3 September 2009 in its discussions on the directions relative to the advanced metering systems for the retail market of natural gas the CRE decided to:

- ask GrDF to organise an experimentation phase to approve certain technical, functional and economic aspects of the advanced metering systems,
- launch a second technical/economic survey on an infrastructure based on a wireless reading via a fixed network. The initial 2008 technical/economic survey would have to be completed and updated and the effects analysed of the deployment of such a system on the gas network as a whole, particularly the expected advantages in terms of energy savings.

On 21 July 2011 following the experiments and the publication of the technical/economic survey and a further public consultation, the CRE voted in favour of launching the construction of the Automatic Meter Reading (AMR) project.

The definition of the main functionalities of the future AMR system

The main three objectives of the project are:

- Firstly, improve customer satisfaction by billing on their real consumption, and not any more on an estimated consumption. Also, customers won't have to set a meeting with the operator so he reads the meter.
- Secondly, European and French directives make it progressively mandatory to master energy consumption. We consider smart meters will offer our customers the necessary information to reach these objectives.
- Thirdly, we are positive these projects will help us modernize the gas network and improve GrDF global efficiency.

The economic balances are known to be complex, particularly for gas. GrDF therefore decided to determine consumers' actual needs by working with the stakeholders to define jointly the expected requirements:

- The Authorities led the joint work between 2007 and 2009 which resulted in the choice of a fixed one-way radio network
- We decided to keep the current mechanical diaphragm meter technology, which is inexpensive to purchase and which has a 20-year service life,
- We conducted technical experiments, details of which are given in chapter 3,
- We conducted surveys with the equipment manufacturers and our Research Department (battery service life, data security)
- We worked with the stakeholders and a panel of customers to determine consumer requirements, which are presented in chapter 3,
- The CRE conducted a two-phase Cost Benefit Analysis resulting in a financial balance of the project with an energy saving of only 0.25%.

On completion of the work we established a pyramid of the following features:

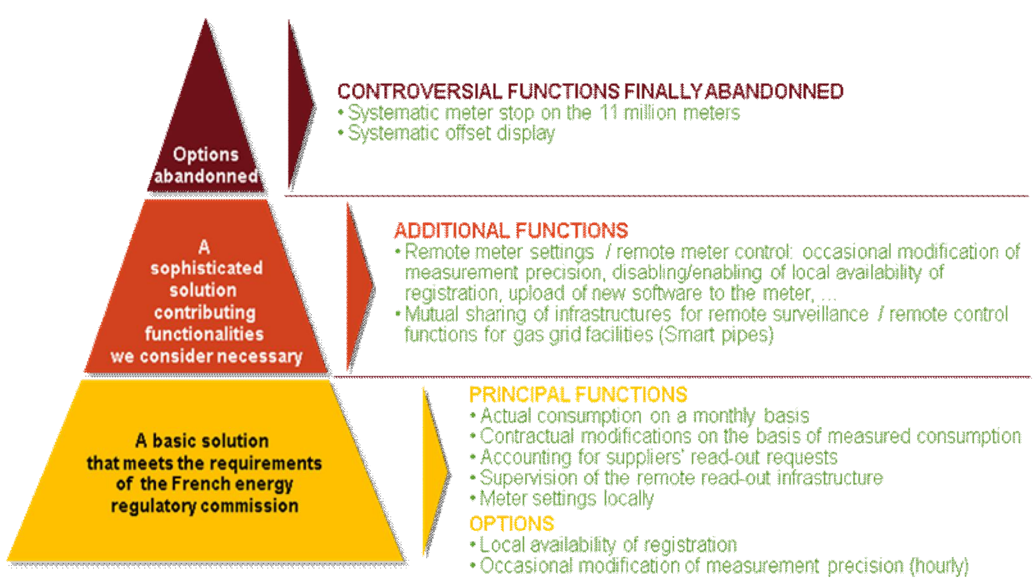

Figure 3 - Synthesis of AMR Functionalities

Main functionalities of the future AMR system

In particular, all the solutions we have experimented with fulfil the fundamental functions of AMR in line with the CRE's 3 September 2009 recommendations:

- Provision of monthly consumption: the solutions we experimented with were configured to collect readings more frequently – from 1 to 24 readings per day transmitted on a daily basis – in order to at least meet this fundamental functionality as well as other more advanced functionalities;
- Modification of contracts on the basis of readings taken. Our experiments revealed two possible ways of implementing this functionality:
    - Interrogation from the Information System (IS) of the module associated with the meter. In this situation two-way end-to-end communication infrastructure is required. The response is usually postponed for up to 24 hours in order to save on battery consumption.
    - Daily data is sent periodically (from 1 to 4 times a day) to the IS. A database provides the reading measured on the date the contract was changed. This implementation needs no two-way infrastructure and makes it possible to meet all reading demands even though it may imply transmission of a potentially greater volume of data depending on the level of service required.

Abandoned functionalities for the future AMR system

GrDF ruled out the possibility of always deploying a shut-off valve in this project for three main reasons:

- Increased safety risk: the reliability of the shut-off valve cannot be guaranteed for 20 years. Furthermore, current safety regulations defined in the 2 August 1977 Government Order impose conditions for the restoration of gas supplies. Remote restoration of supply is therefore not practised given the risks due to the lack of on-site physical inspection. The degree of sophistication of gas metering system is therefore limited by their nature.
- Slight gain in quality of service since the restoration of the gas supply, and therefore the opening of the electronic valve, would have to be effected by human intervention. None of the stakeholders involved want this functionality and the consumer groups are particularly opposed to it.
- Significant additional costs: approximately 300 million Euros (M€) for equipment and impact on battery stand-alone time as well as several hundred million Euros over 20 years for periodic maintenance checks.

Systematically providing a remote display would resul*t* in additional costs of several hundred millions of Euros for the equipment alone as well as presenting technical difficulties, particularly for the 80% of meters located outside consumers' homes on staircases and in cabinets on the periphery of their properties, as well as significant maintenance charges. A multi-fluid data display solution (available on the internet and based on TV or smart phone applications) is therefore preferable to a specific remote display for gas managed at the base by the Distributor. Finally, the use of such equipment over time by consumers, and therefore the justification of the additional cost of such a service, remains to be demonstrated.

It is therefore preferable at the present time to provide only a local output on the meter (Customer Information System – CIS connector) enabling customers to connect the device of their choice (display, PLC, etc.).

3. The experimentation of the roll out of AMR in four French towns and their feedback on technical, operational and organisational aspects

The objectives of the experiments were to derive analyses and feedback on experience for each of the solutions tested so as to define, from best practice, the solution that GrDF proposes to implement for roll-out, if it is so decided, to meet all the internal and external requirements. Consequently the experiments did not test all the technical possibilities of each solution but focused on the main characteristics identified in the context of the CRE (the French energy regulator) consultation groups as having to constitute the basis of the functionalities of the advanced gas metering system in France.

In parallel, various tests on the customer services were carried out with customers who had accepted communicating meters, in order to identify the level of functionalities necessary for the system to be set up and to measure the satisfaction of the customers and the potential gains in terms of energy savings.

Features of technical experiments

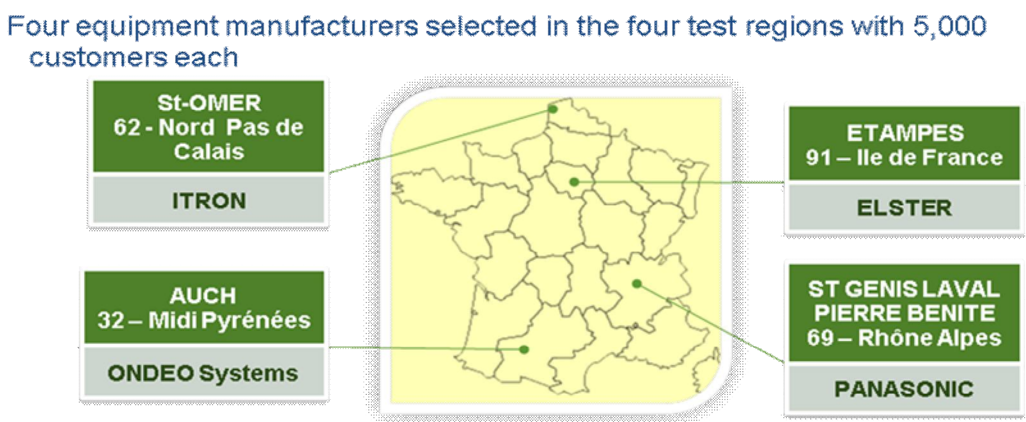

Figure 4 - 4 technical experiments in France

On each of the four pilot sites, a solution was tested by a separate equipment manufacturer.

Each of the four solutions tested consists of a communicating chain, with various levels, and a data acquisition information system. For each solution, the transmission of information takes place by means of a fixed radio infrastructure from the module associated with a meter as far as the data acquisition information system. The main differences are with regard to the architecture of the communicating chain (two or three levels), the character of the solution, bidirectional or not, and the radio-frequency band used for transmitting the data at the LAN.

In Saint Omer, Itron deployed a bidirectional system (on two frequencies 433/868 MHz with collectors/repeaters) for 4,415 customers. This system, called EverBlu, is a system designed for the daily automatic reading of hourly metering data. The communication chain consists of 3 levels, including 2 data concentration levels (2 & 3):

- Radio modules connected to the gas meters;
- Data collectors;
- Access points.

In Etampes, Elster set up a bidirectional system (868 MHz with repeaters) at 4,048 customers. This system is designed for automatic reading of the metering information on demand and functions on 3 levels:

- Radio modules connected to the gas meters (Waveflow);
- Repeaters (Wavetalk);
- Concentrators (Wavegate).

In Auch, Ondeo Systems deployed a single-directional remote-reading system (169 MHz) for 5,385 customers. The communicating chain consists of two levels:

- Radio transmitters installed on the meters;
- Concentrators (receivers).

In Saint Genis Laval and Pierre Bénite, Panasonic established a bidirectional system (at 433 MHz with repeaters) for 4,608 customers. This system is designed for automatic reading of the metering information on demand and consists of 3 levels with 2 data concentration levels (levels 2 and 3):

- Radio modules connected to the gas meters;
- Relays (or repeaters);
- Concentrators.

Description of customer tests

A panel of close on 400 customers over 8 months, who have signed an agreement with GrDF, was established, with the role of:

- Participating in the detailed consumption monitoring tests;
- Supplying the actual reading on their meter and checking consistency of it with the reading sent back via the communicating chain;
- Replying to four qualitative questionnaires over the duration of the experimentation phase in order to evaluate their satisfaction and feedback on their consumption habits regarding the services proposed.

Upstream of the definition of the customer tests, reflection on the objectives sought by the consumers and work on mapping the stakeholders made it possible to identify the types of services that can be envisaged for meeting customer expectations.

Two main objectives were identified:

- Reliability of invoicing;

- Control of consumption (energy saving) at the end customers and in the context of implementation of energy policies.

Six tests were carried out, in order to validate the expectations of the customers with regard to these services:

- **Detailed monitoring of consumption**: Monthly sending of consumption curves to the consuming customers on the panel;

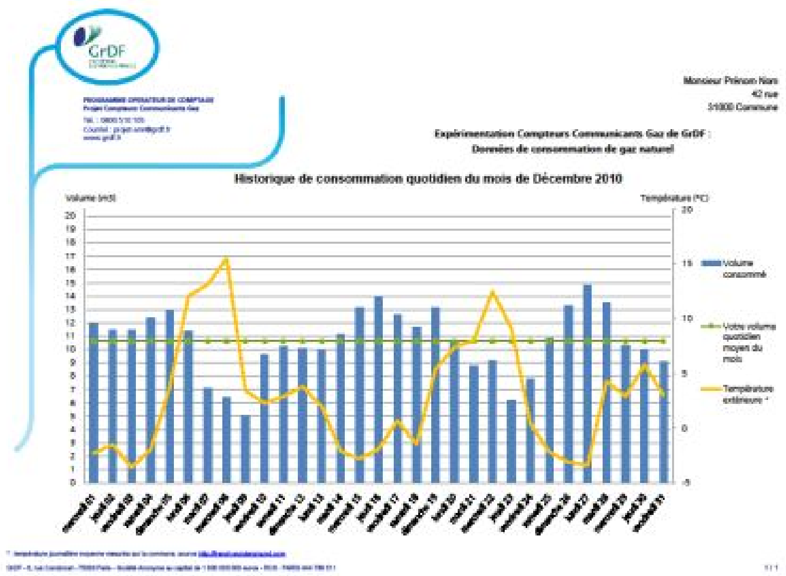

Figure 5 - Example of consumption data sent to customers

- **Threshold consumption alert**: Alert to consumer customers on the panel when a previously defined consumption threshold is reached;
- **Remote display**: Making available to consumers on the panel an In Home Display enabling them to monitor their consumption in real time as well as to consult histories;
- **Consumption analysis**: Making available to consumers on the panel a “simple” internet site for analysing the consumption and sending a monthly letter;
- **Supplier box**: Making available to consumers on the panel a measuring device and an advanced internet site for analysing consumption;
- **Customer round tables**: In addition to the tests carried out, direct interrogation of the gas consumers in order to collect their perception on various themes (consumption monitoring services in general terms, alert service).

It was not possible to evaluate the services using the invoicing mechanisms because of the nature of the experiments.

The experiments took place from February 2010 to June 2011. Many aspects were analyzed:

- technical performance of the system (quality of communication, batteries…)
- conditions of preparation and installation of gas meters
- number, position and installation of concentrators and repeaters

- maintenance
- relationship with the different stakeholders and with the consumers

The next chapter will go through the main results of these different analysis.

Information obtained and technical recommendations on the target solution

On the basis of these experiments and the work carried out in parallel, GrDF developed convictions on the target system to be used:

- Convictions established on a two-level system, without repeaters;
- Convictions established on the need for an integrated meter and a separate radio module, according to the type of the meter;
- Strong convictions on the need for partly bidirectional communication, so that the functionalities can be developed over time, between the concentrator and the acquisition information system on the one hand and between the concentrator and the meter on the other hand;
- Strong convictions on the ability to use self-contained equipment using primary cells having a durability of 20 years for the functionalities proposed (by means of studies carried out by the project team with cell manufacturers and equipment manufacturers in addition to the experiments);
- An essential need for the information systems to be scalable (progressive rise in power of the infrastructure related to the accommodation thereof) in order to deal with a high volume of data and connections.

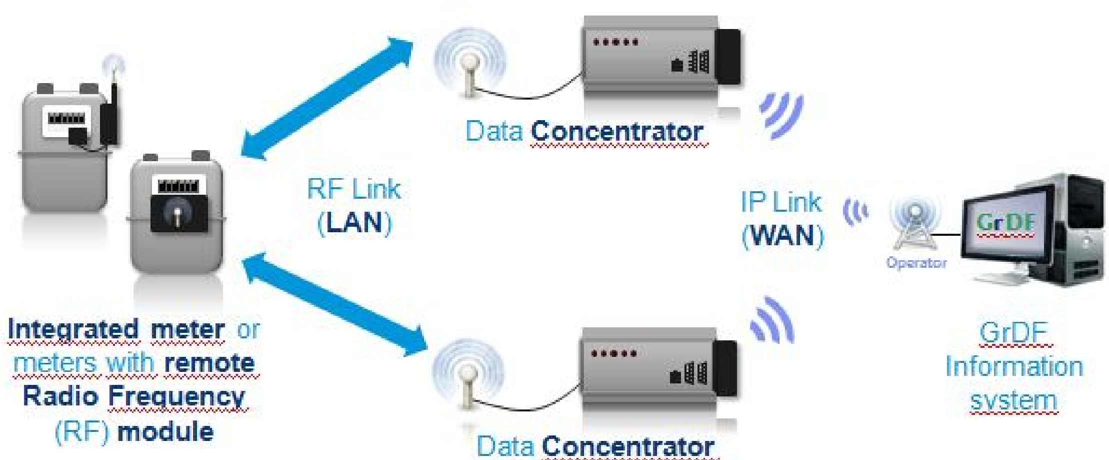

Figure 6 - Overview of the future GrDF AMR System

Information obtained on the design of the experiments

On each of the four experiments, the organisation of the deployment was entrusted entirely to each of the equipment manufacturers adopted, with the support of GrDF concerning external contacts (with local authorities and customers in particular).

Four steps were identified for designing the architecture of the solution to be deployed over a given area:

- Information on local authorities chosen and seeking their cooperation:
- The preparation of customer files concerned: files produced for each of the users identified (equipment manufacturers, installers and other participants) on the basis of downloads from the GrDF databases;
- Carrying out topological studies, with three substeps: conversion of the customer addresses into geographical coordinates, integration of these geographical coordinates in a mapping tool and identification of the strategic points most suitable for installing the concentrators;
- Requests for installation authorisation and accommodation of equipment.

The work carried out in this field revealed the following points for attention:

- Information on the granting authorities and local authorities upstream of the deployment project is a facilitating element, in particular for seeking elevated locations and accommodation of the concentrators. There may also be a relay of information vis-à-vis the customers to whom the deployment relates.

- The files available within GrDF prove to be insufficiently precise for their use during deployment, in particular on mail details of customers (if the correspondence address is different from the consumption site) and detailed characteristics of the meters installed at the customers (make of meters). For preparing customer files for the roll-out phase, it will be necessary to improve existing data reliability. Recourse to the information already available in the supplier files (corresponding addresses, telephone numbers, etc) may be requested, subject to the agreement of the suppliers and in compliance with customer data confidentiality.

- Topological studies in the context of the experiments were carried empirically and, in the case of systems with repeaters, required numerous measurements on site, or even replacement of repeaters in the optimisation phase and a heavy workload. When the target system is rolled out, theoretical studies will have to be carried out using productionised analysis tools. Supplementary local studies will be necessary to adapt these general studies to the realities of the buildings and elevated locations available.

- The experiments show the difficulty of obtaining, in little time, formalised authorisations for accommodating concentrators and repeaters. The support of local authorities was decisive but may not be sufficient. The procedure for identifying elevated locations and obtaining accommodation agreements must be widely anticipated with respect to the employment of the meters. For roll-out, the support of local authorities will be fundamental, and it must be envisaged sharing accommodation sites with other already existing networks, and the conditions for agreements (standard agreements, etc) must be standardised in order to simplify procedures and reduce lead times.

Information obtained on the deployment of the experiments

In order to evaluate the efficiency of operating methods set up by each equipment manufacturer, all the operations necessary to the deployment of the communicating modules were monitored.

- The pre-deployment work;
- Installation of meters/communicating modules;
- Installation of repeaters;
- Installation of concentrators.

<u>Pre-deployment work</u>

In each of the experimentation areas, the pre-deployment work of the experiments was centred on eight dimensions:

- Qualification of files and preparation of access ways;
- The installation procedures to be complied with;
- Training of participants (installation companies and GrDF personnel);
- Work authorisations, safety plan;
- Methods of monitoring installation/operating tools;
- Installers' equipment (tools and equipment, customer documents, tools and information systems relating to reports);
- Organisation of purchasing, logistics and procurement;
- External Communication (local authorities, customers).

In general terms, all the preparatory work was left to the initiative of the equipment manufacturers, who relied on GrDF existing procedures for meter replacement. The main information concerns the need to productionise the various deployment processes, so as to simplify and standardise their implementation by the various participants.

The formalisation of the installation procedures, the required training, the work authorisations and safety plans, the equipment required for doing the work and the means of inspecting and controlling the installation must be taken on board at a national level, very much upstream. The deployment information systems must be a tool assisting compliance with national procedures. Freedom must be left locally to adapt to the various external environments and organisations.

A great deal of work will have to be done locally on the files, so as to qualify as precisely as possible the area of work of the various teams (intensive industrial deployment, more specific industrial deployment, deployment outside an intensive area, etc) to make the lists of meters to be equipped/changed reliable and to formalise the means of access to these meters.

For the requirements of deployment on the four experiments, the procurement chain was heavily used in order to supply related equipment within the deadlines. The main difficulties encountered concern the definition of the forecast on the basis of estimations with the project team in order to pass purchasing early, traceability of equipment and monitoring of the invoicing of equipment manufacturers' orders. These difficulties will have to be anticipated in the context of the roll-out. Productionisation of the monitoring and control tools will secure effectiveness.

Installation of meters/radio modules

Various indicators were monitored during the installation of the meters and radio modules:

- The number of installations carried out;
- The average installation time;
- The installation failure rate, the causes of which were detailed and analysed, including the level of abortive visits.

Concerning the installation time and the average number of successful installations per day, the main findings are that close on half the installation time each day consists of the time taken on travel, procurement of equipment and feeding back the installation results. The productivity of the installation technicians increased as the experiments continued, because of the experience effect, making it possible to envisage an average of 16 meters installed per day per technician, taking account of the failure rate.

The main causes of failure were revealed: on average, during the experiments, one visit out of six resulted in failure. This figure is to be taken into account in the deployment rate since it influences the number of meters to be programmed each day per technician. The main failure causes were identified: the absence of the customer (43% of cases), impossible to remove the meter (18%), customer data inaccurate (12%) or a non-equipable meter (10%). Actions will therefore have to be taken upstream of the deployment in order to remedy this. Few customers refuse installation of their communicating meter (0.4% of customers), which is very encouraging. However, the cases of customers who would refuse installation of the meters will have to be dealt with specifically, going if necessary as far as payment for residual readings on foot.

Number of visits to be envisaged, in the event of customer absence: the great majority (80%) of visits were successful on the first occasion. The second visit swept up a further 5% of customers and is therefore appropriate. The third visit achieved only 0.3% of customers in addition and could therefore be omitted in the context of the roll-out, in favour of a subsequent action of catching meters not deployed during the intensive deployment phase.

To limit the number of inaccurate customer data and to facilitate identification of the addresses of the meters on the ground, studies were carried out on the opportuneness of developing geocoding tools (GPS coordinates from addresses, on file) or geolocation tools (GPS coordinates of the meters, on site) for the meters, taking account of the processing time that that could give rise to and any consequences on the deployment times.

Installation of repeaters

Installation of repeaters is extremely complex and demanding.

The main constraints on the installation of repeaters are of a logistic and aesthetic nature. Repeaters are mainly installed, in the context of the experiments, in the public domain, but must not be too visible (colour, size, positioning). The installation requires the use of an aerial bucket lorry, possible if the slope of the road is less than 10%, and suitable municipal authorisation, since it may greatly interfere with traffic. Good coordination with local authorities is therefore necessary.

The installation work may take place close to live electric lines. Obtaining the necessary authorisations is obligatory.

The resistance of the components and colours to ultraviolet radiation and extreme climatic conditions is to be checked.

Very precise installation instructions must be communicated to the installers, in particular on the installation height of the repeaters, and their orientation, in order to avoid any loss of range or poor functioning of the solution.

Repeaters must obviously be able to be fully parameterised remotely and not require local installation once installed.

The repeaters include cells that it appears necessary to change at a minimum every 7-8 years according to the data traffic on the network (changing a cell representing a complete change of equipment).

Installation of concentrators

The conditions of access to the site chosen, the ability to act rapidly during maintenance and ease of intervention are criteria that must be taken into account when choosing sites to install the concentrators.

The service life of the fixing components and the installation technique must have been validated before the equipment is installed on site in order to ensure durability so as to avoid any incident relating to the rupture of the fixing (involving destruction of the equipment and/or injuries).

It must be possible to check the correct functioning of the concentrator quickly (in less than 1 minute) requiring, as far as possible, no particular computing, telecoms or other competence (presence of an “autotest”).

Information following the network optimisation phase

At the end of the intensive deployment phase, a network optimisation phase has proved necessary on the experiments with repeaters, so as to make the information feedback circuits reliable from the fixed radio module on each meter as far as the concentrator, passing through the most suitable repeater. The parameterising carried out during the deployment phase proved insufficient, which gave rise to a heavy burden during a period almost equivalent to that of the deployment.

The major lesson of this phase is that a system with repeaters is more complex to implement and that the simplest possible solution in terms of initialisation must be sought.

Lessons derived from the operation of the experiments

For the experiment operation phase, the following points for attention concern:

- The ability of the solutions implemented to send back readings daily;
- The breakdown levels of the various components of the communicating chain;
- The conformity of the reading sent back with the actual consumption of the meter;
- The impacts of the new communication systems on the GrDF procedures.

The following diagram represents the change in the level of readings recorded daily:

Figure 7 – Level of readings recording daily for the 4 technical solutions

Legend: all the meters that transmitted a reading on day D from the end of the optimisation phase on 1 November 2010 to the end of April 2011 for all the meters validated as communicating on 1 November 2010

NB: On this diagram, the “abrupt” drops in the level of telereadings noted on the various solutions correspond to breakdowns of concentrators in solutions that include neither physical redundancy nor spatial and/or temporal redundancy.

- The following main results are found:
- On the three architectures without spatial redundancy (curves in light blue, dark blue and red), raw levels of daily telereadings **maximum of 97%** (between 93% and 97% in general).
- On the architecture with spatial redundancy (green curve) daily telereading levels **minimum of 99,5%**.
- On the three architectures without spatial redundancy, we observed a stability of **77% maximum** (which means that only 77% of the meters send every day over one month), with an average stability of between 0 and 50%.

- On the architecture with spatial redundancy, the stability levels observed are **97.5% at a minimum**.

This large difference is due to the spatial redundancy (the reading from a meter is received at a minimum by two concentrators) and temporal redundancy (the reading of the meter is received by a concentrator at a minimum twice in the same day) implementing the context of the solution without repeaters.

We also monitored a “stability” indicator of the solution tested, corresponding to the percentage of meters that were read remotely **every day in the month**, this indicator being reset to 0 at each start of a month.

A certain number of lessons can however be derived from the observations carried out over more than 7 months:

- The solutions tested demonstrated the need for an architecture with spatial and temporal redundancy to achieve a maximum quality level.

- Analysis of a few breakdowns around the concentrator showed the need to protect their electrical supply. Modules or repeaters that have suffered interference on the 433 MHz and 868 MHz frequencies lead either to accelerated drainage of the batteries or to degradation of the radio performance in the area in question. The causes of this interference gave rise to additional requirements for the definition of the target solution.

- Checking the conformity of the reading sent back identified difficulties in initialising the radio modules when they were installed (with or without change of meter), which reinforces the need, already identified, to simplify and productionise the installation procedures, providing them with relevant checks to prevent errors.

- Finally, analysis of the impacts of this new equipment on the activities of GrDF will make it possible to prepare for the changes in procedures, with regard to maintenance of the modules, installation or removal of meters related to the current activity for example, and with regard to the procedures using readings: consumption on inactive accounts, requests for rectifications, special readings, etc.

- Whatever the reliability level of the solution implemented, there will, in residual cases, be missing readings or possible disagreement with the customers. These situations will be limited in number. The methods for dealing with these situations (estimation of a missing daily reading probably on the basis of the previous readings, possible taking account of customer readings subject to consistency thereof with histories, etc), will be discussed in specific working groups of the CRE.

Accompaniment of end customers

Accompaniment of end customers is structured in three key steps for communication:

- Prior communication by GrDF;
- Preparation of meetings;
- Communication during installation.

Prior communication by GrDF

Prior communication by GrDF was carried out through three actions:

- Organisation of a press conference involving local GrDF speakers with regard to the territory and communication;
- Sending an informative letter on the procedure by GrDF, in three or four waves per locality;
- Use of a GrDF hotline.

Major lessons were drawn for accompanying end customers:

- A letter announcing the operation, with the GrDF address, appears to be essential prior to deployment. It makes it possible to inform all the customers on the events to follow.
- The addresses available are only the physical addresses of the delivery sites rather than the customer invoicing addresses. One way of overcoming this problem would be to request of the supplier an updating of the details of the customers just before the deployment in an area, including the invoicing details.
- The accompaniment of the external communication with the establishment of a dedicated hotline (freephone number from a landline) makes it possible to reassure customers, to channel any questions and to prepare suitable responses in the event of emerging themes, to relieve the usual communication channels and in particular the suppliers.

Preparation of meetings

Informative letters have been sent by the equipment manufacturers to the customers to which the meeting relates, approximately two weeks before the meeting.

Two major lessons were drawn for the accompaniment of end customers:

- Equipment manufacturers, responsible for organising the tours, must be those who have discussions for arranging the meetings and ensuring good quality of their telephone hotline in order to manage any changes to the appointments.
- For certain types of building, it is important to identify upstream the necessary supports organising the appointments: caretakers for facilitating access to buildings, technical services staff for boiler rooms or communal buildings.

Communication during installation

The technician must be able to reassure the customer while devoting the most limited possible time to him, in order to keep up a reasonable working rate. Referring the customers to the hotline is then recommended.

When there is an intervention requiring the gas to be cut off, the question of restoring gas to the customer installation must not be underestimated. It will be important, when the target solution is deployed, to provide for means of meeting the customers when the gas is restored (for example by specific tours to restore gas in the evenings).

Cutting off gas may pose real difficulties in a cold period if a customer is temporarily away from his home and is not in a position to restart the heating for example. A differentiated treatment of customer presence will therefore have to be studied according to the geographical area concerned and the time of year.

Accompaniment of stakeholders

The deployment of communicating meters involves numerous stakeholders, internal and external, apart from customers, and all the relationships must be coordinated in order to facilitate the fluidity of the processes.

The stakeholders identified are, in priority:

- GrDF control teams, their objective being reporting, information, training and minimisation of work loads;
- GrDF operational teams, who must accompany the deployment, provide the activities caused (emergency interventions, inspection visits, training, etc);
- Subcontractors (installers and equipment manufacturers), who must comply with the productivity objectives while guaranteeing quality of the performance of the services and customer satisfaction while complying with safety rules;
- Local authorities and granting authorities, who have an important role in the accompaniment of implementation, the obtaining of installation authorisations, information on local populations;
- Suppliers, who must be informed of the deployment timetable and be able to inform the customers calling them. Their role will be decisive for making data available to the customers and taking account of the actual readings in all the invoicing documents, which will require significant adaptations to their information systems.
- Consumer associations and all stakeholders who may facilitate accompaniment of the deployment in the territories, whom it will be important to inform of the deployment timetable of a given geographical area.

The deployment information system will have to make it possible to coordinate the deployment activities between the various stakeholders involved, to control the deployment and to inform the various stakeholders on progress with the deployment.

Main information on customer services

The small number of customers to whom the test related does not make it possible to draw quantitative lessons representing the French population. However, these tests afford trends that in general reinforce the expectations expressed by all the stakeholders. The main results from the analysis of these tests are as follows:

Subject	Result
Data relevancy	26% have initiated actions to save energy, or have thought about it.
Data format	Email preferred. Consumption must be related to cost.
Period of analysis	Monthly analysis is preferred. Few customers require a daily analysis.
Frequency	78% ask for monthly digest.
Price of services	Less than 33% are ready to pay for services on energy consumption.

Figure 8 - Synthesis of Customer Tests results

A confirmed interest on the part of the consumers for detailed consumption information but a diversity of behaviours:

- A widely shared wish, at a minimum, for simple consumption data, metered and communicated monthly, without request from the customer, in terms of volume and Euros.
- Some of the customers also declare themselves interested in consumption measured weekly or daily in order to meet isolated consumption analysis requirements. A supplementary analysis must be made on the production costs of this service and on its free character, or possibly charged for, for customers who choose it.
- Various methods of access to the information are suited to different behaviours: information accessible or pushed towards the client, communication channels (email, Text or mail), various formation levels, etc.
- A first stage of access to the information without additional cost, for all customers, must be determined. Optional supplementary services, possibly charged for, must also be defined in addition.

Useful information for performing energy-saving actions:

- 26% of customers in the panel declare that the service provided encouraged them to envisage or implement energy-saving actions.
- However they don't wish to be made culpable for the comfort level that they have chosen.

An appropriation of the consumption information by the customers:

- Improvement in the knowledge of their natural gas consumption encourages customers to wonder about their practices, but requires appropriation time. A time that may lead to an interest in more advanced consumption analysis and advice around energy consumption.

- Tests carried out showed that a small proportion of the population questioned is ready to envisage payment for this type of service. The added value afforded by the analysis proposed will determine the degree to which customers will subscribe to this.

Working hand in hand with all the stakeholders and promoting open discussion to foster trust and confidence during the experiments has proven to be a successful strategy : this unique relationship has encouraged each stakeholders to express their needs and discuss freely the requirements of the future smart gas metering solution. It allowed GrDF to deploy various technologies on the field and assess their technical performances and functionalities with all the stakeholders. In that regard, GrDF is proud to have been shortlisted for the Roll-Out Innovation Award 2012 in London for using dialogue to secure the roll-out of smart gas meters in France.

4. The planning of future operations

Considering the results of the experimentation phase, on July 21st 2011 the French Energy Regulator deliberated in favour of engaging the AMR Project. The next step will be the decision to launch mass roll-out. The process of decision is currently being defined with all the stakeholders and GrDF awaits a possible decision for mass roll-out around 2013 from the Authorities.

Recommendations from the French Energy Regulator

In its deliberation, the French Energy Regulator recommended that GrDF must provide customers for free with daily consumption information on a web site with personal access codes. The Regulator also recommended that energy suppliers must ensure they send to customers on a monthly basis their consumption in KWh, in Euros, and a consumption history of the last 24 months. Last, suppliers must provide customers at least once a year all the details of their energy consumption over the year with elements to compare with previous years, and the typical consumption behaviour of their profile.

Objectives and planning of the AMR Project

There are three main objectives to the AMR Project :

1. Improve customer satisfaction by billing on real indexes and making valuable betterment to the quality of meter reading,
2. Allow significant energy savings by providing consumers frequent information on their consumption,
3. Increase DSO's efficiency thanks to a modernized and more performing network.

The Construction Phase will last 3 years, from 2011 to 2014, during which prototypes of the AMR System will be specified, designed, and tested. Depending on the decision of the Ministries, mass roll-out is scheduled from 2014 to 2020. Additional studies on roll-out scenarios and hypothesis will be conducted during the Construction Phase to refine investment files on the roll-out, drafted in 2011 following the experiments.

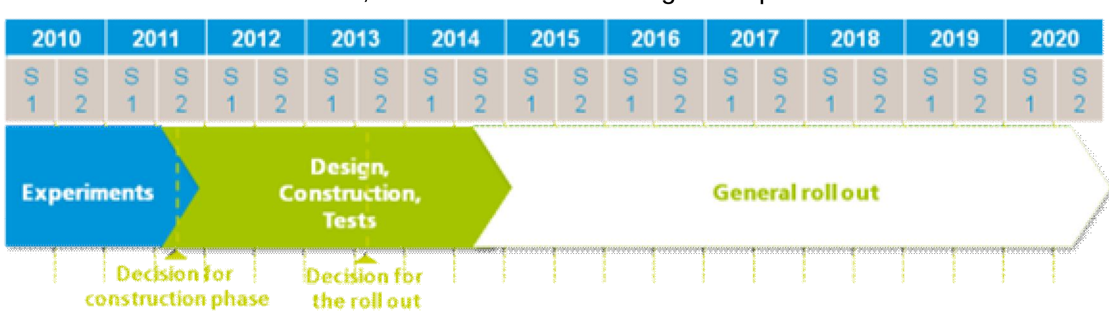

Figure 9 - General Planning of the AMR Project

The Construction Phase starts with defining the General Functional and Technical Specifications of both the communication infrastructure and IT Systems that will need to be developed to support the AMR infrastructure.

Assuming GrDF receives approval for mass roll-out in 2013 from the Energy Regulator and the French Ministries of the Energy and the Consumption, smart meters will need to be compliant with ATEX[1] Standard and MID[2] certified before production. Then a field test of 1,000 meters is planned to be deployed to test equipments and the Communication Infrastructure from end to end in 2014. If this test is successful, a pilot of 100,000 smart meters will be deployed in selected areas of France to distress and validate roll-out tools and processes before the actual mass roll-out. In 2015, one million of meters are planned to be rolled out, and finally 2 millions meters per year approximately from 2016 to 2020.

Challenges of the AMR Project

To achieve the roll-out of a performing end-to-end solution that answers all the needs of the stakeholders and within a reasonable cost, GrDF needs to address three challenges :

- The first challenge consists in the replacement of 11 millions of gas meters with smart meters (or the addition of radio modules on existing meters).
- The second challenge is the creation, installation, and operation of a communication network of around 20,000 concentrators all over the French territory.
- The third challenge lies in setting up brand new information systems and measuring impacts of the project on existing information system.

The overall cost is estimated around one billion of Euros, of which 900 million for mass roll-out.

During the construction phase, impacts on existing assets will need to be assessed. Deploying and operating a communication infrastructure requires new skills GrDF will have to develop, and suggests deep changes within the traditional structure of the Company. Change management is one the main task GrDF teams will have to address during this phase, redefining read-outs processes on one hand, and GrDF mission regarding energy efficiency on the other hand.

Last, another main task of GrDF during the construction phase is preparing mass deployment. In that regard, experimentations were very enriching, as well as the international benchmarking GrDF conducts on other smart metering projects and regulatory evolutions. There is a dedicated team setting up a Deployment Information System which aim is to secure costs, deployment hypothesis, and pilot mass roll-out on the field from 2014. This team also defines work procedures that will need to be applied during the deployment phase to ensure safety of field operators and goods, and maximise the performance of the whole communication infrastructure. It also deals with preparing the Operation and Maintenance

[1] ATmospheres EXplosibles (ATEX) : ATEX Directives 94/9/EC and 1999/92/CE are related to equipment and protective systems intended for use in potentially explosive atmospheres, and security of operators in such environments.

[2] Measurement Instrument Directive (MID) : The MID is an EU Directive that intends to facilitate the free trade of ten types of measuring instruments across the borders of the EU member states by providing common rules for the use of these instruments.

Phase from 2020, ensuring that the solution deployed answers all the needs expressed by the stakeholders.

5. Future developments around automatic metering of gas consumptions

The implementation of Automatic Meter Reading of gas residential consumptions takes part in the generalisation of automatic measurement and data management systems that could be progressively applied to end consumers, network operators and cities. Each of these presents particular technical needs and a specific data management system. Of course, for each of these areas of application, economical profitability, social acceptance and legal aspects differ.

New services for the end consumer?

As soon as automatic meter reading has been forwarded, ideas for new services to the consumer have been studied and proposed, aiming mainly to a better energy efficiency, considering the fact that more than 40% of the energy is used in residential and commercial buildings offering a large potential for energy saving.

Today, Distribution Network Operators are responsible for delivering accurate billing information to energy suppliers. The later are then in charge of accurately billing their customers, and provide services around energy efficiency. However in their last deliberation, French Authorities asked GrDF to provide, as well as accurate billing information to energy suppliers, consumption data directly to consumers on a monthly basis, and even for those requesting it, on a daily basis. Tomorrow, we can imagine new energy services providers will have access to these data to improve service quality on energy management, and even provide multi-fluids services.

Many service providers have developed or experimented new offers about the automatic gas consumption management. These offers are always included in more general ones such as control or management of electricity, gas or water consumptions, heat control, intrusion surveillance, air quality, fire alarms… Many experiments are being conducted throughout the world, revealing potentialities and raising up innovations, but also technical, economical and social difficulties which slow the spreading of such systems.

Optimisation of gas network operations

The development of AMR systems brings intensive information about consumptions along the network, giving a much precise view of the everyday use of the distribution networks. It introduces also new competences in remote information transmission for the network operator and it gives access to a telecommunication infrastructure that can be, even only partially, used for other operators needs.
The possibilities of developing a new concept for gas networks using intensive measurement and transmission have induced numerous discussions in public and professional organisations.

Within years 2010 and 2011, the European commission, that supported many studies about smart electricity grids, decided to launch an Expert Group in its Smart Grids task force, which aimed to think about concepts of smart gas grids. The conclusions presented in June 2011 identified different ways for developing systems that can use the information got through the automaticity of consumption readings, the communication infrastructures built for AMR systems, or at the least, professional skills built about remote transmission. The main orientation for the future is the possibility of developing flexible gas grids which might include different functionalities:

- the optimization of gas grids by a better knowledge of the gas balance and of the gas flows, including the choice of optimal operational schemes or operations during network incidents;
- Gas quality remote monitoring active flow and pressure remote control, which can be very useful for facilitating the injection of non conventional gases such as biomethane or synthetic methane in the distribution gas network;
- The operation of smart gas utilization such as micro hybrid heat pumps or in the other direction, the injection of gas (Hydrogen for example) resulting from exceeding electricity production by wind or solar plants. The gas network operates in this case in interactivity with the electricity network.

Smart gas grids appear today as a source of potentialities for increasing the role of gas networks in a global management of energy.

Automatic meter reading in the town of tomorrow

With the major changes occurring in urban areas, with many new stakes dealing with the growth of towns, the obligation of optimizing energy consumptions and the need of delivering efficient services to people, scientists including sociologists, architects and urbanists are nowadays involved in discussions to define what should be the town of tomorrow. In this framework, energy data management has to be combined in a more general process including many other utilities and city services: waste management, water supply, public lightning, transportation optimization, air quality surveillance…

The Automatic Meter Reading for gas consumptions is a small part in this global approach, but gas industry must nevertheless be aware about a future where all information about energy consumptions and other data concerning the urban life should be collected and processed in order to give means to public authorities to optimize the management of public equipments.

In this concept of the “ubiquitous city” involving the coordination of all utilities, distribution networks operators must be aware about two major points that can influence their decisions:
The importance of harmonisation in the exchange of information between actors
The clear definition of their role facing the other actors, in order to interact with them in due intelligence

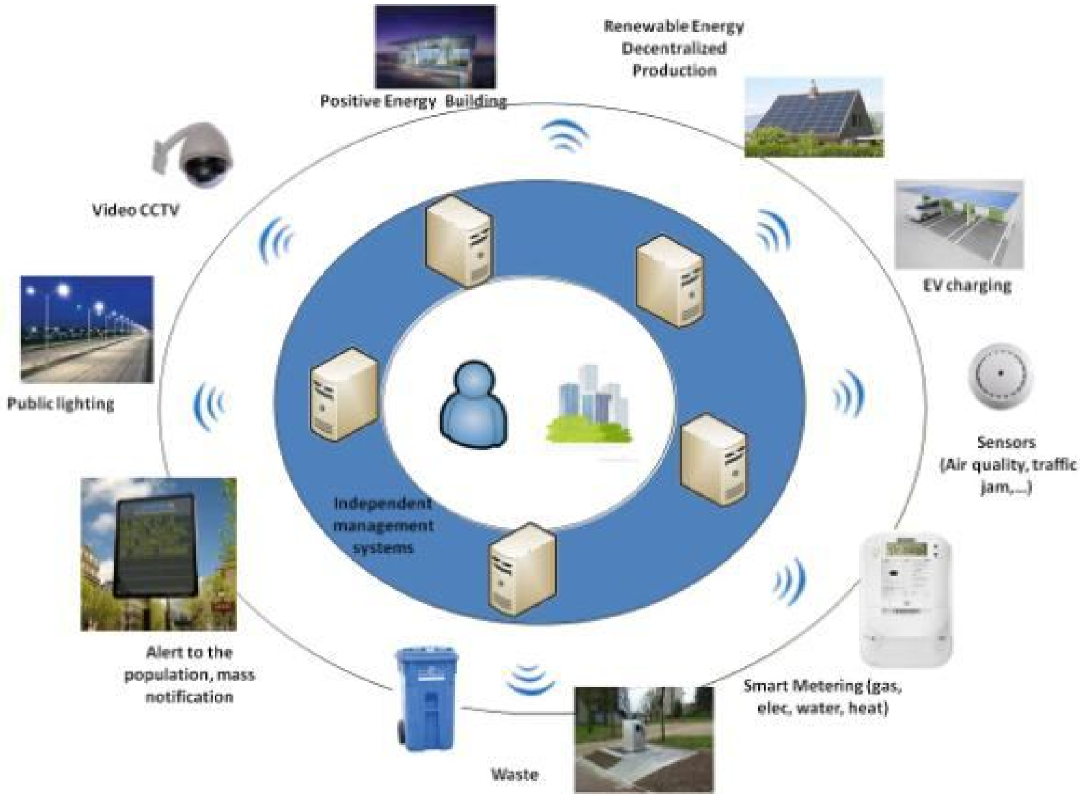

Figure 10 - The Ubiquitous city: Everything is linked to an information system through wireless communication technologies

Questions for the future

Automatic Gas Metering is a first step on the road of designing energy networks of the town of the future. Many uncertainties and questions remain about the role of gas consumption data, beyond the first applications of transmitting billing information to suppliers and consumption data to end consumers. Questions are already raised concerning different obstacles:

- development of low cost technologies for meters, sensors, associated computer systems and IT systems, which can have a major impact on the generalization of such systems in the world
- the interoperability of different measurement systems. Harmonisation and standardisation are therefore a key point. Several international standardisation bodies have launched group with the difficulty raised by the necessity of coordinating actions between utilities, meter and sensor manufacturers and IT providers. As an example, the European committee of standardisation (CEN) has created a Smart Metering Coordination Groups to facilitate the interoperability of metering systems in electricity, gas, water and heat.
- business models on such services are still unclear and uncertain,
- the social acceptance of the system has to be consistent with privacy obligations.

Many experimental operations have been launched in various countries which include the integration of Automatic Meter Reading as a part of a global information system. All energy actors have to be cautious about the results of such operations. The last years have shown that the evolution occurs very quickly and in the same time initial choices about infrastructure and communication protocols are difficult to change, once they have been chosen.

6. Conclusions

This presentation, based on large experiments in an existing gas network gives a good example of a methodology for building an industrial strategy about a major change in metering. It shows the different debates taking place on this kind of new system, not only on technical performances, but also about organisation, relationships between stakeholders. It proves if necessary that today's customers and consumers have high expectations regarding improvement on energy management.

GrDF has always been a committed actor, whether it is on technical performance and quality of service, safety of men and assets, or social responsibility and sustainable development. Since 2004, GrDF has been operating gas smart meters, and is now a recognized expert on the subject. Starting in 2007, GrDF has been working very closely with the Energy Regulator, the Authorities and the stakeholders to define the main functionalities of a future automated meter reading solution for 11 million French gas consumers. 3 years later, in 2010, with the support of all the stakeholders impacted by the profound changes implied by smart metering, GrDF launches four experimentations and customer tests to validate technological choices and precise consumers' need regarding consumption data.

The experiments were a large success and lead to the best AMR solution on both quality and costs points of view, which convinced the Energy Regulator and the stakeholders to give their approval for launching the Construction Phase of the AMR Project. This second phase of the project will last until 2014 and see the first prototypes of GrDF gas smart meters, concentrators, and all the IT systems needed for end-to-end data management (from meters to consumers) and roll-out. Depending on the Company receiving approval from the French Authorities, the Deployment Phase is expected to start in 2014 to 2020. More than 11 million meters and around 20,000 concentrators are expected to be rolled-out on the field in six years time, after a pilot of 100,000 meters in 2014. But behind the challenges lying in deploying such an infrastructure in such a short period of time, the AMR Project induces very deep organisational changes within the Company itself with brand new skills and knowledge to acquire and 12,000 employees to federate behind the project.

Last, Automatic Gas Metering is a first step on the road of designing energy networks of the town of the future. Many uncertainties and questions remain about the role of gas consumption data beyond the first applications of transmitting billing information to suppliers and consumption data to end consumers, but already we can imagine new services in the Ubiquitous City, a city where all utilities infrastructures are shared. In this context, GrDF strives to contribute to the improvement of current technologies to optimise network monitoring and help consumers save energy.