WHITE PAPER

By manufacturers to serve
smart energy

SMART GRIDS

Concrete proposals
for the new organization
of the energy market

"They did not know
it was impossible,
so they did it."

Mark Twain

An industrial revolution underway

The objective of the White Paper is to promote the French electrical industry expertise and the already available offer, in order to develop a stable and secure environment for operators and investors, necessary to set up a French and European electricity system focusing on smart operation and sustainable energy.

For this reason, it is important to emphasize to what extent the combination of smart energy and digital systems is necessary for the industrial revolution represented by smart grids.

The success of this industrial revolution depends both on synergies between the electricity and digital industries and on the integration of all these new functionalities in France to successfully export the French Smart Grid model to international markets.

After a definition of the ecosystem corresponding to the smart grid and a description of the societal objectives entailed by the new electricity economy, the White Paper will present an action programme and measures intended for the French public authorities built around three main aspects to ensure the international success of our electricity industry:

- International standardisation;
- Regulations for an exemplary domestic energy market;
- Incentives to ensure the excellence of the French electricity industry in the long term.

All these recommendations represent a basic set of measures and actions in order to ensure that the French electricity industry and research maintain their status as a sector of excellence throughout the world.

CONTENTS

	Introduction: An industrial revolution underway	3
A.	The ecosystem of smart grids or the new electricity economy	5
B.	The economic, environmental and social objectives of smart grids	7
B.1.	Smart grids: A global market under construction	7
B.2.	Smart grids: A response to societal expectations and benefits distributed over the chain of stakeholders	8
B.3.	The players in a new market for innovative electricity use: Complete mobilization of Gimélec companies	10
C.	The ten integrated functions of smart grids	12
D.	International standardisation and smart grids	23
E.	Regulatory changes and incentives to develop smart grids in France	24

A. The ecosystem of smart grids or the new electricity economy

Smart grids form a complex ecosystem that can be described as a combination of systems in order to seize the most structural factors of this 'new electricity economy' or 'new energy economy' in the broadest sense.

The smart grid ecosystem will accordingly hinge around three systems changing the current grid system based on unidirectional management - from upstream to downstream - for systematic bidirectional management integrated on several levels: from centralised generation to decentralised generation.

The three levels of systems that will interlink are as follows:

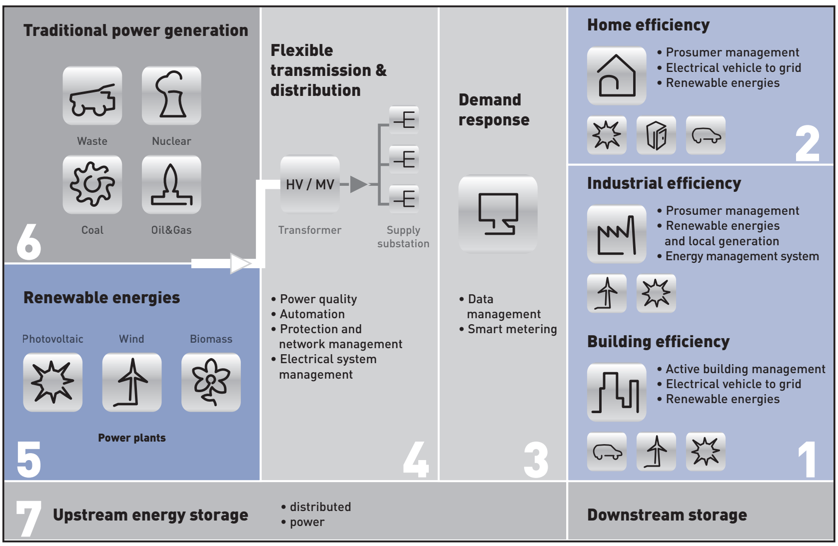
- **Conventional and renewable energy generation systems**, which cover all electricity generation capacity;
- **The cross-cutting system** which consists of the active distribution and transmission systems, controlled and adjusted in real time between the supply of conventional and renewable energies and the demand from the local system;
- **The local system** which corresponds to an activation of smart energy systems in industry, commercial and residential [1], buildings [2], and the integration of renewable energies, storage systems and electric vehicles;

The combination of these three systems accordingly forms the smart grid and meets the priorities of the new electricity economy which can be summarized by three major operating features:

- **Integration** of intermittent renewable energies and new electricity uses;

- **Flexibility** of generation and consumption in order to reduce peak electricity requirements;
- **Management of two-way information and energy flows**[3] between the three levels of systems.

These three systems have been summarized in the following matrix[4] by the working group of the French steering committee "Comité d'Orientation Stratégique des Eco-Industries (COSEI)"[5], dedicated to smart electricity systems and energy storage:



Smart electricity systems and energy storage

Source : COSEI - November 2010

The White Paper describes in detail the industrial product offerings corresponding to the main functions forming the smart grid (see Chapter C.)

B. The economic, environmental and social objectives of smart grids

B.1. Smart grids: A global market under construction

The initiation in 2009 by the US government of a smart grids plan revealed to the general public this concept which, since then, has led to growing awareness generally, especially in countries and continents that are growing rapidly.

This concept has accordingly acquired a global dimension in which the expression 'smart grids' covers different aspects: some see it as a digital solution downstream of the meter designed mostly for residential customers, while **others consider that it is a global systemic vision, transcending the current structure of the energy market** to generate economic, environmental and societal benefits for everyone.

It is this technological, marketing and economic view that the Gimélec manufacturers and their partners want to share and expand in the follow-up of this White Paper dedicated to smart grids.

To back up this impression of an industrial revolution underway, one need merely gives a reminder of the global scale of the smart grid market and the first financial assessment of this new electricity economy:

Assessment of the global market:
between 12 and 50 billion Euros per year on the 2020 horizon [6]

B.2. Smart grids: A response to societal expectations and benefits distributed over the chain of stakeholders

The protection of the air quality and climate, combined with the forecasted increasing shortage of fossil energies, as well as energy security requirements, are leading to an inevitable trend to increased use of renewable energies, whether it comes from wind, sun, earth or sea.

Given the intrinsic volatility of the generation of renewable energies (day/night cycle, weather conditions), it is essential to increase the availability and flexibility of electricity generation and to make it a key structural feature of change in the global and national organization of the existing electricity system.

The supply of conventional and renewable energies also has to meet the needs of consumer demand on the macroeconomic level and, if possible, with an instant matching of supply and demand.

In order to ensure the balance between energy supply and demand, both under radical changes, power grids must be made smarter to at the end incorporate the other energy networks by capillary effect.

The drivers and accelerators of the implementation of smart grids and the expected benefits are summarized in the following tables.

Drivers and accelerators of smart grids implementation

Drivers

1. Add stability to existing electric grids in order to integrate the new energy sources and new end uses of energies.

2. Increase the available electric power and the energy efficiency of grids to cover new needs such as electric vehicle and emergence of new economies.

3. Reduce CO_2 emissions for all the components of the conventional economy through the integration of renewable energies and energy efficiency in end-user consumption.

Accelerators

1. Deploy the energy and digital pre-existing technologies, while promoting innovation, to provide economic stimulus following an unprecedented financial, economic and industrial crisis.

2. Increase the involvement of public authorities in structural stimulus measures to bring changes into the national and European regulatory and fiscal framework.

3. Give consumers a more active role ('prosumers') in their own management of energy efficiency through widely shared societal acceptance.

Expected benefits of smart grids

For the government and the public finances of the nation:

- Achievement of the European Union objectives of the 3x20 Agenda.
- Establishment of conditions favourable to energy efficiency.
- Increased energy independence through incorporation of renewable energies and reduction of peak demand.
- Contribution to the security of electricity grids and more generally to cybersecurity.
- Securing of commercial markets for national manufacturers belonging to electricity sector.
- Penetration of new energy technologies and support for national research.
- Contribution to the circular economy and the conservation of raw materials.

For consumers:

- Access to economically competitive and already existing energy efficiency solutions.
- Promotion of virtuous behaviour through more flexible pricing policy according to uses.
- Proactive changes in behaviour while protecting private life as a result of standardisation and specific data protection legislation.
- Improved control of renewable energy generation and new uses.

For the distribution system operators:

- Optimization of networks and their management according to the source of electricity generation.
- Harmonious integration of the use of electric vehicles and new electricity uses.
- Securing networks' balance.

For the transmission system operators:

- Global control of the generation, transmission and distribution system.
- Preventive management and modelling of available energy generation capacity according to real demand.

For French electricity industry:

- Sustainability of high value added jobs in France.
- Support the export of expertise and excellence of the French and European electricity industry by the growing interconnection of networks.
- Reinforcement of the standardisation to penetrate emerging economies.

For universities and research:

- Deployment of researchers and academics around full-scale application platforms for the combination of technologies.

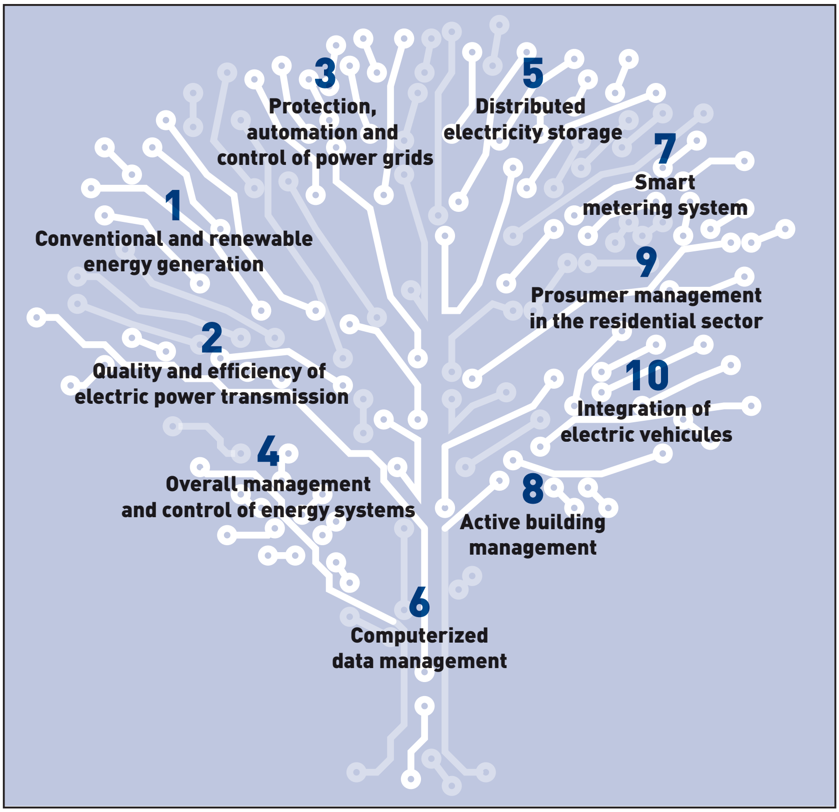
B.3. The players in a new market for innovative electricity use: Complete mobilization of Gimélec companies

The 'smart grid' concept means that the flexibility of energy generation, distribution, storage and use, with the growth in renewable energies, will be based on a capillary information system ensuring the balance of the electrical system from upstream to downstream and, conversely, from end-user to generation. Moreover, the expression 'smart grid' implies, through related legal concepts, fundamental questions surrounding the protection of privacy which will be settled only through widely shared societal acceptance and specific regulations.

Indeed, if there is truly a new player in the new electricity economy, it is the active consumer ('prosumer')[7] resulting from the transformation of the consumer into a producer and user of energies, while remaining a citizen, a taxpayer and a player in the society in the broadest sense.

That is why information technologies have a fundamental role to play to ensure active interaction between the upstream and downstream of the smart meter; the combination of digital and energy technologies will generate a new market with the continued existence of high value-added jobs in French industry, while giving rise to new jobs on the downstream implementation chain[8].

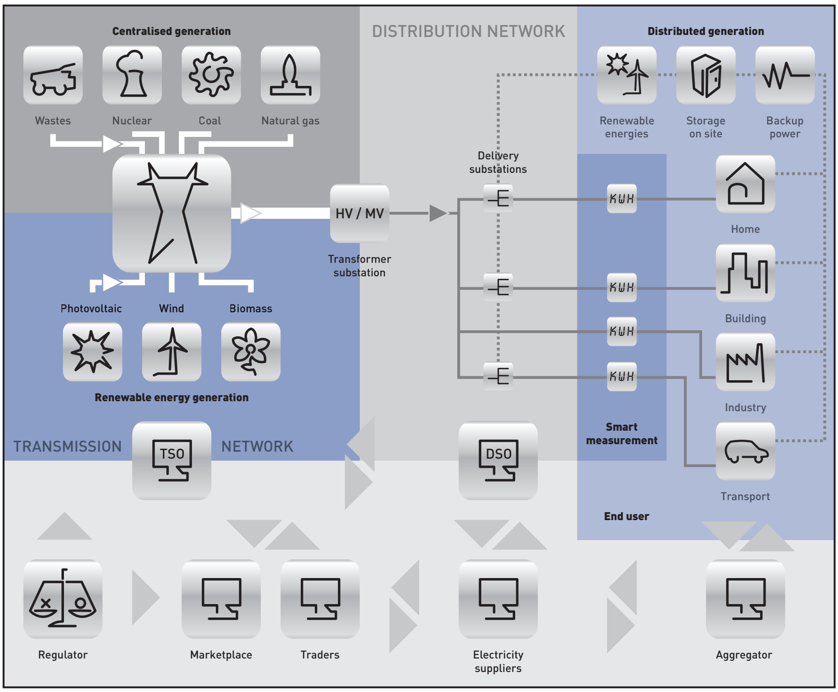
C. The ten integrated functions of smart grids



The tree structure of the ten essential functions shows to what extent their respective integration into the various levels of local and cross-cutting generation systems will take place via the information technologies in their various components.

C.1. Conventional and renewable energy generation

Upstream of the smart energy systems are the generation plants, historically based on conventional centralised generation facilities – coal, gas, nuclear and hydroelectric power – gradually evolving toward decentralised renewable power generation facilities: wind power, solar heating and photovoltaic power, geothermal power, tidal power and fuel cells.



The transition to these generation facilities incorporating a growing proportion of renewable resources poses specific problems with regard to:

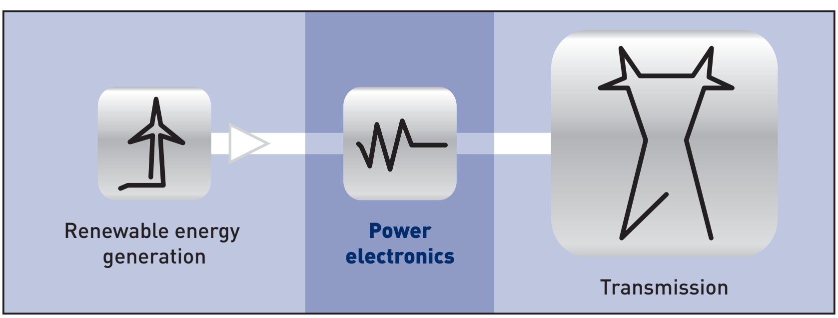
a) The integration of these widely distributed resources – whereas historically real-time balancing of supply and demand was achieved through a few hundred generation points on the grid – requires interaction and adjustment in real time. The scattering of these resources requires interactions at the level of tens of thousands of diffuse monitoring and balancing points in the distribution networks.

b) Intermittency of energy generation: Since some renewable energies, typically wind power and solar power, are directly correlated to meteorological phenomena, they result in a real-time fluctuation in the generation capacity of these resources. This requires not only the integration of flexible new resources capable of balancing these fluctuations, such as storage resources, but also the upgrading of monitoring and control systems in existing conventional power plants to allow a faster response by these resources.

This therefore requires setting up new control and monitoring systems for these generation facilities to obtain sufficient operating flexibility.

C. 2. Quality and efficiency of electric power transmission

Just as intermittent power generation sources disturb the balancing of supply and demand, they also have an impact on the quality of the electric wave, implying, in particular, new stability constraints in case of a fault in the grid, due to their very low inertia.



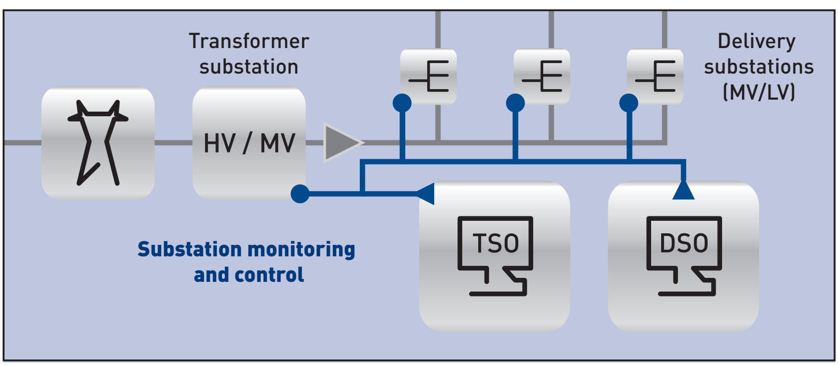
New power electronics systems for improved quality of the electric wave

This requires the installation of **new power electronics systems connected to the grid to compensate for the defects caused in the quality of the electric wave** in the event of a fault, and to optimize the transmission and distribution infrastructure's capacity according to the real-time availability of renewable energy.

These constraints also involve implementing **new power conversion technologies at infrastructure level – wind turbine converters and solar inverters –** to exchange information in real time with the grid operators in order to be adjusted remotely according to the overall operating conditions of the grid.

C.3. Protection, automation and control of power grids

The grids allow a switch power flow between upstream generation and consumption downstream. Their broad dissemination and their critical availability features require **the implementation of extremely fast protective devices** capable, on one hand, of isolating faulty grid sections, and on the other hand of remotely controlling the reconfiguration of certain branches of the grid depending on incidents occurring, or procedures for putting certain devices out of service.



The system operators must be able to remotely control the various substations

This requires the installation of protection, control and automation equipment in each of the substations of the transmission and distribution networks. While these technologies have gradually migrated toward digital technologies in the critical transmission substations, a large amount of automation work remains to be performed at distribution level, to allow two-way interaction with the new energy consumers, incorporating a growing number of microgeneration points. This requires the deployment of technologies open to the monitoring and control ones used at the level of the generation and consumption resources.

C.4. Overall Energy Management and control of electrical systems

The overall optimization of grid systems requires the implementation of 'Control Centre' technologies operating as a 'control tower' for real-time energy flows in transmission and distribution networks. Control centres are distributed at various levels of the grids (national, regional and urban) and operated by the system operators as part of their functions.

These control centres interact in real time not only with the sensors and protection & control equipment distributed in the substations, but also with customers offering enough flexibility to be able to contribute to grid balancing.

Whereas historically only conventional power plants offered this type of service, the growing percentage of intermittent energy sources requires interfacing new generation and storage resources and customers ready to better synchronize their energy demand, which is a key issue of smart grids.

The evolution from grids to smart grids therefore requires a significant revamping of these real-time information systems given the new challenges involved in the incorporation of very large volumes of data – this data could potentially come from each prosumer - and new display technologies as decision aids.

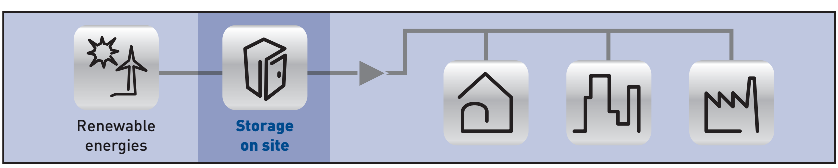
This also requires setting up of new structures for information aggregation in relation with the services (responsibility for network balance) required at market management level.

C.5. Distributed electricity storage

The highly intermittent nature of renewable energy sources requires the implementation of new resources allowing a balance of this intermittency at the energy system level. Electricity storage – though difficult to implement – meets these needs precisely.

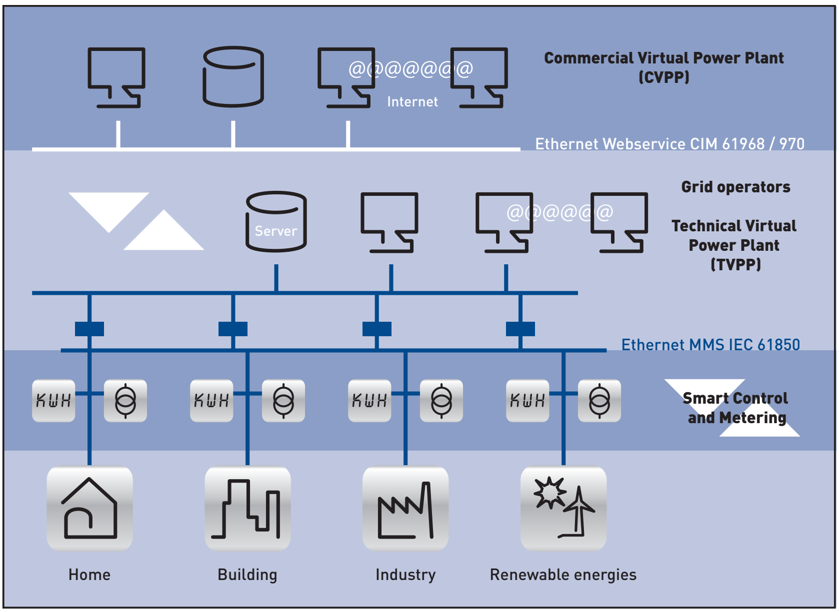
To date, energy storage technologies are mainly limited to hydropower pump-turbine structures for which technological developments have recently allowed increasingly accurate control in response to energy fluctuations.

The significant deployment of electric vehicles has also made it possible to improve battery-based electricity storage technologies in terms of both durability and cost, meaning that new battery uses can be considered, connected to the grids either directly through substations or at the level of renewable power plants or large consumption centres. For satisfactory operation, these widely distributed storage facilities should be integrated with the control centres. Moreover, other storage facilities are currently emerging, based on compressed air or thermal storage in the generation plants and flywheel generators for specific uses.



C.6. Computerized data management

The integration of consumers into the grid requires closer modelling of their consumption use, and in particular of the energy flexibility potentially derived from new 'prosumer' usages. This requires closer integration of the information systems needed to manage these new customer profiles, with the 'aggregator' control centres integrating these new uses.



The smart grid control architecture

This greater integration has the effect of bringing closer together the worlds of the IT integrators and energy efficiency specialists and industries, in order to offer new turnkey solutions integrating information systems and active management solutions based on standardized data interchange.

C.7. Smart metering systems

Smart meters are one of the components of the deployment of smart grids, of which they form the backbone. They are a first step toward the deployment of future smart metering systems. The proposed new products are increasingly complex; they manage the conventional functions of measurement of energy consumed and variable pricing (at least the peak hour/off-peak hour tariffs, but eventually far more flexible and dynamic pricing systems).

These meters are capable of measuring the energy produced (measurement of bidirectional flows), managing the power flow and controlling the load curve. Moreover they have communication capabilities which make them remotely controllable. Therefore they enable consumers to easily have a better understanding of their consumption.

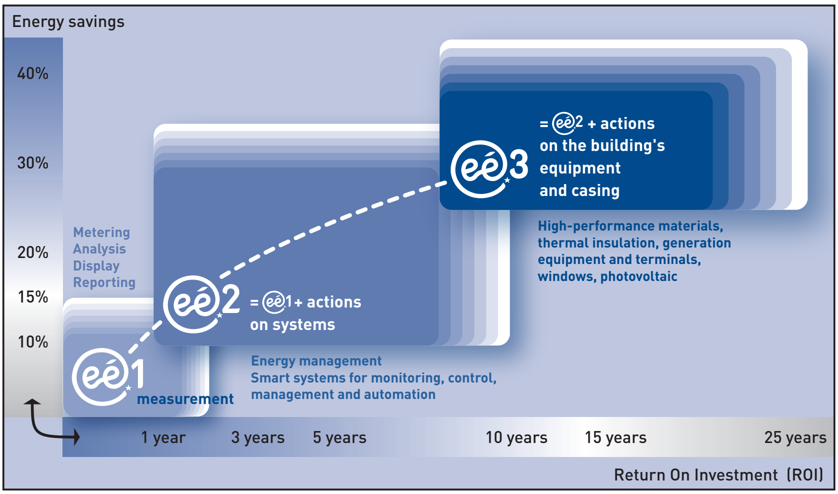
C.8. Active building management

For companies and public authorities, active management is the fastest, most economical and most efficient way of reducing their energy bill and their CO_2 emissions while keeping up with demand growth and industrial generation. Active building management covers the entire energy cycle of a building, new or existing, industrial or commercial.

Based on audits (i.e. verifiable measurements), it involves installing low-consumption equipment, introducing real-time measurement and monitoring facilities, and constantly optimizing all end uses by means of **'added' smart energy systems.**

By integrating lighting, heating and air conditioning, computer hardware and servers, motors for industrial processes, variable speed drives... into a comprehensive building management system, the potential energy savings can be similar to those provided by external insulation [9], so that **active building management becomes an unavoidable complement to passive solutions in order to achieve** and exceed the objectives of the French "Grenelle" energy saving agreements [10].

By connecting buildings that have become active to smart grids via local grids *(microgrids)* within eco-districts, property managers and owners will benefit from the new opportunities available to optimize their capital investment and operating budgets.



Active building management offering

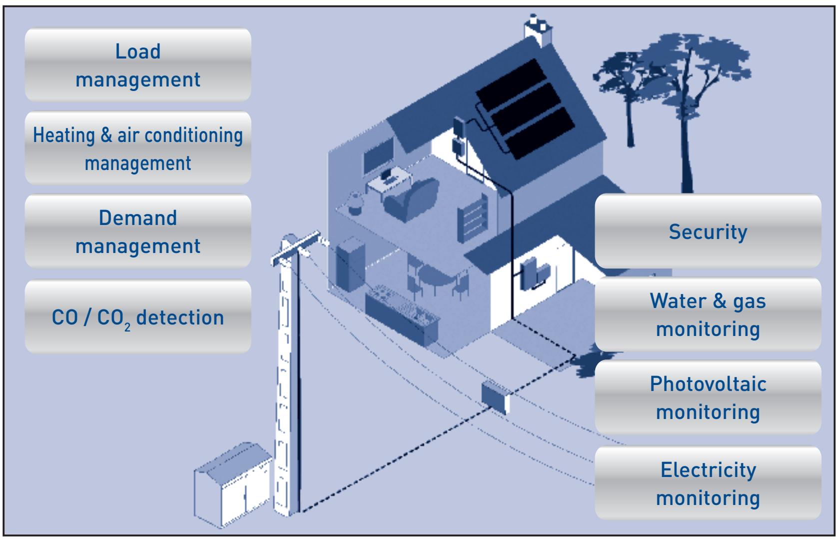
C.9. Prosumer management in the residential sector

Those consumers who want to reduce their electricity bill and play a more active role in energy issues, by helping to fight climate change and contributing to the reduction of energy consumption, now have the means to do so: the user is therefore turning into a "prosumer".

Nowadays, the "prosumer" can already adjust his lighting, heating, electronic equipment and household appliances, and even help to eliminate peak effects through the already available load shedding offers, while being an active player in his gradual behavioural change.

Thanks to new information technologies, each house provided with active management solutions will therefore be connected to the smart grid, and will enable efficient integration of renewable energies as well as optimised electric vehicle recharging.

In this framework, personal data protection is an important point to look at, in order to ensure an acceptable penetration of these new energy and information technologies, as the challenge is to succeed with massification, but without creating mistrust from the consumers-citizens-taxpayers.



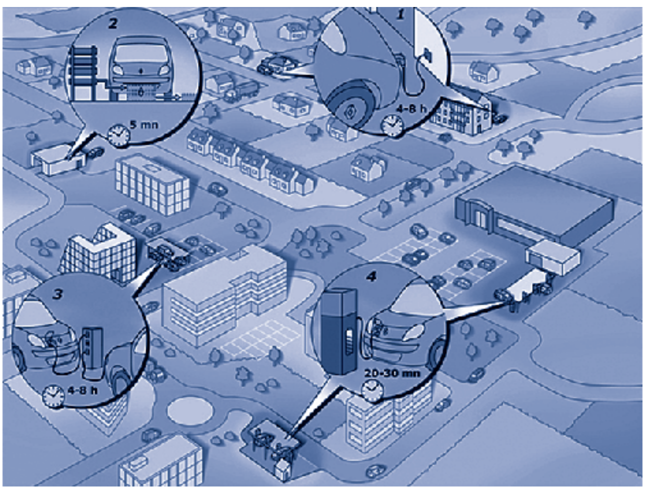
The home energy ecosystem

C.10. Integration of electric vehicles

The planned introduction of the electric vehicle will have a major impact on both urban infrastructure and power grids. Since one of the key factors of success of the electric vehicle is the availability of reliable and easy-to-use charging structures, it will be necessary to increase the number of electrical charging points: in individual houses, in private buildings (car parks of residential and office buildings), in public infrastructures (roads) or accessible to the public (shopping mall parking or service station).

This specific electric power demand, dedicated to electric vehicles recharging, will bring a change in the conventional electricity consumption scenario and involves that specific arrangements for battery charging and its pricing are to incorporated from now on, in order not to disturb power grid balance.

Finally, charging must be performed in perfect safety conditions complying with the applicable standards for the safety of both property and persons, because on this, will depend the successful deployment of electric vehicles in France.



1 and 3: Slow charging on home network

2: Fast battery exchange station

4: Fast charging stations

Electric vehicle: Recharging infrastructure

D. International standardisation and smart grids

Standardisation is essential if the resolution of the equation between achieving the optimum economic market, the networking of the entire electrical system and legal security of investments is a priority for the Government and the stakeholders in the electricity industry.

The priority standardisation measures are already well underway within the International Electrotechnical Commission (IEC), which must remain the primary venue for establishing standards in order to avoid creating redundant or even counter-productive initiatives. Moreover, France is heavily represented and holds key positions in the IEC committees already involved in the standardisation of smart grids.

These priority standardisation measures at the IEC include, in particular:

- Accelerating the processes already underway;
- Harmonizing energy measurements and their monitoring in accordance with current binding rules;
- Increasing cooperation with new information technologies;
- Formalizing rules for the protection and confidentiality of personal data.

E. Regulatory changes and incentives to develop smart grids in France

Gimélec recommends that a number of measures be taken by the French authorities to ensure the successful development of smart grids.

These proposals are classified by decreasing hierarchic order in terms of urgency of action for the electricity industry in order to be successful in winning these new international markets.

Major proposal for an exemplary domestic market

Proposal 1

1.1.	Rapidly initiate several demonstrators in one or more regions for future smart grids within the framework of the 'Spending for the Future' program, provided that they are coordinated together.	I
1.2.	Organize a starting fund dedicated to smart grids to ensure long-term action and earmark existing taxes for the formation of capital.	I

Incentive

Regulatory measures for organization of the new electricity market

Proposal 2

2.1.	Widely adopt the regionalization of smart grid management after assessment of the demonstrator in terms of a transformation of the economic model.	R
2.2.	Increase the transparency of management of the grid use charge (French 'TURPE') in terms of access to financing dedicated to the promotion of innovation by industrial firms in the sector.	R

Proposal 3

Initiate consultation on draft decrees and orders to be adopted following the French NOME law (related to new market organization for electricity) under process, taking advantage of the working group of the French steering committee 'Comité d'Orientation Stratégique des Eco-Industries (COSEI)' [5], dedicated to smart electricity systems and energy storage.	R

Proposal 4

Establish a tariff for self-consumption of the electricity produced by renewable and sustainable energies.	R

Regulation

Proposals in favour of the 'prosumer' to ensure opportunities for the new energy technologies

Proposal 5

	Regulation	Incentive
Organize the fungibility of energy savings certificates as 'carbon certificates' to lay the foundations of a real energy savings market and thus ensure a link with the European market for carbon certificates.	R	I

Proposal 6

	Regulation	Incentive
Make 'energy saving' tax aids for domestic customers dependent on offers guaranteeing real results in terms of energy savings and reduction of CO_2 emissions.	R	I

Proposal 7

	Regulation	Incentive
Adopt specific regulations for personal data protection for the 'prosumer'.	R	

Regulation   Incentive

Cross-cutting proposals in favour of sustainable environmental tax treatment

Proposal 8

	Regulation	Incentive
Create a National Sustainable Energy Council formed of consumer associations, employers' trade associations and trade unions, and state representatives.	R	

Proposal 9

	Regulation	Incentive
Revamp the RT code (thermal regulations for buildings) as R3E (energy and environmental efficiency regulations) to reflect the interdependence between grids and buildings, and evolve toward a result-driven culture through a systematic approach covering all energy vectors.	R	I

Proposal 10

	Regulation	Incentive
Rally the European institutional players to revive the debate on an Energy Climate Contribution (carbon tax) on the borders of the European Union.		

Regulation   Incentive

-oOo-

Explanatory notes

1 Commonly called the 'smart home'.

2 Commonly called the 'smart building', which de facto includes 'microgrids'.

3 The aim is to create a legislative, regulatory and fiscal context favouring physical flows (electrons) and monetary flows (euros).

4 Note that the COSEI SEISE matrix has been deliberately lightened to simplify reading, although without changing the diagram, the functions and their respective titles.

5 Comité d'Orientation Stratégique des Eco-Industries (COSEI) steering committee co-run by the Minister for Ecology and the Minister for Industry which entrusted to Gimélec the chairmanship of the working group on smart electricity systems and energy storage (SEISE).

6 This estimate is a range which varies depending on the analyses and the technical areas covered by said analyses (McKinsey's analysis is given as a reference), which corroborates the market potential identified by the Gimélec manufacturers in their businesses.

7 Concept outlined by Gimélec at a presentation of the "HOMES" research programme in the working group on Energy Demand Management in the Commission de Régulation de l'Energie (Energy Regulation Commission).

8 These are installers, integrators, energy service and consultancy companies, independent energy managers, third-party certifiers, etc., which represent hundreds of thousands of jobs downstream of Gimélec's industrial sector, of a non-offshorable nature.

9 OPECST report on the energy performance of buildings – 2 December 2009.

10 In buildings: 38% reduction in energy consumption, 50% reduction in CO_2 emissions.

Gimélec

Groupement des industries de l'équipement électrique, du contrôle-commande et des services associés
French trade association for electrical equipment, automation and related services
11-17 rue de l'Amiral Hamelin - 75783 Paris cedex 16 - France - Tel.: +33 (0) 1 45 05 71 55 - www.gimelec.fr