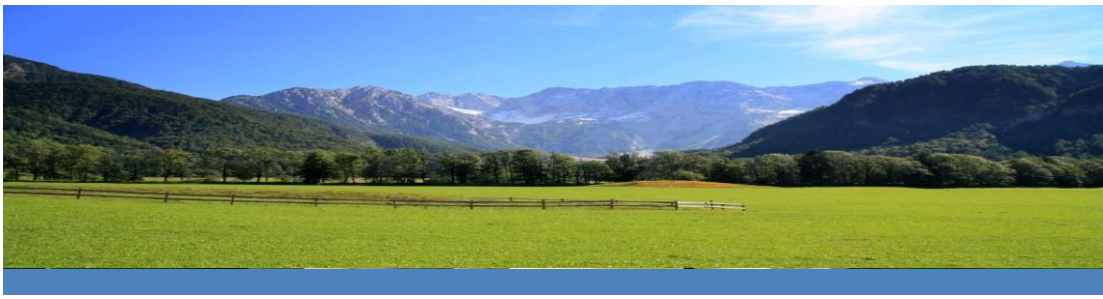

France

Action 4.1.1: National Frameworks

Work Package Responsible

Country Template Completion Responsible: FRESHMILE

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1. Summary

The French energy production mix is dominated by nuclear generation and despite the increase in renewables its share will still represent 72% in 2020, with hydroelectricity being the second most important generation source and the first source of renewable energy, far ahead of wind generation.

While the deployments of wind and solar photovoltaic generation have been slowed down since 2011, the renewable energy plan for France defined in line with EU Directive 2009/28/EC, presents measures to achieve an increase to 23% percent, by 2020, of renewables as a share of gross energy consumption.

France's electrical system is specific because of the nuclear generation contribution to the mix but also because of a high gradient sensitivity to cold weather. This is due to the fact that electrical heating is a key component of the residential demand in France, the consequence being the exceptional peak winter demand in France compared to other European countries. One major consequence is that France is importing electricity for a highly larger number of days in the year.

The increase of the penetration rate of renewable intermittent generation sources as well as the need to manage the peak hour load are the main challenges facing the energy industry and the main drivers for the introduction of smart grid and storage technologies. Many projects for the development of efficient storage techniques and the demonstration of existing technologies are supported in France by public organizations. The most mature storage technologies in France are batteries (mainly Li-ion) and Hydrogen.

2. Storage technology checklist

Biogas digesters and storage tanks

In 2008, there were 480 plants in operation in France, most of them treating municipal waste. In 2012, there were 190 MW of installed capacity in biogas digesters. These are very small numbers, especially to the size of the agriculture industry in the country.

Currently there are 13 installations of solid biomass producing 191 MW of cogenerated power. Transformation of solid biomass into gas allows for enhancement of the performance of cogeneration installations. There is a pilot installation in Morcenx which is generating 10 MW of power and consuming 50,000 tons/year of biomass. Europlasma, the firm which installed this plant is planning to deploy 15 units in France, Germany, UK and Spain.

It is expected that the biogas market will treble in France until 2020. Over 2011-2012, new rules and regulations were introduced that will boost the industry. Overall, official targets for 2020 mention 2,300 MW from biomass (heat and power).

With new laws allowing the injection of methane into the natural gas distribution grid and guaranteeing a feed-in tariff, the number of biogas digesters is due to grow. According to the Ademe state-owned energy conservation agency, biogas is a potentially large resource in France, which is today largely untapped. In its 2030-2050 energy scenario, this agency forecasts 600 new biogas plants per year (half the rate of construction seen in Germany), to generate 6 Mtep of primary energy by 2030. 50% of this energy shall be used for grid reinjection, 30% for combined heat and power and 20% for direct heat usage.

The other main trend is that regulations now make it compulsory for waste-sorting facilities to sort out fermentation-able waste, to be then processed by methane production plants. The available resource for France is estimated at 425,000 tonnes / year. Given the size of its agriculture and the fact that biogas-at-farm is now taking off, France should be one of the most important growth market for biomass in Europe until 2020.

However, projects cost in France on average twice the price they cost to build in Germany. The lack of experience in the industry may be the chief reason. Until costs fall in line with German standard, the economic rationale of the industry is not clear, which represents a treat to its very development.

Power-to-Gas (methane in gas grid)

Biomethane can be injected into the gas distribution grid. The government has organised an auction scheme to ensure a “buyer of last resort” among the existing natural gas companies, providing producers with the assurance that they will be able to sell 100% of their production.

To be injected into the grid, the biogas must be produced from approved feedstocks, such as waste from agro-food industries, municipal waste and agricultural waste. Hazardous waste is not an acceptable feedstock for such use. A mechanism based on certificates of origin is in place to allow an audit trail, identifying the feedstock used to produce the gas. Certificates of origin are managed by an institute, Observ’ER.

The feed-in tariff structure is complex, prices ranging from € 45 to € 125 per MWh. The price depends on the size of the facitlity as well as on the nature of the feedstock used in input. The price is partly indexed on inflation. The tariff is granted for 15 years.

Today, there are only three reinjection plants in operation in France. Most projects rather rely on burning biogas to produce heat and power, as technical constraints are lower. Awaiting a positive decision on the possibility to inject biogas from sludge (byproduct of waste-treatment plants), there is a project led by the Communauté urbaine de Strasbourg (waste-treatment plant in La Wantzenau). This project could be of interest for Alpstore.

Overall, according to GRDF, only 280 projects for biogas reinjection are under development in France.

Biogas can also be used as a fuel for cars. In this case, its price is not linked to the feed-in tariffs for grid reinjection. Today in France, there are only some small experimental fleets of vehicles powered by biogas. The most significant is a fleet of municipal buses near Lille, in Northern France.

Power-to-Gas (hydrogen in gas grid)

We are not aware of any such commercial project currently under development or in operation in France. The Ademe agency launched calls for projects over the last years to cofinance hydrogen related projects but no significant scheme has emerged. France is clearly not at the forefront of the hydrogen economy.

Power-to-Gas (hydrogen local)

Same comment as above.

However, hydrogen as large-scale energy storage solution is considered of interest by Areva, the leading nuclear energy technology provider. One of its corporate venture investments is McPhy, a young French company developing technologies to store energy using magnesium hydrides. This technology works at low pressure and results in an “inert” solid, which should be in theory much safer than high pressure hydrogen tanks (up to 700 bars). This technology requires less energy than compression technologies or liquefaction of hydrogen using up to 33% of the energy content of hydrogen for storage. This technology also allows storing large quantities of hydrogen in containerized units which may be combined to adjust the amount of energy to be stored. Unlike batteries, the hydrogen can be used for both short and long term storage (no loss in time).

One storage unit is already operational at the CEA facilities in Grenoble. Other pilot projets are under study, not only in France.

Chemical storage (zeolite etc.)

No information available.

Compressed air storage

No such facility in France.

Pump storage (regional in Alpine Space)

In France, there are 5 GW of energy transfer stations by pumping (STEP) installed on 11 sites. The power of the pumping storage stations is dispatched mainly during peak periods as a last resort especially because of the pumping of water (power supply). During recent years in France these stations have been used to modulate 3 TWh per year.

Compared to the total installed capacity in the country, pump storage is only a small share of the energy mix and does not represent any significant energy storage capacity at country level.

The most appropriate sites have already been developed. There is little scope for expansion in France in this area.

Pump storage (Scandinavia etc.)

Not applicable

Thermal energy storage system – High temperature

We are not aware of any significant R&D nor any projects in this field in the French Alpine space nor in the country.

Thermal energy storage system – Low temperature

Same comment

Thermal energy storage system - Water

Since the 1970s, the state-owned utility EDF has pushed for the widespread usage of electrical heating and electrical water boilers in homes. The reason is that electrical heating was deemed to be able to absorb large excess capacity of electricity at night, as produced by nuclear power plants, the output of which is not easy to manage. In the same strategy, electrical water boilers are used as a large-scale distributed energy storage capacity. Water heated during night time can be kept hot in adiabatic tanks for hours, hence allowing to displace the need for heating power from peak times to more convenient times.

We do not have any figures for the aggregated power of water boilers, but it must run in the GW order of magnitude.

Thermal energy storage system - Salt

No information on this topic.

Thermal energy storage system – Materials like concrete, stones or sand

No information on this topic.

Flywheels (small-sized)

Flywheel storage installations in France are not common place. There is one R&D project in Toulouse, which is detailed later in this document.

In Rennes, the metro public transportation system carries 115,000 passengers and consumes an average of 21,000 kwh daily. A centralized system for the recovery of braking energy has been placed at the center of the line, the system stores energy from braking energy from the 24 trains with a flywheel of a rotating mass of 2.5 tons. The recovered energy is then re-injected on the line according to the power needs.

This system allows to recover 230,000 kwh per year, or 11 days of power consumption from the metro.
Developed by Keolis who operates the metro, the project cost a total of € 260,000 and was funded by HT Rennes Métropole. Different operations to save energy in the metro Rennes Métropole can save the equivalent of the electricity consumption 150 households per year. The return on investment is expected to be 14 years.

Flywheels (large-sized)

We are not aware of any large-sized flywheel in operation in France.

Mobile batteries (electric vehicles)

Studies led by EDF show that in terms of energy, the challenge of charging electric vehicles and plug-in hybrids (EV and PHEV) on the electrical distribution network represents at a horizon of 10 years, from 1 to 3% of the energy distributed in low voltage (LV) in France today. This energy will be added to the amount of energy already withdrawn from networks and modify accordingly the impact on the national load curve.

Incentives for recharging during low demand periods will be necessary to smooth this new demand. Initially, optimization of charging periods could take account of the production of renewable energy sources. In a second stage, smart grids technologies could be considered to discharge some electric vehicles in order support the electrical system (diffuse support ...). It is widely discussed under the concept of vehicle-to-grid (V2G). For a fleet of one million electric cars connected to the grid (electric vehicles plan of the French government forecasts a total of 2 million EVs by 2020), the storage capacity could reach 10 GWh. This storage capacity could be valuable at peak but it assumes that consumers have adopted the VE and good behavior when it comes to charging their vehicles.

Freshmile is currently discussing with a number of regional electricity providers interested in using the distributed energy storage capacity of electric cars to level their charging curve and source cheaper electricity for their needs on the wholesale markets.

Stationary batteries

Research on electrochemical energy storage (batteries, supercapacitors) represent more than 30 million euro annually and daily work of over 150 researchers, lecturers, engineers, technicians, graduate students, etc.. This R&D effort is spread over fifteen laboratories. 25% of the budget comes from the National Agency for Research (ANR).

The Franco-German project Sol-ion allowed to develop an integrated kit for conversion, storage

and management of PV energy, suitable for production on an industrial scale for decentralized on-grid, residential PV systems. 75 systems are currently deployed and feedback are already available which allowed to determine levels of self-consumption of PV generated electricity based on storage volumes. The technology used is Li-Ion battery (4-6 modules of 2,2 kWh). Analysis of battery aging indicates their capability to run the system over 20 years. More results are expected during 2013 test phase.

Table: Technology - EXAMPLEFehler! Textmarke nicht definiert.	Market availability	Storage period	Storage volume	Response Time	Local Option
Biogas digestion and storage	--	days	+	medium	+
Power-to-Gas (methane in gas grid)	---	weeks	+++	quick	+
Power-to-Gas (hydrogen in gas grid)	---	weeks	+	quick	--
Power-to-Gas (hydrogen local)	---	days	-	quick	+
chemical storage (zeolite etc.)	o	days	o	slow	o
compressed air storage	---	weeks	o	medium	--
pump storage (regional in AS)	+	months	+++	quick	+
pump storage (Scandinavia etc.)	n/a	weeks	++	quick	n/a
Thermal energy storage system – high temperature	o	hours	+	medium	o

Thermal energy storage system – low temperature	o	week	++	medium	o
Thermal energy storage system – water	+++	days	+++	quick	++
Thermal energy storage system – salt	o	weeks	++	medium	o
Thermal energy storage system – lithic material	o	hours	o	Very slow	o
fly wheels (small-sized)	o	minutes	--	very quick	+
fly wheels (large-sized)	o	weeks	o	very quick	o
mobile batteries (electric vehicles)	+++	hours	-	very quick	+++
stationary batteries	+++	days	-	very quick	+++

Explanation

Please complete the above matrix in, following these scales:
Market availability, storage volume, local option: +++ (best), ++, +, o (neutral), -, --, --- (worst)
Storage period: minutes, hours, days, weeks, months
Response time: very quick, quick, medium, slow, very slow

3. Renewable energy status: sources, supplies, network, market

The renewable energy share in France production has been 14,6 % in 2011, RTE forecast for 2016 is 18,3%. The renewable energy plan for France defined by the **Grenelle de l'environnement** framework presents measures to achieve an increase to 23% percent, by 2020, of renewables as a share of gross energy consumption (in line with EU Directive 2009/28/EC).

The long term reference scenario defined by RTE for 2020 and 2030 is based on the following assumptions:

- Nuclear power generation stable at 65 GW
- Renewable thermal biomass production to reach 5 TWh by 2030
- Wind generation capacity to be increased by 1,5 GW every year to reach 17 GW in 2020 and 32 GW in 2030
- Solar generation capacity to be increased by 1 GW every year to reach 8 GW in 2020 and 18 GW in 2030

The French energy production mix is dominated by Nuclear generation and despite the increase in renewables share will still represent 72% in 2020 and 67% in 2030.
While the mix structure in France results in a very competitive energy price compared to other European countries, it also offers very limited flexibility.

The French government has mandated RTE to explore a scenario based on the decrease of the nuclear generation to 40 GW by 2030, relying on an ambitious development of renewable sources as well as the mobilization of energy efficiency, demand response resources and power import increased capacity. This scenario will result in very high stress levels on the transmission network and requires the development of storage capacities to balance renewable generation intermittency.

The French government also decided to close the nuclear generation plant in Fessenheim in 2016. The two reactors of this plant provide an output of 900 MWe each, this represents two thirds of the energy consumed in Alsace region. The Alpstore roadmap for Alsace could represent an interesting contribution to a post-Fessenheim energy landscape.

France electrical system is specific because of the nuclear generation contribution to the mix but also because of a high gradient sensitivity to cold weather. The gradient of sensitivity to cold weather is the increase in power consumption depending on the decrease of temperatures, especially in winter. In France in 2011, this gradient corresponds to 2300 MW per degree of decrease of minimum temperature. This value is greater than the sum of the gradient of the continental European countries.

This is due to the fact that electrical heating is a key component of the residential demand in France, the consequence being the exceptional peak winter demand in France (92 GW in 2009) compared to other European countries (73 GW in 2009 for Germany). This peak power demand is increasing every year and the rate is 21% between 2001 and 2010. RTE forecast for 2020 is 108 MW which translates in a 35% increase since 2001. One major consequence is that France is importing electricity for a highly larger number of days in the year.

There are four levers possible to deal with this situation:

- Reduction of electricity consumption;
- Increased production of electricity from renewable sources;
- Storage of excess production base for reinjection at the peak;
- Clipping the excess consumption at the peak.

A combination of the four levers is desirable. We must also consider the impact on the comfort and the ultimate consumer behavior. Some solutions have no impact (adding the means of production into renewable energy), others are rather intrusive (automatic disconnection of consumption) or require user participation (interaction with networked meter).

In 2010, the French government released a call for tenders for the installation of 95 MW of wind farms on French islands, the technical specifications of this tender required storage technologies to be integrated to the wind generators, in order to promote the emergence of technologies that reduce the impact of wind turbines to the power grid, and make possible a significant increase in the share of renewables in the intermittent electricity production of these territories, currently limited to 30%.
Following the examination of proposals received by the CRE, the Government has identified nine projects across all DOM and Corsica.

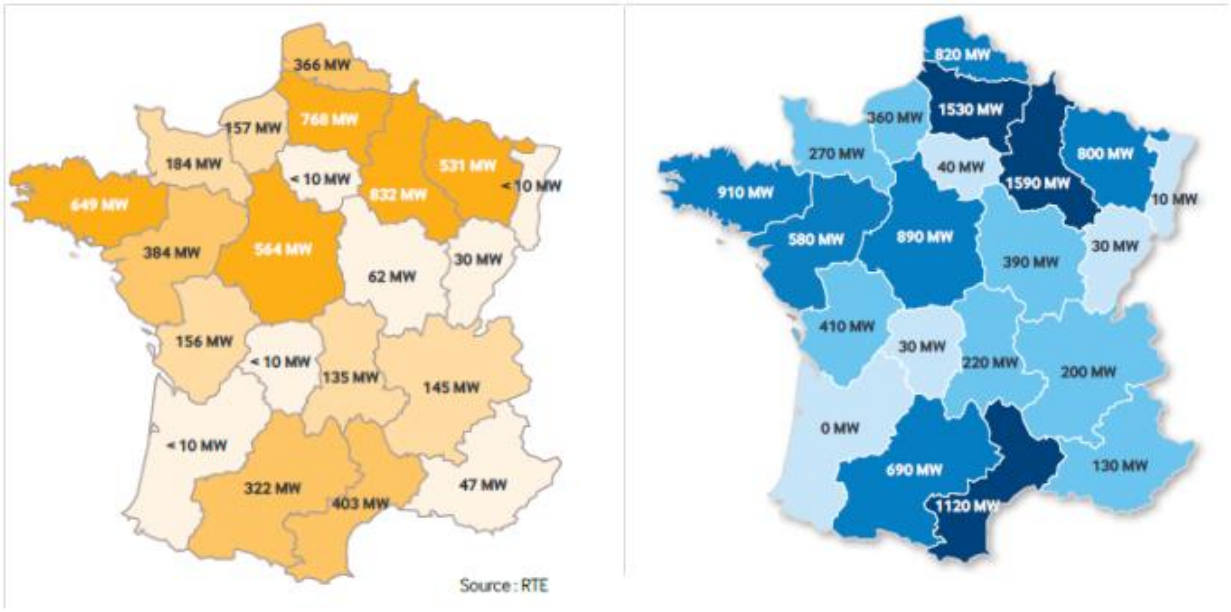
In addition, the government has also launched in 2011 a call for tenders for the photovoltaic power exceeding 250 kWp. It has a lot dedicated to specific for ground solar installations located in Corsica or in the DOM, and integrating storage devices of the energy produced. The specification includes the conditions for energy storage and the daily forecasted production to be met.

National renewables plan

Under the EU Directive 2009/28/CE, the French government defined a national action plan defining the goals for the development of renewable energy sources at the 2020 horizon. ADEME publishes a yearly dashboard showing the progress made by every sector regarding the goals. The 2011 barometer shows that the 2012 and 2020 goals will most probably not be met for wind and solar generation.

Power and energy generation								
Year	2011	2016	%	2011	2016	%	2020	%
	Power Generation GW			**Energy generation TWh**				
Nuclear	63,1	64,7	51%	407,9	429,8	74%	430,2	72%
Coal	6,9	2,9	2%	19,1	12,2	2%	10,7	2%
Gaz Combined Cycle	3,8	6	5%	15,4	20,2	3%	21	4%
Oil , Combustion turbine, Demand Response	10,2	6,1	5%	2,5	2,1	0,4%	1,3	0%
Decentralized thermal not renewable	7,6	4,7	4%	23,2	10,7	2%	9,8	2%
Decentralized thermal renewable	0,8	1,1	1%	3,3	6,7	1%	8,5	1%
Hydro generation & step	25,2	25,2	20%	67	69,4	12%	69,4	12%
Wind	5,8	11	9%	9,7	22	4%	35,8	6%
PV	0,9	4,5	4%	0,6	4,8	1%	8,4	1%
TOTAL	124,3	126,2	100%	548,1	577,9	100%	595,1	100%

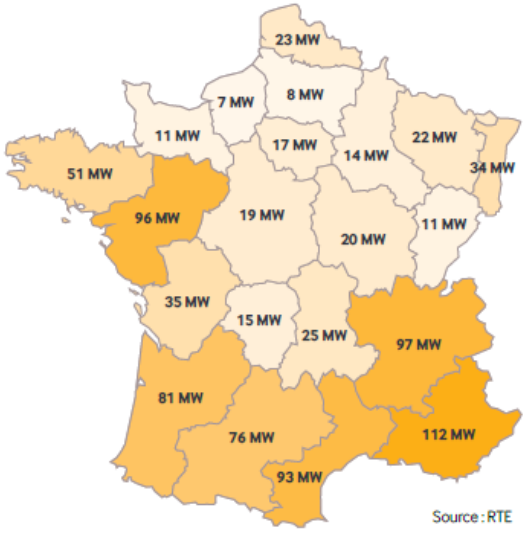
Table: Mean scenario for yearly average power and energy production (Source RTE)



January 2011 wind capacity = 5,8 GW 2017 forecasted capacity = 11 GW

2020 plan wind capacity = 25 GW (19 GW onshore – 6 GW offshore)

Figure: Wind Power Capacity installed in MW in 2011 and forecasted in 2017 (Source RTE)



January 2011 Photovoltaic capacity = 900 MW

2020 plan Photovoltaic capacity = 5,4 GW

Figure: Solar Power Capacity installed in MW in 2011

4. Institutional framework

- CRE (Commission of Regulation of Energy)
  CRE contributes to the smooth operation of energy markets for the benefit of the consumer.
    - Regulating electricity and gas networks
        - Guaranteeing the right of access to public electricity grids and natural gas networks and facilities
        - Ensuring the proper functioning and development of electricity and liquefied natural gas networks and infrastructure
        - Ensuring the independence of system operators
        - Contributing to building the European Internal Market for electricity and gas
    - Regulating the electricity and gas markets
        - Monitoring transactions on the electricity, natural gas and CO2
        - Ensuring the proper functioning of retail markets
        - Contributing to the implementation of measures to support electricity generation and supply of electricity and gas
        - Informing all consumers

- Agence Nationale de la Recherche (ANR)

The National Agency for Research is an administrative public establishment created in 2005, whose mission is to increase the dynamics of the French research and innovation system. On energy storage, the ANR has supported a research program named STOCK-E. Calls for projects
were launched from 2007 to 2009 with a total funding capacity of 20 M€. The ANR 2010 program includes the storage technologies in research programs PROGELEC "Production renewable
and power management "and SEED" Systems Energy Efficient and low-carbon. "

- Agence De l'Environnement et de la Maîtrise de l'Energie (ADEME)

ADEME is a public industrial and commercial institution, under the joint supervision of Ministries of Ecology, Sustainable Development, Transport and Housing, Higher Education and Research and the Economy, Finance and Industry. ADEME participates in the implementation of public policies in the areas of the environment, energy and sustainable development.
ADEME has been mandated to manage on behalf of the State Stimulus funds of up to 2.85 billion euros. The energy storage technologies are addressed by the "demonstrators and technology platforms in renewable energy and green chemistry " (1.35 billion euros), in which a call for expressions of interest was open from April to August 2011.

- Centre National de Recherche Scientifique (CNRS) and universities

CNRS is leading several research themes mainly addressing the heat storage, the hydrogen vector and electricity storage. In this last area, the research on electrochemical storage focus on materials and electrolytes of lithium-ion batteries, nickel / metal hydride, metal-air, in order to increase the capacity, reliability, and cyclability aging of the batteries.

- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA)

CEA has made its entry into the world of batteries with a newer version of the lithium technology to develop a competitive advantage. CEA conducts breakthrough research on the electrodes, to achieve by 2015 technical performance that would, in the case of an electric vehicle, allow to reduce the half the weight of the batteries.

- Institut Français du Pétrole et des Energies Nouvelles (IFPEN)

In the field of energy storage, IFP Energies Nouvelles focuses on power storage for embedded applications, especially for electric and hybrid vehicles. The IFPEN is also working on the development diagnostic and control tools and methodologies for batteries and supercapacitors, and on physical models and simulation tools for storage systems (Ni-MH, Li-ion, and supercapacitors).

- Réseau National de Recherche et Technologie sur le Stockage d'Énergie Électrochimique

A national network of Research and Technology of the batteries was created July 2, 2010. This network aims to accelerate innovation and the development of industrial activity in the field of batteries. To this end, the network brings together key national actors public research and industry. Network relies on CEA and CNRS, two national research centers working closely together.

Besides these agencies, the relevant ministries also deal with renewable energy strategies, especially the ministry of environment.

5. Policy initiatives and plans

The energy storage is the subject of efforts in research and development in France. These efforts mobilize both public and private institutions of basic and applied research, the equipment vendors and network operators or electric heat.

Storage is regarded as a key element to consider in the coming years: DGEC speaks of a "very promising driver of de-carbonized energy" and new storage solutions are tested in different demonstrators: Millener, Nice Grid, Pegasus, etc..

Four priority issues were identified:

- storage systems must take into account all environmental issues (analysis of life cycle type);
- economic valuation of the storage device must be incorporated in the design;
- the development of industrial processes must be accompanied (where the idea of launching demonstrators);
- the institutional and regulatory framework conducive to the deployment of storage must be defined.

The two main objectives of the current works are on one hand to develop competitive technologies and associated industrialization processes compared to solutions without storage, and identify relevant economic models based on the many uses of these technologies. On the second part, these studies rely on demonstration projects and actual uses to verify the technical and economic performance of energy storage solutions.

These include, on the one hand, to reduce the loss of self-discharge flywheels and supercapacitors, and secondly, to increase:

- responsiveness and range of sites relevant to STEP water pumping;
- the energy efficiency of CAES, via thermal storage;
- the lifetime of the electrolysers and fuel cells;
- energy density and lifetime of electrochemical batteries;
- density and thermal storage competitiveness through new materials.

6. Legislation

The laws and regulations in France do not contain specific provisions for energy storage devices. Such devices are now apprehended by their action on the networks.

Thus, any entity storing electricity must pay the fee applicable to consumers using electricity when the electricity is withdrawn from the network to charge the storage device and pay the fee applicable to producers when the storage device injects electricity to the public electricity grid. This mechanism is the one which is today applied to energy transfer stations by pumping (STEP) which are, in terms of their use of public electricity network, in a comparable situation.

The proposed new directive on energy efficiency resulting from a compromise between the Council of the European Union and the European Parliament, was formalized by the latter September 11, 2012. This draft Directive explicitly mentions the storage of electricity and provides that national regulators should ensure that network tariffs do not prevent network operators and suppliers to offer energy efficiency services as displacement of the peak consumption to off-peak periods, the load shedding mechanisms, the development of distributed generation or energy storage.

The capacity market under the NOME law could include an obligation for the storage of electricity. Works for the definition of this market are currently ongoing under the auspices of the Réseau de Transport d'Electricité in consultation with all actors electrical industry.

7. Market

ADEME has conducted a study of the possible future scenarios for the development of the storage market in France.
Four major scenarios have been identified:
1 = Targeted deployment by vertical sector
2 = Niche market for storage aggregators
3 = Generic storage technologies but low penetration
4 = Generic storage technologies with storage operators and a growing market

Scenario 4 offers the best optimization track of energy systems and the more interesting alternative solutions to the consumer, it necessitates to create the right technologies and business models and a clear political vision and policy.

The main technological barriers are:

- Total cost of manufacturing, dismantling and recycling
- Global efficiency
- Self discharging
- Lifetime

The R&D priorities are:

Stationary systems =

- Increased lifetime
- Improve the intrinsic safety
- Systems adapted to mass storage
- Lower costs

Mobile systems =

- Improved energy and power densities
- Cost reduction
- Characterization and modeling of aging
- Improve the intrinsic safety

Network support services that storage can provide in French market :

- participate in the production / consumption balance;
- smooth the peaks and reduce the consumption of fossil fuels;
- avoid investment in new power plants for peak consumption;
- limit stop / starts of thermal plants and improve the performance of power plants;
- compensate for intermittency (eg wind-free period) by a transfer of energy over several days;
- smooth the intermittent generation (photovoltaic and wind);
- enable the development of renewable energies beyond 30% in ZNI (isolated areas);
- contribute to system services;
- overcome blackouts (backup);
- improve the quality of the voltage…

8. R&D

- **Venteea project (Li-ion grid batteries)**

ERDF (Electricité Réseau Distribution France) has launched the Venteea project at Troyes in the Aube region, which aims to demonstrate the integration of wind energy into the electrical grid.
The Aube region is one of the regions concentrating wind power in France. The solutions to be tested in the Venteea project will seek to smooth out fluctuations in the wind power generation and reduce disturbances in the grid (20 kV). In addition the project will explore the possibility of developing storage options for the wind energy.
Funding support for the project is being provided by the Agency for Environment and Energy Management (L'Agence de l'Environnementet de la Maîtrise de l'Energie, ADEME).

- **Greenlys project (electricity production and EV storage)**

GreenLys project is led by distribution networks managers like ERDF and GEG, as well as suppliers and producers of energy, GDF SUEZ and GEG and focuses through a global systemic vision on the sociological dimensions, environmental, economic and technological smart grid. The challenge is to predict the widespread deployment of smart grid solutions proposed and tested by GreenLys.

GreenLys is a full-scale technology demonstrator that will experiment with solutions for:

  - Create a self-healing grid, more automated and intelligent but also more communicative based on the new generation of smart meters;
  - Increase the penetration of distributed generation integrated on the grid, mainly using renewable energy with photovoltaic and electric vehicles for decentralized energy storage;
  - Develop and test the equipment and services of the future to consumers seeking their active participation, and better understand their relationship to electricity (cost, environmental impact ...)
  - Imagine the business model and future regulatory taking into account all the issues;
  - Contribute to the control of energy and to reduce consumer bills through the development of teleservices .

- **Nicegrid project (Li-ion batteries for grid and residential applications)**

Located on the territory of Carros in the department of Alpes-Maritimes, Nice Grid project develops the electrical system of the future seamlessly integrating a high proportion of production of photovoltaic electricity, local units of energy storage and communicating energy management devices installed in the residences who volunteered to the program.

The project will demonstrate the effectiveness and flexibility of electricity storage with integrated Li-ion batteries on three levels of the distribution network, for a total of 2.7 MW:

  - storage at a substation in the area of Carros, who will liaise between the RTE and ERDF networks: Lithium-ion 560 kWh / 1.1 MW;
  - five sets of built-in storage in the low voltage network to handle peaks of consumption and photovoltaic production, allow islanding plan and manage the voltage plan: lithium-ion batteries kWh/100 310 kW;

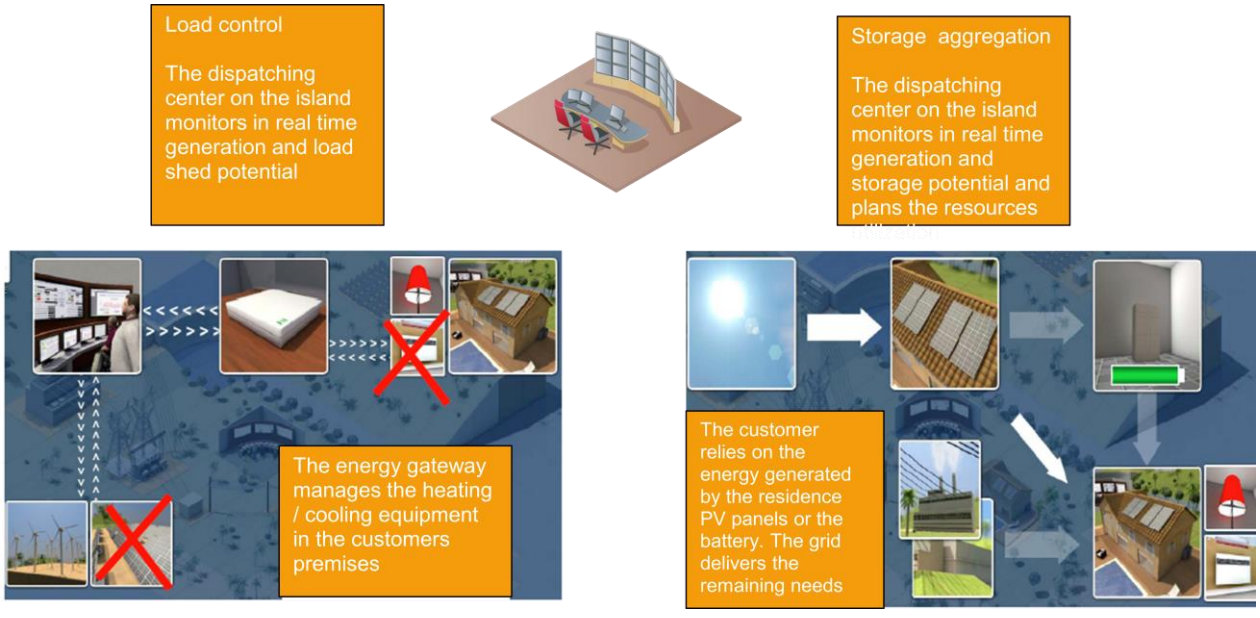
- one hundred storage facilities in residential customers premises willing to contribute to the management of load: lithium-ion 6.6 kWh / 3 kW. Li-ion technology proposed and developed by SAFT's goal is to ensure performance consistent with the requirements of the program, particularly in terms of calendar life, cycle life and energy efficiency.

The storage will help to optimize power flows within an intelligent network and increase its capacity of integration of intermittent renewable energy. The project will also test multiple features, among other peak shaving injection and consumption, islanding or effective management of multiple producers and consumers decentralized network.

- **Millener project (Li-ion residential batteries)**

In Corsica, Guadeloupe and Reunion, the project MILLENER (Mille energy management facilities in the islands), a Smart grids demonstrator, funded by the Research Fund of ADEME, aims to reduce the consumption of electrical end-users and to better integrate intermittent renewables in distribution networks in order to guarantee real-time balance between electricity demand and production. It takes into account the specificities of a non-interconnected network, such as islands, and the need to educate end-users to control their consumption.
The Millener project is one of the first in Europe to integrate management of a thousand diverse distributed energy resources at the edge of the distribution grid. Various combinations of distributed resources will be deployed including solar generation, battery storage and energy load controllers. Volunteer private electric consumers enrolled in the program will also be provided with visualization of their energy consumption, allowing them to monitor their electricity use in real time. EDF will manage all these distributed energy resources via a centralized control system deployed in each region to optimize operational, financial and environmental performance of the electrical network.

- Testing methods and innovative technical equipments to produce and store electricity from distributed renewable energy sources installed at residential customer premises
- Assessing, and optimizing processes equipments to manage power demand (peak shaving / peak shifting) and energy demand
- Studying customer behavior regarding energy gateway, electrical appliances (electric water heaters, AC…) and smart appliances – work on customer empowerment



- **GRYHD project (Hydrogen in distribution network)**

Led by GDF SUEZ, this project aims to convert hydrogen to electricity from renewable energy produced outside peak hour demand. The project proposes to transform into hydrogen the unused power and inject hydrogen into natural gas networks. This project will thus provide a solution to the energy system flexibility coupling the electricity and natural gas through the hydrogen production, and to maximize the share of renewable energy integrated into the French energy.

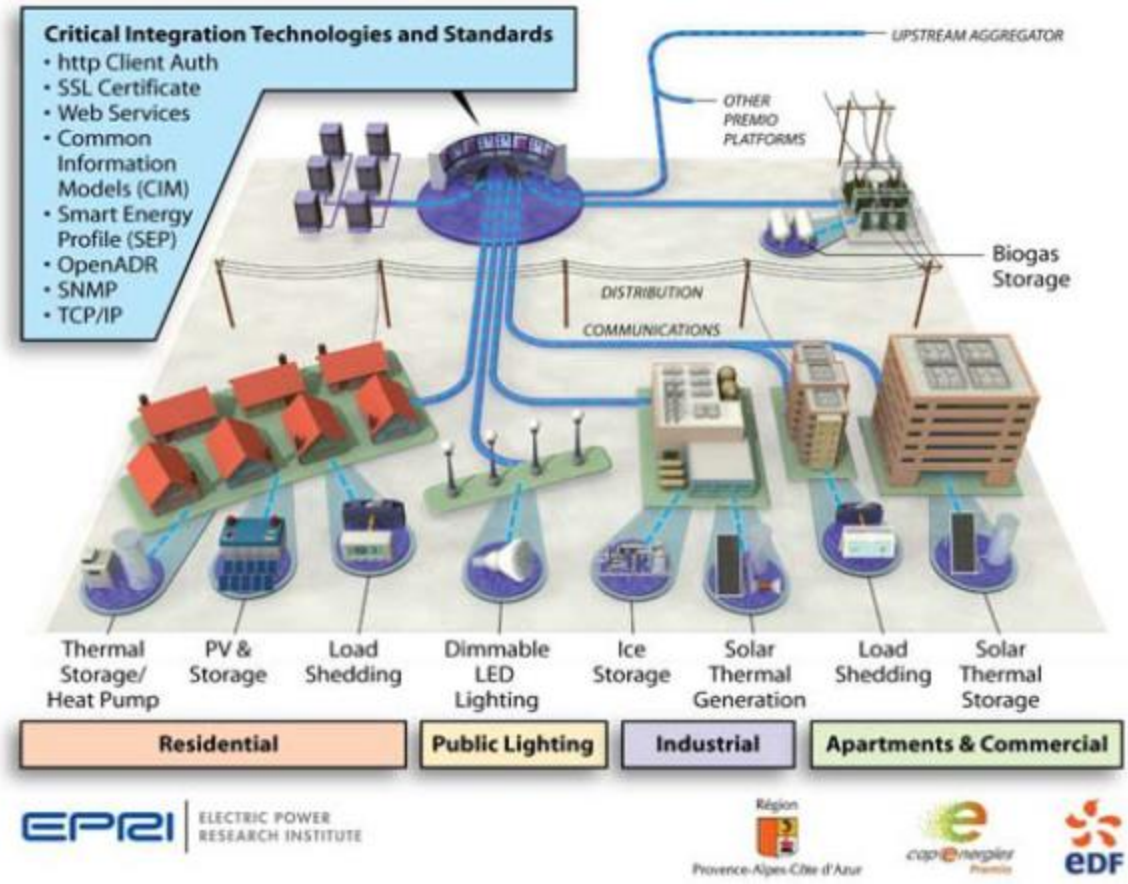
This project will begin with a preliminary phase of study for about 2 years. It is composed of two demonstration projects:
- A project to promote Hythane ® fuel on an industrial scale. CNG bus station will be adapted to hydrogen-natural gas, up to 6% hydrogen and then to 20%.
- A project base on injection of hydrogen into a distribution network for natural gas. A new neighborhood of about 200 homes will be powered by a mixture of hydrogen and natural gas, in varying proportions of hydrogen limited to a maximum of 20% by volume.

Both pilot projects are for a period of 5 years. They will assess the technical, economic and environmental energy sector and this new work in collaboration with communities and residents. The results will assess the relevance of storing renewable energy in the form of hydrogen to maximize the value of renewables, produce and market fuel with less carbon responding to environmental challenges and new eco-city neighborhoods, and provide a new lower carbon fuel to bus fleets and / or communities Vehicles.

- **Premio project**

PREMIO is primarily a technical proposal created to address the following goals in the PACA region:

- to develop a dynamic demand-response at local level,
- to integrate Distributed Generation and especially renewable energies,
- to reduce greenhouse gas emissions from polluting peak power plants
- to manage regional electrical energy from a wide range of local actors
- to increase the flexibility of the power system,
- to promote a new energy culture which encourages energy efficiency



- **PEGASE Réunion island (Sodium grid battery)**

The electrical system on the island of La Réunion has specificities like a high penetration of intermittent renewable energy which will reach, by 2013, the threshold of 30% of intermittent power production.

In addition, the electrical system, because of its small size, is inherently more fragile than large continental interconnected systems with greater risk of rupture of the instantaneous supply / demand balance, including variations related to sudden and large amplitude of intermittent renewables.

To meet these challenges, the Pegase project aims to optimize the supply-demand balance, to better integrate renewables in the generation mix of the island and improve the stability of the power system, by coupling, for the first time in France, a solar farm and / or wind (from 3 to 10 MW) with a storage battery NaS (1 MW) in a production plan that will include the production forecast. The storage battery installed in the town of Saint-André (1 MW) is an experimental facility to restore a power of 1 MW for 7 hours and thus reduce emissions of greenhouse gases by limiting the use means the thermal peak.

- **MYRTLE (fuel cells)**

Located in Corsica on the site Vignola, near Ajaccio, Mission for renewable hydrogen for grid integration (MYRTLE) aims to develop a system and a control strategy to improve the management and stabilization of the

grid in island area. The project goal is to study the feasibility of peak demand clipping and smoothing the photovoltaic power output (to limit fluctuations and disturbances on the grid).
Launched in 2007, the project includes a platform coupling 3700 m2 of photovoltaic panels (installed capacity of 560 kW) and an electrolyzer, which converts electricity into hydrogen and oxygen during times of low consumption. This energy is then returned via a fuel cell, which converts hydrogen and oxygen into electricity on the network during times of high consumption, that is to say, the night when the solar panels do not produce.

- **ADEME storage program**

On 4 May 2011, the French government has launched a call for expressions of interest (AMI) dedicated to energy storage and led by ADEME. With the overall objective of contributing to the emergence and spread of new systems, the AMI mainly target the component or complete energy storage system, manufacturing process and its first experimental validations.

The objectives are:

  - help reduce the cost of use to ensure the best economic competitiveness;
  - minimize environmental impact throughout the life cycle and control the security in the use of these technologies;
  - experiment, under conditions of actual use, the different technological solutions to validate the upstream industrial deployment;
  - to experiment with new business models.

- **Stock-E R&D program**

Taking into account the position of the French industry in the areas of electricity generation, transport vehicle, rail and air, the Agence Nationale de la Recherche (ANR) decided to launch the Stock-E program in order to stimulate research to improve systems and to remove some technological obstacles in the area of energy storage.
The call for proposals launched in 2010 is structured around several modes of energy storage (electrical, thermal, mechanical, magnetic, pneumatic, magnetocaloric hydraulic, ...) and introduces the storage in the energy management.
In addition, given that about half of the energy used in the European Union is used to heat buildings, heat storage could allow reduce both the energy dependence and the rejection of greenhouse gases.
This call has selected 10 projects:

CAP – Compressed Air Assistance Truck

CARBOLEAD 2010 - New carbon grids for light lead batteries

CONIFER - Design and innovative tools for smart grid applied to railway

LiO2 - Development of a high density lithium-air accumulator

MagCool - New materials with magnetocaloric giant effect around room temperature and application to magnetic refrigeration

MICMCP - Using Identification Methods for Characterization of Phase Change Materials (PCM)

SACRE - Storage by Compressed Air for Electricity Network

SoliBat - Batteries "all solid" developed by Flash Sintering

STAID - Inter Seasonal Storage of Thermal Energy in Buildings

Stock Air2 - Thermal Storage Heating thermodynamic air housing

- **STEEVE (EV batteries)**

STEEVE is a technology platform for electrochemical energy storage for electric vehicles for the manufacturing of batteries in small batches from materials synthesis to the mounting in a vehicle. It aims to bring together the expertise and resources of all components of the electrochemical storage: CEA, CNRS, EDF and the National Institute for Industrial Environment and Risks (INERIS).

This platform, unique in Europe, has two test labs 400 m² and saves batteries for niche applications or operations demonstration. It will have a capacity of approximately 1000 kWh / month which is a sufficient amount of batteries to power electric 50 vehicles / month.

- **PROCYiON (Li-ion battery)**

  The project PROCYiON aims to develop Li-ion technology batteries systems (battery, electronic components and packaging) mainly for:

  - urban transport (buses, trams, etc.). requiring very high power densities during phases of braking and accelerating,
  - and stationary applications for the support of electrical networks in the event of failure or coupling with intermittent renewable energy (solar, wind) requiring energy densities (up to 250 Wh / kg) and high power (3 kW / kg) for long lifetimes.

Several challenges need to be addressed by the partners, and in particular:

- synthesis on an industrial scale of new electro-active materials,
- development process of implementation of these materials in the pilot scale
- the development of new performance models vis-à-vis thermal and mechanical properties of the system,
- recycling of rechargeable batteries developed as well as process losses (loss of material during the fabrication process) and faulty production.

- **SETHER (Thermal storage)**

The SETHER project will address all R & D preliminary implementation of a solution of electrical storage (capacity 100 to 1000MW), using breakthrough technology.

Patented by Saipem (ENI Group), project partner, it is based on a thermodynamic cycle in which electrical energy is stored as heat in refractory materials heated to high temperature (sensible heat storage) and then returned when electricity demand appears (on peak for example).

The storage facility comprises two chambers (one chamber for high temperature and another low temperature chamber) interconnected by turbomachines. During the storage phase, the electricity is used to drive a heat pump which transfers heat from a low temperature chamber at high temperature chamber.

During the discharge phase, the heat of the high temperature chamber is converted into mechanical energy by a turbo-compressor which drives a generator of electrical energy. Preliminary studies have shown that the overall performance of 70% is achievable with the existing turbomachinery.

- **PUSHY (Solid hydrogen)**

The project PUSHY (Potential Use of Solid Hydrogen) aims to create an innovative industry in the area of industrial hydrogen through 2 offers: OSSHY and LASHY.
OSSHY (Solid Hydrogen On Site): The OSSHY offer consists of on site use of hydrogen production capacity by electrolysis of water and a solid storage for continuity of industrial activity under optimal security.
LASHY (Local Alternative Solid Hydrogen): The LASHY offer brings into contact producers of renewable energy with industrial hydrogen markets. This offer is based on the installation on renewables production sites of an electrolyser, a hydrogen storage and a management service for the production of hydrogen, called "arbitration system."

- **INGRID (Solid Hydrogen)**

The INGRID project system consists of the production of hygrogen from renewable electricity by electrolysis, then storing hydrogen in solid form to be reused for creating electricity via a fuel cell, or supplying the market hydrogen.

A first industrial demonstrator will be installed in the Pulia region (Southern Italy), an area where are located many wind farms and photovoltaic plants.

The interest of this project is threefold:

  - Act on the balancing of the grid, allowing to store unused electricity and discharge this energy in the network as requested.
  - Supply the Hydrogen market, delivering at customers consuming hydrogen hydrogen-filled solid storages solid.
  - Test mobility by providing the electricity generated from the hydrogen to the point of charge of the electric vehicle.

The energy storage capacity of 39 MWh, will include a new fast response hydrogen generator of 1.2 MW and a solid hydrogen storage technology of more than 1 ton of hydrogen stored safely, the largest facility ever built!

- **HYPER (Hydrogen & Fuel cell)**

The HYPER project aims to develop and commercialize a flexible mobile platform, consisting of a hydrogen storage and a fuel cell for energy supply.

To validate the integration between storage and fuel cell, two systems are being developed:

  - 100 We for example charging applications.
  - 500 We used for extended autonomy for drones.

- **Smart ZAE (Flywheel)**

The project aims to show that through the renewable means of energy production, low environmental impact storage and BMS (Building Management System), a business area economic zone (ZAE) may constitute an "elementary brick " of the electric distribution network promoting:
renewable production means of energy, consumption from the network distribution reduction, support to the network balance when necessary, and establishing a link between economic actors to create value.
The project will be developed on a site near Toulouse, already equipped with 125 kW of PV and 15 kW of wind. A flying wheel of 10 kW will be developed to equip the site with an inertial storage capacity of 100 kW in 2012.

- **SEARCH (CAES)**

The SEARCH project supported by the National Research Agency (ANR) aims to study an adiabatic CAES heat storage media on ceramic and buried cavities in the granite (Line Rock Cavern - LRC). It includes four partners: GDF Suez, Saint Gobain, CEA and ANR Armines and runs over the period 2009-2013 with a budget of 4.8 million euros.

APPENDIX and supplementary material

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b. Key contacts and resources
c. Other material

Review of existing sources and literature

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