Energy storage technologies for electric vehicles and future power systems

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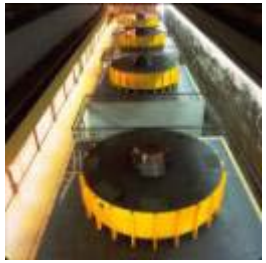
Program presentation

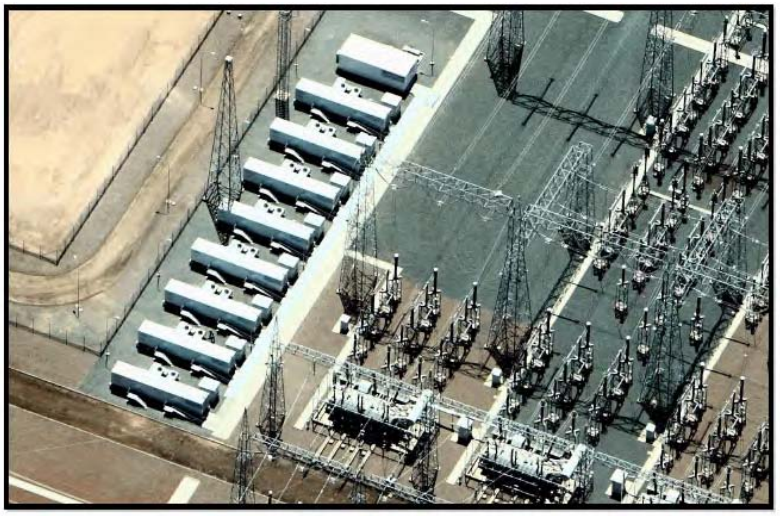
- ✓New applications for batteries
- ✓Overview on electrochemical battery technologies available
- ✓EDF Projects
- ✓Conclusions

Batteries : Today applications for networks



- Emergency for nuclear and hydraulic plants & Substations (UPS)
- PV Isolated sites
- Few EVs
- Experimentation grid stability and Renewable integration

Tomorrow : new applications with batteries are possible



The growing share of intermittent energy sources increases the need for flexibility

Ambitious European and national energy policies : => Opportunity for storage

Energy policies promoted by the EC and Member States design a new context for European power systems

Main trends are :

- Consolidation of a decarbonated generation mix
- Development of renewable energy sources (RES)
- Demand Response
- Adaptation of the physical infrastructure (mainly in transmission and distribution)
- Integration of electricity markets to improve use of the generation and transmission infrastructure and reduce price volatility **both in time and location**

Share of intermittent RES in Europe in 2012 and targets for 2020

Countries	Installed capacity (GW) 2012*	% National mix 2012	2020 Objectives
Spain	28.9 22.5 + 0 + 6.3	22 %	29 %
Germany	63.9 31+ 0,3 + 32.6	12.4 %	26 %
UK	10.6 5.9 + 3 + 1.7	5.6 %	22 %
France	11.6 7.6 + 0 + 4.0	4.0 %	12 %
Italy	24.5 8.1 + 0 + 16.4	9.7 %	8 %
USA	67.7 60 + 0 + 7.7	3.7 %	6 %
China	83.6 75.3 + 0 + 8.3	2.5 %	6 %

Sources : EUROBSERV'ER, EREC, GWEC, IEA, REE, GOV.UK, AGEE, RTE, RenewableEnergyWorld, Gov.cn

Why electrochemical storage ?

- Reactivity (instantaneous availability)
- Flexibility "taylor made" P & E design
- Decentralization and environmental acceptance
- Development potential still important (performance & technology has other applications ...)
- Good prospects for reducing cost (market development)
- Durable and recyclable materials
- Existence and development of a global industry

Electrochemical storage systems are likely to constitute an asset of the electrical systems of the future

A lot and different « use cases » in study ! including : Renewable / Smart grids / Evs…

DECENTRALISED RENEWABLES

RESIDENTIAL STORAGE

RENEWABLES FARMS

SMART GRIDS

DISTRIBUTED STORAGE

EV-PHEV CHARGE

V2G/V2H

5 storage Systems classes

- EV / PHEV systems
- DESS (ie residential)
- Intermediate ESS
- Power ESS (ie FR)
- Energy transfert ESS

5 storage Systems classes

SYSTEM CLASS					
	EV/PHEV	**DESS**	**Inter ESS**	**ESS Power**	**ESS Energy**
Applications (examples)	e-mobility	self-storage & back up Residential with PV	Peak shaving, investment deferral Substations / smart grids / micro isolated networks	Frequency & Voltage regulation / Ramping - Weak networks	Load levelling, Energy transfert Renewale Farm integration
Typical Size	60kW / 20 kWh	3kW / 5-10 kWh	100 kW / 300 kWh	1MW / 500-1000 kWh	1MW / 4-10 MWh
Battery technologies	Li ion / LMP	Li ion / Pb	Pb / Li ion	Li ion (comp. FW, SC)	NaS/ Zebra / Li ion (comp. CAES, STEP, Redox..)
System features	Cells packaged + BMS	Cells packaged + BMS + Inverter	cells + racks + BMS + Inverter + Shelter w/wo cooling	cells + racks + BMS + inverters + PCS + container + cooling	cells + racks + BMS + inverters + PCS containers/building + cooling

Battery technologies used and limitations

Objectives for batteries

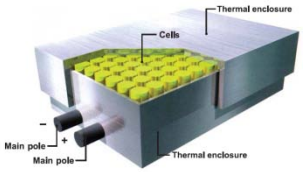
- **Performances @ systems levels :** seems good, to be improved for EV
- **Durability :** to be demonstrated, new technologies seems good
- **Safety and societal acceptance :** to be demonstrated, seems possible
- **Cost :** to be improved, key point, markets ?

The battery families

Lead acid (Pb, VRLA…)

Alkaline (NiCd, NiMH, NiZn ..)

Na (Zebra Na-NiCl2, NaS)



Lithium (Li ion, Li Métal Polymer…)

What best storage technologies ?

- Hydro pumping : The reference for centralized storage
  - The lower cost technology and mature
  - Not very flexible but work is in progress
- Compressed Air : Progress are possible
  - Very expensive today
  - New generations in development
  - Tomorrow costs close to Hydro ?
- Redox Flow : Many systems are under development for stationary applications, to be followed.
- Lead acid : Low cost but lower performances and questionable reliability, lead not dead..
- NaS : Large experience
  - Proved technology for some applications
  - Recent safety problems
  - Cost improvement by kW ?
- Lithium : The future technology for a lot of applications ?
  - Performance and cost prospects are good if markets develop but limited by cost ?
  - Safety should be studied and better demonstrated
  - New technologies ? Na-ion, Li-S, Me-Air…

Cost with LiB

EV Battery pack :

For EV Market : 50k-100kVE$_{20kWh}$ / Year / Car maker

300-400 $/kWh, <2015 ?

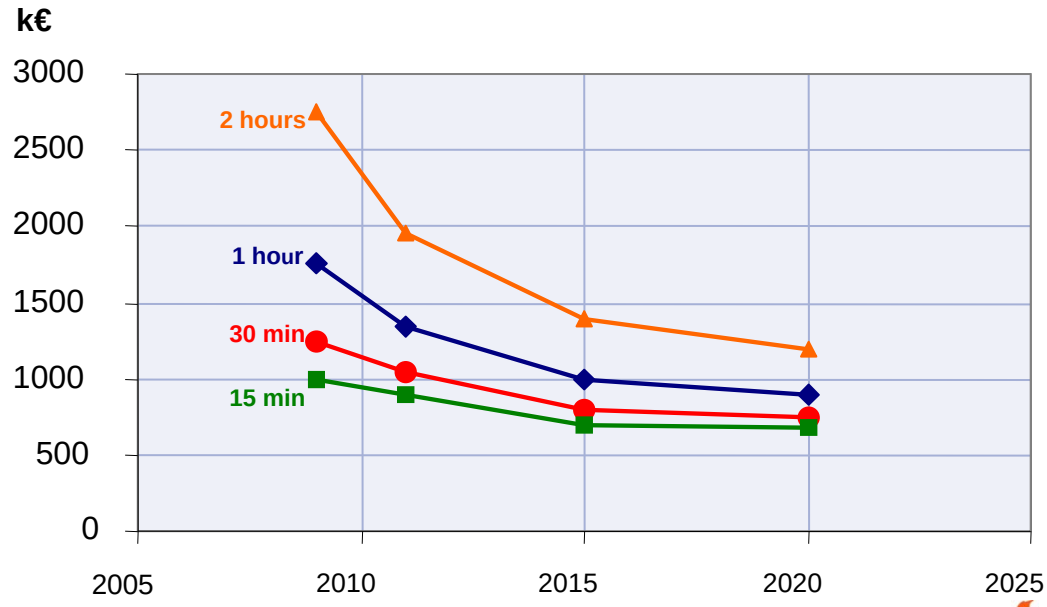
200-300 $/kWh in 2020 ? Less ????

DESS 3-5 kW (2h) :

Today = >15 k$

Cost objective for mass market = <5k$

Large ESS :



Full investment cost for stationary Lithium-ion battery (1MW- X h)

EDF Projects with batteries

Some EDF Projects including batteries

➢ NaS La Réunion Project	Study (>2006-2010)
➢ Pegase Project	Study (2010-2014)
➢ Millener Project	Demonstration (2010-2014)
➢ Nice grid Project	Demonstration (2011-2014)
➢ Ventea Project	Démonstration (2012-2015)
➢ FR Project	Study/Demo (2012-2015)
➢ Kaw Project	Business (>2013)
➢ Toucan Project	Business (>2014)
➢ …	

Example EDF Project - La réunion island

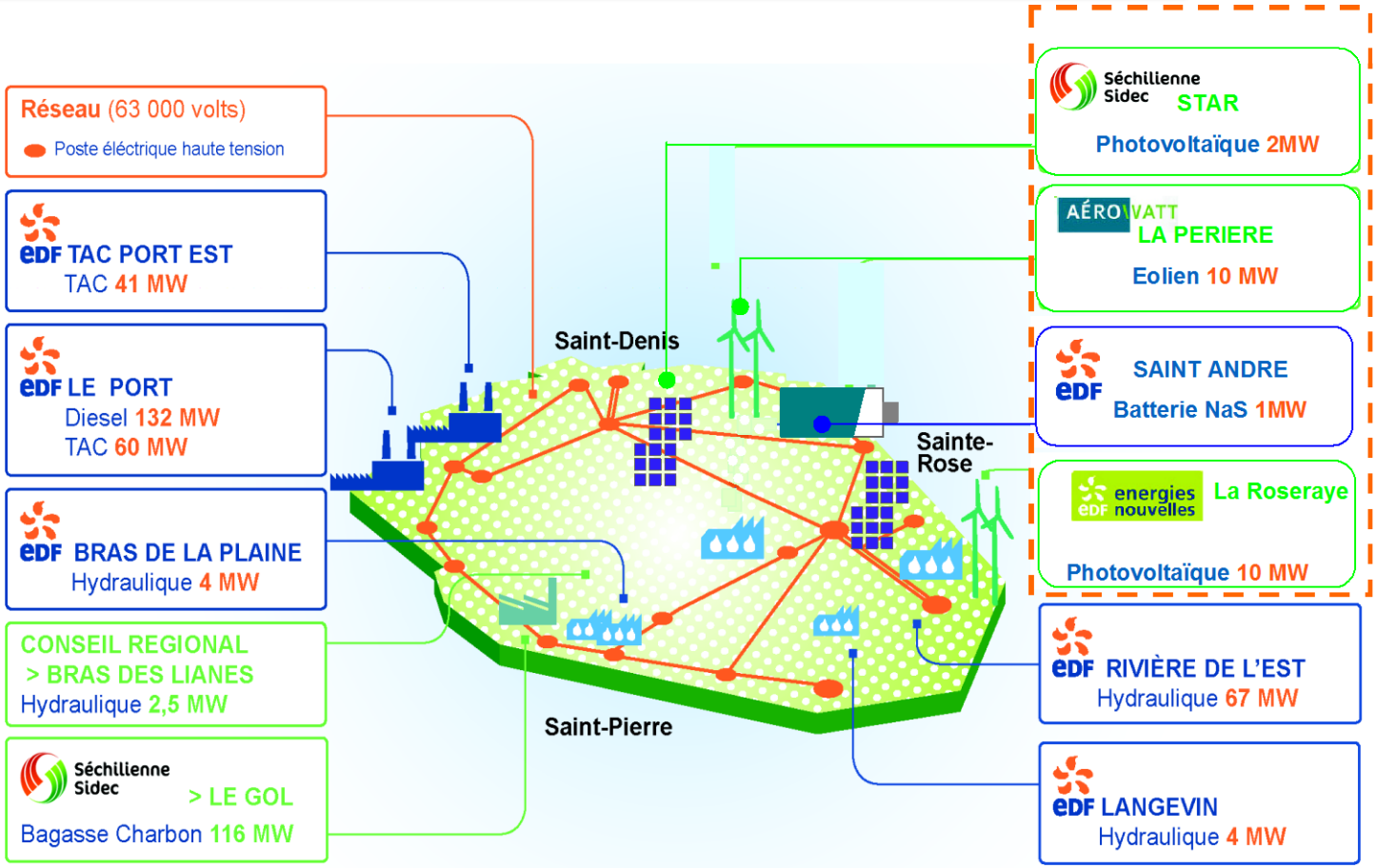
Daily energy transfer.
From 2006 : Installation & Operating NaS, Experience feedback

Battery NaS 1MW – 7,2 MWh. EDF Substation 63kV/15kV Saint André.

Source EDF SEI La Réunion.

Pegase Project

Experimental project for the management of intermittent sources based photovoltaic and wind farms using the energy storage in combination with better weather forecasts.



MILLENER Project : DESS for residential purposes in islands

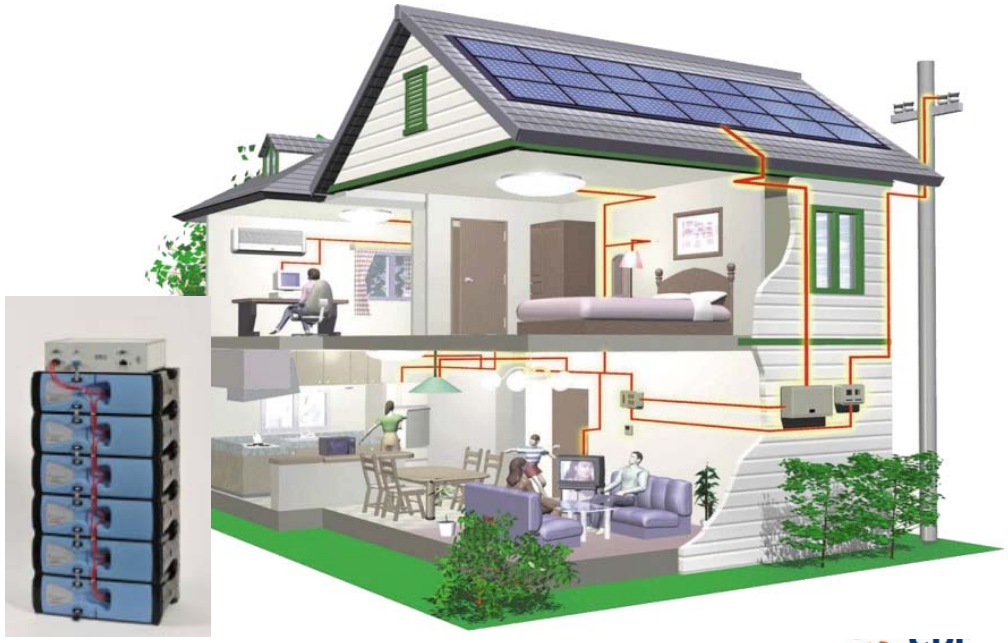
Objectives:

- ✓To develop test methods and operating tools for managing intermittent renewable energy such decentralized production
- ✓To demonstrate the operation of photovoltaic systems associated with electrochemical storage devices implemented in 350 residential customers

Consortium :

EDF, edelia GROUPE EDF, DELTA DORE, bpl GLOBAL BETTER POWER LINES, saft, Sunzil, Schneider Electric

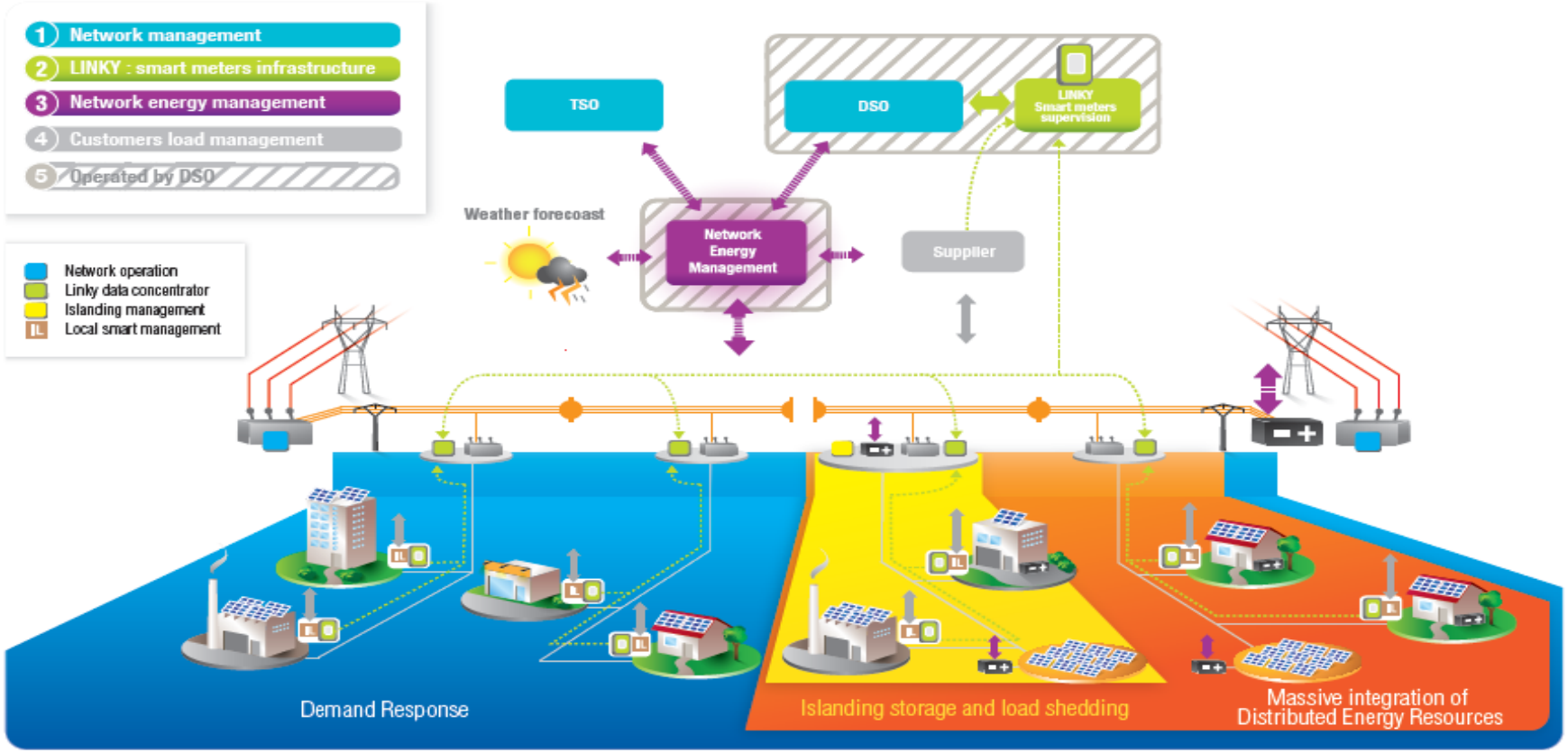
Funding ADEME, Régions Guadeloupe, Réunion et Corse



EDF

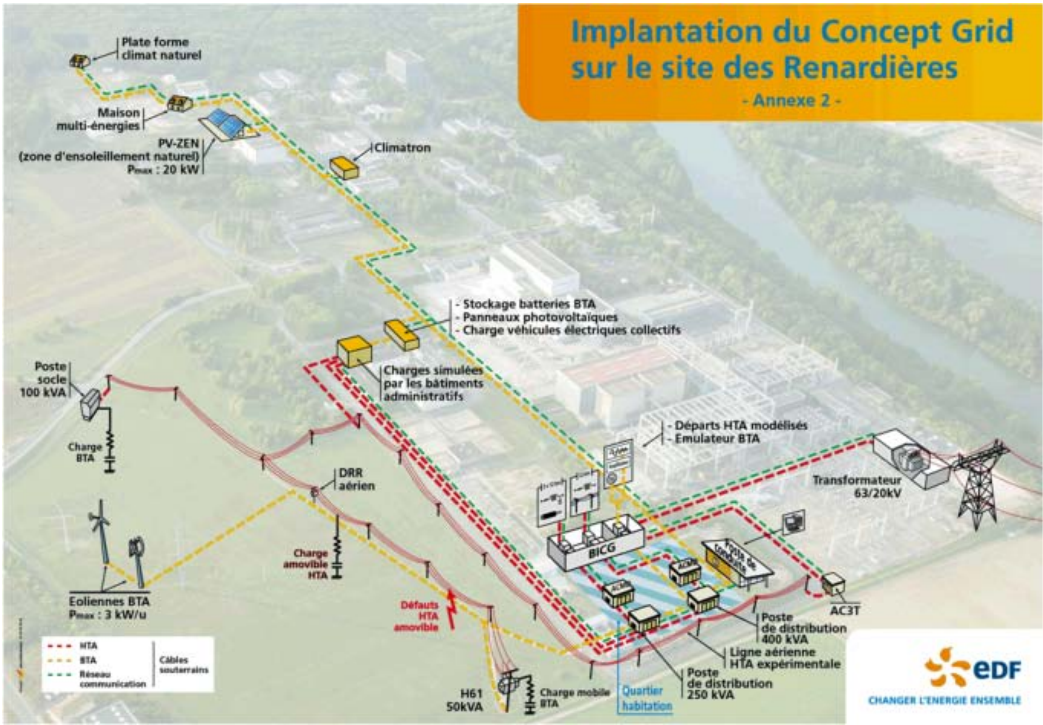
Nicegrid & Grid4U

4 use cases : **Islanding**, **Reduce** power demand, **Manage** maximized PV production on LV network regarding constraints and flexibility programs, **Encourage** resident to adopt smarter habits according to network state

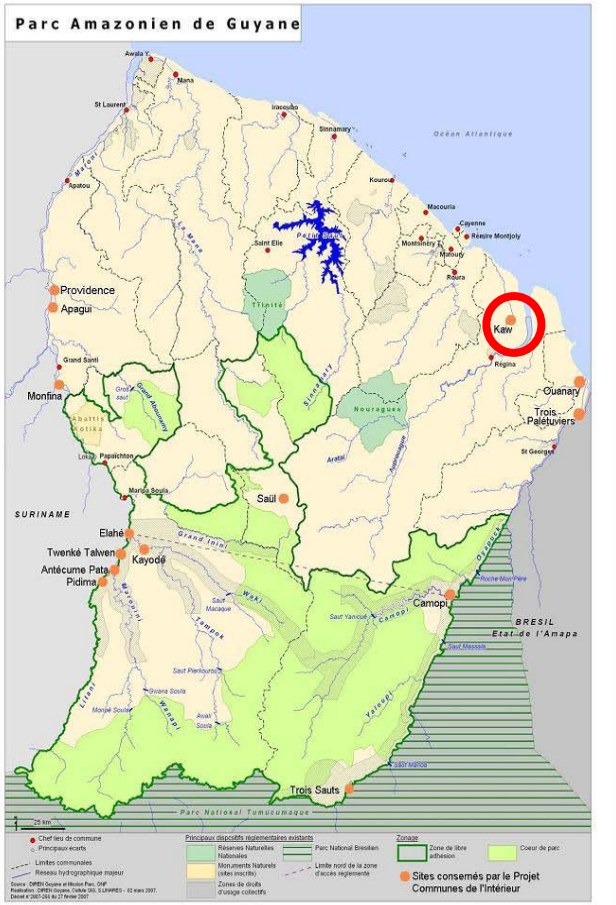


Frequency regulation project @ EDF

- Project :
  - Call for offers
  - Installation1MW pilot system @ EDF R&D
  - Validation of correct technical operations (frequency setting in the current french regulatory context)
  - Checking the batterie ageing
- Planning :
  - Installation pilot system 2014 on EDF Concept grid plat form
  - Tests and studies till 2015 end
  - Transfert on real field
  - Deployment from the project results



KAW hybrid Power plant



KAW : A non connected village accessible only by boat

- **100 kWc PV (800 m²)**
- **2x80kVA genset**
- **1.250 MWh Pb batteries**

- ***Objectives :*** Reducing operational costs compared to a conventional PV plant by implementation of new batteries management systems to optimize genset fuel consumption

Conclusions

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- New applications with batteries are possible and expected including a lot and different « use cases » : Renewable integration/ Smart grids / EVs…
- Electrochemical storage systems are likely to constitute an asset of the electrical systems of the future.
- Lithium should be the future technology for a lot of applications but cost remains the key point depending on markets evolution and especially EV development. Safety is also to be highly considered.
- For stationary applications in future power networks other technologies are still in the competition (other chemistries, Redox, Compressed air, FW..).
- New business projects start for batteries in power systems

MERCI

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