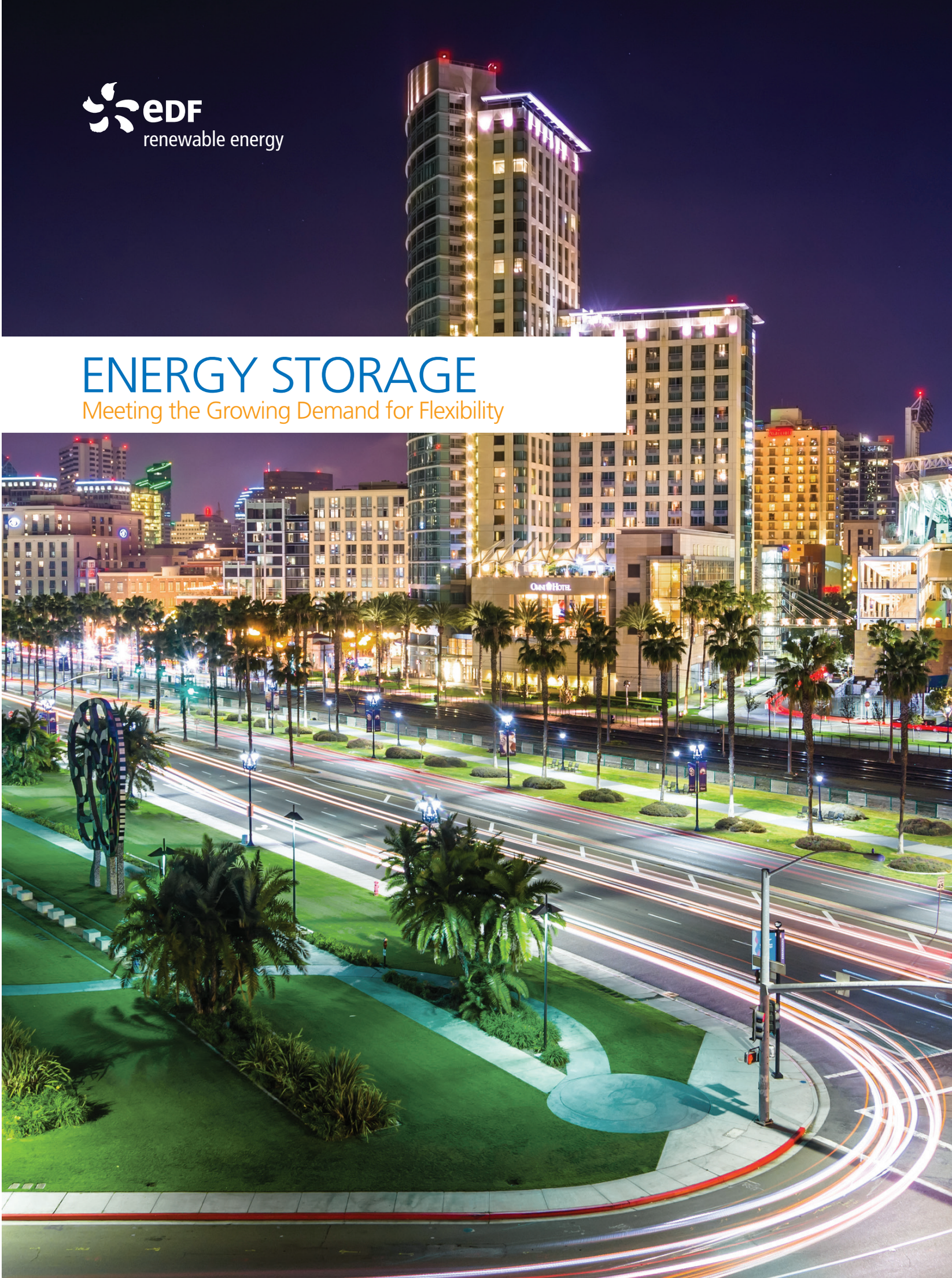
EDF renewable energy

ENERGY STORAGE

Meeting the Growing Demand for Flexibility



The EDF Group meets demand for flexibility with energy storage

As a major global electricty operator, EDF manages a significant number of industrial assets to meet the needs of more than 37 million customers. Ensuring a supply-demand balance around the clock requires significant flexibility in the resources.

With major advances in storage technologies and cost reductions, primarily for batteries, EDF is proactively investigating and testing services and value streams that distributed storage can provide to various locations, such as behind the meter, distribution, and transmission level interconnections.

ENERGY STORAGE

Energy storage systems instantaneously dispatch energy, dramatically increasing resiliency and stability in power systems. Batteries and other storage technologies are also an attractive, cost-effective addition to intermittent energy generation projects.

Battery Energy Storage Operational Capacity

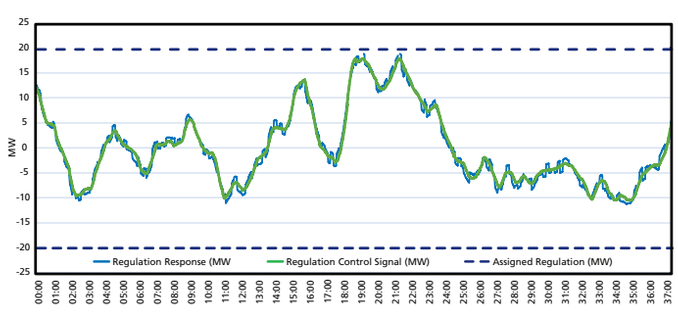
EDF participates extensively in the distributed energy market, currently operating in excess of 330 megawatts (MW) / 824 megawatt-hours (MWh) of battery storage worldwide, including:

- Illinois stand-alone storage
  20 MW
- French overseas territories
  11.7 MW / 21 MWh
- Distribution grids in continental France
  4.5 MW / 3.2 MWh
- Bulk generation power plants
  300 MW / 800 MWh

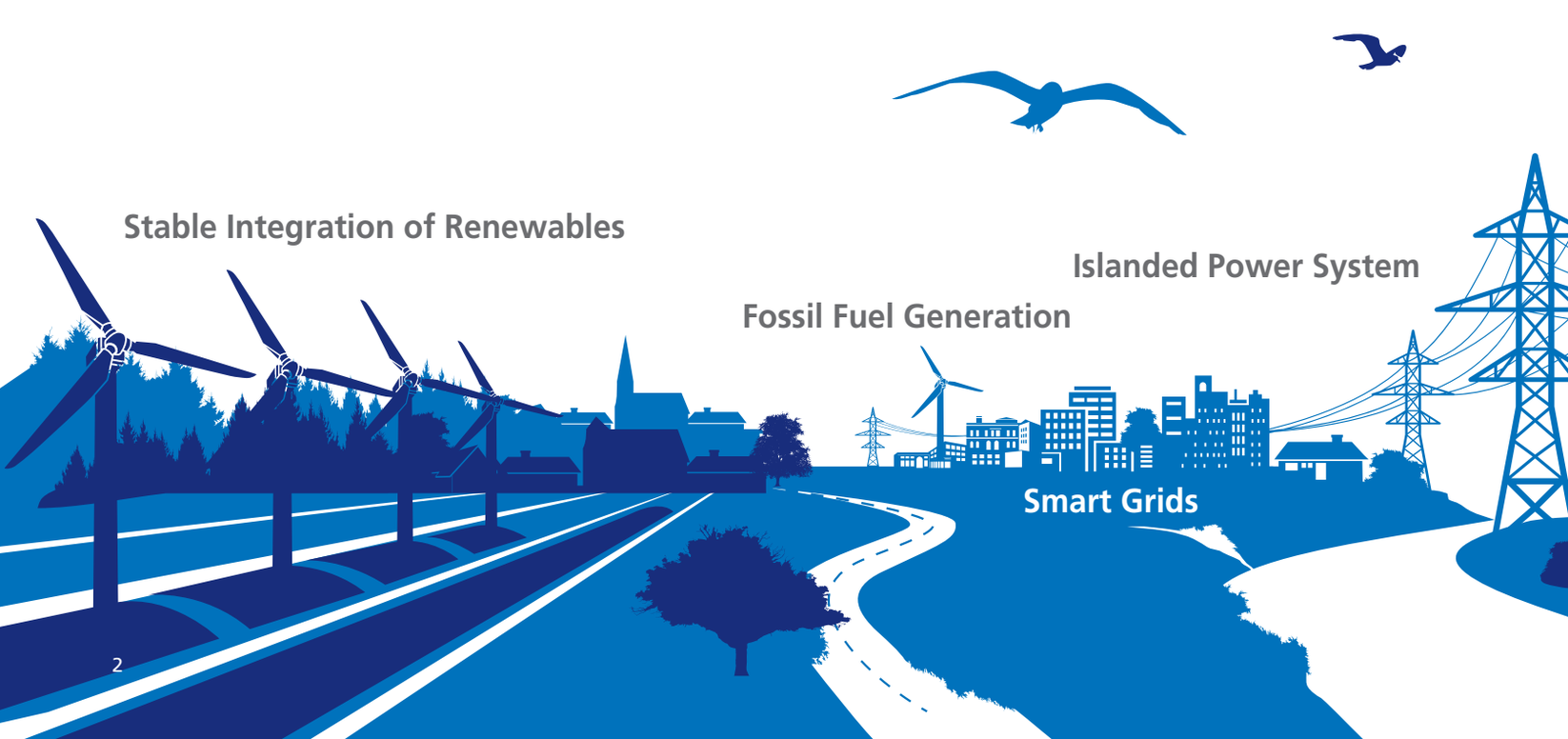
An additional 100 MW of energy storage systems (ESS) is in development in the U.S. market.

McHENRY STORAGE PROJECT • ILLINOIS

- **20 MW stand-alone storage**
- **Balancing function on the PJM network**
- **Participating in primary control PJM market**
- **Reg-D resource in PJM's frequency response market**



STORAGE APPLICATIONS



Strengths of a Battery Energy Storage System:

- Rapid and flexible response
- Accurate and stable output
- High round-trip efficiency
- Operation as both generator and load
- Easy and quick installation
- Low operating costs

Rapidly Advancing Technology Delivers:

- Decreasing capital cost
- Longer life
- Greater safety
- More recycling options

Providing Valuable Services to Grids and Energy Markets:

- Grid support during a frequency event like the loss of generation
- Power sources for frequency disturbance recovery and voltage support
- Absorbing and smoothing the fluctuations of renewables
- Energy shifting from peak production periods to peak consumption periods
- More accurate forecasting of renewables production
- Reliable back-up power for nuclear, fossil and hydro plants

Resulting in:

- Better frequency regulation
- Higher grid penetration of solar and wind plants
- Deferred upgrades to existing infrastructures
- Avoided activation of expensive generation units
- Avoided or deferred investment in expensive transmission lines or substations
- Increased reliability and lower cost of power supply
- Reduced CO_2 and less dependence on fossil fuel resources

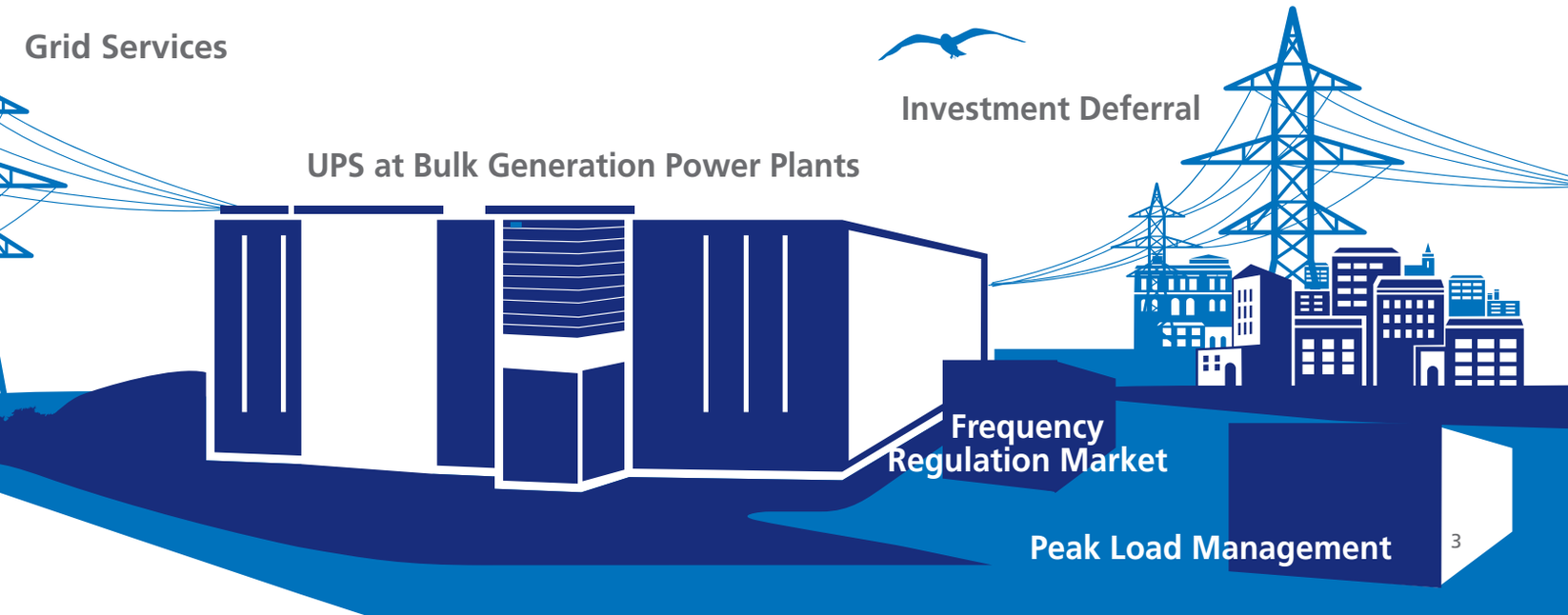
FREQUENCY REGULATION

FREQUENCY RESPONSE

FLEXIBLE CAPACITY

LOAD SHIFTING

LOAD FIRMING



EDF DISTRIBUTED STORAGE PROJECTS

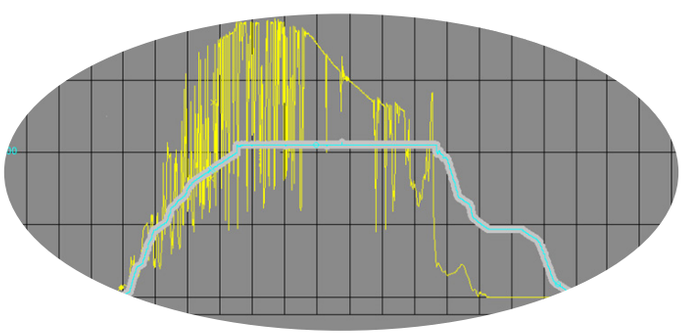
TOUCAN PROJECT

FRENCH GUYANA (SOUTH AMERICA)

- 5 MWp photovoltaic plant with 2 MW / 4.5MWh storage
- Yearly production 5,900 kWh (4,000 households in Guyana)
- 20-year project life
- Operational December 2014

Makes solar production grid friendly:

- Smooths intermittent production (no fluctuations due to the weather)
- Shifts energy to meet evening peak demand
- Provides ancillary services (frequency and voltage regulation)
- Forecasts production (day ahead and hour ahead)



FREQUENCY REGULATION MARKETS

- **WEST BURTON - NOTTINGHAMSHIRE | UK**
  Size: 49 MW
  Status: Development
  Completion Date: 2018

- **McHENRY - ILLINOIS | UNITED STATES**
  Size: 20 MW
  Status: Operational
  Completion Date: 2015

- **LES RENARDIERES - PARIS | FRANCE**
  Demonstration project for grid balancing and frequency regulation software and algorithms
  Size: 1 MW / 600 kWh
  Status: Operational
  Completion Date: 2014

RENEWABLES INTEGRATION

- **REMIRE-MONTJOLY | FRENCH GUYANA**
  Firming, shifting and forecasting of PV production
  Size: PV 5 MW / 4 MWh
  Status: Operational
  Completion Date: 2015

- **TOUCAN | FRENCH GUYANA**
  Firming, shifting and forecasting of PV production
  Size: PV 5 MW / 4.5 MWh
  Status: Operational
  Completion Date: 2014

- **PEGASE PROJECT | REUNION ISLAND, INDIAN OCEAN**
  Demonstration of storage coupled with PV
  Size: 1 MW / 7 MWh
  Status: Operational
  Completion Date: 2011

ISLANDED POWER SYSTEMS

Fully autonomous hybrid power plants (PV + diesel + storage)

- **PROVIDENCE | FRENCH GUYANA**
  Size: 1 MW / 1.25 MWh
  Status: Operational
  Completion Date: 2015

- **TALUHEN | FRENCH GUYANA**
  Size: 1 MW / 1.25 MWh
  Status: Operational
  Completion Date: 2015

- **KAW | FRENCH GUYANA**
  Size: 1 MW / 1.25 MWh
  Status: Operational
  Completion Date: 2009

GRID SERVICES FOR UTILITIES

- **VENTEEA - TROYES | FRANCE**
  Utility demonstration project for development of software and algorithms
  Size: 2 MW / 1.3 MWh
  Status: Operational
  Completion Date: 2015

SMART GRIDS AND HYBRID APPLICATIONS

- **CONCEPT GRID - PARIS | FRANCE**
  An experimental R&D platform to validate smart/ micro-grid elements and functions under real conditions
  Size: 1 MW / 500 kW
  Completion Date: 2014

- **NICE GRID - NICE | FRANCE**
  A smart solar district
  Size: 1 MW / 600 kWh
  Status: Operational
  Completion Date: 2014

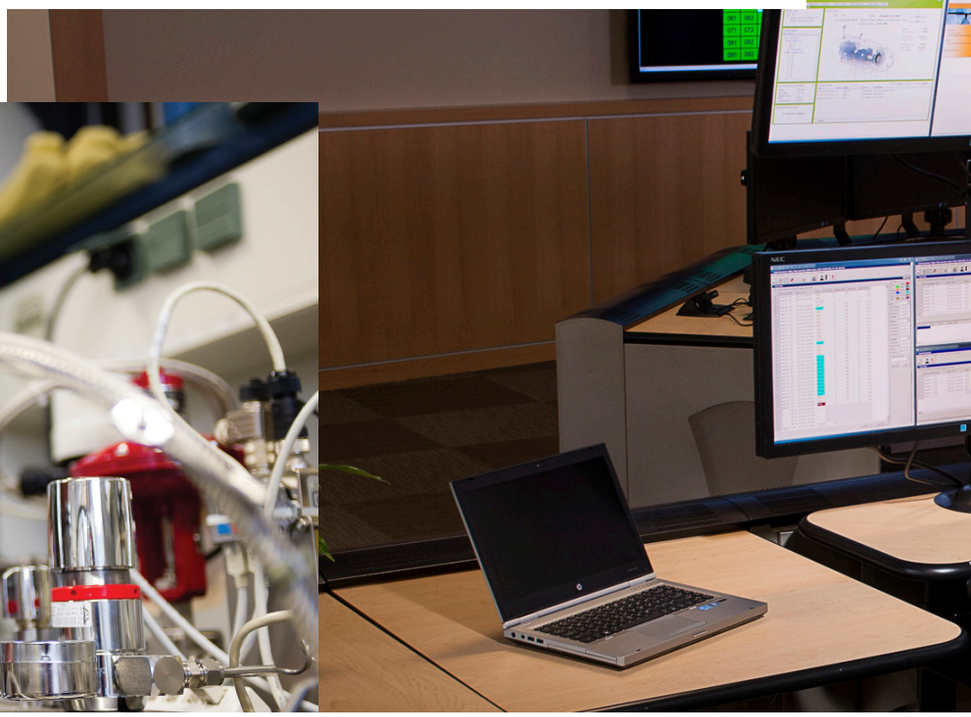
- **PREMIO - LAMBESC | FRANCE**
  A virtual power plant optimizing the integration of distributed generation, storage and demand response
  Size: 100 kW
  Status: Decommissioned
  Completion Date: 2009

UPS AT BULK GENERATION POWER PLANTS

- **VARIOUS PROJECTS | FRANCE**
  Size: 300 MW / 800 MWh
  Status: Operational

Concept Grid, an experimental R&D platform to validate micro-grid elements and functions in real conditions prior to deployment.

BATTERY ENERGY STORAGE R&D ACTIVITIES AND EXPERTISE



Over 30 EDF Innovation researchers bring their advanced level of expertise to various aspects of energy storage. EDF researchers are dedicated to providing research and development, actionable results, and active support to EDF business units, including EDF Energies Nouvelles, EDF Renewable Energy and EDF Store & Forecast. EDF Innovation capabilities have been applied to a wide range of projects in critical areas:

- **Basic research on electrochemistry and development of new battery technologies at lower costs and/or improved capabilities**, including groundbreaking zinc-air cells (14 patents, highest worldwide cycling performance).
- **Characterization of commercial electric vehicle (EV) and stationary storage technologies** at dedicated testing facilities (accelerated aging, harsh conditions, etc.).

- **Evaluation of large commercial systems in real-life conditions at Concept Grid**, a unique smart-grid demonstration platform and testing facility.
- **Development of simulation tools and models to support battery storage system design** as well as analysis of applications and single or multi-services provided by energy storage in current and future contexts.
- **Comprehensive assessment of storage use cases** including ancillary services, active power smoothing, grid investment deferral, self-consumption, islanding, electric vehicles, etc.
- **Development of battery storage scheduling and real-time control systems** for commercial projects.
- **Economic and regulatory evaluations** (Europe, Asia, North America) including cost-benefit analysis, vendors' landscape and trends, stakeholders, business models evaluations, etc.

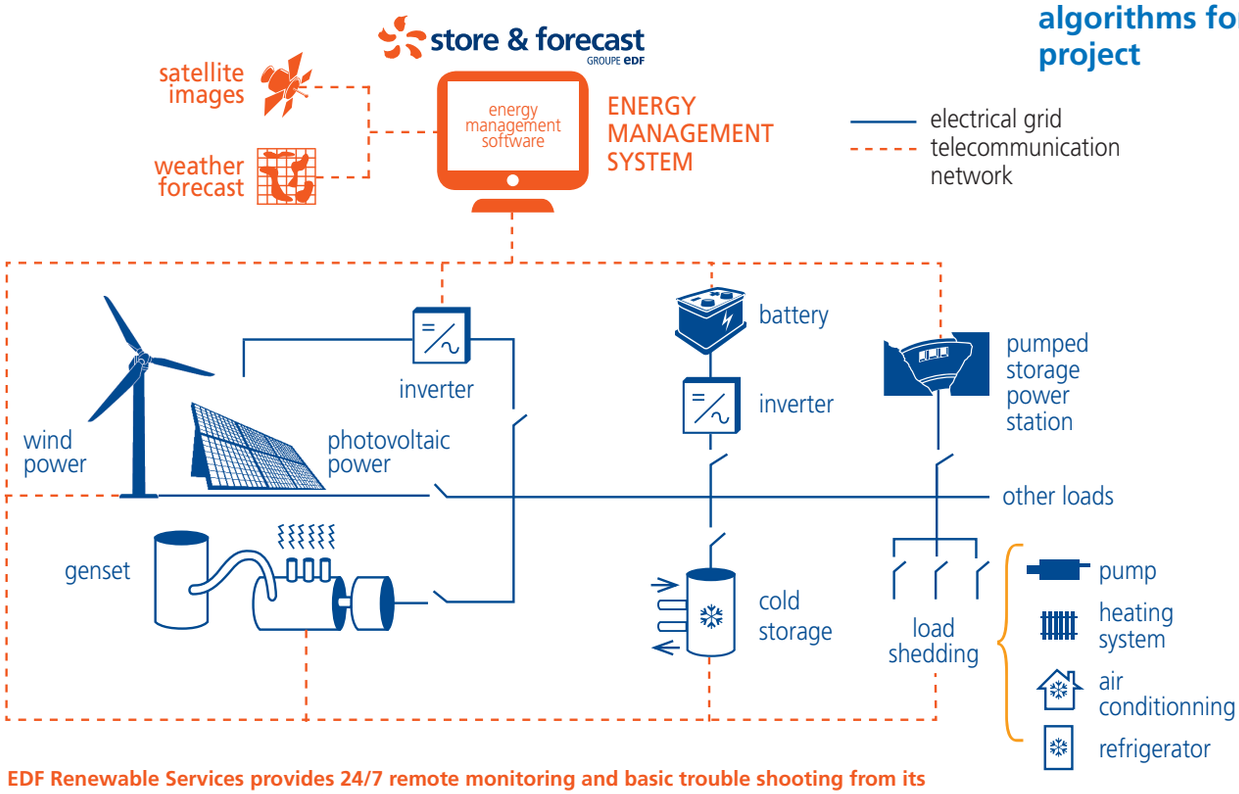
To support these efforts, EDF Innovation has developed strong partnerships with numerous energy storage entities, including The Electric Power Research Institute, Inc. (EPRI), the Joint Research Center of the European Commission, storage manufacturers, leading universities, and others.

EDF researchers also contribute to storage standardization and industrial initiatives such as IEC's TC120 Electrical Energy Storage Systems and EPRI's Energy Storage Integration Council (ESIC).

- **Advanced forecasting tools precisely predict photovoltaic and wind production**
- **A smart control system coordinates production with storage facilities and demand**
- **EDF develops and customizes energy management algorithms for each project**

COMMAND AND CONTROL

Wind and solar energy by nature are intermittent and unpredictable. Their rising penetration rate intensifies the imbalance between supply and demand and creates electrical system instability.



EDF Renewable Services provides 24/7 remote monitoring and basic trouble shooting from its Operations Control Center (OCC). The facility is staffed around the clock, 365 days a year, with trained and experienced operation technicians.

The O&M team services over 10 GW of electricity in the United States, Canada, and Mexico.

EDF ENERGIES NOUVELLES
GLOBAL RENEWABLE ENERGY PRESENCE

NORTH AMERICA

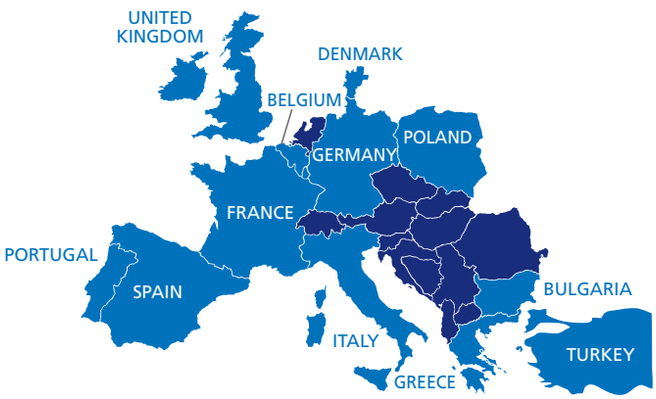
4,089 MW INSTALLED CAPACITY

Canada	Wind/Solar	576 MW
Mexico	Wind	392 MW
United States	Wind/Solar/Biogas/ Biomass/Storage	3,121 MW

SOUTH AMERICA

146 MW DEVELOPMENT

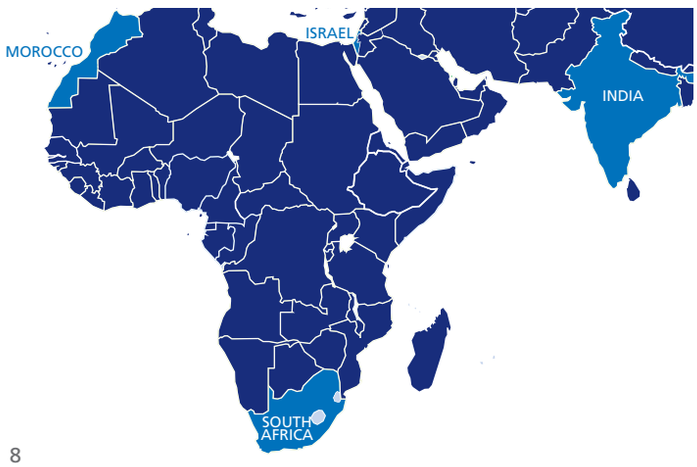
Chile	Solar - Development



EUROPE

4,456 MW INSTALLED CAPACITY

Belgium	Offshore	325 MW
Bulgaria	Small Hydro	63 MW
Denmark	Wind - Development	
France	Wind/Solar	1,401 MW
Germany	Wind	3 MW
Greece	Wind/Solar	277 MW
Italy	Wind/Solar	448 MW
Poland	Wind	106 MW
Portugal	Wind	535 MW
Spain	Solar/Biomass	83 MW
Turkey	WInd	625 MW
UK	WInd/Offshore	590 MW



AFRICA/INDIA/MIDDLE EAST

448 MW INSTALLED CAPACITY

Israel	Solar	159 MW
India	Solar	181 MW
Morocco	Wind - Development	
South Africa	Wind	108 MW

as of 6.30.16

As leaders in the global energy market, EDF Energies Nouvelles with EDF Renewable Energy, its North American subsidiary, develop, construct, own, and operate a diverse portfolio of energy projects in North America and Europe with projects in 27 states and 21 countries.

KEY FIGURES

as of 12.31.15

1,139 M€
Consolidated revenues

211 M€
Net income group share

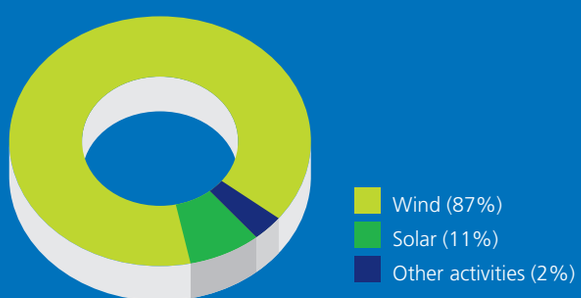
824 M€
EBITDA

3,029 EMPLOYEES
Worldwide

Scope owned by EDF: CR = 833 M; EBITDA = 818 M; NI-GS =203 M

CAPACITY

as of 6.30.16



GENERATION ACTIVITY

8,989 MW GROSS
5,826 MW NET
Installed

1,620 MW GROSS
Under construction*

10.4 BILLION kWh
Green energy generated in 2015

COMPLEMENTARY ACTIVITIES

3,201 MW
Developed, built and sold

14,323 MW
In operation and maintenance*

** For own account and for third party*

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