Integrating renewable power plants with battery storage





Enel Green Power

Okinawa, February 2nd 2015

Outline

- Enel and its subsidiary for Renewables: Enel Green power
- RES and opportunities for storage integration
- EGP Projects and integration of Renewables IPP with battery storage
- Possible Business models and Regulatory framework

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Enel today

An international energy operator

Presence in
40 countries ▪ 4

Installed capacity
99 GW

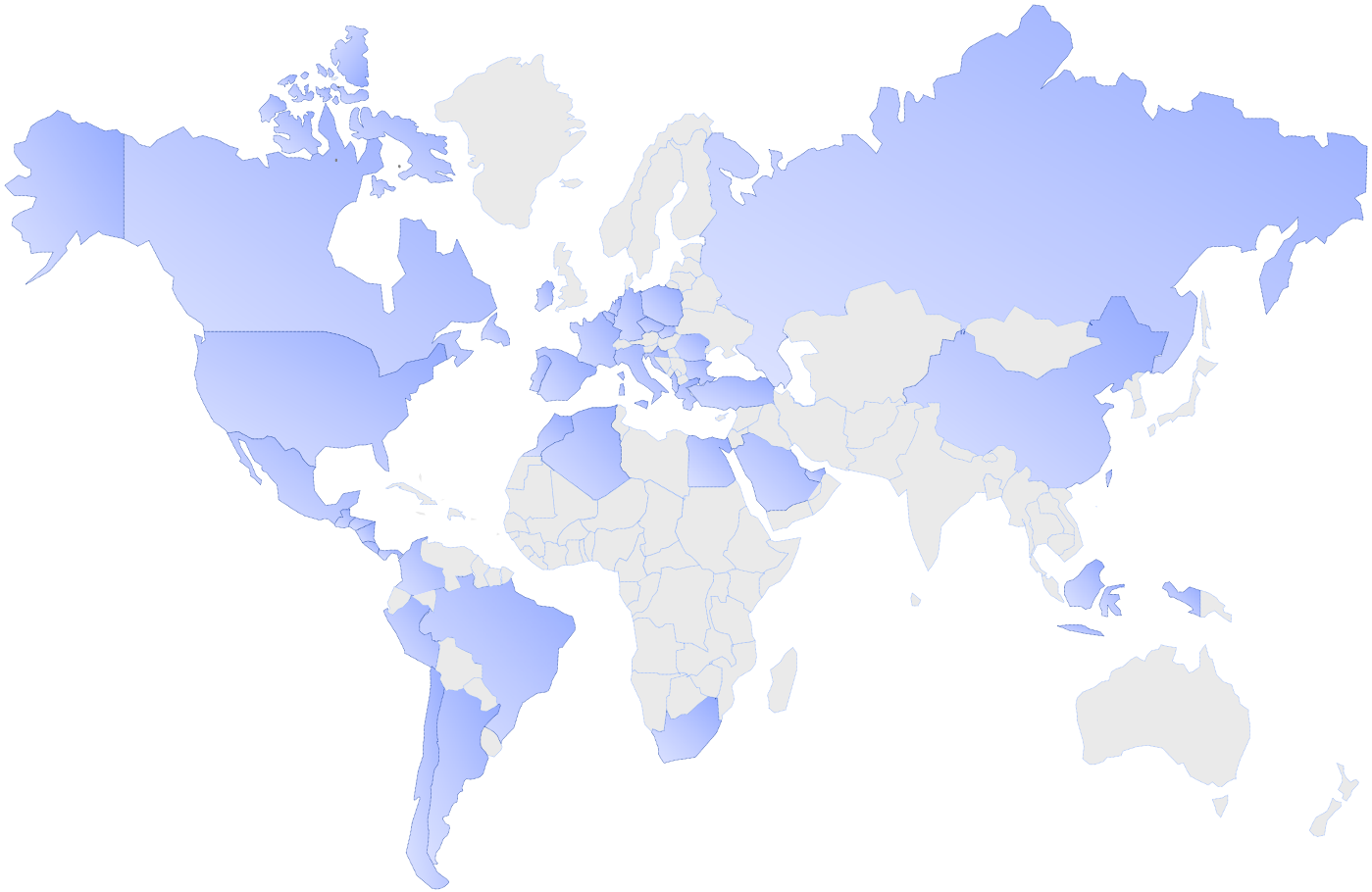
Annual production
286 TWh

EBITDA
~ 16 Bln €

Customers
~61 million

Employees
71,394

Capex 2014-18
~ 26 Bln €

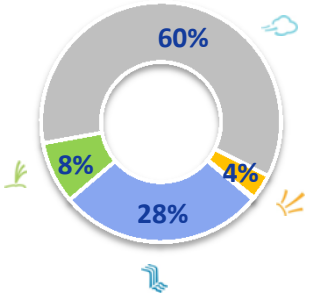
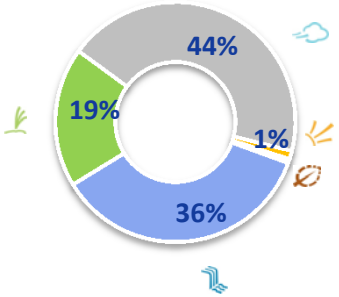
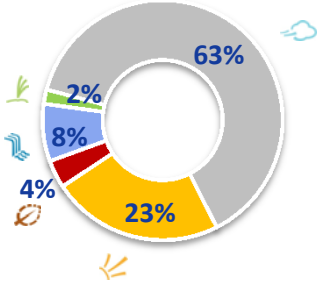


Stock exchange
Enel is listed on the Milan stock exchange (~1.2 mln shareholders). 14 companies of the Group are listed on Milan, Madrid, Mosca, New York stock exchanges and in other Latin American countries

Data as of 31.12.2013

Global leadership in renewables development

3Q 2014 Operating results

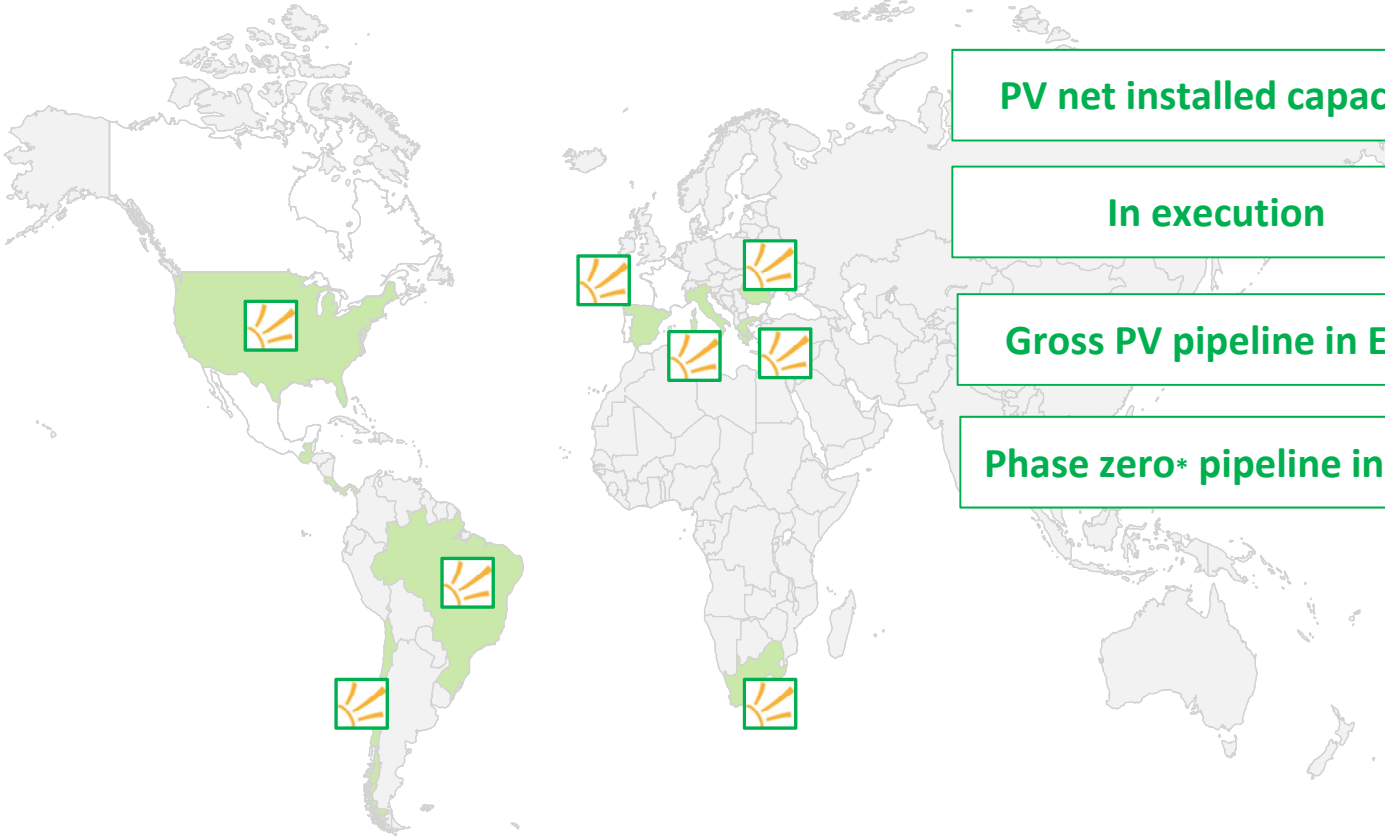
North America	Latin America	Europe
		
Capacity: 2.1 GW - Production: 6.4 TWh	**Capacity: 1.4 GW - Production: 4.0 TWh**	**Capacity: 6.0 GW - Production: 20.8 TWh**
Installed capacity = 9.5 GW	**Net production = 31.2 TWh**	**In execution = 2.0 GW**
		

1. Capacity as of September 30, 2014. Production LTM

Geo Hydro Wind Biomass Solar

Enel Green Power at a glance

EGP experience in PV



PV net installed capacity	~329 MW
In execution	~ 460 MW
Gross PV pipeline in EGP	~ 3900 MW
Phase zero* pipeline in EGP	~ 3200 MW

EGP is an international multi-technology operator, today strongly focused in developing PV technology

EGP projects for ESS testing

Note: 9M 2014 Consolidated results

* Projects that still haven't reach development stage to be included in Pipeline

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RES Energy Investments: a Growing Industry

Expected Worldwide Growth

By technology

Technology	Installed base 2012 (GW)	Installed base 2013 (GW)	Additional Capacity 2012 (GW)	Additional Capacity 2013 (GW)	Additional Capacity 2013 %	Expected Growth CAGR 2013-20 Min	Expected Growth CAGR 2013-20 Max	Investments 2013 (€bn)
Hydro	~ 1,063	~ 1,092	+28	+29	3%	3%	3%	~30
Wind	~283	~319	+45	+35	12%	9%	14%	~60
Biomass	~76	~80	+6	+4	6%	8%	29%	~10
Solar	~102	~142	+32	+40	39%	10%	20%	~86
Geothermal	~12	~12	+1	+1	6%	7%	13%	~2
TOTAL	**~1,535**	**~1,645**	**~111**	**~109**	**7.1%**	**5.4%**	**9.8%**	**~€188 bn**

By geography

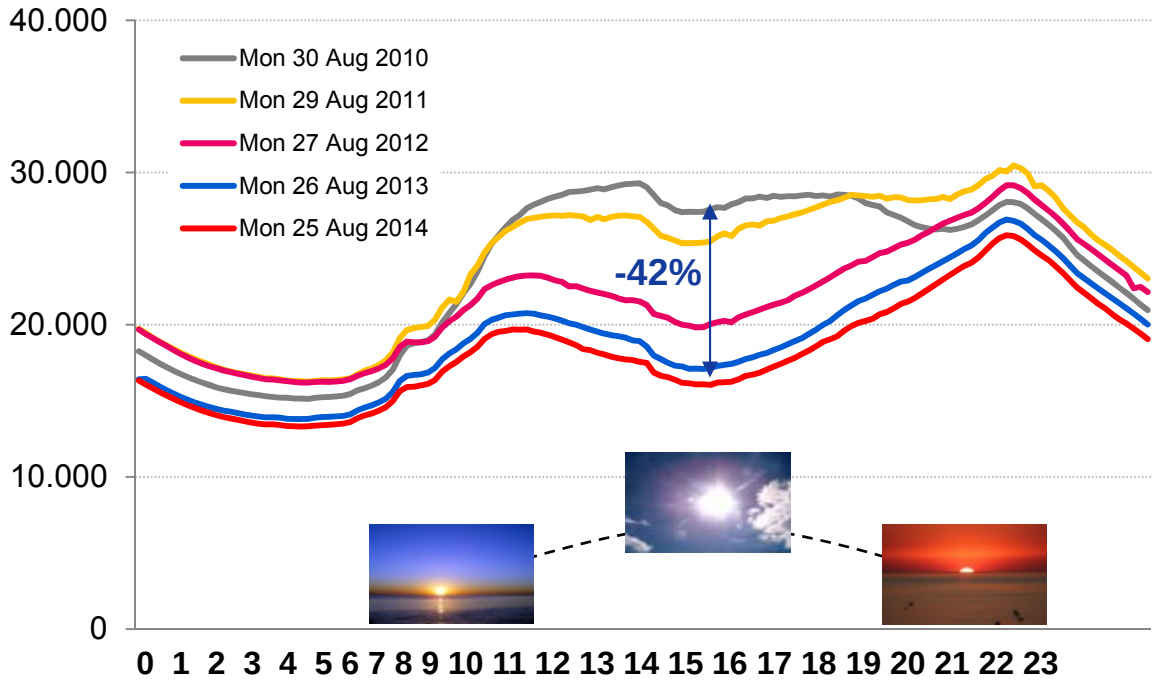
Area	Installed base 2012 (GW)	Installed base 2013 (GW)	2020 Min (GW)	2020 Max (GW)	Expected Growth CAGR '13-'20 Min	Expected Growth CAGR '13-'20 Max
North America	265	275 +4%	371	579	4%	11%
Europe	498	529 +6%	667	1,030	3%	10%
Latin America	179	185 +3%	230	330	3%	9%
Africa	27	27 +2%	56	110	11%	22%
Asia	566	628 +11%	1,048	1,111	8%	9%
TOTAL	**~1,535**	**~1,645**	**~2,371**	**~ 3,160**	**5.4%**	**9.8%**

- **All renewable technologies and regions confirm their strong potential**
- **Investments in small-scale projects accounted for ~€46bn**
- **During 2013, total R&D investments amounted to ~€22bn**

Source: EPIA, GWEC, BNEF, IEA Medium Term Market Outlook, EGP Estimate for 2013; WEO 2013 New Policies scenario (2020 min); industry reports/McKinsey, EPIA (2020 max). Note: Investments based on BNEF data except for hydro figures estimated assuming an average capex equal to 2.0 €/W; US$/€ fx rate assumed at 1.3.

Impact of distributed generation on the grids

Power requested from TSO grid [MW]



Number of transformers HV/MV with inverted flow of energy between 2010 and July 2014: +257%

In Italy **electricity flow is no more unidirectional,** from big power plants to final clients.

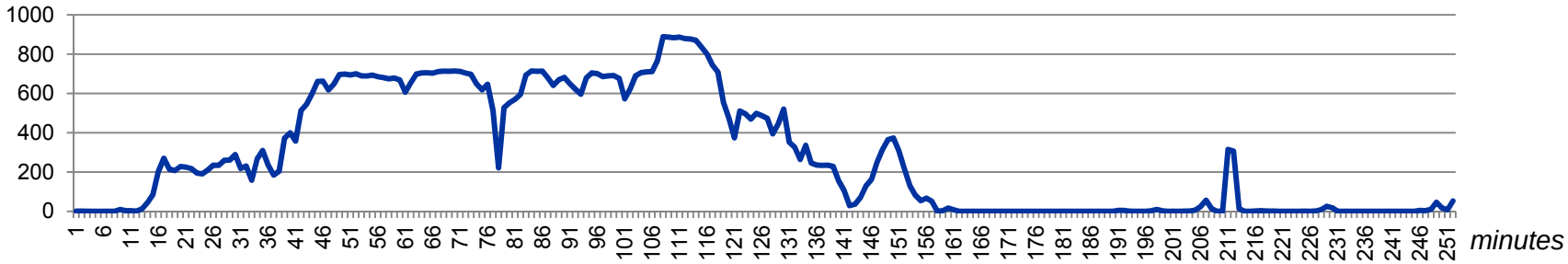
Threat or Opportunity

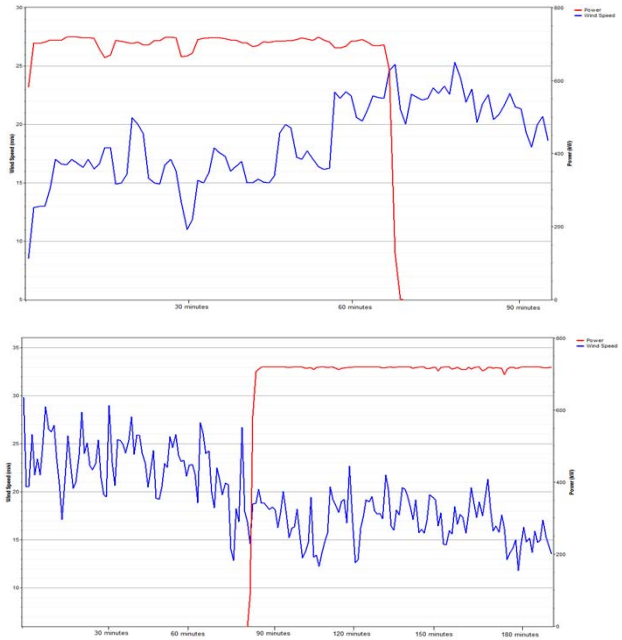
PW power plant

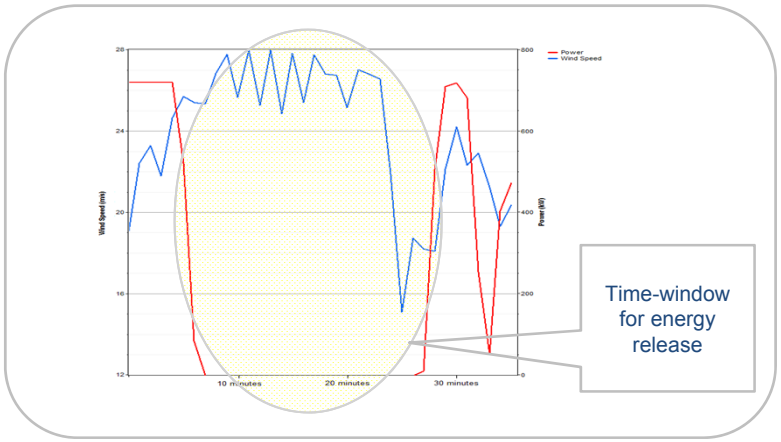
- Large Variation in few minutes in case of cloudy days
- Good average forecast

Threat or Opportunity

Wind power plant







- Large amount on power changing within minutes
- Potential On-Off behavior in case of strong wind
- More challenging forecast compared to PV

Services from Renewable Energy Sources

	Status without current available system	Results	Status with current available system	Results	Cost of upgrade with BESS	Note
Ancillary Services						
Frequency Primary Regulation	Technically possible		Available		Medium	Service is available and cost related to storage solution without limitation of the dispatched power
Frequency Secondary Regulation	Technically possible		Technically possible		Medium-High	Service is technically possible without any loss in production; cost related to storage solution
Frequency Tertiary Regulation	Technically possible		Technically possible		High	Service is technically possible without any loss in production; cost related to storage solution
Reactive power supply / Voltage regulation	Already commercially		Already commercially		Low	Service is already commercially available
Black start	Technically possible		Already commercially		Low	Service is technically possible, available on a reduced size grid
Islanding	Technically possible		Already commercially		Low	Service is technically possible, available on a reduced size grid
Energy Management Functions						
Unbalances Limitation	NOT POSSIBLE		Available		Medium-High	Cost related to storage solution
Energy Time Shift	NOT POSSIBLE		Available		Medium-High	Cost related to storage solution
Energy peak shaving	NOT POSSIBLE		Available		Medium	Cost related to storage solution
Advanced curtailment management	Technically possible		Available		Low-Medium	Cost related to storage solution

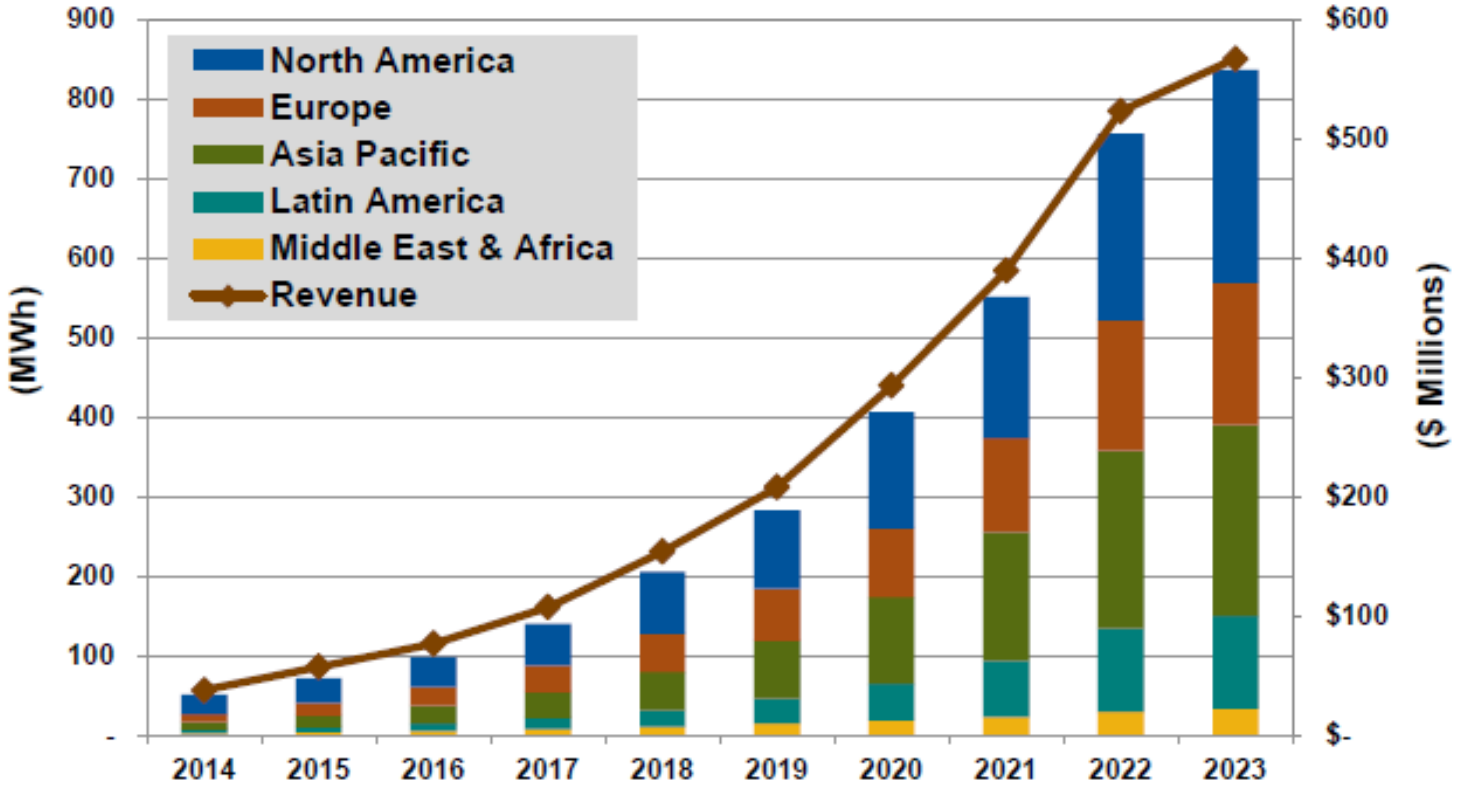
- **Frequency regulation**: storage price currently a limitation for secondary and tertiary regulation
- **Voltage regulation:** commonly implemented
- **Unbalances**: storage supporting forecast, defining the proper sizing in Energy and Power; advanced forecast/nowcast techniques to limit the amount of storage required
- **Time Shift**: amount of energy and market knowledge key factors
- **Peak Shaving**: deep investigation required in order to design the proper system in terms of power and energy

Storage Market Evolution in 2014: Key Facts

- ✓ ESS worldwide utility scale projects in 2014: **100 MW+ Commissioned** (400 MW+ announced)
- ✓ **Market still largely policy driven** (focus in regions with favorable regulatory framework, in particular for demand charge management and frequency regulation)
  - **EMEA**: after 2012-2013 period with several utility-scale pilot projects launched, market stagnated in 2014. Increase in end-users market sales, mainly in Germany (10,000 system sold, fostered by the KFW subsidy program)
  - **Asia-Pacific**: stable development in Japan and South Korea, Australia and India as emerging market
  - Significant increase in **USA** (California, New York, New Jersey, Texas, Arizona, Washington and Hawaii)
- ✓ Market jeopardized application-wise and technology-wise:
  - **Applications**: market currently mainly oriented to grid support, Renewables integration still in development phase
  - **Technologies**: Li-Ion (LMO and NCA) currently appearing as most preferred, driven by EV market
- ✓ **Outlook**:
  - ESS Renewable applications to be facilitated by **cost-reduction trend** driven by EV volumes (Tesla, Samsung, LGchem, Renault-Nissan-Bouygues)
  - Public announcements of **strategic partnerships** (Tesla Mega-factory announcement with Panasonic involvement, Samsung battery supply for BMW , LGchem-Audi agreement)
  - **Renewable/hybrid system** with energy storage as emerging business for grid limited/growth markets

Global Market is expected to rapidly grow for utility scale for ESS

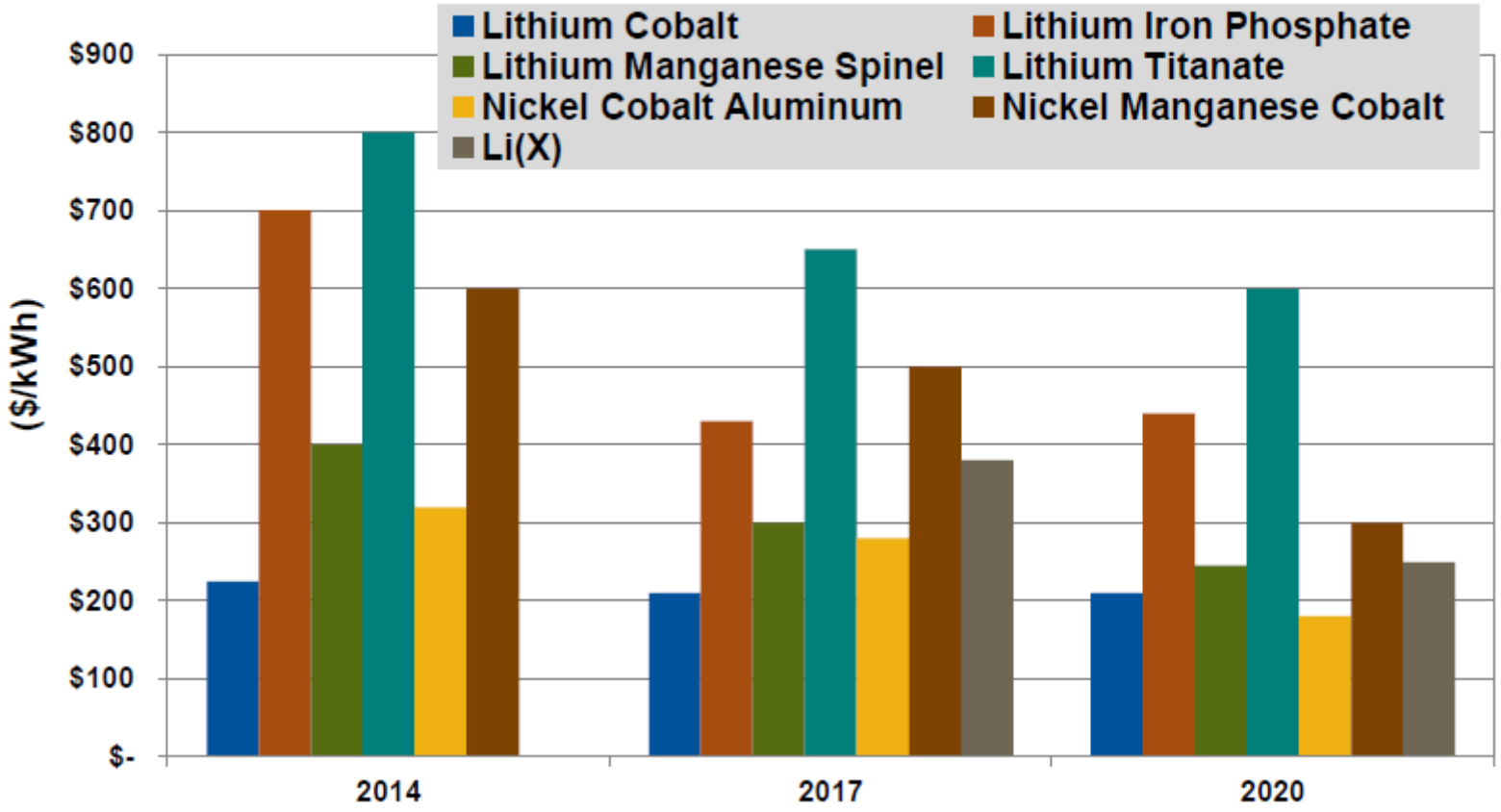
Annual Sales of Advanced Batteries for Ancillary Services, Energy Capacity and Revenue, by Region, World Markets: 2014-2023



Source: Navigant Research ''Advanced Batteries for Utility-Scale Energy Storage

Global Market is expected to rapidly grow for utility scale for ESS

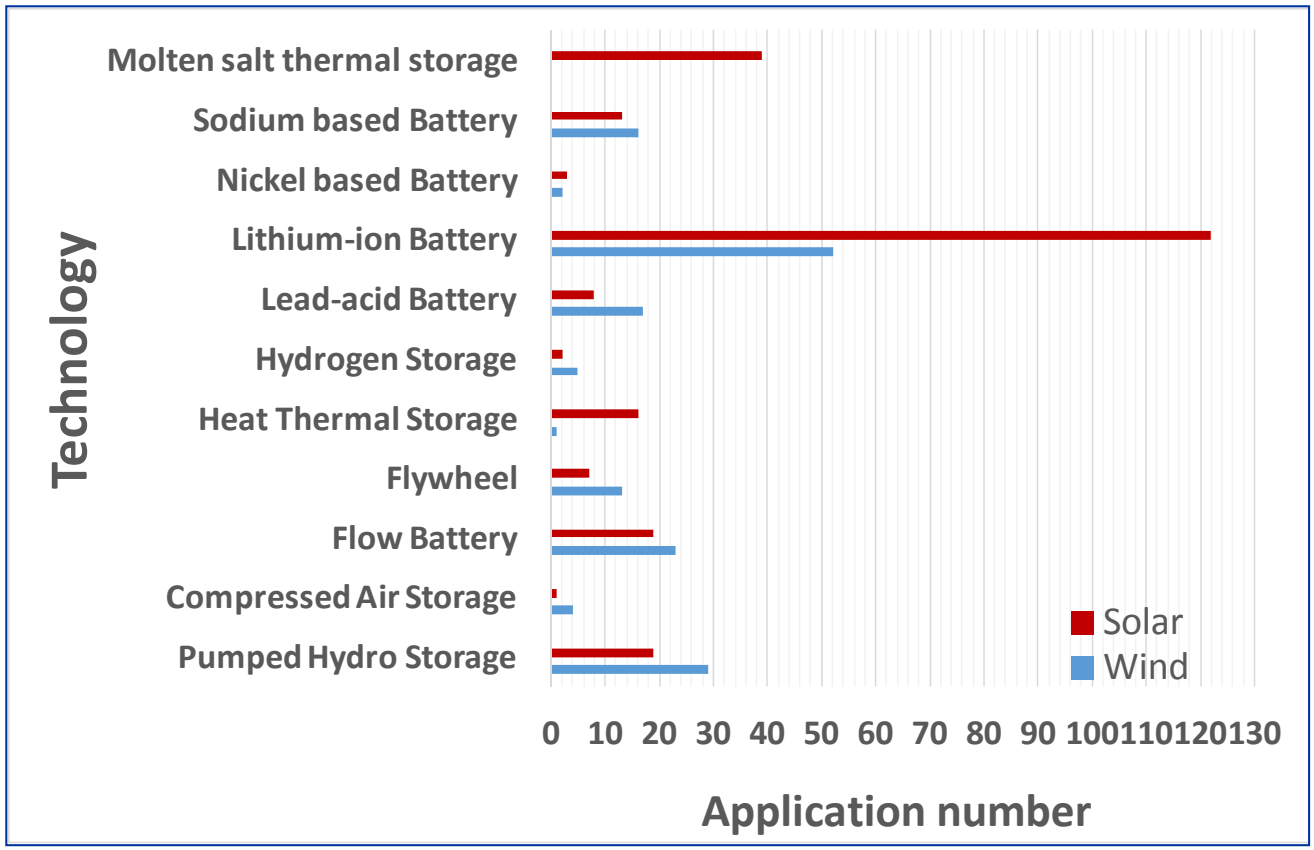
Lowest Cell Price of Li-ion Batteries for Utility-Scale Applications by Subchemistry, World Markets: 2014, 2017, and 2020



Source: Navigant Research ''Advanced Batteries for Utility-Scale Energy Storage

Storage Technologies

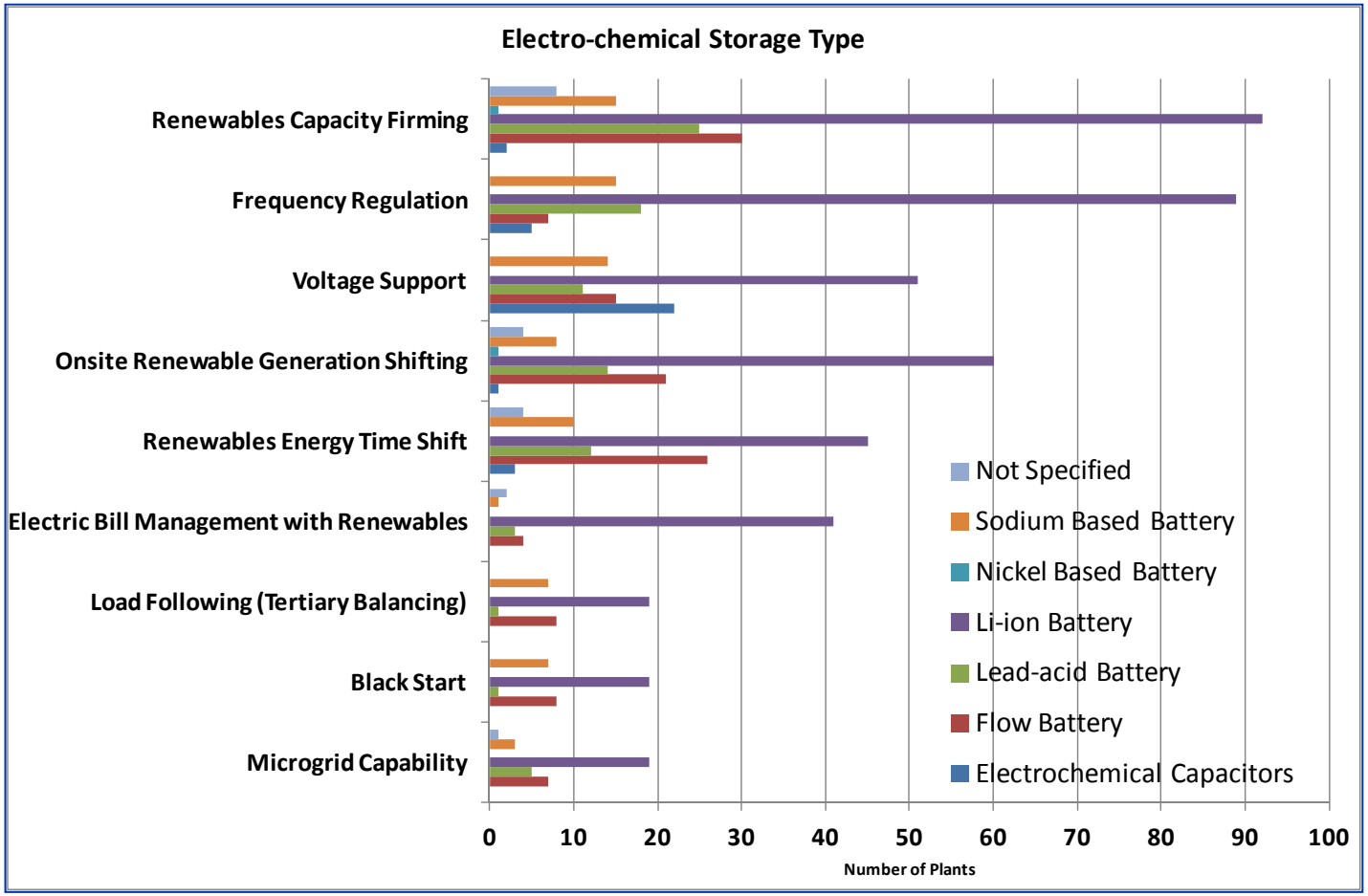
Storage technologies in solar and wind power generation



- Different types of storage technologies for solar and wind power generation
- Lithium – ion batteries are mostly used for RES power generation worldwide

Storage Technologies

Electro-chemical Storage technology



❖ Recent developments of the electrochemical storage systems are representing a bright real opportunity for the close future

❖Li-ion Battery is the most used for renewables integration

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EGP activities for Grid Integration and Support

EGP is currently analyzing technical solutions to enhance **renewable energy sources integration in the grid**:

- Production Forecast Tools e.g. consolidated CFD (Computational Fluid Dynamics) and ANN (Artificial Neural Network) models
- Integration of storage in RES power plants
- Hybridization

EGP has been **testing the most competitive storage technologies** for many years in its storage laboratories:

- Different kind of Technologies selected as currently suitable technologies for industrial scale test with RES power plants PV and WIND.
- Different kind of services will test on industrial scale to find the best economical viable solution

EGP is now testing leading battery storage in **pilot projects**:

- Catania
- Potenza Pietragalla
- Ollague

Pilot projects in Italy

Catania PV, Potenza Pietragalla WIND

Grid Connected RES Power Plants:

- ✓ Ancillary services (active grid integration and regulation)
- ✓ Energy shift (price arbitrage)
- ✓ Unbalance reduction

➢ **Catania 1** (PV – Italy, 10MW limited to 8MW)
- **1MW/2MWh General Electric** Durathon Sodium Nickel Chloride Battery installed on December 2014, currently under commissioning
- Aim of the experimentation: focus on energy shifting and ancillary services, while limiting unbalances

➢ **Potenza Pietragalla** (Wind – Italy, 18MW)
- **2MW/2MWh Samsung** SDI Lithium Battery, to be installed by April 2015; battery currently under construction
- Aim of the experimentation: focus on limiting unbalances and ancillary services

➢ **Additional Wind Site**
- **4MW/1MWh Toshiba** SCiB Lithium Titanate Battery, to be installed by August 2015; battery currently ready for installation
- Aim of the experimentation: focus on limiting unbalances and ancillary services by using high C-rate battery on state-of-art wind power plant

Pilot projects in Cile

Hybrid Generation Power Plant with storage

Off-Grid RES-Hybrid Power Plants:

- ✓ Primary Energy Resource for remote sites, system must be capable of replacing a conventional generation set, while ensuring reliable operation in typically harsh Environments
- ✓ Emerging business of potential EGP interest

➢ **Ollagüe (Hybrid Generation Power Plant with storage - Chile) – Construction completed, in evaluation phase**

Description

- **PV, 200 kWp** 3Sun thin film modules
- **WTG**, vertical axis, **30kWp**
- Fiamm' SoNick Sodium Nickel Chloride battery **250 kW - 520kWh** energy storage system
- **Diesel Generator** as backup ,250kW
- Additional, 2 Thermodynamic systems of 1 kWe + 3kWt each, providing hot water to local school

Aim of the project

- First of a kind off-grid generation system for EGP, possible model to applied to similar off-grid or grid limited sites
- Supply 24hs/day 7 days/week energy to an off-grid village placed at 3700 AMSL in a desert area of Chile, removing the restriction of the village to having access to energy during night time
- Minimizing the consumption of fuel from existing diesel generator to only limited time in winter (expected >84% of generation from RES)
- Testing advanced renewable technologies and storage system in a harsh environment, with large temperature range

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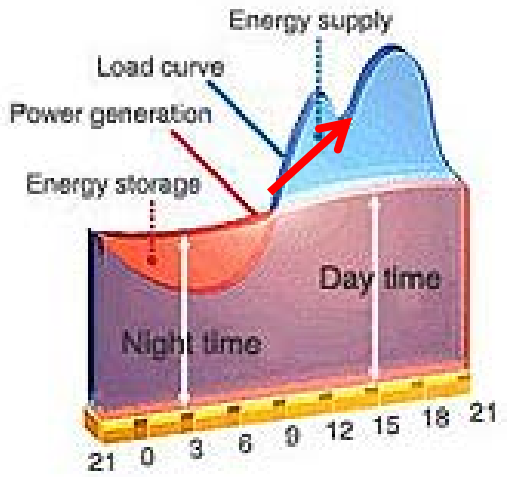
Possible business models

A **Ancillary services**

- **Primary regulation**
- **Secondary regulation**
- **Terziary regulation**
- **Reactive supply and Voltage control**

B **Price Arbitrage (Energy-shift, peak-shaving)**

- **Curtailments**: due to transmission constraints and generator flexibility, energy storage helps to increase grid flexibility and reduce curtailment.
- **Day/night**



C **Unbalance**

Mitigate RES generation unbalance and reduce relevant penalties together with the improvement of weather forecast:

- **Day-ahead market**
- **Intra-day market**

Extract of existing regulatory framework
Ancillary services

IN RAPID EVOLUTION

- Heterogeneous Worldwide Regulatory framework
- Need to match regulatory best conditions with proper market to create business opportunities
- Focus on the *operating EGP countries*, with priority to **some areas:**

ITALY
- **USA**
- **Spain**
- EGP Latin America
- Iberia
- **Mexico** & Central America
- **Chile** and Andean Countries
- Brazil
- North America
- Other countries of potential EGP interest (Australia, …)

		Future and details	Italy	Spain	Romania
1	Primary Regulation	• Tipically 1-1,5% of power plant power within 30 sec for 15 mins • Generator Automatic regulation	• Mandatory if P>10 MVA, NOT Paid • Supply of 1.5% of *actual available* power (as per TSO GC mast be performed on installed power)	• Mandatory • NOT PAID	• Mandatory for conventional generators, and RES >10 MVA
2	Secondary Regulation	• Automatic Regulation by TSO • Tipically 5-6% of power plant power within 200 sec for about 2h	• Supply of 10MW or at least 6% of *actual available* power in 200s (as per TSO GC mast be performed on installed power) (1)	• Voluntary • Market price	• Mandatory (conventional) • Pay as bid
3	Tertiary Regulation	• TSO Dispatch orders • Time and size depend on grid code	• Voluntary(conventional), market place, pay as bid • Supply of 10 MW in 15m (60m for cold reserve)	• Mandatory • Market price	• Mandatory (conventional) • Pay as bid
4	Reactive supply and Voltage control	• Reactive supply for tension control, automatic regulation	• Mandatory if P>100 MVA • NOT PAID	• Mandatory • Paid, Market price	• Mandatory • NOT PAID
5	Curtailments	• Reduction of power supplied by the WTG	• Mandatory, partially paid • Balancing orders sent by TSO to be executed in 15m	• Mandatory • NOT PAID	• Mandatory • Partially paid
6	Voltage-dip ride through	• Due to 84/12 and 165/12 del. AEEG plants have been adapted	• Mandatory • NOT PAID	• Mandatory • NOT PAID	• Mandatory • NOT PAID
7	Disconnection from Remote	• Device active only on newer plants.	• Mandatory • NOT PAID	• Mandatory • NOT PAID	• Mandatory • NOT PAID
8	Islanding (Refusal of Load)	• Auxiliary services feed in case of network disconnection • Automatic	• Mandatory if P>100 MVA • NOT PAID	• N/A	• N/A
9	Black Start	• Last request on the Italian market received in September 2003	• Mandatory if plants are in the recovery plan • NOT PAID	• Mandatory • NOT PAID	• N/A

*services already supplied by RES

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  - ✓Projects and solution