extract from presentation

Storage for the integration of Renewable generation into power systems

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Enel Green Power

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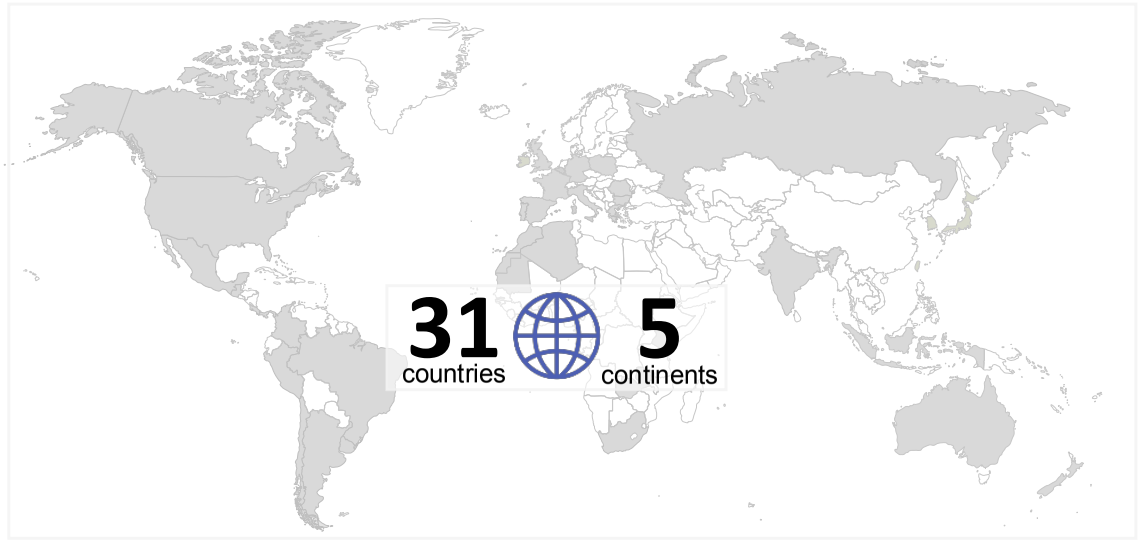
Green Power

Storage for the integration of RES generation into power systems

Agenda

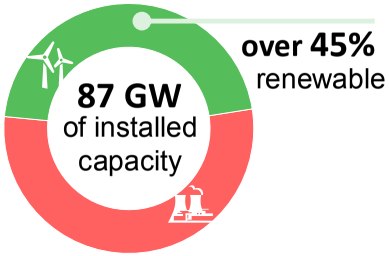
1. About Enel Group and Enel Green Power
2. Why storage coupled with RES. Applications and benefits
3. Technology cost evolution. Overview
4. What Enel Green Power is doing over the world

The Enel Group

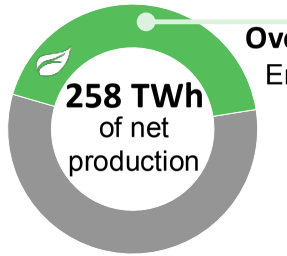


- **Leadership in all segments of the value chain**
- **Diversified by technology & geographically**
- **Focused on sustainability & growth**

2017 Key Figures



over 45% renewable



Over 43 % Emission free

1.9 Million km distribution networks

44 Million smart meters

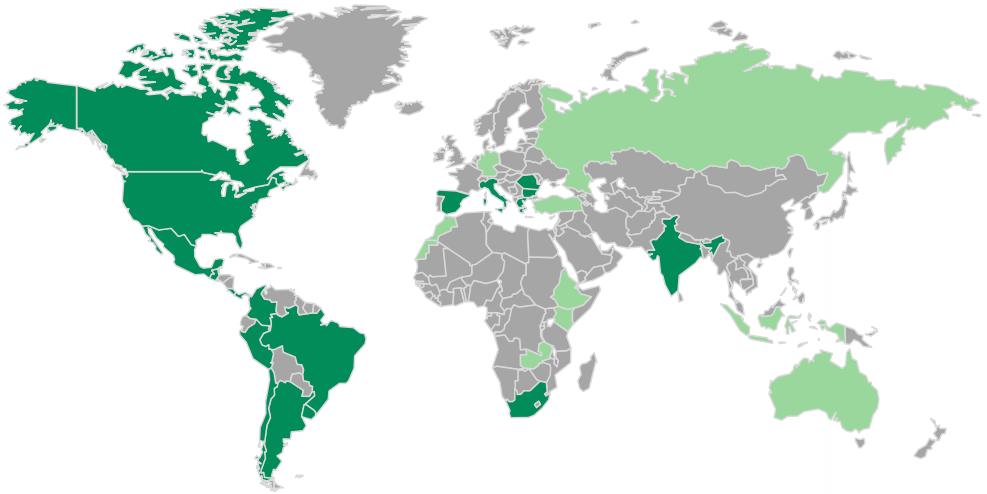
63,500 EMPLOYEES

915,000 SHAREHOLDERS

REVENUES(2016)	EBITDA(2016)	MARKET CAP.(Dec 2017)
70.6 BN EUROS	**15.3 BN EUROS**	**54.0 BN EUROS**

World's largest global utility with the resources and products that are changing the way the world uses energy.

Enel Green Power
EGP in the World



29
countries

1200
plants

more than
7,600
employees

2017 Key Figures

40.5 GW managed

37.1 GW consolidated

9.2 GW WIND

27.8 GW HYDRO

2.6 GW SOLAR

0.9 GW GEO

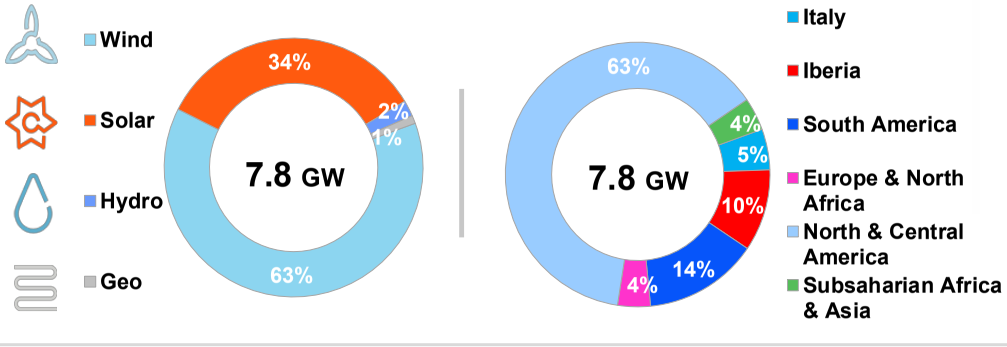
92 TWh managed

89 TWh consolidated

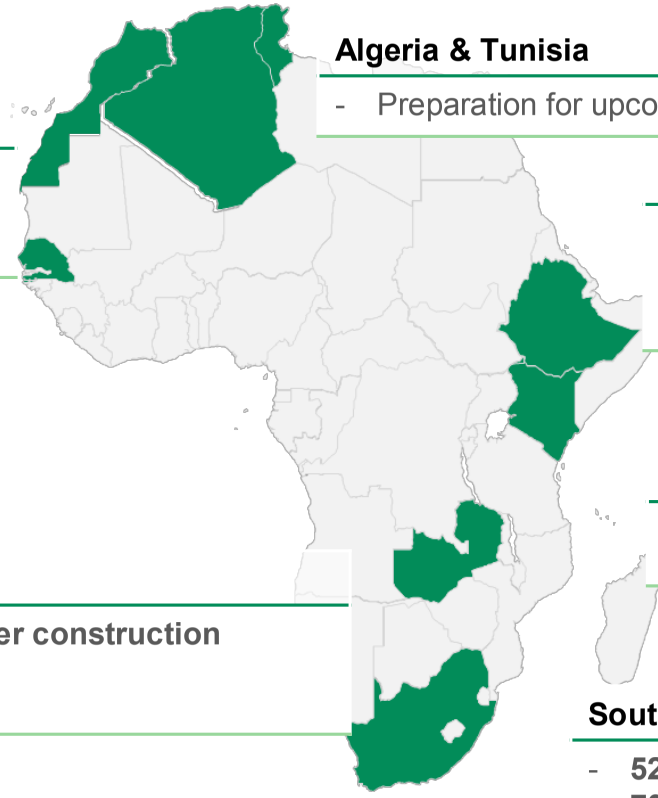
EBITDA
4.1 BILLION EUROS

GROWTH CAPEX
3.4 BILLION EUROS

2018-2020 Industrial Growth Plan



Enel Green Power
EGP in Africa. Activities in the Continent



MOROCCO

- **850 MW wind project**
- Developments: wind and solar

Algeria & Tunisia

- Preparation for upcoming PV tenders

ETHIOPIA

- **100 MW PV awarded**
- 2 PV tenders preparation ongoing (2x100 MW), prequalified in 2017
- Wind, Hydro and Geo under development

Kenya

- Developments ongoing in wind, solar and geo projects

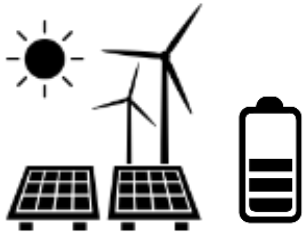
ZAMBIA

- **34 MW PV solar project under construction**
- Scouting for hydro projects
- Scaling Solar round 2

South Africa

- **523 MW installed capacity (5 PV plants and 2 wind farms)**
- **705 MW awarded (5 wind projects), soon under construction**

Why storage *coupled* with RES



The **target** of **storage in EGP** is to be coupled with RES plants in order to enable power systems to exploit the full potentiality of renewable energies and aiming at having 100% clean and reliable energy

1 Advantages for the plant

Storage, coupled with RES, as an **ancillary technological equipment** which:

- lets plants to **overcome** the residual intrinsic *limitations* in terms of **flexibility** and **dispatchability,** *and*
- makes the renewables plant "future proof"

2 Advantages for the grid

It allows to:

- reduce the **needs** of standby generation required to balance the grid due to unpredictable weather and generators contingencies;
- Match the system needs injecting energy when it is required

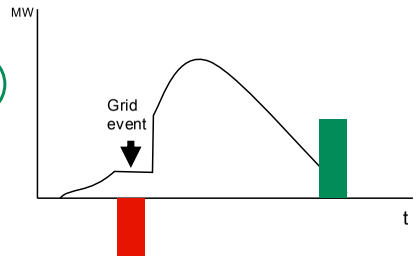
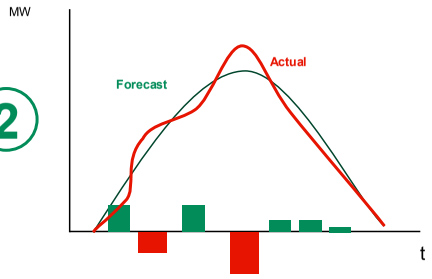
3 Advantages for the end-user

It will help to reduce the dependency from polluting and costly back-up supply enabling the customer to have **100% renewable energy** all the day

*main streams, not exhaustive list

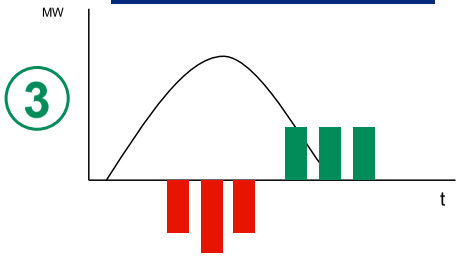
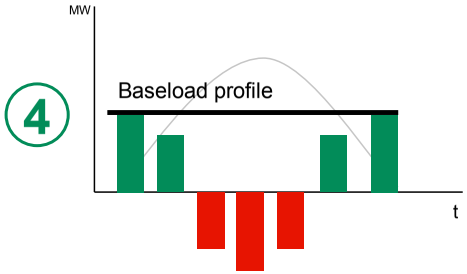
Why storage coupled with RES

Applications (1/3)

Application*	Description
Curtailment reduction 1 	In some cases, the grid has not sufficient capability to transport RES generation or there is a mismatch between generation and consumption and the last resort measure from TSO is to curtail RES generation → the storage can **recover** the power plant production (otherwise lost) **charging** during the **grid event** and **discharging** during **high demand hours**;
Unbalance reduction 2 	The ***unbalance*** is the difference between forecasted and actual production of a plant; the unbalance (mainly due to unpredictable weather, in case of RES) has to be managed by the TSO, which needs to activate other resources (excess stand-by reserve power) to balance the grid, with cost → storage system, coupled with RES, charges and discharges in order to **nullify differences** between power plant **production forecast** and **actual real time** production, so **reducing/avoiding grid balancing costs**

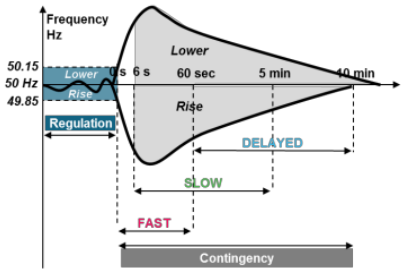
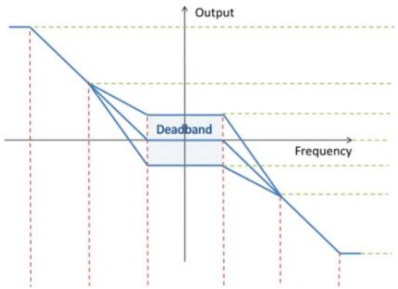
Why storage coupled with RES

Applications (2/3)

Application	Description
(3) Energy Shifting and (4) Capacity firming 	Where the system demand doesn't match with RES generation profile, the storage can charge during low consumption hours and discharge during peak demand hours in order to **move plant production** when **energy is needed** (and has more value)
	The storage has the capability to **adapt the production profile** of the plant to the **needs of the end costumer**, while **ensuring the reliability of the supply** and so **reducing the needs of backup generators**

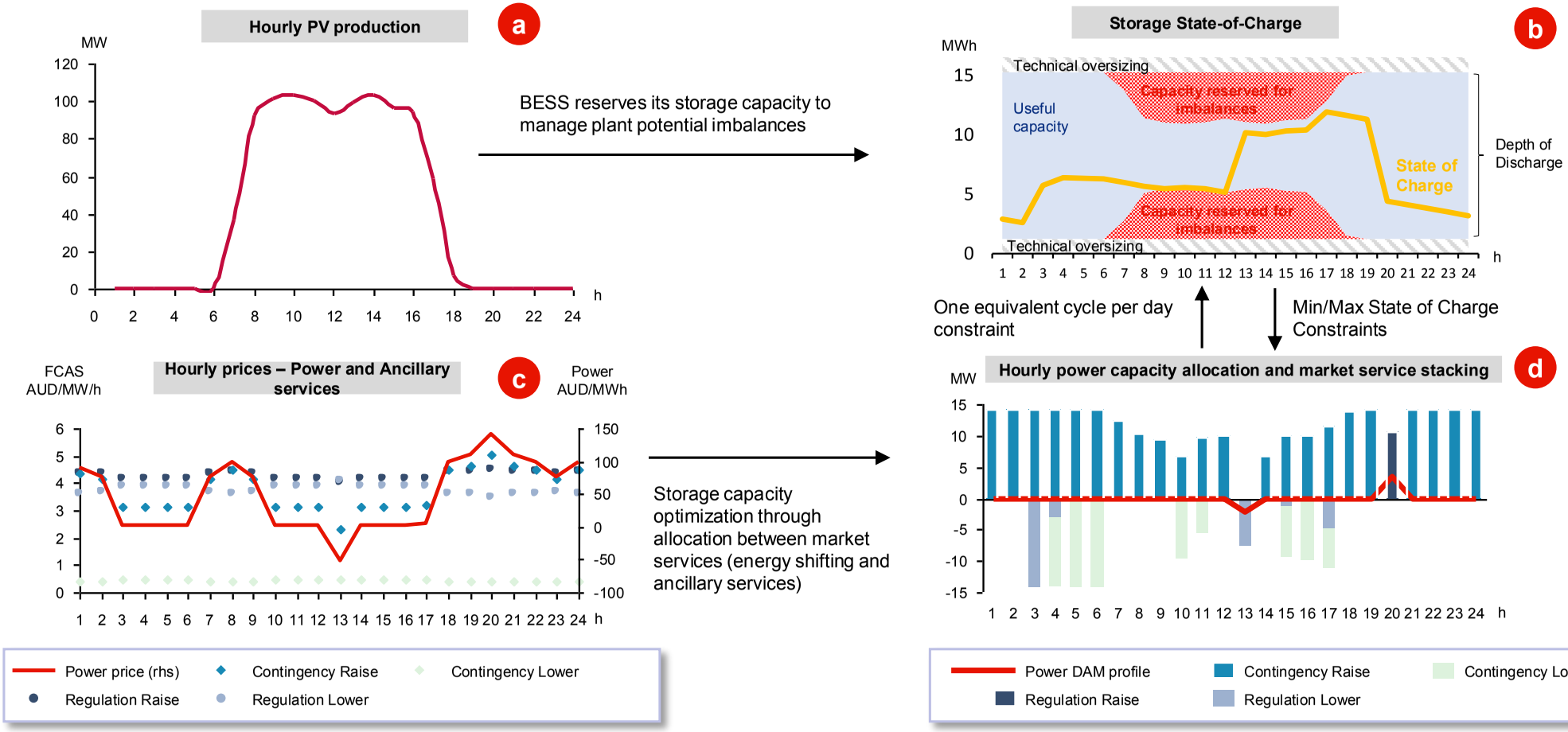
Why storage coupled with RES

Applications (3/3)

Application	Description
Spin/Non spin reserve 5 	→ To help **grid reliability** following a **grid event** in order to bring back system *frequency* within normal parameters → Storage allows faster reactions allowing lighter energy injections in order to restore correct grid parameters.
Frequency Control 6 	Service provided to grid in order to improve **system stability** providing continuously active power in order to counterbalance grid frequency fluctuations and blocking its drift towards unsafe parameters → Storage can provide high quality control on system frequency

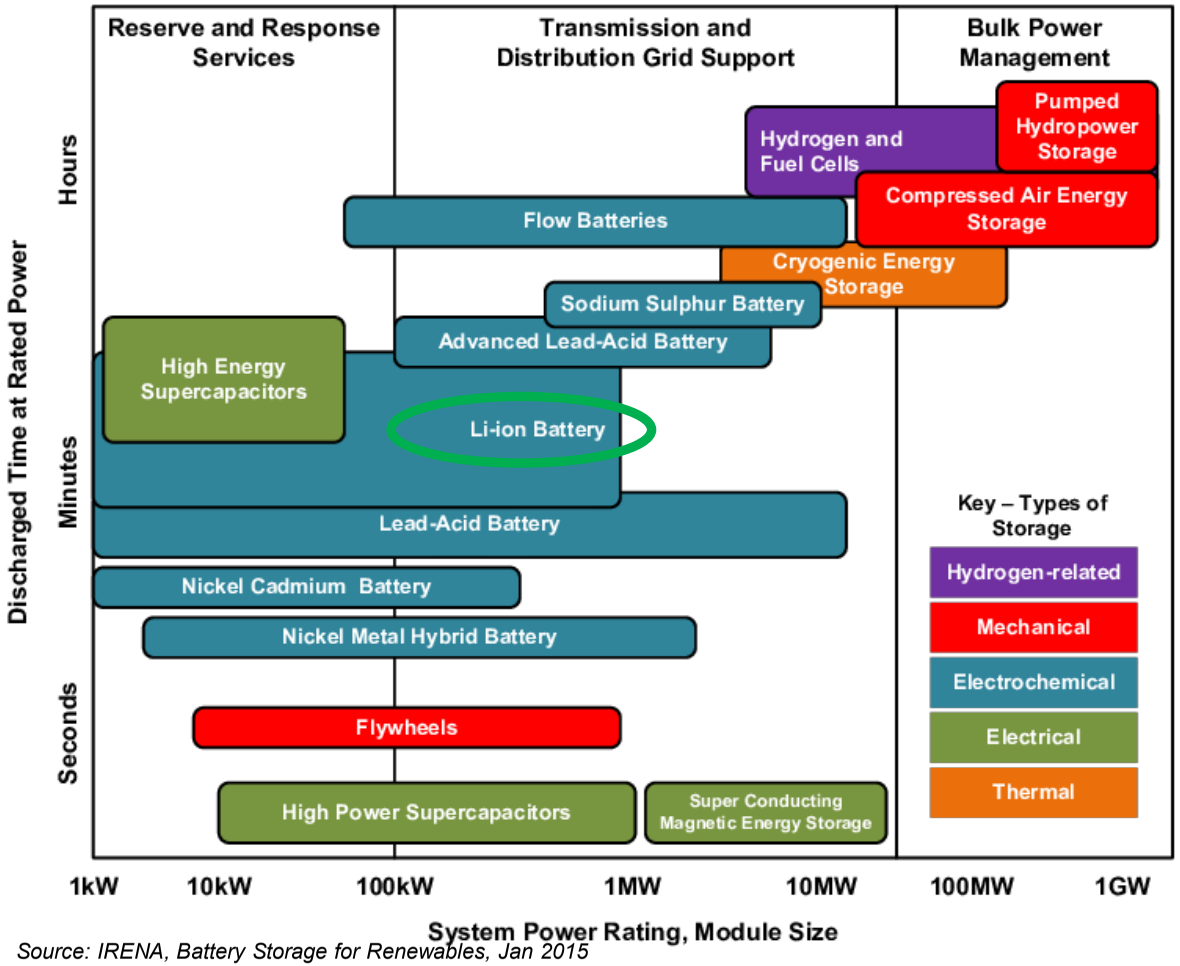
Why storage coupled with RES

Applications. A real life example of *services stacking* from a project “Storage+PV”



*Example from equinox day (22° of Sept 2022) in Year 3 of operation

Technology overview



Source: IRENA, Battery Storage for Renewables, Jan 2015

- Different types of Storage are present on the market, differentiated by their commerciability stage, applications that they enable, costs, efficiency, etc
- More elements rounding around **battery selection** (technical, commercial, regulatory framework, etc)

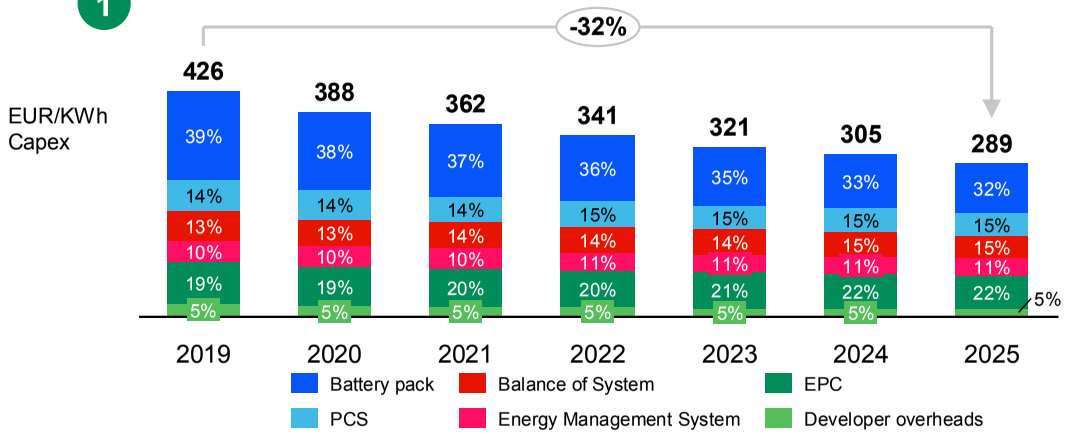
*converted in EUR with 1.16 USD/EUR FX

**indicative figure

Industry scenario for cost evolution

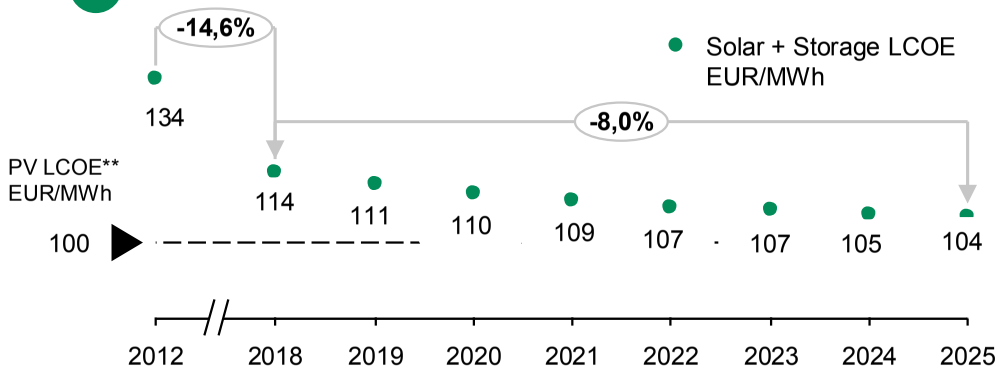
BNEF scenario* for a fully installed BESS with 1 hour duration (lithium-ion)

1



LCOE evolution for a solar coupled with storage *(internal elaboration for specific Country/ applications)*

2



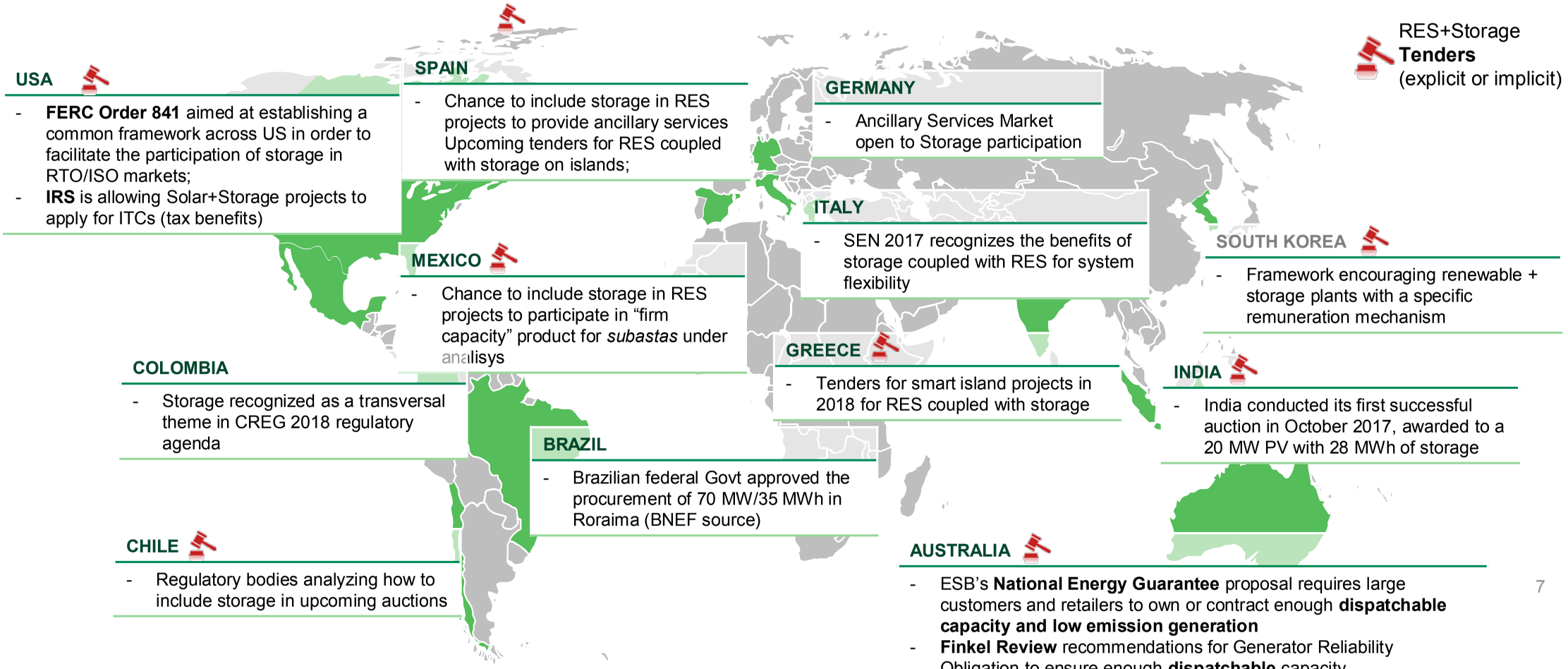
1 The industry agrees on the steep decline in technology cost

2 Storage coupled with RES will have a negligible impact on LCOE of the integrated plant *over the time*

*not exhaustive

Countries* enabling *(progressively)* Storage

RES+Storage **Tenders** (explicit or implicit)



USA

- **FERC Order 841** aimed at establishing a common framework across US in order to facilitate the participation of storage in RTO/ISO markets;
- **IRS** is allowing Solar+Storage projects to apply for ITCs (tax benefits)

SPAIN

- Chance to include storage in RES projects to provide ancillary services Upcoming tenders for RES coupled with storage on islands;

GERMANY

- Ancillary Services Market open to Storage participation

ITALY

- SEN 2017 recognizes the benefits of storage coupled with RES for system flexibility

SOUTH KOREA

- Framework encouraging renewable + storage plants with a specific remuneration mechanism

MEXICO

- Chance to include storage in RES projects to participate in "firm capacity" product for *subastas* under analisys

GREECE

- Tenders for smart island projects in 2018 for RES coupled with storage

INDIA

- India conducted its first successful auction in October 2017, awarded to a 20 MW PV with 28 MWh of storage

COLOMBIA

- Storage recognized as a transversal theme in CREG 2018 regulatory agenda

BRAZIL

- Brazilian federal Govt approved the procurement of 70 MW/35 MWh in Roraima (BNEF source)

CHILE

- Regulatory bodies analyzing how to include storage in upcoming auctions

AUSTRALIA

- ESB's **National Energy Guarantee** proposal requires large customers and retailers to own or contract enough **dispatchable capacity and low emission generation**
- **Finkel Review** recommendations for Generator Reliability Obligation to ensure enough **dispatchable** capacity

* experimental/innovative approach

What EGP is doing over the world

EGP Storage and RES projects on field

Operation

Execution

Cremzow (Wind)
22 MW / 34 MWh Li-Ion
Primary Frequency Regulation + Wind+BESS synergies
COD: Q4 2018

Potenza Pietragalla (Wind)*
2 MW / 2 MWh Li-Ion
Unbalance costs reduction, dispatch optim + grid services

Catania 1 (Solar)*
1 MW / 2 MWh Na-NiCl
Unbalancing minimization + Energy shifting

COD: 2015

Cerro Pabellon (Solar)*
Hybrid Storage: H_2 (50 kW / 450 kWh)
+ Li-Ion (132 kW / 132 kWh)
Off-Grid Application
COD: 2017

Ollagüe (Solar+Wind)*
250kW / 750kWh Na-NiCl
Off-Grid Application
COD: 2015

Australia
Unbalancing costs reduction+
Ancillary services

CUAMM (Solar)*
200 kW / 320 kWh Li-Ion
Off-Grid Application (Hospital)
COD: Q3 2018

Thank you!

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Back-up

Storage projects worldwide

BNEF source