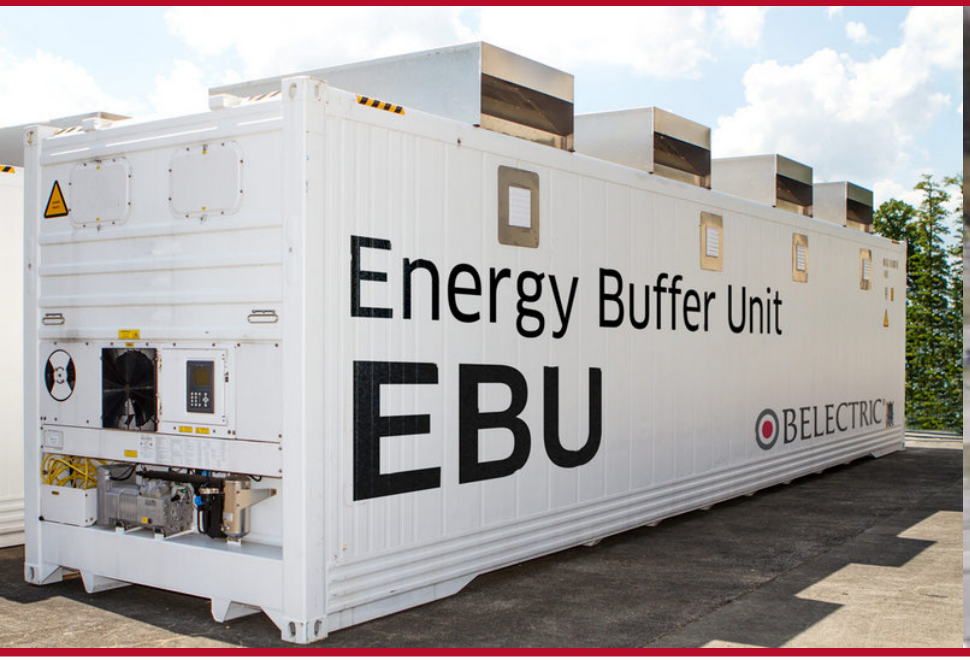


Battery Energy Storage System Business Cases

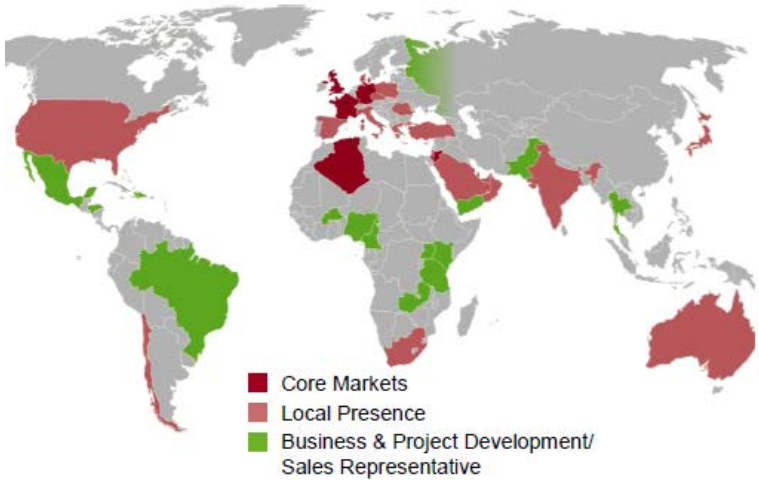
Nir Dekel, sales manager

9th November 2017

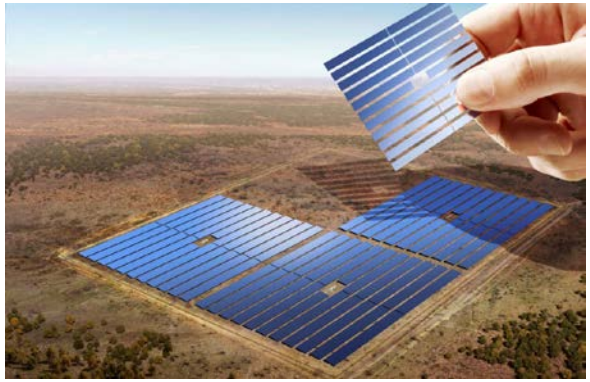
BELECTRIC®

Belectric Overview

- One of the **world's largest** PV system integrator
- **In-house R&D and manufacturing**
- **Over 1.6 GWp** total installed capacity
- **Experience in all continents** and climates



Belectric Overview – Products



Standard PV system block:

- Simplification
- Standardization
- Improved Efficiency

Powerblock

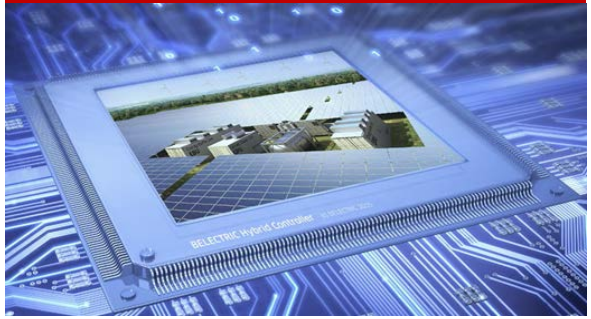
Off-Grid & Hybrid Solution

Energy Storage System

Grid Stabilization

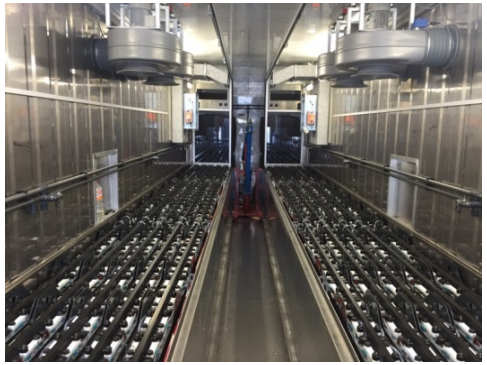
1,500 Volt DC Systems

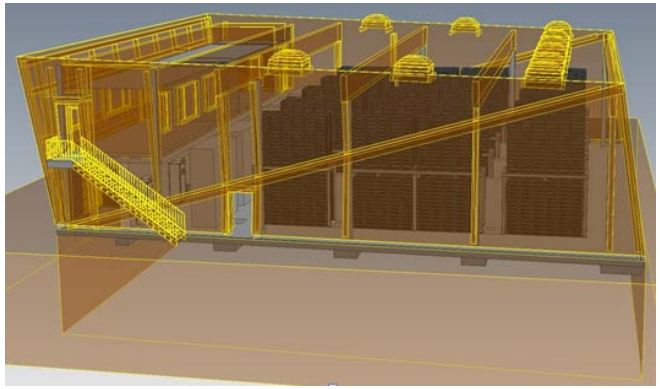
Hybrid controller



Belectric Overview – Storage

- A standard system in 40ft container with up to 4MWh
- **7 years experience** in R&D and product development
- **~75MW power & 55MWh capacity** in Commercial operation





Terminology: Power, Capacity & C-Rate

- **Capacity**: The **amount of energy** stored in the battery [Wh]
- **Power**: The **rate of energy** drawn from the storage system

Capacity (MWh) – The batteries

Power (MW) – The inverters

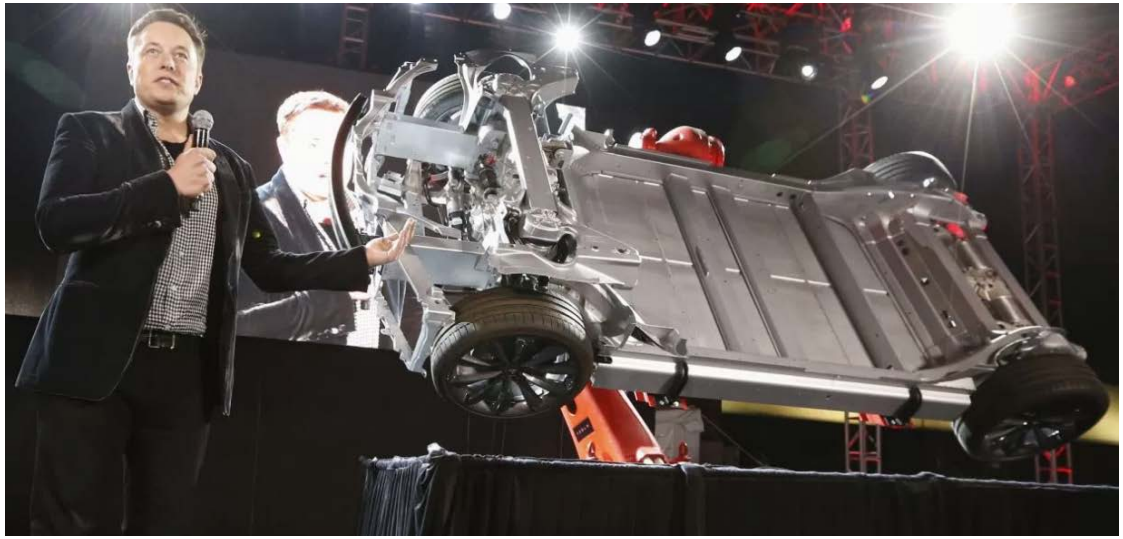
- **C-rate**: The ratio between **Power** and **Capacity**, Higher c-rate → faster energy charge / discharge

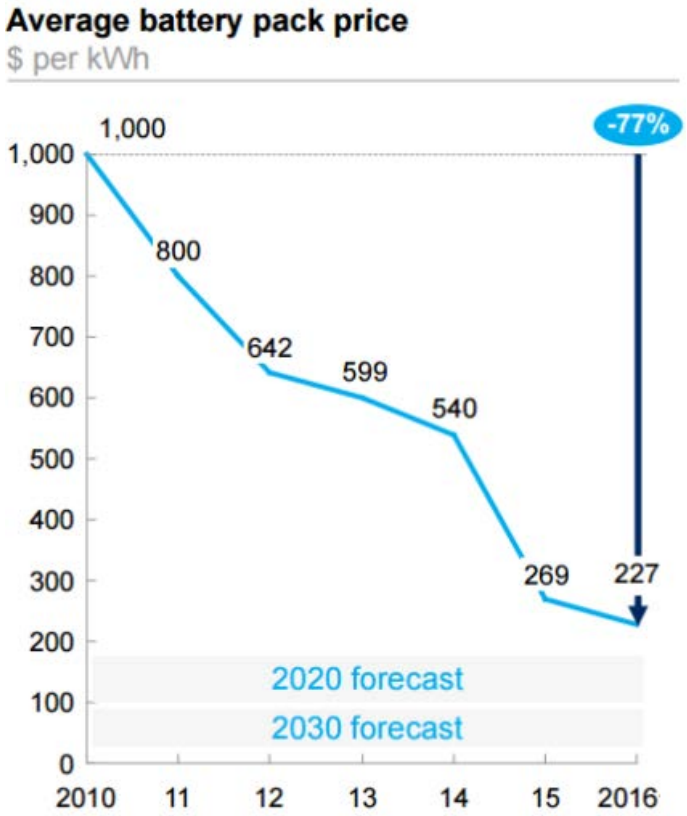
C rate	Configuration examples	Application
High power (High c-rate)	2MW & 1MWh: 2C, 30 min charge/discharge 4MW & 1MWh: 4C, 15 minutes charge/discharge	Frequency regulation, typically 30 or 15 minutes (2C or 4C).
High capacity (Low c-rate)	2MW & 4MWh: 0.5C, 2 hours charge/discharge	Ramp-rate, Energy for peak demand

Storage Power Price

Li-on batteries price dropping exponentially!

- 1995 – 2010: 14% per year over 15 years
- 2010 – 2017: **20% per year, price decrease accelerated** due to investment by IT, Automotive and Energy industries
- 2020 forecast: Below $190/kWh
- 2030 forecast: $100/kWh or lower…





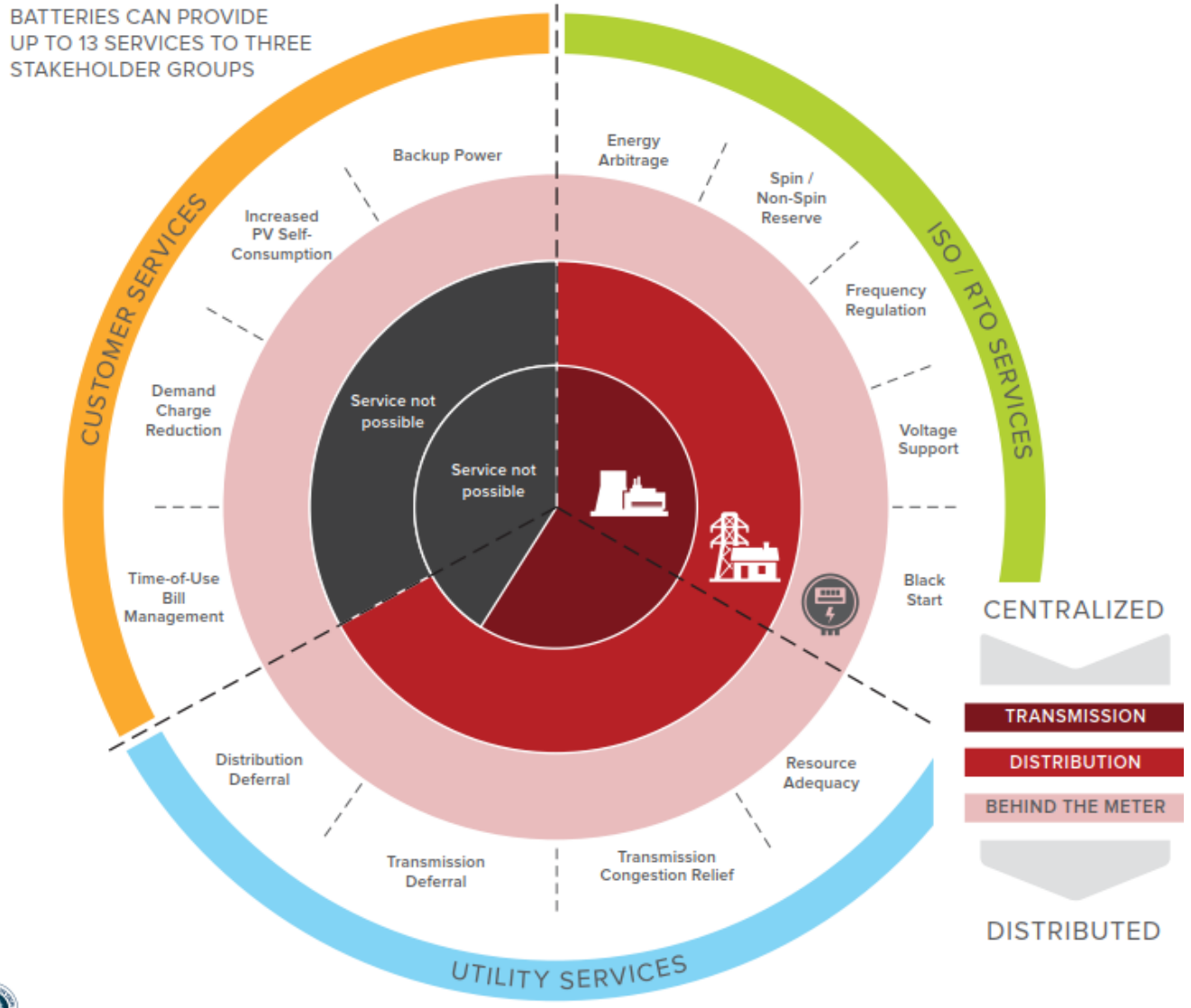
Energy Storage Benefits

Both Generator & Load (discharge & charge)

Extremely Fast Response

Very Cheap

Storage Business Cases Overview

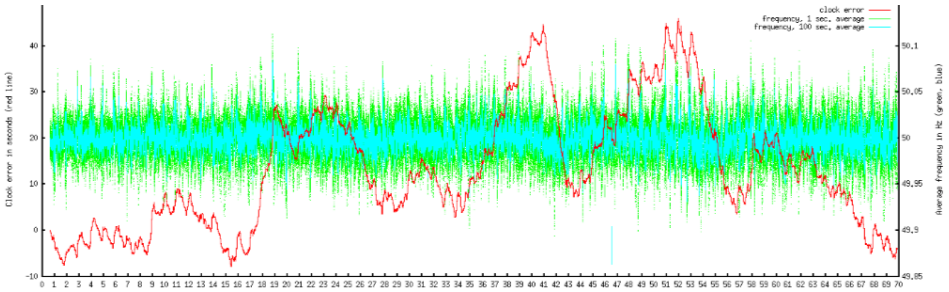


Source: http://www.rmi.org/Content/Files/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport-FINAL.pdf

Frequency Control – The Need

- Transmission grid frequency changes based on load vs generation:
  - When **Generation > Load → Higher frequency**
  - When **Generation < Load → Lower frequency**
- Grid frequency kept within certain range, (eg 50±0.05 Hz in Germany)
- Frequency services:

Control level	Objective	Response Time	Power required
Primary	**Stabilizing** the grid	**Seconds**	**Low** power
Secondary	Grid back to **normal**	**Minutes**	**High** power



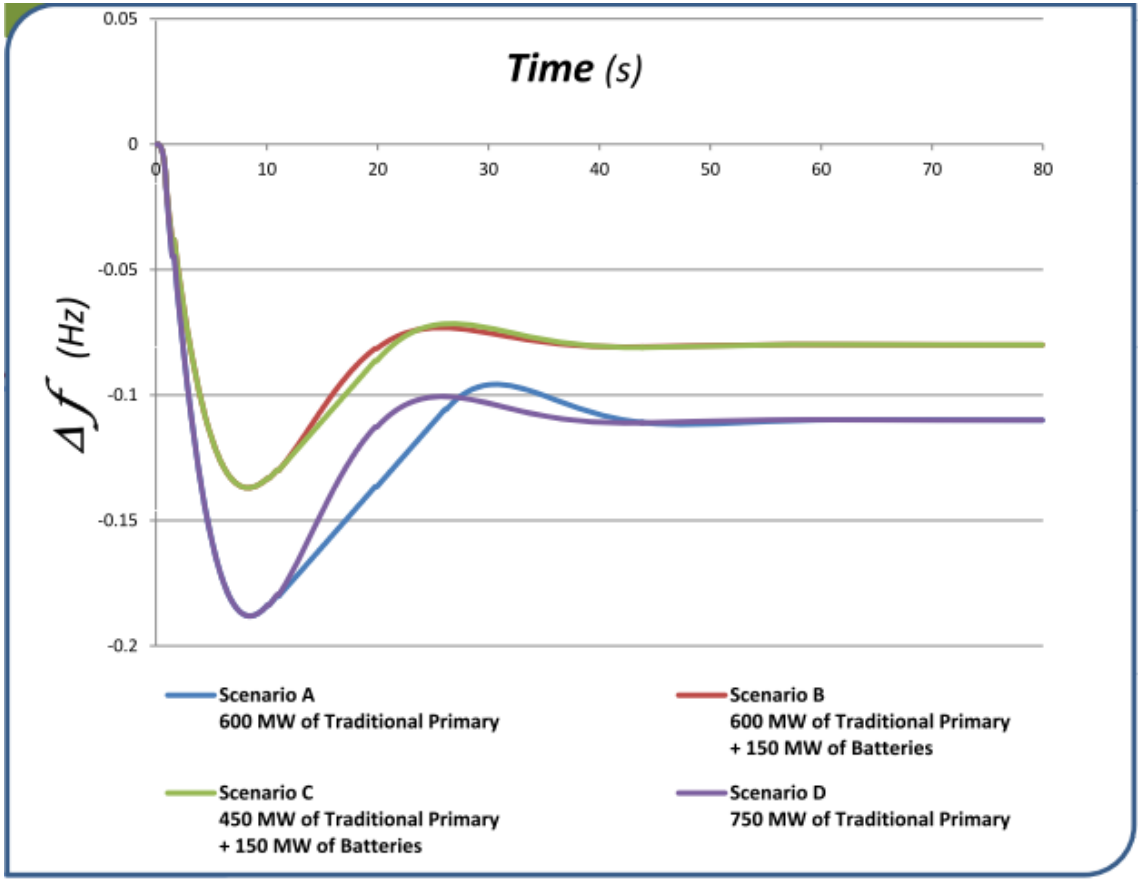
Transmission grid Frequency chart (in blue and green), must be kept at 50±0.05

➢ Batteries can provide **Primary services**, where **fast response is required**: Charging when the frequency is low and discharging when it's high.

Frequency Regulation - TERNA

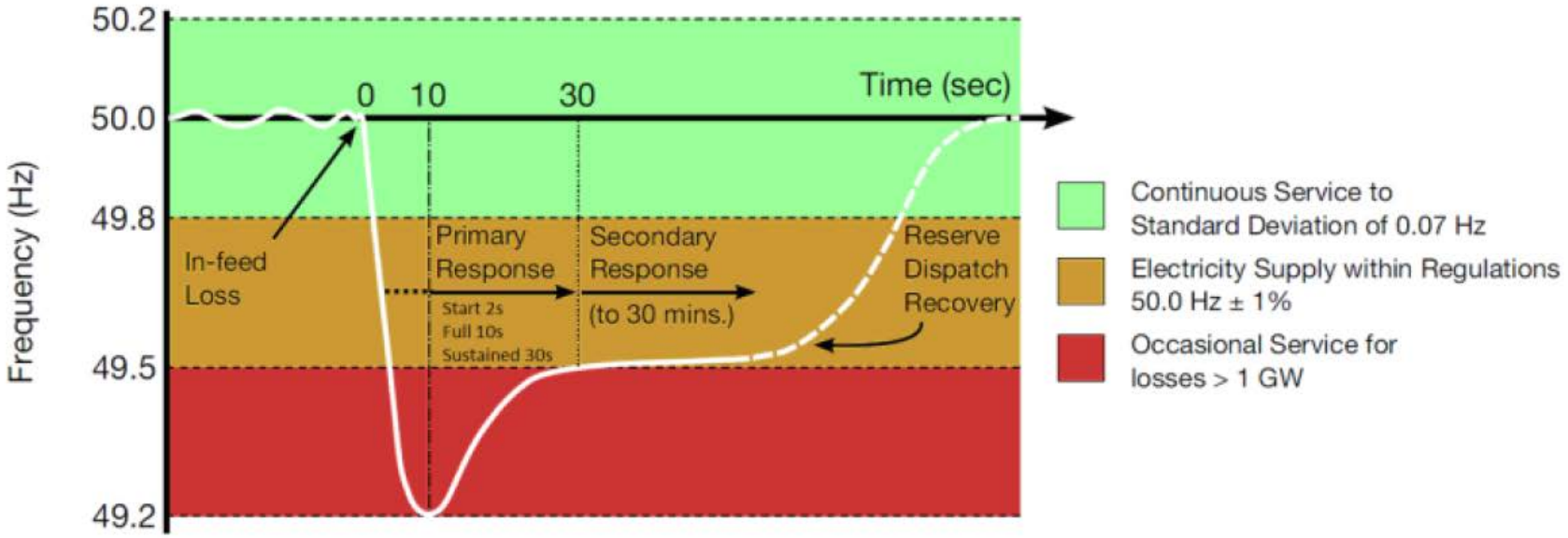
- TRENA: Italy's electricity transmission grid operator
- **Combination of traditional generators and batteries the most cost effective** for frequency regulation

75/25% traditional/storage for frequency regulation is **much better than 100% traditional**



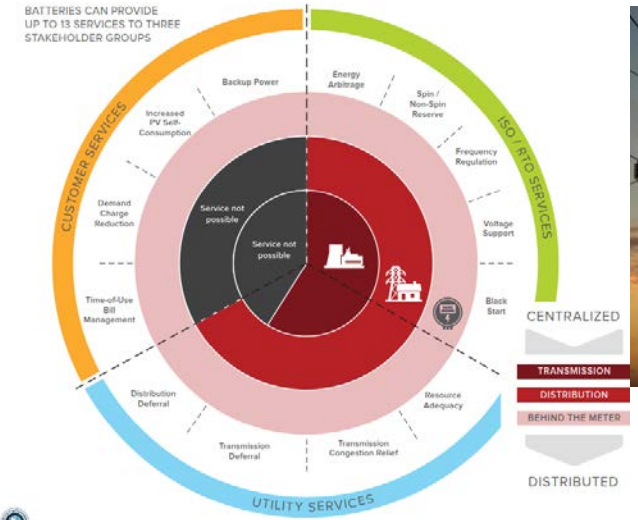
Frequency Regulation - UK

- NationalGrid: UK's electricity transmission grid operator
- Increase of network operation cost by 150-200M € pear year by 2020!



Others Grid Services

- **Voltage Regulation** at the distribution network
- **Transmission / Distribution network Deferral**
- **Transmission congestion Relief:** Assuring sufficient energy to meet customers demands. Eg South-Australia
- **Critical for small grids and grid with a lot of renewables**

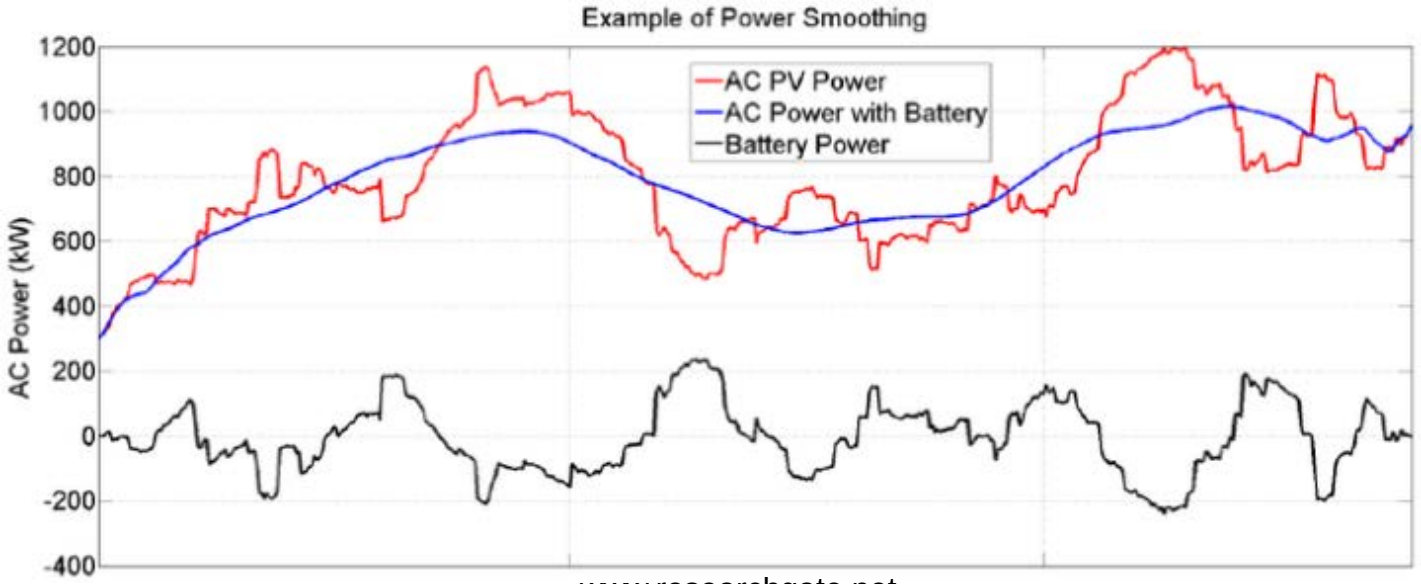


PV + storage Tender in a small Caribbean nation, with solar up to 25% of generation

Frequency control reserve 59.5<f<60.5	Alert state reserve f<59.5	Black start reserve
3.75MWh	1.25MWh	1MWh

Ramp Rate Control

- Storage to **decrease rapid changes of renewable output**, eg cloud event at solar farms
- Storage system **charged & discharged to maintain the max ramp rate** required
- **Kadapa and Pavagada Indian tenders**: Max ramp rate as **±2% of last 15 minutes moving average** of solar output
- **10% storage expected in every solar project in India**



www.researchgate.net

Backup Power for Peak Demand

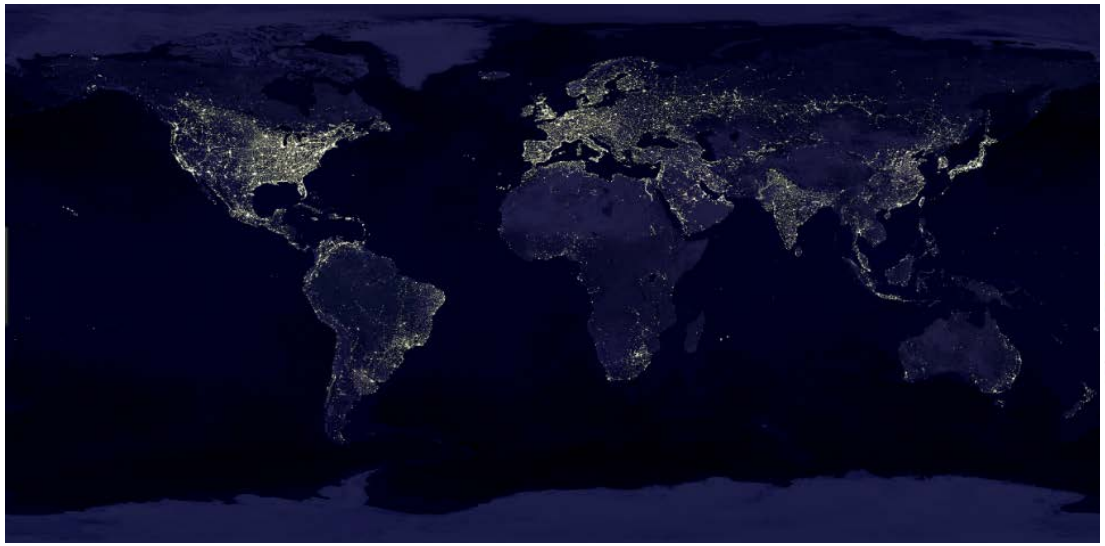
- **Utility scale storage system for peak demand**
- Oct 2015: **Gas leak** at Aliso Canyon's underground storage facility used or peak demand → **Facility shutdown** due to reliability concerns → **Utility scale energy storage as replacement**
- Jan ’17: **20MW/80MWh energy storage system** completed in 88 days

Aliso Canyon gas generator

20MW/80MWh energy storage

Mini Grids

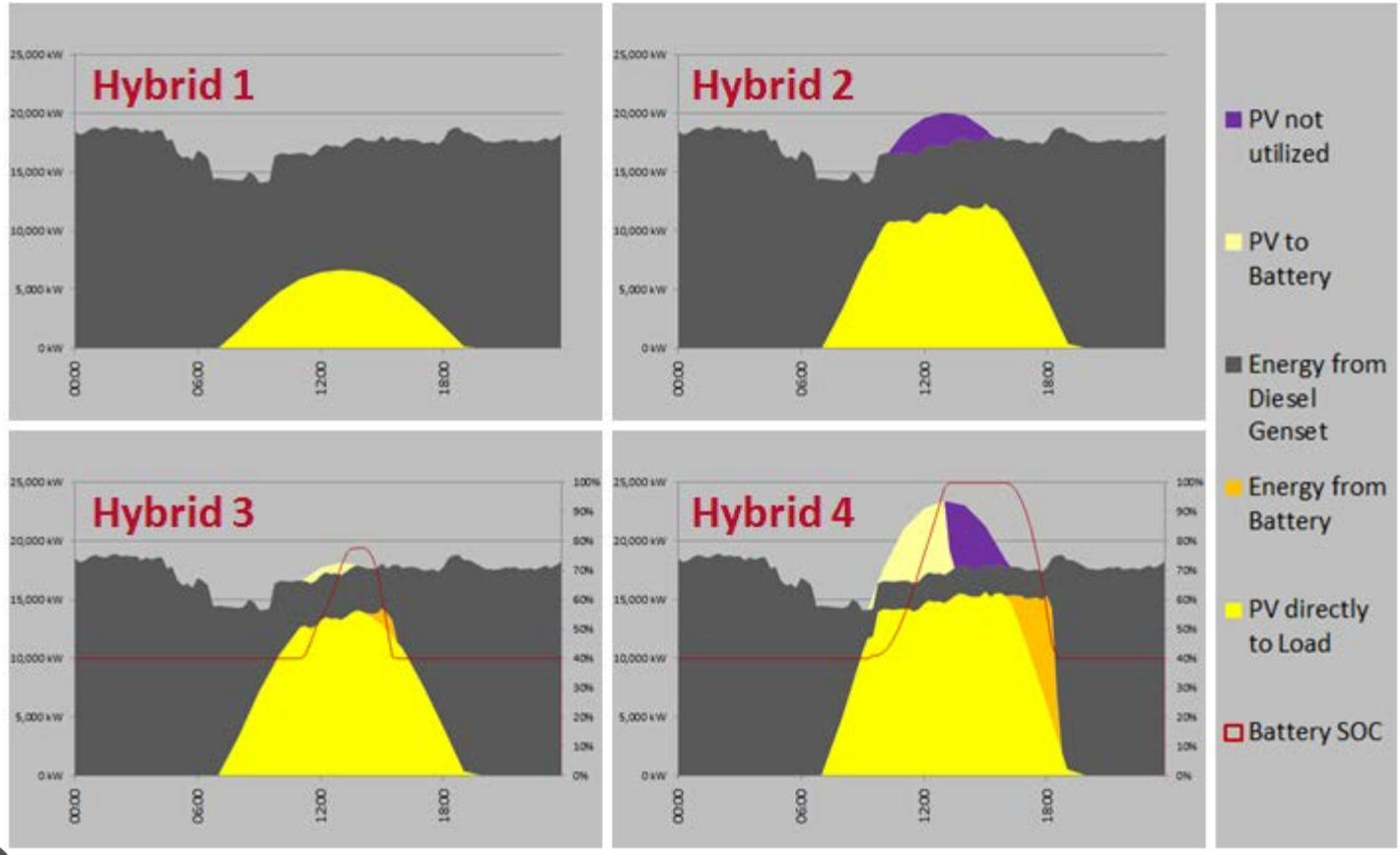
- **Mini Grid** ("micro grid"), **is electricity supply to local customers with power generators** (and storage)
- Potential in Africa, Australia, South-America: **65% of Africa's citizens without** access to **electricity**. **500AU$ diesel subsidies in West-Australia**
- **Storage is key component for micro grids** to **reduce fuel costs** and to **increase reliability**

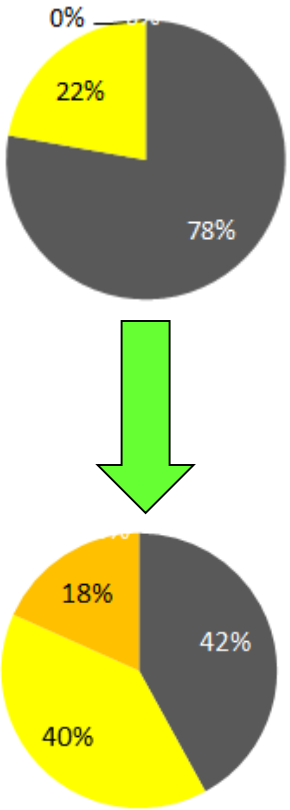


Increase Solar Penetration with Hybrid

- **% of solar power limited to ~20%** to allow diesel ramp-up
- **Storage can significantly increase solar size** & hybrid system

→ **Increased saving** of diesel fuel & use of excess solar output





Virtual Power Plant - VPP

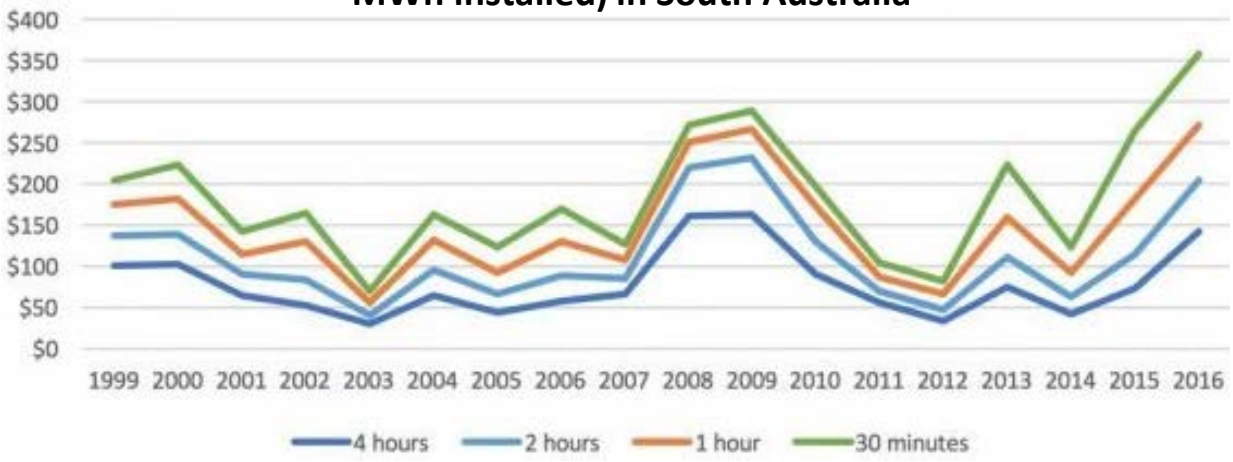
- VPP – **Aggregated distributed energy resources** for energy trading and/or ancillary services
- **Energy storage-enabled VPPs let a utility add the capacity of a power plant without investing in a new physical plant**

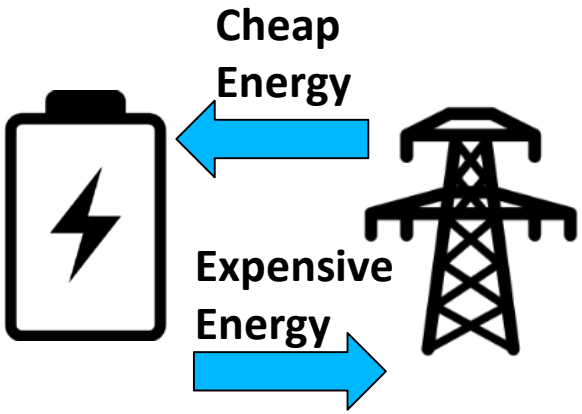
Mar 2017, power company AGL implementing the **world largest VPP** in South Australia: **5MW** VPP made of **100s properties with solar and battery storage**

Energy Arbitrage

- **Revenues due to changes at energy prices**
- **Risky**, makes sense **in combination with other applications**
- **Implemented in the UK**, 2 projects **combining frequency services and arbitrage** business cases
- Evaluated as part of **South-Australia tender**
- **Requires high power system**, to benefit from short duration of price peaks & low

Average Daily Arbitrage Payback AU$/MWh (annual, per MWh installed) in South Australia

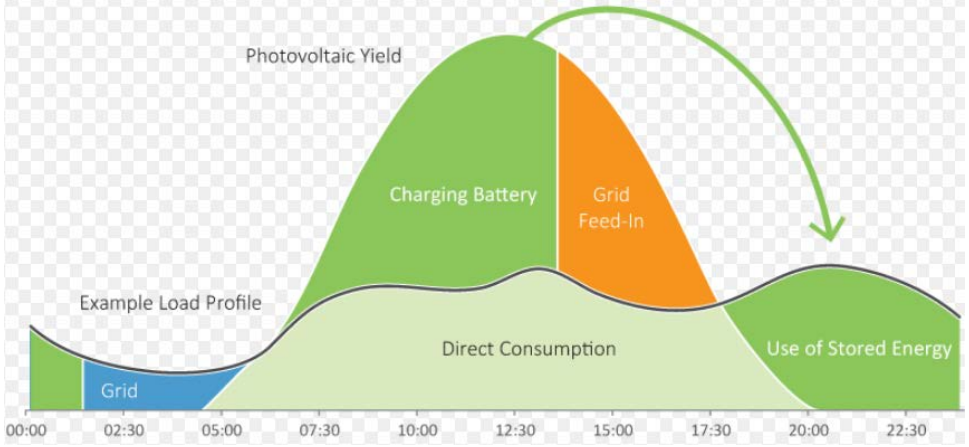




Increased Renewable Self Consumption

- **Avoiding losses** due to renewable energy curtailment at utility applications or generation-demand not aligned at residential & commercial applications.
- **South Australia**: 100MW/129 MWh battery at 309 MW wind farm**, mainly to reduce losses of wind energy** and to provide grid services

Excess solar energy used later through battery

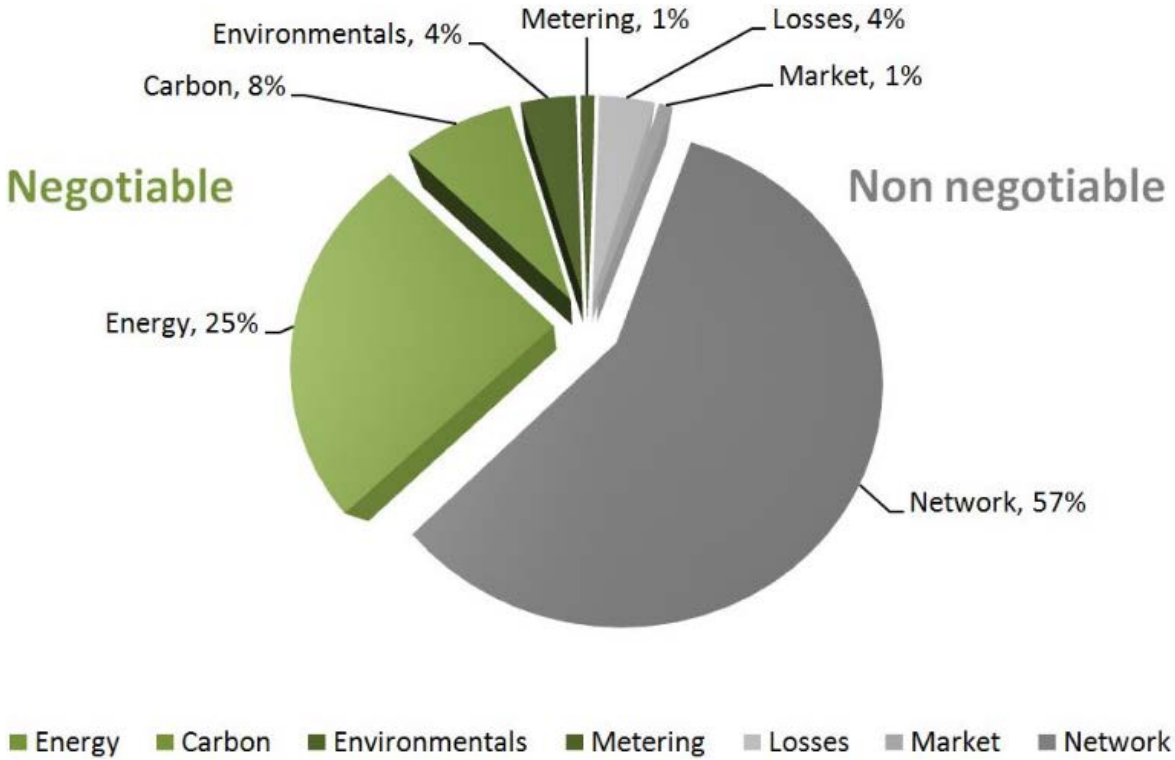


Concept image for the South Australian project

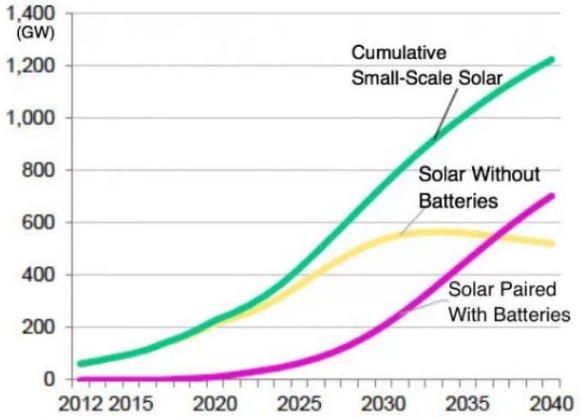
Residential Solar

- **Grid costs are ~60%** of electricity bill in Australia → **Driving consumers to go off grid!** enabled by energy storage
- BNEF: "***Over the next 25 years, small-scale battery storage will become a $250 billion market***" (worldwide)

Typical electricity bill at NSW, Australia



Storage will become standard with rooftop solar by 2030



BNEF, 31 Jan 2017

Storage Commercial Viability

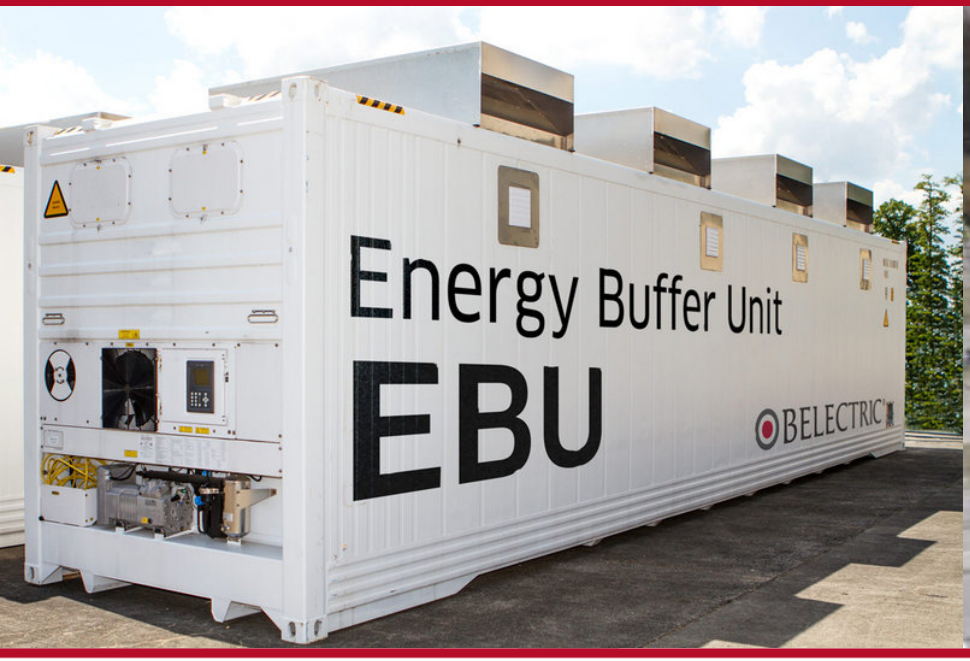
Rule of thumb:

- EPC CAPEX costs **~500 Euro/kWh** (installed capacity)
- **~6,000 cycles** (guaranteed) during system life
- → **~0.08 Euro/kWh** EPC CAPEX cost (=500/6,000)
- Investors CAPEX costs + OPEX costs: **~0.04 Euro/kWh**
- → Total costs **~0.12 Euro/kWh** (usable capacity)

Highly recommended lecture:

Clean Disruption - Energy & Transportation, Mr Tony Seba

https://www.youtube.com/watch?v=2b3ttqYDwF0



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