Defining and Solving For Grid Needs

Workshop on Battery Storage, Hybrid Resources, Frequency Response and Grid Services

September 2019

FLUENCE

A Siemens and AES Company

Keys to a cost-effective and reliable grid (and to evaluating hybrids)

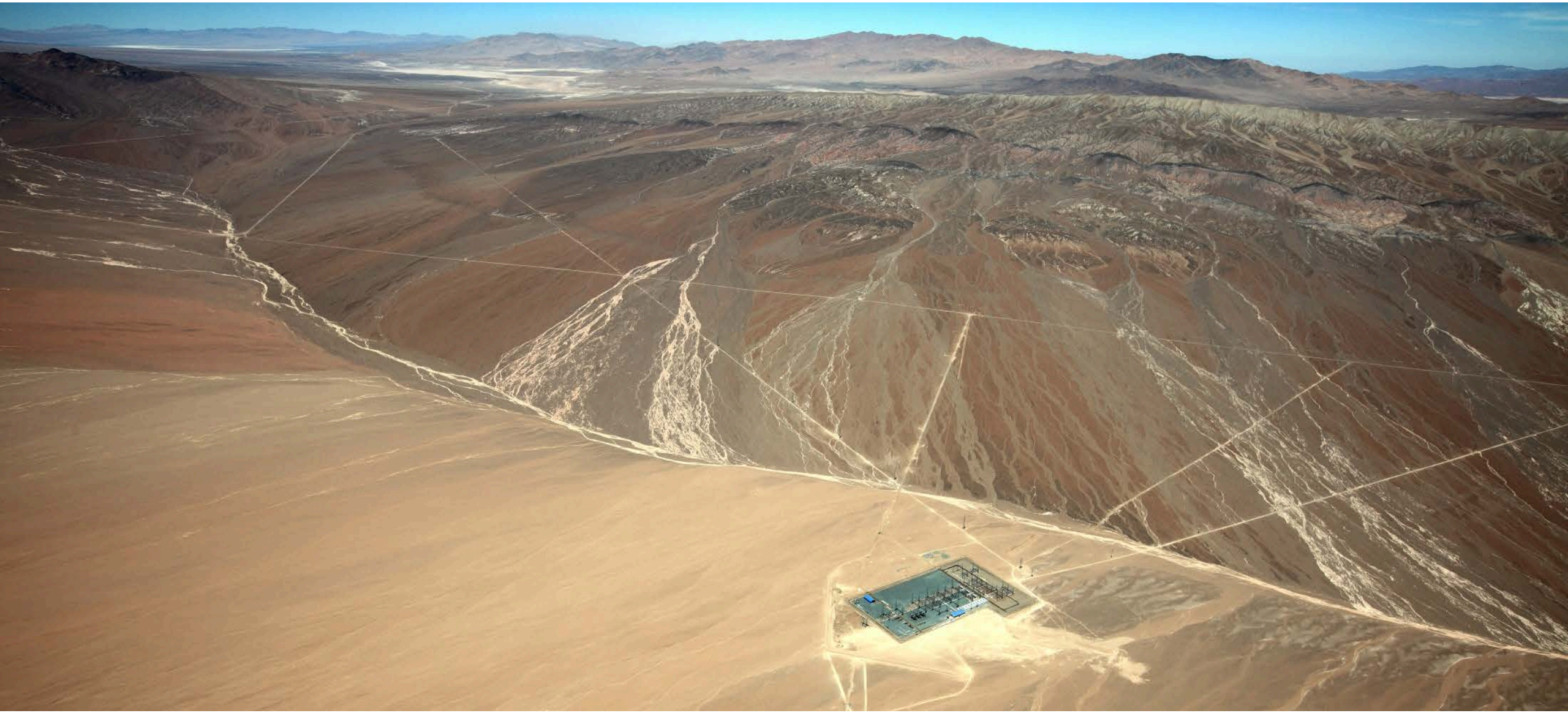
1. Define the core needs (products) needed to ensure a reliable grid
   - E.g., daily firm capacity during the summer months from 3-9pm, or response time to grid disturbance in <300ms

2. Allow a range of technologies to compete for each need to determine the least-cost, most reliable solution
   - E.g., standalone energy storage, storage paired with renewables, gas generation

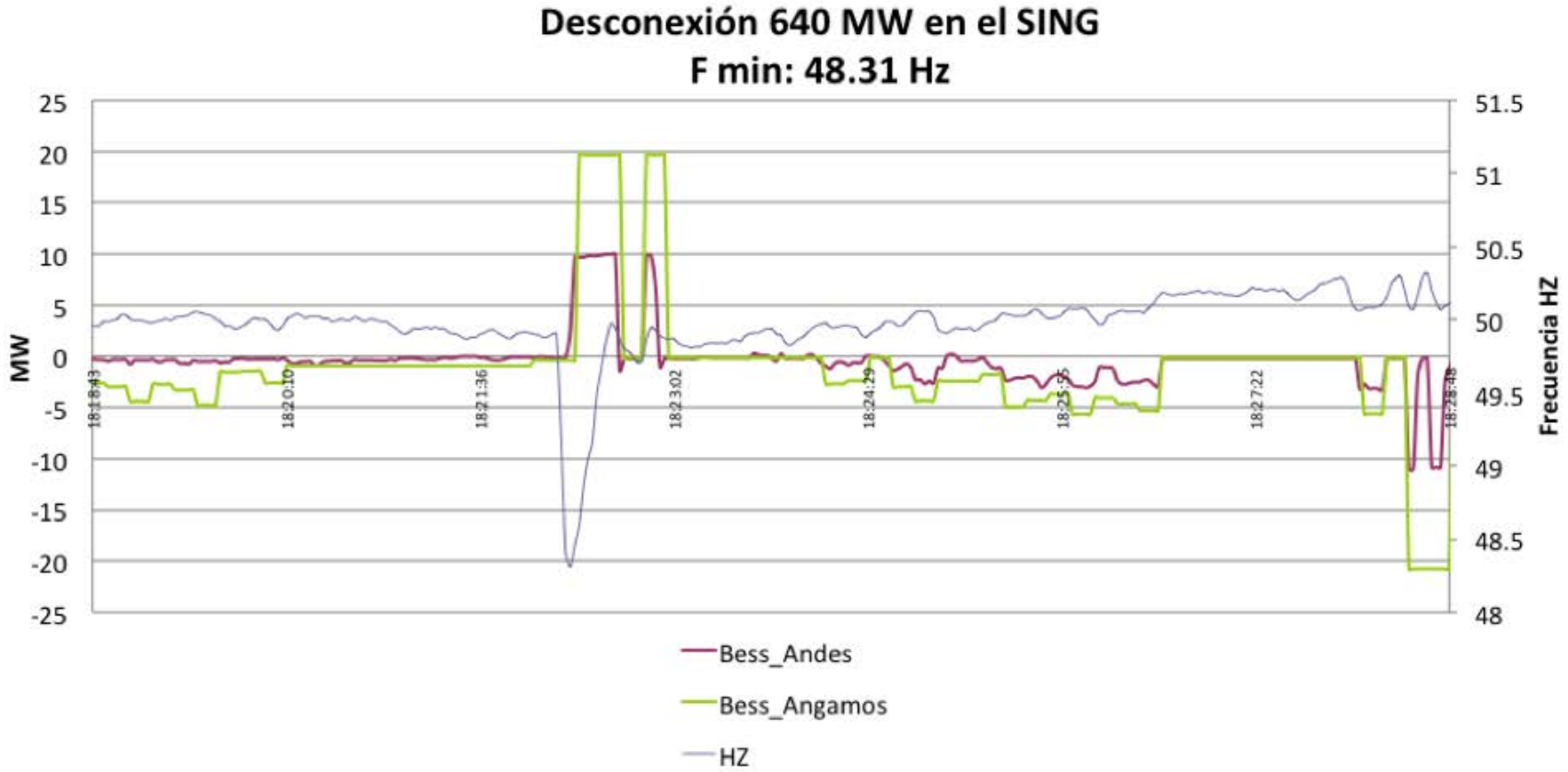
3. Allow the market to determine the solution, rather than pre-ordain it

Energy storage supplying critical spinning reserves

Initial project leading to over 100MW of energy storage in Chile

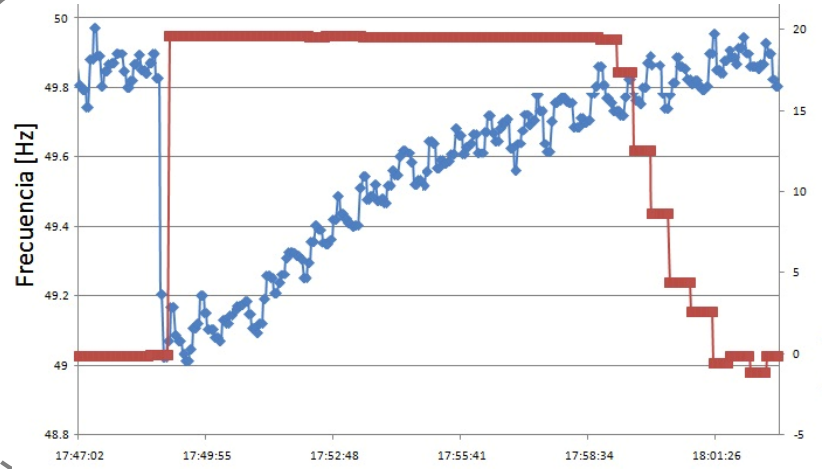


Actual performance: grid disturbance event when storage units autonomously responded to frequency deviation



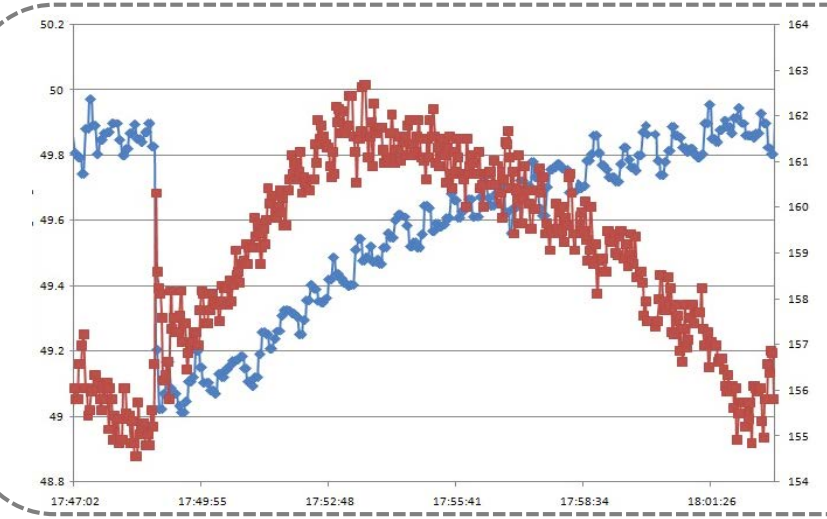
The AES units BESS_Andes and BESS_Angamos both responded immediately and this rapid injection of power helped stabilize the system frequency so that the other thermal units could replace the lost power without tripping.

Actual Performance: Angamos storage resource's quick, precise response to maintain grid frequency



Angamos BESS Response

- ✓ Angamos BESS responds with rapid increase of output from 0MW to 20MW
- ✓ Autonomous response according to programmed profile
- ✓ Output sustained until stability restored

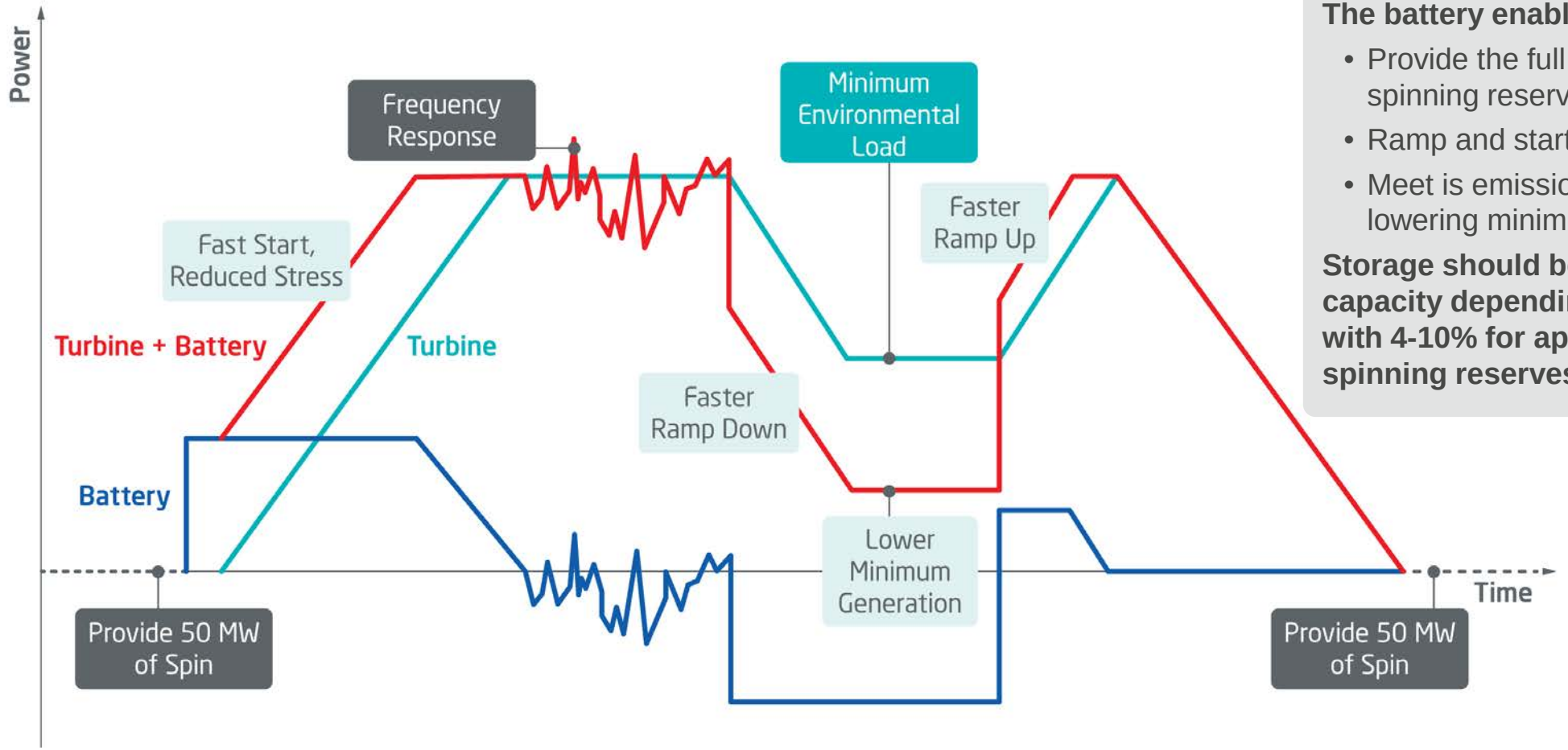


Thermal Units

- ❖ Thermal unit responds with 4MW burst, then output drops off
- ❖ Gradually ramps up in oscillating manner to 7MW output increase over 4 minutes

Hybrid symbiosis: Simple Cycle GT + BESS for spinning reserve

Hypothetical dispatch of 50 MW Gas Turbine and 15 MW Storage



The battery enables the turbine to:

- Provide the full capacity turbine as spinning reserves when the turbine is off
- Ramp and start Faster
- Meet is emissions standards while lowering minimum generation level

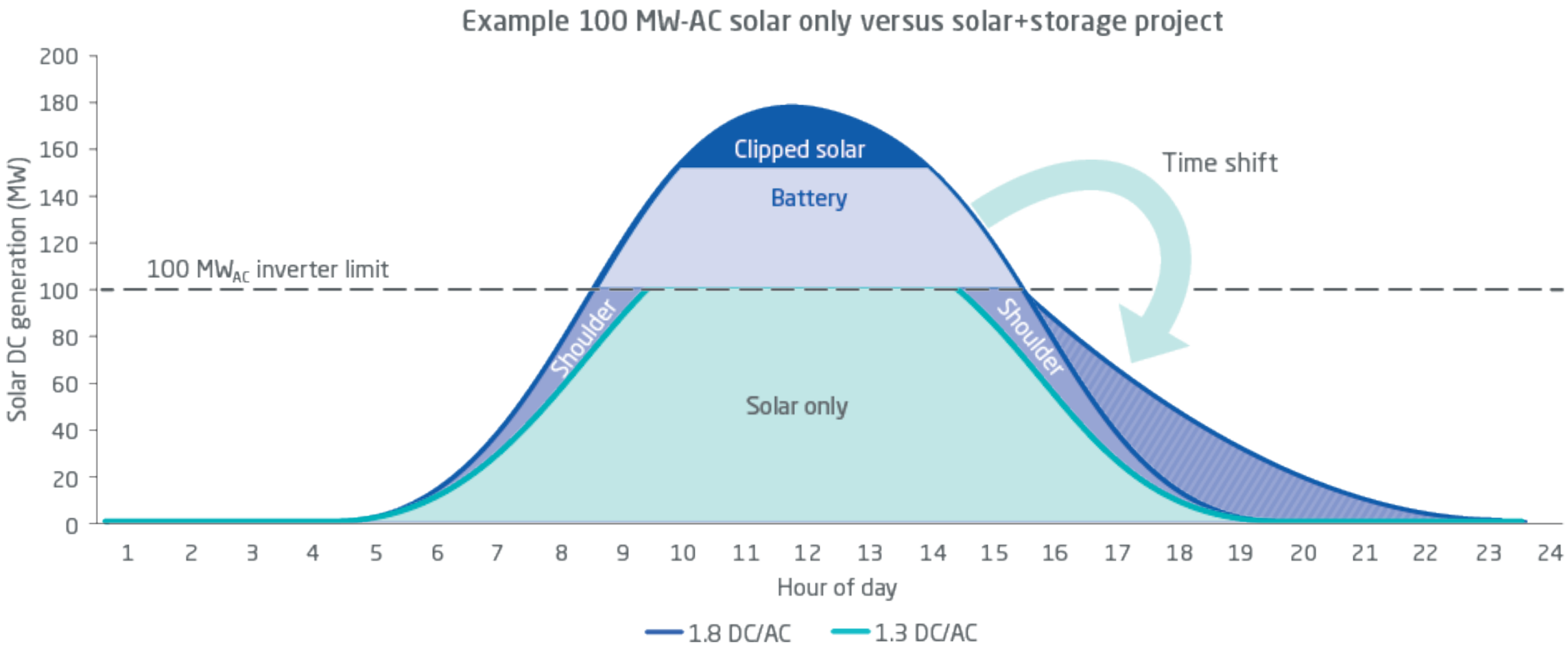
Storage should be 4-30% of thermal capacity depending on the application, with 4-10% for applications focused on spinning reserves

Spinning Reserve and Frequency Response

Decrease minimum load and increase ramp rate

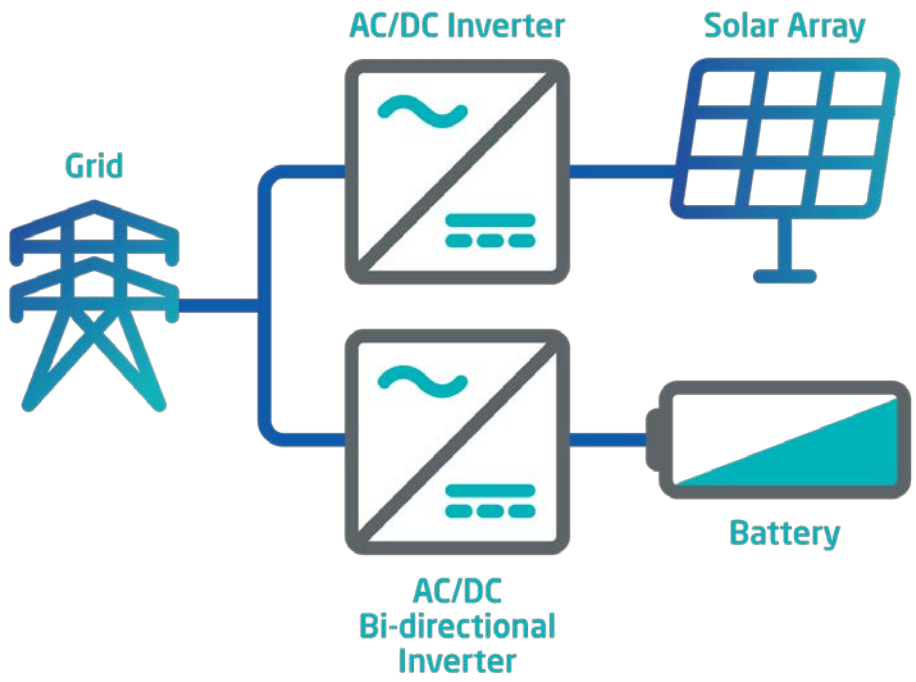
Lower Emissions

Maximizing solar with DC-coupled energy storage

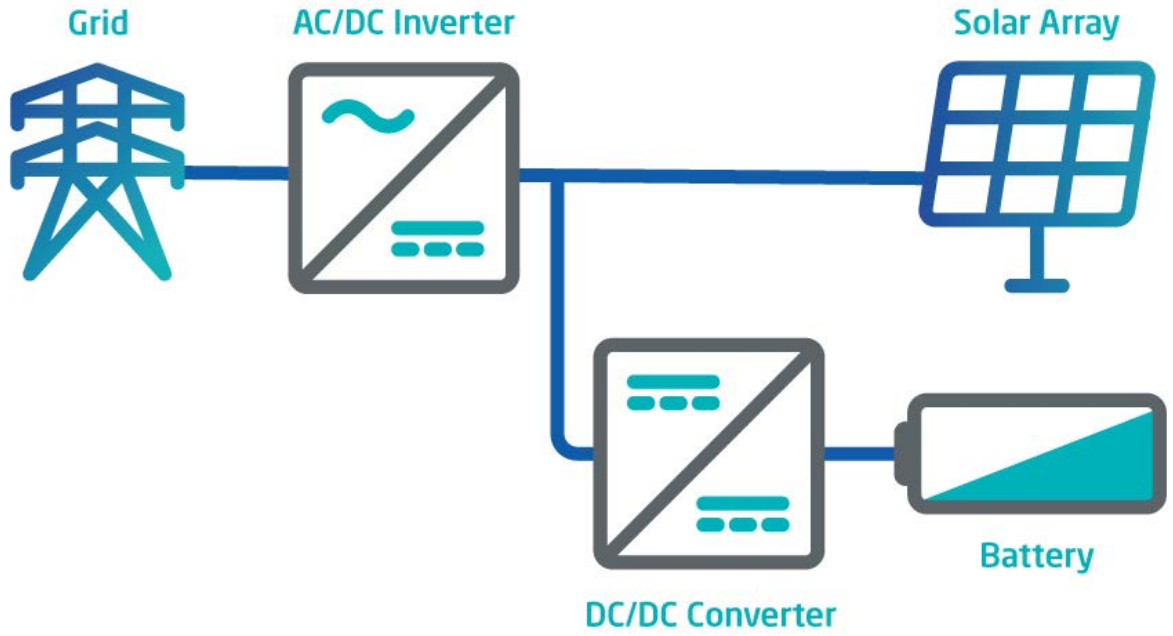


AC versus DC Coupling

AC Coupled



DC Coupled



Renewable integration

US Solar Developer

Massachusetts, United States

SERVICES

- Solar + storage
- Transmission upgrade deferral
- Peak management

IMPACT

- Rapid deployment of preconfigured sizes to customers solar farms
- DC-coupled and AC-coupled offering

Renewables are the most competitive energy source in many markets, and storage costs are declining rapidly

Cheapest Energy Generation Technology By Country

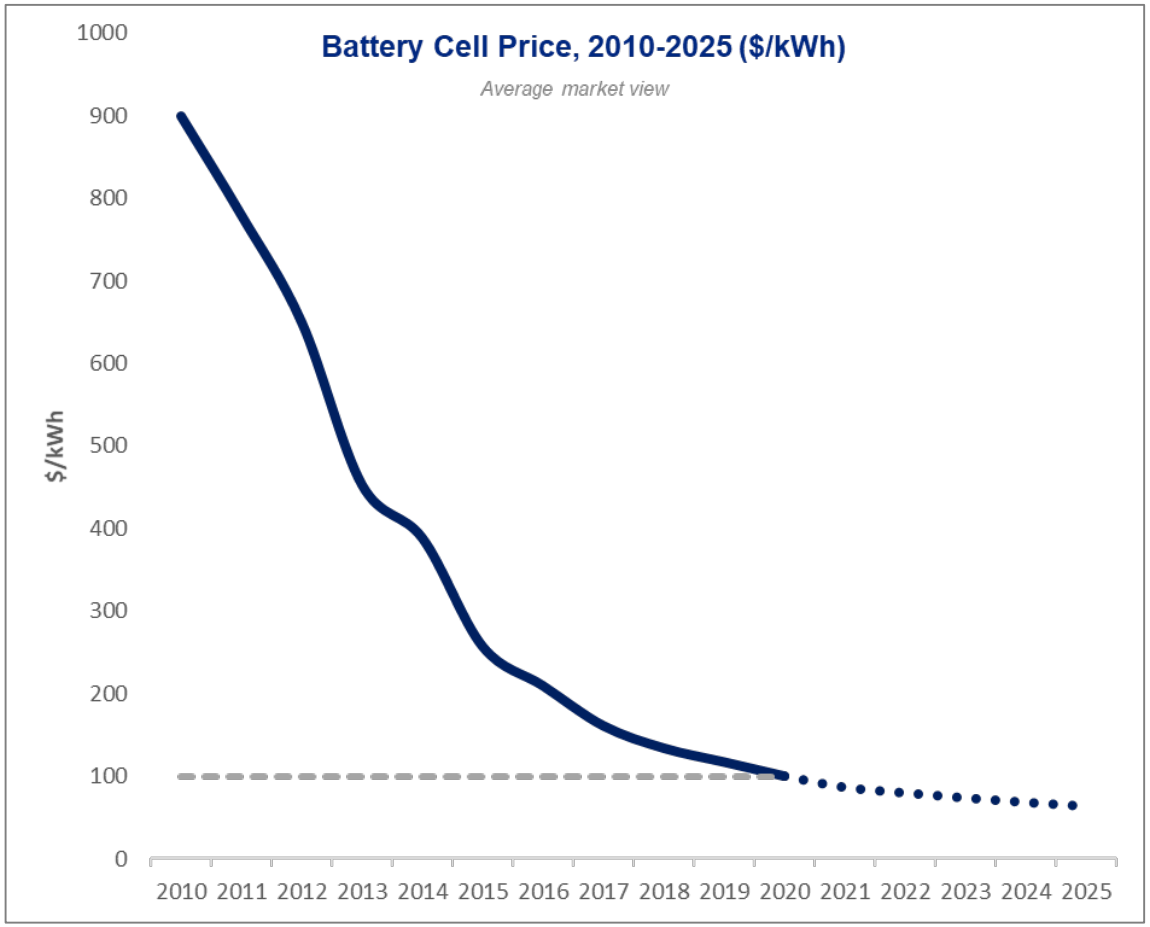
2014

Coal	Gas	Wind	Solar
Belgium	Algeria	Denmark	
Bulgaria	Argentina	Germany	
Chile	Australia	Uruguay	
China	Brazil		
France	Canada		
Greece	Egypt		
India	Israel		
Indonesia	Mexico		
Italy	Peru		
Japan	Philippines		
Malaysia	Russia		
Morocco	Saudi Arabia		
Poland	U.S.		
South Africa	UAE		
South Korea			
Spain			
Thailand			
Turkey			
U.K.			
Vietnam			

2019

Coal	Gas	Wind	Solar
Indonesia	Algeria	Argentina	Australia
Japan	Belgium	Brazil	Chile
Malaysia	Bulgaria	Canada	Egypt
Philippines	Greece	China	France
Poland	Russia	Denmark	India
South Korea		Germany	Israel
Thailand		Mexico	Italy
Turkey		Morocco	Saudi Arabia
Vietnam		Peru	South Africa
		U.K.	Spain
		U.S.	UAE
		Uruguay	

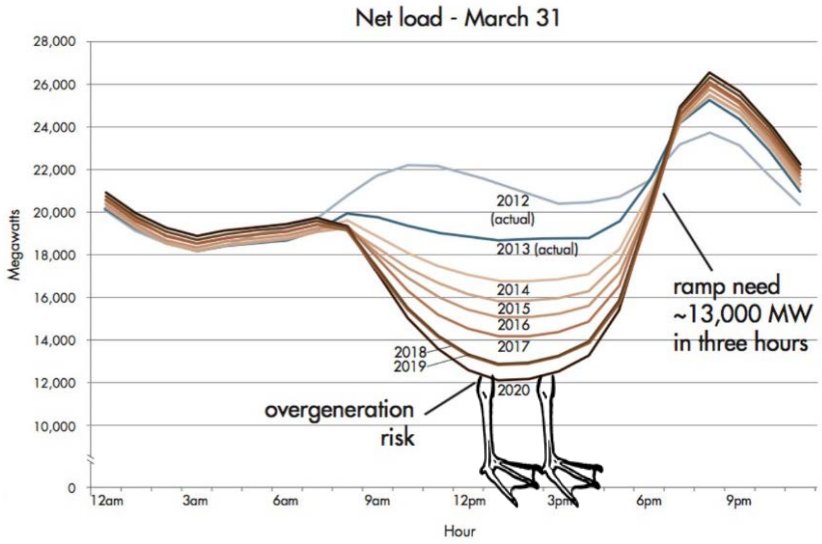
Note: Reflecting the cheapest benchmark project for each technology and market.
Source: BloombergNEF New Energy Outlook



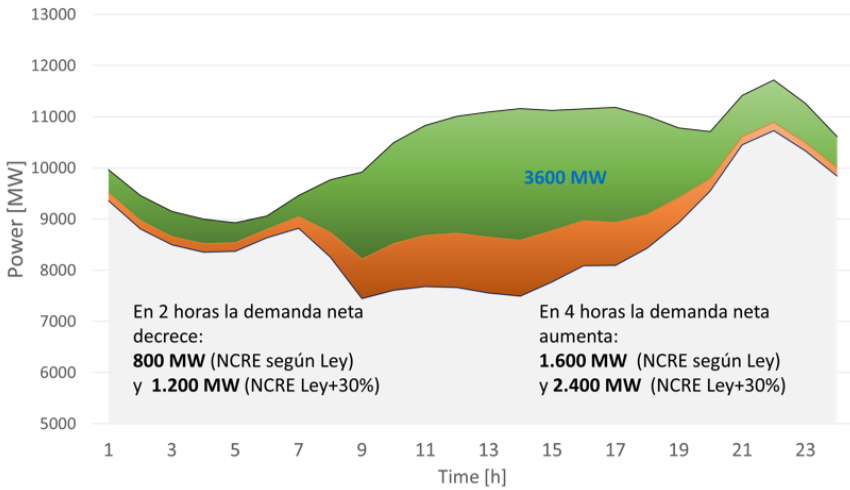
Source: BNEF

The need: ducks, kangaroos, condors, and elephants – strong peaking capacity and balancing needs showing up globally

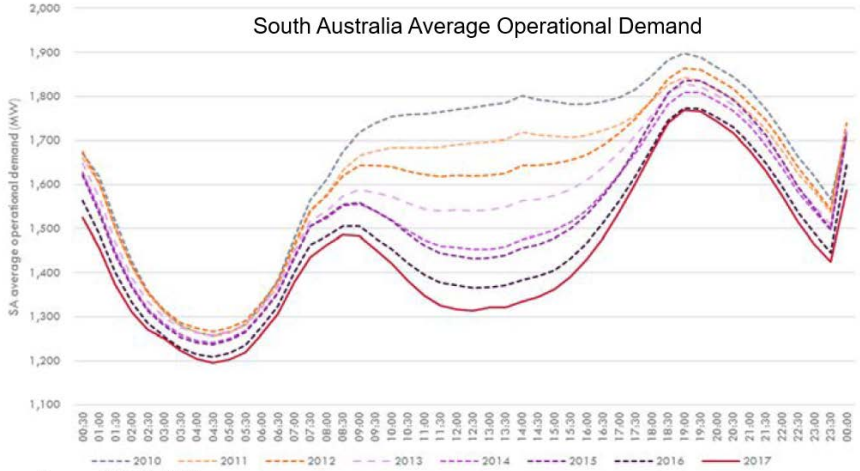
California



Chile

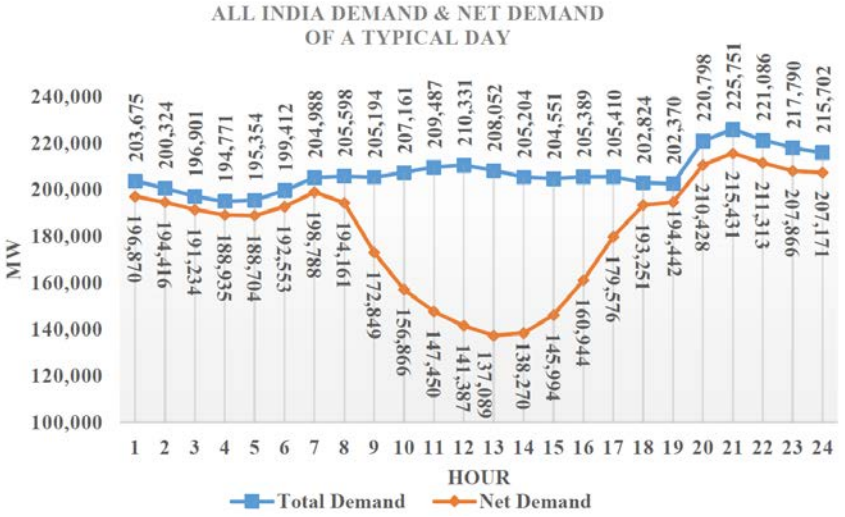


Australia

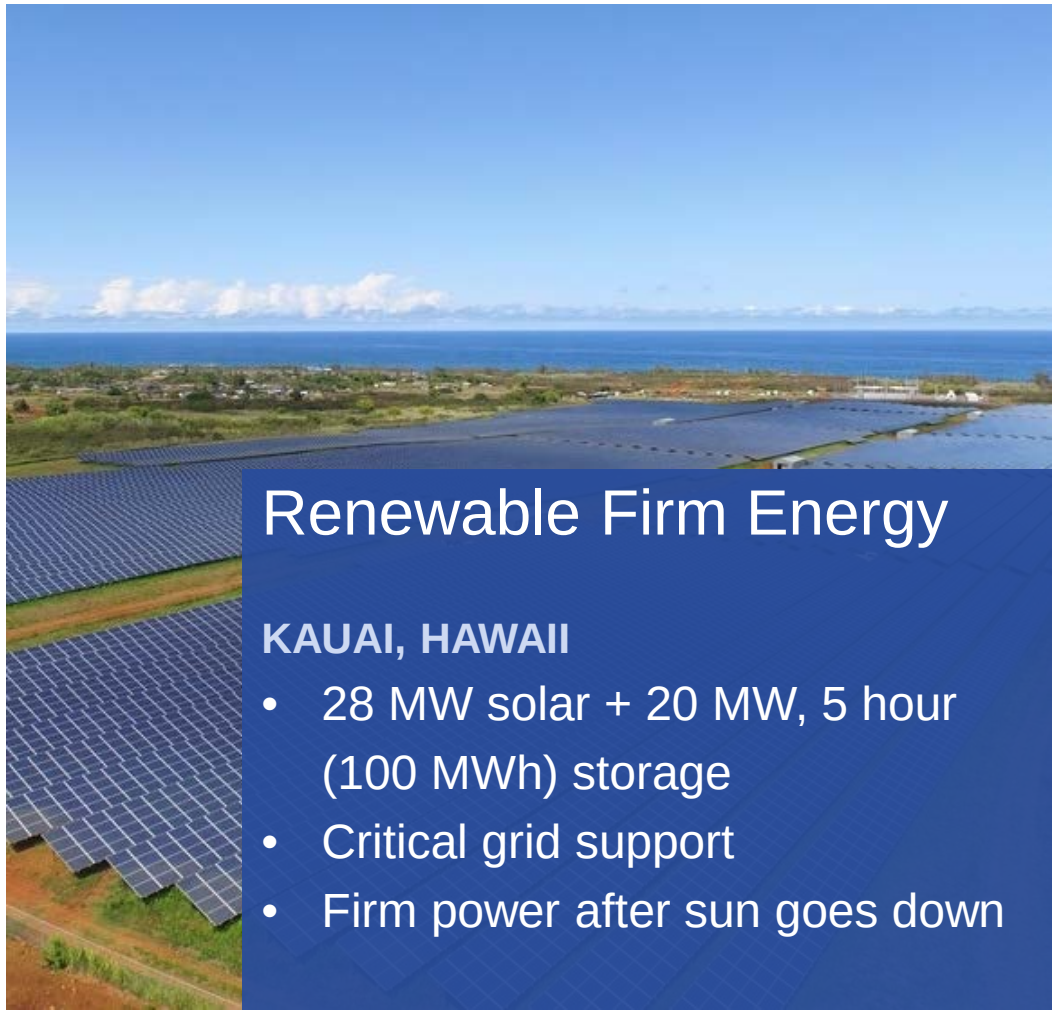


Source: AEMO, 2018

India



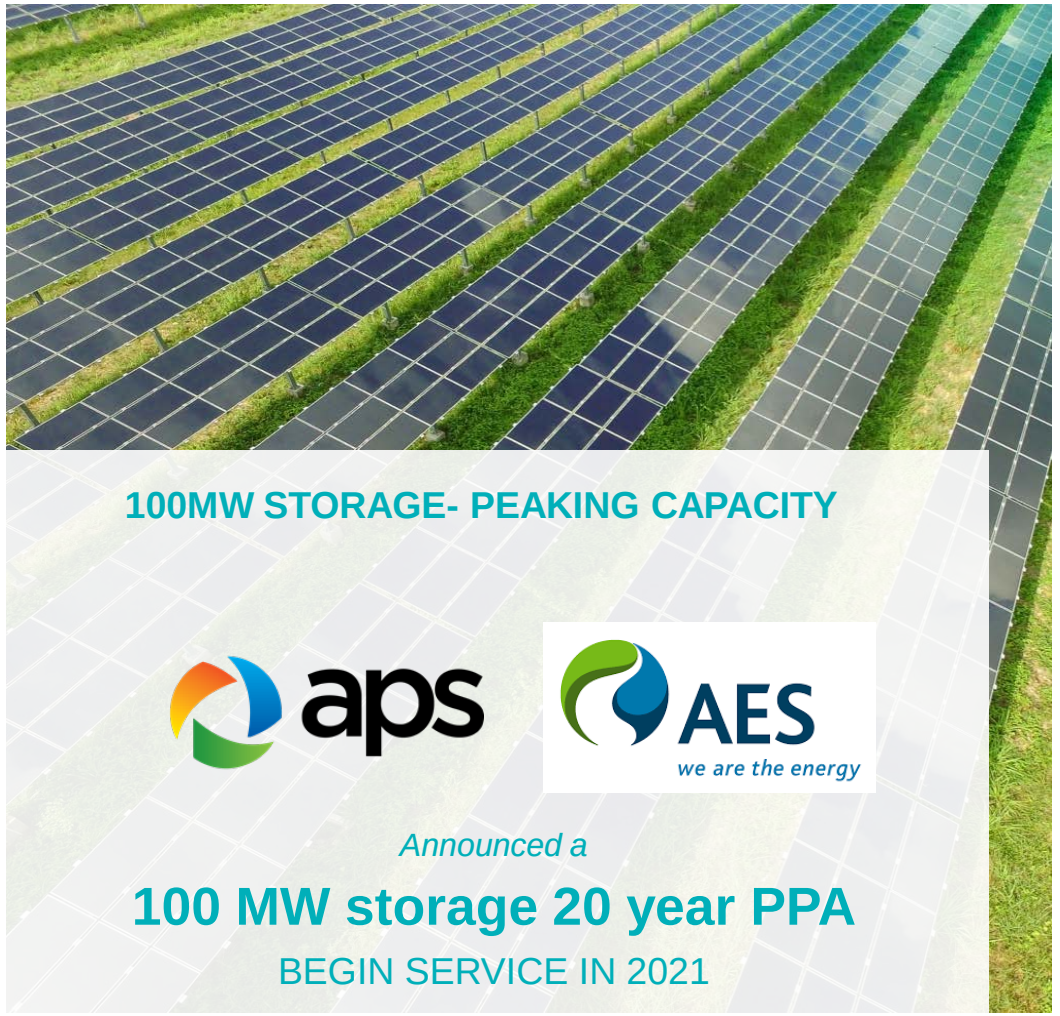
Solar + storage emerging to make firm renewables real today



Renewable Firm Energy

KAUAI, HAWAII

- 28 MW solar + 20 MW, 5 hour (100 MWh) storage
- Critical grid support
- Firm power after sun goes down



100MW STORAGE- PEAKING CAPACITY

aps

AES
we are the energy

Announced a

100 MW storage 20 year PPA

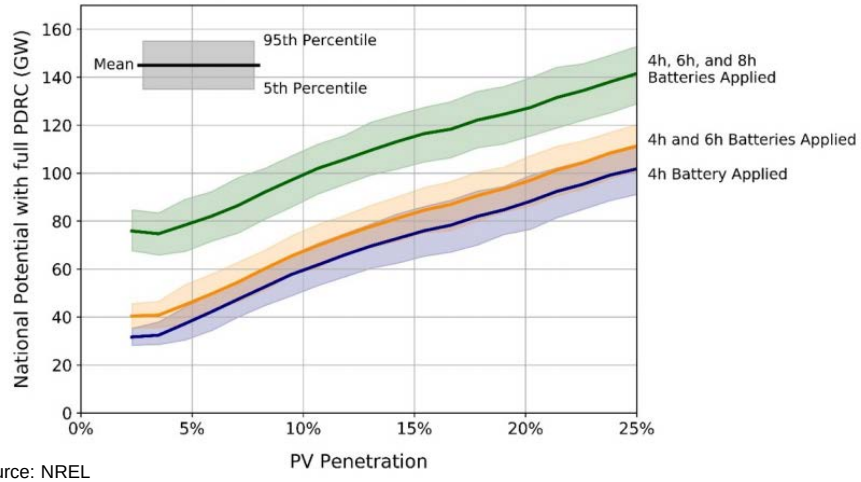
BEGIN SERVICE IN 2021

Net peak duration is economically addressable with existing renewables and storage in most markets for years to come

Country	GWs needed at <= 6 hours duration
China	119+
United States	40+
India	40+
UK	19
Australia	6
Japan	4+
Germany	4

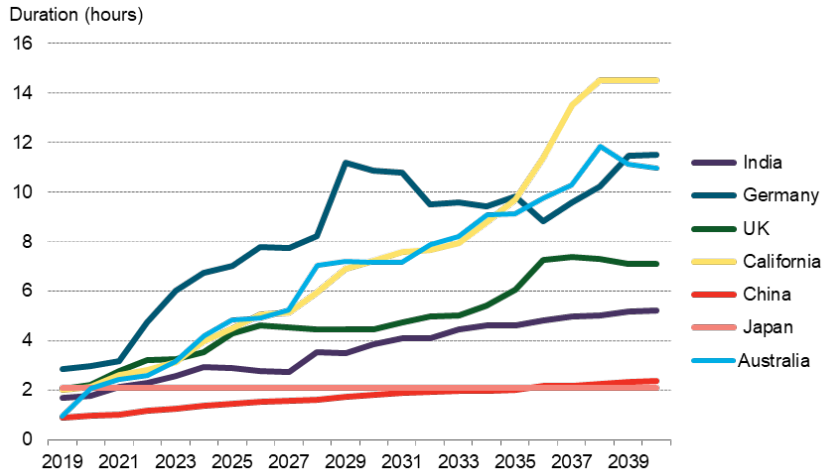
Source: BNEF, NREL

US net peak duration



Source: NREL

Global timeline of marginal net peak progress



Source: BNEF

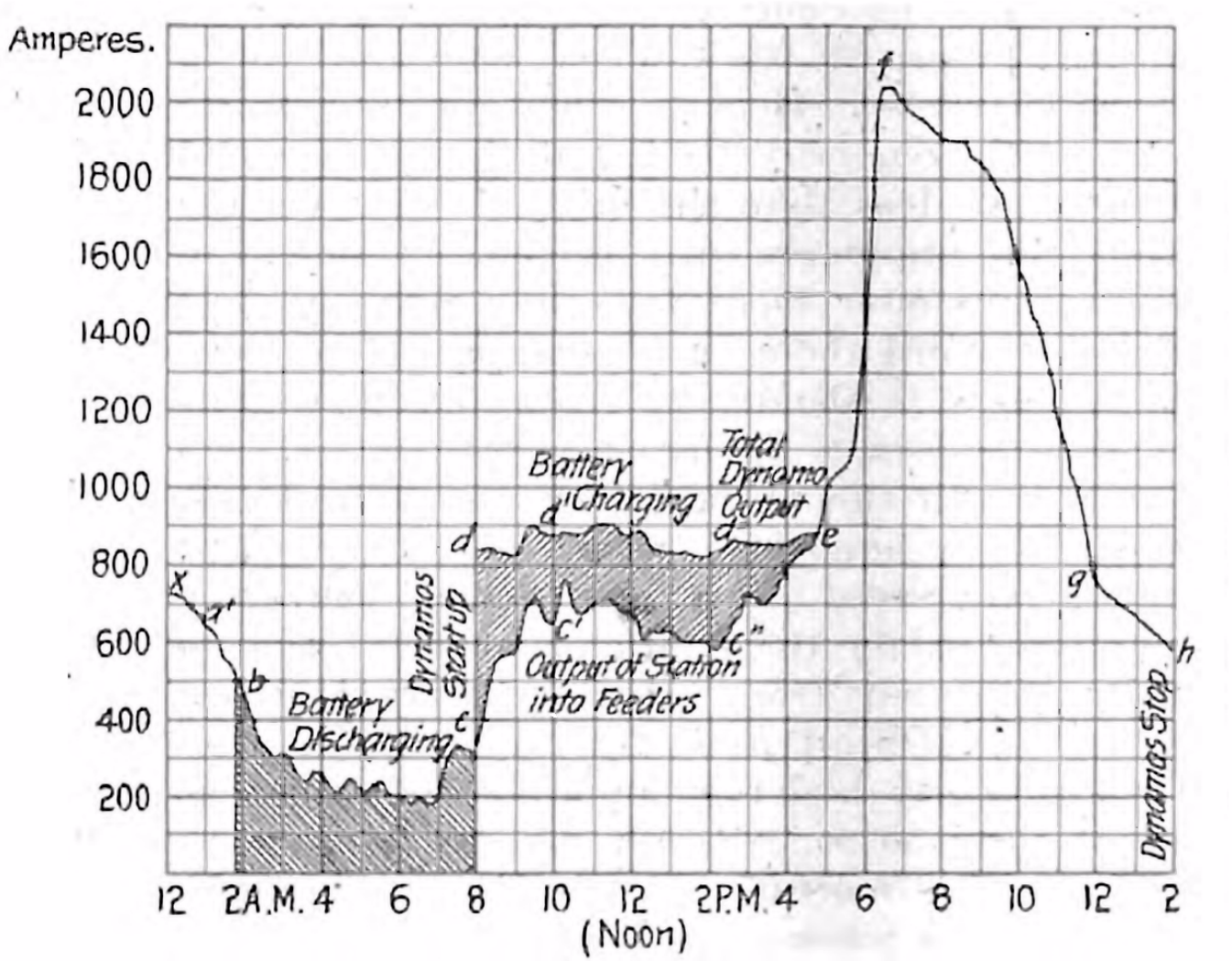


Fig. 3 —Load Diagram of 53d St. Station, Edison Illuminating Co., of New York City, Sept. 30. 1893.

Source: Engineering News, Vol. 30, p 358, Nov. 2, 1893.

"After a 100-year Hiatus, Batteries are Helping Again"

More than 120 years ago, batteries were commonplace on the power grid. Thanks to Thomas Edison's vision, many central station power plants and distribution networks utilized battery systems in the 1890s. This chart shows a 19th century "duck curve" for New York City, and demonstrates the key role that batteries played in smoothing the peaks and valleys of electricity demand throughout the day and night in Edison's time.

Thank You!

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