

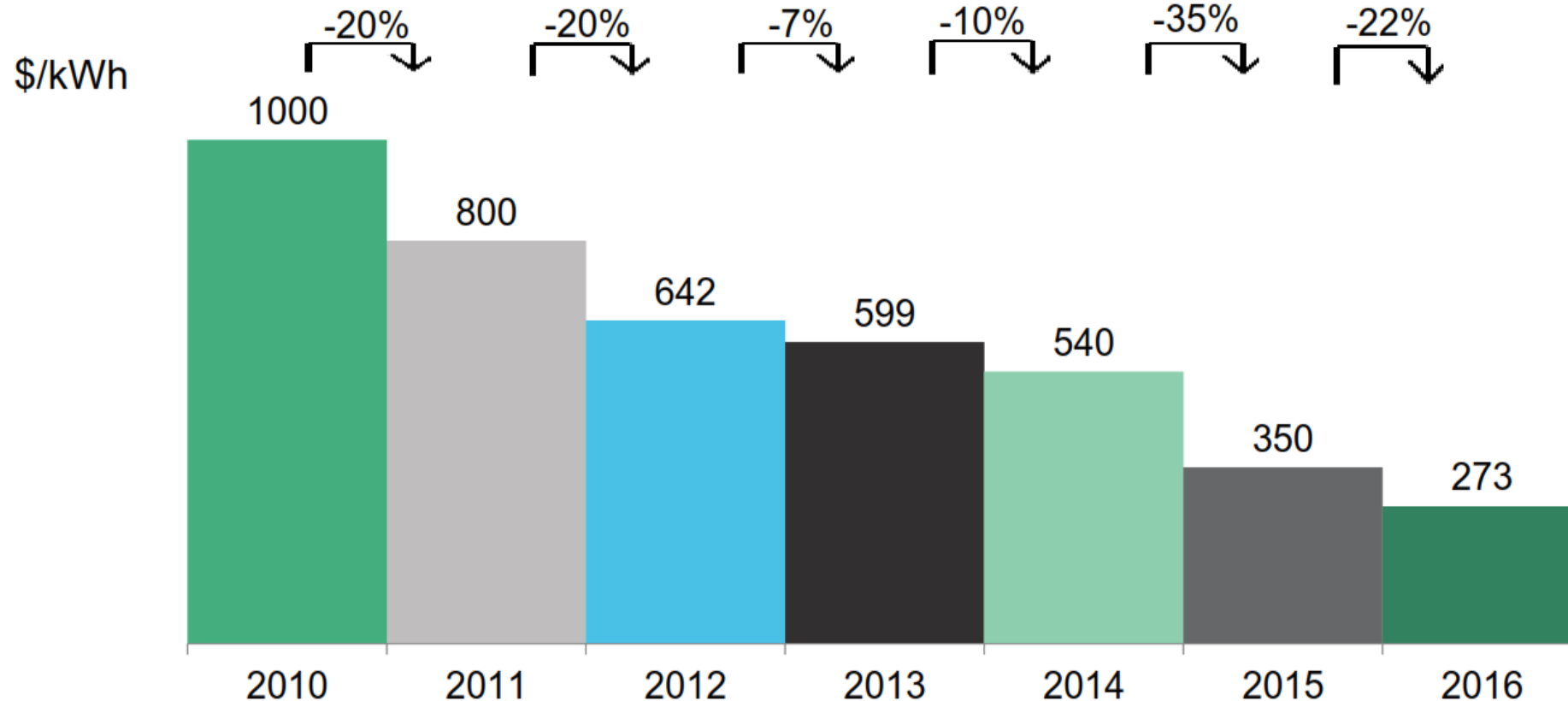


Emerging Applications of Storage

IRENA Innovation Week
6 September 2018

Battery costs are dropping rapidly

BNEF lithium-ion battery price survey, 2010-16 (\$/kWh)



Notes: This includes cells plus pack prices. For years where there were two surveys, the data in this chart is an average for the year.

Source: Bloomberg New Energy Finance

Storage is becoming central to grid transformation

South Australia, Tesla partner for \$800 million virtual power plant

South Australia could play host to the world's largest deployment of residential solar+storage in the form of a virtual power plant. The scheme, announced by SA Premier Jay Weatherill on the election campaign trail, could see 250 MW of rooftop PV and 650 MWh of battery storage added to 50,000 homes over 4.5 years.

FEBRUARY 5, 2018 **JONATHAN GIFFORD**

Source: PV Magazine

BRIEF

PG&E to replace 3 gas plants with world's biggest battery projects

AUTHOR

Peter Maloney
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PUBLISHED

July 3, 2018

Dive Brief:

- Pacific Gas and Electric (PG&E) late last week requested approval from the California Public Utilities Commission (CPUC) for four energy storage projects totaling about 2,270 MWh.
- The CPUC authorized PG&E to issue a solicitation for energy storage projects to replace three power plants that would otherwise require reliability must-run (RMR) contracts.

Source: Utility Dive

BRIEF

Xcel solicitation returns 'incredible' renewable energy, storage bids

AUTHOR

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PUBLISHED

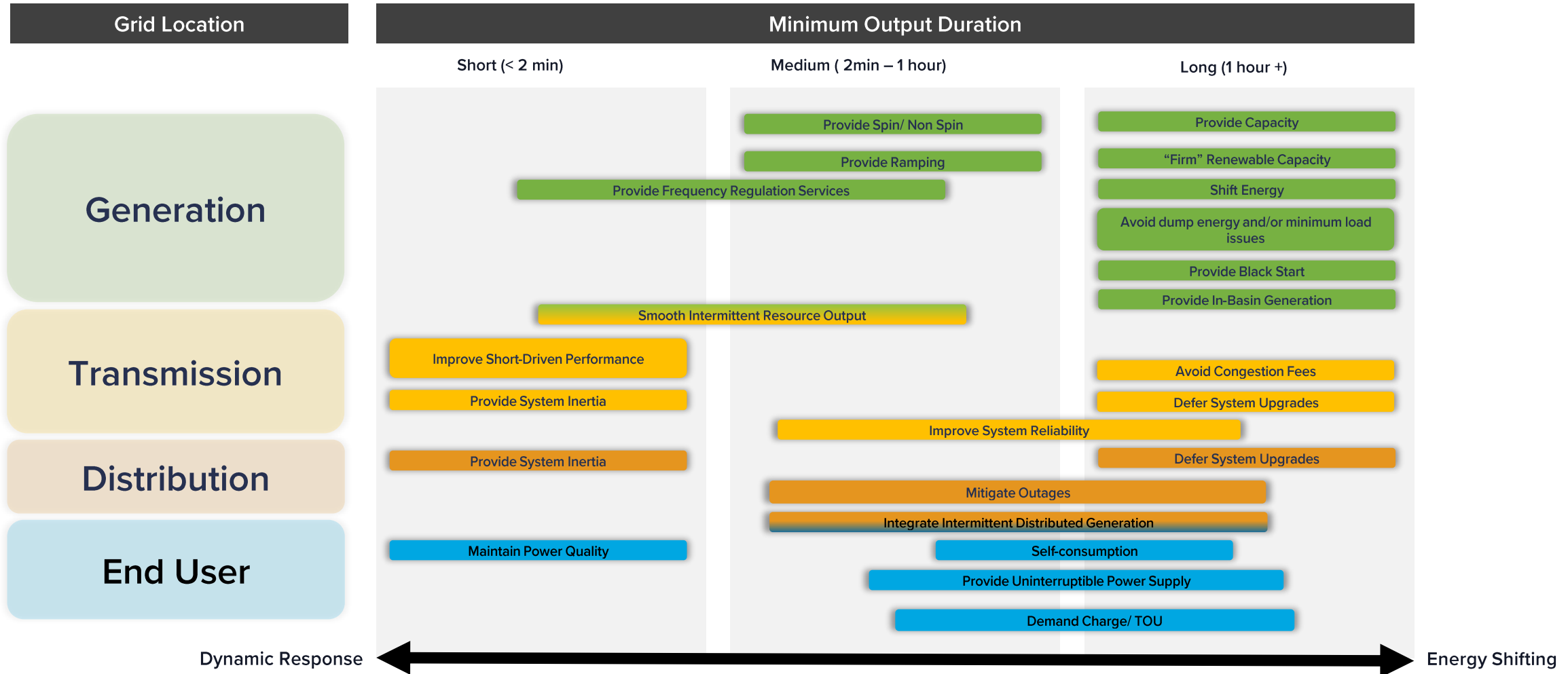
Jan. 8, 2018

Dive Brief:

- An Xcel Energy resource solicitation received more than 400 individual proposals, the utility reported last month, including what may be record-low prices for renewable energy paired with energy storage.
- The median price bid for wind-plus-storage projects in Xcel's all-source solicitation was \$21/MWh, GTM Research's Shayle Kann noted on Twitter, and the median bid for solar-plus storage was \$36/MWh. Previously, the lowest known bid for similar solar resources was \$45/MWh in Arizona.

Source: Utility Dive

With new applications emerging quickly



Source: Modified from SCE 2011 chart

Chapter 1

Frequency regulation

- Frequency regulation (FR) storage projects are low energy applications therefore lower cost for batteries
- Important but shallow market as renewable generation increases
- FR was largest front-of-meter storage application in USA in 2016
 - 265 MW of fast-response storage in 2016
 - Typically 30 minutes duration
 - Volatile market pricing



Source: Energy Storage North America 2017
solarprofessionnal.com

Chapter 2

Local capacity peaker replacement

Primarily a Storage-only Application

1. Southern California: 94.5 MW / 342 MWh Peaker Plant Constructed In 7-months (Aliso Canyon)
2. South Australia: 100MW / 129 MWh In 100 Days (Horseshoe Bend)
3. San Francisco Bay Area: 568 MW / 2,270 MWh In 2020 (Moss Landing)



Counterparty / Name	Storage Technology	On-Line Date	Term (Years)	Discharge Duration (Hours)	Size (MW)	Local Sub-Area
Dynegy Moss Landing Trade, Inc. Moss Landing Energy Storage	Lithium Ion Batteries	12/01/2020	20	4	300	South Bay – Moss Landing
Energy LC ingbird Energy (e)	Lithium Ion Batteries	12/01/2020	15	4	75	South Bay – Moss Landing
Monoc Inc. (mNOC ERS Energy Storage)	Lithium Ion Batteries	10/01/2019	10	4	10	South Bay – Moss Landing
Tesla Inc (Moss Landing Energy Storage) ¹	Lithium Ion Batteries	12/31/2020	20	4	182.5	South Bay – Moss Landing

Source: PG&E Advice Letter 5322-E

Chapter 3

T&D infrastructure deferral

Energy storage for T&D deferral is expected to grow from 332 MW in 2017 to 14,325 MW in 2026.



Use case attributes:

- High distribution upgrade costs when long lines serving remote, small loads
- Radial lines
- High peak-to-energy ratio
- Modest projected load growth
- Uncertainty regarding the timing and amount of major load additions
- T&D construction limitations (siting, access local community opposition to new power lines and infrastructure.)
- An energy storage system used for T&D deferral will be able to provide additional benefits (renewable integration, etc.)

Australia Example: Grid utility support system, 20 energy storage systems to support remote networks

Source: [energy-storage.news](#), [businesswire.com](#), [ergon.com](#)

Chapter 4

C&I and Co-op Demand Charge Mitigation

- Great River Energy Co-op in Minnesota issued RFP for 10 MW PV and 10 MW/20 MWh Storage system in 2018
- Primary use case for storage is to dispatch over 2-4 hours peak period for demand reduction
- Storage to be charged by co-located PV



Source: greatriverenergy.com, advmicrogrid.com,



Irvine Company Hybrid Electric Buildings

- Batteries and advanced software
- 10 MW / 60 MWh
- 20 buildings
- 20% peak demand reduction

Chapter 5

Dispatchable solar – PV + storage peaker



Source: <http://www.lyoninfrastruc.com>

Australia: Toktown Solar and Storage

- 33MW solar plus 1.4MW/5.4MWh Lithium based battery storage
- Change grid location testing boundaries of operation of utility scale solar battery storage
- Project is now in operation

Arizona: Tucson Electric Power 100MW solar plus battery storage plant

- 30 MW of four-hour duration batteries
- 20 year PPA
- ~3 cents/kWh solar – ~4.5 cents/kWh with battery
- Will be largest solar-plus-utility-scale-battery system in the US

Source: <http://insights.globalspec.com/article/4139/solar-storage-peaker-plant-for-kauai>



Chapter 6

DER alternatives

Qualifying Neighborhoods
in Brooklyn & Queens Program



- Customer sited DER and embedded solutions leveraged to avoid utility infrastructure
- New markets and compensation models required to encourage, guide and extract this value
- New grid operation approaches required to compliment new markets

Source: conedbqdmauction.com, arena.gov.au

New York: Brooklyn Queens Demand Management program

- 41 MW customer sited solutions
- 11 MW utility sited solutions

Australia: AGL virtual power plant.

- 1000 aggregated BTM storage systems, 5MW / 7MWh total for customer, distribution and wholesale benefits

Australia: Proposed 250 MW / 650 MWh virtual power plant

- Up to 50,000 aggregated BTM storage systems in South Australia

Chapter 7

Renewable energy + long duration storage

KIUC: The Lawai Project

- 28 MW solar farm
- 100 MWh 5 Hour Li-Ion Battery
- 25-year PPA, 11 cents/kWh
- Supply power at peak evening times



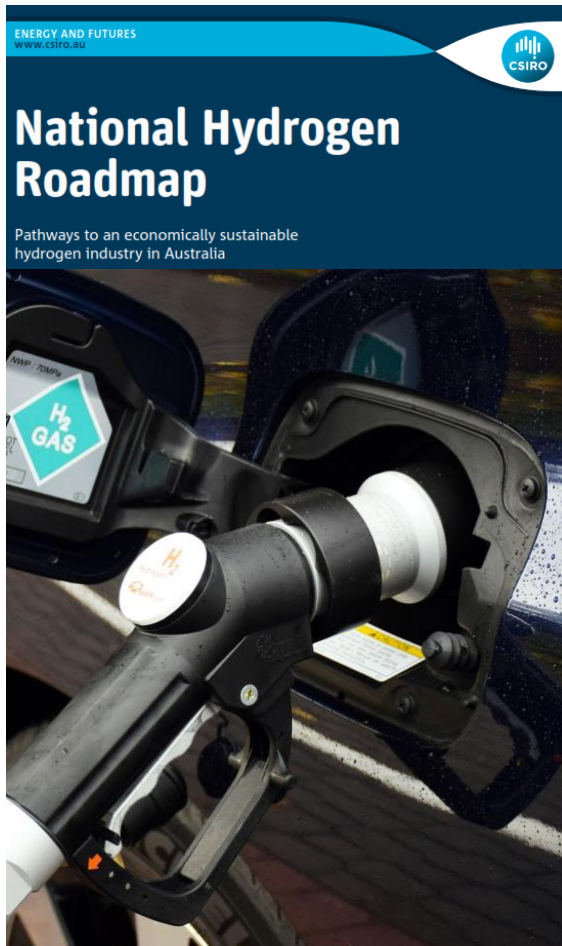
Source: [theverge.com](https://www.theverge.com), [abc.net.au](https://www.abc.net.au), hawaiienergypolicy.hawaii.edu

Solar Q: Australia's largest solar farm

- Proposed 350MW solar PV + storage with a second phase to expand to 800MW
- Storage is critical aspect to serve evening load

Chapter 8

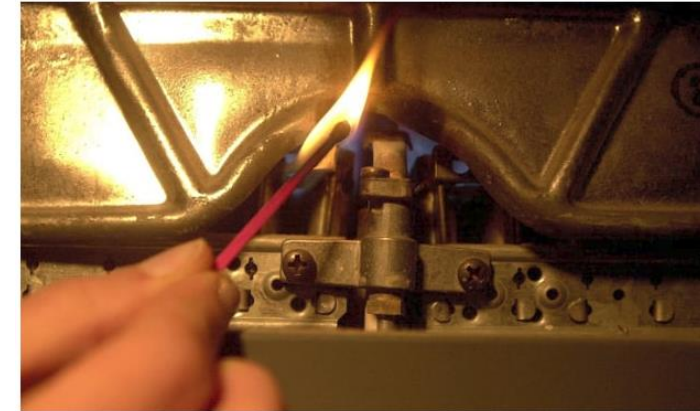
Seasonal storage



Source: CSIRO, Australian National Hydrogen Roadmap

Trial to phase in hydrogen as fuel to begin in north-west

Carbon-free gas to be distributed to industrial users in Liverpool and Manchester, with plans to dilute methane for domestic use



▲ Converting a home to 100% hydrogen would require the installation of compatible boilers. Photograph: Isopress/Rex Features

Source: *The Guardian*

REGULATION & POLICY

California Assembly Passes Historic 100% Carbon-Free Electricity Bill

The world's fifth-largest economy will have to eliminate carbon emissions from electricity by 2045.

JULIAN SPECTOR | AUGUST 28, 2018

Source: *Greentech Media*

- Seasonal storage is necessary to get to carbon free power system & transportation system
- Seasonal technologies (such as hydrogen) are emerging focus of RD&D, regulation, and commercial trials



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1
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Our exclusive focus on clean energy and advanced grid technologies means we bring our clients a sophisticated understanding of industry trends, market drivers and regulatory policy.



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Our clients come to us for our expertise in developing business models, commercial strategies, financing tools and regulatory support that empower them to create sustainable value and long-term solutions.



TEAM

Our team is comprised of well-respected thought leaders and industry experts who have played instrumental roles in shaping the power sector's transformation in the 21st century.



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Thank You!

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