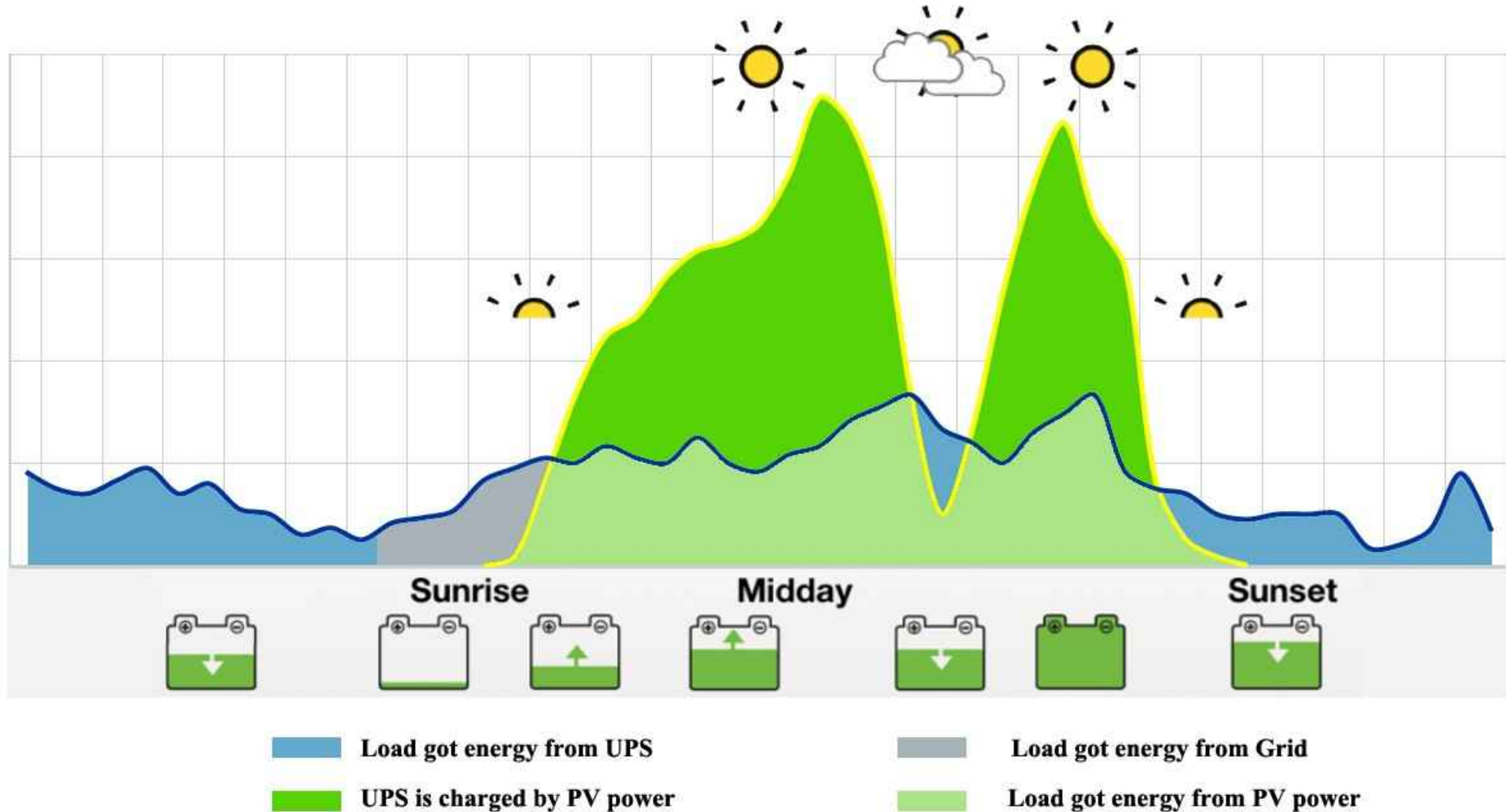


# Renewable Energy Integration and Energy Storage in Commercial Scale

Suwat Kamolpanus  
September 12, 2017

# Solutions for Energy Storage



# Type of ESS by Industry



Power Box

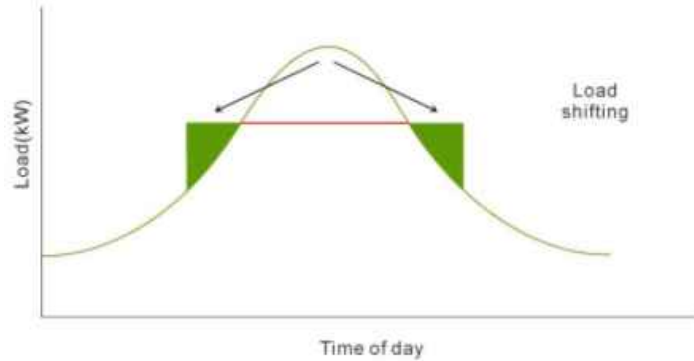


Commercial ESS

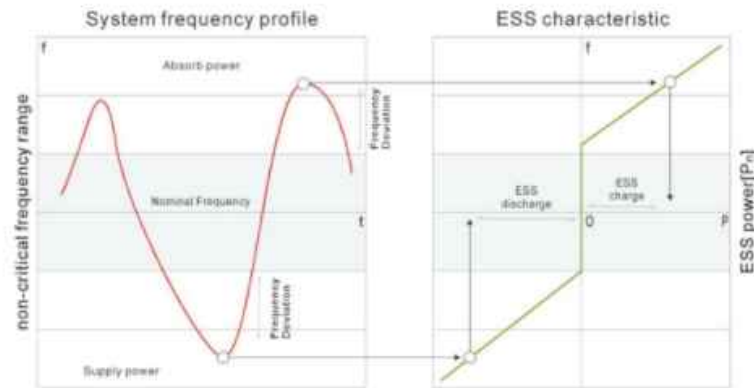


Utility Scale ESS

# Solutions for Peak-load shifting and frequency regulation

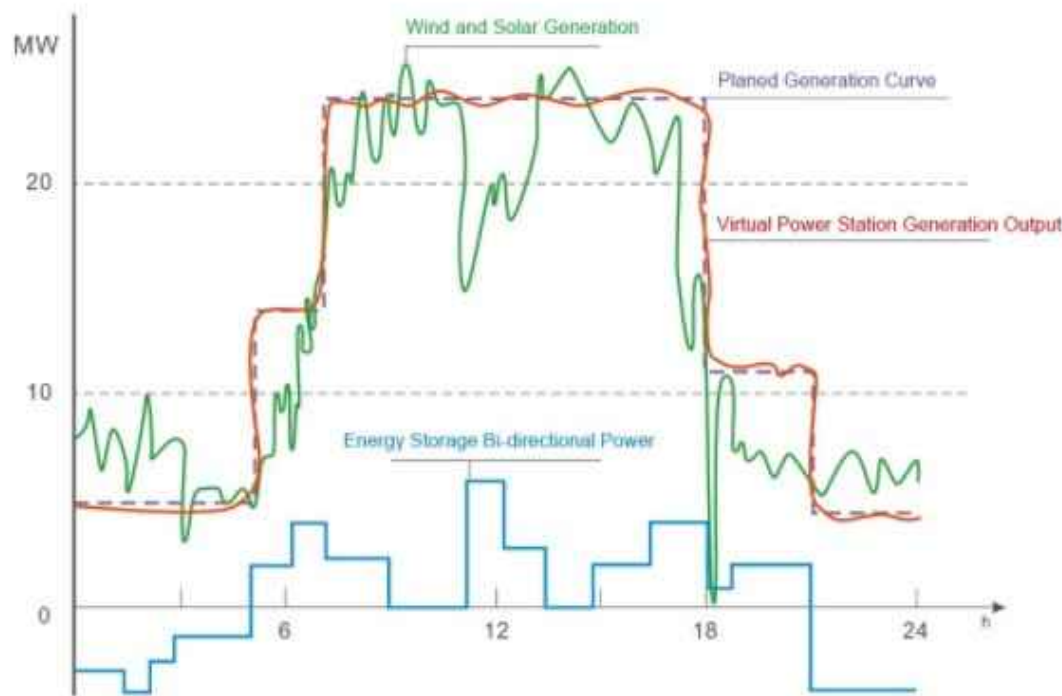


Peak-load shifting can be referred to as "peak shaving" or "peak smoothing." The ESS is charged while the electrical supply system is powering minimal load and the cost of electric usage is reduced, such as at night. It is then discharged to provide additional power during periods of increased loading, while costs for using electricity are increased. This technique can be employed to mitigate utility bills.



Fluctuation of load contribute to unstable grid frequency. Clou ESS helps grid system operators maintain constant and smooth frequency. Energy storage based on lithium ion battery provides reliable and fast frequency response without being subject to fuel prices and with zero emissions.

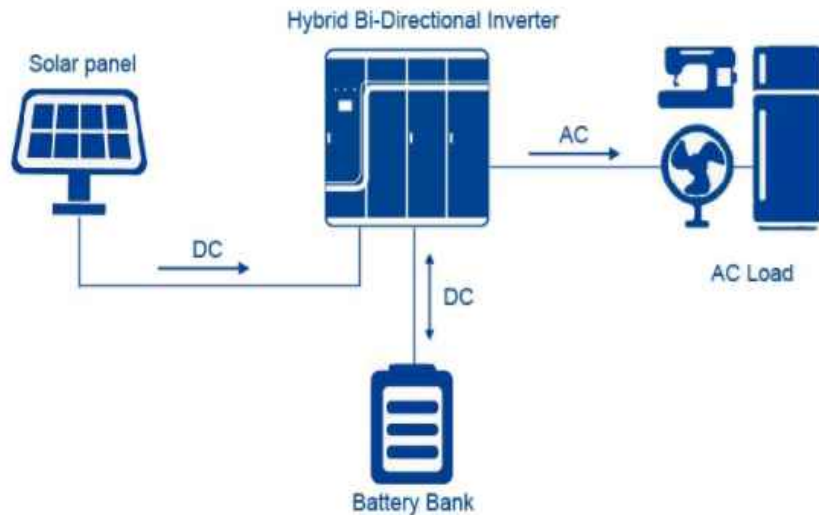
# Solutions for Renewable Energy Integration



ESS solution compensates for intermittency of renewable energy, such as wind and solar. To compensate for wind and sunshine's variability and instability, it provides stored electricity to the grid and stable power output from renewable energy. ESS also provides an energy delay, balancing and backup, which applying smooth power put generation.

- Reduces output variability
- Improves power quality

# solution for off grid applications



## MICROGRID SOLUTIONS

COMPONENTS FOR ISLANDED POWER SYSTEMS  
AND INTEGRATION OF RENEWABLE SOURCES



ESS solution can be used to dramatically reduce reliance on diesel generation, which helping to cut fuel costs significantly. Our ESS are an ideal solution for off grid applications as they can accept a large depth of discharge, making them suitable to provide power during long grid blackouts. Energy storage is used to enhance the stability and efficiency of off-grids by decoupling the generation source from the load.

# ESS in view of Experts

Until batteries can store enough power to allow solar or wind to function without a backup power source, fossil fuels will remain utilities' primary choice.

Others argue that the need for batteries is overblown, that [renewables can grow significantly](#) just by smarter use of the existing electrical grid

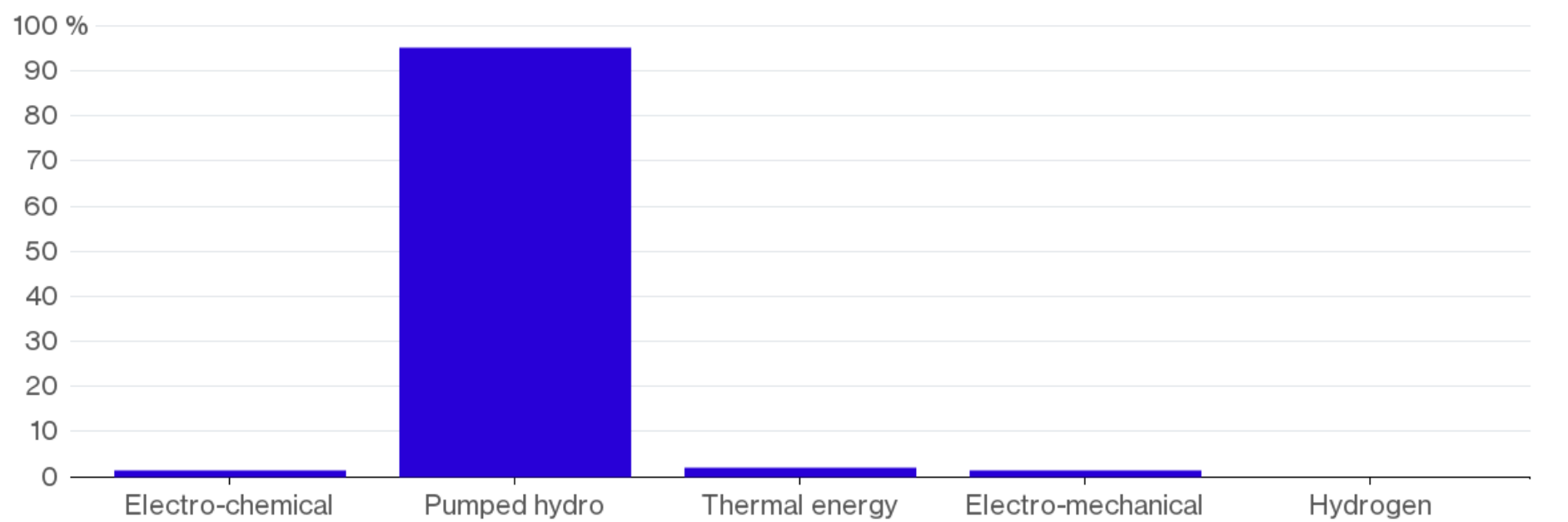
By Chris Martin & Tim Loh

[bloombergbriefs.com/quicktake](https://www.bloombergbriefs.com/quicktake)

“The battery industry today is driven by consumer products like computers and mobile phones,” said Claire Curry, an analyst at Bloomberg New Energy Finance in New York. “Electric vehicles will be the driver of battery technology change, and that will drive down costs significantly.”

## Grid-Connected Energy Storage Projects Worldwide

Pumped hydro dominates and batteries of all kinds are barely on the grid



Source: U.S. Department of Energy Global Energy Storage Database  
Note: As of May 31, 2016



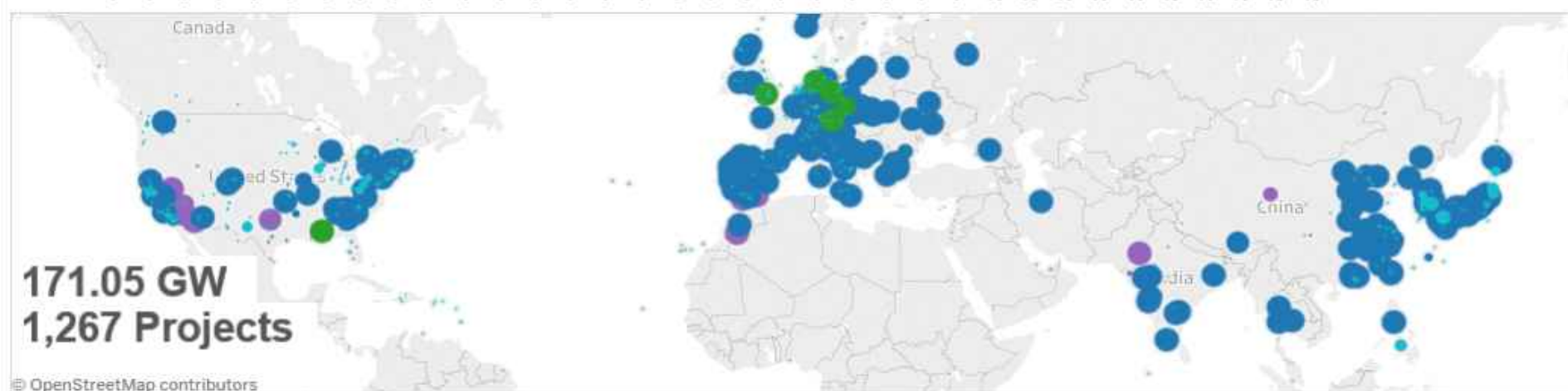
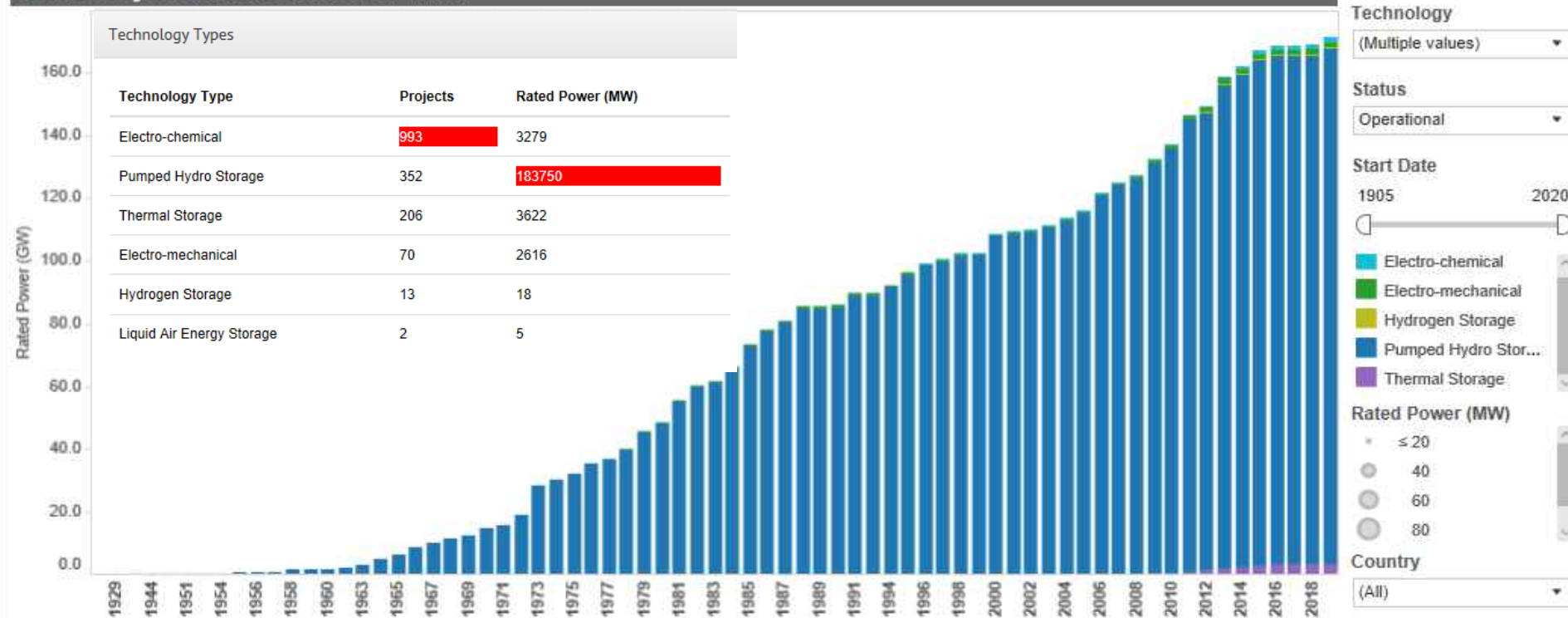
“Utility-scale storage is the new emerging market for batteries, kind of where electric vehicles were five years ago,” said Simon Moores, managing director at Benchmark Mineral Intelligence, a battery researcher based in London. “EVs are now coming of age.”



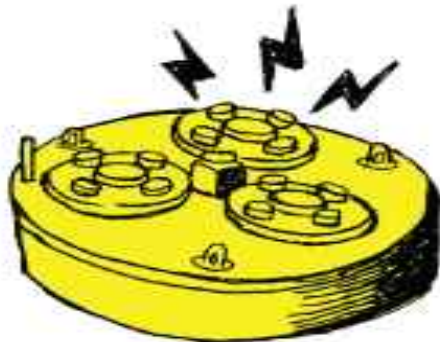
# DOE Global Energy Storage Database

Last Updated 8/16/2016 1:25:38 PM

## Global Project Installations Over Time



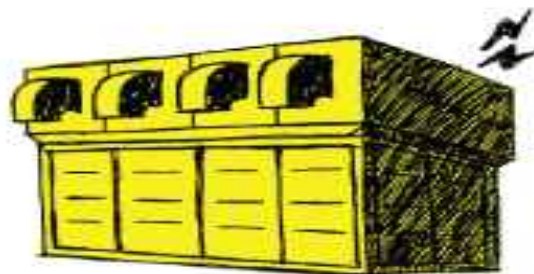
# A Range of Technologies



## The Liquid-Metal Battery

**Potential:** Large, inexpensive, easy-to-construct batteries that would allow unprecedented grid-scale storage. Because they are fluid, they avoid the failures common to solid-state batteries.

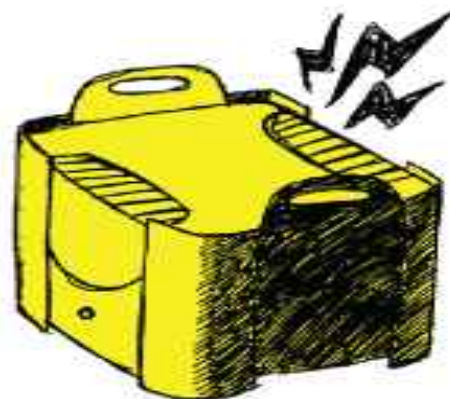
**How they work:** Constructed in big, modular containers, the batteries' positive and negative electrodes are melted down, separated by an electrolyte of molten salt, which lets ions pass back and forth so the battery can store energy.



## The Flow Battery

**Potential:** Like liquid metal batteries, these are aimed at utilities and large-scale commercial and military power storage applications. Because they are constructed in large tanks, the size and storage capacity of the battery is constrained only by the size of the tank.

**How they work:** Electrolytes flow between connected tanks through an electrochemical cell that converts chemical energy to electricity.



## The Lithium-Sulfur Battery

**Potential:** Sulfur is cheap, and lithium-sulfur batteries have a higher energy density and reduced weight, making them a possibly more powerful, cheaper replacement for lithium-ion components in products like iPhones, cars and airplanes.

**How they work:** By replacing one of the electrodes in the lithium-ion design with a sulfur-based version, this battery boosts power and reduces the risk of overheating.



## The Improved Lithium-Ion Battery

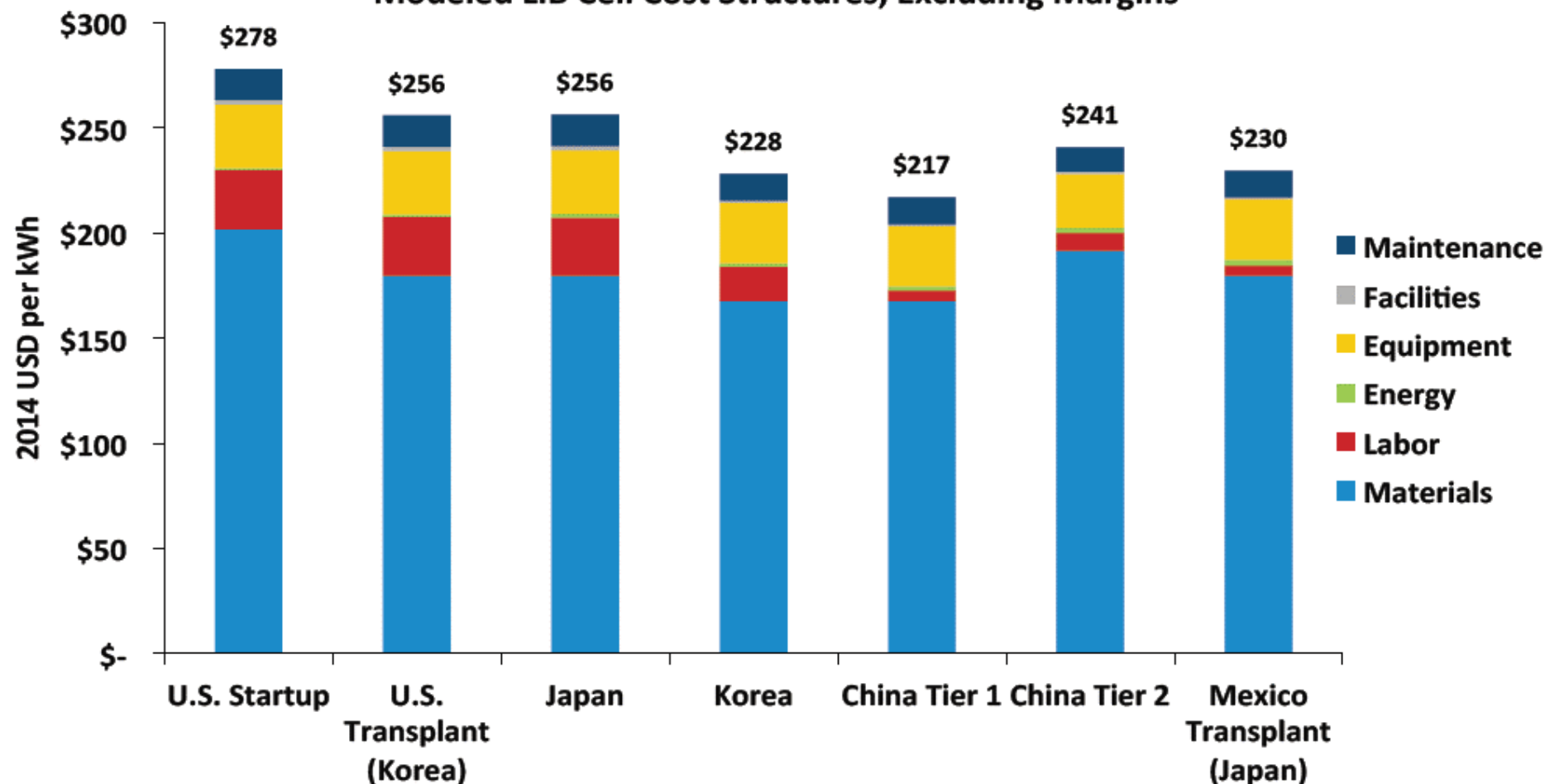
**Potential:** It's still the standard-bearer, and lithium-ion proponents believe economies of scale and technological advances will keep the workhorse battery at the head of the pack.

**How they work:** Positive and negative electrodes with a liquid electrolyte in between.



## Lowest Modeled Costs: China, Korea, and Mexico

Modeled LIB Cell Cost Structures, Excluding Margins

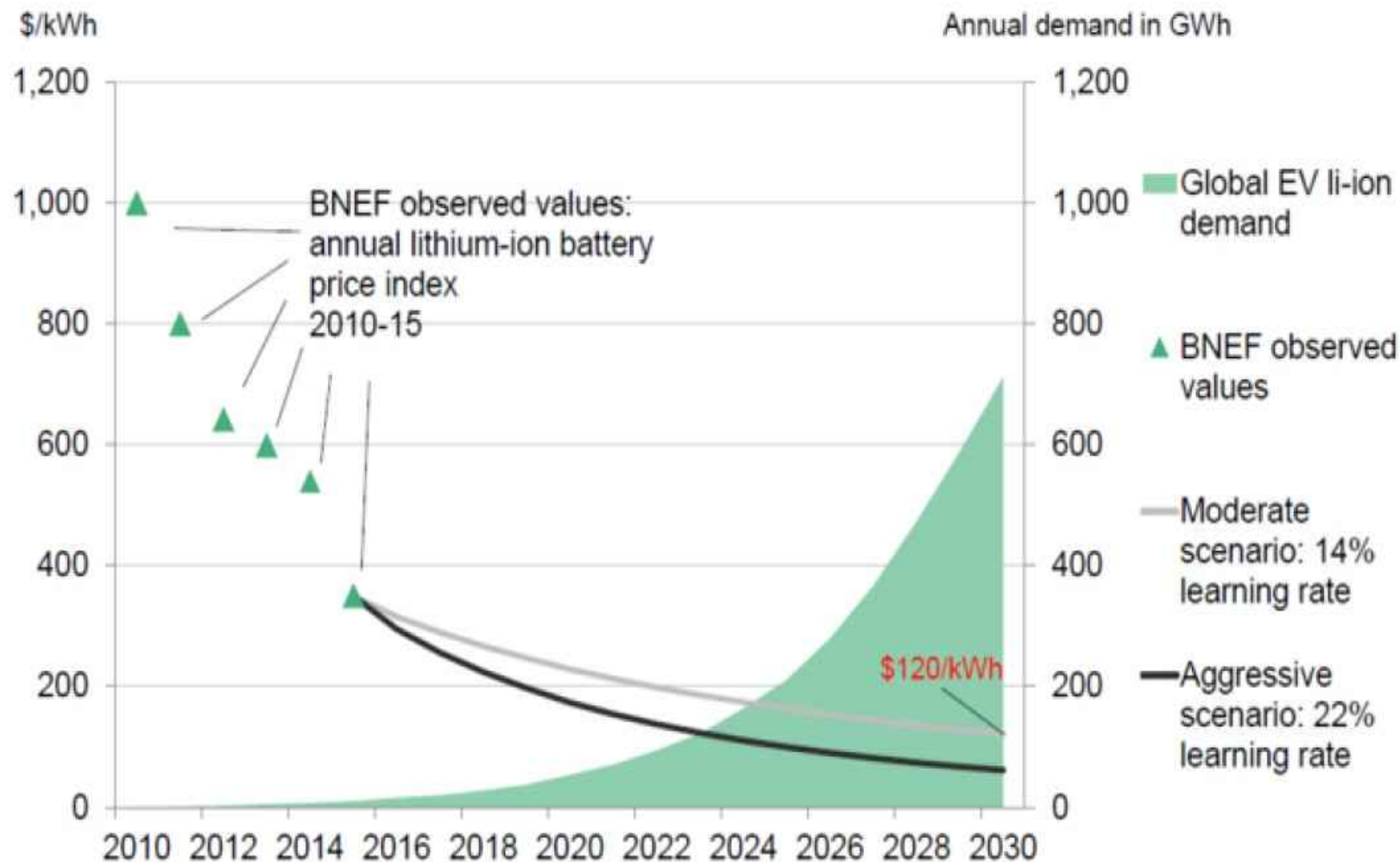


- Materials and labor constitute the key cost differences across countries.
- Labor costs are driven by location, whereas materials costs are driven by country and company characteristics.



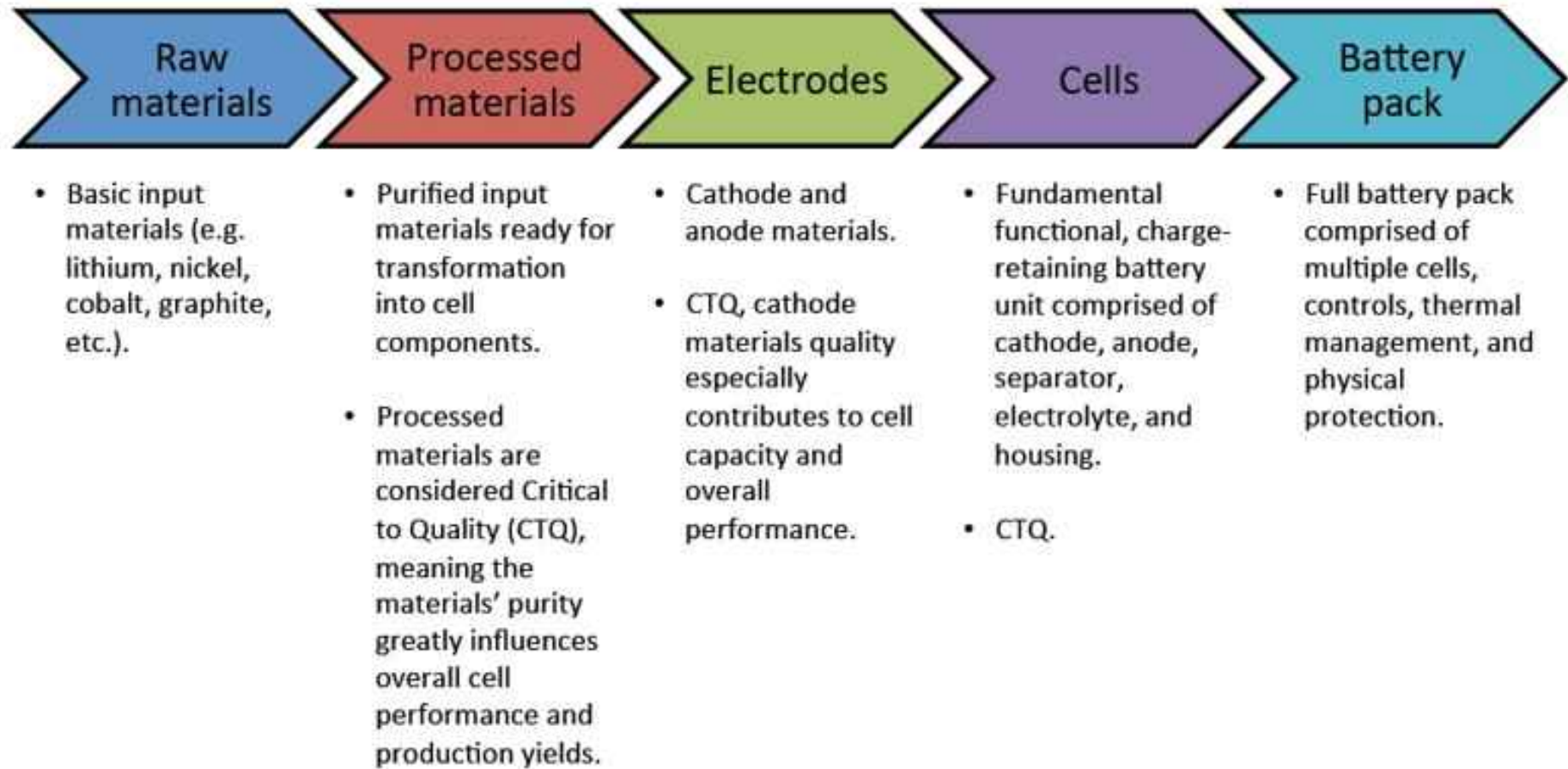
# EV LITHIUM-ION BATTERY PACK COSTS AND DEMAND FROM EVS

NEW ENERGY  
OUTLOOK 2016



Source: Bloomberg New Energy Finance Note: these figures are different than those forecast in our 2015 EV battery price outlook. We have updated our forecast battery demand growth figures, which impacts cost.

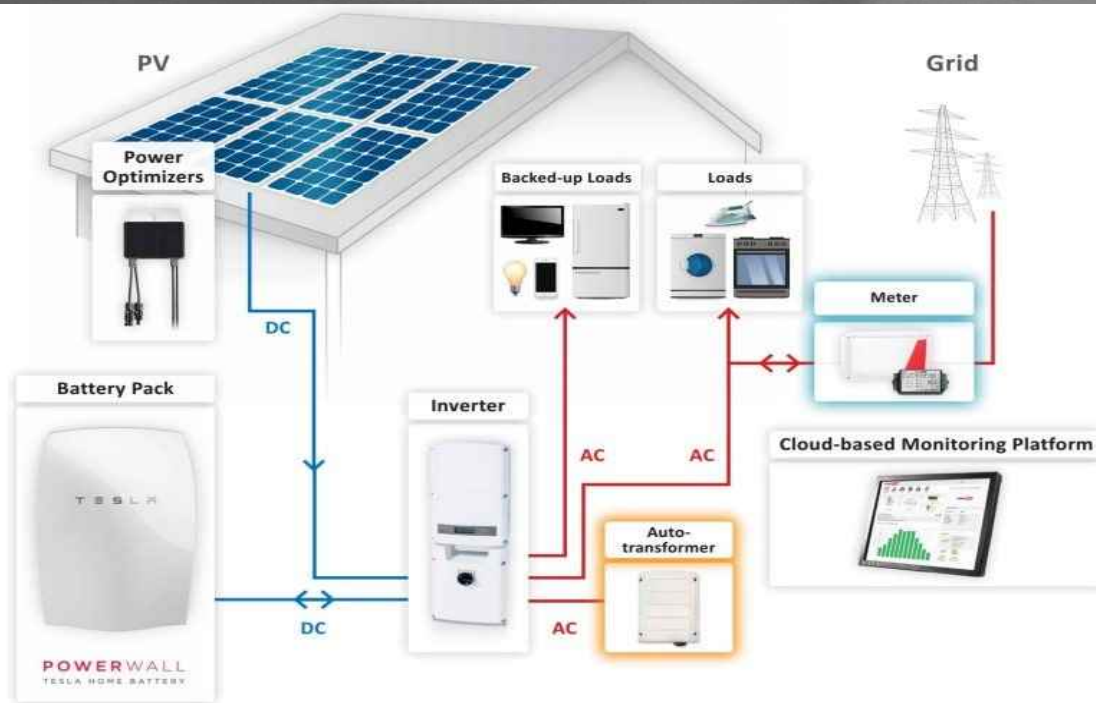
# Simplified LIB Manufacturing Value Chain



**SAN DIEGO, Feb. 24, 2017 /PRNewswire/**

Today, [SDG&E](#) is showcasing the world's largest lithium-ion battery energy storage facility in partnership with AES Energy Storage, which will enhance regional energy reliability while maximizing renewable energy use. The 30 megawatt (MW) energy storage facility is capable of storing up to 120 megawatt hours of energy, the energy equivalent of serving 20,000 customers for four hours.

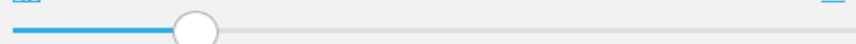






# Order your Powerwall

How large is your home?



1 Bedroom

**2 Bedrooms**

10 kWh per day

6+ Bedrooms

- ☐ I have solar power
- ☒ I'd like to install or add more solar power
- ☒ One day of backup power for my home
- ☐ Lights, power outlets & fridge
- ☒ Entire home

We recommend

**1 Powerwall**



## Order Summary

One 14 kWh Powerwall battery	\$8,000
Supporting hardware	\$1,050
Price for Powerwall equipment	\$9,050
Includes an estimate of \$830 GST	

Requires \$650 deposit for each Powerwall

Typical installation cost ranges from \$1,150 to \$2,900. This does not include solar installation, electrical upgrades (if necessary), permit fees, or any retailer / connection charges that may apply. Installation cost will vary based on your electrical panel, and where you would like your Powerwall installed. Installation will be scheduled after you place your order.

Australia installation [Change Country](#)

First name

Last name

Email

Phone

Installation Address

Credit Card Number

01



2017



CVV

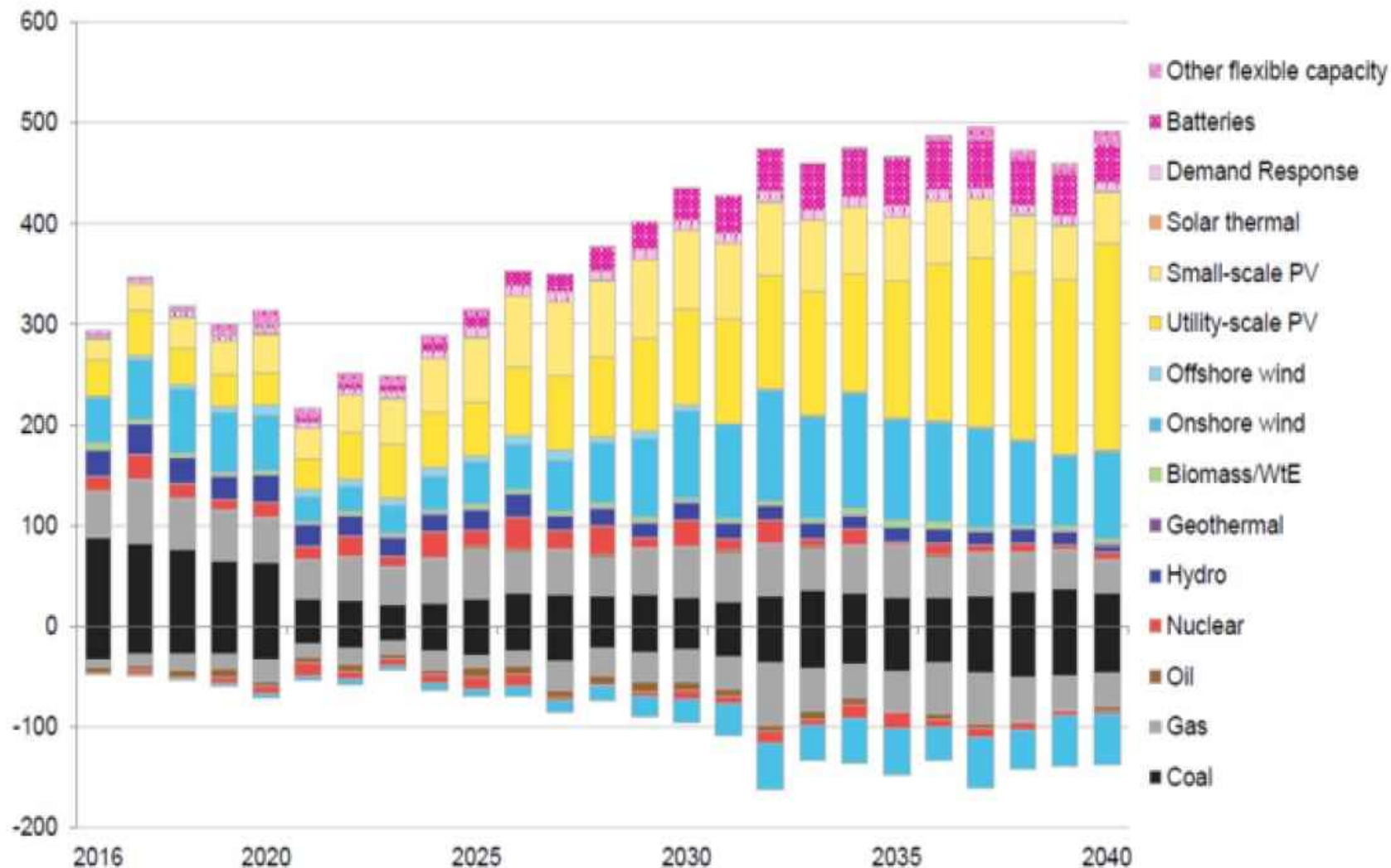
**CHARGE MY CARD \$650 DEPOSIT**

By placing this order you agree to the [Powerwall Order Agreement](#) and the [Customer Privacy Policy](#).



# GROSS ANNUAL CAPACITY ADDITIONS, BY TECHNOLOGY (GW)

**NEW ENERGY  
OUTLOOK 2016**



สภาอุตสาหกรรมแห่งประเทศไทย ร่วมกับ การนิคมอุตสาหกรรมแห่งประเทศไทย ลงนาม  
บันทึกข้อตกลงความร่วมมือ ว่าด้วยการส่งเสริมและสนับสนุน “โครงการสนับสนุนการจัดตั้ง  
นิคมอุตสาหกรรม New S-Curve และอุตสาหกรรมที่เกี่ยวข้อง”

11 เมษายน 2560



# Quick Win Project “Energy Storage Giga Factory”

อุตสาหกรรมสำรองไฟฟ้า (Energy Storage) ซึ่งมีอุตสาหกรรมหลักในตลาดรองรับ คือ

- 1.ระบบสำรองไฟฟ้า Energy Storage สำหรับระบบกักเก็บไฟฟ้าของประเทศ Generation Unit และ Distribution รวมถึงระบบกักเก็บพลังงานของพลังงานทดแทนในรูปแบบต่างๆเพื่อความเสถียรของระบบไฟฟ้าของประเทศ และใช้ในช่วงความต้องการไฟฟ้าสูง Cut Peak
- 2.ระบบสำรองไฟฟ้า Energy Storage ใช้สำหรับยานยนต์ไฟฟ้าประเภท Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV) Battery Electric Vehicle (BEV) และอื่นๆ
- 3.ระบบสำรองไฟฟ้า Energy Storage สำหรับอุตสาหกรรมประเภทอุปกรณ์สำหรับใช้ในชีวิตประจำวัน เช่น สำหรับโทรศัพท์มือถือ และอื่นๆ

