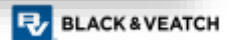


## Exploring the technical potential of long-term storage technologies

Solar and Storage  
versus  
*Stand-Alone* Long-Duration Storage

Prepared for  
SCPPA Board

Prepared by  
Frank Jakob, P.E., PMP  
Technology Manager – Energy Storage  
B&V | Power | Generation | BESS



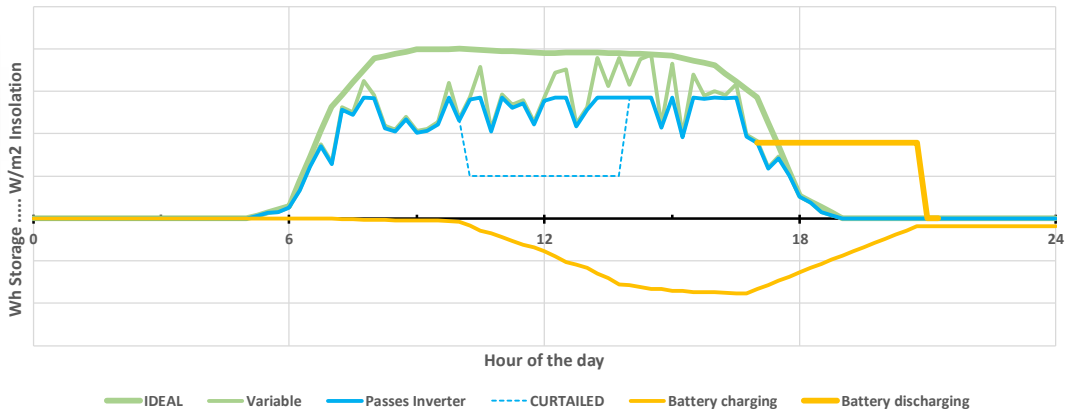
## Black & Veatch Energy Storage Technology Perspective

There are many attributes of energy storage that are ***technically feasible***

As price declines, more and more become ***economically justified***

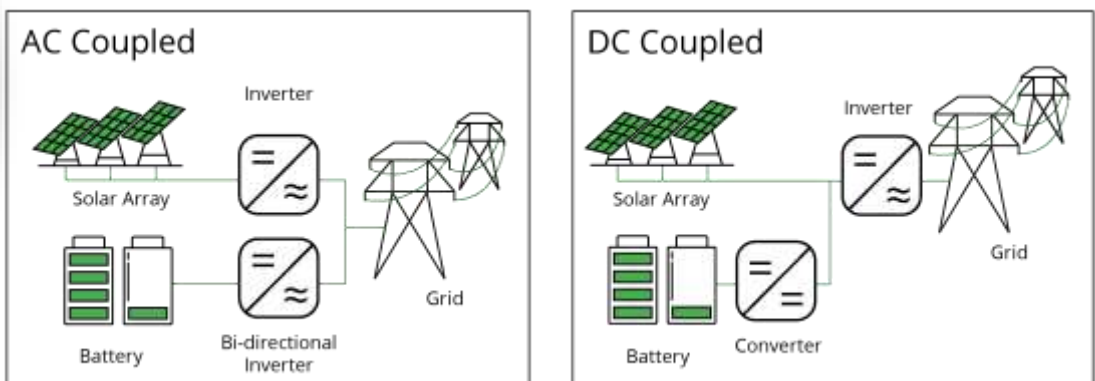
As prices decline for EV batteries, more and longer duration BESS are built. So to, as prices for alternatives to battery cells declines, longer durations are *affordable*

## How Does Solar and Storage Work Best?



Storage captures clipped and curtailed energy as it happens, moving energy through time, delivering it to the grid as the sun sets, and afterwards ... *That is when energy has higher value.*

## Solar with Storage: Two Fundamental Types



AC Coupling is good.  
DC Coupling is better.  
Which one is best?

It captures curtailed energy  
It captures curtailed energy and clipped energy  
*That depends...*

## This Versus That

- **Solar with Storage**

- Firm dispatchable asset
- Smoothing
- Ramping
- Time Shifting

- **Stand-alone Long-duration Storage**

- Independently dispatched asset
- Manages multiple variables
  - Variable generation (solar, wind)
  - Variable loads (new: EV)

## Storage Technology – Power & Energy, Size & Duration

Energy Application

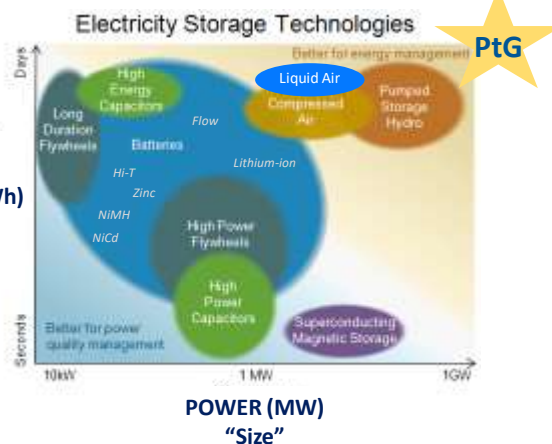
- Over one hour



Power Applications

- Under one hour

**ENERGY (MWh)**  
"Duration"



Others:

PtG: Power to Gas  
 - H2 Hydrogen  
 - SNG Synthetic Natural Gas  
 $2H_2 + CO_2 \rightarrow CH_4 + O_2$   
 for prime movers or fuel cells

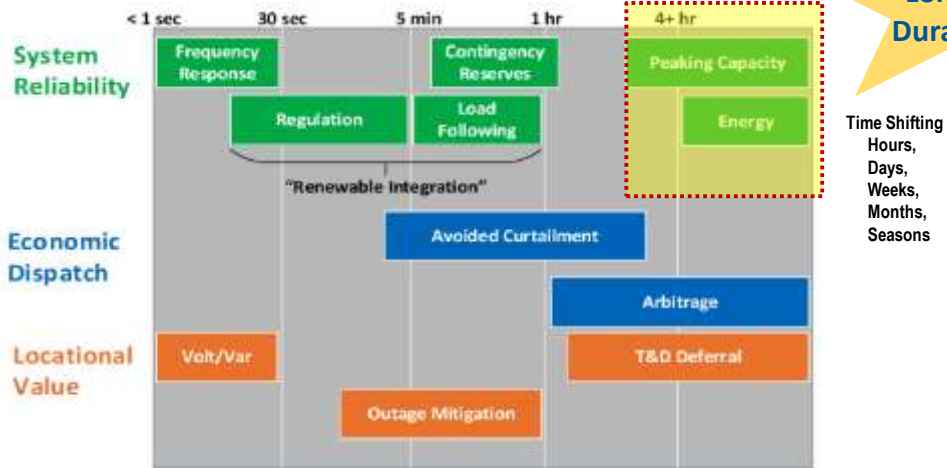
CAES: Compressed Air Energy Storage. "Co-fire"

LAES: Liquefied Air

TES: Energy Storage. "Thermal"

Considerations of Power, Time, and Energy identify the Types of Storage to Use

## Energy Storage Use Cases (Sample)

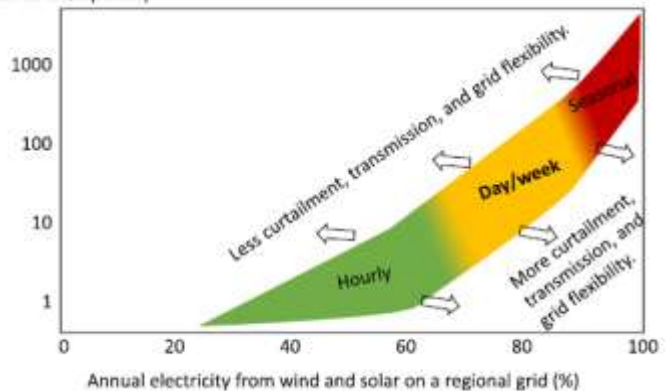


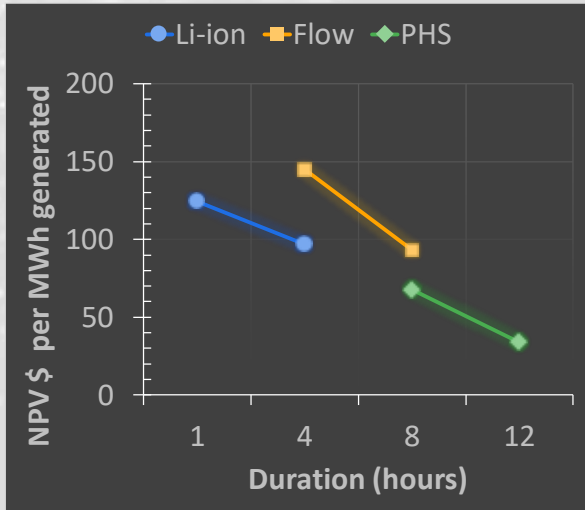
Considerations of Power, Time, and Energy identify the Types of Storage to Use

## Drivers for Long Duration Storage (LDS) (Needs) - VRE

- Paper: Joule (2020)
  - Long-Duration Electricity Storage Applications, Economics, and Technologies
    - Paul Albertus et al
- Article
  - <https://www.greentechmedia.com/articles/read/most-promising-long-duration-storage-technologies-left-standing>

Maximum required storage duration (hours at rated power)





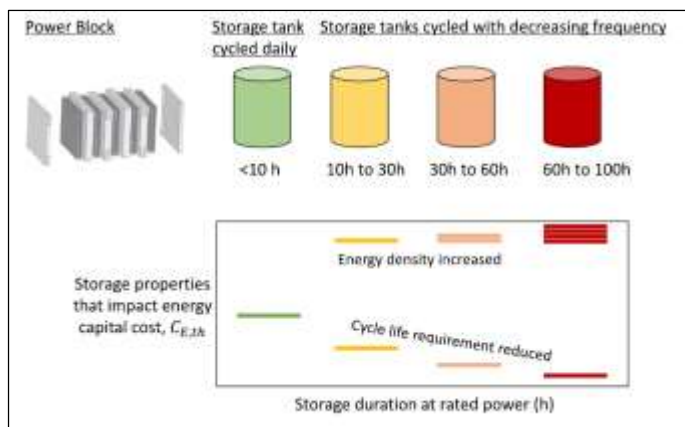
### Economics of Duration (Indicative \$/MWh)

- **Technologies**
  - Lithium ion BESS
  - Flow battery
  - Pumped hydro
- **Durations hr (Life yr)**
  - LI 1 or 4 (15 yr)
  - FB 4 or 8 (30 yr)
  - PH 8 or 12 (60 yr)

Black & Veatch

## Thoughts on Solutions for Long Duration Storage (LDS)

- Paper: Joule (2020)
  - Long-Duration Electricity Storage Applications, Economics, and Technologies
    - Paul Albertus et al
- Article
  - Li-ion BESS: 1<sup>st</sup> \$/kWh = n<sup>th</sup> \$/kWh
  - Idealized LDS. Subsequent kWh
    - Store more energy
    - Cycle less frequently



## Solar + Storage versus Long Duration Storage

- Until
  - There are markets,
  - Valuation of benefits,
  - Monetization of use cases ...
- Long duration storage will be for
  - Demonstrations,
  - Pilots, and
  - At-scale prototypes

Solar + Storage, with its added production and dispatchability will persist,  
... until, maybe after FERC 841' ?



**Imagine**

**Energy storage enabling  
flexible generation and  
stable grid operation**

*Imagine no more*



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