ENERGY STORAGE GRAND CHALLENGE
U.S. DEPARTMENT OF ENERGY

Valuation and Compensation for Energy Storage






IEA Renewable Energy Working Party

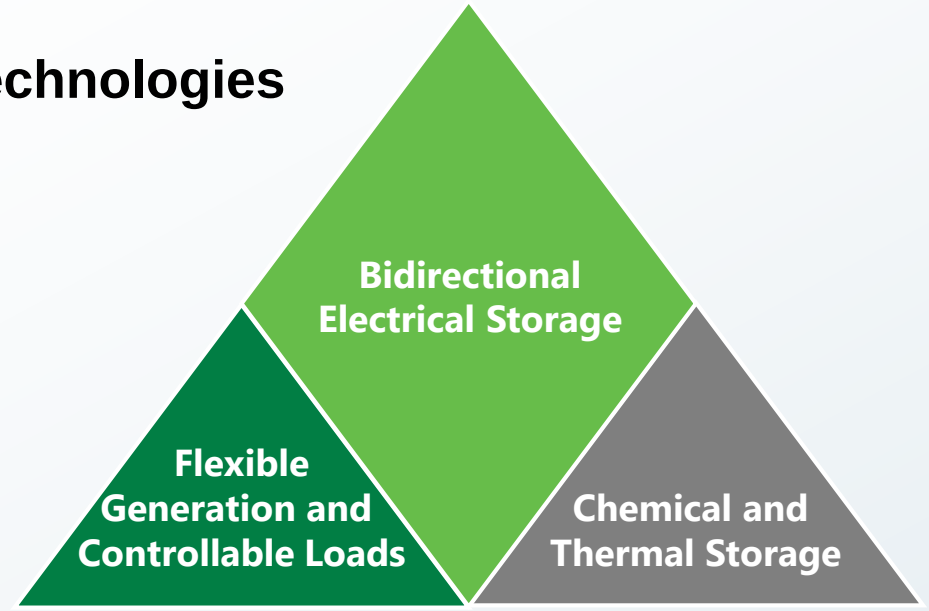
29 September 2020

U.S. DEPARTMENT OF ENERGY

Energy Storage Grand Challenge

DOE-wide strategy to accelerate U.S. leadership in energy storage

Technologies



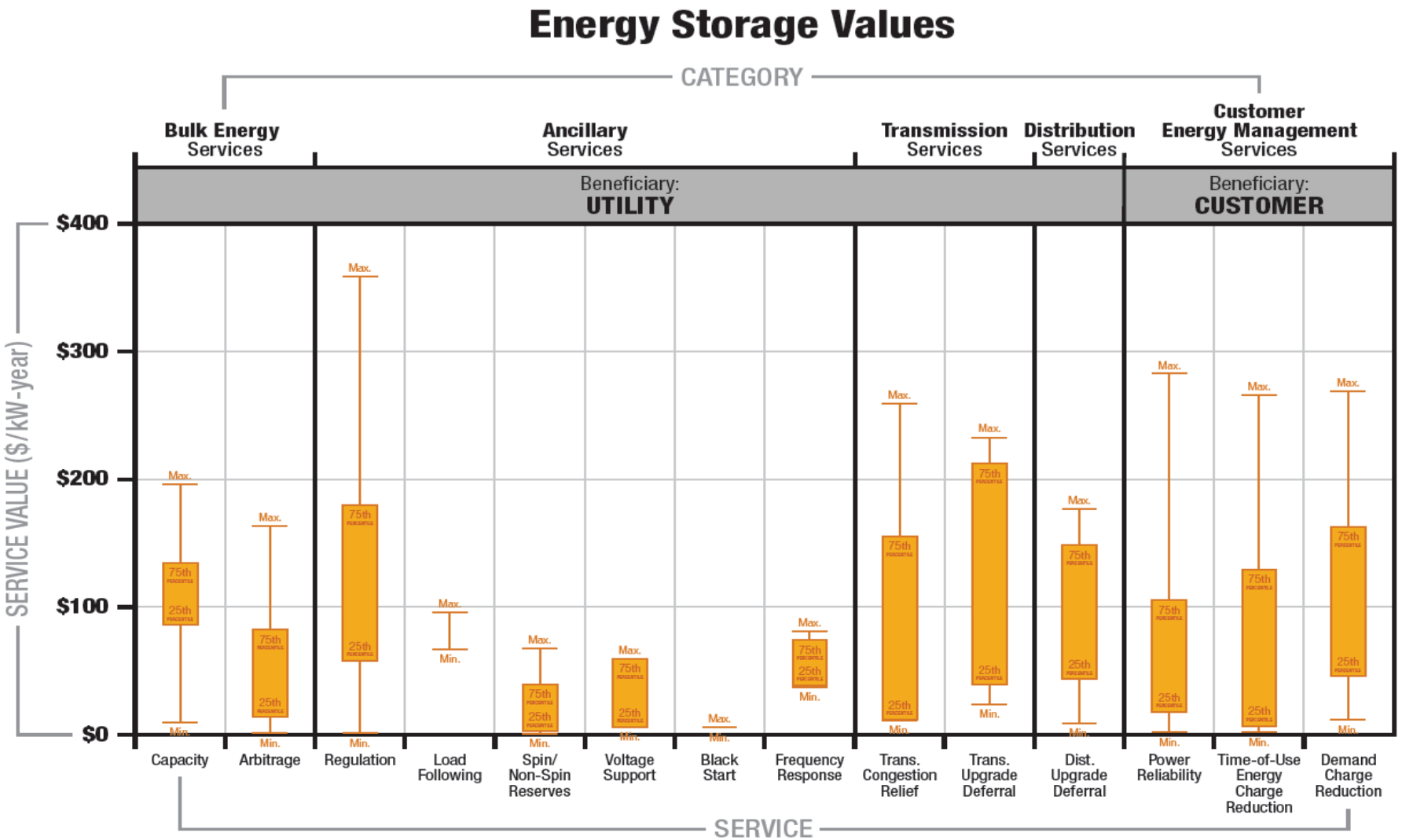
Offices

- Office of Electricity
- Energy Efficiency and Renewable Energy
- Office of Science
- Office of Technology Transitions
- Nuclear Energy
- Fossil Energy
- ARPA-E
- Loan Programs Office

Functions

Basic Science Research & Discovery → Application Driven Materials Development → Applied Device and System R&D → Cost & Performance Metrics, Targets → Demonstration and Performance Validation → Systems Analysis and Valuation → Commercialization Strategy

Energy Storage Provides Wide Range of Services



Source: Balducci, P., J. Alam, T. Hardy, and D. Wu. 2018.

- Capacity
- Energy
- Grid Services
- Defraying other investments

But Faces Significant Financing Challenges

Unpredictable Energy Prices: Energy price spreads are less predictable when driven by net load (wind/solar resource strength + load) than by historical load profiles

Unpredictable Market Products: Grid services often compensated differently from market to market, or not at all

Unpredictable System Value: Different attributes will differ in value based on future power system configuration (e.g. wind/solar mix, transmission build-out, other sources of flexibility)

Uncertainty in Models: Neither power system planning nor operational models represent storage well

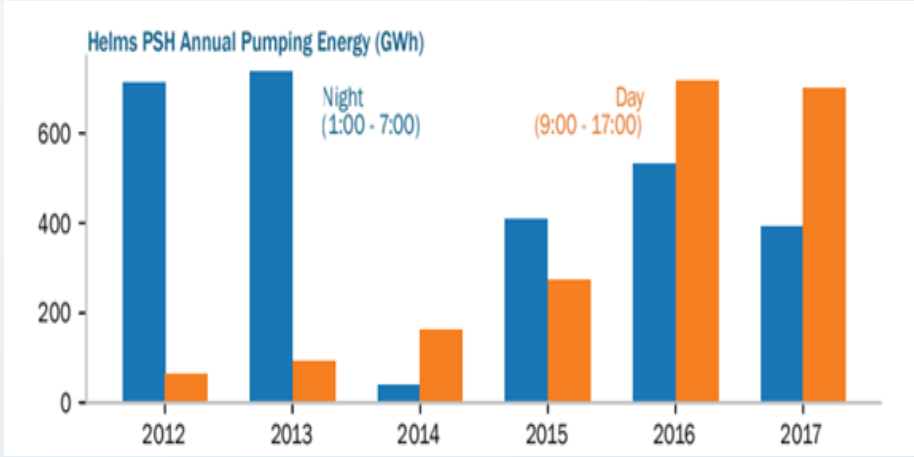
Unique Regulatory Considerations: Allowable ownership models; compensation as generation and transmission asset; state-of-charge-management

Pumped Storage

PSH (and CAES) is typically the most cost-effective alternative for large or long-duration applications

But even harder to finance!

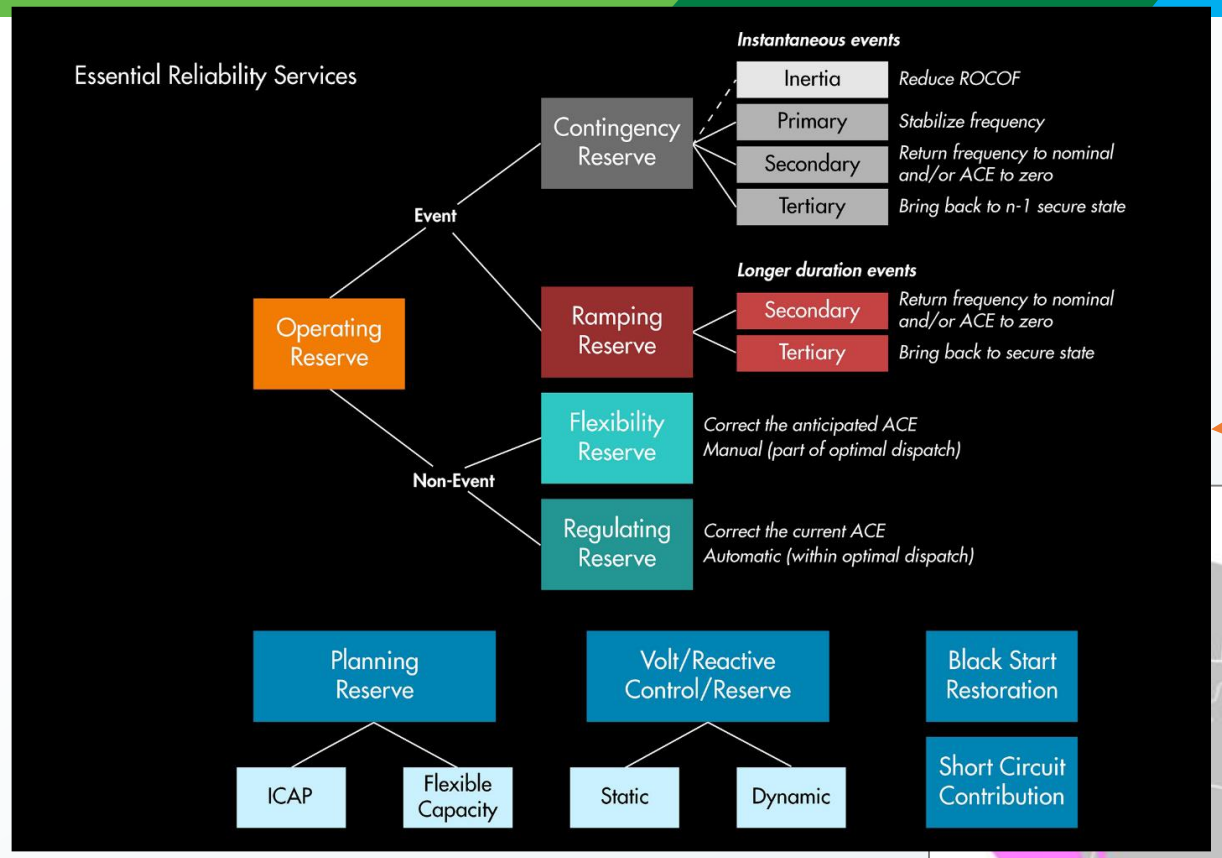
- Levelized cost savings accrue to large scale plants
- High capital costs for equipment and construction
- 10+ years construction and permitting timeline
- 50-100 year life time
- Benefits may accrue across multiple utilities/entities
- Operations changing from historical patterns



Change in operation patterns from 2012-2017 for Helms PSH in CA

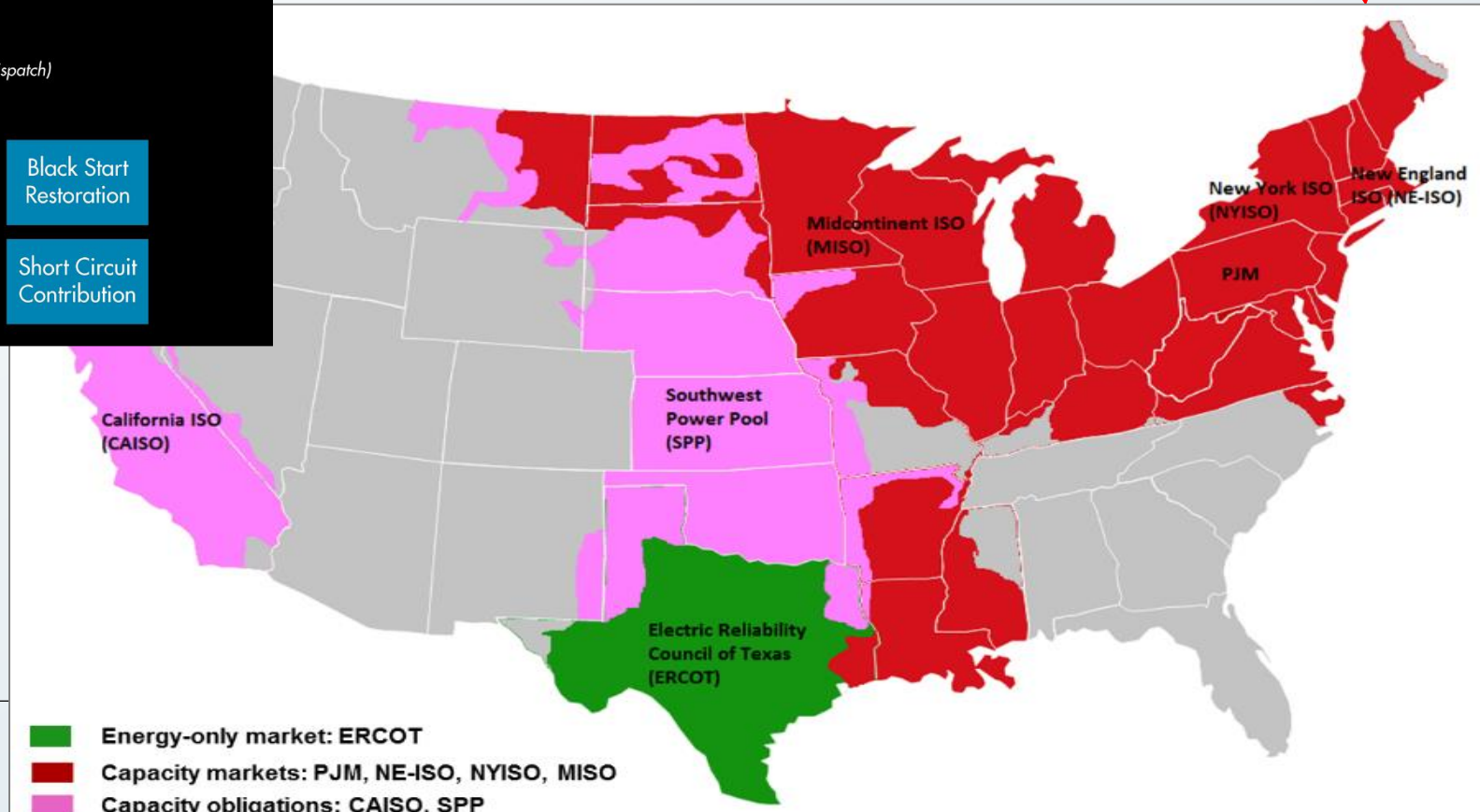
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EPRI 2019

Wide range of market products for capacity, grid services in the U.S.



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U.S. State-level Approaches: Hybrids and Long Duration

Hawaii: Hawaiian Electric Company's Power Purchase Agreement (PPA) for Renewable Dispatchable Generation

- Contracts were intended to solicit firm renewable energy capacity and reduce contract costs associated with curtailment
- 2-part payments
  - guaranteed payment for net energy potential and facility availability
  - energy delivery and performance
- 7 solar plus battery storage contracts signed for 252MW at around US$ 0.10/kWh

Nevada: 2018 Hybrid Solar and Storage Procurement: 1,200 MW PV + 590 MW storage

- PPA structure pays a price during system peak hours (i.e. 4 to 9 pm) that is 6.5 times higher than the price paid for output during other hours ensuring projects provide capacity value.

California: CPUC Resource Adequacy effort identifies need for 973 MW of long duration storage

- Efforts ongoing to identify ways to pay for such capacity. Current resource adequacy payments are not sufficient for development.

Israel and Australia: Pumped Storage

IEC: three-part payment scheme



300 MW Mount Gilboa pumped storage project (operational) *Source: Electra Group*



344 MW Kokhav Hayarden project owned by Star Pumped Storage (under development) *Source: Hutchinson Water*

Snowy Hydro: Government-Owned



Source: Snowy Hydro

Thank You

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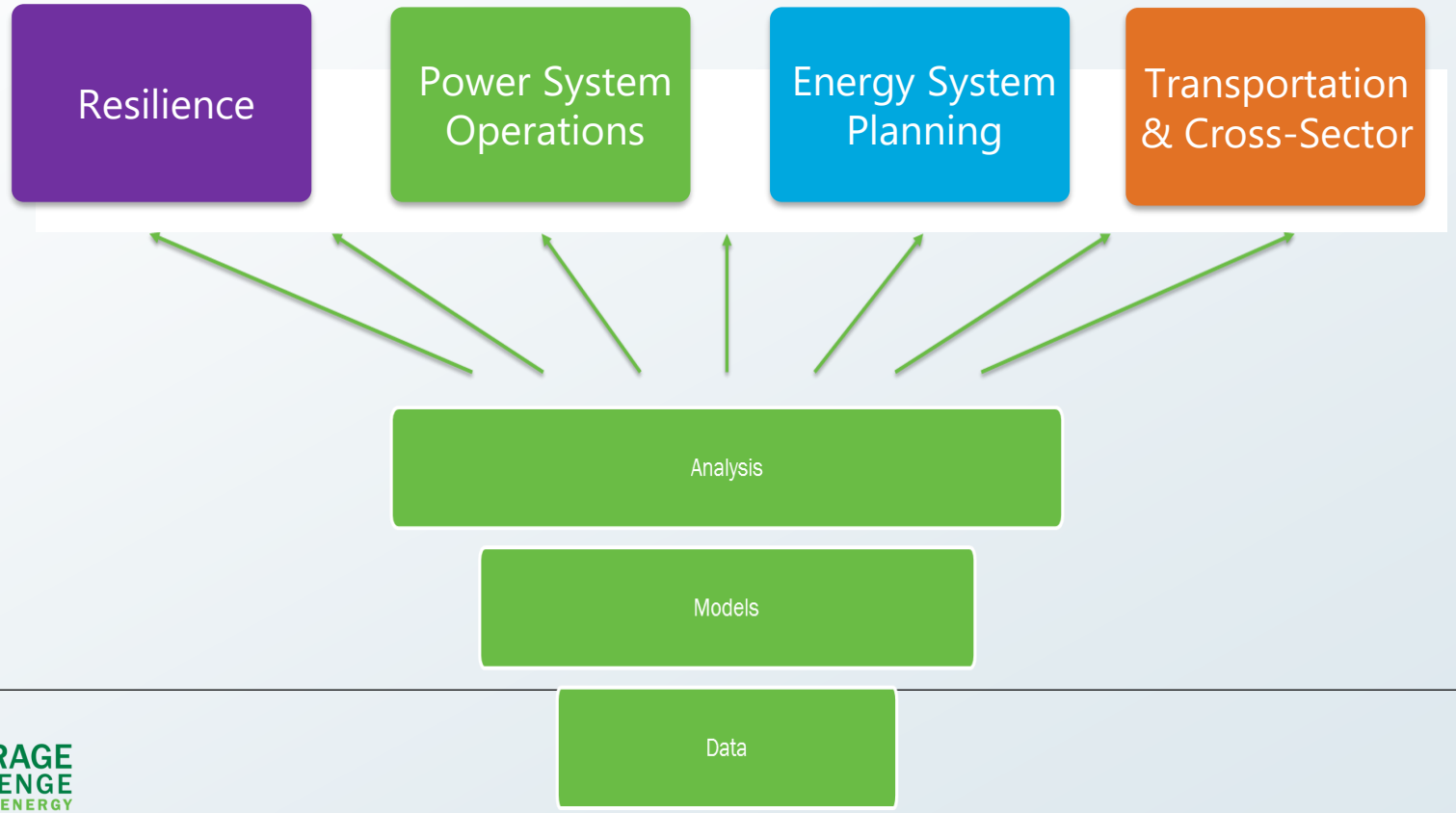
New Products Under Development – e.g. Ramping Products

	CAISO	MISO	NYISO	PJM
Procurement	Only in Real Time Markets	Day Ahead and Real Time Markets	Product presently being designed	No ramping product, but there's a ramping requirement constraint in their unit commitment-economic dispatch formulation
Resource MW Eligibility	MW output a resource can attain within 5 minutes	MW range output a resource can attain within 10 minutes beyond the next 10-minute target setpoint		
Geographic Scope	Entire region (not zonal)	Entire region (not zonal)		
Price Formation	Opportunity cost of energy	Opportunity cost of energy		
Requirement	Maximum flexible ramp up and down requirements are defined as the 2.5% and the 97.5% percentile of net load change	Depends on the sum of the forecasted change in net load and an additional amount of ramp up/down (575 MW for now)		

Policy & Valuation: DOE's Role

DOE has the analytical capabilities, data and computing resources, and institutional credibility to inform more effective and cost-effective policy and regulatory decisions.

Caveat: DOE does not make policy, but offers policymakers the tools to most effectively meet their own policy and regulatory goals.



Australia and Israel : Pumped Storage

- In 2019, Snowy Hydro signed a $5.1 billion contract to build the Snowy 2.0 PSH project (2 GW, 175 hrs).
- The company and project are wholly owned by the Australian Govt., who identified a need for large scale long-duration energy storage to integrate renewables across the National Electricity Market and imminent closure of coal-fired capacity.
- As of 2020, Snowy Hydro is exploring a new ‘super-peak’ contract designed to cover demand during the high-priced morning and evening periods, when solar output is low, enabling participants to manage the risk of very high market prices



Source: Snowy Hydro

Israel: Pumped Storage

- Israel Electric Corporation (IEC) identified a need for long-term reliable capacity to integrate variable renewables: 800 MW of energy storage (5% of system demand)
- IEC developed a three-part payment scheme contract for 18-20 years:
    1. Availability payment (primary source of revenue): requires the plant to be available for a minimum time during a year, with an equipment availability requirement passed to the OEM. Also includes bonus payments for dynamic benefits: ramp rates, pumping to generation switching timeframes, startup and shutdown speeds, etc.
    2. Energy delivery
    3. Start up and shut down payments



300 MW Mount Gilboa pumped storage project (operational) *Source: Electra Group*



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