GRID FLEXIBLE SOLAR

Unleashing the Full Potential of Utility-Scale Solar Generation

First Solar®

LEADING THE WORLD'S SUSTAINABLE ENERGY FUTURE

UTILITY-SCALE SOLAR & THE EVOLVING GRID

As a least-cost new resource, more solar is added to the power grid every day

As solar penetration increases, grid operators face new challenges in dispatching the system

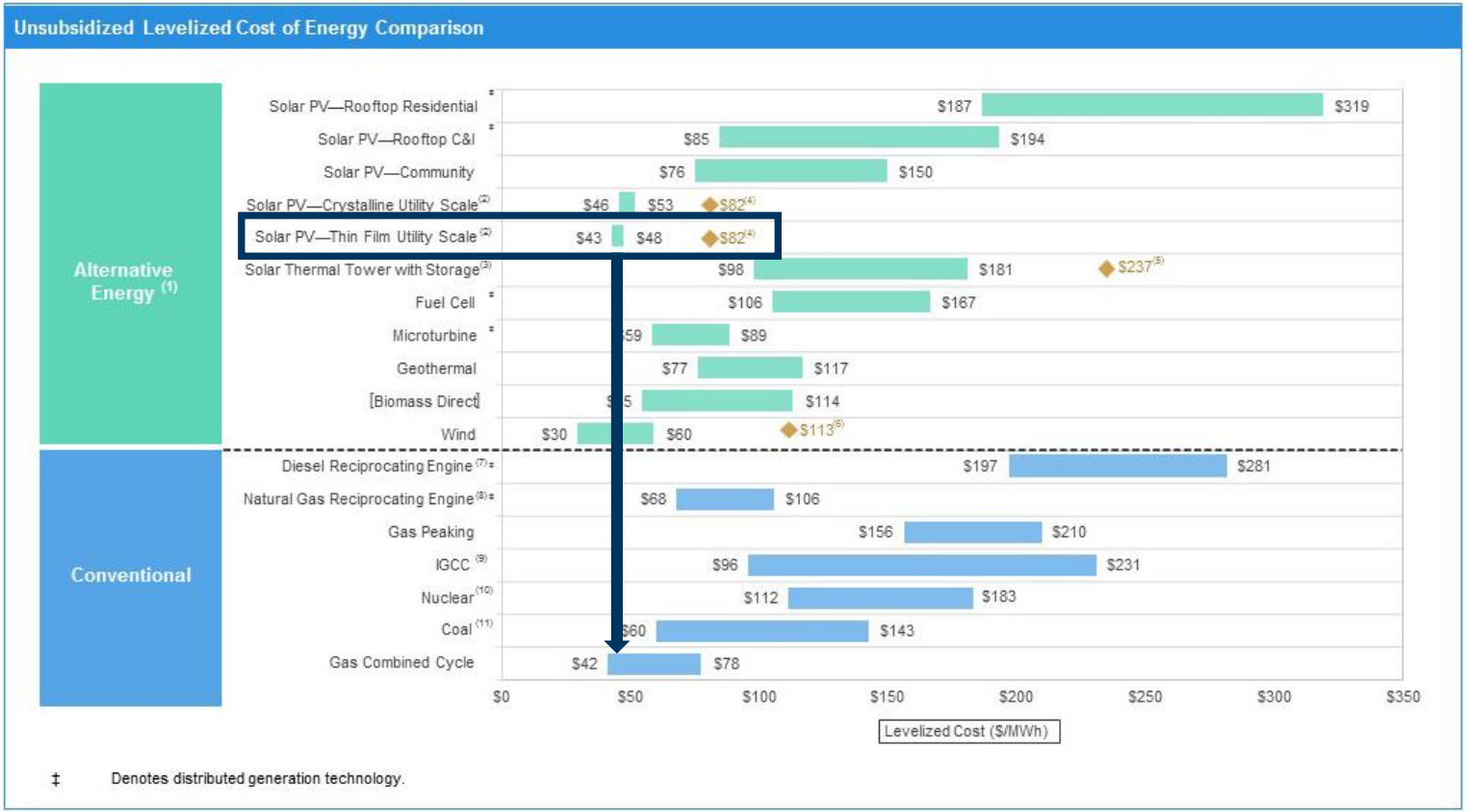
Today, grid operators often rely on fossil-fueled generators to match energy production and consumption, rather than clean resources

Solar has untapped capabilities that enhance the flexibility of the grid to match supply and demand

Solar is the future mainstream generation source, capable of delivering energy when and how it is needed

As a technology leader, First Solar is uniquely positioned to champion market and policy reforms that unleash solar's full potential

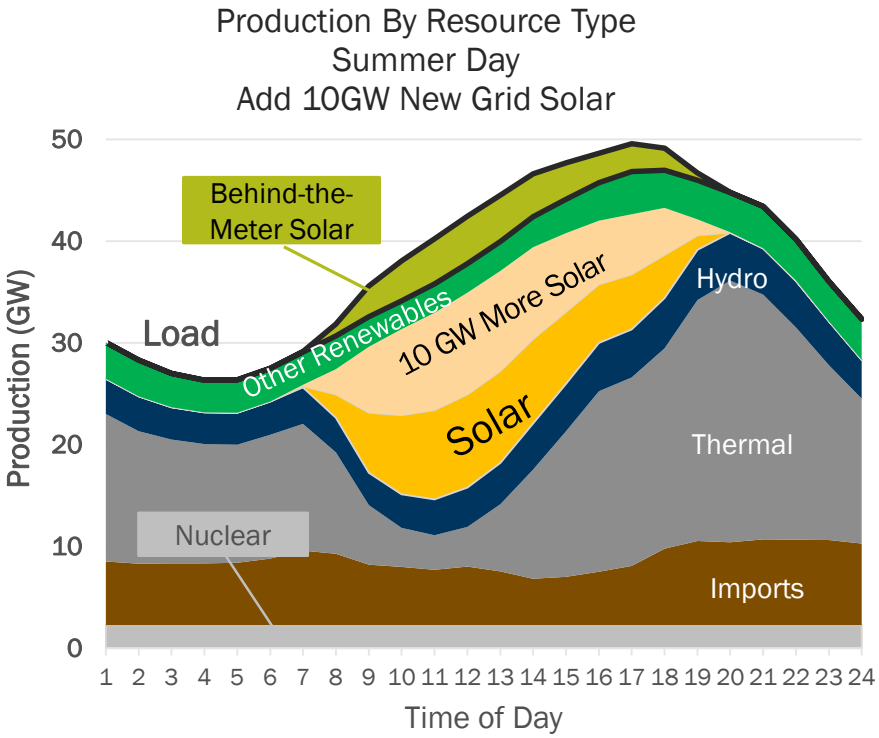
UTILITY-SCALE SOLAR: COST-COMPETITIVE TECHNOLOGY



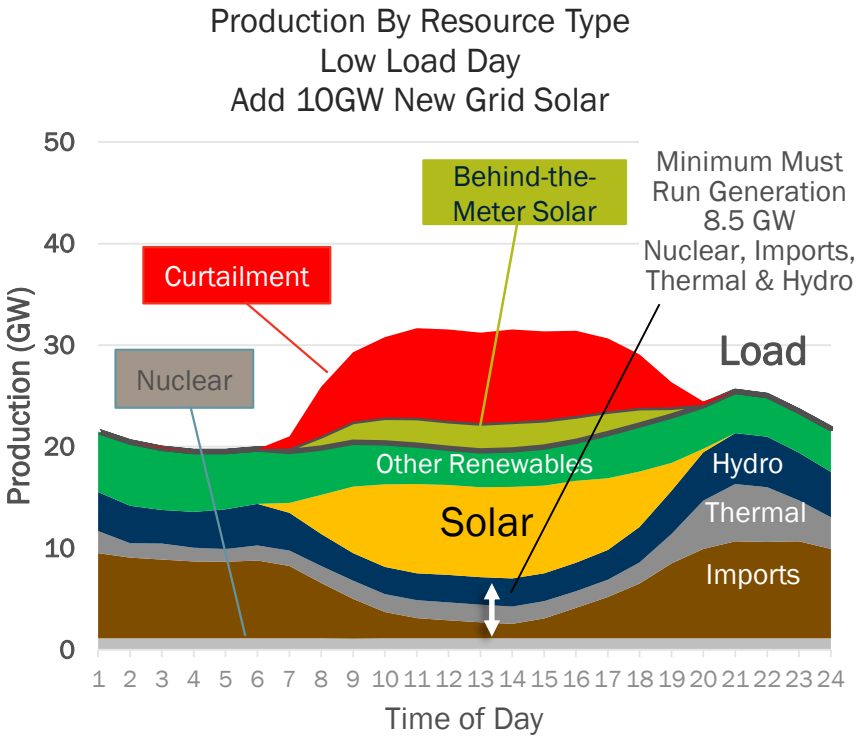
Lazard's Levelized Cost of Energy Analysis, Version 11.0. https://www.lazard.com/perspective/levelized-cost-of-energy-2017/

CURTAILMENT IS A LOW LOAD PHENOMENON: CAISO HIGH PENETRATION EXAMPLE

HIGH LOAD DAY



LOW LOAD DAY



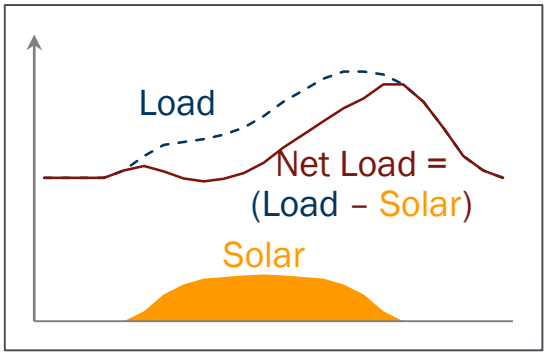
CHARACTERISTICS DRIVING GRID EVOLUTION

Grid 1.0

Grid Characteristics:

- Utility-scale solar is part of mid-day load, offsetting peak or near-peak demand
- Low adoption of DERs
- Renewables are a must-take resource
- Minimal curtailed energy

Solar Product Needed: Energy & Renewable Energy Credits (RECs)

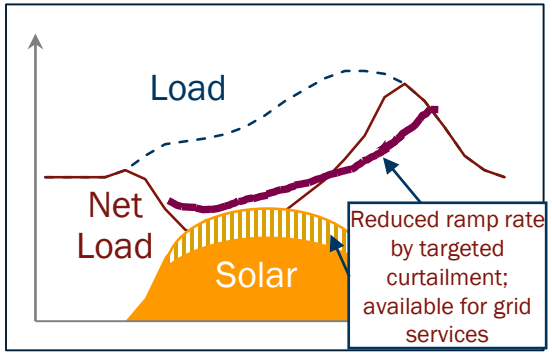


Grid 2.0

Grid Characteristics:

- Grid operators see evening ramp concerns and need for more flexible asset additions
- Growing adoption of DERs that have limited controllability
- Utility-scale solar transitions to a dispatchable resource

Solar Product Needed: Energy, RECs, & Grid Services

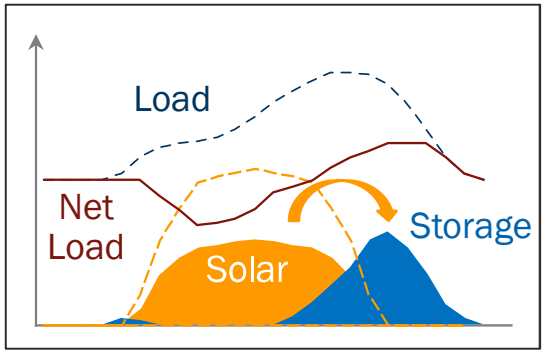


Grid 3.0

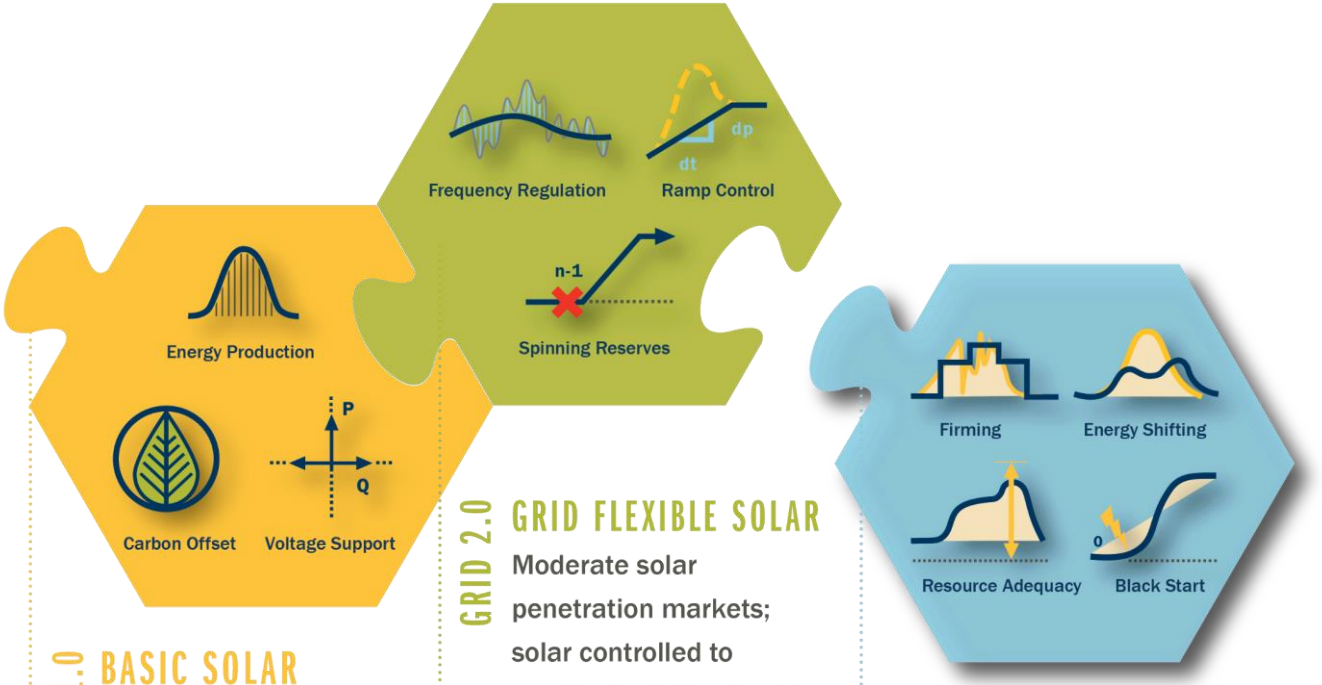
Grid Characteristics:

- Utility-scale solar represents significant portion of resource portfolio; curtailments frequent
- Saturated DER market creates excess energy
- Resource Adequacy needs shift
- Storage becomes economic

Solar Product Needed: Capacity, Energy, RECs, & Grid Services



UTILITY-SCALE SOLAR PROVIDES GRID FLEXIBILITY



GRID 1.0

BASIC SOLAR

Low solar penetration markets; maximizes energy production

GRID 2.0

GRID FLEXIBLE SOLAR

Moderate solar penetration markets; solar controlled to provide flexibility & grid reliability services

GRID 3.0

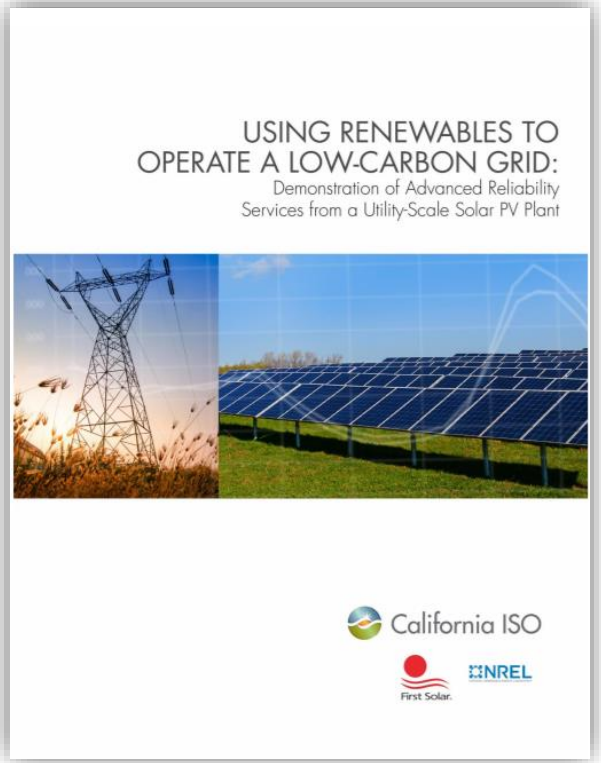
FIRM DISPATCHABLE SOLAR

High solar penetration markets; addition of storage provides firm dispatchable capacity

CONTROLLABLE & DISPATCHABLE PV CAPABILITIES EXIST TODAY

Dispatchable PV Plant

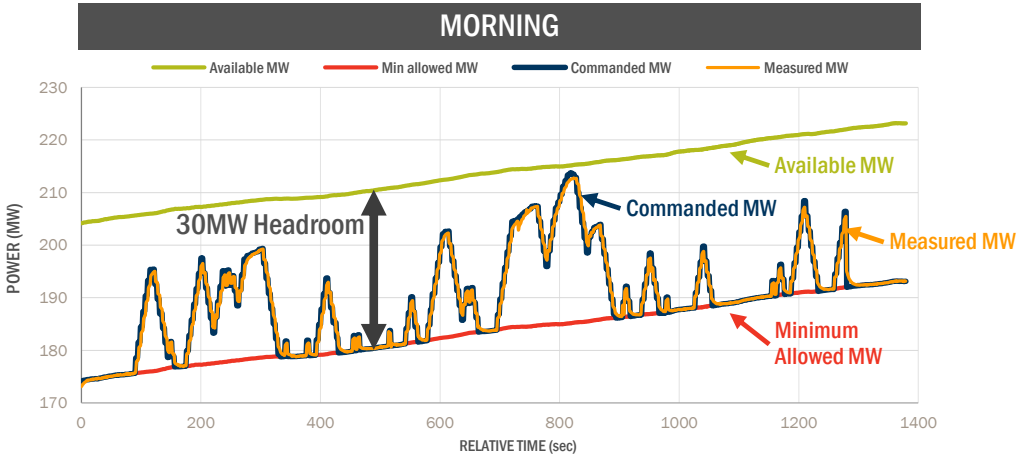
- CAISO, NREL and First Solar pioneering demonstration of advanced reliability services
- Solar can provide NERC-identified essential services to reliably integrate higher levels of renewable resources, including:
  - Frequency Regulation
  - Voltage Control
  - Ramping capability or flexible capacity
- Automated Generation Control (AGC) regulation accuracy of 24-30% better than fast gas turbines
- Reduces need for services from conventional generation
  - Goes beyond simple PV energy value
  - Enables additional solar
  - Reduces need for expensive storage

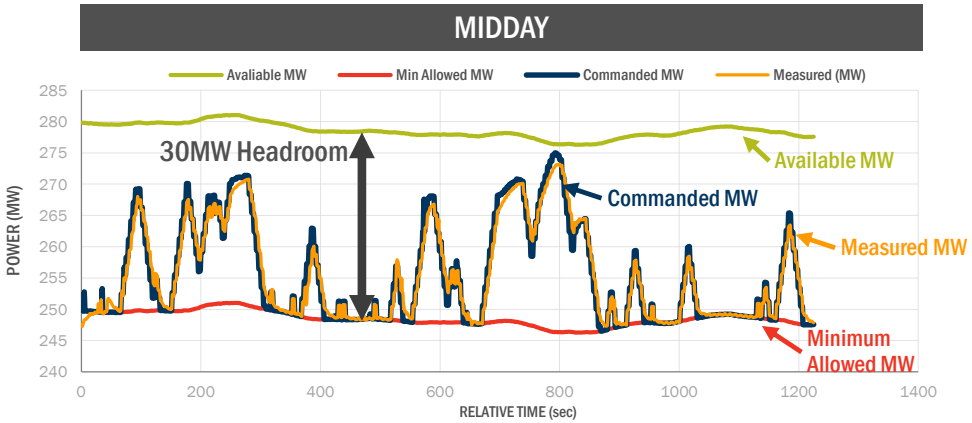


2017 NARUC Award Winner
Utility Industry Innovative Pilots or Demonstration Projects

http://www.caiso.com/Documents/TestsShowRenewablePlantsCanBalanceLow-CarbonGrid.pdf

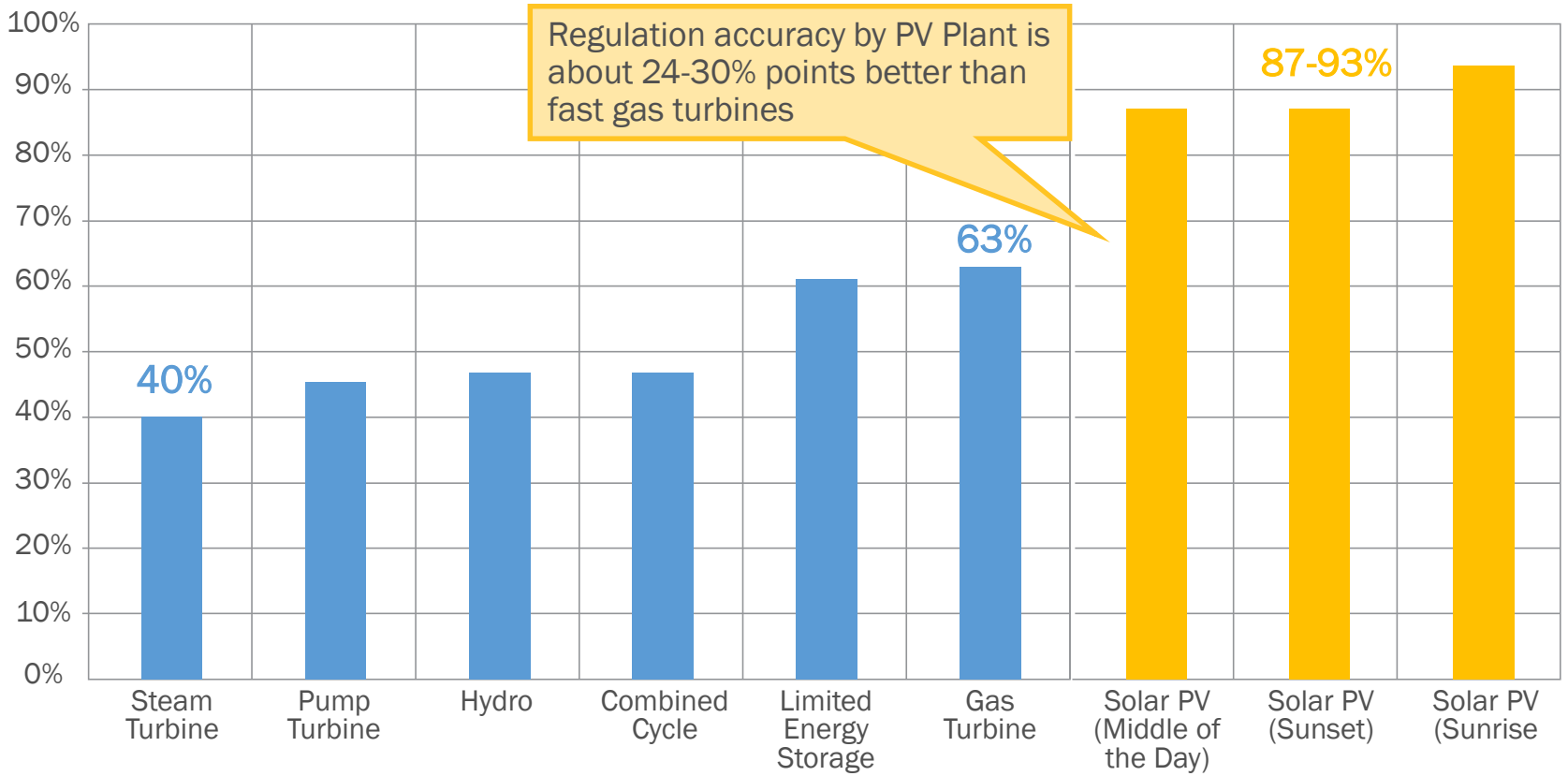
GRID SERVICES IN ACTION: FREQUENCY REGULATION





- 30MW headroom
- 4-sec AGC signal provided to Plant Controller
- Tests were conducted for
  - Sunrise
  - Middle of the day
  - Sunset

PV PLANTS OUTPERFORM CONVENTIONAL RESOURCES IN FREQUENCY REGULATION



California ISO

Blue bars taken from the ISO's informational submittal to FERC on the performance of resources providing regulation services between January 1, 2015 and March 31, 2016

http://www.caiso.com/Documents/TestsShowRenewablePlantsCanBalanceLow-CarbonGrid.pdf

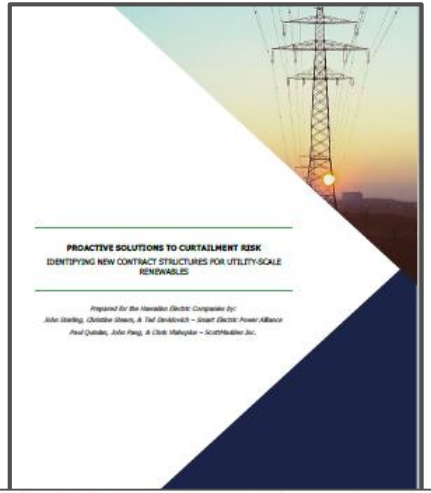
CASE STUDY: Hawaiian Electric Leading the Way in PPA Reform

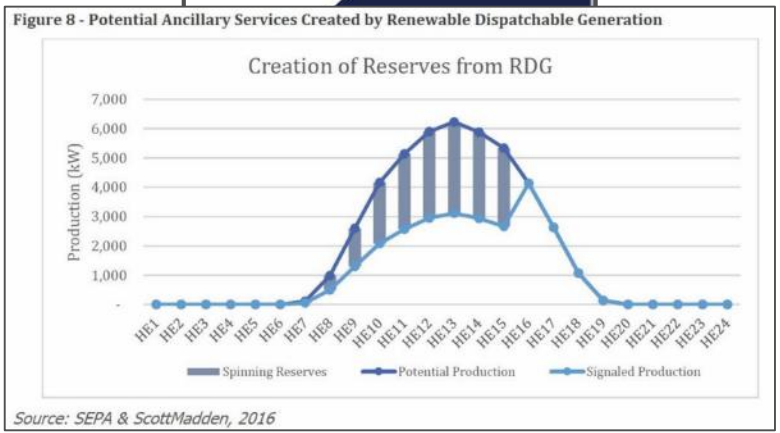
ISSUE

- High penetration of behind-the-meter solar, coupled with an old oil-fired fleet has lead to significant curtailment issues (upwards of 20%)
- Developers have desired “take-or-pay” contracts to mitigate their curtailment risk; however, this shifts the burden to ratepayers

SOLUTION

- New contract structure that balances curtailment risk, creates the opportunity for essential grid services, and results in financeable projects
- Capacity-based payment structure ($/MW-mo)
- In early 2018, HECO formally issued RFPs totaling over 300 MW leveraging the RDG model and new PPA





https://sepapower.org/resource/proactive-solutions-curtailment-risks-identifying-new-contract-structures-utility-scale-renewables/

SUMMARY

As solar penetration increases, the energy industry needs to proactively address its impact on grid operation to maintain delivery of safe, reliable and affordable energy

Large-scale solar power plants are capable of addressing these constraints and increasing flexibility on the grid in a cost effective manner

Solar is the future mainstream generation source, capable of delivering energy when and how it is needed

NEXT STEPS

In order to leverage the full benefits of PV, First Solar recommends the following:

- Convene a workshop including grid operators, utilities, generation owners, and industry leaders to examine how best to leverage PV capabilities
- Ensure that any planning, market, or procurement mechanisms recognize and leverage the grid flexibility that solar PV can provide
- Update procurement and market rules that were built around the constraints of conventional thermal generation to instead reflect the needs of grid operators

To learn more, visit www.firstsolar.com/Grid-Evolution

LEADING THE WORLD'S
SUSTAINABLE ENERGY FUTURE