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<tr>
<th><strong>Docket Number:</strong></th>
<th>15- RETI-02</th>
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<tbody>
<tr>
<td><strong>Project Title:</strong></td>
<td>Renewable Energy Transmission Initiative 2.0</td>
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<tr>
<td><strong>TN #:</strong></td>
<td>211309</td>
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<tr>
<td><strong>Document Title:</strong></td>
<td>Presentation - Achieving a More Flexible Power System by Hal Harvey, 5-2-16</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>N/A</td>
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<tr>
<td><strong>Filer:</strong></td>
<td>Misa Milliron</td>
</tr>
<tr>
<td><strong>Organization:</strong></td>
<td>America's Power Plan and Energy Innovation Policy &amp; Technology LLC</td>
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ACHIEVING A MORE FLEXIBLE POWER SYSTEM

HAL HARVEY
RETI 2.0 IN CONTEXT

40% GHG reduction by 2030...

On the path to 80% GHG reduction by 2050

Source: Low-Carbon Grid Study: Phase II Results, 2016
WHY A FLEXIBLE GRID?

Helps achieve 2050 emissions goal (beyond 50% renewables)

Addresses two kinds of variability created by renewables:

- **Known variability** – daily or seasonal trends are often predictable
- **Unknown variability** (short-term) – relatively small, even under high shares of wind and solar
A SUITE OF FLEXIBILITY OPTIONS

High Cost

Low Cost

Increasing Need for Grid Flexibility

Flexibility Resource Supply Curve

Improved Operations

Demand Response

Grid Infrastructure

Fast Ramping Supply

Energy Storage

IMPROVED OPERATIONS

Expand the EIM

Flexible Imports
IMPROVED OPERATIONS
EXPAND THE EIM

Additional regions

Additional products
IMPROVED OPERATIONS
FLEXIBLE IMPORTS
DEMAND RESPONSE

TWO KINDS OF DEMAND RESPONSE

- Dispatchable
- Price-responsive
DEMAND RESPONSE

GWs of latent DR opportunities across the economy
GRID INFRASTRUCTURE

TRANSMISSION

Regional optimization
Geographic diversity
Technological diversity
GRID INFRASTRUCTURE
REGIONAL OPTIMIZATION

Managing unpredictable variations

(Approximately 8 hours)

15 turbines St.Dev. = 1.21, St.Dev./Mean = 0.184
215 turbines St.Dev. = 15.63, St.Dev./Mean = 0.125
GRID INFRASTRUCTURE
GEOGRAPHIC DIVERSITY

Managing predictable variations

Example: complementary wind resources in the region

GRID INFRASTRUCTURE
TECHNOLOGICAL DIVERSITY

Diverse Resource Mix

High Solar Case

<table>
<thead>
<tr>
<th>Case</th>
<th>Net Cost (% of RevReq)</th>
<th>CA Carbon (MMT/yr)</th>
<th>RE Curtailment (%)</th>
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<tbody>
<tr>
<td>Diverse/Enhanced</td>
<td>0.6%</td>
<td>41.1</td>
<td>0.2%</td>
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<tr>
<td>High Solar/Enhanced</td>
<td>2.2%</td>
<td>42.2</td>
<td>0.5%</td>
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</table>

Source: Low-Carbon Grid Study: Phase II Results, 2016
FAST RAMPING SUPPLY

IMPROVE FOSSIL FLEXIBILITY

Only use existing capacity

Use only for power, not energy
FAST RAMPING SUPPLY

New natural gas WILL NOT put us on track to meeting 2050 GHG goals
1.3 GW storage mandate drives deployment up, costs down
### CURTAILMENT
**THE MOST EXPENSIVE OPTION**

Flexibility is key to reducing curtailment.

![Graph showing curtailment percentages for baseline, target, high solar, enhanced flexibility, and conventional flexibility](source)

Source: G. Brinkman, California Low-Carbon Grid Study, Presentation to RETI 2.0 Stakeholder Meeting, April 18, 2016.
CURTAILMENT

...OR LONG-TERM ELASTICITY?

Excess energy can be a competitive advantage for California

Time of use rates
PUTTING IT ALL TOGETHER

These resources provide a vast suite of options, yielding power that is:

- RELIABLE
- CLEAN
- AFFORDABLE

RETI 2.0 scope should be REGIONAL to capture the full range of cost-effective flexibility options.
OPPORTUNITY #1
EXPORTING SOLAR EASTWARD

New market for excess CA solar?

Source: Arizona Public Service 2014 IRP
OPPORTUNITY #2
TAKE ADVANTAGE OF COAL RETIREMENTS

Add clean resources where transmission lines already exist

Source: WECC 2012 Coal Retirements Study
OPPORTUNITY #3
CONNECT NEGATIVELY CORRELATED RESOURCES

Source: D. Corbus et al., California-Wyoming Grid Integration Study: Phase 1—Economic Analysis, NREL, March 2014.
OPPORTUNITY #4
INCREASE INTEGRATION... INCREASE RESILIENCE

Southwest Intertie Project (SWIP)

Completes transmission loop
Reduces region-wide congestion
- Southwest solar → Northwest
- Wyoming/Montana wind → Southwest

(solid red lines are illustrative)
THANK YOU