

DOCKETED

Docket Number:	15-RETI-02
Project Title:	Renewable Energy Transmission Initiative 2.0
TN #:	211309
Document Title:	Presentation - Achieving a More Flexible Power System by Hal Harvey, 5-2-16
Description:	N/A
Filer:	Misa Milliron
Organization:	America's Power Plan and Energy Innovation Policy & Technology LLC
Submitter Role:	Public
Submission Date:	4/29/2016 2:44:06 PM
Docketed Date:	4/29/2016

ACHIEVING A MORE FLEXIBLE POWER SYSTEM

HAL HARVEY

AMERICA'S
POWER PLAN

ENERGY INNOVATION

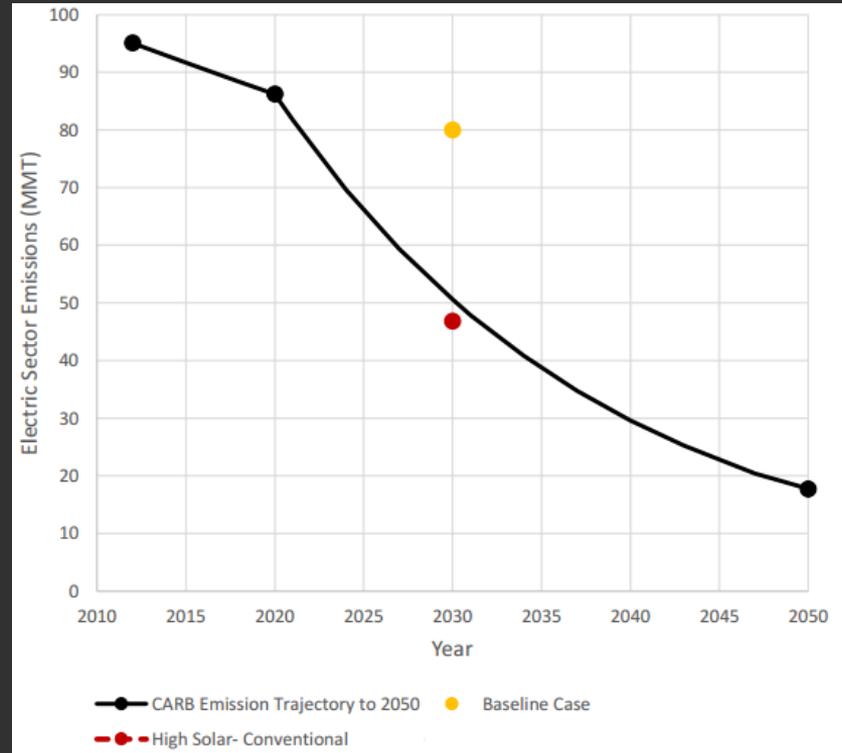
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RETI 2.0 IN CONTEXT

40% GHG reduction by 2030...

On the path to **80% GHG**
reduction by **2050**



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

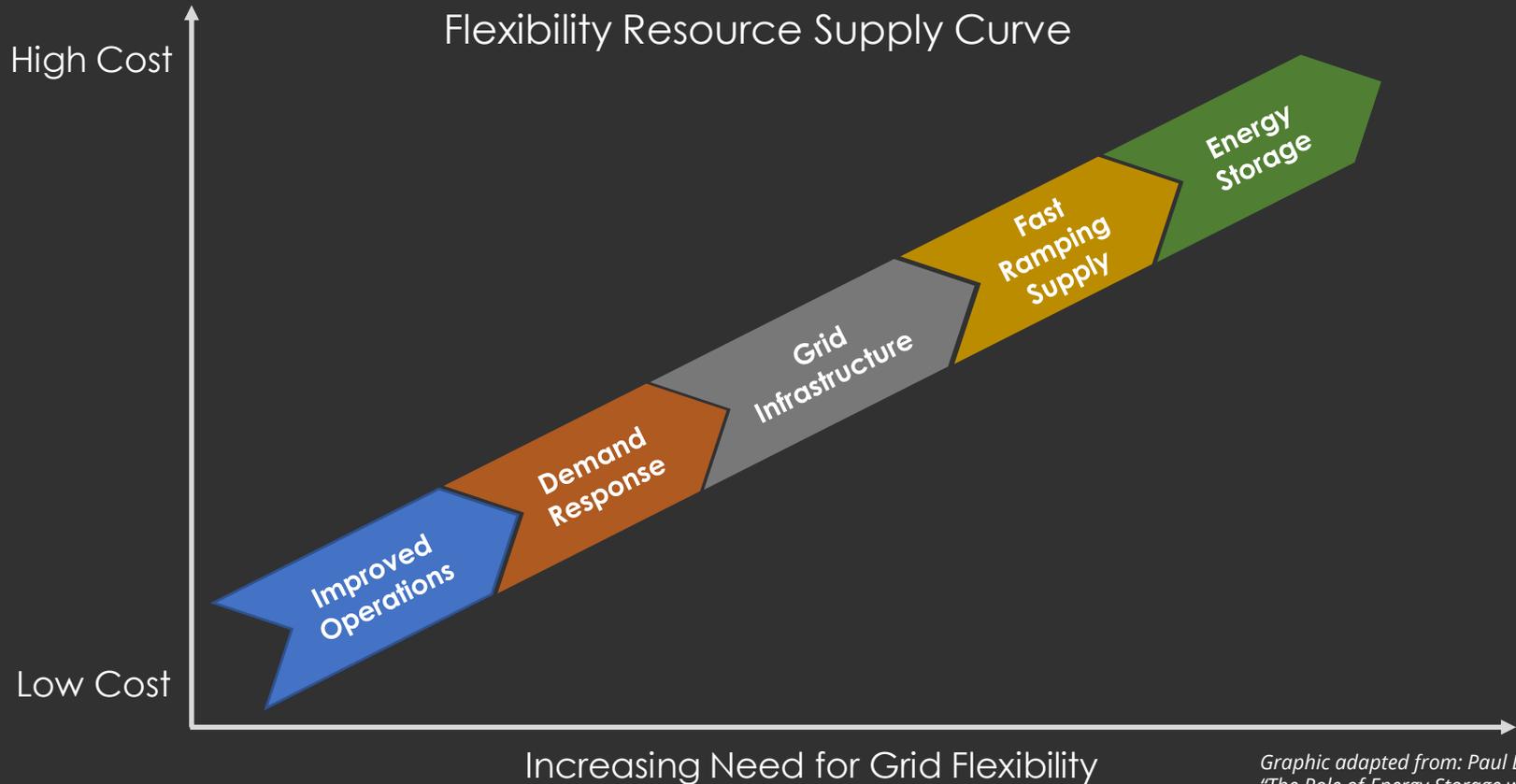
WHY A FLEXIBLE GRID?

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

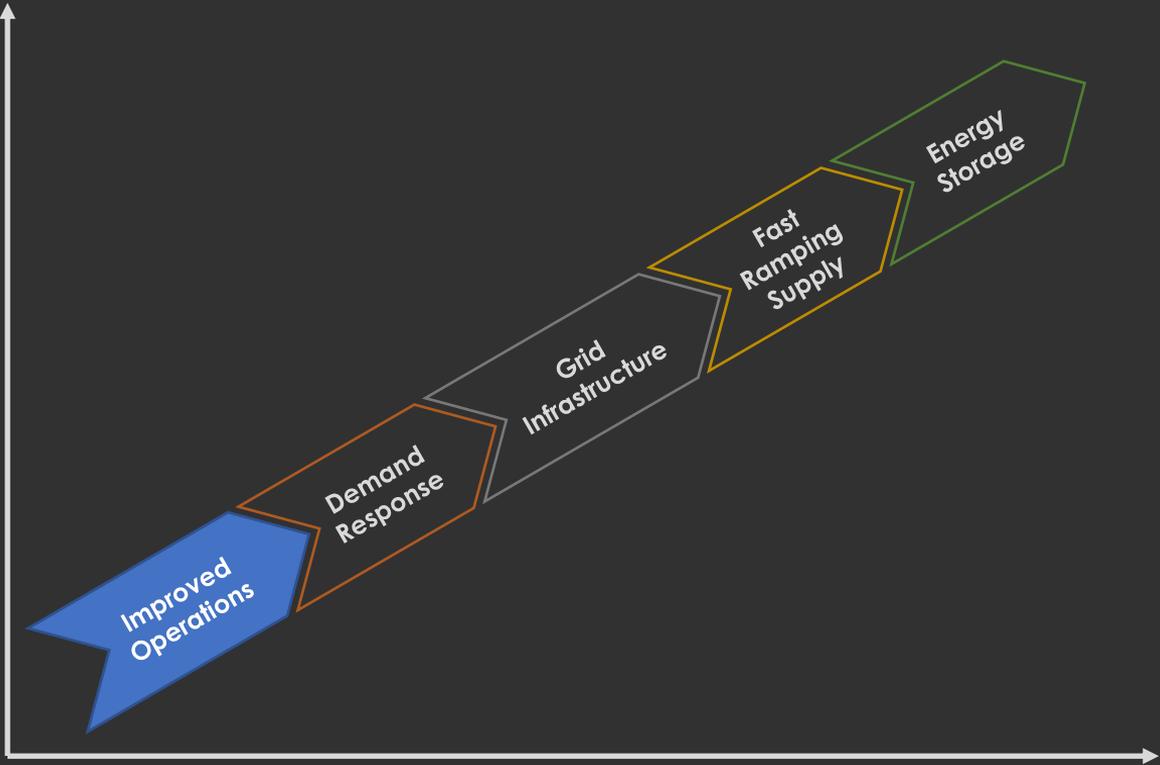


Graphic adapted from: Paul Denholm et al., "The Role of Energy Storage with Renewable Electricity Generation" (NREL, January 2010).

IMPROVED OPERATIONS

Expand the EIM

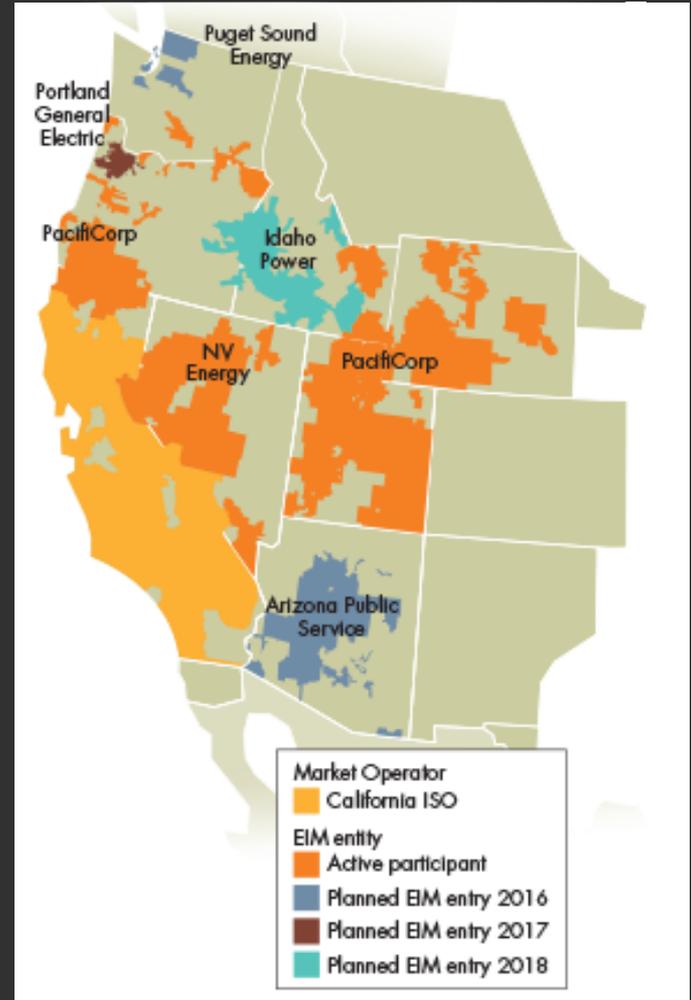
Flexible Imports



IMPROVED OPERATIONS EXPAND THE EIM

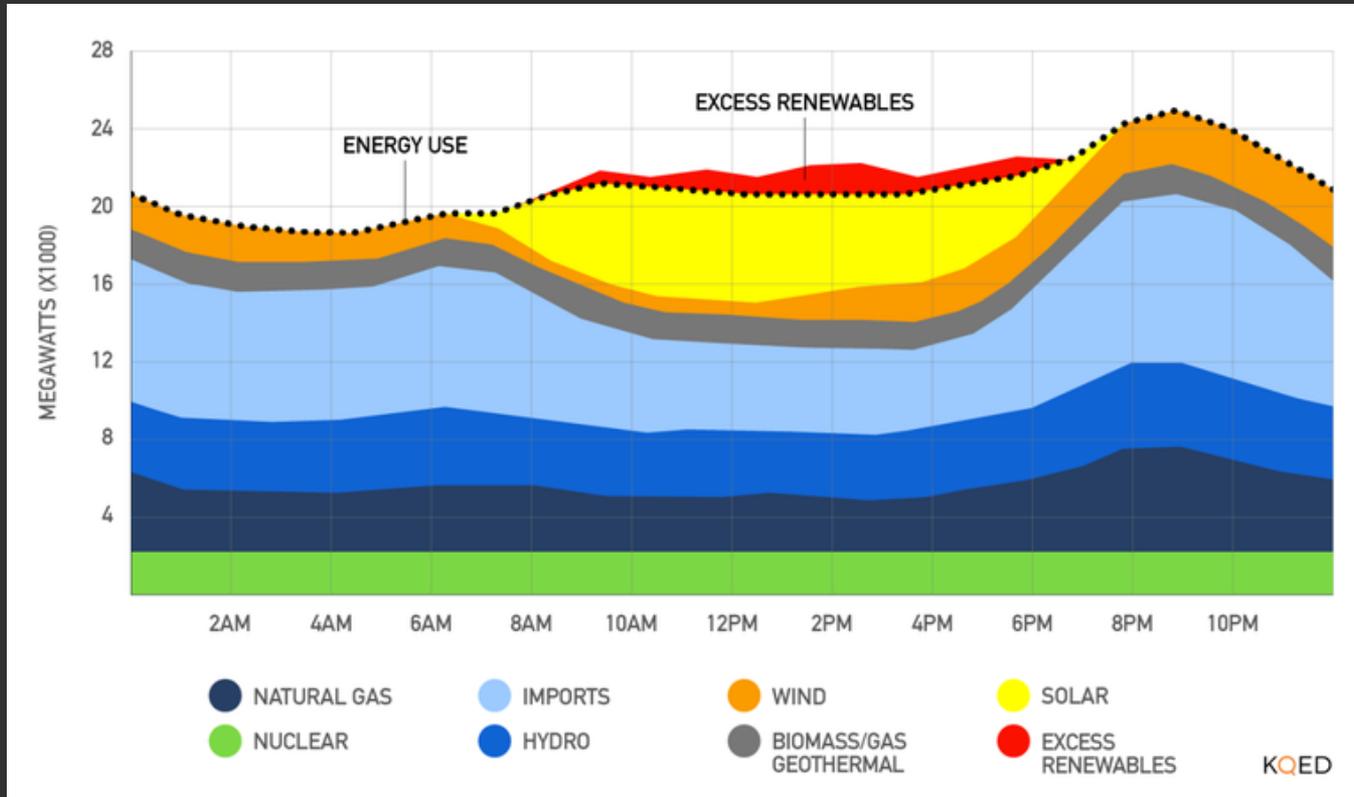
Additional regions

Additional products



IMPROVED OPERATIONS

FLEXIBLE IMPORTS

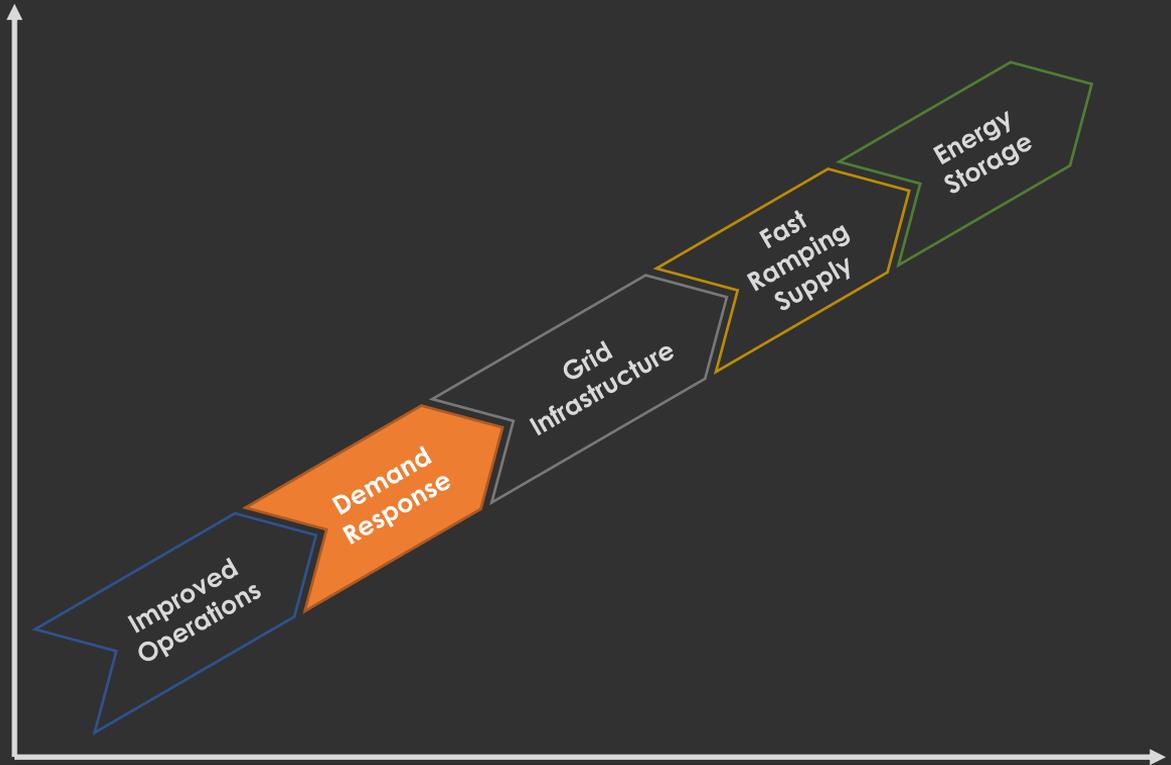


DEMAND RESPONSE

TWO KINDS OF
DEMAND RESPONSE

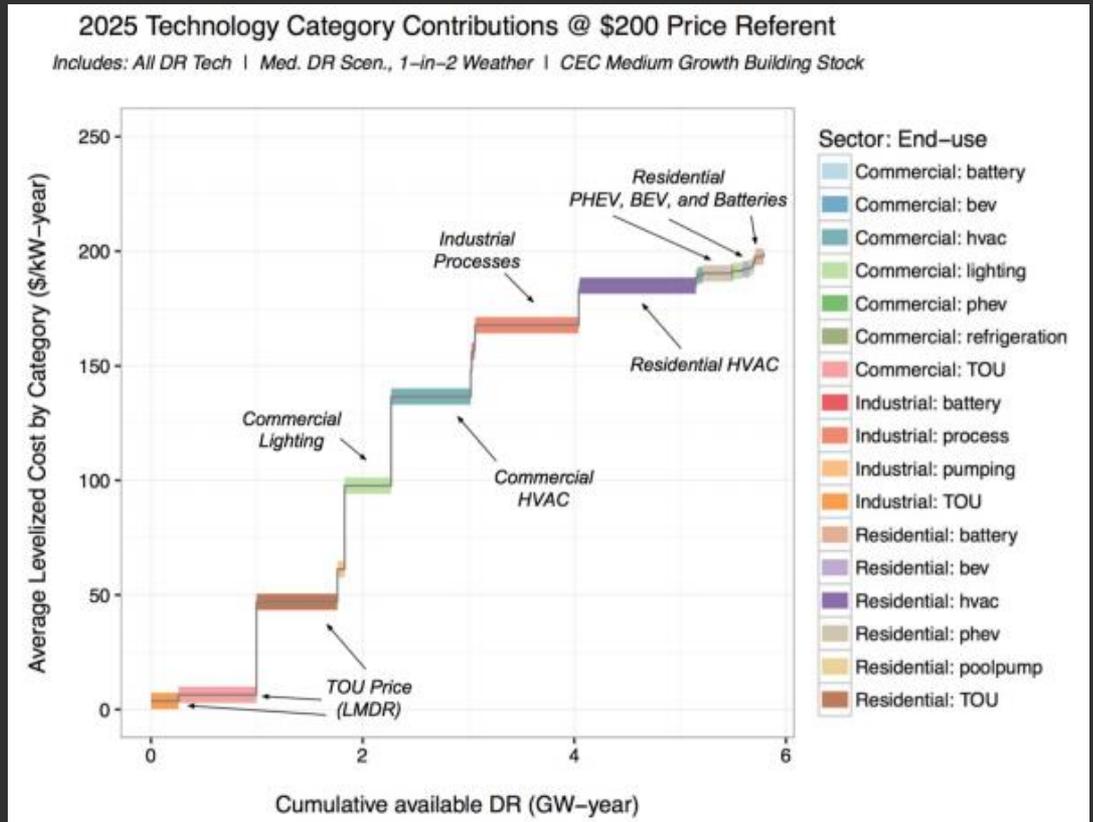
Dispatchable

Price-responsive

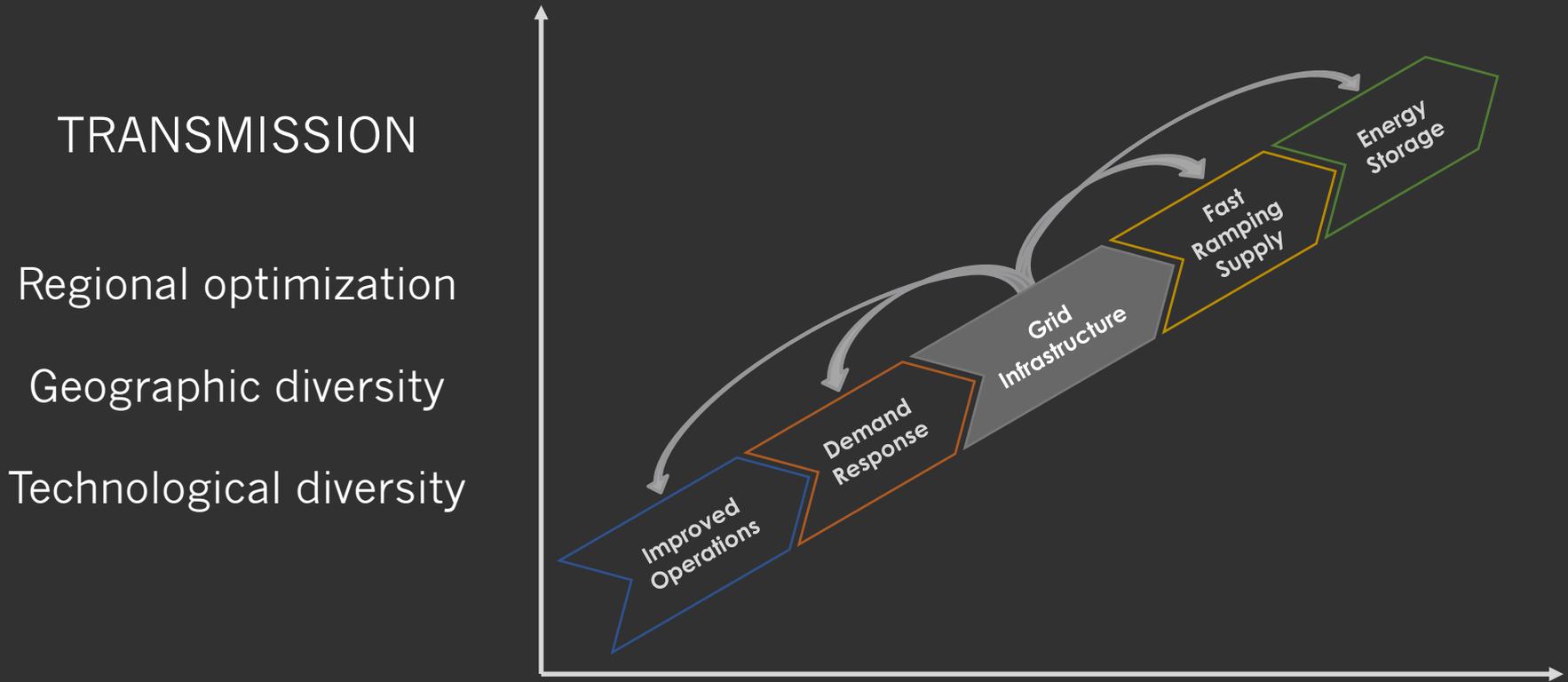


DEMAND RESPONSE

GWs of latent DR opportunities across the economy

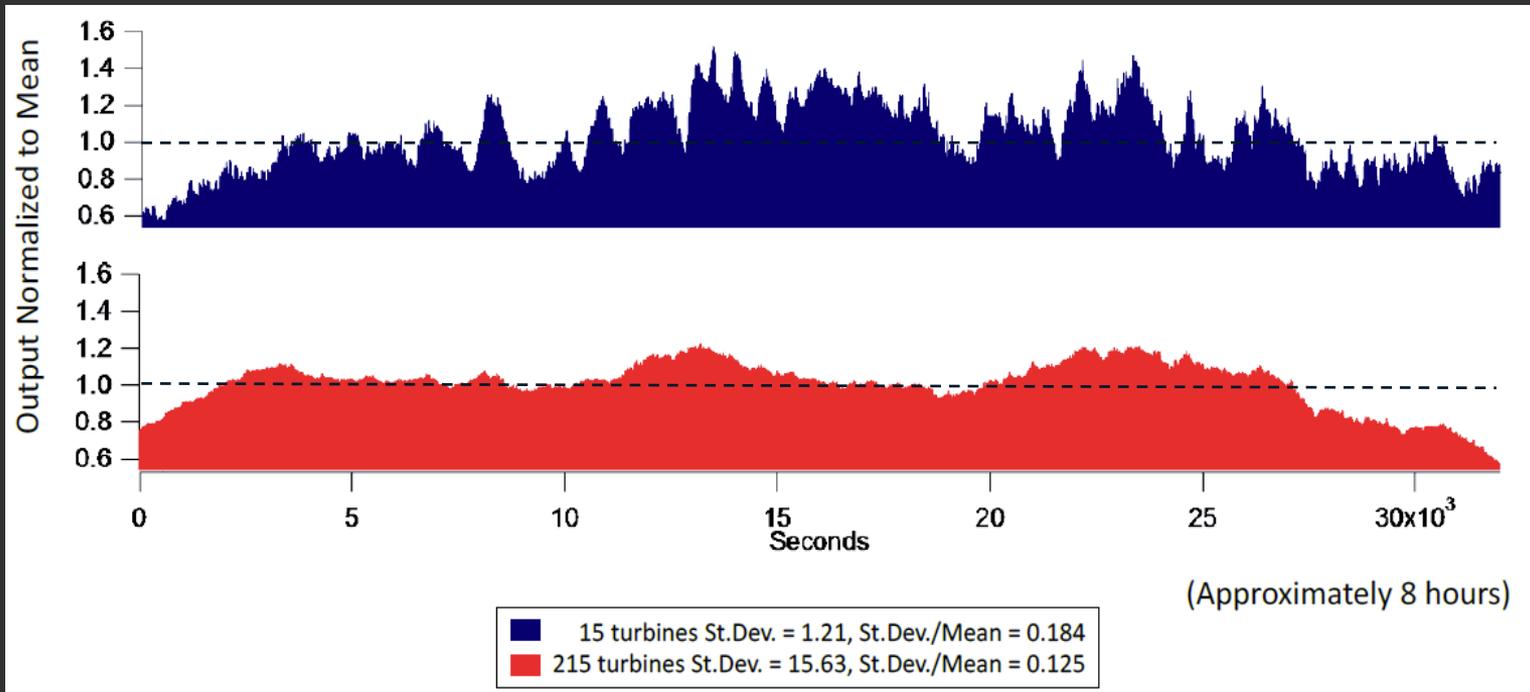


GRID INFRASTRUCTURE



GRID INFRASTRUCTURE REGIONAL OPTIMIZATION

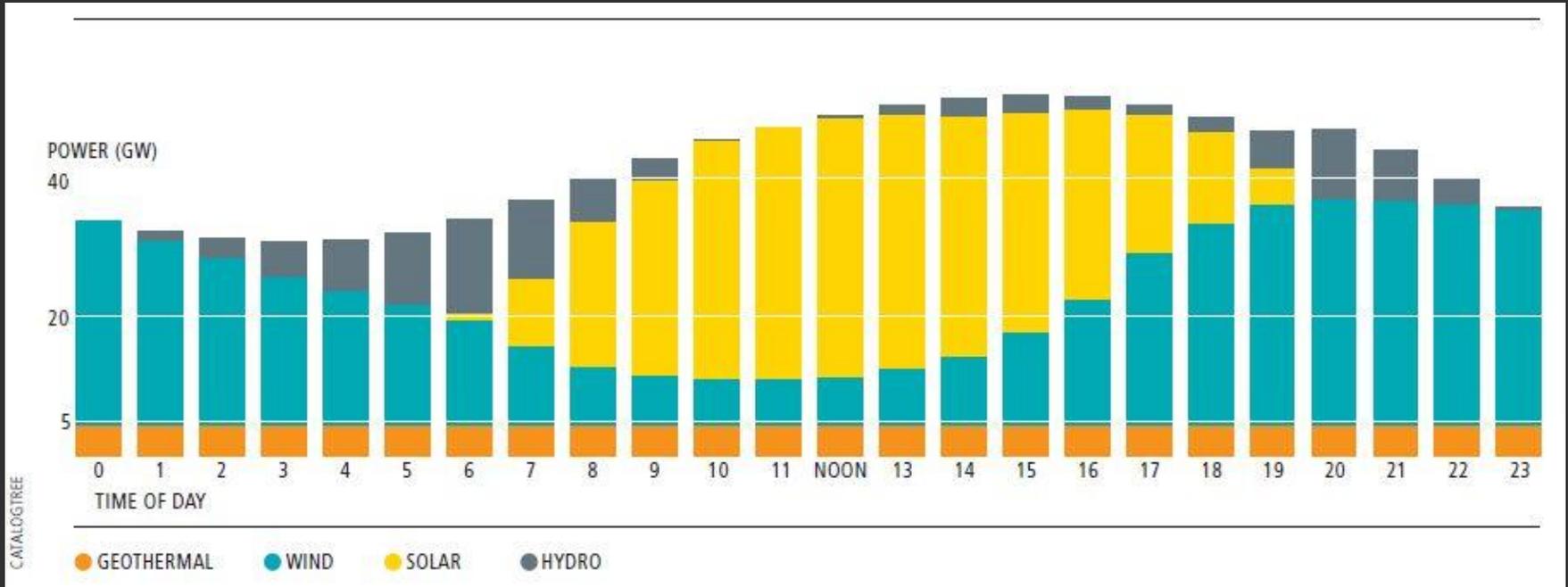
Managing **unpredictable** variations



GRID INFRASTRUCTURE

GEOGRAPHIC DIVERSITY

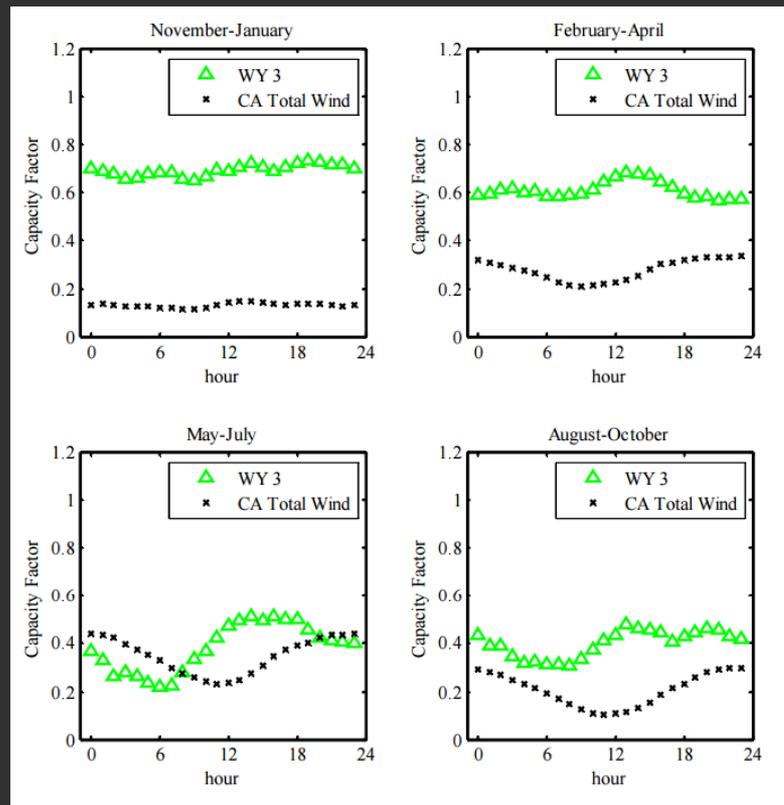
Managing **predictable** variations



GRID INFRASTRUCTURE GEOGRAPHIC DIVERSITY

Example: complementary
wind resources in the region

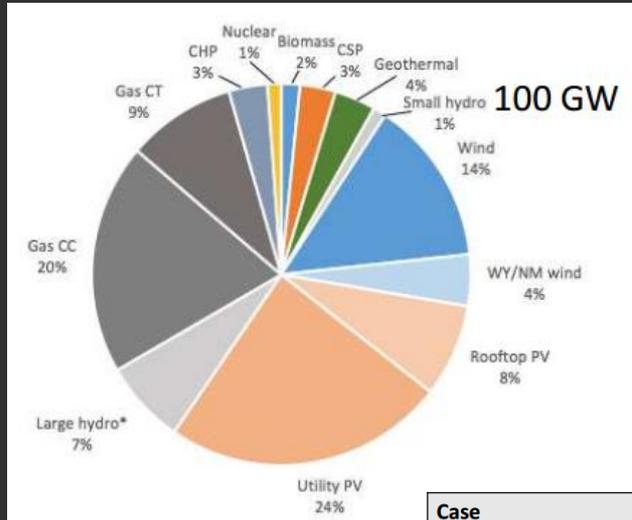
WY & CA Wind



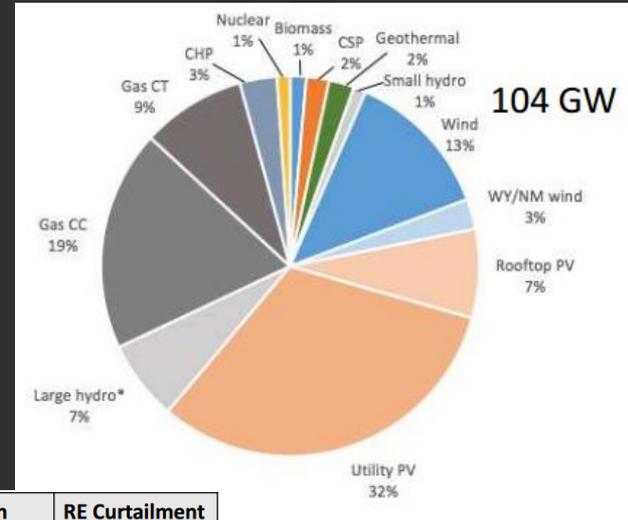
Source: J. Naughton, *Wind Diversity Enhancement of Wyoming, California Wind Energy Projects: Phase 2*, Univ. of Wyoming, Wind Energy Research Center, July 2015

GRID INFRASTRUCTURE TECHNOLOGICAL DIVERSITY

Diverse Resource Mix



High Solar Case



Case	Net Cost (% of RevReq)	CA Carbon (MMT/yr)	RE Curtailment (%)
Diverse/Enhanced	0.6%	41.1	0.2%
High Solar/Enhanced	2.2%	42.2	0.5%

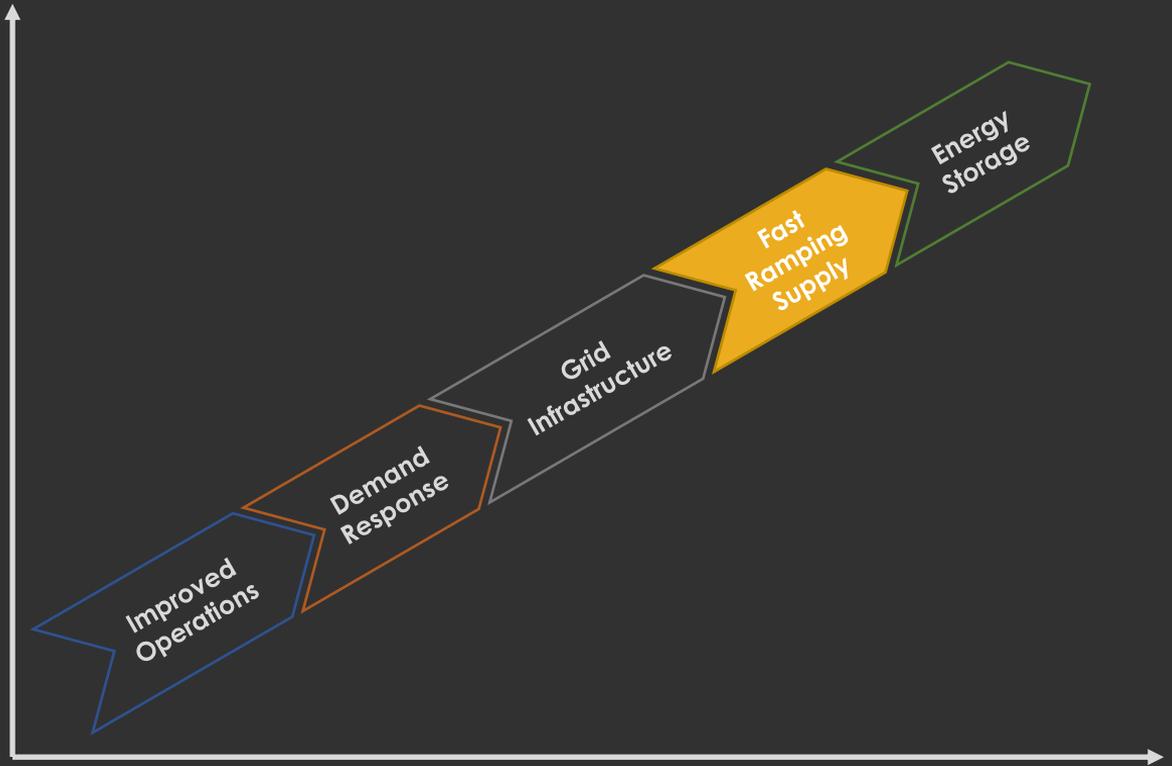
*Source: Low-Carbon Grid Study:
Phase II Results, 2016*

FAST RAMPING SUPPLY

IMPROVE FOSSIL FLEXIBILITY

Only use existing capacity

Use only for power, not energy



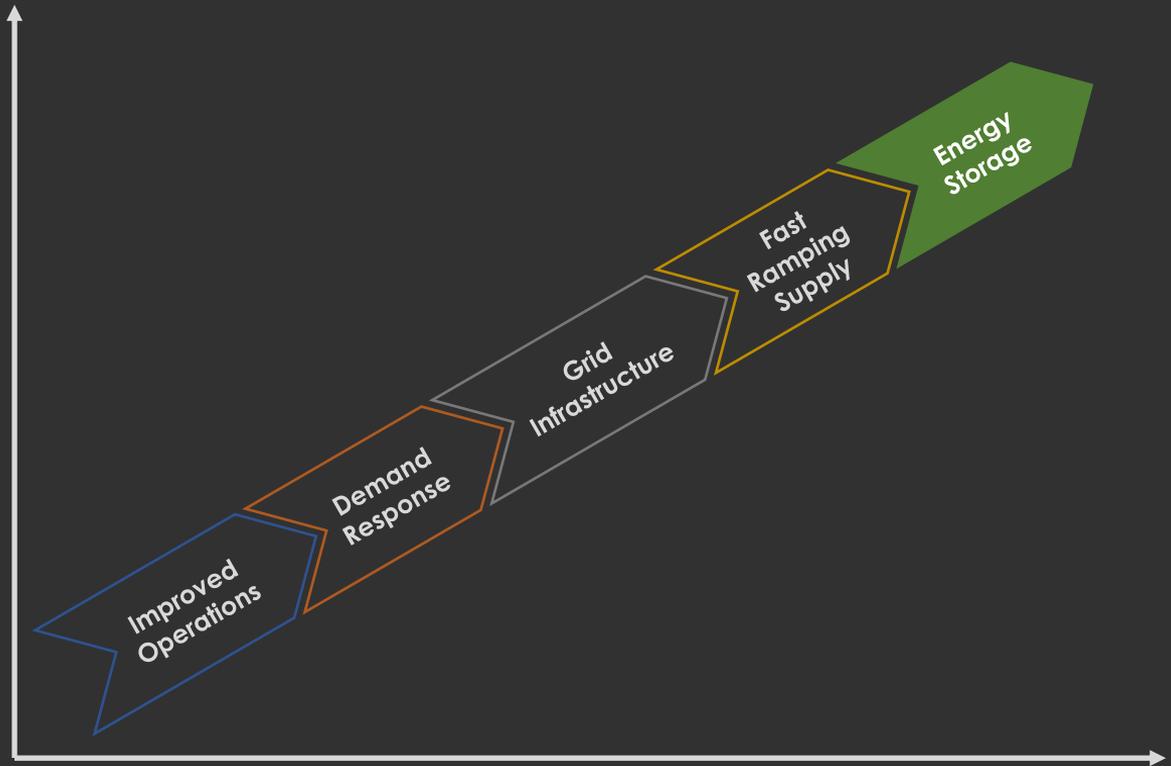
FAST RAMPING SUPPLY

New natural gas WILL NOT put us
on track to meeting 2050 GHG goals



ENERGY STORAGE

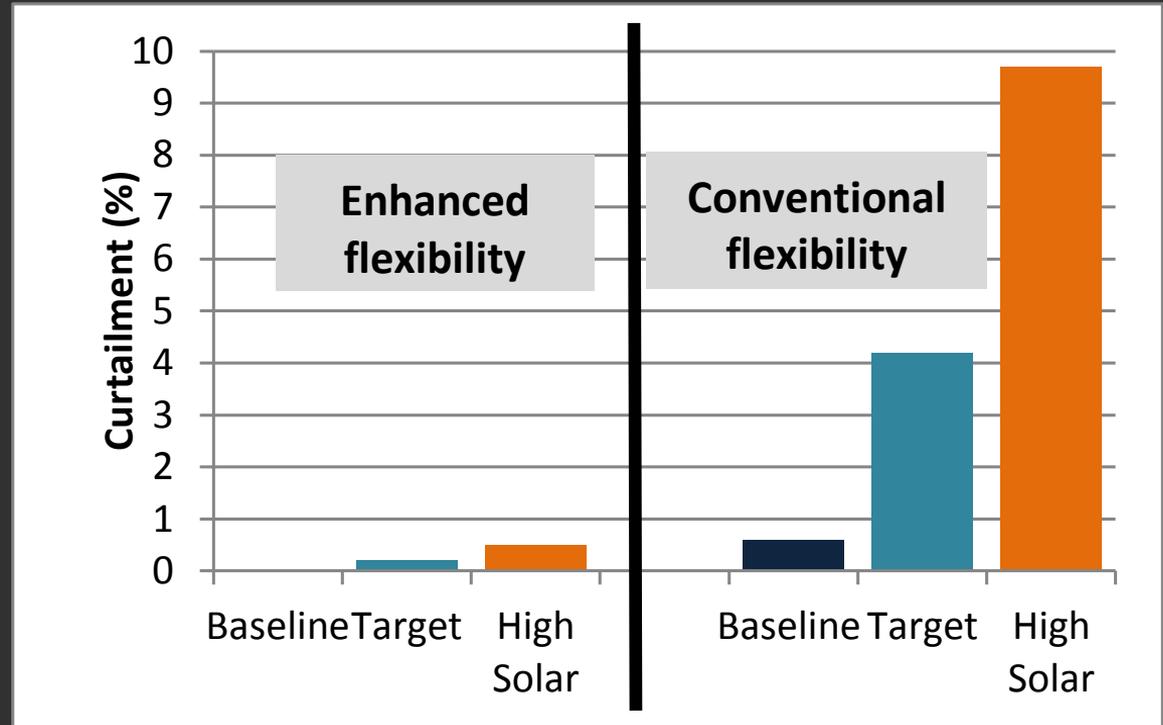
1.3 GW storage
mandate drives
deployment up,
costs down



CURTAILMENT

THE MOST EXPENSIVE OPTION

Flexibility is key
to reducing
curtailment



CURTAILMENT ...OR LONG-TERM ELASTICITY?



Time of use rates

Desalinization



Data Processing

Battery Electric Vehicles



Air Gases

Excess energy can be a competitive advantage for California

PUTTING IT ALL TOGETHER

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



RELIABLE



CLEAN



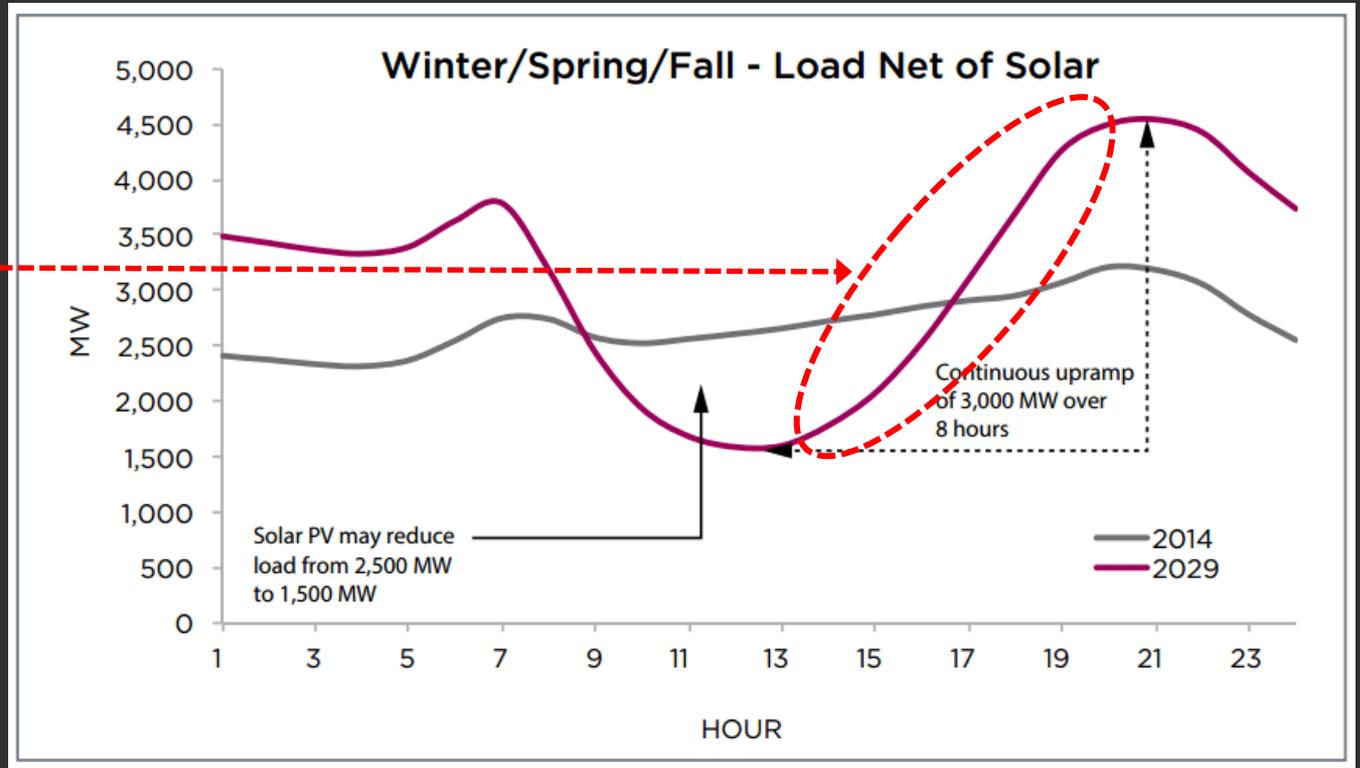
AFFORDABLE

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?



OPPORTUNITY #2

TAKE ADVANTAGE OF COAL RETIREMENTS

Add clean resources where transmission lines already exist

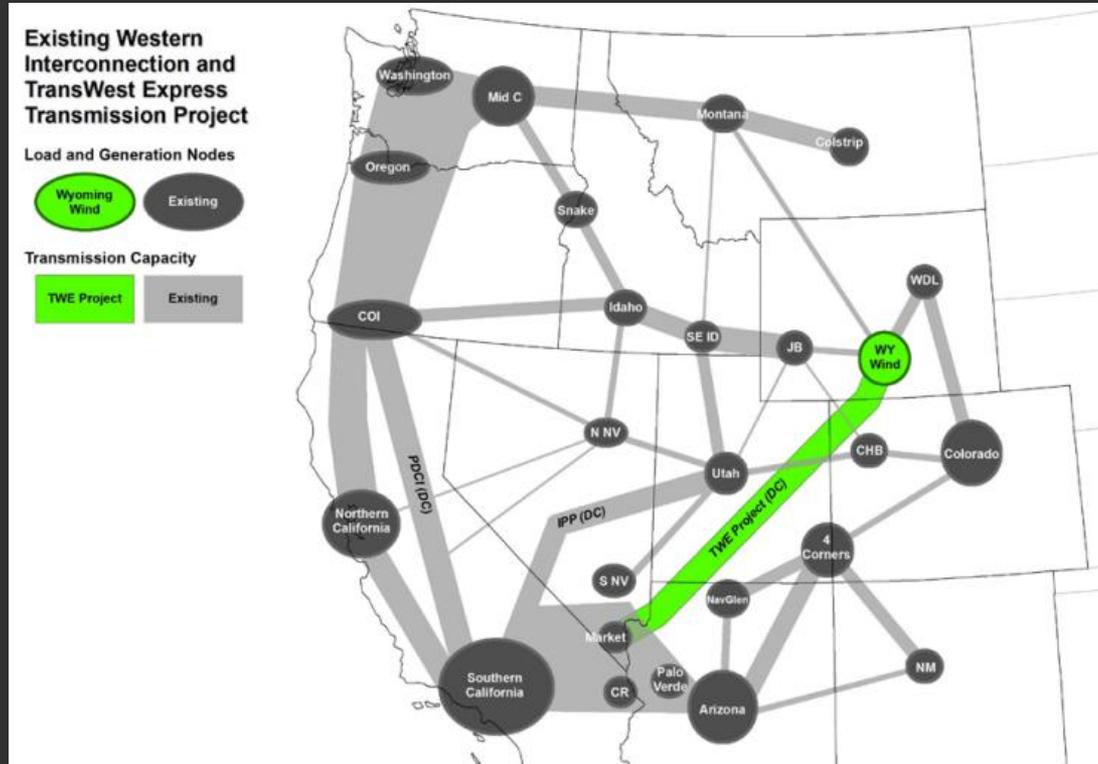


-  Coal Plant Retirement
-  Incremental wind resource
-  Incremental solar resource

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

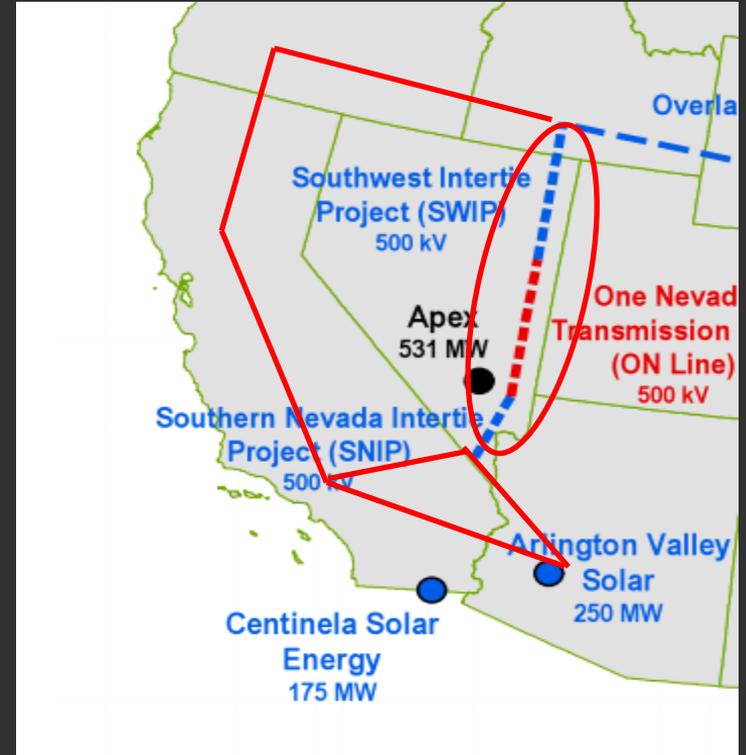
INCREASE INTEGRATION... INCREASE RESILIENCE

Southwest Intertie Project (SWIP)

Completes transmission loop

Reduces region-wide congestion

- Southwest solar → Northwest
- Wyoming/Montana wind → Southwest



(solid red lines are illustrative)

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THANK YOU

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