Grid Integration and Power System Flexibility: Challenges and Trends

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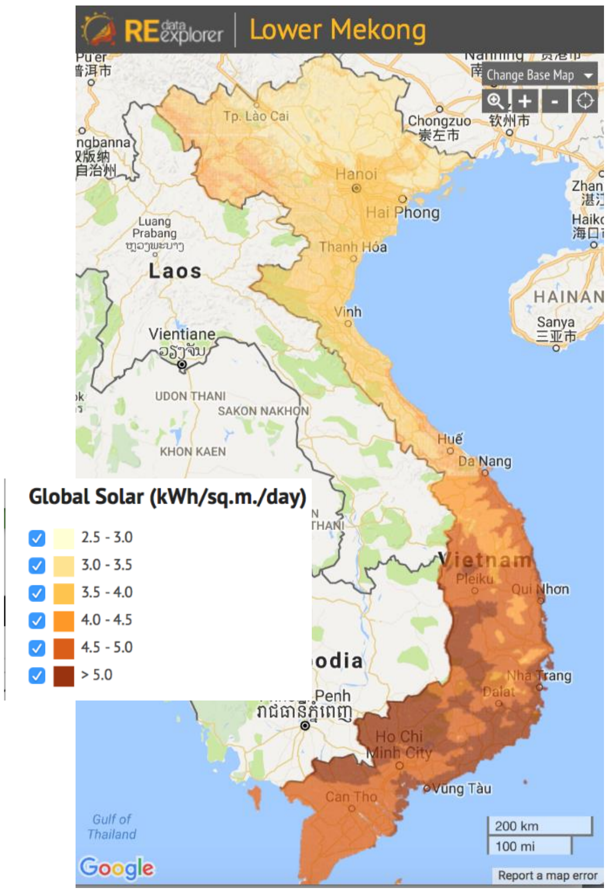
Outline

- Refresher: Variability and uncertainty, and the need for flexibility
- What have we learned since last year?
  - Emerging challenges
  - Innovative solutions

Refresher:
Variability and Uncertainty, and the Need for Flexibility

Wind and solar introduce new considerations for grid planning and operations

Renewable energy (RE) is variable, uncertain, and geographically dispersed

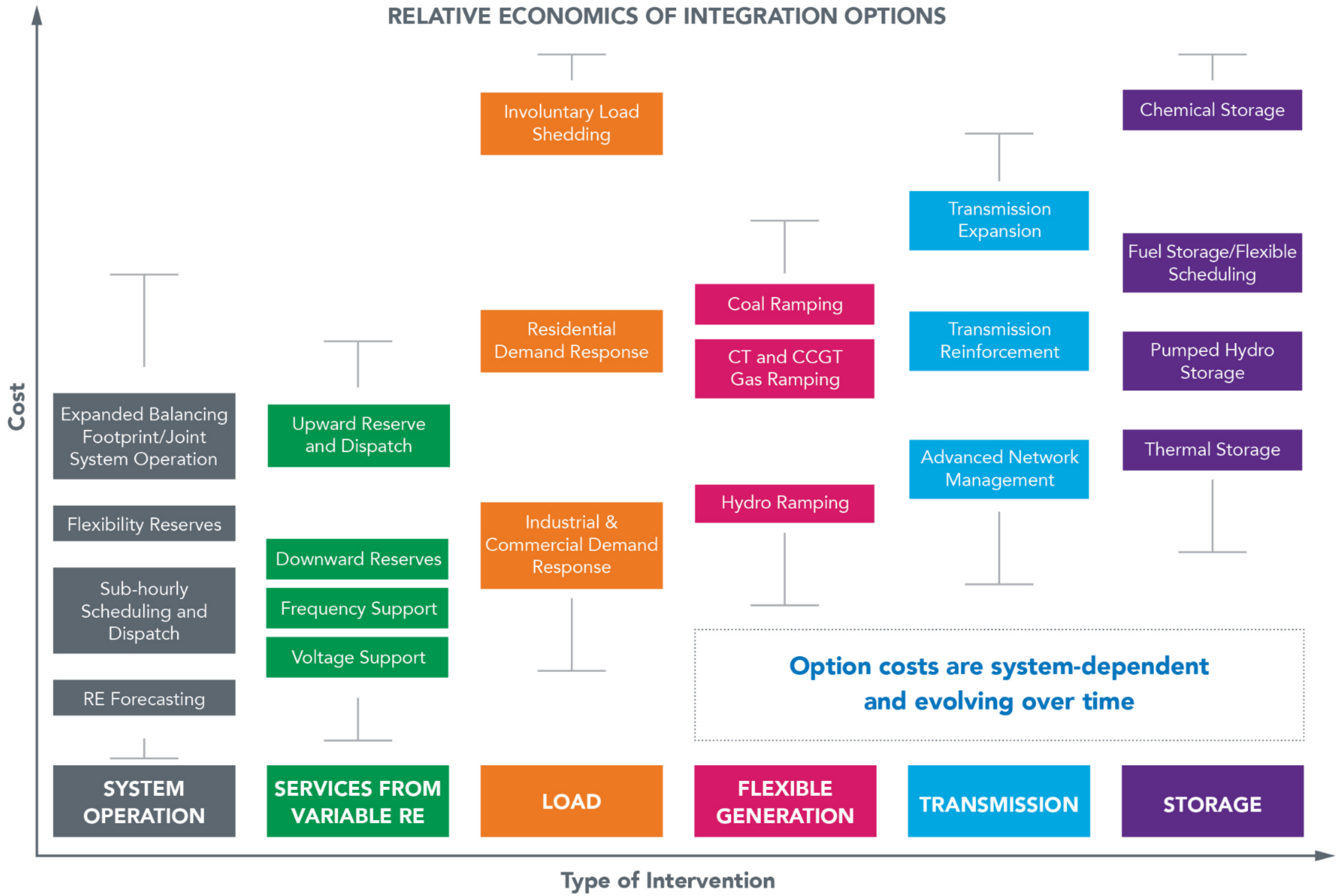


Source: RE Data Explorer for the Lower Mekong

…raising new considerations for grid planning and operations

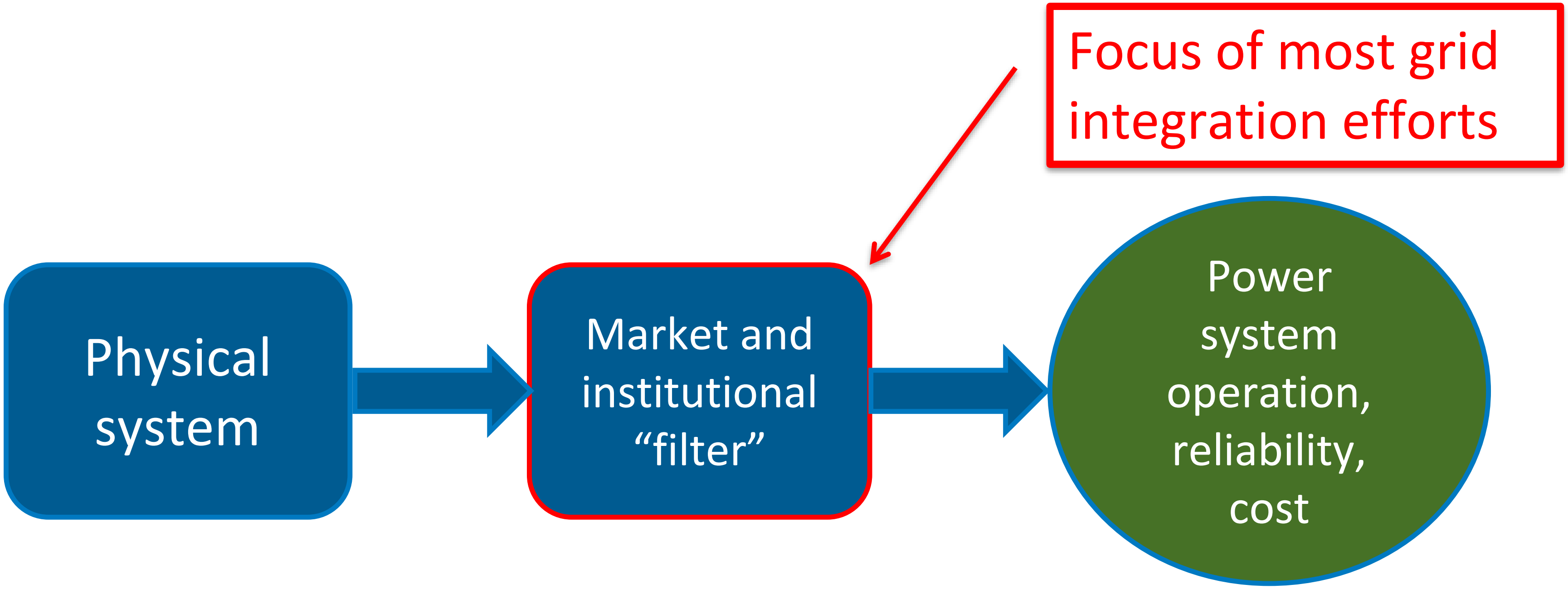
1. Balancing requires more flexibility
2. The need for operating reserves can increase
3. Transmission upgrades, changes in planning may be needed
4. Existing thermal assets used less frequently, affecting cost recovery
5. Voltage control, inertia response come at added cost

Frequently used options to increase flexibility



Many systems have physical flexibility; accessing this flexibility is a key challenge to RE grid integration

- Physical power system: generators, transmission, storage, interconnection
- Institutional system: scheduling and dispatch, forecasting, market rules, collaboration with neighbors

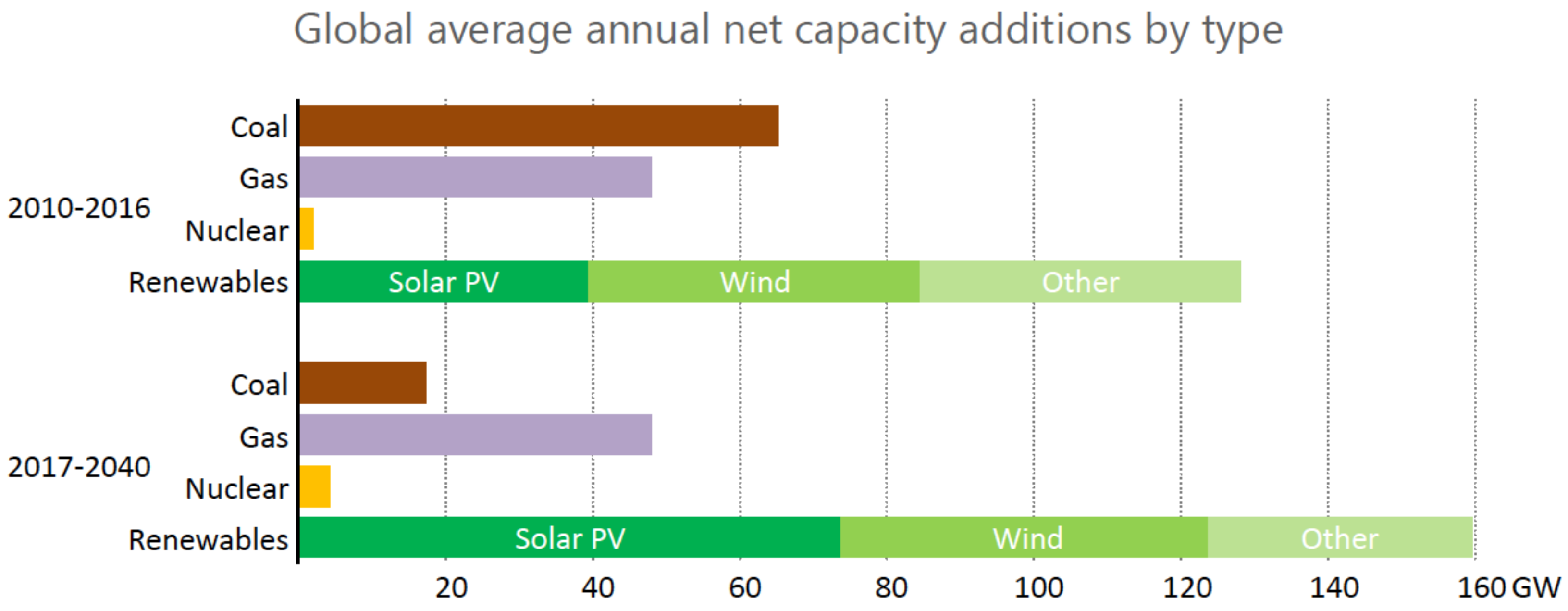


Power system operation (and grid integration!) relies on both

What have we learned since last year?

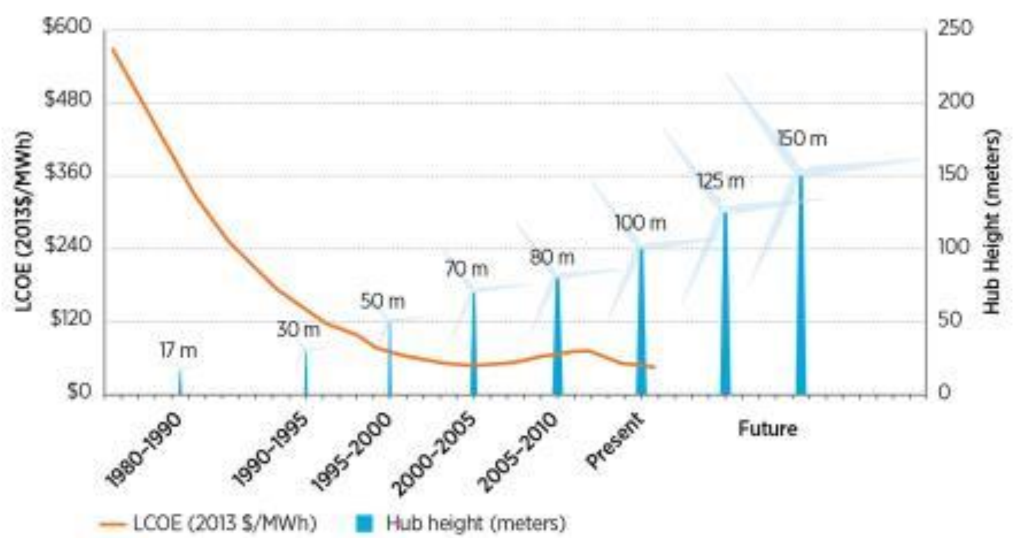
Emerging challenges

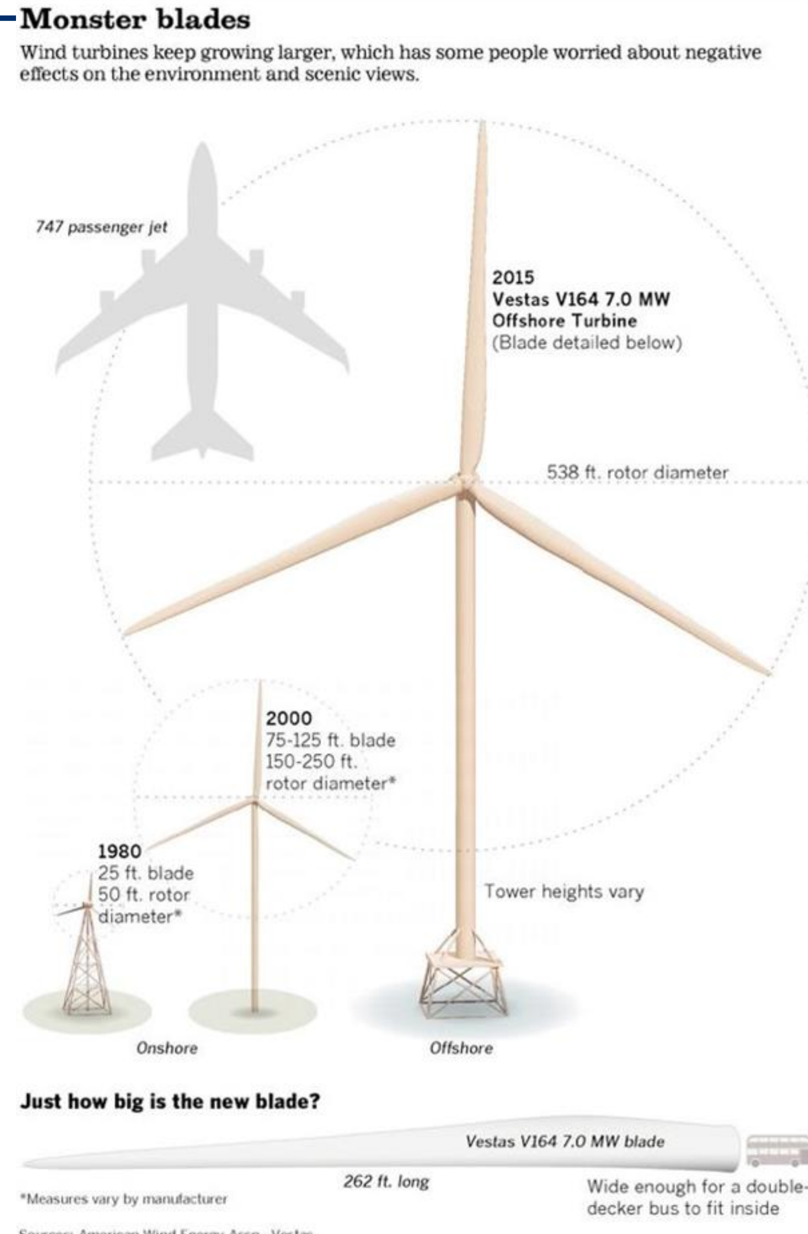
Electrification continues to dominate energy growth, with RE dominating that growth



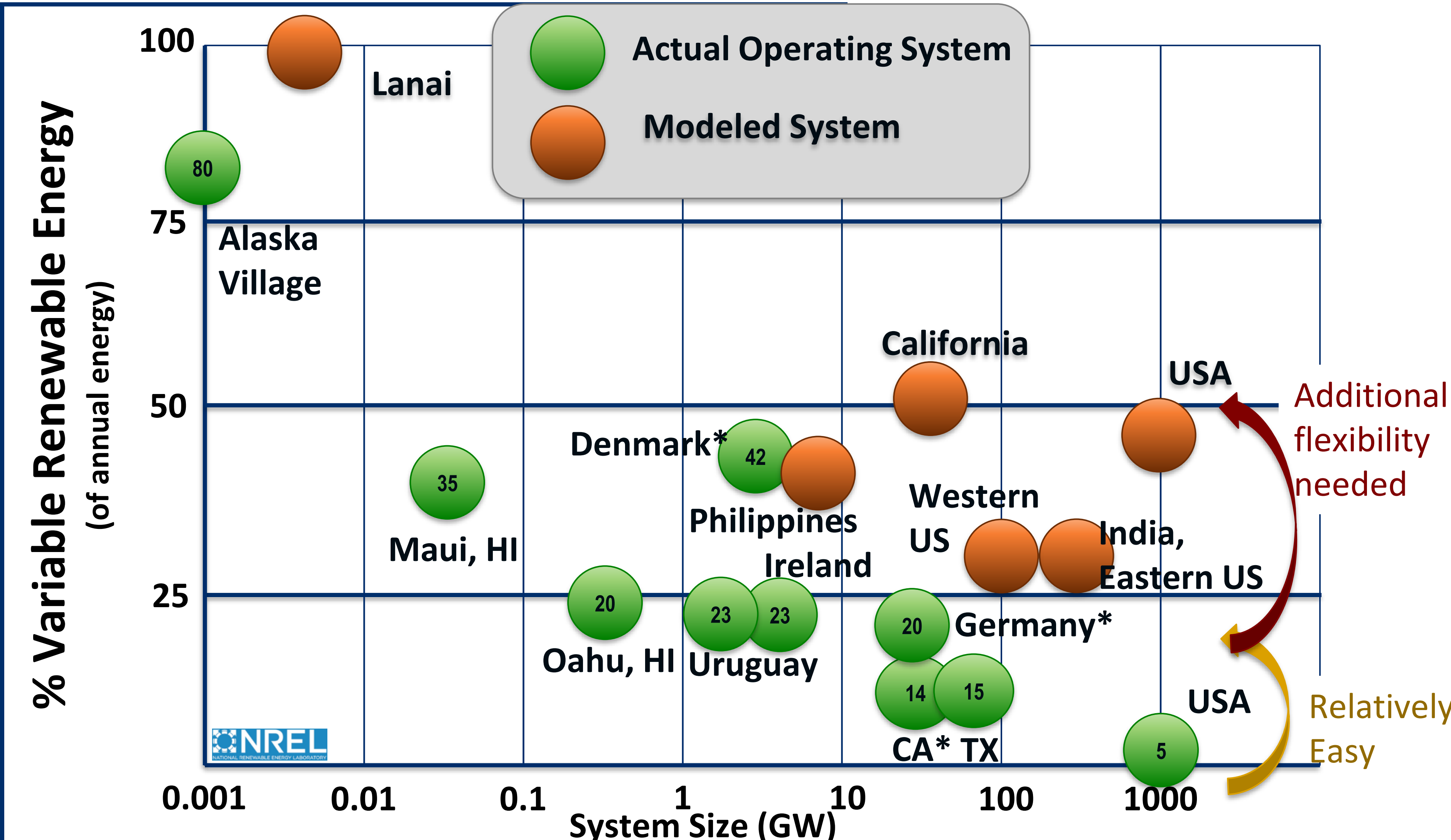
International Energy Outlook 2017

Wind penetration poised to rise quickly with emerging technologies; RE costs are falling



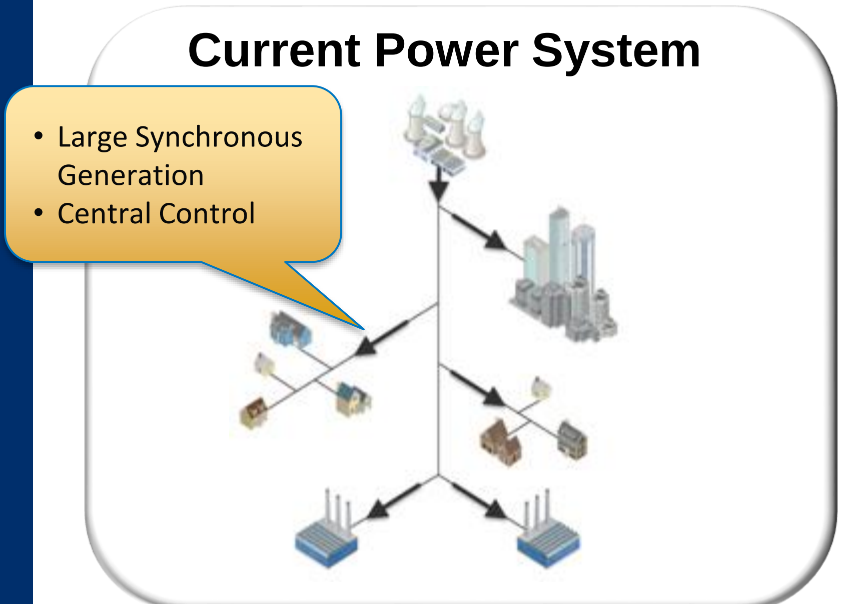


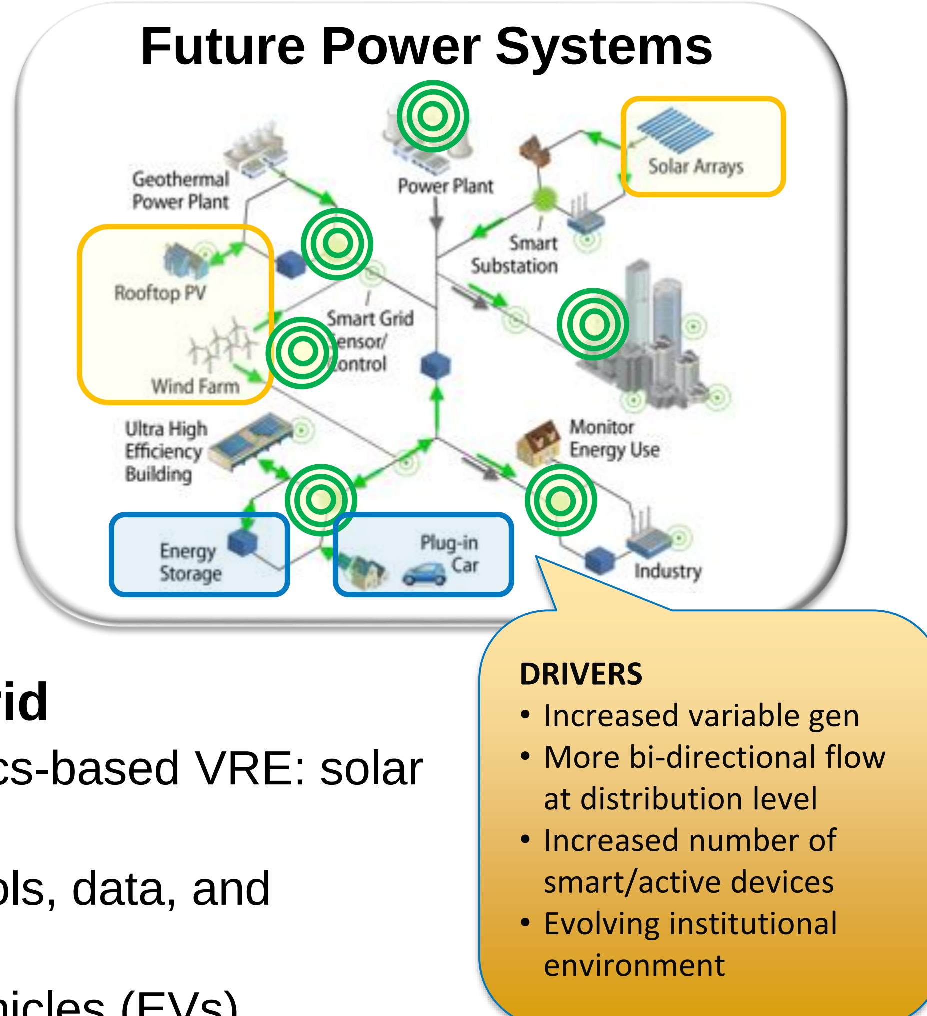
Percentage of variable RE in operation and in targets continues to grow



* Part of a larger synchronous AC power system

The grid is evolving at the distribution level too





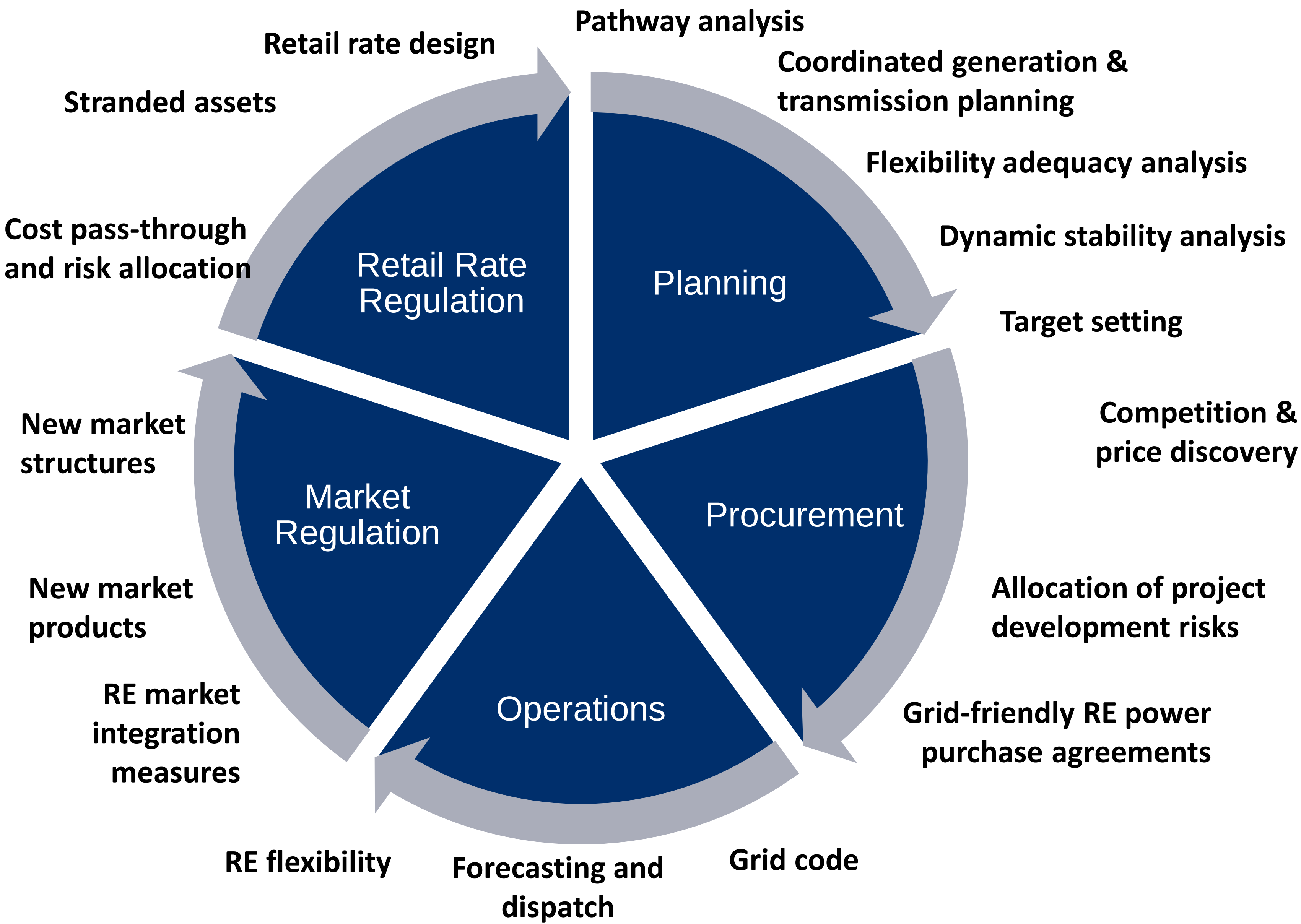
New Challenges in a Modern Grid

- Increasing levels of power electronics-based VRE: solar and wind
- More use of communications, controls, data, and information (e.g., smart grids)
- Other new technologies: electric vehicles (EVs), distributed storage, flexible loads
- Becoming highly distributed—more complex to control

What have we learned since last year?

Innovative solutions

Solutions address many interrelated technical and policy elements



Example: Trend is to treat RE like conventional power plant, removing priority dispatch

- **RE** as a good grid citizen
  - Visible
  - Schedulable
  - Dispatchable
  - Curtailable
  - Able to provide ancillary services

- Control technologies for wind and solar are now reflected in PPAs and grid codes

- Instead of priority dispatch, address RE financing concerns separate from system operations

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This DDW to address solutions in 4 categories

Session 1: Decision Support Tools

Session 2: Generation Flexibility

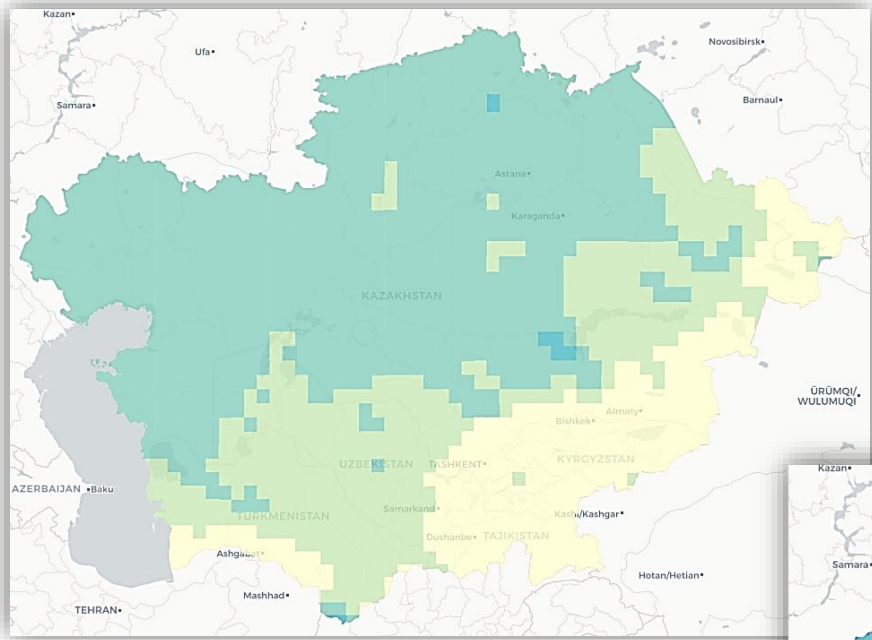
Session 3: Utility-scale Storage

Session 4: Rooftop PV

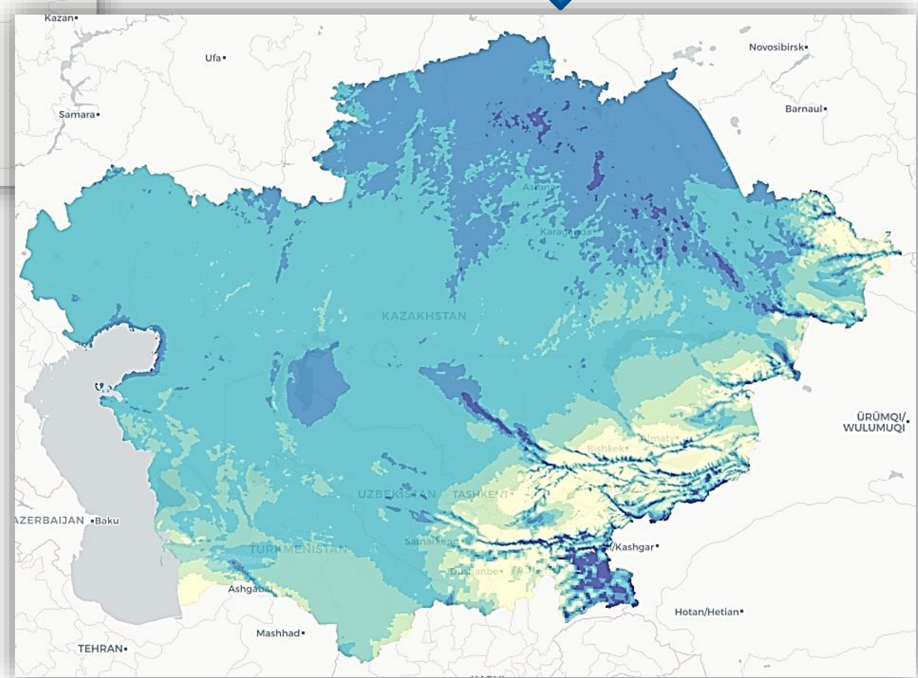
High-resolution RE data underpin effective planning

Session 1: Decision Support Tools

Geographic resolution **50 km**



Geographic resolution **3 km**



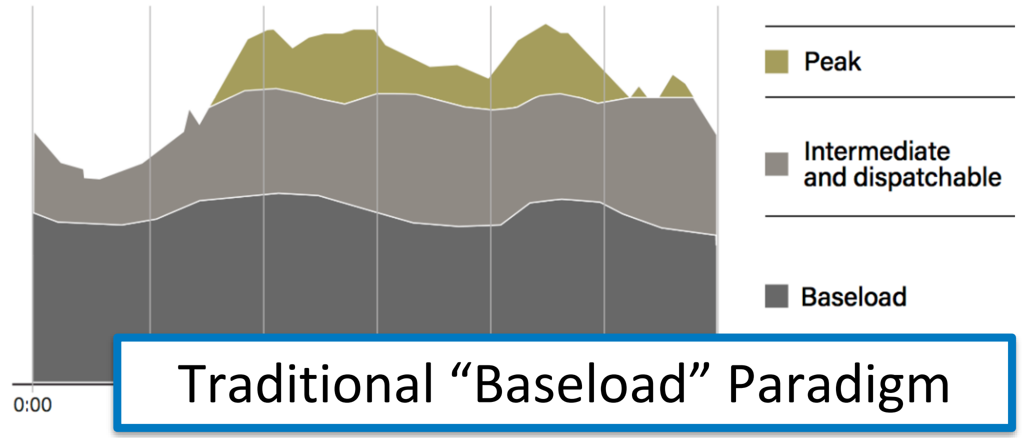
Wind Speed - 80 meters (meters/second)

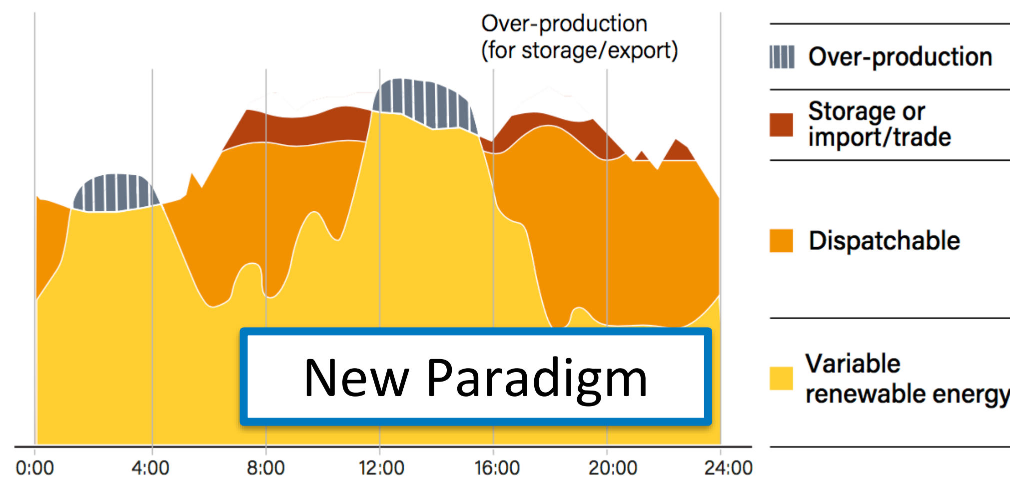
- 0.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- > 10.0

Advanced modeling helps answer new sets of planning questions

Session 1: Decision Support Tools

- Evolution of questions, from:
  - What's the limit? (the original question)
- To:



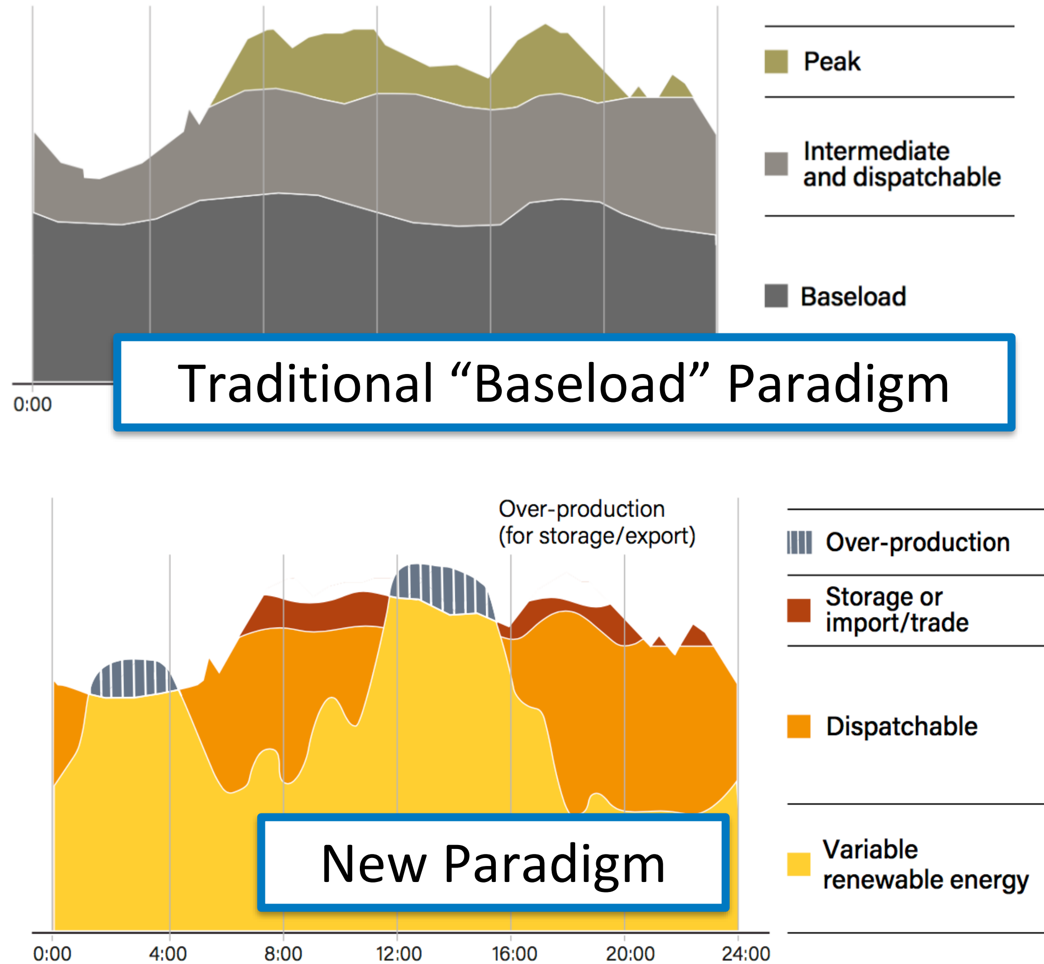


REN21 2017

Advanced modeling helps answer new sets of planning questions

Session 1: Decision Support Tools

- What types of flexibility are needed?
- How does the capacity value of RE change at higher penetrations?
- How do you allocate costs and benefits of network reinforcements?
- How do we transition RE away must-run status in terms of
  - Changes to contracts and interconnection rules
  - Changes to scheduling and dispatch decisions
  - Continued attraction of foreign investments?



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Planning for flexibility

Planning benefits from:

- Large data and better computing
- Integration of multiple models and understanding of how each focuses on different aspects of flexibility
  - Timescales of reliability
  - Types of costs
- Integration of plans with market and commercial considerations

Solutions in Session 1:
Decision support tools to enable flexibility

- Katz (Global)
- Vithayasrichareon (Thailand)
- Wijekoon & Wijekoon (Sri Lanka)

Coal flexibility: importance of addressing commercial considerations

Session 2: Generation Flexibility

- Technical approaches are straightforward
- Commercial considerations are the challenging aspect
  - Contract/market changes to better value flexibility
  - Cost allocation of retrofits, higher O&M
  - Reduced revenue from lower plant load factors, stranded assets; who holds the debt
  - Coal fuel contracts, other impacts (e.g., railways in India)

Lower technical minimums for coal plants

India 2022 RE curtailment

Technical minimum	India 2022 RE curtailment
70% Technical minimum	**3.5%**
55% Technical minimum	**1.4%**

Palchak et al. 2017. *Greening the Grid*
http://www.nrel.gov/india-grid-integration

Coal flexibility: importance of addressing commercial considerations

Session 2: Generation Flexibility

- Technical approaches are straightforward
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Solutions in Session 2: Overcoming barriers to generation flexibility

- Vithayasrichareon (Global)
- Sinha (India)
- Weise (Germany)

Examples from India:

- Regulatory requirements for minimum turndowns
- Automatic generation control
- Payments for less efficient operations

Storage is a versatile grid technology, but market dependent

Session 3: Storage

- Prices are falling and technologies are broadening and improving….
- But market considerations still dictate storage’s potential
- How can planners help improve market potential and make decisions on when and how to employ storage?

Solutions in Session 3: Utility-scale storage

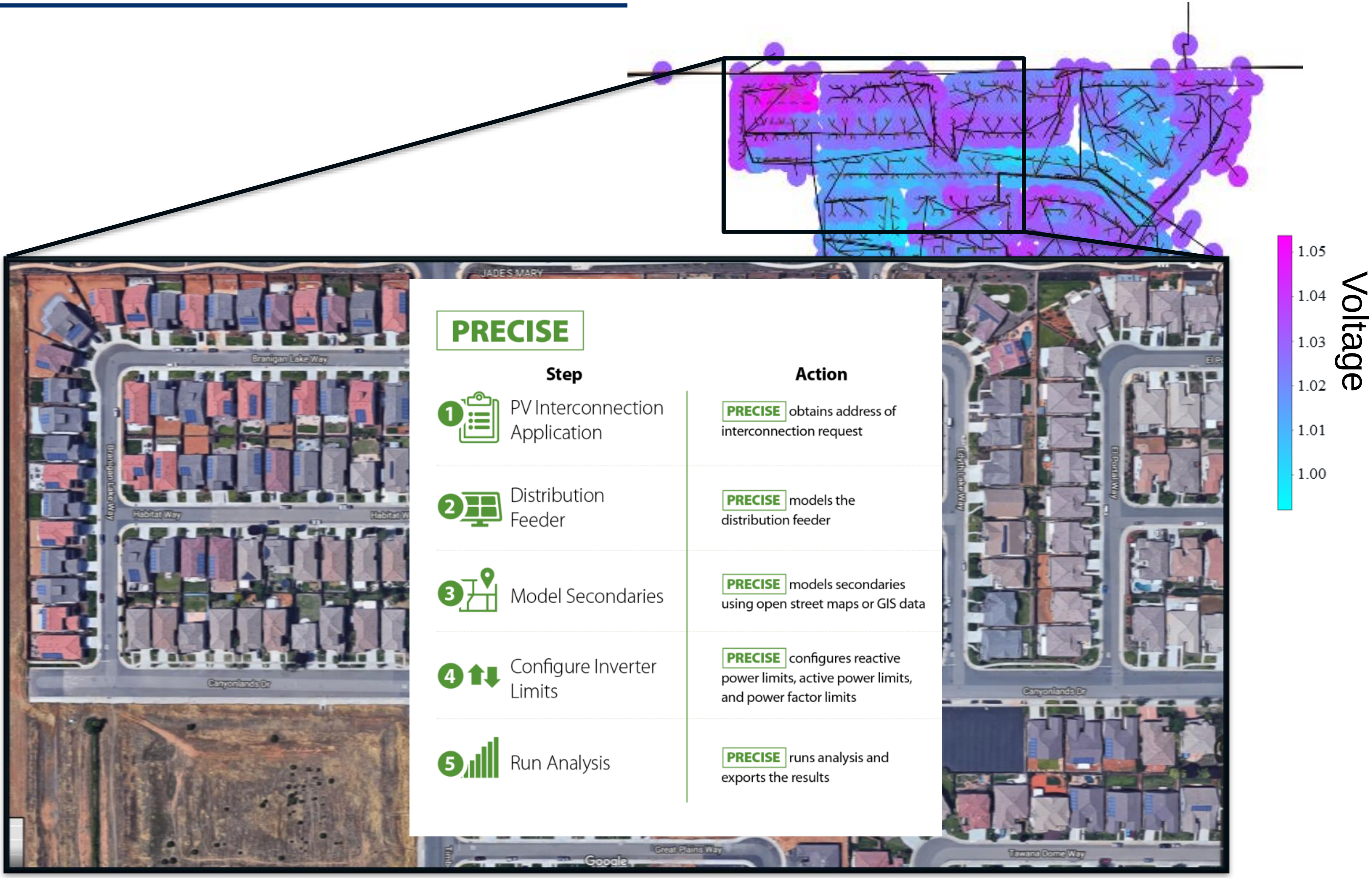
- Katz (Global)
- Roose (Hawaii)

Example:

- Market rules moving to be more technology neutral (e.g., FERC Order 841)

New tools can help optimize resources at the distribution level

Session 4: Rooftop PV



Growing experience with distributed PV has shown effective solutions to maximize value and reliability

Session 4:
Rooftop PV

Experiences in Hawaii, California, Germany, and elsewhere have demonstrated reliable grid operations with significant rooftop PV

Smart inverters, advanced planning tools, and changes to retail tariffs have contributed to planning that aligns utility and consumer interests

Solutions:

Afternoon keynote:

- Ackerman (Global)

Session 4:
Distributed energy resources

- Cochran (Global)
- Gäbler (India)
- Matsuura (Hawaii)

Examples:

- Virtual power plants
- Time-of-use rates
- Smart inverters

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Greening the Grid

greeningthegrid.org