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Integrating Renewable Energy onto the Electric Grid with Automated Demand Response Resources

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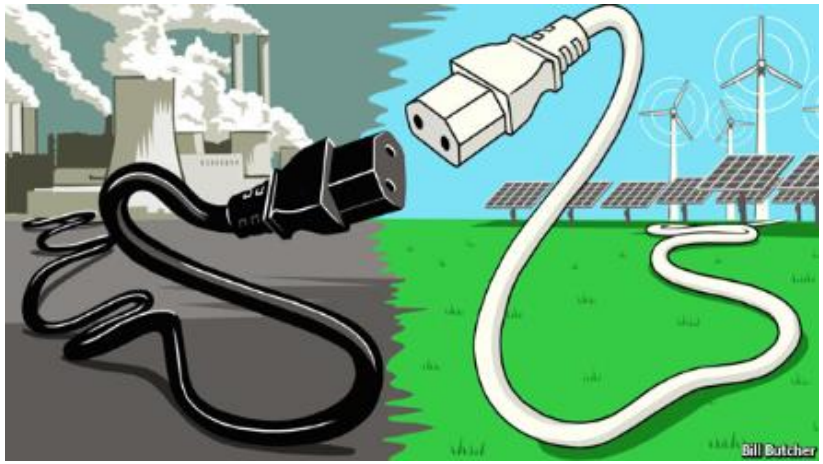
Saving Ourselves from too Much Renewable Energy

The Economist

European utilities

How to lose half a trillion euros

Europe's electricity providers face an existential threat



Source: The Economist, October 12, 2013

Germany—June 16, 2013

- Renewables generation reached 29 GW—more than half of demand
- Market prices fell to minus €100 per MWh

Europe—2008 to 2013

- Utilities' market value lost ~ €700 billion
- *Utilities "…worry that the growth of solar and wind power is destabilising the grid, and may lead to blackouts or brownouts."*

Can "Demand Response" (DR) save utilities and save the grid?

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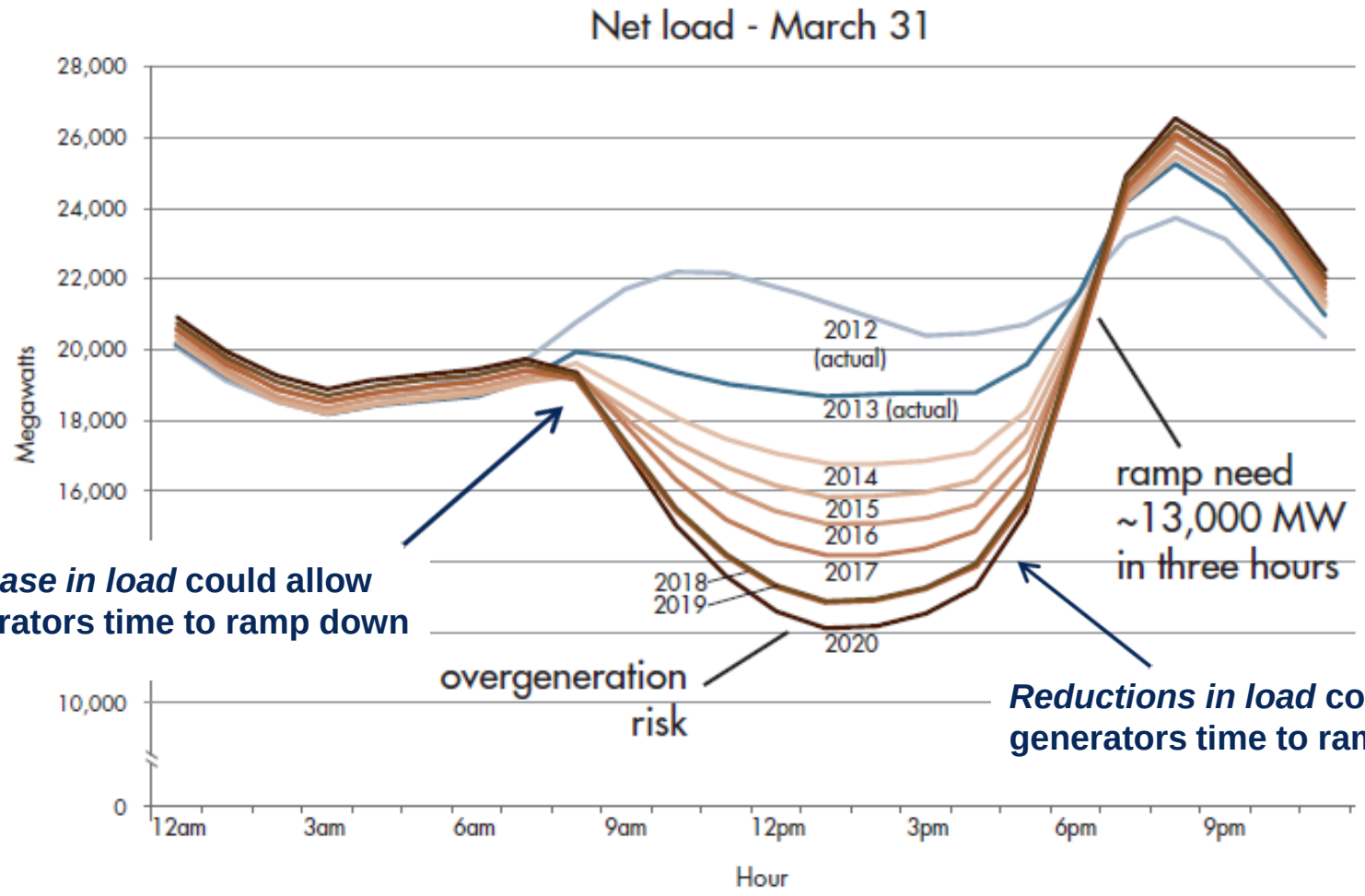
Renewables Growth Creates Challenges for Supplying the "Net Load"



Increase in load **could allow generators time to ramp down**

Reductions in load **could allow generators time to ramp up**

Source: California Independent System Operator

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Can “Fast DR” Keep the Grid Alive?

Hawaiian Electric Co. Fast DR Pilot

“Quick-start bridge resource” to manage the intermittency of renewable energy generation”

- » Pilot period: January 2012 to December 2014
- » Participant Incentive: Up to $10 per kW of reduction each month
- » Automated control linked to building energy management systems (EMS)

Fast DR Event Parameter	Characteristic
Advanced Notice	None (automated)
Speed of Response	Seconds to minutes Full commitment within 10 min.
Event Duration	Maximum one (1) hour
Event Frequency	Up to 40 or 80 times per year

Fast DR Pilot Evaluation Objectives

Market Assessment	• Barriers to participation • Load reduction potential
Technical Readiness	• Performance of communications • Consistency of load curtailment mechanisms
Operational experience	• Hawaiian Electric experience with Fast DR for grid management • Magnitude, speed, and consistency of load impacts
Cost-Effectiveness	• Relative benefits and costs of long-term, full-scale program

Grid Operations – Testing "Fast DR"

Phase I
Pre-planned schedule of events

- All hours & days
- Durations from 15 minutes to 1 hour

Phase II
Day-ahead scheduled events

- Based on forecasted weather conditions
- Transition to "real-time" dispatch

Phase III
Real-time dispatch based on system conditions

- To date used only as a "capacity" resource
- Objective to dispatch as a "bridge" resource

Evaluating Load Impacts of Fast DR

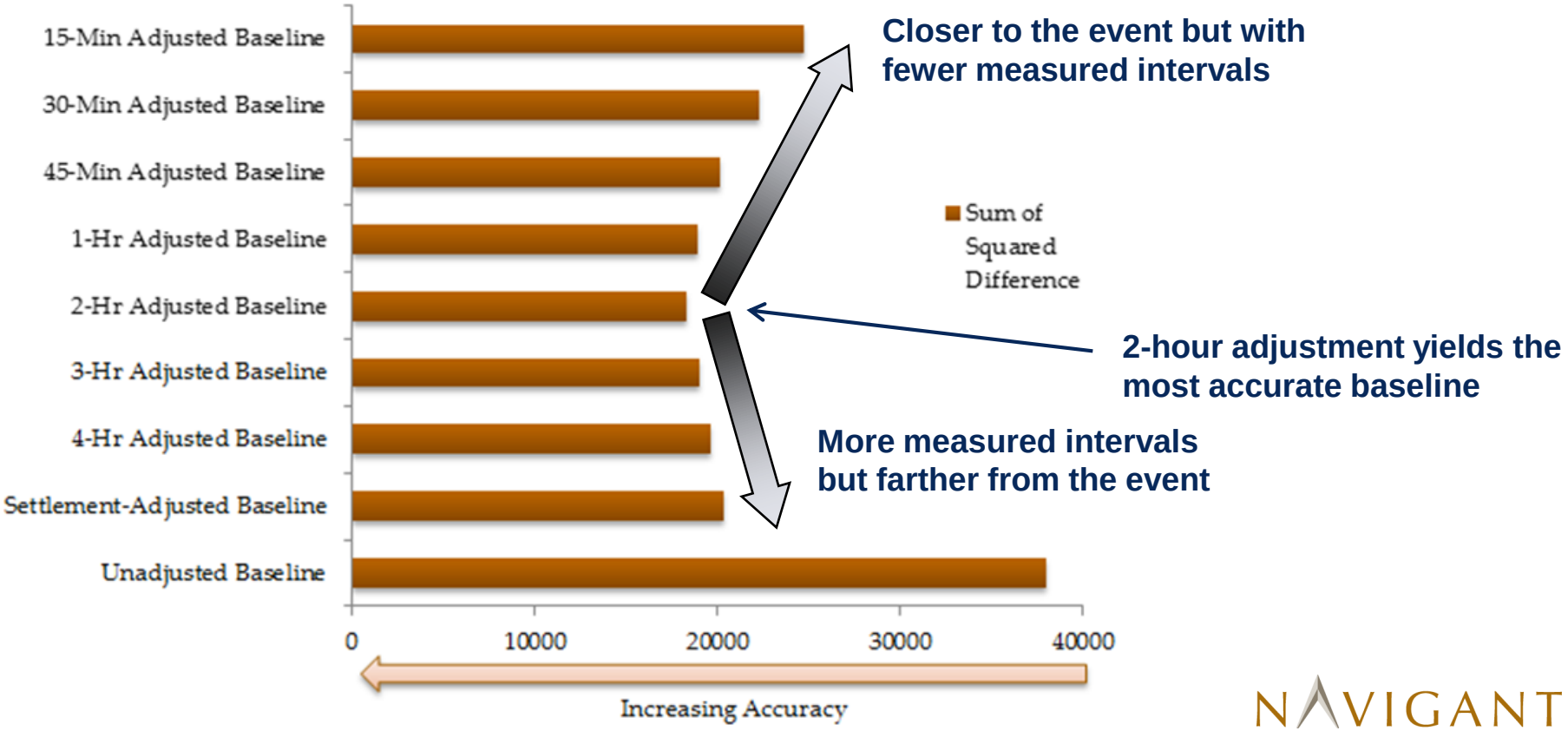
- **We can measure loads directly…but not load *reductions***
- **So we need to estimate *baseline loads* for comparison**
  - For incentive payment: compare to prior days, same hours
  - For grid management planning: use econometric modeling

Baseline Estimation Inputs

- ✓ Time of day
- ✓ Day of week
- ✓ Month
- ✓ Temperature
- ✓ Adjustment for same-day load prior to the event

Baseline Load Estimates Adjusted for Loads in the Two Hours Preceding Each Event

- Accuracy of alternative baselines determined by comparing predicted loads to measured loads during non-event days
- Adjusted baseline period is the length of time prior to an event that is used to predict usage during the event



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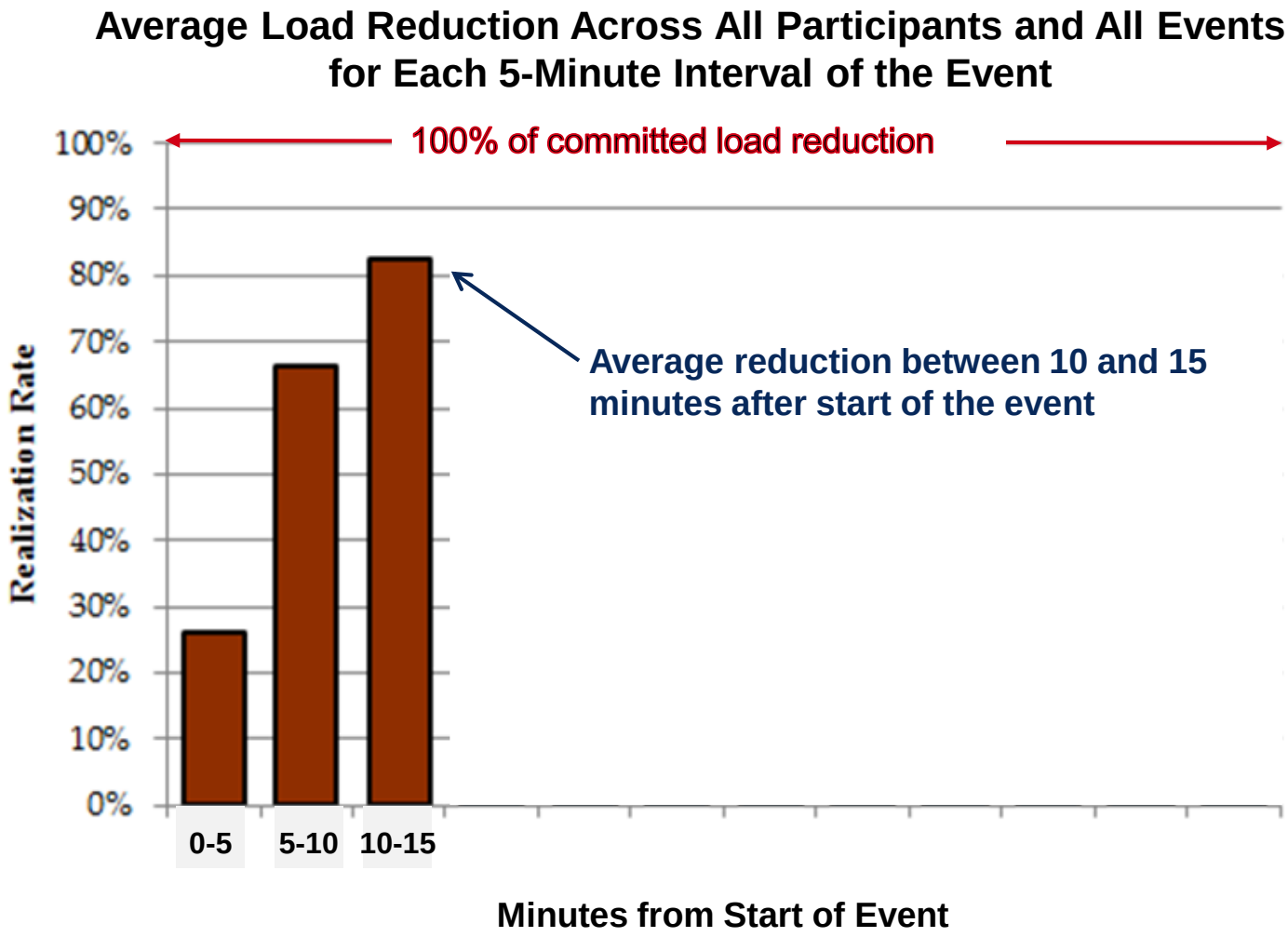
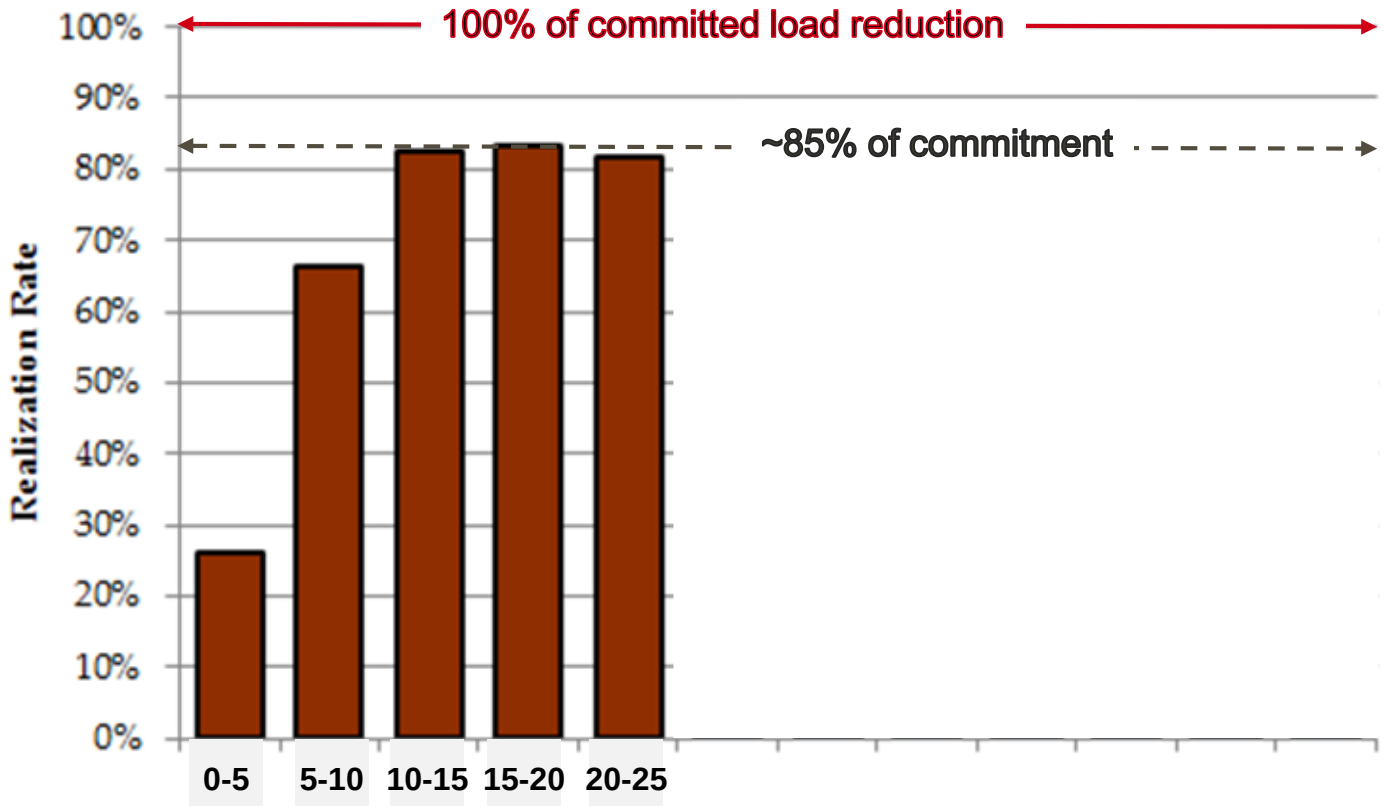
Committed Reductions Not Achieved within 10 Minutes

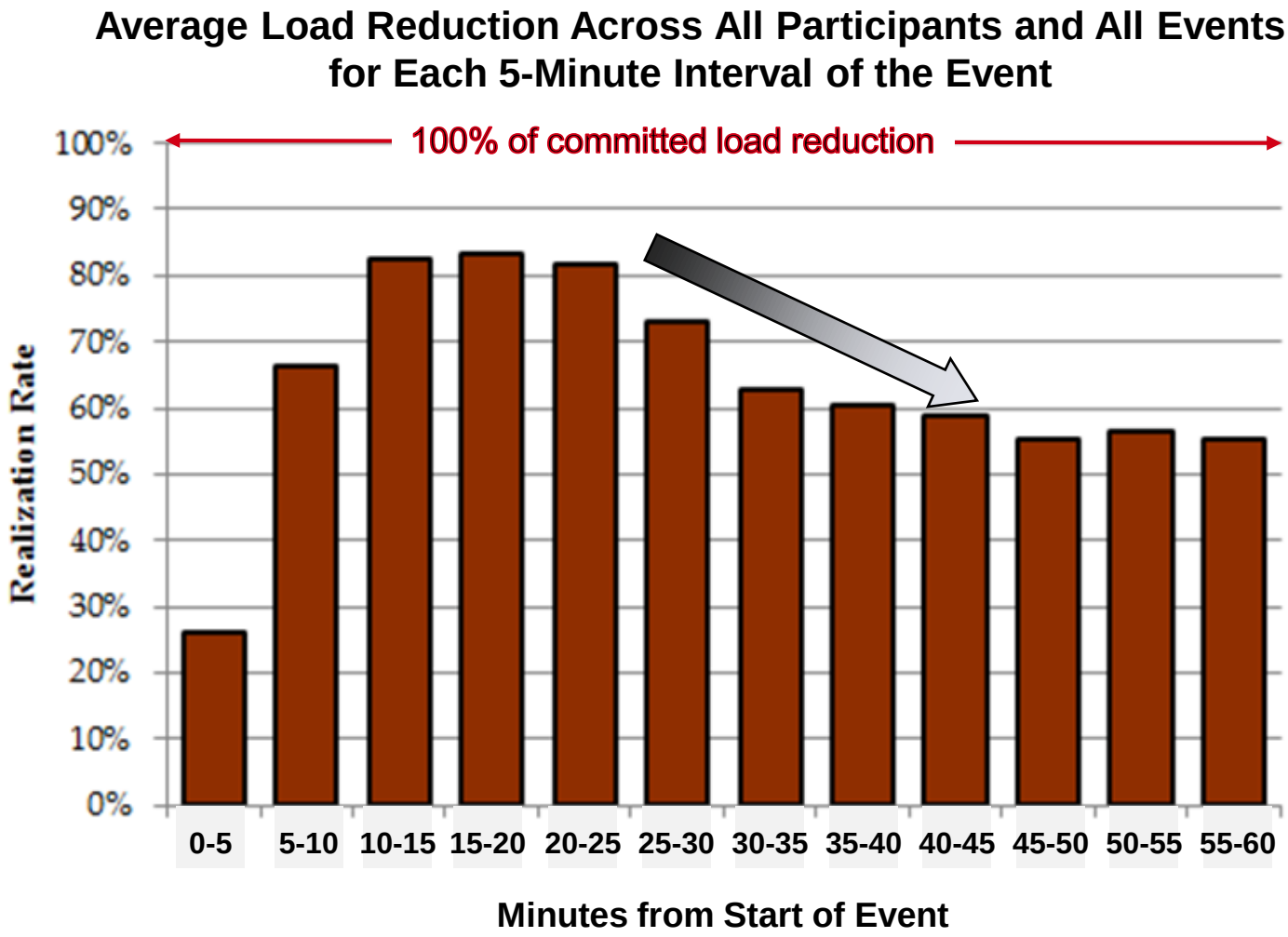


Maximum Load Reduction Achieved within 10 Minutes, But Below Target

Average Load Reduction Across All Participants and All Events for Each 5-Minute Interval of the Event

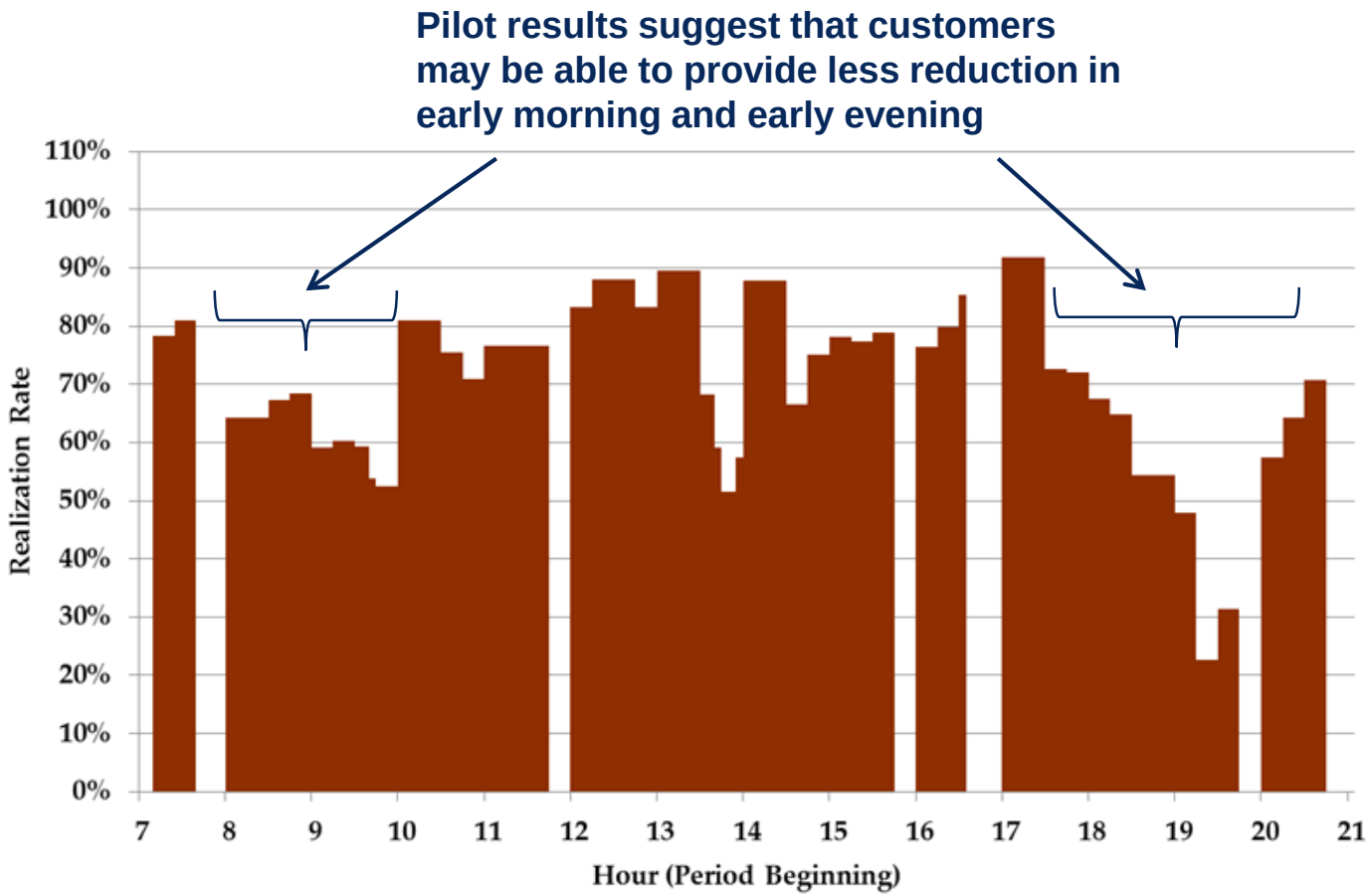


Load Reduction Drops Off After 30 Minutes



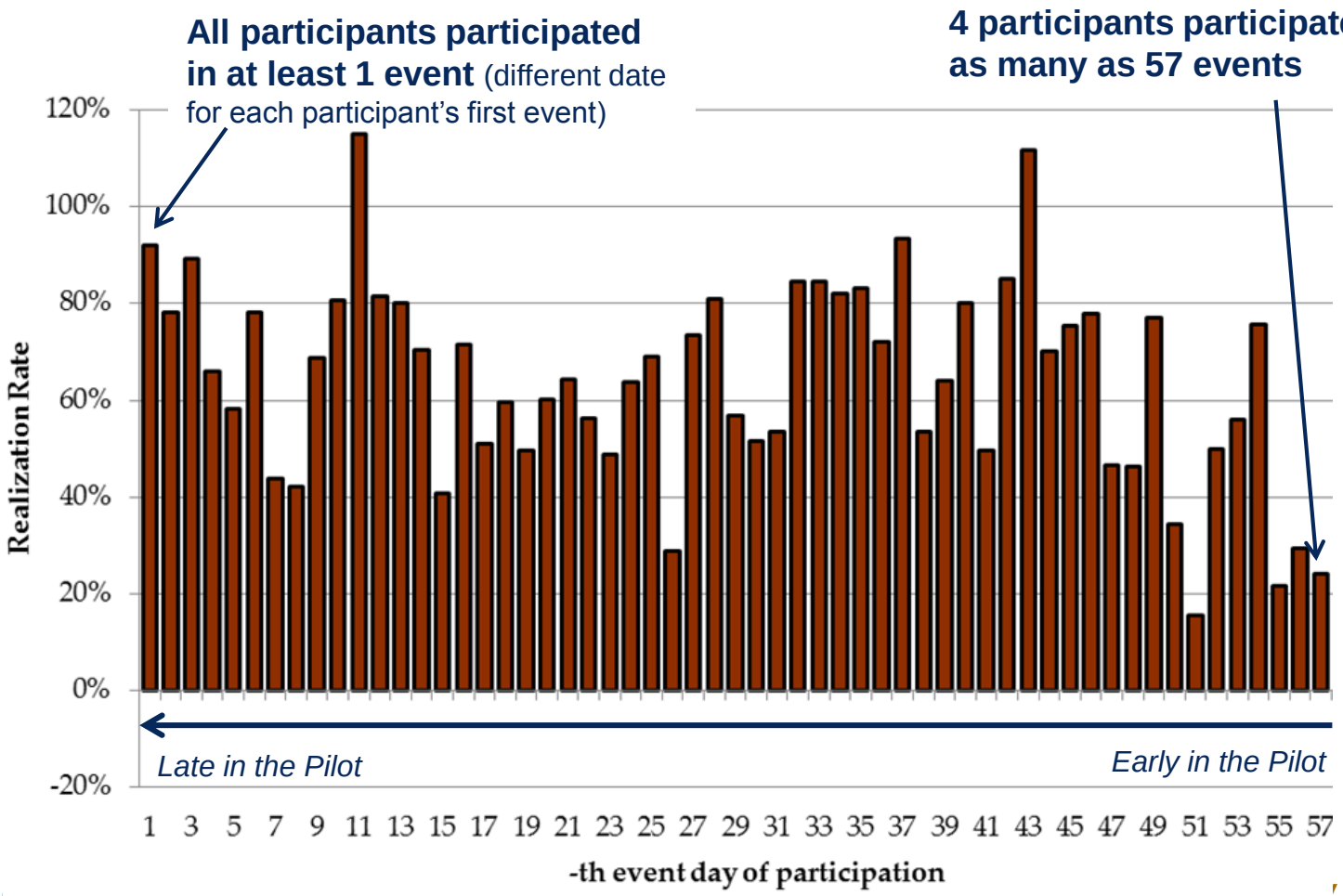
Will Maximum Load Reduction Be Available Early Morning and Evening?

Average Load Reduction Across All Participants and All Events for Each 15-Minute Interval of the Day (07:00 to 21:00)



Customers Sustained Reductions Over Many Events, but with Inconsistent Impacts

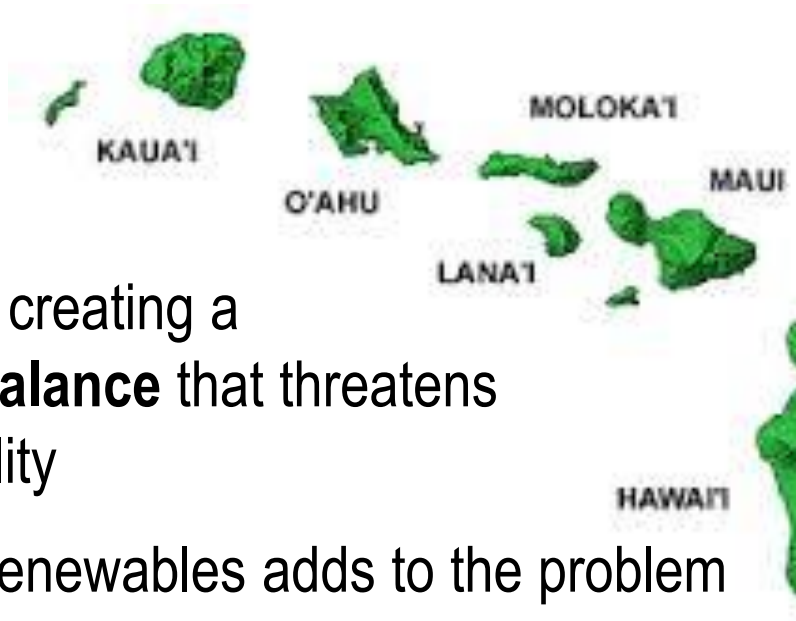
Average Load Reduction Across All Participants and All Events for Participant's 1st Event through 59th Event



Future Fast DR Evaluation Needs

- Success of *real-time dispatch* in response to changing grid conditions
- Load impacts
  - Achievement of more realistic load reduction targets
  - Maintenance of load reductions for 60 minutes
  - Consistency of reductions from one event to another
- Customer acceptance/attrition over as many as 80 events
- Value of grid benefits relative to cost of Fast DR program

“Demanding” an End to Too Much Renewables



- Renewable energy is creating a **supply-demand imbalance** that threatens utilities and grid stability
- The intermittency of renewables adds to the problem by **increasing the need for balancing services** usually provided by generators
- Fast DR holds promise to help address the imbalance, and could **save renewables from outgrowing the ability of the grid to integrate them**

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