# AN INTEGRATED FRAMEWORK FOR EFFECTIVE MANAGEMENT OF DELIVERY RISK IN ELECTRICITY MARKETS: FROM BATTERIES TO INSURANCE AND BEYOND

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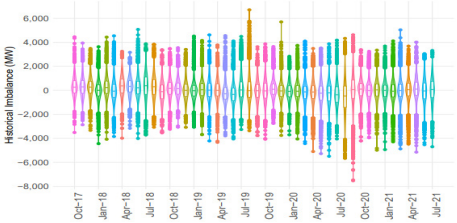
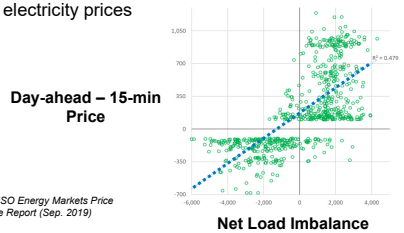
## Motivation

- Imperfect day-ahead forecasts for demand and variable renewable energy sources create net load imbalances (imbalance = forecasted – actual net load)



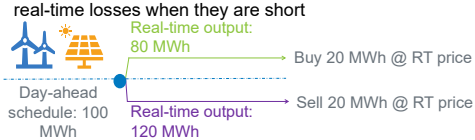

*Source: G. Bautista Alderete and K. Zhao, 'Day-Ahead Market Enhancements Analysis', CAISO report published on 24 Jan 2022.*

- Net load imbalance can cause more variability in real-time electricity prices

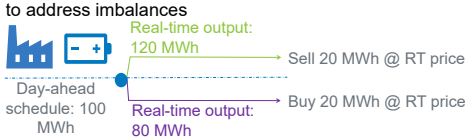



*Source: CAISO Energy Markets Price Performance Report (Sep. 2019)*

- Participants with uncertain real-time output could face real-time losses when they are short

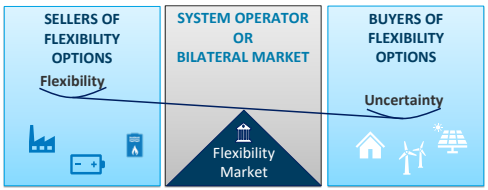



- Participants with flexible output rely on volatile payments to address imbalances




## Flexibility Options

- Flexible resources can help manage net load imbalances
- **Flexibility options** are a new day-ahead market product
  - Allow participants with **forecast uncertainty** to hedge imbalance risk by buying flexibility
  - Allow participants with **flexibility** to receive a stable revenue source

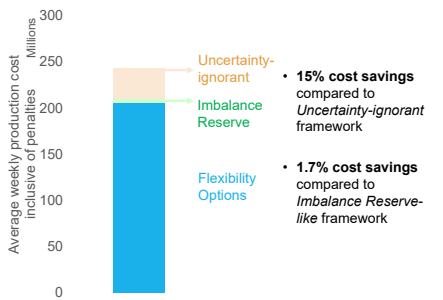



- Flexibility options are co-optimized with day-ahead market
- Sellers specify strike prices for activating flexibility
- Buyers specify their need and willingness to pay for flexibility

## Flexibility Options – Market Simulations

Simulations of an ERCOT-like system show that flexibility options can:

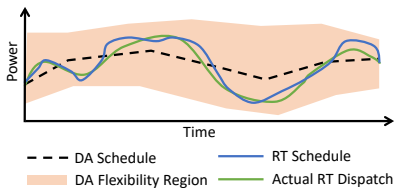
- Reduce total system operations costs
- Reduce variability in revenue for both buyers and sellers of flexibility options




- **15% cost savings** compared to *Uncertainty-ignorant* framework
- **1.7% cost savings** compared to *Imbalance Reserve-like* framework

## DER Flexibility Score

- DER aggregators must balance the benefits of **flexibility** and the penalty of **delivery risk**
- Delivery risk due to uncertainty in occupant behavior and weather




***Flexibility***: the difference between the DA schedule and the RT schedule
***Delivery Risk***: the difference between the RT schedule and the actual RT dispatch

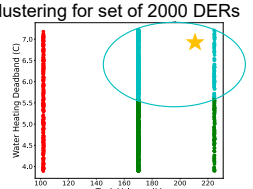
- DER scores quantify flexibility and risk using easy-to-access data to estimate value of individual DERs

## DER Score – Preliminary Results

DER score metrics for water heaters:

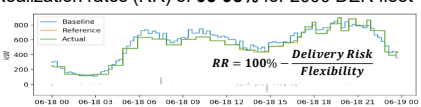
- Flexibility: tank size and deadband temperature range
- Uncertainty: DA scheduling forecast error

- K-means clustering for set of 2000 DERs




Ideal set of water heaters with large tank size and wide deadband

- Realization rates (RR) of **95-98%** for 2000 DER fleet




## PATH TO MARKET

Completed work to date:

- Quantified value of FO using simulated ERCOT-like system
- Developed methodology for DER scores
- 20+ interviews with stakeholders including ISOs, utilities, and DER aggregators

**IMPACT ANALYSIS (2020–24)** → **PILOT (2024–25)** → **WIDE-SCALE USE (2026–…)**

### *PILOT PARTNERS NEEDED*

We plan to pilot the delivery risk framework with:

- Power system operators that will integrate flexibility options in their test systems
- Aggregators and utilities that will use DER scores to manage their DER portfolio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