UIUC Capstone

Fundamentals of Energy Markets

The energy markets characteristics

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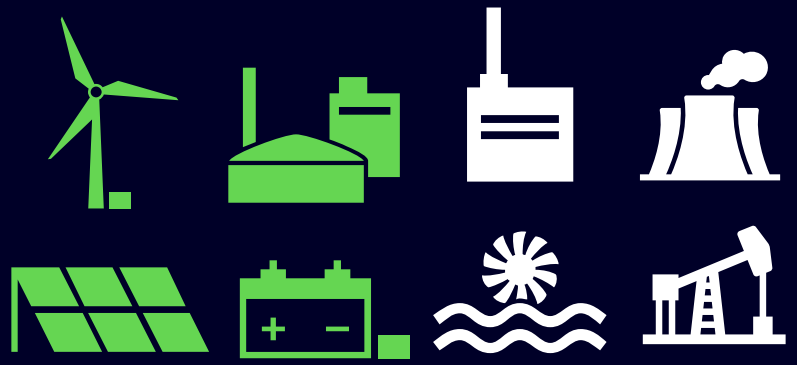
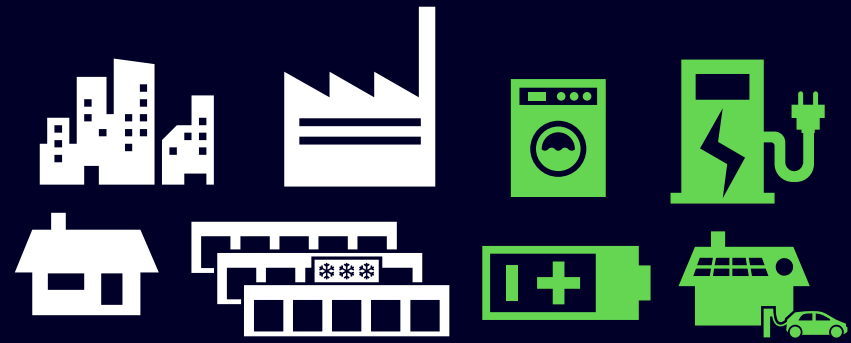
How to ensure **efficiency** and **reliability** in such a diverse environment with conflicting interests and diverse characteristics of the different participants?

Basic Concepts from Energy Markets
Market Participants



(1) Power Producers

(4) System Operator



(2) Power Demands

(3) Market Operator

(5) Market Regulator

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Market Design Principles
Different Types of Markets

Capacity Markets

1. Designed to ensure that **sufficient generation capacity** (in MW) is available in the market for supply security and reliable system operation
2. Provide an incentive for power producers to invest in new generation assets in **long term** (months to several years).
3. Mostly in the form of **auctions** and **bilateral contracts** (Future Markets, Seasonal Markets, Transmission Rights)

Energy Markets

1. **Central marketplace for exchanging energy** (in MWh), i.e., matching of electricity supply and demand:
2. Various energy markets to be cleared in **different points of time**:
   - Week-Ahead (1 week)
   - Day-Ahead Markets (24 hours)
   - Intraday Markets (~3 hours)
   - Real-Time Markets (15 or 5 minutes)

Ancillary Services Markets

1. These markets allow the system operator to procure services required for secure and **reliable operation** of the system, alongside the Energy Markets:
   - Primary reserves
   - Secondary reserves
   - Tertiary reserves
   - Black-start capability
   - Reactive and voltage-control reserves
   - Ramping Flexibility

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Market Design Principles
Typical Design Criteria

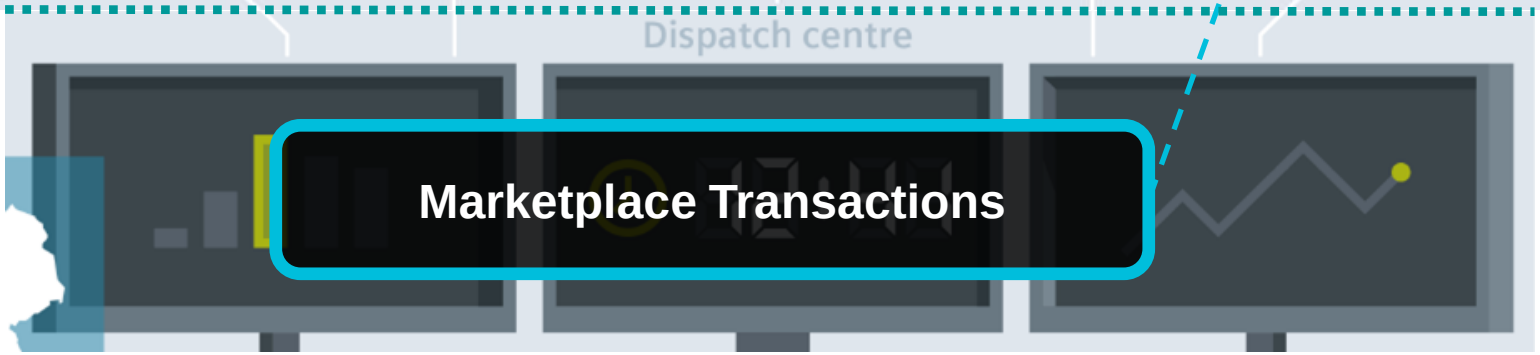
There are six basic criteria for a good electricity market design:

(1) Economic efficiency:	Motivate customers to **adjust** their own electric **energy usage** patterns to match utility marginal costs
(2) Equity:	**Reduce customer cross-subsidies** (i.e. a customer's charges are based on the utility's costs to serve that customer)
(3) Freedom of choice:	Provide customers with **options on the cost and reliability** of supply and how they choose to use electric energy
(4) Customer Acceptance & Understanding:	Customers should be able to **understand the nature of the transactions** and be convinced that they are fair
(5) Utility Control, Operation & Planning :	Consider the **engineering requirements** for controlling, operating and planning an electric power system
(6) Customer Control, Operation & Planning:	The **customers' reaction to transactions** should not have to be unwieldy or unnecessarily complex

Market Design Principles
Diversity of a Resources Fleet and Marketplace Transactions

The five essential ingredients for a successful marketplace are:

1. A **supply side** with varying supply costs that increase with demand
2. A **demand side** with varying demand levels which can adapt to price changes
3. A **market mechanism** for buying and selling
4. **No monopsonistic** behavior on the demand side (monopsony is difficult on the demand side because the number of customers ranges from thousands to millions)
5. **No monopolistic** behavior on the supply side



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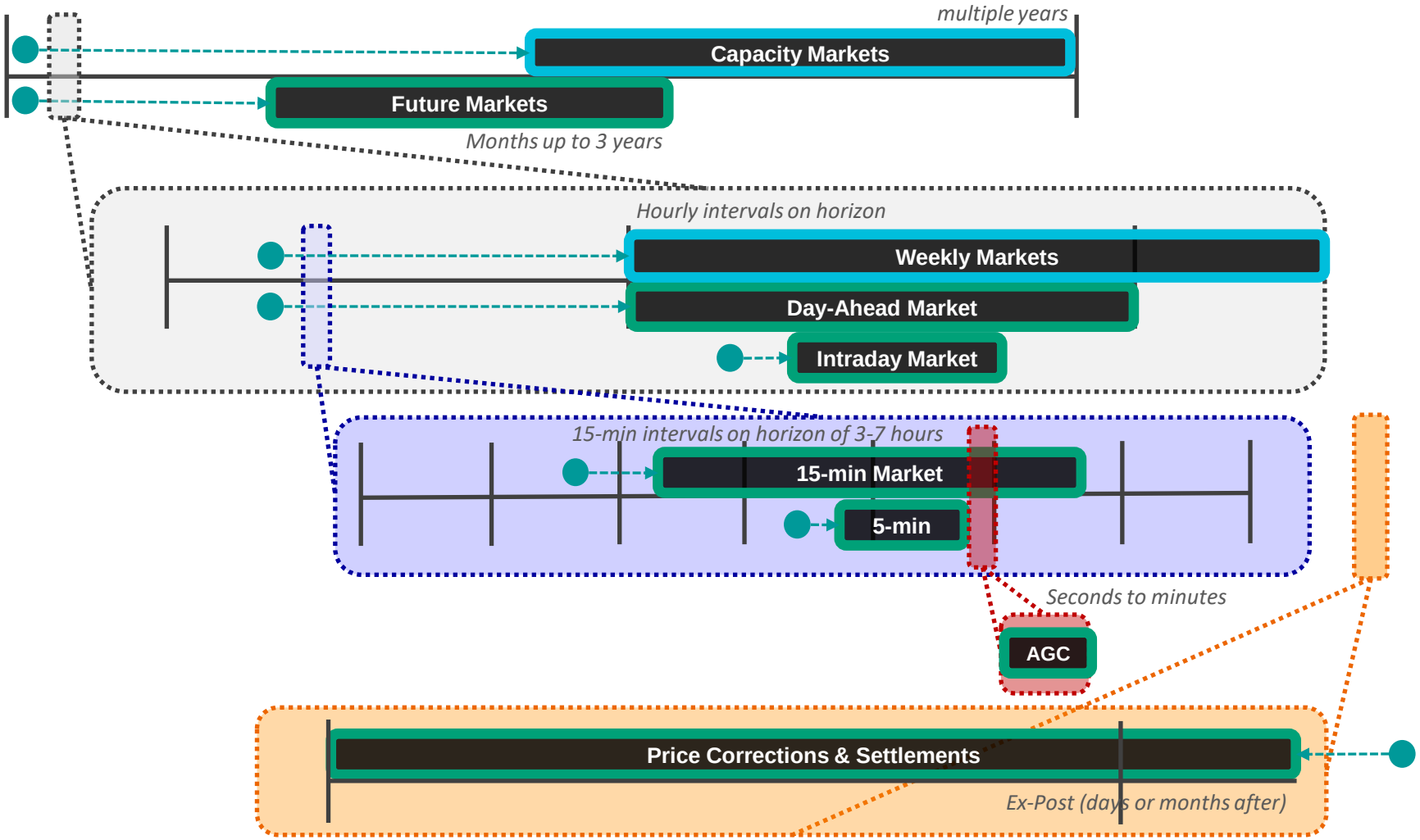
The role of Resources Optimization on Energy Markets
Temporal Dependencies and Adaptability

Forward Markets Timeline:



- *Long term capacity*
- *Resource adequacy*

- *Outage Analysis & Reliability*
- *Energy & Reserve Scheduling*
- *Unit Commitment*
- *Reliability Analysis*

- *Near-term Reliability*
- *Synchronized Reserve*
- *Imbalance Energy*
- *Regulation & Flexibility*

- *Control Actions for Stability*
- *Reserve Activation*

- *Bilateral transactions*
- *Price Corrections*

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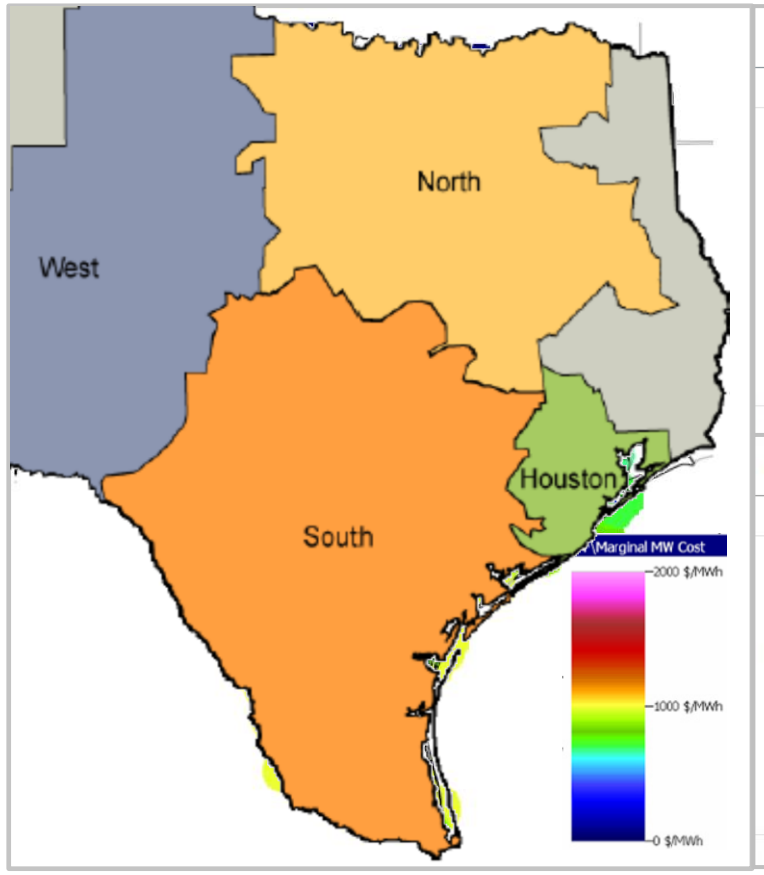
Overview of Energy Markets – Spot Market and Nodal Price Model
From MW to M$

ERCOT (Texas) LMP energy market



Source: IEA – RETD Report 2015

Hourly Day-Ahead and 5-min Real-Time

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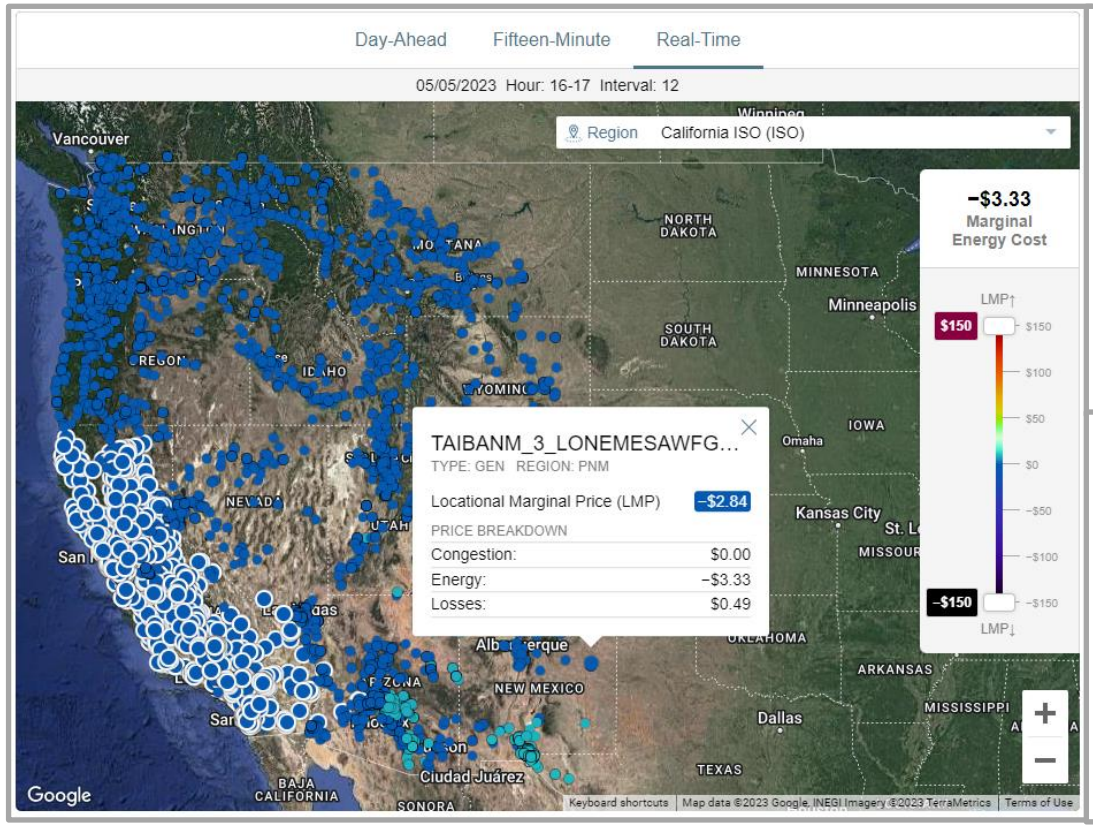
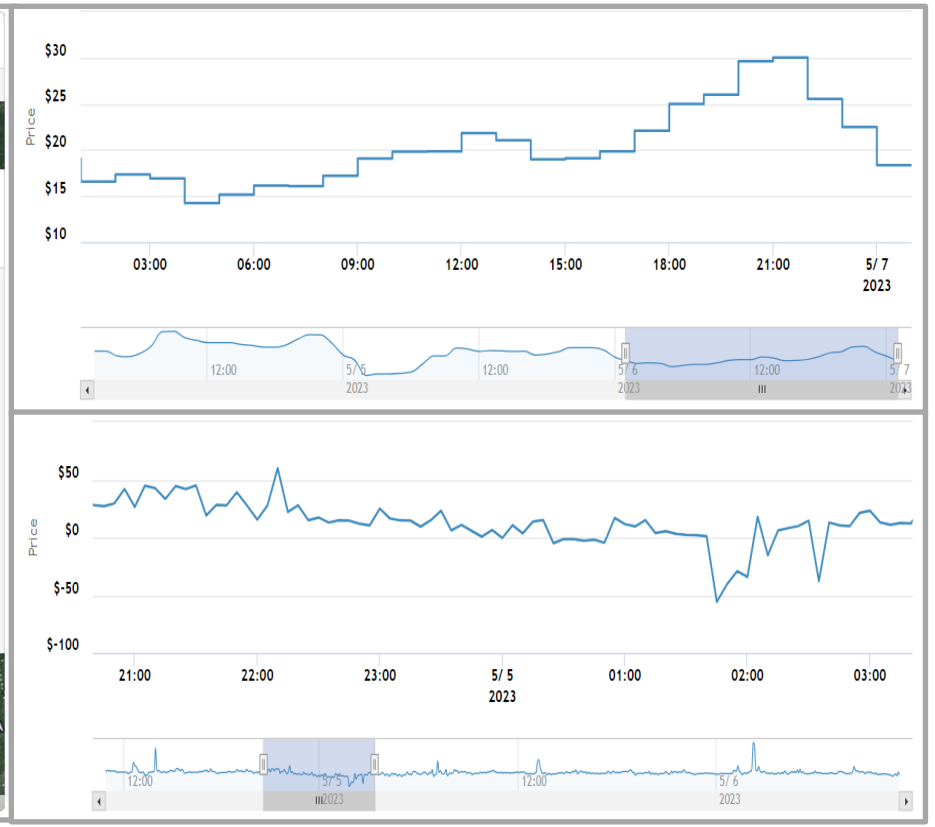
Overview of Energy Markets – Spot Market and Nodal Price Model
From MW to M$

CAISO Nodal LMP Poll energy market



Hourly Day-Ahead and 15-min/ 5-min Real-Time



Source: CAISO 2023

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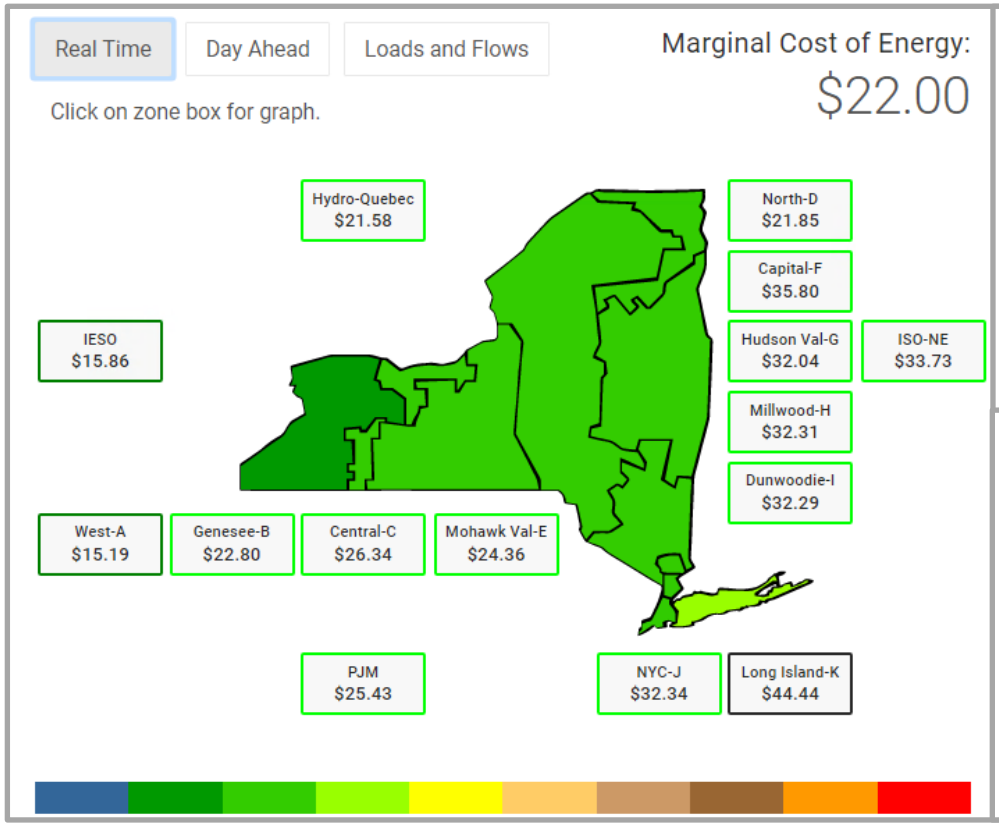
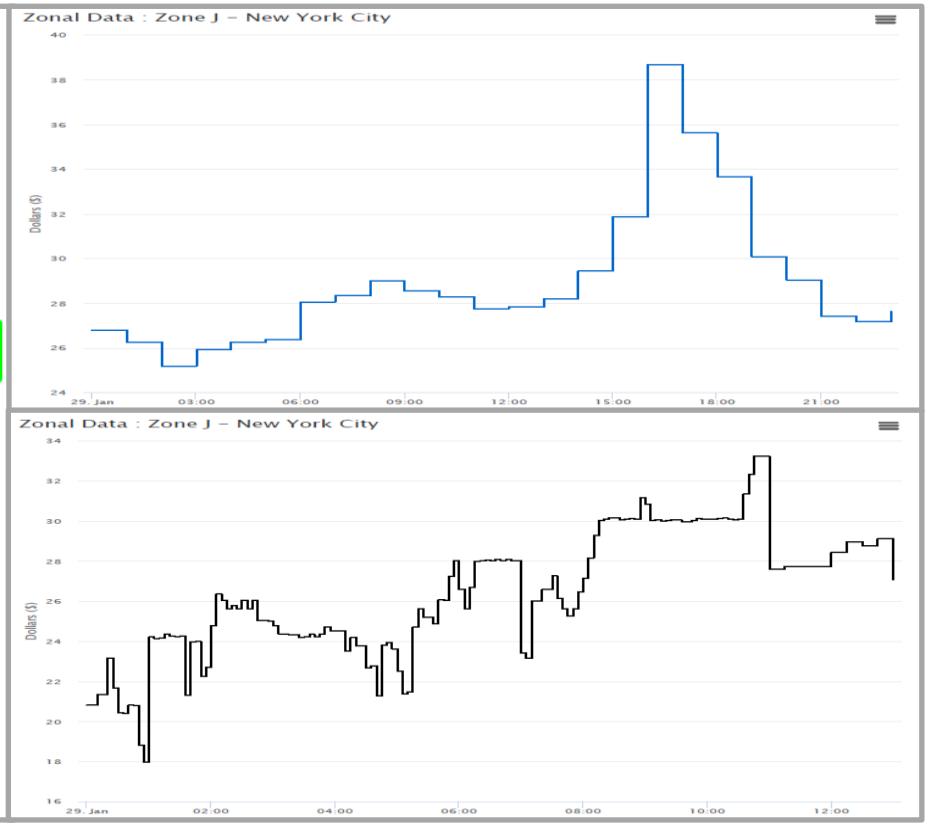
Overview of Energy Markets – Spot Market and Zonal Price Model
From MW to M$

NYISO LBMP energy market



Hourly Day-Ahead and 5-min Real-Time



Source: NYISO 2023

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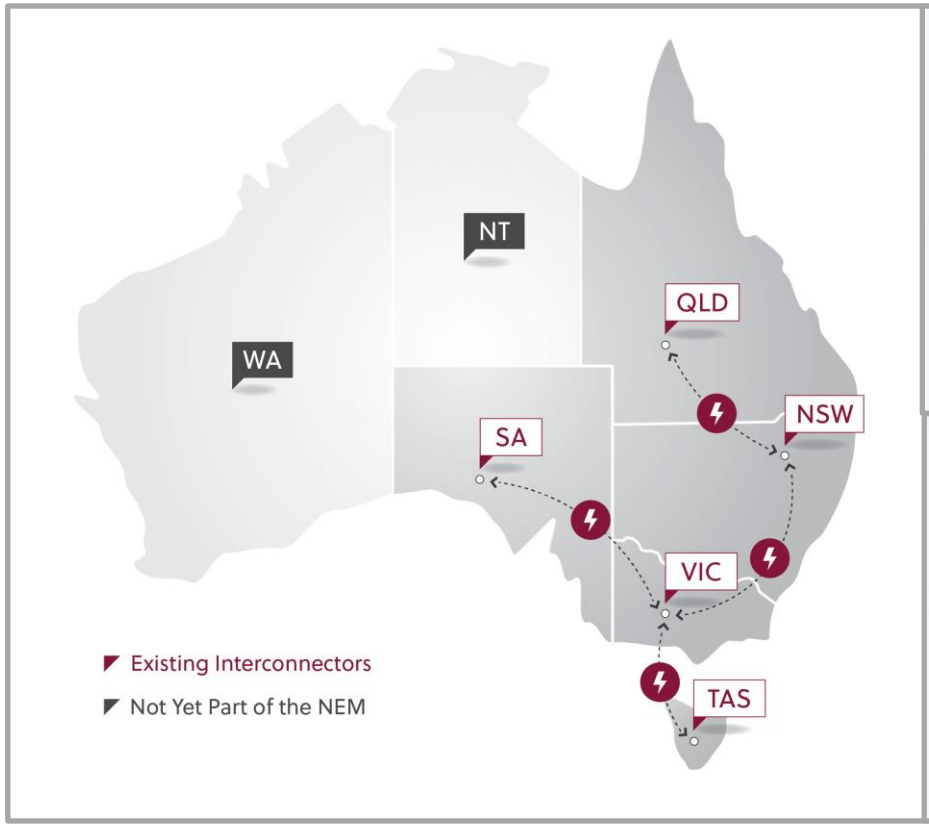
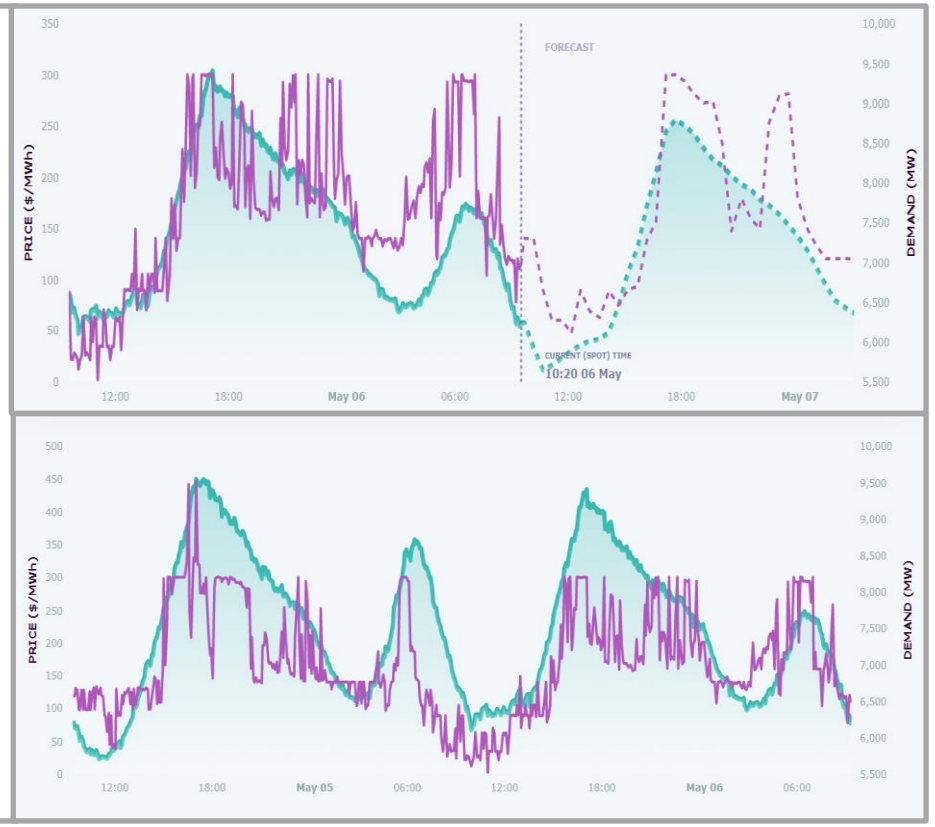
Overview of Energy Markets – Spot Market and Zonal Price Model
From MW to M$

AEMO Zonal Price Pool energy market



30-min Pre-Dispatch and 5-min Dispatch



Source: AEMO 2023

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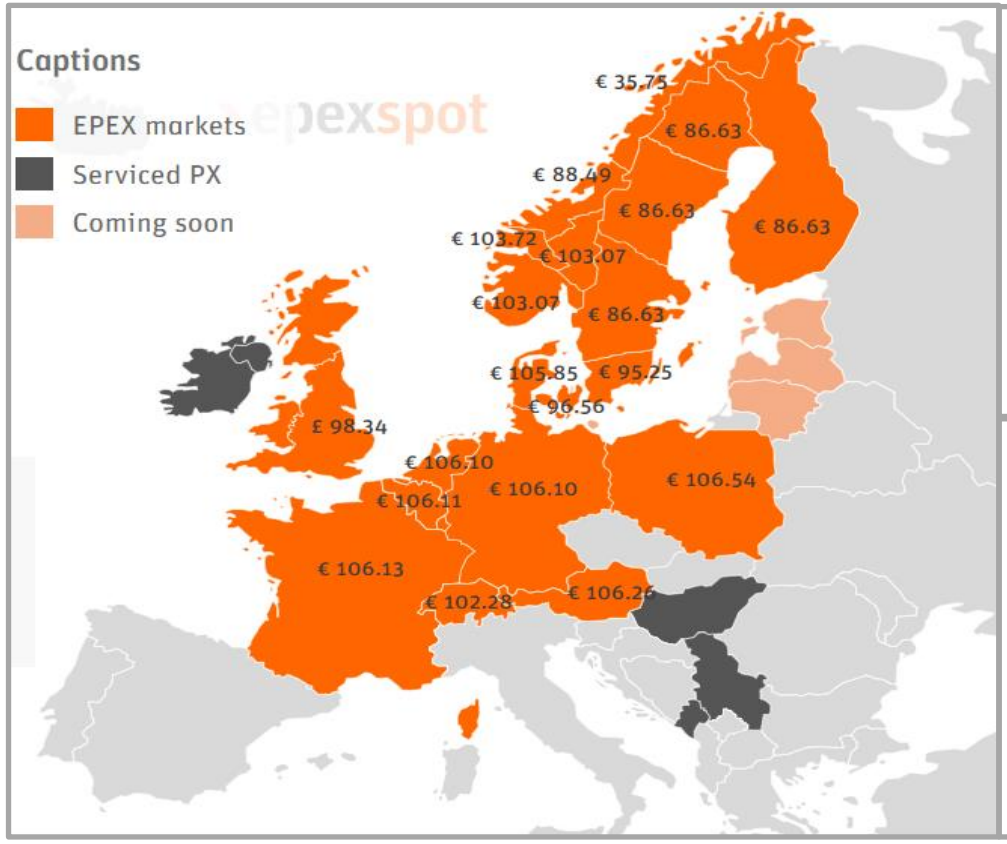
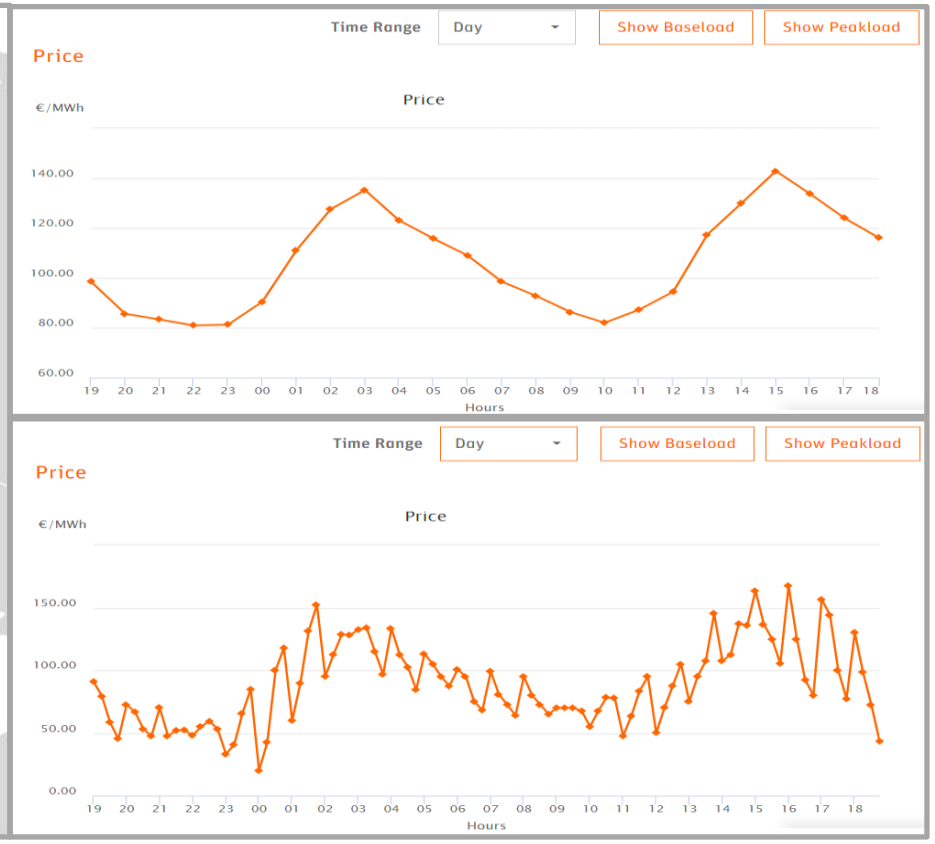
Overview of Energy Markets – Spot Market and Zonal Price Model
From MW to M$

EPEX Spot Zonal Price



Hourly Day-Ahead and Intra-Day 15 min



Source: EPEX 2023

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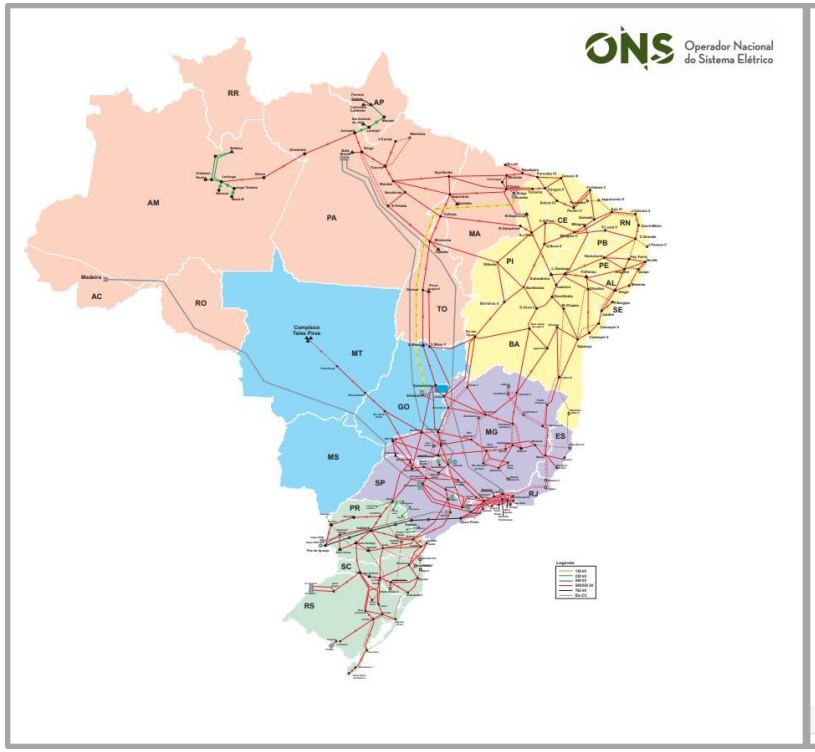
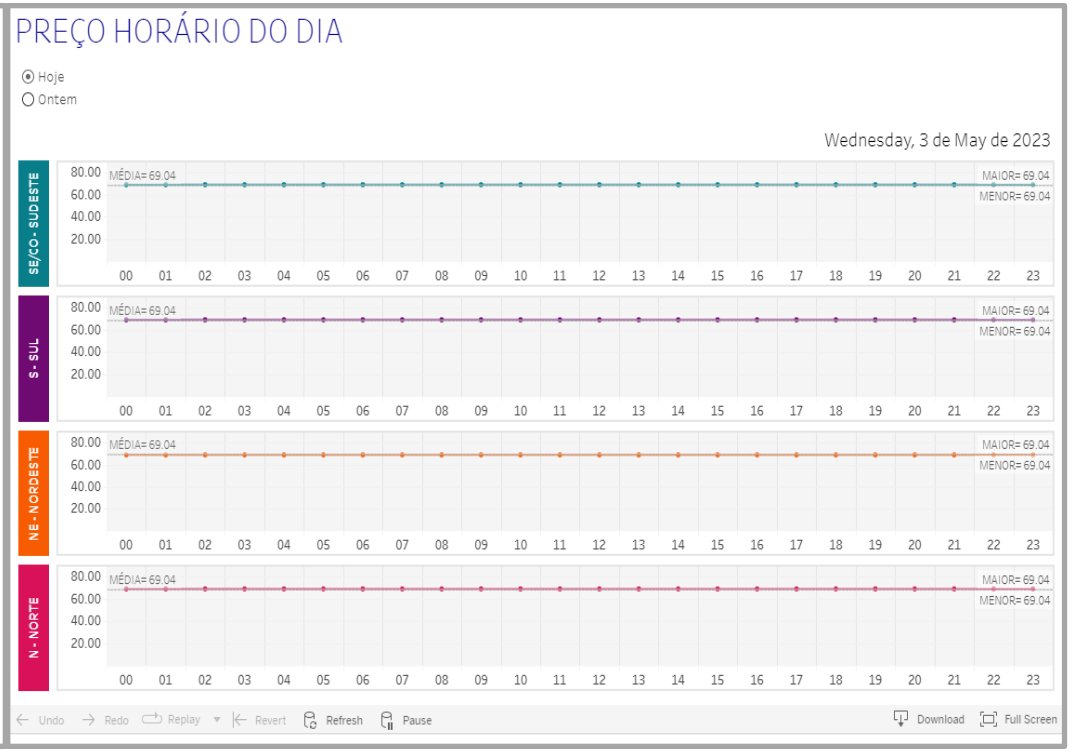
Overview of Energy Markets – Model Based and Zonal Price Model
From MW to M$

Brazilian Spot Market



Hourly Ex-Post Market



Source: ONS/CCEE 2023

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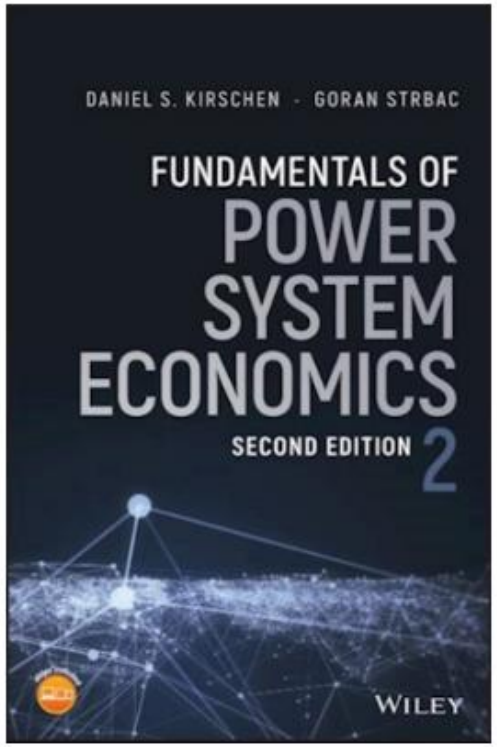
Cool Places to Look:



The discussion of several counterintuitive phenomena related to nodal pricing is refreshing.

Chapter 3 discusses markets for electrical energy. This chapter first introduces the important differences between electrical energy and other commodities, which, as the authors argue, have a profound effect on the origination and the rules of electricity markets. These differences stem from the unique characteristics of electricity, including second-by-second balance, a pool that connects producers and consumers, and predictable cyclical variation. Two forms of open elec-

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Thank You

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