Stochastic (Proactive) Electricity Markets

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Stochastic (Proactive) Electricity Markets

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INTRODUCTION

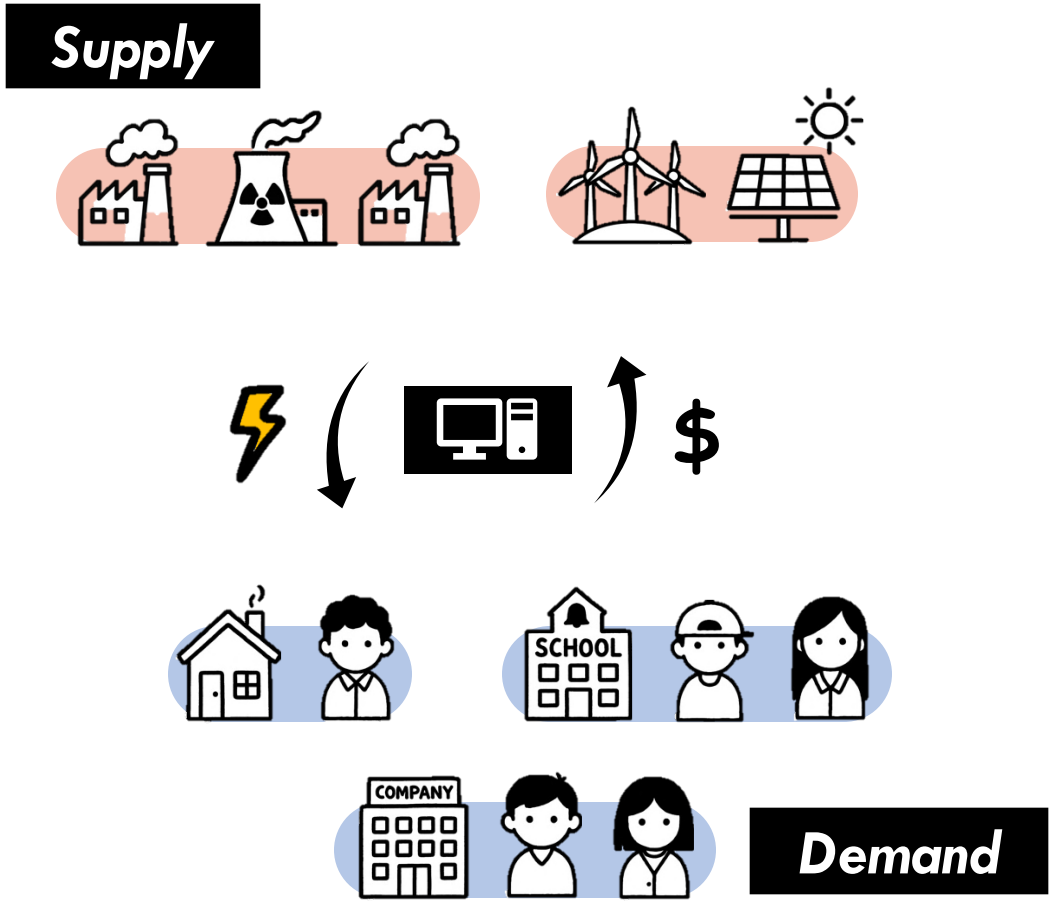
Unconventional

Electricity is a Commodity

- Highly Inelastic (price ↑↓ , demand ---)
- Safety: Supply $\overset{!}{=}$ Demand

Electricity Markets

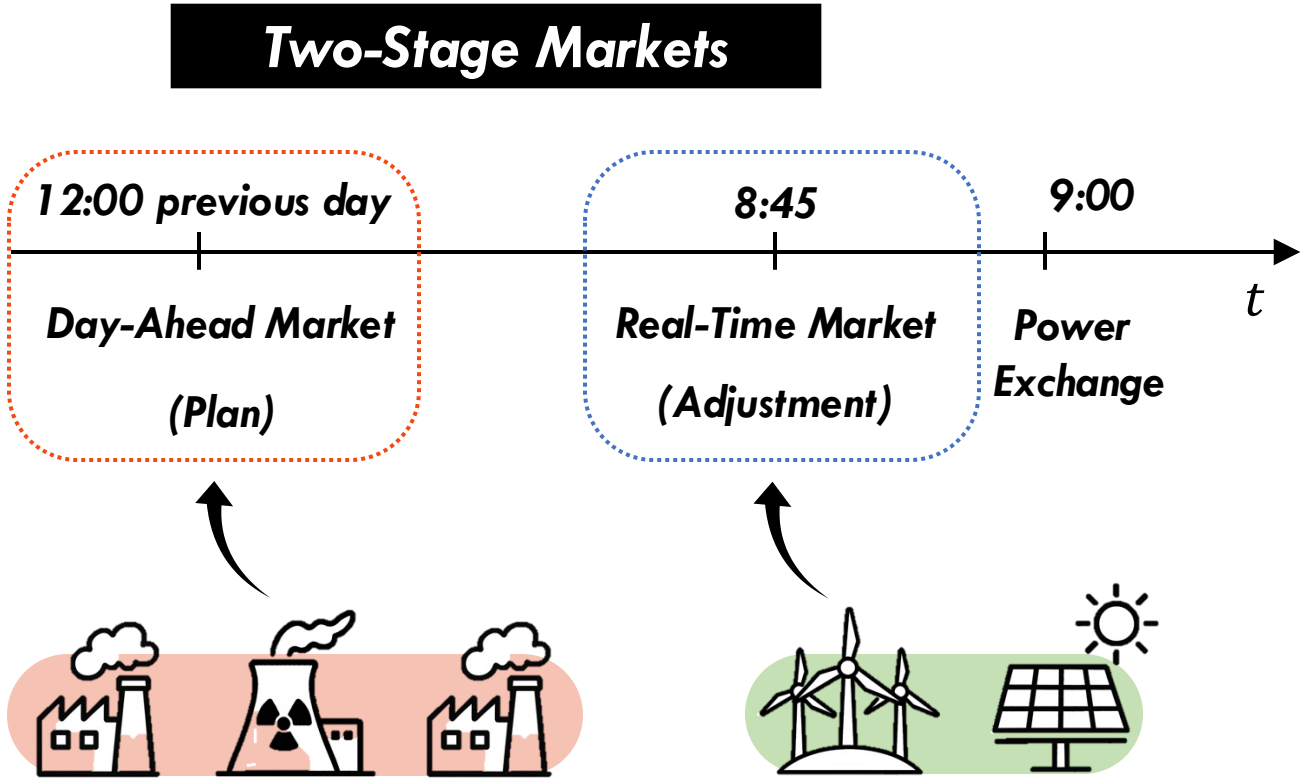
- **How much** to schedule each power plant
- What is the electricity **price**
- **Two-Stage**: Day-Ahead + Real-Time



INTRODUCTION

Different Resources

- Some ***need scheduling*** one day in advance
- Some have ***no exact information*** one day in advance



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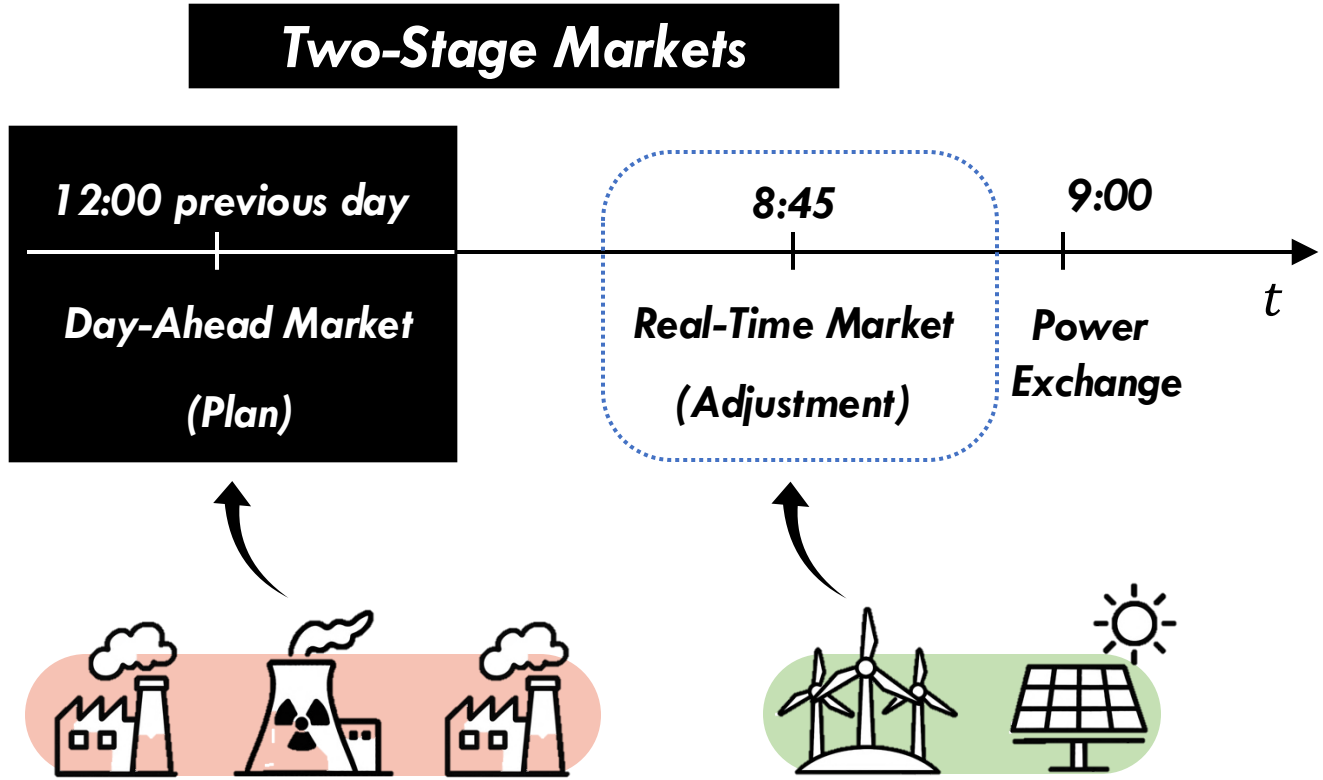
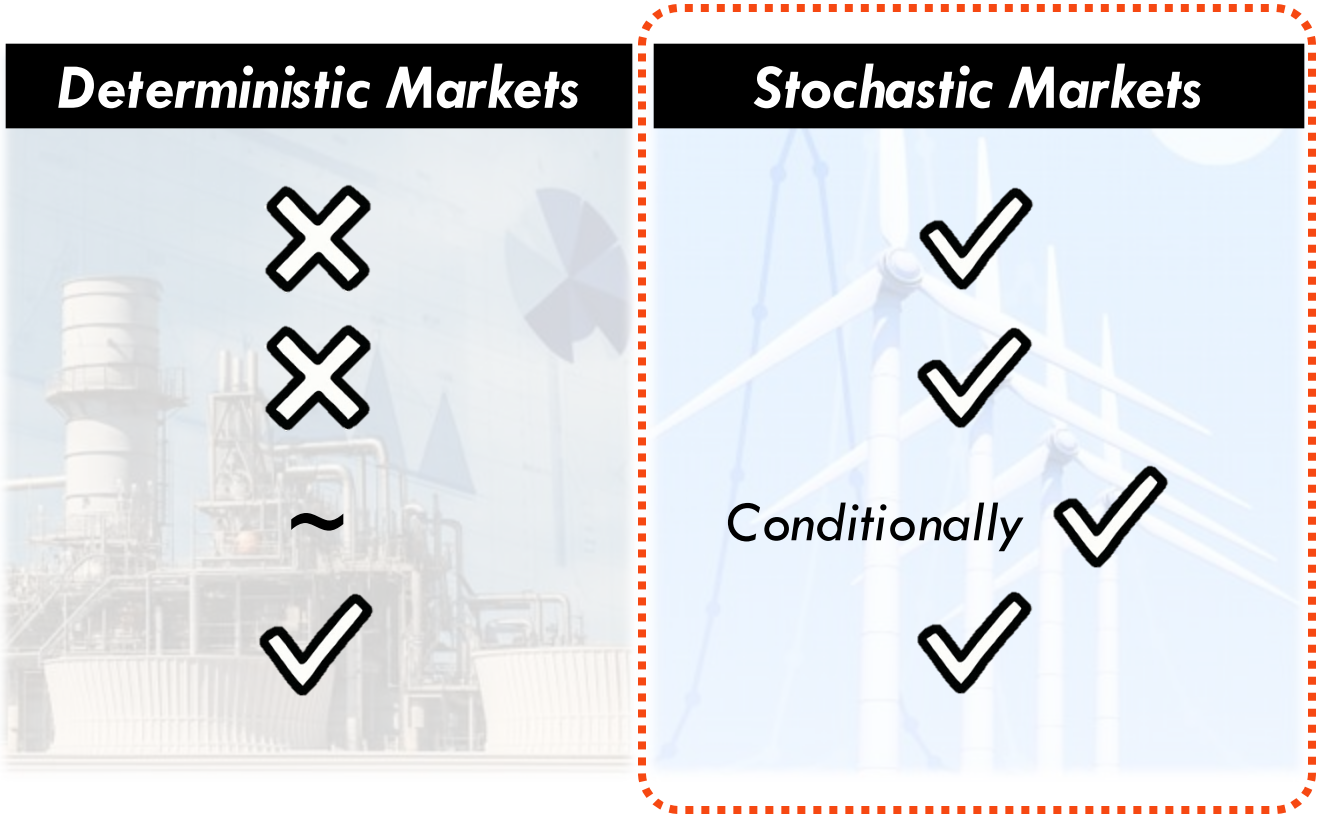


CONTRIBUTIONS

Stochastic DA Markets with Distribution Bidders

Desired Properties

- *Economic Efficiency*
- *Cost Recovery (Individual Rationality)*
- *Incentive Compatibility*
- *Revenue Adequacy (Balanced Budget)*



ELECTRICITY MARKETS STRUCTURE

Consumers

Producers

10 MW
4 $/ MWh

Inelastic Demand

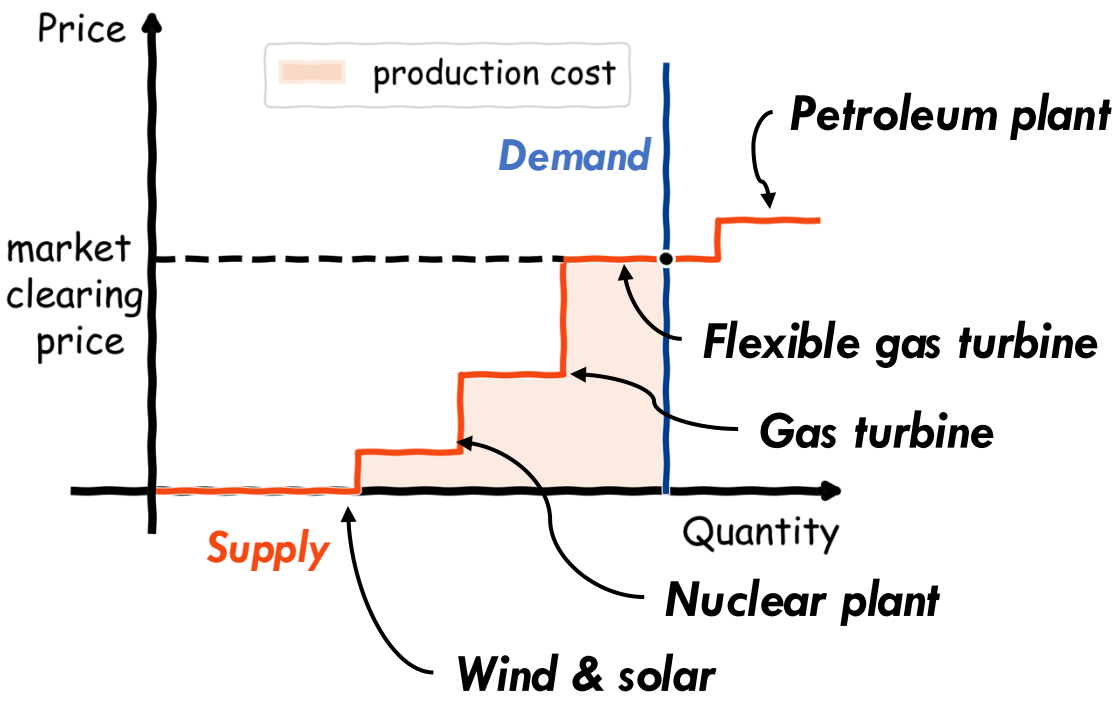
Buying

Selling

Market Operator (MO)

- *Scheduling / Market Price*
- *Minimizing Production Cost*

Minimizing Production Cost



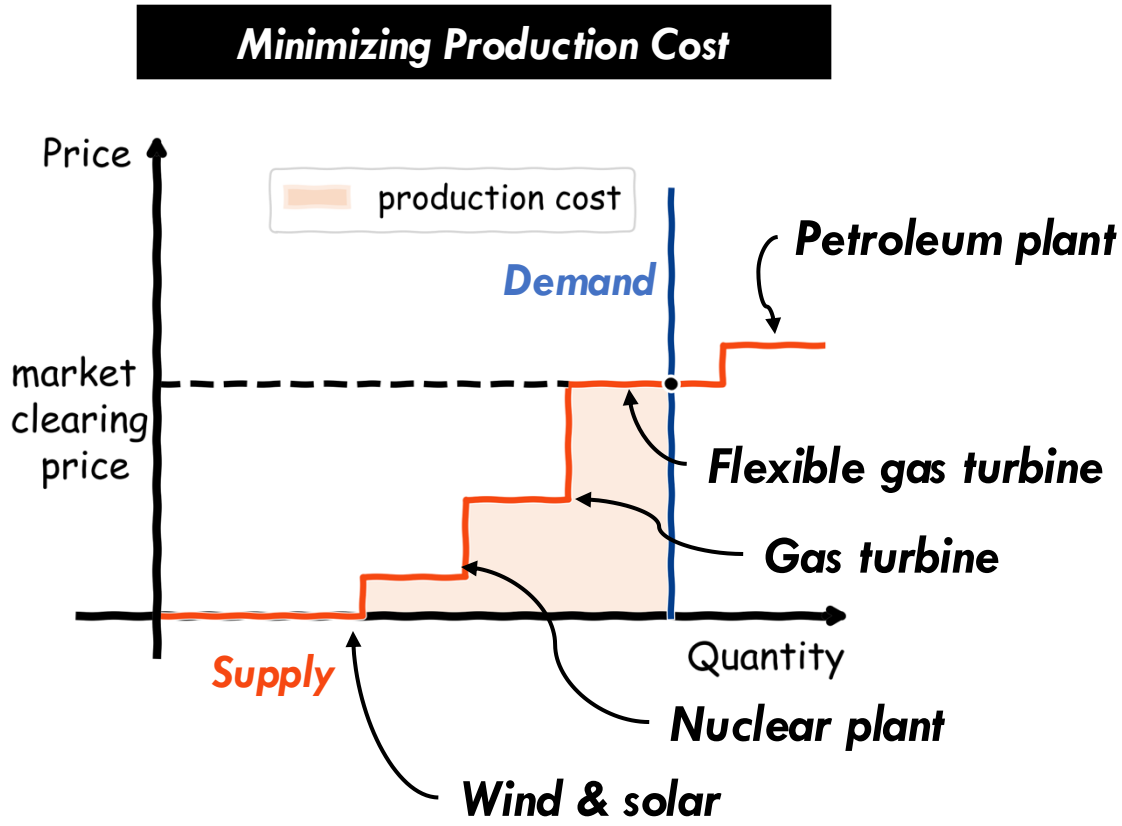
MARKET STRUCTURE

ELECTRICITY MARKETS STRUCTURE

Minimize *Social Production Cost*

s.t. *Supply = Demand* *(λ)*

Capacity



ELECTRICITY MARKETS STRUCTURE

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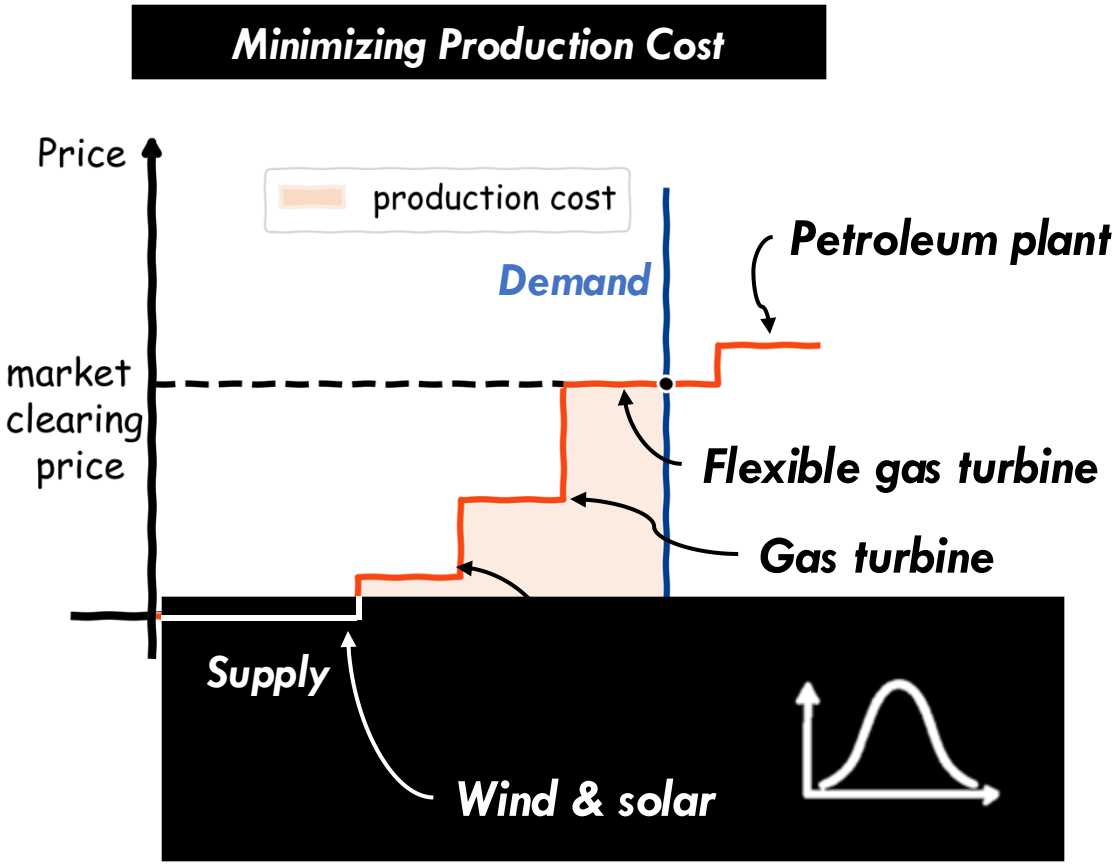
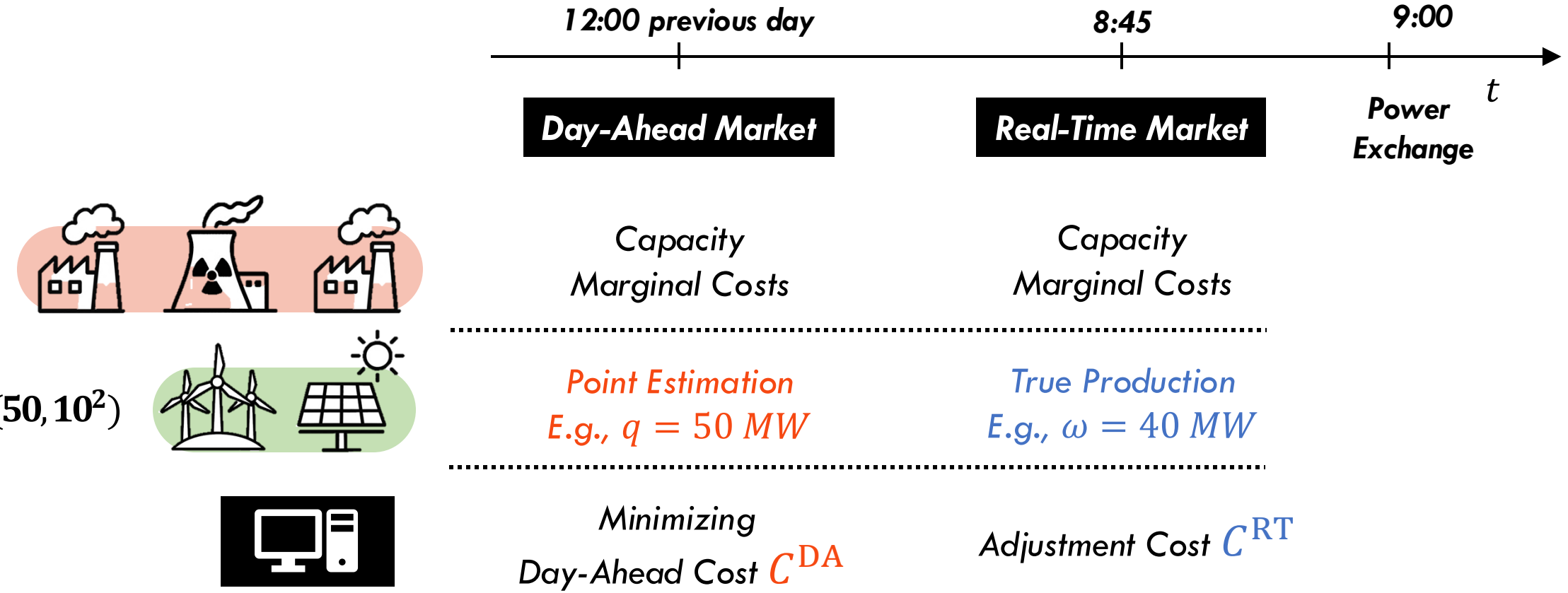
Capacity

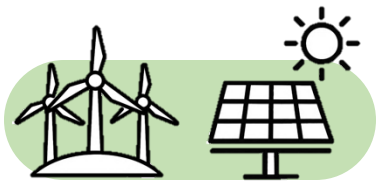


DETERMINISTIC MARKETS



STOCHASTIC MARKETS

$\omega \sim \mathcal{N}(50, 10^2)$

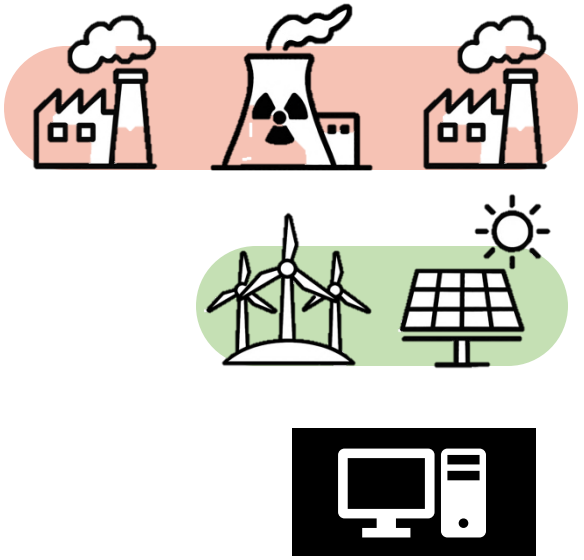


Day-Ahead Market	Real-Time Market
Capacity Marginal Costs	Capacity Marginal Costs
Prod. Distribution $\omega \sim \mathcal{N}(50, 10^2)$	True Production E.g., $\omega = 40\ MW$
Min. Expected Total Costs $\mathbb{E}^{\omega \sim \mathcal{F}}[C^{\mathrm{DA}} + C^{\mathrm{RT}}]$	Adjustment Cost C^{RT}

STOCHASTIC MARKETS (PROACTIVE)

Improves the DA Market

- Different Bidding Structure (renewables as distribution bidders)
- Taking the future into consideration



Day-Ahead Market

Capacity
Marginal Costs

Prod. Distribution
$\omega \sim \mathcal{N}(50, 10^2)$

Min. Expected Total Costs
$\mathbb{E}^{\omega \sim \mathcal{F}}[C^{\mathrm{DA}} + C^{\mathrm{RT}}]$

MARKET EXAMPLE

Demand = 100 MW

One Gas Turbine

- Capacity: > 100 MW
- DA marginal cost: 10 $/MWh
  RT marginal cost: 14 $/MWh
  RT recoverable cost: 9 $/MWh

One Wind Farm

- Zero marginal cost
- Prod. distribution: $\omega \sim U(80,130)$ MW

Economic Efficiency

	Social Cost	WPP Profit	TPP Profit
Deterministic	56 $	- 56 $	0 $
Stochastic	51 $	409 $	0 $

Cost Recovery (Individual Rationality)

EXAMPLE

CONTRIBUTIONS

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Desired Properties

- *Economic Efficiency*
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- *Revenue Adequacy (Balanced Budget)*

Make better decisions!

Deterministic Markets	Stochastic Markets
✗	✓
✗	✓
~	When without market power
✓	✓

THANK YOU !

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