

Market Design, Welfare, and Environmental Implications of Recognizing Wind Production Uncertainty in PJM

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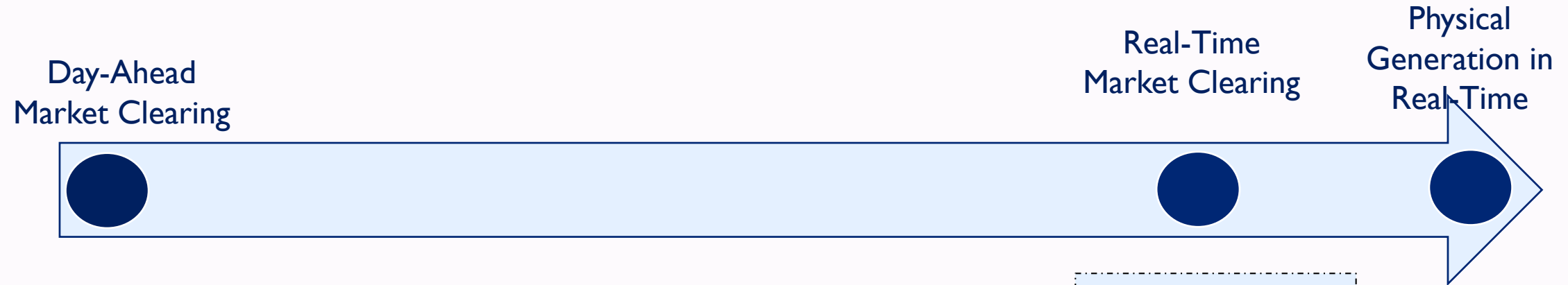
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Outline

- **Background**
- **Motivation and Objectives**
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- **Test System and Data**
- **Results**
- **Conclusions**

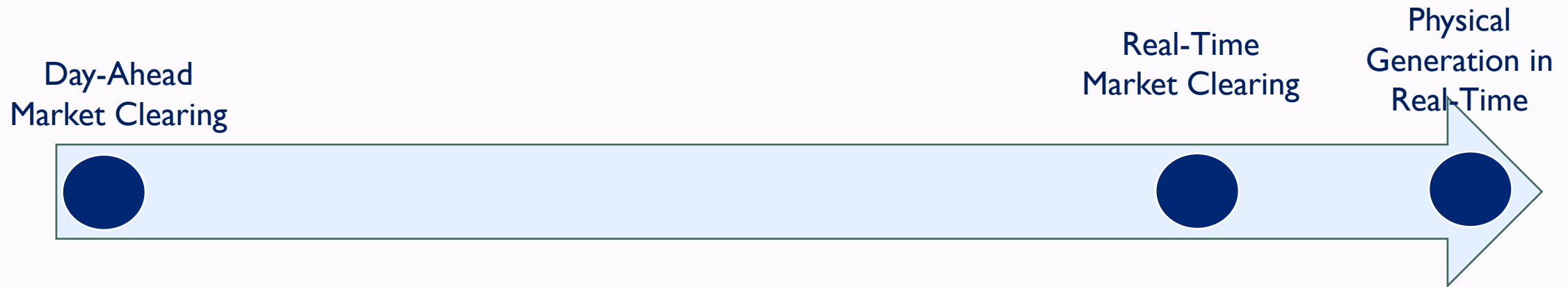
Background

Time Frame of Daily Markets Operations



Background

Challenges/Inefficiencies Posed by Wind Uncertainty

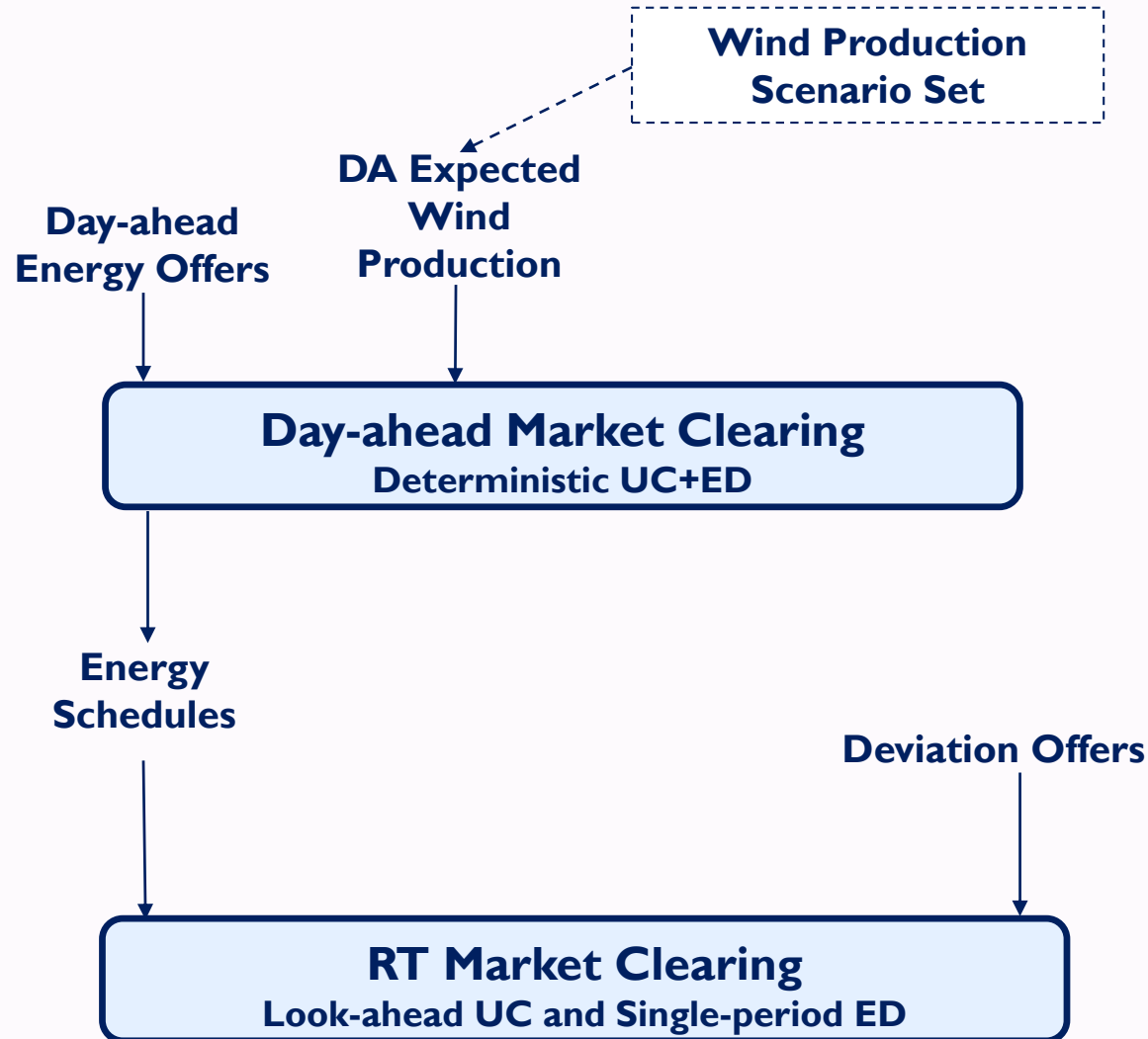


- Inaccurate wind predictions in the DA
- DA commitments inflexible to follow RT variations/deviations
- Over-commitment under-commitment of generators
- Resource Gap in RT
- Commitment of fast but more expensive producers
- Curtailment of wind energy

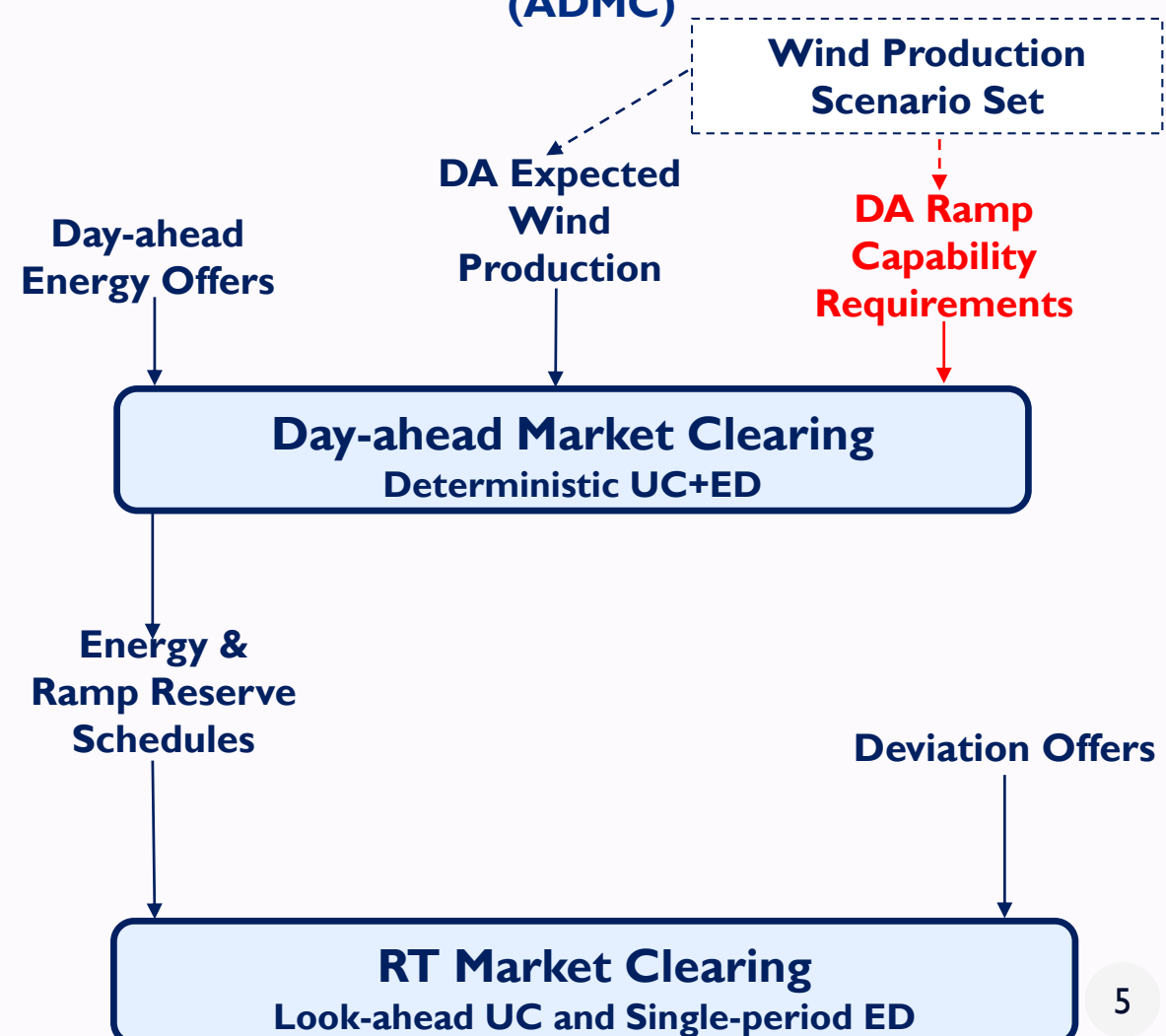
Background

Integration of Uncertainty into the DA Market Clearing Mechanisms

(a) Deterministic Market Clearing (DMC)



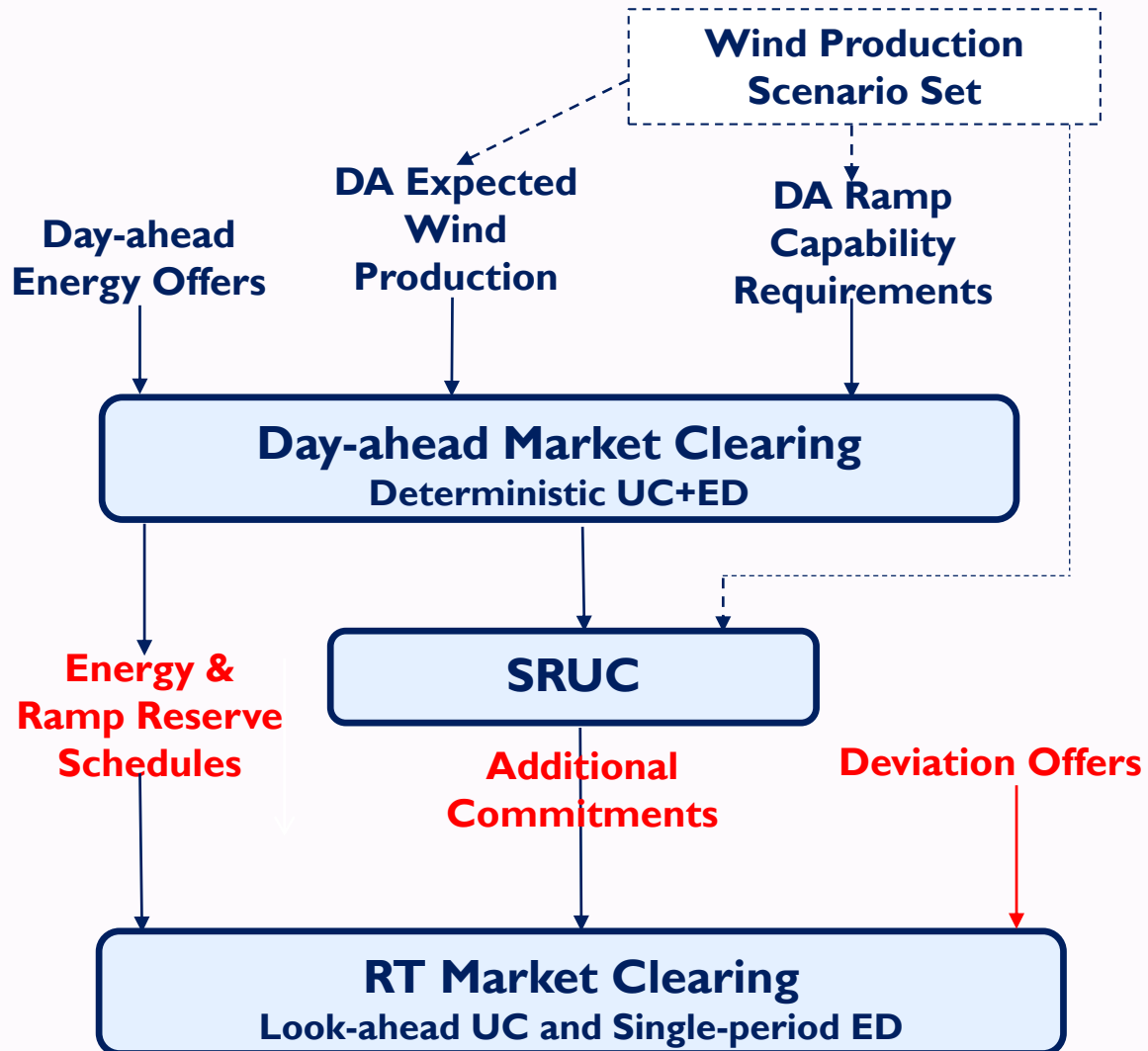
(b) Augmented Deterministic Market Clearing (ADMC)



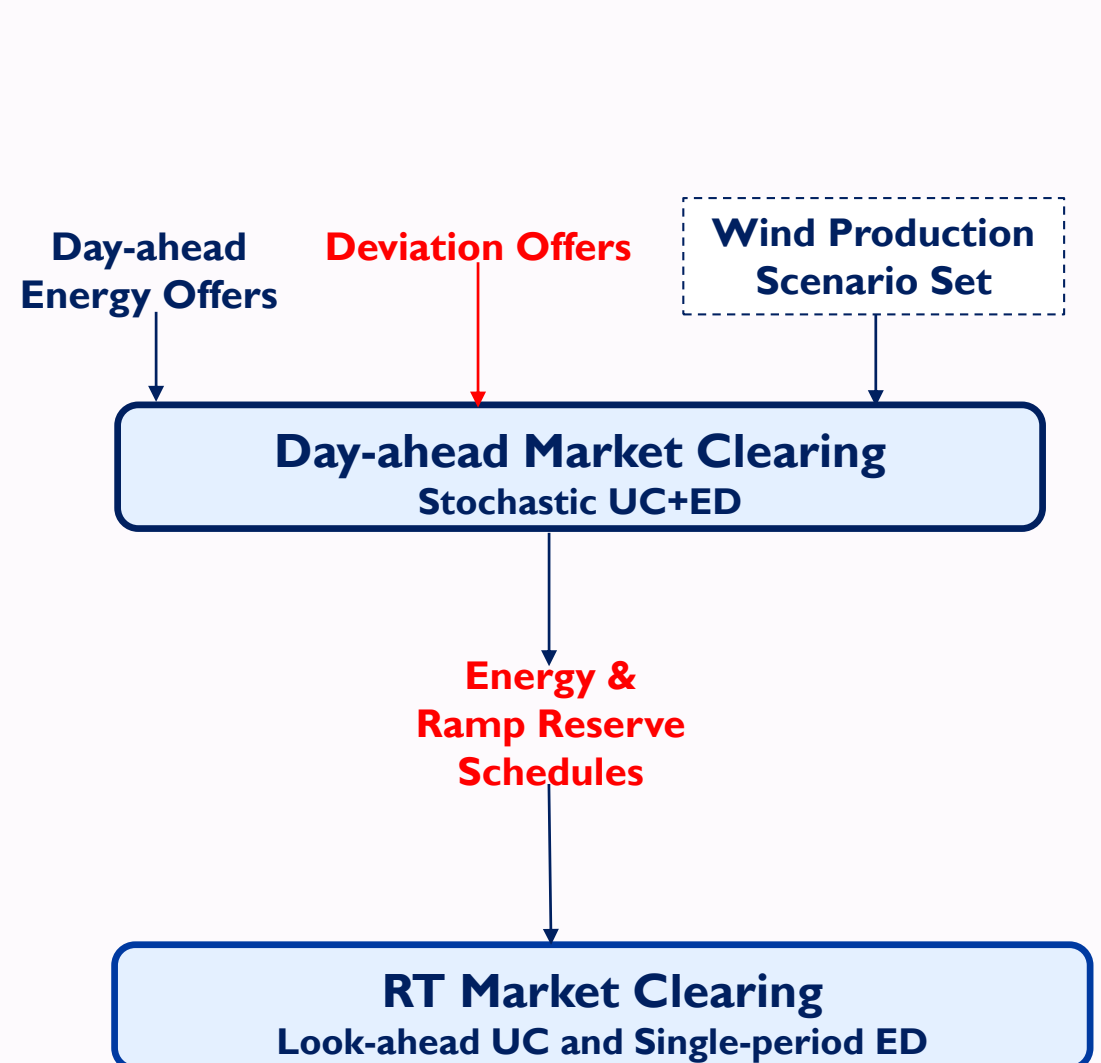
Background

Integration of Uncertainty into the DA Market Clearing Mechanisms

(c) Hybrid Deterministic Market Clearing (HDMC)



(d) Stochastic Market Clearing (SMC)



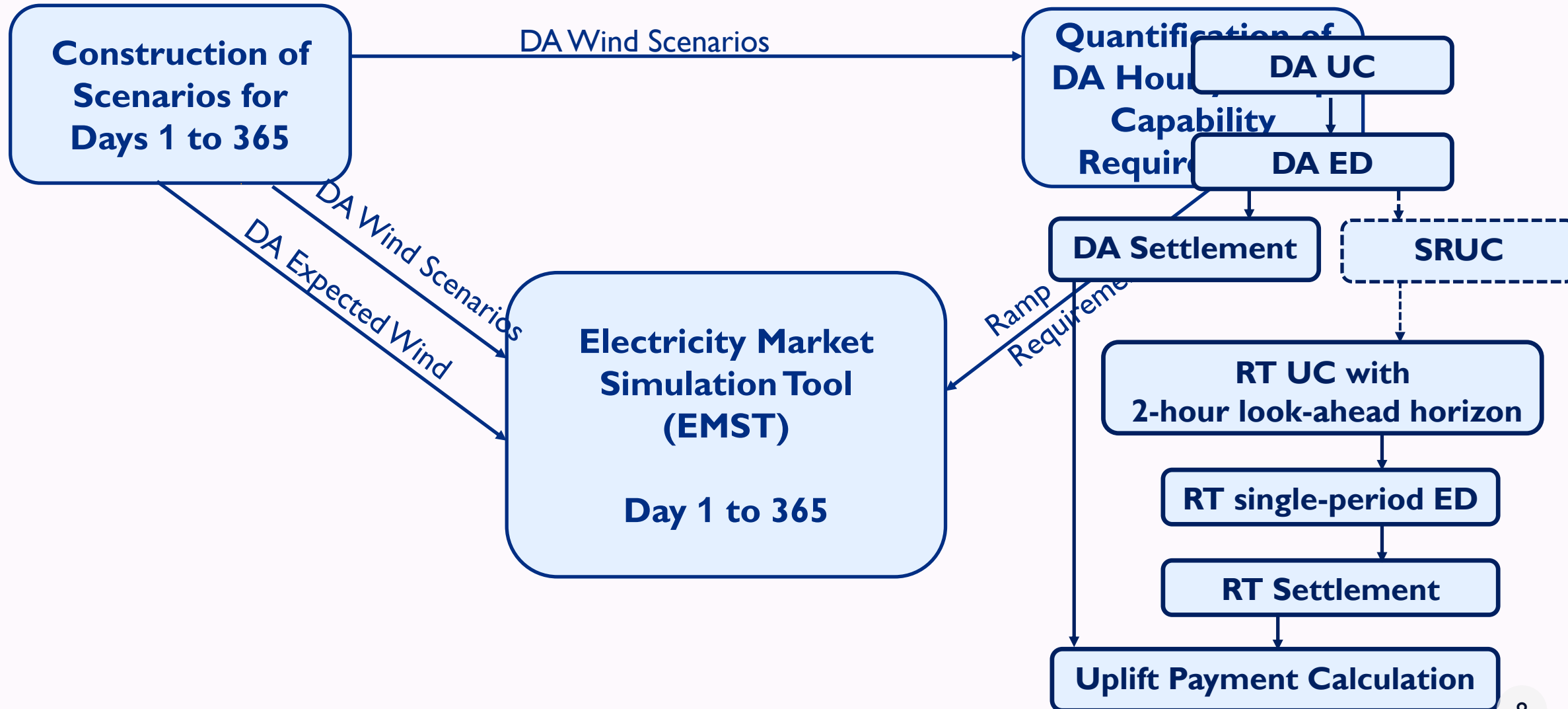
Objectives

- **Evaluating inefficiencies** caused by wind uncertainty
 - **Operation costs, producers' social surplus**
 - **Price spread and uplift payment**
 - **Environmental efficiency**

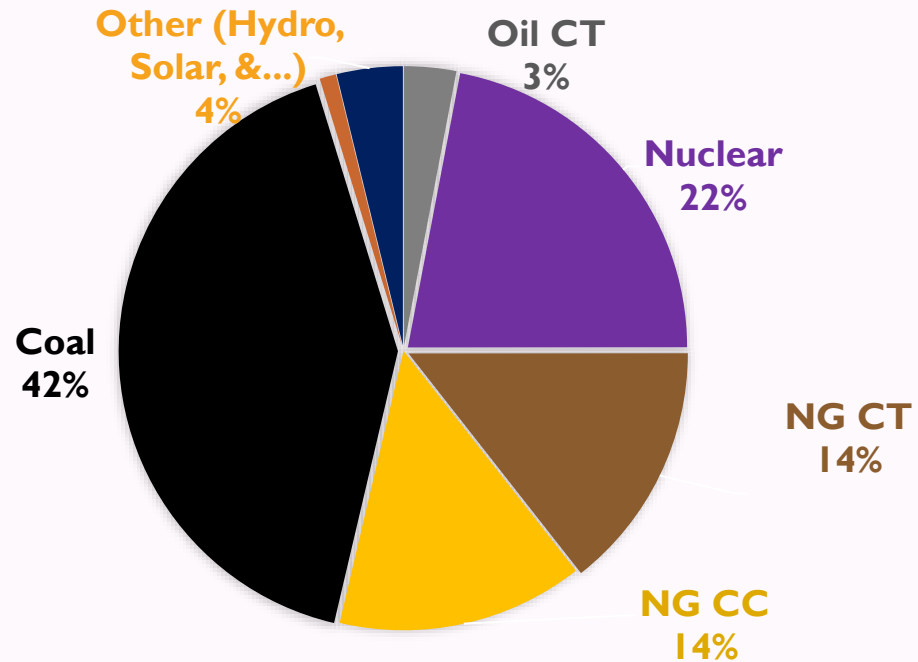
- **Assessing efficiency improvements** achieved by market clearing design adjustments

Method

Simulation of Market Operation with Daily Cycle and Hourly Resolution



Case Study and Data



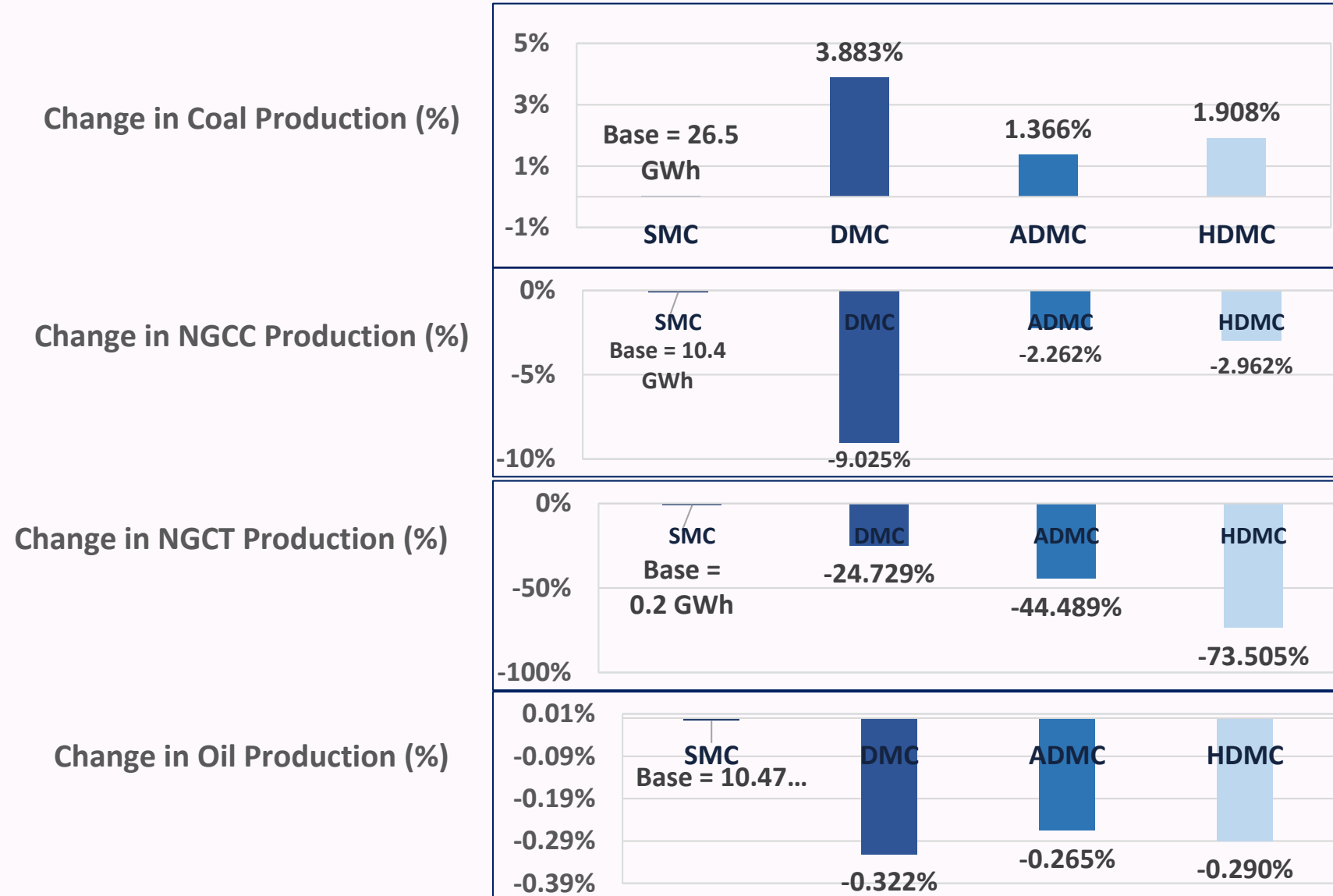
- Heat rate and capacity data from EPA-NEEDS
- 12% scaled version of PJM's fossil-fired generation mix
- Installed capacity of thermal resources = 20000 MW

| Plant Technology/Fuel | Installed capacity (MW) | Number of units |
|-----------------------|-------------------------|-----------------|
| Nuclear | 4616 | 4 |
| Coal | 8727 | 19 |
| NGCC | 2996 | 14 |
| NGCT | 3030 | 22 |
| Oil CT | 631 | 8 |

- Expected Peak = 17314 MW Reserve margin = 15.5%
- Wind Penetration Levels Case 1 = 12% and Case 2 = 21%
- Fuel prices from EIA for year 2016, Average across PJM region

Results

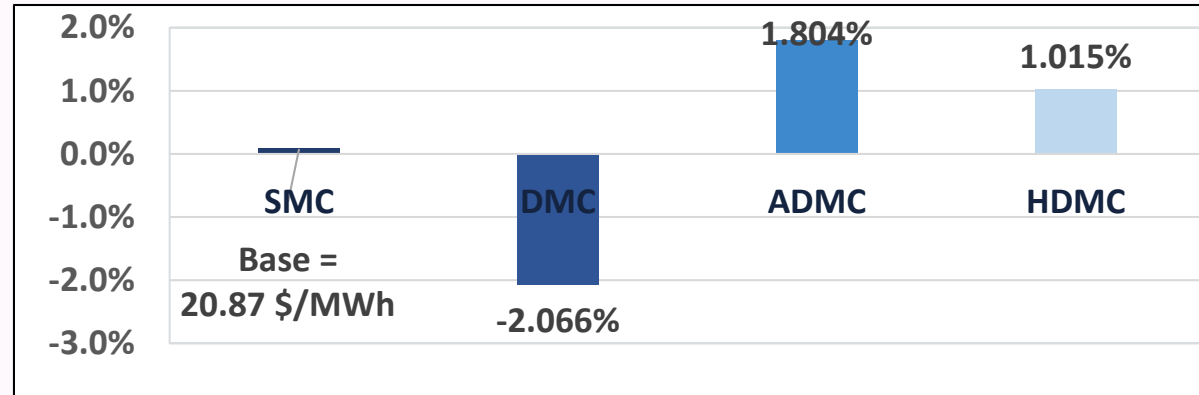
Percentage Change in Dispatch of Generation Technologies



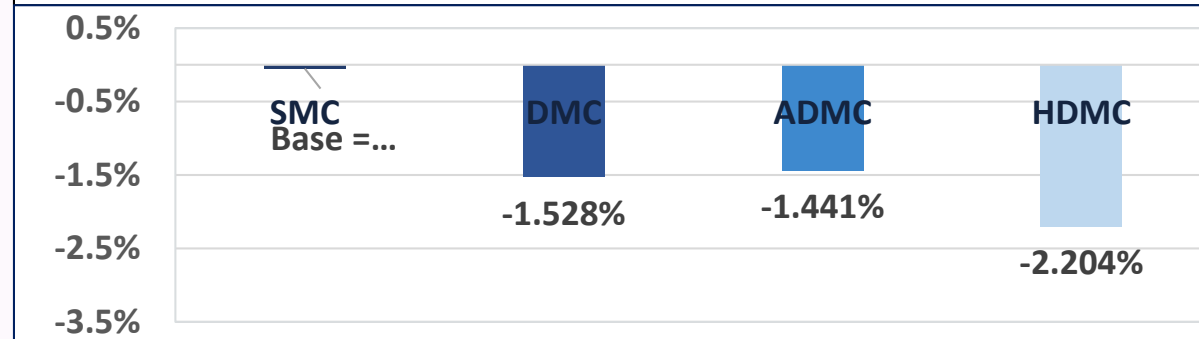
Results

Average Prices (Percentage Changes)

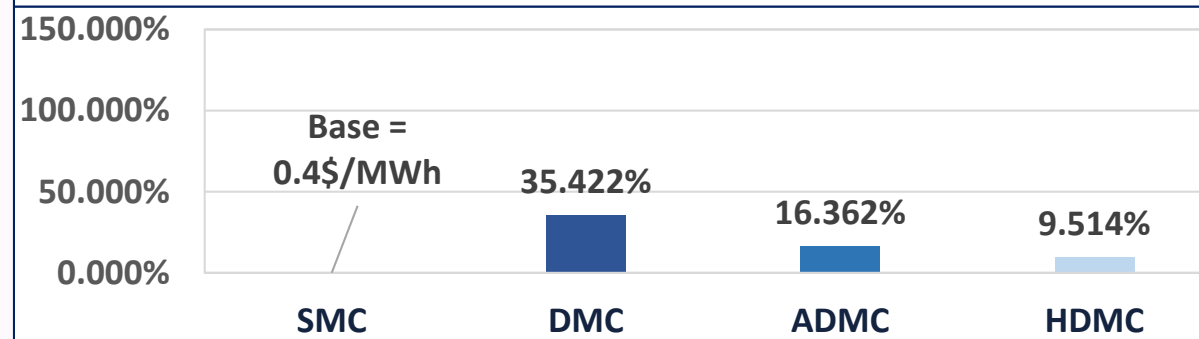
DA Price (%)



Change in RT Price



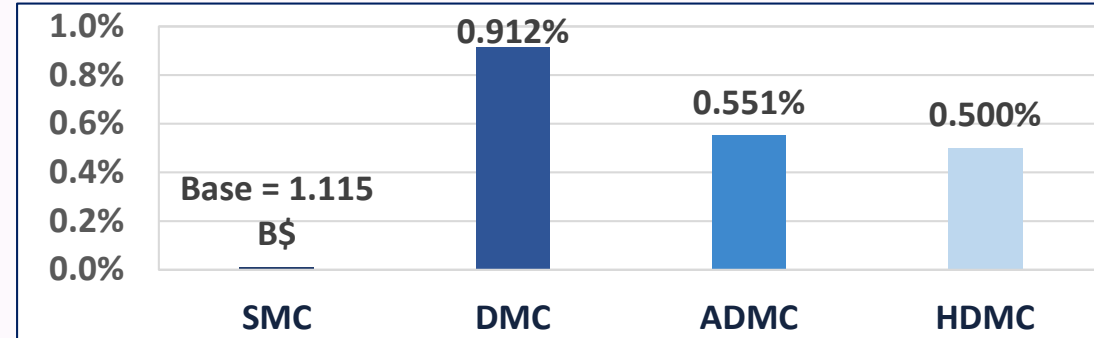
Change in Price Spread (%)



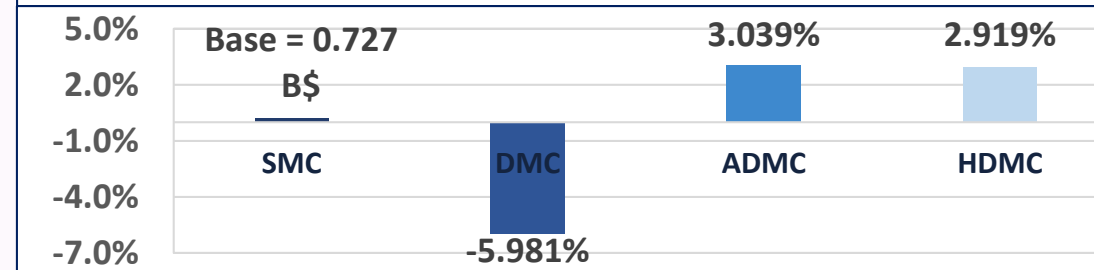
Results

Economic Outcomes

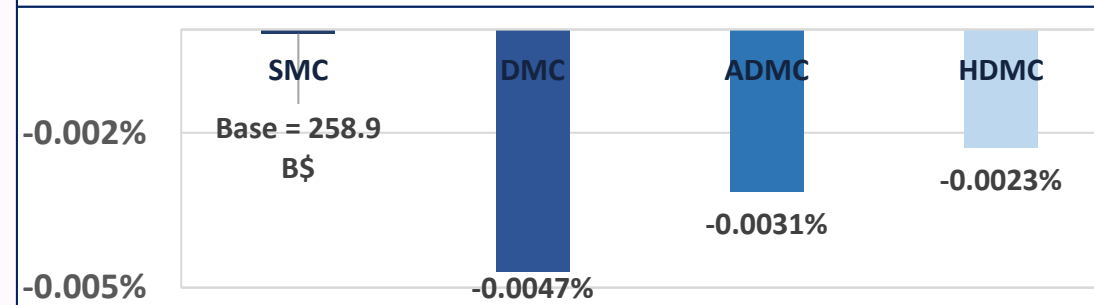
Plants Fuel Costs (%)



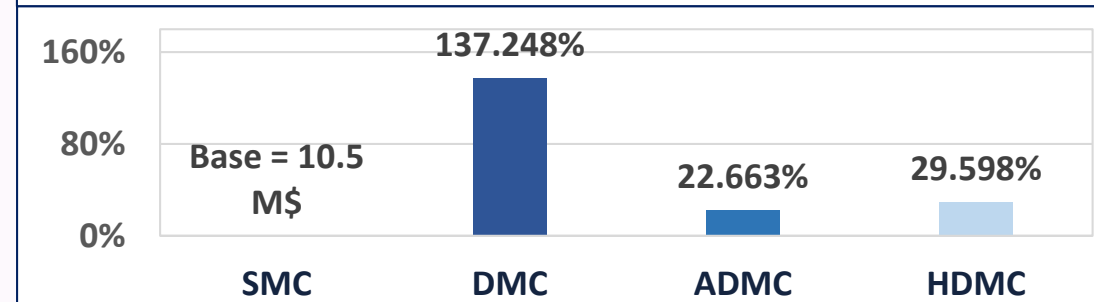
Producers' surplus (%)



Social Surplus (%)



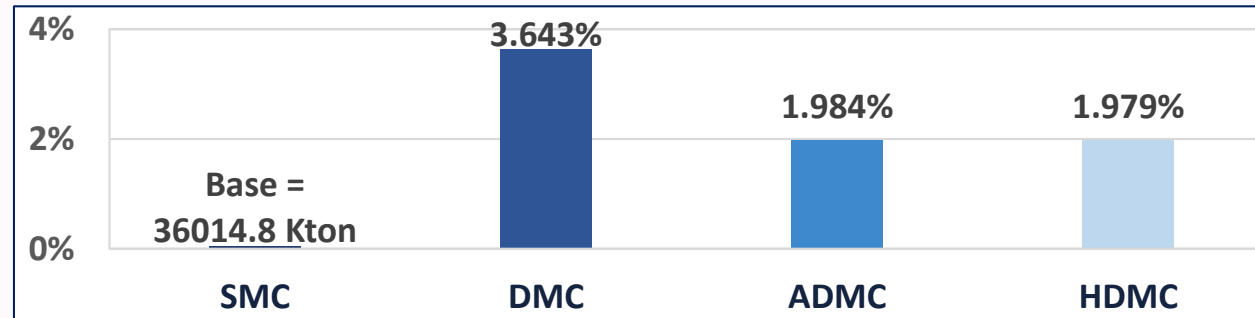
Uplift Payments (%)



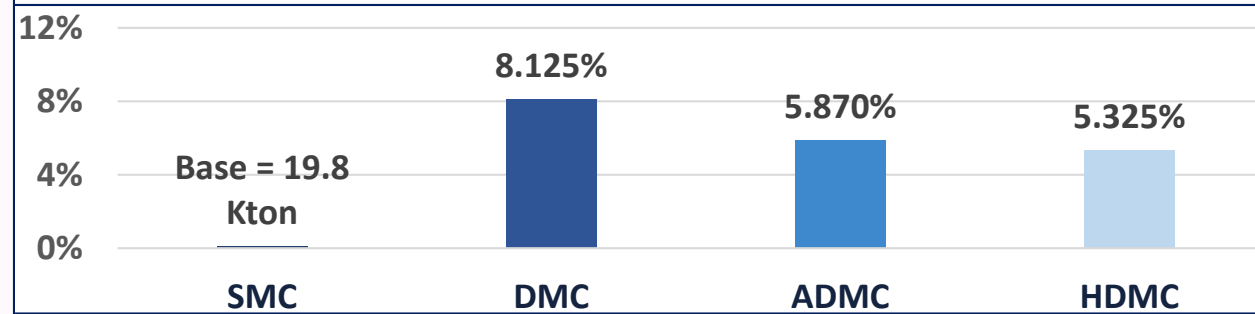
Results

Emissions

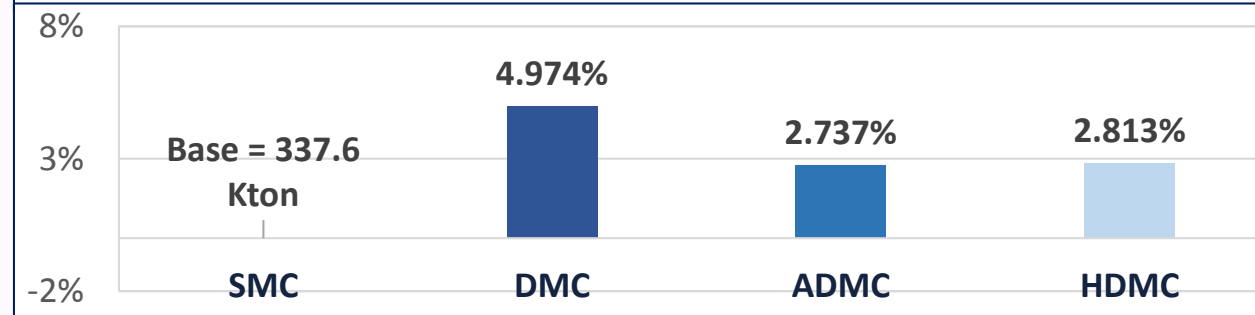
Change in CO₂ Emissions (%)



Change in NO_x Emissions (%)



Change in SO₂ Emissions (%)



Questions?

Thanks for your attention!