Managing Operations While Transitioning to Carbon Neutrality

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CampusEnergy2020
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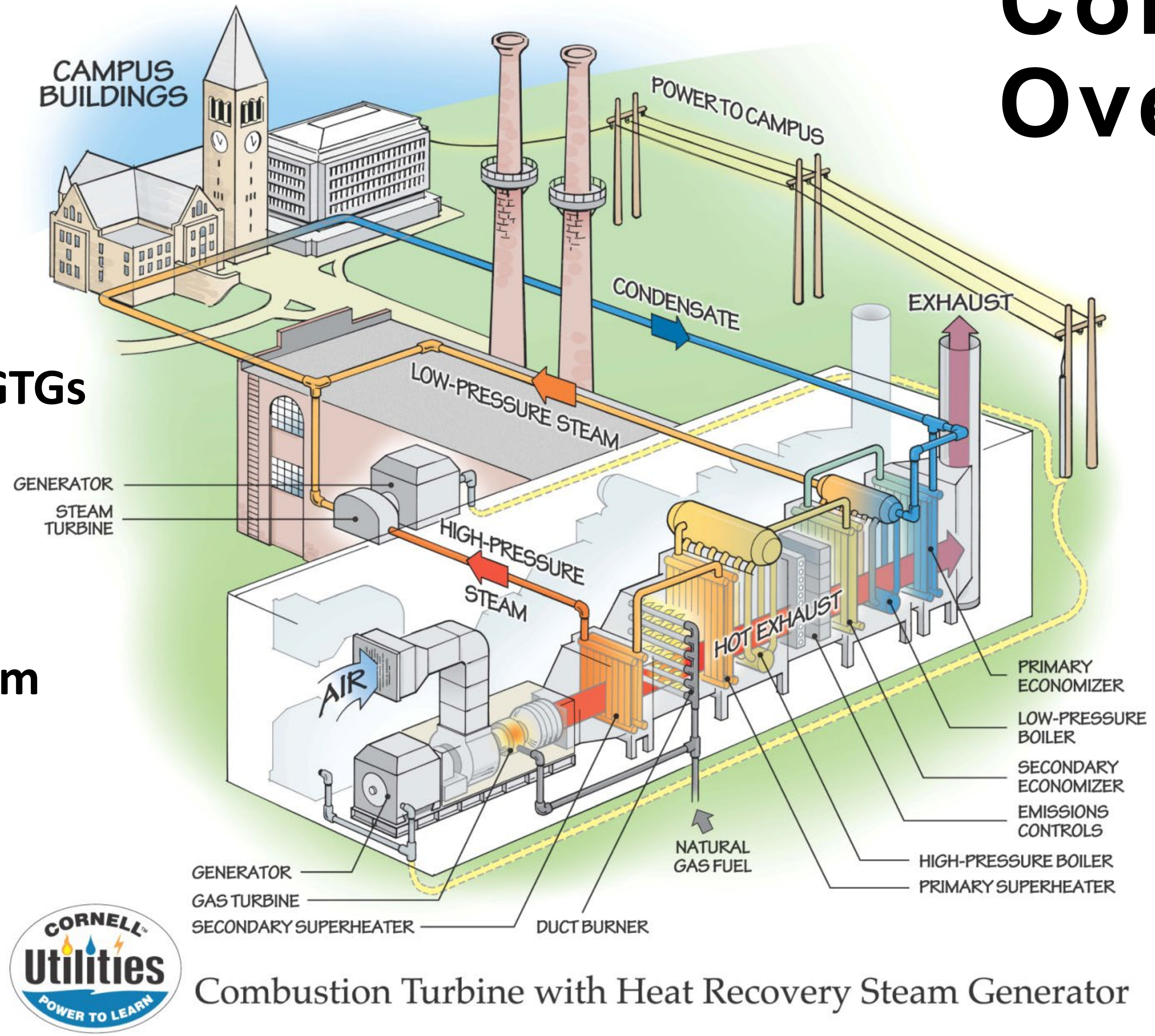
Problem Statement

What factors should be considered when managing Combined Heat and Power (CHP) economics?

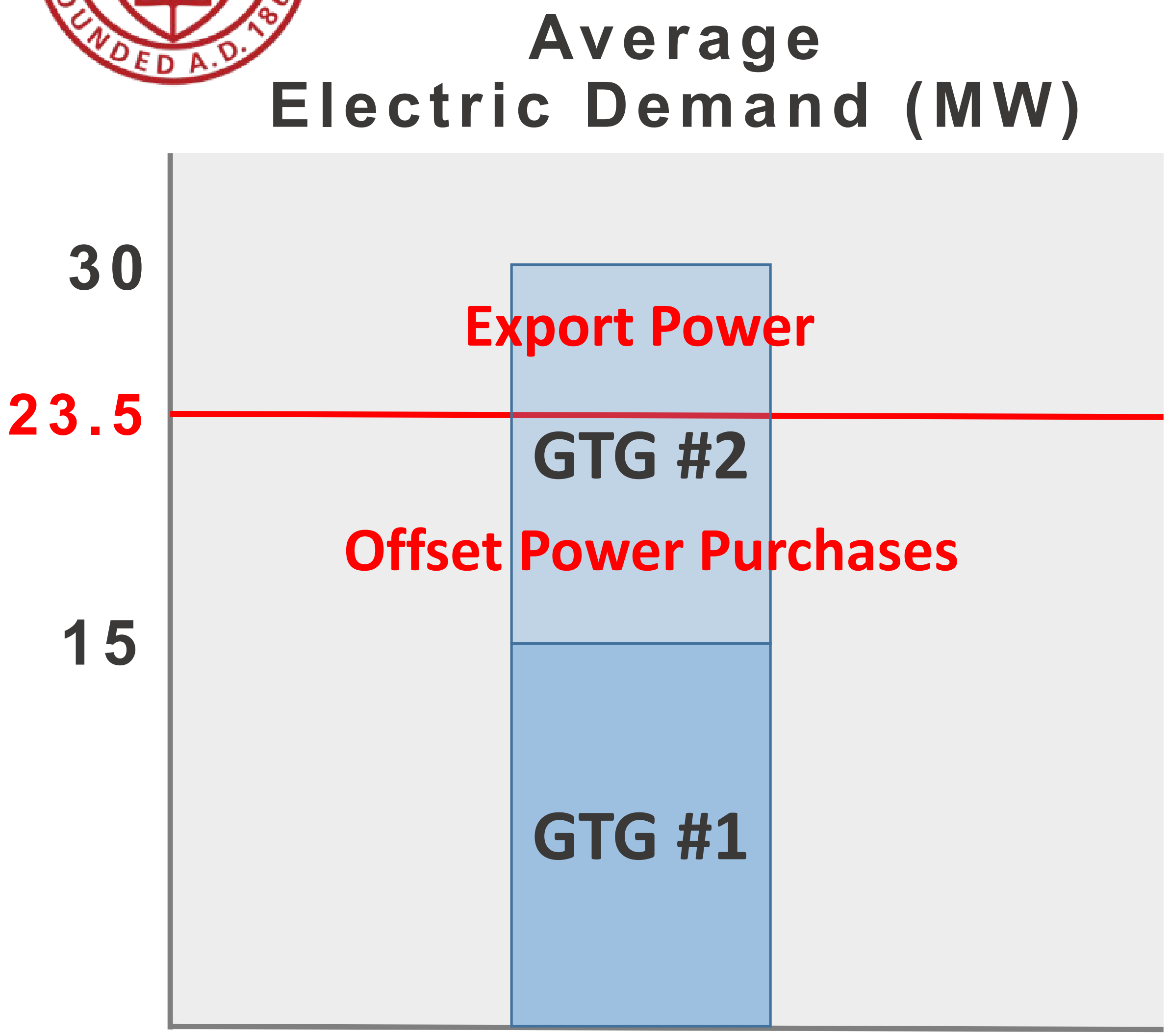
Cornell Overview

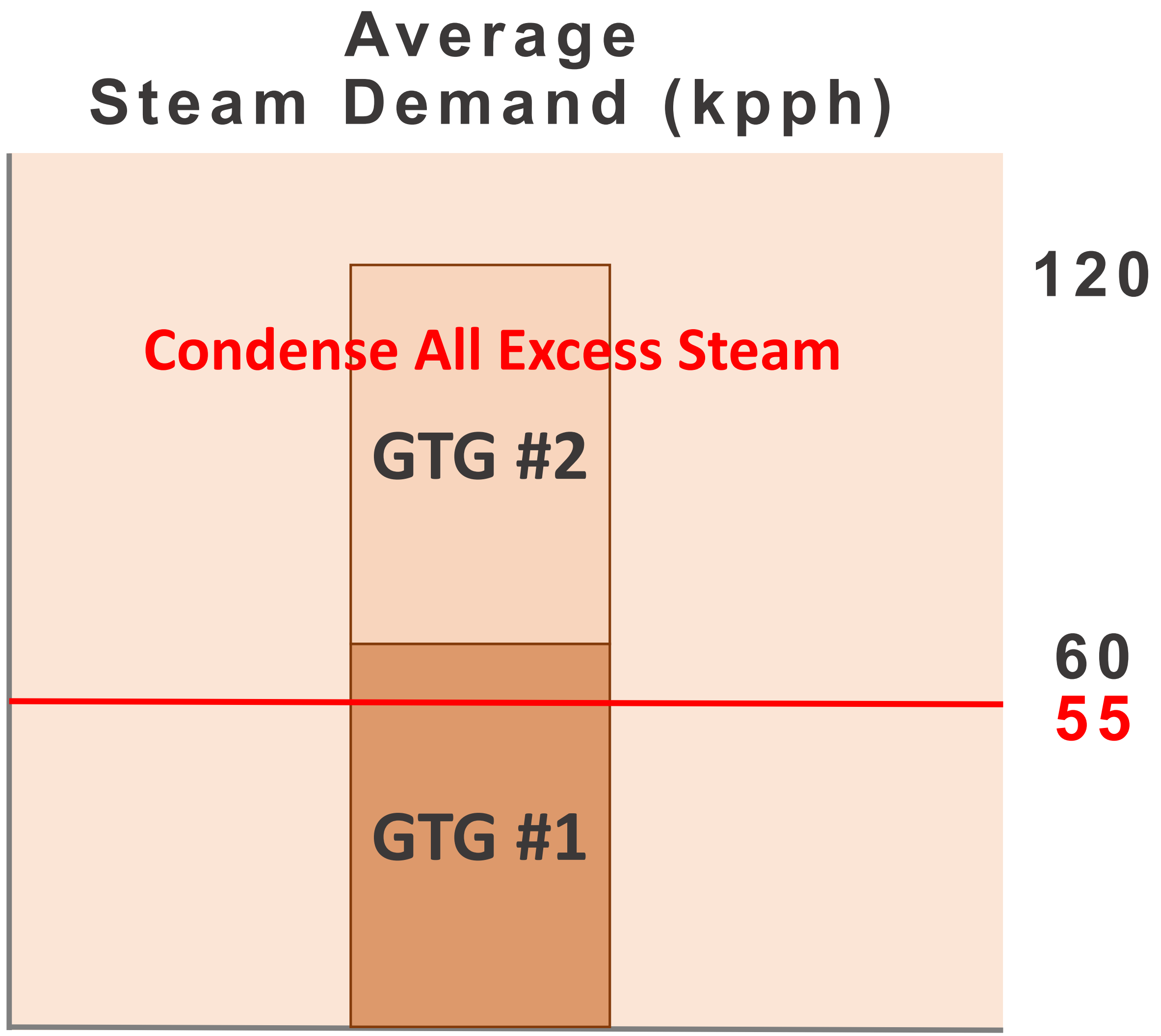
Cornell CHP Plant

- **Two Solar Titan 130 GTGs**
- **Two STGs**
- **Steam Condenser Building allows us to condense excess steam**



Summer Operations

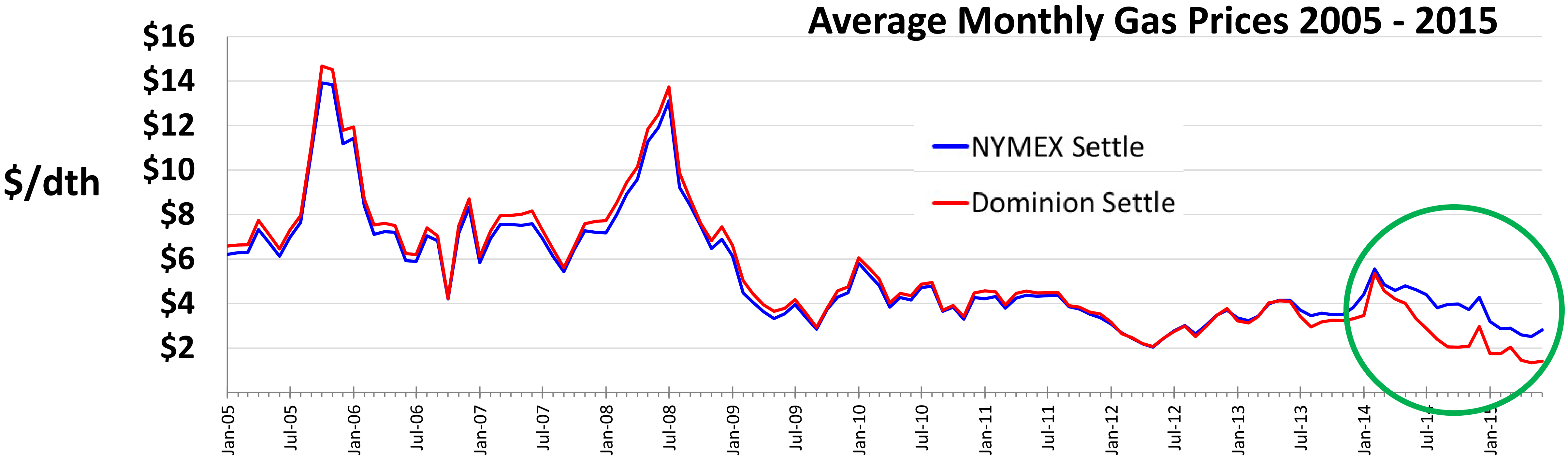




Steam Load Following Operations

Past Operational Strategy *(Pre 2015)*

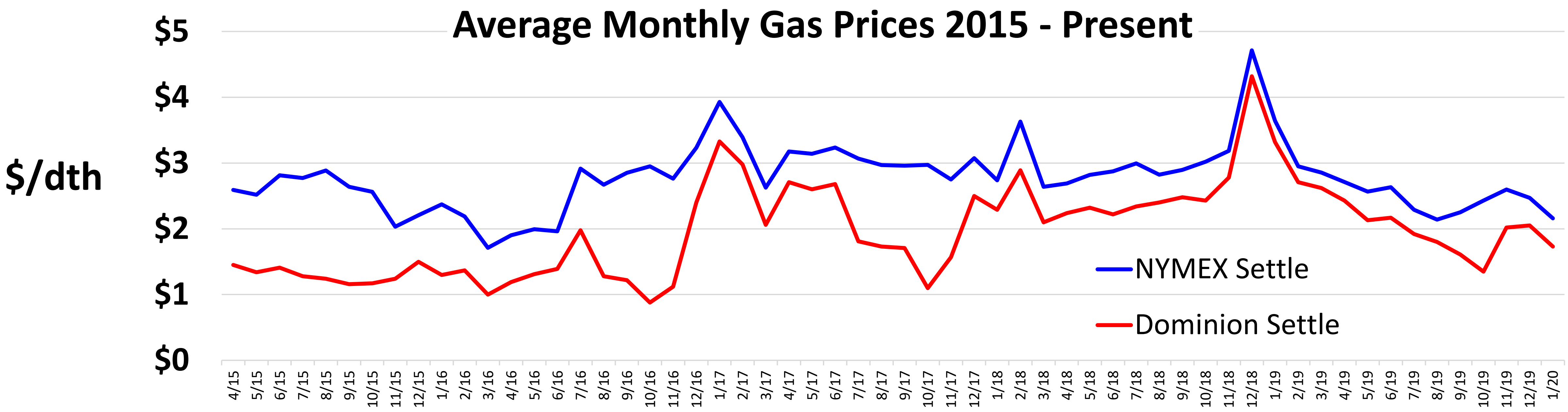
- Shutdown one GTG when steam production is not needed



Electric Load Following Operations

***Present Operational Strategy** (Post 2015)*

- Run both GTGs for power production when rates are favorable and condense all excess steam



When should GTG #2 be turned on?

Should we offset power purchases? (Decision 1)

- If running second GTG results in monetary savings by offsetting grid purchases, then start the unit

Should we export power? (Decision 2)

- If export rates are not profitable, partial load GTG to reduce export

Economic Problem

Maximizing Savings

Electric Savings ($) =

Cost to Purchase Power

- Day Ahead Electric Price
- System Benefit Charge/RPS
- Transition Charge
- NTAC/Ancillary
- Merchant Function Charge
- Supply Adjustment
- Capacity Charge
- As-Used Demand
- Reactive Charge

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Cost to Generate Power

- Natural Gas Price (marginal price not WACOG)
- CHP Heat Rate (define incremental CHP efficiency)
- Marginal Maintenance Fees
- Marginal Operational Costs
- Equipment cycling and reliability

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Export Profit

- Natural gas Price
- CHP Heat Rate
- Real Time Electric Price

Yes: Start GTG #2
No: Import Power

Yes: Run at Full Load
No: Run at Partial Load

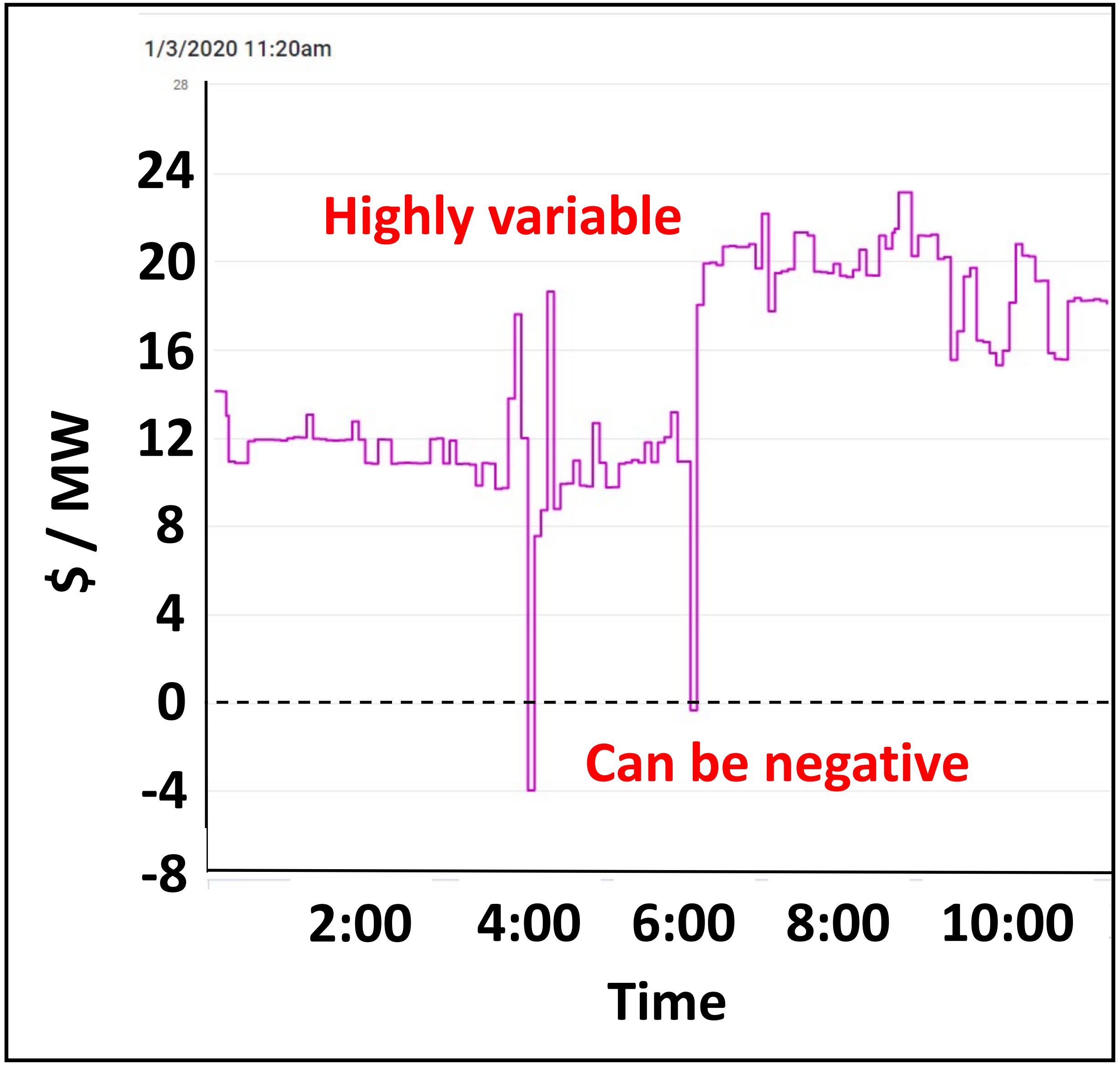
D1: Should we offset purchases by turning on GTG #2?

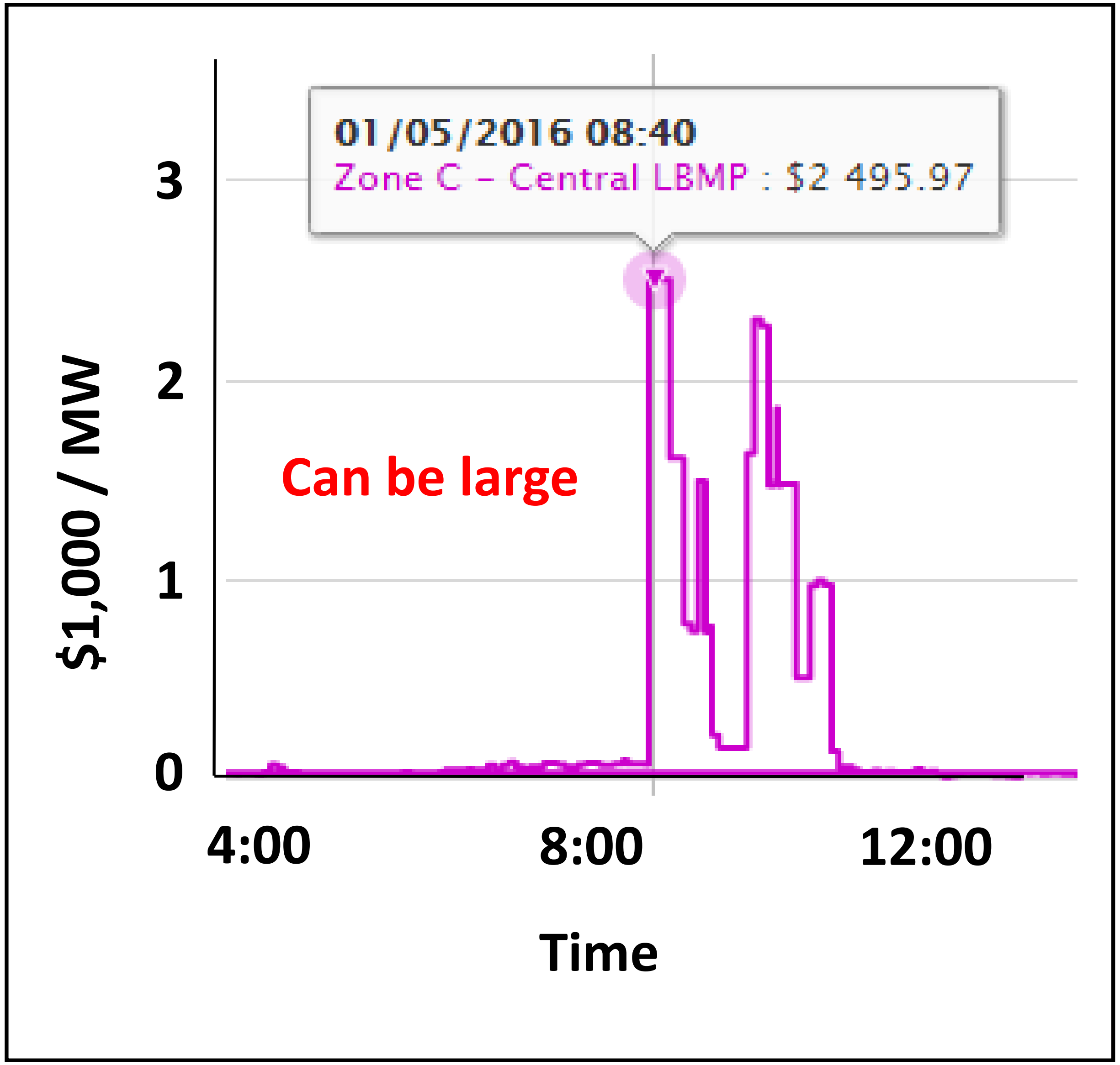
D2: Should we export?

Computational Challenges

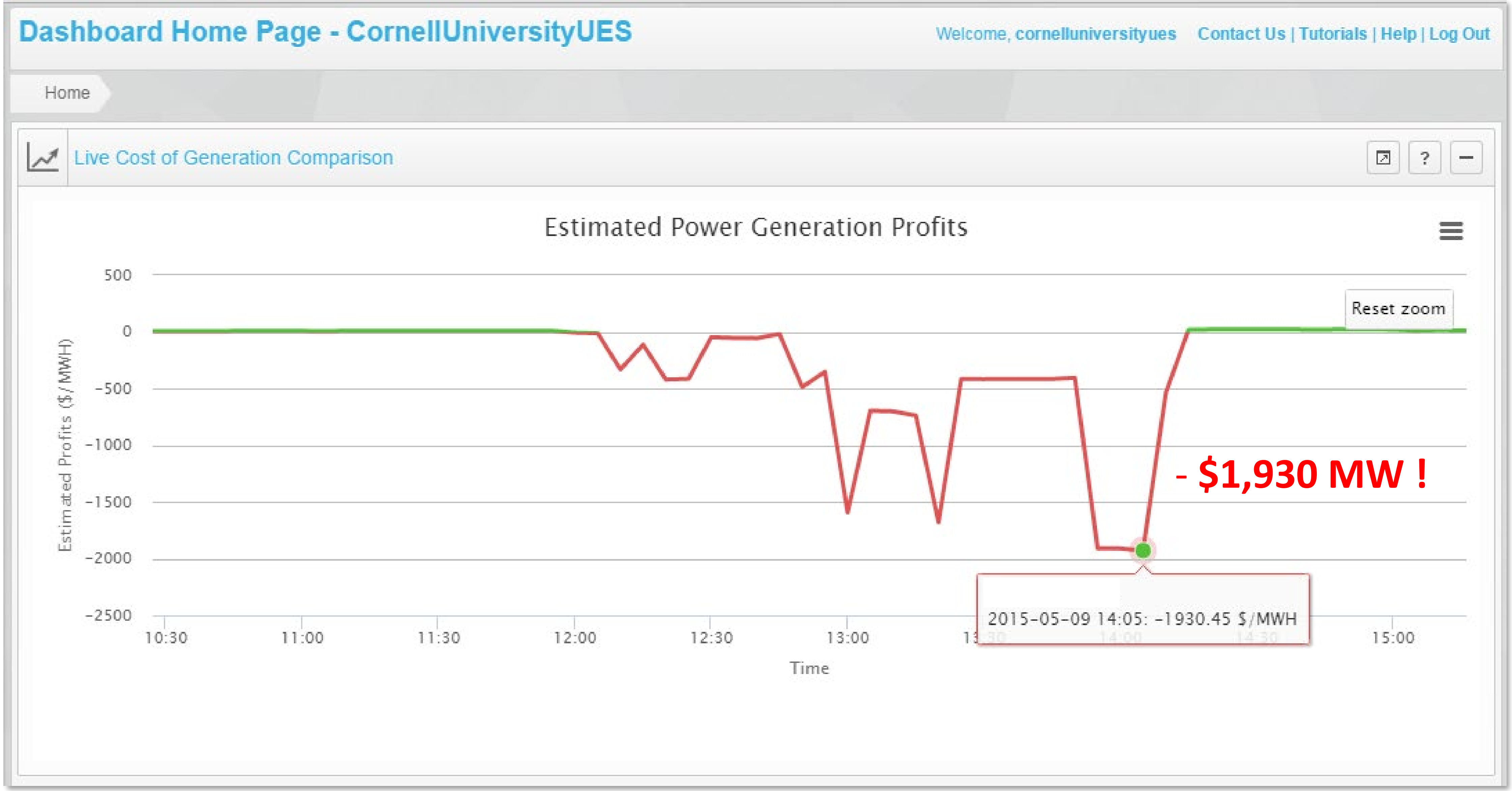
- **Supply Adjustment Charge** – Must be estimated. Can be significant % of variable supply and delivery fees.
- **Real Time Electric Rate** – Highly variable over short time intervals.
- **Emission Rate (Grid)** – Average or Marginal? What is the marginal generating unit?
- **Carbon Value** – Large range of published values ($10 - >$200 per MT CO_2).

Why monitoring Export Rates is important

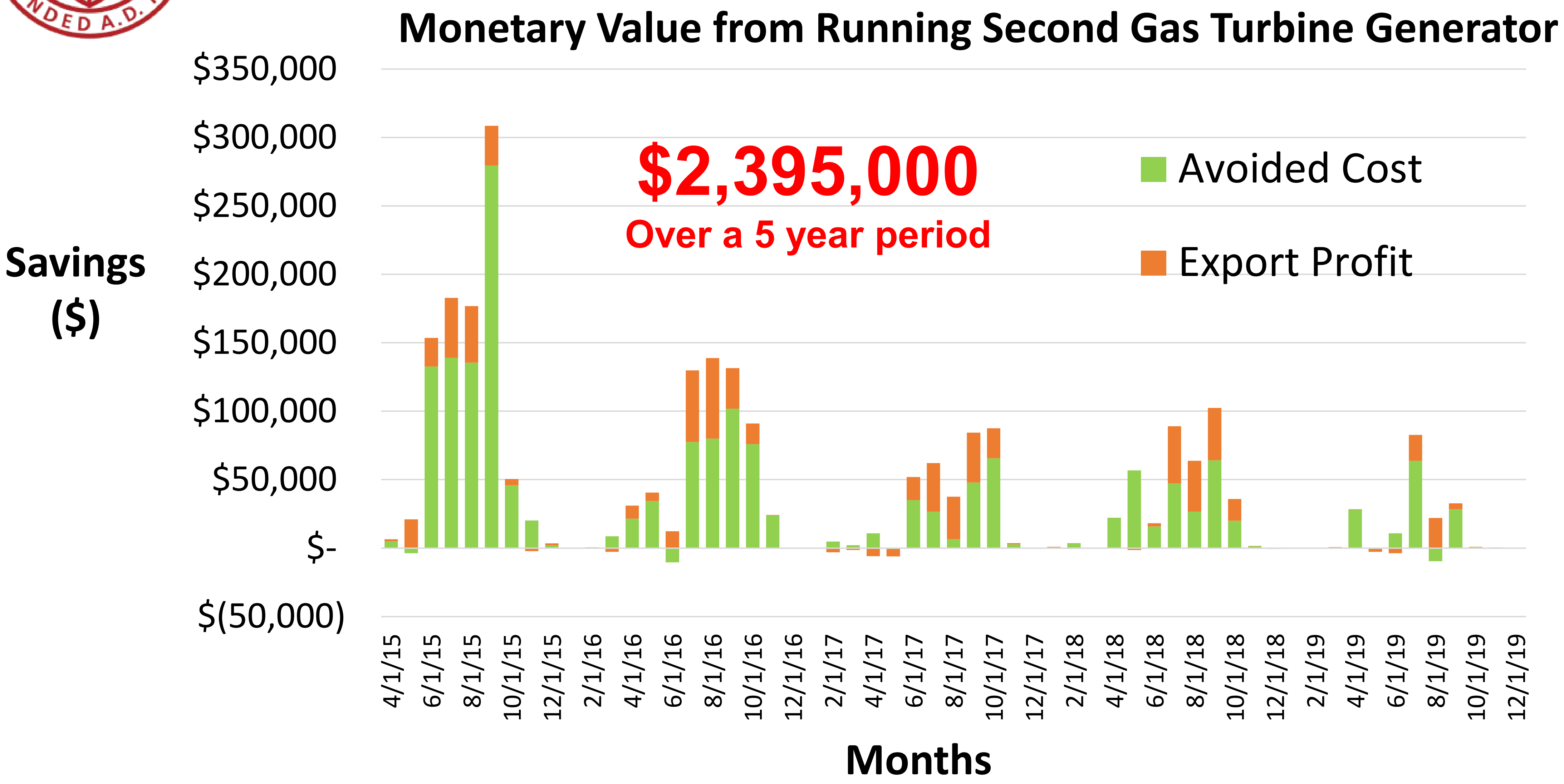




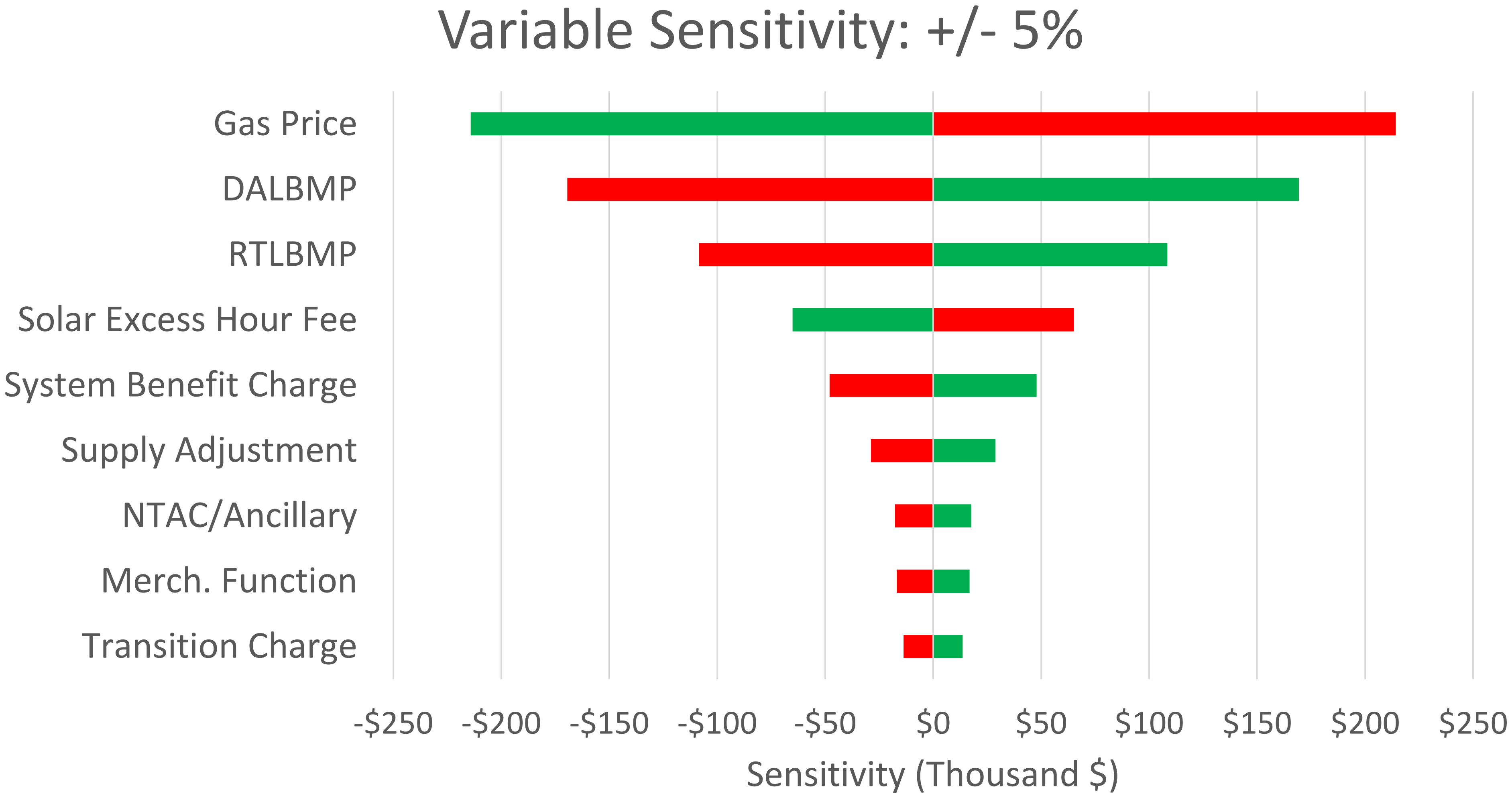
Control Room Export Dashboard



How has this strategy performed?

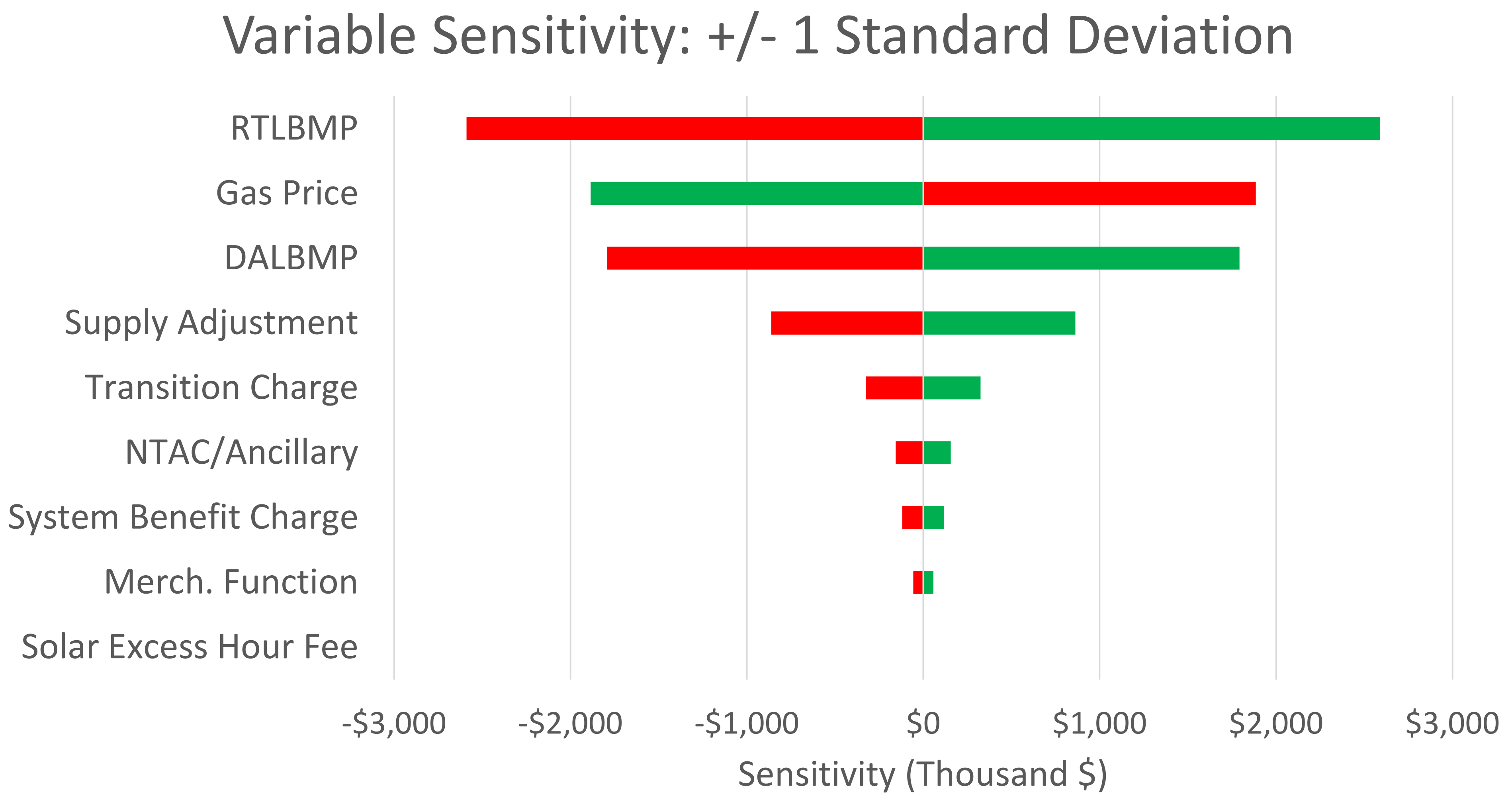


Cost Sensitivity Analysis Results



* Sensitivity shows how the cumulative savings would change over the past five years of operations

Cost Sensitivity Analysis Results



* Sensitivity shows how the cumulative savings would change over the past five years of operations

Campus Stakeholders

- **Faculty**
- **Students**
- **Community**

Why are you burning more natural gas than you need to in the summer? Why are you operating at a lower plant efficiency and condensing steam?

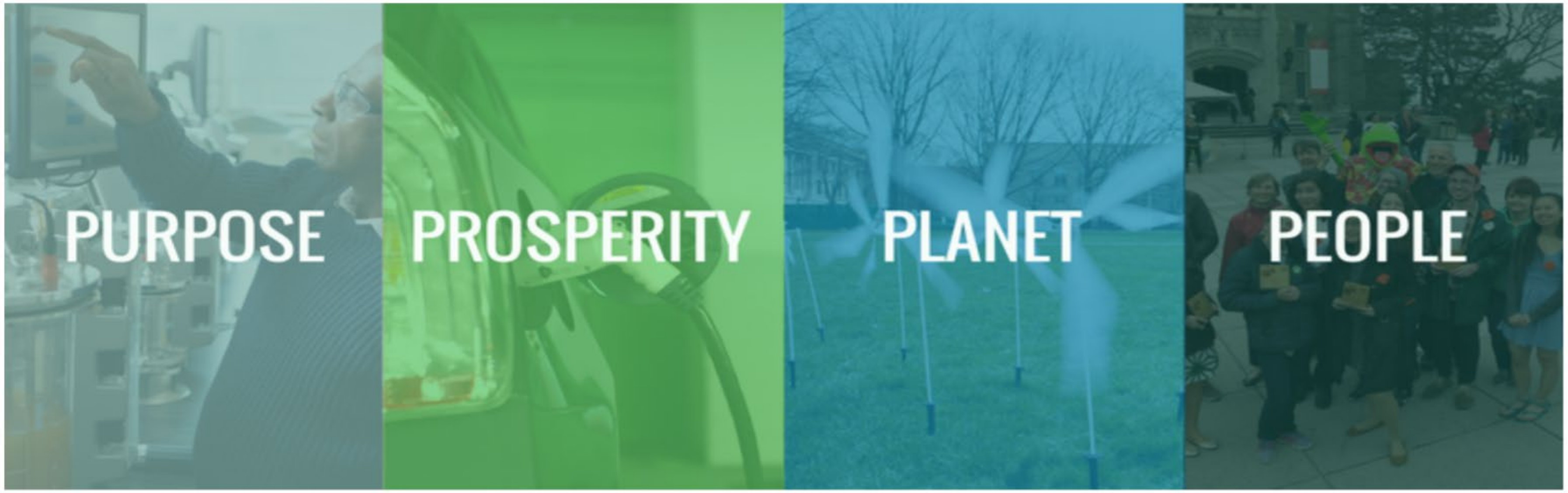
The NYS grid has lots of renewables, you should generate less power and buy more from the grid!

- **Cornell Utilities Staff** – What are my constraints? What should I optimize?

- **Cornell Leadership** – Expand single bottom-line thinking.

Quadruple Bottom Line (QBL)

The QBL framework considers four impact areas in balance



Future Economic Problem

Maximizing Savings while Minimizing GHG Emissions

Electric Savings ($) =

Power Purchase Costs

- Day Ahead Electric Price
- System Benefit Charge/RPS
- Transition Charge
- NTAC/Ancillary
- Merchant Function Charge
- Supply Adjustment
- Capacity Charge
- As-Used Demand
- Reactive Charge
- **Value of Carbon Emissions**
- **Emission Rate (ER) of Grid**

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Power Generation Costs

- Natural Gas Price (marginal price not WACOG)
- CHP Heat Rate (define incremental CHP efficiency)
- Marginal Maintenance Fees
- Marginal Operational Costs
- Equipment cycling and reliability
- **Value of Carbon Emissions**
- **Emission Rate (ER) of CHP**

+

Export Profit

- Natural Gas Price
- CHP Heat Rate
- RT Electric Price
- **Value of Carbon Emissions**
- **$(ER_{GRID} - ER_{CHP})$**

Computational Challenges

- **Supply Adjustment Charge** – Must be estimated. Can be significant % of variable supply and delivery fees.
- **Real Time Electric Rate** – Highly variable over short time intervals.
- **Emission Rate (Grid)** – Average or Marginal? What is the marginal generating unit?
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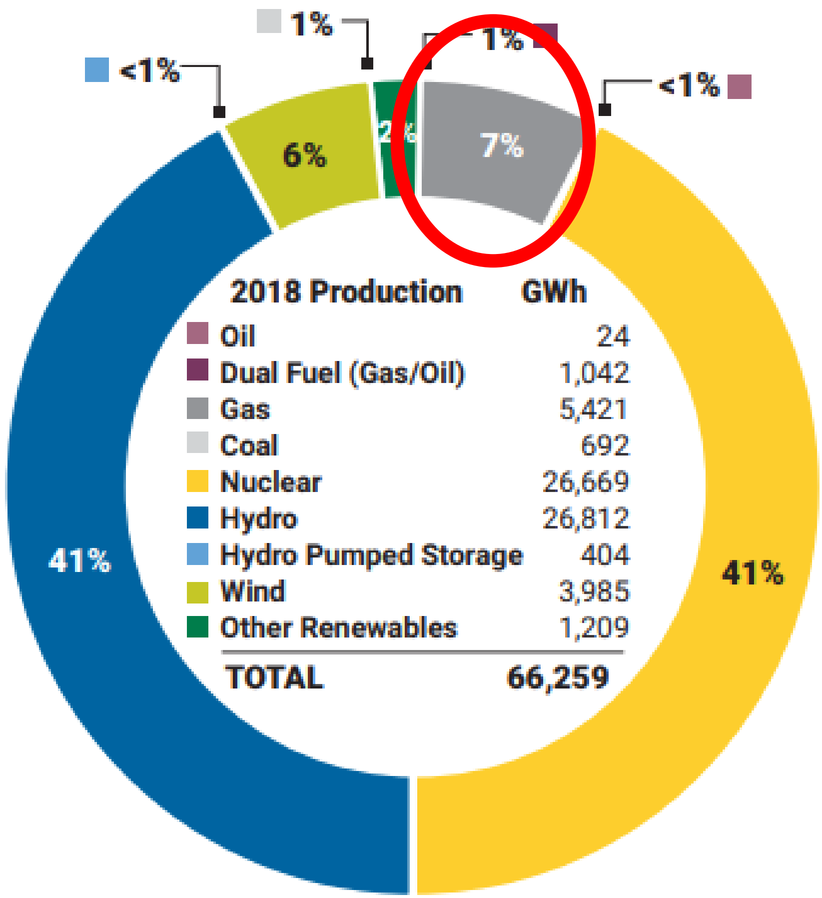
Average Emission Rate (AER) or Marginal Emission Rate (MER)?

Energy Production in Upstate NY, 2018



- NY State Average Emission Rate (MTonCO2/MW) is very low
- 89% carbon free electric production
- Renewables are dispatched first
- Gas generators are marginal units

Average Emission Rate (AER) or Marginal Emission Rate (MER)?

Upstate NY Grid

Average Emissions Rate
253 lb/MWh

Non-Baseload Emissions Rate
(Marginal Units)
932 lb/MWh (43% efficient)

Source: EPA eGRID Data
https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summary_tables.pdf

Cornell Central Energy Plant

Average CEP Emissions Rate
531 lb/MWh

Marginal CEP Emissions Rate
(Non-Condensing)
531 lb/MWh (75% efficient)

Marginal CEP Emissions Rate
(Condensing)
1327 lb/MWh (30% efficient)

Importance of Marginal Quantity when calculating your MER

The emission rate of a 1 MW change

is not the same

as the emission rate for a 15 MW change

External Influences

- Pending Changes to Regional Greenhouse Gas Initiative (RGGI)
  - Cornell's Central Energy Plant falls under the new regulation unless total export to NYSEG is reduced to less than 10% of total generation
- NY State Climate Leadership and Community Protection Act
  - Act is intended to initiate change toward decarbonization in the near future
  - NY State will establish a social cost of carbon value
- NYISO has proposed integrating a social cost of carbon into the wholesale energy market

What is the Value of Carbon Emissions?

Resources:

- Options for Achieving a Carbon Neutral Campus by 2035 Analysis - Cornell University Senior Leaders Climate Action Working Group September 2016

https://sustainablecampus.cornell.edu/sites/default/files/2018-12/Cornell%20University%20-%20Options%20for%20Achieving%20a%20Carbon%20Neutral%20Campus%20-%202016.pdf

- Second Nature - Internal Carbon Pricing in Higher Education Toolkit

https://secondnature.org/climate-action-guidance/carbon-pricing/

- EPA

https://www.epa.gov/environmental-economics/working-paper-social-cost-carbon-made-simple
https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html

- NY ISO carbon pricing initiative, Brattle Group study

https://www.nyiso.com/documents/20142/2244202/2017-Brattle-NY-Carbon-Study.pdf/156a738d-e471-ccad-e146-07ac593ec0c3

Lessons Learned

- Placing a value on carbon emissions will impact traditional CHP economic decision making
- Know how your plant emission rate compares to the grid's emission rate
- Understand what incremental emission rates (lbs/MWh) are appropriate for each of your operating decisions
- Understand the variability in your data
- Anticipate what information your organization's leadership needs in the transition to carbon neutrality.

Questions?

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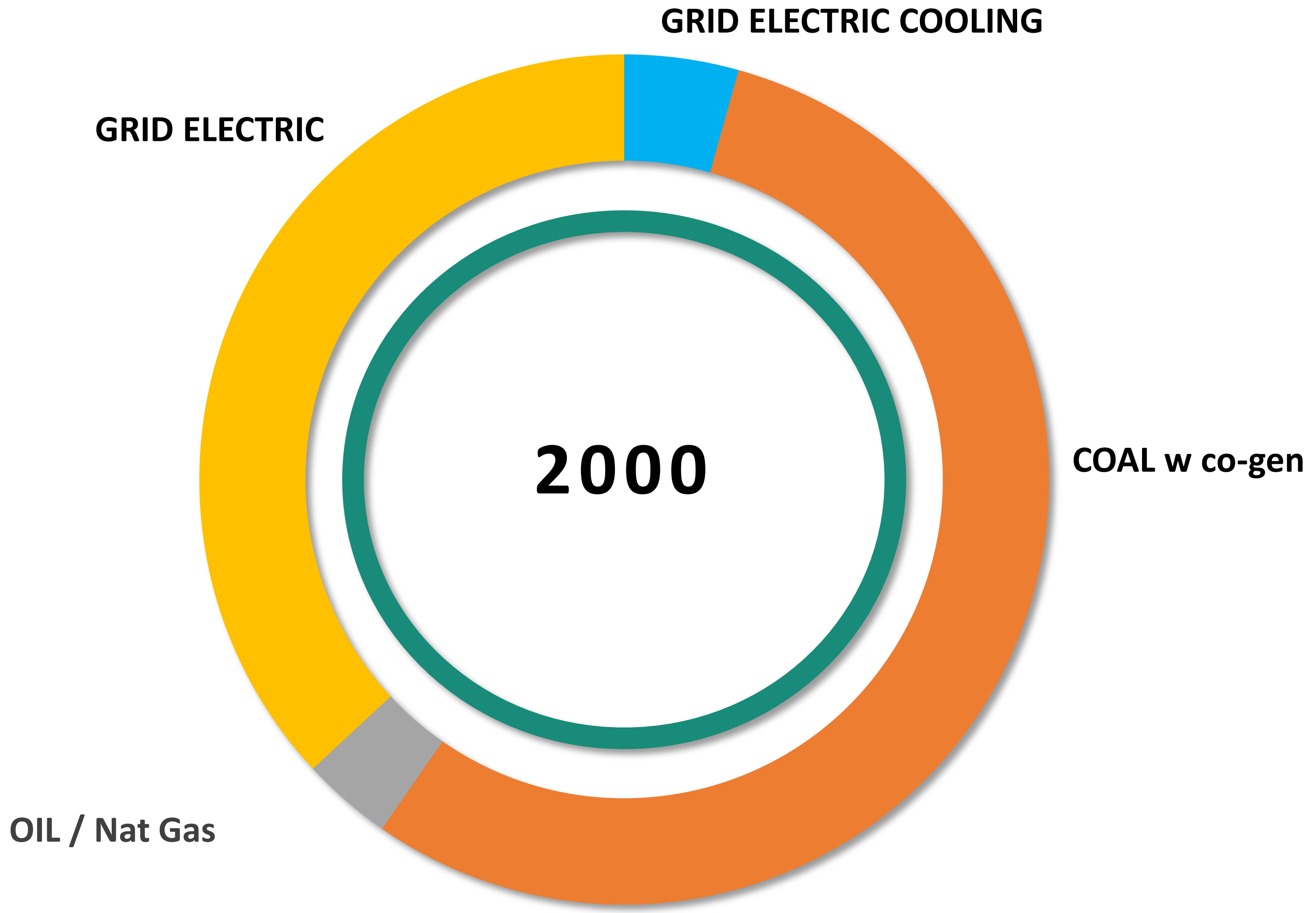
Back-Up Slides

DECARBONIZATION – PAST TO FUTURE

CORNELL DISTRICT PROFILE

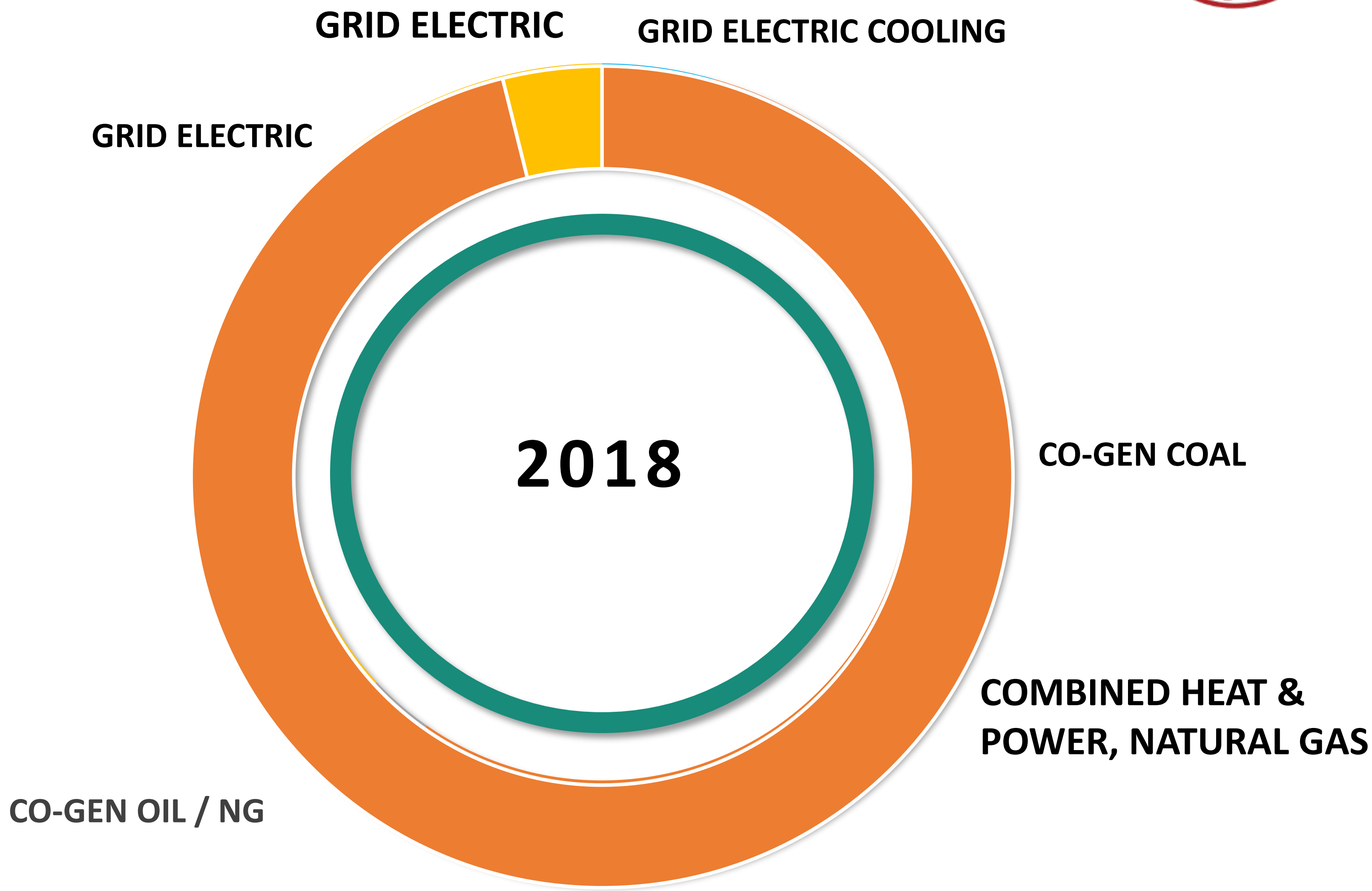
CARBON INTENSITY

2000 **260,000** $MTCO_2e$



DECARBONIZATION – PAST TO FUTURE

CORNELL DISTRICT PROFILE



CARBON INTENSITY

2000 **260,000** MTCO_2e

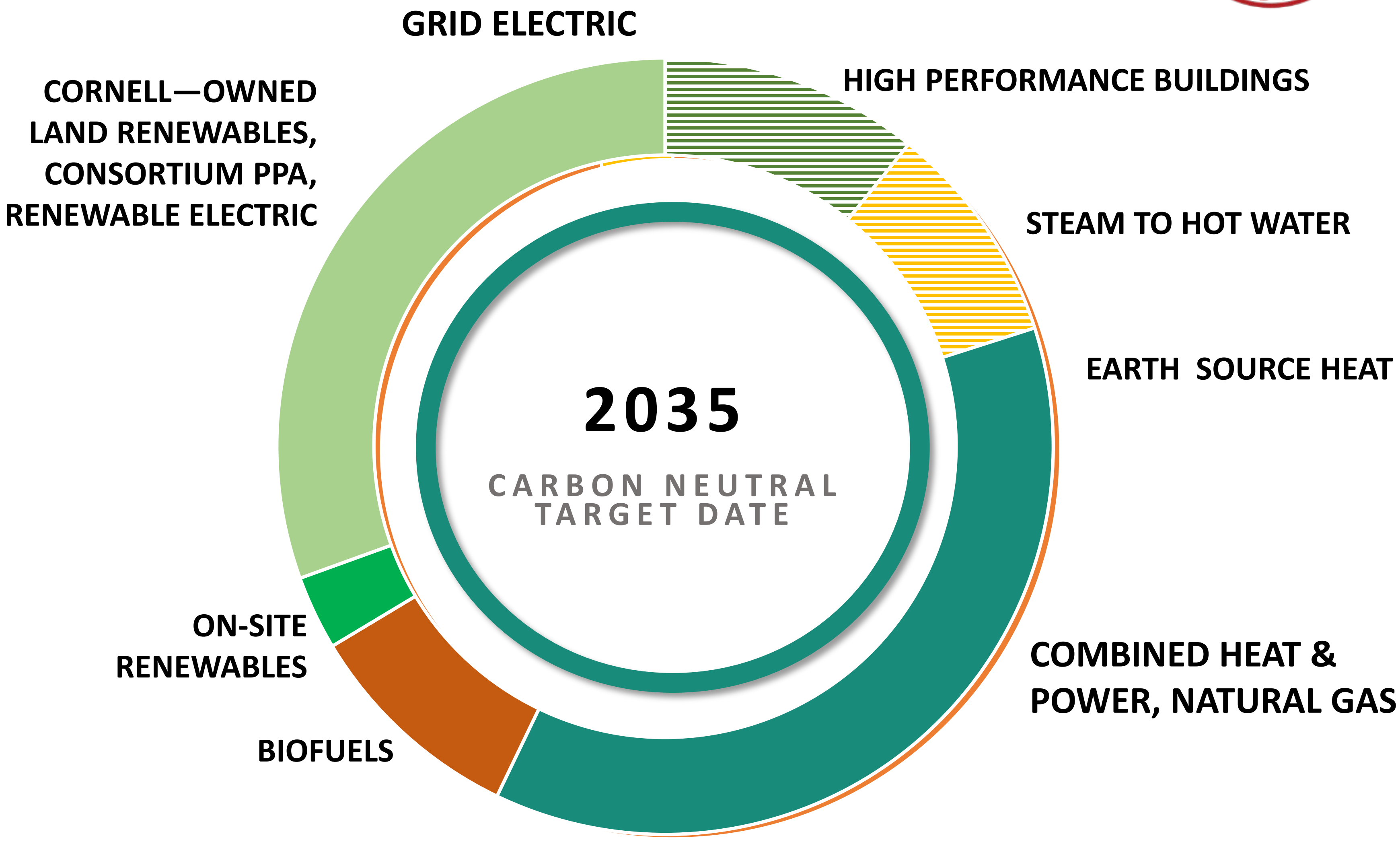
2018 **165,000** MTCO_2e

DECARBONIZATION – PAST TO FUTURE

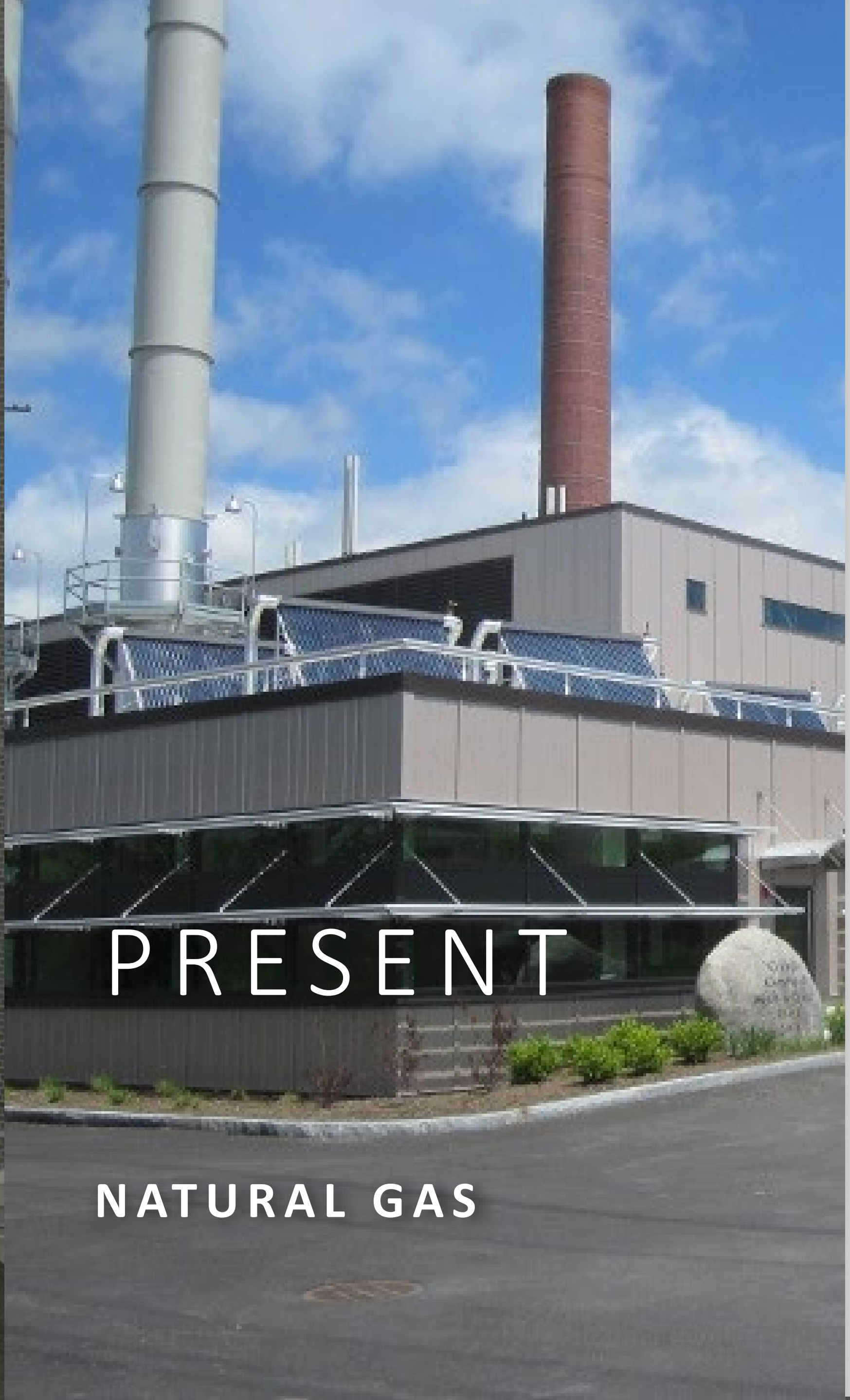
CORNELL DISTRICT PROFILE

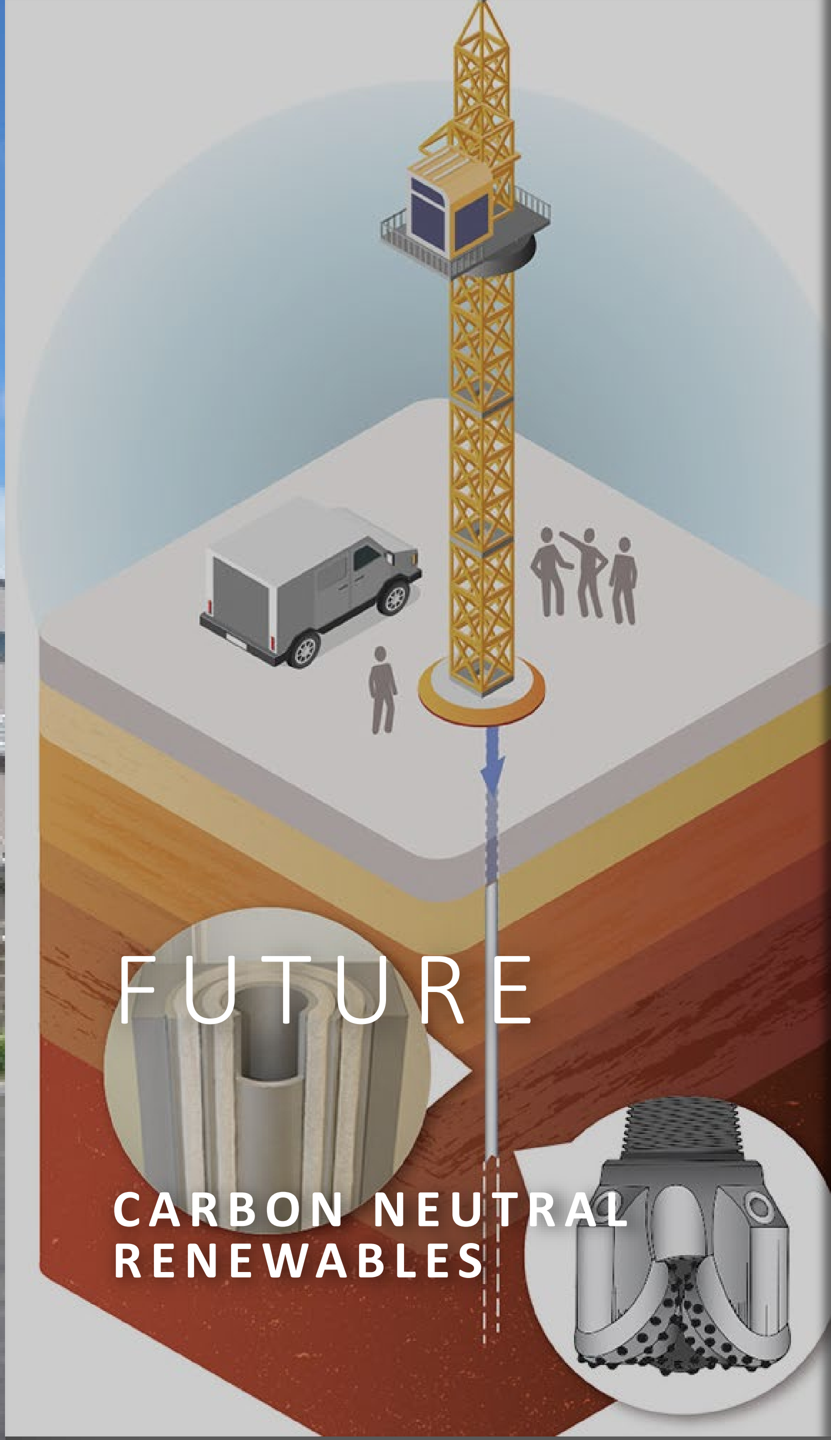
CARBON INTENSITY

2000	260,000 $MTCO_2e$
2018	165,000 $MTCO_2e$
2035	~0 $MTCO_2e$




CORNELL UNIVERSITY
PAST
COAL
June 2019


PRESENT
NATURAL GAS


FUTURE
CARBON NEUTRAL
RENEWABLES

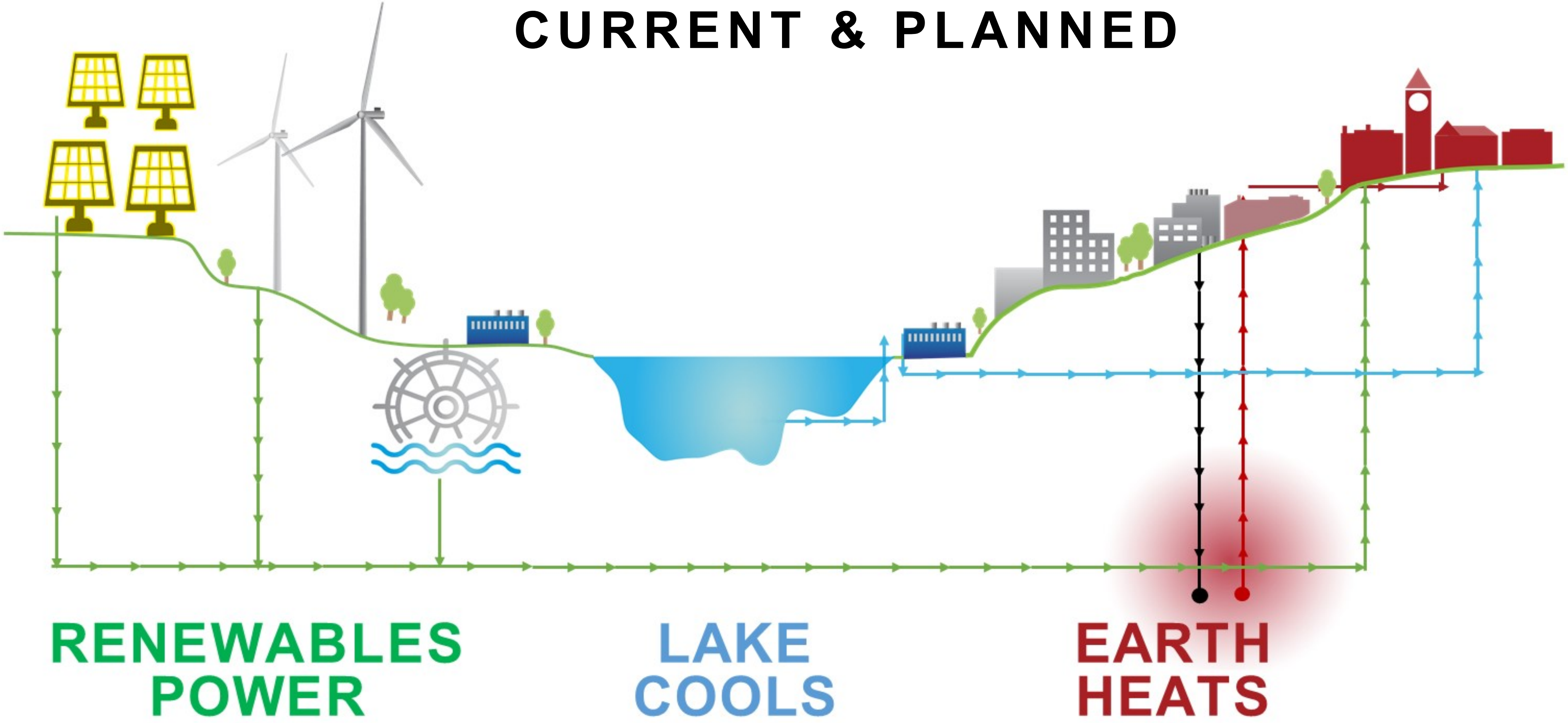

CORNELL UNIVERSITY
CAMPUS SIZE: 14,000,000 GSF
District Energy Connected


CORNELL UNIVERSITY
ELECTRIC: 35 MW_e (PEAK)
STEAM: 90 MW_{th} (PEAK)
COOLING: 90 MW_{th} (PEAK)

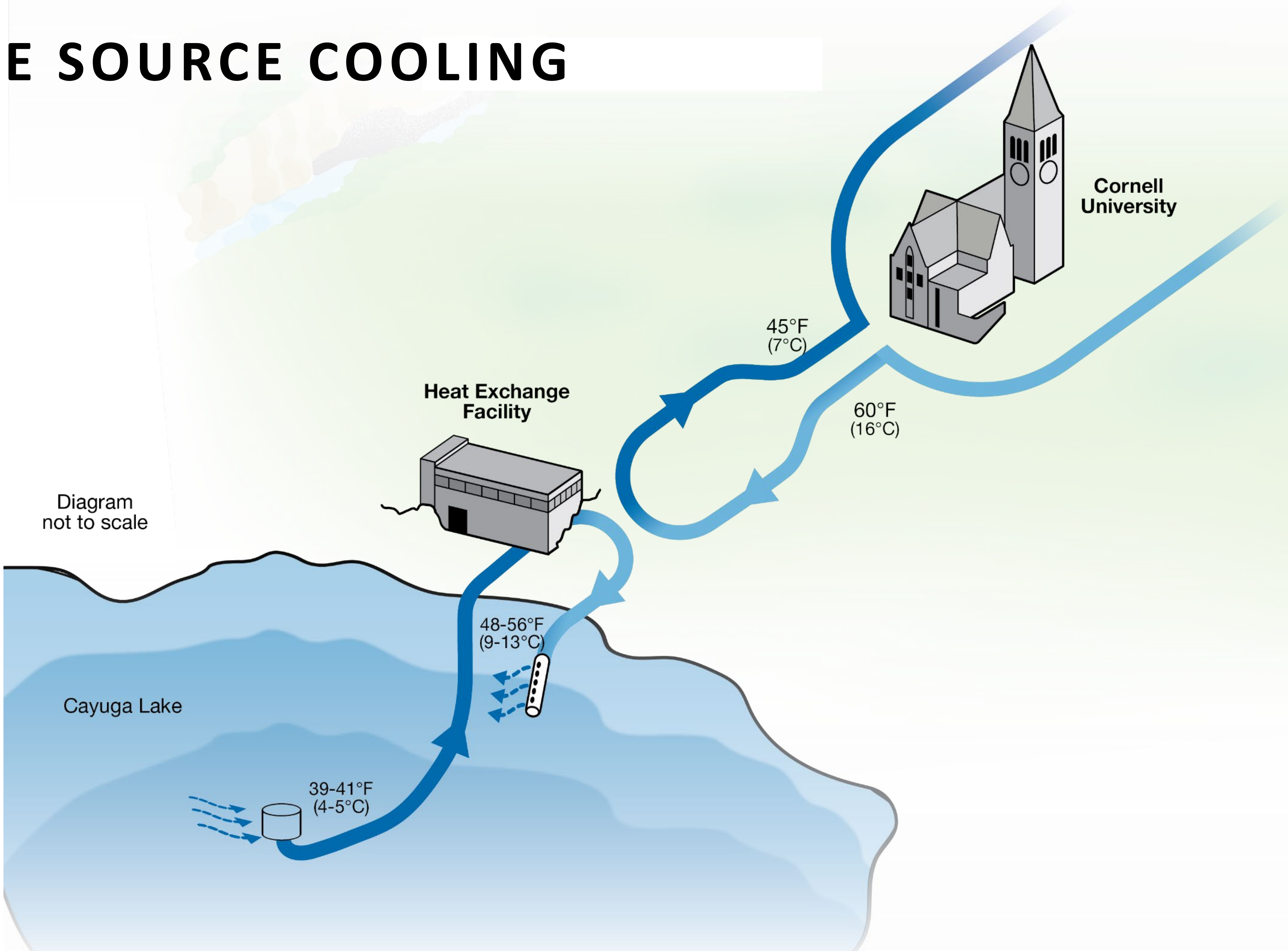
LAKE SOURCE COOLING

2035 CORNELL CARBON NEUTRAL DISTRICT ENERGY

CURRENT & PLANNED



LAKE SOURCE COOLING



CORNELL EARTH SOURCE HEAT