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# CORNELL UNIVERSITY ENERGY MASTER PLAN

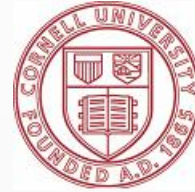


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Inc.

LEVITAN & ASSOCIATES, INC.

# Energy Master Plan (EMP) Study

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- ❑ History and Goals
- ❑ Current Thermal Energy Equipment
- ❑ Future Technologies Evaluated
- ❑ Methodology
- ❑ Financial Analysis
- ❑ Strategic Considerations
- ❑ Recommendations

# History and Goals

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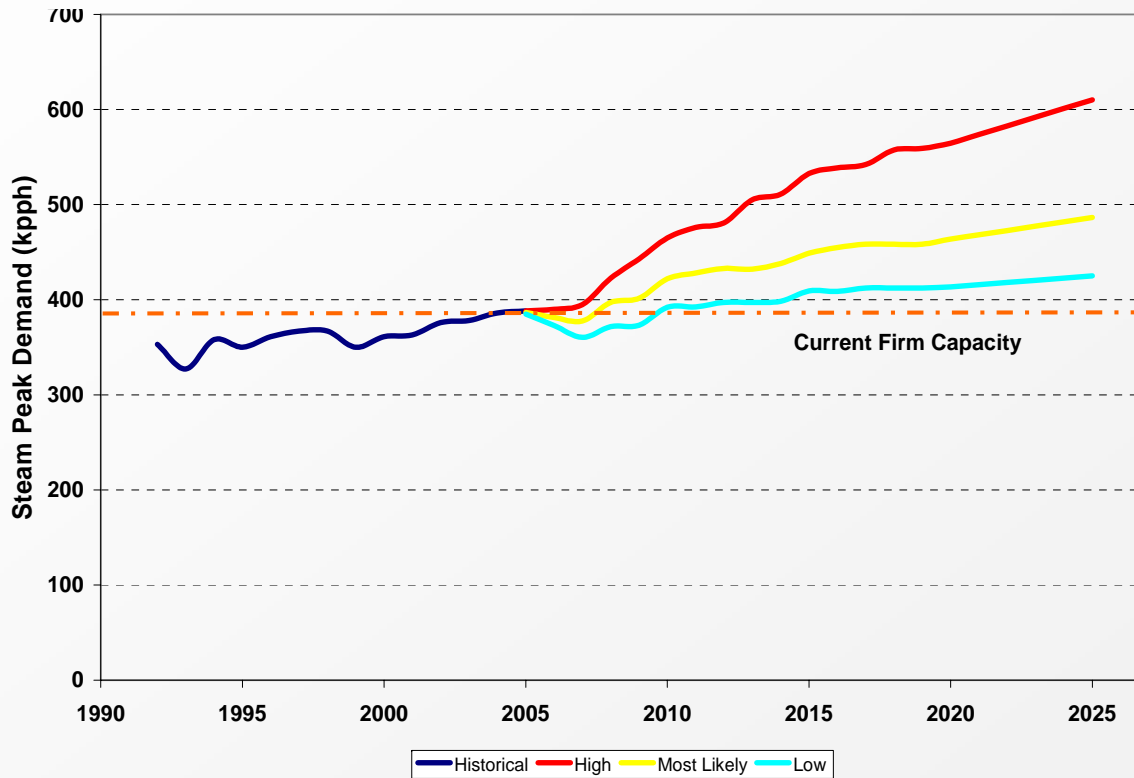
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- ❑ Master planning since 1919
- ❑ Drivers for current EMP:
  - Campus growth
  - Capital renewal in Cornell's Central Heating Plant (CHP)
  - Volatile fuel and electric markets
  - Increasing environmental regulation and awareness
  - Need for predictable costs

# Steam Load Forecasts



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# CHP Boilers

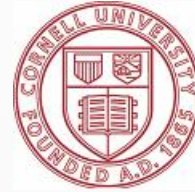


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<b>Boiler No.</b>	<b>Fuel</b>	<b>Capacity (klb/h)</b>	<b>Boiler Type</b>	<b>Year Installed</b>	<b>Outlet Conditions (psig/°F)</b>
1	Coal	90	Spreader Stoker	1981	400/600
2	#6 Fuel Oil	70	Sterling Vibragate	1959	200/550
5	Natural Gas	100	D Type Package	1965	200/550
6	Natural Gas or #6 Fuel Oil	107.5/ 109.5	D Type Package	1992	400/640
7	Natural Gas or #6 Fuel Oil	107.5/ 109.5	D Type Package	1992	400/640
8	Coal	175	Overfeed Stoker	1949	400/600

# Future Technologies Evaluated

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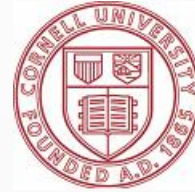


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- ❑ Package boilers capable of burning natural gas or oil
- ❑ Atmospheric Circulating Fluidized Bed (ACFB) to replace Boiler 8
- ❑ Biomass boiler
- ❑ One or two Gas Turbines (GT) with Heat Recovery Steam Generators (HRSG)

# Methodology

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- ❑ Statistical analysis of historical fuel and energy prices to determine volatility parameters
- ❑ Statistical analysis of campus loads to determine daily profiles and variability for each season
- ❑ Base scenario forecast of monthly fuel prices delivered to Cornell and nearby electric generators

## Methodology (cont.)

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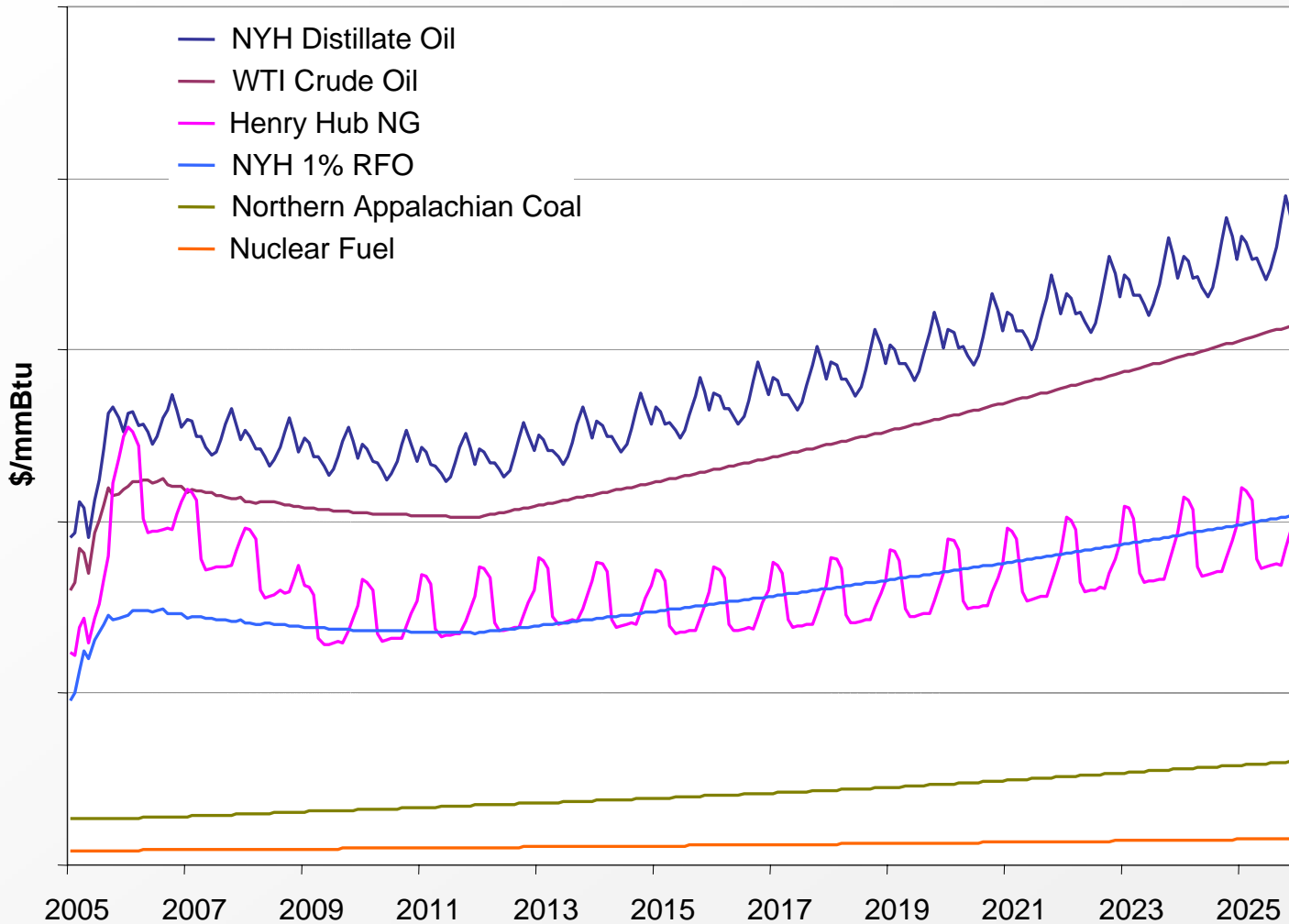
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- ❑ Consistent forecast of hourly regional electric prices based on chronological simulation model of regional electric market
- ❑ Base scenario forecast of Cornell's steam and electric loads based on monthly building requirements
- ❑ Alternative scenarios reflecting high and low fuel price forecasts and high and low growth projections

# Fuel Price Forecast



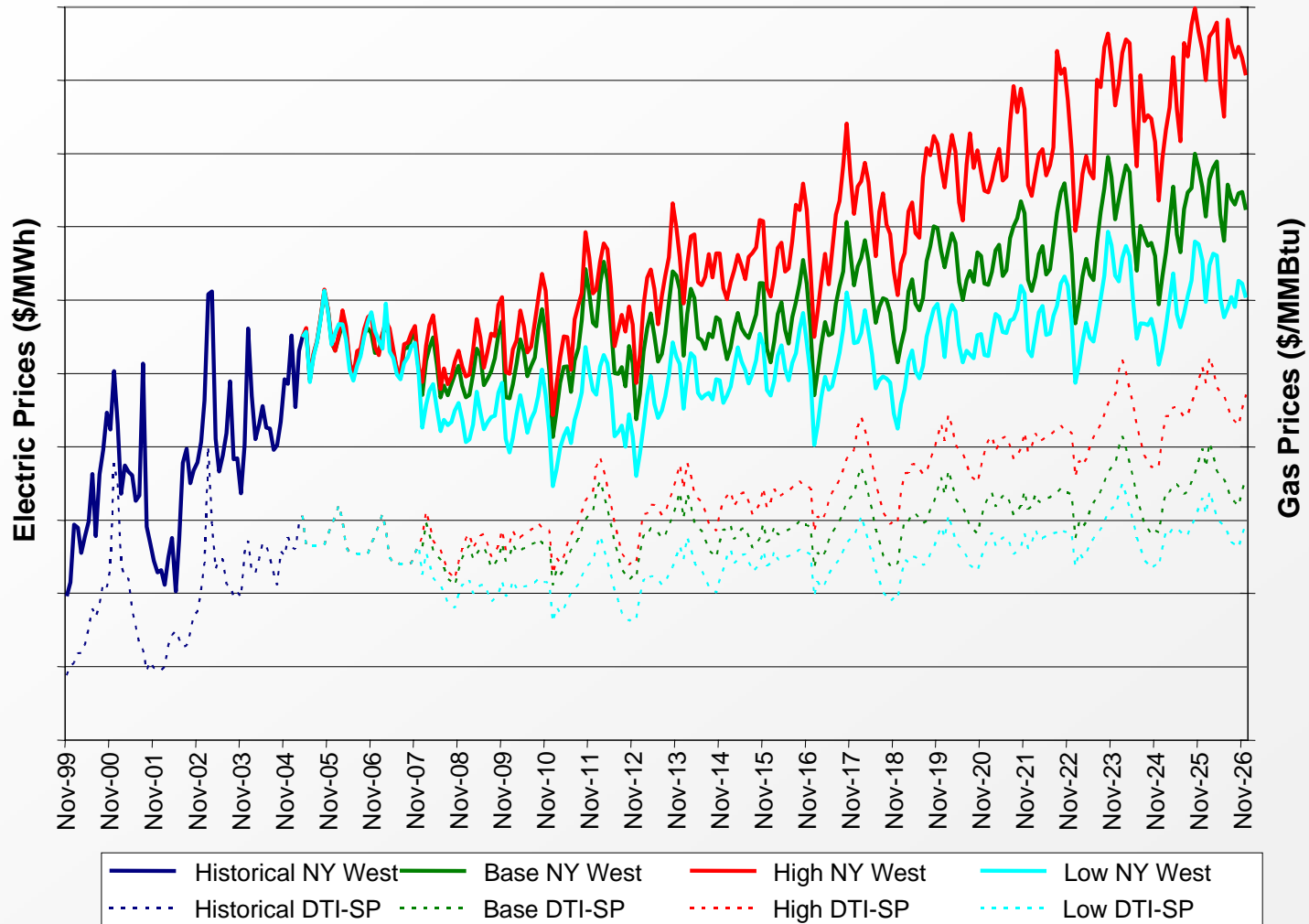
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# Electricity Price Forecast



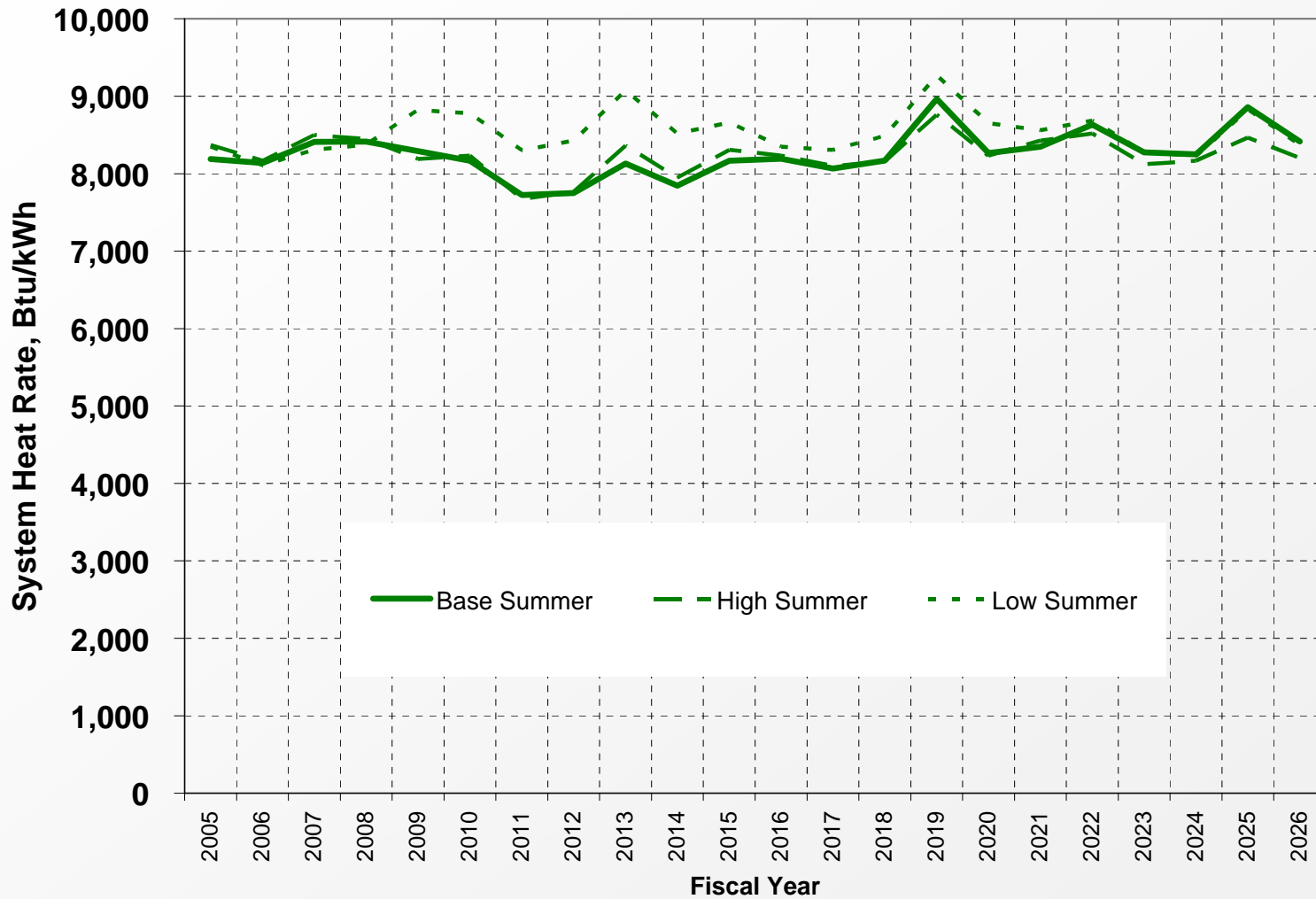
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# Summer System Heat Rates



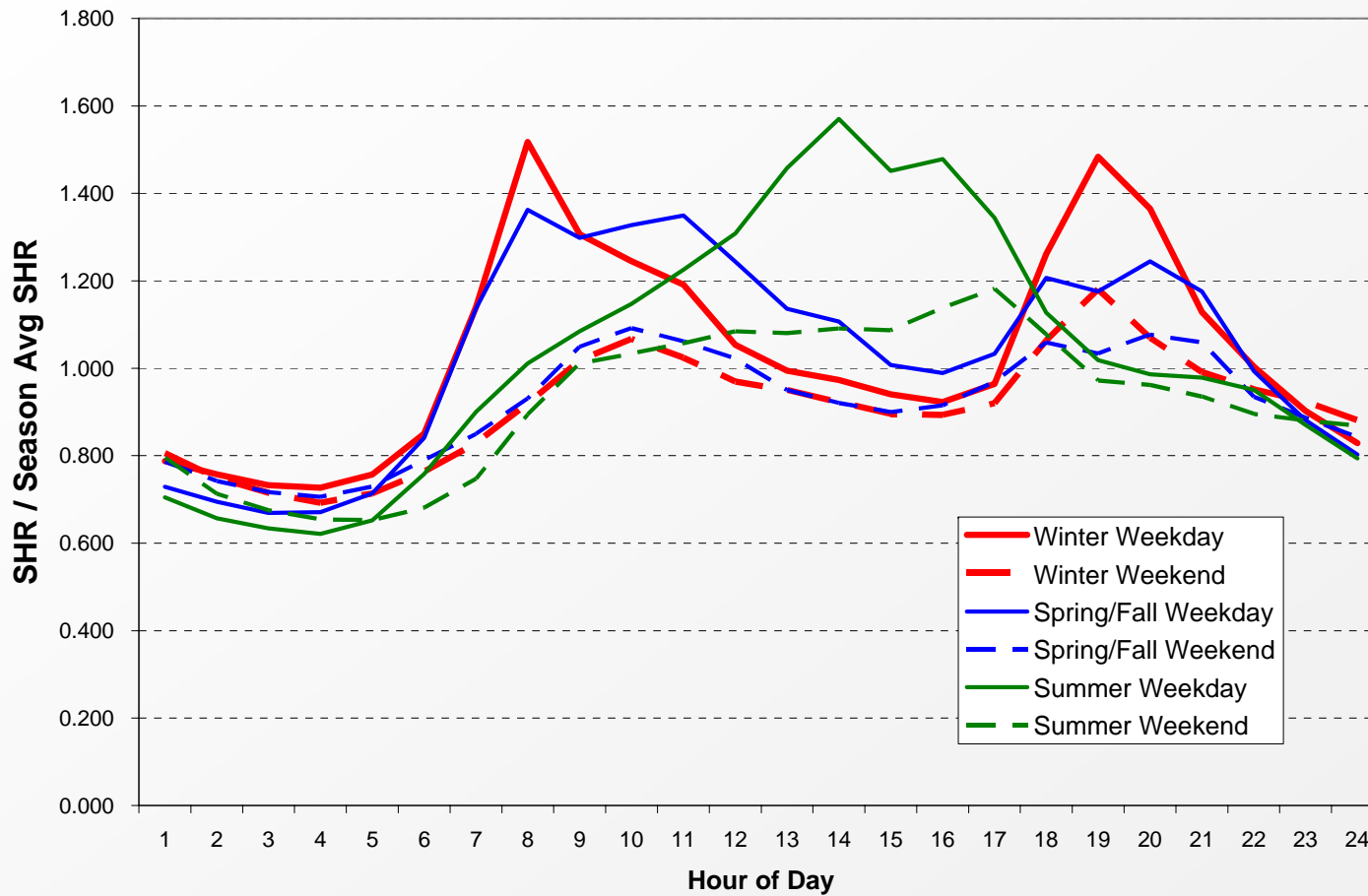
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# System Heat Rate Profiles



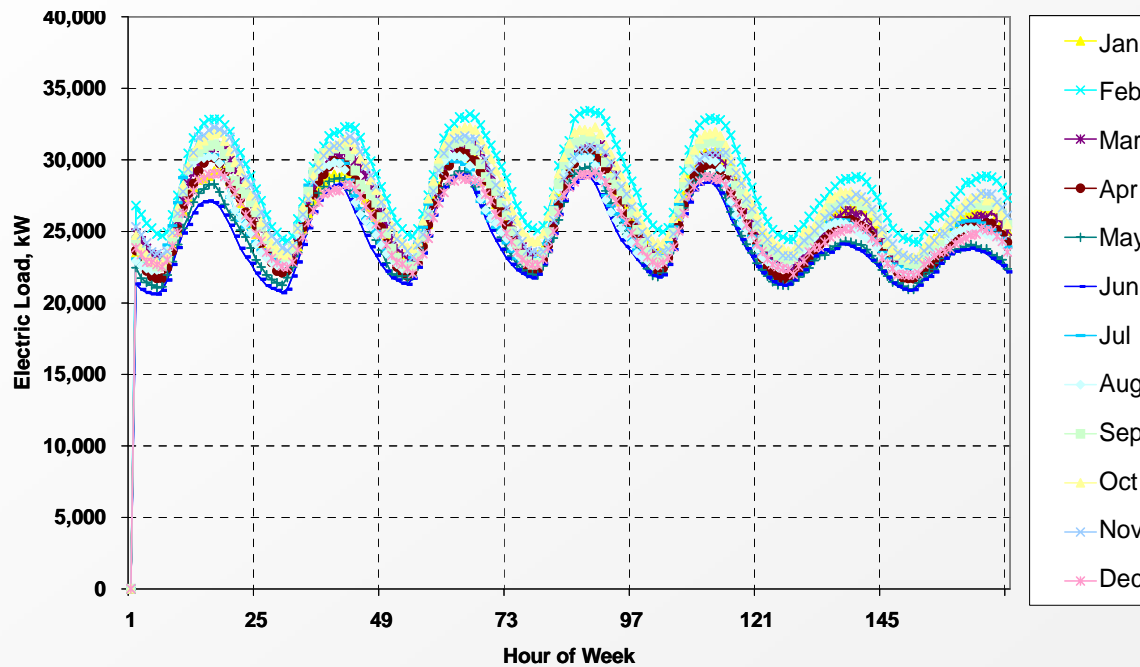
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# Weekly Electric Profiles by Month



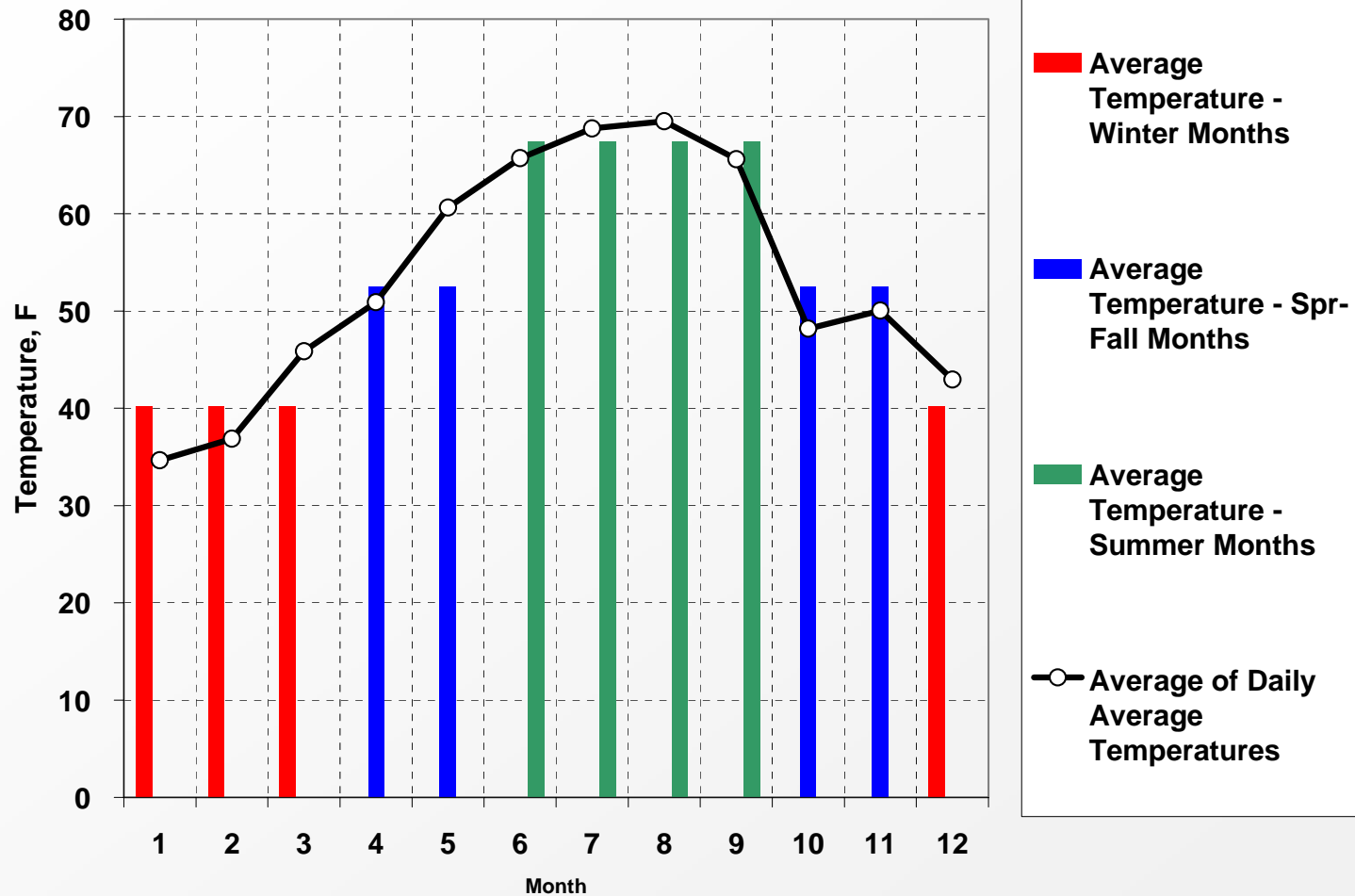
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# Ambient Temperature by Month, Season



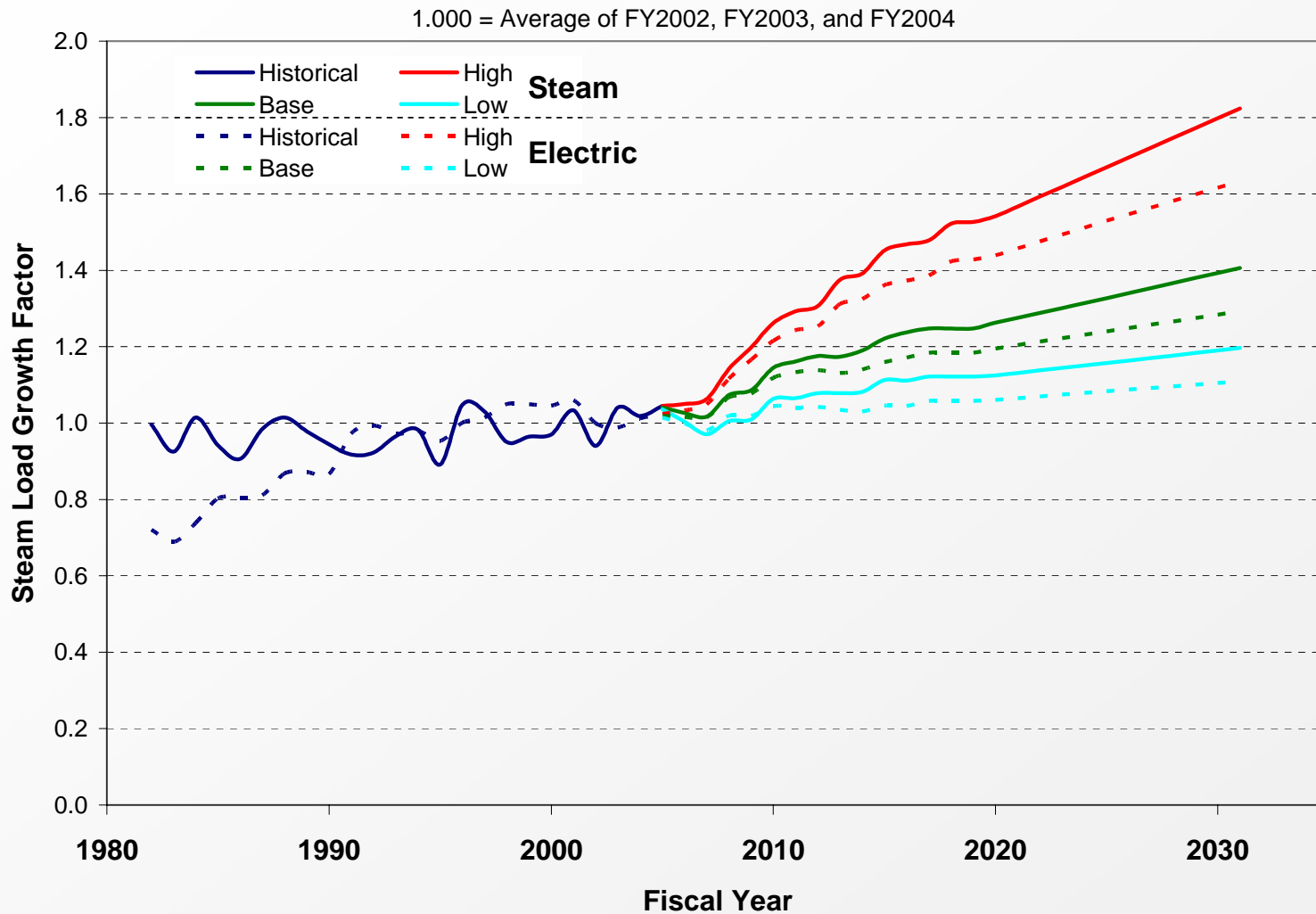
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# Steam and Electric Load Growth Factors



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# Financial Analysis

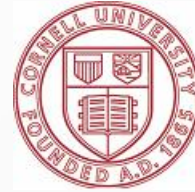
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- ❑ Simulated 25 years of operation (2007-2031)
- ❑ Used Monte Carlo simulation to capture short term variability and volatility effects on
  - loads
  - fuel prices
  - electric energy market heat rate
  - steam unit availability

## Financial Analysis (cont.)



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- ❑ Phase 1 screening
  - Package boiler and GT cases have very similar total costs
  - ACFB has higher cost
  - Biomass boiler is the most expensive
- ❑ Phase 2 probabilistic analysis on three types of variables:
  - Short-term
  - Near-term event
  - Long-term

## Phase 2 Near-Term Technology Choices

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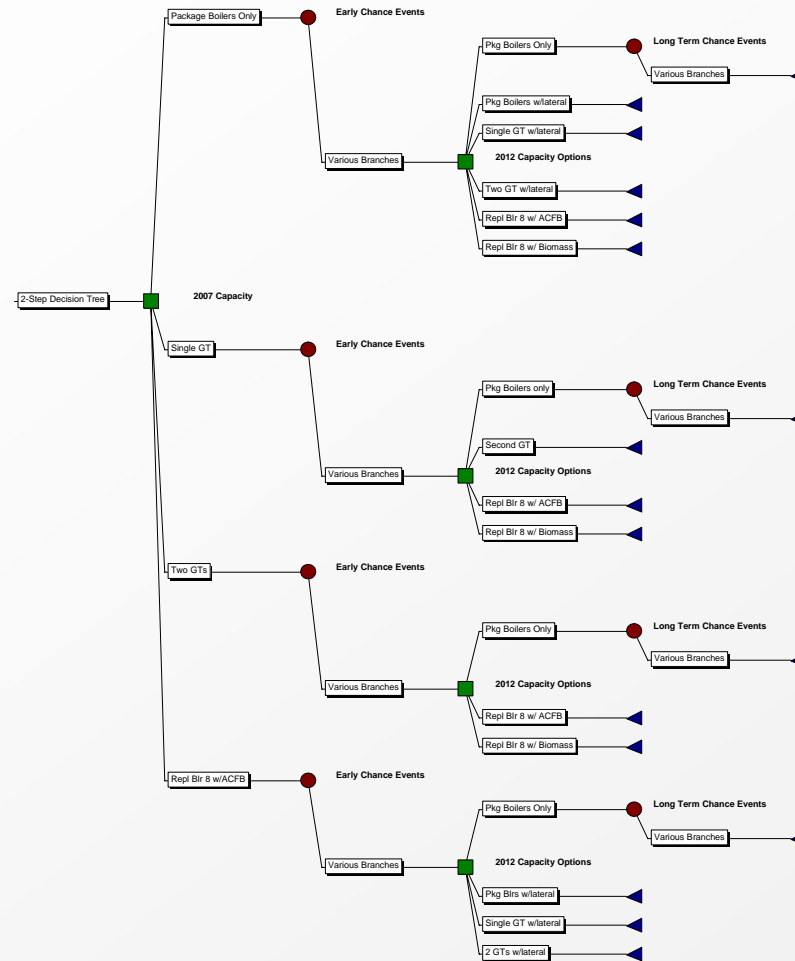
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- ❑ Package boilers as needed to meet reliability criterion
- ❑ Single GT for FY2008
- ❑ Two GTs for FY2008
- ❑ Boiler 8 replaced with ACFB boiler for FY2008

# Phase 2 Decision Tree



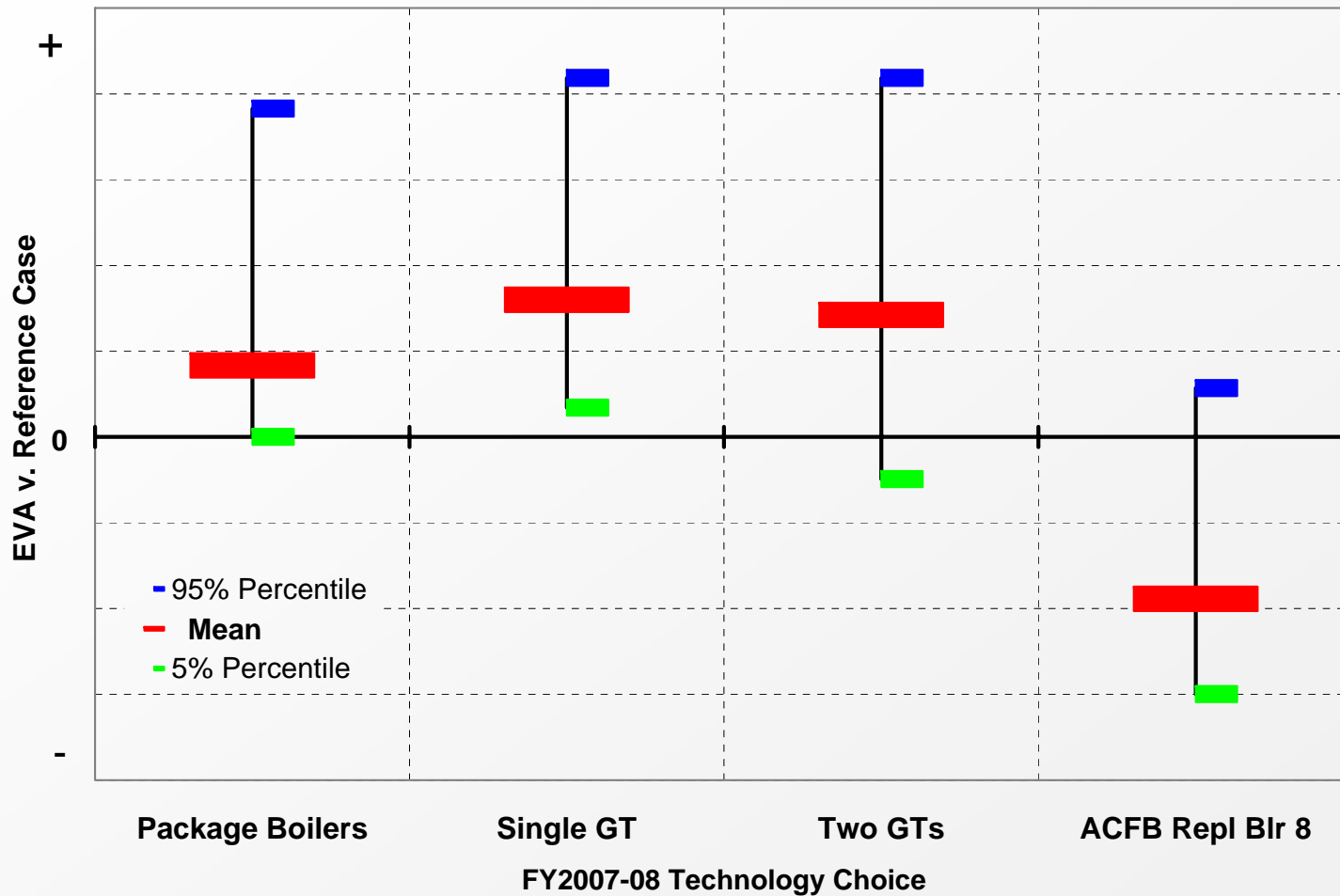
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# EVA Confidence Intervals – All Variables



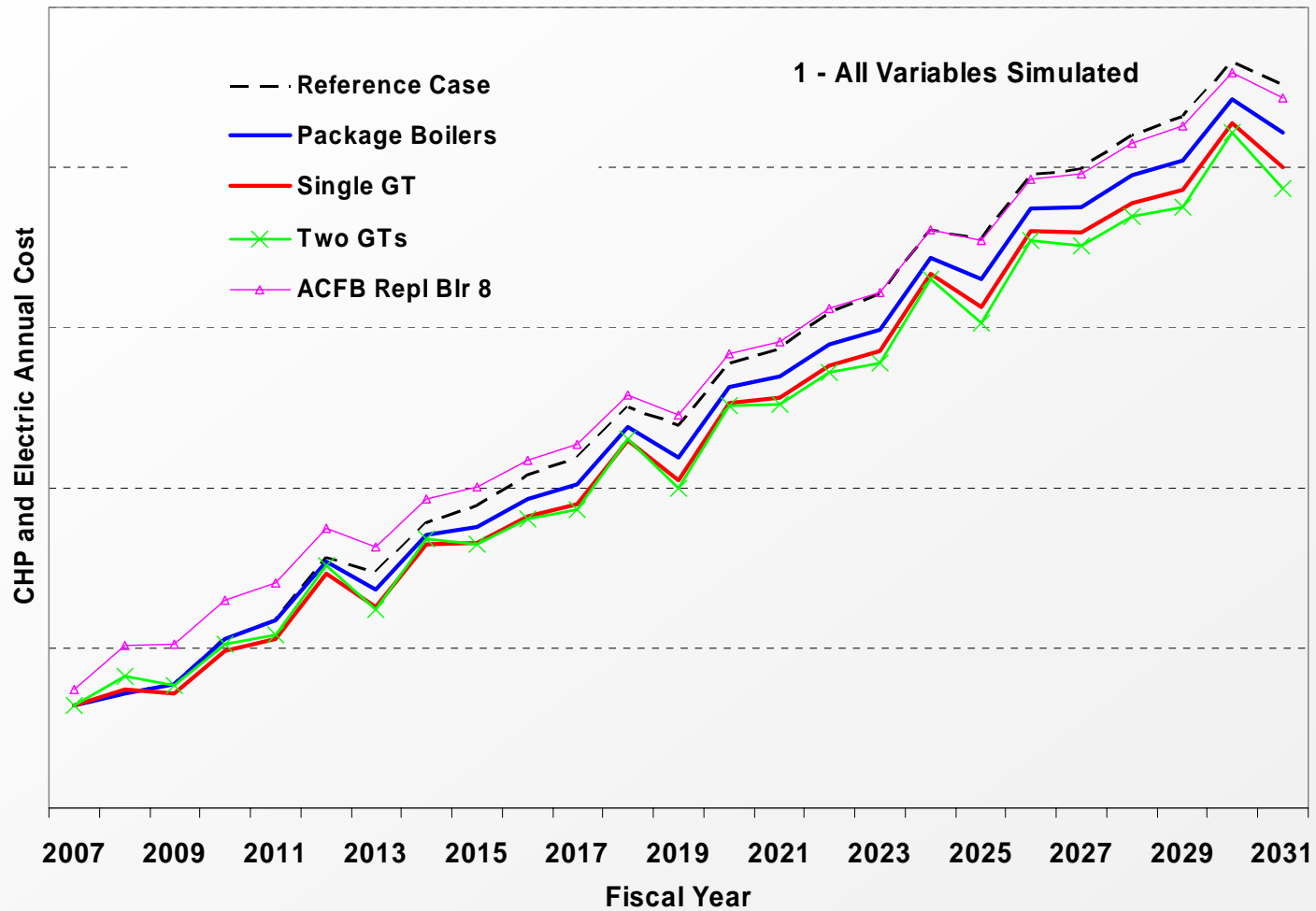
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# Annual Cost Comparison

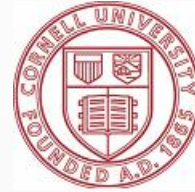


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# Strategic Considerations

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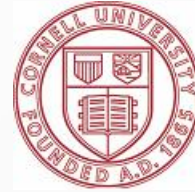


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- ❑ Electric reliability
  - Black start capability for most campus electric loads
  - Benefits of “islanded” operation

## Recommendations

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- ❑ Replacing Boiler 8 with Biomass or ACFB does not make sense
- ❑ Most attractive initial choice is installation of single 14 MW GT with infrastructure to support second GT in future