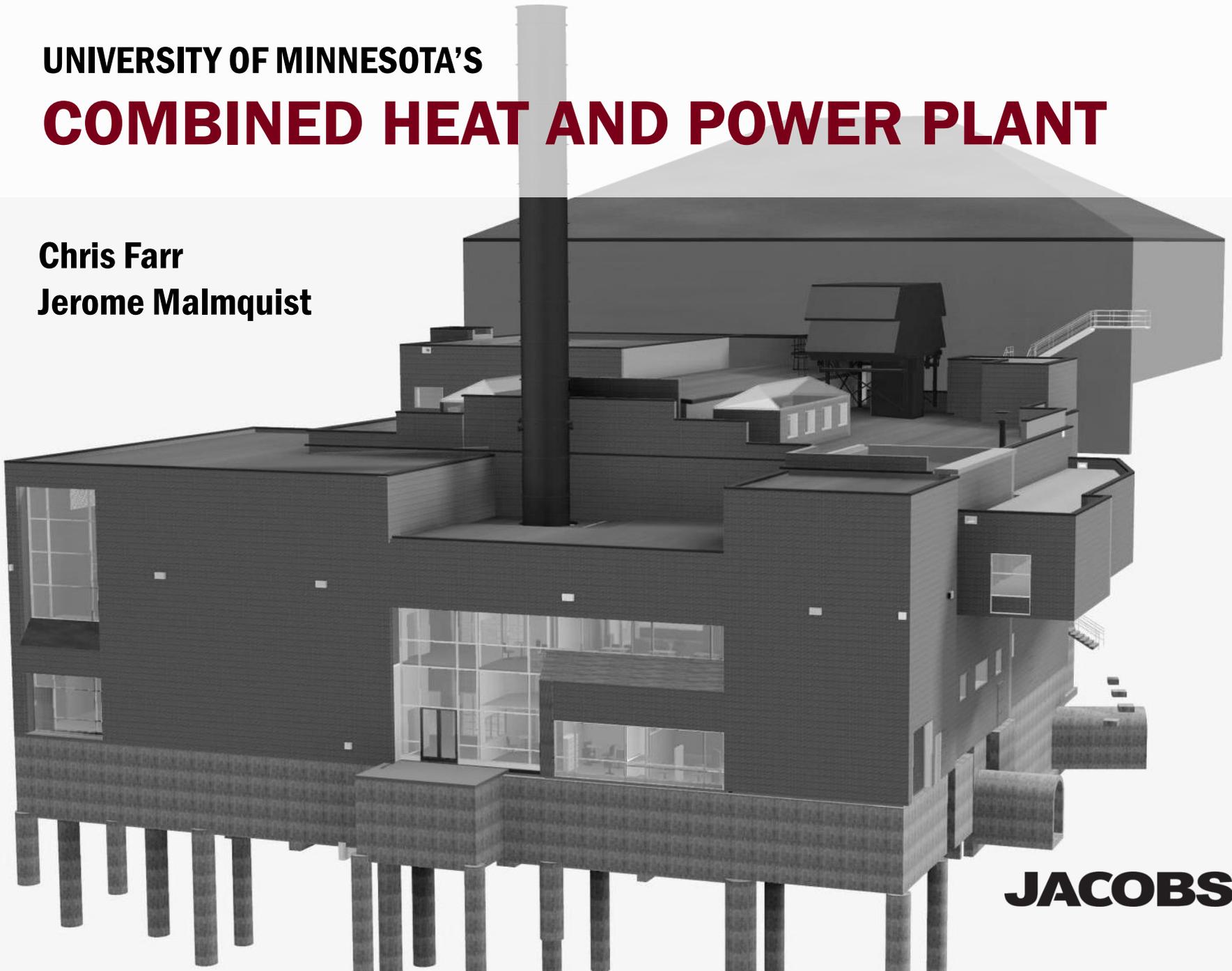


UNIVERSITY OF MINNESOTA'S

COMBINED HEAT AND POWER PLANT

Chris Farr

Jerome Malmquist



JACOBS®



ENERGY MANAGEMENT PRINCIPLES



Reliable



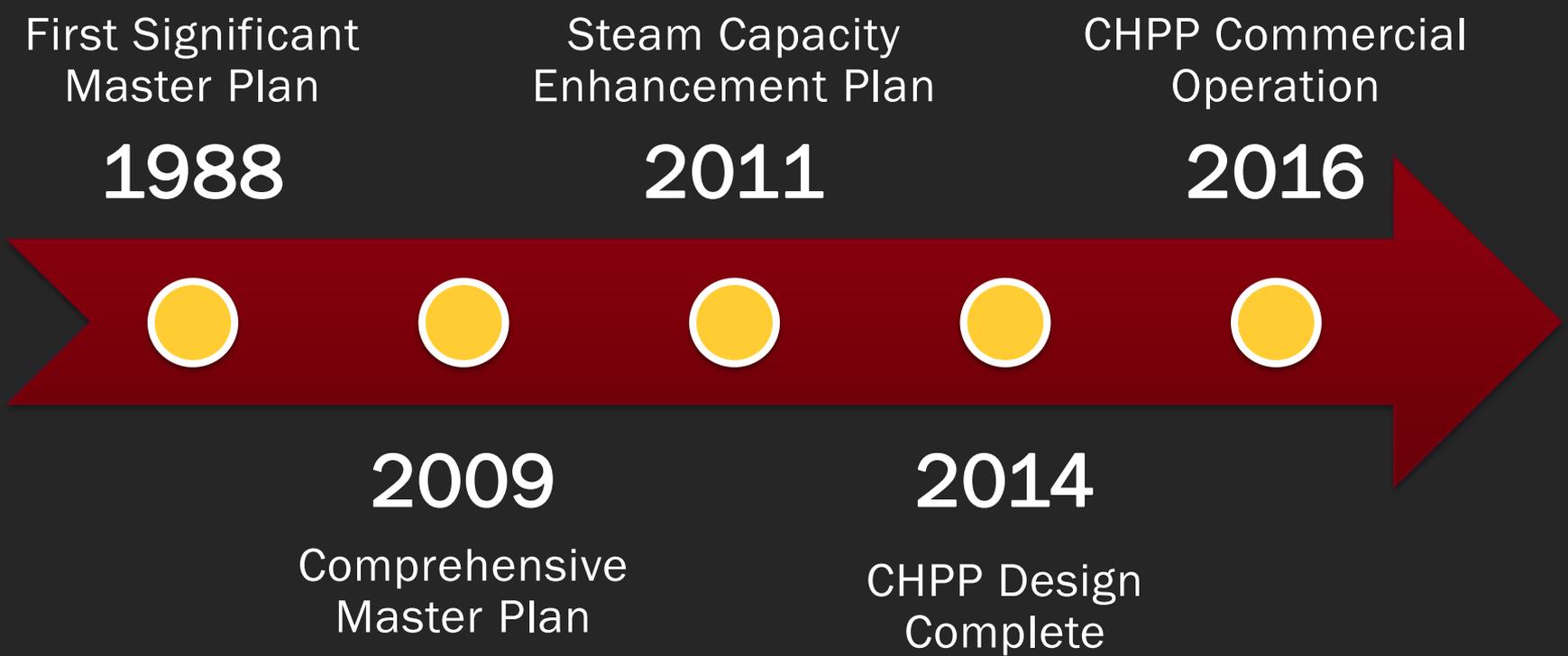
Sustainable



Cost-effective



PATHWAY TO CHP





TIME TO MOVE FORWARD BUT.....

NOTHING IS EASY.....

- In and on a hazardous waste site
- On a National water way
- In the middle of a large metropolitan area
- Next to high density housing
- In a bike path
- Below a walking and biking bridge
- Hanging on a cliff
- Limited access
- On a college campus.... AND....
- The electric utility was not thrilled about losing sales

What could possibly go wrong?!!

**University of Minnesota
Aerial Site Photo**



**COAL
STORAGE**

**OLD MAIN
HEATING PLANT**

**INCINERATOR
BUILDING**

**MISSISSIPPI
RIVER**

River Rd E

River Rd E



RIGHT SIZING PROCESS

**Develop
Load
Profiles**

Heat
Balance
Modeling

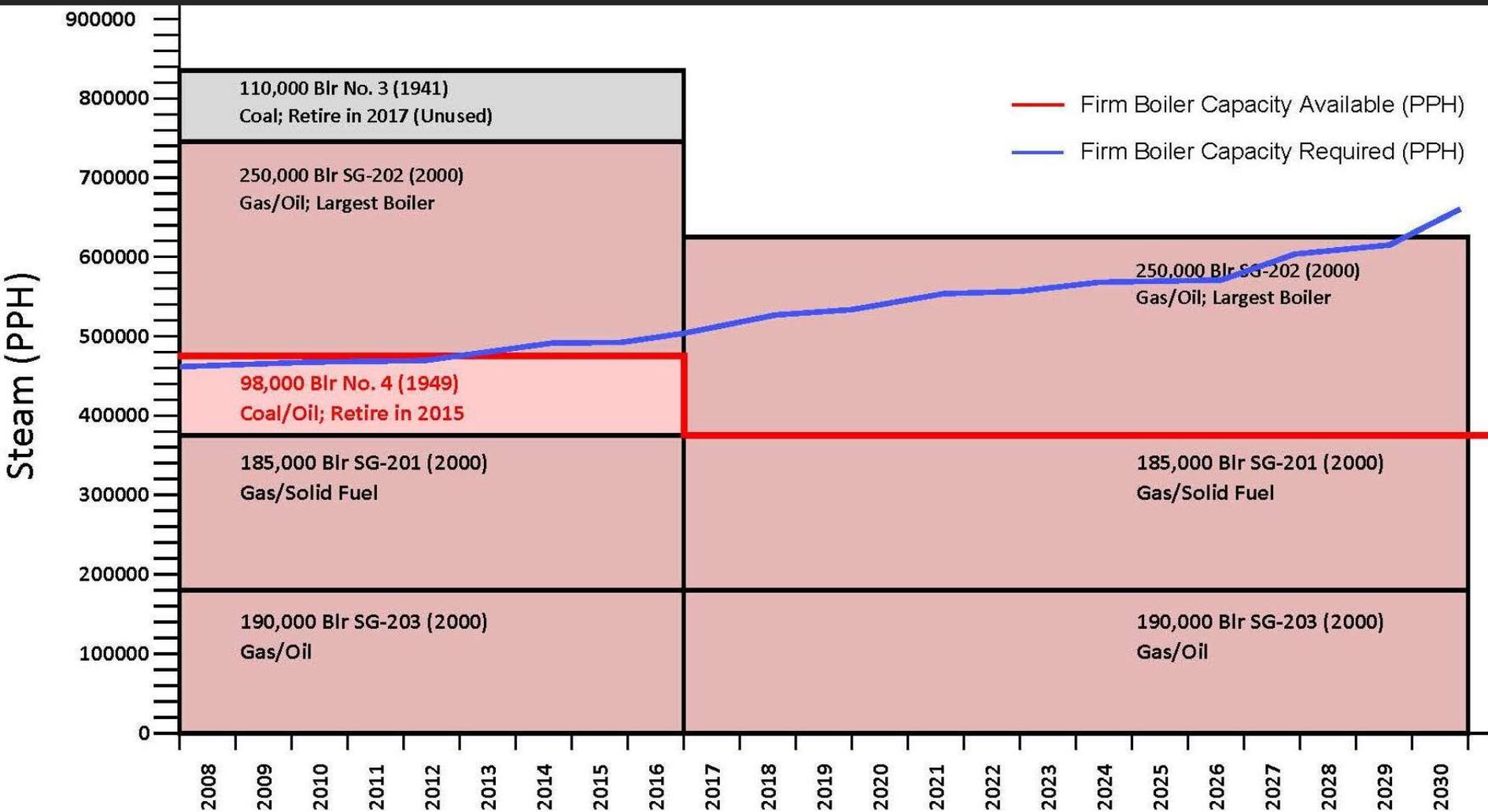
Financial
Analysis

Sensitivity
Analysis

- Hourly steam demand history
- Hourly electrical demand history
- Load growth projections

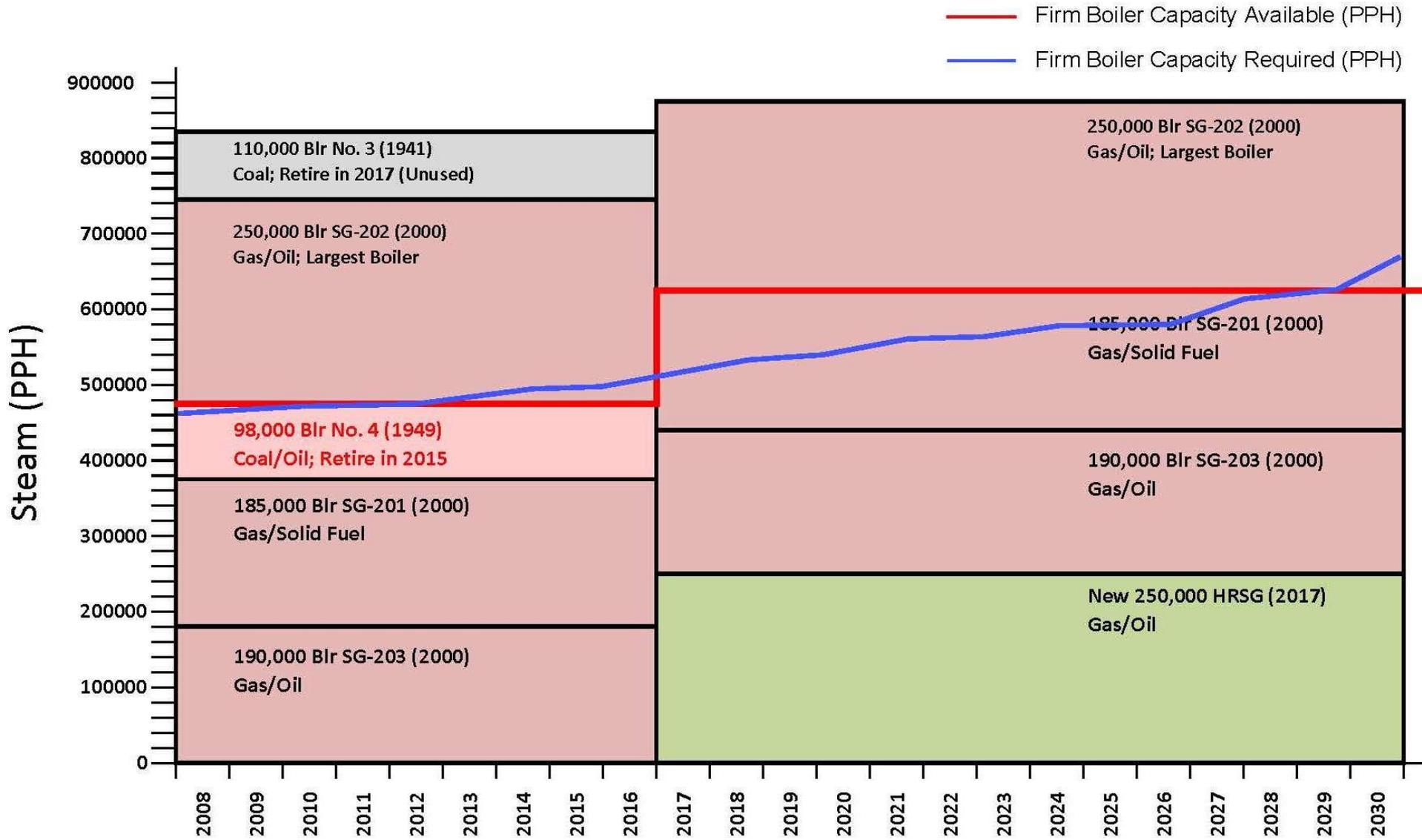


RIGHT SIZING PROCESS





RIGHT SIZING PROCESS





RIGHT SIZING PROCESS

Develop
Load Profiles

**Heat
Balance
Modeling**

Financial
Analysis

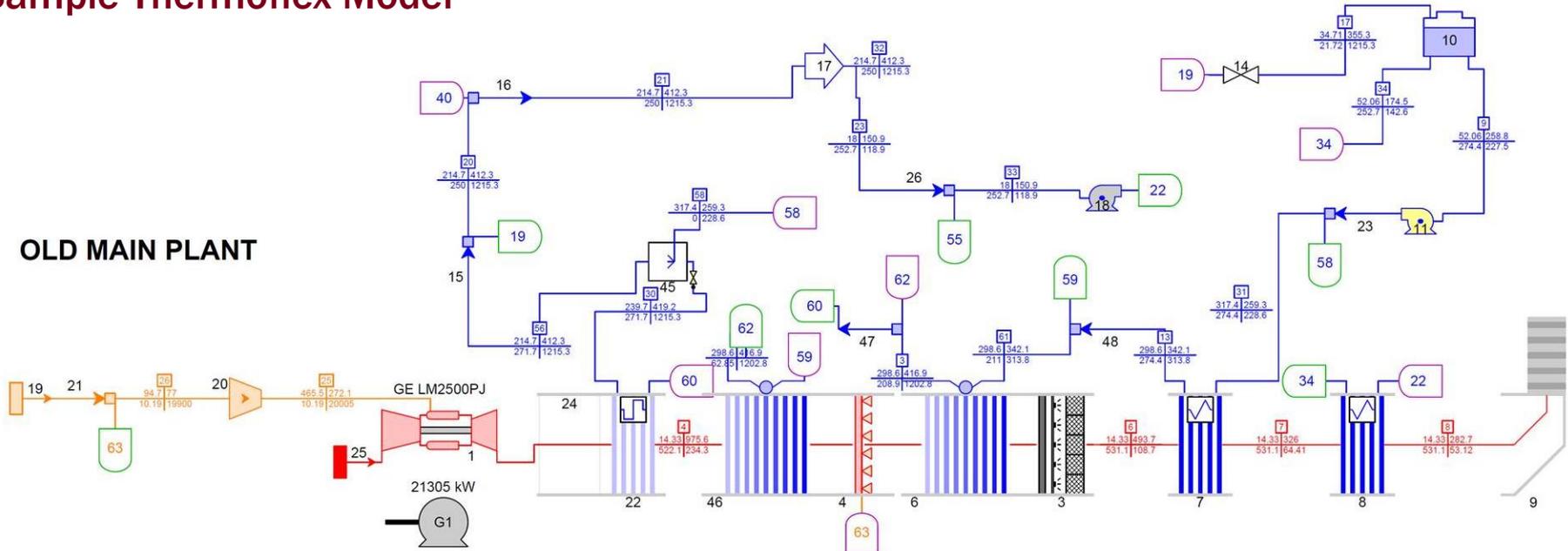
Sensitivity
Analysis

- Thermoflex graphical heat balance software coupled with high-resolution spreadsheet models
- Entire coordinated system (multiple plants) must be modeled
- Evaluate campus performance under varying **load and ambient conditions**

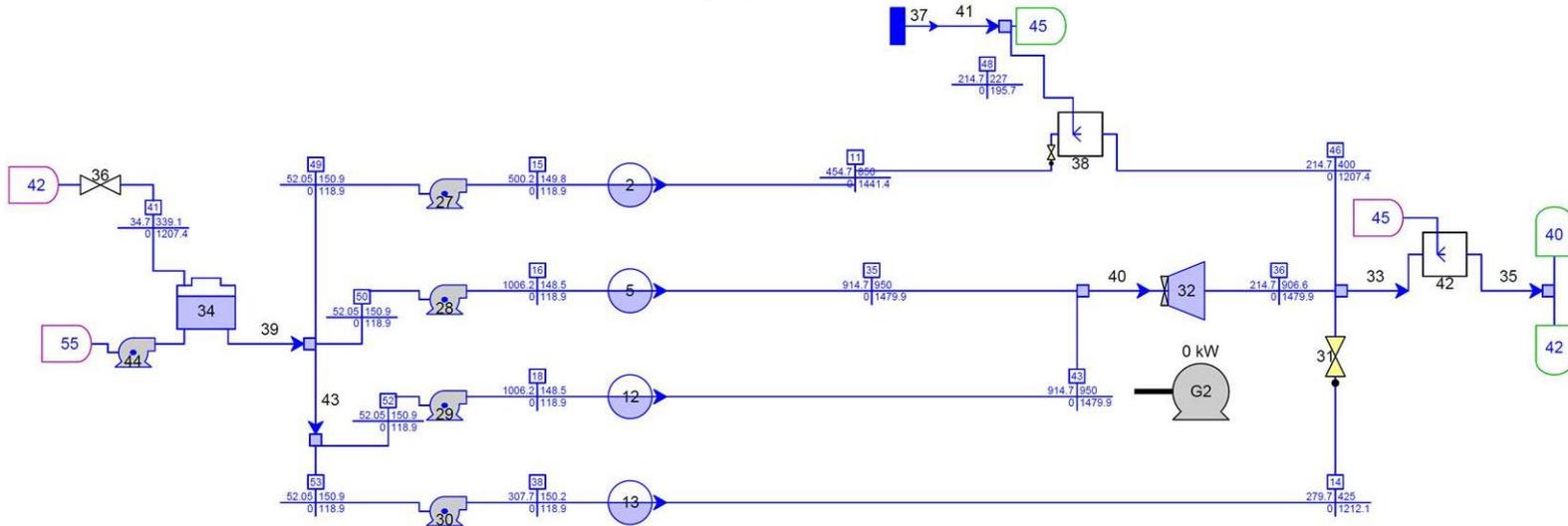
University of Minnesota

Sample Thermoflex Model

OLD MAIN PLANT

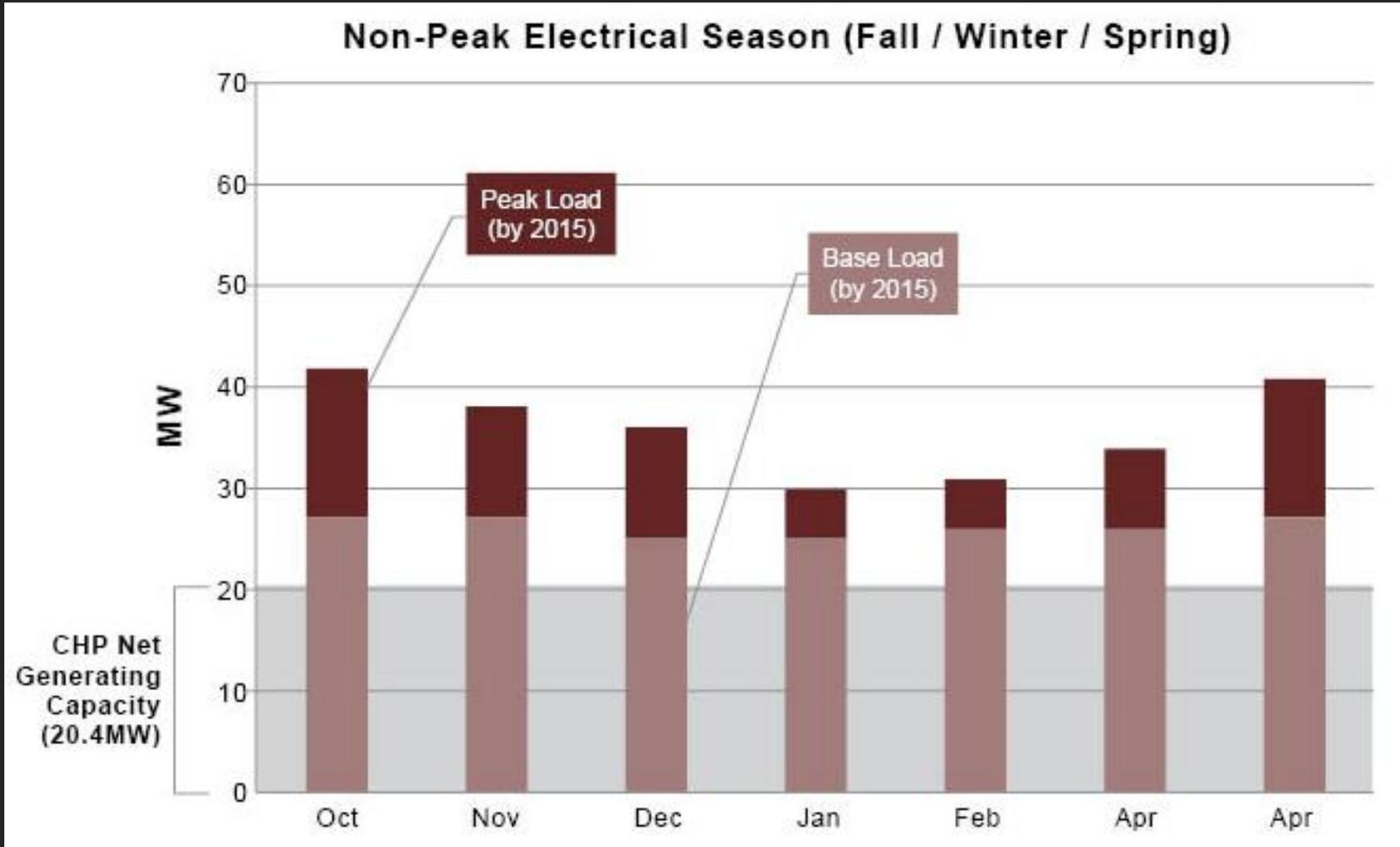


SOUTHEAST PLANT



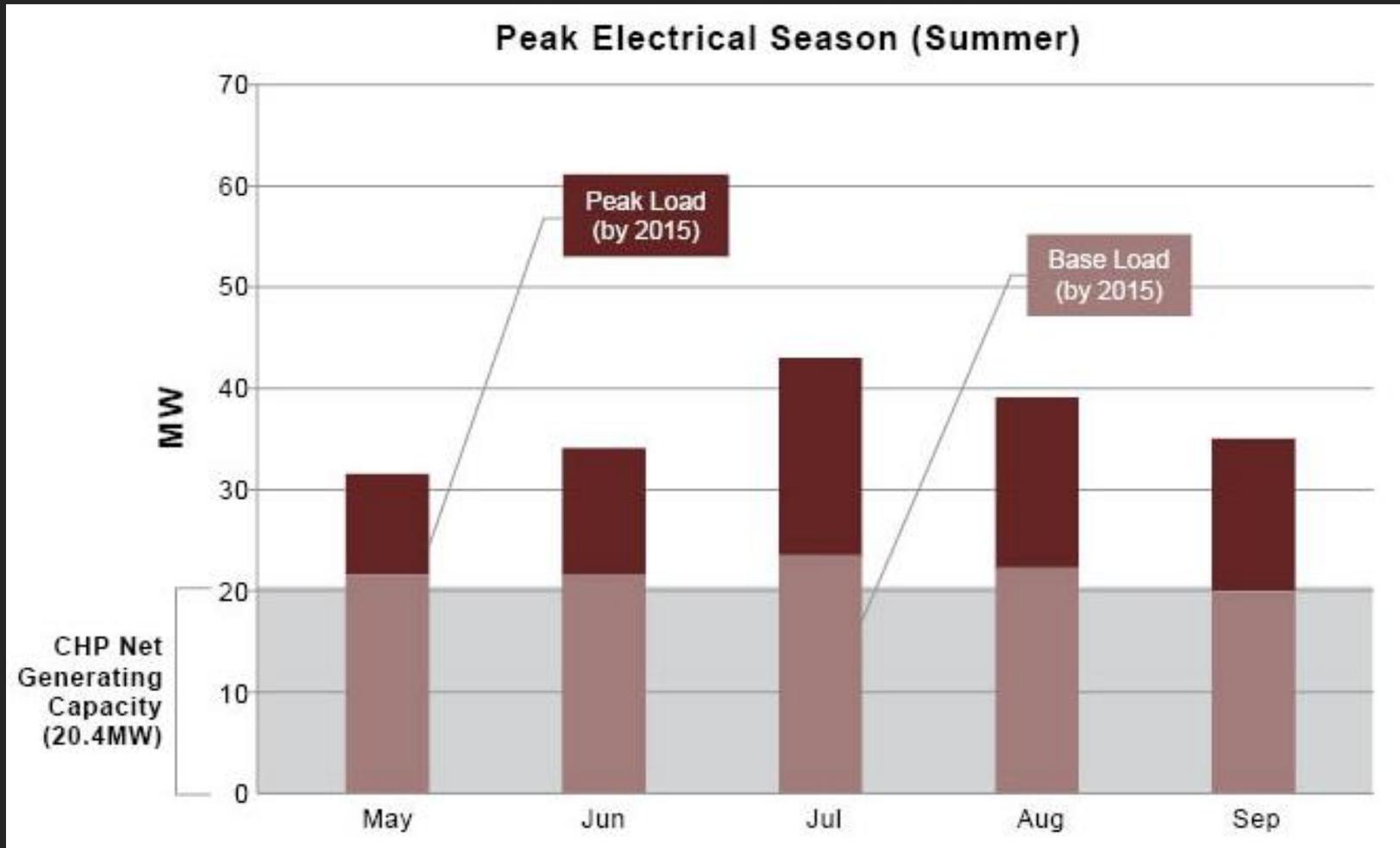


ELECTRIC DEMAND VS CHP CAPACITY





ELECTRIC DEMAND VS CHP CAPACITY





RIGHT SIZING PROCESS



- Spreadsheets used to calculate **total annual fuel consumption and utility costs** for each option
- **O&M costs** calculated for each option
- **Total cost of ownership** calculated for each option



COST-EFFECTIVE: PROJECTED SAVINGS

	Traditional Boiler	Two – 7.5 MW Turbines (15 MW total)	One - 22 MW Turbine
First Cost	Baseline	Plus \$39M	Plus \$40M
Annual Purchased Utility Costs	\$ 25.7M / yr	\$ 20.5M / yr	\$ 18.9M / yr
Incremental Annual O&M Costs	\$ 656K / yr	\$ 2.26M / yr	\$ 2.12M / yr
20-Year Avoided Cost	N/A	\$69M	\$167M



RIGHT SIZING PROCESS

Develop
Load Profiles

Heat
Balance
Modeling

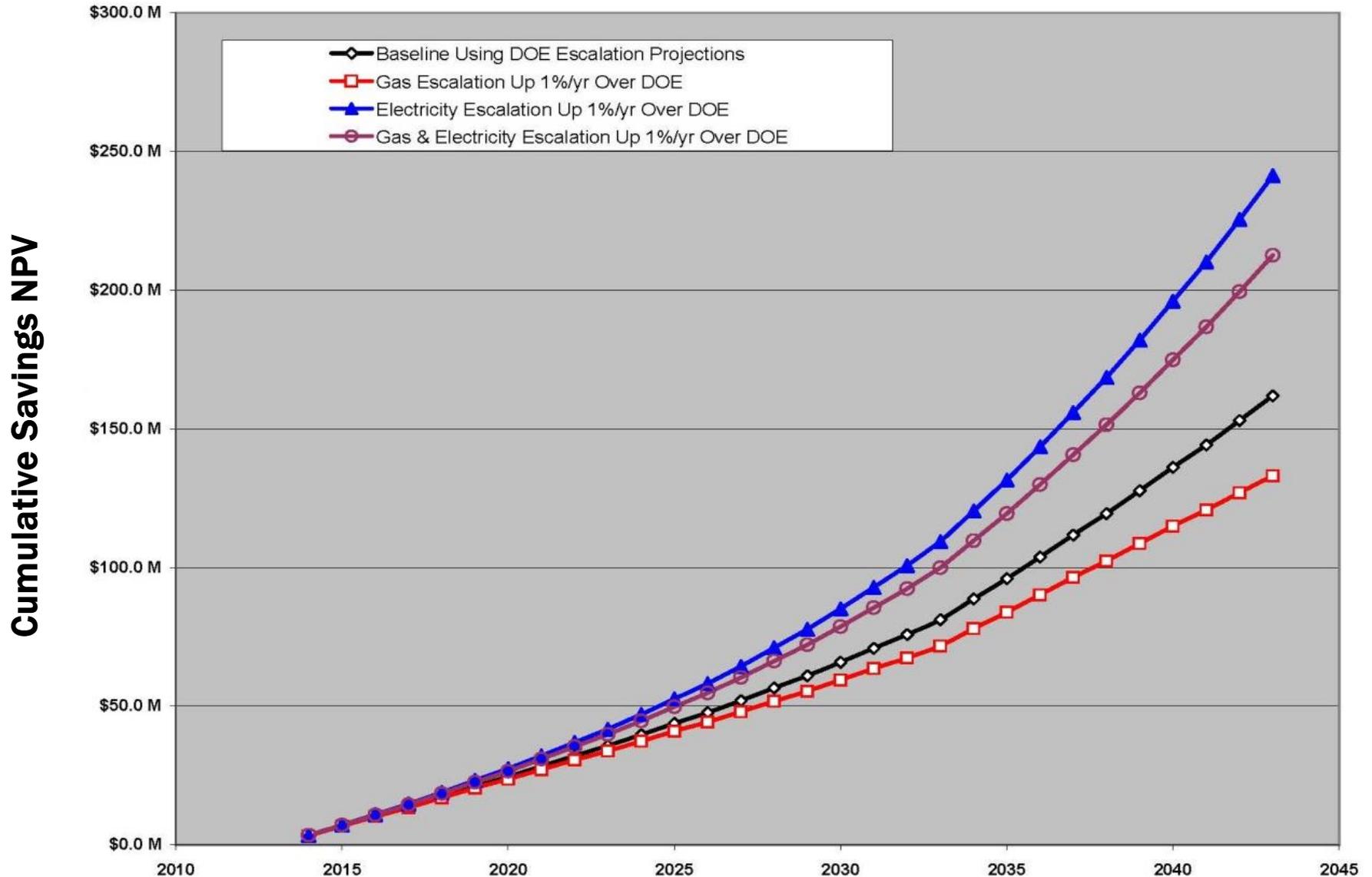
Financial
Analysis

**Sensitivity
Analysis**

- Financial analysis based on DOE projections for utility cost escalation
- Analyzes financial performance of a proposed solution against **unforeseen fluctuations in fuel gas and purchased electricity costs**



UTILITY RATE SENSITIVITY ANALYSIS





SUSTAINABLE: GHG REDUCTION

	Traditional Boiler	Two – 7.5 MW Turbines (15 MW total)	One - 22 MW Turbine
Total GHG Emissions Due to Campus Steam and Electric Demand	205,000 metric tons / year	183,000 metric tons / year	173,000 metric tons / year
Total GHG Savings	N/A	22,000 metric tons / yr	32,000 metric tons / yr
Percent Reduction	N/A	10.7%	15.8%



SUSTAINABLE: GHG REDUCTION



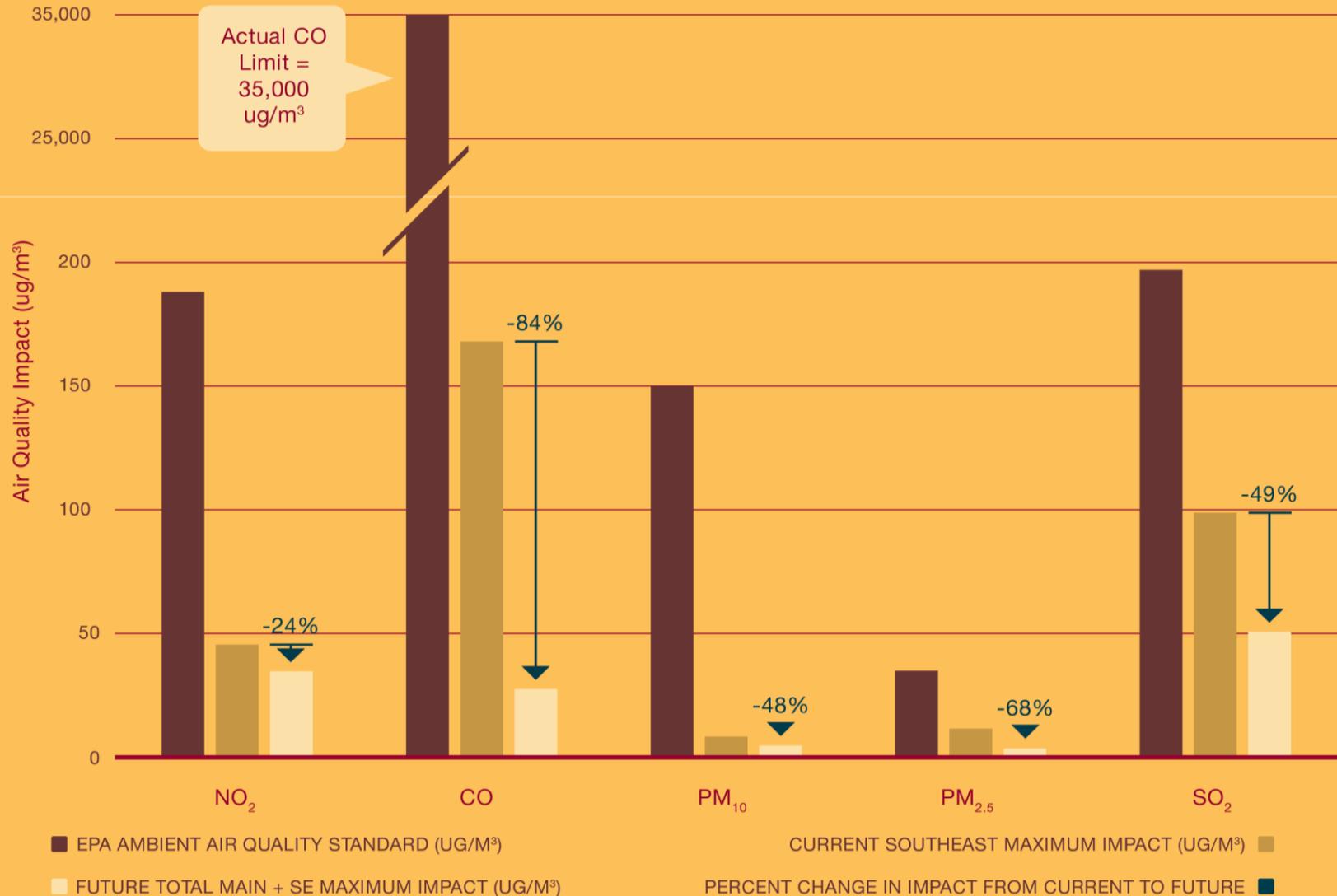
One 22MW turbine
will reduce emissions
by more than

12% – 15%



AIR QUALITY IMPACTS

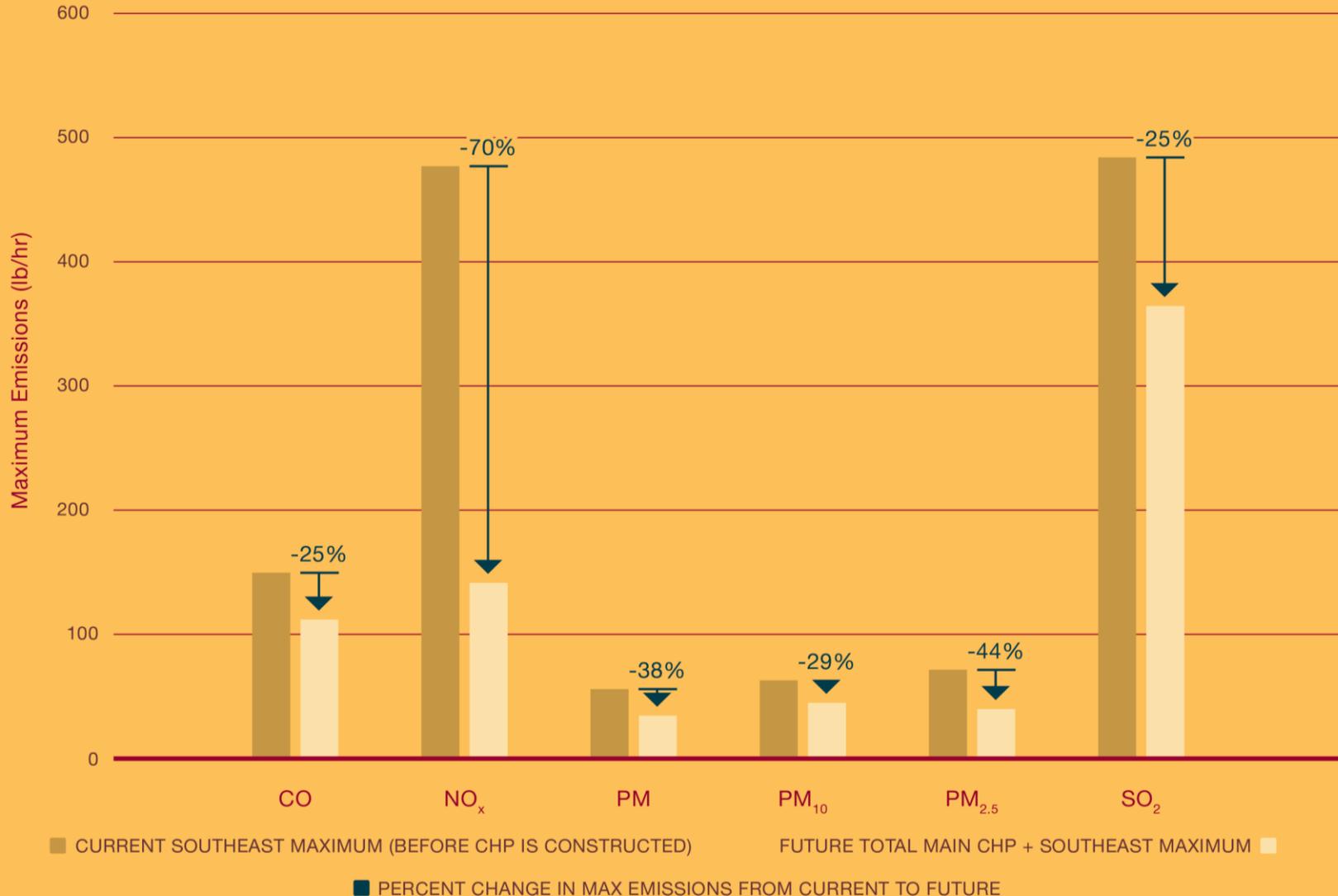
Worst-Case Short-Term Ambient Air Quality Impacts





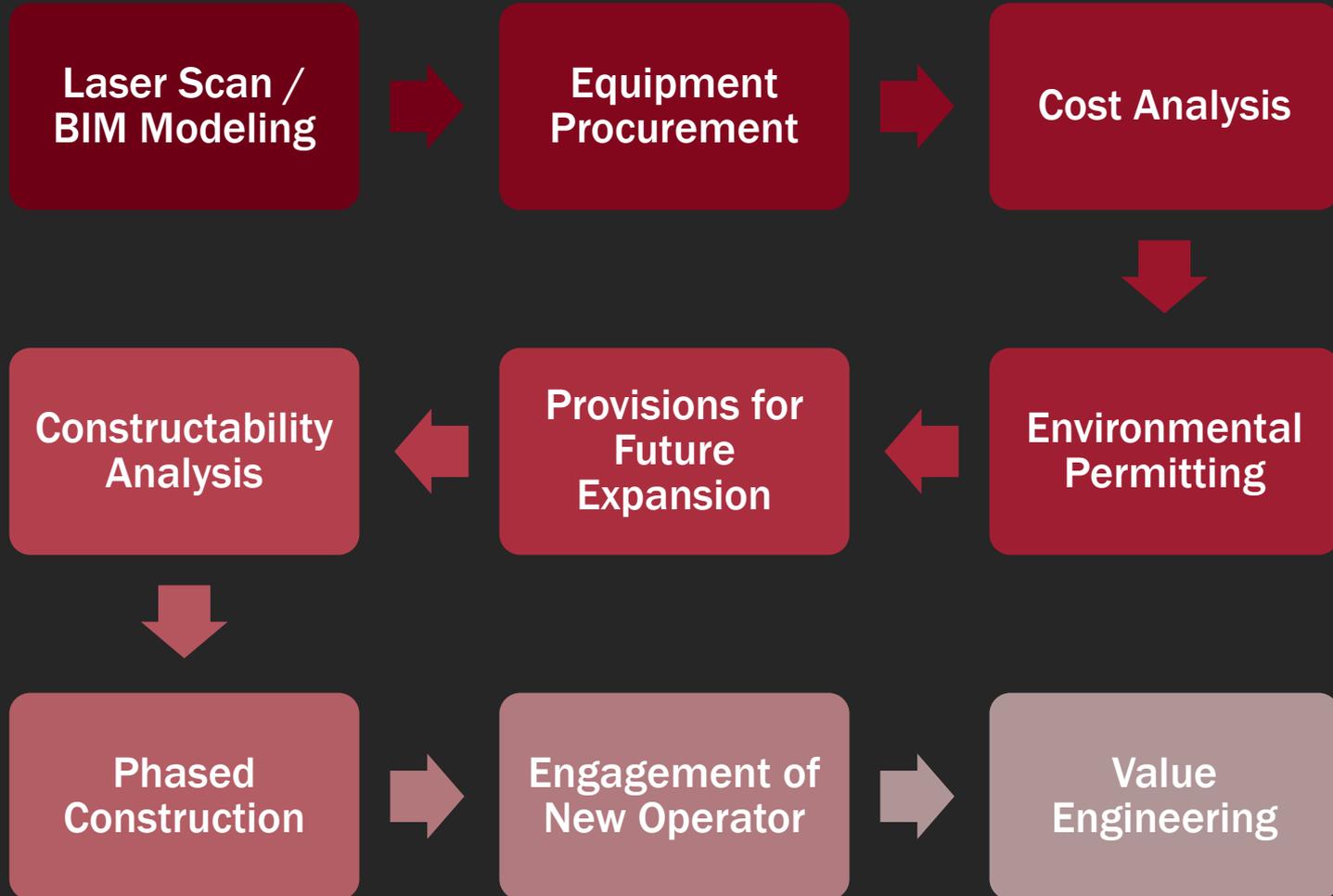
EMISSIONS COMPARISON

Maximum Hourly Permitted Steam Plant Emissions Before and After CHP

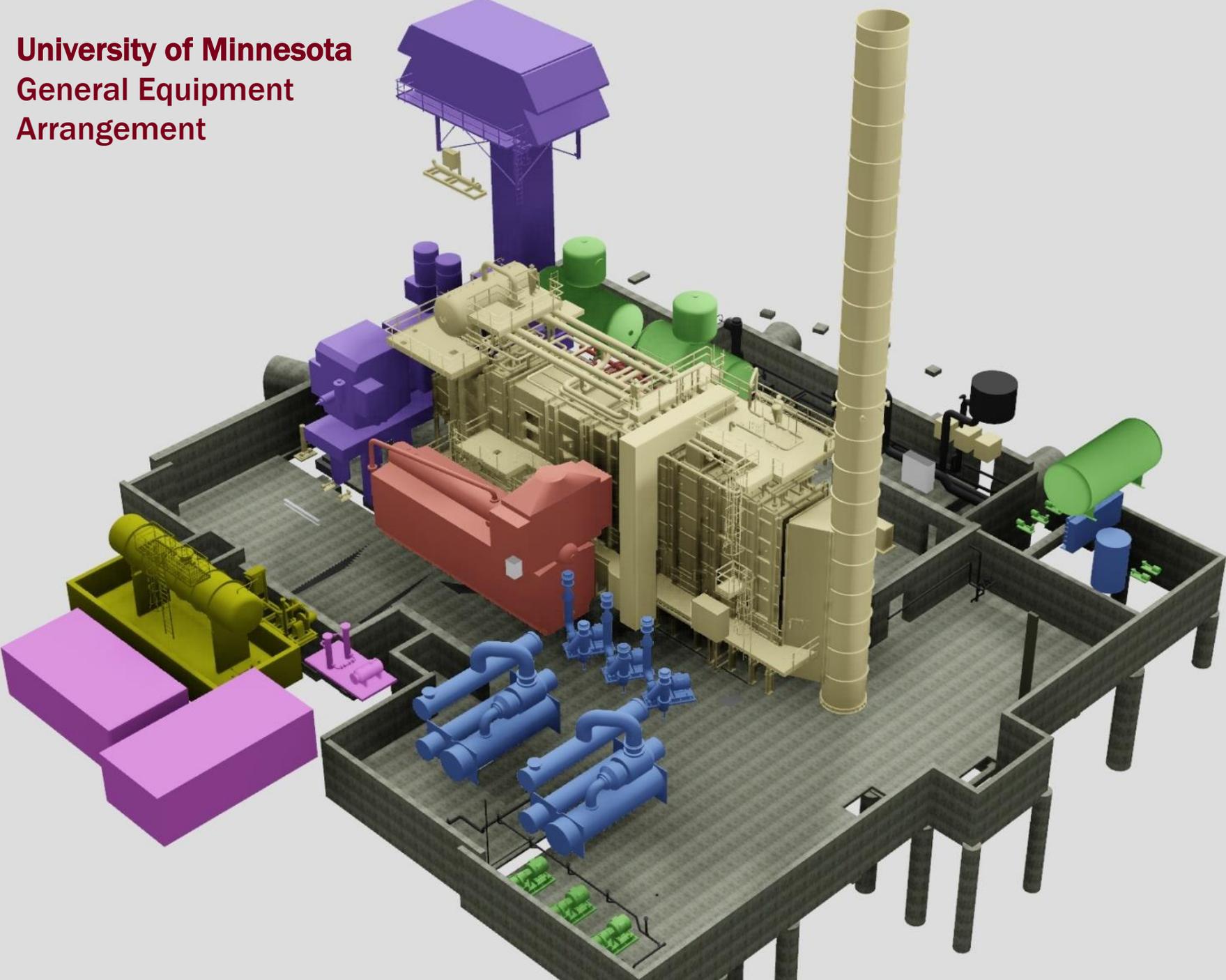




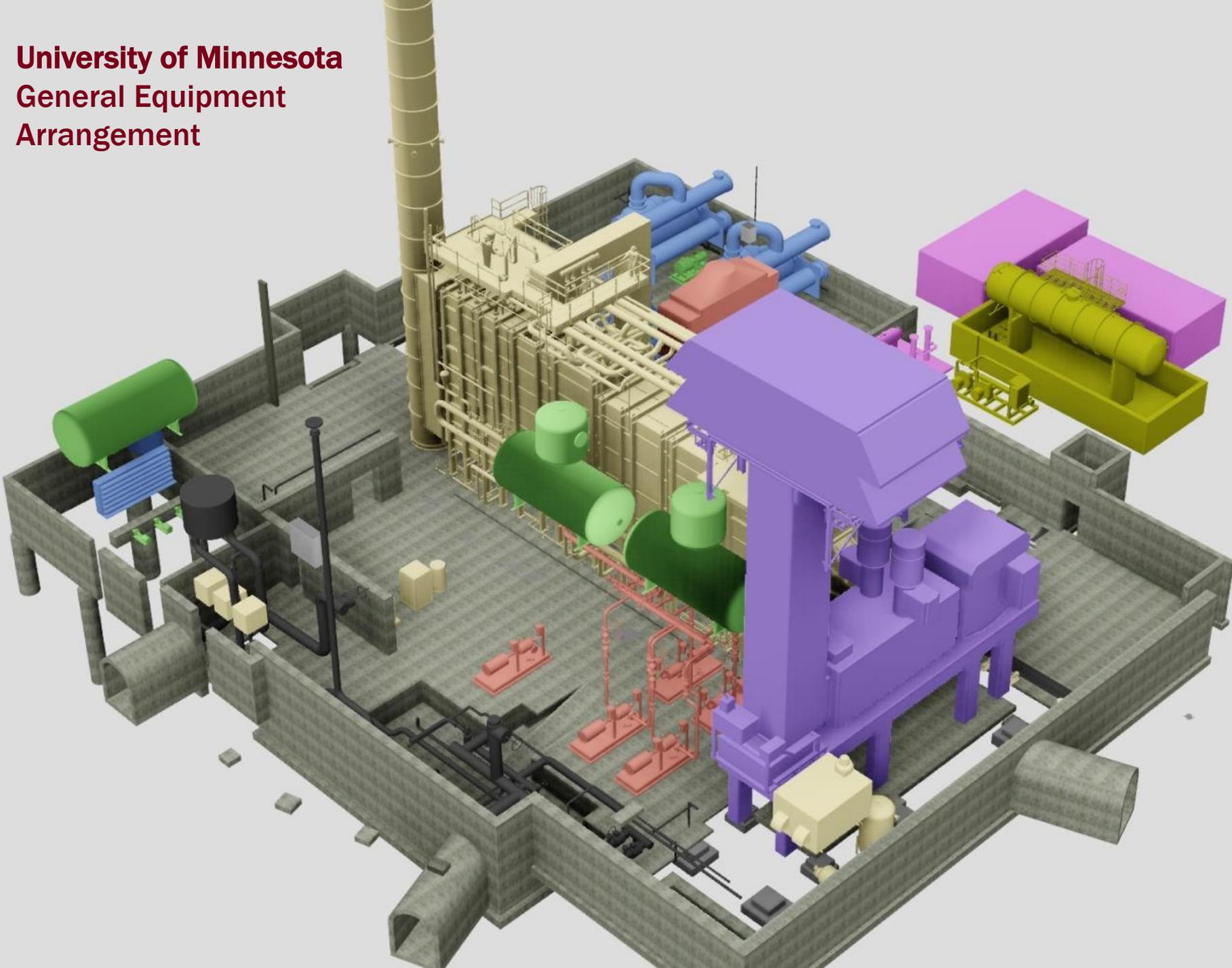
DESIGN PROCESS



**University of Minnesota
General Equipment
Arrangement**



**University of Minnesota
General Equipment
Arrangement**





EQUIPMENT PROCUREMENT

- **Combustion Turbine Generator**
 - RFP – Issued September 2012
 - Responses from GE, Solar, Siemens, Kawasaki in Oct 2012
 - Purchase approved by Board of Regents in Feb 2014
 - Contract signed May, 2013
 - Customer Kick-Off July, 2013
 - Drawings Received Nov 2013 through March 2014
 - Factory Acceptance Test January 2015
 - Ready to Ship February 2015
- **Heat Recovery Steam Generator**
 - RFP issued March, 2013
 - Responses received from EIT, Cleaver-Brooks, Victory and Hamon-Deltak in May, 2013 – awarded to EIT



AIR PERMITTING

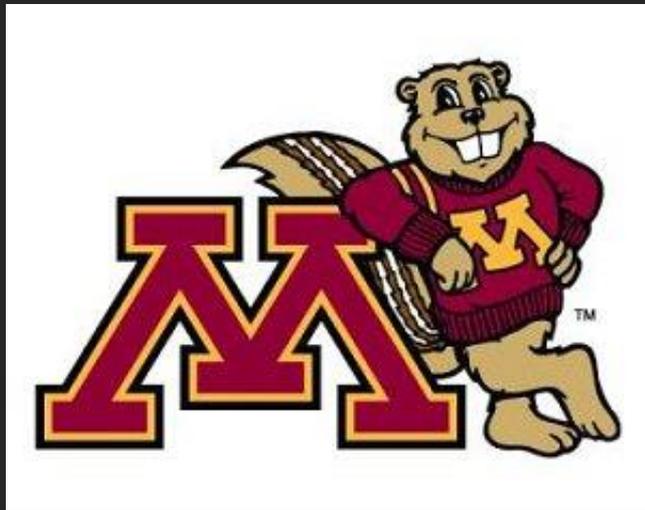
- **GHG Tailoring Rule**
 - Issued in May, 2010, effective January 2011.
 - GHG emissions were added to Prevention of Significant Deterioration (PSD) and Title V Operating Permit Programs.
- **First meeting with MPCA October 2012**
 - Project classified as a Major Modification under New Source Review Rules due to GHG emissions. As a result...
 - No construction was permitted until the amendment was formally approved.
- **First permit amendment submitted in October, 2013.**
- **Permit application revised in April, 2014, to include modeling.**
- **Supreme Court issued judgements in June of 2014 related to EPA's treatment of GHG as an air pollutant**
- **FINAL permit amendment was submitted in October, 2014.**
- **Permit was formally approved in January, 2015.**



UTILITY INTERCONNECTION AND PPA

- **June 12, 2012** – President of NSP (Xcel Energy) meets with the President of the University
- **Dec 3, 2015** – Contracts for another University location were signed
- **Feb 25, 2016** – Letter from the University to NSP
- **Mar 2, 2016** – ½ Day Face to Face Meeting
 - **April 1, 2016** – Deadline set to have IA and PPAs finalized and signed
- **Mar 25, 2016** – First “draft” of IA and PPA
- **May 19, 2016** – All agreements signed and filed with MNPUC
- **June 20, 2016** – Switches may finally be closed.

Questions?



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