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BURNS McDONNELL

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Integrating CHP Assets in High-rise Office Buildings A Case Study

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CAMPUSENERGY2015

Agenda

- Technical/Engineering Challenges
  - Building Service
  - Electrical and Thermal Loading
  - Combustion and Cooling Air
  - Natural Gas Source and Piping
  - Utility Interconnection Requirements
- Developer/Financial Challenges
  - Energy Load Profile
  - Financial Modeling
  - Utility Interconnection
  - Project Risk

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Case Study

- West Coast Office Tower
  - 60+ Floors
  - Over 1.2MM Square Feet
  - Building Design Complete
  - CHP Space – 3rd Floor
  - HAVC Equipment 2nd Floor
  - Multiple Utility Services
- CHP Project
  - 4 – 333kW Micro-turbines
  - Absorption Chiller

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Technical/Engineering Challenges

Building Service

- Typically Low-Voltage Service
- Secondary Spot Network
- Multiple Points of Service
  - Multiple Utility Transformers
  - Multiple Utility Meters
  - Floor Load Split

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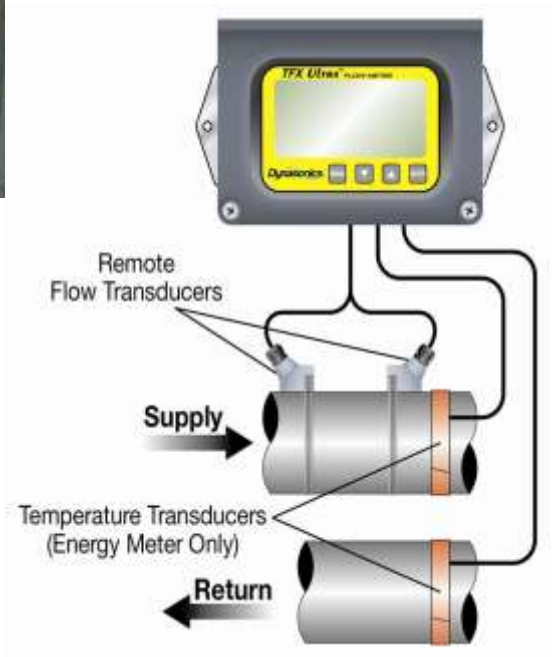
Electrical and Thermal Loading

- Electrical Load
  - Lighting
  - Office Equipment
  - HVAC
  - Divided by Floor
- Thermal Load
  - HVAC
  - Domestic Hot Water
  - Centralized
- Off Peak Majority of Time



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Combustion and Cooling Air

- Significant Air Flow Requirements – Micro-turbine
  - Combustion Air
  - Ventilation Air
  - Limited Louver Space
  - Limited Exhaust Duct Space
  - Exterior Architectural Treatment
    - Mainly Glass
    - Hot Exhaust

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Combustion and Cooling Air – cont'd

- Braking Resistors
  - Stabilize Micro-turbine During Load Swings
  - Significant Hot Air Flow During Operation
    - 7540 scfm at 600 degrees F Per Unit
    - Startup and Shutdown
  - Manufacturer Recommends Outdoor Installation

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Natural Gas Source and Piping

- Utility Gas Delivery
  - Typically Low Pressure – Ounces
  - Micro-turbine Inlet 4” – 1 psig
  - Required Flow Drives Pipe Size
- Negotiate Higher Pressure From Utility
  - 5 psig
  - Significantly Reduces Required Gas Line Size
  - Utility Dependent

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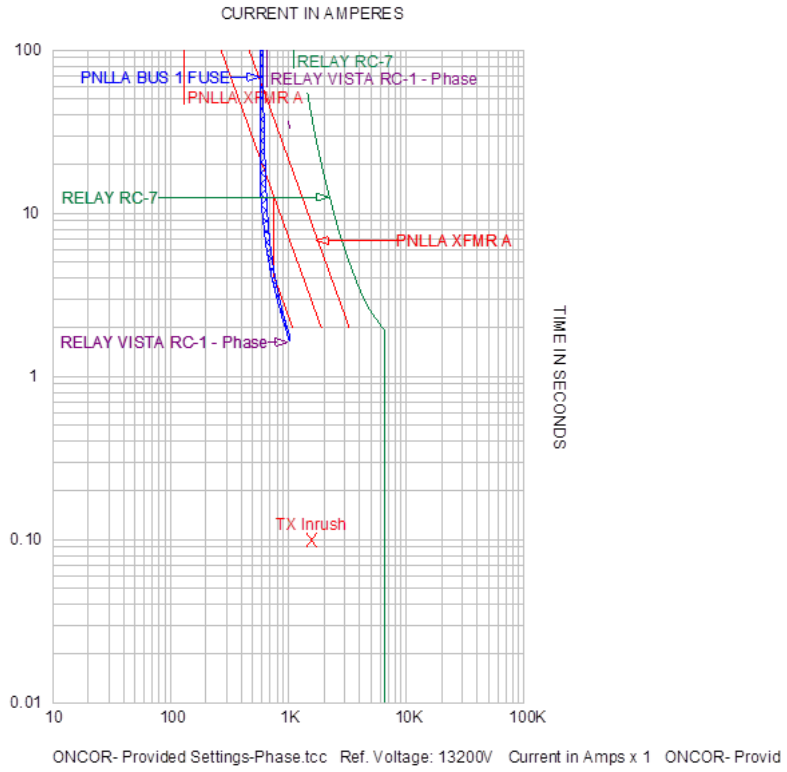
Utility Interconnection Requirements

- Vary By Utility
- Protection Generally Standardized to IEEE 1547
  - Over/Under Voltage 27/59
  - Over/Under Frequency 81O/U
  - Directional Overcurrent 67, 67N
  - Ground Overvoltage 59N
  - Sync Check 25



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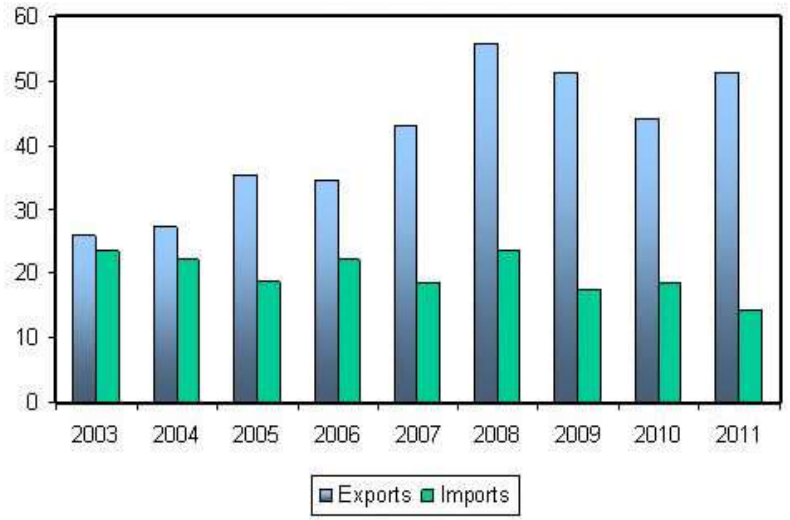
Import/Export Restrictions

Building Minimum Load > Generator Output = Import
Building Minimum Load < Generator Output = Export

- Exporting (Even on a Rare Occasion) Requires Market Participation
  - Additional Metering Requirements
  - Subject to Market Rules and Pricing
  - Location Dependent – Rules Vary
- Import Restriction Based on Utility Transformer Size
  - Ensure Power Flow Into Building



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Generator Islanding

- Planned Islanding
  - Deliberately Separate from Utility
  - Additional Hardware and Controls Required
  - Higher Cost and Complexity
- Unplanned Islanding
  - Generation Energizes a Portion of the Utility System Following a Utility Outage
  - Generation Must Automatically Separate from Utility
  - Separation Must Occur Before Utility Reclosing

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Developer/Financial Challenges

Case Study CHP with Absorption Chilling

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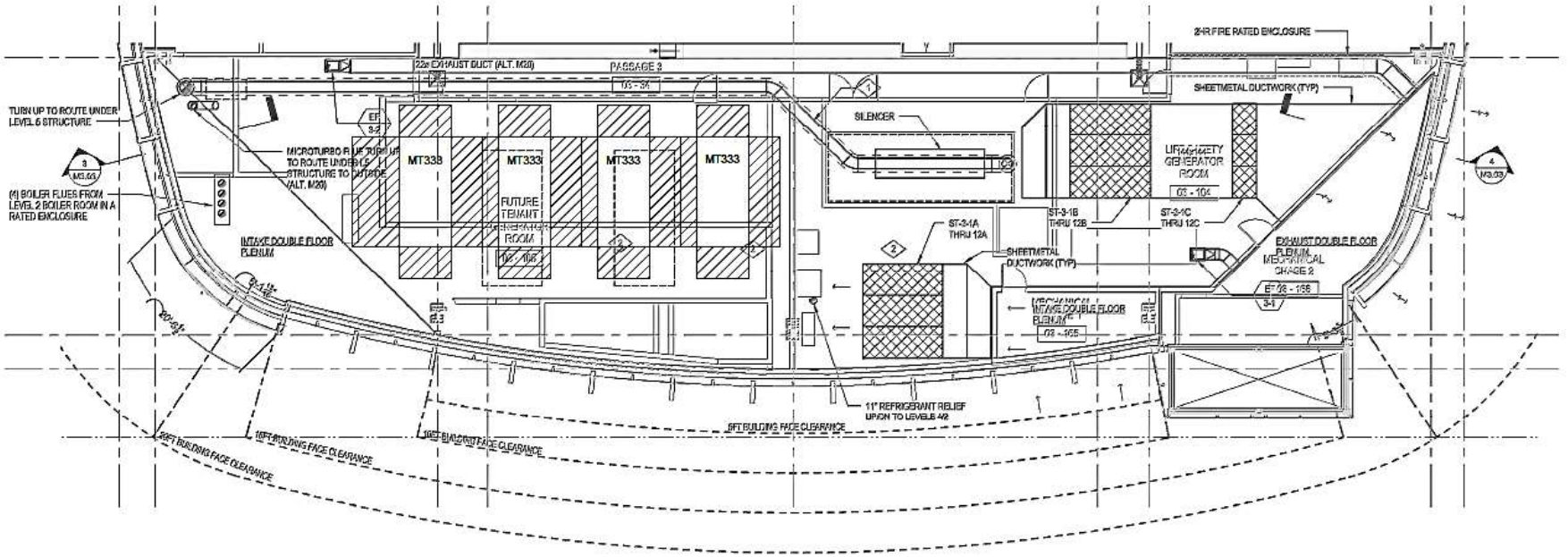
Case Study CHP Plant



1 MECHANICAL LEVEL 3 GENERATOR ENLARGED PLAN
1/8" = 1'-0"

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Case Study Challenges & Risks

Category	Responsible Party	Description
Energy Load Profile	Customer	▪ Estimated Electricity & Thermal Load information ▪ Estimated Electricity & Thermal costs (Demand, Peak , Seasonal) ▪ Source - Title 24 , Energy Pro , Scale data from local building
Building Design	Customer & Developer	▪ Location of Mechanical Room in relation to CHP Plant ▪ Architectural, Mechanical & Electrical Design parameters ▪ Structural, Acoustical and Environmental requirements ▪ Interconnection of Electrical & Mechanical equipment to CHP Plant
Financial Modeling	Developer	• Self Generation Incentives for CHP Projects • Equipment , Material , Installation , Contingency for CAPEX • Operation & Maintenance Costs , Capacity Factory , Contingency • Rate Calculation : projected gas cost , DLC's & Standby Charges
Interconnection	Customer, Developer & Utility	▪ PUC mandated process (Rule 21) (Parallel vs island) ▪ Local Utility Import Minimum per Transformer ▪ Gas Line Capacity for CHP Plant
Project Risk	Customer & Developer	• Construction & Occupancy delay • Project creep during installation phase • Modeled vs Actual Energy Demand • Natural Gas Price and Volumetric Risk • Local Regulations (Utility, Environmental, Fire Department, etc)

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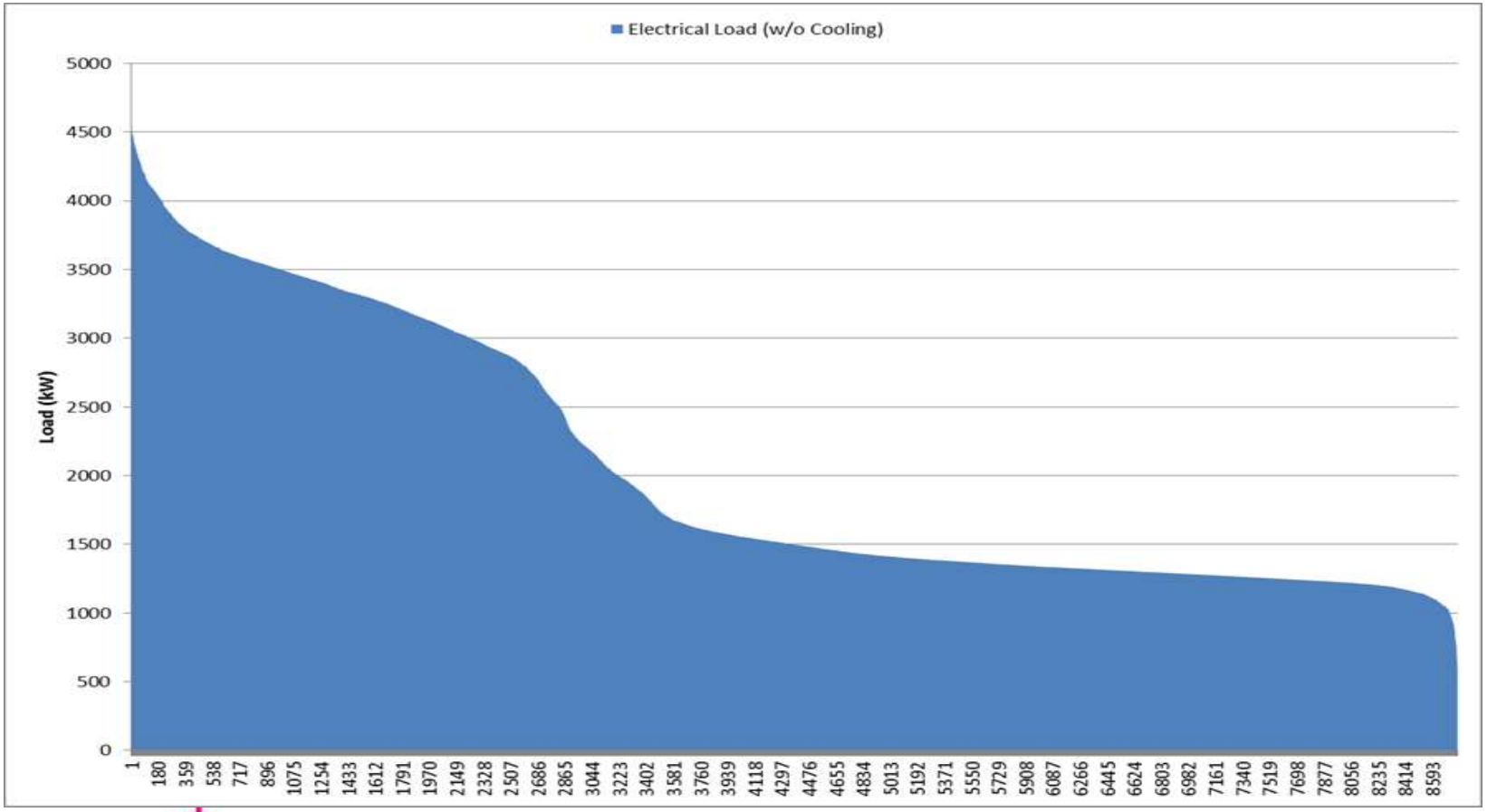
Case Study Load Curve



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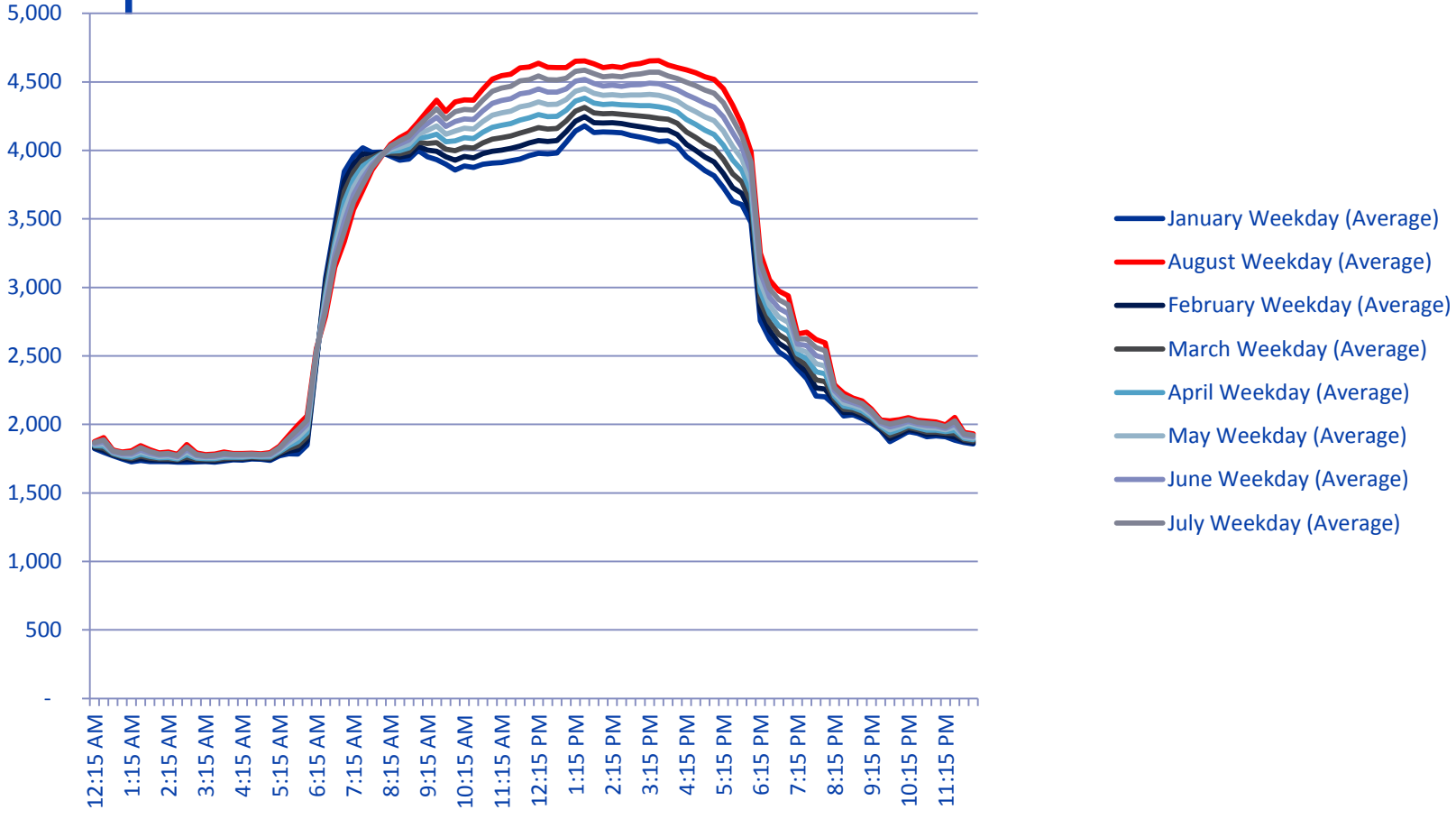
Case Study Electric Loads Interpolated for other Months



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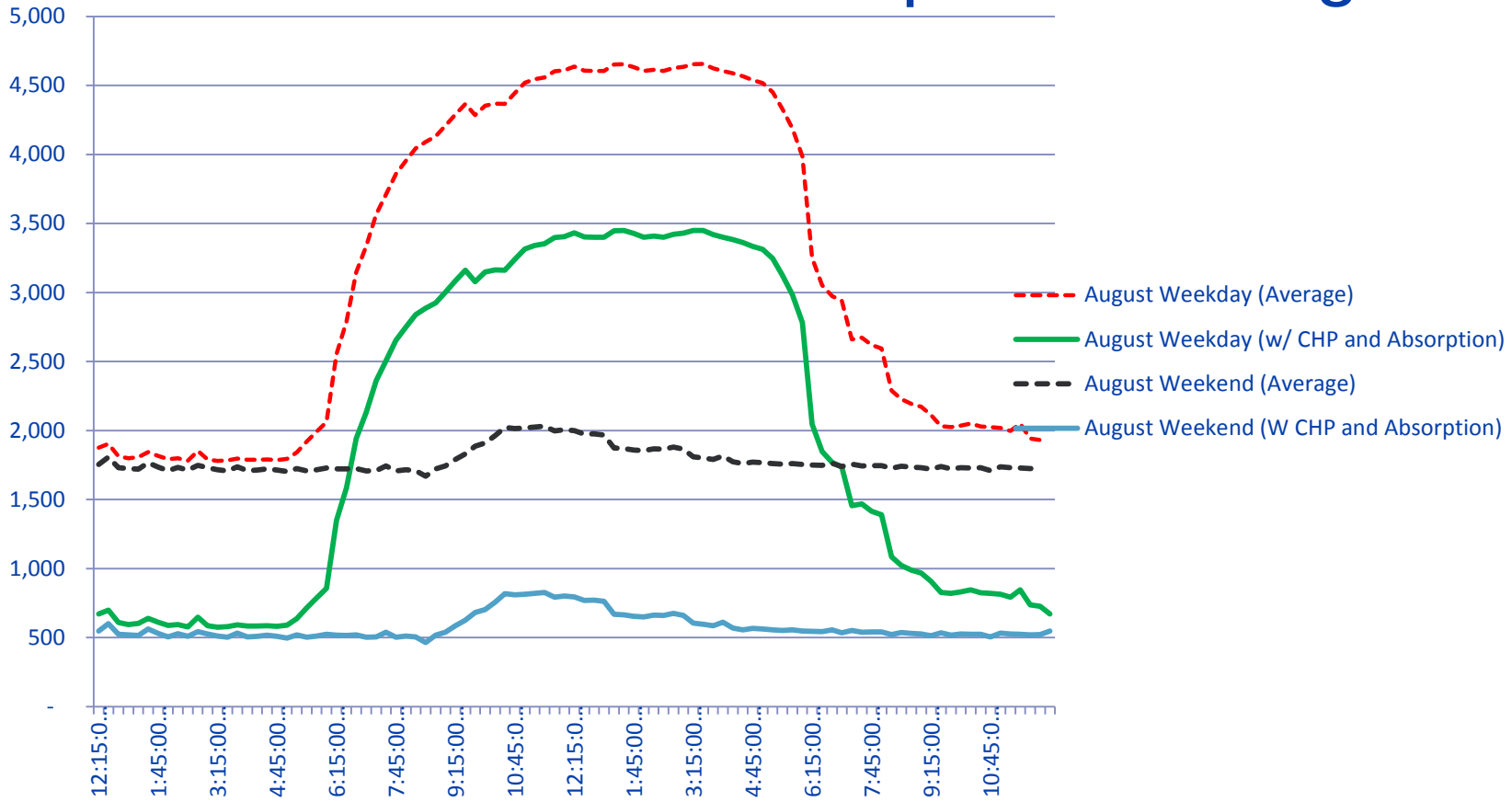
Case Study Electric Loads
Reduced with CHP & Absorption Cooling



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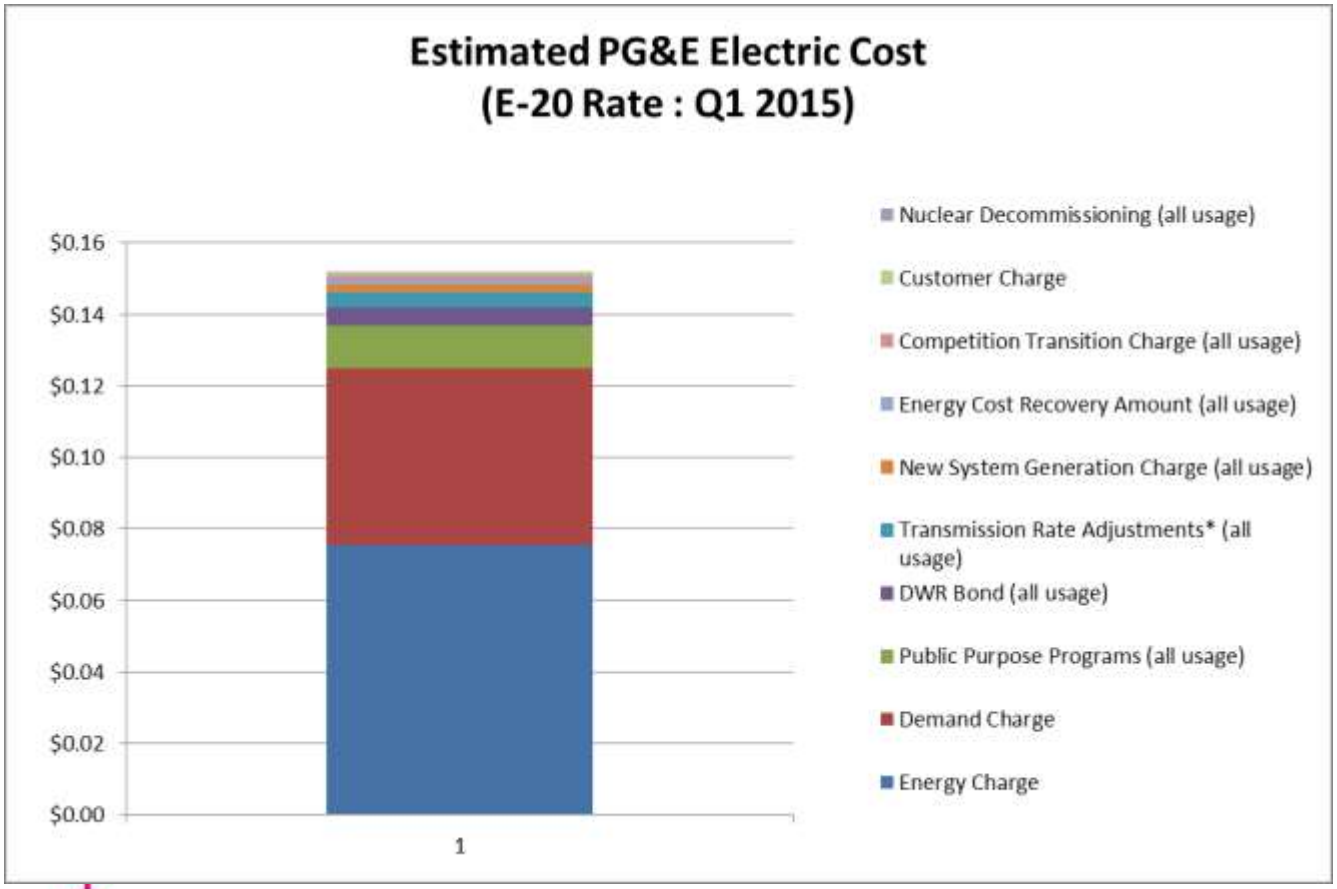
Case Study – PG&E E20 Rate Components



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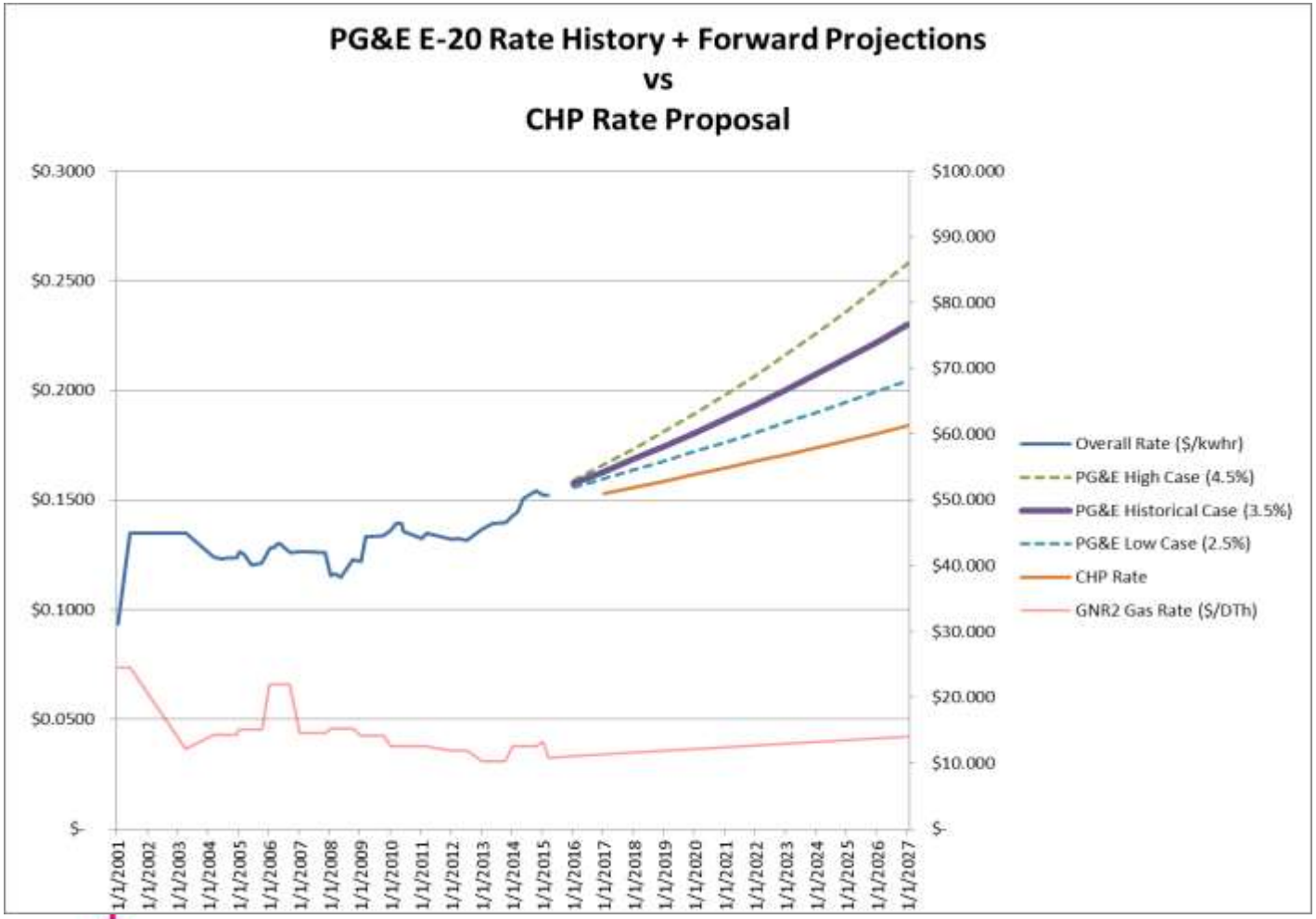
Case Study : Rate Comparison



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Conclusions

- High-Rise Office Tower CHP Projects Require:
  - Early Load Estimation
  - Space Planning
  - Architectural Coordination
  - Utility Coordination
  - Developer Interaction
  - Risk Mitigation
  - Careful Financial Analysis

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