NiSource - Combined Heat and Power and Advanced Control Systems Installed in a Hilton Hotel

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Project Objectives

- Conduct a research and development effort to advance distributed power development, deployment, and integration by developing a CHP package for the hotel industry.
- Develop and conduct laboratory and field tests of methodologies and controls for the application (including command, communications, monitoring, efficiency, and energy systems).
- Completely document results.

Video of Hilton Hotel

Phase I Activities

- **Initiate design and construction of initial test system**
  - Design and develop a program targeted to develop a BCHP packaged product for wide use in the hotel industry.
  - Install various BCHP systems in the hotel during construction
  - Build and operate a BCHP energy center adjacent to the hotel that will house CHP equipment as well as a research office/experimental area.
  - Test various equipment configurations and control approaches

Phase II Activities

- **Realize "whole building" system optimization and interface and integration with the electric grid by considering:**
  - Architecture and design
  - Building heat and power system concepts with artificial intelligence
  - Advanced controls, and interconnection with the larger grid

Phase III Activities

- **Finalize the development of the various systems and interfaces into a prototype BCHP package for use in the hotel industry.**
  - Synthesize the experience and information gained during the prior two phases.
  - Develop a viable BCHP product prototype for the hotel industry.

Technical Challenges of Current Practices

- At the start of the project there were many unanswered questions regarding the design, operation and interconnection of a CHP system for use in the hotel industry.
  - This project has helped to provide answers to many of these issues and thereby facilitate the implementation of CHP
- There is currently limited knowledge regarding the economic viability, efficiency, reliability, and need for CHP designs and advanced controls for the integration of CHP into hotel building systems.
  - This project is providing information, technology, procedures, and designs that can be used in the future to further meet these needs and thereby help to increase the value and viability of CHP technology

Technical Approach

- Further the penetration of CHP technology into the national energy mix by providing a cost effective, environmentally friendly design for use in the hotel industry.
- Utilize advances in CHP dynamic control systems and energy utilization to further the goals of increasing efficiency, energy utilization, and cost savings.
- Develop a field tested design that will accelerate the introduction of CHP technology. This design will include the benefit of actual operating experience in a commercial hotel.
- Utilize statistical techniques including factorial designs to enhance the efficiency of developmental activities.

Key Technical Barriers and Approaches to Overcome Them

- Acceptance of CHP concept by hotel industry
  - Demonstrate feasibility and benefit at operating hotel
- Need to match heat and electric utilization to increase overall efficiency and economic benefit
  - Develop thermal systems, advanced controls, and storage to better utilize heat
  - Investigate value, feasibility, and performance of various heat utilizing and storage devices
- Need to Increase reliability of electric supply
  - Develop transfer switching schemes for the hotel
  - Consider ways to minimize the impact of generating equipment outages
- Need to provide design and operating scheme that provides economic benefit
  - Integrate CHP system into building operation and design
  - Develop standard package that can be made part of standardized designs in the future thereby decreasing equipment and installation costs and increasing efficiency

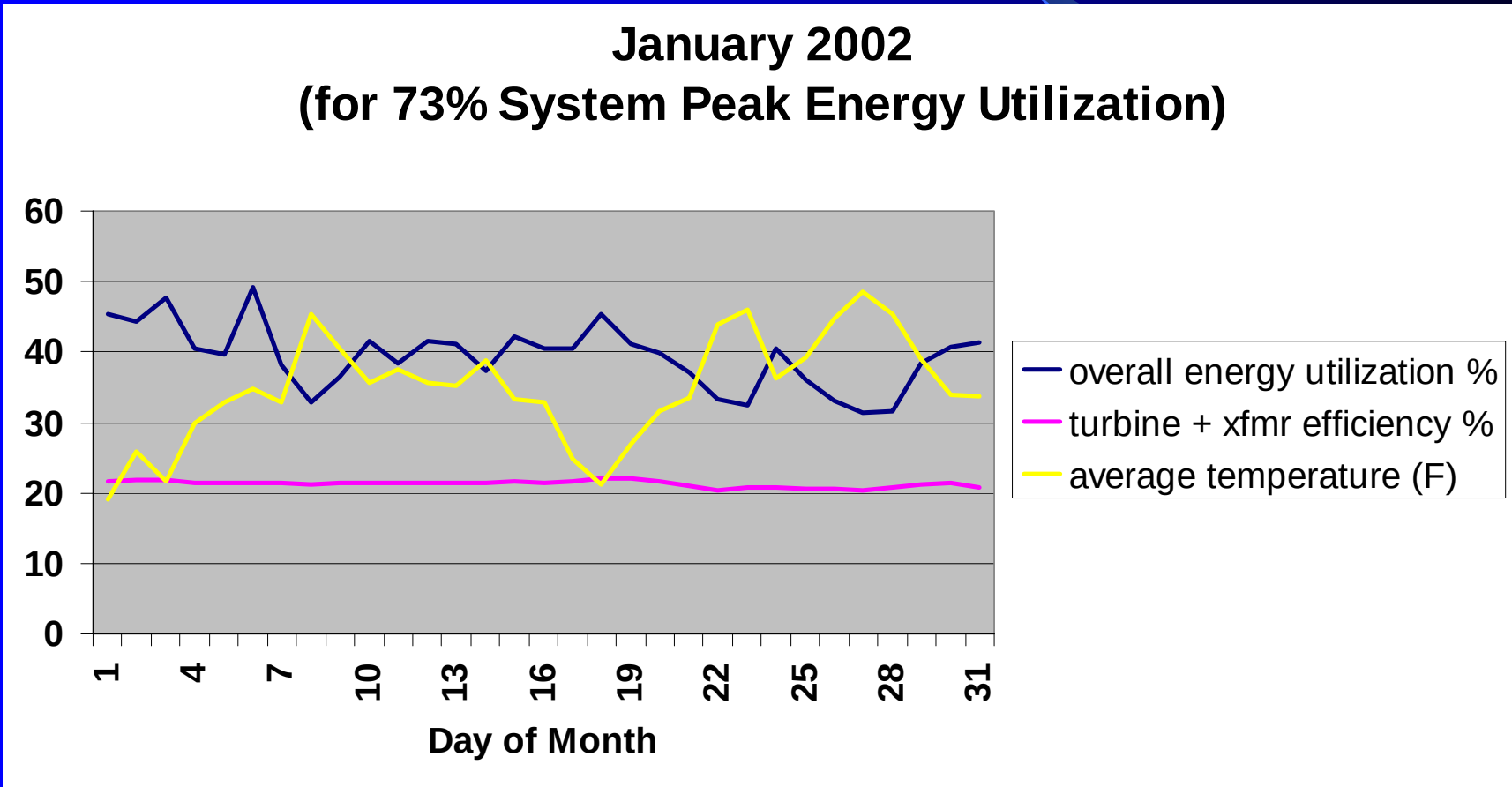
CHP Considerations

- Basic Design Issues
  - Start by considering what the end user wants.
    - Economics
    - Reliability
    - Power Quality
    - Choice

Experience at other commercial CHP test sites developed by NET provided a basis for the inclusion of actual commercial operating information in the design of the current effort.

Version I **Version II**

Energy Utilization (Not Optimized)



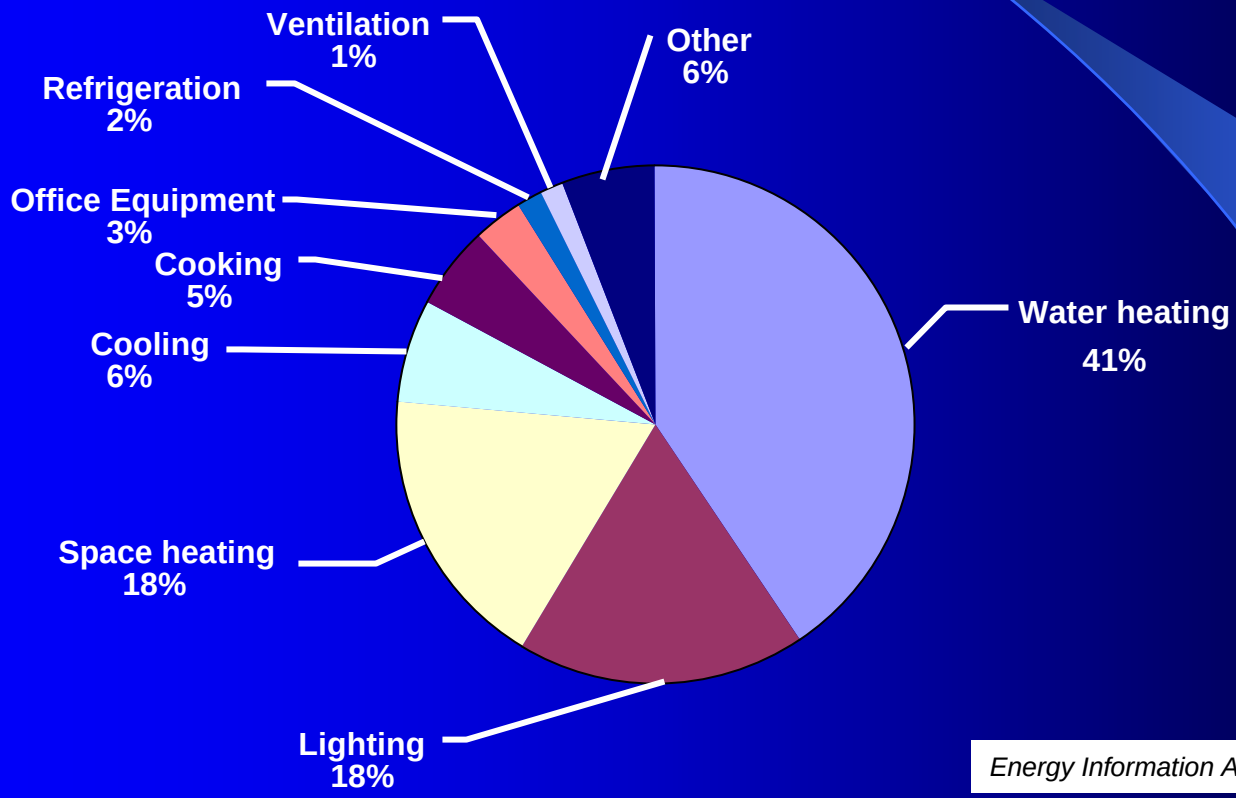
System Design and Performance Issues

- **This energy utilization is not high enough to meet long term goals.**
- **How can we improve this?**
  - **Intelligent controls**
    - **Neural Networks**
    - **Fuzzy Logic**
  - **Integration of the system into the building and the building into the system.**
  - **Dynamic energy management and control**
- **Reliability, PQ, and Grid Interaction**

Why the Lodging Sector ?

- Energy use profile
- Number of new units
- Competitive pressure
- Possibility to standardize CHP into building designs

Major Fuel Consumption for Lodging Sector



Energy Information Administration, 1995

Developmental Package

- 3 Microturbines with advanced heat recovery (solar cells in second year and possibly fuel cell in the future)
- Electricity for use in hotel (selected grid isolation & computer bumpless transition)
- Heat for use in hotel
  - Space heating (multiple hydronic zones in floor)
  - Hot water heating
  - Swimming Pool & Spa Heating (future: desiccant dehumidification)
- Advanced energy controls to maximize efficiency and cost savings.
- Building integration concepts

First Year Accomplishments

- 1. Developed individual component designs and/or specifications for the components of the initial CHP system.
- 2. Determined how these systems will be integrated into the test facility.
- 3. Designed and built initial test systems.
- 4. Tested individual systems.
- 5. Assembled individual systems into an initial package.
- 6. Installed package at Site and integrate with building.
- 7. Performed initial testing of initial CHP system.
- 8. Performed further system tests and developments based on test results.

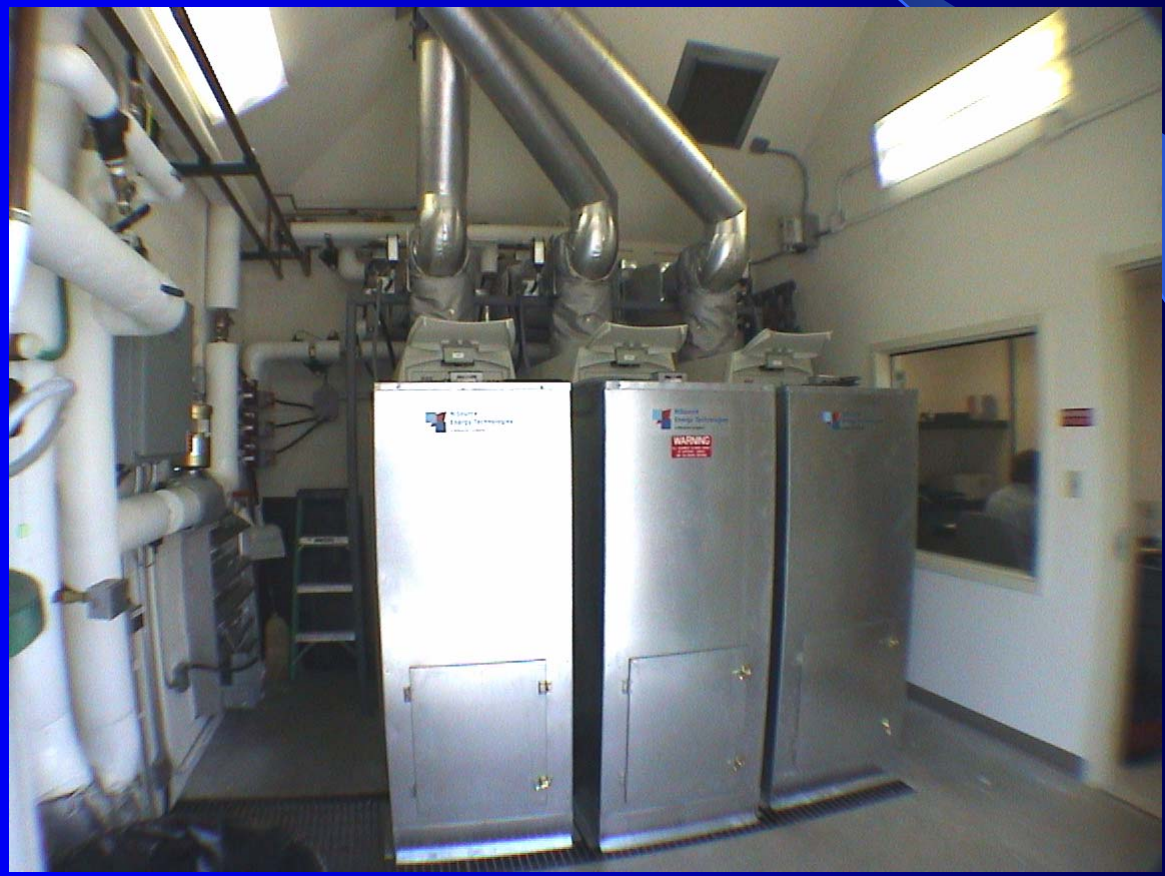
Hotel Site

Hotel IES Overview

Site During Construction

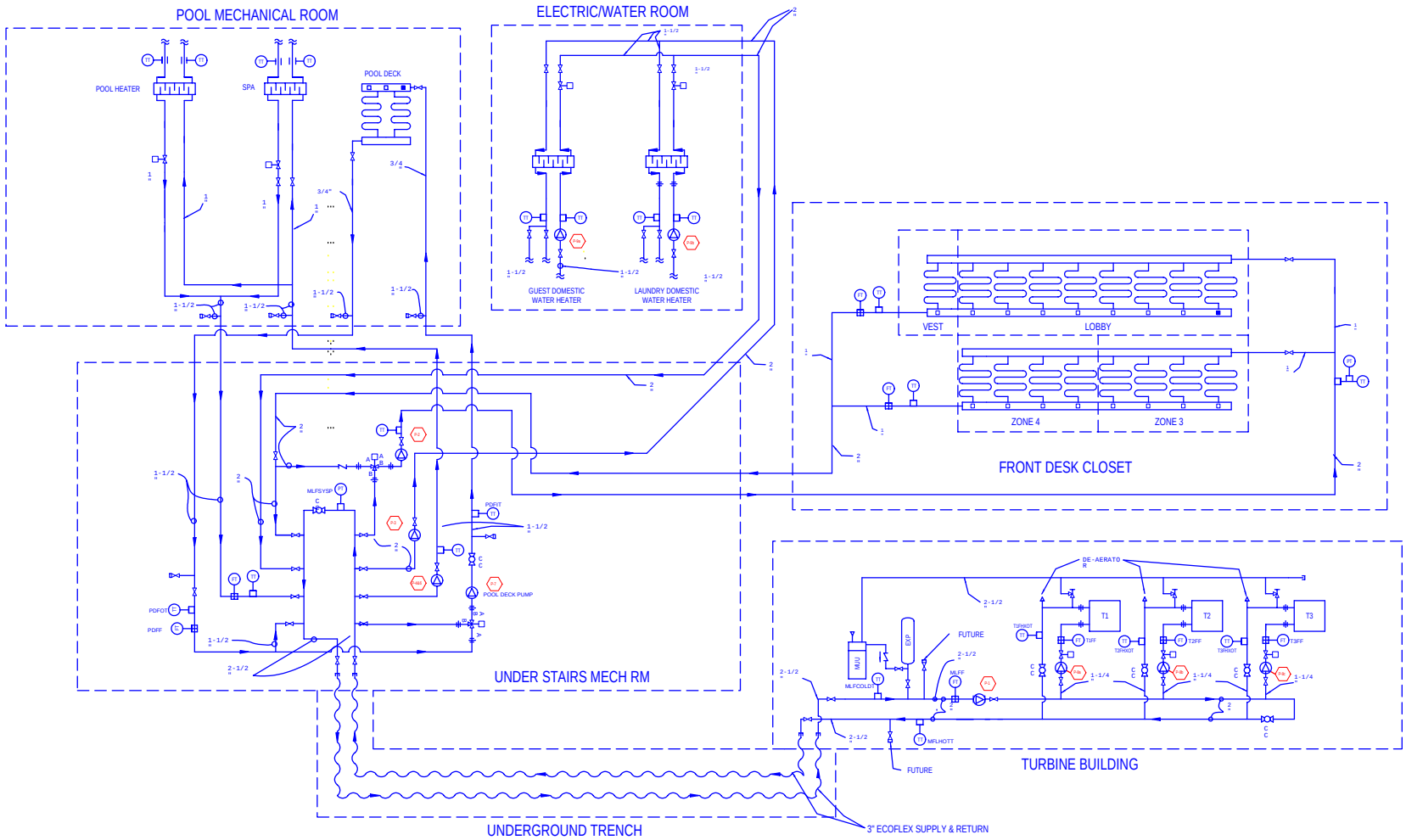
CHP Building

Inside CHP Building

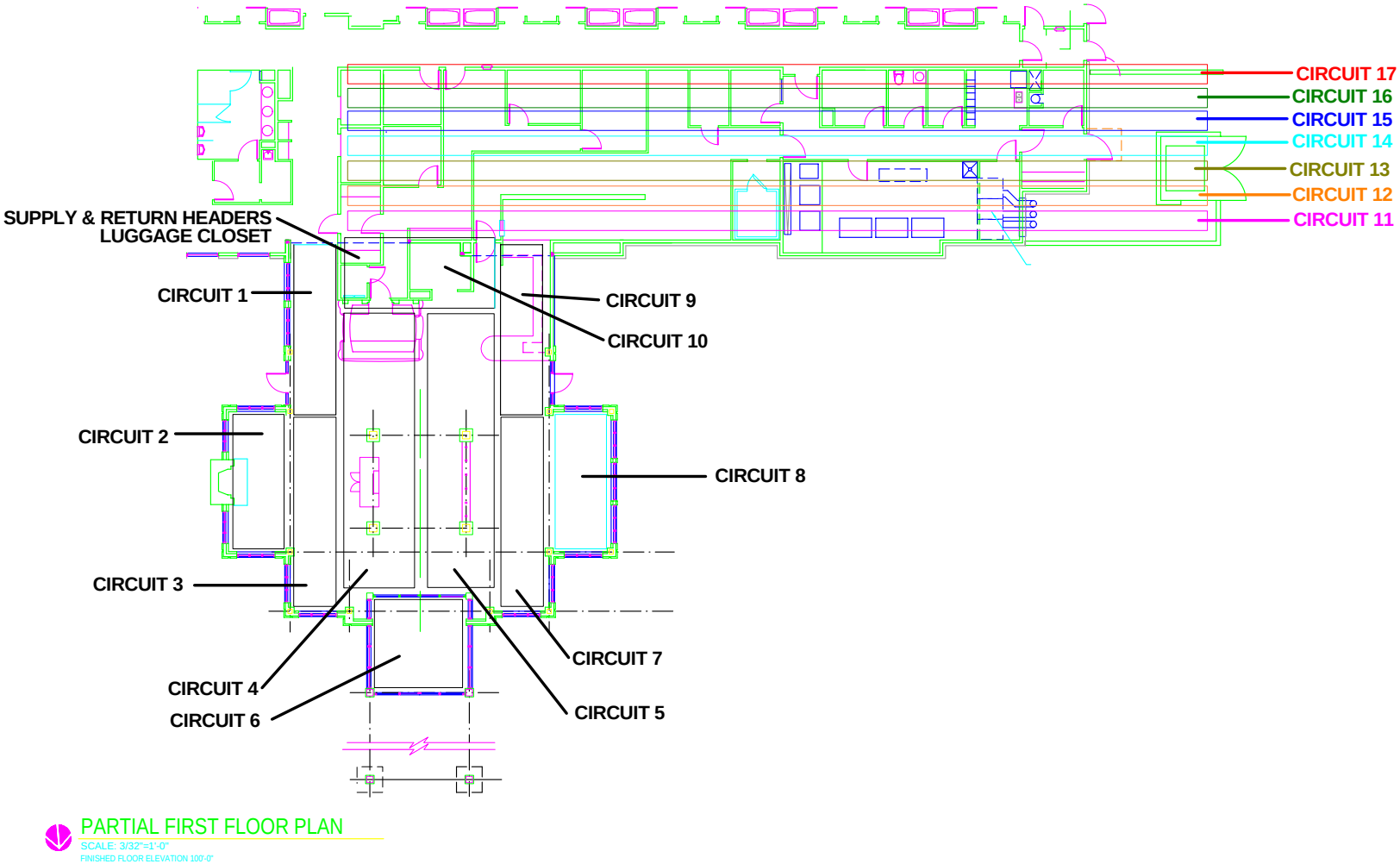


Hydronic Control (Main Floor)

Current System Piping Configuration



Hydronic Zones



Year 1 Objectives

- Realize "whole building" system optimization and interface and integration with the electric grid through the use of the heat and power system, artificial intelligence and advanced controls, and interconnection with the larger grid.

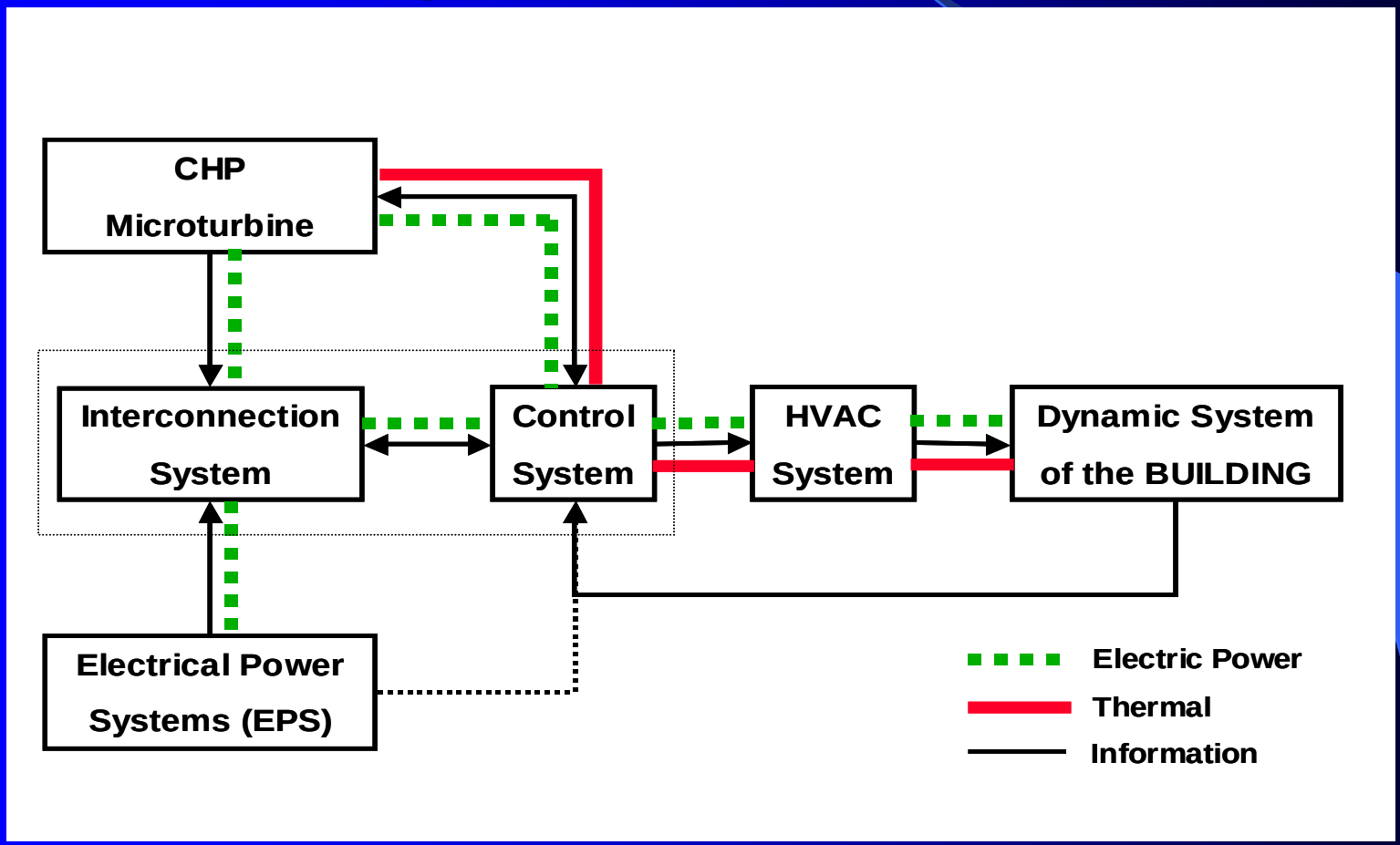
Optimization Objectives

- Develop advanced control techniques for distributed power systems that facilitate development, deployment and integration.
- Long-term goal: Design ways to extend CHP into the physical design and controls of a building itself.
  - Maximize efficiency and commercial viability of the technology

CHP Optimization

- Control algorithm for IES would reduce life time operating cost.
- Compare cost of grid electricity, locally produced electricity, and cost of fuel consumption, e.g. gas, and locally produced heat.
- Energy supply optimized to give maximum benefit from available source options.
- Optimization model determines unit commitment & set points.
- Model predicts hourly building load data, including: kWh use, Btu use, kWh for water heating, Btu for water heating, kWh for space heating & cooling.

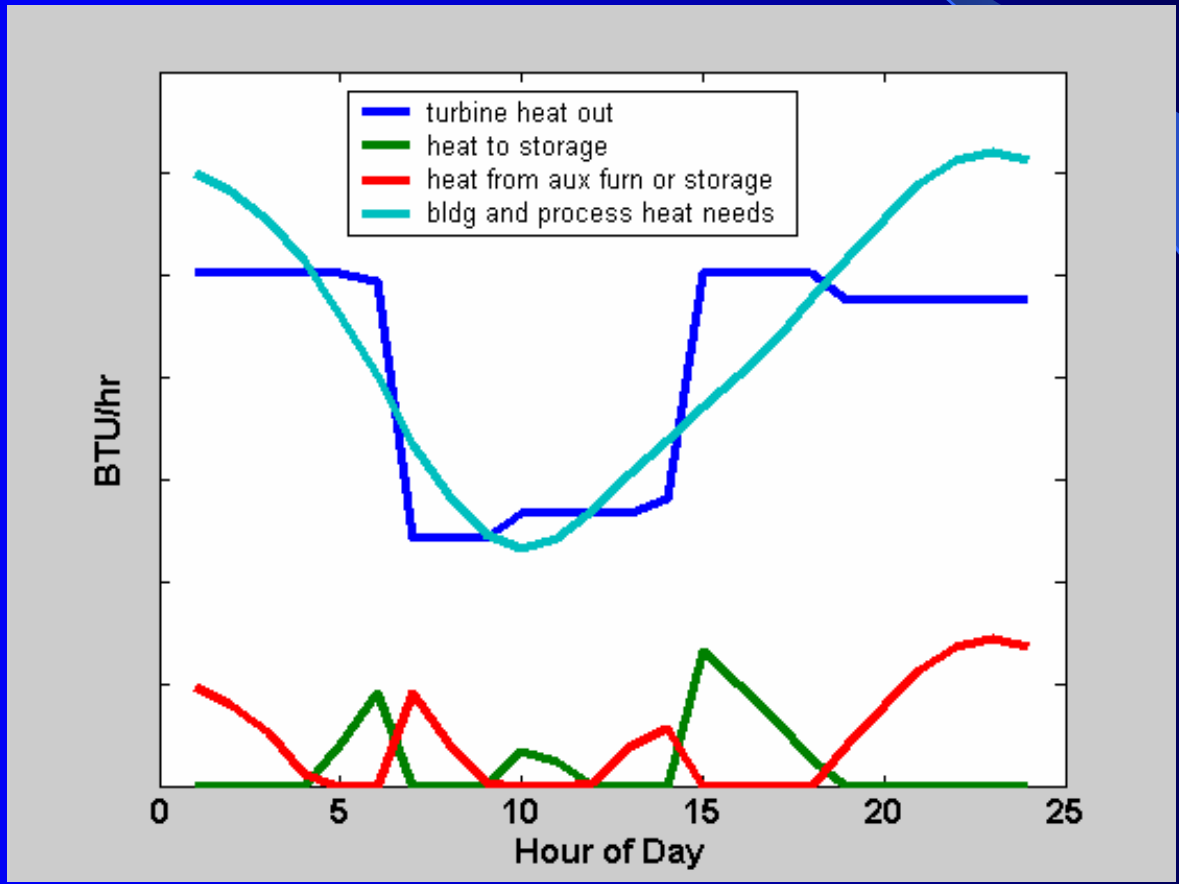
Electrical and Thermal Systems Model



Fast Response Heat Storage to Improve Utilization

- Heat storage provides a means to improve overall energy utilization efficiency.
  - Shift the heat to times where it is needed rather than wasting it.
  - Storing and recovering the heat quickly increases its value over conventional thermal storage.

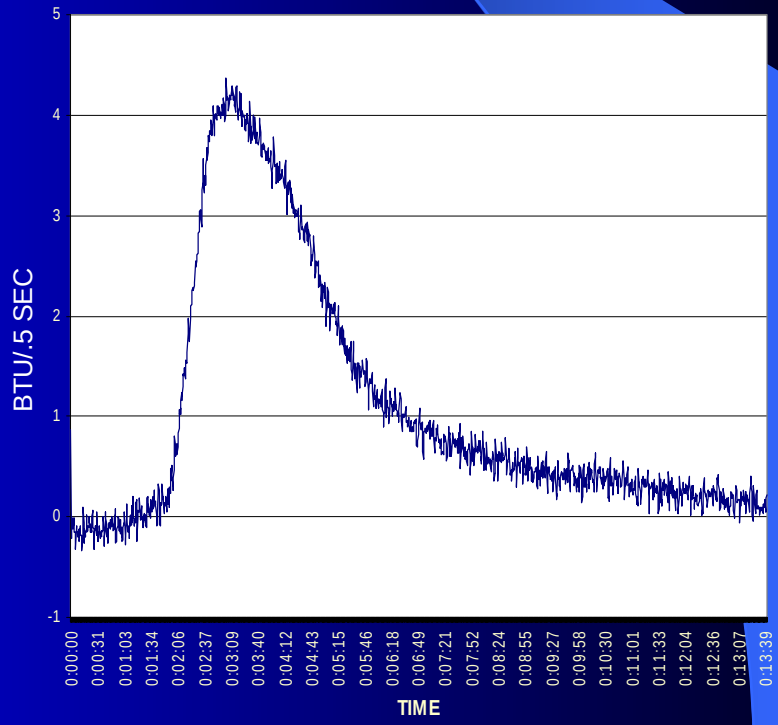
Commercial Building Winter Heat Utilization Example



Fast Response Low Temperature Eutectic Heat Storage Test Unit

Fast Response High Temperature Heat Storage Test Unit

- To improve overall efficiency it is necessary to use as much heat as is possible. Heat storage can significantly improve heat utilization and hence the overall efficiency and viability of CHP.
- Plastic phase change material in a fluidized bed configuration
  - Changes phase at 176°F

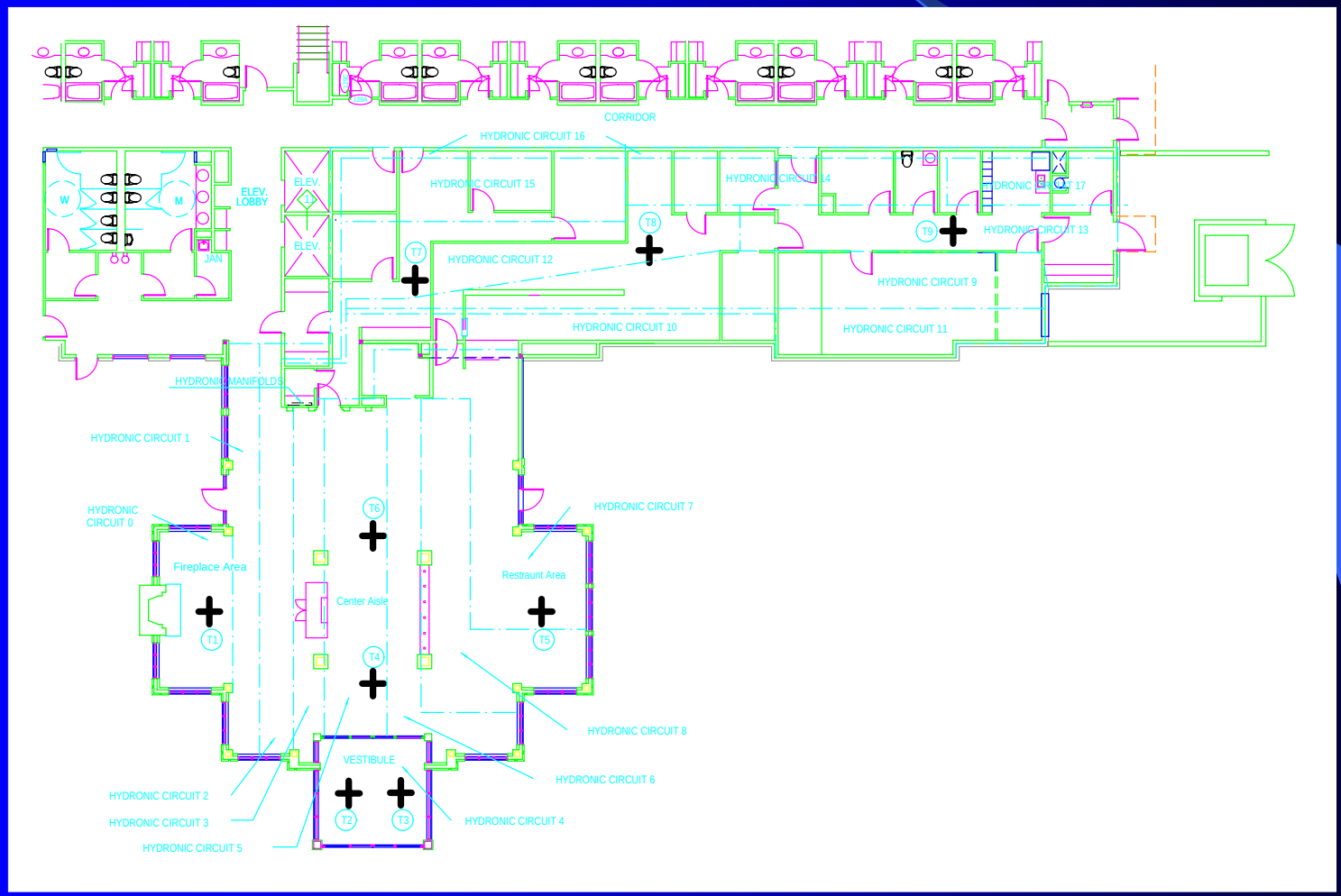


Building Thermal Time Constants

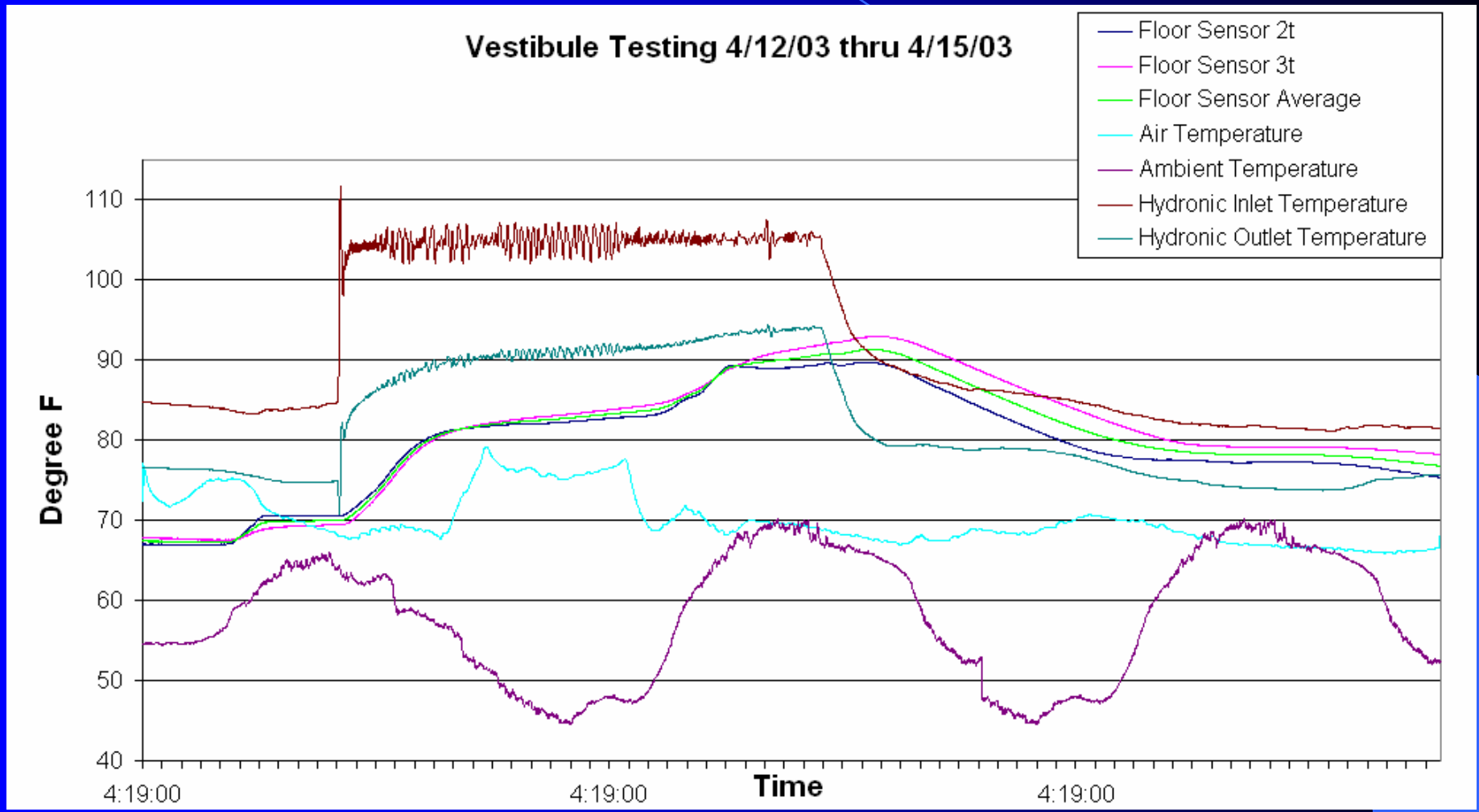
- The rate at which the temperature of various regions of the floor changes temperature is needed for input to the optimizing energy model.
- During construction calibrated TIDs were placed in the floor at various locations.
- Time constants for the various floor regions was determined for various combinations of the hydronic heating system.

Temperature sensor locations for time constant values

- + indicates location of calibrated TID in Hotel lobby area



Time constant data for vestibule area

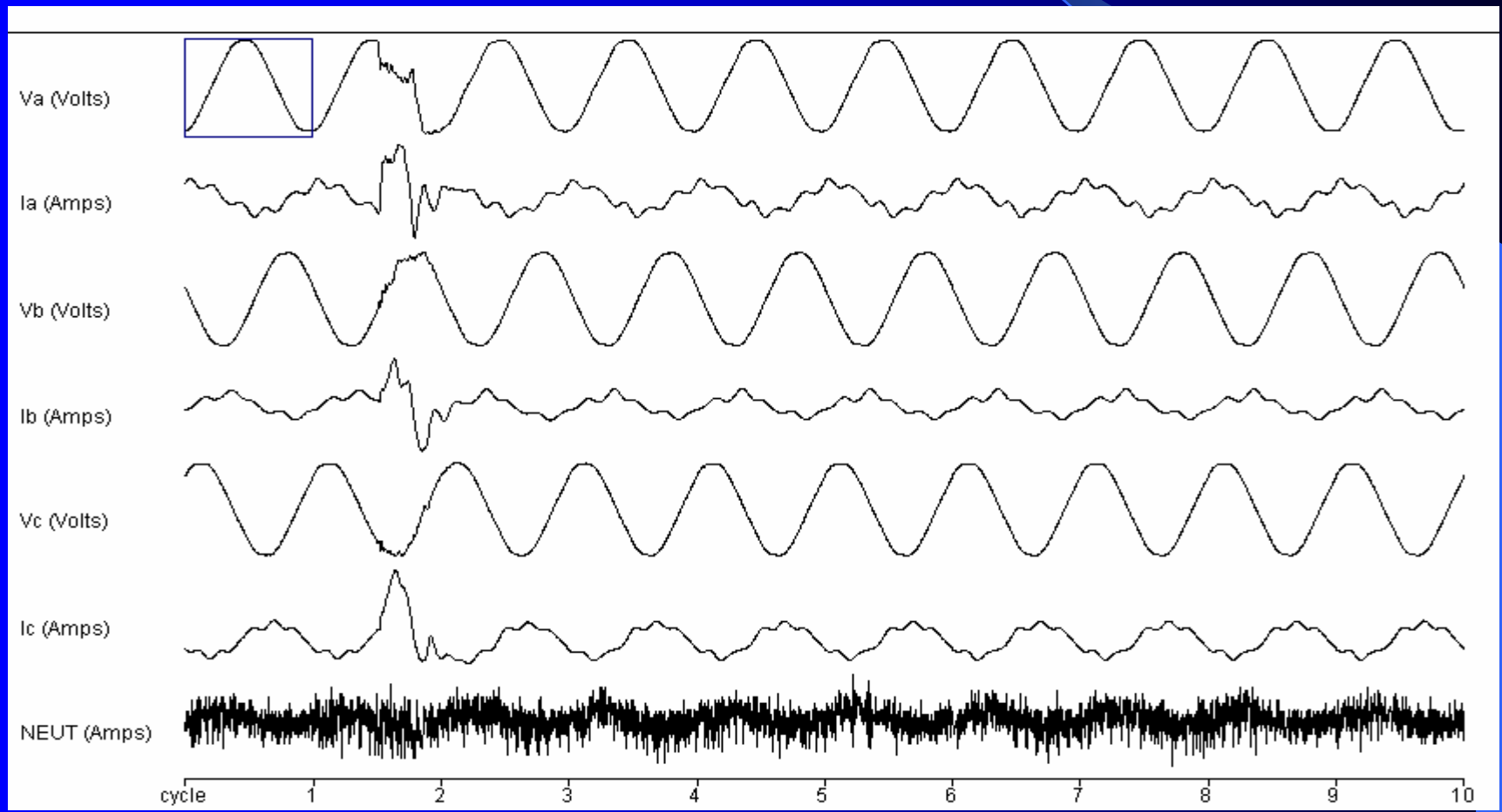


Power Quality Issues

- The quality of power at the CHP - hotel bus was monitored continuously
  - Inverter issues at the hotel
    - Inverter PQ and harmonics
    - Interactions with hotel equipment
    - Interactions between inverters
  - Disturbances from the grid
    - Impact on CHP system

Typical PQ Trigger Incident

- Transient on electric grid from thunderstorm tripped the CHP system.



Solar Cell Installation

- Three solar panels and associated electronics are being tested for inclusion in the energy system.
  - Improve understanding of how a renewable resource might be included in the optimization process.

Milestones Completed

- **This project will optimize energy usage, creating energy and economic savings, and provide a reliable energy system for hotels. The intent is to develop a packaged CHP system for the hotel industry.**
  - Completed construction and installed initial CHP test system at Hotel in Chesterton, IN.
  - Integrated the system into the building and hotel operations
  - Initiated activities to optimize energy value and utilization
  - Developed system to quantify benefits of CHP system from real time data to meet hotel owners needs
  - Completed initial design and started efforts to implement advanced controls for energy system
  - Operated the CHP system as part of hotel operations to gain knowledge for the developmental process

Planned Milestones

- **Phase III**
  - Finalize the development of the various systems and interfaces into a prototype BCHP package for use in the hotel industry. The goal of this phase will be to synthesize the experience and information gained during the prior two phases into a viable BCHP product prototype for the hotel industry.

Summary

- **The current effort is developing technology, designs, and operating strategies to optimize CHP utilization in the hotel industry.**
- **Techniques include:**
  - **Intelligent dynamic control with neural networks and fuzzy logic**
  - **Developmental activities include an operating hotel**
  - **Theory iteratively blended with field experience**
- **Current efforts are proceeding to meet the the overall goal of developing a technically and economically viable packaged CHP unit for use in the hotel industry.**

Thank You