

Ingersoll-Rand Building Cooling, Heating and Power (BCHP) Integrated Energy System

by Jim Kesseli

**Integrated Energy Systems
Peer Review Meeting
Nashville, TN
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BCHP Integrated Energy System Program Objective

- ◆ Objective Develop packaged integrated system that generates steady grid independent power with concurrent production of cooling capacity and hot water year round.

- ◆ Secure electric power - 30 to 100 kWe (PowerWorks)
 - Natural gas driven, propane, and liquid fuel options
 - Operated grid-parallel and stand-alone (emergency)
 - One year service interval

Integrated Energy System Program Objective

- ◆ Ammonia water absorption system
 - Exhaust-driven and air-cooled
 - COP of up to 1.0
 - Competitive equipment cost relative to vapor compression system
- ◆ Customized package for supermarket application
- ◆ Roof top standard installation
 - Single skid, Weather-proof enclosure
- ◆ Factory integrated - turn-key product
 - Built on IR production line
 - Control logic for complete energy system and building (Supermarket) energy management

Ingersoll-Rand BCHP Team

◆ IR Energy Systems

- Microturbine manufacturing, sales, installation, financing, service, energy systems management programs.
Work on packaging, integration, and cost reduction.

◆ IR Hussmann

- World's largest manufacturer of equipment for supermarkets, convenience stores, food service industries, and commercial/industrial refrigeration, including cold storage warehouses and processing plants.
Support development of the package that is attractive to supermarkets. Assist in commercialization.

Ingersoll-Rand BCHP Team

◆ Energy Concept Company (ECC)

- Developer of ammonia water absorption systems.
Optimize and design absorption system to fit Powerworks

◆ Advanced Mechanical Technology Inc. (AMTI)

- Developer of advanced heat transfer products.
Work on design and development of interface heat exchangers.

PowerWorks™ Specifications



70kWe model

- ◆ Has 140% peaking power capacity on cold days (98 kWe)
- ◆ High efficiency
 - 30+% LHV electric
 - Up to 80% total with cogen
- ◆ Built-in heat recovery
- ◆ Built-in gas booster
- ◆ Remote control and monitoring
- ◆ Low emissions
 - <9 ppmv NOx @ 15% O₂ (natural gas)
- ◆ Dual fuel option (future)
- ◆ Compact, low noise enclosures
- ◆ 8,000 hour maintenance interval
- ◆ Up to 80,000 hour engine life

PowerWorks Microturbine



Patented Recuperator

- Critical to high efficiency
- Designed for 80,000 hour engine life
- Cogeneration

Mechanical Shaft Output

- Platform for other products

Proven Generator Technology

BCHP Package Layout/Specification

◆ **Single Skid 6x6 ft 7 ft high with detached condenser**

- Factory assembled outdoor enclosure
- Well packaged with minimum ammonia charge
- Minimal installation cost

◆ **Common cooling loop**

- Absorber cooling in series with PowerWorks lubrication system
- Application heat exchanger and heat dump radiator

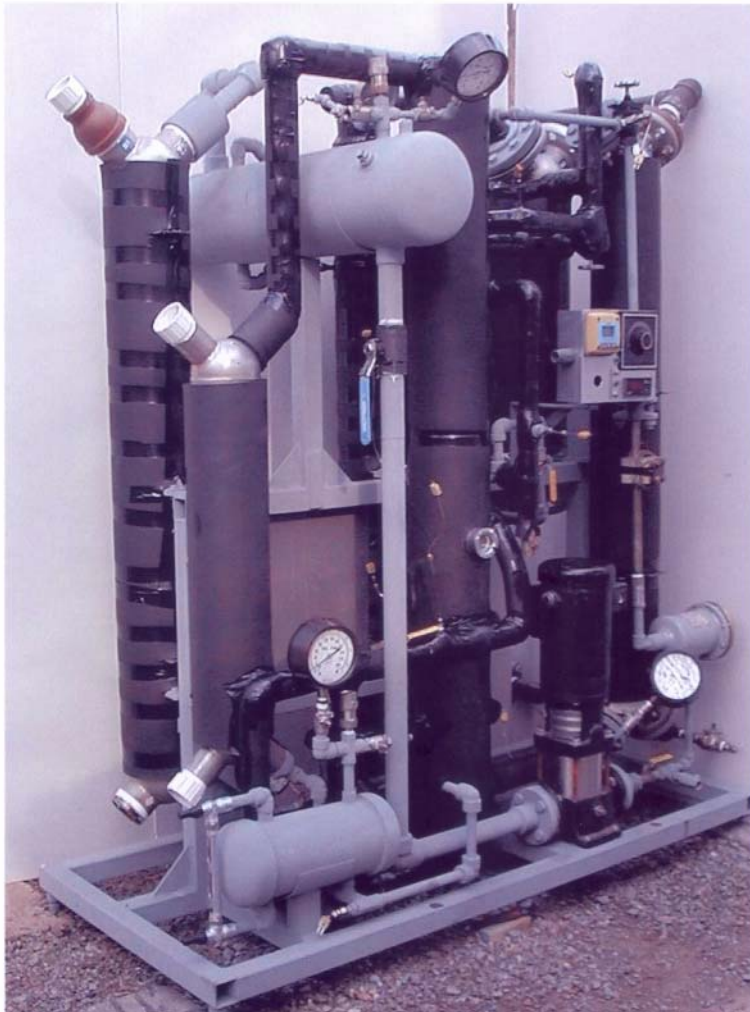
◆ **Year-round operation**

- Base load operation
- Cooling capacity utilized for engine inlet air cooling and supermarket subcooling
- Heat available for space heating, desiccant regeneration, and hot water

◆ **Minimum maintenance**

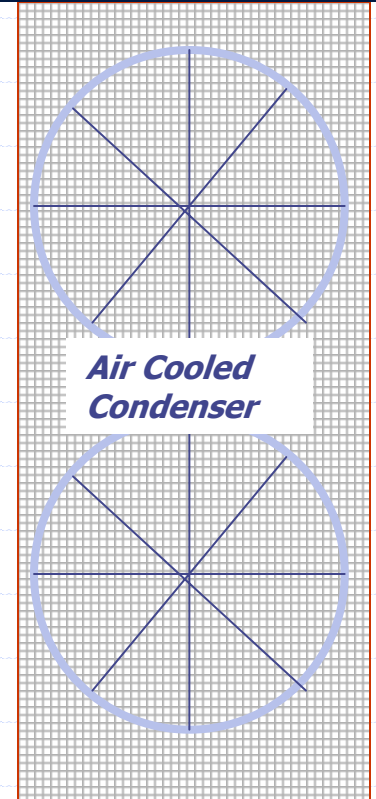
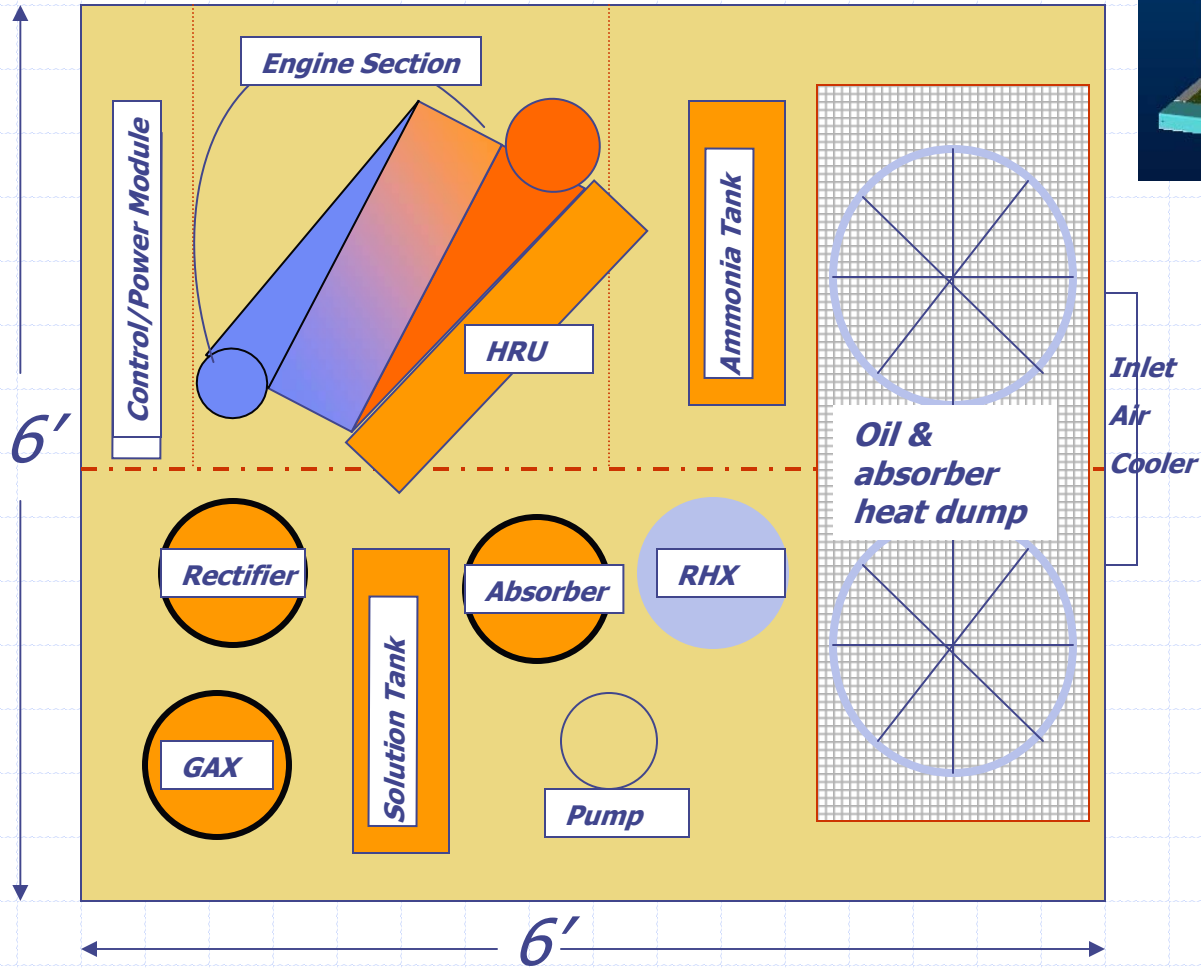
- No winterization
- No cooling tower
- Annual service visit: fans and pump

Absorption System Specifications

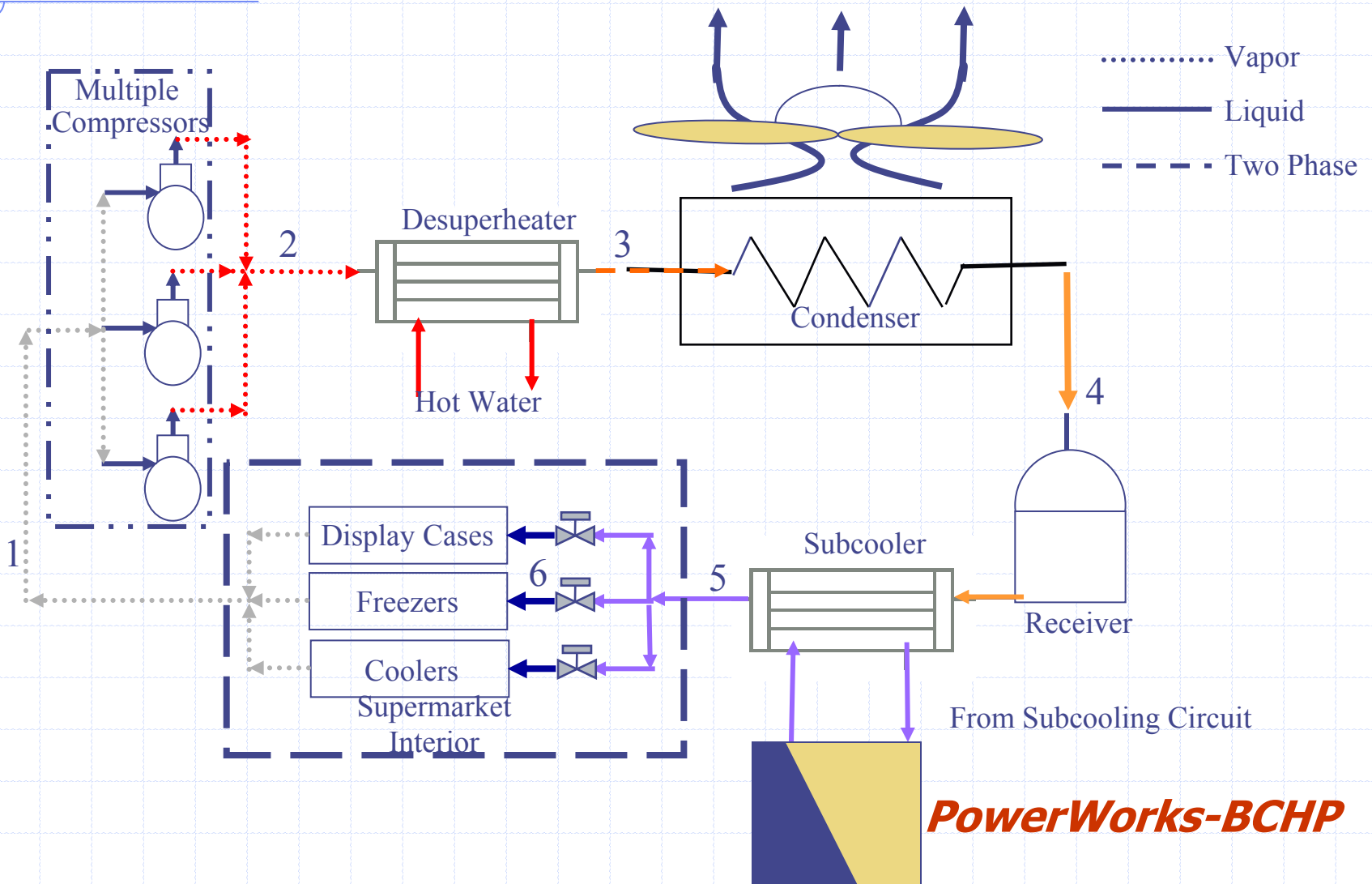


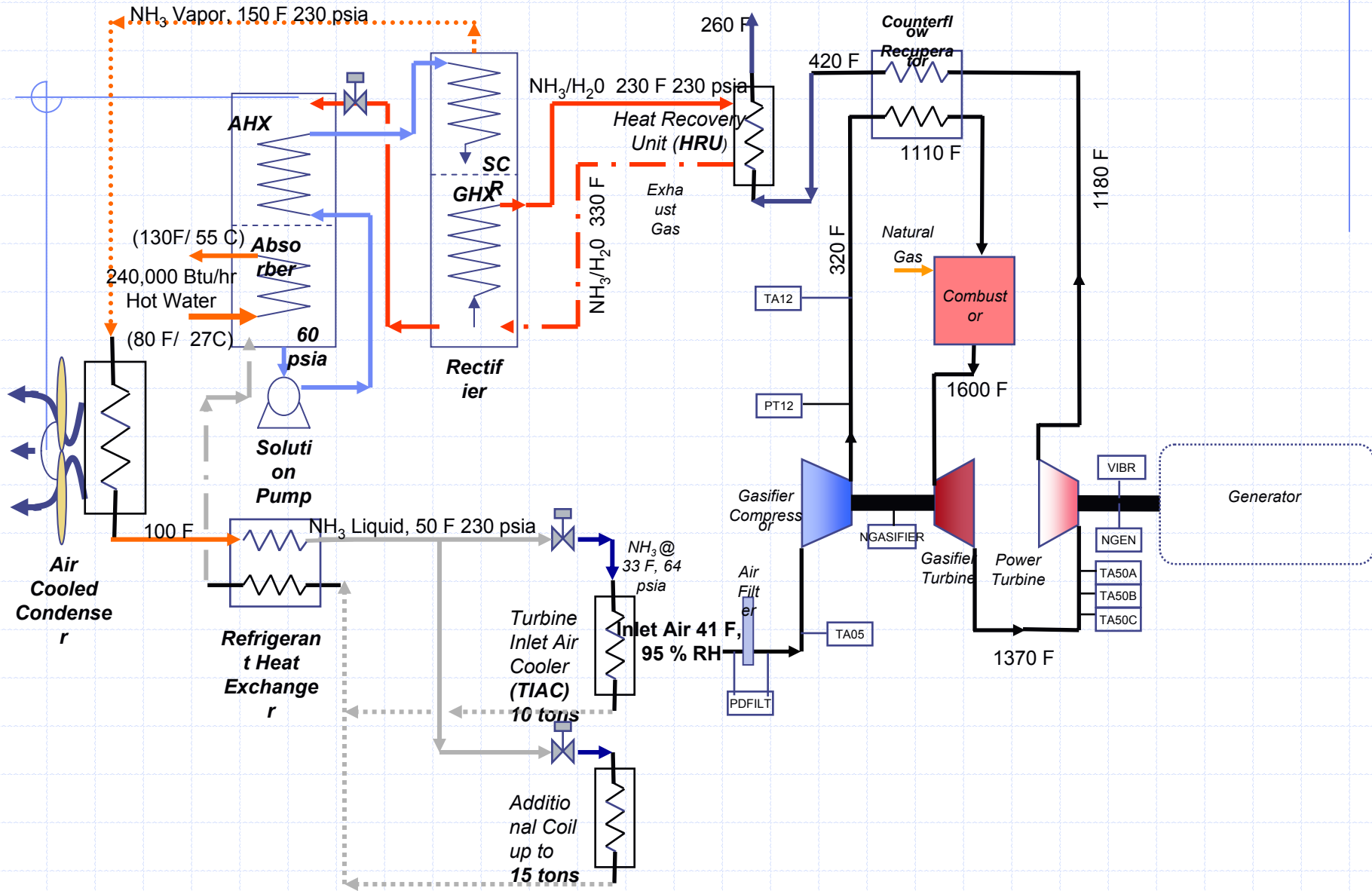
- ◆ Small Size, 2.5'x5, 7 ft high
- ◆ Up to 20 tons of cooling @ 95 F
- ◆ Higher capacities at lower ambient
- ◆ **COP 0.6 - 1.0**
- ◆ Up to 100 kW of hot water @ 140 F
- ◆ Air Cooled condenser & package
- ◆ Small Parasitic Load, Pump and Condenser Fans
- ◆ Excellent Part Load Characteristics
- ◆ Low refrigeration temperatures
- ◆ Simple controls
- ◆ 8,000 hour maintenance interval
- ◆ 20 year life

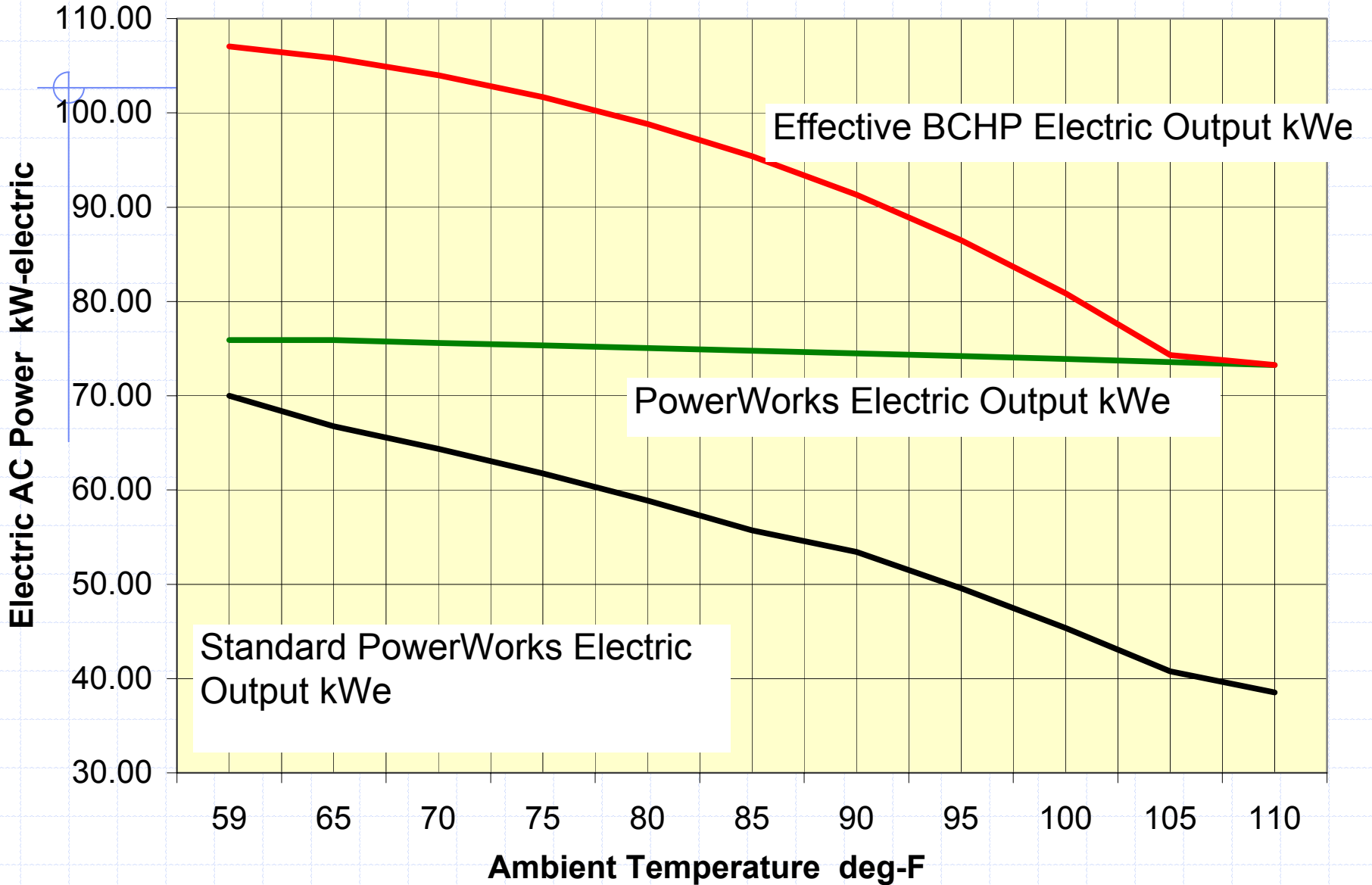
Preliminary Layout Top View



Standard Supermarket Refrigeration System



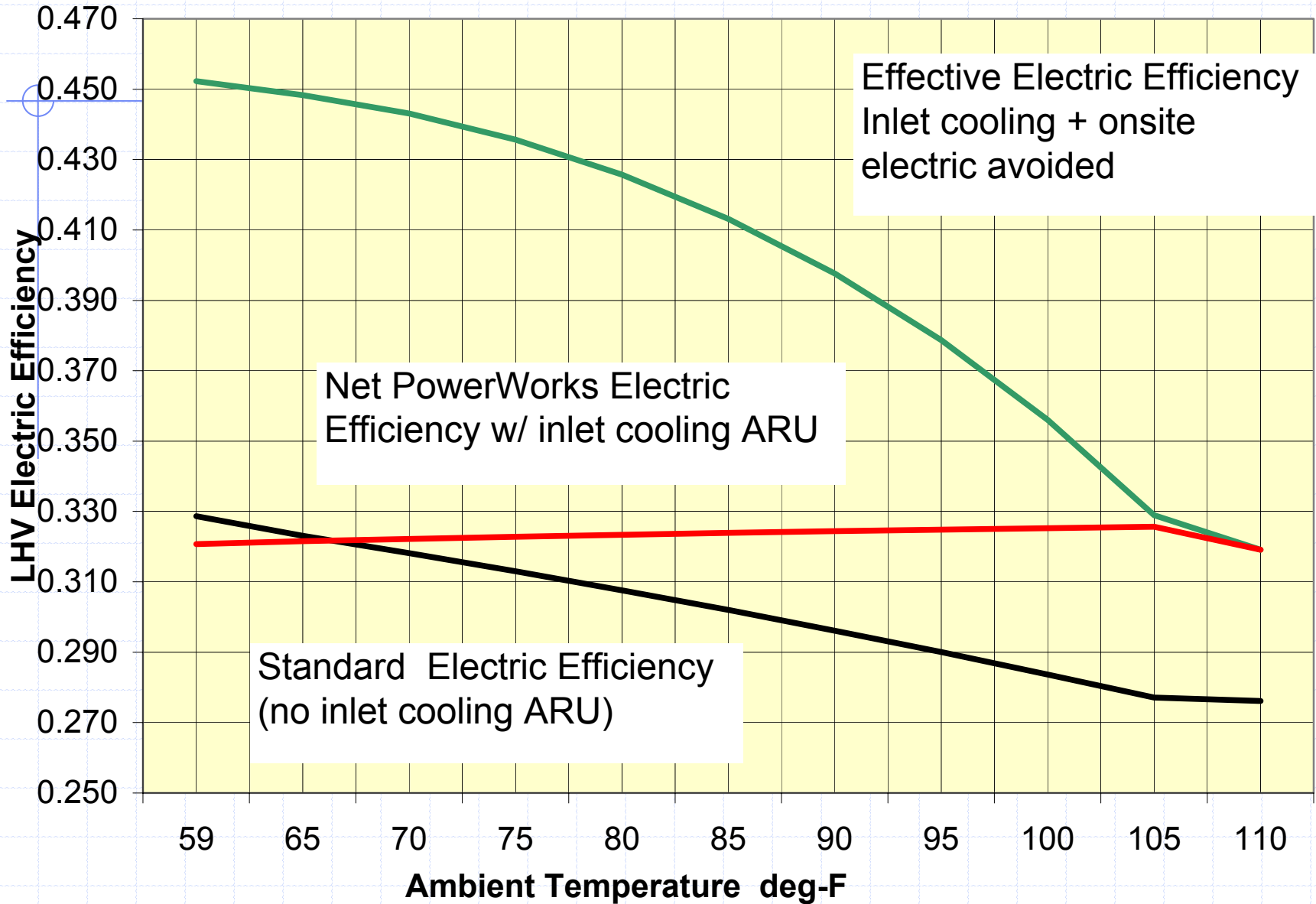




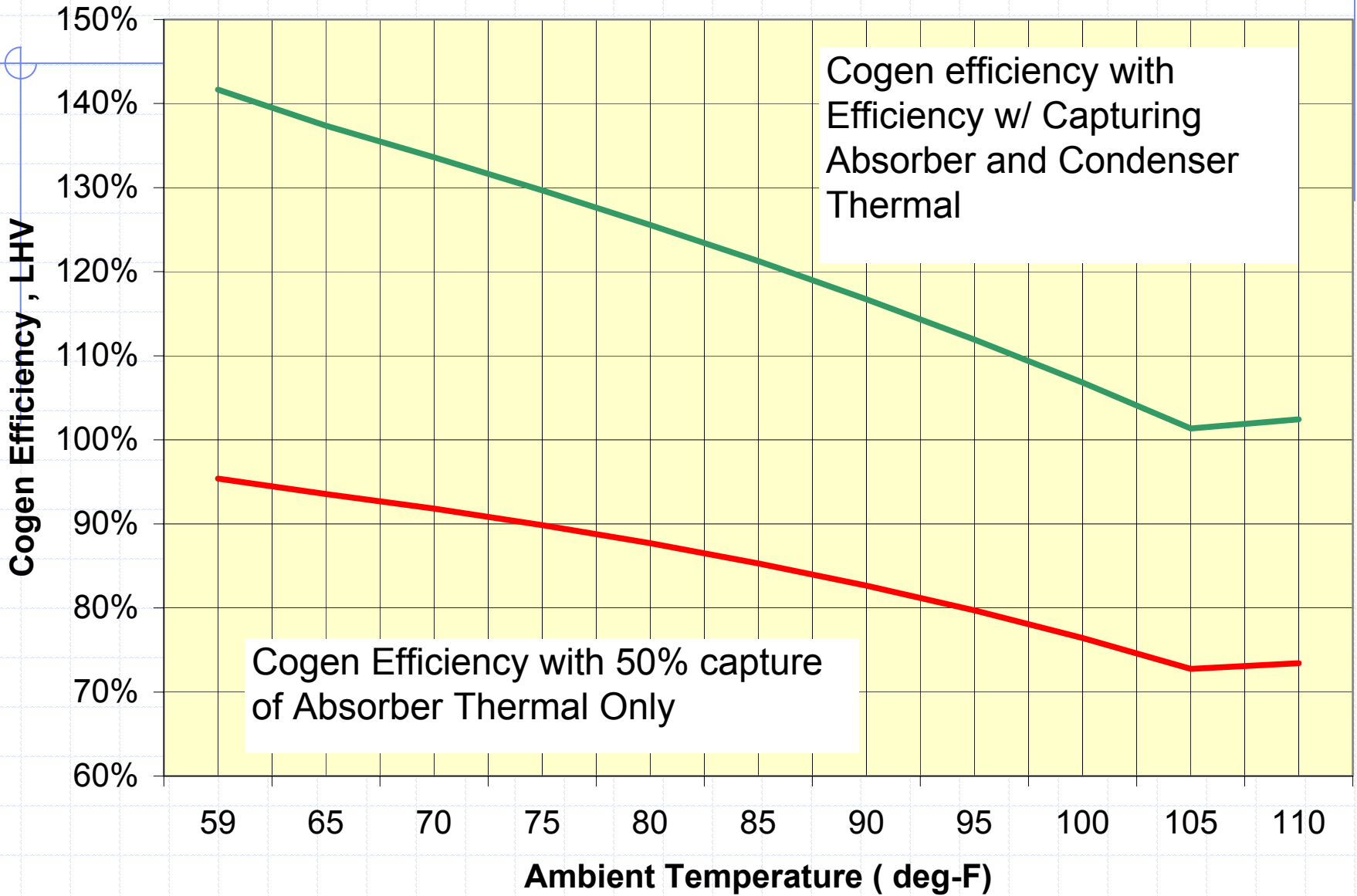


PowerWorks™

Integrated System Performance



$$\eta = \frac{\text{Electric power} + \text{Cooling "tonnage"} + \text{thermal heating}}{\text{Fuel input}}$$



Supermarkets present a significant opportunity for BCHP - microturbine systems

Pros:

- **High utilization (year-round) cooling/refrigeration load**
- **Emergency power back-up is critical facility need**
- **Product standardization is practicable**

Cons:

- **Customers are very cost conscious**
- **Many different store designs and energy management philosophies make standardization challenging**
 - **Typical refrigeration loads are small and dispersed, often difficult to aggregate into a compatible size for BCHP**
- **A microturbine's heat-driven cooling output is inversely matched to the buildings need (on hot days we make much less cooling than is possible on cool days)**

IR-Approach to Market challenge

- ◆ Utilize IR-Hussman installation and service
 - The market leader in this business sector
- ◆ Ship turn-key - standard product
 - hold down capital cost
 - Hold down installation cost
- ◆ Advancements in NH3 GAX
 - Combine industry leaders in chiller R&D with IR manufacturing strengths



Hussmann complete
supermarket equipment
packages



BCHP Program Plan

- Project Plan **Completed: Nov. 2001**
- ◆ Commercialization Study **Completed: March 02**
- ◆ Package System Concept Definition **ongoing, May 2002**
- ◆ Analytical Optimization and Final Design
 - Thermo-economic optimization **Ongoing**
 - Preliminary hardware selection **July 2002**
 - Final design and drawings, **January 2003**
- ◆ Rating Procedures and Standards **January 2003**
- ◆ Prototyped Fabrication
 - Absorption system prototype, **July 2002 - April 2003**
 - Balance of plant (engine) **April 2003**
 - Controller **May 2003**
- ◆ Laboratory Testing
 - Assembly **June 2003**
 - Testing, complete **December 2003**

BCHP Milestones

- **Preliminary Layout** **May 2002**
- **Hardware Selection** **July 2002**
- ◆ **Begin Absorption System Fabrication** **August 2002**
- ◆ **Final Design and Drawings** **January 2003**
- ◆ **Prototype Assembly** **April 2003**
- ◆ **Prototype development completion** **Dec. 2003**

BCHP Package Summary

- ◆ **Steady grid independent power**
- ◆ **Small well integrated package: Single Skid 6x6 ft, 7 ft high**
- ◆ **Minimal maintenance, annual service visit**
- ◆ **BCHP package at 95 F**
 - 75 kWe
 - Up to 10 tons of cooling in excess of inlet air cooling
 - 100 kW or more of 140 F hot water
- ◆ **BCHP Package at 59 F**
 - Up to 100 kWe
 - Up to 25 tons of cooling
 - In excess of 100 kW of 140 F hot water