Integrated Energy Systems
Peer Review Meeting

Opryland Hotel – Nashville, Tennessee
April 30 – May 2, 2002

Thermally-Activated Technologies

Joel Anderson
SVP, Mississippi Valley Gas

“Tomorrow Can Be Beautiful…
… All It Takes Is A Dream”

-- Walt Disney

“Tomorrow Can Be Beautiful…
… All It Takes Is A Dream”

-- Walt Disney

“Plus Commitment, a Plan, Funding and Hard Work”

-- Joel Anderson

The Ugly

- The U.S. is an energy hog
- E-commerce growing as electric reliability and quality decreases
- Threat of terrorism on increase
  - Aggravated by increase dependence on foreign oil
  - Growing need for energy source diversification
  - Allies upset at U.S. rejection of Kyoto accord

The Ugly *(continued)*

- U.S. biggest polluter among developed countries
  - 50 to 100 thousand people die each year
- Indoor air quality 2 to 10 times worse than outside
- Illness on the increase
  - 17 million Americans have asthma
  - 31 million American develop Sinusitis
  - 37 million Americans suffer from seasonal allergens

The Beautiful

- Dramatically improved energy efficiencies
  - Reduced dependence on foreign oil
  - Reduced air pollution
- High electric reliability and quality
- Healthy indoor environment

The Ugly

- Existing remote located power plants
  - Poor efficiencies
    - Range 16% to 50%
    - Typically 30%
  - Additional efficiency losses to transmission and distribution
  - Many plants are large polluters
- Problems associated with aging infrastructure
- Increasing problems associated with high-peak demand

The Beautiful

- Thermally activated technology
  - On-site generation about 30% efficient
  - Thermally activated equipment gives additional 30% to 50%
- Total energy efficiencies 60% to 80%

Thermally Activated Technologies

- Buildings
  - Large commercial
  - Small commercial and residential

- **Unitary equipment consumes over 75% of building HVAC energy**

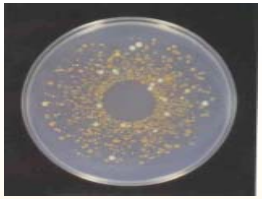
Thermally Activated Applications

- Humidification
- Dehumidification
- Refrigeration
- Space heating
- Water heating
- Space cooling

Healthy Indoor Environment

Indoor Air Quality Problems

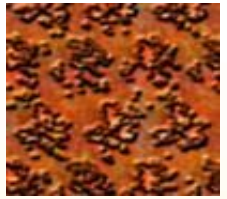
DUST MITES



BACTERIA

FUNGUS

MOLD DAMAGE



CORROSION

Statistics on Asthma and Allergic Diseases

- 17 million Americans have asthma and allergic diseases
  - 4.8 million children
  - 7% expectant mothers
  - Rate on increase
- 31 million Americans develop sinusitis each year
  - 18 million physician visits
  - $8 billion in health expenditures
  - 4 days/year missed work days on average
  - Rate on increase

Statistics on Asthma and Allergic Diseases

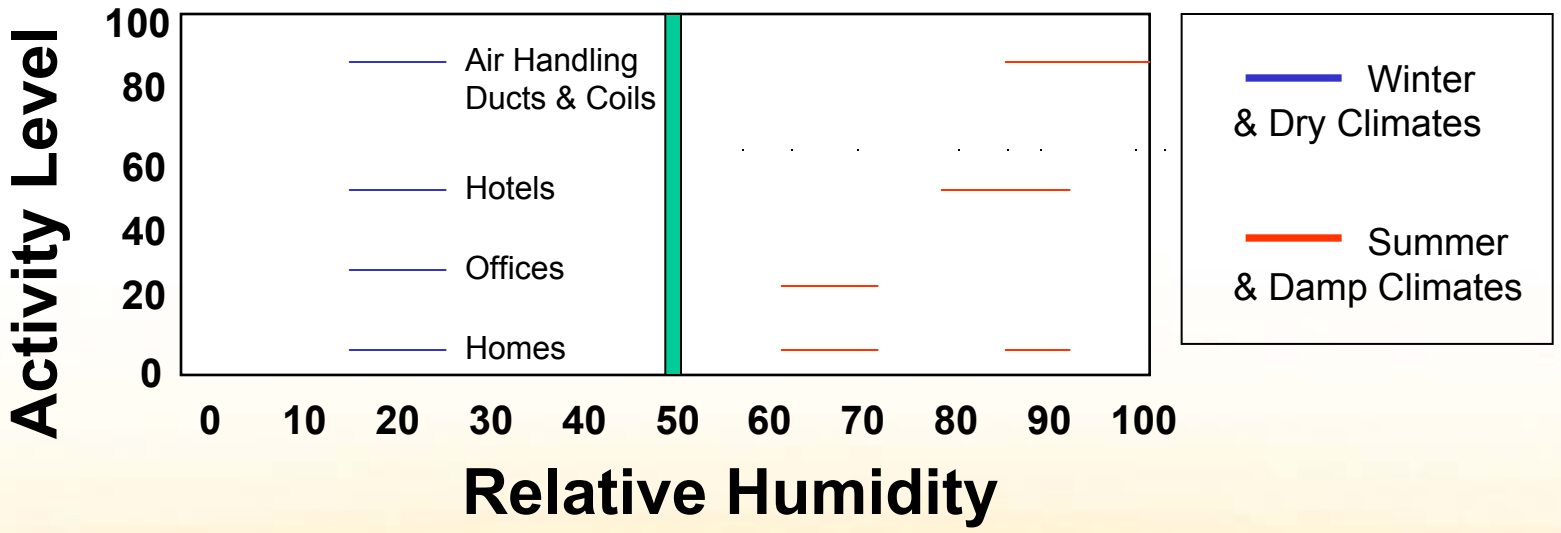
- 36 million Americans suffer from seasonal allergic Rhinitis

Healthy Indoor Environment

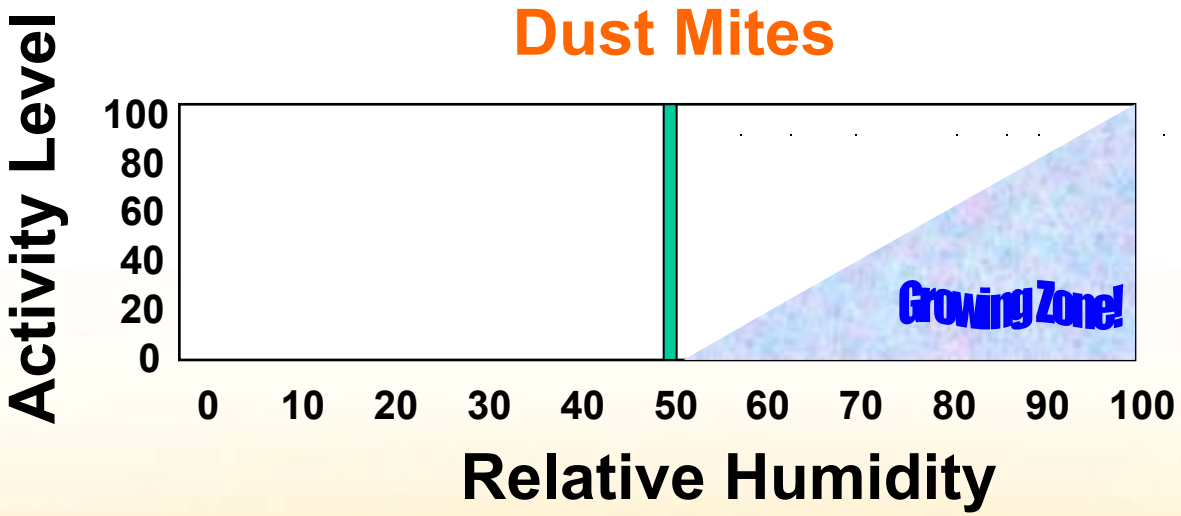
Causes of Asthma and Sinusitis

- **Residue from dust mites**, cockroaches and pets
- Tobacco smoke
- **Mold and fungus**
- **Bacteria**
- Pollen and dust

Observed Relative Humidity In Buildings



Optimum Relative Humidity for Minimizing Adverse Health Effects



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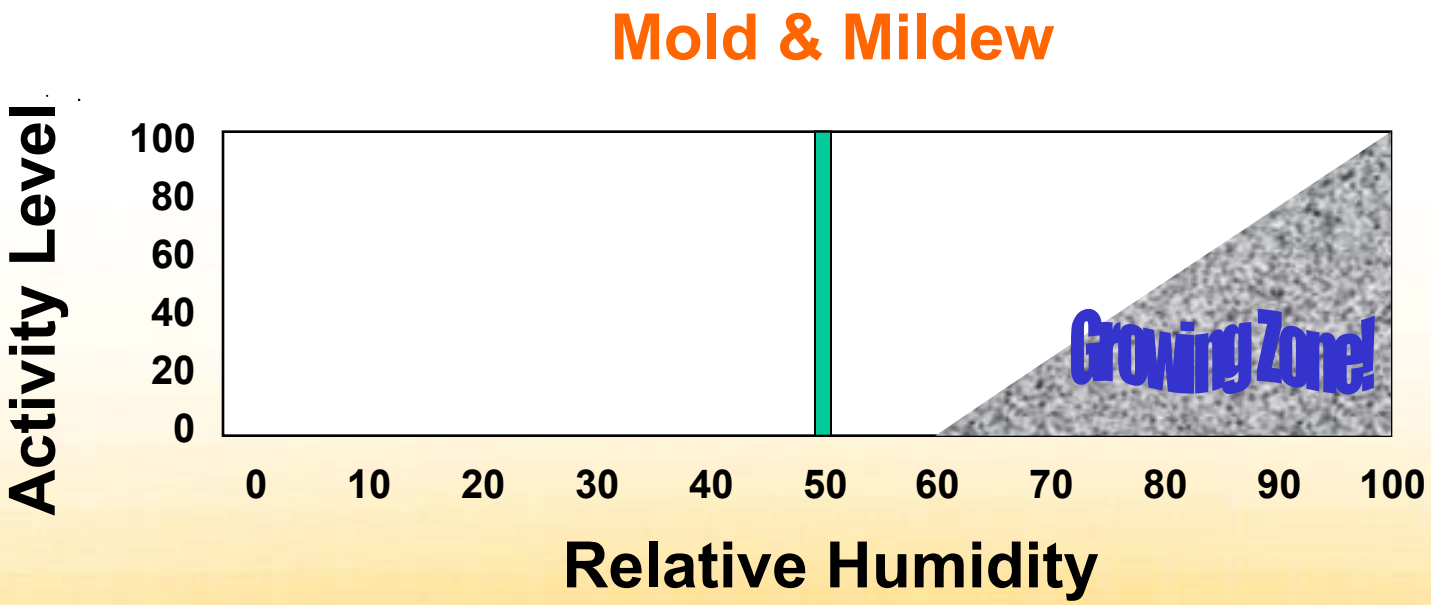

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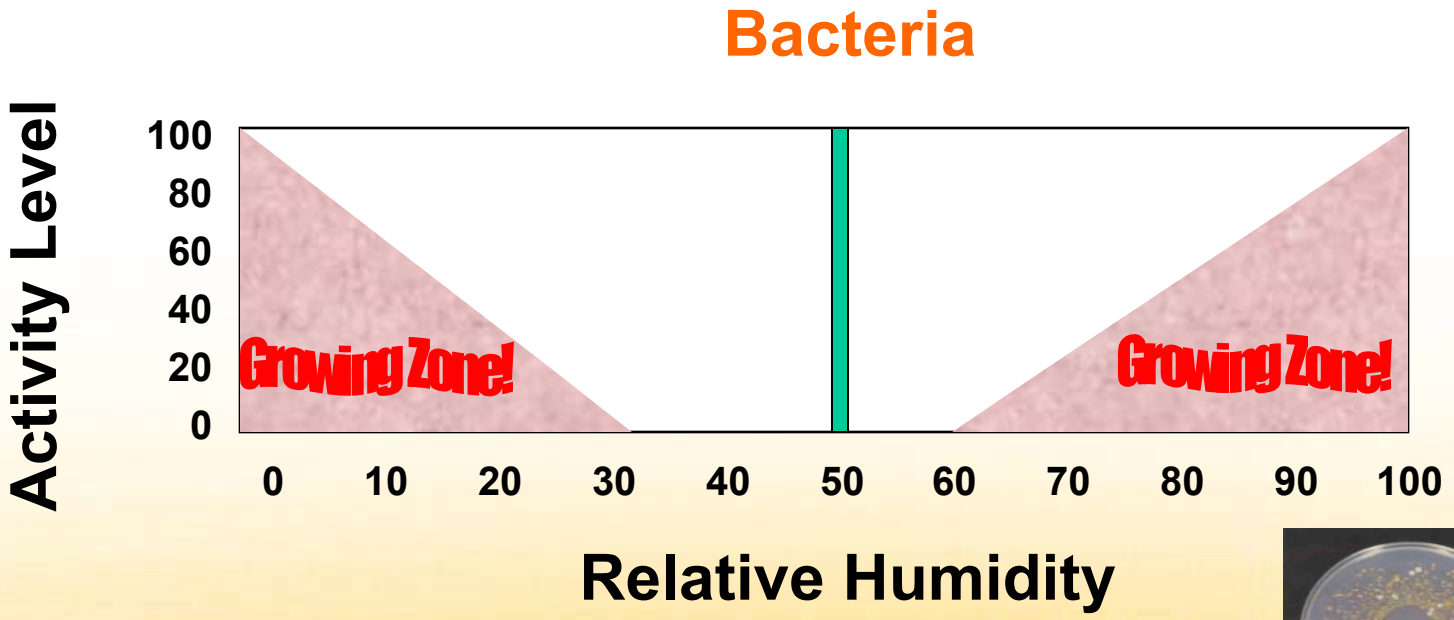
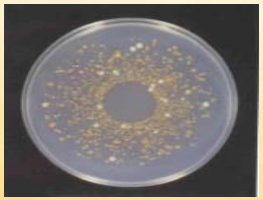




BACTERIA

Residential Desiccant Dehumidifier

Product Development

HEATCRAFT™

gti

TECO PEOPLES GAS

ERC University of Illinois/Chicago Energy Resources Center

The Global Center for Desiccant Technology
Department of Mechanical Engineering
Mississippi State University

Mississippi Valley Gas

Exergy Partners

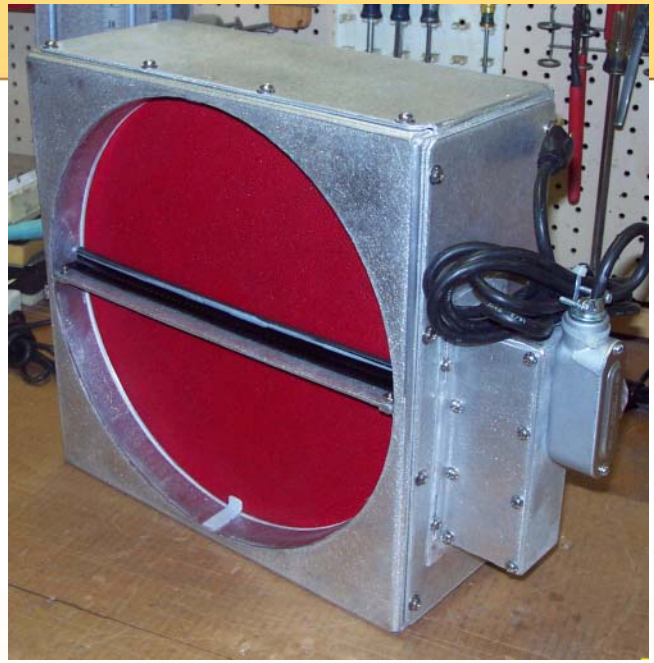
NREL National Renewable Energy Laboratory

AMTI

OAK RIDGE NATIONAL LABORATORY

Rotor Cassette

- NREL performance validated
- Munters old design
  - Caster supported rotor design
  - Separate seal
- Redesign
  - Simpler drive assembly
  - Snap together cassette construction



Alpha Unit Status

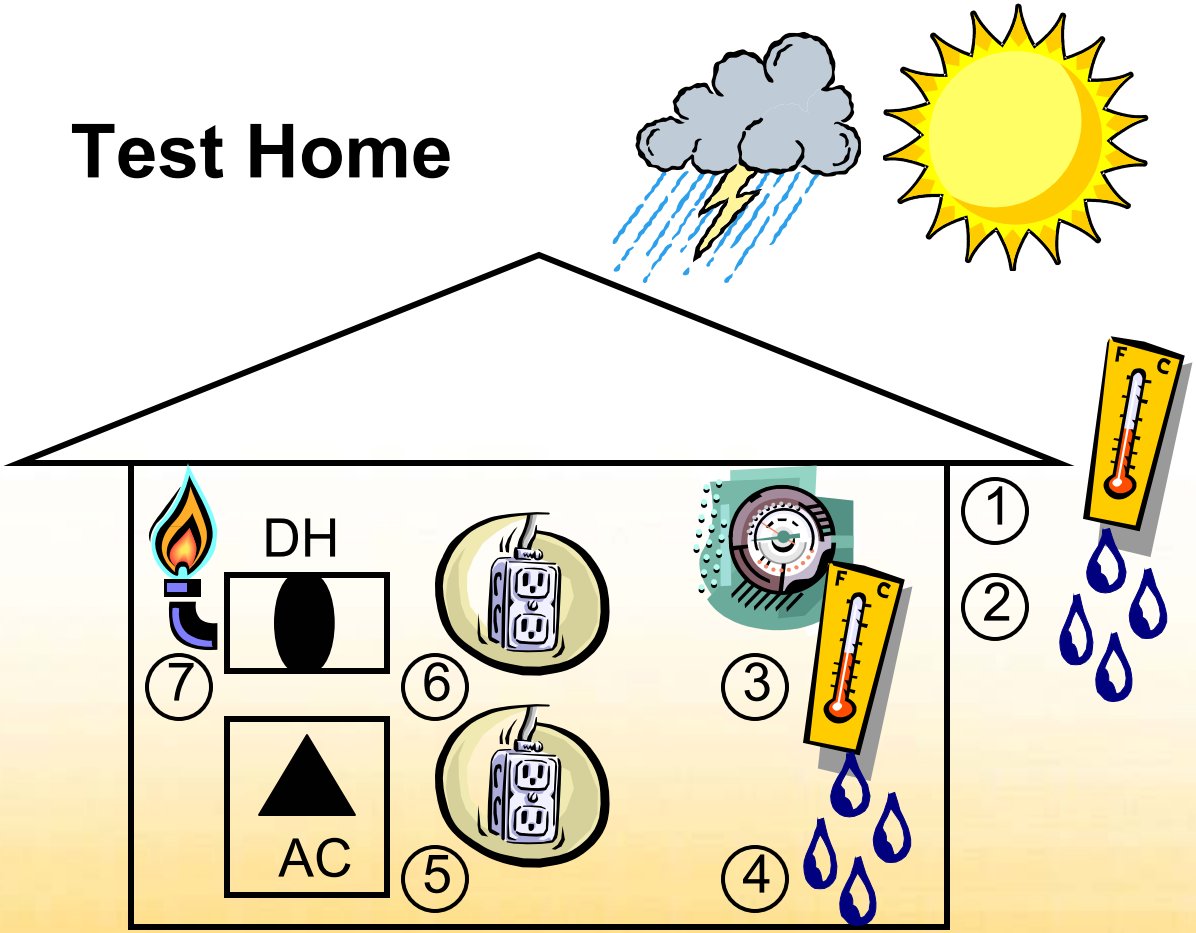
- Prototype Construction
  - Rotor (3 interim alpha prototypes DONE)
  - Burner (3 interim alpha prototypes DONE)
  - Balance of unit (controls, etc. in process)
- Laboratory Testing Plans (DONE)
- 3 Alphas Ready (DONE)
  - Product meeting (DONE)
  - Heatcraft, MSU & GTI lab tests 5/02
- 20 field test units 7/02

Residential Field Tests

Sensors

1) Outdoor T_{db}
2) Outdoor %RH
3) Indoor T_{db}
4) Indoor %RH
5) AC Watthours
6) DH Watthours
7) DH Gas CF -- separate utility supplied gas meter also required

Note) A pulse logger required for 5, 6, & 7



Gas-Fired and Heat-Activated Commercial Refrigeration

Solid-Vapor Complex Compound Sorption Technology

The Technology
Solid-Vapor Complex Compounds

- Heat activated cycle
- Stationary shell and tube pressure vessels
- Solid-vapor sorption process using ammonia and a solid complex compound substrate
  - Large ΔT: Single stage to -40ºF suction temp
  - No internal moving parts
  - Minimal electric parasitics

The Market Need

- Commercial refrigeration with solid-gas sorption technology using natural gas ,propane and/or on-site generation exhaust heat
- Products from 0.7 to 7 refrigeration tons
- Evaporator temperatures from -40ºF to 30ºF

Single-Stage Commercial
Refrigeration Products

- Applications:
  - Frozen meat and vegetable storage (0 to -10ºF)
  - Frozen fish and ice cream storage (-20ºF)
  - Fresh meat, fish and vegetable storage (32ºF)

- Markets:
  - Supermarkets
  - Fast food and chain restaurants
  - Stores and institutional

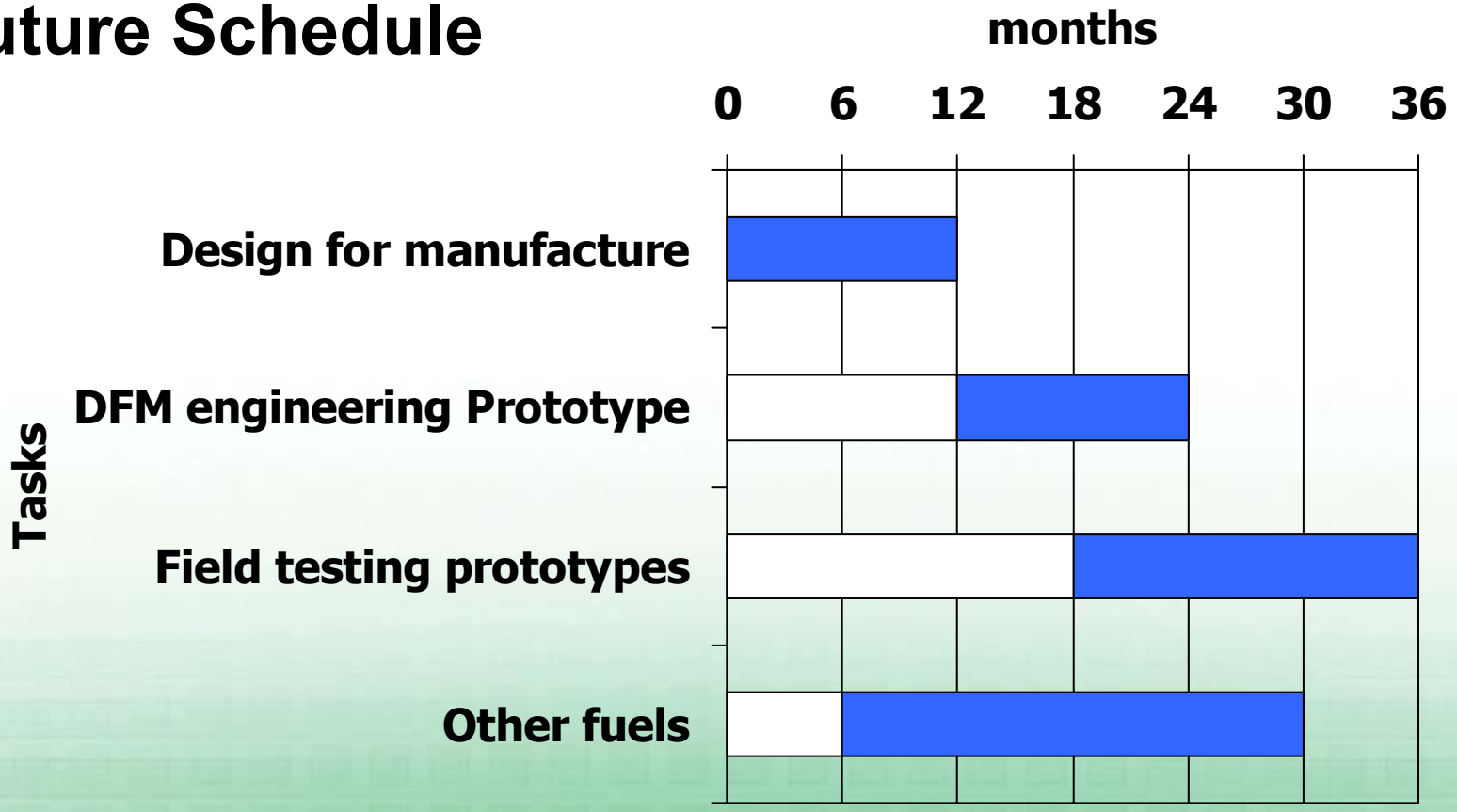
Product Features

- Natural gas or propane fired
- Compatible with exhaust heat (> 500ºF) use for DG
  - Engines and microturbines (Capstone)
- Reduced peak electrical demand
- Low temperature capability (-40ºF)
- No moving parts (except fans, valves)
- No “compressor” lubrication
- No CFCs, HCFCs (uses ammonia)
- Hermetic
- Hot gas defrost
- No compressor noise or vibration
- Low maintenance

Product Design Status

- Sorber design is completed
- A single sorber has been tested successfully for more than 3,500 cycles (60,000 cycles for smaller sorbers)
- Burner-sorber integration design is completed
- Prototype design is completed
- Firing system has been assembled and tested
- Two prototype sorbers have been assembled
- A low-cost generator design has been developed
- All other prototype components have been fabricated and ready for final assembly
- Prototype tested November 2001

Future Schedule



Thank You

The Future is in Thermally Activated Technologies

A New Product Line Based on Advanced
Natural Gas Absorption Technology

Uwe Rockenfeller, Ph.D.
CEO, Rocky Research

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Rocky Research

- DOE contractor through ORNL subcontract
- Responsible for:
  - Research
  - Prototyping
  - Application engineering
  - Design for manufacture
- Sixteen years of experience in gas-driven and ammonia HVACR products

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Our Primary Objective

- Develop a residential and commercial air conditioning and heating system to…
  - Exceed current industry performance via higher energy efficiency
  - Improve comfort and health via improved part load dehumidification
  - Achieve commercial viability through vigorous DFM, manufacturing process optimization, special equipment and dedicated tooling

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Specific Technical Goals

- Achieve a cooling product efficiency of COP = 0.7 @ 95ºF without significant part load degradation
- Provide Unitary packaged product with 60,000 BTU/hr @ 95ºF with minimal capacity reduction at higher temperatures
- Develop a product design/manufacturing process capable of yielding a manufacturer's product cost of $2500 for 5RT units at annual volumes of 10,000

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Specific Technical Goals *(continued)*

- Achieve a heating product efficiency of COP = 1.4 @ 47ºF with minimal efficiency degradation down to 25ºF
- Provide a heating capacity of at least 60,000 BTU/hr at or below 47ºF
- Develop heat pump hardware capable of operating and providing heat at or below 17ºF
- Provide air terminal delivery temperatures at 5º to 10ºF above current electric heat pump systems

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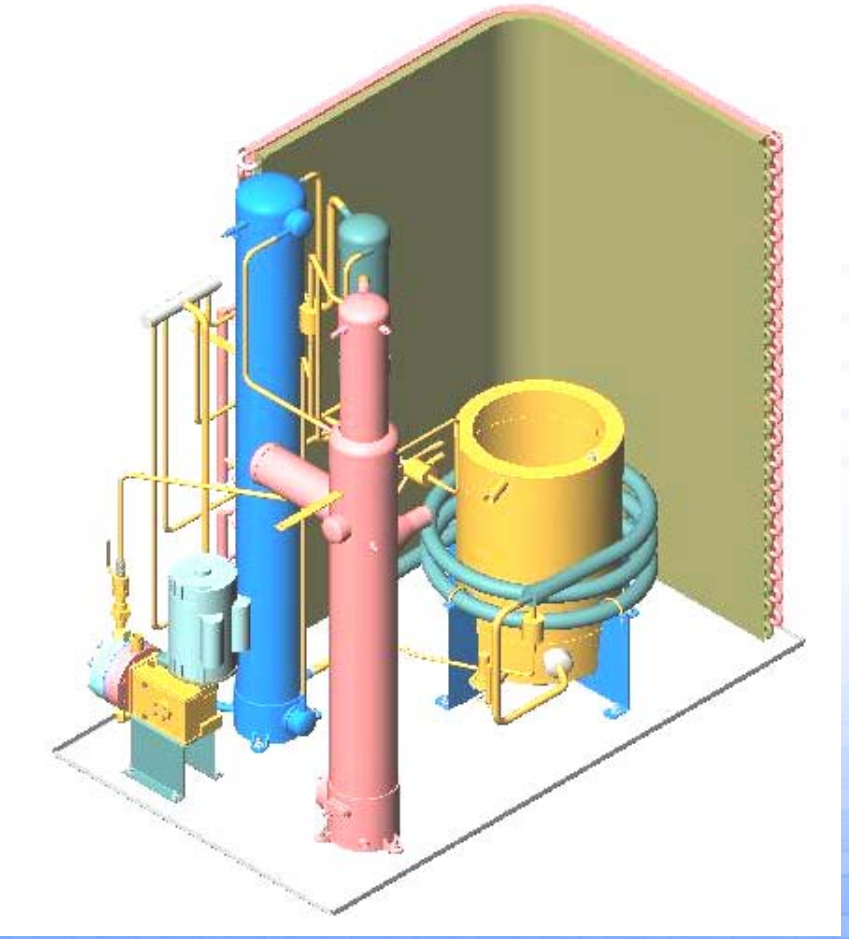
The Technology

- Heat-activated ammonia-water absorption system



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The Technology *(continued)*

- High performance heat transfer components
  - Generator/Absorber Heat Exchanger
  - High efficiency vapor separation
  - Novel heat transfer surface in absorber
- Advanced combustion technology
  - Low emissions
  - Variable speed combustion

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The Technology *(continued)*

- Improved solution pump
  - High Δp capability for heat pumping
  - Low electric power consumption
- Active fluid controls
  - Patented thermal expansion valve refrigerant control
  - Solution flow control
- No chromate inhibitors
  - Proprietary cooperative development of environmentally benign inhibitor

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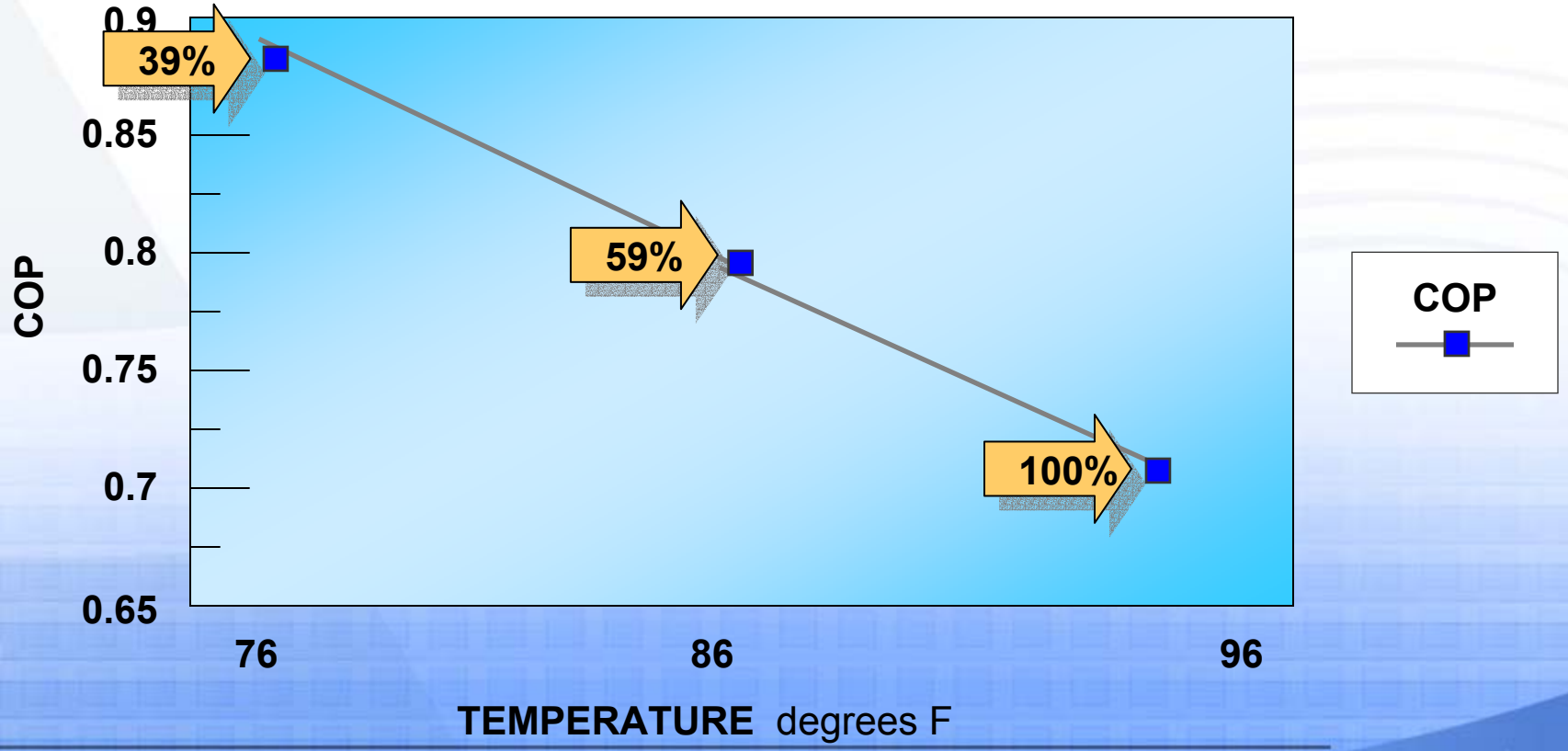
Product Lines

- Chiller
- Chiller/Heater
- Water Heater/Dehumidifier/AC
- Heat Pump

Competitive Advantage Achieved

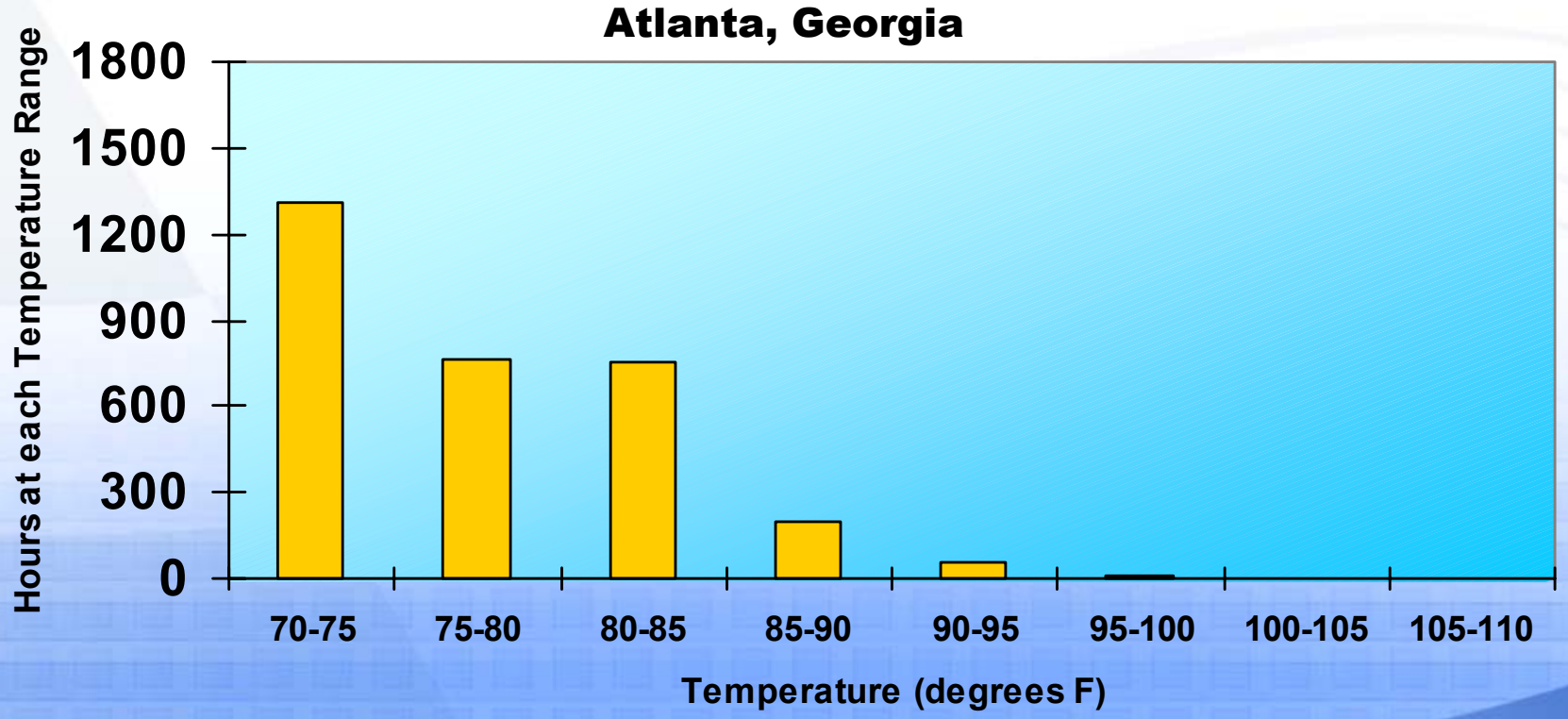
Cooling Energy Efficiency



Competitive Advantage Achieved

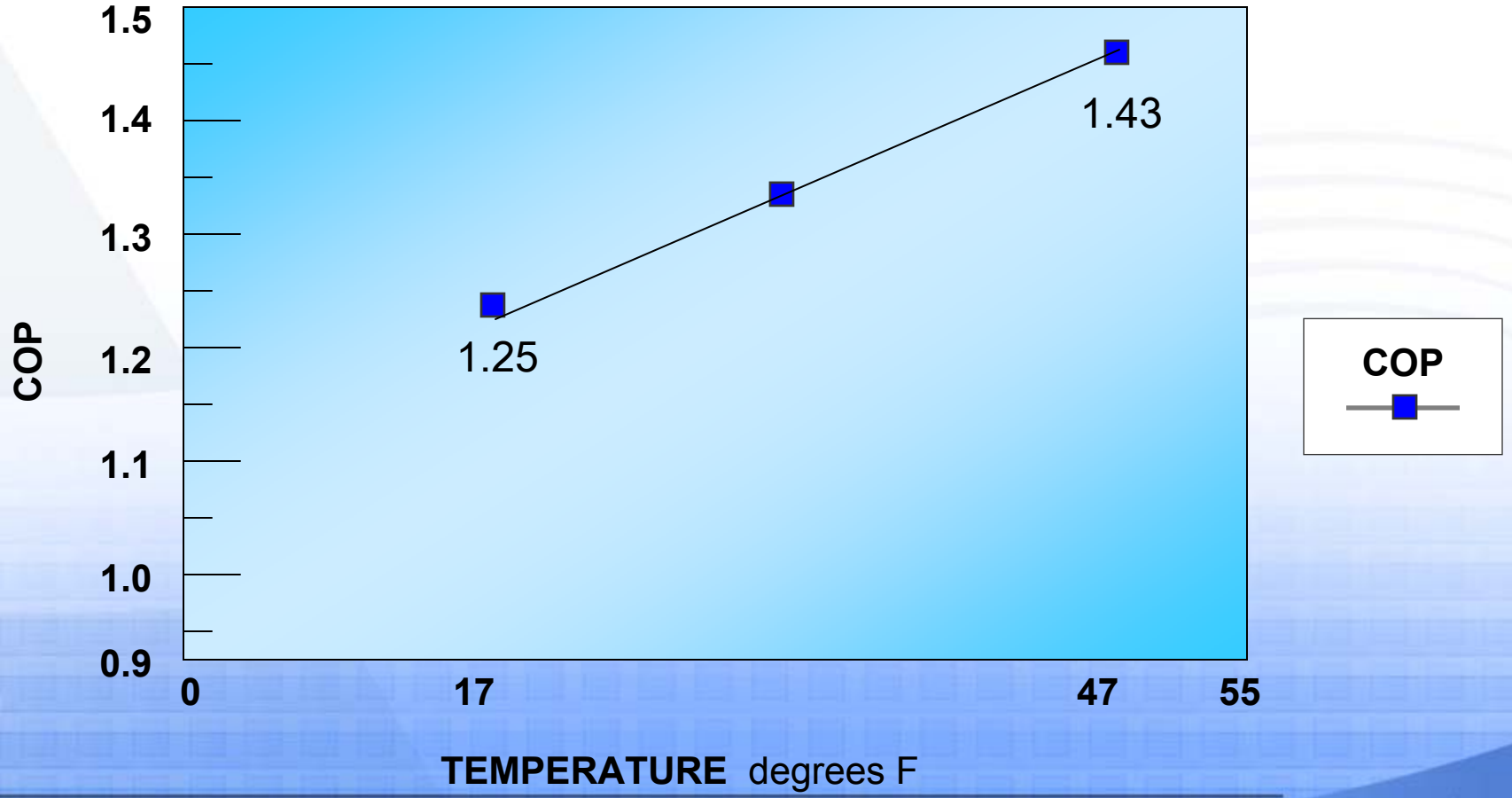
Cooling Energy Efficiency

Part Load COP_c Impact on Commercial Viability



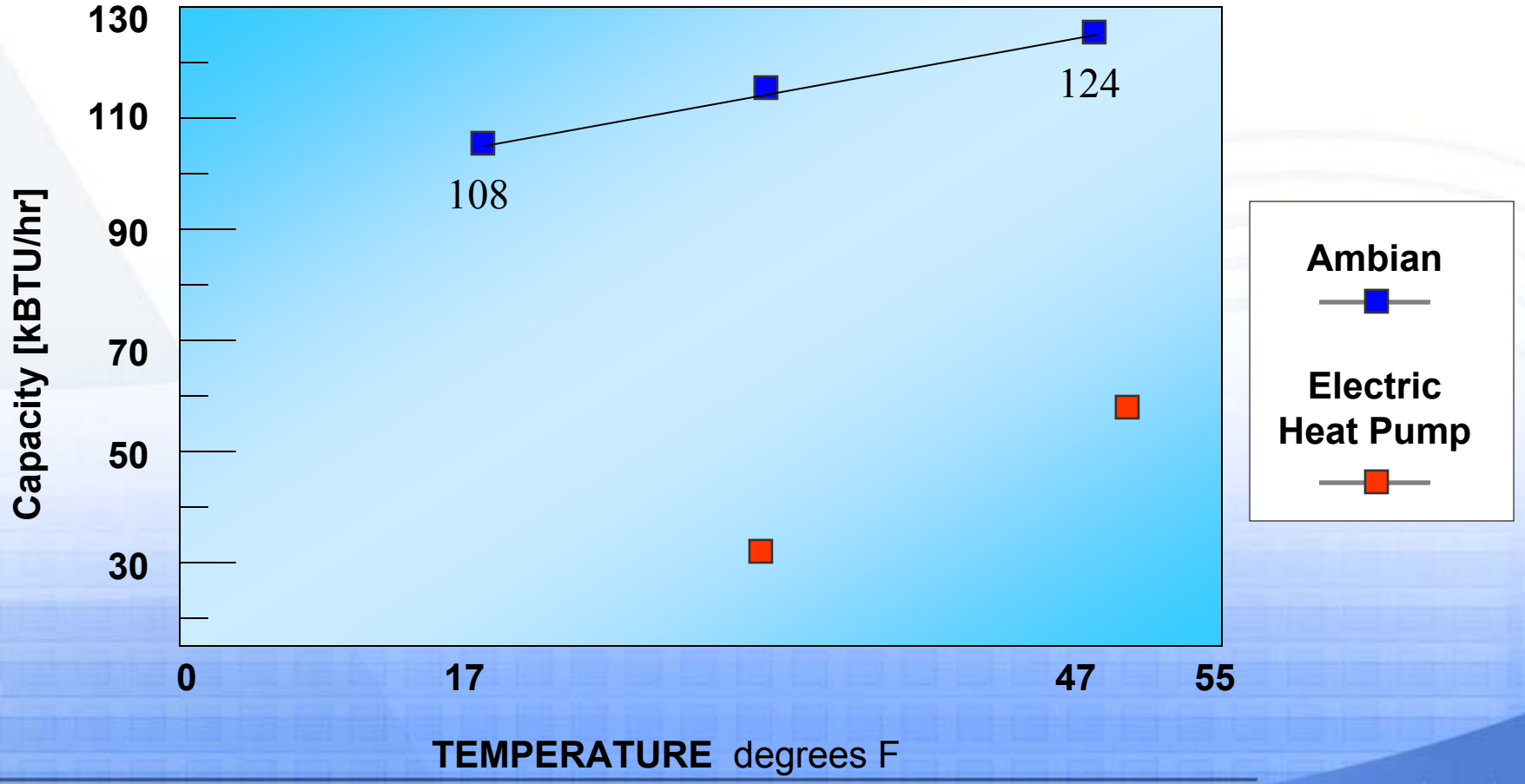
Competitive Advantage Achieved

Heating Energy Efficiency



Competitive Advantage Achieved

Full Heating Capacity



Competitive Advantage Achieved

Additional Heat Pump Benefits

- First heat pump breadboard prototype operation down to 0ºF
- Efficiencies and capacities measured leading to terminal delivery temperatures of over 10ºF above electric heat pump
- Solution pump consumes less electrical power than any solution pump currently available

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Alpha Central Test Stand

Pre-commercial Product Reliability Testing

Vested Commercial Partners of Rocky Research To Date

- Mississippi Energies
- Southern Natural Gas
- Southern California Gas
- Southwest Gas
- Williams SouthCentral

- ITT Heat Transfer
  - Early involvement
- Dectron Internationale
- FMC

and U.S. Department of Energy
Oak Ridge National Laboratory

ITT Heat Transfer
Ambian's OEM Partner

Nick Tranquilli
ITT Heat Transfer
Operations Manager
Ambian Climate Technologies
Product Line

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Role for ITT

- Design for manufacture
  - Work with Rocky Research to refine design for cost effectiveness and ease of manufacturing beginning with R&D phase
- ITT facilities
  - ITT provides superior facilities and work force needed for specialty heat exchanger components
- Customer equipment and processes
  - Establish custom process operations needed for specialty heat exchanger components

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Role for ITT *(continued)*

- Tolerances and specifications
  - Establish and monitor tolerances and specifications that meet **both** cost and performance objectives
- Quality control
  - Implement quality procedures and practices to assure highest quality system

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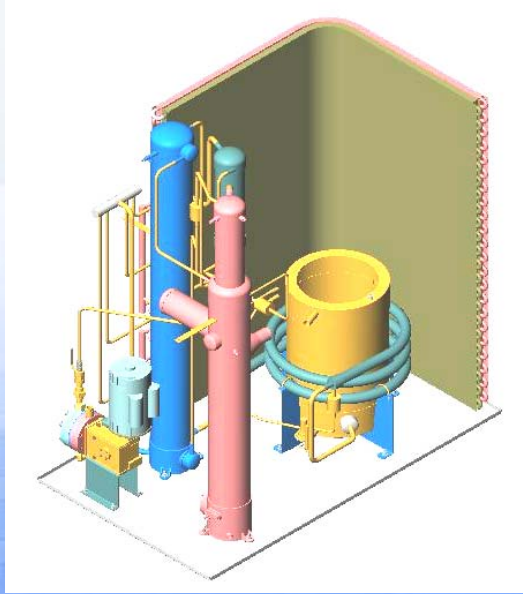
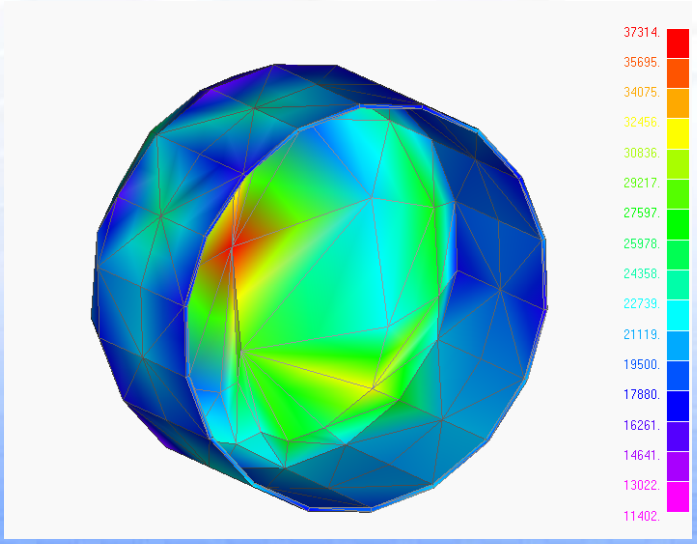
Design for Manufacture

- Use the latest 3-D CAD and analysis technology to minimize errors during assembly and manufacturing process





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ITT Facilities

- Provide necessary square footage for Production
- Use lean manufacturing techniques to provide work cells with optimal material handling and functionality

ITT Facilities *(continued)*

- Utilize latest MRP system for inventory control
- Experienced work force with extensive knowledge of fabrication and welding. ASME Certified.

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Custom Equipment and Processes

- ITT has invested in specialized capital equipment to produce customized heat transfer components

Custom Equipment and Processes *(continued)*

- Using latest in vacuum brazing technology to provide highest quality in enhanced surfaces

Custom Equipment and Processes *(continued)*

- Procedures and equipment to provide optimal surfaces for maximum heat transfer

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Specifications and Tolerances

- ITT is using components fabricated during R&D phase to establish baseline of specifications and tolerances
- Baseline will be used for tolerance study to provide cost effective quality components to minimize assembly time

Quality Control

- To insure components will be clean and free of grease, ITT has purchased a dedicated parts washer that degreases parts and leaves a residue of environmentally friendly rust inhibitor
- Flushing station is used at component level to rinse residual inhibitor and flush any particles accumulated during assembly

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Quality Control *(continued)*

- Sophisticated leak detection systems are used at component level as well as final assembly to insure a leak-tight sealed system to the customer

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Quality Control *(continued)*

- CNC Equipment is used on all crucial parts and components to assure accurate and repeatable results

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Next 12 Months Engineering Improvements

- Reliability test completion of 5 RT Chiller
- Reliability testing of novel solution pump
- Packaged heating unit prototype
- Implementation of improved fluid controls
- Implementation of improved system controls
- Breadboard prototyping of reversing heat pump
- Performance improvement R&D

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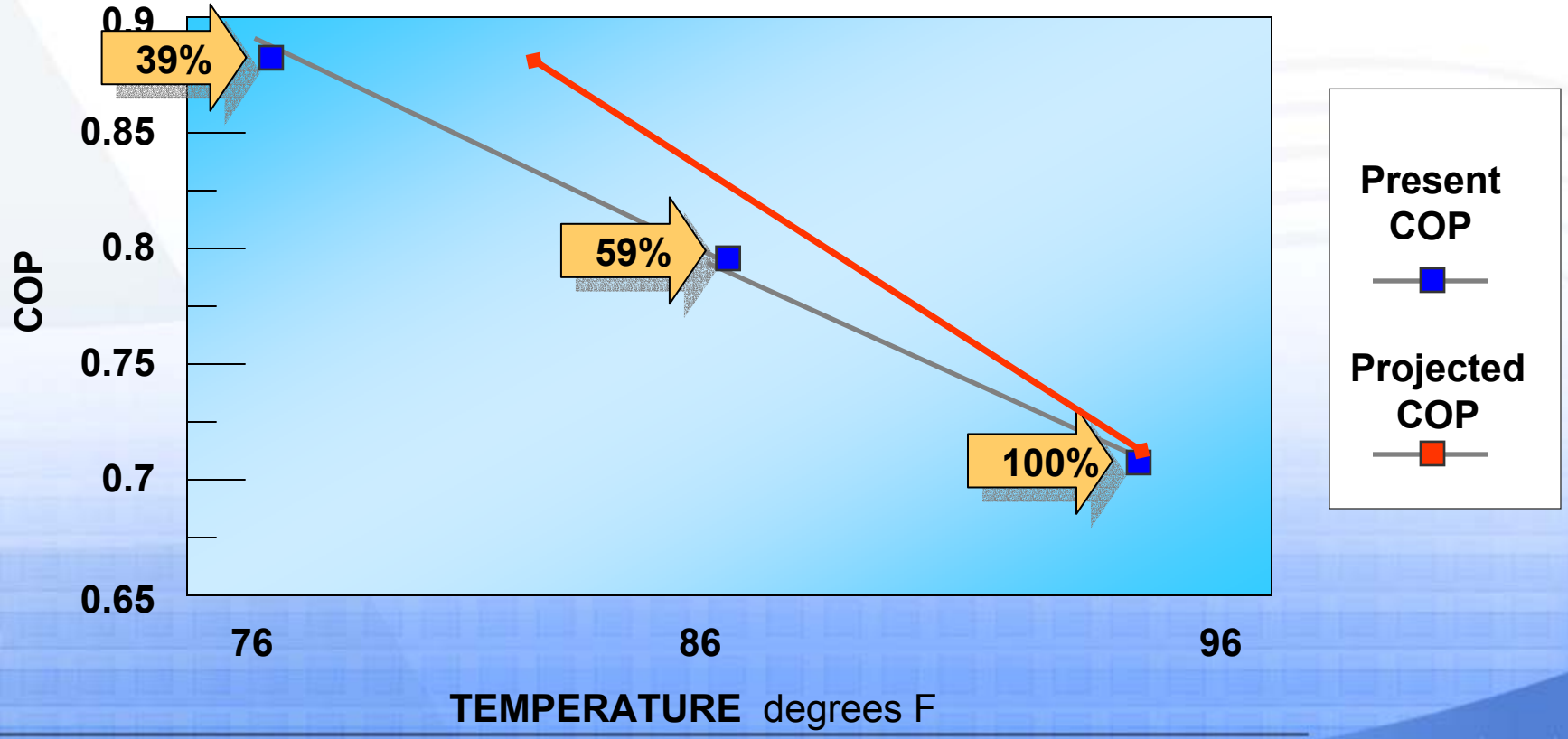
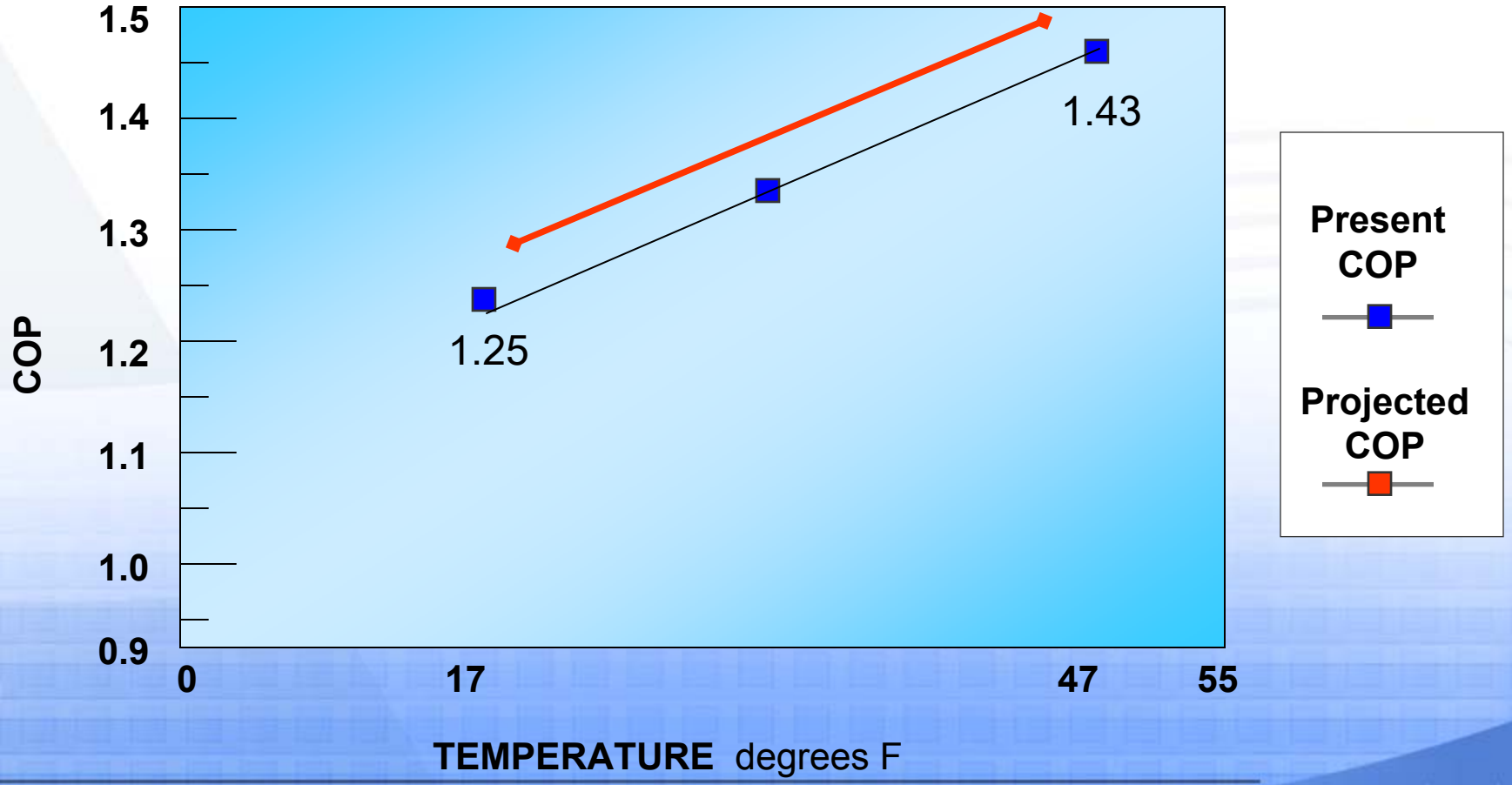
Next 12 Months R&D Improvements

Cooling Energy Efficiencies



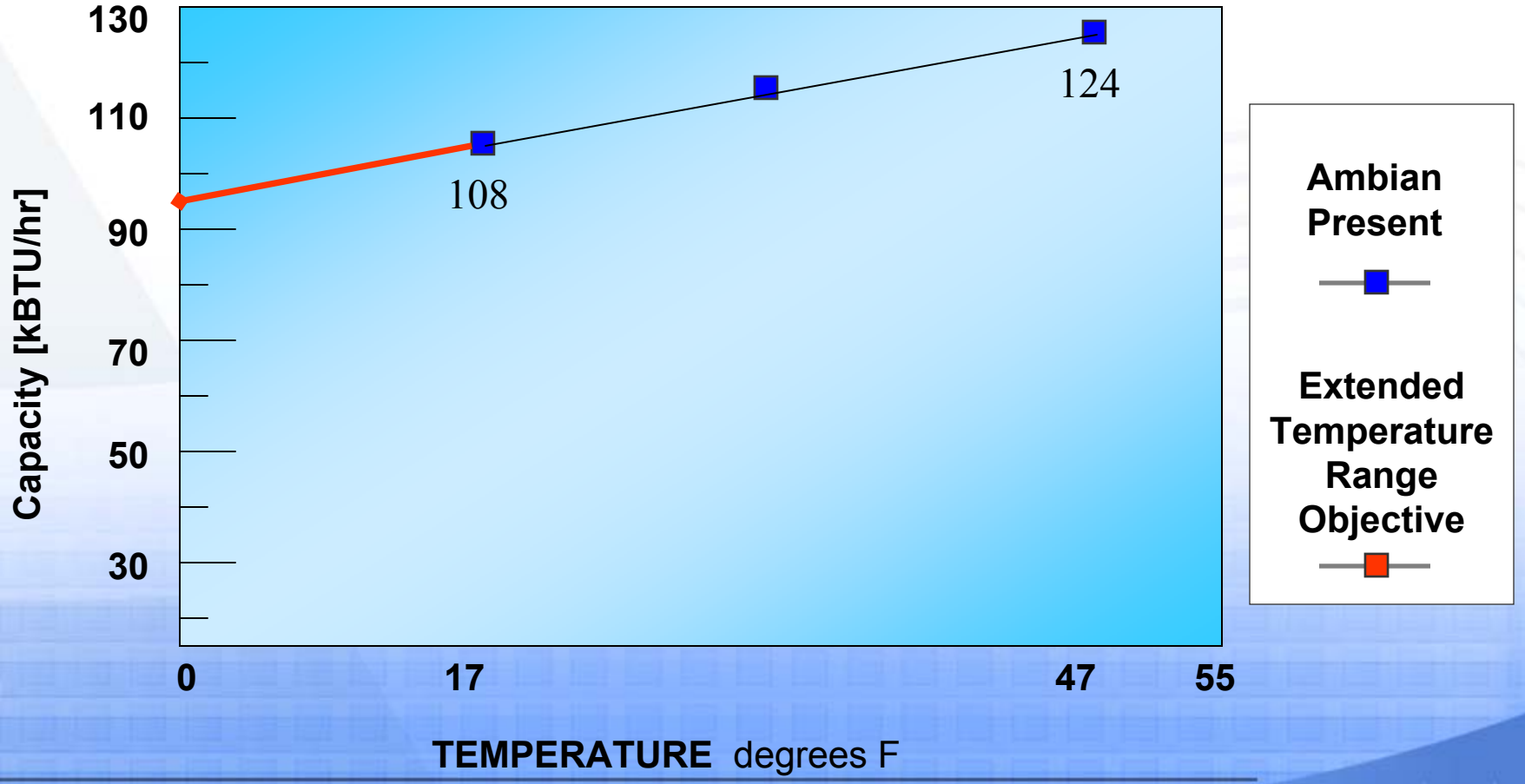
Next 12 Months R&D Improvements *(continued)*

Heating Energy Efficiencies



Next 12 Months R&D Improvements *(continued)*

Heat Pump Temperature Range



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Next 12 Months R&D Improvements *(continued)*

- Optimize electric parasitics on seasonal basis
  - Initial Goal: 1998 225 W/RT
  - Today: < 200 W/RT
  - 2003 Goal: < 160 W/RT

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Select Markets Identified as Suitable

- High-end residential
- High-end home remodeling
- Pool heating and dehumidification
- Medical clinics/physician offices
- Full-service restaurants
- Unitary absorption replacement

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Operating Cost-Sensitive Markets

- Commercial demand charge customer
- Most sunbelt states for cooling
- Heat Pump applicable throughout US (including northeast and mid-west)

Summary of U.S. Market Potential

- Provided we will achieve
  - COPs
  - Capacities
  - Operating temperature range
  - Manufacturing efficiency

Third party market research shows fifth year sales:

- 41,000 units for selected market segments investigated
- 60,000 units based on first/operating economics

Thermally Activated Technology

- Dramatically improved energy efficiencies
  - Reduced dependence on foreign oil
  - Reduced air pollution
- High electric reliability and quality
- Healthy indoor environment

Building A Better Tomorrow