Packaged Refrigerant Based Energy Storage (RBES) Air Conditioning System

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“... this technology provides some of the largest opportunities we have right now to address the peak demand situation. (The) benefits extend beyond being able to downsize the distributed solar systems on residential... but most exciting is it is retrofittable, meaning we can address both retrofit and new construction.”
- Joe Desmond, Chairman, California Energy Commission
Peak Demand Challenges the Reliability of Electricity Supply

Utilities and states recognize that peak demand is the problem.

Air conditioning is the root cause.

Air-Cooled systems suffer highest inefficiency at peak times.

Ice Storage Air Conditioning answers the challenge.

Peak [demand] poses one of the most significant challenges to ensuring reliable electricity supplies.
Cycle Schematic of the RBES

- Complements conventional refrigerant based air conditioning systems
- Controlled by existing thermostat: Transparent to user
- No change in behavior required
T-S Diagram, Conventional Cycle

R22

T = 115

T = 45

T [°F]

s [Btu/lbm-R]
A Better Air Conditioner with Improved Reliability

- RBES unit
  - Draws just 300W on-peak
  - 50 Ton-hours of storage
  - 7.5 Tons for 6 hours continuous
  - Improves overall A/C performance

- As Outdoor Temperatures Rise
  - RBES “cooling capacity” remains constant at 7.5-Tons
  - Evaporator coils cannot freeze-up
  - Superior latent heat removal
Part Load Configuration

- Adds thermal capacity to existing systems
- Additional condenser unit, RBES, and 2nd evaporator coil is added to existing air handler system
- Combination of RBES and Condensing Unit Provides a Total of 15 Tons of Cooling Capacity
Air-Conditioning System Sizing

Single Family Home Air Conditioner Performance (~3000 sq.ft in Denver) - Design Day of 93 F, Indoor 75 F, 50% RH (40% overdesign for design day)

- House Cooling Load (Tons)
- 5T CU capacity (Tons)
- CU Power (KW)

Normal a/c systems are 40% + overdesigned for peak day. Hence, a 7.5 Ton RBES can replace up to a 10 Ton a/c in many situations
Serves Commercial, Government, and Residential Markets

**Commercial**
- Offices (1, 2, 3 stories)
- Retail merchandise and services (small and big box)
- Food Service chains

**Government**
- Offices and facilities (1, 2, 3 stories)
- Schools and Education
- Military facilities

**Residential**
- Semi custom homes (>2500 sq. ft.)
- Mid range production homes (1600-2500 sq. ft.)
- Energy Star and Net-Zero, Solar PV
“At all three locations, compressor and condenser fan power totals in the range of 4 – 9 KW were displaced with power consumption of miscellaneous RBES System components of less than 350 W”

Refrigeration and Thermal Test Center (RTTC)
Dramatic peak shift translates to $ savings
Data from an air-conditioning contractor on a hot 2 day stretch in July (100 F max)

- RBES still displaces first stage completely – 8+ KW displaced
Anaheim California installation is energy neutral

- On Sep. 19, RBES ran for 4 hrs and displaced 22KWh
- Ice Make Power Consumption 20.49 kWh
- Ice Melt and parasitic power 1.37 kWh
- Net Energy Efficiency 0.6%

Colorado installation showed 35% energy efficiency (12.5T, 11EER RTU) on a shoulder day in September (17th)

- 53.7 kWh of RTU power displaced by 36.83 kWh of RBES power (RTU is a 2 stage unit)
  - Ice Make used 34.83 kWh
  - Ice Cooling used 1.99 kWh
  - RTU power displaced 53.7 kWh
- Similar savings present in dry climates
The comparison is between verified 3rd party (ETL) data for a RBES system compared to manufacturer data for a packaged DX system.
“Optimal DX System” Assumptions

- Includes:
  - Standard ASHRAE and CEC performance equations
  - Characterizes a DX system at “new” condition, under full load

- Does NOT include (approx impact):
  - DX partial load performance, cycle losses (18%)
  - Rooftop temperature effect (10%)
  - Psychometric factors (5%)
  - Partial melt savings (3%)
  - Traditional DX oversizing (20%)
  - Equipment degradation (5-25%)
All degradation factors considered

Diurnal Effect vs. Daily KWH Savings

% Savings

0.00%

-10.00%

-20.00%

-30.00%

0 5 10 15 20 25 30 35

Diurnal Effect
EER $\Delta$ (change) at 95°F (35 C) shows energy savings for areas with an average day-night delta greater than 15°F (Max – Min Temp Diff)

- Typical gain is (15%) over the performance of a COP 3.5 (10.3 EER) rooftop unit (RTU) at an ambient temperature of 95°F and rooftop temperature of 105°F
- Results validated by field performance data
Energy savings achievable in majority of climate zones
Building Energy & Sustainable Design Benefits

- LEED Sustainable Building Certification (1-5 Points)
  - Credits in E & A Category
  - Innovative Application Points

- Exceptional reduction in source energy of 20% - 43% (Source: California Energy Commission)

- BuildingGreen Top 10 Green Building Product of the Year
Energy Storage Complements PV Renewable Energy

The problem: Cooling demand lags solar production

Northern California Residential Load Profile with PV

- **July Load Profile**
- **Solar PV Production**
- **Combined Profile**

![Graph showing load profile, solar production, and combined profile over 24 hours.](image-url)
Daily Cycle of Solar PV on a Standard Building Load

- **Standard Commercial Building Load Profile**
- **PV Output**
- **Net Demand**

![Graph showing daily cycle of solar PV on a standard building load.](image-url)
Energy Analysis Software Modeling
Air Quality Benefits

- Study conducted for a Western US Air Quality Management District (SMAQD)
- Calculated the benefit of a RBES system for Emissions Reduction
  - Based on replacing peaking power plant (mainly natural gas) emissions with base load (hydro, nuclear)
- 40% reduction in CO$_2$ reductions
- ~ 56% lower NOx emission rate during off-peak
- 2-3 RBES modules equivalent to taking 1 vehicle off the road
BuildingGreen: Top-10 Green Building Product of 2005
BuildingGreen, Inc., publisher of GreenSpec® Product Directory and Environmental Building News™, selected Ice Energy’s RBES 50 as a 2005 Top-10 Green Building product. This fourth annual award, announced at the U.S. Green Building Council’s Greenbuild Conference in Atlanta, recognizes the most exciting products added to the GreenSpec Directory during the past year.

ASHRAE / ARI Product of the Year for Energy Management Award, 2004
The RBES was recognized as the Product of the Year for Energy Management by ASHRAE and ARI at the 2004 AHR Expo in Anaheim, California. The eight winning companies were featured in the January 2004 edition of ASHRAE Journal.

World’s Best Technology, Gold Award, 2004
The RBES 50 product was selected for the Gold Award by the Federal Laboratories Consortium for Technology Transfer and the National Association of Seed and Venture Funds World’s Best Technology Symposium in 2004. Over 60 participating technologies, considered to be the “best of the best,” were submitted by the nation’s most advanced research facilities and top universities.
Thank You

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