Inverter Technology:
Unlocking the Full Potential of Heat Pumps to Decarbonize the Northeast

Presented by Jon Hacker

for NESEA's BuildingEnergy NYC 2022 Pre-Conference Webinars

on September 9, 2022

DAIKIN

Agenda

1. Introduction to Daikin
2. Inverter and Mechanical System Basics
3. Inverter Impact on Operation
4. Benefits to Society
5. Inverters Applied

Daikin Overview

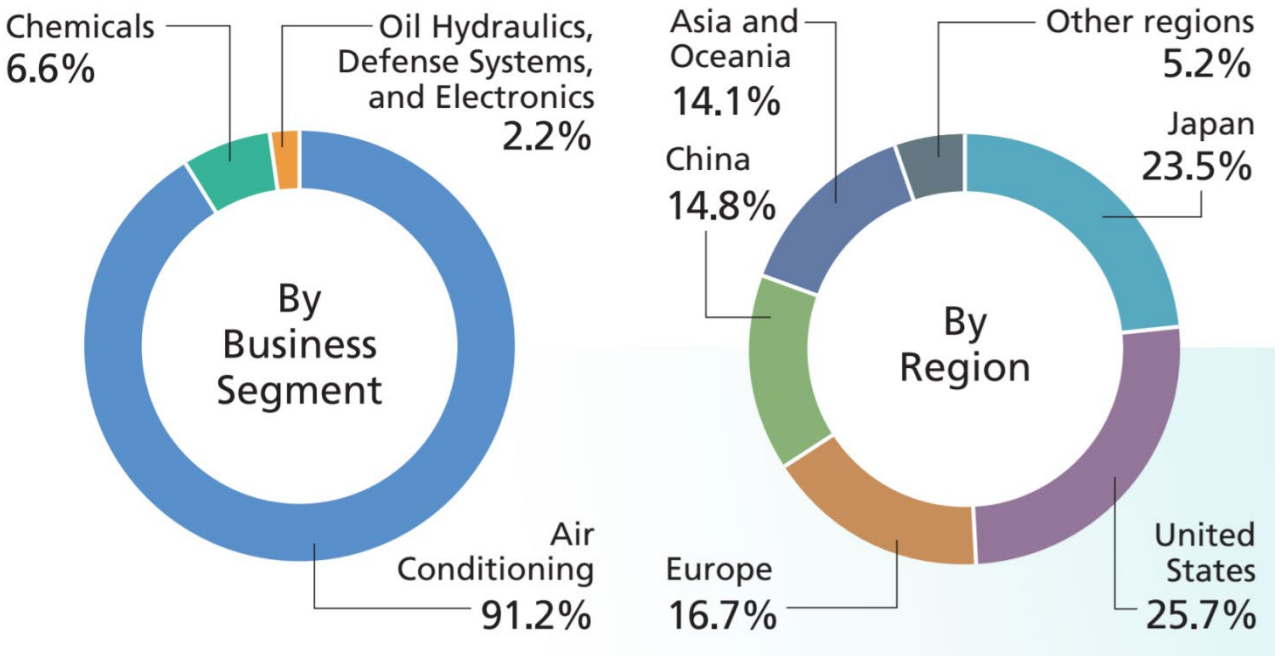
95+ Years of History
Founded in 1924

Annual Sales of
$21
BILLION

More than
100
global production bases for localized production

Business development in more than
160
countries

Ratio of Sales (Consolidated/Fiscal 2020)



- Company: Daikin Industries, Ltd.
- Head Office : Osaka, Japan
- Founded in 1924
- Chairman of the Board : Noriyuki Inoue
- President and CEO : Masanori Togawa
- Employees : 84,870
- Group Companies : 315

As of March 31, 2021

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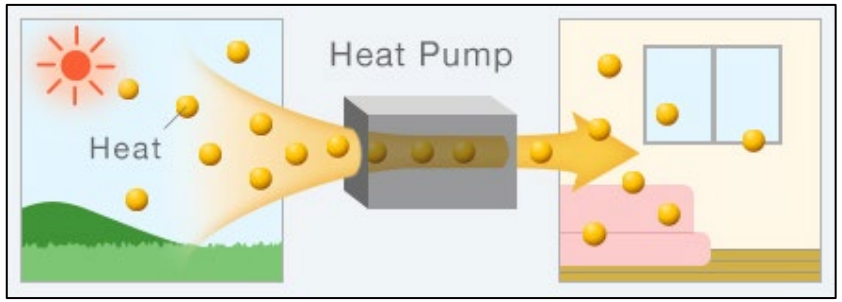
Daikin's Core Competencies

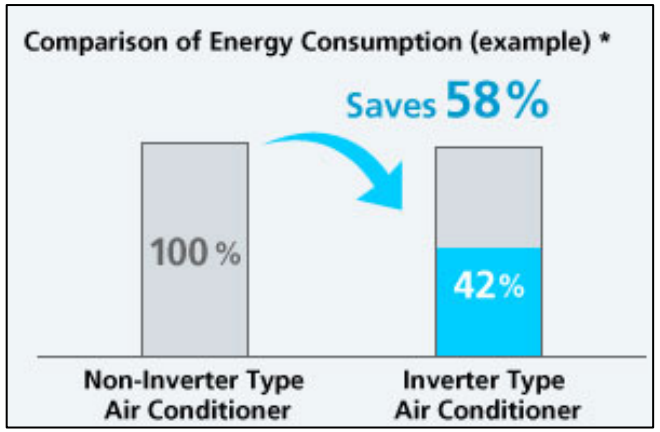
① HEAT PUMP

Heat pump is energy saving technology that conveys heat without the need to generate heat



② INVERTER

Inverter is energy saving technology that eliminates wasted operation in air conditioners by efficiently controlling motor speed.

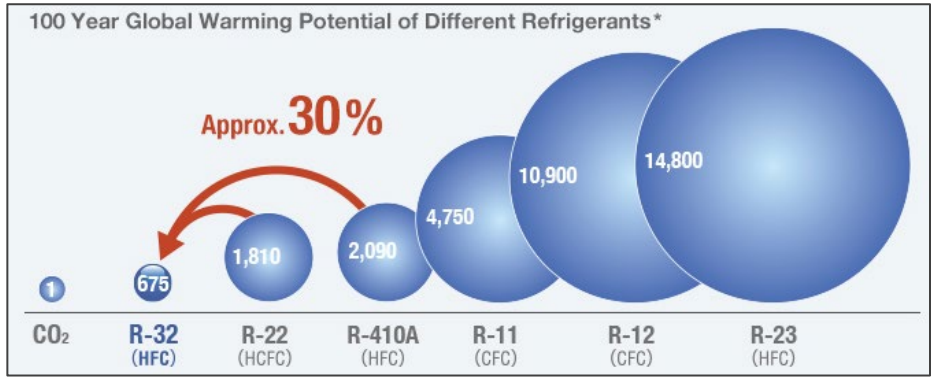


* Energy consumption is calculated complying with JIS B8616:2015 for model SSRC140BA (inverter) and equivalent non-inverter type air conditioners.

DAIKIN CORE TECHNOLOGY

③ REFRIGERANT

R-32 is a next generation refrigerant that efficiently carries heat and has lower environmental impact



*Source: Values for 100 year global warming potential (GWP) from IPCC Fourth Assessment Report. Comparative 100 year GWP: HFC410A, 2,090; HFC32, 675

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Daikin Group Companies and Products

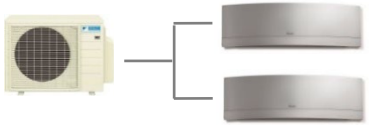
Daikin Group Brands in North America:

DAIKIN
Goodman
Heating & Air Conditioning Amana
AAF | Flanders
ABCO HVACR Supply + Solutions
Quietflex
AHT

Daikin carries lineup meeting all types of needs including those for energy-savings, the environment, comfort, peace-of-mind, safety, and health

Residential AC
Room Air Conditioners

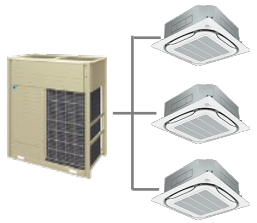
Housing/Multi-Split Air Conditioners



Unitary Air Conditioners

Control/Maintenance Systems

VRV Systems



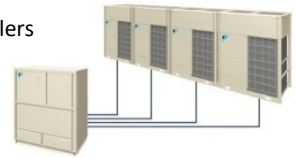
Ventilators

ACs for Facilities and Factories

Applied ACs

Centrifugal Chillers

Chillers



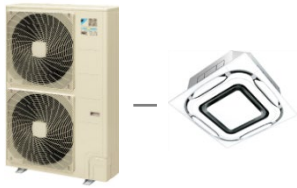
Air Handling Units

Fan Coil Units

Air Purifiers

Heating/ Water Heaters

ACs for Small Shops and Offices



Rooftops

Residential — **Commercial** — **Industrial**

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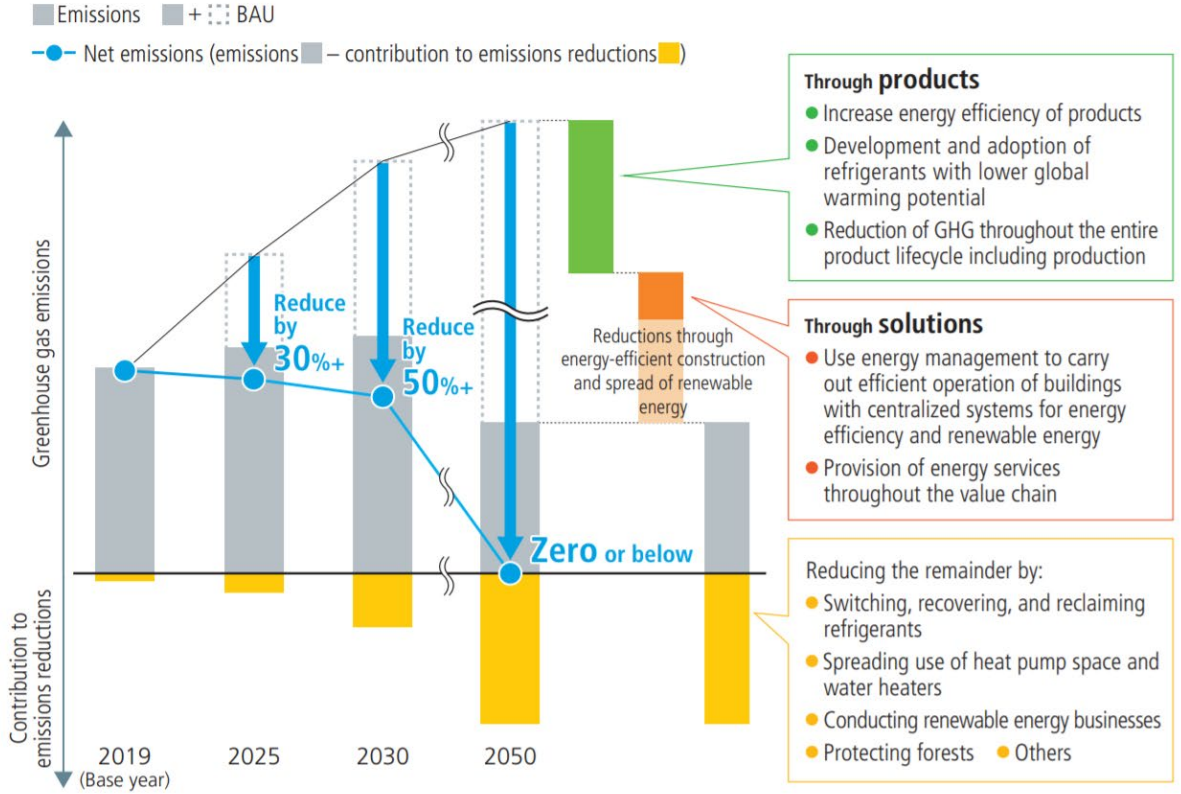
Sustainability at Daikin

Through products | **Through solutions**

Target for reducing greenhouse gas emissions to net zero



Through products

- Increase energy efficiency of products
- Development and adoption of refrigerants with lower global warming potential
- Reduction of GHG throughout the entire product lifecycle including production

Through solutions

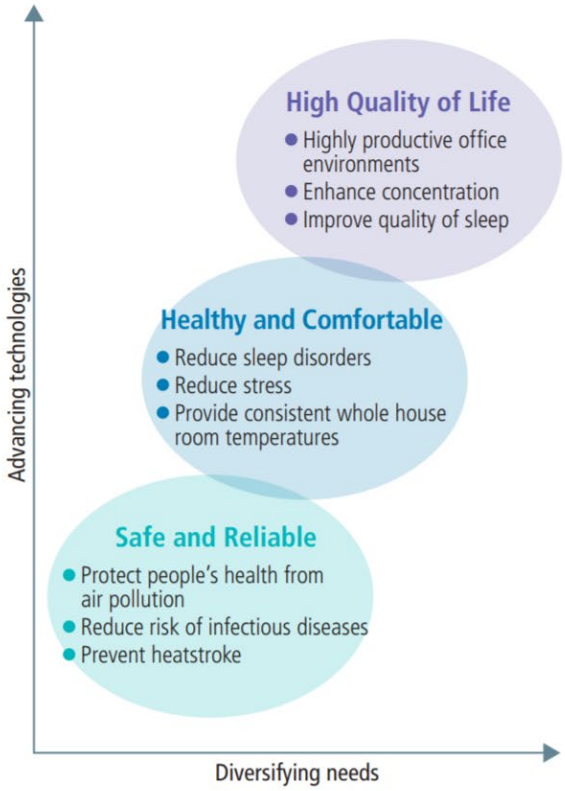
- Use energy management to carry out efficient operation of buildings with centralized systems for energy efficiency and renewable energy
- Provision of energy services throughout the value chain

Reducing the remainder by:

- Switching, recovering, and reclaiming refrigerants
- Spreading use of heat pump space and water heaters
- Conducting renewable energy businesses
- Protecting forests
- Others

Through the power of air

Image: The power of air



Agenda

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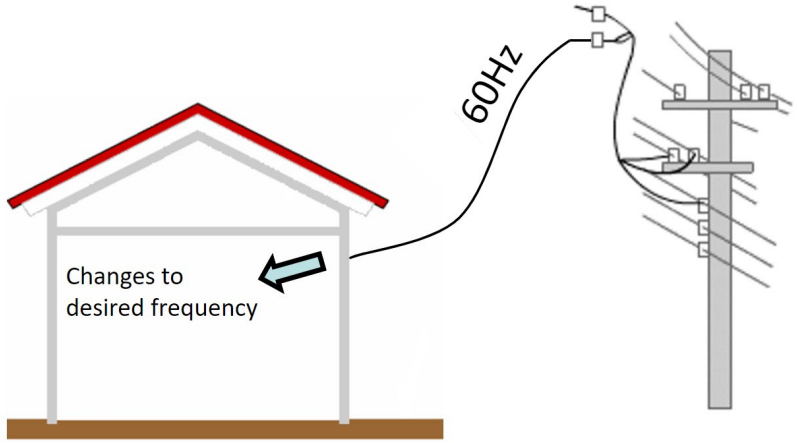
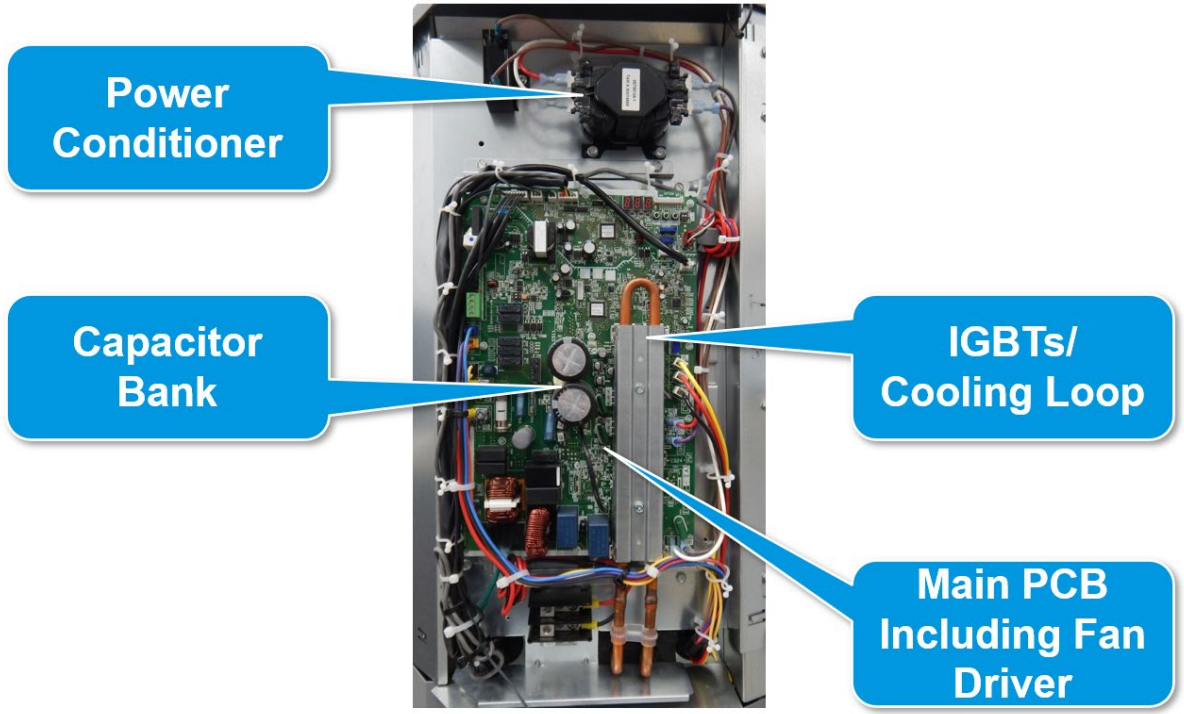
2. Inverter and Mechanical System Basics
3. Inverter Impact on Operation
4. Benefits to Society
5. Inverters Applied

What is an Inverter?

- An Inverter is a technology that changes the power supply frequency provided by power companies into a desired frequency (Hertz)
- In heat pump and air conditioning equipment, inverters are applied to the compressor as that is the main energy consuming component
- When inverters are used in HVAC equipment, it can be referred to by many names:
  - Variable Capacity
  - Variable Speed
  - Inverter driven
  - Extended capacity
  - Extra performance
  - Extreme climate
  - Cold-Climate





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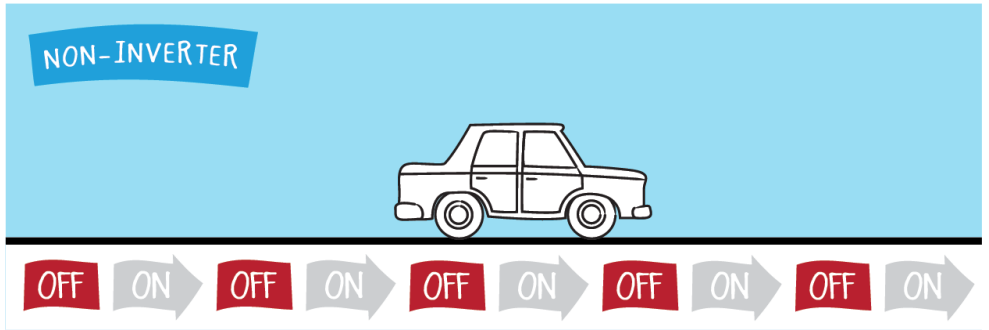
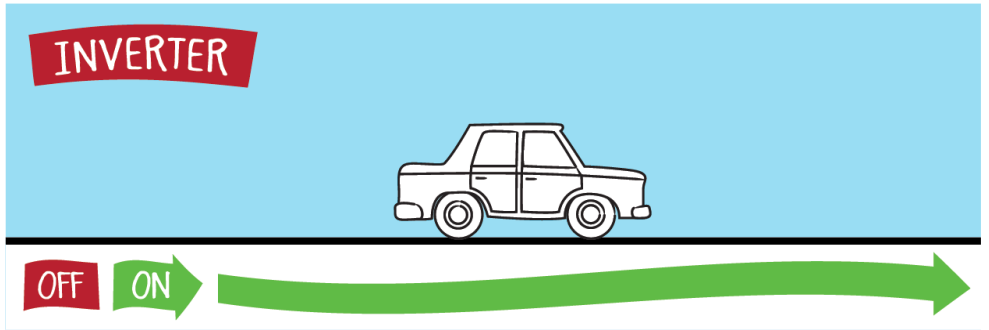
Inverter is Like a Gas Pedal in a Car

Non-Inverter (single and two-stage) HVAC systems function like your car does in the city:
Stop. Go. Stop. Go.



This causes your vehicle to work harder and use more resources to run, decreasing your overall MPG.

Inverter (variable-speed) HVAC systems function like your car does on the highway:
You set the cruise control and go!



Cruise control allows you to match speed to road condition, boosting your overall MPG.

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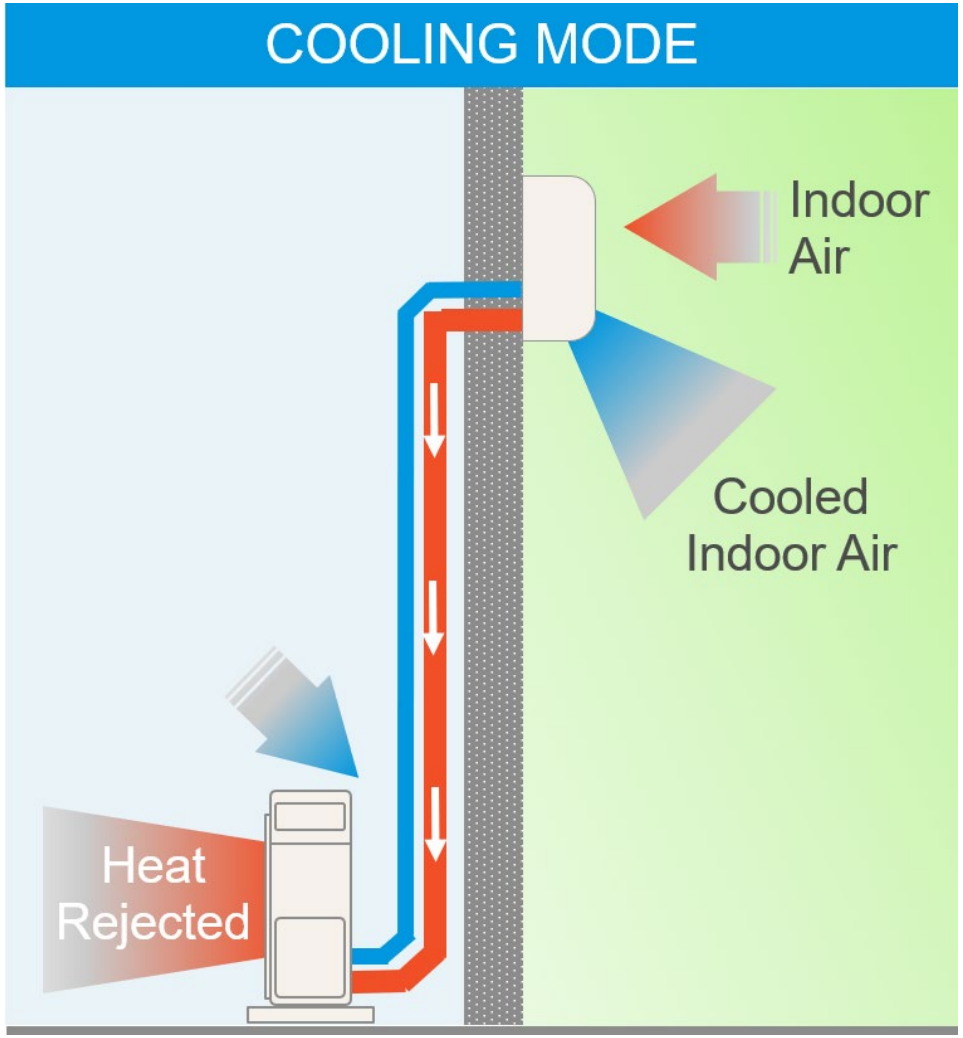
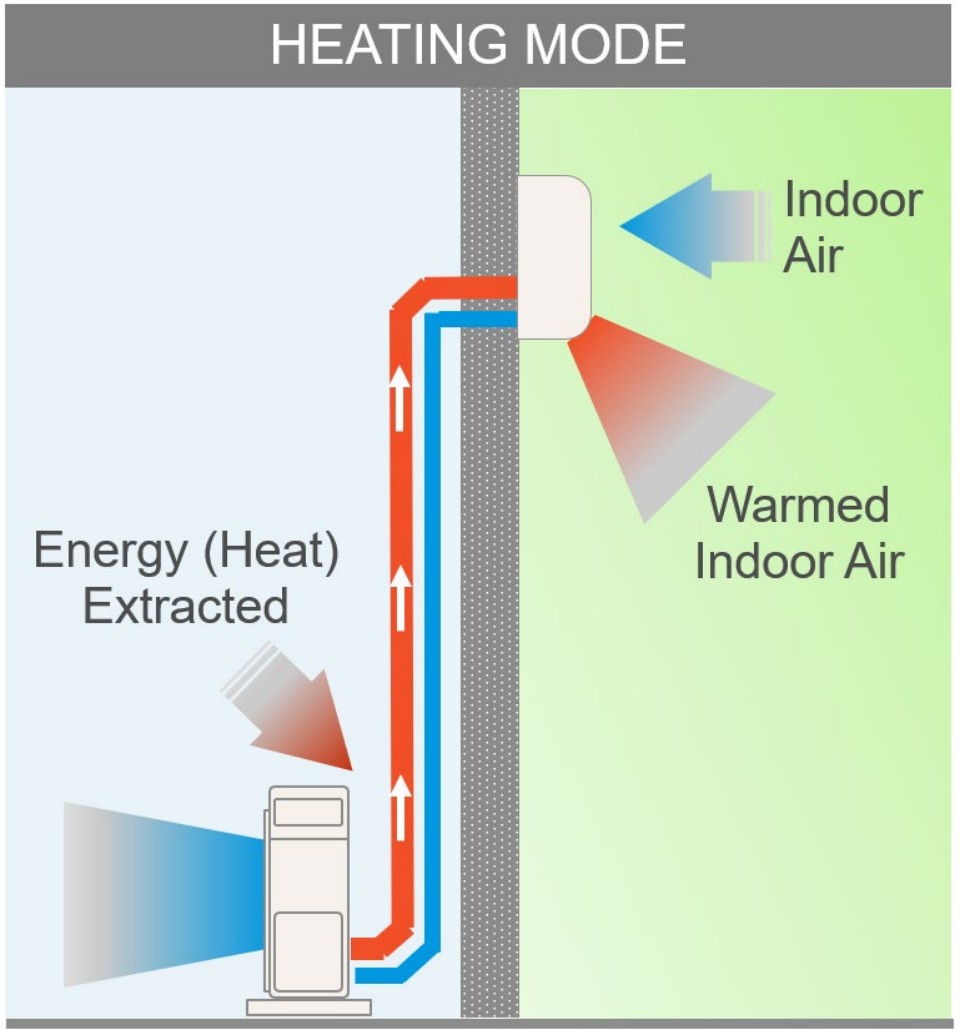
Heat Pump System Basic Operation





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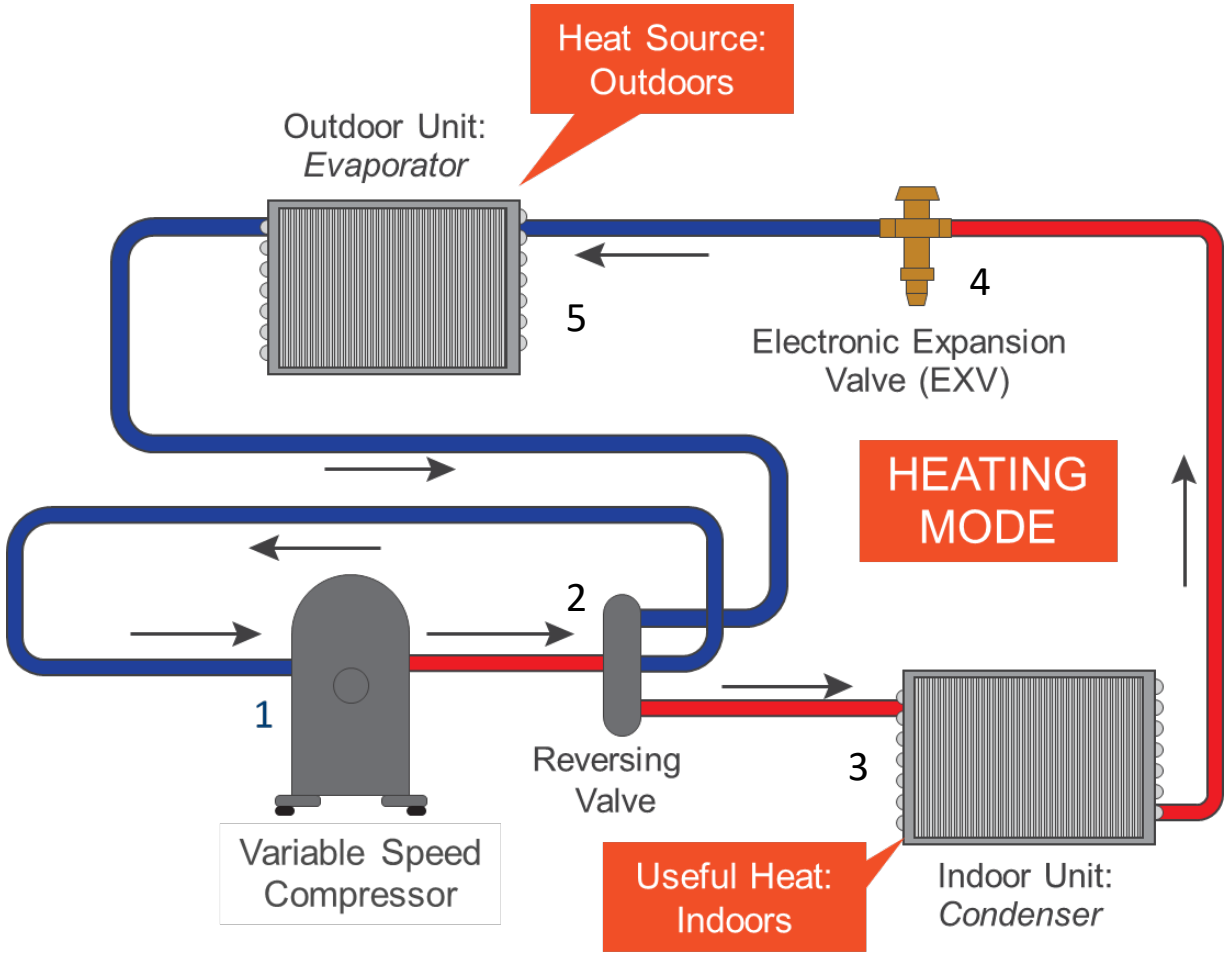
Heat Pump System Main Components

1. Compressor
   - The “heart” that pumps the refrigerant
   - Found in the Outdoor unit
2. Reversing Valve
   - Found in systems that provide both heating & cooling
3. Indoor Unit
   - Also known as the evaporator or fan coil
   - (acts like a condenser during heating cycle)
4. Expansion Valve
   - Regulates the flow of refrigerant
   - Found in either IDU or ODU
5. Outdoor Unit
   - Also known as the Condensing unit
   - (acts like an evaporator during heating cycle)



Heat Pumps are Not New

Circa 1978

Circa 1972

But Inverters in Residential Air Conditioners and Heat Pumps Is Relatively New in the US

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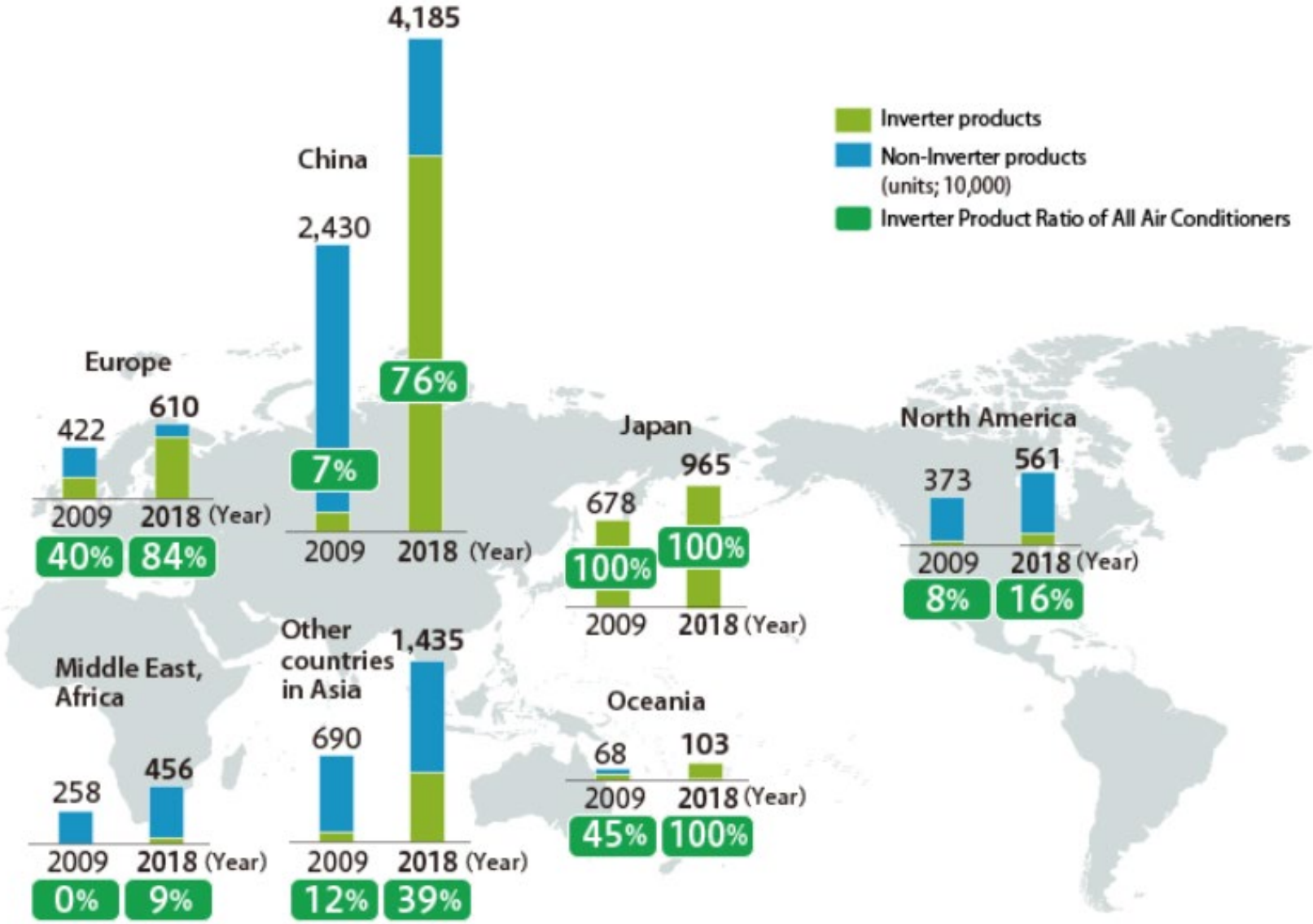
Lots of Opportunity for Inverter Adoption in the US



Note: Residential air conditioners: Ductless air conditioners other than window and portable type products. Only in North America does the category include ducted air conditioners for residential use.

Source: Compiled by Daikin based on data from the Japan Refrigeration and Air Conditioning Industries Association

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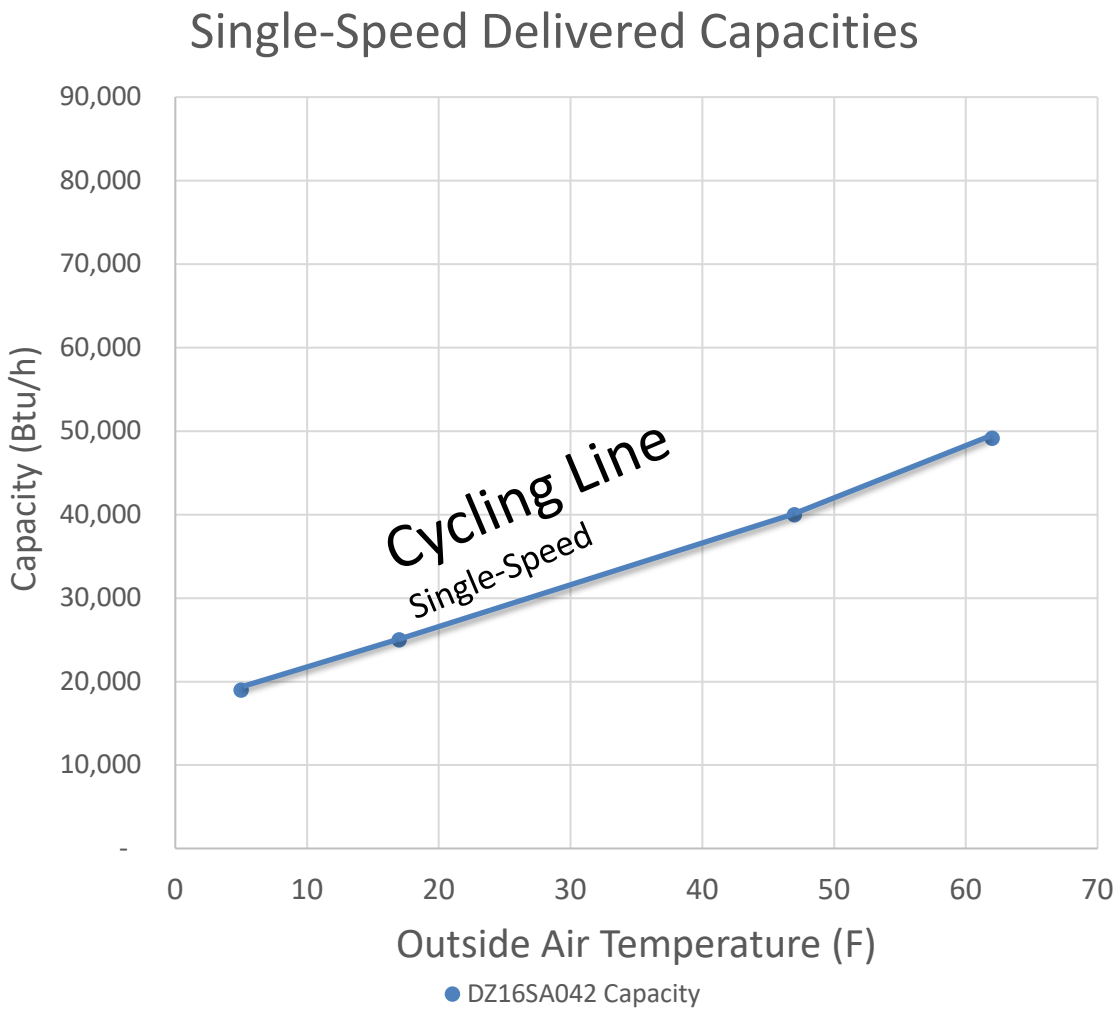
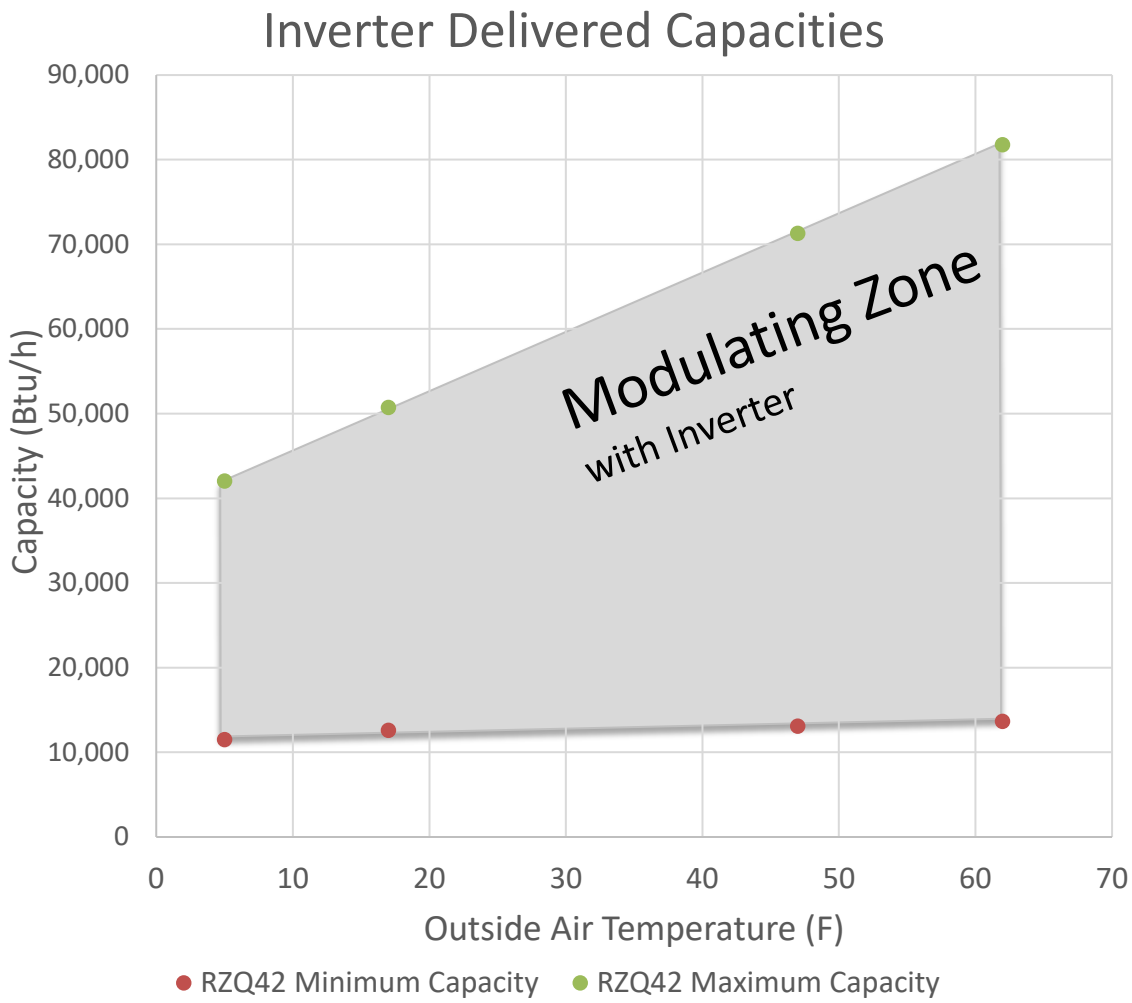
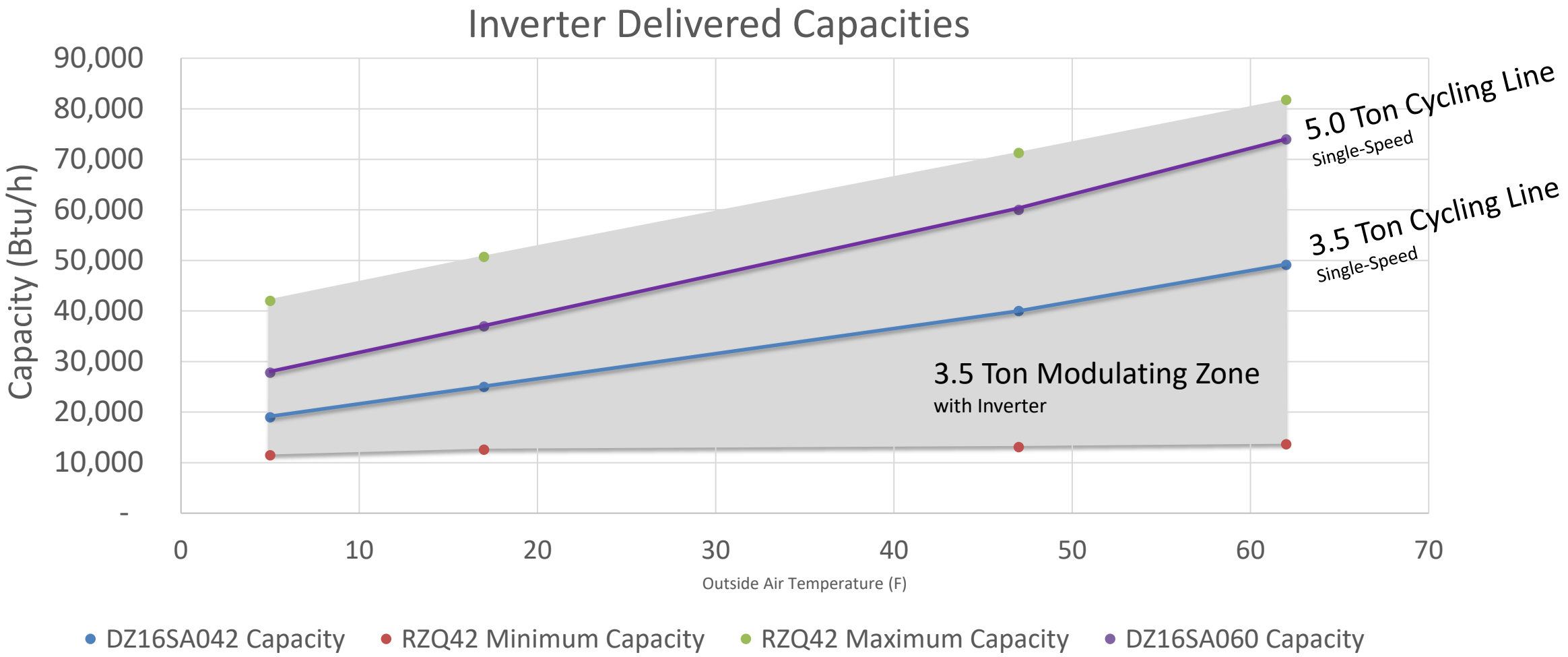
Load Line to Modulating Zone

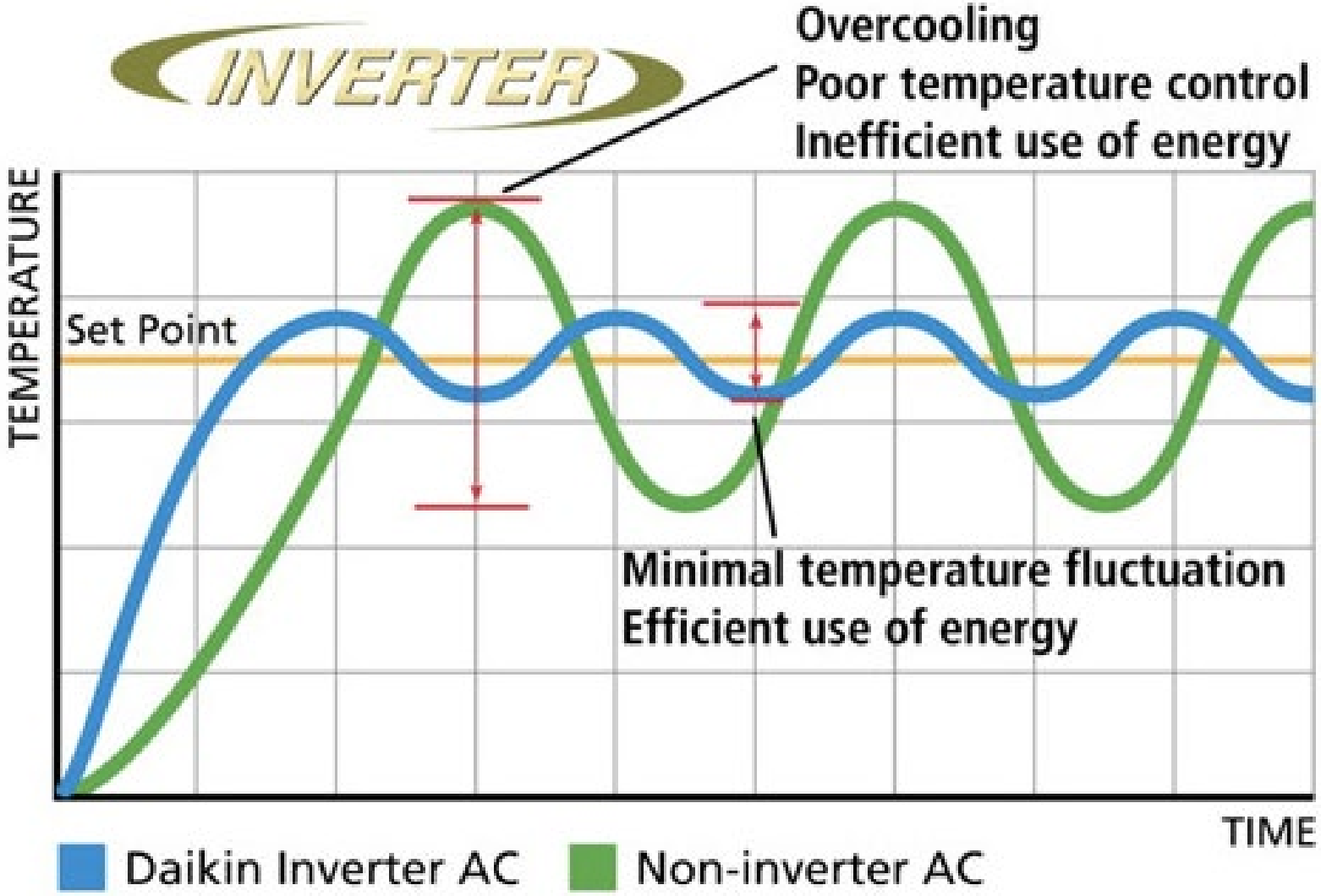




More Heating Capacity Delivered with Inverter



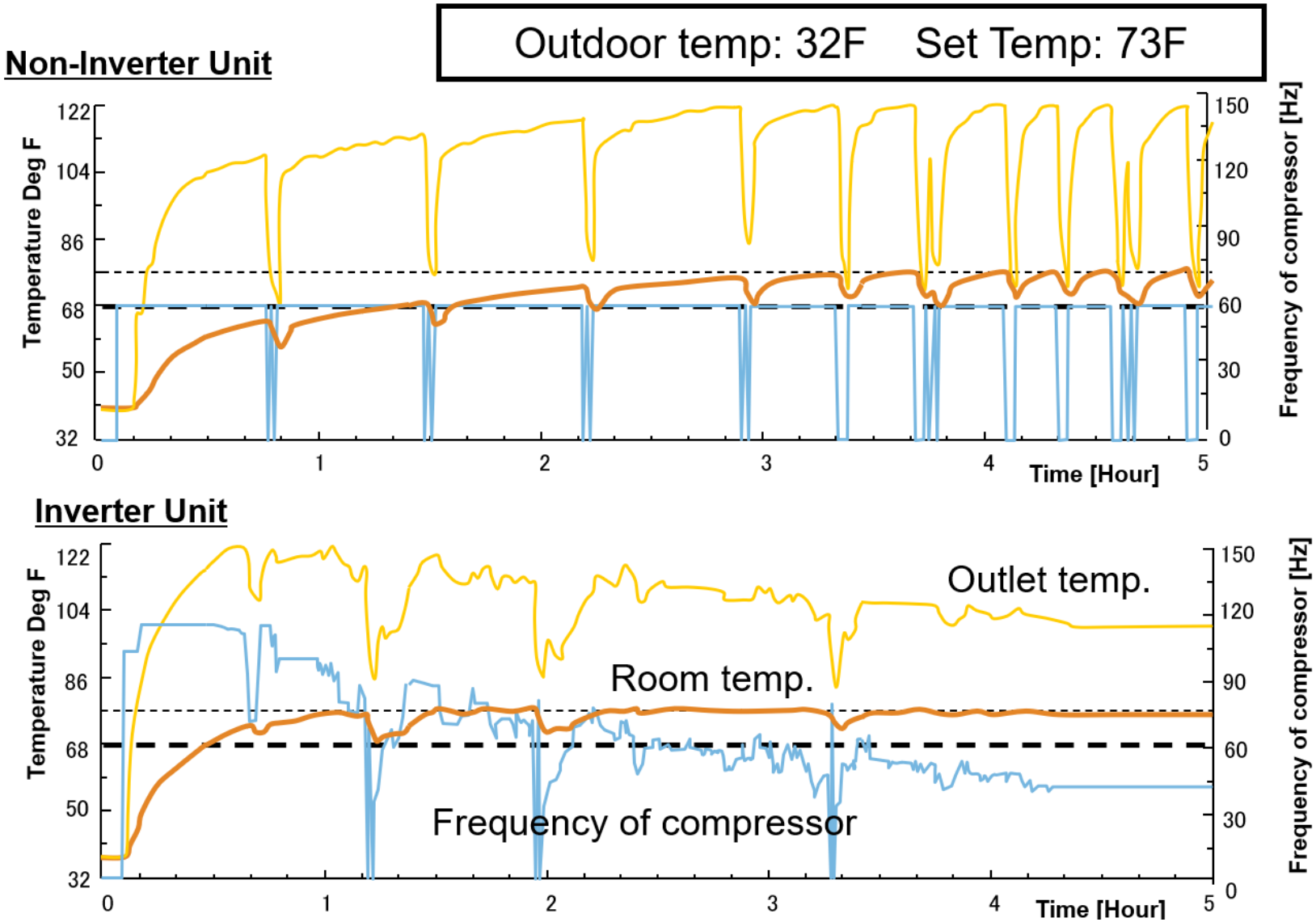
Cycling to Modulating



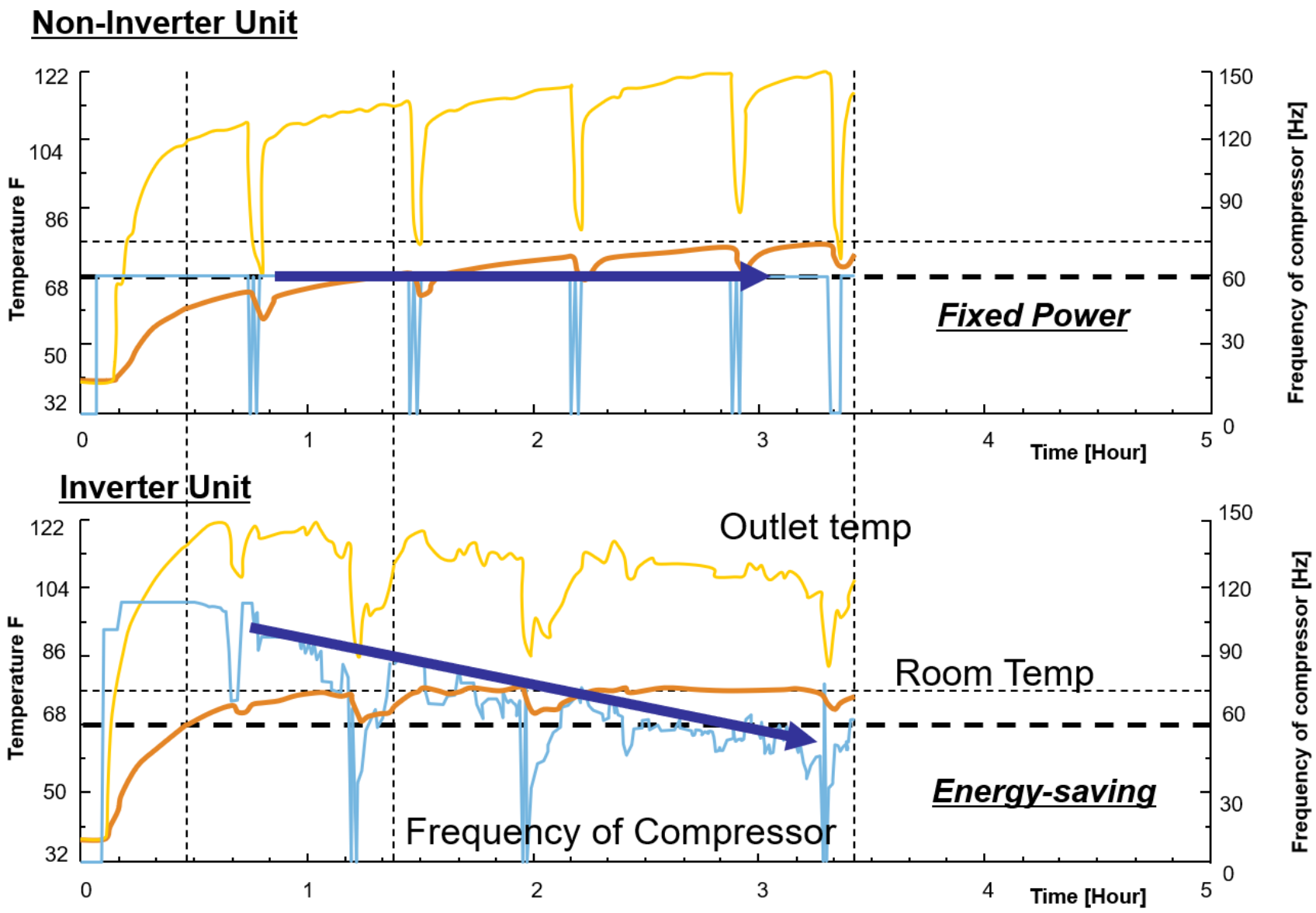
Cycling to Modulating: Trend Data

19 Compressor Starts

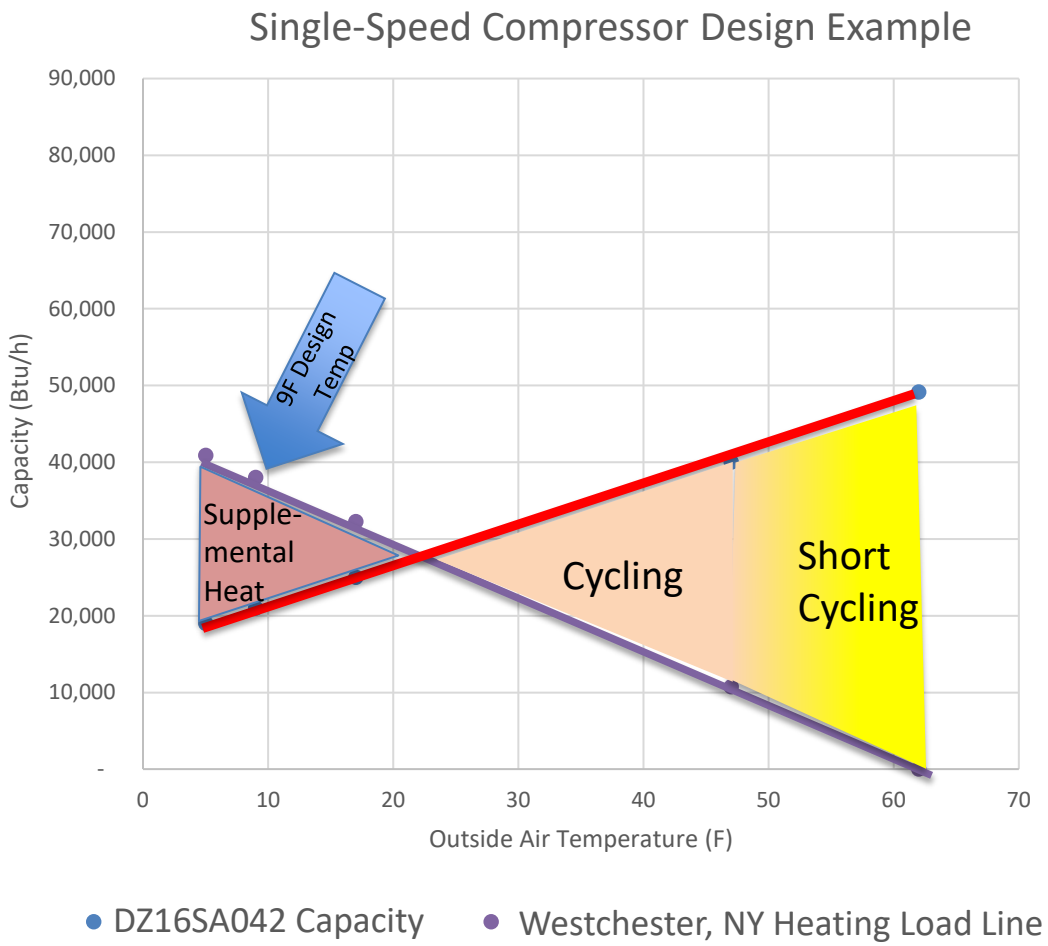
6 Compressor Starts

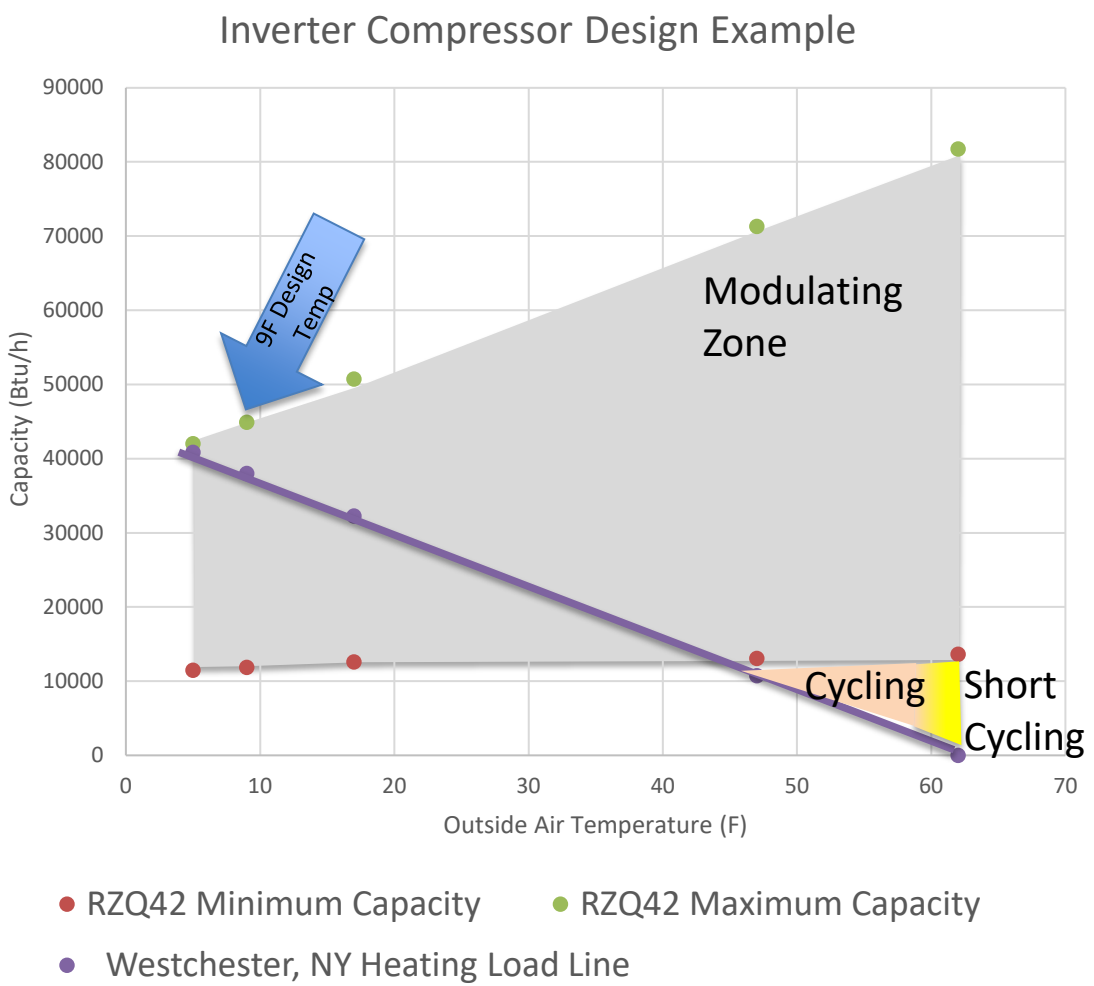


Lower Frequency over Time Yield Energy Savings

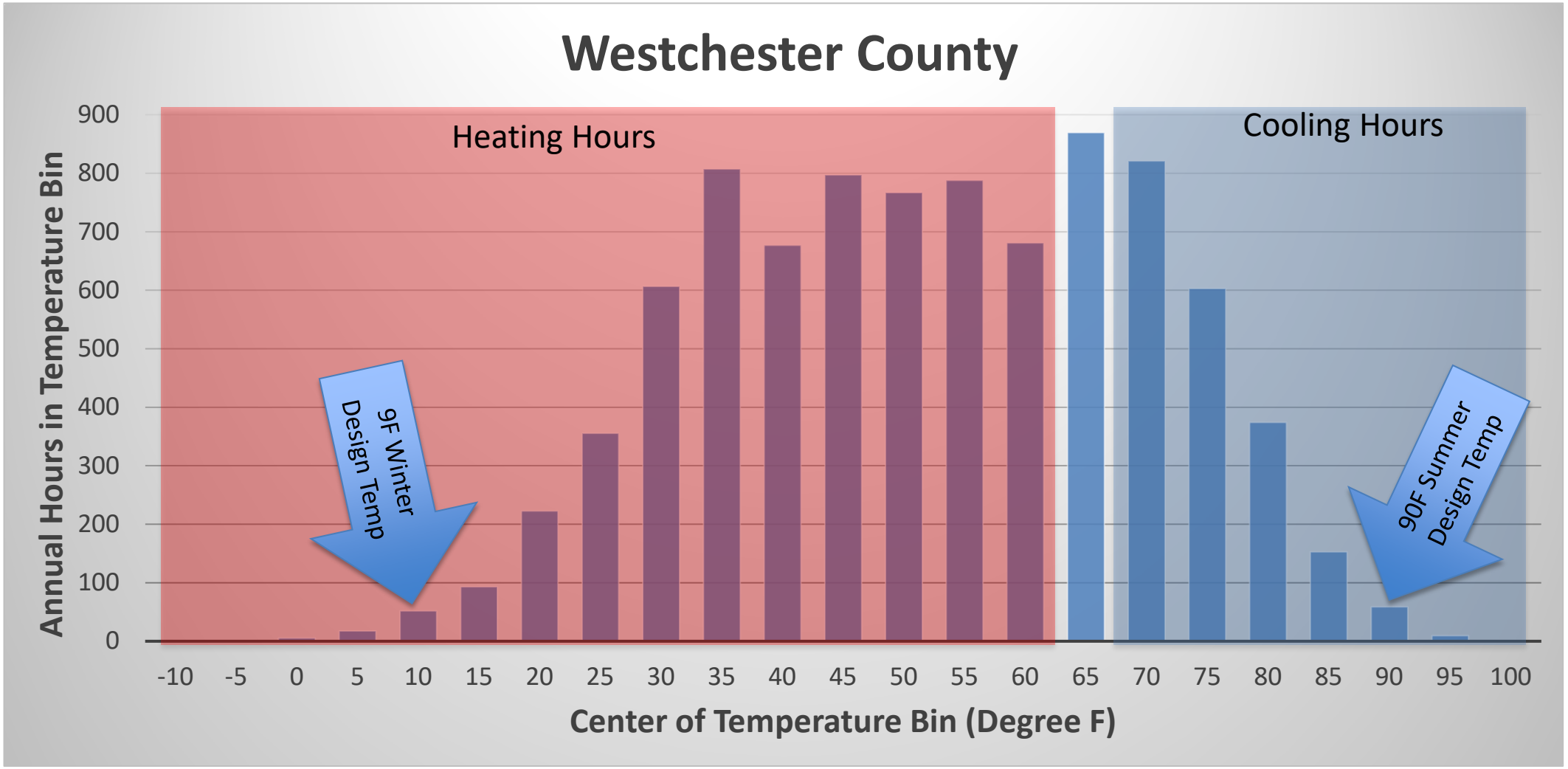


Inverter Impact in Westchester County





Design Temp Extremes vs. Abundant Mild Temperatures



Data Source: ASHRAE Weather Data Viewer Version 6.0

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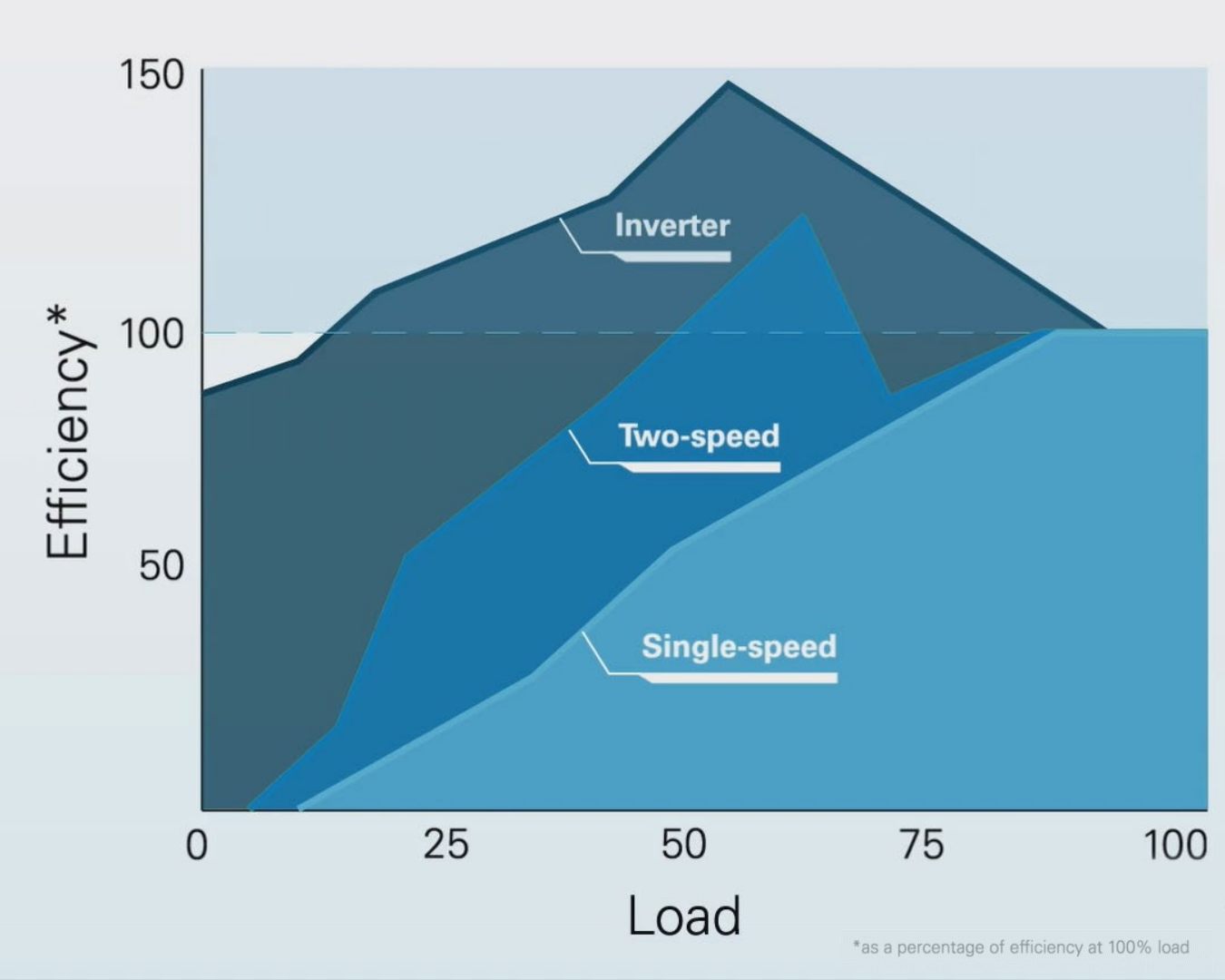
Improved Seasonal Energy Performance



EER

- A peak cooling load metric, evaluates efficiency at 95F (35C) at nominal speed.
- EER is a valuable metric for utilities as it reduces electric system peak demand
- Accord to the Electric Power Research Institute, "*the link or EER and building performance is not straightforward*"

SEER

- A seasonal cooling metric, that estimates efficiency over an entire cooling season.
- SEER is a valuable metric for consumers, as it relates to their energy consumption and costs.
- SEER considers that the efficiency of the equipment varies based on outdoor temperature.
- SEER is based on a lab testing and applies weather bin data to estimate energy-use over a cooling season.

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More Inverter Benefits

- High Efficiency in Part-Load conditions.
- As room temperature nears set point, the capacity is automatically ‘throttled down’
- Better dehumidification, and fewer start/ stop cycles.
- Power factor of near Unity
- Minimal locked rotor amps means less stress on windings
- No “light flicker” or “loud thud” when equipment is energized. It soft starts and stops.
- Better lubrication of compressor.
- System pressures increase gradually, reducing noise and stress on piping.
- Better dehumidification, and fewer start/ stop cycles.
- As room temperature nears set point, the capacity is automatically ‘throttled down’
- Huge decrease in compressor energy consumption

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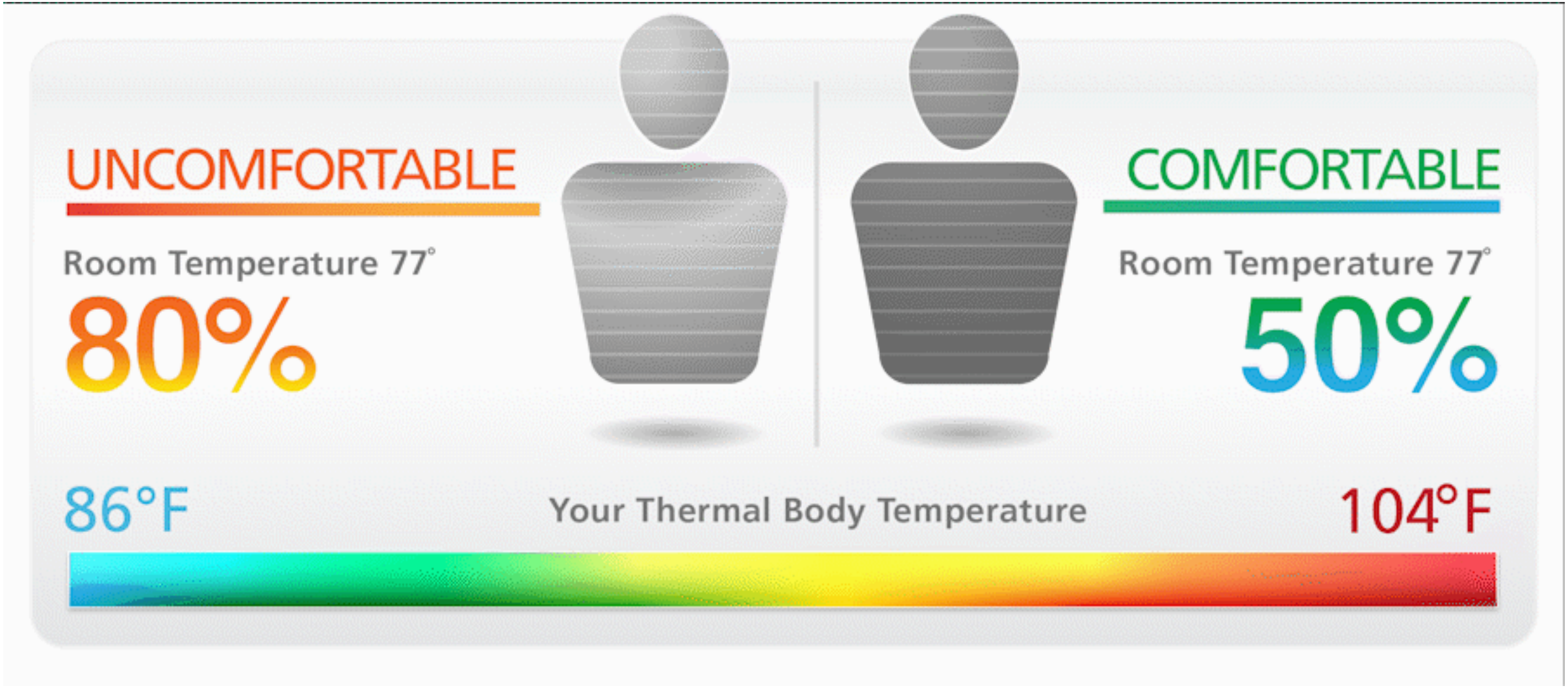
Comfort Without Compromise

Feel the Difference



Hear the Difference

Without Inverter

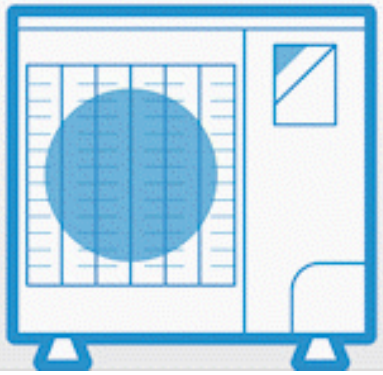
73dB(a)**

**Daikin DZ14SA

With Inverter

*Comparison of VRV LIFE™ outdoor unit to Daikin DZ14SA outdoor unit.

57dB(a)



Efficient Electrified Heat Pumps in Cold Climates

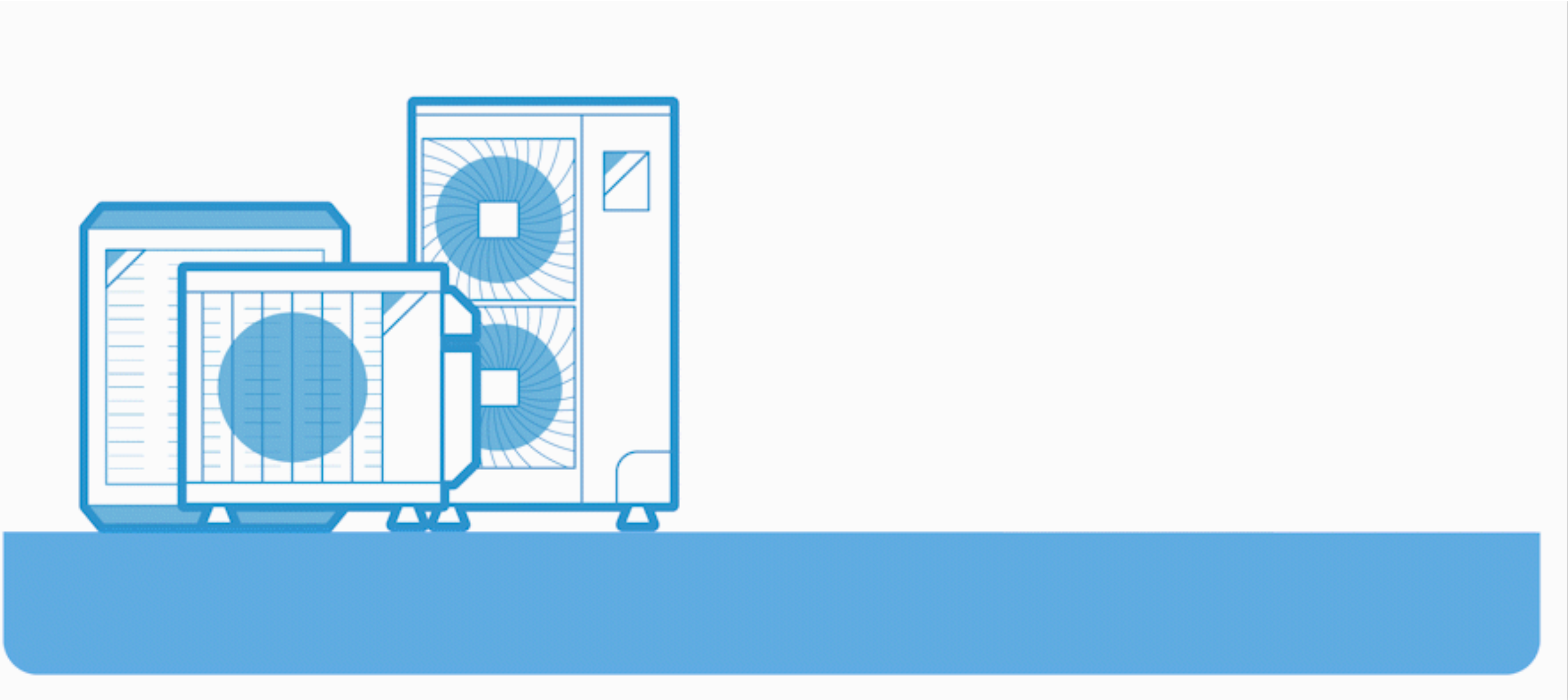
AURORA: 2, 3, 4 zone multi-split

Up to 100% rated heating capacity at 5°F continuous operation to -13°F

"Sky-Air" Large capacity single split

Continuous operation to -4°F

Invest in Tomorrow, Today!



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Questions?

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