

# White Paper: Comparative Evaluation of Three HVAC Compressor Systems

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# Purpose and Scope

This white paper evaluates the **advantages and disadvantages** of three HVAC systems:

1. Fixed-speed compressor system
2. Smart Compressor Control (SCC)/Variable Frequency Drive (VFD) retrofitted compressor system
3. DC inverter compressor system

This evaluation is based on real-time monitored data for each system. All three systems were tasked with cooling a room to a **set temperature of 17°C (62.6°F)**. Each unit was fitted with an **Eyedro Real-Time Electricity Monitor** (three-phase current) to track electricity consumption and compressor behavior independently.

# Systems Evaluated

## **System One:** Fixed Speed HVAC System

Model: *Midea/Carrier KFR-91YSR*

Capacity: *9 kW (36,000 Btu/hr)*

## **System Two:** Fixed Speed HVAC System retrofitted with SCC/VFD

Model: *Midea/Carrier KFR-91YSR*

SCC: *Falkonair Smart Compressor Control (SCC)*

VFD: *Invertek OptiDrive*

Capacity: *9 kW (36,000 Btu/hr)*

## **System Three:** DC Inverter HVAC System

Model: *Midea/Carrier MSMADU-36HRFN1*

Capacity: *9 kW (36,000 Btu/hr)*

# Falkonair Innovation: Smart Compressor Control (SCC)

The **SCC** is designed to deliver **energy efficiency**, **compressor protection**, and **cost savings** in HVAC/R applications by optimizing compressor operation through:



**Soft starts**



**Dynamic speed modulation**



**Compressor load management based on demand**



**Oil return sequences**



**Modbus-based VFD control**

## Key Features:

- Two temperature sensors (suction and discharge lines)
- Algorithm-driven speed/capacity adjustment
- Dip switch settings for scroll vs. reciprocating compressors
- Fan motor compatibility
- No refrigerant line penetration (no pressure transducers required)

# Compressor Behavior & Energy Consumption

Figure 1 – Fixed Speed Compressor

- Initial current spike (Locked Rotor Amps): **4.5 kWh**
- Running current (Run Load Amps): **3.4 kWh**
- Compressor cycles on/off after reaching setpoint

Figure 2 – SCC/VFD Retrofitted Compressor

- Soft start: **3.4 kWh** peak
- Average consumption before shutdown: **2.5 kWh**
- Modulation improves efficiency, reduces peak demand

Figure 3 – DC Inverter Compressor

- Soft start: **3.5 kWh** peak
- Modulates down to **1.8 kWh**, occasionally reaching **0.75 kWh**
- **Does not shut off** completely—maintains temperature continuously

## Efficiency Analysis

Comparison	Improvement Over Fixed Speed
SCC/VFD Retrofitted Compressor	30%
DC Inverter Compressor	40%
DC Inverter vs. SCC/VFD Retrofit	~10%

# Compressor Behavior & Energy Consumption

Figure 1

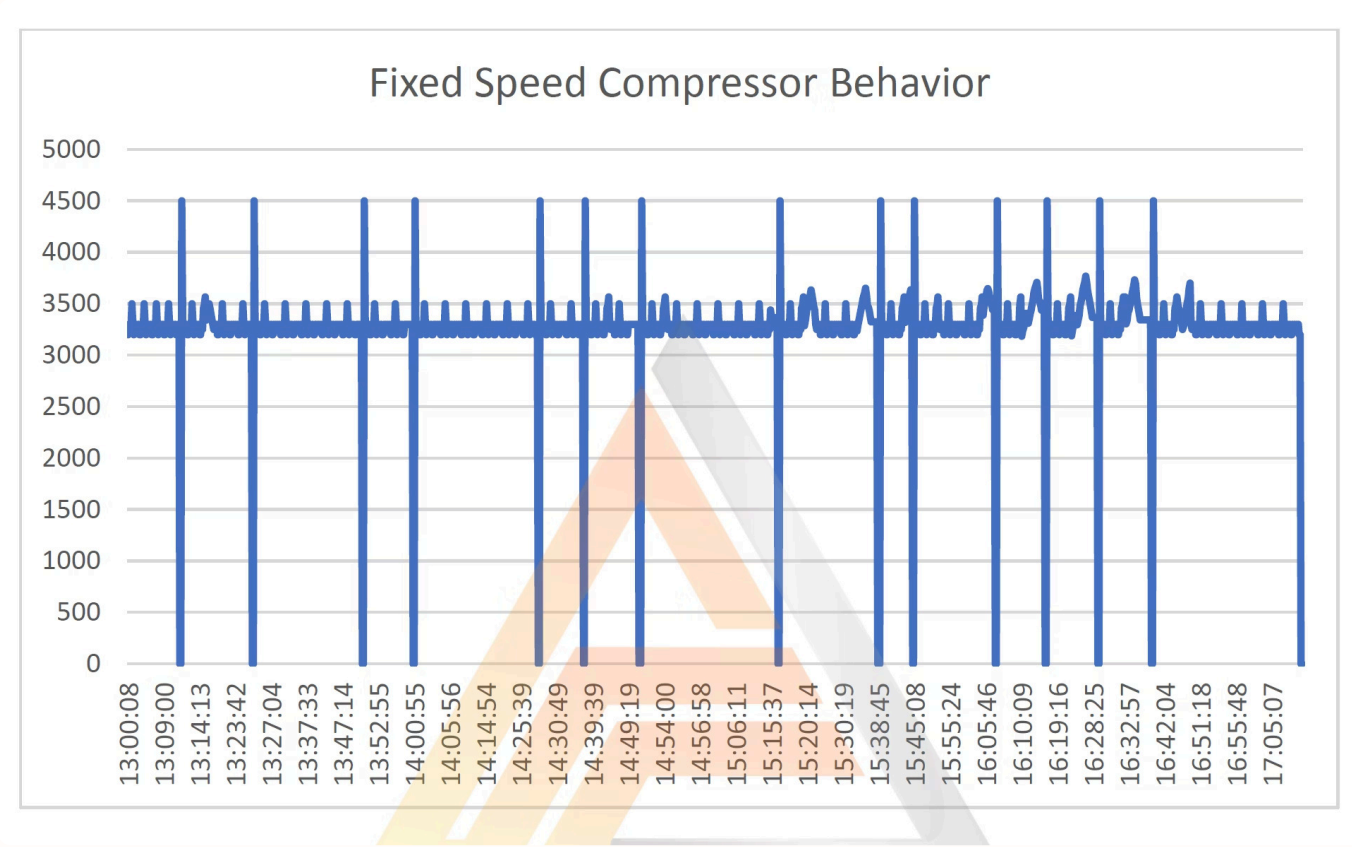


Figure 2:

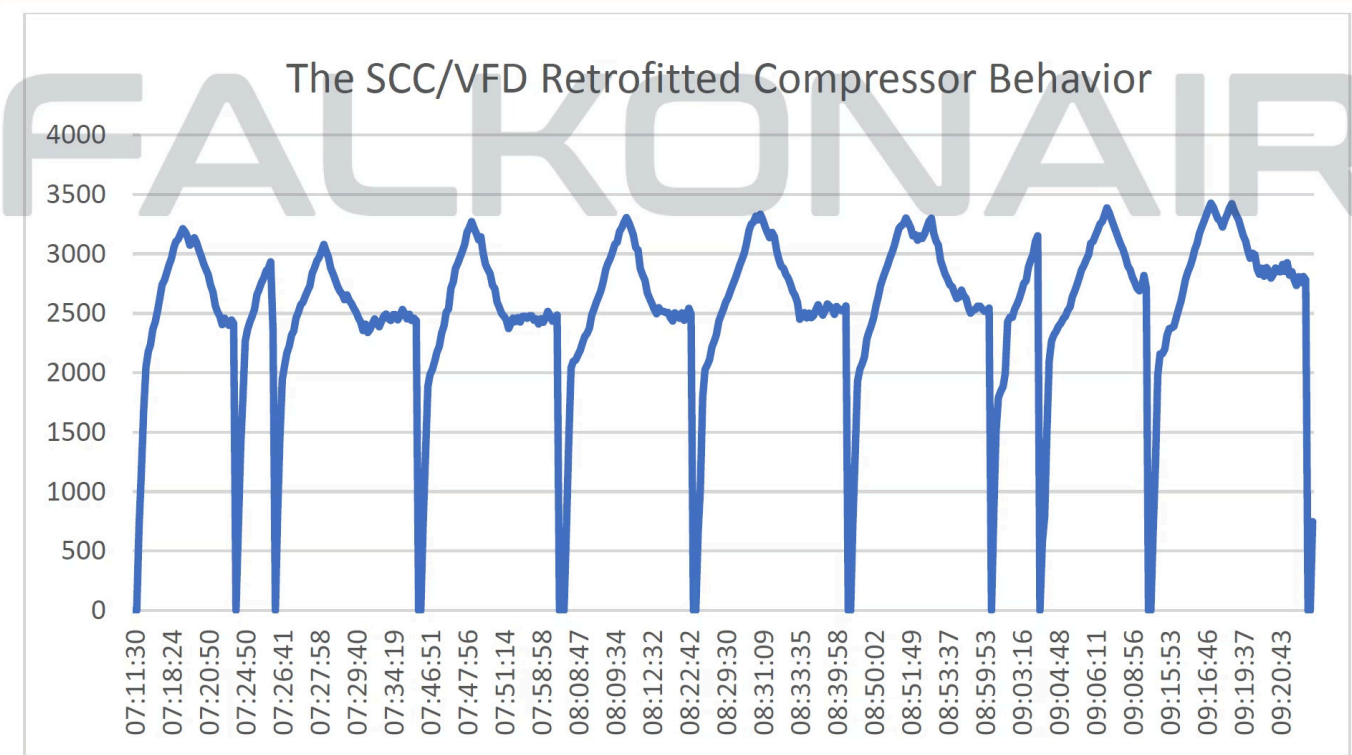
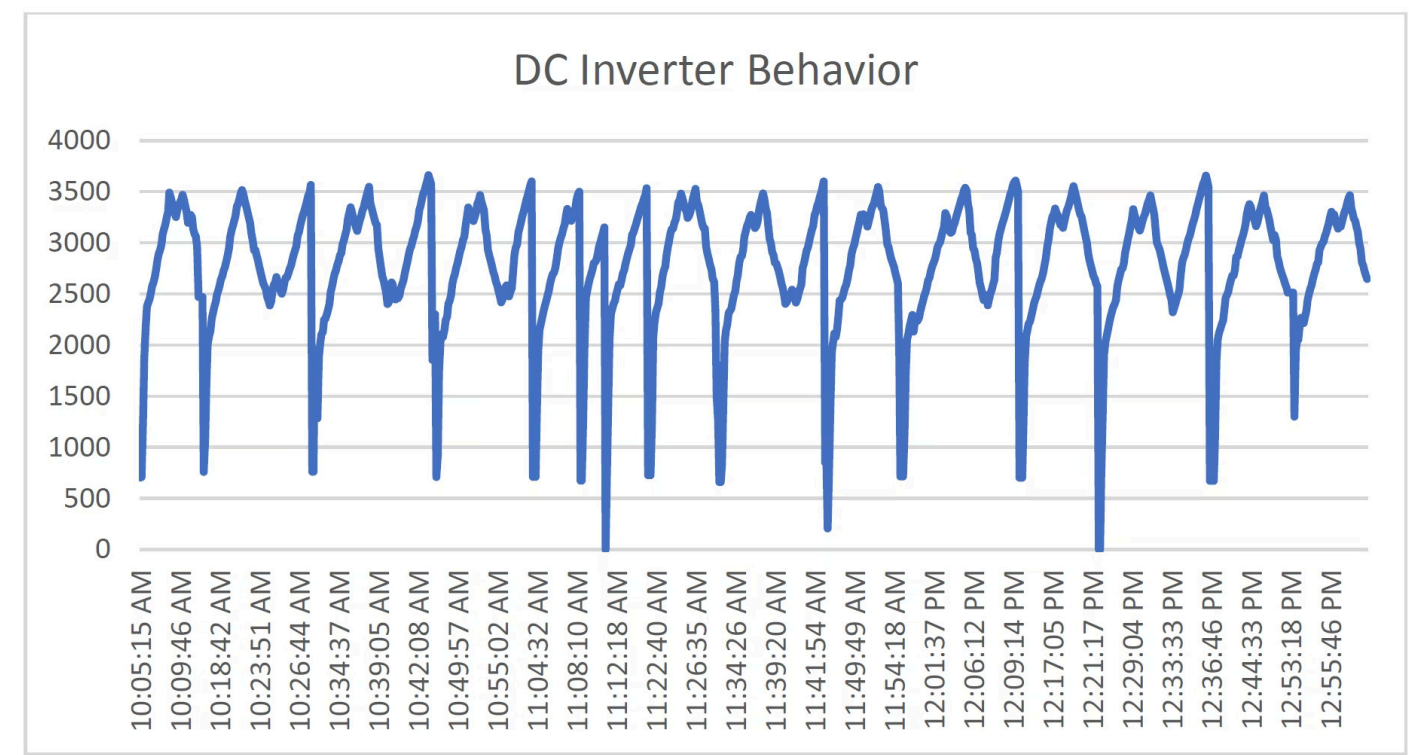


Figure 3:



# System Comparison: Cost and Reliability

## Cost

### DC Inverter Systems:

- 50%–100% more expensive to install and maintain
- Expensive and proprietary replacement parts

### SCC/VFD Retrofitted Systems:

- More cost-effective than full DC inverter systems
- Retrofit approach avoids full system replacement

## Reliability

### Fixed Speed Systems:

- Simple, durable, and typically last **10–20 years**
- Lower cost of repair

### DC Inverter Systems:

- Average lifespan: **~7 to 10 year**
- Complex architecture with multiple PCBs (main board, IPM, rectifier, power board)
- Repairs are costly and require specialized expertise

# System Comparison: Efficiency and Environmental Impact

## Efficiency

### DC Inverter:

- Most energy-efficient option
- Continuous modulation reduces energy use

### SCC/VFD Retrofit:

- Delivers significant efficiency gains over fixed-speed systems
- Reduces short cycling and peak load

## Environmental Impact

### DC Inverter:

- Lowest CO<sub>2</sub> emissions during operation
- Shorter lifespan and **30% non-recyclable components** contribute to landfill waste

### SCC/VFD Retrofit:

- Reuses existing equipment, extending lifecycle
- Lower environmental impact over time



# Conclusion and Market Research

Falconair's analysis shows that **Smart Compressor Control (SCC)** retrofitted systems offer the **most balanced solution** in terms of:



**Cost-effectiveness**



**Energy efficiency (~30% savings)**



**Compressor protection**



**Ease of maintenance and repair**

While DC inverter systems offer the highest efficiency, they come at the cost of **higher complexity, shorter lifespans, and increased long-term costs.**

## Market Research

The global **Variable Frequency Drive (VFD)** market was valued at **\$39billion by 2030**, with a **5.9% CAGR** growth projection. Source: <https://www.grandviewresearch.com/press-release/global-variable-frequency-drive-vfd-market>