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# HVACR Leadership Workshops

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# Event Introduction: **Variable Speed Drives**

**Brian Suggitt**

Chairman

Eurovent Middle East

# Our Members

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# Agenda

1. Applying a "Total System Efficiency" Approach – Danfoss
2. Drives for BLDC Motors – CAREL
3. How Inverter Technology Drives Energy Efficiency in Air Conditioning Works – Daikin
4. Medium Voltage Centrifugal Chillers – Johnson Controls
5. Fan Arrays – ebm papst
6. Connected Future - ABB
7. Moderated Discussion

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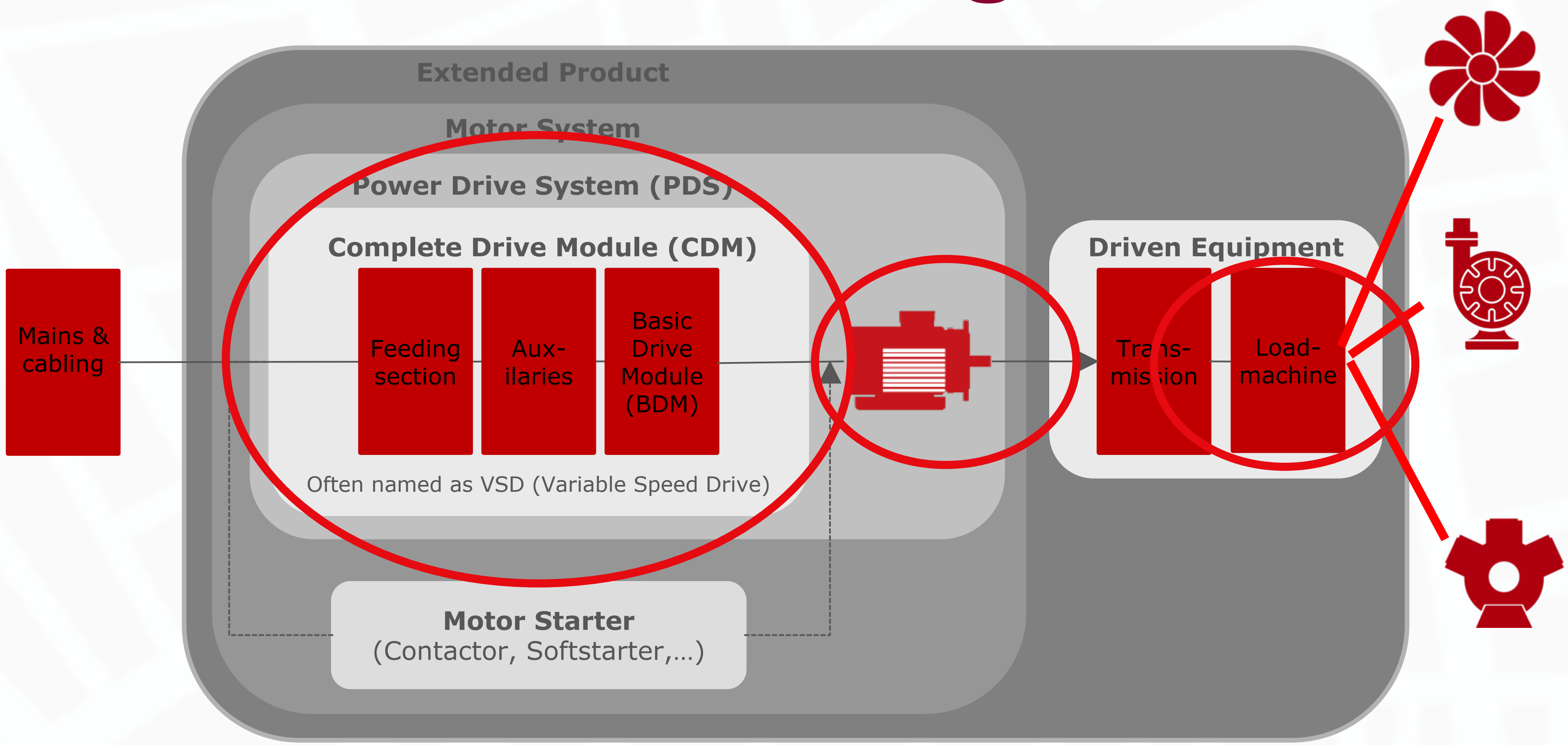
# Applying a Total System Efficiency Approach: Specifying the Sustainable Buildings of Tomorrow

**Jesper Therbo**
Global Head of HVAC/R
Danfoss Drives, Denmark

# Agenda

- Definitions according to IEC 61800-9
- Eco-design around the world
- Classification of Motors and Drives
- Part Load Losses
- Extended Product Approach
- Specifications – motors and energy efficient applications
- Case Study – HVAC Application
- Summary

# Definitions according to IEC 61800-9



# Ecodesign around the world

- Ecodesign is an approach to designing products with special consideration for the environmental impacts of the product during its whole lifecycle – it includes but is not limited to energy efficiency

- Around the world, various countries implement ecodesign policies for motor systems

- The requirements are called **MEPS** (Minimum Efficiency Performance Standard)

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# Classification of Motors and Drives

**Motor**

**IEC/EN 60034-30-1**

- Fixed speed motors (DOL)
- Classes IE1 – IE4

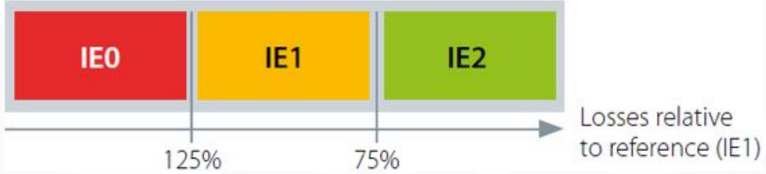
**IEC/EN 60034-30-2**

- Variable speed operation
- Classes IE1 – IE5


**Drive**

**IEC/EN 61800-9-2**

- Complete Drive Module (CDM)
- Classes IE0 – IE2



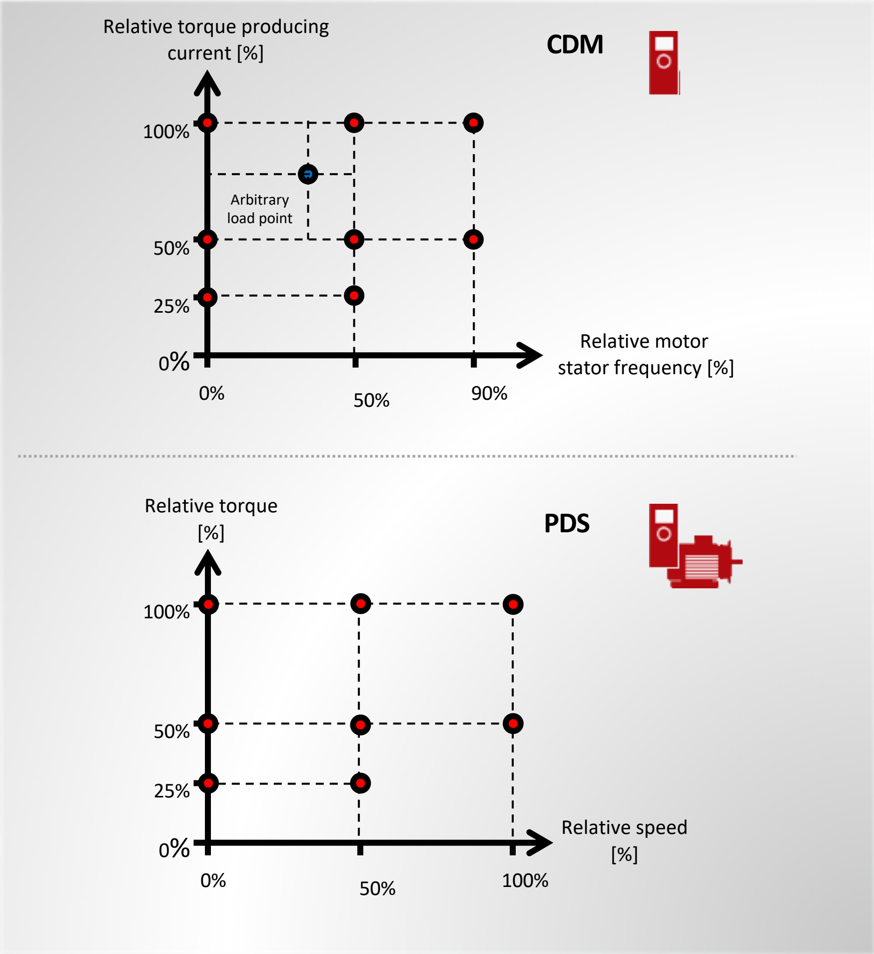

**Drive + motor**

**IEC/EN 61800-9-2**

- Power Drive System (PDS)
- Classes IES0 – IES2

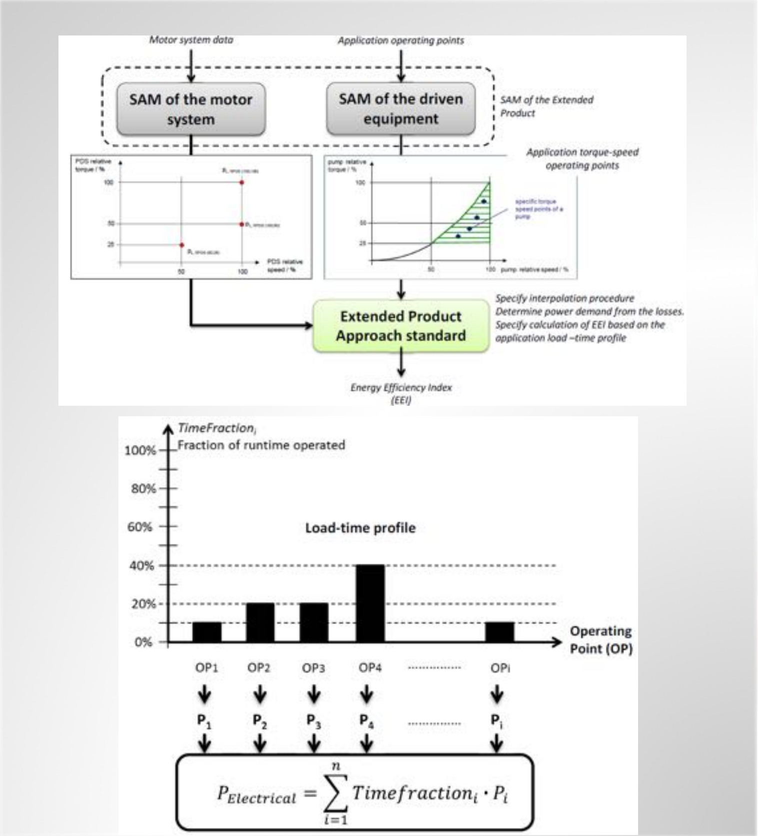
# Part Load Losses

- Part load losses are defined in the nominal point and in 7 additional part load points for:
  - CDM (drive)
  - PDS (drive + motor)
- Note that the nominal point for drives is 90% of nominal load and 100% for systems.
- Part load losses can be determined in any point by interpolating between the 8 standardised points.



# Extended Product Approach

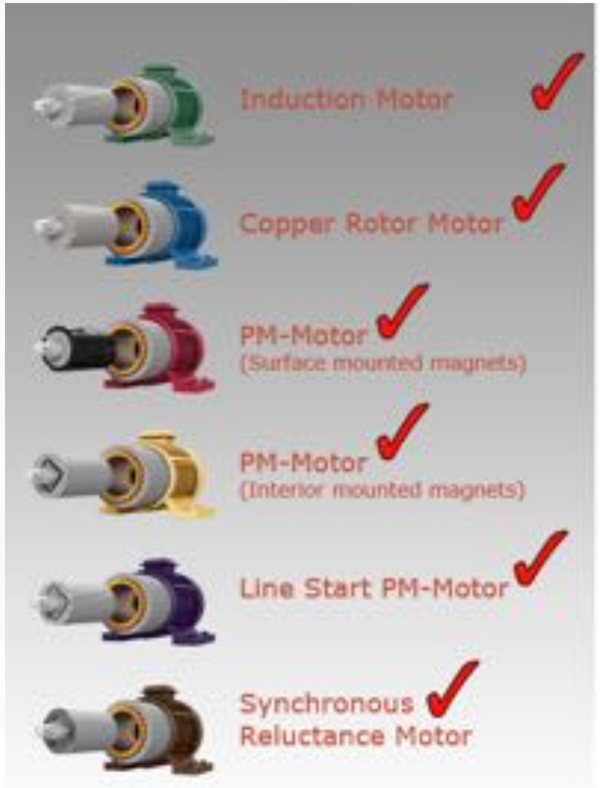
- The extended product approach combines the losses/efficiency of the motor system with the losses/efficiency of the driven system (pump, fan, conveyor, etc.)
- Based on the losses or efficiency of the extended product, the **energy efficiency index (EEI)** can be calculated for a given load-time duty profile
- Knowing the part load losses for the motor-drive system is essential for calculating the EEI, which is the ultimate purpose of the ecodesign standard

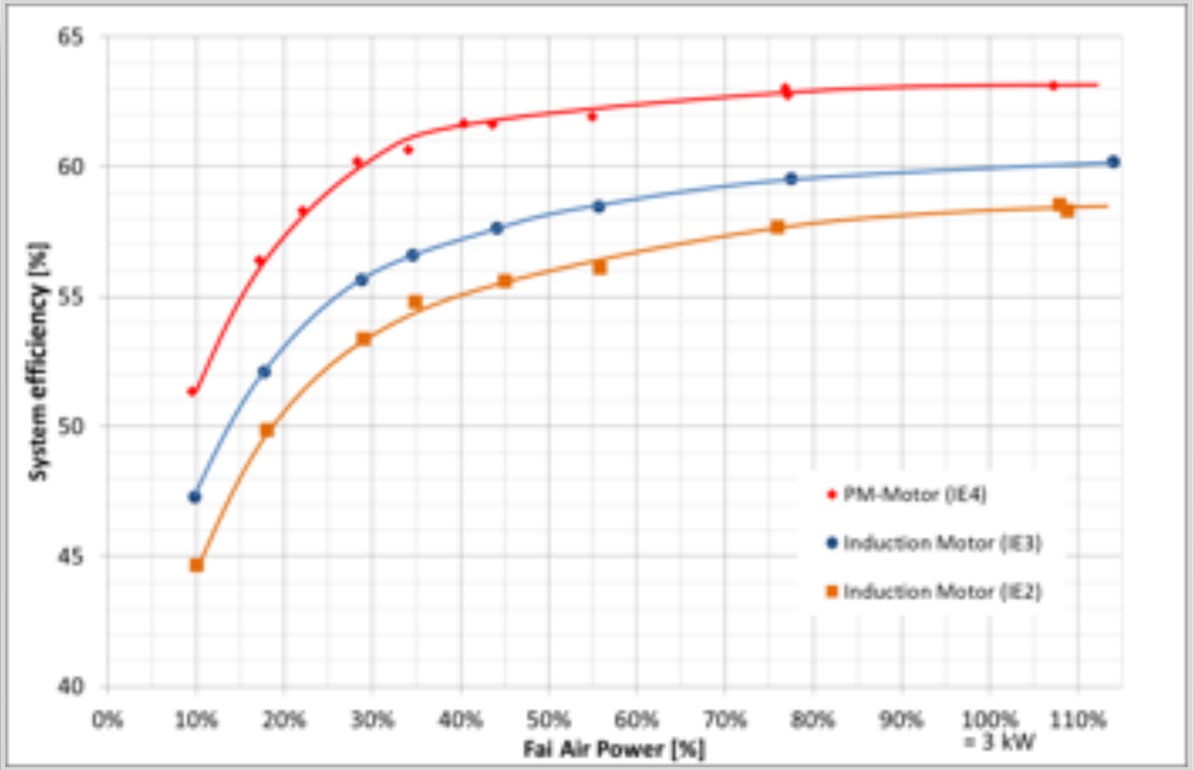


# Specifying the right motor

# Comparison of efficiencies

## Ventilation Unit with IE2, IE3 and IE4 motors




Study from ILK Dresden. Available on Danfoss.com

# Specifying the most energy efficient application

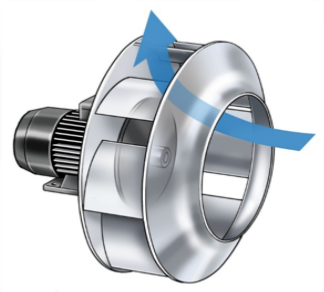
# Comparison Test – Same Installation

## Air Handling Unit manufactured by Trubel Luft-und Klimatechnik GmbH

**AHU w. Radial Fan (Plug Fan)**

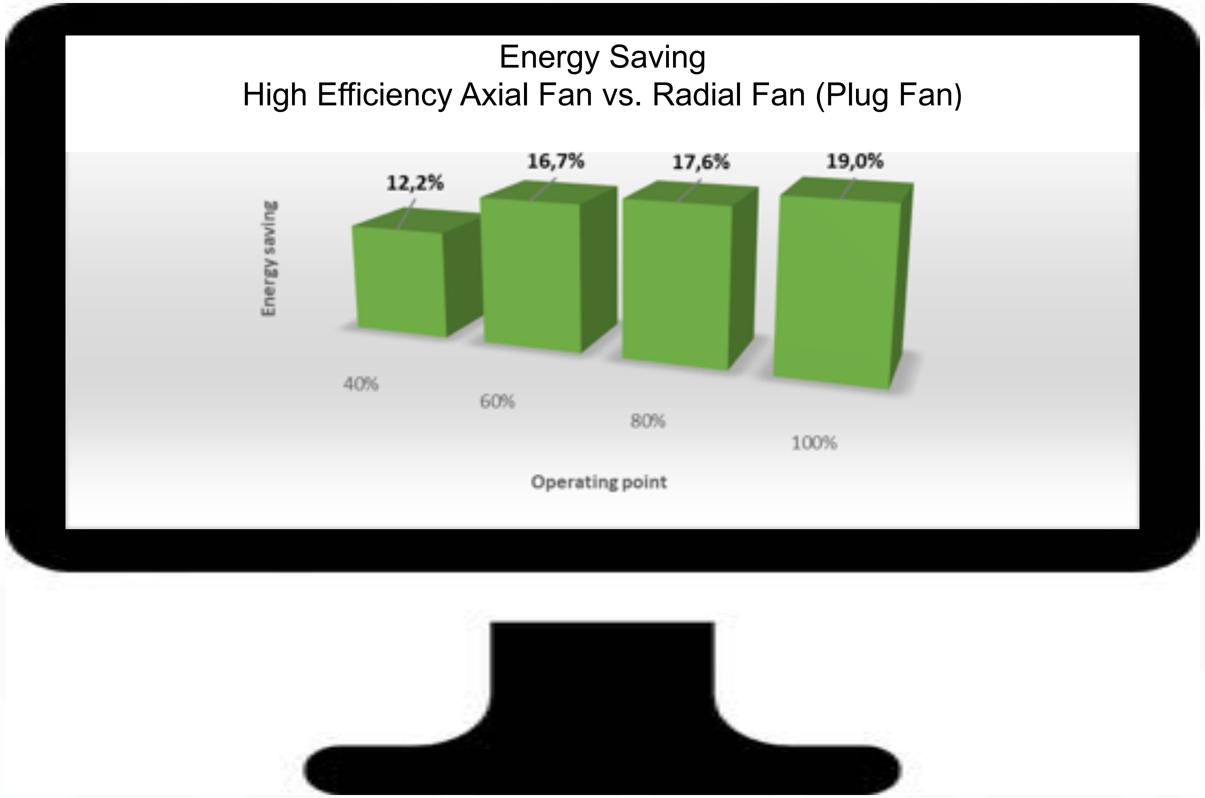
**AHU w. High Efficiency Axial Fan**

**Radial Fan (Plug fan)**



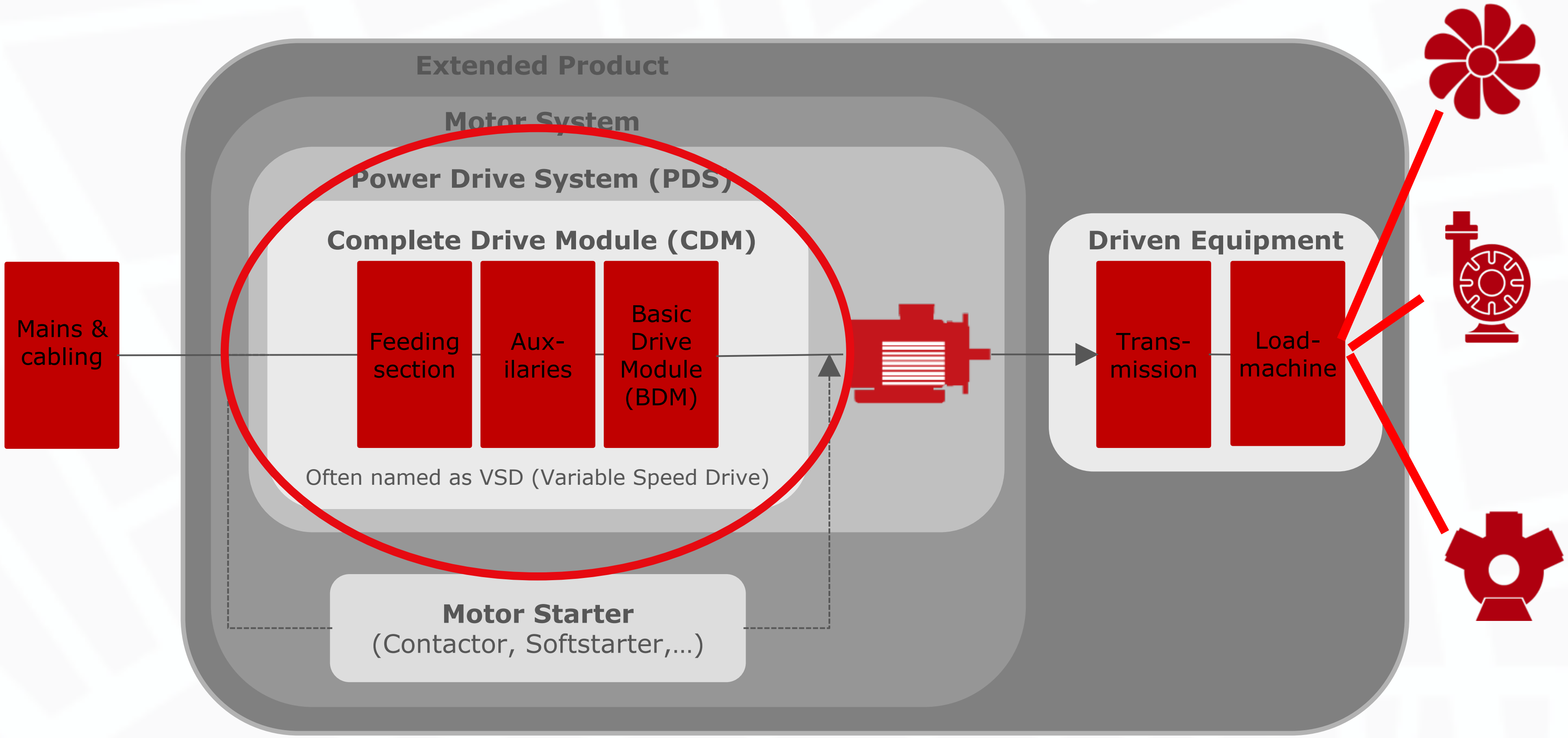
**High Efficiency Axial Fan**

# Energy Cost Saving



# Specifying intelligent ways to remove waste heat

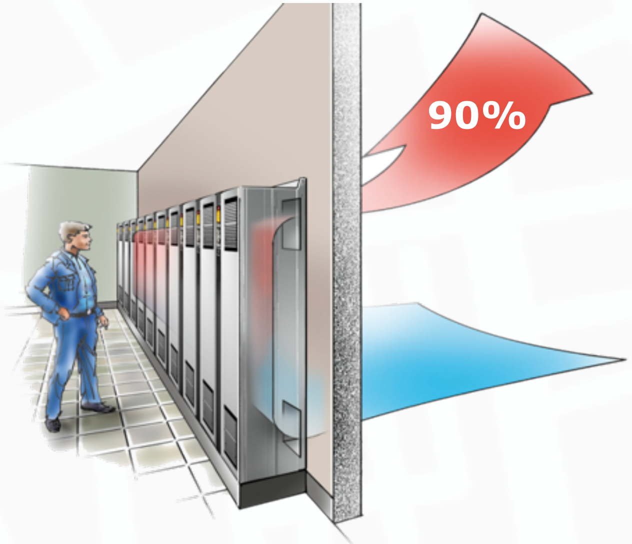
# Definitions according to IEC61800-9



# Intelligent Heat Management

## Part of installed efficiency

The back channel cooling concept transfers up to 90% of heat away from the room. Typically 0,4 W of energy needed to remove 1 W of heat.




The annual energy saving for a 160 kW drive will be about 15 % of investment in a standard AC drive

# Specifying the most energy efficient harmonics mitigation

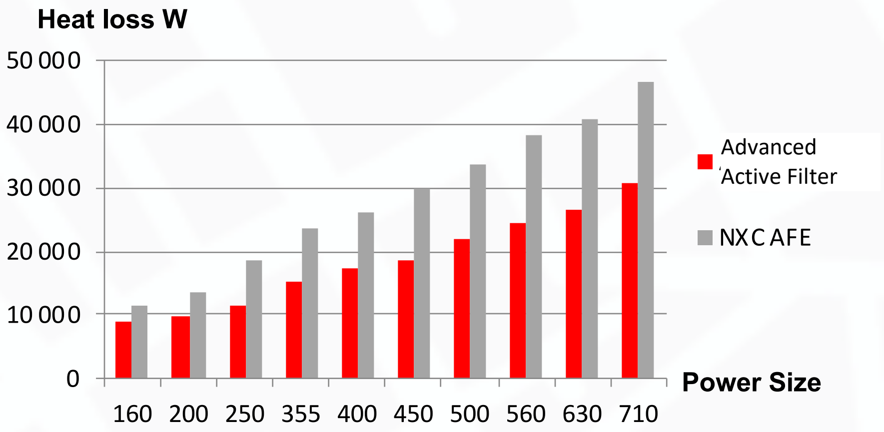
# Energy efficient harmonic mitigation

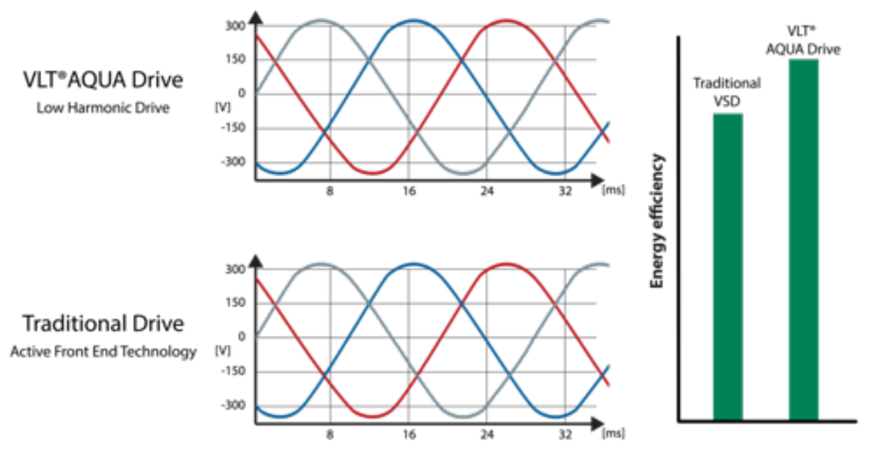
## Part of installed efficiency

### There are many solutions:

- Low Harmonic Drive - AAF based
- Low Harmonic Drive – AFE based
- Central/Sep. solutions – AAF based
- Passive Harmonic solutions

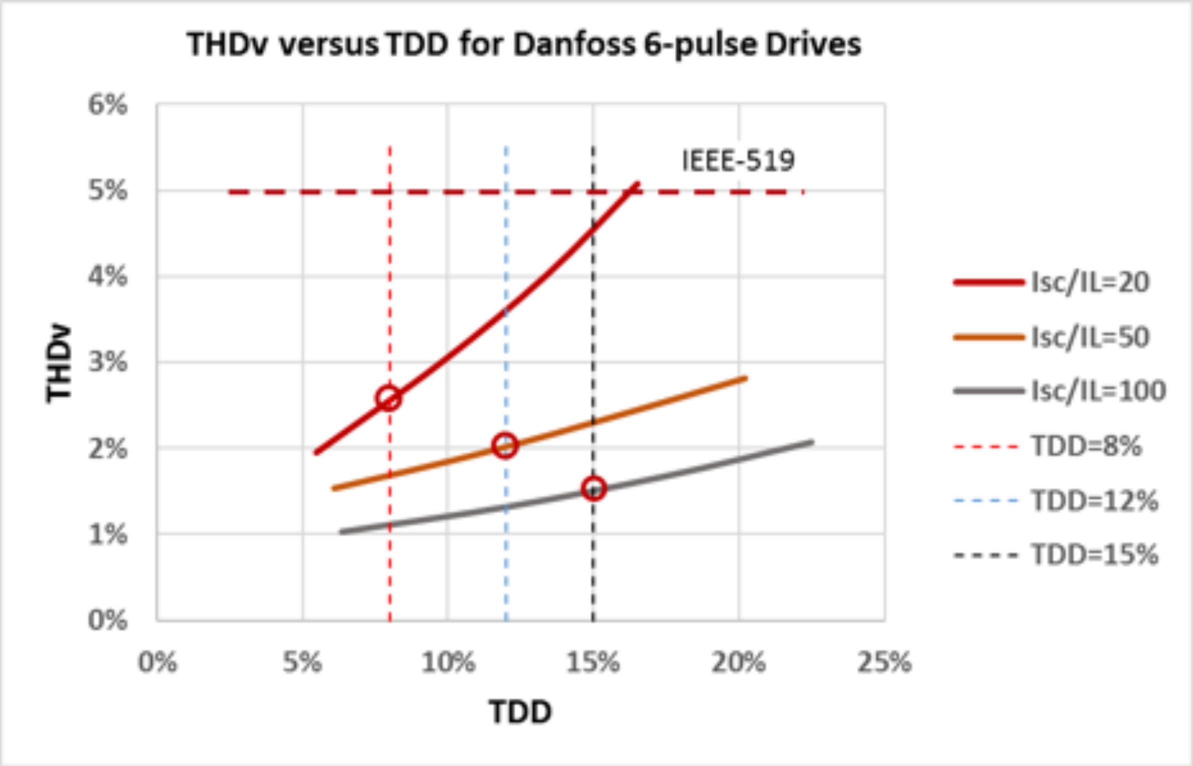
### Heat loss/efficiency difference between AAF vs AFE



# Case Study: HVAC Application

**THDv** (IEC-61xxx) **versus TDD** (IEEE-519)




| IEC-6100-2-4 | | THDv |
|---|---|---|
| | 1 | 5% |
| Class | 2 | **8%** |
| | 3 | 10% |

| IEEE-519-2014 | | THDv |
|---|---|---|
| Voltage at PCC | ≤ 1000V | 8% |
| | ≤ 69kV | **5%** |
| | ≤ 161kV | 2.5% |

| IEEE-519-2014 | |
|---|---|
| $I_{SC/IL}$ | **TDD** |
| < 20 | 5% |
| 20 < 50 | **8%** |
| 50 < 100 | **12%** |
| 100 < 1000 | 15% |
| > 1000 | 20% |

Appling the **IEEE-519-2014** for harmonics calculations ensure **THDv <3%** with Danfoss drives at the PCC.

# Case Study: HVAC Application

## Application with 6-Pulse VLT drives

| | Motor Shaft Power [kW] | | | | | | | | | | Total Values |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **4** | **5,5** | **7,5** | **11** | **15** | **18,5** | **30** | **45** | **75** | **400** | |
| No. of fans (variable torque) | 6 | 3 | 6 | 10 | 18 | 2 | 7 | | | | |
| No. of pumps (variable torque) | 3 | 4 | 2 | 2 | 4 | 6 | 1 | 4 | 4 | | |
| Number of chillers (Constant torque) | | | | | | | | | | 4 | |
| Total No. of drives | 9 | 7 | 8 | 12 | 22 | 8 | 8 | 4 | 4 | 4 | 86 |
| THDi | 42% | 42% | 42% | 42% | 42% | 42% | 42% | 42% | 35% | 35% | |
| Mains Voltage [V] | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | |
| Total efficiency, inverter+ motor | 0,85 | 0,85 | 0,85 | 0,85 | 0,85 | 0,85 | 0,87 | 0,87 | 0,88 | 0,9 | |
| Drive fund. Mains current [A] | 6,8 | 9,3 | 12,7 | 18,7 | 25,5 | 31,4 | 49,8 | 74,7 | 123,0 | 641,5 | |
| Total drive fund. Mains current [A] | 61,1 | 65,4 | 101,9 | 224,1 | 560,4 | 251,3 | 398,2 | 298,6 | 492,1 | 2566,0 | 5019,1 |
| Drive harmonics current [A] | 2,9 | 3,9 | 5,3 | 7,8 | 10,7 | 13,2 | 20,9 | 31,4 | 43,1 | 224,5 | |
| Total drive harmonics current[A] | 12,8 | 13,7 | 21,4 | 42,4 | 105,9 | 52,8 | 83,6 | 81,5 | 111,9 | 583,8 | 887,9 |
| Linear Loads current [%] | | | | | | | | | | | 10% |
| Demand Load Current [A] | | | | | | | | | | | 5591,9 |
| Drive Losses | 2,0% | 2,0% | 2,0% | 2,0% | 2,0% | 2,0% | 2,0% | 2,0% | 2,0% | 2,0% | |
| Costs of Losses for 10 years (80%, 24h, 0.1EUR/kWh) | 6.530 € | 6.983 € | 10.883 € | 23.943 € | 59.857 € | 26.845 € | 42.531 € | 31.898 € | 52.560 € | 274.091 € | 536.120 € |
| **TDD Drive Groups** | **0,2%** | **0,2%** | **0,4%** | **0,8%** | **1,9%** | **0,9%** | **1,5%** | **1,5%** | **2,0%** | **10,4%** | **15,9%** |

Costs of losses calculation: Utilization – 80% /24Hours; Electricity costs - 0.1EUR/kWh; Runtime – 10 years

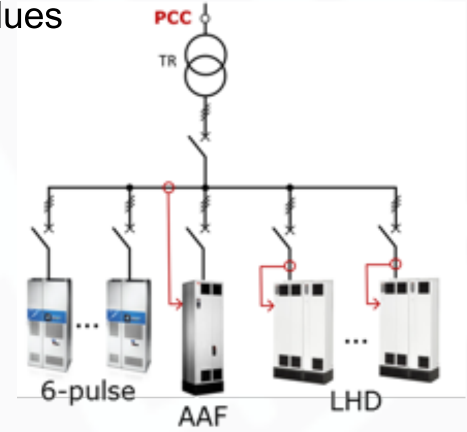
The expected TDD=15.9%. → Applicable only at networks with **Isc/IL>1000**

# Case Study: HVAC Application

**Evaluation:**

| | Motor Shaft Power [kW] | | | | | | | | | | Total Values |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5,5 | 7,5 | 11 | 15 | 18,5 | 30 | 45 | 75 | 400 | |
| Total No. of drives | 9 | 7 | 8 | 12 | 22 | 8 | 8 | 4 | 4 | 4 | 86 |
| TDD Drive Groups | 0,2% | 0,2% | 0,4% | 0,8% | 1,9% | 0,9% | 1,5% | 1,5% | 2,0% | 10,4% | 15,9% |

Two drive groups – **4x400kW** and **4x75kW**, show highest TDD values




**Possible Solutions**

**4x400kW drives are LHD's /AFE's/AAF's**

**4x400kW + 4x75kW drives are LHD's /AFE's/AAF's**

**all Drives ULHD's - AFE's**

Applying LHD's or AAF's ensures lowest losses of the drive installation (losses ~3,5%).

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# Case Study: HVAC Application

## Application with 6-Pulse and 4x400kW + 4x75kW AFE's

| | Motor Shaft Power [kW] | | | | | | | | | | Total Values |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5,5 | 7,5 | 11 | 15 | 18,5 | 30 | 45 | 75 | 400 | |
| No. of fans (variable torque) | 6 | 3 | 6 | 10 | 18 | 2 | 7 | | | | |
| No. of pumps (variable torque) | 3 | 4 | 2 | 2 | 4 | 6 | 1 | 4 | 4 | | |
| Number of chillers (Constant torque) | | | | | | | | | | 4 | |
| Total No. of drives | 9 | 7 | 8 | 12 | 22 | 8 | 8 | 4 | 4 | 4 | 86 |
| THDi | 42% | 42% | 42% | 42% | 42% | 42% | 42% | 42% | 5% | 5% | |
| Mains Voltage [V] | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | |
| Total efficiency, inverter+ motor | 0,85 | 0,85 | 0,85 | 0,85 | 0,85 | 0,85 | 0,87 | 0,87 | 0,88 | 0,9 | |
| Drive fund. Mains current [A] | 6,8 | 9,3 | 12,7 | 18,7 | 25,5 | 31,4 | 49,8 | 74,7 | 123,0 | 641,5 | |
| Total drive fund. Mains current [A] | 61,1 | 65,4 | 101,9 | 224,1 | 560,4 | 251,3 | 398,2 | 298,6 | 492,1 | 2566,0 | 5019,1 |
| Drive harmonics current [A] | 2,9 | 3,9 | 5,3 | 7,8 | 10,7 | 13,2 | 20,9 | 31,4 | 6,2 | 32,1 | |
| Total drive harmonics current[A] | 12,8 | 13,7 | 21,4 | 42,4 | 105,9 | 52,8 | 83,6 | 81,5 | 16,0 | 83,4 | 410,8 |
| Linear Loads current [%] | | | | | | | | | | | 10% |
| Demand Load Current [A] | | | | | | | | | | | 5536,3 |
| Drive Losses | 2,0% | 2,0% | 2,0% | 2,0% | 2,0% | 2,0% | 2,0% | 2,0% | 5,0% | 5,0% | |
| Costs of Losses for 10 years (80%, 24h, 0.1EUR/kWh) | 6.530 € | 6.983 € | 10.883 € | 23.943 € | 59.857 € | 26.845 € | 42.531 € | 31.898 € | 131.400 € | 685.227 € | 1.026.096 € |
| **TDD Drive Groups** | **0,2%** | **0,2%** | **0,4%** | **0,8%** | **1,9%** | **1,0%** | **1,5%** | **1,5%** | **0,3%** | **1,5%** | **7,4%** |

Costs of losses calculation: Utilization – 80% /24Hours; Electricity costs - 0.1EUR/kWh; Runtime – 10 years

4x400kW and 4x75kW drives are LHD's; THDi=5%, Losses=5%

The expected TDD=7.4%. → Applicable at networks with **Isc/IL= 20** and higher

# Case Study: HVAC Application

**Conclusions:**

| Solutions | Expected TDD | Expected Costs of Losses* | Addition Costs of Losses for the Solution | ISC/IL |
|---|---|---|---|---|
| **6-pulse VLT** | **15,9%** | 536.120 € | | >1000 |
| **4x400kW drives are LHD-P's** (Losses 3.5%) | **8,8%** | 741.688 € | **205.568 €** | 50 < 100 |
| **4x400kW + 4x75kW drives are LHD-P's** | **7,4%** | 781.108 € | **244.988 €** | 20 < 50 |
| **4x400kW drives are AFE's,** (Losses 5%) | **8,8%** | 947.256 € | **411.136 €** | 50 < 100 |
| **4x400kW + 4x75kW drives are AFE's** | **7,4%** | 1.026.096 € | **489.976 €** | 20 < 50 |
| **All Drives AFE's** | **< 5%** | 1.218.456 € | **682.336 €** | < 20 |

* Costs of losses calculation: Utilization – 80% /24Hours; Electricity costs - 0.1EUR/kWh; Runtime – 10 years, losses of harmonics in transformer are included also.

**6p-Drives and** 4x400kW + 4x75kW **LHD's** ensure acceptable **TDD** of **7,4% for** practically **all networks** (Isc/IL=20 and higher) and guarantee **Savings** of 682.336€ - 244.988€ = **437.348€** for electricity costs, compare to applying all drives with AFE based drives.

If the Isc/IL=50 and higher, **addition Savings** of 244.988€ -205.568€ = **39.420€** are possible.

# Summary

- Consider Energy Efficiency in all parts of your HVAC System
- Specify high efficient Drive and Motor Systems to meet IEC/EN 61800-9-2 Class IE2 and capability for more motor technologies with same drive (future proof)
- Specify highest efficiency fans, pumps and compressors
- Apply an Extended Product Approach and Specify Energy Efficiency Index
- Utilise Intelligent Heat Management e.g. Back-Channel Cooling.
- There are no regulations which require THDi ≤ 5% at drive mains terminals.
- Apply IEEE-519 recommended limits at the PCC only and not to individual pieces of equipment.
- Do not use harmonics mitigation equipment if it is not needed.

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# Agenda

1. Applying a “Total System Efficiency” Approach – Danfoss
2. **Drives for BLDC Motors – CAREL**
3. How Inverter Technology Drives Energy Efficiency in Air Conditioning Works – Daikin
4. Medium Voltage Centrifugal Chillers – Johnson Controls
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# DC Inverter Technology in the HVACR Business

**Matteo Zanesco**

Managing Director

CAREL Middle East DWC LLC

# Agenda

- Market Drivers
- DC Technology
- Solution Trends for HVAC and Refrigeration
- Benefits of DC Inverter Technology in HVACR Applications
- Food Preservation
- Energy Savings
- OPEX (Operational Cost) Optimisation
- Conclusions

# Market Drivers

| High Energy Efficiency | System Reliability | Temperature Control as Mission Critical | Usability and OPEX |
|---|---|---|---|
| Energy savings in the HVACR market **continuously improving and is a critical driver in the decision making** process. | Reliability is an important benefit for the user. Benefits in the **form of safety**: of the **product preservation** and lower operational costs. | Keeping the **temperature stable** is the first step for optimal comfort, system reliability and food preservation with **longer "shelf-life"**. | How people use a system assists in **evaluating the system performances**. **Data analytics** helps optimise system OPEX and profitability. |

# DC Technology

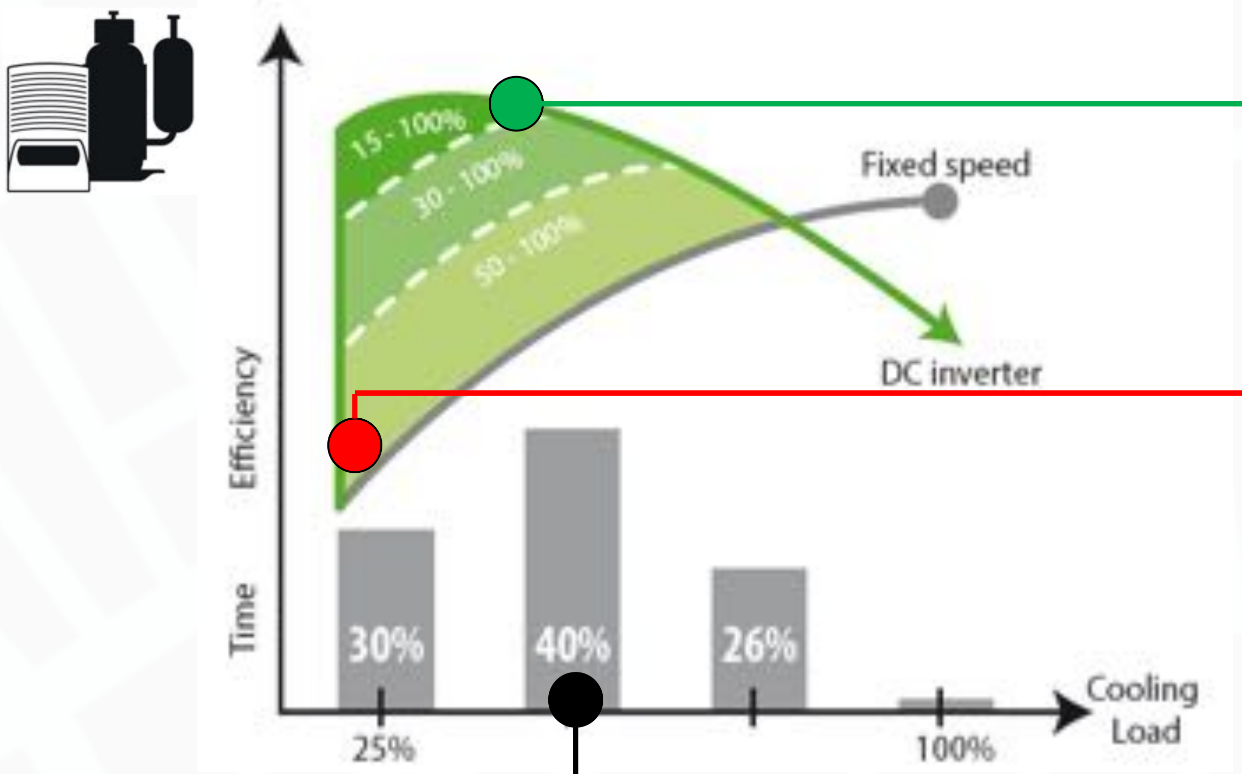
# DC Technology

- DC Technology provides the possibility to modulate the cooling capacity according to the real load in a refrigeration system


| | | |
|---|---|---|
| **Compressor –** BrushLess Direct Current BLDC or DC Motor | **Inverter** modulates the speed of the Compressor. | **Electronics** drive the Inverter and guarantee maximum safety in the system. |

# DC Technology

- Permanent magnet variable speed compressors driven by intelligent DC Drives enables improved energy efficiency in all load conditions




This area represents the **increase of efficiency at part load.**

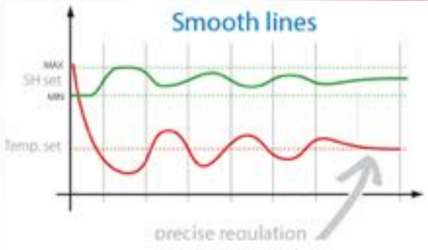
**ON-OFF cycling is not efficient** as the refrigeration circuit needs time to reach the nominal efficiency.

An HVAC-R application is working **for the largest part of the time at partial load.**

# DC Technology

- **Electronic Expansion Valve** for a precise regulation of the evaporator independent from the working condition and refrigerant type ensures:

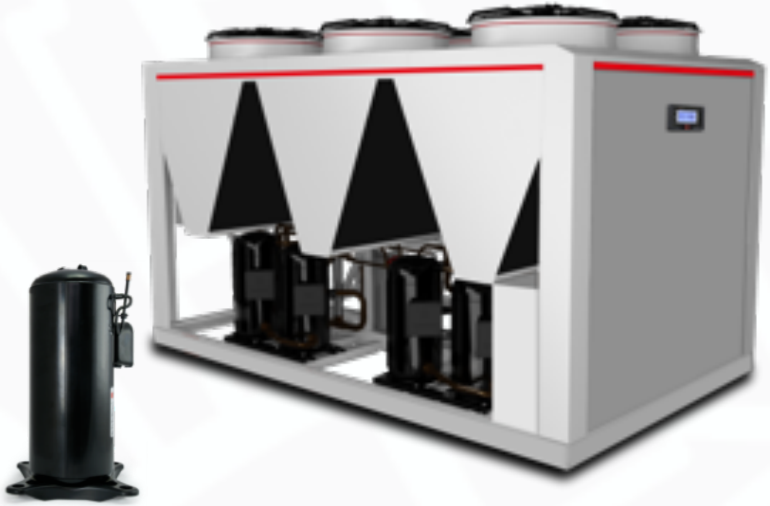
- Stable temperature regulation and dynamic adjustment according to cooling load
- Fast reaction after OFF transitory time («Pull-Down» after defrost in Refrigeration cabinets)
- Suitable for any type of new refrigerant (natural gas included)
- Smart synergy with other components of the system (i.e. CDU / Rack - Smooth line)
- Avoid liquid flow back (to compressor)
- System safety (Oil recovery, High Discharge T.)
- No vibration over the pipe (VS mechanical valve)



# Solution Trends for HVAC

# Scroll Chiller & Package Units

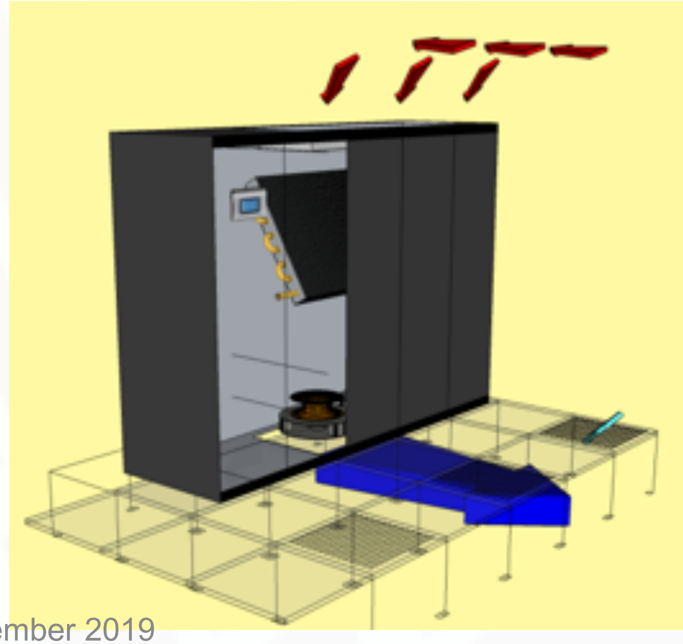
- Scroll chiller and package units are products integrating **at least one electrically driven compressor**, capable of cooling water or air commonly used for residential cooling applications.



- Extended envelope, best working point
- Wide capacity modulation, even with multiple compressors/inverters in the same circuit
- Transitory period out of envelope without blocking units
- Reduced refrigerant charge for each circuit

# Data Centre Units

- Data centre applications show significant energy consumption, with continuous research on technologies that are able reduce it. "Global data centre electricity demand in 2018 was estimated as almost 1% of global final demand for electricity "**About 40% of this consumption is related to cooling”** (source: EJARN Nov 2014)

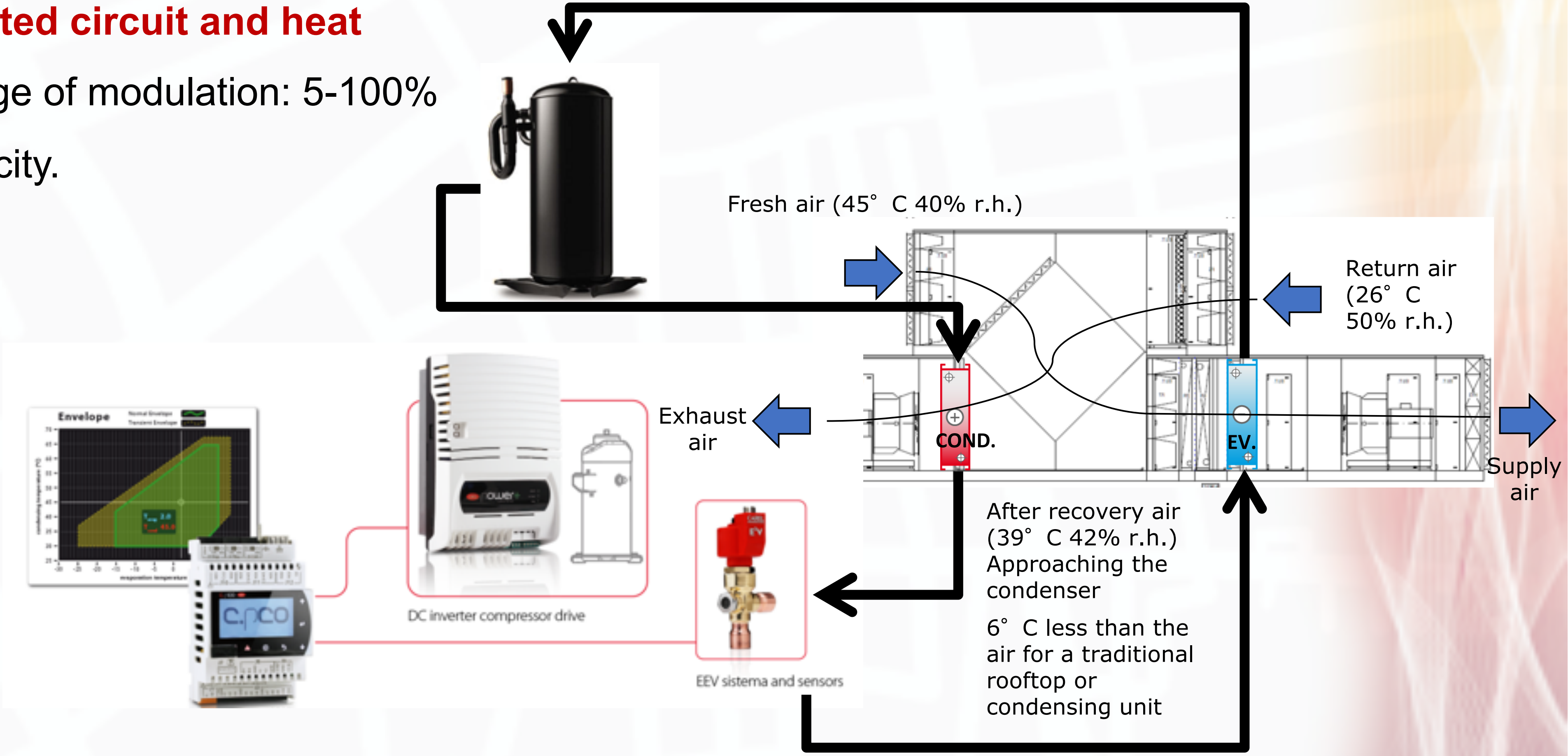


- VS Compressor is effective to maintain the **supply** temperature of air within the specified range of new datacentre layout
- In row units, designed for varying the load continuosly according to the system’s small inertia
- High reliabilty creates redundancy

# AHU with Heat Recovery System

Compact AHU equipped **with single or multiple DC compressors integrated circuit and heat recovery plate.** Wide range of modulation: 5-100% and modular cooling capacity.

- High energy efficiency
- VS compressor to cope with varying fresh air conditions
- Compact design, wide capacity range



# Solution Trends for Refrigeration

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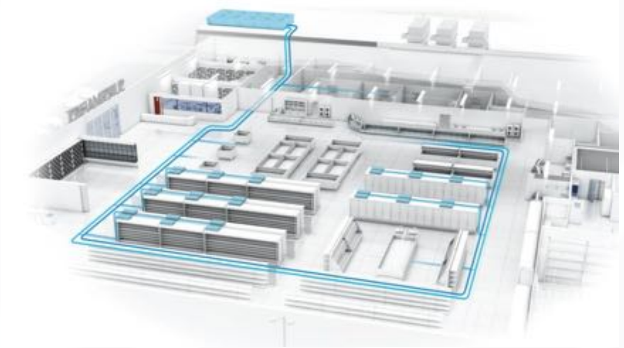
# Condensing Units

"*Condensing unit is a product integrating* ***at least one electrically driven compressor and one condenser****, capable of cooling down and continuously maintaining low or medium temperature inside a refrigerated appliance or system,* ***using a vapour compression cycle*** *once connected to an evaporator and an expansion device"* (Ecodesign Directive, 2009).


- Wide capacity modulation
- Excellent food preservation
- Reduced energy consumption
- Connected to the showcases and cold room evaporators

# Semi Plug-in Units

Semi plug-in units are **self-contained cabinets** with **water-cooled condensing units**, rejecting the heat of condensation by a water loop, thus avoiding an increase in temperature inside the supermarket.



**Discounter**

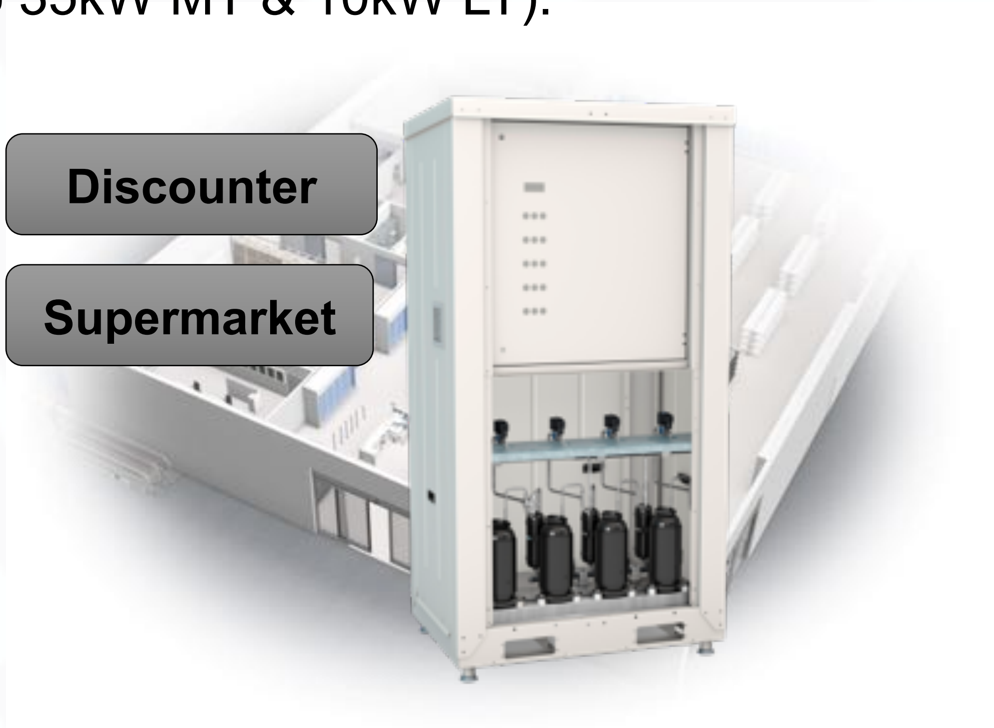
**Supermarket**

**Hypermarket**

- Excellent food preservation
- High energy saving
- Low maintenance
- Limited refrigerant charge
- Zero close leaks frequency
- Extremely low noise application

# Multi DC Boosters

Compact and light-weight rack, equipped with **multiple DC compressors working in parallel** with extremely wide range of modulation: 5-100% and modular cooling capacity (up to 35kW MT & 10kW LT).




- High energy efficiency
- Inside store installation
- Compact design
- Low noise solution

# Benefits of DC inverter technology in HVACR Applications

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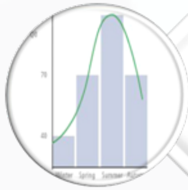
# Benefits of DC Inverter Technology



**Efficiency of the system,**

due to operation at partial-load this technology grant great ENERGY SAVING

**Stability and precision in temperature control:** increased reliability of the equipment cooled and greater comfort for people or mission critical application, FOOD PRESERSERVATION


**System reliability increased,**

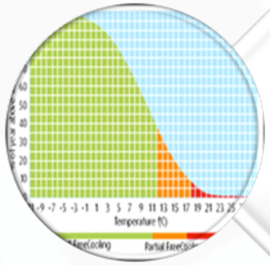
thanks to the reduction in compressor inrush current, with a reduction of mechanical and electrical stress.

**Lower noise level**:

under part-load conditions, units will have lower sound levels than traditional on-off compressor systems in both running and start-up periods

# Benefits of DC Inverter Technology

**Natural refrigerants** adoption is a worldwide trend in HVACR. Small circuits with low refrigerant charge permits an early adoption of these refrigerant without compromise in terms of performance and efficiency thanks to the inverter technology

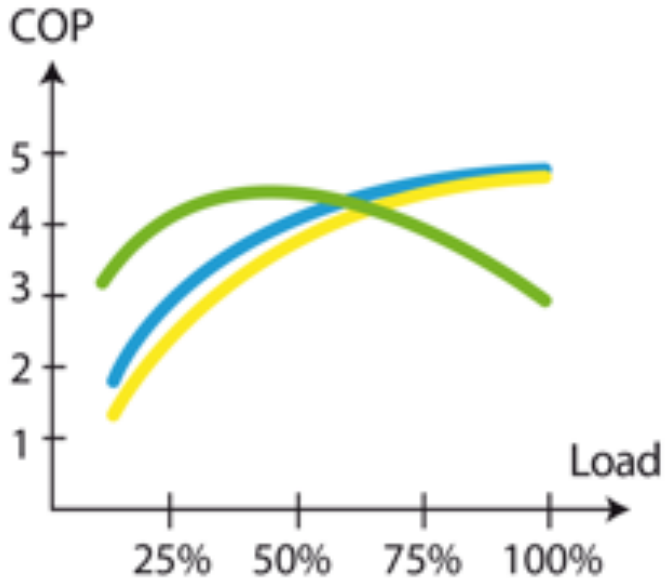


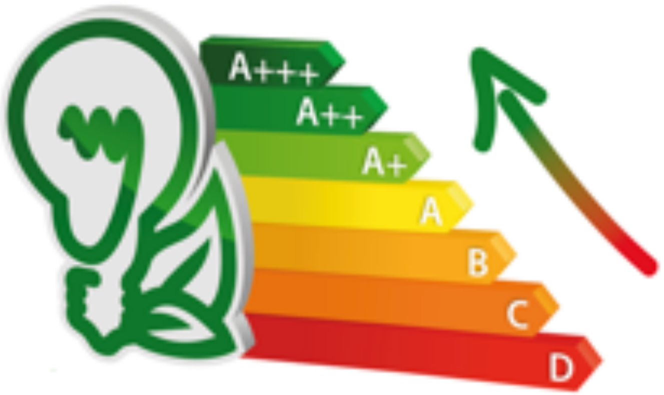
**Adaptability to varying cooling load**, especially when free-cooling is used, will add extra energy savings. **Reduced installation costs:** thanks to the more reactive adaptation to cooling demand, the manufacturer or the installer has the possibility of eliminating or downsizing buffer water tanks, with a significant cost saving and reduction in footprint (case of chillers)


**IOT and ANALITYCS:** thanks to the high technology solutions adopted in a wide range of application a significative amount of data are daily generated. We can collect and translate them into **Analytics** for the process optmization **:** KPI / Benchmark / Reports

# Energy Savings

# Energy Savings for Chiller HP




**ON-OFF**

| | | |
|---|---|---|
| EER | 4.50 | |
| SEER | 3.34 | |

**ON/OFF + EEV**

| | | |
|---|---|---|
| EER | 4.60 | |
| SEER | 3.72 | +11% |

**DC Inverter + EEV**

| | | |
|---|---|---|
| EER | 3.90 | |
| SEER | 4.56 | +37% |

# Energy Savings for Cold Rooms

- **DC compressors and electronic expansion valves**, helps to **reduce the energy consumption** of condensing units.
- The store consists in **3 medium temperature walk-in coolers** with a cooling capacity of **3.5 kW each one**. The data were collected during 4 weeks for each technology.
- Two different solutions were compared, one with condensing units equipped with **DC compressor and electronic expansion valve**, and one with **FIXED SPEED units and thermostatic valve**.



# Energy Savings for Cold Rooms

| *Solution* | *Min T [°C]* | *Max T [°C]* | *Average $T_{amb}$ [°C]* | *Energy consumption [kWh]* |
|---|---|---|---|---|
| FIX SPEED | 22.2 | 36.7 | 27.5 | 2,544 |
| DC TECH. | 23.2 | 39.5 | 31.7 | 1,844 |

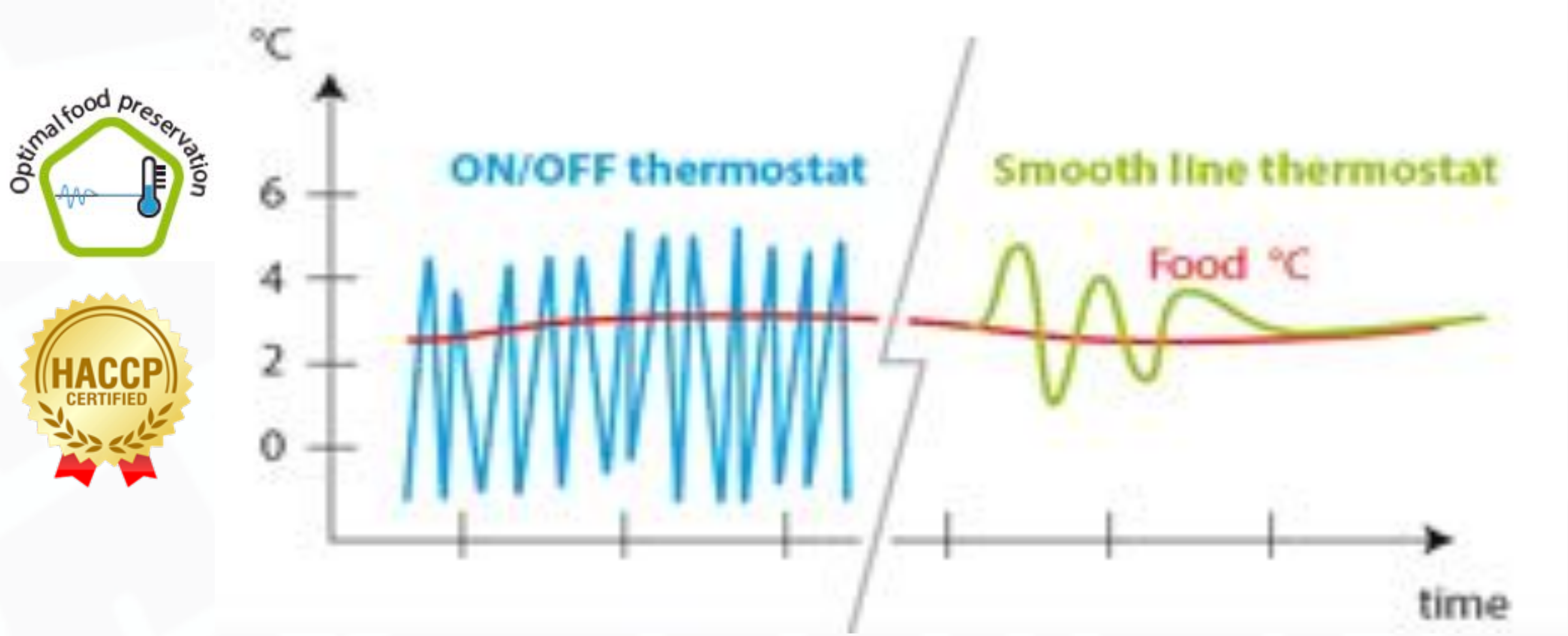
**Reduction on the energy consumption of 28%**

**using DC Technology**

# Food Preservation

# Food Preservation

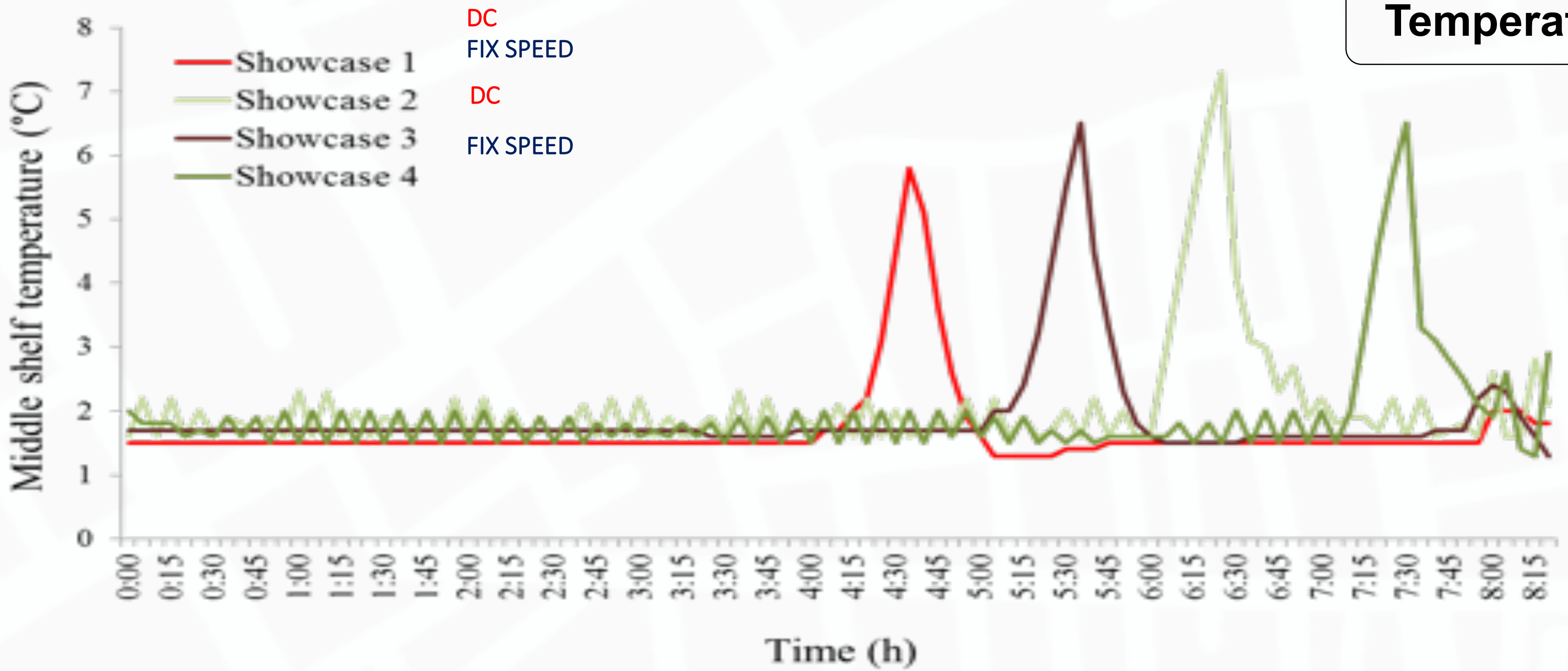
The combination of DC Technology (variable speed compressor), together with the electronic expansion valve, managed by advanced algorithms inside the e-board provide a stable regulation and optimum food preservation.



# Optimal Food Preservation

Effect of the use of DC Technology on semi plug-in condensate by water.

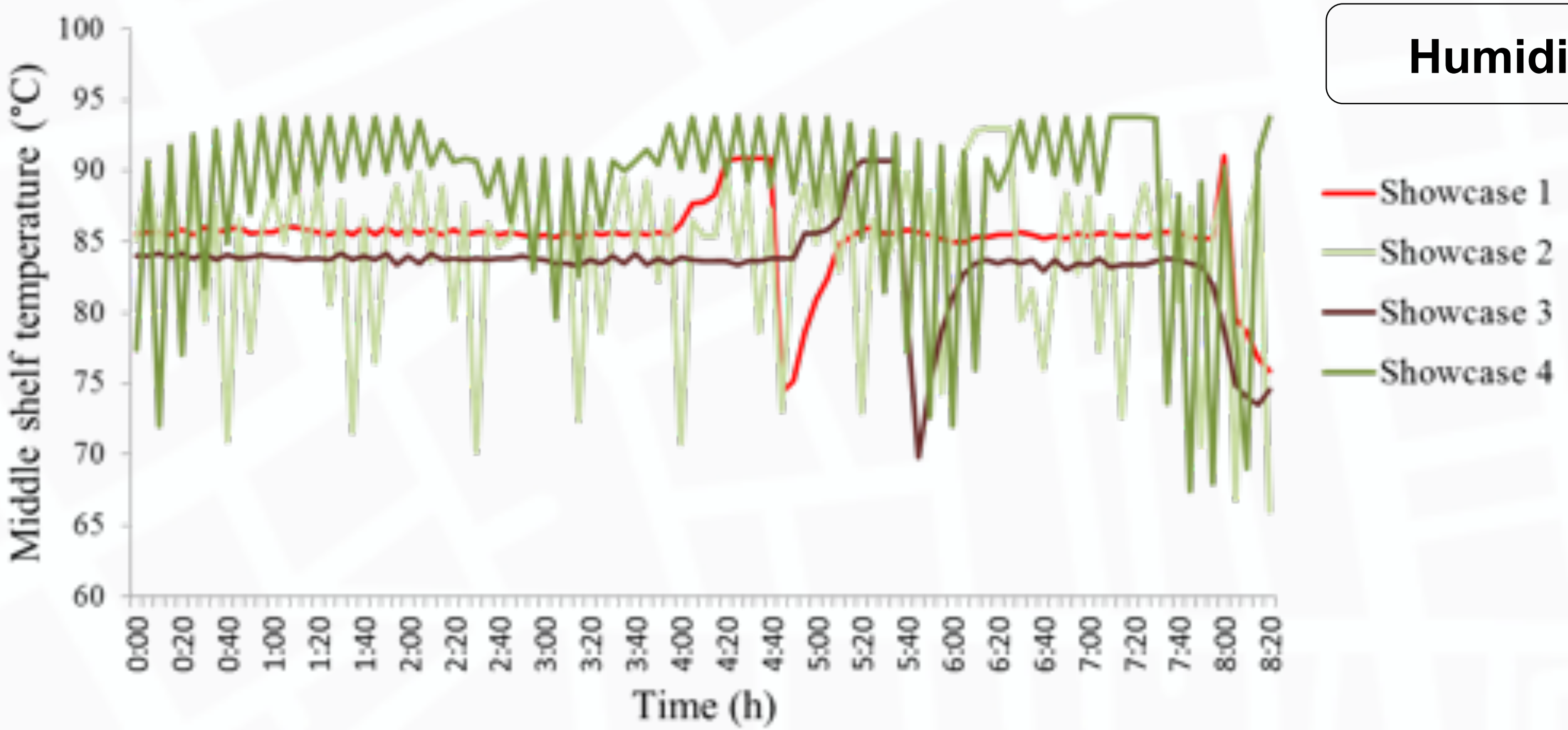
**Temperature**




The variations in temperature can deteriorate the quality of the food, making it shorter its shelf life. (Soo Dong, S. et al., 2013)

# Optimal Food Preservation

Effect of the use of DC Technology on semi plug-in condensate by water.




**Humidity**

The effect of humidity on food is very relevant, in some cases even more than the effect of temperature. (Forney, C.F., 2008 ; Lineberry, K.R., 2011)

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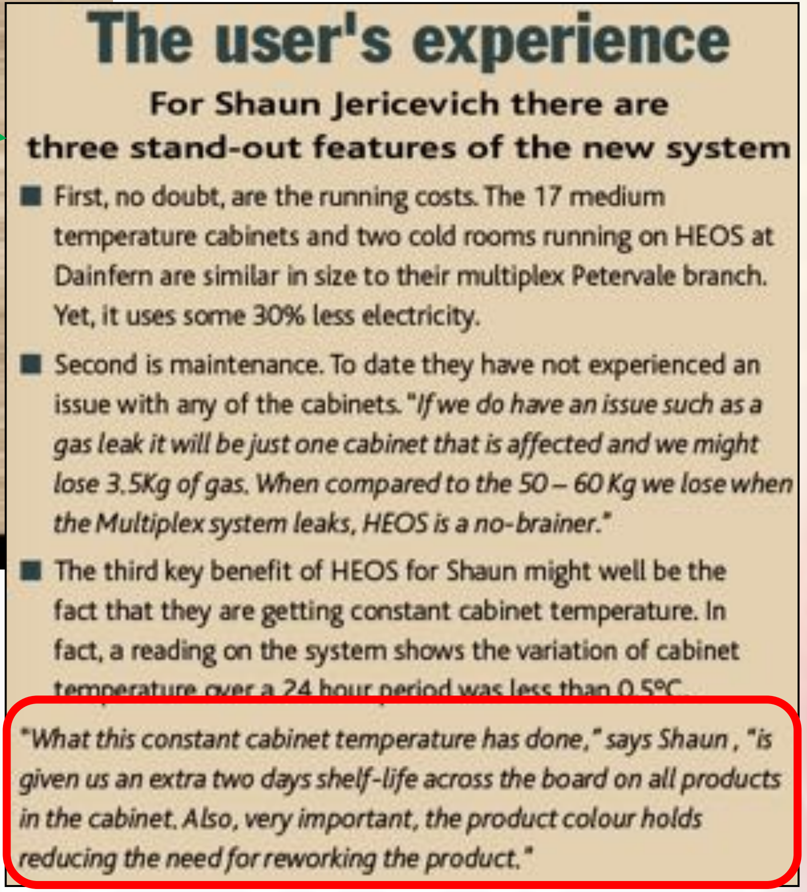


## The user's experience

**For Shaun Jericevich there are three stand-out features of the new system**

- First, no doubt, are the running costs. The 17 medium temperature cabinets and two cold rooms running on HEOS at Dainfern are similar in size to their multiplex Petervale branch. Yet, it uses some 30% less electricity.
- Second is maintenance. To date they have not experienced an issue with any of the cabinets. "*If we do have an issue such as a gas leak it will be just one cabinet that is affected and we might lose 3.5Kg of gas. When compared to the 50 – 60 Kg we lose when the Multiplex system leaks, HEOS is a no-brainer.*"
- The third key benefit of HEOS for Shaun might well be the fact that they are getting constant cabinet temperature. In fact, a reading on the system shows the variation of cabinet temperature over a 24 hour period was less than 0.5°C.

*"What this constant cabinet temperature has done," says Shaun, "is given us an extra two days shelf-life across the board on all products in the cabinet. Also, very important, the product colour holds reducing the need for reworking the product."*

Experience on DC Technology

on **semi plug-in** condensate by water.

Case Study and article published on South

African magazine: **Supermarket.co.za**

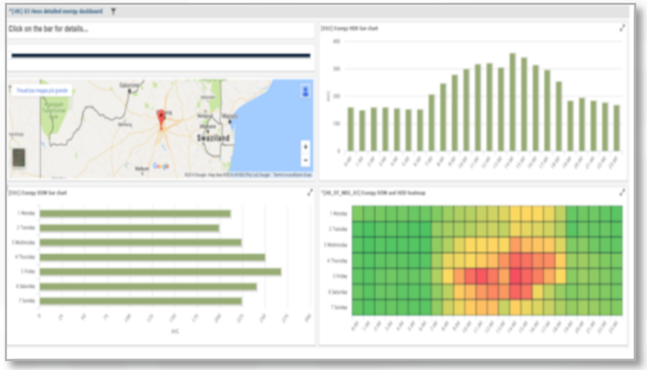
# OPEX Reduction

# Data is Key!


Equipments with DC Technology daily generate a significant amount of Data

There are opportunities for process optimisation by collecting these Data and translate it into **Analytics:** KPI / Benchmark / Reports

Making the refrigeration system **sustainable** and preserve/increase **profitability** of the stores



# Analytics

**Analytics** are possible simply through adequate information management

**Proactive analytics:**

automatic implementation of the proposed actions

**Prescriptive analytics:**

operative/strategic solutions are proposed by the system on the basis of the analysis performed

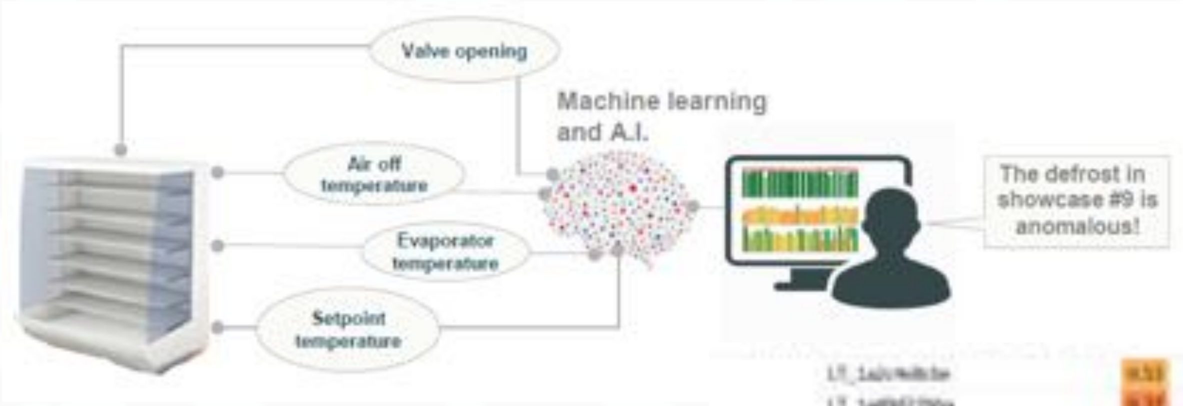
**Preventive analytics:**

understand what might happen in the future

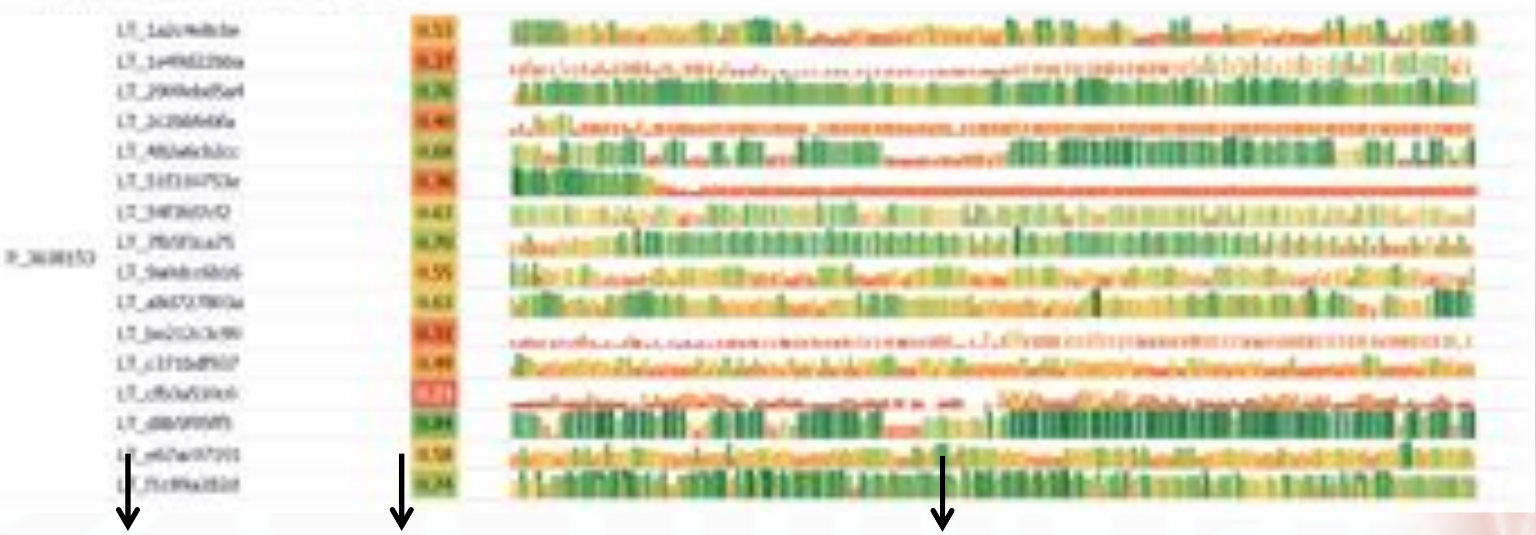
**Descriptive analytics:**

describe the current and past situation, converting the data into information

# Analytics




Show and improve the **defrost status** of supermarket showcases by means of machine learning and A.I.



Showcases Score Visible defrost quality by colors

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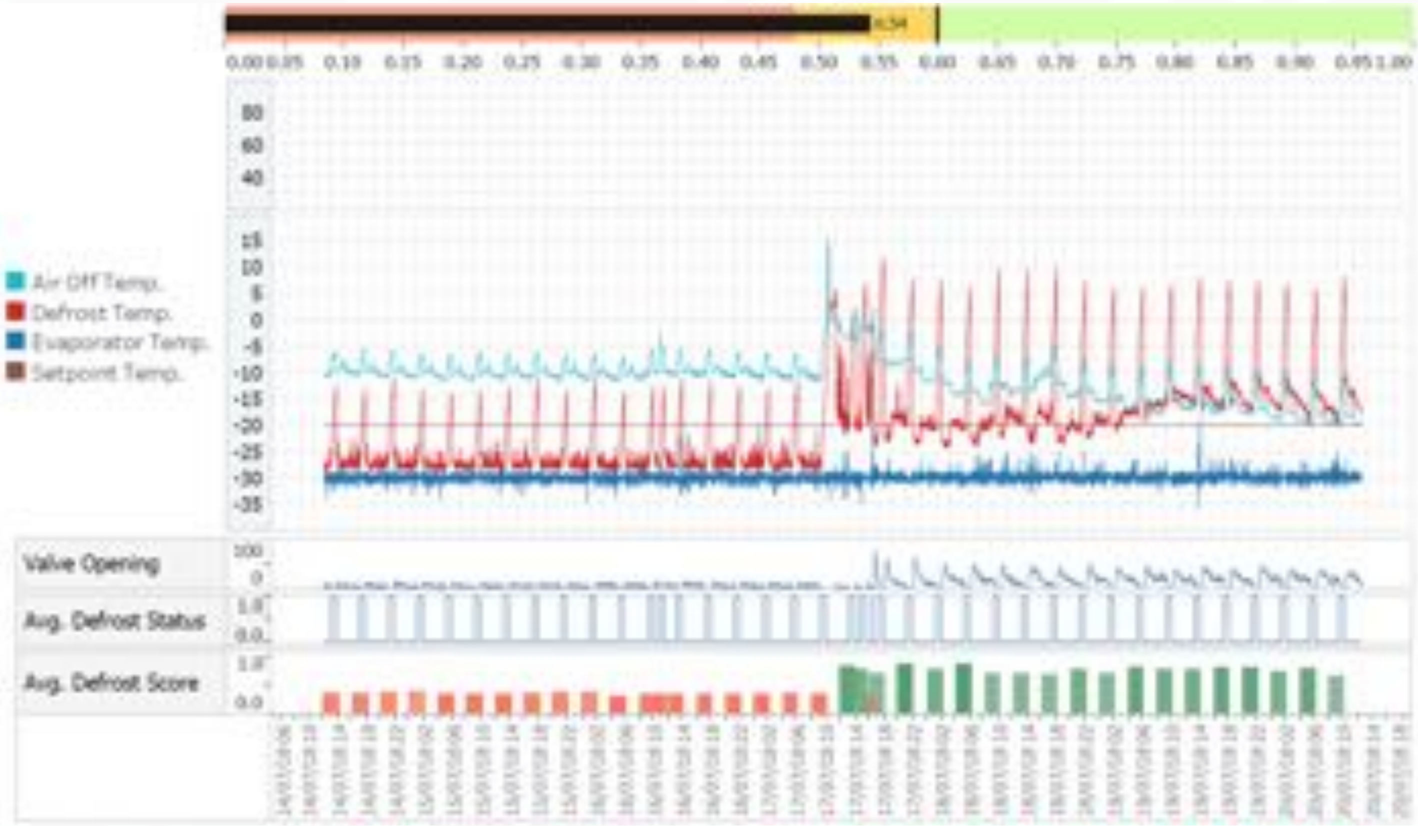
# Analytics




The defrost score indicated that there was an anomaly in the system.

The operator realized that the probe had been wrongly installed.

After relocation, the score became green. No extra maintenance needs.


- Improve evaporator efficiency
- Optimise food regulation temperature
- **Decrease risk of food waste**

# Conclusions

- DC Technology is real; applicable to HVAC and Food Retail businesses and available for a wide range of applications.
- Considerable energy saving results can be achieved.
- Further energy savings with better comfort and food preservation can be achieved by combining the Electronic Expansion Valve and advanced control algorithms.
- Precise temperature regulation for mission critical and extended food shelf-life.
- Environmentally friendly solution ready to use natural refrigerant which grants low noise level in most of the applications.
- High data availability eliminates food waste and increase the overall system reliability (less operational costs).

# Agenda

1. Applying a “Total System Efficiency” Approach – Danfoss
2. Drives for BLDC Motors – CAREL
3. **How Inverter Technology Drives Energy Efficiency in Air Conditioning Works – Daikin**
4. Medium Voltage Centrifugal Chillers – Johnson Controls
5. Fan Arrays – ebm papst
6. Connected Future - ABB
7. Moderated Discussion

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# How Inverter Technology Drives Energy Efficiency in Air Conditioning

**Utpal Joshi**

VRV DX Consulting Sales

Daikin Middle East and Africa FZE

# Agenda

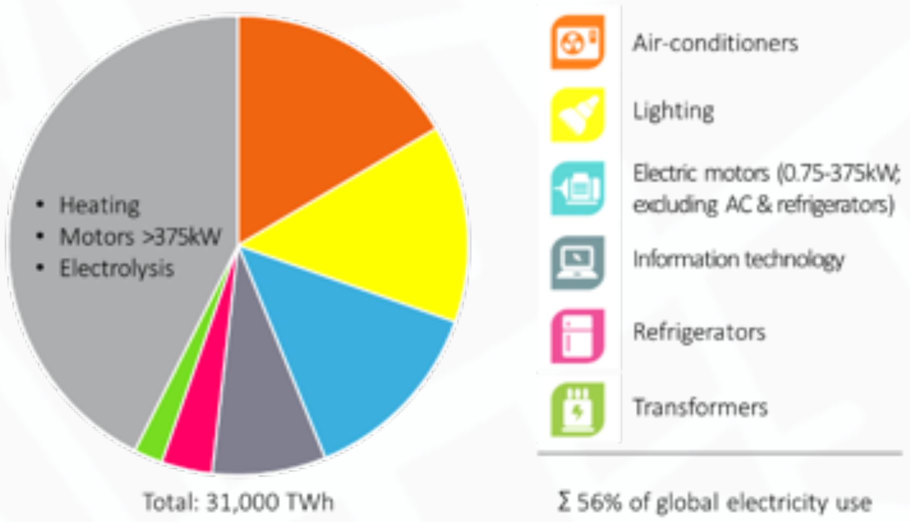
- Air Conditioning Energy Efficiency Drivers
- Inverter Effect in AC systems
- Seasonal Efficiency
- Inverter Application in AC Categories
- Conclusions

# Air Conditioning Energy Efficiency Drivers

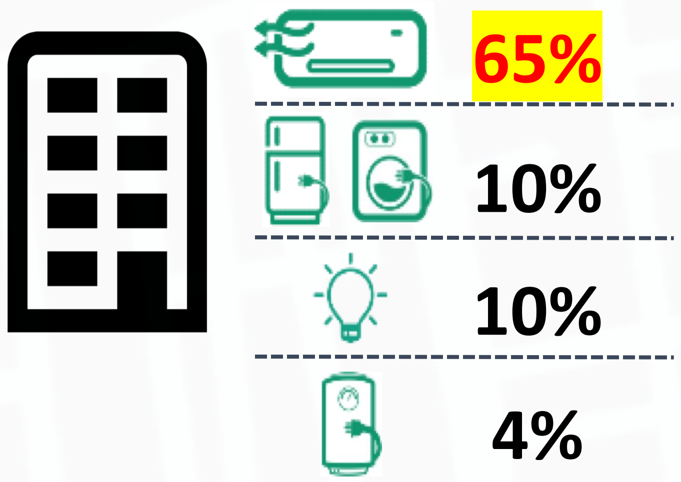
# Air Conditioning

## Actions needed to reduce Energy Consumption

**Global Electrical Consumption in Buildings**




**Electrical Consumption in Buildings in the GCC**



# Air Conditioning
## The Global Warming Cycle

**Population and Income Growth in Emerging Countries**

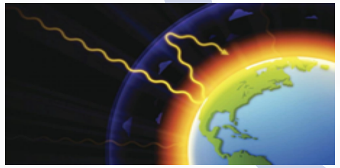
Higher Demand for Air Conditioning

**Need for Net Zero Energy Buildings**

Energy Consumption increases


**Need Higher Energy Efficiency**


$CO_2$ Emissions increases



**Need for Low GWP Refrigerants**

**Designing AC systems**

\+ Refrigerant

\+ Compressor

= unique

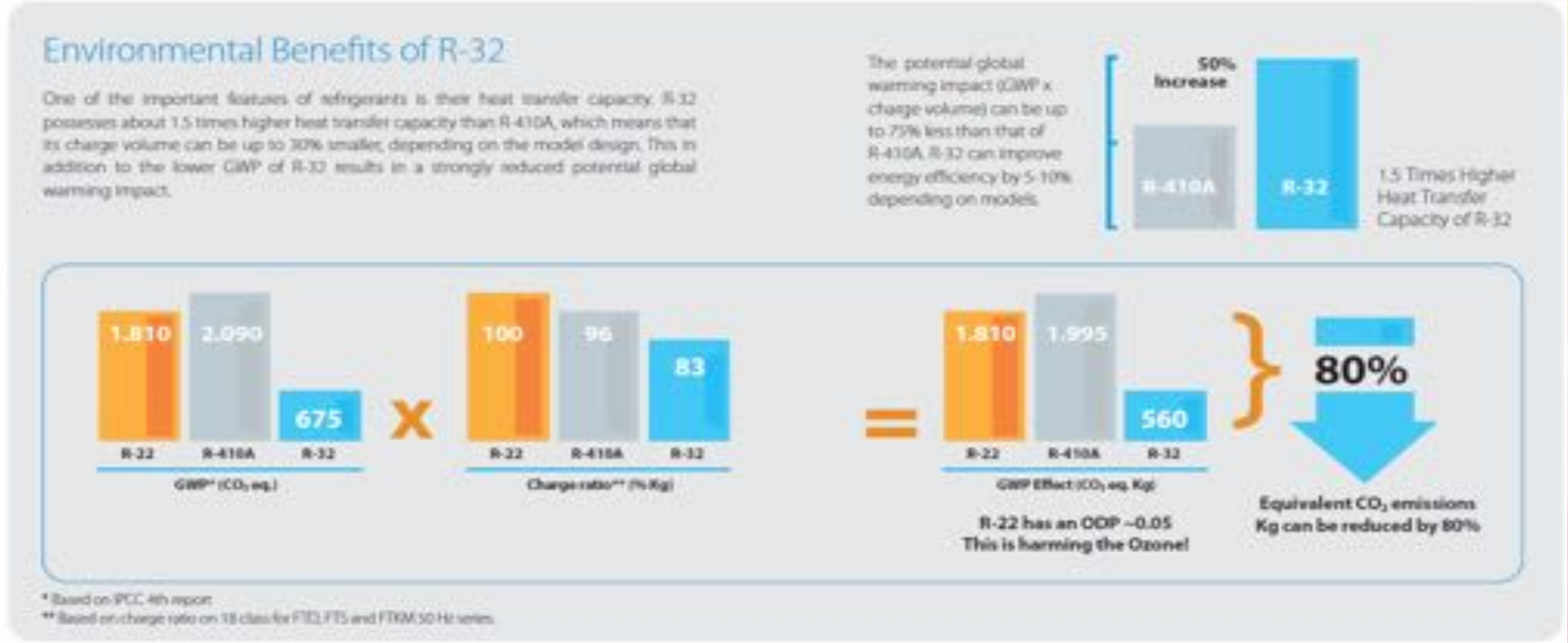
Doing all of above

**For Energy Efficient products:**

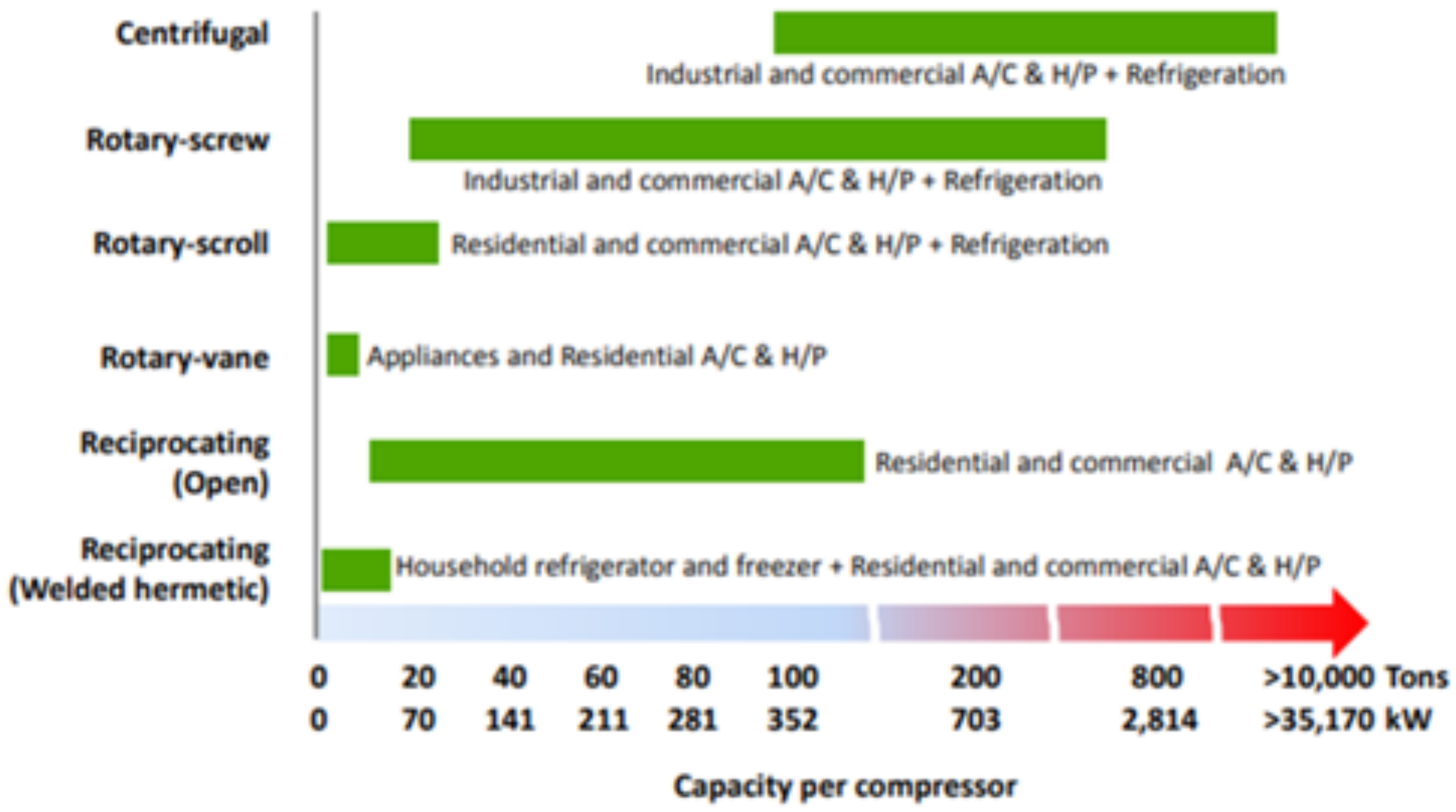
**We need to work on:**

- **Refrigerant**
- **Evap / Cond Efficiency**
- **Compressor Technology**

# Achieving the EU HFC Phase Down



# Compressors

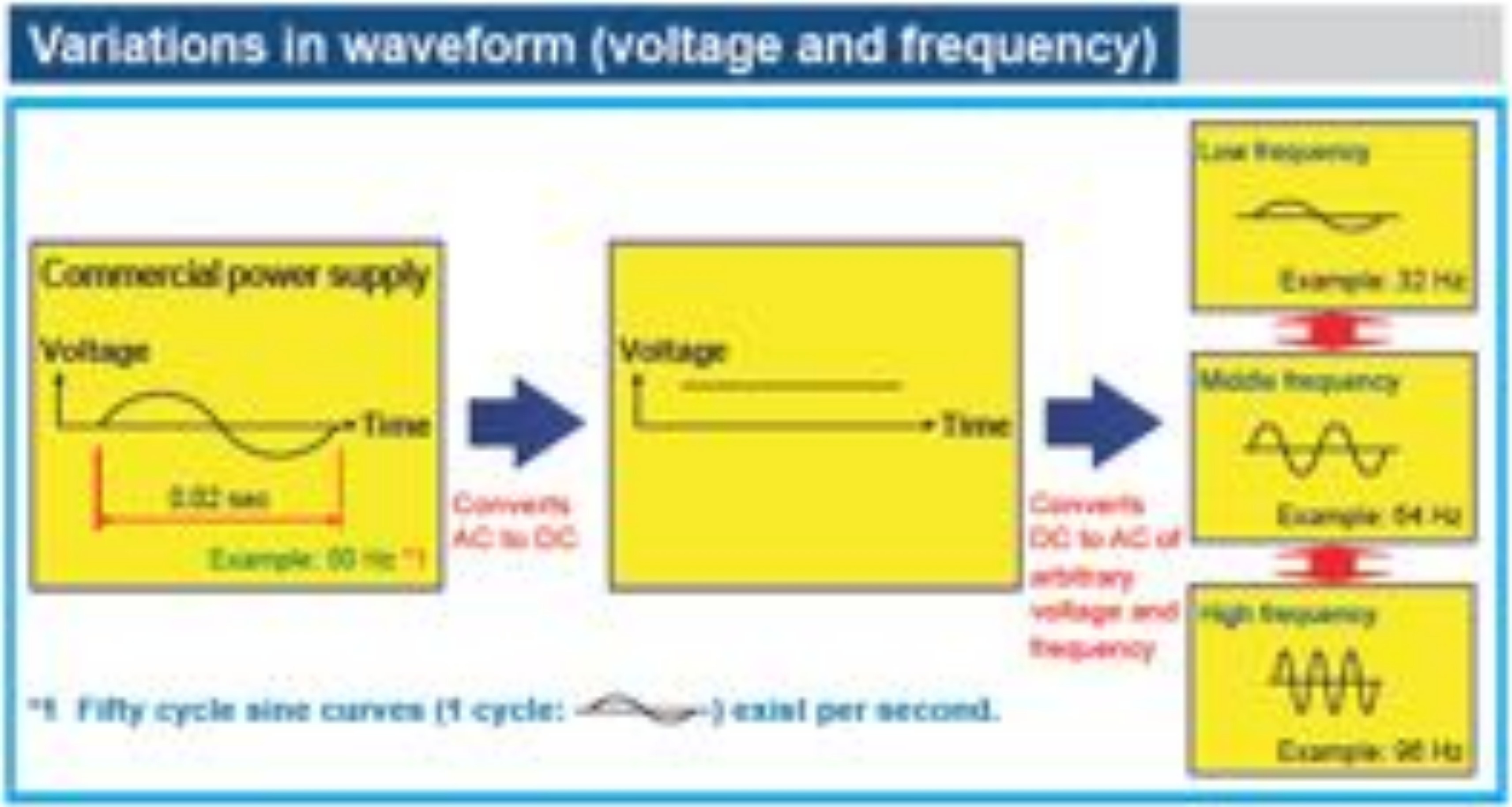




# Inverter Effect in AC Systems

# What is an "Inverter"?

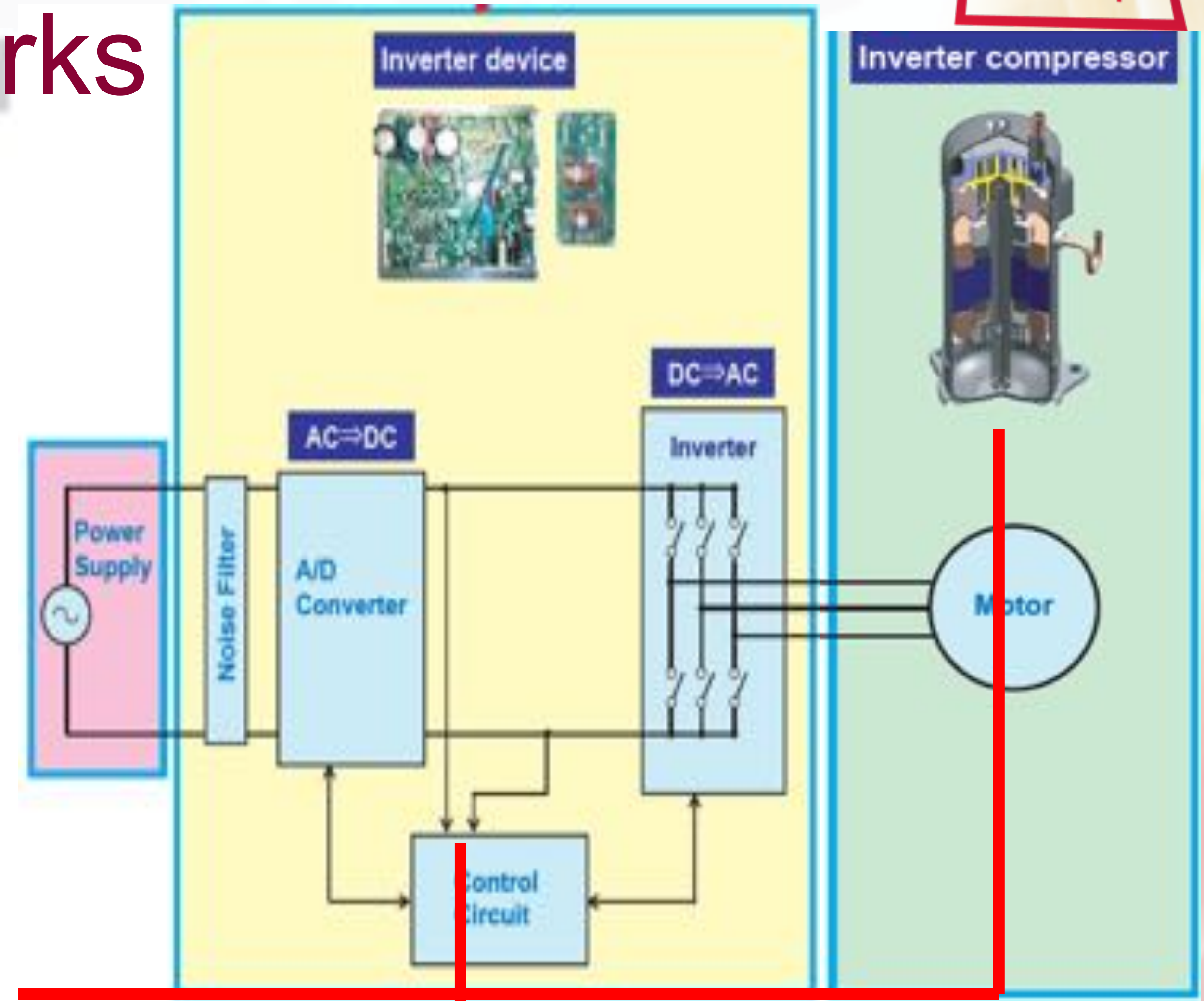
## Variable Speed/Frequency Drives



# How it works

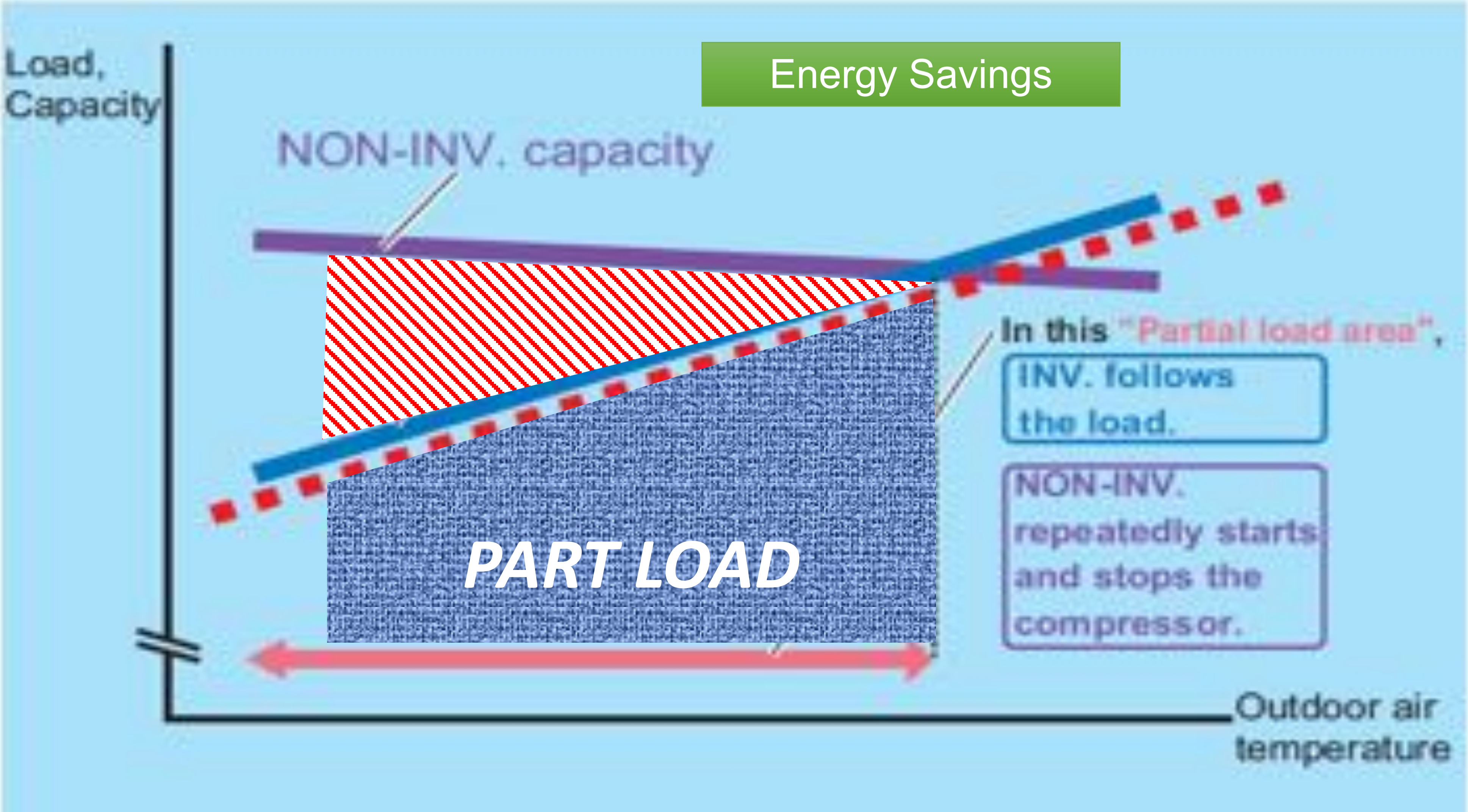
## Inverter for air conditioner

It is used in order to change the motor speed of compressors freely.



## How does the inverter work in an air-conditioner?

The inverter controls the electricity (voltage and frequency) applied to the compressor and changes revolutions, that is correlated with the air conditioning capacity.
NON-INV. applies constant electricity to the compressor; therefore capacity must be adjusted by ON-OFF operations.

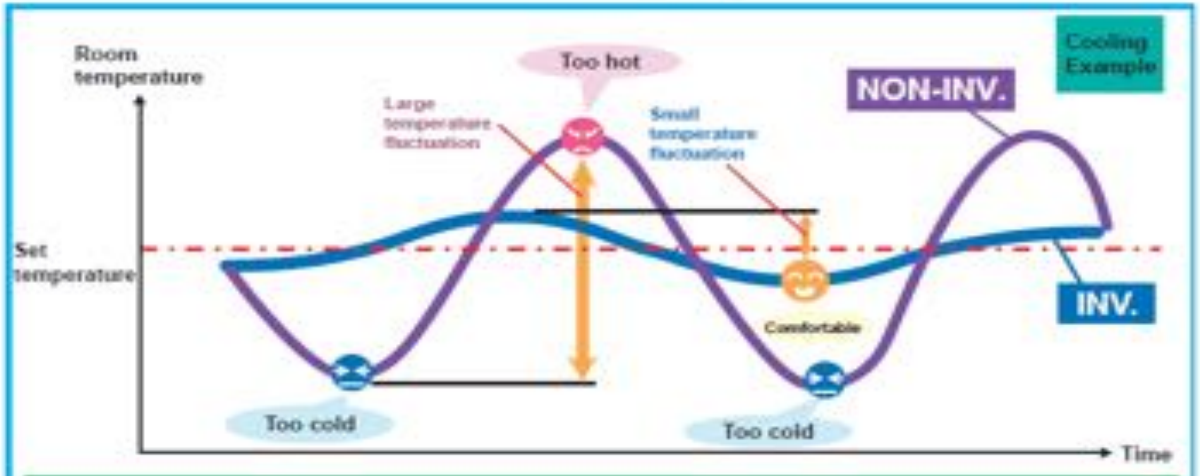

Energy Savings
Load,
Capacity
NON-INV. capacity
In this "Partial load area",
INV. follows
the load.
NON-INV.
repeatedly starts
and stops the
compressor.
PART LOAD
Outdoor air
temperature

# Inverter Benefits

"Inverter" brings mainly 3 advantages to air conditioners, such as

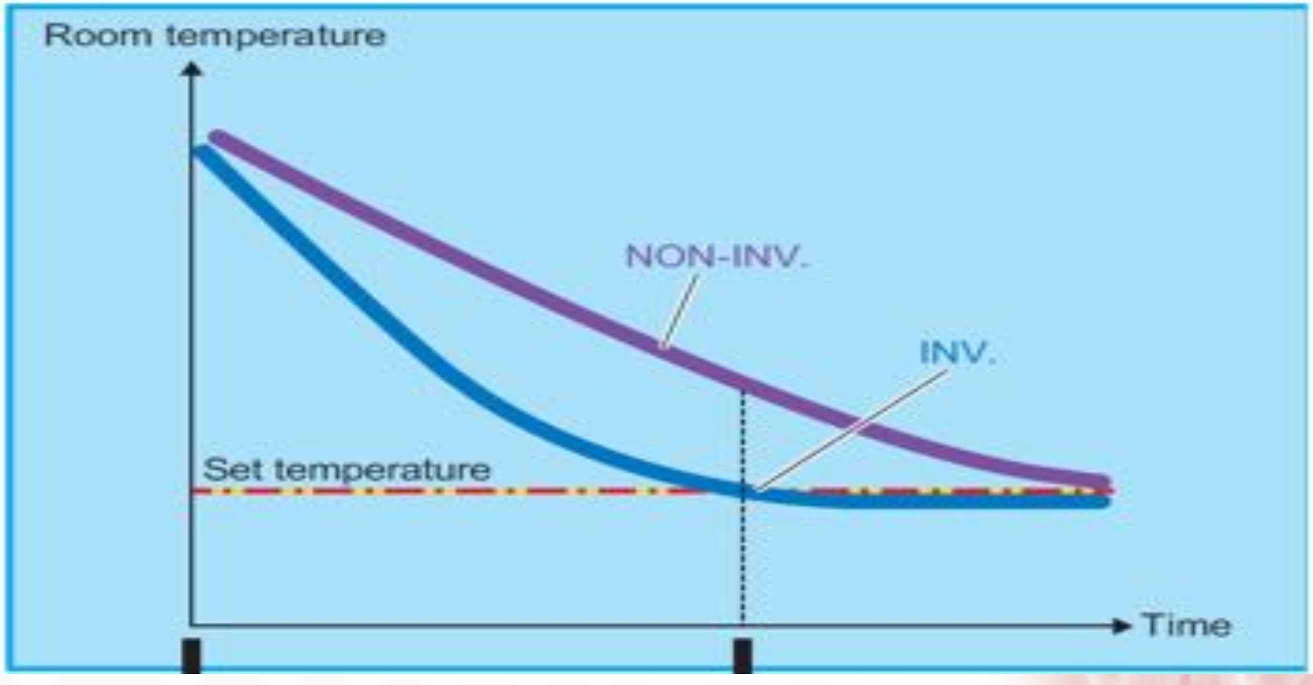
## Advantage 1: Comfort

(1) Temperature Control

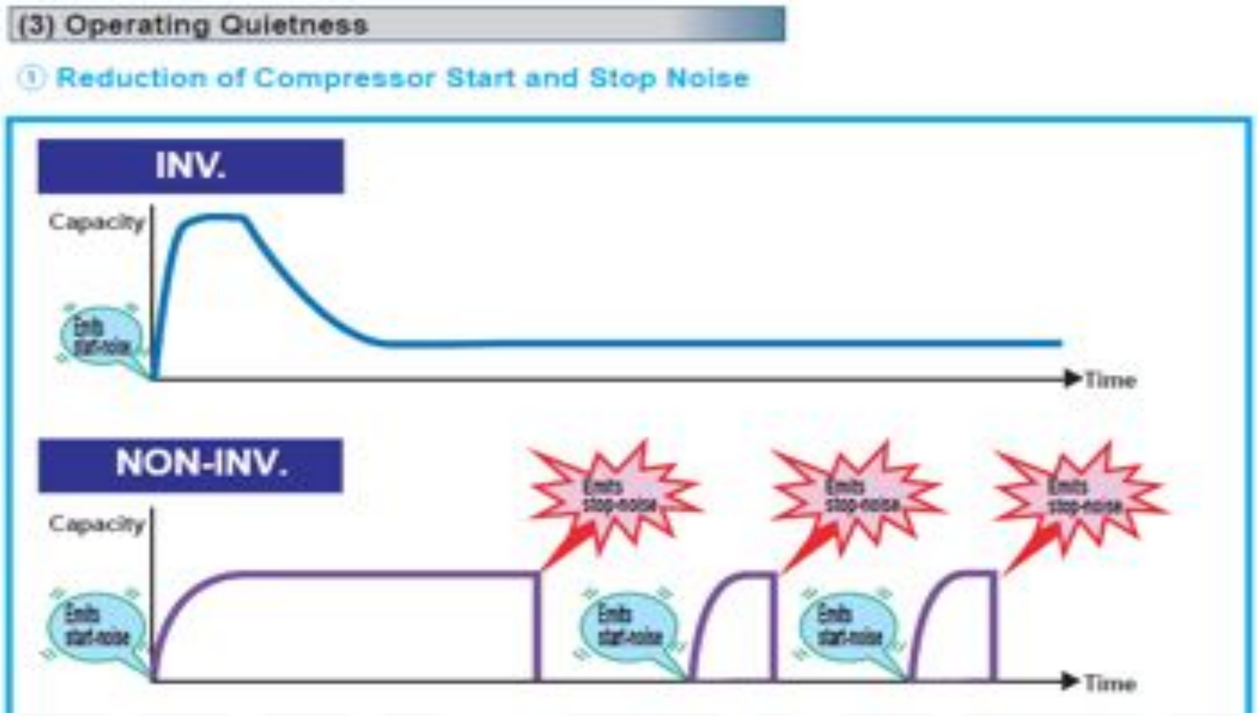


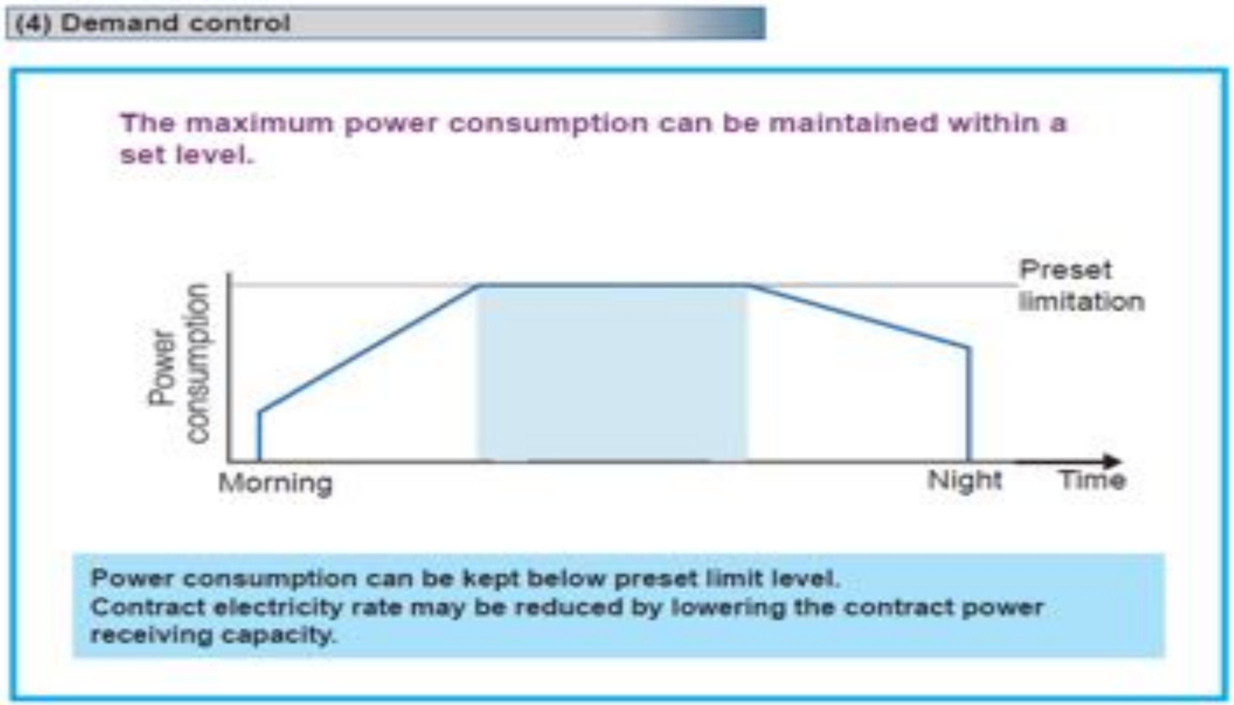

INV. follows the load, therefore, room temperature fluctuation is small.
NON-INV. repeats frequent ON-OFF operation due to load fluctuations or load mismatching, therefore, room temperature fluctuation is not small.

(2) Quick Cooling and Heating



# Inverter Advantages



# Seasonal Efficiency

# Inverter Benefits

## 2. Energy Saving

①Energy efficiency index
COP (efficiency at rated point) and APF, CSPF (annual efficiency)
Annual efficiency is becoming increasingly important.

②Efficiency throughout the year (APF, CSPF) is excellent.
Since power consumption is small at partial load, APF and CSPF are improved, leading to energy saving.

③Since ON-OFF operation is not so much required for capacity control, ON-OFF switching loss is small.

④Demand control is available for energy saving.

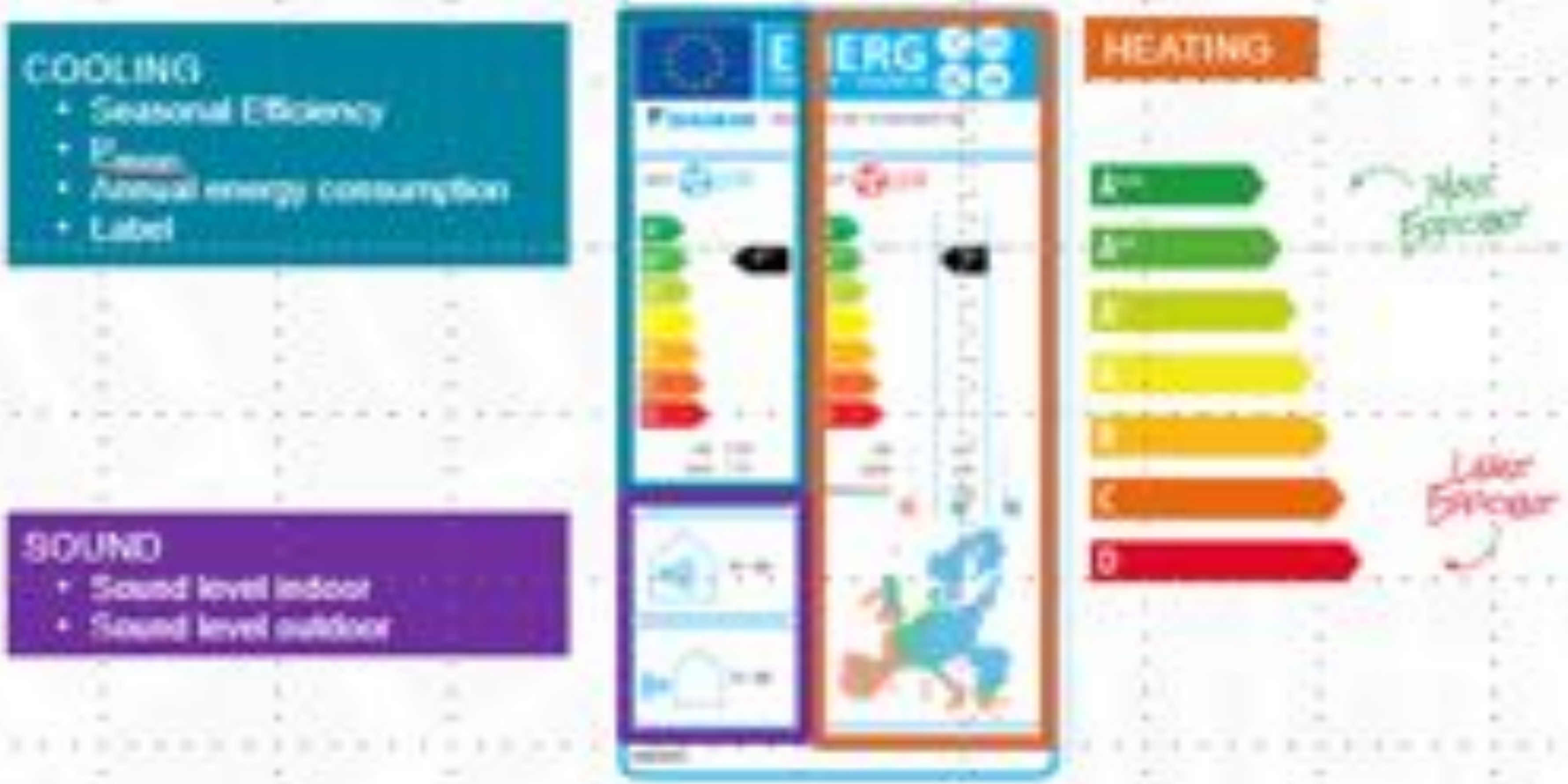

1. IN PRINCIPLE, **SEASONAL = BETTER REPRESENTATION**
2. "Bin" hours need to be adapted to reflect regional conditions

By using adapted seasonal efficiency, **big impact on:**

**– Real energy consumption (cost)**

**– $CO_2$ emissions**

# European Energy Efficiency Regulation



# UAE Energy Efficiency Regulation

## ESMA 5010-1:2018

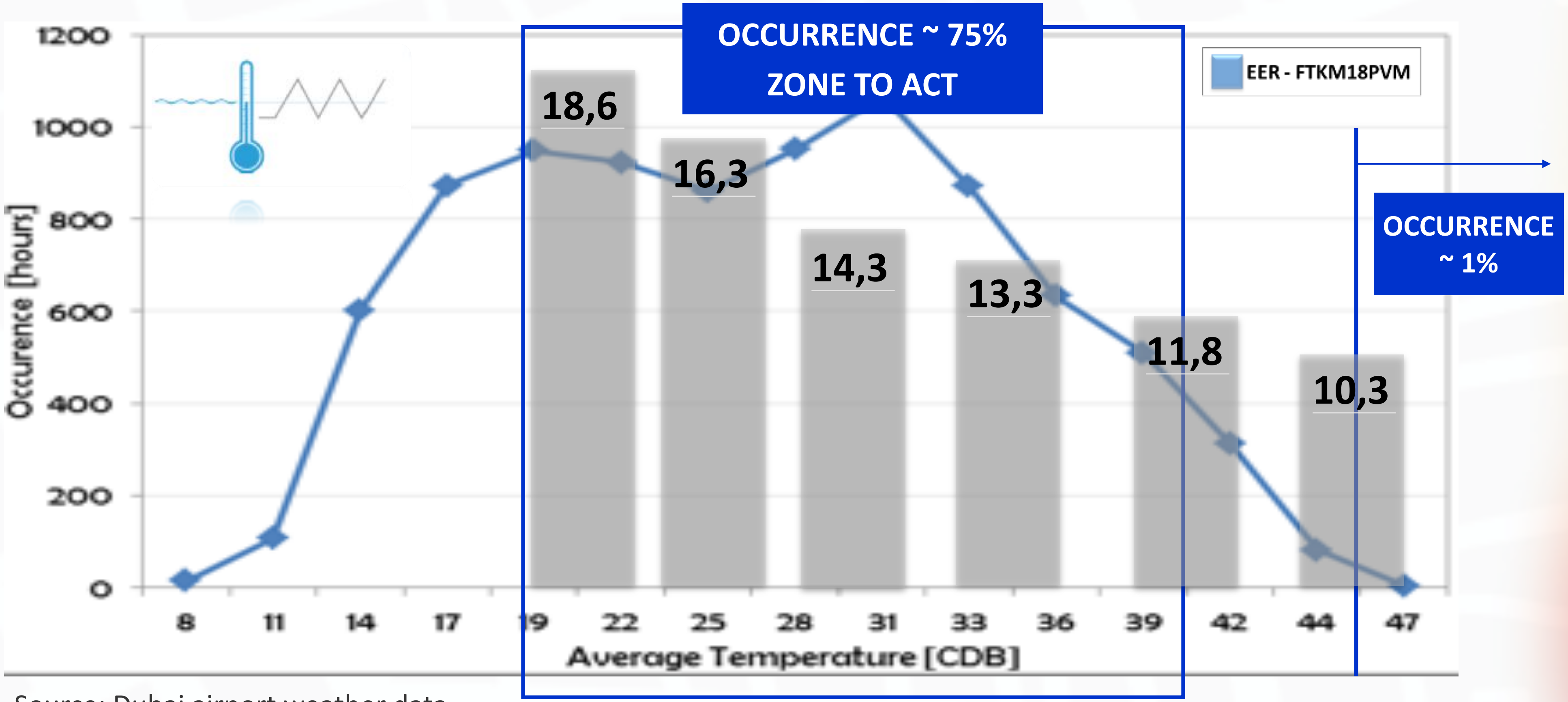
**Inverter (4*)**


**Inverter (4*)**


**Non-Inverter (4*)**


**NO Advantage to Inverter in current Labeling Scheme, all units have the 4* EER rating**

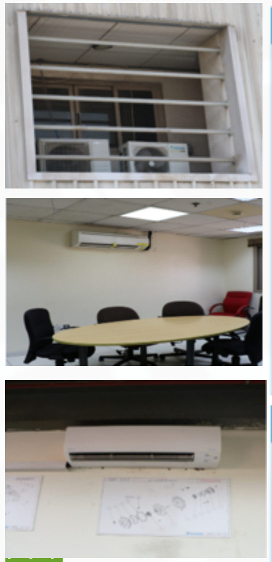
# Inverter Benefits

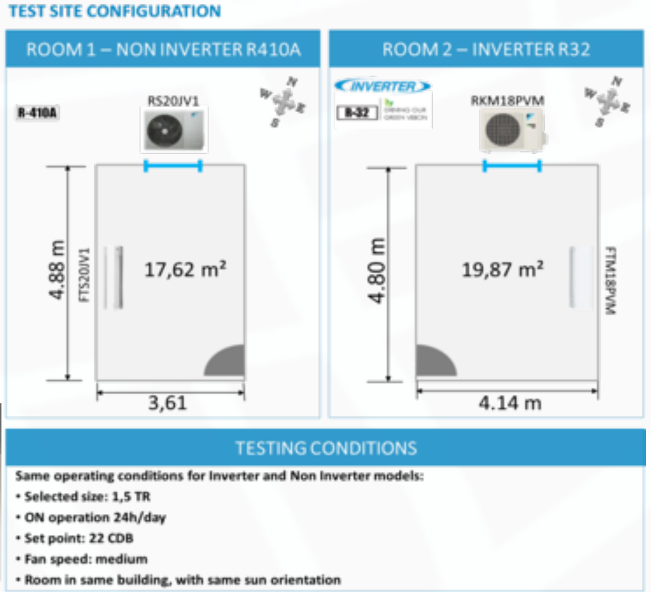



Source: Dubai airport weather data

Excellent Seasonal Efficiency in line with actual operating conditions

# Reference Projects






**ENERGY USE**
**-46%**

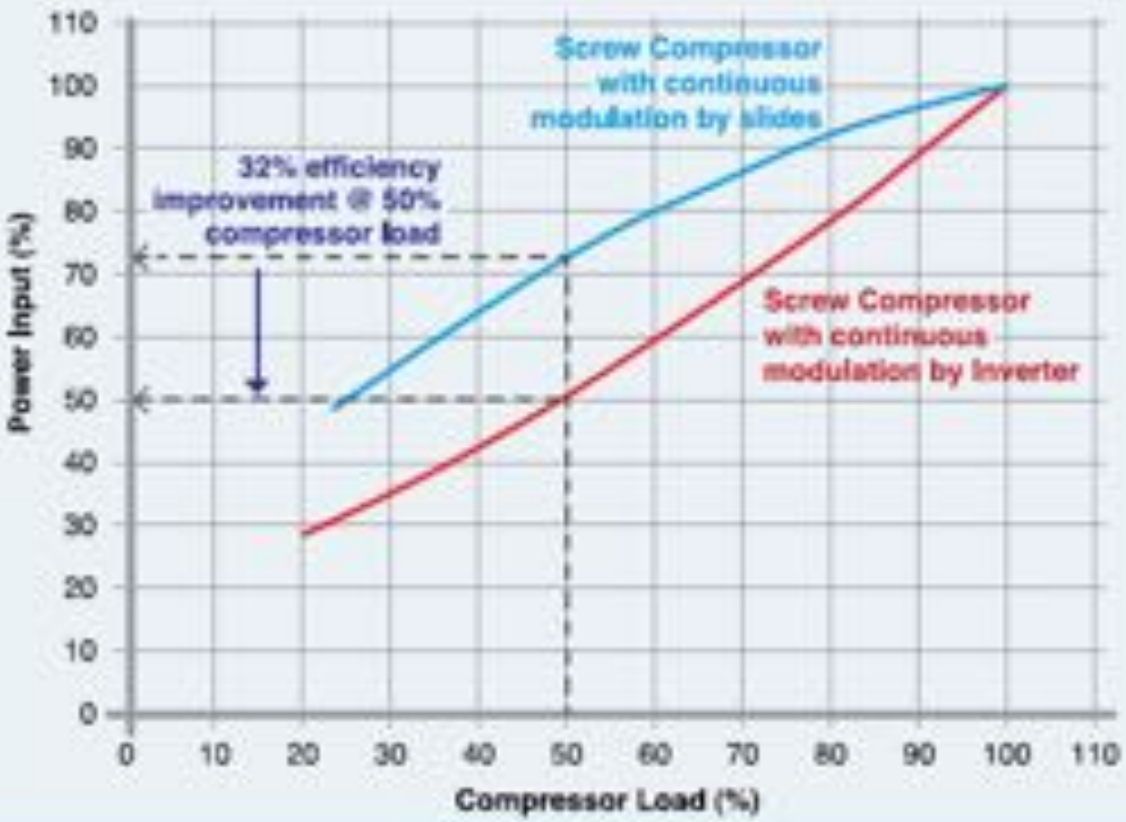


Energy Retrofit Project of the Year

Enova Facilities Management Services LLC

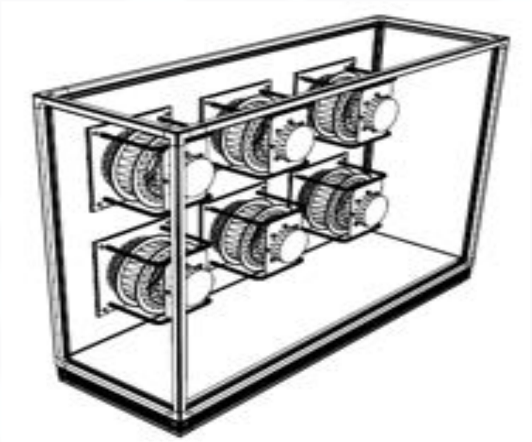
# Chiller Savings

FIGURE 7: COMPARISON COMPRESSOR EFFICIENCY

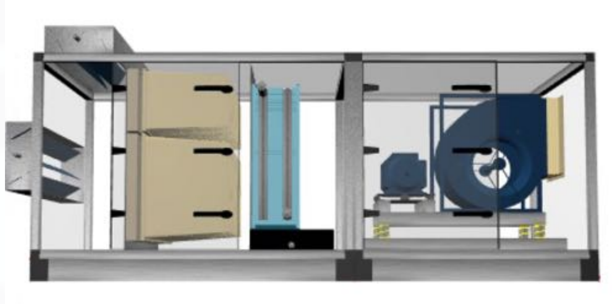



The annual energy savings that can be achieved when operating an inverter controlled appliance often quickly repay the additional investment.

# Savings in AHUs with EC fans

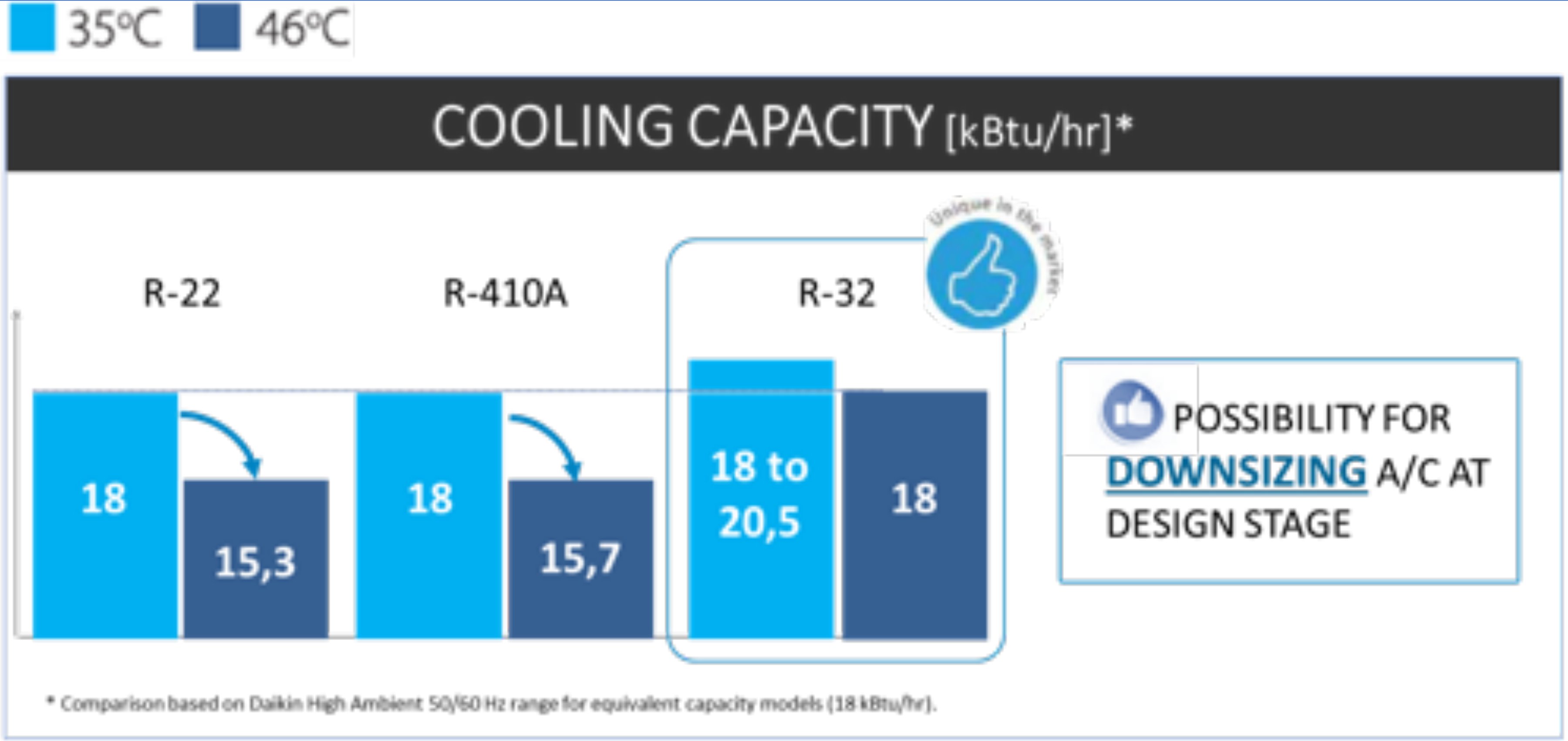


6 or 8 Fan Array Arrangement



| Air Flow | Fan Type | ESP | TSP | Power Input | % Increase in PI | Unit Dimension | | |
|---|---|---|---|---|---|---|---|---|
| m³/h | | Pa | Pa | KW | | Length (mm) | Width (mm) | Height (mm) |
| 6000 | EC Fan | 450 | 868 | 2.28 | | 2380 | 1360 | 1160 |
| | FC Fan | | | 3.16 | 39% | 2640 | 1360 | 1160 |
| | BC Fan | | | 3.01 | 32% | 2640 | 1360 | 1160 |
| | AF Fan | | | 2.65 | 16% | 2640 | 1360 | 1160 |

# Inverter Benefits




**Customise design of system around real needs**

# Inverter Benefits

## THE MAIN BENEFITS OF USING AN INVERTER

A STARTER WITH AN INVERTER HAS THREE MAIN BENEFITS:
1) MECHANICAL BENEFITS
2) ELECTRICAL BENEFITS
3) ENERGY EFFICIENCY
4) END USER BENEFITS

### 1. MECHANICAL BENEFITS

It is known that any mechanical component is subjected to maximum stress in the "starting" and "stopping" phases, which, for that matter, often involve non-ideal conditions of lubrication of the moving components.

FIGURE 2: MECHANICAL COMPONENTS IN A MOTOR, AND/OR COMPRESSOR, AFFECTED BY LUBRICATION CONDITIONS

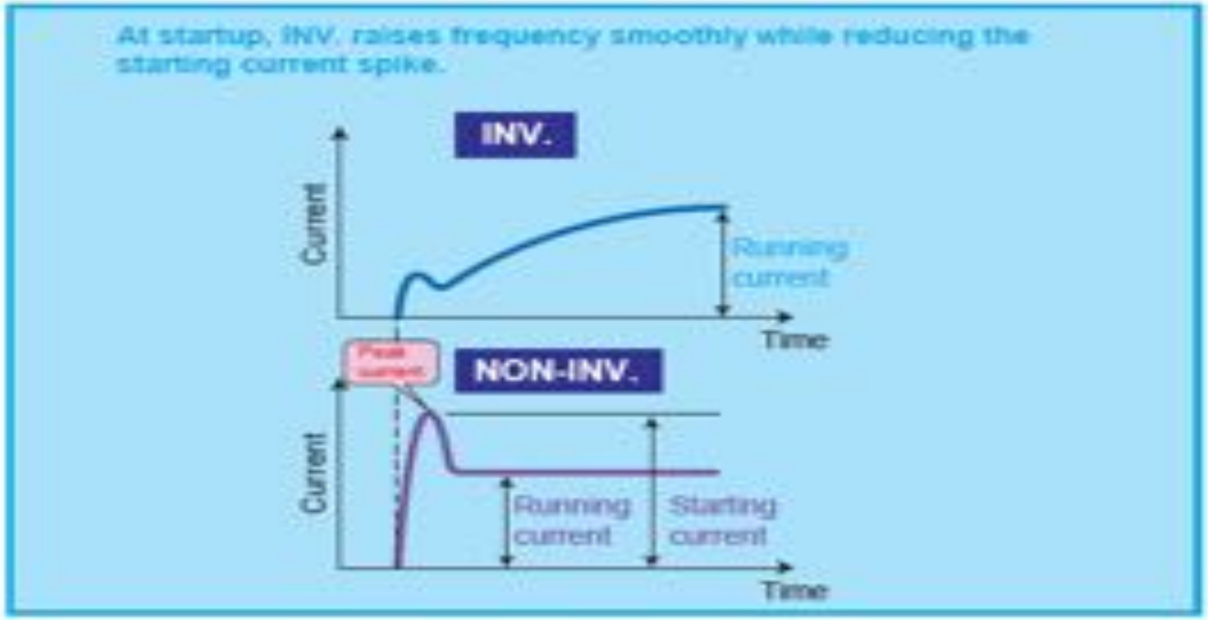
A mechanical component is subjected to maximum stress in the 'starting' and 'stopping' phases, especially in non-ideal conditions requiring lubrication of the moving components.

### 2. ELECTRICAL BENEFITS

The electrical benefits of using an inverter are in three categories:

a) Starting current is minimised
b) High value of the motor power factor
c) Reduction of total power absorbed in kVA at full load.

(2) INV. generates a little inrush peak current.



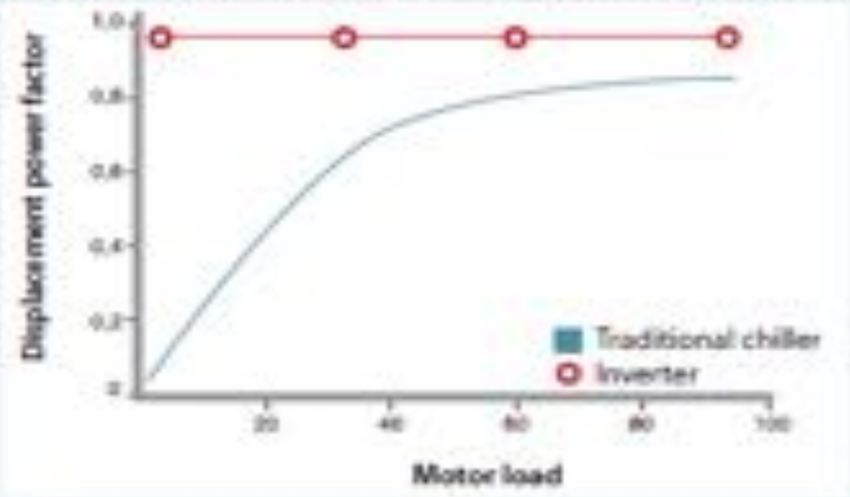
# Inverter Benefits

## 2. ELECTRICAL BENEFITS

The electrical benefits of using an inverter are in three categories:

a) Starting current is minimised
b) High value of the motor power factor
c) Reduction of total power absorbed in kVA at full load.

FIGURE 4: COMPARISON OF THE POWER FACTOR BETWEEN A MOTOR WITH AND A MOTOR WITHOUT AN INVERTER (400 V)



# Inverter Benefits

Example

For a refrigerator of approximately 1,310KW, assuming a maximum voltage loss of 5% compared with the nominal 400V and a distance of about 100m between the refrigerator's power panel and the Low Voltage cabin:

- The unit without an inverter would require three conductors, each with a section of 300 $mm^2$
- The unit with an inverter would require three conductors with a section of 240 $mm^2$

Choosing a unit with an inverter would deliver a saving of around 20% on the electrical installation costs of the refrigerator.

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# Inverter Application in Airconditioning Categories

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INVERTER

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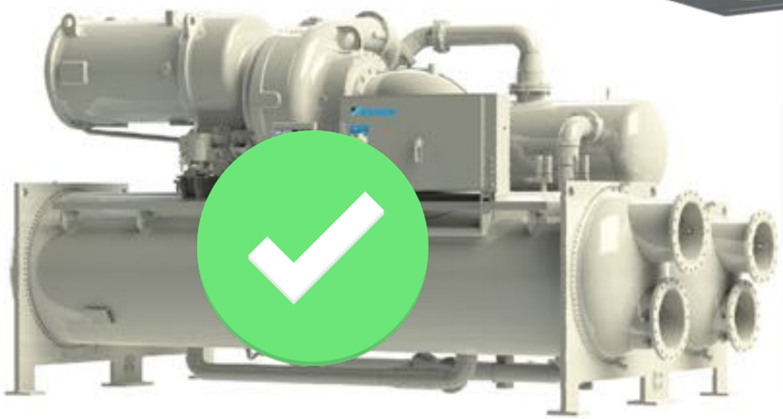
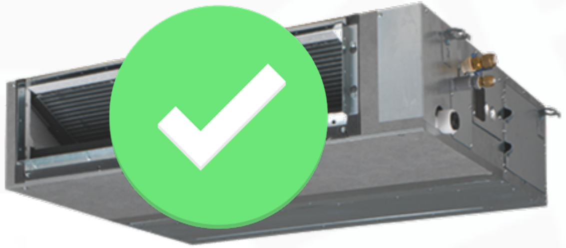


Chillers



FCUs

VRVs

AHUs

Split AC

Residential air conditioners: Ductless air conditioners other than window and portable type products. Only in North America does the category include duct-type air conditioners for residential use.
Source: Compiled by Daikin based on data from the Japan Refrigeration and AC Industries Association

# Inverter Products:
## The new era of smart comfort

# Thank You

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# Agenda

1. Applying a “Total System Efficiency” Approach – Danfoss
2. Drives for BLDC Motors – CAREL
3. How Inverter Technology Drives Energy Efficiency in Air Conditioning Works – Daikin
4. **Medium Voltage Centrifugal Chillers – Johnson Controls**
5. Fan Arrays – ebm papst
6. Connected Future - ABB
7. Moderated Discussion

# Engineered Solutions to Enhance “Real World” Performance: Medium Voltage Centrifugal Chillers

**Deepak Bhat**
Manager - Large Tonnage Chillers Sales (GCC)
Johnson Controls

# Chillers consume the most energy for buildings cooling, and solutions are in place to lower their total cost of ownership

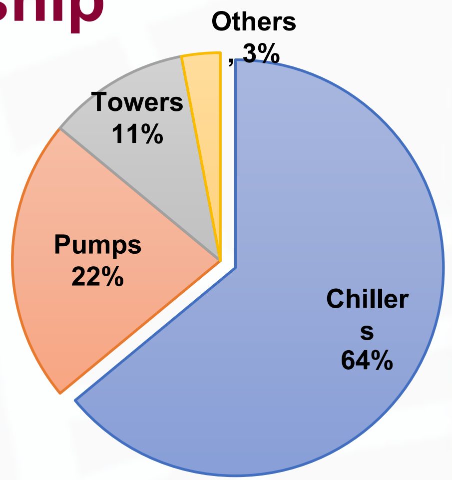
**Objective**:

Lower the chiller energy consumption

**Facts**:

- Chillers are designed for extreme weather conditions. Operations at off-design conditions are **not optimal**
- Chillers spend **over 99%** of operation in off-design conditions. Simultaneous occurrence of 100% load & design outdoor conditions is very unlikely
- Compressor, running at constant speed, drives the chiller energy usage

**Total Chiller Plant Energy Use**




**Solution**:

Operate compressor at lower speed, whenever possible, to reduce chiller energy usage

**Variable Speed Drives ensures correct compressor motor speed for the actual operation**

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# Tackling Myths

Typical assumptions in DC Plants vs. Realities

- MV Variable Speed Drives are expensive, with un-attractive payback
- District Cooling Plants always operate at Full Load Conditions
- Use for Thermal Storage means the chillers will always be operating at full design load
- Chillers must be evaluated for Full Load Efficiency at “Design” Conditions

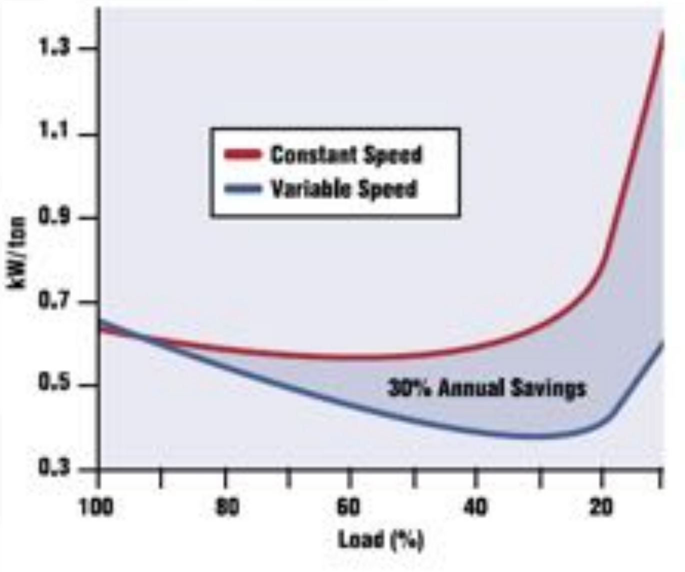

- MV-VSD costs and size, both have reduced with improved technology and its time to evaluate the payback
- DCP’s seldom see full Delta Temperature, As such, chillers are loaded between 60% and 80%
- Limited by the low Delta Temp, Thermal Storage Tank is always charged at off peak conditions and hence at low WB temp it will benefit most with VSD technology
- “Real” World conditions will always see reduced ECWT’s and lower loads. Off design performance of Chillers is critical

# MV – VSD: Tech

Medium Voltage Variable Speed Drives

# MV VSD is a Medium voltage drive that regulates the speed and torque in constant speed chiller by varying motor input frequency and voltage

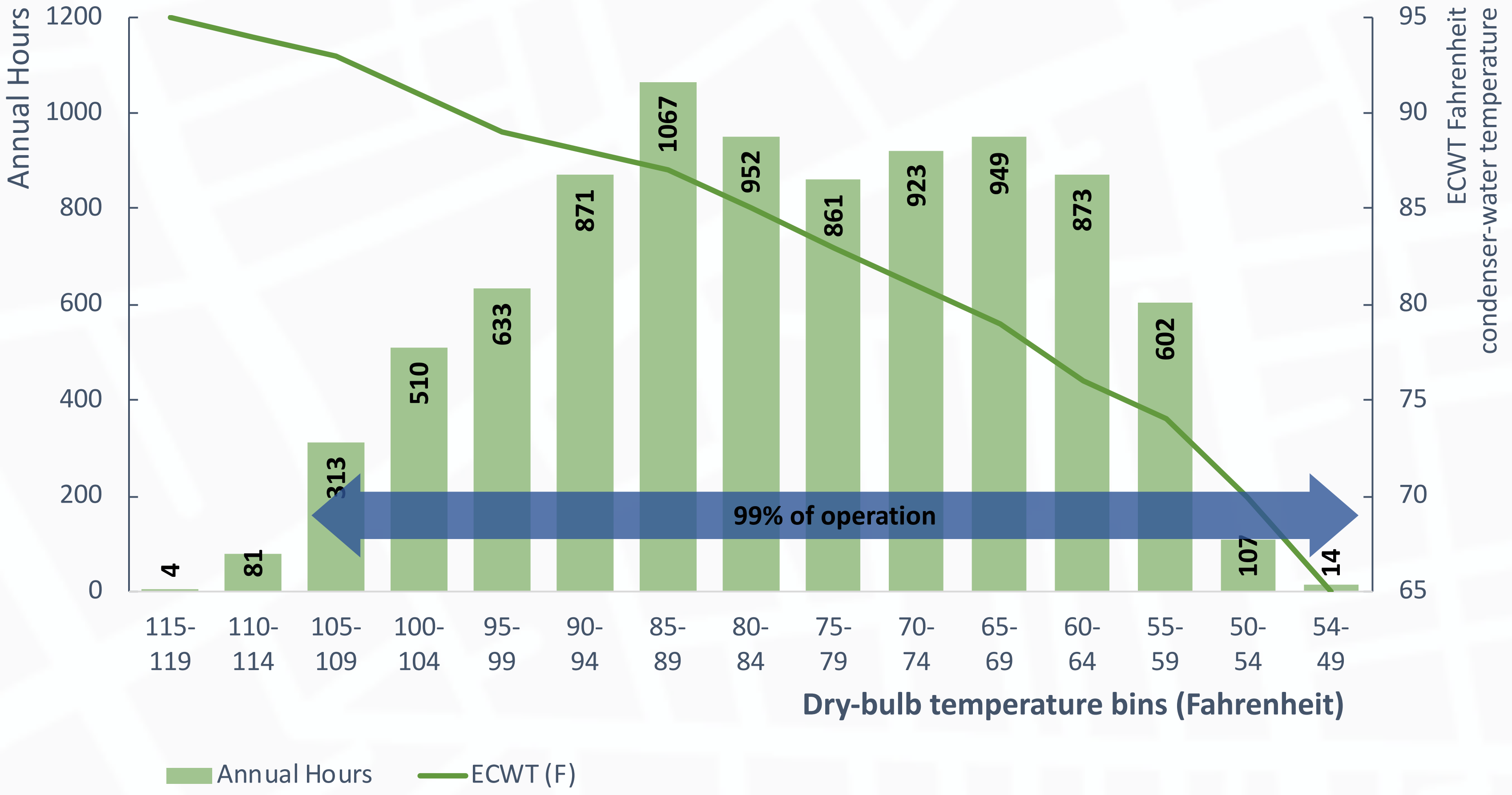
Typical chiller energy curve




- **VSD Advantages**
  - Superior energy efficiency (up to 30% annual savings)
  - Lowers electricity demand / costs / bills
  - VSD provides soft start with zero inrush current
  - Eliminates compressor starting thermal and electrical stress
  - Improved power factor (better use of power)
  - Rapid payback (as little as 2 to 3 years)
  - Longer equipment life
  - Lower noise levels

- **Kw/ton can reduce noticeably with variable speed chillers**

# Less than 1% of chiller run hours are at design conditions

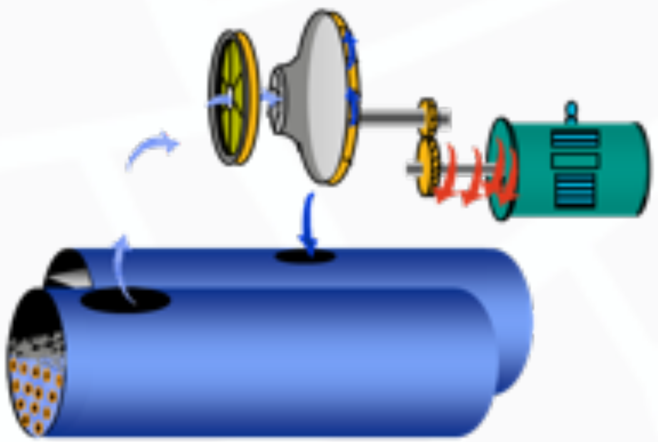



- **General Weather Pattern in the Gulf and chillers operating hours**

For centrifugal chiller, the variable speed allows for slowing the motor in off-design conditions to save energy

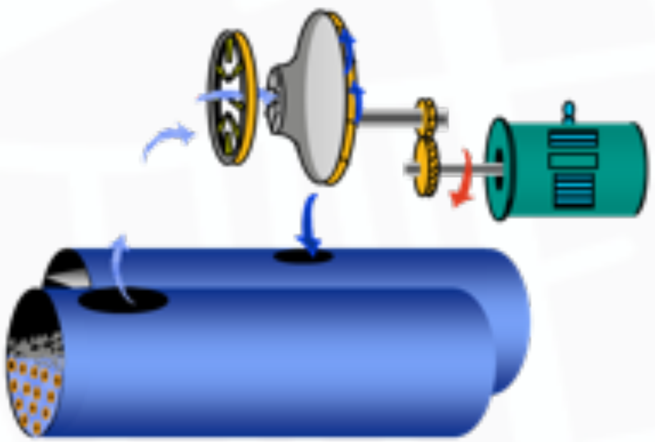
Difference between constant speed and variable speed in off-design conditions

**Constant Speed**



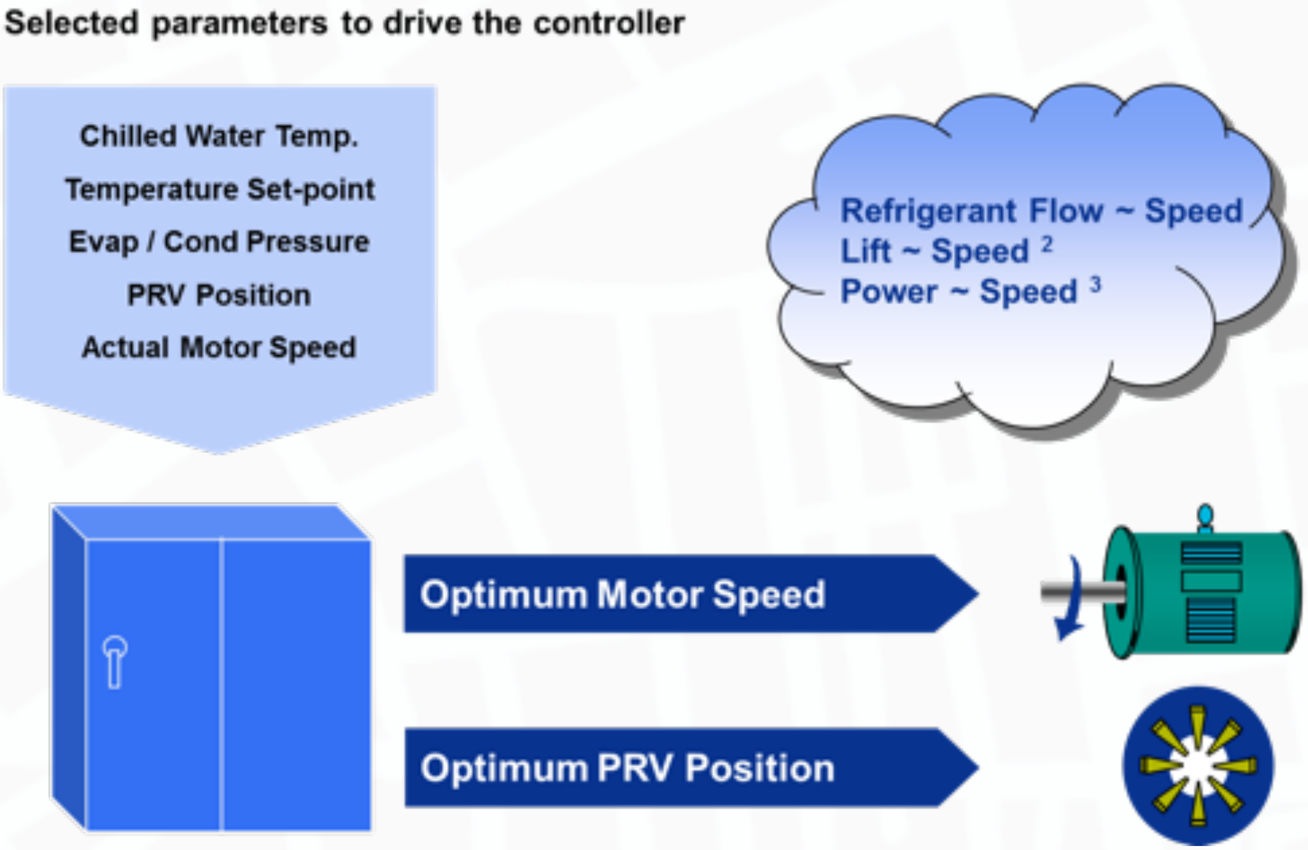
- At lower load, not possible to slow down the compressor motor, which runs at full
- Pressure relief valve (PRV) will close more to restrict air flow, driving energy loss

**Variable Speed**



- VSD will enable slowing down the motor at lower loads reducing energy use
- Pre rotation guide vanes (PRV) allows optimize operation in combination with the VSD

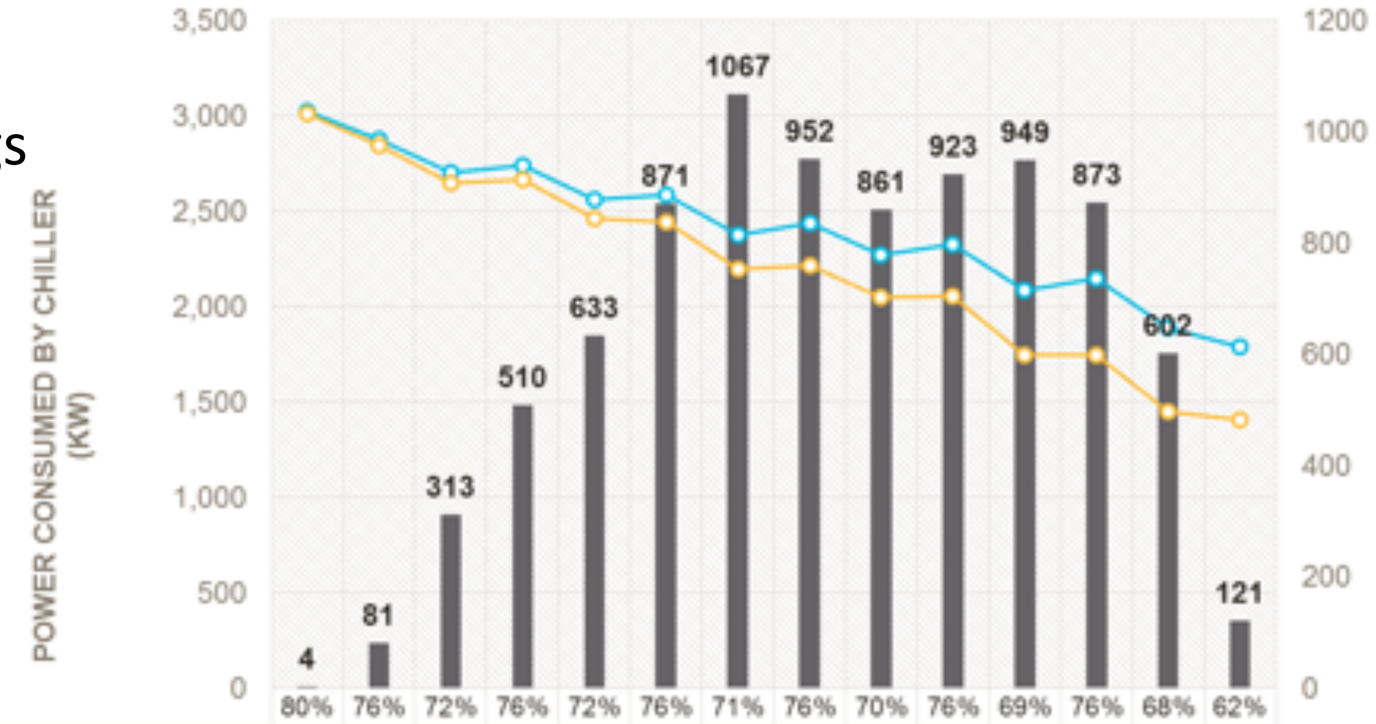
# The VSD controller decides the optimum operation of the chiller based on several input parameters that are acquired from the chiller



# The VSD controller decides the optimum operation of the chiller based on several input parameters that are acquired from the chiller

Power Consumed ~ (Speed)$^3$

80% speed ~ 50% power savings




| | 80% | 76% | 72% | 76% | 72% | 76% | 71% | 76% | 70% | 76% | 69% | 76% | 68% | 62% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of Hours | 4 | 81 | 313 | 510 | 633 | 871 | 1067 | 952 | 861 | 923 | 949 | 873 | 602 | 121 |
| YK-EP (High Efficiency - Constant Speed) | 3,027 | 2,878 | 2,702 | 2,743 | 2,560 | 2,585 | 2,375 | 2,439 | 2,272 | 2,324 | 2,083 | 2,148 | 1,891 | 1,790 |
| YK-EP (High Efficiency - Variable Speed) | 3,012 | 2,846 | 2,646 | 2,664 | 2,461 | 2,441 | 2,196 | 2,217 | 2,050 | 2,054 | 1,748 | 1,748 | 1,453 | 1,408 |
| | | | | | | | | | | | | | | |

Up to 30% Reduction in Annual Energy Consumption!

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# Socio-environmental Impact

**Dubai Integrated Energy Strategy 2030**


**Use of VSD's will reduce 260 MW-hr per year**

**Dubai clean Energy Strategy 2050**

**Use of VSD's will reduce 160 Million kgs of $CO_2$ Emissions per year**

**Demand Side Management Strategy 2030**


**VSD's maintain > 0.95 PF at all loads**

- MV VSD’s on Centrifugal Chillers is now tested and proven
- This is a definite direction to partner with the end user to save on your energy cost and reduce your carbon footprint.

**Thank You.**

# Thank You

# Moderated Discussion

**Markus Lattner**
Managing Director
Eurovent Middle East

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# Workshop Partners

ABB

CAREL

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ENGINEERING TOMORROW Danfoss

ebmpapst

The engineer's choice

Johnson Controls

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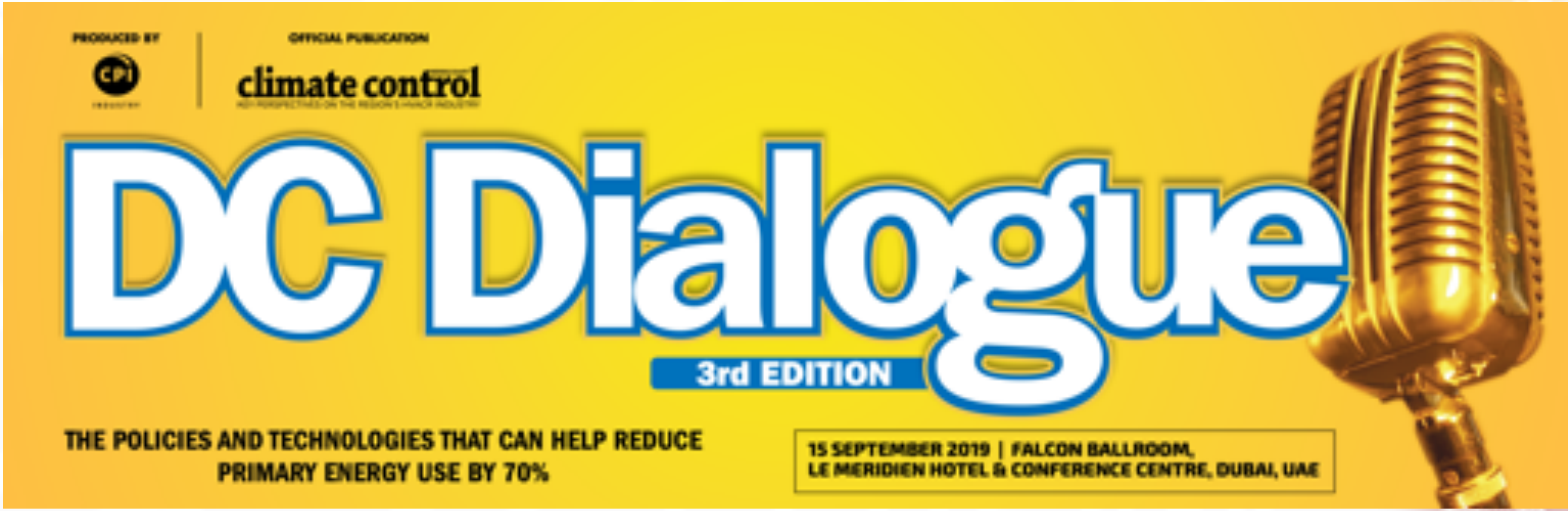
climate control MIDDLE EAST
KEY PERSPECTIVES ON THE REGION'S HVACR INDUSTRY



# Hotel Partner

Le MERIDIEN

# Thank you!