

ENGINEERING
TOMORROW



How to future-proof **HVAC systems** to meet **efficiency** and **carbon emission goals**

Part III: Specific solutions that Danfoss has to fit with these trends

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Variable-speed technology

The HVAC market is rapidly changing

Variable Speed - A quantum leap in energy efficiency



Inverter (VFD) technology is the most energy efficient technology.

It is currently revolutionizing the way air conditioning systems are being designed and built to meet Global climate control needs

While variable-speed technology can be applied to both compressors and fans, we are going to focus more on compressors. Variable-speed technology has offered a quantum leap in energy efficiency. Danfoss has implemented it into our variable-speed, oil-based inverter scrolls and oil-based centrifugal compressors—the key thing is inverters provide variable energy to meet the demands of each building as they are designed. Several benefits offered by variable-speed and inverter scroll technology include great building energy efficiency, reduced energy consumption, lower overall running costs, reduced electricity bills, lower inrush currents, and increased component process.

Variable Speed Benefits

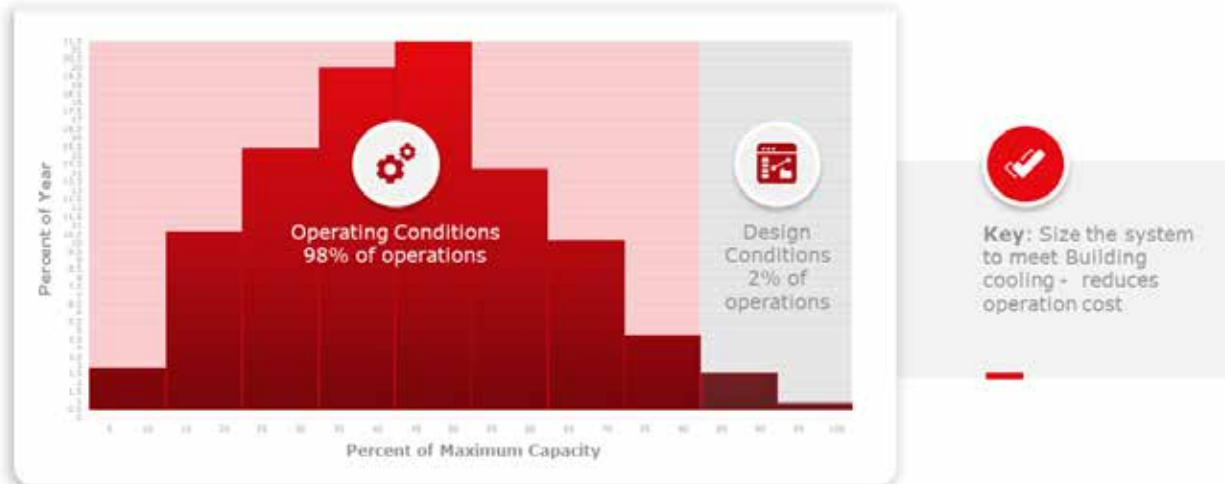


- **Markets** Avoid system oversizing, reduce electricity bill and inrush current, increased comfort and process are some key drivers
- **Additional opportunities:** Energy efficient buildings, reduced energy consumption and lower running costs.

Looking at a building profile. Most buildings today are designed for peak loads which they operate at less than 5% of the time. While it is important to meet those max conditions, we must also consider the overall operating conditions of the building. Capacity modulations attenuates the power of demand peaks which also contributes to increasing grid reliability and power supply quality. Variable-speed compressors also match the power input with the cooling capacity. The unit copes with this activity with changes in temperature and runs a partial load, which can represent a 30% reduction in annual energy bills compared to a fixed-speed or mechanically modulated compressors. Stable temperature control also secures the process in an optimum way, providing better comfort.

Typical **Building Load** Profile

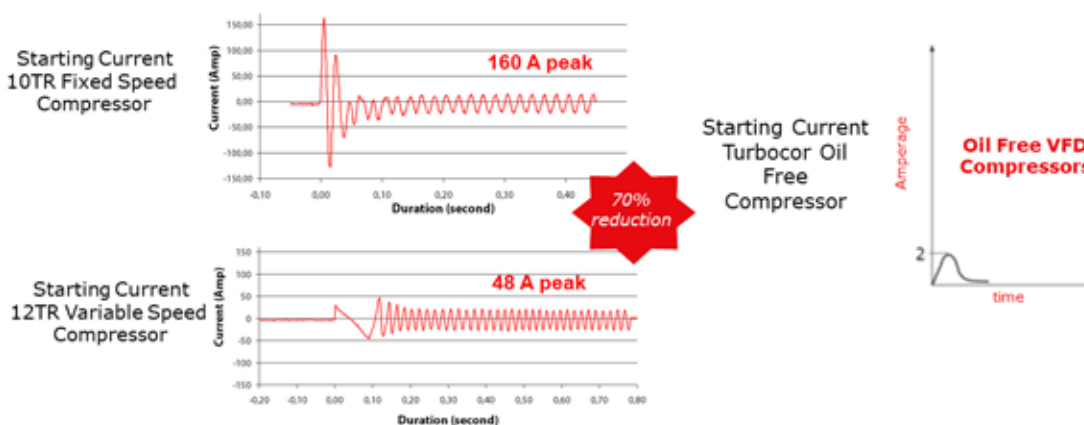
Small percentage of HVAC operation at full load



In the last few years, we have seen a significant change in the commitments of individual states to integrate renewables into their power grid. Just last year, we had a number of states commit to have around 100% of their energy come from renewable sources as early as 2030. That only matters if the reality of what is being implemented reflects the policy of what is being planned.

Near zero in-rush current

Reduced Demand on Power Grid



In comparison, the starting amps on a fixed-speed compressor is reduced through variable-speed by up to 70%. The Danfoss Turbocor compressor offers a very lower inrush current of less than 2 amps at startup. Soft starting compressors avoid torque surges, preventing hard mechanical stresses which results in lower service costs and decreased wear. This lower inrush current also helps saving fixed costs charged by utilities, peak confirmed calculations, and reduces main and powered backup loads.

One aspect of demand response is that variable-speed compressors offer additional bands by reducing the load on the grid and varying the speed that meets the cooling demand. The challenge today is encouraging utilities to offer incentives for variable-speed technology and demand reduction.

Demand Response Capability



Integrating demand response capabilities assures that your building's energy performance is fully **optimized** and **monetized**.

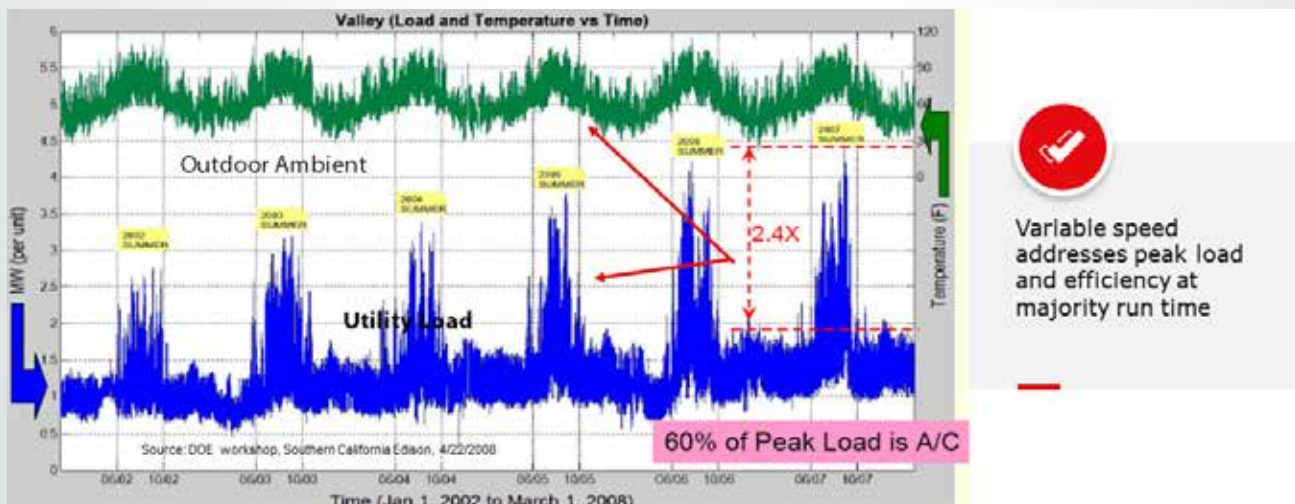
- Danfoss Compressors offer the fastest Compressor Restart Time after power outage
- Through the use of variable speed compressors the load on the grid will vary based on the demand

Encouragement for utilities to offer incentives that reward energy-conserving technologies such as variable speed compressors to reduce demand on the grid

In the chart below, the power grid shows the utility demand over several years where 60% of the peak load is consumed by the HVAC system. A variable-speed compressor offers a maximum demand load reduction which also increases the overall EER. Variable-speed also offers the highest energy savings available where the chiller operates most of the time in the lower 30–80% of the range. Key benefits of avoiding oversizing a system include reduced electricity bills, lower inrush current, and increased comfort and process.

Power Grid Benefits

50-60% of commercial building power is for AC

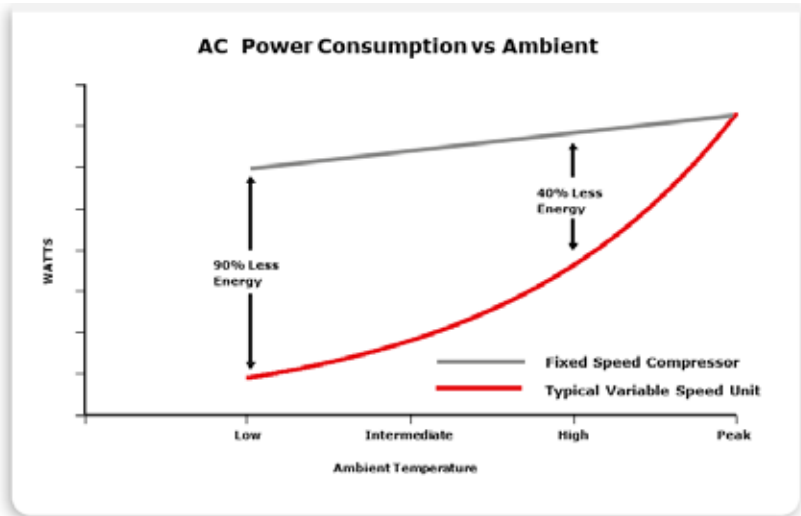


Increase AC EER while responding to demand reduction

By reducing the speed, the sound also decreases compared to fixed-speed compressors. Using a 12-ton scroll compressor as an example, it runs at 35,000 RPM when running at a fixed speed. When running at lower speeds under part-load conditions, the overall decibel (dB) output can be as much as 40% lower. Turbocor compressors run 8 dB quieter than a comparable scroll of the same size. Some of the other benefits offered by the Danfoss Turbocor compressor is more than 40% increased load efficiency and 30% size reduction versus a comparable system. Turbocor compressors that have been in the field for over 10 years have shown zero performance degradation from when they first shipped from the factory, maintaining the same efficiency and capacity as brand-new compressors.

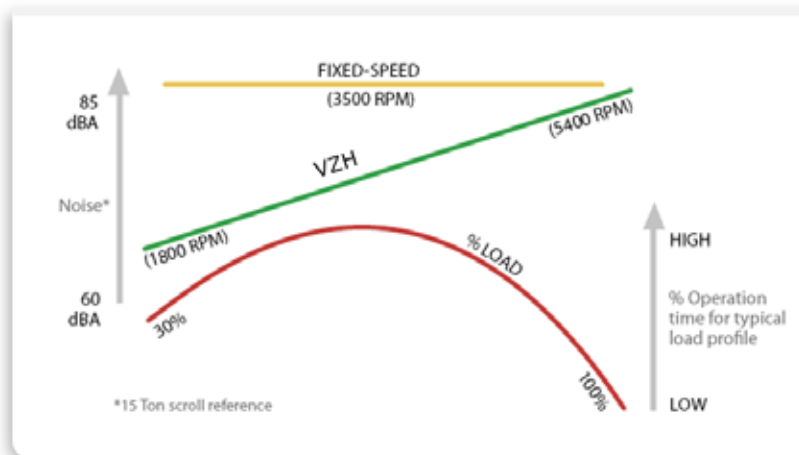
Variable Speed Power Savings

- Very limited operation at peak
- Highest energy savings where the unit operates the most
- Decreased sound at low speed



Variable Speed Power Savings

- Quiet environment over range of loads



VZH Vs. Fixed-speed Noise Under Varying Load Conditions

Danfoss **Oil Free Compressors** Advantages

Superior Performance and Savings over Screw Compressors

More Efficient
Up to 40% Better Part Load Efficiency

Quieter
8 dBA quieter

Smaller / Lighter
Up to 1700 Lbs / 771 kg less weight

No Degradation
Proven 0% Reduction in Performance over Lifetime

Perfect for any application where efficiency, sound, lifetime performance and size are critical

Constant Efficiency

Zero Performance Degradation with Oil-Free

Danfoss undertook a study in 2018 to validate long term operation of Turbocor compressors. The scope of the study consisted of:

- Testing (3) compressors in operation for 10+ years in the field
 - Hershey Factory, USA
 - ABC Studio, Melbourne Australia
- Retested compressors and compared 2018 compressor performance vs original test
- Results prove oil-free compressors incur zero performance degradation and no mechanical wear over their operational life



TEN-YEAR STUDY
Oil-free Refrigeration Compressors Provide Consistent Performance
By Eddie Rodriguez, Danfoss Turbocor® Compressors

Building large buildings typically requires the use of air- or water-cooled chillers that produce chilled water, which then cools the air. About 30% of buildings over 100,000 square feet use chilled water systems employing various refrigeration compressor designs.

Selecting the right chiller and compressor requires a specifying engineer to determine the building's cooling load and the proper chiller capacity. Calculations are also done to determine the return on investment between different systems by comparing the energy

cost per ton of refrigeration along with the operational costs.

When buying a new chiller, specifying engineers and facility owners naturally focus on efficiency ratings to estimate the chiller's

A significant factor that affects chiller performance over time is the oil used by the chiller's compressors.
— Eddie Rodriguez, Danfoss Turbocor® Compressors

Digitalization

Digitalization, sometimes called smart buildings, changes the way we live, work, and interact. There are houses we can tell to turn on the lights, turn on the HVAC system, lower the temperature, etc. And they can all be controlled remotely, usually with a simple smartphone app. This industry trend towards digitalization is often referred to as HVAC 4.0, providing users with better comfort and improved productivity and builders with a better operational excellence with lower cost and better ROI. Service and maintenance turn into fact-based, easily manageable processes with more active solutions versus reactive solutions.

Smart Buildings – Digitalization

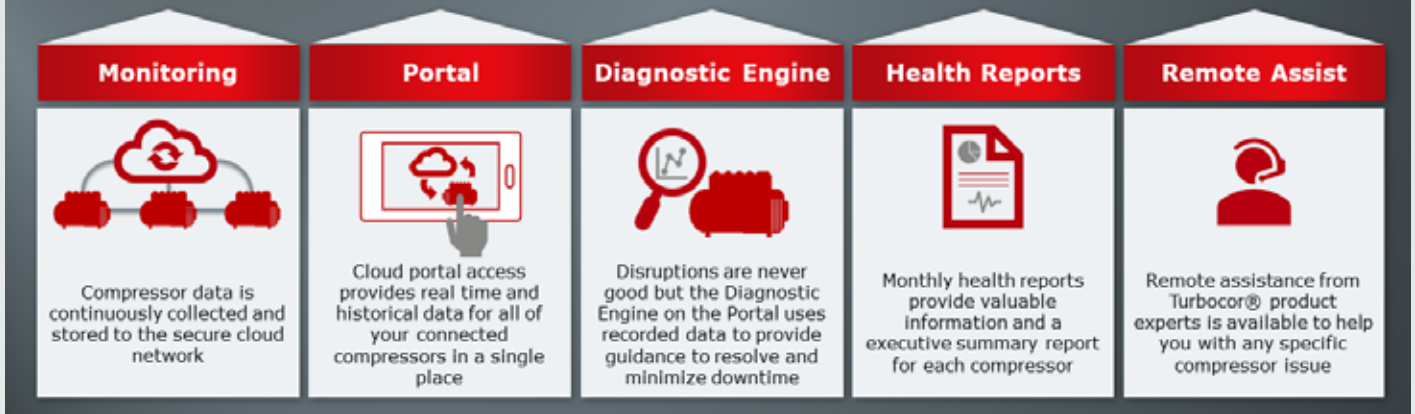
- The transition to HVAC 4.0 requires a close cooperation between many stakeholders - **everyone benefits**
- End users experience personalized **comfort** and improved **productivity**
- Building owners experience operational excellence with lower costs, higher energy efficiency and **increased ROI**
- Specifiers and builders provide **innovative solutions** and reduce liabilities
- Service and maintenance turns into a fact-based, easier manageable process



One advantage of Turbocor, in addition to being oil-free, is the new Turbocor Cloud Services. Turbocor Cloud Services, which is currently in beta testing, is a monitoring platform for the Turbocor line of compressors, allowing compressors to be monitored remotely. From the Turbocor portal, users can access historical data to provide insight on what chiller and compressor performance is over time. Turbocor Cloud Services features a diagnostic engine which provides real-time data, which can identify in advance if something is awry with the system, which would reduce the number repair visits. One thing planned for the future is a compressor health report which provides periodic updates to the business owner on how the compressor performing. Also planned for the future is remote assistance, where a Turbocor Cloud Services expert helps with any specific compressor issues or needs.

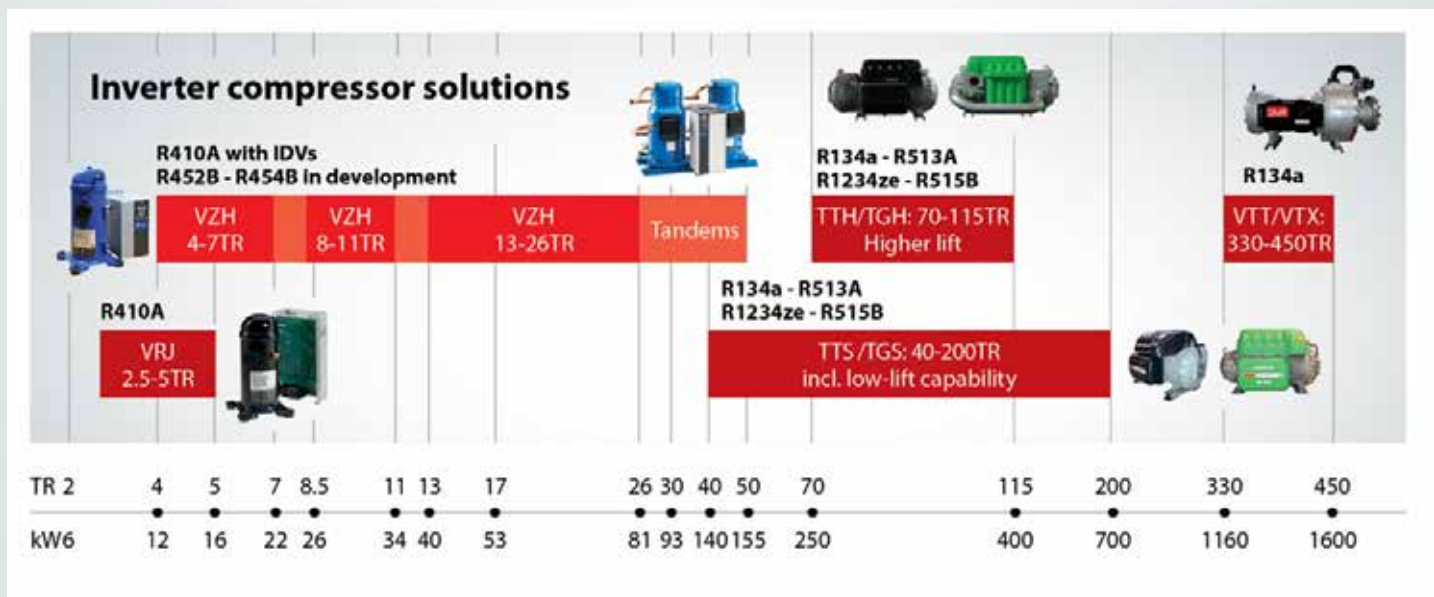
What is Turbocor® Cloud Services?

Turbocor® Cloud Services is the latest connected solution from Danfoss designed specifically for Turbocor® Compressors. The cloud based service platform collects compressor information to provide powerful insight into your compressor and chiller systems performance.



Danfoss offers a wide range of inverter scroll compressors starting as low as 2-tons or 6 KW up to 26-tons, and up to 50-tons with the tandem line—while many of the Danfoss inverter scrolls run on R-410A, there are plans to expand to include lower GWP refrigerants. The larger size Danfoss Turbocor compressors offer a range starting at 50-tons up to 200-tons, compatible with multiple refrigerants. In addition, Danfoss offers large BTT or BTX compressors, which range from 330-tons to 450-tons per compressor, and all of these larger compressors can be added as multiple compressors in order to have chillers achieve even larger tonnage based upon the building requirements.

Danfoss **A/C Compressor** Range



The below picture shows the wide range of variable-speed scrolls and Turboacor compressors Danfoss offers, which can be applied to both comfort and process cooling. There is a need for stable and accurate temperature and humidity control such as hospitals, museums, IT, telecoms, and process cooling.



In summary, Danfoss drives are designed to work together coupled with Turboacor compressors, which has built-in inverters. This has a long list of benefits to our both the manufacturers, consulting engineers, and end users in terms of reduced system error performance, higher reliability, and continuous operation. This technology is easy to implement, reducing both applied costs and time to market.

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