

WHITEPAPER

Leaving VFDs Behind: A 21st-Century Approach to Intelligent Sustainability

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1. Intro

Technology plays a key role in HVAC optimization, and variable frequency drives (VFDs) have become an industry standard for HVAC energy efficiency since their introduction in the 1980s. They offer speed modulation, enabling facilities managers to operate HVAC motors at variable speeds, improving energy efficiency while greatly reducing energy costs.

However, in today's business landscape, facilities managers face business challenges from all directions, such as variable energy costs, regulations, and post-pandemic work environments. The energy reductions from VFDs may help with reducing initial HVAC operating costs but are no longer enough for a long-term sustainable business.

Breakthrough innovations and technologies have emerged, and facilities managers can now lead their businesses to a better foundation for long-term energy conservation and sustainability. Through advances in motor and system design, the Turntide Smart Motor System™ outclasses VFD retrofits in energy efficiency and system performance. Additionally, the Turntide Smart Motor System leverages cloud computing to connect HVAC systems for 24/7 accessibility, providing additional benefits that help facilities managers further reduce HVAC costs and downtime through remote monitoring and control.

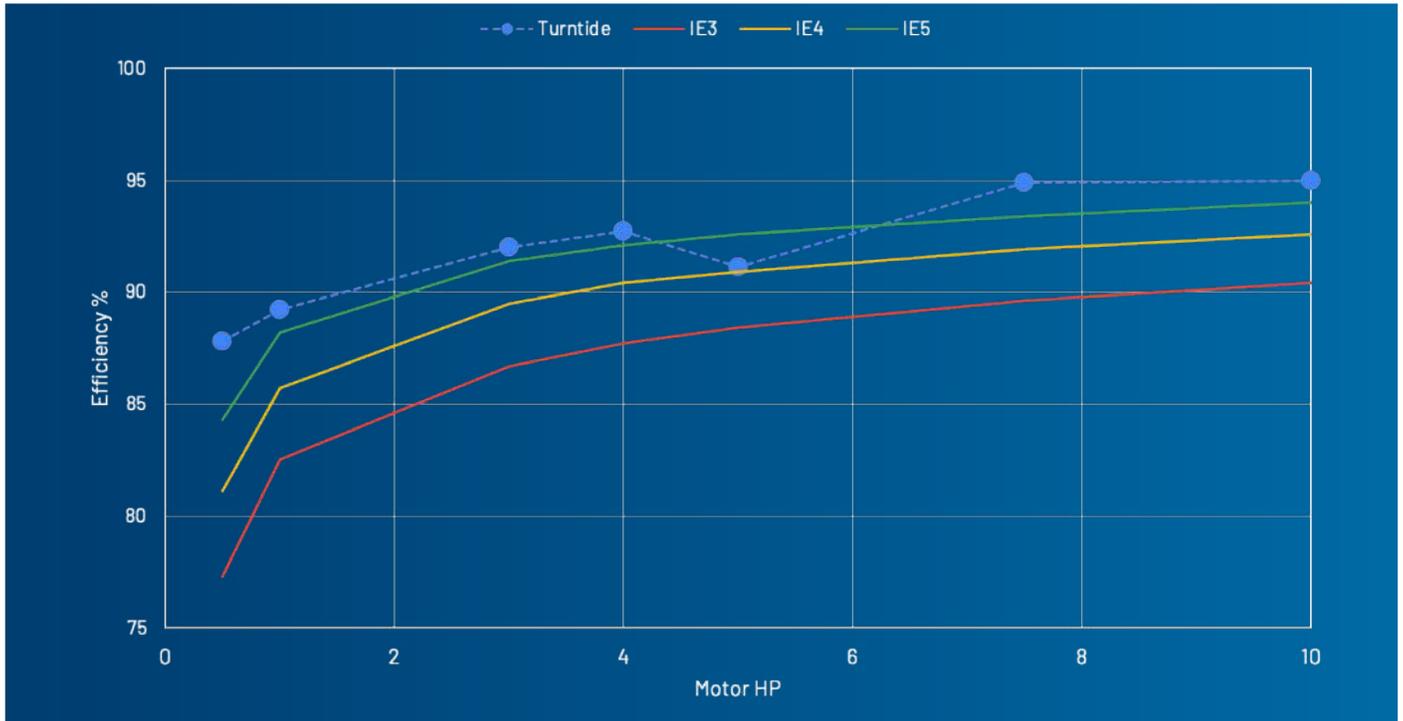
2. Turntide Smart Motor System

The Turntide Smart Motor System uses high-rotor pole switched reluctance motor (HR-SRM) technology, running on patented control algorithms in the Turntide motor controller. The Turntide Smart Motor System can be commissioned, controlled, and adjusted through the suite of Turntide mobile apps, which consists of the Turntide App (for remote monitoring and insights) and the Turntide Technician App (for mobile motor commissioning).

Key Benefit: Efficiency

Through years of R&D, Turntide has optimized the HR-SRM to achieve optimal torque and efficiency, while maintaining robust motor durability by reducing the effects of torque ripple, noise, and vibrations. As a result, Turntide motors can offer long-term motor operation while exceeding IEC IE5 efficiency levels across most HP ranges.

Efficiency Classification at 1800RPM by HP



Key Benefit: Intelligence

Through Turntide edge devices and Turntide mobile and web applications, the end user is able to monitor the operating environment around the motor, providing 24/7 access to monitor and optimize motor behavior. Turntide also generates a range of alerts that can notify facilities managers of potential RTU fault conditions. Turntide is also able to further improve the value of the motor through over-the-air updates.

Sample of Turntide Smart Motor System Alerts

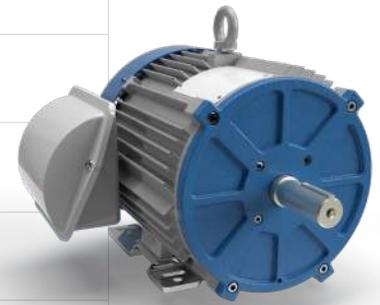
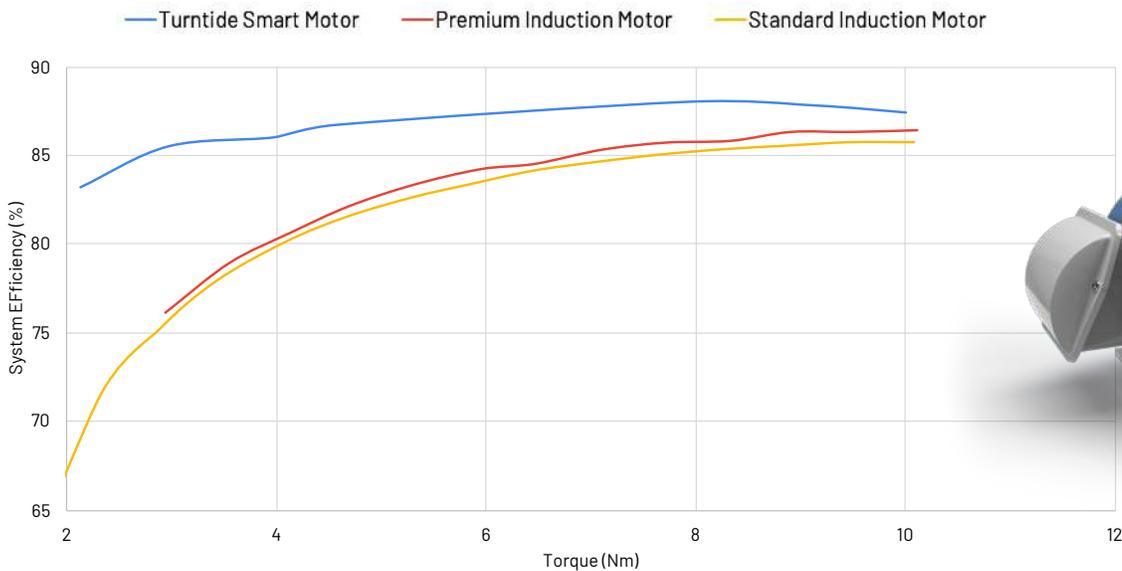
#	Alert	Purpose
1	Motor Torque	Checks torque levels, can predict torn belts within HVAC equipment
2	Motor Connectivity	Indicates potential networking or equipment issues
3	Motor Error	Indicates motor is not running properly within parameters
4	Speed Mismatch	Prevents overheating of the RTU

3. How Does a Turntide Smart Motor System Retrofit Compare with a VFD Retrofit?

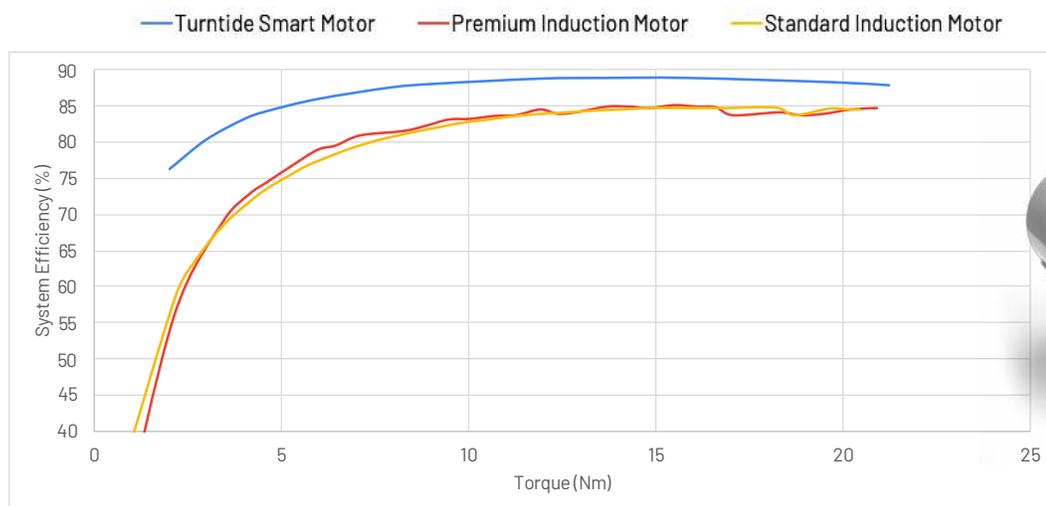
A VFD retrofit typically involves connecting a VFD to the existing AC induction motor on the RTU. In contrast to conventional induction motors, Turntide HR-SRM motors are not capable of operation on line power, so they must be paired with a discrete power drive. A Turntide Smart Motor System retrofit will consist of a swap of the motor alongside a specially engineered motor controller. This requires more components, but a fully integrated motor system provides better overall performance through a system that has been engineered to work together.

Efficiency Comparison

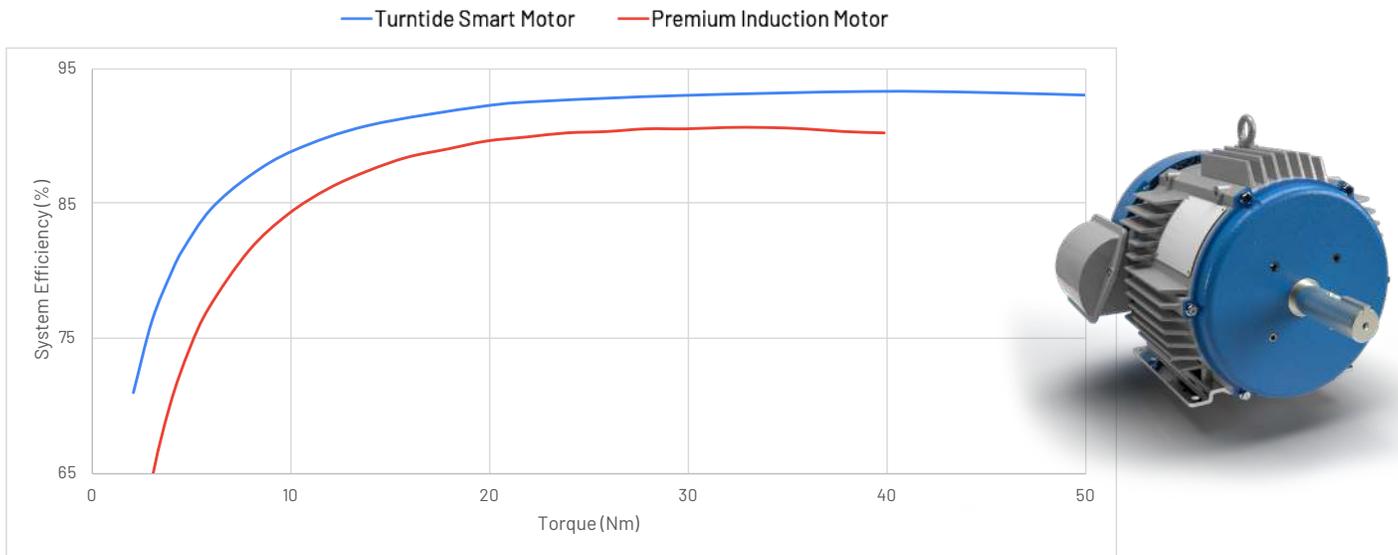
System Efficiency vs. Torque - V01 (3HP) at 1800 RPM



System Efficiency vs. Torque - V02 (5HP) at 1800 RPM

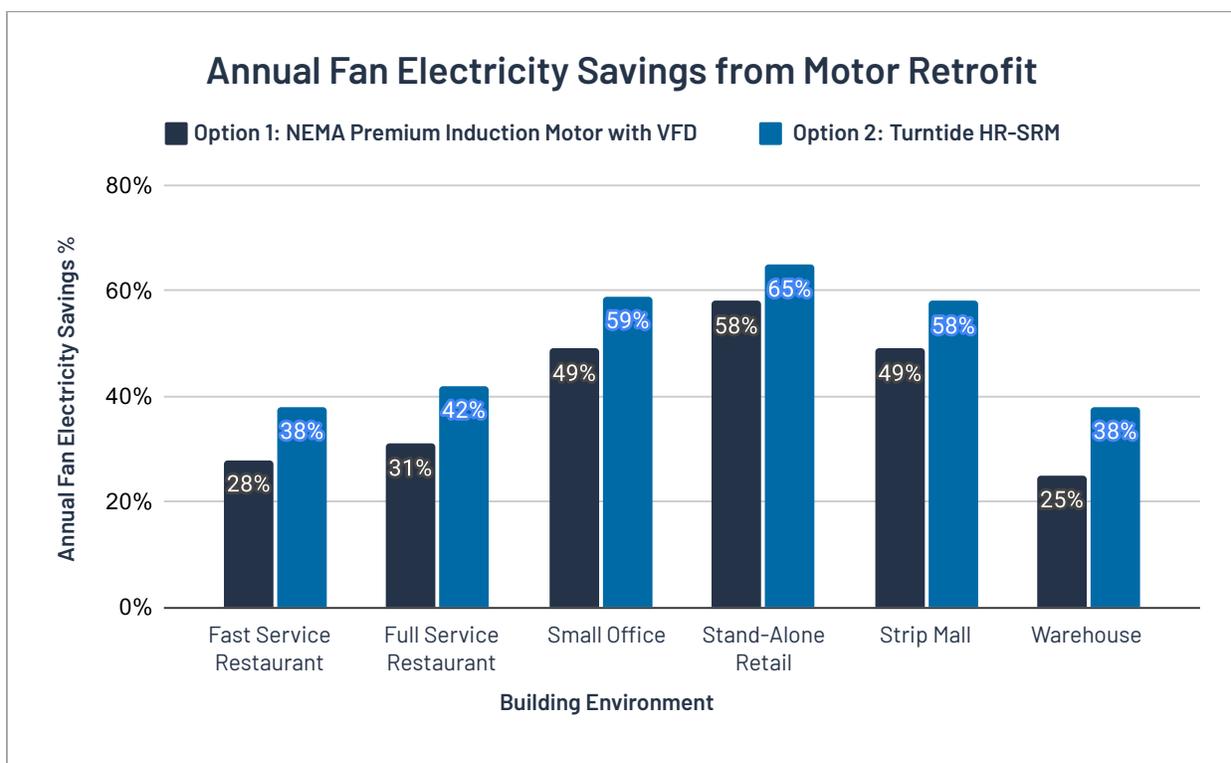


System Efficiency vs. Torque - V03 (10HP) at 1800 RPM



These graphs (generated from Turntide internal benchmarking) show how Turntide motors compare with standard and premium induction motors retrofitted with a VFD, across different HP ratings. Across lower and higher HP, the Turntide motor always runs at higher system efficiency, saving more energy and money.

Turntide’s internal benchmarking is also consistent with a third-party NREL and ComEd Study from December 2020 titled “[Performance Evaluation of 3 RTU Energy Efficiency Technologies](#)”. In the study, the energy savings from Turntide HR-SRM motors were directly compared with the savings from VFDs paired with NEMA premium induction motors. In every building environment tested in the study, the retrofit from Turntide motors proved to demonstrate higher levels of annual fan energy savings compared with a retrofit of a VFD on a NEMA premium induction motor. On average, the study found that Turntide motors provided 9% extra fan energy savings.



Intelligence / Monitoring Comparison

Without connecting the motor to the cloud, a VFD is limited in the intelligence that it can provide to facilities managers. VFDs contain I/O points that can theoretically monitor HVAC equipment but can only be maintained and managed locally on-site through a keypad unless a BMS is used. As building management systems have not been installed in many buildings today, many VFD-connected motors are running blindly.

The Turntide Smart Motor System is connected to the cloud and contains ample I/O points to connect to thermostats and RTU controllers so that facilities managers can monitor the overall health and status of their HVAC equipment 24/7. Turntide motor controllers have built-in 802.11/a/b/g Wi-Fi connectivity, which can be disabled via hardware or software. For simplified customizations, Turntide supports programmable logic via Turntide's easy-to-use platform. To monitor and manage Turntide motors through these connected controls, Turntide has mobile apps (available on both iOS and Android) available for facilities managers (Turntide App) and technicians (Turntide Technician).

Connected motors help facilities managers better maintain their HVAC equipment. For example, torque values can indicate torn belts on motor shaft pulleys and indicate when components need replacement. These intelligent alerts help facilities managers discover equipment issues before they become costly. In addition to the Turntide application, motors can easily be integrated into existing third-party building management systems via BACnet.

Reliability Comparison



Turntide HR-SRM (left) vs. Induction Motor (right)

Motor Design

Induction motors typically have distributed windings, which makes them susceptible to electrical shorts, leading to a higher risk of motor mechanical failure. Turntide HR-SRM motors have concentrated windings, designed with stators consisting of bobbin wound coils, which reduces the risks of winding failures found in AC induction motors.

VFDs

VFDs are in many HVAC efficiency retrofit projects. While they provide efficiency gains, they send peak voltages that can break through motor insulation and short motor windings, which in turn leads to lower product longevity. Additionally, VFDs can overheat induction motors past their thermal design limits. Induction motors are designed with a shaft mounted cooling fan to dissipate heat, but operating at reduced speeds, the fan may provide insufficient cooling airflow. Therefore, by aiming to prevent excessive temperatures that result in shortened bearing life or failure, facility managers are unable to maximize fan affinity laws to achieve optimal motor efficiency; for example, a 1740 RPM induction motor can only reach a minimum speed of ~580 RPM before risking thermal issues. In contrast, a 1740 RPM Turntide HR-SRM motor can turn down all the way to 100 RPM, without impact to bearing life.

Moreover, programming VFDS can be difficult and prone to more human error. VFDs require a great deal of precision to operate, and a high level of nuanced equipment and industry knowledge to operate correctly. VFD configuration errors often lead to motors running incorrectly below the motor's turndown ratio, which creates severe thermal management issues when the motor's stator and rotor insulation break down at temperatures operating above its thermal design limits. Without alerts or notifications, facilities managers may not realize their equipment has failed until it is too late to act.

Unlike VFDs, which can work with different motors within given operating specifications, Turntide motor controllers work exclusively with Turntide HR-SRM motors and cannot work with other motor types. However, Turntide is able to provide a more integrated solution that benefits facilities managers in the long run. Operating schedules can be adjusted on the fly, and issues can be detected through alerts so that facilities managers can take corrective action before issues become more severe. Also, through algorithms built into the Turntide motor controller, Turntide is designed for optimal operation at both lower and higher motor speeds, providing optimal efficiency and reliability across all modes of operation.

User Experience Comparison



VFD interface examples

VFDs are primarily controlled and programmed locally via a keypad on the device itself, which results in a cumbersome, complicated menu structure with limited flexibility due to the display and physical buttons. For VFD users who want connectivity, the VFD must connect to a third-party building management system, requiring complex BACnet integrations to make sure disparate systems can communicate with each other.



Turntide App

Thanks to cloud connectivity, the Turntide Smart Motor System allows facilities managers to remotely maintain and monitor their HVAC systems easily on a modern smartphone or web-based interface, all within the same platform. Unlike VFDs, Turntide motors do not require a long and tedious learning curve, and Turntide provides training programs and resources through Turntide Academy to help users become product experts in no time.

Turntide Retrofit vs. VFD Retrofit Comparison Summary

Description	VFD Retrofit	Turntide Smart Motor System Retrofit
Typical Scope of Retrofit	<ol style="list-style-type: none"> Installing a VFD to the existing AC induction motor 	<ol style="list-style-type: none"> Removal of existing AC induction motor Installing Turntide Smart Motor System (motor, motor controller, Remote Monitoring Kit, RTU sensors)
Max System Efficiency*	86.5% [^]	92%
Intelligence and Monitoring	<ul style="list-style-type: none"> No built-in connection to Wi-Fi or the cloud A user interface for logic programming is only available through a keypad and buttons on the device Requires BMS connection for connected insights 	<ul style="list-style-type: none"> Integrates with thermostats and RTU controllers out of the box Built-in 802.11/a/b/g Wi-Fi connectivity Can be remotely programmed and monitored through the Turntide App Interfaces with BMS platforms via BACnet for integration as needed

<p>Reliability</p>	<ul style="list-style-type: none"> • Induction motors are susceptible to winding failures due to their complex distributed winding design • VFDs send peak voltages that can accelerate winding failures • At lower speeds, VFDs can push motors to their critical thermal design limits. • No built-in alerts for immediate action on fault conditions, leaving equipment issues undetected 	<ul style="list-style-type: none"> • Unique concentrated bobbin stator coil winding design reduces the risk of winding failures found in induction motors • With all components engineered to work together, works just as reliably at both lower and higher speeds
<p>User Experience</p>	<ul style="list-style-type: none"> • Programmed and controlled locally only through the keypad and buttons on the VFD, in a limited interface requiring a complex learning curve • Requires integration with third-party BMS for cloud connectivity 	<ul style="list-style-type: none"> • Modern and intuitive app-based or web-based interface available out of the box for maintenance and monitoring anywhere, anytime • As an option: can integrate with third-party BMS systems

*comparison at 3hp

^for NEMA premium induction motor with VFD

4. Conclusion

The Turntide Smart Motor System represents the latest breakthrough technology in HVAC, surpassing the VFD in performance and capabilities. Unlike VFDs, Turntide products come with continuous firmware and software upgrades that further add functionality and performance over time. The Turntide Smart Motor System is the new standard that facilities managers can rely on for HVAC efficiency and performance in the short and long term.

Best of all, the Turntide Smart Motor System pays for itself quickly. An investment in the Turntide Smart Motor System has saved businesses an average of 64% in energy use, and can typically pay for itself in around 3 years. Furthermore, an increasing number of utility rebates are now available, reducing the payback period and making the Turntide Smart Motor System a win-win solution for every facilities manager.

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