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Know Your TCO: A Look at Medium Voltage VFDs

Medium voltage VFDs from suppliers with a long history of operating experience with various drive technologies and topologies exhibit a low total cost of ownership.

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Medium voltage variable frequency drives (VFDs) are long-lived assets that play a critical role in many industrial manufacturing facilities, making total cost of ownership (TCO) a key factor in purchasing decisions. Medium voltage VFDs are typically rated between 2.3 and 13.8 kV, and deliver power ranging from 150 kW to 120 MW at motor speeds from 10 to 15,000 rpm (Figure 1).

Automation and related components with shorter lives and less critical roles will generally have a TCO that's very closely related to the initial purchase price. But initial purchase price is only one of many factors contributing to the TCO for medium voltage VFDs.

Table 1 lists the main TCO factors and shows that price is only one of its many components. And in many applications, price isn't the most important factor, as shown by a recent survey conducted by Tritech Marketing Inc., a leading market research firm. The survey shows that purchasers of medium voltage VFDs select a particular manufacturer and product by giving weight to a number of factors as shown in Figure 2.



Figure 1: Medium voltage VFDs are complex products engineered and built to order for specific applications.

Medium Voltage VFD Total Cost of Ownership Components
1. Reliability
2. Downtime
3. Required maintenance
4. Customer service and support
5. Manufacturer's reputation
6. Spare parts acquisition and stocking
7. Efficiency
8. Price

Table 1

Leading factors considered by purchasers when selecting medium voltage VFDs

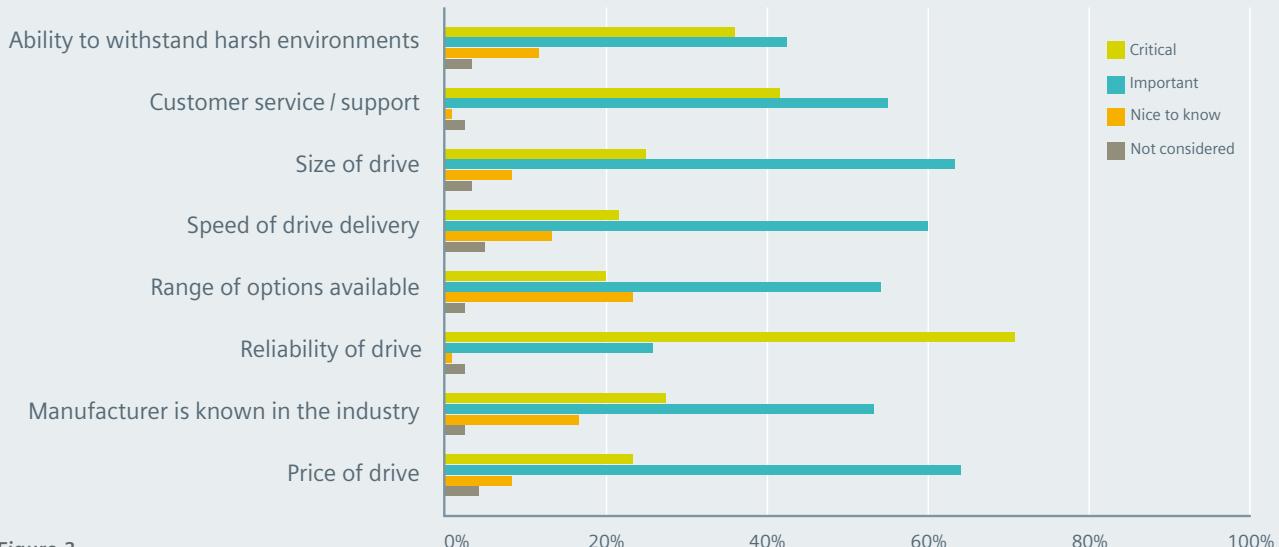


Figure 2

These factors are listed below in order of importance as determined by adding the percentage of respondents who ranked each factor as either critical or important:

1. Reliability—97%
2. Customer service / support—92%
3. Size of drive—88%
4. Speed of delivery—88%
5. Price—86%
6. Ability to withstand harsh environments—85%
7. Manufacturer's reputation—81%
8. Range of available options—74%

A key factor not listed in the survey is longevity of the VFD, with a longer lifespan contributing to lower TCO in an indirect but important fashion.

All survey respondents use or specify medium voltage VFDs, and the industries surveyed included:

- Mining
- Oil and gas
- Chemical / petrochemical
- Water / wastewater
- Pulp and paper
- Engineering, procurement and construction

This white paper will show how factors other than initial purchase price work together to generate a TCO for medium voltage VFDs. Although this paper is specific to medium voltage VFDs, many of the concepts covered are applicable to other long-lived assets that fulfill critical roles in industrial manufacturing facilities.

Explaining TCO

Medium voltage VFDs are a class of equipment with very long lifecycles, typically measured in decades. It is not uncommon for a drive to last for the entire life of a particular application with appropriate maintenance, yet this important fact is often ignored in the purchasing stage.

Purchasing personnel are often enticed by the lowest initial price for the purchased capital equipment. This means that the purchasing agent is swayed against considering TCO.

In reality, TCO is critical to the optimization of the performance for this type of asset. This fact is realized by plant operations and maintenance personnel, particularly the plant manager, as they are responsible for keeping the plant up and running in an efficient manner with maximum performance. Operations and maintenance personnel should therefore be given substantial input into purchase decisions for large capital items like medium voltage VFDs that are critical to plant performance and uptime.

TCO is calculated by determining the net present value (NPV) of all the costs and savings that result from the purchase, installation and operation of a particular asset for the

duration of its useful life. Some of the leading factors in any TCO calculation include price, operating costs and reliability.

NPV normalizes all of the costs and savings to the present. The purchase price is a present value, but any future costs and savings must be discounted to correctly calculate their present value, as a dollar saved 10 years from now is worth much less than a dollar saved today.

For short-lived assets with low operating costs that play a non-critical role in a manufacturing process, the TCO will be very close to the price. But for long-lived items like a medium voltage VFD with significant operating costs and a key role in a customer's process, it's extremely important to calculate TCO, as lower-priced items often have a higher TCO than a higher-priced alternative.

For example, consumers buy a short-lived asset (e.g., motor oil for a car) based chiefly on price, but they strongly consider factors such as reliability, service and operating costs when buying a car—implicitly, if not explicitly, comparing the TCO among prospective vehicles prior to purchase.

All industrial purchasers will take TCO into account to some degree when buying a large capital item with an expected long service life such as a medium voltage VFD. Purchasers will calculate TCO in different ways with widely varying levels of precision, but the basic TCO concepts will hold true in all instances.

When calculating TCO, the initial price is the easiest variable to quantify, and thus it often gets the most attention. But other variables can be just as important, albeit more difficult to estimate at purchase time as they are projected future values.

For example, greater reliability leads to less downtime and lower maintenance costs, two critical factors in many medium voltage VFD applications that can be difficult to put into exact numerical terms. So, most purchasers simply include estimated numbers for TCO factors other than price, and then discount these numbers to the present based on some internal corporate financial metric.

This white paper will identify some of most important factors that purchasers should consider when calculating the TCO of competing medium voltage VFDs as well as the advantages and disadvantages of different classes of medium voltage VFDs. It will also look at other important factors that indirectly contribute to the TCO for a medium voltage VFD.

The first factors that will be considered are reliability, downtime and required maintenance—three closely related elements that work together to have a substantial effect on TCO.

Reliability, downtime and maintenance

It isn't an accident that Tritech Marketing Inc.'s surveys reported reliability as the No. 1 factor in selecting a drive supplier. Reliability is even more important once all the costs of a drive failure are taken into account.

For example, using a crude TCO calculation, the cost of replacement for a medium voltage VFD might be just the purchase cost of the replacement drive. But this doesn't consider the engineering that may be required to make a newer model fit physically, or the re-wiring necessary to reconnect the newer model. It also doesn't include the cost of the installation.

But most importantly, it doesn't include the cost of downtime itself. Downtime costs are usually much greater than even the fully burdened cost of replacing the drive. Unplanned downtime is especially devastating and costly.

If a refinery is producing 60,000 barrels per day of refined products (gasoline, diesel, heating oil, etc.) and one of the dozen or so main pump drives goes down unexpectedly, the refinery may lose anywhere from 20 to 100 percent of capacity for as long as that drive is not working. If there is no shelf spare, or engineering must be done to replace the drive, it may take days or weeks to get the drives running again—all while losing hundreds of thousands of dollars per day in stalled production.



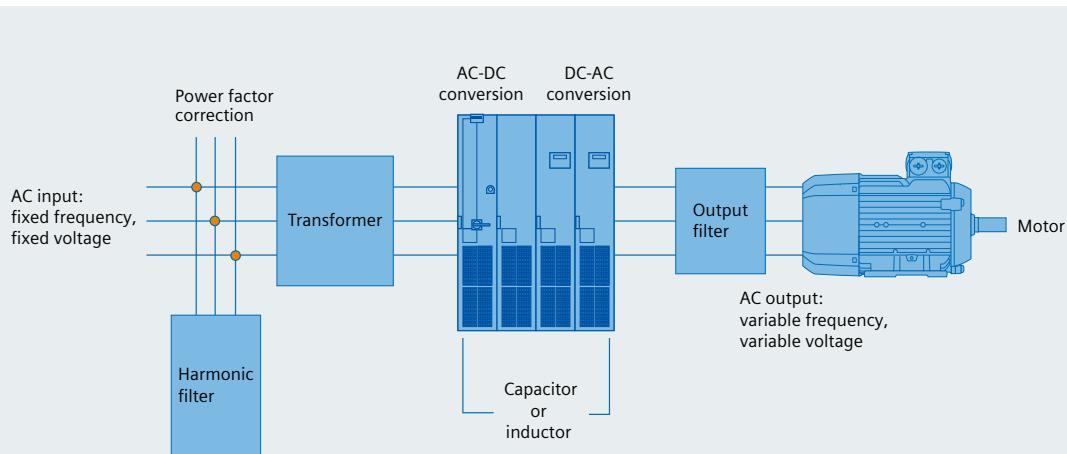


Figure 3: This diagram shows the components that are typically required in a medium voltage VFD installation. Note that the drives from some suppliers may incorporate a number of these components internally in an integrated design.

Therefore, a sophisticated and more accurate TCO calculation would take downtime costs into account, giving much greater weight to drive reliability, an area where some suppliers are known to excel. In particular, the Siemens ROBICON Perfect Harmony drive has a proven track record of customer-defined, two-, five- and seven-year campaigns with no unscheduled shutdowns; they have also been selected as the only VFD used in nuclear power plants.

Suppliers with a known reputation for reliability are often priced higher than suppliers with newer products that have yet to be thoroughly tested by years or decades of operation. Many purchasers feel that selecting a drive with a known high reliability from a trusted supplier is good insurance against unplanned downtime, and may thus be willing to pay a higher price upfront if reliability claims can be proven. But what creates high reliability in a medium voltage VFD?

Drive innovations improve reliability

Some suppliers use an integrated design that results in a drive with a smaller footprint and simplified design. A traditional drive would have up to five separate components: harmonic filter, power factor correction components, transformer, power converter and motor output filter (Figure 3).

An integrated design drive, however, would have only three components: the drive, an isolation transformer and a power converter. To achieve an integrated design, the drive itself must have very high performance, which negates the need

for some of the additional components needed with a non-integrated design. For example, the design progression for advanced drives has been for more levels at output multi-level topologies so that the motor life is extended, rather than stressed by the lower level counts that a cheaper drive may offer. The addition of output filtering isn't required, and while such filters add components and assemblies, they are rarely taken into account when calculating reliability for cheaper drives that focus on converter parts count only. The simplicity of an integrated design results in a more straightforward system with fewer components, thereby increasing reliability and reducing downtime.

Specifically, an integrated design allows the entire drive system to be thoroughly factory tested and then shipped to the site, as opposed to other designs that are often not tested as a system until all components arrive on-site and are interconnected. Thorough testing of the entire drive system for an extended period of time at the factory increases initial reliability by a substantial factor, and is also a contributing factor to better medium- and long-term reliability.

Because the integrated unit has been thoroughly tested and requires no interconnecting wiring on-site, the customer knows the drive will work as designed when it's delivered, reducing commissioning and startup time to the bare minimum. Factory testing of the complete integrated drive system also allows accurate efficiency measurements, which are important for sustainability, a factor growing in importance for nearly every application.

Another innovation that increases reliability is the use of a series of low-voltage cells ganged together in a building-block approach to create the medium-voltage power output required by the drive. If a drive employs this building-block approach, then it's possible to quickly bypass a failed cell while the drive continues to operate.

A third design feature that improves reliability is fault tolerance, which keeps a drive running in the event of a noncritical fault. This strategy ensures that the drive never trips on a single drive fault, and waits for a second condition to confirm that a problem exists. This fault tolerance strategy can also provide a hierarchical series of warnings of drive or component failure.

Fault tolerance gives an operator significant time to review the situation and avoid a system shutdown. Because of their ability to stay online in the event of a noncritical fault, drives with fault tolerance have been used in many critical industry applications in process plants and other facilities, including refineries, power plants, and water and wastewater systems.

High-availability medium voltage VFDs with fault tolerance and cell bypass are the only type certified for use in nuclear facilities, proving their reliability in the most demanding applications.

It stands to reason that a medium voltage VFD with a higher reliability will also have less required maintenance, further contributing to a lower TCO. Medium voltage VFDs are sophisticated systems made up of complex components, so when maintenance is needed, outside service personnel may have to be used. This can be quite costly and time consuming, particularly if the supplier doesn't have an extensive worldwide network of service personnel with access to a wide range of repair parts.

Service, reputation and longevity

Major suppliers generally have a worldwide network of applications engineers and service centers. Some of these suppliers have better support in some regions than others—a factor that should be evaluated by purchasers, as faster local support can reduce downtime and contribute to a lower TCO. Smaller suppliers generally will have a less well-developed support network, a factor that can substantially increase response times and consequent downtime.

Another important customer service factor to consider is the upfront assistance available when selecting the particular type of medium voltage VFD best suited for an application. Suppliers that offer many different types of drive topologies

can use this experience to apply the right topology for each situation, resulting in the best fit. Conversely, suppliers that offer just one or two drive topologies are often forced to fit their solution to the application. Matching the application with the drive type will result in better performance and reliability, which leads to a lower TCO.

A manufacturer's reputation is cited as an important factor in the Tritech Marketing Inc. survey, but this is a subjective factor that's very difficult to quantify. Perhaps the best way to judge reputation is by examining the experience that each supplier has in terms of producing and supporting medium voltage VFDs.

All other things being equal, it would make sense to select a supplier with many decades of operating experience, as opposed to a supplier that's new to the market. The supplier should have many years of experience selling and supporting the particular type of drive and features that are being considered for purchase.

Strictly speaking, longevity isn't a direct component of TCO calculations, but it becomes relevant when comparing two assets with expected service lives that vary significantly. Medium voltage VFDs that use designs with long operating histories have proven longevity, while others do not.

Medium voltage VFDs will have a published specification that indicates a design life expectancy, generally stretching to 20 years. Some suppliers will support discontinued product families for up to 10 years after the products are out of production. And in rare cases, such as nuclear power plant applications, certain suppliers have been willing to offer a design life expectancy of 35 years.

A supplier that's able to extend its design life expectancies in this manner can do so because it has a huge database of applications compiled from decades of medium voltage VFD manufacturing and support.

Other important factors cited by medium voltage VFD purchasers in the Tritech Marketing Inc. survey include available drive sizes, range of options and speed of delivery—all factors that indirectly contribute to TCO, and are thus important when making purchasing decisions.



Drive size, options and delivery speed

Suppliers that offer a wide range of medium voltage VFD sizes and options are more attractive to purchasers because they allow use of the same supplier across many applications. This reduces costs when multiple drives of different sizes are required, particularly if the drives will be installed and operated at a single facility.

Purchasing administration efforts are reduced, as it's only necessary to deal with a single supplier. Fewer parts need to be held in stock by the purchaser, and operations and maintenance personnel are able to diagnose problems and make repairs quicker as they only need to become familiar with one supplier's drives and associated control systems.

Accurate accounting would determine the lower costs realized by using one supplier for a certain quantity of drives, and then allocate these savings to each drive TCO calculation.

The greater the range of sizes and available options, the more optimization can occur to fit the drive to the particular application. Optimizing the drive for the application results in savings due to greater efficiencies and improved operation—factors that reduce TCO, although in a manner that can be hard to quantify.

In terms of speed of delivery, two factors come into play: stated delivery time and time required for installation and commissioning. The stated delivery time is quoted by the supplier, but the time for installation and commissioning is usually not.

A key factor that cuts installation and commissioning time is integrated design of the medium voltage VFD. Installation time is cut because fewer components need to be installed and interconnected.

An integrated design allows the entire drive system to be factory tested and then shipped to the site. Other designs are often not tested as a system until all components arrive on-site and are interconnected.

Commissioning time is therefore less, and some suppliers estimate that drive systems with an integrated design can be commissioned in as few as three to 10 days, depending on drive size and system complexity. This reduces the time required to commission a drive system that doesn't employ an integrated design by at least 25 percent and can be as high as a 50 percent commission time reduction.

Although speed of delivery and commissioning does not directly contribute to TCO, it stands to reason that faster installation times will result in more time-efficient production and a higher cost savings associated with using the drive.

Conclusion

Medium voltage VFDs are long-lived assets with significant operating costs that are often used in critical industrial manufacturing applications, making it necessary to look at the TCO of a drive, as opposed to just its initial purchase price.

In fact, a drive with a low initial purchase price will often have very high costs in terms of other key TCO factors. To make the best purchase decision, buyers should calculate the TCO for a medium voltage VFD by considering reliability and associated downtime, drive innovations, a manufacturer's reputation and customer service, and then select the drive with the lowest TCO.

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