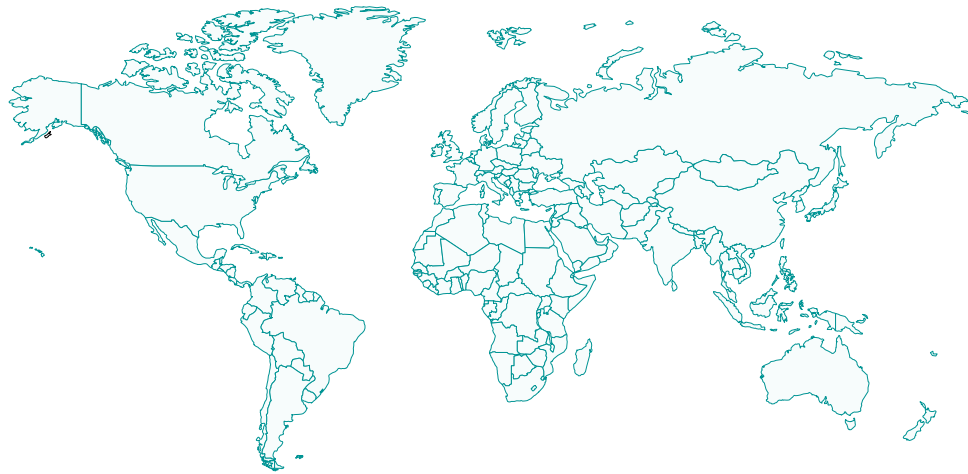


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# Outdoor Power System Design and Cost Considerations



## Introduction

In recent years there has been a dramatic increase in the installation of outdoor electronic devices. As the new outdoor equipment requires reliable and uninterrupted power, the need for outdoor systems with uninterruptible power supplies (UPS) has also grown. Most power conversion, protection, and backup systems being used outdoors are designed for indoor conditions. These systems fail quickly in harsh outdoor environments. Therefore, the solution is a new line of uninterruptible power supplies. Reliable systems that can operate outdoors with minimal downtimes and maintenance requirements are a necessity. This document was created to provide guidance and background to address the needs of system integrators, specifiers, and end users searching for a solution for their outdoor power systems applications. The reasons driving this growth trend, the benefits and drawbacks of outdoor power systems, as well as the challenges associated with developing reliable outdoor power systems, will be discussed.





## Applications, benefits, and drawbacks of standalone outdoor power systems

### Reasons driving the growth trends

Until recently there were relatively few electrical devices in remote areas. Today this is no longer true. In the last ten years, low cost wireless communication via CDMA, GSM, WiFi, WiMax, satellite, and radio has been more commonly used in many areas such as the telecommunications, security, transportation, minerals, and energy industries.

### Standalone outdoor power system advantages

- The standalone outdoor power system delivers the highest quality of power to the mission critical equipment because it can be installed in the immediate vicinity. This advantage increases the quality of power delivered to the load equipment. The transmission loss (and resulting voltage drop) and surge/spike/noise pickup caused by long power wire runs are eliminated. Minimized equipment failure and system downtimes also maximize customer satisfaction and retention, resulting in higher revenue and profit for users.
- In traditional outdoor power applications, existing indoor power systems use long and oversized electrical wires that supply the remote outdoor power equipment. With an outdoor UPS the need for increasingly expensive copper wire is reduced, the feeder wires do not have to be oversized, and the need for protective and costly metal conduit is also reduced.

### Standalone outdoor power system disadvantages

- As outdoor systems are designed and manufactured to much more demanding specifications, they entail greater material, labor, and development costs. In some cases, it may mean a higher upfront capital expenditure which must be offset by reduced operating expenses in order to achieve net financial gain. The financial advantages realized in the installation savings would help towards this end.
- Since outdoor power systems are typically installed in remote sites, their performance is more difficult to monitor. For instance, the mean-time-to-repair is substantially longer than indoor power systems when the travel time (a.k.a. "windshield time") is added to the mean-time-to-repair.

## Should systems integrators build their own outdoor power systems?

Due to the benefits offered by outdoor systems, some systems integrators choose to produce their own. However, careful consideration should be given before choosing such developed products.

### Such considerations are:

- The purchase of components leading to an inadequate system. The do-it-yourself (DIY) approach typically involves the purchase of a commercial off the shelf indoor power product, and then placing it inside a weather-protected commercially available enclosure. This is initially appealing due to the low cost of the indoor-rated product and off the shelf parts. However, this approach often falls short in the areas of proper sealing, vibration damping, corrosion protection, adequate cooling, **as well as the necessary adequate surge protection.**
- Without sufficient protection there will be premature failure of the system. As electrical components are sensitive to a number of environmental phenomena, outdoor environments are quite harsh on all electrical and electronic equipment, including power systems. Most electrical devices are designed to operate satisfactorily in dry environments, close to room temperature with little or no airborne particulates or organic contamination. The lack of these

ideal conditions sets up indoor power equipment for premature failure. Extremes of temperature, wind-driven rain and dust, high humidity, saltwater vapor, roadside vibration, insects, and other creatures, can all cause indoor equipment failure when they are used outdoors.

- In some instances the DIY system may not meet the applicable equipment and personnel safety standards, which dramatically increases the likelihood of overheating, fire, or injury to maintenance and repair personnel.



In the long run, it is more cost effective to use a professionally designed and manufactured outdoor power system. When mandated by local electrical code, products used must be listed by an NRTL (Nationally Recognized Testing Laboratory), i.e. ETL, UL, or CSA. Professionally designed and manufactured outdoor power systems provide maximum safety, performance, reliability, and equipment longevity resulting in the lowest overall cost of ownership. This minimizes unexpected equipment downtimes, repair costs, and the chances of fire or personnel injury.

## Outdoor Power System Design Challenges

Unlike indoor environments, outdoor environments are highly varied. Temperate, tropical, and arctic environments vary radically from each other, as do continental and maritime climates. Climate also varies significantly in the same geographic area by time of day, weather patterns, and seasonal changes. Surge voltages induced by lightning and/or load switching, precipitation, extreme temperatures, humidity, dust, salt, vibrations, and organisms all can cause rapid deterioration of improperly designed and manufactured outdoor power systems.

- **Surge voltage protection:** Surge voltages in the outdoor environment are higher and contain more energy than those that appear inside a building. The protection circuits against surge voltage must be designed to withstand higher currents and voltages while reducing let-through voltages to a minimum.
- **Precipitation:** Water ingress is typically caused by wind-driven rain and condensation inside the cabinet. Water on sensitive electronic boards can cause system malfunctions or catastrophic failures resulting in time-consuming repairs or replacements, not to mention the high cost associated with unexpected system or network downtime.
- **Extreme temperatures:** Uninterruptible power supplies are especially vulnerable to temperature extremes. Most batteries are negatively affected when operating outside of the narrow 50–86°F (10–30°C) temperature range. High temperatures lead to reduced battery life, while low temperatures lead to dramatically reduced battery energy storage and, therefore, reduced reserve time.
- Batteries used in outdoor cabinets must be recharged by **temperature-compensated battery chargers**. This requires measuring the actual temperature of the battery, not just ambient air temperature. Without temperature-compensated charging, batteries are either overcharged or undercharged which results in quick battery degradation and failure.
- **High ambient temperature** can cause power semiconductors to quickly fail when operated above their high temperature limit. Transformers operating at high temperatures can produce extra heat, especially when the transformer core is close to saturation. This may cause insulation breakdown, resulting in catastrophic and expensive transformer failure.
- **Dust** and other airborne contaminants act as thermal insulators, which increase the temperature of electrical components covered in dust or dirt. Dust can also contaminate lubricants and thus introduce friction to components and result in the premature failure of cooling fans.
- **Salt** is another serious cause for concern as it is corrosive and increases the conductivity of water. Rapid corrosion of all unpainted cabinet metal parts caused by salt allows other contaminants to enter the system. Salt water on sensitive electronic boards leads to unwanted current flow in the control and power circuits. These are major causes of premature failures of outdoor power systems installed near coast lines.



- **Vibrations**, including earthquakes, while not common in most outdoor environments, are specific to certain outdoor applications. Devices located near construction activity, heavy machinery, railroads, or heavy traffic will experience frequent or sustained vibrations. Exposure to frequent or sustained vibration may result in the weakening and failure of the solder joints which may lead to premature failure of the entire system. In addition, mechanical failures may result if cabinet/enclosure designs have not been optimized. This is of special concern when outdoor cabinets/enclosures are mounted on poles or off the ground.
- A final challenge of outdoor environments comes from **biological organisms**. Small insects, vegetation, fungus, and mold can infiltrate unsealed outdoor cabinets. Birds, lizards, and small snakes are also attracted by the warmth and safety of outdoor power cabinets. The appearance of these creatures can pose a severe safety risk to a surprised maintenance or repair person, especially while accessing a pole-mounted application where they may fall off a ladder.



Plate 1. An outdoor VRp-ILc unit (precision PWM voltage regulator with isolation transformer power conditioning) with pad mounting 'feet.'

## TSi Power solutions

As has been shown, the requirements for outdoor power conversion equipment are stringent and demanding. Only an innovative and experienced supplier can provide the necessary solutions. TSi has the following unique capabilities, along with the breadth and depth of product knowledge, to provide correctly designed outdoor power systems:

- **Proven standalone outdoor power system design experience**  
TSi has put thousands of units in the field in various climates all over the world.
- **A full line of outdoor power conversion product systems**  
From surge protection, circuit boards, transformers, and battery backup schemes to the housings and enclosures, TSi has the expertise to make sure that products function as intended over their lifetime.
- **In-house engineering and manufacturing**  
TSi's manufacturing facility contains in-house engineering, assembly, testing, and circuit board production. This allows TSi to develop and produce the needed technologies while minimizing reliance on outside suppliers. New systems can be quickly developed and existing systems can be quickly modified to meet customer requirements.



- **Stable, highly skilled workforce**

TSi's workforce is highly skilled and has a very low turnover rate. This ensures that the specialized, detailed knowledge required for designing and producing outdoor systems is continuous and eliminates the need to constantly instruct and train new workers. Additionally, skills and knowledge accumulate over time.

- **Stable and experienced major component suppliers**

TSi maintains excellent relationships with key suppliers of major components. Because of our longstanding associations with these suppliers, they become intimately aware of our needs, as well as the needs of our customers which results in improved efficiencies and quality over time. As we know exactly what to expect from our suppliers, we are better able to make accurate commitments to our customers. It also allows customers to better plan and coordinate their investments.

- **Small-production-run capabilities**

Many outdoor applications are highly individualized warranting very small production runs, sometimes only a single unit, and fast turnaround times. TSi specializes in low volume production runs, with the ability to custom design and manufacture products with short lead times. TSi's standard outdoor power conversion products all have enclosures designed in CAD and are produced to demanding specifications. For small specialty orders which require rapid turnaround, TSi uses an existing enclosure and modifies it. For larger volume custom products, TSi may design a new enclosure for the specific application.

- **Proprietary power conversion designs**

TSi's designs its own power conversion systems to very rigid specifications and very broad component tolerances, thereby reducing the risk of failure and increasing the range of environments in which the systems can be used. The systems are specifically ruggedized with heavier components and proprietary coatings to eliminate the danger from moisture, salt, and other contaminants. The system is then assembled by TSi's experienced workers. The hardware and fasteners used are corrosion resistant. Ventilation is accomplished in such a way as to minimize ingress of water, dust, and other unwanted objects. All gaps are carefully sealed, and the completed unit is rigorously tested. TSi maintains testing records for certification and, if required, independent third party testing may be conducted.



Plate 2. Interior views of two Outdoor VRp-ILc units  
(precision PWM voltage regulators with isolation transformer line conditioning)



## Broad product line

TSi Power offers a broad range of power conversion products including:

- Outdoor XUPs, ac uninterruptible power systems
- Outdoor DcUPs, dc uninterruptible power systems
- VRx, ac outdoor precision voltage regulators
- XUPs, indoor ac uninterruptible power systems
- XINv, dc-ac power inverters
- ATs, ac automatic transfer switches
- VRp, precision voltage regulators
- SLc, voltage regulators
- ILc, isolating line conditioners
- FLc, regulating line conditioners. More information on these products including technical specifications is available on TSi's website.
- Warranty  
TSi provides a factory limited warranty with all its products. Standard warranty terms are two years for parts and labor. ILcs are warranted for five years, and batteries are warranted for one year. TSi's relationship with the customer does not end with the sale. TSi is always willing to provide customer support and technical support for its products or power quality issues in general.



Plate 3. Interior view of an Outdoor-DcUPS-8229 with output of 12 vdc, and 10 amperes maximum output

## Conclusion

The increasing usage of electrical devices at remote sites is altering the power conversion market. Power quality issues remain the same, but conventional means of addressing them are unsuitable. Businesses which fail to adapt their power quality strategy will find themselves at a competitive disadvantage to those who do adapt to the new situation.

Conventional power conversion systems are designed for benign indoor environments only and are not suitable for use in outdoor conditions.

Unlike indoor power conversion systems, outdoor systems must be specifically designed and manufactured for the challenging outdoor conditions. Inclement weather, contaminants, corrosive substances, moisture, vibration, and other hazards must not damage the system. A professionally designed and manufactured outdoor power system can be deployed in a very wide range of environments. As a result, power quality issues are resolved while reducing maintenance costs and downtime.

TSi Power's long experience in the design and manufacturing of outdoor power systems has allowed it to develop a unique set of methods and skills which address the challenges associated with the design and manufacture of outdoor power conversion systems. TSi offers a full line of standard power products, in-house engineering capability, and factory support with flexible and fast-turnaround production. These advantages allow TSi to address a wide variety of power quality problems.

Our ability to design, customize and manufacture our products to your specifications provides our customers with a reliable long term solution.

## About the author

Mr. David Nystrom has been active in the power protection industry since 2001 in manufacturing and as a sales engineer with TSi Power Corporation (located in the state of Wisconsin, USA), a manufacturer of UPS, line conditioners, automatic voltage regulators, automatic transfer switches and dc – ac inverter systems designed to meet the challenging international power conditions.

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