Micro-Wind Turbines & Advanced Marine Solar Panel Systems: Solutions for Mission Critical Off-Grid and Remote Location Power Demands.

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White Paper **Commissioned by Starboard Strategies** LLC This white paper discusses the need for reliable off-grid power generation and how Superwind turbine generators and SunWare solar panels are currently meeting this demand.

INTRODUCTION

Over the past two years, mission critical system equipment manufacturers have been quietly developing and providing end users with telemetry and communications equipment capable (or designed exclusively for) "off-grid" 24 or 48 volt DC power systems. Superwind has been involved with numerous projects designed to operate in areas lacking the infrastructure to deliver utility generated electricity – hence the term "Off-grid".

Even areas that posses an electrical power delivery infrastructure ("the grid") can experience a "shaky grid" phenomenon (unstable service or a loss of grid electric power) when recovering from war or natural disaster. It's at these same locations (on land or sea) that a mission critical need for a reliable electricity supply exists.
Whether designed as a back-up system or main power source, a remote access "off -grid electric system" typically consists of batteries for storage and a number of non-hydrocarbon generators for power and recharging. Lighthouse stations, telecommunications repeater stations, oil & gas well/pipeline security and transducer relays, remote NGOs (Non Gov Organizations – "not for profits") Medical centers and schools, as well as Department of Homeland Security (DHS) and Department of Defense (DOD) asset power (both stationary and remote) are but a few users of reliable, off-grid electric energy.

Additional benefits of reliable Off Grid power systems

Reliable, off-grid power can also be used to expand regional coverage. In remote areas such as islands in Croatia and or waters in Northern Canada, for example, radio and phone call transmissions are routed through both "Grid Substations & Repeater stations" as well as off-grid stations. Off-grid Tsunami and earthquake detection gear at sea can complement or add data to land based, grid-supported systems. This is also true for navigational and meteorological data gathering stations, as well as off-grid sites utilized by DHS, DOD, etc.

Another viable option is the use of mobile off-grid platforms, which can increase effectiveness and decrease rapid response times. Utilizing a truck or trailer-mounted platform, a meteorological station or cell phone repeater station can be quickly deployed after a natural disaster, while base perimeter camera stations (manned and unmanned) can be posted "on the wire" or in a captured area short on manpower assets.
Other examples where the use of mobile platforms could provide enhanced mission capabilities include covert operations, deployment of pilot recovery transmitters, and border security monitoring (cameras (FLIR) day/night, long range, etc) in remote terrain, lakes, rivers or at sea. They can also be used to power radiation monitors, proximity detectors, and seismic monitors. Other uses include Gas & Oil pipeline security and leak

monitoring, as well as remote Operations Field Status System Monitors (health and level of readiness). Such systems range from simple data transmitted from the battery storage system to a full blown Renewable Energy Visual Tableau (REVTOS™) type system providing real time monitoring, data recording and transmission.

Understanding AC & DC Electrical Power

Batteries, solar panels, and micro-wind generators (depending on the model) deliver energy as **Direct Current** (**DC**). In a DC circuit the positive and negative terminals of a battery are always (respectively) positive and negative, meaning current always flows in the same direction between those two terminals.

The power supplied from a power plant via the grid is called **Alternating Current** (**AC**). The direction of the current reverses (alternates) 60 times per second (in the U.S.) or 50 times per second (in Europe for example). The power that is available at a wall socket in the United States is120-volt, 60-cycle AC power.

Wind generators (aka turbines) convert the kinetic energy of the wind into mechanical power and ultimately electricity. This electricity can be used immediately to power equipment, but is typically stored in batteries for future use.

Solar panels convert solar energy into DC electricity, which is also stored in batteries until needed.

Energy storage

Electricity created by renewable energy systems is rarely used in real time – or is often needed beyond the actual time produced. Lighting, for instance, is typically used at night when the sun is down and a solar panel has stopped producing power. Storing the power for special demands or timing priorities means relying on a battery or battery bank.

Batteries, of course, come in many shapes and sizes, depending on their application's design. Basically, a battery is a DC electric storage device capable of discharging the stored power in an orderly way. A disposable battery is one that when once "initially charged" ("powered up" so to speak) will not be able to be reliably re-charged once its power has been discharged (used). The life cycle of a disposable battery then is "1" – that is to say, one complete full charge and one complete full discharge – and the battery is "dead" forever. This being said, all batteries, even those designed to be repeatedly charged and discharged during use have a life cycle. A typical car starting battery is designed to give out high amperage – but with very short durations of discharge. These types of batteries are fine in autos where there is constant charging while the engine is running; however, this would be a poor battery of choice for Off-Grid Systems. "Deep Cycle" batteries are best for remote application work and are designed for a longer discharge of power as well as a more efficient recharge. Most deep cycle batteries also have a longer life cycle based on the total numbers of complete discharges (to the point the battery is very low power) and recharges bringing the battery back to full strength. In today's Off-grid power system environment, battery material designs include different storage/materials all with different cost, maintenance, power storage and lifecycle

characteristics. These include batteries based on lead acid, Gel, Absorbed Glass Mat, and stabilized lithium technologies. Standard off-grid batteries can be found in different sizes and voltages – however most common deep cycles are the size of your car battery but may be found in 6, 12, 18 or 24 volts.

Battery Banks: Simply put, there is strength in numbers. Having more batteries in a system means less wear on the individual battery and also ensures more power for longer periods. Battery banks can be wired in parallel (meaning four 12 volt batteries wired together yield one large 12 volt battery system, or "in series" (meaning four 12 volt batteries wired in such a way that they construct one large 48 volt battery power source). Depending on what is being powered, off-grid systems can be found in many voltage ranges including 12, 24 and 48 volt systems – with any combination of like sized batteries wired in parallel or series. A "dual bank" or "split house bank" system refers to two banks of batteries stored together, sometimes even charged together, but separate for the sake of switch supply redundancy or back-up requirements. Many "Mission critical" off-grid power systems have multiple batteries, or multiple banks.

Superwind and the competition

Micro wind turbines can be an asset – but only if they can survive harsh conditions as well as mitigate over-speed or "run away" operation, which often results in the damage or destruction of the turbine. Since Superwind wind generators were designed with advance feathering pitch blades and manufactured as a commercial (non hobby) wind turbine with marine grade components, Superwind has consistently outperformed the competition. For over a decade Superwind wind turbines have proven themselves more reliable than any other unit available on the market, both during extreme testing and while operating in mission critical roles. During a 2007 comparison of six wind generators, Practical Sailor Magazine (a highly respected marine consumer reports magazine) selected the Superwind 350 as its top choice. During the test period the Superwind 350 provided the greatest overall output throughout a wide range of wind speeds and was described by Practical Sailor as "a robustly built unit that ran quietly and had all the features we look for in a wind generator." The magazine again highlighted the product in 2010 as their first featured on-line video – this in conjunction with Superwind's rollout of its much awaited "silent rotor blade" upgrade.

Superwind has also persevered over its peers in uses by the defense community and is now being integrated by a myriad of DOD and DHS players in North America and Europe.

Superwind's "SW-350", a 350 watt generator, has been used in mission-critical rolls for over a decade. Because of the success of the patented feathering blade set, and heavy duty "real world" construction made to withstand operation in harsh "sea to desert" environments, a dedicated commercial charge control system with load management/diversion, the product is often deployed in remote areas and fully intended for autonomous (unattended) use. Once installed properly, the SW-350 can be relied on for many years at a time.

Again, with over a decade of real world use, it must be mentioned that the Superwind is not an "R&D" or "hobby" wind turbine. A majority of all the original turbines built over ten years ago – are still in service today.

"Sound" vs. Covert ops

As with variables in power output, performance, and durability, all wind generators are not created equal when it comes to "quiet" operation. Loud micro wind turbines can be "found" by the sound they make. In many applications (mountain top DOD operations for example) a cammo-painted Superwind can be installed and remain effectively hidden due to its extremely quiet operation.

The future of Micro-Wind: Superwind "1250"

Because of the overwhelming success of the technology and patents developed in conjunction with the Superwind 350's creation, commercial customers have repeatedly asked for larger micro-wind turbines with these same benefits. Based on this demand, Superwind GmbH of Germany has partnered with Mission Critical Energy, a USA based company, to develop the "Superwind 1250"; a 1250 watt wind generator to be manufactured in the USA in 2014. Like the SW-350, the Superwind "1250" will be maintenance free, and designed for unattended autonomous continuous use for the DOD, DHS, communications, Oil & Gas and Mining Customers in remote areas.

Wind and Solar power – a winning combination

According to the US National Renewable Energy Laboratory "The amount of solar energy that hits the surface of the Earth every minute is greater than the total amount of energy that the world's human population consumes in a year."

"Dual Charging Systems" (sometimes incorrectly referred to as "hybrid systems") utilizing both wind generators and solar panels, are particularly effective in maximizing power generation during a variety of weather conditions. Cloudy days are often accompanied by higher winds, while sunny days often mean lighter airs. It is in these real world conditions that Mission Critical Energy's engineers will spec Superwind equipment to be utilized in conjunction with equally durable and accredited solar panels such as SunWare (a market leader in maritime solar innovation). The successful integration of these two product lines works extremely well as both manufacturers developed their products for use in extreme weather and saltwater conditions.

SunWare Solar Panels

The advantages of Solar Photovoltaic (PV) panels for off grid-power generation have been obvious for decades, however the susceptibility of glass to breakage has been a serious integration issue, particularly as glass panel manufacturers in recent years have resorted to thinner glass as a cost cutting measure. Reports of "residential PV panels" failing in marine and off-grid commercial applications are on the rise, which is understandable as these products were never designed to take the pounding of salt water waves, stress from harsh environmental conditions, let alone the rock or bottle thrown by a vandal.

SunWare's robust non-glass solar panels are lighter than glass, thinner, salt/corrosion resistant and often produce more actual output per watt stated (due to less light reflection). A quality SunWare "Non Glass PV Module" enables fast and repeated redeployment (without glass breakage), smaller storage and weight requirements, and no danger to people or equipment due to the sharp aluminum edges found on most standard solar panels.

Meeting the needs of future off grid power requirements now

The requirement for Renewable Energy solutions to supply power to new technologies continues to increase. As mentioned in the introduction, scores of high demand, high technology products are entering the mission-ready environment – and have been developed to work off-grid.

The success of those new products and systems – and the success of operations and strategies based on those assets - will rely heavily on the power supply. This being of such importance, it is reasonable to want to understand drawbacks to renewable energy systems beyond "the wind does not blow" or, "the sun does not shine".

Failure of many off-grid renewable energy systems in the last decades has typically come from the following seven issues:

1. **"Hobby" or Consumer Rated Equipment placed in harsh environments or harm's way with the intention of commercial use.**
2. **"R&D" equipment being used in Mission-critical situations.**
3. **No site assessment – or site "tuning" on deployment**
4. **Solar being used where wind would be more appropriate (and vice verse) or only one charging method was used instead of both.**
5. **Lack of understanding of true power requirements (duration and load) resulting in under-powered charging systems.**
6. **Undersized batteries and battery banks**
7. **Wrong batteries used.**

Whether it is for customs & border protection, anti-terrorism operations, disaster preparedness & recovery or defense, designing systems to work ***and stay working*** in the real world requires experience, planning and investment in quality products and well constructed installations.

Unmanned Autonomous Equipment & Stations

Off-Grid Power often means no one will be handy nearby to maintain the system. Even if personnel are available for periodic inspections and random maintenance, most off-grid system must be designed to endure harsh condition operations without attention for months and sometimes years at a time, to realize full value.

The envelope for pushing unmanned and autonomous operations to the limit comes from all industries and users – sometimes in unexpected ways. A prime example of this is the planned development of unmanned autonomous surface vessels being developed for DOD operations by such companies as Harbor Wing Technologies, Inc, and others. These wind-powered and environmentally friendly vessels will be able to remain "on station" or conduct coastal patrols for indefinite periods of time and even though they are "wind, sail or wing" powered, they will need electricity on board for operations, safety and telecommunications – power that only renewable energies can deliver.

Cost Savings with Precision Point Delivery of Power

Many of the special projects that Mission Critical Energy has supplied equipment to have often enabled mission command to reduce, or even eliminate, the use of conventional grid power, thus eliminating costly grid connections to remote areas. It is not unusual that the use of individual site power generation provides substantial savings by eliminating the need for installation of grid power to all points (along a border for example).

Mission Critical Energy Off-grid Power Systems and "2025"

Mission Critical Energy has replaced grid power and the need for fossil fuel based generators in many locations. Depending on the project or application, these actions and projects may qualify towards "2025" goal implementations as set forth by DOD.

The National Defense Authorization Act (NDAA) of 2007. The NDAA 2007 codifies DoD's voluntary goal of 25% of all energy consumed by 2025.

United States Defense Secretary Robert Gates has identified energy as one of the department's top 25 transformational priorities and the armed forces – including the Army, Navy, Air Force and Marine Corps – have undertaken specific initiatives to save energy, mitigate climate change and reduce costs. The military is investigating and implementing energy-saving measures in all facets of its operations, both at home and abroad, including housing, vehicles, fuels, weapons, supplies and transmission grids.

Guidance from the Department of Defense, including practical information on renewable energy technologies is available in the DOD Energy Manager's Handbook : http://www.wbdg.org/ccb/DOD/DOD4/dodemhb.pdf.