Energy is the major input

for

overall socio-economic

development.

Following are the major advancement of our proprietary SWS – **S**mall **W**indmill **S**ystem in comparison to its pears PMG – Permanent Magnet Generator and Solar.

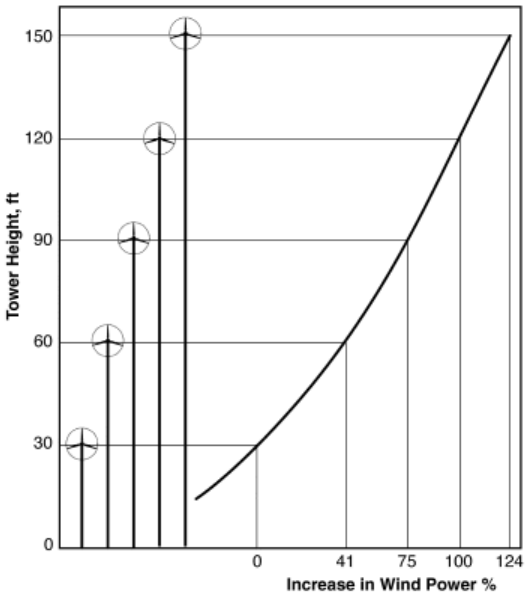
		Solar	Other PMG windmills	Our Windmill-SWS
1	External Power	**Yes - REQUIRED** External Power is not Must - In absence of External Grid Power or Battery Back-up, Solar nor PMG can utilize the Generated Power!! So these systems can't be relied upon in prolonged power cut!!		**NO** **External Power dependency** (electrically SELF-RELIENT / Self-sufficient) Even in absence of any Grid or Battery backup, SWS while meeting daily Captive power needs can also be a sole prolonged power for Disaster Management.
2	Negative Metering	YES Dependence & Consumption of external electricity when generating or even when idle leads to undesirable Negative Metering.		NO Since NOT dependent on ANY external power for ANY of our operations so "NO Negative Metering" is there, just the desirable 'Net Metering' only!!
3	Up-time	Average Uptime 6hrs/ day, Panels are useless when sun temperature exceeds, So 'More Sun = More Power' is NOT true. Sun is not there when needed the most winter and rainy seasons. Even though there may be enough Sun but still in absence of External Power there will be No Electricity Generation.	Low average uptime. Wind is available throughout the day, 4 times more than sun. Still the uptime of PMG is low because of High Starting Torque needs. Moreover a PMG can use the wind in given Min & Max range. So even if high wind is available still it can't use it for power production. At low wind < 7.5 mph & at very high wind speeds there is no wind energy (occurs about 10 -15 percent of the time). PMG need energy 24/7/365 for their own operation. This parasitic energy can be in excess to 20% of rated output, whether operating or not!!	Very high Up-time SWS Patented **S**elf-**E**xcited **i**nverted **S**ynchronous **G**enerator – **SEiSG**, since has no permanent magnets so there is No 'With Holding Torque' to over-come and hence the 'Starting Torque Requirement' is just limited to little friction of rotor mounting low friction & RPM SKF ZZ bearings. Also, being a Synchronous Generator, SWS is always started with NO Load. This two merits put together ensures SWS being always already in state of motion. Further, SWS's **Dynamic Load Management Control System** for **Speed to Torque** Conversion ensures apt loading & also the swift unloading for **Max Power per Rotation** at ALL/ ANY wind, while the Speed/ RPM is still managed to be low & acceleration being linear.
4	Starting Torque	NA	Very high initial Starting torque Requirement. A PMG which can produce a little power at around 3 M/S wind may still need Wind around 3.5-4M/S for starting/ initial rotation. So lot of opportunity to generate power is missed. Being "Permanent Earth Magnate Generator" it has very high withholding torque and as the KW rating increases so the withholding torque requirement.	Zero Initial/ Starting torque Requirement. Being non PMG, there is zero with-holding torque. So even at 2M/S wind it will already always be the state of motion even when not producing power and requires a very little wind (Law of Inertia) to start & generate. Irrespective of KW name plate rating the withholding/ starting torque requirement remains same i.e. low!!

5	Power	Maximum Power Point Tracking (MPPT)	Power is dependent on RPM, more the RPM more the power. So PMG have to run at 150 and above RPM for rated power. Further since output voltage which is proportionate to RPM, so not regulated at generation level hence the generated high voltage has to be step down while the charging current which is dependent on Torque remains the same. So the net power available for Charging which is product of step-down V & I will always be far less than the Generated Power attained using the product of generated Voltage and Current, and hence is misleading.	Our **proprietary** digital *Speed to Torque Converter* ensures maximum power per revolution, from the very first revolution!! So the rated Power can be attained near the blade TSR. i.e. the output voltage is regulated at the source (generation) itself and is not required to be manipulated subsequently at charging level. The power is increased with higher current generation because of high torque. So only SWS can produce and charge the batteries or feed the load with current upto 50ADC at constant output voltage which is 110VDC and 220VDC for 5KW and 10KW Systems, respectively.
6	Acceleration and Retardation	Not Applicable	RPM $\propto$ (wind speed)^3 Since acceleration & retardation is exponential to wind so sudden swings leads to higher stresses in the structure & adversely affects the over-all cost & life of PMG. At high RPM, rotor has very high moment of inertia and exponentially more power for yawing. High RPM leads to high noise & erosion of blades.	Dynamic Load Management System ensures smooth linear acceleration and retardation without sacrificing performance. Linear & low RPM helps in: 1. Stable Mechanical Structure. 2. Easy and efficient Yawing and hence higher production being always in the line of wind. 3. Less Noise, higher Blade & SWS Life.
7	CUF - Capacity Utilization Factor or PR- Performance Ratio	CUF 10 - 19% (max) without deducting external power consumption. Sun is only there for 6-8 hours a day. Rated power is available for 2 hours a day when sun is at peak. If temperature/ radiance is too high panels stop producing power.	CUF 20 - 30% (max) without deducting external power consumption. Note: A PMG designed for Low winds (high torque) doesn't yield its best efficiency at high winds and similarly PMG designed for High Winds is not very productive in Low Winds.	20 - 30% **without** any external power consumption. Our indigenously made generator can work at all the wind speed(s) without sacrificing the efficiency. Dynamic Load Management system and Speed to Torque convertor helps to utilize the every drop of wind in optimum way.
8	Maintenance	Regular Cleaning of the Solar Panel is must, as the efficiency goes down by as much as 17% because of the layering.	Small PMG which are Direst Drive has little wear & tear. But generator wake, high RPM and exponential acceleration leads to high stress on the structure.	SWS being Direct Drive and having NO Withholding Torque i.e. No Starting Torque (wake) stresses are there. More-over acceleration is constant & linear and the desired power is attained at low RPM. Similarly the generator too is forced natural air-cooled. All this leads to very rare Maintenance.

9	Auto Changeover Switch	Condition based Automatic two-way Changeover Switch without External Power Dependence are NOT there. Hence best utilization of generated and stored power is NOT attained.		Electrically Self-powered, Digitally Controlled, Intelligent Auto Switching between SWS & Grid Power ensuring SWS Generated Power is pushed first than Grid Power and then Backup power. This leads to Maximum Utilization of SWS power and Optimum Usages of Battery (otherwise rarely used for backup only), from the Day-one!! Leading to faster **R**eturn **o**n **I**nvestment.
10	Charge Controller	At best a MPPT, PWM, 3 Stage Charge Controllers are available in the market but these are external power dependent and consume power continuously even when not regulating or lying idle leading to negative metering most of the time.		'Maximum Power per Rotation' is attained through 'Speed to Torque Conversion' and 'Regulation of Charging Voltage at Generation Level' is achieved through "Digital Dynamic Load Management System" which ensures terminal VDC between 110% to 120% battery voltage thereby protecting battery from Sulphonation, Corrosion & High Temperature; inspite of charging at 50ADC which is 5 times the normal chargers. Note: SWS Charge Controller DOES'NT USES ANY EXTERNL POWER and hence can work even without battery backup or grid power!!
11	Protection/ Safety	Proven and safe but Dependent upon external power availability.	Proven and safe but dangerously Dependent upon external power availability. Doesn't Protect windmill or battery from over-voltage, just regulates charging voltage. There is NO 'No Load' or Open Voltage protection.	Three level security systems for Windmill & as well as Battery Over-voltage, No load and Over-speed Protection are automatically applied and also rolled-backed, Firstly through Digital Controller, Second line of protection is full-fledged Analog Controller, along with the last layer of safety i.e. Manual Bypass Switch.
12	Net Energy Meter and Data-logger	No Net KW/h metering is done. Even the external energy meters just measures the output power without deducting the external power being consumed by the system for various internal usages.		Proprietary/ Patented True RMS Digital Energy Meter, measuring and registering the cumulative units produces and used after deducting all the losses and internal consumption (as being self-powered). Even this Meter is powered with the generated electricity only. All the vitals are stored and available to end-users too, for criticism or evaluation!!
13	Land - Surface Area	Requires Very High surface / land.	Moderate but heavy structure in-order to support the high RPM as well sudden (non-linear) acceleration. As Dynamic Flux Management is NOT possible.	Moderate with light weight structure as SWS works at low and linear speed attained through Digital Dynamic Load Management - a patented technology. One of the great advantages of SWS is that it is a dual-use technology—its footprint uses only 3*3 Meter of the land, and the rest of the land terrace can still be used. Example – the landowner leasing to a wind farm, revenue ranges between $500 & $2K per turbine per year. That same land used for farming would generate about $100 per year!!
14	Temperature	At high temperature, Solar panels stops power generation!!	At High temperature, PEM – Permanent Erath Magnet losses its magnetic properties and the damage is irreversible.	SWS being air force cooled ensure temperature is never too high. Even in worst case if temperature rises - only resistance of field increases which is a reversible phenomenon.

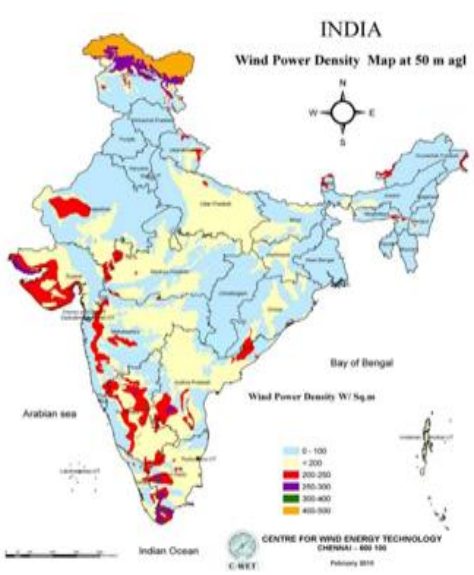
Following facts about wind has made WindSun Solutions Limited to focus more on harnessing power through renewable Wind than Sun:

1. Unlike Sun which is available for 6 to 8 hours a day wind is available 3 times more i.e. 24 hours.
2. SWS comes with 15M & 25M high towers. The graph on the right shows how a change in tower height affects the available power in the wind for a site that does not have obstructions above (buildings, trees etc.): Besides getting it to go turbulent air it can often be financially worth with a taller tower, since so much more energy can be harvested.



Since wind speed is the most important parameter for turbine energy production, getting that wrong has large consequences (the power in the wind goes with the cube of the wind speed, so double the wind speed and the power in it is 2 * 2 * 2 = 8 times as much).

3. India is very well placed on the wind map with respect to small windmill utilization point of view.
4. Power from wind is directly proportionate to wind density and to cube of wind speed; in India, from April to September air density is high this makes it an efficient fuel for power production through windmills.



$P = ½ \rho * A * V^3$ Where, P -Wind Power, ρ -Density, A is Swept Area, V - Velocity.

Or Wind Energy [kWh] = 2.09 • Diameter^2 [m] • Wind^3 [m/s]

The energy it calculates is in kWh per year, the diameter of the wind turbine rotor is in meters, the wind speed is annual average for the turbine hub height in m/s. The equation uses a Weibull wind distribution with a factor of K=2, which is about right for inland sites. An overall efficiency of the turbine, from wind to electrical grid, of 30% is used. That is a

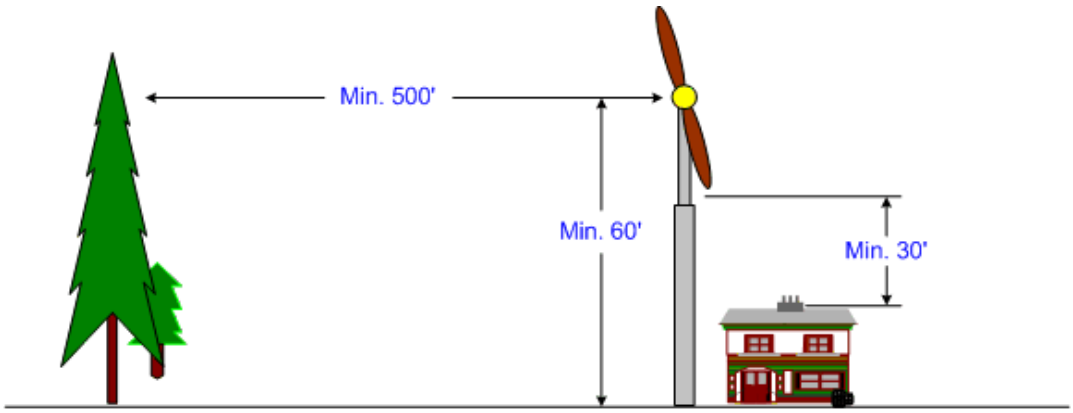
reasonable, real-world efficiency number. Here is a table that shows how average annual wind speed, turbine size, and annual energy production relate:

Diameter (M)	Annual Energy (kWh) by Horizontal Axis Blade							
6	3226	4815	6856	9405	12518	16252	20663	25807
Wind (M/S)	3.5	4	4.5	5	5.5	6	6.5	7

Similarly, Power [Watt] = 192 • Diameter^2 [m]

Diameter-M	Rated WATT @11 m/s		Diameter (ft.)	Rated WATTS@ 25mph
6.0	6920		18.0	5780
7.0	9410		21.0	7870

As can be seen from above formulas and tables; power from wind is significantly proportionate to Swept Area (D^2) and cube of Wind Speed. So SWS by default comes with 6M and 8M blades.



5. Solar Products requires large surface area or the precious land than occupied by the Windmills for producing the same amount of power.
6. Solar power is best utilized with a standalone DC load while our Windmills can be integrated for any existing AC / DC loads. Example Solar Street Lights with DC LED lamps will not active if the solar system is not working or under maintenance but our SWS's intelligent panels can switch to main power if the power from the wind is not available for any reason. This leads to an uninterrupted power in case of our SWS – Small Windmill System.
7. Our SWS can be integrated with any existing Solar System to compliment or supplement the power.

8. Cost of an Electrical Unit produced from our Windmills is less than the cost of an Electrical Unit produced from Solar. As the Rated power of a solar system can be achieved only for peak 1 to 2 hours out of 6 to 8 hours of sun light / heat availability. While Windmill can reach to its Rated Power many times a day.

   Note: maximum of 10% of sun watt falling is converted into electrical wattage, while according to Betz's law; a windmill can capture upto 59.3% of the kinetic energy in wind. Our SWS can achieve at peak 75% to 80% of the Betz limit.

9. In case of windmills particularly ours SWS there is great Ease of installation and Scalability in terms of capacity building which is not true with Solar Panels.

10. There are no or little regular maintenance required in case of our SWS as against Solar Panel Surface required to be cleaned for better heat conversion.

Though, Small/ Domestic/ Off-grid Windmills are/were there for more than a century now, in its modern avatar (windmill being used for electrical power generation instead powering the mechanical work), it's the Solar and the Large Megawatt Windmills which are more popular, even with their many limitations, as follows.

The limitations/ short-comings of Solar:

1. Solar panels require Large Surface/ Land. More power means more land!!
2. Regular cleaning / maintenance of the panel are must. In absence of this efficiency drops significantly. Considering, dust is very common and prevalent in India, Solar is not the right solution.
3. Availability of sun is just for 6 hours a day that to for 8 months a year (sun is not there when it is needed the most – winter and rainy seasons).
4. More sun more generation is NOT true for Solar, when sun is at peak or the temperature increases beyond a limit than the photovoltaic panels stops working. So it can be said that out 6-8 hrs of direct sun, panel do not work around 20% of time.
5. Solar Panels require External Power for generation & regulation too. So in absence of any external power (main or back-up) the Solar Panels will NOT given any OUTPUT even if sun is there!!
6. Even when NOT PRODUCING electricity, solar systems consume external power and most of the times it leads to Negative Metering (consumes more than produce).
7. Solar energy is variable (during a day and during variable cloudiness) and intermittent; usually it is minimal in the morning, maximal at noon about 3-5 hours before the daily peak

demand, minimal in the afternoon, minimal during foggy, overcast, snowy days, and zero at night.

8. Solar energy is variable (during a day and during variable cloudiness) and intermittent; usually it is minimal in the morning, maximal at noon about 3-5 hours before the daily peak demand, minimal in the afternoon, minimal during foggy, overcast, snowy days, and zero at night.
9. About 65-70 percent of the hours of a year solar energy is near zero, and it cannot be turned off, as in Southern Germany with about 1 million PV systems, when on sunny summer days solar energy surges to about 12,000 MW to 14,000 MW and has to be partially exported to France and the Czech Republic at fire sale prices, 5.5 euro cent/kWh or less, after having been subsidized at an average of about 50 euro cent/kWh.

Though Wind turbines are an effective subset of the world's energy supply, providing energy at 1% of the CO2e /GW as coal and even slightly less than nuclear, over windmills full-lifecycle, according to the best meta-analyses available, yet large format Megawatt windmills has following limitations, which our SWS has tried to over-come:

1. Specific windy sites are required.
2. Requires large surface area and baron land in the surrounding.
3. Very engineering oriented installation.
4. Power produced can best be utilized in Grid only.
5. Gear and other mechanical equipment require very high maintenance.
6. Very high initial capital required, not for the mass.
7. At low wind speeds (less than 7.5 mph) and at very high wind speeds there is no wind energy (occurs about 10 -15 percent of the time).
8. At high wind speeds the connected wind turbines may have an output up to about 80% of wind turbine rated capacity (occurs about 2 to 3 percent of the time); it can be kept below 80% by automatic curtailment, i.e., feathering the rotor blades which is much resisted by wind turbine owners because it reduces their incomes.
9. Example: The design capacity of the HVDC lines would need to be about 4,000 MW x 0.8 = 3,200 MW. This would require at least (4) 200 ft wide corridors each with 800 MW HVDC lines on thousands of 80 to 135 ft tall steel structures.
10. The exported wind energy would be 4,000 MW x 8,760 hr/yr x capacity factor 0.30 = 10,512,000 MWh/yr. The energy transmission of a conventional HVDC line is at an average of about 60% of its capacity. Thus the owning and O&M costs for dedicated wind energy transmission is about 2 times greater/MWh than for conventional transmission.

11. Dispersal of Wind Turbines Does Not Reduce Intermittency and Variability: Wind energy generation is variable and intermittent; usually it is minimal during summer, moderate during spring and fall, and maximal during winter. Almost all the time it is maximal at night.
12. About 10-15 percent of the hours of a year wind energy is near zero, because wind speeds are too low (less than 7.5 mph) to turn the rotors, or too high for safety. During these hours, wind turbines draw energy FROM the grid, and also during hours with moderate winds when parasitic energy exceeds the generated energy.
13. Note: Wind turbines need energy 24/7/365 for their own operation. The parasitic energy can be 10% to 20% of rated output on cold winter days, whether operating or not.
14. Example: German wind power output peaked at about 12,000 MW on July 24, 2011; four days later the peak was just 315 MW!!.
15. Require External Power for Power: Power Production/ Generation, Power Regulation, or Braking etc.

DC generators have been discontinued and now universally PMG- Permanent earth Magnets Generators are used as Aerogenerator. But like any other technology PMG too has its own pros and cons. SWS, has addressed & overcome the following limitations of prevalent PMG's:

1. PMG has high Withholding Torque and hence Starting Torque requirement is high.
2. While PMG doesn't require external power for generation but it still needs external power for regulation of the generated power.
3. Other alternate of PMSG- Permanent earth Magnets Synchronous Generators are conventional SG – Synchronous Generator where electromagnets are excited externally and hence the SG requires external power for both generation as well as regulation too.
4. PMG has predefined calculated fixed Magnetic Flux which can't be manipulated while in operation. So Regulation of output power at source itself with respect to Wind Speed or RPM etc, using a dynamic load/ flux management control system is not possible.
5. Temperature, faults and aging, affects the magnetic power of PMG adversely.
6. PMG being direct drive needs to rotate at high RPM in order to produce high power. i.e. Power produced is proportionate to RPM. Large Turbines manage the high RPM through complex costly gear system. High RPM even closer to TSR leads to lot of Blade Noise and surface erosion apart from adversely affecting the structure.

So, our SWS is unique & different in following ways in comparison with Solar, MW Windmills and other pear Small PMGs:

1. While, most commonly used as aero-generator, the Permanent (earth) Magnet Generators uses rare & costly earth magnets for active power my generator uses conventionally proven electromagnets, with significant design alteration.
2. Since there are no permanent magnets so there is NO WITHHOLDING TORQUE, withholding force is the magnetic force which resists the iron core rotor from moving it for the first time.
3. Since there is No withholding torque so STATRTING Torque requirement is limited to just the two bearings friction holding the rotor shaft which is very-very minimal.
4. So SWS comes to action/ rotation with very-very little wind.
5. Since SWS electromagnets are being excited separately but NOT EXTERNALLY, at right time that too with apt magnitude as per the changing winds so the SWS is always loaded and also unloaded dynamically to attain 'Max Power per Revolution'!! Instead of waiting for designed wind speed for best output, such wind may or may not come.
6. SWS while yielding 'Max Power per Revolution' also ensure linear/ constant rate of change of RPM i.e. acceleration as well as retardation is kept constant at low RPM bandwidth.

* Above comparison is based on information available in public-domain. Specs, Features & Performances are subject to change with time and advancement in respective technology.