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Mobile Power Supply For Smaller Military Units In Desert Conditions

By

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Abstract:

This paper presents one possible solution of combined electrical power supply for smaller military unit in desert conditions. Proposed mobile power generation set, of 1 kW rated power, has: photo-voltaic (PV) solar panels (with ability to be oriented in the position suitable for electricity production), wind-generator, storage battery and small petrol aggregate. Such solution allows long-term supply of necessary communication and other equipment, and supply of possible device for water desalting. The paper presents technical characteristics of created model, which consists of 760 W PV-supply, wind-generator of 250 W rated power, storage batteries of capacity 250 Ah at 24 V voltage level, and petrol aggregate of 1000 W rated power. Besides that, some results of the system's testing, done in average, continental climate conditions, are also presented in the paper. Tests were conducted during several months and shown also very high reliability level of system's components itself. The paper also emphasizes the possibility of creating such systems with extended rated power range, over 1 kW. Concerning the fact that the purpose and utility value of this independent electrical power supply system overcome the importance of its investment costs, it can be very prominent for military applications.

Keywords:

Small mobile electric power units, off-grid power supply, photo-voltaic, wind-generator

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1. Introduction:

The conduct of war has been drastically changed in the last few decades with the constant invention and application of new technologies. Inventions in material technology, semiconductors, electronics and informatics influenced the traditional armies of the world to undergo many changes. It is clear now that the wars of tomorrow will not be won only by sending troops on the battlefield but also by superior technology of computer systems, faster algorithms and altogether, reliable machines. The lifeblood of all those systems will be only one thing – reliable supply of electric energy [1].

For the use of military units in any country, electric energy could be supplied by national distribution grid or by some forms of isolated power supply. Under normal circumstances, military units are mostly situated in bases, and can rely on electricity from distribution grid. But being strategically important, every distribution grid is among primary targets in any armed conflict. By severing its electricity supply, a smaller or larger modern military unit could be severely crippled. Second type of power supply is off-grid, isolated type supply. Those systems usually constitute of one or several diesel or petrol generators. Such a power supply has its advantages such as:

- Proven technology of diesel engines,
- Ability to answer to every electric load on-site.

But, those systems have also great disadvantages:

- Dependency on fossil fuels,
- High maintenance needs,
- Noise emissions,
- Heat and gaseous emissions.

Constantly developing technologies of renewable energy systems offer alternative to fossil-fuel power supply [2]. Some advantages of renewable energy systems are [3]:

- Independency on fossil fuels,
- Low maintenance needs,
- No noise, heat and gaseous emissions.

For example, in some applications, small foldable photovoltaic cells could give just enough energy for a small piece of electronic equipment.

2. Military energy needs

Energy needs differ horizontally and vertically in army structure. Horizontal energy needs are needs that differ from one type of military unit to another. Vertical energy needs differ from one soldier to energy needed by the whole battalion. Military consumers of electric energy could roughly be divided into four categories:

- Individual – one or very few soldiers depending on one energy unit,
- Small military units – one mobile power energy system,
- Large military units – one large or a number of smaller mobile power energy systems,
- Very large military units and a number of machines – large (and usually) stationary power supply.

Also, different types of electric energy consumption exist: platform type and electronic type [1]. Platform loads are environmental controls, fans, lighting, desalting units (general energy needs). Electronic load usually consists of small to large electronic devices used for navigation, communication, computers and reconnaissance.

Dependency on fossil fuels has limited diesel and petrol generators so far, because of their constant need of fuel re-supply, as well as very capable maintenance crews in a case of generator failure. Any type of dependency in any military unit is a huge weakness, which could be very well exploited by enemy forces. For example, units which rely on constant fuel supply which are cut-off and left without fuel become completely useless.

Renewable energy technologies rely on ever-existent renewable fuels. Their advantages are:

- No need for fuels,
- Low maintenance,
- Often noise-free, "cold" power generators (no infrared emissions), as well as no gaseous emissions,
- Simple and modular systems.

Their main disadvantages are:

- Energy density – renewable energy systems could supply military units with modest electric energy needs,
- Reliability – renewable energy power generators rely on e.g., sun and wind, and without them, could not deliver electric energy needed.
- Need for electric energy storage – batteries, which are usually very heavy and could limit the mobility of military units.

The system proposed and described in this paper consists of solar photovoltaic panels, small wind-generator and additional back-up petrol generator. Similar system has been constructed and tested in European continental climate conditions. In such conditions, wind could deliver more energy than solar photovoltaic panels and as a consequence, system is made from mostly wind installed power. Desert conditions offer very reliable fuel supply – extended sunny hours, and proposed system gone through a change from mostly wind to mostly solar installed power. Wind generator is reduced in size and now presents a secondary power source. Petrol generator is only a back-up power supply and for higher and short-time electric energy needs.

Such a system could deliver modest amount of electric energy for very long time periods, without any need of re-supply. For military units which have only modest electric energy needs, such a system could prove to be the perfect one.
In a case of several military units being on the same place during a mission, with each one having its mobile supply unit, there is a possibility of interconnecting all mobile power units into one stronger and more reliable power source.

3. Technical characteristics of mobile power supply

Mobile power supply is autonomous hybrid system for providing electric energy to smaller military units. System is placed in simple car trailer, which could be towed by a military truck or even a jeep [4]. Trailer holds following equipment:

- Solar photovoltaic panels which are mounted on top of trailer, or could be placed around it,
- Wind generator which could be assembled on site, and placed by the trailer,
- Several batteries,
- Petrol generator and small gas tank,
- Electronic control system,
- Consumer connection apparatus.

Figure (1): *Mobile hybrid power supply (1 kW installed power)*

Solar photovoltaic modules are placed on top of trailer, and are always connected to electronic control system and batteries. Such a connection provides possibility of charging batteries even if the trailer is in move. Modules have possibility of angle adjustment, for optimization of solar energy conversion. Total installed power of solar photovoltaic panels is 760 W. Only this subsystem could deliver up to 4.5 kWh daily of electric energy throughout the year in desert areas.
Wind generator is disassembled and placed in the trailer's interior. Upon arrival on desired location, wind generator could be assembled by several soldiers, and placed into function. Its maximum power is 250 W, and on convenient locations it could deliver up to 2 kWh of electric energy daily.
Batteries are placed inside a trailer. With voltage of 48 V and capacity of 250 Ah they can store electric energy of up to 12 kWh.
Petrol generator is placed inside a trailer, and could be set to start as soon as battery voltage drops below certain level. With its maximum power of 1 kW, it could deliver electric energy of up to 24 kWh, per day, but only while fuel supply lasts.
Electronic control system consists of charging regulators for photovoltaic panels and wind generator, as well as battery charger for petrol generator.
Consumer connections are devices such as DC/DC converters and DC/AC converters. It is possible to deliver DC energy of any standard voltage level (3, 6, 12, 24, 48, 72 V) through a DC/DC converter. Those electronic devices also protect batteries from over discharging, as well as electrical faults caused by consumer.

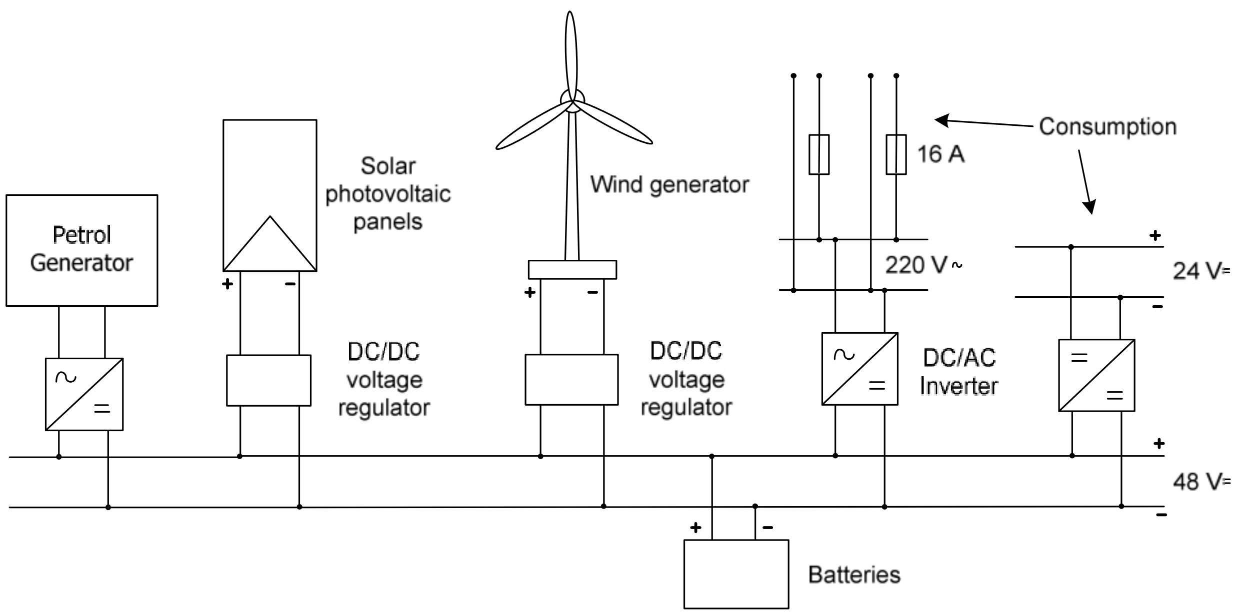

Figure (2): *Simplified scheme of mobile hybrid power system*

DC/AC converters (or inverters) could deliver AC electric energy of standard voltage levels (115, 230 V) and standard frequencies (50, 60, 400 Hz).
Simplified scheme of mobile power supply system is presented in Figure (2).

4. Some results and conclusions after mobile power supply testing

Mobile power supply can deliver instantaneous electric power up to rated power of DC/DC converters or rated power of DC/AC inverters. During testing, mobile electric system successfully delivered electric energy through several systems:

- DC/DC converter 24 V, 10 A,
- DC/DC converter 48 V, 10 A,
- DC/AC converter 500 W, 230 V, 50 Hz,
- DC/AC converter 1000 W, 230 V, 50 Hz,
- DC/AC converter 2000 W, 230 V, 50 Hz.

Testing also included measurement of electric energy harvested by photovoltaic panels and wind generator. Results are shown in Table (1). Data acquisition system also recorded energy delivered by wind generator. Results are shown in Table (2).
It is important to notice that these results are obtained in European continental climate conditions, and therefore could significantly vary from one location to another [5-6].
Possibility of giving an answer to sudden power consumption change and to respond to high motor start-up currents have also been tested, for both petrol generator and electronic converters. Some conclusions emerged:

- Petrol generator answered to any consumption within its rated power range, and maintained voltage level, frequency and sine-wave shape. Its main disadvantage is inability to be overloaded, even for shorter time periods. Also, petrol generator choked when very sudden high power demand (below its rated power) appeared. In few tests, petrol generator shut down. Inertia of petrol engine was not high enough to answer such a quick change.
- DC/DC converters are most flexible within their rated power range and able to deliver any power, practically instantaneously. They could also be overloaded for short periods of time.
- DC/AC converters were mostly compared to petrol generator. They were able to pick up any load change within or 50 % above their rated power very quickly. To a very sudden changes inverters answered with lowering output voltages, but resuming normal function in a very short time. Also, inverters tested were able to withstand overload of up to 300 %. This fact represents an ability which is very well suited for motor start-ups.

Table (1): *Photovoltaic panels electric energy production*

Month	Average monthly production (kWh)	Average daily production (kWh)	Average daily production by square meter (kWh/m^2)
October	85.00	2.74	0.50
November	48.72	1.62	0.30
December	38.11	1.23	0.23
January	43.93	1.42	0.26
February	58.56	2.02	0.37
March	89.98	2.90	0.53
April	103.81	3.46	0.64

Table (2): *Wind generator electric energy production*

Month	Average daily production (kWh)	Average monthly production (kWh)
October	0.59	19
November	1.33	44
December	22.84	740
January	4.65	150
February	1.28	44
March	1.64	53
April	1.05	35

Figure (3) shows the influence of electric fridge (240 W rated power) connection to an inverter of 500 W. Upper image presents voltage drop during fridge compressor start-up, and image below is start-up current.

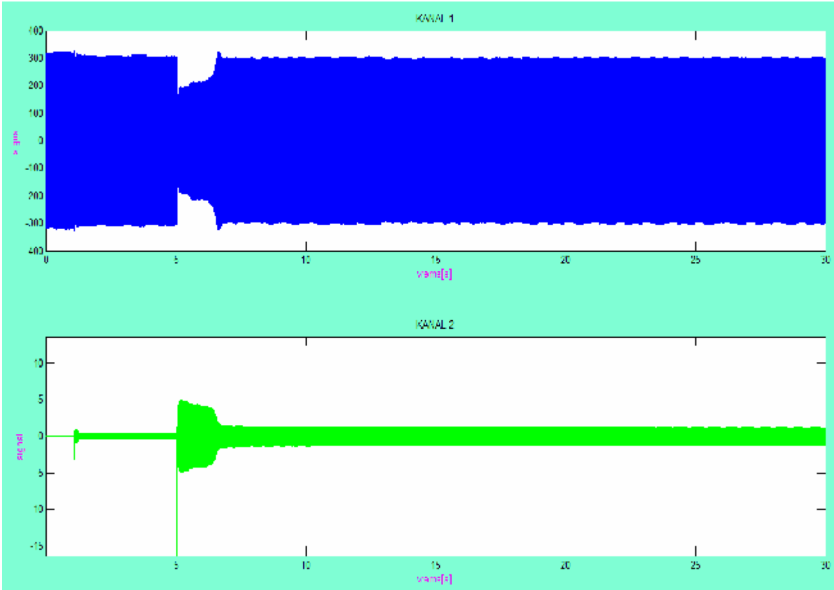

Figure (3): *Testing inverter by connecting small motor consumer*

5. Conclusion

During the year of 2009, mobile power supply has been designed and tested [7]. System was also left alone for extended time periods, during which it constantly powered various measuring and communicating equipment. It was able to replenish its battery storage and maintain itself in ready-state.

One of the system's advantages lies in its modularity, or possibility to add more components like additional solar cells, additional batteries, or another converter for power consumption. Also, if certain element breaks down, it can be very easily replaced. Another advantage is its need for very low maintenance.

System is mobile, and could be very easily transported from one place to another. If higher electric energy needs exist, several mobile power systems could be interconnected together to combine their output power.

Mobile power system does not need refueling and can stand alone for its entire operational life.

Even in situations of catastrophic events (floods, earthquakes, war refugee camps, etc.) [8], military could use such systems to deliver electric energy to those who need it the most – civilians.

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