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Hybrid power generator based on wind, hydro and solar for use as an alternative solution for power supply

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Abstract. The paper proposes the design of a hybrid generator based on wind, solar and/or hydro power. The proposed generator is intended to be used in areas where there is no power supply. Such a situation may be a house located in an isolated geographic area. Another application can be a portable hybrid generator. The existence of many geographic areas where it is not possible to expand the electric grids or isolated places in terms of relief, road access especially during the winter period leads to the necessity to use alternative electric sources. As an example, one can take into account the mountain area where the only access road is non-auto. Conventional alternative electrical sources require refuelling or are sources whose components are fixed and fitted permanently or are difficult to remove-mounted elsewhere. Often, component parts are considerable or require technical skill to be properly designed.

1. Introduction

Solar thermal is one of the main sources of renewable energy because it is the largest available globally. If only 1% of the desert area of the earth were to be used for the construction of plants to produce electricity, the energy needed for the year 2017 would have been assured. Also, solar radiation is more homogeneously spread in the tropical-equatorial area of the globe than wind or biomass, so more locations for plants are available than for the other two sources [1], [2]. Solar energy production technologies are the most economical in terms of costs, becoming competitive with conventional fossil-fueled power plants.

1.1. Why solar energy?

The amount of energy received from the sun corresponds annually to 1.5 billion million MWh, which represents about 23 000 times the current energy consumption, or 5-10 times the sum of all known fossil fuel reserves, including the ore uranium. The availability of this energy depends on the day-night cycle, the latitude of the place where it is captured, the seasons and the cloudy [3], [4]. Photovoltaic solar energy is based on the direct production of electricity through silicon cells [5]. When it shines and when the climate conditions are favorable, the sun provides a power of 1 kW / sqm [6]. Photovoltaic panels allow the direct conversion of electricity to 10 to 15% of this power [6]. For example, a photovoltaic roof of 5x4 meters has a power of 3kW and produces 2-6 MWh / year [7]. The photoelectric effect, namely the conversion of solar energy ("photon") into electrical energy ("volt"), was discovered in 1839 by physicist A. Becquerel [8]. This effect is based on three simultaneous physical phenomena, closely linked to each other: absorption of light by materials, transfer of energy from photons to electrical loads, collection of loads.



2. The proposed solution

The proposed solution takes into account the following mandatory features for such units:

- Easy, portable equipment that can be moved and mounted by a single person.
- All equipment should not exceed 20-25 Kg.
- Ability to capture and store as much electric power as possible in terms of overall dimensions and weight.
- Ability to capture any type of electricity, hydro, solar and wind.
- Operating life of at least 20 years for the system and 5 years for batteries (the batteries can be replaced).
- Easy to mount, exploit and weatherproof.
- Low cost.
- mini-turbine with vertical spindle 24V - 200W
- photovoltaic polycrystalline panel 30Wp
- 12V / 24V / 15W hybrid wind-solar controller
- Inverter 12V c.c. - 220V c.a., 500W
- Non-maintenance gel battery 12V - 24Ah
- 5V power supply c.c. (1 USB port), 12V cc (1 port), 220V c.a. (1 port).
- Portable aluminum frame, copper connectors and cables, fuse 10A (auto), on-off switch.

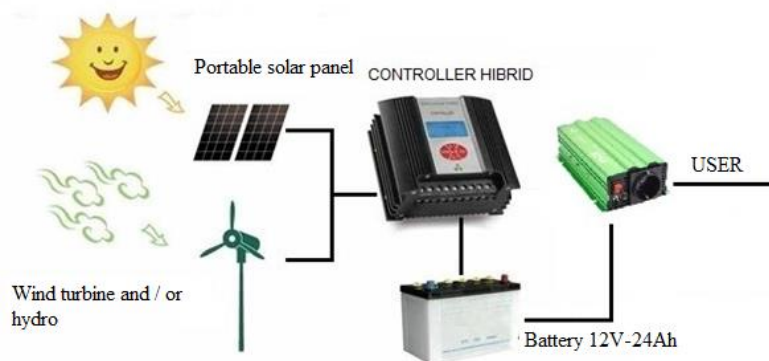


Figure 1. The hybrid power generator

2.1. Technical characteristics of the turbine

The blades capture the kinetic energy of the wind that they transmit to the three-phase generator, synchronous with an AC permanent magnet. It transforms kinetic energy into electrical energy.

Turbine technical specifications:

- Nominal power: 200 W
- Rated voltage: 24 V
- Starting Wind Speed: [m / s]: 2
- Nominal wind speed: 10 m / s
- Wind speed of survival: [m / s]: 45
- Minimum working temperature: [° C]: -40
- Maximum working temperature: [° C]: 80
- Weight: 5 Kg
- Generator type: three-phase, synchronous, permanent magnets



Figure 2. The wind turbine

2.2. Design of the hybrid generator

These turbines are used together with a hybrid controller that can be used in parallel on photovoltaic panels systems. The wind / hydro-solar controller is a device that simultaneously controls the efficient charging of the wind turbine-hydro and the solar photovoltaic panels. To design such a generator, calculate the average charge value for each alternative power source.

Technical characteristics: The load regulator has the ability to automatically detect the 12V / 24V voltage. Possibility of setting the type of solar batteries used: VRLA, AGM, GEL. The charging controller protects the system from overloading or discharging (minimum limit is 11.1V), overheat protection, short-circuit protection.

The hybrid generator nominal power is 350 W, and have connectors for: solar panel + wind turbine, accumulators and consumers.

Without using a controller between a solar panel and a battery, the panel would overload the battery by generating too much energy, causing serious damage to the battery.

When the battery falls below a certain voltage level, the controller disconnects the battery charge to prevent the battery from draining. A fully discharge battery will lose part of its total capacity over time. Low battery voltage may damage the battery if the load is connected. The controller has the function of stopping any current flowing back into the solar panel at night. This prevents damage to the solar charging kit.

It is proposed to use a PWM controller with a new technology to increase battery life, LED indicators to indicate battery charging status, and temperature compensation by automatically changing charging parameters, overload protection, discharge and short circuit and reverse polarity.

The USB port ensures the loading of mobile devices with a direct USB charger. The USB port can connect 2 consumers simultaneously with an absorbed current of max 1.2A. You can set the type of battery that can be charged to avoid damaging it.

The controller used will be a PWM and will be optimized to get the maximum battery charge current, depending on their model (VRLA, AGM, GEL), decoupling other functions that do not require use for this purpose (e.g. twilight sensor, various time-outs), functions that consume extra electricity from the two photovoltaic, wind / hydro units.

Depending on the load algorithm, the solar charge regulators are of two types: PWM (Pulse Width Modulation or Impulse Modulation) or MPPT (Maximum Power Point Tracking or Maximum Power Point Tracking).

PWM Charge Controllers constantly check the battery condition to determine the impulse transmission speed, but also their intensity. In the case of a charged battery, the charging regulator will transmit short pulses, and the impulse will be almost continuous when pulled out. Also, this type of controller can check the charge status of the battery between pulses and adjust them as needed. Basically, the PWM charging controller uses a simple operation system, being an on-off switch. Controllers - PWM load regulators are used in small photovoltaic systems and under high temperature photovoltaic panels.

MPPT Charge Controllers have the ability to manage voltage much better than PWM controllers and are typically used in photovoltaic systems whose output voltage across panels is higher than the battery bank voltage and systems operating under conditions of low photovoltaic panel temperature.

2.3. 30W solar panel

A 30W solar panel normally produces 4A/hr in bright sunshine. For the 12V-24Ah chosen battery, it will take about $24/4 = 6$ hours of sunshine to theoretically charge from 0% to 100% of the battery. Knowing that the storage capacity of the battery will never fall below 20% due to the limitation of the controller we will calculate the average charging time under ideal conditions. Considering the energy losses on the photovoltaic panel-hybrid-battery controller it is considered that the full load time in bright sunshine conditions (ideal case) is about 6 hours. Under average sunshine conditions, the maximum charge time is 7 hours.

2.4. Hydro-wind turbine 24V - 200W

Considering that the electric circuit is equipped with 12V batteries and the controller detects this voltage, it results that this turbine will generate double the power, ie 400W at nominal speed. According to the formula $P = U * I$, taking into account these aspects result in nominal power: $200\text{ W} = 12\text{ V} * I$ resulting approximately $I = 16.5\text{ A}$.

Mathematically speaking, charging the 24Ah battery at a nominal rotation (ideal case) of the generator will take place in less than one hour. As in the case above, the battery will never fall below 20% of the power load and by adding the power losses on the hybrid-battery generator-circuit controller it is considered that the full charging time under nominal rotation conditions (ideal) is about one hour. Under average and fluctuating rotation times of the generator, the maximum loading time is considered 2 hours.

We propose 2 variants

Variant 1 = parallel operation of the photovoltaic panel and of a single hydro or wind generator, we can approximate the average charging time of the whole battery system in maximum one hour.

Variant 2 = parallel operation of the photovoltaic panel and 2 hydro + wind generators, we can approximate the average charging time of the entire battery system in 30 minutes.

Designing the whole assembly will be done taking into account the maximum weight a man can carry for a longer time, 20-25 Kg.

The formula of calculation takes into account the weight of the person wearing the equipment, knowing that a person can carry in average a quarter of his own weight. The average calculation was made for a person of 80-100 Kg.

Considering that the power discharged by two alternative power sources (variant 1) is sufficient to keep the battery loaded and considering that the entire assembly does not exceed the average weight, it will be used for a vertical shaft generator to which the propeller it can be used both in hydro-generator system and in wind system (according to generator image).

In Figure 3 the scheme of the proposed system is shown.

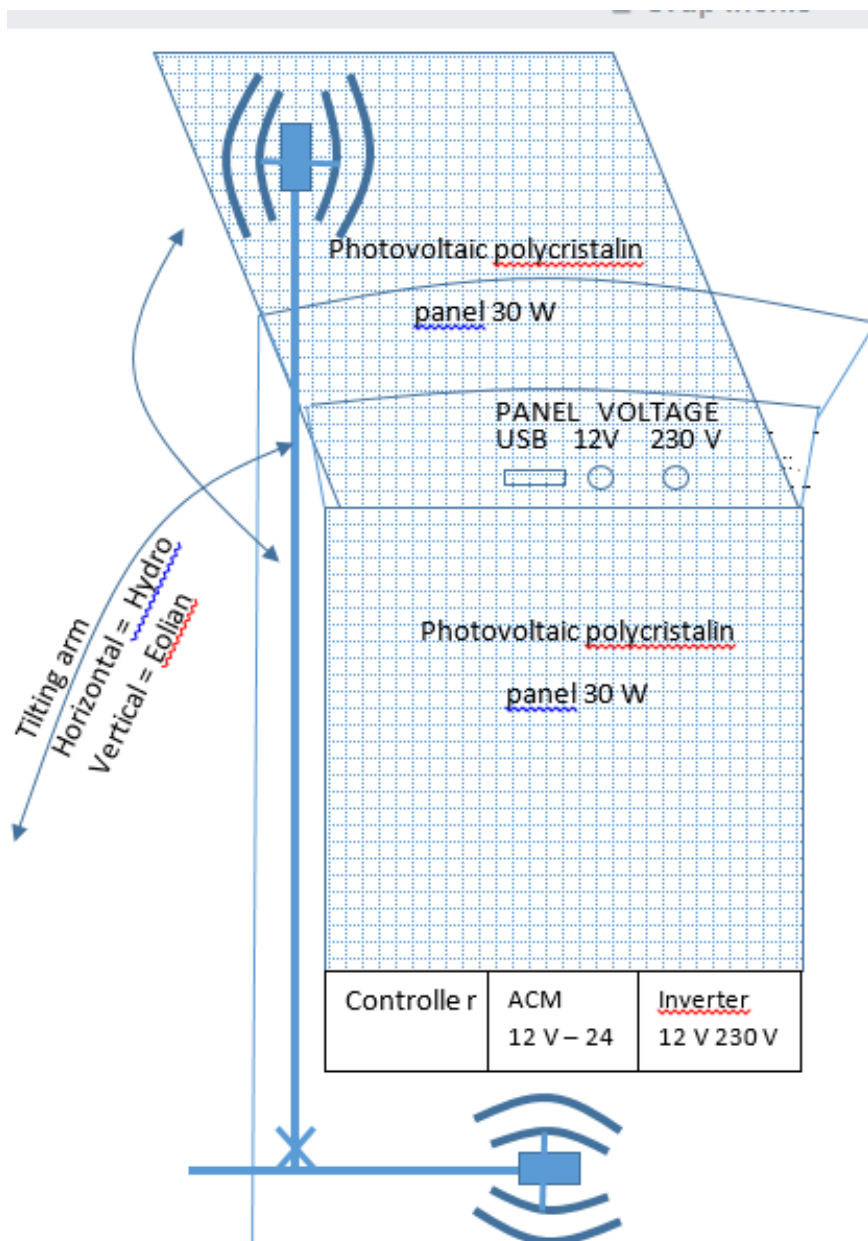


Figure 3. The structure of the propose portable hybrid generator

3. Conclusions

The need to use alternative energy sources is increasing. Transforming solar and hydraulic power especially small hydropower into electricity is not polluting [9], [10]. The paper proposes such a system to capture solar, hydro or wind energy as needed. The proposed solution can be used as a portable mini-generator for areas where there is no power supply. This way, you can supply some equipment that is absolutely necessary. With some modifications the proposed solution can also be used as a generator for a building located in an isolated geographic area where either there is no electricity or it happens frequently that the power supply is interrupted.

References

- [1] Guo S, Liu Q, Sun J and Jin H 2018 A review on the utilization of hybrid renewable energy,

- Renewable and Sustainable Energy Reviews* **91** 1121–1147
- [2] Mahmoudi H, Spahis N, Goosen M F, Sablani S, Abdul-Wahab Sabah A, Ghaffour N and Drouiche N 2009 Assessment of wind energy to power solar brackish water greenhouse desalination units: A case study from Algeria, *Renewable and Sustainable Energy Reviews* **13** 2149–2155
 - [3] Rogers J G, McManus M C and Cooper S J G 2013 Potential for reliance on solar water heating throughout the summer in northern cloudy climates, *Energy and Buildings* **66** 128–135
 - [4] ***https://www.worldenergy.org/wp-content/uploads/2016/10/World-Energy-Resources_FullReport_2016.pdf
 - [5] Yuan J, Farnham C, Emura K and Lu S 2016 A method to estimate the potential of rooftop photovoltaic power generation for a region, *Urban Climate* **17** 1–19
 - [6] Vartanyan Yu L, Grigoryan A K, and Shahinyan H A 2015 Maximum Mass of Strange Stars and Pulsars with the Most Accurately Measured Masses, *Astrophysics* (2015)
 - [7] Desideri U, Campana P E 2014 Analysis and comparison between a concentrating solar and a photovoltaic power plant, *Applied Energy* **113** 422–433
 - [8] ***<http://solenergy.com.ph/solar-panel-philippines-edmond-becquerel/>
 - [9] Deaconu S I, Babău R, Popa G N and Gherman P L 2018 Hydroelectric power plant with variable flow on drinking water adduction, *IOP Conf. Ser.: Mater. Sci. Eng.* **294** 012023
 - [10] Dinis C M, Popa G N and Iagar A 2017 Analysis of synchronous and induction generators used at hydroelectric power plant, *IOP Conf. Ser.: Mater. Sci. Eng.* **163** 012033