Classification of Green Energies and Possibilities of their Effective Use

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Abstract: *Wind, water, earth and fire, according to ancient philosophy, are the basic elements of the entire cosmos, with the help of which the existence of all things on planet earth is realized. Three (wind, water and earth) of these four basic elements represent renewable energy sources (RES), and in that sense also sources of green energy (GE). While the world, especially in the most developed countries of the world, has advanced far in the application of various forms of green energy, in Georgia this field is in its infancy and it cannot be predicted when the first major positive developments in this field will be made. The paper provides a basic division of sources (forms) of energy, taking into account the possibility of depletion over time, as well as examples of efficient application of hybrid green energy systems, for converting energy, primarily wind and sun, into electrical energy. Thus, the development and application of hybrid green energy systems, from a scientific and industrial point of view, will be one of the main goals in the future.*

KEYWORDS: *ENERGY, ENERGY POLICY, GREEN ENERGY (GE), SUSTAINABLE ENERGY (SE), CLEAN ENERGY (CE), RENEWABLE ENERGY (RE), RENEWABLE ENERGY SOURCES (RES).*

1. Introduction

Energy represents the ability of a body or system to do some work. There are many forms of energy, such as: Kinetic energy, Potential energy, Thermal energy (heat), Internal energy, Electrical energy, Chemical energy, Elastic potential energy and others.

One of the most commonly used forms of energy is electricity, which is a basic part of nature. It is produced by the effect of the electromagnetic field on the electric charge. It represents the so-called a secondary (or transformed) form of energy as opposed to the primary ones that occur in nature. The global tendency is for electricity production to increasingly shift to renewable energy sources (RES) for environmental reasons.

The consumption of energy in the world, from year to year, is growing, and therefore the need for its production is also increasing. The vast majority of that energy is from non-renewable sources (currently more than 80%), which is already causing undesirable consequences for the environment. One of the solutions, in accordance with the principles of sustainable development, lies in reducing the share of fossil fuels in the total production and consumption of energy. So, the share of renewable energy sources (RES) should be significantly increased in the future, because there are fewer and fewer non-renewable energy sources and their reserves are running out, and also their harmful influence has become more pronounced in the last few years. The sun, without which there is no life on our planet, gives the Earth several thousand times more energy than humanity manages to consume at the current stage of development. Everything speaks in favor of the fact that renewable energy sources (RES) can and must begin to be used better.

Currently, of the annual energy consumption, at the world level, appr. 50% spend on industry, appr. 25% is used for transport, and the remaining 25% is consumed by households and the commercial sector. Out of the total consumed of all types of energy, 40% is mostly used for the production of electricity, of which app. 60% is spent in households and the commercial sector. China and India have the highest growth in consumption of all types of energy, at the world level, and of the developed countries, the highest growth in energy consumption is recorded in the USA, while the EU records a decrease in energy consumption from appr. 2%.

If this pace of growth in energy production and consumption continues and if the predictions of scientists in this field come true, in fifty years, it is predicted that the total energy consumption will double compared to the current period. With the doubling of energy production and consumption, the consequences for the environment will be unfathomable.

The state and perspectives of the development and application of different types of green energy in different countries of the world are presented in papers [3-4, 17-19, 25-27, 29-30, 34, 38].

All these facts show that the best solution from this situation is in the increasing use of renewable energy sources (RES) and green energy (GE), which is the goal of this paper through the examples of effective application of hybrid green energy systems.

2. Classification of Natural Energy Sources

Considering the time possibility of exhaustion, natural or. primary sources (forms) of energy can be divided into (Fig. 1) [8, 11, 22, 24-25, 28, 37]:

1. Non-renewable energy sources (NRES):
   - Fossil fuels (coal, oil, natural gas, oil shale);
   - Nuclear fuels;
2. renewable energy sources (RES):
   - Water power (energy of water currents, sea currents and waves, tides);
   - Biomass and biogas, including wood and waste;
   - Solar radiation energy;
   - Wind energy;
   - Earth's internal heat (geothermal energy);
   - Tidal energy;
   - Wave energy

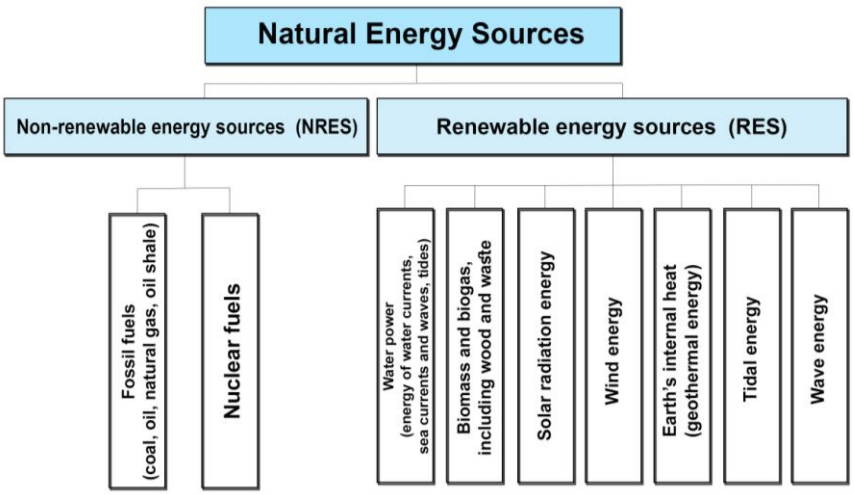

Fig. 1. *Division of natural or of primary sources (forms) of energy, considering the time possibility of depletion*

Renewable energy (RE) is that form of energy that is renewable (naturally replenished) and produced from sources that are constantly renewed, meaning that this form of energy is created from natural sources (Sun, wind, rain, waves, geothermal heat and similarly).

There are different types and categories of renewable energy sources (RES) (Fig. 1). According to the time of creation, renewable energy sources (RES) are divided into two main categories:

- traditional renewable energy sources such as biomass and energy from large hydroelectric plants and
- ”new renewable energy sources” such as solar energy, wind energy, geothermal energy and the like.

In addition to renewable energy (RE), the following terms are often used in the literature: green energy (GE), sustainable energy (SE) and clean energy (CE). The question arises whether there is a difference between: GE, SE, CE and RE energy and what is the difference.

Although the resource of these energies can be simultaneously all these forms of energy at once, it can also be e.g. renewable but not green or clean (as is the case with some forms of biomass energy). For example, energy production that burns organic material from sustainable forests is a type of renewable energy (RE), but it is not green (GE), because of the CO_2 produced by the burning process itself. Or energy sources that use mining or drilling operations that can be harmful to the environmental ecosystem are not green. Also, green energy is energy derived from natural sources, while clean energy is energy gained from sources that do release air pollutants [8, 11, 22, 24-25, 28, 37].

Green energy (GE) or sustainable energy (SE) is any type of energy that is generated from natural resources (such as: sun, wind or water), and the effect of its use is to have as little harmful impact on the environment as possible. Wherein there is a dilemma whether a hydropower dam that can divert water flows and negatively affect the local environment should really be called green [1, 5, 8, 12-16, 23, 37, 40].

The most commonly used green energy sources (GES) are: wind energy, solar energy, hydroelectric energy (including tidal energy, which uses ocean energy from the tides in the sea), geothermal energy, biomass energy and biofuels. Application of GES is expected in modern intelligent, sustainable and green manufacturing systems and digitized and smart factories [6].

The development and use of renewable and green energy, especially from the Sun, wind, water and biomass, is important for the following reasons:

- these energy sources have a very important role in reducing the emission of carbon dioxide (CO_2) into the atmosphere;
- increasing the share of renewable energy sources increases the energy sustainability of a country's system, at the same time helps to improve the security of energy supply and thus reduces dependence on the import of energy raw materials and electricity;
- in due time, renewable energy sources are expected to become economically competitive with conventional energy sources.

Economic competitiveness is already demonstrated by several technologies of renewable and green energy, especially solar energy, wind energy, small hydropower plants, energy from biomass. The main problem for the installation of new plants is their initial price, because it raises the price of the obtained energy in the first years even to the level of complete unprofitability compared to other commercially available energy sources. It should be emphasized that a large share in the production of energy from renewable sources is the ecological awareness of the population as well as the political will to invest in plants for the production of ”green” energy.

3. Examples of Effective Use of Green Energies

Through examples of effective use of green energies, solar energy will be shown, which can be produced on a small scale in people's homes or, alternatively, can be produced on a larger, industrial scale.

Solar energy (SE) is produced from the sun using photovoltaic (PV) cells that capture sunlight and directly convert it into electricity, using the PV effect without emissions, noise or vibration. PV effect depends on interaction of photons, with energy equal to, or more than, the band-gap of PV materials. Some of the losses due to the band-gap limitations are avoided by cascading semiconductors of different band-gaps [7, 10, 23]. Solar energy is also used to heat buildings and hot water, as well as for cooking and lighting. Solar energy has now become affordable enough to be used for domestic purposes, including garden lighting, although it is also used on a larger scale to power entire neighborhoods [23, 34].

Solar photovoltaic (PV) cells were invented at Bell Labs (Bell Telephone Laboratories Inc.) from Holmdel (New Jersey – USA) in 1954 and they have been used in space satellites for electricity generation since the late 1950s [11, 35].

The cost of producing electricity from sunlight is extremely high, despite the fact that sunlight is free, although prices are starting to fall. The main reason is that solar energy has a low energy density, so photovoltaic modules require a large area to produce a small amount of energy.

Main of Grid connected photovoltaic system is shown in Fig. 2, where is the primary component in grid connected PV systems is the inverter, it converts DC power produced by PV array into AC power consistent with the voltage and power quality requirement of the utility gird [23].

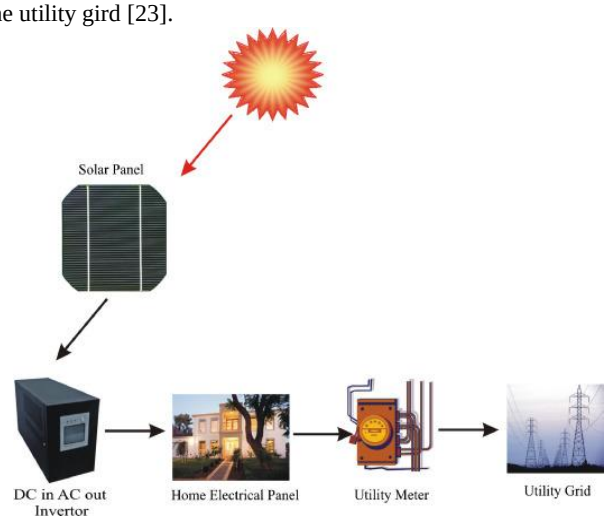

Fig. 2. *Grid connected photovoltaic system [23]*

In the following, several examples of the application of solar panels and solar PV (photovoltaic) plant in different areas of the world will be presented.

On Fig. 3 shows them solar panels installed at the Electronic faculty of the University of Niš (Serbia) for education back in 2011 and serves exclusively educational and demonstration purposes [32]. The software SUNNY DESIGN of the company SMA GmbH from Kasel (Germany) was used for the calculation of energy consumption [31].

On Fig. 4 shows them Solar tower power plants PS10 and PS20 near Seville, in Andaluzia (Spain). Heliostat field of this plant is composed of 1255 heliostats, each surface of 120 m^2. The tower is 165 m high. On the top of the tower there is a steam turbine that starts generator for the production of electrical energy. Construction of the CSP (Concentrating Solar Power) plant PS20 was begun in 2006 and it was installed in 2009. When compared to PS10, PS20 plant has bigger efficiency, better monitoring system and better thermal energy storage [20, 26].

Fig. 3: *Solar panels installed at the Eectronic faculty of the University of Niš (Serbia) [32]*

Fig. 4: *Solar tower power plants PS10 and PS20 near Seville, in Andaluzia (Spain) [20, 26]*

Solar PV energy offers the best solution for remote agriculture and there are numerous applications of solar panel technologies in agricultural farm due to innovations in agricultural technology [2]. Development and application of solar panels and solar energy technologies in agricultural sectors (agricultural systems, agriculture farming, sustainable agriculture farming, big farming, small scale farming and etc.) is shown in the papers [2, 9, 21, 25, 35-36, 39].

On Fig. 5 shows them example use of solar energy in agriculture [35].

Fig. 5: *Use of solar energy in agriculture [35]*

On Fig. 6 shown them solar photovoltaic panels providing green energy for agricultural growth [35].

Fig. 6: *Solar photovoltaic panels providing green energy for agricultural growth [35]*

On Fig. 7 shown them the space, shelter or breeding for livestock and greenhouse heating [2].

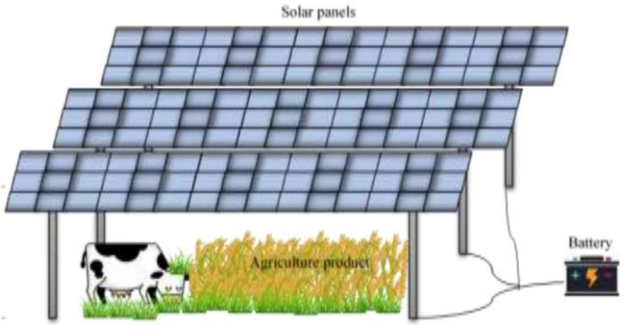

Fig. 7: *Solar panel technology system operation for both agriculture and livestock [2]*

Tractors, the most important and central technology and machine on every farm, usually use diesel oil as their energy source. Solar machines and tractors use solar energy converted into electricity. One way of using solar energy in the form of electrical energy is by using solar panels fixed on machinery or tractors (Fig. 8) [36].

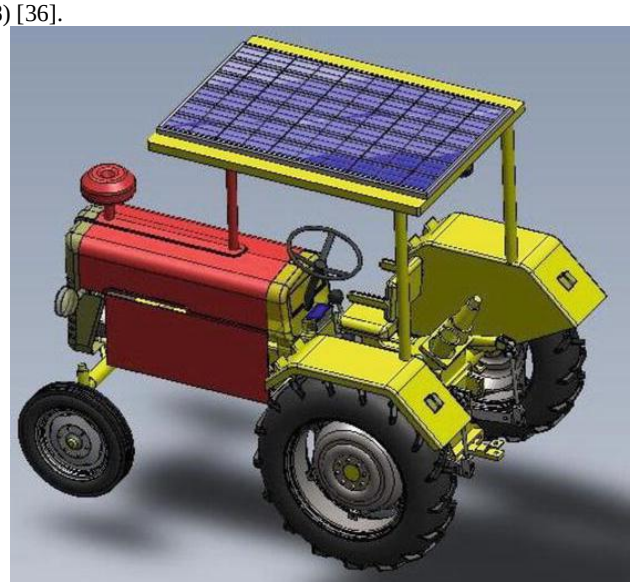

Fig. 8: *Schematic diagram of solar powered tractor [36]*

On Fig. 9 shows the Nellis Solar Photovoltaic Power Plant with power 14.2 MW located in 2007 within Nellis Air Force Base (NAFB) in Clark County, northeast of Las Vegas (Nevada – USA), as largest solar plant in this region. It covers an area of 140 hectares and consists of 72.000 solar modules that follow the movement of the sun during the day (trackers). It is estimated to produce 32 GWh per year of electricity annually and supplied more than 25% of the power used at the base and reduce CO_2 emissions by 24.000 tons per year.

Fig. 9: *Nellis Solar Photovoltaic Power Plant with power 14.2 MW (USA) [20, 25]*

On Fig. 10 shows the Waldpolonez Solar Park which is the world's largest thin-film photovoltaic (PV) power system, is built in on military air base to the east of Leipzig (Germany), with a nominal power of 40 MW. It produces 40 GWh of electricity annually. It covers an area of 2 km^2 and consists of 550.000 solar modules made of amorphous silicon and CdTe which supplies 40 GWh of electricity per year. The investment cost for the Waldpolenz solar park amounts to some 130 million Euro.

Fig. 10: *Waldpolonez Solar Park built in on military air base to the east of Leipzig (Germany) [25, 33]*

On Fig. 11 shown them the Andasol (**Anda**lusia and **Sol**) solar power station, located near Guadix in Andalusia (Spain), uses a molten salt thermal energy storage to generate electricity, even when the sun isn't shining. The Andasol is Europe's first commercial plant to use parabolic troughs with 150-megawatt (MW) power. The Andasol plant uses tanks of molten salt as thermal energy storage to continue generating electricity, irrespective of whether the sun is shining or not.

Fig. 11: *Andasol (**Anda**lusia and **Sol**) solar power station, located near Guadix in Andalusia (Spain) [20]*

On Fig. 12 shows the Serpa solar power plant (also known as Hércules solar power plant), with a capacity of 11 MW, installed in 2007 in Serpa, in Portugal's Alentejo agricultural region, 200 kilometers southeast of Lisbon. This power plant consists of 52.300 solar trackers that produce 20 GWh of electricity per year, which is enough to supply electricity to 8.000 households and reduce CO_2 emissions by 30.000 tons per year. Construction Serpa solar power plant cost of 58 million euro.

Fig. 12: *Serpa solar power plant (also known as Hércules solar power plant) (Portugal) [20, 25]*

4. Conclusion

Sources of renewable (RE) and green energy (GE) will not disappear because they are naturally replenished, unlike fossil fuels such as coal, oil or gas.

Renewable energy sources (RES) and green energy (GE) are predicted to become economically competitive with conventional energy sources in due course.

The use of renewable and green energy has a very important role in reducing the emission of carbon dioxide (CO_2) into the atmosphere.

Increasing the share of renewable and green energy increases the energy sustainability of a country's system.

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