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Hybrid power systems – An effective way of utilising primary energy sources

Józef Paska*, Piotr Biczel, Mariusz Kłos

Warsaw University of Technology, Institute of Electrical Power Engineering, Koszykowa 75, 00-662 Warsaw, Poland

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ABSTRACT

Nowadays in many countries the increase of generating capacity takes place in small units within the framework of so-called distributed power industry (distributed generation – DG, embedded generation), and among them in hybrid power systems (HPS).
In this paper we present our experience of the design, build and exploitation of HPS in the Institute of Electrical Power Engineering, Warsaw University of Technology. The following major subjects are considered:

- the experience of exploitation of a hybrid solar – wind power plant,
- a solar power plant with a fuel cell,
- the concept of a wind power plant with a battery energy storage,
- the utilisation of a DC micro-grid for the integration of different electrical energy sources.

1. Introduction

There are many definitions of Hybrid Power Systems. Our definition of HPS is as follows [1]: *small set of co-operating units, generating electricity or electricity and heat, with diversified primary energy carriers (renewable and non-renewable), while the co-ordination of their operation takes place by utilisation of advanced power electronics systems*.

HPS by definition have been constructed for the generation of electricity or electricity and heat. Mostly, they are connected to the power grid, but they can also work independently feeding separated receivers, from one or several homes/farms, small industrial plants to large local communities. Grid-connected HPS provide electric power reserves and allow surplus power to be fed back to the grid when HPS generate more power than receivers and local energy storage systems require. Obviously, the major aim of HPS is to supply remote, off-grid communities where the costs of connection to the long-distance transmission or distribution grid are too high. HPS use few technologies connected with power generation such as different power generation devices, different energy storage technologies and advanced microprocessor control/supervision systems.

In our opinion hybrid power systems (plants) are a good way to increase availability and flexibility of power supply systems and to have available and flexible sources of electricity which optimise utilisation of primary energy carriers. It may be achieved by combining different primary energy carriers (renewable and non-renewable) utilising, electrical energy storage facilities, and advanced power electronics and microprocessor systems for control/supervision.

2. Why hybrid power plants?

Currently very fast development of new electrical power sources called renewable sources can be observed. These sources are environmentally friendly and use primary energy carriers such as solar, wind and water flow, biogas, biomass etc. The sources mentioned above can be divided into two groups: controlled sources and uncontrolled sources. Controlled sources mean primary energy sources giving rise to the possibility of controlling electrical power production, for example coal. It is obvious that power production from uncontrolled sources is unpredictable and independent of human action. Solar and wind power plants are uncontrolled sources.

On the other hand, electricity should be produced exactly at the time it is needed. Sun and wind do not meet this requirement. So, special kind of power plants should be built to avoid shortages of

* Corresponding author. Tel.: +4822 2345864; fax: +4822 2345073.
E-mail address: jozef.paska@ien.pw.edu.pl (J. Paska).

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power and to utilise all available sun or wind power. There are at least two ways to achieve this aim: electricity energy storage or power plants using two (or more) primary sources with additional control systems. One of the sources must be a controlled power source. Such power plants are *hybrid power plants*.

Developers and manufacturers are looking for ways to combine technologies to improve performance and efficiency of distributed generation equipment. Several examples of hybrid systems include:

- A solid oxide fuel cell combined with a gas turbine or microturbine;
- A Stirling engine combined with a solar dish;
- Wind turbines with battery storage and diesel backup generators;
- Engines (and other prime movers) combined with energy storage devices such as flywheels.

Hybrid power generation systems contain two or more power generation sources in order to balance each other's strengths and weaknesses. In Fig. 1 [2], a matrix is used to illustrate those hybrid combinations that are commercially available, in development or, at a minimum, plausible.

The diagram in Fig. 1 covers almost all variety of possible hybrid combinations. However in power systems with large amount of CHP, such as the Polish (and similar systems in other countries), the diagram seems to miss the options coming from combining the electricity sector with the heat sector. The diagram already includes CHP units, which makes a restriction on the system. However one could also add heat pumps and heat storage, which would then make a flexibility option to the system. Such options have been described among others in [3].

3. Hybrid solar–wind and battery power plant

3.1. Idea and realisation of the plant

The team from Warsaw University of Technology, Group of Electric Power Plants and Power Engineering Economy has built a hybrid solar and wind power plant [4]. That was as a response to a request from a Polish telecommunications company. This hybrid power plant has supplied the telephone exchange. The company wanted to have a clean energy source – something what could replace diesel generators, particularly in installations placed far from the public grid. The power plant had to produce energy all of the time without any breaks.

Fig. 2 shows a general view and Fig. 3 shows a block diagram of the hybrid power plant.

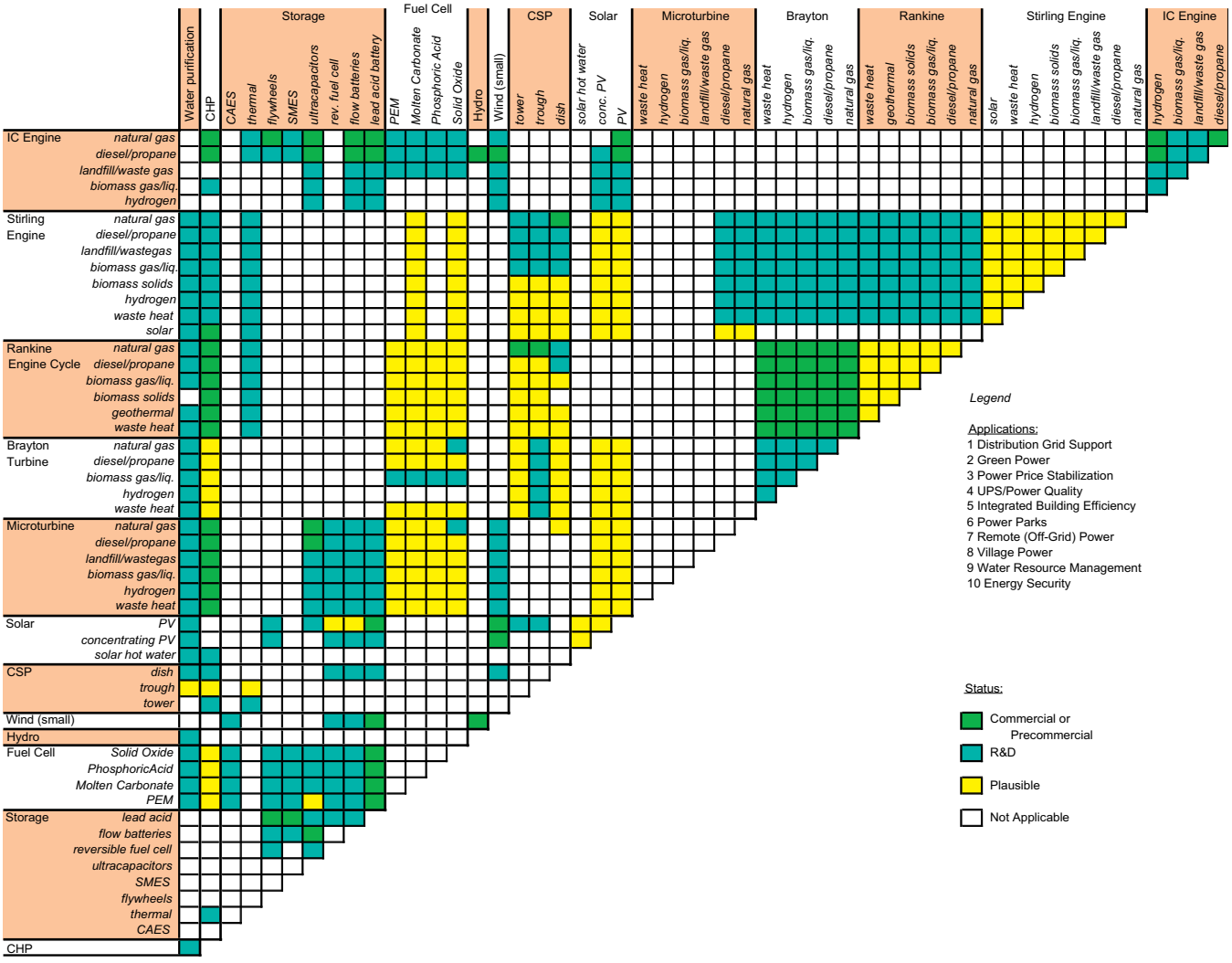

Fig. 1. Hybrid combinations overview.