Potential of Steam Energy in PV-Hybrid Systems

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Introduction

In contrast to the historical constructions of steam engines in the beginning of the industrialisation, today there exist already not used potentials concerning small scale machines and modified thermodynamic processes. This presentation gives an impression of some modern innovative concepts and possibilities with regard to new materials and methods to minimise emissions. New ideas with respect to the above mentioned developments and potentials are given, in order to integrate these modern steam engines in decentralised PV-hybrid systems. These concepts lead to complex combined heat and power systems with the advantage to use biomass for the steam generation with a maximum degree of flexibility.

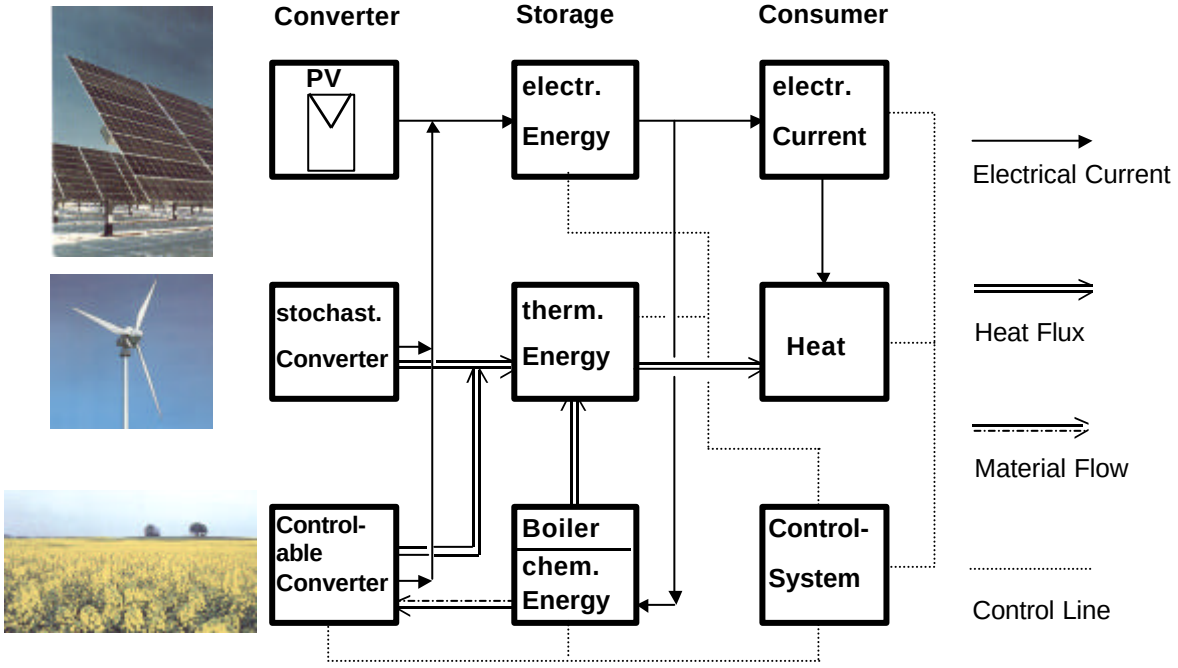

Figure 1: Fundamental Systematic of PV-Hybrid Systems with Steam Engine

PV-Hybrid System

Figure 1 shows the principal schematic of a complex PV-hybrid system with additional stochastic converter, like wind energy converter, and a CHP-Unit to achieve an overall controllable system. The schematic in figure 1 is divided into three columns. The first represents the energy conversion units, the second the energy storage systems and the third column shows the consumer including the important control system.

If we want to supply for example an average private household in Germany self sufficient with energy, electrical as well as thermal, it could be shown [2], that the remaining ratio of electrical to heat energy s, which has to be fulfilled by a combined heat and power unit, can be drastically reduced. Figure 2 shows the conditions for a CHP-unit, if a private household would be supplied by a 2,5 kWp-PV-plant and a permanent amount of 200W from a wind energy converter; monthly and hourly for a representative winter day.

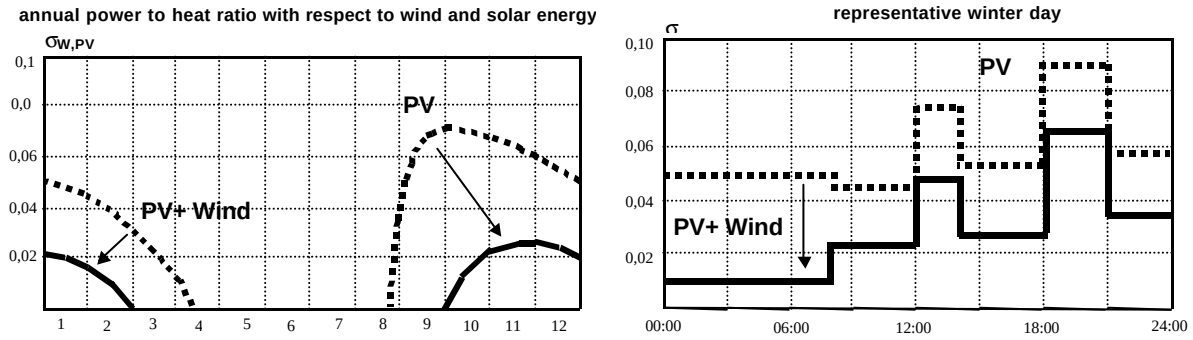

Figure 2: Residual Ratio of Power to Heat with Wind Energy and a PV-Plant [2]

With respect to a sufficient energy storage capacity to equalise the power demand, a small power to heat ratio reduces the necessary electrical efficiency of the CHP-unit in the same way. Therefore, an electrical efficiency of nearly 5% would be sufficient. Figure 2 shows also, that it would be advantageously for a CHP-unit to have a great flexibility in partial load, or to be bypassed by the fuel for a variable heat production.

These conditions can be easily achieved with the help of modern steam engines for domestic applications.

There still exist hopeful activities in the industry to develop and to integrate small scaled steam engines for the market in the nearer future, with a good potential of an economic implementation. But also for other applications, increasing activities for developments of modern steam engines can be seen, to achieve higher efficiencies and lower emission rates.

Modern Steam Engines

Historically, the increasing centralisation for the production of more and more electrical power, which could be distributed with the help of the fast growing electrical grid system, the massive and heavy steam engines came to their natural constructional limit and were displaced by turbines. But nevertheless already today, there exists a fuzzy limit between 500kW up to 1MW, which gives the decision line between the implementation of a steam motor or a turbine, with respect to economic aspects as well as to the efficiency. The steam engine was one of the best understood machines with great simplicity and a good long-term behaviour.

One of the most important reasons for the centralisation of the electrical energy supply, apart from the grid system, is the easy possibility to bring fossil fuels to the power plants, with the help of our modern traffic system and pipe lines. But these fossil primary energy resources may come to an end in a time, which is approximated to be some decades. For this reason renewable energies will be integrated with increasing effort, which leads to a reverse development concerning centralisation. The usage of renewable energies is strongly connected to a decentralised conversion technology. Consequently, this would result in a decrease of the nominal power rate of thermal power plants, especially down to domestic dimensions. A nearly logical consequence of these thoughts is a revival of steam engines, but with a modern high tech construction. Modern materials, like ceramics or carbons, give the opportunity to develop new steam motors with better efficiencies and emission rates then their “grandfathers” had, even with more compact constructions.

Therefore it may be also possible to modify the classical Clausius-Rankine-Process near to a so-called “Isothermal Expansion” or to a process with over-critical steam injection, in order to achieve higher degrees of efficiencies [1].

Figure 3 shows a development of a German engineering company in Berlin [4], [5], a steam motor for a car, designed for 992 cm^3 and 50kW, with an efficiency near 24%.

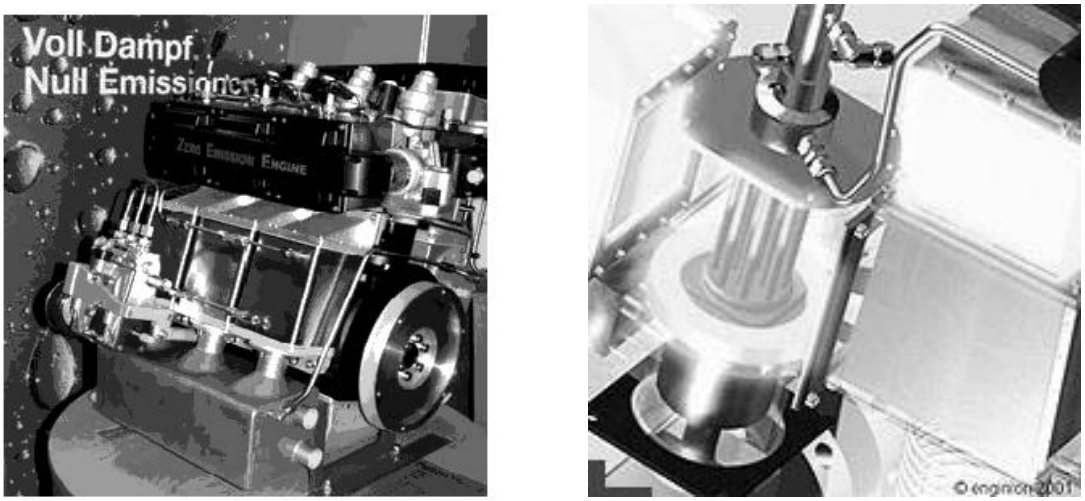

Figure 3: ZEE 03 with super heater [4], [5]

Actually, one of the most interesting developments of steam motors is the so-called “steam cell” [4] designed as auxiliary power unit (APU) for max. 6kW electric power and max. 25kW thermal power, variable adjustable between these values. Figure 4 shows such an engine.

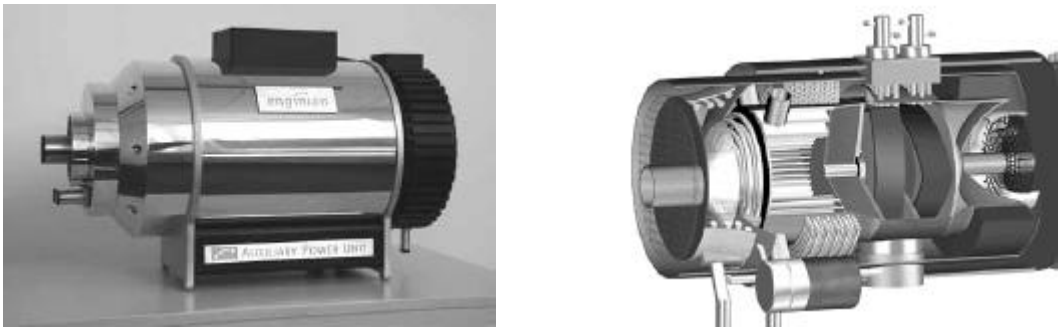

Figure 4: Micro Power Unit [4]

The spatial dimensions of the micro power unit in figure 4 are 470x280x280mm with a weight of 32kg. These units were primarily designed for the implementation in trucks as combined heat and power systems.

But it may also be possible to use this, to support a battery or instead of a battery. A modification of this machine will be prepared for domestic applications as CHP-Unit.

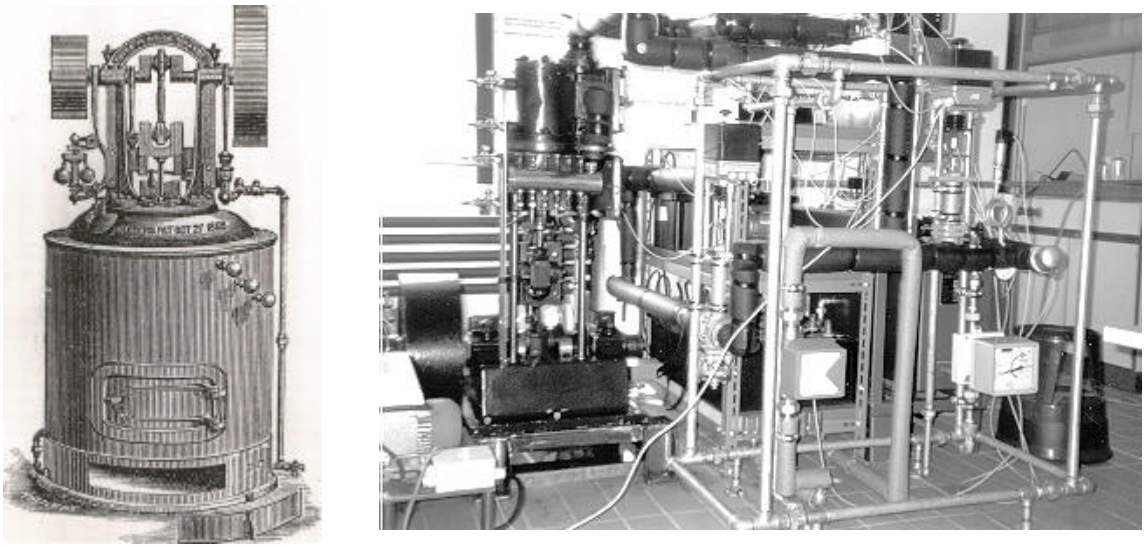

Figure 5: a) Baxter Pat. 1868;
b) Experimental CHP-System with a piston-type engine [1], [2]

The actually developments of modern small scale steam motors are designed for gaseous or liquid fuels, mainly natural gas and fossil fuels, but are also prepared for gaseous or liquid biomass based fuels. An important further research and development step still remains to do, this is a steam motor for solid biomass with comparable compact spatial dimensions like the engines in figure 3 and 4. Figure 5 a) shows a historical idea and b) a research equipment for a PV-hybrid system with a steam engine, built up by the author.

References:

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