ESSENTIAL TECHNICAL PARAMETERS USED IN THE MANAGEMENT OF ENERGY SUBSYSTEMS THAT BELONG TO PRODUCTION SYSTEMS

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Abstract: The paper presents the place of the energy subsystem within the production system and the technical parameters used in its management, considering beside the conventional energy systems, the renewable ones which are capable to offer real solutions for a sustainable development. These solutions contribute to a preservation of the global energy reserves and to a reduction of the global pollution.

Keywords: management, energy, production system, efficiency, renewable.

1. THE PLACE OF THE ENERGY SUBSYSTEM WITHIN THE PRODUCTION SYSTEM

The production system is an economic agent of vital importance within any national economy being associated frequently with an enterprise which represents "the organizing entity where the goods and services are produced" Therefore, the production system can be considered as an aggregate formed by the following components [1,2]:

- *material elements* (natural and artificial);
- *human resources*;
- *concepts* (theories, methods, rules, regulations);
- *experiences* and *abilities*.

These components are organized and combined to accomplish the essential goal of the production system which is *to obtain the profit*, by selling its products and services.

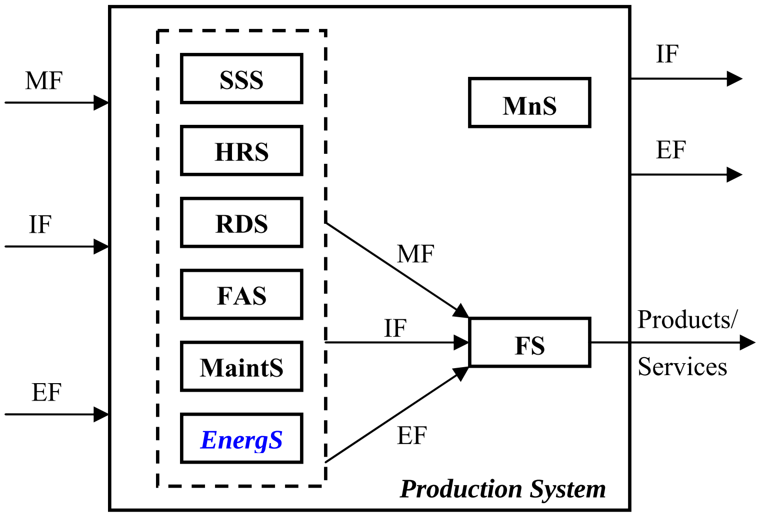

Fig. 1 The structure of a Production System that belongs to

The energy subsystem is positioned within the production function of the enterprise as a part of its auxiliary processes [3]. A structural model of a production system that belongs to the machines and equipments producing industry is presented in fig. 1 [2,4].

The notations used in fig. 1 are the following: **SSS**–the supply & sell subsystem; **HRS**–the human resources subsystem; **RDS**–the research & development subsystem; **FAS**–the financial & accounting subsystem; **MaintS**–the maintenance subsystem; ***EnergS****–the energy subsystem*; **MnS**–the management subsystem; **FS** – the fabrication (manufacturing) subsystem;

the machines and equipments producing industry
MF, IF, EF – the material, informational and energy fluxes.

The energy subsystem together with the maintenance subsystem and the fabrication one (which is limited only to solving tasks according to the physical realization of the product [2]) form the production function of the system (or the production subsystem).

2. THE SYSTEM'S EFFICIENCY PARAMETER

The identified technical parameters that characterize different energy subsystems having a major influence over the production systems (PS), should be found in all energy producing systems (be they conventional or renewable) and also within the systems that contribute to the energy consumption in the PS.

The system's efficiency (η) could be considered as the first identified essential technical parameter which represents the ratio between the result of an action and the effort involved for accomplishing that action. As a characteristic of the efficiency of a technical system this parameter represents the ratio between the useful energy (E_{useful}) expressed in Wh and the energy consumed by the system ($E_{consumed}$) expressed also in Wh [5].

$$\eta = \frac{result}{effort} = \frac{E_{useful}}{E_{consumed}} \quad [\%] \tag{1}$$

The selection of the system's efficiency parameter as an essential technical one, having a major influence over the production system is justified because it directly influences the costs of the PS products, the PS expenses with energy and also the technical efficiency of the production system. The efficiency is a parameter that differs from one system to another and represents an important element taken into consideration in the moment of adoption the investment decision.

2.1. The efficiency of the conventional energy producing systems

For the *thermal energy* production necessary for preparing boiled water and for heating the spaces, the most widespread systems are the *natural gas fired wall mounted boilers*. These heating systems present high efficiencies varying from 85% to 93% depending on the manufacturer and the percentage of using the maximal power of the station. The useful thermal power represents the available power within the process of thermal energy production (table 1) [6,7].

The efficiencies of different gas fired wall mounted boilers according to the thermal power. Table 1

Producer	Max. useful thermal power [kW]	Min. useful thermal power [kW]	Efficiency at 100% power [%]	Efficiency at 30% power [%]	Heated water temperature [ºC]
Ferroli	23.8	9.7	92.2	89.4	25-90
Baxi	24	9.3	90.3	88	35-65
Ariston	24.6	9.9	93	91.6	36-56
Immergas	27.9	10,5	92.2	89.8	20-60
Ferroli	30	12.7	90.5	87.3	25-90
Baxi/Westen	31	10.4	90.3	88	35-65

The natural gas consumption vary according to the useful thermal power of the system, at a maximal power equal to 23.8 kW the consumption being of 2.73 m^3 /h and at a minimal power of 9.7 kW, the consumption reaching the value of 1.22 m^3 /h. For a heating system at a maximal useful thermal power of 30 kW, the natural gas consumption is around the value of 3.5 m^3 /h, the same system at minimal useful thermal power (12.7 kW) consuming a quantity of 1.53 m^3 /h.

For obtaining a greater thermal power necessary for heating the spaces of a PS, the solution used can be the *condensing boilers* which exploit at maximum the energy resources of the used combustible (table 2) [6,7]. In the case of condensing boilers, the natural gas consumption vary from a thermal power to another having higher values than in the case of gas fired wall mounted boilers. For a thermal maximal power of 139 kW the consumption reaches the value of 13.49 m^3 /h, at a power of 185 kW the consumption being of 17.8 m^3 /h.

The efficiencies of different condensing boilers according to the thermal power. Table 2

Producer	Max. useful thermal power [kW]	Min. useful thermal power [kW]	Efficiency at maximal charge 80ºC [%]	Efficiency at maximal charge 50ºC [%]	Heated water temp. [ºC]
Ferroli	34.6	10.2	98	96	60-80
Prestige	49.9	15	96	97	60-80
Junkers	65	12	99	98	60-80
Prestige	72.8	18.3	96	97	60-80
Junkers	90	14.1	98	98	60-80
Rendamax	185	39	97	98	60-80
Rendamax	274	58	97	98	60-80

The *boilers which use solid combustible* can also be considered as heating solutions. These boilers are designed for burning the firewood, compressed sawdust, black coal and lignite [6,7]. The efficiency of these boilers is influenced by the caloric power of the combustible and its moisture content. In the case of firewood with 15 - 20 % humidity the thermal power of the boiler can decrease with 18 - 20 % and for the firewood with 70 - 80% humidity this power can be reduced with 60 - 70 % [6,7].

Average efficiencies of different boilers based on solid combustible and other technical data. Table 3

Type	Max. useful thermal power [kW]	Heating space [m^3]	Average efficiency [%]	Height / Depth / Width [mm]	Maximal temp. [ºC]
CV25	27	300-500	72	1200 / 550 / 560	90
CV32	37	500-900	76	1200 / 660 / 590	90
CV45	52	750-1200	76	1200 / 720 / 720	90
CV65	75	1500-1800	78	1550 / 1165 / 835	80
MCL200	232	3600	75	2160 / 1810 / 1100	90
MCL600	698	10800	79	2750 / 2800 / 1470	90

Regarding the *electric energy* (electric power), all the production systems are connected to the global electricity network, this energy being especially used for driving the electric motors, superchargers and other industrial equipments, in lightning, for running the office equipments, etc.

The *thermo-electric power stations* are still in Romania the most used systems for obtaining electric energy even if they pollute the environment. The maximal theoretic efficiencies of these systems vary in the interval 30% - 65% [5,8,9].

Good solutions offered in the domain of electric energy production are the *hydroelectric power plants* having mechanical efficiencies around 90%. A local example could be the hydro-aggregates from *"Porţile de Fier I"* modernized in the years 1999-2000, obtaining an increase of the turbine optimal efficiency from 94.24% to 94.74%, increasing also the nominal power of the turbine from 178 to 194 MW [10,11]. The hydroelectric power plants have very low operation costs, do not pollute the environment and have a long life time [5].
In the case of *nuclear power stations* the efficiencies are not so high. The reactor *CANDU X* (with 380 channels) of *Unit 1* that belongs to "*Centrala Nuclear Electrica"* from Cernavoda which can deliver a maximum of 910 MW, has an efficiency of thermal cycle around 41 % [11].

2.2. The efficiency of the renewable energy producing systems

As the solar collector's efficiency and the intensity of solar radiation determine the specific heat gain of a solar system, the relation which establish the connection between these indicators is the following [12]:

$$q = I_t \times \eta \ [\mathrm{W/m^2}] \quad (2)$$

Where: q is the specific heat gain expressed in [W/m^2];
I_t is the intensity of solar radiation expressed in [W/m^2];
η represents the collector's efficiency in [%].

The solar radiation intensity – I_t differs from one latitude to another, being advantaged geographical areas positioned closer to the Equator, where the solar radiation intensity records maxim values. I_t varies during a year and also during different hours of a day. For obtaining a maximal energy gain, the solar radiation axis should be perpendicular on the collector's surface and therefore during the summer time the angle between the collector (or panel) with the horizontal should be as little as possible, while during the winter this angle should be as close as possible to 90º [12,13] (fig. 2).

I_t is recorded over o horizontal surface and can be precisely determined by using a device called *pyranometer* (fig. 3). Usually the values of I_t are recorded at each 10 minutes of 24 hours and then stored in a computer database by the help of a device called *Data logger* (fig. 4). From these values the mean solar intensity of a day can be computed and then extended to one month or a year [14].

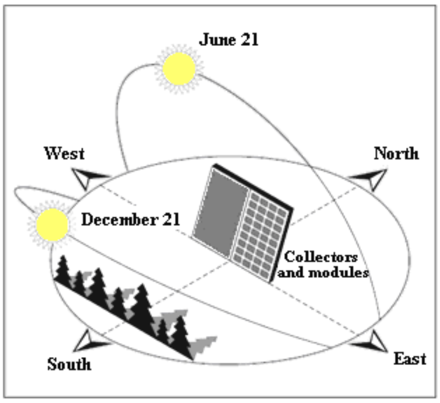

Fig. 2 The position of the sun during the summer and the winter time

Measuring range	0 - 1400 W / m^2 (max. 1400 W / m^2)
spectral range	0,305 - 2,8 µm
Sensitivity	4 - 6 µV / Wm^{-2}
Impedance	700 - 1500 Ohm
Response time	24 s to 99 %
	4 s to 63 %

Fig. 3 Pyranometer type CM 11 from Kipp&Zonen

Fig. 4 Data logger DL2e

The efficiency of the solar collector – η depends on the collector's type (flat-plate or evacuated tube), on the temperature difference between the heated fluid and the environment, on the material used as thermal insulation, on the manufacturing quality, etc. [12,13]. The graphs from the fig. 5a and 5b are essential elements in the calculation of specific heat gained by an m^2 of solar collector installed in any geographic area. From these graphs it can be observed that evacuated-tube collectors have always better efficiencies than flat-plate collectors, requiring minimal values for the intensity of the solar radiation for producing the necessary thermal energy.

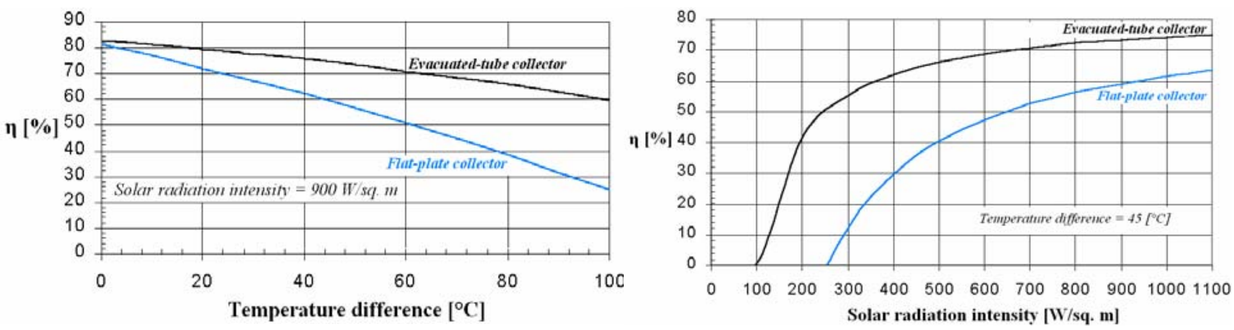

Fig. 5 Variation of the solar collector's efficiency according to the:
a) temperature difference b) solar radiation intensity

Another observation that can be made is referring to the collector's efficiency which has very high values when the temperature difference is minimal (over 80% for both types of collectors – when the solar radiation is 900

W/m^2) and small values at high temperature differences (around 38% for flat-plate collectors and 65% for evacuated-tube collectors at a temperature difference of 80 ºC when irradiated by 900 W/m^2) [14,15].
It also can be noted that small efficiency and as a consequence, low energy gain of the solar collector will be recorded in the winter and cold seasons due to three main aspects:
- the intensity of solar radiation (which is minimal in winter season);
- the temperature difference between the heated fluid and the environment;
- the reduced number of sun hours.

Referring to the efficiencies of the solar systems that produce electric energy, it can be stated that the efficiency of one photovoltaic cell (and implicit of a photovoltaic module) depends on the cell's type reaching the maximum 17% for monocrystalline silicon cells, maximum 15% for polycrystalline silicon cells and 7% for amorphous silicon cells. A photovoltaic (PV) module formed by 36 polycrystalline silicon cells can reach a maximal power of 125 W. The power gained by a PV module is determined with the relation:

$$P_{\mathrm{mod}.fotov.} = panel\ surface \times \eta \times I_t \ \mathrm{[W]} \qquad (3)$$

The energy gain of the PV panel (module) results by multiplying the power gained (where the panel surface is expressed in m^2) with the number of sun hours of the day, month or year for which the calculation is done.

2.3. Conclusions relating to the efficiencies of different energy producing systems

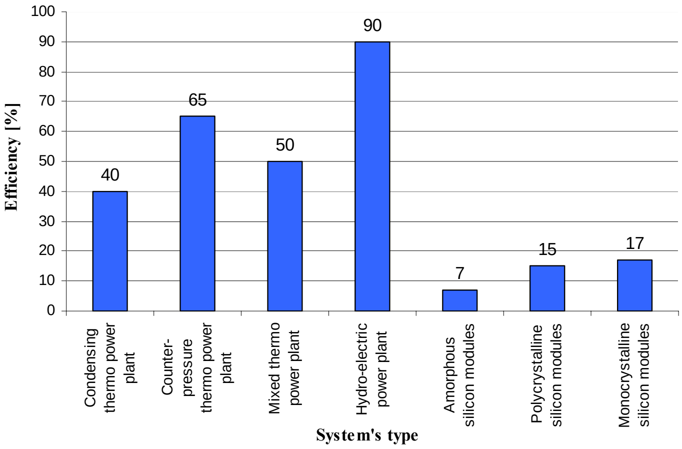

Fig. 6 Maximal efficiencies for different electric energy producing systems

The conventional thermal energy producing systems have better efficiencies than the renewable ones, but it also has to be taken into account the fact that these efficiencies are expressed relating to the quantities of conventional combustible used (in the case of conventional systems), while the renewable thermal energy producing systems use only solar energy, which is "clean" and do not exhaust the global energy reserves. The same conclusion is valid for the electric systems where, excepting hydro-electric power plants, all the conventional systems pollute the environment and reduce the energy resources (especially coal) (fig. 6).

Another conclusion that can be formulated is that higher efficiencies are registered at thermal energy producing systems in comparison with electric ones. However, within the production systems the adopted systems for the implementation are the thermal ones because generally it is cheaper to use the national electric grid.

3. THE AVERAGE LIFE LENGTH PARAMETER

From the technical point of view, *the average life length* represents the period of time between the moment when the equipment is set working and the moment when this equipment is taken out of production. This technical life length is determined by the technical and functional characteristics and by the operating conditions of any equipment. The measurement unit for this parameter is usually the year and the parameter selection as an essential technical one is based on the difference that can be made in the moment of taking the investment decision between different systems existing on the market, determining the investment efficiency and profit obtained by the PS.

In the table 4 there are presented the average life lengths for different energy producing equipments (thermal and electrical) be they conventional or renewable [5,6].

Average life length for different energy producing equipments - Table 4

Equipment	Average life length [years]
Gas fired wall mounted boilers	20-25
Gas fired condensing boilers	20-25
Boilers based on solid combustible	25
Solar collectors	20-25
PV modules	25-30

Conclusion: the average life length parameter is placed between 20 and 25 years for all the energy producing systems (equipments) used, be they conventional or renewable. However, some photovoltaic systems for producing electric energy could reach a life length of 30 years.

4. THE SYSTEM'S POWER PARAMETER

As a derived unit of the *International System of Units*, the *power* represents the propelling force through which a physical system or equipment operates. Its measuring unit is the Watt and usually the power is treated under two forms: thermal and electric [16,17]. The system's power represents a comparison base differentiating the existing systems which have the same acquisition price but different powers, efficiencies or life lengths.

The maximal useful thermal power of different conventional systems used, differs according to the system's type. In the case of gas fired wall mounted boilers it vary from 23.8 to 31 kW, in gas fired condensing boilers being between 34.6 to 274 kW and for the boilers based on solid combustible varying from 19 to 698 kW. The maximal thermal power of a system based on thermal collectors depends on the solar radiation intensity, the number of modules installed (in m^2), the collector's efficiency and its type.

Maximal power of different PV surfaces - Table 5

Max. electric power[W]	PV module's surface [m^2]
190	1,411
170	1,277
125	0,929
85	0,657

Conclusions: the system's power parameter differs according to the system's type used and can be increased or decreased for renewable energy systems by adding or removing some modules. Table 5 shows that maximal electric powers generated by a PV module are not very high, but greater surfaces could generate the entire electricity needed for a office building that belongs to the production system [18].

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