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Aspects regarding the Valorization of the Air Jets Energy Potential from Industrial Technological Equipment

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In the context of obligations to reduce greenhouse gas emissions to which EU countries have pledged, reducing energy consumption is a necessity of the current period. Thus, within Energy Strategy, Romania was among the first countries that have approved targets for the years 2012, 2015 and 2020. In this respect, the article presents a study regarding the assessment to an industrial consumer of the energy potential of the evacuated air jets through the exhaust systems with which technological facilities are equipped. In order to assess the possibility of utilizing the kinetic energy of the air jets evacuated by the exhaust systems, the calculation of the nominal power and power generated by a 600M2 wind turbine was performed. Based on the results obtained during the air jet speeds recording and of the recovered energy potential, it can be concluded that the evacuated air jet kinetic energy is a source that can be converted into electricity for the economic agent own consumption (insularised system).

***Keywords**: energy efficiency, energy potential, air jet, consumption reduction, power*

1. Introduction

The industrial sector represents one quarter of the EU's final energy consumption [1]. The significant increase in energy consumption till now and also the forecasts regarding its tripling up to 2055 compared to the 1998 as reference year, call for the implementation of concrete measures to increase energy efficiency and local solutions application to reduce the consumption and waste of energy. Thus, any possible energy saving solution must be analyzed, implemented, and validated experimentally for sources identified as being carriers of wasted energy.

The production of energy from renewable sources, even for its own needs in an insularised (automatically separated) system, is ecologically a huge benefit. The opportunity to produce useful electricity for industry applications needs to be analyzed in order to reduce the energy costs of primary energy consumption but also to reduce pollutant emissions from combustion of fossil fuels and pollutants emitted into the atmosphere from production facilities, and not only.

To achieve the national target of 2020, the mandatory shares, meaning the annual percentage values of the gross national electricity consumption were calculated progressively and are shown in Figure1 [2].

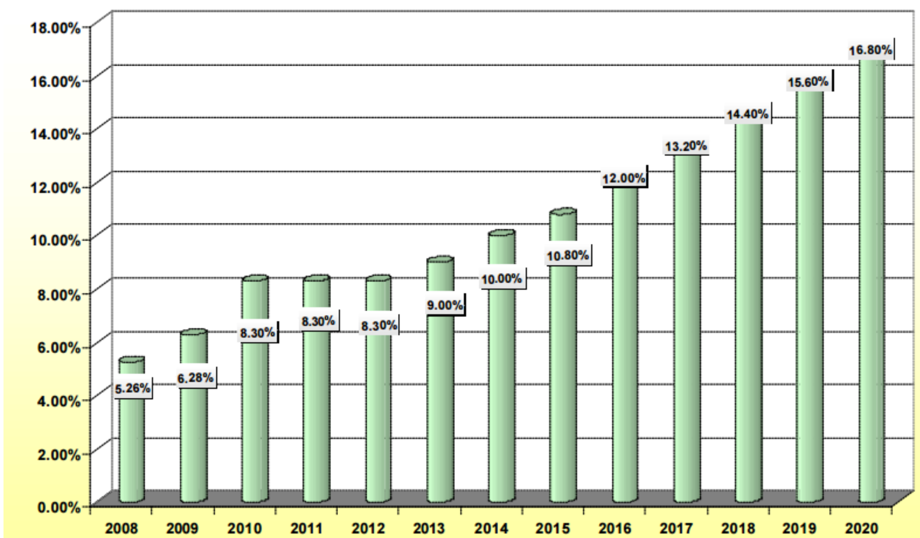


Figure 1. Mandatory shares established by Law 220/2008
(Source: http://ames.ro)

The electricity generation efficiency from renewable sources has led to the development of high-speed (HAWT) and vertical axis (VAWT) wind turbine or as photovoltaic panels and cells (WCW) which wind convert kinetic energy or solar energy, in useful one [3].

For mounting and operation of installations used for power generation based on wind, solar or wind and combined sources, with the injection into the National Power System, requires legal authorization procedures. The scheme for E-RES (Electricity produced from renewable sources) promotion in Romania, established by Law 220/2008 [4], can be represented graphically as in Figure 2 [5] and is applicable to both the electricity supplied in SEN and the one delivered directly to consumers.

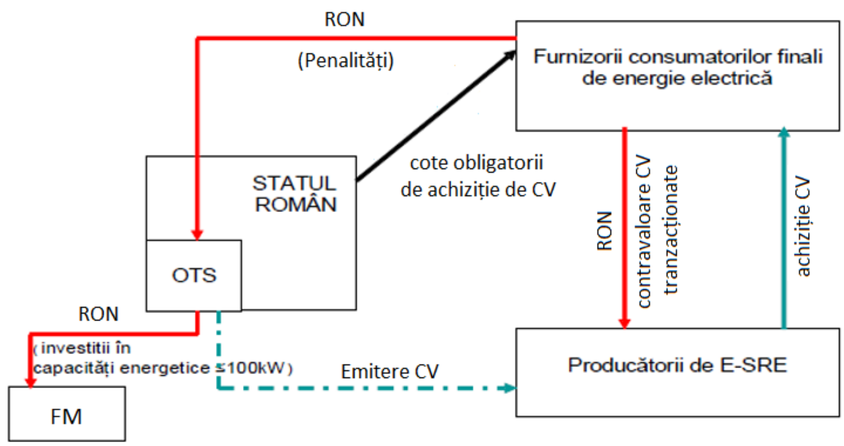


Figure 2. E-RES promotion scheme in Romania [5].
OTS-Transport Operator (C.N. Transelectrica S.A.),
EF-Environmental Fund, GC- green certificates

According to Law 220/2008 republished [4], for new wind power plants/groups, 2GC (green certificates) could be obtained by 2017 and 1GC starting in 2018 for a period of 15 years [5].

For wind turbines, the most important economic factor is given by annual energy production. To the overall uncertainty of the projected annual energy output, which can lead to a high financial risk, contributes greatly the uncertainty in determining the annual speed and the power curve.

In this study, the uncertainty in speed determination is neglected given that the velocity of the exhausted air jet is constant, being dependent only on the distance in relation to the exhaust section. Thus, the article deals with the possibility of producing electricity for own consumption (insularised system) by using the energy of the air jets from the exhaust systems of the industrial technological equipment such as painting / drying cabins to an economic agent (Figure 3).

The air jets' kinetic energy can be assimilated to the wind energy. The issues dealt with in the paper are based on researches carried out within the project No. 74BG / 2016, funded by UEFISCDI through the program "Increasing the Competitiveness of the Romanian Economy through Research, Development and Innovation" -Transfer of knowledge to the economic agent "Bridge Grant" [6].

Figure 3. Dyeing / drying cabins (DDCs)

2. Issues concerning the energy potential of the proposed system

The economic agent obligation to ensure a healthy environment in the workplaces determines the installation of increasing powers systems for exhaustion, treatment /air conditioning, which are large energy consumers. In these systems operating area, air jets are created which are exhausted into the atmosphere at high and constant speeds over the entire operating period.

The energy potential of the air jets can be seen compared to the wind potential.

Generally, energy potential assessment while creating an informational support for its exploitation is the basis for choosing the wind turbine location. Atmospheric motion is influenced by several factors, which does not occur when moving the air jet discharged by the exhausted systems.

One of the requirements for producing electricity using the wind energy is given by the existence of a strong wind constant flow. Wind turbines are designed to generate a nominal power for a certain speed called rated speed. From the analysis of a typical wind turbine power curve (Figure 4) it can be seen that around 4m/s the wind turbine starts to produce power and over 12-13m/s (wind speed at rated power) the turbine continues to produce nominal power, but at lower output until it stops. Speeds over 25m/s to 30m/s become dangerous and there are considered as wind turbine disconnection rates [3].

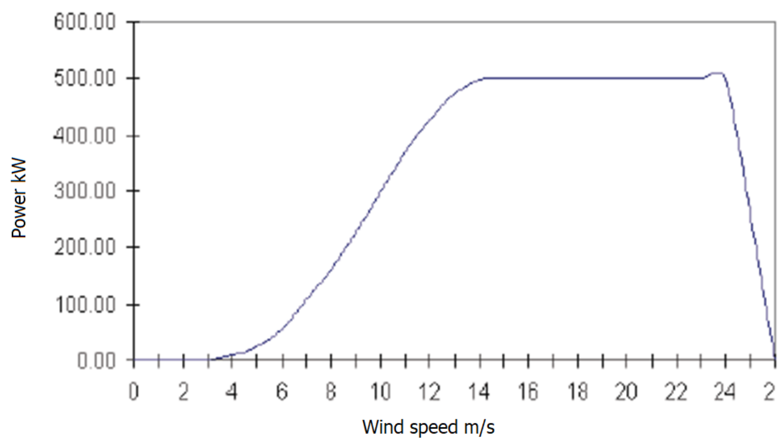


Figure 4. Typical wind turbine power curve [3].

3. Equipment mounting and consumption monitored to DDCs

In order to determine the fuel consumption reduction (combustion natural gas and electricity), the global consumption monitoring was followed.

The mounting and monitoring stages include:

- Electricity meters mounting (Figure 5).

Figure 5. Electricity meters group

- Monitoring the overall power consumption for CV3J and CV4J cabins in order to determine the distribution of electricity consumption (Figure 6) and operating hours (Figure 7) for the analyzed technological equipment (TE);

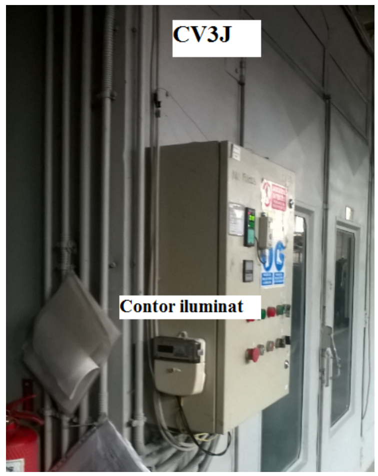


Figure 6. Monitoring of CV3J cabin operating hours

Figure 7. Overall power consumption monitoring

- Monitoring the discharged air jets velocity in order to assess the kinetic energy of the air jets discharged through the exhaust systems required for electrical energy production (Figure 8).

Figure 8. Discharged air jets velocity monitoring

4. The monitoring results

During the monitored five months (December 2016-april 2017) the economic agent recorded an active energy consumption of 241922 KWh, as in Figure 9.

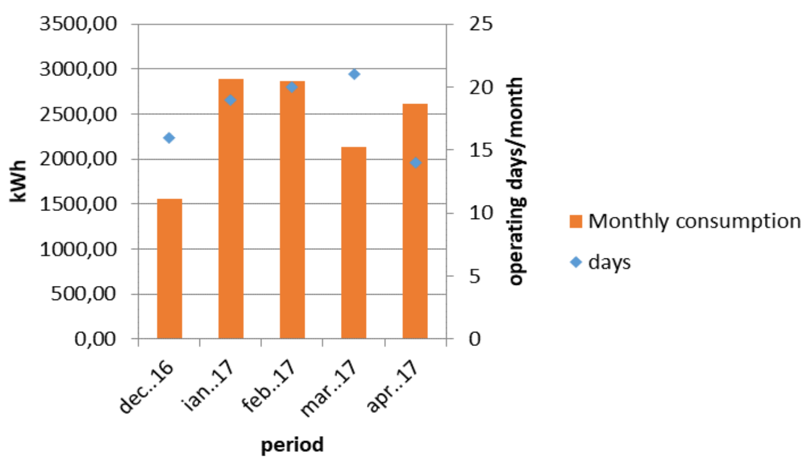
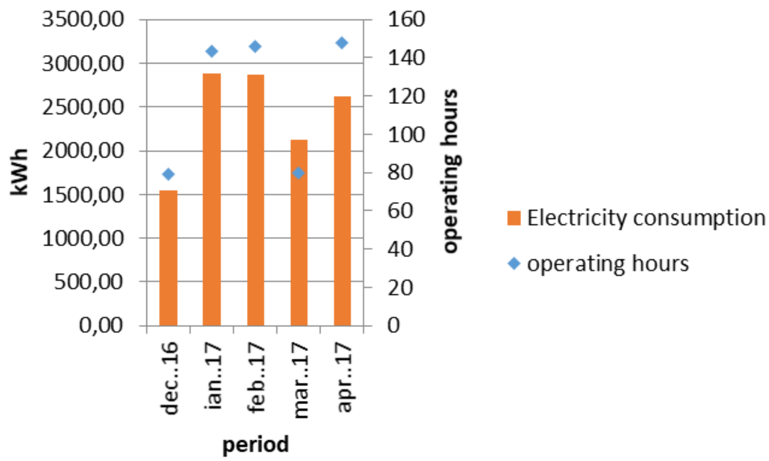
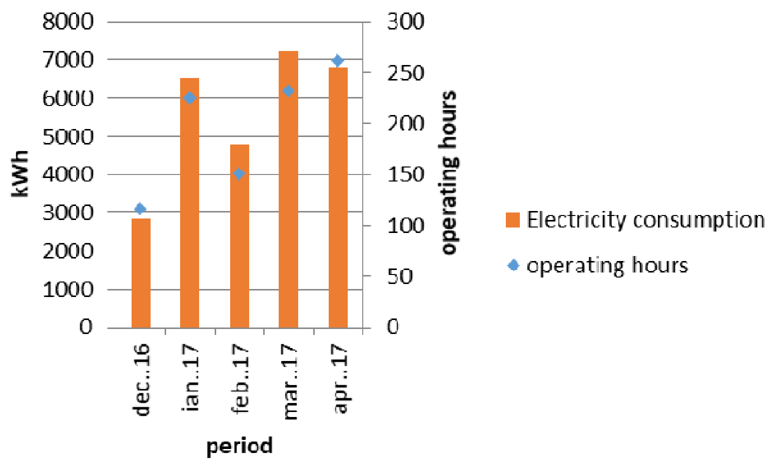


Figure 9. Monthly distribution of the overall active energy consumption and operating day/month to the economic agent

In Figure 10, electric energy consumption and operating hours during December 2016 – April 2017 for both cabins are plotted.



a)



b)

Figure 10. Electric energy consumption and operating hours during December 2016 – April 2017: a) CV3J; b) CV4J

The power consumption monitoring at the CV3J and CV4J dyeing / drying cabins was performed by using T2-CA43 energy meters' type, 3x230 / 400V, I_{max} = 5A, mounted in the distribution panel proximity, body J.

Between December 2016 and April 2017 there were recorded: 595.76 operating hours for CV3J cabin and 996.91 operating hours for CV4J cabin.

During the reported period, the economic operator registered a power consumption (active energy) of 12052.5 kWh at CV3J and a consumption of 28192.5 kWh at CV4J.

Considering that the paper deals with the possibility of using the discharged air jets kinetic energy, we monitored at different distances into the jet axis

The velocity variation of the air jets at the air vents exit from the paint cabins is shown graphically in Figure 11.

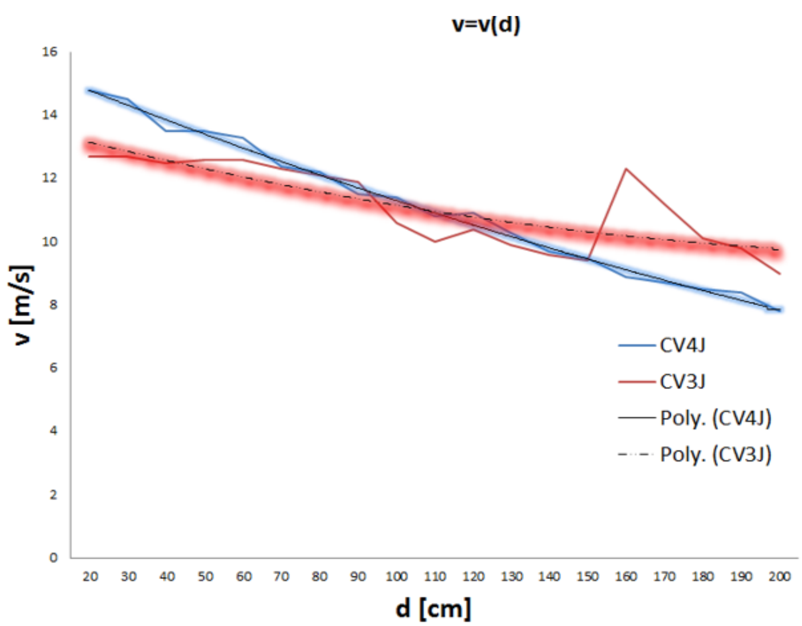


Figure 11. Air jet velocity variation at the air vents exit from the CV3J and CV4J dyeing/drying cabins

Figure 11 shows that a constant speed of 12.6m/s for the CV3J cabin and 14.6m/s for the CV4J cabin were recorded in the exit section. At a distance of 2m the constant velocity of the air jet is of 9.8m/s for the CV3J cabin and 8.5m/s for the CV4J cabin [6].

Wind turbines are designed to generate a nominal power for a certain velocity called rated speed. From the airflow rate variation analysis, it can be seen that at a distance of 2m from the exit section, the wind turbine produces power over the entire cabins operating period in both dyeing and drying modes.

In order to estimate the discharged air's jet kinetic potential, we propose to install a 600M2 wind turbine at a distance of 2m from the CV3J cabin exit section, with a synchronous three-phase generator with a permanent magnet of 0.6kW with the following characteristics:

Rated power	0.6kW;
Maximum power	0.6 kW;
Propeller diameter	D = 1750mm;
Nominal voltage	24V;
Wind speed, starting	2.5m/s;
Wind speed, nominal	13m/s;
Wind speed of survival	45m/s;
Maximum working temperature	80°C;
Minimum working temperature	30°C;
Blade number	3 blades;
Weight	15.5kg;
Generator type	Three-phase

The wind turbine scheme is presented in Figure 12.

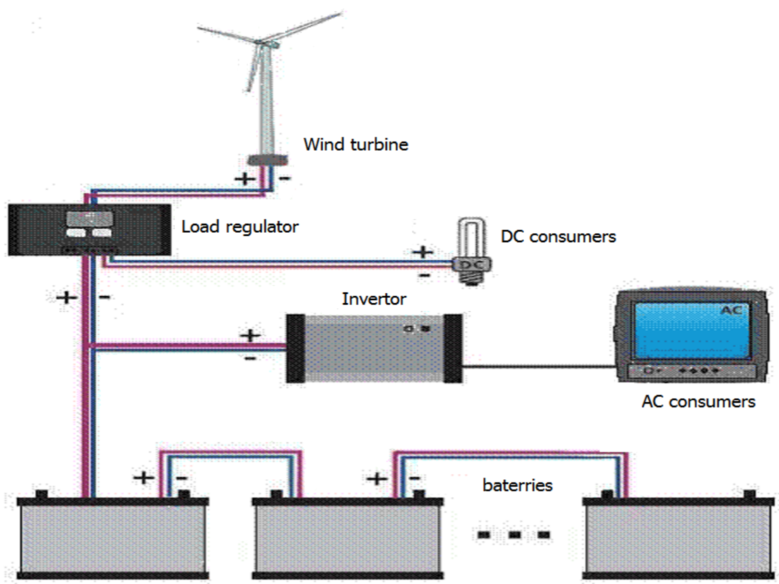


Figure 12. Scheme of a wind energy system with energy storage (Source:http://www.rasfoiesc.com/inginerie/electronica)

5. Conclusions

Usually, the energy consumption reduction is understood as a passive systems feature, such as thermal insulation, watertight construction, solar protection, etc., but to build a low-energy building, it is necessary to use renewable energies and to improve the recovery of the waste heat.

In this respect, the paper deals with the energy consumption reduction by using the kinetic energy of the air jets discharged through the exhaust systems, which can be regarded as a renewable energy source.

In conclusion, the conversion of the discharged air jet kinetic energy into power is a solution to reduce the consumption and, implicitly, the electricity bill to industrial consumers.

Acknowledgment

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