Hybrid Energy Supply with Dominantly Renewable Option for Small Industrial Complex

Tomislav Stambolic and Anton Causevski

Abstract—The deficit of power for electricity demand reaches almost 30% for consumers in the last few years. This reflects with continually increasing the price of electricity, and today the price for small industry is almost 110Euro/MWh. The high price is additional problem for the owners in the economy crisis which is reflected with higher price of the goods.

The paper gives analyses of the energy needs for real agro complex in Macedonia, private vinery with capacity of over 2 million liters in a year and with self grapes and fruits fields. The existing power supply is from grid with 10/04 kV transformer. The geographical and meteorological condition of the vinery location gives opportunity for including renewable as a power supply option for the vinery complex.

After observation of the monthly energy needs for the vinery, the base scenario is the existing power supply from the distribution grid. The electricity bill in small industry has three factors: electricity in high and low tariffs in kWh and the power engaged for the technological process of production in kW. These three factors make the total electricity bill and it is over 110 Euro/MWh which is the price near competitive for renewable option. On the other side investments in renewable (especially photovoltaic (PV)) has tendency of decreasing with price of near 1,5 Euro/W. This means that renewable with PV can be real option for power supply for small industry capacities (under 500kW installed power).

Therefore, the other scenarios give the option with PV and the last one includes wind option. The paper presents some scenarios for power supply of the vinery as the followings:

- Base scenario of existing conventional power supply from the grid
- Scenario with implementation of renewable of Photovoltaic
- Scenario with implementation of renewable of Photovoltaic and Wind power

The total power installed in a vinery is near 570 kW, but the maximum needs are around 250kW. At the end of the full paper some of the results from scenarios will be presented. The paper also includes the environmental impacts of the renewable scenarios, as well as financial needs for investments and revenues from renewable.

Keywords—Energy, Power Supply, Renewable, Efficiency.

T. Stambolic finished M.Sc at Faculty of Electrical Engineering and Information Technologies, St Cyril and Methodius University in Skopje. He works as a manager in Water Supply and Sewerage Authority in Skopje, JP Vodovod I Kanalizacija in Skopje. (phone: 389-70-385684; fax: 389-2-3090334; e-mail: tomislavstambolic@ yahoo.com, tomislav.stambolik@ vodovod-skopje.com.mk).

A. Causevski, PhD, is a professor Faculty of Electrical Engineering and Information Technologies, St Cyril and Methodius University in Skopje. He is now with the Department of Power Plants and Power Systems (phone: 389-71-333324; fax: 389-2-3064262, e-mail: caus@feit.ukim.edu.mk).

I. INTRODUCTION

AS a part of the overall EU energy policy for energy mix achieving stable electricity supply and sustainable development, Macedonia moves towards promotion of "green electricity" production and implementation of Renewable Energy Sources (RES) in the electricity market [3]. The hydro power is the most exploited renewable energy for electricity generation in Macedonia. The wind and solar power systems are still in the beginning for implementation. This paper takes into account demand side of consumption with improving the energy supply in agriculture sector with implementation the measures of energy efficiency and maximum utilization of renewable. The agriculture facilities is connected on distribution electrical network (0,4 kV, 10 kV or 20 kV). The energy needs requirements are not so intensive comparing with other industry, so the technologies for implementation the renewable is the realistic option for energy supply. Anyway the renewable implementation still depends on location of the facility and natural resources on the location (solar irradiation, wind speed, hydro potential and geothermal).

If the requirements for power and energy of the facility are still higher than the renewable option for the location, the hybrid systems of conventional electrical grid with renewable is the additional solution [4] and [5]. Energy parameters needed for the projects are installed power capacity and energy intensity of the technological production process of the facility. As a part of the overall EU energy policy for energy mix achieving stable electricity supply and sustainable development, Macedonia moves towards promotion of "green electricity" production and implementation of Renewable Energy Sources (RES) in the electricity market. The hydro power is the most exploited renewable energy for electricity generation in Macedonia [6].

II. ENERGY NEEDS FOR AGRO COMPLEX

The paper gives the energy needs and possibilities of energy supply systems with hybrid systems dominantly with renewable for real vinery agro complex, located in the southeast part of Macedonia which is famous agriculture region with lot of sunny days. The complex is connected to the distribution grid with transformer 10/0,4 kV and power of 400kVA and the total installed power of the vinery agro complex is about 565 kW. Based on electricity bills, an analysis of power consumption has been made. This industrial complex is LV distribution tariff consumer with electricity consumption (kWh) in high and low tariff, as well as the

World Academy of Science, Engineering and Technology
International Journal of Mechanical and Industrial Engineering
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engaged power in kW over installed which is register on maxi graphs. The following table presents the values of the electricity consumed in the high and low tariff and the active power.

Taking into account the price of electricity for both tariffs and the price of active power, the following table give the monthly financial bill for each part of the structure.

The Table I gives the overview of electricity needs in every month for both tariffs, high and low. The maximum needs are for the months from August until November, because of technological line for vine production.

TABLE I
MONTHLY ELECTRICITY CONSUMPTION IN HIGH AND LOW TARIFF (KWH) AND THE ACTIVE POWER IN KW

	Whigh	*Wlow*	*Whigh+Wlow*	*P*
		(kWh)		(kW)
January	11221	11930	23151	111
February	10802	9833	20635	79
March	8606	8068	16674	91
April	5419	5280	10699	75
May	3342	3091	6433	38
June	8322	8341	16663	102
July	18903	20298	39201	144
August	24031	25971	50002	211
September	48708	29410	78118	252
October	45323	26580	71903	235
November	26686	17158	43844	154
December	21433	15044	36477	133
Total	232796	181004	413800	1625
Average	19400	15084	34483	135

The price of electricity in Macedonia for industrial LV complexes are 58,37 Euro/MWh for high tariff and 29,19 Euro/MWh for low tariff, and 12,20 Euro/kW engaged power.

TABLE II
ENERGY STRUCTURE OF THE EXPENSES FOR ENERGY NEEDS IN EURO

	High T.	Low T.	P	Total	Tax18%	Average
						(Euro/ kWh)
			(Euro)			
1	655	348	1354	2357	2781	102
2	631	287	963	1881	2220	91
3	502	235	1110	1848	2180	111
4	316	154	915	1385	1634	129
5	195	90	463	749	883	116
6	486	243	1244	1973	2328	118
7	1103	592	1756	3452	4073	88
8	1403	758	2573	4734	5586	95
9	2843	858	3073	6775	7994	87
10	2646	776	2866	6287	7419	87
11	1558	501	1878	3937	4645	90
12	1251	439	1622	3312	3908	91

If we take all factors which are included in electricity bill, the average price of electricity is around 110 Euro/MWh. Almost half of the bill is from the power which can be reduced with energy efficiency technologies as soft start solutions or software tool and control of electrical driven motors. The other solution is hybrid systems with dominantly renewable as power and energy supply of the complex.
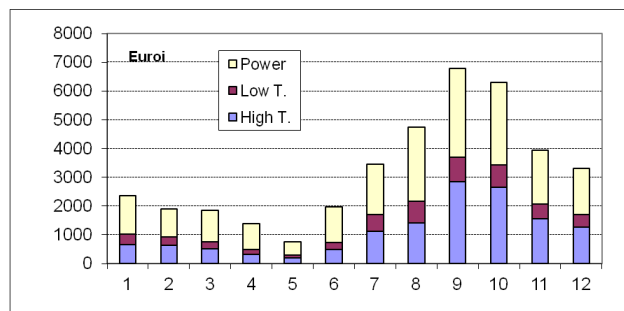

Fig. 1 Structure of the expenses for energy needs in Euro

III. ELECTRICITY PRODUCTION FROM PV IN THE LOCATION

The estimation of the electricity production from photovoltaic (PV) on the location for each hour of the day in a month is given in the Fig. 2. The installed power of the PV system is 200kW.
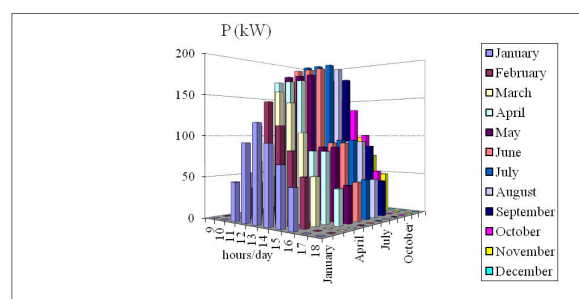

Fig. 2 Expected electricity production for each hour of the month for PV system of 200kW

IV. SIMULATION OF ENERGY SUPPLY WITH HYBRID SYSTEMS DOMINANTLY WITH RENEWABLE

Based on the energy needs for each month and taking into account the solar irradiation for PV system on the site, some cases for energy supply with hybrid systems has been made as the following ones.

- Case with hybrid system with PV of 100kW
- Case with hybrid system with PV of 200kW
- Case with hybrid system with PV of 200kW and Wind power of 200kW

The economical investigation is made with average electricity price of 110 EURO/MWh.

A. Case with Hybrid System with PV of 100kW

This energy supply system consists of PV with 100 kW installed power and grid connection. Fig. 3 gives the graphical overview for covering the electricity needs of the agro complex with PV_100 and the rest from the grid.
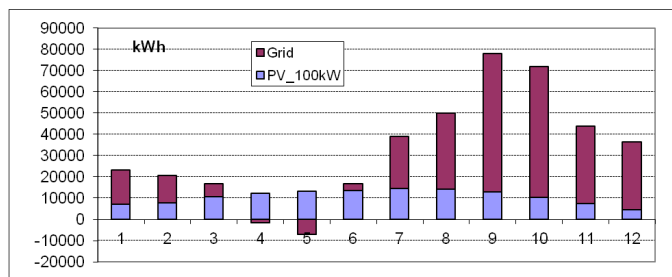
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Vol:7, No:6, 2013

Fig. 3 Energy supply of each month from PV 200 kW and from the grid

B. Case with Hybrid System with PV of 200kW

This energy supply system consists of PV with 200 kW installed power and grid connection. Fig. 4 gives the graphical overview for covering the electricity needs of the agro complex with PV_200 and the rest from the grid.
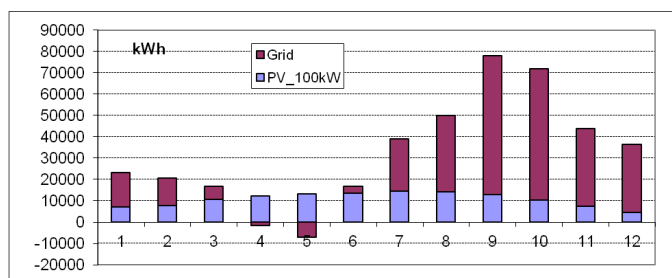

Fig. 4 Energy supply of each month from PV 200 kW and from the grid

It must be mention that the electricity price from the grid is 110 Euro/MWh, and the electricity to the grid (with negative numbers) is with feed in tariff for PV of 290 Euro/MWh.

C. Case with Hybrid System with PV of 200kW and Wind Power of 200kW

This case is the hybrid system for PV and wind power, both with installed power of 200 kW.

TABLE III
ENERGY SUPPLYING (KWH) FROM EACH RENEWABLE SOURCE PV AND WIND
AND FINANCE BALANCE IN EURO

	PV_200kW	WIND_200kW	Grid	EURO
	(kWh)			
1	14229	29760	-20838	-3751
2	15540	26880	-21785	-3921
3	21328	29760	-34414	-6195
4	24690	28800	-42791	-7702
5	26846	29760	-50173	-9031
6	27390	28800	-39527	-7115
7	29295	29760	-19854	-3574
8	28768	29760	-8526	-1535
9	25980	28800	23338	2567
10	20770	29760	21373	2351
11	14700	28800	344	38
12	9238	29760	-2521	-454
Year	258774	350400	-95374	-8321

Table III and Fig. 5 give the energy contribution of PV and wind supply systems in electricity (kWh), as well as the

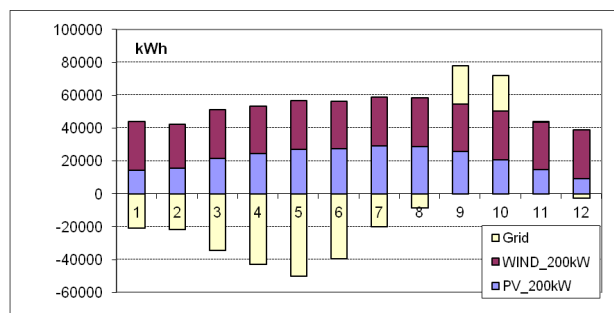financial parameters for each month.

Fig. 5 Energy supply of each month from PV 200 kW, Wind power of 200kW and from the grid

The electricity production from wind power is estimated with the following expression:

$$Wwind\,(kWh) = CF \cdot T(h) \cdot P(kW) \qquad (1)$$

where T is the hours in a month, and CF is the capacity factor which is 0,25.

V. COMPARISON OF THE BASE CASE WITH THE CASES WITH HYBRID ENERGY SUPPLIES

According the results from the simulation for all cases, the following table gives the financial needs in Euro for energy bill of all cases. The months with negative numbers means that the power and energy generated from renewable are more than the energy needs of the vinery complex, and its extra money is additional income for the company.

TABLE IV
EXPENSES AND BENEFIT FOR THE BASE CASE AND THE CASES OF HYBRID
SYSTEMS WITH RENEWABLE

	Base Case	PV_100	PV_200	PV_200 & W_200
	EURO			
1	2357	1764	981	-3751
2	1881	1415	560	-3921
3	1848	661	-1350	-6195
4	1385	-477	-4057	-7702
5	749	-2027	-5920	-9031
6	1973	326	-3111	-7115
7	3452	2701	1090	-3574
8	4734	3918	2336	-1535
9	6775	7164	5735	2567
10	6287	6767	5625	2351
11	3937	4014	3206	38
12	3312	3504	2996	-454
Total	38689	29731	8092	-38321
Money saved	0	8958	30598	77010

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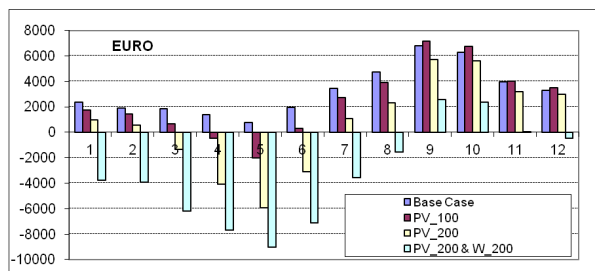Vol:7, No:6, 2013

Fig. 6 Structure of expenses and benefit for all cases

The comparison of the cases in Table IV and Fig. 6 with the Base one shows that the base case has the highest financial needs because the whole energy needs comes from the grid. The other cases with renewable hybrid systems supply, reduced the financials for the energy needs. With increasing the renewable participation in hybrid system, the contribution is larger and in some months the extra money comes as the "green energy" with feed in tariff. The following chart in Fig. 4 gives the total extra money in a year comprising with base case scenario. The last case with PV and wind power, both with 200kW has the large benefit for the company of near 80000 Euro.
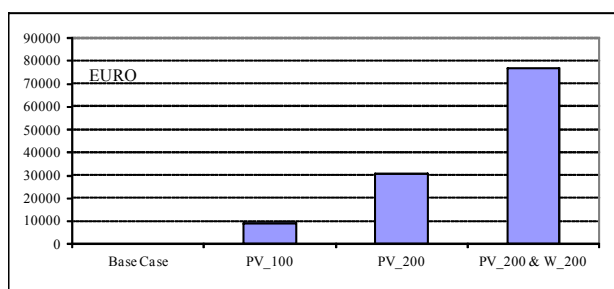

Fig. 7 Contribution of additional income of cases with renewable versus base case

In order to have clear picture of financial benefit from hybrid system with renewable, it should be made additional analysis with investments in renewable that is around 1500 Euro/kW, discount rate and other economical parameters.

Environmental analysis should assess the profit in order to protect the environment, or the project can be declared as CDM Clean Development Mechanism, which can receive additional financial benefits for the project. In the case of larger RES hybrid power system, you can get additional funds for clean green energy project with reducing CO_2 emission [1] and [2].

VI. CONCLUSION

The agriculture sector in Macedonia is one of the main driven factors for the economy and GDP of the country. The objective of the paper is estimating the energy potential in renewable for using in agriculture production facilities taking into account the energy needs and available energy resources.

The goal of every project in agro complex is to estimate technical solution for energy supply with renewable especially

in agriculture farms and production facilities. According technical possibilities and estimation of energy calculation, the other problem is financial support for investment in new technologies for energy supply. Lot of funds and mechanism could be implemented in such pilot project to become realistic in the future. It should help to the private owners of the agriculture complexes in Macedonia how to improve energy supply with energy efficiency and renewable, in order to have less expense for energy needs. The environmental issue is the other part of the project which gives opportunity to determine the project as CDM (Clean Development Mechanism).

The National Strategy for Sustainable Development, in the Republic of Macedonia, supports all cross-sectoral initiatives that increase the economic efficiency on farms and encourage the rural development. The idea of Agro energy is relatively new, here, but extremely important from the point of creating opportunities to encourage the rural development diversification process through so-called non-agricultural income sources. With the idea of Energy from Agriculture - Energy for Agriculture, the small and limited economic capacity of Macedonian farmers can evolve in the direction of utilizing new opportunities offered by the process of sustainable development.

Key recommendations of a group of researchers suggest that proper utilization of renewable energy sources in the rural areas of Republic of Macedonia is possible, by implementing new modern technologies of production, as well as saving of energy through application of energy efficiency principles. Recommendations from the investigations will be realized by the project through application of new technologies for energy saving and energy efficiency, as well as utilization of renewable energy sources in the rural areas of Republic of Macedonia.

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