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 10/0,4 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.

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
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>
<thead>
<tr>
<th>Table I</th>
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<tbody>
<tr>
<td>MONTHLY ELECTRICITY CONSUMPTION IN HIGH AND LOW TARIFF (kWh) AND THE ACTIVE POWER IN kW</td>
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<td>January</td>
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<td>November</td>
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<td>December</td>
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</tbody>
</table>

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.

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The Table II 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>
<thead>
<tr>
<th>Table II</th>
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<tr>
<td>ENERGY STRUCTURE OF THE EXPENSES FOR ENERGY NEEDS IN EURO</td>
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<td>12</td>
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</tbody>
</table>

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.

If we take all factors which are included in electricity bill,
the average price of electricity is around 110 Euro/MWh.

The economic 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.

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.

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.
**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.

It must be mentioned 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**

<table>
<thead>
<tr>
<th>Energy Supplying (kWh) from Each Renewable Source PV and Wind</th>
<th>PV_200kW</th>
<th>WIND_200kW</th>
<th>Grid</th>
<th>EURO</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV_200kW</td>
<td>14229</td>
<td>29760</td>
<td>-20838</td>
<td>-3751</td>
</tr>
<tr>
<td>2</td>
<td>15540</td>
<td>26880</td>
<td>-21785</td>
<td>-3921</td>
</tr>
<tr>
<td>3</td>
<td>21328</td>
<td>29760</td>
<td>-34414</td>
<td>-6195</td>
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<tr>
<td>4</td>
<td>24690</td>
<td>28800</td>
<td>-42791</td>
<td>-7020</td>
</tr>
<tr>
<td>5</td>
<td>26846</td>
<td>29760</td>
<td>-50173</td>
<td>-9031</td>
</tr>
<tr>
<td>6</td>
<td>27390</td>
<td>28800</td>
<td>-39527</td>
<td>-7115</td>
</tr>
<tr>
<td>7</td>
<td>29295</td>
<td>29760</td>
<td>-19854</td>
<td>-3574</td>
</tr>
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<td>8</td>
<td>28768</td>
<td>29760</td>
<td>-8526</td>
<td>-1535</td>
</tr>
<tr>
<td>9</td>
<td>25980</td>
<td>28800</td>
<td>23338</td>
<td>2567</td>
</tr>
<tr>
<td>10</td>
<td>20770</td>
<td>29760</td>
<td>21373</td>
<td>2351</td>
</tr>
<tr>
<td>11</td>
<td>14700</td>
<td>28800</td>
<td>344</td>
<td>38</td>
</tr>
<tr>
<td>12</td>
<td>9238</td>
<td>29760</td>
<td>-2521</td>
<td>-454</td>
</tr>
<tr>
<td>Year</td>
<td>258774</td>
<td>350400</td>
<td>-95374</td>
<td>-8321</td>
</tr>
</tbody>
</table>

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.

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

\[ W_{\text{wind}} \quad (\text{kWh}) = CF \cdot T(h) \cdot P(kW) \quad (1) \]

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 to 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 mean 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**

<table>
<thead>
<tr>
<th>Expenses and Benefit for the Base Case and the Cases of Hybrid Systems with Renewable</th>
<th>Base Case</th>
<th>PV_100</th>
<th>PV_200</th>
<th>PV_200 &amp; W_200</th>
</tr>
</thead>
<tbody>
<tr>
<td>EURO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2357</td>
<td>1764</td>
<td>981</td>
<td>-3751</td>
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<tr>
<td>2</td>
<td>1881</td>
<td>1415</td>
<td>560</td>
<td>-3921</td>
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<tr>
<td>3</td>
<td>1848</td>
<td>661</td>
<td>1350</td>
<td>-6195</td>
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<tr>
<td>4</td>
<td>1385</td>
<td>-477</td>
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<td>326</td>
<td>3111</td>
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<td>7</td>
<td>3452</td>
<td>2701</td>
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<td>3918</td>
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<td>-1535</td>
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<tr>
<td>9</td>
<td>6775</td>
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<td>10</td>
<td>6287</td>
<td>6767</td>
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<tr>
<td>12</td>
<td>3312</td>
<td>3504</td>
<td>2996</td>
<td>-454</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>38689</td>
<td>29731</td>
<td>8092</td>
<td>-38321</td>
</tr>
</tbody>
</table>

| Money saved                                                                         | 0        | 8958   | 30598  | 77010           |

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

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

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

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 CO₂ 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.

REFERENCES