Pump Storage in Macedonia - Opportunities beyond 2020

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Abstract:

The need of new pump storages in Macedonia in the context of the liberalization of the market scheduled for 2015, was considered by the national generation company – ELEM (Macedonian Power Plants) which has a long tradition of hydropower generation, having the first large scale power plant commissioned in 1957th and today having installed hydropower of about 450 MW. The pump storage development projects were considered as relevant because of the following reasons:

- Macedonia has favorable topography and geology (from the existing studies 7 PSHPP with total installed power of 2820 MW are identified),
- Favorable position and interconnection in the regional network with predominant thermal power (Bulgaria, Greece, Kosovo)
- Targets of Macedonia and the region for increase of the installed power of renewable energy sources with stochastic nature of generation (PV, Wind, Small Hydro)
- Opening of the electricity market planned to happen in January, 2015

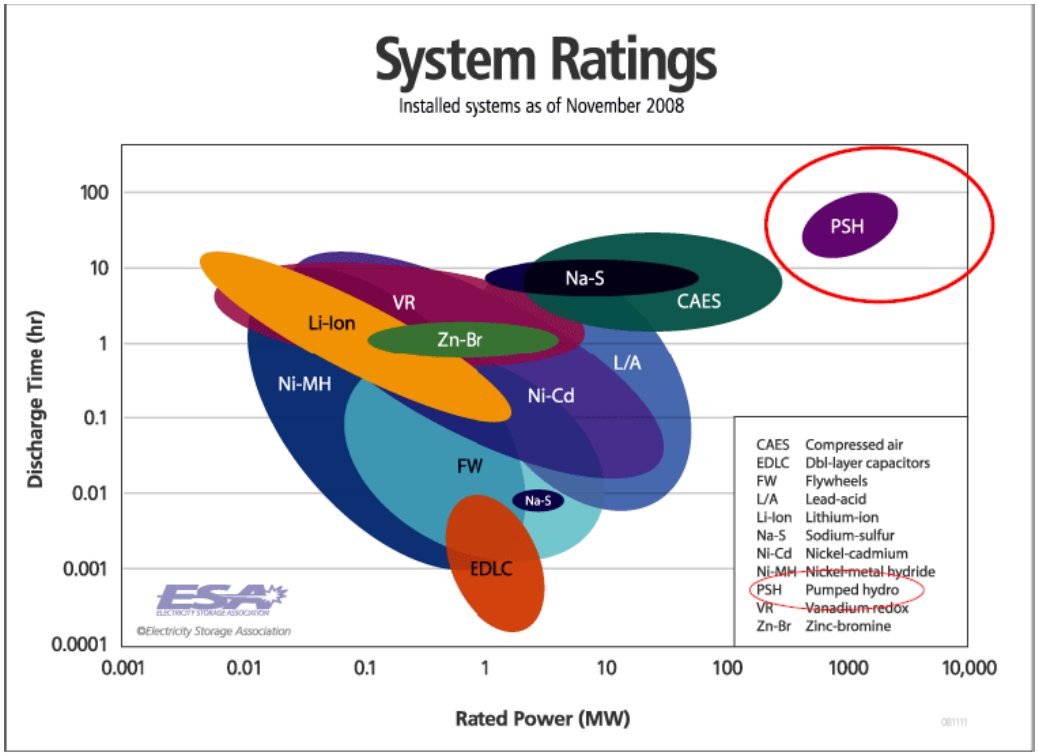
Even though the technical feasibility was proven, the past analyses for the PSHPP had led to a conclusion that the Macedonian Power System itself (with annual consumption of order of 8 TWh) is well balanced even without PSHPP, so their economic viability was in question, but nowadays the liberalized market could offer opportunity for these planned projects. In that aspect, in line with the development goals of the company, ELEM in 2010 has financed a pre-feasibility study for one of the most promising sites for PSHPP in Macedonia, namely PSHPP Tashmarunishte.

The aim of this paper is to:

- Give a general outlook of the possible new sites for pump storage in Macedonia
- Present the latest findings from the Pre-feasibility study for PSHPP Tashmarunishte as most promising site;
- Summarize what the emerging RES and the liberalization of the regional market will bring along for this potential project.

1. General outlook of the possible new sites for pump storage in Macedonia

Pumped storage hydro power plants (PSHPP) or reversible hydropower plants at the time being are the most efficient plants with possibility to store the electric power to potential energy of water, after that when needed to convert it in electric power. Therefrom, they permit the efficient use of the other energetic resources: potential of water, fossil and nuclear fuel, for power generation.



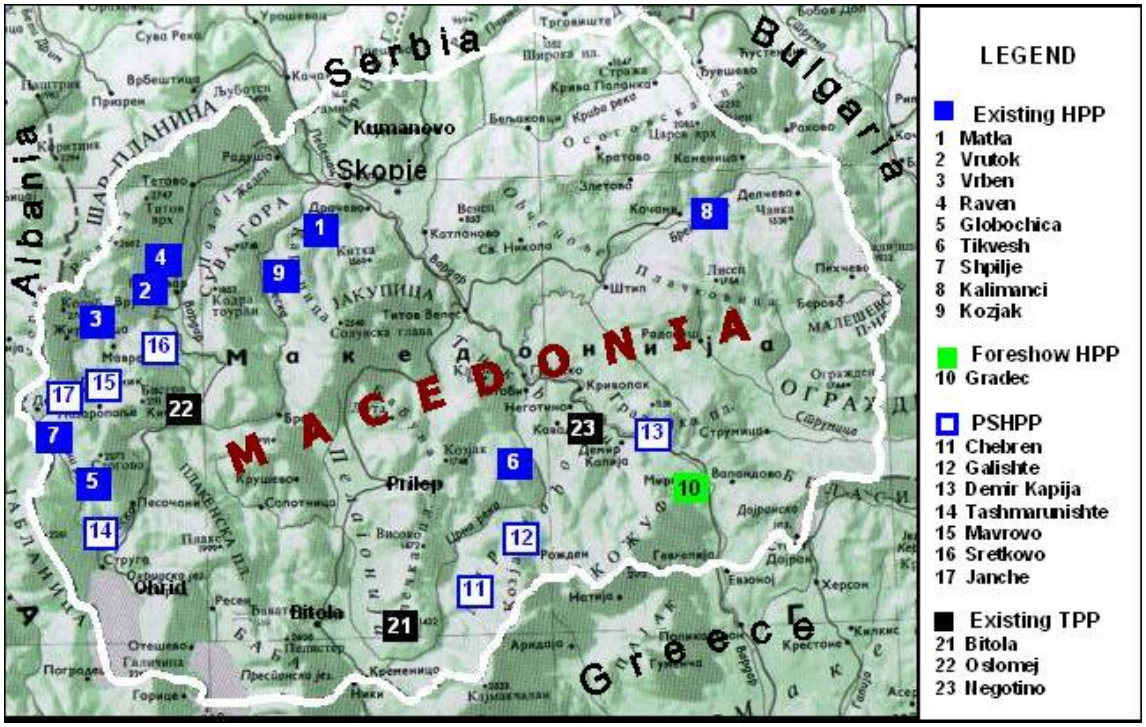
http://electricitystorage.org/tech/technologies_comparisons_ratings.htm (logarithmic scale)

It is obvious that the PSHPP can have storage capacity of about 8 hours with installed power of above 1 000 MW, which is much more than all alternative options.
Besides for storage, the PSHPP are important for:

- Balancing thermal power
- Balancing variable/ intermittent power sources (Renewables)
- Grid stabilization
- Peaking power to grid
- Take power off the grid during over periods of over supply
- Ability to store large quantities of energy

Whan speaking of the topographical, hydrological and geological conditions in Republic of Macedonia the general outlook is that there are favorable conditions for development of PSHPP, and that is why a Study for possible Pumped Storage Hydro power Plants in Republic of Macedonia was elaborated. In the Study the investigation was limited to 7 possible PSHPP: Chebren, Galishte, Sretkovo, Mavrovo, Janche, Tashmarunishte and Demir Kapia (Fig. 1). The selection was based on economic criteria and technical feasibility, however possible PSHPP between natural likes: Prespa Lake and Ohrid Like (different of water levels is 157 m.) were not taken in consideration due to environmental reasons.

Fig. 1 Map of Republic of Macedonia with existing power plants and the locations of pumped storage power plants



1.1.Locations with natural inflow in the upper reservoir

First set of sites analyzed those with natural inflow in the upper reservoir (Fig. 1): Sretkovo (16), on the existing reservoir Mavrovo Lake, Chebren (11), on the planner large reservoir Chebren on Crna River and Galishte (12), on the planned large reservoir Galishte on Crna River.

1.1.1. PSHPP Sretkovo

The existing Mavrovo Lake is created with the construction of Mavrovo dam between 1948 to 1957 year, as reservoir for HPP Vrutok and Raven. In the Study it is foreseen that part of the water of Mavrovo Lake is redirected towards Lakavica River, where is planned an irrigation reservoir “Kunovo” for the Polog region. In these cases existing HPP Vrutok and HPP Raven

would work independently of irrigation requirements. The new reservoir "Sretkovo" will be a downstream reservoir build on left tributary of Lakavica River, upper from a reservoir "Kunovo", nearly on village Sretkovo. It will have total volume 13 hm^3 and useful volume 6 hm^3. The headrace tunnel will be 3 500 m. long, and the penstock 1 400 m. Maximum gross head, between Mavrovo Lake and the reservoir "Sretkovo", will be 398 m, and minimum gross head will be 357 m. There are variants for the installed capacity 3 x 30 = 90 to 3 x 110 = 330 MW.

1.1.2. PSHPP CHEBREN & GALISHTE (CRNA RIVER CASCADE)

PSHPP Chebren & Galiste are top priority projects of the Energy Strategy of R. Macedonia, and of the Government of R. Macedonia, these projects are developed under the Public private partnership model.

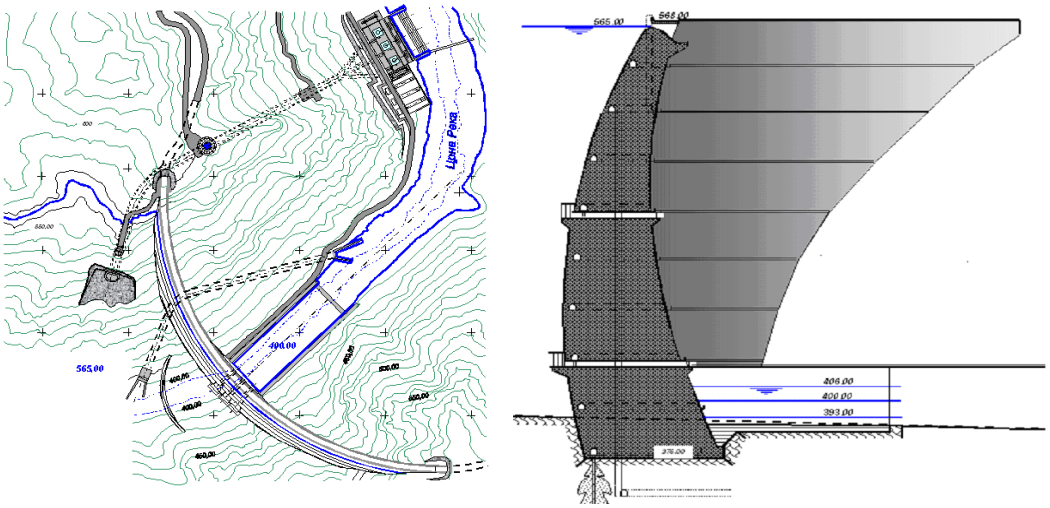


Figure 1: Layout of PSHPP Chebren and Cross section of the Dam

Crna River Cascade comprises the following hydro power plants:

1) PSHPP Chebren, capacity of 332,84MW / 347,34 MW(Turbine Mode/Pump Mode),
2) HPP Galiste, capacity of 193,50 MW, conventional or reversible
3) HPP Tikves (existing) capacity of 116 MW, conventional

Total capacity of the Crna River Cascade 642.34 MW

HPP Galishte could be also pump storage if there is economic interest; there are variants with installed capacity from 90 MW up to 330 MW.

1.2. Locations with build or planned downstream reservoir

In this group the following plants are planned: Tashmarunishte (14), with existing downstream reservoir "Globochica", Bistra (15), with existing reservoir Mavrovo Lake and Demir Kapia (13), on the planned reservoir "Gradec", on the river Vardar.

1.2.1. PSHPP TASHMARUNISHTE

The results of the prefeasibility study for PSHPP Tashmaruniste are presented in detail in chapter 2.

1.2.2. PSHPP BISTRA

The upper basin is planned to be created with construction of two rock fill dams: Smreka and Smrdlivi virovi, with relatively small volumes of about 195 000 m^3 and 4 200 m^3 respectively. With these two barriers the accumulation of Bistra with useful volume of 20.25 mio.m^3 will be created. The powerhouse will be located in proximity to village of Mavrovo, there are variants for the installed power from 200 to 800 MW.

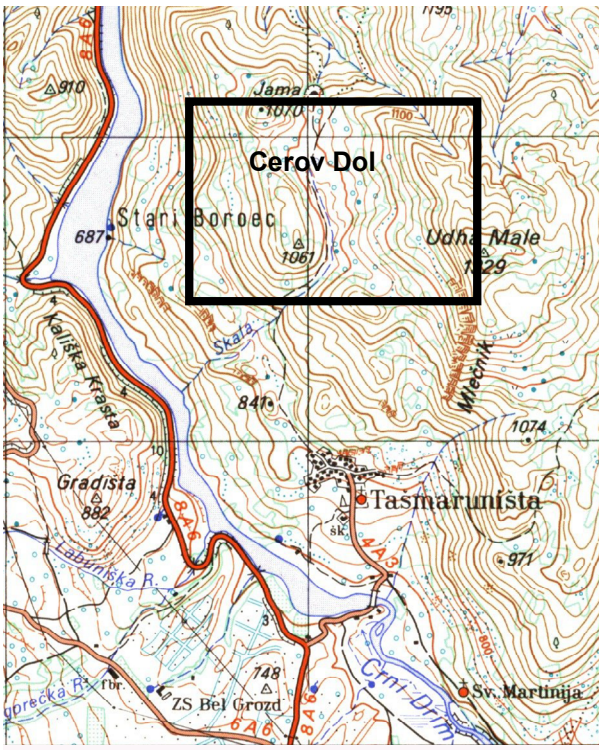
1.2.3. PSHPP DEMIR KAPIA

The reservoir “Gradec” is planned on the river Vardar , about 30 km upstream of the frontier with Greece, with a level oscillation 4 m and useful volume 40 hm3. The upper reservoir is planed on the right small tributary of Vardar, the river Chelavec, with constructed concrete arch dam, high 103 m and volume 160 000 m3. Upper reservoir will has gross volume 26.50 hm3 and useful volume 12.45 hm3. There are two variants for the installed capacity 2x50=100 and 3x75=225 MW.

Among these seven possible PSHPP as mentioned above, PSHPP Chebren with capacity of 332,84MW / 347,34 MW(TM/PM) is the first priority project for the government and is being tendered for development under the public private partnership model, second project in the row is the Project Tashmarunishte, for which ELEM has made pre-feasibility study. The results of the pre-feasibility study are shown below.

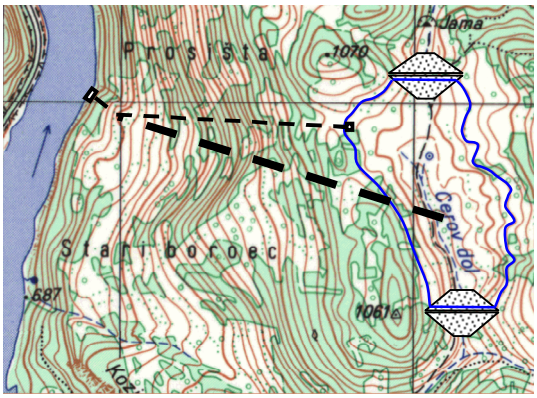
2. Pre-feasibility study for PSHPP Tashmarunishte

In the pre feasibility study for PSHPP Tashmaruniste there have been analysed three possible variants of installed capacity, in combination of 2, 3 and 4 units, i.e installed power of 100 (2 x 50), 150 (3 x 50; 2 x 75) and 200 (4 x 50; 2 x 100) and **225 (3 x 75)** MW. As most economically viable solution is the variant with 3 units of 75 MW, total of 225 MW. However the installation of the units could be done in phases, in first phase 2 units, and in second phase the last thirds unit (the timing of the installation of the third unit is subject of increase of the demand for peaking power).



Map 1: Site for upper reservoir

PSHPP Tashmaruniste is forseen to use the existing reservoir of HPP Globocica, which reservoir will be downstream reservoir of the plant; the upstream reservoir is foreseen to be created at the place called Cerov dol, east of reservoir Globocica and south of village of Tashmarunista, with construction of two dams as shown on map 2.1 and 2.2. The upstream reservoir is on altitude of 1000 m.a.s.l, or more than 310 m above the existing accumulation of Globocica.



Map 2: Upstream and downstream reservoir

Normal level of downstream reservoir – Globocica is on 687.5 m.a.s.l and the minimal operating level is on 682.00 m.a.s.l. Normal level of the upper reservoir is at 1022.5 m.a.s.l and the minimal operating level is on 995.00 m.a.s.l. The intake of the upstream reservoir to the powerhouse is foreseen as tunnel reinforced with steel lining with length of 1280 m and diameter of 3.4 m. The powerhouse is foreseen on the right bank of reservoir Globocica, and the substation above the powerhouse.

Technical parameters of the plant:

- Production of 194 GWh/year
- Consumption of 264 GWh/year
- Useful volume of upper reservoir 5.226.700 m^3
- Maximal denivellation of upper reseirvoir of 27.5 m (1.022,50 m.a.s.l – 995,00 m.a.s.l)

- Maximal denivellation at weekly basis of downstram reseirvoir of 2.3 m
- Possibility to provide emergency power for time of 20 hours.
- The efficiency of the plant is 73.9 %

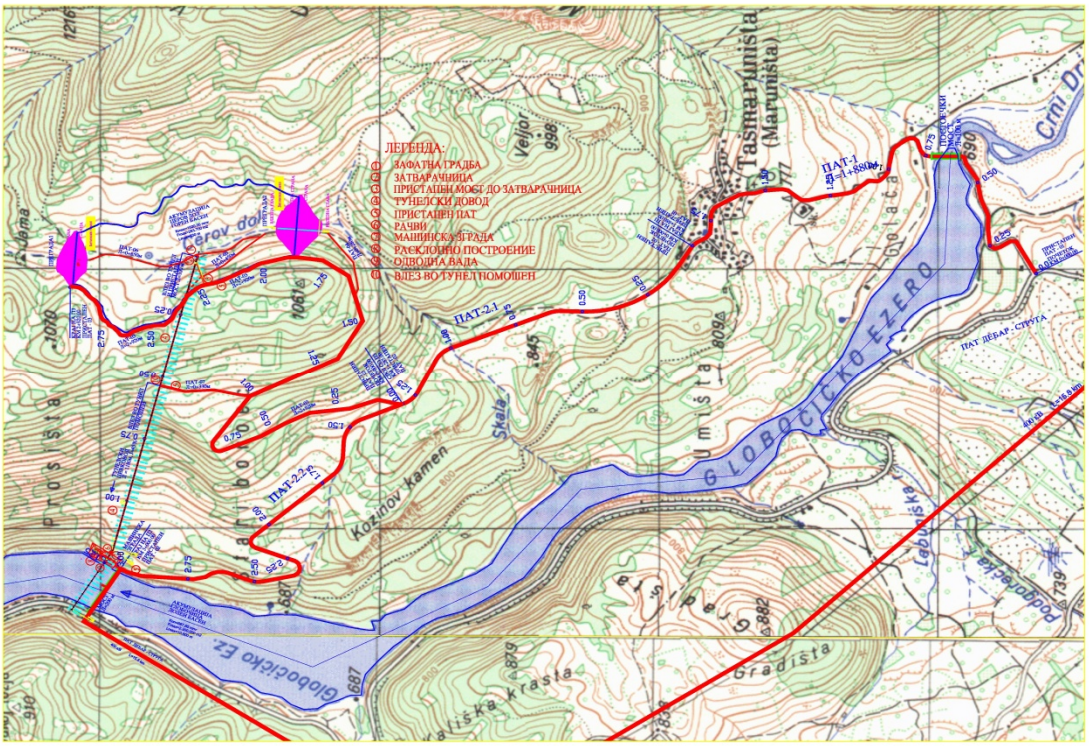


Figure 2: Layout of PSHPP Tasmaruniste, with upstream(to be constructed) and downstream(existing) reservoir

2.1 Economic parameters of PSHPP Tashmaruniste

The price for electricity for pumping in the base year is predicted as 40,00 €/MWh (base load price), the loan period is taken to be 25 year and the interest rate at 2.0 (soft loan) than the price for produced MWh is 104,21 euros. With the three units installed the price of the produce energy decreases to 90.13 €/MWh. In the last case the ratio between the price of the produced and consumed energy is 2.25 which is very good output having in mind that the ratio between the price base load and peak energy can be up to 4.00 and in the last several years in Macedonia is about 3.00.

It can be resumed that PSHPP Tasmaruniste is profitable plant, which can be constructed in three years and with relatively low investments estimated in the range of 68 – 80 mio. euros, or the specific investments are of range of 450 – 355 K€/MW

3. Impact of liberalization of the regional market

It is clear that with the construction of PSHPP Chebren with 347 MW and the eventual construction of PSHPP Tashmarunishte of 150 MW, Macedonia would need nearly 500 MW of base inexpensive power for pumping, and this is approximately 10-15 times the available night inexpensive power of the Macedonian power system. So it is clear that there will be no possibility within Macedonia to provide base load for pumping of these PSHPPs, nor there is need of such peaking capacity by day, therefore it is clear that the target market for the Macedonian PSHPP should be the Balkan region market.

This market has rather large variation in regional load: the hourly load is highest during the cold months which depend on the need for heating (so it is mostly influenced by climatic conditions), the peak demand adds approximately 5,000 – 10,000 MW to the base load in the Balkans, and this is order of magnitude where first two Macedonian PSHPP should easily fit.

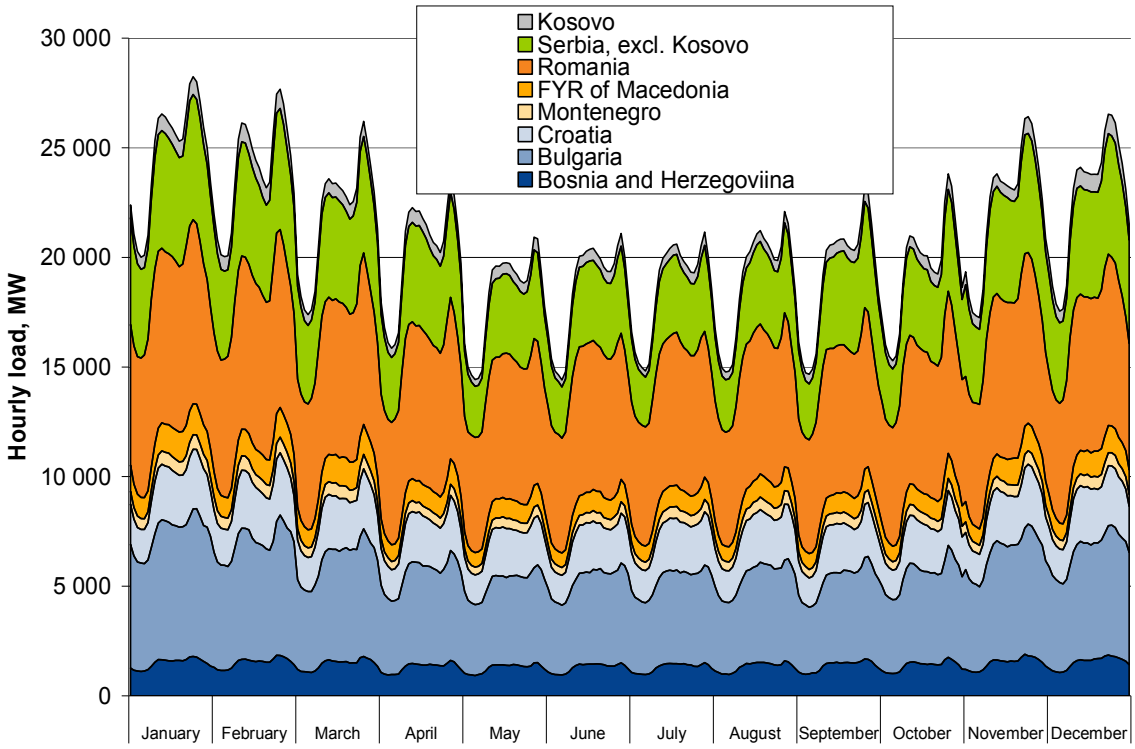


Figure 3: Load curve of the Balkan countries (source Poyry)

It is clear that in the next years (Macedonia has signed the Athens memorandum for liberalization of the market, and by the memorandum Macedonia is obliged by 2015 to have full liberalization of the Market) the regional market will enter into the process of liberalization, and Macedonia has central position in the Balkans interconnected network, therefore there are two important messages to the decision makers in Macedonia:

1. Liberalization of the market, by 2015 as agreed with Athens memorandum

2. Concentrate the efforts for commissioning of PSHPP Chebren by 2020 and PSHPP Tashmaruniste by 2025

3. To construct the planned OHL 400 kV and maintain the existing towards all neighbor countries, net importers or net exporters.

Further, the general idea should be that Macedonian PSHPP imports energy in the hours of low demand, and to export in the high demand hours. By the end of each week difference of exports and imports financial balance should be positive. For grasping the idea, we have used European Energy Exchange prices from past year:

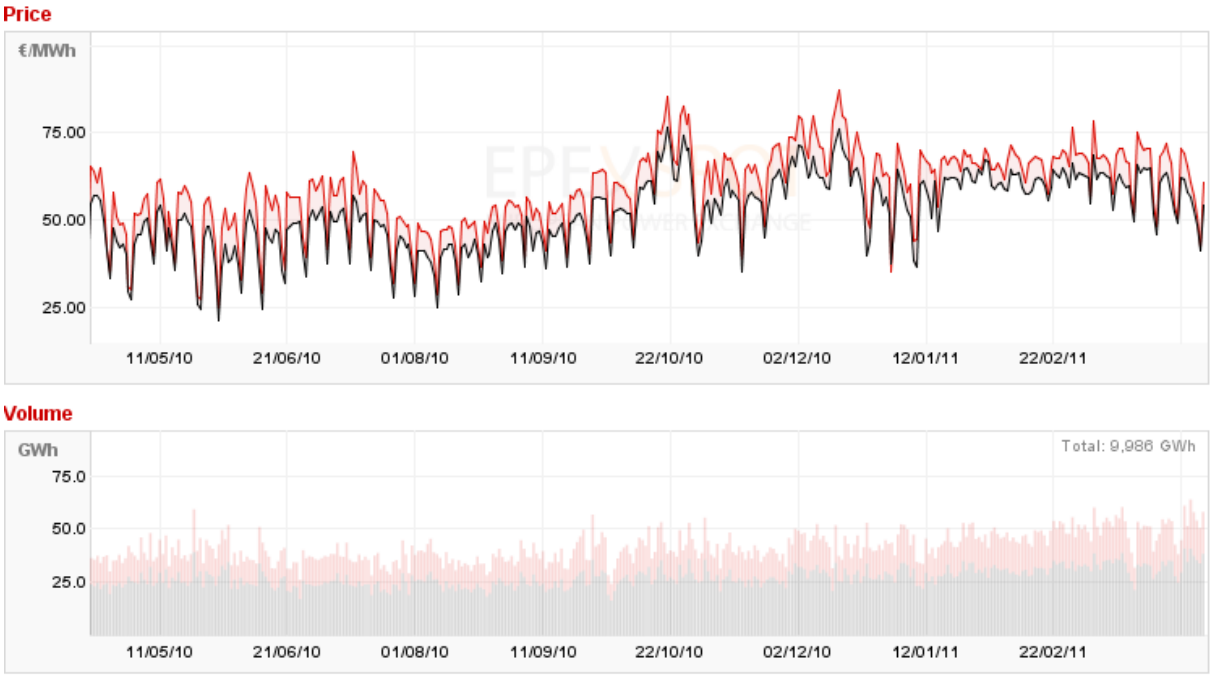


Figure 4: One year price of electricity on spot market (day ahead prices)

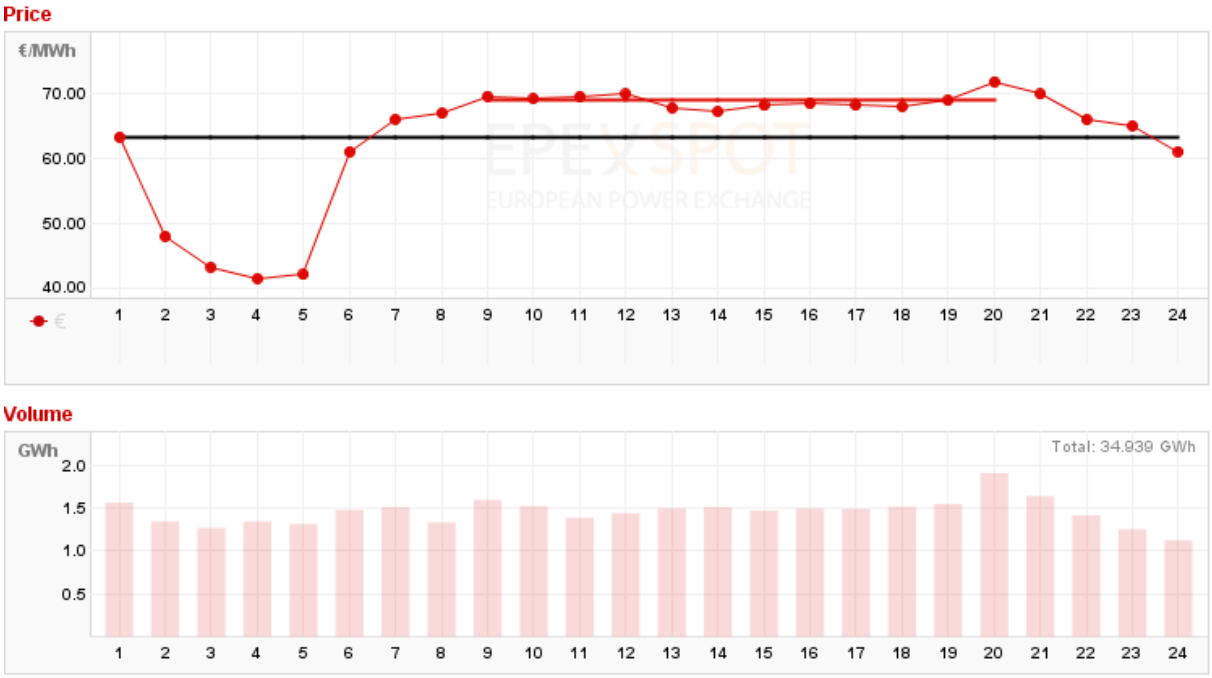


Figure 5: Typical pattern of day variation price of electricity on spot market (day ahead prices)

So just to present the concept not entering in the costs of the plants, just analyzing the market conditions taking conservative approach, we can calculate with 65 euros/MWh for selling price of the peak electricity on the spot market, while for the purchase of electricity the model is power purchase agreement for year ahead contract (PPSHPP can afford so) and for such contract the price should not exceed 35 euros/MWh.

With these assumptions we arrive at following results for Macedonian PSHPP:

	Consumption	Cost of Import	Production	Benefiths of Exports	Export-Import Net
	GWh	mio.€	MWh	mio.€	mio.€
PSHPP Chebren	785.6	2.7496	840.3	5.46195	2.71235
PSHPP Tashmaruniste	264	0.924	194	1.261	0.337
Total	1049.6	3.6736	1034.3	6.72295	**3.04935**

Table 1: Export-Import effect of PSHPP

It is obvious that at volume of import bigger than the export, the financial effect as well the macro economical effect is strongly positive.

4. Conclusions

Macedonian geography is favorable for development of PSHPP, although there is no surplus of thermal generation in the country, these projects should be observed from regional perspective. The fiscal deficit due to imports can be compensated with efforts in order to develop these potentials with much higher added value than the thermal generation, for which Macedonia has limited resources.

Construction of only two above analyzed PSHPP will permit to import about 2000 GWh a year, or net 950 GWh/year (annual generation of thermal unit with capacity of 150 MW) and to have export-import balance at zero.

The message to the decision makers is to:

1. Liberalize of the market, by 2015 as agreed with Athens memorandum
2. Concentrate the efforts for commissioning of PSHPP Chebren by 2020 and PSHPP Tashmaruniste by 2025
3. To construct the planned OHL 400 kV and maintain the existing towards all neighbor countries, net importers or net exporters.

5. References

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