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CLEAN ALTERNATIVES TO PTOLEMAIDA V

Executive Summary of the economic and technical assessment

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The aim of this report is to investigate and offer an economic evaluation of alternative solutions to the planned construction of the Ptolemaida V lignite unit - solutions that are based on Renewable Energy Sources (RES). The role that small and large-scale storage technologies can play in increasing the RES share in Greece's energy mix is also examined.

A new energy landscape

It's been quite a few years since the decision to build Ptolemaida V was taken - the invitation to tender was approved in 2010 -, in a time when the status quo in climate and energy policy, both in Greece and abroad, was notably different than it is today. Key to the recent developments at an international level have been the successive decisions by the USA, China and the European Union to take important measures towards reducing their emissions. These political changes have also affected the attitude of international financial institutions, as one after another, they are placing strict conditions on funding the construction of new coal plants. Quite significantly, the European Investment Bank recently decided to end funding towards coal units whose emissions exceed 550 gr CO_2/Kwh, ruling out in this way Ptolemaida V, which is expected to emit twice as much.

It appears that this change of wind is grasped by Europe's energy giants, which are gradually changing their business plans. Companies such as E.On, RWE, EnBW and EDP have decided to cut down their activity in the fossil fuel sector and turn towards new areas of profit, in RES and decentralized production, networks and energy services sectors.

The aforementioned become of multi-fold importance to Greece, due to the devastating economic situation of the country, as well as the Public Power Corporation's (PPC) limited liquidity. The bleak outlook for Ptolemaida V, a €1.4b project, is further deteriorated by two main factors: a) the expected increase in CO_2 emission allowances costs, particularly following the implementation of the Market Stability Reserve mechanism that was proposed by the European Commission in the beginning of 2014 and b) the strong possibility of a reduction in the hours of operation of the new unit as a result of RES growth, according to the current national energy plan. The effect of these two factors has been examined in a previous study by WWF Greece[1].

Economically efficient alternatives to Ptolemaida V

In the first stage of the current study, a comparison was made between the levelised cost of electricity of various power production technologies (LCOE)[2], which concluded that certain RES

[1] WWF Greece. (2013). "Ptolemaida 5 and Meliti 2, Economic viability report of the new lignite units".

[2] This method aims at calculating the overall production cost per electricity production technology throughout its lifespan, in net present value.

technologies are already fully competitive with conventional power production technologies, and specifically Ptolemaida V.

This trend is expected to grow in the future, as the development of clean technologies will make RES even cheaper. At the same time, the cost of electricity produced in lignite units is expected to increase for a number of reasons, such as for example the high CO_2 emission rights costs and increasing fuel costs. The questionable return of the Ptolemaida V investment is also directly linked to the uncertainty regarding the initial installation cost of the unit. Figure 1 presents sample results of the comparison made between Ptolemaida V and wind and photovoltaic (PV) units up until 2050, demonstrating the competitiveness of land wind farms and medium and large PV stations with regards to the new lignite unit.

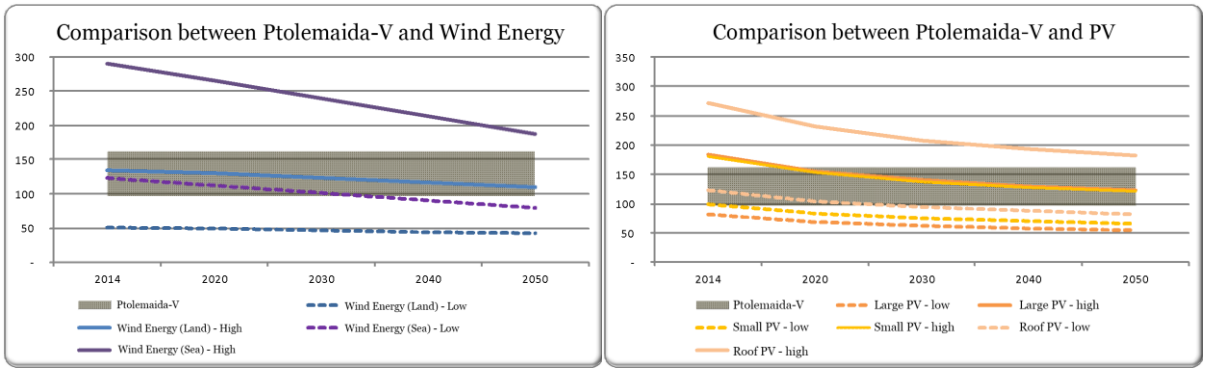

Figure 1. Levelised cost comparison between Ptolemaida-V and selected RES technologies

Assessment of hybrid RES systems and pumped hydro energy storage

Based on the aforementioned facts, it is essential to investigate RES-based alternatives to the construction of Ptolemaida V. The greatest challenge that RES technologies face in meeting base load demands similar to those of Ptolemaida V, is the variable nature of the energy production using wind and PV systems. However, this challenge can be technically overcome by combining RES production with various energy storage systems, such as batteries and pumped hydro energy storage (PHES).

The current study focused on the potential for substituting Ptolemaida V with hybrid systems that combine PHES units and wind and PV stations. A previous study[3] has already demonstrated that the conversion of seven pairs of the PPC's existing hydroelectric power (HP) stations to PHES units is technically feasible and economically attractive, given that it eliminates the need for constructing new reservoirs. This option will also result in minimal environmental impacts.

The energy analysis performed in the current study proved that it is possible to meet the base load demands of Ptolemaida V using hybrid combinations of PHES, wind and photovoltaic stations (Figure 2). Should *almost full* coverage (95%) of the Ptolemaida V load be considered acceptable, the desired outcome can be achieved by using even more combinations of RES power and storage capacity.

[3] Stefanakos I. (2013). "Investigating the construction potential of new pumped-storage units in Greece". NTUA: Research Project 62/2423 (Construction potential of pumped-storage projects in Mainland Greece).

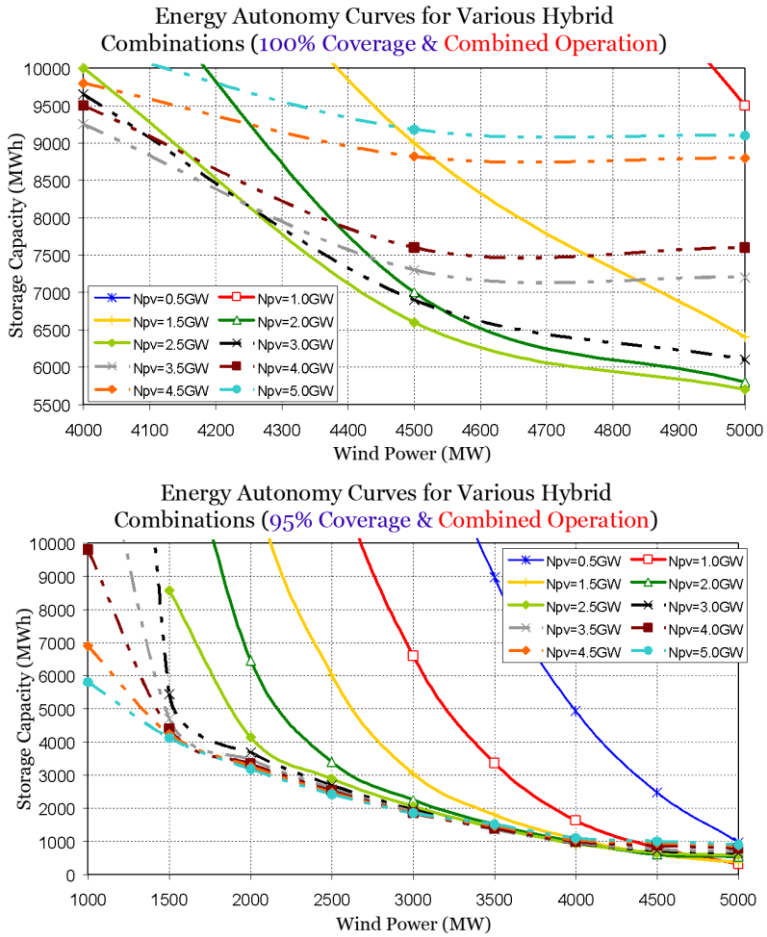

Figure 2. Energy autonomous hybrid combinations that can achieve 100% and 95% coverage of the Ptolemaida-V base load, assuming a 10 GWh upper limit in capacity storage

Most important of all, many of these solutions prove to be economically more favourable compared to Ptolemaida V, as their levelised cost is considerably lower than that of the new lignite unit (Figure 3). These solutions, for different application scenarios, are presented in detail in Table 1.

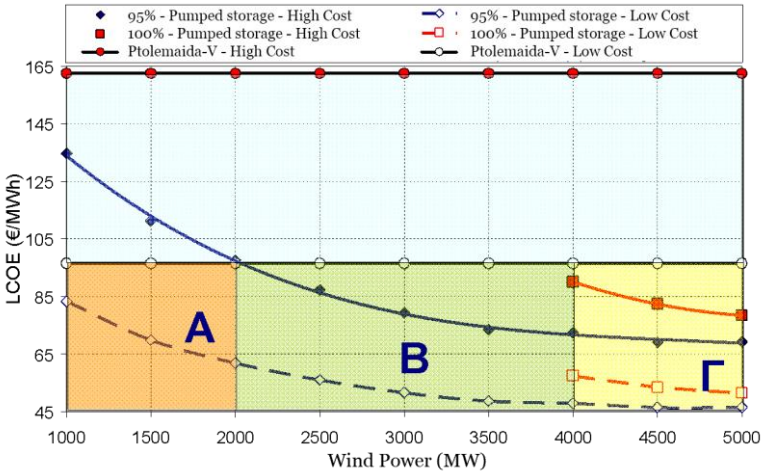

Figure 3. Levelised production cost of energy autonomous hybrid combinations - Achieving 100% (a) and 95% (b) coverage of the base load, assuming a ≤10 GWh storage capacity

Table 1: Hybrid combinations that are economically competitive to Ptolemaida V (minimum cost of Ptolemaida V: 96.47 €/MWh)

Wind power (MW)	PV power (MW)	Storage capacity (MWh)	LCOE (€/MWh) (high cost)	LCOE (€/MWh) (low cost)
100% coverage of Ptolemaida V load				
4,000	2,500	10,000	90.06	57.43
4,500	1,500	9,000	82.35	53.47
5,000	1,000	9,500	78.44	51.42
95% coverage of Ptolemaida V load				
2,000	2,000	6,460	97.50	83.30
2,500	1,500	6,030	87.21	69.86
3,000	1,000	6,600	79.27	61.88
3,500	500	8,970	73.48	56.01
4,000	500	4,930	72.43	51.62
4,500	0	9,150	69.08	48.71
5,000	0	5,210	69.25	47.90

It is important to stress that the assumptions made for calculating the results all but favour the solution of hybrid stations. For example, the assumption of high system minimum loads (4 GW) increases the levelised cost of energy of hybrid solutions, while the rather ambitious capacity factor assumed for Ptolemaida V is larger than the one included in the design specifications of the unit (80%, according to the Environmental Impact Assessment), which results in lower production costs for the proposed lignite unit. Finally, the maximum storage capacity available in the pumped-storage stations was taken to be equal to only 25% of the actual maximum available, in order to avoid hindering the current operation of the reservoirs (autonomous HP, irrigation, flood-prevention), while the efficiency of the pumped-storage stations was also assumed to be particularly low (63.75%).

The results show that the conversion of existing pairs of PPC hydroelectric power stations to pumped hydro energy storage stations, and their use for storing the energy produced in wind and PV stations in not only **technically feasible, but also more favourable in economic terms compared to the performance of Ptolemaida V**.

Small-scale solutions

As the actual hours of operation of Ptolemaida V drop, so does the economic performance of the unit, as was already demonstrated in a previous study by WWF Greece[1]. The reduced demand that Ptolemaida V will be asked to meet beyond 2020 is the result not only of the expected growth of large-scale RES, but also of the recent technological developments in the photovoltaic and battery sectors. These developments can turn current household consumers of electric energy to self-generators (prosumers).

As part of the study, an economic assessment was performed on the implementation of the net metering mechanism that was recently voted in Greece (scenario "Ministerial Decree -MD") in order to promote the use of photovoltaics. The assessment showed that there is great potential in the development of small-scale systems in order to meet household energy demands, partly due to the country's high levels of insolation. Should the net metering mechanism improve on the basis of the change suggested herein ('Alternative Plan' scenario) in the future, this potential could become even greater. The results of the analysis are given in Figure 4.

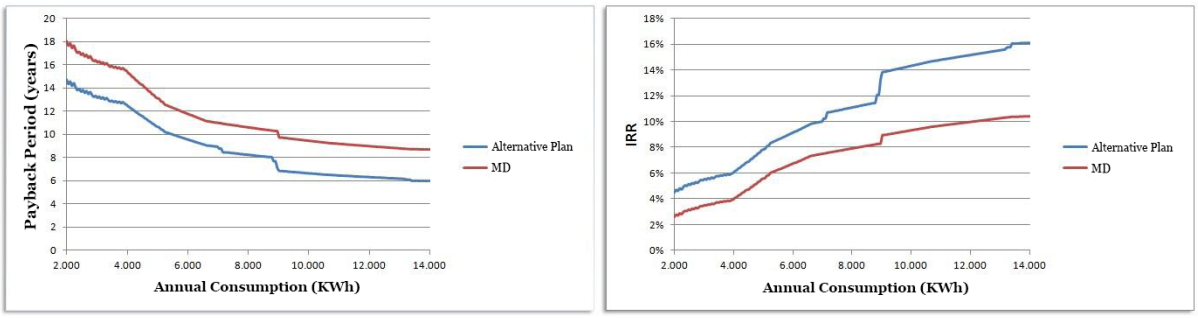

Figure 4. Payback period (left) and IRR (right) as a function of the annual energy consumption for the 'MD' and 'Alternative Plan' scenarios

The return of investments on residential, stand-alone photovoltaic systems using ion-lithium batteries was also examined. The cost of such systems, based on the predictions of market analysts, is expected to drop sharply over the next 10-15 years, due to drastic reductions in battery costs. The realisation of the aforementioned prediction, combined with the drop in PV installation costs, the expected increase in domestic power consumption and the increase in energy prices, could render autonomous systems directly competitive with centralised power production in Greece (Table 2).

Table 2: Payback time and internal rate of return (IRR) of autonomous systems for different scenarios (9,045 KWh annual consumption)

Battery unit cost ($/KWh)	'MD' Scenario		'Alternative Plan' Scenario	
	Payback period (years)	IRR	Payback period (years)	IRR
500	>25	-2.70%	>25	-1.20%
400	>25	-1.97%	>25	-0.40%
300	>25	-1.13%	23.32	0.54%
200	22.94	0.67%	18.30	2.56%
100	15.61	4.00%	12.26	6.44%

Apart from fully autonomous PV systems using batteries, there is also the option of storing energy in the batteries of electric vehicles. The growth of vehicle electrification in Greece can contribute, under certain circumstances, to independence from the use and import of fossil fuels, to peak power smoothing and to the further development of RES, and eventually reduce the electric energy demand that Ptolemaida V will be asked to cover between 2020-2050.

It is, therefore, concluded that the developments in the field of small-scale PV, either employing net metering, stand-alone systems with batteries, or a combination of both, can lead the way in the forthcoming, drastic transformation of the existing model of power production: from centralized, huge, fossil-fuel power plants like Ptolemaida V, towards decentralized, stand-alone systems and ultimately a gradual independence from grid-produced electricity.

Conclusions - proposals

Lignite dependency is not the only option for Greece. This study proposes and provides evidence to support specific alternative solutions that eliminate the need for constructing the Ptolemaida V plant. These solutions are technically feasible and at the same time outmatch the planned unit both economically and environmentally.

In this context, WWF Greece is calling for the Greek state to:

- Re-examine the economic sustainability of the new unit and evaluate the equivalent alternative solutions proposed.
- Establish the appropriate institutional framework regarding pumped hydro energy storage.
- Improve the regulatory framework regarding net metering and, as a next step, design a policy mechanism that will promote the development of small-scale, stand-alone RES systems.
- Provide the necessary infrastructure for the growth of the electric vehicle market in Greece.
- Plan a new business model for the PPC, built around profitable sectors that will maximise the benefits of the business, the customers and the environment.
- Set out a thorough national energy plan that will take into account the emerging developments in the clean energy sector at an international level and will delineate the development over time of the participation of each power generating technology in the country's energy mix up to 2030 and 2050.

“We shan’t save all we should like to – but we shall save a great deal more than if we never tried.”

Sir Peter Scott, founding chairman of the World Wildlife Fund (WWF)

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