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Lignite in Greece: An Assessment

October 2018

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1. Introduction

In 2017, coal use was responsible for 20.6% (669TWh) of electricity generated in the EU. More than 383Mtons of lignite were consumed (see Figure 1 below). The figure for Greece is higher at 39.1% (18.52TWh gross) of total electricity generation down from 52% in 2009. In Greece, in view of the 1.53tonCO_2/MWh emission rate for lignite-based electricity production in 2017, lignite consumption was responsible for 25.5Mtons CO_2 i.e. a little over 28% of all national GHG emissions (in 2016 as stated in the 2018 National Inventory Submission). It is thus imperative that the use of lignite is reduced drastically if one hopes to reach the inspirational targets set by EU for ca. 95% reduction of GHG emissions from electricity generation by 2050.

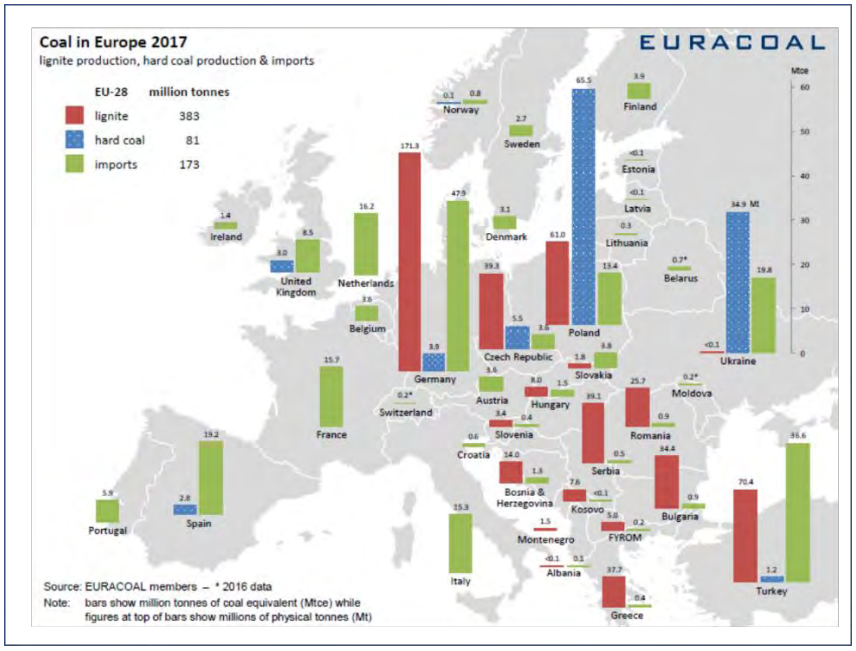

Figure 1: Lignite and coal consumption in Europe (source: EUROCOAL)

Greece is rich in lignite deposits. They are located mainly in four areas (see Figure 2a), namely the Megalopolis basin in Peloponnese, the Ptolemais valley with its 3 basins (Ptolemais, Amyntaio and Florina), Elassona, its continuation to the South, and Drama (including the adjacent Phillipoi peat field). There is no exploitation of the two last areas, nor is such activity contemplated, mostly because the local communities in Drama have been vehemently against it from the beginning.

Lignite exploitation started as early as 1873, with an underground mine that continued operation providing lignite to supply the first power station built at Aliveri in 1951. The Aliveri mine closed in 1980 and the power station was converted first to oil and lately in 2013 to natural gas (NG). In 1955 extraction also started in Ptolemais to supply by 1959 the first plant at Ptolemais basin. Ten years later in 1969, the Megalopolis mine in the Peloponnese started providing lignite for the new station built there.

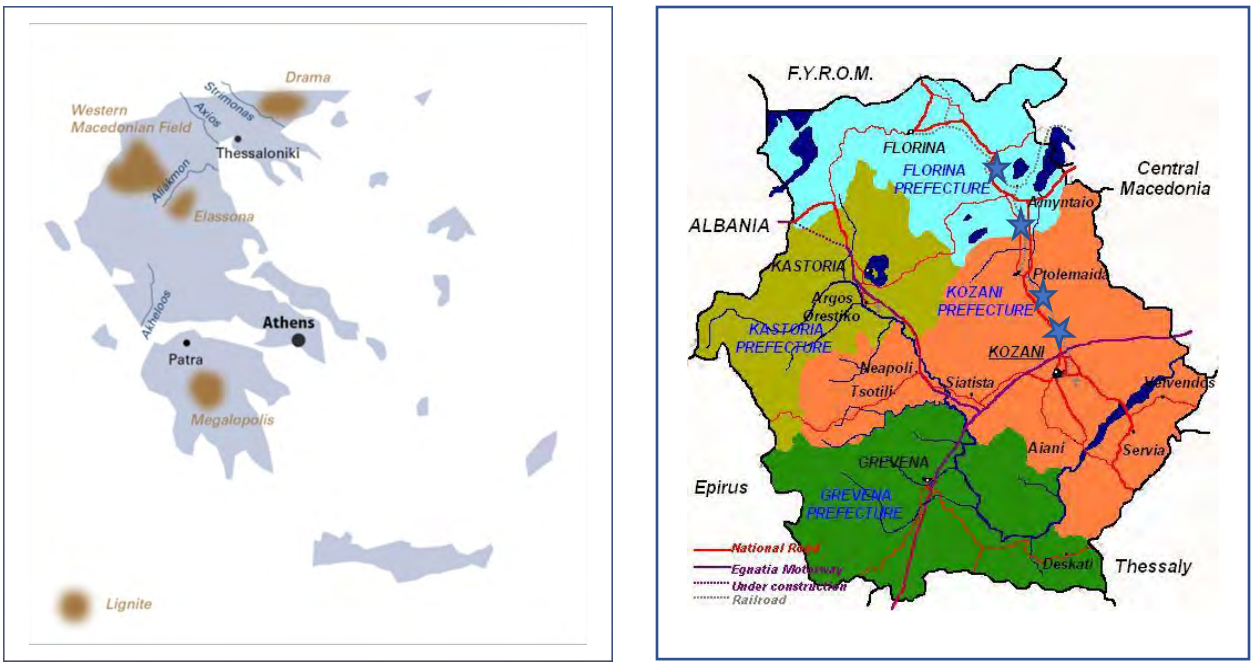

Figure 2: Maps of the lignite deposits areas in Greece (a) and (b) the Ptolemais valley area, its municipalities, regional units (prefectures) and the location of the power plants (marked by stars) starting with Ag. Dimitrios in the south and ending in Meliti with Ptolemais and Amyntaio in between.

This activity centered on the lignite mining has been the lifeline of the local economies now for over half a century and any effort to reduce emissions and consequently lignite use will have severe impacts as their economic circumstances will decline drastically.

In trying to find ways to decarbonize electricity production, it becomes necessary then to collect information and analyze and assess all aspects of the lignite associated activity if one is to design effective ways for the transition of these regions to the post-lignite era. This is the aim of this study which is structured as follows. In Section 2, the current status of electricity production by lignite is presented. In Sections 3, 4 and 5, the lignite reserves, the cost of extraction and the cost of electricity generated respectively are discussed. In Section 6, the status of the tender of 3 plants and the permit for a fourth currently ongoing is given while in Section 7 the long-term energy planning and progress for the compilation of the Greek National Energy and Climate Plan (NECP) is presented. In Section 8, transition considerations to the post-lignite era such as the decommissioning schedule, the local economy parameters (VA and GDP) and the amount of income to be lost are given, followed in Section 9 by aspects for planning while in Section 10, existing proposals for transition already tabled by various organizations are summarized. Finally, in Section 11, a number of conclusions and recommendations for the initiation and financing of the transition are laid out.

2. Electricity production from lignite

Greece has gone through a major financial restructuring since 2010 which included a 25% reduction of its GDP and a concurrent reduction in energy use. Its electricity consumption though remained mostly the same (see Table 1) and most analyses do not foresee a large increase in the coming 20-30 years.

Table 1: Energy Balance Greece - Electricity GWh (Eurostat)

(in GWh)	2017	2016	2015	2014	2013	2012	2011	2010
Net imports	6,237	8,796	9,608	8,819	1,887	1,785	2,011	5,706
Combustible Fuel	29,539	27,426	27,128	26,507	32,006	39,228	39,748	36,165
Lignite	10,984	9,861	14,634	15,885	17,434	22,091	22,269	22,058
Combustible fuel CHP	7,729	7,523	7,735	10,087	9,090	9,245	8,935	8,375
Lignite	7,534	7,309	7,473	9,861	8,817	9,023	8,718	8,308
Auto Producers CHP	1,803	1,815	2,339	1,792	1,885	2,351	2,553	2,492
RES	13,842	14,619	14,615	11,957	14,133	9,947	7,936	10,332
Hydro	4,043	5,548	6,094	4,489	6,350	4,408	4,024	7,455
Wind	5,527	5,140	4,617	3,687	4,164	3,850	3,326	2,710
Solar	3,994	3,931	3,896	3,791	3,652	2,140	2,128	163
Power Plants Own Consumption	1,187	1178	4,068	3,772	4,592	7,305	5,523	4,003
Refineries		804	798	778	755	560	1137	1,158
Coal Mines	657	787	791	789	894	924	968	958
Pumped Storage net used		10	22	56	16	81	116	11
Oil Wells		60	57	50	49	50	46	40
Misc		20	12	68	41	1	5	1
Distribution Losses		3957	4895	4149	3895	1611	2820	3783
Available for FEC		53363	50787	49500	48791	52017	51794	53120

Note: 2017 data provisional

At the same time, the electricity generation from lignite has dropped by a factor of about 38% wrt to 2010 with the major change taking place in the 2014-2016 period as can also be seen in Figure 1 where the lignite consumed is shown.

The amount of electricity missing was replaced by an increase of the production of RES as in the years 2011-2014 the RES installed capacity (excluding large hydro) tripled from ca. 1.5GW to about 4.6GW, and by increased imports. In 2017, a small increase compared to 2016 is evident in consumption and electricity generation (and emissions).

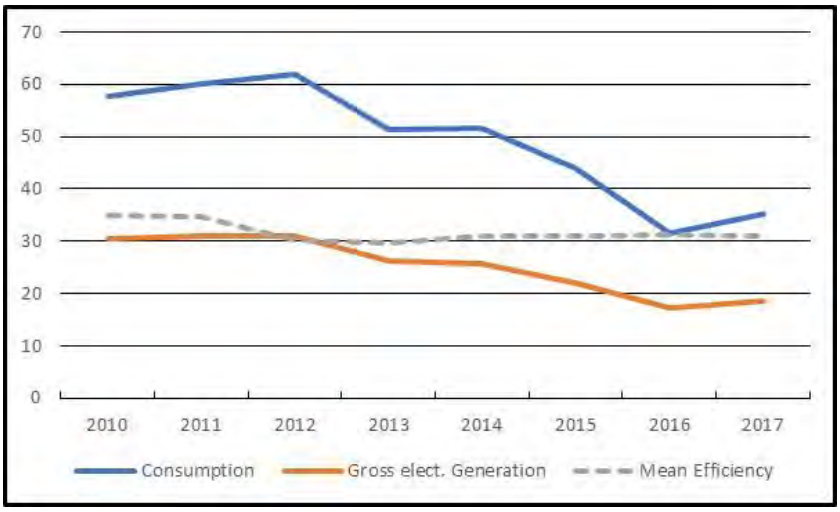

Figure 1: Lignite consumption (in Mt), gross electricity generation from lignite plants (in TWh) and weighted mean efficiency (%) of lignite plants in Greece

The operating ignite plants is Greece are shown in Table 2 below (see also Figure 2b). Clearly, the fleet of lignite power plants features only 2 plants, Meliti I and Ag. Dimitrios V, that are less than 25 years old and neither of them is below 15 years. Of these 2 fairly new plants, Ag. Dimitrios V does not even meet the existing IED limits in any of the pollutants (NOx, SO_2, PM), let alone the new LCP BREF to go in effect in 31 July 2021. The cost necessary for upgrading to meet the IED requirements is substantial.

Table 2: Lignite Power Plants as of 31 Dec 2017

	Nominal MW	Net MW	Age
Ag. Dimitrios I	300	274	33
Ag. Dimitrios II	300	274	33
Ag. Dimitrios III	310	283	32
Ag. Dimitrios IV	310	283	32
Ag. Dimitrios V	375	342	22
Amyntaio I	300	273	31
Amyntaio II	300	273	31
Kardia I	300	275	42
Kardia II	300	275	42
Kardia III	306	280	37
Kardia IV	306	280	36
Megalopolis III	300	255	43
Megalopolis IV	300	256	29
Meliti I	330	289	15
Total	4337	3912	
Ptolemais V	660 (+140 thermal)	614	Under construction
Meliti II		450	Permit issued

Source: ADMIE (TSO) May 2018

The average efficiency (weighted mean by net production per plant) of the lignite plants is about 31.1% with very small variation over the last 3-4 years, down from about 33.9-34.7% in the years before 2013 (see Figure 1).

3. Lignite Deposit Reserves

Lignite fields in Greece are found mainly in 4 regions. The estimated remaining lignite quantities in each of these regions are as follows:

a. Megalopolis: 150 Mt (80-130Mt according to the EE Decision of 17Apr2018, 223Mt according to PPC)
b. Western Macedonia (Ptolemais, Amyntaio & Florina basins): 1500 Mt (1800Mt according to PPC)
c. Elassona: 170 Mt
d. Drama: 900 Mt plus the Phillipoi field with 4 Billion tons Peat (1500 Mt eq.)

Of those, the first two are under exploitation currently. The last two would be very difficult to develop because of strong resistance from the local communities and the adverse investment prospects resulting from EU legislation, and they will most likely remain as strategic reserves to provide security of supply in the very long term (if ever). This is especially true of the Phillipoi peat fields which have other uses in agriculture.

Typical consumption of the existing lignite plants in tons is as follows:

Megalopolis basin

The Megalopolis plants III and IV are to be auctioned in 2018 and most likely will be refurbished. Assuming an average of 2.5t/MWh and a production of 1.75TWh/yr per plant, the remaining lignite would suffice for about 10-15yrs.

Ptolemais basin

The older Ptolemais plants III and IV are not in operation any more due to extensive damages caused by a fire nor are they considered worth repairing. This leaves the Kardia and Ag. Dimitrios complexes together with the new Ptolemais V plant under construction.

The four Kardia plants I-IV are past their projected lifetime as they are 42 years plants I and II) and 36 years (plants III and IV) in operation. As the value of lignite under the plant itself is most likely worth more than the plant itself, it is envisioned that they will operate till the end of the 17500hr opt-out limit. This translates into approximately 80Mt.

The five Ag. Dimitrios plants are 33 (the first four I-IV) and 22 (Plant V) years old. PPC has investigated the possibility of bringing these 5 plants in compliance with the new environmental requirements (but not with the latest LCP BREFs to be met by 2021). This may provide another 10 years of operation for plants I to IV and possibly another 20-25 years for plant V provided it is able to meet the new BREF emission limit

values (ELV). This scenario would imply, assuming current rates, a consumption of about 250Mt for plants I to IV and 120Mt for plant V for a total of 370Mt.

The new Ptolemais V plant currently under construction is required to be CCS ready. If it operates without the extra consumption for CCS until 2035, it would burn about 120Mt for the first 20 years and 135Mt for the next 20 years. It should be noted that Ptolemais V with its present configuration does not meet the latest ELVs of the new LCP BREFs.

In summary, for the next 40 years the expected consumption in the Ptolemais basin would amount to ca. 700Mt.

Amyntaio basin

The 2 plants of the Amyntaio plant are 31 years old. Yet, the Amyntaio lignite is the most expensive to mine (at ca €14/MWh_{th}, 30% higher than the rest) and contains high concentrations of silicon which has caused substantial deterioration of the fuel feeding equipment (mills, piping). It also has the highest values of SO_2 emissions that exceed the current limits by a factor of 5 (and the ELVs of the new BREFs by a factor of over 8). Additionally, lately on 10 June 2017 part of the mine face collapsed resulting in a curtailment of the plants' operation and an additional cost to clear the face from inert material. If it were allowed to operate till the exhaustion of the 17500hrs limit it would consume by 2019 another 35Mt which is estimated to be about 50% of the remaining deposits of the local mine.

Florina basin

The existing plant Meliti I is 15 years old. It will be auctioned in 2018 together with the permits for another slightly larger plant to be built to consume lignite from the 2 fields one belonging to PPC (with reserves of 130-160Mt- EC 2018 estimates) and the other to the Greek State (with reserves of 70-120Mt). In view of the average use of about 2.5Mt/year this would imply 170Mt for the lifetime of the 2 plants.

The lignite consumption estimates presented above are based on representative values of yearly electricity production per plant, typical calorific values per mine and typical plant efficiencies. A detailed list of mines and the lignite deposits in the Ptolemais basin (Ptolemais, Amyntaio and Florina) is given in Table 2 following.

Table 3: Lignate Reserves Ptolemais Valley (Ptolemais, Amyntaio and Florina basins)

(Estimated as per 1 Janury 2014)

	Soil removal (Million tons)	Lignite (Million tons)	Lower Calorific Value (kcal/kg)
PPC Deposits (total)	13,114	1,629	1,443
Operating Mines (total)	8,732	1,204	1,376
Main field - Ptolemais basin	646	141	1,277
West Field -Ptolemais basin	2,711	402	1,372
South Field -Ptolemais basin	3,657	470	1,326
Amyntaio	666	89	1,325
Florina	1,051	102	1,818
Mine fields for future development	4,382	424	1,632
Private mines (total)	1,254	139	2,174
Achada	329	48	1,727
Vevi (partly state owned)	925	90	2,419

In summary, the reserves in the West Macedonia region (Ptolemais, Amyntaio, Florina) seem to be able to supply lignite for the power plants likely to operate in the next 40 years, with a margin of safety of at most 50% provided that the thermal quality of the lignite remains at today's levels.

4. Lignite quality and extracting cost.

In the following Table from the Greek 2018 GHG emissions inventory submission to the UNFCCC, a picture of the quality of the lignite used to produce electricity over the last 20 years is provided. The lower calorific value in TJ/kt is seen to remain approximately constant at about 5.2-5.3TJ/kt.

Table 3.14 Net calorific value of lignite by sector (in TJ / kt) for the period 1990 – 2016

Year	Electricity generation	Industry	Other sectors
1997	5.384	11.300	5.485
1998	5.506	11.380	5.589
1999	5.366	11.110	5.421
2000	5.346	10.902	5.388
2001	5.296	10.006	5.296
2002	5.087	8.620	5.296
2003	5.043	10.886	5.002
2004	5.182	9.807	5.109
2005	5.240	10.471	5.200
2006	5.240	10.471	5.280
2007	5.297	10.235	5.297
2008	5.179	8.025	5.179
2009	5.141	7.435	5.275
2010	5.497	8.025	5.419
2011	5.388	8.479	5.356
2012	5.337	8.501	5.350
2013	5.388	8.205	5.224
2014	5.337	8.205	5.257
2015	5.388	10.077	5.160
2016	5.337	9.140	5.096

This though does not apply to all regions evenly as there are substantial differences from mine to mine both as to extraction costs and to net calorific values. In Table 4 (Leonardos, 2014) that follows, mean values for the net calorific content for the major lignite basins in Greece are presented which show the differences in quality to be substantial, with Megalopolis and Amyntaio being at the bottom and Florina at the top. The poor quality of lignite in Megalopolis has forced PPC repeatedly in the past to augment it by hard coal so that problems in the boilers are prevented.

Table 4: Net Calorific values of Greek lignites		
Basin	NCV (kcal/kg)	NCV (TJ/kt)
Ptolemais	1261 -1615	4.79-6.13
Florina	1927-2257	7.31-8.56
Amyntaio	976-1380	3.70-5.24
Megalopolis	976-1381	3.70-5.25
Drama	976-1382	3.70-5.26
Ellasona	1927-2257	7.31-8.56

Source: PPC website

If the values in Table 4 are compared to the equivalent ones from mines in other EU member states, they are seen to be in the lowest quality category as lignites from other mines vary from a low of 1,600kcal/kg in Maritsa Iztok in Bulgaria to a high of 2,625kcal/kg in Schleenhain, Germany. This also shows why the Florina fields are so attractive and for that reason have become the bone of contention in a legal battle in the European Court of Justice for the right to develop them by a group of private investors, a battle that PPC lost in final judgment on 15 Dec 2016. Note that in a 2014 Booz & Company study on understanding the costs of lignite in Europe (Booz & Co, 2014), the net calorific values used for Greece lie between 900 and 1,500 kcal/kg with a mean of 1,000 kcal/kg.

In Table 5 (Leonardos, 2014) that follows, the cost of extracting in €/ton of lignite and in €/MWh_{th} that is in € per thermal plant of the lignite fuel, is shown together with the equivalent values for mines in neighboring countries. The comparison shows that there are substantial differences between the 3 main Greek regions. The Amyntaio lignite is substantially more expensive to extract which carries over in the cost per thermal unit. The Megalopolis lignite even though its net calorific value is the lowest, is much cheaper to extract and consequently it has the lowest price per thermal unit.

Table 5: Costs of extracting and thermal value			
Mine	€/ton	€/MWh thermal	€/GJ
Ptolemais Main	12.05	9.1	2.5
Ptolemais Kardia	13.99	10.8	3.0
Ptolemais South	11.89	9.7	2.7
Amyntaio	18.99	14.3	4.0
Megalopolis	9.56	8.3	2.3
BU Maritsa Iztok	9.8	6.3	1.8
RO Rovinari	14.8	9.2	2.6
SB Kolubara	13.3	7	1.9
HU Visonta	15	8.8	2.4

Comparing the PPC mines financial figures with those of the neighboring countries (Romania, Bulgaria, Serbia, Hungary) one sees that despite the labor cost differential, the cost of extraction for the Greek mines is comparable to those of the others. When one looks at the cost of lignite in terms of thermal

energy though, one sees that the higher calorific value of the other countries results in cheaper fuel energy stock for electricity generation.

Similar conclusions have been reached by the aforementioned Booz & Co study. In their study the cost per GJ for PPC was found to vary between €1.94 and €3.74/GJ with a weighted mean of €2.95/GJ. This is the highest found in EU Member States with lignite (HU, DE, PL, RO, BU, CZ) with only Turkey, where the corresponding numbers are €1.87/GJ to €6.16/GJ with a mean of €3.3/GJ, being higher. A recent study (Messinis, 2002) for the lignite from the Achlada privately owned mine in Florina which feeds the Meliti I plant estimates the cost at €1.46/GJ.

Finally, the Ministerial Decrees for the calculation of the NOME auctions starting price (NOME, 2016 and NOME 2017) include fuel costs of €18.47/MWh_{elec} for 2017 and €20.01/MWh_{elec} for 2016. These translate, with a 31.1% average efficiency into €1.97/GJ and €2.08/GJ which are in the low part of the Booz & Co range of values as the former do not include capital investment costs and the part of labor cost of the permanent employees. Almost 50% of this cost is attributed to maintenance.

5. Cost of Electricity Generation

a. Fuel cost

Based on an all-inclusive cost of energy of €2.95/GJ which translates into €10.62/MWh_{th} assuming that the efficiency of the lignite plants is on average 31.1%, the cost of just the fuel would contribute €34.15/MWh_{elec} to the price of electricity generated. Note that this does not include the value for the lignite in situ, but it does include the levelized cost of capital invested in the mines. Taking the values for the cost of extraction from Table 4, and the efficiencies and production in 2017 of all the lignite plants except Meliti I, the equivalent cost is €31.76/MWh_{elec}. Note that in 2017, PPC spent €55mil for the purchase of lignite from Achlada Mining SA for the operation of the Meliti I power plant which generated 1.757GWh_{elec} that year. This would correspond to a cost of €31.3/MWh_{elec} which is commensurate.

b. Emissions allowance cost

The verified emissions from the lignite production are given in Table 6 below.

Table 6: Verified CO_2 emissions from lignite plants in Greece

(in kTonnCO_2)	2010	2011	2012	2013	2014	2015	2016	2017
Ag. Dimitrios	14293	14229	14732	13105	11811	10558	9050	8937
Kardia	8400	9285	10635	8905	8549	8871	5589	6397
Amyntaio	4609	5057	5016	4197	4095	3743	2652	2751
Megalopolis IV	2695	3010	2658	2848	2419	2205	2379	2610
Megalopolis III	3423	3077	3238	2402	2782	2422	1899	2624
Meliti I	2196	1900	1878	1453	2098	1606	1558	2274
Total	35615	36558	38157	32911	31754	29405	23127	25592

The CO_2 emissions in tCO_2/MWh in the period 2017 to 2015 were about 1.5 tCO_2/MWh. This would imply that the cost of electricity would be further increased by that value times the price of an EU ETS allowance which in early 2017 was about €5.7/allowance, but in the last 6 months has been increasing and in late July 2018 reached €25/allowance and has been hovering since around the €20/allowance mark. This in turn would imply a cost that would reach €33.27/MWh at 1 October 2018 prices of €21.37/allowance.

c. Power plant running costs

Again the 2 Ministerial Decrees (NOME 2017 and NOME 2018) provide guidance as to the lignite plants running costs. The estimates for the 2 years 2017 and 2016 are €2.94/MWh and €2.98/MWh respectively plus the extra cost for starting and stopping the plants which comes out to €2.40/MWh and €1.62/MWh respectively. This cost also does not include annualized capital investment costs nor does it include the labor cost of permanent staff.

d. Power Plant Labor Costs

As of the end of 2017, permanent personnel employed in the lignite power stations numbered ca. 1650. The approximate cost of their salaries without overtime is ca. €35mil which would correspond to €2.6/MWh.

e. Plant Capital costs

Estimating the annualized cost of the investment hinges on a number of factors that are specific to a particular plant, the financial climate at the time the funding package was put together, the loan structure, own equity, etc. For simplicity, a construction cost of €2315/MW will be assumed which is the cost of the latest plant to be contracted (Ptolemais V), without taking in to account O&M as it was already estimated before, and a 65% utilization rate over a 40-year life span, and a 20-year payback period at a 7% interest rate. A simple calculation leads to a WACC of €12.95/MWh for a lignite-fired station.

f. Levies and Subsidies

Lignite production is subject to a €2/MWh_{elec} levy (Law 4042/2012). The proceeds from this levy go to the RES Special Fund from which RES producers are paid. On 22 October 2018 Mr. Stathakis, the Minister of Environment and Energy announced that this levy imposed on all customers will be eliminated as the RES Special Fund does not need these additional proceeds any more to be solvent. This is to be replaced (Law 4533/2018) starting on 1 January 2019 by a Special Lignite Levy of €1.4/MWh of electricity produced by lignite to be used for environmental improvement works in the 3 lignite mine areas (Megalopolis, Ptolemais and Florina) and for compensation of residents of villages to be relocated to provide access to undeveloped lignite areas.

A further withholding of 0.5% of PPC's annual turnover (Law 4062/2012) has been applied, as PPC is the lone operator of lignite plants at present, which in 2017 came to €24.8mil, i.e. €1.5/MWh. The proceeds have been earmarked to be used for the support of communities that house lignite mines and /or power plants. This withholding will end at the end of 2018.

Lignite plants have been eligible for capacity renumeration. This eligibility, except for the Kardia plants, is maintained in the latest decision of the Greek Regulatory Agency for Energy despite additional requirements that take into account the intensity of their emissions (i.e. the emission rates to be less than 550grCO_2/MWh), and the remuneration proposed is ca. €35-40,000/MW/yr which would amount to about €150million/yr. This is under review by the EC following a submission by the Greek Government on 19 October 2018 as required by the Memorandum of Understanding between Greece and the Institutions. The Ptolemais V also does not meet the 550grCO_2/MWh requirement set by the EC.

g. Benefits to the local communities

Local communities gain from the lignite mine and plant operations in a number of direct and indirect ways. The main ones are the income of the local citizens employed in the facilities and the influx of income from associated activities that have to do with various supplies, local purchases, maintenance work by outside contractors etc. It is very difficult to break down the general expenditure categories of salaries, materials and consumables, electrical power consumed, maintenance and payments to outside parties into local and non-local shares and compute the additional indirect and induced economic active they could generate. A possible means is to use multipliers that are obtained through input-output tables. As these tables are compiled by the national statistical authorities they usually refer to national gains. No regional input-output tables are available but in a number of studies, multipliers of the order of 1.15 have been used for local economy gains from direct inflows to obtain the full contribution including additional indirect and induced jobs and value added.

In summary, adding all the cost components analyzed above, the cost of electricity generated from lignite excluding levies and subsidies comes to €68.2/MWh_{elec} (with 2017 allowance costs for PPC of €11.67/MWh) to be compared with €68.18/MWh_{elec} which was the lowest bid (by EDP Renovables of Portugal) in the latest Greek Regulatory Agency for Energy auction for wind and PV capacity in July 2018.

6. Current state of PPC breakup and sale of 36% of its lignite production capacity

PPC is required by the MoU that Greece has co-signed with the Institutions (ECB, ESM, EC and IMF) to auction off 40% of its total installed lignite fired capacity. This was dictated by the desire to reduce the dominant position of PPC in the electricity sector and its ability to affect the marginal price in the daily (day ahead) electricity market through its use of both lignite and hydro plants. This divesting was considered necessary for a full transition to the Target Model and the end of the intermediate bridging mechanism of auctioning electricity generated by PPC plants through NOME auctions.

After protracted negotiations including relevant decisions by the EC (EC 2018a), in accordance with Law 4533/2018, PPC ceded to two wholly owned new SPV companies the 2 Megalopolis plants and the Meliti I plant together with the permit for Meliti II respectively for a total of up to 1220MW net representing 35.6% (if Meliti II is built) of the installed lignite capacity. PPC then called for non-binding expressions of interest for the purchase of the two companies to be submitted by the 21st of June 2018 . Five (plus one recalled) such expressions have been submitted, namely:

- The GEK-Terna construction company in collaboration with Seven Energy (Indoverse Czech Coal Investments Limited, CZ)
- Copelouzos Group with interests in wind and NG pipelines in collaboration with China Energy (Beijing Guohua Power)
- ELVALHALKOR, a aluminum and metals company
- Mytilinaios Group (with substantial energy holdings in PV, NG)
- Energeticky a Prumyslovy Holding (EPH) CZ

of which one is from a non-Greek entity and one is a joint interest expression with a Chinese company. After the expressions of interest deadline expired on 21 June 2018, a check of legal status and related documents of the enterprises was carried out and a final list was compiled and access to the data room was allowed for the participants to submit binding offers by 1st September. The deadline for submissions is qt the time of this report 7 December 2018 (postponed from 7 October 2018 after a request of China Energy to further examine information from the data room and again on 22 October 2018) with a decision to be made by 17 December 2018. PPC has employed an independent appraiser to determine fair values for the plants.

An additional item that might have some impact on the auction of the Megalopolis plants is the question of the current validity of the environmental permits brought up by a question in European Parliament on 21 March 2018 signed by 48 MPs in which they claim that the renewal of the permits issued in September 2017 is not valid as the Court of the State has questioned the relevance of the accompanying Environmental Impact Assessments as they were carried out in 2007 and in the meantime conditions may have changed. This legal challenge is the result of a writ of annulment filed by WWF, Greenpeace and ClientEarth to be heard on 6 February 2019.

It should be noted that the NOME auctions are closely linked with the progress of the sale. This entails a reduction of the NOME adjustment mechanism by 50% with the launch of the tender and a full elimination when the bidder takes over the auctioned power plants with the NOME auction volume reverting to 13% of the total volume in the interconnected grid.

The local energy press has been reporting reduced interest, in which the latest rally of the EUA price has been playing a role. Note that the question of allowances bears watching as 2 of the participants are eligible by reason of their main activities (aluminum production) for free allowances (667,180 and 76,047 in 2017 respectively).

Of note is also the requirement as inscribed in the 4th Assessment Draft Supplementary MoU of 23 May 2018 that the capacity flexibility mechanism should be revised based on an adequacy assessment including a reliability standard and on open and transparent access to all, and in compliance with State Aid Guidelines.

Finally it should be added that a group of NGOs (ClientEarth, WWF and Greenpeace) have filed a suit in October 2018 in which they argue that the permits of Meliti plants (Meliti I operating and Meliti II with a construction license to be constructed and put in operation possibly by 2025) are also invalid as their Environmental Impact Assessment reports were compiled and submitted before a Strategic Environmental Assessment for the region was available[1]. The challenge will be heard on 13 March 2019.

[1] https://www.clientearth.org/sister-power-plants-in-greece-face-court-challenge-for-disregarding-people-and-planet/

7. Long term Government Planning in the Energy Sector

The Ministry of Environment and Energy (MEE) has set as a deadline for the release of the 1st draft of the Greek National Integrated Energy-Climate Plan (NECP) the beginning of September 2018. This was confirmed on 18 June 2018 by Mr. Stathakis the Energy and Environment Minister although in view of the actual progress this far, a more realistic may be the beginning of November.

The compilation of the NECP is the responsibility of the National Long-Term Energy Planning Committee which was constituted on 2 Feb 2018 with a mandate to present a plan that will need to ensure the meeting of the national reduction targets of GHG emissions overall but also to ensure:

- adequate energy supply and supply security for the whole country, including the islands, through modern infrastructure and efficient interconnections.
- that energy products and services are available in markets that operate transparently and in accordance with competition rules.
- **r**adical treatment of energy poverty and protection of vulnerable consumers
- contributing to the overall economic development effort and reducing the country's energy dependence, through the rational and sustainable exploitation of domestic resources and the upgrading of the country's geopolitical position.
- the support of the regions of the country through decentralized production and the participation of consumers (households, enterprises, municipalities, and Energy Communities) in all energy markets.

The Minister for Environment and Energy further made clear on a number of occasions that the international commitment and central goal of the government is to move to a new mix where lignite remains one of the key fuels, but its share is to be reduced and gradually the largest share of electricity generation to come from RES. In the transition phase the use of natural gas will be called upon to shoulder the crucial bridging role.

The 1st draft of the NECP is now expected to be released and put up for public consultation by the end of November.

8. Transition Considerations

The consequences of lignite plant decommissioning to local communities, mainly the loss of jobs direct and indirect, and the reduction of the economic activity, are well-known and recognized also by EC. A number of decommissioning cases have already taken place in the Netherlands, the Czech Republic, the United Kingdom but also in Germany and even Poland. Numerous analyses (Benn et al. 2018, Tagliapietra, 2018, Graichen and Rozenkranz, 2018, Caldecott et al. 2017, Santor 2017, Schultz and Schwartzkopff,

2016, among others) of the transition process have found that the main obstacles and basic arguments against are (1) job losses and impacts to local/regional economic activity, (2) competitiveness issues, and (3) issues of security of supply. All of these studies examine these obstacles and conclude that transition is technically possible and affordable in a socially acceptable and just manner, and moreover it has already started.

To facilitate this transition, the European Commission has decided in the scope of the “Clean Energy for all Europeans” package to "examine how to better support the transition in coal and carbon-intensive regions. To this end, it will work in partnership with the actors of these regions, provide guidance, in particular for the access to and use of available funds and programs, and encourage exchange of good practices, including discussions on industrial roadmaps and re-skilling needs, through targeted platforms." As a first step, a Platform for exchange of information and good practices has been set up in December 2017 (Coal Regions in Transition) by DG-ENER (officer-in-charge Anna Colucci) and working groups have been formed with representation from all 12 MSs with lignite/coal mining activity. The Working Group in which Greece is also represented, has already met twice (the latest in July 2018). In addition, the European Parliament proposed the establishment of a “Just Transition Fund”, to be funded by the proceeds of the auctioning of 2021-2030 ETS allowances (2% amounting to approximately €320m yearly) but as this was not finally agreed, only portions of the Modernization Fund of each eligible Member-State can be used to support transition measures.

In 4 June 2018, Mr. Sokratis Famellos, the Alternate Minister for Environment and Energy, announced the establishment of a Greek “Just Transition Fund” with a total budget of €60m for the 3-year period 2018-2020 again to be funded by the revenue of the auctioning of allowances available to the Greek Government[2]. The aim of the Fund is to finance (i) projects for the promotion of RES through energy communities, (ii) energy efficiency, (iii) circular economy, (iv) agriculture, (v) promotion of the industrial heritage of the Greek lignite regions and (v) retraining of the unemployed in Western Macedonia and Peloponnese regions in which the existing lignite mines are located in the abovementioned 5 sectors. The Alternate Minister, mindful of the difficulties that local state entities have in realizing projects because of bidding regulations, called for projects that are well advanced in the permitting process to be submitted immediately so that the utilization of the funds can start in 2018.

In June 2018, PPC announced the main conclusions of a major reorganization study that it commissioned to the McKinsey Consultancy. The McKinsey analysis had as a basic aim the optimal way to downsize and enhance productivity of PPC in view of the sale of the Megalopolis and Meliti plants and the obligation to reduce its share in the retail electricity market to 50% by 2020 from the current amount of over 80%. The report recommends the closing of Kardia I-IV plants (1212MW gross) which are serviced by a mine with 612 employees as early as 2021. In the same report, the reduction of personnel in the remaining lignite power stations, beyond the 1300 who are employed in the power stations and mines that will be sold to other enterprises, is estimated at 500 by 2023. This implies that over 20% of the lignite mines and power station personnel will become redundant by 2023. In addition, under the terms of the auction, the enterprises that will acquire the plants and associated mines are required to maintain the personnel for

[2]http://www.opengov.gr/minenv/wpcontent/uploads/downloads/2018/06/Ethniko_tameio_dikaiis_metavasis.pdf

only 6 years. Beyond this period, they are free to consolidate the operation and most likely they will do that by reducing the number of employees further.

8.1 Emission Limits and Decommissioning Plans

In the period after 2021, the operators of the Greek lignite plants need to address the environmental requirements not only of Directive 2010/75/EU but also the restrictions imposed by the latest BREFs in Implementing Decision (EU) 2017/1442 which were adopted at EU level on 28 April 2017. These emission limit values (ELVs) existing and new are given in Table 7.

Table 7: Emission limit values (mg/Nm^3)

	Directive 2010/75/EU		**new LCP BREF**	
Pollutant	Existing PPs	New PPs	Existing PPs	New PPs
SO_2	200	150	130	75
NOx	200	200	175	85
PMs	20	10	8 to 12	5

In Table 8, the emission values as measured by PPC (see WWF, 2017) are given per power plant. From Table 8, it becomes obvious that all stations except Meliti I are not compliant. In addition, even though the specifications of the Ptolemais V currently under construction (just) meet the existing limit values, they are noticeably above the latest BREF ones.

Table 8: Current Emissions from Lignite Stations

Power Station	**SO_2 Emissions (mg/Nm^3)**				**NO_x Emissions (mg/Nm^3)**				**PM Emissions (mg/Nm^3)**			
	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean
Kardia I	244.0	75.0	115.0	144.7	326.0	320.0	288.0	311.3	313.0	253.0	309.0	291.7
Kardia II	283.0	65.0	185.0	177.7	284.0	331.0	280.0	298.3	290.0	421.0	225.0	312.0
Kardia III	305.0	175.0	244.0	241.3	339.0	336.0	301.0	325.3	34.0	76.0	49.0	53.0
Kardia IV	374.0	158.0	170.0	234.0	344.0	360.0	287.0	330.3	37.0	66.0	50.0	51.0
Amyntaio I & II	1144.0	575.0	1255.0	991.3	192.5	194.5	229.5	205.5	25.1	26.8	68.8	40.2
Ag. Dimitrios I & ii	414.9	444.2	313.4	390.8	394.5	333.3	348.3	358.7	20.5	11.7	26.9	19.7
Ag. Dimitrios V	635.6	639.0	360.9	545.1	363,8	348.6	361.2	364.5	7.9	6.2	9.2	7.8
Ag. Dimitrios III & iV	777.5	512.1	984.5	758.0	322.3	315.3	302.8	313.5	18.9	10.5	29.3	19.6
Meliti I	108.0	90,5	121.6	106.7	143.0	167.7	118.0	142.9	4.3	2.9	2.0	3.1
Megalopolis IV	279.0	151.0	223.9	218.0	130.0	137.0	114.0	127.0	4.0	5.2	2.6	3.9
Megalopolis III	343.0	237.0	194.9	258.3	269.0	172.3	186.0	209.1	13.5	9.6	10.1	11.1
Ptolemais V				150.0				200.0				10.0

The cost necessary for upgrading to meet the IED requirements is substantial. Specifically, Ag. Dimitrios V will need installation of a SNCR system for NOx with a cost of ca €19mil and a running cost of the order of 7.2% of installation cost. In addition, it will need a wet scrubbing system for SO_2 control costing ca. €131mil plus 4.9% running cost, and improvements of its electrostatic filters costing about €5mil plus running cost of 4% of investment. This sums up to about €155mil investment and an additional annual running cost of about €8M (DNV 2016, WWF 2017). As a first step, in 2017, PPC awarded a contract for the installation of a wet scrubbing system for SO_2 with a cost of €68mil and a smaller one for €2.9mil for upgrading the NOx emission reduction system.

Additionally, in 2015 PPC awarded 2 contracts totaling €31.4mil for the upgrading of the NOx reduction systems of Ag. Dimitrios I-IV to be completed by the end of 2018. Furthermore, in 2017, the PPC Governing Board decided to call for tenders for the installation of wet scrubbers in these four plants with an estimated budget of €97mil.

The latest plant Ptolemais V which is currently under construction and is expected to go into operation in 2022 does not meet the latest BREF and would need to be modified with a cost of about €92mil additional investment and €4.5mil yearly running cost (DNV 2016, WWF 2017).

In addition to the environmental upgrading costs, one should also take into account the cost of relocation of 2 villages already planned for the operation of the plants and the exploitation of lignite deposits, Anargyroi in Florina for the Meliti plants, and Akrini in Ptolemais. The cost for the Anargyroi relocation is estimated at €42.5mil and is to be equally shared by PPC and the State. The cost for Akrini which would affect 500ha of prime agricultural land is not estimated yet.

The conclusion that can be reached on the basis of the information above is that the majority of the operating power plants will be decommissioned by 2030. Indeed, the schedule that is currently being considered in the discussions for the compilation of the Greek NECP is as given in Table 9 below. In Table 9, the efficiency of the power plants is also given which is taken into account in decommissioning considerations.

If this schedule is kept, by 2031 only 3 of the existing plants (with 887MW net installed power down from 3912MW on 31 December 2017) will be operating, in addition to the one that is currently under construction (Ptolemais V of 612MW net) provided that Meliti II is not built.

Table 9: Lignite Plants Scheduled (Sept 2018) Decommissioning				
	Net MW	Age	Efficiency	Decommission
Ag. Dimitrios I	274	33	30.7%	2029
Ag. Dimitrios II	274	33	30.7%	2029
Ag. Dimitrios III	283	32	30.9%	2030
Ag. Dimitrios IV	283	32	33.4%	2031
Ag. Dimitrios V	342	22	39.1%	2041
Amyntaio I	273	31	30.2%	2028
Amyntaio II	273	31	29.8%	2028
Kardia I	275	42	28.9%	2022
Kardia II	275	42	28.9%	2022
Kardia III	280	37	30.3%	2023
Kardia IV	280	36	30.3%	2024
Megalopolis III	255	43	30.1%	2022
Megalopolis IV	256	29	29.7%	2036
Meliti I	289	15	32.4%	
Total	3912	458		
Ptolemais V	614 (+140 thermal)	Under construction	41.5%	Comm. in 2022?
Meliti II	450	Permit issued		Comm. in 2025?

8.2 Decommissioning economic assessment

To address the impact of the transition, it is important to take into consideration both the characteristics of the two areas, Megalopolis and the Ptolemais/Amyntaio/Florina valley in which lignite plants operate and the schedule of plant decommissioning under the present planning of PPC.

It is instructive to examine the circumstances and economic aspects for each of the 4 areas with lignite mines (Megalopolis, Ptolemais, Amyntaio and Florina) in view of the schedule presented in Table 9 which might be modified according to the rate of consumption of lignite reserves in Megalopolis and relevant decisions of the European Commission.

To do so, first the expenditures that are funneled in each of the lignite areas in Greece will be estimated. According to the latest data published by PPC (PPC 2018) and MEE (NOME 2018) the total cost of the lignite power plant and mines in 2017 was as follows (Table 10):

Table 10: Lignite Electricity Production Expenditures			
	2016	2017	
Lignite PP electricity Net Production (MWh)	14,898,260	16,386,736	
Mines Cost (€million)			Local expenditure (estimates)
Part-time Payroll	59.04	47.7	47.7
Parts and consummables	55.37	45.9	15
Electricity costs	47.68	53.0	
Maintenance	107.3	100.0	100.0
Outrsourcing	1.23	1.3	1.3
Total	269.4	246.6	162.7
Lignite Power Plants Cost (€million)			
Overtime Payroll	3.75	3.6	3.6
Parts and consummables	6.22	7.3	1.5
Electricity costs	10.41	13.2	
Maintenance	2.65	3.7	3.7
Ash and lignite yards	17.65	18.0	18.0
Earth works	3.74	2.4	2.4
Total	44.4	48.2	29.2
Other Costs (€million)			
Purchase of lignite (Florina)	27.38	55.0	45.0
Power Plant Starting costs	24.12	39.3	39.3
Lignite Levy (€2/MWh)	29.78	32.8	
0.5% of PPC gross charge	25.78	24.2	24.2
CO_2 allowance costs	117.73	191.2	
Salaries	120.0	120.0	120
Grant Total	538.6	637.3	420.4
Electricity Running Cost (€/MWh)	36.15	38.89	

According to these data, the total cost of generating electricity by lignite-fired power plants which amounts to about €300mil/yr is channeled to the local lignite mine communities. This includes an amount of 0.5% of PPC's gross income which in 2017 came to €24.2mil which is earmarked for actions supporting the local communities. To this, the payroll of the 5,866 permanent employees in all the mines and the lignite power stations which amounts to approximately €120mil/yr (excluding overtime which is included in Table 10) should be added. It should be pointed out that the amount of €45mil/yr of the €55mil/yr for purchase of lignite is mostly income to the Florina community as the lignite for Meliti I comes from the local Achada mine operated by Achlada Lignite Mines S.A., an enterprise with about 700 employees. If Meliti II and Ptolemais V go on line sometime in the early 2020s then the additional corresponding approximate economic injection (back of the envelope calculation) would amount to ca. €115mil/yr.

Looking next at each basin separately, the losses and possible gains are as follows:

Florina (Meliti)

In all scenarios Meliti I is expected to be in operation past 2040 and consequently no impact is expected in this area except in the case that Meliti II is built which would result in an increase of financial inflows in the basin.

Megalopolis

The lignite reserves in the Megalopolis valley are estimated to last for another 10-12 years of operation. They are characterized by very low calorific value but also very low extraction cost. In view of this, the community has a window of about 10 years (till about 2030) to prepare and manage the closing of the lignite power plants (Megalopolis III and IV) and the associated mine.

- The closing will affect ca. 1250 employees (of whom ca. 1000 in the mine) with very few to be absorbed in other installations of the company be it PPC or the enterprise that may acquire the 2 plants through the on-going bidding process. It should be emphasized that current employment in the power stations including the Megalopolis V NG plant, and the local mine represents about 1412 jobs in total.
- The community will lose the regular payroll amount which is estimated to be about €25mil/yr plus the amounts spent on maintenance (about €27mil/yr) plus the portion of the operational expenditures of about €14mil/yr (see Table 10) plus 6.5mil/yr for startup costs.
- The community will lose its share of the 0.5% withholding on PPC annual turnover earmarked for the support of the local communities which amounted to about €24mil in total for 2017 so the local amount if the total is distributed by production comes to about 4mil/yr. This though will be replaced by the new levy of €1.4/MWh of electricity produced from lignite plants which based on 2017 generation will yield about the same, i.e. €23.5mil, Yet, as the lignite production will be decreasing in the future this revenue will also decrease.
- The community will be given the restored mine area for agricultural or other use.
- PPC (together with the new owner) will inject an amount as yet undetermined for the restoration of the mines.
- The new NG power plant (trial period ended July 2018) of 800MW installed capacity will continue to operate in the basin albeit with an operating ceiling of 500MW until the high voltage grid is strengthened so that stability concerns do not arise.

Ptolemais

In the Ptolemais valley at present the 4 Kardia plants (1212MW gross in total) and the 5 Ag. Dimitrios plants (1595MW gross) are in operation with Ptolemais V (660MW gross) to be in operation most likely in 2022. The Kardia plants are expected to be decommissioned in the near future as they operate with a 17500h limit which is near exhaustion. The McKinsey report commissioned by PPC and released in June 2018 proposes that they close before 2020. Four of the 5 Ag. Dimitrios plants (totaling 1220MW gross) may operate longer provided they are upgraded to meet environmental requirements on emissions in which they may continue to 2030. Thus by 2030, 2332MW of lignite installations are expected to be decommissioned in the Ptolemais basin.

- The closings will result in the redundancy of about 1650 miners plus the ca. 700 personnel of the Kardia and Ag. Dimitrios I-IV power stations.

- The community will lose the payroll which might amount to about €47mil/yr plus the amounts spent on maintenance (about €52mil/yr), plus the portion of the operational expenditures (see Table 10) of about €53mil/yr, plus 18mil/yr for startup costs.
- The community will lose its share of the 0.5% withholding on PPC annual turnover earmarked for the support of the local communities which amounted to about €24mil in total for 2017 so the local amount if the total is distributed by production comes to about 15mil/yr. This though will be replaced by the new levy of €1.4/MWh of electricity produced from lignite plants which based on 2017 generation will yield about the same, i.e. €23.5mil, Yet, as the lignite production will be decreasing in the future this revenue will also decrease.
- The community will be given the restored mine area for agricultural or other use.
- PPC will inject an amount as yet undetermined for the restoration of the mines.
- When Ptolemais V goes into operation (ca. 2022) the personnel reductions will be smaller by about 900 with a corresponding increase in financial flows in the area.

Amyntaio

The two Amyntaio power station units are the most polluting. In addition, the cost of lignite used (both in €/ton and €/MWh_{th}) is the highest (see Table 5). Finally, a major landslide in the mine last year resulted in its closing for safety reasons. Work to restore it has not finished yet. As a result, the expectation is that the Amyntaio station will cease operation very soon in view of the 17500hr limit imposed. Even if the operating hours limit is extended to 32000hr as requested by PPC and the Greek State, the 2 units are not expected to operate beyond 2028. In all cases, the area has only a few years to prepare for the cessation of the operation of the mines and power stations.

- The closing will result in the redundancy of about 450 miners plus the 300 personnel of the power station.
- The community will lose the payroll income which might amount to about €13mil/yr plus the amounts spent on maintenance (about €17mil/yr) plus the portion of the operational expenditures of about €16mil/yr (see Table 10) plus 6.5mil/yr for startup costs.
- The community will lose its share of the 0.5% withholding on PPC annual turnover earmarked for the support of the local communities which amounted to about €24mil in total for 2017 so the local amount if the total is distributed by production comes to about 4mil/yr. This though will be replaced by the new levy of €1.4/MWh of electricity produced from lignite plants which based on 2017 generation will yield about the same, i.e. €23.5mil, Yet, as the lignite production will be decreasing in the future this revenue will also decrease.
- The community will be given the restored mine area for agricultural or other use.
- PPC will inject an amount as yet undetermined for the restoration of the mines.

In summary, the decommissioning of the lignite power plants in the Megalopolis, Ptolemais and Amyntaio basins would result in a shortfall of about €315mil/yr. At the same time, as a large percentage of these employees would retire and receive their benefits which would add ca. 59mil/yr, the shortfall will be reduced by that amount.

As the Ptolemais V plant (of 660MW nominal power) is currently under construction and is expected under the current schedule to start operation in 2022, the local income from its operation should also be taken into account. The personnel to be employed is estimated at 250 for the power plant and 660 for the mines.

Based on these estimates and the data for maintenance and operating expenses from the other mines the total amount accrued to the community would be about 65mil/yr. Similarly, if the Meliti II plant (of 450MW net power) is built and brought on line, the jobs to be created are estimated to be 170 in the power station and 335 in the mines. By a similar calculation, the net income to the local community (Florina) would amount to 45mil/yr. The operation of these two power plants would thus reduce the income loss to the Region by about 115mil/yr, bringing it down to about 160mil/yr.

8.3 Local economy status and Decommissioning impacts

The figures above need to be compared with the general economic parameters of the communities involved. The Amyntaio mine and plant are located in the Municipality of Amyntaio in the Regional Unit of Florina and the Ptolemais basin mines and plants in the Municipalities of Eordaea and Kozani in the Regional Unit of Kozani. The Megalopolis plants and mines are located in the synonymous Municipality of Megalopolis in the Regional Unit of Arcadia.

Municipality of Amyntaio

The Municipality has a population of 16,973 (2011 census) with Ptolemais being the largest urban concentration and an area of 599km^2. It is located in the Florina Regional Unit which also includes the larger Municipality of Florina with a population of 32,881. Between the two of them, they represent 95% of the Regional Unit's total population of 51,414. The value added of the Regional Unit in 2015 (latest data from the Greek Statistical Service) is €974mil which translates to a per capita GDP of €17,867. The annual budget of the Municipality is of the order of €39mil. It should be underlined that the reduction of income for this Municipality will be over 80% and planning for a well-ordered transition to the post-lignite period should have started already.

An additional aspect that needs to be addressed is the continuation of the district heating to the Amyntaio community that is now provided by the Amyntaio power plants. The installation has a power rating of 40MW$_{th}$ and in 2015 provided 38GWh. Currently, several proposals have been tabled for the construction, after decommissioning, of biomass-fired stations to meet the needs of the Municipality of Amyntaio inhabitants.

Municipalities of Kozani and Eordaea

The Eordaia Municipality has a population of 45,591 (2011 census) with Ptolemais being the largest urban concentration and an area of 709km^2. It is located in the Kozani Regional Unit which also includes the larger Municipality of Kozani with a population of 71,388. Between the two of them, they represent 78% of the Regional Unit's total population of 150,191 (2011 census). The value added of the Regional Unit in 2015 (latest data from the Greek Statistical Service) is €2.71bil which translates to a per capita GDP of €17,662. The annual budget of the Municipality of Eordaia is of the order of €61mil and that of the Municipality of Kozani €81mil.

Both municipalities are located in the Region of Western Macedonia which comprises 4 Regional Units (Grevena and Kastoria in addition to Kozani and Florina). The other two Regional Units in which there is no lignite mining activity have per capita GDP of €10,244 and €10,726 respectively. i.e. 35% less, a difference which can be attributed almost entirely to the lack of mining/electricity production activity.

The per capita GDP of the Kozani and Florina Regional Units are the highest in Greece if one excludes the greater Athens area and the Cyclades. They are higher than the corresponding ones for Rhodes and Crete, both major tourist destinations.

One should also note that of the total Gross VA of the Region of West Macedonia which amounts to €3,80bil, €1.73bil i.e. almost 50% comes from NACE categories B, C, D and E which comprise mines (B), processing (C), electricity production (D) and water supply and solid and liquid waste handling (E).

The decommissioning of Kardia and Ag. Dimitrios I-IV will impact the district heating now provided to the Ptolemais and Kozani urban areas. District heating started in the Ptolemais basin in 1993 and was the first such installation in Greece. Heat from the Ptolemais III plant (now decommissioned) originally, and currently from Kardia III and IV (100MW_{th}) is provided to the city of Ptolemais. In 2015, the heat provided reached 181GWh_{th}. From 1999, heat from the Ag. Dimitrios III, and IV (134MW_{th}) and Ag. Dimitrios V plants (7OMW_{th}) is provided to the Kozani urban concentration.

Municipality of Megalopolis

The Municipality has a population of 10,687 (2011 census) with Megalopolis being the largest urban concentration and an area of 727km^2. It is located in the Arcadia Regional Unit which also includes the larger Municipality of Tripolis with a population of 47,254. Between them, they represent 67% of the Regional Unit's total population of 86,685. The value added of the Regional Unit in 2015 (latest data from the Greek Statistical Service) is €1.38bil which translates to a per capita GDP of €16,442. The annual budget of the Municipality is of the order of €21mil.

The Municipality is located in the Region of Peloponnese which comprises 5 Regional Units (Argolida, Korinth, Lakonia and Messinia in addition to Arcadia). The other four Regional Units in which there is no lignite mining activity have per capita GDP of €14,693/cap, €12,743/cap, €12,119/cap and €12,168/cap respectively. i.e. 25% less (12% wrt to Argolida which has both well-developed agricultural production and high-level tourism), a difference which can be attributed almost entirely to the mining/electricity production activity. The per capita GDP of the Arcadia Regional Unit is just below those of the Kozani and Florina Regional Units, with only Rhodes of other Units outside the Greater Athens area coming close (€16,057).

Again, one should keep in mind that of the total GVA of the Region of Arcadia which amounts to €6,87bil, €1.42bil i.e. 20% comes from NACE categories B, C, D and E which comprise mines (B), processing (C), electricity production (D) and water supply and solid and liquid waste handling (E). Loss of the mine/electricity production activity would mean a ca. 15% reduction in the GVA of the Region with all of the loss concentrated in the Municipality of Megalopolis. It should be stressed that for Megalopolis where the lignite reserves will be exhausted, planning for a well-ordered transition to the post-lignite period needs to start immediately.

Since 2011, the city of Megalopolis is heated through a district heating network with the heat coming from the Megalopolis III plant. Its rated power is 20MW_{th} and covers a demand of about 25GWh_{th} annually. The intension is to convert it to biomass firing when the reserves run out.

The Megalopolis useful deposits are expected to be exhausted by 2030 if both plants operate at current rates. Consequently, the impacts to the local community in the Megalopolis area from the decommissioning of the 2 lignite plants and the cessation of the operation of the mines would need to be

assessed under any circumstances and ways to ameliorate them would have to be devised together with the identification of sources for their funding.

The last few months, the closing of just the Megalopolis III plant in 2022 so as to enable Megalopolis IV which is much younger (29 years vs. 43 for Megalopolis III) to operate till 2036 has been proposed. Although this decision will be made by the new owner to be determined by the ongoing tender, such an approach will provide more time for the transition and enable the local community to adjust gradually.

In summary, the impact on the 3 Regional Units (Kozani, Florina and Arcadia) with lignite mines and power plants can be seen in Table 11.

Table 11: Yearly GDP, VA and Overall Income Loss per Prefecture (2015)

(power stations, **red:** planned, **blue:** to remain after 2030)	Local GDP (€mil)	Local GDP (€/cap)	VA (€mil)	VA from mines & electrcity	Direct income Loss/yr (€mil)	Direct income loss with Pension income (€mil)	Direct income loss with pensions, Ptolemais V & Meliti II operating
Kozani (Kardia I-IV, Ag. Dimitrios I-IV, **Ag. Dimitrios V**, **Ptolemais V**)	2653	17,662	2,262	1,228	182	149	80
Florina (Amyntaio I-II, **Meliti I**, **Meliti II**)	918	17,865	799	314	56	47	2
Arcadia (Megalopolis III-IV, **Megalopolis V -NG**)	1427	16,442	1,228	345	76	59	NA

To estimate VA loss to the national economy, one needs to also compute indirect and induced losses. Such an estimate can be made through the use of appropriate multipliers. The Western Macedonia Chapter of the Technical Chamber of Greece has computed (TEE 2012) such (Type II) multipliers based on national input-output tables issued in 1995 and 2007 for both jobs and VA, namely **3.28** and **3.09** respectively. These values are be compared with estimates for local impact of ca. **1.15** which is supported by the economic data for each Regional Unit and Region (Western Macedonia and Peloponnese) by kind of activity according to NACE classification as given by ELSTAT, the Greek Statistical Agency, shown in Table 12 below.

Table 12: Value Added in 2015 for the Regions and Prefectures by NACE category (in €mil)						
NACE activity categories	W.MACEDONIA	Kozani	Florina	PELOPONNESE	Arcadia	GREECE
Agriculture, forestry, fishing (A)	254	98	69	671	84	6608
Manufacturing, mining, quarrying and other industries (B,C,D,E)	**1,737**	**1,301**	**347**	**1,421**	**424**	**21,047**
of which Manufacturing	182	73	33	922	79	14,659
Construction (F)	82	11	54	199	47	3,277
Wholesale and retail trade, transportation and storage (F, G, H, I)	388	196	68	1,350	174	37,285
Information and communication (J)	38	21	9	106	18	5,304
Financial and insurance activities (K)	86	48	12	183	28	7,238
Real estate activities (L)	338	153	55	1,184	177	27,921
Professional, scientific, technical, administration (M,N)	106	50	18	141	15	7,971
Public administration, defense, education, health (O,P,Q)	672	338	143	1,258	209	32,418
Other services (R,S,T,U)	100	47	22	354	53	6,637
VA Total	**3,801**	**2,263**	**797**	**6,867**	**1,229**	**155,706**
VA Mining & Electricity %	41%	54%	39%	7%	28%	4%
GDP	**4,304**	**2,562**	**905**	**7,777**	**1,390**	**176,312**

Looking at Table 12, it becomes clear that the lignite power generation activity represents a substantial percentage of VA in the Regional Units of Kozani and Florina (54% and 39% respectively) and even in the whole Region of Western Macedonia (41%) and a much smaller but still a very important portion of VA (28%) in the Regional Unit of Arcadia and even smaller one (7%) in the Region of Peloponnese.

If one were to subtract the VA generated by the lignite activity, the sectoral distribution (see Table 13 below), which is currently mostly determined by the mining sector, reverts in all three Regional Units to near the Regional ones.

Table 13: Sectoral Distribution of Value Added in 2015 for the Regions and Prefectures by NACE category												
	W.MACEDONIA		Kozani		Florina		PELOPONNESE		Arcadia		GREECE	
NACE activity categories	with	w/o	with	w/o	with	w/o	with	w/o	with	w/o	with	w/o
Agriculture, forestry, fishing (A)	7%	11%	4%	9%	9%	14%	10%	10%	7%	9%	4%	4%
Manufacturing, mining, quarrying and other industries (B,C,D,E)	**46%**	**10%**	**57%**	**9%**	**44%**	**10%**	**21%**	**17%**	**34%**	**11%**	**14%**	**13%**
of which Manufacturing	5%	8%	3%	7%	4%	7%	13%	14%	6%	9%	9%	10%
Construction (F)	2%	4%	0%	1%	7%	11%	3%	3%	4%	5%	2%	2%
Wholesale and retail trade, transportation and storage (F, G, H, I)	10%	17%	9%	18%	9%	14%	20%	21%	14%	19%	24%	24%
Information and communication (J)	1%	2%	1%	2%	1%	2%	2%	2%	1%	2%	3%	3%
Financial and insurance activities (K)	2%	4%	2%	5%	2%	2%	3%	3%	2%	3%	5%	5%
Real estate activities (L)	9%	15%	7%	14%	7%	11%	17%	18%	14%	20%	18%	18%
Professional, scientific, technical, administration (M,N)	3%	5%	2%	5%	2%	4%	2%	2%	1%	2%	5%	5%
Public administration, defense, education, health (O,P,Q)	18%	29%	15%	32%	18%	29%	18%	19%	17%	23%	21%	21%
Other services (R,S,T,U)	3%	4%	54%	4%	39%	4%	5%	5%	4%	6%	4%	4%
VA Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
VA Mining & Electricity %	41%	2%	54%	3%	39%	3%	7%	3%	28%	2%	4%	3%

Finally, one should note that whereas in the Region of Peloponnese where Megalopolis is located the total lignite related employment is only 5% of the Regional Unit workforce of 28,236, in the Kozani Regional Unit it represents 10% of the workforce which, in 2015, amounted to 43,496.The decommissioning of the plants according to the present plan would cause a 4.5% loss in Megalopolis and a similar 5.7% loss in Kozani. This loss in Kozani would decrease to 2.6% if Ptolemais V goes on line.

9. Transition Planning Aspects

In designing actions to assist mine and power plant employees and local communities that will affected by the transition to a low carbon economy and in particular low carbon electricity generation, one should take into consideration their special characteristics of which the most important are the following:

- lignite power plants are located near or even on the lignite mines that provide their primary energy which means that the impacted area is very localized and typically dominates the economic activity of the area. This also results in the development of local identity and sense of belonging of the work force and their dependents based on the existence and operation of the power plant/mine.
- labor mobility especially of those with lower skill levels is very low in Europe.
- coal miners usually possess skills that might not be needed in the lob market, and educational backgrounds that do not facilitate retraining.
- the interests of the individual employees, the owners of the plants, the local community and the elected officials have both common and divergent strands.

From an analysis of transitions in areas in Europe but also in other parts of the world such as the United States, transition strategy needs to include the following:

- Timing

  It is a unanimous conclusion of all analyses that timing is crucial. Advanced planning always resulted in better outcomes. In the case of Greece, the time horizon, as described above is ample (5-10 years), provided that planning commences immediately, and measures are not delayed by bureaucratic obstacles. An additional advantage in the Greek case is that the decommissioning would be gradual over a period of 12-14 years.

  In this respect, one should be aware that the time horizons of the 5 main stakeholders involved (employees, owners, local communities, financial institutions, elected officials) do not coincide and for some may only stretch to 2-3 years.

  Special attention should be paid to the timing of the political cycles and the ownership of policies and measures.

  Planning in advance, when communicated to the local community, will reduce the uncertainty and thus bust development.

- Local circumstances

  Planning cannot be off-the-self. It has to be tailor-made to local circumstance, especially the resources, human, financial and physical, and the mechanisms for adopting policies and implementing actions that would require the cooperation of the local community.

- Human capital

  The management of human capital would need to examine and utilize expected retirements, natural turnover, internal mobility in the operator enterprise, early retirement incentives, voluntary/assisted relocation and termination. The HR management needs to take the long view to 2030.

  HR management needs to take into account the fact that such large job losses affect also the local job market either because of the decrease of economic activity and hence indirect jobs or because retraining and re-employment of miners may dislocate other workers who would then either join the unemployed or seek new employment elsewhere.

  Furthermore, HR management should take into consideration the psychological aspects stemming from job losses of miners and power plant employees which include the diminution of their professional status (pride, responsibility), of their finances and the accrued deterioration of their health resulting from accrued exposure to degraded environmental conditions.

- Financial resources

Central to the transition is the identification of financial resources to replace the lost income of the community. This brings up the question of who pays and how much each.

Funding may come from direct central government disbursements and investments, exemptions of local government from costs, tax increases, and shifting of local obligations to the central government, EU funds from various line items, as well as from private investments with and without incentives.

Attracting funding also requires (i) a robust management structure that includes the selectioin and choice of those administering the funds (most likely local government), (ii) ex-ante planning, (iii) monitoring and periodic evaluation and re-adjustment if need be, (iv) precise targeting, (v) appropriate disbursement timetable over the transition horizons, and (vi) provisions for agreement with all stakeholders

- Training and education

Training needs to be with two horizons: short which aims at retraining both in class and on the job of displaced workers, and long which aims at the broader public to equip the next generation that would have taken over the jobs in the mines and the power stations with skills for employment in other sectors.

It should also take into consideration the local community resources and potential for the development of new areas of activity beyond the ones already present.

10. Plans for a "Just" Transition

10.1 The Ptolemais Basin

10.1.1 The Local Chapter of the National Technical Chamber of Greece

In 2012, the local Chapter of the Technical Chamber of Greece (TEE, 2012) analyzed the economic consequences of the decommissioning of lignite power plants in Western Macedonia using modified versions of the national input-output tables to compute local coefficients for the indirect and induced effects on employment and value added. They estimated that the total direct local income from all the lignite activities (mines and power stations) in the Ptolemais valley which includes the Ptolemais, Amyntaio and Florina basins amounted to about €440mil/yr. This estimate is based on employment and operation and maintenance cost of 2009, i.e. before the economic crisis which resulted in a 25% reduction of the National GDP together with salaries, pensions and investments. In addition, the input-output tables used were the ones from 1995 and 2007, again all before crisis. This is to be compared to the €345mil/yr estimated in this work, post crisis.

In the TEE study, the gradual reduction of the use of lignite from the current levels of ca. 32-35Mtons/yr with points of reduction in 2021 (down to 25Mtons/yr) and 2035 (gradual reduction to 5Mtons/yr in 2050) based all available information at that time (2009) for decommissioning is acknowledged. No recommendations are made on how the loss in income is to be replaced except for the possibility of converting some existing plants to natural gas.

10.1.2 The WWF Proposal

In 2016, WWF-Greece announced the results of a study (Rovolis and Kalimeris 2016) in which they analyzed the operations of the lignite mines and power plants in the Ptolemais valley and examined possible means to address the detrimental to local economy effects of the decommissioning of the older plants Ptolemais III, Amyntaio I-II, Kardia I-IV and Ag. Dimitrios I-IV on the local economy. Their analysis also covered the impacts of the operation of the Ptolemais V plant currently under construction and of the Meliti II plants which is fully permitted.

The main findings and recommendations were recently presented by one of the authors (Mantzaris, 2018) to Members of the European Parliament in Brussels on 13 July 2018. The study finds that 4625 direct (i.e. 3501 permanent and 1124 temporary) jobs and an additional 1497 indirect jobs will be lost and the local economy will contract by €1.14billion. The construction and operation of Ptolemais V will only reduce these losses by about 20% and that of Meliti II by an additional 10%.

The study then examined possible opportunities for development that focus on:

- Primary Sector
  - Saffron Aromatic plants
  - Energy plants
  - Forestry
- Secondary Sector
  - Renewables
  - Energy Savings (Buildings)
  - Fly ash
  - Waste Management
  - Processing of aromatic and pharmaceutical plants
- Tertiary Sector
  - Higher Education and Research
  - Industrial tourism
  - Eco-tourism

The study then investigated 3 scenarios for the rate of development (mild, average, strong) and compared the impacts with the Do-nothing and the operation of Ptolemais V and that of Ptolemais V plus Meliti II cases. An overview of the results based on an input-output tables analysis is given in Figure 2 below.

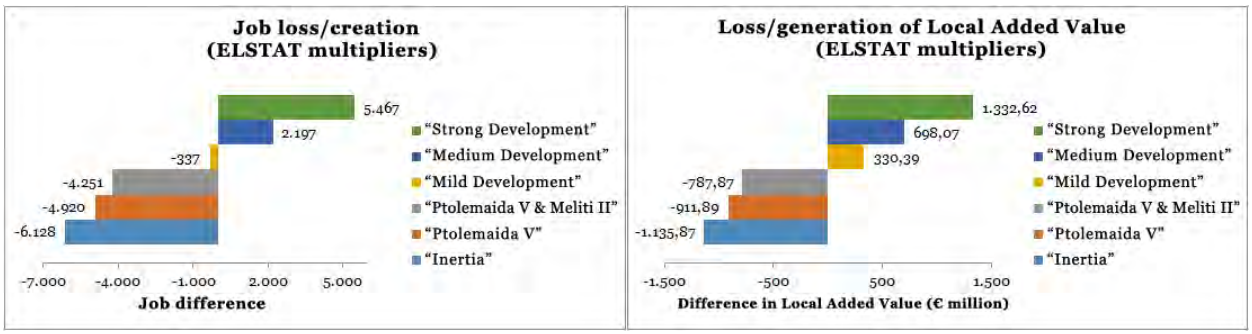

Figure 2: Impacts on jobs and value added in the Ptolemais basin based on the 6 WWF scenarios for the development of the region in view of the reduction of lignite exploitation

In a companion study also by WWF (WWF 2016) the need for district heating is examined if the lignite plants close and it is concluded that CHP plants with biomass-fired Organic Rankine Cycle boilers are the best way to provide heating with prices comparable to those using lignite.

An important action in the WWF Transition Plan is the restoration of the mines area. PPC has developed a long-term timetable for its efforts to restore which covers the period to 2050. PPC estimates that currently about 40km^2 i.e. 27% have been restored and 120km^2 i.e. 81% will be by 2050. It should be noted that about 46% of these areas will be agricultural land and 9% lake.

An attempt is also made in the WWF report to identify sources of funding for the investment needed for development which is estimated to reach from €1.23 (mild) to 2.35bil (strong). The sources include the Solid Fuel Tax of 0.5% of the PPC gross revenue, the income from the CO_2 emission allowances, the Energy Efficiency Fund to be established in the scope of Directive 2012/27/EU, a number of Community Funds such Interreg, Jessica/Jeremie, Leader, Life+ but also EBRD, EIB involvement and even the European Globalization Fund.

In the WWF report, an extensive review of proposals for the post-lignite development of the Region until 2016, is included. These proposals have been put forth by the Development Company of the Regional Government of Western Macedonia (2015), the Western Macedonia Chapter of the Technical Chamber of Greece (2012), the Kozani Ecological Movement (2009) and Greenpeace (2006) as well as the Strategic Development Plan of the Region of Western Macedonia (2015).

10.1.3 The Development Agency of Western Macedonia

The Development Agency of Western Macedonia (henceforth ANKO), an enterprise of the Government of the Region of Western Macedonia has realized that a focal point of its activity should be the compilation of a strategy for the transition to the post-lignite era. By their analysis, the advantages and disadvantages of the Region are:

Advantages

- High concentration of specialized human resources
- Industrial culture
- Important energy and environmental infrastructure
- Diversification of energy resources

- Primary sector with perspective
- Academic and research structures
- Strategic geographic position in S.E. Balkan area

Disadvantages

- 1-D characteristics of labor force
- Scaling decrease of lignite production
- Ongoing decommissioning of lignite plants
- High rates of unemployment
- Energy poverty
- Low diversification of productive model
- Low innovation rates

The new areas for development of activity to replace the income loss do not differ substantially from those proposed by WWF but they are all additional to proposals for more effective utilization of lignite.

10.1.4 The Strategic Development Plan of the Region of Western Macedonia

The Region of Western Macedonia has proposed a strategy for the transition in the scope of its Coal Regions in Transition Initiative participation based on the following three main pillars:

- Strengthening of business activities and enrichment of the region's productive baseline with innovative and competitive activities.
- Capacity building and human resource skills development in areas directly linked to the region's potentially productive environment.
- Protection, promotion and enhancement of the natural and human environment and development of favorable living conditions.

These pillars, though very general and incontrovertible, have been identified in the ANKO study and been adopted by the Regional Council. To this effect, the Region of Western Macedonia has put in place a team, spearheaded by ANKO personnel to keep track of developments in the scope of initiatives under the Coal Regions in Transition Platform of the EC. The team members include staff from the Development Agency and the Region of Western Macedonia, of the faculty of the University of Western Macedonia (with headquarters in Kozani), and representatives of the local municipalities and the Local Chapter of the Technical Chamber of Greece.

A summary of the Team's perception of the transition process map is given in Figure 3 below.

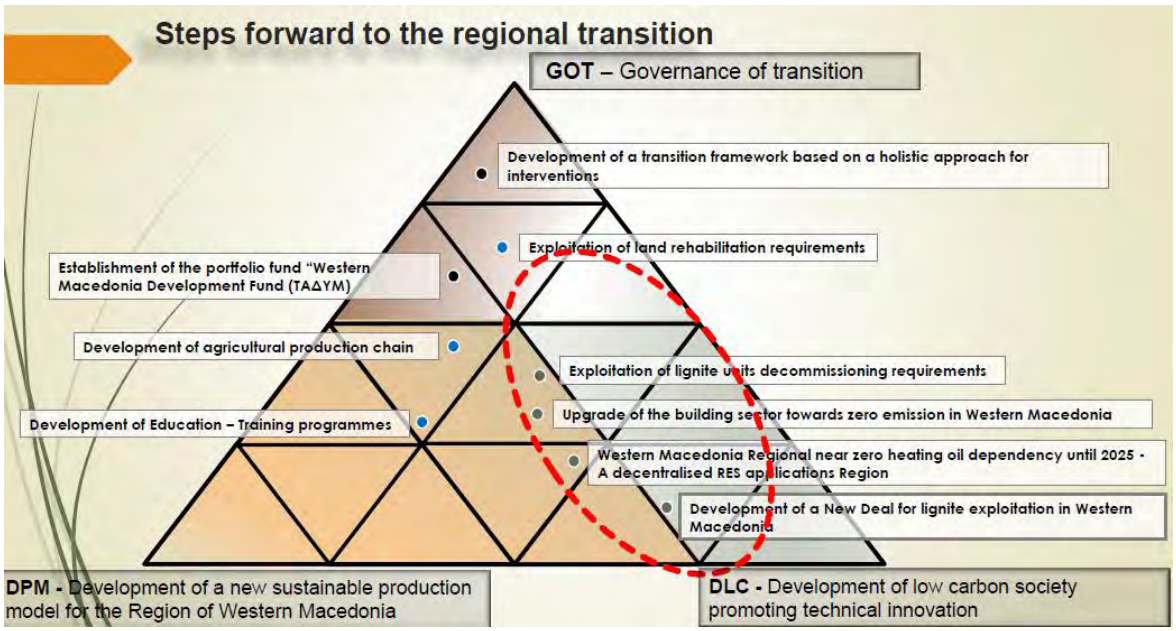

Figure 3: Overview of the main aspects for the transition to the post-lignite era, and development targets according to the Western Macedonia Team for the Transition as presented in the latest meeting of the Workshop organized by the Coal Regions in Transition Platform (Giannakopoulos, 2018)

The Team has proposed the following as a first set of pilot projects to be supported:

- Specification of the decommissioning requirements in view of the fact that PPC has not provided a detailed documentation of its plans
- Installation of decentralized RES to cover local energy use but also to address energy poverty
- Upgrading of the building stock for the same reasons
- Identifying and developing non-energy lignite use.

The Region has solicited comments and proposals from citizens (through the ANKO website[3]) with the view to develop further and flesh out the plan.

10.2 The Megalopolis Basin

The situation in Megalopolis differs from that in Ptolemais because of the accepted fact that the deposits are barely enough to provide fuel to both plants for about 10 more years. This has made the local community more receptive to the need to start immediately planning for the post-lignite era. The local community has been debating perceived advantages that the area may turn to for a sustainable development. The most important include:

[3] http://62.103.204.30/#sthash.2L91HsdR.oMSGiiMf.dpbs

- Good location at the center of Peloponnese within a 30-minute drive to the larger towns of Kalamata, Sparta, Tripolis and the airport (Kalamata) and with rails links to the ports of Kalamata and Gytheio)
- Large areas of agricultural land available including that of the exhausted mines
- Abundant supply of water
- Natural gas availability
- Experienced technical personnel
- District heating network
- The new Megalopolis V NG plant is now (June 2018) on line after extended trial operation and is expected to operate for the next 30 years

It is not clear whether these advantages are indeed sufficient or unique enough to provide a strong basis for development. It should also be mentioned that some of those employed in the mine and power plants live in the urban area of Tripolis (about 15minutes drive away).

In addition, alternate operation scenarios which envision an early (2023) decommissioning of the Megalopolis III plant and an extension of the operation of Megalopolis IV till 2036 have been proposed which would make the reduction of local jobs and income spread over a longer period so that retirement may assist in the human resources management. It should be noted that the fate of these two plants will be decided after the bids of the on-going auction due on 17 December 2018 (after two extensions of the deadline) are evaluated and a winner is declared.

The proposed activities for sustainable development of the area that have been put forth (for example by the Mayor of the Municipality of Megalopolis on 28 June 2018)[4] are very similar to those for the Ptolemais area, namely exploitation of RES, cultivation of specific high value local plants, cultivation of energy plants, and expansion of tourism with enhanced exploitation of the area's cultural heritage.

11. Some Salient Points and Recommendations

The information presented above provides the basis for a number of observations and some recommendations on the future of lignite production and local communities. These are presented below.

The first point to be noted is that the current plans for the decommissioning of the lignite plants provide an adequate but not generous amount of time of the order of 5 to 10years in which to compile and execute a well thought out plan for local development to replace at least part of the income to the local communities that will be lost. It is important then to compile, or finalize in the case of Ptolemais which has already started, such plans as quickly as possible so that the second phase, that is the one of trying to attract and secure investment funds, can start on the basis of serious and realistic business plans. It would

[4] https://www.megalopoli.gov.gr/neamobile/7-nea-anakoinoseis/1462-eisigisi-dimarxou-kou-dionysi-papadopoulou-sxetika-me-to-tameio-dikaiis-metavasis

be very useful if the experience of ANKO is shared with development agencies in Megalopolis as for example the "Arcadia2020" non-profit development agency, which has put together a development plan (Arcadia2020, 2017) not focused solely on the lignite areas, for the periods 2018-2023 and 2024-2030.

A second point that should be kept in mind, especially as regards political considerations is the fundamental difference between the Ptolemais and Megalopolis basins. In view of the expected exhaustion of the lignite deposits in Megalopolis, the closing of the mines and the lignite power stations is a given. This is not the case in the Ptolemais basin where mining activity will continue well past 2040 as, according to present planning after 2040, four power plants (Meliti I and II, Ag. Dimitrios V and Ptolemais V) will most likely be operational with the 2 new ones providing 1200 jobs. A second difference between the two areas is the differential in per capita income between the Regional Units with lignite activity and the neighboring ones without. In the Megalopolis case this is less than 25% while for Ptolemais it is much higher reaching 40%, a difference mostly due to the lower income of the non-lignite Regional Units of the Region of Western Macedonia compared to the non-lignite ones of the Peloponnese Region. All these point out the magnitude of the loss to be expected and the need for policies and measures that into account these specific and different circumstances. They also point out that the neighboring Regional Units will not be in a position to provide jobs to those made redundant or those entering the job market for the first time.

A third point is that the number of workers who would lose their jobs is, relative to other areas in EU and the US with mine closures, small (ca. 1,200 in Megalopolis and ca. 3,250 in Ptolemais plus ca.1000 part-time). Yet these job losses are large compared to the population of the local communities where they are located which have very limited economic activity outside the one associated with the mines and the power plants. This demands a very careful retirement/hiring plan for the whole next decade. It should be noted (PPC 2017) that of the current PPC company-wide technical support personnel of 6,139 (in 2017) almost 60% (3,922) are eligible for retirement in the next 5 years. A similar picture is found for the technical personnel (i.e. 1,432 engineers and scientists) of whom 1/3 (494) are eligible for retirement in the next 5 years as is also the case for unskilled laborer (173 of 599). Judicious hiring and assisted retirement policies would smooth the transition giving additional time for development of other activities to replace lost income.

A fourth point is the need for PPC and/or the new operators if the auction for the Megalopolis plants is concluded successfully, to provide a clear plan for the rehabilitation of the mine lands which includes all necessary steps and is in compliance with the environmental requirements included in their operating permits and a timetable for its implementation. This would provide guidance for local measures and additional employment opportunities and the income to be generated during the rehabilitation period.

A fifth point is that, realistically speaking, all areas will face a reduction of income bringing them closer to that of the surrounding municipalities and regional units which in the case of Ptolemais and Amyntaio and to a lesser extend Megalopolis is 25-40% lower. A possible consequence would be the emigration of the younger workers to the nearby urban areas most likely of Kozani for Amyntaio and Kalamata or Tripolis for Megalopolis or even further afar seeking employment. This would depopulate these parts of the Regional Unit of Arcadia and Florina which already have very low population densities (of the order of 15persons/km^2 for Megalopolis and 34persons/km^2 for Amyntaio vs. 81persons/km^2 on average for Greece) and would affect the demand for social services.

A sixth point is the exploitation of RES. PPC through its subsidiary PPC Renewables has secured, since 2012, production permits for 50MW of PV in Megalopolis and 230MW (one of 200MW and 2 more of 15MW each) of PV in Ptolemais. Since then, not much has happened in realizing these projects. In view of the latest emphasis to include the local community bodies (municipalities, co-operatives, regional government) in energy production and DSM services, a possible revenue source could be the development of RES installations on the mine lands to be rehabilitated in addition to the ones already planned by PPC, by a local "energy community" as defined in Law 4513/2018 on Energy Communities and Other Matters[5] and article 22 of the new Renewable Energy Directive of the EU[6], alone or possibly in conjunction with PPC. Financing for such projects would be easier, including from EU sources such as CSF, EBRD or EIB. It should be noted that this would provide for double dipping as the local communities would also benefit from the 3% RES levy on gross production value that is mandated for community support as well as from the income from the generation and sales of electricity enhanced by the non-profit clause of the energy community agent. In this respect, one should not overlook the development of energy crop plantations as areas which may not be optimal for high quality crops but can be utilized (Zafeiriou et al., 2016) for the cultivation of energy crops such as sweet sorghum, rapeseed, miscanthus and sunflower among others (both for biofuels and solid biomass) and other industrial crops. In this respect, the results of the EC MAGIC project[7] for the utilization of marginal land for the cultivation of industrial crops in which CRES the Greek Center for Renewable Energy and Savings is coordinator, could be of help.

A seventh point is the enhancement of agricultural production both for traditional and specialty crops. The efficiency of agriculture in Greece is not high. This is due to the very small size of plots caused by the fragmentation resulting from the inheritance laws but also due to the inability of Greek farmers to utilize properly and fully the latest technological tools and the CAP funds. It is important to make sure that funds from CAP and other Community Funds to local farmers are used effectively. In this respect, the existing possibilities of CAP funds to finance RES installation (up to 60% of the investment) should be fully utilized and lobbying to include special tranches in the 2021-2027 period for support of RES in agriculture in the areas in transition should be attempted. This would provide an additional income to local communities.

An eighth point has to do with educational activities and (re)training. As mentioned earlier, educational activities should aim at both those already employed in the mining operations but also to the younger generation growing up in the mine areas, and should be based on a short term as well as in a long-term horizon. For the short-medium term where training/retraining should focus on those who might lose their employment, a careful selection of areas of instruction should be made that is based on the future needs of the wider region and not only of the local communities. Vocational training and skill development should not be limited to the miner target group but should also be offered to the community as a whole. Here, providing training to local farmers, a group that includes on a part-time basis mine and plant employees, should be a priority as the agricultural activity will remain one of the main sources of community income. At the same time, as the new generation would not be employed in the mines or the power stations, it is important to select areas for their training beyond the nominal curricular studies, that are judged to lead to future employment either locally or outside the Region.

[5] (http://www.ypeka.gr/LinkClick.aspx?fileticket=e7DQ%2fQFTljs%3d&tabid=555&language=el-GR)
[6] (https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016PC0767R(01)&from=EN)
[7] (http://magic-h2020.eu)

A ninth point is the need for clarification of the actual ownership of the land of the mines after the cessation of operation. PPC clearly has some rights but also obligations for the restoration of the lands. A number of studies have been published on the appropriate design of the restoration (see for example Tsarouhi and Tsanopoulou, 2015 and references therein) and the possible use of the land for both recreational and production purposes. Yet, the extent of PPC rights on the land and the role and rights of the local communities in the final design of the restoration and the split of the proceeds from the exploitation of the land is not laid out by law so that legal disputes do not hinder its use.

A tenth point is related to the newly announced (4 June 2018) National "Just" Transition Fund[8] with a budget of €20M/yr for the 2018-2020 period for a total of €60mil. The fund is to support actions for RES installation, energy conservation, cyclical economy, agriculture, industrial heritage conservation and job creation and entrepreneurship. It is important that these funds are used to kick-start the transition. As the amounts involved cannot replace the loss of income, they need to be leveraged financially and spent for soft actions, in a coordinated way in the 2 regions of Megalopolis and Ptolemais.

One issue that needs to be settled immediately is the selection of the entity that will manage the Fund which cannot be encumbered by the heavy bureaucratic procedures of the Ministry but at the same time can guarantee transparency, zero or minimal overhead (i.e. without the establishment costs of an entirely new organization) and full participation of local community and PPC. This entity should also be part of the representation of the Regions in the EC Coal Regions in Transition Platform.

The Fund's proceeds may be enhanced by an increase and extension of the lignite levy from €1.4/MWh to 3% on gross income from the operation of the lignite electricity plants (as is the case for RES producers) at least until the mines are rehabilitated and returned to the communities, a measure that is administratively straightforward and can muster political support. The Fund income may also be enhanced if a portion (say 10%) of the annual auctioning of allowances which at €21.13/allowance (1 October 2018 price) and today's emissions would bring in more than €500mil/yr is earmarked for facilitating the transition to a post-lignite era.

A final eleventh point is the one brought up first by the local Chapter of the Technical Chamber of Greece and refers to the conversion of the Ptolemais V plant and possibly others to NG. In Figure 4 a comparison of the cost of electricity generated by Ptolemais V as a function of the price of allowances is provided. This cost does not include the levies of €2/MWh and 0,5% of gross income of PPC or other taxes that might be imposed. It does include all costs enumerated earlier and a low and high estimate of the evolution of NG prices which is critical. The low (LP) and high prices (HP) used were €27/MWh_{th} i.e. the average 2017 import price for Greece, and €40.3/ MWh_{th} i.e. the EC suggested price for 2035 respectively. The EC envisions prices of €32.1/ MWh_{th} in 2020, €37.7/ MWh_{th} in 2030 and ca. €41.3/MWh_{th} in 2040 to 2050. The current (October 2018) US price is €13/ MWh_{th} .

With prices above €20/allowance and today's prices for NG, both wind and NG-fired Ptolemais V match the Ptolemais V lignite cost. The rest lignite plants' costs are higher than RES already at €10/allowance. As the allowance price is projected by EC to climb higher, and the NG price is projected by EC to reach €40.3/MWh in 2035 and level out at €41.6/MWh in 2040 at which point the allowance price will reach €69, the cost of electricity from the lignite-fired Ptolemais V plant will be higher than the NG-fired one for

[8] (http://www.ypeka.gr/Default.aspx?tabid=389&sni[524]=5683&language=el-GR)

the majority of its lifetime even at these high NG prices. All fossil fuel fired plants have costs high than wind if the price exceeds €20/allowance.

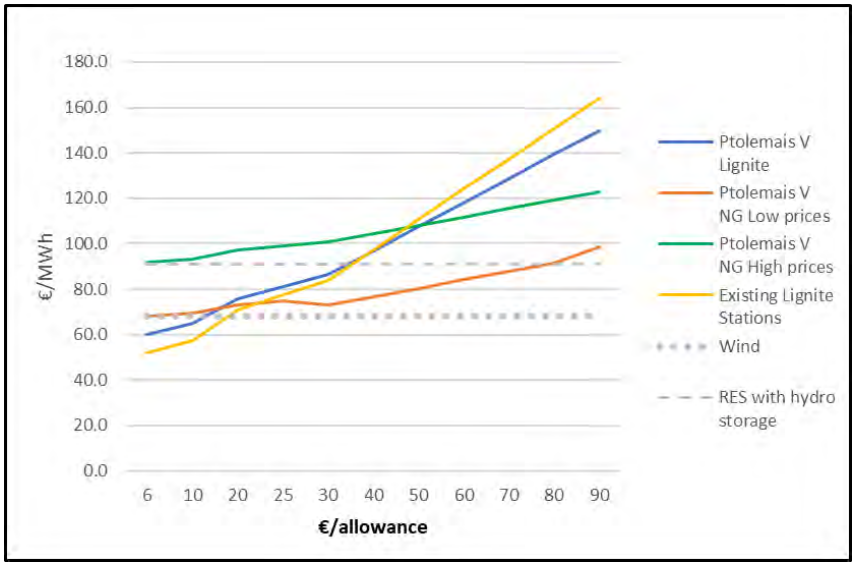

Figure 4: The effect of the price of allowances on the cost of electricity for the Ptolemais V plant using lignite and NG and on the cost of the rest of the lignite -fired stations in relation to wind installations with and without the cost of the additional storage needed for grid stability added.

This financial analysis is in line with the results of a recent economic evaluation of lignite use EU-wide by Carbon Tracker (Gray and Watson, 2017) in which the stranded investment amounts of various electricity producers in EU were estimated. The results are given in Figure 5 below.

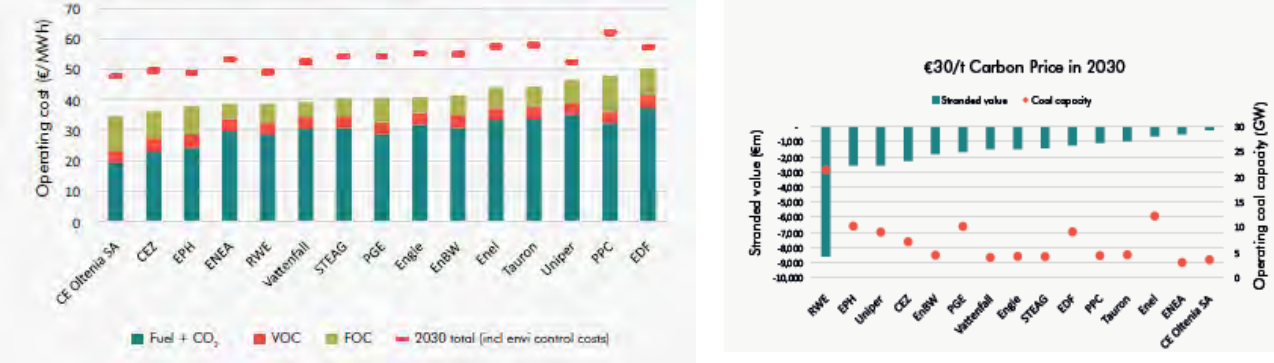

Figure 5: Capacity weighted operating costs in 2017 and 2030 (left) and Stranded investment estimates for lignite plants of EU electricity production companies including PPC (Carbon Tracker)

PPC is seen to have by 2030 the largest operating costs in EU and one of the highest stranded investment amounts. These economic evaluations should give cause for concern to those who are considering bidding

in the on-going tender but also to the management of PPC regarding the wisdom of continuing with Ptolemais V in its present configuration.

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