

Kordas, Ilias

**Conference Paper**

## Lignite As Contributory Factor to Regional Development of Greece

46th Congress of the European Regional Science Association: "Enlargement, Southern Europe and the Mediterranean", August 30th - September 3rd, 2006, Volos, Greece

**Provided in Cooperation with:**

European Regional Science Association (ERSA)

*Suggested Citation:* Kordas, Ilias (2006) : Lignite As Contributory Factor to Regional Development of Greece, 46th Congress of the European Regional Science Association: "Enlargement, Southern Europe and the Mediterranean", August 30th - September 3rd, 2006, Volos, Greece, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/118586>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

EUROPEAN REGIONAL SCIENCE ASSOCIATION

46th Congress - Volos - Greece - 2006

Paper No 938

**LIGNITE AS CONTRIBUTORY FACTOR  
TO REGIONAL DEVELOPMENT OF GREECE -  
The case of Megalopolis basin at Central Peloponese**

**Author : Ilias J. Kordas**

*Ph.D. candidate, Panteion University,  
135, Deinokratous str., 115.21, Athens, Greece  
Tel:69 44.611716 , e-Mail:ilkord@panteion.gr*

**Key Words** : *natural resources, lignite exploitation, environmental rehabilitation, urban settlements relocation, land use planning*

**Thematic Topics** :Regional economic growth and development - Environment, natural resources and sustainability

**1. LIGNITE RESOURCES AND EXPLOITATION  
IN GREECE**

**1.1 GEOLOGY OF LIGNITE RESOURCES IN GREECE**

Lignite, is a carbonaceous sedimentary rock formed by the anaerobic decomposition of plant material and its main use is as fossil fuel, is also known as “brown coal”, and is produced from plant remains through coalification processes. These processes had as a result the enrichment of the plant remains with coal. The plant transformation in peat and the transition from peat (first stage of coalification) into anthracite (final stage of coalification) are related to time, temperature and pressure. The increase of the coalification degree affects the coal physico-chemical characteristics.

Lignites were formed during the first stages of coalification, right after the peat formation. It is estimated that for the creation of a bed of lignite one (1) cubic metre thick, a period of 1000 to 4000 years is required.

Lignite calorific value is three (3) to seven (7) times lower than the heat value of the coal and five (5) to ten (10) times lower than that of oil.

From the beginning of the Kainozoic era to the recent geological years, proper conditions in Greece contributed to lignite formation during certain periods and in specific areas.

Most of the lignite genesis took place during the neotertiary and tertiary geological period. The most important lignite deposits were formed in shallow lakes and swamps in interland basin. The main characteristic of these deposits is tectonism.

## **1.2 LIGNITE IN GREECE : RESERVES AND QUALITY**

The total of proven lignite reserves in Greece, amounts to 10.000.000.000 tons approximately. These reserves exhibit a remarkable geographical distribution throughout Greece.

Considering the current techno-economical situation, the lignite reserves suitable for electric power generation, amount to 4.000.000.000 tons approximately and are equivalent to 550.000.000 tons of oil of a current value of 500.000.000 U.S. dollars.

The main exploitable lignite deposits in Greece are located in Western Macedonia (see 1.2) especially in Kozani – Ptolemais - Amyndeon - Florina basin (2.500.000.000 tons), in Eastern Macedonia especially Drama basin (950.000.000 tons) and in north of Tsessaly nearby Ellassona (150.000.000 tons). There is also an exploitable lignite deposit in Central Peloponnese (see 1.3) in the area of Megalopolis amounting to 420.000.000 tons.

According to the total amount of the exploitable lignite deposits and the planned rate of power consumption in the future, it is estimated that these reserves are adequate for more than 50 years.

The amount of the lignite already mined up to date does not exceed 25% of the total reserves.

Apart from lignite, there is a large peat deposit in Philippi (Eastern Macedonia). The exploitable amount of this deposit is estimated to be 4.000.000.000 cubic meters which is equivalent to approximately 125.000.000 tons of oil.

### **1.3 LIGNITE IN CENTRAL PELOPONESE REGION**

The lignite Central Peloponese basin, was formed during a long period of time (approximately 10.000.000 years) and it is estimated that the process ended 1.000.000 years ago.

This basin was covered at that time by shallow lakes and swamps. The climatic conditions favoured the growth of aquatic plants (mosses, reeds, etc.) in several places of the basin. As time passed, these plants were gathered in great quantities on the bottom of the lakes. Thus the organic matter of the plants being under pressure and with the influence of various micro-organisms, was transformed into lignite beds. This was repeated several times over and in the end, on top of the latest lignite beds other earthy materials, known as overburden, were superimposed. In this way lignite deposits of "zebra" form were created.

The growth of the rich greenery performed in swamps and shallow lakes during warm periods of the Pleistocene period, this being the reason why non continued lignite beds covered by earthy materials from the Alfios river were formed. A total of three lignite horizons were formed with sediment in between. The three lignite deposits have different physico-chemical characteristics, probably because of the existence of three lakes. These deposits are : Choremi-Marathousa (total depth 140 metres), Thoknia-Kyparissia (total depth of 20-100 metres) and Karytaina (total depth of 45 metres). The thickness of the lignite beds varies from a few to 5 metres.

### **1.4 HISTORICAL OVERVIEW OF THE GREEK LIGNITE RESERVES EXPLOITATION**

Lignite is Greece's most important indigenous energy resource, as well as the basis of Public Power Corporation (PPC)'s development and energy plants. Lignite exploitation has made a highly significant contribution to the development of the energy sector of Greece and will, according to estimations continue to contribute to the energy balance for at least another 40 years.

The first serious effort for the exploitation of the lignite reserves in Greece, took place in Aliveri in 1873. Unfortunately a dreadful flood in 1897 ruined all the surface and underground installations. Exploitation began again after the First World War. In 1922 the annual production reached 23.000 tons and it was maintained at that level until 1927. The following year exploitation stopped due to financial reasons. After the Second World War the great need for the country's electrification led to the decision to construct a power station in Aliveri, which would operate exclusively on lignite.

In 1951, P.P.C. undertook the underground exploitation of the mines in Aliveri, managing to raise the production to 750.000 tons per year and to supply power station with a total of capacity of 230 MW. The operation of the Aliveri mine stopped in the early 1980's.

The first systematic research for the detection and evaluation of the lignite deposits in the area of Ptolemais – Western Macedonia, began after 1938.

In 1955 the LIPTOL company was established, the aim of which was lignite exploitation for the production of briquettes, nitrates, coal products and electric power. In 1959, 90% of LIPTOL's stocks were taken over by P.P.C. and in 1975 LIPTOL was incorporated with P.P.C.. The lignite production in 1959 was 1.300.000 tons, raised to 11.700.000 tons in 1975, to 27.300.000 tons in 1985 and to 44.300.000 tons in 1996.

The Megalopolis lignite deposit in Central Peloponese was scientifically evaluated for the first time in 1957 with encouraging results. In 1969 P.P.C. began to exploit the

lignite. It was the first time in the world that lignite of such low calorific value had been mined and used for power production. The Megalopolis mine had started with an annual production of 1.000.000 tons and reached, in 1996 12.000.000 tons.

Today P.P.C. produces approximately 55.000.000 tons of lignite per year. The impressive development of P.P.C. mines gives to Greece the second place in lignite production in EU, the fifth in Europe and the sixth in the world.

## **1.5 METHODS AND EQUIPMENT OF EXPLOITATION AT «CENTRAL PELOPONESE (or MEGALOPOLIS) LIGNITE CENTRE»**

In the operating mines of above mentioned basin, the thickness of the overburden varies from 12 to 230 meters. Overburden usually consists of sand, sand and gravel, soft limestone and clay. The lignite deposits are not united as well, for thin beds of earthy materials called "intermediate beds" are in them. The average width of the lignite beds is approximately 2m and the number of beds varies from 20 to 30.

The exploitation of the lignite deposits is performed in the surface in benches. On one hand the demands for selective mining and on the other hand for high production rates, were the reasons for the selection of the «German» method of open pit surface mining - transportation and dumping.

The mining procedure of a lignite deposit includes continuous extraction, transporting and deposition of materials (lignite and top soil, overburden, intermediate and waste rock materials). The mined lignite is then transported to the thermal power plants for combustion.

As main equipment in this method a system of continuous mining consisting of electric-power bucket wheel excavators, belt conveyors and stackers is used.

In order to mine the lignite deposits, the overburden barren materials and the lignite beds are separated into levels of 10 to 30 metres high, depending on the type of

excavators. The deposit is mined in benches and the barren materials (overburden or intermediate) are transferred by belt conveyors to the stackers, while the lignite is transferred to lignite yards nearby the power stations, or to other consumers (e.g. the briquette factory) or to open-air warehouses. The barren materials are deposited to specially chosen areas together with the coal ash (left-over from the lignite combustion in power stations).

In some areas the overburden consist of hard formations which, in order to be removed, have first to be smashed by the use of explosives and then to be loaded by big shovels and carried away in trucks off high way.

Apart from the main equipment, other smaller machinery, mainly loaders, bulldozers, excavators, trucks etc., are used in the mining process and support the function of the Mine. This equipment is called auxiliary.

The coexcavated materials are transported and put back mainly in the excavation voids of the mines, followed by appropriate restoration works, in an effort to minimize the impact on the landscape.

In the following Table it is shown the characteristics of the exploitation of lignite implemented in the various lignite fields of «Megalopolis Lignite Centre».

	Surface (square metres)	Exploitation Features		Exploitation Quotient (c.m.\ton)
		Barren material (milion\c.m.)	Lignite (milion\ton)	
<b>Main Fields of Exploitation</b>				
«Choremi» Main Field	14.000.000	515	141	2,7:1
«Choremi» West Field	3.000.000	147	62	1,5:1
«Marathoussa» Field	1.700.000	92	23	3,0:1
«Kyparissia» Field	2.800.000	68	55	0,3:1
<b>Total</b>	<b>21.500.000</b>	<b>822</b>	<b>281</b>	<b>2,0:1</b>
<b>Auxiliary Fields of Exploitation</b>				
«Choremi» West Field (part	2.300.000	32	10	2,2:1
«Kyparissia» settlement Fie	1.000.000	6	4	0,6:1
«Karytaina» Field	1.500.000	17	10	0,8:1
<b>Total</b>	<b>4.800.000</b>	<b>55</b>	<b>305</b>	<b>1,4:1</b>

<b>Total general</b>	26.300.000	877	305	1,9:1
----------------------	------------	-----	-----	-------

In the following Table it is shown the characteristics of the equipment used in order to exploit the lignite from the various fields of «Megalopolis Lignite Centre».

<b>EQUIPMENT</b>	<b>NUMBER</b>	<b>CAPACITY</b>
<b>Bucket Wheel Excavator</b>	10	1250-2500 c.m.\hour
<b>Track Crawler</b>	10	1250-2500 c.m.\hour
<b>Barren material Stackers</b>	6	2500 c.m.\hour
<b>Lignite Stackers</b>	3	2500 c.m.\hour
<b>Lignite Loaders</b>	6	800-1100 c.m.\hour
<b>Belt Conveyors</b>	1200 mm Width	23.000 metres
<b>Belt Conveyors</b>	1400 mm Width	33.000 metres
<b>Belt Conveyors</b>	1600 mm Width	1.500 metres

In the following Table it is shown the particular great dimensions of the equipment used for the exploitation of lignite in the various lignite fields of «Megalopolis Lignite Centre».

<b>Dimensional characteristics Of the equipment</b>	<b>Total Length</b>	<b>Total Width</b>	<b>Total Height</b>	<b>Total Load</b>
	Metres.	Metres	Metres	Tons
<b>Bucket Wheel Excavator</b>	68	23	33	1210
<b>Track Crawler</b>	42	4,5	10	167
<b>Stacker</b>	75	11	20	434

In the following Table it is shown the categories of the personnel working at the «Megalopolis Lignite Centre».

<b>PERSONNEL CATEGORIES</b>	<b>NUMBER</b>	<b>PERCENTAGE %</b>
<b>Diploma Engineers</b>	35	2,5
<b>Graduate Engineers</b>	48	3,4
<b>Administrative-Secretariat Staff</b>	60	4,2
<b>Operation-Maintenance Technicians</b>	1090	84,7
<b>Security Crew</b>	35	2,5
<b>Auxiliary Personnel</b>	38	2,7
<b>TOTAL</b>	1306	100,0



## 1.6 «CENTRAL PELOPONESE (or MEGALOPOLIS) ELECTRICITY GENERATION CENTRE»

In Central Peloponese region actually is under operation the «Megalopolis Lignite Center», with annual production rating to 14.510.000 tons and total material transportation of 44.000.000 m<sup>3</sup>. The following Power Plants (Steam Electric Stations or S.E.S.) are feaded by the «Megalopolis Lignite Center» concisting the «Megalopolis Electricity Generation Centre» :

- \* **MEGALOPOLIS «A'» S.E.S.** with three (3) generation Units *[[1<sup>st</sup> Unit (1970) : 125 MW], [2<sup>nd</sup> Unit (1970) : 125 MW] and [3<sup>rd</sup> Unit (1974) : 300 MW]]*, with a total installed capacity of 550 MW, and annual production of 2.890\*106 kWh
- \* **MEGALOPOLIS «B'» S.E.S.** with one (1) generation Unit *{(1991) : 300 MW}*, and annual production of 1.678\*106 kWh

### Megalopolis Electricity Generation Centre

Lignite fired Power Plants – Generation Units	Established	Capacity (MW)
Megalopolis «A'» S.E.S. - Unit «I»	1970	125
Megalopolis «A'» S.E.S. - Unit «II»	1970	125
Megalopolis «A'» S.E.S. - Unit «III»	1974	300
Megalopolis «B'» S.E.S. - Unit «IV»	1991	300
<b>Total Installed Capacity</b>		<b>850</b>

In the following Table it is shown the categories of the personnel working at the «Megalopolis Electricity Generation Centre».

Personnel Categories	Megalopolis S.E.S. «A'»		Megalopolis S.E.S. «B'»		Total
	Number	%	Number	%	
	Diploma Engineers	12	3,5	15	
Graduate Engineers	21	6,2	25	6,8	46
Administrative-Secretariat Staff	36	10,6	39	10,8	75
Operation- Maintenance Technicians	231	68,1	237	65,3	468
Security Crew	21	6,2	26	7,2	47
Auxiliary Personnel	18	5,4	21	5,8	39
<b>Total</b>	<b>339</b>	<b>100</b>	<b>363</b>	<b>100</b>	<b>702</b>

## 2. LIGNITE MINES AND THE ENVIRONMENT IN CENTRAL PELOPONESE REGION

### 2.1 ENVIRONMENTAL IMPACTS OF LIGNITE MINING

The open-pit mining of lignite with this particular «German» method consequently results in :

- The utilization of large areas of land for long periods of time.
- The alteration of the soil's morphology.
- The disturbance of the flora and fauna of the region.
- The necessity for relocation of some urban settlements as well as part of the local road and rail network.
- The emission of air pollutants (dust), noise, solid and liquid pollutants (waste).

P.P.C. acknowledges that restoration of the whole region of Central Peloponese affected by the lignite mines is a major environmental, social and economic issue. In compliance with EU Directives, P.P.C. is proceeding to the restoration of the new

land and the protection and upgrading of the environment at an even more systematic and accelerating pace.

## **2.2 ENVIRONMENTAL IMPACT ASSESSMENT STUDIES OF LIGNITE MINES ACTIVITY AND APPROVAL OF ENVIRONMENTAL TERMS (PERMITS)**

All mines of the entire Lignite Center of Central Peloponese (or Megalopolis), at Central Peloponese region, systematically implement projects in order to minimize the environmental impacts of their operation.

On the basis of the law in force and the specific strategic studies for the restoration of mines' new land, relevant Environmental Impact Assessment studies were drawn up and submitted to the Greek Ministry of the Environment, Physical Planning and Public Works.

The Environmental Terms (Permits) regulating the operation of all existing mines of the entire Lignite Center of Central Peloponese (or Megalopolis), have already been approved while the Environmental Permits pertaining to the new small exploitations are expected to be approved soon.

The Environmental Permits for the mining operation in Central Peloponese region include :

- \* The elaboration of specific technical implementation studies on the redevelopment and the rehabilitation of the final surfaces of the mines (tree planting, agricultural cultivation, formation of lakes etc).
- \* The compilation of special studies on soil stability as well as hydrogeological studies (water balance, integrated management systems of underground and surface water etc) in the greater mining area,
- \* Measures for reducing disturbance to the neighboring areas (creation of green zones, noise and vibration measurements at the borders of residential areas, reduction of the dust emitted etc),

- \* Liquid waste treatment and disposal,
- \* Environmental quality monitoring in the greater mining area using an extended network for of relevant equipment,
- \* Integrated management and disposal of by-products (obsolete equipment, old tires, batteries, oil - lubricants etc).
- \* Fire protection measures to prevent lignite self-combustion,
- \* Keeping logbooks and records on the environmental parameters,
- \* Reporting to the competent authorities at regular intervals and annually.

### **2.3 ENVIRONMENTAL MANAGEMENT POLICY - ACTIONS FOR THE PROTECTION OF THE ENVIRONMENT AT THE MINING AREAS**

In compliance with the basic principles of environmental respect and protection, P.P.C. develops its policy on environmental management focusing on the following :

- Compliance with the Environmental Terms (Permits)
- Compliance with the Greek and European legislation or other regulatory requirements
- Continuous improvement of the environmental performance in every activity
- Development and maintenance of an efficient and effective environmental management system.

The negative parameters of the production activity were timely identified. P.P.C. took a series of actions aiming at maintaining the mining area in harmony with its surrounding region after the extraction of the lignite, so as to cope with these negative parameters in the best possible way, while remaining consistent with the principles and objectives initially set.

The main principles set forth for the success of the environmental management policy are the following :

- Knowledge of the environmental conditions in the lignite areas.
- Selection of the appropriate methods and techniques of ground rehabilitation.
- General Physical Planning of the areas to be restored (land use maps).
- Regular, implementation of environmental protection and restoration in accordance with the approved Environmental Terms (Joint Ministerial Decisions)
- Monitoring and evaluation of the results of environmental restoration, by means of modern Geographical Information Systems (G.I.S.)

## **2.4 ACTIVITIES FOR THE PROTECTION OF THE ENVIRONMENT AT THE MINES AREA**

### **2.4.1 Expropriation of required lands**

P.P.C. proceeds in the expropriation of the required lands of Central Peloponese region, in accordance with the Law in order to exploit the lignite deposits.

P.P.C. indemnifies the owners of this land in compliance with the relative court rulings by paying them significant amounts. The acquisition cost for land with urban settlements that have to be relocated is particularly high.

The land expropriated to date totals 3.600.000 hectares for the Megalopolis Lignite Center. Another 1.500.000 hectares have to be expropriated to complete the mining.

### **2.4.2 Relocation of existing urban settlements**

At the same time it was necessary to relocate some settlements built on the lignite deposits for the development of the exploitation program. To date four (4) settlements named «Psathi», «Marathousa», «Gefyraki» and «Anthohori» have been relocated in the area of Megalopolis, accommodating approximately 250 people. A large part of

the relocated population was settled in the town of Megalopolis, which is now turned into major urban center of the Arcadia Prefecture (county).

<b>No of Relocation</b>	<b>Settlement</b>	<b>Year</b>	<b>People</b>	<b>Houses</b>
<b>1<sup>st</sup></b>	«Psathi»	1980 – 1985	77	190
<b>2<sup>nd</sup></b>	«Marathoussa»	1985 – 1988	71	80
	«Ghefyraiki»	1985 – 1988	37	15
<b>3<sup>rd</sup></b>	«Anthochorio»	2005 – 2010	Not yet	Not yet

The land created after the mining of the lignite deposits, in accordance with Law 2941/12-9-2001 is now owned by P.P.C.

The arrangement is compliant to the regime in force in other EU countries such as Germany, where in similar exploitations the expropriated land and the reclaimed new land are considered assets of the mining enterprises.

It is mentioned that the implementation of the new Law provides the following possibilities:

- P.P.C., after the completion of the reclamation and the relevant restoration works may exchange them with new land required for the development of the Mines, contributing thus to the preservation of the revenue from agriculture in the Central Peloponese region.

This exchange ensures that the farmers of the Central Peloponese region will preserve their main means of living (agricultural cultivations).

### **2.4.3 Ground Rehabilitation**

The «Central Peloponese Lignite Center» systematically implement projects for the restoration of the land gradually released from the mines, in order to render them for farming, foresting and other uses as well.

For this purpose, specific strategic studies have been compiled for the rehabilitation of the mines' new ground by an interdisciplinary team set up by the National Technical University of Athens. These studies have been taken into account in the formulation of the finalized proposals of the Environmental Impact Assessment Studies (EIA) submitted to the Greek Ministry of the Environment, Physical Planning and Public Works.

According to the aforementioned studies, it is anticipated that after the completion of the mining of the «Central Peloponese Lignite Center», the creation of 2.700 hectares of forestland has been anticipated, while the remaining part will include mainly farming land with recreational parks, sport centers, buildings, lakes and wet-lands. To date 582 hectares of forest parks have been created on inclined planes as well as 200 hectares of farming land on the leveled surfaces of the mines. More specifically the land redeveloped to date is grouped as follows:

<b>Extensive Table of the redeveloped land</b>	<b>Square meters</b>
Land formed of Depositions	800.000
Forest Park	5.821.000
Buildings	10.345.000 (*)
Farming Land	1.211.000
Lake	8.000
Total	18.185

(\*) including all installations of Power Stations

#### **2.4.3.1 Tree planting**

To date more than 800.000 trees in the «Central Peloponese Lignite Center» at a rate that now exceeds 40.000 per year. Trees planted are mainly species native to the area of the mines such as acacias, pines trees, elm trees, Arizona cypresses and eucalyptuses along with fruit bearing trees such as walnut trees, chestnut trees, apple

trees, pear trees and pistachio trees planted at selected locations of the mines. Tree planting is performed with three different methods :

- The classic manual way in areas where the use of machinery is inappropriate.
- The riper method with a bulldozer or a suitably shaped plough connected to a tractor, which allows the planting of 1.000 trees per hour.
- The method of transferring an entire forest root system (mainly for acacia trees).

#### **2.4.3.2 Creation of farming land**

The creation of experimental farming land for crops started in 1986 to test the fertility of the rehabilitated land. The crops selected are the durum and soft wheat, due to the fact that this entire area is usually planted with these crops, before exploitation of lignite.

According to the evaluation of the results so far, the productivity of the new land remains at the same levels with the productivity of the wide Central Peloponese region, and in some cases even exceeds it. At the same time, the productivity of this land can be compared to the productivity of the experimental farms created by covering the new land with fertile soil, 40-50 cm thick, extracted from the surface of the expropriated areas.

In the «Central Peloponese Lignite Center» there have been experimental cultivations on specific species of plants (e.g. potato, bean trees, tomato) with satisfactory results for their potential cultivation, while the experimental crops of grains, oats and vetch produced results that are similar to those achieved in the greater areas of Central Peloponese region. Beside the cultivation of crops, a pilot greenhouse for hydroponic cultivations with remote heating (teleheating) is being run at the redeveloped areas of «Central Peloponese Lignite Center»

#### **2.4.3.3 Special works for the rehabilitation of the land**

- **creation of new ecosystems**



In addition to the large-scale works pertaining to the creation of cultivable and forest land, a number of special interventions are being carried out aiming at optimizing the cultivation of the rehabilitated ground at the Central Peloponese region mined areas.

The restored areas are already hosting ecosystems gathering the flora and fauna from the ecosystems that have been affected or disturbed, while fauna is enriched with the species released from the animal husbandry facilities. Lakes and wet-lands were created at all the depositions and as a result a large number of both flora and fauna species are gathered around them, while lakes are enriched with fish.

In the areas of the «Central Peloponese Lignite Center» that have been restored, various projects have been constructed, among which:

- An Expo Center for informing the visitors on the Lignite Center activities.
- A Recreational Park (including a grove, a playground and various playing fields) where various events are held in cooperation with the Municipality of Megalopolis.
- Artificial hydrobiotopes by creating artificial lakes some of which have been enriched with fish.
- A moto-cross track, which has accommodated international races on various occasions and has been qualified as a model track by major international bodies related to this sport.
- A runway used by private associations to carry out flights of ultra light aircrafts.

## **2.5 IMPLEMENTATION OF ENVIRONMENTAL PROJECTS BASED ON ENVIRONMETAL PLANNING, AIMING AT COPING WITH THE IMPACT CAUSED BY THE OPERATION OF MINES**

The Lignite Center of «Central Peloponese», is obliged to take systematically all necessary measures for following the Environmental Terms for the mines, in accordance with environmental planning.

More specifically, the measures aiming at controlling pollutants, that is air pollutants (dust, suspended particles), liquid and solid pollutants (waste) as well as noise, are the following :

### **2.5.1 Dust, suspended particles**

In order to reduce the dust produced at the mines during transportation of the excavated materials with conventional means, special permanent wetting networks constructed along the main road networks or special tanker trucks for secondary roads are used. Moreover, the lignite transportation tracks are equipped with appropriate covers. In addition to that, large sections of the mines secondary roads are being asphalted.

### **2.5.2 Liquid waste**

Liquid waste produced at mining center (offices, changing rooms, workshops) before being conducted to the natural receptors is treated at biological treatment plants. Oil and lubricants used at diesel-motored equipment workshops for machinery and vehicles are collected and sent for recycling..

### **2.5.3 Solid waste and other material storage areas**

In order to achieve a better collection, sorting and clearance of the various waste materials (iron bars, machinery parts etc), open areas (i.e. kind of open air storage areas) have been constructed in areas specifically selected for that purpose.

The materials to be cleared are collected in a waste material storage area and are cleared through tender. Materials that could cause pollution (e.g. electromotor oil) are collected in containers, which will subsequently be cleared. Moreover, materials that

could cause hazardous waste (e.g. machinery batteries) are gathered in a waste storage area in order to be cleared.

#### **2.5.4 Noise**

In order to reduce the noise in the workshops, measures are taken in accordance with the Mining and Quarries Activity Regulation and the laws in force.

Sound barriers made of earth are constructed to reduce the noise created by the machinery and the vehicles used during the lignite mining so as not to disturb the residential areas adjacent to the mines.

Additionally, the «Central Peloponese Lignite Center» will acquire a special modern mobile station for measuring noise and vibrations in order to keep records of noise pollution and deal with it.

## **2.6 IMPLEMENTATION OF ENVIRONMENTAL PROJECTS IN ORDER TO IMPROVE THE ENVIRONMENTAL PERFORMANCE OF THE EXISTING POWER STATIONS**

The Electricity Generation Center of «Central Peloponese», is also obliged to take systematically all necessary measures for following the Environmental Terms for the operation of Power Stations, in accordance with environmental planning.

More specifically, the measures aiming at controlling pollutants, that is air pollutants (Carbon Dioxide, Sulphur Dioxide, Suspended Particulates), liquid and solid pollutants (industrial waste water), are the following :

### **2.6.1 Programme for the reduction of carbon dioxide emissions**

The programme for the reduction of carbon dioxide, emissions regarding generation activities includes: ,

- Incorporation of natural gas into power generation as a new fuel.
- Development of the country's hydro potential.
- Energy saving and rational use.
- Application of the most effective lignite combustion technologies.
- Follow up of the technological developments for carbon dioxide capture and storage.
- Preparation of PPC for the application of flexible mechanisms complying with the Kyoto Protocol with particular emphasis on the implementation of 2003/87/EC Directive
- Programme for the systematic monitoring and reporting of carbon dioxide emissions for all PPC plants as provided for by Directive 2003/87/EC and the European Commission Decision No.156/29.01.2004.

## **2.6.2 Installation of pollution abatement equipment in order to reduce dust (suspended particulates) emissions**

In order to reduce dust emissions from lignite fired power plants, P.P.C. implements a programme for the replacement and upgrading of the existing Electrostatic Precipitators (filters), as well for the adding of new-state of the art high performance filters. The implementation of the programme to PPC lignite fired power plants so far, has led to an impressive improvement in the quality of the ambient air at the power plants regions.

PPC has proceeded to the replacement of the existing electrostatic precipitators (filters) of the fly ash plant at Unit III of Megalopolis «A» SES.

Within the scope of the same programme and in order to provide continuous improvement of the environment, works, pertinent to interventions to the electronic and construction features of existing filters have been carried -out in parallel.

All the above, combined with the introduction of natural gas to the national energy balance, resulted in the reduction of particulates emission specific factor from the lignite fired power plants.

### **2.6.3 Installation of Flue Gas Desulphurization (FGD) plants in order to reduce sulphur dioxide emissions**

The installation of flue gas desulphurization plants in lignite power plants aims at the effective abatement of sulphur dioxide emissions. A flue gas desulphurization Plants is already in operation at Unit IV, 300 MV of Megalopolis «B» S.E.S.

In parallel the following project is in progress «installation of flue gas desulphurization plant at Unit III, 300 MV of Megalopolis «A» S.E.S.», the relevant budget amounts to 80.000.000 euros.

### **2.6.4 Installation of industrial waste water treatment plants**

The environmental investment programme for the improvement, of the existing industrial wastewater" treatment plants includes: .

The installation of an Industrial Waste water Treatment Plant for Units I-III at Megalopolis SES,

### **2.6.5 Programmes aiming at increasing of energy efficiency projects**

PPC implements an upgrading programme for the increase Of power plant energy efficiency and for energy saving purposes combined with emissions reduction. These measures aim at :

Upgrading steam turbines, cooling towers, boilers and auxiliary systems

The following project are already under implementation:

- Upgrading of the cooling tower of Unit III of Megalopolis SES. The project is due for completion in the 2nd semester of 2006 and the total budget amounts to 3.57 million Euros

### **3. CONTRIBUTION OF LIGNITE TO THE REGIONAL DEVELOPMENT OF GREECE**

#### **3.1 NATIONAL ENERGY PROGRAM**

The contribution of lignite to Greece's Electric Power Interconnected System during the past 50 years has constantly increased.

The national electrification program as well as the safe supply of cheap electric power production reached 69% due to lignite. The value of this contribution is currently equivalent to corresponding imported oil, priced at 650.000.000 Euro.

Considering Europe's current energy production map, the geopolitical instability in the areas of energy large reserves, and the long standing trend of fuel prices to increase, lignite is the most important and the safest energy source for Greece.

Lignite in Greece is abundant, and its cost is competitive in relation to other imported fuel. This comparative advantage of lignite is expected to continue in the future. According to the economic and production figures of the past five (5) years, production has increased by 10% and productivity by 35%, with a corresponding decrease in the cost of mined lignite in constant prices during the same period.

#### **3.2 EXPENCES FOR PROJECTS IMPROVING THE REHABILITATION OF EXPLOITED LAND**

In the following Table it is shown the expences of the land rehabilitation activities within the territory of the greater Megalopolis basin, already mentioned on the above paragraphs 2.4 and 2.5, during the years 1996 - 2004

<b>YEAR</b>	<b>EXPENCES</b>	<b>MONETARY UNIT</b>
1996	1.300.000.000	Drachmas
1997	1.350.000.000	Drachmas
1998	1.400.000.000	Drachmas
1999	1.450.000.000	Drachmas
2000	1.500.000.000	Drachmas
2001	1.550.000.000	Drachmas
2002	4.400.000	Euro
2003	4.500.000	Euro
2004	4.600.000	Euro

### **3.3 EXPENCES FOR PROJECTS IMPROVING THE ENVIRONMENTAL OPERATION OF POWER STATIONS**

In the following Table are shown the expences within the Megalopolis basin territory (above mentioned in paragraph 2.6) for the protection of the environment coming from the operation of the Electricity Generation Units of the Megalopolis «A» and «B» Power Stations, during the years 1995 - 2004.

<b>MODERN INSTALLATIONS FOR THE PROTECTION OF THE ENVIRONMENT</b>	<b>Power Unit</b>	<b>Fase</b>	<b>Expences In Euros</b>
Industrial Wastes Treatment Plant	III	Finished	5.000.000
Flue Gases Desulphurisation Plant	IV	Finished	88.000.000
Flying Particles Electrostatic Filters (precipitators)	III	Finished	16.000.000
Wet Ash Filters	III	Finished	18.000.000
<b>Total Implemented Expences</b>			<b>127.000.000</b>
Flue Gases Desulphurisation Plant	III	Handover	68.000.000

Flying Particles Electrostatic Filters (precipitators)	I – II	Handover	25.000.000
Cooling Tower Restauration	III	Handover	4.000.000
<b>Total Programmed Expences</b>			<b>97.000.000</b>

### **3.4 URBAN AND RURAL DISTRICT HEATING (or TELEHEATING) THROUGH CO-GENERATION**

It is to be mentioned that P.P.C. provides thermal energy, from the power stations, for the district heating of the town of Megalopolis and surrounding urban settlements.

The combined, generation of heat and power, also known as «co-generation», and the relevant technologies are applied in Greece, particularly so during the last decade, in regional district heating systems where heat through hot water is used for residential heating within the limits of a particular region.

PPC, in collaboration with several municipal authorities of Megalopolis basin, has proceeded to the implementation of a series of energy generation projects in the form of hot water for district heating purposes, attempting to provide a method of continuous heating of urban residences harmless to the environment"

Especially for Central Peloponese the relevant project is «Megalopolis city Remote Heating, 20 MWth capacity by Unit III, of Megalopolis «A» S.E.S.»

District heating systems for the greater area of Megalopolis have already been successfully in operation for several years providing local residents with high thermal power availability with by the appropriate billing policy applied by the municipal authorities, has led to significant improvement of the residents quality of living, offering more economical heating power and contributing to the reduction of air pollution.

This has led to an increased interest from the part of local municipal authorities of Central Peloponese in adds power by the nearest S.E.S.



### **3.5 LOCAL EMPLOYMENT**

In addition, lignite contributes to the regional development of the country. Lignite mining and the generation of electric power take place in less developed areas, ensuring employment for a large number of scientific and labor personnel, reducing unemployment and urban attraction and increasing the per capita local income in these less developed areas.

More especially, in Greece a total of 16.000 people are directly or indirectly involved in the lignite industry sector (mining, combustion, supply of materials and services ) and from this amount 8.167 are involved in West Macedonia Lignite activities industrial complex, and 2.008 are involved in «Megalopolis Lignite activities industrial complex».

It is to be mentioned here that from a total amount of about 16.000 inhabitants of the Megalopolis basin, the people working as personnel to the installations of industrial complex of the mines and power stations of P.P.C., arrive the amount of 2.008 persons..

It is to mention that one (1) working place in lignite industry sector leads to eight (8) working places in all other subsidiary sectors in the same less developed region .

### **3.6 LOCAL INCOME**

The social and financial impact arising from the development of Central Peloponese (or Megalopolis) «Lignite Center» mainly concern the radical change in the productive backbone of the region in question and the relocation of populations through the regeneration of local urban centers.

Before the commencement of lignite mining, the mining areas were areas of farming, foresting and animal husbandry with low productivity and a declining population. The

development of the energy centers brought about a period of economic recovery and welfare, new jobs were created pertaining to activities different from the traditional activities of these areas, the per capita income of the inhabitants increased and reconstruction took off at an accelerated pace.

Moreover, according to data taken from the Department of accounts of P.P.C. regarding only the salaries (not included commissions, contracts assigned etc) the amount of 30.000.000 Euros (or 12.000.000.000 ex Greek Drachmas) is given to the personnel of power stations annually, and the amount of 18.000.000 euros (or 50.000.000.000.ex Greek Drachmas) is given to the personnel of mines as well.

That means that an amount of 6.600.000 Euros (or 2.500.000.000 ex Greek Drachmas) is spent as monthly salaries within the Megalopolis basin territory, with an economic sprint out advantage to the local societies. of Central Peloponese region.

### **3.7 SOCIAL «COMPENSATION» PROJECTS**

Since his establishment in Megalopolis basin, PPC financed projects of technical infrastructure and social regeneration for the greater areas where the lignite activity has been developed, totaling 500.000.000 ex Greek Drachmas annually (equivalent to 1.500.000 Euros annually).

In this respect P.P.C. cooperates with the local primary and secondary self government authorities, and finances or undertakes social «compensation» projects for life improvement, and the social and financial support of the residential areas near Mines.

P.P.C. also provides technical services and contributes to the carrying out of small projects in municipalities and communities.

At the end P.P.C. finances projects that aim at the preservation of cultural heritage, like archaeological researches and excavations in the areas of Megalopolis basin.

### **3.8 STATUTORY FINANCIAL AID**

Since 1997, the Law 2446\19-12-1996 – Article 20 for the development of industrial areas has been imposed amounting to 0.4% of PPC's annual turnover, and is distributed to the Prefectures (counties) of Kozani and Florina in Western Macedonia as well as to the Prefecture of Arcadia in Central Peloponese, where lignite mines and lignite fired power plants operate.

According to the above mentioned Law, during the period 1997 – 2002, the amount of 60.500.000 Euros was allocated to these three Prefectures (counties). For the period 2003-2007 the total amount to be allocated to these prefectures (counties) is estimated at 80.000.000 Euros.

The allocation of this duty is estimated proportionately according to the amount of power generated by the thermal power plants (S.E.S.) located in the above-mentioned areas and in compliance with the Law in force. The resulting allocations are to be used for the financing of infrastructure works, development and environmental protection. The significant amounts spent on a yearly basis by P.P.C. in this regard are expected to serve as a major springboard for development and progress for the greater area of these regions.

In addition to the works of social regeneration and the duty for the development of industrial areas, for the redevelopment works and environmental protection of the new ground at the lignite mines, more than 1.700.000.000 Greek Drachmas are spent on a yearly basis (1.200.000.000 at the West Macedonia Lignite Center and 500.000.000 at the Megalopolis Lignite Center) or 500.000 Euros.

In the following tables is shown the total amount and the assignation of this amount to various categories of financial aid for Megalopolis basin. These amounts cover the two (first and second) Developmental Programs of the years 1996 – 2001 and 2002 – 2006 respectively for Arcadia Prefecture :

**TABLE SHOWN THE PARTICIPATION OF P.P.C.**

**(BY SPECIAL FINANCIAL AID)**  
**TO THE FIRST DEVELOPMENTAL PROGRAM (1996-2001)**  
**OF MEGALOPOLIS BASIN (CENTRAL PELOPONESE REGION)**

<b>CATEGORY OF FINANTIAL AID</b>	<b>BUDGET IN GREEK DRACHMAS</b>	<b>PARTICIPATION OF P.P.C.</b>
Maintenance – Upgrading of local Road Network	1.717.799.490	1.220.856.812
Upgrating of Water Supply – Sewerage Network	108.615.000	103.787.937
Tourism Sector Development	407.000.000	198.090.546
Rural Sector Development	113.533.633	93.845.023
Teleheating	3.470.000.000	614.406.651
Elaboration of special studies and research programs	476.500.000	436.890.762
Local Development Economic Support	90.000.000	87.980.637
Local Development Technical Support	96.445.893	94.913.786
Various	71.722.175	62.651.241
<b>Total</b>	<b>6.551.616.191</b>	<b>2.907.462.319</b>

**TABLE SHOWN THE PARTICIPATION OF P.P.C.**  
**(BY SPECIAL FINANCIAL AID)**  
**TO THE SECOND DEVELOPMENTAL PROGRAM (2002 - 2006)**  
**OF MEGALOPOLIS BASIN (CENTRAL PELOPONESE REGION)**

<b>CATEGORY OF FINANTIAL AID</b>	<b>BUDGET IN EUROS</b>	<b>PARTICIPATION OF P.P.C.</b>
Rural Sector Development	1.113.800,00	820.800,00
Human Resources	161.000,00	161.000,00

Quality of Life and Environment	2.054.000,00	880.400,00	
Technical Infrastructures	2.935.000,00	440.000,00	
Light Industry - Manufacture – Commerce	293.000,00	293.000,00	
Teleheating	1.467.000,00	1.467.000,00	
Elaboration of special studies and research programs	952.000,00	952.000,00	
Maintenance of local Road Network	5.641.700,00	4.760.700,00	
Local Development Economic Support	161.000,00	161.000,00	
Local Development Technical Support	440.000,00	440.000,00	
Tourism Sector Development	3.935.264,00	3.935.264,00	
Upgrading of Water Supply – Sewerage	1.350.000,00	1.350.000,00	
Various	43.000,00	43.000,00	
<b>Total</b>	<b>20.546.764,00</b>	<b>15.204.164,00</b>	

## BIBLIOGRAPHY

- *Baldwin T.E., Dixon-Davis D., Strenjhem E.J., and Woloko T.D.:* **«A socioeconomic assessment of Energy development in a Small Rural Community»**, Vols 1 and 2, Argonne National Laboratory, Argonne IL 1976.
- *Bender L.D., Temple G.S. and Darrels L.C. :* **«An Introduction to the COALTOWN Impact Assessment Model»** U.S. Environmental Protection Agency, Washington D.C. 1980.
- *Beaver, S. H. (1955) :* **«Land reclamation after surface mineral workings»**, Journal of the Town Planning Institute, 41,146-52.
- *Boudeville J. :* **«L' espace et les poles de croissance»** Presses Universitaires de France, Paris, 1972.

- *Boudeville J.* : **«Amenagement du territoire et polarization»** Genin, Paris, 1972.
- *Bulmer M.* : **«Sociological models of the mining community»**. Sociological Review 23, 61-92, 1975.
- *Champion D. and Ford A.* : **«Boom town effects»**. Environment 22 (5): 25-31, 1980.
- *Christy P.L., Smith W.E. and Filer E.E.* : **«New Land uses created by surface mining»** Mining congress J, May 1979, V65, N5.
- *Coase R. H. (1960)* : **«THE PROBLEM OF SOCIAL COST»**, The Journal of Law and Economics, vol.3, pp. 1-44.
- *Council for environmental conservation (CoEmCo)* : **«Scar on the landscape ? A report on opencast Coal mining and the environment»** London 1979
- *Darwent D.* : **«Growth poles and growth centres in regional planning»** : A review M.I.T. Press, 1975.
- *Freudenburg W.R.* : **«The social impact of Energy Boom development on Rural Communities : A Review of the Literature and some Predictions»** Paper presented at the annual meeting of the American Sociological Association, 1976.
- *Heede R., Morgan R. and Riley S. (1985)* : **«THE HIDDEN COSTS OF ENERGY»**, Center for Renewable Resources.
- *Hohmeyer O., (1988)* : **«SOCIAL COSTS OF ENERGY CONSUMPTION»**, Springer-Verlag, Berlin.
- *Isard W.* : **«Methodes d'analyse regionale»**, Volume 4, Dunod, Paris, 1972.

- *Konsolas N. (1983) : «**Regional Economic Policy**», (in Greek), Papazissis, Athens.*
- *Kuklinski A. P. : «**Poles de development et centres de croissance dans le development regional**», Dunod, Paris, 1970.*
- *Lakshmanan T.R. and Johansson B. (ed) : «**Large - scale Energy Projects : Assessment of Regional Consequences — An International Comparison of Experiences with Models and Methods**» North Holland-Amsterdam 1985.*
- *Mastenbroek A. P. and Nijkamp P. (1983) : "**DETERMINATION OF SOCIAL COSTS OF ENVIRONMENTAL DAMAGE**", Series Research "Memoranda", Faculty of Regional Economics, Free University of Amsterdam.*
- *Meade J. E., (1973) : "**THE THEORY OF ECONOMIC EXTERNALITIES**", Sijthoff, Leiden.*
- *Nijkamp P. (1980) : "**ENVIRONMENTAL EXTERNALITIES**", Series Research "Memoranda", Faculty of Regional Economics, Free University of Amsterdam.*
- *Papadaskalopoulos Ath., Sidiropoulos Il. (1988) : «**The Botom Up Strategy : A new concept for regional development**», Conference on the Interdisciplinary Approach of Development, National Technical University of Athens.*
- *Perroux F. : «**Note sur la notion de pole de croissance**» Economie Appliquee, Numero 1 – 2, 1955.*
- *Opencast mining intelligence group : «**A Reassessment of opencast coalmining**», Leeds 1979.*

- *Regional town planning institute* : **«Coal and the environment - A submission to the Commission on Energy and the Environment Coal study»**. London 1979.
- *Richardson H.* : **Growth poles spillovers : the dynamics of backwash and spread** Regional Studies, Volume 10, Number 1, 1976.
- *Roberts P.W., Shaw T.* : *Department of the Environment, Stevens committee, Verney committee.* **«Mineral Resources in Regional strategic Planning»** Gower 1982.
- *Rosborough L.* : **«Assessing the impact and planning Implications of Colliery Waste»**. Ph. D. thesis, Nottingham University 1983.
- *Spooner D.* : **«Mining and Regional Development»**. Oxford University Press, Oxford 1981.
- *Sweigard R.J., Ramani R.V.*: *Southern Illinois University, Pennsylvania St. University,* **«Regional comparison of postmining Land Use Practices»** Mining Engineering, Sep. 1986 V. 38, No 9.
- *Werner, K.* (1973) **«Reclamation of land damaged by open-cast mining : methods and results»**, Biological Conservation, 5, 277-80.