GREECE

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1 OVERVIEW OF THE REGION

Characteristics of the Region

On 1/12/2011, the Architecture of Governance and Decentralised Administration program, also known as Kalikratis, reformed the administrative division of Greece and redefined the self-government regions. Under this, Western Macedonia is one of the thirteen administrative regions of Greece.

The region of Western Macedonia (*Figure 1 – 2*) is situated in north-western Greece, bordering with the regions of Central Macedonia (east), Thessaly (south), Epirus (west), and bounded to the north at the international borders of Greece with the Former Yugoslav Republic of Macedonia (FYROM / Bitola region) and Albania (Korçë County).Its territory spreads to 9,450 km^2 and hosts about 300,000 inhabitants (as per 2011 census), thus it is a low-density populated region (30 inhabitants/km^2, while the country average is 79.7 inhabitants/km^2). This is mainly attributed to the mountainous nature of the region, as 82% of the total surface consists of mountainous and semi-mountainous areas. This is also reflected in the population distribution, as the major part of the population (56%) lives in rural areas. The capital of the region is Kozani with 53,880 inhabitants. Other main towns are Ptolemaida with 37,289 inhabitants, Grevena with 17,610 inhabitants, Florina with 19,985 inhabitants and Kastoria with 16,958 respectively.

Figure 1 – Region of Western Macedonia

Figure 2 – Borders of Region of Western Macedonia (Wikipedia, 2014)

The average GDP of Western Macedonia reached €18,000 (2010 value) in the second

quarter of 2013, and the employment rate was 67.5% (Hellenic Statistical Authority, 2011). Its economy is mainly based on agriculture and livestock; nevertheless, the sector of manufacturing also plays a crucial role in the economy. To be more specific, 70% of the Gross Domestic Product from the primary sector is attributed to agriculture cultivation; whereas 30% is attributed to stockbreeding. The Region of Western Macedonia has one operational Industrial Area in Florina and another one under construction in Kozani. The secondary sector is very important for the regional economy, mainly due to the mining activities.

The production of electric power, as 70% of country's total power is produced in the region, (Regulatory Authority for Energy, 2013).

"Soft" structures have not followed the general improvement of heavy infrastructures, a situation that has to be remedied, in order to achieve an overall higher economic development of the region. As far as the research and development services are concerned these are at a rather low level: only 3.5% of the country's total research foundations are situated in the Region. Among them, the University of Western Macedonia as well as the Technological Educational Institute plays an important role in supporting the regional research and educational efforts. Some of its more famous products are marbles, saffron (krokos Kozanis), fruits, Florina peppers, local wines (Kozani, Amyntaio), furs (Kastoria, Siatista) and specialised arts and crafts industry.

The Egnatia motorway (Trans-European Network) crosses the region. Along with its two vertical national roads, it forms a network that dramatically improves the transport conditions in the region and alters its traditional "isolated" image, mainly due to its mountainous landscape. On the other hand, the railroad network is insufficient and the two airports (Kozani and Kastoria) can only serve small passenger planes. The telecommunication network has drastically improved over the last decade, providing the regional population with adequate services and modern facilities. During the past years tourism has been developed in the region mainly for winter sports. It is the only Greek region without a sea coast, but there are a lot of lakes, mountains, picturesque villages and two big skiing centres in Florina (Vigla) and Grevena (Vasilitsa), and one other skiing center under construction in Kozani (Velvendos).

There is a commitment of the Regional Authority of Western Macedonia, the local authorities and other regional stakeholders to exploit the competitive advantages of the Region and to promote its historical and technological profile in the fields of Energy and Environment.

Certain regional policies and actions have been promoted towards that direction. A Regional Innovation Pole of Western Macedonia has been created, following the collaborative approach of regional research, technology and business organisations. The aim of the Pole is to design and implement a corresponding programme promoting innovation in the field of energy, under the coordination of the regional authority of Western Macedonia. The Regional Innovation Pole of Western Macedonia aims at improving collaboration between research, innovation and production, technology transfer and new products and services in the field of energy as well as the creation of permanent mechanisms for technology and innovation development and promotion. The administrative building of West Macedonia region is located in Zone of Alternate Urban Planning (ZEP) in the city of Kozani (www.depepok.com)

Energy demand and supply of the Region

The total electricity consumption for the region of Western Macedonia reached 960 GWh in 2011, (Hellenic Statistical Authority, 2011). Of the total of West Macedonia's energy consumption, 79% is related to the domestic, industrial and commercial sectors while the remaining 21% is used for agriculture, public and municipal authorities and street lighting sectors (*Figure 3*).

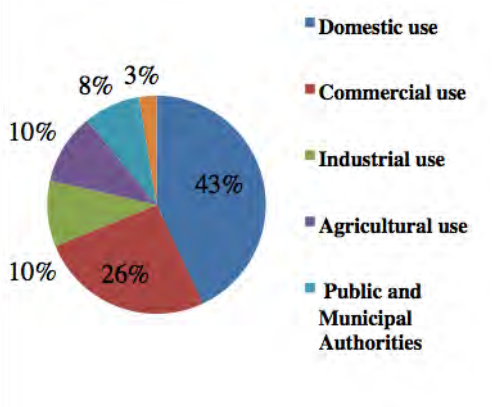

Figure 3 – Distribution of electricity consumption in Western Macedonia

Figure 4 shows that the share of consumption by fuel is dominated by petroleum products and gas, with electricity at 21%. Electricity production from renewable sources accounted for 6% in 2011.

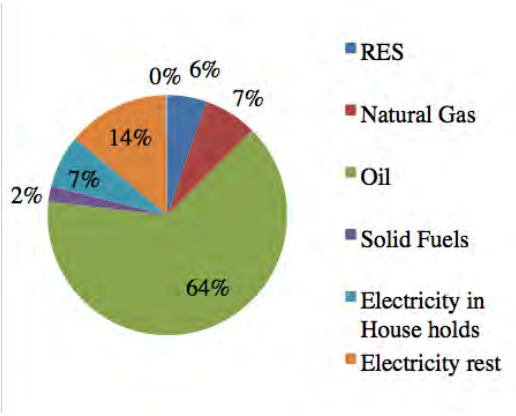

Figure 4 – Energy consumption in Western Macedonia by fuel

The Western Macedonia territory also holds great potential for the development of renewable energy sources through innovative technologies such as hydroelectric plants, PV parks and wind farms. It is noted that West Macedonia is a mountainous region, a factor playing crucial role in the construction of an artificial lake and a hydroelectric plant with capacity of 375 MW, producing 1,880M Whe annually in the Polyfytos area. In addition, there are several small hydroelectric plants in use with total capacity of 8.5 MW and several under construction in the prefectures of Kozani and Grevena. There are also operating PV parks of 23.7 MW and wind farms of total installed capacity of 24 MW.

Apart from the mountainous borders to fYR Macedonia and Albania where a high average wind speed is noted (around 8m/sec mainly in Kastoria and Florina), the rest of the region has a fairly low wind speed (around 4m/sec) (ISFTA, 2013).

Western Macedonia has one of the highest solar irradiation potentials in Greece (around 1800 kWh/m2a) and is thus an ideal place for PV installations (JRC, 2013).

2. CURRENT SITUATION: TARGETS RELATED TO ENERGY POLICY

In 2008, greenhouse gases emissions in Greece were at 126.89 Mt CO2eq equivalent, showing an increase of 22.8% compared to 1990 levels. Greenhouse gases stemming from the energy sector in 2008, accounted for 82% of total greenhouse emissions and increased by approximately 34.1% compared to 1990 levels. Emissions from industrial processes in 2008 represent a percentage of approximately 8.4% of the total emissions and increased by approximately 10.7% compared to 1990 levels. The fluctuation is attributed to the cease of HCFC-22 production. The contribution of the solvents and other products use sectors to total emissions is minor (0.3% of the total emissions) but has slightly increased compared to 1990 level of emissions. The agriculture sector accounted for 7.0% of the total emissions in 2008, a decrease of approximately 21.4% compared to 1990 levels. Total emissions reduction is mainly due to the reduction of N_2O emissions from agricultural soils, because of the reduction in the use of synthetic nitrogen fertilizers. The contribution of the waste sector total emissions came up to 2%. The above mentioned data are presented in *Figure* 5 (Koroneos et al, 2011).

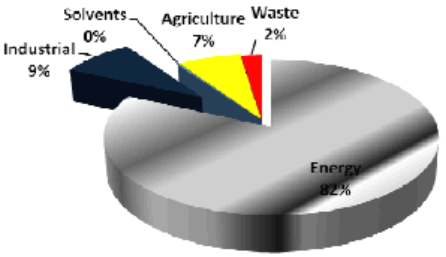

Figure 5 – Greece's GHG emissions per sector in 2008 (MECG, 2009)

Western Macedonia as part of Greece and the EU, has adopted targets for sustainability and environmental protection. With respect to the future development of the power system in Greece, the latest MEECC (Ministry of Environment, Energy and Climate Change) report on the long-term development of the system, entitled "Energy Roadmap to 2050" (March 2012) was analysed. The report examines the 2020-2050 period, using the National Renewable Energy Action Plan (NREAP) as a starting point. The NREAP presents the development plan for the national energy system, with the aim of achieving the obligatory targets set by Directive 2009/28/EC and by law 3851/2010 of the Greek Parliament.

The penetration of RES in the energy system according to the NREAP is presented in *Figure 6* along with the 2020 targets: 20% of the gross end-use energy consumption for heating and cooling, 40% of the electricity consumption and 10% of the energy used in transport.

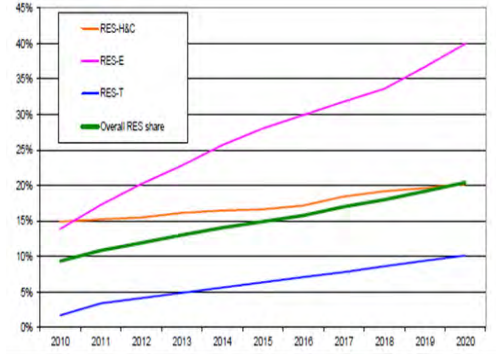

Figure 6 – RES penetration according to the National Renewable Energy Action Plan (NREAP) (Greek Energy Roadmap to 2050)

Figure 7 demonstrates that the main factor to achieve the national targets by 2020 is the reduction of the electricity produced by lignite power stations. Lignite-fired installed capacity is expected to drop to a total of 3,250 MW, while natural gas power production will rise to 5,130 MW. The total RES power in 2020 is expected to rise to 13,271 MW, consisting mainly of wind farms (7,500 MW) and hydroelectric (HEP) stations (4,530 MW, including pumping units), followed by PVs (2,200 MW), biomass and solar-thermal (250 MW) and geothermal (120 MW) units (Greek Energy Roadmap to 2050).

Other Regional targets, barriers and drivers

From previous studies (Koroneos and Nanaki, 2007) it has been pointed out that during the period 1990-2005 the Gross Domestic Product (GDP) had significantly grown in Greece. This growth was strongly related to an increase in the energy consumption, which in turn was related to an increase in the volume of emissions of greenhouse gases.

Furthermore, in the same study it was shown that the generation of municipal waste was a positive function of aggregate income levels and economic prosperity. As the gross income of Greece in the past decade increased, the waste generation showed also an increase. It is pointed out that during the period of 1990 – 1995the GHG increased with an average annual rate of 0.85% while GDP increased with an annual rate of 1.7%. During the period of 1996 – 2000, GHG increased with an annual rate of 3.8% which is higher than the rate of increase of GDP for the same period (3.4%). Finally, the average annual rate of emissions decreased during the period of 2000 – 2008 by 0.9%, while GDP increased with a rate of approximately 4.0% (www.statistics.gr).

The substantial increase of GHG emissions from road transport is directly linked to the increase of fleet vehicles and to the increase of transportation activity. Mobility during the period of 1990 – 2008 was of clear economic importance in Greek society, allowing factors of production (people and goods) to move around to where they could be profitably employed. Nevertheless, mobility is associated

with transport per passenger, which is strongly related to energy consumption and GHG (Koroneos and Nanaki, 2007b).

As far as the energy efficiency of buildings is concerned, it is noted that over 74% of the existing Greek housing stock has inadequate insulation (Balaras et al, 2007 – Healy, 2003) resulting in total yearly energy loss of 83.5 million GJ. The energy loss through walls accounts for MJ/m^2 per year whereas energy loss through the roof is up to 53 MJ/m^2 per year. Wall insulation and weather proofing of openings can reduce the GHG emissions by at least 4 Mtonnes CO2eq *(Balaras et al, 2007)*. Larger energy savings can be achieved when building new houses with the use of environmental friendly technologies such as solar cooling and geothermal cooling (Koroneos et al).

Another issue that arises in the transition to a low-carbon energy system is the need for a strong and flexible energy grid, which calls for additional investment and bears potential conflict with environmental protection and landscape conservation. Despite the increasing production of renewable energy, there are weaknesses in the system of support policies, which are established in Greece as a Nation. There is a need to diversify policies in order to adapt to different development stages of low-carbon technologies. Engagement with industry is essential for the adoption of new technologies and procedures and the delivery of sustainability not only in Western Macedonia but also in Greece.
Regarding the transition towards low-carbon mobility, the necessity to discourage the use of private vehicles is acknowledged while encouraging alternatives such as walking, cycling, car-sharing, personal travel planning and low-carbon public transport. A number of initial measures have already been taken e.g. parking restrictions and pedestrian streets in the city center of Kozani as well as some cycling paths. Another necessary step is the roll-out of electric and hybrid cars, in order to meet the EU targets for reduction of emissions from vehicles. As the low-carbon transition requires not only a technical upgrade but also a shift in people's everyday practice, it is necessary in this context to further investigate social patterns of consumption and identify successful strategies for behavioural change. A holistic approach to sustainability involving public awareness, and the involvement of local communities and the engagement and education of children and young people to sustainable practices should be engaged.

3. CASE STUDY: KOZANI'S DISTRICT HEATING SYSTEM

The Kozani District Heating System covers most of the city of Kozani and is connected to the Ag. Dimitrios power station nearby. It has been selected as a case study to illustrate the possibility to reduce pollution and dependence on oil imports.

A District Heating (DH) System supplies large areas, including apartment complexes, commercial and official buildings. Heat is transferred via hot water that is economically produced by environmentally friendly combined heat-and-power plants (CHP) or other large-scale heat-production facilities. This innovative type of heating system makes it possible to reduce energy consumption by 53% and to reduce air pollutants by 46%, compared with a Central Heating (CH) system which is installed in individual apartment complexes.

CHP – also known as cogeneration – is a way to increase the efficiency of power plants. Standard power plants effectively use just 40% of the fuel they burn to produce electricity. Sixty % of the fuel used in the electric production process ends up being rejected or "wasted" up the smokestack. CHP uses this rejected heat to heat buildings in a surrounding area through a district energy system. CHP is only possible when there is an area near an industrial plant that has a need for the heat – a downtown area, a college campus or an industrial development.

Figure 7 – Pump Station "A3'' of Kozani District Heating

Clients receive heat through hot water circulating in the district heating network. The primary flow temperature of the district heating water usually varies between 60 and 120° C, depending on the system. The temperature is at its lowest in summer, when heat is only needed for hot water. The temperature of water returning from clients to the production plants ranges usually between 25 and 65°C. In buildings, heat is used for heating rooms, for providing hot tap water and for air conditioning. District Heating consumers can also receive heat from a heating plant using for example biomass as fuel.

Typically, CHP systems can be either centralised or decentralised. Centralised CHP are usually much larger than decentralised CHP. Centralised CHP plants were originally electricity plants (generating only electricity), while decentralised CHP plants were originally heating plants (generating only heat).

District heating is used in the residential sector of Kozani (*Figure 7*) in order to provide space heating and hot water demands of different categories of buildings including apartment buildings, duplexes and single family dwellings). The total yearly energy required for heating and hot water production for households in the Region of West Macedonia reaches 2,874,763 GJ/year (Ministry of Development, 2008).

Kozani's district heating system serves more than 17,000 customers out of 55,000 citizens. The total surface area heated is 1,625,000 m^2, out of which 5% covers the public sector. The installed thermal power for serving the base load is 70 MWth. The temperatures outgoing-return are 120oC-65oC respectively. The total distribution network has a length of 285 km, and the company responsible for operating the system is the Municipal district heating company of Kozani. The serving period is from October until the end of April. The peak heating load exceeds 125 MWth, with an annual demand of 230,000 MWh. The annual amount of heat is produced by 90% in the lignite power plant and by 10% in an 80 MWth peak load unit using oil or Liquefied Petroleum Gas (LPG).

The transmission and distribution system is consisted of a two-pipe system in closed circulation. The pipes are installed in parallel, one pipe for the supply of the hot water to the consumers and the other pipe for the return of the hot water for reheating. In each building there is a thermal substation with indirect connection (*Figure 8*).

Figure 8 – Two pipe distribution system for supply and return of hot water

In order to optimise in the long term performance of the District Heating System of Kozani, the Municipal District Heating Company of Company of Kozani has appointed Grontmij (www.grontmij.co.uk) a consultant specialist company. The cooperation started in 2001 with a review of the district heating operation. The review concluded with a number of recommendations to system improvements, which have been implemented over the years. The cooperation is ongoing assuring that Kozani district heating operates with front line principles and technologies.

A number of sub-projects have been realised over the past years. The project activities include:

- strengthening of transmission pipeline by a dn500mm pipeline over 17 km, including hydraulic calculations and tender documents;
- strengthening of distribution network, including hydraulic calculations in a hilly landscape;
- review of the existing SCADA system and recommendations for a new improved SCADA system;
- strategy for increased efficiency and lower return temperature of overall system operation.

This action plan includes:
- demand side management;
- information campaign;
- improved consumer installations at connection points and internally at the customers;
- recommendations to tariff system improvements;
- training of the operation staff;
- design and quality assurance with installation of accumulator plant of 3000 m3 including operation and SCADA system;
- pre-feasibility study for district cooling systems based on absorption cooling (district heating) and mechanical cooling system.

Long term focus
A Regional Innovation Pole (Best Practice Report, 2010) has been developed in order to cope up with the future challenges.
The Regional Pole of Innovation of Western Macedonia (RPIWM) is a union of institutions from private and wider public sector that aim to increase:
- the technological and innovative regional records;
- the creation of environment of innovation and regional conscience in Western Macedonia in the main axe of Energy;
- the increase of competitiveness of regional economy.

The institutions that participate in this effort and, under the auspices of the Region of Western Macedonia, constitute a network of collaboration, are the following:
- University of Western Macedonia;
- ISFTA /CPERI;
- polytechnic colleges in Kozani;
- laboratories of research of higher education Institutions and polytechnic colleges;
- developmental companies;
- enterprises and teams of enterprises;
- chambers and Contacts of enterprises.

The target of the Pole is the reinforcement of regional competitiveness, via the strengthening of research, technological and innovative actions of the Region, as well as the reinforcement of activities of institutions and enterprises in these areas. The Regional Innovation Pole identified the following priority areas:

A.1 Environmental management and support of PPC 's operational decisions system for the region of Kozani, Ptolemaida, Amyntaio and Florina.

A.2 Advanced measures for the improvement of operation of lignite based power plants and for reduction of CO^2 emissions.

A.3 Co-combustion of secondary fuels (biomass) with lignite in a power plant.

A.4 Pilot application of use of cube blocks with high content in flying ash.

A.5 Development and evaluation of innovative catalytic systems for hydrogen production from biogas.

A.6 Promotion of exploitation of wind energy in the region of Western Macedonia.

A.7 Development and manufacture of solar air conditioning devices with small power consumption.

A.8 Study for energy savings and the optimal use of energy at small medium enterprises.
The long-term objectives of RPI of West Macedonia include the following aspects:
- support of demand from SME's of "wider" region of products of research and promotion of technological activities in the enterprises themselves;
- institutional support of the technological, organisational and commercial problems that enterprises face;
- creation of excellent regional conditions of attracting individual and legal entities, with the existence and maintenance of possibility of access in satisfactory energy inquiring infrastructure and installations of high technology, in IT networks, banks of information, libraries etc;
- creation of favourable financing environment for the growth of institutions of research and technology with the creation of collaboration and financing by Greek and foreigner banking or other financing institutions and venture capital companies.

Outcomes
The District Heating (DH)System in Kozani has resulted not only in abatement of air emissions, but the scheme also brought positive economic and social impacts, including a reduction in energy bills. To be more specific, since the

district heating system was set in operation in 1993, the following benefits to the city of Kozani, its residents as well as the national economy, have been reported:

- the operation of the DH system has contributed significantly to the reduction of gaseous and particles emissions and especially in a city which is greatly affected by the 60-years old neighbouring lignite industry;
- the operation of the DH system substitutes yearly more than 20,000 tons oil equivalent, with an obvious benefit for the national economy;
- for every resident there is an annual saving of €70 from the use of DH system instead of oil. Consequently, the city of Kozani provides disposable income €2,900,000 per year;
- the operation of the DH system provides potential for further development of the are in the primary and secondary sectors of the economy (e.g. greenhouses or special plantations.

The district heating system in Kozani has a significant contribution to the reduction of gas emissions during the winter period, particularly in smoke concentration and in SO2 concentration. Based on data collected from the Municipal enterprise of Ptolemaida, the average smoke concentration in the air during January 1988 (before DH) was 58 μg/m^3, while in January 1995 (after DH) was 13 μg/m^3. The equivalent values for SO2 were 55 μg/m^3 and 19 μg/m^3 respectively. As for Kozani the average smoke concentration in the air during January of 1988 was 62 μg/m^3, while in January 1995 it was 22 μg/m3 (District Heating Company of Kozani, 2002). The relevant values for SO2 were 170 μg/m^3 and 15 μg/m^3 (*Figure 9*). There is also a reduction in CO^2 emissions reaching approximately 45% compared to 1990 levels (www.tpt.gr).

The sulphur contained in heating oil and also the deficient combustion conditions in small central heating boilers in towns are to a large extent the factors responsible for the concentration of sulphur oxides, nitrogen oxides and particulate matter in the towns' atmosphere which have adverse effects on public health and also at the environment.

The pricing policy of the district heating company in the town of Kozani since its operation was determined by the following factors:

- the legal status and the public welfare character of the companies;
- their economic viability;
- the attraction of new customers to their district heating networks;
- the covering of the financial and operating requirements of the companies, and finally;
- the parameters which determine the energy market on a national level and especially the cost of diesel oil.

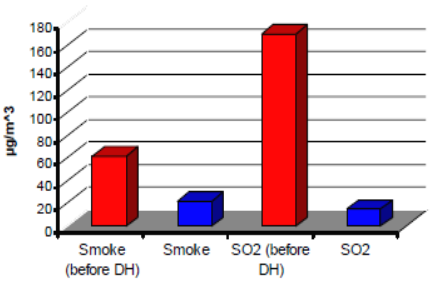

Figure 9 – Average smoke and sulphur oxides air concentration, before (red) and after (blue) the operation of the DH

Bearing in mind the above, the selling price of thermal energy for the companies' consumers is about 65% of its production cost using heating oil. To determine the final cost, the length of the heating period – 7 months – and the efficiency of boilers (0.85 – 0.90%) were taken into consideration. In practice, the benefit for consumers so far from the operation of the installation has been more than 40% if we take into account the fact that the boilers which were replaced were old and poorly maintained and therefore inefficient.

4. CONCLUSIONS

There is a variety of studies document the environmental benefits of District Heating. For instance the Ecoheatcool (Ecoheatcool, 2006) study supported by the European Commission confirms the possibility of saving an extra 404 million tons of CO^2 annually (additional to the 113 million tons/year avoided by DH in 2003) in the time horizon 2020 by doubling and improving District Heating across

32 European countries. At the same time, higher energy efficiency will reduce primary energy supply by 2.6% (2003) or 2,1 EJ (50,7 Mtoe)/year (equal to primary energy supply of Sweden). Increased security of supply will reduce the import dependency by 4,5 EJ (105,4 Mtoe)/year (equal to primary energy supply of Poland). In this respect, the implementation of district heating system in the Region of West Macedonia will bring environmental, economic and social benefits.

In addition, the creation of environmental, social and technical mechanisms of undertaking the research and confrontation of technological, organisational and commercial problems that occupy the enterprises via the Regional Innovation Pole will certainly play a crucial role in the Region's sustainable energy development. This is in alliancw to the context of the objectives set in the European Commission's Europe 2020 strategy and specifically the Innovation Union flagship action, the Regional Innovation Monitor Plus (RIM Plus), which provides a unique platform for sharing knowledge and know-how on major innovation policy trends in European Union (EU) regions. Based on the work of a network of experts, RIM Plus provides detailed information on regional innovation policies for 20 EU Member States: Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden and the United Kingdom (Region Innovation Monitor Plus).

Having begun over 20 years ago the Kozani District heating system is an example of a sustainable mechanism to reduce air pollution and dependency on oil while increasing the overall efficiency of power stations by exploiting the Combined Heat and Power approach. Economic and social benefits are directly related to the end user aiding its acceptability among the population. It is proposed that a number of European regions that fit the pattern of power stations near moderately populated cities could implement the scheme and reap environmental, economic and social benefits.

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COST DESCRIPTION

THE ORGANISATION OF COST

COST - European Cooperation in Science and Technology is an intergovernmental framework aimed at facilitating the collaboration and networking of scientists and researchers at European level. It was established in 1971 by 19 member countries and currently includes 35 member countries across Europe, and Israel as a cooperating state.

COST funds pan-European, bottom-up networks of scientists and researchers across all science and technology fields. These networks, called 'COST Actions', promote international coordination of nationally-funded research.

By fostering the networking of researchers at an international level, COST enables break-through scientific developments leading to new concepts and products, thereby contributing to strengthening Europe's research and innovation capacities.

COST's mission focuses in particular on:
- building capacity by connecting high quality scientific communities throughout Europe and worldwide;
- providing networking opportunities for early career investigators;
- increasing the impact of research on policy makers, regulatory bodies and national decision makers as well as the private sector.

Through its inclusiveness, COST supports the integration of research communities, leverages national research investments and addresses issues of global relevance.

Every year thousands of European scientists benefit from being involved in COST Actions, allowing the pooling of national research funding to achieve common goals.

As a precursor of advanced multidisciplinary research, COST anticipates and complements the activities of EU Framework Programmes, constituting a "bridge" towards the scientific communities of emerging countries. In particular, COST Actions are also open to participation by non-European scientists coming from neighbour countries (for example Albania, Algeria, Armenia, Azerbaijan, Belarus, Egypt, Georgia, Jordan, Lebanon, Libya, Moldova, Montenegro, Morocco, the Palestinian Authority, Russia, Syria, Tunisia and Ukraine) and from a number of international partner countries.

COST's budget for networking activities has traditionally been provided by successive EU RTD Framework Programmes. COST is currently executed by the European Science Foundation (ESF) through the COST Office on a mandate by the European Commission, and the framework is governed by a Committee of Senior Officials (CSO) representing all its 35 member countries.

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