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Energy potential from biomass and other RES

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1. Introduction

The project aims to promote hydrogen electromobility by addressing its main obstacles, such as infrastructure, technology issues and the further penetration of hydrogen in the market. The aim of the project also concerns the market transition of Europe to the minimization of carbon footprint. The main objectives of the project are:

• Exploitation of various hydrogen technologies for electromobility, including its supply chain

• Improving regional and local strategies by creating measures to penetrate the use of hydrogen in the market

• Improving transport efficiency with the use of environmentally friendly vehicles

• Improvement of energy transmission networks and the integration of renewable energy sources in the production of hydrogen by electrolysis

• Enhancing the development and accessibility of hydrogen supply infrastructure in urban and rural areas through private and public sectors

• Formation of financial models for the implementation of environmentally friendly vehicles in public transport

• Strengthen the capacity of public authorities to create policies for public transport with a low carbon footprint

The current work concerns the production of hydrogen from energy produced from biomass (waste from olive mills or olive groves), solar energy or other possible RES. Therefore, the evaluation of the energy potential of the area and the possibility of utilizing the specific type of biomass for energy production and the estimation of the infrastructure costs is carried out. The potential biomass quantities can be obtained from the area of Amfissa's olive which will contribute to its further promotion. Apart from olive trees, other potential biomass sources can be considered, such as a) cereals, b) vineyards, c) nuts trees etc. Alternative biomass resources are also under investigation including: a) olive and kernel mills in the nearby region and b) biomass potential deriving from forestry operations. Finally, the energy potential from renewable energy sources is studied by taking into account the most recent data for the installed capacity of these types of energy production system

2. Area of Study

2.1 Phocis Regional Unit

The Regional Unit of Phocis is located in Central Greece, north of the Corinthian gulf. It is a mountainous area with several small beaches. Capital of Regional Unit Phocis is Amfissa. Phocis is part of the administrative region of Central Greece. It stretches from the western mountainsides of Parnassus, on the east, to the mountain range of Vardousia on the west, upon the Corinthian Gulf. Phocis extends to an area of 2,120 km^2, of which 560 km^2 is forested, 36 km^2 consists of plains, and the remaining area is mountainous. The massive ridge of Parnassus (2,459 m), divides the country into two distinct areas. The neighbouring prefectures are Aetolia-Acarnania to the west, Phthiotis to the north and Boeotia to the east. The south and east areas are deforested, rocky and mountainous, while the valley runs from Itea up to Amfissa. Forests and green spaces are located to the western, northern and central areas. Its reservoir is the Mornos Dam on the Mornos river which covers approximately 1 km^2 to 3 km^2.

Figure 1 : Phocis Regional Unit

2.2. Area Characteristics

The area is characterized by various soil types where the slopes vary from flat (in river valleys, plains and plateaus) to steep (35% -50%), very steep (50 - 70%) or extremely steep (> 70%, mt peaks of Gionas and Vardousia). The area is mostly mountainous, according to Hellenic Statistical Authority (ELSTAT), where 80.97% of the area is mountainous, 16.12% semi-mountainous and 2.91% lowland. According to Directive 85/148 / EEC, 90.33% of the land is mountainous and 9.67% is lowland. The main feature of the soils of the area is the limited availability of arable lands, which are found in the lowlands of the valley of Amfissa and at the mouth of Mornos (Efpalio).

The climate of the area differs depending on the altitude. The following climatic zones can be distinguished: Intense mid-Mediterranean at the southern tip of the region, weak mid-Mediterranean in the Mornos valley, sub-Mediterranean on the mountain slopes and sub-dry cold on the mountain tops. The average annual rainfall ranges from 600mm in the coastal zone to 1400 mm in the mountainous areas, while the absolute minimum temperature reaches -10.3^{o}C. The following Figure presents the altitude zones of the Regional Unit of Phocis.

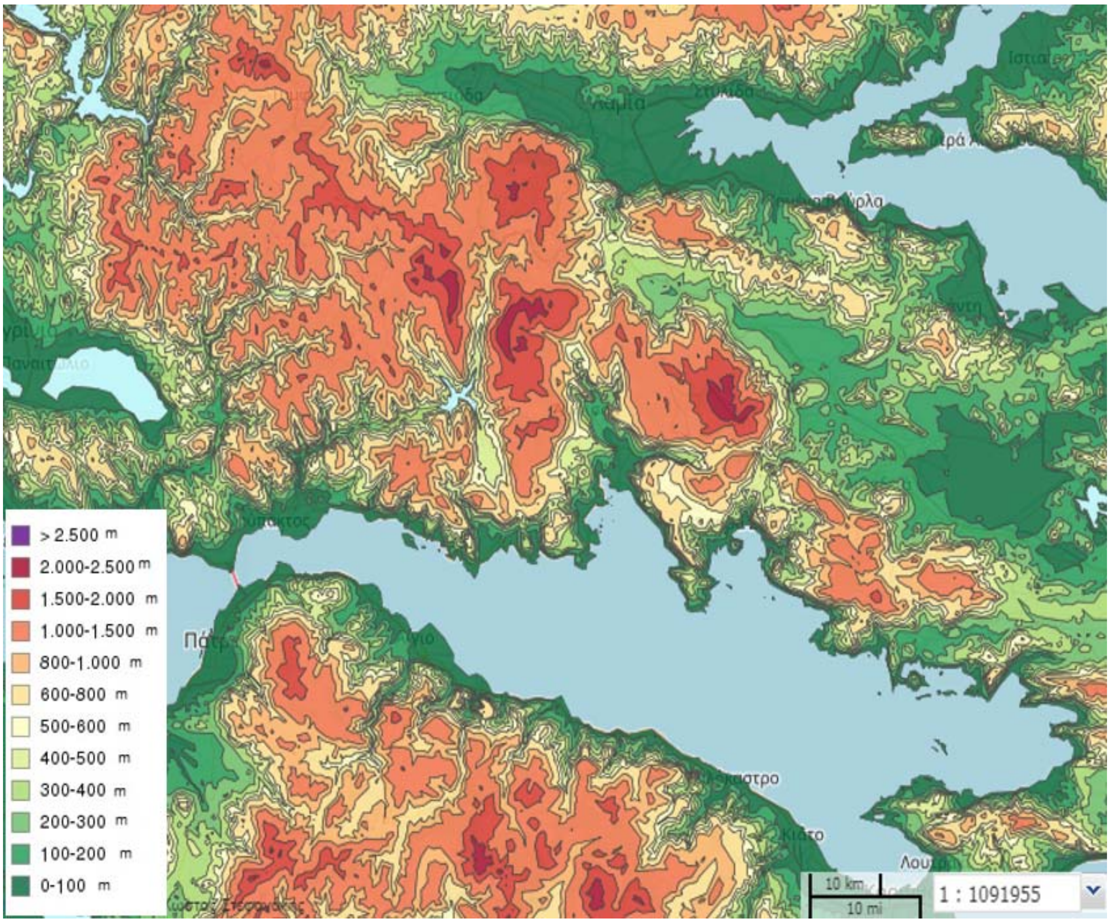


Figure 2 : Altitude Zones of Phocis

2.3. Municipality of Delphi

The Municipality of Delphi is located in the Region of Central Greece, that was established by Law 3852/10 (Kallikratis Program) from the pre-existing “Kapodistrian” municipalities: Amfissa, Galaxidi, Gravia, Delphi, Desfina, Itea, Kalliea. The capital of the Municipality is Amfissa, which is also the capital of the Regional Unit. The Municipality of Delphi is developed in the central-eastern part of the Regional Unit of Phocis and it occupies the largest part of the Prefecture, which has an area of 1,121,671km^2. It is the tenth largest Municipality of Greece. The permanent population is 26,716 inhabitants according to the 2011 census of the Hellenic Statistical Authority. The Municipality is bordered on the north by the Municipality of Lamia (Prefecture of Fthiotida), on the south by the Corinthian Gulf, on the east by the Municipality of Distomo-Arachova-Antikyra and the Municipality of Amfikleia - Elatia (Prefecture of Viotia) and on the west by the Municipality of Dorida. At interregional level, Municipality's geographical position is important as it is located in the central part of the mainland of Greece, in the passage of the mountain range of Parnassos. In relation to the Region of Central Greece, it extends southwest of its geographical center, while it occupies the southern position in relation to the Prefecture.

Figure 3 : Municipality of Delphi

3. Mapping the energy potential from the wide area of Amfissa's Olive grove

3.1 Introducing to the main biomass definition points

Biomass is an appealing source of energy in the current climate and energy context. In general terms, biomass is defined as the biodegradable fraction of products, waste and residues of biological origin from agriculture (including vegetal and animal substances), forestry and related industries, including fisheries and the aquaculture, as well as the biodegradable fraction of industrial and municipal wastes. Focused on its origin, biomass can be categorised into a) residual biomass, b) produced biomass and c) biomass from agricultural surpluses [1], [2].

In fact, the residual biomass is referred to any material that has been generated as a consequence of a human or animal activity but has not generated any economic value in the context and its energy use can turn a residue into a by-product. In this category, the agricultural biomass holds the lions share and it is expectable since agriculture consists one of the most profitable economic activities in the world. However, the residual forestry biomass concentrates vast amounts of residues around the world which in align with the agricultural biomass represent the two main biomass resources around the world. Among them, the agroforestry industry also produces residual biomass during its productive processes, particularly those for olive oil extraction, wine making and wood processing [3], [4]. Moreover, wastes from intensive livestock operations, from poultry farms, pig farms, cattle farms and slaughterhouses are also considered as biomass residues. This potential derives during the raising of sheep, lambs and goats. Since their wastes are scattered, they cannot be used for energy purposes such as large scale biofuel production [5].

Generally, biomass has become increasingly important as a renewable alternative energy source. For that reason, one of the most critical aspects associated with the use of biomass, is its supply chain and all the elements that are part of it. A typical biomass supply chain may include a combination of the following processes: field preparation, cultivation, harvesting, pre-treatment, storage, field/forest transportation, road transportation and biomass utilization at the production station. However, this supply chain differs from any other one, since it is important to plan the different activities from a total chain perspective (regarding a single activity), rather than planning each activity individually. For instance, the best harvesting method, in terms of efficiency and costs, can result in expensive storage or transport requirements. Moreover, the pre-treatment stage has as well a significant role, in the whole supply chain since it can reduce the final transportation and storage cost of the final end user.

Depending on the needs of the final production station, woody biomass is collected in the form of logs, bundles or chips and can be transformed into pellets, briquettes and hog fuel as well. In the following table the physical description and classification of traded solid biomass feedstock is presented.

Table 1. Physical description and classification of Traded solid biomass feedstock. Source :[6]

Physical description and classification of Traded solid biomass feedstock	
Form	**Description**
Bales	Compressed, shaped and bound solid biomass (0.1-4m^3 squares or cylinders), with high moisture level. Field drying is an option.
Chips	Chipped woody biomass with a defined particle size (5 to 100 mm) produced by mechanical treatment, with usually high moisture before drying and relatively low energy density. More difficult to handle than pellets; require large volume fuel storage and regular deliveries.
Pellets	Densified solid biofuel made from pulverized woody biomass with/out additives, usually shaped into cylindrical form (diameter less than 25 mm), random length of typically 5 to 40 mm with broken ends. Low moisture. Easy to handle. Raw material can be woody, herbaceous or fruit biomass, of blends.
Briquettes	Densified solid biofuel made with/out additives, shaped into cubic or cylindrical units, produced by compressing pulverized woody biomass. Briquettes are similar to wood pellets, but physically larger. Low moisture. They offer an alternative to firewood logs (controlled fuel value). Raw material is woody, herbaceous or fruit biomass, of blends.
Firewood logs	Cut and split oven-ready fuelwood used in household wood burning appliances like stoves, fireplaces and central heating systems. Firewood logs usually have a uniform length, typically in the range of 150 to 1000 mm.
Hog fuel	Fuelwood in form of pieces of varying size/shape, produced by crushing with blunt tools (rollers, hammers, flails).

3.2 Feedstock screening at national level

Main goal of this task is to imprint the energy potential from the wide area of Amfissa's olive grove exclusively from residual biomass. In order to achieve this, a more detailed screening concerning the national agricultural production is required aiming in this way to determine in second time the total amounts of the residual biomass produced annually, especially from the wide area of Phocis.

Given the fact that Greece has one of the highest percentages of mountainous/hilly landscape in the EU (more than 80 % of Greece is mountainous), it is extremely strange to report that Greece has the highest percentage of the total Utilized Agricultural Land (UAA) for permanent crops among all member states and is one of the three member-states (along with Cyprus and Portugal) with a higher share than 20 % of the total UAA. Moreover, according to annual reports from ELSTAT the permanent crops in Greece accounted to 33.9 % of the UAA, while vegetables and fallow land amounted to 2 % and 11.2 % respectively. This fact, is attributed to the favorable climatic conditions for growing permanent crops, a spatial distribution of which is presented in the following Figure 4.

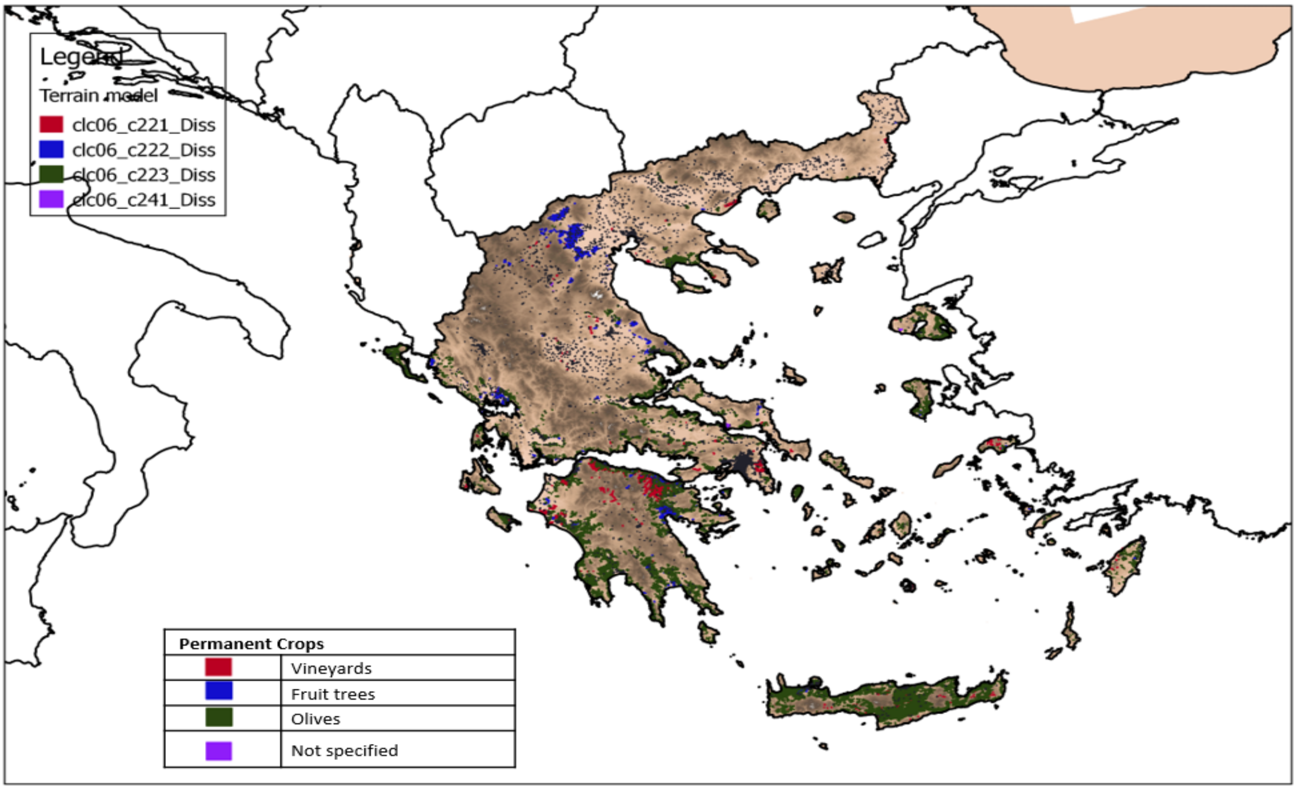


Figure 4. Spatial distribution of the main permanent crop types in Greece[1].

[1] The map has been implemented with QGIS 2.14.0 – Essen version. The crop coverages correspond to Corine Land Cover 2012 (v18.5, Prepared by GISAT 02/2016, available at http://www.copernicus.eu/). The land use denoted as "Not specified" refers to Corine Land Cover Class 241 "Annual crops associated with permanent crops", which indicates the existence of land with either vines, olive or fruit trees

At first glance, it can be observed that olive tree cultivations dominate in the Greek territory, a fact quite expectable, since Spain, Italy and Greece consist the top three olive producers in the world. Furthermore, these countries are also specialized in the wine sector and this is the reason why the residues from vineyards come up with high numbers while fruit trees are following with equally significant quantities of residues. Starting with the olive tree cultivations it is quite clear that most of them are mainly focused in Crete, Southern Peloponnese, Aegean and Ionian islands (e.g. Lesvos and Corfu respectively) and coastal areas. This distribution is mainly related to olive groves that are cultivated mainly for the extraction of olive oil and not for edible olives. And this consists a very good reason that justifies why EUROSTAT reports that Greece has the higher share of olive tree plantations in the total UAA compared to the other Mediterranean countries, with an average size of 1.5 ha, much lower than Spain (5.5 ha) but a little higher than Italy (1.3 ha). Moreover, it should be noted that a large part of the olive tree plantations in Greece are located in mountainous and semi-mountainous areas, a fact that enhance the existing classification of the olive groves in Greece as it is presented below:

- S2: Traditional irrigated on steep slopes. Irrigated orchards with a gradient > 20% and < 180 trees /ha.
- S3: Traditional rain-fed on moderate slopes. Rain-fed orchards with a gradient < 20% and < 180 trees/ha.
- S6: Intensive irrigated. Irrigated orchards with 180–800 trees/ha.

Based on this classification and according to the results from variable studies, focused on how external parameters can affect the variety of the olive tree, 64 different olive tree varieties have been officially recognized in the Greek territory and are summarized in the table below. Among them the most well-known edible olive variety, both in Greece and worldwide is Kalamon, while Koroneiki consists the most common variety for olive oil production, amounting around 60 % of the olive oil production.

Table 2. Distribution of the main varieties and the level of production per olive-producing region of Greece.

Permanent crops, main statistics (2015)								
Region	Olive oil					Table Olives		
	Varieties	Fruit Production (1)		Olive Oil Production (1)		Varieties	Fruit Production (1)	
		(1,000 t)	(%)	(1,000 t)	(%)		(1,000 t)	(%)
Peloponnese	Koroneiki, Mastoeidis, Kothreiki, Agouromanakoelia, Koutsourelia, Megaritiki	1,154.9	46.6	160.3	48.1	Kalamon, Gaidourolia, Megaritiki	43.9	10.2

Crete	Koroneiki, Mastoeidis, Throumpolia	591.7	23.9	91.0	27.3	Throumpolia, Kalamon	2.2	0.5
Central Greece	Megaritiki, Mastoeidis, Kolimpada, Amfissis, Kothreiki	89.8	3.6	15.4	4.6	Amfissis, Karidolia, Kalamon, Kothreiki	92.7	21.5
Ionian Islands	Lianolia Kerkyras, Asprolia, Kalokairida	163.6	6.6	20.7	6.2	Vasilikada, Amfissis	0.6	0.1
Aegean Islands	Valanolia, Adramitini, Throumpolia	91.8	3.7	13.5	4.0	Valanolia, Throumpolia	10.6	2.5
Macedonia	Chalkidikis, Throumpa Thassou	123.3	5.0	12.8	3.8	Chalkidikis	142.5	33.1
Epirus	Lianolia Kerkiras, Amfissis	149.4	6.0	7.5	2.2	Amfissis	31.1	7.2
Aitoloakarnania	Koutsourelia, Koroneiki, Kothreiki	30.2	1.2	3.3	1.0	Amfissis, Kalamon, Karidolia, Kothreiki	34.5	8.0
Country total	-	**2,477.2**	**100.0**	**333.3**	**100.0**	-	**430.7**	**100.0**
(1) **ELSTAT, Agricultural production statistics, 2015.**								

Regarding the rest of the permanent crops appearing in the Greek landscape, vineyards rank second in terms of UAA devoted to their cultivation in Greece, while citrus and fruit trees occupy a significant percentage of Greek territory with vast amounts of annual residual biomass. Vineyards can be found almost all over Greece; Peloponnese is the major wine and raisin producing region, but other regions like Macedonia, Crete, Central Greece and Attica are not far behind. According to Eurostat, in 2015, 41.4 % of the vineyards for wine area in Greece was cultivated with red (R) varieties, 38.1 % with white (W) varieties and 20.6 % with other (O) colour varieties. Furthermore, fruit plantations are mostly found in the coastal areas, the plains of the southern mainland and islands, with orange, lemon, tangerine, peaches and nectarines to be the most frequently cultivated fruit trees in Greece.

For most of the above-mentioned permanent crops, a typical annual pruning frequency is assumed. The exception is olive trees, for which pruning frequencies ranging from yearly to once every three years are observed, depending on crop variety, local conditions and prevalent agronomic practices. Usually, two alternative disposal practices are followed, using mulchers in order to manage the prunings in shorter times with higher purchase cost in the first case, or small-sized chippers/shredders which are less costly and can produce finer material in the second case. Typically, large pieces of prunings (e.g. with diameters of 5 cm or more) are collected separately and used as firewood.

Despite the importance of permanent crops in the Greek agricultural sector, there are no recent national surveys based on field data regarding the availability of the residual biomass in Greece. Besides the annual statistic data, published by the Ministry of Rural Development and Food, there is only one reference study for agricultural prunings – and agricultural biomass in general – in Greece, a study of Apostolakis et al. dating from 1987 [7]. The study presents residue-to-product ratios (RPR) for the prunings produced from various types of permanent crops in Greece and estimates the potential of agricultural prunings based on crop production statistics from 1980.

However, as it was mentioned in the very start of this report, main goal of this task is to imprint the energy potential from the wide area of Amfissa's olive grove exclusively from residual biomass. Furthermore, it is worth mentioning that in the wide area of Amfissa is located one of the largest if not the largest olive grove of edible olives in the whole Greece. For that reason, and having formed a clearer and more complete picture of the general distribution of permanent crops in Greece we can focus on the estimation of the available biomass potential from a specific geographical area, in that case the Regional Unit of Phocis, both from agricultural and forestry sectors.

3.3 Defining the agricultural biomass potential

In general terms, the agricultural biomass can be distinguished into two main categories: prunings, which are produced on a frequent basis throughout a permanent crop plantation lifetime and straw which is produced from the annual arable crops in the area. At this point, it should be highlighted that the focus for estimating the biomass potential from permanent crops will be on the pruning material and not on the trees and stumps that can be removed at the end of a plantation lifetime.

The first step was to evaluate the theoretical biomass potential of Phocis through various statistical data provided by statistical authorities and other "easy to use" toolsets (and respective databases) with updated harmonized datasets at local, regional and national level suitable for the study. From a quick check and based on the collected data (presented on the following Table 3), the largest crops of this Regional Unit were the following: a) cereals, b) vineyards, c) some nuts trees and d) olive tree plantations. At first glance, it can be observed that the highest quantities of residual biomass are found on vineyards, almonds trees and of course on the olive tree plantations, a fact quite expectable considering the fact that Amfissa has the largest olive grove of edible olives in the whole Greece as it was mentioned in a previous section. For that reason, it was decided that the rest of the research should be more focused on the residual biomass produced from the olive tree prunings, since the quantities are high enough to cover the hydrogen production in a significant amount.

Table 3. Theoretical agricultural biomass potential of Phocis

Type	Product/Residue ratio	AREA	Biomass Yield	Moisture	Available Residue	HHV
	(1/RPR)	(ha)	(tn/ha)	(%)	(dry t/yr)	(MJ/kg)
Olive trees	0.98	7165	3.95	35	11081	19.84
Wines	1.20	115	15.97	40%	767	18.98
Wheat Soft	1.00	120	2.08	15%	424	18.44

Wheat Durum	1.00	211	2.03	15%	455	18.44
Barley	1.24	81.2	2.66	15%	164	17.31
Oat	1.27	320	1.90	15%	642	18.07
Almond trees	0.28	122	3.59	40%	1,650	20.01
Walnut trees	0.60	54	3.18	40%	347	18.20

However, in order to have an in depth analysis of the biomass deriving from olive tree plantations, another tool developed by CERTH was used [8], since it has the ability to provide more accurate estimations in specific areas of interest in Greece. This tool uses highly accurate spatial information on the olive grove areas, based on the data from the CAP's beneficiaries' payment (Greek Payment Authority of Common Agricultural Policy). For that reason, the biomass potential has been estimated and imprinted taking into account data both from regional and municipal units. Basic information is presented in the tables below. Moreover and in order to be more clear, screenshots from myGIS platform tool are presented below, representing the total distribution of the residual biomass from the olive crops in Greece but also the more focused depiction of the total agricultural parcels located in the municipal unit of Amfissa.

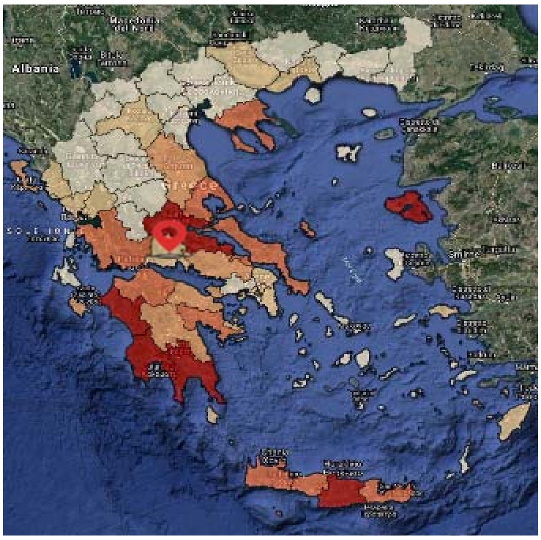


Figure 5. Display of the national olive tree prunings distribution according to myGIS tool.

Table 4. Olive tree pruning potential at regional level

Regional Unit: Phocis	
Total olive grove area (ha)	4,236
Number of trees	746,673
Yield (ton/ha)	4.62
Total dry biomass potential (ton)	**19,588.14**

Table 5. Olive tree pruning potential at municipal level

Municipal Unit: Amfissa	
Total olive grove area (ha)	1,733
Number of trees	337,563

Yield (ton/ha)	5.82
Total dry biomass potential (ton)	**10,075.6**

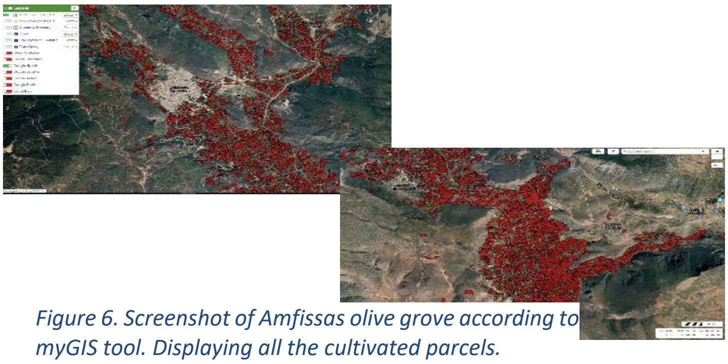


Figure 6. Screenshot of Amfissas olive grove according to myGIS tool. Displaying all the cultivated parcels.

Taking a closer look mainly on the results presented in the above tables, it is quite clear that there is a relative difference in terms of the total amount of dry biomass that comes exclusively from olive cultivation in the regional unit of Phocis. Nevertheless, in comparison with the results obtained from the Ministry of Rural Development and Food, it is considered wiser to take into account the data from myGIS tool since, as mentioned above, it uses and depicts the total registered agricultural plots exclusively from olive groves. It is therefore considered more accurate in terms of its calculations.

At this point, it should also be mentioned that in the wide area of Amfissa even on Phocis, there is no kernel mill, despite the fact that there are at least 19 olive oil mills according to the Delphi business plan 2014-2019. Based on the official data in the Phocis region there are 19 olive oil mills with an average capacity of 1,750kg/hr and expect one the rest are centrifugal. From these mills, 4 follow the two-phase extraction while the rest 14 follow the three-phase. Taking into account these information, the total average quantity of **solid residues** that can be produced from all of these olive oil mills is estimated at around **18.5 tn/hr, which is equal to 13,320 tn** (if it is accepted that the olive oil mills work 8 hours per day for at least 90 days, the average time that olive oil mills work annually). The above quantities should act as input in the kernel mills.

Regarding the logistic options, the first step is to assess whether the tree prunings could be removed in a sustainable manner from the field and they can be used for energy purposes or they should be released on the soil to enhance the soil fertility. According to variable literature sources, crop residues could exert several positive effects on the physical, chemical and biological characteristics of agricultural soils: sustain organic matter, favour nutrients recycling, allow carbon sequestering, improve soil aggregation and structuring, enhance erosion control, increase water infiltration, retention and drainage, etc. Therefore, specific management operations are suggested in order to counteract the supposed soil fertility degradation, thus establishing good agronomic practices that allow both the residues to be removed from the fruit plantation and preserve soil fertility, thus preventing any risk of jeopardizing soil resources.

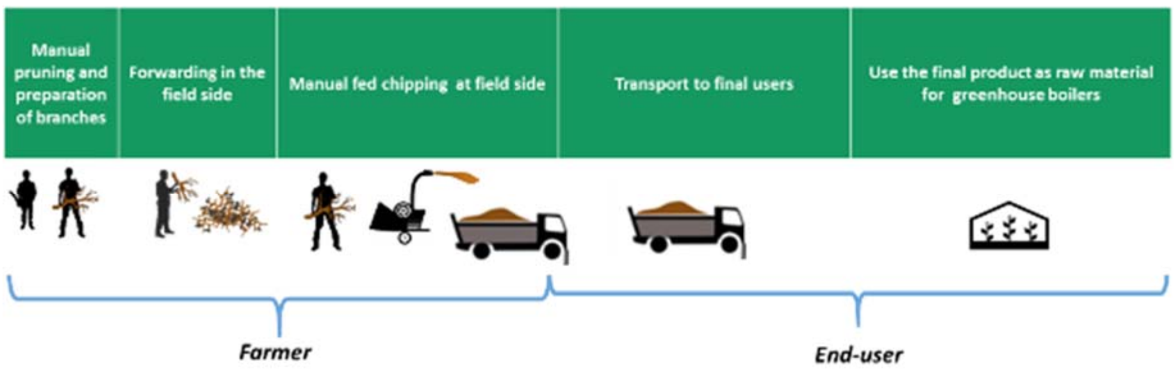
These operations take under consideration the soil conditions which are defined, considering a number of indicators including soil organic matter, soil texture, soil slope and climatic conditions of the area. Based on these, the soil conditions of the area are not optimal but still fairly good for prunings removal. Therefore, olive tree prunings can be removed from the soil and addressed to energy purposes provided that specific management options are applied. These options include fertilization strategies, mechanical soil processing etc.

Table 6. Soil quality indicators considered in the assessment procedure.

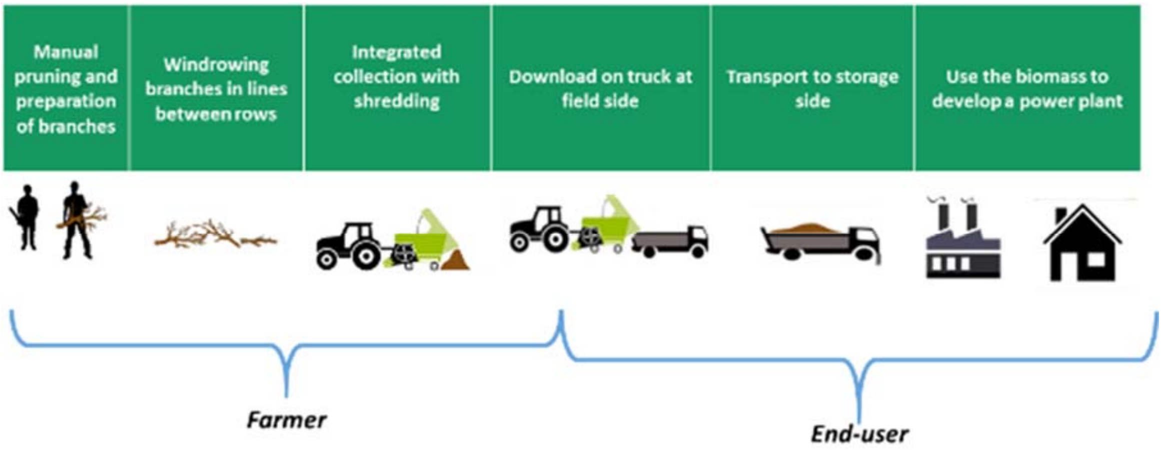
SCORE	SOC *(%)*	TEXTURE *(%)*	SOIL SLOPE *(%)*	CLIMATIC CONDITION*
3	> 3.0	CLAY 10-30; And SILT < 50; And SAND < 50	< 5	> 30
2	1.5 - 3.0	CLAY 10-30; And SILT > 50; Or SAND > 50	5 - 20	20 - 30
1	< 1.5	CLAY < 10 Or CLAY > 30	> 20	< 20
Case of Phocis Greece				
2.5	2	3	3	2

Considering the cost structure of the whole logistic chain, it basically depends on the practice that most of the farmers follow after the pruning operations. The most common practice followed by the majority of farmers is burning. Usually the largest branches are removed from the field in order to be used for space heating purposes and the remaining ones are stacked in piles and burned, since it is quite difficult for most of the farmers to collect them [9]. However, through variable field studies two different scenarios for the collection of prunings are formed and presented below.

The ***first scenario*** is based on the following procedure:



The ***second scenario*** includes the following steps:



The cost structure was estimated for the aforementioned scenarios and depends on the amount of prunings that needs to be collected. The collection of large quantities requires the hiring of greater number of personnel and the purchase of more equipment. Moreover, large quantities of biomass can be collected in bigger distances and this factor increases the cost of the value chain. According to the estimations for both scenarios the final cost ranges **from 35-45€/t,** depending on the required quantities of prunings. However, it is worth to mention that in the first case the total cost of the prunings has high fluctuations depending on the required quantity of the prunings, while the second scenario does not have so high fluctuations, as in the first case, although it requires that the personnel has to work more days in order to collect the required quantities. Moreover, this scenario requires a significant capital cost, 15 times higher than the capital cost that is required in the first scenario.

3.4 Defining the forestry biomass potential

The estimation of the forest biomass potential from the wide area of Phocis is also necessary. In Greece, forests can be exploited either by the forestry authorities, or by the forest cooperatives, which gain permission to access the forest. In general terms, logging activities are hindered due to the steep terrain of the forests, the lack of mechanization and the limited workforce. Moreover, the scattering of the residues in the forests, due to the forest management plans, as well as the overall system of cooperative forest exploitation do not encourage the removal of the forest residues. The amount of log wood per year is not stable, as it depends on the forest management plans of each forestry authority. The removal of the forest residues can deplete nutrients that affect, in long-term, the forest productivity, therefore, the actual availability of forest residues is much lower.

Nevertheless, the estimation of the forestry biomass potential is based on data taken from the BIORAISE GIS platform [10]developed in the framework of the H2020 Project BIOMASUD in which CERTH has participated. This tool was used since it embeds sustainable biomass resources, energetic contents, costs and environmental risks visualization for most of the Mediterranean countries and it is the only way to estimate the residual biomass from near forests. In general terms, the platform estimates georeferenced information about agriculture & forestry potential on an annual basis in a selected location, calculates the harvesting and transportation costs from the field to a user-choice destination and displays market related stakeholders' locations.

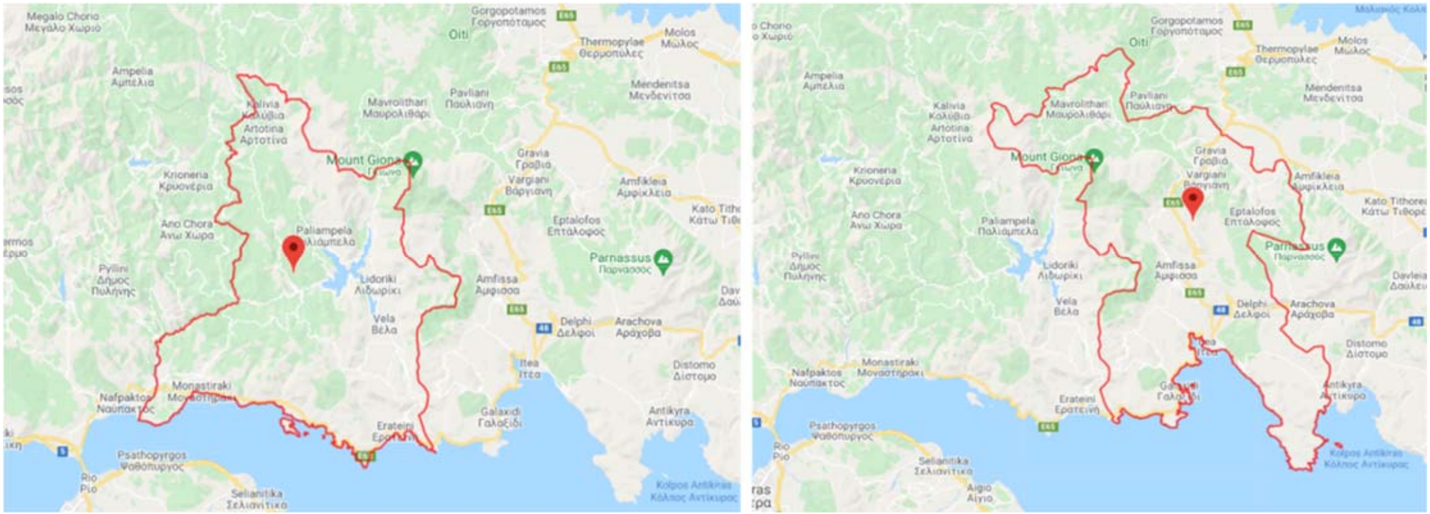


Figure 7. Screenshot from the BIORAISE platform depicting the two main sub-regions of Phocis as the study zone for the estimation of forestry biomass potential.

In particular, after entering the willing study zone and a hypothetical delivery location within this zone (as it is shown in the above Figure 7), the platform returns results concerning the potential and available resources in the area as well as the surface of them. Moreover, it gives an average collection/harvesting cost as well as an average transportation cost for the selected feedstock as it is presented in Table 7.

Table 7.Potential forest residues in the two sub-regions of Phocis. Source :[10]

Type of Biomass	Potential resources (tDM/yr)	Available resources (tDM/yr)	Area of potential resources (ha)	Area of available resources (ha)	Energetic content (GJ/yr)	Average cost of collection (€/tDM)	Average cost of transport (€/tDM)
Sub-region: Dorida							
Conifers	11,166	4,153	11,642	11,272	73,276	65	9
Leafy	4,489	1,435	3,236	3,231	23,422	58	8
Mixed	15,330	4,540	14,234	12,352	77,103	59	8
Sub-region: Delphi							
Conifers	16,972	6,227	19,432	19,225	109,874	67	8
Leafy	1,534	433	1,142	1,059	7,075	53	9
Mixed	5,737	1,908	5,841	5,786	32,409	60	9

According to the results presented in the above table, the sub-region of Delphi (includes the wide area of Amfissa which is required for the study) concentrates remarkable quantities of available forestry resources, especially from conifers trees. Moreover, the corresponding area and the energetic content of them are high enough comparing the rest of the resources. Unfortunately, as mentioned previously, these potential resources are still only theoretical, because each forestry authority has a specific forest management plan, which allows exploitation of significant trees per year.

4. Renewable Energy Potential of the Area

The Regional Unit of Phocis is of significant interest in terms of renewable energy sources. According to the data derived from of the Regulatory Authority for Energy (RAE) [11] the types of renewable energy sources located in the area are the following: a) wind farms, b) photovoltaic systems (on ceilings or on the ground) and c) small hydro plants. RAE's information system provides location data for these renewable energy sources. These RES are divided into units with operating and production license. The following Figure shows, within a selection polygon delimiting the Regional Unit of Phocis, the wind farms that received operating license (Figure 8a) and those that have received a production license (Figure 8b).

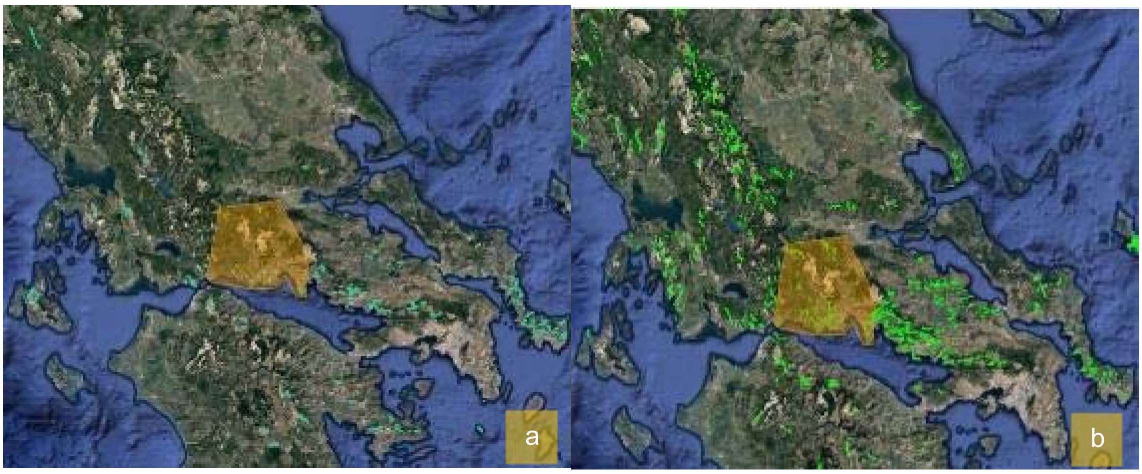


Figure 8 : Wind Farms a) operating and b) production license

Similarly, the following figures show the location of photovoltaic stations (Figure 10a & b) and small hydros (Figure 9a & b). For these cases, a distinction is also made between operating and production licenses. In the case of photovoltaics, the following images present the systems with installed capacity of higher than 1 MW. According to these data, the hydroelectric stations are basically concentrated in the northern part of the Regional Unit of Phocis, while the large scale photovoltaic stations are located in the southeastern part. It should be noted that in addition to the photovoltaic stations presented in these particular figures, there are additional photovoltaic units that are not mentioned in the RAE information system. The rest of the photovoltaics are of installed capacity smaller than 1 MW and refer to systems mounted on the ground and systems installed on the roofs of buildings. The data concerning these types of additional photovoltaic systems are taken from the information system of the Hellenic Electricity Distribution Network Operator (DEDDIE S.A.) and are presented in section 4.3.

Figure 9 : Small Hydros a) operating and b) production license

Figure 10 : PV stations with installed capacity higher than 1MW

4.1. Energy Potential from Wind Farms

As mentioned in the previous section there is a significant number of wind farms in the area. The installed power data for the Regional Unit of Phocis were collected from the RAE information system. In total, the installed capacity of wind farms with production license is approximately 885MW, while the installed capacity of the wind farms with operating license is almost 3.5 times lower, approximately only 248MW. The following figures show the installed capacity of wind farms per year. In the specific data, a distinction is made regarding the wind farms that received an operating and a production license. In addition, the installed capacity of the wind farms is distinguished per Municipal Unit. The data show that the installed capacity of the wind farms that have received a production license amounts to 42% of the installed capacity of the total wind farms of the Regional Unit of Phocis. Respectively, the installed capacity of the wind farms that have an operating license amounts to 37% of the total installed capacity of the Phocis Regional Unit.

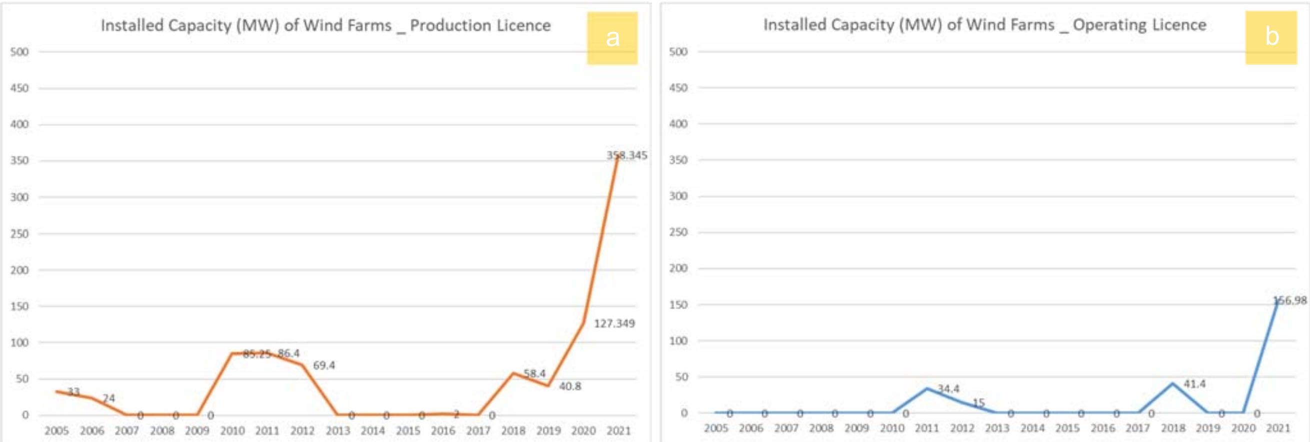


Figure 11 : Installed capacity of wind farms per year a) production and b) operating license

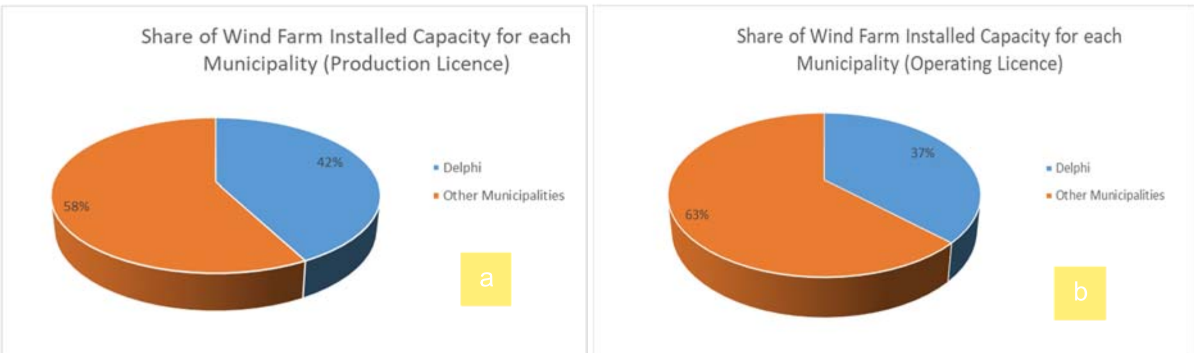


Figure 12 : Share of Wind Farms' installed capacity per Municipality a) production and b) operating license

According to the results deriving from the previous figures, the licensing activity of the wind farms started in 2005 where the first production licenses were issued. However, only by 2011 the first wind farms received operating licenses in the Regional Unit of Phocis. The data also show that for some years, between 2013 and 2017 the licensing of wind farms remained virtually stagnant. A new starting point in the licensing process is the year 2018. Nowadays, it seems that the installation of wind farms is gaining more and more ground as by 2021 production license of 358 MW and operating license of 248 MW were issued. Figure 13 shows the carrying capacity (density of wind installations) of the wind installations per area. Carrying capacity refers to the maximum number of standard wind turbines that can be installed in a unit area, thus creating safety conditions for the lowest possible impact deriving from the installation of wind turbines in the area and environment. From the data of RAE it appears that the carrying capacity is higher in the southern areas of Phocis Regional Unit. The carrying capacity index for these areas ranges from 20-80 (medium) and in one case it exceeds the value of 80, which means that a higher number of wind farms can be installed with lower impacts.

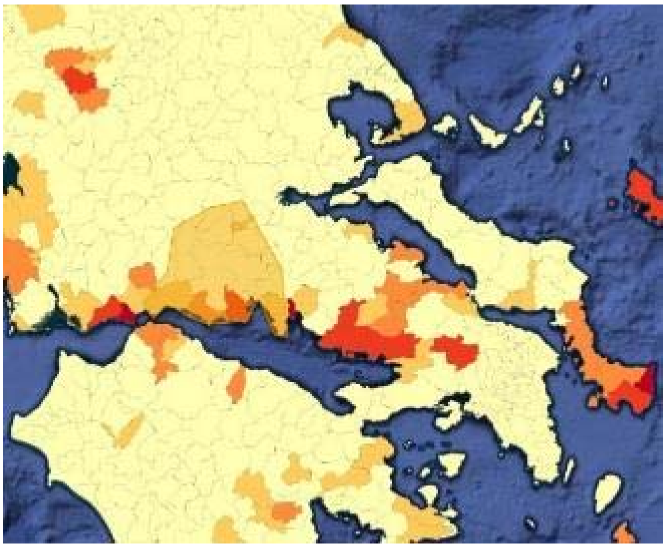
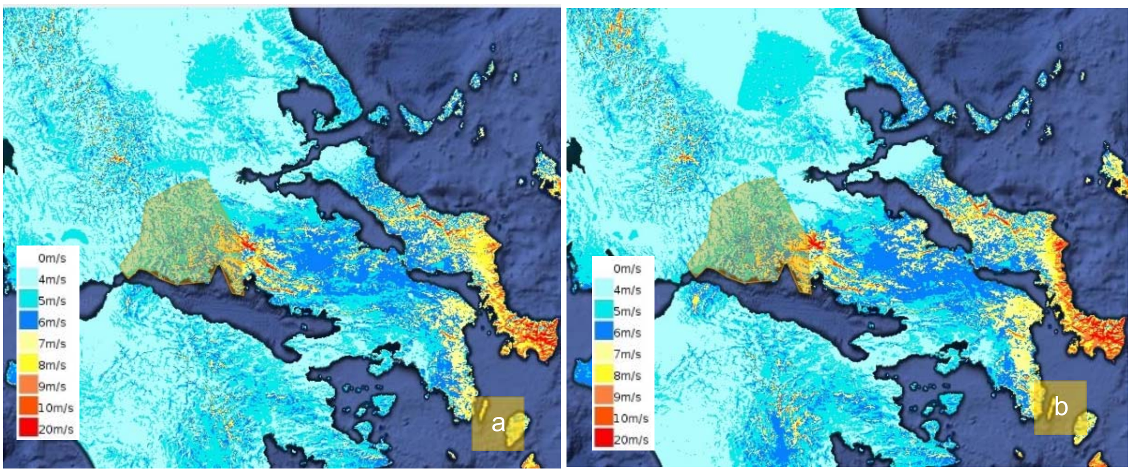


Figure 13 : Carrying capacity of Wind Farms of Phocis Regional Unit

In order to calculate the energy produced from wind farms, various data are needed. The most important data is the wind potential which refers to the average annual wind speeds (per ten minutes). Wind speed values are obtained by processing primary measurement data from sensors located in 160-170 masts across the country. A mass retention model and a boundary layer correction are used during this process. The wind potential is calculated at different heights h80, h100 and h120. The wind potential of the area is illustrated in the following figure (Figure 14). For all the aforementioned three heights, in the eastern mountainous areas of the Regional Unit of Phocis there is a high wind potential with wind speeds exceeding 10m/s. In the rest of the mountainous areas of Phocis Regional Unit, the wind potential is described as satisfactory, as it exceeds 6-7m/s.



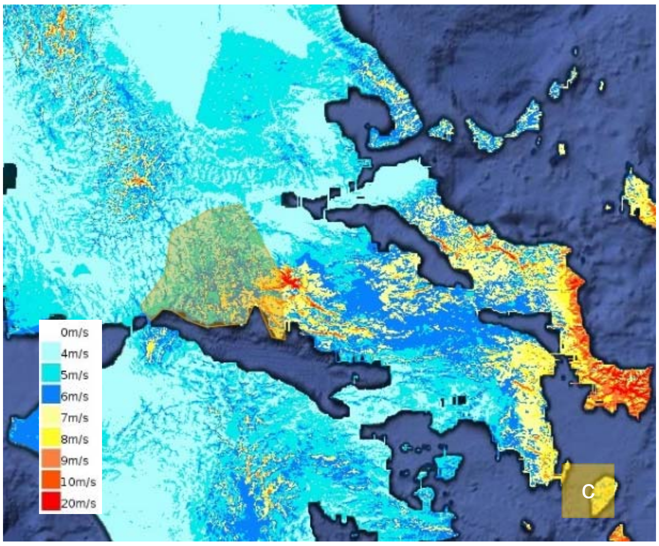


Figure 14 : Wind potential for a) h80, b) h100 and c) h120

Based on the aforementioned data and in order to calculate the electricity generated by the wind farms in the area, the TRNSYS [12] software (Figure 15) was used. TRNSYS is an extremely flexible graphically based software environment used to simulate the behavior of transient systems, such as the electricity generated from the wind farms in the area.

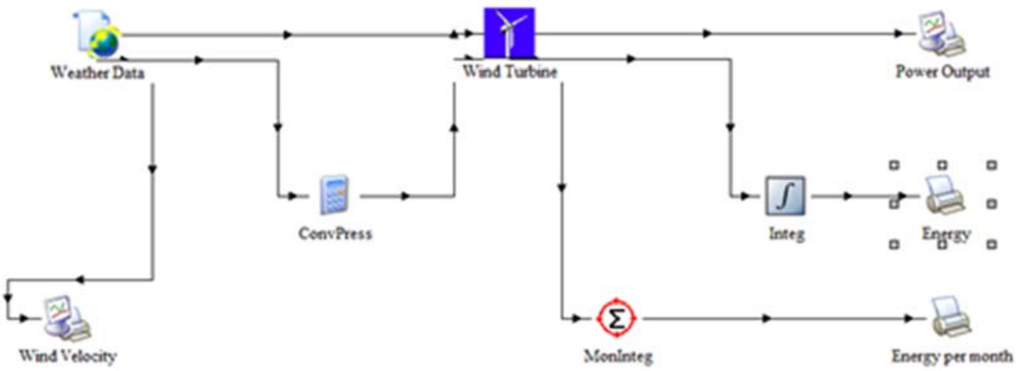


Figure 15 : TRNSYS simulation for Wind Turbines

Initially, the wind data of the study area were examined. These data concern the speed (m/s) and the direction (degrees) of the wind in the study area. The results are presented per hour for an entire year in the Figures below (Figure 16-17). When it comes to the wind speed, the software data seems to be in agreement with the wind data that were taken from RAE's information system.

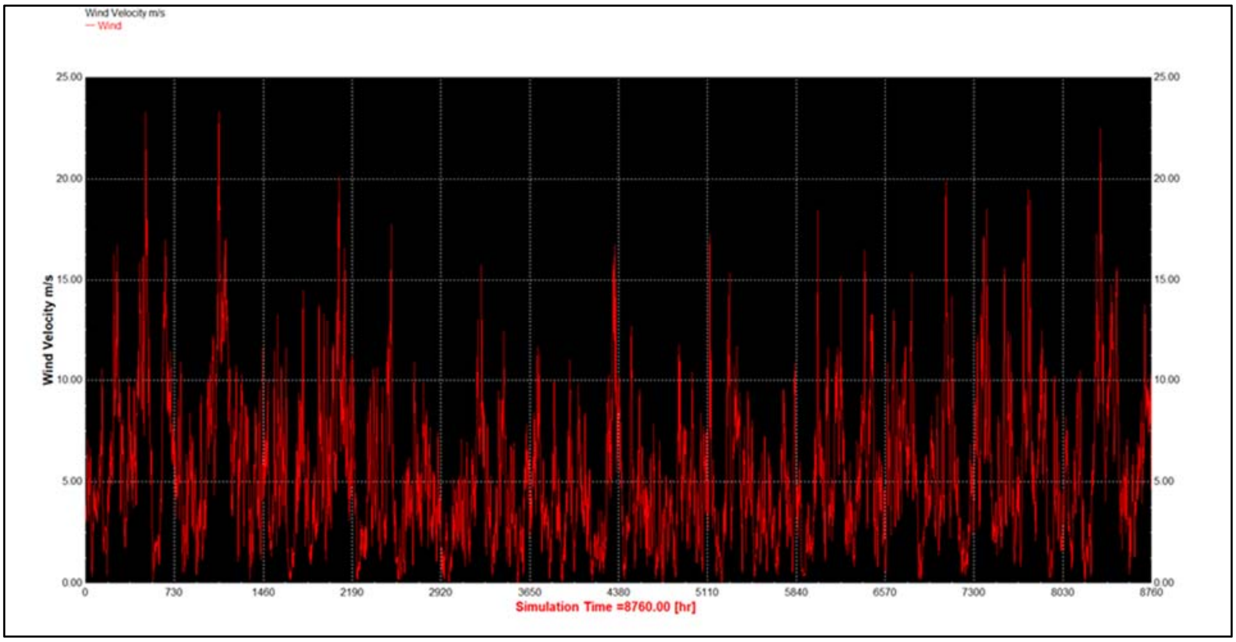


Figure 16: Wind velocity per hour for the study area

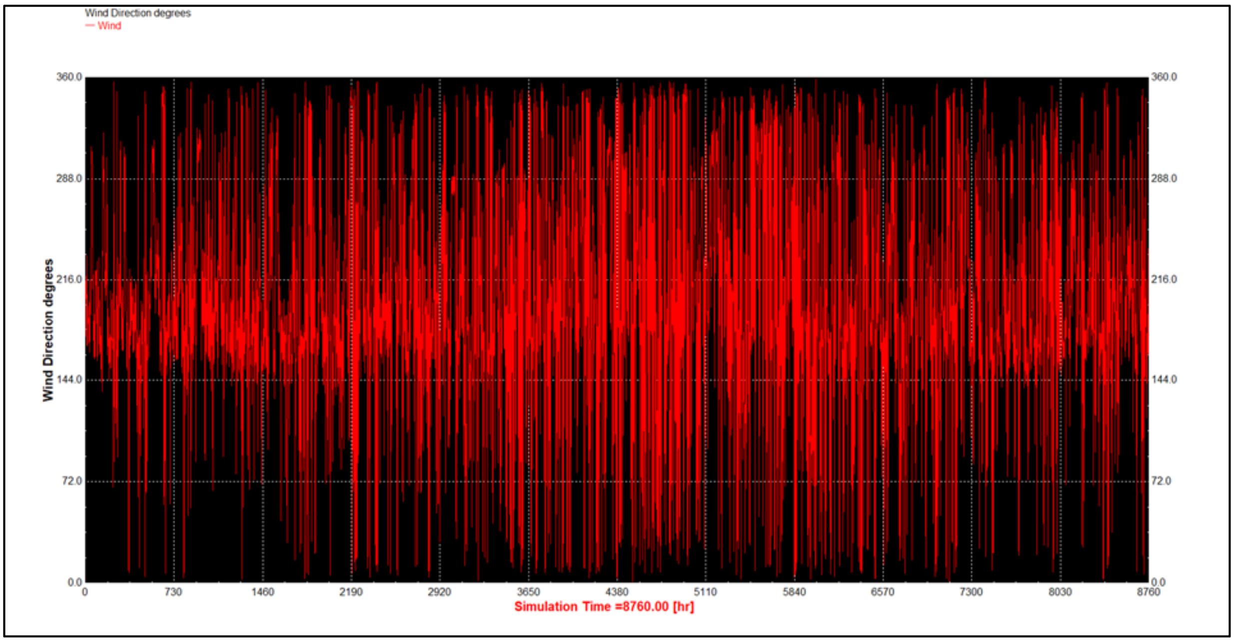


Figure 17: Wind direction per hour

Wind turbine simulations were performed for various characteristics such as wind turbine sizes (heights, wings) and installed capacity, which were collected from commercial wind turbines. The first simulation was carried out for a wind turbine with an installed capacity of rated power of 1,000 kW, rotor diameter of 6 m with hub height of 70m. The results of the annual simulation are presented in the figure below (Figure 18). For the specific simulation the results showed that this particular wind turbine may produce 3.023 MWh of electricity.

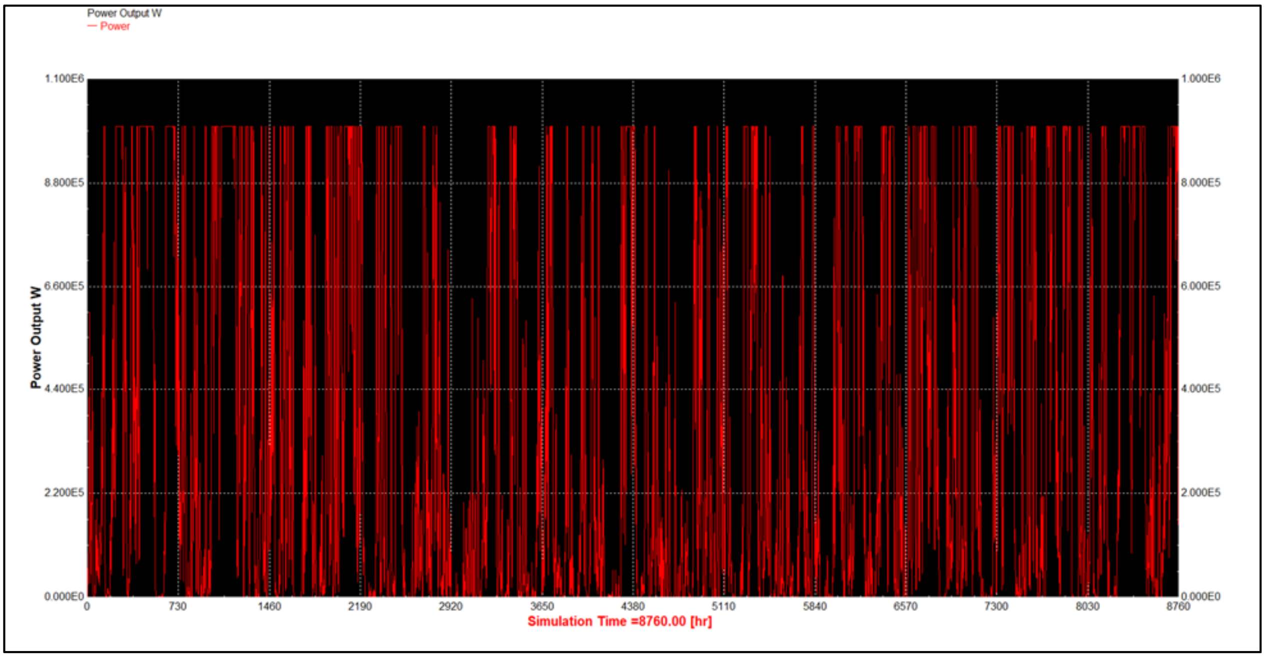


Figure 18: Power Output for Wind Turbine 1MW

The second simulation was about a wind turbine with an installed capacity with rated power 1,500 kW, rotor diameter of 70.5 m and with hub height of 80 m. The results of the annual simulations are presented in Figure 19. This particular simulation showed that this type of wind turbine may produce 5,034 MWh of electricity.

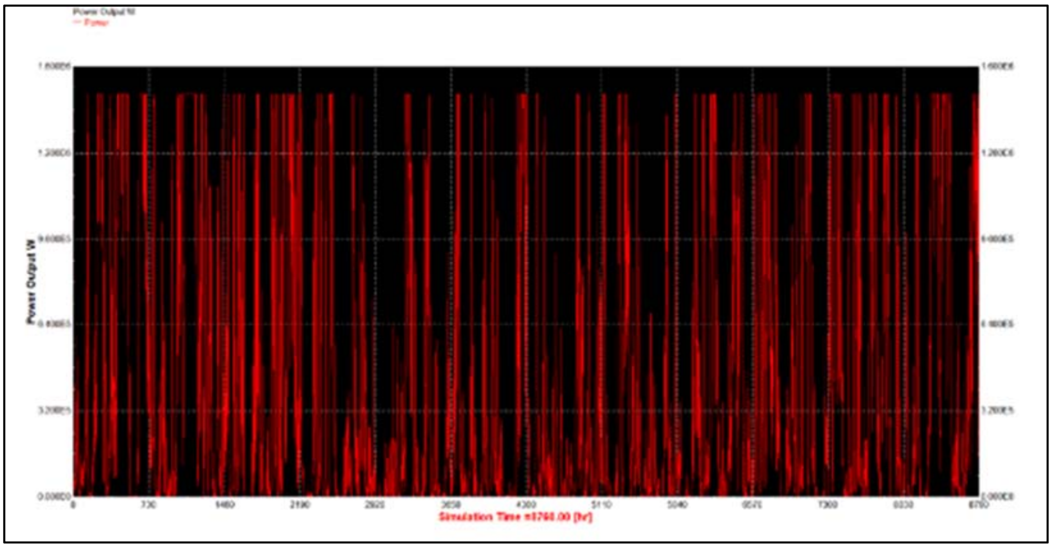


Figure 19: Power Output for Wind Turbine 1.5 MW

The third simulation concerns a wind turbine with an installed capacity of rated power of 2,000 kW, with rotor diameter of 116 m and hub height of 80 m. The results of the simulation are presented in Figure 20. The results of this simulation showed that this type of wind turbine may produce 7,006 MWh of electricity.

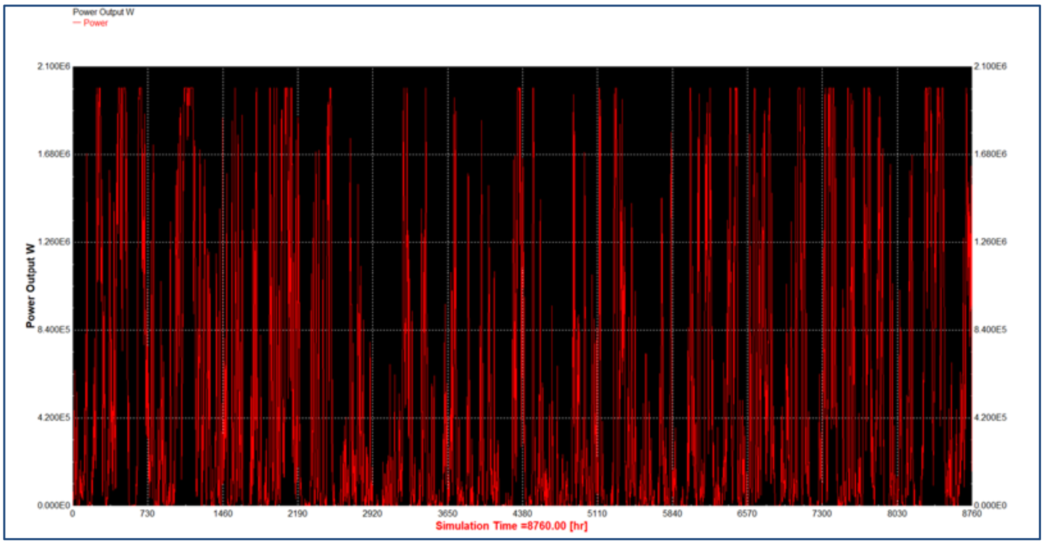


Figure 20 : Power Output for Wind Turbine 2 MW

The fourth simulation was for a wind turbine with an installed capacity of rated power 2,000 kW, rotor diameter 127 m and hub height 89 m (Figure 21). The results of the annual simulation showed that this wind turbine may produce 7,183 MWh of electricity.

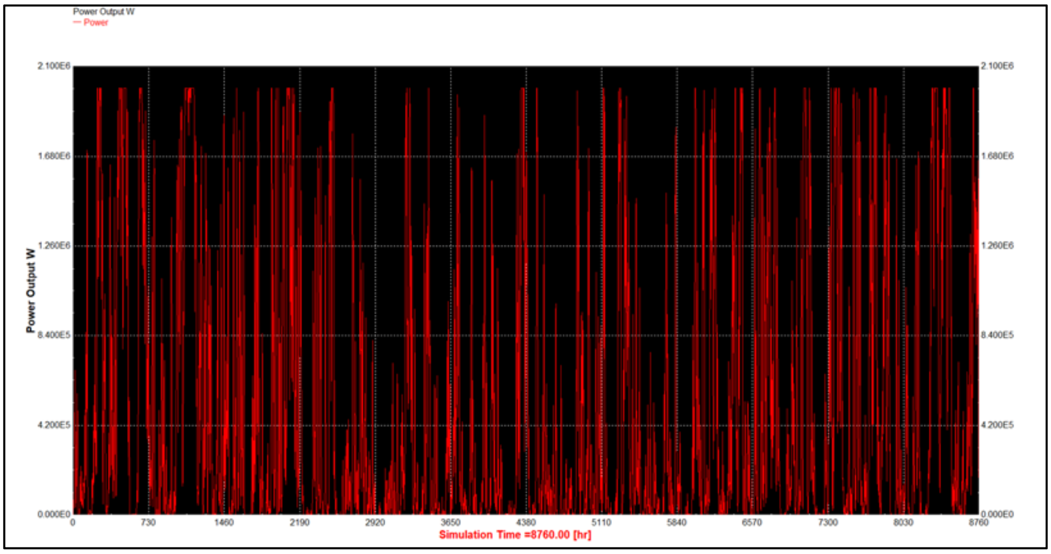


Figure 21: Power Output for Wind Turbine 2MW with hub height 89m

Finally, a fifth was carried out which concerns a wind turbine with an installed power capacity of rated power of 3,400 kW with rotor diameter 130m and hub height 134 m (Figure 22). The annual results of the simulation showed that this wind turbine may produce 12,362 MWh of electricity.

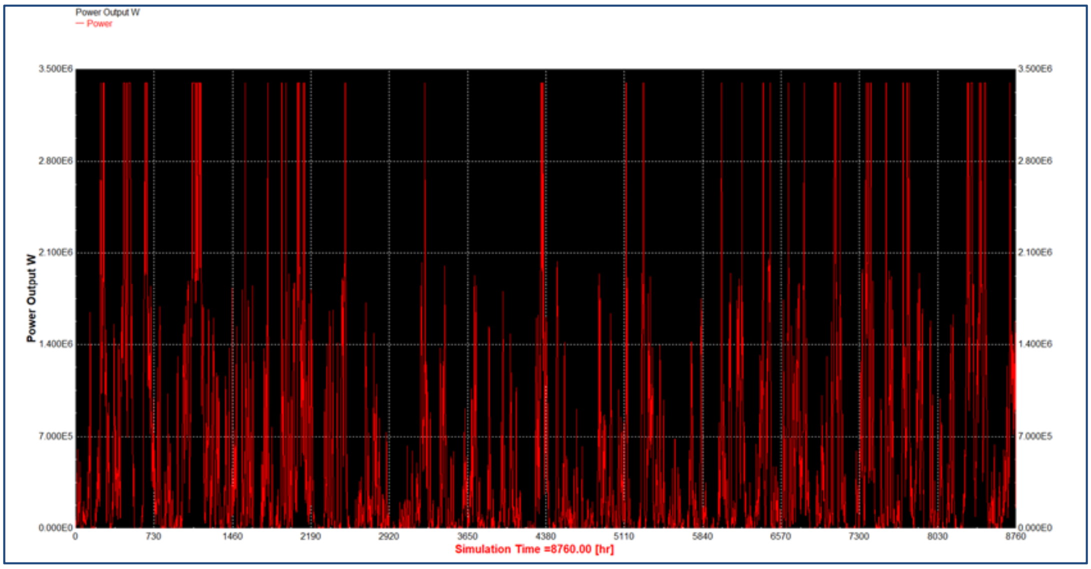


Figure 22: Power Output for Wind Turbine 3.4MW

Based on these simulations, the following results are presented in the Figure 23, for the different types of wind turbines. These results show that the average amount of the energy produced per 1MW of installed power for the wind turbine in the study area, is approximately 3,422 MWh. According to this value, the estimated energy that can be produced by the wind turbines with operating license is approximately 848 GWh on an annual basis. On the other hand, for the wind turbines that have received a production license, the estimated generated electricity is expected to reach 2,926 GWh. Finally, in the Municipality of Delphi, the energy that is estimated to be produced by the wind turbines that have received an operating license is approximately 315.5 GWh on an annual basis and it is expected to reach 1,280 GWh for the wind farms that have production license.

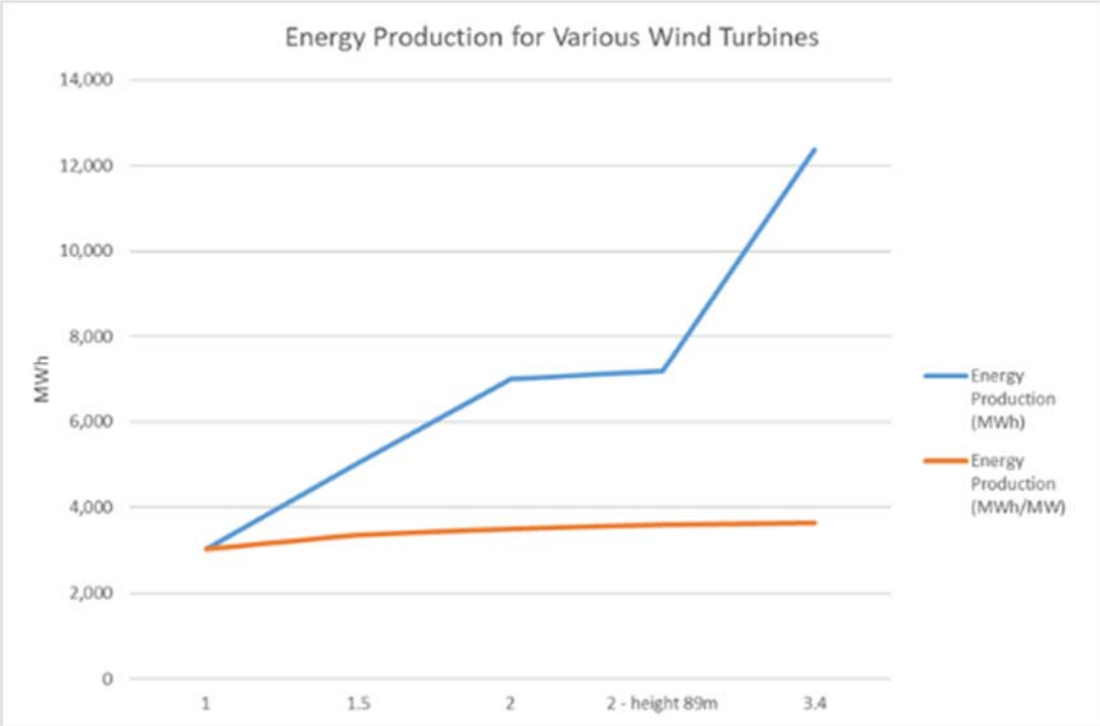


Figure 23 : Energy production for various types of Wind Turbines

4.2. Energy Potential from Small Hydros

As mentioned in a previous section, there are some small hydroelectric power stations installed in the Regional Unit of Phocis. The installed capacity data for the Phocis were collected from RAE's information system. In total, the installed capacity of small hydropower plants that have received a production license is approximately 52.3MW, while the installed capacity of these plants that have received an operating license is almost 3.3 times lower, only 15.7 MW. The following figure (Figure 24) presents the capacity of hydropower plants installed per year in the study area. In these specific data, a distinction is made regarding the small hydros that have received operating and production licenses. According to these data, the starting year for the installation of small hydros in the area was at the beginning of 2002. From 2009 to 2011 the highest amount small hydros took place in Phocis Regional Unit, while from 2012 to 2021 there has been no licensing of these type of RES. In the Municipality of Delphi exist the highest proportion of small hydroelectric plants (78% in relation to those installed in the other Municipalities of Phocis) (Figure 25). Finally, in the Municipality of Delphi there is only a small proportion of small hydros that is in the stage of production license (23% of the total of Phocis).

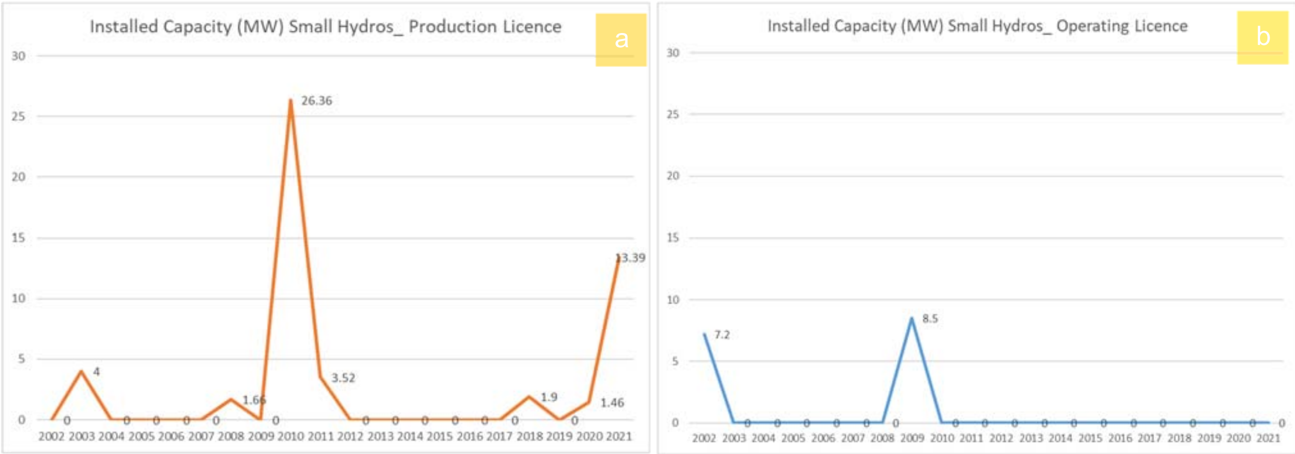


Figure 24: Installed capacity of small hydros per year a) production license and b) operating license

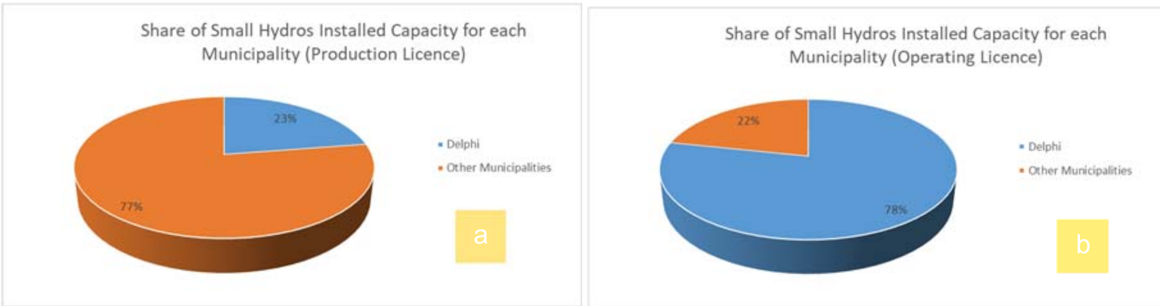


Figure 25 : Share of small hydros installed capacity per Municipality a) production license and b) operating license

RetScreen [13] software was used in order to calculate the energy generated by the small hydros. RETScreen is a Clean Energy Management Software system for energy efficiency, renewable energy and cogeneration project feasibility analysis as well as ongoing energy performance analysis. Initially, a typical area was selected in Phocis for the installation of a small hydro in order to estimate the energy output for a range of small hydros (Figure 26). Based on the selected area, Retscreen software generated a file of climatic data based on NASA's databases (Figure 27). The climate of the area is characterized as mixed - humid. According to the climatic data, simulations were performed for different proportions of electricity exported to the grid from small hydros. The software produces a result file for 1 MW of installed power and various percentages of energy that can be exported to the grid (25% -75%).

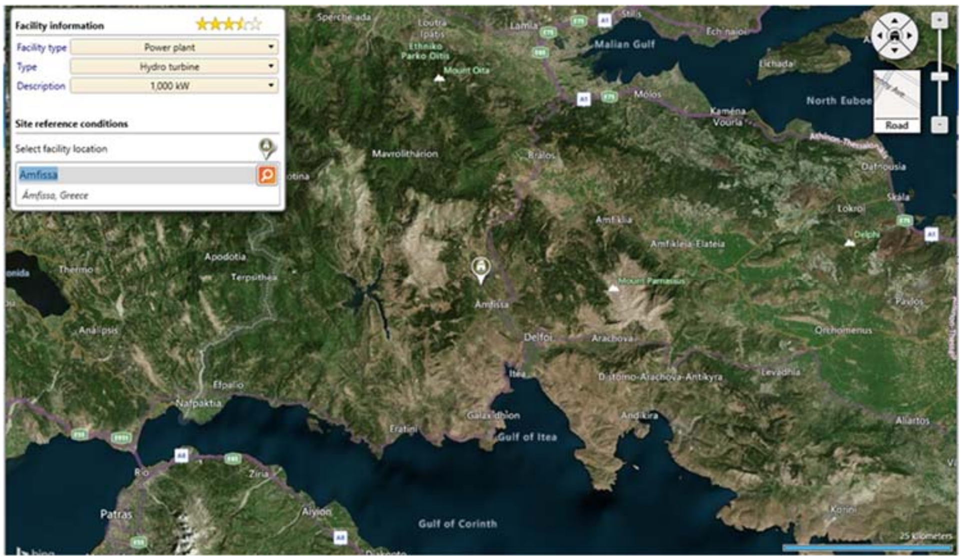


Figure 26 : Location of small hydro

	Unit	Climate data location	Facility location	Source
Latitude		38.9	38.6	
Longitude		22.4	22.3	
Climate zone		4A - Mixed - Humid		NASA
Elevation	m	555	1083	NASA – Map
Heating design temperature	°C	-0.6		NASA
Cooling design temperature	°C	31.7		NASA
Earth temperature amplitude	°C	22.6		NASA

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	4.7	84.8%	68.82	1.94	95.3	3.2	4.4	412	0
February	5.0	82.1%	60.48	2.60	95.1	3.4	5.0	364	0
March	7.5	77.4%	57.97	3.62	95.1	3.2	7.7	326	0
April	11.6	70.5%	42.30	4.89	94.9	3.0	11.8	192	48
May	17.0	61.6%	31.00	5.80	95.1	2.7	17.5	31	217
June	22.5	48.5%	14.10	7.08	95.1	2.6	23.6	0	375
July	25.5	41.9%	15.50	6.93	95.0	2.5	26.9	0	481
August	25.0	44.9%	14.88	6.20	95.1	2.5	26.3	0	465
September	20.5	55.3%	29.70	4.83	95.2	2.5	21.5	0	315
October	15.2	68.6%	64.48	3.16	95.4	2.8	15.5	87	161
November	10.0	80.2%	84.90	2.01	95.3	3.0	9.9	240	0
December	5.8	85.7%	83.39	1.56	95.3	3.2	5.6	378	0
Annual	**14.2**	**66.7%**	**567.52**	**4.23**	**95.2**	**2.9**	**14.7**	**2,030**	**2,062**
Source	NASA	NASA	NASA	NASA	NASA	NASA	NASA	NASA	NASA
Measured at					m	120	0		

Figure 27 : Climate data for the study area

	Capacity	Electricity
Electricity exported to grid	kW	MWh
Power		
Hydro turbine - 1000 kW (25%)	1,000	2,190
Hydro turbine - 1000 kW (35%)	1,000	3,066
Hydro turbine - 1000 kW (45%)	1,000	3,942
Hydro turbine - 1000 kW (55%)	1,000	4,818
Hydro turbine - 1000 kW (65%)	1,000	5,694
Hydro turbine - 1000 kW (75%)	1,000	6,570
Total	**6,000**	**26,280**

Figure 28: Values of electricity exported to grid for small hydro 1MW

Consequently, the simulations were carried out for small hydros with installed capacity of 1.9 MW as these types stations are located in the Municipality of Delphi. Exported to grid percentages between 45% and 75%, were selected for the simulations. The results for the produced energy are presented in the following figure (Figure 29). The results showed that the energy produced by a typical small hydro plant is between 7,490MWh to 12,483MWh on an annual basis. Therefore the average value of the energy produced from a small hydro with installed capacity of 1 MW is approximately 5,256 MWh.

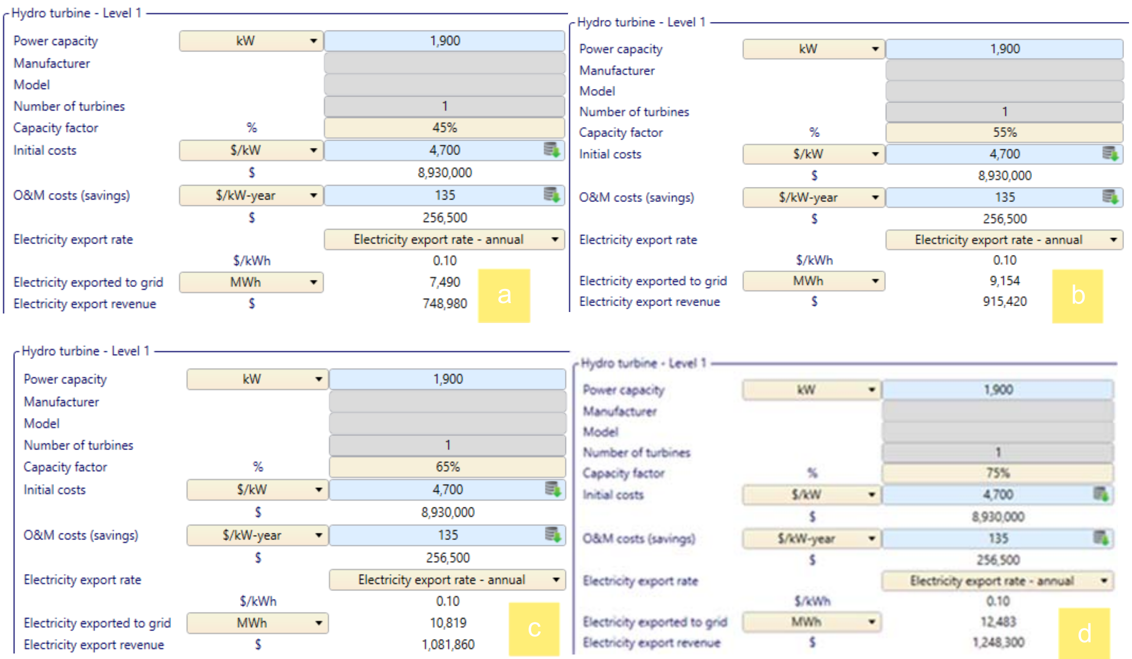


Figure 29 : Electricity exported to grid from 1.9MW small hydro for various capacity factors: a) 45%, b) 55%, c) 65% and d) 75%

According to this analysis, it is estimated that the energy produced by the small hydros that have received an operating license in the Regional Unit of Phocis may produce approximately 82,520 MWh per year, while the energy that can be provided by those systems to the grid that have production license may reach, on an annual basis, 274,834 MWh. Regarding the Municipality of Delphi, the produced energy of small hydroelectric plants with operating license is expected to reach 64,650MWh.

Finally, in the Municipality of Delphi the additional energy produced by small hydros that have received a production license, may rise to 61.916MWh.

4.3. Energy Potential from PV Systems

In section 4 the installed photovoltaic systems of the Regional Unit of Phocis which have installed capacity greater than 1MW, was discussed. The data concerning these systems were obtained from RAE's information system. The large scale PVs (> 1MW) that received a production license have an installed capacity of approximately 864MW, while the installed capacity of the stations which have operating license is approximately 3.76MW. The PVs received production licenses from 2020 to 2021, while the large installed PVs were installed between 2006 and 2007 (Figure 30). The category of photovoltaic stations that have received a production license, are all located in the Municipality of Delphi. On the contrary, 72% of the installed capacity of photovoltaics that have an operating license concerns the Municipality of Delphi (Figure 31).

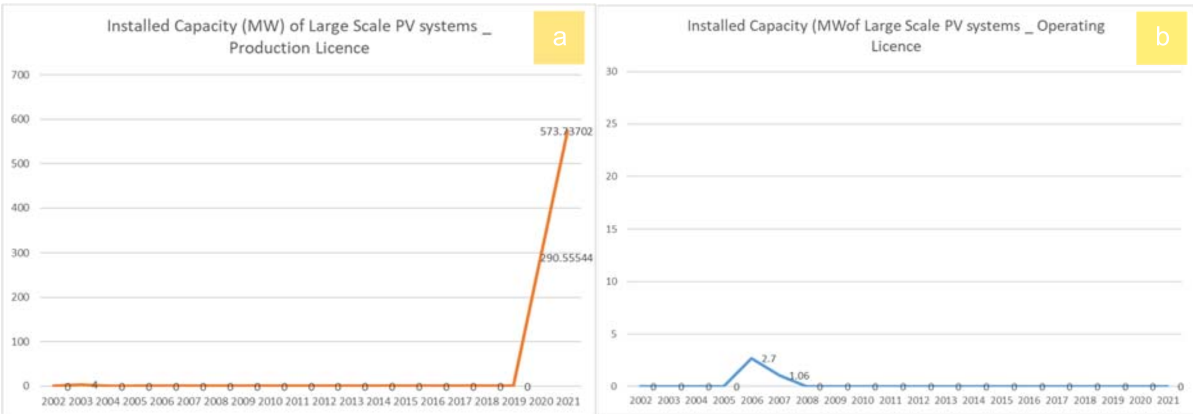


Figure 30 : Installed capacity of large scale PVs per year a) production license and b) operating license

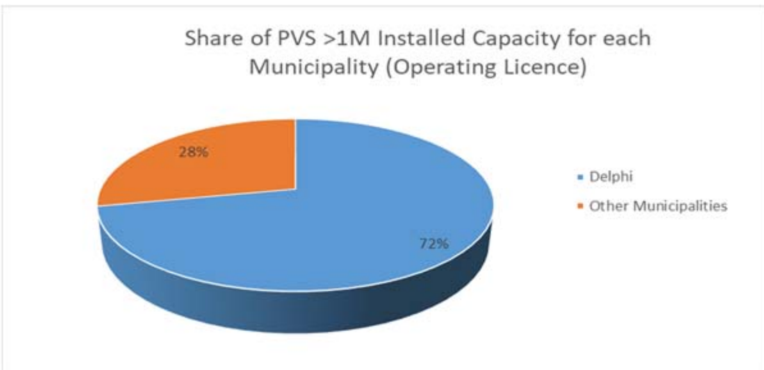


Figure 31 : Share of large scale PVs installed capacity per Municipality (operating license)

However, there are other PV systems stations that are not mentioned in the RAE's information system which concern PVs installed: a) on roofs (capacity up to 10 kW), b) on fields (capacity up to 100kW) and c) mounted on the ground (power up to 1MW). The data for these systems were obtained from HEDNO [15] S.A. (Hellenic Electricity Distribution Network Operator S.A.). The PVs installed on roofs of the Regional Unit of Phocis have an installed capacity of 1,035kW, while the PVs of the Municipality of Delphi have a capacity of 361 kW, which amounts to 32% of the total installed capacity of the Regional Unit (Figure 32).

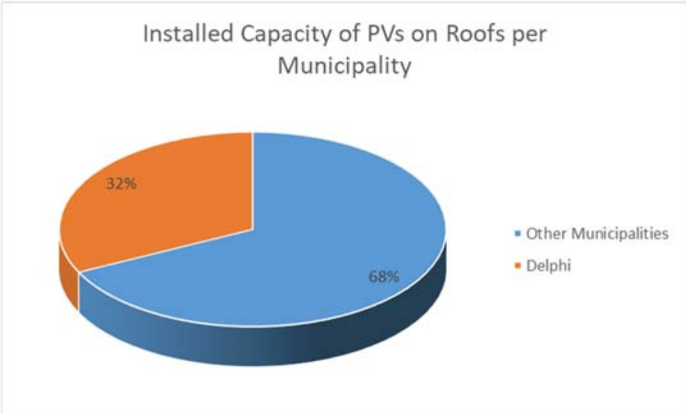


Figure 32 : Share of installed capacity of PVs on roofs per Municipality

The installation of PVs on roofs as shown in Figure 33 for both the Municipality of Delphi and the Regional Unit of Phocis took place in the period between 2011 and 2014, while from 2015 and onwards no PVs of this type were installed in the area.

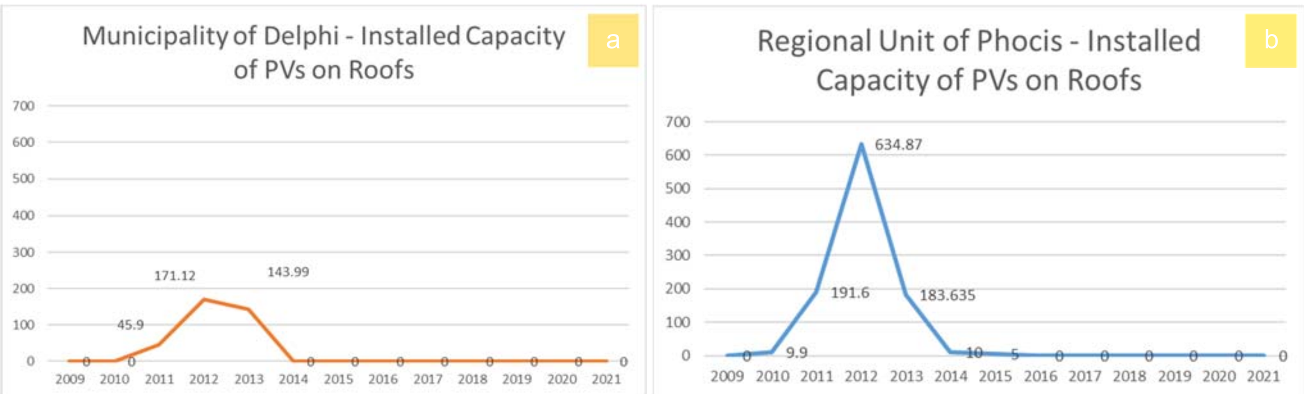


Figure 33 : Installed capacity of PVs on roofs per year a) Municipality of Delphi and b) Regional Unit of Phocis

The third category of photovoltaic systems refers to the systems which are installed on fields and they have a maximum installed capacity of 100kW. The following figure (Figure 34) presents the evolution of the installation of photovoltaic systems on fields for the study area. The installation of these systems took place between 2012 and 2013 and this activity stopped since 2014. All these systems are installed near the city of Amfissa and their total installed capacity is 1 MW.

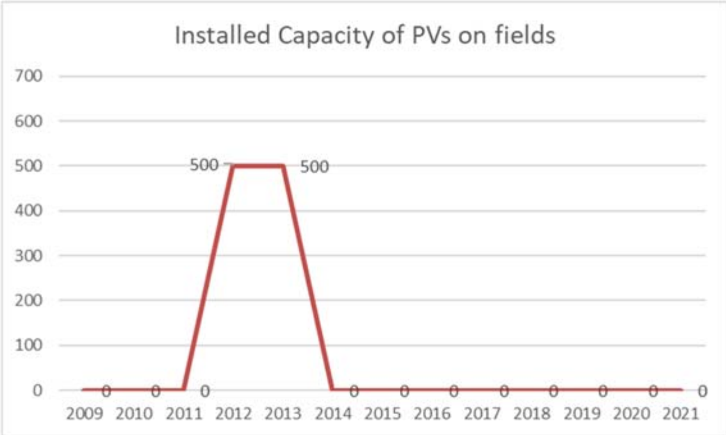


Figure 34 : Installed capacity of PVs on fields per year Municipality of Delphi

Finally, as it was mentioned, in the area of Phocis there are installed PV systems mounted on the ground, which have power capacity lower than 1MW. The total installed capacity of this type of system is approximately 11.5 MW for the Regional Unit of Phocis and 7.04 MW for the Municipality of Delphi. Therefore, in the Municipality of Delphi is installed 61% of the total capacity of these PV systems of the Regional Unit of Phocis (Figure 35).

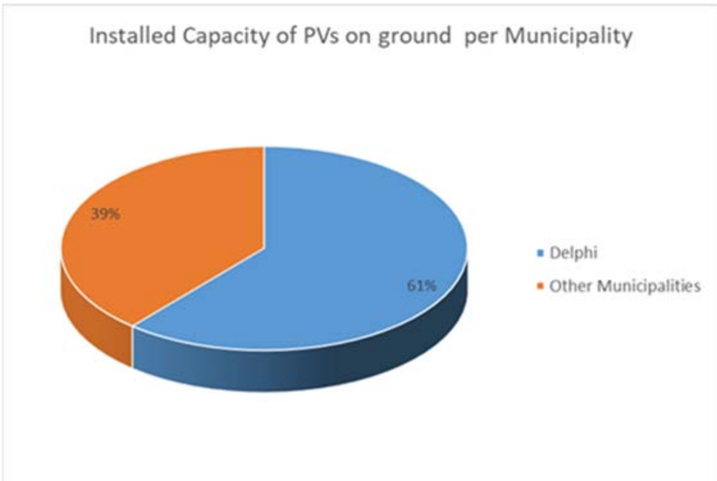


Figure 35 : Share of installed capacity of PVs mounted on the ground per Municipality

The following figure (Figure 36) presents the time evolution of the installation of PV systems mounted on the ground, for both for the Municipality of Delphi and the Regional Unit of Phocis. According to these results, it can be seen that there is intense activity of installation of this type of photovoltaics for the period 2011-2013, while for the period between 2014 and 2018 no installations of these PV systems took place in the area. Finally, in the period 2019-2020, the activity of installation of photovoltaics mounted on the ground is revived, but to a lesser extent when compared to the period 2011-2013.

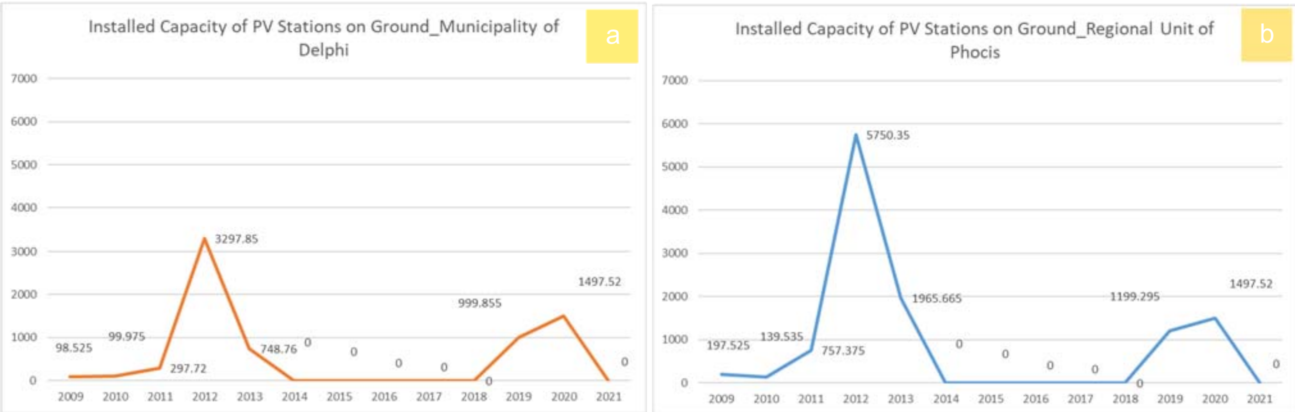


Figure 36 : Installed capacity of PVs on ground per year a) Municipality of Delphi and b) Regional Unit of Phocis

In order to calculate the energy produced by the installed photovoltaics, various data are needed. The most important data concern global horizontal and tilted irradiation. The data were obtained from the Hellenic Network of Solar Energy (HNSE) [14] which has been developed to support applications of solar energy with the combined use of ground-based measurements, satellite images and theoretical calculations with radiative transfer and weather forecasting models. HNSE provides climatological maps of global horizontal and direct normal irradiance (GHI and DNI respectively) in Greece for the period 2002-2012. Satellite-derived information of cloudiness, aerosol information and model calculations of solar irradiance are used in synergy to provide maps of the available solar power at a resolution of 0.05°x0.05°. For the area of interest the maps are presented in Figure 37. The sun's position which depicts the position of the sun in the sky for the specific location at any time is calculated (Figure 38). In addition, the day arc which affects the length of daytime experienced and the amount of daylight received along a certain latitude during a given season is calculated. In this case, an area within the Municipality of Delphi was selected (Figure 39).

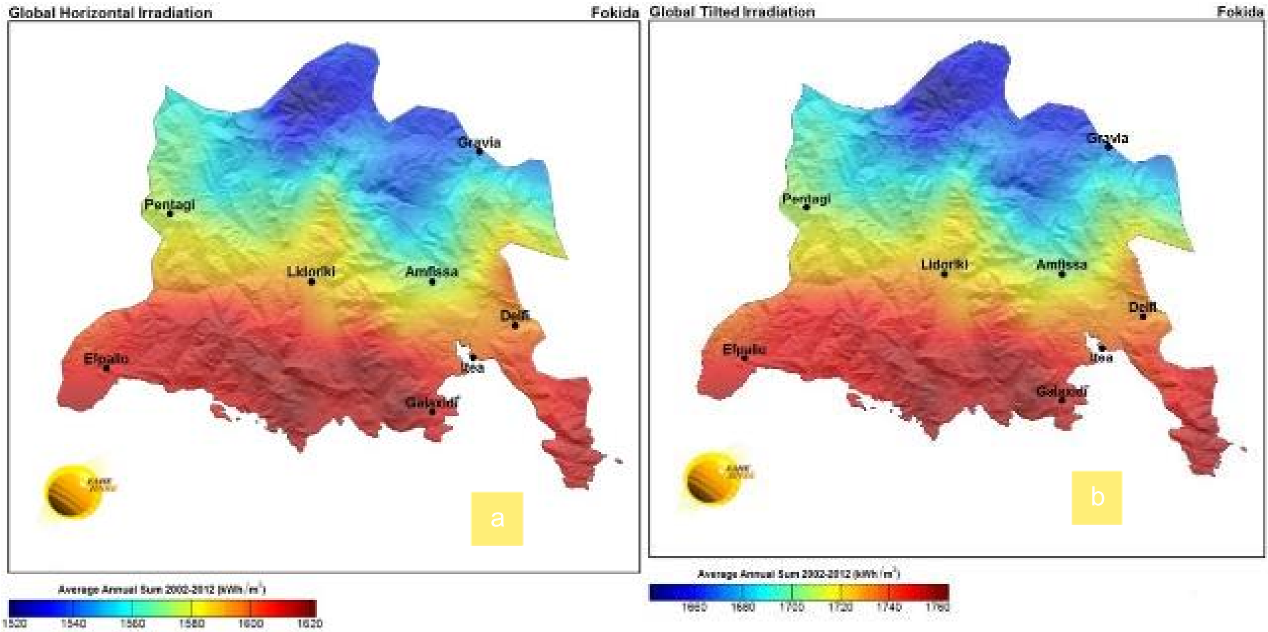


Figure 37 : Global Irradiation a) Horizontal and b) Tilted

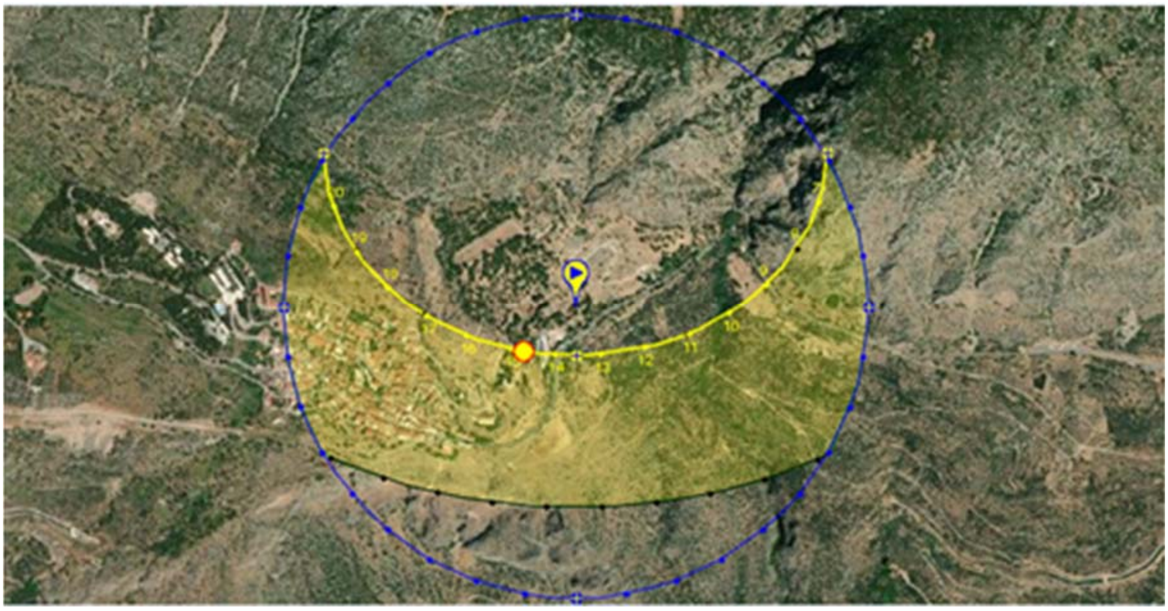


Figure 38 : Sun position

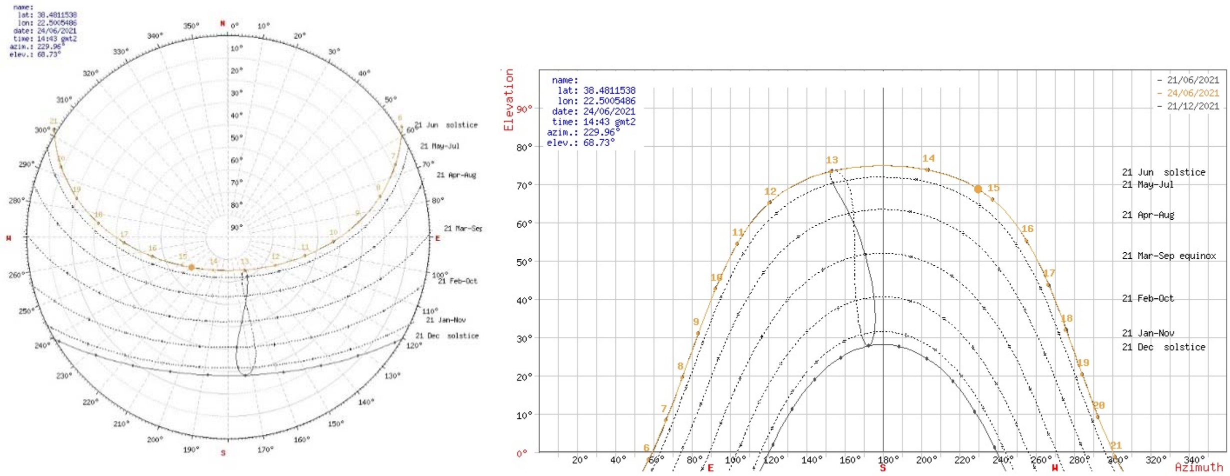


Figure 39: Day arc

As the photovoltaic systems mentioned are of different types, the appropriate simulations were performed in the TRNSYS software (Figure 40). These used the previous data for a specific area of the Municipality of Delphi. More specifically, simulations were carried out concerning: a) system sizes (various kW), b) module types, c) array types, d) system losses, e) tilt & azimuth angles.

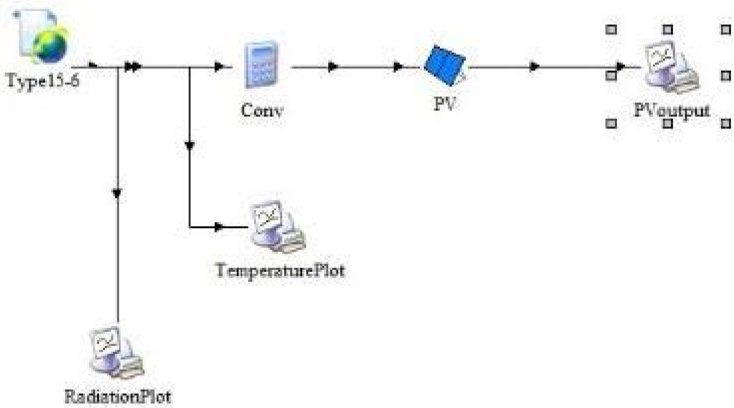


Figure 40: TRNSYS simulation for PV systems

Initially, two very important factors were evaluated for the operation of the PV, such as the temperature and the solar radiation of the study area. The results are presented in the following figures (Figure 41 & 42).

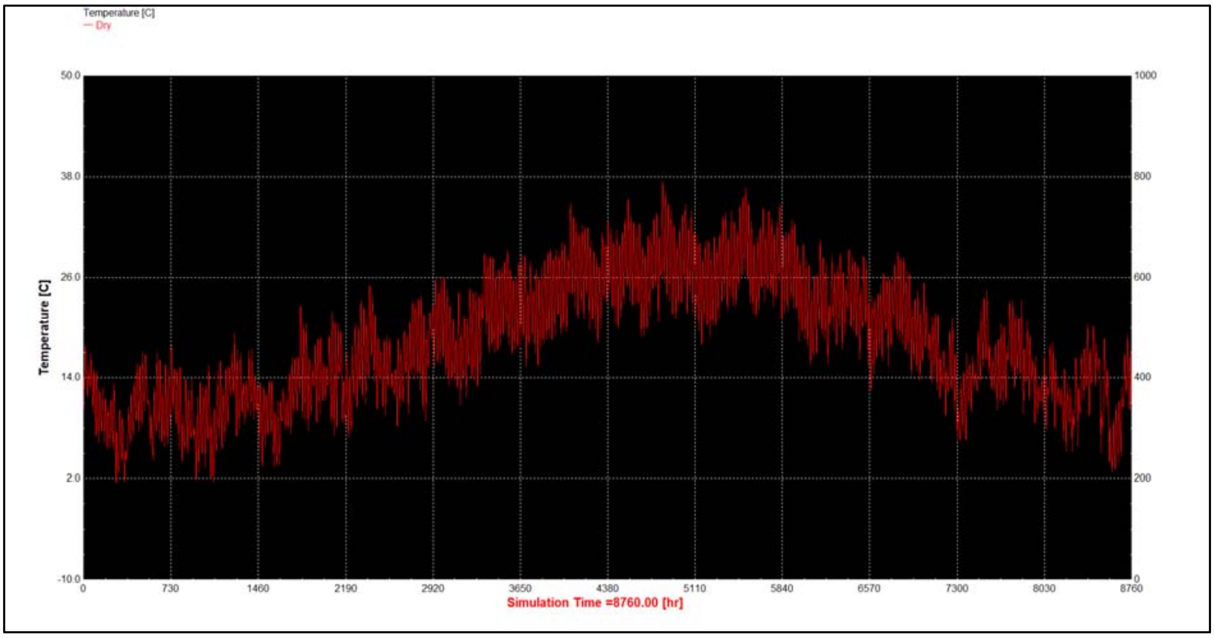


Figure 41: Temperature per hour

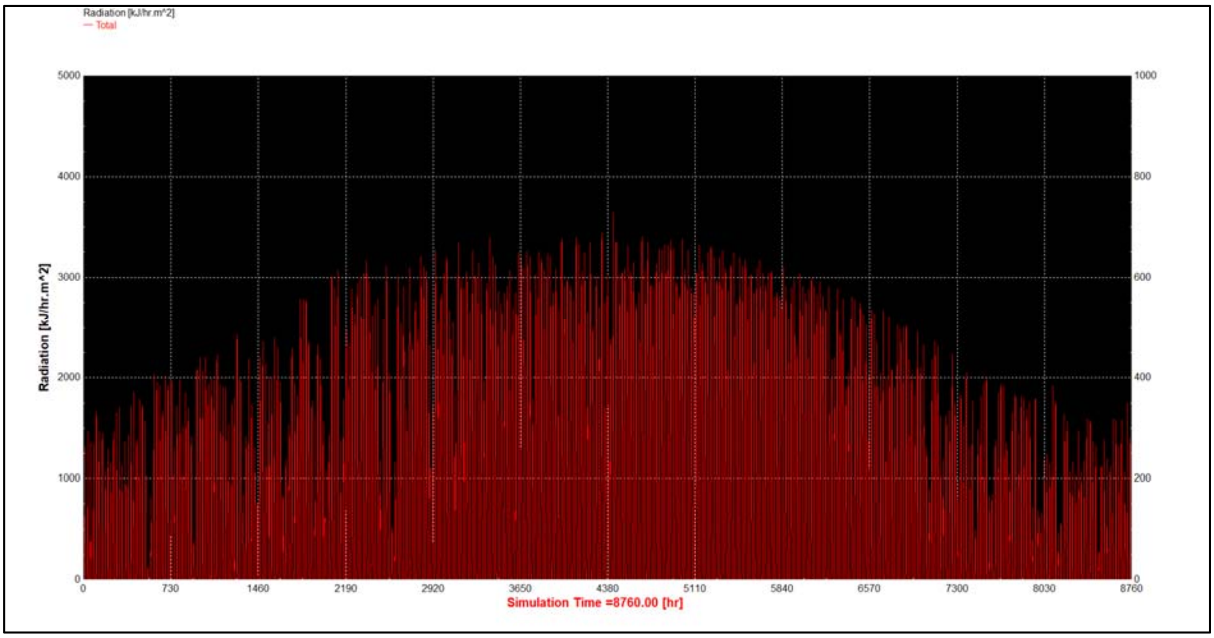


Figure 42: Radiation per hour

The following table (Table8) presents the results of the simulation for the various types of PV systems. The results include the typical solar radiation values of the study area for each month and at the same time it illustrates the typical energy values for the various types of PV systems that were simulated.

Table 8 : Simulation results of PV systems

Simulation Results												
Types	January	February	March	April	May	June	July	August	September	October	November	December
Solar Radiation (kWh/m^2/day)	**Small Scale Systems (<10 kW)**											
	2.22	3.01	3.8	4.83	5.97	6.48	7.4	6.97	5.55	3.35	2.38	1.77
Various PVs 5kWp (kWh)	278	348	482	576	714	731	856	811	628	409	290	224
Various PVs 10kWp (kWh)	556	696	965	1,151	1,428	1,463	1,712	1,621	1,257	819	580	448
Solar Radiation (kWh/m^2/day)	**Medium Scale Systems (<1 MW)**											
	2.34	3.12	3.86	4.82	5.87	6.31	7.25	6.96	5.66	3.45	2.48	1.85
Various PVs on fields 100kWp (kWh)	5,833	7,214	9,793	11,477	14,032	14,243	16,768	16,153	12,786	8,419	6,044	4,678
Solar Radiation (kWh/m^2/day)	**Large Scale Systems (>1 MW)**											
	2.72	3.57	4.38	5.53	7.27	8.22	9.48	8.85	6.87	3.95	2.79	2.05
Various PVs on ground 500kWp (kWh)	29,950	36,722	49,174	56,896	68,814	69,383	81,966	79,968	64,270	42,642	30,886	23,946
Various PVs on ground 1000kWp (kWh)	67,180	82,352	110,811	131,355	173,921	185,224	219,525	206,009	154,947	96,282	67,558	51,375
Various PVs on ground 2700kWp (kWh)	182,635	222,116	299,689	358,127	477,713	512,513	608,340	570,216	428,597	262,962	183,019	138,960

According to the results of the simulations, the energy produced on an annual basis by the photovoltaic systems installed in the study area is estimated. Thus, the energy production for the Phocis Regional Unit is estimated at 24,691MWh and for the Municipality of Delphi at 15,889MWh. Therefore, the proportion of the energy produced by the PV systems installed in the Municipality of Delphi corresponds to 64% of the total energy produced by this type of RES in Phocis (Figure 43).

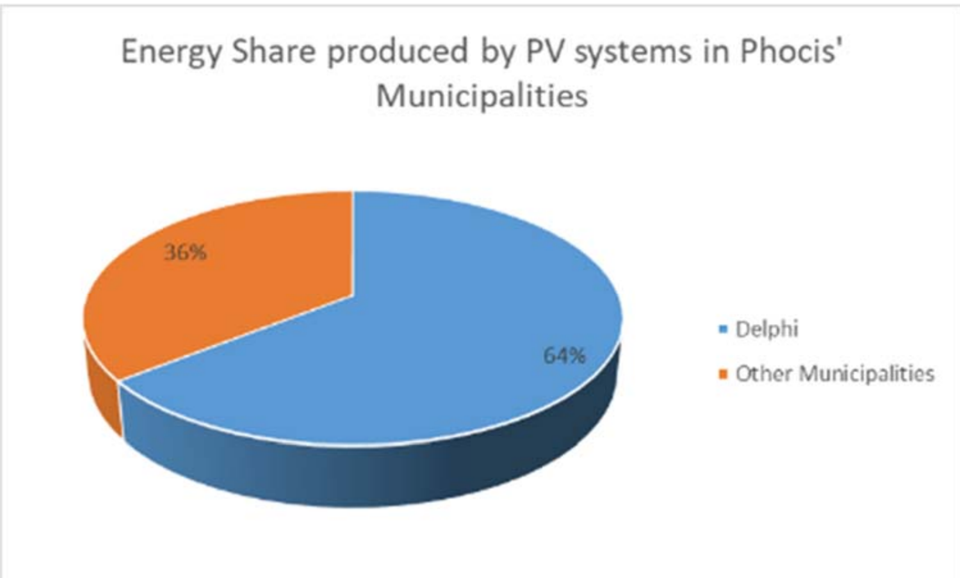


Figure 43 : Energy Share Produced by PV systems in Phocis' Municipalities

In addition, the energy produced by type of photovoltaic systems for the Prefecture of Fokida and the Municipality of Delphi is presented. In both cases it is estimated that the largest contribution to the production of energy from photovoltaics is due to medium-scale systems at a rate of 70% (Figure 44). Finally, if the photovoltaic systems that received operating license function in Phocis Regional function, it is estimated that the energy production can reach approximately 1,377,144 MWh.

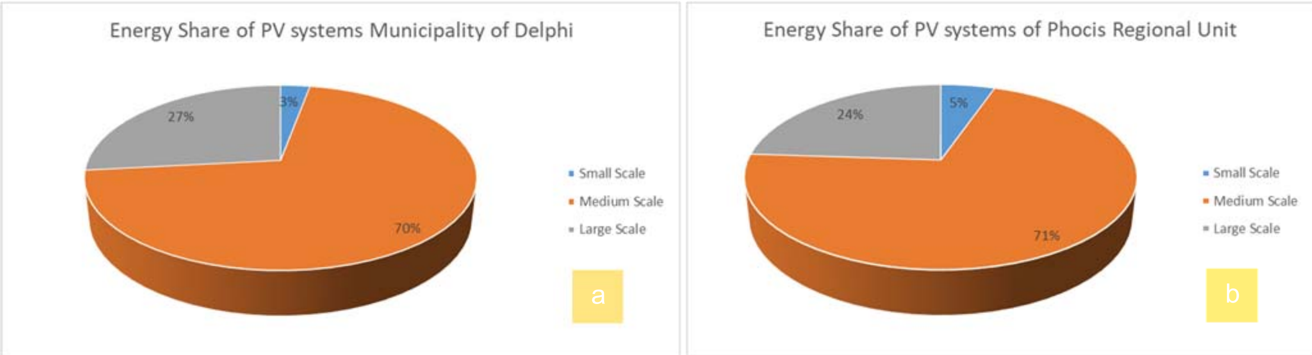


Figure 44 : Energy Share of various PV Systems a) Municipality of Delphi & b) Phocis Regional Unit

4.4. Total Energy Potential from RES

According to the aforementioned estimations, it seems that there is quite significant energy production both in the Regional Unit of Phocis and in the Municipality of Delphi, covered by RES. The three types of RES are wind turbines, small hydros and various types of PV systems. The total energy produced by these three types of RES accounts to 396,041 MWh in the Municipality of Delphi and to 955,097 MWh in the Phocis Regional Unit. Finally, the greatest share in energy production by RES is due to the installed wind farms, with a percentage that reaches approximately 80% for the Municipality of Delphi and with a percentage of 89% for Phocis Regional Unit (Figure 45).

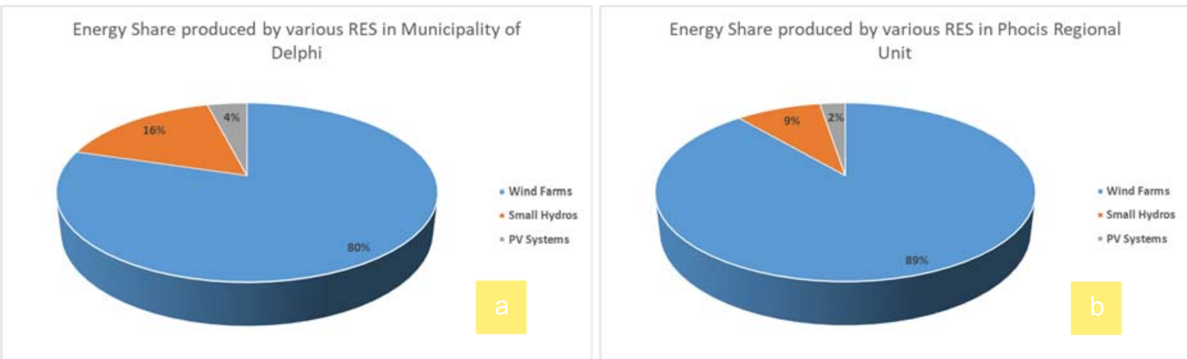


Figure 45: Energy share of energy production from RES a) Municipality of Delphi & b) Regional Unit of Phocis

5. Conclusions

The present work displays a first attempt to investigate all the possible energy sources that can be used in the production of hydrogen, a significant energy source for the promotion of electromobility. The regional unit of Phocis was defined as the main study area and more specifically the Municipality of Delphi. The research aimed to the investigation of the biomass potential that can be collected in this particular area and deriving both from the agricultural and forestry sectors. Regarding the agricultural biomass, the total biomass potential from all the cultivated arable crops was estimated by utilizing two different tools which have been developed by CERTH / CPERI. From the final results, it was concluded that olive tree prunings, was the most important source of biomass in the wide area of Amfissa's olive grove. Moreover, the possibility to use alternative sources of residual biomass deriving exclusively from the olive sector (olive kernel, pomace wood) was also examined, but unfortunately there is no any pomace mill in the region of Phocis, although there are 19 olive oil mills in the wider area. In terms of the forest biomass the results showed that there is a large theoretical potential that can be obtained from coniferous trees. However, these potential resources are still only theoretical, since each forestry authority has a specific forest management plan, which allows exploitation of significant trees per year. Along with these results, scenarios for the exploitation of biomass were also proposed. The energy that can be generated from the renewable energy sources installed in the area was also examined. In the current work, the information systems of RAE and HEDNO were used, which illustrate the RES that are installed in the study area. From these systems, it is concluded that there are three types of RES installed in the area: a) wind farms, b) small hydros and c) various types of photovoltaic systems. These systems were mainly installed at the beginning of the last decade, while in the mid-2010s this activity ceased. In order to estimate the energy that can be produced by each of the aforementioned systems, software simulations were carried out in softwares such as TRNSYS and RETSCREEN along with combination of the collected climate data. The results showed that the area has a remarkable potential for the energy production from RES and more specifically from the wind farms considering the significant wind potential that exists in Phocis and the nearby area.

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