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INITIALISING ENERGY BALANCE TOWARDS ZERO

MARCH 2023

TECHNICAL SUMMARY

FEASIBILITY STUDIES FOR THE ESTABLISHMENT OF ENERGY COMMUNITIES

EGALEO, PAVLOS MELAS, AND FARSALA MUNICIPALITIES

CONGREGATE

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TECHNICAL SUMMARY ON THE CASE STUDIES PREPARED IN GREECE UNDER THE CONGREGATE PROJECT

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1.1 General Description

Pavlos Melas is a municipality in the regional unit of Thessaloniki, Central Macedonia, Greece. It was named after the Greek hero of the Macedonian Struggle, Pavlos Melas. It was formed after the administrative reform introduced by the governmental Kallikratis plan (N. 3852/7.6.2010). It is the result of the unification of the former municipalities of Efkarpia, Polichni and Stavroupoli. The area of the new Municipality is 23.763 km^2. Of this total area, about 60% is a densely populated urban area, while the rest is a suburban area, located in the vicinity of residential areas and major roads. It is occupied by two major hospitals (General Hospital Papageorgiou and 424 Military Hospital) and industrial/manufacturing/commercial facilities, while the above are surrounded by an extensive wasteland of green space.

Its population, based on the last official census of 2021, is 99,969 and the seat of the municipality is in Stavroupoli. The subdivisions comprising the Municipality are:

- Municipal Unit of Efkarpia located on the northern side of the Thessaloniki Conurbation and on the northern side of the Municipality of Pavlos Melas. It has a population of 13.905 residents.
- Municipal Union of Polichni located on the northwest side of the Thessaloniki Conurbation and on the east side of the Municipality of Pavlos Melas. It has a population of 39.332 residents.
- Municipal Union of Stavroupoli located on the west side of the Thessaloniki Conurbation and on the southwest side of the Municipality of Pavlos Melas. It has a population of 46.008 residents.

According to Wikipedia[1] the modern outlook of the Municipality is a result of a gradual town planning which is closely connected to the residential course of action of the northern and western prefecture of the previous urban core of Thessaloniki. Since the homing of refugees - when the first systematic settlement of the area of interest takes place - and at different time zones the advent of new populations broadened its district creating urban pocks of residency that according to the circumstances and the time of development they acquired special town planning and social characteristics. Despite the coordinated efforts of the past decades of restraint of urban diffusion, it is still ongoing and characterises the area of the Municipality, including the areas with especially dense urban web but also regions with greater distance from the city center, legally or illegally developed with less urban characteristics.

The immediate proximity of the Municipality with transportational axes of entry and exit of the city, in the past and today, has as a result the mixture of usually incompatible practices with the existence of industrial and craft units, enough of which have been abandoned or dis-function. The wide peri-urban zone of the Municipality apart from the production units includes other activities of metropolitan and regional scale, such as the two hospitals and other fallow green and reforested areas of the peri-urban mountainous zone.

[1] https://en.wikipedia.org/wiki/Pavlos_Melas_(municipality)

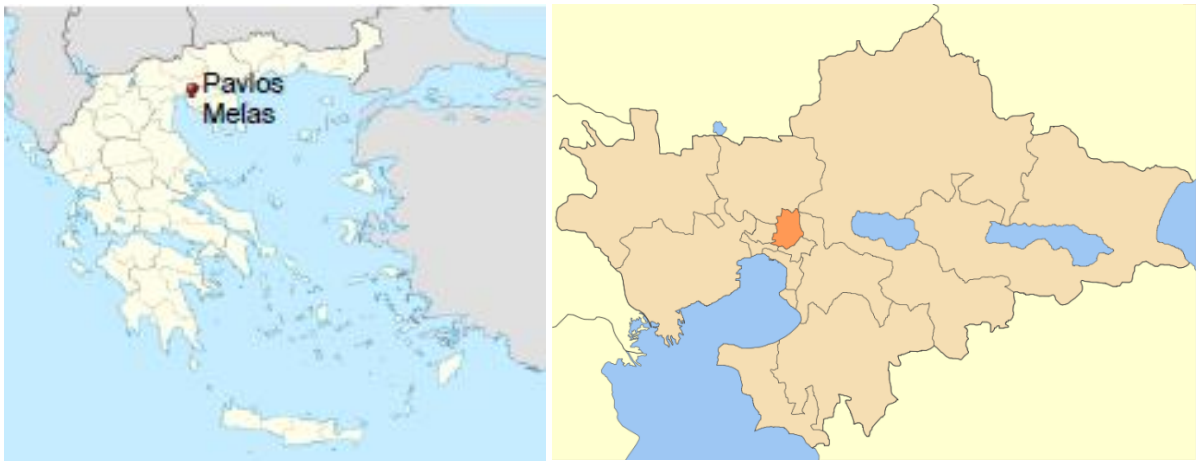


Figure 1: Location of Municipality of Pavlos Melas[2]

The Municipality of Pavlos Melas, belonging to the Regional Unit of Thessaloniki is included according to the Energy Efficiency Regulation of Building in the 3rd Climatic Zone, due to the relatively cold winters.

Table 1: General information of Municipality of Pavlos Melas

Administrative region	Central Macedonia
Regional unit	Thessaloniki
Area	23.763 km2 (9.175 sq. mi)
Elevation	45 m (146.60 ft)
Population (2021 census)	99,969
Municipality density	4,200/km^2 (11,000/sq. mi)
Climatic Zone	C
Coordinates	40°40′N 22°56′E
Website	https://pavlosmelas.gr/

[2] https://en.wikipedia.org/wiki/Pavlos_Melas_(municipality)

1.2 Context

This section presents the brief economic and technical analysis of the proposed energy investment of the Energy Community (EnCom) of the Municipality of Pavlos Melas which collectively concerns the construction of twenty-two (22) PV plants with a total installed capacity of 1.841 MWp in municipal buildings and sports halls as well as in school buildings of Primary and Secondary Education located within the boundaries of the Municipality. The members of EnCom via their participation they will utilise the model of virtual energy metering to cover their electrical needs, while the Municipality of Pavlos Mela through self-generation aims to fully cover the electrical loads of the municipal buildings as well as the school units where the photovoltaic stations will be installed. In particular, any individual who wishes to become a member of EnCom will be able to obtain the required percentage of the installed PV capacity of the Community that he needs, by purchasing corresponding shares, in order to cover its energy needs and thus reduce electricity bills.

1.3 Model Scenarios, Assumptions and Results

The energy analysis of the electricity production model of the EnCom was based on energy simulations and calculations as well as on empirical data and aims to present the main points and characteristics of the proposed project. For the area of Pavlos Melas the average annual energy gain at the level of PV collectors for the six years 2015-2020 amounted to 1828 kWh/m^2 according to the PVGIS-SARAH[3] database whereas the fluctuation of the solar irradiation at the optimal inclination (35^o) per month is presented in the following diagramme.

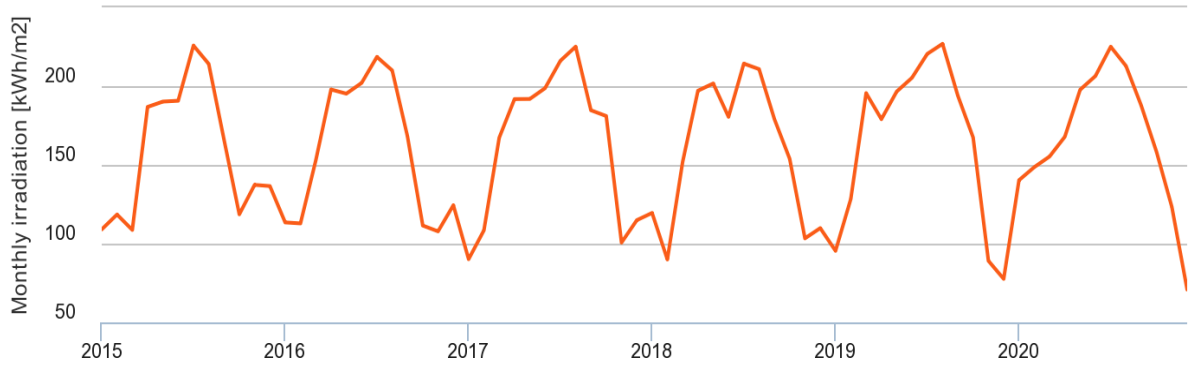


Diagramme 1: Average monthly solar radiation at 35° inclination 2015-2020 (Source PV-GIS)

In order to calculate the power produced, an energy analysis of the proposed photovoltaic plants per building unit was carried out. The energy simulation of the positioning of the photovoltaic units and the shading from the neighboring buildings was done via the PV-Syst software[4], while the simulation of the operation of the photovoltaic plant and the calculation of the produced electricity through the Sunny design web application of SMA[5]. An example of the energy simulation of one school building (Polichni 3rd General High School) is presented below.

[3] https://joint-research-centre.ec.europa.eu/pvgis-online-tool/pvgis-data-download/sarah-solar-radiation-data_en

[4] https://www.pvsyst.com/

[5] https://www.sunnydesignweb.com/sdweb/#/

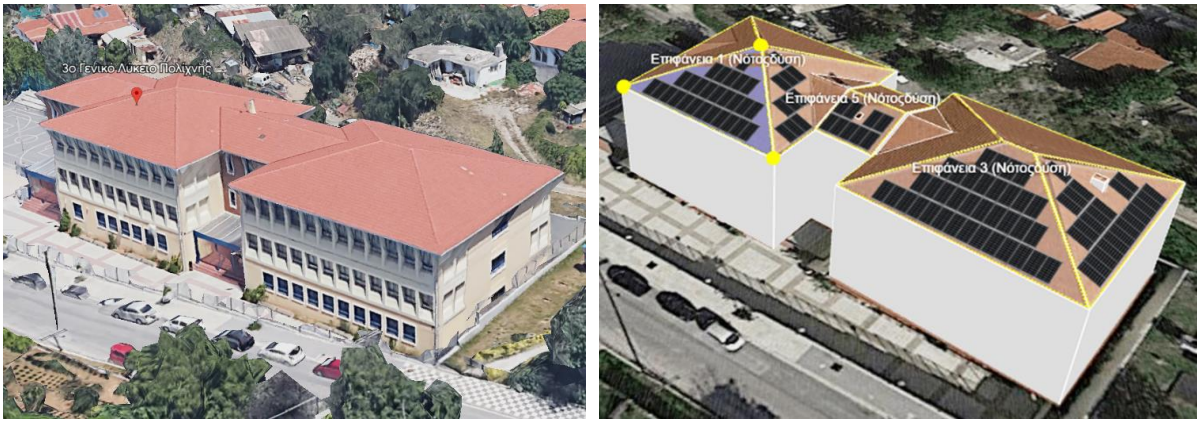


Figure 2: Energy simulation model of the school unit

The following diagramme is indicative of the monthly self-consumption of electricity in relation to the coverage and the quantities injected to the grid on a monthly basis.

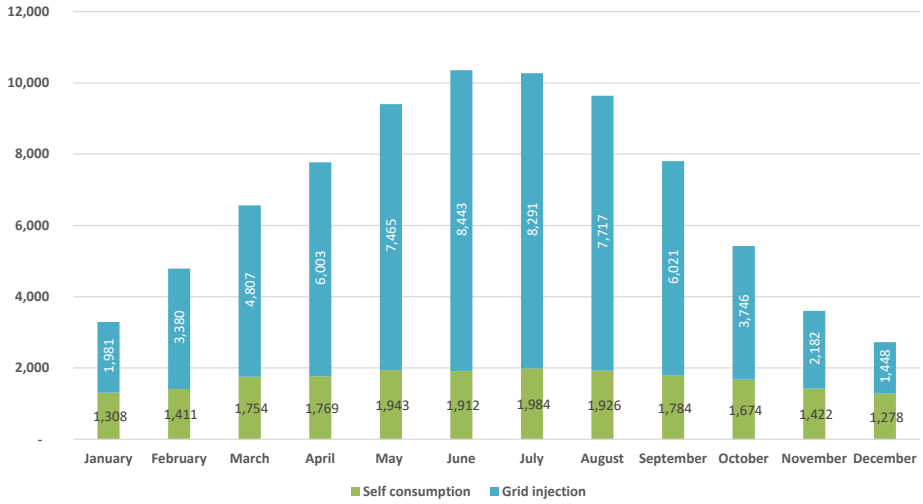


Diagramme 2: Monthly fluctuation of self-consumption and PV power injection to the grid

The summary of the technical-financial data of the proposed PV stations installation projects of the EnCom of the Municipality of Pavlos Melas is presented in the following table.

Table 2 Energy data of the proposed PV stations of the EnCom of Pavlos Melas Municipality

No	Municipal Building	Power needs	PV power production	PV station capacity	Total Cost
		[kWh]	[kWh]	[kW]	[€]
1	**1st Efkarpia Highschool**	41,998	30,060	22.68	29,480
2	**1st Stavroupoli Vocational Highschool**	432,803	340,585	365.58	405,245
3	**3rd Polichni Highschool**	31,200	81,649	56.70	64,475
4	**4th Stavroupoli Lyceum**	26,798	73,712	50.76	58,360
5	**4th Polichni Highschool**	23,340	118,596	82.62	97,955
6	**5th Stavroupoli Highschool**	32,729	55,768	39.42	51,405

No	Municipal Building	Power needs	PV power production	PV station capacity	Total Cost
		[kWh]	[kWh]	[kW]	[€]
7	**4th Stavroupoli Highschool**	38,519	55,543	38.88	47,380
8	**3rd Stavroupoli Lyceum**	41,444	93,669	65.34	75,225
9	**Polichni Conservatory**	27,603	46,217	34.02	39,705
10	**Stavroupoli Conservatory**	35,963	10,737	7.56	11,710
11	**Polichni Sports Hall**	8,756	322,250	237.60	270,000
12	**Alex Nikolaidis Sports Hall**	27,800	299,173	219.24	252,910
13	**Stavroupoli**	124,061	178,413	127.44	138,060
14	**Efkarpia Sports Hall**	18,155	151,720	106.38	119,445
15	**4th Stavroupoli Elementary School**	20,841	68,424	46.98	57,695
16	**6th Stavroupoli Elementary School**	13,897	47,315	31.86	38,015
17	**9th Stavroupoli Elementary School**	14,109	78,157	54.00	61,450
18	**13th Stavroupoli Elementary School**	22,368	27,063	19.98	26,645
19	**16th Stavroupoli Elementary School**	23,218	89,407	64.80	74,370
20	**18th Stavroupoli Elementary School**	26,000	77,432	55.08	64,420
21	**6th Polichni Elementary School**	29,481	90,239	62.64	69,160
22	**10th Polichni Elementary School**	27,080	76,013	51.84	59,460
	Total	**1,088,163**	**2,412,142**	**1,841**	**2,112,570**

From the above analysis it is depicted that a total of 2,412,142 kWh per annum can be produced by the installed PV stations of the Energy Community, covering the own needs of all the municipal buildings involved (1,088,163 kWh) whereas the surplus injected to the grid can cover in average the power needs of nearly 265 - 300 households – members of the EnCom (dependent on the annual energy consumption)[6]. Furthermore, and according to the national Law on Energy Communities and the relative amendments, there is an additional margin of 1.16 MW of additional power capacity that the EnCom of the Municipality could develop in future RES projects.

1.4 Financial Appraisal

For the financial appraisal of the proposed energy production plants, as cash flow is regarded the avoidance of the cost of supplying electricity to the members of the Energy Community (the charges of the Transmission and Distribution System plus municipal taxes are not exempt from the charge) and which on average has been received at a price of **€0.20/kWh** including VAT, since both the Municipality and the individuals who will participate in the Energy Community are not exempt from this. For the calculation of the cash flows and the main financial parameters for assessing the

[6] An average annual power consumption of 4500 – 5000 kWh has been taken as baseline consumption

sustainability of the project, it was assumed that its financing will be covered by the equity capital of the Municipality and its members, without loans.

Table 3: Economic evaluation data of the proposed EnCom projects of Pav. Melas Municipality

Total PV capacity	kWp	1,841
Electricity cost	€/kWh	0.200
Power production during year 1	kWh	2,412,142
Annual degradation of PV power efficiency	%	0.65
Annual energy costs savings	€	482,428
Annual CO_2 reduction	tn	2,050.32
Annual energy cost increase	%	1.50
Inflation rate	%	2.00
Loan interest rate	%	0.00
Discount rate	%	6.00
Investment cost	€	2,112,570
Annual expenses (maintenance, security, insurance etc)	€/kWp	12.00
Project life span	years	20

As already mentioned, the generated energy appears to be a financial benefit, due to the reduction of the tariff via net metering. Therefore, the amount corresponding to this benefit could be considered as the operating profit of the investment. Of this, a portion is the annual operating cost of the project while, in the case of future borrowing, another portion returns to cover the loan. The final amount is the total benefit of the investment. The following graph shows the interest payback period and the annual financial benefit of the investment for the equity financing scenario over the next 20 years, followed by the main financial appraisal indicators.

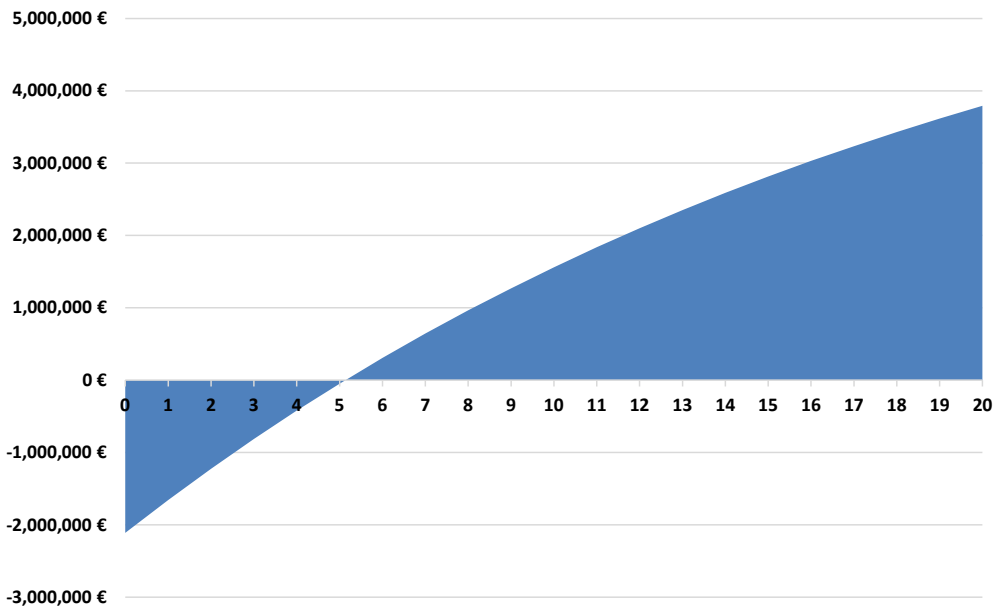


Diagramme 3: Interest payment period for the installation of the EnCom PV stations

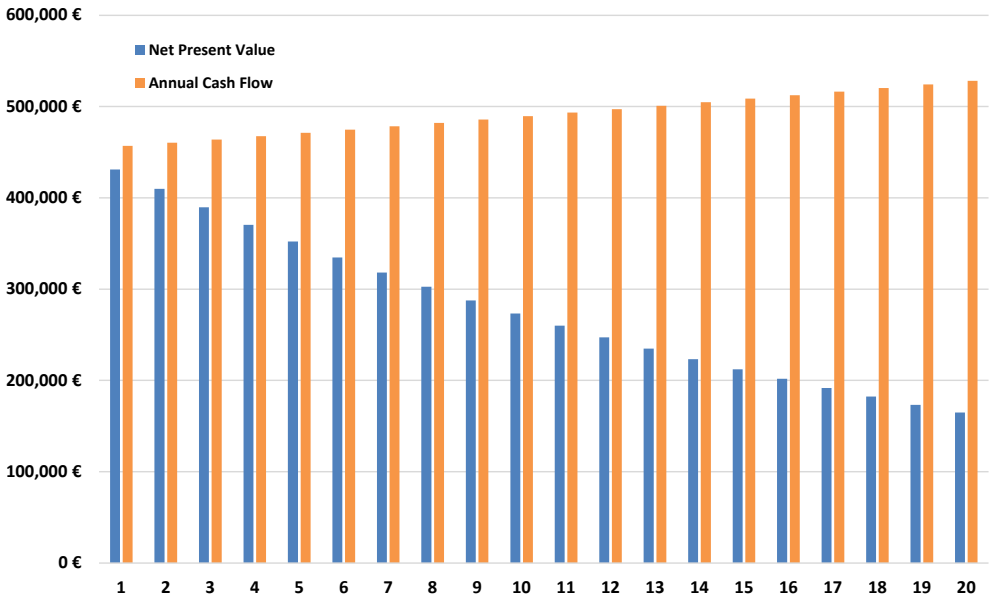


Diagramme 4: Net Present Value and cash flows of the proposed EnCom project

Table 4: Financial performance indicators of the proposed PV plants installation project of the EnCom

Net Present Value (NPV) of proposed investment	**3,447,446 €**

Internal Return Rate (IRR)	**21.92%**

Return of Investment (ROI)	
Investment cost	2,112,570 €
Net Present Value	3,447,446 €
ROI =	**163.19%**

Benefit To Cost Ratio (BCR)	
Net Present Value of Cumulative Outflows	2,455,999 €
Net Present Value of Cumulative Inputs	5,903,445 €
BCR =	**2.40**

2. MUNICIPALITY OF EGALEO

2.1 General Description

Egaleo is an urban area and the municipality is located in the Western Sector of the Athenian Field of the Attica Region with a population of 64,828 inhabitants according to the 2021 census. The Municipality of Egaleo is located in the western part of the urban complex of Athens and has been developed on both sides of the ancient Iera Odo (Holy Road). The city takes its name from Mount Egaleo, from where the Persian king Xerxes watched the destruction of his fleet by the Greeks, in the historic naval battle of Salamis (September 29, 480 BC).

The municipality borders to the east with the Municipality of Athens, to the north with the municipalities of Peristeri and Haidari, to the west with the municipalities of Nikaia - Agios Ioannis Rentis and Agia Barbara and south with the municipality of Moschato - Tavros. Until a few years ago, Egaleo was the capital of Western Attica, with the consequence that the city is home to several public services (Urban Planning, Forestry, etc.). A quarter of the municipality is an industrial area, while its territory is crossed by five major highways, namely the Avenues of Kifissos, Athens, Thebes, Petrou Ralli and Iera Odos. Egaleo is also crossed by the river Kifissos, which today is under the biggest motorway in Greece (PATHE Patras-Athens-Thessaloniki-Evzoni Motorway of 780 km distance).

The final boundaries of the municipality of Egaleo were formed with the successive additions and inclusions of new neighborhoods in the original housing unit which was limited to the narrow boundary of the community created by Presidential decree of January 18, 1934. In 1937 the first modification of the boundaries of the community was made. 1943 was renamed Municipality. Between 1952 and 1967 various neighboring areas were added thus expanding the Municipality's limits. The city consists of the quarters Kato Aigaleo, Neo Aigaleo, Damarakia, Lioumi, Rosika, Agios Spyridonas and Agios Georgios.

The city of Egaleo was inhabited en masse for the first time in the period 1922 - 1928 by refugees from Asia Minor, but also in 1930 by a small group of Christian Assyrians, who brought with them their traditions, culture, and music, so the city was the residence of many important folk artists. In 1934, by decree, the surrounding settlements formed the community of "Nea Kydonia" until 1941, when it became a Municipality.

Then, in the 1950s, it underwent a major wave of internal political and economic migration. In the 60's and 70's it was the place of settlement of the first wave of Pontian Returnees from the Eastern States (1965-1968) and industrial workers from the province, mainly due to the operation in the wider area of large industrial units. In recent years, foreign immigrants, and refugees, mainly Iraqis and Pakistanis, settled in the Municipality of Egaleo in the 1980s, and Greeks, Northern Epirotes and Albanians in the 1990s.

The Municipality of Egaleo has a total area of 650 hectares (Ha), of which the legislated area covers 538 Ha. The area of the non-legislative section 112 Ha concerns the area of Eleonas, most of which is occupied by large facilities of industries and handicrafts.

Egaleo is one of the oldest Municipalities of the country and has always been a pole of attraction for settlers. Its population, according to the 2011 census, is 69,940 inhabitants, but in reality, at least 100,000 people live and work in the city, mainly employees and professionals. It has a centrobaric character in the urban complex of Athens. It is a transport hub, as it is intersected by international and national roads, and hosts 3 Metro stations.

Figure 3: Location of Municipality of Egaleo[7]

Egaleo and the whole Municipality belonging to the Regional Unit of the Western Sector of Athens, are included according to the Energy Efficiency Regulation of Buildings in the 2nd Climate Zone, due to the relatively mild winter.

Table 5: General information of Municipality of Egaleo

Administrative region	Attica
Regional unit	West Athens
Area	6.450 km^2 (2.490 sq. mi)
Elevation	50 m (160 ft)
Population (2021 census)	64,828
Municipality density	11,050/km^2 (26,035/sq. mi)
Climatic Zone	B
Coordinates	37°59′31″N 23°40′41″E
Website	www.aigaleo.gr

2.2 Context

This section presents the brief economic and technical analysis of the proposed energy investment of the Energy Community (EnCom) of the Municipality of Egaleo which collectively concerns the construction of sixteen (16) PV plants with a total installed capacity of **1.995 MWp** in school buildings of Primary and Secondary Education located within the boundaries of the Municipality. The members of EnCom through their participation they will utilise the model of virtual energy metering to cover their electrical needs, while the Municipality of Egaleo through self-generation aims to fully cover the electrical loads of the school units where the photovoltaic stations will be installed. In particular, any individual who wishes to become a member of EnCom will be able to obtain the required percentage

[7] https://en.wikipedia.org/wiki/Aigaleo

of the installed PV capacity of the Community that he needs, by purchasing corresponding shares, in order to cover his energy needs and thus reduce electricity bills.

2.3 Model Scenarios, Assumptions and Results

The energy analysis of the electricity production model of the EnCom was based on the same methodology followed for the case study of the Municipality of Pavlos Melas. For the city of Egaleo the average annual energy gain at the level of PV collectors for the six years 2015-2020 amounted to 1831 kWh/m^2 according to the PVGIS-SARAH database whereas the fluctuation of the solar irradiation at the optimal inclination (33º) per month is presented in the following Table and Diagramme.

Table 6: Average monthly solar radiation at horizontal level 2015-2020 (Source PV-GIS)

Month	2015	2016	2017	2018	2019	2020
January	79.72	77.3	72.2	82.43	74.77	78.12
February	82.06	103.02	97.66	89.72	90.36	104.41
March	119.84	134.43	147.71	144	155.84	143.41
April	182.41	202.71	189.04	191.13	161.44	179.27
May	223.15	206.03	203.08	215.33	205.03	220.19
June	216.06	230.87	220.47	226.2	236.22	238.14
July	251.59	246.88	240.29	234.35	235.35	242.22
August	213.54	216.11	223	217.8	220.96	214.23
September	163.95	156.09	173.06	153.04	166.93	166.08
October	113.32	107.38	133.13	118.49	125.82	120.88
November	93.71	82.41	77.93	76.91	82.25	76.57
December	77.64	71.75	74.27	64.05	63.85	65.46
Total	**1816.99**	**1834.98**	**1851.84**	**1813.45**	**1818.82**	**1848.98**

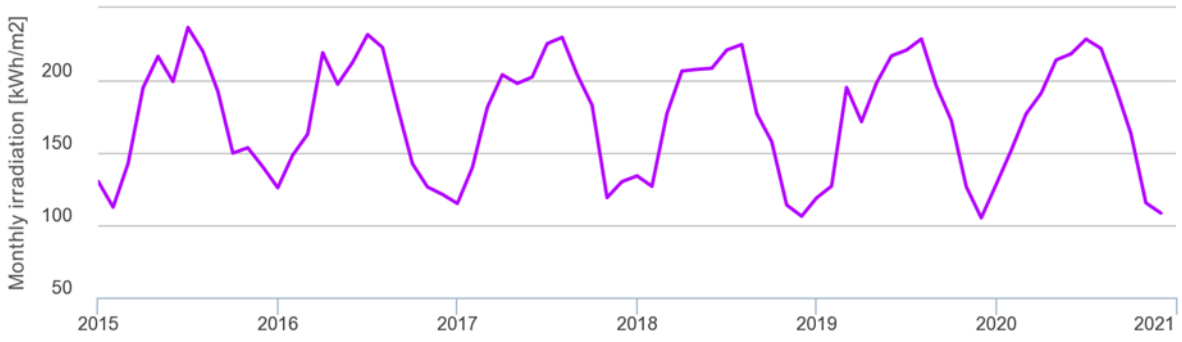


Diagramme 5: Average monthly solar radiation at 33° inclination 2015-2020 (Source PV-GIS)

In order to calculate the power produced, an energy analysis of the proposed photovoltaic plants per building unit was carried out. The energy simulation of the positioning of the photovoltaic units and the shading from the neighboring buildings was done via the PV-Syst software, while the simulation

of the operation of the photovoltaic plants and the calculation of the produced electricity through the Sunny design web application of SMA.

Figure 4: Energy simulation models of various school units of Egaleo

The summary of the technical-financial data of the proposed PV stations installation projects of the EnCom of the Municipality of Egaleo is presented in the following table.

Table 7 Energy data of the proposed PV stations of the EnCom of the Municipality of Egaleo

No	Municipal Building	Power needs	PV power production	PV station capacity	Total Cost
		[kWh]	[kWh]	[kW]	[€]
1	**1st -2nd Vocational Highschool**	63,838	330,049	477.90	514,595

No	Municipal Building	Power needs	PV power production	PV station capacity	Total Cost
		[kWh]	[kWh]	[kW]	[€]
2	**6th and Special Vocational Highschool**	159,666	184,946	228.42	234,800
3	**4th Lyceum**	30,970	156,576	183.60	202,700
4	**3rd Highschool**	18,428	78,867	71.82	75,305
5	**4th Highschool**	16,590	186,511	126.36	132,990
6	**5th Lyceum**	15,740	158,010	179.28	210,220
7	**9th Highschool**	17,655	154,257	165.78	167,600
8	**Special Kindergarten & Elementary**	22,983	133,418	108.54	115,045
9	**5th Highschool**	12,807	116,858	112.32	110,020
10	**20th Elementary School**	11,317	71,694	70.74	76,000
11	**30th Kindergarten**	2,772	29,022	17.82	21,510
12	**6th Kindergarten**	2,163	11,849	9.72	14,187
13	**19th Elementary School**	12,000	124,096	82.08	88,237
14	**14th Elementary School**	11,460	85,556	59.40	63,716
15	**8th Elementary School**	9,767	99,230	71.28	75,260
16	**24th Kindergarten**	3,706	20,060	30.24	35,586
	Total	**411,862**	**1,940,999**	**1,995**	**2,137,771**

From the above analysis it is depicted that a total of 1,940,999 kWh per annum can be produced by the installed PV stations of the Energy Community, covering the own needs of all the school buildings involved (411,862 kWh) whereas the surplus injected to the grid can cover in average the power needs of nearly 304 - 340 households – members of the EnCom (dependent on the annual energy consumption)[8]. Furthermore, and according to the national Law on Energy Communities and the relative amendments, there is an additional margin of 1.005 MW of additional power capacity that the EnCom of the Municipality could develop in future RES projects and further expansion.

2.4 Financial Appraisal

For the financial appraisal of the proposed energy production plants, as cash flow is regarded the avoidance of the cost of supplying electricity to the members of the Energy Community (the charges of the Transmission and Distribution System plus municipal taxes are not exempt from the charge) and which on average has been received at a price of **€0.20/kWh** including VAT, since both the Municipality and the individuals who will participate in the Energy Community are not exempt from this. For the calculation of the cash flows and the main financial parameters for assessing the

[8] An average annual power consumption of 4500 – 5000 kWh has been taken as baseline consumption

sustainability of the project, it was assumed that its financing will be covered by the equity capital of the Municipality and its members, without loans.

Table 8: Economic evaluation data of the proposed EnCom projects of Egaleo Municipality

Total PV capacity	kWp	1,995
Electricity cost	€/kWh	0.200
Power production during year 1	kWh	1,940,999
Annual degradation of PV power efficiency	%	0.65
Annual energy costs savings	€	388,200
Annual CO_2 reduction	tn	1,650
Annual energy cost increase	%	1.50
Inflation rate	%	2.00
Loan interest rate	%	0.00
Discount rate	%	6.00
Investment cost	€	2,137,771
Annual expenses (maintenance, security, insurance etc)	€/kWp	12.00
Project life span	years	20

The following graph shows the interest payback period and the annual financial benefit of the investment for the equity financing scenario over the next 20 years, followed by the main financial appraisal indicators.

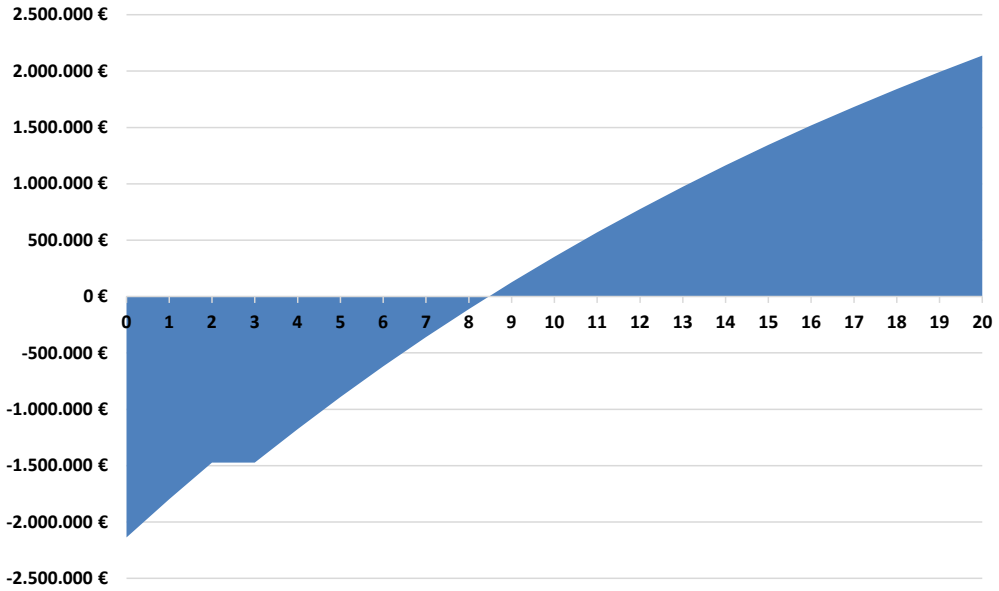


Diagramme 6: Interest payment period for the installation of the EnCom PV stations

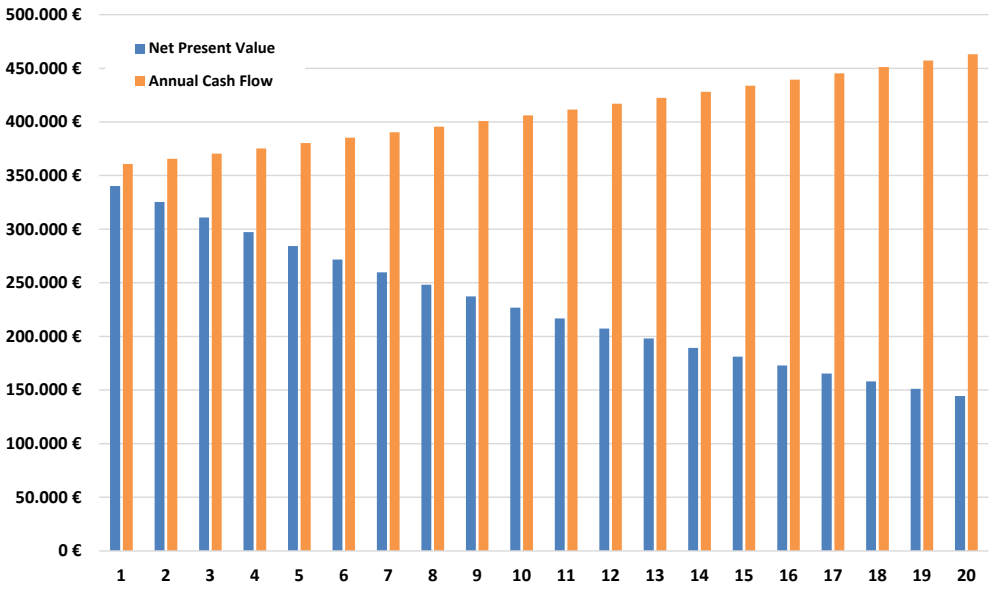


Diagramme 7: Net Present Value and cash flows of the proposed EnCom project

Table 9: Financial performance indicators of the proposed PV plants installation project of Egaleo EnCom

Net Present Value (NPV) of proposed investment	2,448,010 €

Internal Return Rate (IRR)	17.30%

Return of Investment (ROI)	
Investment cost	2,137,771 €
Net Present Value	2,448,010 €
ROI =	**114.51%**

Benefit To Cost Ratio (BCR)	
Net Present Value of Cumulative Outflows	2,491,515 €
Net Present Value of Cumulative Inputs	4,939,525 €
BCR =	**1.98**

3. MUNICIPALITY OF FARSALA

3.1 General Description

The Municipality of Farsala is a Municipality of the Region of Thessaly and occupies the southern part of the Regional Unit of Larissa. Administratively it consists of 1 Municipal Community and 27 Local Communities. The seat of the new Municipality is Farsala. The population of the Municipality, according to the official data for 2021, reaches 22,149 legal residents and 16,310 permanent residents and occupies a total area of 739,737 square kilometers.

Of the 27 local communities and 1 municipal community that comprise the Municipality of Farsala, 2 local communities are classified (according to Directive 75/268 / EEC, as amended and in force) as mountainous, 5 as disadvantaged while the remaining 20 communities and the Municipal Community of Farsala are characterised as dynamic.

Of the total area of the Municipality, 104,803 Km^2 (14.17%) belong to local communities that are classified as mountainous, 130,971 Km^2 (17.71%) are classified as disadvantaged, while the remaining 503,963 Km^2 (68.12%) belong to municipal districts that are characterised as dynamic. Respectively, out of the total population, 620 inhabitants (2.64%) live in local communities that are characterised as mountainous, 2380 inhabitants (10.11%) live in local communities that are characterised as disadvantaged, while the remaining 20,531 inhabitants (87,25%) live in local communities that are characterised as dynamic.

The Capital[9]

Farsala, known in Antiquity, is the capital of Municipality and is one of the largest towns of the Regional Unit of Larissa and the significant economic and agricultural centre. It lies at the southern edge of the Thessalian Plain, 4 km south of the river Enipeas. Farsala is located 38 km south of Larissa, 41 km east of Karditsa, 44 km north of Lamia and 49 km west of Volos. The municipal unit Farsala has an area of 121.433 km2, and the community Farsala has an area of 57.928 km^2.

[9] https://en.wikipedia.org/wiki/Farsala

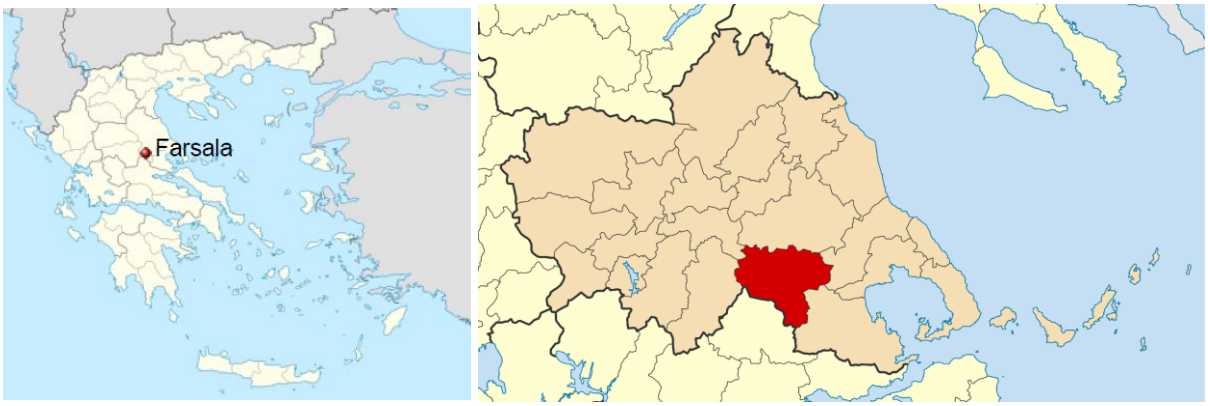


Figure 5: Location of Municipality of Farsala

Farsala and the whole Municipality belonging to the Regional Unit of Larissa, are included according to the Energy Efficiency Regulation of Buildings in the 3rd Climate Zone, due to the relatively cold winter.

Table 10: General information of Municipality of Farsala

Administrative region	Thessaly
Regional unit	Larissa
Area	739.74 km^2 (286.60 sq. mi)
Elevation	160 m (520 ft)
Population (2021 census)	16,310
Municipality density	22.04/km^2 (56.90/sq. mi)
Climatic Zone	C
Coordinates	39°18′N 22°23′E
Website	https://farsala.gr/

3.2 Context

The proposed energy approach for the Energy Community of the Municipality of Farsala is the construction of a **1 MWp** PV plant which will utilise the model of virtual energy metering for the members of the Community and the Municipality itself. In particular, each member will be able to obtain the percentage of the PV plant he needs, by purchasing corresponding shares, in order to cover his energy needs and thus reduce the electricity bills.

The project will be implemented in a municipal area located within the Region of Thessaly and in particular in the wider area of the Municipality of Farsala, in direct or very close access to the region's Medium Voltage grid. The land will be granted by the Municipality.

According to the amendment of the Ministry Energy-Environment as included in Law 4759/2020 (Government Gazette 245/A/09.12.2020) the maximum project that can be implemented by an Energy Community and included in the Virtual Energy Metering scheme is 3 MW. Thus, a further addition of 2 MW installed capacity is foreseen for the municipal EnCom, to be implemented in the second stage of the Community's development via the engagement of additional households and small-middle enterprises.

3.3 Model Scenarios, Assumptions and Results

As already mentioned above, the proposed PV plant will have a nominal capacity of 1000 kW in the first stage of its development, with the prediction to be increased to 3 MW in future stage. The direction of the PV panel is to the south (180°) while the inclination of the PVs bases is chosen to be 33° based on the geographical location of the PV station and the optimal performance of the panels on the specific slope throughout the year. The following diagramme shows the monthly energy production from the PV station. For the simulation and calculations of the energy output of the PV station, the freely accessible online libraries of the Photovoltaic Geographical Information System (PVGIS) of the Institute for Energy and Transport of the European Joint Research Centre were used[10].

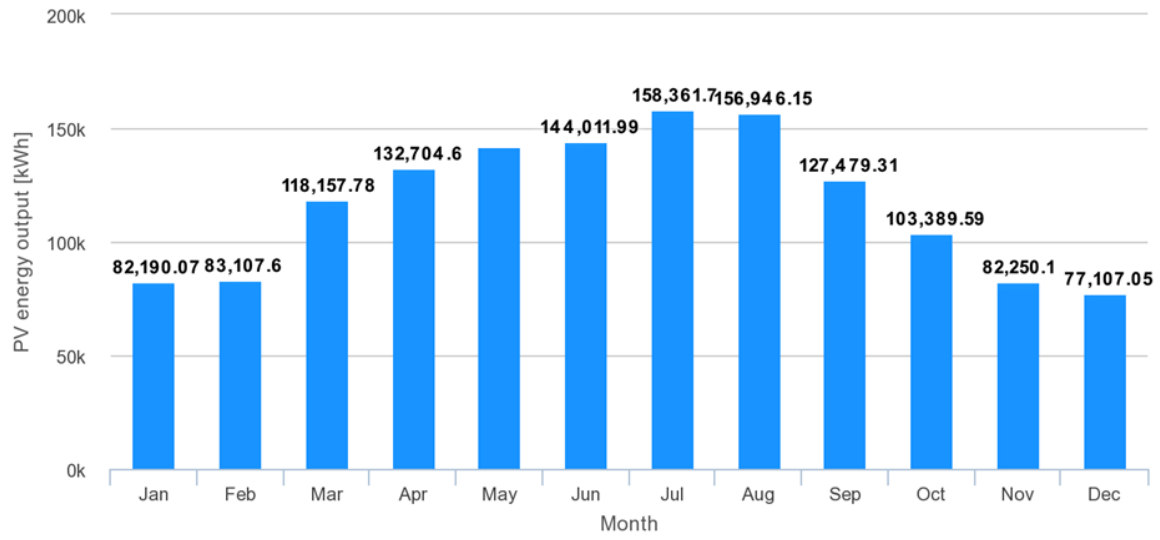
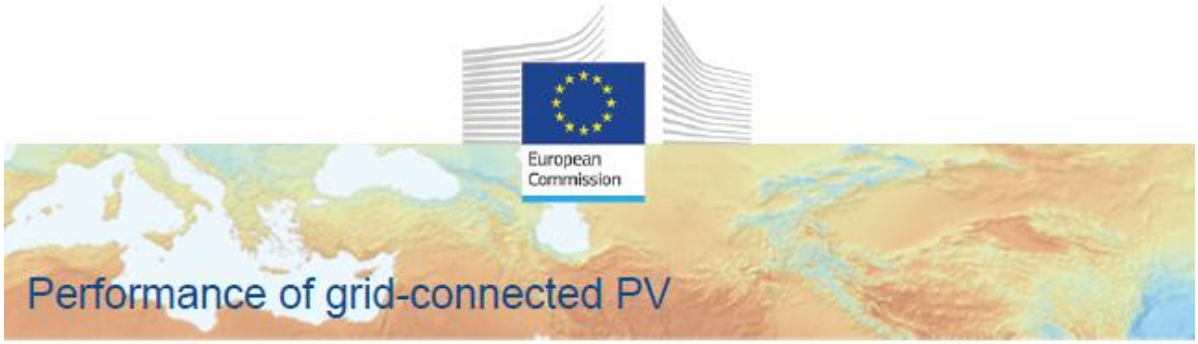


Diagramme 8: PV power output of the PV plant of the Energy Community of Farsala Municipality

[10] https://re.jrc.ec.europa.eu/pvg_tools/en/



PVGIS-5 estimates of solar electricity generation:

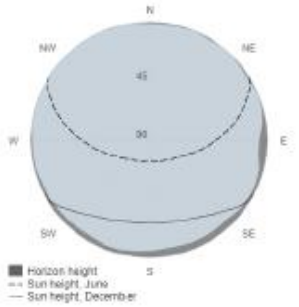
Provided inputs:

Latitude/Longitude:	39.305,22.386
Horizon:	Calculated
Database used:	PVGIS-SARAH2
PV technology:	Crystalline silicon
PV installed:	1 kWp
System loss:	14 %

Simulation outputs

Slope angle:	33 (opt) °
Azimuth angle:	-2 (opt) °
Yearly PV energy production:	1407.5 kWh
Yearly in-plane irradiation:	1852 kWh/m²
Year-to-year variability:	45.39 kWh
Changes in output due to:	
Angle of incidence:	-2.73 %
Spectral effects:	0.75 %
Temperature and low irradiance:	-9.83 %
Total loss:	-24 %

Outline of horizon at chosen location:



Monthly energy output from fix-angle PV system:

Monthly in-plane irradiation for fixed-angle:

Monthly PV energy and solar irradiation

Month	E_m	H(i)_m	SD_m
January	82.2	100.0	22.5
February	83.1	102.8	15.8
March	118.2	149.8	13.1
April	132.7	173.3	12.7
May	141.8	190.0	6.9
June	144.1	197.3	7.4
July	158.4	219.9	5.7
August	157.0	217.0	5.8
September	127.5	171.6	10.6
October	103.4	134.3	17.2
November	82.2	102.3	13.3
December	77.1	93.8	13.7

E_m: Average monthly electricity production from the defined system [kWh].

H(i)_m: Average monthly sum of global irradiation per square meter received by the modules of the given system [kWh/m²].

SD_m: Standard deviation of the monthly electricity production due to year-to-year variation [kWh].

Report generated on 2023/02/09

Figure 6: PV plant output calculation result sheet from the PV-GIS platform

3.4 Financial Appraisal

For the financial appraisal of the proposed PV plant, as cash flow is regarded the avoidance of the cost of supplying electricity to the members of the Energy Community (the charges of the Transmission and Distribution System plus municipal taxes are not exempt from the charge) and which on average has been received at a price of €0.18/kWh including VAT, since both the Municipality and the individuals who will participate in the Energy Community are not exempt from this. For the calculation of the cash flows and the main financial parameters for assessing the sustainability of the project, it was assumed that its financing will be covered by the equity capital of the Municipality and its members, without loans.

Table 11: Economic evaluation data of the proposed Municipality of Farsala EnCom PV station

Total PV capacity	kWp	1,000
Electricity cost	€/kWh	0.16
Power production during year 1	kWh	1,382,130
Annual degradation of PV power efficiency	%	1.00
Annual energy costs savings	€	221,141
Annual CO_2 reduction	tn	1,174.81
Annual energy cost increase	%	1.50
Inflation rate	%	2.00
Loan interest rate	%	0.00
Discount rate	%	6.00
Investment cost	€	850,000
Annual expenses (maintenance, security, insurance etc)	€/kWp	12
Project life span	years	20

The following graph shows the interest payback period and the annual financial benefit of the investment for the equity financing scenario over the next 20 years, followed by the main financial appraisal indicators.

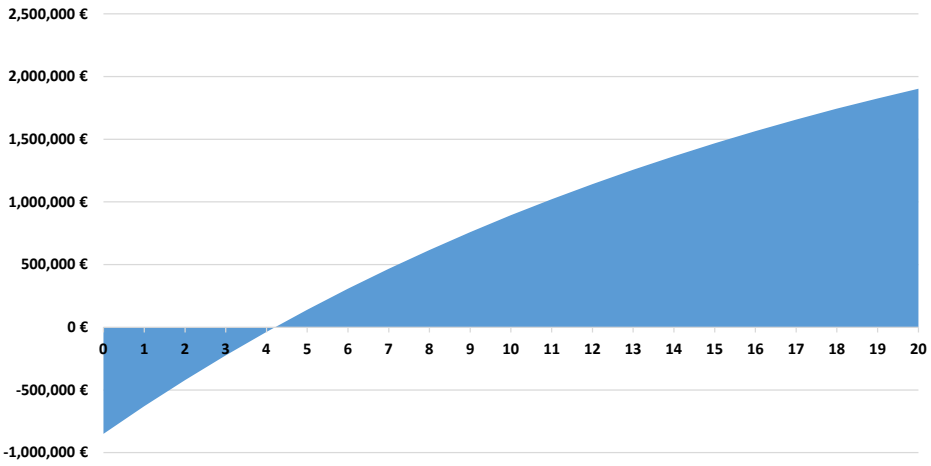


Diagramme 9: Interest payment period for the installation of the Municipality of Farsala EnCom PV station

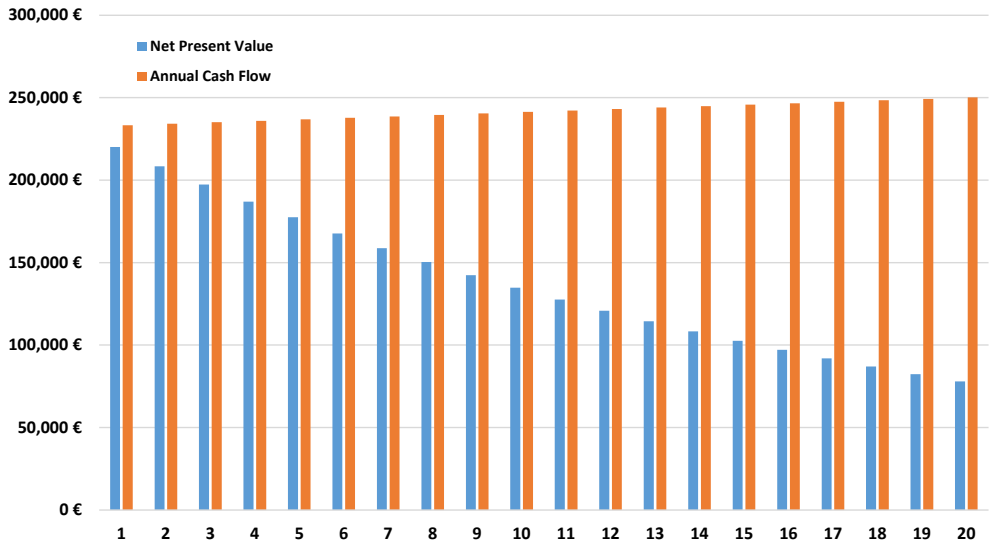


Diagramme 10: Net Present Value and cash flows of the proposed Municipality of Farsala EnCom project

Table 12: Financial performance indicators of the proposed Municipality of Farsala EnCom project

Net Present Value (NPV) of proposed investment	1,904,072 €

Internal Return Rate (IRR)	27.60%

Return of Investment (ROI)	
Investment cost	850,000 €
Net Present Value	1,904,072 €
ROI =	**224.01%**

Benefit To Cost Ratio (BCR)	
Net Present Value of Cumulative Outflows	1,057,961 €
Net Present Value of Cumulative Inputs	2,961,560 €
BCR =	**2.80**

4. ADDITIONAL ENERGY COMMUNITIES' ACTIVITIES

As already mentioned above, it is proposed that the development of the three Energy Communities to take place in two distinct stages. The initial stage will concern the establishment of the EnComs and the licensing and operation of the photovoltaic power plants via virtual net metering, as already described. The land/roof spaces will be provided by each Municipality and the funding will be proportionally divided to all members of each Community according to their shares.

The 2nd stage concerns the further development of the EnComs both in terms of the number of members and the expansion with additional fields of activity. In addition to the "One Stop Shop" function that will provide guidance and consulting services to the citizens and the entrepreneurs of each Municipality in the implementation of energy saving projects and the integration of Renewable Energy Sources, other activities that can be developed, in accordance with the national Law on Energy Communities, are as follows:

- Further development of Renewable Energy Sources (RES) projects and mainly small PV (with power up to 20 kWp) with energy net metering or virtual energy metering in municipal buildings and installations.
- Development of electric vehicle charging network and infrastructure. Each Energy Community can be active in the installation and operation of solar charging stations for electric vehicles in various public spaces of each Municipality. Hence in order to enhance electrification in the area, but also to promote it as a destination that respects the environment and accepts innovation. At the same time, it will be able to procure electric vehicles and create a shared electric mobility network that members of each Energy Community will be able to use for their transportation.
- Provision of energy services, attracting funds for the realisation of investments in the utilisation of RES, Combined Heat and Power (CHP) projects or Energy Efficiency (EE) interventions. Each Energy Community will be able to offer energy services to its members, providing incentives to businesses and citizens to participate in them. In addition, the EnComs will be able to attract funds either from private entities or from co-financed programmes for the realisation of the relative RES or EE investments.
- Compilation of RES, EE and/or CHP utilisation studies or implementing interventions to improve the energy efficiency of buildings and facilities. Provision of technical support to the members of each EnCom.
- Information, training, and awareness at the local level on issues of energy efficiency, smart buildings, RES, circular economy, and sustainability in general.

5. APPLIED SOURCES OF INFORMATION

Municipality of Pavlos Melas Operational Programme 2014 – 2019

Municipality of Egaleo Strategic Plan 2015-2019

Municipality of Farsala Operational Programme 2015-2019

Municipality of Pavlos Melas Sustainable Energy Action Plan 2013

Municipality of Egaleo Sustainable Energy Action Plan 2021

Municipality of Farsala Sustainable Energy Action Plan 2014

Municipality of Pavlos Melas website	https://pavlosmelas.gr/
Municipality of Egaleo website	https://www.aigaleo.gr
Municipality of Farsala website	https://www.farsala.gr/
Wikipedia – Municipality of Pavlos Melas	https://en.wikipedia.org/wiki/Pavlos_Melas_(municipality)
Wikipedia – Municipality of Egaleo	https://en.wikipedia.org/wiki/Aigaleo

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