A new paradigm for local infrastructure to enhance the potential of Finiq and its surroundings

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Abstract- *The main aim of this report is to promote an innovative approach for Municipalities, engineers and designers showing instruments and methodologies to envision a new paradigm for the future of those areas that area suffering emigration of population and lack of infrastructures.*
A specific case study has been identify in the village of Finiq, located in the South of Albania - and topic of the 8th International Workshop of Tirana – which, due to the isolation of its population, related to historical and geo-morphological characteristics, is registering a constant shrinking of the inhabitants in search of occupational and educational facilities.
Whitin the development of the investigation Finiq has been first evaluated at local scale – estimating the needs of the inhabitants – and secondly it has been systemised with the surrounding villages: Aliko, Mesopotam, Vrion. This approach led to an implementation of the interconnection within the villages as necessary action to overcome the isolation of all the inhabitants.
This analysis has been the starting point for the definition of the strategy to adopt as an opportunity to develop an innovative structure for the management of mobility, local resources and energy use, to increase the touristic attractiveness of the site and to provide the inhabitant with a strategic and widespread infrastructure.
To be truly effective, the mentioned approach includes an active participation of the citizen/user, who becomes the main actor and prosumer of his own infrastructure and whom, through an adequate information program, becomes able to modify and align his own behaviors to this new one paradigm.
The outcome of this report has the characteristics to be implemented and replicated in other context with similar issues, not only by designers but also by public administrations or private stakeholders that have to confront with similar social and demographic issues, putting an end to the systematic abandonment of the areas and to unlock their economic and demographic development.

Keywords:
Renewable, energy, isolation, Municipality, photovoltaic, electricity.

Introduction - The aim of this paper is to introduce an innovative approach for the fulfillment of energy needs of small-medium communities that provides energetic independence, leading to both environmental – reducing CO2 and greenhouse gasses emissions – and social – support to people in need or providing services to the community - benefits. These action may contribute to reduce the shrinking of population from small and isolated Communities.
Main actor of this approach is the Municipality, whose active participation is fundamental to involve the inhabitants towards a collective action, led by the Municipality itself. Therefore, target of this paper are both Municipalities, engineers,

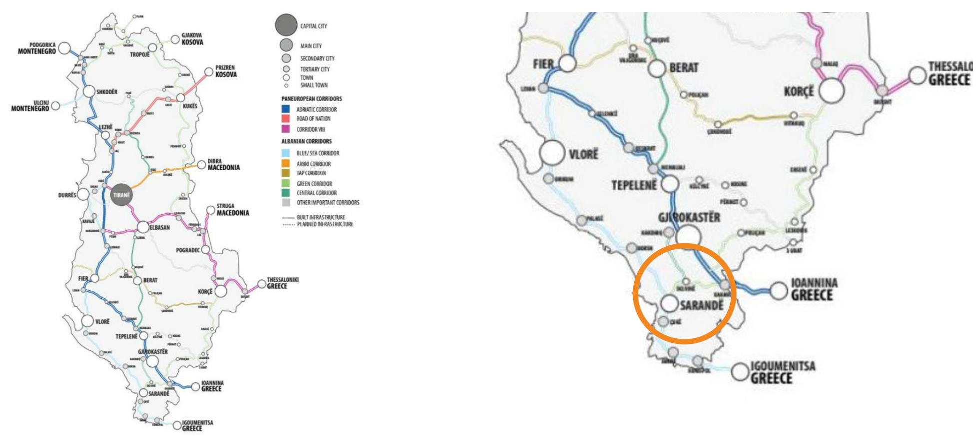

Fig1 / South of Albania - location of Finiq
source / Albania 2030 - Manifesto

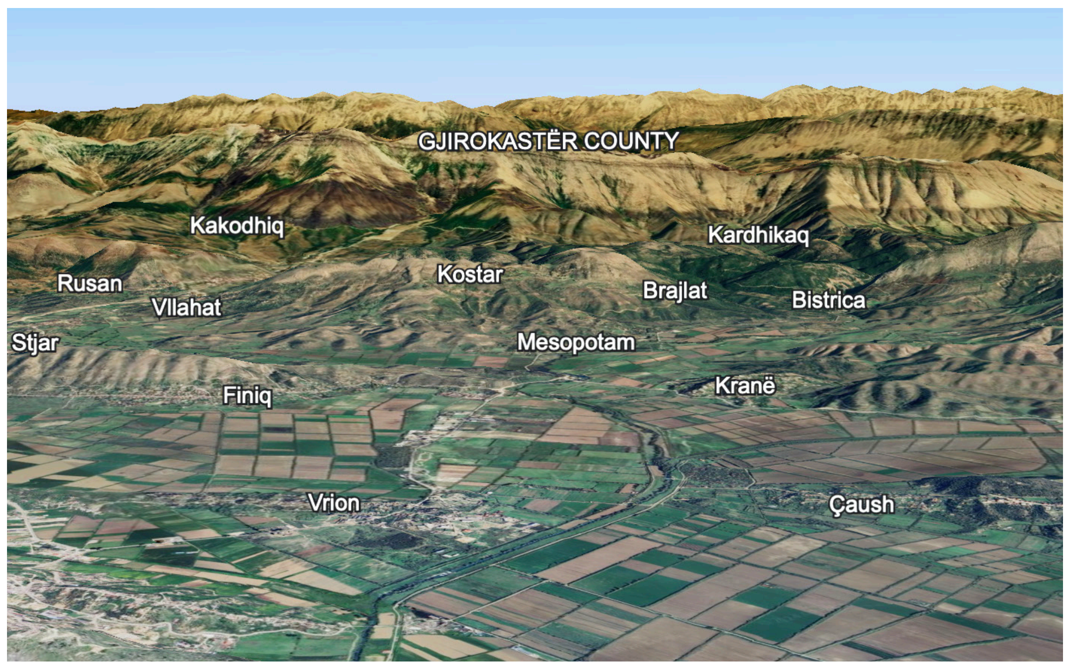

Fig2 / Finiq and surrounding villages
source / google earth

architects and designers that may use the outcome of this analysis as guidelines for the replication of the project in other areas that present similar conditions.
This approach may also represent a solid foundation for the further implementation of additional services for the Community.
In Chapter 2 the methodology approach is described, providing a preliminary analysis of the energetic state of the art of the region of Finiq – case study of this analysis - and an estimation of the energetic need of the local community based on available data; having define the baseline of the calculation, the following step is the elaboration of those data for the identification of the technology that fulfills the estimated energy needs, providing the lower environmental impact.
Chapter 3 analyses the environmental and economic benefit that the adoption of the methodology described will provide to the Community and its inhabitants.
Chapter 4 provides an overview of recommendations for the replicability of the project; those evaluations are based on the results of the analysis of previous chapters.

Methodology Approach

Background

Like many other regions in Albania, the Finiq area is experiencing a constant migration of its inhabitants to other cities or foreign countries – due to the proximity to the border as clear from Fig1 - that present greater possibilities in terms of services offered and job opportunities.
This phenomenon, particularly in the Finiq area, is due to the particular configuration of the area, which is geomorphologically isolated from the surrounding villages (Fig2).
Within the workshop it appeared immediately relevant that the infrastructures present on the territory have a determining role in daily life of its population, affecting its perception of surrounding spaces, the proximity of neighboring villages and their potential.
It is therefore necessary to reverse this process by intervening on existing critical issues and favoring the potential of Finiq. that can be summarized as following:
- Promote local mobility to foster interconnection towards close villages;
- Promote living in small-medium villages by adopting specific policies (i.e.: providing control-priced energy to inhabitant)

The analysis of the territory of Finiq and the infrastructure has highlighted a shortage of public services dedicated to the transport of people within the neighborhood villages: Finiq is therefore difficult to reach both from the main cities, more touristic attractions, and from neighboring countries, due to the lack of alternatives to private wheel mobility.
The implementation of such services is therefore of considerable effectiveness, both for the use of potential tourists and citizens who wish to move differently or are in physical conditions that do not allow the use of private resources.
This solution must be cost-effective, have a low-impact on the territory - meaning providing no increasing in greenhouse gases – and, considering the strategic implication of this action, should be led by the Municipality,.
Thanks to its geomorphological configuration and its wealth of resources, Albania has a significant tradition in the field of hydroelectric technology; the Finiq area has no obstacles in orographic terms (Fig4) and present a Global Horizontal Irradiation slightly higher than surrounding

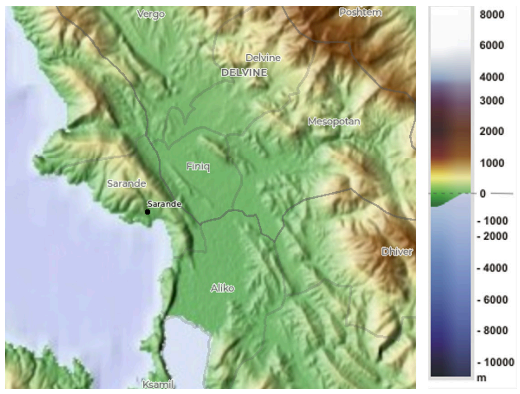

Fig3 / Ground elevation of Finiq Area
source / Globalsolaratlas.info

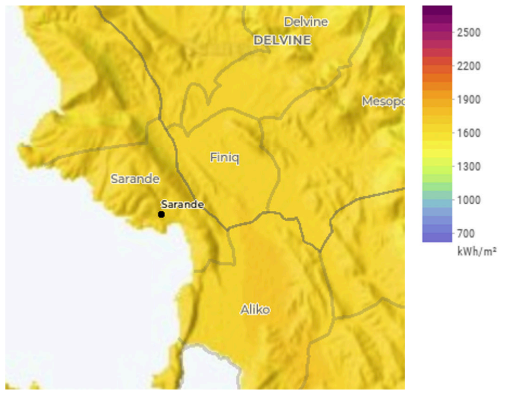

Fig4 / Global horizontal irradiation of Finiq Area
source / Globalsolaratlas.info

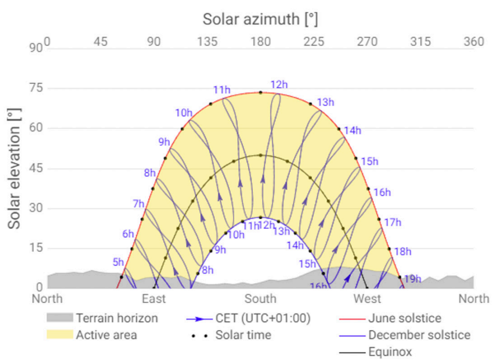

Fig5 / Horizon and sunpath
source / Globalsolaratlas.info

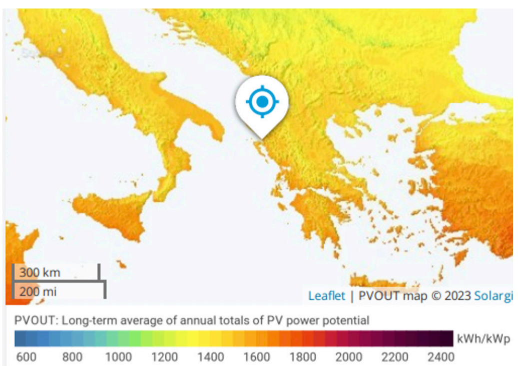

Fig6 / Location of photovoltaic plant
source / Globalsolaratlas.info

Age Group	Population
0-14	265
15-64	841
65+	227
Total	**1333**

Tab. 1 / Population of Finiq by age group
source / Globalsolaratlas.info

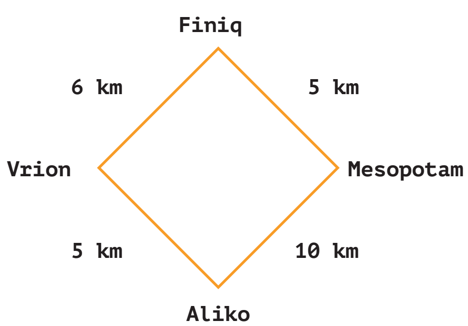

Fig7 / Diagrame of distance
source / author

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5					0.003	0.013	0.004					
5 - 6				0.026	0.091	0.112	0.086	0.039	0.009			
6 - 7		0.002	0.089	0.238	0.338	0.359	0.330	0.286	0.227	0.118	0.012	
7 - 8	0.070	0.244	0.442	0.570	0.689	0.727	0.717	0.680	0.615	0.521	0.289	0.085
8 - 9	0.531	0.620	0.791	0.894	1.012	1.072	1.080	1.054	0.972	0.863	0.644	0.478
9 - 10	0.816	0.890	1.077	1.156	1.261	1.339	1.356	1.342	1.231	1.120	0.878	0.761
10 - 11	0.972	1.052	1.240	1.307	1.415	1.497	1.531	1.523	1.390	1.247	0.986	0.886
11 - 12	1.029	1.117	1.312	1.362	1.455	1.550	1.599	1.590	1.441	1.288	1.017	0.928
12 - 13	1.002	1.102	1.299	1.325	1.407	1.518	1.569	1.559	1.389	1.234	0.955	0.896
13 - 14	0.888	1.015	1.193	1.189	1.260	1.368	1.437	1.416	1.229	1.053	0.806	0.768
14 - 15	0.681	0.795	0.946	0.946	1.016	1.119	1.204	1.165	0.958	0.771	0.559	0.531
15 - 16	0.288	0.521	0.643	0.644	0.720	0.808	0.884	0.823	0.622	0.406	0.165	0.101
16 - 17	0.006	0.126	0.294	0.337	0.392	0.460	0.505	0.439	0.261	0.037		
17 - 18			0.011	0.068	0.123	0.166	0.175	0.117	0.016			
18 - 19					0.009	0.032	0.030	0.004				
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	6	7	9	10	11	12	13	12	10	9	6	5

Fig8 / Average hourly profile
source / Globalsolaratlas.info

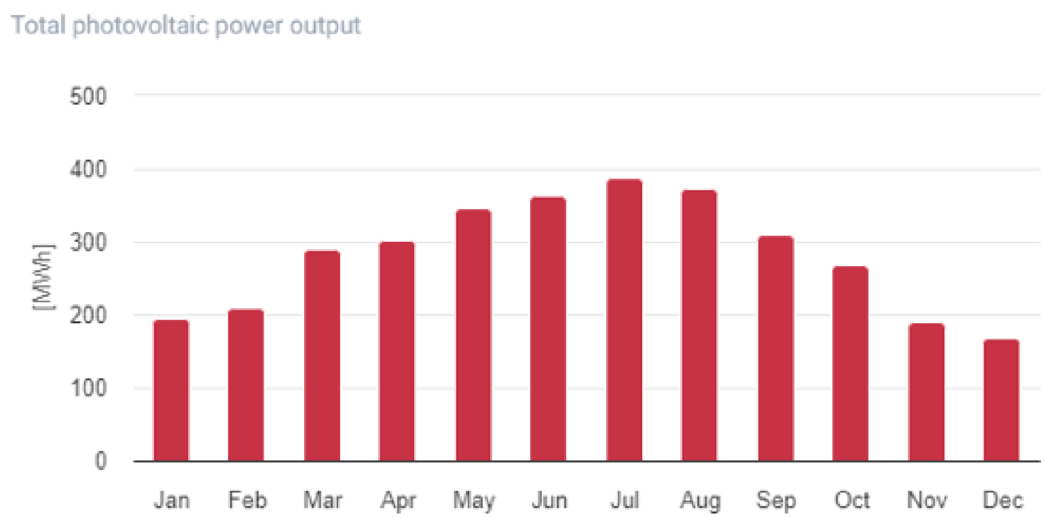

Fig9 / Monthly average power output
source / Globalsolaratlas.info

Authorization costs	20'000	€
Project	80'000	€
Electrical components	276'000	€
Tracker	414'000	€
Structural elements	92'000	€
Installation	161'000	€
Photovoltaic modules	391'000	€
Grid connection	50'000	€
Other Costs (notary, admin,...)	60'000	€
Land purchase	10’000	€
Total Costs of PV Plant	1'554'000	€

Tab2 / costs related to the authorization and construction
source / Author

		2024
Energy need from electric transportation	kWh	56'550
Annual price of electricity [source Eurostat]	€/kWh	0.110
Revenue	€	6'221
Inflation		1.00
Energy need from households	kWh	3'455'412
Annual price of electricity [source Eurostat]	€/kWh	0.080
Revenue	€	276'433
Revenue	€	282'653

Tab3 / Revenues estimated for year 0: 2024
source / Author

		2024
O&M	€	11'500
Auxiliary services	€	1'150
Estraordinary maintenance	€	4'600
Technical costs	€	2'300
Administrative costs	€	1'150
Insurance	€	3'108
General Costs	€	23'808

Tab4 / General costs estimated for year 0: 2024
source / Author

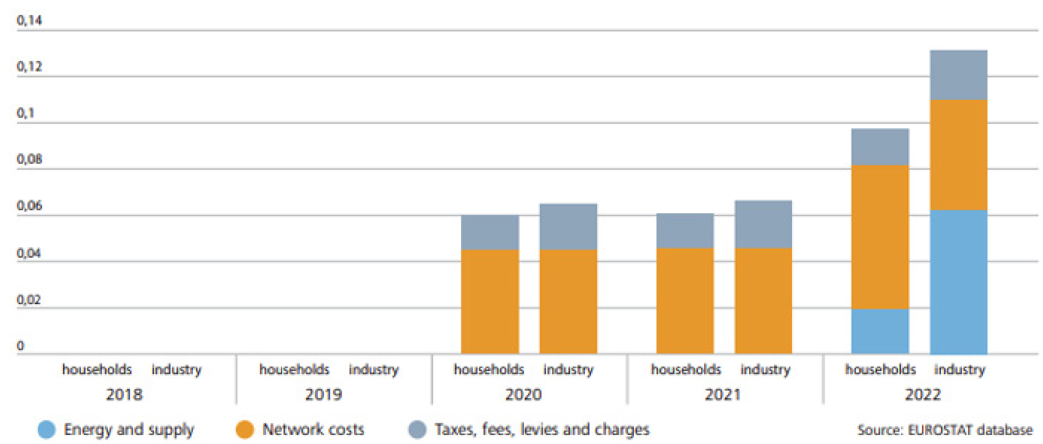

Figure 9: Average annual prices of electricity for end users
source / Author

areas; it is therefore more suited to the use of the solar source, which, thanks to its versatility and ease of installation, makes this configuration easily replicable in other contexts.
This article investigates the application of PV technology to supply electric energy to the area and its inhabitants, considering Finiq as part of a system that extends to the neighboring cities of Vrion, Aliko and Mesopotam. In addition, the scheme proposes the implementation of a public transportation with a fleet of electric buses fed by the PV plant itself.

Electric energy demand from Finiq

Providing the inhabitants with the required energy from locally produced energy from renewable energy would allow Finiq to be more attractive for different activities or new inhabitants; it will also be independent from periodic fluctuations of energy prices and eventual malfunctioning of the grid due to the increasing of the national demand and the incapability of the existing infrastructures to fulfill the expectations.
The following table details the inhabitant of Finiq by age group and the total amount considered for the following phase of the research. [1]
Considering an annual national electric consumption of 7,4 billion kWh/y [2] and an Albanian population of 2’854’000 people [4], we can estimate an annual electricity need of 2600 kWh/y/pro-capita.
Applying this estimation to the inhabitant of Finiq, the overall energy demand for the considered area is: 3’455 MWhe/y.

Electric energy demand from implemented public transportation

In accordance to typology of inhabitant, the main reason to commute are work or education – rush hours can be therefore estimated in 7:00-7:30, 12:30:13:00, 17.30:18.00.
In order to provide the area with an effective system of public transportation, a fleet of 6 daily round routes must be considered for the mentioned time. For the purpose of the research 4 buses operating 5 days/week, 50 weeks/year; this estimation allows to tolerate malfunctioning and periodic maintenance on the vehicles.
Considering the above mentioned data, 19’500 kilometers must be yearly guaranteed. Previous analyses on the subject have estimated an average consumption of a medium- size bus (13 ton) at full load as 1,45 kWh/km.
This calculation leads to an yearly energy demand for public transportation of 56,55 MWhe/y.
The total amount of energy demand from both residential consumptions and local public transportation is therefore estimated as 3,5 GWhe/y.

Electric energy from local photovoltaic power plant

Due to its characteristics, the area presents ideal conditions for the installation of a PV power plant. Considering the direct solar irradiation of the area of Finiq Municipality as 1738 kWh/m2 the sunpath during the year is represented in the figures below. [3]
Considering a traditional PV fixed infrastructure with no tracking, and mono-facial PV modules, in order to fulfill the above mentioned energy requirements is necessary to install a PV plant of 2.3

		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Energy need from electric transportation	kWh	56'550	56'550	56'550	56'550	56'550	56'550	56'550	56'550	56'550	56'550	56'550	56'550	56'550	56'550
Annual price of electricity [source Eurostat]	€/kWh	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
Revenue	€	6'221	6'345	6'472	6'601	6'733	6'868	7'005	7'145	7'288	7'434	7'583	7'734	7'889	8'047
Inflation		1.00	1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.17	1.20	1.22	1.24	1.27	1.29
Annual price of electricity [source Eurostat]	€/kWh	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
Revenue	€	276'433	281'962	287'601	293'353	299'220	305'204	311'308	317'535	323'885	330'363	336'970	343'710	350'584	357'596
Revenue	**€**	282'653	288'307	294'073	299'954	305'953	312'072	318'314	324'680	331'174	337'797	344'553	351'444	358'473	365'642
		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
O&M	€	11'500	11'730	11'965	12'204	12'448	12'697	12'951	13'210	13'474	13'744	14'018	14'299	14'585	14'876
Auxiliary services	€	1'150	1'173	1'196	1'220	1'245	1'270	1'295	1'321	1'347	1'374	1'402	1'430	1'458	1'488
Estraordinary maintenance	€	4'600	4'692	4'786	4'882	4'979	5'079	5'180	5'284	5'390	5'497	5'607	5'720	5'834	5'951
Technical costs	€	2'300	2'346	2'393	2'441	2'490	2'539	2'590	2'642	2'695	2'749	2'804	2'860	2'917	2'975
Administrative costs	€	1'150	1'173	1'196	1'220	1'245	1'270	1'295	1'321	1'347	1'374	1'402	1'430	1'458	1'488
Insurance	€	3'108	3'170	3'234	3'298	3'364	3'431	3'500	3'570	3'642	3'714	3'789	3'864	3'942	4'021
General Costs	€	23'808	24'284	24'770	25'265	25'771	26'286	26'812	27'348	27'895	28'453	29'022	29'602	30'194	30'798
Operative cash flow	-1'554'000	258'845	264'022	269'303	274'689	280'183	285'786	291'502	297'332	303'279	309'344	315'531	321'842	328'279	334'844
Rata	€	(133'068)	(133'068)	(133'068)	(133'068)	(133'068)	(133'068)	(133'068)	(133'068)	(133'068)	(133'068)	(133'068)	(133'068)	(133'068)	(133'068)
Before taxes	€	125'777	130'954	136'234	141'620	147'114	152'718	158'434	164'264	170'210	176'276	182'463	188'773	195'210	201'776
post taxes	€	104'695	107'523	110'364	113'216	116'078	118'945	121'814	124'682	127'545	130'398	133'238	136'059	138'855	141'621
Net Cash Flow	-310'800	104'695	107'523	110'364	113'216	116'078	118'945	121'814	124'682	127'545	130'398	133'238	136'059	138'855	141'621
Cumulated Cash Flow	-1'554'000	-1'449'305	-1'341'782	-1'231'418	-1'118'202	-1'002'124	-883'179	-761'365	-636'683	-509'138	-378'740	-245'502	-109'443	29'412	171'033

Tab4 / Cash flow evaluation and ROI
source / author

MWp, providing an annual production of 3,6 GWhe/y. Further optimisation, adopting a mono-axial tracking structure and bi-bacial modules, may lead to an increasing of specific production and a consequent contraction of the size of the plant.

Effectiveness

Environmental benefits

For the assessment of the environmental benefits in terms of avoided greenhouse gas and pollutant emissions, reference should be made to the specific emission factor as defined in the literature.
ETH Zurich Institute, Institut fur Verfahrens und Kaltetechnik (IVUK), has come to a fairly precise estimate of these factors.
In the case of photovoltaic systems of this size it can reasonably be assumed that the electricity produced by the plants is delivered in medium voltage but likely consumed by final users still close to the production site.
In this case the values to be considered for the specific emissions assessment avoided are:

CO_2: 680 CO_2/kWh_e
SO_X: 1,4 g SO_X/kWh_e
NO_X: 1,699 g NO_X/kWh_e

Assuming the production of electricity of 3600 kWhe/year, the following cumulative benefits are obtained:

CO2: SOX: NOX:
2448 ton CO2/anno 5,04 ton SOX /anno
6,12 ton NOX /anno

Economic benefits and return of investment

This chapter provides an estimation of the Return of Investment related to the installation of a photovoltaic power plant by the Municipality of Finiq, which produced energy is provided to fulfill the electric needs of local inhabitants and implemented public transportation system.

Cost of investment

In tab2 are summarized the main costs related to the authorization and construction of a 2,3 MW photovoltaic plant. The financial plan of the plant considers a participation of the Municipality with 20% equity and a 80% with a debt with a final interest rate of 6,6%.
Annual cash flow consists of Revenue, from the energy sales, and Costs, from maintenance and O&M. Both are listed on the tab3 for year 0.

Annual Revenue

Average annual costs of electricity, according to Eurostat analyst, has registered a significant increase during the last years Electric cost of 2022 is considered for the purpose of this paper: 0.098 €/kWh for households and 0.13 for industry. [5]
According to the intention of the project to foster the transfer to small-medium villages by providing control-priced energy to inhabitant, the following prices are estimated:
- Electricity for households: 0,08 €/kWh
- Electricity for public transportation: 0,11 €/kWh

Return of Investment

Considering annual revenues and yearly maintenance costs, it can be estimated the Return of Investment as 12 years, with an annual performance of 8.3%, as described in the following Table.

Conclusion and Recommendation

The aim of this report is to provide designers and Municipalities with a guidelines to promote a valid alternative to the traditional system of centralized production and local distribution by the installation of distributed plants fed by renewable sources designed according to local needs and tailored made based on sites peculiarities.
Towards the sections of the report has been described the approach to adopt in order to reach the mentioned goals:
- to identify of the area of interest and the data collection
- to elaborate of collective data to identify those crucial interventions that are needed
- to select a technology to fulfill the identified needs according to the geomorphological characteristic of the area
- to provide a financial analysis of cash flow in order to verify the economical sustainability of the initiative and the estimated Return of Investment.
Furthermore, this approach constitutes a valid opportunity to provide services to communities that otherwise would not be accomplished: a social and economic support to family in need, a transportation system that allow not self-sufficient inhabitant to move independently are a few examples.

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