STATE OF HOUSEHOLD ELECTRICITY ACCESS IN THE WEST BANK - 2011

A report on the current state of access to electricity in the West Bank and scenarios through which to increase access.

IPCRI
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CZECH REPUBLIC
DEVELOPMENT COOPERATION

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1. Background Information

Introduction

This report offers a general overview of the current status of electricity needs in those vilages in the West Bank that do not have access to electricity. Also it outlines different scenarios and their feasability to meet those electricity needs. Documented below are significant considerations in explanation of the contents of this report, including the political situation, various challenges to data collection, and a narrative of the findings of the study

Political and Economic Considerations

Israeli occupation of the West Bank and Gaza Strip since June 1967 has limited the ability of the Palestinian territories to develop. The provision and expansion of basic infrastructure such as electricity, vital for economic growth and prosperity has been stymied, such that provision to rural and remote communities has not been universal.

The political situation in the Occupied West Bank creates a set of challenges that make connecting rural villages to electrical power both difficult and expensive. Given Palestine's limited size, connecting all villages to a national or regional power grid would be the most cost effective option. Israeli control of Area C however, renders construction of such power infrastructure almost impossible. This study is assumes continued occupation during the relevant development period. Proposals for all villages in Area C, therefore, are based on independent energy systems, which cost more then if the villages were connected to a national grid, but which require fewer approvals from the Israeli government.

Nevertheless, it is expected that the political situation will change and hence the reader is encouraged to consider the potential infrastructure discussed within to be temporary. An improved political environment could create opportunities for more suitable and cost effective systems.

Many of the inhabitants of the villages included in this report earn minimal incomes. We therefore encourage any party seeking to develop power systems in these areas to think of both the infrastructure and the power delivered as a donation. Residents are unlikely to have the capacity to pay electricity bills. This may be another reason for providing comparatively more expensive renewable energy systems. Independent photovoltaic systems, for example, cost more to purchase and install than a traditional electrical grid connection, but provide cost-free energy to the user.

Challenges to Data Collection.

From the outset there has been difficulty, and competing estimations of the scope of the problem faced by West Bank communities in relation to provision of electricity. There is only limited data available on the location and even existence of some small villages, with. Many of the communities in question have very small populations, and are not recognized by the Israeli Government and some are not considered as separate communities by the Palestinian Authority governments, being that they are Bedouin populations. Some are spread over a few square

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kilometers and others are denser. We therefore wish to inform the reader of this report that the locations of some of the villages will have to be confirmed independently by any organization wishing to plan the development of a power system. The cost of implementing any universally effective plan is therefore incredibly difficult to ascertain.

Fully and accurately to cost project proposals will require professional feasibility studies to be conducted in and around each individual village. Determining the cost of connecting a given village to the grid requires engineers to identify a unique path for the power lines running between the grid connection point and the village. The cost of the internal grid connecting each house within the village can also vary widely, as some villages are more spread out than others.

One additional note regarding estimating costs is that the kind of systems, the amount of electricity produced, the quality of the systems, the nature of maintenance needed and additional variables can create a wide array of costs parameters. Systems that use parts that will last for twenty years with little maintenance will obviously cost considerably more than part which are purchased at low prices but which will not be sustainable in the difficult weather conditions found in the areas of the southern Hebron hills. Making a decision on providing enough electricity for a cave or a tent encampment that will light a few bulbs and enable the charging of a cell phone or alternately enabling them to live in the 21st century with sufficient electricity to run a modern household will create a huge gap in determining costs.

All of the costs suggested in this report are very gross estimates for the second option – providing enough electricity to enable people to live in the 21st century with a fully functional electrified home.

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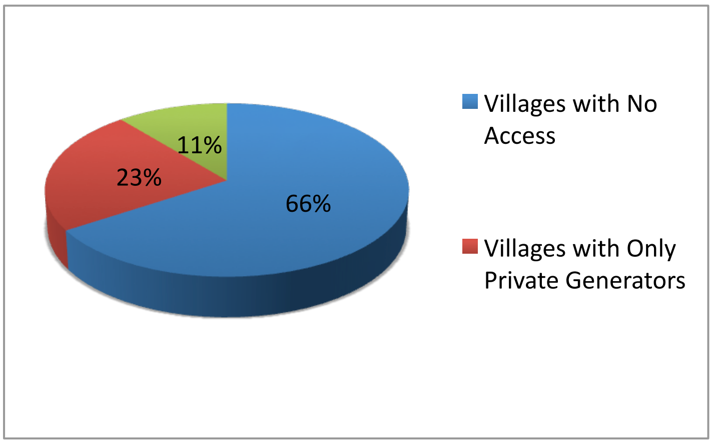
2. Current State of Electricity Access

a) Data summary

This project compiled data collected from the Palestinian Bureau of Statistics, four electricity distributors in the West Bank: SELCO, NEDCO, JDECO, and TDECO and NGOs working on sustainable energy, to identify the number of households and individuals living without electricity. By comparing like communities, identifying physical and institutional barriers to development, and identifying the most appropriate and pragmatic solutions to present infrastructure limitations, this report attempts to determine the approximate cost of ensuring 21st century technology to this disenfranchised group.

Analysis was compiled into a table, and has been included as an annexure to this report.



Summary of the data

There are approximately 1936 households and a total of 72 villages in the West Bank lacking adequate electrical power. Of those 73, 48 (66%) have no access to electricity. The villages that enjoy limited access do so through the use of private generators. Some proportion of the population of the following eight villages also receives power from the grid: *Ein Shibli* (Nablus Area), *Al Buweib, Beit Mirsim, Om Adaraj, An Najada, Anab al Kabir, Khirbet Bir al 'Idd, and Arab al Fureijat* (Hebron Area). The total KWh required by the 73 villages is approximately 530,080 (7261/village average). 32,080 KWh (439/village average) are needed for public use such as schools and street lighting.

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3. Case Studies – Sustainable Energy Systems

Alternative electrification of rural villages is possible through implementation of approaches beyond connection to existing power grids. Micro Hybrid Solar Electrical Generation (MSG) and (PV) present the best use of available technological innovations for the provision of off-grid networks with sufficient capacity to satisfy the power needs of these communities. Indeed projects have been implemented in order to test the necessary networks and management models by which most efficient provision of electricity can be achieved.

It was determined that the systems implemented in these communities were capable of being operated and maintained by a group of people or entities that could hold the responsibilities of management. There is therefore considerable power in the suggestion that RE technologies are responsible for maintaining the welfare of the society and community, and can frequently be responsible for the assurance of excellent economic results.

Empowering neglected communities through electrification

Rural electrification will especially benefit women and children. Traditionally, the women of the southern Hebron hills are responsible for a range of time-consuming manual tasks that take up most of the day. These chores include washing and, in season, the preparation of butter - their main commodity. The use of washing machines and butter churns will provide the women with time to pursue leisure and other activities. Electric lighting would permit children to study at night - which begins at 4pm in winter - increasing their success at school.

A sustainable approach to providing renewable energy

A preliminary survey of the target communities has been carried out by IPCRI to assess community needs and identify key community members as well as technical parameters. In our estimation a hybrid, wind-solar system with a mini-grid is the most cost-worthy system for these small communities. Each mini-grid would provide about two kWh per family per day. There should be a strong emphasis on sourcing components from local craftsman, as IPCRI believes in open source design and local manufacturing, resulting in "home-brewed" wind turbines.

Together with Comet-ME, a local capacity-building program, IPCRI has supported the development of several of these systems, in parallel with their installation. Community members are trained in safety and system maintenance and management, and become responsible for basic maintenance and diagnostics. All communities pay electricity bills to cover the cost of regular maintenance by Comet-ME/IPCRI trained technicians.

The models below provide off-grid stand-alone systems that would provide the off-grid villages with enough electricity to carry on modern 21st century life, at a considerable price.

We have provided three options for exploration:

Option #1 – a local PV field for the whole village
Option #2 – roof-top for housing plus street lighting

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Option#3 – hybrid system PV and diesel (includes monthly costs – tariffs and maintenance - to the residents)

a) Masafer Yatta, Hebron

Several thousand Palestinian farmers and shepherds in the southern part of the West Bank in the Masafer Yatta area live in shanty-like villages, in caves and in tents. This is a very traditional population, located in the southern Hebron hills, subsists on non-mechanized agriculture and herding. Often referred to as “cave dwellers”, the people who call this region home have lived in the area continuously since the early 19^{th} century.

Changing economic conditions, desertification and the ongoing Israeli occupation have left the communities of Masafer Yatta reliant on outside support for survival. Competition with imported and industrialized crops places severe limitations on opportunities for economic growth. These difficulties are exacerbated by constraints imposed by the Israeli authorities, like restricted access to grazing areas and an inability to connect to existing water and electricity grids. Providing renewable energy lets the communities integrate wtih existing markets and to tap into their economic and creative potential. Renewable energy infrastructure releases communities from dependency on external aid, and builds local and regional capacity to manage and maintain such technologies.

Plans for expansion of energy provision

In 2010, Comet-ME completed a thorough survey of the Masafer Yatta region, which yielded a multi-year implementation plan. Comet-ME plans to complete five to ten installations of mini-grids per year. By 2013, a total of 25 communities will have received installations (including the seven communities with mini-grids installed already). Throughout 2011, Comet-ME will run advanced renewable energy courses for between five and ten participants at a time. This comprehensive approach to providing renewable energy infrastructure, which includes capacity-building and long-term community engagement, will transform the whole region into one reliant on decentralized, renewable energy generation.

b) Quwawis

Hybrid wind and solar electricity generating system[1]

In engineering terms COMET built two types of systems: basic family system and bigger community utility centers.

The first are pure solar systems with a 0.5 to one kWh/day capacity and provide enough energy for several light bulbs, cell phone recharging (an absolute necessity in the region) and several hours of radio use. Each system includes the solar panel(s), an electricity box with a charge controller, deep cycle battery, small inverter, all the necessary electric safety equipment and, of course, the actual load: lights and an

[1] Information obtained in cooperation with COMET-ME

electricity plug. Family units all share a common design but vary in size as some of the families are semi-nomadic and take the systems with them when they move.

The bigger utility centers are more complex, hybrid, wind and solar, or even diesel and solar, systems providing four to ten kWh/day. Turbines are made personally based on a design by Hugh Pigott, but altered to household needs. The towers are locally sourced to increase local spending and create local capacity. Typical loads comprise an energy-efficient refrigerator, several butter churns and other electrical goods such as computers and sewing machines.

Off Grid Systems - Sample Village for Analysis

The community of Quwawis (31^0 23'38.85'' N $35^0$07'54.65'' E elevation 827 m) is among the poorest and most marginalized communities in the occupied Palestinian territories. It is a community of five families wedged between two illegal Israeli outposts, whose inhabitants live off goat and sheep herding. The five families are spread over considerable space: two live in tents and three in caves.

The total number of inhabitants in the village is 30, all of whom will be connected to the proposed mini-grid.

The hybrid wind-solar system tried and tested in the field is by far the cheapest of all possible options, second only to hooking the villages to an existing power grid (either Israeli or Palestinian). Independent stand-alone off-grid solutions that provide for all of the energy needs of the communities are still very expensive. The wind-solar hybrid model described above provides for the most basic needs of these small, scattered communities. In some cases these communities become able to charge cell phones, use computers and more basic utilities such as refrigeration and washing machines, thereby joining the 21st century. This system does not generate enough electricity for all homes to use without limits.

Project Budget *(Euro)*

Quwawis	Quantity	Per unit	Total
135W multi-crystalline solar panels	5	670	3,350
Solar charge controller	1	820	820
Wind turbine	1	4,000	4,000
Wind charge controller	1	320	320
1800 W inverter	1	1,575	1,575

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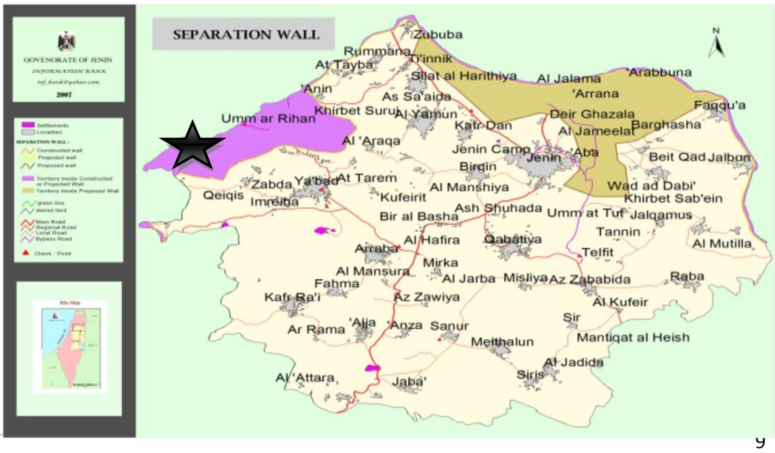
600Ah battery	1	2,200	2,200
Electric wiring	1	300	300
Ground metal mounting for panels	10	60	600
Home wiring	6	100	600
Independent home system	1	800	800
Electric dispenser	1	440	440
Administrative overheads	1	10.00%	1,501
		Total	16,506

c) Em Quques, Jenin

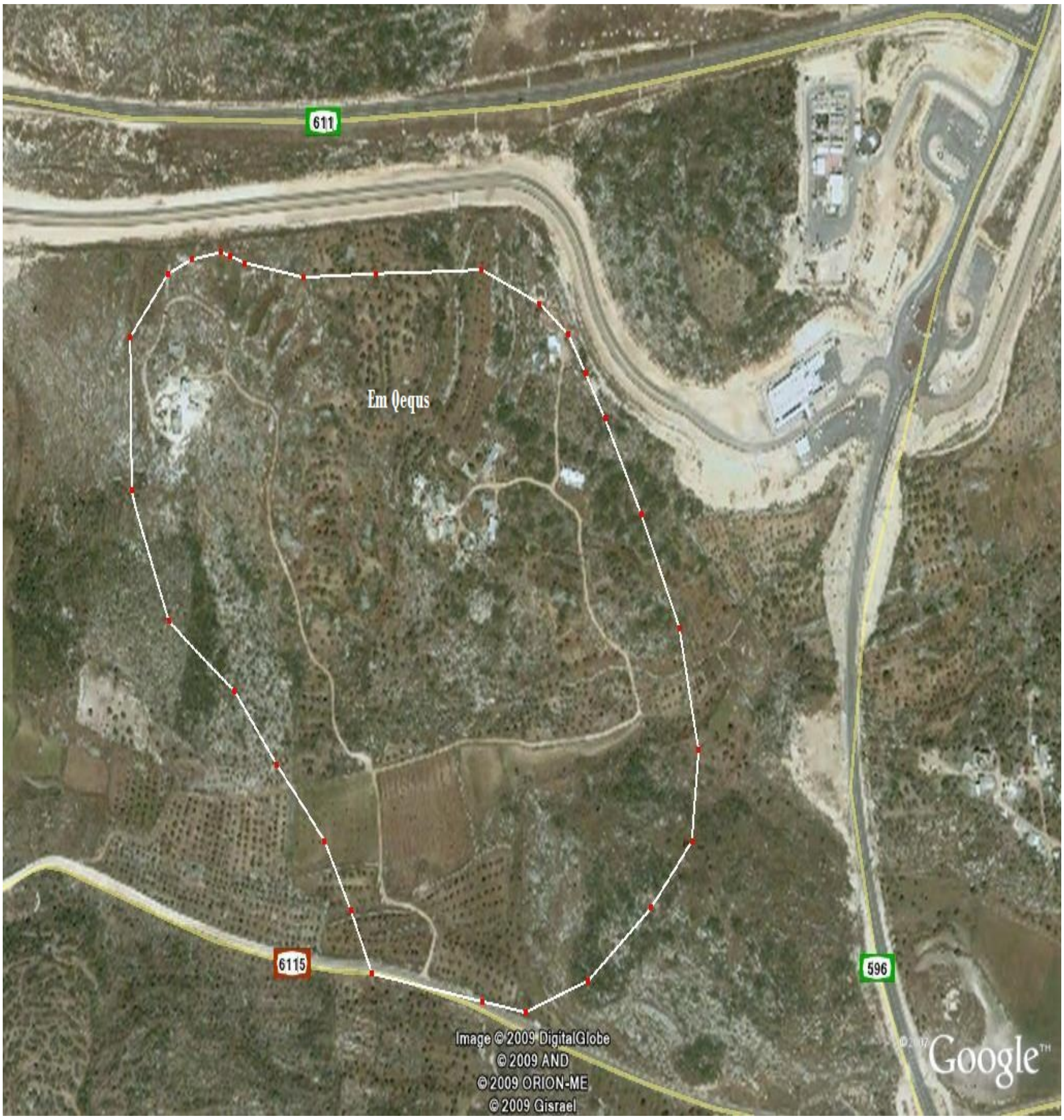
Executed in Em Quqes, Jenin, this project addresses the needs of two communities, composed of 72 individuals who comprise 14 families, capitalizing upon the knowledge gleaned from pilot projects conducted in Atouf in 2006 and in Emnazeil, Hebron in 2010. The community lies along the separation barrier erected between Israel and the Palestinian territories. The coordinates of the western residential community that is as written at the lower middle of the Google map as: '' 31. 47 ' 35° 06 East / '' 00. 75 ' 32 ° 27 North. The coordinates of the Eastern residential community as following: '' 43. 14 ' 35° 06 East / '' 58. 09 ' 32°26 North.

The designs of both earlier projects are intended to conform to the socio economic reality of the inhabitants, and nowadays this project can be replicated as it has shown a good performance and suitability.

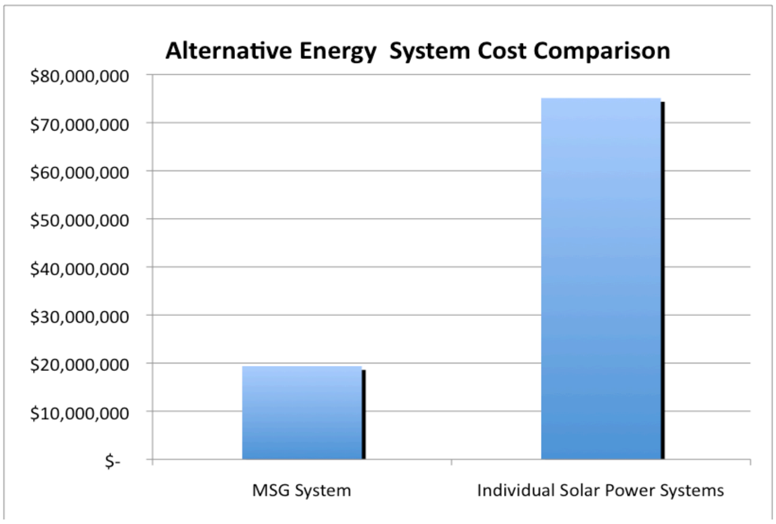
The case study responds to the energy need of **Em Quqes**, in the western part of Jenin Governorate. The village that lies along the separation wall erected and consists of two grouping blocks 300m far from each other. The village lacks basic necessities of life, water, paved roads and electricity. The project provides for a self-sustainable alternative energy system.



For a detailed methodology on this project, please see Annex 2.



4. Findings and Recommendations



The costs associated with providing electrical power to these communities vary widely depending on the proposed solution. Attaching each village to the main grid would be most cost effective. Costing of this solution has not been included however, as it is impossible to estimate costs without conducting a detailed feasibility study for each case. Building micro grid and hybrid solar generation (MSG) systems within each village would cost approximately $19,360,000 (based on present estimates and assumptions, vulnerable to the inaccuracies identified before). Installing independent energy systems for each home would cost a total of around $75,120,000 (this estimate is considerably more accurate as final cost is determined by fewer factors).

<u>Scenarios for improving electricity access</u>

We present four different scenarios for providing access to electricity to those households that currently do not have access to electricity as presented in the matrix.

1) Connection to the Palestinian electricity grid

Connecting all unconnected households to the Palestinian electricity grid is most cost-efficient and reliable, especially because of the limited distances in the West Bank. Connection to the Palestinian electricity grid provides for all energy needs, while alternative energy systems provide limited electricity.

However, because most villages are situated in Area C, and thus fall under full Israeli control, there are serious constraints to expanding the electricity grid to these villages. Furthermore, it needs to be taken into account that some of the households that are currently not being met in their electricity needs are among the poorest in the West Bank. Hence, when these households will be connected to the grid it can be challenging for them to pay for the electricity they consume.

Connection to the Palestinian electricity grid is most likely the best option for the villages that are partly connected to grid already and in cases where an agreement with the Israeli administration can be made for expansion of electricity infrastructure and the households will most likely be able to pay for their electricity consumption.

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Location on map	Locality	Total		Percentage of Available Durable goods per locality				No electricity		Private generator		Public network		Electricity needs unconnected households	Public electricity needs	Total electricity needs	Cost of micro grid hybrid solar system	Costs individual solar system	Costs connection to grid	Costs internal grid
		Population	Households	TV	Washing Machine	Gas/Electric Cooker	Fridge	%	#	%	#	%	#	kW/h	kW/h	kW/h	USD	USD	USD	USD
	TUBAS GOVERNATE																			
1	Al Farisiya	145	28	0	0	0	0	100%	28	0	0	0	0	11200	1120	12320	$280,000	$1,680,000	$394,999	$53,058
2	Al Malih	355	55	1.8	0	52.7	0	76%	42	1.8	1	0	0	16800		16800	$550,000	$2,520,000	$528,786	$53,058
3	Khirbet ar Ras al Ahmar	171	33	30.3	0	72.7	0	100%	33	0	0	0	0	13200	1320	14520	$330,000	$1,980,000	$208,190	$53,058
4	Khirbet Humsa	127	21	19	0	66.7	0	24%	5	0	0	0	0	2000		2000	$210,000	$300,000	$310,889	$53,058
	RAMALLAH GOVERNATE																			
	QALQILIYA GOVERNATE																			
5	Arab ar Ramadin ash Shamali	79	16	81.3	31.3	81.3	75	25%	4	75	12	0	0	1600		1600	$160,000	$240,000		$53,058
6	Arab Abu Farda	112	23	21.7	0	8.7	4.3	26%	6	73.9	17	0	0	2400		2400	$230,000	$360,000		$53,058
	Arab Al-Khouleh	25	6	0	0	100	0	100%	6	0	0	0	0	2400	240	2640	$60,000	$360,000		$53,058
	JERICHO GOVERNATE																			
	BETHLEHEM GOVERNATE																			
	NABLUS GOVERNATE																			
8	Ein Shibli	330	56	67.9	55.4	100	58.9	25%	14	1.8	1	73.2	41	5600		5600	$560,000	$840,000		$53,058
9	Furush Beit Dajan	759	119	70.6	60.5	90.8	62.3	21%	25	79	94	0	0	10000		10000	$1,190,000	$1,500,000		$53,058
10	Ar Rajman	15	4	0	0	25	0	100%	4	0	0	0	0	1600	160	1760	$40,000	$240,000		$53,058
11	Shuhda and Hamllan		7					100%	7	0	0	0	0	2800	280	3080	$70,000	$420,000		$53,058
	JENIN GOVERNATE																			
12	Khirbet Suruj	55	13	56.6	56.6	77.8	0	100%	13	77.8	7	0	0	5200	520	5720	$130,000	$780,000		$53,058
13	Imreiha	415	83	25.3	8.4	21.7	8.4	67%	56	10.8	9	0	0	22400		22400	$830,000	$3,360,000		$53,058
14	Bir al Basha	1282	213	69.8	46.9	97.2	29.6	27%	58	71.9	153	0	0	23200		23200	$2,130,000	$3,480,000		$53,058
15	Al Jumillat		8					100%	8	0	0	0	0	3200	320	3520	$80,000	$480,000		$53,058
16	Khirbet Al Muntar		8					100%	8	0	0	0	0	3200	320	3520	$80,000	$480,000		$53,058
	Khirbet Masoud		13					100%	13	0	0	0	0	5200	520	5720	$130,000	$780,000		$53,058
18	Khirbet Sib'in		15					100%	15	0	0	0	0	6000	600	6600	$150,000	$900,000		$53,058
19	Tanin		11					100%	11	0	0	0	0	4400	440	4840	$110,000	$660,000		$53,058
	Khirbet Al Ra'deiah		13					100%	13	0	0	0	0	5200	520	5720	$130,000	$780,000		$53,058
	HEBRON GOVERNATE																			
21	Jala	243	39	12.8	7.7	97.4	5.1	92%	36	7.7	3	0	0	14400	1440	15840	$390,000	$2,160,000		$53,058
22	Humrush	52	10	0	0	100	0	100%	10	0	0	0	0	4000	400	4400	$100,000	$600,000		$53,058
	Khallet al Masafar	212	38	10.5	0	0	0	89%	34	10.5	4	0	0	13600	1360	14960	$380,000	$2,040,000		$53,058
24	Al Buweib	592	74	56.8	51.4	56.8	52.7	22%	16	74.3	55	4.1	3	6400		6400	$740,000	$960,000		$53,058
25	Beit Mirsim	310	57	28.1	19.3	98.2	7	75%	43	21.1	12	3.5	2	17200		17200	$570,000	$2,580,000		$53,058
	Om Adaraj	792	74	23	5.4	86.5	1.4	91%	67	6.8	5	2.7	2	26800	2680	29480	$740,000	$4,020,000		$53,058
27	Wadi al Kilab	45	6	16.7	16.7	100	0	83%	5	16.7	1	0	0	2000	200	2200	$60,000	$300,000		$53,058
	Kheroshewesh Wal Hadedeyah	370	57	29.8	24.6	89	19.3	63%	36	36.8	21	0	0	14400		14400	$570,000	$2,160,000		$53,058
	Khashem Adaraj	591	91	18.7	0	28.6	0	88%	80	12.1	11	0	0	32000	3200	35200	$910,000	$4,800,000		$53,058
	Um al-Khair	503	67	41.8	11.9	40.3	3	52%	35	44.8	30	0	0	14000		14000	$670,000	$2,100,000		$53,058
31	At Tuwani	318	51	35.3	9.8	66.7	7.8	59%	30	41.2	21	0	0	12000		12000	$510,000	$1,800,000		$53,058
32	An Najada	403	50	70	22	74	34	16%	8	80	40	4	2	3200		3200	$500,000	$480,000		$53,058
33	Anab al Kabir	327	49	12.2	12.2	95.9	10.2	71%	35	20.4	10	8.2	4	14000		14000	$490,000	$2,100,000		$53,058
34	Khirbet Asafi	83	10	0	2	10	0	100%	10	0	0	0	0	4000	400	4400	$100,000	$600,000		$53,058
	Mantiqat Shi'b al Batin	133	22	54.5	0	13.6	0	91%	20	9.1	2	0	0	8000	800	8800	$220,000	$1,200,000		$53,058
36	Khirbet Tawil ash Shih	177	23	56.5	73.7	4.3	0	96%	22	4.3	1	0	0	8800	880	9680	$230,000	$1,320,000		$53,058
37	Khirbet al Fakheit	225	40	15	0	40	0	100%	40	0	0	0	0	16000	1600	17600	$400,000	$2,400,000		$53,058
38	Khirbet Bir al 'Idd	116	22	22.7	0	40.9	4.5	23%	5	68.2	15	9.1	2	2000		2000	$220,000	$300,000		$53,058
39	Khirbet Zanuta	58	13	0	4.5	7.7	0	100%	13	0	0	0	0	5200	520	5720	$130,000	$780,000		$53,058
	Imneizil	380	48	14.6	0	58.3	0	96%	46	2.1	1	0	0	18400	1840	20240	$480,000	$2,760,000		$53,058
	Arab al Fureijat	557	83	51.8	43.4	56.6	38.6	30%	25	38.6	32	31.3	26	10000		10000	$830,000	$1,500,000		$53,058
42	Um Al Butum		11					100%	11	0	0	0	0	4400	440	4840	$110,000	$660,000		$53,058
43	Al Baqar		15					100%	15	0	0	0	0	6000	600	6600	$150,000	$900,000		$53,058
44	Jroon Al Louz		16					100%	16	0	0	0	0	6400	640	7040	$160,000	$960,000		$53,058
45	Khirbet Deir Shams		11					100%	11	0	0	0	0	4400	440	4840	$110,000	$660,000		$53,058
46	Khirbet Saroura		15					100%	15	0	0	0	0	6000	600	6600	$150,000	$900,000		$53,058
	Khirbet Khaleh and Hasheh		3					100%	3	0	0	0	0	1200	120	1320	$30,000	$180,000		$53,058
48	Qawaees		11					100%	11	0	0	0	0	4400	440	4840	$110,000	$660,000		$53,058
49	Khirbet Al Tabaneh		5					100%	5	0	0	0	0	2000	200	2200	$50,000	$300,000		$53,058
	Maghayyer U'beid		15					100%	15	0	0	0	0	6000	600	6600	$150,000	$900,000		$53,058

	Khirbet Kharoushas		8					100%	8	0	0	0	0	3200	320	3520	$80,000	$480,000		$53,058
52	Khirbet Al Rahwa		8					100%	8	0	0	0	0	3200	320	3520	$80,000	$480,000		$53,058
	Um Sedrah		14					100%	14	0	0	0	0	5600	560	6160	$140,000	$840,000		$53,058
	Al Teran		6					100%	6	0	0	0	0	2400	240	2640	$60,000	$360,000		$53,058
	Deir Sa'eideh		5					100%	5	0	0	0	0	2000	200	2200	$50,000	$300,000		$53,058
	A'selieh		4					100%	4	0	0	0	0	1600	160	1760	$40,000	$240,000		$53,058
	Abu Kharouba		2					100%	2	0	0	0	0	800	80	880	$20,000	$120,000		$53,058
	Abu Al Henna		3					100%	3	0	0	0	0	1200	120	1320	$30,000	$180,000		$53,058
	Al Mkoun		4					100%	4	0	0	0	0	1600	160	1760	$40,000	$240,000		$53,058
	Khirbet Falfa		11					100%	11	0	0	0	0	1600	160	1760	$110,000	$660,000		$53,058
	Khirbet Ambsheir		4					100%	4	0	0	0	0	1600	160	1760	$40,000	$240,000		$53,058
	Al Heirzeh		4					100%	4	0	0	0	0	1600	160	1760	$40,000	$240,000		$53,058
	Jabal Ammar		8					100%	8	0	0	0	0	3200	320	3520	$80,000	$480,000		$53,058
	Jiser Souq Al Khaneh		6					100%	6	0	0	0	0	2400	240	2640	$60,000	$360,000		$53,058
	Khalet Al A'qar		10					100%	10	0	0	0	0	4000	400	4400	$100,000	$600,000		$53,058
	Khalet Al Foul/ Al Barkeh		7					100%	7	0	0	0	0	2800	280	3080	$70,000	$420,000		$53,058
	Khelt Al A'dar		11					100%	11	0	0	0	0	4400	440	4840	$110,000	$660,000		$53,058
68	Khirbet Al Khrabeh		5					100%	5	0	0	0	0	2000	200	2200	$50,000	$300,000		$53,058
	Khirbet Ghoueen		11					100%	11	0	0	0	0	4400	440	4840	$110,000	$660,000		$53,058
	Al Qas'a Locality		6					100%	6	0	0	0	0	2400	240	2640	$60,000	$360,000		$53,058
	As'eeda Locality		6					100%	6	0	0	0	0	2400	240	2640	$60,000	$360,000		$53,058
	Za'tra		11					100%	11	0	0	0	0	4400	440	4840	$110,000	$660,000		$53,058
	Wadi Al Rasha		11					100%	11	0	0	0	0	4400	440	4840	$110,000	$660,000		$53,058

JERUSALEM GOVERNATE

2) Connection to the Israeli electricity grid

As a result of the presence of Israeli citizens in settlements in the West Bank an extensive Israeli electricity grid has been developed. Currently it is impossible to connect the Palestinian villages to this electricity grid. However, it could be an option to connect this grid to the Palestinian grid and connect the villages to it if the West Bank will gain independence in the future.

3) Connection to a hybrid sustainable energy system

A hybrid sustainable energy system that provides for sustainable electricity on a small internal grid is currently the cheapest sustainable energy system available. With a system like this there is no need for infrastructure outside of the boundaries of the village, thus the limitations of infrastructure development that the Israeli administration imposes are less relevant. Although also for this system a permit from the Israeli administration needs to be obtained, in practice the Israeli administration has not demolished these systems when placed without a permit. Another advantage of this system is that once the system is in place the electricity obtained is without additional costs.

The downside of these systems is that they provide a limited amount of electricity; hence they cannot suffice for the total electricity needs. Furthermore, these systems suffer from a free rider problem. When certain households use more energy than the amount set for them per day that means that other households will have less.

For villages that are in Area C, this system can be most effective. Especially because of the financial advantage. However, a system like this can only be put in place when accompanied by assistance to the community to set up a social system of cooperation and shared responsibility for the electricity.

4) Connection to individual solar energy systems

Another option providing sustainable energy is the installation of individual solar energy systems. These systems provide a certain amount of electricity per day to every household separately and are installed on the rooftops. Because they require no additional building there is no requirement for permits from the Israeli administration. These systems do not suffer from a free rider problem in the community, as the energy is not shared among households. Also the electricity provided is free.

The downside of these systems is that they are very costly and only provide a limited amount of electricity.

These systems are the best option for villages in area C when the funder of the system cannot assist the community in setting up a social system of cooperation and shared responsibility for the electricity.

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Annex 1. Sources of Data in Matrix

This table compiles information in relation to the number and size of West Bank communities living with inadequate electricity supply.

Locality: This column lists the localities in the West Bank fully or partly unconnected to the electricity grid or to alternative energy systems. The source information is derived from the Palestinian Bureau of Statistics (PBS) (report 2009) and from data collected from the four electricity distributors in the West Bank: The Southern Electricity Company (SELCO), The Northern Electric Distribution Company (NEDCO), Jerusalem District Electric Company (JDECO), and the Tubas District Electric Company (TDECO).

Total population and households: Identifies the total population and number of households, where information was available from either the PBS (report 2009) or from the four electricity distributors in the West Bank: SELCO, NEDCO, JDECO, and TDECO.

Percentage of durable goods: Identifies the percentage of households in possession of a television, washing machine or refridgerator. Where information was available from the PBS (report 2009).

No electricity: Identifies the number and percentage of households in each locality unconnected to the electricity grid or alternative energy systems. The source information is derived from the Palestinian Bureau of Statistics (PBS) (report 2009) and from data collected from the four electricity distributors in the West Bank: SELCO, NEDCO, JDECO, and TDECO.

Private generator: Identifies the number and percentage of households in each locality with access to electricity from a private generator. The source information is derived from the Palestinian Bureau of Statistics (PBS) (report 2009) and from data collected from the four electricity distributors in the West Bank: SELCO, NEDCO, JDECO, and TDECO.

Electricity needs unconnected households: Identifies the annual electricity needs of the unconnected households in kW/h based on the average consumption of Palestinian rural households. The source information is derived from data collected from the four electricity distributors in the West Bank: SELCO, NEDCO, JDECO, and TDECO.

Public electricity needs: Identifies the expected annual public electricity needs in kW/h, for public institutions and installations of presently unconnected localities. Information is based on the average public electricity needs of rural villages based on information from the four electricity distributors in the West Bank: SELCO, NEDCO, JDECO, and TDECO.

Total electricity needs: Identifies the sum of the annual electricity needs of unconnected households and annual public electricity needs in kW/h.

Costs of hybrid system: Identifies the costs of an alternative energy system based on solar and/or wind power available in each locality. Based on average costs of systems build by Israeli-Palestinian NGO Comet-ME in rural villages in the West Bank. Note: these systems do not provide for all the electricity needs as they can only provide a limited amount of kW/h.

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Costs individual solar system: Identifies the cost of an individual solar systems based on one-kilowatt systems that provide energy per household. The costs are based on a tender that SELCO did.

Costs connection to grid: Identifies the costs of village connection to the existing Palestinian electricity grid. This information was only available for the Tubas governorate as TDECO Company did a study on these villages.

Note: not all the villages can be connected in the current political situation, as they are located in Area C, which falls under the authority of Israel.

Costs internal grid: Identifies the costs of an internal grid in the Tubas district. This information was only available for the Tubas governorate as the TDECO Company did a study on these villages. Information based on statistics of TDECO Energy Company.

Annex 2: Methodology for Pilot Project on PV Rural Electrification

1.1. Uses

The installation to locate electricity will be used for supplying:

- Single-family and multi-family housing
- Public Lighting

1.2. Scope of Application

The principal objective of the project is to electrify the housing in the village via **PV** system or micro grid with hybrid solar generation (**MSG**) that will cover the actual and future energy need with an energetic management program.

The system ensures a quality level comparable to that offered by the State Grid:

- Standard Level of Electrification of 230V
- Perfect Voltage Stability of 230v
- Available energy in function of the population need and public lighting
- Forecast of future consumption

2. Background on the Village

2.1. Justification and Objectives

IPCRI has analyzed the electricity needs of Em Quqes and as a result proposes an optimum solution that takes into consideration the economic restrictions as well as social, technical, environmental and legal limitations.

2.2. Social Organization and needs

2.2.1. Population Profile

Em Quqes dwellers are mostly farmers and ranchers lacking the basic necessities of water and electricity.

In Em Quqes's there is an:

- Absence of electricity for water pumping, private uses (housing), refrigerator, and for public lighting.

The annual growth rate is in the range of 5 five %.

In the village there are 72 people distributed in 14 houses living in two different communities 300m far from each other.

2.2.2. Energetic Actual Situation

No electricity.

2.2.3. Communal Facilities

- There is no public hall, no schools, no mosque, no clinic and no social center.
- There needs to be 14 - 20 point for public lighting.
- There is a water well shared by the people and animals

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2.2.4. Telecommunications Coverage

There is phone coverage in the total area of the village.

2.2.5. Community Concern

The community of **Em Quqes** has profound interest to develop the project of rural electrification. They have the will to agree a commission of representative headed by **Mr Shadi Qabaha**, to interact with the project managers.

The basic level of the electrification makes possible the installation of a **PV plant, Roof Top** or **Hybrid PV Plant** (Solar and Diesel).

2.2.6. Census

The representative of both communities is Mr Shadi Qabaha.

Set out below is the community's population, indicating the head of the family, and the number of people under his charge.

The Western Community:

House owner	People under his charge
Ahmad Qabaha	6
Zakaria Qabaha	4
Mostafa Hamdan	2
Saleh Hamdan	3
Fayez Qabaha	8
Tawfiq Qabaha	7
Haitham Ahmad	2
Fadi Fayez	4

The Eastern Community:

House owner	People under his charge
Mohammed Amarneh	4
Mahmoud Amarneh	6
Moteea Amarneh	6
Raed Amarneh	9
Omar Amarneh	3
Fathee Amarneh	5
Fakhri Amarneh	4

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2.2.7. Land Available for the installation

There are two plots of land available for the location of the **PV plant** for clean and free energy for the inhabitants in **Em Quqes**, no smaller than 200m^2 each. The land owners had no problem transferring the space to achieve the project objectives.

2.3. Available local Resources

- **Supply of the equipment: PV panel, batteries, regulator, inverter and control.**
  - Palestinian renewable energy company
- **Supply and Installation of the structure of the Modules**:
  - Palestinian renewable energy company
- **Grid Installation in case of MSG:**

  We will need to clarify the role to play by the NDECO, municipalities and governorate of Jenin
- **Central Installation:**
  - Technical Assistance of the Counterpart and a Palestinian renewable energy company as integrators
- **Electrical Installation of the houses:**
  - Executed by a Palestinian renewable energy company and technical support of the counterpart
- **Technical Warehouse:**

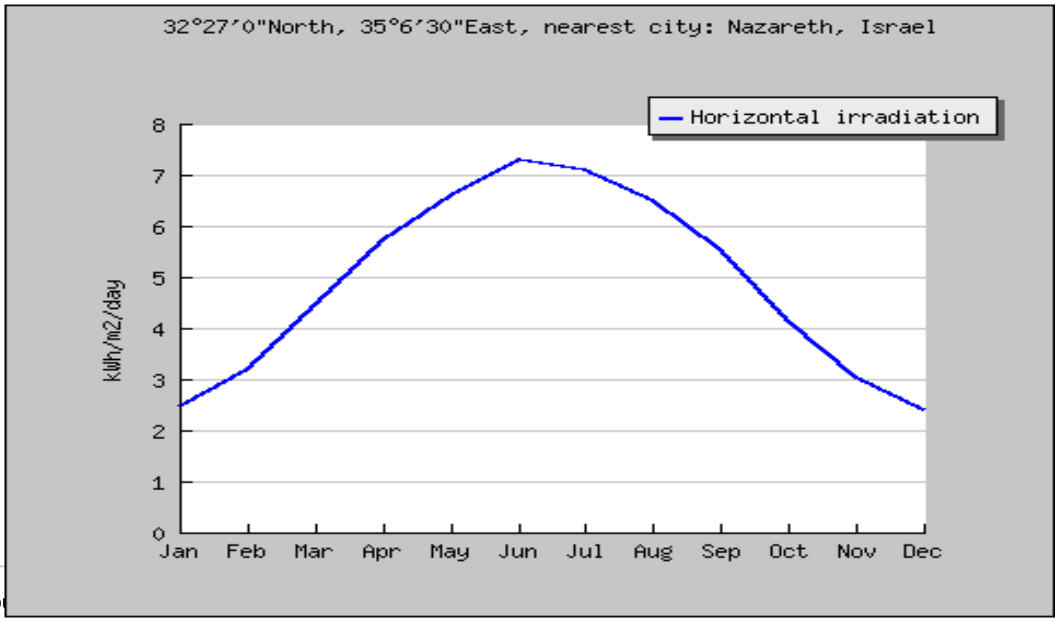
  For storage of electronic equipment; to be built with the aid of the Red Cross, or any local company. Construction is to be provided by the community.
- **Supply of efficient product**

  All necessary construction elements can be found in Ramallah and Hebron, such as energy efficient light bulbs and fridge.

2.4. Natural Resources

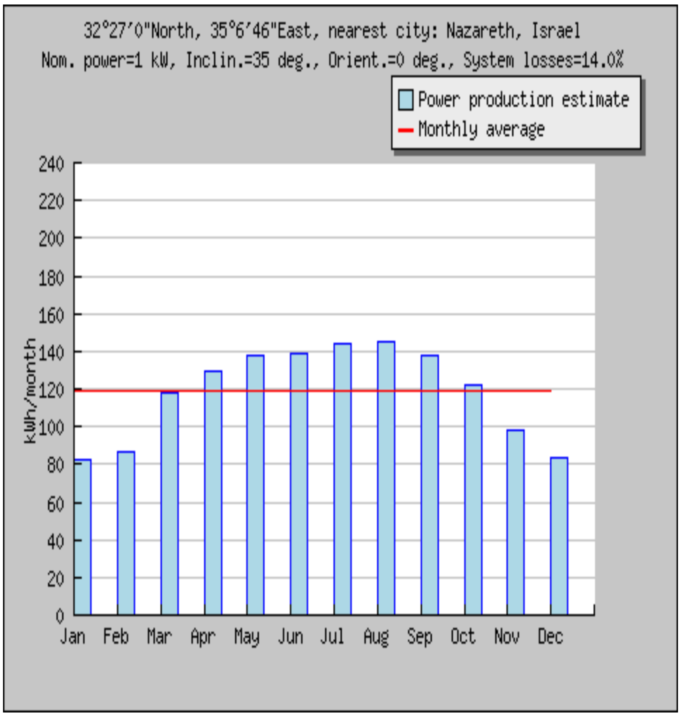
2.4.1. Solar resource

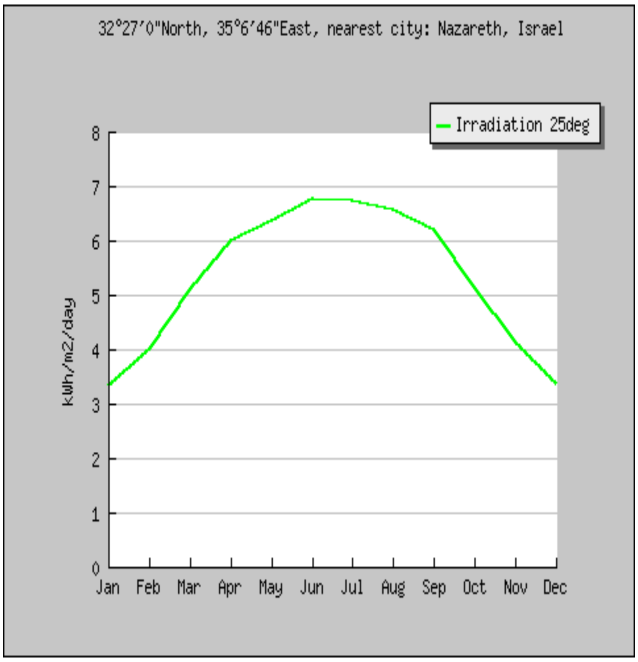
The solar resource is being assessed by joint research center of the European Commission.



- **Location 32º 27’ North, 35º 6’ 30’’ East**:
  - Elevation 197 meters above sea level
  - Optimal inclination angle is: 27 degrees
  - Annual irradiation deficit due to shadowing (horizontal): 0.0 %

- **Location 32º 27’ North, 35º 6’ 30’’ East**
  - Nominal power of the PV system: 1.0 kW (crystalline silicon)
  - Inclination of modules: 27.0°
  - Orientation (azimuth) of modules: 0.0°
  - Estimated losses due to temperature: eight % (generic value for areas without temperature information or for PV modules with unknown temperature dependence)
  - Estimated loss due to angular reflectance effects: 2.6%
  - Other losses (cables, inverter etc.): 14.0%
  - Combined PV system losses: 24.6%





Irradiation at inclination (Wh/m2/day)/ 25º

May	6374	**Dec**	3363
Jan	3338	**Aug**	6560
Jun	6775		
Feb	3999	**Sep**	6188
Jul	6722	**Year**	5310
Mar	5097	**Oct**	5126
Apr	5984	**Nov**	4128

PV electricity generation for:
Nominal power=1.0 kW
System losses=14.0%

Inclination=27° / Orientation=0°		
Month	**Production per month (kWh)**	**Production per day (kWh)**
Jan	78	2.5
Feb	84	3.0
Mar	117	3.8
Apr	132	4.4
May	145	4.7
Jun	148	4.9
Jul	152	4.9
Aug	150	4.8
Sep	138	4.6
Oct	119	3.8
Nov	93	3.1
Dec	79	2.5
Yearly average	120	3.9
Yearly Production (kwh)		**1436**

Conclusion:
The Inclination of the fixed PV panels 27° , orientated to the south. This data correspond the major annual generation. However, Upper form 27° inclination the global annual generation falls.

2.5. Structure Management

2.5.1. Role to play

A committee of no more than five people will represent the community, and be headed by Mr Shadi Qabaha, who will liaise with relevant local Palestinian companies.

The committee will be responsible for management and operation of the plant, charging of tariffs for use, and contracting for any necessary external maintenance necessary for continued use of the installation.

- **The village will have to assign**:
  - One person responsible for basic maintenance of the equipment
  - One community manager in charge of the:
    - Fees collection
    - Fund collection bank account

The village must establish:

- A regulation of service approved by the committee
- A service agreement signed by each user of the system

- **Description of functions:**
  - **Coordination of Women:**
    - To keep individuals informed about the progress of the project
    - To encourage participation in different project activities
    - To represent the interests of women in committee meetings
    - To coordinate and organize community activities
    - To coordinate and organize the participation of women and children in the project
  - **Fees collection, Accounting and General Manager**
    - To keep accounts, and be responsible for monthly collection of fees
    - To maintain a bank account for collection of income and payment of expenses
    - To be responsible for general account-keeping
  - **Preventative Maintenance**
    - To maintain the installation, including cleaning of panels, acquisition of spare parts and maintenance of batteries
    - To monitor and control electricity consumption using the meters
    - To provide solutions for basic technical problems
    - To liaise with external technicians in the event of serious technical problems
  - **User Representative**
    - To organize regular meetings with users in order to discuss concerns, doubts and proposals
    - To redact the regulation of the service
    - To organize construction of the storage warehouse
    - To liaise maintain contact with the community in relation to new connections, changes to tariffs etc

2.5.2. Minimum requirements of the management

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Regulation of the service must be approved by the community, indicating the rights and obligations owed by individuals in return for access to the service. As such, the following should be implemented:

1. Contracts with villagers identifying payment obligations
2. Photovoltaic power generation plant established under villager authority
3. The recruitment procedure of the service during the implementation period.
4. The recruitment procedure of the service after execution.
5. Some designation of maintenance responsibilities to an individual within the community
6. Responsibility to ensure that necessary contracts for equipment maintenance are established and maintained
7. A process by which fees and payment terms are updated as necessary

3. Designing the Renewable Energy (RE) Technical Solution

The multiple proposed systems of electrical supply could be implemented in rural communities, where the communities then hold both the property of, and the responsibility for, management of electricity production within their communities.

Environmental advantages

- NO pollution: CO_2 emission
- Do not consume fuel
- No waste generation
- No noise
- It is inexhaustible

Socio –economic advantages

- Free and clean energy
- Generate employment
- Requires little maintenance
- Long life
- Withstand extreme weather conditions: hail; wind; temperature and humidity
- No dependence on electrical companies

These RE technologies ensure attainment of excellent economic outcomes while supporting the communities and ensuring societal welfare.

3.1.1. Micro Autonomous PV Plant

A micro autonomous PV plant is one which provides electrical service (Sub-Generation), power distribution (Distribution Sub-System) for the benefit of the final users (Sub-Recipient).

The micro autonomous PV plant for users/individuals incorporates two subsystems:

1. Energy generation
2. Demand for energy use in the receptor installation

The energy deficit of Em Quqes is about one KW per house, requiring between 14 and 20 points of light. Aggregated energy demand indicates need of a PV plant producing 20KW at a cost of US$ 600 annually.

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Option #1: Solar field: PV USD/Wp installation Cost for small scale plants

Capacity Installed	Cost USD/WP	Total cost USD
20KW	5	100,000

Concept	USD
Contracted company	40,000
Identification and Development	13,500
Total USD	153,500

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3.1.2.

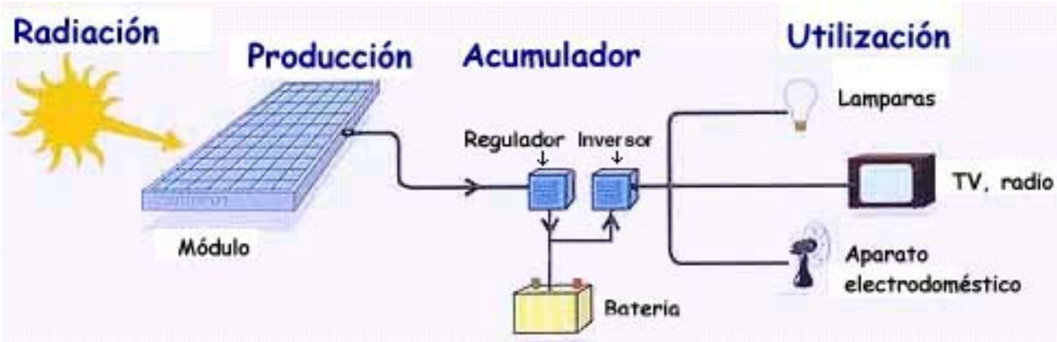
3.1.3. PV Integration Off Grid

This system entails installation of a small PV field on roves, capable of producing free and clean energy.

Components:

- PV generator
- Inverter
- Protection
- Structure

3.1.3.1. Option #2: Roof-top: The design of PV integration off grid



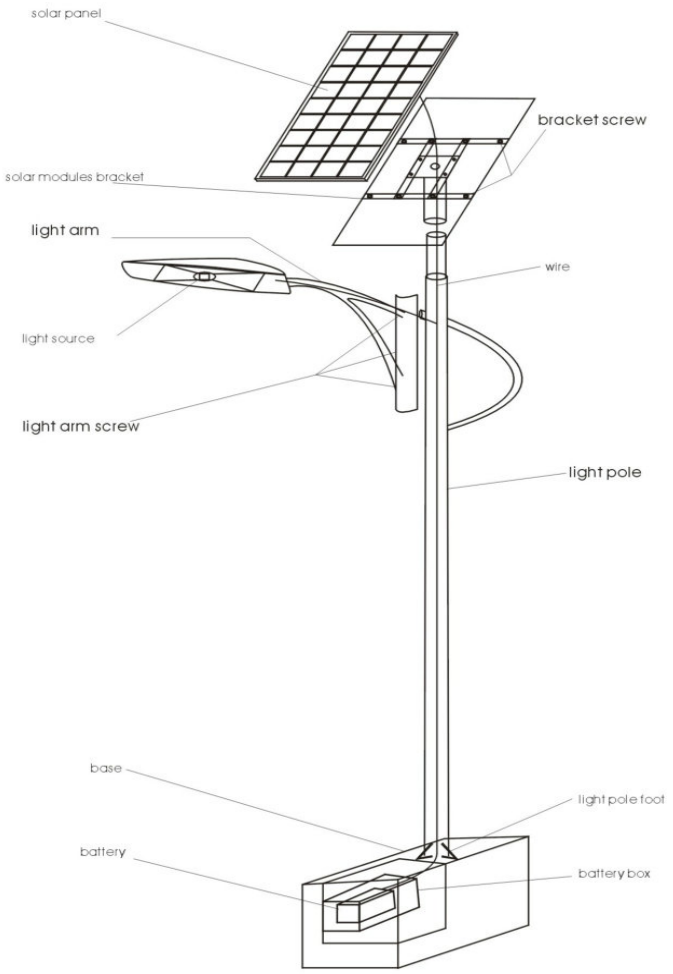
Exploitation Cost US$ 500 per year

Capacity Installed	Cost USD/WP	Units Houses	Total cost USD
1KW	5	14	70,000

Concept	USD
Contracted Company	28,000
Identification and Development	9,450
Total USD	107,450

3.1.4. PV Public Lighting

3.1.4.1. Solar Street System



The solar LED street light system converts and stores solar energy to provide green illumination.

Luminaries utilize High Power white LED with superior thermal management design.

These fixtures are waterproof and durable; designed for both indoor and outdoor use.

Luminaries are supplied fully assembled, ready either for retrofit or new installations.

3.1.4.2. Solar Streetlight Benefits

- Installation requires no wiring
- Simple installation and movement, reducing costs
- Utilizes proven theft-resistant components and hardware
- All parts are corrosion resistant
- Easily and quickly deployed in almost any location
- NO cuts through existing roads, sidewalks or landscaping
- NO Maintenance
- NO Utility bill

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3.1.4.3. The design of solar street system

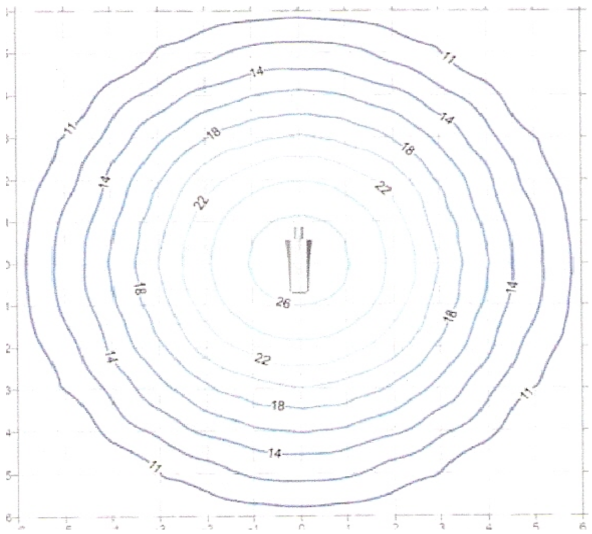
Colum and Arm

Made of heat-galvanized steel (in accordance with UNE 37.501-71 standards) to prevent atmospheric deterioration

Five meters high and support the lighting arm.

Lighting

The circuits housing the LEDs are located within the lighting casing. The standard power for the LED lighting is 30W. Bulbs have been chosen in accordance with light



Accumulator Batteries

12v batteries of varying capacity (dependent on size, range, peak sun hours, lighting, etc)

PV modules

The photovoltaic modules used may have total electrical power of 130wp.

Regulation and Control System

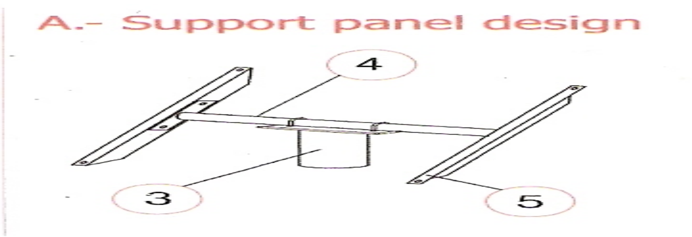
The street-light uses the FAR-50 regulations and control system, either attached to the light or housed in a watertight box to withstand damp or corrosive environments.

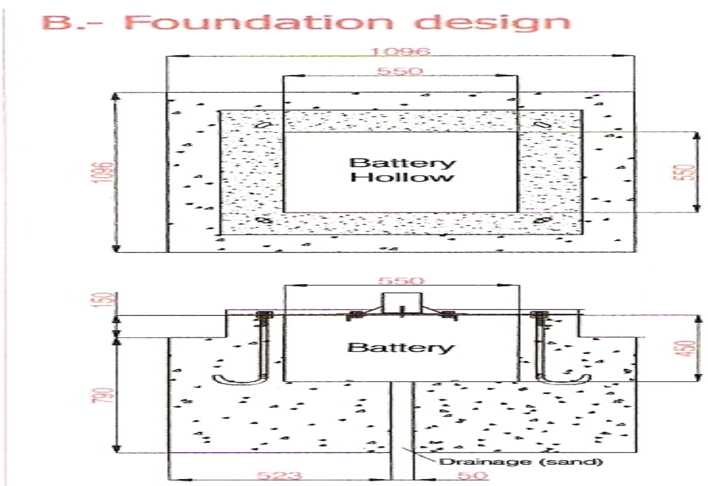
The Far-50 has been specifically designed to manage independent lighting fixtures in PV installation.

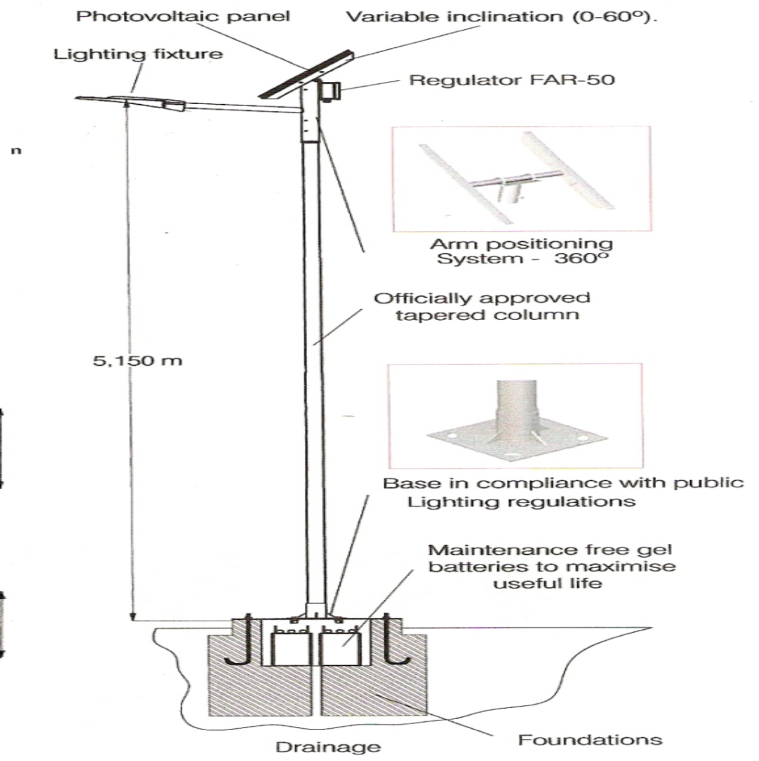
The charge cycle is divided into four stages: **deep charge, equalization, absorption and flotation**. So then it ensures a longer useful battery life.

The twilight switch adjust the time for the lights to be switched on and off at dusk and before dawn.

It has test functions which make maintenance operation easier







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Physical Characteristics	
Support Structure	Galvanized steel
Lighting Fixture	Aluminum / stainless steel
Lamp weight	2.0kg
Measurements	560x210x100mm
Height of light	5.150m
Positioning of the module	360º
Module inclination	0-60º
Level of Protection	IP 54
Electrical Characteristics	
Light Source	High brilliance LED transmitter
Total Luminous Flux	88lm/w
Lighting equivalence	72.5lm/w
Input voltage	12v
Input current	2.5A
Power	30w
Working temp. Range	-25ºC to 65ºC
Approx. Useful life	75.000 hours
Approx. useful life FLE* (Fluorescent Light Equivalent)	10.000 hours

3.1.5. Budget – for street lighting

Equipment and Supply	
Concept	**EURO**
Photovoltaic solar module 135Wp crystalline, 36 6 cells. "Marco Hook 1 Quad box. Tolerance + / -3% 12Vn	5,360
Photovoltaic solar LED streetlight Composted by - Roost + support structure for a module of 135Wp housing for light-LED luminaries and 12V-30W Charge controller + timer twilight switch with FAR-	15,600

50 model 12V	
Stationary battery gel, monoblock, 12 V, 230 Ah	6,918
Transport CIF Ashdod Tel Aviv, storage and transportation Israel-Em Quqes	2,692

Technical Service and Management	
Concept	**EURO**
PV Streetlight installation	3,200
PPLC	12,228
Identification and Development	4,126

Coordination	
Concept	**EURO**
Counterpart	4,585.5
Local	3,439

Total EURO	**58,148.50**

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3.1.6. Option #3: Multi User Solar Hybrid Grids (MSG)

The Micro grid with Solar Hybrid Generation (**MSG**) incorporates three subsystems:

- Multisource energy generation plant via solar irradiation and other technologies (subsystem of generation, micro PV-Hybrid plant)
- Electrical Grid for distribution to the final users (subsystem of distribution – rural micro grid)
- Receptor installation of demand includes an electrical installation in every house and electronic appliances for the final users (subsystem of reception)

3.1.6.1. Functional Description of a Subsystem of Generation

The function of a subsystem of generation is to supply power and electrical energy to a single user or a group of users. It will be able to supply energy even with contingences of availability of the Renewable Energy (RE)'s sources and/or fossils.

The technical objectives assigned to each installation can be summarized in the following points:

1. To generate electricity effectively and rationally (optimizing resource use)
2. To prioritize use of RE technology (RET)
3. To store electricity from the RET for supply regardless of weather
4. To provide auxiliary sources (electric generator) to reach the specific level of service when RET is insufficient or unavailable

This subsystem is able to ensure:

Generation of Energy

This function indicates all necessary technical characteristics of the energy production process: Voltage, Frequency, Harmonic and Energy and clients consumption. It is always according to the quality of the services. Including:

- Energy Conversion (when it comes for primary energies)
- Energy Storage
- Energy Conversion
- Energy Measurements

Supply

This system ensures supply to the distribution facilities and on to both individual and collective consumers.

Administration

The energy produced within this system is limited by the natural resources from which it is derived (Solar radiation, wind speed, etc) and by storage capacity. Consumption management therefore becomes significant, so as to:

- Optimizing usage of available energy
- Conserving energy stored for optimum communal use users (immediate energy need)

- Maximizing the life expectancy of installation hardware
- Minimizing the usage of the fossil resources.

3.1.6.2. Functional Description of a Subsystem of Distribution

The electricity produced by this generation subsystem must be transported to the demand points, often distances between dozens of meters and 2 km, throughout conductors (Power Transmission Lines), safely located high above ground or underground.

Electricity transfer is made at low voltage (the transformation to middle voltage is risky due to self consumption of the inverters) and single phase.

The underground grid installation, under the protocol of security and technical specification, is preferred according to visual effects.

3.1.6.3. Functional Description of a subsystem of demand

This is a set of reception facilities located in each electricity point of demand (homes, community centers, schools, churches, centers health, etc), the connection between distribution subsystem and appliances located at each point of consumption.

Due to proximity to the funal user, strict safety standards must be maintained, and facilities run by professional electricians.

3.1.6.4. The Design of an Autonomous Photovoltaic Hybrid Plant (MSG)

3.1.6.4.1. Characterization of Energy Consumption

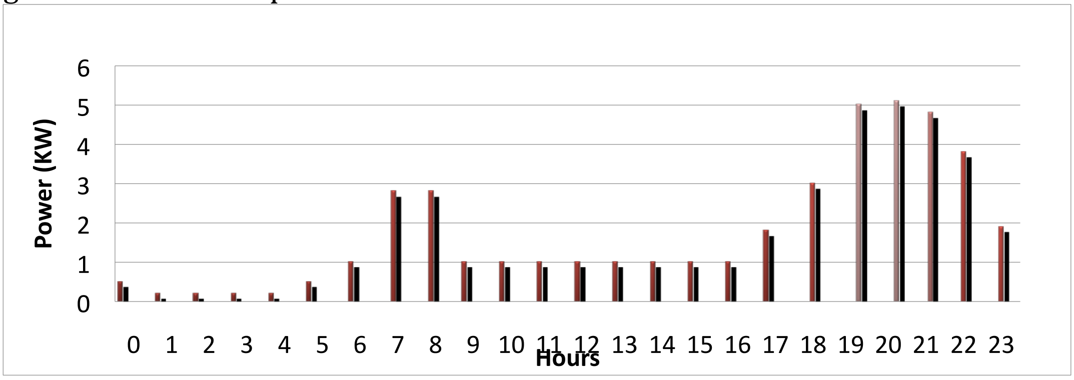
Individual energy consumption rates have been estimated in order to price the flat fee initially imposed by contract between operator and users. The pattern of consumption is defined by the Energy Assurance Provision (Wh/Day), which is a contract between the operator and the user of the installation. The following values have been set based on applications and socioeconomic analysis and it is just a reference.

Tariff	Nominal power limit	Energy at secure disposal	Num.	Increase of Energy per 5min
	KW	Wh/day		Wh
TD-25/0.5	0.5	825	14	3
PV Public Lighting	0.84	7,000	20	-
Total Installation Billable				14
Total Daily Energy Aggregated (production)				18,550Wh
Daily Energy Demand (consumption)				16,695.2Wh
Total Power Aggregated				10.8kw

It has estimated the profile of consumption for different types of uses:

- Domestic uses
- Public Lighting

In the following table is shown an *estimation* of the aggregated demand of the global time consumption.



This data corresponds to a high inference estimate. Although the mean peak power is around the 5.1 kW of power, the inverter has been chosen large enough to withstand the maximum power occasional that may exceed this value.

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3.1.6.4.2. Typology of the Micro Hybrid Plant

PV Generation		
Installed PV power	2573	Wp
Inclination	27°	
Land Space approx.	100	M^2
Auxiliary electricity generator		
Nominal Power (Single Phase)	16	Kw
Charge of batteries	8.77	Kw
Accumulation		
Type of battery	PB-Tubular Acid	
Autonomy	3	days
Working Voltage	48	V
Voltage by accumulation	2	V
N. of element	24	
Capacity C100	3,654	Ah
PV regulator		
Capacity	200	A
Form of regulation	Trace	MPPT

UPS		
Output voltage	230	V
Nominal Power	7.08	Kw

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Harmonic distortion	<3	%
Data achievement		
Memory	300 Kbyte/un	

The facilities are designed for the worst month of radiation, taking into account seasonal facility use.

3.1.6.4.3. Demand Management and Efficient Use of the Energy

Single Phase Distribution		
Service quality	230 V. C.A.	50Hz
Energy-meter dispenser	One per house	
Maximum power per house	1	Kw
Public Lighting		
Point of Light	14	
Type of Luminary	VSAP 70	W

3.1.6.4.4. Proposed Tariff Scheme to the Residents for the Hybrid Option

Tariff	Kwh month	Users	Fixed Cost	Variable Cost	Total tariff Cost
			NIS/Month	NIS/Kwh/Month	NIS/Month
T25	25	14	45	25	70

3.1.6.4.5. Fixed cost of Management, Operation and Maintenance

Concept	Personnel	NIS/Month	NIS/Year
Management Salary			
Administrator	1	51	610

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Operational and Maintenance Salary			
Engineer	1	254.5	3054
Reposition material			
0.2% of the initial investment	-	27.2	326
Total Cost	-	332.5	3,990

3.1.6.4.6. Budget for Option #3 – Hybrid system

Starting date	2011	**Diesel Cost**	5(NIS/Liter)
Discount rate	6%	**Renewable fraction**	95%
Inflation rate	5%		
Currency	NIS		
Exchange Rate	• (1 EURO= 5 NIS) • (1 $= 4 NIS)		

Construction	
Concept	**EURO**
Technical site	10,574
Interior installation	2,650
Distribution line installation	2,100
PV installation	3,200
Construction management	3,500

Equipment & Supply	
Concept	**EURO**
Internal installation equipment	1,400

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Regulator, inverter and dispensers (14 houses)	12,000
Battery recharger	1,500
PV panels	23,500
Metallic Structure	3,622
Battery Varta	10,700
Electrical equipment	6,200
Storage and transportation Israel – Em Quqes	2,000
Construction materials	3,100
streetlights	470

Technical Service	
Concept	**EURO**
Contracted company	43,258
Identification and Development	11,247

Coordination	
Concept	**EURO**
Counterpart	12,640
Local	9,600
Total EURO	**163,261**