HOUSEHOLD ENERGY ACCESS IN AREA C

Hebron, Palestine

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AUTHORS

Main Author

Tommaso Boreatti, MSc student at Politecnico di Milano

Interviewers

Sajidah, Cesvi Social Mobilizer
Abediljawwd, Cesvi Social Mobilizer

Cesvi Team

Marco Caniato, Head of Mission in Palestine

Master Thesis Supervisors

Nicolò Stevanato, Research Fellow – Department of Energy, Politecnico di Milano
Francesco Tonini, Research Fellow – Department of Energy, Politecnico di Milano

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HOUSEHOLD ENERGY ACCESS IN AREA C
Hebron, Palestine

Survey Results, November 2019

Collaboration between Cesvi and Politecnico di Milano for the assessment of needs and level of access to energy in Area C, West Bank.

United Nations Educational, Scientific and Cultural Organization
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ABBREVIATIONS

AC – Air Conditioner

BLEENS - Biogas, LPG, Electricity, Ethanol, Natural Gas and Solar Systems

CM – Cubic Meter

CSP – Concentrated Solar Power

DHW – Domestic Hot Water

DISCOs – Distribution Companies

ESMAP – Energy Sector Management Assistance Program (World Bank)

GDP – Gross Domestic Product

GINI – Gini Index

H2 – Hebron Area H-2

HDI – Human Development Index

HH1 – Cluster 1 of Households

HH2 – Cluster 2 of Households

HH3 – Cluster 3 of Households

ICA – Israeli Civil Administration

IEC – Israel Electric Company

IHL – International Humanitarian Law

IHRL – International Human Rights Law

kV – Kilo Volt

kW – Kilo Watt

kWh – Kilo Watt Hour

kWp – Kilo Watt of Electric Power

l – Liter

LPG – Liquefied Petroleum Gas

M$ - Mega Dollars (Million Dollars)

MENA – Middle East and North Africa

MW – Mega Watt

MWh – Mega Watt Hour

MWp – Mega Watt of Electric Power

NIS – New Israeli Shekel

oPt – Occupied Palestinian Territories

PA – Palestine Authority

PCBS – Palestinian Central Bureau of Statistics

PPA – Power Purchase Agreement

PPP – Power Purchase Parity

PV – Photo Voltaic

SDGs – Sustainable Development Goals

TJ – Tera Juole (Trilion Juole)

toe – Tonne of Oil Equivalent

TPES – Total Primary Energy Supply

US$ - United States Dollars

WHO - World Health Organizatio

Modern energy can be the spark to develop a sustainable society, in other words the creation of a society that offers opportunities and meets people's needs without compromising the ability of future generations to aspire to them.

EXECUTIVE SUMMARY

Access to modern energy is one of the pillars of sustainable development. The rigorous evaluation of energy consumption habits in vulnerable contexts such as Area C of the West Bank, Palestine, is necessary to coordinate strategies and actions in order to tackle the climate change at a global level. The study aims to understand in depth what is the situation of access to energy of households living in this context, with particular attention to the implications on health and water security.

The access to electric power, to energy for cooking and to energy for space heating has been assessed, applying the "Multi-Tier Framework" methodology developed by ESMAP[1]. The research analyses in particular the access features of people living in Area C in the Governorate of Hebron at the household level. The data were obtained through a survey of 210 families from 68 communities with different levels of accessibility to public infrastructure. In particular, a distinction was made between those that have full access to the public electricity grid, to a reliable water network and to paved road, from those that have access to the electricity grid but have limitations towards other infrastructures, and, finally, those that do not have access to the public electricity grid. This criterion for community aggregation offered the best confidence in predicting their levels of energy accessibility.

MAIN FINDINGS

Electricity is available in all the interviewed communities, and no cases were reported where families live without this resource. However, the presence of an electrical system does not guarantee that the quality, availability or affordability of the energy supply is excellent, nor does it guarantee that the user has the right appliances to convert the energy taken from the grid into a useful effect. The evaluation of all these aspects has led to define the accessibility to electricity of the various groups of communities.

Households with at least partial access to public infrastructure have problems with power availability due to service interruptions, rely on old or second-hand appliances that easily breakdown, and find the cost of electric power high compared to their income. In general, however, in this group there are very few cases in which the level of access to electric power is seriously insufficient and the worst results have been obtained by those who do not pay the electricity bill.

Communities that are not connected to the public electricity grid rely instead on solar or hybrid systems donated to them by different organizations. These

[1] Beyond Connections, Energy Access Redefined – The World Bank (2015)

households live mainly on herding, consuming a little amount of electricity just enough to cover their family basic need. They usually rely on indoor lights, one fridge, one washing machine and, in some cases, one milk processing appliance. Their level of accessibility is lower than the previous groups with one third of cases presenting seriously inadequate conditions.

The levels of access to fuels and energy for cooking and heating also need to be assessed. The indoor combustion of unclean fuels for example, may present a serious hazard for people's health. The primary fuel used for cooking is LPG, transported in 12 kg bottles and often expensive compared to the household income. The use of wood as a secondary fuel is widespread, especially for families with access to weak public infrastructure. This resource is burned in three-stone fires or in the taboon, the Palestinian traditional oven, presenting a high risk of burns and a negative impact on the quality of the air breathed. Households that do not have access to public infrastructure, on the other hand, have a gas cooker in all cases, but this is not always the primary solution for cooking. The alternatives are often three-stone fires or taboons, this time fuelled mainly by animal dung produced by the herding activity. In this case, 55% of families have a level of access to energy for cooking that is seriously inadequate. Moreover, where the paved road is not present, an extra cost of transportation needs to be considered, resulting in a price increase of 25% for LPG and 20% for firewood with respect to the communities with access to public infrastructures.

Space heating presents the lowest level of accessibility. In a country like Palestine it is usually necessary only for three months a year and, perhaps for this reason, it presents the lowest level of accessibility. There are seriously inadequate situations even in communities with full access to public infrastructure. Households who do not rely on an electric heater generally use to burn firewood inside metal stoves, with very high risk of burning hazard. Given the scarcity of vegetation the habit of collecting firewood is infrequent and families must buy it with a significant impact on the household economy. For this reason, the heated rooms inside the houses are generally limited to one, with negative consequences on the opportunity of people to carve out private spaces.

In conclusion, a technological solution is proposed for each of the main problems that arise from the study. The dissemination of more efficient and effective systems can certainly improve the resilience of the inhabitants of Area C, but this can hardly change their level of development. Unlike many countries where limited access to energy, and in general to technology, is the main barrier to development, Palestine is conditioned by the political stalemate that slows down both the spread of technology and development.

1. INTRODUCTION

The sun is abundant in Palestine.
Its energy has been exploited since very ancient times to dry the yoghurt in order to obtain the marice, a traditional product of South-Hebron Hills hand made by Bedouin communities. The dried yoghurt can be stored in a shadow and fresh place for later consumption, mainly melted in a soup. Today sun energy is useful for PV power generation, representing the only electric resource for remote communities.

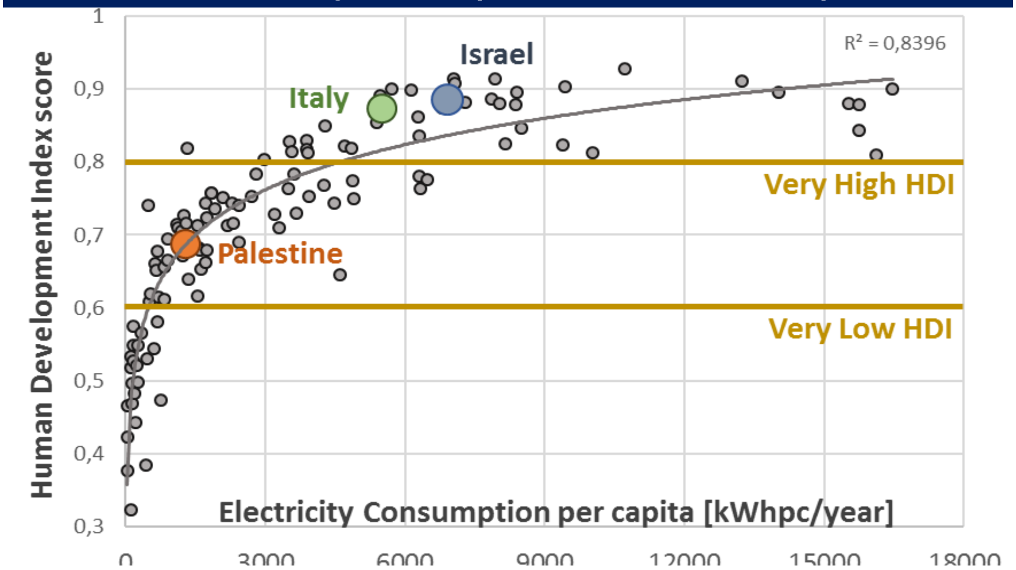
1. INTRODUCTION

Modern Energy

Access to energy is a pillar of development. Energy is indeed needed to travel, to power most of the technological devices we use every day, to communicate, to cook and to live in a comfortable environment. From the ability to control fire in the lower Palaeolithic to the recent 4th Industrial Revolution, energy has been the trigger of human evolution. Global access to energy is one of the Sustainable Development Goals (SDGs), aiming not only at achieving universal access, but also defining the quality of the access to energy. Considering the context of climate change in which we live, energy must be reliable, affordable, clean and safe, in other words modern.

It is impossible to achieve sustainable development without modern energy. All the countries with a Human Development Index (HDI)[2] higher than 0.6 are indeed characterized by an average electricity consumption higher than 1.3 [kWh/day] per capita. Thus, access to modern energy supports develops the economy, contributes to increase the quality of education or of the health care system, and creates the conditions to reduce the impact that human activities have on the environment.

Table 1 - **Electricity Consumption and Human Development**



Sources:
World Data for HDI: UNDP, Human Development Index, 2013, update 2018.
PENRA, Quantity of available electricity in Palestine by year and source of electrical energy, 2010-2017;
PCBS, Estimate population in Palestine mid-year by governorate, 1997-2021.

[2] The Human Development Index (HDI) is a statistic composite index of life expectancy, education, and per capita income indicators, which are used to assess human development within countries.

Palestine is located in the MENA region. It has a population of 4.98 million people of whom 2.99 million live in the West Bank and 1.99 million in the Gaza Strip. The HDI score is 0.686 (GINI 33.7)[3], people have an average income of 5,055 2011PPP$ and a third of the population is below the poverty line (13.9% of the population in the West Bank and 53.0% of the population in the Gaza Strip). 93.9% of people over 25 years attended at least primary school, with an average of 9.1 years of education, increasing to 12.8 years for the expected schooling. The average life expectancy at birth is 73.6 years[4].

Although these numbers describe an apparently normal situation for a middle-income country, Palestinian development is affected by Israel's administrative and military control of borders, infrastructure and natural resources. There are dozens of freely accessible online reports describing the abuses and limitations that affect the Palestinian civilian population on a daily basis[5]. As an occupying power, Israel has defined obligations to the people of the occupied Palestinian territories (oPt) under international humanitarian law (IHL) and international human rights law (IHRL) to allow development during what should be a temporary period of occupation[6]. Despite these obligations, some of which are contested by Israel, in recent years Israeli policies have intensified restrictive and expansionist measures[7].

Energy in Palestine

The total primary energy supply (TPES) of a country depends mainly on the socio-economic context as described above. In the specific case of Palestine, this amounts to 77,780 [TJ/year] of which 87% is imported. The energy intensity, that is the quantity of energy necessary to produce a unit of GDP, is 126.4 [toe/1M$], almost double with respect to the Israeli energy intensity equal to 65.4 [toe/1M$]. Part of the reasons why the Palestinian energy system has this low efficiency in converting energy into economic value can be attributed to losses accounting to 7% of the TPES. In practice, the transmission and distribution networks – as well as the users – are highly inefficient, wasting energy. The most consumed fossil fuels are diesel and gasoline (47% TPES) used for transport, as well as LPG (11% TPES) used for cooking mainly at the household level. Electricity accounts for about 26% of TPES serving residential (62%), commercial (26%) and industrial (12%) consumers.

[3] Palestine’s Economic Outlook – Oct. 2018 – World Bank Publication
[4] UNDP, Human Development Indices and Indicators: 2018 Statistical Update
[5] OCHA, Humanitarian Needs Overview, 2017
[6] UN Country Team oPt, Common Country Analysis, 2016, Chapter 2
[7] Peace Now, Settlement Watch, Settlement Construction Report, 2018

The transport sector is the largest contributor to energy consumption, followed by the residential sector, which together account for 84% of total consumption. The remaining contribution is given by the productive sectors, in first place the commercial sector (9%), followed by the industrial one (5%), while the agricultural sector accounts for only 1% of the total energy consumption.

Domestic energy production in Palestine is very limited. In fact, there are no power plants in the entire West Bank, while the only power plant in Gaza is powered by diesel and provides only 32% of its electricity needs. The electricity imported into the West Bank from Israel accounts for 99% of its electricity needs and amounted to 5,577 [MWh] in 2017, increasing of some 35% from 2010. This electricity is generated in Israel by gas-fired (61%) and coal-fired (36%) power plants, with a small contribution from PV (2.3%).

In the West Bank there is no very high voltage (161 kV) electricity transmission network. There are indeed about 120 high voltage (22-33 kV) connection points from which the Palestinian DISCOs (Distribution Companies) purchase electricity from the IEC (Israel Electric Company). The project to replace these connection points with 4 very high voltage substations located in strategic locations in the West Bank is under development. To date, they have all been completed, but only the Jenin station is currently operative. The others are still not energized because developments are expected in the resolution of the PPA (Power Purchase Agreement) to be signed between the State of Palestine and Israel.

The PPA aims at the establishment of a single buyer of electricity for the West Bank and to address the issue of the debt that the PA (Palestine Authority) has to the IEC and which now amounts to about 2 billion NIS (approx.500 million US$), 1% of the GDP of the West Bank[8]. This debt has been accumulated over the years and it has been generated due to a number of factors, in particular major losses due to technical and non-technical factors such as unauthorized connections, non-payment of bills by users. Moreover, even when revenues are collected by municipalities, they are sometimes diverted to cover other subnational expenditures rather than being channelled to the purchase of power. This means that only 64% of the energy purchased from IEC can be paid back. To compensate at least partially for this difference, part of the money that the Israeli State is required to return to the Palestinian Authority for the taxes paid by Palestinian workers in Israel is retained (Net-Lending), the rest is accumulated as debt.

[8] World Bank, Securing Energy for Development in the West Bank and Gaza, 2016

Local energy production is limited to biomass and solar energy. The former serves as fuels while the latter is used mainly for heating water. The estimated amount of PV power installed in the West Bank is 30 MWp, whose production of electricity does not reach 1% of total energy consumption. The potential for generating electricity from PV in one year ranges from an average of 1769 [kWh/kWp] in the West Bank, to 1827 [kWh/kWp] in the studied city of Hebron, to 1845 [kWh/kWp] that can be produced in the South-Hebron Hills[9].

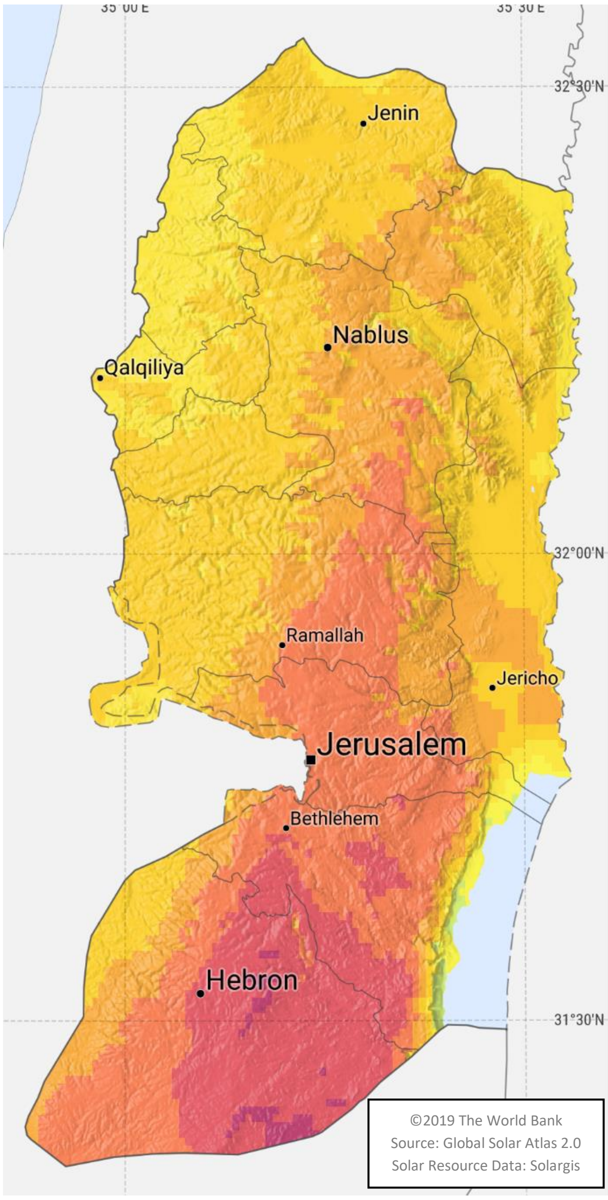
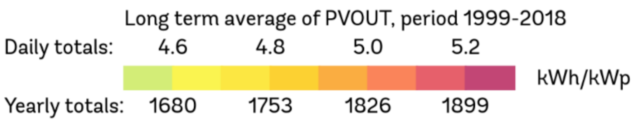


Table 2 - **PV Power Generation Potential in West**

Specific PV Power Output	PVout	4.92	kWh/kWp
Direct Normal Irradiation	DNI	6.06	kWh/m2/day
Global Horizontal Irradiation	GHI	5.61	kWh/m2/day
Diffuse Horizontal Irradiation	DHI	1.70	kWh/m2/day
Global Tilted Irradiation	GTI	6.22	kWh/m2/day
Optimum Tilt of PV Modules	Opta	28°	-
Air Temperature	T	19.5	°C



Securing Energy [10] [11]

The main strategies to be pursued to develop the Palestinian energy sector are identified by the authorities involved in the PPA resolution, and are the construction of a 400 [MW] gas-fired power station located in the city of Jenin and the conversion of the existing Gaza power plant from diesel-fired to gas-fired. To meet the increase in gas demand generated by the two power plants, it will be necessary to step up gas imports, preferably exploiting the Gaza Marine field.

[9] Data and Map: Global Solar Atlas, World Bank Group, funded by ESMAP, and prepared by Solargis, for more information please visit https://globalsolaratlas.info.
[10] Office of the Quartet, Strategy 2018-2020
[11] World Bank, Securing Energy for Development in the West Bank and Gaza, 2016

Upgrading the existing electric transmission lines from Egypt and Jordan is a realistic and feasible option in the medium term, particularly when compared with the commissioning time of the Jenin power plant. This solution would also diversify the supply of energy, making it more flexible and cost-effective.

Increase of the production by renewable resources, in particular PV, could also play a significant role in the future Palestinian energy mix. The potential for the installation of this technology is estimated at 530 [MW] for roof-top systems to which should be added about 100 [MW] for large-scale systems in Area A and Area B. Since Area C occupies about 60% of the West Bank, the potential for the installation of solar energy including both PV and CSP grows to 3000 [MW].

The increase in production facilities must go hand in hand with the upgrading of distribution networks or the construction of new high-voltage transmission networks, which is not an easy task in the political context. A viable option for mitigating the issue of limited capacity of existing networks is “wheeling power”, that is, feeding power into one point of the Israeli network and extracting the same amount of power from a different site under economic conditions to be defined. Measures to reduce losses (that account for 20-30% of final consumption) are also planned paying particular attention to energy efficiency at the residential level. Such an option would be more cost-effective than upgrading the electric networks.

Survey Methodology

The research aims to assess the level of access to modern energy of households living in the West Bank Area C, focusing on the case of the Hebron Governorate. The methodology adopted is "Beyond Connection", created by ESMAP, the World Bank's technical-informative assistance programme. It has been developed with the aim of overcoming the common idea that energy is associated only with electricity and that accessibility is related only with consumption rather than the quality of consumption. In addition, it assesses the household access to clean fuels and modern solutions for cooking and heating.

Each type of energy final use is assessed by numerous attributes (e.g. capacity, availability, reliability, safety, etc.), evaluated on a scale from zero to five. The minimum score obtained by a household among the various attributes will be its level of access to energy. The minimum – an index – is chosen in order to highlight the most problematic issue that characterizes each household. The average over the entire population defines the global level of accessibility to the various forms of energy.

Table 3 - **Example of Access to Electric Power Level Calculation**			
Results obtained by one Household		Number of Households per Level	
Capacity	4 /5	Level 0 /5	5%
Reliability	3 /5	Level 1 /5	15%
Availability	4 /5	Level 2 /5	10%
Quality	4 /5	Level 3 /5	30%
Affordability	2 /5	Level 4 /5	35%
Legality	5 /5	Level 5 /5	5%
Safety	5 /5		
Household Level	**2 /5**	**Group of Households Level**	**2,9 /5**

The results obtained can be used to compare different groups of people or assess the evolution of their level of access over time. The overall index of household access to energy (that aggregates the results of electric energy, energy for cooking and energy for heating) may be calculated as the average of the three sub-local indices, but it involves an apple-to-oranges aggregation and is less meaningful than the individual indices.

The study does not assess the household level of access to energy for transport, although it is a necessity especially for remote communities. The reason why this dimension is not analysed is to be found in the variability of attributes that characterize the different travel habits not only of each individual context, but also of each family reality. The evaluation of the energy consumed by a public transport system, bicycles, animal-drawn vehicles or by walking on foot depends on a number of factors that are difficult to estimate with precision. People's movements vary according to their work, the availability of a vehicle as well as an accessible road, the territorial configuration and so on. Consequently, the transport dimension is excluded from this analysis of energy accessibility.

The access to energy of productive activities and public services has not been evaluated either. Since these are an integral part of the social fabric of any community, the study of these sectors is therefore fundamental to obtain a broader understanding of people's needs to implement future development projects.

2.COMMUNITIES IN AREA C

As part of the 1995 interim Oslo II Agreement, the border of Area C is delineated in order to ensure Israeli control over its infrastructures. For this reason, it often happens that part of the territory of a community is arbitrarily defined as Area C but without presenting substantial differences with respect to the rest of the community.

2. COMMUNITIES IN AREA C

Area C

The Hebron Governorate has a population of 705,000 people living in Area A, with full Palestinian civil and security control, in Area B, under full Palestinian civil control and joint Israeli-Palestinian security control, and Area C, where Israel has both civil and security full control. As part of the 1995 interim Oslo II Agreement, the border of Area C is delineated in order to ensure Israeli control over its infrastructures, such as the main roads, the electricity transmission networks and the settlements. For this reason it often happens that part of the territory of a community, typically the peripheral areas up to a few residential units, is arbitrarily defined as Area C but without presenting substantial differences with respect to the rest of the community (except for the administrative regime).

Administrative control means that households need to obtain permits to carry out any activity, from construction to renovation or installation of new systems. In the eight-year period from 2009 to 2016, only 66 construction permits were approved in Area C by the Israeli Civil Administration (ICA) – the Israeli authority in charge or administrative control over Area C - compared to 3,365 applications (1.96% of approval rate)[12]. Often approval is the result of processes that can last several years. **Security control** entails the widespread presence of military force with the power to search civilians whose possibility of movement is also limited by physical barriers (e.g. the separation wall[13], checkpoints and restricted areas) and bureaucratic barriers (the Permit Regime[14]).

However, assigning a risk coefficient for demolition or seizure to a specific community is not an easy matter. The risk is likely to increase if the community is close to an Israeli settlement, but there are no reliable indicators to obtain a precise estimation. Preference should be given to the use of cheap materials or easily replaceable devices to prevent unsustainable economic losses in case of demolition or seizure. **There is a number of useful measures to mitigate the risks**, although they cannot be considered absolutely valid rules. It can be preferable, for example, to build permanent structures rather than mobile, despite the greater risk. In fact, the execution of demolition orders take more steps and a longer period than seizures (confiscation). Moreover, it ensures the possibility of using the structure for a longer time and to build a legal case to try to protect the structure under threat. In any case, it is essential to limit the visibility of the intervention, for example avoiding the installation of bulky infrastructure such as wind turbines, or working on public holidays. Legal assistance is more effective if

[12] Peace Now, Israel's Decision for Palestinian Construction Permits in Area C, Jul.2019, (ICA Data)
[13] HAMOKED, Human Rights Violations in West Bank Areas Known as the "Seam Zone", 2013
[14] ARIJ, the Israeli Permit Regime: Realities and Challenges, 2018

there is a strong coordination between communities and human rights organizations, while diplomatic support can be an excellent deterrent but still does not offer the total guarantee that risks are zeroed.

Communities' Clusterization

In the Hebron Governorate there are about 120 communities whose territory is totally or partially in Area C. There are about 66,400 people living in these communities, 9% of the governorate population. In some of these communities there are demolition orders pending on more than 50% of the residential buildings. In the whole Area C the total number of demolition orders is now estimated at 17,000. In addition, built with the financial support of the European Union or EU member states were also demolished[15], including energy infrastructures[16], or needed to ensure access to water, education or health. Moreover, seizures of goods are reported at the household level, in many cases concerning livestock or other means of income generation. A detailed mapping of the various vulnerability aspects of the communities involved was drawn up by OCHA in 2014[17].

The characteristics of each community that is located partially or totally in Area C are very different. In order to obtain more reliable results, the communities have been divided into different clusters. The criteria to aggregate communities can be chosen on the basis of geography, vulnerability, number of inhabitants or size of the families. Given the topic of the research, the communities' availability of public infrastructure, such as electricity network, water network or paved roads, was proved to be the most effective. Therefore, three clusters of communities were defined. In order to assign each community to a cluster, the availability of public infrastructures has been evaluated on the basis of OCHA's freely accessible vulnerability data. This research does not include the analysis of specific realities such as those of refugee camps or Area H2 of Hebron, for which a future integration is desirable.

Table 4 – **Communities Clusterization**

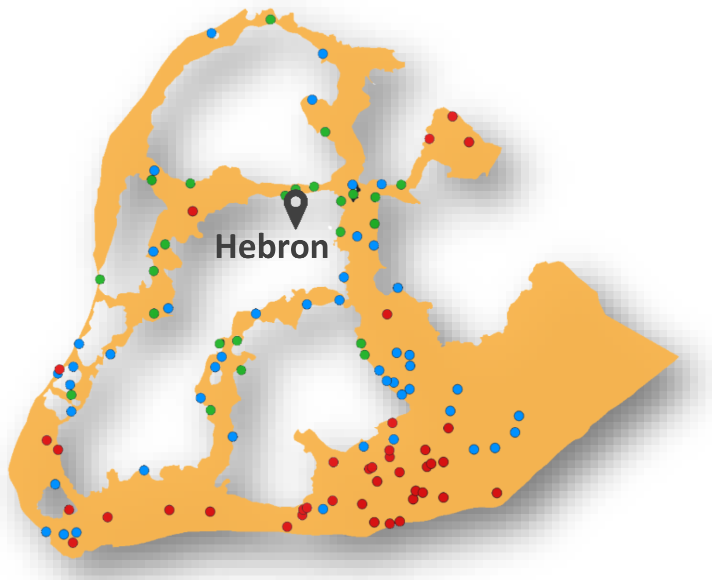
Cluster1	The community has total access to public infrastructures: Electric Grid, Water Network and Paved Road	HH1	
Cluster2	The community has access to the public electric grid; Water network is not available or the price of water is above 25 [NIS/CM]; Access to paved road is interrupted by a dirt track or blocked by physical barriers.	HH2	
Cluster3	The community is in the same conditions as Cluster2 but does not have access to the public electric grid.	HH3	

[15] Office of the European Union Representative (West Bank and Gaza Strip, UNRWA), Six-Month Report on Demolitions and Confiscations of EU funded structures in Area C September 2016 - February 2017

[16] Al-Haq, The Sun Belongs to Everyone, Israeli Demolition and Confiscations of Solar Panel Aid Projects in Area C of the West Bank, 2018

[17] OCHA, Vulnerability Profile of Palestinian Communities in Area C, (http://data.ochaopt.org/vpp.aspx)

Table 5 - **Communities in Area C**			
	HH1	HH2	HH3
Number of Communities	24	47	40
Cluster Population	42000	20400	4000
Population %	63%	31%	6%
Map Legend	Green dots	Blue dots	Red dots



Access to public infrastructure has been chosen as a criterion for aggregation because of its objectivity and the ease to assign each community to a cluster. It is indeed possible to confirm quickly the forecast made by using the information available online simply through direct observation or easy questions to the inhabitants. This research is based on data acquired through a survey based on a sample of 210 households belonging to 68 different communities. The communities were evenly distributed throughout the governorate and selected to include both the largest and smallest ones. The number of households to be interviewed has been weighed on the size of the cluster and on the size of each community, with the aim of obtaining statistical significance in order to make predictions about the population of each cluster.

Applying this criterion, **Cluster1 (HH1) is the largest**, with some 42,000 people distributed in 24 communities where only a small portion of the territory is located in Area C. This cluster comprehends households whose living conditions do not differ substantially from those of the people living in the same community but in Area A or Area B. When the study refers to HH1, however, all interviews and results will concern only residents inside Area C. **Cluster2 (HH2) has the largest number of communities**, 47, totally or partially in Area C and its population presents the highest variety of living conditions, since it is frequent to meet people who live in simple shelters like others who own large villas. **Cluster3 (HH3) is the smallest**, consisting of 40 communities normally inhabited by a few dozen up to a few hundred people, and located far from cities; therefore their territory is completely in Area C.

Communities' Main Features

The inhabitants of the governorate gather around solid family units composed on average of 7 people, and live according to the values and traditions of the Islamic religion, characterized by strict recognition and respect of roles, especially related to gender and to seniority.

Households who have full access to public infrastructure (HH1) work mainly in Israel (43%), in a local business (27%), or in the public sector (18%) and only 8% are farmers or herders. Where public infrastructure is weaker (HH2), the number of people working in Israel decreases because of the reduced availability of the paved roads and therefore greater difficulty in moving. The decrease in the number of workers in Israel leads to an increase in the level of unemployment. As the number of farmers or herders rises, the workers in the public sector decreases (11%), again because of the distance of the community from the public offices. Where there is no public infrastructure available (HH3), families mainly live on farming and herding (77%) or work in Israel (13%), while public sector employees fall to 2%.

Table 6 - **Household Main Source of Livelihood**

	Farmer/Herder	Work in Israel	Unemployed	Public Sector	Local Business
HH 1	8%	43%	4%	18%	27%
HH 2	13%	39%	9%	11%	27%
HH 3	77%	13%	3%	2%	5%

The distribution of the maximum level of education reached by at least one member of the family has a practically identical form for those who have total or partial access to public infrastructure (HH1 and HH2), with 38-39% of families with at least one person having attended university. When considering the communities without access to public infrastructures (HH3), only 23% of the household has a member that is graduated, while most family members (55%) have stopped at primary education.

Table 7 - **Household Highest Education Level**

	None	Primary	Secondary	College
HH1	0%	29%	31%	39%
HH2	1%	29%	31%	38%
HH3	2%	55%	20%	23%

Both the main source of livelihood and the maximum level of education attained by the family are reflected in the income distribution of the various clusters. If those who live with full access to public infrastructure (HH1) have in 78% of cases an income higher than 2,500 [NIS/month] (ca.625 $/month), this percentage drops to 59% if the infrastructure is weak (HH2), swelling the lower levels of the inverted cone. The form of distribution changes for HH3, with modal value falling by one level, and average income around 2,000 [NIS/month] (ca.400 $/month).

Table 8 - **Household Income Distribution [NIS/month]**

	0-800	800-1200	1200-1700	1700-2500	2500+	**Average**
HH1	0%	2%	4%	16%	78%	**2996**
HH2	5%	6%	12%	18%	59%	**2558**
HH3	8%	10%	18%	37%	27%	**2025**

It is remarkable that the average income of the cluster with the worst living conditions (HH3) is still five times higher than the energy poverty limit defined according to the methodology (390 NIS/month), i.e. an income for which the purchase of an energy package of 365 kWh/year is an expense that exceeds 5% of the income itself. This consideration helps to clarify what the Palestinian context is. Unlike many countries where limited access to energy, and in general to technology, is the main barrier to development, **Palestine is conditioned by the political stalemate that slows down both the spread of technology and development**. For example, there are many communities in the HH3 that are located a few tens of meters from the Israeli power distribution network, but they cannot access these infrastructures and rely only on simple stand-alone PV systems.

3. ELECTRIC POWER

During the study it was found that 100% of households have access to electricity.
In this chapter will be investigated the quality of the electricity available will and the systems to convert it into useful effect.

3. ELECTRIC POWER

Electricity Supply

The first significant finding of the survey shows that 100% of the communities in the study area have access to electricity. In fact, even in remote communities every household can rely on a source of electric power. However, the on-off approach, which considers the presence or absence of a grid connection as the only significant parameter to evaluate the access to the electric energy, is inadequate to describe the quality of access. It is indeed essential to assess the quality of the service provided, its safety and reliability, as well as to estimate how much this affects the household economy. These evaluations must be independent from the energy source, highlighting only the aspect of accessibility in terms of supply. The research will deepen the level of access to electric services, such as the availability of appliances, and the household consumption habits.

Communities who are not connected to the public electric grid (HH3), exploit other energy sources to generate electricity, in particular the solar one. The systems are donated by different institutions, such as universities, or local and international organizations. The systems consist of PV or hybrid mini-grid designed to meet the households' basic energy needs. Those who have access to the public electric grid purchase electricity from one of the distribution companies in the region (HEPCO for the urban area of Hebron and SELCO for the remaining communities in the region and in general for the South of the West Bank).

Table 9 - **Household Electric Supply**

	Prepaid Recharge	Postpaid Bill	Do NOT Pay the Bill	Provided by an Organization
HH1	90%	10%	0%	0%
HH2	59%	25%	16%	0%
HH3	0%	0%	0%	100%

In recent years, the use of prepaid meters has become widespread to deal with the phenomenon of non-payment of electricity bills that occurs mainly in peripheral contexts such as Area C or refugee camps. This type of electric meters provides the service after recharging a personal card, similarly to mobile phones. This makes easier to ensure the collection of electric bills and reduces the debt growth with IEC. The survey showed that this type of meter is used in 90% of contexts with full access to public infrastructure (HH1), compared to a national average of about 60%. In contrast, 16% of respondents with access to weak infrastructure (HH2) still do not pay even though they receive their bills. In order to highlight the issue, the non-payment has been considered as illegal connection, assigning the lower access score.

Assessing the extent of the phenomenon of illegal connections is not a simple matter. The service provider may not have accurate information, especially in contexts characterized by high transport losses. The respondents may prefer not to release this kind of information, therefore the result obtained can be considered as a downward estimate of the phenomenon. Moreover, this study does not include contexts such as refugee camps or the inhabitants of the H2 area of Hebron, where it is to be expected that non-payment is even more widespread. In addition to spreading the use of prepaid meters, it is therefore important to further intensify the awareness that this type of habit negatively affects the economy of the PA, not of the IEC.

With regard to the safety of the systems, none of the interviewees had any experience of serious accidents. This result is certainly due to the competence and capillarity of the organizations that operate on the territory, limiting the realization of handicraft systems. Direct observation of electrical systems within communities has not revealed any particularly alarming case or situation that require monitoring.

Electric Availability

Availability and reliability are important attributes for electricity, in particular for needs such as lighting or telecommunications, but they become crucial aspects in the case of food preservation, which could become harmful if not properly refrigerated. While some electrical appliances, such as mechanical loads or washing machines, can be used at different times of the day, other appliances must be available at specific times of the day, such as night-time lighting. In addition, unexpected power outages can be accounted as a cost in terms of non-use of the service. The duration and frequency of power outages are both aspects to be taken into account when assessing the accessibility of users to electricity.

The availability of electricity in the West Bank is very different from that in the Gaza Strip, where shortages are more frequent and more affected by seasonality, resulting in a "rationing" of the service, limiting in some cases the availability of electricity to 4 hours per day. The public network in the West Bank offers the service with continuity and with only few defections in the peripheral areas and in the winter season. The electric availability is very different for those who rely on the solar resource, which manages to ensure the service for 87% of the time in summer but reducing to 73% in winter. Overnight, households of the HH3 have access to electric power only for 3.5 hours out of 5 in winter (considered as evening from 18:00 to 23:00), growing to 4.5 hours in summer. The availability of electricity does not differ much in the evening hours compared to daytime for communities connected to the public electricity grid (HH1 and HH2).

Table 10 - **Household Electric Availability**

	Daily [24 hours]		Evening [5 hours] (6:00pm-11:00pm)	
	Summer	Winter	Summer	Winter
HH1	100%	96%	100%	93%
HH2	98%	90%	98%	93%
HH3	88%	73%	88%	73%

Table 11 - **Household Electric Reliability**

	Weekly Shortages	
	Summer	Winter
HH1	0.1	0.4
HH2	0.7	0.9
HH3	2.7	3.6

Unscheduled shortages are slightly more frequent for communities connected to weaker public networks. For the households in HH1 unscheduled interruptions occur between one and three times a year, for households in HH2 frequency increases to almost ten interruptions per year. In the case of stand-alone systems, the frequency of interruptions has another order of magnitude, typically varying between 10 and 14 times per month, with a more pronounced seasonal effect. If the results of the survey are in line with the public electric grid performances in the West Bank, on the other hand, concerning stand-alone systems there is an inconsistency with the data available online. According to the real-time monitoring of the stand-alone electric systems[18], electricity is available to the communities for weeks without any interruption. These shortages are therefore not to be attributed to solar or hybrid mini-grids, but to the management model implemented by Comet-ME[19], the organization that is providing the systems to 83% of the interviewed communities.

Electric Appliances

Electricity is an energy vector whose availability is useless if the user does not have the appropriate appliances able to convert the motion of the electrons in a useful effect (eg. lighting, refrigeration, etc.). Household appliances help to carry out daily activities, satisfying different people's needs and consuming different loads of energy, both in terms of power and duration. Hence, a refrigerator will operate and consume in a different way from a washing machine and the two appliances cannot replace each other. For this reason, the methodology proposes a specific indicator that features the accessibility of users to electrical services, regardless of supply or consumption.

The available appliances have been classified according to their role in ensuring comfort and improving the quality of life. The first level is occupied by appliances that meet basic needs, such as the refrigerator, indoor and outdoor lighting and the phone charger. Of these, only outdoor lights for households in HH3 is below the level of 90%. The second level is occupied by communication and entertainment appliances, such as television and laptop. The result of the survey shows that this type of device is widely used in all categories of communities, with the exception of the laptop, which is owned only by 7% of HH3, up to 25% of HH1.

[18] Comet-ME Tech.Info – Real Time System Monitoring (https://comet-me.org/tech-info/)
[19] Described later in this Chapter

Table 12 - **Household Basic Appliances**

	Phone Charger	Indoor Lights	Fridge	Outdoor Lights	Fan	TV	Laptop
HH1	100%	100%	100%	96%	96%	98%	25%
HH2	99%	98%	98%	96%	93%	95%	19%
HH3	92%	98%	98%	85%	50%	92%	7%

The main differences that have been found concern medium and high energy consumption appliances. In fact, the communities that live mainly on herding (HH3) have food processing machines in 40-45% of the cases, especially for the production of yoghurt, butter and cheese from goat's and sheep's milk. These appliances are practically absent in more urban contexts. The washing machine is a household appliance owned by all families while the water pump for domestic purposes is owned by 68% of households in rural areas (HH3), rising up to 90% for households in HH2. The pump is not an indispensable component if the public network already gives sufficient pressure to the water, it is therefore normal to find a greater presence of pumps where the network is weaker (HH2).

Table 13 - **Household Medium Consumption Appliances**

	Water pump	Washing M.	Butter Churns	Yoghurt M.
HH1	80%	100%	2%	0%
HH2	91%	96%	3%	8%
HH3	68%	93%	43%	42%

As for energy-intensive appliances, these are a rarity for rural communities (HH3). The PV or hybrid mini-grid systems must be affordable and for this reason provide a smaller amount of energy than the public network. Those who have access to the public electric grid (HH2 and HH3) typically have several energy-intensive appliances (AC, water boiler, electric oven, electric heater, etc.) depending on their needs. According to the methodology, the availability of at least one of these high consumption appliances allows to assign the maximum score to the household accessibility to the electrical services.

Table 14 - **Household High Consumption Appliances**

	Electric Oven	Water Boiler	Kettle	Air Conditioner
HH1	27%	43%	27%	25%
HH2	39%	30%	16%	32%
HH3	0%	0%	3%	0%

There have been many cases of broken or damaged devices in the last year. Broken or damaged appliances need to be repaired or replaced with new ones, with a consequent considerable burden on family economy. Almost 50% of households in HH1 and in HH3 have experienced this kind of issue, while the percentage rises to 58% for those who have access to weak public infrastructure (HH2). The fact that both those connected to the reliable public grid (HH1) and those connected to a mini-grid (HH3) have similar results in terms of breakdowns suggests that the cause of this problem is not to be attributed to the grid as much as to household appliances. These grids both meet the standards of service provision in terms of voltage fluctuations, while often families rely on old, second-hand or even obsolete appliances.

A rough estimate of the impact that network quality has on breakdowns can be derived by comparing the results obtained by households connected to the reliable public network (HH1) with those connected to the peripheral sections of the public network (HH2). Having found that these two groups have similar appliances, it can therefore be assumed that the increase in breakdowns between the former (HH1) and the latter HH2) is to be attributed to the network.

Electricity Consumption and Affordability

Certifying what is the link between power consumption and the price of electricity is not very meaningful. Electricity is a basic need and therefore has a very low elasticity of consumption. Moreover, the function depends on the household income but also on the priorities people have, as well as on the size of the family and so on. To overcome these difficulties, the methodology evaluates economic convenience independently of consumption, defining it on the basis of the proportion of the cost of purchasing a package of 365 kWh per year, which must not exceed 5% of household income. Considering, with a conservative approach, the price of the recharge of 0.578 NIS/kWh (approx. 0.145 $/kWh), this results in a total expenditure of 17.34 NIS/month for the purchase of 30 kWh, or 1% for lower incomes. We can therefore consider electricity as affordable for all the households with an income. The result is very different if we compare the income with the total electricity expenditures. The consumption of electric energy does not impact much on the household income only for those in HH3, but exceeds the threshold of 5% for households both in HH1 (7.4%) and in HH2 (9.9%), resulting in "*Energy Poverty*".

Table 15 - **Household Electricity Affordability [% income]**

	365 kWh/year	Considering current HH Consumption
HH1	0.6%	7.4%
HH2	0.7%	9.9%
HH3	0.9%	3.3%

“Energy Poverty” depends on many factors. Households in HH2 have a lower average income than those in HH1, while in terms of consumption there is not a big difference between the two clusters considered. Both average income and consumption are symmetrically distributed around the averages and aligned with those that are typical national consumption. The average consumption of 12.5 [kWh/day] in HH2, slightly higher than the consumption of 11.5 [kWh/day] in HH1, may depend in part on the quality of electrical systems, which is likely to be characterized by greater losses, in part on the need to use appliances to address the weakness of the infrastructures (e.g. water pump in HH2), thus justifying the different impact (2.5%) that the expenditure on electricity has on households’ income.

Table 16 - **Household Electric Consumption Distribution [kWh/day]**

	0-2	2-3	3-6	6-10	10-20	20 +	**Average**
HH1	0%	4%	14%	31%	37%	14%	**11.5**
HH2	0%	1%	10%	22%	45%	17%	**12.5**
HH3	17%	33%	50%	0%	0%	0%	**3.0**

The HH3 distribution of power consumption never exceeds the value of about 4 kWh/day. The reason for this is to be attributed to the system model designed and implemented by Comet-ME, the organization that provides electric power to 83% of the interviewed communities. Tier model is characterized by a cap on consumption set at 2.5 kWh/day per HH, typically 7 people. This limit is reportedly imposed in such a way as to prevent excessive demand fluctuations that may cause stress on the stand-alone systems. Unexpected loads would lead to the necessity of more frequent maintenance, resulting in increased operating costs, and a shortening of the useful life of the components. In addition, this limit also helps ensure that the energy stored in the batteries is equally exploited by all members of the community. The batteries are the source of energy for all the households connected to the same centralized hybrid mini-grid, thus this cap on household consumption guarantees equality and avoid that excessive consumption by one family penalizes the access to basic services of all the others.

The amount of energy consumed by HH3 corresponds to about a quarter of the average consumption of the other groups. The limit on consumption is calculated in order to be sufficient to ensure the daily operation of only the basic services, such as refrigerator, indoor lighting, television and phone charger, as well as the use, not simultaneously and only with sufficient charge in the batteries, of the washing and yoghurt machines. Yoghurt machines and butter churns are often supplied by the organisation jointly with the user's connection to the electrical system, together with a 50 kWh package of electric energy for free. Energy-intensive appliances such as electric heaters or kettles are prohibited, resulting in the almost total absence of availability of this type of devices by HH3. The price applied to the provision of the service is in line with that of public network’s prepaid recharge, which, however, offers greater power and no limit in terms of consumption. Revenues are used by the organization to cover the maintenance costs and the replacement of components at the end of their useful life, thus guaranteeing continuity in the provision of the service and sustainability.

Access to Electric Power

The results discussed so far led to the determination of the level of accessibility to electric energy of the three clusters, obtained according to the methodology "Beyond Connection", created by ESMAP. The scores range from 2.9/5 for HH3, to 3.8/5 for HH2, up to 4.2/5 for HH1. The distributions are in all cases symmetrical to the average, none of the HH1 has a very worrying level of accessibility (i.e. equal to or less than 2.0/5). The conditions are worst for the other two clusters: 7% of the HH2 have a worrying level of access, mainly because of the not-paying phenomenon. On the other hand, 25% of the HH3 have a problematic level of access, a result mainly due to the absence of energy-intensive appliances, the cap on consumption and the seasonality of the solar resource that limits the power availability and causes more frequent shortages.

Table 17 – **Household Level of Access to Electric Power**

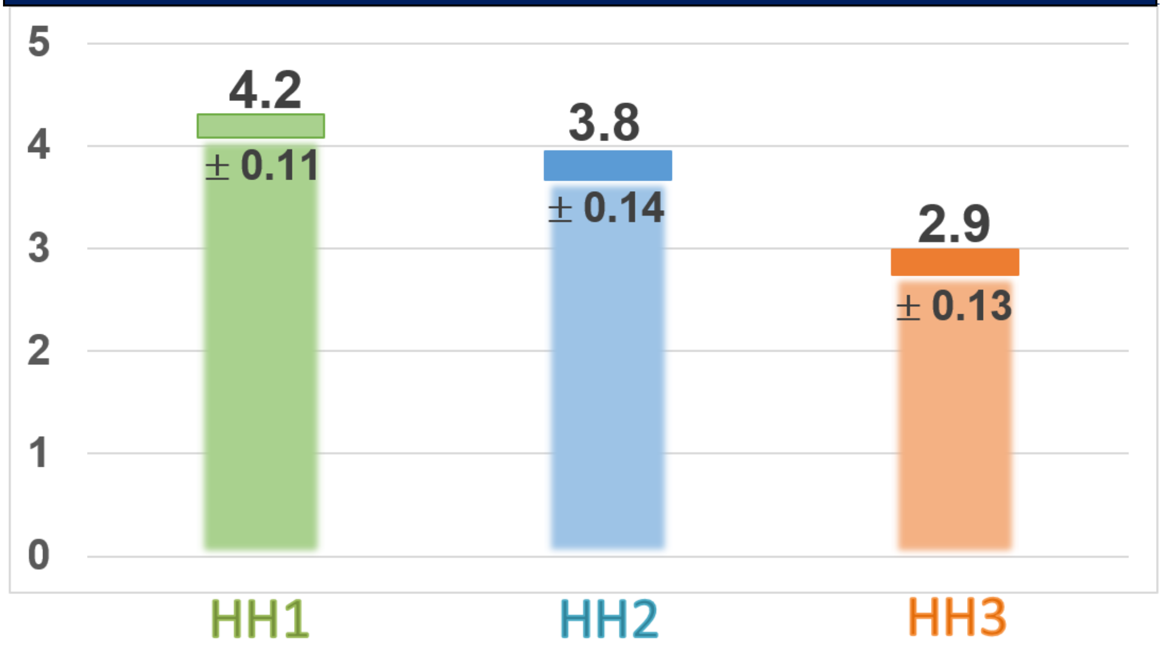
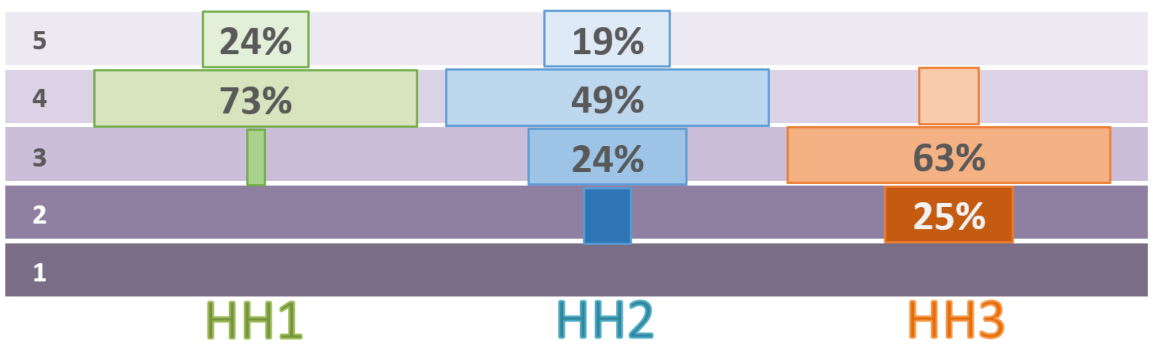


Table 18 – **Household Distribution of Access to Electric Power**



4. ENERGY FOR COOKING

The *Taboon*, the traditional Palestinian oven. Its firing chamber is made of clay and sealed by a metal lid. The fuel, usually manure, is accumulated around this chamber until it is completely covered. Once the manure is lit, a layer of ash is added covering the fuel in order to ensure slower consumption. Heat is accumulated inside the clay and stones, allowing bread to be baked and a wide variety of other dishes to be cooked. Generally, a stone structure covered with canvas or metal plates protects the fire, which can therefore function even on rainy days.

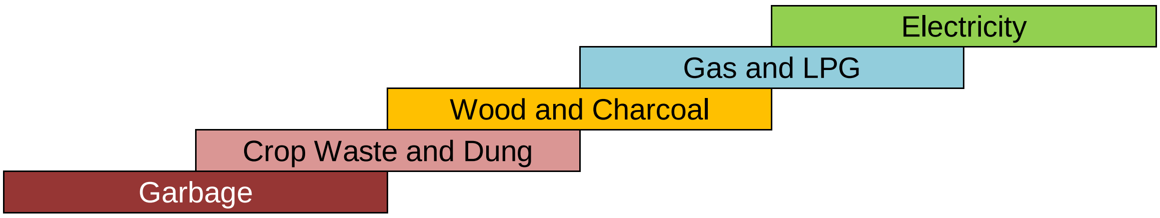
4. ENERGY FOR COOKING

Indoor Cooking

The level of accessibility to the energy needed for cooking is defined in accordance with the guidelines of the World Health Organization (WHO)[20]. It assesses indoor air quality and the performance of the solutions used for cooking. In a similar way to what was done to evaluate the accessibility to electricity, the minimum of seven indicators is used to determine what is the household level of access. Although there is ample evidence that inefficient cooking solutions emitting indoor toxic fumes have a negative impact on health and therefore on the socio-economic development of the community, the use of these devices is still widespread. The health hazard is higher for those people who spend more time indoor, in this context typically women and children, with significant consequences on gender equality or accessibility to education.

The indoor air quality depends on several independent factors, such as the performance of the solutions used, the amount and type of fuel consumed, the operating time of the device, the emissions from other devices such as those for space heating or lighting, the volume of the kitchen, the air exchanges and finally the outdoor air quality. It should be noted that air changes only contribute positively in the case of good outdoor air quality. As an alternative to direct measurement of pollutant concentrations or long-term assessment of mortality directly associated with air quality, an approach based on the assessment of primary and secondary cooking solutions can be used conservatively to obtain more approximate but still consistent results. An indoor air quality ladder has been designed based on the household consumption behaviour of different types of fuel, starting with the fuel that presents the worst health hazard, represented by garbage and solid wastes, ending with electricity.

Table 19 - **Household Fuel Ladder**



[20] WHO (World Health Organization) - World Health Report 2002: Reducing Risks, Promoting Healthy Life. Geneva: WHO. 2002

Main Fuels

The first element to consider when assessing air quality is the type of fuel used. The most consumed fuels are LPG, used by all households interviewed, and wood, used by 67% of HH2, from 80% of HH1, up to 93% of HH3. Unlike the gas that is imported, the wood is produced and sold within the West Bank. The cost of fuel for users varies significantly depending on the community's accessibility to public infrastructure, in particular on the presence of the paved road. In fact, where the communities do not have direct access to the paved road, there is a 25% increase in costs for LPG and 20% increase for wood. The expenses for these fuels have an overall impact of 25.8% on HH3 income.

Table 20 - **Household LPG Access**

	Users	Consumption	Cost	Expense	Affordability
		[kg/month]	[NIS/12kg]	[NIS/month]	[%income]
HH1	100.0%	19.58	66	108	3.6%
HH2	100.0%	24.54	67	138	5.4%
HH3	100.0%	18.96	82	129	6.4%

Table 21 - **Household Firewood Access**

	Users	Consumption	Price	Expense	Affordability
		[ton/year]	[NIS/ton]	[NIS/month]	[%income]
HH1	80.0%	2.46	87	215	7.2%
HH2	67.0%	1.76	81	142	5.6%
HH3	93.0%	3.83	104	398	19.7%

The proximity of the community to a settlement significantly affects the price of fuels because of the increasing difficulties encountered in transporting gas bottles and the travel in general. For Area C inhabitants is indeed safer to reach the cities taking a longer way than to pass close to a settlement, because controls are more frequent and the transportation of goods is subject to a higher risk of seizure[21].

The amount of time required to provide the family with a fuel is another key element to consider when assessing access to energy. Transportation is always included when firewood is purchased, and, given the scarcity of vegetation typical of this region, only 3% of HH3 up to 8% of HH2 use to collect firewood in the surroundings. The situation is different when considering LPG, since the time spent to refill one gas bottle ranges from a few minutes for HH1 and HH2, for which the refill company usually includes home delivery in the service, to an average of one hour and 30 minutes spent weekly by HH3 (no home delivery).

[21] This Report, Chapter 2.

It's rare for a person to go to the city just to fill the gas bottle. Usually the trip coincides with other commissions, for this reason it is difficult to derive a precise assessment of the amount of time that could actually be saved if a home delivery service is provided. Moreover, although this amount of time seems very large compared to urban standards, convenience in terms of time spent is **never** the limiting element to define accessibility. In fact, this result is very positive when compared with other development contexts. In India, for example, women spend more than 7 hours a week collecting wood.[22].

Table 22 - **Household Main Fuel Convenience**

	Availability [%time]	Time Spent to Provide Fuel	People Collecting Firewood
HH1	96.1%	0h05min /week	4.9%
HH2	95.5%	0h07min /week	7.6%
HH3	89.5%	1h33min /week	3.6%

Other types of fuel consumed include waste from agriculture and the olive oil production process, used to feed the oven or for space heating. This is a cheaper alternative to wood, typically chosen by those who own agricultural land and produce this type of waste. It has also been donated by the Ministry of Agriculture as a form of support for people selected mainly from communities that do not have access to public infrastructure. 22% of HH3 use crop waste, while the percentage drops to 20% for HH2 and 10% for HH1.

Charcoal is very rarely used. Only 17% of HH2 and 12% of HH3 regularly buy charcoal, which is used for smoking hookah and, less frequently, for outdoor cooking such as barbecues. The amount consumed remains very low. The use of kerosene is even more limited, given the difficulty in transport due to the few resale stations, always located in the city and therefore far from the communities under study. In Palestine kerosene is used by 2.6% of the population for space heating[23], while its use for lighting is as obsolete as it is for candles.

[22] Global Alliance for Clean Cookstoves, Gender and Levelihoods Impacts of Clean Cookstoves in South Asia, 2015

[23] PCBS, Annual Statistics, Percentage of Households that Used Energy by Region, 2015, http://www.pcbs.gov.ps/Portals/_Rainbow/Documents/HE-%20EA11%202015.htm

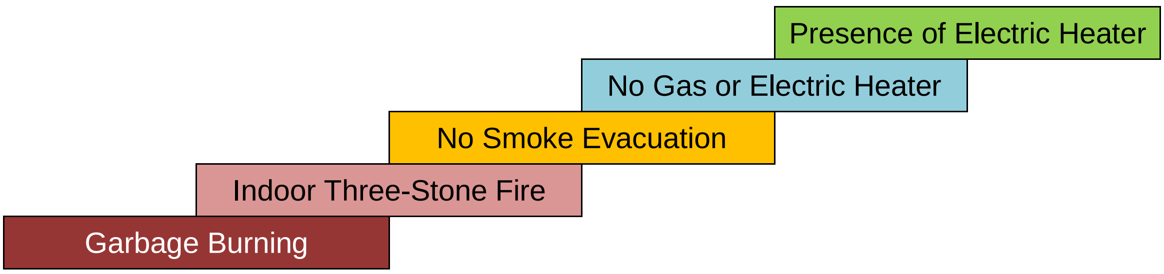
The use of manure as a fuel is much more widespread. The communities that do not have access to public infrastructure rely on herding activities as main source of livelihood, thus producing animal waste. Dung is a valuable resource of energy that can be exploited as fuel, used by 14% of HH2 to 43% of HH3 mainly to feed the *Taboon*, the traditional Palestinian oven. Its firing chamber is made of clay and sealed by a metal lid. The fuel is accumulated around this chamber until it is completely covered. Once the manure is lit, a layer of ash is added covering the fuel in order to ensure slower consumption. Heat is accumulated inside the clay and stones, allowing bread to be baked and a wide variety of other dishes to be cooked. Generally, a stone structure covered with canvas or metal plates protects the fire, which can therefore function even on rainy days. Although it is a cheap alternative, the burning of manure near the house can pose a serious health hazard, particularly for the respiratory system[24].

Table 23 - **Household Fuel Type Users**

	Crop Waste	Dry Dung	Charcoal	Garbage	Kerosene
HH1	10%	0%	4%	0%	2%
HH2	20%	14%	17%	2%	0%
HH3	22%	43%	12%	20%	3%

The habit of burning solid waste in roadside containers is a widespread practice of disposal throughout Palestine, indirectly impacting on the indoor air quality as it is the case of the *taboon*. Moreover, the survey found that in winter, when the primary fuel is not available, 20% of HH3 use to burn solid waste as their only source of heat. This practice has been defined as the zero level of the scale for the approximate evaluation of indoor air quality. The survey shows that the average level of air quality inside the home is 4.0/5 for HH1 and HH2, while it falls to 2.3/5 for HH3, mainly due to the practice of burning solid waste, the use of manure as fuel for the taboon, the use of three-stone fires for cooking and the use of firewood stoves for space heating without a chimney[25].

Table 24 - **Household Indoor Air Quality Ladder**



[24] Bulletin of the World Health Organization, Indoor air pollution in developing countries: a major environmental and public health challenge, 2000.
[25] This report, Chapter 5.

Cooking Solutions

Although a clean fuel such as LPG is used by every household, it results to be the primary energy resource for cooking only for the totality of households in HH1 and HH2. In contrast, only 75% of HH3 cases consider it as the primary fuel, although they have a gas reserve and a device to burn it. For reasons related to the cost of gas and the inconvenience in terms of time spent for its supply, 20% of HH3 uses three-stone fires typically burning wood, while 5% of HH3 has identified in the taboon its primary solution for cooking.

Table 25 - **Household Main Cooking Solution**

	Gas Cooktop	Three-Stone Fire	Taboon
HH1	75%	20%	5%
HH2	100%	0%	0%
HH3	100%	0%	0%

Cooking solutions such as three-stone fire and taboon have lower performance in terms of efficiency. As already discussed in the case of air quality, the research context has not presented the possibility of accurately measuring the level of performance of each cooking solution. A rough but consistent approach was chosen and a ladder for efficiency was established, from three-stone fire up to BLEENS (Biogas, LPG, electricity, ethanol, natural gas and solar systems). Again, if HH1 and HH2 have an average efficiency level of 4.0/5, the average level of HH3 does not exceed 2.6/5. However, this result does not seem to be particularly worrying for HH3, whose answers show that the average level of satisfaction for the primary cooking solution reaches 3.6/5. On the other hand, the result on satisfaction for the primary cooking solution is 4.1/5 for HH1 and 3.9/5 for HH2.

Table 26 - **Cooking Solution Efficiency Ladder**

- TIER3+ Electric Oven or Kettle
- TIER3+ Gas or Wood Oven
- Gas Cooktop as Primary Solution
- Taboon and Three-Stone Fire are used
- Taboon or Three-Stone Fire as Primary Solution

The safety assessment of the device depends on the presence of hot, sharp surfaces, and on the stability and containment of the fuel. Considering the use of numerous devices and the impossibility in the context of the research to experimentally verify the safety of each of these, safety has been assessed based on past experience within the household of serious accidents related to the cooking system, with particular attention to burns. The result shows that the average level of safety is maximum for HH1, with no case of accidents reported, and falls from a result of 4.4/5 for HH2 to the lower result of 3.6/5 for HH3.

Other solutions for cooking are one of the main differences between the various clusters. Those who have at least partial access to public infrastructure own usually electric ovens (39% of HH1 and 27% of HH2), or gas ovens (82% for both clusters). The presence of these devices collapses dramatically when HH3 are considered. None of the respondents reported owning an electric oven, while only 12% had a gas oven available. These devices are replaced by the taboon, used as a secondary solution by 73% of HH3, only 11% of HH2 and none of the HH1.

The wood-fired oven is a valid alternative to the taboon, being used by 25% of HH3, 16% of HH2 and 12% of HH1, and it is typically built with a brick structure, thermally insulated, and equipped with a smoke evacuation system. In these cases, the combustion chamber is completely separated from the cooking chamber, preventing food contact with waste fumes. The low diffusion of this solution is due, in urban contexts, to its bulky size and to the need to be placed outdoor. In rural contexts, its diffusion is limited by the higher construction costs and fuel consumption if compared with the *taboon*. However, people who own a firewood oven state that the taste of the food, especially bread, is not the same as the *taboon*'s one. The smoke contact with food in fact gives a characteristic flavour that is lost if you replace the *taboon* with any other solution.

Table 27 - **Household Other Cooking Solutions**

	Gas Cooktop	Three-Stone Fire	Gas Oven	Wood Oven	Electric Oven	Taboon
HH1	0%	2%	82%	12%	39%	0%
HH2	0%	9%	82%	16%	27%	11%
HH3	25%	27%	12%	25%	0%	73%

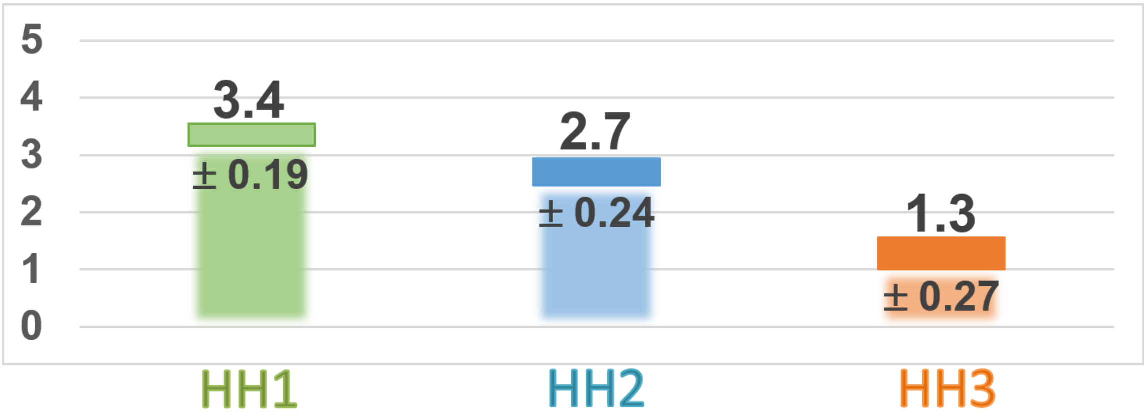
The choice of using one solution rather than another depends on its performance, preparation, start-up time and operating costs. If the gas cooker operates on average between 3 and 3.5 hours a day, resulting in a total cost of around 100 NIS/month (approx.25 $/month), the use of ovens is typically much lower. The electric oven is in fact active between 4 and 5 hours per week, involving a total cost between 65 and 70 NIS/month (approx.16 $/month), while the gas oven does not exceed 4 hours per week, for a cost of about 45 NIS/month (approx.11 $/month). An equivalent use, between 4 and 5 hours per week, of the wood-burning oven instead leads to a total expense of about 280 NIS/month (approx.70 $/month), some 4 times higher than expenses generated by the electric oven.

The taboon instead remains typically lit for several consecutive days. Two buckets of dry manure, one in the morning and the other in the evening, are in fact enough to keep it operational for the whole day. It requires one full day to be cleaned, some small pieces of wood and about 6 buckets of manure to be rekindled. For those who do not have their own manure production, the operating cost of the taboon is around 50 NIS/month (approx. 12 $/month), not too different from electric or gas ovens. For shepherds, on the other hand, the consumption of manure is certainly advantageous but also constitutes a loss of profit since there are people ready to buy it and save money from wood.

Access to Energy for Cooking

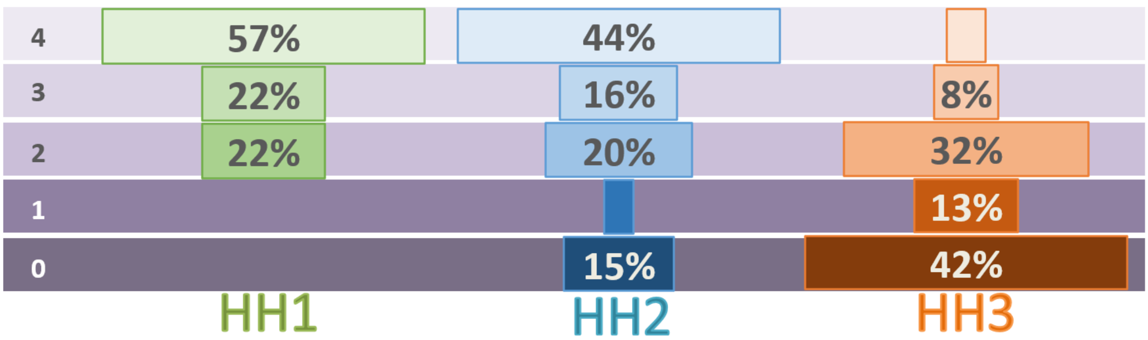
In conclusion, access to energy for cooking is worse than for electricity. If the HH1 reach a level of 3.4/5, the result drops to 2.7/5 for the HH2, and to 1.3/5 for the HH3. Nevertheless, communities that have at least partial access to infrastructure have a distribution of accessibility levels that is not symmetrical to the average, as it was happening for electricity, but is rather an inverted cone. This fact indicates a positive situation: most of the households belonging to this category have a high rank of accessibility, 57% for HH1 and 44% for HH2. However, it should be noted that there is a base in the distribution of the HH2, indicating that in 15% of cases there are problematic situations. This is mainly due to the poor safety of the devices used, 5% of families have had accidents related to the cooking system, and to the cost of the primary fuel, which weighs heavily on 6% of HH2 incomes.

Table 28 – **Household Level of Access to Electric Power**



When considering the communities that do not have access to public infrastructure (HH3), the situation is even worse. The effect of the use of inefficient and polluting systems are critical. The form of the distribution is symmetrical but presents a very broad base, consisting of 42% of HH3. Low indoor air quality affects 37% of HH3, while efficiency, affordability and safety are a serious problem for about a quarter of them.

Table 29 – **Household Level of Access to Electric Power**



5.ENERGY FOR HEATING

In a country like Palestine space heating is usually necessary only for three months a year and, perhaps for this reason, it presents the lowest level of accessibility.
There are seriously inadequate situations even in communities with full access to public infrastructure.

5. ENERGY FOR HEATING

Space Heating Solutions

Access to energy for space heating is a necessity in the winter months even for the inhabitants of the most temperate regions, such as Palestine. Although there are methods, more or less effective, to avoid the use of heating devices (e.g. the use of heavy clothes, the intake of hot drinks or the setting of barriers to avoid the domestic heat losses), during a period ranging between 2 and 3 months these solutions are not sufficiently adequate. The amount of energy needed to heat an indoor space and make it comfortable depends on the number of people stationed in it, the activity that these people perform and, in general, the heat losses to the outside. In addition, in a comfortable environment air temperature should be as uniform as possible, so solutions that exchange energy at low temperatures should be preferred, avoiding very hot or very cold surfaces.

People living in Area C adopt different solutions for space heating. Communities that have access to public infrastructure choose firewood stoves (81% of HH1 and 65% of HH2), electric heaters (37% of HH1 and 31% of HH2), or gas heaters (33% of HH1 and 38% of HH2). Almost all the households that do not have access to public infrastructure (HH3) use wood as a fuel for space heating, with devices that in 33% of the cases do not have a smoke evacuation system. Where a space heating device is not present, the house is heated while cooking or by means of a small fire in the middle of the room. This practice can be noticed immediately by observing the ceiling of houses, in most cases caves, where the carbon black is deposited. The indoor combustion of biomass can present a serious health hazard, as well as a negative impact on household economy.

Table 30 - **Household Space Heating Users**

	Firewood Stove		Gas Heater	Electric Heater
	Smoke Evacuation	No Evacuation		
HH1	75%	6%	33%	37%
HH2	60%	5%	38%	31%
HH3	58%	33%	3%	0%

In general, families rely on more than one heating solution, but they are rarely adopted at the same time. The firewood stove can offer comfort with greater space coverage, so it is preferred by larger families. It is operative for 20 hours per day, requiring a manual wood refill every 2 hours. Electric heating is chosen if the room to be heated is small and the household is connected to the public electric network. The operating costs are comparable to those of wood (approximately 1.50 NIS/hour) but the performances of these heaters is lower. Gas is the less affordable option. It usually gives a better comfort, but the operating costs are prohibitive (approximately 2.00 NIS/hour). For these reasons the gas stove is used only for special occasions, such as in the presence of guests, and never operates for more than 2 hours a day.

Space Heating Quality

The operative time of space heating is one of the indicators used to assess the access to energy. Owning one or more heaters is not enough if people cannot afford to turn these devices on. The duration in general depends on the specific habits of the family, according to the methodology this indicator is evaluated as a percentage of the times that heating system responds positively to the family needs. On average, the situation is good, it exceeds the level of 4.0/5 for the entire population surveyed. This result is obtained in many cases at the cost of indoor garbage burning, demonstrating how even in a warm country such as Palestine the energy for space heating is an essential need.

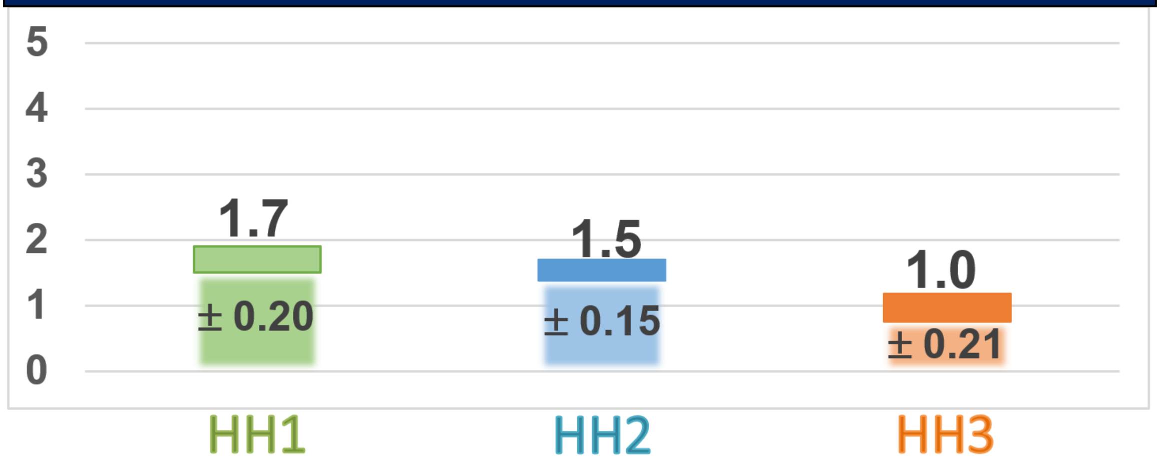
The capacity of the heating solutions is another attribute to be evaluated. The possibility to meet the household needs depend on the size and number of the available devices. To produce comfortable climate conditions in more than one room in the house is important to allow privacy and in general the opportunity to carry out activities that require an isolated environment, such as study. Capacity needed therefore depends on the number of people spending time inside the house and the size of the house itself. The capacity indicator for space heating has resulted as one of the worst in the entire assessment. It ranges from 2.25/5 for HH3 to about 2.0/5 for HH1 and HH2. In this case, communities that do not have access to public infrastructure have a better rank because they typically live in smaller dwellings, with one single room.

It is preferable that the heating system does not present very hot or cold surfaces, for safety and for comfort reasons. As mentioned above, hot air increases the losses if the house does not have a good insulation, while not homogeneous indoor air temperature is uncomfortable, especially when the room is surrounded by very cold walls. Safety is another reason why it is not preferable to use devices with very hot exchange surfaces. Serious accidents related to the heating system have occurred in 23% of HH3, 14% of HH2 and 10% of HH1, all due to the use of firewood stoves, whose design is characterized by metal external surfaces that reach very high operating temperatures. Household level of satisfaction for the space heating system is slightly lower than the one for the cooking system, ranging from 3.2/5 of HH3, to 3.5/5 of HH1 and 3.6/5 of HH2.

Access to Energy for Space Heating

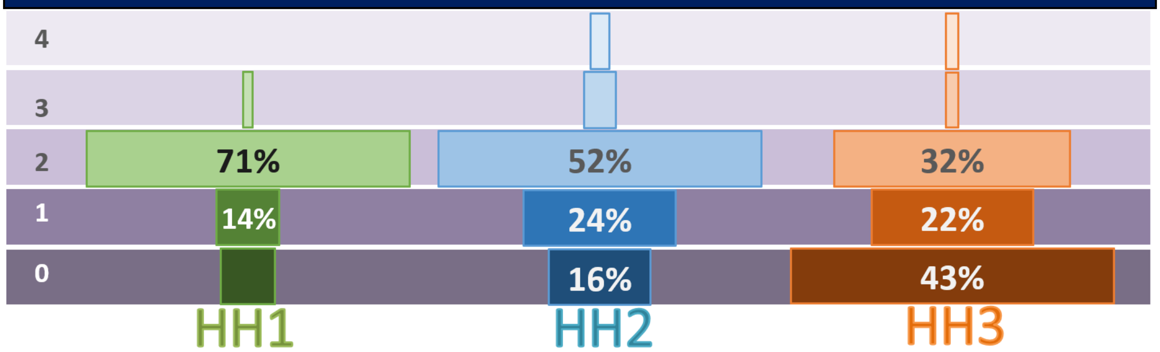
The result of accessibility to energy for space heating is the worst of the three. In fact, when compared to the levels reached by electricity[26] and cooking energy[27], space heating is very low for all the communities surveyed. The best result is however obtained by the communities that have full access to infrastructure, with a level of accessibility equal to 1.7/5 (HH1), those who have only partial access to public infrastructure reaches the level of 1.5/5 (HH2), while those who do not have access to public infrastructure stops at a level of 1.0/5 (HH3).

Table 31 – **Household Level of Access to Electric Power**



As happened in the case of energy for cooking, also the distributions of the levels of access to energy for space heating are different from cluster to cluster. The distributions present a symmetrical shape for HH1 and HH2, this time slightly unbalanced downwards, and a symmetrical shape with a significant base (43%) for HH3. The aspects that most affect these results are air quality, safety, capacity and cost effectiveness for HH3. Capacity is a critical issue for 22% of the HH2, safety for 14% and affordability for 6%. Space heating is the only form of energy end use that has worrying cases also for HH1, with 12% having serious issues with capacity and 10% with safety.

Table 32 – **Household Level of Access to Electric Power**



[26] This Report, Chapter 3.
[27] This Report, Chapter 4.

Water Access

Although the methodology adopted does not propose a protocol for the analysis of access to energy for water heating, given the widespread use of solar systems, especially at the domestic level, it was considered appropriate to include some considerations in this regard. For the same reasons as energy, access to water is often limited by the political context. In Palestine in general, and even more in Area C where the public network is very limited and weaker, water supply interruptions are frequent. In Bedouins communities there have been numerous cases of demolition of water storage systems.

The survey found that water consumption also depends on the community's access to public network. Households that are not connected to the public water network rely on a reserve of water stored in tanks typically located on the rooftop of the house. These tanks need to be refilled periodically at a higher cost than the price from the public water network. Moreover, the numerous shortages in the water supply that affect the public network, force also the households connected to this network to equip themselves with rooftop tanks as a form of preventive reserve. The collection of rainwater instead is an alternative used since ancient times and that contributes significantly to ensuring a reserve of water for domestic use.[28].

The water consumption depends on household income only if water availability is low. The price of water increases with the distance to be covered for its transportation and the quality of the road. It ranges from 5 [NIS/CM] (approx.1.25$/CM) of the public network to the 18 [NIS/CM] (approx. 4.50$/CM) average spent by the HH1, to the 25 [NIS/CM] (approx. 6.25$/CM) average spent by the HH2, to the 34 [NIS/CM] (approx. 8.50$/CM) spent by the HH3, with cases in the most remote communities exceeding the 50 [NIS/CM] (approx. 13$/CM). In this context water consumption strongly depends on the price, thus decreasing if its price increases. Water consumption ranges from the national average of about 80 [l/day] per capita, to 73 [l/day] per capita in communities with at least partial access to public infrastructure (HH1 and HH2), falling to about 50 [l/day] per capita in remote communities (HH3). All these results are below the minimum recommended quantity of 100 [l/day] per capita indicated by WHO.

[28] Mahmoud et alt., Assessment of rainwater harvesting for domestic water supply in Palestinian rural areas, 2018

Energy for Water Heating

Domestic water consumption serves partially for cleaning and hygiene purposes. Depending on family needs and the comfort desired, energy needs to be consumed in order to raise its temperature. The devices used for this purpose vary in capacity, energy source, load response time and operating costs. Typically, each family has several solutions at their disposal to be used according to their different needs. According to PCBS[29], in the South of the West Bank, gas boilers are identified by 44.1% of families as the primary solution for water heating, 38.3% choose the electric water heater, 16.1% burn wood and **only 1.3% consider the solar collectors their primary solution**. The households equipped with solar collectors for water heating are about 56% in Palestine, but almost half of them use the system very rarely, preferring more reliable solutions, typically electric or gas heaters.

The results emerging from the research are slightly inconsistent with these national averages. Households who do not have access to public infrastructure have never answered that they own a solar water heater (HH3), instead 40% of HH2 own this type of system and the percentage rises to 78% in the case of HH1. According to the interviews, in some 60% of cases these systems are equipped with a storage tank for hot water, that allows hot water to be available even after the sun has set. Hot water is thus available on average 70% of the time it is demanded. Installation and maintenance costs are generally low if compared with the average household income.

Solar water heater systems are generally affordable. The average installation costs for solar water heaters sized to meet normal family needs is around 3000 [NIS] (approx.750 $), equal to a single month's salary for the average of workers, and very low if compared to the 20 years lifespan that this technology can have with proper maintenance. Maintenance is carried out only by 50% of the HH1 that have this system, reaching 78% of the HH2. The annual cost for maintenance is some 100 [NIS/year] (approx.25 $/year), paid in different ways every 1, 3 or 5 years.

Table 33 - **Household Solar Water Heaters**

	Users	DHW[30] Storage	DHW Availability	Maintenance [%Users]
HH1	78%	63%	70%	50%
HH2	40%	61%	68%	78%
HH3	0%	-	-	-

[29] PCBS, Annual Statistics, Percentage of Households who are Water Heating by Region and the Main Energy Source for Water Heating, 2015, http://www.pcbs.gov.ps/Portals/_Rainbow/Documents/HE-%20EA9%202015.htm

[30] DHW – Domestic Hot Water

6.CONCLUSIONS

The dissemination of more efficient and effective systems can certainly improve the resilience of the inhabitants of Area C, but this can hardly change their level of development.
Unlike many countries where limited access to energy, and in general to technology, is the main barrier to development, Palestine is conditioned by the political stalemate that slows down both the spread of technology and development.

6. CONCLUSIONS

Main Conclusions

These paragraphs will draw conclusions from the results of the survey and the subsequent application of the methodology, direct observation and opinions kindly shared by some of the organizations operating in the sector or on the territory. Trying to outline the profile of a complex and extremely variable situation such as that of access to energy in Area C in the Hebron Governorate by few numbers can lead to generalizations. The aim of this study is to generate consistent forecasts on the impact of future energy development projects. Further and more specific future research is required to give more details about specific household conditions, refugee camps, H2 in Hebron or other areas not specifically covered by this study .

Comparing the clusters' levels of access to energy, it is evident that energy for cooking and energy for space heating present the worst conditions. Communities that are not served by public infrastructures (HH3) result to have the worst access, except for the electricity supply, where the lowest level is reached by the communities with limited access to public infrastructures (HH2), due to non-payment of bills. The cluster where energy is more reliable is that of communities with total access to public infrastructures (HH1) and it presents indeed worrying results only for space heating, caused by low levels of safety and capacity.

Table 34 - **Household Access to Energy**[31]

	Electric Power			Cooking			Space Heating		
	level	st.dev.	error	**level**	st.dev.	error	**level**	st.dev.	error
HH1	**4.0**	0.398	0.092	**3.4**	0.820	0.190	**1.7**	0.855	0.198
HH2	**3.6**	0.747	0.124	**2.7**	1.452	0.241	**1.5**	0.929	0.154
HH3	**2.7**	0.524	0.112	**1.3**	1.223	0.274	**1.0**	0.991	0.211

For the inhabitants of communities not served by public infrastructure (HH3), the main issues to be tackled are the **availability of electricity** and **absence of energy-intensive appliances**. Electric power to energize high-consumption appliances are both needed to ensure better living standards.

For urban contexts, served by the public electric network, the **cost of the energy bill** is a burden, especially for those who do not have an income. Moreover, in these communities it is also necessary to overcome **the problem of non-payment of bills**, which affects Palestinian society as a whole. With regard to cooking and space heating solutions, when these are fuelled by biomass, they constitute a **serious health hazard**, particularly for the people who spend more time indoor. These devices do not affect only health but have a further negative impact on opportunities in general, mainly for women and children.

[31] Confidence Interval: 90%

Average Access

The average of the indicators used to define the various levels of access to energy give an interesting output of this study. The methodology, in order to assess the household access to energy takes the worst of the attributes that describe the situation of each family. The resulting index gives greater prominence to the most problematic aspects that would be blunted considering instead the average of the indicators. Comparing the indices obtained according to the methodology with the indices obtained by calculating the average of the indicators, every level of access increase greatly. This suggests that each family is affected only by one specific problem and, in fact, there are few households who have more than one low level indicators.

Table 35 - **Number of Specific Problems**

	Electric Power			**Cooking**			**Space Heating**		
	0	1	1+	**0**	1	1+	**0**	1	1+
HH1	**100%**	0%	0%	**100%**	0%	0%	**74%**	20%	6%
HH2	**76%**	22%	2%	**81%**	15%	4%	**60%**	33%	7%
HH3	**67%**	30%	3%	**45%**	20%	35%	**35%**	45%	20%

Projects tailored on specific households' situations should be preferred rather than general interventions aimed at communities on a geographical basis, with a strong emphasis on the involvement of the individual beneficiary to understand its actual needs. The risk of proposing solutions not related to real problems exists, especially in this context where the limits linked to access to technology are the consequence and not the cause of the steady state in which the Palestinians find themselves. A participatory approach of the beneficiaries in the design and implementation of a project is therefore fundamental.

People's Needs

From the point of view of the population interviewed, there are several urgent aspects of energy access to be tackled. The questionnaire allowed the respondent to choose from two lists the intervention that he/she considered most urgent. The first list was related to energy supply, the second to energy consumption and services.

The choices made by people confirm the results obtained by the study, with those who have access to infrastructure (HH1) who would like to reduce expenditures on electricity (73%), increase the power of the electrical system (12%) or improve the stability of the energy supply (10%). Also most of people with weak access to public infrastructure (HH2) would like to decrease their expenses on electricity, but the percentage falls to 56%, with an increase to 20% and 21% in the demand for more power and greater stability. Those who do not have access to the public electric network (HH3), and therefore rely on hybrid or solar systems, mainly hope to increase the available power (53%) and capacity (35%). Some households would like to improve the stability of supply (10%), while none of the respondents in this group identified costs as the most urgent problem.

The priorities regarding consumption and services are the water system for HH1 (33%), followed by the quality (25%) and safety (10%) of space heating solutions, as well as high consumption household appliances (16%). HH2 showed similar results, but preferred high-consumption appliances (24%) over the quality of the heating system (16%). As for HH3, they would like to improve appliances availability, in particular energy-intensive ones (25%), medium-consumption (20%) and low-consumption (20%). This result can be explained considering that a washing machine allows a family to save on average 2h30min per day, while a milk processing machine saves up to 4h45min. Moreover, the volume of yoghurt or butter produced by a machine is enough to meet the family needs and sell the rest in markets generating revenues. The possibility to save this amount of time is a priority if compared to cooking and space heating issues.

Reducing the risk of seizures or demolitions has been identified as a priority only by 1% of the entire sample of respondents, all belonging to the Cluster1 that has full access to public infrastructure. The reasons for this result can be attributed to the perception that the population of Area C has of the political context in which they live. Overcoming the current political situation is an issue that far exceeds the power of any organization or person. The widespread perception is that without the occupation there would be no need for any kind of assistance. Without the discrimination that people are experiencing daily there would be no need to discuss which technological solution could give them dignity.

Women's Needs

The number of women interviewed vary with the cluster considered. The women who responded to the survey were 37% of HH1, 24% of HH2, and 48% for HH3. The reasons for this variability can be attributed to the cultural context in which the research was carried out. Communities are bound to strict rules and customs on interactions between people of different gender not belonging to the same family. In remote areas where these constraints are more stringent, having at least one woman in the working team is needed to be accepted by the community, since men spend their time herding away from their homes.

Women's answers concerning the improvement of energy supply regard in 89% the cost reduction of electric bill for those who have full access to public infrastructure (HH1). The remaining 11% instead hope in the reduction of the risk of seizures or demolitions. All the respondents who gave this answer were women from Cluster1. Improving the stability of the electricity supply (25%) is the most urgent issue after the costs (50%) and equal to the power (25%) according to the HH2 women. For HH3 women, on the other hand, the priorities are increasing the power (38%) and capacity (48%) opposite from the result obtained by the total group. The reason for this reversal is to be attributed to the time spent by women inside their home. People who spend most of the day indoor prefer to ensure that the electricity lasts until night rather than having powerful machines that would drain the batteries in a short time.

Among women's answers to the questions concerning the improvement of services and energy consumption, the preference for household solutions stands out for the same reasons discussed above. In particular, high consumption appliances are preferred over basic ones in order to achieve better comfort and to improve the quality of life, especially of those who spend more time indoor. Moreover, the choice often lies with electric heating systems that guarantee better performances and, above all, more safety.

The energy needs for transport were not the study of this research. However, it should be kept in mind that not owning a driving license or a vehicle is a huge limitation in terms of opportunities for the inhabitants of the most remote communities. In this sense, women are the most vulnerable category since they are not accustomed to drive. The costs and time needed to cover the relatively few kilometres to reach the urbanized areas constitute a burden for families, especially if the whole expenses for energy are considered.

Solutions and Recommendations

Given these premises, there is no magic solution that can solve all the problems that have been arisen at once. Technological systems that can improve local living conditions by reducing the time spent on activities, the money spent to obtain more efficient performances, or which have a lower impact on health, exist and are accessible. In this context, technology is not the very core of the problem, but the dissemination of more efficient and effective solutions can definitely improve the resilience of the inhabitants of Area C. By acting on what are the most problematic aspects that limit access to energy, it is therefore possible to imagine various solutions that leverage the resources already available to the population. The proposed solutions have been numbered and associated to each problem affecting the population, as summarised in the tables at the end of this chapter.

SP1: Rooftop Solar PV. An interesting example for households connected to the public electricity grid (HH1 and HH2) concerns PV systems. There is the possibility of receiving a discount on the electricity bill if consumption is lower than the production of electricity. In this particular case, in fact, the grid operator applies a 25% discount of the difference between production and consumption, a bonus that can be accumulated from April 1 until March 31 of the following year. Given the enormous potential of PV in the region, in these economic conditions the installation of a solar system can be paid back in 4 to 10 years, depending on consumption (compared to a lifespan of up to 20 years). Alternatively, the money saved from this discount can be used to replace the firewood stove with an electrical device, sizing the PV system to compensate for the increased power consumption. In this case, the impact on the single household access to energy for space heating would be considerable, with a growth of 112% for 86% of the beneficiaries.

This solution presents implementation difficulties concerning the economic investment required to purchase and install a PV system, whose total costs range from 24'000 to 30'000 [NIS] (approx.6'000-7'500 $). This investment is a prohibitive amount of money for many families, especially considering the risk of demolition or the habit of not paying the electric bills. Moreover, the payback time of the investment would be much longer than expected if household consumption increases considerably after the intervention.

For this reasons, forms of economic and legal support can be studied, so as payment on instalments or support in case problems arise. There may also be a technical problem related to the capacity of the public electric grid to absorb new energy inputs. The installation of new rooftop PV systems should be handled carefully, with the involvement of the grid operator, especially if the intervention was to be implemented on a large scale. However, local energy production would have a positive effect on acceptance by the population as it would lead to a reduction in the electricity imported from IEC, helping to address the Net-Lending issue.

SP2: Infrared Heaters. Communities that do not have access to public infrastructures and that already have solar systems for the production of electricity, need to improve their access to energy for cooking and space heating. The stoves used have metal surfaces that become incandescent when the fire is lit, with risk of burns. In many cases there is not a smoke evacuation system, making the home environment potentially very harmful for health. The installation of an infrared heater, a stove covered by stone instead of metal, would have a huge impact on access to energy for space heating. It provides better performance and better safety with an estimated 110% increase in the level of accessibility of the entire group following an intervention aimed at 33% of the population, about 170 families.

Also in this case, the barrier to the spread of such a technology is linked to the high cost of investment, not sustainable for the families belonging to this group. In order to limit expenses as much as possible, it is advisable to assemble the system on site. This would also facilitate the transport for distribution and involve the population in the development of the intervention. In addition it could be an important opportunity to address with possible beneficiaries the issue of energy efficiency and the harmful impact that smoke has on health. Moreover, proposing a model that can be assembled would make it easier to transport outside the house in the summer. In fact, the size can be one of the limiting factors for the acceptability of the proposed solution, as well as the reduced flexibility when compared with a metal system. If a soapstone stove can release thermal energy up to 14 hours after the last recharge, it is also true that the time needed to reach a comfortable temperature increases. In addition, people who have a wood stove typically use it in winter to cook or heat water, the model proposed should therefore be able to meet these needs, avoiding the risk of other fires being lit inside the home.

SP3: Brick Ovens. Other effective solutions are for example the construction of brick, insulated ovens that evolve the current structure of the taboon to obtain a more efficient system and that limit the contact of the fumes produced by the combustion of manure with food. Increasing the efficiency of the oven is an aspect that could be well received by the population that does not invest on it because of high costs and risk of demolition. The separation of the combustion chamber from the cooking chamber instead may not be so easily accepted because changing the cooking method would affect the final taste of the food.

SP4: Handmade Solar Collectors. The demand for small volumes of hot water can be met by simple solar collectors, almost entirely made from waste materials and adaptable for communities that do not have access to public infrastructure. The impact on the domestic economy, however, would be very limited given the small volumes and long response times of the system when compared to combustion heaters. This solution can be an interesting way to involve beneficiaries, especially children, and bring them closer to the issues of recycling and clean energy.

SP5: Solar Cookers. The distribution of modern solar-concentration cooking systems equipped with Frenel Lens or Vacuum Tubes could be an interesting strategy to reduce the current fuel consumption. LPG constitutes a significant cost for families that do not have access to public infrastructures, both in affordability and convenience terms. With an average of 40 days of rain per year in Palestine, these devices can guarantee very high performance, but they could not completely replace the use of fuels.

The main limitations of these technologies are the drastic reduction in performance if they are not equipped with a good solar tracking system. If manually oriented every 10 minutes, Fresnel Lens systems can be suitable for any type of cooking but require a large mobile structure that in this context is subject to greater risk of seizure or demolition. The Vacuum Tube solar cooker has very small dimensions, but the device is not excellent for any type of cooking. In fact, the food is sealed inside the vacuum chamber without the possibility of releasing the steam, making it effective for the preparation of cereals or "wet" dishes, but not excellent for more "dry" types of cooking, such as frying or grilling. If not equipped with a vacuum chamber, parabolic solar cooking systems would be too cumbersome to be considered a valid alternative in this context, also exposing large surfaces at high temperatures that could pose a risk.

SP6: Replacement of Obsolete Appliances. The distribution of modern high-efficiency appliances could have a good impact on consumption and, given the frequent breakdowns, provide a good shock absorber for the expenses necessary to replace the old devices. Again, this can be an important opportunity to discuss with the beneficiaries the issue of efficiency and how energy losses have a negative impact on the environment. The widespread use of laptops would also lead to an improvement in the level of access to services.

SP7: Comet-ME Model for Business. The Comet-ME model could be extended to the installation of PV systems in parallel to the domestic ones that serve small business realities. Bedouin communities are not just herders, diversifying their income resources could help improve their resilience. The gen-sets used today could be upgraded if coupled with a renewable resource. Moreover, the Comet-ME model could be improved by excluding from the cap of consumption at least the indoor lights and the fridge, significantly raising the level of availability of electricity for households.

SP8: LPG Delivery. Proposing a cooking gas delivery service to communities that do not have access to public infrastructure would save them the time needed to obtain this fuel. Considering the costs they incur for the transportation of gas, setting up a business that exploits economies of scale and delivers bottles at home could be sustainable. The social dimension of the business and the involvement of the beneficiaries are of paramount importance, in order not to risk falling back into the bizarre idea of solving poverty through capitalism. The limits of the intervention are constituted by the risk of seizure of the transported goods, due to the large volume of bottles to be delivered.

Table 36 - **HH1: Problems and Solutions Proposed**

Problem	# Affected	% Cluster	% Total	Solution Proposed
HH1: Electric Power				
Peak Capacity	-	-	-	
Availability	-	-	-	
Reliability	-	-	-	
Quality	-	-	-	
Affordability	-	-	-	
Legality	-	-	-	
Health and Safety	-	-	-	
Electricity Supply	-	-	-	
Electricity Services	824	2%	1,2%	SP6
Electricity Consumption	-	-	-	
HH1: Energy for Cooking				
Indoor Air Quality	-	-	-	
Cookstove Efficiency	-	-	-	
Convenience	-	-	-	
Safety	-	-	-	
Affordability	-	-	-	
Quality	-	-	-	
Primary Fuel Availability	-	-	-	
Access to Energy	-	-	-	
HH1: Energy for Space Heating				
Indoor Air Quality	-	-	-	
Capacity	4941	12%	7,4%	SP1, SP2
Convenience	824	2%	1,2%	SP1
Safety	4118	10%	6,2%	SP1, SP2
Affordability	-	-	-	
Quality	2471	6%	3,7%	SP1, SP2
Duration	824	2%	1,2%	SP1, SP2
Access to Energy	10706	25%	16,1%	SP1, SP2

Table 37 – **HH2: Problems and Solutions Proposed**

Problem	# Affected	% Cluster	% Total	Solution Proposed
HH2: Electric Power				
Peak Capacity	-	-	-	
Availability	412	2%	0,6%	
Reliability	618	3%	0,9%	
Quality	-	-	-	
Affordability	1030	5%	1,6%	SP6
Legality	3297	16%	5,0%	
Health and Safety	206	1%	0,3%	SP6
Electricity Supply	4945	24%	7,4%	SP6
Electricity Services	1442,424242	7%	2,2%	SP6
Electricity Consumption	-	-	-	
HH2: Energy for Cooking				
Indoor Air Quality	412	2%	0,6%	SP5
Cookstove Efficiency	-	-	-	
Convenience	-	-	-	
Safety	2473	12%	3,7%	SP5
Affordability	2061	10%	3,1%	SP5
Quality	-	-	-	
Primary Fuel Availability	-	-	-	
Access to Energy	3915	19%	5,9%	SP5
HH2: Energy for Space Heating				
Indoor Air Quality	412	2%	0,6%	SP1
Capacity	4533	22%	6,8%	SP1, SP2
Convenience	206	1%	0,3%	SP1
Safety	2885	14%	4,3%	SP1, SP2
Affordability	1236	6%	1,9%	SP1
Quality	618	3%	0,9%	SP1, SP2
Duration	-	-	-	
Access to Energy	8242	40%	12,4%	SP1, SP2

Table 38 – **HH3: Problems and Solutions Proposed**

Problem	# Affected	% Cluster	% Total	Solution Proposed
HH3: Electric Power				
Peak Capacity	-	-	-	
Availability	333	8%	0,5%	SP7
Reliability	133	3%	0,2%	SP6
Quality	-	-	-	
Affordability	267	7%	0,4%	SP6, SP7
Legality	-	-	-	
Health and Safety	-	-	-	
Electricity Supply	667	17%	1,0%	SP6, SP7
Electricity Services	720	18%	1,1%	SP6
Electricity Consumption	-	-	-	
HH3: Energy for Cooking				
Indoor Air Quality	1467	37%	2,2%	SP3, SP5
Cookstove Efficiency	1000	25%	1,5%	SP3, SP5
Convenience	-	-	-	
Safety	933	23%	1,4%	SP3, SP5
Affordability	933	23%	1,4%	SP3, SP5, SP8
Quality	-	-	-	
Primary Fuel Availability	-	-	-	
Access to Energy	2200	55%	3,3%	SP3, SP5, SP8
HH3: Energy for Space Heating				
Indoor Air Quality	1467	37%	2,2%	SP2, SP8
Capacity	400	10%	0,6%	SP2
Convenience	67	2%	0,1%	SP2
Safety	933	23%	1,4%	SP2
Affordability	200	5%	0,3%	SP7
Quality	333	8%	0,5%	SP2
Duration	267	7%	0,4%	SP2
Access to Energy	2600	65%	3,9%	SP2, SP7, SP8

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