DEVELOPING CAPACITY BUILDING PROGRAM ON SOLAR PV FOR SELECTED RURAL AREAS IN YEMEN

DRAFT REPORT

CAPACITY BUILDING NEEDS ASSESSMENT

Capacity Building Program Team

MFD

Sana'a

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List of Abbreviations:

AC	Air Conditioning
ESCO	Energy Service company
GOV	Governorate
kW	Kilowatt
kWh	Kilowatt per hour
kWp	Kilowatt peak (Solar PV specific unit)
LED	Light-Emitting Diode
na	Not available
PC	Personal Computer
PV	Photovoltaic
ToT	Training of the trainers
TP	Technical Personnel
TV	Television
UNDP	United Nations Development Program
Wh	Watt per hour

1. Introduction

The market for solar photovoltaic (PV) systems in urban and peri-urban households has developed dynamically in Yemen since 2015, when the military confrontations in Yemen began. A solar market boom has been unfolding in past years, mainly due to the continuous energy crisis in Yemen, which accelerated tremendously since the beginning of armed conflict in April 2015.

The historically unstable power grid in Yemen's cities is characterized today by total shut-down or frequent daily blackouts. The situation on the country-side is even worse because of the lack of availability and the high costs of diesel and other fuels. This has sharply reduced the usage of generators and thus the availability of power. When the Yemeni Government stopped subsidizing fossil fuels in July 2014, prices quickly reacted with 60% to 90% increases. Since the military conflict escalated in spring 2015, the availability of fuels has further degraded and prices have soared to historical highs of 2 up to 4 times the prices of late 2014. Many energy consumers cannot bear such elevated power expenses on the long run. With purchase prices of PV-systems having decreased considerably in past years, solar power is now becoming an attractive alternative to small power generators in the range of a few kW.

From the perspective of the Yemeni population, no immediate improvements of the energy infrastructure can be expected due to the unstable situation in the country. This is why a lot of people (private households and institutions) consider today affording a Solar PV system, given falling system prices allowing for competitive economics of Solar PV power generators. Other immediate and long-term advantages of Solar PV systems are increasingly being understood by stakeholders on the demand and offer side as well as by market development facilitators. Also, the good functioning of most installed systems has contributed to significant image improvements, notably concerning reliability and availability.

Yemen has been using PV power generation since many years in areas remote from the power-grid, mostly in the framework of rural electrification programs and often funded by international donors. Today, a growing number of urban households, small trades and other relatively small power consumers are investing in autonomous PV-based power generation, making up what can be qualified an emerging Solar PV boom in Yemeni cities and increasingly also throughout the whole country.

In the light of these remarkable developments, UNDP Yemen which is actively involved in promoting solar energy in Yemen since many years, decided to carry out a market survey among key value chain actors on the demand- and the offer-side. The goal is to understand the new solar market dynamics and their implications on capacity building requirements among all involved market actors.

This report presents the results of the conducted survey: It provides snap shots on the unfolding PV market from the perspective of users and suppliers of autonomous PV

systems and analyses capacity building requirements, which when fulfilled are able to foster a sound and durable Solar PV market development.

2. Methodology

The survey on Solar PV capacity building requirements in four Yemeni governorates is based on three questionnaires addressing decision makers and users of PV systems, traders selling PV systems as well as training centers and vocational training institutes. It was carried out on the ground in the calendar weeks 6, 7 and 8 of the year 2017. The questionnaires originally developed in English were translated into Arabic and then used by Yemeni interview agents who had been trained beforehand to work with the questionnaires in the field. The filled questionnaires were translated back into English and the results transcribed into an Excel database for statistical analysis during calendar weeks 9 and 10. The data analysis was performed during calendar week 11 and 12 and a draft report submitted by the end of calendar week 12.

The number of answered questionnaires received amounts to 96. The target groups interviewed are as follows:

a) 53 questionnaires answered by decision makers and users of PV systems
b) 40 questionnaires answered by traders of PV components and systems
c) 3 questionnaires answered by training centers and vocational training institutes

The 53 decision makers and users of PV systems can be classified as follows:

1) 10 decision maker at governorate level
2) 8 decision makers at district level
3) 5 Leader at municipal/local community level
4) 14 Operative manager of a power consuming facility
5) 15 Other working fields
6) 1 Not cited

The geographical origin of the 96 questionnaires is as follows:

1) 10 questionnaires from Abyan Governorate (10,4% of total)
2) 26 questionnaires from Hajjah Governorate (27,1% of total)
3) 41 questionnaires from Hodeidah Governorate (42,7% of total)
4) 19 questionnaires from Lahj Governorate (19,8% of total)

The quality of received questionnaires was sufficient to allow for a rather brief quantitative and qualitative analysis providing meaningful interpretations. However, the results cannot be qualified as statistically representative, given the relative small samples of various target groups interviewed in each of the four governorates and covering up to distinct 8 districts. Representativeness would require samples of at least 100 interviewees for each surveyed regional target group.

Furthermore, up to 10% of the questionnaires were not comprehensively or homogeneously answered and filled by involved interview agents, leading to minor but yet acceptable inconsistencies. Several questionnaires also seem to display some kind of social desirability in the answers provided. When reading the statistical data analysis, one should therefore rather think in terms of trends than expect absolute accuracy and representativeness of provided and interpreted data.

The three used questionnaires can be viewed in English language in annex 1, 2 and 3. All findings presented in this report are based upon the Excel file “Statistical Evaluation_Solar PV Capacity Building_31-03-2017.xlsx” into which all questionnaire results where transcribed from a total of 96 filled questionnaires and then analyzed statistically, using graphs.

This report presents the analysis and interpretation of demand and offer-side survey results, provides conclusions and concludes with recommendations for the development of capacity building programs oriented at the questioned target groups and market actors.

3. Survey results from the demand-side group: PV-system deciders and users

Administrative deciders and institutional users of small to medium sized PV-systems (the capacity ranging between 1,5 and 4 kWp) represent the demand-side of the developing solar PV market. They are the best surveyed target groups of this survey, with 53 from 96 questionnaires received and analyzed, equaling approximately 55% of the entire interview sample.

Short characterization of surveyed institutions and persons

Table 1 provides a profile of the main surveyed target groups in the four investigated governorates. 26 schools & educational facilities (11 from Hodeidah alone), equaling 53% of all inquired power consuming users, as displayed in Figure 1. Also, 14 medical facilities (29%) have been questioned. Other types of surveyed institutions displayed in figure 1 were local community services and administrations, water supply facilities and farmers. Operative managers of power consuming facilities make the single biggest surveyed target with 14 persons, among which 12 alone from Hajjah. Furthermore, 11 school principals and health center managers have been interviewed, besides 10 decision makers at governorate level, 8 at district level and 6 at municipal/local level.

The sample of 24 questionnaires received from Hodeidah and 15 questionnaires from Hajjah governorate provide a statistically more relevant data basis than Abyan with just 5 and Lahj with 9 questionnaires. The most interviewed high-ranking decision makers stem from Hodeidah, with alone 5 governorate offices participating in the survey. The most operative managers of power consuming facilities have been interviewed in Hajjah.

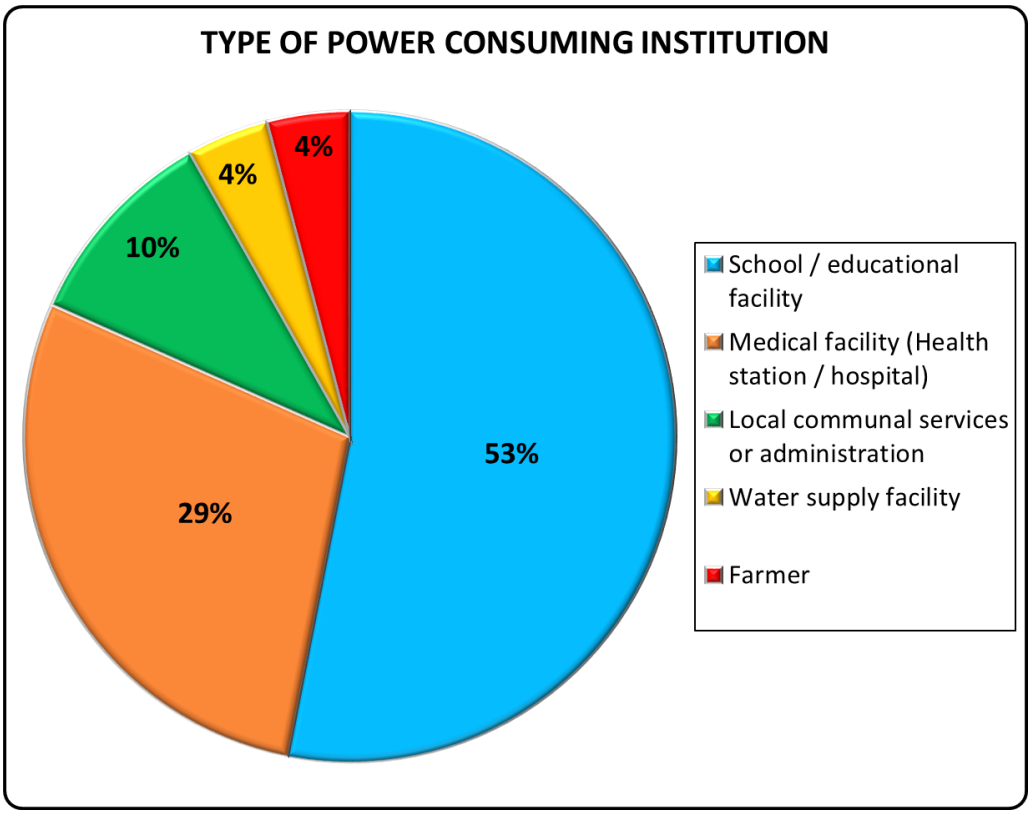


Figure 1: Type of power consuming institutions

CHARACTERIZATION OF INTERVIEWED PERSONS AND INSTITUTIONS					
	ABYAN	**HAJJAH**	**HODEIDAH**	**LAHJ**	**ALL GOVs**
Administrative working level					
decision maker at governorate level	0	0	8	2	**10**
decision maker at district level	3	1	1	3	**8**
Leader at municipal/local community le	0	2	4	0	**6**
Operative manager of a power consumi	0	12	0	1	**13**
School principles & teachers	0	0	6	1	**7**
Technical staff	2	0	5	2	**9**
				Total	**53**
Type of power consuming institution					
School / educational facility	4	7	11	4	**26**
Medical facility (Health station / hospita	1	6	5	2	**14**
Local communal services or administrati	0	1	1	3	**5**
Water supply facility	0	1	1	0	**2**
Farmer	0	1	1	0	**2**
				Total	**49**

Table 1: Types of interviewed persons and institutions in absolute numbers

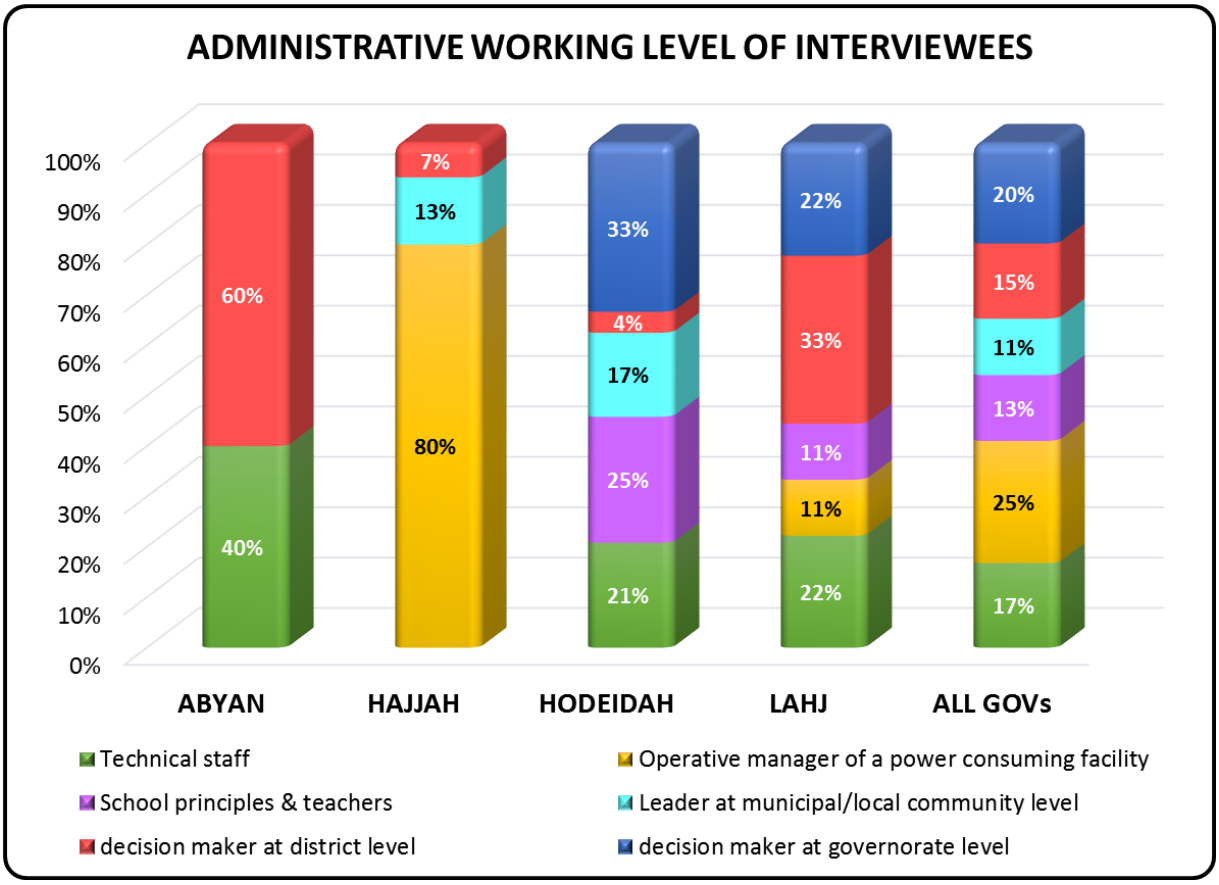
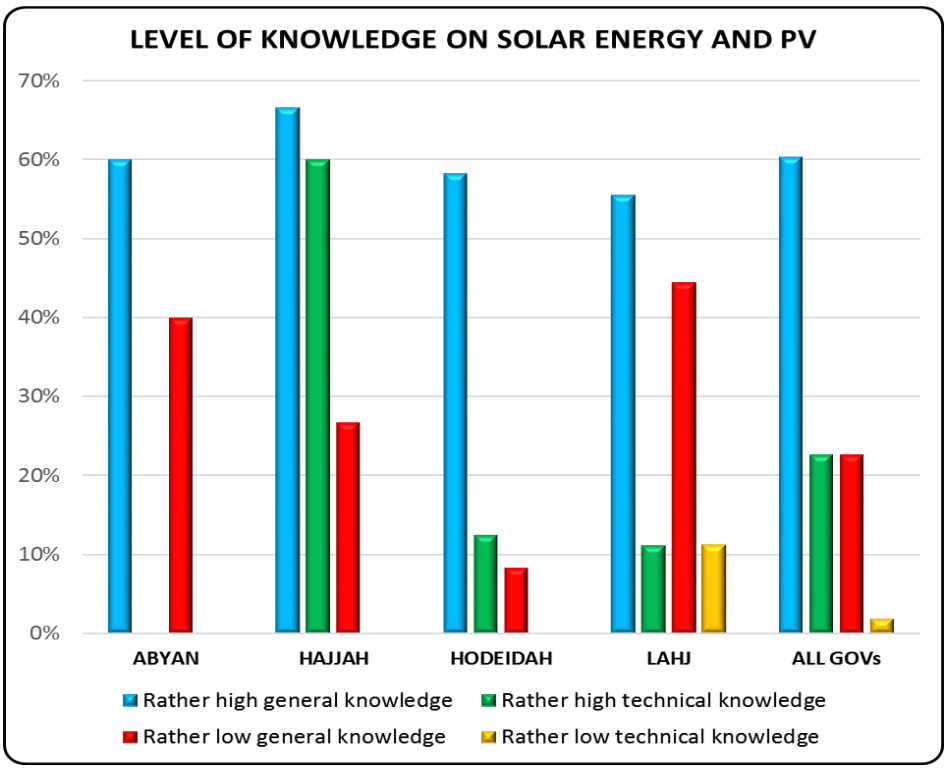


Figure 2: Administrative working level of interviewed demand-side actors

The administrative working level of interviewed actors is displayed in Figure 2 and Table 2. The share values over all governorates show that the various professional working levels questioned are quite evenly distributed in total, although they vary greatly between the governorates. The significant regional disparities among the working levels of each governorate reflect regionally varying survey conditions and some lack of methodic homogeneity among interview agents. For example, just 5 questionnaires came from Abyan compared to 24 from Hodeidah.

25% of the interviewed professionals are operative managers of power consuming facilities. In Hajjah, with a share of 80% the number of interviewed operative managers of power consuming facilities was especially high. Decision makers at governorate level represent 20% of interviewed professionals. This target group notably participated in Hodeidah and Lahj governorates; but was not approached in the survey of Hajjah and Abyan. Note that decision makers at district level participated in every governorate.

In Figure 3, the level of knowledge on solar energy and PV of the interviewed demand-side target groups is rated in a self-assessment on two criteria:



a) Rather high or low general knowledge and b) Rather high/low technical knowledge. 60% of all interviewees attested themselves rather high general solar energy and PV knowledge. Only 22% have a high technical knowledge on solar energy and PV.

Figure 3: Level of knowledge of demand-side interviewees on solar energy and PV

General knowledge of solar and PV seems to be rather well developed throughout the investigated governorates with 60% of self-assessment, much to the contrary of technical knowledge which stands at mere 23%. The lowest solar/PV knowledge level is encountered in the governorate of Lahj (9 questionnaires received), where 44% of interviewees state having a rather low general knowledge of solar and PV. The highest apparently in the governorate of Hajjah (15 questionnaires received).

With the exception of Hajjah, where 80% of interviewees where operative managers of power consuming facilities (with rather high general and technical knowledge, thus distorting somewhat the statistical results on regional knowledge levels), the technical knowledge seems to be rather weakly developed in other governorates. It is notable that the level of 'rather high technical knowledge' is poorly rated (merely 23%) and also, that the negative rating 'rather low technical knowledge' was systematically avoided by interviewees (only one citation in Lahj).

It can be concluded that technical knowledge is clearly underdeveloped with a potential for improvement of at least 77%. General knowledge has a 40% potential for improvement.

CHARACTERIZATION OF INTERVIEWED PERSONS AND INSTITUTIONS					
	ABYAN	HAJJAH	HODEIDAH	LAHJ	ALL GOVs
Administrative working level					
decision maker at governorate level			33%	22%	20%
decision maker at district level	60%	7%	4%	33%	15%
Leader at municipal/local community l	0%	13%	17%	0%	11%
Operative manager of a power consum	0%	80%	0%	11%	25%
School principles & teachers	0%	0%	25%	11%	13%
Technical staff	40%	0%	21%	22%	17%
Total	100%	100%	100%	100%	101%
Level of knowledge on solar energy and PV ***(incl. multiple and missing entries)***					
Rather high general knowledge	60%	67%	58%	56%	60%
Rather low general knowledge	40%	27%	8%	44%	23%
Rather high technical knowledge	0%	60%	13%	11%	23%
Rather low technical knowledge	0%	0%	0%	11%	2%
Total	100%	153%	79%	122%	108%
Type of power consuming institution ***(incl. multiple and missing entries)***					
School / educational facility	80%	47%	46%	44%	49%
Medical facility (Health station / hospi	20%	40%	21%	22%	26%
Local communal services or administra	0%	7%	4%	33%	9%
Water supply facility	0%	7%	4%	0%	4%
Farmer	0%	7%	4%	0%	4%
Total	100%	107%	79%	100%	92%

Table 2: Characterization of interviewed persons and institutions

3.1 Questions on Power and consumption

Appliances for which electric power is most used

Table 3 further below provides an overview about what type of electric appliances and usages are operated in the four surveyed governorates and how many hours per day. Figure 4 displays the operation duration of the 6 most popular electricity usages in the four surveyed governorates. Refrigerators and

Refrigerators and freezers have by far the longest operation time with 16,7 hours in average; they constitute a kind of 'base load' demand. Public and room lighting requires power during an average of 8,7 hours and 6 hours respectively; they constitute a kind of 'mid load' demand. Ventilation & air conditioning is running more

than 5 hours a day. Agricultural water exploitation and water pumping for domestic applications (roof water tanks) seem to be more important in Lahj with a daily use duration of 5,5 hours and Abyan with 4 hours. Given that power is a scarce resource, the information and leisure appliances TV, computer and radio are selectively used, running an average of approximately 3 hours a day.

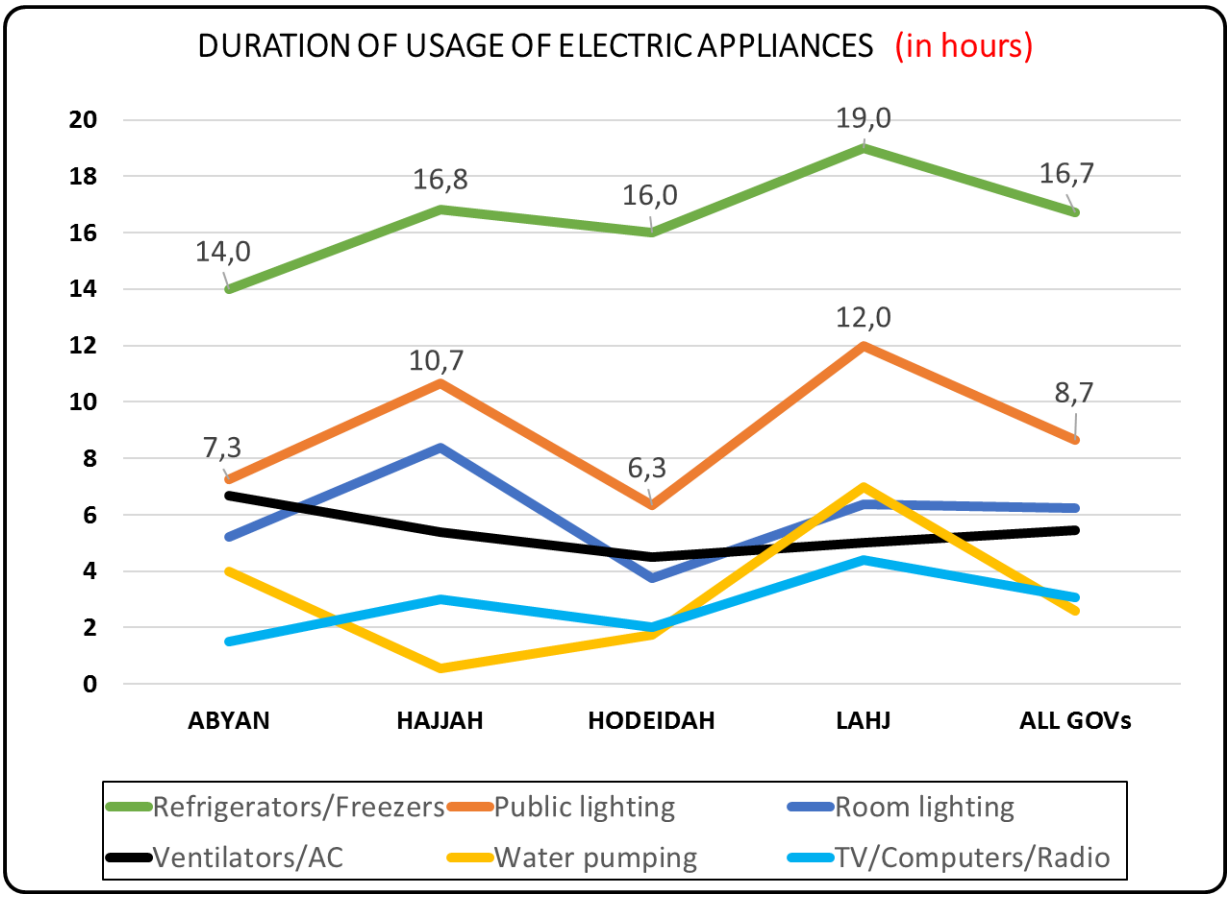


Figure 4: Duration of usage of electric appliances (in hours)

Figure 5 displays the relative importance of the 6 most popular electric applications in the four observed governorates. The last stacked bar shows the average value considering all four governorates.

Room lighting is by far the most cited application cited, followed public lighting and ventilation/air conditioning. Ventilation/air conditioning are especially often cited in Lahj and Hajjah indicating a higher than average cooling need in these regions. In Hodeidah governorate, room lighting and water pumping applications play an important role due to large urban populations and the intensive agriculture.

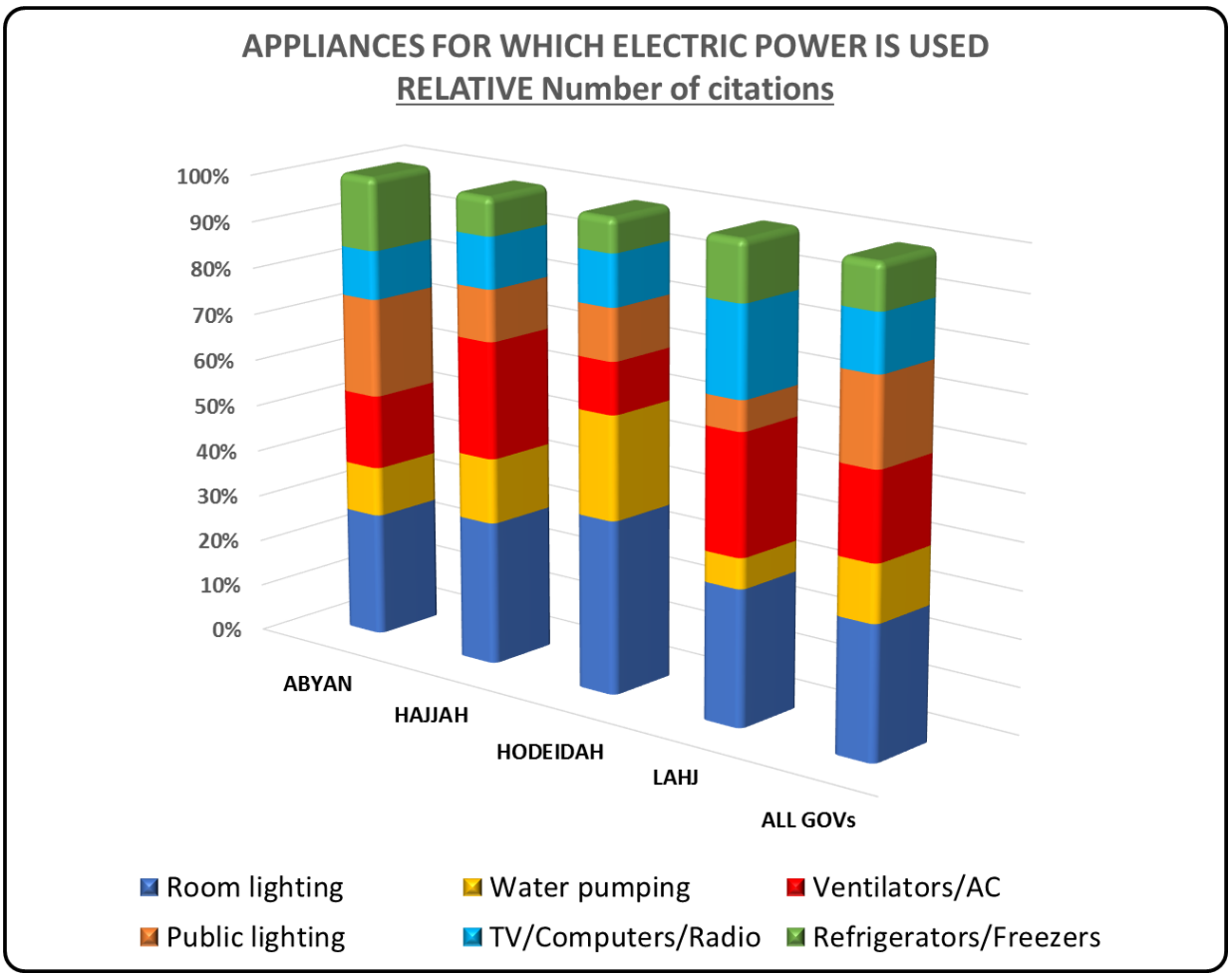
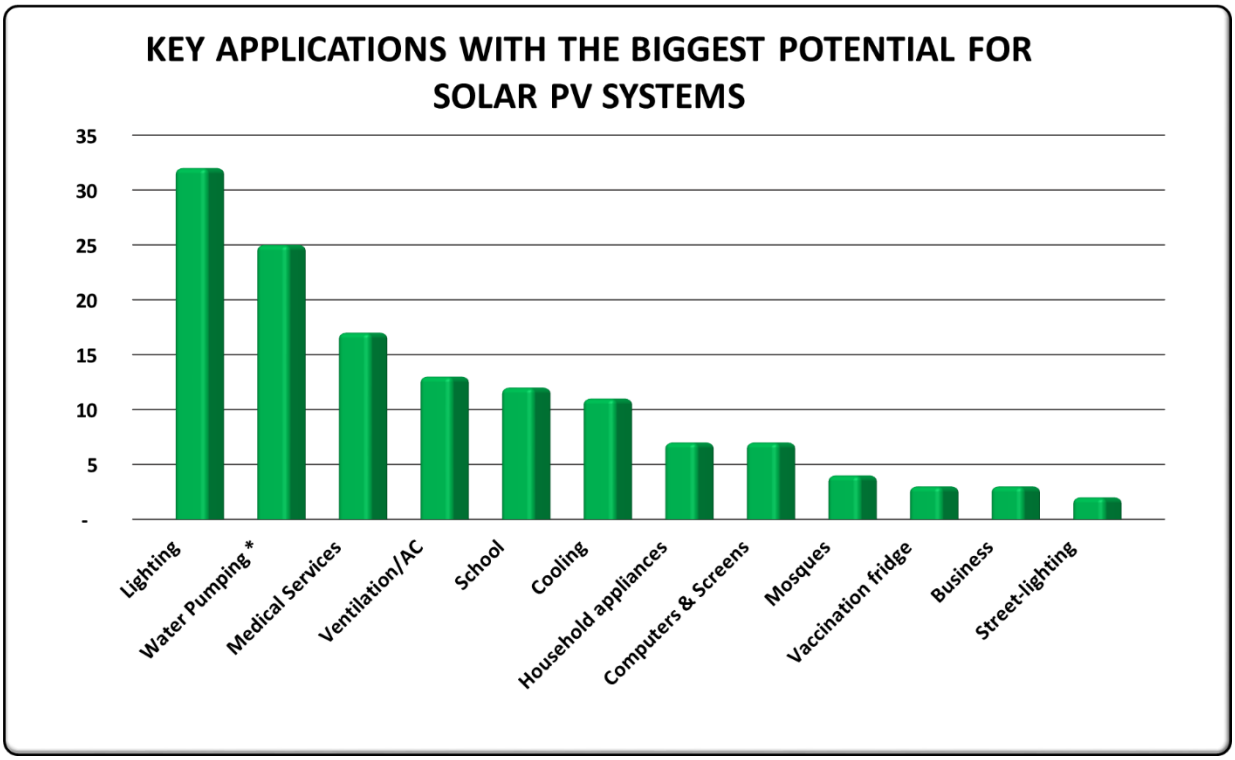


Figure 5: Appliances for which electric power is used (absolute/relative)

Key applications with the biggest potential for solar PV systems

Figure 6 list the twelve most cited applications for PV power by all interviewees which are assessed to have biggest market potential. The list is led by room lighting with 32 citations, water pumping (25), medical services (17), ventilation/AC (13), school (12) and cooling (11).

Although, the nomenclatures of 'Key Applications for Solar' in Figure 6 and 'Appliances Using Electric Power' in Figure 5 are not fully consistent, their statistical findings are widely congruent: Room lighting, water pumping and ventilation are the most common consumers of power to be served by solar PV systems.



*) Water pumping includes home and agricultural applications

Figure 6: Key power consuming applications for solar PV systems

APPLIANCES FOR WHICH ELECTRIC POWER IS USED *(Number of citations by interviewees)*						
		ABYAN	HAJJAH	HODEIDAH	LAHJ	TOTAL
Room lighting		100%	73%	42%	100%	**66%**
	Hours/ day	5,2	8,4	3,8	6,4	**6,2**
Public lighting		80%	27%	13%	22%	**43%**
	Hours/ day	7,3	10,7	6,3	12,0	**8,7**
Ventilators/AC		60%	60%	13%	89%	**43%**
	Hours/ day	6,7	5,4	4,5	5,0	**5,5**
Water pumping		40%	33%	25%	22%	**28%**
	Hours/ day	4,0	0,6	1,8	7,0	**2,6**
TV/Computers/Radio		40%	27%	13%	67%	**28%**
	Hours/ day	1,5	3,0	2,0	4,4	**3,1**
Refrigerators/Freezers		60%	20%	8%	44%	**23%**
	Hours/ day	14,0	16,8	16,0	19,0	**16,7**

Table 3: Appliances for which electric power is used

Sources of power available in the surveyed governorates

The interviewed professionals stated that there was no grid power available in Hajjah and certain regions in Hodeidah. And even if power grid infrastructure is available, this doesn't prevent regular power outages. A majority of 62% of respondents stated that their power consumption is supplied by self-generation, while 58% are also being supplied with grid power.

Hence, small PV systems of a capacity range of 1 to 4 kWp are a welcome power supply alternative in all 4 governorates, especially in Lahj and Hajjah. The most commonly installed system size seems to be 1,5 kWp. The average daily solar power requirement is reckoned at between 3,5 kWh and 6,4 kWh.

Extension of the power supply infrastructure is planned by 62% of interviewed actors, and solar PV is by far the leading extension technology option cited by 66% of actors; in contrast to this power grids extension are cited by just 8% of actors.

SOURCES OF POWER AVAILABLE IN THE 4 GOVERNORATES					
	ABYAN	**HAJJAH**	**HODEIDAH**	**LAHJ**	**AVERAGE**
Electric grid	100%	NO GRID	NO GRID	78%	**23%**
Hours/ day	8,4	NO GRID	NO GRID	5,5	**6,8**
Power generator	na	na	17%	33%	**13%**
Hours/ day	na	na	5,7	7,0	**6,3**
Others: Small PV-system	40%	73%	4%	89%	**42%**
Hours/ day	6,0	7,6	na	4,3	**7,2**
Share of power consumption from:					
Power grid	43%	NO GRID	NO GRID	67%	**58%**
Self-generation	na	na	100%	53%	**62%**
Type of self-generation energy systems:					
Diesel generator	na	12 kW	3 to 5 kW	5 to 1.000 kW	
Solar PV system	1 to 4 kWp	All 1,5 kWp	1 to 3 kWp	0,6 to 10 kWp	
Extension of power infrastructure					
Electric grid	20%	NO GRID	NO GRID	33%	**8%**
Fuel generator for power generation	na	na	4%	22%	**6%**
Solar PV system	100%	80%	38%	100%	**66%**
Min/Max daily solar PV power requirement					
Minimum daily PV power requirement	5.400	2.042	3.383	4.875	**3.574**
Maximum daily PV power requirement	9.500	5.000	5.333	7.750	**6.400**

Table 4: Sources of power available in the four governorates

70% of interviewees stated that they already use a solar PV system. The lowest user rate was found in Hodeidah with only 54% of interviewees using a PV system. All interviewed users of PV systems state they are very satisfied. Some specify that they are economic, cheap, safe, clean, practical, comfortable as well as beneficial when electricity cuts. They are also seen as helpful for educational purposes. PV systems are viewed today as a temporarily and emergency solution, covering lighting needs and small consuming applications.

However, since most installed systems are too small to fully cover power needs, many interviewees stated that the installed solar PV capacity is not sufficient and needs extension. PV systems require knowledge to operate and maintain.

3.2 Questions on power related services

53% of respondents know a local distributor from whom to buy PV systems or components and are also able to cite the name of the store. 62% state to have a service provider who is in charge of maintenance (the proper meaning of the term ESCO = Energy Service company including guaranteed power supply, used in the English questionnaire has probably not been misunderstood or maybe lost in translation).

Only 14% have currently maintenance arrangements for the maintenance and servicing of their PV-system (86% stated they don't have such arrangements). This points at operation problems within few years after start of operation, especially concerning the battery system which need regular control and maintenance, also because they are frequently operated (far) beyond specifications and recommendations. Continuous maintenance is key to an increased durability according to technical specifications and guarantees.

As shown in Figure 7, between 40 to 50% of respondents were in agreement that power from donated PV systems should be billed to cover maintenance and replacement costs. A kWh consumption based tariff designed to cover maintenance costs got the highest acceptance. A tariff that would also cover replacement costs found 43% of approval.

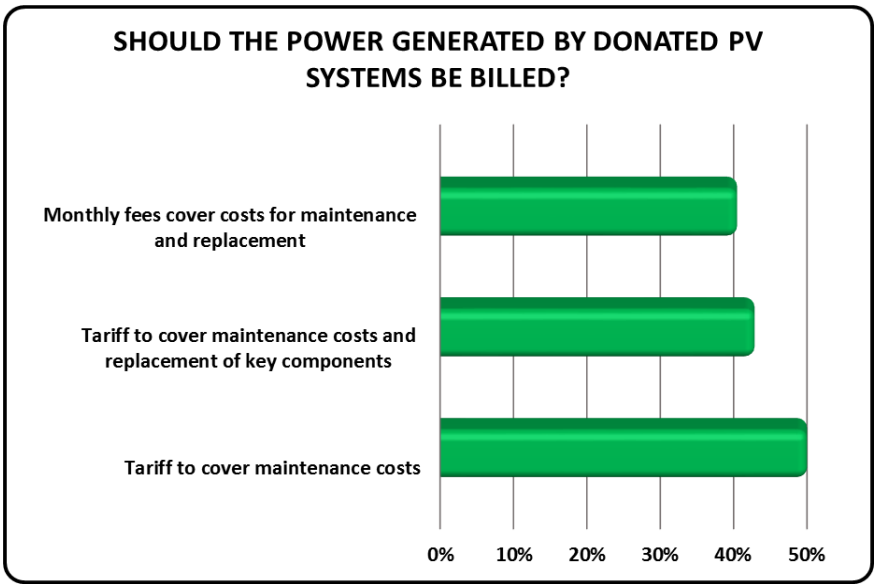


Figure 7: Key power consuming applications for solar PV systems

3.3 Questions on the Solar PV knowledge of surveyed target groups

This chapter presents the results of the questions on solar power knowledge and derivable training needs as answered by the demand-side actors, showing their specific perspective on the topic.

3.3.1 Questions answered by operative managers and users of power consuming facilities

The assessment of the solar power knowledge of Technical Personnel (TP) by operative managers and users of power generating facilities - who are practice people experiencing Solar PV technologies on the ground - can probably be considered the most experienced and plausible; it is thus worth of particular attention. This is why the assessment of this target group is the first analyzed and presented here. All other assessments by interviewed target groups presented hereafter should be compared to this initial one.

Abilities of technical personnel in charge of PV systems

Those 43 respondents who were competent to answer these questions stated that 33% of Technical Personnel (TP) dispose of/ has solid basic knowledge about electric installations, in other words: electric competence. Among this third, 64% of TP has specific solar PV competence, or 21% off all TP that are operating PV plants. Only 14% of TP have already been trained about Solar PV systems; the spread of training quality in the four governorates may however be considerable.

The concrete abilities of TP to service solar PV systems, including batteries are presented in Figure 8. There are 4 main abilities required to display a comprehensive and established competence back-ground on all technical aspects of Solar PV systems (as listed in the legend of Figure 8). Since there will be division of work, not all TP necessarily need to know everything about all technical aspects, because some TP will specialize on certain functions.

Figure 8 shows that the abilities of TP assessed by demand-side actors tend towards ‘Some’ and ‘None’, indicating a rather low competence level. This can quite easily be improved with comprehensive and specialized theoretical and practical training seminars since technical affinity and interest can be presumed as given in this target group. The most urgent training requirements concerns installation and maintenance and the medium-term goal should be to leverage the general competence level of this target group towards ‘Good’. This can be achieved within 3-4 years through a targeted intensive training program initiative which also focusses on frequent repairs and trouble shooting.

The results presented in Figure 8 must be compared with those in chapter 3.3.2 (Figure 11), where decision makers on various public administration levels also assess

TP. They must also be compared with those in chapter 4.2 (see figures 13 and 14), where offer-side actors answer a set of very similar questions from their specific offer-side perspective. The consideration of both perspectives enables to make some funded recommendations for the donors and implementers of solar PV capacity building programs in the four surveyed governorates.

It can also be noted that there is virtually no knowledge about low power consumption or energy efficient appliances, although this aspect is critical for well using and saving solar power which is limited by system and storage capacities. The basic knowledge can be acquired quite easily in training seminars. This knowledge also allows to increase sales volumes and even to develop new business opportunities.

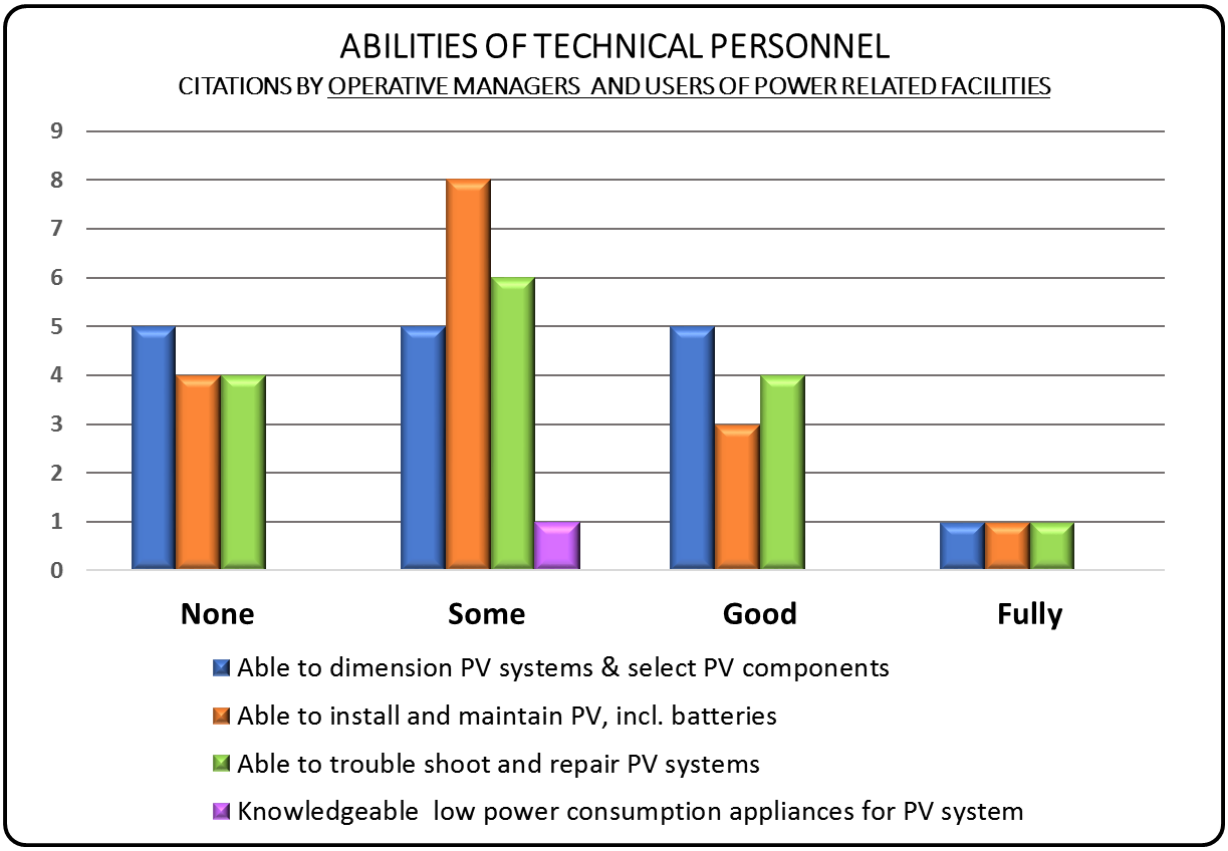


Figure 8: Abilities of technical personnel on the demand-side (operative managers and users of power related facilities

The number of technical staff requiring a technical training on solar PV is estimated to be between 2 and 3 per institution which adds up to approximately 150 training courses to be delivered to the participants of this survey. However, although there is a definite

demand for qualified capacity building, the large majority of 91% of respondent don't know a training center or vocational training institute where to send their TP.

93% of respondents think that basic trainings on solar energy & energy efficiency would be also useful for management personnel. Such a training can be of more general nature, with basic technical topics and a focus on economic and administrative topics.

Education level of power users in energy conservation

When asked about the education level of power users/consumers on energy conservation topics, 31 demand-side interviewees (ca. 75%) think that they have some knowledge and 8 (ca. 20%) even say they have none. Merely 2 interviewees (5%) say that the education level is good and nobody gives the best rating 'Fully'. This clearly marks the needs for energy user/consumer education, by the means of information campaigns.

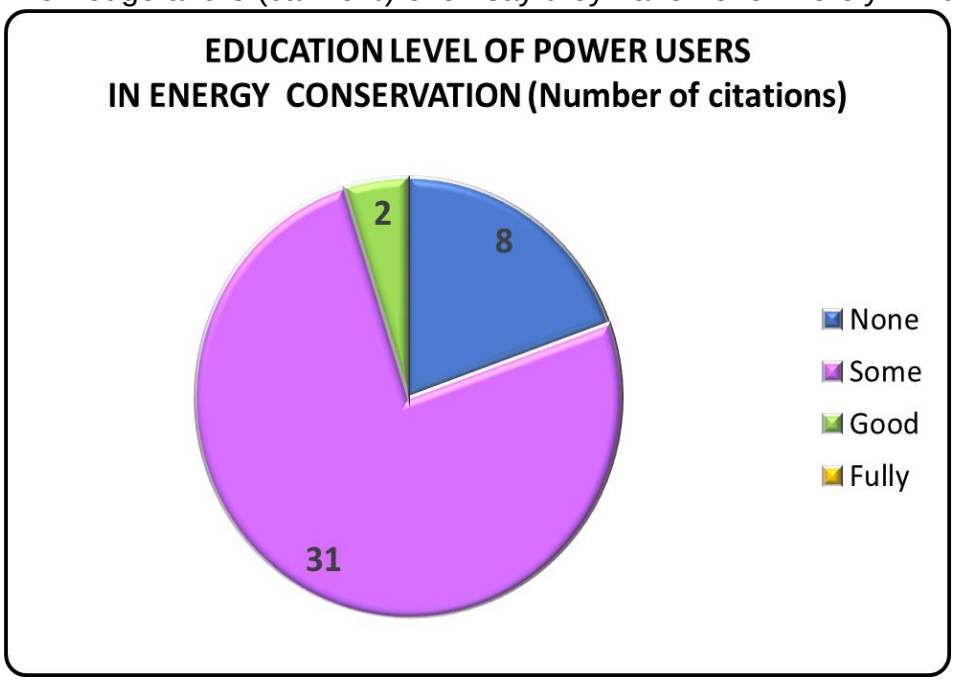


Figure 9: Education level of power users in energy conservation

3.3.2 Questions answered by deciders at governorate / district / local community level

The Solar PV related general knowledge displayed in Figure 10 is assessed to be generally low among district decision makers, project beneficiaries and local community leaders. However, 45% decision makers at governorate level seem to have 'High' or better than average knowledge on Solar PV (still leaving 55% in need for focused capacity building). Altogether, the 62% of 'Low' quotations and 16% of 'None' quotations (=78%) indicate an acute lack of solar knowledge by decision makers on all public institutional levels and PV system beneficiaries. In fact, all levels of administration deciders require focused capacity building.

Decision makers and PV system beneficiaries assess the general and technical knowledge of technical personnel (TP) to be rather low, in fact even lower than decision makers assess themselves (92% against 78% above). The TP of water supply facilities and farmers are assessed with the lowest knowledge. Although still much to low, the target group with the most developed general and technical knowledge seems to be the 'Youth solar-based micro-businesses' (who are mostly small start-ups or at early stage enterprises).

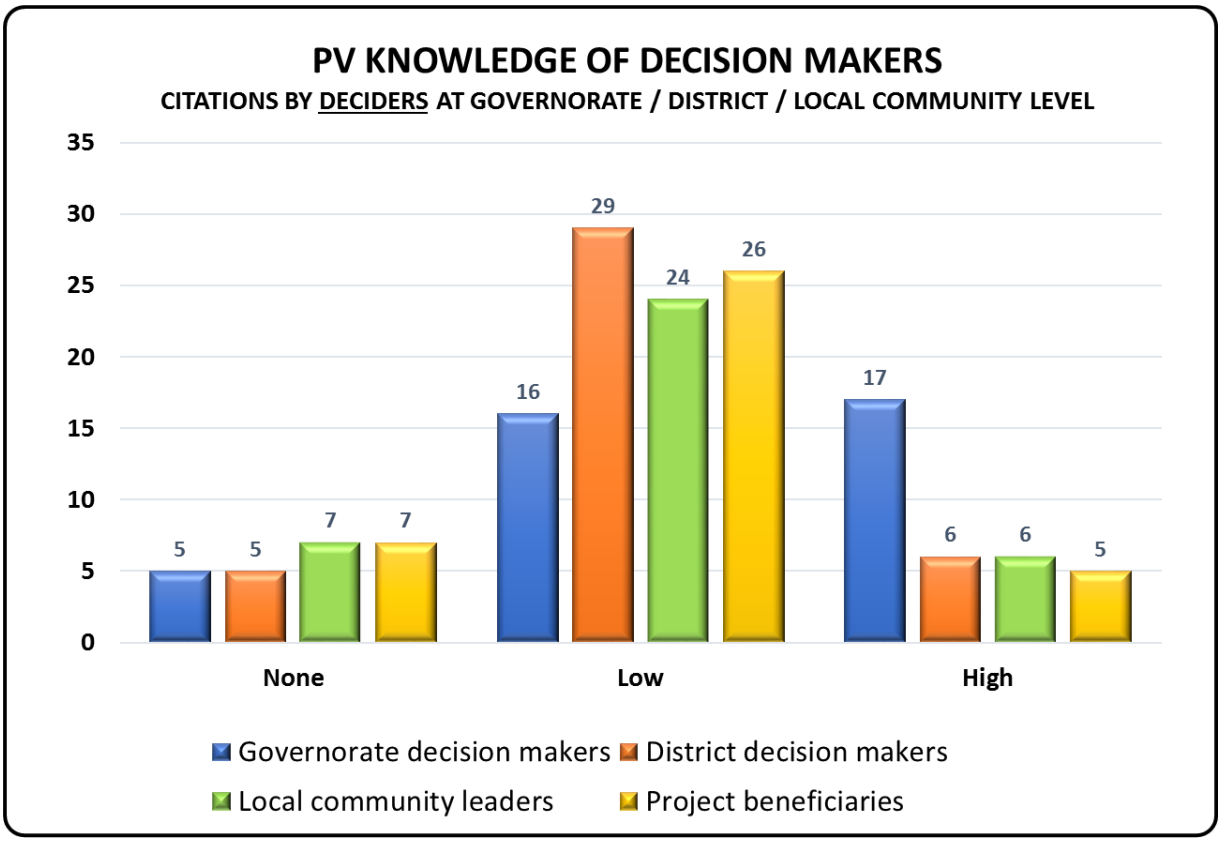


Figure 10: PV knowledge of decision makers on the demand-side

The results in Figure 11 mirror and confirm the findings in Figure 8 (see page 18) where the abilities of technical personnel were assessed to be rather low by operation managers and users of power related facilities. They make evident the need for capacity building measures to improve the competence level of technical personnel operating Solar PV systems.

Only few decision makers at governorate, district or municipal level know of training centres or vocational training institutes that are logistically accessible. The respondents from Abyan and Hodeidah governorates didn't cite any training centres or vocational training institute. The training centers listed below are mostly not sufficiently prepared to carry out Solar PV training seminars:

a) Hajjah governorate: Community College of Abs District, Technical and Vocational Institute, both in Abs District

b) Lahj governorate: Medical Science Institute, Al Anad Training Center, Optic center (in Tupan District), Bu Madian Institute (Saber region).

These training institutes require capacity building programs in the form of train-the trainer course. It should also easily be possible to identify an adequate training center in Hodeidah and support it with ToT-courses. If no training centers can be found in Abyan, then Aden is certainly an alternative.

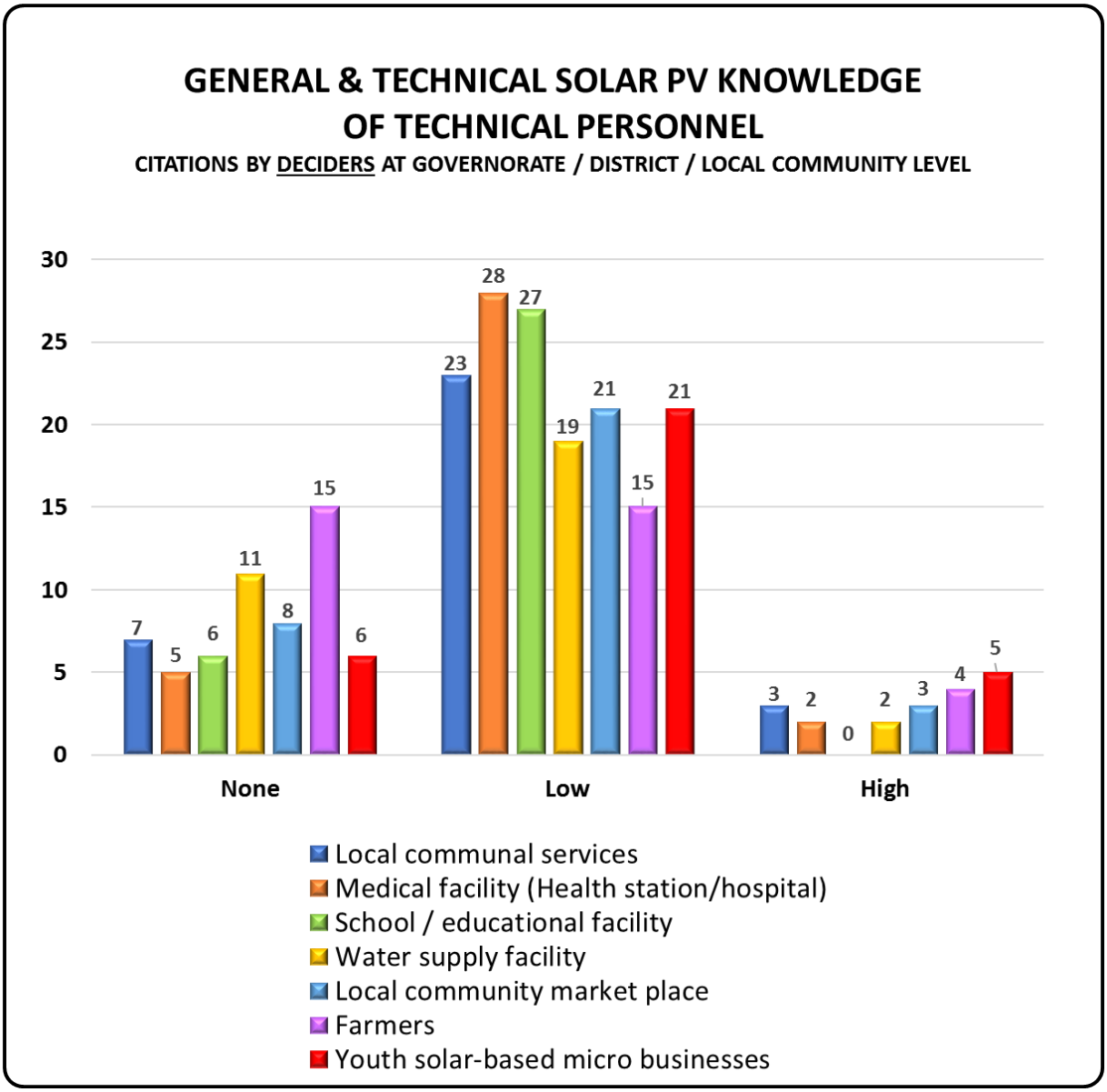


Figure 11: PV knowledge of decision makers on the demand-side

4. Survey results from the offer-side group: Traders of solar PV systems

Traders of solar PV systems and components are the biggest single target group of this survey with 40 received questionnaires.

4.1 Product categories offered to customers

Traders are no homogeneous group because they act according different business strategies. There are well-established companies and relative newcomers who use the PV market boom to start a business.

Established stores

The well-established traders are often wholesalers and retailers (groups) of industrial electric components and systems, electric home appliances (white goods, TVs and computers), office equipment and also construction materials. These stores complement their existing products and technical solutions ranges with the trendy new solar PV product lines. They increasingly also sell energy efficiency products (LED) and water pumping solutions.

Newcomer Solar PV traders

Newcomers often specialize on solar equipment, mostly complemented by energy efficient lighting and other low power products. Some also go for water pumping equipment when local demand justifies it. They often start as retail shops and grow into wholesale when successful.

Solar PV system services

Figure 12 displays the electric services offered to customers of PV-systems. Power supply guarantees - obviously based on the guaranteed output of PV-modules sold - lead the field (the lowest hanging fruit at 58%), followed by Installation services (43%), Maintenance and repair services (40%) and Regular inspection services with just 30%.

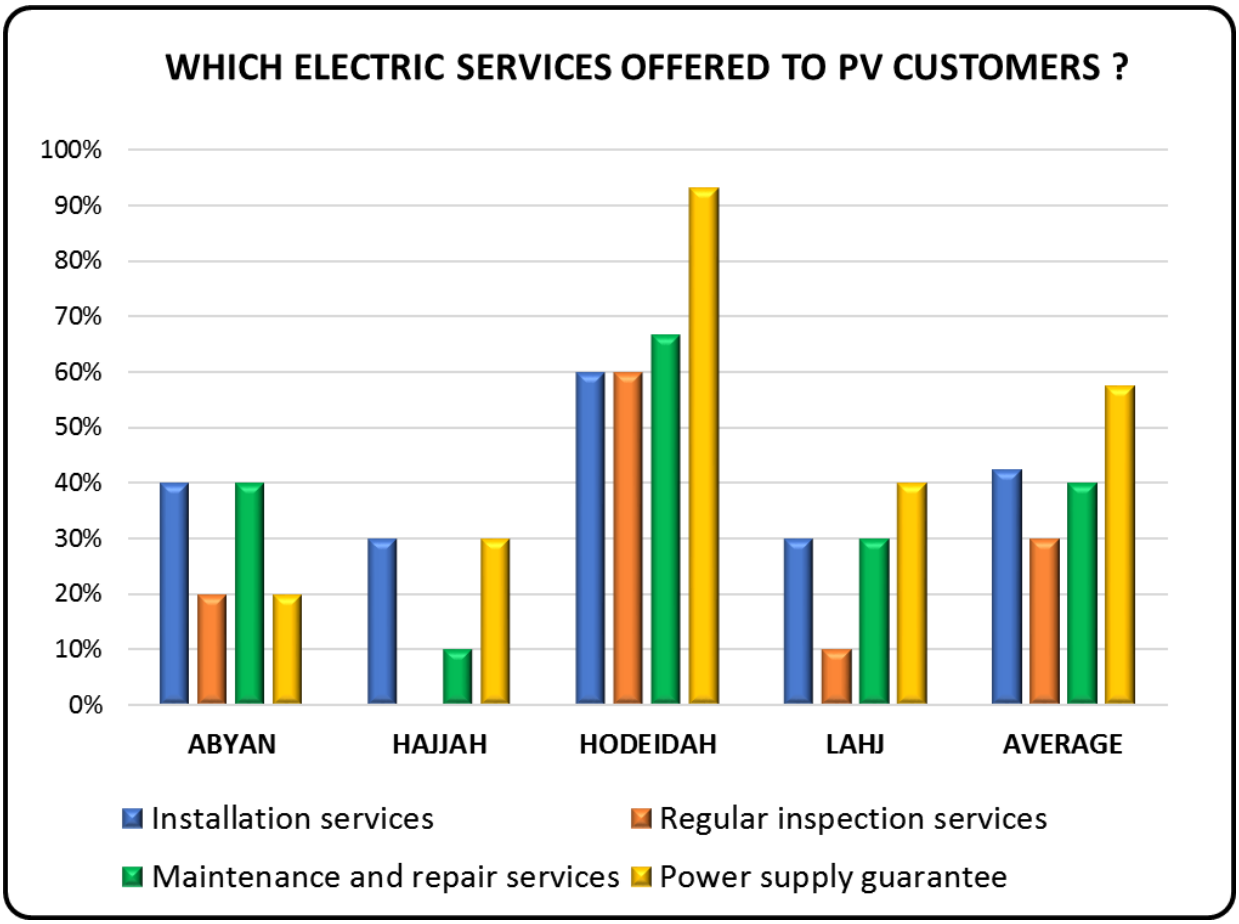


Figure 12: Electric services offered to PV customers by PV traders

Hodeidah seems to have the most developed solar PV market because the level of all solar services around PV systems is above 60%, Power supply guarantees (PV-module output) even reaching 93%. The least developed solar PV markets according to survey results are found in the governorates of Hajjah and Lahj, while Abyan probably takes advantage of its proximity to the city of Aden.

The solar product traders were asked if their sales personnel received basic training about solar PV and 28% approved but with large discrepancies between governorates. While 60% of sales personnel was trained on solar PV in Hodeidah governorate, no such trainings are reported from Hajjah and Lahj governorates.

53% of solar PV traders employ their own installation technicians for power systems (likely mostly electricians) but the situation varies considerably between governorates: While Hodeidah, as the most developed market, displays a level of 67% employing own TP, the governorates of Abyan and Lahj just reach a level of just 40%.

In contrast to the above, some 43% of solar PV traders collaborate with independent installation technicians for Solar PV (likely mostly electricians). Their competence is assessed further below.

4.2 Abilities of technical personnel for Solar PV systems

The results presented below can be compared to the results in Figures 8 and 11.

Abilities of employed Technical Personnel for Solar PV systems

The technical competence level of TP displayed in Figure 13 is rather 'Good' with a majority of 38% of the rating. It should however be noted that rating one's own employees is kind of a self-assessment in this context. With only 17% of ratings on 'Fully' competent, there is certainly room for improvement, not to talk about the remaining 45% of TP rated 'Some' and 'None'.

An average of 25% of TP has already received a training about Solar PV system, most of them in Hodeidah (47% of respondents from Hodeidah), while nobody have been trained in Lahj governorate and only 10% in Hajjah.

It must be noted here again, that the governorate of Hodeidah displays the best competence ratings with an average value of 3,1 ('Good'), followed by Hajjah with a value of 2.8 (fairly 'Good'), Abyan with a value of 2,3 (More than 'Some') and finally Lahj with a value of 1,7 (Less than 'Some').

The questioned solar PV traders estimated the number of technical staff requiring technical training on solar PV to 2,7 persons in average, thus rather rather 3. This adds up to 120 TP to be trained in the four governorates where nearly half of the potential stems from the governorate of Hodeidah. When asked about known training centers or vocational training institutes teaching on solar PV, only 20% of respondents from Hodeidah (8% of all questioned traders) could cite 4 training centers (Technical Institute, Abu Musa Street, Technical Workshops (AL-Hakemi WS), Tihama institute and Innovation Institute, both on Port Street). The traders in the three other surveyed governorates couldn't cite any training center at all.

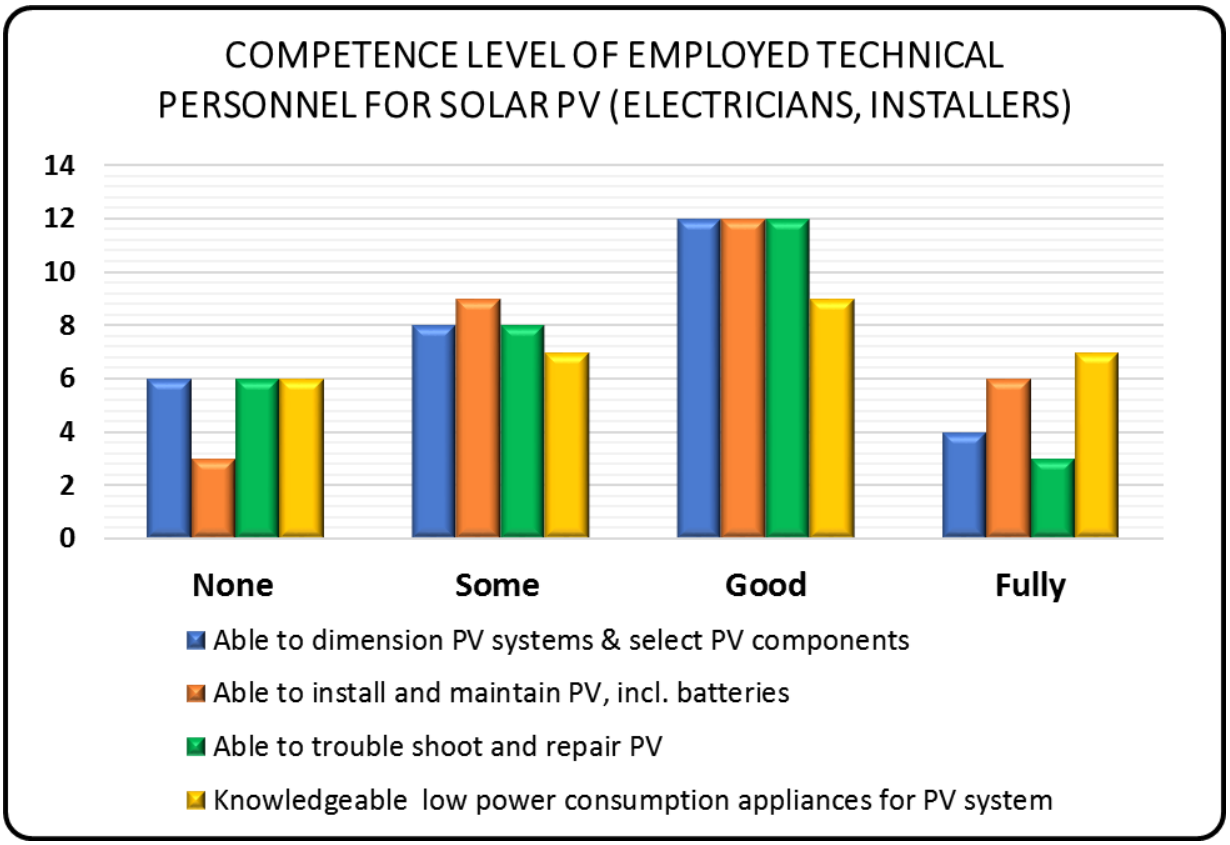


Figure 13: Solar PV competence level of Technical Personnel (TP)

Abilities of independent installation technicians for solar PV systems

An average of 43% of solar PV traders collaborate with independent installation technicians for Solar PV (likely mostly electricians). The most collaborations with independent installers can be found in Hodeidah where 53% of traders practice collaboration. Abyan features a number of 60% which is less representative since based on just 5 interviews, Hajjah and Lahj display each a value of 30%.

Their technical competence level is assessed as fairly 'Good' by traders but generally somewhat less 'Good' as they assess their own employed TP (32% against 38% above). However, the rating 'Fully' is more frequently attributed to independent installation technicians, which suggests that the competence level of independent service providers can be higher, especially in complex tasks.

Independent installers in Abyan received the best statistical rating of 3,1 ('Good'). This result is however based on small sample, but it seems that they occupy the market niche of solar PV installations and services with some success. The governorate of Hodeidah displays once more the widest and best competence ratings with an average value of 2,9 ('Good'), followed by Hajjah with a value of 2.5 (fairly 'Good') and Lahj with a value of 1,6 (Less than 'Some').

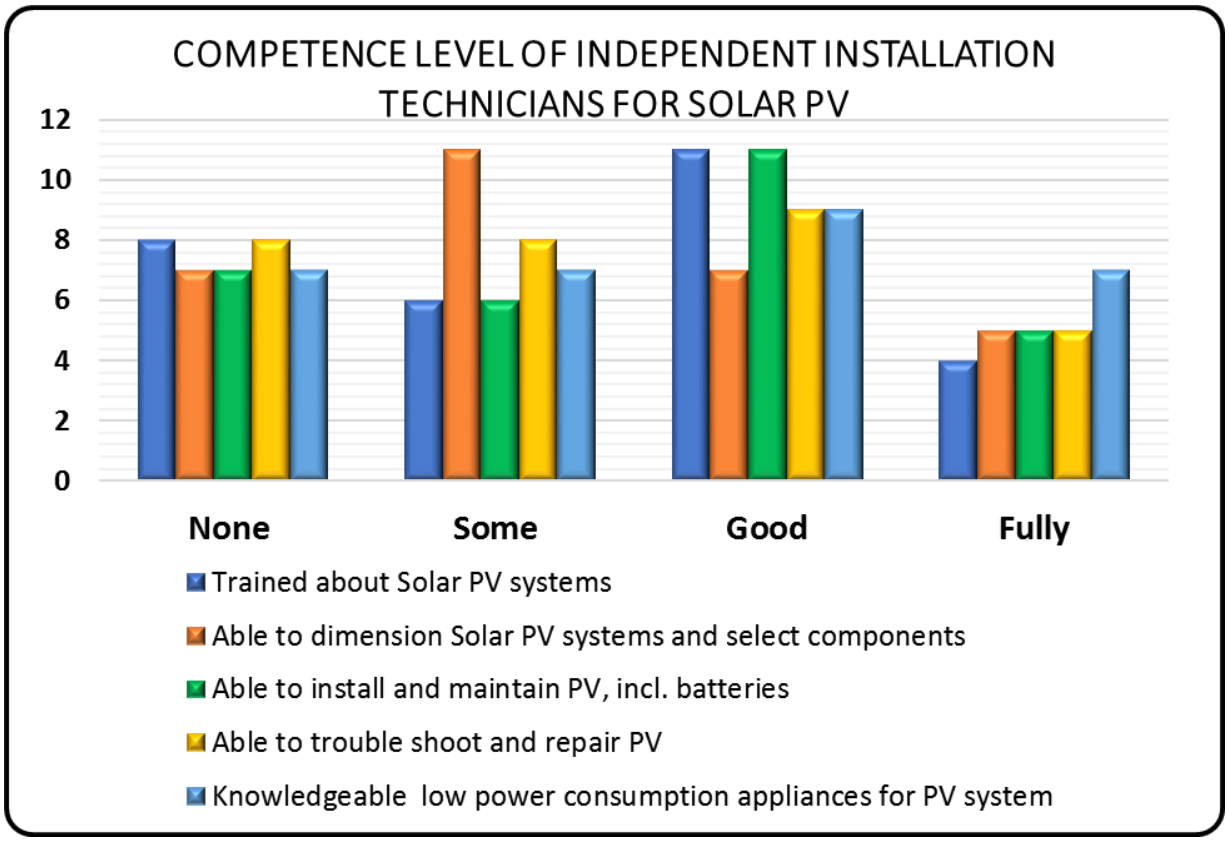


Figure 14: Solar PV competence level of independent installation technicians

5. Survey results from the group of training centers and vocational training institutes

Only 3 capacity building institutions (training centers) participated in the survey which targeted actors able in principle to provide general and technical capacity building on Solar PV topics, these are:

1) Technical and Vocational Institute (in Abs, Hajjah governorate): Has already implemented Solar PV courses, in collaboration with the BENA centre (WS) for maintaining electronic equipment
2) Community College (in Abs, Hajjah gov.): No solar courses offered yet. Provides courses in management and administration, PC and IT applications as well as health care and nursing.
3) Adbon Academic Institute (in Bajil, Hodeidah gov.): No solar courses offered yet. Provides courses on human development, management, PC-applications and English.

All 3 training centers target the following trainee target groups: TP (installers and electricians), trainers (ToT courses) and administrative decision makers, with the exception of the Community College Abs which doesn't target installers and electricians.

Among the three institutes, only the Technical and Vocational Institute in Abs yet provides courses on Solar PV covering the topics: Electricity and power systems, Solar PV systems (remote-grid systems) and Energy efficiency / power saving appliances. These courses apparently cover all of the following training subjects:

- Dimensioning of Solar PV systems and components
- Installation of Solar PV systems
- Maintenance of Solar PV systems
- Trouble shooting of Solar PV systems
- Special course on batteries
- Energy efficiency and power saving techniques
- Low power consumption appliances for PV
- Education of final power consumers
- Others: electronic maintenance and spare parts replacements

6. Conclusions from the survey results

Solar PV Market situation

All over Yemen, Solar PV markets display considerable dynamics since early 2015 which have also been fueled by the energy crisis and the escalation of military conflicts. This positive trend belongs to the rare promising developments in Yemen in recent years; it has been documented in a Solar PV market survey carried out by GIZ in Sana'a during late 2014[1]. In the four surveyed governorates, solar markets for PV systems have developed very well to fairly well in past two years, though with notable geographical differences between the governorates. Agglomeration centers and intensive agriculture tend to have a positive impact on the speed of market development. This can be well observed in Hodeidah.

Competence level of surveyed target groups

The above presented results show that the general and technical competence levels in Solar PV is rated as insufficient among all surveyed target groups:

a) Decision makers and in public administrations and managers of public facilities often already using Solar PV power

b) Traders and store owners selling solar PV systems, components and energy accessories

[1] Survey Report on Solar PV Market Development in Sana'a, Yemen 2015, GIZ PSDP, contracted by Integration GmbH, Author: Olivier Drücke, December 2015.

c) Installation and maintenance technicians (often electricians)

d) Technical Personnel operating Solar PV systems

e) Power consumers of Solar PV power in the facilities

The best level of general and technical competence can be found with Technical Personnel working directly with solar PV systems on a regular basis. They are not so well rated by their clients on the demand-side, composed of decision makers and institutional users of solar PV systems Electric. On the offer-side, the solar stores (self-) ratings of their employed TP tend to be better than as perceived by the clients. The best rating was actually given to independent installation technicians by solar stores and traders who collaborate with those technical service providers working their own business. Independent installation technicians are reliant on word-to-mouth recommendation and thus keen on their image ideally built on proper and good work. Decision makers on all public administration levels rated their own knowledge level on Solar PV power fairly well; the competence of decision makers on governorate level is the single highest.

Regional differences in Solar PV market development

There are clearly differences in the development stages of solar PV markets between the 4 governorates. Hodeidah governorate seems to have the most developed solar PV market, followed by northern neighbor governorate Hajjah. Both governorates have vast regions without access to the power grid. This has probably speeded up the solar PV market, notably in Hodeidah. Among the South Yemeni governorates Abyan and Lahj, Abyan's solar market seems to be more developed, while Lahj seems to be the least developed market from all four surveyed governorates.

Quality issues with Solar PV hardware, installation and maintenance

It has been established by the above mentioned "Survey Report on Solar PV Market Development in Sana'a, Yemen 2015" that most interviewed PV-users operate their PV-systems since only few years: consequently, rather short termed operational experiences are available to date. While at least 10% of PV-systems display initial installation errors, all of them must still prove their long-term performance and durability for up to 20 years which is seen as an international standard.

One of the major issues identified by the above cited survey clearly point towards a variety of quality problems, related to all levels along the value chain (import/manufacturing, distribution, purchase, installation, maintenance, repair and replacement):

➔ Qualities of manufactured hardware components 'made in Asia or India'

➔ Quality of competent, credible and neutral sales advice in PV-shops

- ➔ Quality of installation, often compromised by unqualified installing personnel, poorly trained electricians and self-installers (DYI)
- ➔ Quality of after-sales services and maintenance, which are seldom offered and used although they are very important.

Many of the newly installed PV-systems will require maintenance services, rather sooner than later. This will increase the demand for more systematic after-sales, maintenance, repair and replacement services and thereby improve the general quality awareness along the value chain.

Quality problems can be tackled through adequate regulation and by competent, systematic capacity building with training seminars customized to targeted trainee groups. However, this survey shows that well operated training centers are rare in Yemen and not very well known by their potential stakeholders, clients and students. They are yet seldom proposing capacity building and training courses on Solar PV energy and they are consequently viewed as not very competent in solar PV power by decision makers and institutional PV users. Much can be done to foster solar PV capacity building with established capacity building providers. The main weakness of this survey is that merely 3 capacity building institutions have been approached for interviews, where only one, the Technical and Vocational Institute in Abs, Hajjah governorate, had a Solar PV capacity building program in place. Hence, this report cannot provide full transparency on a capacity building infrastructure that is able or not to provide training to solar market actors.

7. Recommendations for Solar PV capacity building

A sustainable longer term PV-market development ultimately depends on good quality of hardware and services along the complete value chain as a premise for customer satisfaction. Persisting lack of quality can seriously undermine PV-market potential and development. Given the present situation in Yemen, neither systematic market structuring nor a quality regulation framework for solar PV can be envisaged in the near future.

To nevertheless support and foster the promising momentum of actual Solar PV market dynamics and to improve quality aspects in the meantime, it is recommended to invest in the capacity building of most important demand- and offer-side market actors.

The technical knowledge is clearly underdeveloped with a potential for improvement of at well above 70%. 47% of respondents from Hodeidah have already received a training about Solar PV systems, while nobody has been trained in Lahj governorate and only 10% in Hajjah. This rather low competence level of TP and installers can quite easily be improved with comprehensive theoretical and practical training seminars. The most urgent training requirements concerns installation and maintenance. For this, accurate training materials must be developed that can be easily customized to various target

groups and a number of competent training centers must be established. However, the capacity building infrastructure for Solar PV in Yemen is weak because training institutes and centers are rare, not well known and mostly not competent on solar PV.

Since the capacity building infrastructure has been insufficiently investigated so far in this survey (only three training centers out of 10 identified training centers were interviewed), it should be considered to complement this data by carrying out an additional flanking survey to identify more training centers and/or to focusing at least on those 10 training centers and vocational training institutes cited by respondents:

a) Two training centers In Hajjah (page 20): They already participated in this survey, as described in Chapter 5

b) Four training centers in Lahj (pages 20): No center participated in this survey

c) Four training centers in Hodeidah (pages 23-24): Only one center, the Adbon Academic Institute participated in this survey

d) No training center known or identified in Abyan governorate.

It is of major importance that training centers with attractive and relevant solar training seminars and competent trainers be established as knowledge hubs in regional centers of the four surveyed governorates. Where solar markets are fairly developed such as in Hodeidah, it would make sense to establish a larger and more differentiated Solar PV training program addressing many target groups, because there is a good demand basis already which attracts more interest from the periphery. Less developed regions should be provided with smaller, though well-equipped, flexible training centers that are able to train the most important target groups of TP and installers (electricians) and can ideally travel to carry out their training courses in less populated regions or smaller town.

Hence, the first priority must be to establish a nationwide training program serving all four governorates and that enables training centers and vocational institutes to quickly build up a good base of trainers and teachers. The primary focus should be on curricula for installation technicians dealing with quality equipment, proper installation, after-sale services, not to forget user advice concerning safety, basic maintenance and low power consuming products (This knowledge also allows installing companies to increase sales volumes and even to develop new business opportunities). The traders participating to this survey indicated a demand of approx. 120 of such training courses to be delivered. Another main focus should be curricula for technical personnel operating PV-plants that deal with maintenance, trouble shooting, repair and replacement (The questioned institutional PV-users indicated a demand of approx. 150 of such training courses to be delivered).

Decision makers on all levels of public administration are in general not very knowledgeable about solar energy and energy efficiency. Special courses should therefore be developed to close these gaps. Foremost, these courses should specifically

address the economics of solar energy including funding and subsidies, the regulatory aspects of safety and quality as well as the important topic in perspective of grid-connection.

Since most power users are not well aware of energy conservation opportunities, they should be educated about energy efficient power appliances by means of public information campaigns involving the press, internet, radio, TV.

Annex 1: The three questionnaires used for the survey in four governorates

Questionnaire for decision makers on and users of PV systems in rural or remote grid areas

DECISION MAKER or USER ? (please mark what applies)

Organization name: 7th July School

Name:

Address: Abyan Gov., Khanfar district

Telephone:

E-mail: _____

SECTION I: GENERAL QUESTIONS

1) Please indicate from which governorate you are answering to this questionnaire? (Please tick what applies)

	Hajjah Govenorate
	Hodeidah Governorate
	Lahj Governorate
X	Abyan Governorate

2) Please indicate on which administrative level you are working (Please tick what applies)

	Administrative decision maker at governorate level
X	Administrative decision maker at district level
	Leader at municipal/local community level
	Operative manager of a power consuming facility
	Other working field? Which: _____

If you are an administrative decision maker, please make sure to answer Section **V. QUESTIONS ON SOLAR POWER KNOWLEDGE & TRAINING for decision makers at governorate / district / municipal/local community level**

3) What type of power consuming institution are you representing or working for? (Please tick what applies, multiple ticks are possible)

	Local communal services or administration
	Medical facility (Health station / hospital)
X	School / educational facility
	Water supply facility
	Local community market place
	Farmer
	Young company start-up (business or service provider)
	Other:_____

4) Please indicate the exact function in which you are working in the above institutions?

Female Teacher at school

5) Please evaluate your own level of knowledge concerning solar energy and especially concerning solar energy and PV (Please tick what applies)

X	Rather high general knowledge about solar energy and PV
	Rather low general knowledge about solar energy and PV
	Rather high technical knowledge about solar energy and PV
	Rather low technical knowledge about solar energy and PV

SECTION II: QUESTIONS ON POWER CONSUMPTION

6) Please describe the actual power consumption of your facility/facilities:

a) What is the amount of electric energy you are consuming today in total per month?

_____ kWh

b) What are the approximate yearly energy expenses you are paying for today?

250,000.- Yemeni Rial

c) For what purposes are you using electric energy today?
(Tick all the types of appliances used and fill usage hours per day)

	Type of appliance	Hours used per day
X	Room lighting	3 Hours/ day
X	Public lighting	2 Hours/ day
X	Refrigerators/freezers	12 Hours/ day
X	Water pumping	6 Hours/ day
X	TV-video / Radio	2 Hours/ day
	Others:	
	Others: _____	

d) What are the sources of power available today and average time of use per day
(Tick the types of power sources used and fill hours of use hours per day)

	Source of power	Hours per day
X	Electric grid	3 Hours
	Power generator	
	Others: small PV-system	

e) What are the respective shares of your power consumption from the power grid / from self-generation?

Power consumption from:	in %
Electric grid	00_%
Electric self-generation	00_%

f) What kind of self-generation energy systems are you using today?
(Please indicate the installed power capacity)

Self-generation system:	Capacity in kW
Diesel generator	_____ kW
Solar PV system	4 kW
Other system? Which: _____	_____ kW

g) Do you already use PV systems? If so, please describe briefly your experience

NO

7) Are there plans for extensions/modernization of the electric supply in your community or your facilities? If so, please indicate which technology
(Tick the types of power sources to be extended/modernized)

X	Extension / modernization:
	Electric grid
	Fuel generator for power generation
X	Solar PV system
	Other: _____

8) Please indicate the minimum and maximum energy in watt-hours (Wh) required to be supplied by the PV system on a daily basis:

Minimum requirement for appliances per day	4000 Wh
Maximum requirement for appliances per day	10,000 Wh

9) Please cite the 3 key applications with the biggest potential for solar PV systems in your region:

a) Lightening

b) PC and screen operations

SECTION III: QUESTIONS ON POWER RELATED SERVICES

10) Do you have a distributor from whom to purchase your power equipment?

YES

Is it a local or regional distributor?	local
Can you please indicate who it is?	Universal centre

11) Do you have a local service provider such as a local Energy Service Company (ESCO) which can take care of maintenance services and guarantee you a stable power supply?

NO

Space for comments: PV system is good and we are satisfied

_____

12) What are your current maintenance arrangements for your existing power equipment? Please describe briefly.

_____

13) Should the power generated by donated PV systems be billed?

NO	A power consumption tariff per kWh should be set to cover at least the maintenance costs.
NO	A power consumption tariff per kWh should be set to cover the maintenance costs and the replacement of key components after 3-10 years (especially for batteries).
NO	None of the above: The costs for maintenance and replacement should be covered through the collection of monthly fees.

SECTION IV: QUESTIONS ON SOLAR POWER KNOWLEDGE & TRAINING

for operative managers of power consuming facilities

14) Does your institution have an electrician or a technical operator (technical personnel) with solid basic knowledge about electric installations?

No

15) Is this electrician or technical operator (technical personnel) knowledgeable about Solar PV power systems?

a) Have your technical personnel already been trained about Solar PV systems?

b) Are your technical personnel able to dimension Solar PV systems and select all Solar PV power systems components according to the specific requirements and the state-of-the-art?
(Please assess the level of knowledge of your technical personnel by ticking)

None	Some	Good	Full proficiency

c) Are your technical personnel able to install and maintain the Solar PV systems, incl. batteries according to the state-of-the-art?

None	Some	Good	Full proficiency

d) Are your technical personnel able to trouble shoot and repair the solar PV systems according to the state-of-the-art?

None	Some	Good	Full proficiency

e) Are your technical personnel knowledgeable about low power consumption appliances especially suitable for solar PV system?

None	Some	Good	Full proficiency

f) Please indicate or estimate how many technical staff in your domain of responsibility would require a technical training on solar PV systems?

Number of technical personnel:

16) Do you know about a training center or vocational training institute where to send your technical personnel?

NO

Please indicate which and where: _____

17) Would you consider a basic training course on solar energy and energy efficiency a useful measure also for the leading management personnel of your organization?

YES

18) How educated on energy conservation are the power users/consumers in your institution/facilities?
(Please tick what applies)

	Level of education on energy conservation
X	Not at all educated
	A little educated
	Very well educated

SECTION V: QUESTIONS ON SOLAR POWER KNOWLEDGE & TRAINING

for deciders at governorate / district / local community level

19) How do you estimate the general knowledge on Solar PV power of decision makers in the following target groups?
(Please tick what applies)

	None	Low	High
Governorate decision makers			
District decision makers		X	
Local community leaders			
Project beneficiaries			

20) How do you estimate the general and technical knowledge on Solar PV power of technical personnel in the following target groups?
(Please tick what applies)

	None	Low	High
Local communal services			
Medical facility (Health station/hospital)			
School / educational facility			
Water supply facility			
Local community market place			
Farmers			
Youth solar-based micro businesses			

21) Please indicate below the training centres or vocational training institutes you know and that are logistically accessible for the personnel in your region?
Please also indicate how you assess their competence level to train technicians on solar PV power topics!

	Competence to train on solar PV		
Training centers and vocational training institutes	None	Low	High

Questions for (potential) traders of solar PV systems:

Trading company: Universal Centre

Name: _____

Address: Shukura city/ sub-district

Telephone: 772666321

E-mail: _____

1) Please indicate from which governorate you are answering to this questionnaire (Please tick what applies)

	Hajjah Govenorate
	Hodeidah Governorate
	Lahj Governorate
X	Abyan Governorate

2) What type of products are you trading today?

A. Panels

B. Batteries

C. Inverters and Chargers

3) Which electric products do you provide to your customers?

A. Electric mixers

B. Screens

C. Irons

4) Do you already sell PV systems? If so, please list the type of solar PV components you are selling to your customers? Yes

A. panels

B. Batteries

5) Which services for electric products do you offer to your customers?

NO	Installation services
NO	Regular inspection services
NO	Maintenance and repair services
NO	Power supply guarantee

6) Did your sales personnel receive a basic training about solar PV systems?

NO

7) Do you employ your own installation technicians for power systems (electricians)

NO

8) If YES, please answer the following questions:

a) Have your technical personnel already been trained about Solar PV systems?

YES / NO

b) Are your technical personnel able to dimension Solar PV systems and select all Solar PV power systems components according to the specific requirements and the state-of-the-art?
(Please assess the level of knowledge of your technical personnel by ticking)

None	Some	Good	Full proficiency
X			

c) Are your technical personnel able to install and maintain the Solar PV systems, incl. batteries according to the state-of-the-art?
(Please assess the level of knowledge of your technical personnel by ticking)

None	Some	Good	Full proficiency
	X		

d) Are your technical personnel able to trouble shoot and repair the solar PV systems according to the state-of-the-art?
(Please assess the level of knowledge of your technical personnel by ticking)

None	Some	Good	Full proficiency
X			

e) Are your technical personnel knowledgeable about low power consumption appliances especially suitable for solar PV system?
(Please assess the level of knowledge of your technical personnel by ticking)

None	Some	Good	Full proficiency
	X		

f) Please indicate or estimate how many technical staff in your domain of responsibility would require a technical training on solar PV systems?

Number of technical personnel: _____

9) Do you know about a training center or vocational training institute where to send your technical personnel?

YES / NO

Please indicate which and where: _____

10) Do you collaborate with independent installation technicians for Solar PV power systems (electricians) to market your solar systems?

NO

11) How do you assess the competence level of the independent installation technicians you collaborate with in the following fields of expertise
(Please tick what applies)

	None	Some	Good	Full proficiency
Trained about Solar PV systems			X	
Able to dimension Solar PV systems and select components		X		
Able to install and maintain the Solar PV systems, incl. batteries		X		
Able to trouble shoot and repair the solar PV systems	X			
knowledgeable about low power consumption appliances for PV		X		

Questions for training centers and vocational training institutes:

Training center: _____

Name: _____

Address: _____

Telephone: _____

E-mail: _____

1) Please indicate from which governorate you are answering to this questionnaire
(Please tick what applies)

	Hajjah Govenorate
	Hodeidah Governorate
	Lahj Governorate
	Abyan Governorate

2) Does your training institution already offer training courses for technicians in the following fields?
(Please tick what applies)

	Electricity and power systems
	Solar PV systems (remote-grid systems)
	Energy efficiency / power saving appliances

3) If your training institution offers training courses in the field of energy and power, which trainee groups do you target?
(Please tick what applies)

	Electricians / Installers / technical personnel
	Trainers (ToT courses)
	Administrative decision makers
	Others: _____

4) If your training institution offers Train-of-the-trainers (ToT) courses, If yes, please cite some technical disciplines of ToT courses that you offer:

_____

_____

5) If your training institution offers courses on Solar PV systems and Energy efficiency, please briefly specify the contents of these courses:
(Please tick what applies)

	Dimensioning of Solar PV systems and components
	Installation of Solar PV systems
	Maintenance of Solar PV systems
	Trouble shooting of Solar PV systems
	Special course on batteries
	Energy efficiency and power saving techniques
	Low power consumption appliances for PV
	Education of final power consumers
	Others: _____
	Others: _____