



Assessment of Training Needs for Solar PV in Nepal

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Promotion of Solar Technologies for Economic Development (POSTED)

NTNC Complex, Khumaltar
Lalitpur, Nepal
P.O. Box 1457
T +977 1-553 8129
E posted@giz.de
I www.giz.de

Developed by

Integration Umwelt & Energie GmbH, Germany

Authors

Kushal Gautam, Kathmandu
Felix Nitz, Kathmandu

Review

Felix Nitz, Kathmandu
Eric Lespin, Curitiba, Brazil

Coordination

Felix Nitz, Kathmandu

Photo credit

Kushal Gautam, Kathmandu

Responsible

Felix Nitz, Kathmandu

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Acronyms

AC	Alternating current
A.D.	Anno Domini
ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
BoQ	Bill of quantity
B.S.	Bikram Sambat
CES	Center for Energy Studies, Tribhuvan University
CTEVT	Council for Technical Education and Vocational Training
CRM	Customer relationship management
DC	Direct current
DFS	Detailed Feasibility Study
EPC	Engineering, Procurement and Construction contract
ESAP	Energy Sector Assistance Programme
ESCO	Energy Service Company
FY	Fiscal year
ISPS	Institutional solar power systems
IWMI	International Water Management Institute
KfW	Kreditanstalt für Wiederaufbau
kW	Kilowatt
kWh	Kilowatt-hour
kWp	Kilowatt-peak
L1	Level 1 (CTEVT solar technician course offer)
L2	Level 2 (CTEVT solar technician course offer)
LG	Local government
MGEAP	Mini Grid Energy Access Project
MW	Megawatt
NEA	Nepal Electricity Authority
NPR	Nepalese Rupees
NRREP	National Rural and Renewable Energy Programme
O&M	Operation & maintenance
PG	Provincial government
POSTED	Promotion of Solar Technology for Economic Development, a development programme of GIZ
PPA	Power purchase agreement
PV	Photovoltaic
RETS	Renewable Energy Test Station

RERL	Renewable Energy for Rural Livelihood
SASEC	South Asia Subregional Economic Cooperation
SEMAN	Solar Electric Manufacturers Association Nepal
SESC	Solar Energy Sub-component
SHS	Solar home systems
SIP	Solar irrigation pumps
SMG	Solar mini-grid
SOP	Standard operating procedure
SRT	Solar rooftop (grid-tied)
SWP	Solar water pumps
T&C	Testing & commissioning
TSLC	Technical School Leaving Certification
TU	Tribhuvan University
TVET	Technical and vocational education and training
UNDP	United Nations Development Programme

1. Nepal's Solar PV Market

1.1 Solar home systems

The exact entry of solar PV into the Nepalese market cannot be ascertained, but it is said that the first PV module was used in 1963 at an airport for navigational purposes¹. The recorded use of solar PV for domestic electrification started in 1991¹. During this period, most of the systems promoted were for basic use such as for lighting purposes and are known as solar home systems (SHS). These systems have a capacity generally in hundreds of watts. Figure 1 and Figure 2 show data published on cumulative capacities and the year-wise number of SHSs installed.

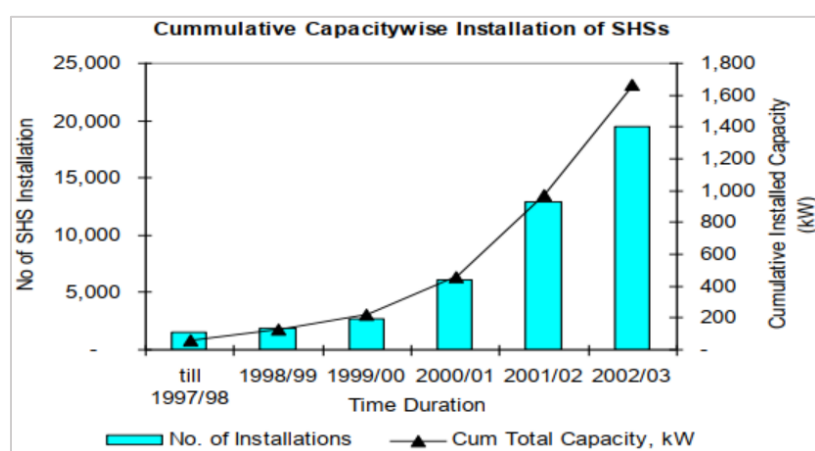


Figure 1: Cumulative capacity-wise installation of SHSs until mid-July 2003²

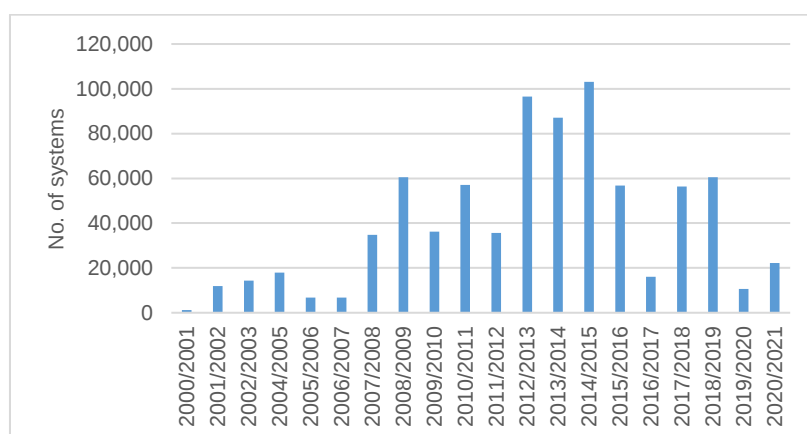


Figure 2: Number of SHS installations from the Alternative Energy Promotion Centre³

¹ Ramchandra Bhandari and Ingo Stadler, "Electrification using solar photovoltaic systems in Nepal," *Applied Energy*, vol. 88, no. 0306-2619, pp. 458-465, 2011.

² Obtained from: Jagan Nath Shrestha, Tri Ratna Bajracharya, Shree Raj Shakya, and Bijay Giri, "Renewable Energy in Nepal – Progress at a Glance from 1998-2003," in RETRUD, Kathmandu, October 2003.

³ Alternative Energy Promotion Centre. <https://www.aepc.gov.np/statistic/solar-home-system> (further updated by data published in progress reports).

It has to be noted that in Figure 2, data for the fiscal year 2003/04 is missing due to a lack of data published.

The cumulative number of SHSs reached more than 960,000 by the fiscal year 2020/21¹. Since the early 2000s and up to 2015, the deployment of SHS has followed an increasing trend. This can be attributed to increasing awareness of SHS in rural households, growing confidence in the technology and low access to electricity nationally. In 2000, Nepal's access to electricity (% of the population) was 29% after which it gradually increased and reached 82.5% in 2015². SHS served the need for basic electricity access in rural areas. However, the number of new SHS installed per annum is declining since it peaked between 2011 and 2015. One reason for the decline can be correlated with the increase in the electrification rate of Nepal reaching 90% in 2020¹. The government has set a target to reach 100% electrification by FY 2023/24³. Furthermore, the energy crisis in Nepal which started in 2006 and caused frequent load-shedding, ended in early 2017^{4,5} leading to better reliability of the grid. Both these factors can be attributed to the decline of SHSs in Nepal.

SHS will continue to serve unelectrified households in scattered settlements where grid electricity will be challenging to reach. The subsidy amount for SHS is dependent on the region it is deployed and defined in the Renewable Energy Subsidy Policy.

Institutional solar power systems

Another solar PV application, an upgrade over the SHS, that enjoys subsidy support is institutional solar power systems (ISPS). As per the Renewable Energy Subsidy Policy (2078 B.S.), ISPS can obtain up to 65% subsidy not exceeding NPR 500,000 that will be provided for systems installed in public institutions in rural areas, particularly for operating computers and other electrical equipment in schools, vaccine refrigerators, electrical equipment and lighting purposes in health posts, and government and community hospitals.

1.2 Solar water pumps

The first solar water pumping (SWP) system of 4 kW was installed in Nepal in 1993 at Sudarighat. Within a few years, larger solar pumping systems were installed in Bode (40 kW) in 1995, Bhulke Siraha (60 kW) in 1996 and Phulberiya, Siraha in 1998⁶.

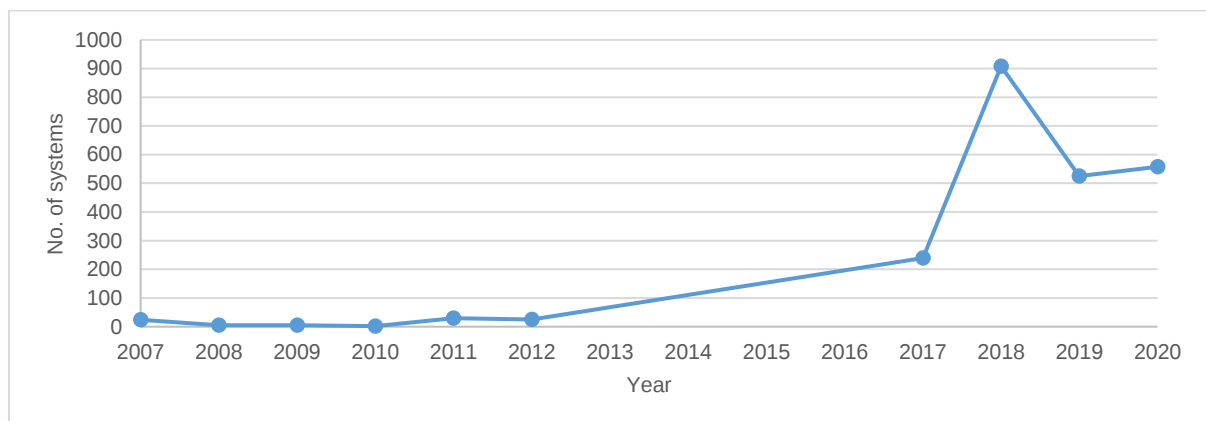


Figure 3: Trend of SWP installation (obtained from AEPC annual report 2007 – 2020)

¹ Alternative Energy Promotion Centre, "Progress at Glance: Year in Review FY 2019/2020 and FY 2020/2021" report.

² The World Bank. (2022) <https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=NP>

³ Nepal Electricity Authority, "A year in review - Fiscal year 2021/2022" report.

⁴ Ratna Sansar Shrestha, "Electricity Crisis (Load Shedding) in Nepal, Its Manifestations and Ramifications," Hydro Nepal, no. 6, January 2010.

⁵ Sushil Sah. (2019, November) Power-Less to Powerful. <https://www.worldbank.org/en/news/feature/2019/11/25/power-less-to-powerful>

⁶ Renewable World, "Is solar pumping technology a viable solution for irrigation system in Terai plain of Nepal?", 2018.

Although there is a gap in the data between 2013 to 2016 due to data unavailability, it can be seen that the installation of SWPs began to increase after 2012 and peaked in the year 2018. However, the number of systems decreased in the succeeding year of 2019. For 2018, reports of the Alternative Energy Promotion Centre (AEPC) show that it had overachieved its target for SWP by 176% whereas in 2019 the numbers installed were on target by 105%. Although AEPC had been keeping an annual target of SWP at approximately 500 systems, it can be speculated that following 2018, it optimized its focus and resources to implement SWP systems only within the target. The cumulative number of solar water pumping systems for drinking and irrigation reached 2,446 by the fiscal year 2020/21¹.

The SWPs implemented have no battery backup and are off-grid as subsidy eligibility is limited to off-grid systems. Only recently, with the expansion of the national grid, grid-connected SWP has been on the radar of organizations such as the International Water Management Institute (IWMI) which is exploring the implementation of grid-connected SWP in coordination with AEPC and Nepal Electricity Authority (NEA). Furthermore, common SWP systems implemented are AC (alternating current) pumps while DC (direct current) pumps are installed as well.

One of the applications of SWPs is irrigation, for which it is termed solar irrigation pumps (SIP). The major driver for SIPs is the subsidies from AEPC. More than 80% of the applications for SIPs are received from the private sector². This subsidy is reaching out to relatively well-off farmers (with more than 1 *bigha* land) than small-holder, marginal communities and landless¹.

According to IWMI's rapid assessment report on AEPC's subsidy delivery mechanism for SIPs, the requirement for energy mix demands self-produced and green energy, and socio-political circumstances may still drive demands for SIPs at least for the next 7-10 years¹.

1.3 Solar mini-grids

The history of solar mini-grids (SMG) begins with the installation of three solar mini-grids of 130 kWp cumulative capacity in Gamgadhi, Simikot and Tatopani in 1989 with the support of the French government³. Following this, a solar-wind mini-grid of 12 kW was installed in Dhaubadi, Nawalparasi in 2011 with support from ADB¹. Later the Government of Nepal and various development programmes, such as ADB's SASEC, World Bank's MGEAP, UNDP's RERL programmes and others have been supporting AEPC in the implementation of solar and solar-wind mini-grids which continue to date¹.

The cumulative capacity of solar mini-grid systems (excluding solar-wind mini-grids) reached 1,581 kWp by 2022 as shown in Figure 4. Looking at how the SHS market has evolved since the late 1990s and how the government support for SMGs has grown in the last decade, SMGs now enable rural households to raise energy consumption above basic use that was limited by SHSs. SMGs, for rural areas, simulate grid access in households giving the beneficiaries confidence with reliable electricity to uplift their living standards.

¹ Alternative Energy Promotion Centre, "Progress at Glance: Year in Review FY 2019/2020 and FY 2020/2021" report.

² Vishnu Prasad Pandey et al., "A Rapid Assessment of AEPC's Subsidy Delivery Mechanism for Solar Irrigation Pumps (SIPs) in Nepal," International Water Management Institute, 2020

³ Santosh Rai. (2019, September) Introduction to RE Mini Grid Projects in Nepal. [Online]. https://energypedia.info/images/6/6a/Sesion_0_Introduction_AEPC_Mr_Rai_090419.pdf

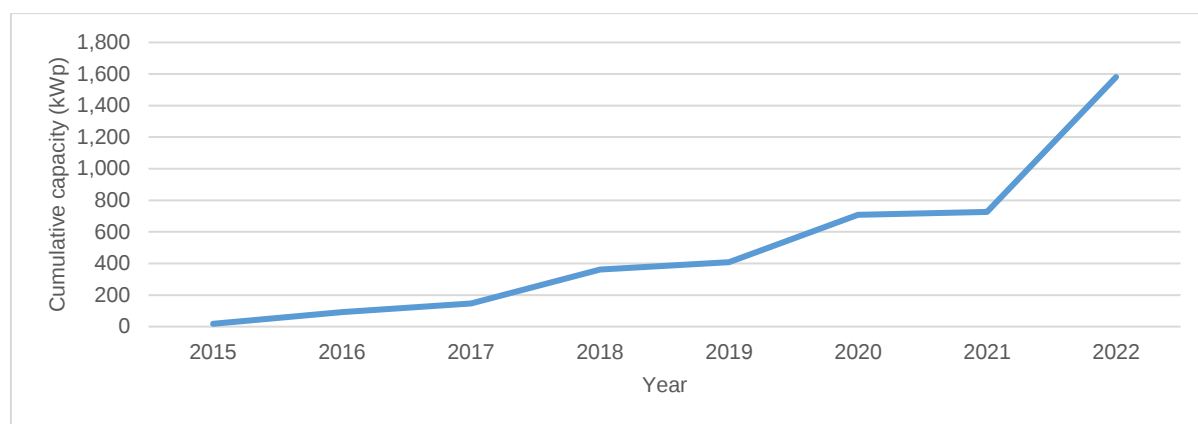


Figure 4: Year-wise cumulative installed capacity of SMGs (excluding solar-wind mini-grids)

Based on the types of systems implemented so far, SMG locations that are foreseen to have grid access within the design lifetime of the system, are designed with the flexibility of grid integration in the future. In locations where grid access is not foreseen within the design lifetime of the system, SMGs with no grid integration options (purely off-grid) are selected. These selective design options based on the site conditions allow for system optimization and flexibility.

In the last decade, to ensure regular and transparent collection of electricity tariffs, SMGs require pre-paid energy meters for all users. The user tariffs shall not exceed the tariff for grid electricity (from NEA). This causes a debate about whether the grid-based tariff will justify enough tariff collection for the general repair and maintenance of the SMG. In cases where the grid-based tariff is not justified, the project owner can define alternative tariff rates via a public hearing procedure defined in the Public Hearing Directive published in 2020 A.D. (2076 B.S.) by the Electricity Regulatory Commission.

The adoption of SMGs is subsidy-driven, with subsidies from AEPC and local governments (LG). SMGs will continue to serve unelectrified remote areas of Nepal where NEA grid electricity will be challenging to reach. This comes from AEPC and NEA's coordinated mechanism to identify and install distributed generation systems in remote areas to improve grid quality and increase access to electricity. Therefore, the outlook of SMGs looks promising given that there is ongoing government support for these systems (the subsidy scheme is described in Section 1.6) but there is little or no hope currently that energy access through SMGs could sustain in a free market without subsidies.

1.4 Grid-tied solar rooftop and ground-mounted systems

Grid-tied solar rooftops and ground-mounted systems (SRT) in Nepal are still at their nascent stage. The first grid-connected utility-scale PV plant in Nepal was commissioned in 2012 with a capacity of 680 kWp at Dhobighat, Kathmandu with grant support from the Japan International Cooperation System.

In 2021 the government revised the guidelines on the "Grid-connected alternative energy development procedure". The document describes the procedure for electricity generated from solar PV to be fed into the grid.

The promotion of SRT is market driven with companies focusing on the commercial and industrial sectors seeing opportunities for the energy service company (ESCO) model that offers clients lower tariffs from SRT compared to the grid. The revenue for the ESCO is then tied to electricity sales to the industry based on a power purchase agreement (PPA) with the client and grid export if net-metered or net-billed. Other companies rely on donor-funded projects where companies install SRT under engineering, procurement and construction (EPC) contracts.

As for residential grid-tied systems, their popularity is low. Although residential grid-tied systems have been demonstrated, the uptake has been slow or even stagnant. In the author's view, this is due

to a lack of awareness among households on SRT systems and realisation of financial benefits (closely linked with lack of marketing) paired with the lack of clear and efficient implementation mechanism of NEA, creating process confusion and a wall of bureaucracy.

In the future, considering declining costs, electricity from SRT will continue to become financially attractive in comparison to grid electricity and especially diesel generators. Commercial and industrial sectors that consume high amounts of energy, and have large areas for solar PV installation and those that suffer from intermittent grid outages (reliance on diesel generators as backup) will continue to become attractive customers to private companies offering SRTs. However, it must be highlighted that the policy environment around SRTs must be stable and effectively implemented for SRTs to evolve with the highest potential.

A private sector needs assessment conducted by Promotion of Solar Technologies for Economic Development (POSTED) and discussed in Chapter 2 has highlighted that the most common barriers perceived by companies are policy-related. This is because of the hassles that companies face during net-metering applications, which have recently faced a roadblock as NEA's distribution and consumer service offices are reluctant to accept net-metering applications citing the expiry of the grid-connected alternative energy directive.

1.5 Utility-scale solar PV plants

On the other end of the spectrum, utility-scale solar PV plants (>1MW) are entirely market driven. The guidelines require a survey license and a generation and transmission license before signing PPAs with the utility operator. Recently, this fixed tariff was reduced from NPR 7.3 per kWh to NPR 5.94 per kWh¹ by the Electricity Regulatory Commission. In addition, NEA will now require open competition which means that NPR 5.94 per kWh is the maximum rate while companies will have to submit bids at a lower price to compete¹.

The recent lowering of the maximum PPA rate has caused a negative stir in the solar PV market where the move is viewed as a discouragement of the uptake of solar PV. There is also a lack of clarity in the terms and conditions of the revised PPA provisions which have resulted in increased market risks for developers and low confidence in aiming for ambitious solar PV implementations. Therefore, the outlook of utility-scale solar PV seems very uncertain.

1.6 The role of subsidies

Subsidies are the main driver for SMGs and SWPs in Nepal. The central provisions according to the Renewable Energy Subsidy Policy (2078 B.S.) for SMGs and SWPs are as follows:

SMG subsidy

- Up to 90% for projects up to 250 kWp for areas not connected to the national grid in case of ownership and co-funding by local governments.
- Up to 60% for projects up to 100 kWp in areas not connected to the national grid or other mini-grid sources in case of co-ownership and co-funding by communities, cooperatives, private parties (ESCO model) or public-private partnerships.

SWP subsidy

- Up to 90% of solar water pumping projects for drinking water that is co-funded by local government or user committees.
- Up to 60% not exceeding NPR 20 *lakh* (NPR 2 million) per system for PV pumping systems for irrigation of agricultural land co-funded by the community or a private company.

¹ New Business Age. (2022, March) New Business Age. <http://www.newbusinessage.com/Articles/view/14933>

Given the high level of subsidies, the promotion of SMGs and SWPs in Nepal relies almost entirely on subsidies. In a hypothetical case, if the subsidy schemes were to be terminated, future adoption would chiefly collapse. However, considering the demand for SWPs and the government's focus on last-mile electrification, it is highly likely that subsidy schemes for SMGs and SWPs will continue in the foreseeable future.

2. Solar PV Companies

2.1 About the survey

Promotion of Solar Technologies for Economic Development (POSTED) conducted a needs assessment survey on private companies involved¹ in solar PV implementation. The survey was conducted throughout Nepal to gain first-hand insights into the challenges faced by solar companies and their specific capacity development needs. The major pain points of the solar companies have informed this training needs assessment for the overall market development needs of the Nepalese solar PV sector in the long run.

Out of the 66 identified active solar PV companies across Nepal, 57 companies were interviewed. Companies working in various solar PV technologies, such as SMG, SRT, SWP, SHS, ISPS and others throughout Nepal were included in the survey. Figure 5 shows the geographical spread of the survey across the seven provinces. More than 70% (40 out of 57) of the companies were based in Kathmandu, Province 3 (Bagmati).

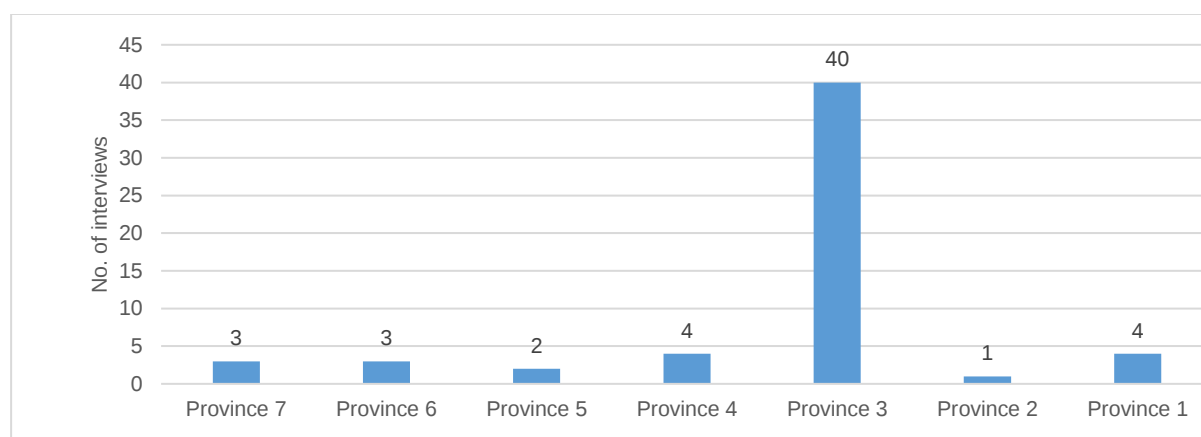


Figure 5: Geographical spread of solar PV companies interviewed²

Similarly, most of the companies involved in SMG, SRT and SWP technologies were also based in the Bagmati Province as shown in Figure 6. From the perspective of experience in a particular technology, the majority of the companies involved in SMG and SRT are based in Kathmandu, whereas SWPs are implemented by companies in all provinces as shown in Figure 7.

¹ Involved companies mean companies those are currently involved in developing projects.

² The graph is arranged from Province 7 in the left to Province 1 in the right following the direction from west to east.

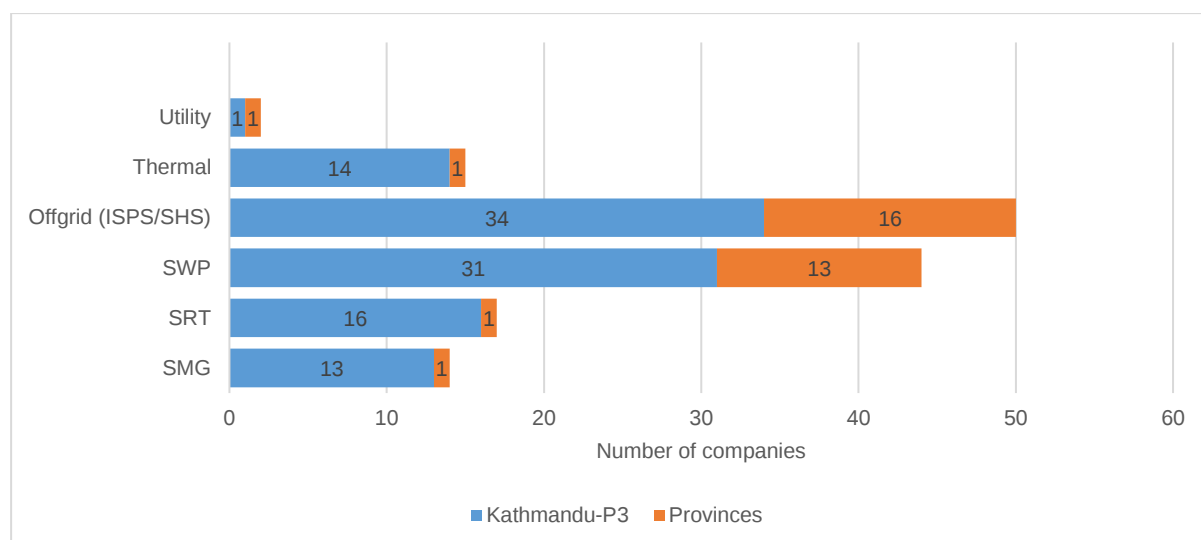


Figure 6: Involvement of companies in different technologies (Kathmandu – Province 3 vs. other provinces)

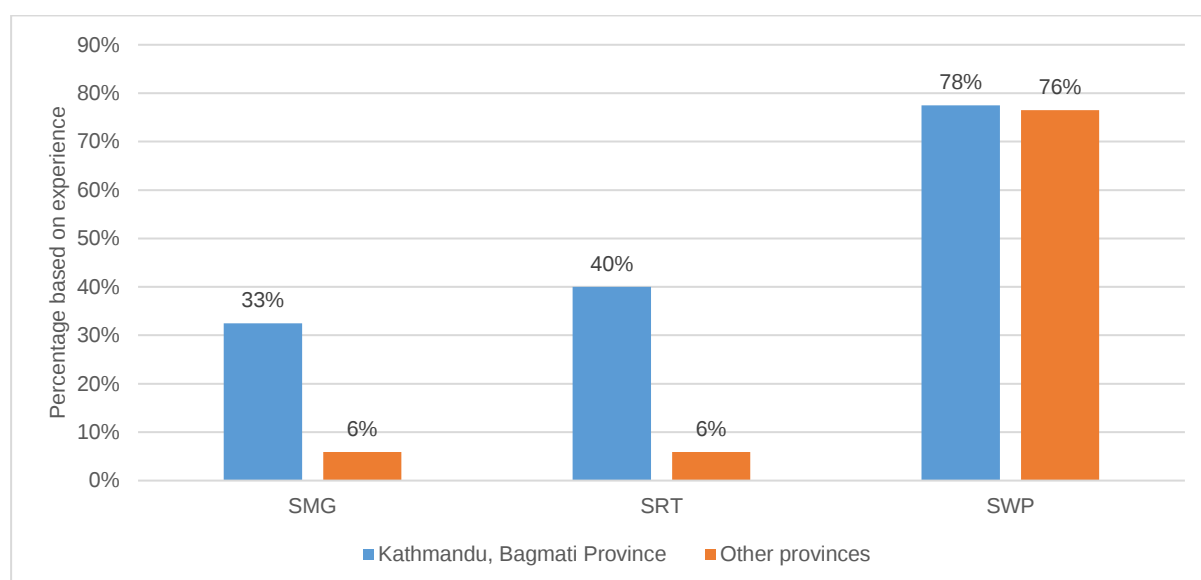


Figure 7: Companies experienced in SMG, SRT and SWP

2.2 Perceived barriers

2.2.1 SMG

Of the companies that are involved in SMGs, the most common barrier they perceive to scaling up is in the community front. These barriers include customer awareness, social disputes, local technical capacity and community contribution to the project.

Similarly, policy-related barriers such as policy unclarity, tariff benchmarking with grid electricity and subsidy-driven projects were perceived; followed by technical barriers such as lack of product validation and repair & maintenance challenges.

Other barriers included poor bid document quality, lack of skilled human resources and SMG plant loading during operation – either under-utilized or overloaded.



Figure 8: Perceived barriers – SMG

The most common barriers that the companies perceive relate to the community and are thus outside of the sphere of direct influence of companies. These barriers can be said to be outside of the company's control which affects its operation. For example, resolving social disputes in SMG project locations does not fall under the scope of private companies who are implementing these systems under engineering, procurement and construction contracts.

The barriers that fall within the control of the company are human resource shortage, product validation and repair and maintenance. SMGs, which have more components compared with SRTs and SWPs with batteries, several inverters, control systems etc., are implemented in remote locations that are difficult to access. Any technical issue in the system has to be attended to by the companies themselves which are mostly concentrated in Kathmandu. Similarly, establishing service centre branch offices is not usually financially viable for most companies as the concentration of projects is low. Therefore, this makes even minor repair and maintenance work a major barrier to companies who have to send a technical resource person to remote sites which proves costly.

2.2.2 SRT

Of the companies involved in SRT, the most common barrier they perceive to scaling up in the market is on the policy front. These barriers include confusion about applicable PPA rates (previously NPR 7.3 per kWh fixed-tariff to recent reduction to NPR 5.94 per kWh base rate), hassle in the net-metering processes, uncertainty regarding changes in policy and requirement of Renewable Energy Test Station (RETS) testing. The recent lowering of the PPA tariff has cast doubt regarding the negative perception of policymakers towards solar PV in general.

Similarly, technical-capacity barriers such as lack of skills for techno-economic study and lack of skilled human resources were perceived; followed by client-end barriers such as lack of basic technology awareness and targeted marketing to convince customers of the benefits of SRT. Furthermore, strategic publicity of SRT is needed to influence industrial and political figures to drive the market of SRT.

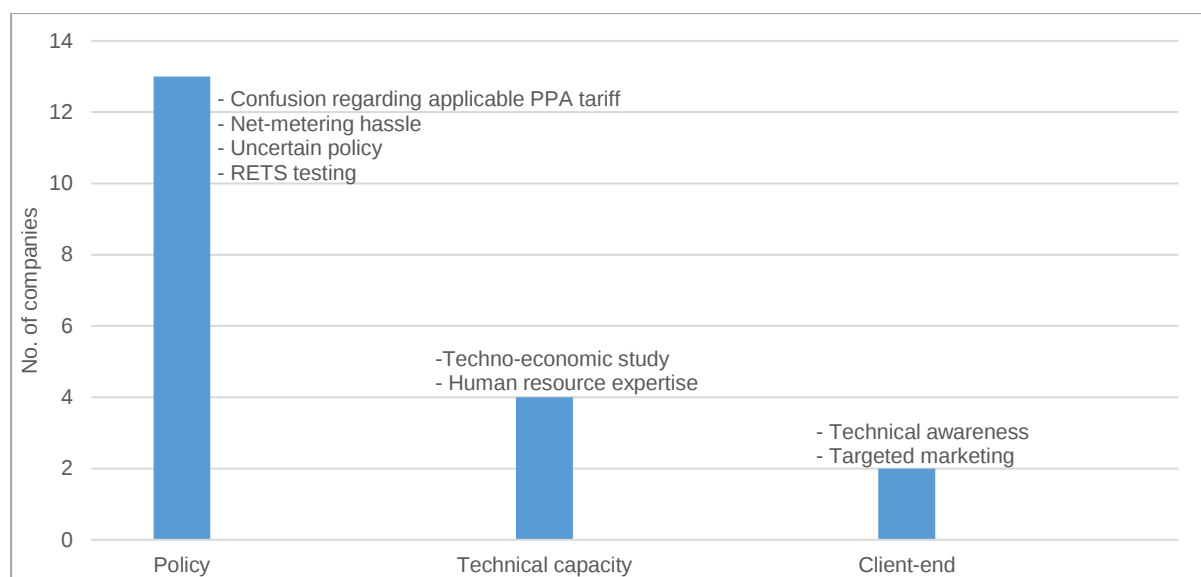


Figure 9: Perceived barriers – SRT

Similar to SMG, the most common barriers for SRT that the companies perceive are related to policy and are thus outside of the sphere of direct influence. The reported occurrences of policy-related barriers trump other technical and client-end barriers by more than three-fold. This is not surprising given the current unclarity and uncertainty regarding approval for net-metering which, followed closely, can even be interpreted as a reluctance from NEA to scale distributed solar PV connected to the grid falling within their least priority.

The barriers that fall within the control of the company are techno-economic study, human resources and targeted marketing. Techno-economic skills especially require theoretical understanding combined with the practitioner's experience. In Nepal's market where SRTs face policy-level uncertainties, it creates a chicken-and-egg situation where the limited growth perception stagnates the demand for specialized knowledge. This is further described in section 2.4.

2.2.3 SWP

Of the companies involved in SWP, the most common barriers they perceive to scaling up SWPs in the market are in the tendering and community fronts. Barriers related to tendering include deviations in design and bill of quantity (BoQ) in the bidding document compared to site conditions, lack of process standardization, lack of monitoring, outbidding by civil contractors that have little to no experience in SWPs, entry barriers in large SWP projects due to the requirement of construction license and finally, the high concentration of workload near the end of the fiscal year resulting in rushed and low quality of implementation. Barriers related to the community level include a lack of local operation and maintenance (O&M) and technical capacity, lack of affordability, lack of community cash contribution, basic awareness of the technology and political instability. On the technical front, barriers related to inadequate knowledge of system design, civil works, hydrology, system repair, water quality assessments and product authenticity validation are faced.

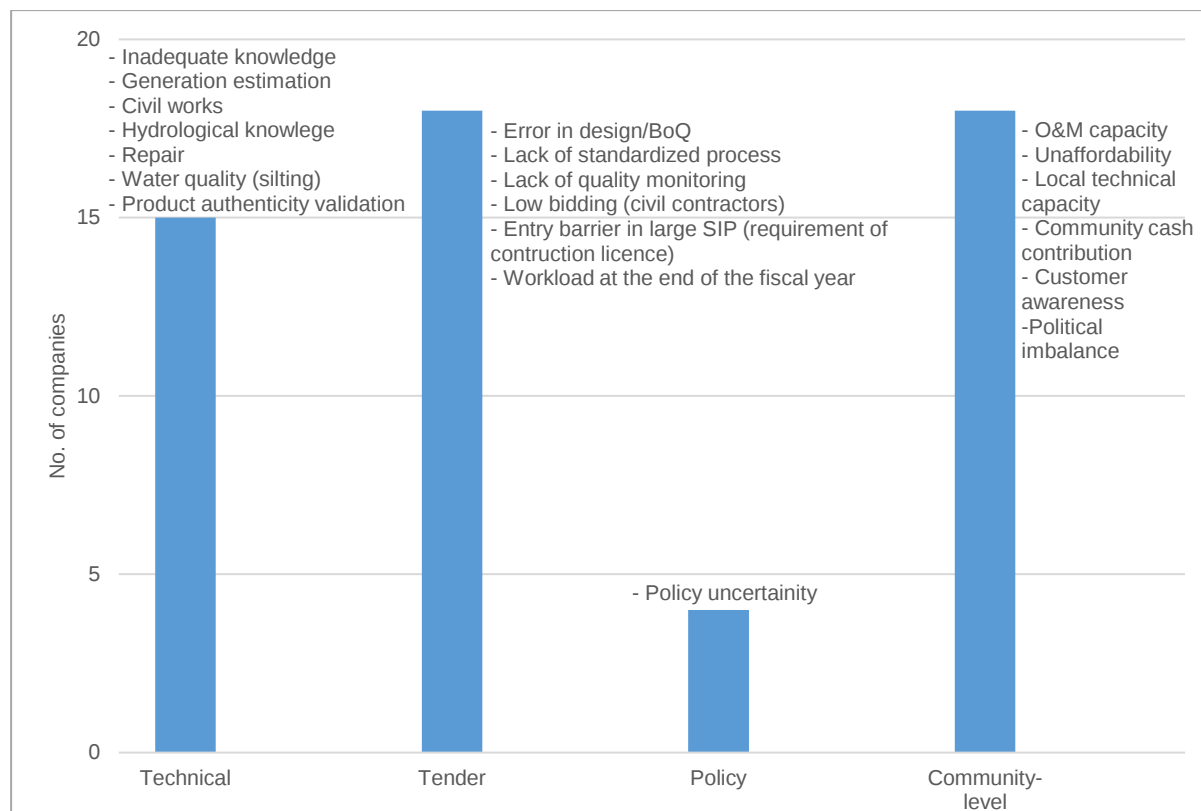


Figure 10: Perceived barriers – SWP

The most common barriers for SWPs that companies perceive relate to tendering and community aspects and are thus outside of their sphere of direct influence. However, the presence of technical capacity barriers – which are within the sphere of control of the companies – are comparable to tender and community-related barriers. This means that a significant number of companies reported technical capacity barriers.

Compared to SMG and SRT, companies see more deficits in SWP technical capacities. However, notwithstanding this admission, companies have not invested in seeking or lobbying for training offers and rely on in-house training (more in section 3.3). This gives rise to the following conjectures:

- A prevailing lack of formal SWP training offers that are hands-on and effective – none was identified during the survey.
- High attrition of employees demotivates management to invest in the capacity enhancement of their employees.

2.3 Perceived deficits linked to capacity

2.3.1 SMG

Diving deeper into the process-specific capacity deficits, significant capacity shortcomings for SMGs were reported in customer awareness & acquisition, survey, design, installation, after-sales and O&M stages. There is a correlation with the perceived barriers of the companies in the earlier section, where customer awareness ranks in the highest category of community-level barriers which is mainly a business development aspect of the companies. On the technical capacity front, both engineers and technician level competencies need support and are within approximately the same priority levels (10 companies report shortcomings on survey and design and, similarly, 8 and 11 companies report shortcomings on installation and O&M respectively).

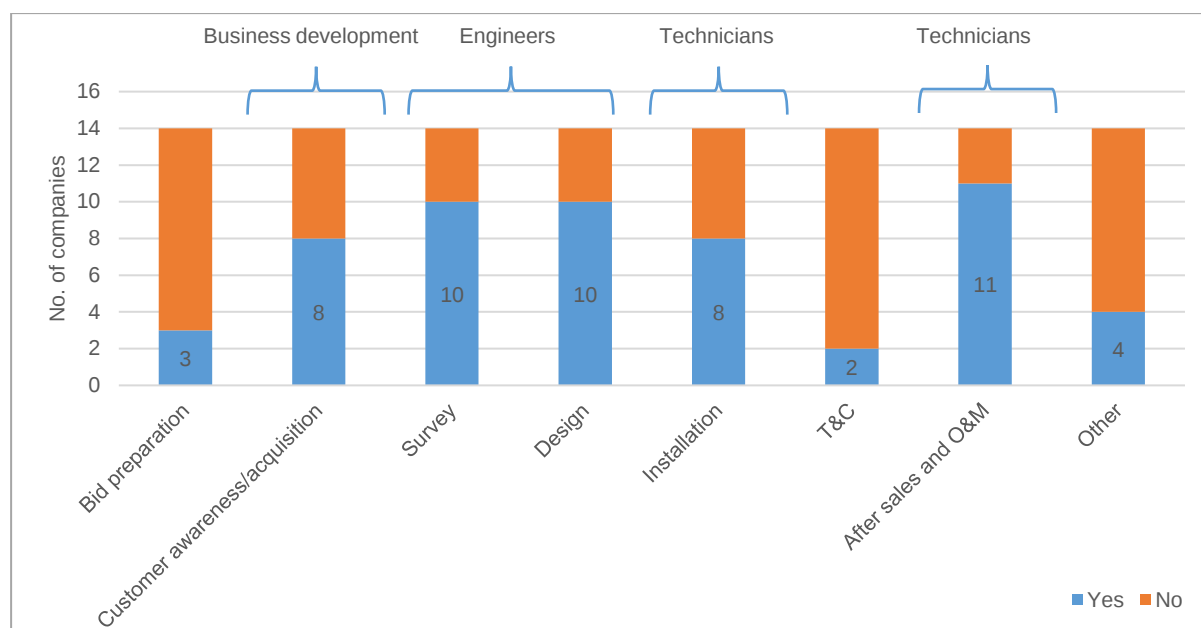


Figure 11: SMG - Capacity shortcomings

2.3.2 SRT

Similar to SMGs, significant capacity shortcomings for SRTs were reported in customer awareness and acquisition, survey, design, installation, after-sales and O&M. For SRT, the shortcoming is skewed more towards customer awareness and acquisition which is not surprising given that SRTs do not enjoy subsidies and are driven by the market, unlike SMG and SWP which are subsidy driven. Again, on the technical capacity front, both engineers and technician level competencies need support and are within approximately the same priority levels (11 and 10 companies report shortcomings on survey and design and, similarly, 7 and 11 companies report shortcomings on installation and O&M respectively).

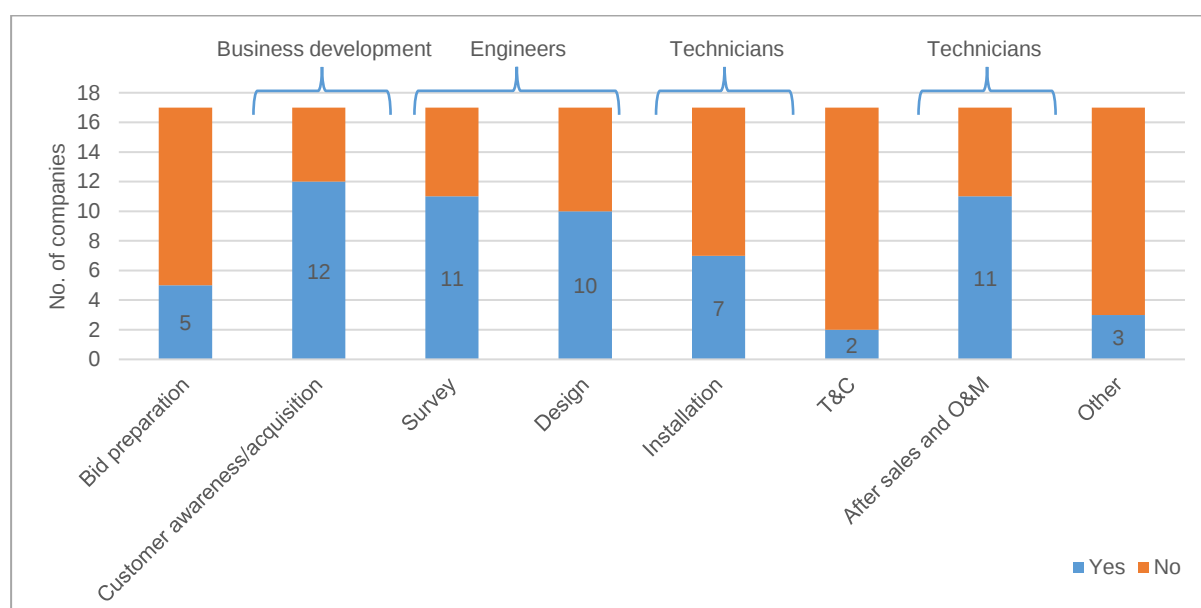


Figure 12: SRT - Capacity shortcomings

2.3.3 SWP

For SWP, the scenario is different. Here, capacity shortcomings are significant in all project stages except testing & commissioning (T&C). It must be noted that despite more companies being experienced in SWP compared to SMG and SRT across the sector (Figure 7), and a larger number of SWPs have been implemented, companies perceive there are serious shortcomings in capacity. The bid preparation and customer awareness-related shortcoming can be correlated with companies having reported high tendering and community-related barriers.

Again, in the technical capacity front, both engineers and technician level support are approximately in the same priority levels (32 and 30 companies report shortcomings on survey and design and, similarly, 27 and 33 companies report shortcomings on installation and O&M respectively).

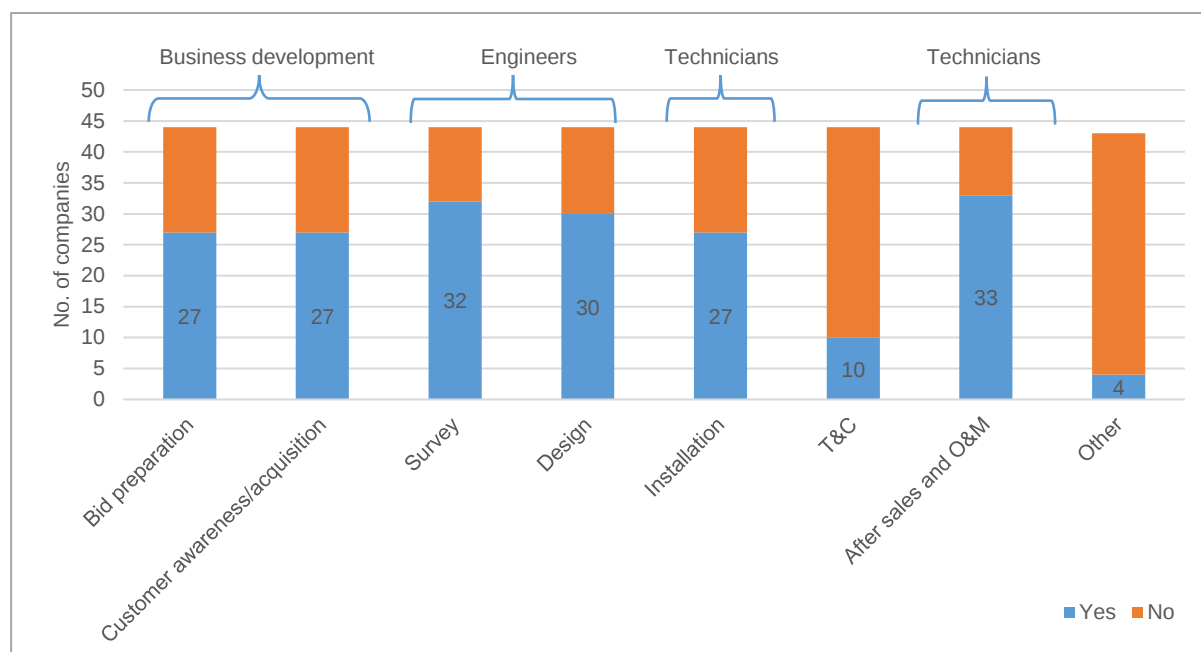


Figure 13: SWP – Capacity shortcomings

Across all three technologies, companies have reported significantly lower shortcomings in T&C. While looking at the data in isolation, companies seem confident in testing and commissioning systems, however, the interpretation changes when viewing the entirety of the project cycle. It can be misleading to interpret that companies are confident and capacitated in testing and commissioning. This is because T&C is simply a stage towards the end of installation where components are systematically checked and charged, the quality of workmanship is inspected and the performance is ensured as per design. In this light, T&C builds on the skills of proper design and installation, both of which have reported capacity shortcomings. This anomaly in the recorded data can be attributed to companies not distinguishing T&C as a separate procedure (usually requiring inspection by a third-party or project developer) and systems are deemed complete after it is charged.

Key takeaways

The results of the capacity linked shortcomings reported for all three technologies show that capacity development appears critical for both engineers and technicians to prevent reputational damages, build market confidence to support an increased adoption, and business development for solar PV. Besides this, customer awareness is important for companies to grow and sustain, especially for SRTs.

2.4 Expected market development

In terms of the perceived market growth of SMGs, SRTs and SWPs, companies expect the highest market growth in SWPs as shown in Figure 14. The reason for the perceived high growth is because of an increasing number of provincial and local government-issued work orders and the large market size for solar-based irrigation.

In contrast, among the three technologies, companies perceive limited growth in SRT with the majority mentioning that the market for SRT is uncertain or even shrinking. Private solar companies in general seem sceptical regarding the future of solar PV in light of the recent lowering in solar PV PPA tariff rate. They might see it as an indication of a negative perception of the government towards solar PV technology in general. Correlating with the perceived barriers, net-metering uncertainties, the reduction of PPA rates etc. led to low market confidence and declining investment in SRT. Furthermore, the market of SRT is not subsidy driven creating a direct business-to-customer relationship that requires rigorous studies by businesses to avert market risks. With policy-related barriers which are outside of the companies' control, the risks become high, resulting in limited growth perception.

Similarly, companies also perceive the market growth of SMGs to be uncertain for reasons such as uncertain policies regarding grid connection, weak financial viability for subsidy-free systems, and financing options. However, compared to SRT, the market confidence seems to be marginally higher, because the percentage of involved companies that have reported a shrinking market is lower than that of SRT (21% for SMG vs. 35% for SRT). This might be because SMGs enjoy subsidies from central and local government (most SMGs are 90% funded by AEPC and 10% from the respective local rural municipality). Furthermore, with the 90% electrification status of Nepal in 2020¹, SMGs are promoted in regions where the national grid will not reach in the immediate near future i.e. last-mile electrification areas. It can be predicted that the Nepal government will continue to promote SMGs in remote areas and the number of SMG-involved companies (although limited compared to SRT and SWP) see an opportunity in implementing SMGs under engineering, procurement and construction contracts.

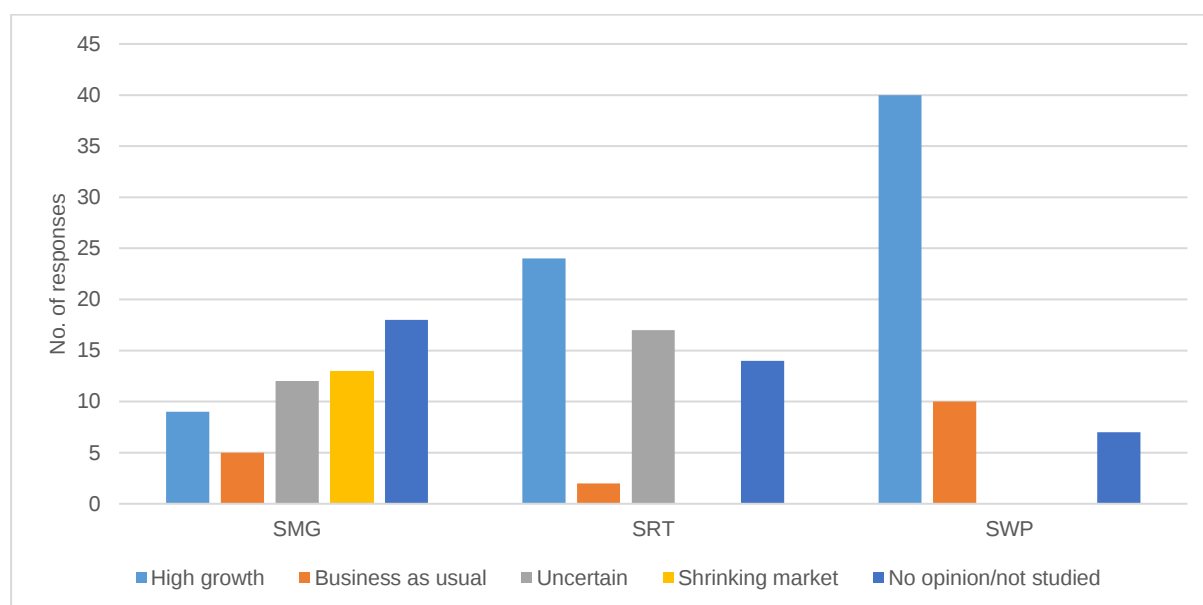


Figure 14: Perceived market growth

¹ The World Bank. (2022) <https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=NP>

Key takeaways

For SMGs and SRTs, 64% and 70% respectively of the involved companies see the market as uncertain or shrinking. SRTs, which are not driven by subsidies, are perceived to have the lowest growth potential. This perception is alarming as it suggests that without policy interventions, the customer base and investor confidence will wane as suitable framework conditions for future market growth do not exist as yet.

2.5 Future hiring plans

In the needs assessment survey, 44% of the companies preferred hiring freshers and training them as shown in Figure 15. While 38% preferred hiring experienced practitioners. Only 9% indicated preferences for hiring already trained people. It is however interesting to note that only 9% of the 57 companies interviewed expressed no interest in future hiring, meaning that 91% project the need to increase staff.

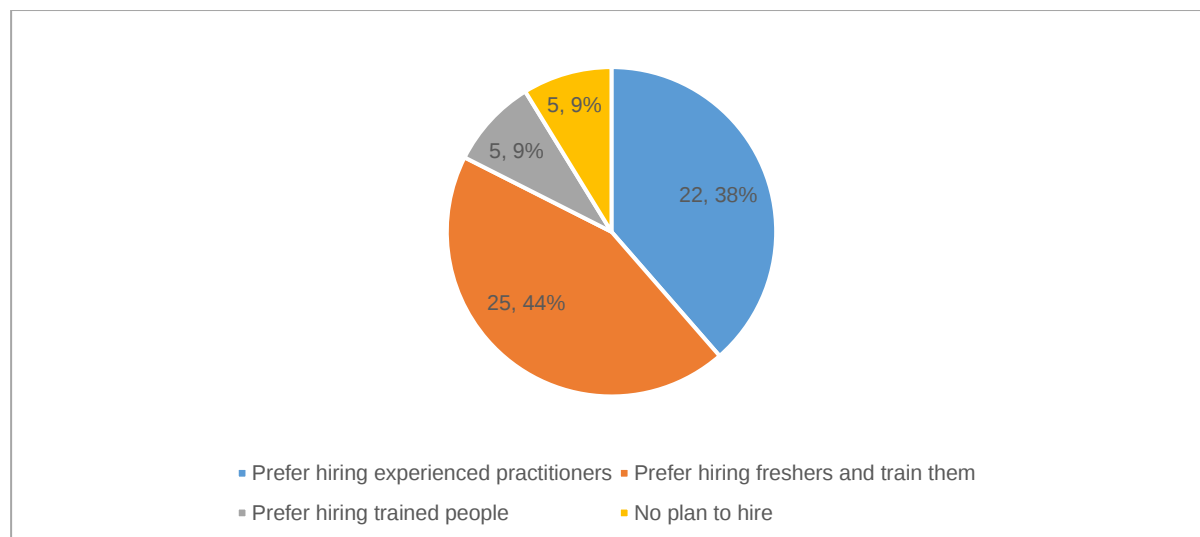


Figure 15: Hiring preferences

Narrowing down into the priority of the roles that companies are looking to hire in the short term, the majority of the companies are looking for engineers and technicians, followed by business development and management roles. The hiring plans for the short-term (6 months) are shown in Figure 16. It is interesting to note that companies plan to hire technical positions (36 of the total 53 hiring mentions) which is a strong indicator of confidence in individual growth. Though this appears to contradict the conclusions of chapter 2.4., in reality, this may be a token that individual companies have greater faith in their own success in business development and expansion compared to an overall market that is not expected to expand in the same measure.

Assessment of Training Needs for Solar PV in Nepal

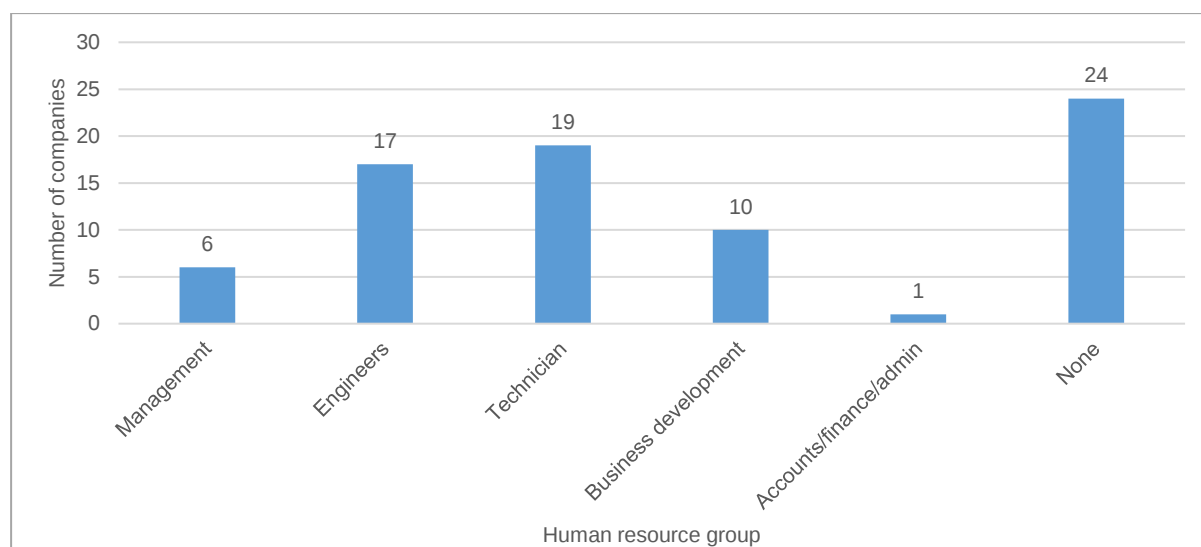


Figure 16: Hiring plans in the short-term

3. Existing Training Offerings

3.1 Overview

The Council for Technical Education and Vocational Training (CTEVT) is the apex body for technical and vocational education and training (TVET) for the production of technical and skilled human resources in Nepal. CTEVT's formal 'practical' training offerings for the solar PV private sector include the following short-term courses:

- Solar Photovoltaic Technician, 2010 A.D. (460 hrs)
- Assistant Solar Electric Technician, Level 1 (L1), 2019 A.D./2076 B.S. (160 hrs)
- Solar Electric Technician, Level 2 (L2), 2019 A.D./2076 B.S. (240 hrs)

Figure 17 shows the number of institutions affiliated with CTEVT that have listed solar PV technician short-term programs as their offering. Please note that the mere listing of solar PV technician courses does not mean that it is conducted regularly or have been conducted ever.



Figure 17: Number of institutions that have listed solar PV technician short-term programmes as their offering¹

Figure 17 shows a high concentration of training institutions in Bagmati Province with a drastic decrease in presence in other provinces, especially the Sudurpashchim Province.

¹ Map obtained from: <https://www.nationsonline.org/oneworld/map/nepal-administrative-map.htm>

3.1.1 AEPC support for training

Table 1 shows a brief snapshot of AEPC's training history collected from its annual reports. There is a data gap between 2013 and 2018 due to the lack of annual reports in the public domain. From 2009 to 2013, numerous trainings focused on local-level technicians were conducted including delivery of Level 1 and Level 2 training. Most trainings during this period were focused on SHSs. The same level of training support is not seen in 2018 where training participants are lower but the training was focused on SMG and SWP. This brief history shows that training delivered each year varies considerably. Training is not well institutionalized or well in demand and is dependent chiefly on AEPC's activities in a particular year.

Table 1: Snapshot of AEPC's training history

2009 - 2010	Training related to solar energy technologies was organized by AEPC/Energy Sector Assistance Programme (ESAP). 204 persons received basic training on solar electric systems and 50 persons participated in the higher level training. 100 technicians belonging to the pre-qualified companies were given field monitoring training. likewise, representatives of pre-qualified companies also participated in refresher courses on subsidy processing.
2010 - 2011	Training related to solar energy technologies was organized jointly by AEPC/ESAP and SEMAN. To train the local technicians of the companies who are involved in the installation and after-sales service of SHS, 5 batches of solar electric level I technicians training were carried out in Mahendranagar, Nepalgunj, Chitwan, Pokhara and Itahari. 200 participants were trained in total. Repair and maintenance training: The field monitoring visits of SHSs identified the need for equipped repair and maintenance service centre at the local level. AEPC conducted 3 batches of repair and maintenance training in Kathmandu. In each batch, 20 technicians from 20 different districts were trained. AEPC/ESAP provided tools required for repair and maintenance. These trained technicians then set up a repair and maintenance centre in their respective districts and were effectively providing service to SHS users. Training to overseers on SWPs: German government through KfW in ESAP II supported the installation of 100 community-based PV drinking water projects. To give overseers an understanding of SWPs under AEPC/ESAP, a weeklong training was organized from 13 to 18 March 2011. Training to quality assurance & monitoring consultants: Seven organizations were qualified to carry out monitoring and 65 monitors were trained to carry out the monitoring activities of SHSs. Training for school teachers: AEPC organized 7 training sessions for the training of science teachers in basic operation and maintenance skills of SHSs. To make the training more effective, teachers from high-density SHS-installed areas were invited. The teachers then trained their secondary-level students in the basic operation and maintenance of SHSs. The objective was for the teachers and the students to use their knowledge and skill for the general maintenance of the SHS components and its installation at their homes and neighbourhood.
2012-2013	Level 1 and level 2 training for thermal technicians - supported by Solar Energy Sub-component (SESC), National Rural and Renewable Energy Programme (NRREP) (number not specified).
2013-2018	Data gap arising from a lack of annual reports in the public domain.
2018	Solar mini-grid engineers training supported by AEPC and SASEC for 24 engineers of solar companies and consulting firms. Training on solar irrigation design for AEPC's productive end-use component, Renewable World, AEPC's solar component and other engineers of AEPC for 3 days, 13 participants.

3.1.2 CTEVT Level 1 and Level 2 technical training

In the current scenario, there is little or no demand for solar PV technician training coming forward from the provinces to justify training institutes to conduct short-term courses regularly. These training are hence conducted on a one-off demand basis, mostly sponsored by organizations (especially donor-funded programmes). One of the reasons why the demand for solar PV-specific courses for technicians is low is because of the specialized nature of the course. For example, technicians certified by CTEVT for solar PV systems can use that certification only in the solar PV sector, whereas, technicians certified as an electrician can use that certification in various sectors with electrical works – thus, a larger market and more employment opportunities.

Training institutions such as Gorkha Technical Training Center recently have been conducting two solar PV training for technicians on average for over a year which are sponsored, whereas, Balaju School of Engineering and Technology has not conducted any such training in the last five years. According to them, the demand for solar PV training was at its peak during the load-shedding era (2006–2017). This correlates with the establishment of many solar PV companies during the same period, indicating a period of high market growth and thus, the demand for solar PV training.

The Solar Electric Manufacturers Association Nepal (SEMAN) which aims to represent the solar PV industry in Nepal has previously delivered various trainings to the private sector with financial support from AEPC. The training record of SEMAN to date shows the following:

- 3,600 Level 1 technician training,
- 600 Level 2 technician training,
- 100 repair and maintenance of SHS training,
- 300 training of trainers,
- 300 repair and maintenance of SHS/ISPS/SRT and SMG systems.

However, these training have been halted for the last five years due to a lack of budget allocation from AEPC.

Key takeaways

- Training packages should be linked to the market and employment opportunities. In Nepal's market, training offers for technicians should allow for diversified employment opportunities.
- To institutionalize training offers, they must be financially viable, either through revenue from fees, grants, scholarships or a combination of them.
- Besides CTEVT's short-term courses, there are private institutes that have solar PV-related training on a fee basis which is geared towards SHS and ISPS at scale. However, these private training institutes are developed independently and are geared only towards technicians, not engineers.

3.2 Perceived relevance

When it comes to the impression of the relevance of existing training offerings, 9% of companies surveyed consider them of limited relevance while a significant 61% perceive existing training to be relevant, tagged as 'mostly good' and 'some good' in Figure 18. 30% of companies have withheld any judgement as they have not had exposure to or experience with current offerings.

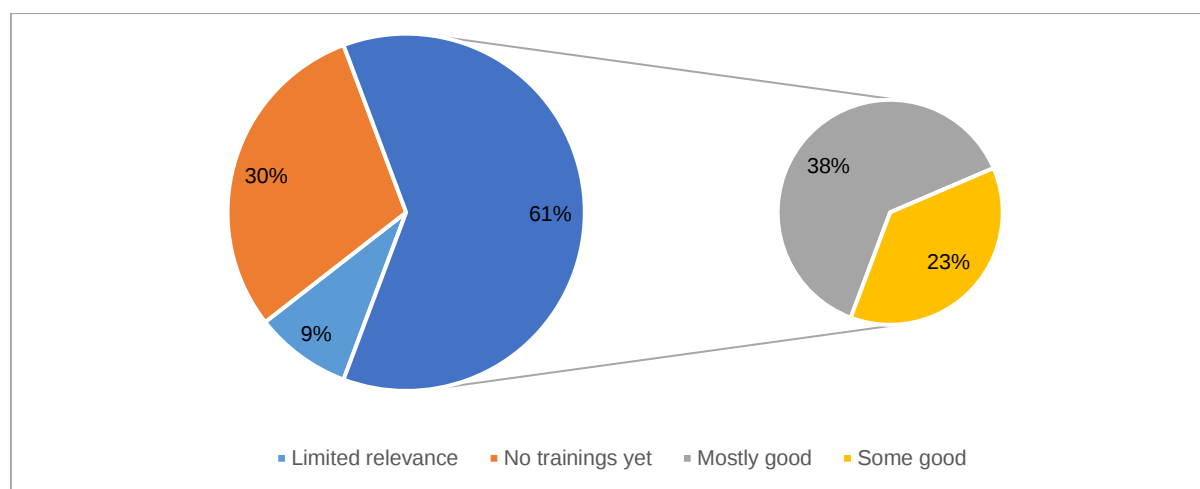


Figure 18: Impressions of previous training

The reasons why companies perceived the training as relevant were because the training subject was specific, the training was accredited (for example, CTEVT's L1, L2 training), the training translated to business development (for example, proposal writing training) or the training was delivered by external experts who brought a new perspective. Whereas, reasons for the limited relevance of training were because it was not hands-on and interactive, or the training did not translate to improved operations. For example, companies that received SMG design training could not qualify for SMG bids or the companies could not reap the benefits of the training due to staff attrition. Table 2 below lists the reasons that companies cited for judging the relevance of training.

Table 2: Statements regarding the relevance of training

Reasons why the training was perceived as relevant	Reasons why training was perceived to be of limited relevance
- Technology specific. - Software skills development. - Technician training (CTEVT L1, L2). - Proposal writing – business development-oriented. - Delivered by external experts.	- Did not translate to improved operations. For example, received SMG design training but could not qualify for SMG bids. - Not hands-on. - Not interactive. - High staff attrition.

Key takeaways

A key factor that can increase the relevance of training offers is communicating the path to employment, business development or entrepreneurship. In the survey, companies have mentioned that one of the reasons for limited relevance of training is because the training did not translate to improved operations. Future training should provide a credible path to potential employment or entrepreneurship for individuals and to business development for employers.

To support this narrative, trainings have to be acutely relevant and build reputation and wide sector recognition. Such could be supported by information on certified trainees and mandatory certification as eligibility criteria for subsidies by government entities during bidding.

3.3 The current appetite for training

From the results of the survey, it was learnt that not a single enterprise sends their engineers to specialised training. However, this is not surprising given that no such training exists outside of one-off offerings by international manufacturers of solar PV components. At the level of technicians, a fair share report reliance on external training offerings. However, the majority of the companies state that they rely on in-house training. In most cases, such would not rely on a structured training process but rather training on the job that varies with candidate, project and context. Other companies participated in free or sponsored training (organized by AEPC, SEMAN and donor partners), while others trained their staff only on a need basis.

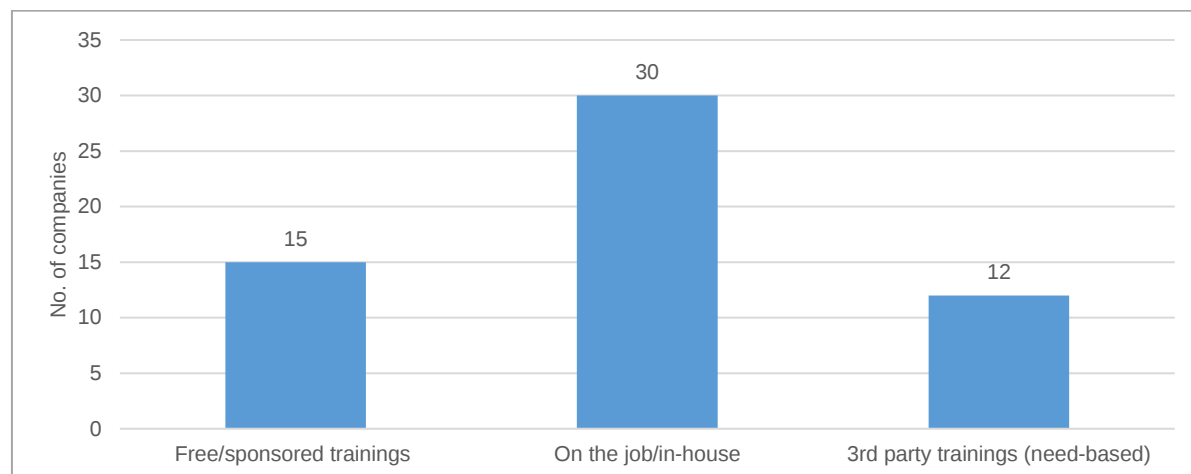


Figure 19: Organizational training practices

In the current market environment, it can be seen that companies might continue with in-house training because of a lack of training offerings that directly translate to operational efficiency to address the perceived barriers and capacity shortcomings.

SEMAN however aims to continue conducting training which it has highlighted in its proposal for the next five years:

- CTEVT Level 1 and 2 training to 800 technicians,
- Repair and maintenance of SHS/ISPS/SRT and SMG systems to 182 participants,
- Training of trainers to 41 participants,
- International exposure visits of the SEMAN team (one visit each year) to expand the capabilities of the team.

It must be noted that these training are not confirmed.

The training offers that SEMAN is planning are geared towards technicians. Therefore, the common practice of solar companies to provide in-house or on-the-job training for engineers can be because no engineer-focused training exists. This observation is further strengthened by the fact that companies perceive engineer-level survey and design capacity shortcomings in all three technologies which are on the same priority level as that of technician-level capacity shortcomings.

Key takeaways

Training should deliver financial returns to sustain operation for the institution that carries it forward. For a subsidy-driven SMG and SWP markets and a nascent SRT market, training offers via few (or even one) institution can be financially attractive which may result in sustained training offers with adequate resources for effective training delivery.

3.4 Accessibility

Based on the survey, most companies are not actively searching for training offers. For companies that are looking for training offers, the majority find it expensive or hard to access ('too far' in Figure 20). Only 16% (9) of the companies felt they can manage their training needs, 7 of which are Kathmandu-based companies.

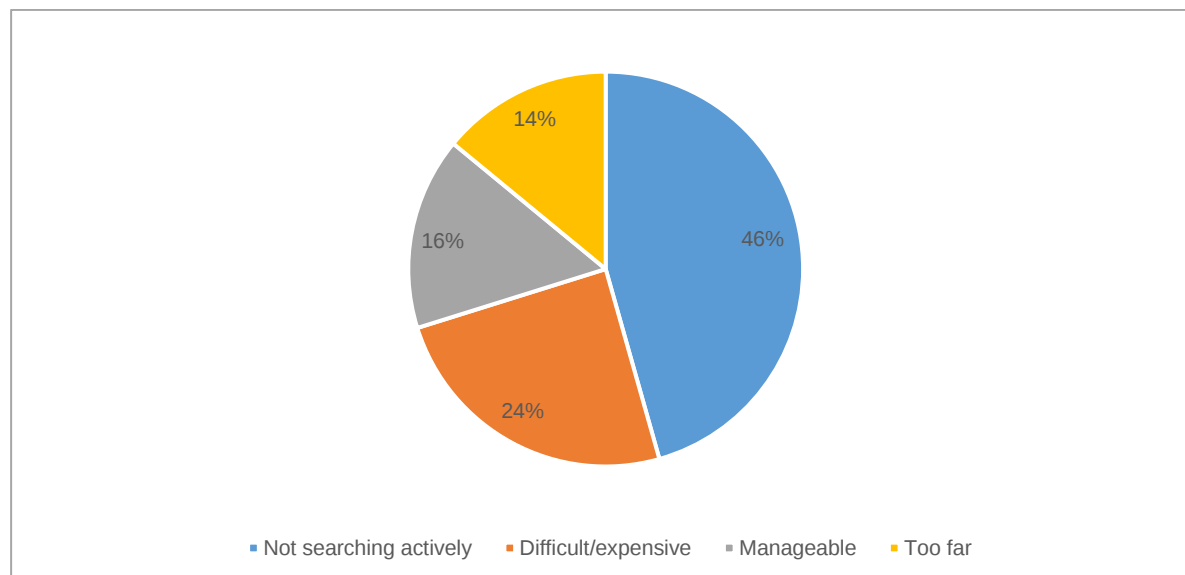


Figure 20: Access to training

Key takeaways

Given that a significant portion of companies mentioned that the training offers were hard to access, mechanism should be devised for making training available in all provinces.

3.5 Limitations of current offerings

Building on the two priorities of the hiring plan; for technicians, the existing solar PV-specific L1 and L2 training of CTEVT are conducted on a demand and sponsorship basis. This limits access to these courses across Nepal. Although SEMAN plans to continue L1 and L2 training, these are not confirmed and no regular offers are currently projected or found in the market.

For engineers, there are no nationally recognized specific training offers (similar to CTEVT courses) that cover all the major technical aspects of SMG, SRT and SWPs. This is a gap that needs to be filled. Surprisingly, despite the gap, SEMAN's training proposals for the next five years (see Section 3.3) do not include any training offers for engineers – neither for the development of such courses nor their delivery. However, the perceived barriers by private companies, especially for SWPs, clearly show the need for the technical capacity of engineers (energy generation estimations, civil design etc.). The reasons could probably be attributed to:

- The absence of a regular national-level solar PV private sector needs assessment which informs AEPC, SEMAN and training developers/providers and,
- The lack of linkage between the solar PV private sector, training developers and the public sector. This results in limited dialogue on technology advancements, training offers that keep up the technology advancements, the expertise required to cater to capacity gaps and funds required to support capacity development.

4. Public Sector Needs

4.1 Alternative Energy Promotion Centre

Based on the interactions with the management team of AEPC, it is learnt that although AEPC has extensive in-house technical skills in the design and implementation of solar PV projects, it is limited in terms of human resources to carry out field-level activities such as surveys, installation monitoring, testing and commissioning, and performance monitoring. This also limits its ability to extend support to the provincial and local governments.

AEPC's engineers also require better familiarisation with project implementation cycles and due diligence. Although AEPC has experience in implementing advanced solar PV systems (SMGs and SRTs), the less-than-ideal public presentation of guidelines, templates, forms and checklists etc. specific to solar PV technologies impedes accessibility of such documents to the private sector and subnational governments. AEPC requires streamlining of current resources and focusing on enhancing the technical capacity of its engineers for project due diligence to improve operational efficiency that could in some measure compensate for its insufficient human resources.

Key takeaways

In light of the limited human resources in AEPC to support subnational governments, streamlining project implementation process documents can improve the operational efficiency of AEPC and its outreach to subnational governments.

4.2 Provincial and local governments

Among other things, federalisation has shifted responsibilities for the implementation of solar PV projects from AEPC to provincial governments. And though they are endowed with funding, they have little or no experience with the subject at hand. The local and provincial governments need support across the entire solar PV project implementation cycle to ensure the effective mobilization of the funds. This is due to the lack of exposure to solar PV technologies and the lack of sufficient human resources in the provincial and local governments.

The technical team in the government offices do not have the resources to cover the different engineering disciplines (for example, separate teams for electrical, mechanical, and civil engineering as required). Most engineers hired are of civil engineering discipline and have to take up diverse roles in various engineering projects (for example, feasibility studies of irrigation canal projects alongside feasibility studies of solar PV projects) in the respective province and locality. This results in two issues, i) a lack of foundational knowledge of public sector engineers on electrical systems which are crucial to developing solar PV projects and ii) a lack of sufficient human resources to properly conduct project due diligence, tracking, quality control and monitoring. This leads to the technical team having to prioritize their time for selected projects where small-scale solar PV systems with low budgets (for example, smaller solar water pumping systems) receive low attention in their development (poor feasibility studies) ultimately leading to poor execution.

For solar PV projects, some provincial and local governments request support from AEPC, but again, due to its limited human resources, AEPC is not in a position to fulfil the demands of provincial and local governments.

Against this backdrop, the local and provincial governments finally have to rope in the private sector for the development and implementation of solar PV projects. However, this creates a risk of biased system design because it leaves the project vulnerable to inflated costs and company-biased technical requirements as the subnational government bodies themselves do not have adequate knowledge to conduct due diligence.

5. Required Training Identified

5.1 The post-project perspective

Virtually every donor-funded project and programme contributes to capacity development. Many of them use training as an instrument for this, delivered by either international/national experts or national institutions or a combination of them. What is common to nearly all of these efforts is that, while the project is running, training is provided as desired. But when projects end, these offerings typically collapse. Nepal has seen countless training interventions in the energy sector that have come and gone of which little or nothing remains.

While short-lived training interventions can and do catalyse development, the capacity challenges in the PV sector cannot be fully addressed through training interventions that are limited to the project lifespan. Several of the training offers will be of exponentially greater benefit if they are institutionalised and sustained. This raises the topic of creating adequate institutional capacities to deliver training offerings and financial resources for sustaining them. The charging of a training fee to cover the costs incurred by providing training is essential, as well as the ability to provide a value corresponding to the fee. Without such, no training can be sustainable.

The ability of institutions to command meaningful fees – and the willingness to pay by potential participants – is tied to several criteria: the relevance of training for the profession, a credible reputation of the training provider, local ownership, convincing evidence of training quality, a perception of increased earning potential commensurate with the time and money investment, staying up to date with market requirements, and last but not least, successful efforts for marketing of training programmes. Most of these aspects resonate with private sector efforts for promoting products or services but not with typical training interventions, which frequently operate insulated from industry/community needs and market forces. However, only when these aspects are addressed can one hope to sustainably institutionalise professional training as is required for many functions of Nepal's solar PV sector. In the case at hand, training provision is better seen as a long-term requirement that cannot be attained through short-term goals.

In addition, in Nepal's context, considering the limited number of companies conducting solar PV business (66 active companies identified during the needs assessment survey), the linkage between private companies and a pool of trained and documentable competent professionals is crucial. For example, with consent from training participants, training institute(s) could circulate the details of the training graduate to solar PV companies (via SEMAN or in direct partnership with local solar companies). Further, the partnering institutions could be supported in developing their post-study placement support. This would improve matchmaking and increase the chances of employment of trained individuals which ensures that the knowledge learnt will be applied in the relevant sector. Furthermore, this would improve the visibility and credibility of the training, increasing its value to individuals and stimulating training demand – keeping the training sustained.

5.2 Principal tenets

Training offerings that need to be sustained beyond the project lifetime must be responsive to the actual market demand, foster employment or entrepreneurship, and be as short as possible, using time efficiently and cutting non-essential material. They also must be fee-based to provide the keystone for building a sustainable training delivery environment. Charging a fee also helps to dispel the impression that free-of-charge offerings have little value to offer. They should be accessible through

competing institutions with regional accessibility. Also, competition among training providers can be advantageous to create a market-like situation that fosters competition for pricing and quality. However, as the ownership rests with local intuitions, the project's hold over training and its quality is limited. For this, training quality and related parameters such as the traction of knowledge transfer, participant centricity and the linkage between knowledge and application can be influenced and raised through accompanying measures such as support from experienced mentors. This might even be necessary to uphold the value proposition.

As much as possible, training to be sustained should not be made mandatory as this would create a perception of training as not an instrument to improve business development but rather an impediment to it. However, public tenders and subsidy regulations are excellent tools that provide an opportunity for promoting training and qualification. These could and should be used to insist on adequate qualifications to foster demand for training.

Training offerings that fulfil their purpose by being delivered within the project duration need not be institutionalised or made sustainable. This considerably simplifies the implementation of training delivery and offers the advantage of almost full control of content and quality. Market mechanisms are not required to be introduced here, but a contribution to the cost of training from the employer of beneficiaries is beneficial to uphold a value proposition and its perception.

5.3 Delivery mechanism

Institutionalised training offerings that should be accessible across locations would benefit from centralised ownership through institutes that own solar PV training offers and partner with training institutes in the provinces, such as would be the case with CTEVT. The central institute can then deploy its resources for provincial training on a demand basis (refer to Figure 21).

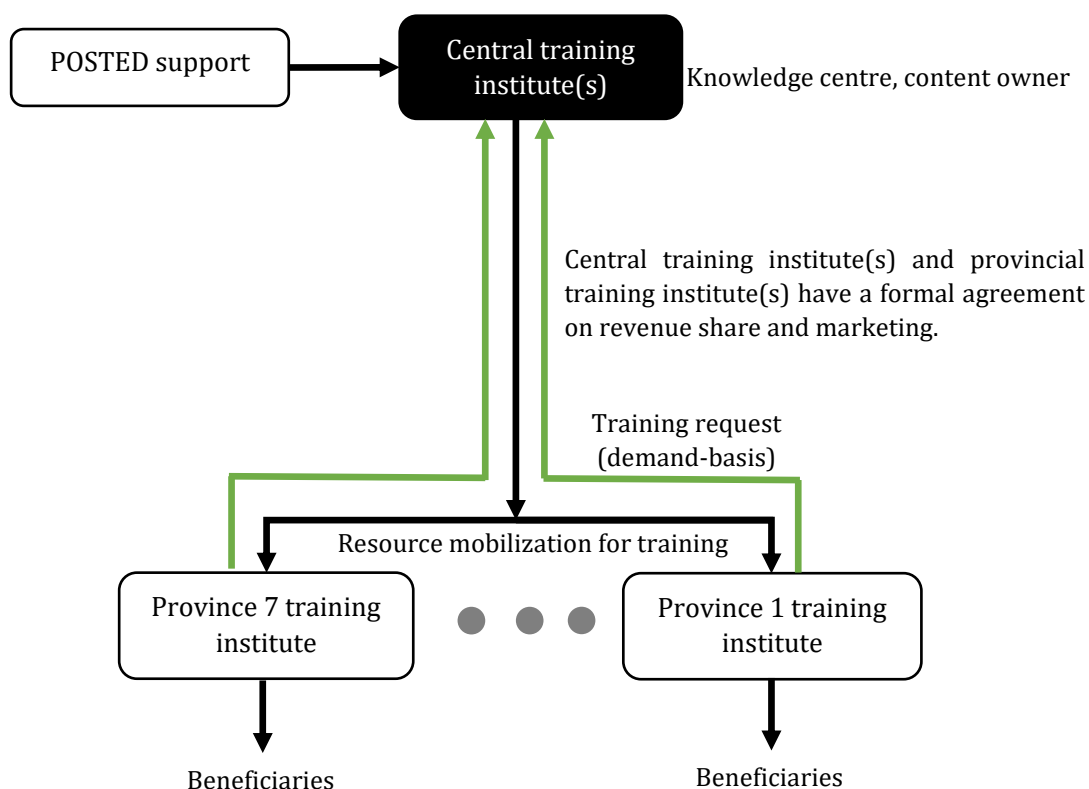


Figure 21: Mechanism for institutionalised training offerings

5.4 Training courses identified and envisioned modalities

Course topic	Focus	Envisaged duration	Potential hosts	Envisaged modalities
Target audience: Technicians				
Electrical & Solar PV Installation	Vocational training (TSLC, pre-diploma) addressing workmanship and providing a nationally recognised qualification.	12+6 mth or 24 mth	CTEVT affiliates	Institutionalised; Fee-based; Support through scholarships.
Solar Pump Repair	O&M focused on resilience and problem solving; demand expansion; exposure to new technology solutions becoming available.	2-3 days	To be defined, ideally through a nascent service network.	One time per location; to build a service network.
Solar Electric Technician L1, L2	Sponsorship of existing short-term training.	160 hrs+ 240 hrs	CTEVT centres and affiliates	Sponsorship; Supported by scholarships for the duration of POSTED.
Target audience: Engineers				
Detailed Feasibility Study (DFS)	DFS for SMG, SRT, SWP – Feasibility study, design, BoQ, planning, economics, tariff incl. 2 projects.	2 weeks	CES, TU	Institutionalised; Fee-based
Solar Rooftops & Mini-Grids	Implementation for SMG and SRT – Installation, T&C, O&M, user training	2-3 weeks	CES, TU	Institutionalised; Fee-based
Solar Water Pumps	Implementation – Installation, T&C, O&M, and user training for irrigation and drinking water systems.	1 week	CES, TU	Institutionalised; Fee-based
Battery Storage	Battery storage and battery technology options for solar PV systems.	2 days	CES, TU	Institutionalised; Fee based
Target audience: Community operators				
SMG O&M	Tariff collection, Customer relationship management (CRM) concepts, Standard Operating Procedures (SOP) on O&M and basic troubleshooting, and escalation.	1 day	Provincial governments	Institutionalised; Free of charge; Costs could be borne from LG or PG allocations.
SWP O&M	Tariff collection, CRM concepts, SOPs on O&M and basic troubleshooting, escalation.	1 day	Provincial governments	Institutionalised; Free of charge; Costs could be borne from LG or PG allocations.
SRT O&M	Tariff collection, CRM concepts, SOPs on O&M and basic troubleshooting, escalation.	1 day	Provincial governments	Institutionalised; Free of charge; Costs could be borne from LG or PG allocations.
Target audience: Local and provincial governments				
Project Implementation Processes	Project implementation processes for SMG, SRT and SWP. Emphasis on post-project viability: technical function, sound administration, financial operational health, revenue flow for capital replacement.	3-5 days	Provincial Training Centres in tandem with AEPC.	One time per location; Free of charge
Target audience: AEPC				
Project Implementation Processes	Project implementation processes for SMG, SRT and SIP. Emphasis on post-project viability: technical function, sound administration, financial operational health, revenue flow for capital replacement.	3-5 days	POSTED	One time per location; Free of charge.

Legend: Limited to project Institutionalised

5.5 Outlook: Intent and feasibility

POSTED intends to develop, establish and operationalise the training courses identified in section 5.3 in Nepal. This is based on the assumption that suitable institutional partners can be engaged, that the scope of work can be mutually agreed on with partners, that partners share POSTED's vision of the market relevance of these courses, that the empowerment of partners produces favourable results, and that timescale and resources of the project prove sufficient to conduct the work as well as respond to the numerous challenges one is certain to encounter in such endeavour.

Following up on this assessment report, the feasibility of establishing each of these training with suitable modalities will be reviewed, keeping in view the sustainability-related tenets. This assessment is not part of the report. Rather, this report presents the information that forms the basis for the review of feasibility and opening dialogue with potential hosts for training.



Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices Bonn and Eschborn

Friedrich-Ebert-Allee 36 + 40
53113 Bonn, Germany
T +49 228 44 60-0
F +49 228 44 60-17 66

Dag-Hammarskjöld-Weg 1 - 5
65760 Eschborn, Germany
T +49 6196 79-0
F +49 6196 79-1115

E info@giz.de
I www.giz.de