TECHNOLOGY AND QUALITY ASSURANCE FOR OFF-GRID CLEAN ENERGY
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1. About This Report

This study looks at the technology related issues of CLEAN energy practitioners in India, based on consultation with 25 different organisations. It aims to identify key technology barriers that are limiting the ability of practitioners in India from extending energy access to unserved and underserved communities. After identifying these issues then possible interventions are presented, along with a discussion on how CLEAN could take these forward.

1.A Research Methodology

A phone survey was used to provide a base on the topics of technical issues related to assessment of customer needs, design of systems as per need, product availability & quality, supply chain and installation & service. If and when it became clear that a specific product had pain points, focus was given to the same during discussion.

With time constraint in mind it was decided to interview 20 enterprises and visit 10 companies over a period of 4 weeks. Care was taken while selecting enterprises to be as representative as possible, ensuring diversity in technology, region and business models.

Fig 1 - Breakup of organisations surveyed in terms of a) geography, b) technology and c) size
2. Issues raised by practitioners

The technology related issues of practitioners surveyed were vast, and related to all the parts of the technology ecosystem for clean energy access. For clarity in presentation, the following 5 areas are defined, and used to group concerns and issues raised together:

A. Needs assessment
B. Design
C. Supply Chain
D. Installation and service
E. Product Quality

For the first four areas, a summary from the consultation is given with a discussion of possible solutions, including optimistic and pessimistic views from practitioners on these solutions. **Product quality** was highlighted as a key issue, and the next section takes a deep-dive into this issue.
2. A Needs assessment

Assessing the need of a group of customers or an individual customer is the initial and most important step. It is seen that mistakes done in this phase or ignoring the importance of this phase can lead to wrong solutions flooding the market. As renewable energy is a novel technology then inappropriately designed products and solutions can lead to a poor view of the technology in the market. Hence there is reason for CLEAN to look at adopting necessary measures to facilitate and smoothen the needs assessment process and propagate the importance of this phase.

Below three areas of needs assessment are highlighted, along with the key issues highlighted by practitioners.

**Needs assessment vs. technology choice:** The technology offering of a practitioner determines the type of information that must be gathered before designing the system and the importance of this information. Hence different issues were faced by different practitioners. Micro-grid companies, as well as those using non-solar energy sources, felt needs assessment was key. However companies selling portable solar products, or basic solar-home-system, did not always echo this concern, due to the lower customisability of their solutions.

**Experience and customisation:** It is interesting to note that all companies with 10+ years of experience stated that customisation was key to success. Also, companies of 3-10 years penetrated new regions with 2 or 3 selected products before moving to customisable solutions.
Possible Interventions for CLEAN

Below some possible interventions are listed, with optimistic and pessimistic views expressed by practitioners on these interventions.

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<tr>
<th>Resource data: CLEAN creates provision to gather information on wind profile, seasonal head and flow availability for hydro, biomass availability etc at selected sites and provide members easy access to such data or an organization capable of providing such data. Solar irradiance data available is quite widespread and a support may not be required.</th>
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<tr>
<td>This reduces the time and cost of gathering data for different organisations.</td>
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<tr>
<th>System performance data: For various systems, the actual output at the site can be shared through an online portal. This helps analyze the geographic and climatic parameters specific to certain regions.</th>
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<td>This could also help analyze product performances at different locations and help practitioners select products accordingly</td>
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<tr>
<th>Capacity building for needs assessment. Tools for energy audit and financial assessments are available for industrial energy management purposes. For small scale applications, either they are not available or they are too expensive, making such detailed assessment of these applications infeasible. CLEAN could intervene to facilitate availability of easily usable tools and training to use them for clean energy access practitioners.</th>
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<tr>
<td>Many enterprises ignore need assessment due to this fact. Hence availability of easily usable tools to small enterprises can lift them from just being resellers to solution providers.</td>
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<tr>
<th>Transparency in electrification planning: CLEAN should work towards making access to information about electrification plans of DISCOMs, their demand side management goals, tariffs, peak load and power outage characteristics etc easy. Networking, with DISCOMs, govt. agencies etc, is one way to achieve this. Another way is to monitor it independently through long term monitoring devices.</th>
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<td>It helps plan micro grids, grid tie systems, operational strategy of off-grid enterprises</td>
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2.B Design

Design of solution is the next stage once need assessment is completed. This includes selection (or development) of products most suited for generating/transmitting energy and also energy management techniques on the loads that utilize the energy. The solution usually is not entirely technology and product quality dependent but also depends on economics, cultural and habitual practices, financing access, policy etc. This section will mainly focus on the technology related issues of design.

Accurate product data is often difficult to obtain for certain products, and this leads to a number of difficulties in this area. For example, interpreting nameplate specifications is difficult, and often when information is unreliable practitioners resort to internal testing. However this leads to duplication of efforts across the sector, and younger organisations suffer from lack of accurate information.

Innovation is a key area of importance for this sector; solutions being developed here may be suitable for other parts of the world and can help towards a more sustainable development. However innovation is particularly difficult for this sector, given small initial numbers, high costs for development, difficulty in understanding real needs and some unhelpful subsidy schemes.
Possible interventions for CLEAN
Below some possible interventions are listed, with optimistic and pessimistic views expressed by practitioners on these interventions.

**Innovation linkages.** CLEAN can function as an easily accessible entity for bridging the ideas from practitioners working on the ground to the R&D activities of research institutions. A method to incentivize the practitioner for identifying the issue or novel solution and submitting it to CLEAN could be developed.

| This can be useful for small enterprises and for the industry as a whole | Although good if worked out, it is extremely difficult to surpass practical issues like patents. Also it is not easy to get such inputs from enterprises struggling in day to day business. |

**Capacity building for design.** CLEAN can be an easily approachable entity to help with design procedures and design training especially by small enterprises. Workshops on nameplate interpretation or dissemination of information through web portal could help.

| Small enterprises with not much technical expertise might benefit a lot from this | Enterprises not facing issues with their current selling practice may not find a reason to start following design practice. Enterprises already following may not need a support in this area. |

**Technology specification in government schemes.** CLEAN can influence technology definition mechanism in subsidy schemes to allow for customization and flexibility in design.

| This would ensure appropriate solutions receive support from subsidy | It is difficult to impact government schemes. |

**Testing and characterization.** CLEAN can facilitate testing and characterization services to generate the data generally missing from manufacturers that is essential to system design. Off-grid specific parameters need to be given attention while testing. An online portal to share product data, experience and reviews of various vendors can be formed.

| Information unavailability is what forces designers to rely on assumptions. Such a service would be beneficial. | Standard lab testing is usually a time consuming process whereas practitioners often need quick results. Enterprises may see performance data of products as commercially sensitive and so may not be comfortable with shared data. General reviews and experience about products could be shared instead. |
**Publish List of certifications:** Create a list of certifications available for various products with most recommended certification and basic testing methodology for the same to avoid confusions. Publish the same through an online portal

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<th>This helps organizations start internal testing facilities</th>
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**Market awareness.** CLEAN can create market awareness about enterprises engaged in designing better, efficient machineries and appliances. It will help such enterprises find their market with other CLEAN members. CLEAN can provide inputs to such enterprises based on members’ feedback.

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<tr>
<th>There are enterprises already interested in redesigning machineries for better efficiency &amp; productivity. Most of them are not good crowd pullers and hence need help from organization like CLEAN to spread the word.</th>
<th>The idea is noble but it is a time consuming process. Need persistent effort to make this happen</th>
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**New technology standards** CLEAN can try to facilitate the creation of new technology standards (eg. DC ports in all appliances using DC power like Television)

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<th>Can encourage more products for off-grid</th>
<th>Long drawn process to get all on-board</th>
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**Benchmarking:** CLEAN can carry out benchmarking of design practices of enterprises and quality of products. This can be later used for practices like labeling to ensure quality.

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<tr>
<th>One of the most proven solutions to such issues</th>
<th>The solution to be effective, the labeling agency need to be quite popular among the end users or enterprises. Communicating with end-users may be difficult, and enterprises may disagree on the benchmarks.</th>
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**Customer awareness.** CLEAN can take up customer awareness programs on differences between long term solutions, short term solutions and wrong solutions. Terms like “Mileage” developed in vehicle industry need to be developed and popularized to convey benchmarking results easily to a layman

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<tr>
<th>This will boost enterprises also to focus on long term benefits of the end users</th>
<th>Customer awareness is a vast topic. There are numerous needs and solutions. It should be strategy of individual enterprises to advertise their solutions to needs. It’s totally impractical to outsource it to a third party</th>
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2.C Supply chain

Supply chain issues cannot be ignored while talking about technology since easy availability of products plays an important role in usage of them in the solutions. The issues related to supply chain is very prominent especially when it comes to remote and difficult terrains. This is also the most important issue to be tackled when it comes to solutions in North East region of India.

Local manufacturing vs. easier importing: some products do not have a strong manufacturer base in India, for example wind-turbine blades. These products must be imported, and road permit issues can hinder transport internally. One option is to make importing of such products easier, reducing taxes etc. Another option is to train local fabricators for making these products. Local training is a good long term solution, but initially quality may suffer, manufacturing costs may be higher and efforts for training would be high.

Particularly difficult areas, such as the NE of India, have the most acute difficulties with supply chain. Transportation difficulties can require completely different products, for example LiIon batteries, but this further heightens the supply chain problems.
**Possible interventions for CLEAN**

Below some possible interventions are listed, with **optimistic** and **pessimistic** views expressed by practitioners on these interventions.

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<tr>
<th><strong>Vendor Database.</strong> CLEAN can create database of vendors operating in various regions for components related to off-grid energy sector. Their operating regions, service network and product information would be ideal.</th>
<th>It should be an online portal where information is continuously updated. It should act like a Wikipedia for product and vendor information in off-grid sector.</th>
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<tr>
<td><strong>Transportation, tax, etc. Policy.</strong> CLEAN should strive to be the representative of off-grid sector to influence the policy makers and make changes in the policy suitable for easy transportation, tax &amp; duty suggestions etc.</td>
<td>The expectation is that it is one of the primary reasons why the CLEAN Network was created. Have lost hope in the concept called “influencing policy makers through collective voice”. It just doesn’t work.</td>
</tr>
<tr>
<td><strong>Spread the word of benefits:</strong> The benefits to enterprises and end users using higher quality products can be advertised by CLEAN Network</td>
<td>Success depends on the medium of advertising and the trust upon CLEAN as a brand by end-users and practitioners.</td>
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<tr>
<td><strong>Support local manufacturing:</strong> In difficult terrains like some regions of Meghalaya, Arunachal Pradesh etc; promoting and training own fabrication of products like water mill, turbines etc would reduce dependency on external products and hence solve supply chain issues. CLEAN can facilitate this concept</td>
<td>The technology skills in rural areas would also improve by this method and make people more self sustaining. Issues related to non-servicing would no longer exist. The fast pace with which technology advances in other parts of the world cannot be immediately utilized in such cases. There is trade-off on quality at least till the local manufacturers gear up to the skills required for high quality products.</td>
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2.D Installation and service

As far as an end user is concerned, he/she judges the whole renewable energy technology and compares it with performance of conventional energy based on the performance and service available at his/her premises and how much it satisfies his/her needs. So it’s finally about how a solution is commissioned and serviced at end user premises. Hence installation and service are key components of any system. For matured technologies this becomes a competitive factor. But for novel technologies, like renewable energy, each enterprise has to be responsible towards contributing to the success of the technology and hence accountable to the industry as a whole.

A strong link between service quality, customer opinion and willingness to pay for the service makes this area key, but the difficulty of providing service in rural areas makes scale-up of such enterprises difficult. Furthermore the risks of product malfunction are amplified by the difficulty of service and importance of service quality.
Possible interventions for CLEAN
Below some possible interventions are listed, with optimistic and pessimistic views expressed by practitioners on these interventions.

<table>
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<tr>
<th><strong>Installation standards and guidelines.</strong> CLEAN can come up with guidelines and standardization procedures for installation and service of various off-grid technologies</th>
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<td>It is very helpful to small organizations and startups</td>
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<tr>
<th><strong>Certification of enterprises.</strong> CLEAN can certify enterprises for installation and service practices.</th>
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<td>This lets people know about the quality of enterprises.</td>
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<tr>
<th><strong>Training and skills development</strong> of skilled technical staff would facilitate in the scale-up of enterprises, and ensure a good service.</th>
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<td>This would reduce the effort of practitioners for training</td>
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<tr>
<th><strong>Identification of and training on technologies that reduce service costs</strong> such as remote monitoring systems or data collection, as well as remote service instruction methods.</th>
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<td>This could help reduce HR overheads for servicing.</td>
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A common thread amongst complaints from practitioners was centered around the issue of quality assurance. For example practitioners could not be certain of the accuracy of nameplate specifications, they presented cases where failed components had caused significant loss of customers or mentioned the significant time and resources that were required for product testing in-house. Hence product quality is taken up in more detail. First, to elaborate on these problems in more detail four products which were highlighted by practitioners are discussed in turn.

A. Batteries
B. Controllers and converters
C. Luminaries
D. Motorise appliances

3. A Batteries

Batteries are used in energy systems to store electric power from a source and deliver it when the source is not available. This requires a charge controller and load controller (with or without inverters/converters). The most commonly used battery in the off-grid energy sector is flooded/tubular lead acid battery. Sealed “maintenance free” lead acid batteries are also used, and different variations of Lithium Ion batteries are gaining popularity, particularly in portable applications, as costs reduce. With storage technology currently a hot topic for research a number of new technologies are also appearing on the market.

Three key aspects to consider for storage technology are the usage profile of the storage, the control required for that technology and the cycle life of the battery. These three parameters are interlinked.

Usage profile
The way that a battery is used has a strong influence on its ability to store and release energy. A lead acid battery has a particularly strong correlation between the rate of charging and discharging and the amount of energy it can store and release. Whereas this correlation may be less for Lilon batteries.

Control
Different technologies require different types of control. Tubular lead acid batteries are fairly robust, but to maximise lifetime the battery should never be overcharged or undercharged (requiring voltage cut-off control). Additionally the rate of charging should be limited, fast charging can cause longer term damage. In comparison, a Lilon battery can be fully discharged without a low-voltage cut-off, but the temperature of the battery should be closely monitored to prevent thermal runaway.
Cycle Life
A battery’s life is determined by the number of charge and discharge cycles it can support before an 80% reduction in energy storage ability. This is known as the cycle life of the battery. This is a difficult parameter to put to use as the cycle life will be defined for a particular charge and discharge profile, at a certain temperature. For different scenarios the cycle life will vary. Hence both usage profile and control affect the lifetime of the battery.

The market for flooded lead acid batteries is very mature and widespread in India, and as such there are manufacturers that offer accurate data on the battery performance under different conditions, and warranties of 5 years or more are honoured. For less mature or common technologies this is not the case. The lifetimes for LiIon batteries vary hugely between different manufacturers, and warranties of more than 6 months are difficult to obtain.

Possible further work
A potential area for further work would be to observe usage profiles and lifetimes/performance of different technologies in the field. As prediction of lifetime is complex, then hard field data would be valuable, but the best use of the extensive work done before by different organisations should be assessed. This work would be useful for manufacturers in deciding warranty terms, and for practitioners in better understanding what to expect in different scenarios.

3.B Controllers and converters
These are electronic components that form the brain of a system. They control the power flow, manage the utilization of various energy sources based on different logics and usually house protection features required in a system. For example, solar PV systems require controllers to ensure batteries are properly charged and discharged, maximising the amount of solar irradiation harvested. Pico-hydro and small-wind systems require dump loads to prevent damage to the rotating mechanical parts. Converters ensure power is provided at a suitable voltage (AC or DC) for the load.

There are three key areas to consider for controllers and converters. As electronic items then the build quality and design of the electronics is key to the lifetime. Furthermore the performance specifications, particularly efficiency, should be considered. Additionally, the logic of control plays a major role in the system performance overall.

Build quality and design
Controllers and regulators being electronic components are prone to failures due to failure of small components like capacitors, ICs etc. Their quality depends on the quality of components used, as well as the design and build quality of the system and the protection put in place. Another common issue noticed is the closeness of positive and negative terminals of the regulators. This increases the chance of shortage and system failure. This is an example of how basic design inputs could affect lifetime of the product in the field.
Performance specifications
Manufacturers of a product must compete for market share, and hence they are primarily concerned with attracting people to their products. For relatively immature markets then there is therefore a risk of manufacturers claiming better performance specifications to attract buyers. This is particularly noticeable for some controllers, where efficiency may be overstated for example.

Logic of control
As the controller acts as the brains of decentralised energy systems then the logic employed is of key importance to ensure optimal performance of the system (e.g. maximising solar PV charging) and to maximise the lifetime of components (e.g. preventing overcharge of batteries). Testing the suitability of this logic, as well as the resulting implications on the system performance is non-trivial. There are currently no tools available to practitioners that allow for detailed assessment of the logic of controllers, and simulation of different parameters to model, for example, the resulting amount of energy consumed from the grid vs. that from solar, or the lifetime of a battery. Hence, claims made by manufacturers of “optimal logic” cannot be tested or easily verified.

Possible further work
In more developed markets the first two concerns are covered by standards in component quality and specifications. As the decentralised energy systems market grows in India, similar measures should be taken here. Further work should be done on understanding the logic of systems. For example through the creation of tools, or through monitoring of systems in the field, and identifying which logic fits different scenarios.

3.C Luminaries
Luminaries include LED or CFL lighting for domestic or outdoor applications, as well as any other specific uses such as portable lighting systems. It is a sector where new products are coming to market regularly.

The main issues surrounding luminaries is the quality of light output (including the lumen output and the aesthetic qualities) as well as the lifetime, warranty and service terms.

Quality of light
Luminaries are often defined by their power consumption, e.g. a 20W CFL, or a 5W LED lamp. Whilst convenient, this does not capture the specification that actually matters to an end-user: the actual light output and the quality of that light. Hence, for optimally designed systems, information on the lumen output, efficacy and colour of the light is required. As well as the provision of this information, practitioners need to be properly equipped on how to design taking this information into account.
**Lifetime, warranty and service**

LED lights are gaining popularity in the name of better efficiency and so cost savings. But if there is a circuit failure within 3 months, to get the service can be extremely difficult. This is true in the case of especially remote off-grid regions. This makes the entire payback calculation over extended life only a paper theory.

**Possible further work**

As the market for LED lights in India matures then the certification and warranty of such components must and should improve. However, this may only cover AC lighting. Similar is also required for DC lighting, which is commonly used in decentralised energy systems.

**3.D Motorized appliances**

Motorised appliances cover energy services that have the potential to improve the livelihood opportunities of end-users and communities. For example, this would include pumping for irrigation, sewing machines, wood turning lathes, rice mills and powerlooms. New efficient motor technologies, such as brushless DC motors, or variable frequency drives, increase the viability of powering these appliances from decentralised energy sources due to improved efficiency. Hence, energy efficiency for livelihoods has the potential to both increase a business's output and an existing entrepreneur’s economic status, as well as allow access to new businesses or enterprises for potential entrepreneurs without reliable energy access.

Whereas larger industries benefit from energy auditing and the efforts of organisations such as BEE, smaller industries and businesses often do not have energy efficient technology available, or even the knowledge of possible improvements. However, these smaller industries make up for a larger proportion of economic activity, particularly amongst lower sections of the pyramid, and often suffer from poor power availability and reliability. Fuel costs are therefore high, and incomes are reduced. Fuel subsidies lead to losses for the government as well.

Hence there are three main concerns for motorised applications. Firstly the **customisation and design** for the multitude of different applications. Secondly the quality of **magnetic materials and winding**. Thirdly, particularly for DC motors, is the **maintenance and lifetime** of the motor.

**Customisation and design**

Understanding the power-torque requirements of a machine is very difficult, and requires detailed study into machines and their application. Instead, motors are used with broad rules of thumb, for example a 1hp motor may be installed, but only used at a fraction of the power. This is highly inefficient. Motors are defined by their power-torque and efficiency curves and these curves are essential for matching motors to machines specific to each application. However, detailed curves are not always available due to an immature ecosystem for some of these products manufactured in India. This limits the ability of designers to produce quality designs.
Magnetic materials and winding
The performance of DC motors is dependant on magnetic materials. The quality of these materials is highly variable, and hence manufacturers must carefully select appropriate suppliers. For AC motors, the quality of winding is key. Poorly wound motors can suffer from efficiency drops of up to 30%. It is common for grid fluctuations to damage pump motor windings, for example, and locally rewinding these can greatly reduce the quality. Longer core, larger conductor help to reduce fixed losses significantly (core loss accounts for 50-60% of total losses). Now there are BEE certified energy efficient motors are available in the market which is about 5% more efficient than the standard one.

Maintenance and lifetime
AC motors benefit from a wide reaching service network, which ensures these motors continue working for many years. However DC motors, or new efficient motors, would not have such a mature network to benefit from. Without this service network then any cost savings in efficiency improvements may be lost by the inability to service products, and the end-user ends up paying more for the energy service.

Possible future work
A drive could be facilitated to identify the torque requirements of common livelihood machines and publish results so that it is easier for practitioners to select motor drives in the most efficient manner. It would also be beneficial to study the tendency of oversizing drives in Indian context and recommend for changing national code of motor nameplate rating suitably. For example if tendency is to select a 1HP drive when 0.75HP is required (25% higher), the rating should be such that peak efficiency falls at 75% of the rated value. However the feasibility of this recommendation need to be studied further as a national code deviating from international standards, even if for a good cause, might create a lot of confusion among practitioners and manufacturers.

Also workshops and trainings need to be provided on selection of drive, mechanical transmission systems and speed controls to create focus on efficiency in the entire process. Even governmental schemes like pump subsidy schemes should be flexible to choose drive to maximise efficiency.

To facilitate the maturing of the market for more efficient motors, performance specifications provided by manufacturers must become common place, as well as standards for performance and quality.
4. Product Quality - Existing Quality Assurance Mechanisms

For technology products in India there are already existing quality assurance mechanisms. However these mechanisms do not fully meet the needs of practitioners, so the problems described before come up. This section describes these different mechanisms, highlights some general difficulties and weaknesses and makes suggestions of future work that could be done to improve them.

A. Manufacturer test reports
B. Enforced standards
C. Third party test laboratories
D. Internal testing
E. Information dissemination
F. Benchmarking

4.A Manufacturer test reports

Manufacturer tests typically involve testing the basic technical parameters of products. These parameters are used for designing as well as selection between vendors. Most manufacturers have a QC department which mandates quality check in every sample of product manufactured. These QC procedures should be as per IEC or BIS standards. A designer who selects a product for use in an application essentially has to match the need of the end user to the parameters given by the manufacturer. This ensures operating the product at its maximum efficiency for the given site conditions and usage patterns.

Typical issues faced by the off-grid market is that the QC report is not used or demanded by the practitioners or is not shared by the manufacturers.

QC reports not used or demanded by practitioners

Often dealers and small enterprises also do not possess the technical resources to interpret nameplate readings provided by the manufacturer and match it with the exact requirement. Thumb rules are quite commonly used in the sector to select products based on vague data. An example would be Pumps which is commonly selected based on thumb rule and only its HP rating is considered for selection. Whereas given two pumps of same HP rating, its pump curve might be different which is often neglected. Also the efficiency curves might be different for the two pumps. If these factors are not considered, the pump might function at a lower efficiency leading to higher energy expenditure. This may not be a defining factor when energy source is extremely subsidized but becomes important when stand-alone systems are designed in off-grid regions where energy cost can be restrictively high. Such examples are plenty across most of the products used in off-grid energy sector.
QC reports not provided by manufacturers
If is often the case that even if practitioners have the ability and will to use detailed specification data, manufacturers may not provide it. In mature markets, a manufacturer that does not provide this information would be rejected in favour of a competitor that does. However in nascent markets there may be limited alternatives manufacturers may be supplying only small numbers of products, so would not invest into accurate quality checks and in-house testing for detailed specifications, instead favouring approximate claims. Alternatively a manufacturer may rely on other aspects of its offering, other than accurate product specifications, to attract customers. For example, a reliable service network, or a low-cost product.

Further work
Wrong selection of products creates two types of issues. Firstly that the end users loses faith in alternate energy technologies and the secondly it creates unhealthy competition by promoting products with lower initial cost but lower quality as against better quality product which would have lower life cycle cost and higher life in spite of slightly higher initial cost. Product specification can become a marketing tool rather than a service required by practitioners for accurate design. Workshops or information on interpretation of nameplate readings would help in effective selection of products, which in turn would also promote the practitioners to demand for QC reports from manufacturers. To create awareness among end users also requires a coordinated effort by practitioners.

4.8 Enforced standards
For some of the products used in off-grid energy systems, governmental organizations like MNRE (Ministry of New and Renewable Energy), BEE (Bureau of Energy Efficiency) etc; has enforced standards. Only products meeting such standards are provided due support of various government schemes like subsidy. These enforced standards play a key role in strengthening the ecosystem, but the use of standards must be carefully guided to prevent negative consequences. Two consequences are described: The combination of standards and subsidy, as well as the difficulty of building and enforcing standards.

Standards and subsidy
By linking standards to subsidy there is a risk of over-inflation of prices as well as limiting customisation and innovation. If a subsidy is communicated to end-users then system integrators not able to avail of subsidies are at a disadvantage. So providing subsidy to end-users becomes more of a marketing technique; two systems may be similar in price, but that which claims subsidy is included would be more attractive to end-users. Hence, system integrators will be willing to pay more for certified products, and manufacturers can charge more. This leads to an artificial inflation of prices for products that have gone through the certification process. Often a certified product may not be of better quality than a non-certified product.

This linkage between subsidy and standards can also lead to a prevention of customisation in design. If solar pumping is considered as an example here, 1HP pump with 1.2kWp solar panel
is a pre-approved model in solar pumping system under MNRE subsidy scheme whereas a 0.6HP pump is not. Hence in a system where 0.6HP is suitable, practitioners prefer to choose 1HP pump to avail subsidy, as inclusion of subsidy is a key selling point to end-users. Similarly, standards do not encourage continuous innovation of products, as each new product must go through a lengthy certification process.

**Enforcing standards**
Unless standards are universally acknowledged by end-users then manufacturers will not see the need to adopt them, and hence end-user will not become aware of them. This cycle needs to be broken by appropriate government policy or intervention.

**Potential further work**
Studies should be done into the suitability of different standards for different products and policies should be analysed to see where linking standards to subsidy would be beneficial or not. The design of these standards is also critical, and should be designed based on careful examination of their impact on the ecosystem. Furthermore, standard testing could be subsidised for new products to encourage innovation, or other methods to foster innovation should be considered.

**4.C Third party testing laboratories**
There are third party testing laboratories like TuV Rheinland, CPRI (Central Power Research Institute), Underwriter’s laboratory etc who would test various products either against manufacturer’s claim or according to internationally or nationally accepted standards like IEC, BIS, ISO etc. In most cases, selected samples submitted by the manufacturer are tested. There are, however, options to certify the manufacturing facility itself for its quality and the practices followed. There are standards laid down like ISO 9001 certification for certifying manufacturing facilities that it adheres to the quality management processes. The products released out of such certified facilities can be safely expected to be meeting all quality standards.

The main issues with third party testing are the **cost of services** and the fact that **practitioners do not use these facilities**.

**Cost of services**
If a practitioner or end user decides to cross check the claims of a manufacturer, products can be taken to such third party testing laboratories. But unfortunately high cost of testing products often doesn’t make this option attractive. Since the demand from end users is also not much, seldom does practitioners take the extra effort of checking manufacturer claims.

**Frequent Market study on issues**
In off-grid market, smaller organizations may not demand testing agencies to take up market study of quality issues although such demands are commonly made by large industries to plan their strategies. Hence, to make this practice common in off-grid market too, centralized testing agencies need to proactively take up market study of quality issues in off-grid region and share the findings with research organizations and manufacturers to boost innovations. Such research
Potential further work
Third party testing could be facilitated by subsidizing the cost of testing through monetary support. As the ecosystem strengthens then this support could be reduced as more sustainable ways of bringing testing are introduced, for example recuperating costs from manufacturers, in return for publicity of their product. Third party testing laboratories can be supported in two other ways:

1. Facilitating testing of even non-standard parameters upon demanded by a practitioner. If needed a random sample of a brand without informing the manufacturer needs to be procured as test sample. This would build support for the test facility with practitioners.
2. Facilitating proactive study of issues faced by off-grid market and submitting report with researchers and manufacturers to boost innovation. This would help build support for the test facility with manufacturers.

4.D Internal testing
Practitioners often resort to internal testing of products to establish performance specification as well as for quality checks. For larger or more experienced enterprises this has become a more established process. However for smaller organisations the costs and efforts involved are often prohibitive. Hence sharing of information as well as capacity building for practitioners and other methods of support are key.

Sharing of information
To prevent duplication of efforts practitioners could benefit mutually by sharing test data and ratings on products. Quality assurance of purchased products should not be part of a practitioner’s competitive advantage; there are already many challenges involved when reaching remote customers and providing service for these. This will also benefit smaller companies, perhaps focusing on particularly underserved areas. Larger enterprises will benefit from having improved information for selection of products and design, without spending more resources.

Capacity building
For organisations without established testing methodologies, support could be given to build capacity in these organisations. If wider help is given, for example financially supporting testing efforts, then testing results could be shared with a wider audience. Common, low-cost testing procedures should be developed for practitioners to facilitate a common platform for practitioner lead quality assurance.

4.E Information dissemination
Energy access practitioners in India are often more than willing to share information on certain issues and solutions that they face. Often this is done through informal channels, and this support has been key to growth of some organisations. As quality issues related to products
sourced from vendors are not of a competitively sensitive nature then sharing information on product quality is possible, and this is one area of information already shared by some practitioners.

There was a clear need voiced by the practitioners on need of intervention from a third party organization like CLEAN to help them access information necessary to deliver quality solutions. This information includes those from government institutions or related bodies (e.g. clarity on subsidy disbursement), practitioners (e.g. experience and learnings with different technologies), manufacturers (e.g. products of various brands, their specifications, nameplate data, reviews and test reports), end users (e.g. unique needs, complaints etc), or research organizations (e.g. information about an innovative solution to a reported problem, a new product etc).

For quality assurance in particular the following information is key:

1. Advice on interpreting nameplate data, e.g. capacity ratings of batteries
2. Relevance of international and national standards to different products, and how widely accepted these standards are
3. Testing reports on various products
4. New products entering the market
5. Practitioner experience with different products
6. Practitioner experience with different manufacturers
7. Testing methodologies

Potential further work

For inter-practitioner information sharing, the uptake and buy in for different practitioners should be worked on to ensure a fair deal for practitioners involved. As the larger organisations may contribute more, getting their buy-in is essential. Furthermore practitioners should be consulted on their willingness to share information. Setting up an information hub for non inter-practitioner information sharing is a first step.

4.F Benchmarking

All the above mentioned points were about supporting practitioners with necessary information and facility to design and deliver quality solutions. But what if few practitioners are indifferent towards quality? In order to compete in the market with lower cost products, practitioners might sometimes opt for lower quality products. End users may not be able to realize this until they burn their hand with a bad experience.

Through a benchmarking procedure, such issues could be prevented. Solutions from practitioners could be evaluated against benchmarks and could be labelled or ranked based on the same for end users to assess them. However this is not an easy job. Firstly, benchmarking itself is a herculean task of assessing various products and solutions. Secondly, a trustworthy organization is needed before all the stakeholders accept it as a benchmarking agency.
4. Product Quality - Example Testing of Solar-Grid PCU

Testing is the only method by which quality can be observed. Testing can be done in-house by practitioners or by centralised testing labs. Hence, an example testing was done to demonstrate how this can bring quality assurance, as well as give inputs on innovations. From this example testing it is possible to draw lessons for improving in-house testing and centralised testing.

Three inverters of 800VA, 12V were selected for comparative testing. 800VA represents the off-grid sector requirement as most of the domestic requirement in off-grid regions falls in this category. The selection of inverters represented a variety of expected quality.

The aims of the testing were to:
1. Check manufacturer claims with test results. Draw implications for design, showing how differing claims can affect practitioners’ system performance.
2. Investigate the operating logic of inverters and highlight areas for innovation in the field.

With these three aims it is hoped to demonstrate how accurate testing and communication of results can:
1. Improve design quality
2. Bring quality assurance to practitioners
3. Foster innovation in the energy access space.

4. A Test Setup

As given in the figure below, a Power Conditioning Unit (PCU) generally has grid power and/or other source(s) as input. A battery provides backup energy storage, and an AC load is connected via an inverter. The power flow throughout the system is controlled by the inverter logic, which decides when each source should be used to charge the battery, and when the load should be switched on and off.
Grid
A variac is used to simulate different grid voltage conditions, and so test for low and high-voltage grid protection.

Solar PV
A DC power supply is used to simulate the Solar PV panel. This allows for quick simulation of various irradiance conditions, so allowing charging efficiency curves to be drawn. If MPPT is used, then a more advanced PV simulator, or real PV panels, must be used to determine the accuracy of MPP tracking.

Battery
Charging and discharging of lead acid batteries takes time, so a DC power supply with a dump load is used to simulate. This allows study of the efficiency curves with various battery voltage levels.

Loads
To simulate different loading conditions, incandescent bulbs and dummy loads were used. This allowed study of the inverter performance under varied loading conditions.

Measurement
The following equipment was used to measure different parameters:

- **DC energy meters** - these measured DC voltage, current, power and energy for the PV and battery connections
- **AC energy meters** - these measured DC voltage, current, power, power factor and energy for the grid input and AC inverter output connections.
- **Clamp meter** - this can measure peak current, harmonic distortion of the output and inrush currents. This is also useful for quick measurements and checks.
- **Oscilloscope** - this allows viewing of the inverter output waveforms
### 4.B Summary of testing results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter</strong></td>
<td>Claimed</td>
<td>Witnessed</td>
<td>Claimed</td>
</tr>
<tr>
<td><strong>PV charging efficiency</strong></td>
<td>&lt;80%</td>
<td>85%</td>
<td>&lt;86.4%</td>
</tr>
<tr>
<td><strong>Grid charging efficiency</strong></td>
<td>&lt;70%</td>
<td>70%</td>
<td>&lt;71.69%</td>
</tr>
<tr>
<td><strong>Peak efficiency</strong></td>
<td>&gt;90%</td>
<td>76%</td>
<td>&gt;90%</td>
</tr>
<tr>
<td><strong>Inverter efficiency between 40% and 60% loading</strong></td>
<td>&gt;65%</td>
<td>&gt;90%</td>
<td>~86%</td>
</tr>
<tr>
<td><strong>Output AC voltage</strong></td>
<td>230V±3%</td>
<td>230V±6%</td>
<td>230V</td>
</tr>
<tr>
<td><strong>Output waveform</strong></td>
<td>Pure sine wave</td>
<td>1.38 average crest factor</td>
<td>Pure sine wave</td>
</tr>
<tr>
<td><strong>Input grid voltage lower cut-off</strong></td>
<td>120V</td>
<td>&lt;115V</td>
<td>120V</td>
</tr>
<tr>
<td><strong>Input grid voltage upper cut-off</strong></td>
<td>270V</td>
<td>&gt;270V</td>
<td>270V</td>
</tr>
<tr>
<td><strong>Output rating</strong></td>
<td>875VA</td>
<td>840VA</td>
<td>720W</td>
</tr>
<tr>
<td><strong>Low battery voltage shut-off</strong></td>
<td>10.5V</td>
<td>10.5V</td>
<td>10.5V</td>
</tr>
<tr>
<td><strong>Charging current</strong></td>
<td>-</td>
<td>&lt;10A</td>
<td>-</td>
</tr>
<tr>
<td><strong>No load power</strong></td>
<td>-</td>
<td>~20W</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total harmonic distortion</strong></td>
<td>8% max</td>
<td>18%</td>
<td>5% max</td>
</tr>
</tbody>
</table>
4.C Comparison of claimed and witnessed performance specifications

Efficiency
For all three inverters, the claimed and witnessed output efficiency of the inverter did not match. Whilst C managed to match at the peak efficiency, the value given should be the efficiency under common loading conditions, i.e. between 30% and 60% of the rated output. All three manufacturers claimed a minimum efficiency of 90%, the best performance was B, which reached a maximum of 86%.

Output rating
The output ratings were over claimed by two manufacturers. A reached 840VA or the claimed 875VA, whereas both B and C only reached 600W of the claimed 720W.

Impact on design
The efficiency and output rating are two basic design parameters for energy systems, and inaccurate information would lead to inaccurate design.

For example: A claimed to have 90% efficiency but tests showed 76% efficiency at common loading range of 30% to 60% of peak output power. If a system was designed using 90% efficiency to provide 6 hours of backup, in reality it would only provide 5 hours. This would not be acceptable for the customer, and demonstrates clearly the impact of false claims on end-users and manufacturers.

4.D Other observations

Output power quality
The quality of the output power is measured by “Total Harmonic Distortion”. This is a metric which captures how similar the output of the inverter is to a perfect sine wave. If the output has a high THD then it can cause issues of voltage quality for the grid, or interference with other devices. 3% is kept as a recommended guideline for appliances, and only B managed to keep THD below this level at a medium to high output loading.

Solar PV charger
When there is low solar irradiation then the efficiency of the solar PV charger is low. This would affect the quality of design as morning and evening, or cloudy day charging, would be less efficient. In this regard it is important to mention that phocos inverter uses MPPT logic whereas other two inverter follows PWM logic.
Grid charger
Whilst A did not make any claims about grid charging efficiency, the other manufacturers claims where reasonably accurate.

Transformerless design
The better efficiency of the B model is due to using a transformerless design for the inverter. This reduces losses and lowers the weight of the device. However, as there is no galvanic isolation between the DC and AC sides then the DC side cannot be grounded. This is different from standard practices, where the battery negative is usually grounded. Installation practices should be modified, including different selection of protection components and PV panels.

4.E Logic test results
The summary of logic embedded in the three inverters tested are as given below.

<table>
<thead>
<tr>
<th>Energy Sources</th>
<th>Load Logic (common)</th>
<th>A Battery Logic</th>
<th>B Battery Logic</th>
<th>C Battery Logic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid</td>
<td>Solar</td>
<td>Battery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>High</td>
<td>Low</td>
<td>Solar</td>
<td>Solar</td>
</tr>
<tr>
<td>Yes</td>
<td>Low</td>
<td>High</td>
<td>Solar + Battery</td>
<td>Discharging</td>
</tr>
<tr>
<td>Yes</td>
<td>Low</td>
<td>Low</td>
<td>Grid</td>
<td>Solar + Grid</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>Low</td>
<td>Grid</td>
<td>Grid</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>High</td>
<td>Grid</td>
<td>Disconnect</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>High</td>
<td>Battery</td>
<td>Discharging</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>Low</td>
<td>Disconnect</td>
<td></td>
</tr>
</tbody>
</table>

Load logic
All three inverters had the same load logic: when the battery is high then energy for the load will come from the battery and solar. When the battery goes low then the load will be connected to the grid (in presence of solar).

Battery charging logic
Here a key difference is highlighted in blue. When battery is low but solar is not available, both A and B will charge the battery from the grid. However the C inverter will wait for solar to become available. This essentially ensures that grid is only used to charge the battery in emergency cases, and so minimises grid use and maximises solar use.
4.F Other quality aspects
Other major factors for inverters are the build quality, durability and serviceability. These factors would affect the lifetime of the product, and so the lifetime-cost to the end-user. However to test these factors before installing requires accelerated lifetime testing, which is outside the current ability of SELCO Foundation's test lab. National Laboratories should play an important role in these tests.

4.G Inputs for innovation
For manufacturers seeking to provide the best products for a market, feedback on their performance is essential. Controlled testing which takes into account a strong knowledge on field conditions can greatly assist in providing this feedback, so giving technology developers accurate guidance in the future development of their products. As examples, some key issues are highlighted, along with some suggestions for innovations. It should be noted that these are suggestions only, and are meant to spur on further thoughts.

Grid charging
For the tested inverters grid charging was generally at around 70%. When taken with an inverter efficiency at 80% (good case) then the cost of grid supplied via the battery (i.e. grid energy stored for backup) would increase by 75%. I.e. if grid energy costs 7Rs/kWh then stored energy supplied during load-shedding (or backup) would cost effectively 12.3Rs/kWh.

As seen by some practitioners surveyed, customers can face increases in bills after installing a solar PV system. Whilst this may be due to increased load use in some cases, other cases could be due to a mismatch of the PCU logic and the specific use case. For example, a customer using the PCU for backup power in the evening may use all of the energy stored in the battery. By 10pm the PCU would switch on grid charging, and by morning the battery would be full. If there is minimal day-time usage, then the energy available from solar would not be fully utilised. Hence the customer would only be using the system as a UPS, and so paying 12.3Rs for evening use, rather than 7Rs.

Improved logic would reduce this problem, but understanding the logic and its suitability for a particular use-case is complicated. C has implemented an alternative logic, and further simulation and field tests could determine how suitable it is for different load profiles.

Software development - For prediction of logic function
The logic test of the inverter reveals that the logic provided is not suitable for all scenarios. Each inverter logic has limited usage patterns for which it is suitable. However to communicate this to the consumer is very difficult. Hence it is easy to propagate false promises on payback and hence exploitation.

Software could be developed where upon uploading the inverter parameters, logic details, battery curves, solar PV VI curves and the load profile expected at site, the software can calculate total energy per day spent by various sources, total cycling of battery etc per day. This
could allow for clear performance information to be given to end-users, as well as enabling practitioners to do more accurate designs.

**Field changeable logic and design feedback**
The logic of the inverter plays a huge role in determining the installed performance of the system. How much solar PV is utilised, the reliability of energy supply and the lifetime of the battery are all determined by the effectiveness of the logic. However, the logic must match the use case, and this can either be difficult to predict, or change over time. By allowing the logic to be changed after installed, through a switch or interface, the system could be tweaked to match field conditions. However, knowledge on these field conditions must be accessible.

An inverter could analyse its own performance, or log data to allow a system integrator to analyse. This information could be used to modify logic parameters accordingly, such as adding a timer or adjusting battery voltage thresholds.

**No load loss**
It was noted that the no load losses, which is the inverter consuming power even with no load in use, is a major concern in off-grid systems. For example, an 800VA inverter may be used to power a TV, two fans, and a few lights, as well as a mixer-grinder. Here a 20W no-load loss for 24 hours is greater than the energy consumed by the TV. Hence the source of power needs to be oversized for meeting such huge losses and hence the cost increases just to cover losses. This particularly affects smaller systems, and so inverter based solutions for lower-income households either with or without a grid connection become prohibitively expensive.

There are inverters with better no-load management, such as a standby mode in which inverter goes to sleep mode consuming very little power when no load is connected to it. In such cases, the inverter wakes up again only when a load more than a minimum threshold value is sensed. This is a disadvantage as it take little delay for a load to switch on (due to time taken by the sensor to operate). In some cases the load totally fails to switch on, for example in certain TVs when first switched ON it just switches on in idle mode consuming very little power and then only when the remote is operated it consumes considerable power. The inverter fails to detect the load initially when it is in idle mode and hence the inverter doesn’t wake up thus failing to switch on the TV until any other considerably higher load is connected.

Other methods to either improve the no-load shutdown feature, or alternative ways to reduce no-load loss could be considered. For example, conveniently placed switches to wake up the inverter could be provided in addition to the automatic switch-on. Or higher voltage storage with loads that work on higher voltage DC could be provided. Most off-the-shelf televisions are able to work as low as 70VDC with no modifications. Additionally, with Lilon battery technology becoming cheaper and more common place, a high voltage battery pack could become feasible.
Efficiency
The running efficiency is also equally important factor in off-grid systems. Using more efficient transformer core, winding, transistor components etc even at a higher price, would substantially reduce energy needed from the source and hence its cost. Transformerless inverters have started to enter the market, but doubts around their longevity, particularly in rural conditions have been raised, due to a lack of isolation.

4.H Inputs for practitioners
Whilst the specific results will be of interest to practitioners choosing a supplier of an 800VA inverter, more generally the following lessons from the exercise are gained:

Using manufacturer specification
A clear lesson to be learnt from this example testing is that the specifications quoted by manufacturers cannot blindly be used for design. For one of the tested inverters there was a 20% difference in the claimed and actual values, which would have lead to 4 hour vs. 5 hour backup if each value was taken for design. This would be unacceptable to

For inverters, the key issues for practitioners are manufacturers using false claims of payback, higher no load loss, lower peak efficiency, oversizing and unreliable service network. Following interventions may be planned to overcome these issues.

1. Support customer awareness on payback through detailed tests and by publishing field test data from various end users.
2. A software could be developed to help practitioners easily assess payback for a given load profile
3. Researchers, manufacturers and practitioners could be incentivised to introduce solutions in off-grid regions with improved efficiency and reduced no load losses
4. It is seen that most UPS systems in the country run at around 30% to 60% of its rated value. This oversizing tendency cannot be radically changed. Manufacturers can be promoted to strategize peak efficiency setting with this in mind and efficiency at 30% to 60% loading should be mandatory to display.
5. To reduce the need for service networks for new products, a barrier to entry for new manufacturers, technicians engaged in electronic repair works in rural region could be trained to function as independent entrepreneur servicing common inverters used in the region.
In light of the inference given above, these are the recommended immediate actions that will catalyze the off grid energy access market. These items should be explored in more detail, with further consultation with practitioners. The others should be addressed in separate projects.

A. Information dissemination through web portal
B. Testing facility for off-grid projects
C. Methodology for internal testing
D. Benchmarking for off-grid industry
5. A Information dissemination through web portal

The immediate action expected from practitioners from CLEAN is creation of a web portal. A number of issues identified in the study are related to information gap that currently exists between different stakeholders of the industry. Through the web portal CLEAN can disseminate all necessary information to its members. Members can also share their thoughts in the portal.

A lot of ground work needs to be done for collecting the data required for the web portal. Hence the data collection strategies need urgent brainstorming. The information required to disseminated, as suggested by practitioners, is as follows:

- Best practices or guideline for designing, installation and service.
- List of suppliers and vendors for different regions.
- Technical specifications of products. For example: power rating, efficiency curves, characteristic curves of pump, torque-speed graph of motor etc.
- Testing & characterization reports for products.
- Experience and reviews on various vendors.
- System performance data logged from different geographic and climatic regions.
- Standardized test methodology for performance assessment of products.
- A portal for enterprises to inform others of solutions for special problems.
- A section for feedback and suggestions for other services.
- Electrification plans and energy data (e.g. load profile of generators) from DISCOMs.

<table>
<thead>
<tr>
<th>1st year</th>
<th>2nd year</th>
<th>3rd year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch a basic web portal and design for user friendly dissemination of availed data</td>
<td>Continuously update design and marketing use of platform</td>
<td></td>
</tr>
<tr>
<td>Strategize collection of data for the web portal and organizations to partner with for the same</td>
<td>Collect and publish data online, such as design procedures, best practices of installation etc</td>
<td>Continuously engage practitioners on information requirements</td>
</tr>
<tr>
<td>Form an expert committee with members from organizations ready to facilitate knowledge dissemination to needy enterprises</td>
<td>Facilitate frequent communication of support needing enterprises with expert committee. Needy enterprises to be identified and approached by CLEAN since the reverse may not always happen</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Develop expert committee into a knowledge hub which can reach out to consumers too</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A grievance input to cater to consumer complaints</td>
</tr>
</tbody>
</table>
5.B Testing facility for off-grid projects

Through a network of test centers, CLEAN can provide testing and characterization services of off-grid specific products to its members. This type of centralized test center will support start-up firms and small scale practitioners to sustain and eventually scale up their business. For providing this type of service, CLEAN can engage with different test centers or laboratories who have expertise in different functional areas (e.g. solar, bio-gas, wind, micro-hydro etc.) These test centers should be located near the areas where demand for off grid power is the most, as well as covering different climatic regions. Areas like N.E. India, where there is good potential for off-grid energy services, would be ideal places for these test centers.

<table>
<thead>
<tr>
<th>1st year</th>
<th>2nd year</th>
<th>3rd year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form partnerships with organisations identified for testing and research</td>
<td>Get identified products tested, where appropriate</td>
<td>Strengthen existing test centres and identify locations for new ones</td>
</tr>
<tr>
<td>Collect existing quality related documents from institutions like GACC, GIZ, Lighting Global etc.</td>
<td>Document replicable processes in testing and publish</td>
<td>Settle on process to receive materials from members for testing</td>
</tr>
<tr>
<td>Get a sample product test conducted for practically analyzing the hindrances and benefits. So creating knowledge of testing internally.</td>
<td>Get feedback on format of test reports</td>
<td>Collaborate with research organisations for the development of test equipment for off-grd space, based on practitioner feedback</td>
</tr>
</tbody>
</table>

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5.C Methodology for internal testing

A centralized lab may reduce the operational cost of testing but cannot completely eliminate the requirement of internal testing. The majority of the practitioners realize that to scale up their operations, an internal testing facility is necessary. To support them, CLEAN can come up with recommended testing methodologies and publish them on a web portal. CLEAN can also seek inputs from members for low cost testing procedures to assess the performance of products. This will help to reduce the operational costs of testing.

Also it’s important to mention that laboratory based testing under controlled inputs is not sufficient to evaluate the reliability of off-grid products. In addition, field based tests (with uncontrolled inputs) is necessary. Methodologies for such field tests are also required.

- Form a committee of quality managers from various institutions and organisations for easy communication.
- Gather existing information on test methods used by practitioners for internal testing of selected products.
- Have multiple reviews and feedback to arrive on consensus for test methodologies.
- Publish important information as and when required.
- Standardize processes and procedures wherever possible.
- Collaborate with manufacturers and other networks in the manufacturing sector to facilitate better communication on quality related aspects.

1st year | 2nd year | 3rd year
### 5.D Benchmarking for off-grid industry

A detail study is required to create a baseline for the products of off grid market. In future it can serve as a benchmark in the industry. However this requires buy in from practitioners, which may currently disagree on what the benchmarks should be. As CLEAN develops, and as the market develops, then benchmarking can be introduced. But this development must first happen, building trust with practitioners and end-users.

- **Identify organisations to start baseline studies on the ground for various products and create partnerships.**
- **Start baseline study after consulting with expert committee, and create consortium of Quality Managers for industry.**
- **Publish benchmarks when enough data and consultation has been done.**
- **Study and understand previous history of benchmarking efforts in India and worldwide.**
- **Plan appropriate record keeping and data analysing strategies to use for baseline study for benchmarking.**
- **Slowly start to enforce benchmarks for select products, using labelling practices etc.**

---

1st year | 2nd year | 3rd year
6. Conclusion

This report has summarised the views collected from various practitioners related to technology issues in the off-grid market. These views were collected during interviews and consultations as part of an investigation into, specifically, product quality issues. From these views it was clear that there is good potential for CLEAN to facilitate growth of the off-grid sector through a few particular interventions. These interventions were suggested as next steps.
7. Appendix

List of organisations consulted:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agni Power &amp; Electronics Pvt Ltd</td>
</tr>
<tr>
<td>2</td>
<td>Ashutosh Solar Light</td>
</tr>
<tr>
<td>3</td>
<td>Assam Energy Development Agency</td>
</tr>
<tr>
<td>4</td>
<td>Boond</td>
</tr>
<tr>
<td>5</td>
<td>Claro Energy</td>
</tr>
<tr>
<td>6</td>
<td>Donton Solar</td>
</tr>
<tr>
<td>7</td>
<td>Eastern Envo Protect</td>
</tr>
<tr>
<td>8</td>
<td>E-Hands</td>
</tr>
<tr>
<td>9</td>
<td>Free Power Tech Pvt. Ltd.</td>
</tr>
<tr>
<td>10</td>
<td>GPS Renewable</td>
</tr>
<tr>
<td>11</td>
<td>Gram Oorja</td>
</tr>
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