IMPACT ASSESSMENT REPORT GRAM OORJA SOLUTIONS

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EXECUTIVE SUMMARY

This report provides an evaluation of the long-term sustainability and impact of Gram Oorja's community-owned model for energy access and solar-pumped water installations in remote Indian villages. The evaluation is based on a comprehensive approach where the model's effectiveness is assessed across five sustainability dimensions (technical, institutional, economic, social and environmental) using measures and indicators. Qualitative and quantitative data were gathered for 24 Solar Micro Grids and 20 Water installations through field visits, administering surveys with households, reviewing project records and technical readings from system components and semi-structured interviews with plant operators, village committees and stakeholders from Gram Oorja and partnering organizations.

The assessment reveals that high quality technical installations combined with strong social interaction with the communities at all stages of project implementation are the two key components for the success of Gram Oorja's community model. High quality components and installations ensure that systems are reliable and able to provide energy that meet user's expectations and needs over long periods of time. This combines with strong social engagement, initiated early-on during the implementation, where relationships of trust are built and assistance is provided to establish inclusive and effective forms of governance. When effective governance is established, communities are able to enforce and adapt rules, ensure regular payments and timely resolution of issues, hence users are engaged and satisfied with the system. This ultimately leads to high social impact in the areas of education, health, increased safety and sense of connectedness among the communities and with the outside world. In cases where women have the opportunity to play a leading role in the governance and day-to-day operations of the infrastructure, this also results in more effective and inclusive systems.

Specifically, findings suggest that Gram Oorja's installations are able to provide clean and affordable energy and water services to the communities sustainably over long periods of time. With the oldest implementation little older than five years, the model shows signs of being successful, providing a power supply that is of high quality, durable, reliable and affordable. Community-led governance of the energy infrastructure was found to be effective with local communities generally capable of managing ongoing operations, requiring little to no external assistance in the majority of the cases. The underlying economic model and financial self-sustenance shows a viable alternative to central grid based electrification for these remote communities.

Some minor causes of concern emerged from this analysis. Public illumination was partial and inconsistent in many cases. Given the impact that this has on social wellbeing, the assessment recommends Gram Oorja to act on this issue promptly. Additionally, despite providing high quality supply, the assessment found low levels of energy consumption and low engagement in livelihood activities, generally across all newer and older sites. This suggests that economic development resulting from energy access in these location may not occur organically and might require intervention. Although this is not the primary goal of Gram Oorja's energy service, this finding represents a missed opportunity to support economic development and assist communities move up the energy ladder. The remoteness of these locations as well as their traditional nature and mentality may be an explanation as to why engagement in energy use beyond lighting was found to be challenging. The assessment suggests that capacity building activities to educate communities on the opportunities for increased energy use beyond lighting, use of energy efficient appliances and compatible machines with the system could help increase awareness and drive engagement. Additionally, provision of productive loads and machines as part of the capital costs of installation, as tested in few installations, could also assist in bridging this gap.

1. OBJECTIVES AND OVERALL APPROACH

This report presents results from an Impact Assessment (IA) to evaluate long-term sustainability and impact of Gram Oorja's (GO) Solar Micro Grids (SMGs) and Solar-pumped water installations in remote villages in India.

The analysis is based on approaches commonly used in the development sector to evaluate impact of energy interventions and it focuses on comprehensive evaluation across five dimensions of sustainability: technical, economic, institutional, social and environmental. Dimensions are evaluated starting from metrics used in development studies, further adapted and tailored to reflect Gram Oorja's model and objectives. Each installation is assessed through a set of Measures and Indicators, resulting in a total of 12 Measures and 31 Indicators across five Dimensions. Increasing levels of performance for installations are ranked assigning scores, ranging from 1 (lowest) to 5 (highest), corresponding to clearly defined sustainability benchmarks for each measure. At the beginning of the study, Gram Oorja was also asked to provide internal targets for the scores, allowing for a comparative analysis between actual performances at each installation and those set internally by Gram Oorja. Combining methodologies used by international development agencies and sustainability researchers with metrics that are specifically tailored for Gram Oorja's model, this approach provides a comprehensive evaluation of the model and it contextualizes results in the wider space of energy access.

The study is conducted for 24 SMGs and 20 Solar Water pumping installations for drinking purposes in remote villages in the states of Maharashtra, Jharkhand and Karnataka. All SMG sites visited are geographically remote and were not connected to the central electricity grid at time of SMG installation. Data collection spanned from June to December 2017, involving site visits to all locations to collect quantitative and qualitative data from multiple stakeholders. Interviews and group discussions were held with village communities, individual households, local partnering organizations and Gram Oorja's founders and staff. This approach allowed for a multitude of perspectives to be captured through structured processes of data collection, integrating diverse stakeholders' views in the assessment.

The report is structured as follows: Section 2 provides an overview of Gram Oorja's model for energy access; Section 3 describes the profile of remote communities where Gram Oorja operates, positioning the villages within the wider context of the energy access agenda mandated by the Government of India (GoI); Section 4 describes in detail the methodology used for this assessment, including an overview of the sites covered; in Section 5 results from the analysis are presented. Emerging trends are discussed, highlighting key positive findings and bottlenecks detected in the model. The report concludes by looking at overarching themes across all sustainability dimensions, identifying strengths and challenges of the model, while also highlighting opportunities for improvement to achieve ensure long term sustainability and increase the impact.

2. GRAM OORJA'S MODEL

Gram Oorja is a social enterprise founded in 2008 whose vision is to achieve social good under a commercial framework, acting with highest levels of ethics, integrity and professionalism. Its mission is to act as a catalyst in delivering and commercializing on-the-ground viable renewable energy and water solutions for the rural sector, fulfilling the energy needs of remote rural communities through the use of natural resources. As an organization, Gram Oorja aims to lower the dependence of remote rural Indian villages on large centralized power systems, helping rural communities becoming self-sufficient for their own electricity and water requirements, and empowering local actors through the provision of sustainable, clean and community-driven energy and water solutions. Gram Oorja operates in some of the remotest rural areas of India, where central grid extension is often not a financially viable nor technically feasible option, and water scarcity poses challenging barriers for the health and wellbeing of these communities.

Each SMG installation is designed to serve an individual village community. It comprises of a Solar Photovoltaic (PV) plant located in the proximity of the village with an attached control room. The control room hosts technical equipment including inverter, charge controller, battery tank, timers and other electronic parts. Over ground lines connect all houses in the village, street lights, and provide illumination in public spaces such as schools, community halls or Primary Health Centres (PHC). Plants are designed to provide 24X7, single phase AC power supply to each house with a capacity of around 200Wp for each domestic connection. The overall capacity of the plant varies for each village based on the number of households and expected usage. Each house is provided with four 5W LED bulbs, 2 fittings for connecting electric appliances and an individual meter. Water installations for drinking purposes are made of PV panel(s) attached to a motor located at the water source, and which pumps water to a storage tank that is in the village. Contrary to SMGs systems, water installations may serve more than one community, depending on the location and water availability. Distribution taps are available at various locations in the village, each providing water for drinking and sanitation purposes, and serving a group of neighbouring households. Taps in villages are normally open twice a day for one hour.

All installations are community-owned, where the technical and financial responsibility for the ongoing management of the plant resides with the communities. In each location, Gram Oorja partners with local organizations such as NGOs and trusts who have an established presence in the region and acquired a reputation with the villagers, owning a deep understanding of the local realities and communities' needs. These partnerships provide Gram Oorja with the necessary social-cultural context in each location, facilitating the initial process of trust building and social engagement. Gram Oorja invests significant time and resources in building knowledge of remote rural communities and their needs for development beyond water and energy. Its team is often engaged in regular site visits and building relationship with local organizations much before a community is selected for an intervention.

The design and installation phases are characterized by a combination of technical and social activities to ensure that both usable power supply is provided to the communities and local institutional capacity to govern the systems is established early on. Village Energy/Water Committees are established in each village, with local community members selected by the community, ensuring 30-50% women representation. These committees are ultimately accountable for the ongoing effective operation of the plant and retain the authority to set rules according to the communities' needs, ensuring their enforcement on an ongoing basis. Governance procedures include regular village committee meetings to discuss technical and service issues, billing and collections of tariffs, adapting rules when required. All members of the community are encouraged to participate to meetings, raise issues for discussion and propose changes in the rules. A local technical operator is also appointed in each village and informally trained by Gram Oorja staff. The operator is responsible for performing basic technical tasks such as turning on and off the plant/water supply, maintaining the system clean and operative, and inform Gram Oorja or local NGO in case any major issues arise. The Operator is also generally in charge for the monthly billing and collection of tariffs from each house. Over time, involvement of the local NGO and Gram Oorja reduces as local institutional capacity is built. However, Gram Oorja continues to hold long-term accountability for any major technical issues with the system.

The financial model is hybrid where capital costs are provided upfront, through Corporate Social Responsibility (CSR) grants and donations, whereas recurring Operations and Maintenance (O&M) costs are addressed through regular billing from energy and water use by each household. Revenues are deposited in a village bank account that is often managed by the village energy committee. A combination of fixed charge and per-unit charge is applied to SMGs installations whereas water installations use a fixed monthly fee. A one-time connection charge is collected from each household at the beginning of each SMG installation, ensuring user's buy-in and commitment. Cost for public lighting is included in the fixed monthly fee and villagers also make in-kind contribution in the form of labour for construction, material for installation or land for the plant and control room.

Typical costs for Gram Oorja's SMG systems are 3.5 Lakhs INR per kWp installed, monthly electricity tariffs range between 50Rs to 100 INR for fix charge and 10-20 INR per unit of electricity consumed, connection charge being usually between 1500 and 2000 INR per household. Water fees are generally flat 30-50 INR per month per household. Figure 1 depicts the basic structure of Gram Oorja's model and involved stakeholders.

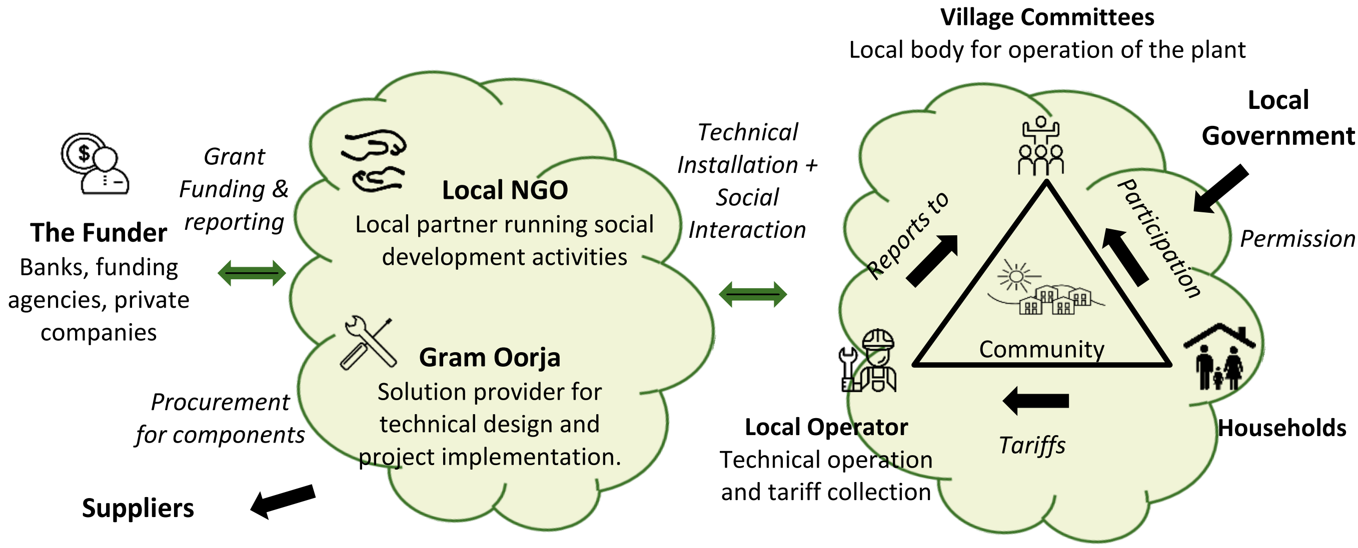

Figure 1 Stakeholder map for Gram Oorja's model

To date, Gram Oorja has installed over 33 SMGs, 70 solar water pumping systems for irrigation and domestic use, 2 biogas cooking grids and electrified 45 schools and public health centres across tribal communities of India.

3. PROFILE OF THE VILLAGES

This section provides an overview of the geographical and socio-cultural profile of the communities where Gram Oorja operates and the position these communities occupy in the wider electrification agenda promoted by the GoI. This section is particularly crucial to understand and interpret the results from the assessment and to evaluate strengths and weaknesses of the company's business model while operating in these regions.

Gram Oorja focuses on some of the remotest rural locations of India. Even though each village has unique characteristics, there are some common themes that can be outlined. The sites are often inhabited by tribal communities, majority of which are officially regarded as living Below Poverty Line. Village size is relatively small, in the range of 30 to 50 households on average, with some as low as 6 households and others as large as 90 households. Due to their relatively small size, these communities do not make an autonomous administrative unit and are officially regarded as group of habitations within a larger hamlet and revenue village. This feature often makes it complicated to understand the legal status of these communities and how these are regarded by GoI within the development plans for rural areas.

Accessibility in these sites is very limited and many villages are located in protected forest areas, often remaining disconnected for weeks at times of severe weather conditions in the monsoon months. Public transport is generally not available in the proximity of the village, thus limiting the connections communities have with markets or larger centres for trade and business. Mobile connectivity is also very limited, with no stable mobile signal in most of the villages.

Agriculture remains the main source of income with limited ability to harvest second crop due to water scarcity. Rice and pulses are grown and mainly used for personal consumption. Seasonal migration to neighbouring cities or larger villages for labour work as well as occasional opportunities to work with the local forest departments are also a key source of income for men and women alike. Occasionally, especially in villages located in forest areas, there is abundance of natural resources with income potential generated by, for example ayurvedic medicinal herbs. Local business activities are very limited as market linkages are weak and therefore mainly centred around processing of agricultural crops, small crafts producing utensils for farming or small shops serving the village communities. Cooking is performed on firewood or kerosene and no LPG connection is available.

Development needs in these villages are often more than basic energy provision and water accessibility. Local NGOs and trusts with whom Gram Oorja partners, are very active in many areas of social development, including health, education, livelihood generation or women empowerment.

Looking at the GoI official figures for rural electrification, it remains unclear as to what the official status of electrification in these villages currently is and information on the government plans to provide electrification in these locations is lacking. The Dindayal Upadhyaya Gram Jyoti Yojana (DDUGJY) [1] policy, which aims at providing power supply to rural Indian villages by extension of central grid, officially regards all three states where Gram Oorja's SMGs are installed as 100% electrified[1]. Village level connectivity however does not translate into energy availability at household level, and there are still 25 million rural households yet to be electrified or not covered under the DDUGJ program to date [2]. Saubhagya [3], the most recent policy aims to extend electricity infrastructure to each and every household by March 2019 or alternatively provide Solar PV based standalone systems[2] to those located in 'remote and inaccessible areas'. Five lakh (equivalent to half a million) households are estimated to fall under this 'remote village' category, but no clear definition is provided on how 'remote and inaccessible' villages and households are defined nor is a list of villages/hamlets/households falling under this category available.

Table 1 provides a list of the electrification in the three main states where Gram Oorja's SMGs are installed and the current state of electrification for rural households under each scheme as reported by official figures accessed in March 2018.

Table 1 Household level electrification in the states where Gram Oorja operates

State	**Total Rural Households (Lakh)**	**Electrified (Lakh)**	**Non Electrified (Lakh)**	
			Covered by DDUGJY	Covered by Saubhagya
Maharashtra [4]	139.15	135.53	3.61	+ 2.39 under construction
Karnataka [5]	61.31	57.97	1.84	1.51
Jharkhand [6]	54.81	24.4	12.77	17.64

Since Gram Oorja's SMG villages are also not officially regarded as a village entity per se, probably falling under the definition of smaller settlements such as hamlets or habitations within lager villages in the same areas, it is also difficult to understand the government electrification plans for these communities. At time the assessment

[1] Official definition of Electrified village After October 1997:

- Basic infrastructure such as Distribution Transformer and Distribution lines are provided in the inhabited locality as well as the Dalit Basti hamlet where it exists.
- Electricity is provided to public places like Schools, Panchayat Office, Health Centers, Community centers
- The number of households electrified should be at least 10% of the total households in the village.

[2] This include 200-300W system with battery pack, maximum of 5LED lights and 1 DC fun, 1DC plug with 5 year warranty for repair and maintenance

was conducted, government electricity grid had been extended in two of Gram Oorja's sites in the state of Karnataka. In one case, central gird electricity was only operational for few months before monsoon rain damaged the lines and no action had been taken to re-establish the connection. In the other location, grid connectivity arrived only 2 months before the assessment visits and users reported reliability issues as a key cause of concern with central government grid.

To provide rough figures for comparison, academic publications [7] looking at the costs of distributing central grid electricity to rural communities in India estimate that, connecting a 30 household village at a distance of 5-25km from the central grid in hilly terrain, would require a cost of 46 to over 200 INR per unit, which is twice to 10 times higher than the maximum tariff Gram Oorja communities are currently paying.

In conclusion, it remains unclear whether grid electricity is planned to reach those villages as part of the government 100% electrification scheme or if grid extension costs are regarded as too high, ultimately making these communities only eligible for small domestic portable renewable power sources.

4. METHODOLOGICAL APPROACH

The assessment evaluates energy sustainability of Gram Oorja's interventions focusing on five sustainability dimensions; Technical, Economic, Institutional, Social and Environmental. Each of the five Dimension is characterized by a set of variables (Measures), in turn composed of core components (Indicators).

The Technical dimension for SMG installations is evaluated using the Multi Tier Framework (MTF) [8] devloped by the World Bank and ESMAP initiatives. The MTF focuses on the actual usability of energy for domestic users and in public spaces, and the level of individual household energy consumption. The MTF assigns a score from 1 (lowest) to 5 (highest) to indicators based on clearly defined benchmarks describing increasing levels of technical performances. Such rigorous methodology allows for a comprehensive evaluation of interventions, where scores are reflective of specific levels of service. Recognising the strength of this approch, this assessment develops a similar scoring methodology for the remaining four dimensions, assigning scores to each measure on the same 1-5 scale. Scores are benchmarked against clearly defined and model specific criteria for sustainability, with performances increasing with increasing scores in each area.

The data used to assign scores is mixed, qualitative and quantitative, and collected from multiple stakeholders, representing multiple levels of information, i.e. household, village and organizational levels (Figure 2). Household level data was collected through surveys with individual households, whereas semi-structured interviews with local operators and discussions with members of local village committees were used to gather data at village institutional level. Additionally, data at organizational level includes perspectives from solution providers, partnering NGOs and funders, and collected through semi-structured interviews and group discussions. Where possible, data was also gathered from meter readings in the control room, and village bank account passbooks to determine the payment flow for the service and cash accumulated from energy and water tariffs.

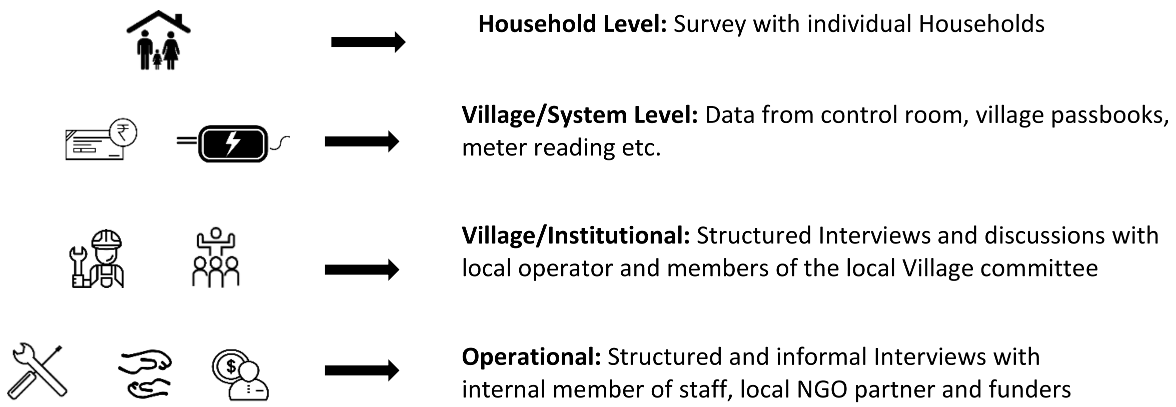

Figure 2 Multi-level analysis: Data collection across stakeholders

Each installation is described by a total of 12 scores, one for each measure, and based on data collected from multiple stakeholders. Scores for each site represent the performance detected during the assessment and can be used to identify areas of strengh and those in need of interventions. Looking at the complete set of scores across all villages, this methodology also portrays a comprehensive picture of Gram Oorja's model, highlighting positive linkages and bottlenecks of the company's approach, revealing core strengths of the model as well as opportunities where the service can be improved.

Below a descriptive overview and definition of the five sustainability dimensions and their core measures is provided. Definitions of benchmarks are based on Gram Oorja's model and reflect the organization's aims and objectives for long term sustainability and success. Detailed benchmarks and scores for each measure across the five dimensions are tabulated in the Appendix (Table 7 to Table 17)

4.1 TECHNICAL SUSTAINABILITY

Technical Sustainability refers to the ability of the system to meet present and future needs for energy for domestic and commercial users and in public spaces. Particularly, this assessment focuses on three core technical measures; *Domestic Supply*, *Public Lighting* and Household *Energy Consumption*. This report adopts the World Bank MTF to assess usability of energy supply for domestic users and in public spaces looking the following indicators: capacity, duration, reliability, quality, affordability and safety. Since the MTF is technology neutral, slight modifications of benchmark across indicators are used to reflect key characteristics of SMG installations. Energy Supply is then compared with household energy consumption to reveal any discrepancy between energy availability and its actual use.

A similar approach is also used to evaluate water interventions, where technical sustainability is achieved through provision of sufficient clean water for drinking and sanitation purposes to all houses in the village. Water access points should be available at a convenient distance, ensuring good level of health and sanitation to all members of the community. The water tiers are defined in the same way as the MTF, looking at directives provided by the World Health Organization (WHO) [9] on health and sanitation for the single measure of *Domestic Water Supply*. Key indicators for this measure are: Supply, Capacity, Duration, Reliability, Accessibility, Affordability, and Safety.

In both SMG and Water installations, a tier/score (1-5) is assigned to each Indicator and the final Measure-level score corresponds to the lowest scoring indicator in that particular measure. Although this may seem a conservative approach, it is nonetheless useful to identify bottlenecks and areas where intervention is needed to improve the service. When indicators span across a range of scores, only the higher-end score is considered. Overall, technical sustainability is evaluated by comparing the actual score (i.e, energy tier) in each village with the internal target set by Gram Oorja prior to this study, allowing for a comparison between expected and actual service delivered.

4.2 ECONOMIC SUSTAINABILITY

Economic Sustainability looks at the business model implemented, the cost-effectiveness of the solution as well as any contribution to of the installation to income-generating opportunities. This analysis looks at two primary measures of long-term financial viability of the model and system's ability to contribute to livelihood-related activities.

For Gram Oorja's SMGs, a clear indicator for the *Model Economic Sustenance* is reflected by the communities' ability to collect monthly tariffs through regular bills from each house, take care of O&M costs and plan for replacement of the battery tank at the end of life, usually predicted after five years of operation. In the case of Water installations, recurring O&M costs include maintaining the tank, pump, taps and pipes operational, with no external financial support needed. Particularly, this assessment looked at money flow in the bank passbook in each village, considering the total amount collected and deposited in the bank versus the expected amount at time of visit[3]. Recognising the difficulties faced in such remote areas to regularly visit the nearby bank to deposit money, particularly at times of high workload or severe weather conditions, passbook data is also corroborated with qualitative information from discussion with members of the Village Energy/Water Committees and local Operator, looking for references to timely tariff collection, instances of delayed payment and the type of response from the local committee in case of any financial issues.

To evaluate *Livelihood Generation*, the assessment focuses on the number of commercial activities and small businesses in the village, looking also for cases where electric appliances were purchased and used to help with existing businesses and crafts. Additionally, increase in productivity in farms, local businesses and/or crafts which are linked to electricity availability are also considered.

4.3 INSTITUTIONAL SUSTAINABILITY

Institutional Sustainability is regarded as the ability of the local governance organizations, structures and processes to ensure systems function as desired, providing an efficient and effective response when issues arise. This dimension looks at three main Measures: the degree of local ownership in the governance, the nature of community involvement and trust in the local governance, and the reported level of satisfaction with the institutional set-up, service and tariffs.

To determine the *Effectiveness of Local Governance*, the analysis looks at a mix of qualitative and quantitative data collected across key stakeholders at several levels. The primary data comes from interviews and group discussions held with VC members and local operators in each village. From Village Committee discussions the assessment considered the level of internal organization, signs for clear and transparent system to elect members and define roles. Additionally, accountability structures linking committee members, local operator, members of the community and external stakeholders like Gram Oorja or the local NGO are also considered. During community discussions, specific examples were asked around situations that required intervention from the committee, asking to describe how the village acted in these situations, if and how the community was able to handle the issue autonomously and any particular learning from the experience. Discussions with the local operator provides data to understand his/her ability to perform tasks autonomously and seek external help when needed. In order to corroborate the data, opinions from household interviews are also used to identify

[3] Assumptions for these calculations are:

- SMG: 1) 9Rs/Wh battery replacement costs 2) Operator salary of 500INR/month 3) Recurring O&M 750Rs/month 3) Connection charge paid by all Houses and deposited in the account.
- Water installations: 1) Op salary of 500INR/month 2) O&M costs of 350Rs/month

any contrasting view in the village. *Community Participation* is evaluated looking at household participation in governance meetings and perspectives on their ability to raise issues and influence change in the governance processes. Finally, *User Satisfaction* is measured at many levels, looking at perceived satisfaction of the household with the service, the institutional arrangements, the tariffs, as well as satisfaction of the village committees and local operator.

4.4 SOCIAL AND ENVIRONMENTAL SUSTAINABILITY

To evaluate *Social Sustainability* the report looks at two primary measures of *Household Wellbeing* and *Community Connectedness*. The first focuses on benefits around child education, health of the family, safety at home and in public places, women participation in energy-related systems of governance and sense of independence in the house. Additionally, an increased sense of connection, both within the community, arising from inclusive local governance, and with the outside world, due to communication technologies enabled by energy access, is captured in the community connectedness measure. Data used to measure social impact comes from a combination of qualitative data and quantitative remarks from household-level interviews.

Environmental Sustainability is measured on local and global scale as improvements in indoor air quality, and reduction in carbon emissions due to reduced kerosene usage respectively.

The definitions above result in five dimensions, 12 Measures, and 31 Indicators for SMGs. The framework for SMGs is visually depicted in Figure 3 a&b, where the last row represents the legend for the images.

4.5 COVERAGE OF THE ASSESSMENT

For this study a total of 304 households are surveyed across 24 SMGs, 6 of which are also provided with a solar pump for drinking purposes, and 20 solar water pumping installations (Table 2). At the time when the assessment began, Gram Oorja had a total of 28 operative SMGs and 68 Water pumps. With time, more installations were completed and the portfolio now counts for 33 SMG and 70 water pumps.

The assessment targeted 100% coverage for SMG installations and 30% for water sites. Four SMG sites were left out of the analysis due to lack of time from the locally appointed field staff to perform the visits at time of monsoon. In the case of Water installations, a smaller sample size was considered sufficient for a representation of these types of interventions, as similar features and characteristics emerged during site visits.

In each village, interviews were carried out with 15-20% of the households, randomly selected to provide a representation of a range of social and economic segment in each village. Group discussions with Village Committee members and local operators were held in each location and data collected from control room, meter readings, and passbook of village bank account. Table 2 highlights the overall coverage for the assessment. For a breakdown of sites, location and total number of household surveys refer to Table 5 and Table 6 in Appendix.

Table 2 Overview of sites covered

Installation Type	Villages served at the time of survey	Villages Surveyed	HHs surveyed	People interviewed
SMGs	28	24	161	986
Solar Water Pumps	68	20	143	873

The data were gathered between July and December 2017 by trained local staff in 5 different geographical locations or clusters of villages (Jawhar, Melghat, Jarkhand, Karnataka and Junnar) and analysed between January and March 2018 by independent researchers who are also the authors of this report.

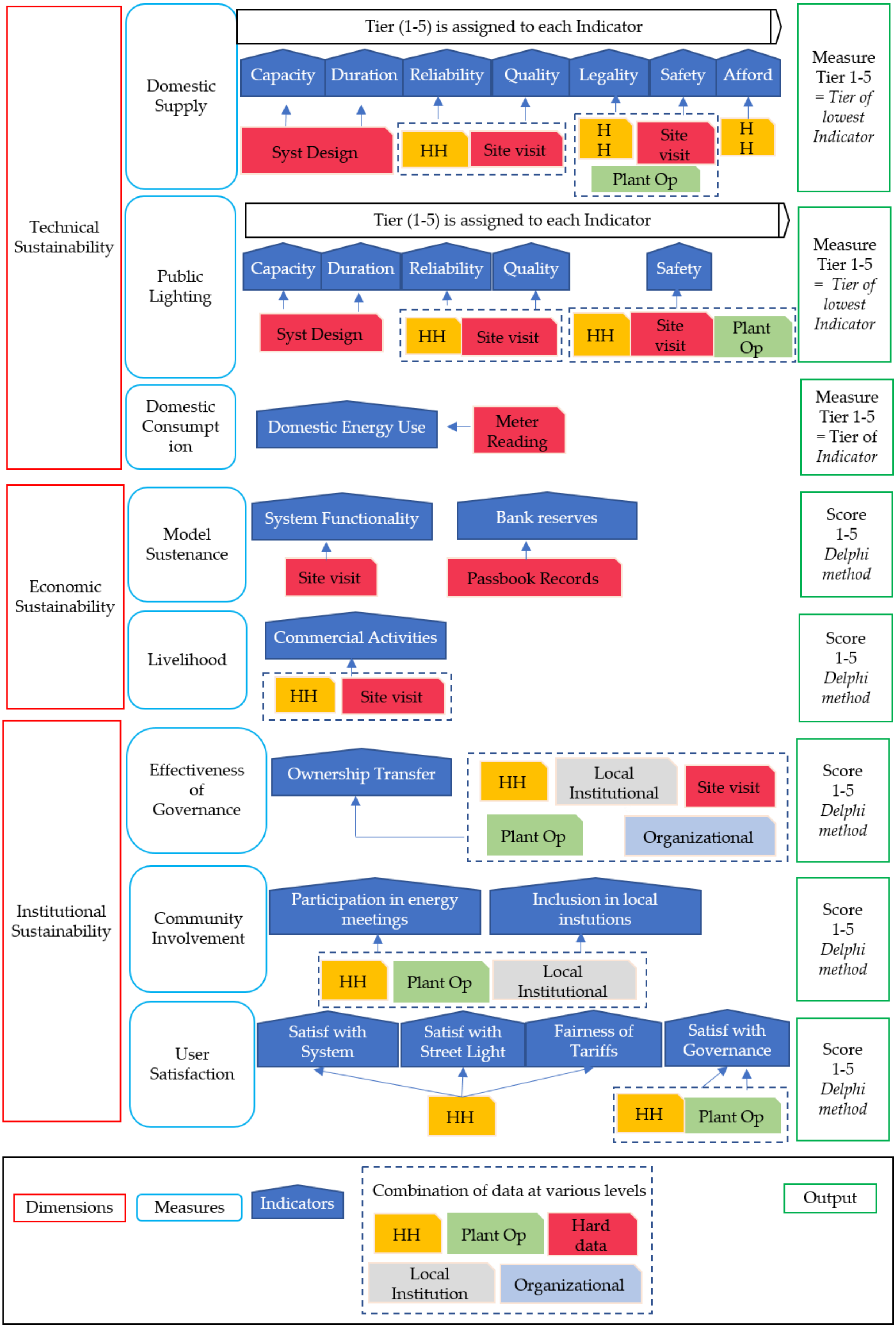

Figure 3a Framework for SMGs: Dimensions, Measures and Indicators

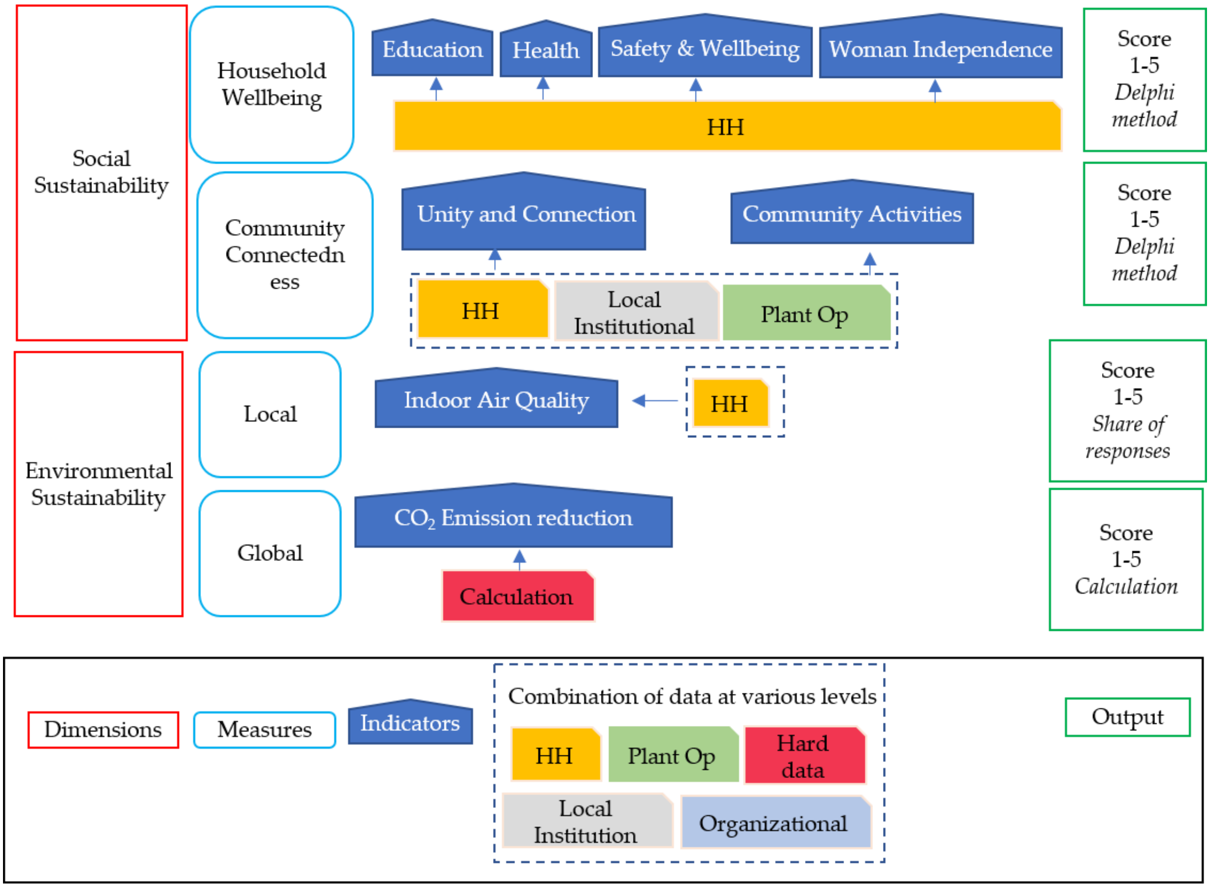

Figure 3b Framework for SMGs: Dimensions, Measures and Indicators

5. RESULTS AND ANALYSIS

This section presents results from the assessment, covering all sustainability Dimensions and Measures. Complete set of scores are presented for all SMG installations across all five dimensions, whereas for water installation results are only presented for the technical and social areas. As a matter of clarity and brevity, a full assessment of water sites across the remaining areas will be provided in a separate report.

Starting with *Technical Sustainability*, Figure 4 shows measure-level scores across all SMGs and Waters installations in pie charts showing the percentage of audited projects falling under each tier for Domestic Supply, Public Lighting, Energy Consumption and Water supply and compared to the internal target.

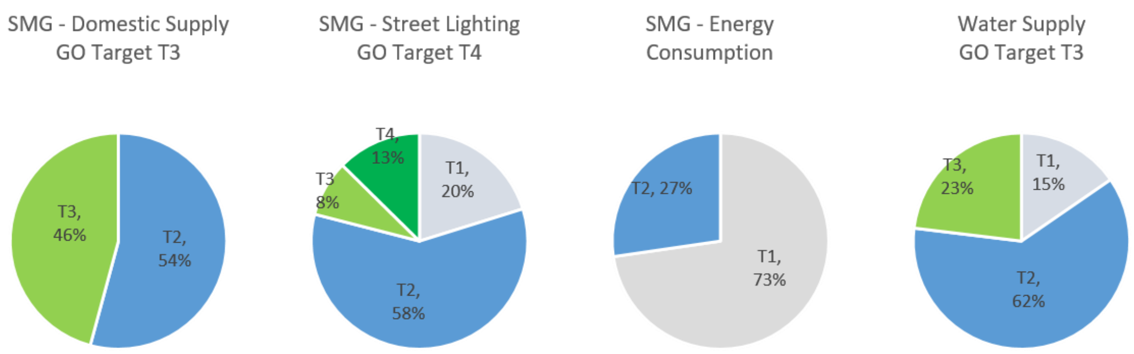

Figure 4 Technical Sustainability - SMGs and Water installations

Mode tiers for each indicator across all sites is also presented in Table 3. Highlighted in red are the lowest scoring Indicators, which are to be intended as the 'limiting factor' to higher performances, hence highlight priority areas of intervention to improve the service. Internal targets set by Gram Oorja are also highlighted in a separate column. Figure 13 in the Appendix presents a breakdown of Technical indicators showing the percentage of villages under each score, comparing operative performance and internal targets. The details for each measure and indicator are discussed below.

Table 3 Operational and Target Tiers for Technical Indicators

Indicator	**SMG – Domestic Supply**		**SMG- Public Lighting**		**Indicator**	**Water Supply**	
	Mode Tier	**GO Target**	**Mode Tier**	**GO Target**		**Mode Tier**	**GO Target**
SMG/SL Capacity	3	3	3	4	Supply	4	4
Duration	5	4	5	4	Capacity	3	3
Reliability	4	4	4	4	Duration	3	3
Quality	5	5	2	5	Reliability	3	3
Affordability	4	4	NA	NA	Accessibility	3	3
Legality	5	5	NA	NA	Health	3	5
Safety	5	5	5	5	Affordability	4	4
					Safety	5	5

Domestic Supply for the SMGs shows consistent performance where all sites score between the second and third, in alignment with internal target set by Gram Oorja. The limiting factor for this measure is the SMG's installed *Capacity,* highlighted in red in the table above. This is a design characteristic, which for Gram Oorja installations is around 200 Wp per household. The capacity installed is usually decided considering each village's expectations for energy use and aspiration for growth, internal paying capacity, and available capital costs. About a third of the villages assessed in this study had and the installed capacity designed to correspond to the high end of Tier 2, just little below 200Wp. *Duration* and *Quality* of supply all showed high scores: 96% of sites and reported having a continuous 24x7 supply (tier 5) and 88% had limited or no issue with power quality (Figure 13) since about 46% reported a maximum of 1-2 days without power in monsoon months (tier 4), corresponding to the internal target for Gram Oorja. On the other hand, 29% also registered more than 5 days of power outages in the monsoon period which is attributable to weather conditions particularly severe in these locations. Particularly, at time of visit, the majority of the sites in the region of Jharkhand were affected by severe weather conditions, with lightening damaging system's components and leading to poor reliability in this area. The issue was however fixed in the following weeks after the visit and operation was quickly reported as back to normal. Some reliability complaints were also reported during summer times, particularly in few villages in Jawhar area, where utilization of inefficient fans at night led to quick discharge of the batteries. Most of the houses reported good levels of *Affordability,* with 83% performing at or above the internal target of tier 4 (Figure 13). A small number of sites described regular payment delays. However, households in most cases are able to handle payments in the following month when money became available, very seldom leading to complete disconnection of houses from the grid. High scores for *Legality* of connections and *Safety* of installation) with all sites performing at expected levels, indicates that the systems are well designed.

The measure of *Public Lighting* reveal relatively poor performance. The explanation for deviation of performance of *Reliability* is same as that for Domestic Supply. Data reported from houses outside the centre of the village also highlights that *Capacity* and distribution of poles is a limiting factor, with availability of illumination often limited to few poles in central areas of the village. The biggest issue with Public lighting is however the *Quality* indicator, where only 29% of villages performed at the desired level. Quality of the infrastructure is reported as poor, meaning that the majority of the poles installed were found to be either faulty or not functioning. Of the approximately 170 poles installed, over 40% were not functioning at time of visit and five villages had no functioning streetlight. Major issues reported were due to either faults with the LED lamps, broken timer, or monsoon rain entering the casing and causing short circuits. From discussions with local operators, actions had been taken to contact Gram Oorja to assist with the issue however no prompt response was provided in the majority of the cases.

Service for *Water Supply* appears to be of a moderate quality with the majority of sites ranking in the second tier. *Capacity* and *Duration* of supply are adequate (Figure 13). Due to water scarcity issues in the area of Jawhar, where all installations surveyed for this report are located, almost all villages experience around 2-3 months of water scarcity in the year, leading to reliability score of 3 for 75% of villages. Accessibility is adequate as 76% of the households report spending around 5-10 minutes to collect water each time indicating significant savings in time. As compared to SMG installations, where all sites were operative at time of visit [4], three installations were found not operational due to severe technical issues or internal disputes leading to complete shutdown of the plant[5]. Generally, respondents reported a 30% increase in the amount of water used on a daily basis by each household, translating in significant improvements in personal hygiene and sanitation. Water availability allows for around 50 Litre per person per day, in line with WHO directives of medium requirements to ensure decent level of health and sanitation. Despite this, the amount of water consumed by each household remains 120 Litres, thus suggesting a lower usage than the maximum availability. Remarks from field staff highlighted slight concerns around the quality of water, particularly pointing at cleanliness of the tank as a slight cause of concern. For this reason *Health* registered a score of Tier 3 in 74% of sites, and Tier 2 in 13% of sites, which is a cause of concern. No issues with *Affordability* nor concerns over *Safety* of installation were reported.

Data on daily household *Energy Consumption* was gathered from meter readings in the control rooms at time of visit and averaged across all households in the village, considering the difference between time of survey and

[4] Issues detected with SMGs were temporary and action was promptly being taken to fix the issue : 1) Jharkhand sites had fault of the inverter due to heavy monsoon rains 2) Viral had fault in the inverter probably due to central Grid construction work 3) Humranpada lines were temporarily off but fixed within a week.

[5] Kanhatpada, Kudawa and Andheri were found to be inoperative for many months with no plans on commencing operation soon

time of installation. Figure 4 shows that household energy consumption remained largely low across all sites, with 73% of villages ranking in the first Tier. For the types and profiles of villages surveyed, the benchmarks provided in the MTF tends to flatten results to the first two tiers, which span between 12 and 1000Wh per household per day. Internal expectations from GO on energy consumption levels are represented by a linear growing trend starting from 70Wh/day per household at the start of the project, reaching 750Wh/day achieved after 5 or more years of installation. A display of raw values of energy consumption in each location plotted against time from installation reveal more significant information.

In the plots below (Figure 5), time dependency appears along the X-axis and scores are presented on the Y-axis. Different colours refer to different geographical areas and the diameter of the circles are proportional to the number of households served by the installation in each village. Particularly, sites in Jarkhand, Jawhar, Melghat, Karnataka, and Junnar are colored in Green, Yellow, Red, Violet and Blue respectively. In Figure 5, where the black dotted line represents Gram Oorja's internal target for energy consumption.

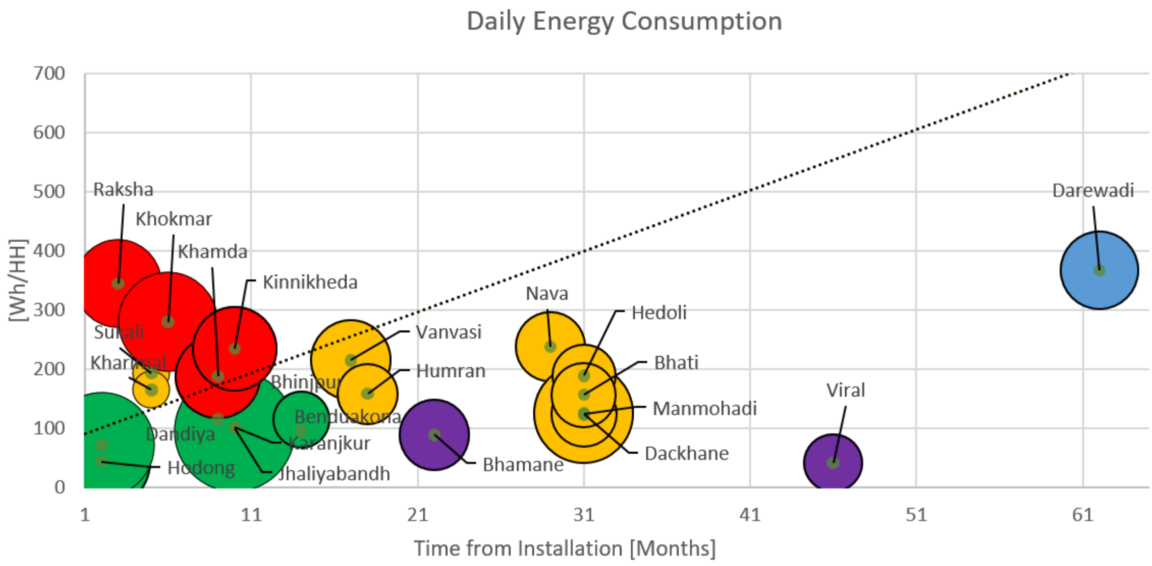

Figure 5 Household Daily Energy Consumption

Generally, daily electricity use per household varied between 100 and 400Wh, with significant variation registered across sites. This spread in energy consumption however decreases when considering sites within the same cluster (same color), thus suggesting a possible influence of geographical location or cultural profile of the communities. Surprisingly, the assessment did not reveal a growing trend of energy consumption with time from installation, as expected by Gram Oorja. Particularly, installations in Karnataka (Purple) and Jawhar (Yellow) had limited energy consumption, despite being operative for longer periods of time. On the other hand, consumption in younger installations like Melghat (red) was generally higher than expected.

Energy consumption levels in each village can be linked with the Economic measure of *Livelihood Generation* (Figure 6) to understand whether sites that are showing higher energy consumption are also engaged in productive/economic activity using electricity.

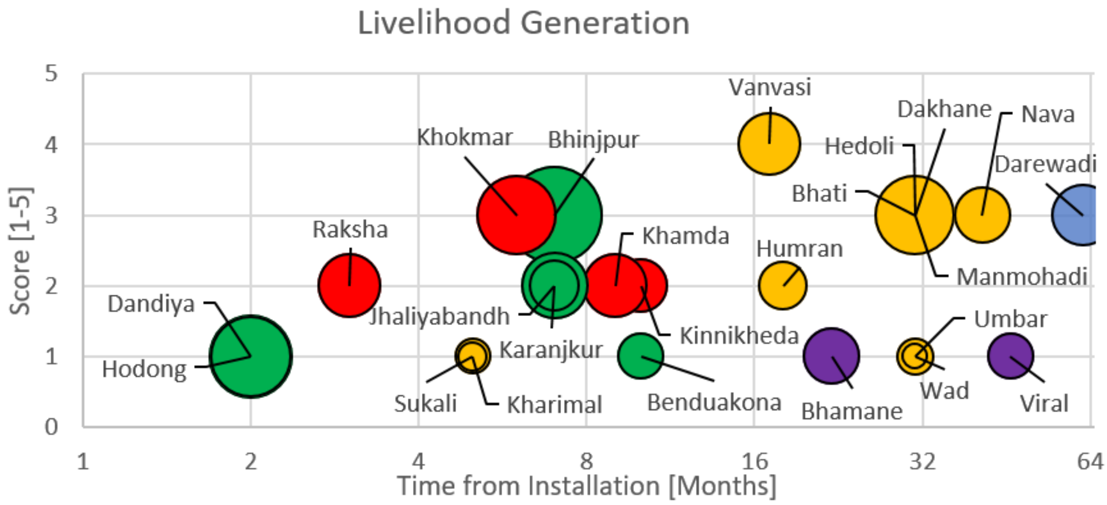

Figure 6 Economic Dimension - Livelihood Generation for SMGs

A closer look at Figure 6 reveal fairly limited engagement in productive activities in the villages, and a mode score of 1. In the SMGs visited, a total of 29 appliances used for commercial purposes were found. These include:

- 15 machines for processing agricultural crops (flour mills and rice hullers) of which:
  - 9 fully operational
  - 4 not operational but plans were in place to fix the machine in the near-to-long-term future
  - 2 not operational with no plans in place for fixing the machine
- 15 shops/small businesses of which:
  - 10 shops purchased an electric appliance such as fridge or cooler
  - 5 shops using only light and no other electric appliance
- 3 small water pumps for irrigation
- 4 craft activities (wood or carpentry) of which 1 purchased an electric drill

Of the surveyed sample, 28% mentioned having some idea or interest in engaging in a new business linked to energy use, particularly expressing interest in purchasing solar water pump for irrigation, flour mill, or fridge for existing shop. The main reasons mentioned by households for not having invested money in purchasing electrical equipment were a combination of money constraints and limited incremental revenues expected from the purchase of any electrical equipment.

The revealed mismatch between high-quality power supply and low levels of domestic consumption, and limited engagement in business activity, suggests that there may be other factors, beyond provision of durable, reliable and affordable supply, influencing the approach communities have towards electricity available at home.

Firstly, village characteristics such as such as size, wealth and accessibility, as well as the local culture and norms of the beneficiaries was key. Particularly the assessment reveal that all villages of less than 10-15 houses have not engaged in any productive activity (Wad Pada, Umbar Pada, Sukali Pada, Karimal) and are not reporting any direct economic benefit from the solar installation. Overall the small, isolated and relatively poor communities where GO operates, provide limited opportunities to establish local businesses that can be successful in isolated and remote environments. Accessibility issues and lack of infrastructure also limits linkages with external market, restricting commercial activities to those linked to agriculture and use of natural resources. Additionally, socio-cultural profiles of these communities, which generally tend to be conservative and wary of changes in established habits, was also found to limit individual entrepreneurial initiatives, ultimately affecting the collective approach towards electricity provision.

Secondly, some repeatedly pointed at the need for support and guidance in order to venture in business activities, as pointed in Testimony 1. In some villages, small productive loads such as flour mills provided at discounted rates during project implementation phase, had marked positive effect as it inspired other houses to venture in small business activities.

Thirdly, misconceptions around energy availability during daytime and the ability of the system to supply enough power and support larger appliances was also found to be a reason for limited engagement (Testimony 2).

"If some hand holding is done and support is provided, we could venture into some business activity in future. It gets very difficult to start as of our own" – **Testimony 1**

"We saw it [i.e., the flour mill] was broken down. However, we noticed the power is too low and the voltage also is no enough to run it. So we left it unrepaired" – **Testimony 2**

Looking at the Economic *Model Sustenance* (Figure 7) the assessment indicates reasonable performances, with majority of sites ranking in the range of 3 or above. Overall, this shows that tariffs are affordable and set at a level that ensures adequate revenues for O&M and savings to be built in time. Effective mechanisms for money collections and deposits are established in the majority of villages, Village Committees are generally able to enforce late fees and eventually disconnect houses if payments are not met for prolonged periods of time. Most of the bank passbook[6] accessed during this analysis showed some degree of engagement in the process of money collection and deposits, and an average of 60-70% had been deposited in the bank accounts against the total expected amount at time of visit. Particularly noticeable are villages of Raksha, Bhamane and Vanvasi Pada, all of which have reached almost 100% collection rate. Success in these cases are due to rigorous and accountable methods for money collection, including transparent calculation of bills, receipts provided to each house, enforcement of late payments and eventual disconnection if needed. On the other side, sites like Wad Pada and Umbar Pada, seemed to have completely stopped collecting money several months before the assessment visit and it was unclear as to when payments would have started again. Sites in Jharkhand also performed relatively poorly compared to others due to technical issue encountered with the inverter after only two months from installation. Village Committees in these sites decided to halt collection of tariffs until the moment when the issue with inverter would have been fixed. Some sites in Melghat (Kinnikeda and Khamda in particular) also points to some degree of concern and require continued attention. Particularly, Committees in these villages unanimously decided to lower the tariffs, was not able to enforce late penalties or disconnection of houses, and tariffs collection was not happening on a regular basis.

[6] Of 24 SMG sites, 14 passbooks were inspected at time of visit. For the remaining 10 installations data on money available in the village account was retrieved from discussion with VEC when discussing the status of payments. Additionally, this report assumes that connection charge had been paid and deposited by all houses connected to the SMG.

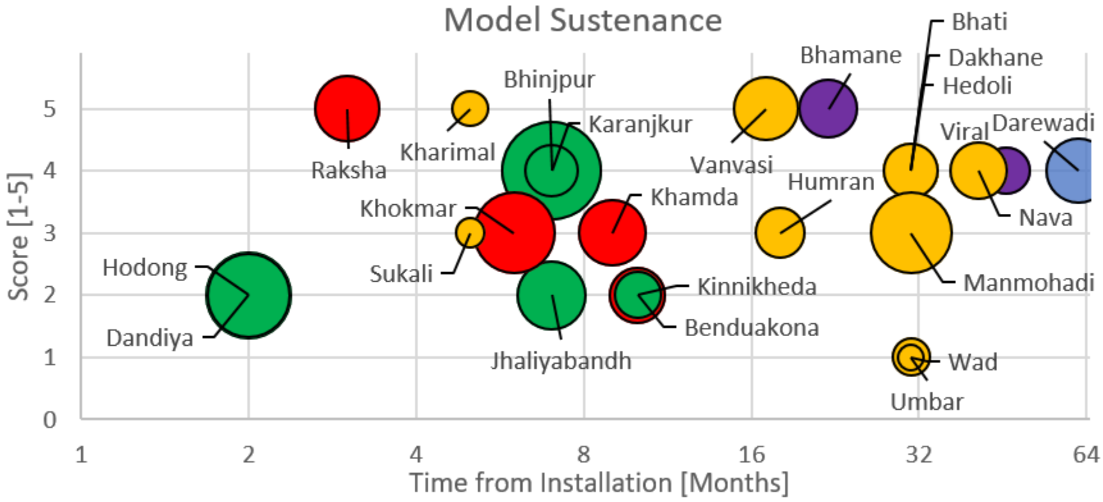

Figure 7 Economic Dimension - Model Sustenance for SMGs

The Institutional measures of *Effectiveness of Governance* (Figure 8) and *Community Participation* (Figure 9) generally show high scores across all sites and a growing trend with time of installation. This suggests that institutional capacity and community participation established through Gram Oorja's community model is able to sustain and reinforce with the passage of time. Particularly, effective local governance structures are created when time is allowed for local institutions to establish and prove their ability to address issues and manage the system over longer periods of time. Exceptions to this observation are small sites in the area Jawhar (Wad Pada, Umbar Pada and Sukali Pada), where internal disputes and divisions pre-existing to the SMG installation, may have played a role in a sense of disengagement, leading to low levels of governance effectiveness. Additionally, sites where woman have more prominent voices as members of the Committees and actively participate in meetings, seem to be able to establish more effective governance structures, being also able to ensure model sustenance (Bhinjpur, Kharanjkur, Vanvasi Pada)

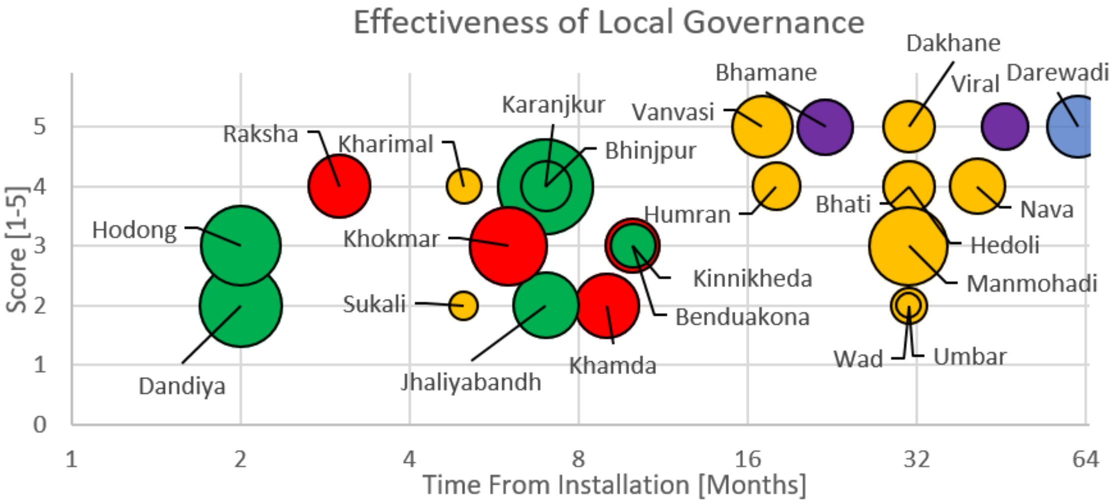

Figure 8 Institutional Dimension – Effectiveness of Local Governance for SMGs

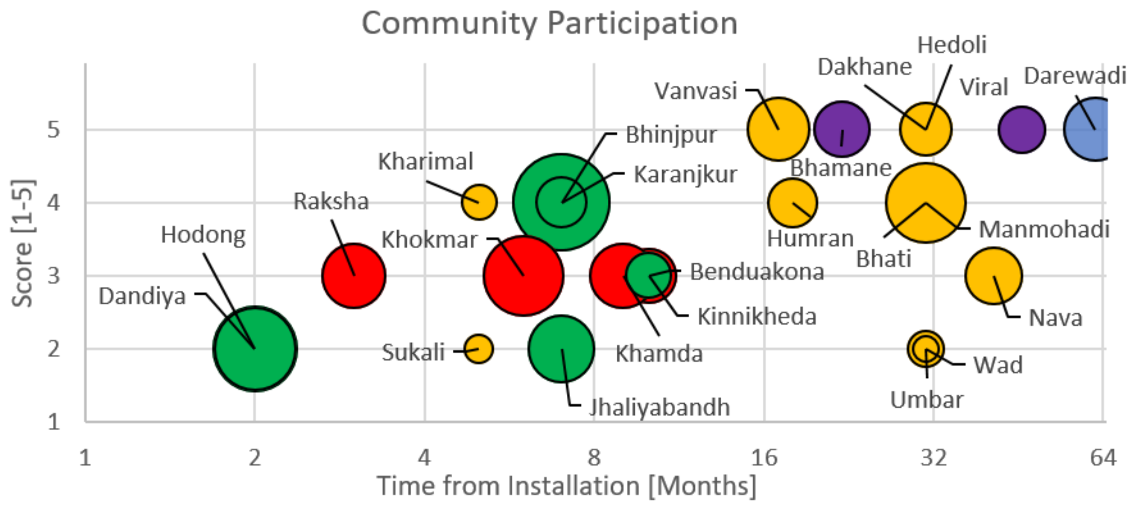

Figure 9 Institutional Dimension – Community Participation for SMGs

Overall, 74% of respondents mentioned a feeling of the community being able to take care of the solar grid, in many cases mentioning a feeling of pride in the fact that the installations were managed entirely by community members. Regular attendance at meetings across all SMG sites was reported by 77% of households and 58% thought meetings were useful occasion to discuss and address issues internally. Particularly, the localized dimension of the institutional set-up and the knowledge of those accountable and responsible for the operation of the plant, was a key driver for community engagement and participation (Testimonial 3).

"THEY [THE VILLAGERS] ARE FREE TO RAISE THEIR ISSUES WITH US. THEY COME TO THE MEETINGS WHEN THEY HAVE AN ISSUE AND WE TALK TOGETHER TO ARRIVE TO AT A SOLUTION. IF IT WERE THE CENTRAL GOVERNMENT THEY SIMPLY WOULD NOT KNOW WHERE TO RAISE THESE ISSUES." – ***TESTIMONIAL 3***

Communities also reported high levels of satisfaction with the system (Figure 10*),* generally scoring 3 or above. Also in this case, older installations reported higher levels of *User Satisfaction*, following a similar pattern as that shown by *Community Involvement* and *Effectiveness of Governance*. This suggests a strong link between the three Institutional measures and their central role in driving economic model sustenance and ultimately long term success of the community-led interventions.

Good quality and reliable power supply, and few issues reported by households with domestic installations, fitting or lamps resulted in over 78% of respondents mentioning being 'very satisfied' with the service provided at home. Marked dissatisfaction however was reported with the status of street light as 50% of those interviewed openly expressed feelings of dissatisfaction with the service in public spaces. Regarding affordability, 84% of respondents across all SMG installations reported a feeling of charges being adequate and fair. Additionally, many of the local operators interviewed also expressed interest in receiving more technical training, and become more independent when addressing issues locally. Like for other measures, also in this case some of the sites in Jharkhand (Green) generally reported lower level of satisfaction with the installation and lower institutional participation and effectiveness. Again, the issue with inverter encountered at the early stages of installation was the main cause of this feeling of disengagement and low participation. Generally, smaller villages in the area of Jawhar (Wad Pada, Umbar Pada and Sukali Pada) also expressed lower satisfaction, referring to low capacity available at home, and very limited ability to power appliances when needed.

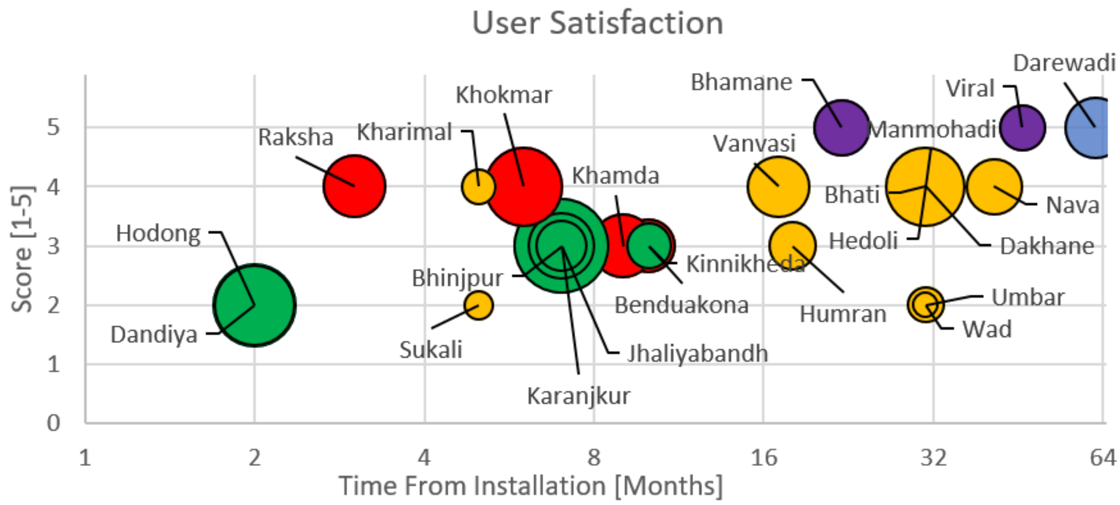

Figure 10 Institutional Dimension – User satisfaction for SMGs

Social and Environmental dimensions also showed high-to-moderate impact across all measures. In this case, results are presented in pie charts, highlighting the percentage of projects under each score for *HH-Wellbeing*, *Community Connectedness*, *Indoor Air Quality*, and *CO_2 emission reduction* are coloured in Red, Green, Blue and Grey respectively (Figure 11).

Overall, factors that limited higher social impact were due to limited participation of women in institutions, their reported sense of empowerment and the limited nature of perceived benefits from the installation to their lives. Additionally malfunctioning street lighting was reported by several users as a cause of limited sense of safety at night for women and children, generally lowering the measure for wellbeing and connectedness. Lower scores for air quality were mainly determined by cooking habits since all houses are reliant on firewood for cooking. Additionally, many also used clean SHS and solar lantern for lighting before the SMG arrived, hence reporting limited perception of improved air quality in the house. Regarding kerosene use for lighting, houses reported a decrease from 4L to around 1L per month, a decrease of 75%. Only 9% of the respondents mentioned using kerosene for lighting on a daily basis and over 40% mentioned having completely stopped using kerosene for lighting purposes. Despite this, households still purchase their allotted amount of subsidized kerosene from the ration shop, using what's available for purposes other than lighting.

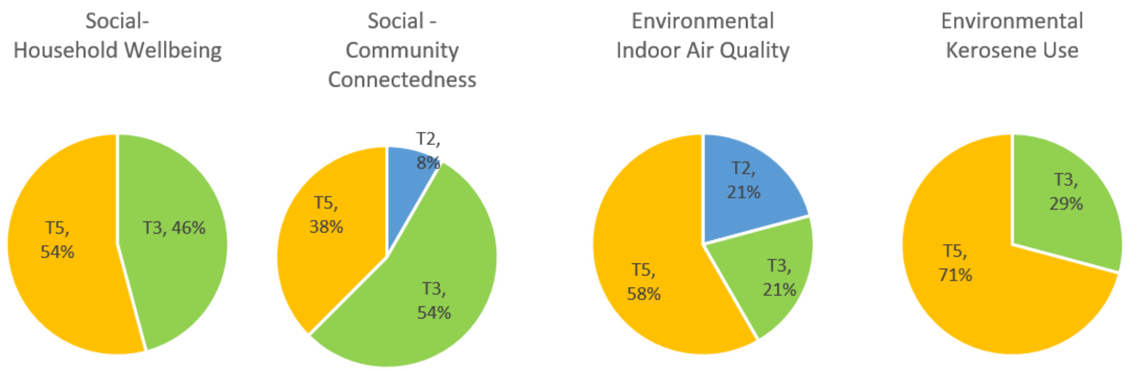

Figure 11 Social and Environmental Scores for SMGs

Table 4 shows aggregated values for significant indicators across all SMGs and water sites. Qualitative data collected from individual household in the form of remarks during interviews also provided key insights to evaluate social impact on individual households and are presented below.

Table 4 Indicator values for Social and Environmental Dimensions

SMG		Water Installation	
Extra time for children's education	0.7 hrs/day	Positive effect on Education (particularly for girls)	90%
Woman reporting improvements in indoor air quality	62%	Woman reporting health improvements	95%
Feeling of improvements in eye sights, reduction in respiratory diseases	60%	Feeling of improved quality of water and reduced water-related health issues	96%
Feeling of increased safety at night for woman	92%	Feeling of improved sanitation and personal hygiene	95%
Feeling of increased safety at night for children	85%	Woman feeling of reduced accidents caused by travelling to fetch water	97%
Feeling of reduced accidents in house previously caused by use of fire/ kerosene	67%	Houses where daughters used to accompany their mother to fetch water regularly and now have more free time	86%
Feeling of reduced accidents previously caused by encounters with wild animals	78%	Extra time available for woman to engage in productive activities	0.80 hrs/day
Feeling of connection within the village & outside world	83 %		
New community activities in the village	34%		

Particularly, remarks on better opportunities for children's *education* were reported in terms of increased time availability to study in the evenings, improved grades at school and better environment for children to grow and live (Testimony 4). Families who benefitted from water installations were also particularly vocal in expressing satisfaction for better opportunities for girls, who no longer had to accompany their mothers fetching water on most days and could now enjoy more free time and concentrate on studies.

"Before the kids used to come home after school at 5 in the afternoon and only had 1 or 2 hours to study and play with the other kids before darkness. As soon as it was dark they had nothing to do at home and were getting very bored. Now even in the evening I allow my children to go out and play with other kinds. They are much happier now" – ***Testimony 4***

Among adults, many also referred to opportunities to learn about electricity and water issues since these topics were being frequently discussed during meetings. Local operators also were appreciative of the training received and showed interest in learning more about technical functioning of electronic equipment and management of finance.

With regards to *Health*, increased hygiene and sanitation were reported in the majority of the cases. For SMGs, qualitative remarks mainly pointed to increased cleanness of the house as woman were able to see better with artificial lights as they clean in the evenings. For water sites, reduced water related diseases, mainly stomach ache and diarrhoea, and better health for woman, thanks to reduced bone pain and neck ache, were reported.

Many remarks also points to increase sense of safety at night thanks to public lighting and woman enjoyed being able to visit friends and other family members in the evenings. Limited functionality of street light in some villages however was also mentioned as a cause of discontent. (Testimony 5)

"I often go to visit other woman in the village in the evening and chat. I was very scared before because it used to get very dark in the evenings and the batteries [eg. portable torches] *are not enough for good vision. I am sad that now lighting outside is not available and I hope it will be fixed soon."*

Testimony 5

Improved comfort and general sense of an 'easier life' also emerged. Women generally enjoy more time and flexibility when performing household tasks, are more productive in the farms and businesses, and are able to spend more time with family and children. Many mentioned a sense of empowerment and ability to use the extra time to participate in village-level meetings, Self Help Groups and other women activities, particularly in water installations.

In terms of overall *Community Empowerment*, there is a strong feeling of increased connectedness within the community and a general sense of unity created within the village. Many interviewees mentioned for example how people were more willing to help each other out since the water/solar installation had started. SMG users also reported ability to better connect with the outside world through TVs, which in many cases acted as a gathering space for the villagers, also taking pride when people from outside the village came for visits. Additionally, increased opportunities to communicate with other family members living in other villages thanks to mobile phones was often mentioned as a source of happiness. However, we observed that greater connectedness did not lead to an increase in new community level initiatives in the villages, with exceptions being collective engagement in building of a temple in the village.

6. CONCLUSIONS AND RECOMMENDATIONS

Some key themes emerged from the assessment of Gram Oorja's sites. Firstly, Gram Oorja's model demonstrated its ability to provide high quality, durable, reliable and affordable power supply with consistent technical performance across many years. Performance are largely in line with internal expectations and the variance registered can be largely attributed to teething problems with the Jharkhand cluster which however is not significant enough to pose threats for overall technical sustainability. Smaller installations of the size of around 10 households also need some attention due to complaints over Capacity, Quality and Reliability, particularly relevant in such small installation. This poses questions as to whether community-level SMGs systems are feasible for such small villages or if alternative house level solutions such as SHSs might be preferred.

Service for public illumination was found to be relatively poor, with significant variance of service capacity and quality against targets. This is a cause of concern and requires attention. Good quality illumination in public spaces is crucial as it impacts directly the social dimension, affecting woman's freedom of movement, determining the sense of safety and enhancing the liveability of villages in evening times. Additionally, availability of public illumination is a key factor to favour more costly village-scale DRE installations compared to cheaper household level solutions such as SHSs. If Gram Oorja's village SMG model is to make financial sense, functionality of street light must be ensured. To address this issue we recommend that:

- Operators should be trained to monitor the operational status of street lighting and perform basic repairs independently, particularly if the issues are minor like malfunctioning of the timer
- Village Commitees can be supported by providing decision-making authority and purchasing procedures to autonomously manage small repairs and select desired level of service
- Repairs that need intervention from GO or other contractors should be clearly defined, offering prompt responses to issues when these are raised by the communities.

Installations providing solar-powered water supply indicate considerable positive social impact in the form of increased household wellbeing and community connectedness. The impact on the lives of women and girls is significant as considerable amount of time is saved from trips to fetch water. This resulted in cascading positive effects reported in the form of better health and reduced back and neck pain. Health benefits also extended to all other family members as sanitation and personal hygiene improved. Although the percentage of cases where cleanliness of tanks was reported as low is not alarming, there is an opportunity for Gram Oorja to train the operators and committees to monitor the service ensure higher quality of water is maintained.

Low levels of energy consumption and limited engagement in livelihood activities remain a barrier to socio-economic development in all communities visited. This reveals limitations in the model to encourage utilization of energy for productive activities and facilitate rural consumers to climb the energy ladder. Despite systems are designed to provide reliable and high quality power supply, and the fact that spare capacity is available to connect more domestic and commercial appliances, the increase in energy consumption with time does not seem to be happening. This mismatch between supply and energy consumption, regardless of how long the system has been operational, represents a key area where intervention from all stakeholders is needed to ensure that greater impact is delivered. Firstly, both the local NGO and Gram Oorja could take steps to help communities understand the opportunities that access to electricity provides beyond domestic illumination. To facilitate pure organic growth in consumption, any fear that increase in consumption lowers the amount of electricity available for basic lighting must be addressed. Methods such as the traffic light system at the Isle of Eigg in Scotland [10] could potentially be useful to address this issue. Education around the type of appliances that are compatible to the SMGs and awareness of energy efficient appliances could also help to ensure longer lifetime of the installations and lower electricity bills to households. To proactively support socio-economic development and commercial activities, funds from the initial grant capital could be invested to provide productive appliance at discounted rates to willing houses. This mechanism has already proved to be effective in demonstrating and piloting use of small productive loads in villages, inspiring other households to follow the example.

Additionally, it is important to ensure that benefits from social development programs, including those providing access to electricity and clean water, are equally distributed to all members of the communities, across gender, casts and ethnicity. This assessment particularly revealed that, when women are included and able to participate in governance process, systems are more just and chances of establishing successful governance increase.

From a look at the interconnectedness of various sustainability measures (Figure 12), this assessment concludes that a key factor for Gram Oorja's model to succeed relies in a combination of technical proficiency of installation and strong social engagement and interaction with the communities. For user's to be satisfied, a high quality service should be provided, meaning a reliable, readily available and affordable service where rates are perceived to be fair based on actual utilization of energy. Strong community engagement at all stages of the project is crucial to create effective local governance for community-owned installations. Guiding the communities at the early stages while local institutions are being built is crucial. This enables institutions to establish, gain trust from community members and the authority to establish and enforce procedures. Once the governance is strong, communities are involved and participate in the ongoing management of the installation, ultimately ensuring economic sustenance of the systems. This, coupled with high technical performance results in satisfied users, ultimately leading to the well-being of communities. This, by far is the most important finding from the independent assessment.

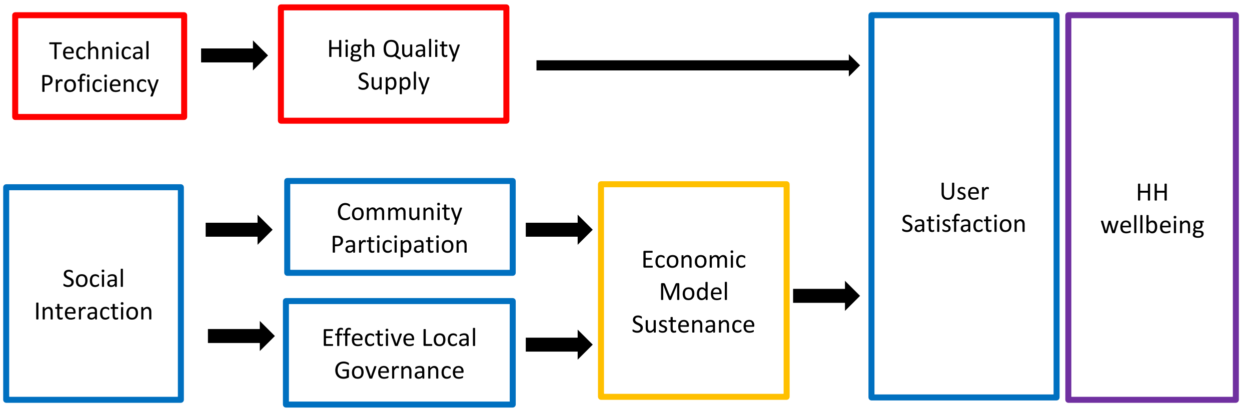

Figure 12 Multi-dimensional correlations to ensure GO's model success

We conclude with high-level of confidence that Gram Oorja's model can provide access to electricity in remote rural communities sustainably and generate positive social impacts. Although the model uses grant donation to cover installation costs, recurring O&M costs are bore by the communities who should generate enough capital to pay for the replacement of the battery with no external financial support needed. As mentioned earlier in the report, the costs for extending the central grid to such remote small villages where limited levels of energy consumption are expected, would require a per unit tariff that is several times higher than that in Gram Oorja's model. Additionally, the uncertainty surrounding GoI's plans for electrification of these communities makes DRE systems a valid alternative to supply reliable power to these communities for the foreseeable future.

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APPENDIX

Table 5 SMG -List of all Villages covered

Village	Location, State	Capacity [W]	Completion date	HHs served	HHs Interviewed
Darewadi	Pune, MH	9360	04-Jul-12	39	6
Viral	Uttar Kannada, KA	5040	13-Mar-14	22	5
Bhatipada	Palghar, MH	6000	03-Apr-15	27	9
Hedolipada	Palghar, MH	6000	13-Apr-15	26	16
Dakhanechapada	Palghar, MH	6000	12-Apr-15	28	7
Manmohadipada	Palghar, MH	10500	08-Apr-15	63	16
Umbarpada	Palghar, MH	2000	11-Apr-15	14	3
Wadpada	Palghar, MH	1500	05-Apr-15	7	2
Navapada	Palghar, MH	6000	12-Jun-15	32	16
Bhamane	Uttar Kannada, KA	3000	21-Mar-16	32	3
Humranpada	Palghar, MH	4900	28-May-16	24	6
Vanvasipada	Palghar, MH	8820	31-May-16	41	10
Kinnikheda	Amaravati, MH	7020	17-Nov-16	32	7
Khamda	Amaravati, MH	11700	23-Nov-16	46	7
Benduakona	Gumla, JH	7500	23-Nov-16	21	5
Bhinjpur	Gumla, JH	18000	24-Feb-17	91	6
Jhaliyabandh	Gumla, JH	9000	04-Mar-17	44	5
Karanjkur	Gumla, JH	7500	04-Mar-17	26	4
Khokmar	Amaravati, MH	11700	06-Mar-17	62	6
Raksha	Amaravati, MH	9600	02-Jun-17	48	8
Kharimal	Palghar, MH	3120		13	3
Sukalipada	Palghar, MH	3120		9	3
Dandiya	Khunti, JH	13500	22-Jul-17	69	4
Hodong	Khunti, JH	11250	25-Jul-17	61	4

Table 6 Water Installations - List of all villages covered

Village	Location	Completion date	HHs served	HH interviewed
Pardhipada	Palghar, MH	20 January,2012	30	5

Borichaghoda	Palghar, MH	21 August,2013	45	Visited
Meghwalpada	Palghar, MH	6 April,2014	25	5
Wakichapada	Palghar, MH	7 April,2014	20	4
Dongaripada	Palghar, MH	15 February,2015	NA	5
Kanhatpada	Palghar, MH	16 March,2015	15	4
Pasodipada	Palghar, MH	12 March,2015	46	11
Karoli	Palghar, MH	12 March,2015	63	8
Asaranagar	Palghar, MH	13 March,2015	27	7
Zappada	Palghar, MH	14 March,2015	125	18
Osarvihira	Palghar, MH	17 March,2015	25	5
Kudawa	Palghar, MH	18 March,2015	57	7
Sutarpada	Palghar, MH	16 April,2015	57	10
Umbarpada	Palghar, MH	11 Dec,2015	60	10
Beriste	Palghar, MH	11 Dec,2015	48	Visited
Saprewadi	Palghar, MH	12 Dec,2015	45	10
Vanganpada	Palghar, MH	14 Dec,2015	53	5
Nadgemuh	Palghar, MH	14 Dec,2015	44	6
Andheri	Palghar, MH	19 Jan,2016	115	Visited
Ambyachapada	Palghar, MH	1 Apr, 2016	7	Visited
Bhaupada & Sheltimal	Palghar, MH		30	6
Chambilpada	Palghar, MH	23 May, 2017	75	12
Nirgudwadi	Palghar, MH	25 Jun, 2017	22	5

Table 7 SMG Domestic Energy Supply – Benchmarks for tiers across Indicators

Indicator	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Capacity (W/HH)	Min 3	Min 50	Min 200	Min 800	Min 2000
Duration	> 4 hrs > 1hr @ night	> 4 hrs > 2 hrs @ night	> 8 hrs > 3 hrs @ night	> 16 hrs > 4 hrs @ night	> 23 hrs > 4 hrs @ night
Reliability (monsoon)	Frequent outages > 5 days/month		2-5 days/month	1-2 days/month	No unscheduled outages
Quality	Frequent issues with V / *f*		Few issues with V/*f*	No issues with ability to use appliances	
Affordability	House unable to pay at time of collection and still in debt		House unable to pay at time of collection and facing difficulties in paying on following month	House unable to pay at time of collection but easily paid back the following month	No difficulties with regular payments
Legality	Illegal connections and irregularities with payments		No illegal connections and bills paid to authorized representative		
Safety	Unsafe connection and installation		Absence of past accidents and perception of risk in the future		

Table 8 SMG Public Lighting Benchmarks for tiers across all Indicators

Indicator	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Capacity (village coverage)	1 street light	> 25%	> 50%	> 75%	> 95%
Duration (Night)	> 2 hrs/day	> 4 hrs/day	> 50%	> 75%	> 95% s
Reliability (monsoon)	Frequent outages	> 5 days/month	2–5 days/month	1–2 days/month	No outages
Quality	No functioning lights	Failures, brightness flicker issues	No early failures, no issues with brightness, flicker, etc.		
Safety	Unsafe connection and installation		No perceived risk of electrocution due to poor installation or maintenance		

Table 9 SMG Daily Energy Consumption Tier

Indicator	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Daily Consumption [Wh/HH]	≤12–200>	≤200–1000 >	≤1,000–3425>	≤3425– 8219>	≥ 8219

Table 10 Water Installations – Benchmarks for tiers across Indicators

Indicator	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Supply	1 access point for > 10-15 HHs		1 access point for 10HHs	Abundant: 1 access point for 5HH	Water system piped into the home
Capacity	5-7.5 LCD	7.5-20 LCD	50 LCD	> 100 LCD meeting all needs.	
Duration	Once a day for less than one hour		Twice a day for a> 1hr	24 hour supply	
Reliability	Severe water scarcity (3+ months)		Moderate (1-2 mths)	No issue with supply in the year	
Accessibility	> 1km or 30 min for collection	btw 100m -1km or 10-30 min for collection	around 5 minutes for collection	Water on-plot	Water available at home
Health	*High concern*. Hygiene not assured, consumption needs may be at risk. Quality of water difficult to assure.	*Medium concern*. Not all requirements may be met. Quality of water difficult to assure.	*Medium - Low concern*: basic hygiene and consumption needs are met. Bathing and laundry possible on-site.	*Very low concern*. All uses can be met, quality readily assured.	

Affordability	User unable to pay for service and still in debt	User unable to pay for service and reporting difficulties in paying fee on following months	User unable to pay for service but easily paid back following month	No difficulties with regular payments
Safety	Unsafe connection and installation	Absence of accidents and perception of risk in the future		

Table 11 Economic Sustainability – Sustenance of the Model

Score	Description
1	System not operational. Information from community finances show little to no collections happening and no sign to re-establish the mechanism for tariff collections.
2	System is operational/partly operational. Information from community finances show big difference between expected and actual balance at time of inspection and energy tariffs are not being collected regularly by the local operator.
3	System is operational. Information from community finances show few deposits but quite sparse in time. Difference between expected and actual balance at the time of the visit may still be substantial but money collection happens regularly.
4	System is operational. Information from community finances shows regular and timely deposit. Difference between expected and actual balance at the time of the visit is small.
5	System is operational. Information from community finances show regular deposits and consistency between expected and actual balance

Table 12 Economic Sustainability – Score for Livelihood Generation

Score	Description
1	No economic activities in the village linked to energy use. Users are not reporting feeling of increase in productivity that can be linked to available electricity at home.
2	Limited livelihood generation activities in the village and limited increase in productivity registered
3	Few households are starting to use electricity and are purchasing applianced to help with existing businesses. A growing number of people in the village is also reporting increased productivity.
4	Few households have invested money to actively start a new business and purchase electrical equipment. Majority of people are also noticing an increase in productivity thanks to electricity at home.
5	Engagement in income activities is extended to few houses in the village, and many examples of houses actively investing money to start new businesses.

Table 13 Institutional Sustainability – Score for Effectiveness of Local Governance

Score	Description
1 / 2	Very ineffective**.** Major external intervention needed to keep the project going. Local operator is not able to collect tariffs from households nor take care of small technical issues. Institutional meetings for energy-related issues are infrequent and ineffective.
3	Medium Effectiveness. Local operator and members of local institutions are able to solve small technical and financial issues autonomously. Energy-related meetings are happening, though not very frequently. External intervention from higher organizational level is still largely needed to initiate meetings and discuss issues. System for accountability and enforcement of rules is in place but not solid.
4	Effective. Local Operator and members of local institutions have demonstrated ability to take care of the majority of technical and financial issues autonomously in many occasions. External intervention may still be needed to take care of more serious technical issues, or to solve major internal disputes. Despite this, representative of local governance are able to seek external help when issues arise without compromising the system's functionality.
5	Very Effective**.** Local institutions have demonstrated ability take care of technical and financial issues autonomously over a long period of time, timely seeking help when serious issues arise and limiting the down time of the system due to O&M to the lowest possible level. Meetings happen regularly, and local institutions have been able to craft and modify rules around the use and management of the system to accommodate local necessities.

Table 14 Institutional Sustainability – Score for Community Involvement

Score	Description
1 / 2	Low involvement. Few people participate in meetings and there is limited sense of ownership being transferred to the community.
3	Medium involvement. About half of the village attends meetings that happen at regular intervals. Sense of ownership and trust on institutions is also good.
4 / 5	High level of involvement. Meetings happen regularly and the majority of people participate and interact. Confidence on local institutions and governance is also high

Table 15 Institutional Sustainability – Score for User Satisfaction

Score	Description
1 / 2	Low satisfaction. Users at various levels report high level of dissatisfaction over many indicators.
3	Medium satisfaction. Users at various levels are fairly satisfied with the system . However there may b some emerging factors limiting to higher score.
4	Medium-high. Users at various levels report high level of satisfaction across many indicators. There ar however still 1 or 2 limiting factors.
5	High. Very high satisfaction at all levels across all indicators.

Table 16 Social Sustainability – Scores for Household Well-being and Community Connectedness

Score	Description
1 / 2	Low. Limited-to-no improvements across many Indicators
3	Medium. Some improvements reported but limitations noticed across 1-2 indicators
4 / 5	High. Improvements noticed across all indicators and high degree of confidence

Table 17 Environmental Sustainability – Scores for Local and Global Effects

Score	Description
1 /2	Local <30% of HHs noticing improvements in indoor air quality Global: <30% reduction in monthly kerosene use at household level
3	Local ≤ 30% - 65% > of HHs noticing improvements in indoor air quality Global ≤ 30% - 65% > reduction in monthly kerosene use at household level
4 / 5	Local ≥65% of HHs noticing improvements in indoor air quality Global ≥65% reduction in monthly kerosene use at household level

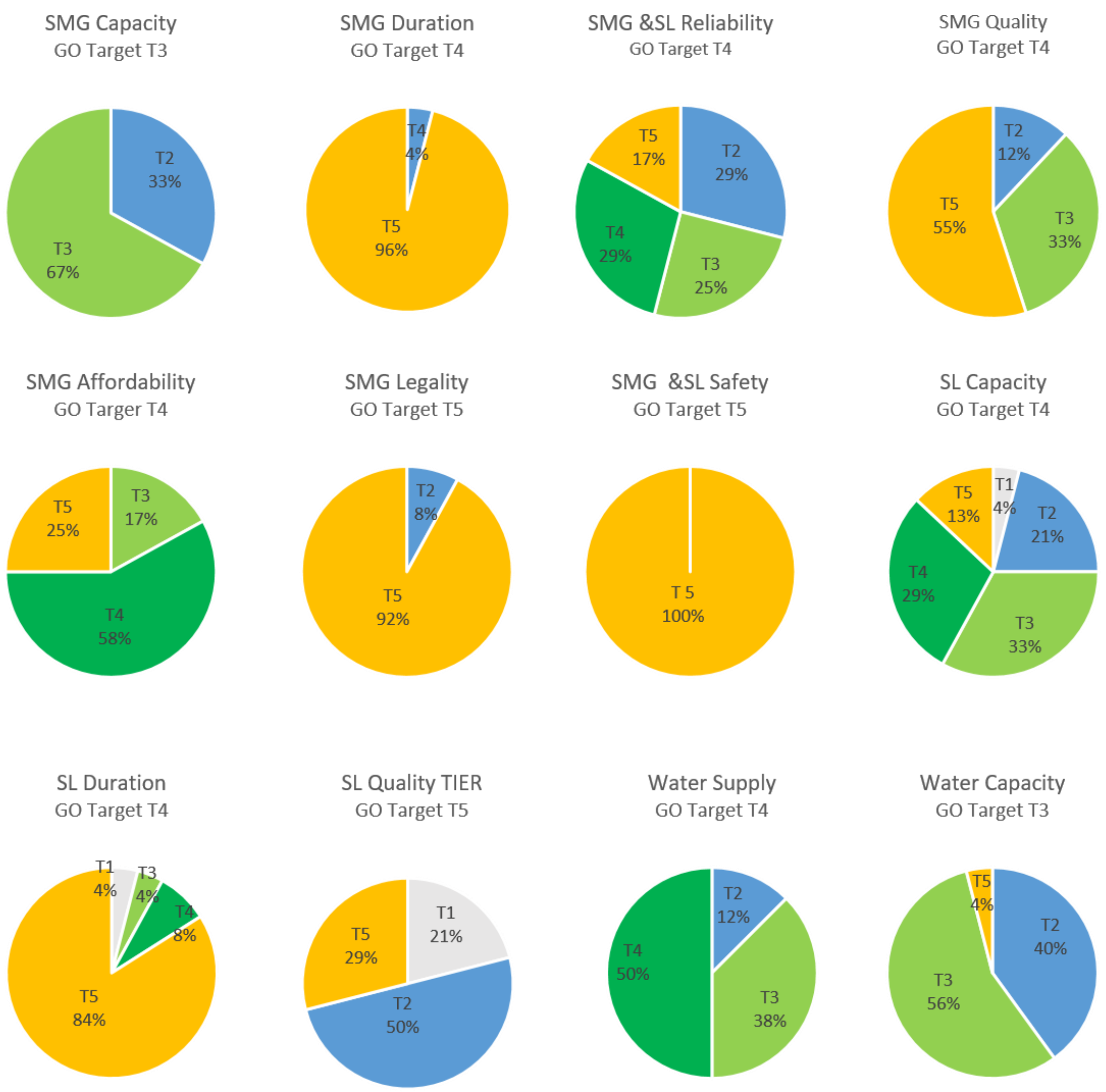

Figure 13a Break down of scores for all Technical Indicators

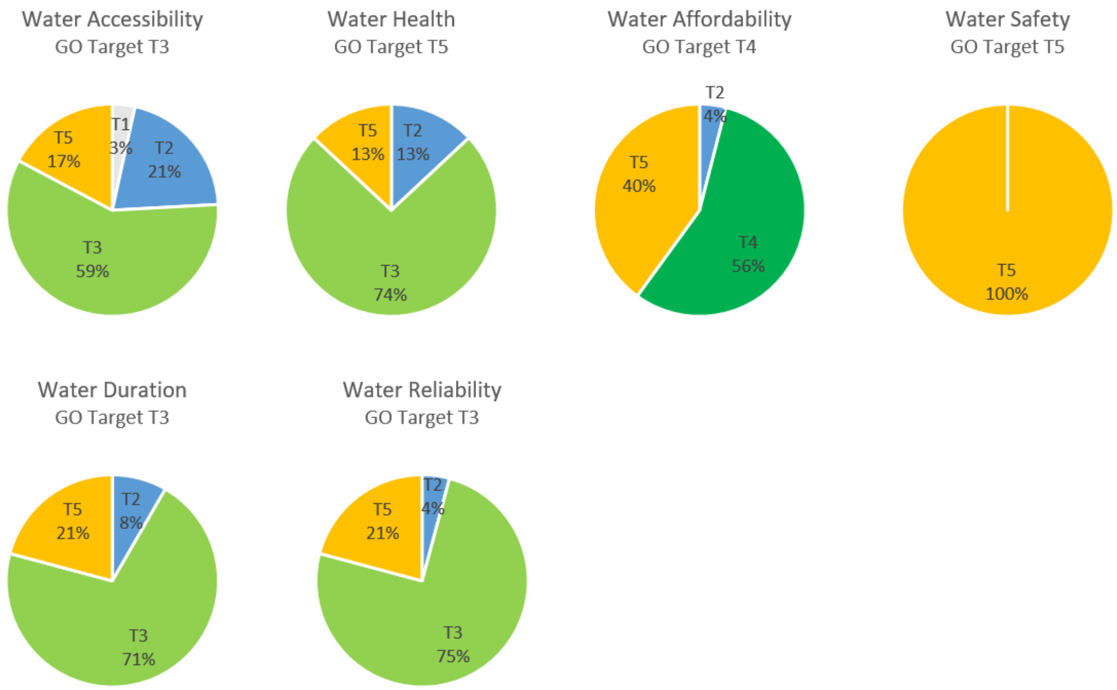

Figure 13b Break down of scores for all Technical Indicators