Enabling Electricity Access in Myanmar

Diesel Mini Grid Assessment, november 2016

U Kyaw Thu comes home at 6pm after spending the day at his farm growing lentils and sesame. A diesel engine starts growling in the background and the street lamps light up. Some of his friends and neighbors switch on their television sets while the children open their books to make best use of these 2 hours before the village plunges into darkness. After 9pm, while the village prepares to sleep and the diesel engine stops, children light up candles in their homes to study for another few hours so that they do not have to spend their lives being farmers in this darkness of these villages in Myanmar.

Through this assessment, Pact Myanmar seeks to understand the struggle, needs, ingenuity and outlook of villagers seeking to gain access to electricity in Myanmar and who have established diesel mini grids in their villages. We explore U Kyaw Thu's village, Kone, which lies in Seikphyu Towhship and another 9 villages in Magway Region to understand how the village community has collaborated to establish basic electrification and whether there could be ways to improve the systems and provide electricity for not only lighting but also productive use, which could accelerate the overall village development.

MANDALAY YOMA
Renewable Energy & Sustainable Agribusiness

pact building local promise.

About Pact Myanmar

Pact Myanmar's programming aims to fundamentally improve people's lives to affect positive material impact on Myanmar's development. We do this by operating simultaneously at scale and at the village level to maximize impact. We believe passionately in community involvement in designing solutions to everyday problems. The community, our ultimate customer and beneficiary, lies at the heart of every program we design and implement.

We focus on sectors that are most relevant to the communities we serve, with access to energy being one of the fundamental needs for rural Myanmar. Renewable energy brings the potential to transform tens of thousands of communities – through renewable-powered clinics, schools, and enterprises linked to rapidly developing markets. RE can enhance community strength and resilience and create the foundation for sustained development in long-isolated communities.

Pact's renewable energy program is bringing electrification to tens thousands of rural households in Myanmar, with the goal of providing electrification to 1 million citizens by 2021. We envision turning base-of-pyramid communities into customers with buying power, with Pact providing links between community needs and RE solution providers, using market forces in combination with our unique community approach to ownership. Our rural renewable electrification interventions are supplemented by a revolving RE capital fund that makes renewable energy access more affordable to the rural poor. Pact's initial emphasis on solar home systems is expanding toward a focus on more-productive, sustainable RE supply via micro- and mini-grids.

Over the past decade, a number of communities that Pact has assisted to create Village Development Funds have used these funds to provide, on their own initiative, electrification in their villages, typically through purchasing a diesel-powered generator to power a micro-grid. These diesel micro-grids demonstrate that there is demand and willingness to pay for electricity services. Many appear to be operationally sustainable and they could potentially be improved by hybridizing with solar or other renewable power.

Pact commissioned Mandalay Yoma to conduct this assessment in order to better understand communities' experiences with these mini-grids, and thereby better inform Pact's and others' efforts to bring renewable mini-grid electrification to rural Myanmar.

Mandalay Yoma provides consultancy, design & implementation of renewable energy solutions to enable access to clean & sustainable electricity for rural communities and commercial enterprises in Myanmar.

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ABBREVIATIONS

DG	Diesel Generator
DMG	Diesel Mini Grid
DRD	Department of Rural Development
FGD	Focus Group Discussion
ha	Hectare
HH	Household
IDI	In Depth Interview
KVA	Kilo Volt Ampere
KW	Kilo Watts
KWh	Kilo Watt Hour
LCOE	Levelised Cost of Electricity
LT	Low Tension
MOEE	Ministry of Electricity & Energy
PV	Photovoltaic
VDC	Village Development Committee
VDF	Village Development Fund
W	Watts
Wh	Watt Hour

Currency used in Myanmar: Kyats (MMK)
1 USD = 1300 Kyats (Nov'16)

FOREWORD

With one of the lowest percentage of population having energy access and lowest GDP per capita in Asia-Pacific, Myanmar presents an interesting and important opportunity for rural electrification. Close to 70% of the population of Myanmar, about 35 million people, live in rural areas with no or limited access to electricity. Most have found their own energy solutions, by purchasing batteries, solar panels or by establishing diesel generator run mini-grids in their communities. The Myanmar government has a vision for electrifying the entire country by year 2030 and has devised roadmaps to achieve this goal wherein majority of this would be achieved through extending the national grid which will be rolled out in phases. The grid extension plan indicates that a large number of villages will have connectivity only by 2025 which means that until then, they have to continue to find their own solutions. Solar home systems or mini grids are thus becoming more popular as a way forward for these households.

Sustainable provision of electricity in villages across Myanmar, enabling productive use of energy, could become one of the foremost drivers of the economy.

We have observed that a number of communities in the central Dry Zone in Myanmar have drawn on their Village Development Funds, established with Pact's assistance, to provide for electrification in their village, typically through purchasing a diesel generator to power electricity grids. These DMGs demonstrate that there is a demand and willingness to pay for electricity services. They appear to be financially sustainable, and they could potentially be improved by creating hybrid systems with solar power.

To date, in-depth information about these DMGs and communities was lacking, including questions about how they were established, their objectives, operations and profitability.

Through this study, Pact and Mandalay Yoma sought to better understand the dynamics in the decision-making process, and the role of community in the execution, operations, and maintenance of DMGs, and ultimately to find insights that would help focus efforts for increased access to renewable energy (RE) in rural Myanmar. We believed that we could learn from these DMGs and find ways to provide better, reliable electricity to these villages which have ingeniously created these systems, often without any external support. We started this assessment from a clean slate, with limited information on these villages and learnt about challenges faced, tariffs they pay and tried to assess whether the villages were satisfied with their current electricity levels. Moving forward, we aim to create a strong understanding of the DMG establishment process and recommend models for creating a lasting, sustainable solution for electrification which can succeed in these villages.

EXECUTIVE SUMMARY

For the assessment, with Pact's assistance, 10 villages were selected across 2 townships in Magway where diesel mini grids (DMG) are operating currently or used to run previously. The model of establishing a DMG points to the willingness of rural communities to gain access to electricity even without significant technical or financial knowledge. The model of electrification shows a strong democratic process & intensive community engagement where alignment and approval from the community is paramount and responsibilities for installing, operation and maintenance are shared. Unfortunately, the same lack of access to information which leads to everyday poverty shows itself in limited access to information about electrification as well. These villages with limited resources are spending on occasions up to 40 times more for a unit (cost/kWh) of electricity than a person living in Yangon for just having a light in their houses. Lack of technical knowledge has, however, not subdued efforts to electrify their communities, and with the right knowledge transfer, partnerships and support, the community-driven electrification model could be leveraged as a new model of sustainable rural electrification.

It is evident from the assessment that diesel mini grids are popular in the Dry Zone where we conducted our interviews with the low fixed cost and limited requirements for technical know-how. Also, data from DRD Myanmar shows that over 13,000 villages are considered to have been electrified by diesel generators serving over 1 million households.

Generation Type	# of Villages	# of Households		
		Rural	Urban	Total
Generator	13,088	835,840	177,309	1,013,149
Hydropower	2426	151,721	25,786	177,507
Biomass	1232	na	na	na
Solar	2693	902,431	42,811	945,242

Off-grid electrification: Department of Rural Development and Ministry of Livestock, Fisheries and Rural Development, "Rural Electricity Access" (MoLFRD & World Bank Off- Grid Electrification in Myanmar, Naypyitaw, Myanmar, January 28, 2015). Source of household data: 2014 Myanmar Census.

The Myanmar National Electrification Plan (NEP): Least-Cost Geospatial Electrification Planning study has stipulated that "throughout the country, approximately 300,000 households, with a total population of perhaps 1.5 – 1.7 million (3-4% of the population) reside in communities which, due to sparse and remote settlement patterns, estimated to cost more than USD 1,200 per household for grid connection."

Connecting households in certain regions to the national grid might not be economically feasible and given the high distribution losses and the low consumption rate in those villages which will increase the cost of electricity, mini grids can be established as a more affordable and viable alternative.

Diesel Mini Grid Set-Up

The diesel mini grids used in most of the villages are extremely basic and are established using funds that the village is able to collect from various sources ranging from savings in VDFs to leasing land and even dowry in some cases. Due to limited technical capability existing with the village, existing DMGs are prone to technical failures, high distribution losses and offer basic services with most operating between 7-9pm.

In most cases, the VDC authorizes execution of the diesel mini grid after reaching a consensus with the village and the entire community participates in the process of establishing it from purchase of equipment to operations & collection. The DMG is a combination of a diesel generator and a dynamo which are paired together based on the recommendation of the store owner in a nearby town where the village purchases them. Any technical calculations, are non-existent, which impacts the electricity available to households. Distribution losses are significant due to

incorrect cable sizing and thus voltage available at households further from the source is extremely low and complaints due to dissatisfaction with the quality of electricity are common.

Diesel Mini Grids Operations

Establishing the DMG, collection of monthly tariffs and maintenance & repairs, if any, are performed by the community. In most of the villages, a farmer or a group of farmers are given the responsibility of starting the DMG every evening. Collection of payments is managed by the VDC with the village chief ensuring the collections himself or through volunteers from the community. Tariffs are not consistent across villages but are mostly seen to be in 2 tiers according to the needs - basic lighting and lighting & television. As a result of the low quality equipment and mismatch of technical requirements, the DMG requires frequent repairs.

Villages without any saving mechanisms are unable to collect funds for repairs forcing them to stop operations. In addition, the quality of electricity is poor due to high distribution losses and the low quality operations further inhibit investments by the village community into upgrading the system. Conflicts in the village are common due to low power being available and expectations not being met by the DMG.

The cost per kWh paid by consumers for DMG operations ranges from 500 kyats to 1200 kyats. This seems to be in the range where solar mini grids could operate with private investment if they are able to address the existing challenges.

Current Challenges

One of the biggest barriers that needs to be resolved is the perception of mini grids, which, as a result of the current DMGs that are operating, are considered a basic form of electrification, a tier below solar home systems (SHS). Unlike other countries, Myanmar has a program known as SRE (Self Reliant Electrification) running since the early 2000s, through which the VDC can collect funds from their village to connect it to the national grid. As a result of poor perception of mini grids and existence of the SRE program, villages in Myanmar seem to weigh their choices differently and aspire to have SHS as a temporary solution in addition to the diesel mini grid till they are able to connect their village to the grid.

Having an expectation of connecting to the national grid in the near future means that they would not prefer to pay a high up-front fixed cost for a mini grid as they see MGs as a temporary solution. A strong need & willingness to pay for electricity exists, but the mini grid solution doesn't look right to the villages given the experience with DMGs. Many consider SHS better than a solar mini grid, as they have no monthly tariffs. Education will be a key component to establish mini grids, through which communities can learn about the total life-cycle costs, reliability, operational requirements, and compare mini grids, SHS, and national grid electricity on these parameters. Finally, clear government policy and a framework defining mini grids and their ability to supplement the national grid, rather than being replaced by it, are needed. Without such guidance, it will remain challenging to interest communities in the benefits and reliability of renewable MGs, as well as to attract private investors, who may be concerned that connection to the national grid will arrive earlier than scheduled.

Key Take-Aways from our Assessment

I. High Potential for Solar/Hybrid Mini Grids in Myanmar

i. *Communities understand the meaning of mini grids & tariff systems due to the existing diesel mini grids*

ii. *Around 25,000 villages will be electrified in later phases of Myanmar's Electrification Plan, making MGs a potential solution*

iii. *Villages are currently paying 500-1200 kyats/kWh which is in the range to attract private investors*

iv. *Most communities plan to invest in SHS/grid extension and thus have the ability to invest in fixed cost for setup*

v. *Communities show strong inclination towards productive use and setting up business with electricity access*

vi. *Usage for education and thus impact is significant as currently students use candles costing 1500-2000 kyats/month*

II. Positioning the Mini Grid Solution correctly is required

i. *Current diesel MGs with low quality equipment & high distribution losses are considered sub-optimal solutions by the village*

i. *Education is required in helping communities understand benefits of MGs*

ii. *MGs will compete with village grid extension budgets for fixed costs & low electricity rate (35 kyats/unit) at one end & with SHS which have a perceived zero running cost.*

III. Leveraging the Community based model is key to success

i. *Communities have established models for purchase of equipment to operations of DMG keeping people costs, theft or evasion negligible and any plan which could leverage this has an inherent advantage*

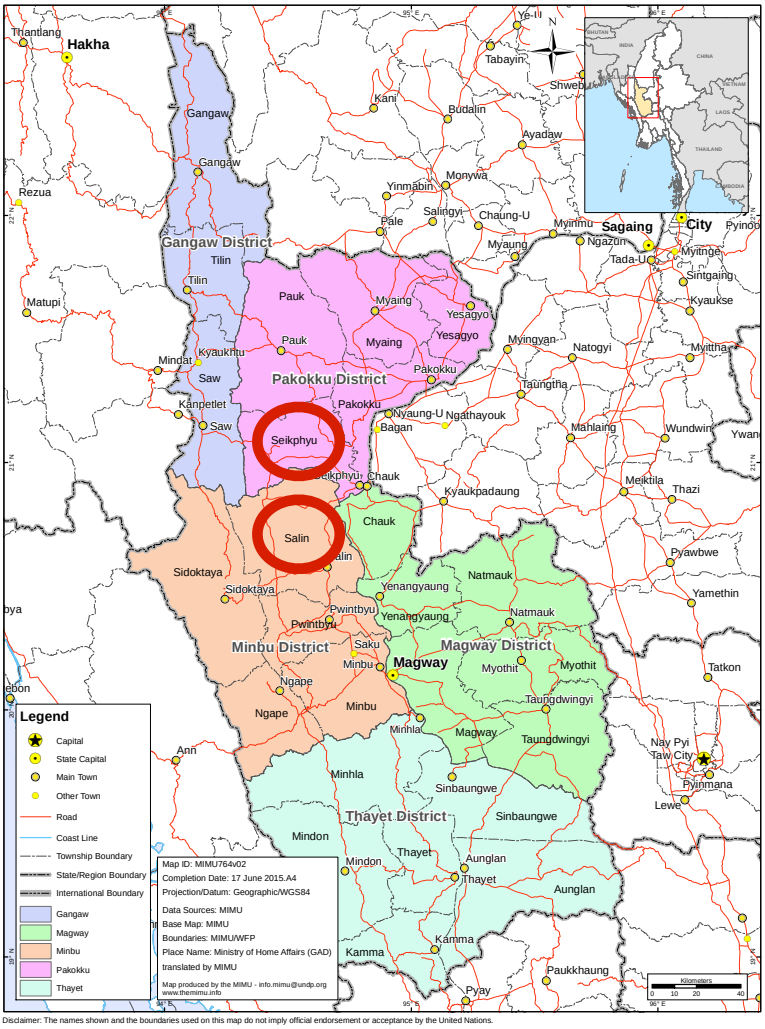
ii. *Village participation and engagement are essential starting from VDC engagement for fixed costs & tariffs to execution & operations where training people at the village for maintenance/repairs would create jobs & reduce costs for companies*

IV. Policy Framework & Clarity of government plans

i. *Clarity on national grid extension plans and communication to the township level offices of DRD & MOEE*

ii. *Outlining subsidies, key permits required along with legal framework to work with villages & the government*

1: INTRODUCTION & SCOPE OF STUDY



Map 1: Map of Districts & Townships in Magway

Table 1: List of Villages

Seikphyu	Nga Chin Chaung
	Kyun Chaung
	Kone
	Than Pu Yar Pin
Salin	Ra Day
	Ah Mhu (East)
	Myin Khaung
	Naung Taw Ywar Lay
	Kya Pin (north)
	Tha Pyay

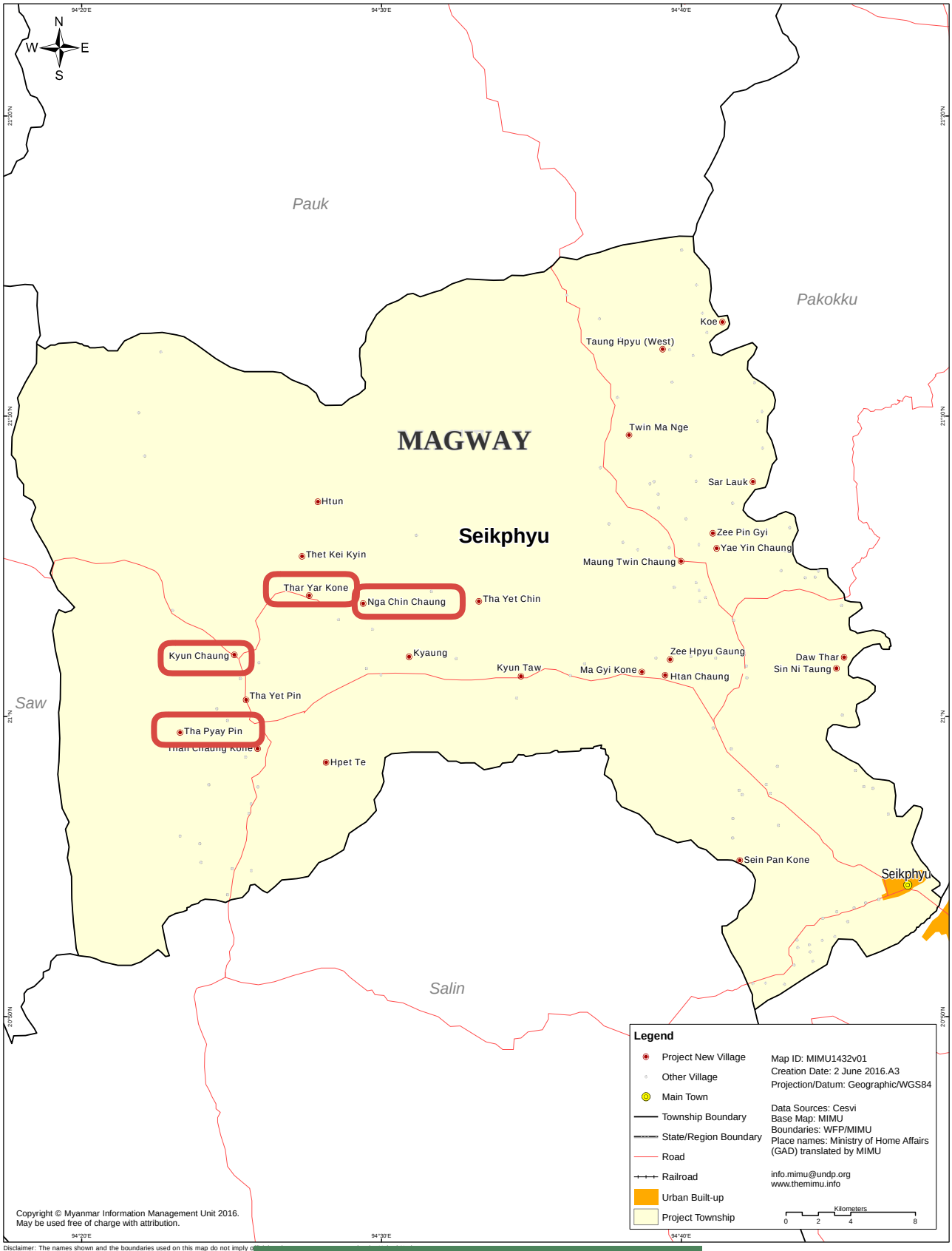
Magway, Myanmar's second largest division lies in the dry zone. Besides the main economic activities in extraction and production of fossil fuels - oil and natural gas, the region is dependent on agriculture. Lentils, groundnuts and sesame are the chief products, some of which are exported from Myanmar.

10 villages, four in Seikphyu and six in Salin township, were chosen for this assessment, located in Pakkoku and Minbu Districts of Magway Division, respectively.
The villages were identified from a set of villages where Pact operates and where DMG were known to be installed and/or functional in the past.

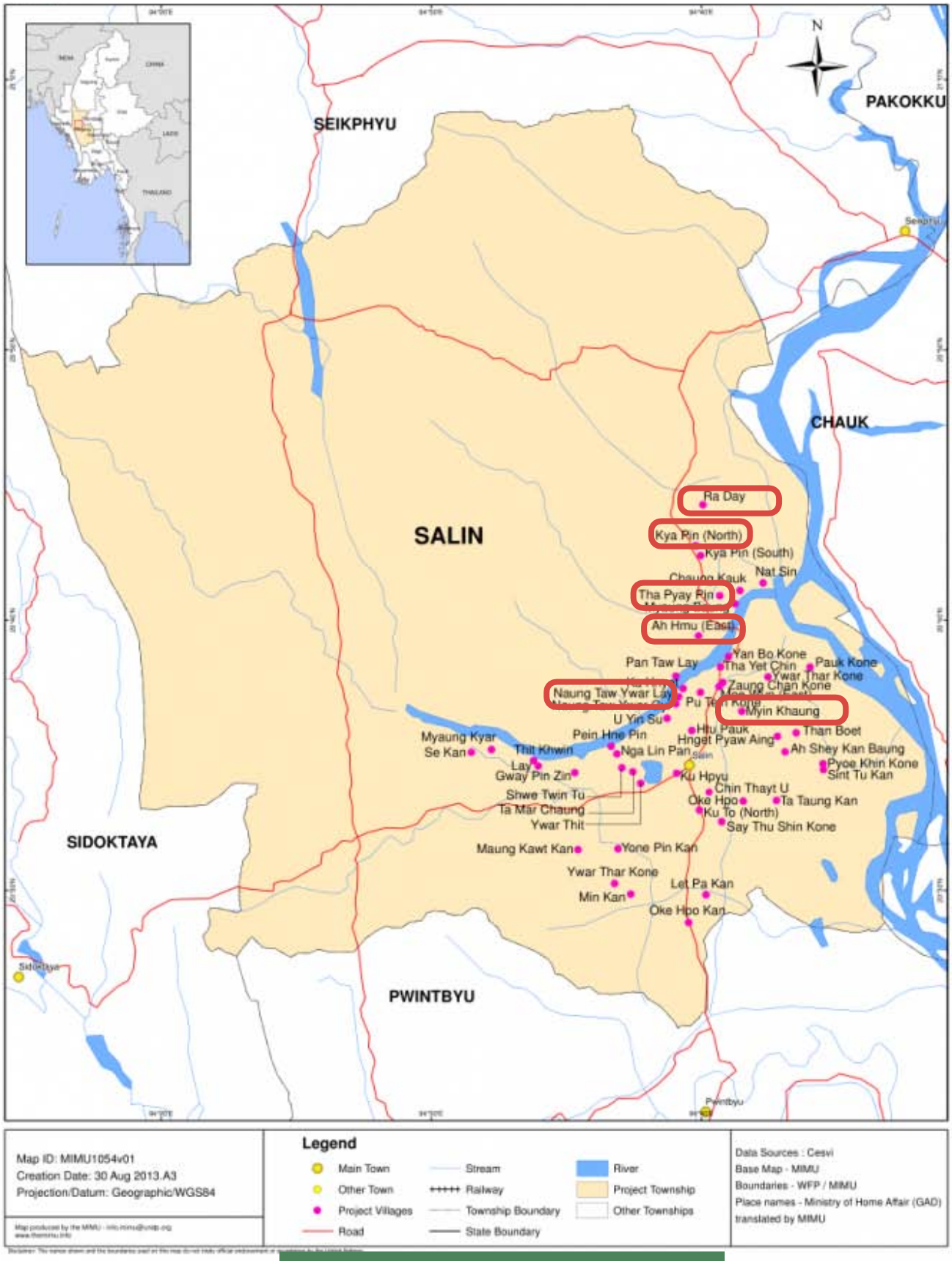
Mandalay Yoma's team conducted field visits in 10 villages during Sep 2016 and engaged with the VDC, VDF members as well as with the DMG operators and villagers to understand the community dynamics when taking the decision about the village electrification. Part of this assessment was to identify the community needs and future outlook for mini-grids.

Objectives:

1.Understand the decision-making process in the communities on executing DMGs
2.Understand the financial aspects of DMG operations along with the profitability for operators
3.Understand consumer needs and demand for electricity, along with the willingness to pay
4.Understand overall consumer spending for electricity with DMGs & any other means
5.Understand current gaps and points of failure of the DMGs and how they could be improved
6.Explore feasibility of electrification & development models based on the above understanding



Map 2: Map of Seikphyu showing villages visited



Map 3: Map of Salin showing villages visited

2: Assessment Design

Mandalay Yoma conducted field visits to 10 villages in Seikphyu and Salin townships in Magway to better understand how these DMGs had developed, what were the factors that made them sustain along with challenges that forced them to shut down. We also wanted to understand how the communities perceived electrification, what they knew about the national grid extension and whether they had plans for higher tiers of electrification of their villages.

To get a holistic understanding of the above issues, we designed a mix of qualitative and quantitive assessments across these villages.

The study was focused on gaining insights from 3 perspectives:

1. From the perspective of the VDC/VDF
2. From the perspective of the DMG Operator
3. From the perspective of consumers of electricity

1. Qualitative

The purpose of the qualitative assessment was to understand the drivers leading communities to take a decision on spending a significant proportion of the VDF for electrification. We also wanted to understand the challenges faced in operating the DMGs and how these were being resolved.

1. **Focus Group Discussions (FGD) with VDC, VDF**
10 such discussions were carried out

2. **In Depth Interviews with the DMG operators**
10 such interviews were carried out

3. **In Depth Interviews with Villagers**
28 such interviews were carried out

2. Quantitative

We also decided to conduct a quantitive assessment in these villages to understand their current usage and spending on electricity to better assess their needs and wants.

1. Data Collection: 92 respondents

Please note that for the quantitive aspect, we collected data from 92 villagers. It is a good sample size from these villages but it might not be representative of Myanmar given the sampling considers only 1 region of the country and villages were not picked at random.

3. DEMOGRAPHICS

Table 2: Crops grown per season in Villages

	Season 1	Season 2	Others
Nga Chin Chaung	Paddy	Lentils/Sesame	Onion
Kyun Chaung	paddy	Lentils/Sesame	
Kone	Paddy	Lentils/Sesame	Onion
Than Pu Yar Pin	Onion	Betel	Bean
Ra Day	Bean	Lentils/Sesame	
Ah Mhu (East)	Paddy	Lentils/Sesame	
Myin Khaung	Paddy	Lentils/Sesame	
Naung Taw Ywar Lay	Paddy	Lentils/Sesame	Peanut, Onion
Kya Pin (north)	Bean	Lentils/Sesame	
Tha Pyay	Paddy	Lentils/Sesame	Onion

All villages are completely dependent on farming - sesame, groundnuts and lentils are their main income generation. Income from secondary processing or value adding services are non-existent.

There is a wide-ranging monthly income in the villages, from 45,000 kyats to 130,000 kyats per HH with the median being around 80,000 kyats. The villages' economic activities are centred around farming, the seasons thus affect their cash flow and ability to pay for expenses. In general, neither expenses nor income are documented well, which might be accounted to the variability and unpredictability of income generation. The income levels should thus be taken as estimates. For in-depth understanding of incomes and expenses, further studies might be needed, referencing other studies done in these regions.

We see that most of the households spend their income on agricultural production, food, along with consumer goods and recently mobile phones & top up cards for them. The disparity of incomes in the villages is also significant with the top layer consisting of landowners who employ landless laborers from the bottom of the pyramid.

Table 3: Demographics of Villages

Township	Village	# of HHs	# of people	Average Income/ Month* (kyats)	DMG Currently Operating
Seikphyu	Nga Chin Chaung	163	696	46,000	Yes
	Kyun Chaung	202	910	110,000	Yes
	Kone	263	1190	80,000	Yes
	Than Pu Yar Pin	114	501	48,500	No
Salin	Ra Day	285	1236	81,000	Yes (Pvt)
	Ah Mhu (East)	93	743	128,000	Yes
	Myin Khaung	92	365	134,000	Yes
	Naung Taw Ywar Lay	61	253	99,000	No
	Kya Pin (north)	132	563	130,000	No
	Tha Pyay	202	947	81,000	Yes

Note: Please note that Quantitative data on demographics might not be representative of the village due to the fact that the respondents in our study were not picked randomly but were rather people who could discuss the -DMG operations and thus would in our judgment tend to be more influential or affluent than the average making the results skew towards the higher end.

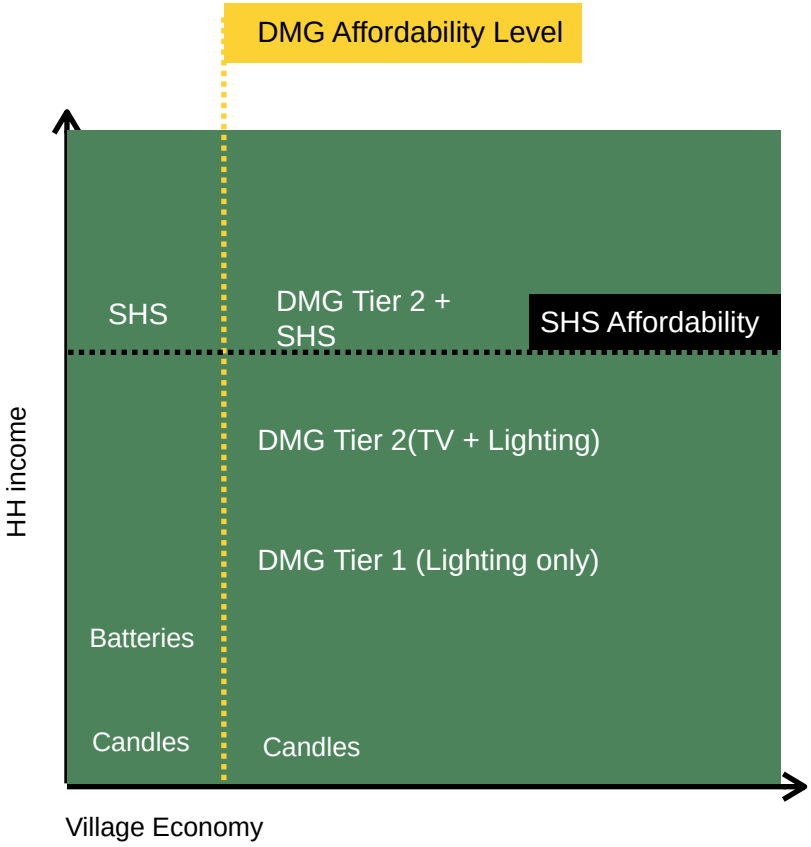
Current Choices made by Villages

We have formed a model to map the pattern of choices made by the villages when deciding about electricity access solutions.

From the model, we see that the villages and people living in these villages follow a simple logic as explained by the chart below. The choice of solutions depends on 2 factors that keep the technology & thus the options limited:

1. **Overall village economy**
2. **Household income level**

A typical diesel engine used to run a dynamo



Understanding and reviewing the choices made by villages, we see that when a village has available funds for electricity, the village starts investing in DMGs. Most of the villages we've assessed, invested in DMGs when they had funds at their disposal through savings, grants or other means to cover the fixed capital cost. If a particular household in this village has a sufficient income, it invests in a TV & lighting plan, otherwise village chooses a lighting-only plan. In case the household is at the bottom of the pyramid, it won't connect to the DMG and opts for candles instead.
However, if the entire village is not sufficiently well-off, individuals with sufficient HH Income opt for SHS or batteries while others use candles.

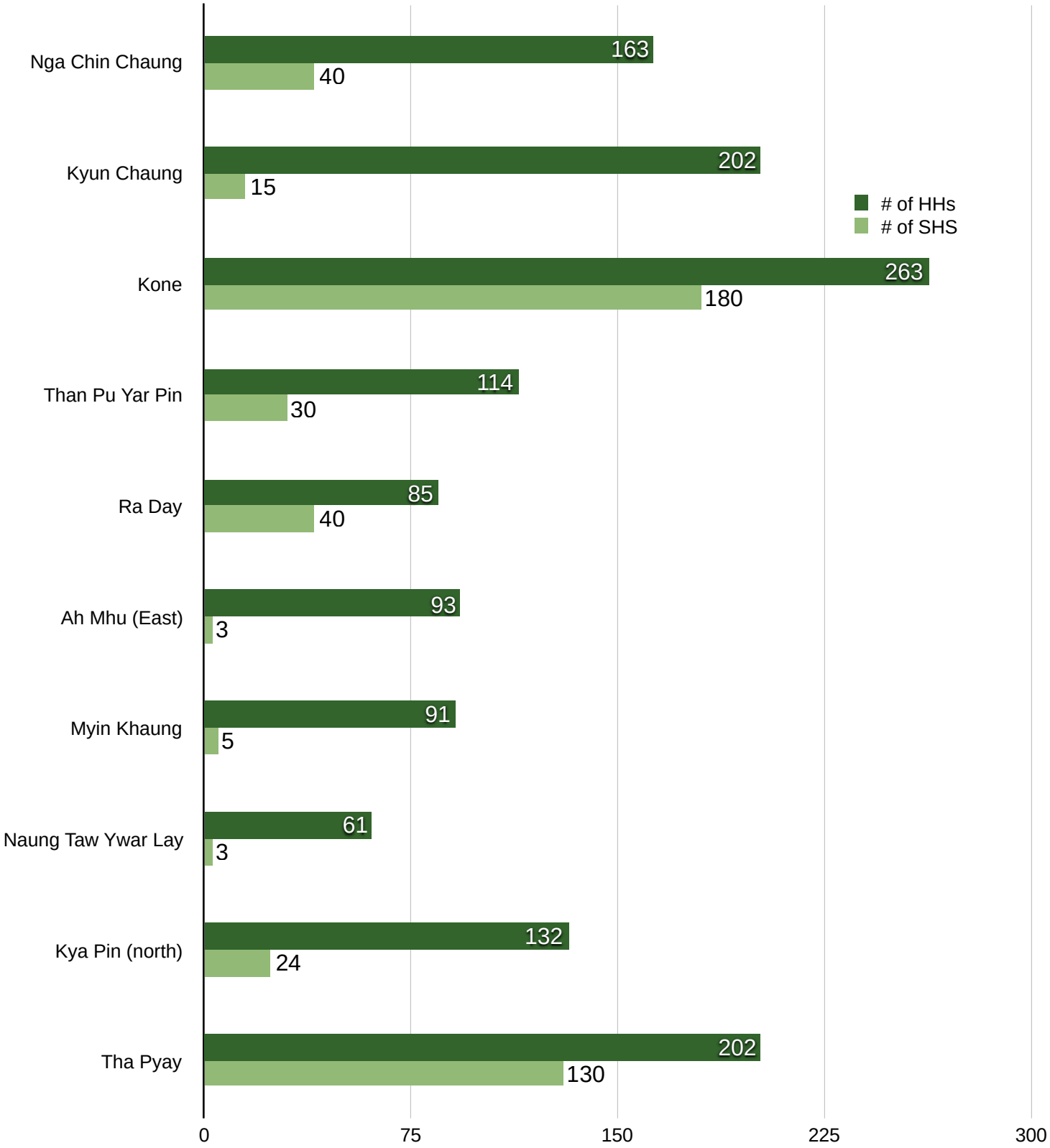
The villages can be imagined as microcosms of countries with different standards of living dependent on their economy and choices dependent on household's income, but with the difference that the basic costs of living remain relatively same across these villages.

Chart 1: Tiering of Choices made by HHs Currently

We see that the villages reach the level of establishing DMGs fairly quickly through savings, small grants, donations etc. This is denoted by the DMG Affordability line. The SHS affordability limit depends on the income of individual HHs, which is reached at a much higher relative level in the village and thus the number of people purchasing SHS would be much lower.

1. Given the current options, if all HHs cross the SHS affordability barrier then their best option would be to go for SHS given their perception of low/negligible running costs, though cost for batteries' replacement are a recurring expense but not factored by HHs.
2. DMGs don't seem to have a great reputation as the perception is limited to cheap, low quality, community-run systems which provide basic electricity for few hours only. Thus one of the challenges would be to improve the overall perception of Mini Grids and position them as a grid-quality solution rather than an entry level solution.

Chart 2: Number of SHS Owned in Each Village



THE CURRENT DEFINITION OF DMG

A Diesel Mini Grid comprises of the below:

1. **Diesel Engine**
2. **Dynamo**
3. **Poles (mostly wooden without insulators)**
4. **Wires (galvanized steel wires)**

The DMG serves 60-90% of the village for basic lighting & TV for 2 hours (7-9 pm) everyday.
HHs commit to a fixed monthly payment in 2 tiers, depending on whether they own & use a television or not.

Current Definition of a DMG: It is a combination of a diesel engine and dynamo which runs for 2 hours and provides basic lighting and/or TV to the households that connect to it.

A dynamo connected to the generator (DMG setup) in a village in Seikphyu

4. PROCESS OF DMG DEVELOPMENT

Summary of Qualitative Surveys

The following section summarises the discussions carried out with the communities

Village 1: Nga Chin Chaung Village

Households : 163
People : 696

VDC & Operators

The DMG in Nga Chin Chaung was installed in 2013, with contribution of 400,000 kyats from the VDF & 500 kyats collected from each household. The remaining majority came from a UN funding that was available for this project. More details about the UN funding could not be found.

The total cost of setting up the DMG is estimated to be 3,500,000 kyats and the village bought the equipment from a nearby town, Chauk. The equipment was transported using a car/truck, which amounted to 50,000 kyats. Installation for the DMG was said to be simple, straightforward and fast, with an active community participation in the installation that took only 7 days.

The households can choose one of of the 2 tariff plans a) lighting only or b) lighting + TV, paying 1000 kyats and 2500 kyats, respectively. Among the challenges with the DMG are issues with the cables as the villagers purchased the smallest cable size given the funding limitations. We know that cables are important as they determine the voltage drop & the regulation due to loads. Due the lack of technical knowledge and budget, the village faces significant voltage drops and thus encounters frequent problems during operations. We will see this particular issue arising across other villages visited during this assessment.

When asked about which businesses might get enabled by electrification, they don't seem to have instant answers but hint towards using motors for paddy de-husking, for which they currently use diesel engines. One person wants to start a photo booth and an internet cafe once the village receives electricity. The exact usage can be known when these villages get connected to a regular power supply but in general, there seems to be an indication towards establishing commercial activities.

Their expectations of getting power from the national grid are low as they understand that their village is too far from the grid. Another interesting observation is that the VDC and village leaders seem to be aware of the benefits of solar power, citing lower ongoing cost although higher initial fixed cost and more importantly the advantages for the environment. Whether they would pay more for greener electricity is difficult to state but the fact that they're educated and knowledgable about this issue is a step towards the right direction.

The DMG is operated on a voluntary basis by a farmer who was asked to take this responsibility by the village leader. He was known to take care of machines 'well' and was thus assumed to be the right person to operate and maintain the diesel engine and the dynamo. The operator commented that during the past 3 years, repairs were required once.

Consumers

In this village, we decided to interview women and men separately. The women shared their needs and stated that they would buy rice cookers, irons or other appliances, if provided with more electricity. The men on the other hand would like to invest in pumps/motors for agriculture. Payments and ability to pay is strongly linked to seasons and an expenditure between 20,000 to 30,000 kyats per quarter seems feasible to them. Knowledge of solar being clean, efficient and cheap for operating exists and solar home systems are considered the high standard.

"If we could pay in instalments, it would easier to buy solar as it is cheaper and better in the long run."

Village 2: Kyun Chaung Village
Household : 202
People : 910

VDC & Operators

The DMG started operating in 2011 with 700,000 kyats from the VDF and 1000 kyats collected per household from villagers. This village like Nga Chin Chaung had a contribution of 1,200,000 kyats seemingly from the same UN funds. The total cost of setting up the DMG was estimated to be 2,900,000 kyats and they bought the equipment from Chauk as well. The community jointly established the DMG.

Starting a diesel engine

The proposition to establish a DMG came from the village leader and the whole village approved it in a meeting called for by the VDC. After the meeting they collected money from the households, with which they bought the generator and other equipment. The villagers collaborated and completed the entire setup themselves and HHs that contributed were connected to the DMG.

Similar challenges as in Nga Chin Chaung exist in this village. Due to improper cable sizing, loads could not be regulated and short circuits cause significant power outages. The wires aren't proper electrical conductors or cables but cheap steel wires with high resistance.

The operator chosen for running the DMG is a farmer who was considered to be good with equipment and had knowledge about operating diesel engines and dynamos. He operates the DMG and in case he is not available, other community members take over the work. The operator commented that the DMG had been repaired thrice and the villagers conducted the repairs itself. The village leader and the operator collect the payments each month. The rules and timing for the collection don't seem to be rigid: **"Most of the people pay regularly, but in case someone is unable to pay they can make the payment next month".**

The VDC said that they would certainly want more power but cost and knowledge were the barriers. They commented that the demand was growing and from the initial 100 houses connected, the number has now increased to 120 HHs. In 2007, the villages had tried to set up a DMG for street LED lighting but were not successful in executing the project due to limited technical expertise.

Consumers

The consumers talked about the benefit of having electricity for students as they currently have to use expensive candles for studying (150-200 kyats/night).

They don't expect to connect to the national grid given the distance and the lack of infrastructure available to their village. Also, they don't know how much connecting to the national grid will cost them. "The current DMG is not the best solution but it is best we can get given our budgets and its better than nothing", stated one villager.
Their understanding of solar is limited to SHS and they would like to use it to watch TV and for their children to study. "Solar is good for the environment" is a statement we heard again along with another benefit: no noise compared to the diesel generator. High fixed costs for solar/SHS seem to be the a barrier to purchases and they hope for a good financing plan to be able to make this purchase in instalments.

Village 3: Kone
Households : 263
People : 1190

VDC & Operators

The DMG was established in this community in 2008 with a funding of 1,300,000 kyats from the VDF and another 1,500,000 kyats collected from the villagers. The rest came from a unique source - a marriage dowry of a girl from this village. **If a boy from another village wants to marry a girl from Kone,** he has to contribute some money to Kone's community. The VDC decided to collect this money and put it in the fund for electrification.

Diesel Generator in Kone

The decision to set up the DMG was taken by the VDC and the village community. Interestingly, households that are not connected to the DMG, also pay 500 kyats/ month as the VDC decided that public lighting (street lamps) powered by the DMG system benefit them as well. The total cost of setting up the DMG was 3,000,000 kyats and the DMG is currently operating for 2 hours daily, from 7 to 9 pm. Households using TV + Lighting pay a higher monthly contribution of 4500 kyats/month vs. 1500 kyats paid by households using only lighting.

After the village decided to install the DMG and collected the funds for it, they chose to buy the equipment from a nearby town and set it up together with the entire community.
A key point to note here is that the current DMG operator did not participate in the initial meetings nor in setting up the DMG. The head monk in this village asked this farmer to take care of the operations and the farmer has been doing it since then. Additionally, there are 3 more people from the village working on the operations and helping to manage fuel supply, maintenance and tariff collections.

“ The most important thing for setting up the DMG was having money and unity of the village”

This villagers claim that they will have a connection to the national grid in the next 5 years and they expect to pay 600,000 kyats per HH for it. Among the challenges, they seem to have had some arguments: the DMG setup failed to reach all the people who had initially contributed to its cost by a fixed amount and thus the HHs needed to purchase additional cables and poles to connect to the DMG.

The VDC is aware of solar, which for them is essentially an equivalent to SHS. They say that they prefer solar, given the low running cost, but that high upfront cost is a barrier. We estimate that about 50 households in Kone are connected to the the DMG and currently use solar in parallel to meet their electricity needs.

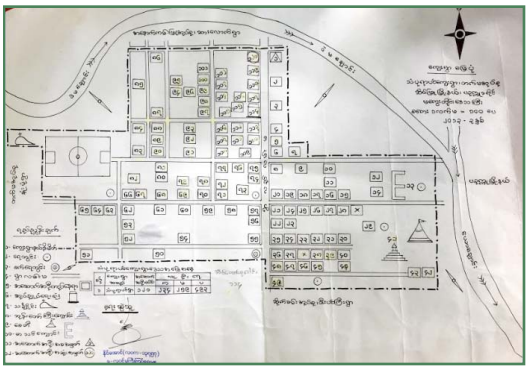
Consumers

When asked about the core need for electricity, the villagers talked about students. **Most students study at night and have to use candles which have a significantly high cost and moreover, there’s a risk of fire.** They understand that in the future, connecting to the national grid would solve all the problems of electricity supply but at present they do not know the timing and how much they would need to pay for it.

Village 4: Than Pyar Pin
Households : 114
People : 501

VDC & Operators

In this village, the DMG started operating in 2011 but was shut down in 2014. The DMG was set up by a contribution of 300,000 kyats from the villagers and the rest came from a lease of the common village land to a rich farmer. The DMG used to run for 2 hours daily, from 7-9pm. The villagers were paying 500 kyats for lighting and 1500 kyats for access to lighting and TV. A farmer was working as a volunteer to operate the grid and other villagers helped him when necessary.



Layout of the village

The village leader proposed the idea of having DMG and it was approved by the community in a village meeting. The budget amount was determined, using which the necessary equipment was bought from Chauk, a nearby town. The collection for the fuel costs was done by the village leader who visited the individual HHs on a monthly basis.

There were challenges on operating the DMG as the dynamo coupled with the diesel engine was of a smaller capacity than required and got thus damaged. They tried repairing the dynamo thrice and spent roughly 55,000 kyats on repairs but were not successful. With no available funding, they haven't managed to buy a new dynamo since then.

During the operating period, no one was using solar panels but in the last 2 years, around 50 HHs have simultaneously purchased them. According to their statements, they are very interested in purchasing solar solutions - which for them are equivalents to SHS. Again, high initial costs were stated as a barrier. The expectation of getting electricity from the national grid is low and they believe it would require a roughly 600,000 kyats per household connection.

Consumers

The consumers in this village have shifted to using SHS, batteries or candles, depending on their purchasing ability. The villagers with batteries only use the solar panels from the neighbouring houses to charge their batteries and pay 200 kyats per recharge. Most of the villagers aspire to own a solar panel but are looking for available financing solutions to make the purchase. We also see the difference in knowledge about grid connectivity - the VDC cited 600,000 kyats per household connection, while the villagers believe to pay 100,000 kyats.

Diesel Generator in Than Pyar Pin

"We don't expect the national grid to electrify our village but think that we will have to pay around 100,000 kyats per HH for the connection. Only limited number of HHs which will opt for it, maybe only 40"

Village 5: Ra Day
Household : 285
People : 1236

VDC & Operators

Ra Day had a public DMG operated since 1985 until 2011. At that time, 100 HHs were connected and were paying 1500 kyats & 4500 kyats for usage of lighting and lighting & TV, respectively. The DMG set up was very similar to others we've seen - with wooden poles used for distribution along with steel wires.

Diesel Engine in Ra Day

The DMG operation was stopped due to quarrels between the villagers caused by the lack of electricity available at most households. This was particularly due to the voltage drops as a result of cheap wires being used to conduct electricity. Without the right sizing, voltage drops are inevitable. With no possible solution to resolve the escalating quarrels, the village leader & VDC decided to stop operations. Some of the customers had already stopped paying for the electricity due to its quality and availability being much lower than what they expected. The diesel generator was donated to the local monastery and they use it for their electrification.

A new DMG was established in 2011/12 by a villager who was not available for an interview at the time of our visit. **This operator looked at the failure of the previous DMG as an opportunity and invested in a new diesel engine & dynamo but did account for a proper setup up of poles and wiring.** He offered people an option to connect to his generator provided that the households purchase their own wires. initially connected 30 consumers for electricity distribution, but the number of people using his service have dwindled to only 15 currently. Although the operator was not available to comment, the villagers believe that he will stop the operation soon as there are too few people purchasing electricity to keep running his business.

The operator had an entrepreneurial approach and came up with a smart tariff system.
Besides the monthly billing of 1500 kyats & 4500 kyats for lighting and lighting & TV respectively, he offered an additional plan. If someone needed electricity for a short period (i.e. during an event) he would offer it for 200 kyats/HH/night.

We wanted to understand the reason behind reluctance in connecting to the private mini grid given that the rates of electricity provided were pretty similar to what the villagers paid before. Our interviews did not uncover this directly but from the information provided we think it might be the result of 2 key factors:

1. **Cost:** The cost of a connection increased as any HH who wanted to connect needed to purchase their own wires.
2. **Loss of Community Ownership:** As the entire community didn't make a commitment to purchase and own the diesel generator, households had limited intent to keep the system running, especially when knowing about its low reliability. This can have implications for mini grids established for profit that are not in agreement or alignment with the community and thus do not create local ownership.

Consumers

The villagers in Ra Day echoed the views of others. SHS are the ideal solution for them but they would need a good financing plan to enable SHS purchases. The needs of students and high expenses on candles were pronounced as crucial recurring points in multiple villages.

Village 6: Ah Mhu
HH 93
People 743

VDC & Operators

This village has established a DMG and has also a low tension (LT) network to connect to the National Grid.The DMG started operating in 1976 and has been running since then with practically all HHs connected to it. The decision about DMG was taken a long time ago and seems to follow the same model of the community and execution as we have seen in other villages.

Meeting the community to understand their needs in Ah Mhu

This village has one of the most evolved models for running the DMG with fixed payments and tariffs as below. They also hold an annual meeting to discuss the plans for the next year and solutions to any problems with the DMG.

Electricity Tariff

1. Lighting : 1000 kyats/month
2. Lighting + TV: 3000 kyats/month

Annual Fee for maintenance

1. Lights: 2000 kyats/month
2. DVD Player: 2000 kyats/year
3. TV: 6000 kyats/year

The DMG runs for 2 hours everyday from 7 to 9pm and powers 35 additional public street lights. As most of the houses are connected to the DMG, the power supplied by the DMG is not sufficient to meet the requirements of the entire village and the community has a load shedding plan in place where 1 of the 4 existing circuits is switched off every week.

The village knows about the plan for the National Grid extension from their local authorities. Even with no written documents or hard data points the village established an LT grid so that they could be easily connected to the National Grid. They hired a private contractor who charged 12,500,000 kyats to connect 60 HHs (each contributed 200,000 kyats) and installed 37 poles for the LT Grid in the village. Once it reaches this village, only these 60 HHs will be connected to the national grid.

The entire LT grid set up was completed 9 months ago with no progress and news since then. They expect that it will be done soon -“ We will have to pay another 1-2 lakhs (100,000 - 200,000 kyats) per HH as a connection fee and we are working on that”

Also important to note is that there are no plans to dismantle the DMG once the national grid is connected. The village understands that the power supplied by the National Grid might not be sufficient or available 24/7. They want to keep the DMG operational in case of any specific needs or backup requirements for events.

The houses that will connect to the national grid will most likely go back to using candles or batteries as the DMG would not operate everyday. It would simply not be viable to run it without majority of the households not connected to it. There is a team of 5 farmers for DMG operations and they take turns in this responsibility every year. The engine has lasted them for 6 years but requires frequent repairs.

Consumers

A large number of houses use TV in this village. Most of them are satisfied with the monthly costs but not happy with the quantity of electricity and wish they could have more electricity. They would use it to help their children study, to watch TV and to use appliances like rice cookers and even air conditioners as mentioned by a few people.

“ We can also set up computer/printing business using electricity”

Given that they have a chance of connecting to the National Grid, they would not invest in solar as it limits their choices on appliances.

Old DMG setup (wooden poles) and new LT grid setup to connect to the national grid in Ah Mhu

Village 7: Myin Khaung
Households : 92
People : 365

VDC & Operators

The DMG is running in this village since 2012 . The idea was proposed by the VDC, discussed within the village and executed together as a community. Establishing the DMG cost 1,000,000 kyats with a full contribution from the VDF. The land for DMG was donated by an individual and the operators are 5 farmers who were asked by the VDC.

The responsibility rotates amongst these 5 people who take turns in managing and operating the DMG and any issues, depending on their availability and time. The operators and village leaders collect the monthly charges form the village. This village is also in the process of building the LT network to connect to the National Grid.

Diesel Engine in Myin Khaung

"Most of the electricity issues like duration of electricity and quality of electricity would be resolved once we are connected to the National Grid"

They've collected 200,000 kyats per HH for preparing the LT network with 35 poles. They decided that this would be the best investment for village electrification and expect that they would get it in the next 2 years. They have already established 13 poles for this LT network and the set up and erection of poles is being carried out by a private contractor. All the materials were purchased by the villagers themselves.

"Once our village is connected to the National Grid, we don't plan to dismantle the DMG as it can operate for special ceremonies, events as they require special provisions of electricity"

Consumers

The consumers were excited about the connection to the National Grid and talked about planned appliances they would use when connected. Though the current DMG provides only electricity for lights and TV, their plans are to purchase appliances like rice cookers, irons, TV, refrigerators. Benefits for students from the continuity and availability of electricity were mentioned again, highlighting the importance of this need across all the villages. The villagers also seem interested in SHS and expect that at times they will have to use it as a backup source.

Village 8 - Naung Taw Ywar Lay (Not Operating)

Households : 61
People : 253

The DMG operated in this village for 12 years since 2000. There was no contribution from the VDF and funding was achieved by leasing out land for 3 years for 1,200,000 kyats. The DMG operated for the same duration of 2 hours from 7 to 9pm as seen in other villages.

There was no contribution from the community at the start of this project besides the money that come from leasing the land and this factor might have affected the DMG operations that were not sustainable.

All HHs were connected to the DMG and tariffs were different from we have seen in other villages. This village was collecting 50-100 kyats per HH per day for fuel, depending on what the HH could afford to pay. The collection of money was managed by the 5 members from the VDC on a rotational basis every day.

The operations stopped when the diesel engine failed due to lack of maintenance. The villagers took the engine to a nearby village for repairs and were given a recommendation to purchase a new one. With no funding mechanism for maintenance or repairs in place and no model of using the common village funds for investment, the village gave up the project and most villagers moved to purchasing batteries instead which they now charge in a nearby village' s store for 200-500 kyats, depending on the battery size.

Discussions with the community in Naung Taw Ywar Lay

Village 9: Kya Pin (Not Operating)
Households : 132
People : 563

The DMG was established in this village in 2008 and discontinued later in 2013. The VDC approved the decision on DMG in alignment with the community. Funding came from donations from individuals in the village and amounted to 800,000 kyats, while another 100,000 kyats were donated by a private company. Monthly charges were 3000 kyats and 4000 kyats per HH, depending on the usage of lights or TV. The DMG was operating for roughly 4 hours daily (6-10pm), which is twice as long as what we've seen in the other villages.

Most households were connected to the distribution network but the sizing of the generator and dynamo were insufficient to meet the load of the village. We believe that there was discontent in the village related with this topic which might have prompted the VDC to decide on shutting it down.

Another factor which came up on probing further was the fuel cost which we had mentioned earlier as being higher given that the DMG used to run for 4 hours vs. the 2 hours we saw in other villages. The increased fuel cost coupled with the discontent amongst villagers forced them to shut down operations.

"We could not come to a decision on how to use it fairly for all and thus decided to shut it down"

The village is still using the diesel generator but only for street lights and also when they have ceremonies or events. The street lights are run completely by donations from the community while any events are paid for by the HH organising those. The youth in the community go from door to door to collect donations for running the street lights and each HH contributes whatever they can for it.

No private connections are allowed anymore to keep it simple and prevent conflicts in the village.

Diesel Generator in Kya Pin

They are hopeful of being able to connect to the National Grid and their expectation is that it should be in 2017. They were not sure about the costs but guessed that they would need to pay 250,000 kyats per HH for the connection to the National Grid.

Consumers

A large number of households resorted to using SHS when the DMG operations were stalled. The overall village does not seem to be affected as those who didn't invest in SHS resorted to using batteries which they now charge for free taking help from their neighbors. They don't seem to account for the additional fixed cost of batteries. The meaning of solar is limited to SHS but it doesn't seem like a strong need given that their batteries are being charged by the neighbours. They have hopes of connecting to the National Grid and using various appliances like rice cookers, TV etc. which they would purchase once they are connected.

"Students will be much happier as electricity will enable them to study more and get higher marks".

Village 10: Tha Pyay
Households : 202
People : 947

The DMG was established in this village recently in 2014. The leader of the village proposed it and got agreement from the VDC. The VDC then shared the plans with the village community who aligned it with the village and thus the decision was taken to start a DMG. Also, UN funding of 800,000 kyats which was initially deployed for drinking water were later allocated for electrification of this village. Another 400,000 kyats came as a contribution for the villagers with no fixed amount being asked from each HH. Also, important to note is that they received the diesel engine from the UN which reduced their overall expense on the fixed costs. The community established and constructed the DMG themselves but received consultancy from a person in Mandalay for sizing of the components.

Wooden Poles for DMG in Tha Pyay

Current operations are managed by a group of 3 farmers who run the generator and collections are managed by a group of 20 who go door to door each month. This village seemed to have a good record keeping practice and the VDC calculates the money collected each month. In the recent years, there have been a lot of repairs (6) and each repair cost 70,000 - 90,000 kyats which has drained the resources of the community. They collect 90,000 kyats per month for repairs from the village.

The village hopes that they will get connected to the National Grid in the next 4 years. They guess that it would cost 200,000 - 300,000 kyats for the connections and they think that only 70 HHs will be able to afford it. The rest of the HHs will maintain SHS or candles.

The village is currently not very happy with their electricity supply and are looking for funds through savings, donations so that they can purchase a bigger generator. They are also aware of solar but again as others, solar means SHS. The main attraction is the low running cost and full ownership without recurring payments which the people seem to prefer over the higher monthly costs.

“Once we have more electricity, we could start businesses like battery recharging which other villages are doing and also use pumps for farming”

Consumers

There are challenges in the operations, mainly due to voltage drops but also due to the demand of the village not being fulfilled. With the loads attached being significant and the wiring not being of the right sizing, the voltage drops across the lines and for the houses furthest from the generator become very significant. We’ve seen this becoming a major pain point in other villages and also a cause for conflicts as it makes some HHs feel unfairly treated as they pay the same amount as others.They don’t think they will need to invest in solar if they can get the National Grid but they aren’t sure about the cost of the connection and apprehensive of it being higher than what they might be able to afford. Appliances like rice cookers, refrigerators, TV are on top of the list of purchases once they get access to more electricity.

“Some of us currently own rice cookers but can’t use them because of the low voltage"

SUMMARY OF DMG DEVELOPMENT

The DMG Development process, as seen in the qualitative interviews, follows a basic community level planning & execution, shown below:

1

VDC PROPOSES TO THE VILLAGE

In almost all cases, the village leader or member of the VDC proposed DMG to the village community and people on the common need and solution. The village community is very closely knit and most decisions for the progress of the village are taken jointly.

2

PUBLICLY-OWNED DMGs

The villages then financed the DMG and looked for additional funding solutions and contributions. The funding sources differed in each case and depended on various factors, such as the number of households that agreed with the DMG installation. Without any technical knowhow, the cost estimates were based on advice from neighboring villages or from stores in the nearby town from where the diesel engine & dynamo were purchased. Sizing of wires and the quality of equipment is based on the cheapest available and not the most optimal, thus requiring frequent repairs and additional expenses.

3

PRIVATE DMG

Only in some cases private DMGs emerge. We have observed that the acceptability from the community is low and the number of consumers of the private operator remains small due to:

a) Lack of commitment from the consumers
b) Suboptimal quality of electricity
c) In addition to tariffs, additional cost of wiring to be borne by the households

4

THE VILLAGE CONTRIBUTES AND EXECUTES TOGETHER WITH VOLUNTEERS

As mentioned above, money for the equipment was collected from multiple sources and village contribution in most cases is not the majority part of the budget. The community participates in the DMG installation and O&M, as well as in the monthly tariff collections, with no profit motive. Volunteers known as *skilled with machines* are chosen to perform the necessary DMG operations. The basic electrification by the DMG serve individual households and in some cases public spaces and street lighting for a limited time in the evenings. Technical issues seem to be present due to wrong sizing of cables or mismatch of dynamo and engine which lead to recurring costs and sometimes lead to operations being discontinued.

CURRENT FUTURE PLANS

As the village economy grows, consumers aim to move to using SHS if not provided an option of connecting to the national grid. High fixed costs pose a clear barrier, though a strong understanding of lower running costs exists. In cases where the villages are aware of the national grid extension plans they perceive it as the best option for meeting their energy needs. Appliances like rice cookers, TVs, refrigerators and pumps seem to be the primary planned purchases once they receive stable electricity supply.

5: DMG OPERATIONS

Diesel Generator

Technical Details & Costs

Table 4: Technical Aspects of the DMGs

Name of Village	Grid Running Hours	Grid Running Months	Time of grid running	Voltage of the Grid (V)	Freq of Grid (Hz)	Size of Engine (HP)	Size of Alternator (KW)
Nga Chin Chaung	2	12	1900-2100	204	47	30	not documented
Kyun Chaung	2	12	1900-2100	225	52	20	10
Kone	2	12	1900-2100	235	53	28	20
Than Pu Yar Pin	not running					-	7.5
Ra Day	2	12	1900-2100	not documented	not documented	not documented	not documented
Ah Mhu (East)	2	12	1900-2100	190	47	32	15
Myin Khaung	2	12	1900-2100	220	51	25	10
Naung Taw Ywar Lay	not running	12	1900-2100			-	10
Kya Pin (north)	not running	4	1800-2200	209	48	25	10
Tha Pyay	2.5	12	1830-2100	235	53	32	15

We studied the equipment being for the DMGs, especially the diesel engine and the dynamo and the above table captures the data that we collected. We can see that the voltage across the DMGs varies from 190 to 235V and this is confirmed by measurements at the alternator. We believe that the voltage received across HHs would be much lower as indicated during our FGDs but it was not possible to measure and quantify it during this assessment. The diesel generators do not have automatic voltage control and need to be adjusted manually as loads are switched on, which is usually done by the operator by increasing the speed of the diesel engine.

Table 5: Outline of the DMGs

Township	Village	DMG Established	DMG Operating	Financing	DMG Cost (kyats)	Additional Cost Paid/HH (kyats)*
Seikphyu	Nga Chin Chaung	2013	Yes	Mixed	3,500,000	500
	Kyun Chaung	2011	Yes	Mixed	2,900,000	1000
	Kone	2008	Yes	Mixed	3,000,000	700
	Than Pu Yar Pin	2011	No	Mixed	2,700,000	Voluntary
Salin	Ra Day	1985	Yes (Pvt)	Mixed	1,000,000	
	Ah Mhu (East)	1976	Yes	Mixed	5,000,000	
	Myin Khaung	2012	Yes	VDF	1,000,000	0
	Naung Taw Ywar Lay	2000	No	VDF	1,200,000	0
	Kya Pin (north)	2008	No	Mixed	900,000	Voluntary
	Tha Pyay	2014	Yes	Mixed	1,200,000	Voluntary

**Cost Paid/HH shows the amount contributed beyond the VDF and any donors*

We've seen the voltage issue being critical due to high voltage drops in the low quality and wrongly sized wiring. This has caused conflicts in some villages where the consumers did not receive the electricity they had expected and paid for. In one of the villages, we saw that the DMG was shut down when the conflicts were not possible to resolve.

Upgrading the existing systems or creating hybrid models with solar would require the entire grid infrastructure in the village to be overhauled - starting from poles, insulators to cables. This would have cost implications beyond just replacing the diesel generator with solar panels and batteries. We estimate that the cost would not be very different from creating a new grid system altogether in these villages and its quality would depend on whether the local village grid would connect to the national grid or not.

The current set up of the DMG can be explained by a few factors which we've found out through the interviews. These are linked with one another as they influence the outcome of the decision for village electrification and will thus be crucial to address for any developer wanting to create rural electrification solutions.

Wooden Poles used for distribution

1. Limited Technology & Know-how

The options for technology and the equipment is limited to what is available in the nearby towns and the villages do not have access to information on diversified choices and solutions for their electricity needs. Given these limitations, the village usually decides to invest in the easiest and lowest cost option, usually a diesel mini-grid.

2. Budgets Deployed

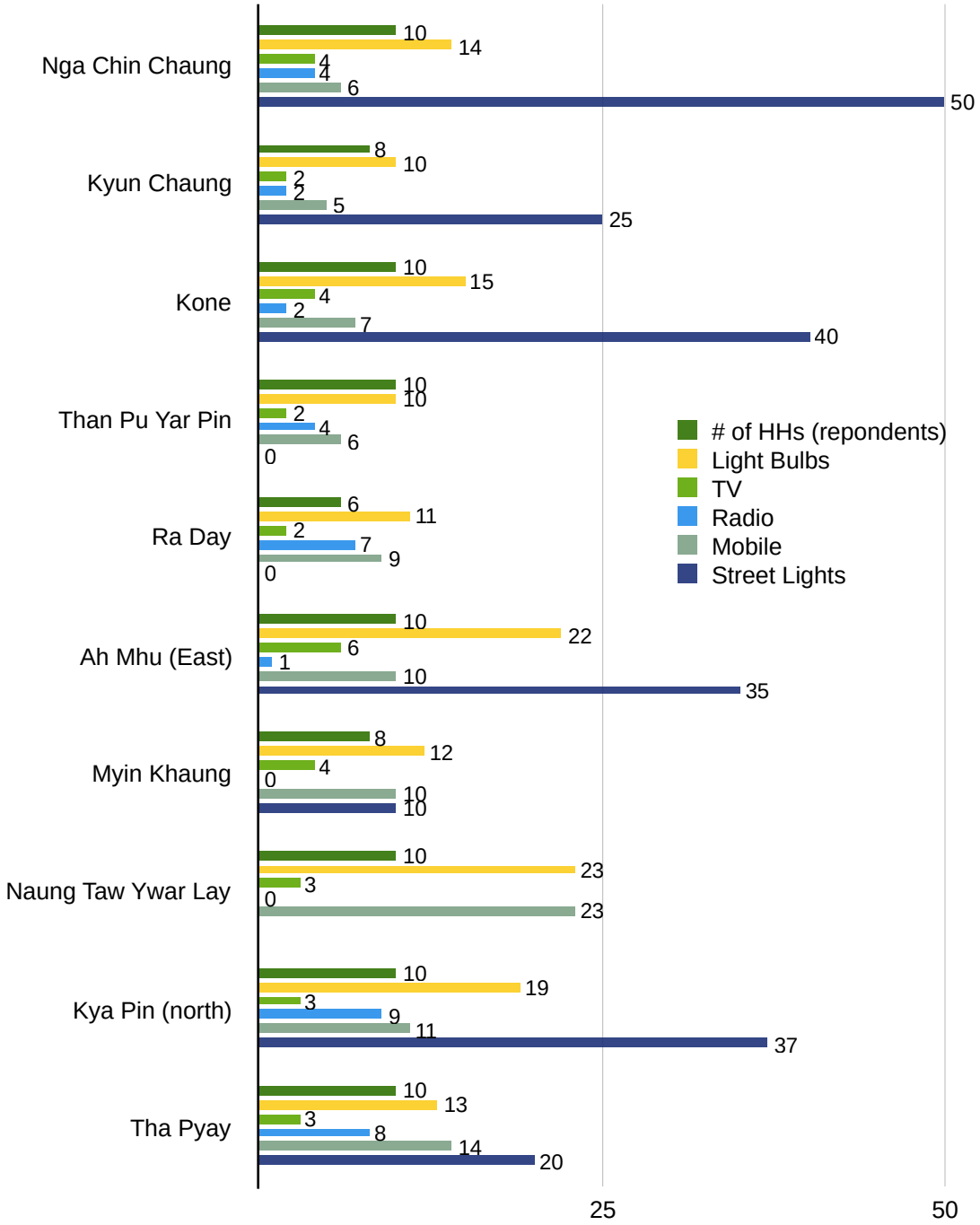
In most cases, majority of the budget comes from VDF savings, land leases or other creative means. Contributions from the households for establishing the DMG remain low as seen in Table 5. This is linked to the prior expectation of the DMG providing basic electrification.

3. Expectations & Perception of DMG

The villages do not expect the DMG to be the complete and final solution for their electrification needs and consider it being a temporary arrangement while they save enough money for SHS or wait for the National Grid to connect their community.

We see that the current system has its advantages in being established & operated by the community. This keeps the costs of construction low and more importantly the regular operations & maintenance easy, while reducing instances of theft.

Chart 3: Number of Electric Appliances



We ran quantitative surveys for 92 respondents/HHs to understand their current usage patterns. We asked them about their current consumption based on the electrical appliances they had in their houses.

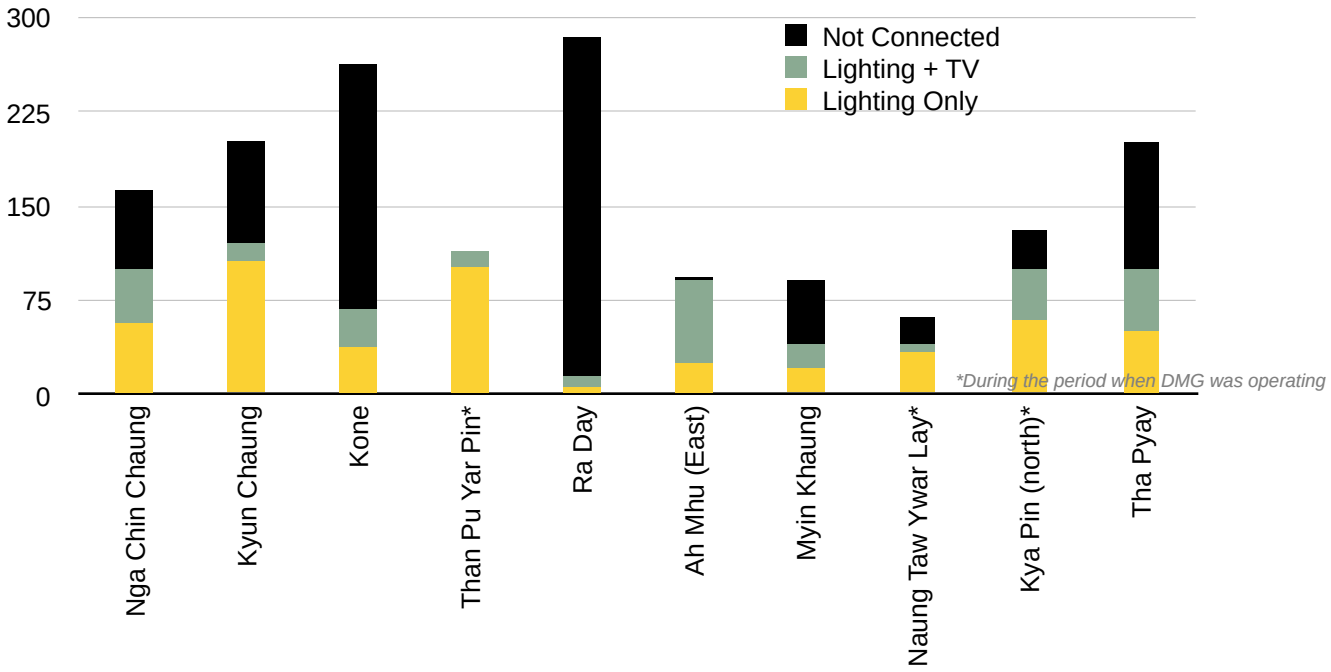
It is clear from the results that lighting and TV are the major requirements served by these DMGs.

Most houses have 1-2 lights installed, with the average being 1.6. Over 35% of the HHs own a TV and this contributes to the maximum energy consumption during the DMG operating period. 66% respondents in our sample use mobile phones. Radio & CD players are owned by 40% of the HHs.

Conclusions:

1. DMG operations are basic and serve lighting and TV (entertainment) along with phone charging and radio
2. DMG operates for roughly 2 hours (7-9 pm) across these villages
3. Lighting needs are increasing with more electricity provided
4. Usage of TV is limited currently due to the higher monthly tariffs for Television (2.5 times more than Lighting only tariff)

Chart 4: Types of Connections with DMGs



We also tabulated the different kinds of connections which shows a variation from one village to another on the adoption of the community DMG. In Ah Mhu, all the HHs seem to be connected while in Ra Day, the private DMG does not have enough consumers and might be on the verge of shutting down operations.

As we found during the FGDs, Ah Mhu seems to have one of the most evolved models for running the DMG which does not come as a surprise, given their DMG has been operating since 1976. They also have an annual meeting to discuss the plans for the year and solutions to any problems with the DMG.

We believe that the following factors have played a role in the strong DMG operations in this village.

Electricity Tariff
1. Lighting : 1000 kyats/month
2. Lighting + TV: 3000 kyats/month

Annual Maintenance Fee
1. Lights: 2000 kyats/month
2. DVD Player: 2000 kyats/year
3. TV: 6000 kyats/year

1. Reasonable tariff structure for operations
2. Annual maintenance Fee outlined separately to cover any repair costs
3. Annual meetings to resolve any issues faced by the community

Ah Mhu has had time to streamline and perfect its DMG operating processes, which has not been established in other communities. We have seen that other villages have resorted to shutting down their operations due to lack of budgets for repairs or unresolved conflicts.

The model in Ah Mhu shows strong community engagement and willingness, essential for creating models for rural electrification. In this case, the community benefits come from the fact that apart from 3 HHs in Ah Mhu that use SHS, the majority of the village funds are saved and can be deployed for the community DMG. The DMG has established credibility but the needs of consumers have grown and they are now awaiting the national grid connection. If provided a better means of reliable, sufficient electrification we think they would be keen to adopt it.

6:CONSUMER NEEDS & ABILITY TO PAY

In this section, we aim to identify what consumers are paying for electricity as a whole. The different kinds of payments made can be summarised as below:

1. **Fixed Cost for Set up of DMG**
2. **Contribution to the VDF**
3. **Monthly Tariff for a) Lighting only b) Lighting & TV**
4. **Annual/Monthly Repair Costs**

Table 6: Tariff Structure For Mini-Grids (Kyats)

Township	Village	Payment/Month (Lighting)	Payment/Month (TV)
Seikphyu	Nga Chin Chaung	1000	2500
	Kyun Chaung	1000	2500
	Kone	1500	4500
	Than Pu Yar Pin	500	1500
Salin	Ra Day	1500	4500
	Ah Mhu (East)	1000	3000
	Myin Khaung	1500	5000
	Naung Taw Ywar Lay	Voluntary 50-100 kyats per HH per day	
	Kya Pin (north)	3000	7000
	Tha Pyay	1500	4500

The definition of electricity needs to be noted as stated earlier being low quality, unreliable in most communities we assessed.

An assessment needs to be done on understanding in-depth about village electrification economics where all costs borne with the village for electrification are mapped in addition to the above costs. A sum total of these costs in addition to the ones outlined above will be required to understand the true cost of electrification.

1. **Cost of SHS owned by the village**
2. **Cost of batteries owned**
3. **Any torches, lanterns etc.**
4. **Replacement of batteries**
5. **Cost of battery charging**
6. **Cost of establishing, maintenance & repairs of mini grid**
7. **Expected expenditure for connecting to the national grid**
8. **Amount spent on candles, kerosene & charcoal**

These when compared with the new distributed generation models should be able to indicate the total expenses that the village should be able to bear. It is important to note is that all such expenses are deployed over a longer time and most HHs cannot account for them together.

Table 7: Understanding Cost of Electricity Paid Currently

Township	Village	DMG Setup Cost (kyats)	DMG Monthly Cost (kyats)	Approx Monthly kWh Produced	Cost/kWh (kyats)
Seikphyu	Nga Chin Chaung	3500000	164500	373	441
	Kyun Chaung	2900000	142500	293	486
	Kone	3000000	322000	255	1265
	Than Pu Yar Pin	2700000	69000	269	256
Salin	Ra Day	1000000	52500	71	742
	Ah Mhu (East)	5000000	256667	446	576
	Myin Khaung	1000000	130000	161	808
	Naung Taw Ywar Lay	1200000	69000	102	676
	Kya Pin (north)	900000	460000	360	1278
	Tha Pyay*	1200000	300000	402	746

The cost paid by the village for the DMG is in the range of 256 to 1200 kyats/kWh as seen from above. This wide range reflects the practices in the village, from which we can draw some conclusions.

Than Pu Yar Pin has the lowest cost/unit of 256 kyats and as we saw earlier, the DMG in this village was stopped after 3 years of operation. The electricity charges in this village were one of the lowest amounting to 500 kyats and 1500 kyats per unit respectively for lighting & TV. Given the low contributions and no maintenance or repair budgets kept separately like Ah Mhu, this village had to stop operations.

The median electricity rate lies around 700 kyats as seen in Naung Taw Ywar Lay, Ra Day and Tha Pyay. In Naung Taw Ywar Lay, we saw that the fixed costs were not contributed by the village but were achieved through the lease of the village land thus creating low incentive for maintaining the DMG by the community. Also, given the small size of the village, the cost for kWh seems higher than usual. The village also followed the donation model with no fixed tariff but freedom to donate 50-100 kyats per day, depending on customers' capacity to pay.

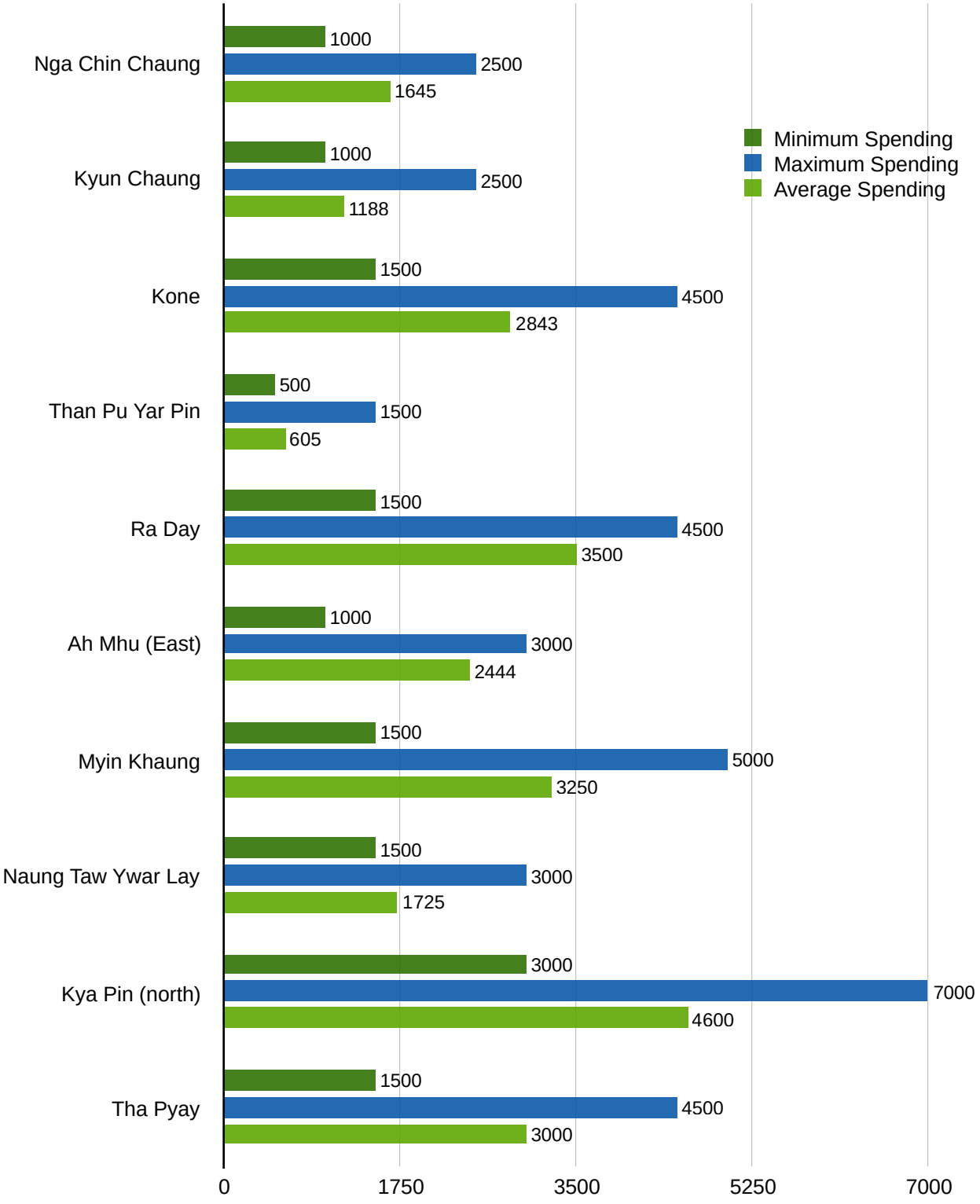
The villages with the highest cost per unit of electricity are Kone and Kya Pin. Operations are ongoing in Kone but have stopped in Kya Pin due to the conflicts created by insufficient electricity supply. This shows the difference in outcome caused in cases where the consumers are paying a significant amount but don't receive the service in line with their expectations. In Kone, higher cost per unit enables the DMG to operate smoothly while in Kya Pin, there are technical issues such as sizing of the generator and dynamo insufficient for the loads. Kya Pin also operates the DMG for 4 hours vs. 2 hours in Kone and thus the maintenance costs in the former are expected to be higher as well. We assume that if the technical requirements were met in Kya Pin, the consumers would be satisfied, and the DMG would still be operating.

Important Factors from this discussion

1. **Tariff Rate Sufficiency for Fuel / Maintenance**
2. **Technical Performance in-line with expectations**
3. **500-600 kyats / unit being the average rate of electricity currently paid across villages**

Approximate KWh are calculated on the basis of # of connections of each kind, usage observed from our sample set and the duration of electricity. Fuel cost and maintenance cost are factored in the DMG monthly cost and should be taken as an estimate provided by the community due to lack of documented data available.

Chart 5: Estimated Monthly Spending on Electricity per Household (kyats/Month)



In Chart 5, we have tabulated the monthly expenses on electricity and again see a wide range spanning from a minimum of 500 kyats/HH to 7000 kyats/HH which shows the wide range of income levels existing in the village and the DMG plans that were devised to operate.

Chart 6: Cost of Electricity for TV paid Across Villages

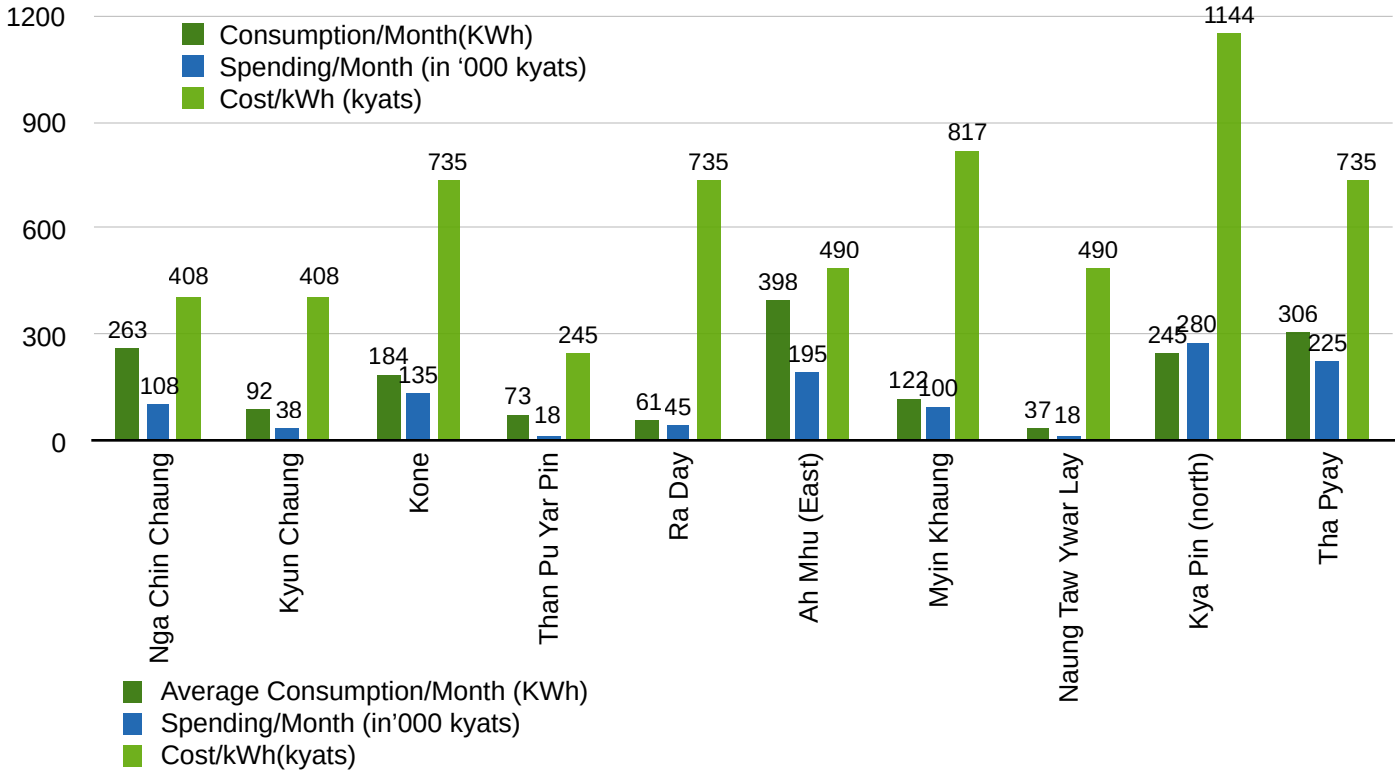
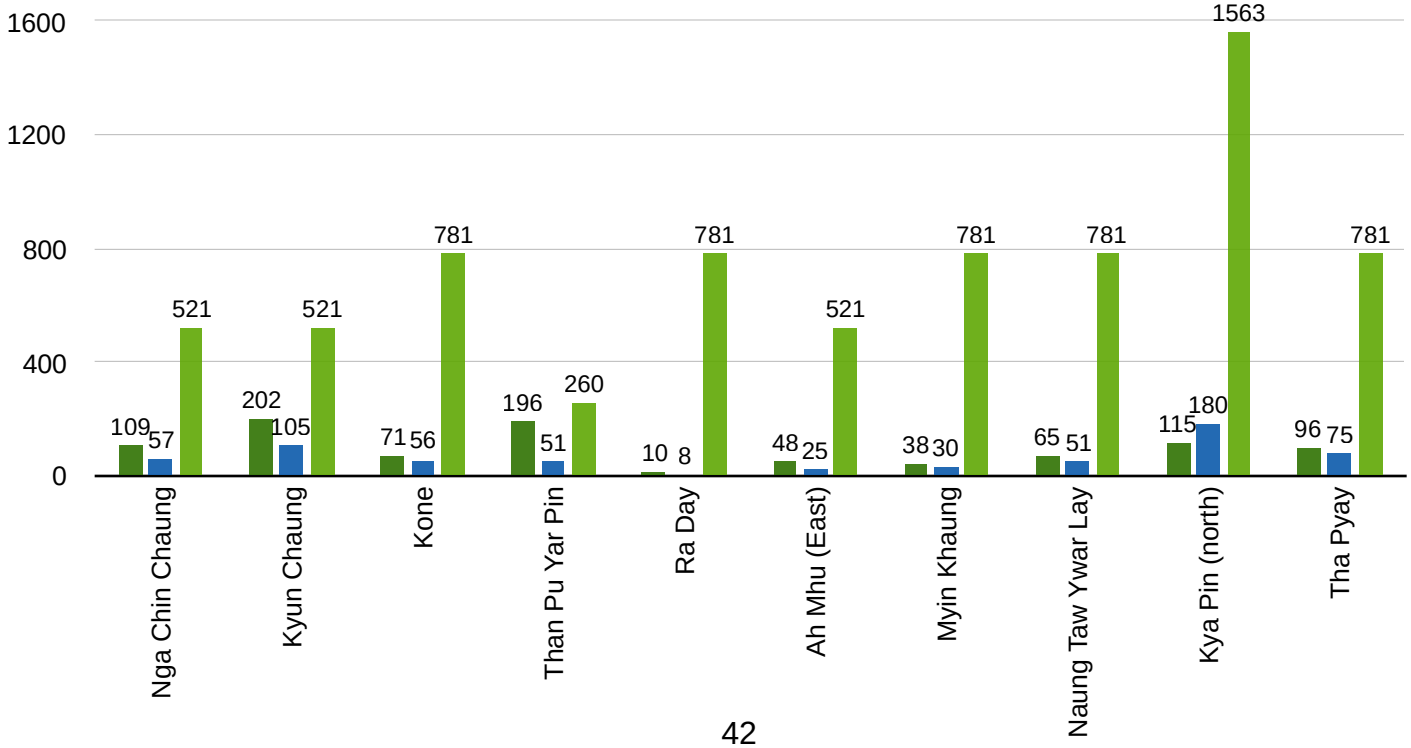


Chart 7: Cost of Electricity for Lights paid Across Villages



We've seen earlier that the villages paying the highest amounts have not always been the most successful in maintaining and running their operations and we see this here again as high expenditure in villages like Kya Pin have not ensured continued operations.

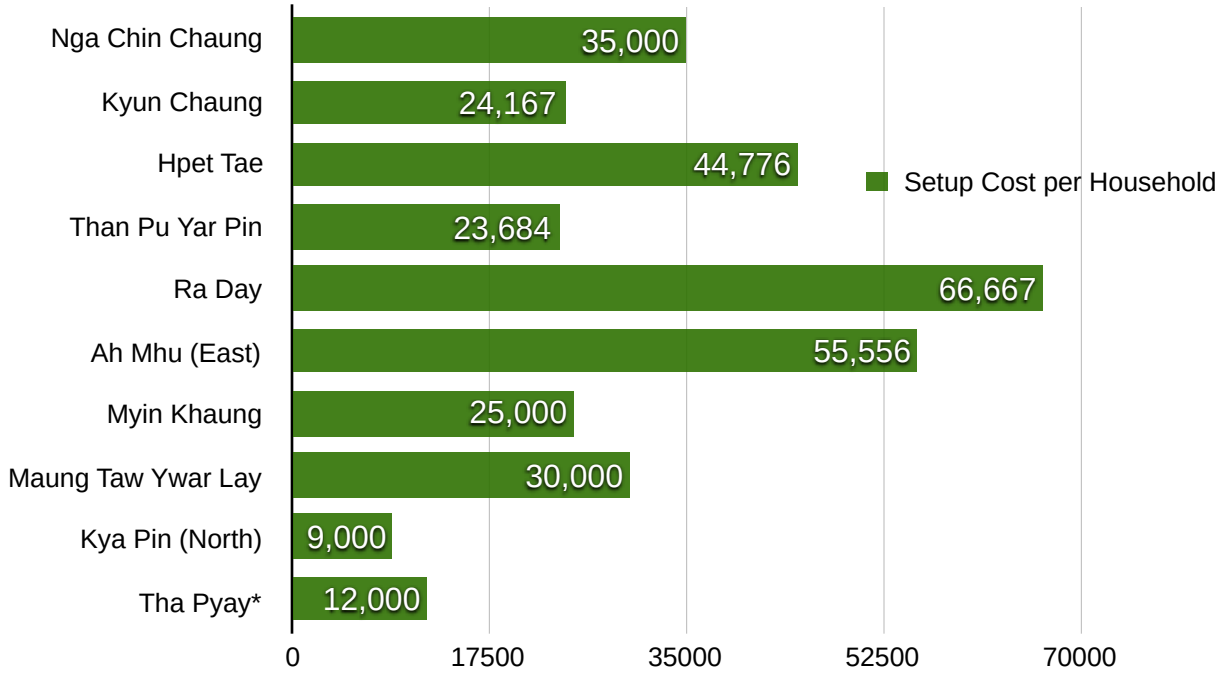
Using Charts 6 & 7, we attempt to break down the costs paid by HHs that opt for TV vs the HHs that have opted for a lighting only plan. We wanted to explore if any cross subsidy exists between the two groups.

What we see is that the HHs using TVs are paying a lower cost/unit vs. the HHs using only lighting. This is reflective of the national electrification system where the villages with lower incomes are paying much higher tariff/unit than the consumer in cities. Furthermore, the consumers in these villages with lower incomes are paying much more than the consumers who can afford paying higher tariffs for TVs.

In Chart 8 below, we see the average amount spent per HH in setting up the DMG .

In Kya Pin and Tha Pyay, the cost for HHs connected was significantly lower than in other villages. Tha Pyay received the generator as a donation hence the cost is lower due to an exception whereas for Kya Pin the investment in the equipment itself seems to be lower. Though numbers provided by the villages might not be exactly accurate, they show a clear cost-versus-equipment trend, pointing out that the insufficient consideration of sizing will result in issues with electricity supply, as seen in Kya Pin.

Chart 8: DMG Setup Cost per HH Connected (kyats)



NEEDS ASSESSMENT & OUTLOOK

Though the quantitive data recorded in this assessment is not comprehensive, we found certain points from our study that could be beneficial for creating MG solutions for rural Myanmar.

Most consumers stated that the decision to connect the grid was their own, however the majority of the financial decisions were taken jointly - by the whole community or the VDC. Choices about tariff plans were made on the individual basis, but the overall setup fee, cost of each plan and any maintenance fee were jointly agreed in VDC meetings. The satisfaction level with the current DMG seems to be evenly spaced out with half the consumers on either end.
It is interesting to note that appliances are the major planned purchase once the HHs receive more electricity. This has been an outcome of numerous other studies where communities purchase appliances until their certain needs are fulfilled and then engage in productive use of energy beyond this threshold. A complete analysis of these thresholds is not in scope of this assessment and will need to be investigated further.

Key Points

1. **Communities and VDC jointly decide about the tariff structure**
2. **Consumers opt for electricity supply based on their own needs**
3. **Satisfaction with the current DMG seems neutral and is a factor of the expectations/perception of the DMG**
4. **Appliances seem to be the primary planned purchase**

Chart 9: What drives your decision for connection to DMG?

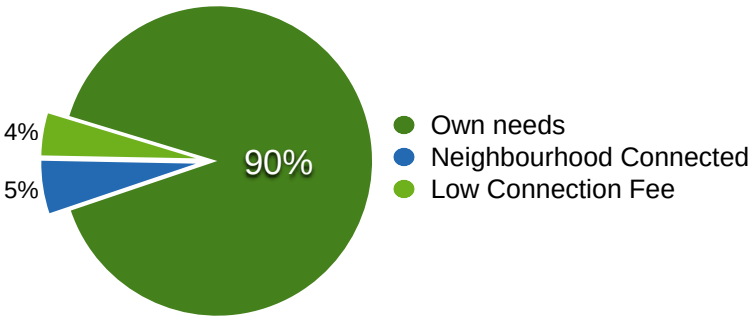


Chart 10: Who decides how much to pay for Electricity?

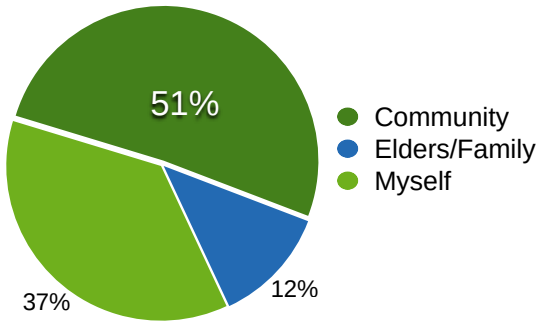


Chart 11: Are you happy with the current level & service of electricity?

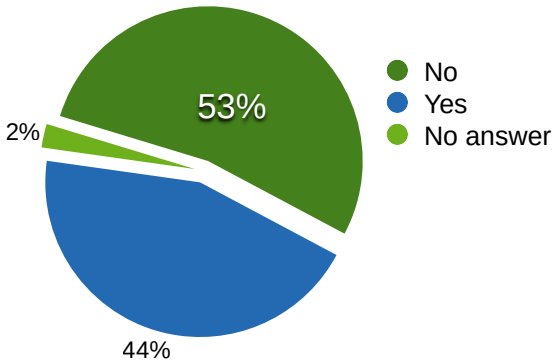
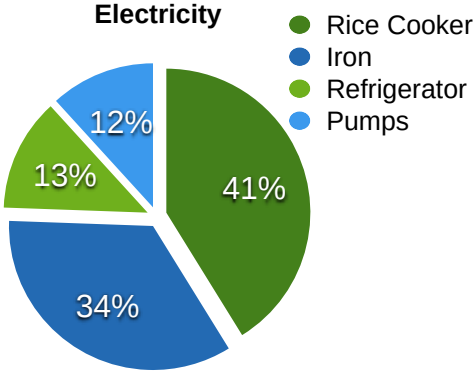


Chart 12: Top Choices Made by Consumers if Provided More Electricity



7: CONCLUSION & RECOMMENDATIONS

Can the existing DMGs be converted to Hybrid Solar MGs?

This can be analysed on different factors as below:

1. Existing Infrastructure

The existing DMG infrastructure is basic and constructed to enable a simple set up and low costs. The cables and poles need to be upgraded which would be a major cost component for the upgrade. There is scope to use the funding for the Grid connection that some villages are considering. The distribution network established in 2 villages for connecting to the grid is of good quality and could be utilised for the MG operations but to have this expense paid by the village will require changing the positioning of the MG and establishing credibility of MG operations.

2. Tariff Per Month

The villages are currently spending on an average 500-600 kyats per unit of electricity with their monthly expenditure averaging around 2500 kyats. We believe that this tariff could support operations of MGs for the private sector. The current DMGs show that there is willingness and capacity to pay for electricity and more reliable electricity can command a premium and will have users in the villages.

3. Fixed Cost of Construction

Currently, the financing for the DMG is coming from various sources including savings in the VDF, leasing of land, donations etc. which aren't concentrated at a single point of time. The villages might not be able to draw out the same funds at once and will need financing options to enable them to make this choice.

Success Factors & Pit-Falls to avoid

In this assessment, we observed 10 DMGs of which 6 were currently operating & community run, 3 were forced to shut down due to various reasons and 1 was being operated privately. We attempted to understand the outcomes and linkages with the inputs and have come up with a couple of factors which we believe are critical to the success of MGs and future operators could learn from these.

1. Fixed Cost Contribution

a) Fixed Costs and System Sizing

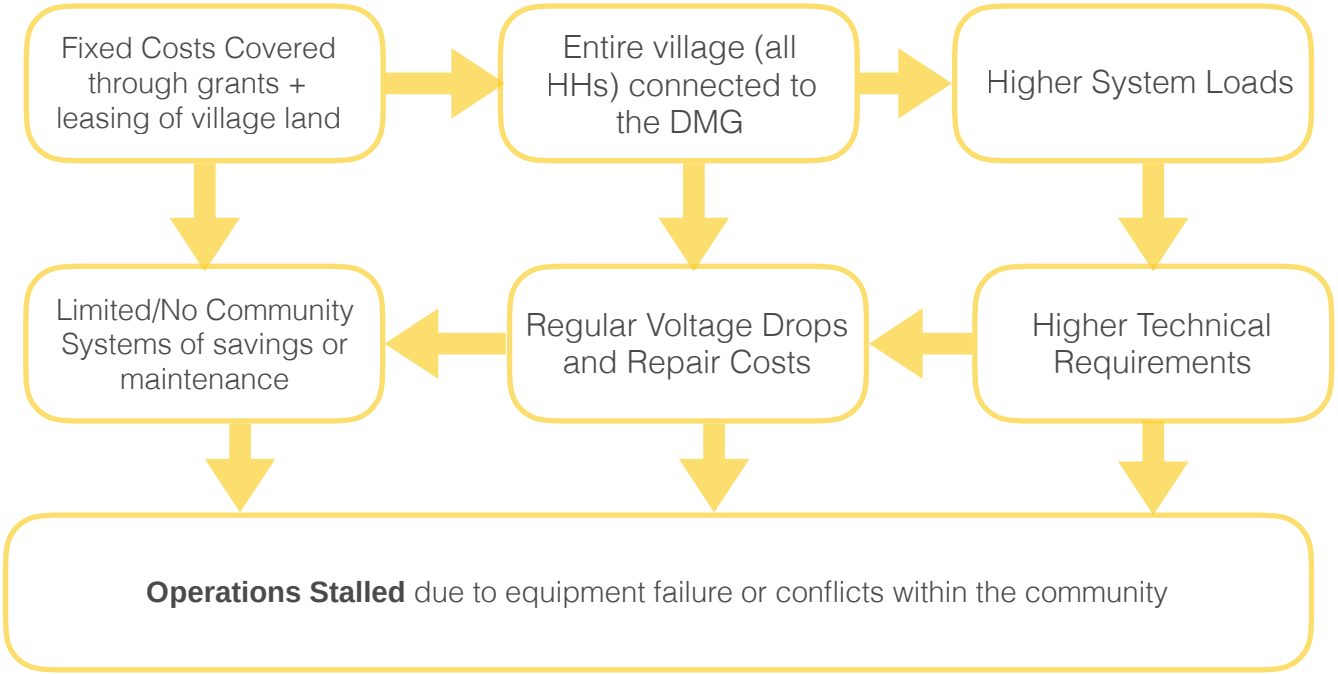
In the villages where the DMG failed, we noticed that the fixed costs were paid through a combination of leasing of land and donations from the village without any specific fee paid per household. The issue wasn't a lack of commitment from the village as is often sighted as the reason for failure but rather the fact that as a result of this arrangement, the entire village was connected to the DMG

Once the entire village is connected to the DMG, the system requirements need to be higher not only on the generation side, but also on the distribution end. We saw that in Than Pu Yar Pin, the dynamo failed, while in other villages like Maung Taw Ywar Lay, the DG couldn't be repaired. In Kya Pin, though the equipment was working, it couldn't supply sufficient power to all the households connected thus creating conflicts within the community.

b) Maintenance & Repair Budgets

In villages, where the fixed costs were met through leasing of village land or through donations, there were no formal processes by which the villages could save or collect money for maintenance and repairs. Thus in case of equipment breaking down, there were no funds which could be used for repair or purchase of a new one.

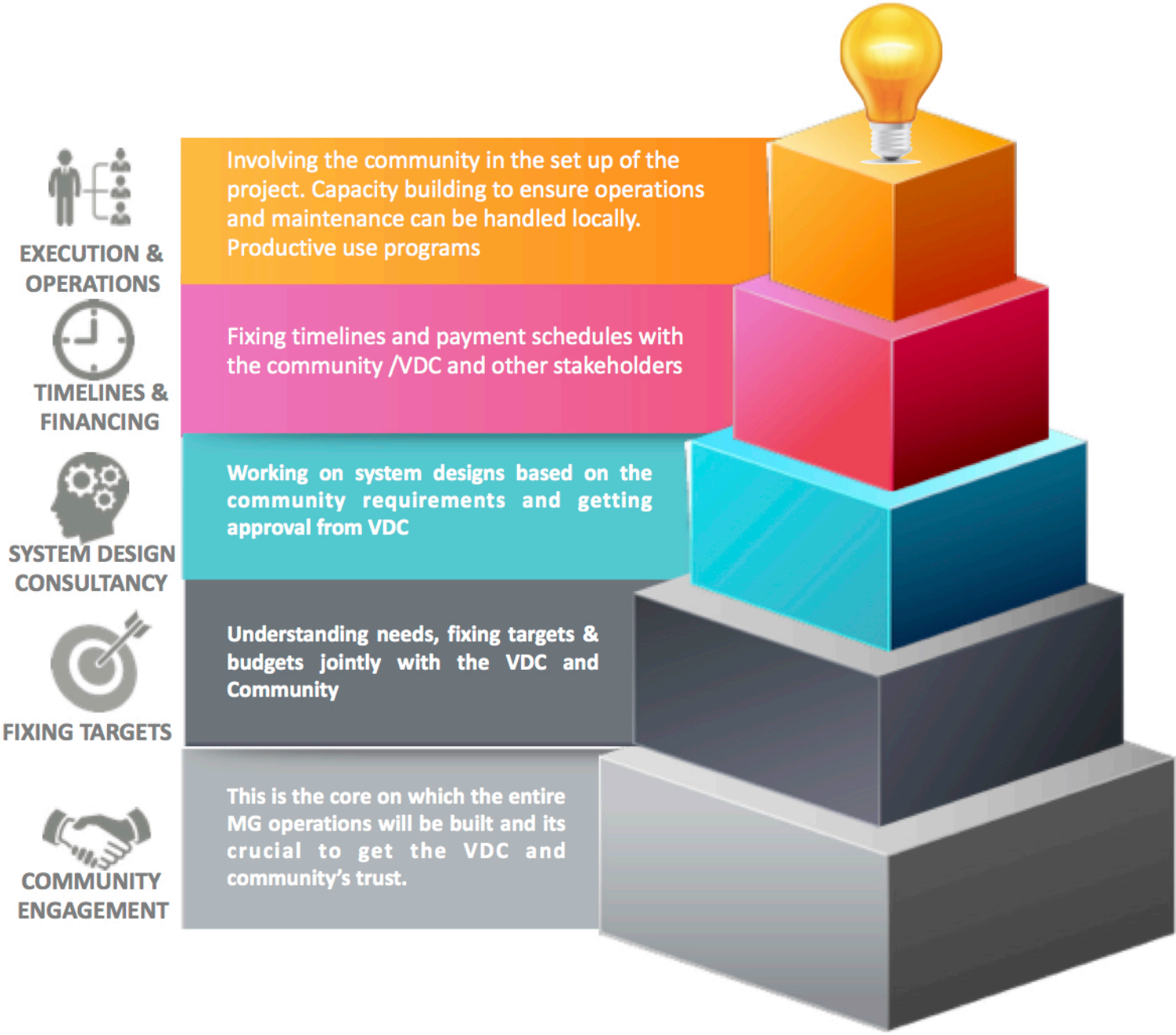
Representation of the steps leading to failure of mini grids observed in this assessment



2. Strong Community Engagement from the start

Community engagement and participation is central to the operations starting from the decision, budget allocation and needs and then extending to the execution and operations. At each step, strong community participation ensures the success of the project and increases the probability of more HHs connecting to the MG and thus its viability.

The below illustrative diagram shows how the community & VDC trust and participation forms the base and is crucial at each step of the process. Stronger community participation and engagement from the start will ensure that the community offers support at later stages.



RECOMMENDATIONS

A Model for Rural Electrification using Mini Grids

1. POSITIONING OF THE MINI GRID TO BE CHANGED

- Education on meaning of a MG from Low Cost/ Basic to Reliable & Sufficient
- Establishing Credibility & Reliability of MG Operations
- Educating on Current Costs of Operations including expenses on
  - a)SHS
  - b)DMG
  - c)Batteries & recharging
  - d)National Grid Extension
  - e)Candles

2. USING A STRONG COMMUNITY BASED MODEL FOR OPERATIONS

- Getting Alignment from the VDC & Villages
- Training the community on technical operations of MGs to keep costs low
- Engaging communities for operations and maintenance by leveraging their current systems
- Inducing Community Ownership of the MG
- Creating models to make selection of electrification plan easy for the village

3. ESTABLISHING FINANCING FOR MG SETUP

- Communities have the ability to pay for monthly tariffs but require education as stated above
- Financing available for villages & developers

4. CLARIFYING NATIONAL GRID EXTENSION PLANS

- Working with MOEE & DRD on sharing National Grid Extension Plans and educating villages
- Creating Cost Benefit Analysis of MG vs other options
- Creating financial models with a sound understanding of grid extension plans

5. GETTING CLARITY ON POLICY FRAMEWORK

- Defining key permits required
- Outlining subsidies available
- Providing constraints and guidelines within which MGs can operate

6. PRODUCTIVE USE OF ENERGY

- Ensuring income generation for the village so that the community can pay for their expenses
- Establishing other livelihood and capacity building programs into the villages which build on productive use of electricity

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