



Decentralised Energy Market Assessment in Myanmar

Summary

MAY 2019

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List of Acronyms used in the Report

ADB	Asian Development Bank	LCOE	Levelised Cost of Electricity
AFD	Agence Française de Développement	MESC	Mandalay Electricity Supply Company
AICS	Agenzia Italiana Cooperazione allo Sviluppo	MG	Mini-grid
AIIB	Asian Infrastructure Investment Bank	MMK	Myanmar Kyat
CAPEX	Capital Expenses	MOALI	Ministry of Agriculture, Livestock and Irrigation
DESCO	Distributed Energy Service Companies	MOEE	Ministry of Electricity and Energy
DRD	Department of Rural Development	MOPF	Ministry of Planning and Finance
EEP	Energy and Environment Partnership	NEP	National Electrification Plan
EGAT	Energy Generating Authority of Thailand	OPEX	Operational Expenses
EMS	Energy Management System	PV	Photovoltaics
ESCO	Energy Service Company	REF	Rural Electrification Fund of Cambodia
ESE	Electricity Supply Enterprises	SME	Small and Medium Enterprise
EU	European Union	SPD	Small Power Distributor
FAO	Food and Agriculture Organization	SPP	Small Power Producer
GDP	Gross Domestic Product	UN	United Nations
GEF	Global Environment Facility	UNDP	United Nations Development Program
GHG	Greenhouse Gases	USAID	United States Agency for International Development
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit	USD	United States Dollar [1USD =1378 MMK (2018)]
GSMA	Global System Mobile Association	VSP	Very Small Power Producer
IFC	International Finance Corporation	WWF	World Wildlife Fund
IMF	International Monetary Fund	YESC	Yangon Electricity Supply Company
IPP	Independent Power Producer		
IRENA	International Renewable Energy Agency		
IRR	Internal Rate of Return		
JICA	Japan International Cooperation Agency		
JICS	Japan International Cooperation System		
KfW	Kreditanstalt für Wiederaufbau		



Preface

Over the past two years, Smart Power Myanmar has spoken to hundreds of companies, donors, investors, micro-finance agencies, non-profits, community members and government officials to understand the key challenges at a systems level that prevent and inhibit greater access to energy in Myanmar, and to develop solutions for overcoming those challenges. We have done this to try to plug one of the biggest key gaps: the need for a clear understanding of the potential size of the market for decentralised energy solutions, an analysis of where and when such solutions make the most sense, and the steps various market participants must take in order to capture that market potential.

Through the generous financial and technical support of The Rockefeller Foundation, GIZ and Agence Française de Développement, this Market Assessment therefore began with a simple premise: develop a clear and credible evidence base, and set forth a series of recommendations to expand access to energy in Myanmar. We hope that this Assessment will serve as an advocacy tool and a strengthened vision for electrification where the national grid explicitly includes decentralised power generation at scale.

One of our clearest findings is that investing in decentralised energy solutions is not only the *lowest cost* option for Myanmar, but it is also the *fastest route* towards energy access for millions of under-served people. This Assessment makes the case for various market participants to view decentralised energy solutions as part of a national infrastructure base, instead of stand-alone solar or hydro-mini-grids. We could call this vision for an interconnected future “Grid 2.0.”

The case for scaling up decentralised energy solutions in Myanmar is compelling. Based on our analysis, in the next couple of years — if the correct actions are taken — the viable, potential market could be as large as 2,300 mini-grids covering 2 million people, helping to increase GDP by more than \$230 million. Longer term, with the adoption of clear measures as outlined in this Assessment, the number of viable mini-grids could be as high as 16,000 by 2030, which would cover more than 20 million people — or almost two-thirds of all under-served people in Myanmar today.

Needless to say, turning this potential into reality will require investment, determination, cross-sectoral coordination, positive market conditions and favorable policies and our Assessment attempts to highlight these issues in detail. One thing is clear: achieving scale will require *systemic solutions* on a large scale — support structures that successfully match the *supply* of electricity with the effective and profitable use of electricity.

Connecting rural customers to reliable and affordable sources of electricity has thus far proven very challenging without philanthropic support. In addition to the financing of energy infrastructure through extensive subsidy programs, for example, financing for connections, appliances and equipment will be needed. Most developing countries that have invested in electricity infrastructure have failed to invest in demand and related productivity improvements. We estimate that in Myanmar, less than 1% of current total financing in energy access is connected to productive use; a lesson that should have been learned from experiences elsewhere. As Rocky Mountain Institute states in their 2018 publication “Closing the Circuit”:

“..from 2000 to 2008, supply expansion represented almost half of the nearly \$4 billion the World Bank approved for investment in energy access, whereas investment in productive use represented 0.7%.” And goes on to add: “In Africa, all investment in productive use financed technical assistance; no such financing was directed to implement productive use investment projects.”

In short, Myanmar’s future “Grid 2.0” will need to operate as a system comprised of a wide range of components, spanning community structures, rural businesses, equipment suppliers, state and non-state actors, commercial banks, global financing institutions and development institutions, all supported by conducive policies and regulations.

While Myanmar’s nascent energy market may lag behind many of its neighbors, the country has the distinct advantage of being able to learn from mistakes and to accelerate growth. Choices can be made now. We have seen such tremendous change happen before, with the transparent liberalization of the telecom sector, helping to bring cellphone ownership to the vast majority of the population in just a few years. Such radical transformation and change had been almost unthinkable several years ago. We hope that this Assessment goes some way to positively influencing those policies and the communities that depend on them.

Richard Harrison
CEO, Smart Power Myanmar
Yangon, May 2019

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Lead consultants/researchers and authors

Dieter Billen, *Roland Berger*
Giovanni Bianchi, *Roland Berger*

Technical feedback & reviews

Adriana Karpinska, *Smart Power Myanmar*
Ashish Dhankhar, *GIZ*
Clare Boland Ross, *The Rockefeller Foundation*
Mark Hayton, *GIZ*
Mathilde Gasperi, *AFD*
Matthew Cullinen, *Pact*
Matthew Tiedemann, *Pact*
Martin Cosier, *UNDP Myanmar*
Pariphan Uawithya, *The Rockefeller Foundation*
Patrick Pawletko, *GIZ*
Peter du Pont, *Asia Clean Energy Partners*
Regine Dietz, *GIZ*
Richard Harrison, *Smart Power Myanmar*
Roy Torbert, *Rocky Mountain Institute*
Ruosida Lin, *Rocky Mountain Institute*
Stephanie Posner, *Pact*
Sunil Kumar Khosla, *The World Bank*

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Bridge

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Smart Power Myanmar



- Access to electricity remains an issue in Myanmar with an estimated 58% of the population, approximately 30 million people, not connected to the main power grid
- In 2015, the Government of Myanmar formulated the National Electrification Plan (NEP), an ambitious program structured around 5 phases aiming to reach 100% grid electrification by 2030 – in the NEP, mini-grids played a limited role as interim electrification solutions covering 0.7 million people or 2% of the off-grid population
- Based on global benchmarks, implementation of the 2015 NEP roadmap appears very challenging – instead it is expected that grid electrification will take considerable time and investment
- In this context, mini-grids could play a pivotal role as a “grid 2.0” distributed solution bringing electricity to off-grid areas while expansion of the main grid progresses
 - » Mini-grids cost per connection is on average approximately 40% lower than main grid expansion
 - » Mini-grids have substantial development impact as they can support demand from business users (productive loads)
 - » If “grid-ready” mini-grids are developed, they can be easily integrated once the main grid arrives. Mini-grids generation and energy storage assets can be leveraged as small-scale distributed generation and energy storage systems, and distribution assets can be utilised to ensure last-mile connections to households and businesses in villages
 - » Thus mini-grids support a bottom-up “grid 2.0” solution that can accelerate electrification while expansion of the main grid is carried out

- However, grid-ready mini-grids are still expensive and require subsidy support. In addition, absence of a comprehensive regulatory framework and of a clear transition mechanism in case of grid arrival, pose risks for mini-grid projects close to the main grids
 - » Currently mini-grids serving residential and local businesses are financially viable from private developers' perspective only if investment subsidies are provided
 - » Mini-grids are not regulated under a licensing system and no compensation and/or transition mechanisms exist in case of grid arrival. Hence, only remote sites under Phase 4 and 5 of the NEP with low likelihood of grid arrival are targeted by private developers for mini-grid investment
- Thus, with the current subsidy budget availability and without any regulatory changes, the size of the potential market is expected to remain limited to approximately 230 mini-grids by 2025, covering 110,000 people or 0.3% of the off-grid population, and growing to 590 mini-grids by 2030, covering 531,000 people or 2.3 % of the off-grid population
 - » By 2025 only mini-grids under the investment subsidy scheme are financially viable. With the current level of budget available for investment subsidies, approximately 230 mini-grids can be developed
 - » By 2030, as equipment costs decrease, mini-grids beyond the investment subsidy scheme are expected to become financially viable in favourable locations. However, in the absence of regulatory reform, investible sites are limited to villages in the phase 4 and 5 of NEP resulting in a total potential market of 590 mini-grids
- Instead, scenario analysis shows that implementation of five combined measures could trigger in the short term a potential market of up to 2,300 mini-grids covering approximately 2 million people or 6.5% of the off-grid population:
 - 1 Increase power demand from businesses through demand-side support measures
 - 2 Decrease private developers' hurdle return rate by facilitating access to finance and de-risking mini-grids
 - 3 Enable investment in mini-grids in villages under Phase 3 of NEP in addition to those under Phase 4 and 5 by de-risking grid arrival
 - 4 Increase number of mini-grid projects by increasing available budget for investment subsidies to generate sufficient scale in the market
 - 5 Enable economies of scale through larger scale developers or by pooling resources across developers
- With the five measures above and thanks to equipment cost reduction and technology improvement, the potential market is projected to increase to ~8,000 mini-grids by 2025 and then double to more than 16,000 mini-grids by 2030
- Roll-out of all 2,300 mini-grids viable in 2020 would require a USD 537 million investment. In the longer term, if the market fulfills its potential, USD 1.8 billion investment would be required to implement all viable mini-grids

Table 1. Summary view of potential market projections by scenario

Scenario	Potential market metric	Potential market projections		
		2020	2025	2030
Business as usual scenario <ul style="list-style-type: none"> • Subsidy budget unchanged at USD 18.6 million • No regulatory reform to de-risk grid arrival 	Number of viable mini-grids	229	229	584
	Population covered	108,000	108,000	570,000
	% of off-grid population covered	0.4%	0.4%	2.5%
	Investment required to roll-out all viable mini-grids	USD 31 m	USD 31 m	USD 202 m
Scenario with 5 measures <ul style="list-style-type: none"> • Demand-side measures • Access to finance • De-risking of grid arrival • Subsidy budget at USD 100 million • Economies of scale 	Number of viable mini-grids	2,253	8,051	16,444
	Population covered	1,954,000	5,894,000	10,229,000
	% of off-grid population covered	6.4%	21.9%	45.2%
	Investment required to roll-out all viable mini-grids	USD 537 m	USD 1,844 m	USD 3,356 m

- Based on these findings, a comprehensive framework of initiatives structured around 3 pillars and enablers is recommended
 - » **Pillar 1:** promote de-risking and access to finance to increase investible sites and decrease hurdle return rate for private developers. Recommended actions include introduction of a comprehensive regulatory framework to de-risk grid arrival, measures to de-risk cash flows such as revenue guarantees and measures to support access to finance such as two-step loans schemes
 - » **Pillar 2:** support growth of demand, focusing on productive loads through direct subsidies of electricity prices, or through micro-finance of electrically powered machinery and technical assistance
 - » **Pillar 3:** support generation of economies of scale through pooling of key development and procurement processes, and supporting growth of sizeable private developers
 - » **Enabling initiatives** include extension and optimization of the current subsidy scheme and cost reductions, initiatives to increase community involvement, to develop and share best practices and capacity-building initiatives to train the required workforce
- In addition to triggering a large potential market covering millions of off-grid households, these measures could result in an increase of GDP by up to 233 million USD and create 48,300 jobs
 - » Mini-grids can accelerate socio-economic development in Myanmar in three ways: direct economic impact, indirect economic impact and social impact
 - » Most of the economic benefits of mini-grid projects would be derived indirectly from the impact of electrification on businesses; this reinforces the importance of productive loads not only in ensuring the viability of mini-grids, but also in supporting development impact through GDP growth and job creation

This study provides an assessment of the current market for mini-grids in Myanmar, the projected size of the market by 2030, the key market drivers, and a set of scenarios based on those drivers.

The study is articulated along three axes:

- Review of current status, issues, market participants, their business models, sources of funding, and pipeline
- Identification of key market drivers and their implications
- Formulation of scenarios for evolution of the market for mini-grids in Myanmar and assessment of potential market size for each scenario

Based on best practices and the outcome of scenario analysis, the study also identifies key recommendations for stakeholders including policymakers, investors and international donors, local and global private developers and the wider business community to help accelerating the deployment of mini-grids in Myanmar.

This study involved numerous interviews with key stakeholders, including Government officials, multilateral institutions, current and potential mini-grid developers and equipment manufacturers.

1.0

Electrification in Myanmar

1.1 Current status of electrification in Myanmar

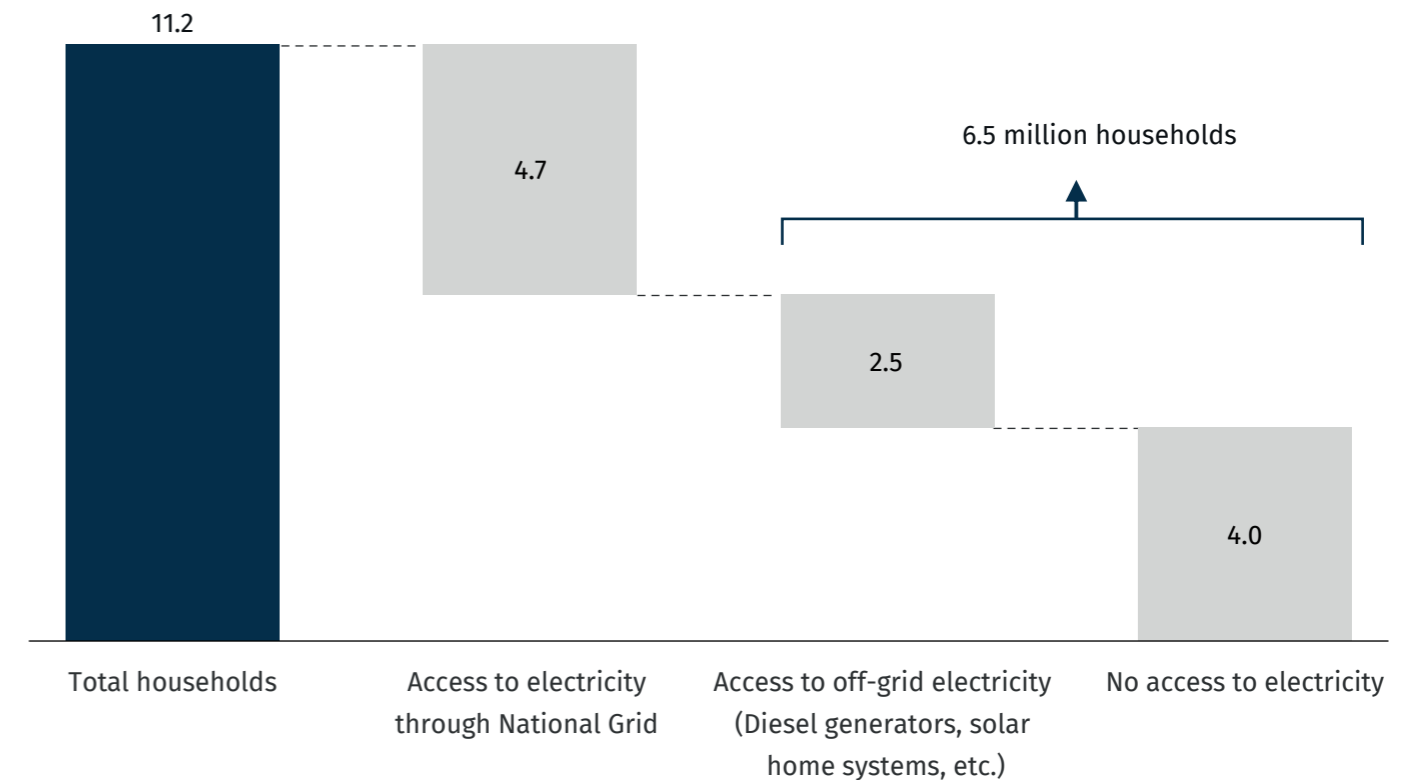
Access to reliable electricity is a long-standing problem in Myanmar. Out of 11 million households, 6.5 million or approximately 58% are not connected to the national electricity grid. Among off-grid households, 4 million have no access to electricity at all and utilize kerosene, oil and solid fuels as energy sources for lighting, cooking and other domestic uses. The remaining 2.5 million off-grid households have access to electricity through diesel generators, solar home systems or other on-site power generation devices¹ —however, supply from these off-grid solutions is often unreliable and expensive.

Providing reliable electricity at affordable tariffs to off-grid households and businesses is critical for Myanmar’s socio-economic development. In other developing countries, electrification of off-grid areas greatly benefited rural areas. For example, in India rural electrification programmes have revealed significant social, health and economic benefits².

¹ Roland Berger estimates from Census and Department of Rural Development

² Sambodhi, “Understanding the Impact of Rural Electrification in Uttar Pradesh and Bihar, India”, 2017

Figure 1. Current status of access to electricity among Myanmar’s households



Source: Roland Berger estimates from Census and Department of Rural Development

1.2 The National Electrification Plan

To increase electricity access, the Government of Myanmar in 2015 set an ambitious roadmap to reach 100% grid electrification by 2030 (National Electrification Plan — NEP). The NEP roadmap was structured around a two-pronged approach:³

- Extend medium-voltage distribution lines to connect off-grid villages according to a prioritized roadmap in 5 phases.
- For villages in Phase 4 & 5 of grid roll-out (about 3% of total off-grid population), leverage pre-electrification solutions in the short term. The optimal solution is identified depending on the size of villages: for villages with less than 50 households utilise solar home systems, for larger villages, utilise mini-grid solutions

³ World Bank, “Myanmar: Towards Universal Access to Electricity by 2030”, 2014

Figure 2. Roadmap and costs for the National Electrification Plan



Source: World Bank, “Myanmar: Towards Universal Access to Electricity by 2030”, 2014

The NEP identified 100% grid electrification as the most suitable option for Myanmar, while mini-grids and other off-grid solutions occupy only a very marginal role, only in the interim, and are confined to low-density areas. However several caveats exist.

Although the total investment for extending medium-voltage lines (distribution lines) was estimated at 5.8 billion USD, the total required investment in high-voltage transmission lines and additional power generation capacity required to power the new on-grid areas is not specified in the roadmap.

World Bank estimates suggest that, to cover additional residential demand only, approximately 2.5-3 GW additional generation capacity would be required.⁴ Assuming that Myanmar maintains the current fuel mix in installed generation capacity, building 2.5-3 GW of new generation capacity would require 5.5-6.6 billion USD investment⁵ (only considering capital costs). It should be noted that these estimates of additional generation capacity are highly conservative. For example, according to research by the Asia Foundation, the latest pipeline for expansion of generation capacity in Myanmar includes about 12.7 GW worth of power plant projects, with roughly half the projects having received a Notice to Proceed, and half of the projects undergoing feasibility assessments.⁶ It should also be emphasised that subsidised tariffs for grid electricity generate vast annual losses in government budget.⁷

In addition, the NEP roadmap only defines a programme for the expansion of the distribution network infrastructure down to transformers located at the village limits – the “last mile” low voltage connections to homes and businesses are not included. Interviews with stakeholders suggest that households typically need to pay 300 to 700 USD for each connection depending on the population density and morphology of the village site.⁸ Therefore this will result in an additional 2.2-5.0 billion USD required (for ~7 million households) to fund grid electrification.

In terms of funding, so far only 706 million USD have been secured from Union and State governments, multilateral and bilateral institutions. The World Bank is currently the largest contributor and approved a 400 million USD loan to support NEP projects. Taking into account only the 5.8 billion USD investments required to extend medium-voltage lines, a funding gap of approximately 5.1 billion USD exists.

Going forward, a number of multilateral, bilateral and development organisations are considering increasing funding for electrification in Myanmar, for instance:⁹

⁴ World Bank, “Myanmar: Towards Universal Access to Electricity by 2030”, 2014
⁵ Fuel mix in generation capacity: 60% hydroelectric, 36% natural gas, 4% other (mainly diesel) — source MOEE; assumes 2,948 USD/kW (hydro), 999 USD/kW (natural gas combined cycle) and 1,371 USD/kW (diesel) capital costs for generation as per US National Energy Administration estimates in 2019
⁶ The Asia Foundation, “The Role of States and Regions in the Myanmar Energy Sector”, 2019
⁷ Ministry of Electricity and Energy lost ~ USD 300 million in 2017 and nearly USD 500 million in 2018 dueto subsidised electricity tariffs. Losses are projected to be grow to USD 1 billion by 2020 source : <https://www.mmtimes.com/news/real-cost-myanmars-electricity.html>
⁸ Interview conducted by Roland Berger with Ministry of Electricity and Energy (MOEE)
⁹ Interview conducted by Roland Berger with Agence Francaise de Developpement (AFD)

- AFD is considering a loan for renewable mini-grids and rural energy (biomass)
- EU is considering grant funding for rural electrification (budget not confirmed)
- United Nations Development Programme (UNDP) is considering funding for rural electrification projects through Global Environment Facility (GEF)

In addition, direct investment into private developers has been implemented, such as the IFC and Norfund investment.

Taking into account these funding sources, an additional budget of approximately USD 25 USD million is expected to become available for electrification in Myanmar. However, this is still insufficient to fill the 5.1 billion USD funding gap.

1.3 Evolution of electrification – assessment through benchmarks

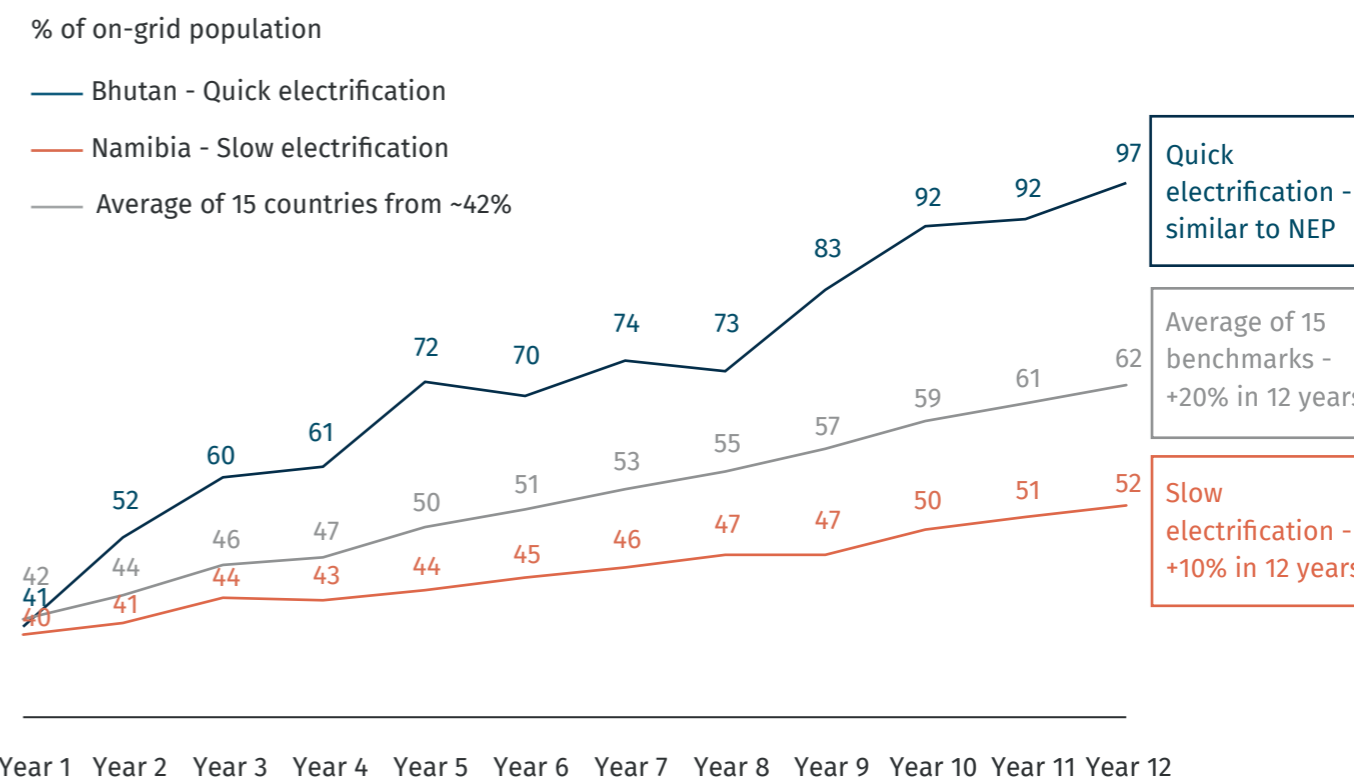
Analysis of previous electrification programmes in other countries indicates that the NEP target of increasing electrification by 58% points, from 42% to 100% in 12 years is unlikely to be achieved.

Past electrification programmes in China and Brazil show that it can take more than 20 years to connect the last 10-20% of households in the most remote areas. This is consistent with the electrification rates in Southeast Asian countries such as Thailand, Vietnam and Indonesia. For further comparison, it took 27 years to reach 85% from 42% in India. This is because grid expansion in remote areas is more costly and investment cannot be recovered easily through electricity sales as these areas have low demand potential.

In order to assess future electrification to 2030 for Myanmar, the evolution of electrification over 12 years in 15 benchmark countries starting from the same level of electrification as Myanmar today (~42%) was examined. Based on these benchmarks, three possible evolutions were identified:

- **Quick electrification similar to NEP leading to nearly 100% electrification from 42% in 12 years.** This has been observed in one case (Bhutan) where the electrification rate increased to 97% over the observed period. However, Bhutan’s population is only approximately 800,000, covering a significantly smaller geographic area

Figure 3. Evolution of electrification rates from approximately 42% over 12 years for 15 benchmark countries globally



Source: World Bank Sustainable Energy for All Database, Roland Berger¹⁰

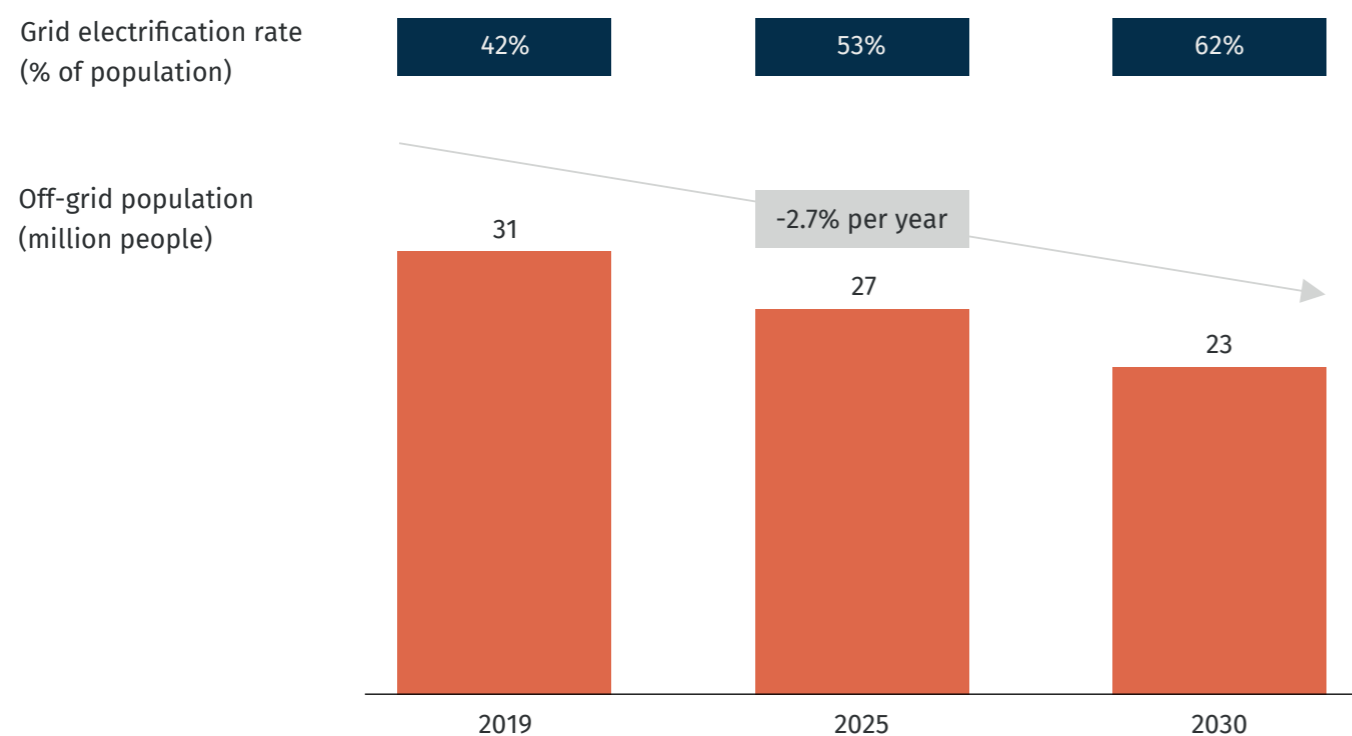
- **Average electrification** using the average of the 15 benchmark countries considered. In this case, the rate increases by approximately 20% points to reach 62% after 12 years
- **Slow electrification** based on Namibia, the worst performer in the benchmark group. In this case the rate increases only by 10% points to 52% after 12 years

In subsequent market modelling conducted in this study, the electrification rate is assumed to follow the average case (i.e. +20% points electrification rate by 2030 from 42% to 62%). Assuming 62% electrification rate by 2030 and an overall population growth rate of 0.8% per year,¹¹ it is estimated that the off-grid population would decrease at an annualised rate of 2.7% from 31 million people in 2019 to 23 million people in 2030.

¹⁰ Data reporting inconsistencies may account for year-on-year fluctuations seen in some of the data

¹¹ The 2014 Myanmar Population and Housing Census

Figure 4. Estimated evolution of grid electrification rate and of off-grid population in average electrification case



Source: Roland Berger analysis based on Census data

1.4 Power demand from off-grid areas

Power demand in off-grid areas in Myanmar is driven by four key components:

1. Residential demand – i.e. demand for domestic use by households

A review of energy consumption in Myanmar was conducted by the Asian Development Bank (ADB) in 2017.¹² This resulted in an assessment of the potential for residential electricity demand in off-grid areas depending on the unit price of electricity.¹³ For a price level of 510 MMK/kWh (see discussion in Section 3.1 for rationale of this price level), the assessment indicates yearly per capita demand between 23.7-51.4 kWh depending

¹² Asian Development Bank, “Myanmar Energy Consumption Surveys”, 2017

¹³ Available on DRD website as part of documentation for Call for Proposals for Engineering, Procurement, Construction and Operation of Mini-Grid Projects in Rural Villages (<http://drdmyanmar.org/index.php?page=bmV3ZGV0YWlsJmlkPTE3Nw>)

on the State/Region. Taking into account the off-grid population of each State/Region, the resulting weighted average of the electricity demand is approximately 32 kWh per capita.

This level of per capita electricity demand corresponds for example to a total average power rating of 100 W, and usage patterns between 2 and 6 hours per day.¹⁴ Typical use cases consistent with this demand level include lighting, a radio, a small fan and a small TV that would be used mainly in the evening.

This capita demand level (32 kWh per capita per year) is consistent with benchmarks of 11 mini-grids in Asia and Africa showing average yearly residential consumption of 29 kWh per capita.¹⁵

It is expected that Myanmar’s per capita electricity consumption in rural areas will increase rapidly with increasingly large appliances and longer usage patterns developing beyond the current levels.

2. Productive use demand – i.e. demand from agricultural, and small-scale industrial and commercial activities

Productive use demand in off-grid areas in Myanmar is driven by agriculture, processing of agricultural commodities and commercial activities, e.g. welding, carpentry workshops. A demand study across 43 villages in different locations in the dry region of Myanmar conducted by TFE Consulting in 2018 revealed that productive demand per capita¹⁶ is on average approximately 41 kWh per year and varies between 31 kWh per year in villages with low productive loads to 63 kWh per year in villages with high productive loads.

Productive use demand in off-grid areas is determined by the following factors:

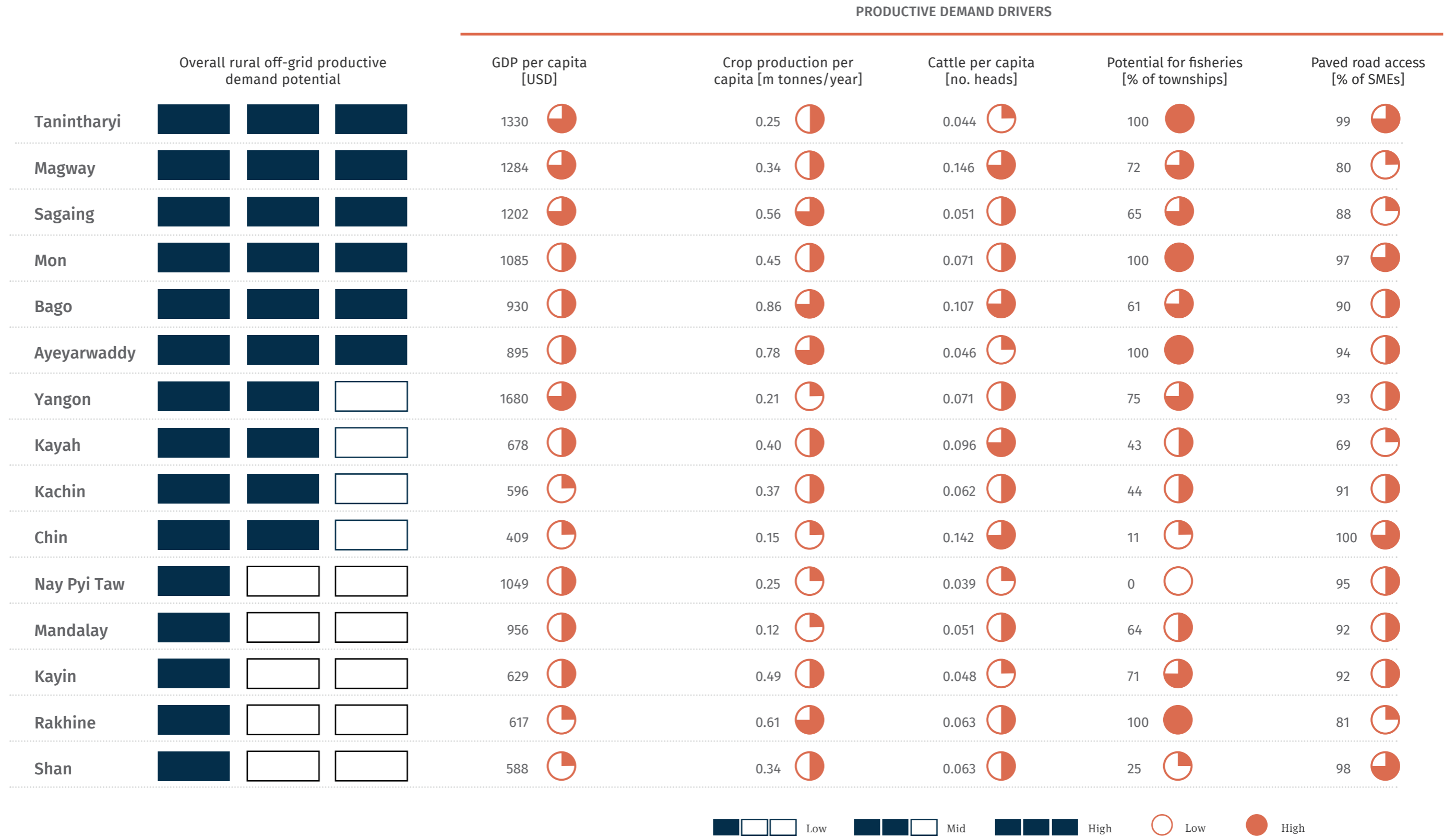
- Economic activity. In areas of high economic activity, higher demand for goods and services drives energy consumption. In addition, in these areas, businesses are able to afford electrically-powered machinery with higher power rating
- As agriculture is an important contributors to productive loads in off-grid areas, crop production, livestock are drivers of productive loads

¹⁴ Average use of 4 hours per day x 100 W x 365 days / 4.6 persons per household

¹⁵ IFC, “Benchmarking Mini-grids DESCOS”, 2017

¹⁶ TFE Consulting, “Bridging the Energy Gap: Demand Scenarios for Mini-Grids in Myanmar”, 2018

Figure 5. Analysis of rural off-grid productive demand potential by State/Region



Source: Roland Berger

- Potential for fisheries, estimated as % of townships with access to water bodies suitable for fishing activity, is taken as an additional parameter to assess productive load potential
- Areas where local businesses are connected to other regions by a reliable road network (e.g. paved roads not subject to flooding during the wet season) or waterways tend to have higher productive loads. This is because local businesses can serve not only the local village community, but can also provide their products or services to neighboring villages and towns

Based on these factors, productive load demand of off-grid areas has been estimated by State/Region (see Figure 5).

High-potential States/Regions include locations such as Tanintharyi, Ayeyarwaddy, Magway, Sagaing, Mon and areas with a flourishing agricultural economy such as Bago. These locations have a good combination of GDP per capita levels and agricultural/fisheries activity. Mon and Tanintharyi also have high GDP per capita driven by e.g. trade with neighbouring Thailand and local small businesses enjoy a good level of access to paved road, facilitating trade.

3. Public demand – i.e. demand from public buildings such as libraries, hospitals, monasteries and from public lighting

In rural villages in Myanmar, public buildings typically include religious buildings such as monasteries, local clinics/hospitals, schools and libraries. A typical village of 200 households has 1 load for each of these typologies.

Public lighting can be rather sparse, with typically 1 street light every 5 houses.

Interviews indicate that under the above scenarios the public-use yearly demand per capita in rural villages in Myanmar is approximately 2.5 kWh.¹⁷

4. Demand from anchor loads – i.e. demand from larger commercial or industrial facilities or telecommunication towers (typically above 50 kWh per year)

Interviews suggest that in off-grid areas in Myanmar industrial loads are very limited as almost all manufacturing is located in areas with grid connectivity.¹⁸ However, new anchor loads in off-grid areas may emerge upon mini-grid electrification (e.g. water irrigation systems, financial institutions, ATMs, fuel stations, etc.),¹⁹ as electricity supply becomes more reliable in these regions.

On the contrary, a large portion of telecommunication towers in Myanmar is located in off-grid areas. Of these towers located in off-grid areas, currently mostly powered by diesel generators, 70% can be potentially targeted as anchor load for mini-grids (actual feasibility depends on the distance of towers from villages).¹⁸

Load per telecommunication tower varies heavily depending on the number of tenants that share the tower under colocation agreements: single-tenant towers have typically 2 kW load, towers with 2 tenants have 3.5 kW load and towers with 3 tenants have 5 kW load. On average, an off-grid tower has a 2.2 kW load, leading to around 164 GWh yearly electricity demand from off-grid towers in Myanmar.

Mini-grids can potentially cover all these four components of power demand, and by combining supply to different demand sources, mini-grid viability can be increased. Systems serving primarily anchor loads can be extended to serve residential, productive and public loads in villages if these are located in the vicinity of anchor loads.

¹⁷ Interviews with multilateral institutions and private developers conducted by Roland Berger

¹⁸ Interviews with private developers, mobile network operators and tower companies conducted by Roland Berger

¹⁹ Shared Value Initiative, “Smart Power for Rural Development”, 2017



2.0

Review of current market and of the key drivers for off-grid solutions in Myanmar

2.1 Current market for off-grid solutions and mini-grids in Myanmar

As outlined in Section 1, 6.5 million households are not connected to the national electricity grid in Myanmar. Out of these, 2.5 million households have access to electricity through off-grid solutions.

Data from the Department of Rural Development (DRD) show that almost 25,000 villages are electrified²⁰ (i.e. provided with electricity) through off-grid solutions including diesel generators, solar systems, mini-hydro systems and biomass generation systems.

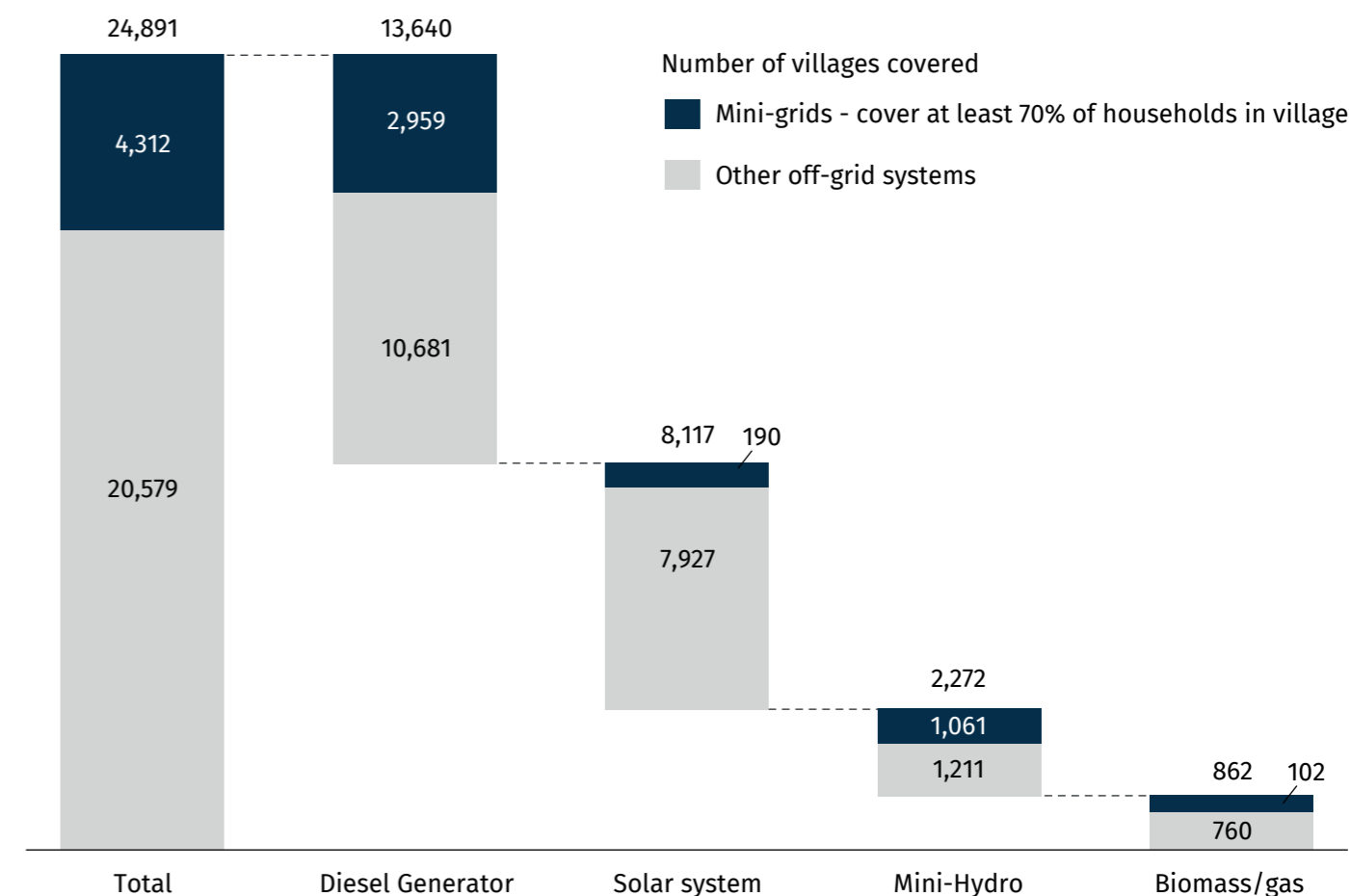
DRD estimates that about 4,312 of these off-grid systems supply electricity to at least 70% of households in the village where they are located and hence can be defined as mini-grids (see Figure 6). Details on the definition of mini-grids are included in Annex 1.

Interviews with stakeholders suggest that only a small fraction of these systems were built for commercial purposes and most are not “grid-ready”, i.e. the infrastructure is not compatible with that used in the national grid.²¹

²⁰ Some electrified villages may only have electricity for commercial use demand and not for residents

²¹ Interviews with multilateral organizations, equipment suppliers and private developers conducted by Roland Berger. Grid readiness include infrastructure compliance with grid code (e.g. poles, cables) and possibility to connect and synchronize generation equipment to the grid.

Figure 6. Estimated number of villages covered by off-grid solutions and number of existing mini-grids in Myanmar



Source: DRD, World Bank “Myanmar Mini-grid Overview”, presentation at Up scaling Mini-Grid Workshop (2017)

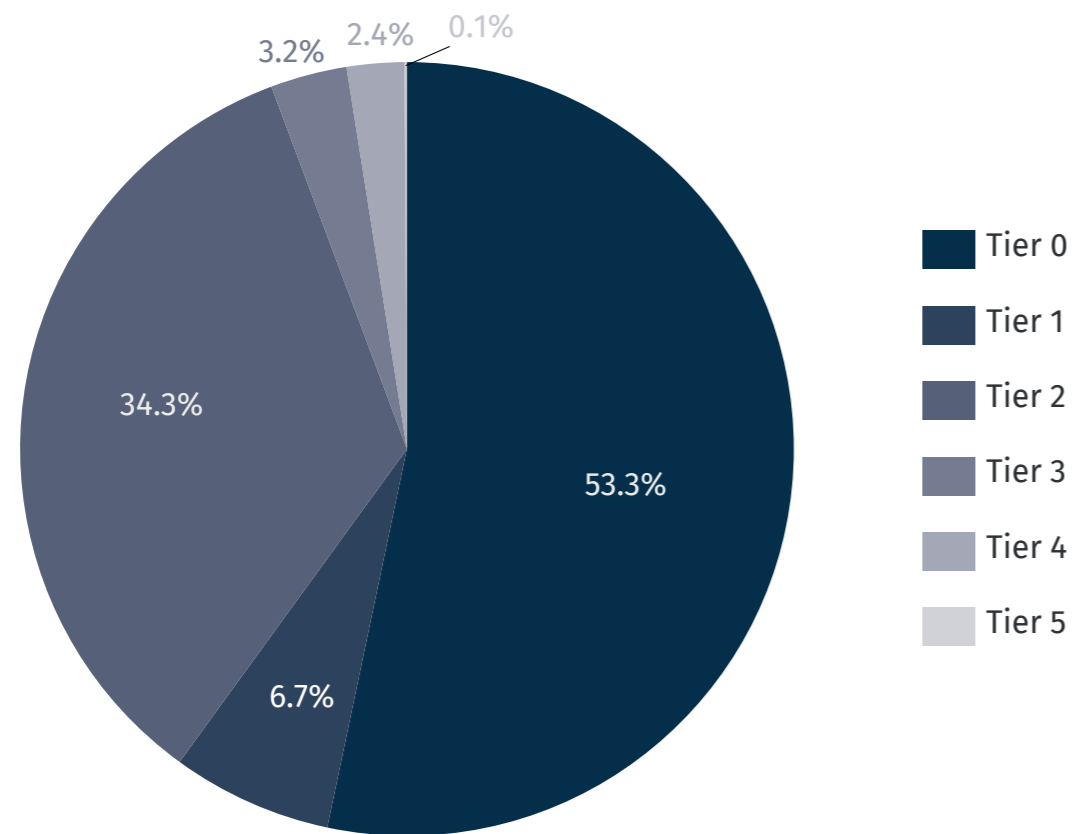
Furthermore, a survey on energy access in Myanmar conducted by the World Bank using the Multi-Tier Framework for quality of energy supply confirms that the vast majority of existing mini-grids in Myanmar can only provide lower tier electricity access. Taking into account mini-grids not developed under the DRD subsidy scheme, an estimated 94% of the population with electricity access through mini-grids can only enjoy Tier 0 to Tier 2 electricity access.²²

Out of the existing mini-grids, only a small fraction is thought to be grid-ready (about 68 existing and planned grid-ready mini-grids were identified during this study). These grid-ready mini-grids are developed by private developers²³ and mostly relying on solar PV generation combined with batteries and backup diesel generators.

²² World Bank, “Myanmar: Energy Access Diagnostics Results Based on Multi-Tier Framework”, 2019

²³ Refer to Annex 1 for an outline of private developers

Figure 7. Quality of electricity supply of existing mini-grids

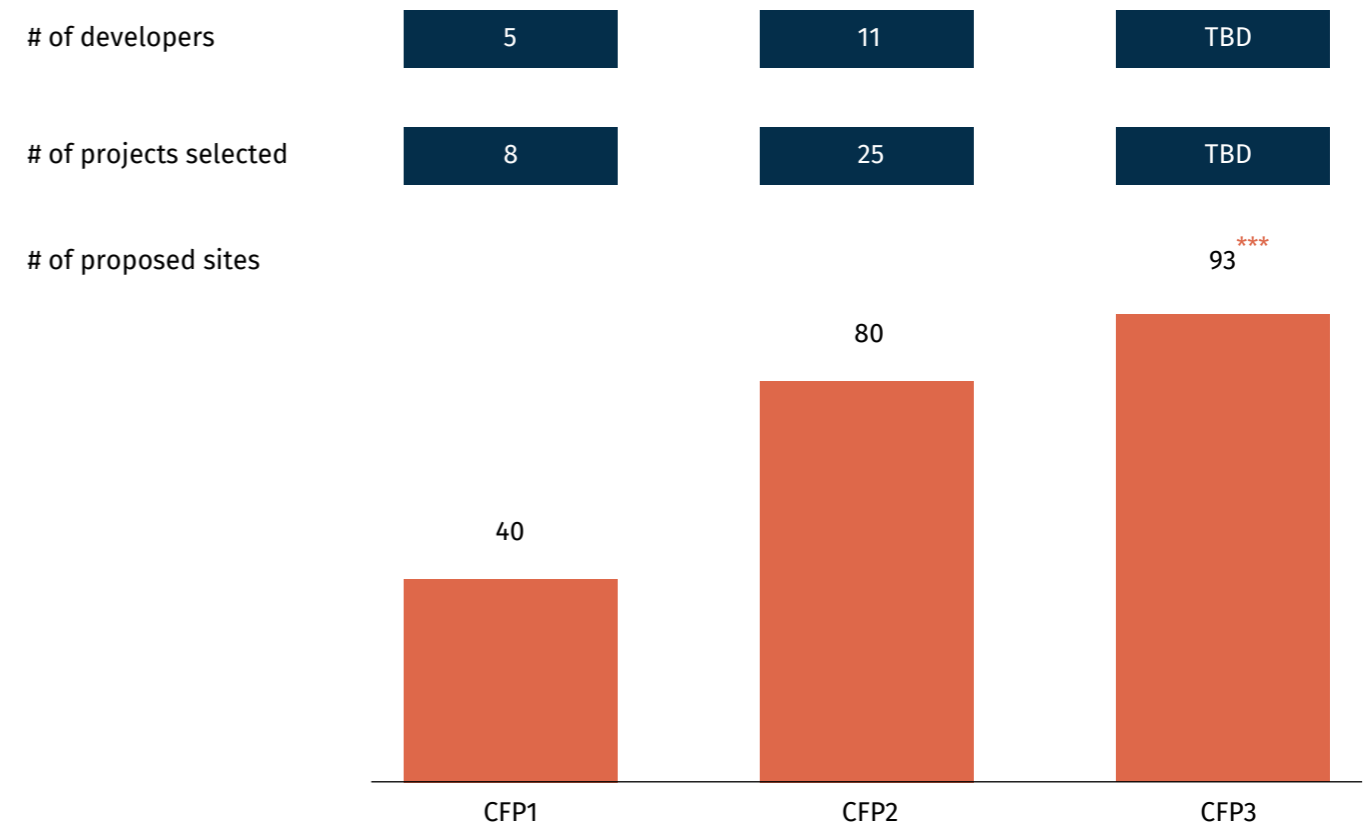


Source: World Bank, “Myanmar: Energy Access Diagnostics Results Based on Multi-Tier Framework”, 2019

The subsidy programme introduced (see Section 2.3 for details) by the Department of Rural Development (DRD) and backed by a World Bank loan, has been a major driver for the development of this new generation of grid-ready mini-grids and resulted so far in the selection of 33 mini-grid projects announced and developed by private developers in the first two years of the scheme — selection of projects for year 3 is currently under way and it is expected that an even larger number of projects will be implemented.²⁴

²⁴ Interview with GIZ conducted by Roland Berger

Figure 8. Evolution of number proposed sites, projects selected and developers under the Call for Proposal (CFP) for investment subsidies



^{***} Number of villages which have been pre-screened and released to prospective developers

Source: Interviews with market players, Roland Berger Analysis

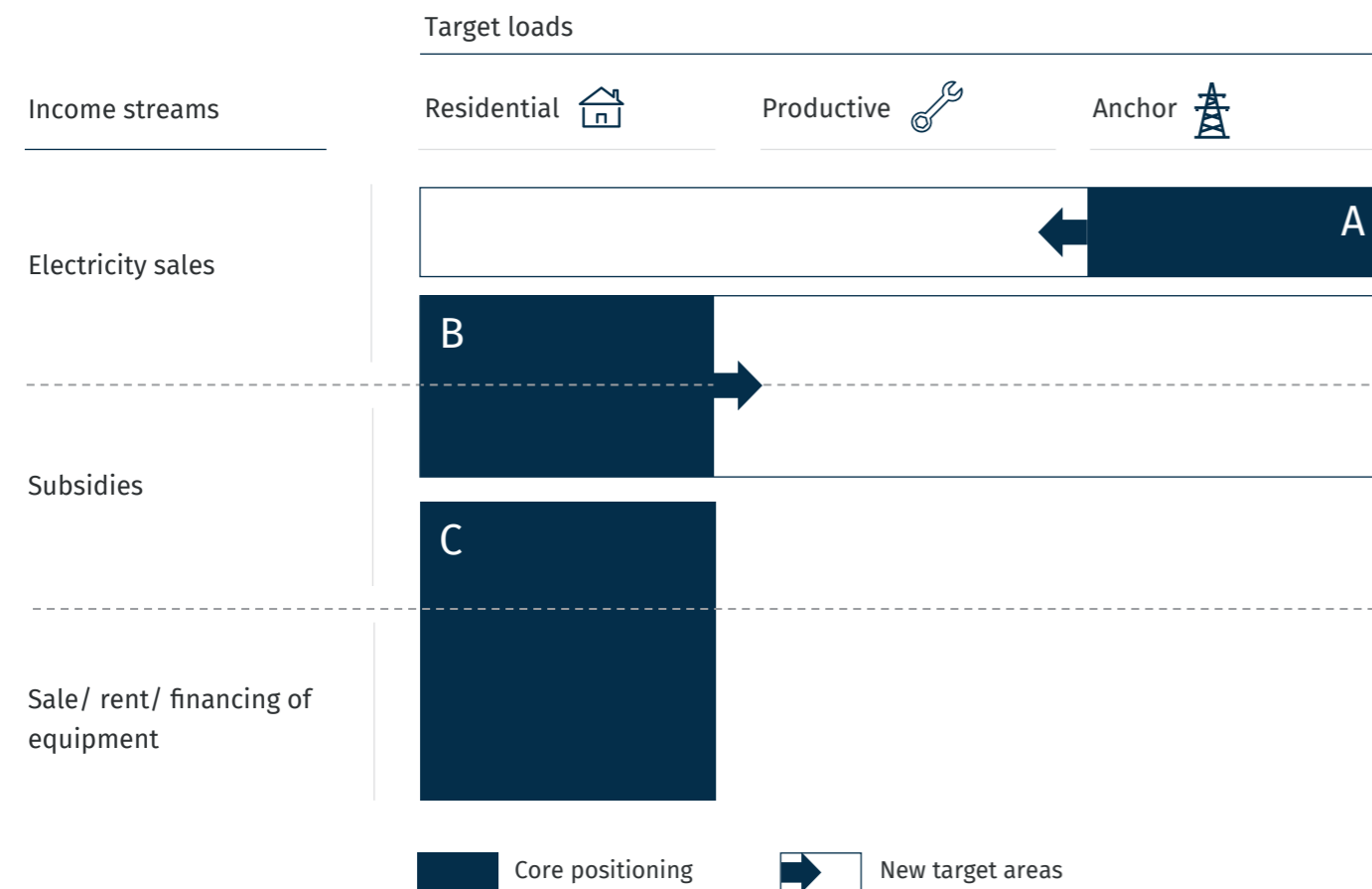
2.2 Business models and market drivers

Off-grid business models

As described in Section 2.1, there are thousands of mini-grids in Myanmar of which only a few are grid ready and are managed by private developers. This section describes the business models of these private developers as well as adjacent business models for off-grid electrification that may be leveraged by mini-grid developers.

Business models can be classified according to the nature of the target load and the type of income streams. Possible income streams include not only sales of electricity, but also subsidies from government and multilateral organizations, contributions from village households to be connected to the mini-grid and sales/rent of equipment to final customers.

Figure 9. Categories of current off-grid business models in Myanmar



A. Anchor-focused

- Core business: sales of power to anchor loads under PPA or Service Level Agreement
- Sustainable without subsidies & highly scalable in case of telco towers
- Now expanding to residential & productive loads.

B. Residential-focused subsidised

- Core business: sales of power to villages under pay-as-you-go or fixed fee model
- Relies on subsidies
- Expanding to productive & anchor loads

C. Equipment-focused

- Mainly used by Solar Home System players in combination with subsidies
- Mini-grid developers considering use to enhance and stabilize power demand

In the **anchor-focused business model**, the private developer supplies electricity mainly to an anchor tenant such as an industrial site or a telecommunication tower, covering most of the generated supply. The existing case studies in Myanmar rely on off-grid telecommunication towers as anchor tenants. The contractual agreement between the private developer and the telecommunication tower company involves typically a fixed price per kWh of electricity supplied that is negotiated prior to project development and that can be reviewed periodically thereafter. This model has potential to be scaled nationwide for several reasons: (1) 80% of the approximately 15,000 telecommunication towers existing in Myanmar are owned by 6 companies²⁵ – hence private developers could potentially ink multi-site agreements covering hundreds or thousands of sites, (2) tower design and power requirements are standardized – hence private developers could potentially use standardized power systems significantly simplifying multi-site roll-out. Currently, the leading player in Myanmar relying on this business model is Yoma Micro Power. As of end 2018, Yoma Micro Power had 10 mini-grid projects in Myanmar of which 6 supply power to telecom towers only and 4 supply power to telecom towers and some nearby households. Going forward, Yoma Micro Power is targeting to scale up the number of projects to more than 2,000 by 2023.²⁶ SolaRiseSys also is targeting to scale up its mini-grid portfolio to more than 1,000 projects.²⁷ Other companies such as Voltalia are active in providing off-grid power solutions to telecommunication towers, and manage portfolios exceeding 100 projects, but do not operate mini-grids serving villages in addition to towers.

In the **residential-focused subsidised business model**, the private developer supplies electricity mainly to village households. The existing case studies include pay-as-you-go tariffs with pre-paid schemes to limit payment collection risks. In addition, this model is dependent on subsidies and contributions from the local community to ensure financial viability. This model is less scalable than the anchor-focused model as project development requires negotiations and site specific engineering on a village-by-village basis. Some players relying on this model, such as Mandalay Yoma, aim to combine residential and anchor loads to increase viability and scalability.²⁸

Source: Interviews with market players, Roland Berger analysis

²⁵ Interviews with mobile network operators and tower companies conducted by Roland Berger

²⁶ Interview conducted by Roland Berger with Yoma Micro Power

²⁷ Interview conducted by Roland Berger with SolaRiseSys

²⁸ Interview conducted by Roland Berger with Mandalay Yoma

Private developers developing mini-grid projects under the investment subsidy scheme are also adopting this business model – the structure of the subsidy scheme is outlined in Section 2.3. It should be noted that, as of now, there is no private developer with unsubsidised mini-grids focusing on residential supply, as these projects are not viable at this stage²⁹ – further analysis of viability of unsubsidised mini-grids is presented in Section 3.3.

The **equipment-focused model** is mainly by solar home system players that rent electrically-powered equipment to end users to secure power demand. Mini-grid private developers are also considering applications of this model to support growth of demand in off-grid villages to increase mini-grids viability. A new approach that is being explored based on successful case studies in other markets such as Africa is financing of electrically powered equipment to be by small businesses to increase their productivity.

Market drivers

Five types of key drivers for the mini-grid market can be identified: (1) Grid electrification, (2) Power demand from off-grid areas, (3) Subsidies and contributions, (4) Regulatory environment, (5) Technology potential.

Grid electrification directly impacts the addressable market for mini-grids as grid-electrified locations become unattractive to mini-grid development due to subsidised grid electricity tariffs. In addition, in the absence of appropriate regulatory provisions, uncertainty on grid expansion plans can prevent investment in mini-grids.³⁰

Power demand from off-grid areas both in terms of load size, density and types of loads (residential, productive, anchor loads and public buildings) determines the financial viability of mini-grids in terms of capacity sizing, investment, operating costs and revenues.

Subsidies and contributions are an important determinant to assess the size of the mini-grid market, as most mini-grid models without subsidies are not currently viable standalone.

²⁹ Interview conducted by Roland Berger with Smart Power India

³⁰ If appropriate regulations are in place existing mini-grids can be integrated into the national grid at the time of grid arrival or mini-grid developers can transfer the assets to the national grid operator upon compensation.

Regulatory environment defining for example, legal status, rights of developers, options for transition at the time of grid arrival, affects the risk profile of mini-grid projects influencing investment decisions.

Technology potential chiefly in terms of generation and storage technologies, their standardization and modularization impacts mini-grids development; for example more cost effective solar PV and batteries leading to enhanced financial viability of mini-grids.

2.3 Investment subsidies

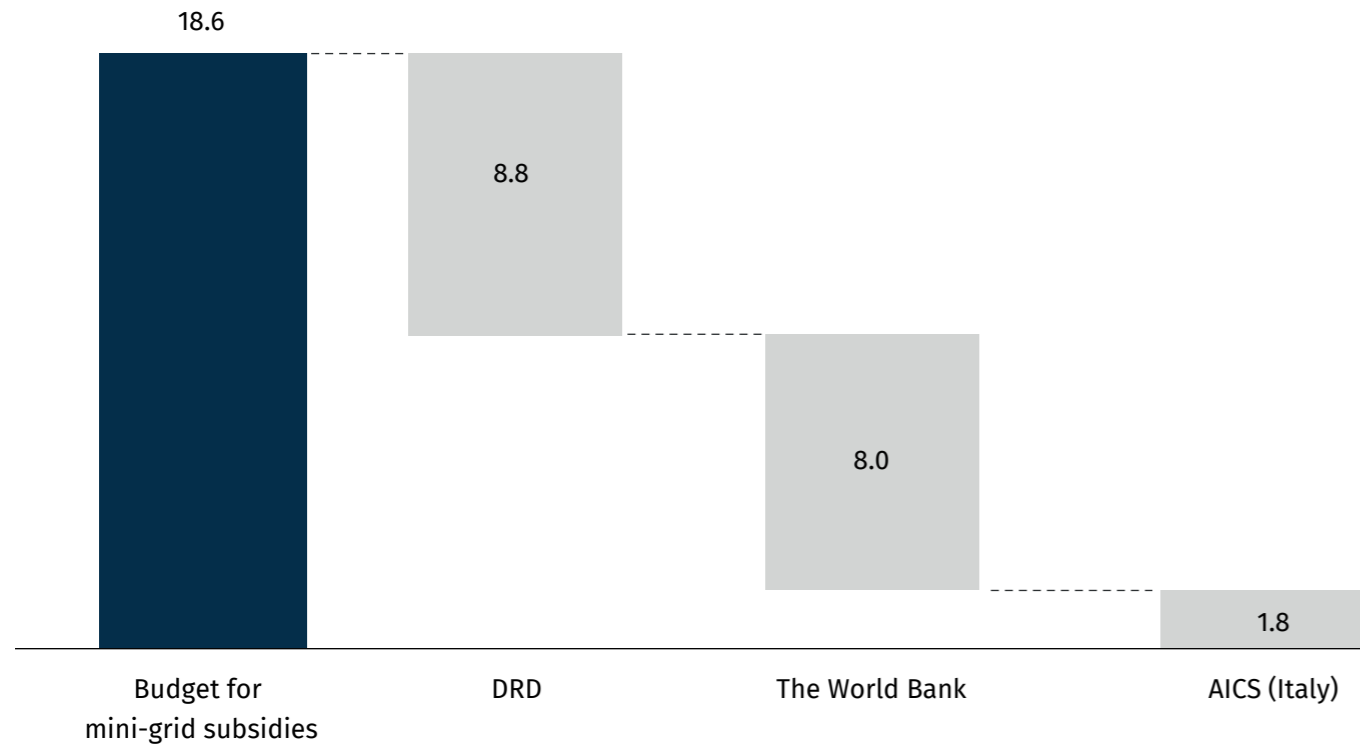
In the context of NEP, a subsidy system was put in place to finance mini-grid projects. The primary targets for subsidies are mini-grid projects in areas that are unlikely to be reached by on-grid electricity in the next 10 years. Eligible projects have less than 1MW capacity.

The current system involves three flows of funding complementing the investment by private developers:

- Communities, through Village Committees raise funds to pay part of mini-grid investment, typically 20% of total investment. The funds are channelled through a dedicated account managed by the Department of Rural Development
- The Department of Rural Development funds subsidies from a loan obtained by the World Bank contributing typically to 30% of project investment
- The Department of Rural Development funds subsidies from its own budget contributing typically to 30% of project investment, thereby matching the contribution from the World Bank loan.

Therefore in the current system, selected mini-grid projects are subsidised at 60% by DRD through own budget and World Bank loan; communities typically cover 20% of investment in cash or in kind, while mini-grid developers cover the remaining 20% of investment.

Figure 10. Estimated annual budget availability for mini-grid subsidies for next 3 years (2019 to 2021)



Source: Interviews with DRD and bilateral institutions

Based on interviews with DRD and bilateral institutions,³¹ the total funding available for the mini-grid subsidy scheme has been increased and between 2019 and 2021 is expected to reach approximately 18.6 million USD per year. The mini-grid subsidies budget comprise of funding from three sources: (1) DRD, (2) The World Bank, and (3) AICS (Italy).³²

³¹ Interviews conducted by Roland Berger with DRD and bilateral institutions

³² The budget for mini-grids subsidies from DRD for 2018 was 8.8 million USD. According to DRD, this budget is likely to be maintained over the next few years. The World Bank has a budget of 80 million USD for mini-grids and Solar Home Systems up to 2021. As of the end of 2018, 30 million USD of the 80 million USD budget had been spent. For the remaining 50 million USD, the budget allocated to mini-grids was increased from 7 million USD to 24 million USD, which translates to 8 million USD per year from 2019 to 2021. AICS (Italy) is expected to deploy additional budget of 30 million USD for SHS and mini-grids, to be rolled out from 2019 to 2021. This budget targets 90,000 household connections for SHS, and 6,500 household connections for mini-grids. Assuming 1,369 USD per connection and 60% investment coverage, the budget for mini-grids would be 5.3 million USD. This translates into 1.8 million USD per year budget for mini-grids.



2.4 Regulatory environment

Following the Electricity Law enacted on the 27th of October, the Government of Myanmar, through the Ministry of Electricity and Energy (MOEE), issues permits to invest in and operate projects classified as Large Electrical Businesses (more than 30 MW) and for all other projects that are connected to the national grid. Permitting and regulation of Small and Medium Electrical Businesses (less than 30 MW) not connected to the national grid are under the authority of the regional and state governments where the projects are located.³³

Hence, mini-grids in off-grid areas fall under the jurisdiction of regional and state authorities. At the time of grid arrival, negotiations to integrate the mini-grid into the national grid have to be undertaken with MOEE. While on-grid electricity prices are regulated and include government subsidies, there are no explicit regulatory provisions on the tariffs that private developers can charge for electricity supply through mini-grids.³⁴ This provides freedom to optimize tariffs, but adds uncertainty to the future cash flows of mini-grid projects.

At present, the regulatory framework surrounding mini-grids in Myanmar is not defined; however DRD is proposing a possible regulatory framework for mini-grids, currently under discussion. In the DRD proposal, mini-grids would fall under regulation by the state/regional government as non-grid connected entities with less than 30 MW capacity. DRD also proposes a multi-step mini-grid licensing process, including:

- Permitting to undertake power generation, distribution and retail activities
- A certificate of exclusivity for undertaking development in specified locations to de-risk development activities
- A certificate to ensure transition in case of national grid arrival with two possible mechanisms: (1) transfer of asset to national grid operator upon payment of compensation, (2) connection of asset to national grid under independent power producer status for generation assets or under a distribution franchise for distribution assets

³³ VDB Loi, “The legal and regulatory framework of foreign investment in Myanmar’s power sector”, 2017

³⁴ Interview conducted by Roland Berger with bilateral institutions

2.5 Technology potential

The majority of mini-grids currently installed in Myanmar (69%) are powered by diesel generators, followed by small hydroelectric systems (25%) and biomass gasification or biogas systems (2%). Solar mini-grids represent a minority (~4%) of the total number of mini-grids.

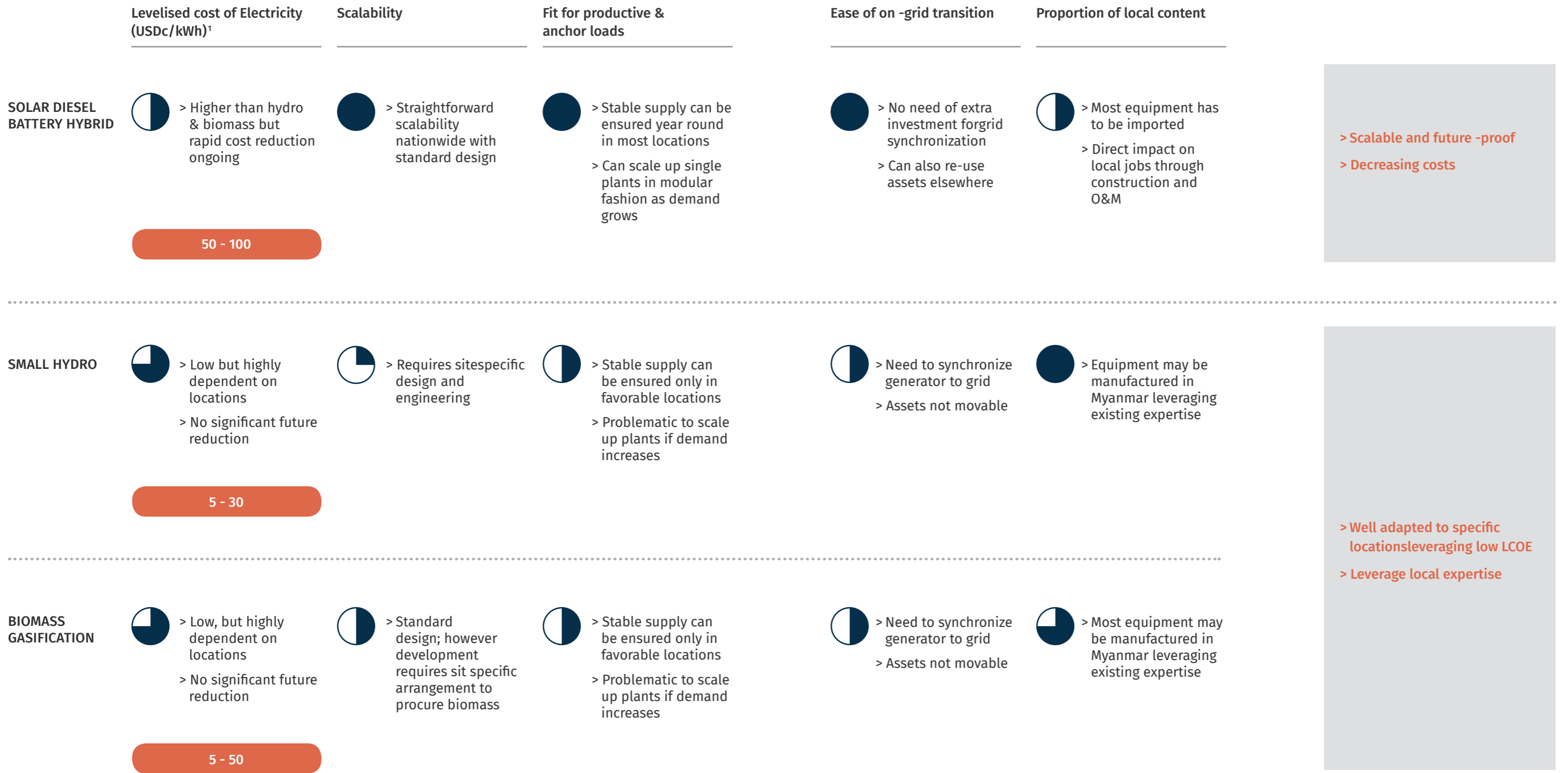
As mini-grids development shifts from local communities to private developers and rapid evolution of solar technology costs occur, a shift in technology towards solar PV is expected.

Although at present solar/diesel/battery hybrid mini-grids are less cost-competitive than hydropower and biomass mini-grids, in terms of expected cost evolution, scalability, ability to serve anchor loads and easiness of on-grid transition, they represent the most attractive technology to support growth of the mini-grid market. However, hydropower mini-grids and partly biomass mini-grids ensure a higher proportion of local content, thus potentially offering greater direct support to local rural economies (for a detailed analysis of direct and indirect socio-economic impact of mini-grids, refer to Section 4.7).

In specific locations with favorable hydrological conditions and stable supply of raw material, small hydro and biomass mini-grids can represent the most cost-effective and viable way to deliver electrification and support the rural economy. Hence these technologies can play an important role alongside solar/diesel/battery hybrid mini-grids in the growth of the mini-grid market in Myanmar.

In Figure 11, a comparison of the three renewable mini-grid technologies along five criteria is shown.

Figure 11. Comparison between mini-grid technologies



1) Skat Foundation global estimates

3.0

Assessment of financial viability and investibility of mini-grids in Myanmar

3.1 Definition of viability for mini-grids

Key metrics for viability assessment

In this study, two perspectives are combined to define the viability of mini-grid projects: cost-competitiveness and financial viability.

Firstly, the cost of electricity from a mini-grid is assessed versus current off-grid electricity supply costs. For this, the Levelised Cost of Electricity (LCOE) is used: this metric reflects the sum of the capital costs for building the mini-grid and of the operational costs to run the mini-grid divided by the electricity supplied over the lifetime of the mini-grid. Hence the LCOE represents the average cost per unit of electricity supplied by the mini-grid. A mini-grid is cost-competitive if its LCOE is lower or equal to the cost of electricity currently paid by customers in off-grid areas.

Secondly, to assess financial viability, the Internal Rate of Return (IRR) is used: this metric reflects the annualised return on investment generated by the mini-grid. A mini-grid project is viable if its IRR is higher or equal to the cost of capital (discount rate) shouldered by the investors to build the mini-grid.

Thresholds for viability of mini-grids

To estimate the cost of electricity currently paid by customers in off-grid areas, data from a variety of studies focusing on price of electricity from diesel generators (the most common source of electricity in off-grid areas as outlined in section 2.1) are used:

- Estimates by the ADB in 2015 for low consumption use cases (1 lightbulb or 2 lightbulbs and 1 TV set with 3 hours/day supply) indicate a range of equivalent tariffs between 0.85 USD/kWh to 1.23 USD/kWh for electricity provided by diesel generators³⁵
- A 2016 study of 10 diesel mini-grids conducted by Pact considering 1 lightbulb and a TV set found equivalent tariffs ranging from 0.37 USD/kWh to over 1 USD/kWh³⁶
- A 2018 study covering over 44 off-grid villages conducted by TFE Consulting including residential and productive loads indicates a range between 0.16 USD/kWh to 0.77 USD/kWh and average tariffs of USD 0.37/kWh³⁹

As the 2015 ADB and 2016 Pact studies took into account only low consumption use cases, equivalent tariffs per kWh may be comparatively high, thus likely overestimating willingness to pay for larger loads. Therefore, 0.37 USD/kWh³⁷ (approximately 510 MMK/kWh) is used in this study. This threshold has been validated as a realistic tariff for mini-grids in off-grid areas.³⁸ Currently, private developers charge tariffs ranging from 350 MMK/kWh to 700 MMK/kWh, which is consistent with the threshold of 510 MMK/kWh used in this study.

Note that the threshold is much higher than electricity prices in on-grid areas (range 35-50 MMK/kWh depending on consumption level – most households fall into 35 MMK/kWh rate or 0.03 USD/kWh) for multiple reasons: (1) on-grid electricity prices are heavily subsidised by the Government and do not reflect actual cost of generation and supply, (2) small diesel generators such as those typically used in rural Myanmar are highly inefficient compared to large grid-connected power plants, (3) size and operation of diesel generators are rarely optimized in off-grid villages – typically generators are used under capacity to power small loads which adversely impacts efficiency and hence generation costs.³⁹

³⁵ Asian Development Bank, “Off-Grid Renewable Energy Program in Myanmar”, 2016

³⁶ From World Bank, “Upscaling mini-grids for low-cost and timely access to electricity services”, 2017

³⁷ 1USD =1378 MMK (2018). Lower tariff of 0.29 USD/kWh (approximately 400 MMK/kWh) used for telco towers

³⁸ Interviews conducted by Roland Berger

³⁹ TFE Consulting, “Bridging the Energy Gap: Demand Scenarios for Mini-Grids in Myanmar”, 2018

The appropriate threshold for IRR has been estimated through interviews with stakeholders and market players, and takes into account inflation – typical target for mini-grids in Myanmar is around 20% IRR.⁴⁰ This IRR level is high due to the inability for developers to access debt finance and to the high perceived risks:

- Myanmar country risk
- Risks specific to mini-grid investment in Myanmar (e.g. uncertainty related to grid arrival, uncertainty in actual power demand and willingness to pay in rural areas)

Structure of LCOE and IRR for Mini-Grids and key drivers

The LCOE is calculated by summing all capital and operational expenses and dividing the sum by the generated energy. The sum is carried over the lifetime of the project and each term is annualised using a discount rate.

The IRR represents the rate at which initial investment in the project is recovered through returns generated by the project. It is calculated as the discount rate that makes the annualised sum of cash flows generated by the mini-grid equal to zero.⁴¹

3.2 Investibility of mini-grids and de-risking of grid arrival

In addition to viability, investibility of mini-grids from a private developer’s perspective must be considered to assess the potential market. At present there is no clear licensing system regulating mini-grids and formalising “the right to exist”, and there is no mechanism in place to compensate developers or to ensure business continuity in case of grid arrival. Hence villages located in areas closer to the main grid are considered non-investible by mini-grid developers as risks are too high.

⁴⁰ Interviews with multilateral organizations and private developers conducted by Roland Berger; this IRR is in real terms

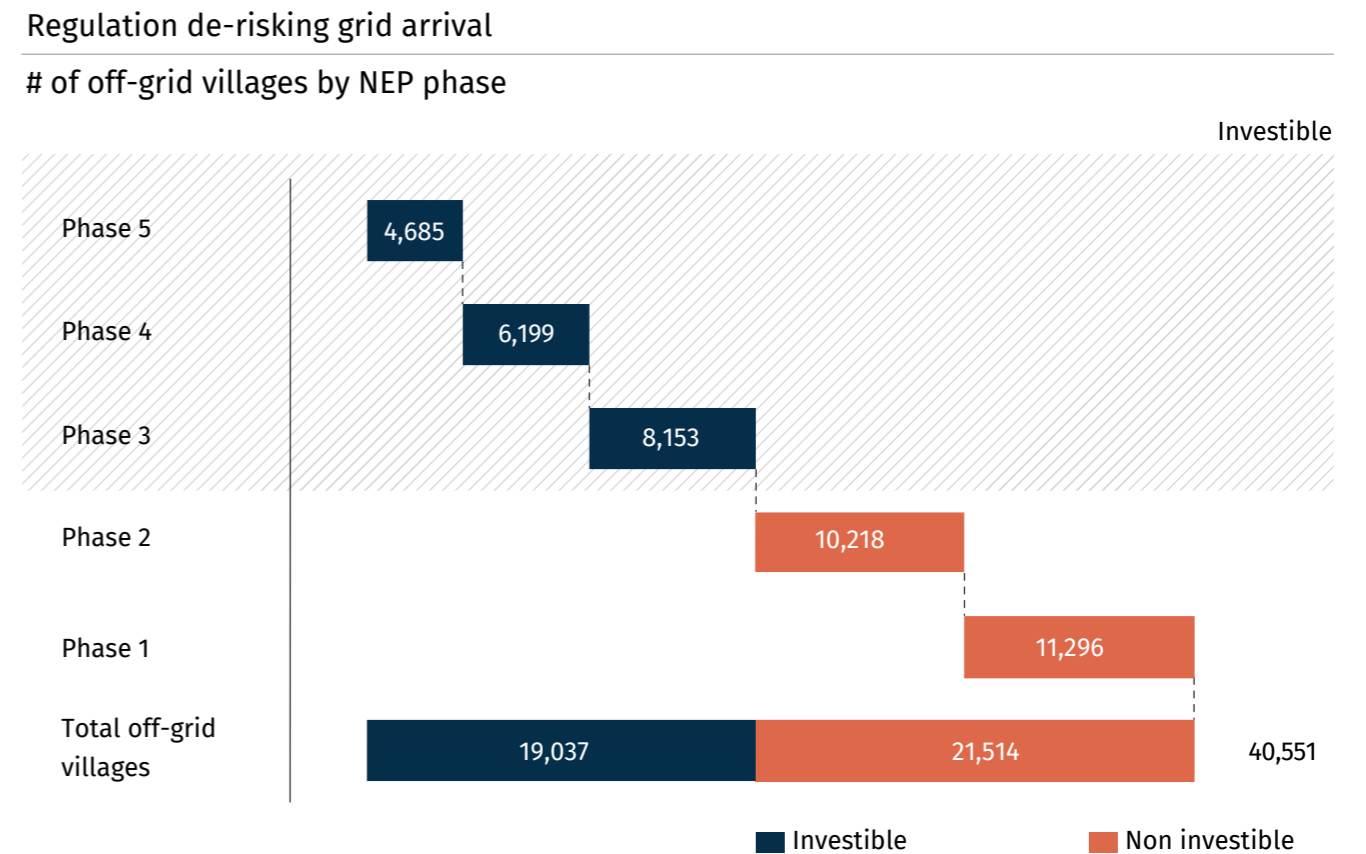
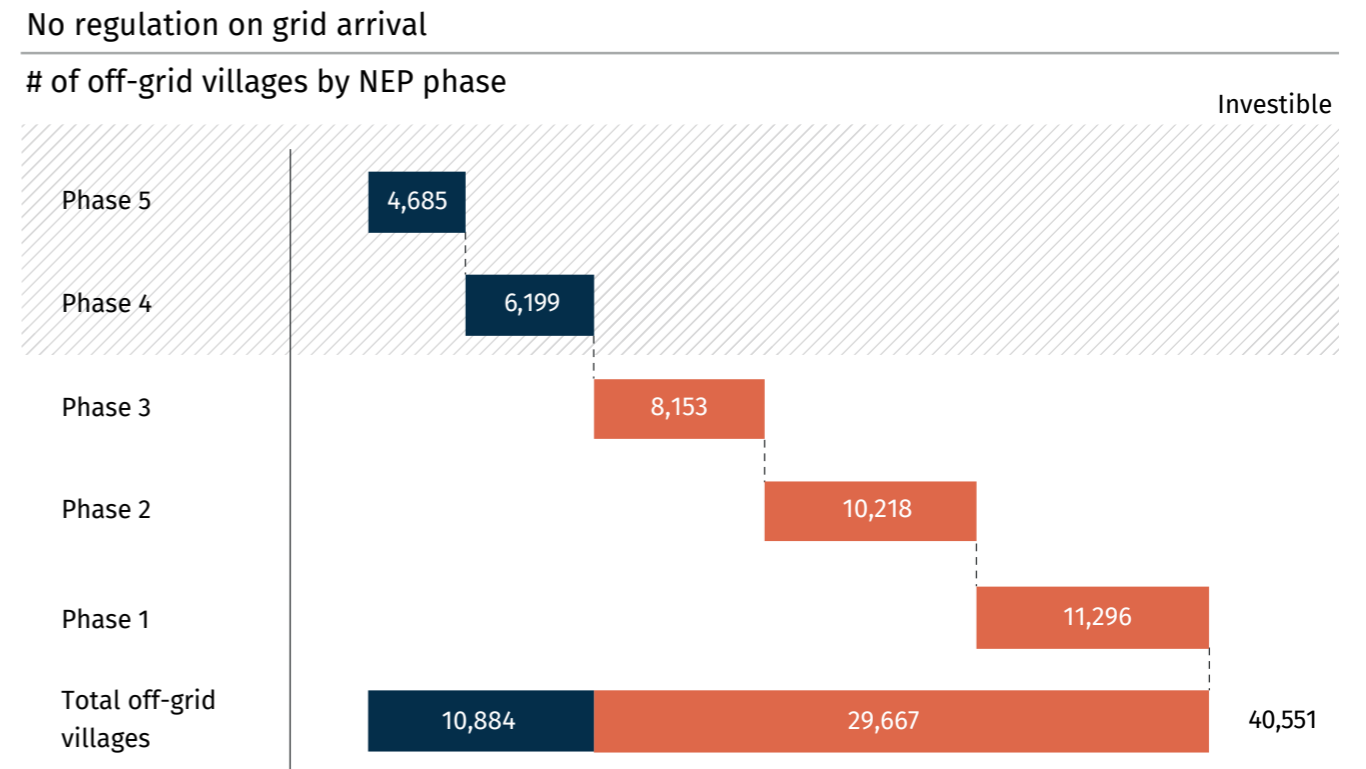
⁴¹ Formulas for calculation of LCOE and IRR:

$$LCOE = \frac{\sum_{t=1}^N (CAPEX_t + OPEX_t) / (1+r)^t}{\sum_{t=1}^N (E_t / (1+r)^t)}$$

$$0 = NPV = \sum_{t=1}^N ((CF_t / (1 + IRR)^t)$$

where, CAPEX is capital expense, OPEX is operational expense, t is year, r is the discount rate, E is the energy generated, N is the lifetime of the mini-grid, NPV is the net present value and CF is cash flow

Figure 12. Number of off-grid sites investible for mini-grids depending on regulation on grid arrival



Source: National Electrification Plan

For the purpose of this study, the likelihood of grid arrival in the next 10 years and the existence of regulatory provisions de-risking grid arrival are taken as the key criteria determining investibility. Potential mini-grid sites (i.e. off-grid villages) can be segmented along these criteria to establish investibility by site:⁴²

- In case no regulation de-risking grid arrival is introduced, only off-grid villages with low likelihood of being reached by the grid in the next 10 years are considered investible. In practice, these correspond to villages under Phase 4 and 5 of NEP, amounting to almost 11,000 villages (see Figure 12)
- In case regulation is introduced to de-risk grid arrival (see also discussion in Section 2.4 and recommendations outlined in Section 5.1), additional villages with mid likelihood of grid arrival in the next 10 years may also be considered as investible by private developers. In this case, villages under Phase 3 of NEP are also included in addition to villages under Phase 4 and 5 resulting in 19,000 potentially investible villages, almost twice as much as in the case without regulations (see Figure 12)

Thus the regulatory environment plays a crucial role in determining the pool of villages that are potentially suitable for mini-grid investment.

3.3 Simulation results for different mini-grid configurations and subsidy contributions

LCOE and IRR Simulations for different configurations, subsidies/ community contributions and year

LCOE and IRR simulations are conducted for various types of mini-grids categorized by:

- Village population size, namely small population cluster of 250 people, mid-sized cluster of 470 people or large cluster of 850 people⁴³
- Customer type, namely residential customers only, residential and productive load, or residential, productive and anchor (tower) load; and
- Geography (dry zone, mid-dry zone or non-dry zone)⁴⁴ impacting solar irradiation

⁴² Criteria were chosen after consultation with GIZ

⁴³ Village population tiers from Gaussian fitting distribution of off-grid villages by population (see Annex 3)

⁴⁴ Solar irradiation levels determine the amount of CAPEX required – in high irradiation zones, less CAPEX is needed per unit of power generation. The solar irradiation levels for the three zones (dry, mid-dry and nondry) are based on the average horizontal solar irradiation each month in regions representative of each zone (Magway for Dry, Yangon for Mid-dry and Kachin for Non-dry). Refer to Annex 4 for solar irradiation curves in the three regions.

In the case of no subsidies or community contributions, LCOE in 2020 varies from approximately 1.5 USD/kWh (small population cluster, residential-only loads and location in the non-dry zone) to 0.46 USD/kWh (small population cluster, residential, productive and anchor loads, location in the dry zone). IRR can reach up to 11.1% (See Figure 13). These figures show that, given a LCOE threshold of 0.37 USD/kWh (around 510 MMK / Kwh) and an IRR threshold of 20%, without subsidies and community contributions, none of the mini-grid configurations are viable as of 2020 on a standalone project basis (i.e. assuming no economies of scale).

Incorporating subsidies of 60% and community contributions of 20% of total investments, as per the current DRD scheme, substantially decreases LCOE and increases IRR. IRR becomes as high as 38.5% for large population clusters in the dry zone with residential and productive loads in 2020 (See Figure 14). These results are in line with the current market status, where there is little private investment in projects not supported by the DRD subsidy scheme, however numerous private developers propose projects to be subsidised by DRD.

For both the unsubsidised and subsidised cases, a key determinant of LCOE and IRR levels is the inclusion of productive loads. The effect of productive loads is much more important than the size of the population cluster. For example, for the subsidised case, in the dry zone, increasing the population cluster from small to large in a mini-grid with residential-only loads increases IRR to 4.0%. Instead, adding productive loads to the same mini-grid configuration increases IRR to 9.2%. This is explained by two reasons: (1) productive loads support higher demand per connection than residential loads – hence revenues are maximized for a given level of investment in distribution infrastructure, (2) productive demand is concentrated during daytime and matches solar generation profile better than residential demand – hence increasing productive loads requires comparatively lower investment in battery storage capacity. Interviews with market players and stakeholders also confirm this conclusion.⁴⁵

Simulations for 2030 take into account the evolution of project costs and of consumption per head. As solar PV develops into one of the key power generation technologies globally, the cost of solar panels is expected to decrease by 7.2% on average per year and that of inverters by 8.5% on average per year until 2030.⁴⁶ In addition, consumption per capita is expected to increase in line with Myanmar's GDP per capita growth of 6.6% per year, thereby increasing revenue generation per connection. This impacts especially the viability of mini-grids in the unsubsidised case.

⁴⁵ Interviews with private developers conducted by Roland Berger

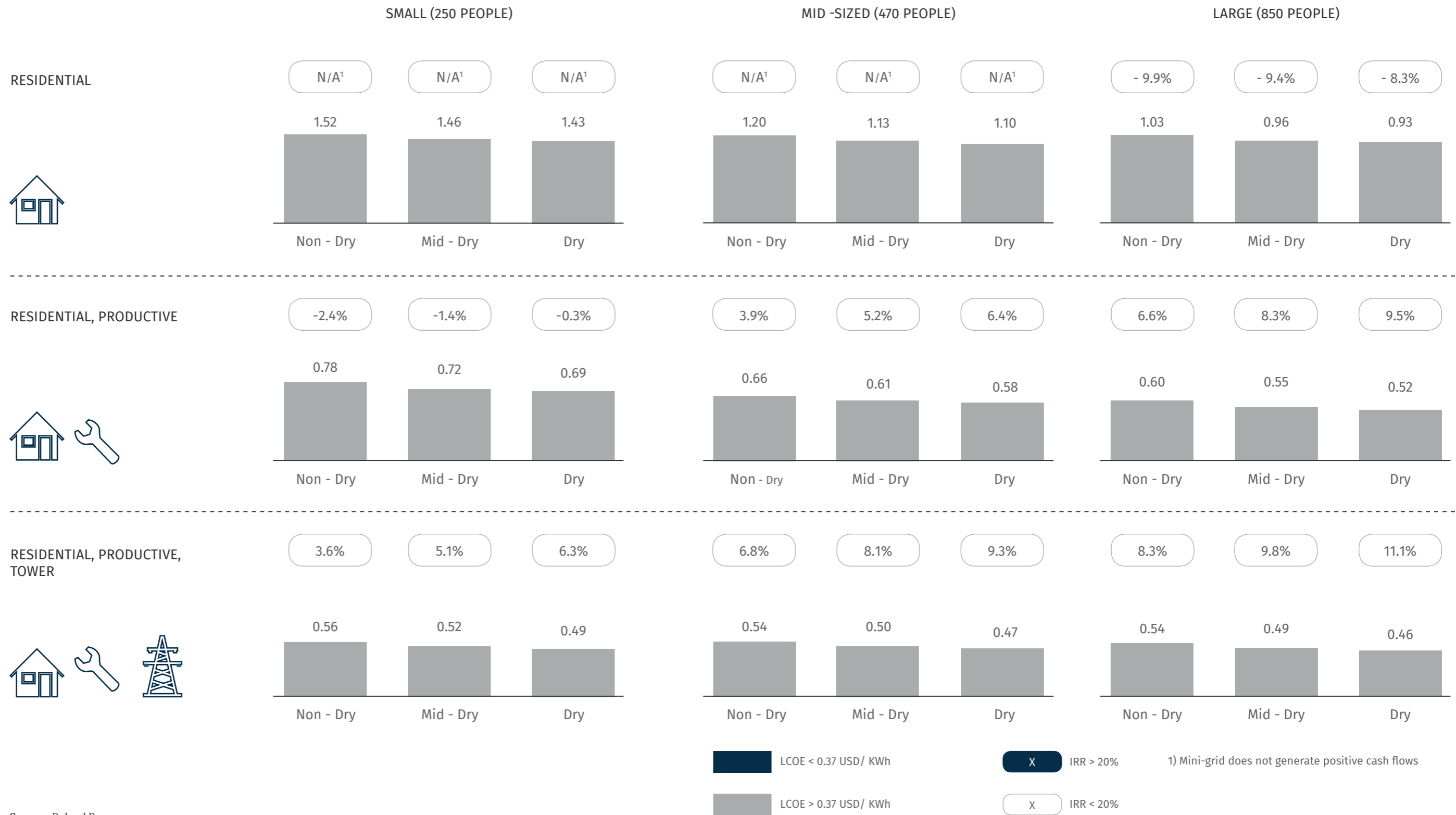
⁴⁶ IRENA, "Electricity Storage and Renewables: Costs and Markets to 2030", 2017

Figure 13. Viability of mini-grids in 2020 based on cost, size, and climate, No Subsidies or Community Contribution

IRR N/A when configuration does not generate positive cash flows;

TYPE OF LOAD

POPULATION CLUSTER



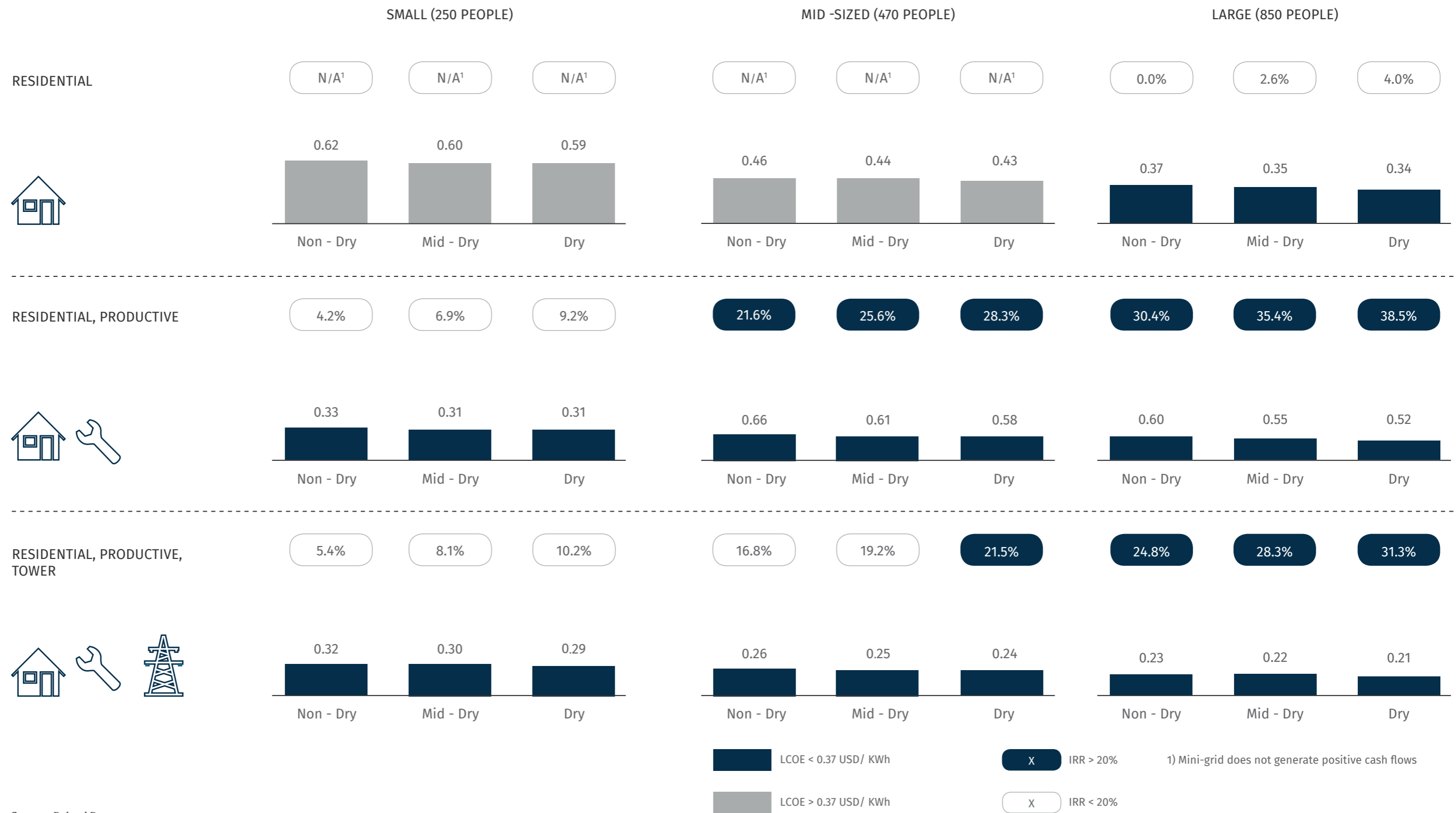
Source: Roland Berger

Figure 14. Viability of mini-grids in 2020 based on cost, size, and climate, 60% Subsidies and 20% Community Contribution

IRR N/A when configuration does not generate positive cash flows; Note that viability deteriorates as anchor loads are added because it is assumed that CAPEX related to equipment to supply power for anchor loads is not subsidised or covered by community contributions

TYPE OF LOAD

POPULATION CLUSTER



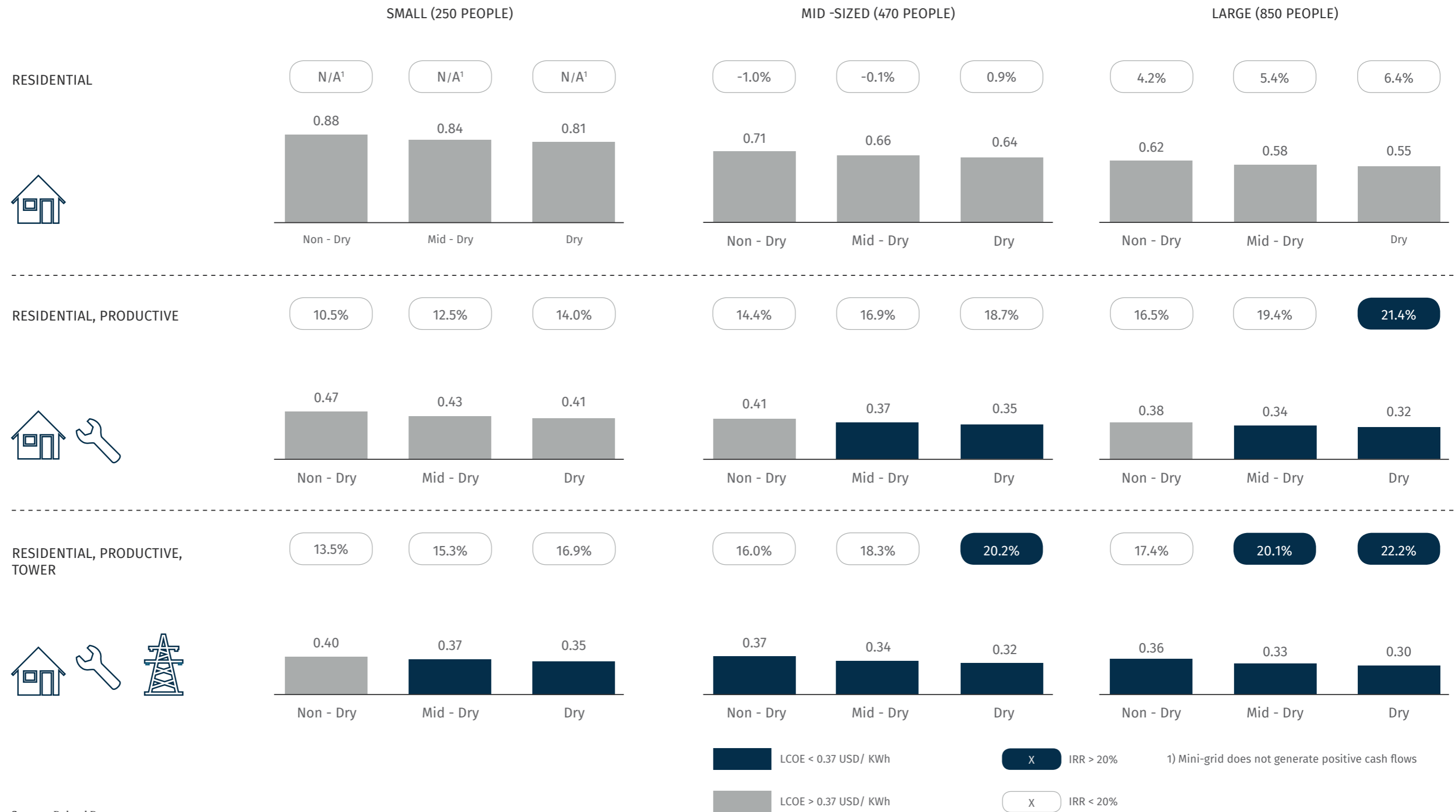
Source: Roland Berger

Figure 15. Viability of mini-grids in 2030 based on cost, size, and climate, No Subsidies or Community Contribution

IRR N/A when configuration does not generate positive cash flows;

TYPE OF LOAD

POPULATION CLUSTER



Source: Roland Berger

By 2030, it is expected that in favourable configurations (large and mid-sized villages in the dry zone, representing ~3,000 sites) mini-grids become viable even without subsidies and community contributions (See Figure 15 before).

LCOE and IRR simulations for hydropower mini-grids

As outlined in Section 2.5, although solar/diesel/battery hybrid mini-grids are expected to emerge as the key configuration for mini-grid applications in Myanmar, hydropower mini-grids are currently the most widespread type of renewable mini-grids in Myanmar and can play an important role if suitable locations with exploitable hydrological potential can be identified.

Hydropower LCOE and IRR depend critically on the morphology of the exact location of the mini-grid and capital expenses per kW for the generation system can vary considerably. In this study a range between 3,600 USD/kW (Low CAPEX locations) and 4,000 USD/kW (High CAPEX locations) is considered for suitable locations based on data from IRENA.

Our simulations show that in the case of mini-grids with investment subsidies, most configurations are viable. LCOE vary between 0.16 and 0.45 USD/kWh. However, as in the case of solar, without subsidies, most mini-grid configurations are not viable as of 2020. Hence as of 2020, hydropower mini-grids may be developed under the DRD scheme if suitable locations with CAPEX in the range outlined above are identified.

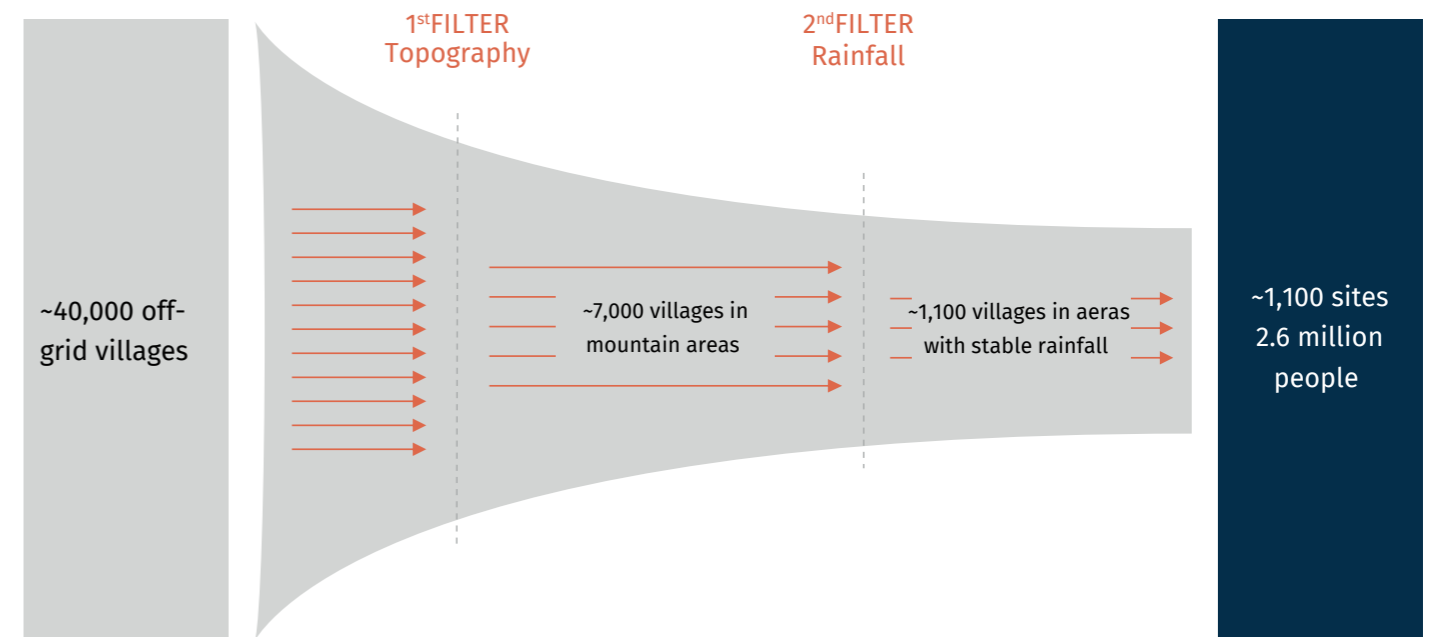
It should be emphasised that in the context of this study viability is defined using parameters and required thresholds typical of private developers. Existing hydropower mini-grids built and managed with significant involvement of local communities may be considered viable without government subsidies as shareholders may have markedly different requirements in terms of rate of returns compared to private developers.⁴⁷

As outlined above, site-specific conditions are important to determine actual viability of hydro-powered mini-grids. Two key determinants of viability are the local topography and the hydrological conditions. Areas with low topographical gradients require large civil works to achieve suitable level of heads driving high investment costs. Locations with irregular water flows (e.g. low flows during the dry season) are also unsuitable as stable supply cannot be guaranteed.

⁴⁷ See for example Pandey, B., A. Reddy, D. Vaghela “Assessing the Impact of Community-Managed Structures on the Economic Viability of Small-Scale Hydropower in Nepal and Myanmar, Working Paper, Hydro Empowerment Network”, 2018

In order to estimate the approximate number of potential sites for hydro-power mini-grids, off-grid villages with likely favourable conditions are identified. To determine favourable topography, off-grid villages in mountainous areas with high topographical gradients are selected using maps. It is estimated that approximately 7,000 off-grid villages lie in favourable areas. As there are no available data at the national level defining hydrological conditions, rainfall statistics are used as a proxy to assess stability of water flows – villages in areas where the driest month has at least 10 mm average precipitation are selected.

Figure 16. Estimation of approximate number of potential hydro mini-grid sites



Source: Roland Berger

Using the filtering approach described above yields an estimated 1,100 sites potentially suitable for hydro-powered mini-grids corresponding to 3% of off-grid villages. This admittedly rough estimate is consistent with expert opinions gathered through interviews.⁴⁸ The potential sites identified are concentrated in Chin (especially in the northern part of the State), Kachin, parts of Sagaing and Shan and cover 290, 000 households. The corresponding mini-grid capacity would be 54 MW.

⁴⁸ Interview conducted by Roland Berger with GIZ

It is worth noting that the potential areas identified here do not overlap with areas most favourable for solar/diesel/battery mini-grids (dry and mid-dry zone). Thus, although the estimates above suggest that hydro power mini-grids can potentially cover only a small fraction of off-grid villages, this technology may play an important role in enabling electrification in specific areas that are not favourable to solar mini-grids.

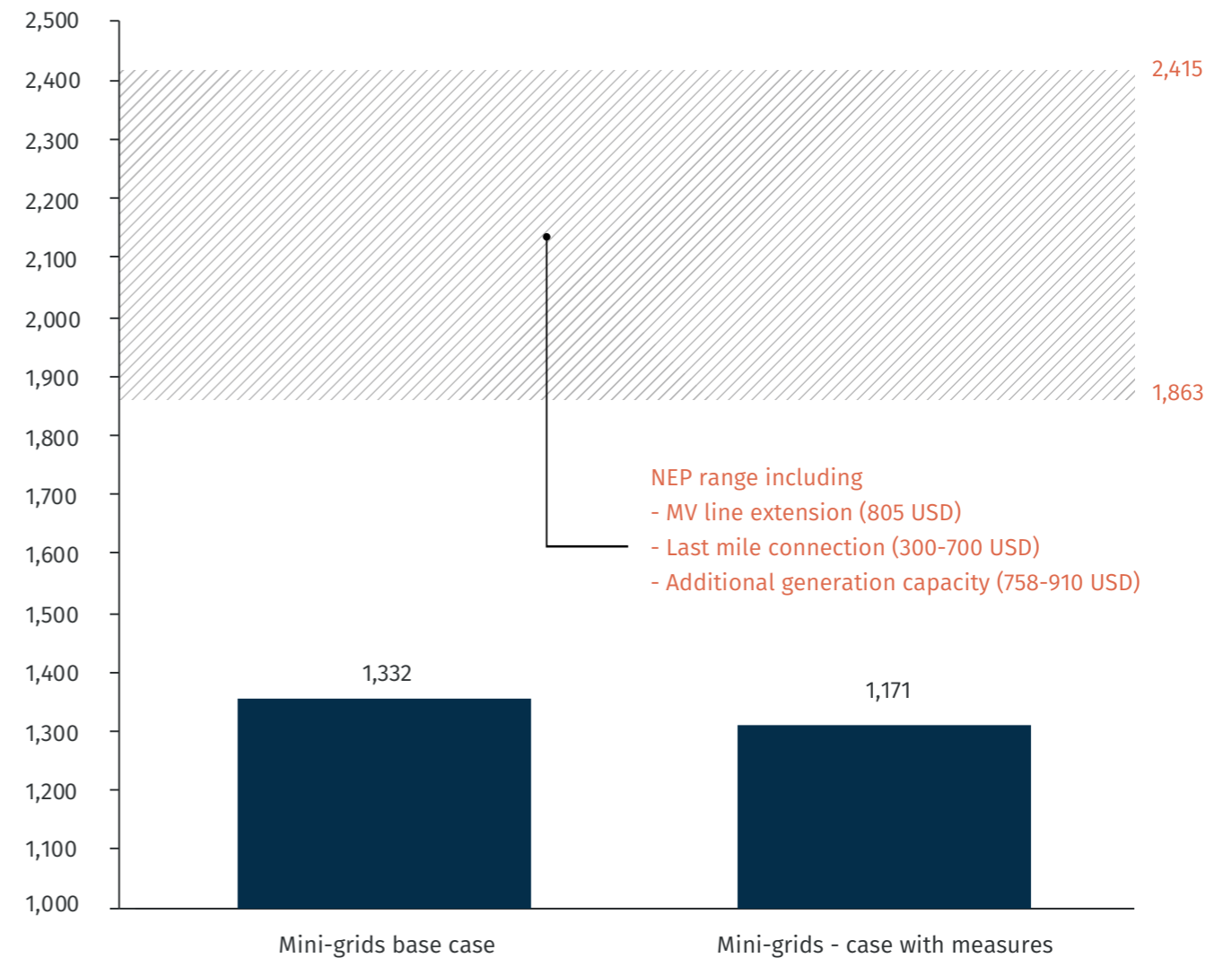
3.4 Cost per connection

In Figure 17, a comparison of electrification costs per connection between on-grid electrification (as planned in the NEP) and mini-grids is presented.

Estimated costs per connection for grid electrification range between 1,863 to 2,415 USD per connection, including average costs of extending MV distribution lines, cost of last mile connections and cost to increase installed generation capacity to supply newly-electrified areas. (see Section 1.7)

Scenarios for mini-grid development show much lower costs per connection. In the base case for 2020, estimates indicate cost levels of 1,332 USD per connection. Note that this is consistent with World Bank estimates of 1,400 USD per connection for mini-grids in Myanmar.⁴⁹ In the case with measures (i.e. when (1) investment subsidies budget is increased to 100 million USD, (2) economies of scale is achieved, (3) IRR threshold is decreased to 15%, and (4) productive load is increased by 20% and (5) grid arrival is de-risked through regulatory reform), cost per connection decreases to 1,171 USD or approximately 40% less than grid electrification. Hence these scenarios provide strong evidence that mini-grids can offer a cost-effective solution to electrification of off-grid areas in Myanmar while the main grid is extended.

Figure 17. Comparison of cost per connection between mini-grid (base case), mini-grid (case with measures) and NEP



Source: Roland Berger

Note that NEP cost include average costs for extension of distribution lines (805 USD), cost of last mile connection (300-700 USD) and cost of additional generation capacity needed to supply electrified areas (estimated at 758-910 USD)

⁴⁹ World Bank, "Myanmar: Towards Universal Access to Electricity by 2030", 2014

4.0

Projections of Potential Market for Mini-Grids in Myanmar Under Different Scenariosw

4.1 Definitions and methodology

In this chapter, a quantitative assessment of the potential market for mini-grids in Myanmar is provided for 2020, 2025 and 2030 and different scenarios for market evolution are explored.⁵⁰

The potential market size is based on (1) the number of mini-grids that would become financially viable and investible for mini-grid developers at a certain point in time (2020, 2025 and 2030), (2) the corresponding coverage of off-grid population and, (3) the amount of investment that would be required to build all the potential mini-grids identified.

It should be stressed that the actual number of mini-grids that will be built by 2020, 2025 and 2030 could differ substantially from the potential market estimated here as implementation of mini-grid projects depends on numerous factors such as availability of private financing and of resources to build mini-grids as well as the likelihood of obtaining consensus and buy-in from local communities.

⁵⁰ Focusing on solar/diesel/battery hybrid mini-grids



The market potential is assessed using a filtering approach, building on the analysis outlined in Chapter 3 (see Figure 18) and including three steps:

• **Create a list of off-grid villages**

» The original list of off-grid villages from the National Electrification Plan is utilised. This list contains 42, 110 off-grid villages and also specifies the NEP Phase for each village (Phase 1-5, with Phase 1 villages planned for early electrification).⁵¹ The list is then updated to 2020/2025/2030 following expected electrification rate (see Section 1.3)

• **Filter out non-viable and non-investible off-grid villages**

» Following the analysis at 3.1, each village is categorized based on its potential mini-grid configuration given its population cluster size (small, mid-sized or large), location (dry zone, mid-dry zone or non-dry zone), proximity to anchor load (whether it is located within 1.4 km from a telecommunication tower) and productive load potential (high, mid, low as categorized in Section 1.4)

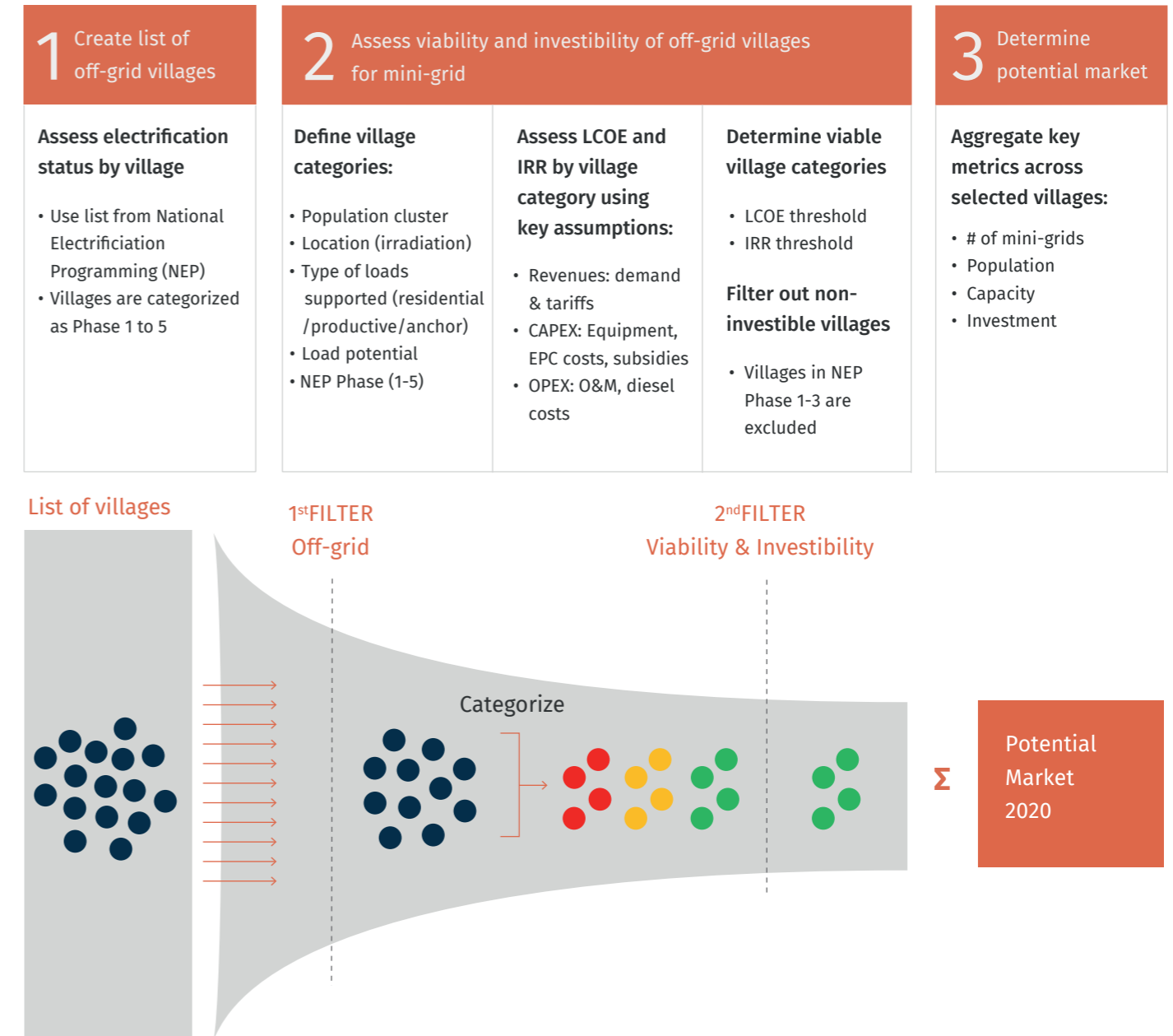
» Based on the categorisation above and on the analysis at 3.3, mini-grid viability in each village is assessed and non-viable villages are excluded

» Villages in early phases of NEP are excluded as in these locations mini-grid developers may not be ready to shoulder the risk of early grid arrival (villages are deemed non-investible). Assuming no specific regulation on transition upon grid arrival is introduced, villages in Phases 1 to 3 of NEP are deemed non-investible⁵²

• **Determine overall potential market by aggregating key metrics across selected villages after filtering**

» Sum potential market metrics over all viable and investible villages identified in step 2: number of mini-grids (assuming one mini-grid per village), population covered, generation capacity, investment required to build mini-grids in all selected villages

Figure 18. Filtering approach used to estimate potential market



Source: Roland Berger

⁵¹ Columbia University, "Myanmar — Geospatial based Least Cost Modeling Output", 2014

⁵² Based on interviews with GIZ

Market projections and scenarios are built by taking into account changes in the filtering process described above due to (1) impact of electrification, (2) impact of the evolution of key parameters (e.g., capital costs, demand per capita, etc.), and (3) impact of the evolution of scenario drivers (see Figure 19):

• **Impact of electrification**

- » The status of electrification for each village is projected to 2020, 2025 and 2030 based on the expected evolution of electrification rate outlined in Section 1.3
- » Hence, as a result of electrification, the pool of off-grid villages that go through filter 1 becomes smaller

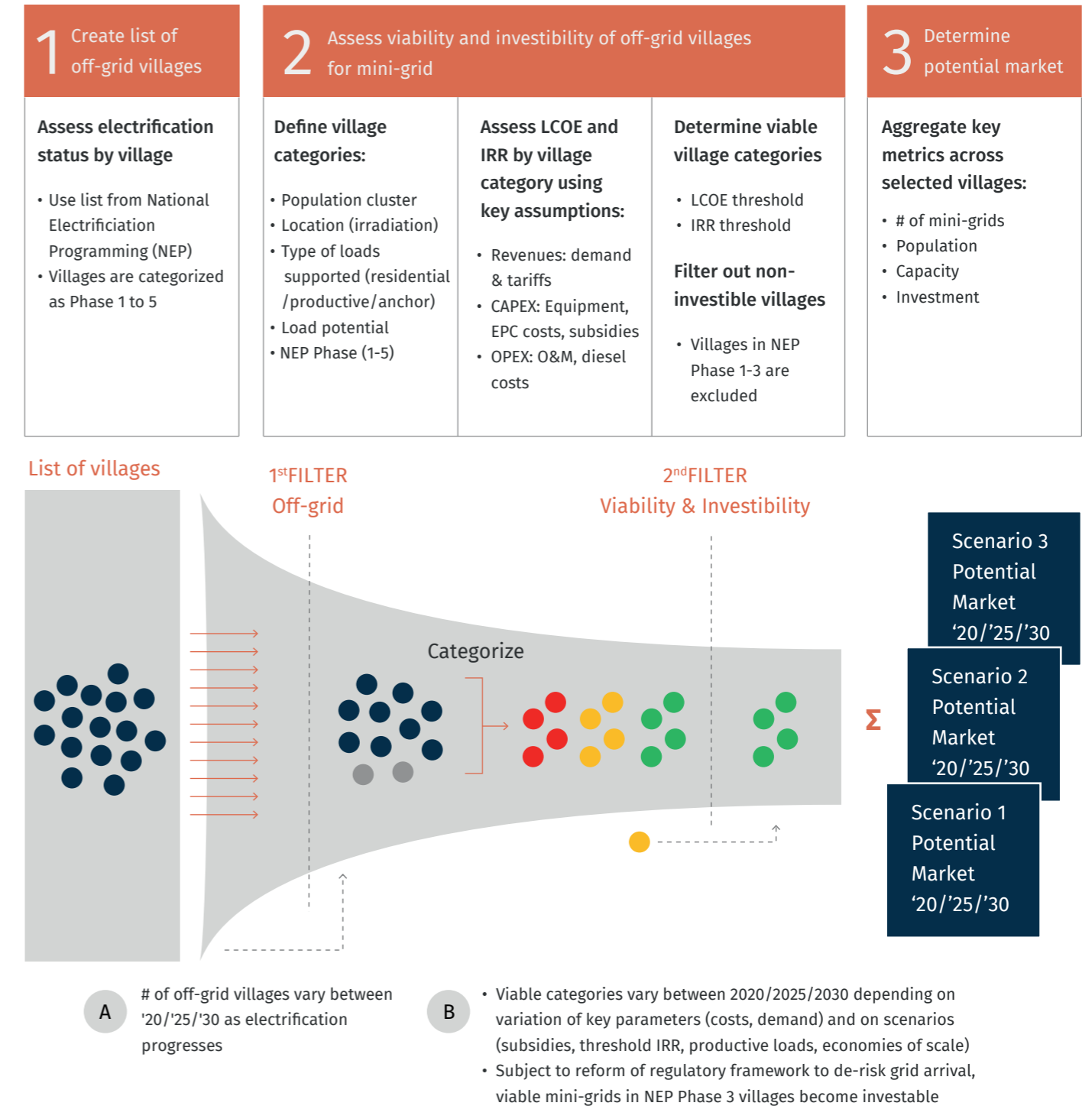
• **Impact of evolution of key parameters**

- » Evolution of key parameters affecting revenues and costs is taken into account to determine evolution of LCOE and IRR of mini-grids thus impacting the viability assessment performed at filter 2

• **Impact of scenario drivers**

- » As outlined in Section 4.3, five scenario drivers are considered in the current study: (1) Subsidies and contributions, (2) Regulatory framework, (3) Access to finance, (4) Demand per load (5) Economies of scale
- » Drivers (1) Subsidies and contributions, (4) Demand per load and (5) Economies of scale impact directly LCOE and IRR of mini-grids, thus impacting the viability assessment performed at filter 2
- » Drivers (2) Regulatory framework and (3) Access to finance, impact the required internal rate of return to make mini-grids viable from an investor perspective thus lowering the IRR threshold required for filter 2
- » In addition, driver (2) Regulatory framework, which includes proposed regulations to de-risk grid arrival, crucially impacts the criteria used for selecting investible mini-grids. In case regulatory provisions to de-risk grid arrival are introduced, viable mini-grids in NEP Phase 3 villages would also become investible by developers and can be included the quantification of the potential market

Figure 19. Approach to generate potential market projections and scenarios



Source: Roland Berger

4.2 Potential market forecast to 2030 in base case scenario

In the base-case scenario, it is assumed that the current investment subsidy and community contribution system is maintained, ensuring coverage of 80% of the initial investment required to develop mini-grids (60% through investment subsidies and 20% through community contributions). An 18.6 million USD budget is assumed for the investment subsidy scheme which is the expected budget available in the foreseeable future derived from interviews with DRD and bilateral institutions. Evolution of electrification is assumed to be in line with the average of 15 benchmark countries as outlined in Section 2.3 – by 2030 electrification rate is expected to reach 62% implying an off-grid population of 22 million people. To define mini-grids viability, a LCOE threshold of maximum 0.37 USD/kWh and an IRR threshold of minimum 20% are utilised.⁵³

As outlined in Section 3.3, under the existing investment subsidy scheme,⁵⁴ most mini-grid configurations are viable. In addition, based on simulations using our model, by 2030, thanks to the decrease in key equipment costs and increase in demand per capita, mini-grids in large villages in the dry zone with productive and tower loads are expected to become viable even without investment subsidies.

Consequently the market projections show that for 2020 and 2025, the number of viable mini-grids is determined by the budget available for subsidies under the DRD scheme. By 2020, an estimated 229 mini-grids could be developed given the expected 18.6 million USD subsidy budget. The total investment required would be 31 million USD.

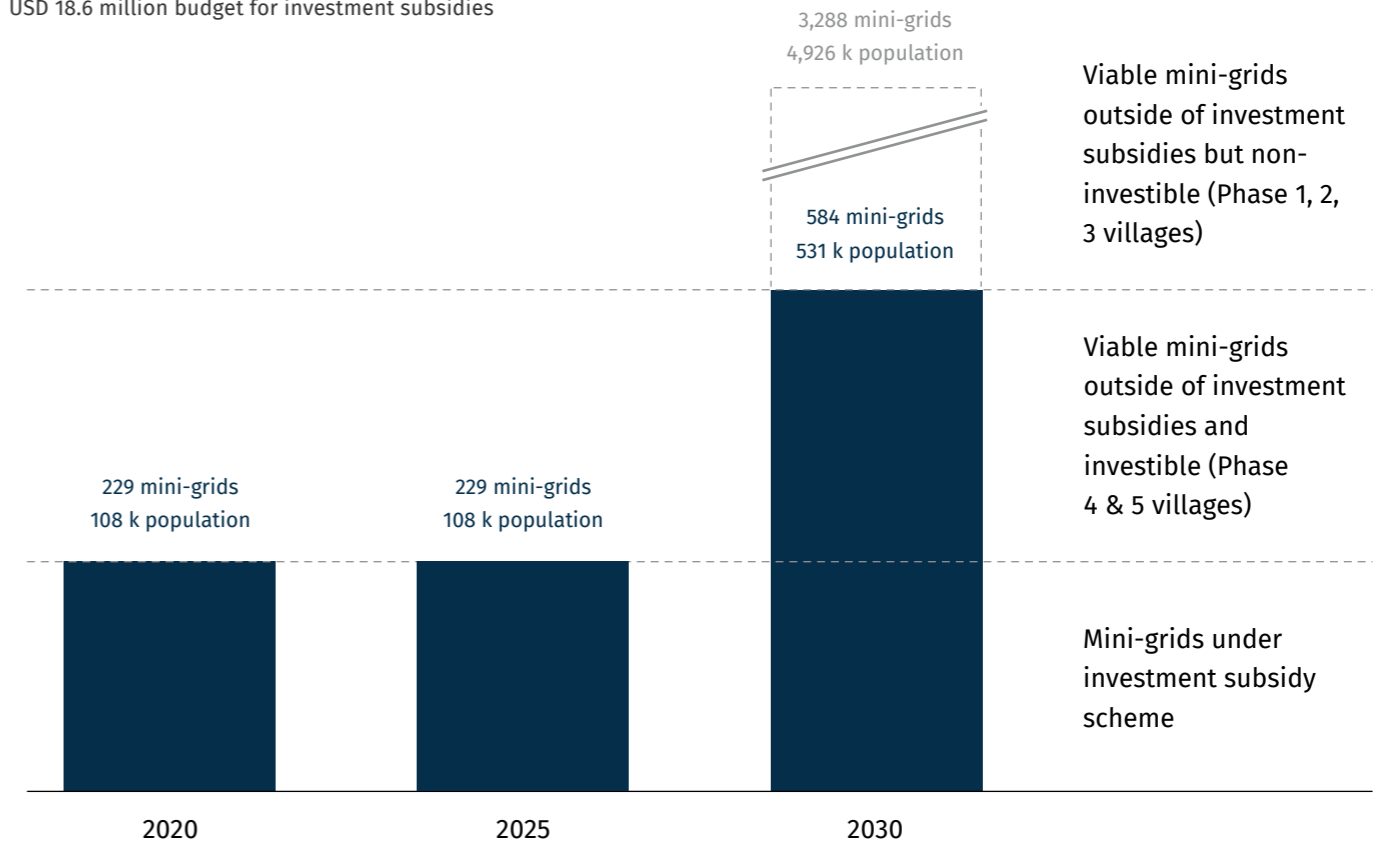
By 2030, in addition to 229 mini-grids that could be developed using investment subsidies, mini-grids that are outside the investment subsidy scheme become viable in large and mid-sized villages in the dry zone, and in large villages in the mid-dry zone, generating an increase in the potential market to 584 mini-grids.

⁵³ The IRR threshold used is much higher than for utility-scale solar (7-12% depending on Country). This is because utility-scale solar projects typically sell generated power through long-term power purchase contracts with merely fixed volumes and prices. Hence, project cash flows are de-risked. On the contrary, mini-grid projects still carry cash flow risk as customer demand and sales volumes are difficult to predict.

⁵⁴ In this analysis mini-grids developed by private developer outside of the investment subsidy scheme under the anchor-focused business model are not taken into account as they only cover selected parts of villages nearby telecommunication towers to maintain viability

Figure 20. Mini-grid market potential in Myanmar in base case scenario with current subsidy scheme and 18.6 million USD subsidy budget

Base case, 60% investment subsidies, 20% community financing, USD 18.6 million budget for investment subsidies



Source: Roland Berger analysis

This would allow coverage of approximately 2.3% of the off-grid population or 531,000 people at a total investment of 204 million USD (See Figure 20).

Market projections show that unsubsidised mini-grids become viable in 2030 in 6 States/Regions that can be grouped into two categories:

- States/Regions combining high irradiation levels (dry zone)⁵⁶ with high potential for productive loads: Magway, Sagaing.
- States/Regions with average irradiation levels (mid-dry zone), but high potential for productive loads: Ayeyarwaddy, Bago, Tanintharyi, Mon

⁵⁵ Refer to section 2.4.2 for analysis of productive load potential by State/Region

⁵⁶ Refer to Annex 4 for average irradiation level for each type of zone

These market projections suggest that with the current subsidy scheme and budget levels, only a minority of off-grid villages can be reached by newly-developed mini-grids in the short to mid-term up to 2025. Only in the longer term (from 2030), coverage in regions with high productive demand potential and mid-to-high irradiation levels may increase.

Consequently, in order to reach significant electrification through mini-grids in the short to mid-term, different options should be explored to increase subsidy budgets and/or enable development of mini-grids by complementing the current investment subsidy scheme with other support measures. In order to inform recommendations on the possible options, a number of scenarios have been developed as outlined in the following sections.

4.3 Selection of scenario drivers and definition of scenarios

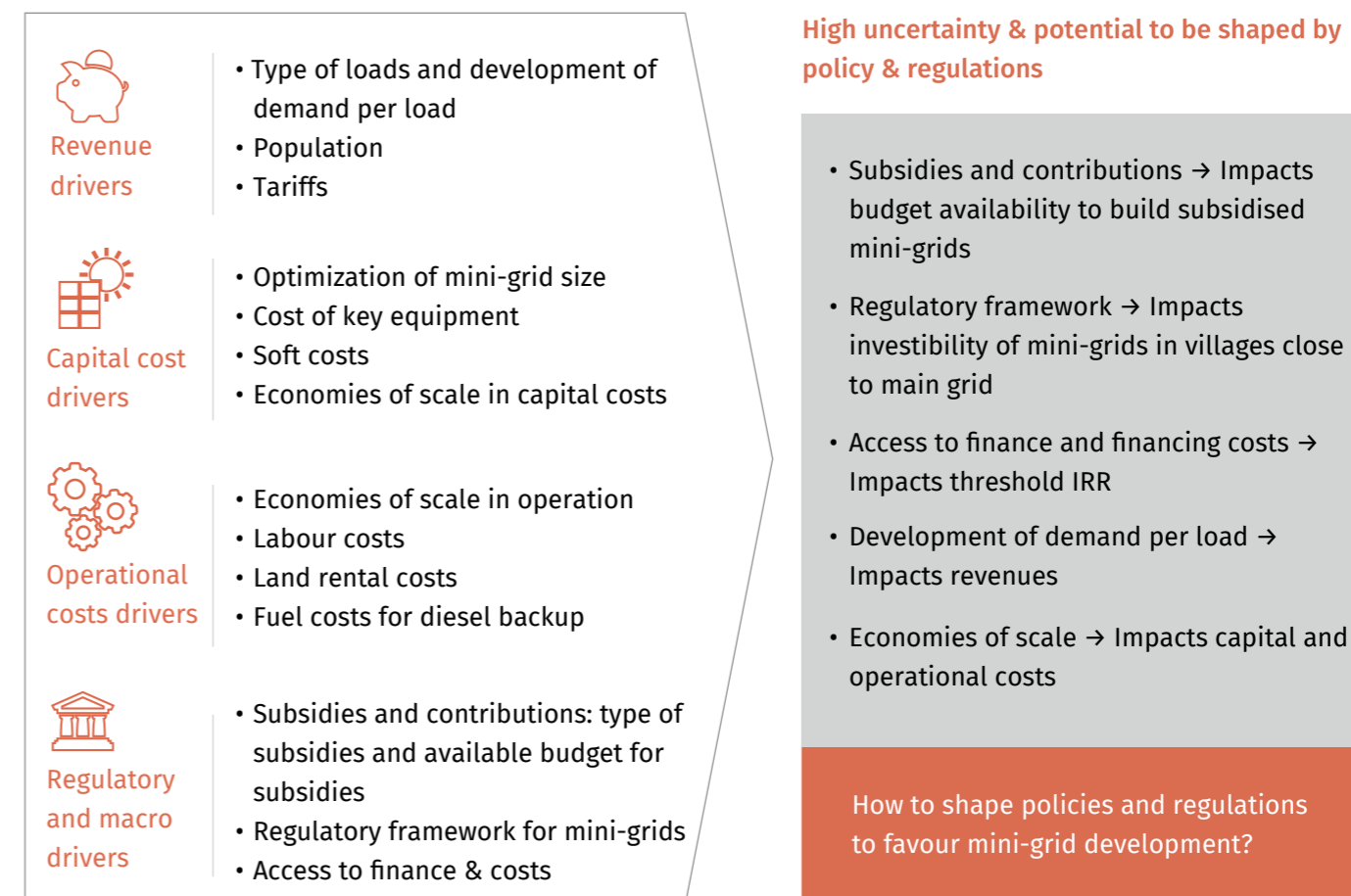
As discussed in Section 3.1 and 3.2, the following four categories of key drivers have significant impact on the viability and investibility of mini-grids: revenue drivers, capital and operational costs drivers, regulatory/macro-economic drivers.

In this study, scenario drivers are selected among these four categories using two criteria: (1) Drivers whose evolution is uncertain at present, (2) Drivers that may be influenced through deliberate policy and regulatory action.

In this way, five scenario drivers with high uncertainty and potential to be shaped by policy and regulations are identified:

- Subsidies and contributions
- Regulatory framework
- Access to finance and financing costs
- Development of demand per load
- Level of economies of scale in development of mini-grids

Figure 21. Key drivers for scenarios



Source: Roland Berger

Based on the selection of scenario drivers, the following quantitative scenarios can be defined (these scenarios are discussed in Section 4.4):

- **Subsidy Scenarios:** Determine potential market as a function of total available budget for subsidies assuming the current investment subsidy scheme remains in place (i.e. DRD covers 60% of capital costs, community contribution covers 20% of capital costs and private developer covers remaining 20% of capital costs). These scenarios would inform recommendations to optimise subsidy budgets to promote greater coverage of off-grid population through mini-grids. In addition, impact of reducing subsidies contribution as a percentage total investment from current 60% can also be explored.

- **Regulatory Scenarios:** Determine impact on potential market of introducing a comprehensive regulatory framework, including a clear mechanism for transition at the time of grid arrival. This regulatory framework would reduce overall risk perception and most importantly allow investment from developers in villages closer to the main grid⁵⁷ that, without certainties on grid arrival transition, would be considered too risky and non-investible.
- **Financing Scenarios:** Determine potential market size as a function of IRR threshold (%) reflecting possible changes in access to finance, financing costs for private developers as well as lower perceived risk for mini-grid projects. These scenarios would inform recommendations for actions to facilitate access to lower-interest finance by private developers, for example through two-step loan schemes, whereby bilateral/multilateral institutions would support local financial institutions through loans, enabling the latter to issue loans to mini-grid private developers at attractive conditions. In addition it would support further regulatory reform to de-risk grid arrival as a lever to decrease perceived risk of mini-grid projects.
- **Demand Scenarios:** Determine potential market size as a function of demand per load. These scenarios would inform recommendations for demand-side support actions such as new forms of subsidies to end-customers to stimulate electricity demand in addition to the current supply-side-focused investment subsidy scheme.
- **Economies of scale Scenarios:** Determine market size for different levels of economies of scale driving capital and operational cost reductions. These scenarios would inform recommendations for: (1) Actions to centralise project development and procurement for “blocs” of projects and (2) Actions aiming at favouring more market consolidation thereby allowing the development of sizeable private developers that would be able to develop multiple projects in parallel enhancing economies of scale.

4.4 Estimate of potential market in 2020 by scenarios

4.4.1 Standalone scenarios for 2020

Market size simulations conducted by Roland Berger show that if actions to impact market drivers are taken individually, only very large variations of key driving would lead to sizeable effect on the market size. Consequently, to inform actionable recommendations, the **combined** effect of variations of the four key drivers outlined at 4.3 is considered.

⁵⁷ Interviews with GIZ

4.4.2 Combined scenarios for 2020

The simulations outlined above show that, as of 2020, if measures to impact market drivers are taken individually, only very large variations of the scenario drivers, that are unlikely to be realised, would enable development of viable mini-grids beyond the current investment subsidy scheme. Consequently, to inform actionable recommendations, the combined effect of variations of key scenario drivers should be considered.

Potential market triggered by 5 combined scenarios in 2020

The effect on potential market size of implementing a combination of the following five measures is explored:

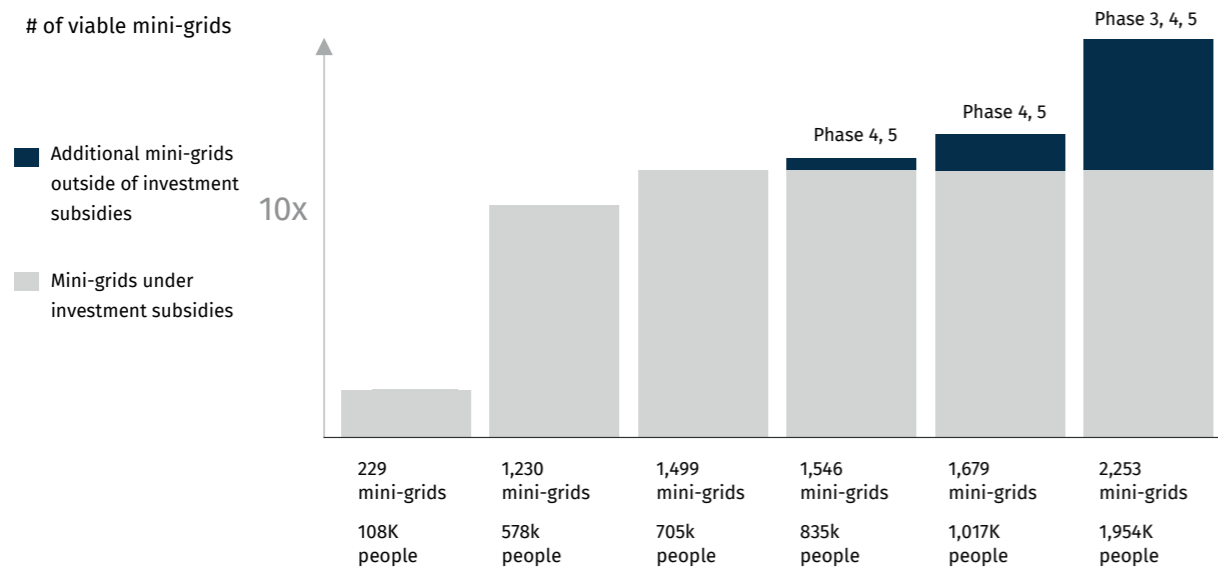
- Increasing investment subsidies budget to 100 million USD to ensure sufficient initial market volume to support economies of scale
- Enabling economies of scale by pooling of development processes or through market concentration
- Decreasing Internal Rate of Return (IRR) threshold to 15% through financing support measures and by de-risking mini-grid development
- Increasing productive loads per capita by 35% on average through demand-side measures
- Enabling private developer investment in viable mini-grids in NEP Phase 3 villages through regulatory reform de-risking grid arrival

Simulations show that by 2020 the combined effect of the five measures above would trigger a potential market of 2,253 mini-grids,⁵⁸ including 754 mini-grids that would become viable outside of the current investment subsidy scheme (see Figure 22).

Potential coverage for these mini-grids would amount to 2 million people or 6.4% of the total projected off-grid population in 2020. Total investment that would be required to realize all these mini-grids is estimated at USD 537 million.

⁵⁸ These 2,253 mini-grids represent the potential market size in 2020, i.e. the number of sites in which minigrids would become viable and investible from a private investor's perspective as of 2020. This can differ from the actual number of mini-grids that will be realised.

Figure 22. Simulation of number of viable mini-grids in 2020 (i.e. potential market size in 2020) with combined actions on investment subsidies budget, economies of scale, financing support, demand-side support and regulatory framework reform to make NEP Phase 3 villages investible. Assumes top three players have equal market share; assumes current investment subsidy scheme (DRD covers 60% of capital costs, community contribution covers 20% of capital costs and developer covers remaining 20% of capital costs)



Current Status: Investment subsidies of 18.6 m

Proposed Measures

Measure	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Phase 3, 4, 5
1. Increase Investment subsidies budget to USD 100 m	●	●	●	●	●
2. Facilitate economies of scale		●	●	●	●
3. Decrease IRR to 15%			●	●	●
4. Increase productive load by 35%				●	●
5. Regulatory framework reform to make Phase 3 villages investible					●

1) Upper limit of potential market - off-grid villages in Phases 1 & 2 of NEP are excluded from potential market

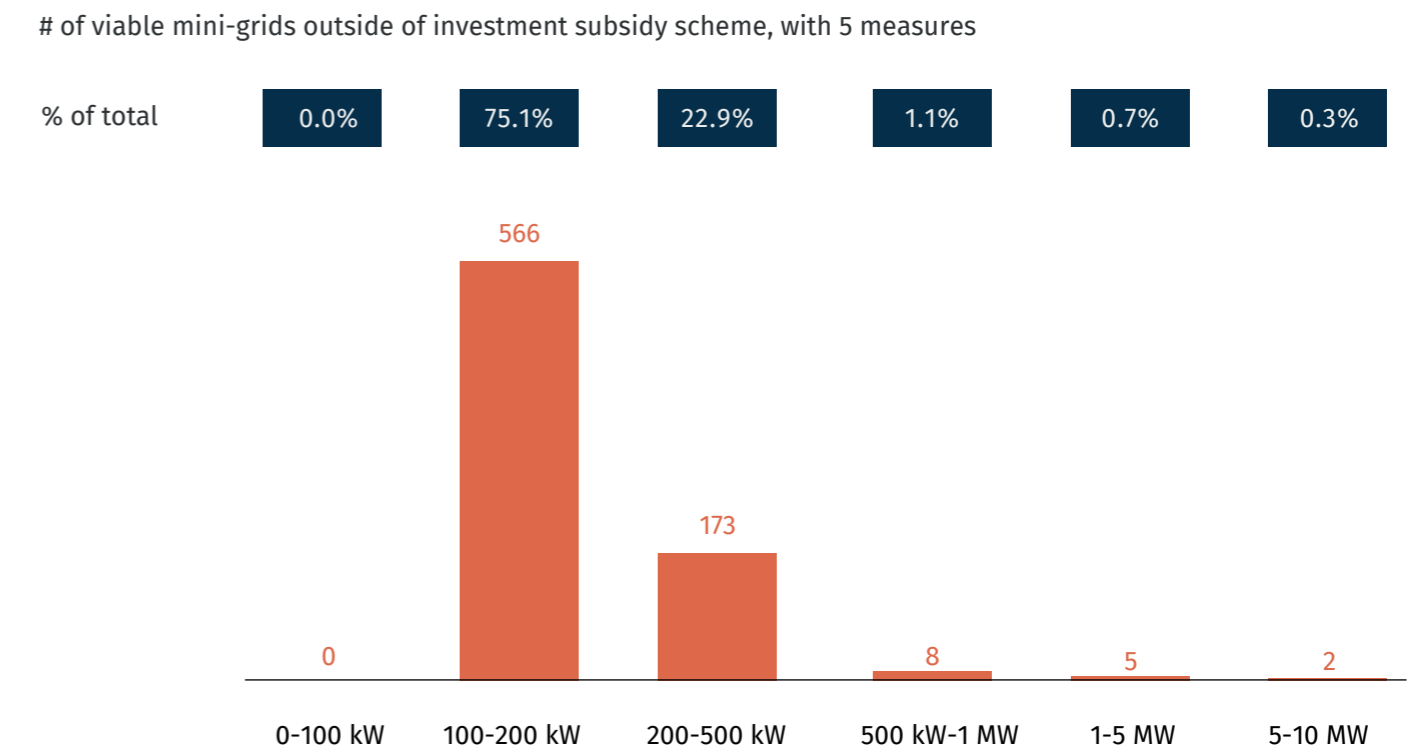
Source: Roland Berger analysis

It should be emphasised that combined implementation of the five measures is required to trigger a large potential market. In particular, the simulations in Figure 22 show that in order to fully leverage the impact of demand-side and access to finance measures, it is crucial to introduce clear regulations on transition at grid arrival that opens up the potential market to villages under NEP Phase 3.

Distribution of viable mini-grids by capacity

Mini-grids developed without investment subsidies would be viable in Regions and States with high irradiation and high potential for productive loads. The median size of these mini-grids would be 157 kW, and 75% of mini-grids are expected to be between 100 to 200 kW. The median size of mini-grids estimated here is relatively large because viable mini-grids are located in large villages. A large mini-grid capacity is important because it allows a large number of people to benefit from a single mini-grid project. Furthermore, larger mini-grids may be favoured in any potential transition to distribution franchises at the time of grid arrival due to their greater number of connections.

Figure 23. Simulation of number of viable mini-grids in 2020 outside of investment subsidy scheme by capacity, after the five measures



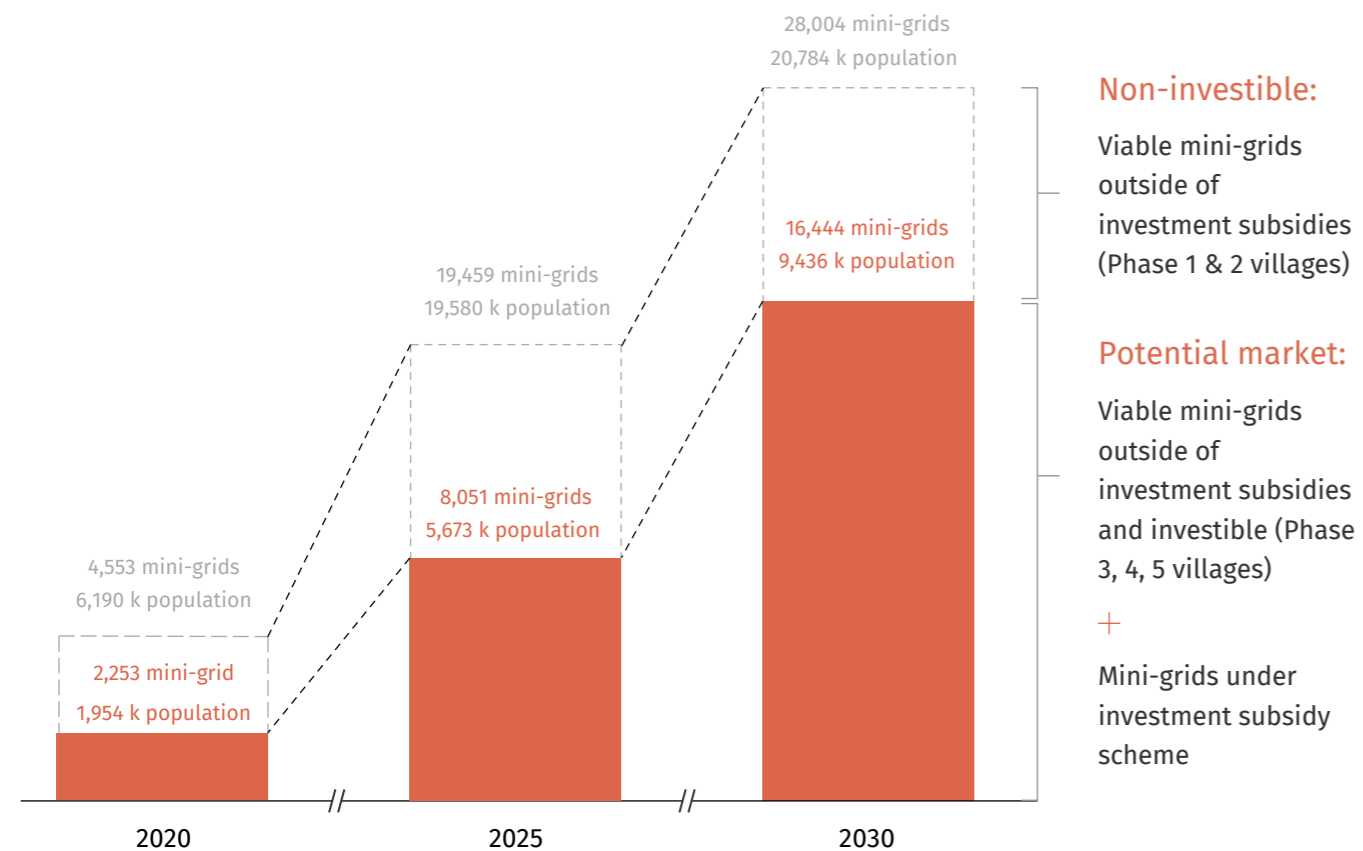
Source: Roland Berger Analysis

4.5 Potential market forecast to 2030 under combined scenarios

Projections of the potential market size to 2025 and 2030 after implementation of the five measures described in Section 4.4.2 show that these measures can stimulate a vast potential market for mini-grids covering large portions of the off-grid population.

By 2025, the potential market would grow to more than 8,000 mini-grids (from 2,253 mini-grids in 2020), covering 5.6 million people or 21% of the projected off-grid population in 2025.

Figure 24. Mini-grid market potential in Myanmar with combined actions on investment subsidies budget, economies of scale, financing support, demand-side support and regulatory framework reform;



Source: Roland Berger

By 2030, the potential market could be approximately twice as big as is 2025: more than 16,000 mini-grids, covering 9.4 million people corresponding to 41.7% of the projected off-grid population in 2030. Thus, despite progressing grid electrification, thanks to cost reductions / technology improvement in equipment and economies of scale, the potential market for mini-grids is expected to be very large in 2030.

In order to actually implement these very large portfolios of mini-grids, substantial investment would be required, in addition to building resources and capabilities. To realise all potential mini-grid project as of 2025 an estimated 1.8 billion USD would be required. For the projects becoming viable in 2030, 3.6 billion USD would be required.

4.6 Implications

Analysis of combined scenarios outlined in Section 4.4 and 4.5 indicates that targeted measures to increase subsidy budget availability, de-risk mini-grids in order to increase the pool of investible mini-grids and decrease IRR hurdle rate, support generation of economies of scale and productive demand, could kick-start viable mini-grids outside of the investment subsidy scheme.

As of 2020 this nascent mini-grid market would be confined to a few areas in favourable locations, but by 2025 and, even more so by 2030, the additional impact of falling equipment costs and increase in per-capita demand would allow nationwide market to develop.

Hence, given supportive policies and measures (see Section 5 for actual recommended action), between now and 2030 large off-grid areas in Myanmar could be electrified through mini-grids developed by private investors while the expansion of the national grid is underway.

4.7 Economic impact assessment by scenario

A review of global case studies on the impact of rural electrification indicates that mini-grids can accelerate socio-economic development in Myanmar in three key ways.

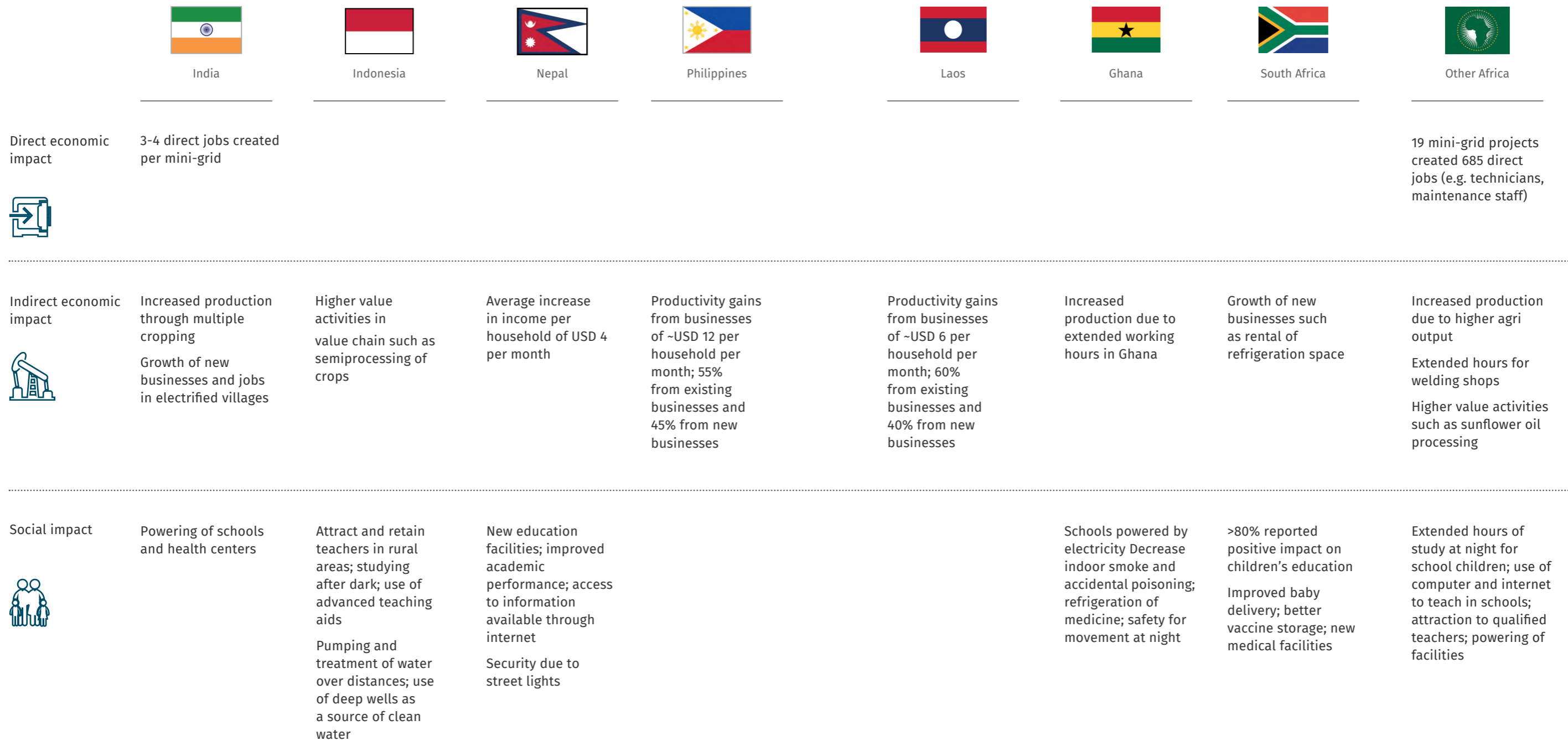
Firstly, mini-grid projects have a direct economic impact on Myanmar's economy through investments into the installation and operation of mini-grids, greater consumer expenditure on electricity produced by mini-grids, and creation of mini-grid related jobs.

Secondly, electrification has an indirect impact on the wider economy by accelerating growth. Electricity facilitates the growth of existing and the creation of new businesses, thereby increasing GDP and creating new jobs indirectly.

Thirdly, electrification also creates societal value, particularly in education and healthcare.



Figure 25. Selected case studies: socio-economic impact of electrification via mini-grids






Source: Desk research; Interviews with market participants; Roland Berger analysis

4.7.1 Direct economic impact

Mini-grid projects directly impact the economy in terms of GDP growth and job creation. GDP grows because of increased investment into power generation and storage equipment, energy management systems and construction. Another direct impact on GDP is the increase in consumer expenditure in off-grid non-electrified villages, as households and businesses start to consume electricity which was previously unavailable or at higher cost. Jobs are also directly created in addition to GDP growth. For example, in case studies in Africa, residents were offered temporary employment during the construction phase, and permanent jobs were created to operate and maintain the system. Sales and payment collection jobs, many of which employed local women and youth, were also created.⁵⁹

Figure 26. Direct economic impact of electrification via mini-grids

Key impact drivers	Explanation	Assumption
 Investment expenditure by developers and government into mini-grid projects	<ul style="list-style-type: none"> Investment expenditure by developers and government directly contributes to GDP; includes spend on equipment, software and construction & installation Most equipment and software expected to be procured outside of the country and not contribute to GDP; only construction & installation to be captured in GDP 	~13% of the cost of mini-grids to impact GDP (estimated percentage of cost that is attributed to construction & installation)
 Consumer expenditure by villagers on electricity produced by mini-grids	<ul style="list-style-type: none"> Increase in consumer expenditure on electricity directly contributes to GDP Villages with off-grid electricity (e.g. diesel, solar home systems) will not generate incremental expenditure when electrified by mini-grid, as spend on mini-grid electricity assumed to be same as spend on prior systems 	~62% of villages (i.e. villages with no access to electricity prior to mini-grids) to generate incremental consumer expenditure and impact GDP; revenue of mini-grids in these villages a proxy for consumer expenditure
 Jobs created in order to build and operate the mini-grids	<ul style="list-style-type: none"> Construction & installation of mini-grids and infrastructure Operation & maintenance of the mini-grid system Sales & payment collection/ customer service for electricity produce 	~4 direct jobs created per mini-grid based on interviews with market participants




Source: Desk research; Interviews with market participants; Roland Berger analysis

59 Energy and Environment Partnership, "Opportunities and Challenges in the Mini-grid Sector in Africa", 2018

4.7.2 Indirect economic impact

In addition to direct economic impact, significant indirect economic impact is expected from mini-grid electrification especially through supply of electricity to local businesses. Case studies show that the electrification of business activities (1) spurs the growth of existing businesses, and (2) facilitates the creation of new businesses.

Figure 27. Indirect economic impact of electrification via mini-grids

Key impact drivers	Description/ case studies (non-exhaustive)
 Increased production	<ul style="list-style-type: none"> Higher agricultural output (e.g. multiple cropping in India; improved crop yields in Africa) Longer working hours (e.g. extended working hours in Ghana; extended operating hours for welding shops in Kenya)
 Growth of existing businesses	<ul style="list-style-type: none"> Sale of higher value goods to customers (e.g. cold drinks and fresh foods in South Africa) Perform higher value activities in the value chain (e.g. processing of sunflower seeds to get sunflower oil in Tanzania; emergence of semi-processing of crops in Indonesia)
 Creation of new businesses	<ul style="list-style-type: none"> New businesses directly related to the use of electricity (e.g. electrician, battery charging stations, and photocopier shops in India; rental of refrigeration space in South Africa) New businesses enabled through the electrification of households and villages (e.g. betel leaf cutting and manufacturing of craftworks in households in India, made possible by time saved and indoor lighting through electricity)

Source: Desk research

Growth of existing businesses — Higher value goods & activities

Existing businesses will grow faster thanks to mini-grids, because of the opportunity to engage in sales of higher value goods and activities. Electricity enables businesses to focus on selling greater volume and variety of high-value goods to customers. In South Africa for instance, grocers and restaurant owners were able to sell more cold drinks and fresh foods due to cost-effective electrical refrigeration.⁶⁰ Besides higher-value goods, electricity has also enabled several rural communities to perform higher-value activities in the production value chain. Villagers in Tanzania, through the use of electrical tools, were able to process sunflower seeds to get higher-value sunflower oil instead of merely harvesting sunflower seeds for export.⁶¹ In Indonesia, the emergence of small scale industries for semi-processing of crops was facilitated by electrification, thus enhancing value addition.⁶²

Creation of new businesses

Electrification via mini-grids also creates new income generation and entrepreneurial opportunities. For example, in the Sunderbans region of India, 11 out of 40 electrified households in grid connected villages and 9 out of 40 electrified households in solar mini-grid villages started new businesses or jobs after electrification.⁶³ The availability of stable electric power made it possible for some households to run small businesses such as electrical equipment repair, battery charging stations and photocopier shops. The time saved on household chores and the availability of electrical lighting enabled other households to engage in home businesses such as producing betel leaf and craftworks.

A similar evolution is expected in Myanmar. For example, aquaculture and fish processing in southern Myanmar is currently limited due to a lack of reliable electricity supply. Raw fish is being exported to Thailand, instead of being processed in Myanmar. Mini-grids will create opportunities for new businesses in Myanmar, including fish processing.

⁶⁰ Malardalen University, “Sustainability and Development Impacts of Off-grid Electrification in Developing Countries”, 2016

⁶¹ World Resources Institute, “Accelerating Mini-grid Deployment in Sub-Saharan Africa”, 2017

⁶² United Nations Development Programme, “Supporting Indonesia’s Renewable Energy Development in Remote and Rural Areas Through Innovative Funding”, 2018

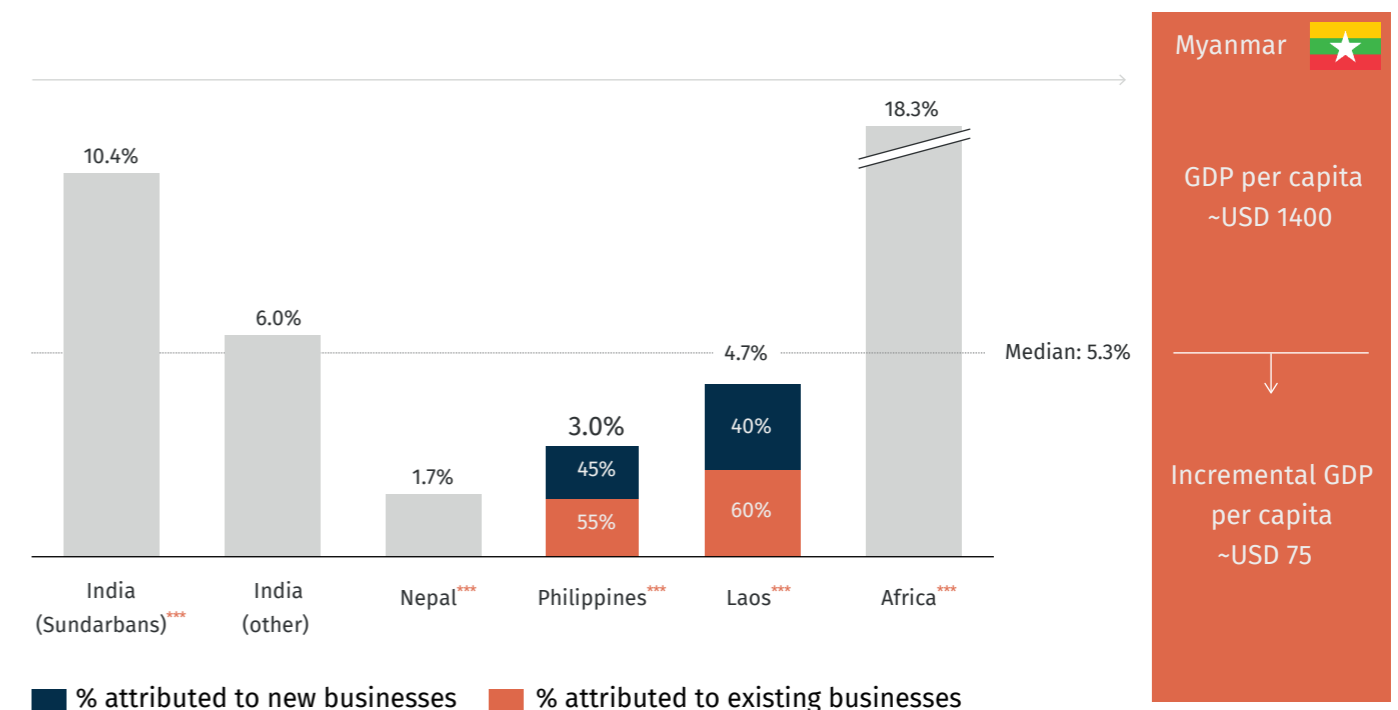
⁶³ The International Journal of Environmental Sustainability, “Impacts of Electrification with Renewable Energies on Local Economies: The Case of India’s Rural Areas”, 2015

Impact on GDP

Benchmarking of other developing countries and interviews with market participants in Myanmar were conducted to estimate the incremental impact on GDP from the growth of businesses.

Based on benchmarks, the incremental impact on GDP is estimated to be USD 75 per capita per year. It is also estimated that ~60% of the impact from businesses is due to the growth of existing businesses, with the remaining due to creation of new businesses. This is in line with impact studies conducted in the Philippines and Laos, which suggest 55-60% of productivity gains from businesses are from existing businesses, while the remaining 40-45% are from new businesses.⁶⁴

Figure 28. Incremental GDP per capita due to electrification



^{***} Incremental income per capita used as a proxy for incremental GDP per capita

Source: Desk research; Roland Berger

⁶⁴ Independent Evaluation Group, “The Welfare Impact of Rural Electrification”, 2008

Mini-grid case studies in Africa (e.g. Engie in Tanzania) also confirm that the impact on existing businesses is the main driver of economic benefits.⁶⁵

Interviews with market participants indicate that most of the economic benefits observed in other developing countries (i.e. increased production, higher-value goods & activities, growth of new businesses) will also be realised in rural villages in Myanmar,⁶⁶ thus suggesting that the quantitative economic impact would be similar.

Impact on jobs

New jobs from businesses (either expansion of existing businesses or growth of new businesses) are expected to be created for 15% of households in electrified villages. This is in line with studies in Sunderbans region of India that indicate 27.5% electrified households in grid connected villages, 22.5% of electrified households in mini-grid villages, and 10% of non-electrified households (in both grid connected and mini-grid villages), started new businesses or jobs.⁶⁷

4.7.3 Social impact

In addition to the economic impact, electrification will also create societal value, particularly in education and healthcare.

Electrification can directly improve the education of individuals. Electrical lighting enables extended hours of study at night for school children, while electronics such as computers enables more effective self-study as well as access to greater amount of information through the internet.⁶⁸ Furthermore, electrification may also indirectly improve an individual's education by attracting quality teachers to rural areas, enabling the use of advanced teaching aids (e.g. visual audio equipment) and powering education facilities.⁶⁹

65 The Economist, "Mini-grids could be a boon to poor people in Africa and Asia", 2018

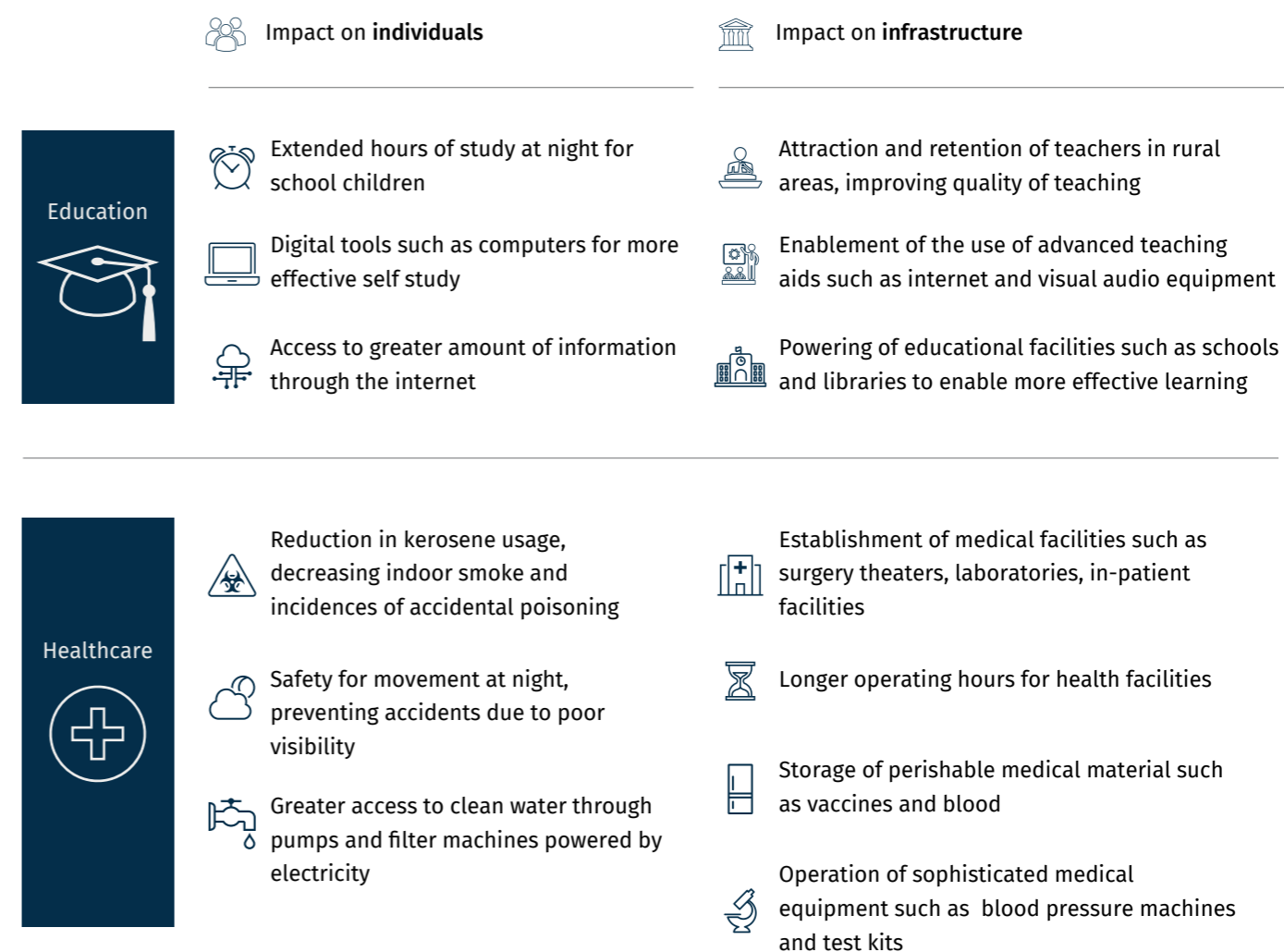
66 Interviews with multilateral institutions and private developers conducted by Roland Berger

67 The International Journal of Environmental Sustainability, "Impacts of Electrification with Renewable Energies on Local Economies: The Case of India's Rural Areas", 2015

68 University of Jyvaskyla, "The Potential Socio-economic and Environmental Impacts of Solar PV Mini-grid Deployment on Local Communities: A Case Study of Rural Island Communities on the Volta Lake, Ghana", 2016

69 United Nations Development Programme, "Supporting Indonesia's Renewable Energy Development in Remote and Rural Areas Through Innovative Funding", 2018

Figure 29. Social impact of electrification (non-exhaustive)



Source: Desk research

In terms of healthcare, the reduction in kerosene usage due to electrical lighting can decrease indoor smoke and incidences of poisoning via accidental ingestion.⁶⁸ Better visibility from electrical street lights can also improve safety at night.⁶⁸ Electrically-powered pumps and filter machines also provide villagers with greater access to clean water, reducing health problems associated with drinking non-potable water.⁶⁹

Besides its direct impact on individuals, electricity also enables the establishment of advanced medical facilities (e.g. surgery theatres, laboratories), and longer operating hours. Medical practitioners can also store medical material such as vaccines and blood, as well as operate sophisticated equipment such as blood pressure machines, to improve health-related outcomes for patients living in electrified villages.

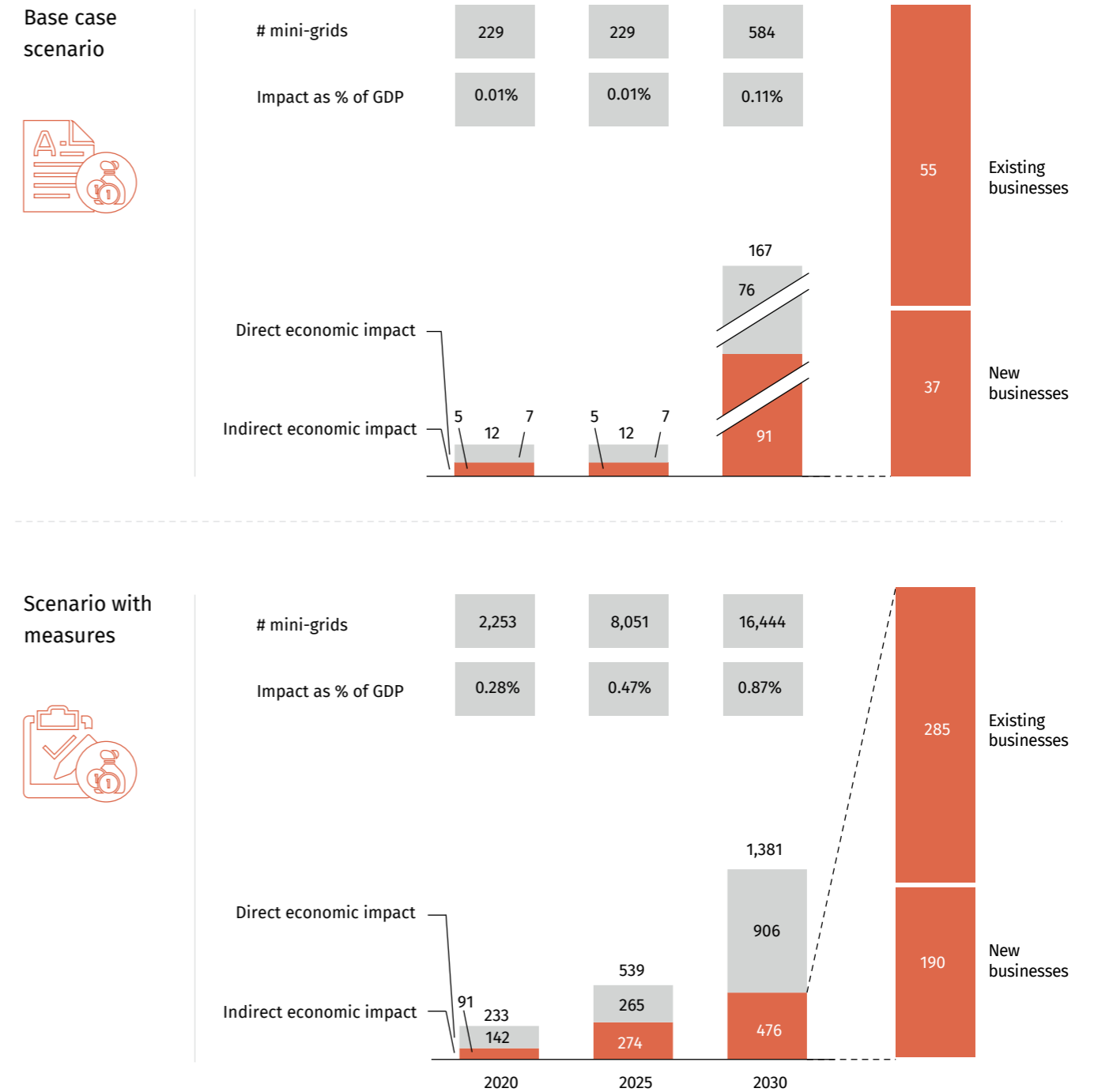
4.7.4 Quantitative impact on GDP and jobs

The quantitative impact of mini-grid electrification on GDP and jobs is simulated in two mini-grid market scenarios:

- The base case scenario assumes that the current investment subsidy and community contribution system is maintained, ensuring coverage of 80% of the initial investment required to develop mini-grids (60% through investment subsidies and 20% through community contributions). A 18.6 million USD budget is assumed for the investment subsidy scheme which is the existing subsidy budget (7 m USD from the World Bank loan and matching budget from DRD’s own budget as outlined in section 2.8)
- The scenario with measures includes the following measures as outlined in section 4.4:
 - » Increasing investment subsidies budget to 100 million USD to ensure sufficient initial market volume
 - » Allowing 70% market share for the top three players to generate economies of scale leveraging market volume, or pooling of activities of smaller private developers to the same effect
 - » Decreasing IRR threshold to 15% through financing support measures;
 - » Increasing productive loads per capita by 35% on average through demand-side measures
 - » Introducing regulatory measures to de-risk grid arrival thereby extending investible mini-grids to villages under Phase 3 of NEP

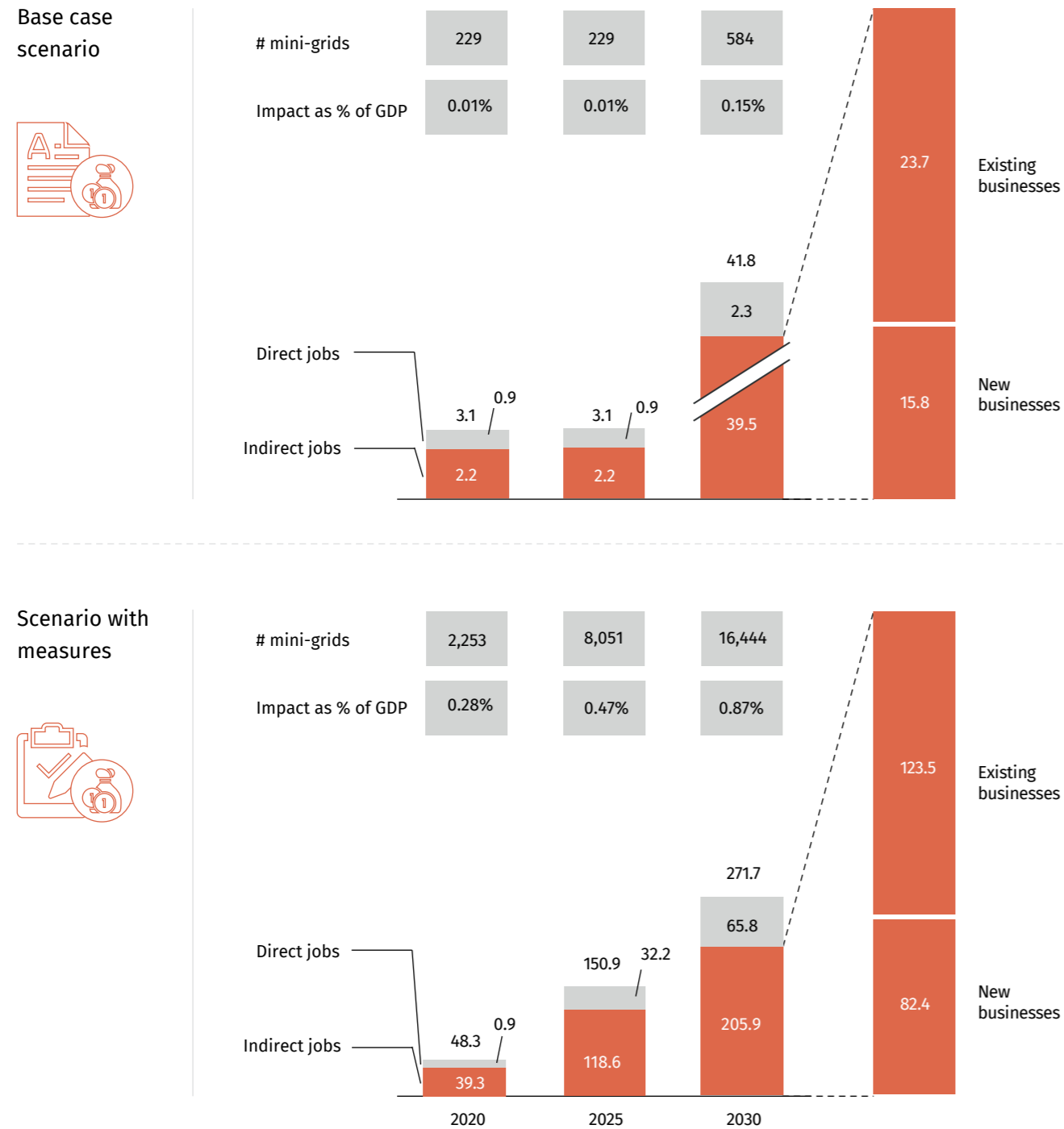
For 2020, implementation of all the viable and investible mini-grid projects would result in a GDP increase of 12 million USD in the base case scenario (229 mini-grids), and 233 million USD in the scenario with measures (2,253 mini-grids), respectively 0.01% and 0.28% of the overall GDP. For 2030, implementation of all the viable and investible mini-grid projects in the scenario with measures (more than 16,000 mini-grids) could generate USD 1.38 billion USD or almost 0.87% impact on GDP.

Figure 30. Estimated increase in Myanmar’s GDP from mini-grid electrification [USD m]



Source: Roland Berger

Figure 31. Jobs created ('000 jobs)



Source: Roland Berger

For 2020, potential impact on jobs would be ~3,100 in the base case scenario, and ~48,300 in the scenario with measures. For 2030 the scenario with measures could potentially have a substantial employment impact with more than 270,000 additional jobs.

This analysis indicates that much of the economic benefits of mini-grid projects would be derived indirectly from the impact of electrification on businesses. In particular, existing businesses would be the main driver of economic growth due to electrification.

The significance of businesses to the economy reinforces the importance of productive loads. Productive loads are not only important in ensuring the viability of mini-grids by increasing IRR and decreasing LCOE, they are also important in contributing to the growth of GDP and creation of jobs in the economy. In contrast, while the social impact from residential loads should not be understated, it is not as easy to measure. Thus, emphasis should be placed on ensuring that electricity from mini-grids can be used for commercial activities during project implementation, in order to realize maximum economic benefits from electrification of rural villages.

4.7.5 Environmental impact

Solar mini-grids may have a positive impact on the environment by reducing (1) diesel fuel and kerosene usage and (2) dependency on firewood.

Rural electrification via solar mini-grids may yield long-term benefits in terms of pollution abatement and climate change mitigation, due to their relatively low environmental impact. Current fossil fuel energy sources used in rural areas such as diesel fuel and kerosene contribute to climate change by emitting not only greenhouse gases, but also pollutants such as black carbon. The environmental impact is significant, as 7 to 9% of fuel from kerosene lamps converts to almost pure black carbon.⁷⁰

⁷⁰ Environmental Science & Technology, "Household light makes global heat: High black carbon emissions from kerosene wick lamps", 2012

In addition, solar mini-grids can have positive impact by reducing dependency on biofuels. Many rural communities without access to appropriate energy sources depend on biofuels (such as firewood) for heating, cooking and lighting, thus contributing to deforestation and degradation of the environment. In Ghana, the dependency on biofuels between 2000 and 2008 was estimated at 72%.⁶⁸ Increase in solar PV electricity and lighting systems in the country allowed reduction of biomass dependency to 64%.⁷³ Moreover, utilising renewable energy sources for mini-grids will help to support carbon financing and actively contribute to reduced Greenhouse Gases (GHG) on top of achieving 100% electrification target.

Although solar mini-grids are recognised for their light ecological footprint, they also carry risks that could negatively impact the environment. One major potential source of adverse environmental impact is inappropriate battery disposal. For instance in Nepal, used batteries were disposed indiscriminately on the ground, resulting in damages.⁷¹ Therefore, measures should be taken in the operation and maintenance of solar mini-grids to ensure the net impact on the environment is positive and that they remain an ecologically viable alternative to large-scale generation options to drive grid expansion in Myanmar.

⁷¹ University of Montana, "Socio-cultural dimensions of cluster vs. single home photovoltaic solar energy systems in Rural Nepal", 2010



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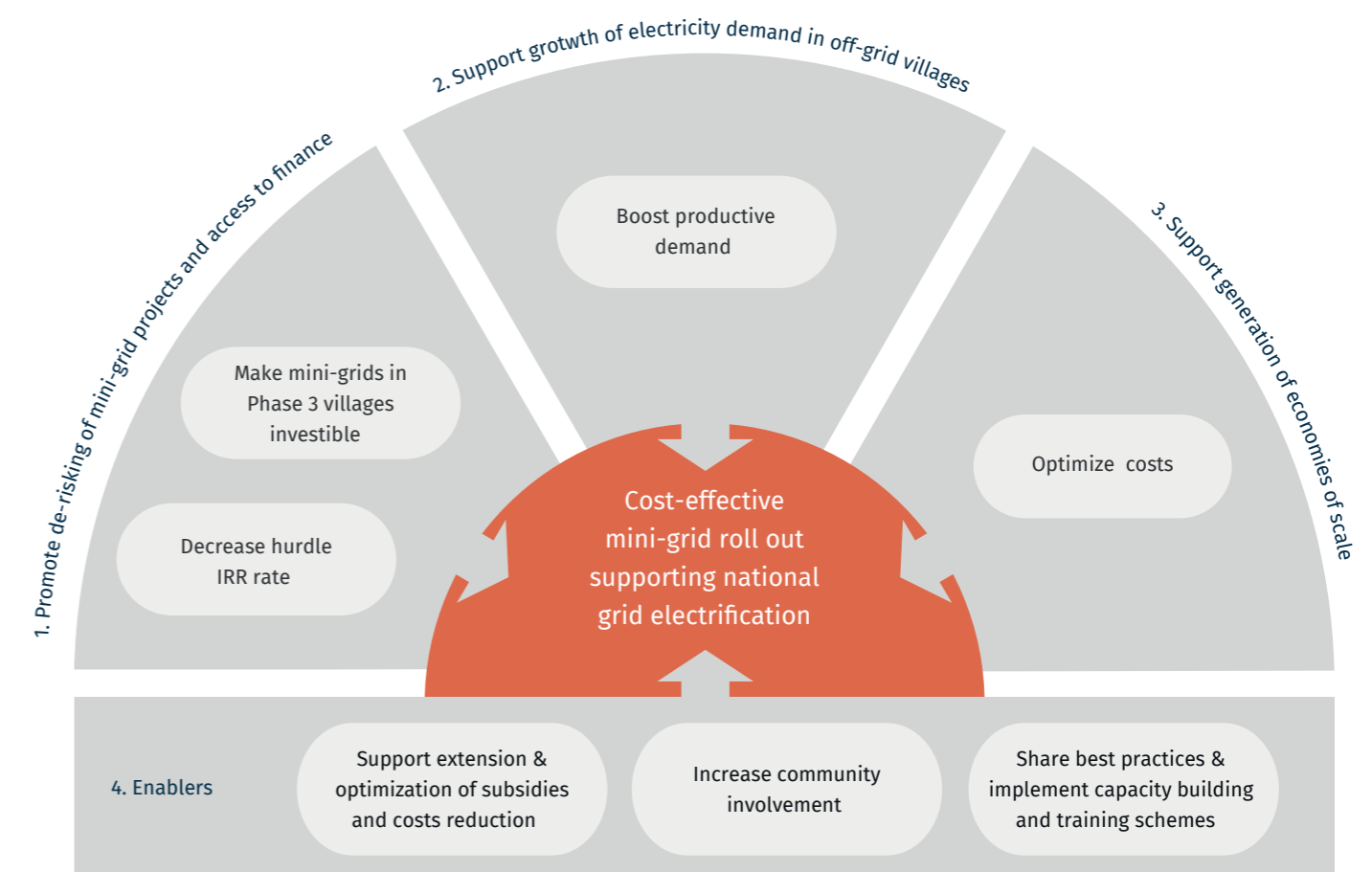
Key Recommendations

Based on the findings of the scenario analysis, key recommendations are developed to achieve a cost-effective roll-out of mini-grids supporting, in the longer term, national grid electrification of rural areas.

The proposed recommendations are structured along a strategic framework supported by three key pillars and enabling initiatives:

- **Pillar 1: Promote de-risking of mini-grid projects and access to finance;** the goal of this pillar is to put in place comprehensive initiatives to **maximize the number of investible mini-grids, including villages in Phase 3 of NEP, by de-risking grid arrival** and to **decrease the hurdle IRR rate** required to develop mini-grids
- **Pillar 2: Support growth of electricity demand in off-grid villages;** the goal of this pillar is to boost demand to increase viability of mini-grids — following results of scenario analysis and of economic impact assessment, focus should be on productive demand
- **Pillar 3: Support generation of economies of scale;** the goal of this pillar is to enable development of large mini-grid pipelines of projects to optimise overall costs through economies of scale
- **Enabling initiatives** - these include (1) extension of **subsidies scheme** in order to kick-start economies of scale and support to reduce equipment costs, (2) support to increase involvement of communities to maximise socio-economic impact and (3) development and sharing of best practices to enable continuous improvement and capacity building/training schemes

Figure 32. Proposed strategic framework



Source: Roland Berger

We recommend to prioritize measures covering the three key pillars and the enablers as follows:

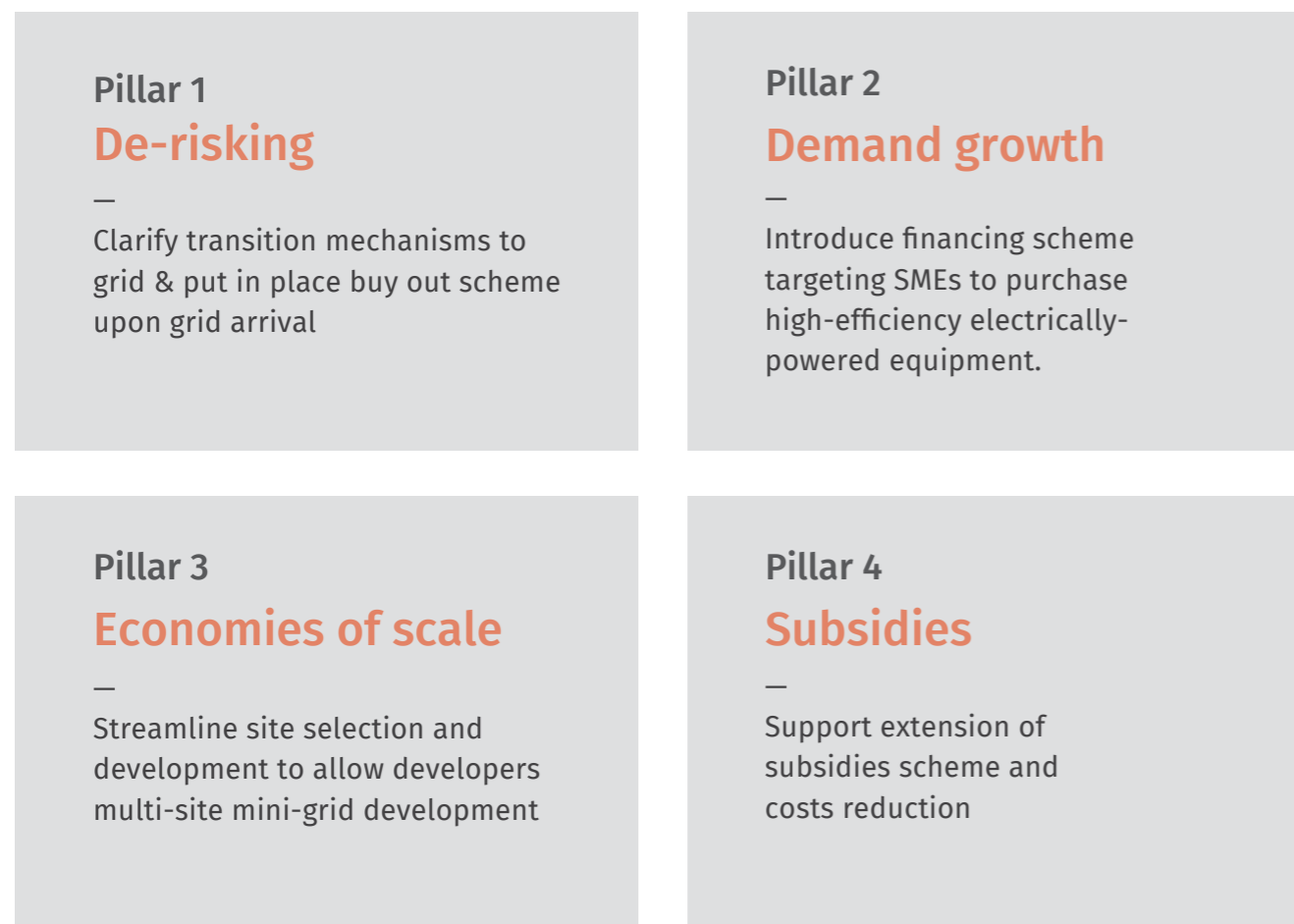
- **De-risking:** take action to mitigate the most important uncertainty, namely the impact of grid arrival on mini-grid projects. To do so, introduce clear mechanism defining transition of mini-grid private developers to distribution system operators or independent power producers. In addition define a buy-out scheme or compensation mechanism whereby the private developer could optionally sell the mini-grid assets at to the grid operator at the time of grid arrival
- **Support growth of demand,** prioritizing productive loads. To do so, set up financing schemes targeting SMEs to help them purchase high-efficiency electrically-powered equipment

- **Enable economies of scale.** To do so streamline site selection and development to allow private developers multi-site mini-grid development. This could involve the government and/or other organizations selecting and conducting initial development of sites and then handing over sites to private developers, thereby enabling private developers to build multiple mini-grids in parallel.
- **Support extension of subsidy scheme.** In the short term this may involve allocating greater budgets to mini-grids as well as defining extension of the subsidies beyond 2021.

In the following sections (5.1 to 5.4), priority measures are further detailed as well as complemented with additional recommended action.

Figure 33. Recommended priority measures

Details and additional recommendations are outlined in Sections 5.1 to 5.4



Source: Roland Berger

5.1 Pillar 1: Promote de-risking of mini-grid projects and access to finance

As outlined in the previous sections of this study, currently, only villages in Phase 4 & 5 of NEP are considered investible by mini-grid developers, which limits considerably the pool of potential mini-grid sites. In addition, the hurdle IRR rates for private developers are high — around 20%. Such high IRR hurdle rates hinder the development of projects that are not subsidised through the DRD scheme. Three main categories of issues limit the pool of investible villages and drive high IRR hurdle rates:

- High perception of risks surrounding mini-grid projects, particularly regarding risks and impact of grid arrival in the absence of a clear regulatory framework and transition mechanism. In addition to uncertainty over schedule of the NEP, investors fear that lack of coordination between Union and State Government may result in unplanned electrification initiatives at the State / Region level.⁷²
- Uncertainty over actual demand in off-grid villages. Early evidence from mini-grid projects backed by investment subsidies indicate that actual demand is often lower than expected, implying high perceived risk on future cash flows.
- Difficulties in accessing debt finance with sustainable interest rates and conditions for private developers (mostly local small companies), driving high average cost of capital and hence high IRR hurdle rates.

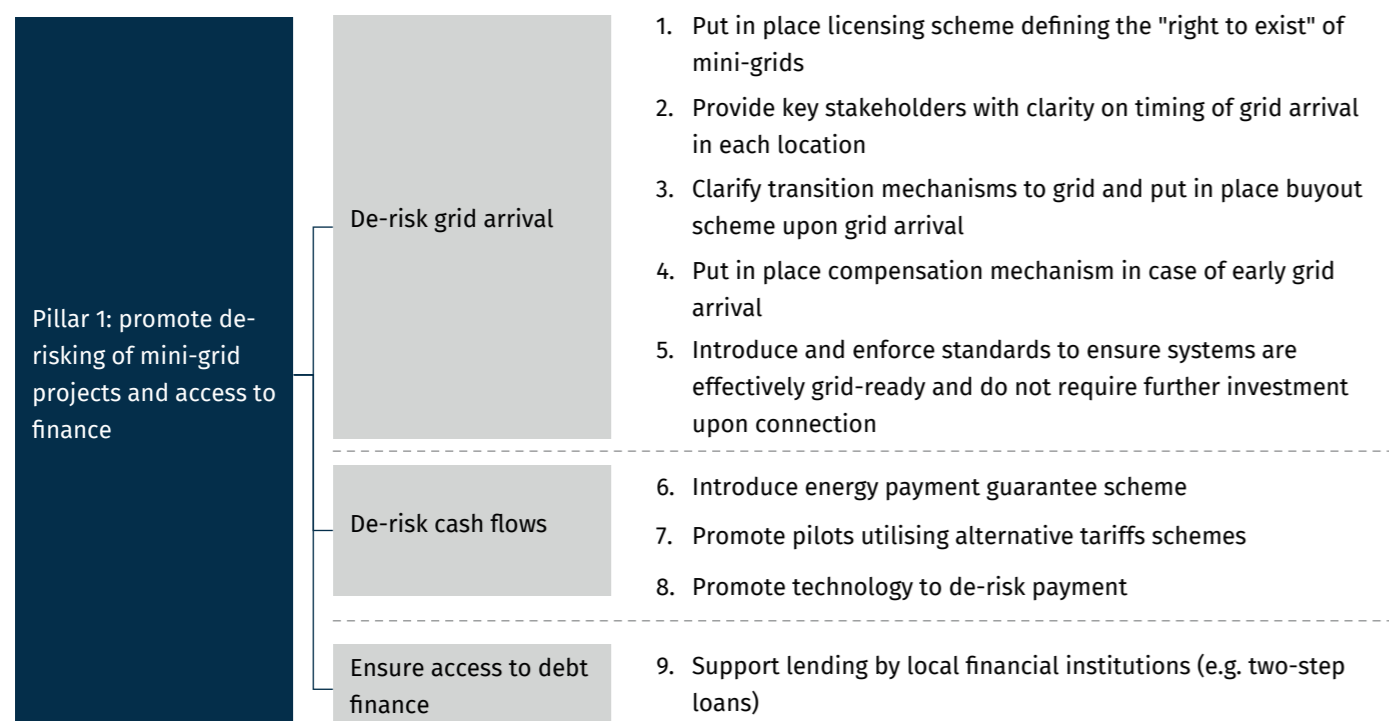
9 initiatives are identified to tackle these 3 categories of issues:

- **Initiatives to reduce risk perception of private developers, investors and debt finance providers on timing of national grid arrival and subsequent transition options**
 - » **Put in place licensing scheme defining the “right to exist” of mini-grids.**⁷³ Currently mini-grids legal status and rights are unclear as they are not licenced under any of the existing categories of power system actors under the Electricity Law enacted on the 27th of October 2014. Introduction of a system defining mini-grids legal status and rights is a pre-requisite for de-risking grid arrival. This has been proposed by DRD and is currently under discussion (see also Section 2.6)

⁷² Interview conducted by Roland Berger with multilateral institution

⁷³ Interview conducted by Roland Berger with GIZ

Figure 34. Initiatives identified for Pillar 1



Source: Roland Berger

- » **Provide key stakeholders with (more) clarity on timing of grid arrival in each off-grid location.** The Government of Myanmar, is currently updating the National Electrification Plan with new geospatial information and a new roadmap for extension of the grid infrastructure is expected to be completed by 2020. It will be crucial that this information is available to key stakeholders including private developers, investors and financial institutions
- » **Clarify transition mechanisms to grid:** two different transition schemes to distribution system franchisee and to independent power producer can be recommended based on global case studies. It should be noted that global case studies (e.g. Indonesia) for subsidised mini-grids that were handed over to local communities show that the transition to grid-connected franchises is often unsuccessful and mini-grids end up being abandoned. In case private ownership is (at least partly) maintained and future profitability supported as in the case of Cambodia, mini-grids may successfully transition to grid connected distribution franchises or generation entities and further grow through private investment⁷⁴ thereby supporting electrification in the long term

74 ESMAP, "Mini-grids and the arrival of the main grid – Lessons from Cambodia, Sri Lanka and Indonesia", 2018

- » **Put in place well-defined buyout scheme upon grid arrival.** An "exit mechanism" should be developed whereby the mini-grid developer would be able to sell the assets to the national grid operator under pre-agreed conditions upon grid arrival
- » **Put in place compensation mechanism in case of grid arrival.** This could be funded in two ways: (1) Create a fund to compensate developer through government budget and/or donors contributions, (2) Create a fund financed through a fixed contribution by developers
- » **Introduce and enforce stricter standards** to ensure systems are effectively grid-ready and do not require further investment upon connection. "Grid-readiness standards" may cover not only distribution infrastructure, but also generation assets. To ensure enforcement, make renewal of licence dependent upon meeting technical standards

- **Initiatives to reduce risk perception of private developers, investors and financial institutions on future mini-grid cash flows**

- » **Introduce energy payment guarantee scheme whereby external funding is provided to cover potential shortfall in revenues from mini-grid projects.** The scheme can be funded through government/donor subsidies budgets and also complemented by a sharing scheme in case of higher than expected revenues. Note that funds are disbursed only in case of suboptimal revenues, so it may be a more effective way of utilising government/donor budgets than direct subsidisation of mini-grid projects⁷⁵
- » **Promote pilots utilising alternative tariffs schemes.** Some private developers partly de-risk cash flows by utilising fixed monthly tariffs irrespective of consumption levels⁷⁶
- » **Promote technologies to de-risk payment.** Currently some private developers utilize pre-paid tariffs to simplify and de-risk billing. This could be further enhanced by smart metering technologies that could also enable tariff optimization (e.g. time-of-use tariffs). Smart metering systems could be introduced individually by private developers or, a third party could manage procurement and management of metering and billing systems on behalf of multiple private developers as proposed in the context of Pillar 3 initiatives

75 Smart Power Myanmar, "Mini-grids in Rural Myanmar – Unlocking the Potential for Decentralised Energy" Presentation at 5th Myanmar Power Summit 2018

76 Interviews with private developers conducted by Roland Berger

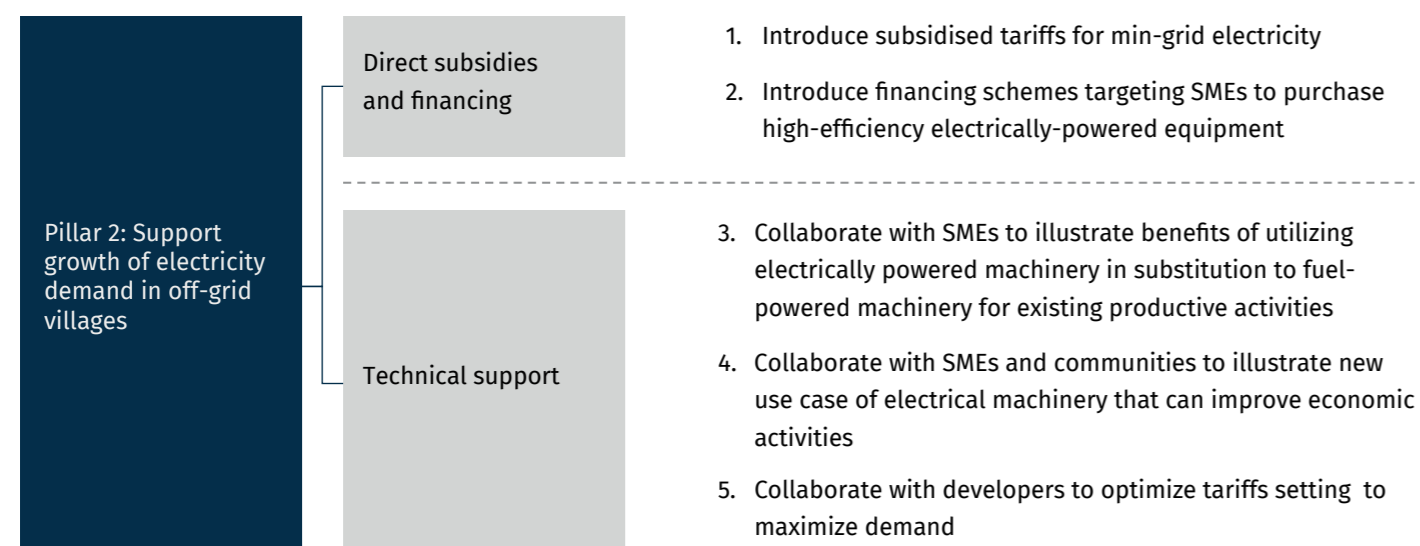
- **Initiatives to promote availability of access to debt financing**

- » **Support lending by local financial institutions.** Schemes have been implemented or are under study to support local banks through two-step loans whereby bilateral/multilateral institutions would support local financial institutions through loans, enabling the latter to issue loans to mini-grid private developers at attractive conditions.⁷⁷ These schemes would enable private developers to finance part of the mini-grid through debt finance, increase financial leverage and greatly decreasing hurdle rates for IRR. As shown in the scenario analysis, this could kick-start large-scale development on mini-grids

5.2 Pillar 2: Support growth of electricity demand in off-grid villages

As outlined in the previous sections of this study, a key lever determining mini-grid viability is productive use demand. Five initiatives are proposed to boost productive demand:

Figure 35. Initiatives identified for Pillar 2



Source: Roland Berger

⁷⁷ Interviews with unilateral institutions conducted by Roland Berger

- **Direct subsidies and financing**

- » **Introduce subsidised tariffs for mini-grid electricity.** Subsidies could cover both connection costs and unit price of electricity. Differentiated subsidies to specifically support productive loads could also be considered
- » **Introduce financing schemes targeting SMEs to purchase high-efficiency electrically-powered equipment**

- **Technical assistance to users and suppliers**

- » **Collaborate with SMEs to illustrate benefits of utilising electrically powered machinery in substitution to fuel-powered machinery for existing productive activities.** Case studies show that a combination of productive use incentives and technical assistance put in place by developers may help increasing productive demand^{78 79}
- » **Collaborate with SMEs and communities to illustrate new use case of electrical machinery that can improve economic activities.** This scheme was successfully implemented in Kenya⁸⁰
- » **Collaborate with developers in setting tariffs to optimize demand.** Best practice can be based e.g. on pilot projects or “Demand Labs”⁷² where price elasticity and willingness to pay of SME customers could be explored systematically

Pillar 3: Support generation of economies of scale

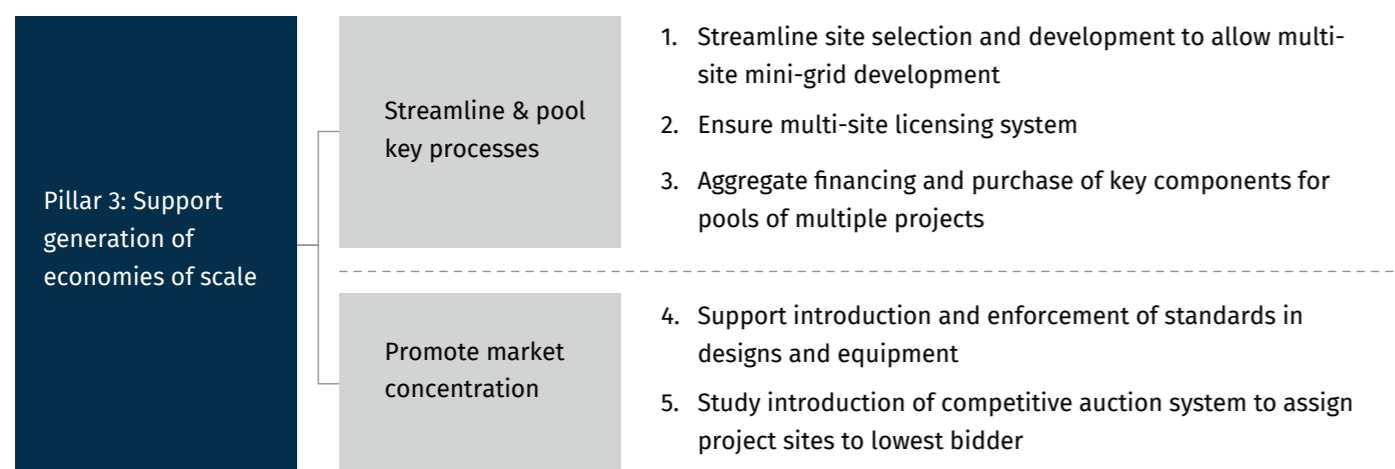
As shown in the previous sections of this study, economies of scale can generate enough cost savings to boost significantly mini-grid viability. Five initiatives have been identified to promote economies of scale through two mechanisms: (1) by streamlining and pooling key processes into shared platforms managed by the government or by third parties, (2) by supporting a certain level of market concentration allowing large players with sufficient size to emerge.

⁷⁸ See for example The Economist, “Mini-grids could be a boon to poor people in Africa and Asia”

⁷⁹ Interview conducted by Roland Berger with multilateral institutions

⁸⁰ International Institute for Environment and Development, “Energising local economies – Experiences of solar start-ups in Kenya’s small-scale fishing and agriculture sectors”

Figure 36. Initiatives identified for Pillar 3



Source: Roland Berger

- **Initiatives to streamline and pool key processes**

- » **Streamline site selection and development to allow developers multi-site mini-grid development.** Target sites could be selected and developed by the government (e.g. by DRD).⁸¹ Alternatively, site selection and development for “pools of projects” could be done by multilateral or other independent stakeholders on behalf of DRD⁸²
- » **Ensure multi-site licensing system** to facilitate building of a large pipeline by developers using a single licence. Licensing provisions to transition to distribution franchisee or IPP upon grid arrival should also be given at developer level covering multiple sites. This may also favour “regional strategies” whereby developers are incentivized to develop portfolios of adjacent mini-grids in the same area in view of transitioning to regional distribution franchises or regional IPPs upon grid arrival⁸³

⁸¹ Interviews with ESCOs conducted by Roland Berger

⁸² Smart Power Myanmar, “Mini-grids in Rural Myanmar – Unlocking the Potential for Decentralised Energy” Presentation at 5th Myanmar Power Summit

⁸³ Interview with ESCOs conducted by Roland Berger

- » **Aggregate financing and purchase of key components and systems for pools of multiple projects.** Estimates based on interviews with suppliers indicate that pooling of a few hundred projects would be sufficient to generate significant economies of scale. In addition, opportunities to centralise design, procurement and management of metering, billing systems, communication systems and data centres should be explored⁸⁴

- **Initiatives to support scale of players**

- » **Support introduction and enforcement of standards in designs and equipment.** In addition to de-risking mini-grids as outlined in Pillar 1, introduction and enforcement of strict standards can also favour larger developers.⁸⁵
- » **Consider introducing competitive auction system** to assign project sites to lowest bidder. This typically favours more efficient bidders that can leverage economies of scale to bid competitively.^{86 87}

5.4 Enabling initiatives

In addition to initiatives related to key strategic pillars, enabling initiatives are recommended .

- **Support extension/improvement of the current subsidy scheme and cost reductions**

- » In the simulations presented in this study an increase in subsidy budget to USD 100 million would enable to support sufficient number of projects to kick-start economies of scale

⁸⁴ A similar approach was implemented, albeit in a different context, for the roll-out of smart meters in the UK where a single actor (“Data Communication Company”) led the design, build, test and integration of the data and communications infrastructure to secure connection between customers and different energy suppliers. See for example <https://www.smartdcc.co.uk/>

⁸⁵ Interview with equipment manufacturer conducted by Roland Berger

⁸⁶ Interview with Myanmar conglomerate conducted by Roland Berger. For example, site assignment could be based on lowest proposed mini-grid electricity tariffs in MMK/kWh

⁸⁷ A similar system has been put in place in multiple jurisdictions globally to assign utility-scale renewable energy projects (wind, solar PV) resulting in significant tariff reductions For example in India introduction of competitive auctions for utility-scale solar development resulted in decrease of feed-in-tariffs by 80% from 2010 to 2018. Source: Mercom

- » In order to ensure alignment of priorities between developers and the end-users, consider introducing result-based subsidies (subsidies payment linked to pre-defined and measurable objectives)⁸⁸
- » In order to ensure alignment of priorities between developers and the end-users, consider introducing result-based subsidies (subsidies payment linked to pre-defined and measurable objectives)⁸⁸
- » As mentioned in section 5.1, complete handover of subsidised mini-grid to local communities may compromise their long term sustainability after the grid arrives. It is therefore recommended to study options to maintain part-private ownership and management of subsidised mini-grids
- » In addition to increasing budget availability, measures should be taken to increase the capability of implementing agencies within the Government of Myanmar to implement effectively and rapidly the subsidy scheme⁸⁹
- » Furthermore, carbon pricing and emission trading may be explored in conjunction with other renewables incentives as an additional source of financing to support renewables mini-grid

• Increase community involvement

- » Promote participation of communities as stakeholders in mini-grid projects. This can be achieved by (1) allowing part ownership of mini-grids through direct investment by communities⁹⁰ and (2) involving the local population in the operation and maintenance of mini-grids as employees or sub-contractors of developers – this should also include active training of professional workforce throughout the off-grid communities
- » It should be noted that rural electrification models that subsidize all, or nearly all, capital or that involve donation of hardware (e.g. solar home systems) without creating a strong community involvement and support structure have not been sustainable in the long term and may also hamper profitability and thus prevent investment by commercial players⁹¹
- » Involving communities through communication and engagement activities throughout the mini-grid project lifecycle: planning, design, construction, operation, extensions, grid connection

⁸⁸ For example subsidy could be linked to actual number of connections to households. This approach has proven successful in other geographies – see e.g. ESMAP “Results-Based Financing in the Energy Sector – An Analytical Guide”, 2015

⁸⁹ Interview conducted by Roland Berger with multilateral institutions

⁹⁰ Smart Power Myanmar, “Mini-grids in Rural Myanmar – Unlocking the Potential for Decentralised Energy” Presentation at 5th Myanmar Power Summit, 2018

⁹¹ See e.g. Hisham Zerriffi, “Rural Electrification – Strategies for distributed generation”, Springer 2011

• Develop and share best practices and key data

- » Gathering, analysis and sharing of key data and information on mini-grids is crucial to raise interest, secure buy-in and commitment by investors thereby supporting access to finance
- » Best practice and data sharing would allow continuous improvement of mini-grid planning and design and developers operational performance by allowing benchmarking and setting of targets based on best-in-class operators

• Support capacity building and training

- » Development of a specialised workforce for planning, financing, engineering, developing, building and operating & maintaining mini-grids is crucial to enable large-scale development of mini-grids
- » University-level training or vocational training schemes could be supported by Government, donors and private players





Annexes

Annex 1

Definitions and Scope of the Market Assessment

What are mini-grids?

Mini-grids are systems integrating all the key components of the electricity supply chain on a small scale, typically covering a village community:

- A power generation facility
- A low voltage (<11 kV) network of power cables to distribute power to households, businesses and other customers
- Power retail operations to measure the customers' power consumption, issue bills and manage payments

Power generation in mini-grids relies mainly on renewable sources such as solar PV; a battery and a diesel generator may also be integrated to secure reliable supply when renewable generation is not available – e.g. at night or during cloudy periods in the case of solar PV generation.

The size of the mini-grid generation facility is typically in the order of 10 kW to a few hundred kW – in the case of solar PV in rural Myanmar, this is sufficient, in combination with a battery and diesel generator, to power a typical off-grid village with approximately 100 households. Numerous case studies of larger, MW-scale mini-grids supplying power to entire townships exist in Myanmar (notable examples are found in Tanintharyi and include diesel-fuelled mini-grids in Myeik – 12 MW, Kawthaung – 8 MW, Dawei – 6MW).

The ability to provide power for typical village communities is the key feature of mini-grids.

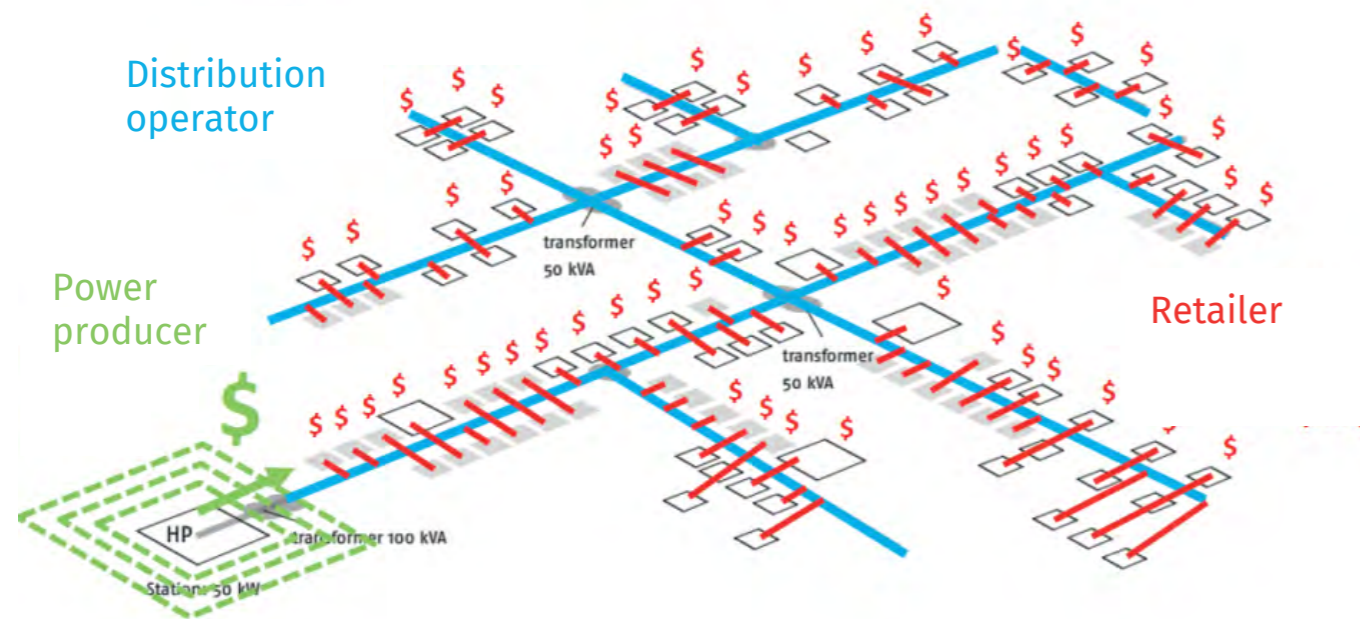
- In DRD statistics, mini-grids are defined as systems covering at least 70% of households in the village where they are located
- Although the distinction is not always clear-cut, systems with less than 10 kW power generation capacity are commonly classified as micro-grids
- Systems with limited distribution infrastructure such as solar home systems, systems serving factories or individual/groups of buildings are usually classified as on-site generation systems

Off-grid versus on-grid

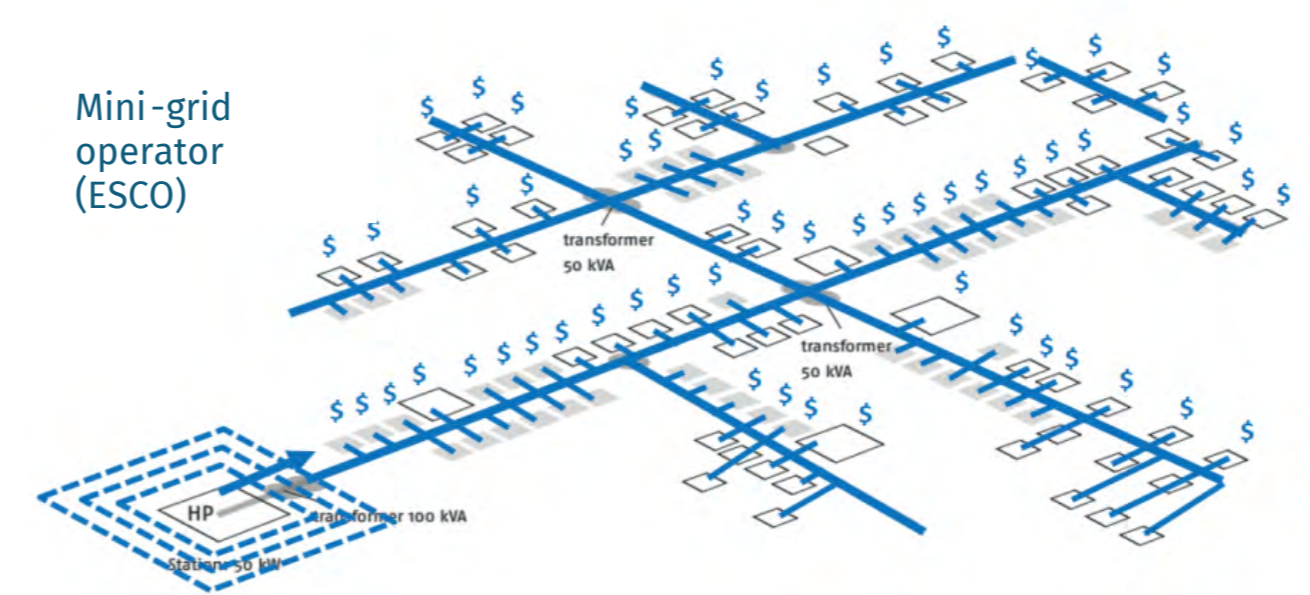
In developing countries with large areas not covered by the national grid, mini-grids are typically not connected to the grid and provide power to off-grid rural communities. In addition to Myanmar, examples of developing countries with existing mini-grids in off-grid areas include Nigeria, Kenya, Rwanda, India, Sri Lanka, Cambodia and Indonesia.

Figure 37. Illustration of mini-grids

Key roles in power supply chain



Mini-grid operator integrates roles in supply chain



- > Mini-grids integrate a power production facility, a distribution network and a retail system allowing to supply power to households, commercial customers and other loads.
- > Power generation capacity for mini-grids is typically in the order of 10 kW, however larger systems exist

- > Power generation mainly relies on renewable sources, coupled with backup diesel generator

Source: GIZ

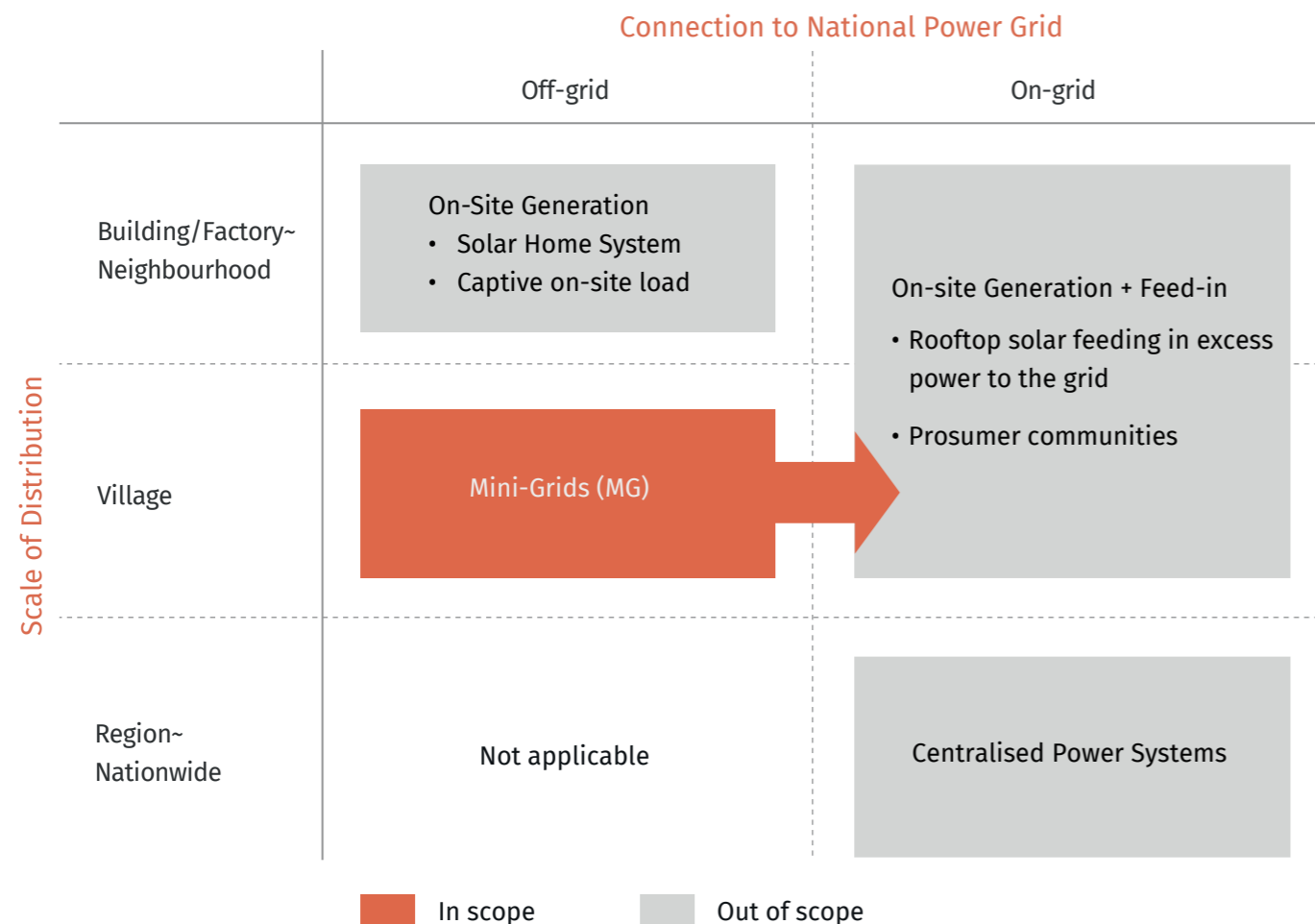
In developed countries, mini-grids that are not connected to the national grid are typically found on small islands that are too far from the mainland to be connected through power cables – notable examples include the Azores islands in Portugal.

A new trend is also emerging in Europe and the United States where residential communities equipped with rooftop solar PV generation and battery systems pool power generated by members of the community to satisfy demand. These communities are physically connected to the grid. However, they form virtual mini-grids that are energetically independent from the rest of the power grid.

Although at the time of construction, mini-grids may not be connected to the national grid, there are multiple examples of transitions from off-grid to on-grid systems at the time of national grid arrival. The most successful transition occurred in Cambodia, where more than 100 private mini-grids originally built in off-grid areas have been connected to the national grid and granted long-term distribution licences as private sector franchisees (Small Power Distributors – SPD). This allowed to leverage the initial investment into mini-grids and to accelerate expansion of the national grid into rural areas.

In this study we focus primarily on the market potential for mini-grids in off-grid locations of Myanmar, bearing in mind that they may transition to on-grid systems at the arrival of the national grid, subject to introduction of policies and regulations.

Figure 38. Scope of systems discussed in this study



Source: Roland Berger

The importance of ESCOs

Mini-grids combine all the key components of the electricity supply chain – power generation, distribution and sales /billing. In addition, for mini-grids powered by renewables, integration and optimization of renewable sources with batteries and diesel generators is typically required.

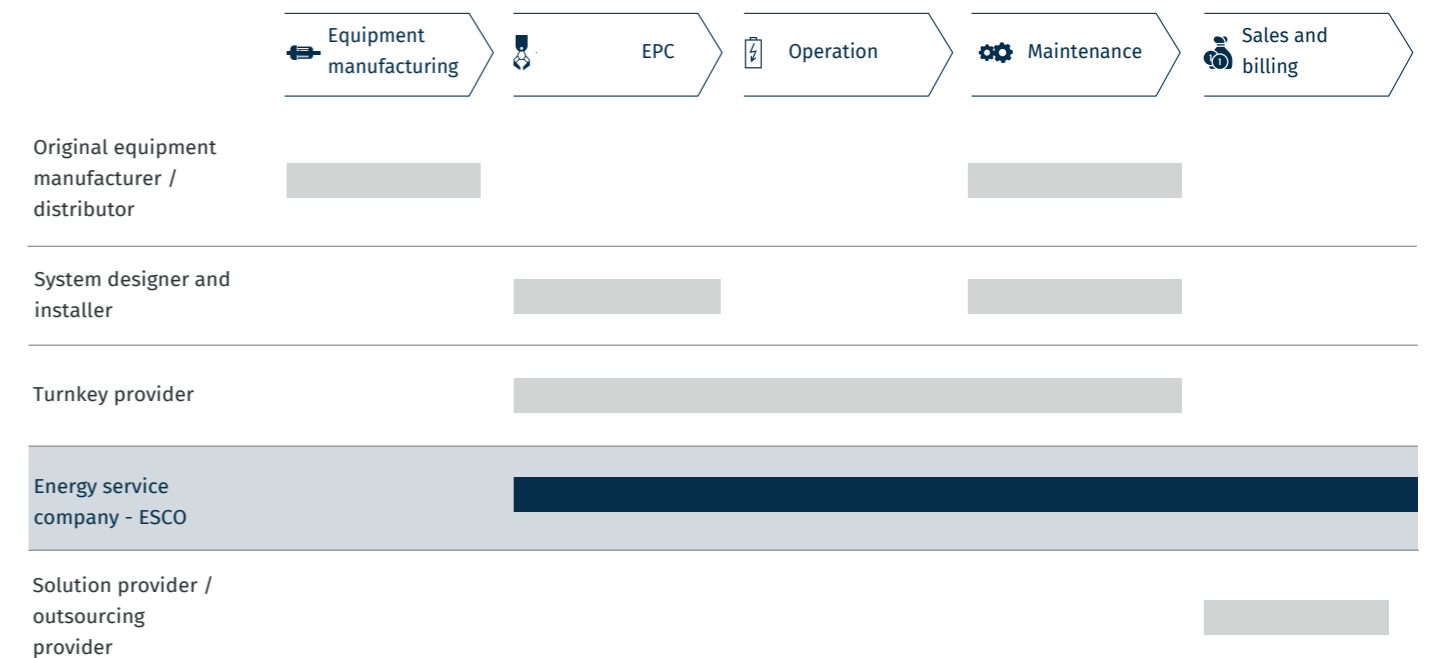
Hence, from an engineering and business perspective, mini-grids are far more complex than other off-grid power solutions such as on-site power generation and solar home systems. The latter can be sold or leased to the customer and require only provision of installation and maintenance services as they can be operated by the user.

Instead, specialised players are best placed to optimize mini-grid design, engineering and operation and to manage key business processes professionally. These specialised players operating along the value chain are known as Energy Service Companies (ESCOs).

After purchasing equipment from Original Equipment Manufacturers (OEMs), ESCOs typically lead the design, engineering and construction of the mini-grids, including integration and optimization of the various components.

In addition, they operate and are responsible for maintenance of the power generation, distribution, metering and billing infrastructure. Finally they manage all key business processes related to sales and billing.

Figure 39. Key players and roles in various off-grid power solutions



Source: Roland Berger

Annex 2

Cambodia: a case study showing successful transition from isolated to grid-connected mini-grids

In Cambodia mini-grids played a crucial role in electrification of rural areas. Currently 56% of the population has access to electricity: 20% or 3.5 million people, mostly in urban areas, access electricity through the national grid infrastructure built by the national utility Electricité du Cambodge and more than 30% or 4.8 million people in rural areas are supplied by grid-connected or isolated mini-grids.

Mini-grid development in Cambodia followed three phases: an initial unregulated bottom-up development phase, then introduction of a stricter licensing system and technical standards, and currently a transition to regulated tariffs.

Figure 40. Three phases of mini-grid development in Cambodia

Phase 1 (1990's to 2001)

- Mini-grids in rural areas developed independently by local communities and entrepreneurs
- No strict licensing and standards requirements
 - Poor technical standards and power supply service - mostly diesel generators and improvised distribution infrastructure
 - High electricity costs

- 5% population w/electricity access
- Supply only few hours/day
- 0.5-1 USD/kWh tariffs for MGs

Phase 2 (2001-2016)

- Introduction of strict license system & standards
 - Isolated MGs: consolidated generation+distribution license
 - Technical standards enforced
 - Upon grid connection: mini-grid shifts to distribution license and decommission generation assets
- Regulated tariff based on costs recovery system ensuring return on investment for isolated and grid-connected MGs

- Increase to 56% el. access
- Supply few hours to 24 h/day
- 0.29 USD/kWh av. tariffs for MGs

Phase 3 (2016-)

- Reform of tariff system
 - Grid connected MG must charge same tariff as main grid
 - Subsidies from REF cover difference with cost based tariffs
- Possible consolidation going forward as pressure on earnings increase

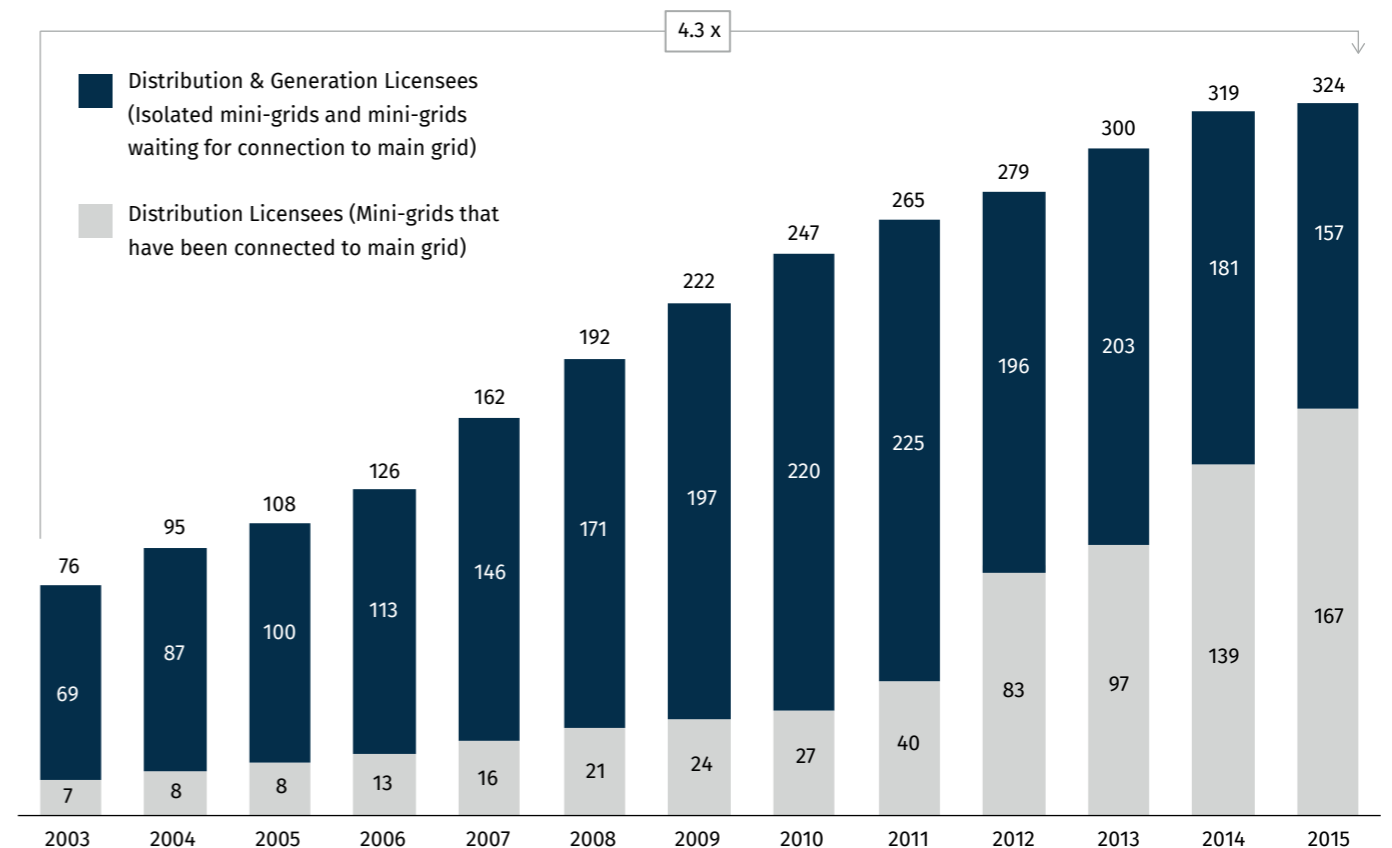
- 56% population w/electricity access
- Supply typically 24 h/day
- Tariffs up to 0.2 USD/kWh

Source: World Bank, “Mini-grids in Cambodia, a Case Study of a Success Story”, 2018

The licensing system introduced in the early 2000’s includes a “consolidated licence” for mini-grids combining generator and distribution licences. Technical standards for grid readiness are enforced as key requirement to obtain and to periodically renew the licences. Upon grid arrival, the mini-grid operator can convert its licence to a distribution operator and decommission the generation assets. A regulated tariff system for mini-grids ensures a certain level of return on investments, incentivizing further expansion of the distribution network after grid connection.

As a result of this system the number of licences for isolated and grid-connected mini-grids has more than quadrupled from 2003 to 2015 and the number of grid-connected licences is increasing even more rapidly. As a result of continued scaling up of infrastructure after grid connection, the average population covered per licensee is now almost 15,000 people.

Figure 41. Evolution of number of isolated and grid-connected mini-grids licences in Cambodia

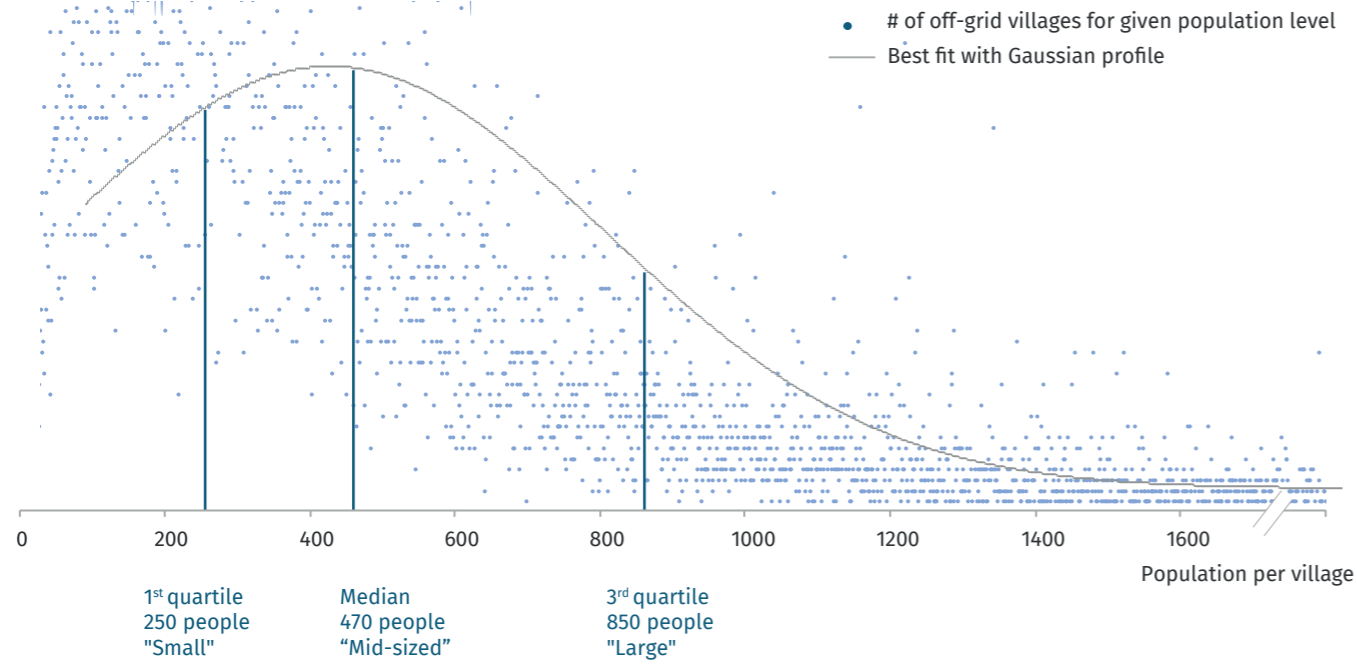


Source: World Bank, “Mini-grids in Cambodia, a Case Study of a Success Story”, 2018

Annex 3

Distribution of off-grid villages by population in Myanmar

Figure 42. Distribution of off-grid villages by population

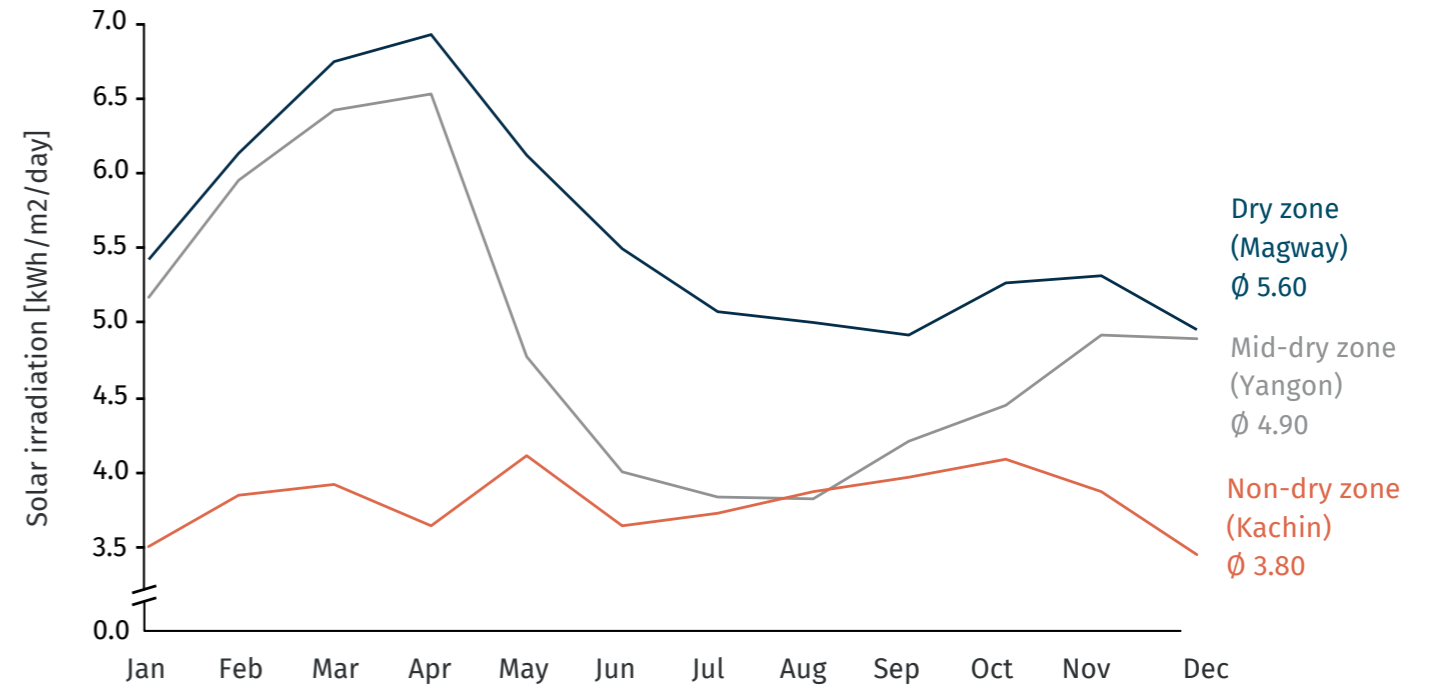


Source: Census, Roland Berger

Annex 4

Average solar irradiation

Figure 43. Average solar irradiation each month for each zone



Source: ADB, World Bank



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