Draft Version Deep Dive Analysis

WP5: Recommendations to include off-grid RE in the NDC update 2019

Madagascar

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1. Rationale of Deep Dive

The overall aim of this project is to support "Strategies for Renewable Energy for Climate Protection in Developing Countries", for which the GIZ has nominated a consortium of Reiner Lemoine Institut and the greenwerk. The specific objective of this study is to assess the climate action relevance of the dynamically developing off-grid sector with a particular focus on NDC and international support elements.

Sub-tasks are to quantify the impact of off-grid renewable energy (RE) technologies for providing electricity access, the overall emissions of the growing sector, their market potential in low electrified countries and the respective socio-economic benefits besides GHG emission mitigation. Additionally, three country deep dive reports shall provide the following elements to developing country stakeholders, particularly policy-makers:

- Share detailed country specific recommendations for ambition raising of NDCs;
- Share country level recommendations for inclusion of off grid RE elements in NDCs;
- Reflect on the results from our global report in view of the 2020 NDC updates; and,
- Initialize international support to foster off-grid RE development.

2. Background Madagascar

Madagascar is a large island located in Southeastern Africa in the Indian Ocean. It is the fourth largest island in the world. In 2019, the population is estimated at 26.97 million. It has been one of the fastest growing economies in the world since 2016, largely due to their abundance of natural resources[1].

Despite this, Madagascar is among the poorest countries in the world with 75% of the population living on less than $1.90 per day. It has the world's fourth highest rate of chronic malnutrition, with one child in two under five years suffering from stunting. An estimated 1.4 million children dropped out of primary school in 2012, the fifth highest number in the world. (UNICEF 2018). Its HDI ranks 161 out of 189 countries with an index value of 0.51, counting to the group of the least developed countries (UNDP 2017). More than 80% of the population live in rural areas. The increase of urbanisation is equally low. Madagascar's challenging topography, mostly characterized by thin coastlines separated by a rugged high plateau cut by deep gorges and waterfalls, significantly complicates the establishment of regional transport infrastructure and interconnected power grids.

Madagascar has no significant energy related greenhouse gases emissions. Primary sectors, particularly agriculture and fisheries, are prominent in the national economy (USAID 2016). Furthermore, the country has an exceptional biodiversity with approximately 7 million hectares, representing 11.9% of national territory declared as protected areas, as of May 2015 (Madagascar INDC 2015).

The country is one of the hardest hit by extreme weather events in Africa, with an average of three cyclones per year. Climate change impacts, particularly severe during the last two decades, are: extended drought periods; increased variability of the rainfall regime; intensification of cyclones; and floods associated with cyclone disturbances: Madagascar is among the 10 most affected countries within the Climate Risk Index for 2017 as it was hit by the biggest storm for more than a decade in March 2017. Climate induced events in recent years have led to the destruction of social infrastructure such as schools and health centres as well as of administrative buildings and infrastructure, but also agricultural crops and fields[2].

Madagascar has one of the greatest amounts of biomass per hectare. A severe decrease of forest area is mainly due to bush fires and the unsustainable management. The use of wood

[1] http://documents.worldbank.org/curated/en/282991557158098216/pdf/Madagascar-Economic-Update-Managing-Fuel-Pricing.pdf

[2] ttps://germanwatch.org/sites/germanwatch.org/files/Global%20Climate%20Risk%20Index%202019_2.pdf

for agriculture, cooking and building materials has a significant effect on the forest (Praene 2017). In its Energy access outlook 2017, the IEA estimates that 23.9 Mio. people, which reflects more than 95% of the population rely on biomass and have no access to clean cooking energy. Madagascar's energy balance shows that about 80% of its overall energy consumption is based on biomass (mainly firewood 68%, charcoal 10% and other biomass 2%), 17% on petrol (transport), 2% on electricity (hydropower and diesel power plants) and 1% on coal. Petroleum products are all imported. The energy consumption per head is around 0.2 toe, which is one of the lowest in the world.

Within our own GIS analysis of current infrastructure, we estimated an electrification rate of 23.0% in 2017, considering both urban and rural population. This is one of the lowest rates in sub-Saharan Africa with considerable disparities between urban areas (67.3%) and rural areas (17%).

For the last three years, Madagascar has ranked last globally in the World Bank's *Doing Business* indicator regarding the difficulty, delay, and cost of getting electricity (The World Bank 2019).

The country's development vision, laid out in its National Development Plan (NDP) 2015–2019, is aligned with the multidimensional approach to development set by the UN Sustainable Development Goals (SDGs). National reconciliation, reinforcement of democratic institutions, and a better management of the economy are objectives of the NDP and strongly rely on progress in reinforcing the rule of law, improving governance (also at the local level), ensuring a stable macroeconomic framework, promoting inclusive growth in combination with poverty reduction, investing in human capital, and cherishing the natural resources of the country. Mining, tourism, agriculture, and fisheries, helped by comprehensive infrastructure development, are identified as the key productive sectors expected to facilitate growth with spill-overs for the overall economy. The NDP is the Government's medium-term planning tool to progress on the overarching ambition of the General Policy of the State (Politique Générale de l'Etat).

In summary, the Government of Madagascar, one of the poorest countries in the world, struggles to provide basic infrastructure and services to its people. Despite being rich in natural resources, the country is least developed and high inequalities exist. In addition, it is challenged by climate change impacts. Thus, infrastructure development, especially in the power sector, should tackle both, electricity access as well as climate change mitigation and adaptation.

3. The Power Sector in Madagascar

Six big hydro power plants provide the largest portion of the electricity production in Madagascar. Hydropower in general provides approximately 68% of the country's electricity, the rest is produced by diesel power plants. There is only a very limited national electricity grid between the capital Antananarivo and the city of Antsirabé. The rest of the electrified cities and villages rely on isolated small and mini grids. These small grids usually only work for a few hours in the evening and prices per kWh are high. The high disparity of access to grid electricity between urban and rural areas is largely due to the country's high surface area, which results in low population density outside urban areas. Due to its location, Madagascar has an immense solar energy potential, with most regions receiving over 2,800 hours of sunshine per year (Get invest 2019). Despite this, the PV power plants provide very little of the power generation mix and have only been integrated since 2006.

3.1 RE off-grid policies and the NDC (Nationally Determined Contributions)

The (I)NDC of the Republic of Madagascar was developed taking into account the national development objectives and priorities stated in main national strategic documents including the *Politique Générale de l'Etat, the Plan National de Développement* 2019-2025, and the *Politique Nationale de lutte contre le Changement Climatique*.

In its (I)NDC document of 2015, the Government of Madagascar focuses on both, climate mitigation and adaptation actions in order to fight against the severe impact of climate change induced events.

In 2030, Madagascar aims to reduce approximately 30 MtCO2 of its emissions of GHG, representing 14% of national emissions, compared to the BAU scenario, with projections based of GHG inventory from the years 2000 to 2010. This reduction is additive to the absorptions increase of the Land Use, Land-Use Change and Forestry (LULUCF) activities, which are estimated at 61 MtCO2 in 2030. Total increase in GHG absorption is expected at 32%, compared to the BAU scenario. These objectives remain conditioned by international support (financial, technology, capacity building) and are hence conditional contributions.

The energy sector is mentioned in the mitigation section of the NDC. Activities to reduce the GHG emissions in the energy sector as stated in the NDC document are the following:

- Facilitate access to energy by strengthening existing systems and by promoting renewable and alternative energies;
- Rehabilitate energy producing network and plant stations;
- Reinforce renewable energy (hydraulic and solar) from the current level of 35% to 79%;
- Improve energy efficiency;

- Rural electrification;
- Disseminate improved stoves (by 2030: 50% of households adopting improved stoves)

Madagascar's NDC document does not mention the promotion and implementation of off-grid technologies, neither does it specify its foreseen actions for rural electrification. The energy sector is mentioned in the mitigation sector, however not in the adaptation sector.

3.2 Legal framework, policies and plans

Stakeholders

At present, there are several stakeholders involved in the Malagasy electricity sector. In order to understand the political framework, the most relevant players for off-grid electrification are introduced in the following:

Ministry of Energy, Water and Hydrocarbons (or Ministère de l'Eau, de l'Energie et des Hydrocarbures (MEEH)) is responsible for the national energy policy and coordination of the activities in the energy sector. The *Direction de l'Electricite et des Energies Renouvelables (DEER)* implements the policy in the electricity and renewable energy domain.

JIRAMA: Since the energy sector reform in 1999, JIRAMA is a limited liability company fully state owned and responsible for the provision of electricity (production, transport, and distribution) and water services in the urban areas of the whole country.

Activities concerning rural electrification have been ceded to the Rural Electrification Agency (*Agence pour le Développement de l'Electrification Rurale*, ADER): Under supervision of the MEEH, the ADER has been established in 2004. It is responsible for ensuring the implementation of the rural electrification policies and the administration of related instruments, for promoting the provision of private-sector-services and providing technical advice to the private operators and for supervising the realization and financing of rural electrification projects.

Office de Règulation de l' Electricité (ORE) was established in 2004 and is responsible for the application of the norms, the quality of services, the principles of competition and the approval of the tariffs.

Private operators: With the reform of the energy sector, implemented between 1998-2004; it was decided to promote the private sector participation in the sector of electrification, where private companies can operate in rural areas or sell electricity to JIRAMA in urban areas. Until today, some 20 operators – mainly small and medium-sized companies - have realized approx. 80 projects in the rural areas. The Association des Opérateurs Professionnels en

Electrification de Madagascar (AOPEM) is intended to improve the association between the private stakeholders, however it is rather inactive.

The National Office for Climate Change Coordination (or *Bureau National de Coordination des Changements Climatiques* (BNCCC-REDD+)) is working under the Ministry of the Ecology, Environment and Forests (or *Ministère de l'Environnement et Développement Durable*, MEDD) and is in charge of coordinating the NDC process, including the sections Adaptation and Mitigation.

Policies and Strategies

"Our energy policy for 2015-2030 addresses several pressing economic, social, and environmental challenges. It supports the transition to the energy mix for electricity and lighting, which will include 80% of renewable resources. To achieve our goal of providing electricity to 70% of the population, we will have to produce 7,900 GWh by 2030, as opposed to the 1,500 GWh currently produced," (Lantoniaina Rasoloelison, Minister of Energy and Hydrocarbons, 2017)

The MEEH has determined two strategic objectives in its performance contract with the Malagasy government for 2019:

1) To ensure access to affordable electricity by the end of 2023 for 50% of the population
2) To double the production of electricity within five years (800 MW by the end of 2023)

In 2015, the GoM adopted the New Energy Policy (NEP) that arose from the challenges left by the reforms of the 1990s and 2000s. It aims to promote liberalisation and private participation in electricity and hydrocarbons as part of the 2015-2019 National Development Plan. The NEP foresees that 70% of households will have access to electricity or a modern lighting source, compared to 15% as of 2015. This objective will be achieved through 70% extension of the interconnected network (with a production mix of 75% hydroelectricity, 15% thermal to be defined according to the local hydrocarbon development, 5% wind, and 5% solar); 20% of mini-grids (with a production mix of 50% hydroelectricity, 20% biogas from rice husks, 25% diesel, and 5% solar); 5% Solar Home Systems; and 5% solar lamps. In total, 80% of the energy mix targeted for 2030 will be of renewable origin. 60% of households, businesses, and industries will adopt effective electricity consumption measures, compared to a penetration rate almost non-existent in 2015 (NPE of GoM, 2015).

A study of the World Bank shows that Stand-alone off-grid solar systems, distributed and operated by the private sector, have started filling the service gap left by the slow expansion of

public electricity service in Madagascar and are now estimated to already serve almost as many households as the grid (The World Bank 2018).

Box 1: Key targets and plans in recent policy documents

The New Energy Policy (NEP) lays out a National electrification strategy (NES) of the Government of Madagascar (GoM), which aims to raise electrification to 70% by 2030 through both on-grid and off-grid solutions. The electrification policy framework under the NEP is underpinned by three principles: (a) 'Least Cost'—the electrification of specific sites and localities to make use of the most economical technology option for providing the needed minimum service level and resulting economic benefits, (b) 'Grid-based renewable energy solutions'—the prioritization of grid-based renewable energy solutions, (c) 'Social justice'—introduction of the notion of modern lighting solutions as economically and financially viable means to accelerate efforts to reduce inequality and close the persistent gap between urban and rural electricity services. In line with the directives of the NEP, the NES attributes a strong priority to support the development of rural growth poles and lays out a least-cost electrification strategy that relies significantly on off-grid technologies.

In 2018, a new Law n° 2017-020 on the Electricity Code in Madagascar has been promulgated, replacing the former electricity sector reform law. The new law is part of the implementation strategy of the NEP. The purpose of this is mainly to integrate provisions relating to the exploitation of renewable energy sources, so that Madagascar can align itself with international guidelines in this field and benefit from related initiatives; make the electricity sector more attractive and more secure for potential investors/project developers; ensure a better quality of service for users of the electricity sector, at an affordable cost and to contribute to improving the governance of the electricity sector, in terms of transparency and accountability.

National Sustainable Energy Fund (or *Fond National de l'Energie Durable*, FNED)

The Mission of the FNED is to co-finance, facilitate and catalyse the financing of projects and investments by renewable energies contributing to rural electrification excluding the extension of the interconnected grid. The FNED is replacing the FNE that is currently still administered by ADER. It is specifically targeting the rural electrification sector in Madagascar. A consumer tax on electricity bills for consumptions being higher than a certain amount per month is paid to the electricity provider JIRAMA or the private operator who in turn is instructed to transfer this amount to the FNED. Using this funding, the ADER offers a maximum of 70 % of investment

costs to private operators who contribute the remainder and receive the concession to exploit a plant with a renewable energy share for 10-20 years. The FNED will be managed by an independent financial institution instead of ADER.

3.3 Obstacles for Off-grid Energy Technologies and Services

Even though the implementation of (off-grid) renewable energy systems has been more and more acknowledged as suitable electrification solution and there are some laws and frameworks in place that favour these systems, a large part of Madagascar remains un-electrified and the country faces some major challenges in the actual electrification process, which affect both customers (demand side) and private sector enterprises (supply side).
Based on literature review and stakeholder consultations in Madagascar, the following (interlinked) challenges have been identified for off-grid electrification:

Political-institutional

A major challenge mentioned by almost all interview partners is the implementation of the existing laws. GIZ supports in creating implementing regulations, however insufficient coordination and poor regulatory structures slow down or prevent the processes. Whereas the new electricity law that strongly favours electrification through RE, the implementation of the law is hampered.

Stakeholder exchange is poor, especially between the energy and the climate sector, but also between public and private entities within the electricity sector. Joint action and strategies are lacking and the subjects of sustainable development, energy access and climate change mitigation/adaptation are not acknowledged as cross-cutting issues that are interlinked with each other. Furthermore, a stronger link of the national to the regional level would be required in order to better address the regional and local needs and facilitate data gathering activities. Moreover, vested interests of stakeholders in the power sector are weakening the development of mini-grid and stand-alone solar solutions.

Many rural areas don't have any industry and activities rather serve self-subsistence. Households use electricity for lighting, and since recently for phone charging, however electricity usage on a bigger scale and for productive use cannot be expected in most of the rural areas. Moreover, the expected outcome on the uptake of economic activities through access to electricity is often not justified. It is expected that the economic situation in many of the rural areas will remain the same even after having access to electricity, and inhabitants are not able to afford appliances. Even though the technology costs for mini-grids are decreasing,

the costs of connections are prohibitively high as expensive distribution networks for small numbers of very poor customers in remote areas have to be built. Without further financial incentives or the provision of micro-credits for the poor, there will not be any significant changes and private investors will not be attracted.

Even though the FNED is in place, its impact is restricted as the funds available are very limited and its actual structure does not allow for financial contributions by other stakeholders like international donors, finance institutions or private investors. Furthermore, ADER has the mandate but restricted means to promote rural electrification through the FNED as the agency is limited by personnel and financial capacities: Due to this, the measures implemented through the ADER remain limited and are not coordinated with other international interventions. Even worse, most of the mini-grids implemented by private operators under the supervision of ADER are not in operation anymore.

The policies and regulations have also failed to introduce quality standards, especially of Solar Home Systems. The lack of differentiation of fiscal incentives between low- and high-quality products discourages private sector enterprises from selling high-quality products, and there is no monitoring in place, which leads to the sale of numerous low quality products especially in rural areas, that are not sustainable and create a lot of waste. This again can lead to low consumer confidence in RE off-grid systems. The new budget act however also refers to quality standard of Solar Home Systems.

Access to Finance

The private sector is relatively dynamic but faces some problems regarding experiences with renewable electrification schemes and getting access to financing for the projects. Even though private operators should get subsidies of up to 70% of the initial investment costs for an electrification project with renewable energies, local enterprises who want to engage in the sector are mostly of small to medium size, and have little experience, e.g. in setting-up business plans and bank loans. The lack of knowledge and experience also complicates access to already existing donor-based funding schemes such as programmes of the Green Climate Fund that Madagascar is part of (see https://www.greenclimate.fund/countries/madagascar)

Moreover, as mentioned above, the FNED, that should provide these subsidies, is currently insufficiently operated by ADER. Additionally, the cross-subsidies that the electricity provider

JIRAMA is expected to provide to the fund for rural electrification projects are not being paid as JIRAMA itself is under financial difficulties.

It is planned to create an independent finance institution (FI) to administrate the FNED and reform its structure. Donor agencies have already expressed their interest and willingness to provide funding, however it currently lacks an institution with enough experience to execute such a FI.

Data Availability and Accessibility

All consulted experts mentioned difficulties in the availability and the accessibility of data.
Even though targets regarding the country's electrification are specified in the New Electricity Policy, the means to achieve these targets are not yet clarified. This is mainly due to the lack of spatially resolved and validated data regarding household electricity demand in rural areas, ability to pay for energy services, usage of electricity, availability of individual systems in rural areas and current infrastructure. If existent, data is often not reliable or accessible which complicates planning as well as monitoring and evaluation processes of (rural) electrification. GIZ supported the MEEH in the establishment of an Energy Information System (EIS, accessible under energie.mg), that can facilitate the accessibility of data. Relevant stakeholders (MEDD, MEEH, JIRAMA, ADER, etc.) are required to provide their data and upload it to the EIS. However, this is only happening in an uncomplete and slow manner. The challenge is therefore to establish and implement rules of regular data provision that need to be followed by the stakeholders. At the same time, a better coordination among the stakeholders is necessary (see previous paragraph) as data on energy access is also relevant for the calculation of greenhouse gas emission reduction potential, e.g. used in the NDC document, which means that a coordination and data exchange between the different sectors is of utmost importance.

4. International support

There are various existing international support initiatives for the power sector in Madagascar:

In 2019, the World Bank approved a $150 million International Development Association credit to provide improved access to electricity services for households, enterprises, and health facilities in Madagascar. Part of this is the Least-Cost Electricity Access Development (LEAD) program that will finance cost-effective investments in grid extension and densification to maximize the number of new connections on the one hand and with its off-grid component, create an off-grid market development fund (OMDF) to engage both private sector companies and financial institutions in accelerating the scale-up of the market for solar off-grid technology. In the frame of their project PAGOSE, the World Bank is providing technical support to the GoM for electrification planning.

GIZ with its program PERER is providing technical support to MEEH, ADER and ORE with the goal to strengthen transparency and regulation through legislation, the introduction of an energy information system, the digitisation of processes and the development of grid connection conditions.

In a second component PERER supports the optimised allocation of financial resources for rural electrification through tendering procedures and support for the establishment of the National Sustainable Energy Fund (FNED).

The European Union (EU) has a funding scheme for PV mini-grids and mini-hydro plants.

UNIDO with its Renewable Energy programme is also promoting the development of hydro mini-grids and is supporting the BNCCC-REDD+ in the development of a MRV for RE systems that includes tools to calculate the emission factor of an electricity system.

The Agence Francaise pour Développement (AFD) is supporting the MEDD and specifically the BNCCC-REDD+ in its development and revision of the NDCs, however herein does not focus on the energy sector.

5. Simulation of off-grid RE pathways until 2030

The analysis has shown that Madagascar lacks concrete numbers and scenarios for achieving full electrification (SDG 7) and on the climate relevance of such activities (SDG 13). In order to fill this gap we conducted a detailed study on different electrification scenarios to understand the respective electrification mix, initial investments needed and the related GHG emissions to achieve SDG 7 on securing electricity access for all by 2030. Details on the methodology can be found in the Fehler! Verweisquelle konnte nicht gefunden werden.. The analyzed scenarios show different ways on how to electrify the people without electricity access in Madagascar considering grid extension, mini-grids and solar-home-systems (SHS). The following table gives an overview on the three considered scenarios which is complemented by a more detailed description below.

Table 1: Overview on electrification scenarios for Madagascar

Scenario name	Business-as-Usual (BaU)	Universal-Electricity-Access (uEA)	Progressive Off-Grid (prOG)
Background	Relative values applied for people to be electrified based on New Policy scenario of IEA	Based on GIS analysis of current grid infrastructure and settlement patterns combined with current policy frameworks	Based on GIS analysis of current grid infrastructure and settlement patterns combined with most progressive policy frameworks for off-grid
Description	Focus on grid-extension SDG7(1.1) not achieved	Mix of off-grid and grid-extension SDG7 (1.1) achieved	Strong focus on off-grid SDG7 (1.1) achieved

The Business-as-Usual (BaU) Scenario

What it shows: The Business-as-Usual (BaU) scenario quantifies the number of new technology-specific electrifications (Grid Extension, Mini-Grids or Solar-Home Systems) until 2030 by projecting current business-as-usual growth rates into the future.

How it is obtained: Regional projections of electrification rates and technologies are mapped to the country-level and modelled until 2030. The BaU scenario is based on the "New Policies" Scenario of the International Energy Agency's World Energy Outlook 2018.[3]

[3] https://www.iea.org/weo2018/scenarios/

The Universal-Electricity-Access (uEA) Scenario

What it shows: The Universal-Electricity-Access (uEA) scenario estimates the number of new technology-specific electrifications (Grid Extension, Mini-Grids or Solar-Home Systems) necessary to achieve the universal access goal until 2030. These estimations account for expected population growth rates and current infrastructure and *current* regulatory frameworks.

How it is obtained: Existing datasets providing night lights, population densities and transmission grids are combined to estimate the number of people lacking access to electricity. Appropriate electrification options are determined based on the remoteness and density of neglected populations. In this way the model estimates the share of people that remain to be electrified by either Grid Extension, Mini-Grid deployment or Solar-Home-System adoption until 2030.

The GIS-based estimates are further refined by accounting favourable technology-specific frameworks through the integration of ESMAP's RISE Indicators of 2019 into the model's calculations.[4]

The Progressive-Off-Grid (prOG) Scenario

What it shows: The Progressive-Off-Grid (prOG) scenario estimates the number of new technology-specific electrifications (Grid Extension, Mini-Grids or Solar-Home Systems) necessary to achieve the universal access goal until 2030. These estimations account for expected population growth rates and current infrastructure and *progressive* regulatory frameworks.

How it is obtained: Existing datasets providing night lights, population densities and transmission grids are combined to estimate the number of people lacking access to electricity. Appropriate electrification options are determined based on the remoteness and density of neglected populations. For the 2030 horizon, in this way the model estimates the share of neglected people that remain to be electrified either by Grid Extension, Mini-Grid deployment or Solar-Home System adoption.

In the prOG scenario, the GIS-based estimates are modified to showcase the impact of fully favourable off-grid (Mini-Grid and Solar Home Systems) frameworks through the integration of maximized ESMAP's RISE Indicators into the model's calculations.

[4] https://rise.esmap.org/

For all scenarios, two different cases are defined:

Lower Tier Case

Starting with the number of people per electrification option, the respective minimum electricity demand is estimated. In this case, the minimum threshold for electricity access is defined as the equivalent of ESMAP's Tier 2 (compare Figure 1) where Solar-Home-Systems find application, and Tier 3 where Mini-Grids are deployed.[5]

Higher Tier Case

Starting with the number of people per electrification option, the respective minimum electricity demand is estimated. In this case, the minimum threshold for electricity access is defined as the equivalent of ESMAP's Tier 3 where Mini-Grids find application, and Tier 4 where Mini-Grids are deployed or Grid Extension takes place.

Figure 1: The Tiers of Electricity Access of the Multi Tier Framework[6]

[5] https://www.esmap.org/node/55526
[6] https://www.esmap.org/sites/esmap.org/files/DocumentLibrary/measuring-energy-accessFinal_PPT_Optimized.pdf

Electrification Mix

As first step the electrification mix for the three scenarios was calculated. Results are shown in the following table and figure.

Table 2: People gaining electricity access in Madagascar until 2030: different scenarios

	BaU	uEA (2019)	prOG
Grid	8,692,244	3,253,068	536,289
Mini-Grid	2,871,546	2,189,723	3,029,771
SHS	5,975,919	21,963,005	23,839,737
No access	9,866,087	-	-

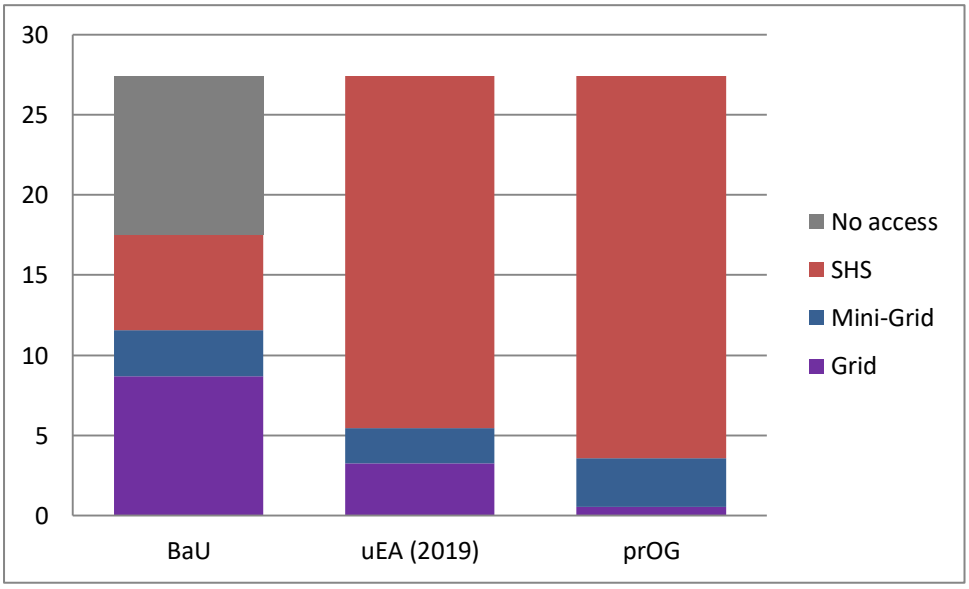

Figure 2: People gaining electricity access in Madagascar until 2030: different scenarios in Million people[7]

According to data of the UN, we assumed a population growth rate of 2.5 %, with a total population of 35.6 Mio. in 2030. This means new electrification of 27.4 Mio people, or 5.8 Mio households by 2030 in order to achieve 100% electrification rate. Scenario BaU shows no electricity access for all in 2030 with 9.87 Million people being left un-electrified (36% of the population). The suggested electrification mix has 32% grid extension, 10.5 % mini-grids and 22% SHS. uEA and prOG show both 100% electrification rates in 2030. In the uEA (2019) and prOG scenario a strong focus is set on SHS (80% and 87% respectively). This reflects the currently low developed grid infrastructure and scattered settlement patterns, which favour SHS as the most suitable electrification strategy for many off-grid communities in

[7] shs: Solar-Home Systems; mg: Mini-Grids; grid: Grid Extension

Madagascar. Maximized ESMAP's RISE Indicators of the prOG scenario in comparison with the uEA scenario are leading to a shift of the grid extension share (from 12% to 2%) towards Mini-Grids (11%) and more SHS (87%).

Initial investment needs

The initial investments needed to achieve the electrification mix for the different presented scenarios are shown in the next figure. They reflect both cases, lower Tier and higher Tier electrification, which affects the minimum size of mini-grids and SHS. The investment costs for mini-grids and SHS include generation, storage, and – if needed – distribution. For grid extension only the grid infrastructure cost (extension of medium voltage grid plus distribution grid and household connection are considered)[8].

Table 3: Initial investment needs until 2030 in Billion USD

	Lower Tier case			*Higher Tier case*		
	BaU	uEA (2019)	prOG	BaU	uEA (2019)	prOG
*Grid**	4.62	1.73	0.28	4.62	1.73	0.28
Mini-Grid	0.61	0.47	0.65	1.97	1.50	2.08
SHS	0.73	2.66	2.89	1.62	5.94	6.45
Total	***5.96***	***4.86***	***3.82***	***8.21***	***9.17***	***8.81***

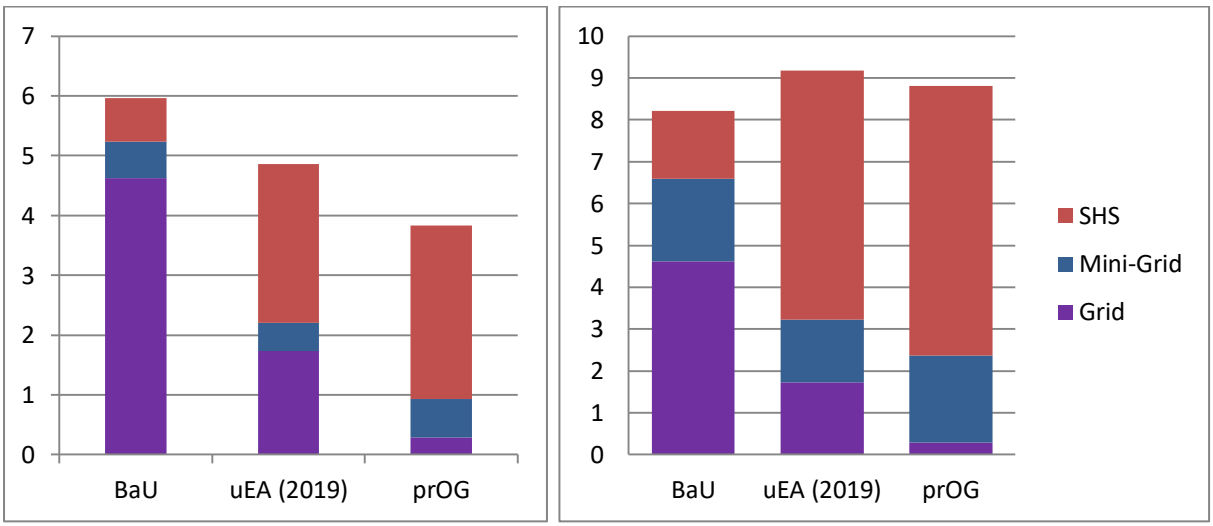

Figure 3: Initial investment needed until 2030 in billion USD (left: lower tier case; right: higher tier case)

[8] Common approach in electrification planning is to only consider grid infrastructure investments and not investments into the central power generation. Those will follow based on the increased on-grid demand, but the costs for grid supplied electricity will remain the same.

Even though in BaU 9.8 million people remain without access to electricity it has the highest initial investment needs for the lower tier case and not significantly lower investment needs than uEA and prOG for the higher tier case. For the higher tier case all scenarios show similar initial investment cost. The prOG scenario has the lowest initial investment cost for the lower tier case.

GHG emissions

Similar to the investment needs, the related GHG emissions for all scenarios under the two cases were calculated. It needs to be notified that also emissions of non-electrified people based on the use of kerosene lamps are considered in the cumulated results. As we are looking at an (linear) electrification pathway until 2030, we can still observe a significant amount of cumulated emissions related to non-electrified people, even if in 2030 universal electricity access is achieved. The results are shown in the following table and figure.

For the BaU scenario, the highest number of people cumulatively do not get access to electricity and therefore continue to use kerosene lamps that emit significant GHG emissions while the uEA and prOG scenario achieve universal electrification by 2030 leading to substantial emission reductions.

Table 4: Cumulated GHG emissions in million tons of CO_2-equivalent (2017-2030)

	Lower Tier case			*Higher Tier case*		
	BaU	*uEA (2019)*	*prOG*	*BaU*	*uEA(2019)*	*prOG*
Grid	2.608	0.976	0.161	8.933	3.343	0.551
Mini-Grid	0.312	0.238	0.329	0.855	0.652	0.902
SHS	-	-	-	-	-	-
No access	16.463	10.968	10.968	16.463	10.968	10.968
Total	**19.384**	**12.182**	**11.458**	**26.251**	**14.963**	**12.421**

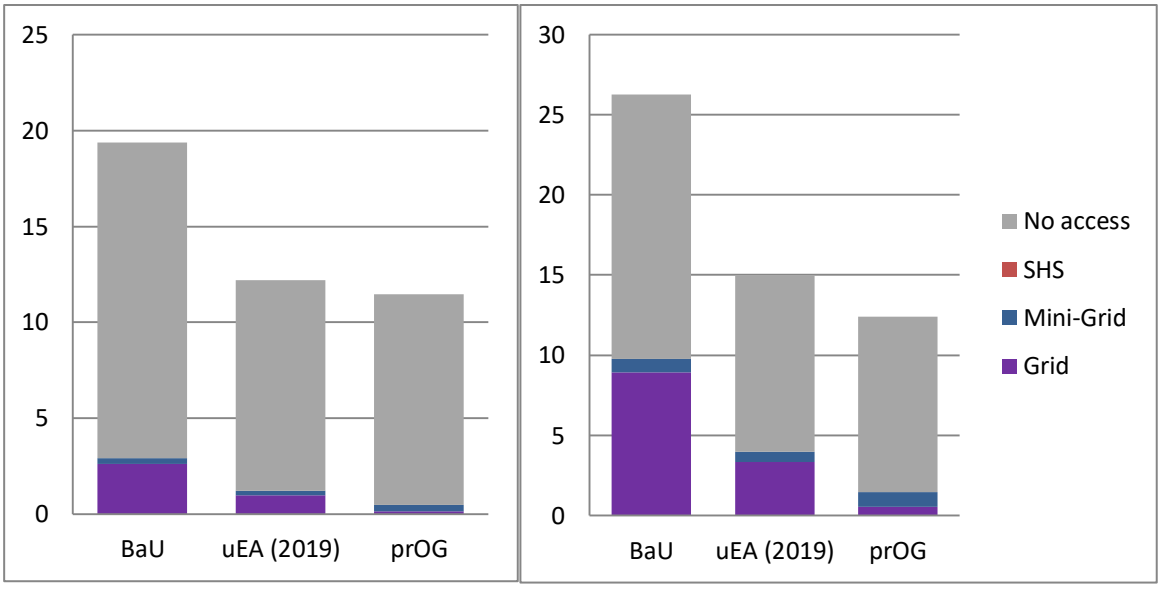

Figure 4: Cumulated GHG emissions in million tons of CO_2-equivalent (2017-2030) (Lower tier case left, higher tier case right)

The overall emission reduction potential can reach up to 7.36 $MtCO_2$ between 2017 and 2030 compared to the baseline scenario (BaU_NewPol) under consideration of lower Tier levels. For a higher consumption level simulated through an increased tier level, the aggregated emission reduction until 2030 rise to 12.84 $MtCO_2$. For all scenarios, the cumulated GHG emissions related to non-electrified people are the highest. This means, the faster the electrification of all people can be achieved, the earlier those emissions can be reduced.

6. Conclusion and recommended actions

Linking the qualitative and the quantitative country analysis, it becomes clear that Madagascar is a high needs country in terms of electrification and required support in order to achieve universal electricity access until 2030 as defined by the SDG 7.

The interviews as well as the quantitative analysis show that off-grid electrification is a suitable solution for the case of Madagascar and an acceleration of the electrification through off-grid technologies is highly recommended.

In the case of Madagascar, the lower demand scenario (Tier 2/3) should be prioritized to as a start achieve a minimum level of electrification and to substitute the high "non-electrified" emissions caused by kerosene lamps in not-electrified areas.

The lower demand scenario also reflects the low ability to pay of the consumers in the rural remote areas of the country. In these areas, climate adaptation and the strengthening of resilience to extreme weather events is of utmost importance. Off-grid systems can therefore contribute not only contribute to climate change mitigation in Madagascar but also strengthen the resilience and adaptive capacities, if e.g. used in combination with irrigation.

It is hence recommended to take the developed prOG scenario as base for further electrification planning as it can serve to achieve universal electrification by 2030 and at the same contribute to climate action (mitigation of and adaptation to climate change). This would mean a strong and well coordinated focus on Solar Home Systems for the electrification rural areas. In total, almost 4 bn USD in initial investments are needed to fulfill the prOG low demand scenario until 2030.

NDC Revision Process and initial Recommendations

In the context of the Paris Agreement, Parties have to revise their Nationally Determined Contributions (NDCs) by the end of the year 2020. The Malagasy NDC revision process is managed by the BNCCC-REDD+ under the Ministry of the Ecology, Environment and Forests (or *Ministère de l'Environnement et Developpement Durable*, MEDD).

The findings of the country analysis suggest considering the following renewable energy and off-grid related elements during the NDC revision process:

a. Reflecting off-grid RE in the mitigation and adaptation section of the NDC: In its 2015 (I)NDC, Madagascar mainly refers to mitigation benefits of renewable technologies in a qualitative manner. As Parties can describe the (relative) mitigation potential or target of

(off-grid) renewable energy solutions also in a quantitative way, Madagascar might reflect its National Electrification Plan targets in their NDC revision. In addition, the resilience and sustainable development benefits of improved livelihoods through electricity access can be communicated in the adaptation section of the NDC.

b. Quantifying costs and financing needs: The first round of NDC submissions delivered only limited information on costs and financing needs. In order to facilitate international support, the Government might consider including this information in the revised NDC based on potential financing needs and cost information defined in the PANCLLL. For the renewable off-grid sector, also the NEP can provide helpful assumptions.

c. Conditional and unconditional elements: NDCs represent helpful vehicles to communicate international support needs with regard to financial, technology and capacity building requirements. Parties can highlight what they achieve unilaterally and what is conditional on international support. Madagascar is encouraged to make use of this tool and communicate key support requirements, e.g. financial support, application of market mechanisms, capacity building or technology transfer needs.

International support areas

In order to address the above categorized main challenges for off-grid electrification in Madagascar (cf. chapter 3.3) it is suggested that international support should focus on the following interventions:

a) Political-institutional

- Analysis of existing institutional structures and responsibilities for electrification and climate action
- Constant mapping of national planning and strategies to align tasks of different institutions / ministries
- Mapping and coordination of donor activities to improve international support
- Creation and coordination of working group on electricity access and NDCs

b) Data Availability and Accessibility

- Primary data collection in rural areas to improve baseline data for planning. This should include household and commercial enterprise surveys in relevant rural areas.
- Strengthen cooperation between academic and public sector for primary data collection, processing and management
- Capacity development for data management with relevant institutions
- Capacity development for survey conduction and data evaluation using open software.

c) Access to Finance

- Quantify subsidy and financing needs for off-grid electrification
- Development of Market Development Credit Lines for SHS & mini-grids (e.g. supported with results based financing grants).
- Capacity building activities to enhance capability of involved stakeholders to execute a FI
- Workshops with Malagasy banks to enhance interest in (Off-Grid) RE sector

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