Scenario Development for Rural Electrification & Off-Grid Market and Mitigation Potential

Dr. Catherina Cader

International Off-grid Renewable Energy Conference & Exhibition

1st of November 2018
The Reiner Lemoine Institut gGmbH (RLI)

Overview

- Not-for-profit research institute
- 100% owned by Reiner Lemoine Stiftung (RLS)
- Based in Berlin, established in 2010
- Managing director: Dr. Kathrin Goldammer
- 25 researchers + students

Mission

Scientific research for an energy transition towards 100% Renewable Energy

Reiner Lemoine
Founder of the Reiner Lemoine Foundation
## Research Fields at RLI

<table>
<thead>
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<tbody>
<tr>
<td>“We analyze and optimize future scenarios with an energy supply largely based on renewable energy sources.”</td>
<td>“We support the development of sustainable energy supply for remote regions.”</td>
<td>“We study sustainable mobility concepts through sophisticated implementation and optimization of renewable energy systems.”</td>
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</table>

- **Strategic planning**
- **Geographic Information System**
- **Energy System Modelling**
- **Financial Assessment**
- **Market Potential Analysis**
Agenda

1. Introduction
2. Scenario Development for Rural Electrification
3. Off-Grid Market Potential
4. Off-Grid Climate Change Mitigation Potential
5. Conclusion & Outlook
Motivation for improving electricity access
Share of the population with access to electricity, 2014

Data represents electricity access at the household level, that is, the number of people who have electricity in their home. It comprises electricity sold commercially, both on-grid and off-grid.

Source: The World Bank

OurWorldInData.org/energy-production-and-changing-energy-sources/ • CC BY-SA
Power outages in firms in a typical month

Power outages are the average number of power outages that establishments experience in a typical month.

Source: World Bank – WDI

OurWorldInData.org • CC BY-SA
Electrification Challenges and Opportunities

2030: New Policies Scenario
Baseline Scenario of International Energy Agency

Number of people without access to electricity projected to fall by 36%
~ 390 Mio. people

Still, no energy access for:

8 % of world population
~ 674 Mio. people without access

90 % of which will be in rural areas

Status Quo: Rural Electrification

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- Introduction
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Country Selection

Selection Criterion: Countries selected, if >1 Mio. inhabitants without access to electricity

52 countries selected

TOP 10
~ 40% of people without electricity in all selected countries

Literature Analysis and Data Collection

Selection Criterion: Countries selected, if >1 Mio. inhabitants without access to electricity

52 countries selected
Scenario Development: Overview

- Time horizon: 2030
- 100% access: Achieve SDG 7 most economically including all necessary measures and technology developments
- Scenario definition based on different Tier Levels\(^1\) (2-5), Population growth. Economic growth, in-country urbanization, migration

\(^1\) Based on Multi-Tier Framework by ESMAP

GIS based analysis

Game-Changer Assessment
Night light
Definition of non-electrified areas per country

Population
Share of people living in non-electrified areas

Transmission grid
Electrification options for non-electrified population
Base Scenario Development (GIS)

Step I - Night lights

Step II - Population

Step III - Transmission grid
Base Scenario Development (GIS)
Base Scenario Development (GIS)

- Share and capacity (MW) of SHS, Mini-Grid, Grid Extension per country and scenario
Scenario Development: Overview

Base Scenario (GIS)  
Population 2016

Base Scenario (Extrapolation)  
Population 2030

100 %  
Tier 2

100 %  
Tier 3

100 %  
Tier 4

100 %  
Tier 5

mixed  
Tiers

= 10 scenarios
Game-Changer: Overview

- Availability to pay
- Seasonal and environmental effects
- Action done by development funding institutions and donor banks
- Policy change
- Technology development
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Off-Grid Electrification Opportunities

Solar Home Systems

Mini-Grids

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Off-Grid Market Potential

Cost estimation of SHS and Mini-Grid option per MW

Forecasted capacity expansion

Underlying assumptions SHS – Example of Tanzania

<table>
<thead>
<tr>
<th>Category</th>
<th>Premium</th>
<th>Medium</th>
<th>Pico</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ppl. w/o access to electricity assigned to SHS</td>
<td>20 M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HHs / Pot. Customers [#]</td>
<td>8M (HH size of ~5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size range [W]&lt;sup&gt;1&lt;/sup&gt;</td>
<td>50+</td>
<td>11 – 49</td>
<td>3 – 10</td>
</tr>
<tr>
<td>Customer share [%]</td>
<td>10%</td>
<td>20%</td>
<td>70%</td>
</tr>
<tr>
<td>Monthly payment [USD]</td>
<td>15</td>
<td>5</td>
<td>2</td>
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</table>

“Pay-as-you-go” Reselling

SHS > 10W market potential [M USD p.a.]

Country A  39
Country B  10
Country C  17
Country D  26
Country E  42
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Off-Grid Climate Change Mitigation Potential

- Emission accounting achieved by standards and methods under the Clean Development Mechanism (CDM)
- Combination of approved CDM baseline methods and country-specific standardized baselines (SBs) under the UNFCCC

\[ ER_y = BE_y - PE_y - LE_y \]

- \( ER_y \) = Emission reductions in year y (t CO\(_2\)/y)
- \( BE_y \) = Baseline Emissions in year y (t CO\(_2\)/y)
- \( PE_y \) = Project emissions in year y (t CO\(_2\)/y)
- \( LE_y \) = Leakage emissions in year y (t CO\(_2\)/y)
Off-Grid Climate Change Mitigation Potential

Example: Mini-Grid (MG) Baseline Emissions

\[
BE_{MG} = EF\, [kg\, CO_2 eq \, kWh] \times expected\, annual\, RE\, generation\, [kWh]
\]

CDM AMS-I.F Emission factors (EF) for diesel-based Mini-Grid CDM in kg CO2e/kWh

<table>
<thead>
<tr>
<th>Sizes</th>
<th>Load Factors</th>
<th>25%</th>
<th>50%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 15 kW</td>
<td>25%</td>
<td>2.4</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>&gt;=15&lt; 35 kW</td>
<td>50%</td>
<td>1.9</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>&gt;= 35 &lt; 135 kW</td>
<td>100%</td>
<td>1.3</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>&gt;=135 &lt; 200 kW</td>
<td></td>
<td>0.9</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>&gt; 200 kW</td>
<td></td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Impact Assessment

Socio- Economic Impact

Example: Environmental Impact

- Deforestation: change in cooking demand to more efficient or electrical stoves are derived based on the Multi-Tier Framework by ESMAP
Achieving SDG7 until 2030 is an immense task
Off-grid technologies will play a key role in achieving this goal
Climate relate emissions will increase with higher electrification rates
Scenario development will create an overall understanding of market potentials of different technologies and effects of electrification
Impacts of electrification on climate need to be understood in order to create the right policies for the focus on renewable energy-based technologies

Measures towards reaching SDG7 needs to be in line with reaching SDG13
Thank you for your attention!

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