With the current pace of financing, SDG7 will be missed by more than 100 million households in sub-Saharan Africa.

Shell Foundation and Catalyst Off-grid Advisors have produced a report that puts the shortfall in sharp focus, and highlights the level and type of funding required to meet the UN goal.
SDG 7 is a global imperative, yet we are falling far behind its achievement, especially in Africa
At the current pace, SDG 7 will be missed by more than 100 million households.....

Image Description:
- **Graph Title**: Share of SSA Households with Electricity Access: SDG7 vs. BAU
- **Y-axis**: Share of households with electricity access (%)
- **X-axis**: Years from 2010 to 2030
- **Legend**:
  - Historical
  - Business as Usual
  - SDG 7 Met

**Graph Details**:
- **Timeline**:
  - 2010 to 2030
- **Data Points**:
  - 2010: Historical 30%, Business as Usual 40%, SDG 7 Met 50%
  - 2020: Historical 60%, Business as Usual 70%, SDG 7 Met 80%
  - 2030: Historical 100%, Business as Usual 100%, SDG 7 Met 100%

**Key Notes**:
- **65%** of HHs will have electricity access by 2030 when continuing with Business as Usual.
- **104 million** HHs will remain without access (only 20M fewer than today).
- **$11 billion** in capital required for mini-grid and SHS.
.....and yet the progress to date on OGS has been remarkable, thanks to pioneering enterprises

**SSA Cumulative Sales of Off-Grid Solar Products***

* Sales data of Lighting Global quality verified products (both lanterns and SHS)

...and financial backers

**Off-Grid Solar Investments in Africa by Type and Year***

* Catalyst analysis
The scope of the challenge, however, is daunting

- Over **125M HHs** lack access to modern energy services.

- With current grid extension and population growth trends, a total of **210M off-grid HHs** will need to be connected by 2030.

- Only **4 of 48 markets are “Active” off-grid electricity markets**, where more than one company selling solar home systems at scale (>20,000 customers) in that market.

*numbers denote # HHs without access to electricity*
Our approach to analysing SDG 7 in Africa
We’ve focused on portions of SDG 7

<table>
<thead>
<tr>
<th>SDG 7</th>
<th>Our Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>SSA only</td>
</tr>
<tr>
<td>Access to affordable, reliable, sustainable, and modern energy for all</td>
<td>Clean Cookstoves, Grid Extension, Off-Grid Solutions (SHS and MG), Households</td>
</tr>
<tr>
<td>Increase Share of Renewables</td>
<td>Outside of scope</td>
</tr>
<tr>
<td>2x rate of improvement in energy efficiency</td>
<td>Outside of scope</td>
</tr>
<tr>
<td>Enhance international cooperation</td>
<td>Scaling Off-Grid Energy Platform</td>
</tr>
<tr>
<td>LDCs, SIDs, Land-locked</td>
<td>Yes – Universal Access</td>
</tr>
</tbody>
</table>

- Full alignment
- Partial fit
- Outside of our scope
We combined top-down and bottom-up analyses

**Top-Down, predictive model:** Framing the Continental Challenge

**Bottom-Up:** Enterprise-Level Perspectives

**Combined Insights:** Shifting onto an SDG 7 Achievement Trajectory

- Where are we now vis-à-vis SDG7?
- Where are we headed?
- What is the gap between BAU and SDG 7?
- How much time and capital is required to build an off-grid enterprise?
- What pace of deployments are required?
- What does this mean for SDG 7?
- How many enterprise deployments, when?
- What markets?
- How much capital?
- What type of capital?
- What else?
Top-down analysis: Overview and Approach

- **Unit of analysis:** Sub-Saharan Africa

- **Approach:** Modelled the continuum of capital required continent-wide to achieve universal electricity access
  - Includes breakdown of household service levels and direct subsidy requirements

- **Suitability of approach:**
  - OGS and mini-grid companies operate across borders;
  - Granular, country-level detail is not required; and
  - Working under a short timeline

- **Capital requirements** to be driven by key intermediate determinations, including:
  - The quantum of HHs in need of OGS or mini-grid solutions;
  - The all-in cost of delivering such systems; and
  - The technology blend of products delivered
Predictive Model: Architecture (Visualised)

Core Data (Fixed Assumptions)
- Market Size
- Technology & Costing
- Household Economics (Affordability)

Key Levers (Var. Assumptions)
- Pace of Off-Grid Electrification
- Capital Blend
- Cost of Capital
- Technology Blend (OGS vs. MG)

Intermediate Outputs
- Total New HHs w/Access
- Service Levels Achieved (Tier 1, 2, 3, 4)
- Consumer Subsidy Requirement

Final Output
- Overall Capital Requirement

Levers: can be adjusted to generate a variety of key scenarios
Data sources for predictive model

**Population:** UN DESA

**Grid connectivity:** International Energy Agency – Africa Energy Outlook, World Bank data

**Mini-grid connectivity:** Various World Bank data sources (concessions study, project appraisal documents)

**Off-grid solar sales:** GOGLA off-grid market reports

**SHS costing:** Various industry sources

**Mini-grid costing:** Various industry sources

**Affordability:** World Bank PovCal data
### Demographics

| 2017 Avg. Household Size | 5 PAX/HH |

### OGS Sales Data

| Share of Active OGS Systems in SSA | 50% |
| Hist. % of OGS Sales to HHs w/o Grid | 80% |
| Hist. % of OGS Sales to HHs w/Grid | 10% |
| Hist. % of OGS Sales to SMEs | 10% |

### OGS Trends

| WC Loan Interest Rate (US$) | 10% |
| Consumer Finance Interest Rate (US$) | 10% |

### Off-Grid Solar

| Tier 1 SHS 2017 FOB Price | $55 |
| Tier 2 SHS 2017 FOB Price | $130 |
| Annual Change in SHS FOB Price | -5.0% |
| Annual OPEX as % of Total T1 SHS Cost | 40% |
| Annual OPEX as % of Total T2 SHS Cost | 30% |
| Tier 1 SHS Customer Pmt (for 18 mths) | $6 |
| Tier 2 SHS Customer Pmt (for 24 mths) | $13 |
| Non-Payment Rate | 10% |

### Mini - Grids

| Mini-Grid Generation capacity per customer | 250 |
| Mini-Grid CAPEX Cost | $2.5/W |
| Annual Change in CAPEX Cost | -3.0% |
| Upfront Soft Costs | $1/W |
| Annual Change in Soft Costs | -3.0% |
| Mini-Grid All-In Investment Cost | 3.5 |
| 2017 OPEX Cost as % of Total CAPEX | 5% |

### Financing

| SHS Lifetime (years) | 4 |
| Annual Change in Tier 1 % Sales | -1.0% |
We modelled scenarios using the following inputs and variable assumptions:

- **Grid Electrification**
  - BAU “Business as usual” (51.5%)
  - Aggressive BAU (57.3%)*
  - Heavy Investment (62.9%)*

- **Mini-Grid Electrification**
  - BAU “Business as Usual” (0.4%)
  - Aggressive BAU (1.5%)
  - Heavy Investment (2.5%)

- **Off-Grid Solar**
  - Typical range: 13% to 41% (depending on combination of scenarios)

- **Access Rate**
  - BAU “Business as Usual” (65%)
  - Aggressive BAU (78%)
  - SDG 7 Met (100%)

*NB: Even in the IEA’s African Century Scenario, grid expansion rates are lower than these estimates.*
Framing the Continental Challenge

Top-Down: Framing the Continental Challenge

Bottom-Up: Enterprise-Level Perspectives

Combined Insights: Shifting onto an SDG 7 Achievement Trajectory
Not surprisingly, the grid still delivers the majority of energy services to households.

2017 HH Access Rate Via Modality:

- **No Access:** 59.2%
- **Grid:** 39.4%
- **Off-Grid Solar:** 1.2%
- **Mini-Grid:** 0.2%

Of access to date is provided through grid connections (84M HHs).

3.7 million New grid connections per year, over past 5 years.

4.3 million HHs with off-grid access*

*This includes sales of Quality Verified lanterns and SHS, plus an estimate of mini-grid penetration to date.
Even with heavy grid and mini-grid projections, SHS would still need to deliver 34.6% of access in order to achieve SDG 7.
Consumer affordability will be a challenge: our simulation shows that US$4 billion may be needed

37% of SSA households may not be able to pay for off-grid solar products

$4B shortfall in the ability of households to pay

How this was derived:

- Used the World Bank PovCal tool to develop several “poverty lines” across SSA
- Attributed a resultant level of ability to pay shortfall
- And assumed:
  - A household would be willing to pay 5% of its total income on electricity
  - The shortfall represents the remaining costs to provide a needed $6/month on electricity.

For example:

- HH with an income of $1.5/day will have a $3.7/month shortfall
- HH with an income of $2.0/day will have a $3.0/month shortfall
- HH with an income of $3.0/day will have a $1.5/month shortfall
Enterprise-Level Perspectives

Top-Down: Framing the Continental Challenge

Bottom-Up: Enterprise-Level Perspectives

Combined Insights: Shifting onto an SDG 7 Achievement Trajectory
An Enterprise lens is critical: delivering off-grid access happens one SHS or mini-grid deployment at a time.
And it’s hard work: establishing and scaling an SHS off-grid deployment in one country takes years and millions of dollars.

Customers and Annual Revenue by Funding Group

<table>
<thead>
<tr>
<th>Capital Sources</th>
<th>Pre-Seed</th>
<th>Seed</th>
<th>Series A</th>
<th>Series B</th>
<th>Series C</th>
</tr>
</thead>
<tbody>
<tr>
<td># customers at end of Stage</td>
<td>200</td>
<td>1,500</td>
<td>25,000</td>
<td>70,000</td>
<td>150,000</td>
</tr>
<tr>
<td>Debt (USD)</td>
<td></td>
<td>300,000*</td>
<td>1,000,000</td>
<td>3,750,000</td>
<td>9,500,000</td>
</tr>
<tr>
<td>Equity (USD)</td>
<td>50,000*</td>
<td>200,000</td>
<td>5,000,000</td>
<td>7,500,000</td>
<td>11,000,000</td>
</tr>
<tr>
<td>Grants (USD)</td>
<td>150,000</td>
<td></td>
<td>1,000,000</td>
<td>1,000,000</td>
<td></td>
</tr>
<tr>
<td>Founders, friends and family</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angels, foundations, family offices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early stage impact funds, foundations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFIs, specialised funds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial sources, de-risking instruments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Convertible Debt
* Founders (Friends/Family) Equity
Meanwhile, the industry’s sales are flat. While there are explanations, this trend is worrisome.

![SSA Annual Sales of Off-Grid Solar Products](chart)

**Currency Devaluation**
The industry’s FX risk is considerable given that most enterprises are capitalised in hard currency and paid in local currency.

**Drought**
The disposable income of many rural customers was heavily impacted by recent droughts.

**Import Tariffs**
Policy changes within EAC countries has resulted in higher tariffs and affected solar product sales.

**Market Concentration**
Figures are subject to the “lumpiness” of individual orders, particularly in four East African markets where the industry is concentrated.
...particularly given that only 1% of off-grid households have been reached.

Only 4 of 48 markets are “Active” off-grid electricity markets (more than one company selling solar home systems at scale [>20,000 customers]).

Concentration in “easy” markets:
- open markets, where private sector-led activities relatively easy
- Anglophone countries
- “Silicon Savannah” - Kenya as epicenter

*numbers denote # HHs without access to electricity
Achieving SDG 7 in “active” markets alone is a daunting task, with greater scale and competition needed.

1. Growth within each market*

For 1st Generation (scaling) OGS companies, financing to achieve:
- Scale
- Profitability
- Sustainability

Types of capital required:
- Growth stage equity
- Debt, mostly local currency

* Modelling Assumptions:
10 1st Generation company deployments capture 75% of market share in these markets.

2. Competition within markets**

Enable competitive, sustainable markets via new deployments (among 1st, 2nd and 3rd Gen OGS companies)

Early stage capital, to enable deployments to reach growth capital phase

Types of capital required:
- Grants
- Patient equity
- Early debt

** Modelling Assumptions:
remaining 25% market share captured by 2nd and 3rd generation company deployments, capped at 250,000 customers each.
“Active” markets have 15 scaled deployments, with total market penetration of around 6%.

Uganda
6.2M HHs - Off Grid Market Size
250,000 HHs - Market Penetration to date
4 - Deployments currently at scale:

Rwanda
1.7M HHs - Off Grid Market Size
100,000 HHs - Market Penetration to date
3 - Deployments currently at scale:

Kenya
7.1M HHs - Off Grid Market Size
750,000 HHs - Market Penetration to date
4 - Deployments currently at scale:

Tanzania
7.2M HHs - Off Grid Market Size
200,000 HHs - Market Penetration to date
4 - Deployments currently at scale:
To achieve SDG7 in “active” markets, 43 new deployments and $4.7 billion of capital (including $137M of grants) are needed.

**Uganda**

10 1st gen company deployments serving 4.5M HHs and requiring:
- $24M Grant
- $321M Equity
- $657M Debt

7 2nd and 3rd gen company deployments serving 1.5M HHs and requiring:
- $16M Grant
- $178M Equity
- $154M Debt

**Rwanda**

4 1st gen company deployments serving 1.2M HHs and requiring:
- $9M Grant
- $111M Equity
- $124M Debt

2 2nd and 3rd gen company deployments serving 0.4M HHs and requiring:
- $5M Grant
- $50M Equity
- $40M Debt

**Kenya**

10 1st gen company deployments serving 5.1M HHs and requiring:
- $24M Grant
- $337M Equity
- $718M Debt

7 2nd and 3rd gen company deployments serving 1.7M HHs and requiring:
- $16M Grant
- $183M Equity
- $175M Debt

**Tanzania**

10 1st gen company deployments serving 5.4M HHs and requiring:
- $24M Grant
- $345M Equity
- $751M Debt

8 2nd and 3rd gen company deployments serving 1.8M HHs and requiring:
- $19M Grant
- $205M Equity
- $184M Debt
And yet those are the “easy” countries. What about the rest of the continent, which is virtually untapped?

- “Latent” markets require substantial early-stage, risk tolerant capital in order to be unlocked

- New 2nd and 3rd generation OGS companies need to be seeded, while 1st generation OGS companies need support for international expansion

- Consolidation likely occur through M&A activities among the 1st, 2nd, 3rd generation companies
First, we have the “Big 3”: 46M off-grid HHs, requiring 142 new deployments and $9.2 billion

**Nigeria**

7.8M HHs to be served by 10 1st gen company deployments requiring:
- $24M Grant
- $411M Equity
- $849M Debt

12M HHs to be served by an estimated 47 2nd and 3rd gen company deployments requiring:
- $110M Grant
- $1.2B Equity
- $1.2B Debt

**Ethiopia**

5.8M HHs to be served by 10 1st gen company deployments requiring:
- $24M Grant
- $356M Equity
- $626M Debt

8.6M HHs to be served by an estimated 35 2nd and 3rd gen company deployments requiring:
- $82M Grant
- $920M Equity
- $894M Debt

**DRC**

4.9M HHs to be served by 10 1st gen company deployments requiring:
- $24M Grant
- $331M Equity
- $527M Debt

7.3M HHs to be served by an estimated 30 2nd and 3rd gen company deployments requiring:
- $70M Grant
- $786M Equity
- $758M Debt

**Modelling Assumptions:**
40% market captured by 1st generation deployments, remainder captured by 2nd and 3rd generation deployments, capped at 250,000 customers each
West and Central Africa have 36M off-grid HHs, and need 117 new deployments and $7.2B

**West Africa 1**
Cabo Verde, Gambia, Guinea, Guinea-Bissau, Mali Republic, Mauritania, Senegal Republic and Sierra Leone

- 3M HHs to be served by 10 1st gen company deployments requiring:
  - $24M Grant
  - $278M Equity
  - $318M Debt

- 4.5M HHs to be served by an estimated 19 2nd and 3rd gen company deployments requiring:
  - $45M Grant
  - $495M Equity
  - $468M Debt

**West Africa 2**
Benin, Burkina Faso, Ghana, Liberia, Niger, Sao Tome and Principe, Togo and Ivory Coast

- 5M HHs to be served by 10 1st gen company deployments requiring:
  - $24M Grant
  - $335M Equity
  - $544M Debt

- 7.6M HHs to be served by an estimated 31 2nd and 3rd gen company deployments requiring:
  - $73M Grant
  - $812M Equity
  - $781M Debt

**Central Africa**
Burundi, Cameroon, Central African Republic, Chad, Congo, Equatorial Guinea, Gabon, South Sudan and Sudan

- 6M HHs to be served by 10 1st gen company deployments requiring:
  - $45M Grant
  - $495M Equity
  - $468M Debt

- 9M HHs to be served by an estimated 37 2nd and 3rd gen company deployments requiring:
  - 86M Grant
  - $968M Equity
  - $925M Debt

**Active Markets**

**Modelling Assumptions:**
40% market captured by 1st generation deployments, remainder captured by 2nd and 3rd generation deployments, capped at 250,000 customers each.
Southern Africa and the rest of east Africa have 22M off-grid HHs, require 85 new deployments, and $4.8B

**Southern Africa 1**

Angola, Botswana, Lesotho, Namibia, South Africa and Swaziland

2M HHs to be served by 10 1st gen company deployments requiring:
- $24M Grant
- $258M Equity
- $234M Debt

3.4M HHs to be served by an estimated 14 2nd and 3rd gen company deployments requiring:
- $24M Grant
- $32M Grant
- $367M Equity
- $32M Equity
- $353M Debt
- $353M Debt

**Modelling Assumptions:**
40% market captured by 1st generation deployments, remainder captured by 2nd and 3rd generation deployments, capped at 250,000 customers each

**Rest of East Africa**

Comoros, Djibouti, Eritrea, Madagascar, Reunion, Seychelles and Somalia Republic

2.6M HHs to be served by 10 1st gen company deployments requiring:
- $32M Grant
- $367M Equity
- $353M Debt

Southern Africa 2

Malawi, Mauritius, Mozambique, Zambia and Zimbabwe

3.9M HHs to be served by 10 1st gen company deployments requiring:
- $24M Grant
- $268M Equity
- $278M Debt

5.9M HHs to be served by an estimated 24 2nd and 3rd gen company deployments requiring:
- $24M Grant
- $304M Equity
- $421M Debt

**Active Markets**

4M HHs to be served by an estimated 17 2nd and 3rd gen company deployments requiring:
- $24M Grant
- $39M Grant
- $441M Equity
- $413M Debt

- $258M Equity
- $304M Equity
- $421M Debt
SHS enterprise lens – what’s needed to hit SDG 7: 298 deployments and $26 billion, including $943 million in catalytic grants

Latent Markets

**104M HH** Off-Grid Market Size

- **42M HHs** to be served by 1st gen company deployments
- **62M HHs** to be served by 2nd and 3rd gen company deployments

1 1st gen company deployments requiring:
- **211M** In grant finance
- **2.9B** In equity
- **4.5B** In debt

254 2nd and 3rd gen company deployments requiring:
- **596M** In grants
- **6.7B** In equity
- **6.4B** In debt

Established Markets

**22M HH** Off-Grid Market Size

- **16M HHs** to be served by 1st gen company deployments
- **5M HHs** to be served by 2nd and 3rd gen company deployments

10 1st gen company deployments requiring:
- **80M** In grants
- **1.1B** In equity
- **2.3B** In debt

24 2nd and 3rd gen company deployments requiring:
- **56M** In grant finance
- **617M** In equity
- **555M** In debt
Mini-grids could catalyse rural SMEs and HH productive use; would require considerable grant capital given business model economics.

<table>
<thead>
<tr>
<th>Pre-Seed</th>
<th>Seed</th>
<th>Series A</th>
<th>Series B</th>
<th>Series C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6K</td>
<td>16K</td>
<td>40K</td>
</tr>
<tr>
<td>cumulative customers by end of stage</td>
<td>cumulative customers by end of stage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 Customers at end of Stage</td>
<td>600 Customers at end of Stage</td>
<td>6K Customers at end of Stage</td>
<td>16K customers at end of Stage</td>
<td>40K Customers at end of Stage</td>
</tr>
</tbody>
</table>

31.8M In total Capital Needs:
- 8M Debt
- 10.4 M Equity
- 13.4 M Grant

40,000 cumulative customers by end of series C
To serve 2.5% of SSA households via mini-grids in 2030 would require an additional 39,000 MG deployments and $7.1B in capital.

**Today 2017**

0.2% Of households served by mini-grids

0.5M* HHs with mini-grid connections

3,000 Total mini-grids

**In 2030 Assuming 2.5%**

2.5% Of households served by mini-grids

7.5 M HHs with mini-grid connections

42,000** Total mini-grids

*$7.1 billion In total capital would be required to achieve this

** Inferred from recent analysis of mini-grid concessions in Africa and authors’ knowledge of market trends

* * Assuming the following: 50kW installed capacity; 200 customers per site; $2.5/W capex and $1/W upfront soft costs
Shifting onto an SDG 7 Achievement Trajectory

Top-Down: Framing the Continental Challenge

+ Bottom-Up: Enterprise-Level Perspectives

= Combined Insights: Shifting onto an SDG 7 Achievement Trajectory
What the analysis tells us

Top-Down, predictive model:
Framing the Continental Challenge

- OGS must contribute massively toward SDG7
- Yet OGS not even keeping pace with population growth
- Financing requirements are massive

Bottom-Up: Enterprise-Level Perspectives

- OGS gets delivered through enterprises, one connection at a time
- OGS business are resource intensive
- Much more early stage capital is required, even for “established” enterprises

Combined Insights:
Shifting onto an SDG 7 Achievement Trajectory

- 298 new SHS deployments needed
- 39,000 new MGs
- $20B for SHS; $7B for MGs
- $4.5B patient capital required (75% for MGs)
- $4B affordability shortfall at household level
Summary: Achieving SDG7 in each model

Top-Down
Predictive Model

Achieving SDG7

Bottom-Up
Enterprise Level Model*

$31\text{billion}$
In mini-grid and OGS capital requirement

$7.5\text{million}$
HHs with Mini-Grid connections by 2030

$103\text{million}$
HHs with SHS connections by 2030

$4\text{billion}$
SHS affordability shortfall

$33\text{billion}$
In mini-grid and OGS investment

$7.5\text{million}$
HHs with Mini-Grid connections by 2030

$126\text{million}$
HHs with SHS connections by 2030

$4\text{billion}$
SHS affordability shortfall

Notes: SHS connections differ due to each model’s assumptions: the bottom-up model uses a static value for total # of HHs, while the top-down accounts for grid expansion and population growth. The financing figures being proximate are a coincidence, given the different inputs/assumptions used to derive them

* assuming 2.5% access via mini-grids and heavy grid investment
What this means for key stakeholders

**OGS Entrepreneurs**

What this means for established players:
- Growth in existing markets + massive expansion (and growth) in new markets.
- Need to figure out new ways to move into new markets.
- Need to double down on grant capital to fuel expansion.

What this means for 2nd and 3rd generation companies:
- Many, many more are needed.
- Space to enter established markets, but latent markets hold the real opportunity.
- Differentiate approach to market entry.

**Mini-Grid Entrepreneurs**

- Massive scale up required, comes down to capital raises and execution.
- Productive use and SME growth keys to justifying higher Capex.
- Focus on ring-fencing sites, raising capital around those
  - (including massive concessional financing).

**Investors**

- Industry demands much more patient capital:
  - Still an infant industry that requires significant concessional financing.
  - Especially for equity investors, very few opportunities
    - And yet there needs to be massive amounts of equity going into the market
      - Signals that new ventures need to be seeded.
    - Fundamental change required in order to motivate expansion into new markets and mobilise early stage capital.

**African Governments**

- Create enabling conditions for industry takeoff.
- Fiscal incentives and predictable regulatory environments will be critical.
- Consider the fiscal implications of off-grid vs grid, and public vs private sector led.
- Infrastructure finance principles: just like the grid.