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Photo by Damian Patkowski

Structuring and financing mini-grids

December 2021

Topics

1. Why are mini-grids interesting?
2. Legal frameworks for private sector mini-grids
3. For additional insights...

Why are mini-grids interesting?

- **What is a mini-grid?**

  Mini-grid – An off-grid electricity distribution network involving small-scale electricity generation. Mini-grids are used as a cost-effective solution for electrifying rural communities where a grid connection is challenging in terms of transmission and cost for the end user population density.

  Source - Wikipedia

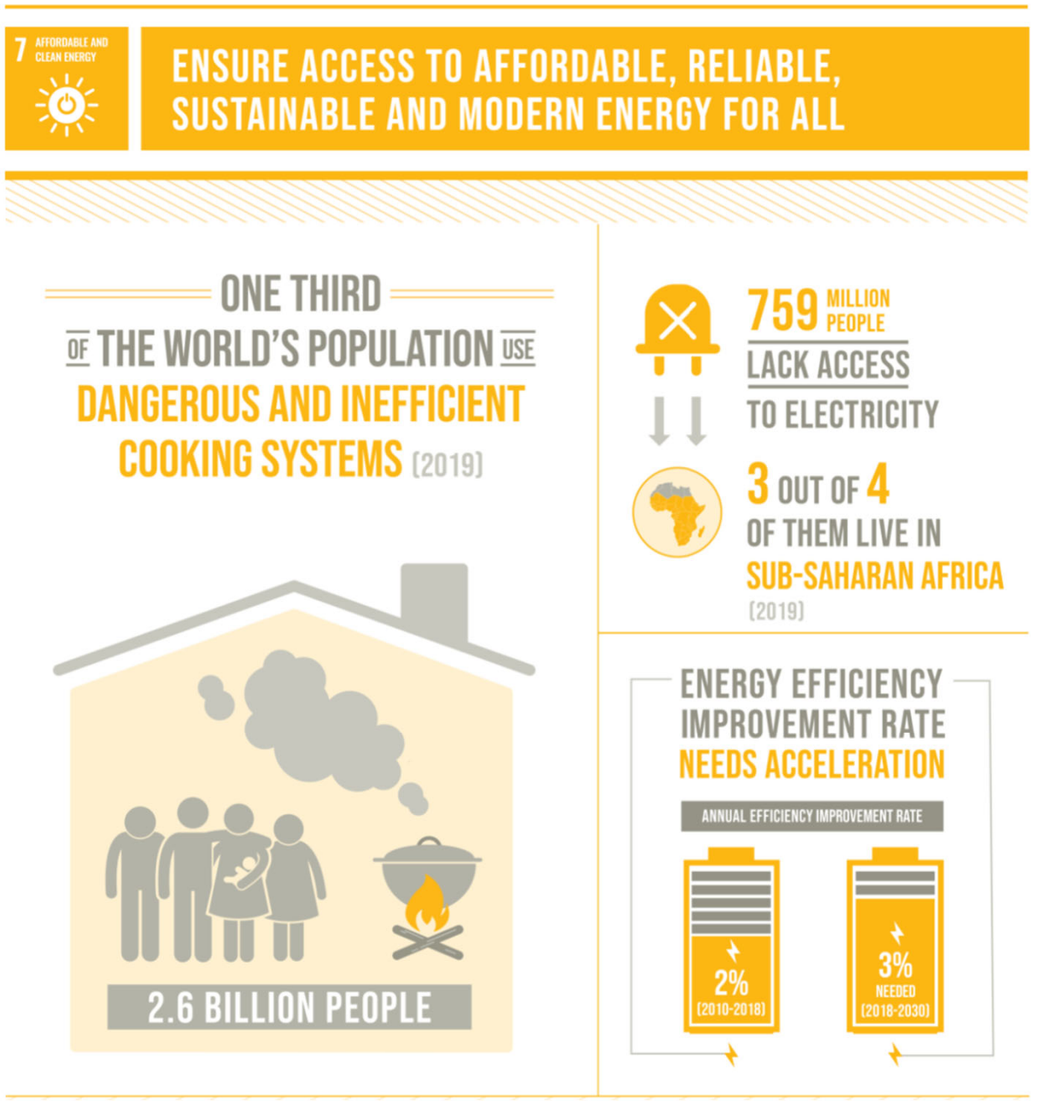
Why are mini-grids interesting?

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.

Source – sdgs.un.org

Why are mini-grids interesting?

SDG7 calls for action to ensure access to affordable, reliable, sustainable and modern energy for all.

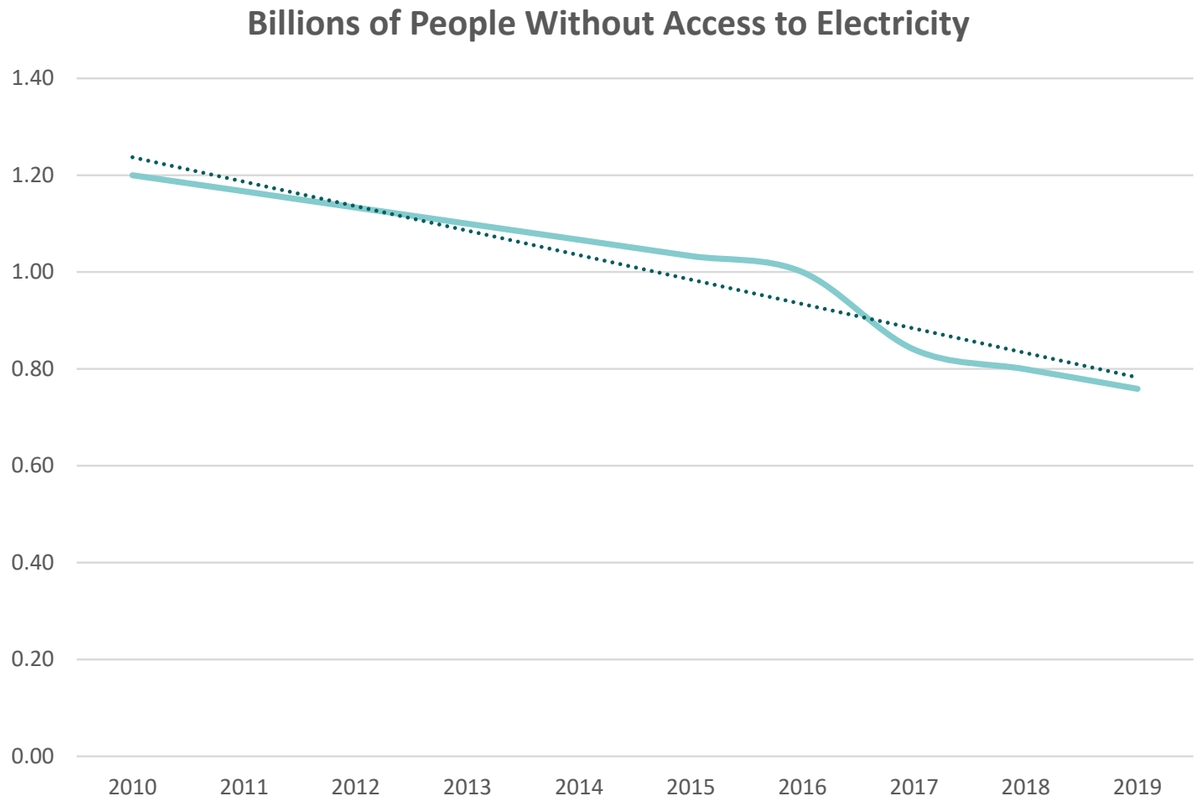


Source – sdgs.un.org

Why are mini-grids interesting?

Progress towards fulfilling SDG7 is real, but more is needed to achieve it by 2030.

- **In 2017, 89% of the world's population had access to electricity**
- **The World Bank projects that:**
  - **by 2030 approx. 8% will still lack access to electricity**
  - **90% of people without access to electricity will live in Sub-Saharan Africa**



Source –sdgs.un.org/goals/goal7, Mini-grids for Half a Billion People
Note – Data for some years is interpolated. Data for 2019 was calculated using different methods

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Why are mini-grids interesting?

Extending the main grid is probably not the best solution to reach half a billion people.

- **Extending the grid is expensive**
  - World Bank funded rural electrification programs to national utilities revealed an average cost of US$ 4,000 per connection for rural grid extensions constructed between 200 and 2014.
  - In 2019 the average cost per connection to 3rd generation mini-grids in Sub-Saharan Africa was less than $1,000.
- **Many emerging market utility companies struggle financially**
  - Only two utilities in Africa (in Uganda and the Seychelles) charge cost-reflective tariffs.
  - On average, implicit and explicit subsidies result in utilities in Africa selling electricity at a 41% discount to their actual costs
    - Most subsidies from government are non-transparent, periodic capital contributions

Sources – Re-thinking Power Sector Reform in the Developing Word, , Benchmarking Africa's Mini-Grids, Mini-grids for Half a Billion People

Why are mini-grids interesting?

Extending the main grid is probably not the best solution for reaching half a billion people.

- **Many emerging market utilities struggle to provide reliable electricity**
  - In several countries in Sub-Saharan Africa, households connected to the main grid report having electricity less than half the time
  - The average uptime for a modern 3rd generation mini-grid is 99%

Sources – Mini-grids for Half A Billion People, Clean Energy Mini-Grid Policy Development Guide

Why are mini-grids interesting?

Alternatives to the main grid are increasingly promising.

- **Solar home systems**
  - Capabilities
    - Affordable systems power limited lighting and charge light electronics
    - Larger systems may power televisions, fans
    - Modular systems with inverters and back-up generators:
      - can be sized to power almost any household load, but
      - are prohibitively expensive
  - Load growth leads to consumer frustration[1]
- **Mini-grids**
  - Can be sized to power almost any load, including productive loads
  - Are increasingly cost-effective
  - Have a proven track record

1. *Study commissioned by the US Africa Development Foundation to measure the effectiveness of its grants, 2020*

Why are mini-grids interesting?

Have we seen mini-grids before?

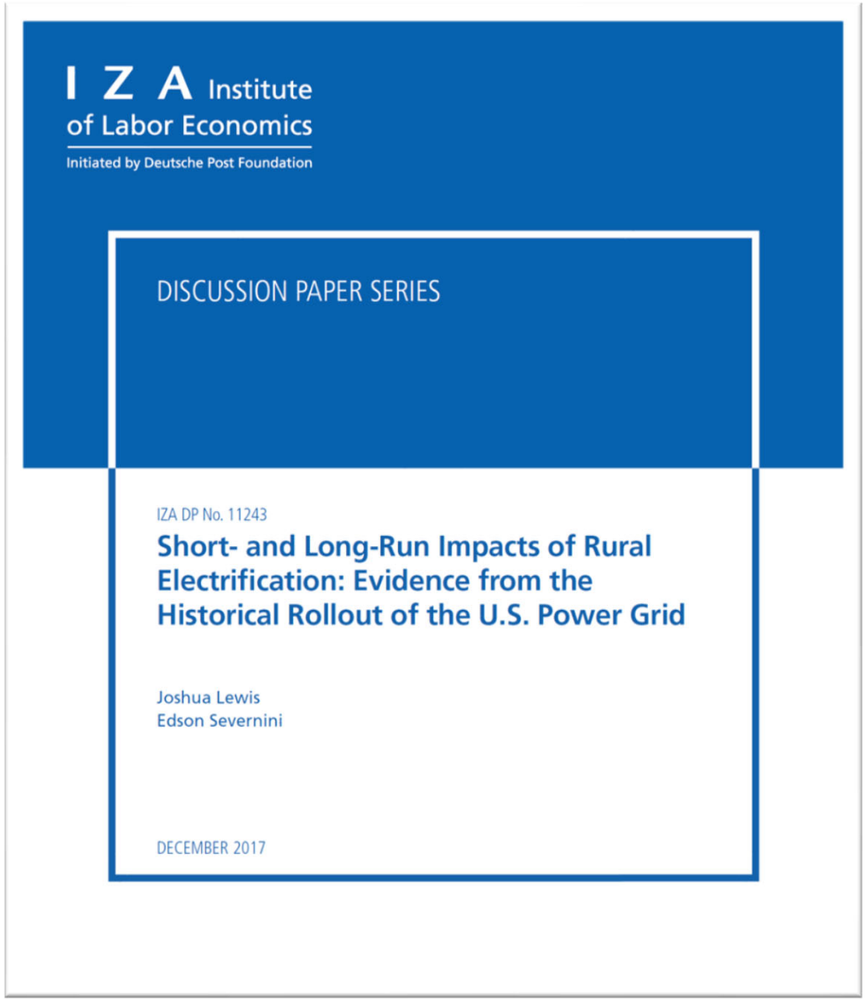
- **Between 1930 and 1960, 90% of rural U.S. households gained access to electricity**
  - 1930 – 10% of rural households served
  - 1960 – almost 100% of rural households served[1]
- **How was this achieved?**
  - Small distribution systems were developed as ‘islands’
    - Typically developed, owned and operated by municipalities or co-operatives
    - Rural electrification agencies (REAs) provided loans, loan guarantees, grants, and technical assistance
    - REAs and utilities financed household and productive appliances
  - Growing distribution systems were interconnected to increase reliability and decrease costs
  - Investor owned utilities formed by (i) acquiring (most of) these systems, and (ii) strengthening the transmission systems that interconnect them

1. *Short- and Long-Run Impacts of Rural Electrification: Evidence from the Historical Rollout of the U.S. Power Grid, J. Lewis, E. Severnini, 2017*

Why are mini-grids intersting?

What impact did mini-grids have on economic development in the U.S.?

- A 2017 paper by concluded that, “rural counties that gained early access to electricity experienced increased economic growth that persisted for decades after the country was fully electrified.”



Have we seen mini-grids outside the U.S.?

- As a rule, electricity systems in developed economies started as mini-grids
- By 2019, 19,000 mini-grids in 134 countries served 47 million people[1]

1. *Short- and Long-Run Impacts of Rural Electrification: Evidence from the Historical Rollout of the U.S. Power Grid, J. Lewis, E. Severnini, 2017*

Why are mini-grids interesting?

Breakthrough Energy

We need to act right away

The choices we make today will determine the kind of world our children and grandchildren inherit.

Getting to zero might be the most difficult challenge humankind has ever taken on. That's because nearly everything we do in our daily lives contributes to greenhouse gas emissions – from how we plug in to how we grow things, from how we make things to how we get around and how we stay cool and warm.

But we can avoid a climate disaster if we act now and act with purpose to launch the most ambitious innovation program the world has ever seen.

"To reach net-zero emissions, we need to first decarbonize electricity generation, then adopt carbon-free electrification across all sectors of the economy."
Breakthrough Energy

Why are mini-grids interesting?

Today's mini-grids are technically and economically superior.

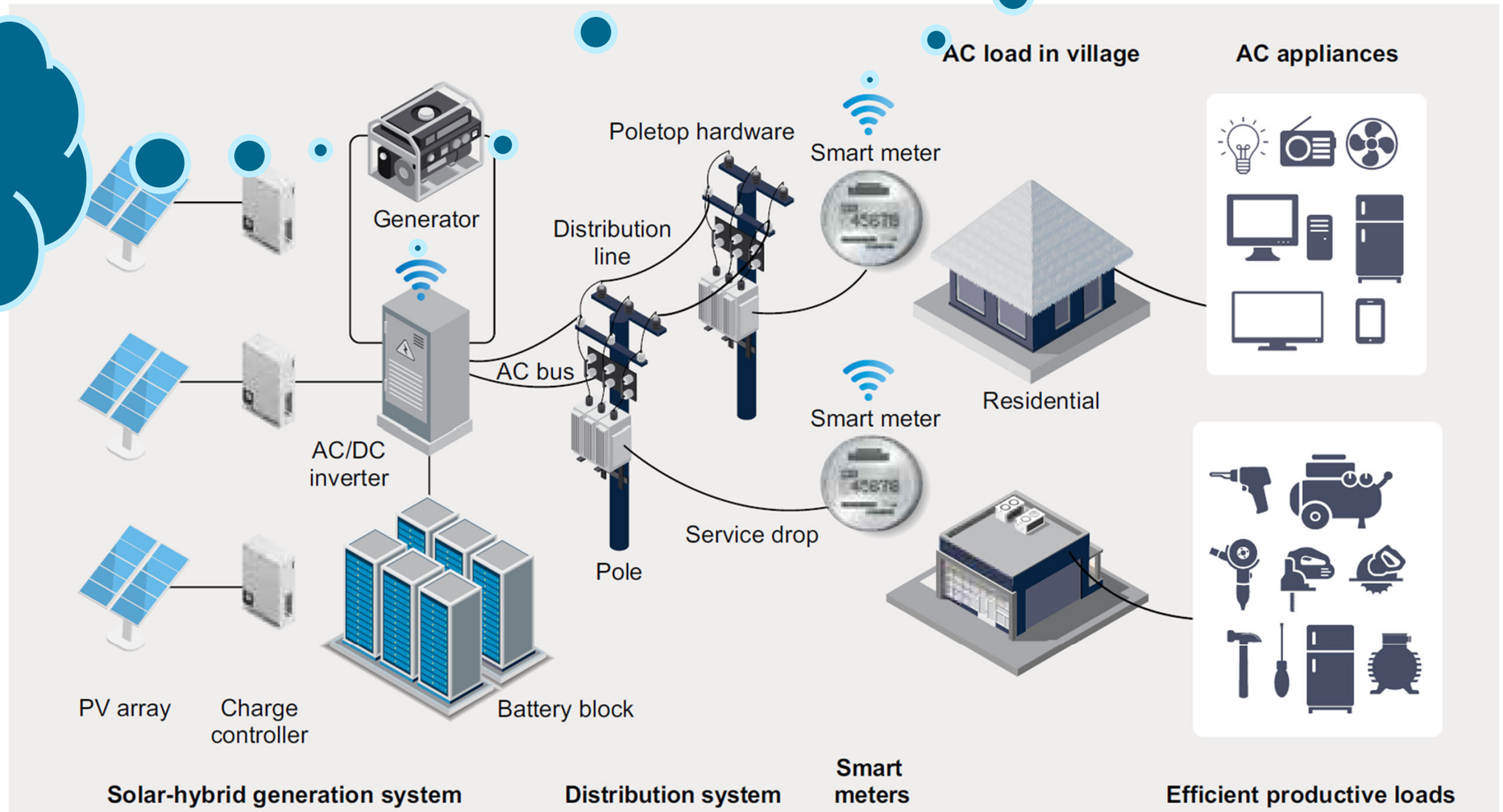
- **ESMAP (the World Bank's Energy Sector Management Assistance Program) identifies three generations of mini-grids**
- **1st generation**
  - Developed in the early 1900s, evolved into today's utilities
- **2nd generation**
  - Developed to serve rural areas in low income countries in the 80s, 90s, early 2000s
  - Use hydro or diesel as primary energy sources
  - Typically developed by communities, entrepreneurs, faith-based organizations
- **3rd generation**
  - Mostly hybrid systems (solar, diesel, battery energy storage)
  - Typically developed by private companies

Why are mini-grids interes

Remote monitoring of system performance increases O&M efficiency

Smart meters allow for prepayment, time of use tariffs, diagnostics, theft detection

Generators dramatically reduce the cost of firm power, even when used infrequently



Source – Mini-grids for Half a Billion People

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Why are mini-grids interesting?

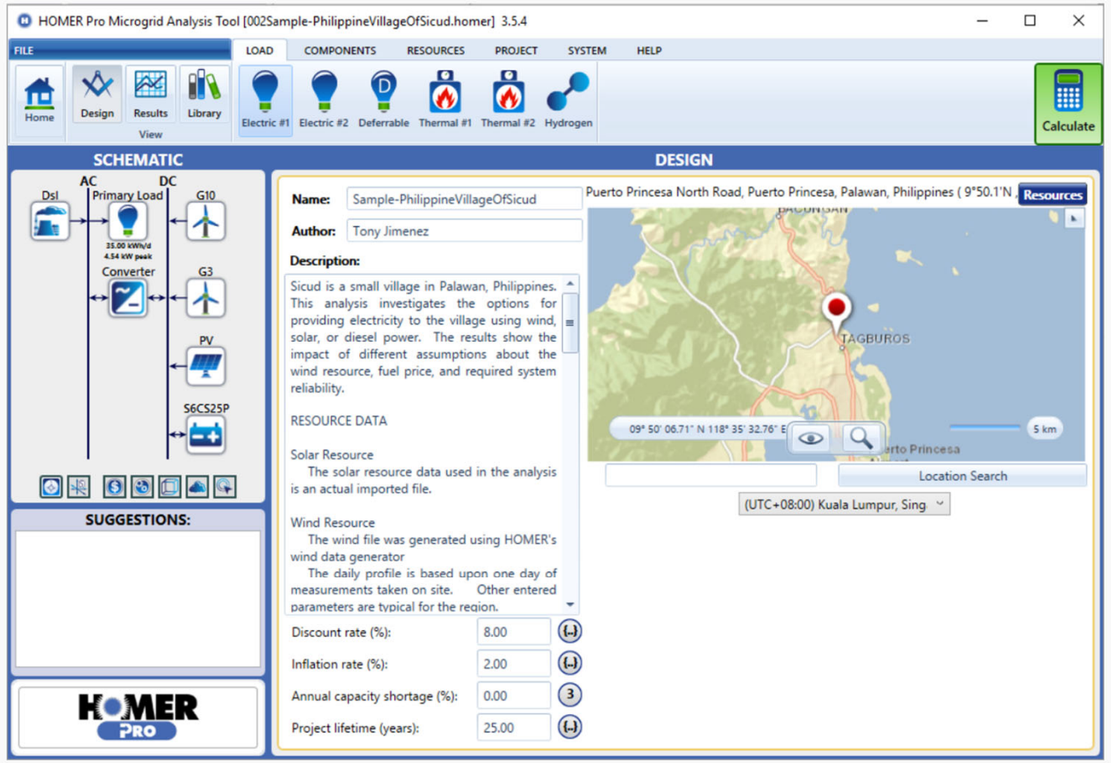
Optimizing a mini-grid presents an interesting engineering and economics problem. Fortunately, many smart minds have tackled this problem. HOMER is an example.

The HOMER Pro® microgrid software by HOMER Energy is the global standard for optimizing microgrid design in **all** sectors, from village power and island utilities to grid-connected campuses and military bases. Originally developed at the National Renewable Energy Laboratory, and enhanced and distributed by HOMER Energy, HOMER (Hybrid Optimization Model for Multiple Energy Resources) nests **three powerful tools in one software product,** so that **engineering and economics work side by side:**

Simulation

At its core, HOMER is a simulation model. It will attempt to simulate a viable system for all possible combinations of the equipment that you wish to consider. Depending on how you set up your problem, HOMER may simulate hundreds or even thousands of systems.

HOMER simulates the operation of a hybrid microgrid for an entire year, in time steps from one minute to one hour.

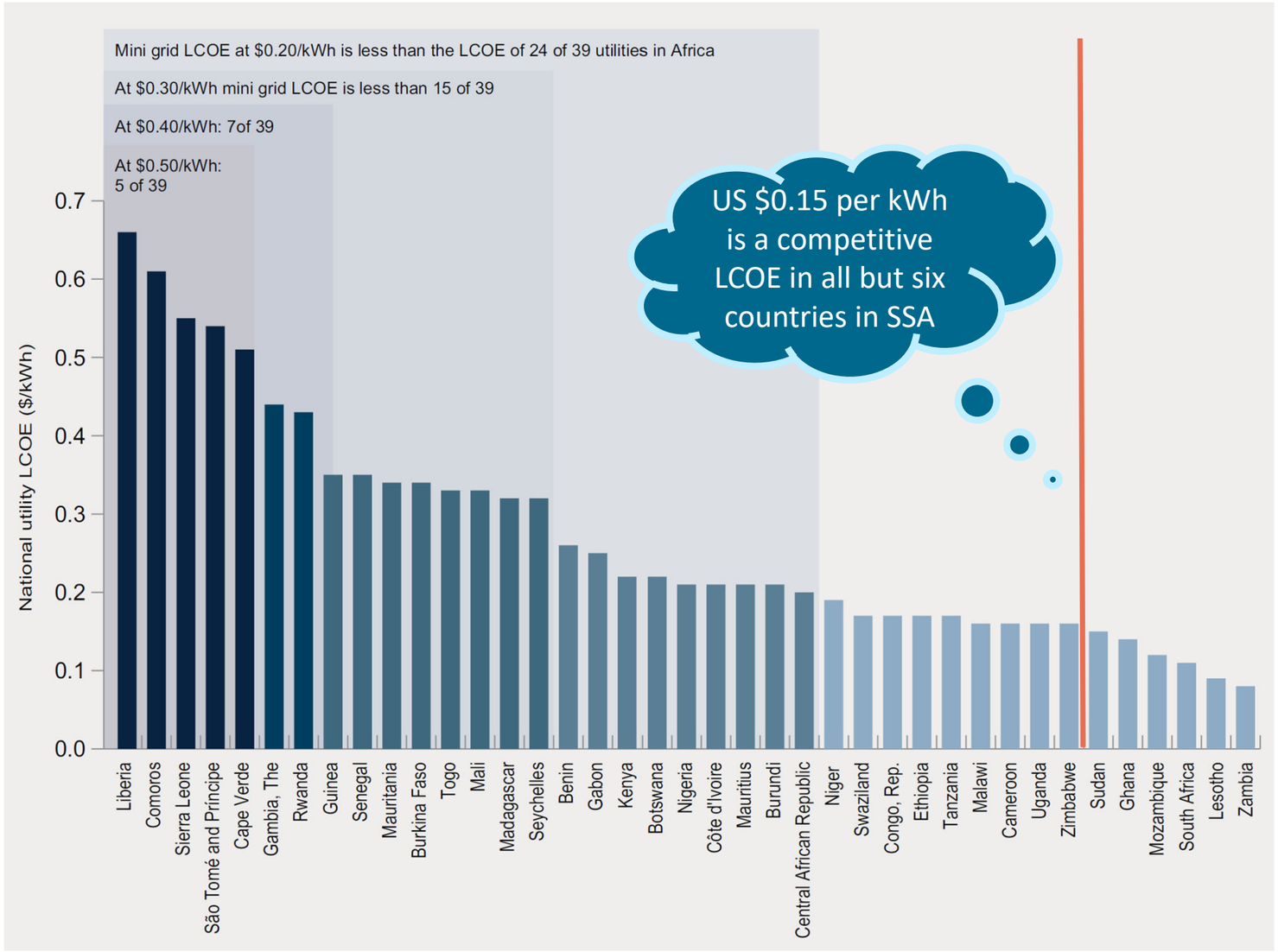


Source – homerenergy.com

Why are mini-grids interesting?

Properly optimized mini-grids will soon be (or are already) competitive with main grid power.

- Between 2010 and 2018 the cost of components dropped by approximately 70%
- Homer Energy suggests that mini-grids constructed today can achieve a levelized cost of energy of ~US$0.015[1]
- ESMAP's survey of mini-grids showed average uptimes of 97%



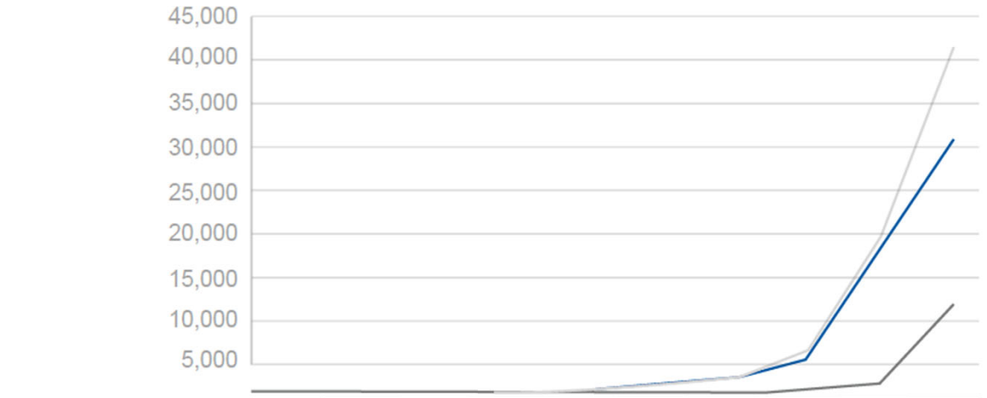
Source – Mini-grids for Half a Billion People

1. Webinar hosted by Homer Energy in 2020 using 2020 cost data. Levelized costs of energy are very sensitive to load factors. It is likely that ESMAP's calculations assume lower load factors.

Why are mini-grids interesting?

Since 2016, the development of mini-grids in Sub-Saharan Africa has rapidly accelerated.

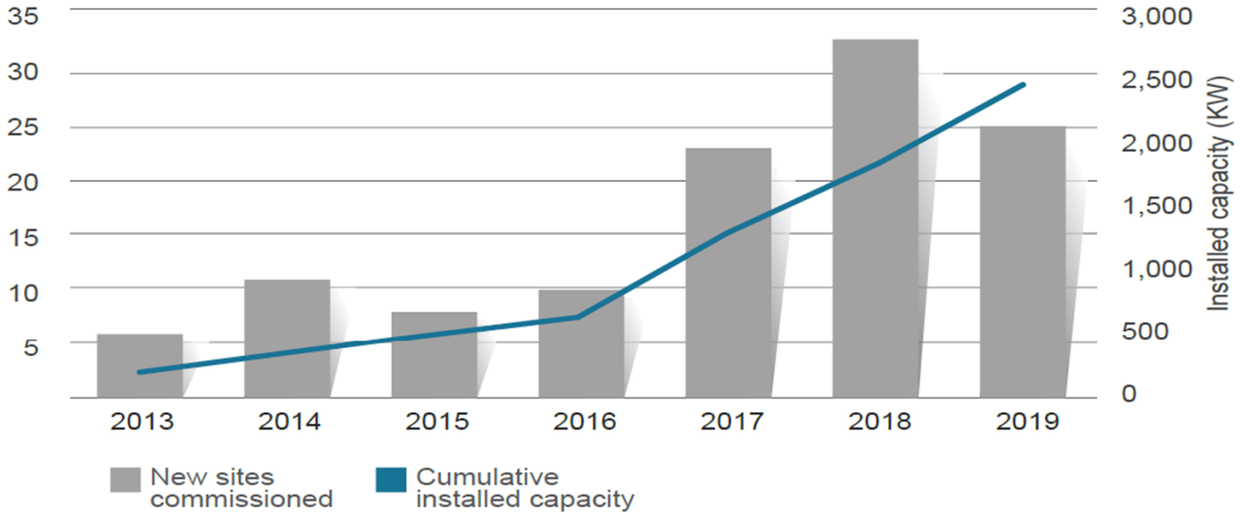
Total number of connections to mini-grids developed by members the African Mini-Grid Developers Association



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Eastern & Southern	85	85	85	407	778	1014	1,892	4,428	17,102	29,860
Western & Central	0	0	0	0	10	10	40	616	1,421	10,875
Total Connections	85	85	85	407	788	1,024	1,932	5,044	18,523	40,735

Source – Benchmarking Africa's Mini-Grids, AMDA

Installed capacity and new sites for mini-grids developed by members the African Mini-Grid Developers Association



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Why are mini-grids interesting?

In spite of this growth, significant challenges to true scaling up remain.

- **Legal & regulatory**
  - Legal and regulatory frameworks are sometimes missing
  - Regulatory and administrative processes are not designed for scale
  - On average, obtaining required licenses and permits take 12 months in Sub-Saharan Africa
- **Availability of finance**
  - Small-scale infrastructure is difficult to finance
  - Mini-grids do not sell energy to corporate offtakers

Topics

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3. For additional insights...

Legal frameworks for private sector mini-grids

The African Mini-Grid Developers Association (AMDA) has identified several business models for delivering mini-grids.

Utility driven approach

- National utility constructs and operates mini-grids
- Cross-subsidies and subsidies to national utility may lower price per kWh
- Pace of implementation likely constrained by national utility's access to funds

ESCO approach

- National utility finances and owns mini-grids installed and/or operated by private investors or cooperatives
- Tariffs charged to customers cover operator's operating expenses

Split asset approach

- Distribution network financed and owned by national utility
- Private developers finance and install generation assets and operate both generation and distribution

Private investment (with capex grants)

- Private developers develop, finance, install, own and operate mini-grids
- Government regulates the sector
- Capex grants (from governments or donors) are required to achieve affordable tariffs

Legal frameworks for private sector mini-grids

The AMDA also developed a decision tree to assist governments in deciding which model to pursue.

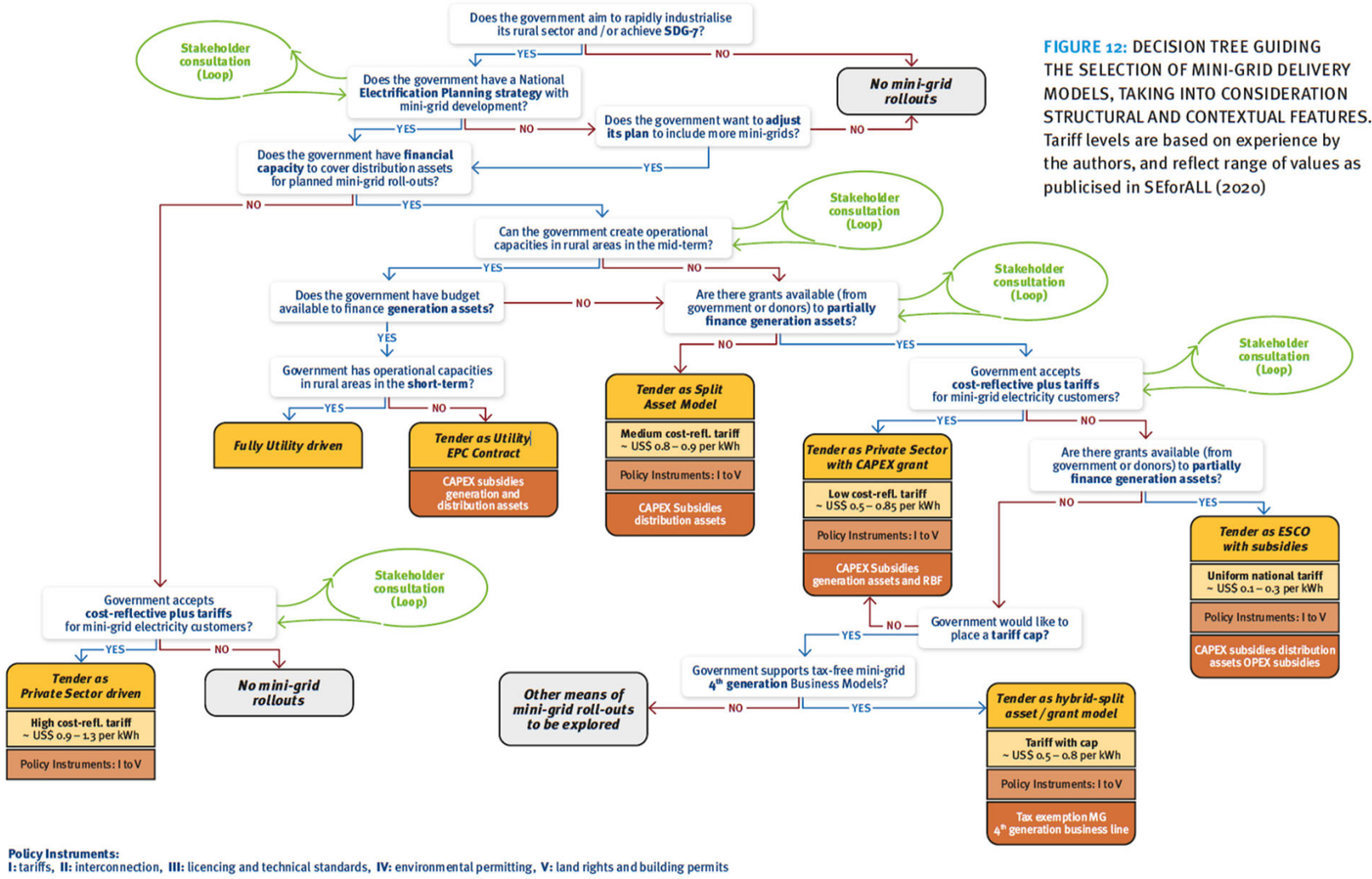
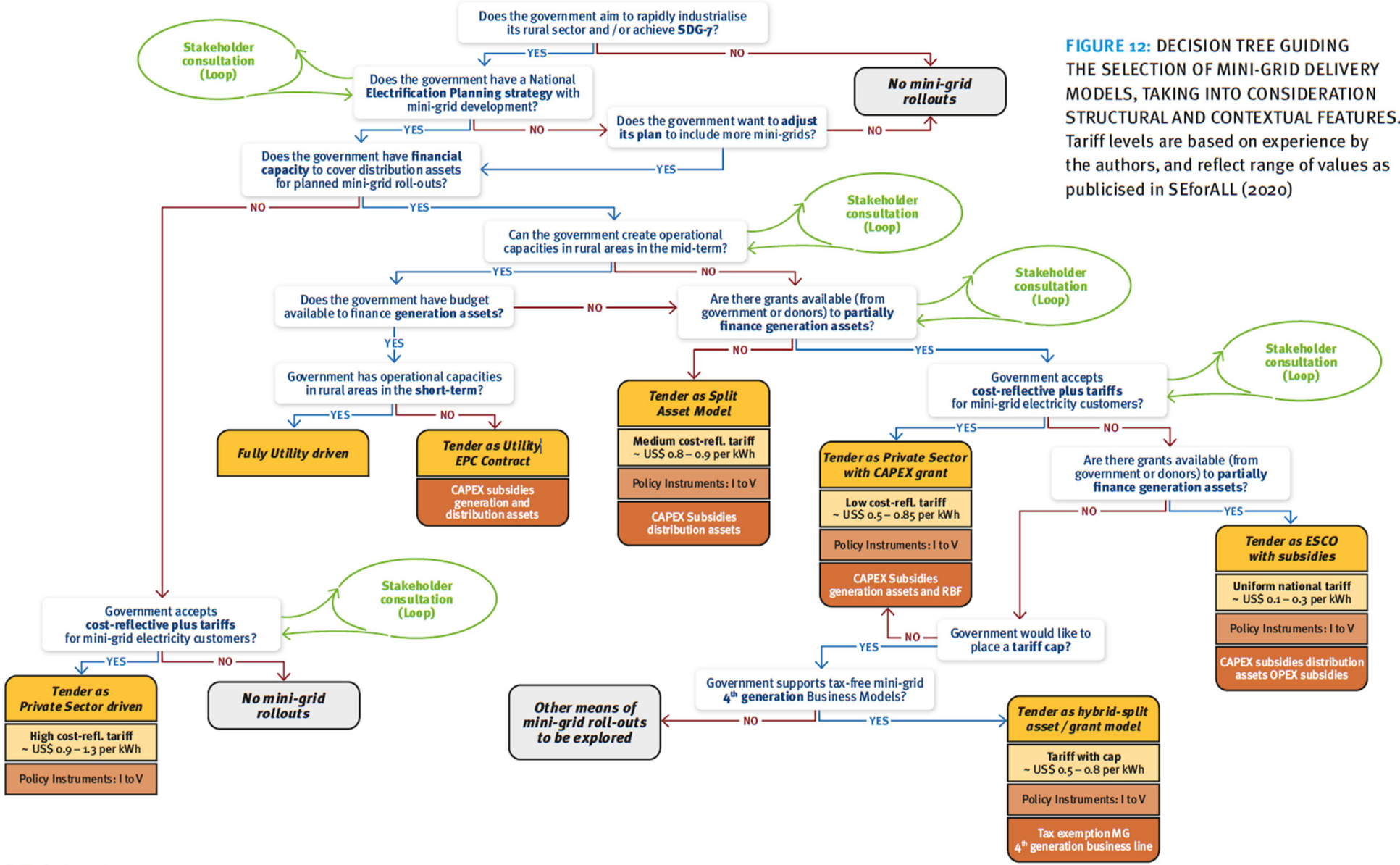


FIGURE 12: DECISION TREE GUIDING THE SELECTION OF MINI-GRID DELIVERY MODELS, TAKING INTO CONSIDERATION STRUCTURAL AND CONTEXTUAL FEATURES. Tariff levels are based on experience by the authors, and reflect range of values as publicised in SEforALL (2020)



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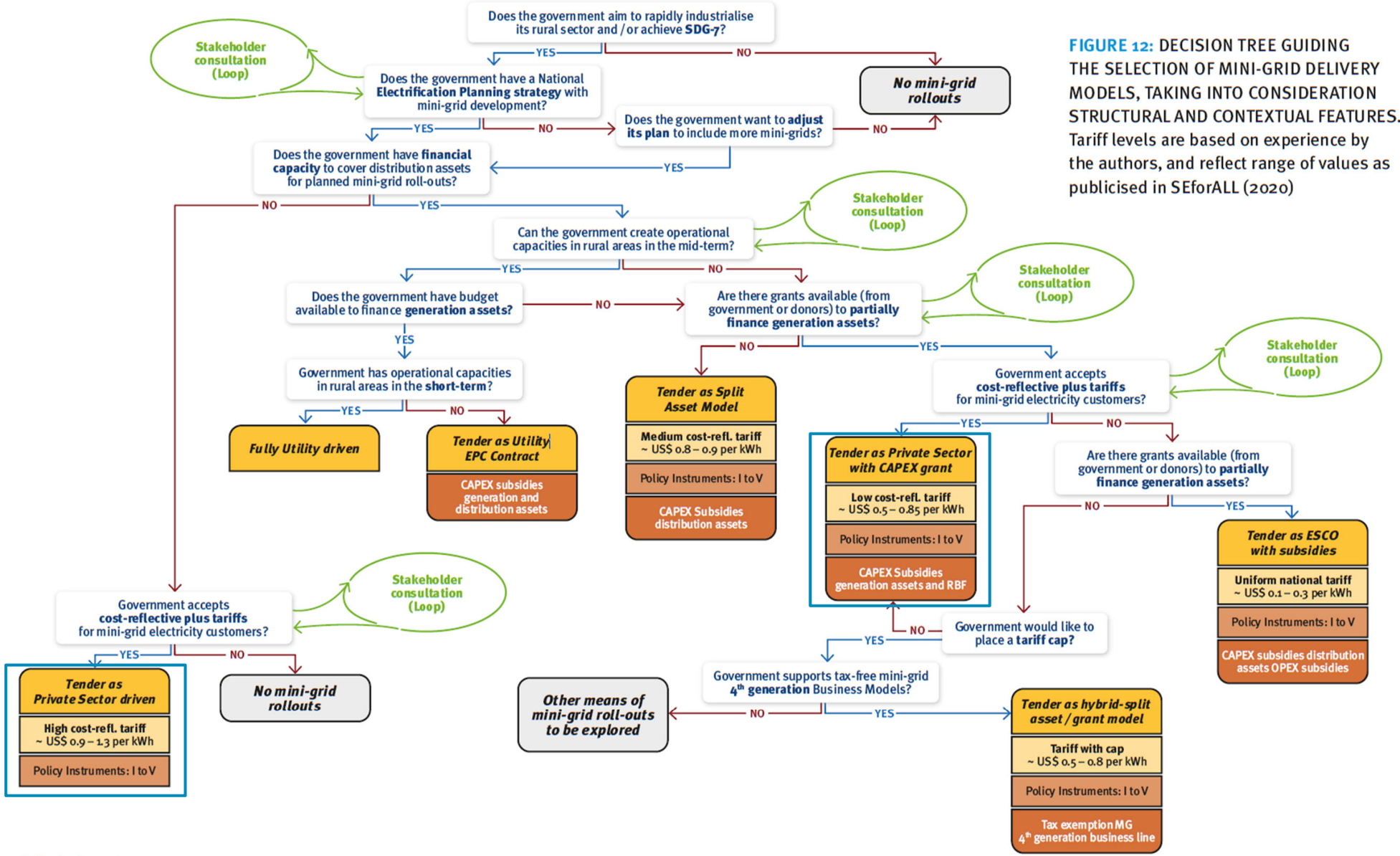
Policy Instruments:
I: tariffs, **II:** interconnection, **III:** licencing and technical standards, **IV:** environmental permitting, **V:** land rights and building permits

Source – Clean Energy Mini-Grid Policy Development Guide

Private sector-led options are highlighted in blue.



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Source – Clean Energy Mini-Grid Policy Development Guide

Legal frameworks for private sector mini-grids

Legal frameworks designed to facilitate private investment should address at the following issues.

- Market entry
- Tariffs
- Technical requirements
- Main grid arrival

} These two issues are highly inter-dependent

Legal frameworks for private sector mini-grids

Options for regulating market entry include:

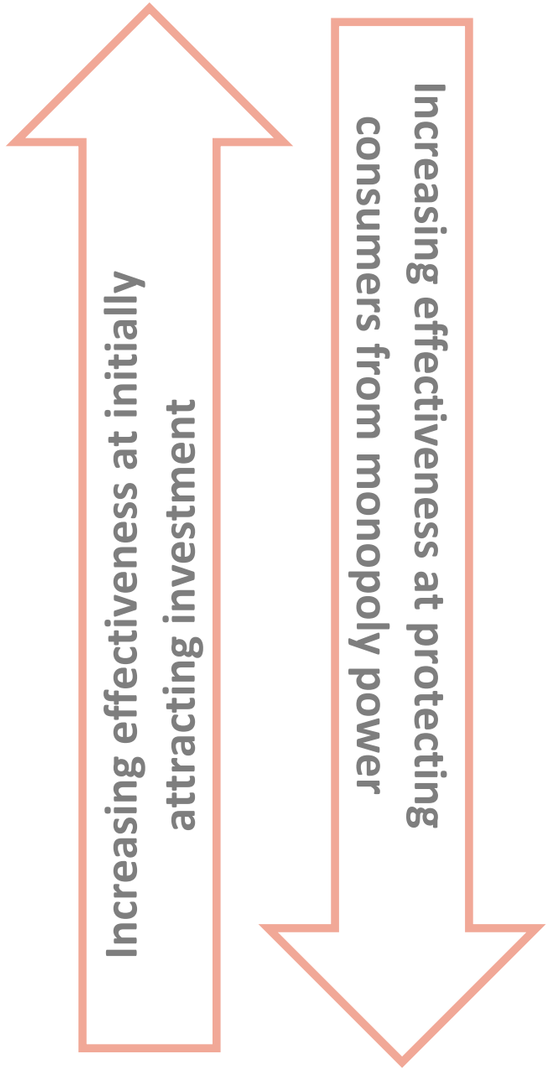
- Don’t regulate market entry
- Require operators to register by providing minimal information
- Require operators to obtain a (relatively standard) permit
- Require operators to obtain (tailored) licenses

In some countries, different requirements will apply based on the size of the mini-grid

Legal frameworks for private sector mini-grids

Options for setting tariffs include:

- **The willing buyer, willing seller model (don't regulate tariffs)**
- **Set price caps based on the efficient costs of a new market entrant**
  - Similar to feed-in tariffs
  - Performed very well in Tanzania
- **Require developers to bid the tariff they will charge**
  - Increases up-front costs, reduces investor interest
- **Individualized cost-based tariffs**
  - Requires significant effort by regulators and developers/operators
  - Likely to destroy the viability of all but the largest systems
- **Apply national uniform tariffs**
  - For investment to occur, LCOE for a particular mini-grid must be significantly lower than the national tariff



Legal frameworks for private sector mini-grids

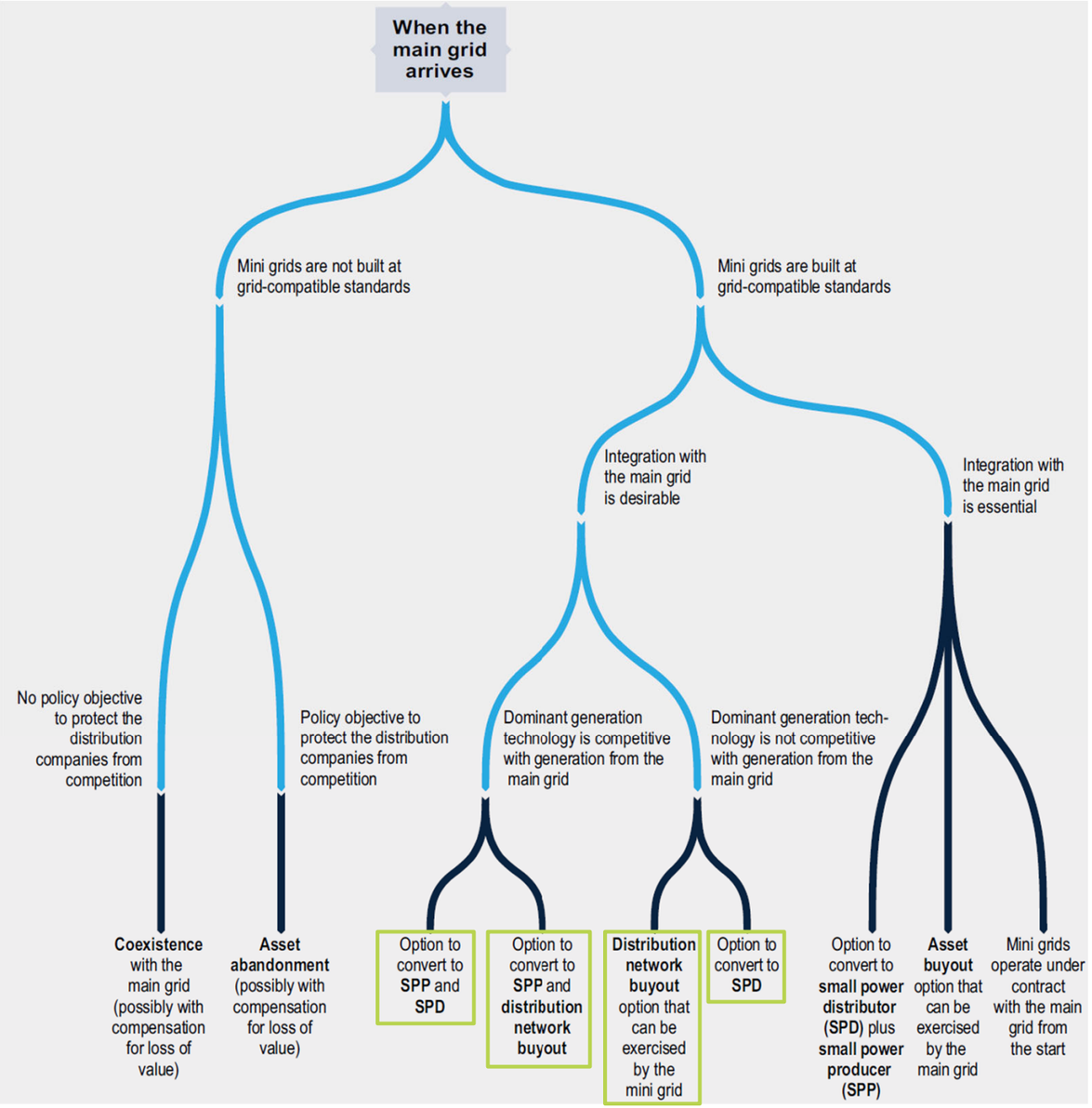
Options for technical specifications include:

- **Regulate safety only**
  - Allows for innovation (DC mini-grids are much less expensive)
  - May limit productive uses
  - May result in stranded assets if/when main grid arrives
- **Require mini-grids to meet main grid standards**
  - Higher up-front capital costs
  - Limits potential for stranded assets upon main grid arrival
  - This is how electricity systems in OECD countries developed

Legal frameworks for private sector mini-grids

When the main grid arrives

- **To facilitate investment, legal frameworks must address main grid arrival at the outset**
- **Are these options feasible?**
  - Most of these options do not seem feasible in our view.
  - Options that are feasible in our view are highlighted in **green**.



Source – Mini-grids for Half a Billion People

Legal frameworks for private sector mini-grids

Options for regulating technical specifications include:

- **Regulate safety only**
  - Allows for innovation
  - May limit productive uses
  - May result in stranded assets if/when main grid arrives
- **Require mini-grids to be compatible with main grid standards**
  - Higher up-front capital costs
  - Limits potential for assets to become stranded upon main grid arrival
  - This is how electricity systems in OECD countries developed

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Clients often ask us why an emerging market government tendering a PPP may prefer to use a put & call option agreement (a "PCOA") to provide sovereign credit support for an offtaker's or contracting authority's obligations instead of a sovereign guarantee. This note examines five of the most commonly cited reasons that a government may prefer to offer a PCOA

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