Welcome to this month's educational webinar

Optimizing Design & Mitigating Risks

For Mini-grids and Distributed Generation

In Africa

Our presentation will begin
at the top of the hour.
See you soon!

Optimizing Design & Mitigating Risks

For Mini-grids and Distributed Generation in Africa

Peter Lilienthal

Founder, HOMER Energy by UL/ Global Microgrid Lead, UL

Joseph Padbury

Business Development Manager Sub-Saharan Africa, UL Renewables

James Trudeau

Global Business Development Manager, UL

David Mintzer

Head of Microgrid Advisory Services, UL

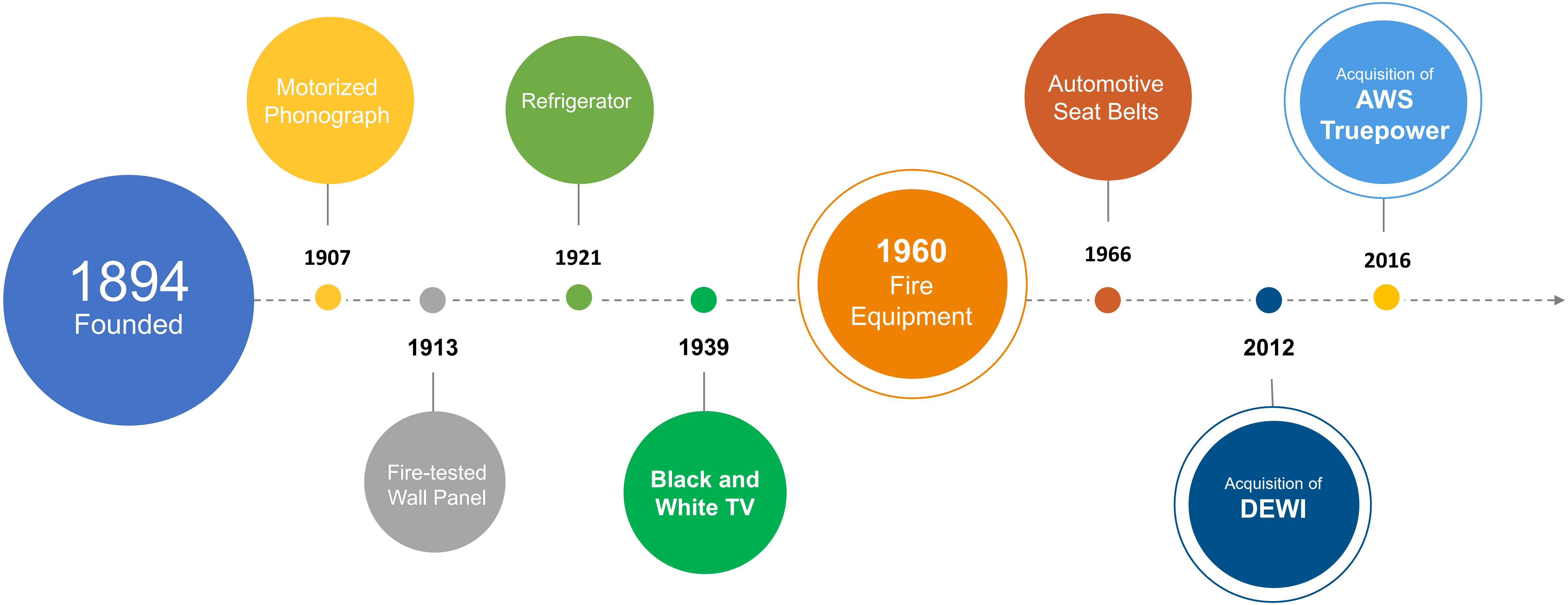
HOMER Energy by UL

Agenda

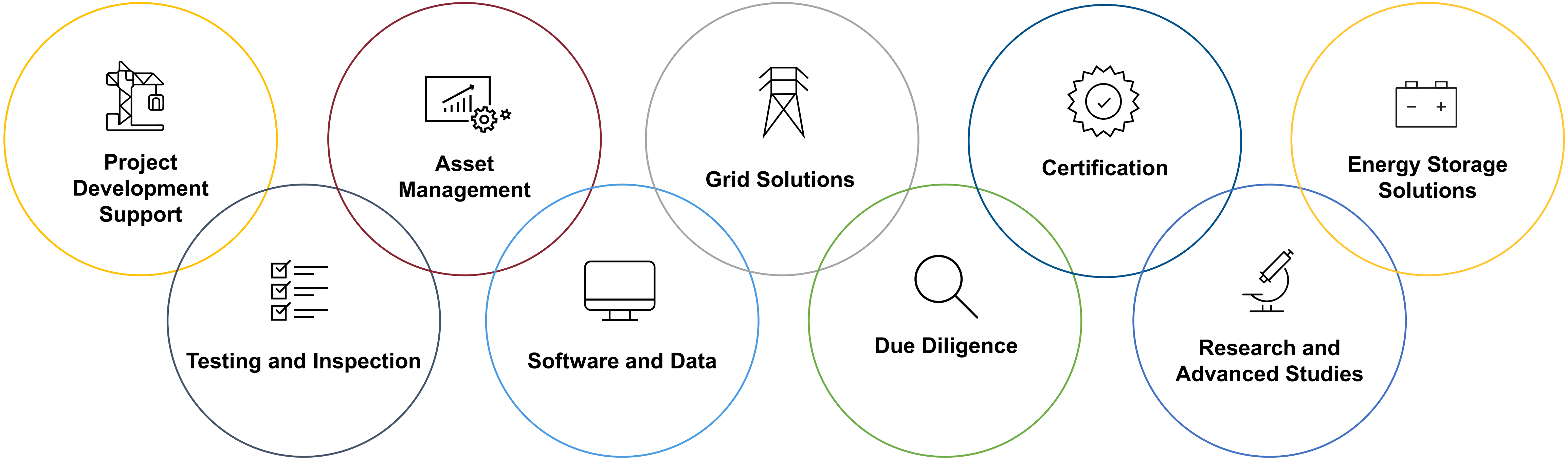
- **Growth & Need in Africa** – Joseph Padbury
  UL Business Development Manager, Sub Saharan Africa
- **Design Issues in Early Stage Development** – Dr. Peter Lilienthal
  UL Global Microgrid Lead, HOMER Energy Founder
- **Equipment & Operations** – James Trudeau
  UL Global Business Development Manager
- **Finance Stage** – David Mintzer
  Head of Microgrid Advisory Services, UL
- **Q&A** – Marilyn Walker
  UL Microgrids Operations Manager, HOMER Energy Founder

UL Builds Trust in Renewables

UL: A History of Trust



Renewable Energy Solutions



Key Office Locations - Renewables

500+
RENEWABLE ENERGY EXPERTS

35+ *years of*
EXPERIENCE IN RENEWABLE ENERGY

UL has assessed
100+
UTILITY-SCALE SOLAR PROJECTS SINCE 2013

UL has issued
350+
Type certificates on over 150 wind turbines

UL has performed
700+
WIND TURBINE POWER PERFORMANCE TESTS

ADVISED 90%
of the wind industry's top project developers and plant owners

Forecast provider for
70+ GIGAWATTTS
OF INSTALLED RENEWABLE ENERGY PROJECTS

Independent Engineer/Owner's for
600+
WIND AND SOLAR PROJECTS SINCE 2012

Mini-Grids – A Growth Market

The need

- Estimated 600 million people in Sub-Saharan Africa without access to electricity
- UN SDG – “Ensure access to sustainable, affordable, reliable and modern energy for all” by 2030.
- Too costly for utilities to extend grid to rural communities

Mini-Grids – A Growth Market

The solution

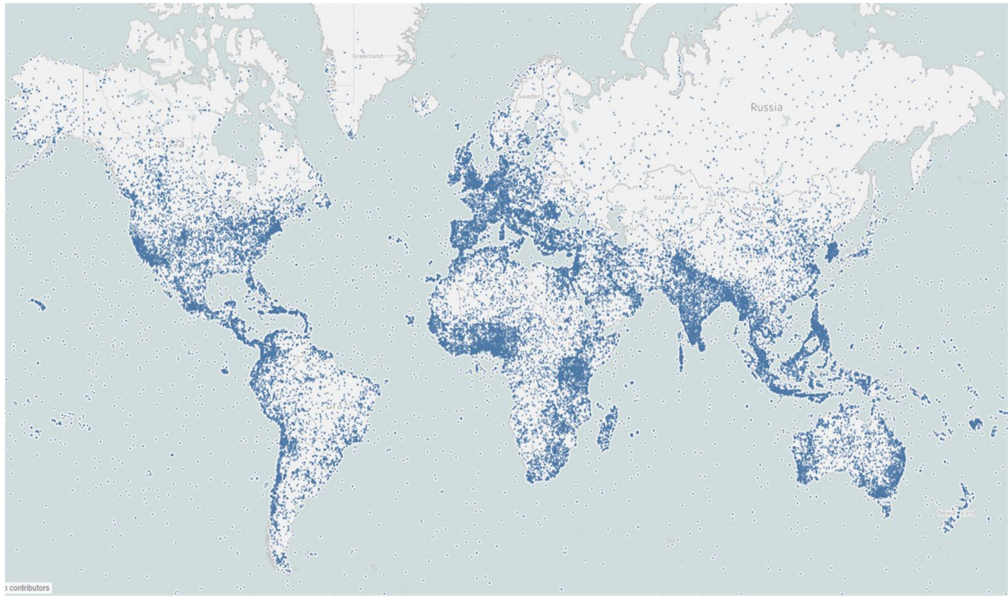
- Rapid technology development and operational efficiencies in recent years
- Mini-grids now a practical and viable solution to electrifying rural areas.
- Mini-grids fill an important space between individual solutions
  - solar home systems
  - extensions of national grid
- Mini-grids offer cost effective, rapid deployment options for utilities and private developers for rural, isolated communities
- However, in order for mini-grids to be safe and sustainable, meeting the needs of the end user and funders, there needs to be real effort made in risk mitigation, from the initial concept design, through to equipment selection.

HOMER Energy by UL

Presented by Peter Lilienthal, Ph.D.
Founder, HOMER Energy by UL
Global Microgrid Lead, UL

Designing Hybrid Systems for over 25 years

- 1992 – 2008 at NREL
- 2009 – HOMER Energy created; exclusive license



De-facto Global Standard

- >250,000 people have used HOMER
- >100,000 opted-in to our hybrid system design network

Global Data

- >3 million HOMER files
- >75,000 projects modeled since 2014

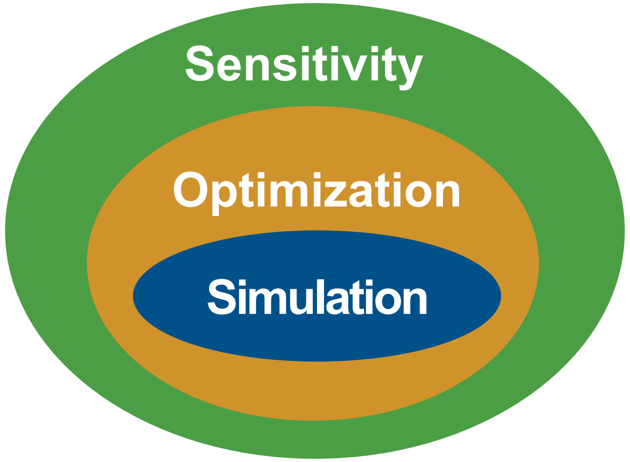
Microgrid/ DER Optimization & Design in HOMER®

Inputs

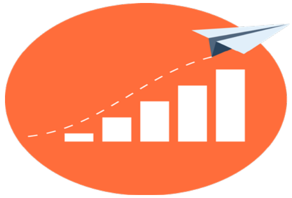
- Economics
- Load Profile
- Site-Specific Renewable Resources
- System Components

Analysis

HOMER Pro / HOMER Grid



Results

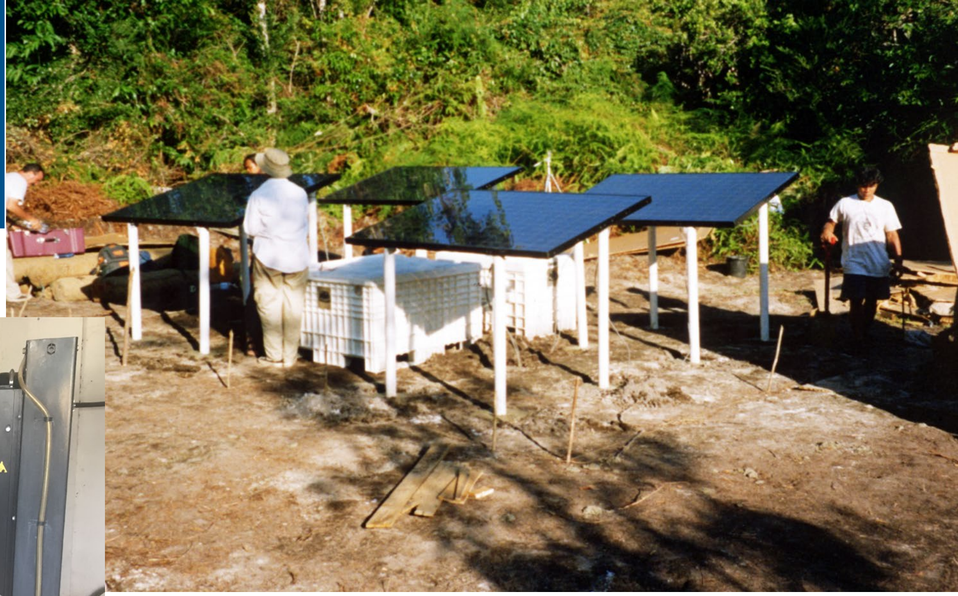


Economics & Engineering

- System Sizing
- Performance Details
- Financials
- Proposal & Detailed Reports

HOMER Energy by UL

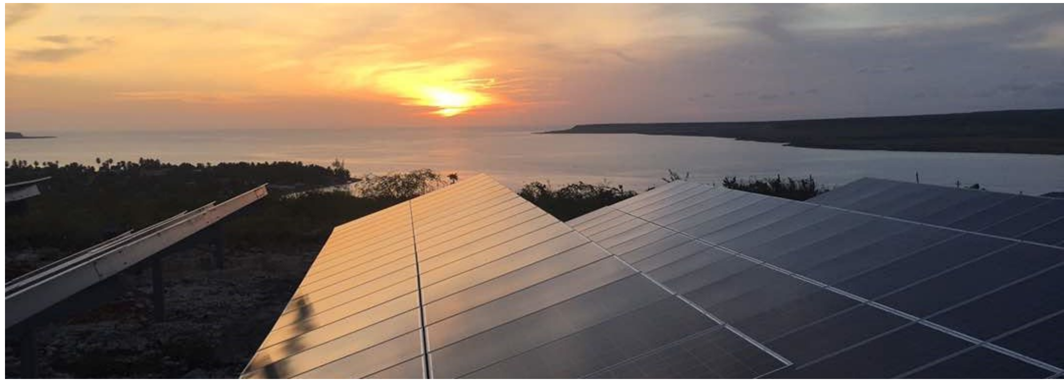
Options for Energy Access



- Old
  - Grid extension
  - Diesel generators
- New
  - Minigrids
  - Stand alone solar (SHS)

Distributed Generation Landscape

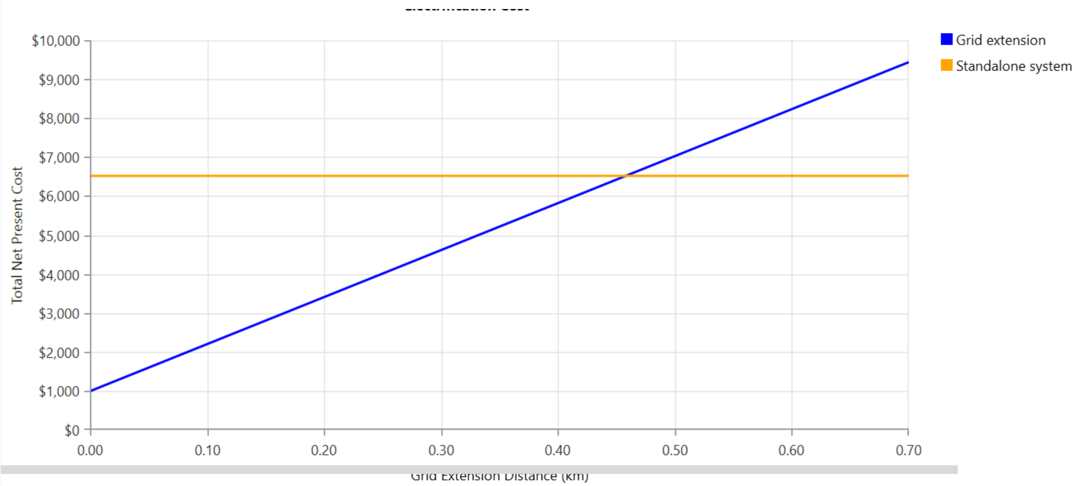
- Distributed Generation
  - Power produced where it is used
- Microgrids
  - Capable of isolated operation
- Minigrids
  - Always operates isolated



Grid Extension vs. Minigrids vs. SHS

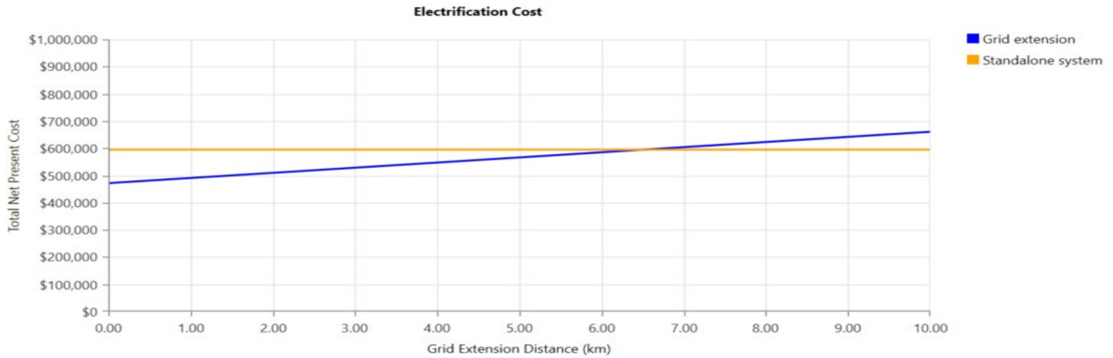
- Key considerations
  - Distance
  - Load size
  - Power quality & reliability
- SHS preferable for small homes
- Hybrid systems preferable for productive uses
  - ABC Model
    - Anchor, Business, Consumer

Breakeven grid extension distance = 460 meters



Very small water pumping system

Breakeven grid extension distance = 6.5 kms.



Village with 62 kW peak load

Designing Hybrid Systems

- Degrees of design freedom
  - PV sizing
    - Daytime power
    - Battery charging
  - Battery sizing
    - 24-hour power
  - Tariff considerations
  - Reliability
    - Backup requirements
- Lots of choices, often with incomplete data
- **Sensitivity Analysis**

Diesel Alone Is No Longer Suitable for Prime Power

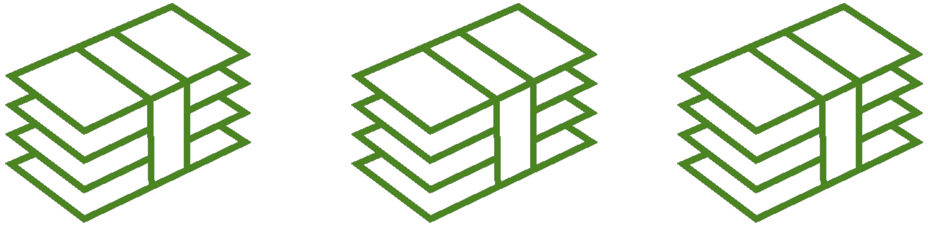
- Solar + batteries now less expensive
  - But more complex
- Diesel generators still ideal for backup power

	Diesel	Solar + batteries
Capital cost	Low ↓	High ↑
Operating cost	High ↑	Low ↓

- Complementary resources
- Diesel backup used infrequently provides reliability
  - Greatly reduces size of solar + batteries

Financing is the Key

Hybrid minigrids are clearly preferable, but they require capital up front.



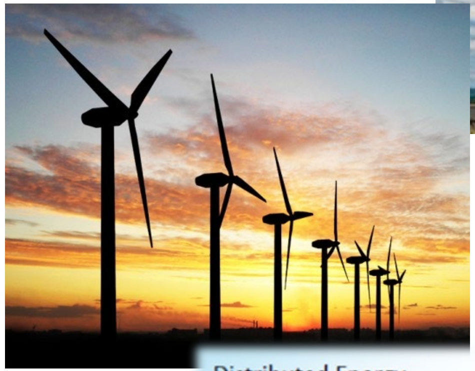
Energy Storage – What is it?

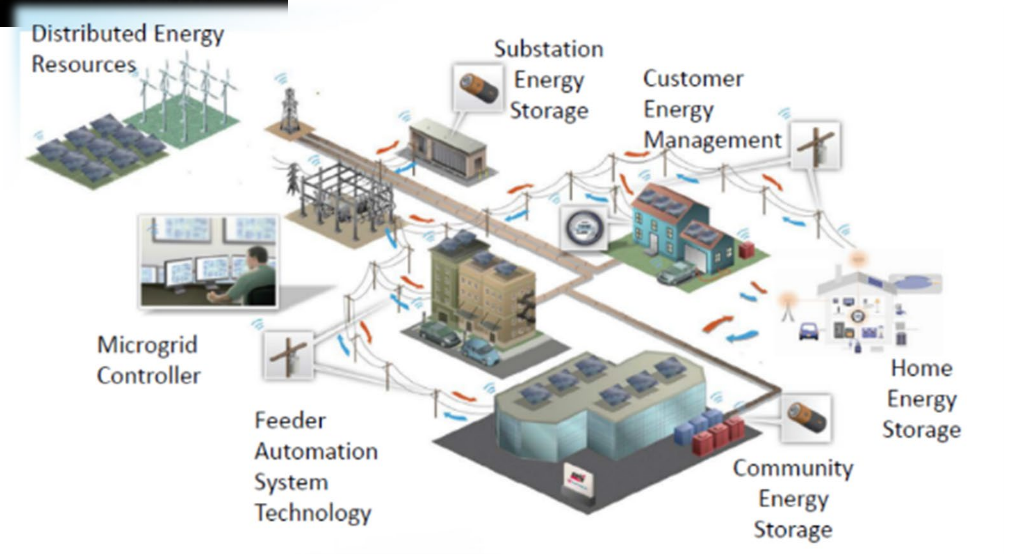
Presented by James Trudeau
Global Business Development Manager, UL

- Energy can be stored electrically, chemically, or mechanically
- Lithium-ion batteries are over 95% of the energy storage market, but many other technologies are being developed
- Energy Storage can serve loads ranging from small homes to minigrids to large utility scale projects
- The definition of what Energy Storage is has been changed by international fire codes like NFPA 855 and IFC 2021. It now includes battery systems for UPS, telecom, and any application over 20 kWh in size.

Energy Storage – Great Benefits

- Enables wider use of renewable energy
  - Solar
  - Wind
  - Reduces variability of renewable energy
- Improves electric grid stability
  - Voltage
  - Frequency
- Enables broader microgrid and minigrid use
  - Can be connected to the grid
  - Or completely off grid
- Provides improved reliability for end users
- Replaces fossil fuel power plants
  - Energy Storage combined with solar can often replace diesel generation, reducing energy costs from $0.45 to $0.15/kWh
  - The Solar + Storage solution reduces ground and air pollution, and reduces O&M costs





Energy Storage – Great Risks

28 Major
ESS Fires
in South Korea
2017 – 2019

Energy Storage – Great Risks

ESS System Explosion, Arizona

Energy Storage – Great Risks

Thermal Runaway - 25 Lithium-Ion Cells

Energy Storage – Great Risks

Thermal Runaway - 25 Lithium-Ion Cells

Let’s do the math…

- A single 18650 Li-Ion cell is about 10 WH
- 25 cells is about 250 WH
- A typical ESS module has 5,000 WH
- A typical rack has 10 modules for 50,000 WH
- A typical rack has over 200 times more energy than the 25 cells in the video
- A typical 2 MW container has over 3,000 times more energy than the 25 cells in the video

Energy Storage – Risk Mitigation

3 Layer Safety Approach

Installation Codes

NEC: National Electric Code (NFPA 70)

NFPA 855: Standard for the Installation of Stationary Energy Storage Systems

IFC 2018 / 2021: International Fire Code

Battery Safety Certification Standards

UL 1973: Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications

UL 9540: Energy Storage Systems and Equipment

Testing for Performance or Safety

UL 9540A: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

Energy Storage – Risk Mitigation

It Is All About Risk Management

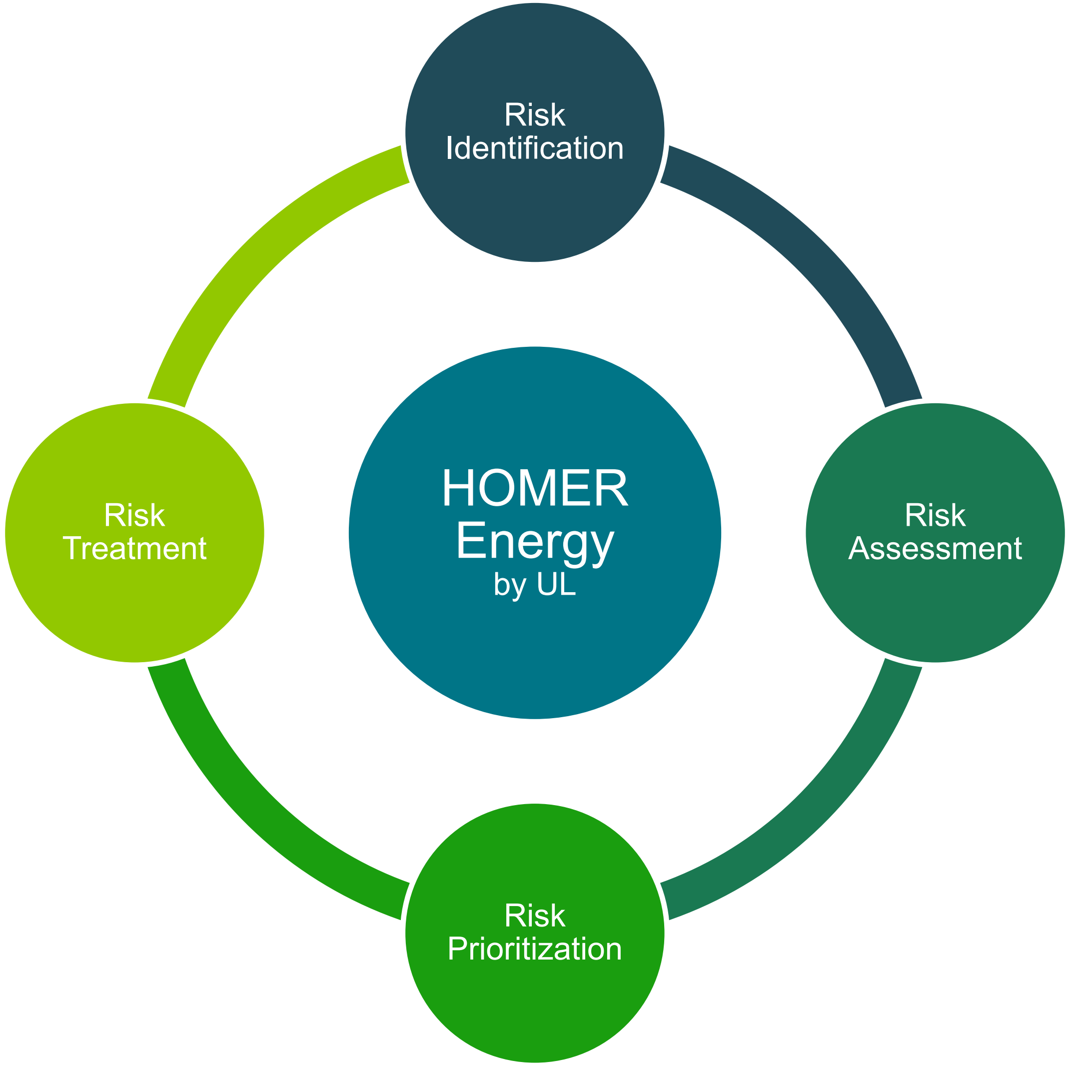
The use of good installation codes and equipment standards, coupled with system testing and experienced independent project oversight, is the most effective method to manage the risk profile of battery energy storage projects.

- Financial Risks
- Operational & Performance Risks
- Safety Risks
- Environmental Risks

Project Bankability

Presented by David Mintzer
Head of Microgrid Advisory Services, UL

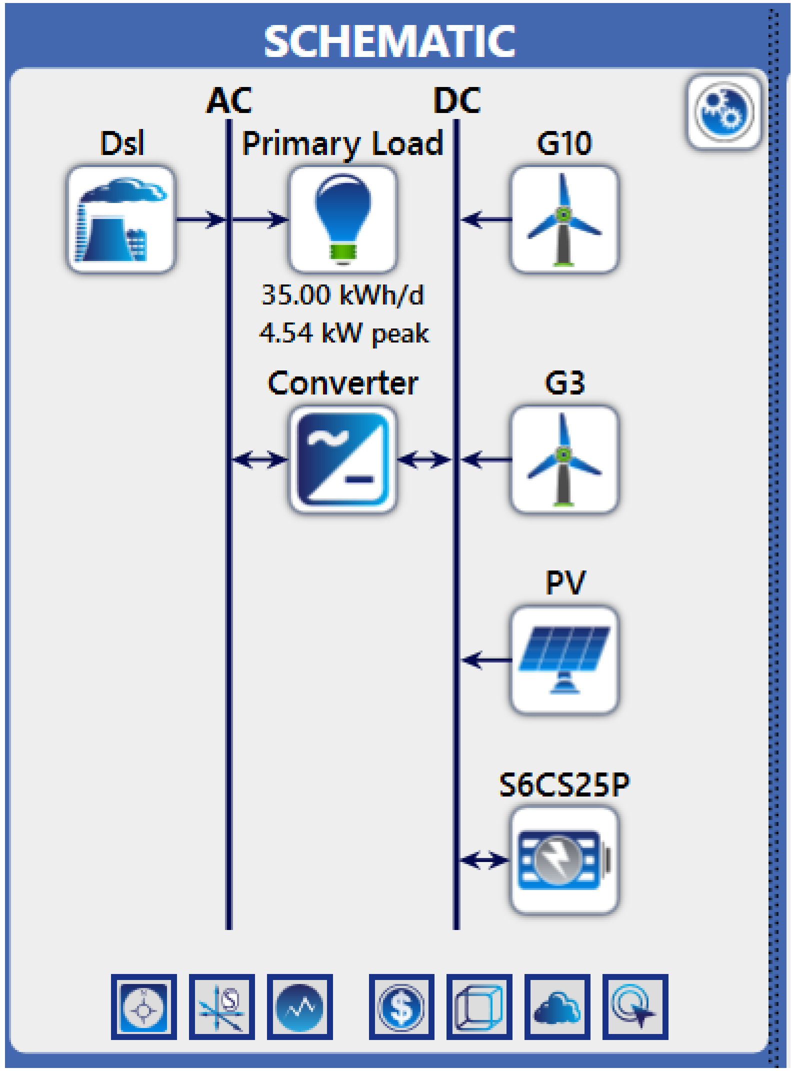
- DG & minigrid projects provide a variety of services to a diverse user base
- Projects are not expense-free and usually financed
- Obtaining funding is largely an exercise in Risk Management



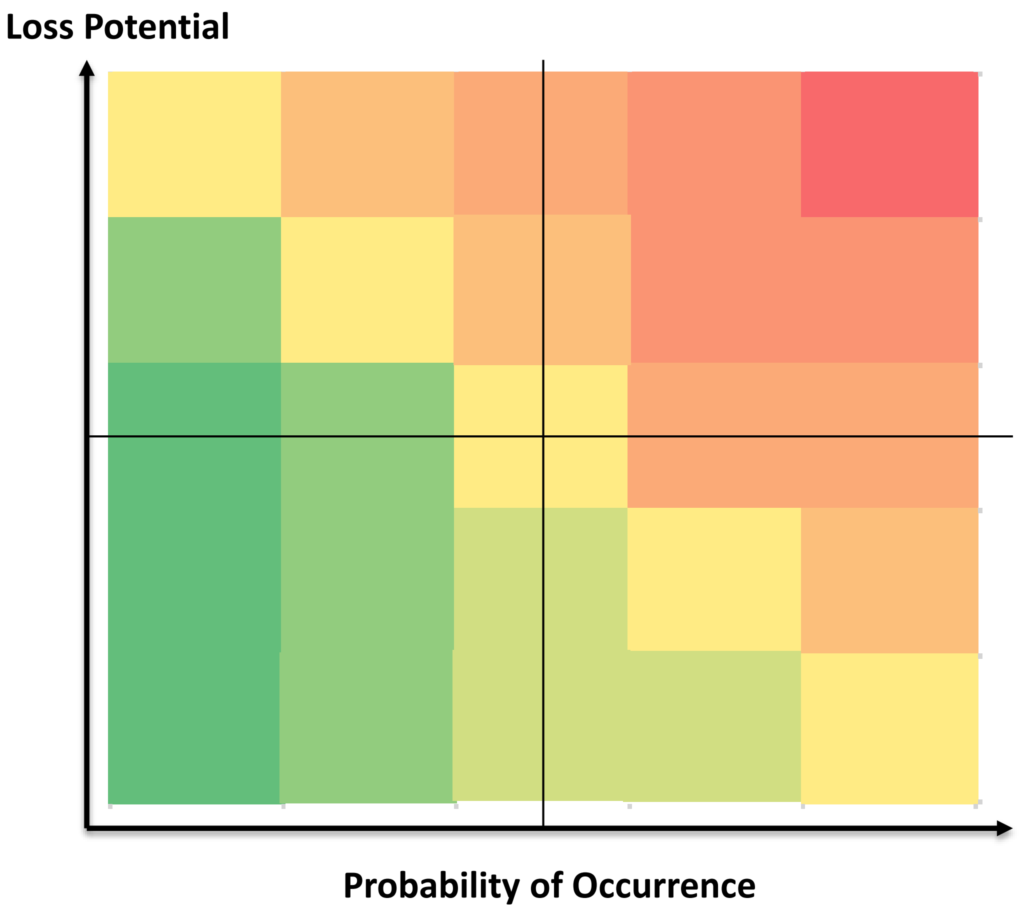
System & Functional Risks

A system can only be as smart and as strong as the weakest element

- **Generating Equipment**: Many technologies, each has its pros/cons
- **Power Electronics**: Connection to loads, gen. sources and grid
- **Management System**: Controls energy flow
- **Safety Concept**: Technology and regulatory requirements
- **System Integration**: Building a reliable, running system out of all the above components. Probably one of the most underestimated contributions to a system.
- **Construction**: Turning the ideas into reality, execution
- **Operation**: Keeping the system running, to serve the customer
- **End-of-Life Concept:** sustainable and economical



Identification/Assessment/Prioritization



Level 1 - Avoidance
Unacceptable risk potential, sophisticated tools recommended

Level 2 - Transfer
High risk potential, measures necessary

Level 3 - Reduction
Medium risk potential, usage of measures recommended

Level 4 - Tolerance
Low risk potential, proofing measures of risk mitigation

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Mitigation – Example

Simulation Results

System Architecture: Diesel (8.00 kW) HOMER Cycle Charging
PV (50.0 kW) Generic 1kWh Li-Ion (100 strings)
Generic 3kW (20.0) Converter (4.00 kW)

Capacity Shortage (0.00 %)
Scaled Average (3.00 m/s)

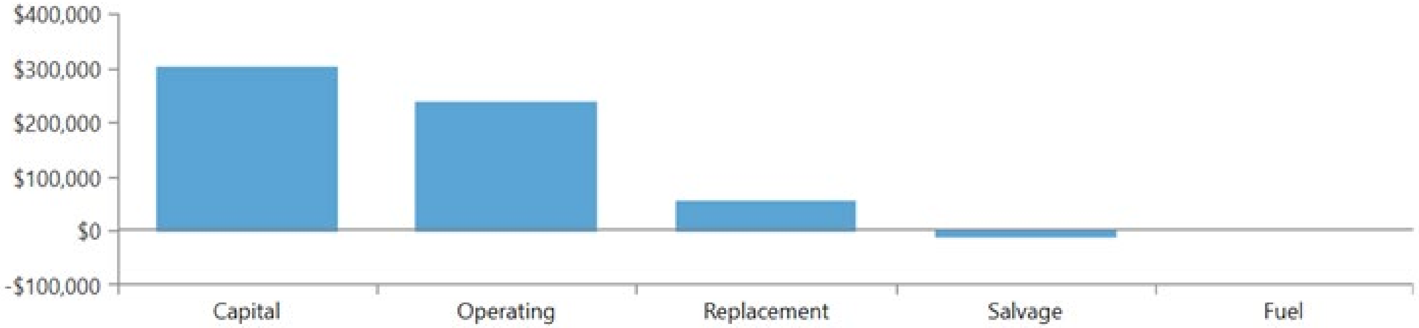
Total NPC:	$589,785.80
Levelized COE:	$3.57
Operating Cost:	$22,068.10

Emissions

Cost Summary | Cash Flow | Compare Economics | Electrical | Fuel Summary | Diesel | Renewable Penetration | Generic 1kWh Li-Ion | PV | Generic 3kW | Converter

Cost Type
- Net Present
- Annualized

Categorize
- By Component
- By Cost Type



Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Converter	$5,000.00	$1,594.04	$517.10	$0.00	-$898.34	$6,212.80
Diesel	$6,500.00	$0.00	$240.45	$0.00	-$1,113.35	$5,627.11
Generic 1kWh Li-Ion	$55,000.00	$12,728.21	$129,275.17	$0.00	-$2,395.58	$194,607.80
Generic 3kW	$182,000.00	$43,275.93	$45,569.50	$0.00	-$8,144.97	$262,700.46
Other	$6,000.00	$0.00	$0.00	$0.00	$0.00	$6,000.00
PV	$50,000.00	$0.00	$64,637.58	$0.00	$0.00	$114,637.58
System	$304,500.00	$57,598.18	$240,239.80	$0.00	-$12,552.23	$589,785.75

Simulation Report | Time Series Plot | Other...

Summary

Presented by Joseph Padbury
Business Development Manager Sub-Saharan Africa, UL Renewables

Risk Mitigation

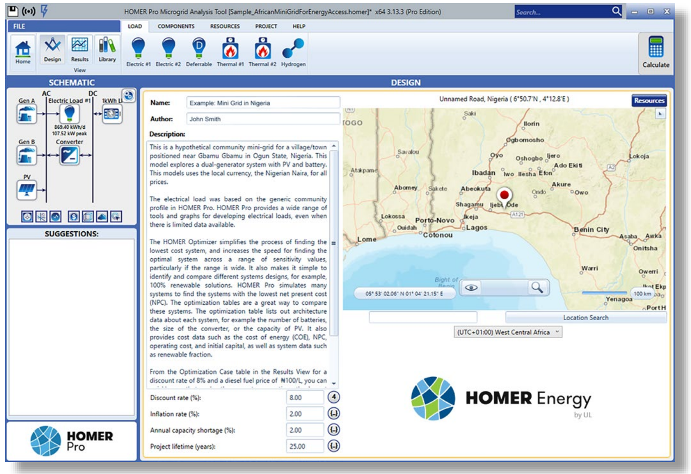
- Mini-grids and Distributed Energy Systems are needed to fill unmet electrical needs in Africa
- In order for a project to be bankable from a technical perspective great care should be taken in the following phases :
  - Project Design – needs of the user and funders must be fulfilled
  - Equipment Selection - especially hybrid design with energy storage devices
  - Risk Identification and Mitigation – demonstrate managed risks

Need help with your project?

Software Solutions

Advisory Services

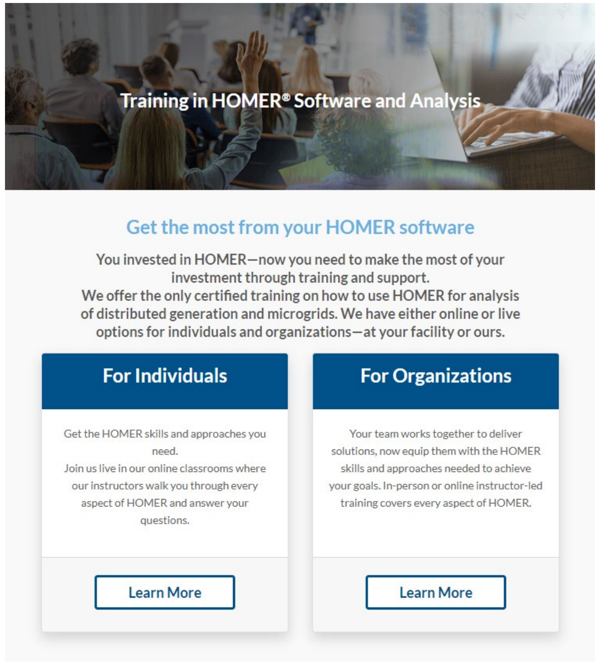
HOMER Pro Modeling Software



Free 21-Day Trial or Trial Renewal

HOMERenergy.com/TryPro

Training & Premium Support



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Questions & Answers

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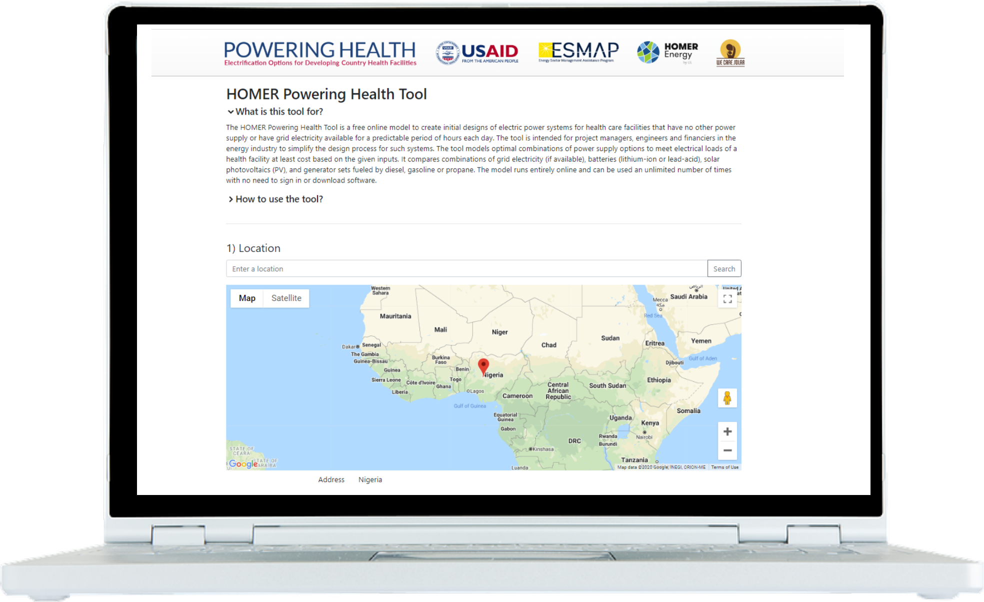

Free Trial of HOMER software: HOMERenergy.com
Learn more about UL Renewables: UL.com/renewables

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