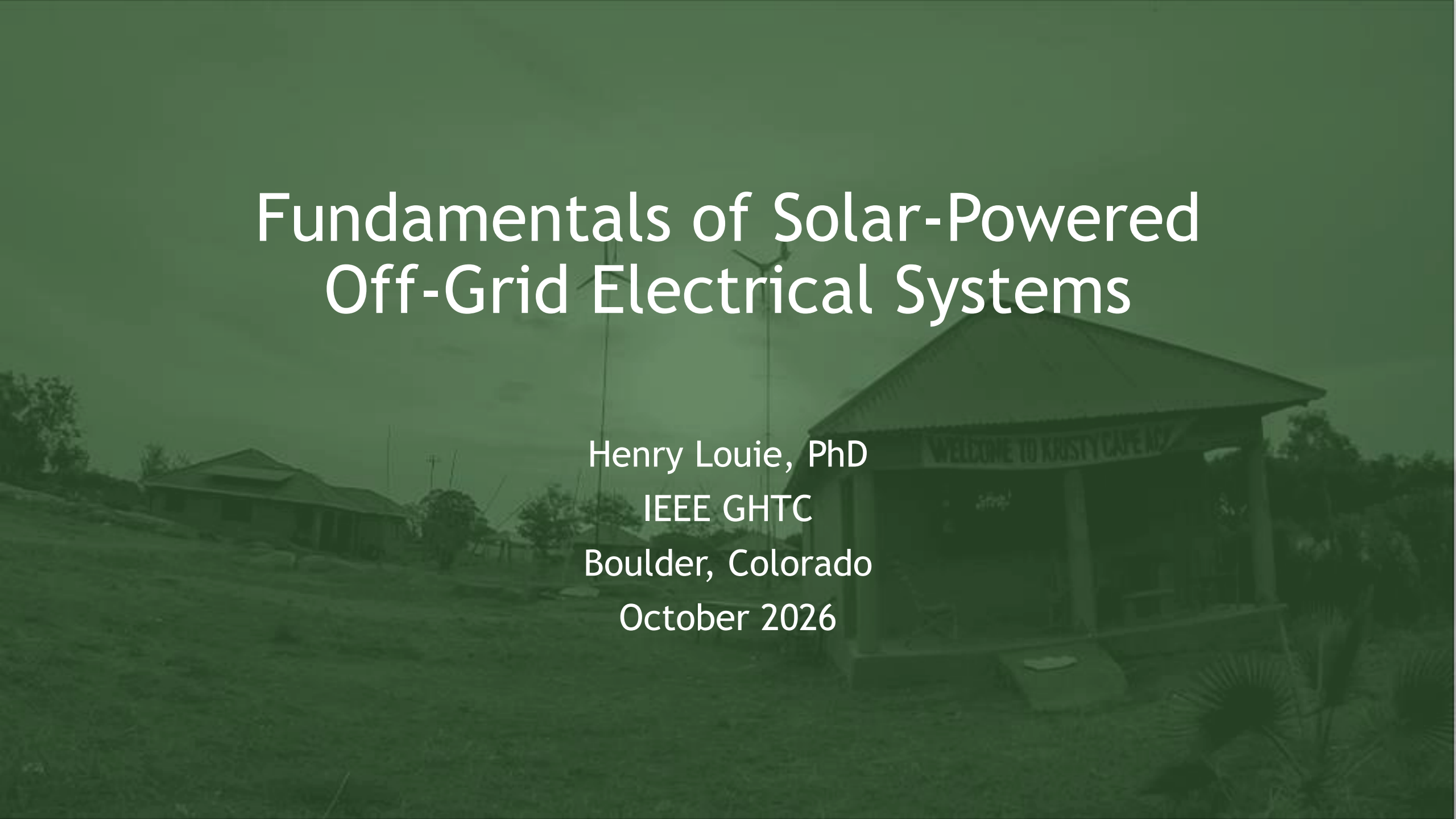
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(email hlouie@ieee.org)

Fundamentals of Solar-Powered Off-Grid Electrical Systems



Henry Louie, PhD

IEEE GHTC

Boulder, Colorado

October 2026

Henry Louie, PhD

Dr. Henry Louie is a Professor in the Department of Electrical and Computer Engineering at Seattle University.

In 2015 Dr. Louie was Fulbright Scholar to Copperbelt University in Kitwe, Zambia, and a Fulbright Specialist to the Zambian National Institute of Public Administration in 2025. He is the President and Co-founder of KiloWatts for Humanity, a non-profit organization providing off-grid electricity access and business opportunities in sub-Saharan Africa. Dr. Louie is an Associate Editor *for Energy for Sustainable Development* and is a founding member of the IEEE PES Working Group on Sustainable Energy Systems for Developing Communities.

Dr. Louie is recognized as an IEEE Distinguished Lecturer for his expertise on energy poverty. He is a Senior Member of the IEEE and has been a registered professional engineer in Zambia. He previously served as Vice President of Membership & Image of the IEEE Power & Energy Society. He is the past chair of the IEEE PES/IAS PowerAfrica Conference Steering Committee and previously served on the IEEE Smart Village Steering Committee. He is the recipient of the 2024 IEEE PES Peter W. Sauer Outstanding Power Engineering Educator Award.

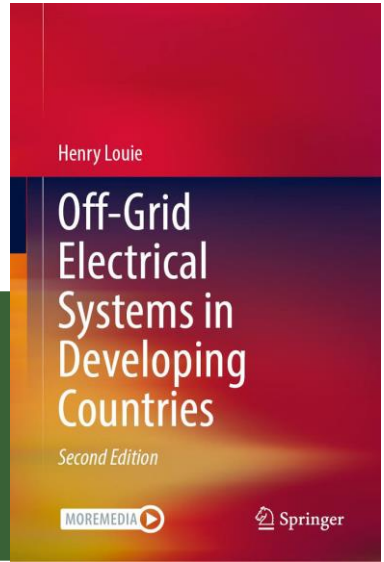
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16: Off-Grid Energy Production System Design
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18: Solar Lanters and Solar Home Systems
19: Economic, Social, and Other Considerations



These slides available at:
drhenrylouie.com/ghtc

Additional slides available at:
https://github.com/Off-Grid-Textbook

Other information
drhenrylouie.com



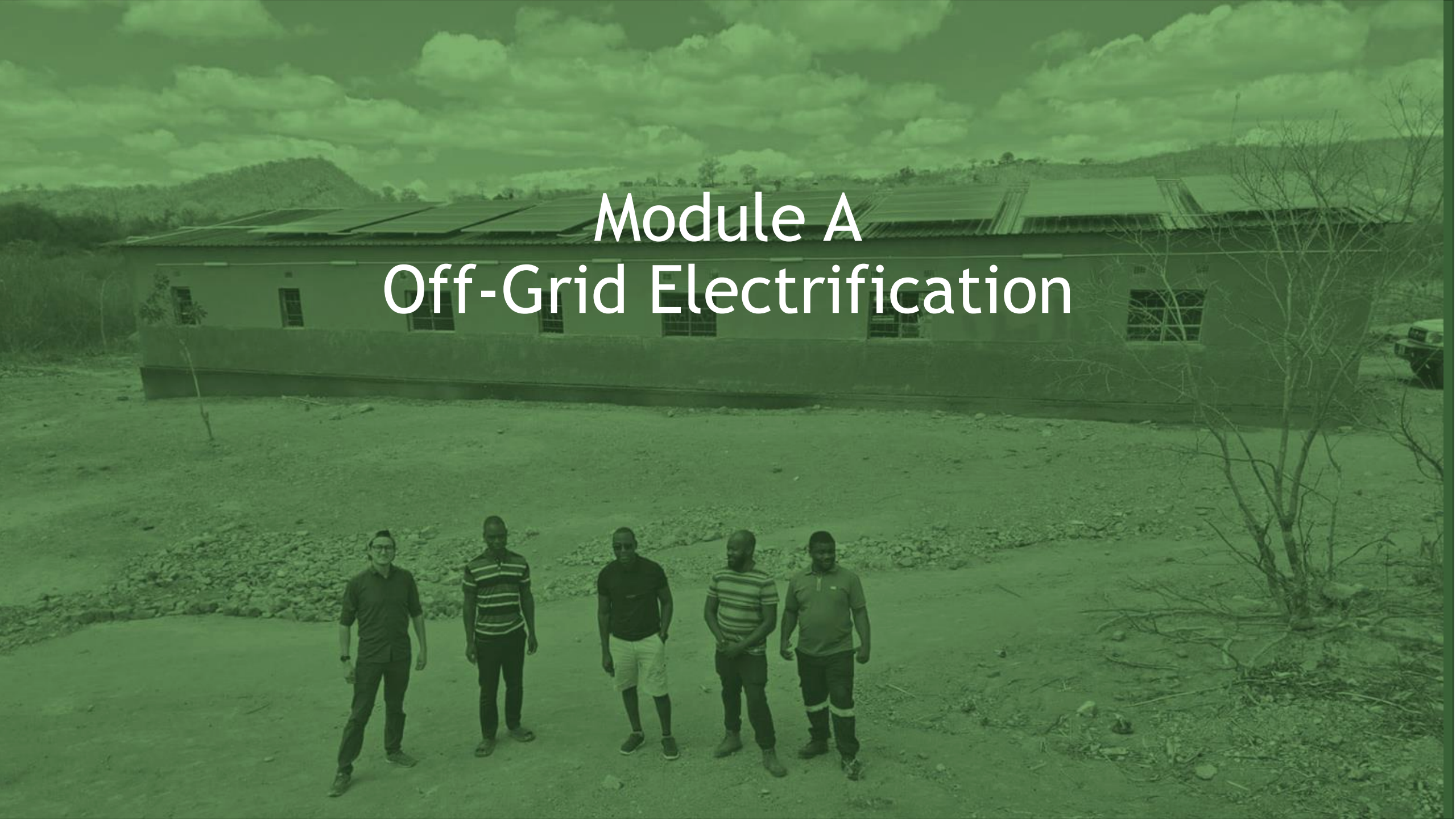
Agenda

Off-Grid Electrification (10 minutes)

Off-Grid System Components & Architectures (30 minutes)

Design Process (30 minutes)

Life Cycle (20 minutes)



Module A
Off-Grid Electrification

Off-Grid Electrification

Off-Grid Electrification: *providing electricity to an unserved population by a means other than a connection to the existing centralized grid*

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The Grid is Not Everywhere

Zambia

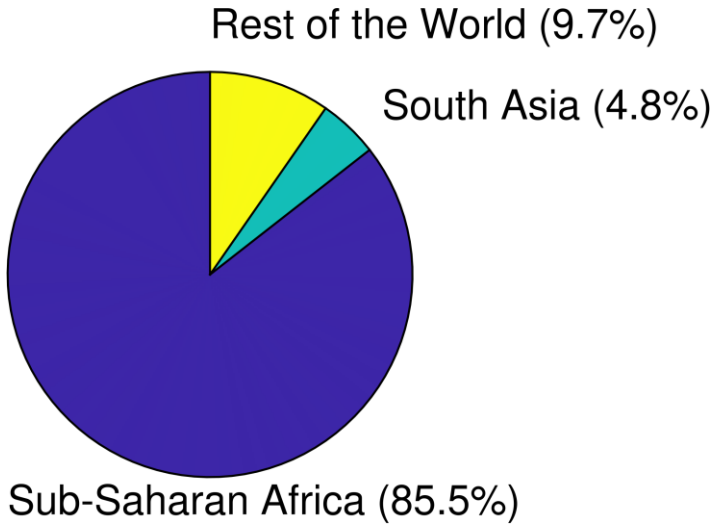


Navajo Nation (Southwest U.S.)



Electricity Access

- As of 2022, +685 million people without access to electricity in their home
- Majority live in Sub-Saharan Africa (SSA)



Why Study Off-Grid Electrification?



Humanitarian/social justice

- rural poor most likely to be energy impoverished
- access to electricity improves lives and livelihoods



Business opportunity

- >200,000 mini-grids needed
- >30 million solar lanterns and solar home systems sold each year



Intellectual merit

- intersection of technology & society
- dynamic and growing space—there is a need for innovation and problem solvers
- technical principles are widely applicable

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Energy & Human Development

Access to energy underpins all human activities


food


transportation


healthcare


education

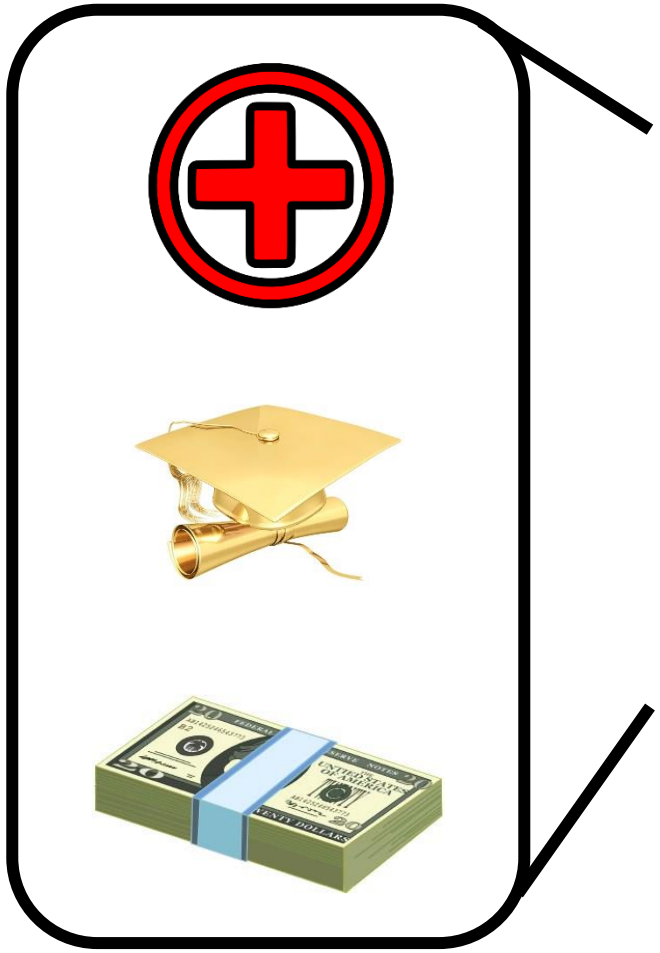

business

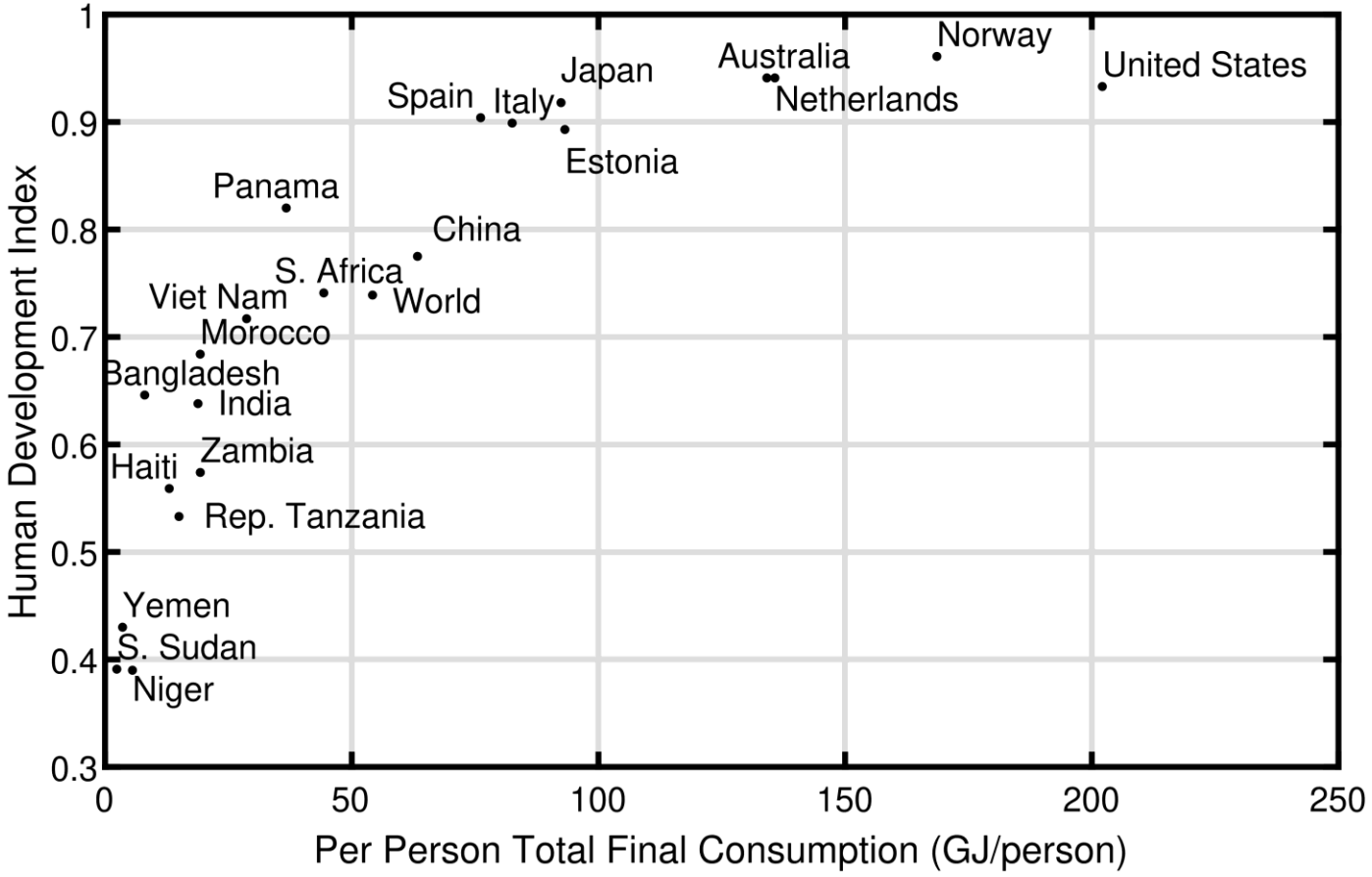

entertainment


information/ communication

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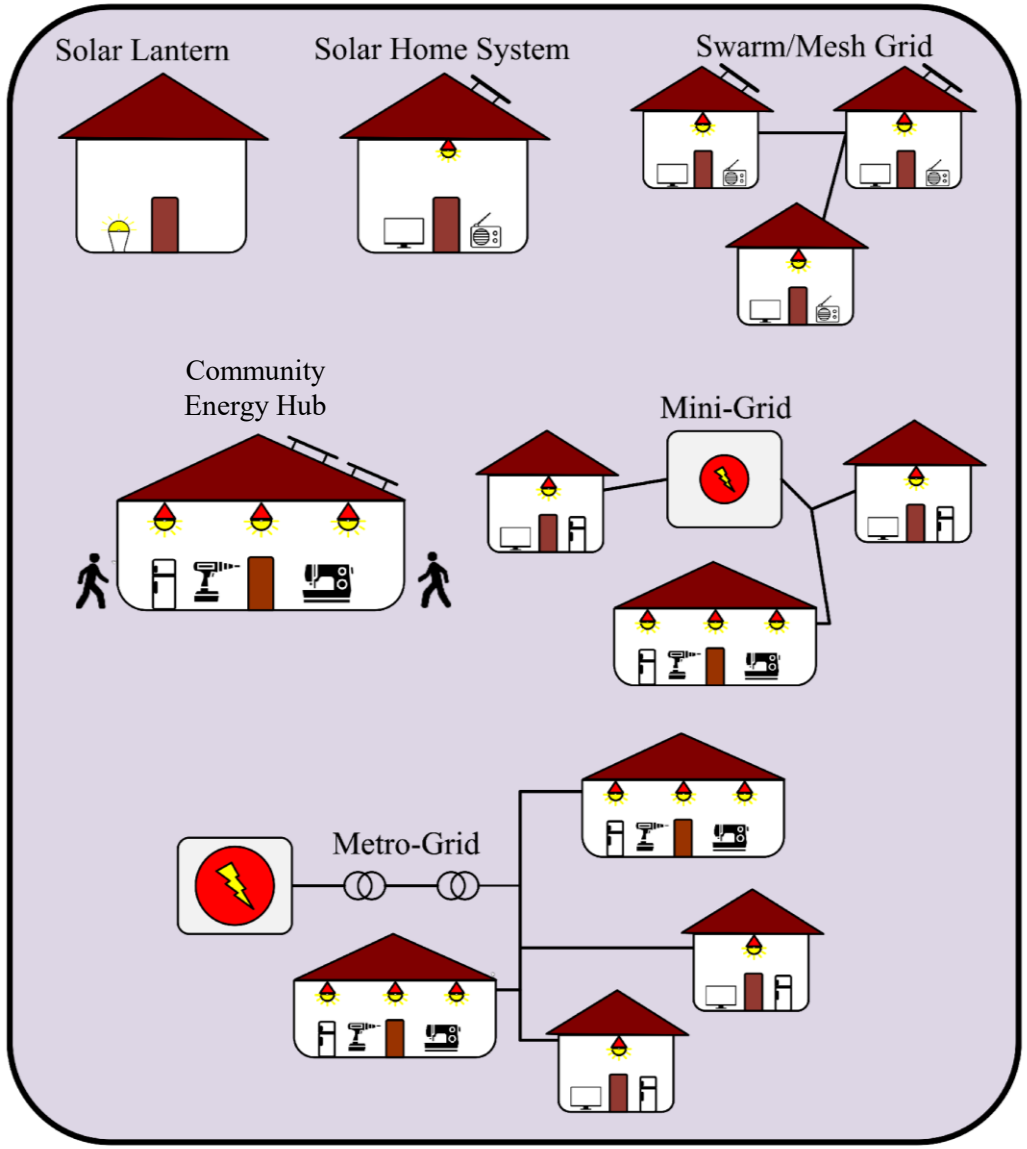
Human Development Index





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Electrification Approaches



Solar Lanterns (“pico solar”)

- “Entry level” electricity access
- Components
  - small (<10W) photovoltaic (PV) panel
  - Battery (usually <20Wh)
  - LED light(s)
  - USB port for charging (on larger systems)
- Designed for portability
- Low-cost $5-$20



d.Light S30



Sun King Pro 2000



M-KOPA 4



forsera Group
PSHS 3000

Solar Home Systems (SHS)

- Higher-tier electricity access
- Components
  - Larger PV panel (usually 20W to 60W)
  - Battery (100Wh-300Wh)
  - LED lights
  - USB ports
  - Inverter (larger systems)
  - Appliances (DC TVs, fans)



BBOXX



d.light X850

Community Energy Hubs

- High tier electricity access, focusing on businesses and productive uses of electricity
- Can supply high-power loads
  - refrigerators
  - pumps
  - mills
- Walk-up retail service model
  - phone/battery recharging
- No or limited distribution system









Mini-Grids (also “micro-grid”)

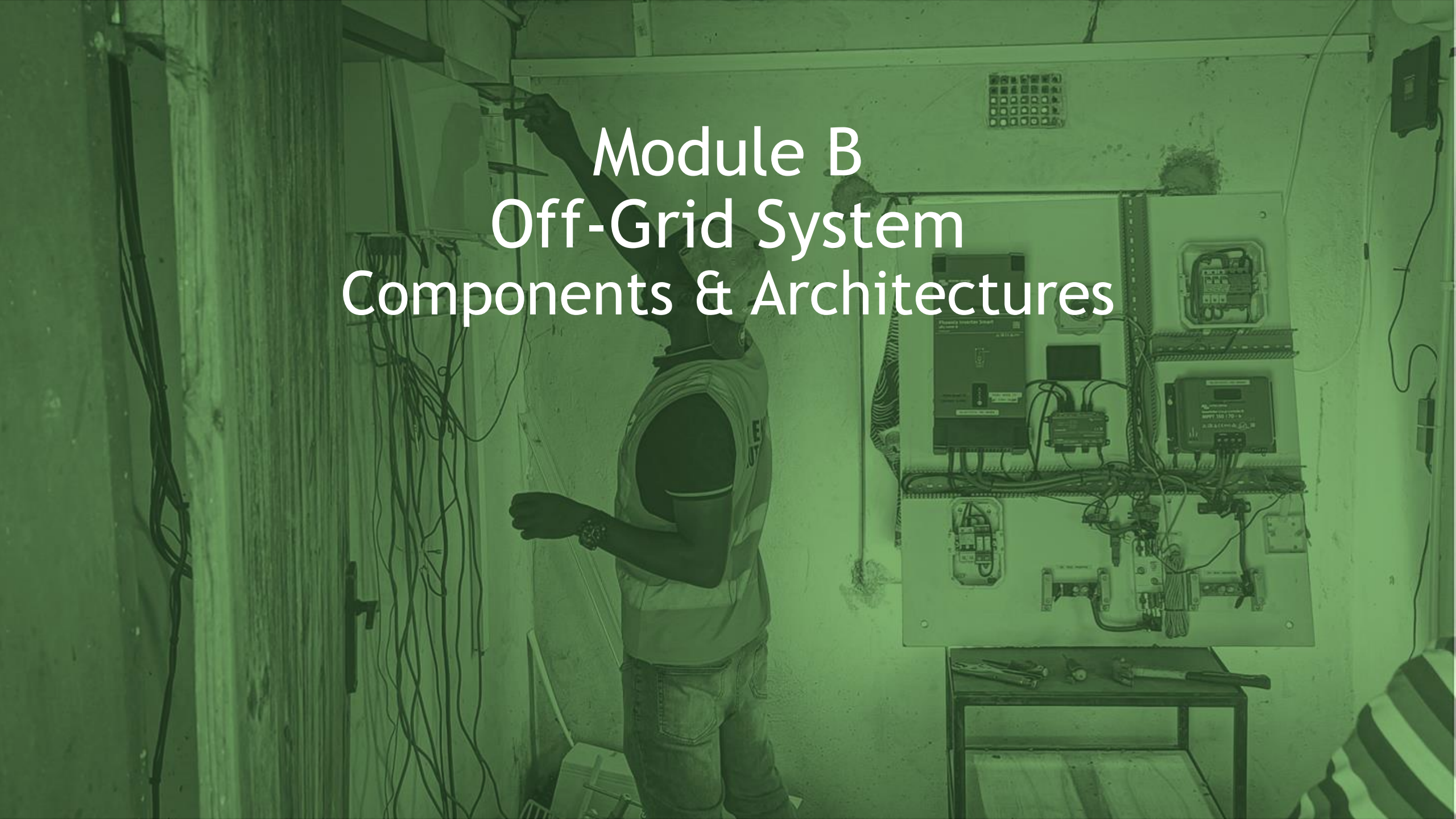
- High tier electricity access
- Tens to hundreds of user connections
- Low voltage distribution system



(*courtesy of PowerGen Renewable Energy*)

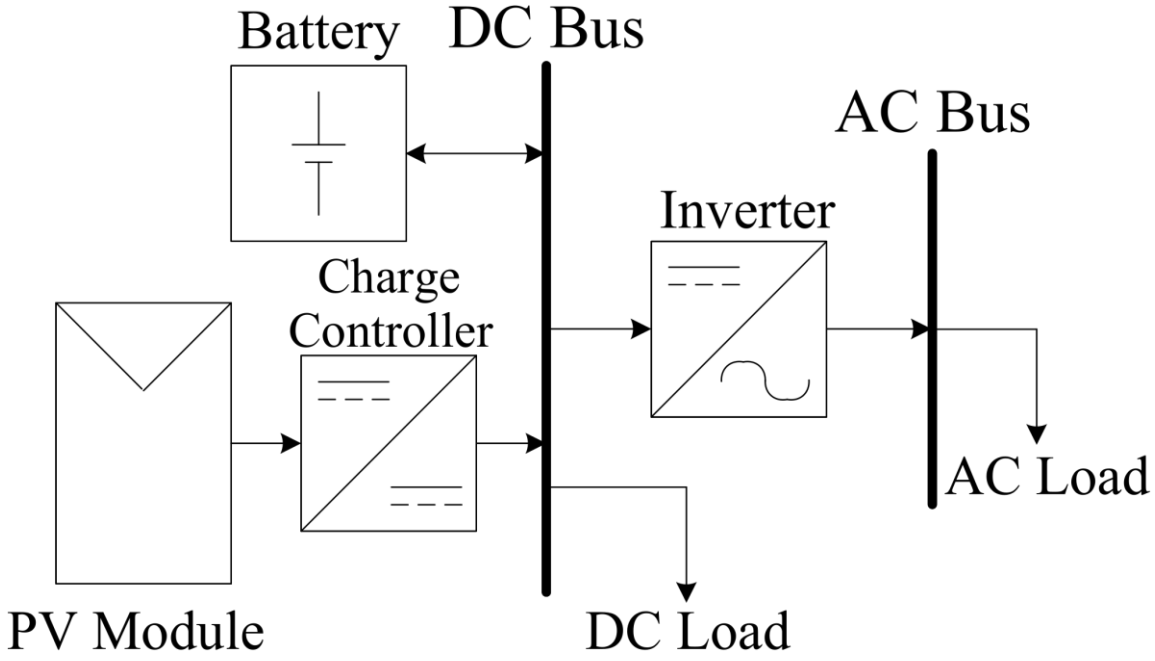
Metro-Grids

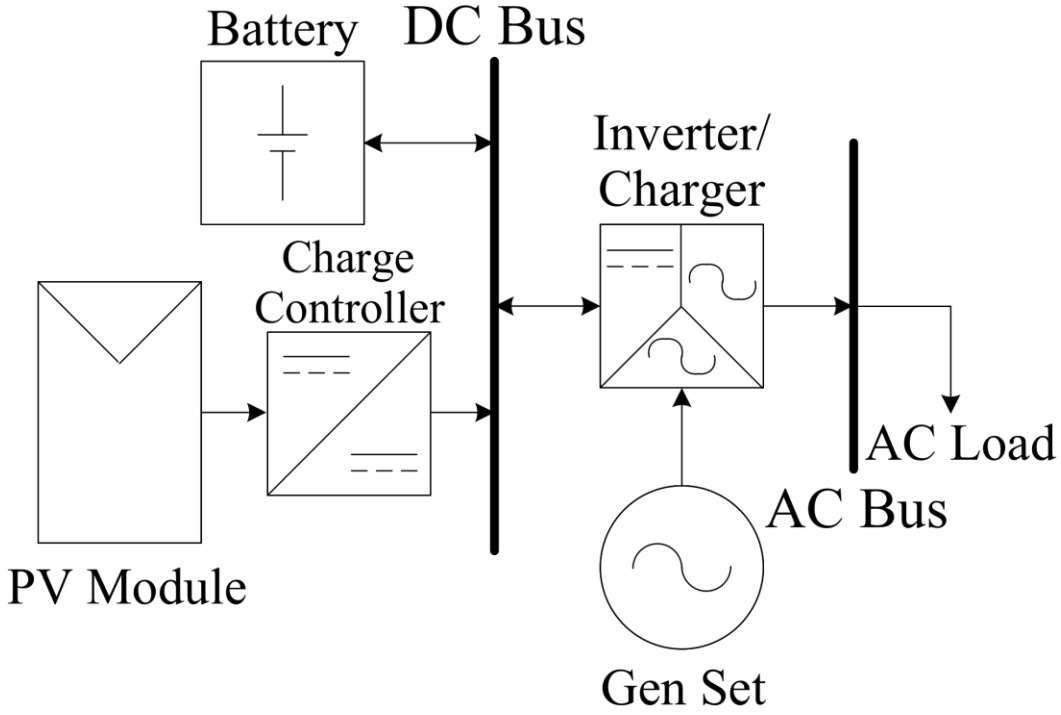
- High tier electricity access
- Large mini-grid that serves an urban area
- High capacity (usually +1 MW)
- +1000 end-user connections
- Medium (+11 kV) distribution



Module B
Off-Grid System
Components & Architectures

Common PV Architectures





04-Off-Grid Architectures © 2025 by Henry Louie is licensed under CC BY-NC-SA 4.0 www.drhenrylouie.com

PV Modules: Physical Description

Silicon cells are most commonly used in off-grid systems

PV cells are connected in series to form PV modules



monocrystalline



polycrystalline



(*courtesy P. Dauenhauer*)

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Basic Principles

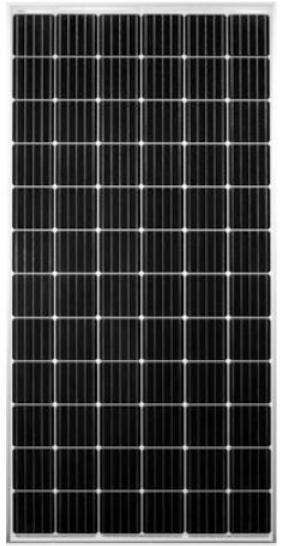
- Electricity is produced via the *photovoltaic* effect
  - PV cell is a p-n junction (diode)
  - Recall p-n junctions are made from doped silicon crystals, which have internal built-in electric fields
  - Photons from sunlight excite electrons into the conduction band, built-in field separates charge and voltage appears
- Power produced by PV module is approximately proportional to incident irradiance
- Power is inherently DC
- Efficiency typically 14-23%

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Example Efficiency

Irradiance

1000 W/m^2



Area: 2m^2
(2000 W)

DC Power



Power: 350 W

Efficiency: 17.5%

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Main Factors Affecting PV Power Production

Irradiance



Temperature



Load

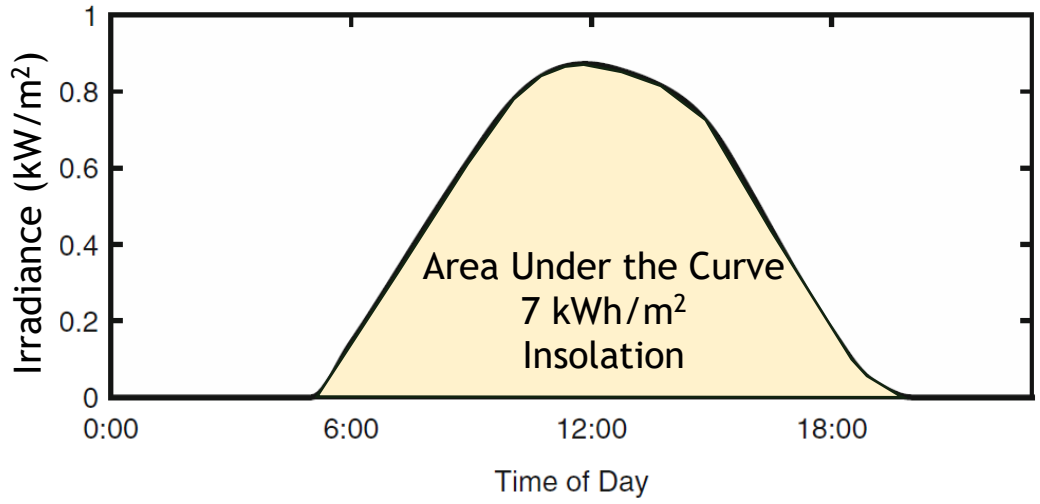


Spectral distribution of irradiance also affects production

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Irradiance and Insolation

Irradiance: *G*, power density of sunlight (W/m^2)
Insolation: *I*, energy density of sunlight over a period of time ($kWh/m^2/day$)



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Solar Resource

- Insolation over the course of a day *d* is:

$$I_d = \int_{t=0}^{24} G_d(t)\, dt$$

Units of I_d are kWh/m^2/day if t is expressed in hours and G_d are in kW/m^2

- The average insolation across D days in set $\mathcal{D}$ is simply:

$$\overline{I}_D = \frac{\sum_{d \in \mathcal{D}} I_d}{D}$$

a month, year, 10 years, etc.

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Daily Energy Production

- If temperature effects are ignored, the power produced by a PV array is

$$P_{PV} = P^*_{STC} \times G$$

P^*_{STC}: rated nameplate power of the PV array, in W
Note: we are assuming irradiance G is expressed in kW/m^2, not W/m^2

- The estimated energy production for day d is therefore:

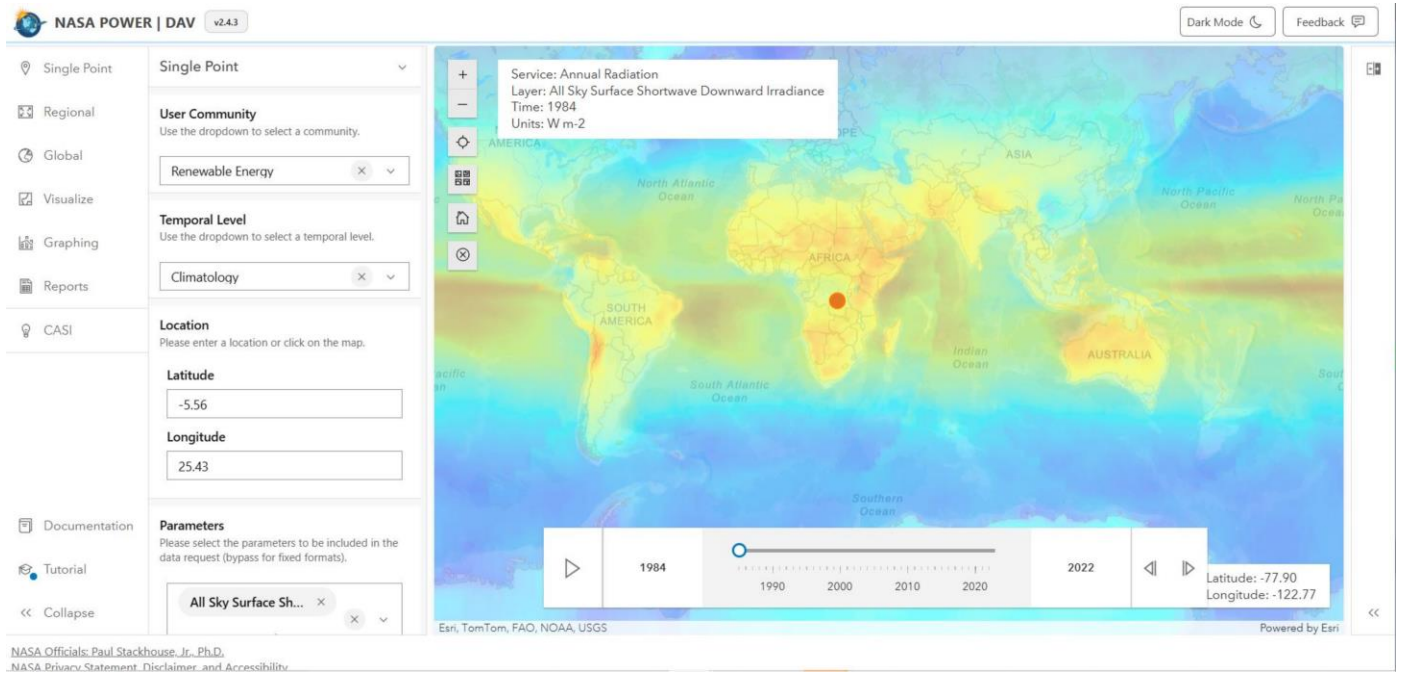
$$\hat{E}_{PV,d} = P^*_{STC} \int_{t=0}^{24} G_d(t)\, dt = P^*_{STC} I_d$$

Energy is equal PV rating x insolation

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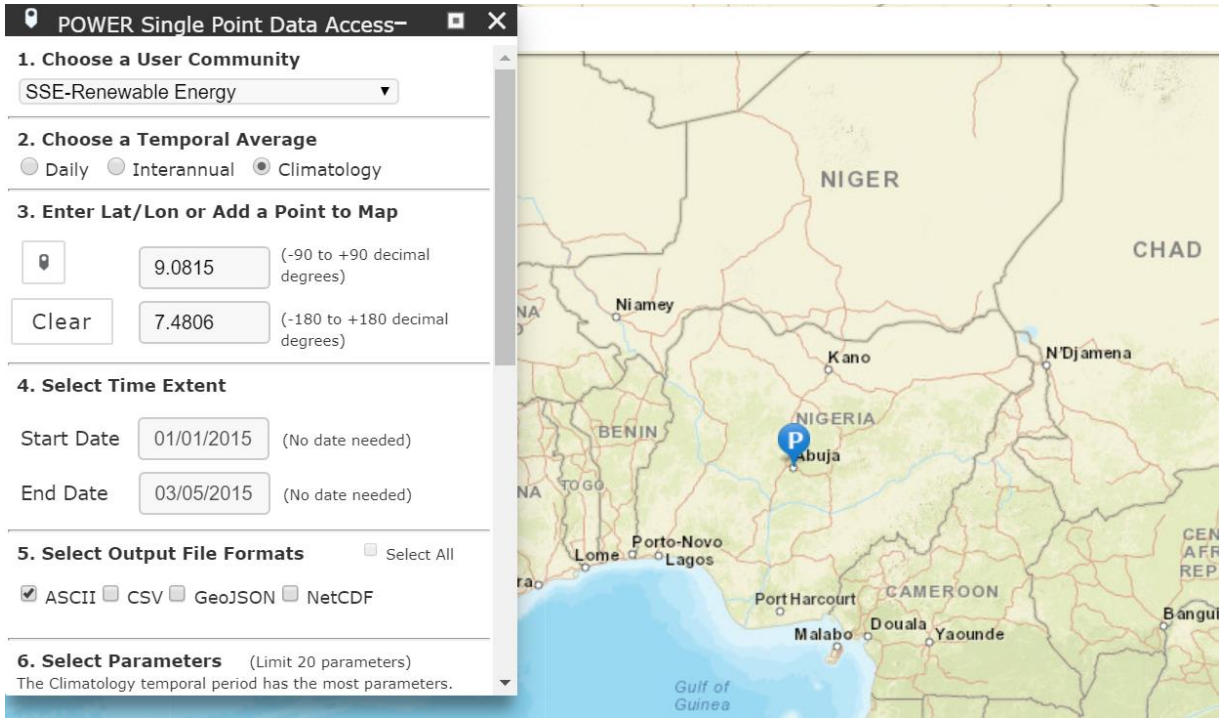
Solar Resource Databases

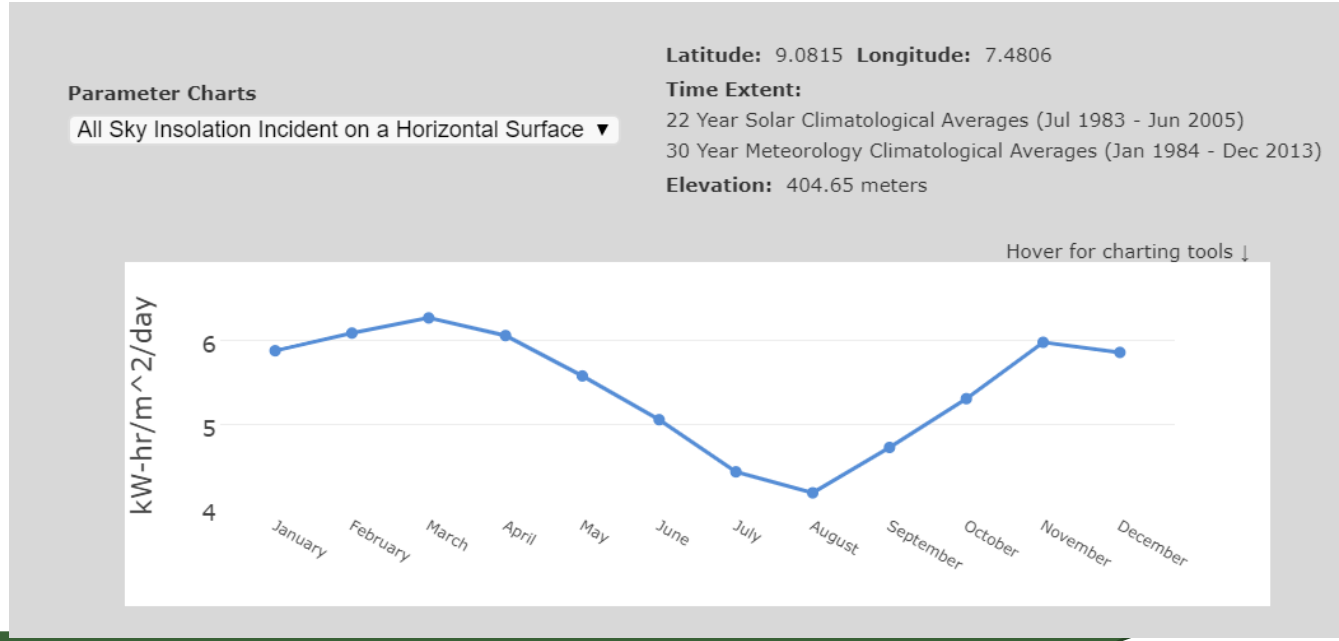
Insolation and other solar resource data for most locations can readily be found in online databases



NASA's Prediction of Worldwide Energy Resources (POWER) Data Access Viewer (DAV) interface. The data was obtained from the POWER Project's Climatology 2.4.3 version on 2024/12/22 (courtesy NASA)

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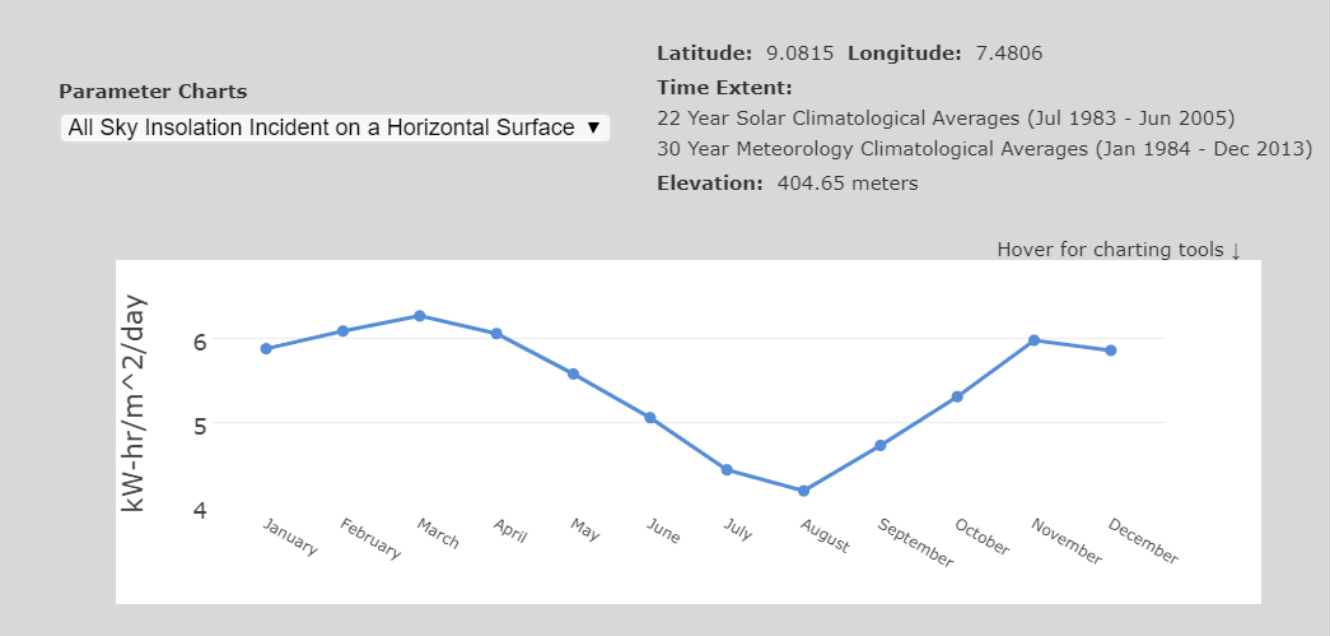




https://power.larc.nasa.gov/data-access-viewer/

Knowledge Check

The average insolation on a 350 W PV module for the month of September is 4.7 kWh/m^2/day. What is the average daily energy produced by the module?



Knowledge Check

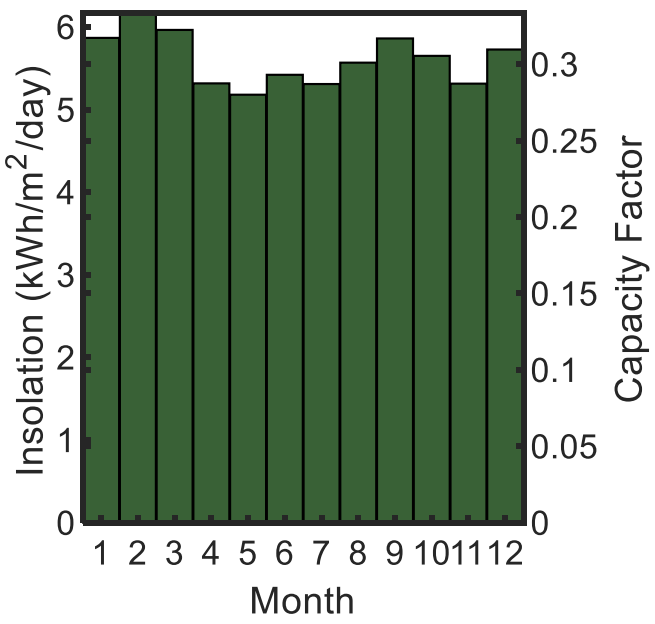
The average insolation on a 350 W PV module for the month of September is 4.7 kWh/m^2/day. What is the average daily energy produced by the module?

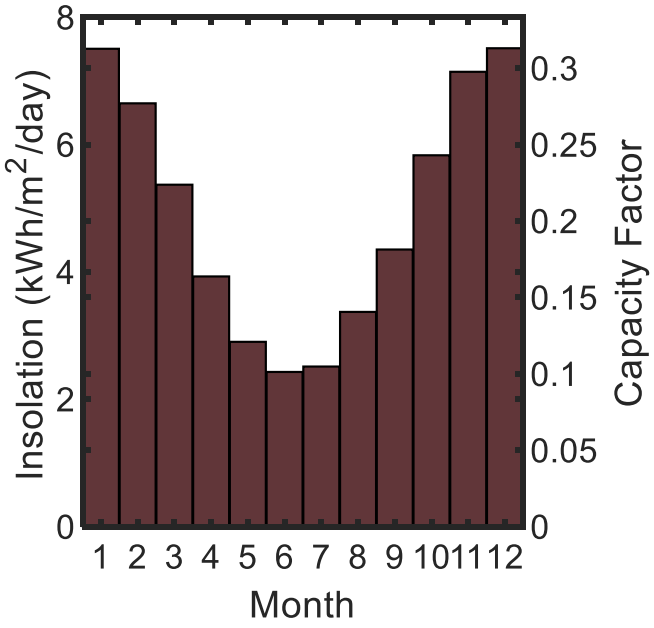
$$\bar{E}_{PV} = 350 \times 4.7 = 1645 \text{ Wh}$$

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Energy Production is Influenced by

- Season (day of year)
- Location (lat. and long.)
- Weather conditions
- Orientation of array





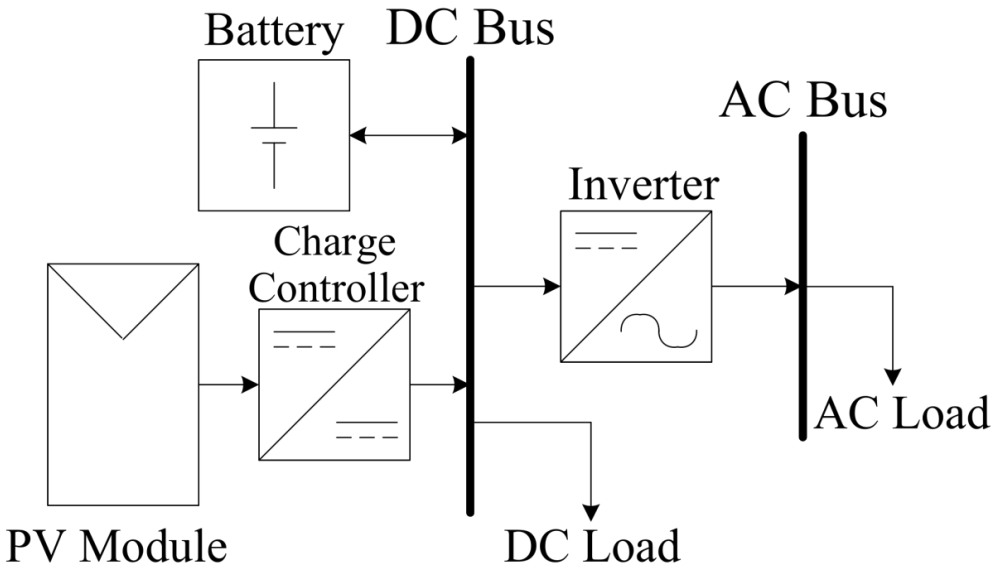
Insolation and capacity factor for a horizontal arrays near the equator and 34^o S

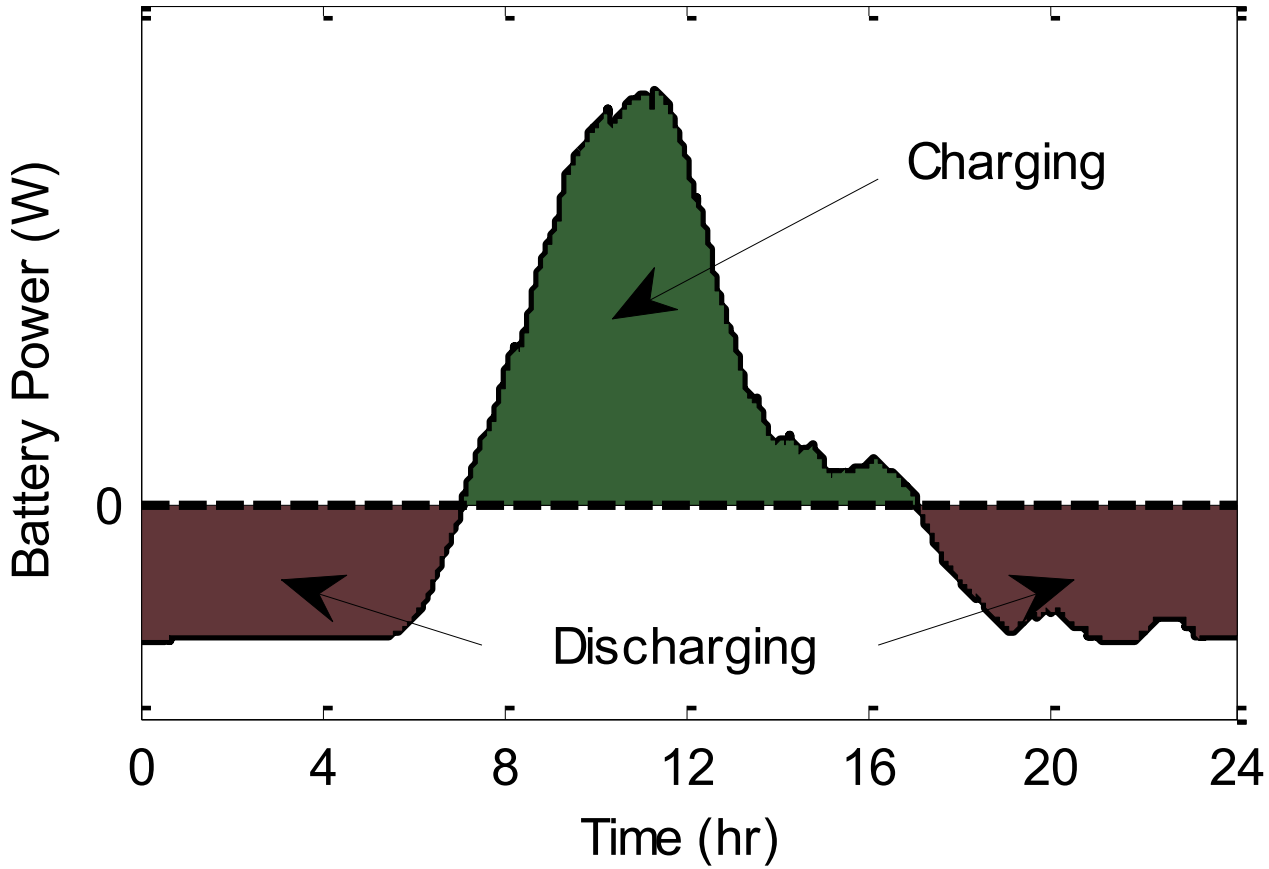
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Off-Grid Energy Storage

- Energy storage devices decouple when energy is generated from when it is consumed
- Off-grid systems use chemical batteries
  - Lead-acid
  - Lithium-ion
  - Other chemistries have been piloted in limited use

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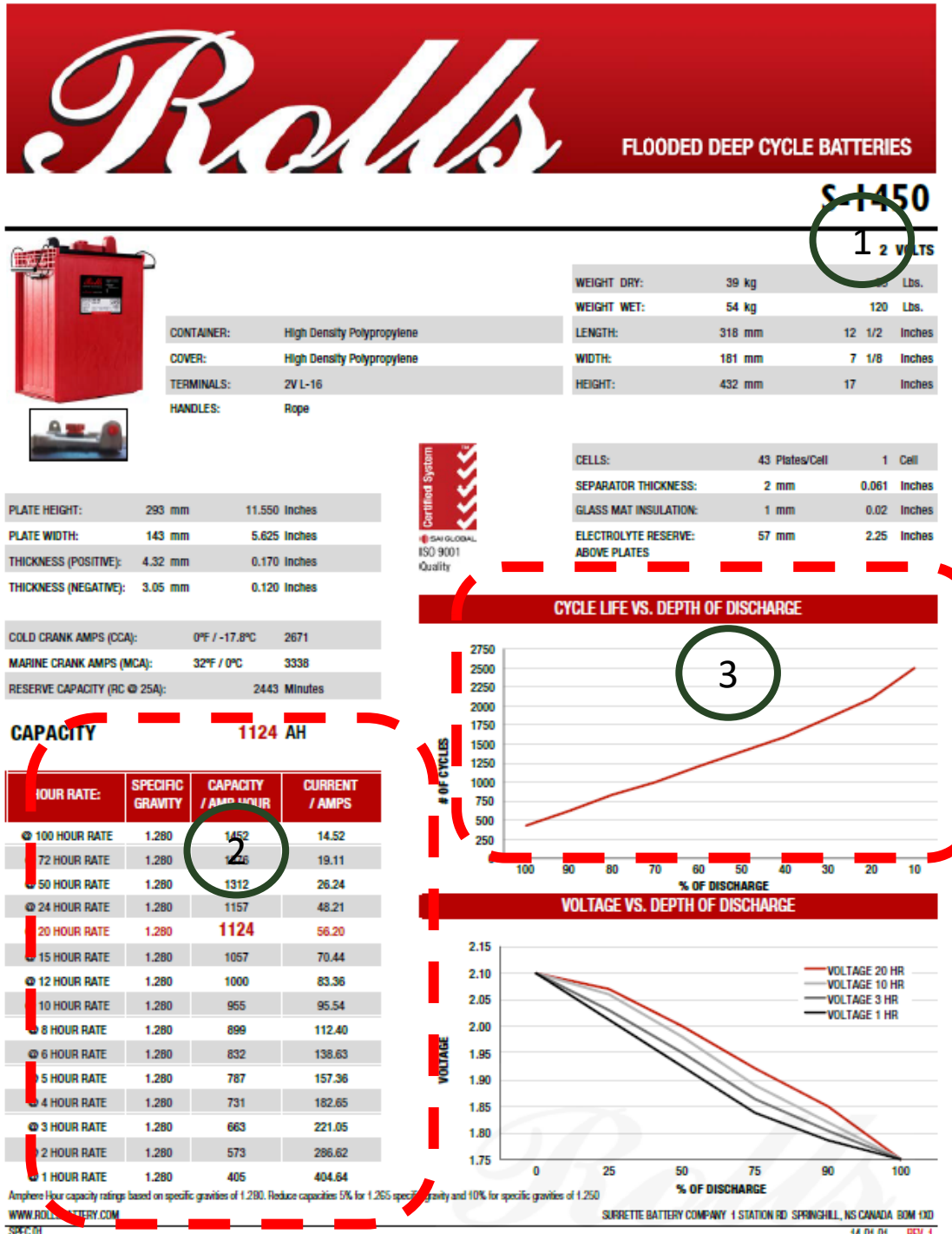

UP5000
PYLONTECH
UP5000
PYLONTECH


US3000C
US3000C


Deye
Deye
Deye
Deye

Battery Specification Sheets

- Provide technical information on battery characteristics and performance
- Not always easy to interpret
- Most important characteristics
  1. Nominal Voltage
  2. Capacity
  3. Cycle life



Nominal Voltage

- Cells, batteries, and battery banks are often referred to by their “nominal voltage”
  - automobile batteries are called “12 V” batteries
- Nominal voltage is not the same as the open-circuit voltage

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Nominal Voltage

- Nominal voltage: approximately equal to the average battery voltage during a charge and discharge cycle
- Lead-acid batteries typically have nominal voltages of 2V, 6V, 12V or 24V
- Nominal voltage of a lithium-ion cell typically between 3.2V and 3.8V (depending on the chemistry used)

Battery Capacity

- Battery Capacity: indication of how long a battery can meaningfully supply a constant current load

- "Battery Capacity" can refer to either:
  - Charge capacity, measured in amphours (Ah) (more common)

    OR
  - Energy capacity, measured in kilowatthours (kWh) (less common)

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Capacity: a more specific definition

- Battery Capacity: charge that a battery can supply at a particular, constant, current before its voltage drops before a manufacturer-defined cut-off voltage (e.g. 1.75 V/cell)
  - battery is capable of supplying additional charge, but at a lower voltage and possibly damaging the battery (until the active material is entirely depleted)
  - Lithium ion batteries cut-off voltage 2.0 to 3.0 V/cell
- Empirically determined by manufacturer

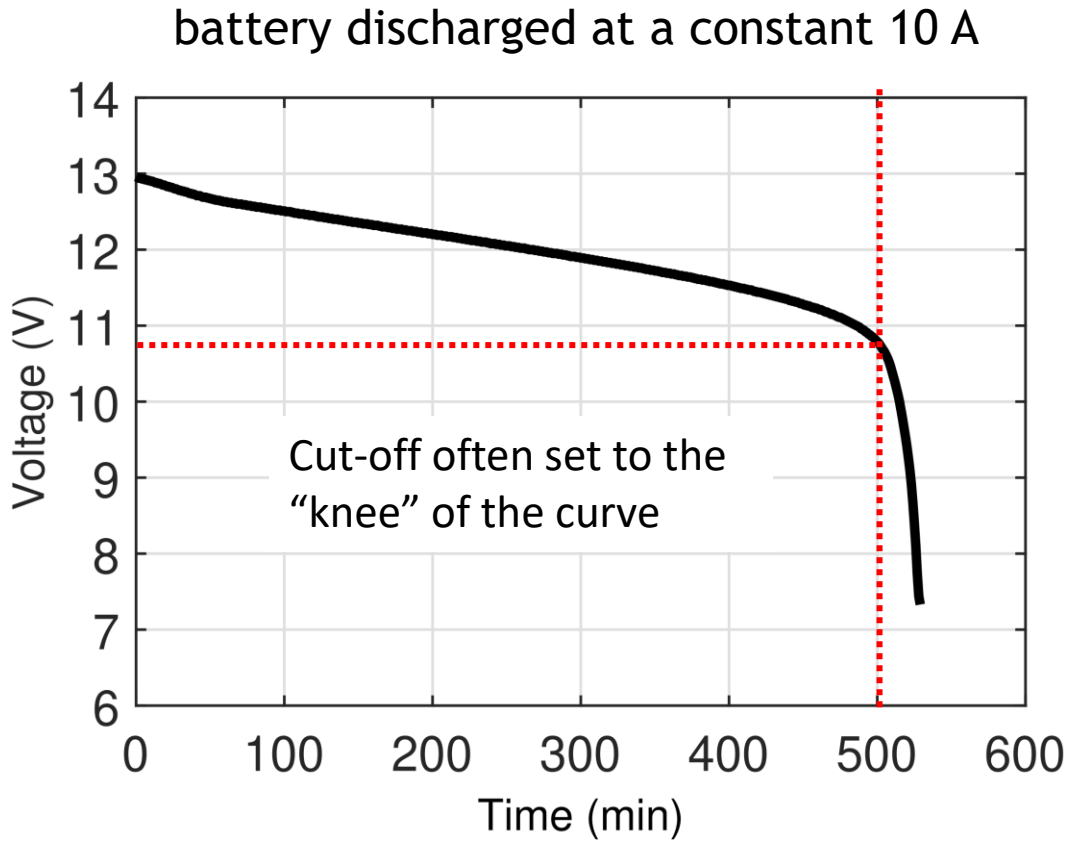
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Charge Capacity Test

In this example, the battery reaches cut-off voltage of

6 cells x 1.8 V/cell = 10.8 V at 500 minutes (8.3 hours)

Capacity of the battery when discharged at 10 A is 10 A x 8.3h = 83 Ah

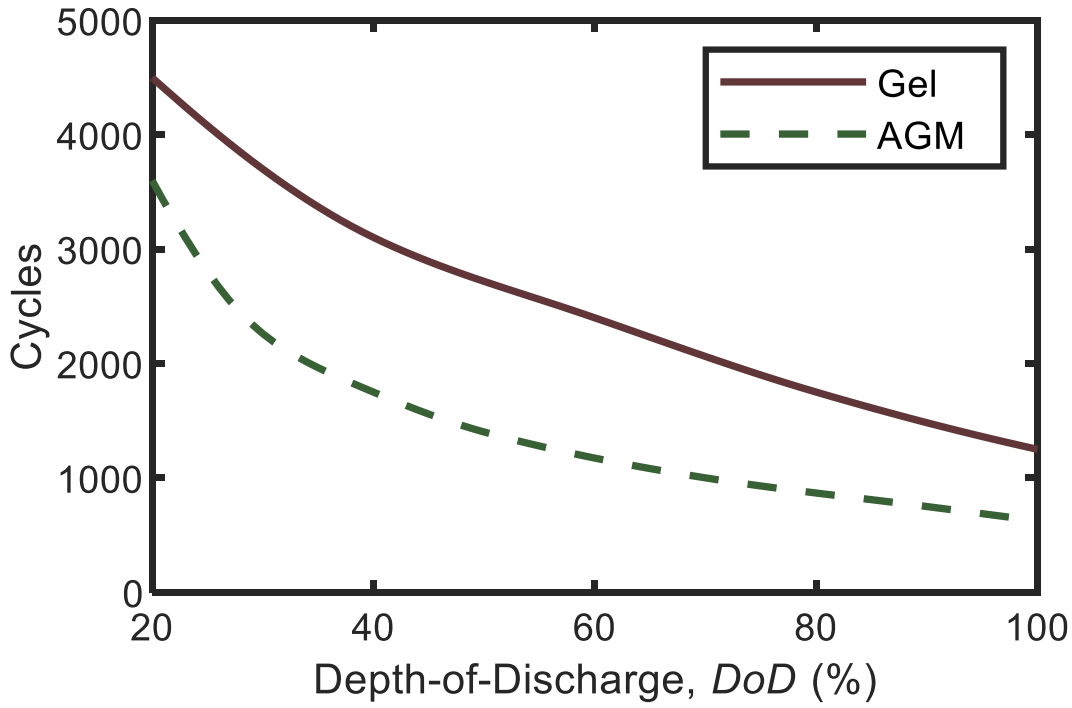


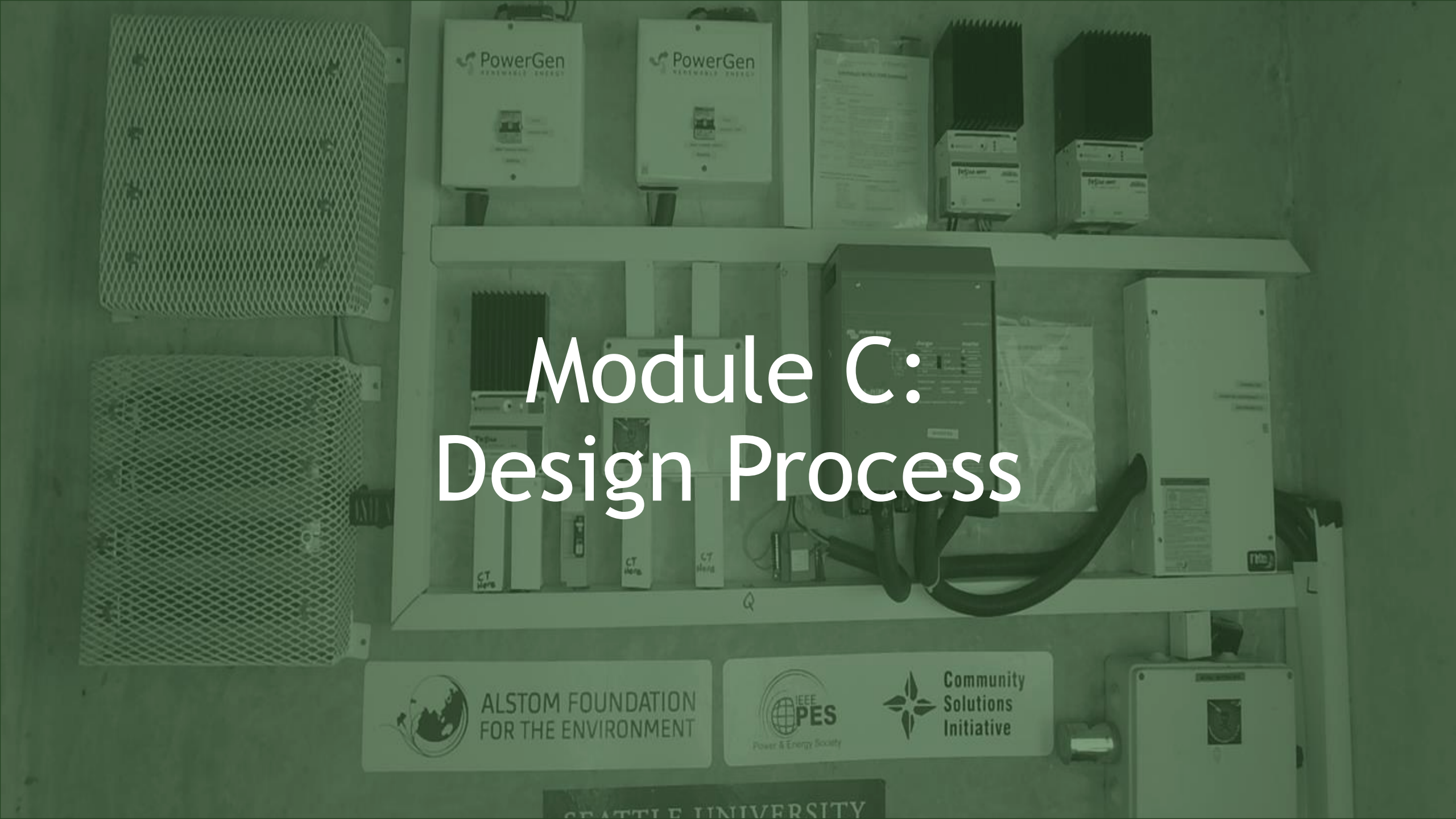
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Cycle Life

Typical cycle is one 24-hour period of charging/discharging

- Batteries degrade over time and with use
- End of life when maximum charge capacity drops to 80% of rated (new) capacity
- Depth-of-Discharge affects number of times battery can be “cycled” before end-of-life capacity is reached

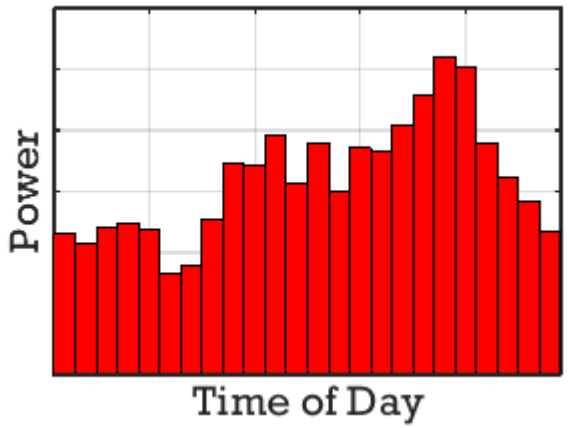




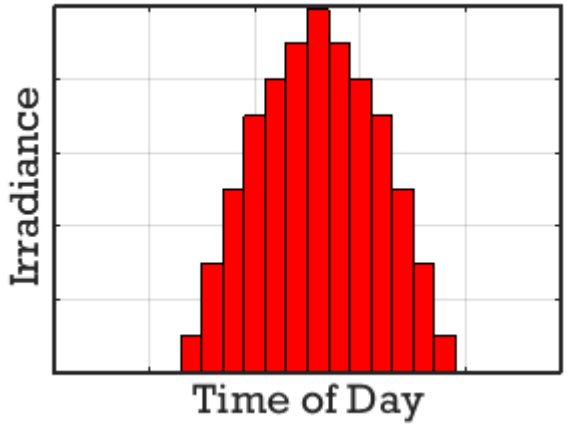
Module C: Design Process

Inputs

Demand



Solar Resource



Design Approaches

- Computer Simulation
- Standards
- Ad Hoc (Guidelines)

Outputs

Component Ratings, Cost



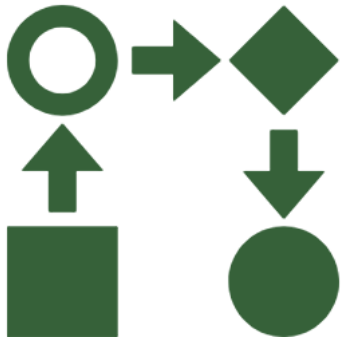


Load Estimation Approaches

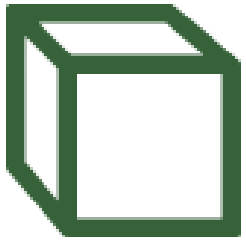
- Bottom-up
- Survey
- Regression
- Data-driven



Design Steps



1. Architecture Selection



2. Component Sizing



3. Component Selection & Layout

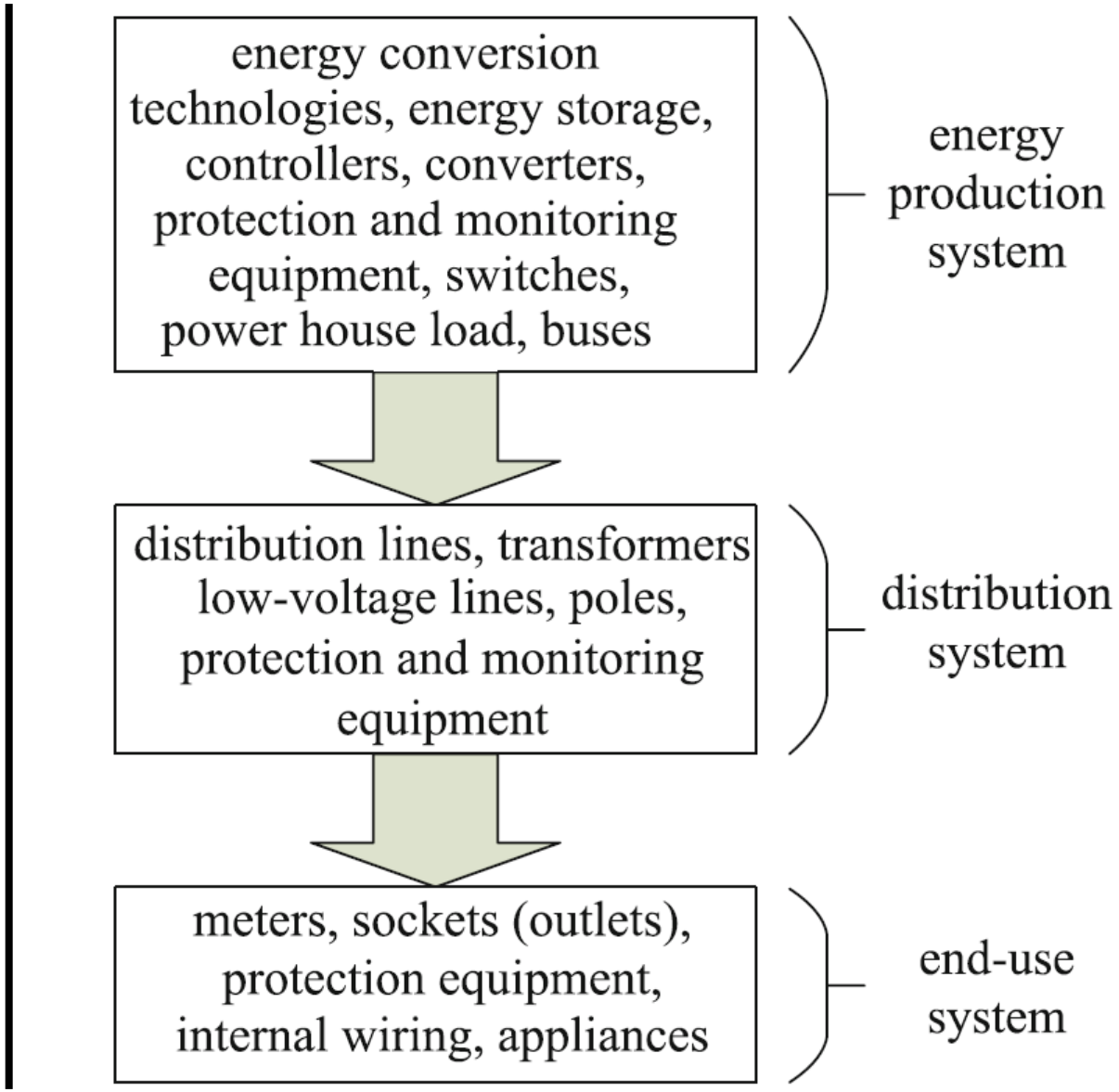


4. Final Electrical Design

See text for examples of electrical design drawings

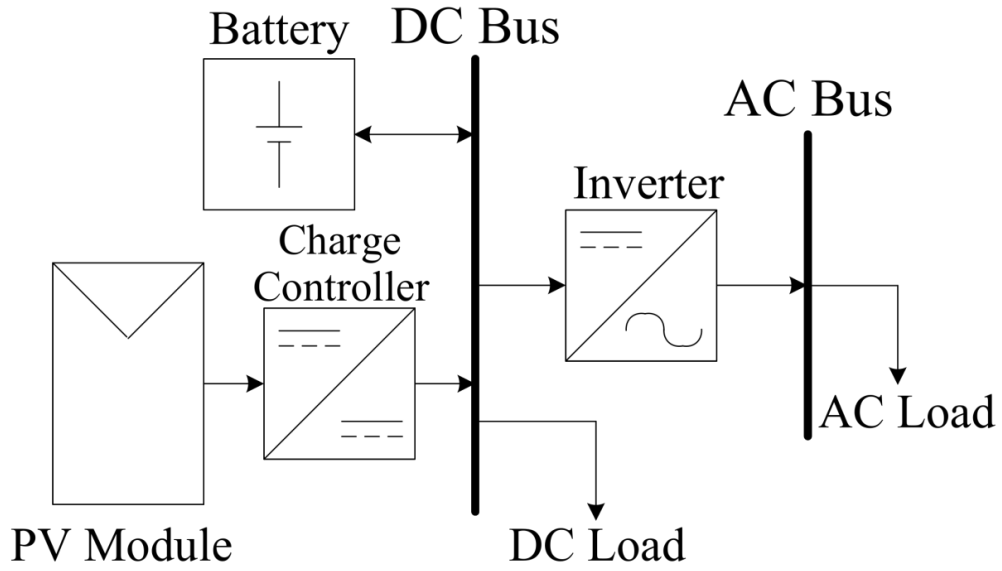
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Mini-Grid Sub-Systems



Architecture Selection

- Define which energy conversion technologies, energy storage, converters, and controllers will be used, as well as the coupling type (AC, DC, AC–DC)
- Architecture largely depends on energy resource characteristics and load requirements
- See Chap. 4 for designing a valid architecture



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Component Sizing

Use an intuitive or numerical design approach to determine the required ratings of the components to achieve the desired reliability or tier of service



Intuitive

Design by standards or guidelines to size system components



Numerical

Design/analysis through computer-aided simulation

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Intuitive Design

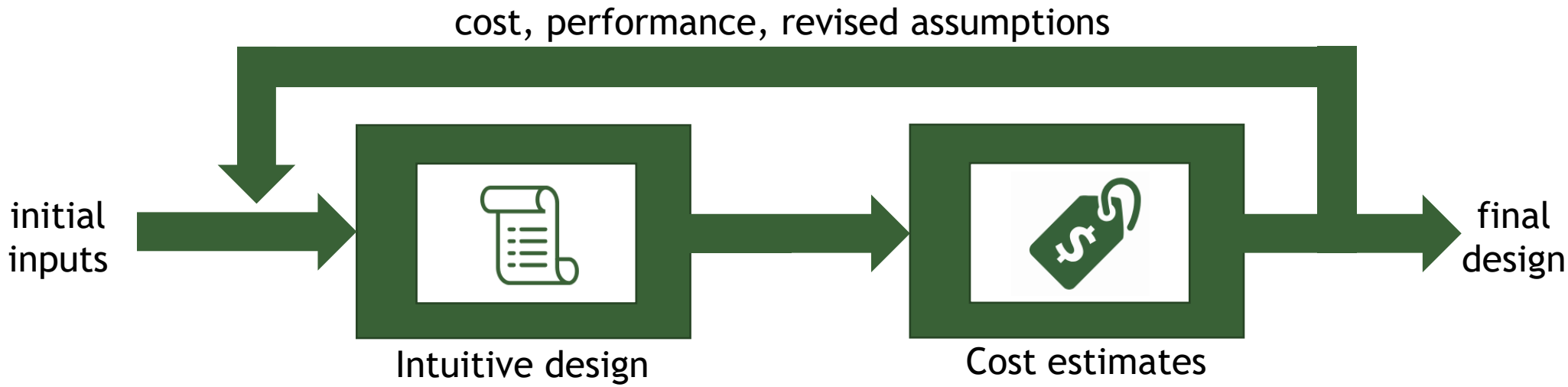
Related standards

- IEEE 1546.4: Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems
- IEEE 1526: Testing the Performance of Stand-Alone Photovoltaic Systems
- IEEE 1013: Sizing Lead-Acid Batteries for Stand-Alone Photovoltaic (PV) Systems
- IEEE 2030.10: Standard for dc microgrids for rural and remote electricity access applications
- IEC TS 62257: Recommendations for renewable energy and hybrid systems for rural electrification
- Others

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Iterative Design

- Developed design is a starting point
- Modified to reduce cost, increase reliability



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Numerical Design

Designer



Technical and economic parameters of the system (system architecture, component sizing, energy resource characteristics, load, fuel cost)

Design Program



Hourly deterministic simulation of the system

Results



Technical and economic performance (capital expense, operating expense, cash flow, Levelized Cost of Energy)

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Numerical Design

- Particularly useful for hybrid systems and those with complex control
- Allows for cost/reliability trade-offs of different designs to be recognized
- Input data requirements are high
- Results are only as good as the input information

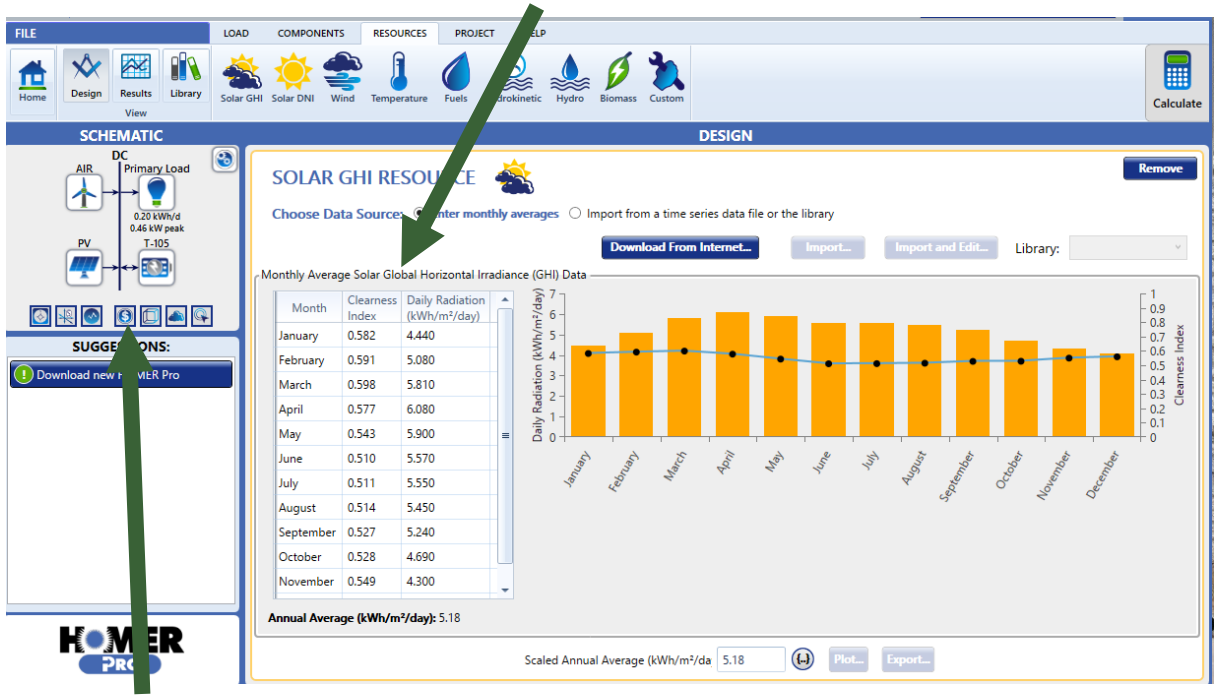


"garbage in, garbage out"

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Example: HOMER

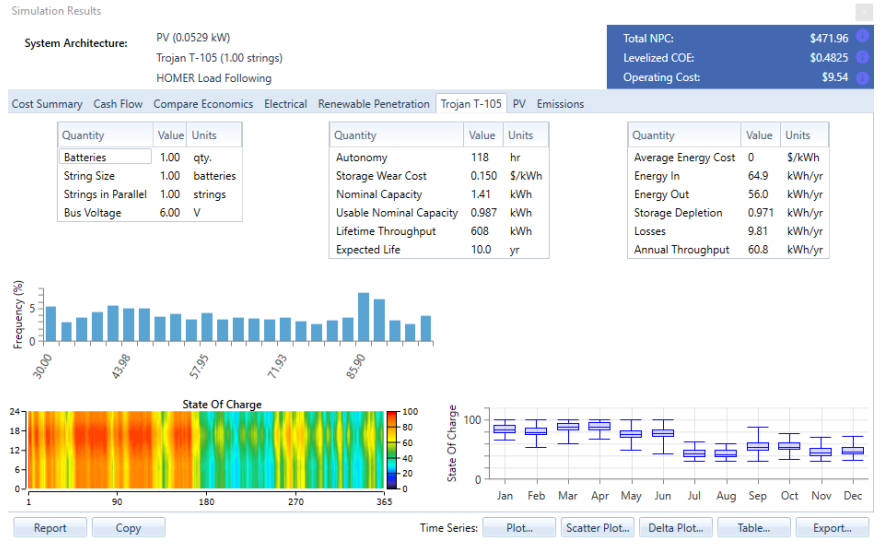
Resource Input



(*courtesy of HOMER Pro from UL Solutions*)

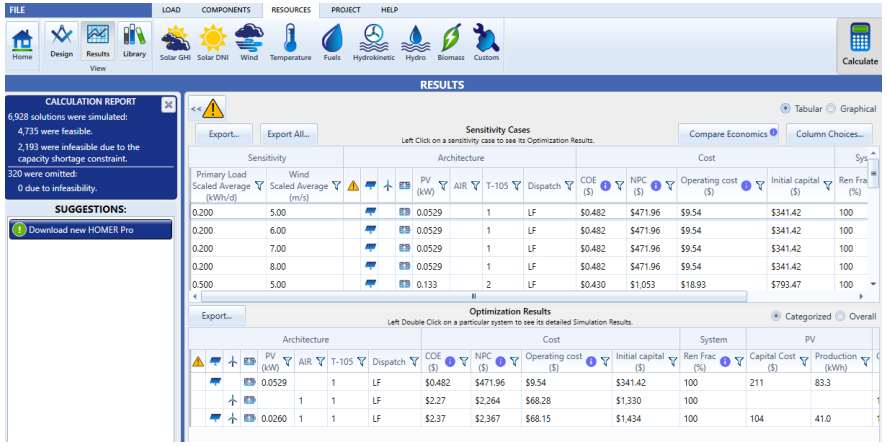
System Architecture

Simulation Results



(*courtesy of HOMER Pro from UL Solutions*)

Optimization Results

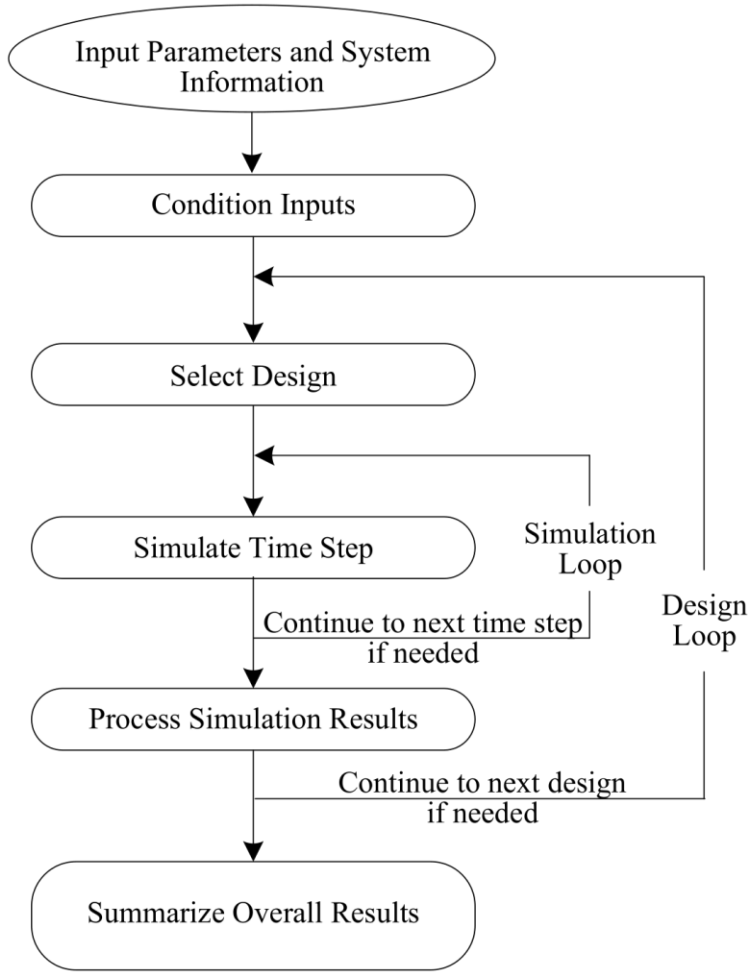


(*courtesy of HOMER Pro from UL Solutions*)

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Numerical Design Algorithm

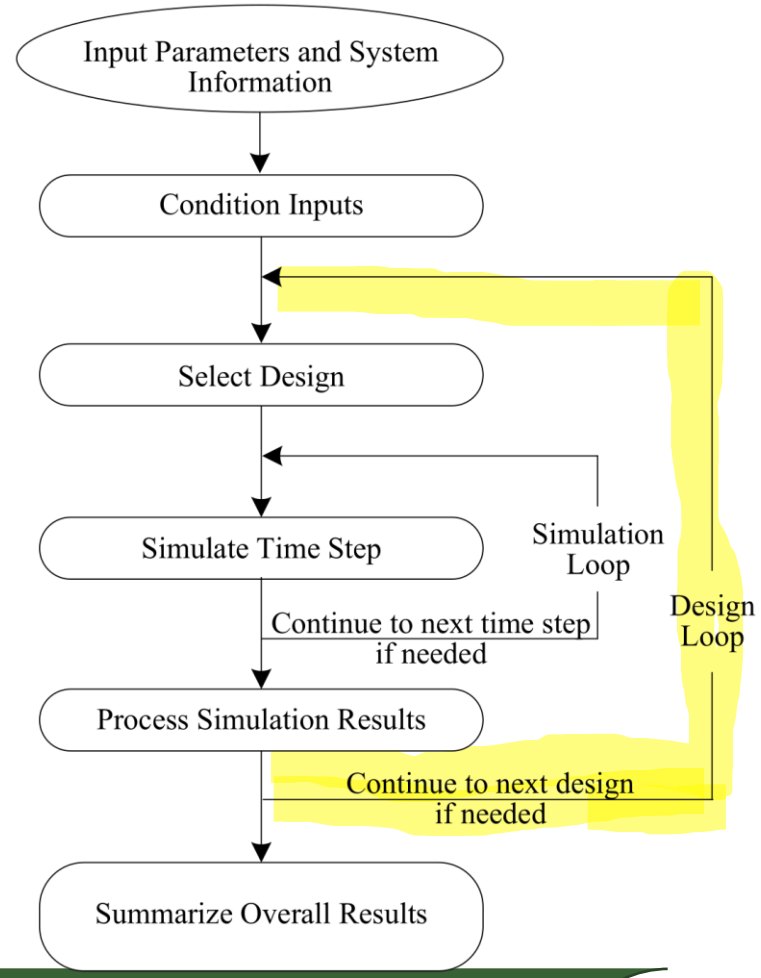
- Simulate several designs individually
  - advance through time at specified time step (e.g. hourly) for desired time period (e.g. one year)
  - process results (cost, reliability, etc.)
- Select next design to consider
- Compare results and the user selects the design for further design work



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Design Loop

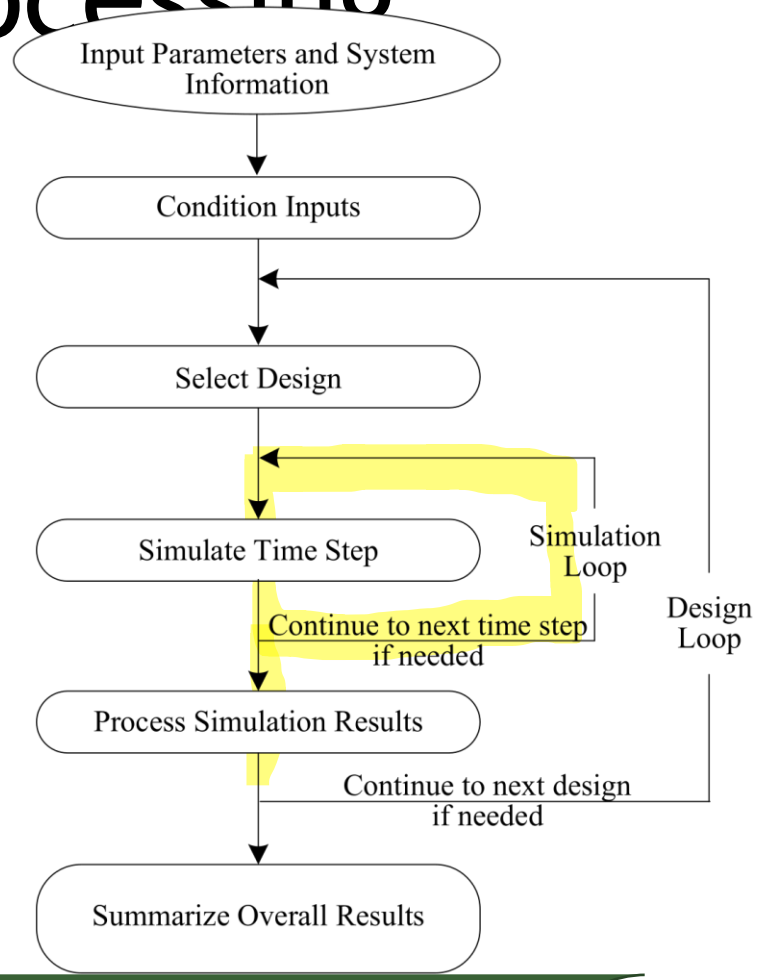
- Determines which combination of component sizes within the search space to simulate
- Example:
  - Inverter 8 kW
  - PV array: 36 kW
  - Battery bank: 55 kWh
  - Gen set: 15 kW



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Simulation Loop & Results Processing

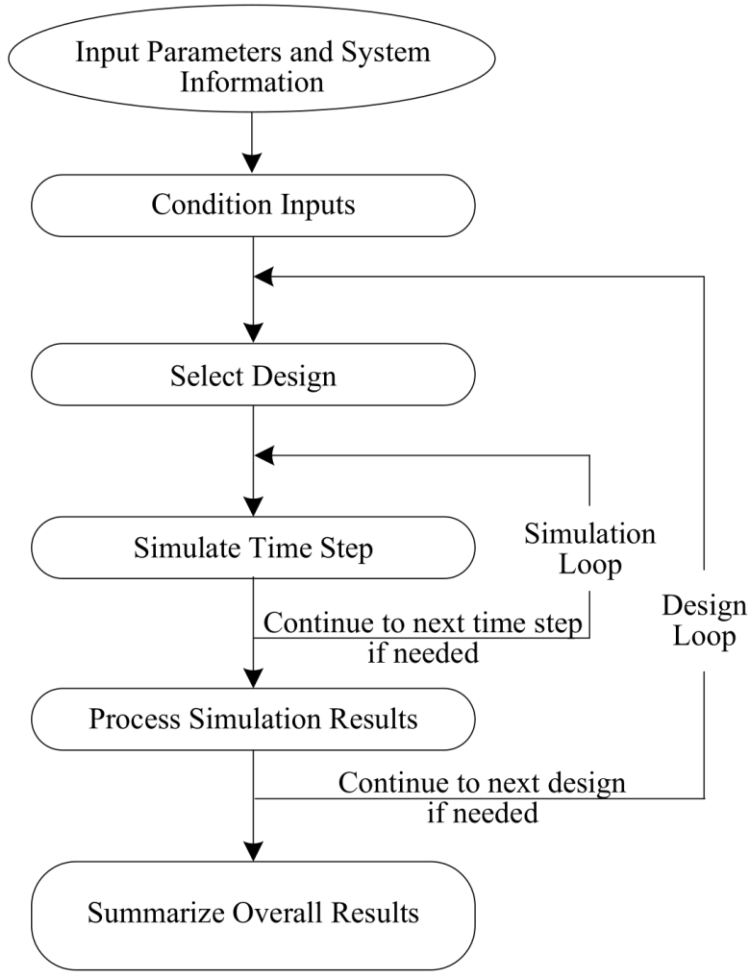
- Simulate system based on the sizes passed into it by the Design loop
- Process results to calculate:
  - operating costs
  - reliability
  - emissions
  - others of interest



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Results Interpretation

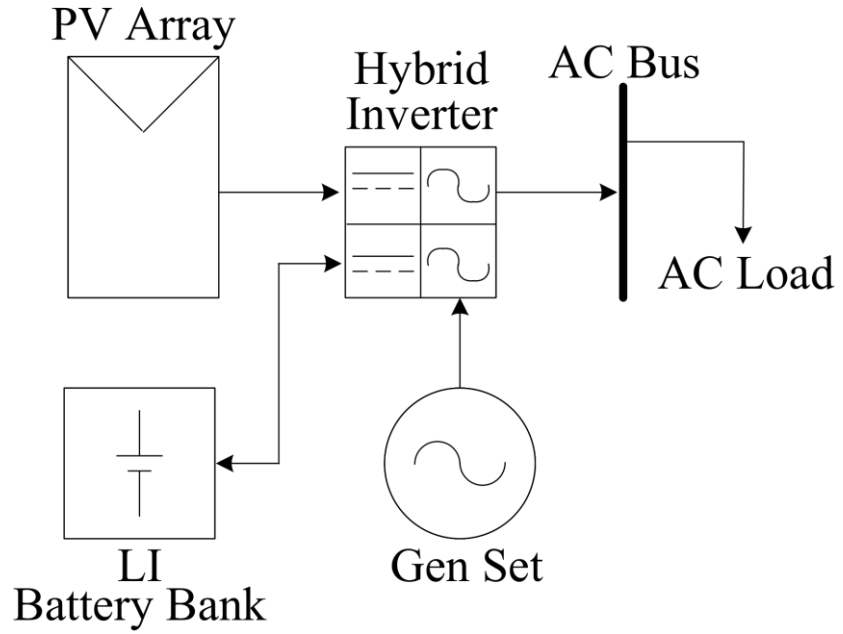
- After all designs have been considered, results are compared
- Further analyses:
  - search space might be changed (tightened or relaxed) and algorithm re-run
  - sensitivity: change one or more input parameters (such as load, fuel cost, irradiance) to see how results are affected
- Once design is selected, proceed to component selection and layout and final electrical design



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Search Space Example

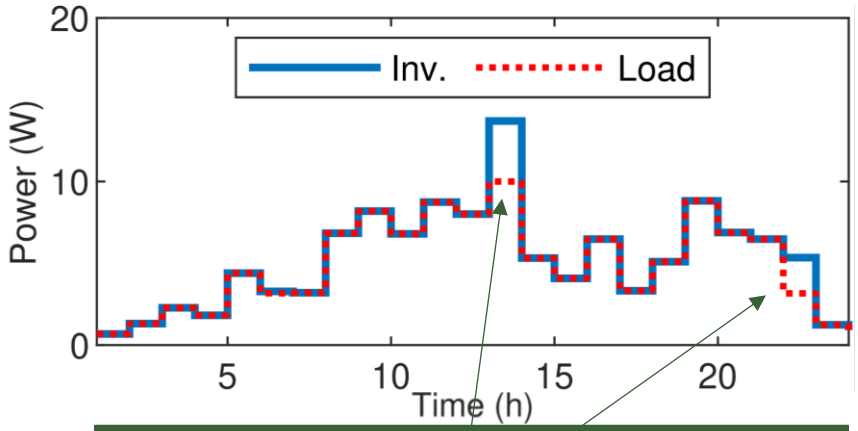
- Try several size combinations
- Setting a size to “0” removes that component from the architecture
- In practice 100s or 1000s of designs would be considered



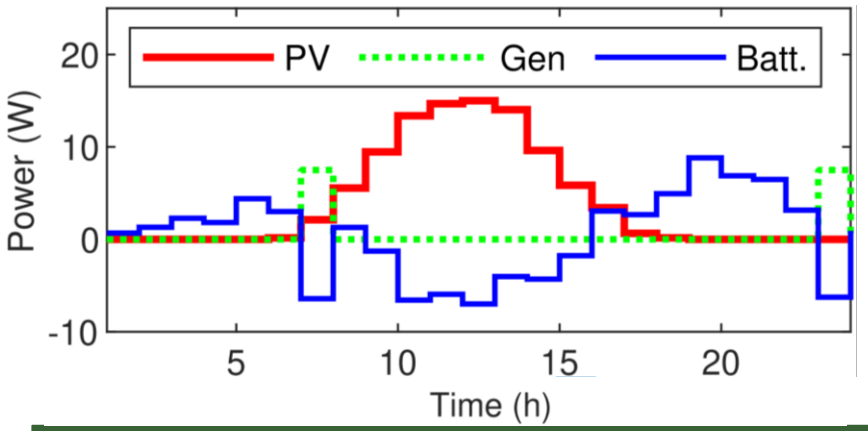
Design	PV Array S_{PV} kW	Battery S_B kWh	Inverter S_{inv} kW	Gen Set S_{gen} kW
A	22	45	10	7.5
B	22	45	10	0
C	32	68	10	0
D	30	40	12	7.5
E	14	50	12	7.5
F	34	80	18	7.5

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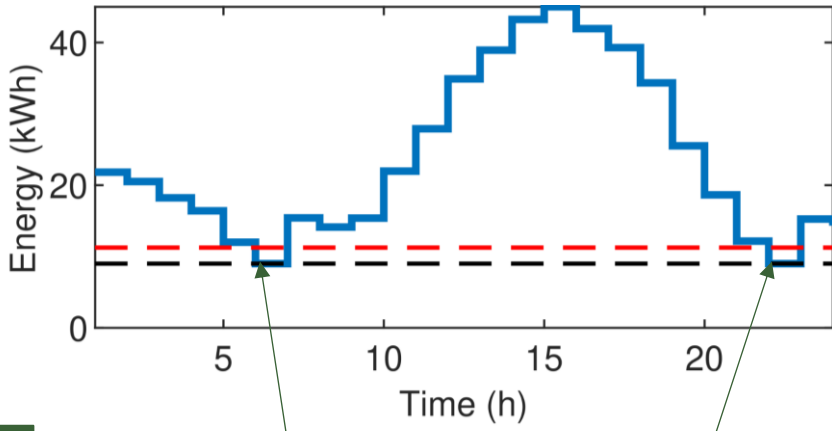
Simulation for Day 1 for Design A



Difference in inverter power and load is energy not served



PV power is produced during day
Battery power is negative when charging
Gen set operates at full power when on



Gen set operates when battery energy falls below 25% SoC

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Results Evaluation Example

Design	PV S_{PV} kW	Battery S_B kWh	Inverter S_{inv} kW	Gen Set S_{gen} kW	Capital Cost US$	5-Year Fuel Cost US$	Total Cost US$	ENS kWh	ES %
A	22	45	10	7.5	49,275	14,963	64,238	1377	97
B	22	45	10	0	48,150	-	48,150	10148	78
C	32	68	10	0	68,200	-	68,200	1227	97
D	30	40	12	7.5	58,325	14,085	72,410	846	98
E	14	50	12	7.5	42,625	31,219	73,844	1745	96
F	34	80	18	7.5	80,725	203	80,928	0	100

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Results Evaluation

reasonable design

Design	PV S_{PV} kW	Battery S_B kWh	Inverter S_{inv} kW	Gen Set S_{gen} kW	Capital Cost US$	5-Year Fuel Cost US$	Yearly Total Cost US$	ENS kWh	ES %
A	22	45	10	7.5	49,275	14,963	64,238	1377	97
B	22	45	10	0	48,150	-	48,150	10148	78
C	32	68	10	0	68,200	-	68,200	1227	97
D	30	40	12	7.5	58,325	14,085	72,410	846	98
E	14	50	12	7.5	42,625	31,219	73,844	1745	96
F	34	80	18	7.5	80,725	203	80,928	0	100

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Results Evaluation

Design	PV S_{PV} kW	Battery S_B kWh	Inverter S_{inv} kW	Gen Set S_{gen} kW	Capital Cost US$	5-Year Fuel Cost US$	Yearly Total Cost US$	ENS kWh	ES %
A	22	45	10	7.5	49,275	14,963	64,238	1377	97
B	22	45	10	0	48,150	-	48,150	10148	78
C	32	68	10	0	68,200	-	68,200	1227	97
D	30	40				35	72,410	846	98
E	14	50				9	73,844	1745	96
F	34	80	18	7.5	80,725	203	80,928	0	100

Renewable energy only designs lower reliability or higher cost

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Results Evaluation

Design	PV S_{PV} kW	Battery S_B kWh	Inverter S_{inv} kW	Gen Set S_{gen} kW	Capital Cost US$	5-Year Fuel Cost US$	Yearly Total Cost US$	ENS kWh	ES %
A	22	45	10	7.5	49,275	14,963	64,238	1377	97
B	22	45	10	0	48,150	-	48,150	10148	78
C	32	68	10	0	68,200	-	68,200	1227	97
D	30	40				35	72,410	846	98
E	14	50				9	73,844	1745	96
F	34	80	18	7.5	80,725	203	80,928	0	100

Renewable energy only designs lower reliability or higher cost

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Results Evaluation

Design	PV S_{PV} kW	Battery S_B kWh	Inverter S_{inv} kW	Gen Set S_{gen} kW	Capital Cost US$	5-Year Fuel Cost US$	Yearly Total Cost US$	ENS kWh	ES %
A	22	45					64,238	1377	97
B	22	45					48,150	10148	78
C	32	68					68,200	1227	97
D	30	40	12	7.5	58,325	14,085	72,410	846	98
E	14	50	12	7.5	42,625	31,219	73,844	1745	96
F	34	80	18	7.5	80,725	203	80,928	0	100

Design D: large PV, small battery
Design E: large battery, small PV
Both have higher costs than Design A

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Results Evaluation

Design	PV S_{PV} kW	Battery S_B kWh	Inverter S_{inv} kW	Gen Set S_{gen} kW	Capital Cost US$	5-Year Fuel Cost US$	Yearly Total Cost US$	ENS kWh	ES %
A	22	45	10	7.5	49,275	14,963	64,238	1377	97
B	22	45	10	0	48,150	-	48,150	10148	78
C	32	68	10	0	68,200	-	68,200	1227	97
D	30	40	12	7.5	58,325	14,085	72,410	846	98
E	14	5(					73,844	1745	96
F	34	80	18	7.5	80,725	203	80,928	0	100

Highest reliability, significantly higher cost

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Sensitivity Analysis

- Design A and C are selected for further analysis
- Consider scenarios where load is +/-10% from estimate

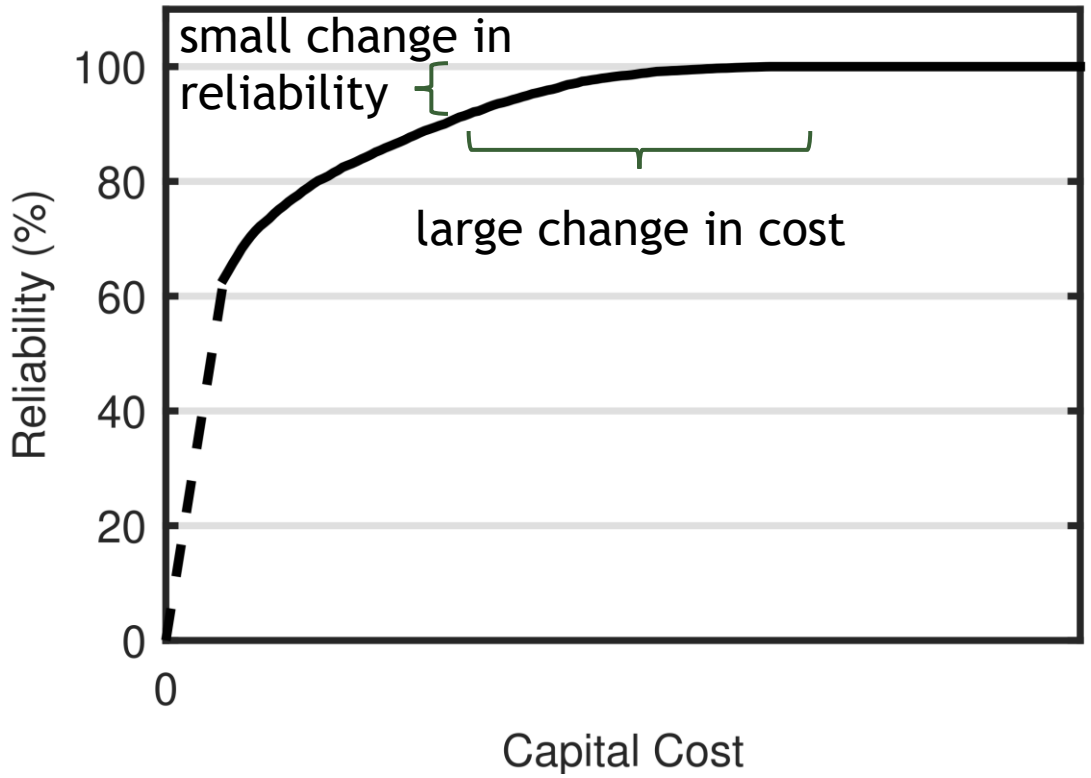
Design	Load Scaling %	PV S_{PV} kW	Battery S_B kWh	Inverter S_{inv} kW	Gen Set S_{gen} kW	Capital Cost US$	Fuel Cost US$	Total Cost US$	ENS kWh	ES %
A	−10%	22	45	10	7.5	49,275	11,228	60,503	568.85	99
A	+10%	22	45	10	7.5	49,275	19,080	68,355	2473.8	95
C	−10%	32	68	10	0	68,200	0	68,200	268.4	99
C	+10%	32	68	10	0	68,200	0	68,200	3789.4	93

Design C reliability is too low for the +10% case.
Select Design A for next design steps

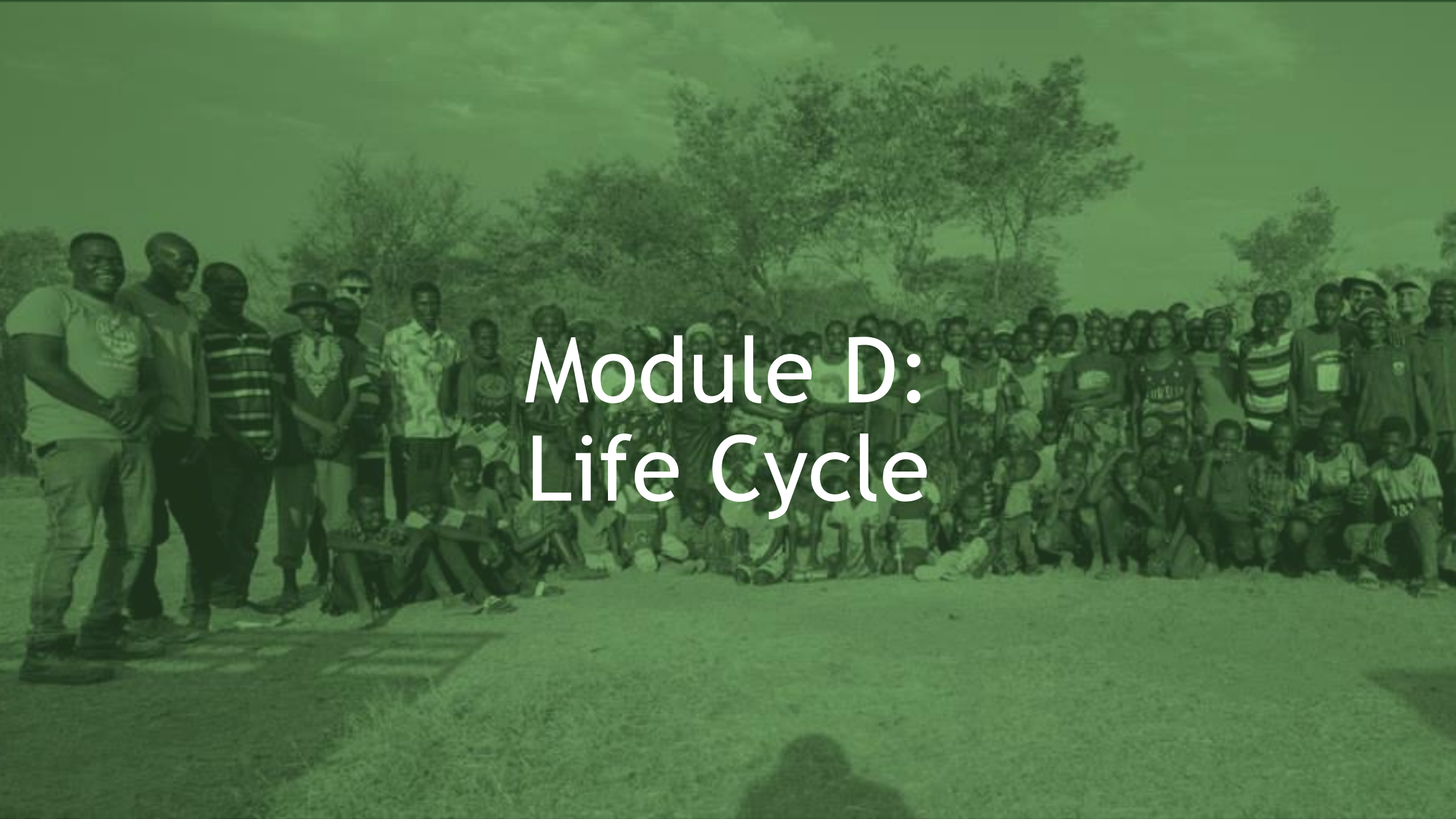
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Cost and Reliability Trade-off

- Increasing reliability of system can be accomplished by increasing generation source and/or energy storage capacity
- Costs often rapidly increase for small improvements in reliability
- Tradeoff: which is preferred, a more reliable system or a less expensive system
  - is it better to serve fewer people with highly reliable electricity or many more people with somewhat less reliable electricity?

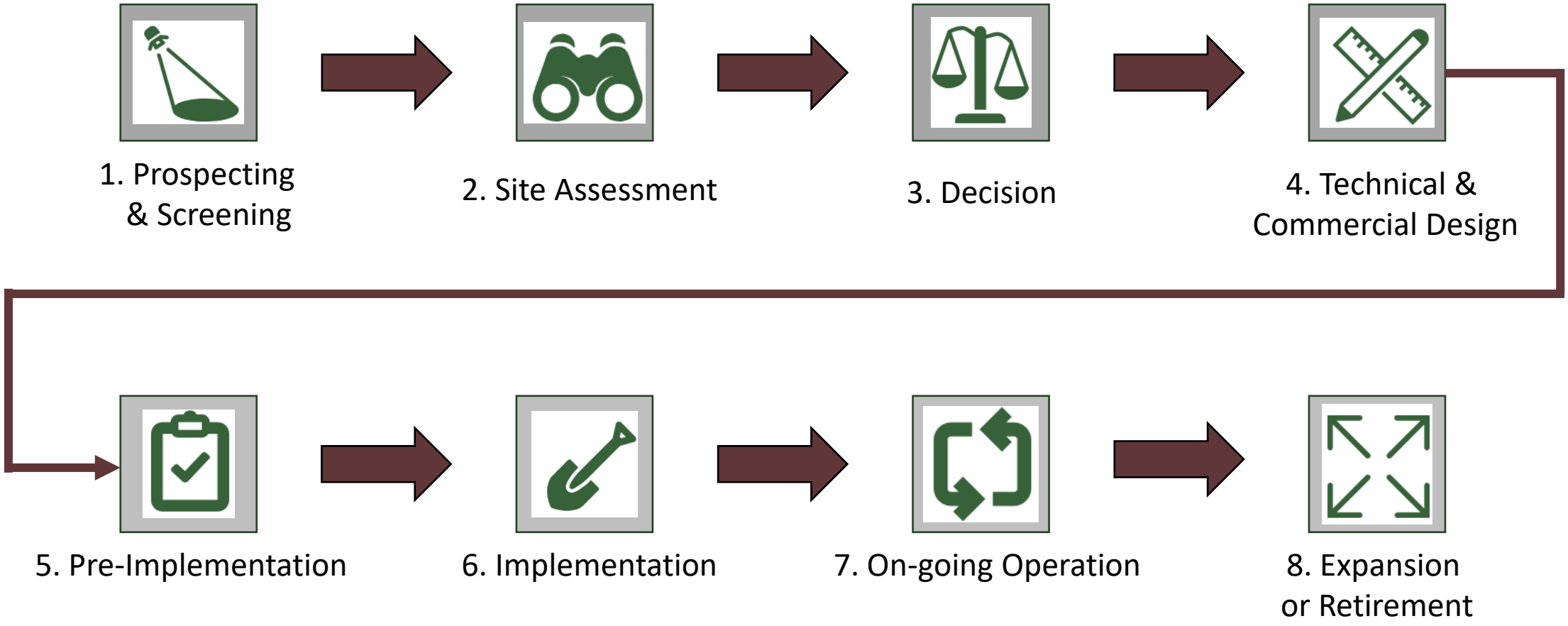


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Module D: Life Cycle

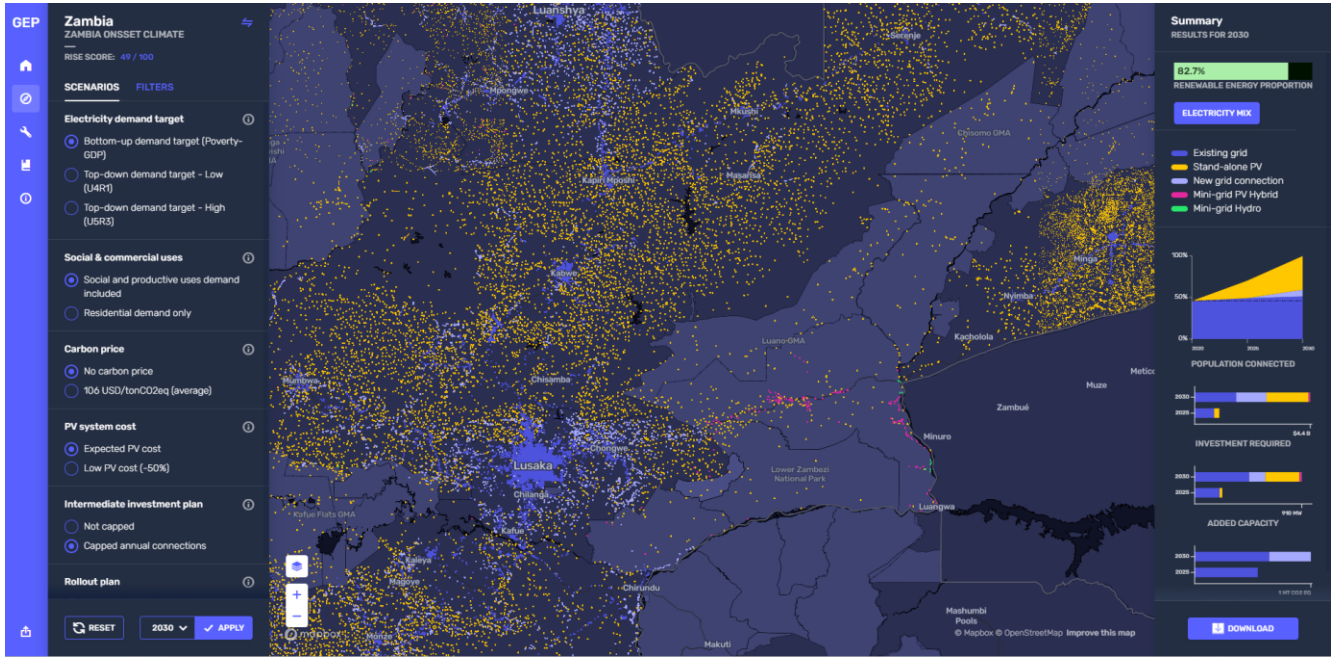
Off-Grid System Life Cycle



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1. Prospecting & Screening

- Which community to chose?
- Success often depends on location
- Quickly and inexpensively screen potential communities
  - distance from existing grid
  - resource availability
  - other demographics
- Create short list of promising communities



Global Electrification Platform geospatial tool, which is part of the ENERGYDATA.INFO and World Bank Group Energy and Extractives Open Data and Analytics Initiative, and created by the KTH University (courtesy of World Bank Group, KTH University and the Energy Sector Management Assistance Program (ESMAP))

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2. Site Assessment

On-site data collection

- observe community firsthand
- meet with local officials
- confirm secondary data are reasonable
- conduct surveys/focus groups
- collect preliminary energy resource data
- identify possible location for assets



(*courtesy Kilowatts for Humanity*)

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2. Site Assessment

- Not all off-grid communities are suitable for mini-grids
- What characteristics make a community a good candidate?



Source: Google Earth

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2. Site Assessment: Preferred Characteristics

- ✓National grid is located far away (20 km or more) with no credible plans for it to be extended to the community
- ✓No other off-grid systems installed or planned to be installed
- ✓Estimated demand for electricity is high, and the planned uses are productive or improve the quality of life
- ✓Sufficient ability and willingness to pay for electricity at a cost-reflective rate or a rate that aligns with the implementing organization's ability to operate the mini-grid

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2. Site Assessment: Preferred Characteristics

- ✓At least 50 structures (homes, businesses, etc.) within a 1 km radius (the area that can usually be served with low voltage distribution)
- ✓Community is densely populated
- ✓Basic infrastructure, including roads and cellular network coverage
- ✓Politically stable
- ✓Low risk of theft and vandalism

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2. Site Assessment

Social/development preferred characteristics

- access to electricity is a high-priority developmental goal for the community
- access to electricity aligns with and supports other developmental goals, for example, healthcare and education
- community is able to organize itself to manage and operate the mini-grid (if applicable)



(*courtesy Kilowatts for Humanity*)

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3. Decision



- Prioritize communities based on organizational objectives
  - profit
  - humanitarian impact
  - others
- Decision methods
  - PESTLE (political, environmental, social, technological, legal, economic) analysis
  - risk matrices
  - Theory of Change
  - others

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4. Technical & Commercial Design



- Detailed technical and commercial plan design and development
- Iterative and inter-related process
- If design is not projected to meet certain technical or business targets, consider next community on list
  - capital expense
  - operating expense
  - access tier
  - Average Revenue Per User (ARPU)

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5. Pre-Implementation

- Permitting (if applicable)
- Vendor identification and contracting
- Procurement
  - importing equipment (may take many months)
- Community/customer identification and orientation
- Base line monitoring & evaluation to determine impact (see Chap. 19)



(*Courtesy A. Stewart*)

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6. Implementation

- Construction of energy production, distribution and end-user system
- Implementation can be quick---as few as several days
- Commissioning and verification



(*Courtesy P. Dauenhauer*)

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7. On-Going Operation

- Serving users
- Maintenance and repair
- Technical data collection
- Commercial data collection
- Social data collection



(*Courtesy PowerGen Renewable Energy*)

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8. Expansion or Retirement

- Expansion
  - serve additional users
  - improve access tier

- Retirement
  - restore land and environment to original condition
  - dispose, re-use or re-cycle equipment in a responsible way
  - community relations

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Monitoring and Evaluation (M&E)

- M&E plan are used to understand the impact an electrification program has
- Monitoring: routine measurement or observation of users and others affected by the system
- Evaluation: periodic assessment of how or to what extent the off-grid system is meeting its objectives

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Monitoring and Evaluation (M&E)

- M&E can apply to technical and economic aspects of the project
- Investors and donors may require M&E plans and programs and certain metrics tracked
- Community should be involved in developing M&E program
  - What metrics are important to them?
  - What voice do they have in expressing concerns about an on-going project?



(*courtesy NRECA International*)

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Community Engagement

- Off-grid programs impact community directly and indirectly
- Impacts can be beneficial, burdensome, anticipated, and unexpected
- Important to engage community early and often throughout program
- Examples:
  - Training, hiring local labor, have local group or co-op operate/maintain system



(*courtesy P. Dauenhauer*)

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Community Engagement Best Practices



Build relationships



Speak and listen



Be linguistically and culturally appropriate



Be inclusive



Be realistic and transparent



Engage with traditional structures

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Capacity Building

- Electricity access programs are an opportunity for “capacity building”
- Capacity building: increase the skills, experience, and infrastructure of a community
- Ways to build capacity
  - hire local, in-country vendors, installers, etc. whenever possible
  - offer training to local community (technical, business, safety, etc.)
  - do not rely on volunteer labor from abroad



(*courtesy P. Dauenhauer*)

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Summary

- Off-grid electrification is a worthy subject to study from academic, humanitarian, and commercial perspectives
- Variety of engineering components and methods used: solar and battery design, power electronics, controls, operation
- Life cycle of off-grid systems involve several steps, from prospecting through design and operation to expansion of retirement
- Technical aspects are often the least challenging---socio-cultural, economic, etc. require thoughtful attention

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Further Resources

- B. Krogh, J. Mutale, H. Louie, IEEE eLearning “Minigrids in Africa”, https://www.ieee.org/education/elearning-library
- www.drhenrylouie.com
- H. Louie, “Off-Grid Electrical Systems in Developing Countries,” 2nd Ed., Cham, Switzerland:Springer Nature, DOI: 10.1007/978-3-031-88542-6, 2025.

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KiloWatts for Humanity™

About KWH

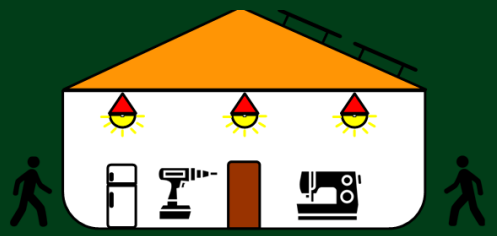
- Founded in 2015 by Dr. Henry Louie, Steve Szablya, Jenna Isackson
  - Henry and Steve longtime PES members
- Registered 501(c)3 tax-exempt organization in Washington State
- Entirely volunteer run
- Program expenses +90% of budget

Mission:

To improve people's lives by providing access to electricity and fostering the development of sustainable businesses.

KiloWatts for Humanity™

Community Energy Hub





Ntanga, Zambia

KiloWatts for Humanity™

Productive Use of Electricity





BOSS
Lady















KiloWatts for Humanity™

KWH Implementation Process: Partnerships





KiloWatts for Humanity™

KWH Implementation Process: Assessment/Feasibility





+2 year process

Candidate locations identified by partners

Surveys, focus groups, fact-finding lead to a mutual go/no-go decision



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KWH Implementation Process: Training/Planning and Engagement



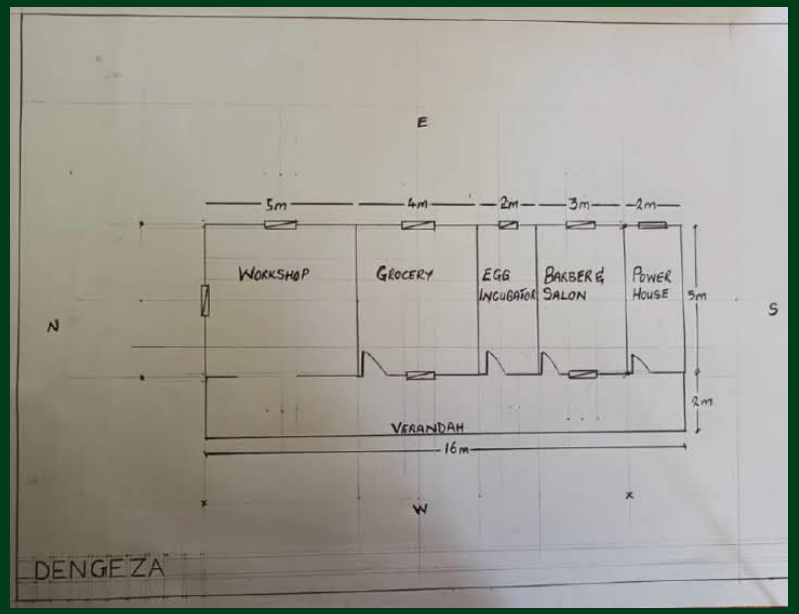


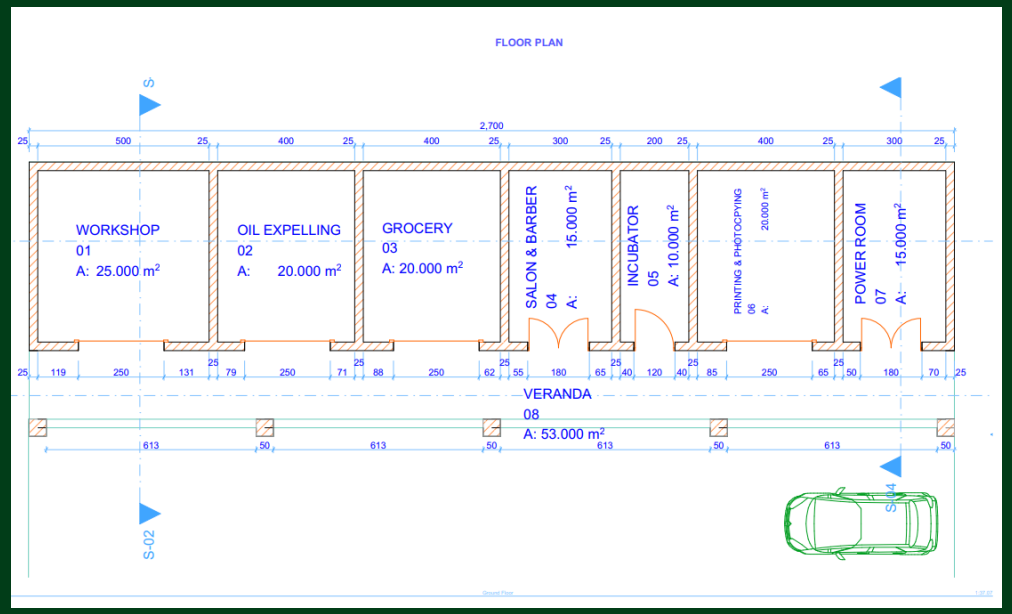
With mentorship, communities develop: Business plans, Organizational plan, Security plan

KWH partners offer training

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KWH Implementation Process: Hub Construction

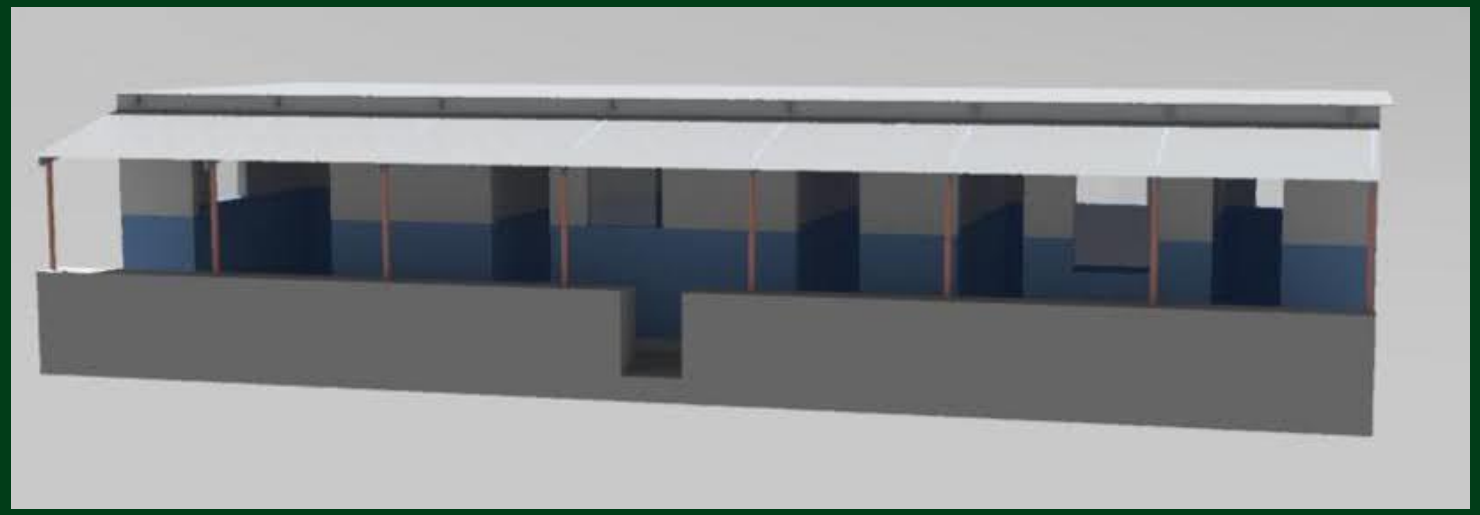


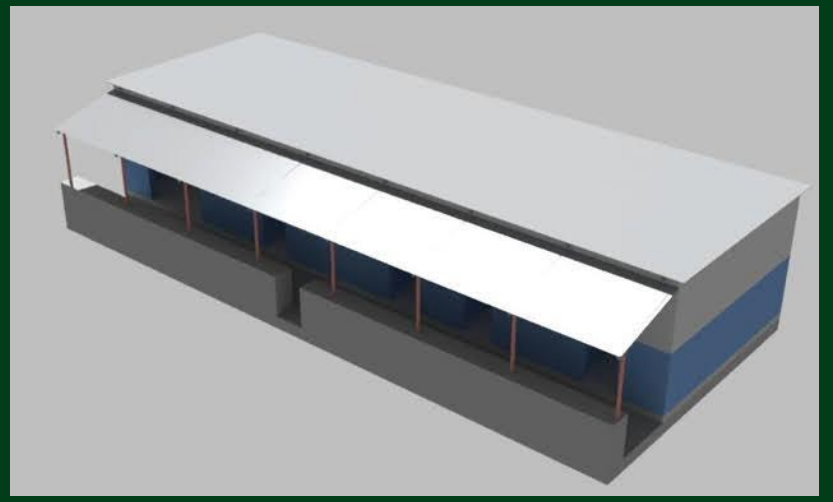


Footprint: +100 m^2
Dedicated power equipment room
Rooms for each business

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KWH Implementation Process: Hub Construction





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KWH Implementation Process: Hub Construction





Community contributes materials and labor

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KWH Implementation Process: Hub Construction









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KWH Implementation Process: Hub Construction



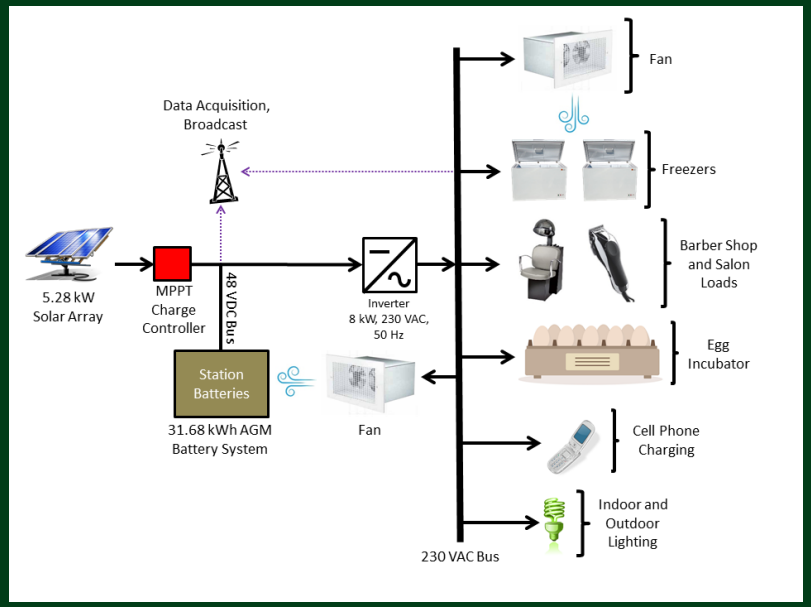




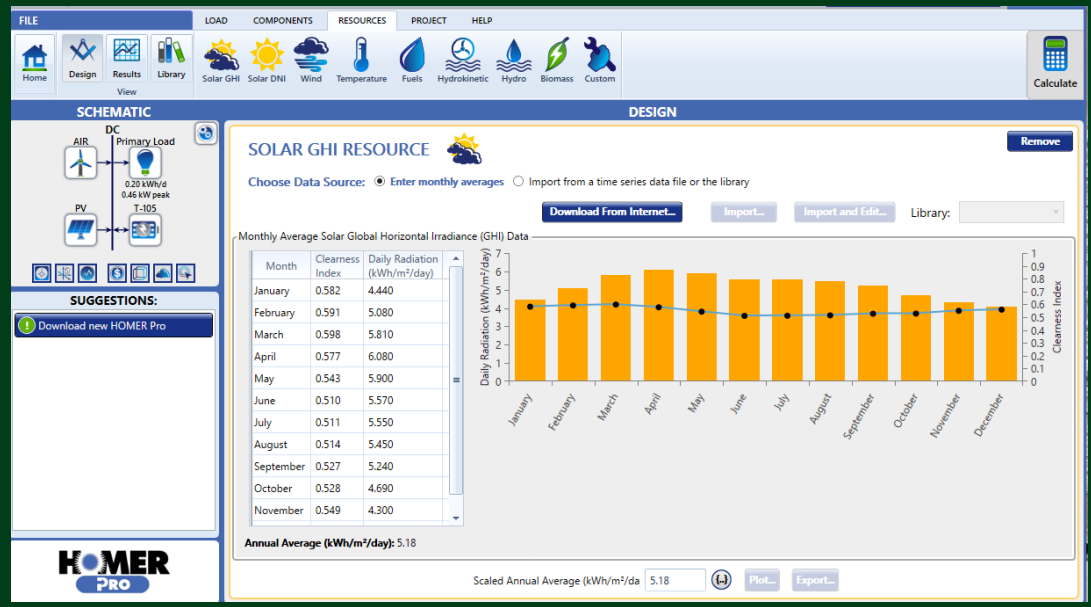


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KWH Implementation Process: Electrical Design



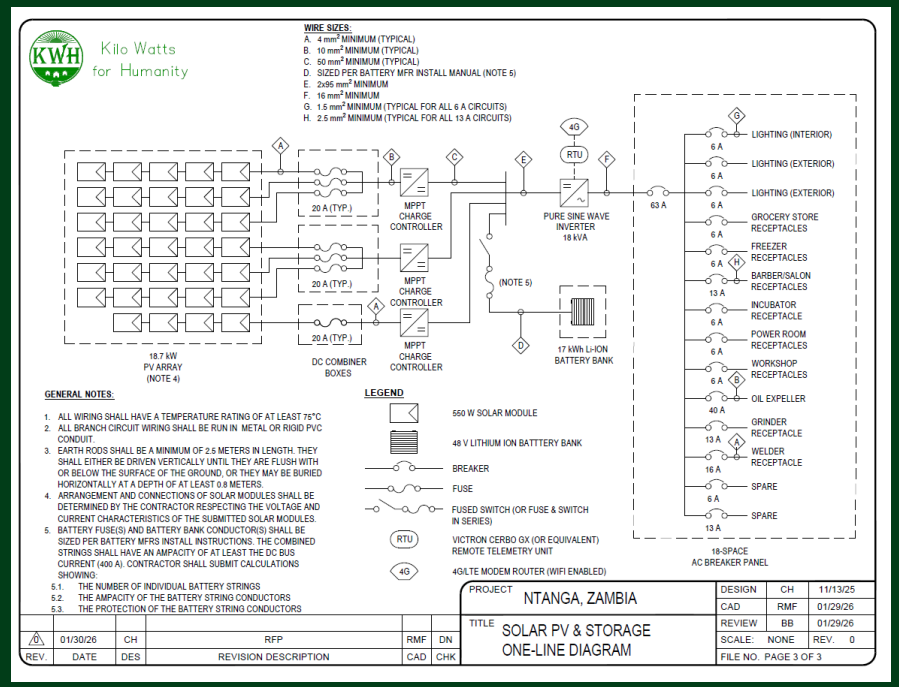
Load modeling based on business plan

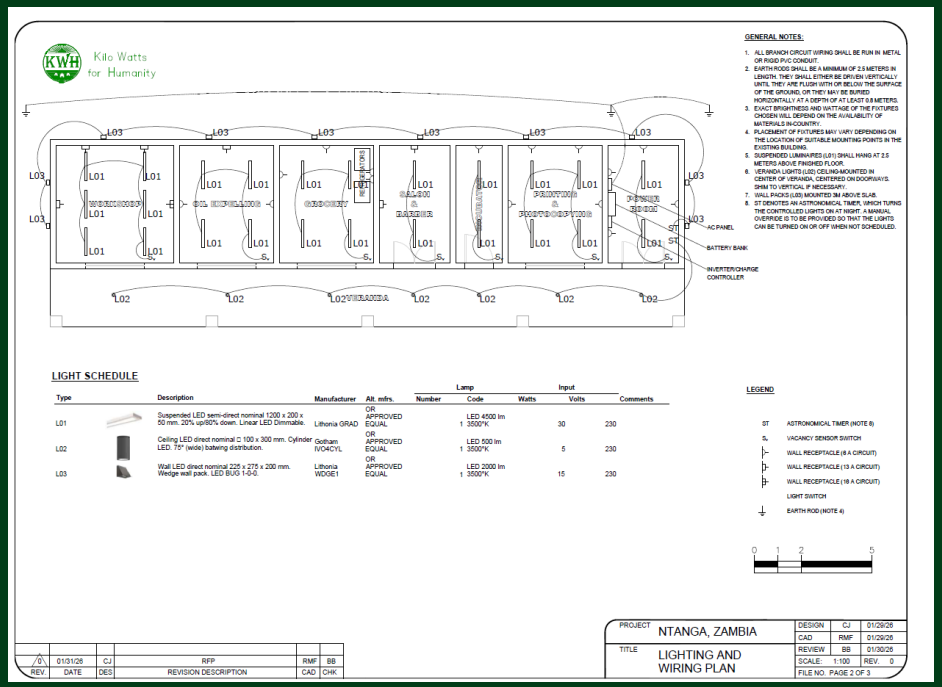


Computer-aided design + in-house cost modeling

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KWH Implementation Process: Electrical Design





Design package: Solar, electrical, lighting, grounding

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KWH Implementation Process: Electrical Design

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Request for Proposal

KiloWatts for Humanity

Hambelele Solar Kiosk

Solar PV System Procurement and Installation Services

Contact: Daniel Nausner, PE
+1 206 735 1989
daniel@kilowattsforhumanity.org
John Davis
+1 425 263 7404
john@kilowattsforhumanity.org

Release Date: Aug 19, 2024

Due Date: Aug 26, 2024 5:00 PM GMT+2 (Central Africa Time)



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KWH Implementation Process: Electrical Installation/Commissioning









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KWH Implementation Process: Continuing Support









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KWH Implementation Process: Continuing Support

