Solar Microgrid Methodology User Manual

I. Introduction

A. **Purpose**: This user manual supports the Solar Microgrid Methodology (SMM), which provides users with the skills and knowledge needed to develop a Solar Microgrid Feasibility Study. This user manual covers key tasks such as analyzing electrical meter data, modeling solar systems, sizing Battery Energy Storage Systems (BESS) to maximize economic and resilience benefits, conducting economic analyses, and presenting findings in a clear, professional format. By the end of the course, users will have a strong understanding of the SMM and be ready to apply their knowledge to real-world projects.

B. **Benefits of Solar Microgrids:** A Solar Microgrid delivers a trifecta of economic, environmental, and resilience benefits.

1. Economic
    a) A Solar Microgrid can significantly reduce electricity costs compared to traditional utility purchases, while also providing increased long-term savings as utility rates continue to rise. In addition, they offer Value-of-Resilience (VOR) by maintaining critical operations during outages—often at a lower lifecycle cost than fossil-fueled generators.
2. Environmental
    a) A Solar Microgrid generates clean, renewable electricity on-site, reducing reliance on fossil fuels and cutting greenhouse gas emissions. It enhances grid stewardship by decreasing demand during California's 4–9 p.m. peak period, when both grid stress and emissions are at their highest. By producing and consuming energy locally, a Solar Microgrid eliminates transmission and distribution losses and lowers the environmental impact of centralized power plants and the large-scale infrastructure they require.
3. Resilience
    a) A Solar Microgrid provides an unparalleled level of resilience compared to traditional fossil fuel generators. According to the Clean Coalition, resilience is defined as the ability to keep critical loads online indefinitely in the face of extreme or damaging conditions. This goes far beyond conventional reliability, which is typically measured after just five minutes of grid outage. A Solar Microgrid delivers 100% ride-through for short-duration outages, with costs scaling based on desired backup duration. It also offers the flexibility to design for indefinite resilience for selected critical loads, depending on the proportion of load served.

C. **Target Audience:** This manual is intended for users, professors, teachers, and instructors in the fields of engineering, environmental studies, or energy systems — as well as anyone interested in analyzing the technoeconomic feasibility of a Solar Microgrid.

D. **Overview:** This user manual is designed to be flexible — it can be used for self-guided learning, integrated into existing curricula, or delivered as a standalone course. By the end of the manual, users will be equipped to complete a comprehensive Solar Microgrid Feasibility Study, gaining valuable experience in both the technical and economic dimensions of Solar Microgrid design. The manual emphasizes project-based learning and the use of industry-standard tools, ensuring that users develop not only theoretical understanding but also practical, real-world skills.

II. Teaching Methodology

A. This manual follows a structured, step-by-step approach based on the Clean Coalition's SMM. It is designed to be adaptable for a variety of educational settings. Instructors may integrate individual modules into existing courses or deliver the material as a focused, standalone training.

B. Educators and training providers have flexibility in how they implement assessments, supplemental materials, and hands-on activities. The methodology supports both theoretical instruction and applied learning, allowing instructors to customize the depth and delivery to match student needs, course objectives, or institutional requirements.

III. Recommended Tools

A. UtilityAPI: A secure platform that automates the collection, standardization, and sharing of utility customer data, including electric and gas usage, billing information, and interval data.

B. HelioScope: A web-based solar design and sales platform developed by Aurora Solar. HelioScope streamlines the process of designing photovoltaic (PV) systems by integrating site layout and energy yield simulations, enabling rapid creation of accurate solar array designs.

C. Energy Toolbase (ETB) Developer: A comprehensive software platform designed for the financial analysis and modeling of solar and energy storage projects. The platform calculates the economic impacts of various system configurations, providing precise assessments of utility costs, energy savings, and overall project economics.

D. Clean Coalition's Solar Microgrid Analysis Processor (SMAP): A specialized tool used to clean and analyze electrical meter data, size the BESS, and evaluate resilience outcomes and their associated value.

Step 1: Load Profiles

Overview

Step 1 introduces users to core technologies and the rationale behind the SMM. Users begin by collecting and cleaning electricity interval data, reviewing utility billing information, and developing both Adjustment and Master Load Profiles. This foundational step is critical for building an accurate and effective Solar Microgrid Feasibility Study.

Core Concepts

- **Interval Data:** A full year's worth of energy consumption data recorded in either 1-hour or 15-minute intervals. There are 8,760 hourly intervals or 35,040 15-minute intervals in a year.
- **Load Profiles:**
    - **Baseline:** The historical annual electricity usage for a site. This forms the foundation for developing the Master Load Profile.
    - **Adjustment:** Modifications to the Baseline Load Profile (BLP) to account for anticipated changes, such as EV charging infrastructure (EVCI), electrification of gas appliances, energy efficiency improvements, and/or new facility loads.
    - **Master:** The forecasted annual load profile used for analysis, created by combining the Baseline and Adjustment profiles (Baseline + Adjustment = Master).
    - **Critical:** Mission-critical and/or life-sustaining loads that require 100% resilience. These typically represent 10–25% of a facility's total load.
- **Total Annual Load:** The total energy consumption (in kWh) over the course of a year, calculated by summing all usage across every 15-minute (or hourly) interval.
- **Peak Load:** The highest hourly demand (in kW) observed during the year. If using 15-minute interval data, the peak 15-minute load is multiplied by 4 to estimate the peak hourly load.
- **Net Zero Energy (NZE):** Achieved when annual energy generation equals or exceeds total annual energy consumption. NZE percentage is calculated as: (Total Annual Generation ÷ Total Annual Load) × 100. A target of 100–110% NZE is recommended.

Tools

- **Utility API**: A secure, automated platform used to access and download historical electric load data directly from utility accounts, ensuring accurate and up-to-date interval data for analysis.
- **Clean Coalition's (SMAP)**: A specialized tool used to clean and process raw load data, as well as to visualize and analyze baseline, adjustment, master, and critical load profiles over the course of a year.

Procedure

1. **Download and Clean Raw Interval Data:**
    - Create a Utility API Account:
        - Sign up at UtilityAPI.com to access customer utility data.
    - Access Utility Data using Utility API:
        - Request Data:
            - Enter the customer's name, email, and utility information.

        - Preview the request before sending.
        - Have the customer approve your request to grant access.
    - Collect Historical Data:
        - Once approved, view the account's electrical meter(s) and determine the meter you need to download data for.
        - Select "get data" for this meter and then "collect historical data" to start the process of collecting historical data for the specified meter.
        - Once the data has fully been collected, select "see data" for the meter and then download "Intervals: all intervals [csv]".
        - Also, download "Bills: latest pdf [pdf]".

2. **Review and Understand the Utility Bill:**
    - Review the Latest Monthly Bill pdf:
        - Confirm the site address and meter number, ensuring both are verified by the site itself and match the information in the interval data.
    - Understand Energy Procurement, Demand, and Delivery Charges:
        - The utility charges for energy delivery, while a Community Choice Aggregator (CCA), if present, may appear on the bill as the entity charging for the energy supply itself.
        - If onsite generation (e.g., solar) exists, review net energy usage (produced vs. consumed).
    - Identify Key Information:
        - Review the bill to identify the utility rate schedule and the CCA program associated with the meter. This information will help determine whether a rate schedule switch is needed later in Step 1 and will also inform key inputs during Step 4.
3. **Clean the interval data using the SMAP**
    - Set up a New Project:
        - Log into the SMAP and click "Start a New Project+". Then, name it based on the site.
    - Upload Raw Interval Data from UtilityAPI:
        - Click "Create New Scenario" button and name the scenario based on the meter.
        - Under the Configure Load and Generation section, click "Create Aggregated Profiles Spreadsheet".
        - Under Baseline Load Profile, click "Select File" and upload the .csv interval data downloaded from UtilityAPI.
        - Set a fixed threshold of 0 to identify and correct near-zero or missing data values. This setting addresses abnormally low values near zero, which may indicate a grid outage or dataset error. The threshold function replaces these values with data from surrounding timestamps to improve accuracy.
        - Choose the energy unit. kWh if the data is in 15-minute intervals and kW if the data is in hourly intervals.
        - Click the "Generate Profile". The SMAP will automatically clean the data and organize it into the most recent full calendar year, consisting of 35,040 intervals (for 15-minute data).
    - Visualize Clean Data:
        - SMAP will generate visual outputs and summary tables of the BLP in the Load Profiles Explorer tool, including:

            - Average hourly consumption by month.
            - Hourly usage patterns by day of week.
            - Hourly usage patterns by month.
            - Maximum, minimum, and average daily demand by month.

4. **Create an Adjustment Load Profile (ALP)**
    - Define EV Charging Needs:
        - Determine the number of Level 2 EV charging ports (typically 7 kW per port).
        - Choose an EV charging profile shape that best reflects the site's usage type — e.g., residential, municipal fleet, employee and public, etc.
        - Apply the chosen profile shape to the total number of charging ports to estimate demand over time.
    - Develop any electrification load profiles:
        - If all gas appliances are to be electrified:
            - Download gas interval data from UtilityAPI.
            - Convert gas usage to electricity using the standard conversion: 1 therm = 29.3 kWh.
            - For improved accuracy, divide each interval by 3 to account for the greater efficiency of electric appliances compared to gas (electric systems are typically ~3x more efficient).
    - Aggregate Adjustment Profiles:
        - Combine all adjustments—including EV charging, appliance electrification, and any other anticipated changes — into a single ALP.
    - Upload to SMAP:
        - Upload the finalized ALP into SMAP, following the same steps used for the Baseline Load Profile.
        - Double-check that the energy units (kWh or kW) are set correctly based on your data intervals.
5. **Create the Master Load Profile (MLP) and Critical Load Profile (CLP)**
    - MLP will be Automatically Generated
        - After uploading the ALP to the SMAP and clicking "Save and Aggregate Profiles," the MLP will be automatically generated.
    - Define the CLP
        - In the Quick Configure pane, input the percentage of the Master Load Profile that should be designated as critical load.
        - According to the Clean Coalition's VOR123 methodology:
            - 10% of the load is considered Critical (mission-critical or life-sustaining)
            - 15% is Priority (important but not essential)
            - 75% is Discretionary (non-essential)
6. **Other considerations**
    - Load Growth Rate
        - Review and update the Load Growth Rate found in the Degradation Parameters section to reflect expected changes in site energy demand over time. Increasing the Load Growth Rate could be a replacement for an ALP.
    - Explore Load Profile Visualizations
        - Use the Load Profiles Explorer tool to view detailed visualizations of baseline, adjustment, master, and critical load profiles.

Additional Resources
● **UtilityAPI Youtube Channel:** A curated playlist of tutorial videos demonstrating how to request and download interval load data and billing information using UtilityAPI. ● **SMAP Step 1 Training (Coming Soon):** Tutorial videos will be available to guide users through the Step 1 process in UtilityAPI and the SMAP, including data upload, cleaning, and profile generation.

Step 2: Resource Scenarios

Overview

In Step 2 of the SMM, users learn to design and size solar photovoltaic (PV) systems and BESS. Using HelioScope, they draw solar segments, choose panels and inverters, perform shading analyses, and optimize array configurations. Users then generate a solar production profile, upload it into SMAP, and create aggregated load and generation profiles. These are used to properly size the BESS to support critical loads and improve system resilience.

Core Concepts

- **Solar Design**
  - **Panel Configuration**: Selecting appropriate solar panels, tilt angles, azimuth, and row spacing to minimize shading and maximize energy production efficiency.
  - **Shading Analysis**: Evaluating the impact of nearby structures or landscape features on panel performance and optimizing layout to reduce shading losses.
  - **Specific Yield**: Calculating the ratio of total annual generation to system size (kWh per kW) to assess solar design efficiency.
  - **Net Zero Energy (NZE)**: A performance metric that compares total annual energy generation to total annual energy consumption. NZE is calculated as: (Total Annual Generation ÷ Total Annual Load) × 100**.** An NZE value of 100% indicates the system produces as much energy as it consumes over the course of a year.
- **BESS Sizing**
  - **State of Charge for Resilience (SOCr)**: The portion of battery energy capacity reserved specifically to support critical loads during grid outages.
  - **Total Critical Load Required (TCLR):** The total amount of stored energy (in kWh) required to sustain a site's critical loads for a specified outage duration.

Tools

- **HelioScope:** A solar design platform used to draw system layouts, select panels and inverters, conduct shading analyses, and generate specific yield data for energy production estimates.
- **Clean Coalition's SMAP:** Used to upload solar production data and finalize the Aggregated Profile Spreadsheet (APS), which visualizes the interaction between load and generation across time.
- **Clean Coalition's SOCr Calculator (embedded within SMAP):** A SMAP-native tool for calculating the battery size required to sustain critical loads during grid outages. It leverages site-specific load and generation profiles to determine the appropriate BESS energy capacity sizing.

Procedure

1. **Create a New HelioScope Project**
   - Select the "New Project" button and enter the project name and the site address (from the utility bill), then select the "Create New Project" button. There's no need to specify a Profile (advanced) or Description unless desired.

- Select the “New” button and name the description accordingly, which typically consists of Full Siting Potential design or MLP NZE design.

2. **Design Segments and Select Modules**
    - Under Mechanical Settings, click the “New” button to draw your solar segments:
        - Fixed Tilt (flat roofs)
        - Flush Mount (angled roofs)
        - Carport (shade structures)
    - Choose the solar module you intend to use for your design.
3. **Segment-Specific Design Guidance**
    - Fixed Tilt Racking (Flat Roofs)
        - Surface Height: Set to roof height.
        - Tilt Angle: Set approximately equal to the site’s latitude for optimal solar exposure.
            - Note: Higher tilt angles increase panel-to-panel shading unless row spacing is increased.
        - Azimuth:
            - Preferred: South-facing (180°)
            - Alternative: West-facing (270°)
            - Third option: East-facing (90°)
        - Adjust the following to balance shading and system capacity:
            - Default Orientation: Typically Landscape
            - Row Spacing: Sufficient to prevent shading losses
            - Module Spacing: Usually 0 ft
            - Frame Spacing: Usually 0 ft
            - Setbacks: Check local codes (typically 4 ft for flat roofs)
    - Flush Mount (Angled Roofs)
        - Surface Height: Set to roof height
        - Tilt Angle: Match the roof’s tilt
        - Azimuth: Match the roof’s orientation
        - Default Orientation: Adjust to maximize usable roof area
        - Row, Module, and Frame Spacing: Set to 0 ft
        - Setbacks: Check local codes (typically 1.5 ft for tilted roofs)
    - Carport (shade structure):
        - Surface Height: Set to 14 ft
        - Azimuth:
            - Preferred: South-facing (180°) but it mostly depends on the parking lane orientation.
        - Module Tilt: Set to 5 degrees
        - Default Orientation: Portrait
        - Row, Module, and Frame Spacing: Set to 0 ft
        - Setbacks: Set to 0 ft
    - Define Keepouts and Trees
        - Keepouts: Draw over obstructions (e.g., vents, skylights) to prevent panel placement.
        - Trees: Mark nearby trees to account for potential shading impacts.
    - Electrical Configuration
        - Inverter Type: Select based on system design—string inverters, microinverters, or

central inverters.
    - Optimizer Type: Select based on system design and panel size.
    - DC:AC Ratio:
        - Recommended starting ratio is >1.0, ideally around 1.2–1.3, to account for long-term DC degradation (~0.5% per year).
        - A higher ratio ensures inverters remain efficiently loaded over the system's lifetime.
    - Inverter Loading: Adjust in HelioScope to fine-tune performance and efficiency.

4. **Refine Design**
    - Once the solar system layout is complete, the design should be refined to meet two primary objectives — maximize system efficiency and achieve Net Zero Energy (NZE). This involves including only the most effective panels necessary to offset the annual energy demand defined by the Master Load Profile.
        - Simulate the Initial Design
            - Save and simulate the design in HelioScope to generate key performance outputs:
            - Specific Yield (kWh per kW): Target a value around 1,500, which indicates how much energy is produced per unit of nominal panel power.
            - Annual Solar AC Generation: Found in the Shading Report.
        - Assess Segment Effectiveness
            - Evaluate the fractional contribution of each segment to total annual generation.
            - Use the Total Solar Resource Factor (TSRF) to assess how efficiently each panel or segment is performing relative to ideal conditions.
                a. Higher TSRF = Better performance
                b. Lower TSRF = Candidates for removal
        - Refine the Design for NZE
            - Begin by removing panels in segments with the lowest TSRF.
                a. Do not delete entire segments. Instead, deselect individual panels within the segment.
                    i. This retains the segment's overall shading impact and allows for easier future edits.
            - Re-simulate the design after making adjustments.
                a. Review updated TSRF values and annual generation.
                b. Continue refining by removing underperforming panels until total annual generation closely matches or slightly exceeds the Master Load Profile (100–110% NZE).
        - Consider Installation Efficiency
            - Favor contiguous panel groupings over isolated panels for real-world installation efficiency and cost-effectiveness.
            - When deciding between two panels or segments with similar TSRF, prefer the one that preserves uniform array alignment.
    - **Save & Exit**

5. **Download Solar Generation Data**
    - In the Project Overview dashboard, locate the Current Project section.
    - Navigate to the Reports area and click the "Simulate" button to run your final design.
    - Once the simulation is complete, the button will turn blue and display the system's

Specific Yield (kWh/kWp).
  - Click this button, then select the “CSV” option at the top of the screen to download the hourly Solar Generation Data for your design.

6. **Upload to SMAP and Finalize the APS**
   - Log into SMAP and open your existing project.
   - Navigate to the Configure Load and Generation section.
   - Under the Solar Generation Profile, click “Select File” and upload the hourly performance CSV exported from HelioScope.
   - Click “Save and Aggregate Profiles” to generate the Aggregated Profile Spreadsheet (APS).
   - Using the Load Profiles Explorer tool:
     - View a comparison bar chart of solar generation versus the Master Load Profile.
     - Hourly and monthly generation trends for further analysis.
7. **Size the BESS**
   - The SMAP platform enables users to size a BESS based on two key resilience scenarios:
     - BESS Sizing Based on the TCLR
       - Navigate to the Battery Sizing tab in SMAP.
       - Locate the TCLR Summary graphic.
         a. The far-right column displays the TCLR (in kWh) for each day.
         b. The maximum TCLR value shown in that column represents the BESS energy capacity needed to support the entire load for 24 hours.
       - Use the Scenario Setup tool to adjust inputs such as:
         a. Solar and BESS degradation rates
         b. Design year for resilience (e.g., Year 1 vs. Year 15)
         c. Note: Planning for future years requires increasing BESS size to compensate for system degradation over time.
     - BESS sizing based on the SOCr
       - In the Battery Sizing tab, find the Max SOCr Time Series Visualization.
         a. A red line indicates the Max SOCr, along with the corresponding kWh value.
         b. This represents the BESS size required to support the defined percentage of critical loads from the Master Load Profile (MLP), indefinitely.
       - Consider how parameters in the Scenario Setup tool influence Max SOCr:
         a. Charge/discharge losses
         b. Initial, maximum, and minimum SOC limits
         c. Battery degradation rates
   - Setting a BESS Power Rating
       - After determining the BESS energy capacity (kWh), input the BESS power rating (kW) in the BESS Parameters section of the Scenario Setup tool.
       - Best practice:
         a. Set the BESS power rating greater than the Peak Load of the MLP to ensure the battery can fully support demand during outages.

Additional Resources

- **Helioscope Youtube Channel:** A curated playlist of tutorial videos demonstrating how to design a Solar PV system using HelioScope, including layout creation, shading analysis, and system simulation.
- **SMAP Step 2 Training (Coming Soon):** A set of tutorial videos will be available to guide users through Step 2 in SMAP, including solar data upload, APS generation, and BESS sizing.

Step 3: Site Layouts

Overview

In Step 3 of the SMM, users learn how to conduct detailed site walks to gather key infrastructure data, including electrical meters, service panels, and critical load pathways. The focus is on mapping the physical layout of the site to support the optimal placement of solar panels, BESS, and EV chargers. Users will also document critical load pathways to identify essential circuits, forming the foundation for effective resilience planning.

Core Concepts

- **Site Walk Execution:** Applying best practices during site walks to document equipment locations, electrical service entry points, meter connections, and conduit/electrical pathways.
- **Infrastructure Documentation:** Capturing detailed photos, hand sketches, and field notes to support accurate design, layout planning, and coordination with engineers or contractors.
- **Critical Load Pathway Identification:** Tracing how electricity flows from the grid to essential loads within the facility, helping to define circuits that require backup during outages.
- **Site Layout Mapping:** Identifying physical constraints, available roof space, parking structures, and potential solar/battery installation sites.

Tools

- **Site Walk Checklist:** A field-ready checklist to ensure all key components are documented, including electrical meters, service panels, conduit pathways, roof setbacks, and potential equipment locations.
- **Site Layout Templates:** Tools such as Google Drawings, CAD software, or hand-drawn templates used to map site features, electrical infrastructure, and equipment placement zones.
- **Panel Photo Instructions**: Guidelines for photographing breaker panels, disconnect switches, and labeling to ensure clear, complete documentation for later design and engineering use.

Procedure

1. **Pre-Site Walk Preparation**
    - Gather all available site documentation, such as:
        - Building blueprints
        - Electrical single-line diagrams
        - Panel schedules or maps
    - Create a preliminary site layout identifying:
        - Potential solar installation zones (roofs, canopies, ground-mounts)
        - Tentative locations for BESS and EV chargers
2. **Conducting the Site Walk**
    - Walk the entire facility and document:
        - Meter locations, service panels, and distribution panels
        - Conduit pathways and physical space for new conduit runs
        - Available roof space, shade obstructions, and canopy options
    - Take clear photos of key infrastructure:

        - Electrical panels and breaker boxes (with panel doors open)
        - Panel labels and and schedules
        - Disconnect switches, inverters (if present), and main service equipment
        - Any existing solar or generation equipment
    - Verify setback requirements for local code compliance (roof edges, fire access, etc.)
3. **Documenting Critical Load Pathways**
    - Identify and document circuits serving mission-critical loads, such as:
        - Refrigeration and HVAC systems
        - Emergency lighting
        - IT and communication equipment
    - Trace power flow from:
        - Utility meter → Main service panel → Distribution panel → Subpanel → Critical load breakers
4. **Finalizing the Site Layout**
    - Convert site notes, photos, and field sketches into a formal site layout map using digital tools (e.g., PowerPoint, Google Drawings, or CAD).
    - Ensure the final layout includes:
        - Solar array locations
        - BESS placement with clearance and ventilation space
        - EV charging station locations (if applicable)
        - Labeled critical load circuits for resilience planning

Step 4: Economic Analysis

Overview

In Step 4 of the SMM, users learn to evaluate the economic performance of a Solar Microgrid system, financed either through a cash purchase or a Power Purchase Agreement (PPA). This step emphasizes financial modeling and cost-benefit analysis, including assessments of utility savings, tax incentives, capital expenditures, and payback periods. Users will develop the skills to calculate and interpret key financial metrics such as Internal Rate of Return (IRR), Net Present Value (NPV), and Return on Investment (ROI), enabling them to make informed and data-driven recommendations. In addition to standard economic analysis, users will apply the Value of Resilience (VOR123) framework to quantify the financial benefit of maintaining critical loads during outages. This step also involves determining the optimal BESS size based on both economic and resilience factors, and analyzing energy flows within the Solar Microgrid to support comprehensive project evaluation.

Core Concepts

- **Capital Expenditure (CapEx)**: The initial, upfront costs required to purchase and install a Solar Microgrid system. These include expenses for solar panels, inverters, battery storage, microgrid controllers, permitting, engineering, and construction. CapEx is typically higher for full microgrid systems due to the added complexity and equipment required for energy management and resilience functionality.
- **Operational Expenditures (OpEx)**: The ongoing costs associated with operating and maintaining the system over its lifetime. This includes routine maintenance, equipment monitoring, software updates, insurance, and eventual component replacements such as inverters or batteries. OpEx may vary based on system complexity and ownership structure.
- **Incentives**: Financial incentives play a key role in improving the economic viability of Solar Microgrid projects. Common incentives include:
    - **Federal Investment Tax Credit (ITC)**: A federal tax credit that offsets a percentage of system CapEx, available for both solar and battery components under current legislation.
    - **Self-Generation Incentive Program (SGIP)**: A California-based rebate program that provides funding for battery storage installations, particularly for projects serving disadvantaged or high-fire-risk communities.
    - **Local CCA Program Funds**: Community Choice Aggregators (CCAs) may offer additional incentives or grants to support solar and storage projects within their service areas.
    - **Depreciation (MACRS/Bonus)**: Accelerated depreciation benefits available to tax-paying entities, allowing for a significant portion of system costs to be recovered in the first few years of operation.
- **Electric Bill Savings**: Reductions in energy costs resulting from lower electricity consumption, reduced Peak Load charges, and battery time-shifting to avoid high-rate periods.
- **Electricity Cost Escalation**: The assumed annual increase in utility electricity rates, typically modeled between 2–5% per year. This escalation compounds over time, increasing the value of utility bill savings and significantly impacting long-term financial projections for Solar Microgrid projects. Accurately estimating this rate is critical for evaluating total cost savings and payback periods.
- **Cash Purchase Agreements**: A Cash Purchase Agreement is a financing model in which the site owner pays the full upfront cost of the Solar Microgrid system and, in return, retains all

associated financial benefits. These include utility bill savings, tax incentives (such as the ITC and depreciation), and long-term energy cost stability. This option is best suited for entities with available capital who want full ownership and control of the system, along with the highest potential return on investment.

- **Power Purchase Agreements (PPA)**: Under a Power Purchase Agreement, a third-party developer finances, installs, owns, and operates the Solar Microgrid system. The host site agrees to purchase the electricity generated—typically at a fixed or escalating rate—without incurring upfront capital costs. This model is ideal for organizations that lack sufficient capital for a Cash Purchase Agreement but still want to benefit from clean energy and potential cost savings. Maintenance and performance risk remain with the developer, making it a low-risk option for the host.
- **VOR123:** VOR123 is a framework developed by the Clean Coalition to quantify the financial value of maintaining uninterrupted power to critical loads during grid outages. By estimating avoided costs associated with downtime (e.g., lost revenue, spoiled goods, safety risks), VOR123 provides a structured approach to justify investment in battery storage and microgrid capabilities.

Tools

- **Energy Toolbase (ETB):** A platform for scenario-based financial modeling. ETB allows users to analyze Capital Expenditures (CapEx), Operational Expenditures (OpEx), rate schedules, utility bill savings, and tax incentives to evaluate Solar Microgrid project economics.
- **HelioScope:** Used to import solar system designs directly into ETB. Ensures accurate system specifications, layout parameters, and production data for financial modeling.
- **SMAP:** Supports iterative battery sizing alongside ETB scenarios. Enables users to assess how different battery capacities affect system performance and resilience outcomes.
- **VOR123 Tool (Embedded within SMAP):** A SMAP-native tool that calculates the economic value of resilience by estimating the benefit of maintaining critical loads during outages.

Procedure

1. Create a Solar Microgrid Proposal in ETB
    - Start Proposal and choose Existing or New Lead:
        - Begin a new proposal in ETB by selecting an Existing or New Lead.
        - Enter the site and user information.
        - Set default financial assumptions:
            - Discount rate: 10%
            - Electricity cost escalator: 5%
    - Input Energy Use Profile
        - In the Meters section, go to “Energy Use Profile” and select “Add Energy Use Profile.”
        - Choose Spreadsheet Interval Data and paste the kWh column from the Master Load Profile.
        - Verify:
            - Data is in two-column format (timestamp and kWh)
            - Intervals match across the full calendar year
    - Set Utility Rate Schedule

        - Navigate to "Rate Details":
            - Select the utility provider, rate schedule, voltage, and phase.
            - Ensure the selected rate matches the utility bill.
            - If a current rate schedule is not listed, request an update from ETB support.
    - Upload Solar Design from HelioScope
        - In the PV Section, select "Add PV Array" → "Import HelioScope Design."
        - Choose the design developed in Step 2.
        - Set the CapEx for each field segment (e.g., fixed tilt, roof mount, canopy) based on project type.
    - Add the BESS
        - Go to "Add Energy Storage System."
        - Choose your control settings:
            - Use ETB's built-in controllers, define your own, or import a BESS profile via Spreadsheet Interval Data.
        - Select a BESS size that:
            - Meets or exceeds the SOCr battery size calculated in Step 2
            - Matches or exceeds the MLP peak load.
        - Configure:
            - Model quantity.
            - CapEx per unit.
            - Controller settings (use default if unsure).
        - Under System Replacement, select:
            - "Replace the ESS and include associated costs in analysis."
    - Add Incentives
        - Navigate to the Incentives section and configure applicable incentives:
            - Federal Investment Tax Credit (ITC).
            - Self-Generation Incentive Program (SGIP).
            - Local CCA programs.
            - Depreciation (MACRS) for tax-paying entities.
    - Add Transaction Type
        - Go to the Transactions section and click "Add Transaction."
        - If no user-defined transactions exist, select one from the ETB Transaction Gallery.
        - Cash Purchase with O&M:
            - Choose "Cash Purchase w/O&M" and define:
                a. O&M cost ($/Wdc), e.g., $0.002–$0.005.
                b. Start year and annual escalation rate.
        - Power Purchase Agreement (PPA):
            - Choose "PPA" and define:
                a. PPA Name.
                b. Starting PPA Rate (typically provided by financier).
                c. Upfront Payment, End-of-Term Buyout, and Escalation Rate (often 0%).
                d. PPA Term: Typically 25 years.
            - Leave host-related tax credits/incentives unchecked (developer retains them).
    - Add a Utility Rate Switch (if necessary)
        - In the Energy Use Profile & Utility Rates section, click "Add Rate Switch."

        - Research alternative rate schedules that may better support solar + BESS.
        - ETB will compare savings and recommend the most cost-effective rate.
    - Generate Proposal Document
        - Navigate to “Manage Documents.”
        - Click “Add Document”, then choose:
            - “User Defined Documents” (if applicable)
            - Or from the ETB Document Gallery → select “(v4) Updated Legacy: PV+ESS.”
        - Click “Next,” name the document, and Save.
        - View your newly created proposal document to analyze project economics.
2. Calculate the VOR
    - Log in to the SMAP and open your project.
    - Navigate to the VOR123 tool and select “New VOR Calculation.”
    - Enter:
        - Name
        - Critical Load Percentage (from Step 1)
        - Year 1 Utility Bill
        - Utility Escalator (e.g., 5%)
    - VOR Calculation:
        - If Critical Load % ≥ 10%:
            - Year 1 VOR = 25% × Year 1 Utility Bill
        - If Critical Load % < 10%:
            - VOR = 25% × (Critical Load % × 10) × Year 1 Utility Bill

Step 5: Reporting & Recommendations

Overview

In the final step of the SMM User Manual, users learn how to effectively communicate their feasibility study results using clear tables, visualizations, and professional presentations. This step emphasizes the synthesis of technical and financial findings into a concise, stakeholder-ready report. By the end of this step, users will have completed a fully documented Solar Microgrid Feasibility Study that includes system design, economic analysis, and resilience metrics — ready to support informed decision-making and next steps.

Core Concepts

- **Effective Data Visualization:** Learn how to clearly and accurately represent key project components — such as solar generation, load profiles, battery storage performance, and resilience outcomes — through well-designed tables, charts, and graphs.
- **Key Report Elements:**
  - **Project Summary**: A concise overview of the site, project goals, and key system design objectives.
  - **Load Analysis**: Detailed insights from interval data, including Peak Load and the Net NZE target.
  - **Solar & BESS Sizing**: System configuration, solar and storage capacity, energy flow diagrams, and resilience duration.
  - **Economic Summary**: Capital and operational cost comparisons, applicable incentives, payback period, and ROI.
  - **Resilience Benefits**: Visual representations of critical load coverage and battery backup capabilities over time.
- **Presentation Best Practices:** Learn how to structure a compelling narrative that guides stakeholders through your feasibility study. Emphasis is placed on translating technical findings into accessible language, balancing depth and clarity for both technical and non-technical audiences. Best practices include effective use of slide decks, summary visuals, and clean report formatting.

Tools

- **Google Slides / PowerPoint:** Used to create professional, stakeholder-ready presentations that communicate project findings clearly and visually.
- **Google Sheets / Excel:** Ideal for generating custom tables, graphs, and charts from project data, supporting both analysis and visual storytelling.
- **Energy Toolbase (ETB):** Generates detailed financial reports, including utility savings, cash flow analysis, and side-by-side scenario comparisons.
- **SMAP:** Exports visuals for, load profiles, solar generation, battery sizing, and energy flow diagrams — used to support both technical documentation and stakeholder presentations.

Procedure

1. **Organize Key Findings for Visual Representation**

- Summarize Core Report Elements:
    - Project Summary: Location, site objectives, and scope of the feasibility study.
    - Load Analysis: Utility billing summary and visualized baseline, adjustment, and critical load profiles.
    - Solar & BESS Sizing: System configuration, equipment choices (brands and sizes), storage capacity, and BESS resilience duration.
    - Economic Summary: Cost comparisons, tax incentives, payback period, Internal Rate of Return (IRR), and Return on Investment (ROI).
    - Resilience Benefits: Duration of critical load coverage during grid outages.
- Identify Data for Visualization:
    - Peak Load and load profile trends.
    - Solar generation vs. energy consumption.
    - Cost and savings comparison across financing scenarios.
    - BESS capacity and resilience duration.

2. **Create Visualizations**
    - Use Google Sheets / Excel to Generate Custom Graphs:
        - Resilience Charts: Visualize SOCr profiles and BESS coverage during outages.
        - Load Trends: Monthly time-series comparisons of baseline, adjustment, and critical loads.
        - Economic Tables: CapEx, OpEx, tax credits, and financial performance over time.
    - Use SMAP and Energy Toolbase (ETB) for Built-In Visuals:
        - From SMAP:
            - Export energy flow diagrams showing contributions from solar, battery, and grid (color-coded for clarity).
            - Export battery sizing outputs and load generation overlays.
        - From ETB:
            - Generate detailed financial tables, cash flow summaries, and economic metrics.
            - Include CapEx/OpEx breakdowns, tax credit calculations, and key assumptions used in the model.
    - Best Practices for Clarity:
        - Use consistent color schemes and labels across all visuals.
        - Include legends and brief captions to explain each figure.
        - Avoid overcrowding—limit each graphic to a single key insight.
3. **Structure the Presentation**
    - Create a Professional Slide Deck (Google Slides / PowerPoint):
        - Title Slide: Project name, presenting team, and date.
        - Introduction: Goals and context of the feasibility study.
        - Methodology: Summary of the approach—data collection, modeling tools, and analysis process.
        - Key Findings:
            - Load profile insights
            - Solar and battery system sizing
            - Financial analysis
            - Resilience metrics
    - Conclusion & Recommendations:
        - Summary of overall economic performance

        - Recommended next steps for implementation or further study

4. **Follow Presentation Best Practices**
    - Keep slides focused and concise (no more than 3–5 bullet points per slide).
    - Use visuals and charts instead of text-heavy content.
    - Highlight key messages with bold text or color.
    - Maintain consistency in font styles, sizes, colors, and layout across the presentation.
5. **Prepare for the Presentation**
    - Rehearse:
        - Be ready to explain technical concepts clearly for both technical and non-technical audiences.
        - Anticipate questions related to feasibility, financial performance, and system design.
    - Prepare Supporting Materials:
        - Have all backup data ready (spreadsheets, detailed analysis, rate schedules).
        - Be prepared to share full reports, including:
            - SMAP outputs.
            - ETB financial reports.
            - System specifications and assumptions.

Conclusions

1. **Assistance**
    - Thank you for engaging with the SMM. We hope this User Manual has equipped you with the tools, knowledge, and confidence to evaluate and advance Solar Microgrid projects. From data collection to economic analysis and stakeholder reporting, you now have a comprehensive framework to guide real-world applications.
    - While the Clean Coalition's time is limited, we are happy to support with a few questions along the way—whether related to the methodology, software tools, or overall project development.
    - For assistance, please contact: Gregory Young
        - Program Director, Clean Coalition
        - 📧 gyoung@clean-coalition.org
2. **Stay Connected with the Clean Coalition**
    - To stay informed on future projects, publications, and clean energy policy initiatives:
        - 🌐 Website: clean-coalition.org
        - 📬 Newsletter Signup: clean-coalition.org/newsletters
    - Follow us on social media:
        - https://www.linkedin.com/company/clean-coalition
        - https://www.youtube.com/@cleancoalition554/videos
        - https://x.com/Clean_Coalition
        - https://www.facebook.com/CleanCoalition