



# Energy System Sizing

June 28<sup>th</sup>, 2017

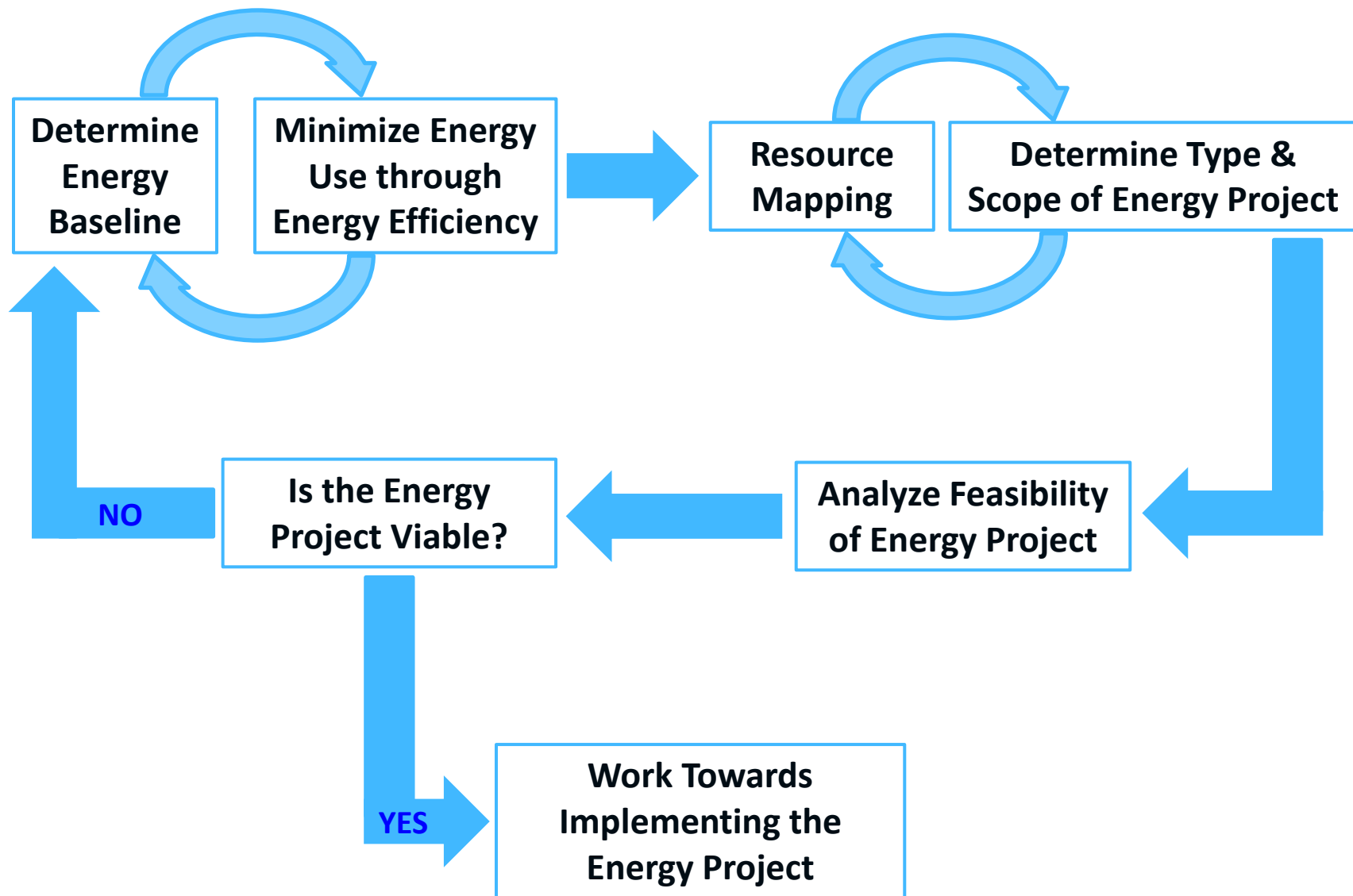
Jimmy Salasovich, NREL

# Components of Energy System Sizing

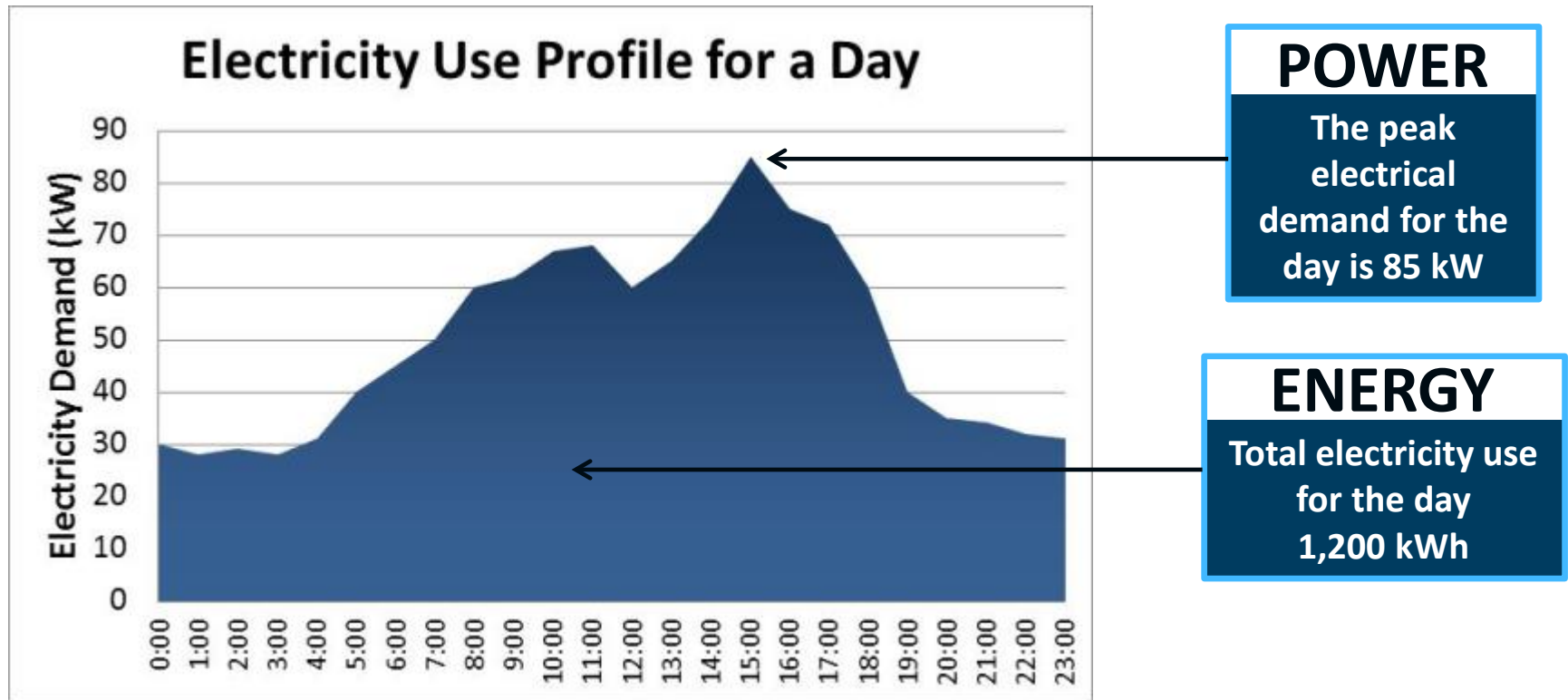
- Determine energy baseline
- Minimize energy use through energy efficiency
- Resource mapping
- Determine the type & scope of the energy project
- Analyze the feasibility of the energy project
- Work towards implementing the energy project



# Typical Workflow of Energy System Sizing



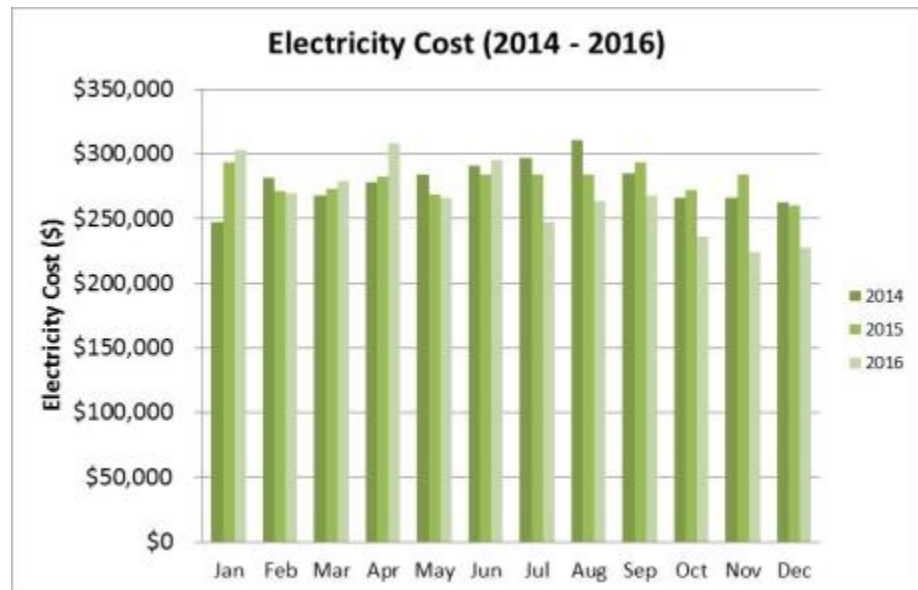
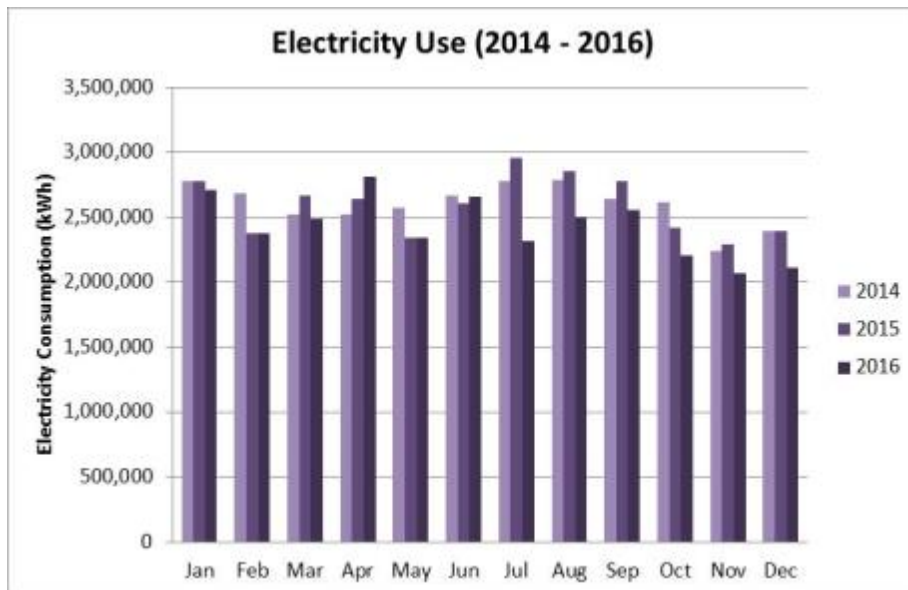
# Energy Baseline: Power vs. Energy



- Homes and smaller buildings typically have an electricity rate with only an energy charge
- Larger buildings and sites could have an electricity rate with both an energy charge and a demand charge

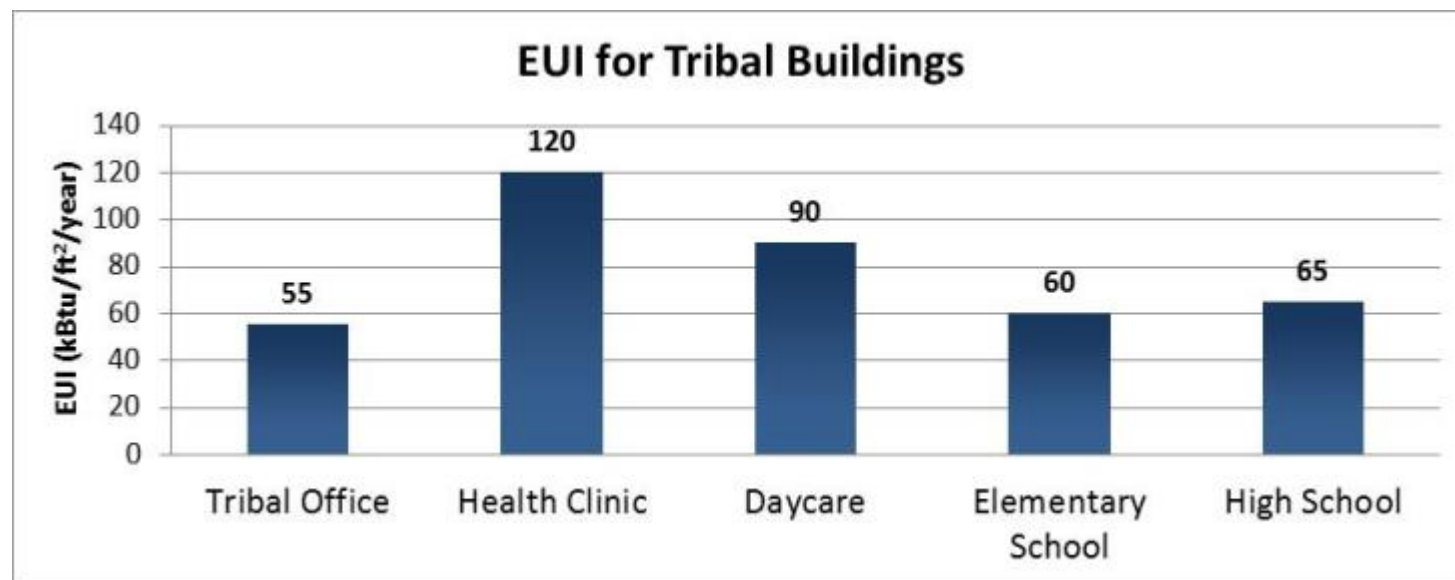
# Energy Baseline: Collect Energy Data

- Consider all energy uses
  - Electricity, natural gas, propane, diesel, etc.
- Collect energy use and cost data
  - Data can be for an individual building or an entire site
  - Collect monthly data for multiple years
- Analyze utility rate structure (e.g., \$/kWh, \$/therm, etc.)



# Energy Baseline: Energy Use Intensity

- Energy Use Intensity (EUI) is the energy use of a building divided by the square footage
  - Typical units are kBtu/ft<sup>2</sup>/year or kWh/ft<sup>2</sup>/year
- The EUI allows for the comparison of energy use across a portfolio of buildings and to standard building types
  - Buildings with a high EUI can be targeted for implementing energy efficiency measures (EEMs)



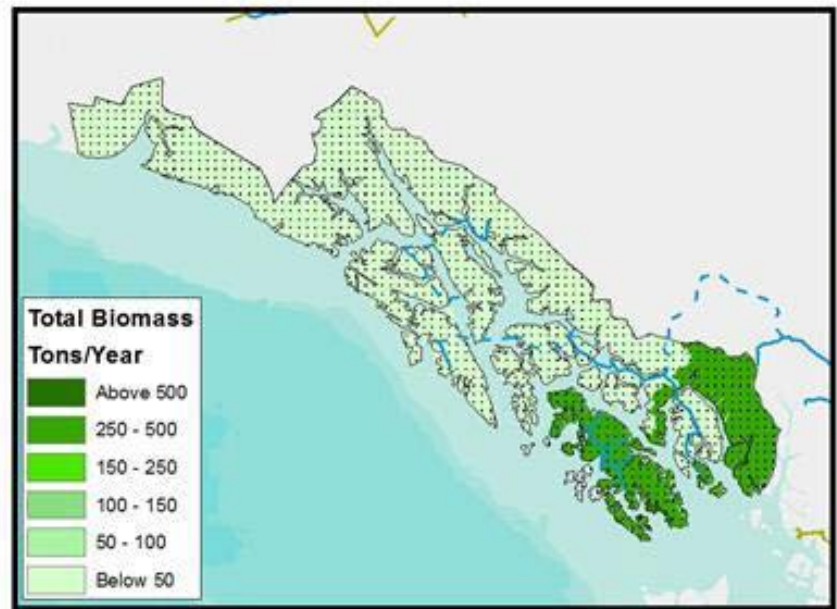
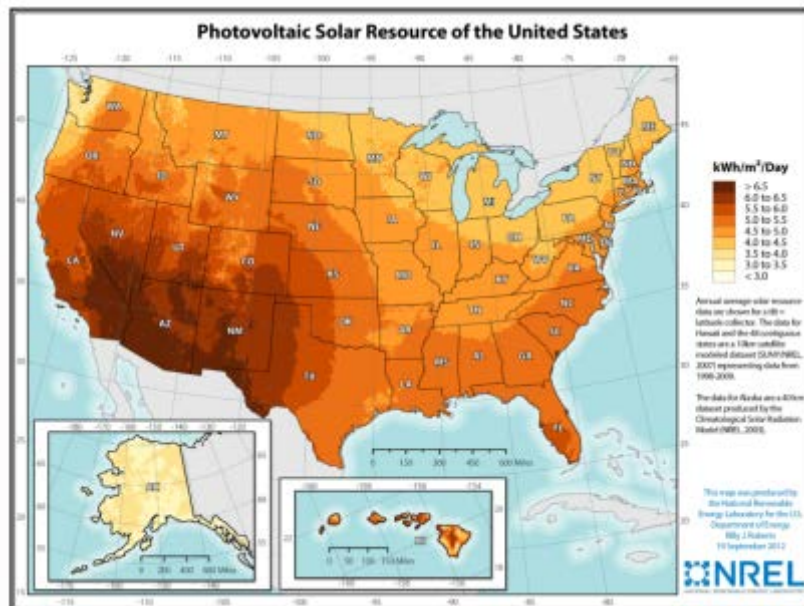
# Minimize Energy Use

- Implement energy efficiency projects first
  - Energy efficiency is typically more cost effective than renewable energy
  - Implementing energy efficiency measures (EEMs) reduces energy use, which impacts energy system sizing
- Typical EEMs include:
  - Heating, ventilating, and air-conditioning (HVAC)
  - Lighting & plug loads
  - Building envelope
- Building energy audits are good way to identify EEMs



# Resource Mapping

- Analyzing resource maps is a good first step at determining what energy technologies might be most feasible at a given site
- U.S. resource maps can be found on the internet
  - Wind, solar, biomass, geothermal maps can be found at: <http://www.nrel.gov/gis/>
- More refined resource maps for a specific location can be generated by Geographic Information System (GIS) teams





# Determining the Type & Scope of Energy Projects

- Use all of the information gathered thus far
  - Energy baseline data
    - This data is helpful in determining a range of sizes for potential energy projects
    - This data is also be helpful in determining if there is a building or group of buildings well suited for a particular energy technology
  - Minimize energy use through energy efficiency
    - Tracking the energy use after implementing energy efficiency measures is helpful in right-sizing energy systems
  - Resource mapping
    - Resource maps are helpful in choosing appropriate energy technologies by location based on the resource available

# Google Earth is a Useful Tool During the Scoping Phase

- Determine areas available
- Determine distance to nearest substation
- Google Earth can also be used during the Analysis Phase



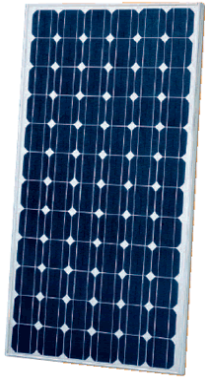
# General Guidelines when Determining the Type & Scope

- Choose energy technologies that match the way energy is being used
  - For example, a biomass boiler might work well for a cold climate housing complex but might not in a warm climate office building
- Size the energy system to meet the energy load
  - Can size the system based on current energy load
  - Can also be sized to meet future energy load
- Start with U.S. resource maps and consider more refined resource maps if needed

# Analyze the Feasibility of an Energy Project

- Define what constitutes a viable project
  - Typically the viability of a project is based on the financial parameters (e.g., simple payback, Net Present Value, etc.)
  - Viability can also be based on a site's goals (e.g., carbon reduction)
- Choose the proper tools to analyzed a project
  - Technical analysis
  - Financial analysis
- Report the findings
  - It is important to report on energy projects that are both feasible and not currently feasible
  - Report on when I project could become feasible (e.g., report at what electricity rate that a Photovoltaic project becomes feasible)

# Electrical Resource Assessment



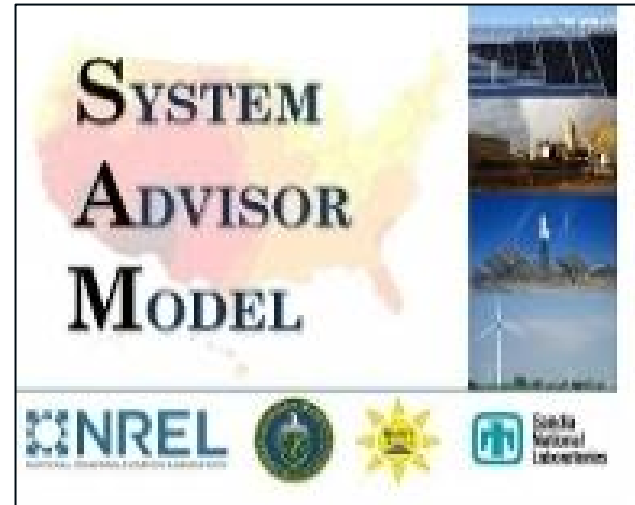
## Solar PV

- PV Watts
- SAM
- HOMER Energy



## NREL's PVWatts® Calculator

Estimates the energy production and cost of energy of grid-connected photovoltaic (PV) energy systems throughout the world. It allows homeowners, small building owners, installers and manufacturers to easily develop estimates of the performance of potential PV installations.

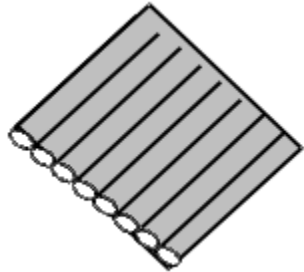


## Wind

- HOMER Energy
- SAM

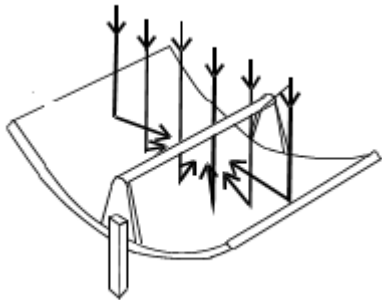


# Thermal Resource Assessment



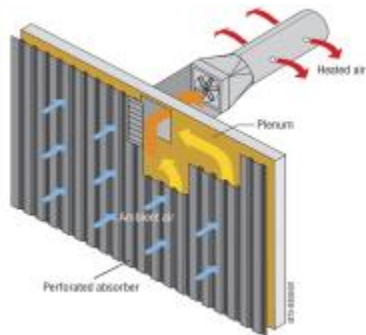
## Solar Hot Water

- SAM
- RETScreen



## Concentrating Solar

- SAM



## Solar Ventilation Preheat

- RETScreen



 Natural Resources Canada / Ressources naturelles Canada

 Canada

 RETScreen<sup>®</sup> International  
[www.retscreen.net](http://www.retscreen.net)

Clean Energy Project Analysis Software

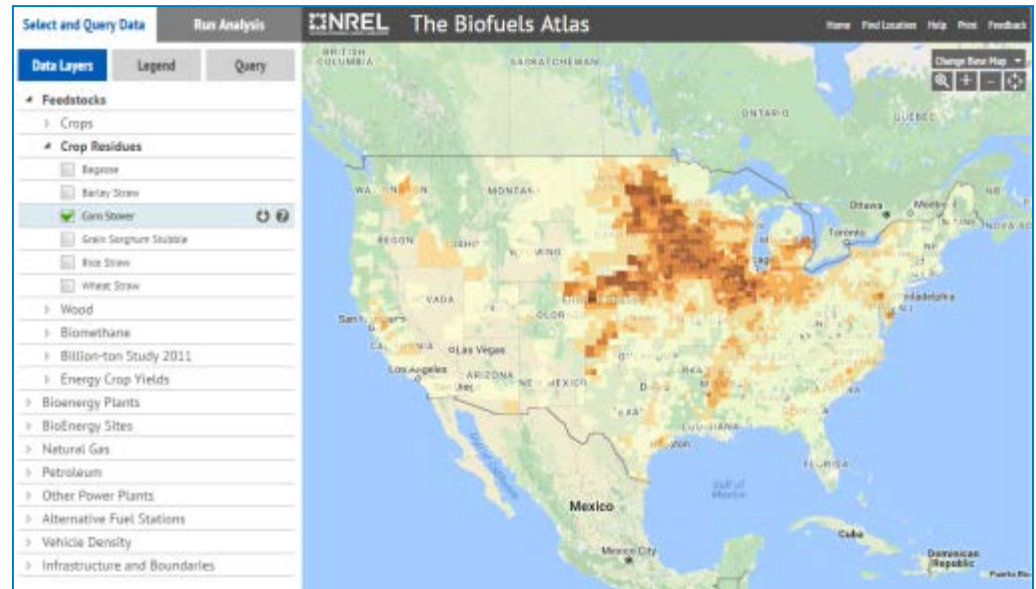
# Thermal Resource Assessment

## Biomass

- SAM
- RETscreen

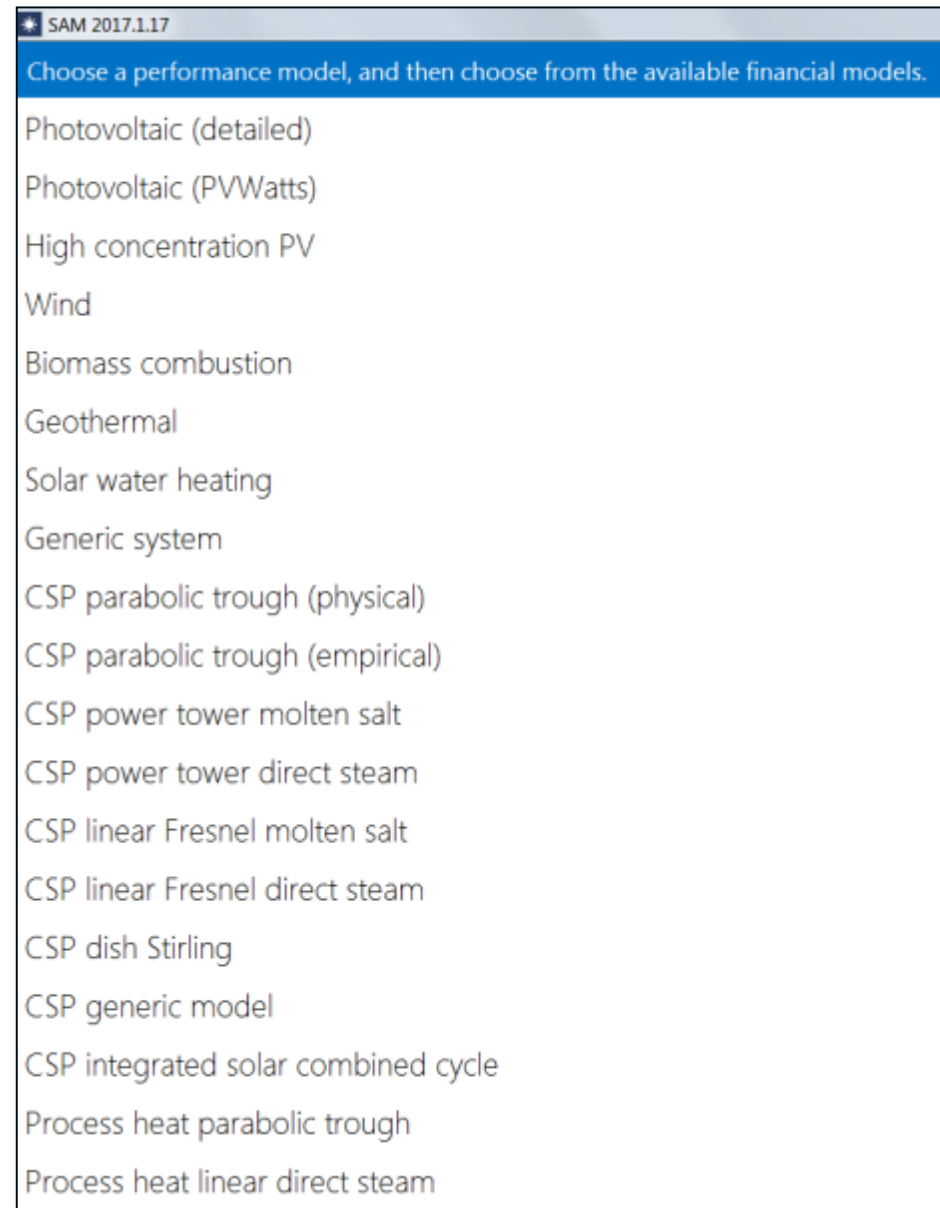
## Biomass Resource

- BioEnergy Atlas - <https://maps.nrel.gov/bioenergyatlas/>



# Software Tool Example: System Advisor Model (SAM)

- Free web download
  - <https://sam.nrel.gov/>
  - Tutorial is available
- Uses TMY hourly weather data
- Models many energy systems →
- Detailed Performance modeling
- Detailed financial modeling
- Detailed results





# SAM: Software Layout & Detailed Performance Modeling

- SAM is pre-populated with default values
- SAM is set up with input boxes and dropdowns
  - Inputs are in black font
  - Calculated values are in blue font
- Detailed Performance modeling
  - Location & Resources
  - System Design

The screenshot displays the SAM 2017.1.17 software interface. The left sidebar shows a navigation menu with 'Location and Resource' highlighted in a red dashed box. The main window is divided into several sections:

- System Parameters:** Includes fields for System nameplate size (100 kWdc), Module type (Standard), DC to AC ratio (1.2), Rated inverter size (83.33 kWac), and Inverter efficiency (96 %).
- Orientation:** Features a diagram of a solar array with Azimuth (0°) and Tilt (20°) indicators. Parameters include Array type (Fixed open rack), Tilt (20 degrees), Azimuth (180 degrees), and Ground coverage ratio (0.4).
- Losses:** A table of loss components with their respective percentages:

Loss Component	Percentage
Soiling	2 %
Shading	3 %
Snow	0 %
Mismatch	2 %
Wiring	2 %
Connections	0.5 %
Light-induced degradation	1.5 %
Nameplate	1 %
Age	0 %
Availability	3 %

User-specified total system losses: 20.95 %  
Total system losses: 14.08 %
- Shading:** Includes buttons for 'Edit shading losses', 'Edit shading...', and 'Open 3D shade calculator...'.
- Curtailement and Availability:** Includes an 'Edit losses...' button and text explaining that curtailment and availability losses reduce system output to represent system outages or other events. It also lists: Constant loss: 0.0 %, Hourly losses: None, Custom periods: None.

At the bottom, there is a 'Simulate' button and a navigation bar with 'Parametrics', 'Stochastic', 'P50 / P90', and 'Macros' options.

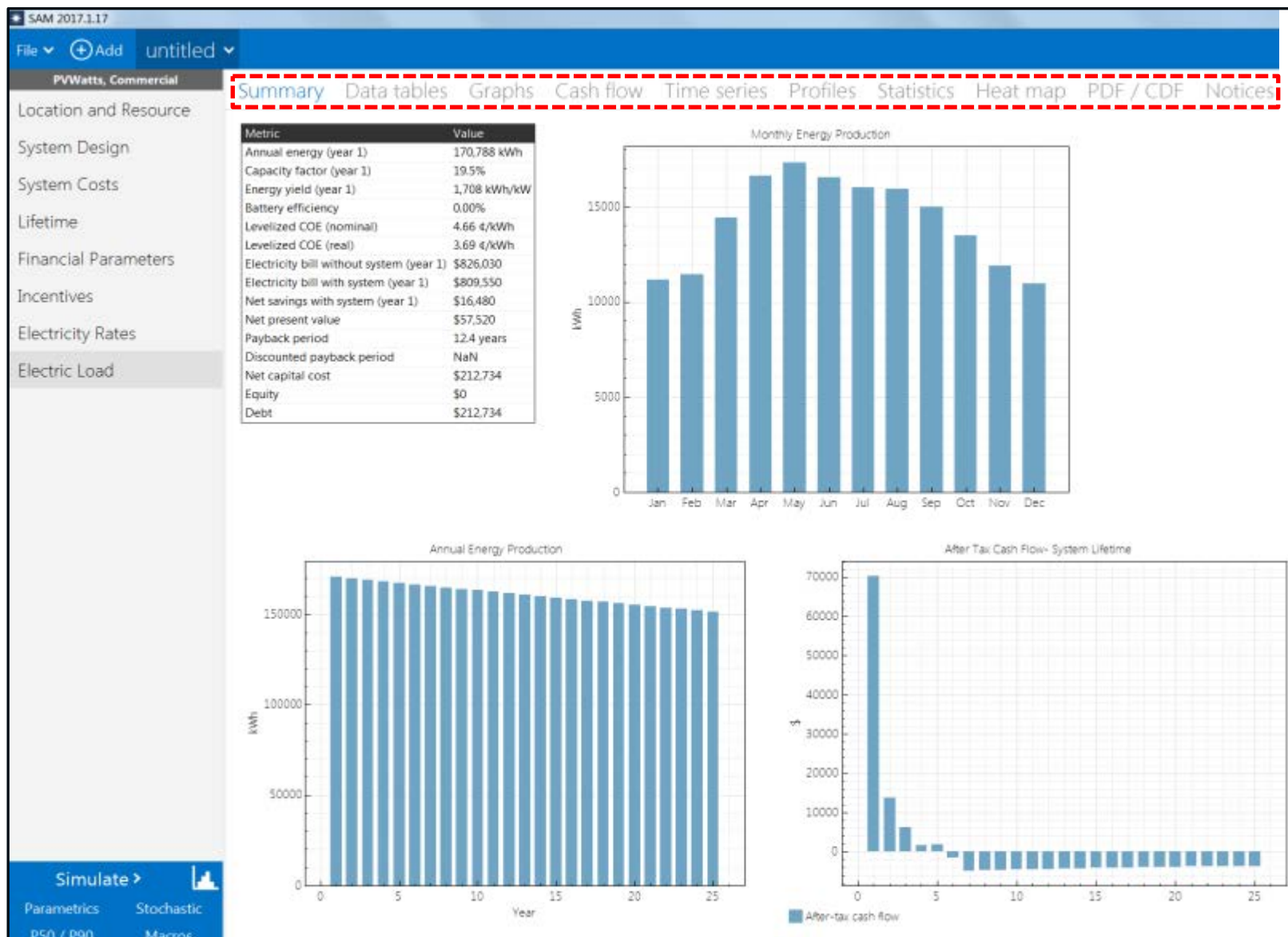
# SAM: Detailed Financial Modeling

The screenshot displays the SAM 2017.1.17 software interface. The left sidebar contains a navigation menu with the following items: Location and Resource, System Design, System Costs (highlighted with a red dashed box), Lifetime, Financial Parameters, Incentives, Electricity Rates, and Electric Load. The main workspace is divided into several sections:

- Project Term Debt:** Debt percent (100%), Loan term (25 years), Loan rate (5 %/year), Net capital cost (\$ 212,733.50), Debt (\$ 212,733.50), and WACC (3.35 %). A note states: "The weighted average cost of capital (WACC) is displayed for reference. SAM does not use the value for calculations. For a project with no debt, set the debt percent to zero."
- Analysis Parameters:** Analysis period (25 years), Inflation rate (2.5 %/year), Real discount rate (5.5 %/year), and Nominal discount rate (8.14 %/year).
- Tax and Insurance Rates:** Federal income tax rate (28 %/year), State income tax rate (7 %/year), Sales tax (5 % of total direct cost), Insurance rate (annual) (0.5 % of installed cost), and **Property Tax:** Assessed percentage (100 % of installed cost), Assessed value (\$ 212,733.50), Annual decline (0 %/year), and Property tax rate (2 %/year).
- Salvage Value:** Net salvage value (0 % of installed cost) and End of analysis period value (\$ 0).
- Depreciation:** Federal (5-yr MACRS, 7 years) and State (5-yr MACRS, 7 years) options, each with an "Edit..." button for percentages.

At the bottom left, there is a "Simulate >" button and a sub-menu with "Parametrics", "Stochastic", "P50 / P90", and "Macros".

# SAM: Detailed Results



# Summary

- Track energy use and create an energy baseline
- Implement energy efficiency projects first and then consider renewable energy projects
- Use the tools available
  - Resource mapping
  - Google Earth
  - Software tools
    - PVWatts
    - SAM
    - HOMER
    - RETScreen
- Keep in mind the overall goal of reducing energy use and implementing renewable energy projects

# Links to Resources & Tools:

Resource Mapping (free):	<a href="http://www.nrel.gov/gis/">http://www.nrel.gov/gis/</a>
Google Earth (free):	<a href="https://www.google.com/earth/">https://www.google.com/earth/</a>
PVWatts (free):	<a href="http://pvwatts.nrel.gov/pvwatts.php">http://pvwatts.nrel.gov/pvwatts.php</a>
System Advisor Model (free):	<a href="https://sam.nrel.gov/">https://sam.nrel.gov/</a>
HOMER (pay):	<a href="http://www.homerenergy.com/">http://www.homerenergy.com/</a>
RETScreen (free):	<a href="https://www.nrcan.gc.ca/energy/software-tools/7465">https://www.nrcan.gc.ca/energy/software-tools/7465</a>
PV System Costs Report (free):	<a href="http://www.nrel.gov/docs/fy16osti/66532.pdf">http://www.nrel.gov/docs/fy16osti/66532.pdf</a>

Thank you

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