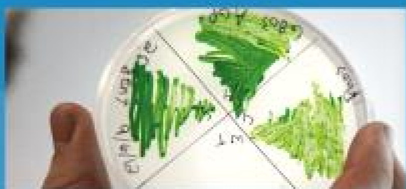



Energy System Sizing

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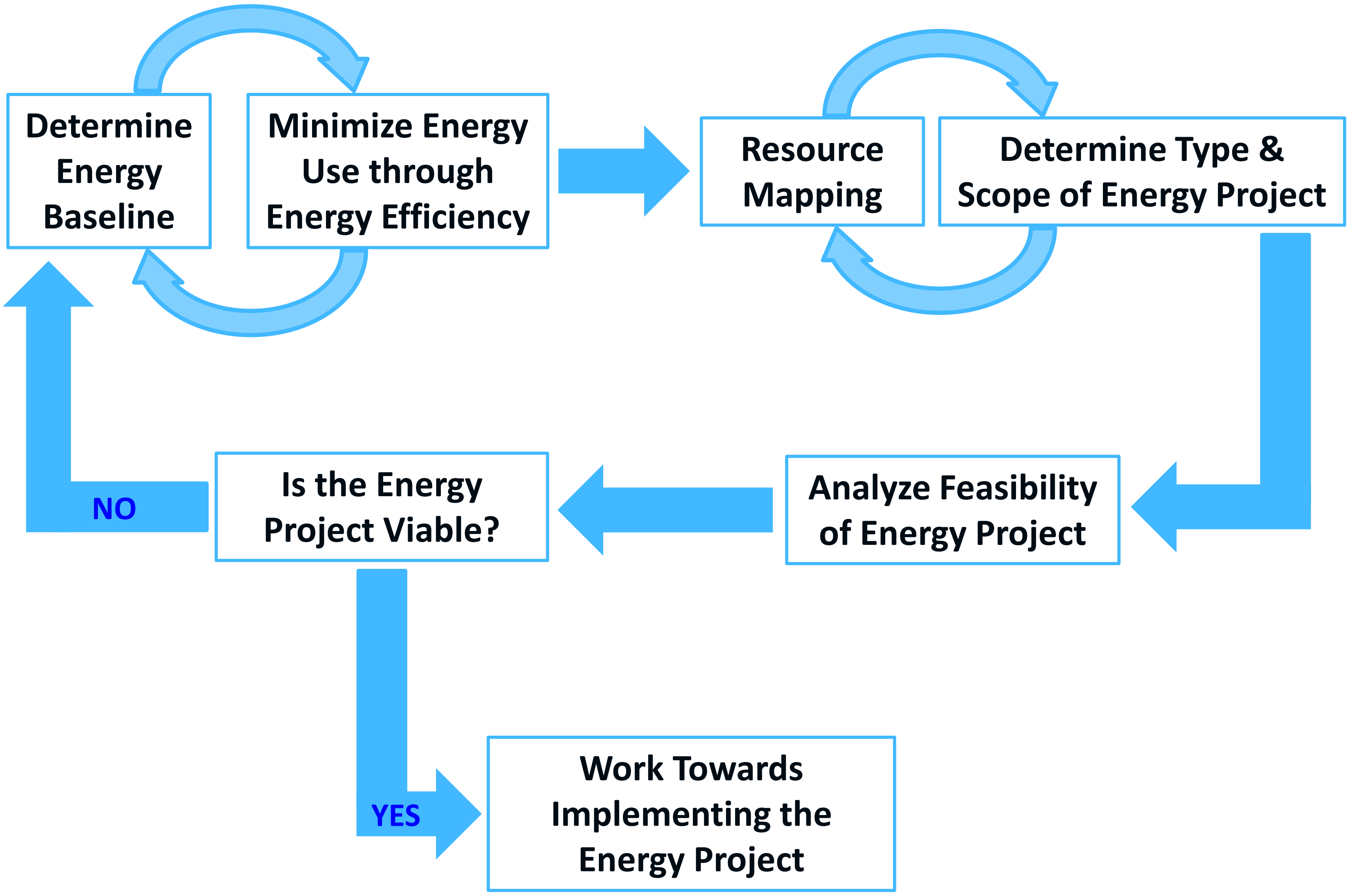
NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Components of Energy System Sizing

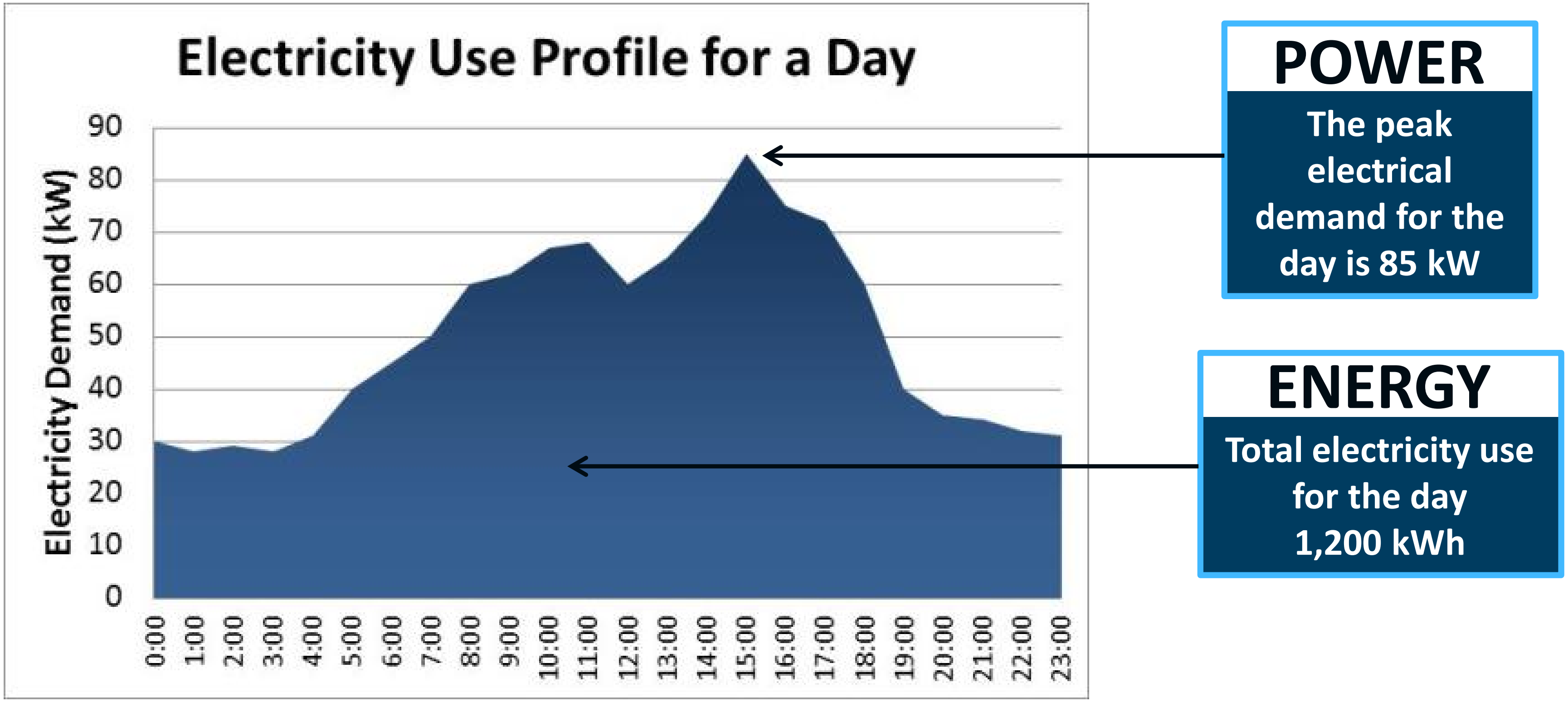
- Determine energy baseline
- Minimize energy use through energy efficiency
- Resource mapping
- Determine the type & scope of the energy project
- Analyze the feasibility of the energy project
- Work towards implementing the energy project




Typical Workflow of Energy System Sizing



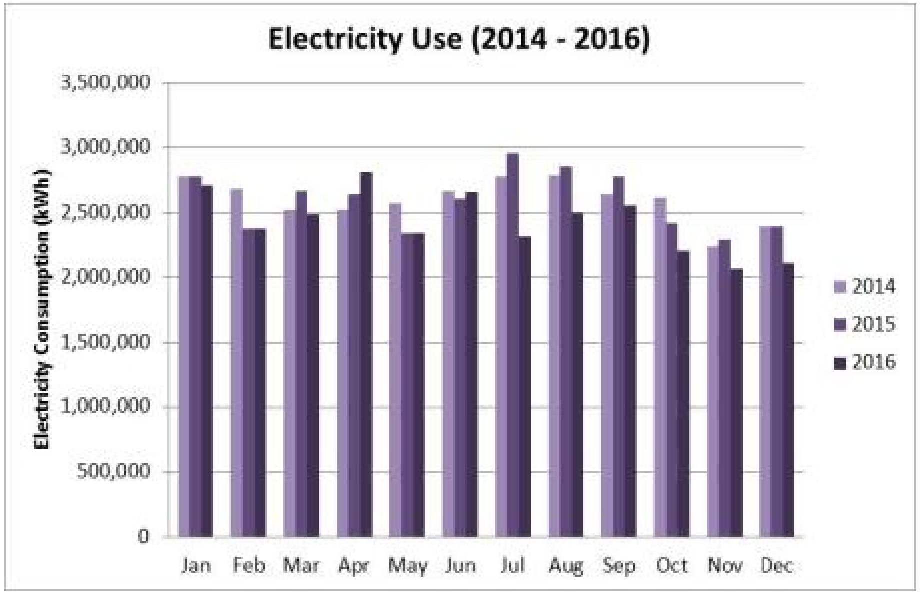
Energy Baseline: Power vs. Energy

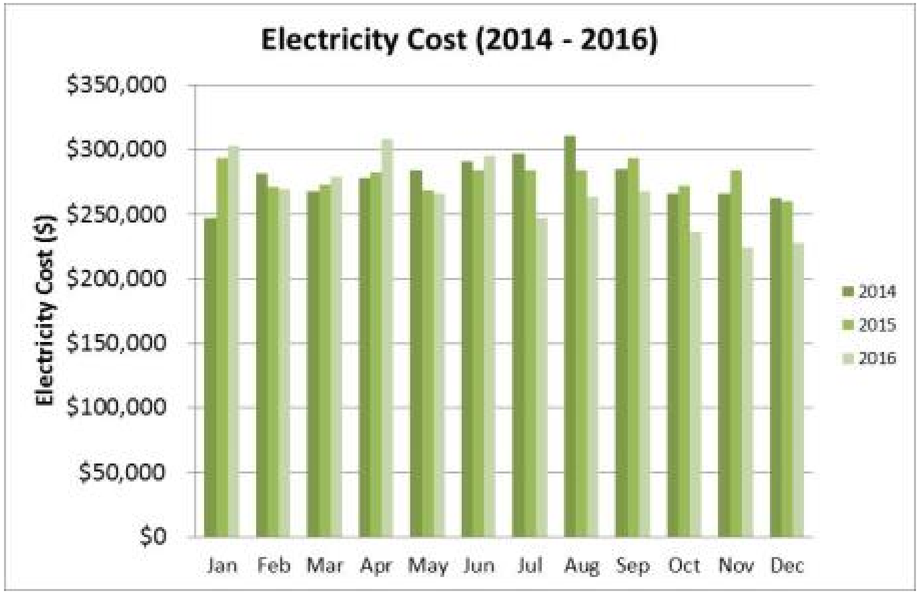


- Homes and smaller buildings typically an electricity rate with only an energy charge
- Larger buildings and sites could have an electricity rate with both an energy charge and a demand charge

Energy Baseline: Collect Energy Data

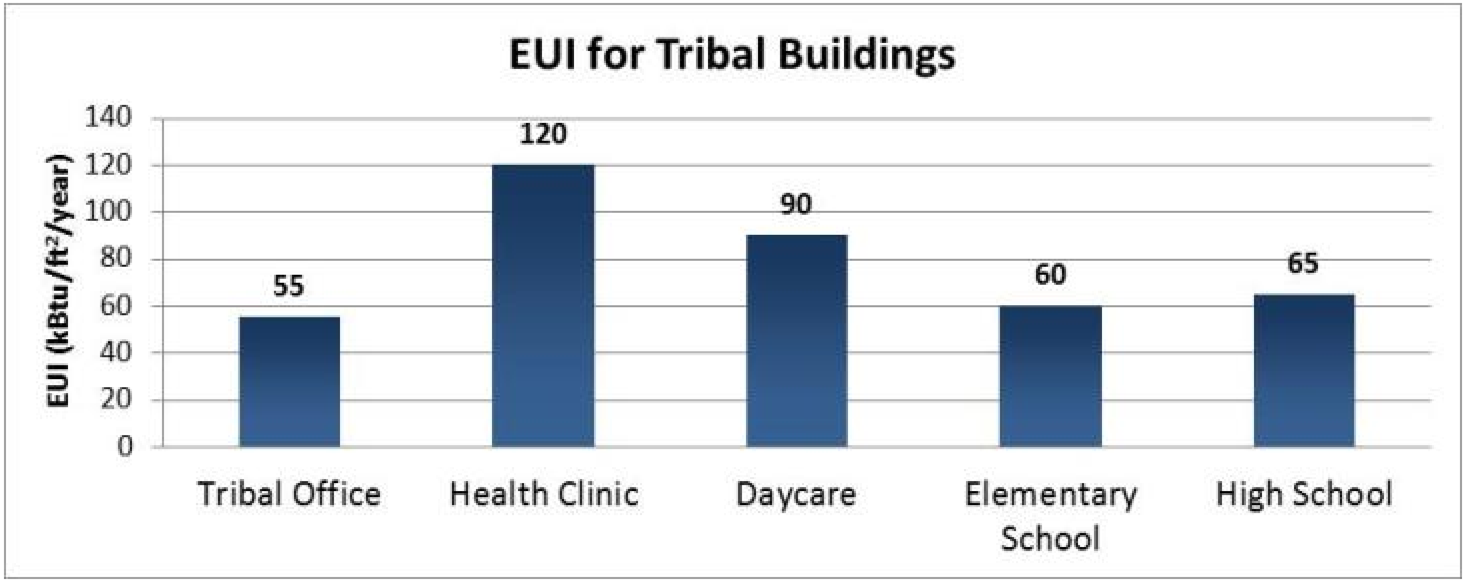
- Consider all energy uses
  - Electricity, natural gas, propane, diesel, etc.
- Collect energy use and cost data
  - Data can be for an individual building or an entire site
  - Collect monthly data for multiple years
- Analyze utility rate structure (e.g., $/kWh, $/therm, etc.)





Energy Baseline: Energy Use Intensity

- Energy Use Intensity (EUI) is the energy use of a building divided by the square footage
  - Typical units are $kBtu/ft^2/year$ or $kWh/ft^2/year$
- 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)

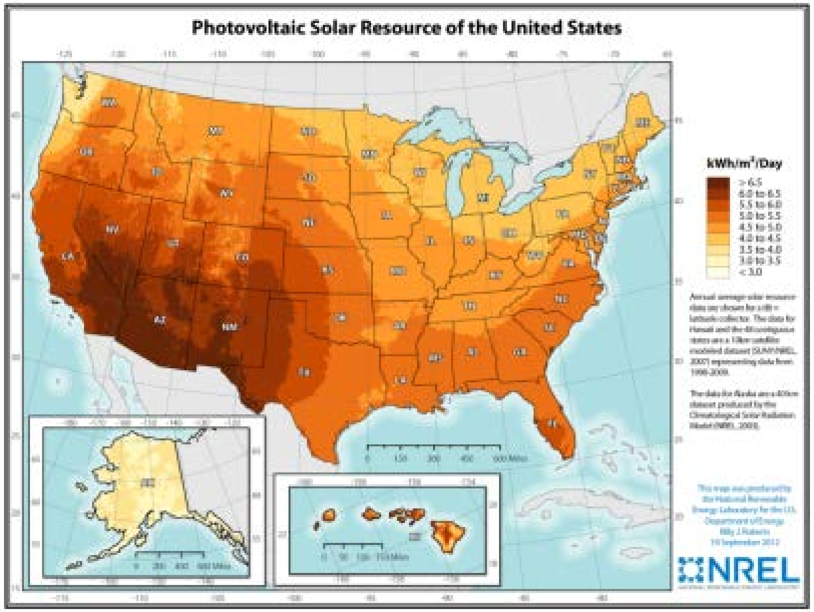


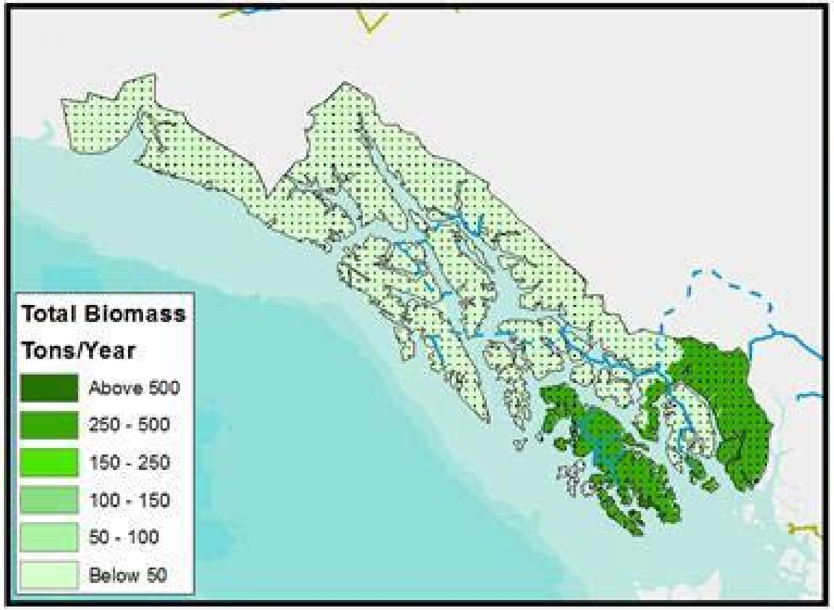
Minimize Energy Use

- 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

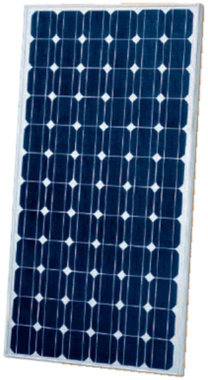
General Guidelines when Determining the Type & Scope

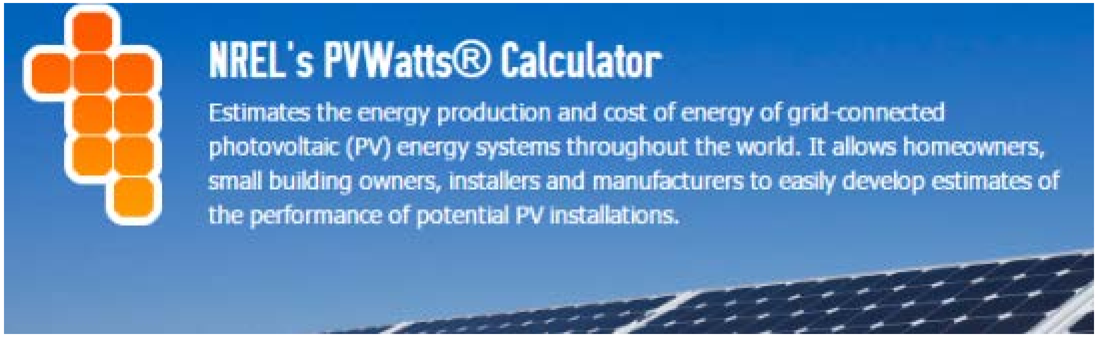
- Choose energy technologies that match the way energy is being used
  - For example, a biomass boiler might work well for a cold climate housing complex but might not in a warm climate office building
- Size the energy system to meet the energy load
  - Can size the system based on current energy load
  - 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

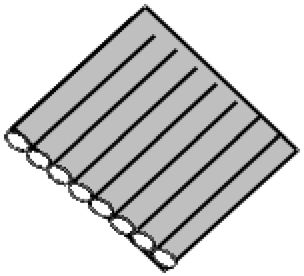
- PV Watts
- SAM
- HOMER Energy

Wind

- HOMER Energy
- SAM

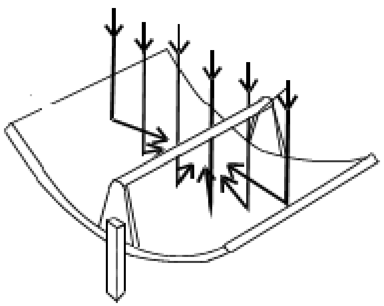
HOMER ENERGY

Thermal Resource Assessment



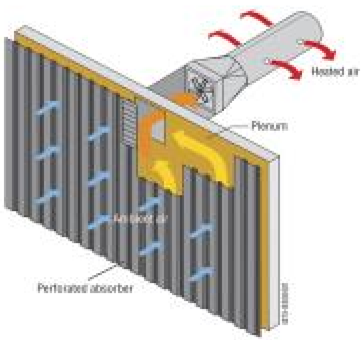
Solar Hot Water

- SAM
- RETscreen



Concentrating Solar

- SAM



Solar Ventilation Preheat

- RETscreen

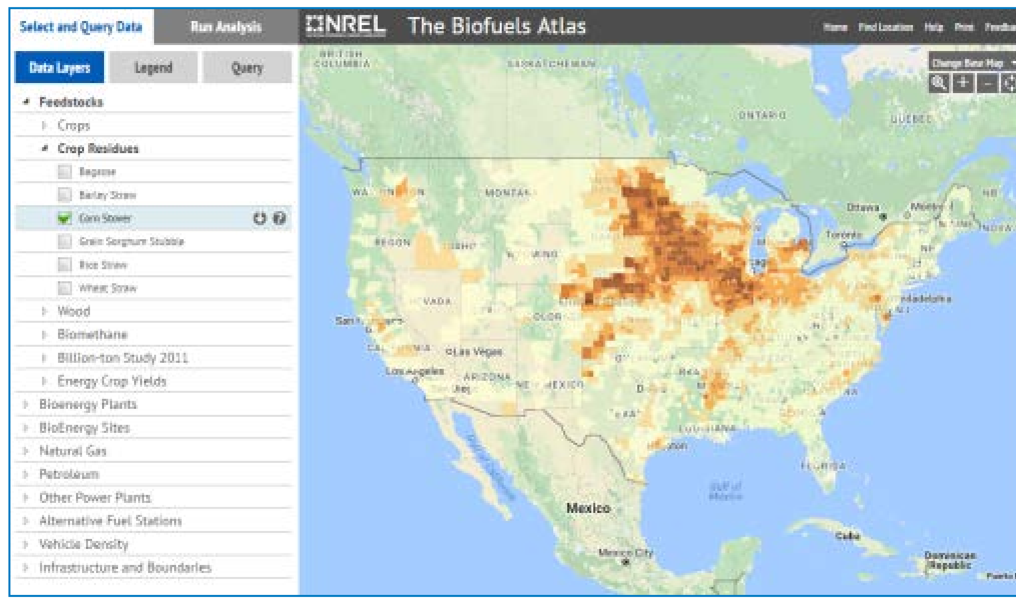
Thermal Resource Assessment

Biomass

- SAM
- RETscreen

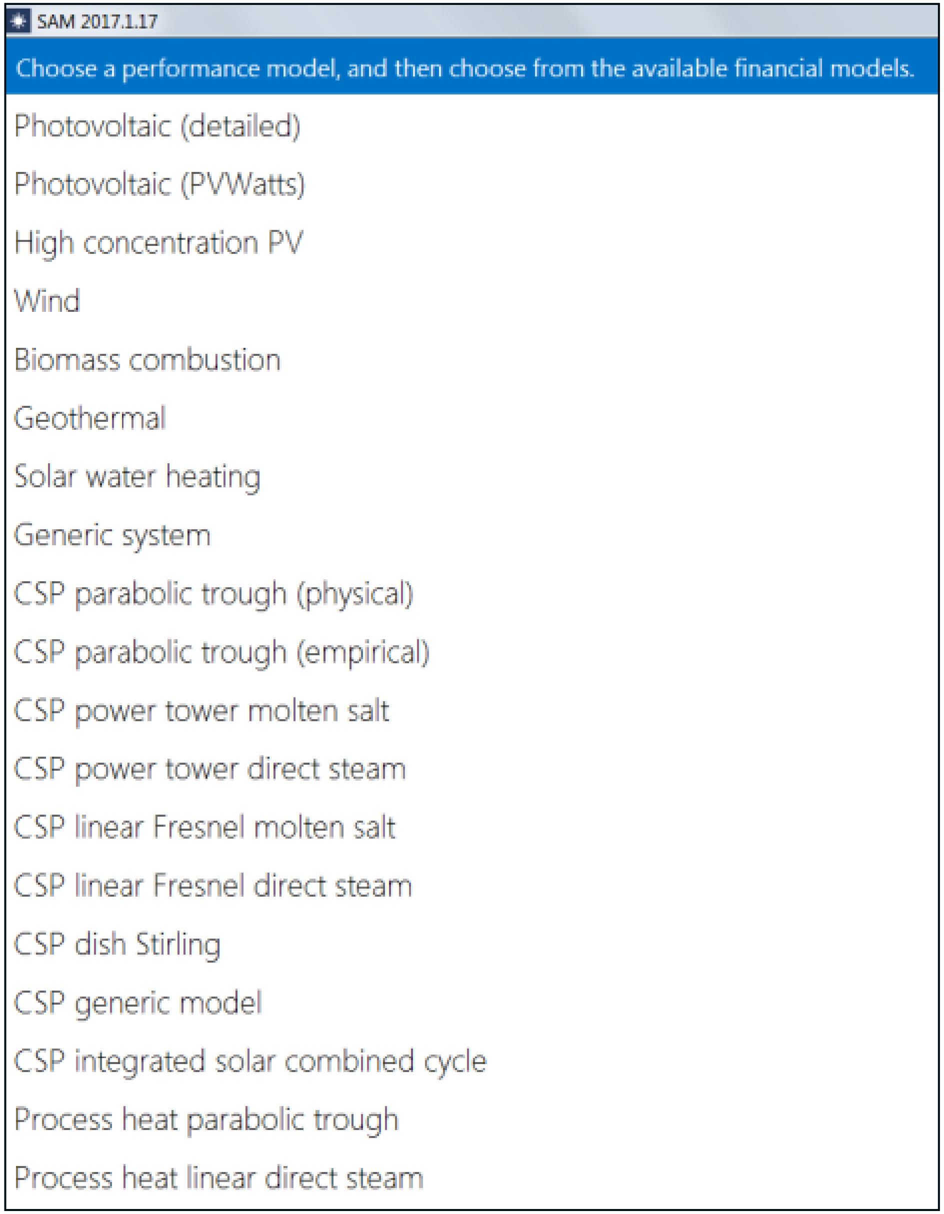
Biomass Resource

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



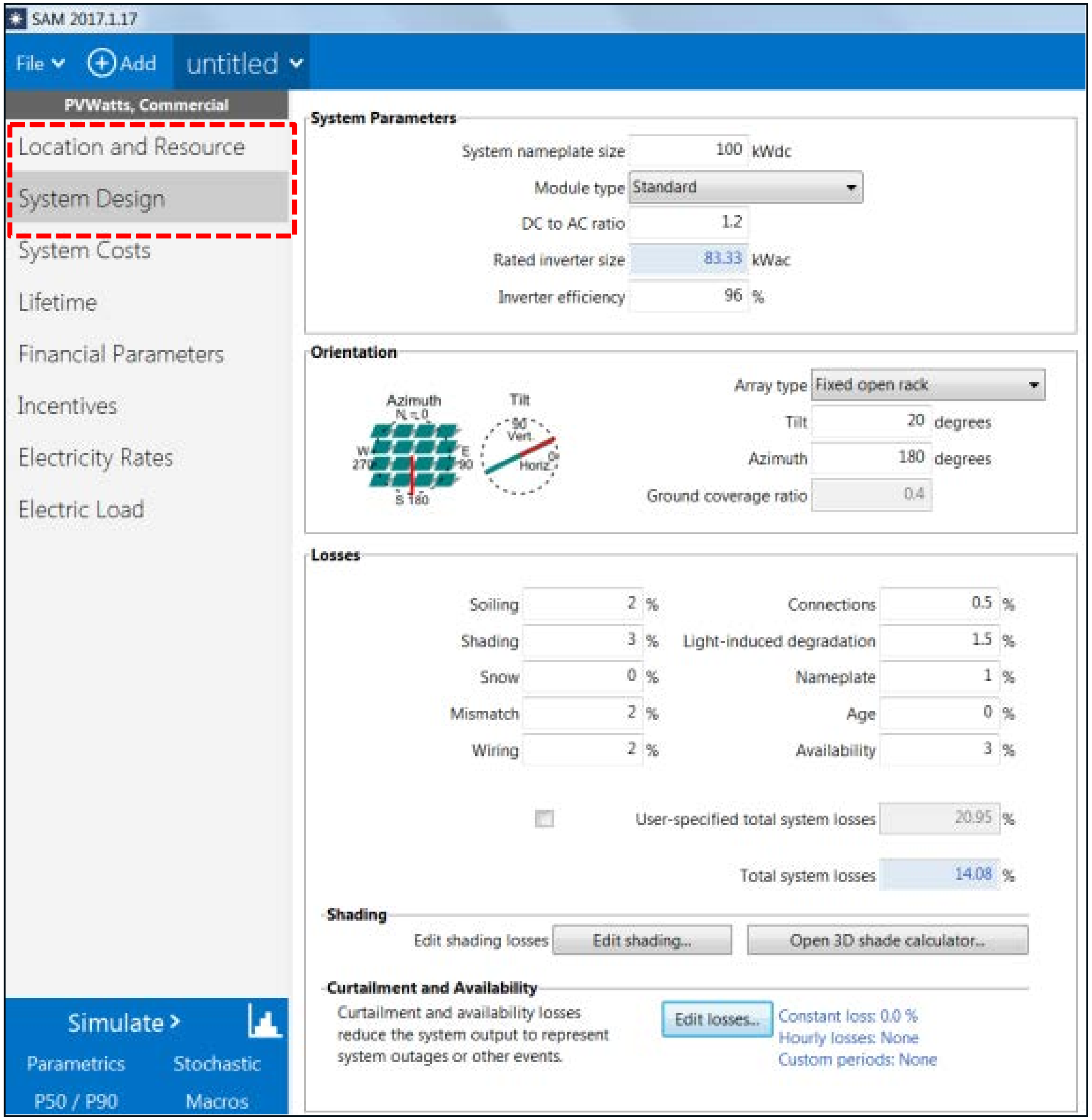
Software Tool Example: System Advisor Model (SAM)

- 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

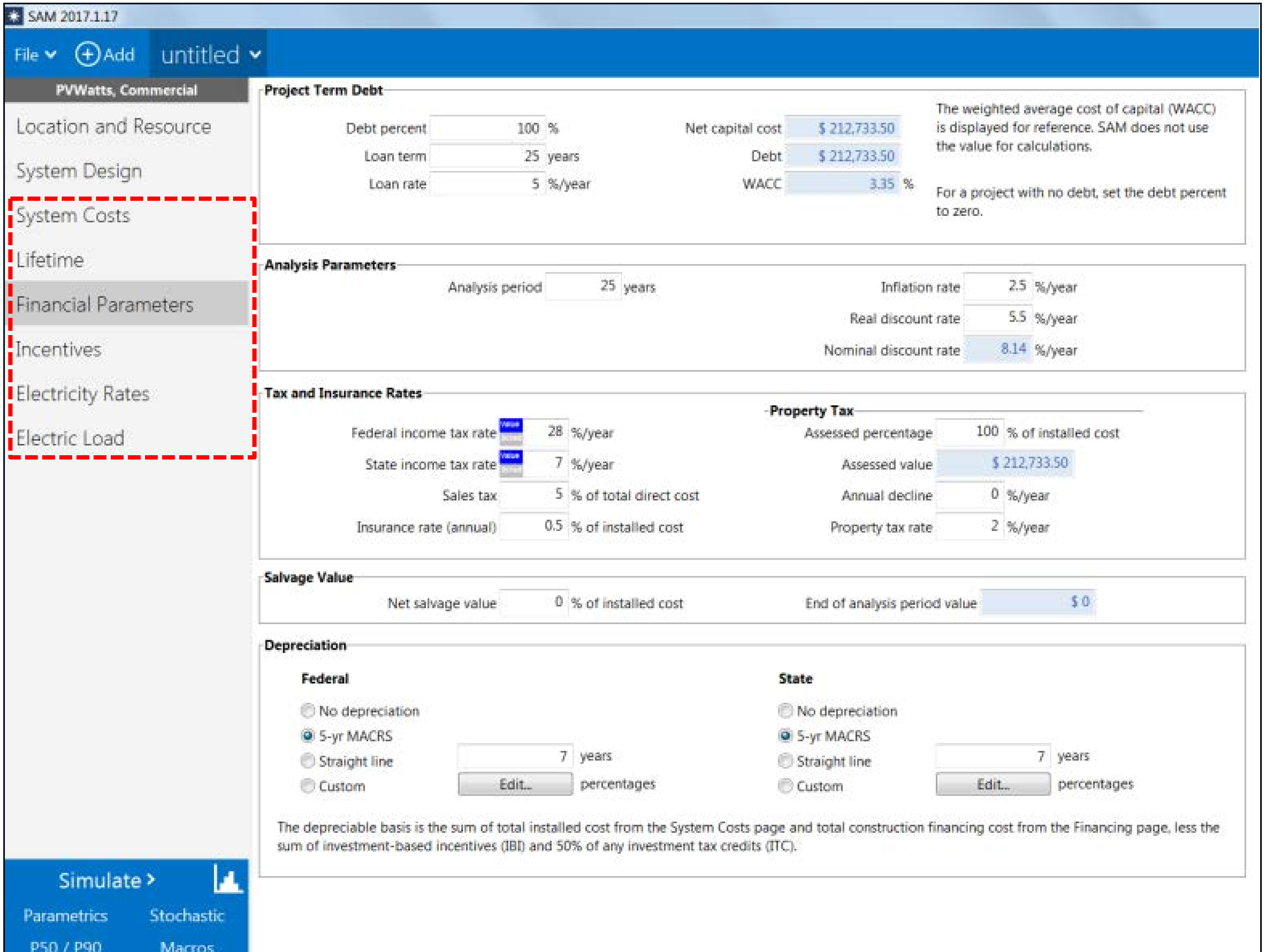


SAM: Software Layout & Detailed Performance Modeling

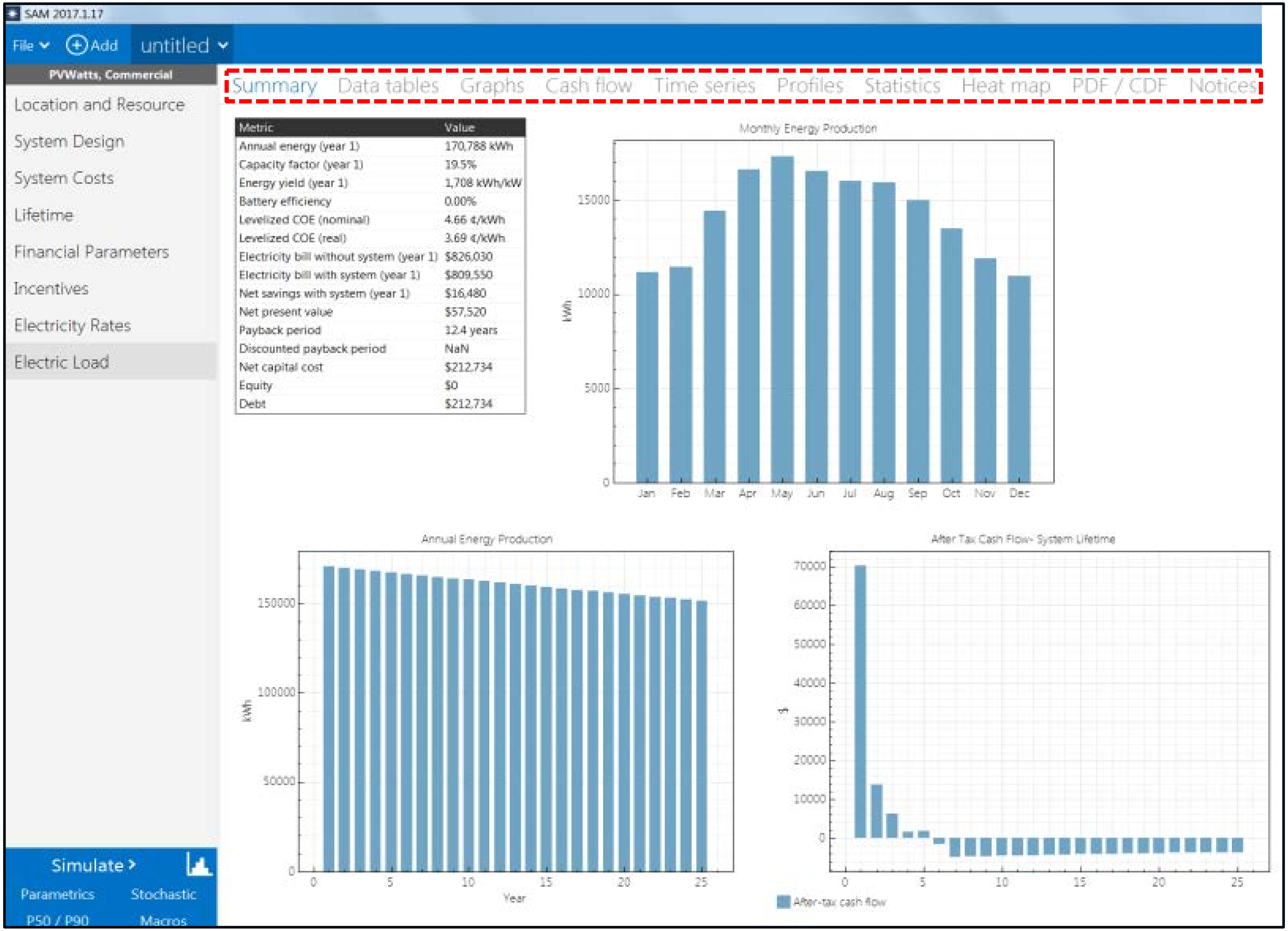
- SAM is pre-populated with default values
- SAM is set up with input boxes and dropdowns
  - Inputs are in black font
  - Calculated values are in blue font
- Detailed Performance modeling
  - Location & Resources
  - System Design



SAM: Detailed Financial Modeling



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

Thank you

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