TECHNICAL ASSESSMENT AND SCREENING TOOLS WE USE IN OUR PROJECTS

- Campus/Base Assessments
- Infrastructure
- Buildings Assessment
- Renewable Supply Side
- Vehicles & Tools
- Infrastructure
Renewable Energy Technologies

- Photovoltaics
- Wind Power
- Solar Water Heating
- Solar Vent Air Preheat
- Concentrating Solar Heat/Power
- Biomass Heat/Power
- Daylighting
- Ground Source Heat Pump
- Landfill Gas
Renewable Energy Resources
Geographical Information System (GIS) Datasets

- NREL Datasets (http://www.nrel.gov/gis/)
  - solar radiation 10x10 km grid
    - Horizontal, South-facing vertical, tilt=latitude
  - Wind Energy 200mx1000m grid
  - Biomass Resources
  - Illuminance for Daylighting
  - Temperature and Heating Degree Days

Purchased Datasets
- utility rates (wholesale/retail) for each service territory and customer class (residential, industrial, commercial) (Platts)
- City Cost Adjustments (RS Means & Co.)

Location Independent
- State and utility incentives and utility policy (from www.DSIREUSA.org)
- Installed Hardware Costs from NREL technology databook
- Economic Parameters (discount rate, inflation rate)
  - http://www1.eere.energy.gov/femp/program/lifecycle.html
Photovoltaics Tools

• Solar Energy Resources
  – NREL
    • http://www.nrel.gov/rredc/
  – TMY or Weather Data

• Solar PV Analytical Tools
  – Solar Advisor Model (SAM)
    • https://www.nrel.gov/analysis/sam/
  – HOMER
    • https://analysis.nrel.gov/homer/
  – PVWatts
    • http://www.nrel.gov/rredc/pvwatts/
  – IMBY
    • http://www.nrel.gov/eis/imby/
PV Watts

• **Version 1**
  – Users select a location from a map or text list of pre-determined locations throughout the world

• **Version 2**
  – Users to select any location in the United States
PV Watts v1

- Select a location
- Select default values or input customized system parameters for size, electric cost, array type, tilt angle, and azimuth angle
- Typical Meteorological Year weather data for the selected location (TMY files) used to calculate incident solar radiation and PV cell temperature for each hour of the year
- PVWatts calculator outputs monthly values of AC energy production (kW) expected from the specified PV system
PV Watts v2

- Flex Viewer
- Solar Atlas
- Internet Map Server
Solar Water Heating Tools

- **Resources**
  - FEMP Solar Hot Water System Calculator
    - DOE Energy Efficiency and Renewable Energy Solar Energy Technologies Program
    - [http://www1.eere.energy.gov/solar/solar_heating.html](http://www1.eere.energy.gov/solar/solar_heating.html)
  - FEMP Federal Technology Alerts
    - [www.eere.energy.gov/femp/pdfs/FTA_para_trough.pdf](http://www.eere.energy.gov/femp/pdfs/FTA_para_trough.pdf)
  - FEMP Case Studies
  - Resource maps
  - Solar Radiation Data Manual
Step 2. Estimate System Cost and Annual Savings

Annual energy and cost savings are calculated based on the current hot water heater fuel type, fuel price, and water heater efficiency level. Select the appropriate fuel type from the drop-down menu. The average efficiency level and fuel cost is provided, but can be changed to match your conditions.

- **Annual Energy Savings:** 113,345.71 kWh/year
- **Estimated System Cost:** $71,839.00 based on $90.00 per-unit-area cost
- **Annual Cost Savings:** $3,445.60 based on $9.15/1,000 c.u. ft. of gas
- **System Efficiency:** 0.434
- **Savings to Investment Ratio:** 1.15
- **Simple Payback Period:** 20.85 years
- **Solar Fraction:** 90%
- **Annual Greenhouse Gas Reduction:** 45,229.47 lbs. of CO₂
Solar Hot Water (SHW)

- Takes building information on the domestic hot water system, fuel costs, weather data files and runs an hourly production calculation

Photovoltaic (PV)

- Takes building orientation, electrical usage, electrical rates, weather data files, and runs an hourly production calculation

Finds the best mix of the two technologies
System Advisor Model SAM

• **Performance predictions for**
  - grid-connected solar,
  - small wind,
  - geothermal power systems
  - Solar hot water
  – Economic estimates
    – cost of generating electricity
    – type of financing,
    – applicable tax credits and incentives.

• **Free download**
  https://www.nrel.gov/analysis/sam/
Solar Vent Preheat Resources

• **FEMP Federal Technology Alert**
  – Solar Ventilation Preheating Resources and Technologies

• **NREL**
  – Solar Process Heat
  – Solar Space Heating Maps
    • [http://www.nrel.gov/gis/femp.html#space](http://www.nrel.gov/gis/femp.html#space)
Levelized Cost of Energy Calculator

Web-based simple LCOE calculator
Compares alternative to utility purchased energy
Includes cost guidance for PV, wind, SWH, SVP

http://www.nrel.gov/analysis/tech_lcoe.html
**FRESA**

**Federal Energy Management Program**

**FRESA Federal Renewable Energy Screening Assistant**

- **PV, SWH, SVP, and wind**
  - For federal site energy managers to quickly screen viability
  - Easy to learn, easy to use
  - Returns economic viability using FEMP specified discount rates and energy cost escalation rates per 10CFR436
  - Savings to investment ratio (SIR), simple payback, energy and cost savings

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**Facility-Scale Photovoltaic Analysis Results**

Below are results of the facility-scale photovoltaics (PV) analysis generated by the Federal Renewable Energy Screening Assistant (FRESA). Use the buttons to see more details on the specific results.

Your PV project is considered life-cycle cost effective according to 10 CFR 436 if the life-cycle cost of the PV system is less than the life-cycle cost of the base case.

Click "View Data Inputs" to make changes to your facility-scale inputs and re-run the analysis.

A full report can be exported in multiple file formats (.pdf, .csv, and .rtf) by using the Reports item in the left tree menu. Please note that .RTF files can be opened with Microsoft Word, and .CSV files can opened with Microsoft Excel.

Additional information is available in the FRESA user manual.

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**View Data Inputs**

**Facility: Federal Facility PV Example**

<table>
<thead>
<tr>
<th>SIR</th>
<th>1.020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Payback</td>
<td>17.0 years</td>
</tr>
<tr>
<td>Utility Electricity Savings</td>
<td>211,262 kWh/yr</td>
</tr>
<tr>
<td>Electricity Cost Savings</td>
<td>$35,918 /yr</td>
</tr>
<tr>
<td>Distillate Fuel Oil Savings</td>
<td>0.0 MMBTU/yr</td>
</tr>
<tr>
<td>Distillate Fuel Oil Cost Savings</td>
<td>$0 /yr</td>
</tr>
<tr>
<td>Natural Gas Savings</td>
<td>0.0 MMBTU/yr</td>
</tr>
<tr>
<td>Natural Gas Cost Savings</td>
<td>$0 /yr</td>
</tr>
<tr>
<td>Propane Savings</td>
<td>0.0 MMBTU/yr</td>
</tr>
<tr>
<td>Propane Cost Savings</td>
<td>$0 /yr</td>
</tr>
<tr>
<td>Base Case Life Cycle Cost</td>
<td>$24,325,300</td>
</tr>
<tr>
<td>Life Cycle Cost of PV</td>
<td>$24,309,829</td>
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<tr>
<td>Net Savings</td>
<td>$15,471</td>
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<tr>
<td>Rated Capacity</td>
<td>150 kW</td>
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<tr>
<td>Annual Energy Output</td>
<td>211,262 kWh</td>
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<tr>
<td>Footprint Area of PV Array</td>
<td>11,875.00 ft²</td>
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<tr>
<td>PV Panel Conversion Efficiency</td>
<td>18.00 %</td>
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<tr>
<td>Capital Cost</td>
<td>$750,000</td>
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<tr>
<td>Annual O&amp;M Cost</td>
<td>$4,956</td>
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</tbody>
</table>
REO: Renewable Energy Optimization

Optimization

Life Cycle Cost

Dispatch Algorithm

PV  Wind  SVP  SWH  CSP  Biomass  Daylighting

Geographical Information System (GIS) Data

Site Data

Incentive Data from DSIREUSA.ORG

Technology Characteristics.
Example results using the Renewable Energy Optimization to create a “net zero” energy zoo.
National Zoological Park (NZP) and Conservation Research Center (CRC), Washington DC
### REO for Land and Ferry Points of Entry

<table>
<thead>
<tr>
<th></th>
<th>Without Tax Incentives</th>
<th>With Tax Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV (kW)</td>
<td>0</td>
<td>737</td>
</tr>
<tr>
<td>Wind Energy (kW)</td>
<td>2,491</td>
<td>3,689</td>
</tr>
<tr>
<td>Solar Ventilation Air Preheat (sf)</td>
<td>93,265</td>
<td>119,652</td>
</tr>
<tr>
<td>Solar Water Heating (sf)</td>
<td>28,464</td>
<td>90,703</td>
</tr>
<tr>
<td>Solar Thermal Parabolic Trough (sf)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Solar Thermal Electric (kW)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Biomass Gasification Boiler (MBH)</td>
<td>1.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Biomass Gasification Cogen (kW)</td>
<td>134</td>
<td>193</td>
</tr>
<tr>
<td>Biomass Anaerobic Digester (ft³)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Biomass Anaerobic Digester Cogen (kW)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Skylight Area (sf)</td>
<td>190,951</td>
<td>209,666</td>
</tr>
</tbody>
</table>

### Energy Breakdown

- **Photovoltaics (Mbtu)**
- **Wind (Mbtu)**
- **Solar Water Heating (Mbtu)**
- **Solar Thermal (Mbtu)**
- **Biomass Gasifier (Mbtu)**
- **Anaerobic Digester (Mbtu)**
- **Daylighting (Mbtu)**
Optimization Problem

Objective: Minimize Life Cycle Cost ($)

Variables: Size of Each Technology (kW of PV, kW of wind, etc)

Constraints: examples:
- 100% energy from renewables (Net Zero)
- $140M investment limit
- 14 acre land area limit
- 20% carbon reduction

The optimum is often along a constraint.
HOMER

A tool for comparing and evaluating micro-power technology options

- Community, villages and island power systems
- Stand-alone or grid-connected systems
- Conventional technologies (generators, batteries)
- Renewable technologies (photovoltaic, wind turbines, fuel cell, CHP)

HOMER uses simulation, optimization, and sensitivity analysis to:

- Find the combination of components that can serve a load at the lowest life-cycle cost
- Simulates typical year by performing energy balance calculations for 8,760 hours (=1 year)
- Performs sensitivity analysis to show how results can vary given different assumptions
Kauai HOMER Analysis

Technical Assessment and Screening – Project Examples

Kauai Base Case + Biomass + Landfill gas + 4 MW PV

- System Architecture:
  - 4,000 kW PV
  - 4,000 kW Diesel 1 & 2
  - 5,000 kW Diesel 3 & 4
  - 7,860 kW Diesel 7
  - Total NPC: $613,576,128

- Levelized COE: $0.1164/kWh
- Operating Cost: $54,539,42

- Cost Summary
  - Production: 7,243,483 KWh/yr
  - Consumption: 4,936,663 KWh/yr
  - Excess electricity: 33,528 KWh/yr
  - Renewable fraction: 0.5865
  - CAPEX: $4,936,663
  - OPEX: $250,000
  - Total NPC: $613,509,128

- Monthly Average Electric Production

- Metric
  - Present worth: $154,568,496
  - Annual worth: $14,479,788/yr
  - Return on investment: 55.9%
  - Internal rate of return: 58.3%
  - Simple payback: 1.97 yrs
  - Discounted payback: 1.99 yrs
• Thank You!