Alternative Energy Committee 2016
Report Submission
January 2017

Committee Membership:
Mr. Wes Doane
Dr. James Masi
Mr. Laurenz Schmidt
Ms. Julia Bassett Schwerin (chair)
Mr. Richard Smith

Town Council Representative:
Ms. Patty Grennon

Town Liason:
Mr. Greg Marles
Dirctor of Facilities & Transportation

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Committee Statement & Town Council Charge

Charge

The committee shall explore opportunities to provide alternative energy to municipal and school buildings and vehicles. This includes a look at utilization of town and school land and buildings for solar energy opportunities. Its work product shall be a report to the town council providing specific proposals and cost estimates. Any proposals with cost impacts shall include the cost to implement as well as projected costs savings, future energy cost projections, and a risks section which identifies and quantifies all risks associated with the use, lease, rental or financing of a system including operation, performance, maintenance, guarantees, indemnities (including taxes and changes to Tax Law and/or Net Metering) and credit (vendors and financing parties). (TC,1.2016)

Alternative Energy Committee Mission Statement *(created by Committee, July 2016)*

To facilitate delivery of the best available decision-making information to empower the town council and inspire the community to engage in low risk/high reward projects that capture immediate and long-lasting benefits from energy efficiency and renewable energy technology by significantly reducing our energy costs and carbon emissions. (adopted by the AEC, 7.2016)

Committee Statement

Community participation in decisions on how the town pays for utilities is uncommon, but in the case of renewable energy, everybody is going to be interested in why, how and how much of any kind of an investment the town will make in a solar system, big or small. It is critical that communications for any project between the town government and the community be handled well so as to pave the way for future expansion and diversification of our energy assets. Fortunately, the impulse for creating the Alternative Energy Committee was a town forum where the subject of several townspeople wanting municipal solar array was raised and made the list of the council investigations. The work of the Alternative committee has followed the new town rules of meetings and disclosure, and in addition, has shared a great deal of information on its section of the town website pertinent to its work, however, we do not expect townspeople to sift through this materials, or even to read this report.

Executive Summary

The Cape Elizabeth Town Council approved the formation of an Ad Hoc Committee on January 4, 2016 to explore alternative energy solutions for the Town of Cape Elizabeth as well for the Cape Elizabeth School Department. The Alternative Energy Committee would be made up of 5 voting community members, a non-voting Town Council liaison, and a non-voting Town staff liaison with a committee budget of $10,000 for studies or engineering services. The Town of Cape Elizabeth and Town Council requested community members to submit an application if they wanted to be a part of the committee with the Town Council interviewing perspective committee members. On March 14, 2016 the Town Council appointed the following committee: of Mr. Wes Doane, Dr. James Masi, Mr. Laurenz Schmidt, Ms Julia Bassett Schwerin, and Mr. Richard Smith. The Town Council assigned Town Councilor Ms Patty Grennon as the Town Council liaison and Director of Facilities, Mr. Greg Marles as the Town Staff liaison.

The first meeting of the Alternative Energy Committee was held on March 29, 2016 at 7:00pm in the Town Hall lower level conference room. The Assistant Town Manager Ms. Debra Lane as well as Town Councilor Ms. Patty Grennon reviewed the Cape Elizabeth Town Council committee charge and rules for conducting meetings. The first order of business was to elect a committee chair. Ms Julia Bassett Schwerin was nominated and elected by a unanimous vote of the committee members.

The committee created a mission statement in July of 2016:
"To facilitate delivery of the best available decision making information to empower the Town Council and inspire the community to engage in low risk/high rewards projects that capture immediate and long lasting benefit from energy efficiency and renewable energy technology by significantly reducing our energy costs and carbon emissions"

The committee met over a seven (7) month period conducting eleven (11) regular meetings and two (2) sub-committee meetings. The committee reviewed the findings of the last energy audit dated December 2008 conducted by CM3 Building Solutions of Fort Washington, PA. The committee collected data on existing Town and School facilities, utility costs and usage, and available open land in Cape Elizabeth. Each member was tasked with providing the committee with information on other communities within Greater Portland as well as communities throughout New England on their municipal energy reporting, projects, and other measures for alternative energy and carbon footprint reduction. All collected data was posted to the Town of Cape Elizabeth website under a special resource tab for the Alternative Energy Committee. An extensive review of energy incentives, grants

and other funding opportunities was also undertaken by the committee in an effort to find alternative funding methods to fund projects in Cape Elizabeth. Another important area of review by the committee was educational opportunities for students and community members for any systems that may be recommended.

Having collected data, reference materials, inviting in an alternative energy contractor to do a presentation, and researched possible funding opportunities, the committee deliberated on what types of projects would make the best sense for the community of Cape Elizabeth. The committee felt after reviewing all data that their efforts should be focused around solar solutions for the community.
The town and school facilities receive grid energy via forty-two (42) meters with an annual consumption of five million-six hundred thirty thousand (5,630,000) kilowatt-hours (kWh). The schools and pool which are served by one meter consumes approximately ninety (90) percent of the total energy or four million-eight hundred thousand kilowatt-hours (kWh), comparing this to the next largest community user, Town Center Fire Station uses less than 5% of that amount, at one hundred-sixty thousand (160,000) kilowatt-hours. With all of the collected data the committee worked toward a solar solution for Cape Elizabeth.

Cape Elizabeth Facilities

The Cape Elizabeth Facilities and Transportation Department manages all of the physical plants and sport fields for the town and schools. This equates to thirty-seven (37) different buildings, approximately seven hundred-fifty thousand (750,000) square feet of facilities, 7 athletic fields, and a turf field.

In 2010 a major relamping project was conducted in many of the town and school facilities with a focus in cost electricity usages. The cost for this program was offset with a large rebate from Efficiency Maine with a payback period of three to five (3 to 5) years. The Department has a policy established regarding lighting upgrades that shall be the latest in energy efficiency fixtures and a large focus on LED lighting. Over the past seven (7) years the community has continued to see a decrease in electrical costs in our facilities due to the completion of projects with rapid investment returns. During the summer of 2011, the School Department upgraded the boiler plants at the high school with a first year fuel oil saving of twenty thousand (20,000) gallons; this will provide a payback period of nine (9) years. In 2014 the School Department upgraded the boiler plants for Pond Cove and the Middle school with first year oil saving of fourteen thousand (14,000) gallons; this will provide a payback of fourteen (14) years.

During the high school boiler upgrade project, both the high school and middle school were outfitted with an evacuated tube domestic hot water pre-heating solar arrays. These systems have a payback for the investment of approximately nine (9) years. The middle school system has been able to provide for all of the domestic hot water for most of the summer from June to August and into September depending on the weather.

In 2016, Donald Richards Pool underwent a major mechanical renovation, including a new dehumidification unit, gas fired boilers, and chlorinating system. The new equipment is more operational efficient thus saving energy costs. We put measures in place that will allow us to operate the heating side of the system by propane or heating oil, depending on which fuel cost less to heat the pool water. These operational changes give the community a saving in energy costs as well as reducing our greenhouse gases emissions.

Cape Elizabeth has opportunities to meet the goals of energy and greenhouse reductions with the addition of solar arrays on buildings, possible Microgrid or another type of system that can provide the community with a good return on their investment. The committee reviewed several options to meet the goals of energy cost saving and greenhouse gas emission reductions.

Natural Gas

The committee reviewed the option of bringing natural gas to the town center which could be used for facility heating, domestic water heating, and possibly vehicle fueling. It was determined that although the use of natural gas has a lesser impact on the environment than heating oil, the cost to bring the line from South Portland to Cape Elizabeth would, at this time, produce a negative return on investment. The committee focus was on creating options that significantly reduce greenhouse gas emissions as well as moving away from fossil fuel options. The committee rejected this option for further consideration.

Biomass

The committee reviewed the option of biomass type fuel products such as wood chips, wood pellets, or reclaimed wood materials to provide energy for town and school facilities. The committee rejected this option due to the possibility of supply interruptions, infrastructure upgrade costs, and increased local traffic from large delivery vehicles. The committee also had concerns about an on-going debate that still continues about the true reduction in greenhouse gas emissions.

Biofuels

The committee looked at biofuels for trucks, buses, and other vehicles owned and operated by the town and schools. They also explored the idea of using biofuels for heating of town and school facilities. The committee rejected this option for further consideration based the cost to upgrade fuel tanks for heating and the possible issues surrounding converting existing vehicles from regular diesel to a biofuel source. Concerns centered at the cost of biofuels being at a higher rate than the community is currently paying and the lack of true greenhouse emission reductions.

Geothermal Systems

The committee reviewed the equipment needs and cost of installation of geothermal systems for town and school facilities. The committee rejected this option for further consideration, as the system would not be cost effective for existing facilities. **The committee is recommending that the town or schools look into geothermal systems for major renovations or new building construction.**

Power Generation and Heating

The committee considered a Microgrid system that would generate power which would be sold back to the power company as well as creating a grid independent Microgrid system for town and school facilities. These systems could not only generate electricity but the by-product of the generation process creates heat that could be used to provide heating to the facility. The committee rejected this option from further consideration because: 1) intensive labor to operate these systems, 2) existing equipment is not well tested in the market place, and 3) the equipment necessary to operate a fully functional system is very expensive.

Wind

The committee decided not to consider wind energy based on the inconsistent data for smaller scale projects and the results for other projects in the general area.

Clean Fuel Vehicles

The Town Council requested the committee also look at reducing environmental impact of town and school vehicles. The committee took an ancillary look at different vehicle options such as biofuels, propane, natural gas, battery-electric, and hydrogen-electric, but due to the complexities of the subject, the committee decided it would be better to focus on a building based type of energy programs.

Solar Thermal and Photovoltaic

The committee looked at several different options for solar within Cape Elizabeth that would reduce and/or stabilize energy costs while reducing greenhouse gas emissions. It was the decision of the committee to focus on solar-based systems due to rate of return on the investments, the ability to reduce or stay cost neutral for energy, and areas of availability for a system installation. Several different options were reviewed such as Greenfield photovoltaic solar systems which generate electricity that can be directly utilized for town and school facilities, roof mounted photovoltaic solar systems which offer the same results as Greenfield solar but at small scale, and roof mounted thermal solar systems that would heat the pool water.

Thermal Solar with Photovoltaic Pool Facility

An analysis of the application of solar thermal energy was undertaken for the Richards Community Pool/Spa and associated electrical energy needs. The supporting documents describe the rationale, data, references/resources, and conclusions regarding the concurrent use of solar thermal and photovoltaic installations for this specific energy intensive segment of our study (pool, pool pumps and photovoltaic, spa, spa pumps, compressors, etc.). The parametric data used in these documents are taken from the actual pool and spa known values. Other losses, financial, and unknown parameters are best estimates.

The town pays roughly thirty-four thousand ($34,000) each year to (i) heat the water in the swimming pool and (ii) purchase electricity to power existing pumps to circulate the pool water. This report recommends (i) heating the water with solar thermal panels that cost approximately twenty-seven thousand ($27,000) (including heat exchanger and associated pump to heat exchanger)(see diagram on p. 11; and (ii) recommends supplying the forty-six (46) kilowatt hours (kWh) electricity for the pumps with propane driven generators[1] costing (up front) approximately sixteen thousand three hundred ($16,300) plus labor, plus approximately seventeen thousand ($17,000) yearly for fuel to cover non-solar and unforeseen outages. **The total investment would be roughly sixty two thousand ($62,000) for the solar thermal panels and propane backup plus one hundred twenty two thousand ($122,000) for the PV solar daytime running of the pumps (48kW x $2.55/watt, installed), pool, and SPA.**

[1] Kohler 48 kW Generator, 48RCLA single or three phase, Natural Gas/LPG, $16,236 MSRP* plus installation

If the town adopts the recommendations in this report, the town will pay roughly seventeen thousand ($17,000) each year to heat and circulate the pool's water, a savings of seventeen thousand ($17,000) per year (assuming grid tie for 50% of system operation).

The annual savings results in a payback period for the one hundred eighty four thousand ($184,000) investment (PV + solar thermal) of approximately 11 years. In the absence of the PV panels, the payback for the sixty two thousand ($62,000) would be 4 years. However, this assumes the combined use of grid and propane generation backup.

Greenfield Photovoltaic Installation:

Designated area: (transfer station capped Greenfield)	1.8 acres max
Available nameplate capacity from this area:	350 kW ±*2
Annual output from a 350 kW installation (first year)	439,000 kWh ±*2
Output over the life of the system (.5% annual degradation, 40 years)	15,960,000 kWh ±*2
Utility price (first year)	$ .135
Utility rate escalation (annually)	1.5% p.a.
Power Purchase Agreement (PPA) price (first year)	$ .130 [3]
Power Purchase Agreement (PPA) rate escalation (annually)	1.5% p.a.
Cost estimate of the system all-in	$ 858,800
IRR to the investor	8.97%
Non-discounted cash flow breakeven	7.8 years

Cumulative benefit to the municipality over lifetime of the system

Perpetual Power Purchase Agreement (PPA) (NOT RECOMMENDED)	**$ 107,201**
Power Purchase Agreement (PPA) 7 years buy out @ $ 515,200	**$ 1,651,600**

Environmental benefit for either economic scenario over the life of the system (40 years)

Reductions of local emissions

CO_2 emission avoidance	18,860,000 pounds
SO_2 emission avoidance	4,500 pounds
NO_X emission avoidance	6,900 pounds

*2The numbers shown are fairly accurate estimates based on the accuracy of available geographical, macro topological and meteorological data. The exact numbers will depend on the amount of shading resulting from the specific micro topography, exact layout of the field and any efficiency advantages gained by technology improvements between now and the installation of the field. The actual numbers should be within 5%± range.

[3] The current minimum market investor rate of return (IRR) for an investor and highly rated buyer of power is 9%. A Power purchase agreement (PPA) kWh price of .13$kWh is needed to get close to the required 9%; Cape Elizabeth would qualify as highly rated.

The 7 Year Power Purchase Agreement (PPA) along with a buy-out for a Greenfield installation meets the economic criteria is doable and does not require any net metering income or offset. It produces a conservative return of one million seven hundred thousand ($1,700,000) over forty (40) years with no front-loading. We recommend that solution.

The method employed for the comparative analysis was to use National Renewable Energy Laboratory (NREL), National Aeronautics and Space Administration (NASA), and Department of Energy (DOE) databases to obtain specific solar energy availability for the selected location. These databases allow calculating the typical energy output considering geographical location, seasonal impact (temperature and wind), meteorological conditions at the location and topography. We considered the panels to be mounted on a fixed framework with a tilt of 32° South. The cost of project development, panels, inverters, wiring and interconnections was taken from actually existing projects of comparable size in the New England region and prorated to the project size in question. No property tax burden was assumed for the Greenfield installation as the land is currently owned by the municipality and does not pay taxes. Any property tax burden would be passed through to the sole beneficiary of the power output, the municipality. Hence, for the sake of analyzing the economic impact on the town, the tax burden would be zero. Note that due to unknown variables like soil condition, change orders, etc. the final numbers can be influenced. These numbers are not a quote but rather a best effort estimate based on actual, life projects, to which quotes can later be compared.

The committee would like to thank the professionals in the community who gave their expertise pro bono to the highly sophisticated modeling of the data used by the committee. Additionally, the committee would especially thank Mr. Greg Marles and Ms. Patty Grennon for their diligent work and positive attitudes throughout the process of creating this report.

Respectfully submitted,
2016 Alternative Energy Committee

Conclusions & Recommendations

CONCLUSIONS

The committee has reviewed many different options for the town and schools facilities of Cape Elizabeth: looked at rate of return on investments, long term maintenance and operational costs, environmental benefits to the community, and necessary installation requirements for different types of systems.

These results and detailed research indicated that the best opportunity for the community is:

1. a thermal solar pool water heating system with a photovoltaic system to provide power to the pumping systems
2. a photovoltaic solar grid to be located at the transfer station capped Greenfield area to supply energy to town or school facilities.

Thermal solar with photovoltaic:

The thermal solar with photovoltaic system shows that an investment of one hundred eighty-four thousand ($184,000) with a rate of return on the investment of eleven (11) years and a life cycle expectancy of twenty (20) to twenty-five (25) years. Should the Town Council decide to only go with a thermal solar water heating system, the cost would be sixty two thousand ($62,000) with a rate of return on the investment of four (4) years and a life cycle expectancy of twenty (20) to twenty-five (25) years.

Greenfield photovoltaic:

The Greenfield photovoltaic system would require no upfront investment from the community if a power purchase agreement (PPA) is utilized to construct system with the vendor taking advantage of available tax incentives directly as they are not available to the Town of Cape Elizabeth. It is recommended that a PPA agreement be utilized with a buy-out provision at seven (7) years with the Town taking over operations of the system. With the seven (7) year buy-out clause, the town and schools would realize a one million seven hundred thousand ($1,700,000) saving over the life expectancy of the system. If the town decides not to buy-out the PPA contract after seven (7) years the total realized saving over the same period would be one hundred seven thousand ($107,000). The PPA buy-out at seven (7) years would cost the town and schools five hundred fifteen thousand ($515,000) which has been calculated into the rate of return over the life cycle of the project.

RECOMMENDATIONS

The 2016 Alternative Energy Committee recommends that the Town of Cape Elizabeth and Cape Elizabeth Town Council move forward with the two (2) projects detailed in this report with the thermal solar system having an investment of one hundred eighty-four ($184,000) and a power purchase agreement with no cash or upfront investment until the completion of year seven (7) of the operating system. The Committee understands that these projects will have permitting and regulatory approval processes to go through before their completion. The committee feels that the sooner this process can begin the quicker the Town of Cape Elizabeth can start to realize a return of their investment as well as reducing our current impact on the environment.

In addition to the solar recommendations, the 2016 Alternative Energy Committee requests that the Town Council authorize the committee to continue into 2017. The Committee would focus on monitoring and providing guidance to help facilitate the project process. The Committee also requests permission to publish a series of articles regarding the solar projects, with workshops aimed at various groups within the community of Cape Elizabeth.

Please see page 12 for the Project Reference Guide.

Project Reference Guide

Solar Project options	Cost Investment	Rate of Return	Life cycle	Buy-out	Projected savings
Thermal Solar					
1. Thermal solar with Photovoltaic	$ 184,000.00	Eleven (11) years	20 to 25 years	N/A	$17,000.00 (heating fuel/electricity)
1.a. Thermal solar without Photovoltaic	$ 62,000.00	Four (4) years	20 to 25 years	N/A	$11,250.00 (heating fuel)
Solar Greenfield					
2. Solar Photovoltaic with buy-out (PPA)	zero ($0.00) Upfront costs	N/A	30 to 35 years	$515,000 after seven (7) years	$1,700,000 (electricity on life cycle) (1.5% Escalator)
2.b. Solar Photovoltaic without buy-out (PPA)	zero ($0.00) Upfront costs	N/A	30 to 35 years	N/A	$107,000 (electricity on life cycle) (1.5% Escalator)

The 2016 Alternative Energy Committee is recommending that option 1 under Thermal Solar and option 2 under Solar Greenfield offer the best rate of return of investment for the Town and Schools of Cape Elizabeth.

Glossary of Solar Photovoltaic Thermal Terms

ABBREVIATIONS

AC - Alternating Current
ACP - Alternative Compliance Payment
DC - Direct Current
DG - Distributed Generation
ITC - Investment Tax Credit
kW - Kilowatt
kWh - Kilowatt-hour
LCoE - Levelized Cost of Electricity
LSEs - Load Serving Entities
MACRS - Modified Accelerated Cost Recovery System
MW - Megawatt
MWh - Megawatt-hour
O&M - Operations and Maintenance
NREL - National Renewable Energy Laboratory
PPA - Power Purchase Agreement
PV - Photovoltaic
REC - Renewable Energy Credit
RPS - Renewable Portfolio Standard
SREC - Solar Renewable Energy Credit

GENERAL TERMS

Battery Storage - batteries that capture energy produced by solar panels at one time for use later

Compliance Entities - Entities that must comply with the Renewable Portfolio Standard by providing a percentage of their load from renewable sources. Also referred to as Retail Electricity Suppliers and Load Serving Entities.

Customer Sited (or behind the meter) - Refers to technology that provides electricity directly to a customer on site and not from a utility central power plant. A common form of distributed generation (DG), or electricity generated close to its use, is customer-sited DG.

Derate - To lower the rated output of a Solar PV system due to external factors, roof pitch, size, etc.

Greenfield - Previously undeveloped sites for commercial development or exploitation

Grid Parity (or socket parity) - Grid parity (or socket parity) occurs when an alternative energy source can generate electricity at a levelized cost of electricity (LCoE) that is less than or equal to the price of purchasing power at a retail price from the electricity grid. Simplified, it means the cost of renewable electricity equivalent to the retail price of utility supplied electricity.

Inverter - Converts the variable direct current (DC) output from photovoltaic solar panel into alternating current (AC) that can be fed into a commercial electric grid

IRR - Metric used in measuring the probability of a potential investment

Levelized Cost of Energy (LCoE) - The constant price per unit of electricity that causes the investment to break even. The calculation will often consider capital costs, operations and maintenance (O&M), performance, and fuel costs and could include financing issues, discount issues, future replacement, or degradation costs.

Microgrid - A localized grouping of electricity sources that normally operates connected to and synchronous with the traditional centralized electrical grid, but can disconnect and function autonomously as physical and/or economic conditions dictate. In this instance, a Microgrid would include Solar PV and Energy Storage.

Name Plate Capacity - the intended full-load sustained output of a facility

Retail Electricity Supplier - A company that sells retail electricity (electricity to the consumer). In Massachusetts, regulated utilities and competitive electric suppliers can sell retail electricity. (Delivery of electricity remains with the distribution companies). Also referred to as Load Serving Entities (LSEs) and Compliance Entities.

Solar Photovoltaic (Solar PV) - Technology that converts solar energy to usable electricity that can be used, stored, or converted for long-distance transmission. A photovoltaic system minimally includes an array of solar panels, an inverter, and interconnection wiring.

Solar Thermal - Technology that converts direct and indirect solar energy into thermal energy to provide usable heat for a number of applications including but not limited to water heating, space heating and cooling, and process heat.

Utility Price - Price the municipality is currently paying for electricity from the Utility

Utility Rate Escalation - Estimate of how much utility electricity rates will increase each year

Utility Scale (or utility side of the meter) - Renewable energy generation that feeds directly into the electric grid (such as 1 MW or greater stand alone solar PV projects). This is in direct contrast to customer-sited distributed generation.

MEASUREMENT TERMS

Watt - A derived unit of power. A watt is a measure of electrical power.

Kilowatt (kW) - 1,000 watts. A typical residential sized solar PV system is 5-7 kW.

Kilowatt-hour (kWh) - A kilowatt-hour is a unit of energy that measures the amount of power used over a given period of time. Electricity bills are provided to customers in kWh. In 2010, Massachusetts's residents on average used 633 kWh of electricity monthly.

Megawatt (MW) - 1,000 kW or 1,000,000 Watts

Megawatt-hour (MWh) - A unit of energy that measures the amount of power used over a given time. In 2010, the average annual electricity consumption for a U.S. residential utility customer was 11.5 MWh (or 11,496 kWh).

STATE POLICY TERMS:

Alternative Compliance Payment (ACP) - A payment that utilities must pay if they are not able to produce enough renewable energy to satisfy the State's renewable electricity mandate (RPS).

Net Metering - Net metering is a state regulation allowing customers to receive retail value during periods when their eligible on-site distributed generation (such as a solar array) generates more electricity than they use. That is, the electric meter runs backward whenever a customer's net metered facility is producing more power than is being consumed and the customer receives on bill net metering credits for the net excess generation.

Renewable Energy Credit (REC) - REC (pronounced: rěk) represents the property rights to the environmental, social, and other non-power qualities of renewable electricity. A renewable energy system owner is eligible to receive one REC for every MWh of renewable energy generated.

Renewable Portfolio Standard (RPS) - A state program requiring a certain percentage of the instate energy load served by Retail Electric Suppliers (RES) to come from renewable energy resources such as wind, solar, biomass, and geothermal.

Solar Renewable Energy Credit (SREC) - REC generated from solar energy technologies.

SOLAR FINANCING TERMS

Investment Tax Credit (ITC) - The federal Investment tax credit (ITC) is a 30 percent tax credit for renewable energy systems on residential and commercial properties. The ITC reduces the tax liability for individuals or businesses that purchase qualifying energy technologies.

Modified Accelerated Cost Recovery System (MACRS) - The capitalized cost (basis) of tangible property is recovered over a specified life by annual deductions for depreciation. The lives are specified broadly in the Internal Revenue Code. The IRS publishes detailed tables of lives by classes of assets.

Power Purchase Agreement (PPA) - A PPA is a financial arrangement in which a third-party developer owns, operates, and maintains an energy generating system, and a host customer agrees to site the system on its property and purchases the system's electricity output from the third-party owner for a predetermined period and price. This is a common mechanism that allows commercial and residential customers to, in effect, lease solar energy on site.

Solar Thermal Pool Heating and Pumping Analysis

An analysis of the application of solar thermal energy was undertaken for the Cape Elizabeth High School Pool/Spa and associated electrical energy needs. These related documents describe the rationale, data, references/resources, and conclusions regarding the concurrent use of solar thermal and photovoltaic installations for this specific energy intensive segment of our study (pool, pool pumps an PV, spa, spa pumps, compressors, etc.). The parametric data used in these documents are taken from the actual POOL and SPA known values. Other losses, financial, and unknown parameters are best estimates. The detailed calculations are shown on pages 20-26.

The town pays roughly thirty four thousand ($34,000) each year to (i) heat the water in the swimming pool and (ii) purchase electricity to power existing pumps to circulate the pool water. This report recommends (i) heating the water with solar thermal panels that cost approximately twenty seven thousand ($27,000) (including heat exchanger and associated pump to heat exchanger; see diagram on p. 27); and (ii) recommends supplying the forty six (46) kW electricity for the pumps with propane driven generators[1] costing (up front) approximately sixteen thousand three hundred ($16,300) plus labor*, plus approximately seventeen thousand ($17,000) yearly for fuel to cover non-solar and unforeseen outages. **The total investment would be roughly sixty two thousand ($62,000) for the solar thermal panels and propane backup plus one hundred twenty two thousand ($122,000) for the PV solar daytime running of the pumps (48kW x $2.55/watt, installed), pool, and SPA**.

If the town adopts the recommendations in this report, the town will pay roughly seventeen thousand ($17,000) each year to heat and circulate the pool's water, a savings of seventeen thousand ($17,000) per year (assuming grid tie for 50% of system operation).

The annual savings result in a payback period for the one hundred eighty four thousand ($184,000) (PV + solar thermal) investment of approximately 11 years. In the absence of the PV panels, the payback for the sixty two thousand ($62,000) would be 4 years. However, this assumes the combined use of grid and propane generation backup.

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[1] Kohler 48 kW Generator, 48RCLA Single Phase or Three Phase, NATURAL GAS|LPG, $16,236.00 MSRP* plus installation

CONCLUSIONS:

- The initial data shown in the attached calculations show results which favor the adoption of solar thermal panels for heating the POOL and SPA (p.24) and associated PV water pumping (p. 20) and propane generators used as backup for grid power outage and unforeseen downtime.
- Discourage the application of solar PV energy and battery storage ($350/kW-h), at this time, to the system and compressors (p.26).
- The cost of the thermal panels and associated balance and engineering is approximately twenty seven thousand ($ 27,000). The payback time, after operational stability, is approximately two years (p.24).
- The cost of the associated pumping photovoltaic electrical power is approximately one hundred twenty two thousand four hundred ($122,400) ($2.55/installed watt)(p. 26). This is highly recommended for the project.
- The proposed location of the panels for the POOL project is the rooftop of the pool area.
- There are no thermal storage costs, since the pool itself is the water storage.
- A PPA is recommended, since the costs of the buyout are only slightly over one hundred eighty four thousand ($184,000) for the PV/PROPANE STORAGE complete system.
- Due to the near lack of financial incentives in Maine, financing calculations are less than adequate and should be revisited when adoption of the thermal section is nearer to reality. Perhaps the renewable energy attitudes and funding in Maine will become a reality once again. The data calculations/simulations should be run again as more financial information is made available.

The references that follow describe the rational, model, and sources for pages 20-26.

NOTES.

The solar water heating models calculate the thermal output of the system, assuming that it displaces electricity that would normally heat water in a conventional electric water heating system. NREL System Advisor's detailed photovoltaic, PV Watts, solar water heating, and functional models, used for these calculations, can perform sub-hourly simulations for advanced analyses, but require sub-hourly weather data to do so.

The solar water-heating model calculates the value of electricity saved by the system, assuming that heat from the system displaces heat that would be generated by a conventional electric water heater without the solar system.

References, Models, and Databases

This topic lists all of the performance models and describes the component-level models and databases used.

System Performance Models

The system models represent a complete renewable energy system and were developed by NREL using algorithms from partners listed below and the team.

Model Name	NREL Partner (if any)
Detailed Photovoltaic	Component models from Sandia National Laboratories and the University of Wisconsin
PVWatts	
Solar Water Heating	Modifications of Sunport Master Spreadsheet
Solar Water Heating	University of Wisconsin

Component Performance Models

The detailed photovoltaic and wind power models include options for choosing a component performance model to represent part of the system.

Model Name	Component	Developer
Simple Efficiency Module Model	Photovoltaic module	NREL
CEC Performance Model with Module Data base	Photovoltaic module	University of Wisconsin
CEC Performance Model with User Entered Specifications	Photovoltaic module	Adapted by NREL
Sandia PV Array Performance Model with Module Database	Photovoltaic module	Sandia National Laboratories
Single Point Efficiency Inverter	Inverter	NREL
Sandia Performance Model for Grid Connected PV Inverters	Inverter	Sandia National Laboratories

Component Parameter Databases

Some of the component models use a library of input parameters to represent the performance characteristics of the component. The libraries listed below are owned by organizations other than NREL.

Library Name	Component	Owner
CEC Modules	PV module	California Energy Commission
Sandia Inverters	Inverter	Sandia National Laboratories
Sandia Modules	PV module	Sandia National Laboratories

Online Financial Model Data

System Advisor can automatically download data from the following online databases to populate values on its financial model input pages.

Database Name	Type of Data	Database Manager
OpenEI U.S. Utility Rate Database	Retail electricity prices and rate structures	NREL and Illinois State University

Online Renewable Resource and Weather Data Sources

System Advisor can automatically download renewable energy resource and weather data from the following online databases.

Database Name	Type of Resource Data	Database Manager
National Solar Radiation Database	Solar and Meteorological	NREL

Solar Resource Files

NREL System Advisor comes with a database of weather files for the solar performance models. The solar resource files are in the CSV format and contain data from:

- National Solar Resource Database (NSRDB): TMY3 (1991-2005) and TMY2 (1961-1990)
- Solar and Wind Energy Resource Assessment Programme (SWERA)
- The ASHRAE International Weather for Energy Calculations Version 1.1 (IWEC)
- Canadian Weather for Energy Calculations (CWEC)

DETAILS OF SOLAR POOL CALCULATIONS THERMAL SOLAR DESIGN FOR POOL

Conversion factors:

1 gal H_2O = 3.79 kg
1 gal/min = 227.27 kg/hr
1 hp = 746 watts
1 gal = 0.0038 m^3
$^oC = 5/9(^oF - 32)$

NEEDS FOR SOLAR THERMAL DESIGN FOR POOL

Pool

1. Total capacity of water in pool and ancillary storage; 250,000 gal = 947,000 kg= 3598.6 m^3
   (a) Separate size of storage (if available) N/A
2. Flow rate of water during use; 350 gpm = 79544.5 kg/hr
3. Desired temperature of water; 82F = 27.8C
4. Power (V, A, phases, PF)/hp/flow design of water pump(s); 208 V, 3f
   2-15 hp = 22380 W
   1-10 hp = 7460 W
   1-5hp = 3730 W
   TOTAL ELECTRICAL (POOL) = 33570 W = 33.57 kW
5. Other: 40 ton unit, 208 V, 3f, 2-35 hp compressors = 52220 W = 52.22 kW

Spa

1. 10,000 gal = 37,900 kg = 144 m^3
2. 2-7.5 hp = 11,190W= 11.190 kW, 208V, 3f
3. Water 102 F = 38.9C, space 84F = 28.9C

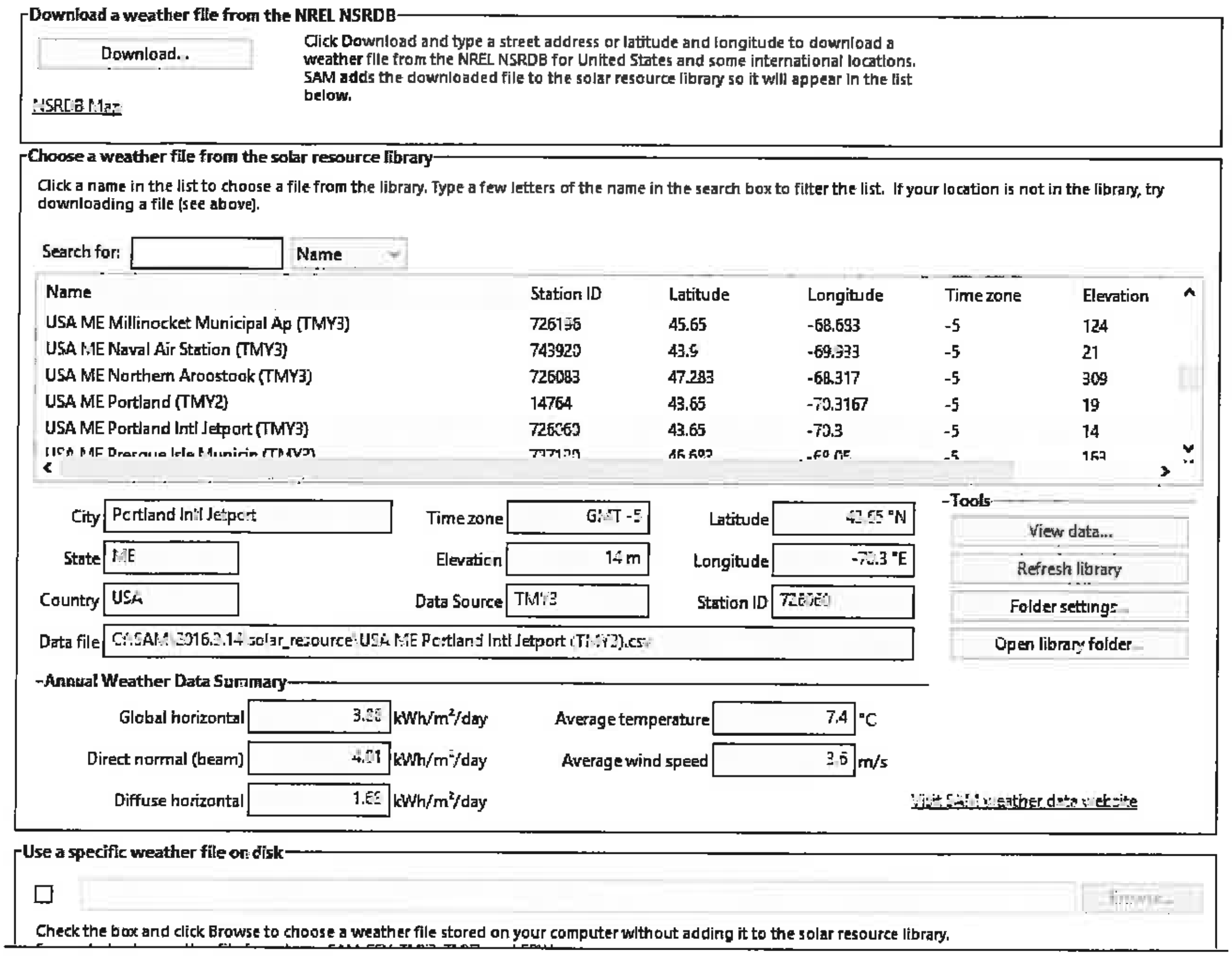
Total power needed for POOL and SPA pumps 33.57 + 11.19 kW = 44.76 kW

PROPANE USAGE FOR DOWN TIME SCENARIOS (in place of PV and storage)

Here are some general numbers we use to estimate propane consumption on generators. Each generator manufacturer quotes slightly different numbers but these should be close.

45kw - 7.86gph or 720kBTU
7.86 gph x 24 hr x365 days = $68,853.60 /year 24/7
Considering 12 hr/day = $34,427/yr 12/7
for 4 day downtime: 7.86 gph x 24 hr x 4 = $754.56 per 4-day downtime

JVM 11/29/2016


Download a weather file from the NREL NSRDB
Download...
Click Download and type a street address or latitude and longitude to download a weather file from the NREL NSRDB for United States and some international locations. SAM adds the downloaded file to the solar resource library so it will appear in the list below.
NSRDB Map
Choose a weather file from the solar resource library
Click a name in the list to choose a file from the library. Type a few letters of the name in the search box to filter the list. If your location is not in the library, try downloading a file (see above).
Search for:
Name
Name
Station ID
Latitude
Longitude
Time zone
Elevation
USA ME Millinocket Municipal Ap (TMY3) 726196 45.65 -68.693 -5 124
USA ME Naval Air Station (TMY3) 743920 43.9 -69.933 -5 21
USA ME Northern Aroostook (TMY3) 726083 47.283 -68.317 -5 309
USA ME Portland (TMY2) 14764 43.65 -70.3167 -5 19
USA ME Portland Intl Jetport (TMY3) 726060 43.65 -70.3 -5 14
City Portland Intl Jetport
Time zone GMT -5
Latitude 43.65 °N
State ME
Elevation 14 m
Longitude -70.3 °E
Country USA
Data Source TMY3
Station ID
Data file
Tools
View data...
Refresh library
Folder settings...
Open library folder...
Annual Weather Data Summary
Global horizontal kWh/m²/day
Direct normal (beam) kWh/m²/day
Diffuse horizontal kWh/m²/day
Average temperature 7.4 °C
Average wind speed m/s
Use a specific weather file on disk
Check the box and click Browse to choose a weather file stored on your computer without adding it to the solar resource library.

Hot Water Draw

Hourly hot water draw profile [Edit data...] kg/hr

Scale draw profile to average daily usage ☑

Total annual hot water draw 5.95911e+008 kg/year

Average daily hot water usage 1.90907e+006 kg/day

System

Tilt	30 deg	Diffuse sky model	Isotropic
Azimuth	180 deg	Irradiance inputs	Beam and Diffuse
Total system flow rate	22.1 kg/s	Albedo	0.2 0..1
Working fluid	Glycol	Total system collector area	32 m2
Number of collectors	8	Rated system size	12.704 kW

Shading

Shading losses [Edit shading...] [Open 3D shade calculator...]

Curtailment and Availability

[Edit losses...] Constant loss: 0.0 %
Hourly losses: None
Custom periods: None

Collector

◉ Enter user-defined parameters
○ Choose from library

User-defined collector

Collector area	4 m2
FRta	0.7
FRUL	3.95 W/m2.C
Incidence angle modifier	0.2
Test fluid	Glycol
Test flow	0.06 kg/s

Search for: [ ] Name

Name	SRCC Number	Type	Area	IAM	FRta
Thermo Dynamics Ltd. Micro-Flo S32-P	2009007A	Glazed Flat-Plate	2.98	0.34	0.685
TiSUN LLC TiSUN FM-W S 4	2007054A	Glazed Flat-Plate	2.55	0.17	0.733
TiSUN LLC TiSUN FA 2 5	2007052C	Glazed Flat-Plate	10.1	0	0.732
TiSUN LLC TiSUN FA 2 6	2007052D	Glazed Flat-Plate	12.1	0	0.731
TiSUN LLC TiSUN FA 2 3	2007052B	Glazed Flat-Plate	6.1	0	0.726
TiSUN LLC TiSUN FA 2 4	2007052A	Glazed Flat-Plate	8.08	0	0.708
TrendSetter Solar Products Inc. Trendsetter TS-22-S	2007023B	Tubular	3.16	-0.09	0.355
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tsinghua Solar Systems Ltd. Tsinghua Solar SLU-1500 12	2007034Ai	Tubular	1.28	-1.8	0.3

Solar Tank and Heat Exchanger

Solar tank volume	3598.6 m3	Heat exchanger effectiveness	0.75 0..1
Solar tank height to diameter ratio	0.5	Outlet set temperature	55 C
Solar tank heat loss coefficient (U value)	1 W/m2.C	Mechanical room temperature	27 C
Solar tank maximum water temperature	28 C		

Piping and Pumping

Total piping length in system	20 m	Pump power	33570 W
Pipe diameter	0.019 m	Pump efficiency	0.85 0..1
Pipe insulation conductivity	0.03 W/m.C		
Pipe insulation thickness	0.006 m		

Advanced

Use custom mains profile ☐

Hourly custom mains profile [Edit data...] C

Use custom set temperatures ☑

Hourly custom set temperatures [Edit data...] C

Direct Capital Costs

Number of Collectors	8	Collector cost	600.00 $/m2	$ 19,200.00
		Storage cost	0.00 $/m3	$ 0.00
			Balance of system	$ 4,000.00
			Installation cost	$ 2,000.00
		Contingency	0 %	$ 0.00
			Total direct cost	$ 25,200.00

Indirect Capital Costs

	% of Direct Cost	Non-fixed Cost	Fixed Cost	Total
Engineer, Procure, Construct	10 %	$ 2520.00	$ 0.00	$ 2,520.00
Project, Land, Miscellaneous	0 %	$ 0.00	$ 0.00	$ 0.00
Sales tax of	0 %	applies to 100 %	of direct cost	$ 0.00
			Total indirect cost	$ 2,520.00

Total Installed Costs

Total Installed Cost excludes financing costs (if any, see Financing Page)

Total installed cost: $ 27,720.00

Total installed cost per capacity ($/Wt): $ 1.48

Operation and Maintenance Costs

	First year cost	Escalation rate (above inflation)
Fixed annual cost	0 $/yr	0 %
Fixed cost by capacity	50 $/kW-yr	0 %
Variable cost by generation	0 $/MWh	0 %

In Value mode, SAM applies both inflation and escalation to the first year cost to calculate out-year costs. In Schedule mode, neither inflation nor escalation applies. See Help for details.

System Performance Degradation

Degradation rate 0.5 %/year

Applies to the system's total annual AC output.

In Value mode, the degradation rate applies to the system's total annual kWh output for the previous year starting in Year 2. In Schedule mode, each year's rate applies to the Year 1 value. See Help for details.

Project Term Debt

Debt percent	0 %	Net capital cost	$ 27,720.00
Loan term	0 years	Debt	$ 0.00
Loan rate	0 %/year	WACC	0.00 %

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	0 years	Inflation rate	0 %/year
		Real discount rate	0 %/year
		Nominal discount rate	0.00 %/year

Tax and Insurance Rates

Federal income tax rate	0 %/year
State income tax rate	0 %/year
Sales tax	0 % of total direct cost
Insurance rate (annual)	1 % of installed cost

Property Tax

Assessed percentage	100 % of installed cost
Assessed value	$ 27,720.00
Annual decline	0 %/year
Property tax rate	1 %/year

Salvage Value

Net salvage value	0 % of installed cost	End of analysis period value	$ 0

Depreciation

Federal

- (◉) No depreciation
- ( ) 5-yr MACRS
- ( ) Straight line — 7 years
- ( ) Custom — Edit... percentages

State

- (◉) No depreciation
- ( ) 5-yr MACRS
- ( ) Straight line — 7 years
- ( ) Custom — Edit... percentages

The depreciable basis is the sum of total installed cost from the System Costs page and total construction financing cost from the Financing page, less the sum of investment-based incentives (IBI) and 50% of any investment tax credits (ITC).

Input Time Series Load Data

Electric Load Data

Energy usage [Edit data...] kW

☐ Normalize supplied load profile to monthly utility bill data

Scaling factor (optional) 1

Monthly energy usage [Edit values...] kWh

[View load data...]

Monthly Load Summary

	Energy (kWh)	Peak (kW)
Jan	25,415.11	46.14
Feb	22,835.36	45.12
Mar	25,201.86	47.77
Apr	24,737.45	56.53
May	26,654.73	58.69
Jun	29,219.67	69.53
Jul	32,255.26	71.41
Aug	31,188.28	70.87
Sep	27,258.54	69.91
Oct	25,535.31	51.36
Nov	24,607.17	47.10
Dec	25,465.73	46.08
Annual	320,455.03	71.41

Annual Adjustment

Load growth rate 0 %/yr

In Value mode, the growth rate applies to the previous year's annual kWh load starting in Year 2. In Schedule mode, each year's rate applies to the Year 1 kWh value. See Help for details.

CE PV COST FOR POOL/SPA NEEDS ($122,000 NECESSARY FOR DAYLIGHT POOL PUMPING)

Total PV Cost

Direct Capital Costs

Module	1 units	150.0 kWdc/unit	150.0 kWdc	0.71 $/Wdc	$ 106,500.00
Inverter	1 units	136.4 kWac/unit	136.4 kWac	0.21 $/Wdc	$ 31,500.00

	$		$/Wdc		
Balance of system equipment	0.00		0.57		$ 85,500.00
Installation labor	0.00	+	0.15	=	$ 22,500.00
Installer margin and overhead	0.00		0.75		$ 112,500.00
				Subtotal	$ 358,500.00

Contingency

Contingency 0 % of subtotal $ 0.00

Total direct cost $ 358,500.00

Indirect Capital Costs

	% of direct cost		$/Wdc		$		
Permitting and environmental studies	0		0.06		0.00		$ 9,000.00
Engineering and developer overhead	0	+	0.00	+	0.00	=	$ 0.00
Grid interconnection	0		0.00		0.00		$ 0.00

Land Costs

Land purchase	0	+	0.00	+	0.00	=	$ 0.00
Land prep. & transmission	0		0.00		0.00		$ 0.00

Sales Tax

Sales tax basis, percent of direct cost 92 % Sales tax rate 5.0 % $ 14,698.50

Total indirect cost $ 23,698.50

Total Installed Cost

Total installed cost $ 382,198.50

Total installed cost per capacity $ 2.55/Wdc

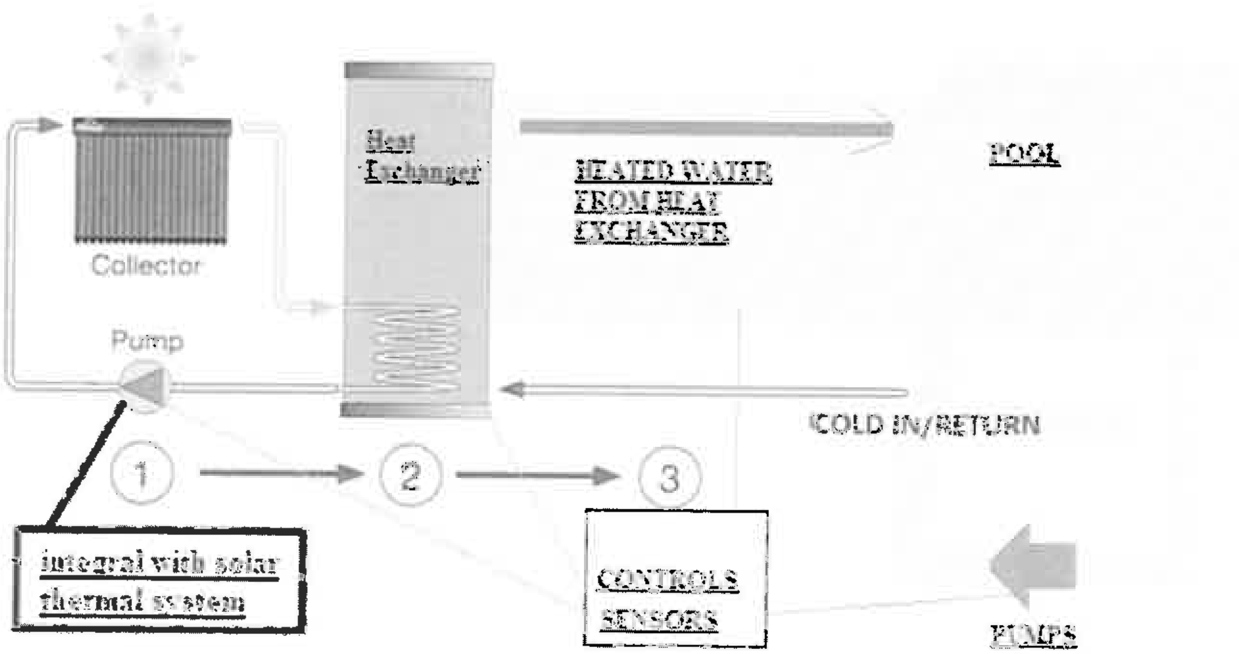
Collector/System Operation

Step 1: The evacuated tube solar collector converts sunlight into heat. A circulation pump (**powered by integral/dedicated PV panels**) moves liquid through the collector, carrying heat back to the heat exchanger.

Step 2: Gradually throughout the day the water in the POOL is heated up, either directly or via a heat exchanger (as shown).

Step 3: Circulation pumps exchange/filter (as described on p. 7) the pool water and sensors control the operation to maintain the desired temperature, flow, mode switching.

NOTE: A similar system is employed from the solar thermal panels for heating the SPA water to a slightly higher temperature than the pool



Greenfield Hypothetical $ 5.0 Million Bond Impact on Taxes for Median Valued Homes

Inputs	
Amortization Period	20
Interest Rate	3.00%
Borrowing	$1,400,000

	Outstanding Principal	Int Rate	Principal	Interest	Total	Total Valuation	% chng	Est Tax Rate for Bond	Median Home Value	Cost for Median Home	Per month
	$ 1,400,000										
2018	$ 1,330,000	3.00%	$ 70,000	$ 42,000	$ 112,000	$ 1,658,694,776		0.07	$ 335,000	$ 22.62	$ 1.89
2019	$ 1,260,000	3.00%	$ 70,000	$ 39,900	$ 109,900	$ 1,674,247,174	0.94%	0.07	$ 335,000	$ 21.99	$ 1.83
2020	$ 1,190,000	3.00%	$ 70,000	$ 37,800	$ 107,800	$ 1,689,799,572	0.93%	0.06	$ 335,000	$ 21.37	$ 1.78
2021	$ 1,120,000	3.00%	$ 70,000	$ 35,700	$ 105,700	$ 1,705,351,970	0.92%	0.06	$ 335,000	$ 20.76	$ 1.73
2022	$ 1,050,000	3.00%	$ 70,000	$ 33,600	$ 103,600	$ 1,720,904,368	0.91%	0.06	$ 335,000	$ 20.17	$ 1.68
2023	$ 980,000	3.00%	$ 70,000	$ 31,500	$ 101,500	$ 1,736,456,766	0.90%	0.06	$ 335,000	$ 19.58	$ 1.63
2024	$ 910,000	3.00%	$ 70,000	$ 29,400	$ 99,400	$ 1,752,009,164	0.90%	0.06	$ 335,000	$ 19.01	$ 1.58
2025	$ 840,000	3.00%	$ 70,000	$ 27,300	$ 97,300	$ 1,767,561,562	0.89%	0.06	$ 360,000	$ 19.82	$ 1.65
2026	$ 770,000	3.00%	$ 70,000	$ 25,200	$ 95,200	$ 1,783,113,961	0.88%	0.05	$ 360,000	$ 19.22	$ 1.60
2027	$ 700,000	3.00%	$ 70,000	$ 23,100	$ 93,100	$ 1,798,666,359	0.87%	0.05	$ 360,000	$ 18.63	$ 1.55
2028	$ 630,000	3.00%	$ 70,000	$ 21,000	$ 91,000	$ 1,814,218,757	0.86%	0.05	$ 360,000	$ 18.06	$ 1.50
2029	$ 560,000	3.00%	$ 70,000	$ 18,900	$ 88,900	$ 1,829,771,155	0.86%	0.05	$ 360,000	$ 17.49	$ 1.46
2030	$ 490,000	3.00%	$ 70,000	$ 16,800	$ 86,800	$ 1,845,323,553	0.85%	0.05	$ 360,000	$ 16.93	$ 1.41
2031	$ 420,000	3.00%	$ 70,000	$ 14,700	$ 84,700	$ 1,860,875,951	0.84%	0.05	$ 360,000	$ 16.39	$ 1.37
2032	$ 350,000	3.00%	$ 70,000	$ 12,600	$ 82,600	$ 1,876,428,349	0.84%	0.04	$ 360,000	$ 15.85	$ 1.32
2033	$ 280,000	3.00%	$ 70,000	$ 10,500	$ 80,500	$ 1,891,980,747	0.83%	0.04	$ 360,000	$ 15.32	$ 1.28
2034	$ 210,000	3.00%	$ 70,000	$ 8,400	$ 78,400	$ 1,907,533,145	0.82%	0.04	$ 360,000	$ 14.80	$ 1.23
2035	$ 140,000	3.00%	$ 70,000	$ 6,300	$ 76,300	$ 1,923,085,544	0.82%	0.04	$ 360,000	$ 14.28	$ 1.19
2036	$ 70,000	3.00%	$ 70,000	$ 4,200	$ 74,200	$ 1,938,637,942	0.81%	0.04	$ 360,000	$ 13.78	$ 1.15
2037	$ -	3.00%	$ 70,000	$ 2,100	$ 72,100	$ 1,954,190,340	0.80%	0.04	$ 360,000	$ 13.28	$ 1.11
			$ 1,400,000	$ 441,000	$ 1,841,000	Est. 1% Growth				$ 359.34	

School Debt Repayment

	Principal	Interest	Total	CUMULATIVE DEBT PMNT
2013	1,109,762	251,083	1,360,845	1,109,762
2014	1,102,262	223,006	1,325,268	2,212,024
2015	1,009,762	194,356	1,204,118	3,221,786
2016	438,512	171,319	609,831	3,660,298
2017	438,512	154,483	592,995	4,098,810
2018	438,512	137,648	576,160	4,537,322

Total CE Debt Outstanding

2011	19,998,958
2012	17,922,784
2013	15,878,815
2014	13,842,001
2015	11,907,293
2016	10,614,639
2017	9,228,991
2018	7,840,294

Muni Debt Repayment

	Principal	Interest	Total	CUMULATIVE DEBT PMNT
2013	794,738	237,131	1,031,869	794,738
2014	792,238	215,736	1,007,974	1,586,976
2015	789,738	195,196	984,934	2,376,714
2016	795,988	174,177	970,165	3,172,702
2017	770,988	153,143	924,131	3,943,690
2018	770,988	132,204	903,192	4,714,678

Oil & Gas and the General Impact on Cape Elizabeth

The United States depends less and less on foreign sources of oil and gas. The widespread use of fracking to extract U.S. reserves of oil and natural gas is the primary reason for this trend, but it is not the only reason. As a country, we are turning to vehicles, heating and cooling equipment, industrial and office equipment and personal habits that make more efficient use of petroleum-based products and electricity. We are reducing the rate of growth in demand for these energy sources and can reasonably hope for a day when our actual consumption will stop its annual rise without reducing our economic output. Simultaneously, we are reducing the rate of increase in our production of air and water polluting chemicals associated with the production distribution and use of energy generally.

Like municipalities everywhere, Cape Elizabeth's contribution to these fossil fuel use and pollution reduction trends is small but cumulative with those of other municipalities. As the committee looked at the town's energy consumption we asked what other sources of fuel and electricity might be used to accelerate these national trends. As noted elsewhere in this report, the town's present Director of Facilities has focused his efforts on acquiring efficient equipment and adopting energy use reduction practices. His successful efforts will continue, and the town, through other committees, may decide to work with him to increase the town's implementation of energy efficiency strategies and assure future facilities directors will continue them. This committee's charge, however, is not energy efficiency, but alternative energy production, and we will look at the town's energy use through that lens.

The town's municipal buildings receive grid electric energy through forty two (42) electric meters showing an annual consumption of approximately five million three hundred sixty thousand (5,360,000) kilowatt-hours (kWh). Ninety percent (90%) of that amount, 4,840,000 kWh, comes through one meter at the school complex. Only one other town owned building or building complex uses more than one hundred thousand (100,000) kWh per year, the town center fire station at about 160,000 kWh. The town also uses thirty five thousand (35,000) gallons of propane each year, eighteen thousand (18,000) of which is used to heat the pool. These facts have clear implications for the selection of a source of electricity other than the grid.

If our objective were to maximize the number of town-owned buildings that benefit from receiving renewable power, we would be limited to two very different energy production models:

(i) on-site generation at each building; picture rooftop solar arrays either photovoltaic to generate electricity or solar thermal to provide hot water, or small wind machines at each site; and, (ii) a centralized wind farm or ground-mounted solar photovoltaic array connected to all of the town's buildings using CMP's lines. Installing new dedicated lines to each building has a theoretical appeal, but the committee sees that option as too expense too warrant further consideration. Both of these energy production models have drawbacks of sufficient magnitude to warrant deferring consideration of these options until the town has developed some experience with renewable energy generation in less complicated systems. The primary drawback of the each-building model is administrative; too many low-power systems, each with its own idiosyncratic monitoring and maintenance needs for a small staff to handle. The primary drawback of the centralized all-building method is regulatory. In order for a centralized system to serve all buildings, the generation facility would not be on the same lot as the buildings using the power. That is the definition of a utility, requiring licensing at the state level as a municipal utility, and proper zoning at the local level. At this writing, there is no zone in Cape Elizabeth in which a utility generating operation would be allowed.

These considerations lead directly to the committee's recommendations. As described in detail elsewhere in this report, the committee is recommending the use of (i) a solar thermal array on the school rooftop to supply hot water to the pool; and (ii) a photovoltaic array installed on a small (1.8 acre) site to generate approximately four hundred thousand (400,000) kWh per year to be used at the school complex. The administrative monitoring and maintenance burden is limited to two installations and the zoning and regulatory issues are eliminated because the 1.8-acre site for the array and the school complex site are on contiguous parcels of town-owned land, so the power being generated on the site is used at that site, and is therefore not a utility that would require a license. The size of the proposed system is important, too. Because the solar array will be generating less electricity than the school complex uses, even in the summer months, there will never be a need to "sell power back to the grid" and the economics of the system are therefore not dependent on the political vagaries of net metering. The system does require running a dedicated line from the array to the school complex. However, even with the cost of this line, the town can use energy production to reduce its carbon footprint on a cost-effective basis.

The committee was also charged with seeking alternatives to the gasoline and diesel used in the town's vehicles, the only fossil-fuel-free alternatives being hydrogen-electric drive, battery electric drive and 100% bio-diesel. Town and school vehicle categories presents different challenges for fossil-free fuel use: the school bus category offers most desirable combination of greenhouse gas reduction and cost-effectiveness through biodiesel; sedans and small vehicles, the best opportunity for either battery electric or hydrogen electric drive; and the SUVs the best opportunity for hydrogen electric drive. Exploring the details of each of these opportunities requires far more time than that allotted to this ad hoc committee and further study on each is highly recommended.

The problem common to all of the fossil-fuel-free solutions is the availability of the fuel.

Electricity is easy to get, but 100% fossil-free electricity requires either relying on a bookkeeping entry (and higher per kWh cost) to be able to say that wind power alone produced the electricity being used; or, requires that the town's photovoltaic power production be sufficient to charge any electric vehicles it chooses to buy. That is possible as an adjunct to the recommended system but should not be attempted until the own gains experience with the basic system.

Hydrogen fill stations, though becoming more common in California, are not expected in New England until 2018 when AirLiquide and Toyota will be building ten to twelve stations in the Hartford-Boston corridor (with Portland being considered) in connection with the New England roll-out of the Toyota Mirai hydrogen electric sedan. There are eight hundred (800) 2015-2016 Mirai sedans on the road in California along with scores of SUV-sized vehicles from Hyundai, GM and Toyota. For Cape Elizabeth, these vehicles fit best with a micro-grid for the school and adjacent town building complex that the committee suggests deferred to future years. In that system, the hydrogen would be made on-site from the town's own solar power and water as part of a fuel cell combined heat and power installation.

Even biodiesel, especially 100% bio-diesel, has spotty availability and, like battery-electric drive, results in substantially diminished winter weather performance.

In summation, the opportunities for the town to reduce its vehicular carbon footprint on a cost-effective basis require further study and are not likely to be implemented successfully until the 2018-2023 time frame.

Other Benefits of Renewable Energy for the Town

Regardless of the cost per kilowatt hour or cost per fuel oil or gasoline gallon equivalent, the solar energy project recommended by the committee will provide Cape Elizabeth with a range of financial, educational and environmental benefits. The project will:

1. Provide price stability, a hedge against future fuel and power price increases and winter's price spikes
2. Provide hands-on curriculum enhancement opportunities in both STEM (science, technology, engineering & math) and sustainability, public policy and government studies programs
3. Reduce harmful greenhouse gas emissions
4. Reduce air-polluting particulate matter, sulphur dioxide and nitrous oxides
5. Potentially lower the rate of asthma cases, especially for children
6. Potentially lower the rate of bioaccumulation of toxic substances in seafood, birds and other animal species
7. Lessen the demand for fracking and for pipelines for natural gas
8. Keep energy dollars in the local job market and local economy generally
9. Contribute to achieving Cape Elizabeth's sustainability goals as a municipality and a community
10. Lay the foundation for future fire, police and school resiliency projects

Price Stability

Municipal solar systems provide long-term price stability, which can be beneficial in setting and keeping consistent municipal budgets. Having a fixed power purchase agreement reduces the negative impacts of electricity price volatility and long-term price increases. Once the solar system is paid for, considering either the term of a lease agreement, or a power purchase agreement, the municipality typically is able to purchase the solar system based on a residual valuation. In some cases, the system can be transferred for a nominal cost. Once the ownership of the system is transferred to the municipality, the cost of electricity is reduced to the cost of annual maintenance, insurance and a reserve for replacement of inverters and damaged panels, any or all of which may be part of other budget items.

Curriculum Enhancement Opportunities

The committee does not presume to advise the town's school administrators and teachers on how to design curricula or lesson plans. A school does not need a solar power installation in order to provide engaging offerings on alternative energy. The committee simply notes that monitoring the output of such a system provides an easy to understand and perhaps more engaging way to introduce students to certain types of engineering concepts, calculations and data presentation skills. Similarly, public policy discussions related to alternative energy, sustainability and environmental impacts can be more meaningful when students have access to both the final result of the policy-makers' decisions and to the decision-makers themselves.

Other school systems using on-site solar power, or solar power from municipal utility-size solar arrays, have created a wide range of resources that may be available to Cape Elizabeth's educators. The committee would add to those possible sources the resources of the National Renewable Energy Laboratory (NREL) that has been helpful to the committee in other aspects of its work. By way of example, NREL offers materials at the elementary school level that include: Fun With the Sun, Getting Energized, Make a Solar Cooker, Solar Coloring Book, Solar Water Heating; at the middle school level that include How to Build an Energy Efficient Home, School Energy Audit, NESEA Solar Kit Lessons, Renewable Energy Activities - Choices for Tomorrow, How Solar Cells Convert Light to Energy, Solar Energy Science Projects; and, at the high school level that include Introduction to Renewable Energy Technology; Renewable Energy Science Projects, History of Solar Cells, How Solar Cells Convert Light to Energy, Photovoltaics in the Classroom, Solar Energy Science Projects and NESEA Cars of Tomorrow. Corresponding materials for teaching the teachers are also available.

Reduction in Emissions and Greenhouse Gasses

The operation of a solar energy system generating approximately four hundred thirty nine thousand (439,000) kWh per year will reduce the amount of electricity Cape Elizabeth needs to purchase from the grid. Based on the actual emissions associated with using electricity in Cape Elizabeth, a reduction in the use of four hundred thirty nine thousand (439,000) kWh of grid power by Cape Elizabeth would reduce NOx by one hundred eighty nine (189) pounds per year; SO_2 by one hundred twenty three (123) pounds per year and CO_2 by three hundred sixty eight thousand (368,000) pounds per year. Oxides of Nitrogen (NOx) contribute to acid rain adversely impacting aquatic species, especially trout, and produce ground level ozone causing damage to lung tissue, worsening respiratory diseases such as emphysema and bronchitis, and aggravating pre-existing heart disease. They also reduce crop yields. Sulphur Dioxide (SO_2) n the atmosphere has a range of adverse health impacts, including the respiratory system and premature mortality. It disproportionately impacts the elderly and the young, especially those already suffering from respiratory ailments including asthma. The mechanisms taken by sulfur dioxide are indirect, with secondary chemical compounds, chiefly sulfate aerosols in particulate form, finding their way deep into the pulmonary system. Sulfur dioxide also forms sulfuric acid that precipitates into rivers and lakes and lowers the pH of aquatic ecosystems.

During forty years of operation, the recommended system will eliminate over seventy three thousand (73000) tons of carbon dioxide, one of a host of greenhouse gasses (GHG). Among other impacts GHG contributes to increases in seawater temperature. The Gulf of Maine Research Institute reports that the temperatures in the Gulf of Maine have risen faster that 99 percent of the world's other oceans, rising at a rate of 0.23 degrees Celsius per year over the past 10 years. The result of this sea temperature rise on New England fisheries and aquatic species has been dramatic. Cod stocks in the Gulf of Maine are on the verge of collapse, hovering around levels that are 3 to 4 percent of what are considered sustainable population levels. Green crabs are moving northward into the Gulf of Maine, which is decimating the state's soft-shell clams and sea grass meadows. Black sea bass are showing up in lobster traps, which had never occurred before 2012, creating a concern for lobster stocks as the sea bass may be developing a taste for juvenile lobsters. The shrimp catch, already completely depleted in Massachusetts, is also experiencing a collapse in Gulf of Maine. There is also concern that lobsters are experiencing earlier and earlier moltings associated with temperature rise, and are now subject to shell disease that has moved northwards to effect lobsters in the Gulf of Maine. There are also concerns that lobsters along with other shellfish may be impacted by rising ocean acidification associated with increasing carbon dioxide and resultant carbonic acid in the ocean. Recent research showed that juvenile lobsters grow more slowly as the levels of carbonic acid increase. Land temperatures are on the rise, too, with a myriad of impacts, the most notable of which for Cape Elizabeth is the increased incidence of Lyme disease with reported cases statewide skyrocketing from one hundred eight (108) reported cases in 2001 to one thousand three hundred seventy seven (1,377) cases reported in 2013, an increase of 1,376%! This is due in part to the expanded habitat that is suitable for deer ticks and deer.

Natural Gas Impacts

As noted elsewhere in the committee' report, the committee does not view natural gas as a sufficiently clean energy source to warrant Cape Elizabeth's support on environmental or sustainability grounds. It is a fossil fuel and does generate GHG and other pollutants, despite being well recognized as a substantially cleaner fuel than coal, oil and even propane. Without wading into political waters too deeply, the committee simply notes that a solar facility in Cape Elizabeth will reduce regional demand for natural gas and associated demand for expanded natural gas exploration, production, transmission, meaning less fracking and fewer new pipelines. Although these technologies have contributed to dramatically lower natural gas and grid electricity prices, those lower prices are constantly at risk from the possibility of a significant adverse environmental event heralded by, among other trends, the over 40,000% increase in earthquakes in a fracking-dense areas of Oklahoma.

Jobs and Economic Impact

The economic impact of a solar project is broader than simply creating construction and maintenance jobs. The New England energy economy sits at the end of a very long energy supply chain, with natural gas coming from the Gulf Coast, Louisiana and Pennsylvania, electricity coming from New York and Quebec, and oil coming from North Dakota and Venezuela, among other sources. As such, New England dollars end up leaving New England to pay for these energy resources. The installation of a solar system on Cape Elizabeth provides the opportunity to keep our dollars at home, and to pay for local resources, including installation and maintenance labor. This strengthens the local economy, creating jobs and tax revenues.

Facility Initiatives Currently in Place

The Cape Elizabeth Facilities and Transportation Department manages all of the physical plants and sport fields for the town and schools. This equates to thirty-seven (37) different buildings at approximately seven hundred fifty thousand (750,000) square feet of facilities, 7 athletic fields, and a turf field managed within the department. The Facilities and Transportation Department works with all school and town administrators and departments with a large working relationship with the Public Works Department as a part of its regular operations.

The Facilities and Transportation Department was created in 2009 during the budget process and placed into operation in 2010. Since its inception it has a large focus on long-term facility management, energy reductions, and updating our infrastructure throughout the community.

In 2010 a major relamping project was conducted in many of the town and school facilities with a focus in cost electricity usages. The cost for this program was offset with a large rebate from Efficiency Maine with a payback period of 3 to 5 years. Since then a departmental policy has been established regarding lighting upgrades that requires any lighting upgrades shall be the latest in energy efficiency fixtures with a large focus on LED lighting. Over the past 7 years the community has continued to see a decrease in electrical costs in our facilities. During the summer of 2011 the department upgraded the boiler plants at the high school with a first year fuel oil saving of twenty thousand (20,000) gallons, which has provided a payback period of nine (9) years. The same format was undertaken for Pond Cove and the middle school in 2014 and has represented a reduction in the first season of fourteen thousand (14,000) gallons.

During the high school boiler upgrade project both the high school and middle school were outfitted with an evacuated tube domestic hot water pre-heating solar array. These systems have a payback term of nine (9) years. The middle school system has been able to provide for all of the domestic hot water needs for most of the summer from June to August and into September depending on the weather.

The Department also handles all energy purchasing, except for road fuels, for all town and school facilities. Over the past year we were able to reduce our costs for electricity by .01 per KwH, oil pricing has trended down for the past several years with a 2016/2017 heating season rate of $1.49 per gallon and $1.92 per gallon for propane. We continue to watch the markets and purchase energy related commodities when the price is low thus saving the community thousands of dollars annually.

In 2016 the Donald Richards Pool underwent a major mechanical renovation, this includes a new dehumidification unit, gas fired boilers, and chlorinating system. The new equipment is not only much more operational efficient, we put measures in place which will allow us to operate the heating side of the system by propane or heating oil, whichever one is cheaper at any given time. These operational changes not only give the community a savings in energy costs but also reduce our green house gases emissions.

As we go forward we continue to look at different options to not only reduce energy costs, but additionally green house gases emissions reducing our carbon footprint. Cape Elizabeth has opportunities to meet these goals with the addition of solar arrays on buildings, possible micro grid or another type of system that can provide the community with a good return on their investment.

Neighboring Municipalities Initiatives

Portland

Then Mayor James Cohen, Jill Duson and Nathan Smith formed the Sustainable Portland Taskforce in 2006. In 2007 the Taskforce submitted the Sustainable Portland Report to the City and many of the initiatives outlined therein have since been carried out. The City has a green building ordinance that requires all new and/or major renovations to City buildings over a certain size to be certified LEED Silver through the USGBC rating system. Portland's Regional Transit District is a Compressed Natural Gas Fleet. Portland's School Department is a Compressed Natural Gas fleet of school buses. Portland's Parking Enforcement and Police Department use bicycles in the summer to carry out their duties. In 2014 the City added a CNG trash collection vehicle and an electric car. The City operates a number of solar installations at City facilities which all range in size from 1-2 KW. These facilities are located on school buildings and are used for educational purposes.

Portland is currently in final negotiations on a 1 MW solar project that will be financed through a Power Purchase Agreement.

Scarborough

The town of Scarborough, ME installed a 42 kW photovoltaic array in 2014. Scarborough has an Energy Committee similar to the Cape Elizabeth Alternative Energy Committee that is currently meeting every month in order to make recommendations to the town council. They have focused on looking at conservation such as expanded use of LED lighting, creating energy goals, and other energy options. The Town has been additionally looking into solar, tri-generation, bio-diesel for vehicles, and expanding educational programming to the community.

Falmouth

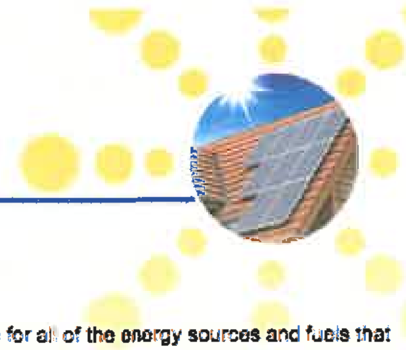
Falmouth has set a target to reduce their emissions an average of 2% every year. They signed the Cool Counties Climate Stabilization Initiative that includes forty (40) other counties in Maine as part of this initiative. The high school has received a grant to install a photovoltaic system and the new Elementary School will be installing a biomass boiler. The town has a Recycling and Energy Advisory Committee that advises the Town Council on solid waste recycling, energy efficiency and related matters. Falmouth also has a full time Sustainability Coordinator.

Saco

Saco installed multiple wind, solar and geothermal projects between 2006 and 2010. The wind projects under delivered which extended their payback period to the town. Saco has made many efficiency upgrades to the largest consumer of town energy, the waste treatment facility. Saco has an energy committee of its own which currently meets monthly. Their goals include reducing fossil fuel dependence, promoting conservation and maximizing the use of renewable energy.

South Portland

In 2007 the City of South Portland signed onto the U.S. Conference of Mayors Climate Protection Agreement, pledging to reduce its carbon footprint 17% by 2017. The city had its own Recycling & Energy Committee that submitted its Climate Action Plan to the town council in 2014. South Portland's Sustainability Office has been tasked with carrying out the recommendations made in the Climate Action Plan. In addition to the 17% reduction in carbon footprint by 2017, they have set a goal to increase the recycling rate to 40% by 2020. The city has already installed a solar array on the Planning & Development Department. South Portland has also added four new electric vehicles to its fleet with five charging stations installed throughout the city. In addition, they have approved funding in 2016 to replace all city streetlights with LED's. The city is currently in final negotiations on a 1 MW solar project to be installed on the town landfill that will be financed through a Power Purchase Agreement.



Solar *Explained*

Basics

Energy from the sun

The sun has produced energy for billions of years and is the ultimate source for all of the energy sources and fuels that we use today. People have used the sun's rays (solar radiation) for thousands of years for warmth and to dry meat, fruit, and grains. Over time, people developed devices (technologies) to collect solar energy for heat and to convert it into electricity.

Collecting and using solar thermal (heat) energy

An example of an early solar energy collection device is the solar oven (a box for collecting and absorbing sunlight). In the 1830's, British astronomer John Herschel used a solar oven to cook food during an expedition to Africa. People now use many different technologies for collecting and converting solar radiation into useful heat energy for a variety of purposes.

Radiant energy from the sun has powered life on earth for many millions of years.

Source: NASA

We use solar thermal energy systems to

- heat water for use in homes, buildings, or swimming pools
- heat the inside of homes, greenhouses, and other buildings
- heat fluids to high temperatures in solar thermal power plants

Solar photovoltaic systems convert sunlight into electricity

Solar photovoltaic (PV) devices, or solar cells, change sunlight directly into electricity. Small PV cells can power calculators, watches, and other small electronic devices. Arrangements of many solar cells in PV panels and arrangements of multiple PV panels in PV arrays can produce electricity for an entire house. Some PV power plants have large arrays that cover many acres to produce electricity for thousands of homes.

Solar energy has benefits and some limitations

The two main benefits of using solar energy are

- Solar energy systems do not produce air pollutants or carbon dioxide.
- Solar energy systems on buildings have minimal impact on the environment.

The main limitations of solar energy are

- The amount of sunlight that arrives at the earth's surface is not constant. The amount of sunlight varies depending on location, time of day, season of the year, and weather conditions.
- The amount of sunlight reaching a square foot of the earth's surface is relatively small, so a large surface area is necessary to absorb or collect a useful amount of energy.

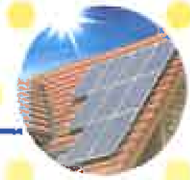
Learn More

- Solar Energy Basics — http://www.nrel.gov/learning/re_solar.html
- Sunshot Initiative — http://energy.gov/eere/sunshot/sunshot-initiative

Last Updated: December 14, 2016

U.S. Energy Information Administration

http://www.eia.gov/energyexplained/index.cfm?page=solar_home

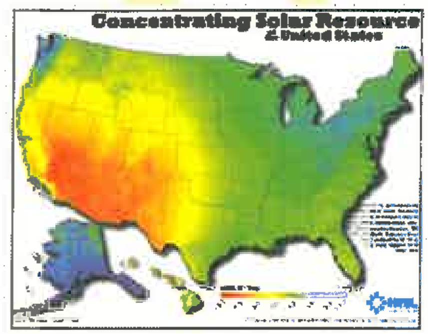


Solar *Explained*

Where Solar Is Found – Basics

Solar energy is sunshine

The amount of solar energy that the earth receives each day is many times greater than the total amount of all energy that people consume. However, on the surface of the earth, solar energy is a variable and intermittent energy source. The amount of sunlight and the intensity of sunlight varies by time of day and location. Weather and climate conditions affect the availability of sunlight on a daily and seasonal basis. The type and size of a solar energy collection and conversion system determines how much of the available solar energy we can convert into useful energy.



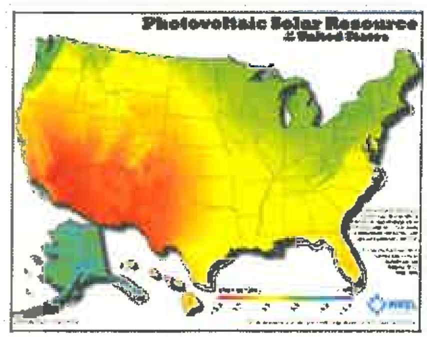
Source: National Renewable Energy Laboratory, U.S. Department of Energy

Solar thermal collectors

Low-temperature solar thermal collectors absorb the sun's heat energy to heat water or to heat homes, offices, and other buildings.

Concentrating collectors

Concentrating solar energy technologies use mirrors to reflect and concentrate sunlight onto receivers that absorb solar energy and convert it to heat. We use this thermal energy for heating homes and buildings or to produce electricity with a steam turbine or a heat engine that drives a generator.



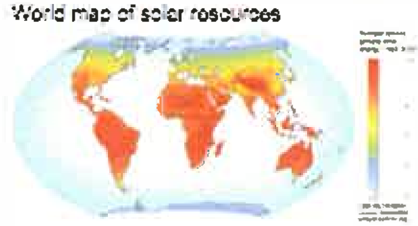
Source: National Renewable Energy Laboratory, U.S. Department of Energy

Photovoltaic systems

Photovoltaic (PV) cells convert sunlight directly into electricity. PV systems can range from systems that provide tiny amounts of electricity for watches and calculators to systems that provide the amount of electricity that hundreds of homes use.

Millions of houses and buildings around the world have PV systems on their roofs. Many multi-megawatt PV power plants have also been built. Covering 4% of the world's desert areas with photovoltaics could supply the equivalent of all of the world's daily electricity use.

World map of solar resources



Source: United Nations Environment Programme (UNEP), NASA Surface meteorology and Solar Energy (SSE), 2008.

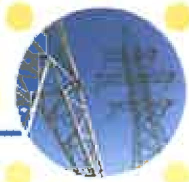
Learn More

- SunShot Initiative — http://www.energy.gov/eere/renewables/solar/
- Solar energy basics — http://www.nrel.gov/learning/re_solar.html
- Solar resource information — http://www.nrel.gov/rredc/solar_resource.html
- Articles on solar energy — http://www.eia.gov/todayinenergy/index.cfm?tg=%20solar

Last Updated: January 10, 2017

U.S. Energy Information Administration

http://www.eia.gov/energyexplained/index.cfm?page=solar_where



Electricity *Explained*

Electricity in the United States – Basics

Most of the electricity in the United States is produced using steam turbines

A turbine converts the kinetic energy of a moving fluid (liquid or gas) to mechanical energy. In a steam turbine, steam is forced against a series of blades mounted on a shaft. The steam rotates the shaft connected to the generator. The generator, in turn, converts its mechanical energy to electrical energy based on the relationship between magnetism and electricity.

In steam turbines powered by fossil fuels (coal, petroleum, and natural gas), the fuel is burned in a furnace to heat water in a boiler to produce steam.

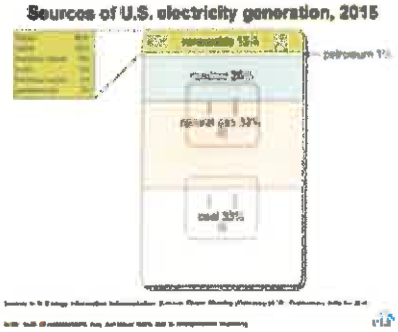
Most of U.S. electricity is generated using fossil fuels

In 2015, coal was used for about 33% of the 4 trillion kilowatthours of electricity generated in the United States.

In addition to being burned to heat water for steam, natural gas can also be burned to produce hot combustion gases that pass directly through a natural gas turbine, spinning the turbine's blades to generate electricity. Natural gas turbines are commonly used when electricity use is in high demand. In 2015, nearly 33% of U.S. electricity was fueled by natural gas.

Petroleum can be burned to produce hot combustion gases to turn a turbine or to make steam that turns a turbine. Residual fuel oil and petroleum coke, products from refining crude oil, are the main petroleum fuels used in steam turbines. Distillate (or diesel) fuel oil is used in diesel-engine generators. Petroleum was used to generate less than 1% of all electricity in the United States in 2015.

Sources of U.S. electricity generation, 2015



More data

Nuclear power provides about one-fifth of U.S. electricity

Nuclear power plants produce electricity with nuclear fission to create steam that spins a turbine to generate electricity. Most U.S. nuclear power plants are located in states east of the Mississippi River. Nuclear power was used to generate nearly 20% of all U.S. electricity in 2015.

Renewable energy sources provide 13% of U.S. electricity

Hydropower, the source of about 6% of U.S. electricity generation in 2015, is a process in which flowing water is used to spin a turbine connected to a generator. Most hydropower is produced at large facilities built by the federal government, like the Grand Coulee Dam. The West has many of the largest hydroelectric dams, but there are many hydropower facilities operating all around the country.

Wind power is produced by converting wind energy into electricity. Electricity generation from wind has increased significantly in the United States since 1970. Wind power provided almost 5% of U.S. electricity generation in 2015.

Biomass is material derived from plants or animals and includes lumber and paper mill wastes, food scraps, grass, leaves, paper, and wood in municipal solid waste (garbage). Biomass is also derived from forestry and agricultural residues such as wood chips, corn cobs, and wheat straw. These materials can be burned directly in steam-electric power plants, or they can be converted to a gas that can be burned in steam generators, gas turbines, or internal combustion engine-generators. Biomass accounted for about 2% of the electricity generated in the United States in 2015.

Geothermal power comes from heat energy buried beneath the surface of the earth. In some areas of the United States, enough heat rises close enough to the surface of the earth to heat underground water into steam, which can be tapped for use at steam-turbine plants. Geothermal power generated less than 1% of the electricity in the United States in 2015.

Solar power is derived from energy from the sun. Photovoltaic (PV) and solar-thermal electric are the two main types of technologies used to convert solar energy to electricity. PV conversion produces electricity directly from sunlight in a photovoltaic (solar) cell. Solar-thermal electric generators concentrate solar energy to heat a fluid and produce steam to drive turbines. In 2015, nearly 1% of U.S. electricity generation came from solar power.

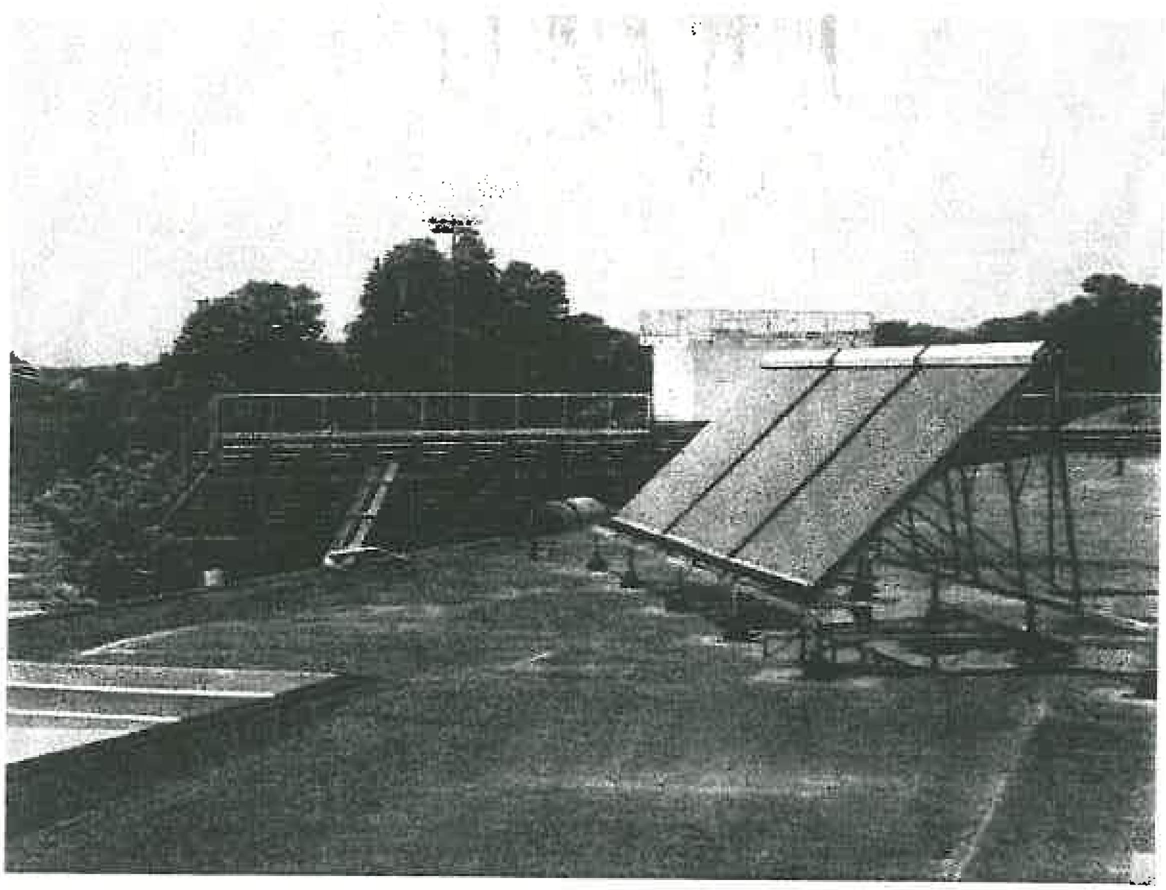
Learn More

- Electric Power Monthly — http://www.eia.gov/electricity/monthly/index.cfm
- Electric Sales, Revenue, and Average Price — http://www.eia.gov/electricity/sales_revenue_price/
- Electric Power Annual — http://www.eia.gov/electricity/annual/
- U.S. Energy Mapping System — http://www.eia.gov/state/maps.cfm
- Power Profiler — http://oaspub.epa.gov/powpro/ept_pack.charts
- Electricity data, analysis, and projections — http://www.eia.gov/electricity/
- Articles on electricity — http://www.eia.gov/todayinenergy/index.php?tg=electricity

U.S. Energy Information Administration

Last Updated: March 29, 2016

http://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states



Solar thermal system installed on high school roof in Cape Elizabeth

Proposed Area for Thermal Solar at Donald Richards Pool

Proposed Greenfield Solar Photovoltaic Grid

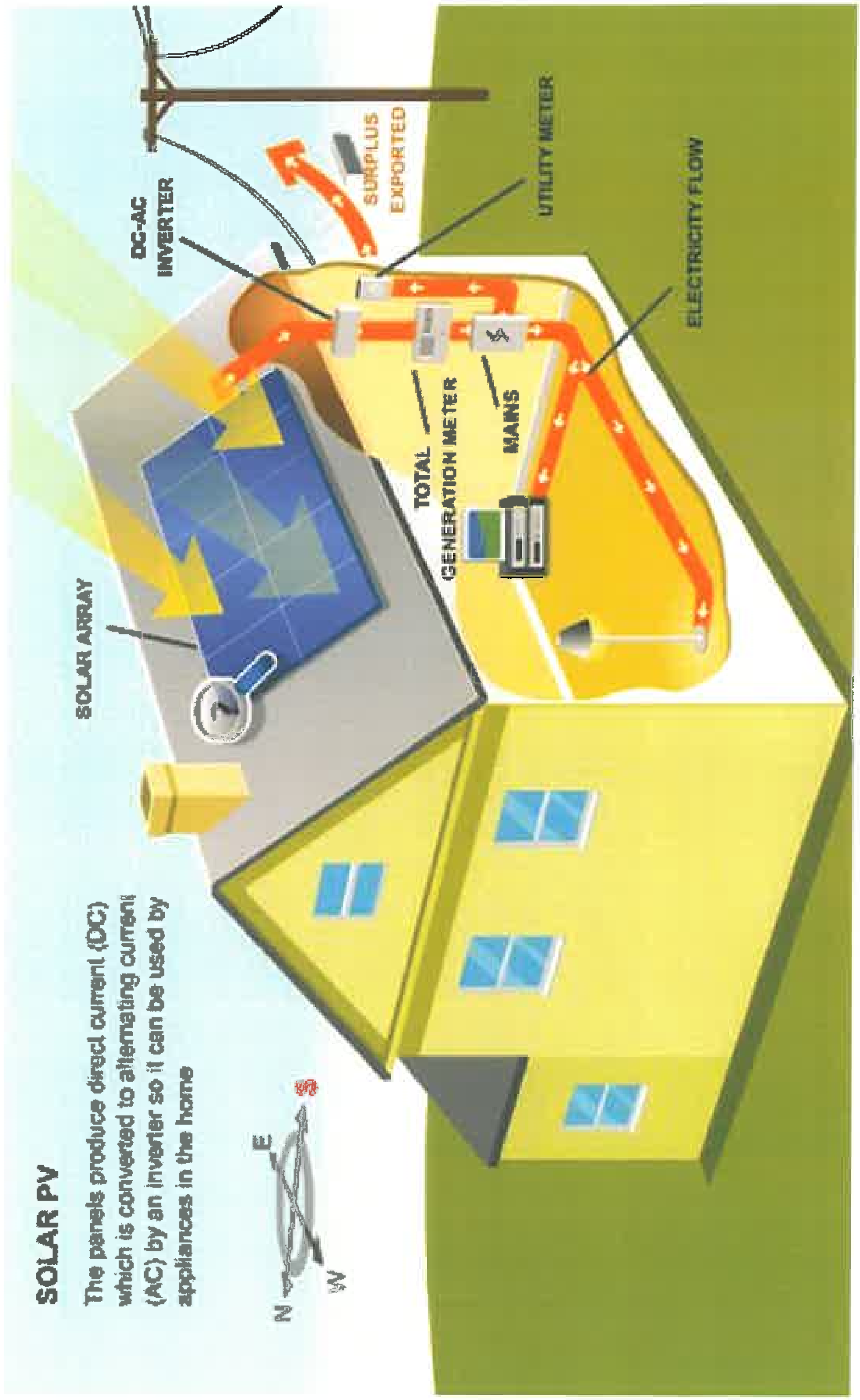
Example of Solar Thermal Collector

retreived January 12, 2017 from www.greenoptomistic.com

Example of Solar Photovoltaic Collector

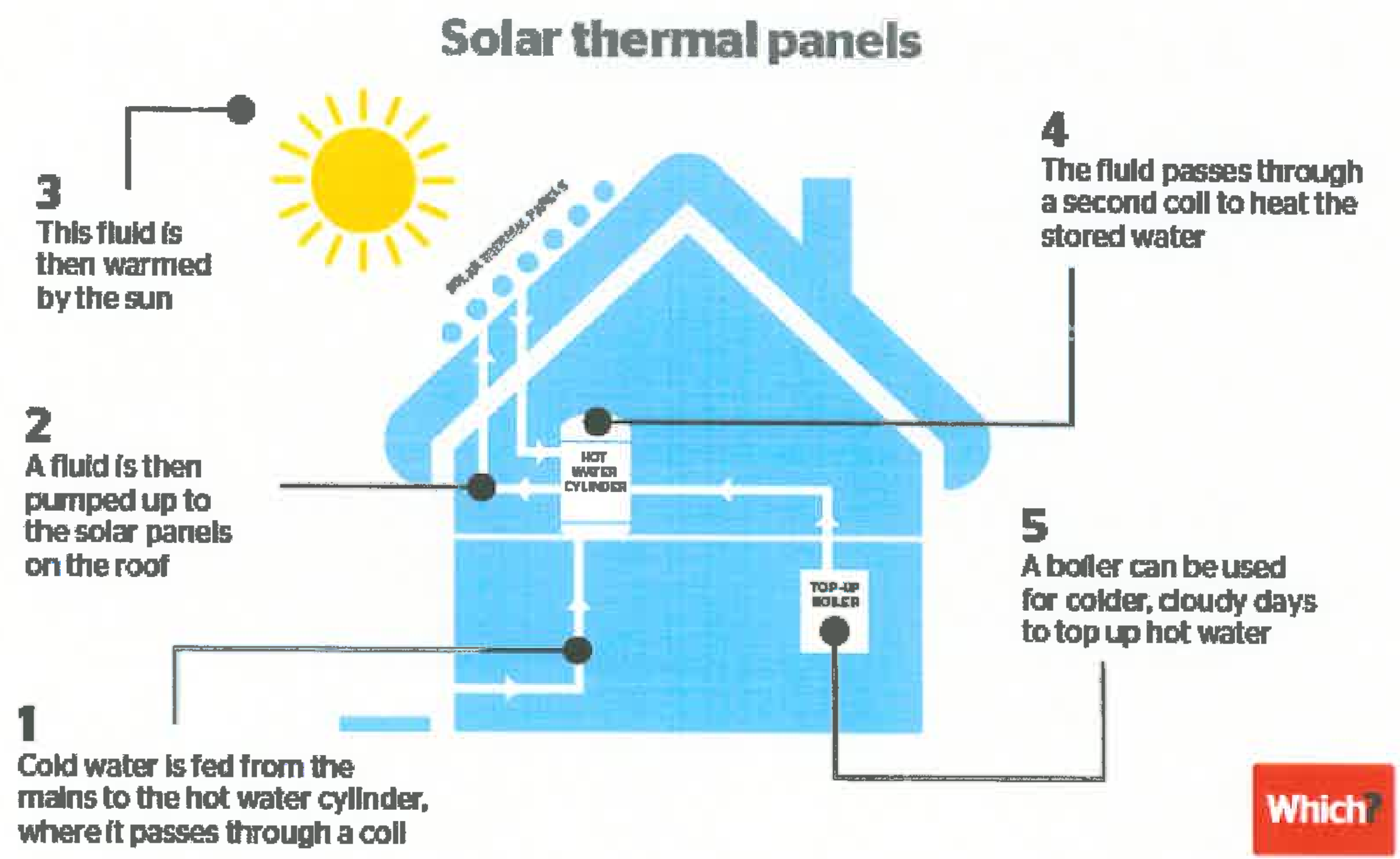
retreived January 12, 2017 from www.linesolar.com

Solar Photovoltaic Basic Operational Diagram



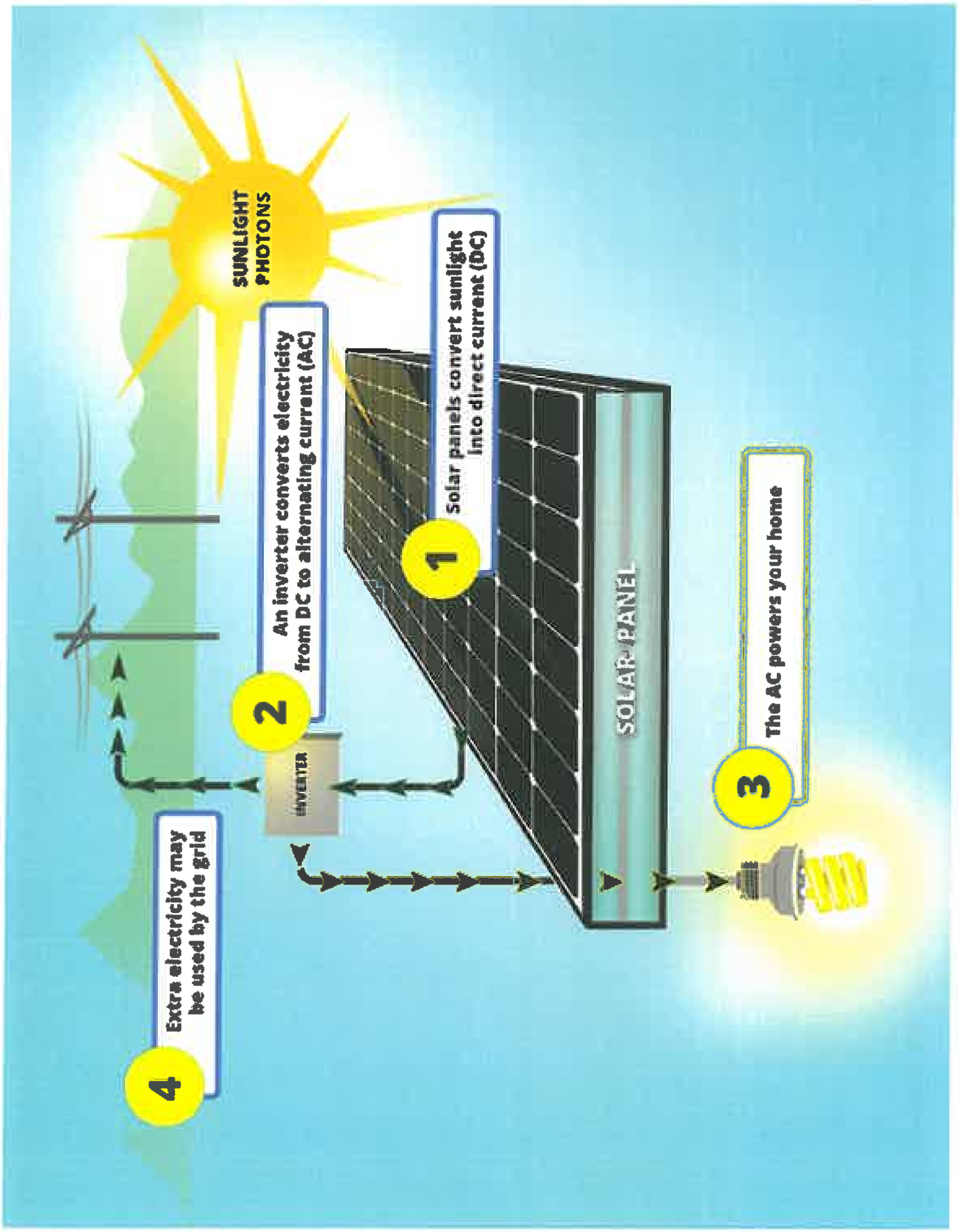
retreived January 12, 2017 from lifefreeenergy.com

Solar Thermal Basic Operational Diagram



retreived January 12, 2017 from www.which.co.uk

<u>How Solar Energy Works</u>



retreived January 12, 2017 from us.sunpower.com

Full Town Council Charge

Approved by the Town Council 1/4/2016

Cape Elizabeth Alternative Energy Committee
Purpose and Charge

Committee Structure
The Cape Elizabeth Alternative Energy Committee will consist of five citizens appointed by the town council utilizing its appointments committee process. The committee shall elect its own chair and secretary. Any vacancy on the committee after the initial appointees have first met shall be filled by the town council chair after consultation with the appointments committee chair. The facilities manager shall serve as a non-voting ex-officio member of the committee and shall provide staff services to the committee. No one of the committee shall have a personal financial interest in any proposal.

Committee Purpose
The committee shall explore opportunities to provide alternative energy to municipal and school buildings and vehicles. This includes a look at utilization of town and school land and buildings for solar energy opportunities. Its work product shall be a report to the town council providing specific proposals and cost estimates. Any proposals with cost impacts shall include the cost to implement as well as projected costs savings, future energy cost projections, and a risks section which identifies and quantifies all risks associated with the use, lease, rental or financing of a system including operation, performance, maintenance, guarantees, indemnities (including taxes and changes to Tax Law and/or Net Metering) and credit (vendors and financing parties).

Duration of Committee
The committee shall continue in existence until December 31, 2016 unless its term is extending by the town council. [Term extended to January 31, 2017].

Funding and Staff Resources Needed
The town council will make available $10,000 for the town manager to consider authorizing any technical reviews requested by the committee and for any costs relating to report writing, legal review and miscellaneous committee expenses. The anticipated staff time for the committee is 44 hours. This consists of six meetings at four hours each including preparation time and 16 hours of miscellaneous activity related to the work of the committee for the principal staff liaison and 10 hours for the town manager. In addition, the town council will spend an estimated two hours each reviewing the committee report for a total of 14 hours. The committee members will be anticipated to spend approximately 28 hours each for a total of 140 hours. It is not known if school board time will be needed. This will depend on the direction of the committee.

Summary
$10,000 cash expense
50 hours staff time
14 hours council time
140 hours volunteer time

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