CORNELL UNIVERSITY

Community Energy Choices

Guide and Planning Overview

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Interim Report

This September 26, 2011 Interim Report includes the complete background for a procedure to guide community energy choices. However, it does not yet include all the individual energy sources and energy savings methods that will be covered in the final report. For example, the final report will add further information on such topics as geothermal heat pumps, improved insulation of buildings, biodiesel, and other topics. We expect the final report to be available in early 2012. The Excel spreadsheet that is being used for carrying out calculations is being documented and edited for easy use and modification and is expected to be released by the end of October 2011.

This document outlines a process developed with the assistance of the Cornell Cooperative Extension and the town of Caroline to help small communities develop new energy use and production models centered around "green" energy sources. It is intended for consumption by community organizers and planning officials, as well as technically inclined members of the general public. As a sample case it uses a community roughly modeled to be similar to the Township of Caroline in New York State to help make the report more applicable to its users.

Contents

Introduction

At the national, state, and local level, many governments in the United States are beginning to perceive a number of benefits in investing in the development of new energy systems. This can be for purely economic reasons – based around the need for a sound energy policy that provides adequate power at a reasonable cost without excessive price fluctuations and that lessens our dependence on foreign energy suppliers. But there is also a growing demand for new energy systems based on less immediate interests. Ethical concerns regarding environmental conservation can be important. There is an increasing demand for sustainable power sources and people are becoming aware of the coming transitions away from dependence on fossil fuels. This creates an environment where many governments are looking to alternate power sources -- even if they do not have any direct objections to their present power supply. The federal government and the individual states have widely varying approaches to this problem, but local governments often find themselves facing sharply limited resources. Information on the development of new power systems at the local level is not widely available, and collecting it is beyond the resources of many local governments.

Cornell University has partnered with the Town of Caroline to help create an information base for an energy development plan for the township that can serve as a model for other localities as well. This plan's purpose is twofold – to offer policy and technical advice to the Town of Caroline relevant to their specific needs, and to outline general information, research methods, and decision making methodology generally applicable to small communities that might be considering a similar development plan. By arranging general information in a format that lends itself to cost-benefit analysis based on the energy resources available in a given location, and giving costs and probable returns for the surveying and research required to find those resources, this report will greatly speed the decision-making process for any local government that wishes to follow Caroline's example of examining what options might be most beneficial. It will also provide local governments that may be unclear as to the nature of their options with a "jumping off" point, allowing them to orient themselves as they consider new power development options.

At the end of this report is a specific, sample plan for a town modeled approximately on the Town of Caroline, fully working through the methods in this report in order to demonstrate their application and produce specific technical advice. This sample is not intended as a direct advisement to action, but rather, serves as an example of how such plans could be generated for the Township of Caroline, allowing them to easily modify it to their needs. This plan was not made in full partnership with the town of Caroline, but rather was made by the authors based on their limited knowledge of Caroline, with the assistance of the organization "Energy Independent Caroline" (http://www.townofcaroline.org/energyindependent/) and Cornell Cooperative Extension. However, it was tailored to be more illustrative and, as a result, while it is believed to be fully technically accurate, it may not reflect the actual wants and desires of the overall Caroline community.

Project Statement

This report endeavors to:

- Offer Guidelines for Energy System Modification Decisions
    - Clarify specific priorities that must be established before planning.
    - Offer systems for turning those priorities into specific goals.
    - Introduce 4 “Basic” goals.
        - Cost Efficacy
        - Local Sustainability
        - Energy Independence
        - Environmental Friendliness
- Present Basic Information on Standard and Alternative Power Sources
    - Offer a one-page, two-sided visual summary of each technology’s merits and advantages.
    - Provide technical data on each technology using a series of standardized metrics.
    - Show cost-efficacy data to assist local governments.
    - Present information to help local governments determine if they need to hire professional advisors to perform full technical analysis
- Present Widely Applicable Energy Saving Techniques and Technologies
    - Offer one-page summaries of strengths and weaknesses as with power sources.
    - List possible financing plans for each technology in order to maximize energy saved.
    - Demonstrate methods to select which energy saving techniques are significant return investments on a given timeframe.
- Develop Sample Plan for the Town of Caroline
- Demonstrate Sample Timeline and Budget

Executive Summary

While the actual technical details of developing new power saving and renewable power generation options can be very complicated, they are not something a community interested in developing new power options need consider in the initial stages of energy decisions. Expert assistance is available for a small fraction of the total installation cost, and should always be used before and during the actual construction and installation process. However, such expert assistance is not free, and so communities should only use it for new technologies that they are seriously interested in developing. This report enables communities to determine what new power technologies are practical for their area and budget and to help them decide what new infrastructure they should be considering.

The first step in this process is to create fully defined goals. Formally defining goals can be awkward, but is important for determining what technologies are useful in achieving those goals. This report simplifies that process by using four “basic goals” on which communities can rank themselves, allowing them to create a simple guideline: Cost Efficacy, Local Sustainability, Energy Independence, and Environmental Friendliness.

Once a community has formally determined its goals, the next step is to determine the total amount of money the community could raise in various ways. This includes government grants, bonds, community support, and pledges from supportive businesses. Some idea of these figures is required because often more expensive power sources are more efficient, and so having a ballpark figure for the maximum investment available greatly simplifies that part of the decision-making process.

Using the goals and amounts of money potentially available, unaffordable energy sources can be eliminated; all remaining energy sources can be given an “adjusted price”, reflecting the “value” they bring to the community. Ranking these power sources from most to least desirable and eliminating socially undesirable options produces a basic list of variable power source technologies for the area.

Improving energy use efficiency and preventing waste is almost always the most desirable way to meet energy, environmental, and societal needs. Thus, finally, by combining the ranked source list with already available data on improving energy use efficiency and preventing waste, the community can produce a list of the best investments of their time and resources in order to accomplish their energy goals. This list will then provide an excellent foundation for community discussion and planning on how to best fulfill their town’s energy needs, and allows expert consultation to be arranged without the potential for inefficient use of funds.

The actual process of creating this list requires a reasonable amount of technical data, which is contained in the report’s appendices – however, an Excel file has been created that performs most of these calculations automatically. (This Excel file is not presently attached to this document; it is being edited be usable by the public and is expected to be available by the end of October 2011.) After the main body of this report, a one-page summary of each item of technology considered so far has been included. It gives a brief overview of the technology, as well as a number of standardized technical metrics for evaluating its performance. These sheets are provided in order to give an accessible overview of the technical concerns involved. The final version of this report, which is expected to be released early in 2012, will include more source and conservation technologies than the present interim report.

At the end of the report, the methods contained inside are used to fully work a possible example case for the somewhat similar to the Town of Caroline. This is not intended as a recommendation or even to represent Caroline’s interests accurately, but merely to showcase how the methods contained in this report function.

Planning Overview

Declaring Goals

Abstractly, most community activist groups looking for sustainable power options want the same thing – for their community to be a greener, more prosperous and more verdant place at reasonable economic cost. Practically, there are many different ways renewable and local power options can be used to help accomplish those goals, depending on exactly what the community is looking for. “Make the community better” is not a goal that can be used for decision making by putting it into a community process, computer program, or spreadsheet, and so a more formal definition is required for planning purposes.

One way to more easily produce a formal definition of a community’s goals is to use pre-calculated metrics, which can represent common goals. This report uses four metrics: Cost Effectiveness, Local Sustainability, Energy Independence, and Environmental Friendliness. Each rank, or rating in each of these goals corresponds to, say, a roughly a 2% increase in the value of energy infrastructure that advances that goal. For instance, a town that gives itself a score of 1 on the Environmental Friendliness metric is expressing that it considers green, environmentally friendly power to be about 2% more valuable than normally produced power. Most communities will therefore be unlikely to rate themselves above a 5 in any of these categories as that would imply a 10% increase in energy costs. Thus a rating of 5 in a goal is considered “extremely committed” to that goal. In general, this report assumes a community will rank itself 0 to 5 on each of these goals, though higher rankings are possible in this process.

- Cost Effectiveness
  - Some renewable energy technologies pay for themselves – money goes in, and over time, money comes out. By the same token however, some do not – using up money but producing other desirable results. The cost effectiveness metric helps define the line between those two points – a measurement of how long the community is willing to wait to see a return on an investment. Roughly speaking, a community is willing to wait twice as long in years as their rating on this metric to see a system pay for itself. For instance, if a Solar Panel takes eight years to pay for it, but a community is only willing to wait four years to see a return on their investment, then the last four years are not counted when determining the effective price of the panel. Thus, the higher a communities rating on this metric, the more long term investments the decision system will produce.
- Local Sustainability
  - A solar panel farm owned by the power company and operated in a distant town away is not technologically different from a power farm owned by your neighbor and operated next door. It may have different features, or different add-ons – but fundamentally, panels are panels. They produce power for about the same cost, with about the same environmental impact – but the money you pay for power from one goes to the power company, while the money you pay for the other stays in your town. And for many, that makes the solar panels next door better. Supporting this kind of local business is a key goal of many communities, and this metric supports that.
- Energy Independence

- For communities that pride themselves on their independent nature, true energy independence – that is, the removal of their town or parts of its energy supply from the main power grid -- may be an objective. This is usually much more expensive than simple local power generation, as the grid provides many useful services, but it can be done. This metric is advanced by having enough reliable power at all times to power all the needs of the community. This is difficult to achieve fully but may be possible for some partial power needs.

- Environmental Friendliness

- Environmental friendliness is a broad term, but every day more communities are embracing it in some respect -- becoming aware of the impact they have on the environment around them. At present this report does not include any particularly polluting power sources – every power source inside it is at least somewhat better than the national average for carbon emissions and other measures of environmental friendliness. But, some communities are willing to pay more for cleaner power, and the environmental friendliness metric measures their commitment to that goal.

Obviously, four numbers on a simple scale cannot summarize the full complexity of a towns goals in pursuing new power options – but they can go a long way to defining a community's economic objectives. This report's decision making methodology does not make a final recommendation for power options, but produces a list that sorts potential developments by economic standards for further consideration, and so these simple metrics should be helpful.

Determining Possible Available Funds

Eventually -- for a community that is serious about developing renewable power systems through careful cycles of development and investment -- the money to pay for new developments may come from the proceeds of old developments. But for the initial, smaller cycles of investment, the community will need to raise money on its own. Since most small communities will probably not want pay for this sort of endeavor with taxes, they must raise funds by other means.

The most efficient way to raise these funds – although not necessarily the easiest – is to collect commitments from members of the community, businesses, and other institutions to buy the generated power at a slight markup over common electricity costs. This reflects the approximate measure of economic commitment used in the metrics above, and provides a steady, general source of income without asking for money directly.

Alternative methods of raising money include levying a bond or taking out a loan from a bank or other private institution. Also one can apply for a government grant, or receive private funding. These can be generally lumped under the categories of a subsidy, or a lump sum investment. To some extent, the labor of the community can be counted as a subsidy – reducing the construction and labor costs of a project, if possible.

Appendix B contains more information on potential means of raising funds, as well as calculating the expected return of those means – but the decision-making methodology presented later in this report distills the result into five measures: Immediately available funds (representing money that can be raised immediately), potentially available funds (representing loans and the like), subsidy (a percentage discount of cost), and purchasing percentage (the amount of power that has been committed to be bought at what percentage price increase over normal). In lieu of formal calculations, rough numbers for each category can be used to produce an approximate result.

Ranking Available Options

Once available funds and goals are determined, power options can be properly ranked and sorted – We have automated this in an Excel file which is being made easier to us and is expected to become available by the end of October 2011. Although the details of the math can be fairly complicated, the basic methods used are quite simple.

The first step is to eliminate unaffordable options. Each potential new power source or technology has a listed minimum cost. Power sources with a minimum cost higher than the sum of the immediately available funds and potentially available funds can be removed from consideration – the town simply cannot raise the money for their construction. (Of course, the community could reevaluate how it might obtain more money if they wanted, making this an iterative procedure.)

Power sources with a minimum cost higher than the immediately available funds but within the range of potentially available funds have their construction costs adjusted to reflect the difficulty of raising the money to construct them. The community's Cost Effectiveness rating is used to make the final adjustment to the construction cost – discounting the inflation-adjusted returns the power source will produce over the town's period of patience.

The second step is to adjust the power sources' effective outputs. Here, the other three goal metrics are employed – each one is used to adjust the effective output of a power source by its given percentage, based on how much the power source accomplishes that goal. For instance, a power source that was only at an average level of environmental friendliness would not have its effective output adjusted upwards based on the Environmental Friendliness metric – but a particularly clean power source would. The cleaner the power source, and the higher a community's Environmental Friendliness metric, the more its effective output is adjusted upwards. This makes power sources that accomplish the community's goals proportionally more valuable.

The third step is to rank the power sources by their adjusted cost effectiveness – their effective yield divided by their effective cost. This ranks the power sources by their effective benefit to the town against the effort it would take to raise the money to produce them, creating a reasonable guide for which options should be first considered.

The fourth and final step is to add power saving technologies to the list. Power saving technologies have different technical specifications, and so must be handled somewhat differently, but saving power is often more desirable then producing it. The economic specifications for a number of common power saving methods and technologies can be pre-calculated and included in the Excel file. One example is given in this Interim Report. Adding power saving methods to the list and sorting them with the power sources produces a complete list of the town's power options, arranged in order of likely feasibility.

Final Selection

The list of power source and savings technology produced by the methods above takes into account the key economic factors involved in the options a community is presented with – but it does not reflect other concerns the community may have. For instance, wind power may produce more noise than some persons in the community find acceptable, or there may be a particular strong interest in developing new micro-hydro power in local streams. The list is therefore intended as a guide – allowing a community to move along it from top to bottom, accepting or rejecting the items one at a time. What is left is a greatly truncated list of possible options, making it possible for a community to seek expert consultation for some of them without undue expense.

Sample Case

Decision Tree

This sample case serves as an example of how to employ the data and methodology contained in this report. It is a simplified hypothetical example, Sampletown, derived but modified from the actual Caroline case, so as to make the techniques explained here clearer. The data used in this example case is generally reflective of realistic conditions. However, since it has been artificially generated to ensure it showcases all of the features of this report's decision methodology, it is **not** particularly reflective of any particular real world community's interests, and should **not** be employed in an actual decision making process. I.e., while the Town of Sampletown in this example case is based on the actual town of Caroline, certain assumptions have been made and certain details have been altered in order to make it a more effective example. It should not be taken as any statement reflecting the goals or resources of the town of Caroline.

In order to more clearly illuminate why one power source would be selected over another in full detail, only five power sources and one power conservation method will be considered in this example case. The methods used to analyze them should be applicable to any number of power source or saving technologies.

Some of the information contained in this report has a very large range, making the information somewhat vague – this is because the report must cover a wide variety of potential technologies. For instance, the range of possible productivity for solar power systems includes solar power systems built anywhere from the equator to near-permafrost regions. If more specific information is available, it is possible to manually enter it into the Excel sheet, and then analyze it using the methods covered here.

It is also possible to manually enter new power sources that this report has not yet included. The Excel file will automatically update itself to process them properly.

Goals and Background Information

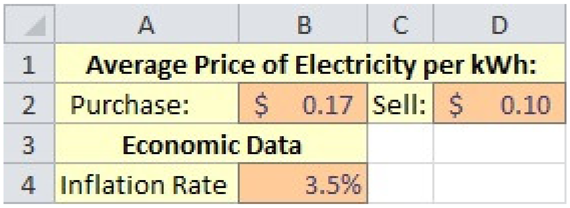
First, the community's goals must be determined, and its economic information entered. In this example, the Town of Sampletown wants their community to be more independent and environmentally friendly. The town is split on whether environmental friendliness is important, but can definitely agree that they would like the community to produce more of its own power, particularly because that means the money stays in the community. Although they would like the town to produce more of its own power, they do not think that going "off the grid" is particularly important. The community's members are fairly patient, as they plan to live in the community for some time, but not all of them plan to retire there, and so they would like to see their new power developments pay for themselves within 10 years, giving a "Cost Efficacy" rating of 5.

	A	B
1	Goal Data	
2	Goal:	Rating:
3	Enviromental	1
4	Cost Efficacy	5
5	Self-Sufficency	3
6	Independence	0

Based on these considerations,

Sampletown can give itself an Environmental Friendliness rating of 1, a Cost Efficacy (Acceptable Payback Time) rating of 5, a Self Sufficiency rating of 3, and an Independence rating of 0. These values can be entered into the Excel sheet (as shown above).

In order to try to accomplish these goals, Sampletown has secured a promise from a nearby university to buy 250,000 kWh of electricity from the town at 10% above standard rate. Twenty-six members of the community have also agreed to purchase power at 10% above the standard rate, for no more than one year each. The average house in Sampletown uses 920 kWh of electricity per month, so this amounts to a promise to buy another 287,000 kWh of electricity, for a total of 537,000 kWh pre-purchased. Looking up the price of electricity in the area, Sampletown finds that the average price of electricity, including delivery charges, is $0.17/kWh, while the power company will buy their excess power for $0.10/kWh. This information can be entered into the included Excel spreadsheet, along with the current inflation rate (example left). This general information is important for many economic calculations the Excel spreadsheet will perform later.



	A	B	C	D
1	Average Price of Electricity per kWh:			
2	Purchase:	$ 0.17	Sell:	$ 0.10
3	Economic Data			
4	Inflation Rate	3.5%		

In addition to these purchasing promises, the town of Sampletown has been able to raise a total of $3000 from donations or a bond levy rendered to its members, and another $4000 from taxes and other funds that have been made available for the towns use. After consulting with a bank and members of the community, the town has estimated it has a potential credit line of approximately $30,000, available at 8% interest. (Companies responsible for the creation of various renewable power systems also will often provide loans to their clients at varying interest rates in order to aid in purchasing.) In this case, the town is potentially interested in Solar PV, Wind, Mini-Nuclear, Concentrated Solar, and Biomass Gasification. The community was able to research corporate offers for construction loans, and add them to each individual technologies entry in the Excel sheet.

Goal Data	
Goal:	Rating:
Environmental	1
Cost Efficacy	5
Self-Sufficiency	3
Independence	0

Economic Data						
Power Category:	Immediate	Potential	Interest	Subsidy	Purchase (kWh)	Purchase ($/kWh)
General	$ 7,000.00	$ 30,000.00	8%	10%	537,000.00	$ 0.19
Solar PV	$ -	$ 50,000.00	10%	40%		$ -
Wind	$ -	$ 30,000.00	9%	30%	-	$ -
Nuclear	$ -	$ -	0%	20%	-	$ -
Concentrated Solar	$ -	$ 70,000.00	12%	40%	-	$ -
Biomass Gasification	$ -	$ 2,000.00	8%	10%	-	$ -

Finally, there are numerous state and federal subsidies that apply both in general, and to specific power sources. After some research, Sampletown discovers that they qualify for a $5000 federal grant to develop renewable power sources in small communities, a 10% federal subsidy for the development of new small town power systems, and numerous federal and state incentives that subsidize solar, wind, and biomass based power sources. They add these to the Excel sheet, completing the economics section of the sheet (as shown).

Reading the Results of the Calculations

With the town's economic and goal data entered, the Excel sheet can perform its calculations. As all of the technical data for the power sources under consideration has already been entered, the Excel sheet will immediately produce the final result. However, all of the intermediate steps are displayed for the user's own reference. They are explained in the planning overview above.

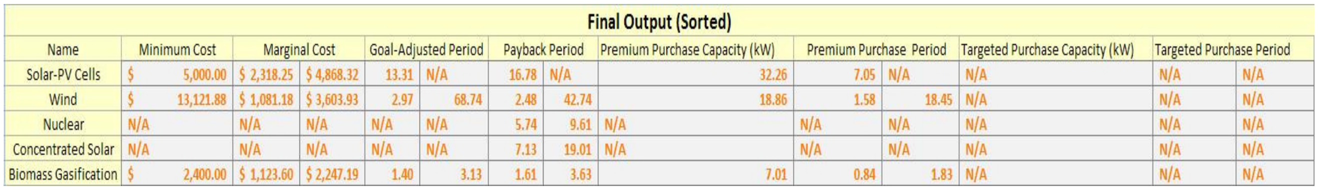
The final results condense this information down into seven key numbers: Payback Period (i.e., Unadjusted Period, Monetary Period), Goal-Adjusted Period, Premium Purchase Capacity, Premium Purchase Period, Targeted Purchase Capacity, Targeted Purchase Period, and Average Cost.

Payback Period is the actual period, measured in years, it will take for a new technology to fully pay for itself (including capital and basic operating costs in the period)' assuming the power is purchased at standard market rates. Goal-Adjusted Period is a weighted number, designed to indicate how quickly a technology fulfills the town's goals. For instance, if a town indicates that Environmental Friendliness is only somewhat important, environmentally friendly power sources will just have a slightly lower Goal-Adjusted Period. However, if they indicate that environmental friendliness is very important, environmentally friendly power sources will have a *significantly* lower Goal-Adjusted Period. As with Payback Period – shorter period is better.

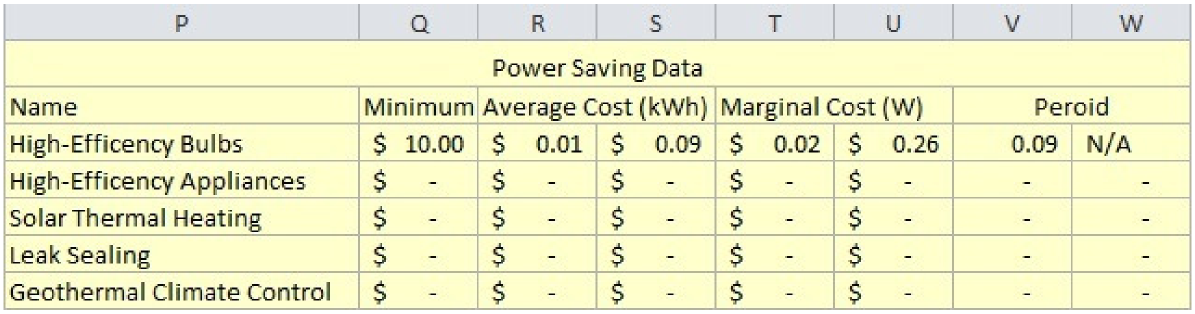
Premium Purchase Capacity refers to the capacity a power plant would need to fulfill all of the town's premium purchase offers – that is, offers to buy a certain amount of power at an increased rate, a common way of raising funds. Premium Purchase Period refers to the payback period if this hypothetical power plant, assuming it sells all its power at the premium rate. Targeted Purchase Period and Targeted Purchase Capacity reflect the same numbers -- except for offers to buy power only from a specific kind of source, instead of from the community in general.

Average cost refers to the total life-to-death cost of a new device, measured per kWh (Kilowatt Hour) produced or saved over its entire lifespan.

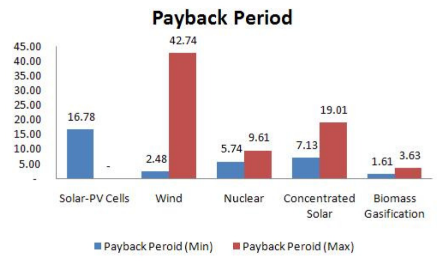
These results are displayed in both tabular and graph format.

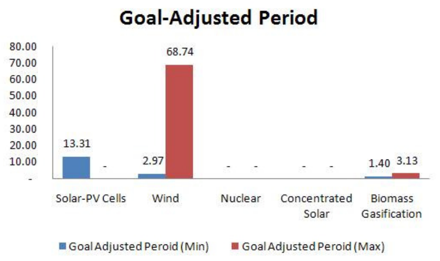


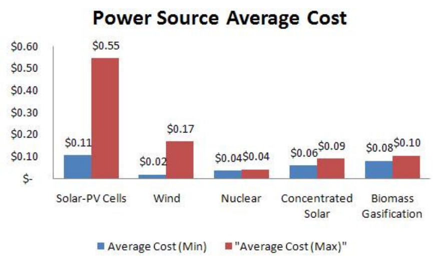
Final Output (Sorted)													
Name	Minimum Cost	Marginal Cost		Goal-Adjusted Period		Payback Period		Premium Purchase Capacity (kW)	Premium Purchase Period		Targeted Purchase Capacity (kW)	Targeted Purchase Period	
Solar-PV Cells	$ 5,000.00	$ 2,318.25	$ 4,868.32	13.31	N/A	16.78	N/A	32.26	7.05	N/A	N/A	N/A	N/A
Wind	$ 13,121.88	$ 1,081.18	$ 3,603.93	2.97	68.74	2.48	42.74	18.86	1.58	18.45	N/A	N/A	N/A
Nuclear	N/A	N/A	N/A	N/A	N/A	5.74	9.61	N/A	N/A	N/A	N/A	N/A	N/A
Concentrated Solar	N/A	N/A	N/A	N/A	N/A	7.13	19.01	N/A	N/A	N/A	N/A	N/A	N/A
Biomass Gasification	$ 2,400.00	$ 1,123.60	$ 2,247.19	1.40	3.13	1.61	3.63	7.01	0.84	1.83	N/A	N/A	N/A

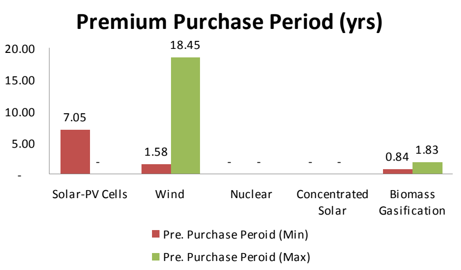


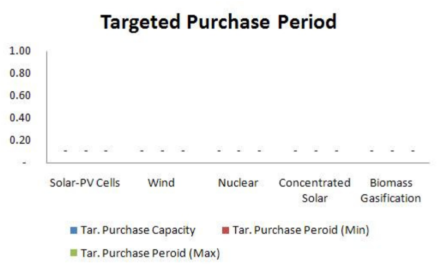
P	Q	R	S	T	U	V	W
Power Saving Data							
Name	Minimum	Average Cost (kWh)		Marginal Cost (W)		Peroid	
High-Efficency Bulbs	$ 10.00	$ 0.01	$ 0.09	$ 0.02	$ 0.26	0.09	N/A
High-Efficency Appliances	$ -	$ -	$ -	$ -	$ -	-	-
Solar Thermal Heating	$ -	$ -	$ -	$ -	$ -	-	-
Leak Sealing	$ -	$ -	$ -	$ -	$ -	-	-
Geothermal Climate Control	$ -	$ -	$ -	$ -	$ -	-	-

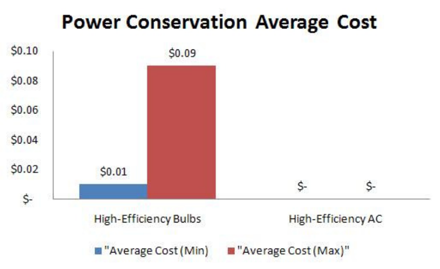












Interpreting Results

Goal-Adjusted Period is the first result to be considered – it measures how quickly a technology can serve to fulfill Sampletown's interests. All the relevant data for this consideration is contained in the Goal-Adjusted Period graph (above). The lower the adjusted period, the better a given power option is for Sampletown. In this case, Biomass Gasification is clearly the best option if biomass input is available – followed shortly by wind *but only if* Sampletown is in an area with particularly significant wind resources. Solar power comes in a distant third overall – however, should Sampletown prove to be an area with significant solar resources and inferior wind resources and this information used to refine the estimates of energy costs and outputs and , it could supplant second place. Nuclear and concentrated solar power facilities are beyond the resources of Sampletown, and so may be removed from consideration.

The next factor to be considered is the Premium Purchase Period. Since there are no specific purchase options in this scenario, all the relevant data is contained in the Premium Purchase Period graph (above). In this graph, the fundamental order of power technology favorability remains unchanged – however, the difference in period between wind and biomass is now significantly reduced, with wind possessing a significantly higher Premium Purchase Capacity. This may make wind a more favorable #2 choice, affirming what the earlier graph suggested. Examination of the payback period graph yields similar results.

With biomass as a first choice, wind as second, and solar-PV as third, it is possible to look at the Average Cost graph, in order to compare it to potential power conservation technologies. In this example case, Sampletown is only considering energy efficient bulbs as an alternative to new power generation technology. In comparing these two graphs, energy efficient bulbs have lower average cost then the considered power sources in almost every case. Thus, for comparable period, they are the superior option for Sampletown.

Examining wind powers technical summary, we see that is has surveying costs in the range of $10,000 to $15,000 before construction can begin. Given that Sampletown's total potential budget is only $37,000, this makes wind an unreasonable consideration unless wind is going to prove to be Sampletown's only power option. Given that wind is a shaky second in economic consideration, and its average output is significantly worse than biomass or favorable solar-PV, this flaw is likely enough to merit removing it from consideration.

With wind eliminated, Sampletown's options have been reduced to two power sources – one available only in discrete units, one in flexible quantities – and one power conservation device, available in flexible quantities. This is a sufficient narrowing of possible options to move onto final power plan selection.

Final Selection

Examining biomass gasification's power handout and appendix, we see that biomass gasification generators tend to come in manufacturer specified sizes, depending on what and how much biomass is easily available in the area. Deciding on the amounts of biomass available and contacting manufacturers would be Sampletown's next steps in this example case, in order to get more specific information. Likewise, a Solar-PV provider would be contacted in order to ascertain better information for the expected yield of solar panels. This gives Sampletown flexibility in how it allocates its funds. By selecting the optimized sized and typed biomass gasification generator for the area, and then "filling in" their remaining funds with Solar-PV options, Sampletown has the ability to produce a result that is most ideal for their goals and the funds at their disposal.

Power conservation options, such as energy efficient bulbs, may be preferable to new power sources, if their payback period and average costs are less than the available, feasible power options for Sampletown. Earlier, we saw that the average costs for energy efficient bulbs beat both solar-PV and biomass gasification, and so only require a shorter payback period to be the superior option. Reading through the information for bulbs, we see that a bulbs payback period is primarily dependent upon how often it is used. A bulb that operates 24 hours a day has the startlingly low payback period of 0.09 years, allowing us to do some simple math. Going by fractions of the day, we can calculate that under standard conditions, to have a superior result compared to biomass gasification, an energy efficient bulb must be used to replace a bulb that operates for at least 0.94 hours a day. We can do similar math for the other power options:

Power Generation Option	**Energy Efficient Bulbs Equivalent**
Biomass Gasification (Standard)	0.94 Hours/Day
Biomass Gasification (Purchase Option)	1.61 Hours/Day
Solar-PV (Standard)	7.72 Minutes/Day (1 Hour/Week)
Solar-PV (Purchase Option)	18.38 Minutes/Day (2.1 Hours/Week)

It seems that bulbs are clearly the superior option for Sampletown. The ease of tracking bulbs and measuring their total savings makes them an excellent primary power conservation option. In order to complete its search for more detailed information, Sampletown must determine approximately how many such bulbs can be found within it and might be replaced. Once that information – and the Solar-PV and biomass gasification manufacturer data are in hand – a final power plan can be created, focusing on the options that will most quickly pay dividends that can be used to develop more expensive power sources.

An example, phased, implementation plan is provided below, assuming typical Solar-PV performance for Sampletown’s area of New York, and wood-burning biomass gasification units based on waste wood types found in Tomkins County, including Sampletown.

Possible Sampletown Energy Development Plan

- Phase 1: Distribution of Energy Efficient Bulbs

- In Phase 1 of Sampletown energy development plan, high-efficiency LED bulbs will be used to replace all remaining incandescent bulbs that meet specified usage limitations. These bulbs will be made available to all citizens of Sampletown, free of charge, assuming the town can fractionally collect the savings induced. (This may not actually be realistic.) From the town's initial investment, $240,000 of bulbs will eventually be distributed over a four-year period, assuming an average of 8 replaceable bulbs per participating household.

- Phase 2: Construction of Biomass Gasification Facility

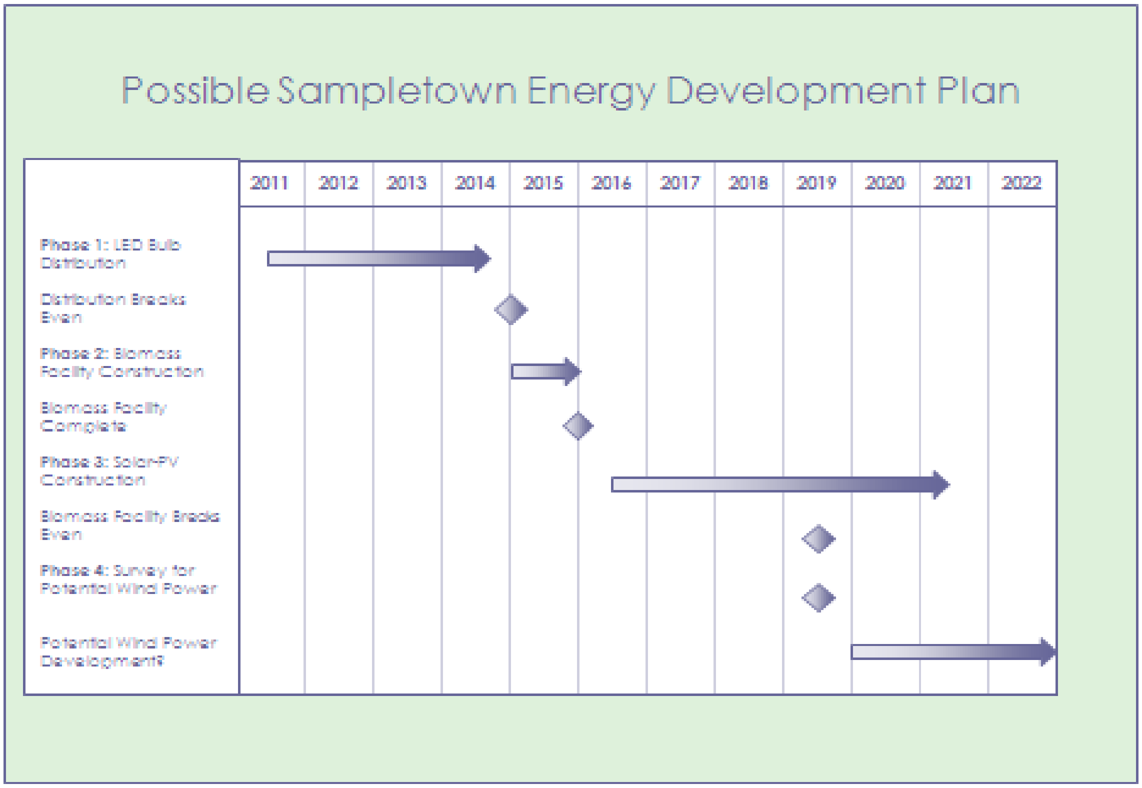
- Once the debts incurred by Phase 1 are repaid in full, Sampletown can begin Phase 2, in which a 5kW biomass gasification plant is constructed to supply the community with electricity, employing waste wood gathered from public areas and neighboring forests, supplemented by imported wood waste. The 5kW size is selected in order to make full use of assumed available waste wood resources, bearing in mind that the availability of local wood waste will vary seasonally.

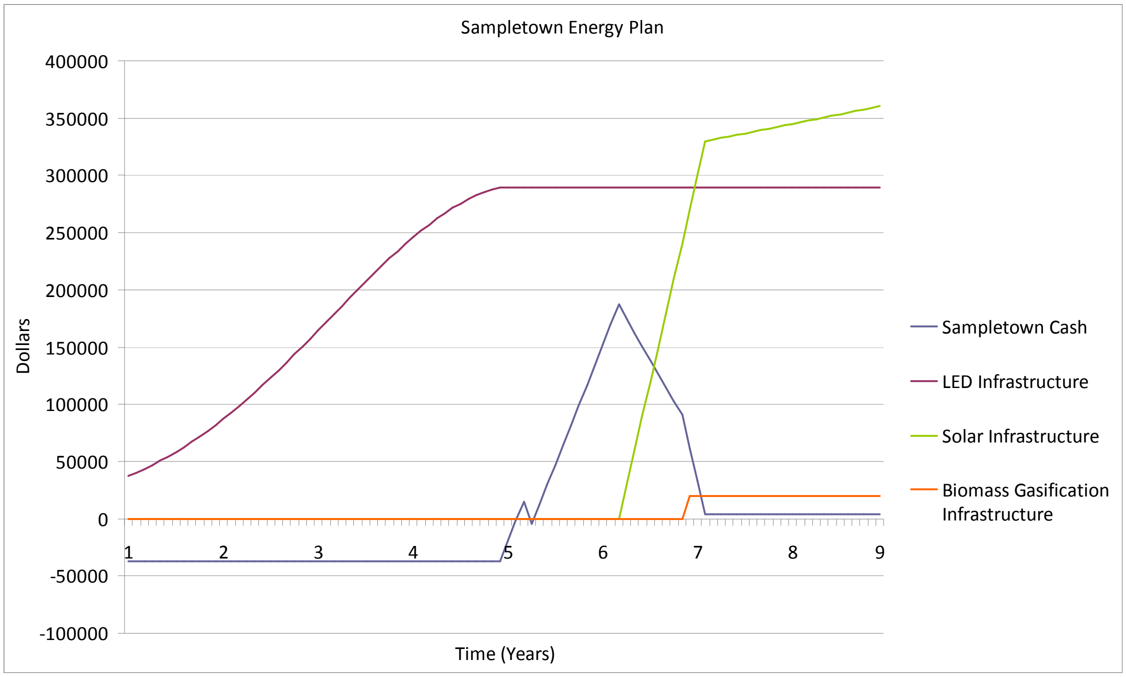
- Phase 3: Construction of Solar-PV Facility

- Six months after the biomass gasification facility begins producing power, sufficient resources will have been accrued by the community to begin construction of rooftop solar-PV panels on public buildings and participating local homes. Over the course of five years, construction of a 50kW solar-PV field can be completed.

- Phase 4: Potential Addition of Wind Power

- Depending on survey results, the addition of wind power to Sampletown's community power systems may be pertinent after the ten year mark.


Possible Sampletown Energy Development Plan
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Phase 1: LED Bulb Distribution
Distribution Breaks Even
Phase 2: Biomass Facility Construction
Biomass Facility Complete
Phase 3: Solar-PV Construction
Biomass Facility Breaks Even
Phase 4: Survey for Potential Wind Power
Potential Wind Power Development?


Sampletown Energy Plan
400000
350000
300000
250000
200000
150000
100000
50000
0
-50000
-100000
Dollars
1
2
3
4
5
6
7
8
9
Time (Years)
Sampletown Cash
LED Infrastructure
Solar Infrastructure
Biomass Gasification Infrastructure

Appendix A: Power Metrics Discussion

- ***Economic Costs***

The economic costs of a given power system are represented as a *minimum cost,* an *average cost*, a *marginal cost*, and a *productivity ratio*. The minimum cost reflects the minimum dollar investment required to consider the technology, including the cost of any surveying required before construction. The average cost is the average dollar cost per kWh (Kilowatt Hour) the power system will produce under actual conditions over its lifespan. The *marginal cost* is the cost of adding an additional watt of capacity to the system, once the minimum has already been achieved. The productivity ratio is the ratio of the amount of power a facility actually produces, to the amount it would produce if it could run 24 hours a day year-round.

- ***Environmental Effects***

The environmental effects of a given power system are represented by measurements of *carbon emissions* and *secondary emissions* as well as a list of *local environmental effects*. The carbon emissions measurement records the total percentage carbon emission of the system relative to the average. Thus, buying power from the existing grid would have a carbon emissions score of 100%, while a particularly inefficient coal plant might have a score of 200% or more. This metric includes the emissions used in producing the system, driving it to the final site, disposal, etc, and so no system has a score of zero. A very clean system, such as solar panels, has a score of 1-10%. The secondary emissions measurement reflects any potential emissions of metals, oils, groundwater contamination, and non-carbon based emissive concerns. The local environmental effects measurement covers erosion, deforestation, noise concerns, disruption of wildlife – and generally any non-numerical environmental concern.

- ***Security***

The general security concerns of a power system are twofold – *local security* and *global concerns*. The former covers immediate, practical problems – is this system subject to theft or vandalism? Are there any potential safety risks? With these and other important questions, local security is more generally defined to cover any potential, sudden misfortune that could befall the power system. The global concerns metric reflects less immediate problems, which any given community will need to decide their interest in – will this technology send money which will help people or encourage corruption in the third world? Does it support Middle Eastern oil interests or overseas conflicts? Some communities may wish to consider alternative power just to avoid these questions, and so they are generally relevant to the decision-making process.

- ***Reliability***

An electrical engineer's job would be simpler if a 10 kilowatt power plant actually produced 10 kilowatts of power at all times. But in reality, energy systems of all kinds can have periods when they produce less than full power, and the average output of a system does not necessarily reflect its output at any given time. This is reflected with the two measures of *flexibility* and *regularity*. Flexibility measures the ability of a given power source to produce energy when it is most needed – a hydroelectric dam can fill its reservoir during low hours and drain it during peak load, but solar panels produce power only when the sun shines, regardless of if that power is needed or not. Regularity measures the ability of a technician to anticipate when a given system will actually produce power – while solar powers hours may be outside its operator's control, the movement of the sun is far more predictable then temperamental wind power. Each of these measures is put on a three-point scale: None, Low, and High.

- ***Connectivity***

Connectivity – the ability of a power system to be attached to the grid and supply power back to the power company – is significant for multiple reasons. It allows a power system to sell power and earn money during a period of surplus, and further allow some power systems to repay their creators investment in cash instead of savings. Unfortunately, not all power systems possess this ability – and for those that do, installing it is not always profitable. This metric discusses what interconnection options are available for a given power system, and how much it costs to install them.

- ***Zoning and Planning***

On the average, the government is a distinct positive influence in small communities search for reasonable power solutions. Although they are discussed relatively little in this report, government subsidies and incentives can open options that would never have been otherwise available. Unfortunately, government can also introduce some hindering regulation to the process. Even something as simple and inoffensive as solar panels can have significant zoning concerns associated with it, besides the regulations associated with potentially polluting power systems. This metric offers a brief discussion of the relevant regulations of each system, as well as an approximate dollar cost (should one be required) of meeting these regulations.

- ***Social and Community Impact***

Buying power from your neighbor instead of the power company keeps the money in the community, helping it to prosper. The construction of a solar power facility can bring new jobs, as can the cleanup of old, outdated systems. But in some areas, solar panels can potentially lower property values. It is possible that a temporary influx of hundreds of construction workers for a large new plant might cause spikes in crime, ambulance use, and emergency room visits. The social impacts of a given piece of technology are hard to quantify, but this metric attempts to give an overview of them, reflecting how important they can be to a community’s final decision.

- ***Land Costs***

Almost all power systems occupy land, but not all of them do so obstructively. The land costs of a system can be represented with measures of *exclusive* and *non-exclusive* use. Measured in kilowatts of capacity per square meter, these two metrics reflect a power system that is exclusionary in its land use, or that occupies very little of the space dedicated to it. A wind turbine farm occupies a far larger area than a power plant, but leaves most of that area open for agriculture or natural, wild spaces.

- ***Resource Opportunity Cost***

This report contains only a fraction of the many types of power systems available – but even it contains several distinct solar systems, different methods of lighting a home, and, eventually different sources of natural gas. In considering new power systems, a community must divide a finite amount of resources – and many of the options they face prohibit each other. Presented as a list, this metric lists what other power systems a given technology may exclude with its presence.

- ***Development Time***

Development time reflects the total period it takes to construct a given power system – from the day a final decision is made to the day it begins actually supplying power. This time includes all necessary surveying and professional assessment, as well as construction itself. This metric is important for scheduling as well as economic considerations.

- ***Survey Costs***

The final metric, survey costs reflect the cost of determining if a given technology is viable. The costs of construction surveys and other prerequisites to building a new power facility are included in its economic data – survey costs represents the investment to determine if a technology is suitable for the area, where the answer may be no. In effect, survey costs are how much money must be risked to consider developing a new power technology. For instance, Solar Power tends to have very low survey costs (as the sun’s position is easily mapped), while hydro power requires more complicated river and river bank and geotechnical surveys.

Appendix B: Economics of New Energy Systems

Overview

Successful investment is a cycle. Money invested in new infrastructure and technical improvements yields greater returns – which can then be re-invested in more equipment which could not have been afforded before. This basic principle of business has several fundamental implications for community power systems development. It means that no power option is too expensive for a community – some power options just take longer to develop then others. It means that a community should think one step ahead, planning what power options are best now, and what developments will be part of the next cycle. And it means that to fully develop its renewable, local, energy potential, a community needs a way to capture the benefits of its power options in cash or capital.

Thus, the decisions a community needs to make are technical, legal, and economic. Each cycle of investment must suit the community's needs, but must also fit longer term, classical economic interests. It would be almost impossible to do this from the top down – finding the "correct" technical solution and then raising the funds for it. For most communities, it makes far more sense to work from the bottom up – determining what resources are available, and using that information to pick from possible options.

The economic advice given here follows this bottom-up reasoning. Starting with possible means of raising money and estimating available funds, it then moves on to possible methods of collecting a return on energy infrastructure investments, and then onto how energy systems are ranked. This puts all available economic data in the format that is used in Appendix C, which discusses the actual selection process in which, economic and technical data are combined to produce a final plan.

Throughout this appendix, the concepts of inflation and interest are used repeatedly. Most people are already familiar with these ideas, but how this report handles them bears mention. Inflation is, in simplest terms, the decrease of value of money over time. In these calculations, inflation is represented as a loss -- $100 subject to 1% inflation a year "loses" a dollar for every year it sits unused. This causes options that require money to be stored for long periods to be rated less favorably. Interest – specifically interest on loans or bonds – is directly represented as increased cost. A project that is paid for with a $100, one year loan at 5% interest has a "real cost" of $105 dollars. This means that projects that require expensive loans to construct will be rated less favorably.

The actual calculations involved in each of these steps are simple, but can be somewhat lengthy. They are automated in the Excel file.

Raising Funds

The amount of money a community can raise is represented by five measures: Immediately Available Funds, Potentially Available Funds, Subsidy, and Purchasing Percentage.

Immediately Available Funds is the figure most probably thought of as raised money – the amount of money the community can raise in cash within several months time. Potentially Available Funds represents a sum of the amount of money they could raise over a considerably longer period, or through loans – including the interest that needs to be paid on those loans, if any. Subsidy represents a commitment from another organization – usually the government or a private trust – to support the development of the town's energy options, discounting construction price by a certain percentage. Purchasing Percentage represents a commitment by another body or group of citizens to buy a certain amount of power at a certain percentage of the average price. While not technically money raised, this is an important factor for determining how safe an investment a given technology will be.

In order to raise these funds, communities have a number of different options, each of which contributes to the four metrics in a different way. Some examples are listed here, along with how much each one adds to each of the four metrics, but communities may want to pursue alternate choices.

Taxes

Taxes are an unpleasant proposition for any community – particularly small rural communities, which are often limited to more regressive taxes. However, they are also one of the most effective ways for a community to raise large amounts of money in a short period. By using tax revenue to take advantage of otherwise unavailable federal government subsidy, a community can produce a great value of infrastructure for a relatively small cost. A temporary tax – intended to raise a lump-sum of funds – is represented as an addition to immediate funds. A longer term tax that gradually raises money is represented by an addition to the potential funds measure – in effect, the town is loaning money to itself. The interest rate of this imaginary loan is determined by how long the tax money would have to be stored before being spent. In this case, the interest represents losses due to inflation (if any).

Bond Levies

Bond levies represent a fair, equitable way of raising money, while allowing the members of a community to profit from the community's growth and success. They add to the potential funds economic measure for a community – in effect, bonds are a loan, with interest, paid to the community's members instead of to a bank or other outside entity. The only significant downside to bonds is that it can be difficult to raise a sufficient amount of money with them. The enthusiasm of a community for such investments is important to determining if bonds will be an effective means of raising money.

Individual Ownership

Some power generation systems can be mounted on individuals' homes or property – such as solar-PV cells or micro-wind turbines. In such cases, the community can employ a "rent-to-own" system of development, where the homeowner pays over time for some fraction of the device, and it becomes their property once it has been paid off. This is most effective when the system significantly increases the resale value of the home or property, ensuring the homeowners' investment is safe. This is represented as a subsidy for that particular power source, based on what fraction of the cost the homeowner bears.

Government Grant

Some federal government grants are available for community level planning and development – enabling small towns to develop power systems they could not otherwise afford. Application for these grants is straightforward, and can bring significant money into a community. However, more grants are available for individuals and home development. By helping individuals who otherwise could not qualify for these grants meet the prerequisites, a community can maximize the amount of federal money benefitting their town. It is also possible for the money developed from the infrastructure added to then go back to the town, returning the community's initial investment even as it allows the home owner to benefit. Government grants – depending on whether they are a direct money injection or a discount – add to either the Immediately Available Funds measure or the Subsidy measure.

Purchasing Commitment

,A purchasing commitment is an indirect method of raising funds where a group of individuals or outside organization agrees to buy a certain amount of power at a pre-agreed upon price before the new power source is constructed. This ensures a certain return on the initial investment, making the power source a more desirable option – and if the price agreed upon is above the commercial rate for electricity, it can give the power source a shorter return period. Such commitments are represented by their own, unique economic measure – defined by the amount of power, and the price at which it will be purchased.

Collecting Returns

Collecting returns on a new power source is easy – metering is not a significant expense for new power systems of any reasonable size, and so, fees can be charged for the electricity generated. This is true for power systems hooked up to the grid, but can also be used as a method of payment for power sources connected to a house, such as rooftop panels. An increasingly popular method of solar panel financing is for the homeowner to receive the panels for free, but commit to buying power from the panels on his roof at a specified rate, until such time as the panels are paid off. This is an effective way of ensuring a return on investment for small community projects.

Collecting returns on power saving technologies is more difficult. At present, New York State law states that any municipal loan rendered for the purposes of home improvement is secondary to the bank's mortgage. This makes it difficult for communities to take loans against a building itself for the purposes of improvements such as insulation and energy efficient heating systems, a significant legal hurdle.

For efficiency upgrades with a relatively short payoff period – short enough that the owner of the dwelling knows he won't sell it in that time -- this can be circumvented by attaching the loan to a person, instead of to the structure. However, this is a non-ideal arrangement, as many desirable power options have reasonably long payoff periods, or can be attached to homes that might reasonably be sold in two to three years.

Some power saving devices – such as rooftop solar thermal heating panels – significantly increase the resale value of the structure, allowing an arrangement where the owner can buy the panels at any time at a discounted rate, allowing them to sell the structure and still reasonably profit.

As a final option, some power systems can be sold with a mandatory contract – for instance, solar panels may be "rented" to the owner of the house on which they are placed, with ownership to transfer from the town to the landholder at the end of the given period. Such contracts can be held to the building, instead of to an individual, and thus circumvent several legal hurdles to clean energy investment.

Generally, when a community decides to make collective investments in the energy efficiency of its homes, there will be a fraction of homes that have to be excluded due to legal difficulties. This is not a problem – so long as some homes are available, investment can continue. Given the limited budgets most communities face, it is not uncommon for there to be more homes then are needed even with legal limitations.

Ranking Available Options

Once a community has determined available funds, the next step is to rank the desirability of the available power options. This process is automated in the Excel file which will be released later, but will be covered here for the sake of completeness. First, the economic data for each power source and technology is listed:

Power Source Technical Data											
Name	Minimum Cost	Average Cost		Marginal Cost		Productivity Ratio		Emissions		Reliability	Predictability
Solar-PV Cells	$ 10,000.00	$ 0.21	$ 1.09	$5,000.00	$10,500.00	11%	27%	3%	13%	None	High

Figure B 1: The economic data for solar-PV cells as it appears in the given Excel file. In order, minimum cost, a range for average cost, a range for marginal cost, a range for productivity ratio, a range for carbon emissions, and reliability figures.

Next, the goals for the target community – as represented in the four metrics – must be listed. This will allow the effective costs and other measures of each power source to be adjusted to reflect how well it fits the community's specific power needs. From this point on, the payback period (real period) is referred to as the "unadjusted" period, to prevent it from being confused with the adjusted period.

	A	B
1	Goal Data	
2	Goal:	Rating:
3	Enviromental	1
4	Cost Efficacy	3
5	Self-Sufficency	2
6	Independence	1

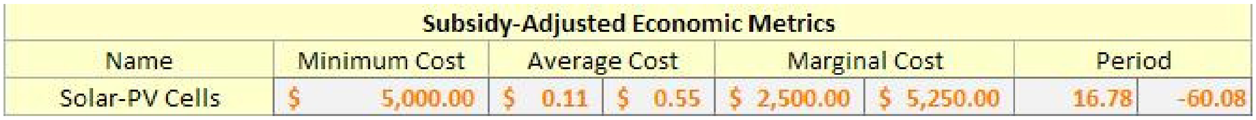
Figure B 2: The goal data for a sample community, as it appears in the Excel file.

After this, the economic data for the community must be listed. Frequently, a community will have access to technology-specific funds. For instance, a grant may be available only for the development of solar power. For this reason, the community's economic data must be listed individually by each power source, as well as generally for the community as a whole. If funds are available for multiple categories but are still limited – for instance, a grant for wind *or* solar power – the full amount should be listed in both categories. Adding $1 to every individual category is identical to adding $1 to the general pool.

Economic Data						
Power Category:	Immediate	Potential	Interest	Subsidy	Purchase (kWh)	Purchase ($/kWh)
General	$ 7,000.00	$ 30,000.00	8%	10%	537,000.00	$ 0.19
Solar PV	$ -	$ 50,000.00	10%	40%		$ -
Wind	$ -	$ 30,000.00	9%	30%	-	$ -

Figure B 3: The economic data for a sample community, showing only the General and Solar-PV lines as they appear in the Excel file. In a full analysis, there would be one additional line for every power source and technology.

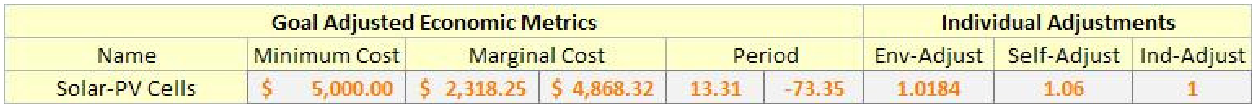
Next, the costs for each power source should be adjusted for any available subsidy, and the unadjusted period calculated. The unadjusted period is calculated as a range, measured in years. The unadjusted period will be used to determine how much real interest a given interest rate adds to a loan. On the Excel file, this is performed in the sheet “Step 1.”



Subsidy-Adjusted Economic Metrics							
Name	Minimum Cost	Average Cost		Marginal Cost		Period	
Solar-PV Cells	$ 5,000.00	$ 0.11	$ 0.55	$ 2,500.00	$ 5,250.00	16.78	-60.08

Figure B 4: The subsidy-adjusted economic and period data for Solar-PV cells at a hypothetical subsidy level, as it appears in the Excel file.

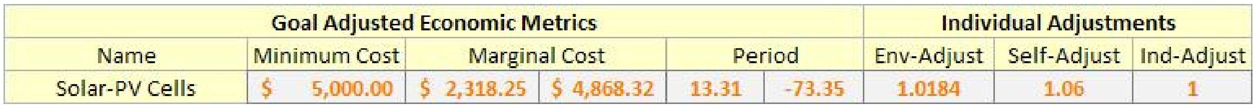
Next, the minimum cost for each power source should be compared to the total possible available funds for that power source. Any power source with a minimum cost higher than such is outside the means of the community at this time, and can be eliminated. Power sources that require the community to draw upon potential funds – in essence, power sources that require the community to borrow money – can then have their costs upgraded to reflect the final true cost of the device, including interest. On the Excel file, this is performed in the sheet “Step 1.” Note that these calculations do not yet include the effects of purchasing promises – that is covered later.



Goal Adjusted Economic Metrics						Individual Adjustments		
Name	Minimum Cost	Marginal Cost		Period		Env-Adjust	Self-Adjust	Ind-Adjust
Solar-PV Cells	$ 5,000.00	$ 2,318.25	$ 4,868.32	13.31	-73.35	1.0184	1.06	1

Figure B 5: The loan-adjusted data for Solar-PV cells at a hypothetical interest rate, as it appears in the Excel file.

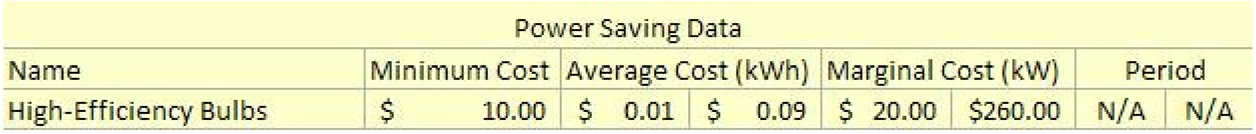
Once adjustments have been made for any necessary loans, it is possible to go from real, cost-adjusted economic data, to goal-adjusted economic data. In this step, the effective output of a power source or technology is adjusted upwards to reflect how well it meets the community’s goals. For instance, a community that ranked 3 on the Environmental Friendliness would add 6% to the effective output of a completely clean, environmentally friendly power source. Less environmentally friendly power sources would benefit less, and an average source would not benefit at all. On the Excel file, this is performed on the sheet “Step 2 and 3.”



Goal Adjusted Economic Metrics						Individual Adjustments		
Name	Minimum Cost	Marginal Cost		Period		Env-Adjust	Self-Adjust	Ind-Adjust
Solar-PV Cells	$ 5,000.00	$ 2,318.25	$ 4,868.32	13.31	-73.35	1.0184	1.06	1

Figure B 6: Goal-Adjusted cost data for Solar-PV cells in hypothetical background conditions, as they appear on the Excel sheet.

The fourth step is the addition of power-saving technologies to the generated table of power sources, so that they can be economically compared to the other options available. The technical information for power savers is included in the “General Technical Data” sheet, and is run through some of the calculations mentioned above. Unlike the power source data however, most of the information for power saving technologies is pre-calculated for the average case in order to make calculations easier. On the Excel file, this is performed on the sheet “Step 4.” Note that, due to the small scale of many power saving devices, their marginal cost is specifically measured in watts, as opposed to kilowatts – the marginal cost of power sources is also measured in watts. Some power savers do not list a period – this indicates that the power saving technology depends heavily on how much it is used. For instance, a light-bulb saves a set amount of energy over the course of its lifespan, but how long it takes to save that sum of energy depends entirely on how frequently the bulb is used.



Power Saving Data

Name	Minimum Cost	Average Cost (kWh)		Marginal Cost (kW)		Period	
High-Efficiency Bulbs	$ 10.00	$ 0.01	$ 0.09	$ 20.00	$260.00	N/A	N/A

Figure B 7: Sample power saving data for high-efficiency bulbs, as it appears in the excel file.

Once this step is completed, the final data set can be calculated. This is included in numerical form under the sheet labeled “Final Output,” and in graphical form on the sheet labeled “Output Graphs.” These two sheets do not contain distinct information – one is a graph of the other, in order to enable easier use of the data.

Appendix C – Summary Information on Various Energy Systems and Conservation Methods