Renewable Energy and Energy Assurance Planning

for Local Governments

LEAP

Local Government Energy Assurance Planning

Public Technology Institute

U.S. DEPARTMENT OF ENERGY

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Public Technology Institute

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Local Government Energy Assurance Planning (LEAP)

To find out more about local government energy assurance efforts, we invite readers to visit www.energyassurance.us. This site, maintained by PTI, supports local governments, large, medium and small, across the nation that want to learn more about creating energy assurance plans for their communities. Once created, these plans help ensure that local governments can provide life-saving services during an energy emergency.

Editorial Team

This publication would not have been possible without the efforts of Erin Sweet and Charles McClelland of The Cadmus Group, Inc. This work was managed by Ronda Mosley, Assistant Executive Director for Research and Government Services, Public Technology Institute.

Renewable Energy and Energy Assurance Planning for Local Governments

1 Overview and Background

Advancements in – and the associated decreases in cost of – renewable energy technologies, such as solar photovoltaic (PV) and wind turbines, have created unprecedented opportunities for local governments to incorporate renewables into their energy portfolios. As a result, local governments are increasingly benefitting from the ways in which renewable energy can support local energy assurance planning goals. By harnessing renewable energy resources, local governments build energy resilience, diversify their energy portfolio, stabilize energy costs, and reduce reliance upon fossil fuels. Renewable energy systems can also provide backup power for critical infrastructure facilities during an energy emergency.

The National Association of State Energy Officials' (NASEO) State Energy Assurance Guidelines outlines two approaches for incorporating renewables into energy assurance planning:[1]

1. A long-term resource planning approach that diversifies, or hardens, energy supplies through the increased use of renewable resources and energy efficiency.

2. A tactical approach that could include renewable backup power to support critical facilities in the event of an energy disruption.

This document outlines the potential role of renewables in each of these approaches to local government energy assurance planning and also discusses the benefits, risks, and implementation challenges of various renewable energy technologies.

2 Long-term Resource Planning Approach to Energy Assurance

The following section introduces renewable and alternative energy options that can be used to diversify local energy portfolios, and thereby increase the resilience of local energy infrastructure. The section outlines the attributes of renewables that are well suited for longer-term (i.e., non-emergency) energy assurance planning. The corresponding guidance for implementation appears in Section 4.

[1] National Association of State Energy Officials (NASEO). *State Energy Assurance Guidelines*, Version 3.1. 2009. http://www.naseo.org/eaguidelines/State_Energy_Assurance_Guidelines_Version_3.1.pdf.

2.1 Why Include Renewables in a Long-Term Approach to Energy Assurance Planning?

2.1.1 Diversifying an energy portfolio increases its resiliency, that is, diversification reduces vulnerability to energy disruptions. Diversification that includes ***renewable energy*** further increases the resiliency of energy infrastructure and allows local governments to benefit from the many additional attributes of these systems, which include contributing to one or more of the following:

- **Energy security.** Renewable energy can provide an abundant, affordable, and diverse energy supply and reduce dependence on imports. Some systems harvest energy from the local environment and may be sited over a wider area than conventional fossil-fuel plants. These "distributed generation" systems add geographic diversity to an energy portfolio, further improving resiliency.[2]

- **Economic development.** Economic benefits of renewable energy can include price stability and decreased costs, which can create financial resiliency. PV systems providing electricity to municipal buildings, for example, help protect against rising and volatile grid electricity rates.

- **Environmental benefits.** Utilizing renewable technologies can also support broader societal goals. By reducing fossil fuel use, local governments can reduce greenhouse gas emissions and help protect air and water resources.

2.2 What Role Can Specific Renewable Energy Technologies Play?

Renewable resources such as wind and solar are renewed constantly, and over a shorter time period, than conventional energy sources. While the potential benefits of renewable energy make it a good fit for a long-term approach to increasing energy resilience, not every system provides the same benefits. Local governments should assess their energy assurance needs and local resources, and prioritize renewable energy efforts accordingly.[3]

2.2.1 Solar Energy

Solar resources can be used to generate electricity (solar PV) or produce heat and hot water (solar thermal). PV systems are particularly well-suited for energy assurance planning purposes due to their ease of implementation, the large geographic region in which they are feasible, and their suitability for powering critical infrastructure.

Solar Energy Technologies and Important Considerations

Solar PV cells are semiconductors that create electricity when exposed to sunlight. Solar PV modules may be mounted on the ground or on buildings, including homes, office buildings, and parking structures. In 2010, 878 megawatts (MW) of grid-connected PV capacity was installed in the United States – a 102 percent increase over 2009 – bringing

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[2] The U.S. Department of Energy (DOE) Wind and Hydropower Technologies Program and the National Renewable Energy Laboratory's (NREL's) National Wind Technology Center (NWTC) define distributed wind applications as wind generation systems of any size that are installed remotely or connected to the grid but at a distribution-level voltage. http://www.nrel.gov/docs/fy08osti/39851.pdf

[3] Also see Section 4, Appendix A, and Appendix B.

total installed PV capacity to 2.1 gigawatts (GW).[4] Solar thermal technology uses flat-plate or tubular collectors to heat water. Heated water is then used to heat and/or cool buildings or provide hot water to building tenants.[5] Installed capacity for solar water and space heating has increased each year since 2004.[6] Concentrated solar power (CSP) uses lenses or mirrors to concentrate the sun's rays on a small area (Figure 1). Due to their size, complexity, and cost, CSP projects are typically developed by utility companies and are generally not appropriate for local energy assurance planning purposes.

Figure 1: CSP System in Kramer Junction, California

While quality solar resources are available throughout most of the United States (Figure 2), site-specific conditions determine individual project feasibility. Even small amounts of shade can significantly decrease PV system production.[7] Structural or geotechnical limitations may also impact feasibility. Roofs, for instance, should be relatively new and have the load-bearing capacity to accommodate these systems. Both roof- and ground-mounted systems require permits.

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[4] Solar Energy Industries Association. *U.S. Solar Market Insight*^{TM}*: 2010 Year in Review: Executive Summary*. 2010. http://www.seia.org/galleries/pdf/SMI-YIR-2010-ES.pdf.

[5] Where solar thermal is used for cooling purposes, air is passed over a common, solid desiccant (e.g., silica gel) to draw moisture from the air. This allows for an efficient evaporative cooling cycle. The desiccant is then regenerated by using solar thermal energy to effectively dry it out, in a cost-effective, low-energy-consumption, continuously repeating cycle.

[6] Solar Energy Industries Association. *U.S. Solar Market Insight*^{TM}*: 2010 Year in Review: Executive Summary*. 2010. http://www.seia.org/galleries/pdf/SMI-YIR-2010-ES.pdf.

[7] While solar PV production decreases exponentially with total shaded area, the relationship between solar thermal collection and total shaded area is more linear. That is, small amounts of shading are not likely to significantly decrease solar thermal collection.

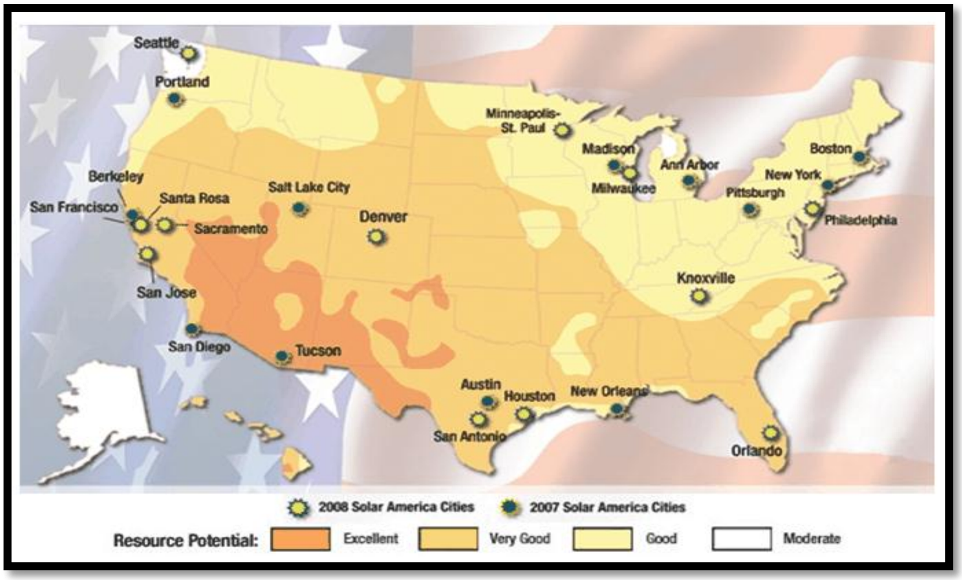

Figure 2: U.S. Solar Resource Potential

Source: U.S. Department of Energy (DOE), Solar America Communities, *http://solaramericacommunities.energy.gov/home.aspx.*

Local governments considering solar energy as part of their energy assurance plans (EAPs) should complete a site assessment to help determine the technical and financial feasibility of a proposed project by estimating costs and potential production. Such studies can prevent the locality from wasting time and money on unviable projects.

Cost Considerations for Renewable Energy Projects

The economic feasibility of any renewable generation system depends on numerous factors, including:

- Equipment costs
- Installation costs
- Site characteristics
- Renewable resource characteristics
- Retail cost of grid electricity
- Availability of project financing
- Availability of incentives
- Operation and maintenance costs

Solar technologies have some of the highest per Watt installed costs of any mature renewable energy technology. As non-taxable entities, local governments are unable to take advantage of federal government tax incentives for these systems. In many States, however, communities can indirectly benefit from tax incentives by entering into third-party ownership agreements, such as solar Power Purchase Agreements (PPA).[8] Utility rebates and net metering incentives are also available in many regions.

Solar Energy for Energy Assurance

Many attributes of solar PV and solar thermal technologies make them a good fit for long-term energy assurance planning. These attributes include:

[8] In solar PPAs, private developers own, operate, and maintain PV systems located on leased municipal land and rooftops. Developers then monetize tax credits and pass these benefits on to local governments in the form of long-term contracts for the sale of electricity produced by the solar PV system at a rate that is, ideally, less than the rate of grid electricity.

- **Mature, proven technology.** Solar technologies have operated successfully for decades. The life expectancy of PV modules is 20 to 30 years, and the life expectancy of solar thermal collectors is 40 years.

- **Decreasing costs.** The installed cost of grid-tied PV systems has decreased dramatically over the last decade. In 2010 alone, the national average non-residential installed system cost fell by more than 10 percent, from $6.36 per Watt to $5.71 per Watt.[9] Costs continue to decrease with advancements in solar technology. While the performance of PV systems will degrade over time, systems require little maintenance, as they typically lack moving parts.

- **Appropriate for diverse applications.** While available space can be a limiting factor, solar energy systems can be designed to match almost any electric or thermal load. Solar PV systems are suitable for both the built environment (e.g., rooftops in densely populated areas) and open spaces (e.g., brownfields, greenfields).

- **Relative ease of deployment.** Solar PV and solar thermal projects generally require less permitting than other renewable energy projects and therefore can be implemented in less time. Due to their low visual impact, solar projects tend to attract relatively little opposition.

- **Predictable output.** Solar resources are more predictable than wind. If these systems are properly sited and technically sound, they generally operate as expected.[10] Predictable output provides for easier energy budgeting.

Case Study: Solar America Cities Offer Best Practices for Community Solar

In 2007 and 2008, DOE selected 25 major U.S. cities including Ann Arbor, Denver, Orlando, Seattle, and Boston as Solar America Cities, the foundation for DOE's Solar America Communities program. Partnerships between the federal government and the Solar America Cities have allowed DOE to help identify and overcome barriers to solar PV development.

SOLAR AMERICA COMMUNITIES

Lessons learned and best practices from the program are outlined in *Solar Powering Your Community: A Guide for Local Governments*. This guidebook outlines successfully field-tested policies and programs, including feed-in tariffs, solar access ordinances, and property tax incentives. Benefits, implementation tips, case studies, and additional resources and references are provided for each policy and program.

Sources: U.S. DOE. Solar America Communities Program. October 2011. http://solaramericacommunities.energy.gov/home.aspx.

U.S. DOE. *Solar Powering Your Community: A Guide for Local Governments.* January 2011. http://solaramericacommunities.energy.gov/resources/guide_for_local_governments.

[9] Solar Energy Industries Association. *U.S. Solar Market Insight™: 2010 Year in Review: Executive Summary*. 2010. http://www.seia.org/galleries/pdf/SMI-YIR-2010-ES.pdf.
[10] Except under atypical weather conditions.

2.2.2 Wind Energy

Wind turbines harness the power of the wind for the production of electricity. Wind power can be an attractive component of energy assurance planning as it is one of the most abundant and cost-competitive renewable energy resources.

Wind Energy Technologies and Important Considerations

Wind projects face many potential fatal flaws – perhaps more than any other renewable energy technology – including available wind resources, available space, site control, and environmental issues. Just one of these issues can make a project technically or economically infeasible.

Wind energy projects can range in size from several kilowatts to many megawatts. The success of a wind project is largely dependent on the local wind resource quality (a minimum average wind speed of 6.0 meters per second at hub height[11] is typically necessary for a project to be economical). The need for smooth, consistently strong winds greatly restricts the area where wind turbines may be practically deployed. Wind feasibility studies, which examine the viability of wind development at a particular site, typically occur once candidate sites have been screened in a preliminary fatal-flaws analysis.[12] Environmental impact and electrical interconnection studies may also be necessary to help determine potential impact on the environment (e.g., avian mortality) and on the electric grid.

Noise considerations and potential shadow flicker require adequate set-back distances between the location of the turbine and nearby residences. Many areas have acoustic impact thresholds that limit the increase from ambient noise conditions at neighboring property lines. Local, county, and State governments determine setbacks, which vary based on the nature and use of the adjacent property. Typically, a turbine must be sited three times the blade tip height,[13] at minimum, from nearby property lines. Not all wind turbines are large enough to trigger these concerns, and local governments may benefit from wind projects of any size.

On-shore wind projects are less expensive than most other renewable energy systems on a per-kilowatt-hour (kWh) basis. As with all energy projects, the cost of electricity generated by a specific wind system is a function of the installed cost, which, in addition to the system cost, depends on site factors such as electrical infrastructure, road access, and soil type. Larger systems often require significant upfront capital costs associated with establishing project feasibility (e.g., wind resource monitoring, environmental impact assessment, complex permitting, etc.). Some States offer grants to help communities fund wind feasibility studies or construction.

Wind Energy for Energy Assurance

[11] A turbine's hub height is measured from the ground to the center of the turbine's rotor.
[12] Full feasibility studies are standard requirements for projects larger than 600 kilowatts (kW).
[13] Blade tip height is the turbine's height, including the length of the blades. Blade tip height is measured from the ground to the tip of a blade at its highest point.

Attributes of wind energy that make it suitable for long-term energy assurance planning include:

- **Mature, proven technology.** Wind is now the fastest growing source of electricity in the world – more wind power was installed in the United States in 2007-2008 than in the previous 20 years combined. Today, total U.S. wind power capacity exceeds 42 GW.[14]

- **Scalability.** Successful wind projects range from several kilowatts to many megawatts. In general, larger turbines provide lower-cost electricity than smaller turbines due to economies of scale.

- **Water savings and other environmental benefits.** Electricity generation is estimated to be responsible for 49 percent of all water withdrawals in the United States, followed by irrigation at 31 percent.[15] Wind energy, however, does not require water for cooling. Wind systems also help avoid air pollution and emissions from conventional fossil-fired power sources.

- **Significant direct revenue potential.** While capital costs may be high for the installation of large wind projects, municipalities can benefit from significant property taxes paid by developers. Wind projects can also provide lease payment income to landowners exceeding thousands of dollars each year, depending on project size.

Case Study: Loess Hills Wind Farm Offsets 100 Percent of Electricity Use in Rock Port, Missouri

Some communities are going beyond diversification to transform their energy portfolio. In Rock Port, Missouri, four 1.25-MW wind turbines produce more than enough electricity to meet local electricity needs. The Loess Hills Wind Farm generates approximately 16 million kWh each year – exceeding the city's annual historic use of 13 million kWh.

Since the project was completed in 2008, the City has benefitted from the sale of excess electricity to neighboring municipalities, property taxes paid by the developer, and reduced transmission costs previously associated with bringing power to this remote part of Missouri. The project will also offset an estimated 10,000 metric tons of carbon dioxide annually, equivalent to taking 2,000 cars off of the road each year.

Sources: Wind Capital Group. "Loess Hills." Accessed January 6, 2012. http://www.windcapitalgroup.com/projects/loesshills.aspx.

National Public Radio (NPR). "Missouri Town Is Running On Vapor — And Thriving." August 9, 2008. http://www.npr.org/templates/story/story.php?storyId=93208355.

[14] U.S. Department of Energy. "Wind Powering America: U.S. Installed Wind Capacity." Last updated September 30, 2011. http://www.windpoweringamerica.gov/wind_installed_capacity.asp#current.

[15] U.S. Department of the Interior, U.S. Geological Survey. *Estimated Use of Water in the United States in 2005*. By Joan F. Kenny, *et al*. September 2009. http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf.

2.2.3 Hydropower

Hydropower technologies convert energy from moving water into electricity. The durability, dispatchability, and scalability of hydropower make it well-suited to long-term energy assurance planning.

Hydropower Technologies and Important Considerations

Hydropower systems, which use flowing water to generate electricity, may include dams or take advantage of existing terrain and rivers. Water released from the dam or diverted from a river spins turbines, which are connected to electric generators. The appropriate system type for a given site depends on terrain, river flow, water quality, and rainfall. Impoundment hydropower uses dams to create reservoirs. Diversion or "run-of-river" systems use a portion of a flowing river without relying on damming, and therefore have less environmental impact. In some hydropower systems, water is pumped from a lower reservoir to a higher reservoir; when electricity demand increases, water is released, passing through turbines.[16] This is known as pumped storage hydropower.[17]

Large-scale hydropower projects can create significant economic development and new jobs, in addition to low-cost electricity; however, new projects have high capital costs and require significant planning efforts. Such projects also face environmental concerns (e.g., flooding, fish migration) and require extensive permitting. Local governments considering large-scale hydropower projects should consult the U.S. Federal Energy Regulatory Commission (FERC), the region's utility company, and neighboring communities.

The per-kWh cost of electricity from run-of-river systems is higher and more difficult to predict than impoundment systems, as they are subject to seasonal or other variations in available water. Run-of-river systems, however, have less impact on the environment and are easier to implement.

Head – the vertical distance that water travels in a hydropower system – influences system output, required equipment, and cost. High-head systems require less water to produce a given amount of electricity, and lower-cost equipment can be used.[18] Small-scale hydropower systems are largely infeasible where the vertical drop is less than two feet; however, required head can be created where none exists naturally. For example, cities and towns are increasingly using their drinking water treatment infrastructure to generate electricity (see case study below).

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[16] Idaho National Laboratory. "Hydropower: Types of Hydropower Facilities." Last updated July 2005. http://hydropower.inel.gov/hydrofacts/hydropower_facilities.shtml.

[17] Emerging technology has also made it possible to generate electricity, as well as thermal energy, from ocean currents and tides. These are known as hydrokinetic systems.

[18] Tester, Jefferson W., *et al*. *Sustainable Energy: Choosing Among Options.* 2005. Print.

Case Study: Hydroelectric Turbine at Drinking Water Treatment Plant in Lee, Massachusetts

Providing water and wastewater treatment services can be extremely energy-intensive. An estimated three percent of total U.S. energy consumption is used for these purposes.

The Town of Lee, Massachusetts operates a water treatment facility that provides more than 300 million gallons of drinking water to customers each year. To help meet the energy needs of this facility through on-site renewable power generation, the town optimized its 80-kW hydroelectric microturbine system and installed a 34-kW solar PV system. The more efficient hydroelectric turbine now generates enough electricity to meet 50 percent of the facility's annual needs – a cost savings of $28,000 each year.

While these renewable energy investments were 100 percent funded by the American Recovery and Reinvestment Act (ARRA), Lee would have seen a positive cash flow in the first year of the project due to electricity savings and the existing Massachusetts market for solar renewable energy credits (SRECs).

Source: U.S. Environmental Protection Agency. *Achieving Zero-Net Energy at Drinking Water and Wastewater Facilities.* EPA-830-F-10-002. August 2010. http://www.mass.gov/dep/water/priorities/zeronet.pdf.

Hydropower for Energy Assurance

Attributes of hydropower that make it a good fit for long-term energy assurance planning include:

- **Mature, proven technology.** Water has been used to perform work for centuries. Today, hydropower produces approximately 20 percent of the world's electricity.[19]

- **Robust and durable.** Hydropower, perhaps more than any other renewable energy technology, is appropriate for very long-term energy assurance planning. The average lifetime of hydropower facilities is 50 to 100 years.[20]

- **Dispatchability.** Hydropower systems can store energy in reservoirs through damming or pumping. Unlike intermittent resources (e.g., solar, wind), hydropower systems can release water on-demand to meet increased need for electricity. Hydropower's dispatchability makes it suitable for helping a locality transition away from baseload generators such as nuclear or coal-fired facilities.[21]

- **Scalability**. Hydropower system sizes can range dramatically – from a few kW to 10,000 MW or more. Local governments can pursue the most appropriate project size based on their needs and resources.

[19] *IBID.*
[20] U.S. Department of the Interior, U.S. Geological Survey. *Advantages of Hydroelectric Power Production and Usage.* Last updated December 2011. http://ga.water.usgs.gov/edu/hydroadvantages.html.
[21] Baseload generators such as nuclear and coal-fired facilities are used to constantly generate a baseline amount of electricity. Dispatchable generators generate electricity at the request of power operators when baseline demand is exceeded. Output from intermittent generators such as wind turbines, however, cannot be controlled by power operators.

- **Abundant and affordable.** DOE estimates that over 30,000 MW of electricity can still be harnessed from hydropower in the U.S.[22] A significant portion of the additional capacity may come from distributed, low-head projects.

- **Ability to expand or optimize existing facilities.** In early phases of energy assurance planning, local governments might consider expanding or optimizing existing hydropower systems. Retooling existing hydropower facilities may allow local governments to benefit from modern hydroelectric turbines, which are more efficient and environmentally friendly than older turbines.

2.2.4 Biomass, Biogas, and Alternative Fuels

Biomass is derived from plant and animal matter (e.g., microorganisms). Wood, grasses, landfill gas, and even municipal solid waste can be converted to useful forms of energy, including electricity, heat, and alternative fuels. Biomass is well-suited for energy assurance planning as it is often compatible with existing energy infrastructure and may involve local, low-or no-cost waste feedstocks such as crop wastes.

Biomass Technologies and Important Considerations

Biomass is created by the conversion of solar energy to high-energy organic compounds.[23] Biomass technologies convert this energy into useful forms. Woody materials can be pressed into pellets for space heating or burned to generate electricity. Barn waste (e.g., manure) can be collected into digesters that separate methane gas from liquid and solid wastes, and the methane may be burned to generate heat or electricity. Transportation fuels (e.g., biodiesel, ethanol) are also derived from biomass. Biodiesel is made from vegetable and animal fat; ethanol is made from high-starch crops (e.g., corn).

Biomass resource availability is dependent on growing conditions and operable space. Much land is required to produce a small amount of biomass energy. Since intense cultivation can threaten water resources and compromise soil conditions, biomass is probably best suited for distributed use (e.g., wood waste to pellets for space heating).[24]

Biomass systems are associated with environmental impacts such as carbon dioxide and particulate emissions. In regions with poor air quality, local governments incorporating biomass into their energy portfolios should first consider non-generation systems to limit emissions.

The cost of energy from biomass-based systems is higher than that of energy from fossil fuel-based systems on a per-kWh basis. Costs are reduced, however, where the biomass feedstock is low- or no-cost (e.g., waste inputs such as urban wood waste and mill residues). The cost of biomass feedstocks such as municipal or food waste can be negative where waste collectors are paid to remove the biomass.

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[22] Idaho National Laboratory. "Undeveloped Hydropower Potential by State." Last updated December 2006. http://hydropower.inel.gov/hydrofacts/undeveloped_potential.shtml.
[23] Carbohydrates are made by plants, for example, using chlorophyll, carbon dioxide, and water.
[24] Managing environmental issues is still important at this small scale; many new wood stoves include catalytic converters to reduce emissions.

Biomass for Energy Assurance

Attributes of biomass that make this renewable energy resource a good fit for long-term energy assurance planning include:

- **Abundant and affordable.** Biomass feedstocks are diverse and abundant. More than one billion tons of biomass are available annually in the United States.[25] Even waste matter can be used as a feedstock – and biomass projects can be used to help manage municipal wastes.

- **Appropriate for diverse applications.** Biomass can be used to generate electricity, heat, or alternative fuels, and systems can be scaled to meet any load. Biomass can be co-fired with coal in existing coal-fired power plants; in a much smaller and more distributed application, it can be used to heat homes.

- **Baseload resource.** Biomass-based generators, which can constantly provide power, are an especially good fit for communities trying to move away from an energy portfolio dominated by conventional baseload generators.

- **Protection against fossil fuel shortages, price increases, and volatility.** Local governments are increasingly converting their municipal fleet to alternative fuel vehicles (and partnering to take advantage of bulk purchase pricing) to protect against fuel price volatility and make energy budgeting easier.

Case Study: Improving Air Quality and Creating Savings with Alternative Fuel Vehicles in Columbus, Ohio

Columbus, Ohio – ranked the nation's fourth cleanest city – has helped improve local air quality by converting its municipal fleet to alternative fuels. The city is also benefitting from the resulting cost savings and protection against fossil fuel prices and price volatility.

In 2007, the city began using biodiesel in snowplows and other heavy-duty vehicles. In its Green Fleet Action Plan, the city set goals for fleet conversion, including annual targets for petroleum use and purchases of new, "green" on-road vehicles and/or equipment. Through this initiative, Columbus replaced close to one million gallons of petroleum with biodiesel in 2009 alone.

Sources: U.S. Department of Energy. "Natural Gas Fleet Experiences: Columbus Strives to Become No. 1 Cleanest City." Last updated January 4, 2010. http://www.afdc.energy.gov/afdc/progs/fleet_exp_fuel.php/NG.

City of Columbus. *City of Columbus Green Fleet Action Plan, 2009 Year-end Update.* Issued January 1, 2008. http://columbus.gov/uploadedFiles/Area_of_Interest/Get_Green/Documents_and_Principles/GreenFleetUpdate09YrEnd.pdf.

2.2.5 Geothermal

Radioactive decay within the earth's core creates a continuous source of heat called geothermal energy. Geothermal resources, including steam and hot water, vary by site

[25] U.S. Department of Agriculture and U.S. Department of Energy. *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*. USDA/DOE, DOE/GO-102005-2135. By Robert D. Perlack, *et al*. April 2005. http://www1.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf.

and may be used for generating electricity or heat. While not all cities and towns are close to high-grade geothermal resources (e.g., Yellowstone National Park), all regions can take advantage of ultra-low grade geothermal resources.

Geothermal Technologies and Important Considerations

While the majority of the country does not have access to high-grade geothermal resources (i.e., those that naturally produce hot water or steam), low-grade geothermal resources are nearly ubiquitous. Geothermal heat pumps (GHPs) use ultra low-grade geothermal resources for heating and cooling, making them a good fit for those areas without high-grade geothermal resources. GHPs use the constant temperature of the earth at shallow depths as a heat source or sink.

Large-scale, or high-grade, geothermal energy plants tap into geothermal reservoirs that contain heat to produce electricity. These plants use processes similar to the fossil fuel industry, and therefore present similar environmental issues as conventional energy projects (e.g., waste heat, noise, visual impact, induced seismic activity). For example, extracting heat from liquid geothermal reservoirs releases dissolved carbon dioxide and hydrogen sulfide gasses into the atmosphere (emissions of nitrogen oxides and sulfur dioxide, primary compounds responsible for acid rain, are greatly reduced in comparison with conventional coal plants).

There are significant barriers to expanding large-scale geothermal development in the United States. Exploring geothermal resources is costly, and few policies or incentives encourage more wide-scale investment in these resources. All communities, however, can take advantage of GHPs and might do well to consider implementing local GHP projects.

Geothermal for Energy Assurance

Geothermal systems, too, may be a good fit for long-term municipal energy assurance planning.

- **Mature, proven technology**. Geothermal resources were first used to produce electricity at the turn of the 19th century. Current U.S. geothermal generation capacity is 2,930 MW, with another 2,900 MW of capacity planned. DOE estimates that the continental U.S. has more than 100,000 MW of potential geothermal capacity.[26]

- **Baseload and peaking resource.** Geothermal resources are constantly available, naturally stored within the geothermal reservoir, and may be dispatched when needed. As such, these systems can be baseload or peaking systems – useful for local governments trying to reduce their dependence on fossil fuels ranging from coal (generally a baseload resource) to natural gas (generally a peaking resource).

[26] U.S. Department of Energy, Geothermal Technologies Program. "How an Enhanced Geothermal Systems Works." Last updated February 16, 2011. http://www1.eere.energy.gov/geothermal/egs_animation.html.

- **Both high- and low-grade geothermal resources can be advantageous.** Cities and towns far from high-quality geothermal resources can still take advantage of GHPs that use ultra low-grade geothermal resources. Even in Alaska, GHPs are used to keep greenhouses warm and support year-round agriculture.

- **Protect against natural gas and heating oil price volatility.** Using geothermal resources for heating (e.g., direct heating, geothermal heat pumps) provides protection from the volatility of natural gas and heating oil markets.

2.2.6 Combined Heat and Power (CHP)

Combined heat and power (CHP) systems produce electricity and heating or cooling from a single energy source. In the United States, more than two-thirds of fuel used to generate power is lost as waste heat.[27] Also known as cogeneration systems, CHP systems recover this heat to provide useful thermal energy. CHP systems use less fuel than conventional systems to provide the same amount of useful energy.

CHP systems provide distributed energy and environmental benefits, and they are a very cost-competitive alternative energy option.[28] CHP systems can help local governments decrease fuel use, decrease energy costs, and increase energy supply reliability.

CHP Technologies and Important Considerations

CHP systems are integrated systems that can use a different technology based on individualized needs. Commonly, a gas turbine or steam boiler is used to produce electricity, and an appropriate recovery system captures waste heat for heating and cooling purposes. While systems typically burn natural gas, biomass or biogas can also be used as a fuel source.

Project payback time varies based on the efficiency of the CHP system, the cost of electricity, the price of fuel, and whether or not the system is connected to the electric grid. CHP is presently an underutilized technology, given its cost-competitiveness and other benefits. Barriers to CHP deployment on a larger scale include a lack of familiarity with CHP technologies, utility business practices, regulatory ambiguity, environmental permitting, tax treatment, and interconnection requirements.[29]

CHP for Energy Assurance

CHP systems can be a good fit for long-term energy assurance planning in many communities.

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[27] U.S. Department of Energy, Oak Ridge National Laboratory. "Combined Heat and Power: Effective Energy Solutions for a Sustainable Future." By Anna Shipley, *et al*. December 2008. http://www1.eere.energy.gov/industry/distributedenergy/pdfs/chp_report_12-08.pdf.
[28] *IBID*.
[29] U.S. Department of Energy, Oak Ridge National Laboratory. "Combined Heat and Power: Effective Energy Solutions for a Sustainable Future." By Anna Shipley, *et al*. December 2008. http://www1.eere.energy.gov/industry/distributedenergy/pdfs/chp_report_12-08.pdf.

- **Mature, proven technology**. CHP systems are already used by many large industrial, commercial, and institutional facilities, such as hospitals, universities, and wastewater facilities.

- **Very high efficiency.** CHP systems not only use less fuel than conventional electricity generators, they are more efficient. CHP systems can be up to 90 percent efficient, while conventional electricity generation is typically 30 to 40 percent efficient.[30]

- **More cost-effective than other alternative energy options.** Developing CHP systems may be easier for many local governments to implement, as these systems are often more cost-competitive than renewable energy systems. Local governments might consider CHP projects for near-term energy assurance planning.

3 Tactical Approach to Energy Assurance: Protecting Critical Infrastructure

Critical infrastructure is essential for maintaining public safety and protection, public health, information security, and other societal needs. During an energy disruption or emergency, it is therefore important to ensure energy continuity for critical infrastructure.

While Section 2 outlines the potential role of renewable energy in longer-term resource planning for energy assurance, this section explores the steps that can be taken at the local level to prepare for energy emergencies (e.g., natural disasters, deliberate attacks on energy infrastructure), and the potential role of renewable energy. Such a tactical approach to energy assurance planning will help mitigate negative consequences, maintain critical services, and facilitate rapid recovery after such an event.

3.1 Why Include Renewables in a Tactical Approach to Energy Assurance?

Attributes of renewable energy that make it well-suited for helping ensure energy continuity include:

- **Enhanced reliability.** Renewable energy systems are typically connected to the grid, and will not operate in the instance of grid failure. Renewable energy generators, however, may be integrated with a diesel generator ("genset") and/or battery storage for providing power in areas without a grid connection. These systems are typically referred to as hybrid power systems (HPSs), and can be installed in areas with grid-power for the purpose of maintaining energy continuity. Such systems are commonly installed in hospitals, schools, and industrial facilities, and can be configured to meet a variety of load sizes and profiles. Typical renewable HPSs feature solar PV systems or wind turbines, combined with a battery bank. Diesel gensets, which can provide dispatchable

[30] NAHB Research Center. "Combined Heat and Power Systems for Residential Use." Accessed January 8, 2012. http://www.toolbase.org/Technology-Inventory/Electrical-Electronics/combined-heat-power

power and/or battery recharging capabilities, significantly enhancing the reliability of the system.

- **Longevity.** Properly designed renewable energy systems can help maintain energy continuity for key facilities throughout extended energy disruptions. Shorter-term solutions such as diesel generation may only provide backup power for minutes or hours.[31]

- **Protect against fuel shortages**. Fuel routing challenges can prove formidable during extreme weather and other natural disasters. For instance, a community may have diesel fuel stockpiles, but may not be able to transport the fuel during an emergency. Where alternative, renewable energy sources are already in place, the impact of such challenges can be greatly reduced.

3.2 Ensuring Energy Continuity during Grid Outages with Hybrid Power Systems

Renewable HPSs capable of operating without grid power are particularly well-suited for maintaining energy continuity for decentralized emergency response infrastructure such as hospitals and police stations.[32] Despite the increased cost of electricity from an HPS as compared to electricity from the grid, these systems are increasingly used to provide energy continuity to critical infrastructure, given the importance of these facilities and services during emergencies.

Distributed, renewable energy systems are ideally suited to HPSs, as they extract energy from their local environment which can then be stored onsite in a battery or used to supply a critical load. For this reason, renewable HPSs can be more resilient and long-lasting than conventional, diesel hybrid systems, since functionality of the latter depends upon fuel availability.

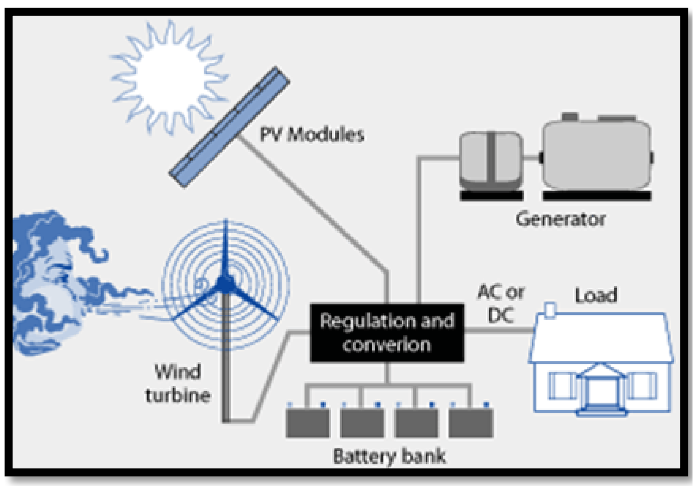

Figure 3: Hybrid Renewable Power System
Source: U.S. Department of Energy, Energy Savers. "Small 'Hybrid' Solar and Wind Electric Systems." Last updated February 2, 2011.
http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=11130.

Renewable HPSs are highly robust, as they are capable of

[31] For a definition of critical infrastructure, see: U.S. Department of Homeland Security (DHS). "Critical Infrastructure." Last updated November 30, 2010.
http://www.dhs.gov/files/programs/gc_1189168948944.shtm and Public Technology Institute (PTI). *Local Government Energy Assurance Guidelines, Version 2.0.* 2011. p. 8.
http://dl.dropbox.com/u/14265518/leap/PTI_Energy_Guidelines.correx.v2.pdf.

[32] This assumes that the renewable HPS is installed onsite and that the energy emergency or disruption affecting the electric grid (e.g., severe weather) has not damaged the HPS or its connection to the facility it serves.

self-recharging. High storage capacity can help ensure continued operation even when renewable resource availability is low. These systems also reduce total fuel consumption by the conventional generator component of the system; again, this is especially important when energy emergencies limit access to fuel. Figure 3 illustrates a highly resilient renewable HPS consisting of a wind turbine and solar array coupled with a fuel-powered generator and battery storage.[33]

Utilizing renewable energy to meet the needs of critical infrastructure in times of grid failure requires a higher level of sophistication in system design, infrastructure, and control. Depending on the size and complexity of the system, HPSs may require power electronics for power conversion and regulation, as well as switch gear and other controls. More complex systems can require more maintenance than conventional renewable energy systems or HPSs without a renewable energy component. Due to these complexities, renewable HPSs generally exceed 500 kW, although a variety of capacity options are possible. HPSs can be designed to meet a variety of low-draw continuous power needs (e.g., remote telecommunications stations); however, the cost of power from HPSs, like any energy generation system, typically increases as system size decreases. Given the importance of critical infrastructure to public health and safety, many local governments may find that the benefits of energy continuity offered by renewable HPSs outweigh the costs.

Case Study: City of Boston Pilots Solar-Powered Evacuation Route

The City of Boston, Massachusetts has incorporated solar PV into its emergency preparedness planning to ensure the continuity of emergency evacuation lighting. An emergency preparedness survey of city departments (including the Police, Fire, Transportation, and Emergency Medical Service Departments) explored how solar PV could best be used to support emergency preparedness in Boston. As a result, the city is piloting a program aimed at ensuring the continued operation of traffic and street lighting and emergency-related equipment along routes identified in Boston's mass evacuation plan.

In its pilot phase, critical evacuation infrastructure along one emergency evacuation route will have off-grid functionality. This route will be equipped with 21 "solarized" intersections, 27 light emitting diode (LED)-solar streetlights, five solar-powered message boards, and 10 solar radio repeaters. A hybrid renewable power system (a 50-kW solar PV system and battery backup) will be installed atop the city's main emergency vehicle fueling station. This pilot project was funded with a $1.343 million ARRA grant to the city.

Source: U.S. Department of Energy. "Solar in Action: Challenges and Successes on the Path Toward a Solar-Powered Community." September 2011. http://solaramericacommunities.energy.gov/pdfs/boston.pdf.

4 Recommendations and Next Steps

Renewable energy can play a significant role in energy assurance planning by helping to ensure energy continuity, stabilize energy costs, and offset supply disruptions. The extent to which renewables can be incorporated into a local EAP is ultimately a function of natural and capital resources. The following steps can help local governments evaluate

[33] U.S. Department of Energy, Energy Savers. "Small 'Hybrid' Solar and Wind Electric Systems." Last updated February 2, 2011. http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=11130.

the compatibility of available renewable resources with their energy assurance goals and incorporate renewables into their energy portfolio:

- **Locate technical assistance, as needed.** Evaluating the potential benefits of any renewable energy project necessitates a thorough understanding of the site, including resource, load profile, and local environment. Tap into the expertise of your State's energy department, your utility company, or local academic institutions for technical assistance. Valuable guidance may also be gained from neighboring municipalities that have explored or implemented renewable energy projects.

- **Use available tools to assess what, if any, renewable energy resources are available in your community.** Free, online resource assessment tools can help focus energy assurance planning efforts (see Appendix A for a list of online site and resource assessment tools). Identify available renewable resources and estimate the feasible capacity of appropriate renewable energy systems. While some of the tools available in Appendix A can assist with preliminary planning, detailed feasibility assessments may require professional consultation.

- **Conduct a consequence analysis to anticipate the effects of energy emergencies.** Determine the extent of impact that energy emergencies would have on the operation of existing and potential backup energy systems. Consider the fuels in your energy portfolio (e.g., diesel generation may be compromised by fuel supply disruptions). No single system will be resilient to all disaster types. Floods, for example, render most ground-based power systems inoperable, including hybrid power systems.

- **Identify resiliency goals for power systems.** Consider the level of redundancy desired to keep critical facilities and services in operation. This will have a direct impact on the system configuration, as well as the size of the generator and any associated storage. For example, a renewable HPS that includes three renewable energy systems, a conventional generator, and battery backup will provide greater assurance of energy continuity than a renewable HPS with two renewable energy systems and no conventional generator component.

- **Compare the cost effectiveness and resiliency of conventional and renewable energy systems.** While there are many reasons to incorporate renewable energy into an EAP, conventional systems may be more practical and economical for a particular load or location.

- **Align energy assurance efforts with other municipal planning initiatives.** Coordinate with other local governments to take advantage of possible synergies. Bulk financing and/or purchasing (e.g., communities might purchase solar PV system components together to benefit from lower prices) is just one of the ways in which municipalities can work together to achieve energy assurance goals.

- **Explore funding opportunities.** Visit the online database of State renewable energy incentives (DSIRE)[34] for a comprehensive overview of loan programs, rebates, and tax incentives available in your area. Refer to Appendix C for specific resources related to incentives and relevant regulations, which vary by technology and region.

- **Continue energy efficiency efforts.** Energy efficiency is the most cost-effective energy investment. Energy efficiency improves resilience of local energy infrastructure by displacing demand for fossil fuels, reducing strain on the grid, and decreasing the load to be served by a renewable HPS or other backup system (and the cost of such a backup system). For more information on energy efficiency, see PTI's *Energy Efficiency and Energy Assurance Planning for Local Governments*.[35]

Key Questions

Addressing Renewable Energy Options for Energy Assurance Planning

1. Which renewable technologies are best for the locality (wind, solar, geothermal, or other)?
2. What renewable technologies are already in place and what has been the experience with these technologies (e.g., lower/higher than anticipated operation and maintenance costs)?
3. What are local utilities doing in the renewables area, and is it possible to participate in any of the programs that they are managing (e.g., renewable energy rebate programs)?
4. What expertise can be gained from the local energy assurance planning team, State energy department, local utilities, neighboring communities, and renewable energy developers?
5. Are there any State, federal, utility, or private sector incentives offered on renewable technologies that could be used at the local level?
6. Is it feasible to partner with other local or regional governments on a mass purchase of renewables to decrease costs?
7. Is there a public education and/or outreach program that should be implemented along with the renewable technologies that are under consideration?
8. What training will be required of emergency providers and other local staff to ensure operation of systems under emergency and non-emergency conditions?
9. Do your financial models for your renewable energy project include estimated operation and maintenance costs? Is there a plan in place for allocating operation and maintenance funds when needed and managing this work?

[34] U.S. Department of Energy, Interstate Renewable Energy Council, and N.C. State University, North Carolina Solar Center. "Database of State Incentives for Renewables & Efficiency." Undated. http://www.dsireusa.org/incentives/index.cfm?state=us.

[35] Public Technology Institute (PTI). *Energy Efficiency and Energy Assurance Planning for Local Governments.* Forthcoming in 2012. Will be available at www.energyassurance.us.

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Appendix A: Site and Resource Assessment Tools

There are numerous tools available to help local governments calculate potential costs, energy savings, production, and viability of renewable resource projects. Table 1 summarizes several of the renewable energy resource and site assessment tools available online.

However, as any renewable energy project includes financial risk, energy assurance planners should be prepared to seek expert advice to facilitate the evaluation of these projects. Resources provided in Appendix B are meant to provide initial guidance.

As a first step, local governments should evaluate their baseline (i.e., non-emergency) energy use. To better understand overall municipal energy use or learn more about energy use at specific critical facilities, local governments can access a number of online tools, such as the U.S. EPA's ENERGY STAR measurement and tracking tool, Portfolio Manager.[36]

Table 1: Online Site and Resource Assessment Tools

Online Site /Resource Assessment Tool	Renewable Resource Examined	Provider	Outputs
HOMER[37]	Hybrid Renewable Power Systems (including PV, Wind, Biomass, Hydro, Diesel Generation, CHP, Batteries, etc.)	National Renewable Energy Laboratory (NREL)	• Simulations of different hybrid renewable power systems to optimize costs and benefits • Electricity production • Capital and operating expense
PVWatts[38]	Solar PV	National Renewable Energy Laboratory (NREL)	• Electricity production • Value of energy produced (i.e., savings)

[36] http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager. DOE-sponsored building energy tools are listed at http://apps1.eere.energy.gov/buildings/tools_directory/doe_sponsored.cfm. Additional building energy software tools for evaluating energy efficiency, renewable energy, and sustainability factors are listed at http://apps1.eere.energy.gov/buildings/tools_directory/subjects_sub.cfm.

[37] HOMER URL: http://www.homerenergy.com/.

[38] PVWatts URL: http://www.nrel.gov/rredc/pvwatts/.

Online Site /Resource Assessment Tool	Renewable Resource Examined	Provider	Outputs
In My Backyard[39]	Solar PV or Wind	U.S. National Renewable Energy Laboratory (NREL)	**For Wind:** • Wind resource • Electricity production **For Solar:** • Economics (e.g., system cost, payback, available incentives) • Electricity production • Comparison of system output with site's load profile
DSAT (Distributed Wind Site Analysis Tool)[40]	Wind	U.S. Department of Energy	• Wind resource • Electricity production • Visual impact map • Environmental benefits • Site elevations map
BioFuels Atlas[41]	Biomass and Biofuels Feedstocks	National Renewable Energy Laboratory (NREL)	• Comparison of biomass resources across locations • Biofuels potential for a given area • User-generated queries
GREET Fleet Footprint Calculator[42]	Alternative Fuel Potential for Vehicle Fleets	U.S. Department of Energy, Argonne National Laboratory, Great Plains Institute	• Petroleum footprint of vehicle fleet • Greenhouse gas footprint of vehicle fleet • Comparison of different alternative fuels and vehicle technologies for hypothetical vehicle purchases
Virtual Hydropower Prospector[43]	Water Resources	Idaho National Laboratory	• GIS maps of natural stream water energy resources • Gross power potential • Locations of feasible potential projects • Context features (e.g., roads, power infrastructure, land use)
RETScreen Ground-Source Heat Pump Model[44]	Ground-couple, Groundwater, and Surface Water Heat Pumps	Natural Resources Canada	• Energy production • Savings • Costs • Greenhouse gas emission reductions • Financial feasibility
RE Atlas[45]	Hydro, Geothermal, Biomass, CSP, Solar PV, Wind, Wave Power Density	National Renewable Energy Laboratory (NREL)	• Comparison of resources across locations • Renewable resource potential for a given area • User-generated queries

[39] In My Backyard URL: http://www.nrel.gov/eis/imby/.
[40] DSAT (Distributed Wind Site Analysis Tool) URL: http://dsat.cadmusgroup.com/.
[41] BioFuels Atlas URL: http://maps.nrel.gov/biomass.
[42] GREET Fleet Footprint Calculator URL: http://greet.es.anl.gov/fleet_footprint_calculator.
[43] Virtual Hydropower Prospector URL: http://hydropower.inel.gov/prospector/index.shtml.
[44] RETScreen Ground-Source Heat Pump Model URL: http://www.retscreen.net/ang/g_ground.php.
[45] RE Atlas URL: http://maps.nrel.gov/re_atlas.

Appendix B: Understanding the Renewable Energy Development Process: A Guide for Local Governments

Local governments are not typically in the business of developing, owning, and operating renewable energy systems. As a result, public entities may encounter many challenges when undertaking these complex, often time-intensive projects. This section aims to introduce local governments to the renewable energy development process and common challenges.

Conceptual Design and Initial Feasibility Work

Motivated by potential cost savings or revenue, regulatory mandates (e.g., State renewable portfolio standards) or environmental benefits, projects typically begin with conceptual design by local officials or staff members, volunteer energy committees, renewable energy developers, or others. A preliminary evaluation of available renewable resources, technology options, and feasibility allows local governments to determine whether the project is worth pursuing.

If a particular site has been identified, early feasibility work typically includes an estimate of potential system capacity given resource and site constraints. A "fatal flaws" analysis conducted during this preliminary review phase will also determine if there are any definite project roadblocks. Early feasibility work may also evaluate various project approaches (e.g., outright system ownership, third-party ownership) and identify alternative project sites, if needed.

Depending on a community's clean energy expertise, local governments may consider procuring technical assistance in evaluating project options and preliminary feasibility. Grant funding or State or federal government-sponsored technical assistance is available in many areas.

Considering Various Approaches to Renewable Energy Projects

At this stage, local governments should consider the following with regard to project configuration when planning a project:

- The host site is the location where the system is installed. The site owner may or may not own the renewable energy system or use the energy produced.
- The system owner has legal title to the system and may use the energy generated or sell it to another party. The system owner can be the site owner, the system developer, or a separate party.
- The project developer may design and construct a system for the system owner, maintain ownership and lease the system to the site owner, or sell the power generated to the site owner.

Local governments should work with their project team and the developer to determine how to best structure their project to take advantage of incentives. For example, public entities that develop their own systems cannot take advantage of tax credits; however, in PPAs, third-party system owners can benefit from these incentives. Incentives can then be passed on to public entities in the form of a reduced rate charged for electricity from the renewable energy system.

Detailed Feasibility Studies

Once a technology and site are selected, the next step is a detailed feasibility study. Here, all potential project obstacles are examined, including permitting, interconnection with the electric grid, and project finance. Local governments work together with the project developer to gather information about the site for due diligence purposes and to complete permit applications. In order to execute successful renewable energy projects, quality information must be evaluated. To evaluate the economics of a community wind project, for example, actual, historical municipal electricity data, as opposed to estimates, may be required. Gathering as much current and quality information as possible about the resource, site (e.g., site ownership, existing liens, environmental issues), available incentives (and upcoming changes to available incentives), and relevant regulations (e.g., zoning ordinances) helps identify fatal flaws early, reducing the risk that infeasible projects are pursued. This also helps keep financial models up to date. In this phase, it is also critical to identify project elements that require careful and ongoing management (e.g., interconnection process).

The Interconnection Application Process

Interconnection – or connection of a renewable energy system to the electric grid – requires approval from the local utility. This process may include an engineering study and can be very time-intensive. Through a power engineering study, the utility company must confirm that local distribution infrastructure is capable of handling the amount of energy that will flow back onto the grid from a given renewable energy system. In some areas, smaller systems go through an expedited review process. Larger systems, however, may be subject to more extensive, regional review.

Evaluating the technical and financial implications of complex environmental permitting issues (e.g., wetlands, endangered species, and flood zones) can require the expertise of environmental engineers. Environmental impact assessments may be required, and these studies vary by renewable energy technology and region. Wind projects, for example, typically require much more intensive review than solar projects (see Section 2). Required permits and available waivers typically vary by project size and system capacity (e.g., Federal Aviation Administration permitting is only required for projects over 200 feet tall).

Failing to carefully manage the permit application process (e.g., by not leaving sufficient time for permit review and approval) or failing to acquire needed permits can cause significant delays and compound project costs. In some cases, projects may become infeasible. Project teams that fail to get early approval to participate in a net metering program, for example, may later find that the net metering program quota has been filled.

Financial Analysis

Details of technical feasibility work are inserted into financial models to determine a project's economic feasibility. Financial models can include available incentives, grid electricity rates (or PPA rate), available capital, cost of required permits and feasibility studies, and anticipated revenue from renewable energy credits (RECs) and/or net metering. Dynamic financial models allow stakeholders to explore the costs and benefits of different input, such as system sizes, to help identify a project that is most in line with a local government's resources and goals.

A primary determinant of project cost from a community's perspective (and the framework of the financial model) is the ownership model. Common ownership models include:

- Outright ownership
- Third-party ownership (i.e., PPA)
- Leasing

Each ownership model has its own costs and benefits. Local governments that do not want to be responsible for operation and maintenance may not want to own a renewable energy system. While this work can be contracted out, the cost remains the responsibility of the system owner. Local governments may also lease a renewable energy system, pay lease payments to the owner, and benefit from free electricity generated by the system.

Assumptions about REC values are another key in financial models, especially in States with high-value solar RECs (SRECs). REC and SREC markets are volatile, and prevailing wisdom about these markets evolves quickly. Changes to a State's renewable portfolio standards (RPS), fear of changes, or simple pessimism can significantly impact (S)REC value. Market research, via (S)REC brokers or aggregators, can help ensure that models are as accurate as possible; however, assumptions about (S)RECs should be revisited regularly, and risk adverse communities should use conservative assumptions.

As with (S)RECs, net metering revenue can be difficult to predict. Net metering regulations and local utility policy should be carefully reviewed to avoid anything that would make the project ineligible or limited in its net metering capacity. The public utility commission is an important resource in some States; in others, questions about net metering should be directed to other entities. The Database of States Incentives for Renewables & Efficiency (DSIRE)[46] lists contacts in each State for questions about relevant policies and incentives, including net metering.

Procurement and Construction

Renewable energy development by local governments is subject to State and local public procurement laws. Bid documents (e.g., requests for proposals) are often modeled off of successful documents issued by other communities or prepared in partnership with technical consultants or energy assurance team members. It is important to include as much accurate technical content as possible in bid documents so as to present potential vendors with the information needed to submit an accurate bid. Technical content might include site conditions, environmental issues, preliminary estimates of resource availability and system capacity, and required permits.

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[46] U.S. Department of Energy, Interstate Renewable Energy Council, and N.C. State University, North Carolina Solar Center. "Database of State Incentives for Renewables & Efficiency." Undated. http://www.dsireusa.org/incentives/index.cfm?state=us.

A comprehensive bid process might also include a pre-bid site visit for interested developers. Local governments should be prepared to answer technical questions from developers at and/or following any site visit.

Operation and Maintenance

Fully evaluating the financial feasibility of a renewable energy project requires attention to operation and maintenance costs. Local governments should ensure that estimated operation and maintenance costs are built into their financial models. In the early years of a system's operation, warranties may cover needed repairs; however, without a plan in place and dedicated funding to remove and reinstall warrantied equipment when broken, it is not uncommon for local governments to allow system operation to stall for months. To ensure continuity of operation – especially important where renewable energy systems are providing energy assurance to critical infrastructure – those cities and towns with renewable energy systems might consider contracting with a maintenance provider. The project developer is likely able to conduct this work or recommend a maintenance provider.

Operation and maintenance costs might include ongoing costs (e.g., regular maintenance) and large, one-time investments. Simple rules of thumb can be used to plan for these expenditures. Solar PV systems typically require inverter replacement in year 15, and total operation and maintenance costs are typically equivalent to 20 percent of total installed cost. Wind systems typically require gear box replacement in year 10; with proper maintenance, modern turbines now commonly remain operational for more than 20 years. Local governments should ensure that their financial feasibility assessments for municipally-owned systems include estimated operation and maintenance costs.

An additional and potentially significant cost to plan for is system decommissioning. Decommissioning involves removing the renewable energy system at the end of its useful life and restoring the site to its original condition. A system developer can provide an estimate of system decommissioning costs to facilitate financial planning. Communities entering into PPAs often require that the PPA provider put a bond or other assurance mechanism in place to ensure that funds are available to remove the system at the end of the PPA term, should the developer fail to complete this work for any reason.

Appendix C: Additional Resources

Category	Tool or Information Resource	Renewable Energy Technology						
		Solar	Solar (non-PV)	Wind	Biomass	Hydro	Geothermal	Hybrids
General Background Information	U.S. Department of Energy, Energy Efficiency and Renewable Energy http://www.eere.energy.gov/	X	X	X	X	X	X	X
	North Carolina Solar Center http://ncsc.ncsu.edu/	X	X	X	X		X	
	U.S. Department of Energy Solar Energy Technologies Program http://www1.eere.energy.gov/solar/sunshot/index.html	X	X					
	Solar Electric Power Association http://www.solarelectricpower.org/	X	X					
	The Open PV Project http://openpv.nrel.gov/	X						
	U.S. Department of Energy Wind Powering America http://www.windpoweringamerica.gov/			X				
	American Wind Energy Association (AWEA) http://www.awea.org/			X				
	U.S. Department of Energy Biomass Program http://www1.eere.energy.gov/biomass/				X			
	Biomass Energy Resource Center http://www.biomasscenter.org/				X			
	U.S. Department of Energy Water Power Program http://www1.eere.energy.gov/water/index.html					X		
	U.S. Department of Energy Geothermal Technologies Program http://www1.eere.energy.gov/geothermal/						X	
	Geothermal Energy Association http://www.geo-energy.org/						X	
	U.S. Department of Energy, "Small 'Hybrid' Solar and Wind Electric Systems" http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=11130							X
System Performance Calculators and Resource Assessment Tools	National Renewable Energy Laboratory, Renewable Resource Data Center http://www.nrel.gov/rredc/	X	X	X	X		X	
	System Advisor Model (SAM) https://sam.nrel.gov/	X	X	X	X		X	
	RETScreen http://www.retscreen.net/	X	X	X	X	X	X	

Category	Tool or Information Resource	Renewable Energy Technology						
		Solar	Solar (non-PV)	Wind	Biomass	Hydro	Geothermal	Hybrids
	Solar-Estimate.org http://solar-estimate.org/	X	X	X				
	Hydropower Evaluation Software http://hydropower.inl.gov/resourceassessment/software/					X		
	Wind Powering America Maps and Data http://www.windpoweringamerica.gov/wind_maps.asp			X				
	Geothermal Technologies Program Maps http://www1.eere.energy.gov/geothermal/maps.html						X	
	National Renewable Energy Lab Biomass Maps http://www.nrel.gov/gis/biomass.html				X			
Implementation Guidance	U.S. Department of Energy, *Local-level Energy Assurance Framework: 10 Steps to Build a Plan* http://www.energyassurance.us/docs/LEAP_10-Step_Framework_July_2010.pdf	General resource						
	Interstate Renewable Energy Council, "Community Renewables: Model Program Rules" http://irecusa.org/wp-content/uploads/2010/11/IREC-Community-Renewables-Report-11-16-10_FINAL.pdf	General resource						
	U.S. Department of Energy Solar America Communities Program http://solaramericacommunities.energy.gov/home.aspx	X	X					
	Solar Minnesota & the Minnesota Renewable Energy Society, "Creating and Implementing Your Community Solar Plan" http://www.state.mn.us/mn/externalDocs/Commerce/Community_Solar_Plan_032509032652_CommunitySolarGuide.pdf	X	X					
	Windustry, Community Wind Toolbox http://www.windustry.org/CommunityWindToolbox			X				
	University of Massachusetts Wind Energy Center, Community Wind Fact-Sheets http://www.umass.edu/windenergy/publications/published/communityWindFactSheets/			X				
	Alliance for Rural Electrification, "Hybrid Power Systems Based on Renewable Energies: A Suitable and Cost-Competitive Solution for Rural Electrification"							X

Category	Tool or Information Resource	Renewable Energy Technology							
		Solar	Solar (non-PV)	Wind	Biomass	Hydro	Geothermal	Hybrids
	http://www.ruralelec.org/fileadmin/DATA/Documents/06_Publications/Position_papers/ARE-WG_Technological_Solutions_-_Brochure_Hybrid_Systems.pdf							
	U.S. Department of Energy, "Operating Your System Off-Grid" http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10610							X
Incentives	Database of State Incentives for Renewables & Efficiency (DSIRE) http://www.dsireusa.org/	General resource						
	Network for New Energy Choices, "Freeing the Grid: Best Practices in State Net Metering Policies and Interconnection Procedures." http://www.newenergychoices.org/uploads/FreeingTheGrid2011.pdf	General resource						