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Public Service Commission of Wisconsin
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Focus on Energy Renewable Energy Technology Evaluation

April 4, 2012

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EXECUTIVE SUMMARY

In 2009, during the most recent Focus on Energy Quadrennial Planning Process (Docket 5-GF-191), the Public Service Commission of Wisconsin (Commission) determined that renewable energy and energy efficiency projects would be evaluated equally under the cost-effectiveness requirements to which Focus on Energy must adhere.

However, the Commission recognized the appropriateness of considering public policy to guide decisions regarding the incorporation of renewable resources in the portfolio of Focus on Energy programs and proceeded to develop proposed criteria that would be used to guide these decisions. An order released in November 2011 directs the Focus on Energy Program Administrator to work with Commission staff to develop a list of renewable resource measures to include in Focus on Energy programs, and a corresponding incentive budget to capture these renewable resources.

The Program Administrator conducted a review of renewable resources to identify commercially available technologies suitable for implementation in Wisconsin. Four (4) renewable resources were found to have commercially available technologies suitable for implementation in the state: solar energy, wind energy, biomass and geothermal.

For each resource, commercially available technologies were evaluated to determine both the cost-effectiveness of the technology and other non-monetary benefits that may accrue from implementation of the technology. A cost-effectiveness calculator was used to determine the benefit to cost ratio (B/C) for each technology. The calculator takes into account the economic impacts of changes in measured energy consumption of natural gas and electricity in Wisconsin. In general, a B/C greater than 1.0 demonstrates that the benefits of the technology outweigh the costs of the technology.

The results of the cost-effectiveness calculations showed that biomass resources and biogas resource applications at farms yielded a B/C ratio greater than one. All other resources and technologies evaluated had B/C ratios less than 1.0. In addition, geothermal HVAC and Wind 100 kW-1 MW resulted in B/C ratios over 0.5. Finally, all solar applications as well as the smaller wind applications resulted in low B/C ratios.

Following the cost-effectiveness analysis, the Program Administrator performed an evaluation of non-monetary benefits based on criteria developed by the Commission. The commercially available technologies evaluated had non-monetary benefit scores ranging from four (4) to 17. Overall, biogas, biomass and geothermal HVAC technologies ranked the highest. Evaluation of solar technologies resulted in low non-monetary benefit scores and low B/C ratios. Finally, small scale wind projects had the lowest non-monetary benefit scores and B/C ratios.

After the benefit-cost analysis and non-monetized benefits analysis were completed, the Program Administrator proceeded to model the impact of various renewable energy technologies on the cost-effectiveness of the entire Focus on Energy Mass Markets and Targeted Markets portfolios. A total of twenty (20) different scenarios were modeled that assumed (1) various funding levels for renewable energy technologies and (2) a combination of measure mix penetration for the technologies evaluated.

According to the results of the scenario modeling, regardless of the renewable energy measure mix, the inclusion of renewable energy technologies reduces the cost effectiveness of a program only incentivizing energy efficiency measures. In addition the following trends can be recognized through the scenario analysis:

- The higher the budget allocation to renewable the lower the cost-effectiveness of the portfolio.
- Using the forward looking (future) avoided cost methodology yields higher cost-effectiveness values than the historic avoided costs.
- Technologies that have individual higher B/C ratios have a lower impact on overall portfolio cost-effectiveness than technologies with lower B/C ratios.
- Technologies with a longer measure life yield better B/C ratios when using the future avoided cost calculation methodology.

RESOURCE EVALUATION

I. BACKGROUND AND OVERVIEW

In calendar year 2011, funding provided by Focus on Energy to renewable energy technologies comprised approximately 18.6% of total incentives. Historic data for Focus on Energy, however, shows that energy savings for installing renewable energy technologies are not robust and affect the program's cost-effectiveness. For example, in calendar year 2011, for the residential sector, renewable energy technologies accounted for 5.0% of total kW, 2.7% of total kWh and 1.5% of total therm savings for the program. On the targeted markets side, renewable energy technologies accounted for 5.4% of total kW, 3.0% of total kWh and 2.7% of total therm savings.

Under Wisconsin Act 141, the Public Service Commission of Wisconsin (Commission) is charged with evaluating energy efficiency and renewable resource programs and to set or revise goals, priorities and measureable targets for the programs. This review, completed under a Quadrennial Planning Process, must be conducted at least once every four (4) years.

During 2009, the Commission began the most recent Quadrennial Planning Process (Docket 5-GF-191). The Commission determined that renewable energy and energy efficiency projects would be evaluated equally under the cost-effectiveness requirements to which Focus on Energy must adhere. However, the Commission recognized the appropriateness of considering public policy to guide decisions regarding the incorporation of renewable resources in the portfolio of Focus on Energy programs. The Commission staff was directed to develop proposed criteria to guide these decisions.

Docket 5-GF-191 stipulates the criteria to be used to evaluate renewable resource programs. The docket also directs the Focus on Energy Program Administrator to work with Commission staff to develop a list of renewable resource measures to include in Focus on Energy programs, and a corresponding incentive budget to capture these renewable resources.

Act 141 defines a renewable resource program as a program that encourages the use of customer applications of renewable resources and encourages the transfer of new or emerging technologies to commercial implementation.

Consistent with the direction from the Commission, the Program Administrator conducted an evaluation of commercially available renewable energy technologies that derive energy from the following resources identified in Wisconsin Act 141:

- Solar energy;
- Wind power;
- Geothermal energy;
- Biomass;
- Water power;
- Fuel cells that use a renewable fuel; and
- Tidal or wave action

The results from the evaluation are outlined in this report. Note that the evaluation of commercially available technologies was limited to those technologies that can be implemented by customers of Focus on Energy. Renewable energy technologies that are more suitable for implementation on a utility scale are not evaluated in this report.

II. SOLAR ENERGY

Solar energy technologies produce energy by capturing the solar radiation emitted from the sun. These systems range from small capacities that provide localized power to large systems that can produce electricity that is distributed in the electric power system.

The amount of solar radiation available at any location is a function of the time of day, time of year, local topography, weather conditions and geospatial location. This is because the solar radiation strikes the surface of the Earth at different angles as the Earth orbits around the sun. The tilt of the Earth results in more sunlight in the northern hemisphere in the spring and summer seasons and less in the fall and winter seasons.

When solar radiation passes through Earth's atmosphere, some of the radiation is absorbed, scattered and reflected by interactions with gases, water vapor and particulates. Solar radiation that reaches the Earth's surface after these interactions is termed diffuse solar radiation; solar radiation that reaches the Earth directly without these interactions is termed direct solar radiation. Solar power technologies convert captured solar radiation into either electric energy or thermal energy.

Electric Systems: Photovoltaic panels (PV) are an electric generation technology suitable for implementation by Focus on Energy customers. These systems can be used to provide localized electricity needs, or export electricity to the grid. PV systems are modular in nature, allowing for easier installation and the ability to expand capacity over time.

Thermal Systems: Thermal systems transfer captured solar radiation to fluids, which raises the temperature of the fluid. Thermal systems are either active or passive systems. Active systems utilize circulation pumps to maintain a more consistent temperature of the collecting fluid and often include a storage tank to increase system capacity. Passive systems rely on the normal use patterns of the system to circulate fluid through the system. Passive systems have almost no moving parts and do not suffer parasitic losses from operation of a pumping system or storage tank. Solar hot water systems are not as modular as PV electric systems but are still fairly simple to install and active systems commonly use typical plumbing equipment for pumping and storage functions, making them widely available.

I.A Solar Energy Potential

Figure 1 displays the solar energy potential for photovoltaic (PV) systems in the United States. PV systems capture both diffuse and direct solar radiation. As solar technology can only produce energy based on the amount of solar energy available, solar technologies are more effective in the southwestern states.

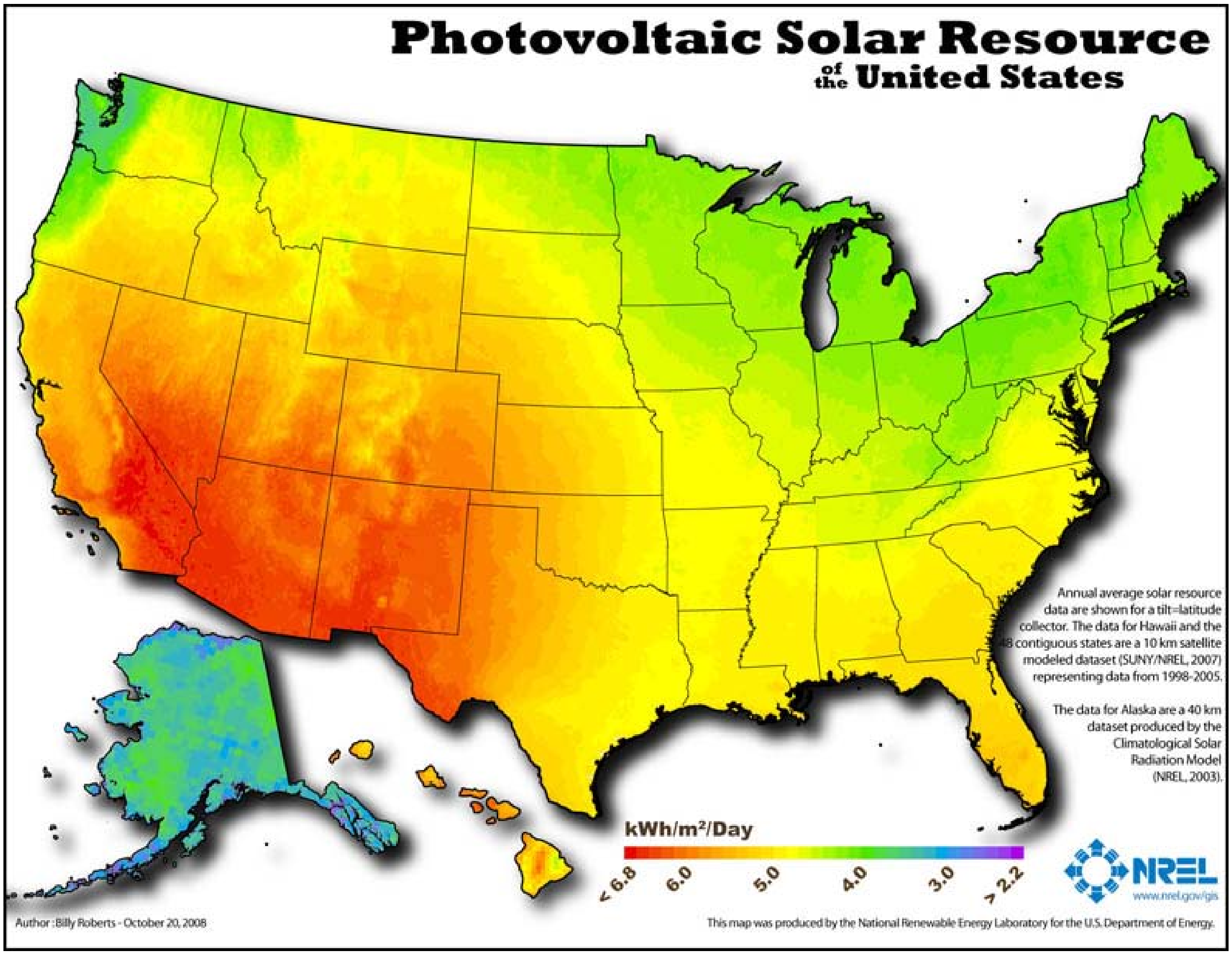

Figure 1. Solar Energy Potential for Photovoltaic Systems in kWh/m2/Day.

I.B.1 Wisconsin Photovoltaic Generation Potential

According to Figure 1, the average solar energy potential for basic (flat plate) PV panels tilted at 40-50 degrees (according to latitude) in Wisconsin is approximately 4.5 kilowatt-hours per square meter per day (kWh/m^2/day). This is further confirmed in Table 1, which was produced using PV Watts (Version 1). PV Watts is a simple web-based calculator developed by the U.S. Department of Energy that estimates the electric generation potential of PV systems for specific locations. PV Watts uses the latitude and historic weather data to determine average available solar radiation.

Table 1. PV Watts Estimated Daily Electricity Production by City

City	Average kWh/m^2/day
Eau Claire, WI	4.44
Green Bay, WI	4.45
La Crosse, WI	4.57
Madison, WI	4.58
Milwaukee, WI	4.53
Duluth, MN (Superior, WI)	4.42

I.B.2 Wisconsin Solar Thermal Potential

Solar thermal systems can displace natural gas or electricity, so the units for Figure 2 are in Btu per square foot per year to allow for easier calculation of reduced space or domestic hot water heating fuel requirement. Wisconsin lies on the border between the lowest and second lowest potential categories for the United States at about 160 Btu/ft^2/year.

Solar thermal systems can be used to provide energy needed for heating, but traditionally in Wisconsin these systems have been used only for the production of hot water. The use of solar thermal systems for heating is prevalent in Europe.

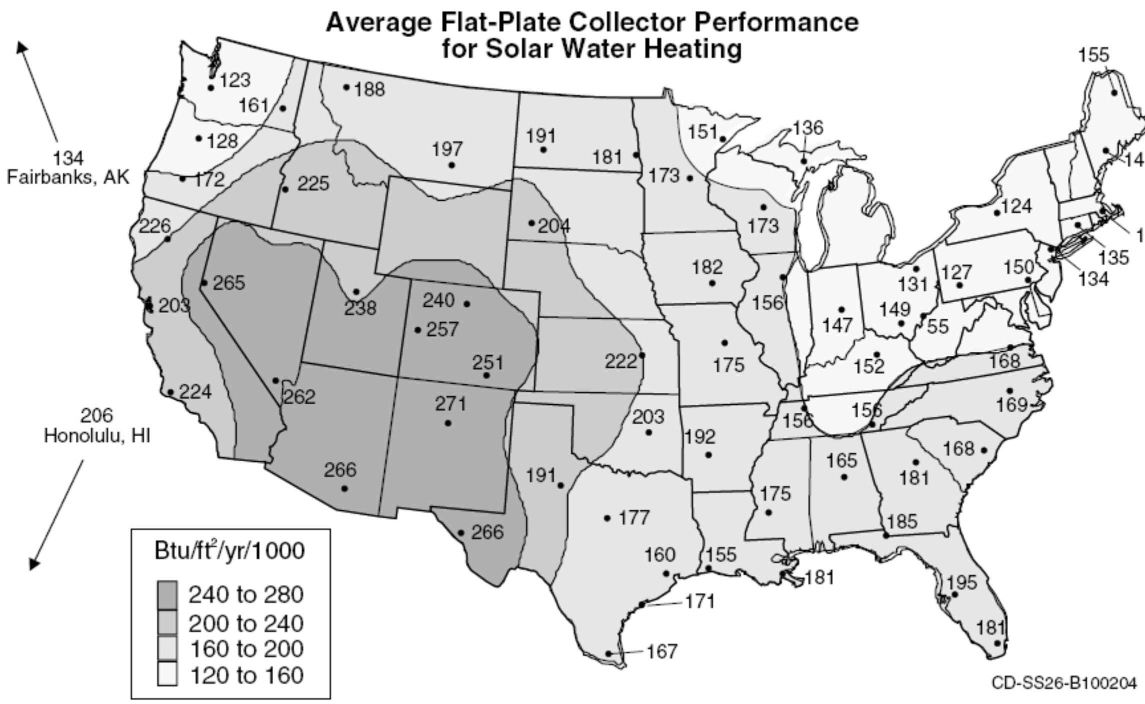

Figure 2. Solar Radiation for Thermal Systems. Excerpted from Federal Energy Management Program Federal Technology Alert: Solar Water Heating. (http://www1.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf).

I.C Commercially Available Solar Technologies

Commercially available solar technologies include:

- Electric systems for the direct or indirect conversion of solar radiation to electricity (PV).
- Thermal systems for the direct or indirect conversion of solar radiation to thermal energy.

I.D Wisconsin Commercially Available Technologies

In 2010 and 2011, Focus on Energy incentivized installation and/or feasibility studies for about 1000 PV systems at commercial facilities or residences throughout Wisconsin. During those same years, Focus on Energy provided incentives for installation or feasibility studies of approximately 100 solar hot water systems at businesses and multi-family facilities.

The use of solar tubes or skylights to reduce electricity demand during daylight hours can reduce electricity usage and peak demand. The use of skylights and solar tubes that allow sunlight to enter buildings are not evaluated in this report as they do not convert solar energy into another energy form. Furthermore, although solar tubes can be used to generate renewable resource credits, there is insufficient public information to assess the effectiveness of solar tube technology for the State of Wisconsin at this time.

III. WIND ENERGY

Wind energy is harnessed by utilizing blades to generate mechanical energy which in turn drives an electrical generator. As the wind blows over the blades, a pocket of low-pressure air forms on the leeward side of the blade. The force of the lift on the leeward side of the blade is much stronger than the drag on the windward side of the blade, causing the turbine to spin. The blades are attached to a main shaft within the turbine that spins a series of gears linked to a generator that covert the mechanical energy into electrical energy which can then be used at the source of generation or added to the gridded power supply.

II.A Wind Power Potential

The United States has abundant and regionally distributed wind energy potential. The National Renewable Energy Laboratory (NREL) calculated the wind energy installed capacity potential of the United States to be 11 million MW, and 38 million GWh. This is roughly 10 times the total electricity consumption of the United States in 2010 as estimated by the EIA.

Offshore wind resources are strongest on the east and west coast, while terrestrial wind resources are situated within the interior of the country, with the strongest wind speeds just east of the Rocky Mountains.

II.B Wisconsin Wind Power Potential

The most viable wind resources in Wisconsin are in the southern third of the state. A wind resource potential map for Wisconsin is shown in Figure 3.

According to NREL, the statewide wind resource is estimated to be 103,757 MW at 80 meters of altitude. Wisconsin's wind resources have the potential to provide over four (4) times the state's electricity demand through utility-scale resource development.

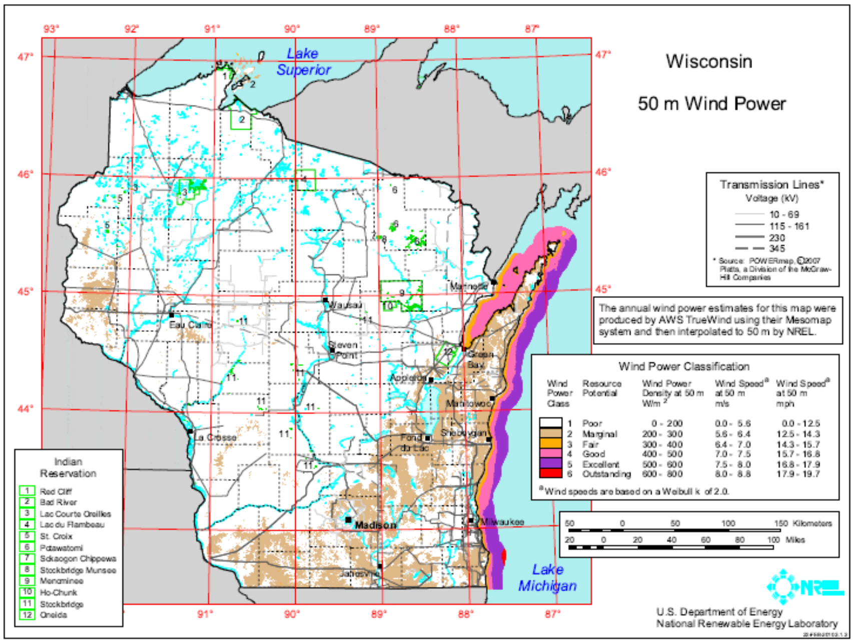

Figure 1. Wind Resource Potential for Wisconsin. Obtained from the Department of Energy, National Renewable Energy Laboratory, http://www.nrel.gov/.

According to the American Wind Energy Association (AWEA), as of August 2011, there were 469 MW of wind capacity online in Wisconsin. In addition, there were 162 MW under construction and 908 MW proposed during the year. The majority of the wind installations in the state are owned and operated by utilities.

II.C Commercially Available Wind Technologies

Excluding utility-scale wind energy developments, there are two commercially available wind technologies: horizontal and vertical axis turbines. As their names imply, the fundamental difference between these technologies is the axis on which they rotate.

Horizontal axis turbines are much more common than vertical axis turbines in the marketplace. Horizontal axis turbines have the main rotor shaft oriented horizontally and are typically oriented along an axis parallel to the wind direction to generate electricity. The most common turbines for production of electric power are three-blade horizontal axis turbines that are turned into the wind by an electronic motor. Due to limited energy production, vertical axis turbines were excluded from this analysis.

Sizes of horizontal axis turbines vary greatly, from 5 kW residential models to 6 MW experimental utility-scale models. Horizontal axis turbines have been further classified into three (3) groups:

- 0-20 kW capacity;
- 20-100 kW capacity; and
- 100 kW-1000 kW capacity

II.D Wisconsin Commercially Available Technologies

Wisconsin has a well developed wind energy market. The Environmental Law and Policy Center, a Midwestern nonprofit environmental organization, identifies that 171 companies in Wisconsin that contribute to the wind power supply chain. Nearly all wind turbines available commercially are three-blade, horizontal axis turbines. As such, turbine technologies in all three (3) size brackets are commercially available in Wisconsin.

IV. GEOTHERMAL ENERGY

Geothermal energy may be harnessed for the purposes of generating geothermal electricity or for sources of heating/cooling. Geothermal resources include:

- Heat retained in shallow ground;
- Hot water and rock found beneath the Earth's surface; and
- Extremely high-temperature molten rock located deep within the Earth.

In locations where hot water is found near the surface of the Earth, the water can be tapped to provide thermal energy to heat homes, greenhouses, industrial activities or even for drying crops. High temperature reservoirs of water can be used to produce electricity.

III.A Geothermal Energy Potential

The most favorable geothermal resources are found throughout the western U.S. In many areas of the western U.S. the direct use of shallow geothermal resources for heating is less expensive than the use of fossil fuels for heating.

III.B Wisconsin Geothermal Energy Potential

Wisconsin does not have a geothermal potential to support generation of electricity, nor are there locations of shallow hot water that can be tapped to provide thermal energy to heat homes or businesses.

However, there are suitable resources to use geothermal resources for heating and cooling in Wisconsin.

III.C Commercially Available Geothermal Technologies

Commercially available geothermal technologies include:

- Production of electricity from the generation of steam by the dry steam method;
- Production of electricity from the generation of steam by the flash steam method;
- Production of electricity by the binary cycle method;
- Direct heating of homes and businesses by shallow hot water; and
- Direct heating or cooling of homes by ground source heat pumps.

III.D Wisconsin Commercially Available Technologies

The only geothermal technology with a reasonable potential for use in Wisconsin is the ground source heat pump.

Ground Source Heat Pumps (GSHP) or Geothermal Heat Pumps use the underground energy as a heating source in the winter and as a heat sink in the summer. Energy is obtained through a heat exchanger installed at depths ranging from three (3) to 500 ft below surface, depending on system and design needs. In a direct exchange system, the refrigerant is looped through the heat exchanger, although closed loop systems more commonly run a secondary water loop through the heat exchanger.

Commercially, the technology exists for sizes ranging from residential sizes to large scale district heating and cooling. Variations of this technology include:

Direct Exchange: The heat exchanger is typically a copper piping loop buried near the appliance cabinet. The refrigerant is run directly through the exchanger.

Closed Loop: The primary refrigerant exchanges heat in the appliance cabinet with a secondary water loop. The secondary water loop is run through the ground heat exchanger. Loops are typically classified as vertical or horizontal.

- Vertical Loop is composed of pipes installed vertically in the ground 75-500 ft down. Pipe pairs in the hole are joined with U shaped connectors at the bottom of the hole to create a closed loop.

- Horizontal Loop is installed in a long horizontal trench installed below the frostline. U shaped or slinky coils are placed horizontally inside the trench. Installation costs for this system are considerably smaller than vertical drilling, but require adequate access to land.

Open Loop: Also called a ground water heat pump. A secondary loop pumps natural water from a well or body of water into a heat exchanger inside the heat pump.

Traditional energy savings of 30% or more can theoretically be obtained with these systems. More reasonably, the cost for installation of deeper and larger heat exchangers remains the barrier for mass appeal to these systems.

V. BIOMASS

Biomass resources includes biological material that can be used to produce energy. This includes plant matter such as trees, grasses, agricultural wastes, and solid waste. For purposes of this evaluation, when the material is in a solid or liquid form, it is termed biomass. Biogas will be used for the gases created during the anaerobic digestion of biomass materials.

Energy is most commonly obtained through combustion, either by directly burning the biogas or biomass. The biomass can also be processed into a high energy value solid, liquid, or gas material that can be used to produce energy.

For discussion of resource potential and commercially available technologies the biomass category has been separated into biogas and biomass. The biogas category is for recovery of methane from anaerobic decomposition of biological matter; biomass serves to cover the use of solid or liquid biological material.

IV.A.1 Biogas Potential

Biogas is a mixture of gases created during the anaerobic digestion of nutrient rich materials. Anaerobic digestion occurs when microorganisms break down the organic material in an environment free of oxygen. Through digestion, the bacteria generate methane and other flammable gasses that can be combusted to generate energy.

There are three (3) dominant market sectors where anaerobic biogas digestion technologies are used. These are wastewater treatment facilities, solid waste landfills and agricultural facilities.

Industrial wastewater plants with high biological oxygen demand (BOD) waste streams are good candidates for anaerobic treatment. This would include wastewater treatment at food processing plants such as vegetable processing, milk producers and cheese manufacturing.

Land fill gas is created when organic waste decomposes in an anaerobic environment in a landfill. The gas produced is typically composed of 50% methane and 50% carbon dioxide. The amount of gas created by a given landfill is dependent on climate, the composition of the waste material, as well as other site specific factors. The U.S. EPA lists Wisconsin among the national leaders in landfill gas utilization with 26 facilities actively capturing landfill gas.

Anaerobic digestion is also used in the management of livestock manure. Recent legislation requiring the implementation of specific manure handling practices has led to increasing adoption of anaerobic digestion. In calendar year 2010 there were 24 agricultural biogas digesters constructed with funding from the Focus on Energy program, and six (6) more under construction.

In its high-level nationwide analysis of agricultural facilities, the EPA Combined Heat and Power Partnership *Biomass Combined Heat and Power Catalog of Technologies* identified approximately 2,290 dairy operations and 6,440 swine operations that might be suitable for biogas digesters.

IV.A.2 Biomass Potential

The U.S. Energy Information Administration (EIA) estimates that 590 million wet tons (equivalent to 413 million dry tons) of biomass resources are available in the United States on an annual basis. There is a wide range of biomass available, and biomass is more abundant in areas where climatic conditions support the growth of biomass. Biomass includes forest products, forest residues, crops and crop residues, and animal wastes.

IV.B Wisconsin Biogas/Biomass Potential

Approximately 10% of the public wastewater facilities in Wisconsin use the anaerobic process to treat their wastewater. Often the gas obtained from the anaerobic decomposition is used onsite to generate heat or electricity. Most often, wastewater treatment facilitates will use the installed digesters for heat generation during the winter months to offset process heat.

The NREL *Biomass Atlas* and EPA Combined Heat and Power Partnership *Biomass Combined Heat and Power Catalog of Technologies* provide a large amount of aggregated data regarding the potential for expanding solid and liquid biomass in Wisconsin.

Woody Biomass: Figures 3-1 and 3-3 in the *Catalog of Technologies* show that there may be some remaining potential to generate electricity or process heat from woody refuse. Wisconsin is shown with a peak production capability of 50-250 MW from forest residue and 10-50 MW from primary mill residue. Summing current capacity of large scale energy generating facilities found in the US EPA Emissions & Generation Resource Integrated Database (eGRID), Wisconsin is currently using about 80 MW of this 60-300 MW of primary woody biomass potential.

Crop Residue and Energy Crops: Energy production from crop residue biomass has a relatively high potential in Wisconsin, with a total anticipated capacity of 100-1,100 MW from corn stover and wheat straw (Figures 3-4 and 3-5 in the *Catalog of Technologies*). Energy crops are raised specifically for the purpose of energy production in contrast to crop residue, which is a by-product of a primary commodity that is utilized for another purpose. Anticipated capacity that could be satisfied with switchgrass is somewhere between 500 and 1,000 MW (*Catalog of Technologies* Figure 3-6).

Animal Waste: Combustion of animal waste is an option for smaller biomass installations, and has been tested in Wisconsin. Despite wide availability of the feedstock, the Focus on Energy Emerging Technology program has not found this option to be reliable and is currently not pursuing any additional installation of this technology for funding.

IV.C Commercially Available Biogas/Biomass Technologies

The energy contained in biogas and biomass is converted to either thermal energy or electrical energy. This conversion is obtained from combustion of the biogas/biomass. Biogas can be combusted in boilers, in gas turbines or internal combustion engines. Combustion of biogas in gas turbines and internal combustion engines is to produce electricity. Combustion of biogas in boilers can be used to produce process steam or steam that can be expanded in a steam turbine to produce electricity.

Biogas can also be recovered and processed to produce a gas stream suitable to replace natural gas. Biomass can be combusted in fixed bed or fluidized bed boilers. It is typically co-fired with other fuels. The following technologies are commercially available nationwide:

- Fixed bed/stoker boiler powering a steam turbine;
- Fluidized bed boiler powering a steam turbine; and
- Co-fired coal (cyclone, stoker, pulverized, and bubbling and circulating fluidized bed) powering a steam turbine

Steam generated from the combustion of biomass is either used as process steam or expanded in a steam turbine to produce electricity.

IV.D Wisconsin Commercially Available Technologies

Biomass has long been used in Wisconsin to generate steam and electricity. The paper industry relies on the combustion of bark and black liquor to produce steam and electricity; several utility plants combust wood waste to produce electricity; wood pellets are combusted for space heating in small and medium facilities; and anaerobic digesters are used for the treatment of animal manures.

VI. HYDROPOWER

Hydroelectric dams produce energy by using the gravitational force of water in rivers and streams flowing downhill. Hydroelectric power is generated as water passes through the dam turning a turbine that is attached to a generator. There are three (3) principal types of hydropower facilities: impoundment, diversion, and pumped storage.

Impoundment: Impoundment facilitates are the most common hydroelectric facilities. Impoundment facilities use a dam to store water in a reservoir, and are typically larger systems. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water may be released either to meet changing electricity needs or to maintain a constant reservoir level.

Diversion: A diversion, sometimes called run-of-river, facility channels a portion of a river through a canal or penstock. It may not require the use of a dam.

Pumped Storage: When the demand for electricity is low, a pumped storage facility stores energy by pumping water from a lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir to generate electricity.

V.A Hydropower Potential

At present, there are approximately 100,000 MW of hydropower generating capacity in the United States, which provides about 7% of the country's electricity demand. In 2009, Navigant consulting, a firm commissioned by the National Hydropower association estimated that the total potential for the United States is four (4) times that, around 400,000 MW.

V.B Wisconsin Hydropower Potential

A 1996 study by the Idaho National Engineering Laboratory modeled the total undeveloped nameplate potential of Wisconsin to be 452.9 MW, predominantly on the Chippewa and Wisconsin Rivers. Currently, the Energy Information Administration reports that hydropower accounts for 3.3% of Wisconsin's total net electrical generation.

V.C Commercially Available Technologies

There are two (2) main types of hydro turbines used to convert the energy of water to mechanical energy – the impulse turbine and the reaction turbine. The type of turbine selected depends on the height of the standing water as well as the volume of water available.

An impulse turbine uses the velocity of the water to move the blades of the turbine. Impulse turbines are suitable for situations with a large change in elevation of the water and a low flow rate. A reaction turbine uses the combined action of pressure and moving water to produce power. They are suited to sites with a small change in water elevation and higher flow rates.

V.D Wisconsin Commercially Available Technologies

Wisconsin currently has a number of hydroelectric facilities with a total capacity of 492 MW. The development of hydroelectric power raises environmental and recreational concerns that limit the potential for new developments in Wisconsin. The Focus on Energy program has funded only one (1) hydropower project in the past 10 years.

VII. FUEL CELLS

Under Act 141, Wisconsin identifies fuel cells that use a renewable fuel as a renewable resource. A "renewable fuel" is defined at the discretion of the Commission. Fuel cells are much like typical batteries where chemical energy is converted to electricity. However, the process taken to create the electrical energy is different.

A typical fuel cell consists of five (5) main components; an anode, cathode, catalyst, external circuit, and fuel. The anode serves as the negative side of the cell while the cathode serves as the positive pole. Etched into the anode and cathode plates, are small channels spanning the entire width of the plate that allow maximum exposure to the catalyst as the fuel moves through the channel. Between the cathode and anode is a membrane that is coated with a catalyst on each side. Typically, platinum is used as the catalyst.

The fuel, most commonly pure hydrogen, is routed through the channels of the anode where the catalyst causes the hydrogen atoms to give up protons (positively charged subatomic particles). In the same manner that hydrogen is moved through the anode, oxygen gas is sent through the cathode. Because the atoms of oxygen gas have a strong negative overall charge, the proton given up by the hydrogen atoms is pulled toward the oxygen atoms through the proton exchange membrane. Meanwhile, the electrons left after losing the proton of the hydrogen atom are sent through an external DC circuit where they are used for doing useful work. As the electrons complete the circuit, they combine with the oxygen and protons where H_2O, or water, is created as a by-product of the reaction.

In reality, stacks of fuel cells are used to increase the voltage of the fuel cells to more useful levels. There are several different types of fuel cells, each of which was designed for a specific purpose. Most fuels cells were created with the intention to be used as a source of power generation. Smaller fuel cells have been designed to supplement or in some cases completely replace the automobile internal combustion engine, an inherently inefficient form of power generation. Larger fuel cells have been designed to provide several megawatts in utility scale power distribution, perfect for peaking plants or remote power generation. Often times, larger utility scale fuel cells operate at higher temperatures and the heat is recovered and used to produce steam that can be expanded in turbine power generators. This is called combined heat and power (CHP).

Fuel cells have several benefits as well as many critical challenges to success. Because the chemical reaction creates water as a by-product, the emissions from fuel cells are almost nonexistent. In addition to minimizing overall emissions, many of the fuel options available for fuel cell plants can be sourced domestically. The material cost of fuel cell manufacturing is a large hurdle. Because of the need for precious metals as catalysts, the average cost to manufacture a fuel cell is still relatively high. In terms of hydrogen fuel, transporting and storing the element in small spaces is difficult.

VI.A Resource Potential

On a national level, much of the attention around fuel cells is directed towards developing cells that can cost-effectively replace or supplement the automobile engines. The primary focus is on the public transportation fleet industry but includes several passenger vehicles as well. In addition to replacing automobile engines, stationary fuel cells are incorporated into a number of remote facilities where fuel cells are used to provide primary or emergency power supply. There is a total of 50 MW installed or recently purchased stationary fuel cell power generated in the United States.

VI.B Wisconsin Potential

With respect to other states, Wisconsin's fuel cell market is still in its infancy. Wisconsin is likely to rank in the lower percentile of actual fuel cell installations, due to the higher cost of fuel cells and the still large gaps in fuel cell development.

VI.C Commercially Available Technologies

There are five (5) primary types of fuel cell technologies. The technologies are distinguished by the type of electrolyte used in the fuel cell. Fuel cell technologies are:

Proton Exchange Membrane: This technology employs an ion-exchange membrane that is a good conductor of protons. Overall, electrical efficiencies can reach 45%, but very pure hydrogen is required.

Alkaline: This type of technology uses potassium hydroxide as the electrolyte. Pure hydrogen and pure oxygen are required.

Phosphoric Acid: The electrolyte in this type of fuel cell is phosphoric acid. An electrical efficiency of about 37-42% can be obtained.

Molten Carbonate: A combination of alkali carbonates serve as the electrolyte in this type of fuel cell. Because this type of fuel cell operates at high temperatures, both thermal and electrical energy can be used, resulting in overall efficiencies of more than 70 percent.

Solid Oxide: The electrolyte is a solid, nonporous metal oxide. Both thermal and electrical energy are generated.

VI.D Wisconsin Commercially Available Technologies

Phosphoric acid and proton exchange membrane fuel cell technologies are installed in Wisconsin. While stationary fuel cell installations in Wisconsin are rare, the best known and most recent documented implementation was of a 400-kilowatt fuel cell that supplies 45% of the electricity to the Diversey headquarters in Sturtevant. In addition to on-site power generation, about 80% of the heating within the facility is provided by the fuel cell.

Two (2) other fuel cell installations in Wisconsin provide back-up power to remotely located communication towers. These installations use the proton exchange membrane technology. A large portion of the Wisconsin fuel cell market is focused on stationary and distributed generation type fuel cells and fuel cell components. However, the market penetration of fuel cells is still a fraction of the more proven renewable technologies; wind, biomass, and hydropower generation.

In terms of transportation fuel cells and hydrogen fueling stations, there are no documented stations located in Wisconsin and consequently a very small to nonexistent fuel cell vehicle population in the state.

VIII. TIDAL OR WAVE ACTION

Tidal or Wave Action: Tidal energy is produced from the sea level change and the movement of tide that occurs twice per day. Wave energy is produced from the wind blowing over the surface of the ocean. When the wind blows consistently and with sufficient force, continuous waves can be produced. Tidal and wave energy can be captured in the following manner:

- Converting the movement of the tide to kinetic energy of the blades of a turbine (change of kinetic energy to electric via turbine-generator).
- Converting the potential energy change of the tide to kinetic energy, kinetic energy to electricity via turbines/generators. The potential energy change must be at least five (5) meters for this technology to be effective.

VII.A Tidal or Wave Action Potential

Tidal energy is a result of the gravitational pull exerted on the Earth by the Moon and Sun. The effect shows up in the Earth's oceans, which are pulled toward the Moon by the Moon's gravity. The oceans are subject to two (2) periods of high tide and two (2) periods of low tide each day.

Wave power, which is produced from wind, varies throughout the world. It cannot be effectively captured in every location that has water resources. Consistent wave areas include Australia, northwestern coasts of the U.S., northern Canada and the western coasts of Scotland.

VII.B Wisconsin Tidal or Wave Action Power Potential

Wisconsin does not have water resources that are significantly influenced by the gravitational pull of the Moon. The change in water elevation for Wisconsin ports located on Lake Michigan and Lake Superior are usually less than two (2) feet. Wisconsin does not have consistent wave energy suitable for capture.

VII.C Commercially Demonstrated Tidal and Wave Power Technologies

The following technologies have been used commercially to convert tidal or wave energy into electricity:

- Axial Flow turbine;
- Point absorber – floating;
- Oscillating wave surge converter;
- Cross flow turbine;
- Oscillating water column;
- Point absorber – submerged; and
- Overtopping

VII.D Wisconsin Commercially Available Technologies

Wisconsin does not have tidal or wave energy that can be effectively captured and converted to other forms of energy. Tidal and wave energy resources are extremely low value in Wisconsin waters.

COMMERCIALLY AVAILABLE TECHNOLOGIES SELECTED FOR EVALUATION

Based on the resource evaluation, four (4) resources can potentially be utilized in Wisconsin as a source of energy. These resources are solar energy; geothermal energy; wind energy; and biomass energy.

For these resources, 10 commercially available technologies were selected for evaluation. The selection of these technologies was based on projects historically funded by Focus on Energy and those technologies identified by the U.S. Department of Energy, National Renewable Energy Laboratory as commercially available.

These technologies selected for evaluation include:

- Solar Thermal
- Solar PV
- Wind up to 20 kW
- Wind 20 - 100 kW
- Wind 100-1 MW
- Geothermal – HVAC
- Biomass
- Biogas – Industrial Electric Generation
- Biogas – Industrial Cogeneration
- Biogas – Farm

Tidal, hydropower and fuel cells do not have commercially available technologies that are likely to be adopted in Wisconsin by non-utility generators. For this reason, these resources were no longer included in the evaluation.

COST-EFFECTIVENESS EVALUATION

I. APPROACH

Docket 5-GF-191 directs the Program Administrator to evaluate energy efficiency and renewable technologies equally under cost-effectiveness requirements. The cost-effectiveness of energy efficiency measures can be determined using a Total Resource Cost (TRC) test.

Ideally, a TRC test should determine if the benefits of a particular technology outweigh the costs of the technology. This is expressed as the B/C ratio for "benefit to cost". In general, measures are considered cost-effective when the B/C is greater than 1.0. In other words, more benefits accrue from implementation of the technology than the cost of the technology. The TRC test is used nationally to determine the cost-effectiveness of energy programs, and is the standard test by which all technologies incentivized by Focus on Energy are evaluated for inclusion in the program portfolios.

For purposes of this evaluation, the TRC test was applied to each commercially available renewable technology, using the comprehensive Focus on Energy cost-effectiveness calculator. The cost-effectiveness calculator is a MS Excel-based spreadsheet application used to support the planning, implementation and evaluation of energy efficiency projects as well as Focus on Energy programs and portfolios. The cost-effectiveness calculator (tool) provides a transparent and systematic framework for calculating the cost effectiveness of a set of energy efficiency or renewable resource measures in comparison to the conventional energy supply resources they displace.

The cost-effectiveness calculator evaluates the cost-effectiveness of technologies by comparing the present values of technology costs and benefits, based on avoided generation capacity and energy costs. The tool takes into account the economic impacts of changes in measured energy consumption of natural gas and electricity in Wisconsin.

II. ASSUMPTIONS

For each technology, the TRC B/C ratio was obtained using (1) the historic avoided cost calculation methodology that has been used by Focus on Energy as a result of a July 2010 decision from the Commission; and (2) future avoided cost calculation methodology approved by the Commission. This second analysis using estimated future avoided costs, is a result of a Commission order issued January 13, 2012 in which the Commission determined that while avoided capacity shall continue to be based on the cost of a new peaking plant, it is appropriate to revise the basis for valuing avoided energy costs so that it is based on long-term price forecasts.

Note, the cost-effectiveness calculator does not consider average rate structures from different utilities across Wisconsin and is not sector specific (commercial, agricultural, residential etc.) with respect to input values such as avoided costs.

The measure-level detail is in some cases sector specific. If, for example, hours of operation are different between sectors, this might be reflected in the cost-effectiveness calculator as different sector energy savings at the measure level for the same measure.

Finally, to complete the cost-effectiveness evaluation, incremental installed cost data was derived from projects funded by Focus on Energy that were installed in calendar years 2010 and 2011:

Biogas: Cost and energy savings data were based on a review of Focus on Energy data from the WISeerts database for calendar years 2010 and 2011. The installation cost was normalized per nameplate kW. There were no residential sector projects utilizing biogas during calendar years 2010 and 2011. Measure life is assumed to be 25 years.

Geothermal: Cost and energy savings data were based on a review of Focus on Energy data from the WISeerts database for calendar years 2010 and 2011 and Focus on Energy Deemed Savings Manual. Cost and savings data was normalized based on building square footage of conditioned space. Unit cost is based on new construction incremental cost, not existing replacement. Normalized data showed no distinct difference between commercial and residential sectors. Measure life is assumed to be 15 years.

Biomass: Cost and energy savings data were based on a review of Focus on Energy data from the WISeerts database for calendar years 2010 and 2011. Most systems installed were smaller, utilizing residential scale equipment in agricultural applications or medium-sized equipment for small industrial/institutional applications. Two large projects at industrial facilities were identified in the analysis. The measure life is assumed to be 25 years.

Solar: Cost and energy savings data were based on a review of Focus on Energy data from the WISeerts database and residential programs database for calendar years 2010 and 2011. Approximately 600 projects for this time frame were analyzed, split almost evenly between residential and non-residential customers. Cost and savings data was based on a linear regression analysis of claimed kW and claimed kWh data which produced favorable R^2 results. Measure life is assumed to be 20 years based on review of equipment warranties used in Wisconsin installations.

Wind: Cost and energy savings data were based on a review of Focus on Energy data from the WISeerts database for calendar years 2010 and 2011. Cost and savings data was normalized per kW of nameplate capacity. The measure life is assumed to be 25 years.

III. RESULTS

The results of the TRC test and values used are shown in Table 2.

The results of the cost-effectiveness calculations showed that biomass resources and biogas resource applications at farms yielded a B/C ratio greater than one. All other resources and technologies evaluated had B/C ratios less than 1.0. Geothermal HVAC and Wind 100 kW-1 MW resulted in B/C ratios over 0.5. All solar applications as well as the smaller wind applications resulted in low B/C ratios.

Table 2. Total Cost Resource Test Values for Renewable Technologies

Technology	Technology Life (Years)	Incremental Installed Cost Unit	Incremental Installed Cost per unit (2011$)	Natural Gas Savings per unit (therms/yr)	Energy Savings per unit (kWh/yr)	Summer Coincident Peak Load Reduction per unit(kW-yr)	TRC B/C Ratio (Historic Avoided Cost)	TRC B/C Ratio (Future Avoided Cost)
Biogas - Industrial Electric Generation	25.0	kW (Nameplate)	$20,579.85	(8.1)	4,130.0	0.470	0.21	0.35
Biogas - Industrial Cogeneration	25.0	kW (Nameplate)	$10,020.00	46.0	1,833.4	0.222	0.28	0.41
Biogas - Farm	25.0	kW (Nameplate)	$1,961.23	0.0	2,590.2	0.298	1.42	2.35
Geothermal - HVAC	15.0	SF	$5.00	0.3873	(2.4544)	0.00059	0.86	0.69
Biomass – Industrial Sector	25.0	Therm (Production)	$5.57	1.0	(0.1)	(0.0)	3.13	3.11
Solar Thermal	20.0	Therm (Production)	$42.98	1.0	(0.0)	(0.0)	0.38	0.38
Solar PV - Commercial	20.0	kW (Production)	$14,339.00	0.0	2,626.0	1.0	0.26	0.37
Solar PV - Small Business	20.0	kW (Production)	$12,946.00	0.0	2,480.0	1.0	0.28	0.39
Solar PV - Residential	20.0	kW (Production)	$20,670.00	0.0	3,640.0	1.0	0.21	0.32
Wind up to-20 kW	25.0	kW (Nameplate)	$5,980.90	0.0	1,226.3	0.170	0.23	0.38
Wind 20 kW-100 kW	25.0	kW (Nameplate)	$6,122.00	0.0	1,776.6	0.202	0.31	0.52
Wind 100 kW-1 MW	25.0	kW (Nameplate)	$3,500.00	0.0	2,000.0	0.220	0.61	1.45

NON-MONETIZED BENEFITS EVALUATION

I. APPROACH

During calendar year 2010, the Commission determined that both renewable energy and energy efficiency projects would be evaluated equally under the cost-effectiveness requirements. In addition to the cost-effectiveness test, the Commission developed non-monetized criteria to help guide decisions with respect to renewable energy technologies (Docket 5-GF-191).

These criteria include aspects of the technologies that are difficult to capture as a monetary value. They account for technology risk, maturity, job creation, tax credits, impact on peak loads and other costs that may be associated with implementation of the technology. In all, the Commission came up with 13 criteria that could be scored from a value of -2 up to 2. Thus, technologies evaluated could have a benefit score ranging from -26 up to 26.

II. ASSUMPTIONS

Commercially available technologies were evaluated using calendar year 2011 data from Focus on Energy. This data came from the WISeerts database and a database maintained by Wisconsin Energy Conservation Corporation (WECC) that compiles data on funded Focus on Energy programs for single family residential properties. Additionally, Focus on Energy data was used to establish realistic equipment sizes for projects installed in Wisconsin.

Information on technologies from the Department of Energy was used for equipment lifetime, maintenance requirements and ability of technology to produce electricity during peak demand hours.

III. RESULTS

The commercially available technologies evaluated had scores ranging from four (4) to 17. Overall, biogas, biomass and geothermal HVAC technologies ranked the highest. Some of the technologies could not obtain the maximum allowable score for criteria such as "supply-side market for technology is mature" because there are no certification programs available for that technology.

The technology and the non-monetized scores are provided in Table 3. Completed matrices for each technology with evaluation criteria follow this page.

Table 3. Commercially Available Technologies and Non-Monetized Scores

Technology	Non-Monetized Score
Biogas – Farm	17
Biomass	15
Biogas – Industrial Electric Generation	13
Biogas – Industrial Cogeneration	13
Geothermal HVAC	12
Wind 100 kW to 1 MW	8
Solar Thermal	8
Solar Photovoltaic	7
Wind 20 to 100 kW	5
Wind up to 20 kW	4

Table 4. Biogas – Farm Technology: Expanded Cost-Effectiveness Evaluation of Focus Renewable Resource Measures

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure's Focus on Energy cost-effectiveness is good.	2	Measure's cost effectiveness is ≤0.2	Measure's cost effectiveness is >0.2 and ≤0.29	Measure's cost effectiveness is >0.3 and ≤0.49	Measure's cost effectiveness is >0.5 and ≤0.7	Measure's cost effectiveness is >0.7
Technology Risk: Technology's installation, operation & performance issues are known, product certifications exist.	2	Tech is unknown, has few or no installations in WI that have undergone Focus M&V.	Tech has installations in WI but M&V shows performance and energy savings are unreliable.	Tech's issues are known but it is unknown if they can be resolved near term via more product development.	Tech has energy savings reliability issues and is showing gradual improvement.	Tech is well understood with few performance or energy savings reliability issues.
Comment: *Technology is well understood - several installations throughout the state. Few energy reliability issues.*						
Technology Maturity: The technology is not undergoing rapid upgrades that affect cost or performance.	0	Tech is very early stage, undergoing many changes, with no commercial installations.	Tech has one or two commercial installs, but has many improvements needed.	Tech is mature, many installations and few improvements planned.	Tech is undergoing small but steady improvements in performance.	Tech is making large performance improvements every few years.
Supply-side market for technology is mature (plenty of sellers & choices) & seller/installer certifications exist.	0	No certified sellers serving WI, few product choices.	Five or fewer sellers serving WI, no certifications exist.	More than five sellers & products in WI but weak or no certifications.	More than five sellers & products in WI with draft certifications.	More than five sellers & products in WI with national certifications.
Customer Payback: Measure's simple payback is within one measure lifetime (value of energy savings compared to the customer's after-tax investment).	2	Payback is greater than 2 measure lifetimes.	Payback is between 1.5 and 2 measure lifetimes.	Payback is between one and 1.5 measure lifetimes.	Payback is between 15 years and one measure lifetime.	Payback is between 2 and 15 years.
Additional Customer Maintenance: Costs to owner not included in normal payback calculation.	2	Over measure life, non-fuel O&M costs can be >=80% value of energy produced/saved.	Over measure life, non-fuel O&M costs are between 50-79% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 30-49% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 11-29% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are <10% of the value of energy produced/saved.
Federal tax credit returned to WI.	0	N/A	N/A	No tax credits are available.	For the customer segment, between 0-49% of tax credits return to WI entities.	50-100% of federal tax credit returns to WI-based entities in the customer segment.

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure produces or can cost-effectively be designed to produce primarily on-peak kWh (on-peak hours = 8 am to 9 pm M-F, about 40% of all hours).	0	Unknown what percent of energy is produced on-peak, measure can't be dispatched, storage is not cost effective.	Measure produces between <30% of its energy on-peak, can't be dispatched and fuel or energy storage is not cost effective.	Measure produces >30% and ≤44% of its energy on-peak but may improve via fuel or energy storage.	Measure produces >45% and ≤59% of its energy on-peak.	Measure produces ≥ 60% of its energy on-peak.
Supports jobs after system installation such as fuel collection & processing in WI. O&M jobs should be excluded from consideration since conventional resources also have large O&M components.	1	N/A	N/A	Has no job impacts above conventional resources.	Support of jobs is limited. (For example, biogas CHP systems require more O&M and fuel handling than the "zero" category, but not enough for the +2 category.)	Biomass thermal and CHP would be prime candidates for their biomass harvest, transport and process jobs.
Increases diversity of energy supply.	2	N/A	N/A	Increases supply diversity but in increments too small to be meaningful <100 kW or <10,000 therms/yr	Increases supply diversity in increments > 100 kW and ≤300 kW or > 10,000 therms/yr and ≤100,000 therms/yr.	Increases supply diversity in increments > 300 kW or >100,000 therms/yr.
Uses waste stream as a fuel.	2	N/A	N/A	N/A	Energy production is an easy disposal or mass reduction method (i.e. black liquor boilers & waste biomass.	Energy production makes waste stream more valuable for other uses or solves important waste management issues (i.e. biogas).
Comment: *Uses waste as fuel.*						
Helps meet energy shortfalls/emergencies.	2	N/A	N/A	Helps meet energy shortfalls but in increments too small to be meaningful <100 kW or <10,000 therms/yr (i.e. solar, small wind).	Helps meet energy shortfalls in increments >100 kW and ≤300 kW or >10,000 therms/yr and ≤100,000 therms/yr.	Helps meet energy shortfalls in increments >300 kW or >100,000 therms/yr.
Creates renewable by-products other than energy (i.e. biogas systems produce fertilizer, soil amendments and bedding).	2	Creates toxic by-products that must be handled specially and disposed of properly.	By-products that must be handled specially and disposed of properly.	By-products can be safely land filled or land spread.	Value of by-products is up to 10% of the value of energy produced.	Value of byproducts is up to >10% of the value of energy produced.
Comment: *Creates useful by-products.*						

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
TOTAL SCORE FOR NON-MONETARY BENEFITS	**17**					
** Non-Monetized Benefits Not Included in Simple TRC*						

Table 5. Biomass Technology: Expanded Cost-Effectiveness Evaluation of Focus Renewable Resource Measures

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure's Focus on Energy cost-effectiveness is good.	2	Measure's cost effectiveness is ≤0.2	Measure's cost effectiveness is >0.2 and ≤0.29	Measure's cost effectiveness is >0.3 and ≤0.49	Measure's cost effectiveness is >0.5 and ≤0.7	Measure's cost effectiveness is >0.7
Technology Risk: Technology's installation, operation & performance issues are known, product certifications exist.	1	Tech is unknown, has few or no installations in WI that have undergone Focus M&V.	Tech has installations in WI but M&V shows performance and energy savings are unreliable.	Tech's issues are known but it is unknown if they can be resolved near term via more product development.	Tech has energy savings reliability issues and is showing gradual improvement.	Tech is well understood with few performance or energy savings reliability issues.
Comment: *Some variation in reliability based on fuel, fuel availability.*						
Technology Maturity: The technology is not undergoing rapid upgrades that affect cost or performance.	1	Tech is very early stage, undergoing many changes, with no commercial installations.	Tech has one or two commercial installs, but has many improvements needed.	Tech is mature, many installations and few improvements planned.	Tech is undergoing small but steady improvements in performance.	Tech is making large performance improvements every few years.
Comment: *Basic technology is very mature, occasional improvements specific to fuel types.*						
Supply-side market for technology is mature (plenty of sellers & choices) & seller/installer certifications exist.	0	No certified sellers serving WI, few product choices.	Five or fewer sellers serving WI, no certifications exist.	More than five sellers & products in WI but weak or no certifications.	More than five sellers & products in WI with draft certifications.	More than five sellers & products in WI with national certifications.
Comment: *Products available directly in or shipped to WI, but no installer certifications.*						
Customer Payback: Measure's simple payback is within one measure lifetime (value of energy savings compared to the customer's after-tax investment).	2	Payback is greater than 2 measure lifetimes.	Payback is between 1.5 and 2 measure lifetimes.	Payback is between one and 1.5 measure lifetimes.	Payback is between 15 years and one measure lifetime.	Payback is between 2 and 15 years.
Additional Customer Maintenance: Costs to owner not included in normal payback calculation.	0	Over measure life, non-fuel O&M costs can be >=80% value of energy produced/saved.	Over measure life, non-fuel O&M costs are between 50-79% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 30-49% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 11-29% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are <10% of the value of energy produced/saved.
Federal tax credit returned to WI.	2	N/A	N/A	No tax credits are available.	For the customer segment, between 0-49% of tax credits return to WI entities.	50-100% of federal tax credit returns to WI-based entities in the customer segment.
Comment: *Federal tax credit available to residential customers for biomass stoves.*						

Description of Non-Monetized Benefit	Benefit Score	-2	-1	0	+1	+2
Measure produces or can cost-effectively be designed to produce primarily on-peak kWh (on-peak hours = 8 am to 9 pm M-F, about 40% of all hours).	0	Unknown what percent of energy is produced on-peak, measure can't be dispatched, storage is not cost effective.	Measure produces between <30% of its energy on-peak, can't be dispatched and fuel or energy storage is not cost effective.	Measure produces >30% and ≤44% of its energy on-peak but may improve via fuel or energy storage.	Measure produces >45% and ≤59% of its energy on-peak.	Measure produces ≥ 60% of its energy on-peak.
Comment: *Some facilities co-generate steam and electricity, Focus on Energy has limited experience with these. In order to represent the most likely scenarios for implementation with Focus on Energy's, natural gas displacement (only) is assumed. Based on the assumption that natural gas peak hours occur overnight during heating system (lowest temperature and no solar heat gain), the minimum score for this technology is a zero, but could be as high as 2 if a combined heat and power system is installed.*						
Supports jobs after system installation such as fuel collection & processing in WI. O&M jobs should be excluded from consideration since conventional resources also have large O&M components.	2	N/A	N/A	Has no job impacts above conventional resources.	Support of jobs is limited. (For example, biogas CHP systems require more O&M and fuel handling than the "zero" category, but not enough for the +2 category.)	Biomass thermal and CHP would be prime candidates for their biomass harvest, transport and process jobs.
Comment: *Generates jobs directly in fuel collection or processing, especially in rural areas of the state.*						
Increases diversity of energy supply.	2	N/A	N/A	Increases supply diversity but in increments too small to be meaningful <100 kW or <10,000 therms/yr.	Increases supply diversity in increments > 100 kW and ≤300 kW or > 10,000 therms/yr and ≤100,000 therms/yr.	Increases supply diversity in increments > 300 kW or >100,000 therms/yr.
Comment: *A few systems in WI have been installed with natural gas displacement of 1 million therms per year or greater.*						
Uses waste stream as a fuel.	1	N/A	NA	N/A	Energy production is an easy disposal or mass reduction method (i.e. black liquor boilers & waste biomass.	Energy production makes waste stream more valuable for other uses or solves important waste management issues (i.e. biogas).
Comment: *Typically uses waste as fuel. Some facilities use waste by-products produced in other industries.*						

Description of Non-Monetized Benefit	Benefit Score	-2	-1	0	+1	+2
Helps meet energy shortfalls/emergencies.	2	N/A	N/A	Helps meet energy shortfalls but in increments too small to be meaningful <100 kW or <10,000 therms/yr (i.e. solar, small wind).	Helps meet energy shortfalls in increments >100 kW and ≤300 kW or >10,000 therms/yr and ≤100,000 therms/yr.	Helps meet energy shortfalls in increments >300 kW or >100,000 therms/yr.
Comment: *A few systems in WI have been installed with natural gas displacement of 1 million therms per year or greater.*						
Creates renewable by-products other than energy (i.e. biogas systems produce fertilizer, soil amendments and bedding).	0	Creates toxic by-products that must be handled specially and disposed of properly.	By-products that must be handled specially and disposed of properly.	By-products can be safely land filled or land spread.	Value of by-products is up to 10% of the value of energy produced.	Value of by-products is up to >10% of the value of energy produced.
Comment: *Ash from combustion typically can be safely placed in a landfill.*						
TOTAL SCORE FOR NON-MONETARY BENEFITS	**15**					
** Non-Monetized Benefits Not Included in Simple TRC*						

Table 6. Biogas – Industrial Electric Generation Technology: Expanded Cost-Effectiveness Evaluation of Focus Renewable Resource Measures

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure's Focus on Energy cost-effectiveness is good.	-1	Measure's cost effectiveness is ≤0.2	Measure's cost effectiveness is >0.2 and ≤0.29	Measure's cost effectiveness is >0.3 and ≤0.49	Measure's cost effectiveness is >0.5 and ≤0.7	Measure's cost effectiveness is >0.7
Technology Risk: Technology's installation, operation & performance issues are known, product certifications exist.	2	Tech is unknown, has few or no installations in WI that have undergone Focus M&V.	Tech has installations in WI but M&V shows performance and energy savings are unreliable.	Tech's issues are known but it is unknown if they can be resolved near term via more product development.	Tech has energy savings reliability issues and is showing gradual improvement.	Tech is well understood with few performance or energy savings reliability issues.
Comment: *Several installations.*						
Technology Maturity: The technology is not undergoing rapid upgrades that affect cost or performance.	0	Tech is very early stage, undergoing many changes, with no commercial installations.	Tech has one or two commercial installs, but has many improvements needed.	Tech is mature, many installations and few improvements planned.	Tech is undergoing small but steady improvements in performance.	Tech is making large performance improvements every few years.
Supply-side market for technology is mature (plenty of sellers & choices) & seller/installer certifications exist.	0	No certified sellers serving WI, few product choices.	Five or fewer sellers serving WI, no certifications exist.	More than five sellers & products in WI but weak or no certifications.	More than five sellers & products in WI with draft certifications.	More than five sellers & products in WI with national certifications.
Customer Payback: Measure's simple payback is within one measure lifetime (value of energy savings compared to the customer's after-tax investment).	2	Payback is greater than 2 measure lifetimes.	Payback is between 1.5 and 2 measure lifetimes.	Payback is between one and 1.5 measure lifetimes.	Payback is between 15 years and one measure lifetime.	Payback is between 2 and 15 years.
Additional Customer Maintenance: Costs to owner not included in normal payback calculation.	1	Over measure life, non-fuel O&M costs can be >=80% value of energy produced/saved.	Over measure life, non-fuel O&M costs are between 50-79% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 30-49% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 11-29% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are <10% of the value of energy produced/saved.
Federal tax credit returned to WI.	0	N/A	N/A	No tax credits are available.	For the customer segment, between 0-49% of tax credits return to WI entities.	50-100% of federal tax credit returns to WI-based entities in the customer segment.
Measure produces or can cost-effectively be designed to produce primarily on-peak kWh (on-peak hours = 8 am to 9 pm M-F, about 40% of all hours).	0	Unknown what percent of energy is produced on-peak, measure can't be dispatched, storage is not cost effective.	Measure produces between <30% of its energy on-peak, can't be dispatched and fuel or energy storage is not cost effective.	Measure produces >30% and ≤44% of its energy on-peak but may improve via fuel or energy storage.	Measure produces >45% and ≤59% of its energy on-peak.	Measure produces ≥ 60% of its energy on-peak.
Supports jobs after system installation such as fuel collection & processing in WI. O&M jobs should be excluded from consideration since conventional resources also have large O&M components.	1	N/A	N/A	Has no job impacts above conventional resources.	Support of jobs is limited. (e.g., require more O&M and fuel handling than the "0" category, but not enough for	Biomass thermal and CHP would be prime candidates for their biomass harvest, transport and process jobs.

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
					the +2 category.)	
Increases diversity of energy supply.	2	N/A	N/A	Increases supply diversity but in increments too small to be meaningful <100 kW or <10,000 therms/yr.	Increases supply diversity in increments > 100 kW and ≤300 kW or > 10,000 therms/yr and ≤100,000 therms/yr.	Increases supply diversity in increments > 300 kW or >100,000 therms/yr.
Uses waste stream as a fuel.	2	N/A	NA	N/A	Energy production is an easy disposal or mass reduction method (i.e. black liquor boilers & waste biomass.	Energy production makes waste stream more valuable for other uses or solves important waste management issues (i.e. biogas).
Comment: *Uses waste as a fuel.*						
Helps meet energy shortfalls/emergencies.	2	N/A	N/A	Helps meet energy shortfalls but in increments too small to be meaningful <100 kW or <10,000 therms/yr (i.e. solar, small wind).	Helps meet energy shortfalls in increments >100 kW and ≤300 kW or >10,000 therms/yr and ≤100,000 therms/yr.	Helps meet energy shortfalls in increments >300 kW or >100,000 therms/yr.
Creates renewable by-products other than energy (i.e. biogas systems produce fertilizer, soil amendments and bedding).	2	Creates toxic by-products that must be handled specially and disposed of properly.	By-products that must be handled specially and disposed of properly.	By-products can be safely land filled or land spread.	Value of by-products is up to 10% of the value of energy produced.	Value of by-products is up to >10% of the value of energy produced.
Comment: *Creates useful by-products.*						
TOTAL SCORE FOR NON-MONETARY BENEFITS	**13**					
** Non-Monetized Benefits Not Included in Simple TRC*						

Table 7. Biogas - Industrial Cogeneration: Expanded Cost-Effectiveness Evaluation of Focus Renewable Resource Measures

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure's Focus cost-effectiveness is good.	-1	Measure's cost effectiveness is ≤0.2	Measure's cost effectiveness is >0.2 and ≤0.29	Measure's cost effectiveness is >0.3 and ≤0.49	Measure's cost effectiveness is >0.5 and ≤0.7	Measure's cost effectiveness is >0.7
Technology Risk: Technology's installation, operation & performance issues are known, product certifications exist.	2	Tech is unknown, has few or no installations in WI that have undergone Focus M&V	Tech has installations in WI but M&V shows performance and energy savings are unreliable	Tech's issues are known but it is unknown if they can be resolved near term via more product development	Tech has energy savings reliability issues and is showing gradual improvement	Tech is well understood with few performance or energy savings reliability issues.
Comment: *Several installations.*						
Technology Maturity: The technology is not undergoing rapid upgrades that affect cost or performance.	0	Tech is very early stage, undergoing many changes, with no commercial installations.	Tech has one or two commercial installs, but has many improvements needed.	Tech is mature, many installations and few improvements planned.	Tech is undergoing small but steady improvements in performance	Tech is making large performance improvements every few years.
Supply-side market for technology is mature (plenty of sellers & choices) & seller/installer certifications exist.	0	No certified sellers serving WI, few product choices	Five or fewer sellers serving WI, no certifications exist	More than five sellers & products in WI but weak or no certifications	More than five sellers & products in WI with draft certifications	More than five sellers & products in WI with national certifications
Customer Payback: Measure's simple payback is within one measure lifetime (value of energy savings compared to the customer's after-tax investment).	2	Payback is greater than 2 measure lifetimes	Payback is between 1.5 and 2 measure lifetimes	Payback is between one and 1.5 measure lifetimes	Payback is between 15 years and one measure lifetime	Payback is between 2 and 15 years.
Additional Customer Maintenance: Costs to owner not included in normal payback calculation.	1	Over measure life, non-fuel O&M costs can be >=80% value of energy produced/saved	Over measure life, non-fuel O&M costs are between 50-79% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are 30-49% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are 11-29% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are <10% of the value of energy produced/saved
Federal tax credit returned to WI.	0	N/A	N/A	No tax credits are available	For the customer segment, between 0-49% of tax credits return to WI entities	50-100% of federal tax credit returns to WI-based entities in the customer segment
Measure produces or can cost-effectively be designed to produce primarily on-peak kWh (on-peak hours = 8 am to 9 pm M-F, about 40% of all hours).	0	Unknown what percent of energy is produced on-peak, measure can't be dispatched, storage is not cost effective	Measure produces between <30% of its energy on-peak, can't be dispatched and fuel or energy storage is not cost effective	Measure produces >30% and ≤44% of its energy on-peak but may improve via fuel or energy storage	Measure produces >45% and ≤59% of its energy on-peak	Measure produces ≥ 60% of its energy on-peak

Description of Non-Monetized Benefit	Benefit Score	-2	-1	0	+1	+2
Supports jobs after system installation such as fuel collection & processing in WI. O&M jobs should be excluded from consideration since conventional resources also have large O&M components.	1	N/A	N/A	Has no job impacts above conventional resources.	Support of jobs is limited. (For example, biogas CHP systems require more O&M and fuel handling than the "zero" category, but not enough for the +2 category.)	Biomass thermal and CHP would be prime candidates for their biomass harvest, transport and process jobs.
Increases diversity of energy supply.	2	N/A	N/A	Increases supply diversity but in increments too small to be meaningful <100 kW or <10,000 therms/yr	Increases supply diversity in increments > 100 kW and ≤300 kW or > 10,000 therms/yr and ≤100,000 therms/yr	Increases supply diversity in increments > 300 kW or >100,000 therms/yr
Uses waste stream as a fuel.	2	N/A	NA	N/A	Energy production is an easy disposal or mass reduction method (i.e. black liquor boilers & waste biomass	Energy production makes waste stream more valuable for other uses or solves important waste management issues (i.e. biogas)
Comment: *Uses a waste stream as fuel.*						
Helps meet energy shortfalls/emergencies.	2	N/A	N/A	Helps meet energy shortfalls but in increments too small to be meaningful <100 kW or <10,000 therms/yr (i.e. solar, small wind)	Helps meet energy shortfalls in increments >100 kW and ≤300 kW or >10,000 therms/yr and ≤100,000 therms/yr	Helps meet energy shortfalls in increments >300 kW or >100,000 therms/yr
Creates renewable by-products other than energy (i.e. biogas systems produce fertilizer, soil amendments and bedding).	2	Creates toxic by-products that must be handled specially and disposed of properly	By-products that must be handled specially and disposed of properly	By-products can be safely land filled or land spread	Value of by-products is up to 10% of the value of energy produced	Value of by-products is up to >10% of the value of energy produced
TOTAL SCORE FOR NON-MONETARY BENEFITS	**13**					
** Non-Monetized Benefits Not Included in Simple TRC*						

Table 8. Geothermal – HVAC Technology: Expanded Cost-Effectiveness Evaluation of Focus Renewable Resource Measures

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure's Focus on Energy cost-effectiveness is good.	2	Measure's cost effectiveness is ≤0.2	Measure's cost effectiveness is >0.2 and ≤0.29	Measure's cost effectiveness is >0.3 and ≤0.49	Measure's cost effectiveness is >0.5 and ≤0.7	Measure's cost effectiveness is >0.7
Technology Risk: Technology's installation, operation & performance issues are known, product certifications exist.	1	Tech is unknown, has few or no installations in WI that have undergone Focus M&V	Tech has installations in WI but M&V shows performance and energy savings are unreliable	Tech's issues are known but it is unknown if they can be resolved near term via more product development	Tech has energy savings reliability issues and is showing gradual improvement	Tech is well understood with few performance or energy savings reliability issues.
Comment: *Several installations.*						
Technology Maturity: The technology is not undergoing rapid upgrades that affect cost or performance.	1	Tech is very early stage, undergoing many changes, with no commercial installations.	Tech has one or two commercial installs, but has many improvements needed.	Tech is mature, many installations and few improvements planned.	Tech is undergoing small but steady improvements in performance	Tech is making large performance improvements every few years.
Supply-side market for technology is mature (plenty of sellers & choices) & seller/installer certifications exist.	2	No certified sellers serving WI, few product choices	Five or fewer sellers serving WI, no certifications exist	More than five sellers & products in WI but weak or no certifications	More than five sellers & products in WI with draft certifications	More than five sellers & products in WI with national certifications
Comment: *Numerous certified installers in WI.*						
Customer Payback: Measure's simple payback is within one measure lifetime (value of energy savings compared to the customer's after-tax investment).	2	Payback is greater than 2 measure lifetimes	Payback is between 1.5 and 2 measure lifetimes	Payback is between one and 1.5 measure lifetimes	Payback is between 15 years and one measure lifetime	Payback is between 2 and 15 years.
Additional Customer Maintenance: Costs to owner not included in normal payback calculation.	2	Over measure life, non-fuel O&M costs can be >=80% value of energy produced/saved	Over measure life, non-fuel O&M costs are between 50-79% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are 30-49% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are 11-29% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are <10% of the value of energy produced/saved
Federal tax credit returned to WI.	2	N/A	N/A	No tax credits are available	For the customer segment, between 0-49% of tax credits return to WI entities	50-100% of federal tax credit returns to WI-based entities in the customer segment
Measure produces or can cost-effectively be designed to produce primarily on-peak kWh (on-peak hours = 8 am to 9 pm M-F, about 40% of all hours).	-2	Unknown what percent of energy is produced on-peak, measure can't be dispatched, storage is not cost effective	Measure produces between <30% of its energy on-peak, can't be dispatched and fuel or energy storage is not cost effective	Measure produces >30% and ≤44% of its energy on-peak but may improve via fuel or energy storage	Measure produces >45% and ≤59% of its energy on-peak	Measure produces ≥ 60% of its energy on-peak

Description of Non-Monetized Benefit	Benefit Score	-2	-1	0	+1	+2
Supports jobs after system installation such as fuel collection & processing in WI. O&M jobs should be excluded from consideration since conventional resources also have large O&M components.	0	N/A	N/A	Has no job impacts above conventional resources.	Support of jobs is limited. (For example, biogas CHP systems require more O&M and fuel handling than the "zero" category, but not enough for the +2 category.)	Biomass thermal and CHP would be prime candidates for their biomass harvest, transport and process jobs.
Increases diversity of energy supply.	1	N/A	N/A	Increases supply diversity but in increments too small to be meaningful <100 kW or <10,000 therms/yr	Increases supply diversity in increments > 100 kW and ≤300 kW or > 10,000 therms/yr and ≤100,000 therms/yr	Increases supply diversity in increments > 300 kW or >100,000 therms/yr
Comment: *Systems for commercial buildings can generate large therm savings.*						
Uses waste stream as a fuel.	0	N/A	NA	N/A	Energy production is an easy disposal or mass reduction method (i.e. black liquor boilers & waste biomass	Energy production makes waste stream more valuable for other uses or solves important waste management issues (i.e. biogas)
Comment: *Does not use waste as fuel.*						
Helps meet energy shortfalls/emergencies.	1	N/A	N/A	Helps meet energy shortfalls but in increments too small to be meaningful <100 kW or <10,000 therms/yr (i.e. solar, small wind)	Helps meet energy shortfalls in increments >100 kW and ≤300 kW or >10,000 therms/yr and ≤100,000 therms/yr	Helps meet energy shortfalls in increments >300 kW or >100,000 therms/yr
Comment: *Systems for commercial buildings can generate large therm savings.*						
Creates renewable by-products other than energy (i.e. biogas systems produce fertilizer, soil amendments and bedding).	0	Creates toxic by-products that must be handled specially and disposed of properly	By-products that must be handled specially and disposed of properly	By-products can be safely land filled or land spread	Value of by-products is up to 10% of the value of energy produced	Value of by-products is up to >10% of the value of energy produced
Comment: *Does not create any by-products.*						
TOTAL SCORE FOR NON-MONETARY BENEFITS	**12**					
** Non-Monetized Benefits Not Included in Simple TRC*						

Table 9. Wind 100-1000 kW: Expanded Cost-Effectiveness Evaluation of Focus Renewable Resource Measures

Description of Non-Monetized Benefit	Benefit Score	-2	-1	0	+1	+2
Measure's Focus cost-effectiveness is good.	1	Measure's cost effectiveness is ≤0.2	Measure's cost effectiveness is >0.2 and ≤0.29	Measure's cost effectiveness is >0.3 and ≤0.49	Measure's cost effectiveness is >0.5 and ≤0.7	Measure's cost effectiveness is >0.7
Technology Risk: Technology's installation, operation & performance issues are known, product certifications exist.	2	Tech is unknown, has few or no installations in WI that have undergone Focus M&V	Tech has installations in WI but M&V shows performance and energy savings are unreliable	Tech's issues are known but it is unknown if they can be resolved near term via more product development	Tech has energy savings reliability issues and is showing gradual improvement	Tech is well understood with few performance or energy savings reliability issues.
Comment: *Many installations, DOE tools available to estimate production, Focus on Energy M&V reports.*						
Technology Maturity: The technology is not undergoing rapid upgrades that affect cost or performance.	0	Tech is very early stage, undergoing many changes, with no commercial installations.	Tech has one or two commercial installs, but has many improvements needed.	Tech is mature, many installations and few improvements planned.	Tech is undergoing small but steady improvements in performance	Tech is making large performance improvements every few years.
Supply-side market for technology is mature (plenty of sellers & choices) & seller/installer certifications exist.	2	No certified sellers serving WI, few product choices	Five or fewer sellers serving WI, no certifications exist	More than five sellers & products in WI but weak or no certifications	More than five sellers & products in WI with draft certifications	More than five sellers & products in WI with national certifications
Comment: *Numerous certified installers in WI.*						
Customer Payback: Measure's simple payback is within one measure lifetime (value of energy savings compared to the customer's after-tax investment).	0	Payback is greater than 2 measure lifetimes	Payback is between 1.5 and 2 measure lifetimes	Payback is between one and 1.5 measure lifetimes	Payback is between 15 years and one measure lifetime	Payback is between 2 and 15 years.
Additional Customer Maintenance: Costs to owner not included in normal payback calculation.	2	Over measure life, non-fuel O&M costs can be >=80% value of energy produced/saved	Over measure life, non-fuel O&M costs are between 50-79% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are 30-49% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are 11-29% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are <10% of the value of energy produced/saved
Federal tax credit returned to WI.	1	N/A	N/A	No tax credits are available	For the customer segment, between 0-49% of tax credits return to WI entities	50-100% of federal tax credit returns to WI-based entities in the customer segment
Measure produces or can cost-effectively be designed to produce primarily on-peak kWh (on-peak hours = 8 am to 9 pm M-F, about 40% of all hours).	-1	Unknown what percent of energy is produced on-peak, measure can't be dispatched, storage is not cost effective	Measure produces between <30% of its energy on-peak, can't be dispatched and fuel or energy storage is not cost effective	Measure produces >30% and ≤44% of its energy on-peak but may improve via fuel or energy storage	Measure produces >45% and ≤59% of its energy on-peak	Measure produces ≥ 60% of its energy on-peak
Comment: *Ability to provide energy is weather-dependent.*						

Description of Non-Monetized Benefit	Benefit Score	-2	-1	0	+1	+2
Increases diversity of energy supply.	1	N/A	N/A	Increases supply diversity but in increments too small to be meaningful <100 kW or <10,000 therms/yr	Increases supply diversity in increments > 100 kW and ≤300 kW or > 10,000 therms/yr and ≤100,000 therms/yr	Increases supply diversity in increments > 300 kW or >100,000 therms/yr
Uses waste stream as a fuel.	0	N/A	NA	N/A	Energy production is an easy disposal or mass reduction method (i.e. black liquor boilers & waste biomass	Energy production makes waste stream more valuable for other uses or solves important waste management issues (i.e. biogas)
Comment: *Does not use waste as fuel*						
Helps meet energy shortfalls/emergencies.	0	N/A	N/A	Helps meet energy shortfalls but in increments too small to be meaningful <100 kW or <10,000 therms/yr (i.e. solar, small wind)	Helps meet energy shortfalls in increments >100 kW and ≤300 kW or >10,000 therms/yr and ≤100,000 therms/yr	Helps meet energy shortfalls in increments >300 kW or >100,000 therms/yr
Comment: *Ability to provide emergency energy is weather-dependent.*						
Creates renewable by-products other than energy (i.e. biogas systems produce fertilizer, soil amendments and bedding).	0	Creates toxic by-products that must be handled specially and disposed of properly	By-products that must be handled specially and disposed of properly	By-products can be safely land filled or land spread	Value of by-products is up to 10% of the value of energy produced	Value of by-products is up to >10% of the value of energy produced
Comment: *Does not create any by-products*						
TOTAL SCORE FOR NON-MONETARY BENEFITS	**8**					

Table 10. Solar Thermal: Expanded Cost-Effectiveness Evaluation of Focus Renewable Resource Measures

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure's Focus cost-effectiveness is good.	0	Measure's cost effectiveness is ≤0.2	Measure's cost effectiveness is >0.2 and ≤0.29	Measure's cost effectiveness is >0.3 and ≤0.49	Measure's cost effectiveness is >0.5 and ≤0.7	Measure's cost effectiveness is >0.7
Technology Risk: Technology's installation, operation & performance issues are known, product certifications exist.	2	Tech is unknown, has few or no installations in WI that have undergone Focus M&V.	Tech has installations in WI but M&V shows performance and energy savings are unreliable.	Tech's issues are known but it is unknown if they can be resolved near term via more product development.	Tech has energy savings reliability issues and is showing gradual improvement.	Tech is well understood with few performance or energy savings reliability issues.
***Comment:** Many installations, DOE tools available to estimate production.*						
Technology Maturity: The technology is not undergoing rapid upgrades that affect cost or performance.	0	Tech is very early stage, undergoing many changes, with no commercial installations.	Tech has one or two commercial installs, but has many improvements needed.	Tech is mature, many installations and few improvements planned.	Tech is undergoing small but steady improvements in performance.	Tech is making large performance improvements every few years.
***Comment:** Technology is mature, no further improvements expected.*						
Supply-side market for technology is mature (plenty of sellers & choices) & seller/installer certifications exist.	2	No certified sellers serving WI, few product choices.	Five or fewer sellers serving WI, no certifications exist.	More than five sellers & products in WI but weak or no certifications.	More than five sellers & products in WI with draft certifications.	More than five sellers & products in WI with national certifications.
***Comment:** Significantly more than 5 NABCEP certified installers in WI.*						
Customer Payback: Measure's simple payback is within one measure lifetime (value of energy savings compared to the customer's after-tax investment).	-2	Payback is greater than 2 measure lifetimes.	Payback is between 1.5 and 2 measure lifetimes.	Payback is between one and 1.5 measure lifetimes.	Payback is between 15 years and one measure lifetime.	Payback is between 2 and 15 years.
***Comment:** Cost-effectiveness calculator lifetime energy benefit gives a payback greater than 2 measure lifetimes.*						
Additional Customer Maintenance: Costs to owner not included in normal payback calculation.	1	Over measure life, non-fuel O&M costs can be >=80% value of energy produced/saved.	Over measure life, non-fuel O&M costs are between 50-79% of the value of energy produced/saved .	Over measure life, non-fuel O&M costs are 30-49% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 11-29% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are <10% of the value of energy produced/saved.
***Comment:** Very sensitive to assumptions about how many repairs will be needed. Assume that panels and tank last for full measure life; maintenance cost is equal to 10% of balance of system capital cost.*						
Federal tax credit returned to WI.	2	N/A	N/A	No tax credits are available.	For the customer segment, between 0-49% of tax credits return to WI entities.	50-100% of federal tax credit returns to WI-based entities in the customer segment.
Measure produces or can cost-effectively be designed	2	Unknown what percent	Measure produces between	Measure produces >30%	Measure produces >45%	Measure produces ≥ 60% of

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
to produce primarily on-peak kWh (on-peak hours = 8 am to 9 pm M-F, about 40% of all hours).		of energy is produced on-peak, measure can't be dispatched, storage is not cost effective.	<30% of its energy on-peak, can't be dispatched and fuel or energy storage is not cost effective.	and ≤44% of its energy on-peak but may improve via fuel or energy storage.	and ≤59% of its energy on-peak.	its energy on-peak.
Comment: *Solar Thermal displacing electric water heat coincides with peak demand period. However, for solar thermal displacing natural gas the score would be lower (-1 or 0).*						
Supports jobs after system installation such as fuel collection & processing in WI. O&M jobs should be excluded from consideration since conventional resources also have large O&M components.	0	N/A	N/A	Has no job impacts above conventional resources.	Support of jobs is limited. (For example, biogas CHP systems require more O&M and fuel handling than the "zero" category, but not enough for the +2 category).	Biomass thermal and CHP would be prime candidates for their biomass harvest, transport and process jobs.
Comment: *No non- O&M jobs after installation.*						
Increases diversity of energy supply.	1	N/A	N/A	Increases supply diversity but in increments too small to be meaningful <100 kW or <10,000 therms/yr.	Increases supply diversity in increments between 100 kW & ≤300 kW or > 10,000 therms/yr & ≤100,000 therms/yr.	Increases supply diversity in increments > 300 kW or >100,000 therms/yr.
Comment: *Limited Focus on Energy history of systems with equivalent capacity greater than 10,000 therms per year, but possible to achieve a value up to 100,000 therms.*						
Uses waste stream as a fuel.	0	N/A	NA	N/A	Energy production is an easy disposal or mass reduction method (i.e. black liquor boilers & waste biomass.	Energy production makes waste stream more valuable for other uses or solves important waste management issues (i.e. biogas).
Comment: *Does not use waste as fuel*						
Helps meet energy shortfalls/emergencies.	0	N/A	N/A	Helps meet energy shortfalls but in increments too small to be meaningful <100 kW or <10,000 therms/yr (i.e. solar, small wind).	Helps meet energy shortfalls in increments >100 kW and ≤300 kW or >10,000 therms/yr and ≤100,000 therms/yr.	Helps meet energy shortfalls in increments >300 kW or >100,000 therms/yr.
Comment: *Limited Focus on Energy history of systems with capacity greater than 10,000 therms per year, but possible to achieve a value up to 100,000 therms. Score is lower for emergency shortfalls because Focus on Energy experience with larger systems reduces the certainty that these systems would provide reliable backup capacity.*						
Creates renewable by-products other than energy	0	Creates toxic by-	By-products that must be	By-products can be safely	Value of by-products is up	Value of by-products is up

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
(i.e. biogas systems produce fertilizer, soil amendments and bedding).		products that must be handled specially and disposed of properly.	handled specially and disposed of properly.	land filled or land spread.	to 10% of the value of energy produced.	to >10% of the value of energy produced.
Comment: *Does not create any by-products.*						
TOTAL SCORE FOR NON-MONETARY BENEFITS	**8**					
** Non-Monetized Benefits Not Included in Simple TRC*						

Table 11. Solar PV: Expanded Cost-Effectiveness Evaluation of Focus Renewable Resource Measures

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure's Focus on Energy's cost-effectiveness is good.	-1	Measure's cost effectiveness is ≤0.2	Measure's cost effectiveness is >0.2 and ≤0.29	Measure's cost effectiveness is >0.3 and ≤0.49	Measure's cost effectiveness is >0.5 and ≤0.7	Measure's cost effectiveness is >0.7
Technology Risk: Technology's installation, operation & performance issues are known, product certifications exist.	2	Tech is unknown, has few or no installations in WI that have undergone Focus M&V.	Tech has installations in WI but M&V shows performance and energy savings are unreliable.	Tech's issues are known but it is unknown if they can be resolved near term via more product development.	Tech has energy savings reliability issues and is showing gradual improvement.	Tech is well understood with few performance or energy savings reliability issues.
Comment: *Many installations, DOE tools available to estimate production, Focus on Energy M&V reports.*						
Technology Maturity: The technology is not undergoing rapid upgrades that affect cost or performance.	1	Tech is very early stage, undergoing many changes, with no commercial installations.	Tech has one or two commercial installs, but has many improvements needed.	Tech is mature, many installations and few improvements planned.	Tech is undergoing small but steady improvements in performance.	Tech is making large performance improvements every few years.
Comment: *Basic technology is evolving steadily, decreases in cost coming as a combination of scale economy and technology improvements*						
Supply-side market for technology is mature (plenty of sellers & choices) & seller/installer certifications exist.	2	No certified sellers serving WI, few product choices.	Five or fewer sellers serving WI, no certifications exist.	More than five sellers & products in WI but weak or no certifications.	More than five sellers & products in WI with draft certifications.	More than five sellers & products in WI with national certifications.
Comment: *Significantly more than 5 NABCEP certified installers in WI.*						
Customer Payback: Measure's simple payback is within one measure lifetime (value of energy savings compared to the customer's after-tax investment).	-2	Payback is greater than 2 measure lifetimes.	Payback is between 1.5 and 2 measure lifetimes.	Payback is between one and 1.5 measure lifetimes.	Payback is between 15 years and one measure lifetime.	Payback is between 2 and 15 years.
Comment: *Cost-effectiveness calculator lifetime energy benefit gives a payback of 4.16 x measure lifetime. Assuming energy cost inflation and system degradation, gives a payback of 1.66 x measure lifetime. Since median of this range is over 2 x measure lifetime, -2 is assigned.*						
Additional Customer Maintenance: Costs to owner not included in normal payback calculation.	1	Over measure life, non-fuel O&M costs can be >=80% value of energy produced/saved.	Over measure life, non-fuel O&M costs are between 50-79% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 30-49% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 11-29% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are <10% of the value of energy produced/saved.
Comment: *Inverter replacement is 6.8% of total lifetime capital cost. Replacement is ~10% of value of energy produced, assuming linear degradation to 80% of capacity in 25 years, $0.10/kWh and 3% annual inflation.*						
Federal tax credit returned to WI.	2	N/A	N/A	No tax credits are available.	For the customer segment, between 0-49% of tax credits return to WI entities.	50-100% of federal tax credit returns to WI-based entities in the customer segment.

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure produces or can cost-effectively be designed to produce primarily on-peak kWh (on-peak hours = 8 am to 9 pm M-F, about 40% of all hours).	2	Unknown what percent of energy is produced on-peak, measure can't be dispatched, storage is not cost effective.	Measure produces between <30% of its energy on-peak, can't be dispatched and fuel or energy storage is not cost effective.	Measure produces >30% and ≤44% of its energy on-peak but may improve via fuel or energy storage.	Measure produces >45% and ≤59% of its energy on-peak.	Measure produces ≥ 60% of its energy on-peak.
Comment: *By design, Solar PV produces energy during daylight hours.*						
Supports jobs after system installation such as fuel collection & processing in WI. O&M jobs should be excluded from consideration since conventional resources also have large O&M components.	0	N/A	N/A	Has no job impacts above conventional resources.	Support of jobs is limited. (For example, biogas CHP systems require more O&M and fuel handling than the "zero" category, but not enough for the +2 category).	Biomass thermal and CHP would be prime candidates for their biomass harvest, transport and process jobs.
Comment: *No non- O&M jobs after installation.*						
Increases diversity of energy supply.	0	N/A	N/A	Increases supply diversity but in increments too small to be meaningful <100 kW or <10,000 therms/yr.	Increases supply diversity in increments > 100 kW and ≤300 kW or > 10,000 therms/yr and ≤100,000 therms/yr.	Increases supply diversity in increments > 300 kW or >100,000 therms/yr.
Comment: *PV systems over 100 kW are not widely installed in WI.*						
Uses waste stream as a fuel.	0	N/A	NA	N/A	Energy production is an easy disposal or mass reduction method (i.e. black liquor boilers & waste biomass.	Energy production makes waste stream more valuable for other uses or solves important waste management issues (i.e. biogas).
Comment: *Does not use waste as fuel*						
Helps meet energy shortfalls/emergencies.	0	N/A	N/A	Helps meet energy shortfalls but in increments too small to be meaningful <100 kW or <10,000 therms/yr (i.e. solar, small wind).	Helps meet energy shortfalls in increments >100 kW and ≤300 kW or >10,000 therms/yr and ≤100,000 therms/yr.	Helps meet energy shortfalls in increments >300 kW or >100,000 therms/yr.
Comment: *PV systems over 100 kW are not widely installed in WI; ability to provide emergency energy is weather-dependent.*						
Creates renewable by-products other than energy (i.e. biogas systems produce fertilizer, soil amendments and bedding).	0	Creates toxic by-products that must be handled specially and disposed of properly.	By-products that must be handled specially and disposed of properly.	By-products can be safely land filled or land spread.	Value of by-products is up to 10% of the value of energy produced.	Value of by-products is up to >10% of the value of energy produced.

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Comment: *Does not create any by-products.*						
TOTAL SCORE FOR NON-MONETARY BENEFITS	**7**					
** Non-Monetized Benefits Not Included in Simple TRC*						

Table 12. Wind 20-100 kW: Expanded Cost-Effectiveness Evaluation of Focus Renewable Resource Measures

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure's Focus on Energy cost-effectiveness is good.	0	Measure's cost effectiveness is ≤0.2	Measure's cost effectiveness is >0.2 and ≤0.29	Measure's cost effectiveness is >0.3 and ≤0.49	Measure's cost effectiveness is >0.5 and ≤0.7	Measure's cost effectiveness is >0.7
Technology Risk: Technology's installation, operation & performance issues are known, product certifications exist.	2	Tech is unknown, has few or no installations in WI that have undergone Focus M&V.	Tech has installations in WI but M&V shows performance and energy savings are unreliable.	Tech's issues are known but it is unknown if they can be resolved near term via more product development.	Tech has energy savings reliability issues and is showing gradual improvement.	Tech is well understood with few performance or energy savings reliability issues.
Comment: *Many installations, DOE tools available to estimate production, Focus on Energy M&V reports.*						
Technology Maturity: The technology is not undergoing rapid upgrades that affect cost or performance.	0	Tech is very early stage, undergoing many changes, with no commercial installations.	Tech has one or two commercial installs, but has many improvements needed.	Tech is mature, many installations and few improvements planned.	Tech is undergoing small but steady improvements in performance.	Tech is making large performance improvements every few years.
Supply-side market for technology is mature (plenty of sellers & choices) & seller/installer certifications exist.	2	No certified sellers serving WI, few product choices.	Five or fewer sellers serving WI, no certifications exist.	More than five sellers & products in WI but weak or no certifications.	More than five sellers & products in WI with draft certifications.	More than five sellers & products in WI with national certifications.
Comment: *Numerous certified installers in WI.*						
Customer Payback: Measure's simple payback is within one measure lifetime (value of energy savings compared to the customer's after-tax investment).	-2	Payback is greater than 2 measure lifetimes.	Payback is between 1.5 and 2 measure lifetimes.	Payback is between one and 1.5 measure lifetimes.	Payback is between 15 years and one measure lifetime.	Payback is between 2 and 15 years.
Comment: *Cost-effectiveness calculator lifetime energy benefit gives a payback greater than 2x measure lifetime.*						
Additional Customer Maintenance: Costs to owner not included in normal payback calculation.	2	Over measure life, non-fuel O&M costs can be >=80% value of energy produced/saved.	Over measure life, non-fuel O&M costs are between 50-79% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 30-49% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are 11-29% of the value of energy produced/saved.	Over measure life, non-fuel O&M costs are <10% of the value of energy produced/saved.

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Federal tax credit returned to WI.	2	N/A	N/A	No tax credits are available.	For the customer segment, between 0-49% of tax credits return to WI entities.	50-100% of federal tax credit returns to WI-based entities in the customer segment.
Measure produces or can cost-effectively be designed to produce primarily on-peak kWh (on-peak hours = 8 am to 9 pm M-F, about 40% of all hours).	-1	Unknown what percent of energy is produced on-peak, measure can't be dispatched, storage is not cost effective.	Measure produces between <30% of its energy on-peak, can't be dispatched and fuel or energy storage is not cost effective.	Measure produces >30% and ≤44% of its energy on-peak but may improve via fuel or energy storage.	Measure produces >45% and ≤59% of its energy on-peak.	Measure produces ≥ 60% of its energy on-peak.
Comment: *Ability to provide energy is weather-dependent.*						
Supports jobs after system installation such as fuel collection & processing in WI. O&M jobs should be excluded from consideration since conventional resources also have large O&M components.	0	N/A	N/A	Has no job impacts above conventional resources.	Support of jobs is limited. (For example, biogas CHP systems require more O&M and fuel handling than the "zero" category, but not enough for the +2 category).	Biomass thermal and CHP would be prime candidates for their biomass harvest, transport and process jobs.
Increases diversity of energy supply.	0	N/A	N/A	Increases supply diversity but in increments too small to be meaningful <100 kW or <10,000 therms/yr.	Increases supply diversity in increments > 100 kW and ≤300 kW or > 10,000 therms/yr and ≤100,000 therms/yr.	Increases supply diversity in increments > 300 kW or >100,000 therms/yr.
Uses waste stream as a fuel.	0	N/A	NA	N/A	Energy production is an easy disposal or mass reduction method (i.e. black liquor boilers & waste biomass.	Energy production makes waste stream more valuable for other uses or solves important waste management issues (i.e. biogas)
Comment: *Does not use waste as fuel.*						
Helps meet energy shortfalls/emergencies.	0	N/A	N/A	Helps meet energy shortfalls but in increments too small to be meaningful <100 kW or <10,000 therms/yr (i.e. solar, small wind).	Helps meet energy shortfalls in increments >100 kW and ≤300 kW or >10,000 therms/yr and ≤100,000 therms/yr.	Helps meet energy shortfalls in increments >300 kW or >100,000 therms/yr.

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Comment: *Ability to provide emergency energy is weather-dependent.*						
Creates renewable by-products other than energy (i.e. biogas systems produce fertilizer, soil amendments and bedding).	0	Creates toxic by-products that must be handled specially and disposed of properly.	By-products that must be handled specially and disposed of properly.	By-products can be safely land filled or land spread.	Value of by-products is up to 10% of the value of energy produced.	Value of by-products is up to >10% of the value of energy produced.
Comment: *Does not create any by-products.*						
TOTAL SCORE FOR NON-MONETARY BENEFITS	**5**					
** Non-Monetized Benefits Not Included in Simple TRC*						

Table 13. Wind 0-20 kW: Expanded Cost-Effectiveness Evaluation of Focus Renewable Resource Measures

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
Measure's Focus cost-effectiveness is good.	-1	Measure's cost effectiveness is ≤0.2	Measure's cost effectiveness is >0.2 and ≤0.29	Measure's cost effectiveness is >0.3 and ≤0.49	Measure's cost effectiveness is >0.5 and ≤0.7	Measure's cost effectiveness is >0.7
Technology Risk: Technology's installation, operation & performance issues are known, product certifications exist.	2	Tech is unknown, has few or no installations in WI that have undergone Focus M&V	Tech has installations in WI but M&V shows performance and energy savings are unreliable	Tech's issues are known but it is unknown if they can be resolved near term via more product development	Tech has energy savings reliability issues and is showing gradual improvement	Tech is well understood with few performance or energy savings reliability issues.
Comment: *Many installations, DOE tools available to estimate production, Focus on Energy M&V reports.*						
Technology Maturity: The technology is not undergoing rapid upgrades that affect cost or performance.	0	Tech is very early stage, undergoing many changes, with no commercial installations.	Tech has one or two commercial installs, but has many improvements needed.	Tech is mature, many installations and few improvements planned.	Tech is undergoing small but steady improvements in performance	Tech is making large performance improvements every few years.
Supply-side market for technology is mature (plenty of sellers & choices) & seller/installer certifications exist.	2	No certified sellers serving WI, few product choices	Five or fewer sellers serving WI, no certifications exist	More than five sellers & products in WI but weak or no certifications	More than five sellers & products in WI with draft certifications	More than five sellers & products in WI with national certifications
Comment: *Numerous certified installers in WI.*						
Customer Payback: Measure's simple payback is within one measure lifetime (value of energy savings compared to the customer's after-tax investment).	-2	Payback is greater than 2 measure lifetimes	Payback is between 1.5 and 2 measure lifetimes	Payback is between one and 1.5 measure lifetimes	Payback is between 15 years and one measure lifetime	Payback is between 2 and 15 years.
Comment: *Cost-effectiveness calculator lifetime energy benefit gives a payback greater than 2x measure lifetime.*						
Additional Customer Maintenance: Costs to owner not included in normal payback calculation.	2	Over measure life, non-fuel O&M costs can be >=80% value of energy produced/saved	Over measure life, non-fuel O&M costs are between 50-79% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are 30-49% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are 11-29% of the value of energy produced/saved	Over measure life, non-fuel O&M costs are <10% of the value of energy produced/saved
Federal tax credit returned to WI.	2	N/A	N/A	No tax credits are available	For the customer segment, between 0-49% of tax credits return to WI entities	50-100% of federal tax credit returns to WI-based entities in the customer segment
Measure produces or can cost-effectively be designed to produce primarily on-peak kWh (on-peak hours = 8 am to 9 pm M-F, about 40% of all hours).	-1	Unknown what percent of energy is produced on-peak, measure can't be dispatched,	Measure produces between <30% of its energy on-peak, can't be dispatched and fuel or energy storage	Measure produces >30% and ≤44% of its energy on-peak but may improve via fuel or energy storage	Measure produces >45% and ≤59% of its energy on-peak	Measure produces ≥ 60% of its energy on-peak

Description of Non-Monetized Benefit*	Benefit Score	-2	-1	0	+1	+2
		storage is not cost effective	is not cost effective			
Comment: *Ability to provide energy is weather-dependent.*						
Supports jobs after system installation such as fuel collection & processing in WI. O&M jobs should be excluded from consideration since conventional resources also have large O&M components.	0	N/A	N/A	Has no job impacts above conventional resources.	Support of jobs is limited. (For example, biogas CHP systems require more O&M and fuel handling than the "zero" category, but not enough for the +2 category.)	Biomass thermal and CHP would be prime candidates for their biomass harvest, transport and process jobs.
Increases diversity of energy supply.	0	N/A	N/A	Increases supply diversity but in increments too small to be meaningful <100 kW or <10,000 therms/yr	Increases supply diversity in increments > 100 kW and ≤300 kW or > 10,000 therms/yr and ≤100,000 therms/yr	Increases supply diversity in increments > 300 kW or >100,000 therms/yr
Uses waste stream as a fuel.	0	N/A	NA	N/A	Energy production is an easy disposal or mass reduction method (i.e. black liquor boilers & waste biomass	Energy production makes waste stream more valuable for other uses or solves important waste management issues (i.e. biogas)
Comment: *Does not use waste as fuel*						
Helps meet energy shortfalls/emergencies.	0	N/A	N/A	Helps meet energy shortfalls but in increments too small to be meaningful <100 kW or <10,000 therms/yr (i.e. solar, small wind)	Helps meet energy shortfalls in increments >100 kW and ≤300 kW or >10,000 therms/yr and ≤100,000 therms/yr	Helps meet energy shortfalls in increments >300 kW or >100,000 therms/yr
Comment: *Ability to provide emergency energy is weather-dependent.*						
Creates renewable by-products other than energy (i.e. biogas systems produce fertilizer, soil amendments and bedding).	0	Creates toxic by-products that must be handled specially and disposed of properly	By-products that must be handled specially and disposed of properly	By-products can be safely land filled or land spread	Value of by-products is up to 10% of the value of energy produced	Value of by-products is up to >10% of the value of energy produced
Comment: *Does not create any by-products*						
TOTAL SCORE FOR NON-MONETARY BENEFITS	**4**					
** Non-Monetized Benefits Not Included in Simple TRC*						

COMBINED EVALUATION

Once the cost-effectiveness and the non-monetized benefits analysis were concluded, it is possible to compare the results of both tests in order to draw final conclusions. The complete results of the TRC and non-monetary benefit evaluations are provided below in Table 14.

Table 14. Renewable Technology

Technology	TRC B/C Ratio (Historic Avoided Cost)	TRC B/C Ratio (Future Avoided Cost)	Non-monetized Benefit Score
Biogas – Farm	1.42	2.35	17
Biomass	3.13	3.11	15
Biogas – Industrial Cogeneration	0.28	0.41	13
Biogas – Industrial Electric Generation	0.21	0.35	13
Geothermal HVAC	0.86	0.69	12
Solar Thermal	0.38	0.38	8
Wind 100 kW to 1 MW	0.61	1.45	8
Solar Photovoltaic	0.21 - 0.28	0.32 – 0.37	7
Wind 20 to 100 kW	0.31	0.52	5
Wind up to 20 kW	0.23	0.38	4

In terms of non-monetized benefit scores and B/C ratios, biogas - farm and biomass are the top ranked technologies. They are followed by biogas – industrial and geothermal - HVAC. Note that the recovery of biogas at industrial facilities had high non-monetary benefit scores, but low benefit to cost (B/C) ratios. Evaluation of solar technologies resulted in low non-monetary benefit scores and low B/C ratios. Finally, small scale wind projects had the lowest non-monetary benefit scores and B/C ratios.

IMPACTS TO THE PORTFOLIOS

After the TRC and non-monetized benefits analysis were completed, the Program Administrator proceeded to model the impact of various renewable energy technologies on the cost-effectiveness of the entire Focus on Energy Mass Markets and Targeted Markets portfolios. Ultimately, Focus on Energy portfolios need to remain cost-effective in order to ensure the long-term sustainability of the program and provide value to Wisconsin ratepayers.

Note that, as this evaluation is being completed, several Targeted Markets and Mass Markets programs are being competitively bid out and redesigned. Thus, this presents a challenge in that not all of the cost-effectiveness values for individual programs were available at the time of analysis. In order to complete the analysis, the Program Administrator extrapolated the currently established programs using linear functions where other programs have not yet been finalized due to the transition of multiple program offerings.

I. SCENARIO MODELING

To allow for an effective analysis, the Program Administrator modeled, with the use of the Focus on Energy cost-effective calculator, several scenarios that assumed (1) various funding levels for renewable energy technologies and (2) a combination of measure mix penetration for the technologies evaluated.

The renewable energy technologies evaluated were grouped based on their TRC B/C Ratio and non-monetized Benefit Score as follows:

- **Group 1:** includes biogas, biomass, and geothermal technologies.
- **Group 2:** includes solar and wind technologies.

A total of 20 different scenarios were modeled through this process. For these scenarios, the measure mix was modified by changing the penetration level of Group 1 and Group 2 measures in quarter percent increments ranging from 0 to 100 percent of each group. Modeled funding levels were based on 10 percent, 7.5 percent, 5.0 percent, and 2.5 percent of the total 2012 Focus on Energy budget of approximately $96 million. For comparison purposes, a Scenario 0 was also developed to model all Focus on Energy programs without renewable energy technologies.

The measure mix and renewable energy budgets for each scenario are found in Table 15:

Table 15. Scenario Description

Scenario	Measure Mix	Renewable Energy Budget
Scenario 0 – Comparison	0% Group 1; 0% Group 2	-
Scenario 1	50% Group 1; 50% Group 2	$2.35M
Scenario 2	50% Group 1; 50% Group 2	$4.70M
Scenario 3	50% Group 1; 50% Group 2	$7.05M
Scenario 4	50% Group 1; 50% Group 2	$9.40M
Scenario 5	75% Group 1, 25% Group 2	$2.35M
Scenario 6	75% Group 1, 25% Group 2	$4.70M
Scenario 7	75% Group 1, 25% Group 2	$7.05M
Scenario 8	75% Group 1, 25% Group 2	$9.40M
Scenario 9	25% Group 1, 75% Group 2	$2.35M
Scenario 10	25% Group 1, 75% Group 2	$4.70M

Scenario	Measure Mix	Renewable Energy Budget
Scenario 11	25% Group 1, 75% Group 2	$7.05M
Scenario 12	25% Group 1, 75% Group 2	$9.40M
Scenario 13	100% Group 1, 0% Group 2	$2.35M
Scenario 14	100% Group 1, 0% Group 2	$4.70M
Scenario 15	100% Group 1, 0% Group 2	$7.05M
Scenario 16	100% Group 1, 0% Group 2	$9.40M
Scenario 17	0% Group 1, 100% Group 2	$2.35M
Scenario 18	0% Group 1, 100% Group 2	$4.70M
Scenario 19	0% Group 1, 100% Group 2	$7.05M
Scenario 20	0% Group 1, 100% Group 2	$9.40M

Additional assumptions included:

- With a fixed budget for calendar year 2012 for both renewable energy and energy efficiency technologies, the renewable energy budget value reduced the Targeted Markets and Mass Markets energy efficiency budgets by a ratio of 3:1 respectively. This is consistent with past Focus on Energy funding levels for renewable energy technologies.
- Incentives levels were assumed at 30 percent of incremental cost for each renewable technology.
- A 40 percent non-incentive program implementation cost was assumed across the board for all programs. This is consistent with past Focus on Energy program offerings.
- An equal distribution of measure penetration was assumed within each group. For example, for Group 1, if the total penetration were six measures it would be assumed that two measures were biogas, two measures were biomass, and two measures were geothermal HVAC.
- The measure life, incremental installed cost, natural gas savings per unit, and electric savings per unit were averaged for those technologies that had multiple applications (i.e., Biogas – Farm, Biogas – Industrial Cogeneration, and Biogas – Industrial Electric Generation).

II. RESULTS

The modeling of Scenario 0, where no renewable energy technologies are included in the analysis, the historic avoided cost values resulted in a TRC B/C ratio of 2.23 for the entire Focus on Energy program portfolio. Using the future avoided cost values but holding all other things constant the efficiency only model resulted in a TRC B/C ratio of 3.04.

The results of the overall cost effectiveness analysis, by scenario, are provided below in Table 16. These results include the TRC B/C ratios using both the historic avoided cost calculation methodology and future avoided cost calculation methodology.

Table 16. Scenario Results

Scenario	TRC B/C Ratio (Historic Avoided Cost)	TRC B/C Ratio (Future Avoided Cost)
Scenario 0	2.23	3.04
Scenario 1	2.195	2.98

Scenario	TRC B/C Ratio (Historic Avoided Cost)	TRC B/C Ratio (Future Avoided Cost)
Scenario 2	2.16	2.92
Scenario 3	2.125	2.86
Scenario 4	2.09	2.80
Scenario 5	2.2	2.98
Scenario 6	2.17	2.93
Scenario 7	2.14	2.87
Scenario 8	2.11	2.82
Scenario 9	2.185	2.97
Scenario 10	2.14	2.91
Scenario 11	2.095	2.84
Scenario 12	2.05	2.78
Scenario 13	2.205	2.99
Scenario 14	2.18	2.95
Scenario 15	2.155	2.90
Scenario 16	2.13	2.86
Scenario 17	2.18	2.97
Scenario 18	2.13	2.90
Scenario 19	2.08	2.83
Scenario 20	2.03	2.76

According to the results, regardless of the renewable energy measure mix, the inclusion of renewable energy technologies reduces the cost effectiveness of a program only incentivizing energy efficiency measures. In addition the following trends can be recognized through the scenario analysis:

- The higher the budget allocation to renewable the lower the cost-effectiveness of the portfolio.
- Using the forward looking (future) avoided cost methodology yields higher TRC values than the historic avoided costs.
- Group 1 technologies have a lower impact on overall TRC than Group 2 technologies.
- Technologies with a longer measure life yield better B/C ratios when using the future avoided cost calculation methodology.

III. CONCLUSIONS AND RECOMMENDATIONS

Independent of the measure mix and budget levels allocated to renewable energy technologies, it is the Program Administrator's recommendation that the program design for larger renewable energy technology installations is based on a competitive grant approach, instead of a first-come first-served basis.

National best practices suggest that a competitive approach for instances where technologies have traditionally low cost-effectiveness ratios, allow funding projects that result in greater energy production and lower costs when compared to the average project, thus pushing for higher benefit/cost ratios than typical.

In addition, a competitive approach will allow incorporating the non-monetized benefits identified by the Commission into the selection criteria, which further emphasizes the recognition that renewable energy technologies provide benefits to the economy and society which cannot be adequately monetized or evaluated with traditional cost-effectiveness tests.

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12. **NREL Biomass Atlas** (http://maps.nrel.gov/biomass): shows point information regarding existing facilities that utilize biomass as a primary fuel. In addition, data from the US EPA, US DOE, USDA, and other agencies have been aggregated to produce feedstock availability maps on a county-by-

county basis for the entire state.

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15. **Historical assessment of Focus on Energy projects (Focus Prescriptive)** filtered 2010 and 2011 data to review renewable projects implemented in the residential sector (implementation costs, annual energy stats, etc.).

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