***Renewable Energy Question 3**. How do Michigan's costs for renewable energy compare to the cost of existing generation and to the cost of new non-renewable generation today?*

Executive Summary

1. **Renewable energy is more expensive than the cost of existing generation as are most sources of new generation.** Based on known costs of electricity sources located in the state, Michigan's per-unit costs for renewable energy are considerably higher, at least 67 percent, than existing generation. It should be emphasized, however, that *most* sources of new generation are higher than existing generation.
2. **Costs for renewable energy can be higher or lower than new non-renewable generation based on the technology.** Based on EIA projections of per-unit levelized costs of different generation types, utility-scale wind energy, the least-cost renewable option,[1] is approximately a third more expensive than the least-cost non-renewable option (natural gas) and comparable to a new coal plant. With additional environmental controls, coal generation becomes more expensive than wind energy. Biomass is more expensive than natural gas but comparable to a new coal plant with advanced emission controls (without carbon sequestration). Solar PV is at least two times the cost of natural gas.
3. **The projected cost of energy, as shown in the EIA estimates, is only one consideration when comparing different sources of generation**. The EIA projections are levelized costs for the *energy* produced by the different generation sources. But planning by utilities and grid operators to ensure long-term supply of generation is done on a *capacity* basis. Certain types of renewable energy, namely wind and solar, have less capacity value due to their intermittency, which means that system operators cannot count on them during peak periods of high electricity consumption in the same manner as other types of generation.[2] So even though a certain generation type may have a relatively low per-unit energy cost, it may have less value to the electric system as a whole.
4. **Caution should be used when making these comparisons.** The cost estimates should be interpreted with caution given: (1) uncertainties and fluctuations in fuel and other cost drivers, (2) costs that are not quantified or reflected in the estimates, and (3) cost is but one feature to consider when evaluating future resource options for an individual utility or the state as a whole. Moreover, there are costs, such as transmission upgrade costs, that are not reflected in the estimates and may be more significant for specific types of generation, such as renewable energy, due to their remote location or operational characteristics.

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1. Renewable energy is more expensive than the cost of existing generation as are most sources of new generation.

Michigan's costs for renewable energy compared to the cost of existing generation in Michigan are documented in a briefing paper by Public Sector Consultants (PSC), *Proposal 3: Key Questions and Answers*, issued in September 2012 (see pp. 1–4, excerpt attached as Appendix 1). The PSC briefing paper includes the average cost to produce power from existing generation of Detroit Edison and Consumers Energy, the state's two largest electric utilities. The analysis also shows the average and per-project costs for existing renewable energy projects in the state. Based on these data, the levelized

[1] The EIA national projections list the cost of new hydro-electric generation at less than wind energy but there are significant regional variations in these cost projections and it is unlikely that new hydro-electric generation would be developed in Michigan. See Renewable Energy Question 8 for additional background on renewable resource options in Michigan.
[2] Moreover, data show that wind generation in the Midwest is often conversely correlated with periods of peak electricity usage.

cost of renewable energy in Michigan is at least 67 percent higher than existing generation in the state. Data on other existing generation of other electric utilities in the state are not included.

It is important to review the notes included in the paper to understand this is not an apples-to-apples comparison and there are other limitations with the comparison as well. In particular, most sources of new generation—renewable or non-renewable—are expected to cost more than the existing generation fleet, which includes older, depreciated assets. Therefore, as new generation sources are brought online they will, in almost all cases, cost more than the status quo. Because of this fact, it is important to carefully consider when, what type, and under what circumstances (e.g., environmental, reliability) new generation is built.

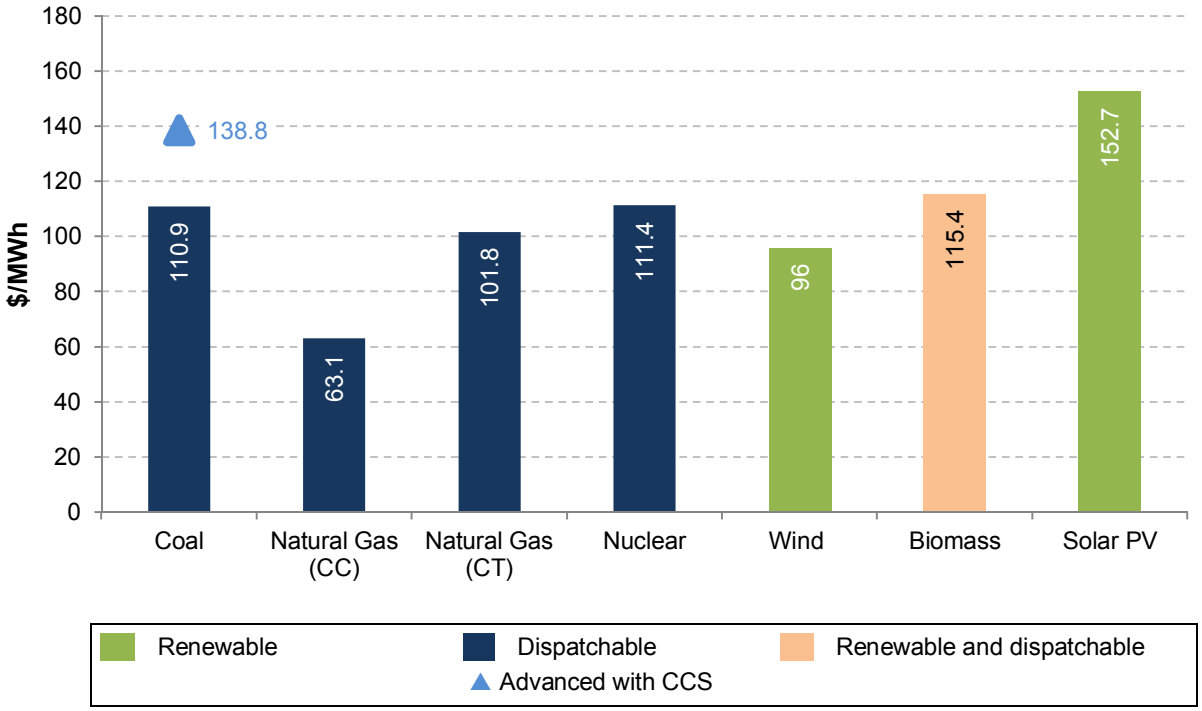
2. Costs for renewable energy can be higher or lower than new non-renewable generation based on the technology.

There are no new non-renewable generation plants in Michigan to compare to the new renewable generation installed in response to PA 295. Therefore, projections are used to answer this question. The EIA makes annual projections of the levelized per-unit costs of different generation sources by fuel type (see Appendix 2).[3] The EIA data are for new utility-scale generation brought into service in 2017 (2010 dollars). Exhibit 1 highlights the EIA cost projections for common generation types. Using these data, wind energy, at approximately $96/MWh, is approximately a third higher than the cost of a new advanced combined cycle natural gas plant (at $63/MWh) and less than coal plant with advanced emission controls ($111/MWh). Biomass is slightly higher than a coal plant. Solar PV is more than two times the cost of a natural gas plant. The EIA estimates for renewable sources do not reflect federal production or investment tax credits. These credits do not apply to generation built in 2017 under current law. The credits can significantly affect the cost estimates as discussed under Renewable Energy Question 4 in more detail. The numbers in Exhibit 1 are the EIA's midpoint values. Minimum and maximum values are shown in Appendix 2.

[3] See U.S. Energy Information Administration, Annual Energy Outlook 2012, June 2012, DOE/EIA-0383(2012). Available at *http://www.eia.gov/forecasts/aeo/electricity_generation.cfm*. There is an early release of Annual Energy Outlook 2013, which includes cost estimates for generation with an in-service date of 2018.

***Renewable Energy Question 3**. How do Michigan's costs for renewable energy compare to the cost of existing generation and to the cost of new non-renewable generation today?*

EXHIBIT 1. EIA Levelized Cost of New Generation Sources (2017 In-Service Date)



SOURCE: Public Sector Consultants, using data from U.S. Energy Information Administration, Annual Energy Outlook 2012, June 2012, DOE/EIA-0383(2012). Available at www.eia.gov/forecasts/aeo/electricity_generation.cfm.
NOTE: Natural gas and coal technologies are all based on "advanced" technology option. For natural gas combined cycle and combustion turbine units, the levelized costs for "advanced" units are less than conventional options.

3. The projected cost of energy, as shown in the EIA estimates, is only one consideration when comparing different sources of generation.

As emphasized by the DOE, caution should be used when comparing different sources because generation units whose output can be varied to follow demand (dispatchable) have more value to a system than less flexible generation or those whose output is linked to the availability of an intermittent resource, such as solar or wind.[4]

The EIA estimates show the projected cost of **energy**. But planning by utilities and grid operators to ensure long-term supply of generation is done on a **capacity** basis.[5] That is, utilities have to own or procure a certain amount of generating capacity plus a cushion, or reserve margin, in order to ensure that there is enough energy to supply customers during periods of high electricity consumption. Certain types of renewable energy, namely wind and solar, have less capacity value due to their intermittency. This means that system operators cannot count on them during peak periods of high

[4] As discussed under Renewable Energy Question 35, wind generation with the available technology within MISO can now be registered and operate as a dispatchable intermittent resources under MISO tariff guidelines. These advancements change the operation and utilization of wind generators and other conventional generation on the MISO system.
[5] Think of "energy" as the water flowing through the pipe and "capacity" as the diameter of the pipe. Wind energy and other intermittent sources produce energy (in the form of kilowatt hours) but do little to increase the capacity (kilowatts) to ensure there is adequate energy at critical times.

electricity consumption in the same manner as other types of generation. For example, the Midwest Independent Transmission System Operator, or MISO, studies actual wind generation during periods of peak consumption in order to calculate the maximum "capacity credit" that can be applied to wind generation if it is used by a utility to meet its reserve margin obligation. The current wind capacity credit for 2013–2014 is 13.3 percent, suggesting that, on average, only 13.3 percent of the total wind capacity across the MISO system can be counted on to be available during these periods.[6] For comparison, other types of generation such as coal, nuclear, or natural gas may have values in the range of 80–95 percent.[7] The EIA levelized cost projections are not adjusted to reflect this capacity value but it has a cost for the system as a whole. The response to Renewable Energy Question 5 includes additional discussion on this topic.

4. Caution should be used when making these comparisons.

It is important to consider the following when making these types of cost comparisons.

- ***Uncertainties of forecasts***—Forecasts and projections of costs fluctuate considerably based on commodity prices, technological advancements, labor costs, and other factors. The cost of renewable energy to meet the RPS in Michigan has declined over time.
- ***Intra-state and regional differences***—As detailed by the EIA in its Annual Energy Outlook, there are regional variations based on resource quality (wind and solar), labor, transportation, etc. Solar photovoltaic, in particular, has a significant range of projected costs. Michigan's installed utility-owned solar PV systems are closer to the high end of the EIA range than the midpoint shown in Exhibit 1 above. This is due in part to different solar resource potential in Michigan compared to other states, particularly in the southwest United States, as well as the smaller scale of projects that have been deployed. Moreover, the same type of renewable energy can vary *within* a state based on the available site and other siting considerations (e.g., wind resource classification, configuration of wind turbines based on approved siting plans).
- ***Additional costs***—The amounts shown do not reflect the full cost of delivering power. For example:
  - Transmission costs to connect and transport power from the new generation source are not included. Transmission costs can vary based on location and the size, type, and operating characteristics of the generation facility. Transmission update costs are discussed in more detail under Renewable Energy Question 5.
  - Integration costs to manage variations in output from intermittent resources, such as wind energy, are not included. (Based on several studies outside of Michigan, these costs can be roughly $5/MWh,[8] but these costs can vary by location and depend on the existing generation mix, transmission infrastructure, and wholesale market structure. See Renewable Energy Question 5 for additional detail.)
  - Targeted tax credits such as production tax credit for wind, solar, and biomass are not reflected in the EIA estimates.

[6] Midwest ISO, Planning Year 2013–2014 Wind Capacity Credit December 2012. Available at: www.midwestiso.org/Library/Repository/Study/LOLE/2013%20Wind%20Capacity%20Report.pdf.
[7] See, e.g., graph on slide 7 of the presentation at: www.midwestiso.org/Library/Repository/Meeting%20Material/Stakeholder/SAWG/2009/20091210%20SAWG/20091210%20SAWG%20Wind%20Capacity%20Credit.pdf.
[8] National Renewable Energy Laboratory, Eastern Wind Integration and Transmission Study, available at: www.nrel.gov/wind/news/2010/803.html.

***Renewable Energy Question 3**. How do Michigan's costs for renewable energy compare to the cost of existing generation and to the cost of new non-renewable generation today?*

- Environmental "externalities" from emissions or waste are not captured although EIA did assume in its calculations a higher cost of capital for technologies with high greenhouse gas emissions, such as coal. See Renewable Energy Question 4 for detail.
- The EIA data is based on utility-scale generation, including solar PV. Distributed applications of solar for residential or commercial cost more than EIA estimates.

Finally, when evaluating different resource options to meet Michigan's energy needs, cost is just one consideration. Other factors include: price stability; environmental attributes; operating characteristics (flexibility, dispatchability); siting feasibility; lead time; and others.

Appendix 1

PSC
PUBLIC SECTOR CONSULTANTS

Putting thought into action

September 2012

Proposal 3:
Key Questions and Answers

Proposal 3, known as the 25% by 2025 (25x25) ballot initiative, would amend the state's constitution by requiring electricity providers to obtain by 2025 at least 25% of their electricity from renewable energy sources. A constitutional amendment of this nature raises numerous technical, legal, social, and economic issues. The following questions and answers highlight some of these topics.

Costs and Rates

QUESTION: **How does the cost of existing conventional generation compare to renewable generation in Michigan today?**

ANSWER: ***Renewable generation is considerably more expensive than existing generation.***

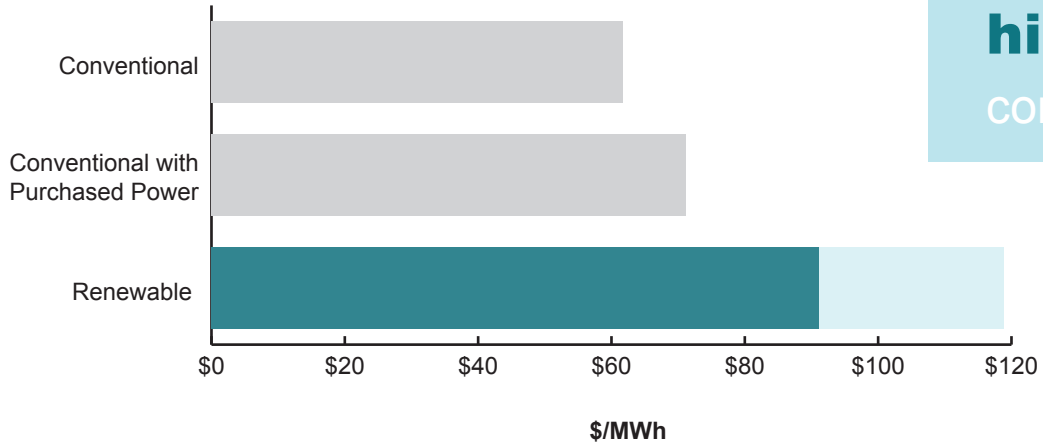
Forecasts or projections of prices, demand, and other factors in the energy industry fluctuate considerably. And despite the extensive analysis that goes into forecasting by government and industry experts, the numbers are often not consistent with the actual values due to unforeseen factors and the inherent complexities. Public Sector Consultants was asked by the Clean Affordable Renewable Energy for Michigan Coalition to document and compare the cost of producing power by Michigan's two largest electric companies to the cost of renewable energy sources in Michigan. Exhibit 1 illustrates the results of this analysis and documents the known costs of electricity sources in the state.

- **CONVENTIONAL** represents the average cost to produce power from Detroit Edison and Consumers Energy's existing generation, including coal, natural gas, nuclear, and hydroelectric plants, as applicable. It includes all current costs to generate power, including capital and operating costs. It does not include purchased power used to serve the utilities' customers—only the utilities' own generation.
- **CONVENTIONAL WITH PURCHASED POWER** represents the average cost of Detroit Edison and Consumers Energy to supply power to serve customers in Michigan. Like the figure for "conventional," it includes costs for generating electricity but it also includes purchased power and transmission costs. And it is based on the approved costs in the utilities' most recent rate cases.
- **RENEWABLE** represents the average price of all renewable energy projects that are or will be in service by the end of 2012. Only projects with pricing available are included. We have taken into consideration the federal production tax credit (PTC) by including it in the cost, as applicable to the particular technology, because it is a direct subsidy. The PTC is shown as an add-on to the Renewable bar in Exhibit 1.

For both conventional and renewable sources, the amounts shown do not represent the full cost of delivering power. Notably, transmission costs and losses are not included for either renewable or conventional production in the analysis despite being an important cost component. Transmission costs are an important consideration for renewable energy because enhanced transmission capacity is often needed to connect new generation and handle the intermittency of wind energy. Transmission is included in the "Conventional with Purchased Power" amount shown.

EXHIBIT 1. Cost of Existing Renewables Compared to Existing Conventional Generation in Michigan

Renewable is at least **67% higher** than conventional



SOURCE: Public Sector Consultants Inc., using data for conventional generation cost obtained from Detroit Edison Company and Consumers Energy Company rate cases filings and Annual Report of Electric Utilities, 2011, April 2012, based on MPSC Form P-521. Certain items augmented by data provided by utilities. Data on "conventional with purchased power" is from the MPSC's cost of service studies in case numbers U-16472 (Detroit Edison) and U-16794 (Consumers Energy). Data on renewable energy cost (without production tax credit) obtained from MPSC, Report on the Implementation of P.A. 295 Renewable Energy Standard and the Cost-Effectiveness of the Energy Standards, February 15, 2012.

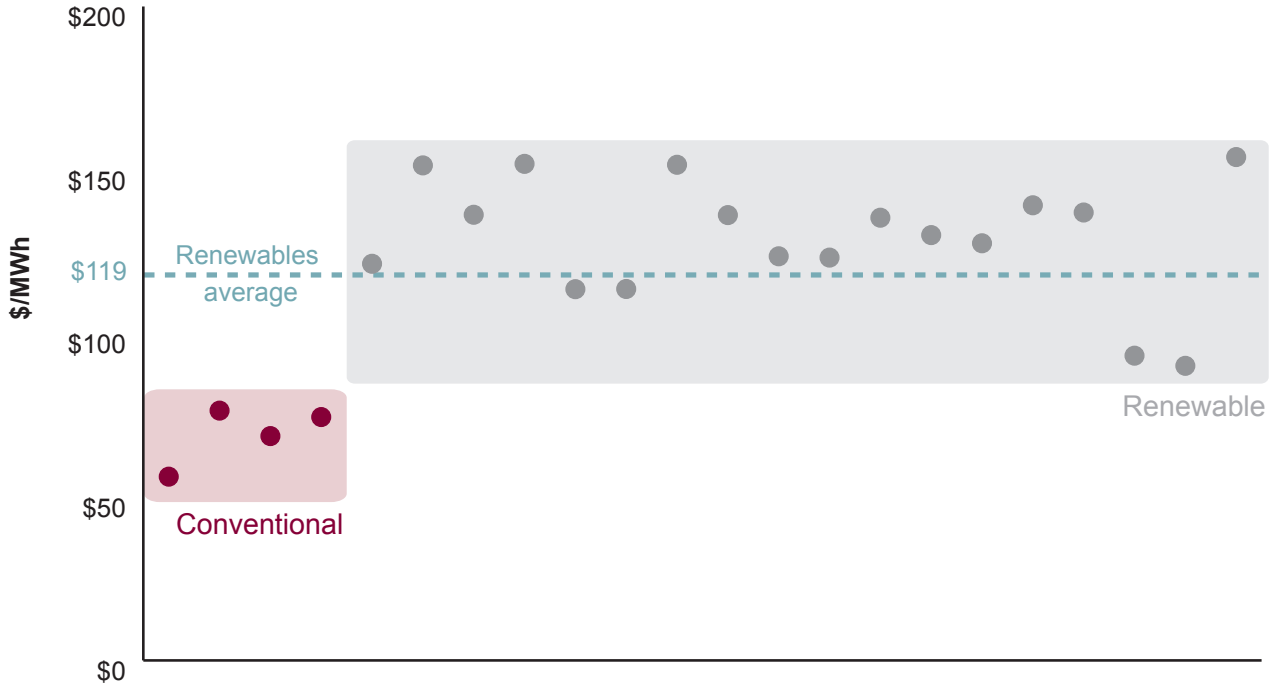
NOTES: Conventional generation amount is the weighted average of Detroit Edison Company and Consumers Energy Company cost of producing electricity using their existing generation. The cost represents the 2011 actual busbar cost of electric generating facilities divided by generation output net of plant use. It includes the capital, operating, and maintenance costs, including return on investment, depreciation of assets, fuel, taxes, insurance, etc. It does not include transmission service or purchased power expenses.

Conventional with purchased power amount is the weighted average of Detroit Edison Company and Consumers Energy Company production cost of service based on MPSC-approved costs. It includes all production costs, including purchased power and transmission service.

Renewable cost is the weighted average levelized cost of all renewable energy contracts submitted to the MPSC with per-unit pricing available. Pricing of some contracts not available. In addition, the amount includes the federal production tax credit for wind energy of $29.20 per megawatt-hour and $14.60 for biomass and landfill gas, as deemed applicable. The PTC is based on current credits of $22 per megawatt-hour and $11 per megawatt-hour for biomass and landfill gas adjusted for inflation, levelized, and grossed up for taxes. See also MPSC, "Michigan Utility Scale Wind Farms," updated June 2012, for project commercial operation dates.

The cost of renewable energy to meet the renewable portfolio standard (RPS) is declining, particularly with several wind energy projects that are expected to go into service this year. Exhibit 2 plots individual renewable projects and the costs for conventional generation at Detroit Edison and Consumers Energy. Only renewable energy projects with publicly available pricing submitted to the Michigan Public Service Commission (MPSC) are included. Some of the higher prices shown were renewable projects implemented before or shortly after the passage of Michigan's current energy plan, PA 295, and there has been a downward trend in pricing overall. See the table following Exhibit 2 (page 4) for a full listing of renewable energy projects and related pricing. As in Exhibit 1, we have included in the cost the federal production tax credit, as applicable, for renewable projects. Note that the PTC for wind, currently set at $22 per megawatt-hour, expires at the end of 2012 but applies to projects that went into service prior to that date. If the credits are not extended by Congress, this may affect the purchase cost and viability of future projects.

EXHIBIT 2. Conventional vs. Renewable Energy Costs



SOURCE: Public Sector Consultants Inc., using data for conventional generation cost obtained from Detroit Edison Company and Consumers Energy Company rate cases filings and Annual Report of Electric Utilities, 2011, April 2012, based on MPSC Form P-521. Certain items augmented by data provided by utilities. Data on "conventional with purchased power" is from the MPSC's cost of service studies in case numbers U-16472 (Detroit Edison) and U-16794 (Consumers Energy). Data on renewable energy cost (without production tax credit) obtained from MPSC, Report on the Implementation of P.A. 295 Renewable Energy Standard and the Cost-Effectiveness of the Energy Standards, February 15, 2012.

NOTES: Conventional generation amounts represent Detroit Edison Company's and Consumers Energy Company's actual costs of producing electricity using their existing generation. The cost represents the 2011 actual busbar cost of electric generating facilities divided by generation output net of plant use. It includes the capital, operating, and maintenance costs, including return on investment, depreciation of assets, fuel, taxes, insurance, etc. It does not include transmission service or purchased power expenses.

Conventional with purchased power amount is the weighted average of Detroit Edison Company and Consumers Energy Company production cost of service based on MPSC-approved costs. It includes all production costs, including purchased power and transmission service.

Renewable cost is the levelized cost of renewable energy contracts submitted to the MPSC with per-unit pricing available. In addition, the amount includes the federal production tax credit for wind energy of $29.20 per megawatt-hour and $14.60 for biomass and landfill gas, as deemed applicable. The PTC is based on current credits of $22 per megawatt-hour and $11 per megawatt-hour for biomass and landfill gas, adjusted for inflation and levelized and grossed up for taxes. See also MPSC, "Michigan Utility Scale Wind Farms," updated June 2012, for project commercial operation dates.

This is a simplified analysis of the cost of producing power from different sources. Therefore, several points are important when reviewing the graph and underlying information:

- The per-unit costs for utilities' existing conventional generation is not an "apples to apples" comparison to per-unit contract prices for renewable energy projects. First, the accounting of conventional generation owned by a regulated utility differs from a renewable energy contract. For example, utilities' cost of conventional generation includes all current costs to generate power, including capital and operating costs. The renewable energy purchased power price may not necessarily account for all of these expenses and represents the levelized costs over the life of the project. The conventional generation amount represents the actual costs for 2011, and these costs may fluctuate from year to year based on several factors such as fuel costs, unit efficiency, plant retirements, and new capital expenditures such as environmental control equipment. Second, the conventional generation includes costs associated with both newer and older power plants that make up the utility's

	$/MWH	$/MWH w/ PTC**	Type	In-service date
Conventional				
Detroit Edison	$56.2	N/A	Coal, nuclear, natural gas, and hydro	Varies
Consumers Energy	76.4	N/A	Coal, natural gas, and hydro	Varies
Detroit Edison Conventional with Purchased Power	68.61	N/A	Mixed	Varies
Consumers Energy Conventional with Purchased Power	74.43	N/A	Mixed	Varies
Renewable				
Elk Rapids	$121.31	$121.31	Hydro	2009***
Zeeland	122.20	151.40	Landfill gas	2009***
Scenic View Dairy*	121.70	136.30	Biomass	2009–2010***
NANR Lennon	137.27	151.87	Landfill gas	2010
L'Anse Warden*	98.94	113.54	Biomass	2010-2011
Blue Water Renewables—Smith Creek	99.00	113.60	Landfill gas	2011
Northern Oaks	122.39	151.59	Landfill gas	2012
Stoney Corners*	107.00	136.20	Wind	2008-2012
Gratiot County	up to 94.40	123.60	Wind	2012
Michigan Wind II	94.00	123.20	Wind	2012
Garden I	106.20	135.40	Wind	2012—Expected
Blissfield	100.88	130.08	Wind	2012—Expected
Harvest Wind II	98.38	127.58	Wind	2012—Expected
Lake Winds	110.00	139.20	Wind	2012—Expected
WM Renewable Energy - Pine Tree Acres	122.39	136.99	Landfill gas	2012—Expected
DTE Thumb Wind project	61–64.00	93.00	Wind	2012—Expected
Tuscola Bay Wind	60.90	90.10	Wind	2012—Expected
Fremont Community Digester	139.35	153.95	Biomass	2012—Expected

* Weighted average for multiple project phases.

** The federal Production Tax Credit of $29.20/MWh for wind energy and $14.60/MWh for landfill gas and biomass are included.

*** Prexisting project prior to PA 295. Date refers to effective date of contract, not actual in-service date.

NOTE: Experimental Advanced Renewable Project (customer-owned solar installations) not shown on graph.

generation fleet. Some of these facilities are fully depreciated assets. In contrast, the renewable energy projects shown are for individual projects, the majority of which were placed into service fairly recently.

- Production tax credits for renewable energy projects are included, as deemed applicable based on the generation type, size, and in-service date. Any subsidies for conventional generation are not known or reflected in the cost.

QUESTION: **Will Proposal 3 increase electricity costs?**

ANSWER: ***Yes.***

As a new government mandate, Proposal 3 would increase the level of capital investment by and risk to the utility industry. The industry would be required to make a multibillion-dollar investment in new generation to meet the mandate imposed by Proposal 3. These costs will ultimately be borne by utility ratepayers. Proposal 3 is also expected to increase the need for transmission upgrades and may raise operating costs, all of which would be passed on to ratepayers.

Without any renewable portfolio standard, utilities invest in new generation if and when it is needed to maintain reliable electric service—as well as making regular, ongoing investments in infrastructure to replace aging equipment and meet government mandates such as environmental requirements. These investments are subject to need and prudence reviews by regulators. An RPS mandate can change that paradigm, requiring utilities in some cases to build or purchase renewable energy even if it is not needed to meet customer demand for electricity. This is a potential issue under the current RPS but may have a greater impact on rates as the RPS level is increased, particularly given the more limiting definition of qualifying renewable resources under Proposal 3. In addition, mandates of this kind may lead to greater leniency from regulators in terms of the utility's cost recovery because the utility was operating under the mandate.

Appendix 2

Independent Statistics & Analysis
U.S. Energy Information Administration

July 2012

Levelized Cost of New Generation Resources in the Annual Energy Outlook 2012

This paper presents average levelized costs for generating technologies that are brought on line in 2017[1] as represented in the National Energy Modeling System (NEMS) for the *Annual Energy Outlook 2012* (AEO2012) reference case.[2]

Levelized cost is often cited as a convenient summary measure of the overall competiveness of different generating technologies. It represents the per-kilowatthour cost (in real dollars) of building and operating a generating plant over an assumed financial life and duty cycle. Key inputs to calculating levelized costs include overnight capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and an assumed utilization rate for each plant type.[3] The importance of the factors varies among the technologies. For technologies such as solar and wind generation that have no fuel costs and relatively small O&M costs, the levelized cost changes in rough proportion to the estimated overnight capital cost of generation capacity. For technologies with significant fuel cost, both fuel cost and overnight cost estimates significantly affect the levelized cost. The availability of various incentives, including state or federal tax credits, can also impact the calculation of levelized cost. The values shown in the tables below do not incorporate any such incentives[4]. As with any projection, there is uncertainty about all of these factors and their values can vary regionally and across time as technologies evolve.

It is important to note that, while levelized costs are a convenient summary measure of the overall competiveness of different generating technologies, actual plant investment decisions are affected by the specific technological and regional characteristics of a project, which involve numerous other considerations. The ***projected utilization rate***, which depends on the load shape and the existing resource mix in an area where additional capacity is needed, is one such factor. The ***existing resource mix*** in a region can directly affect the economic viability of a new investment through its effect on the economics surrounding the displacement of existing resources. For example, a wind resource that would primarily displace existing natural gas generation will usually have a different value than one that would displace existing coal generation.

[1] 2017 is shown because the long lead time needed for some technologies means that the plant could not be brought on line prior to 2017 unless it was already under construction.
[2] The full report is available at http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf.
[3] The specific assumptions for each of these factors are given in the *Assumptions to the Annual Energy Outlook*, available at http://www.eia.doe.gov/oiaf/aeo/index.html.
[4] These results do not include targeted tax credits such as the production or investment tax credit available for some technologies. Costs are estimated using tax depreciation schedules consistent with current law, which vary by technology.

A related factor is the ***capacity value,*** which depends on both the existing capacity mix and load characteristics in a region. Since load must be balanced on a continuous basis, units whose output can be varied to follow demand (dispatchable technologies) generally have more value to a system than less flexible units (non-dispatchable technologies) or those whose operation is tied to the availability of an intermittent resource. The levelized costs for dispatchable and nondispatchable technologies are listed separately in Tables 1 and 2, because caution should be used when comparing them to one another.

Policy-related factors, such as investment or production tax credits for specified generation sources, can also impact investment decisions. Finally, although levelized cost calculations are generally made using an assumed set of capital and operating costs, the inherent uncertainty about future fuel prices and future policies, may cause plant owners or investors who finance plants to place a value on ***portfolio diversification***. While EIA considers all of these factors in its analysis of technology choice in the electricity sector, these concepts are not well represented in the context of levelized cost figures

The levelized cost shown for each utility-scale generation technology in the tables below are calculated based on a 30-year cost recovery period, using a real after tax weighted average cost of capital (WACC) of 6.8 percent. However, in the AEO2012 reference case a 3-percentage point increase in the cost of capital is added when evaluating investments in greenhouse gas (GHG) intensive technologies like coal-fired power and coal-to-liquids (CTL) plants without carbon control and sequestration (CCS). While the 3-percentage point adjustment is somewhat arbitrary, in levelized cost terms its impact is similar to that of an emissions fee of $15 per metric ton of carbon dioxide (CO_2) when investing in a new coal plant without CCS, similar to the costs used by utilities and regulators in their resource planning. The adjustment should not be seen as an increase in the actual cost of financing, but rather as representing the implicit hurdle being added to GHG-intensive projects to account for the possibility they may eventually have to purchase allowances or invest in other GHG emission-reducing projects that offset their emissions. As a result, the levelized capital costs of coal-fired plants without CCS are higher than would otherwise be expected.

Some technologies, notably solar photovoltaic (PV), are used in both utility-scale plants and distributed end-use residential and commercial applications. As noted above, the levelized cost calculations presented in the tables apply only to utility-scale use of those technologies.

In the tables below, the levelized cost for each technology is evaluated based on the capacity factor indicated, which generally corresponds to the high end of its likely utilization range. Simple combustion turbines (conventional or advanced technology) that are typically used for peak load duty cycles are evaluated at a 30-percent capacity factor. The duty cycle for intermittent renewable resources, wind and solar, is not operator controlled, but dependent on the weather or solar cycle (that is, sunrise/sunset) and so will not necessarily correspond to operator dispatched duty cycles. As a result, their levelized costs are not directly comparable to those for other technologies (even where the average annual capacity factor may be similar) and therefore are shown in separate sections within the table. The capacity factors shown for

solar, wind, and hydroelectric resources are simple averages of the capacity factor for the marginal site in each region. These capacity factors can vary significantly by region and can represent resources that may or may not get built in EIA capacity projections. These capacity factors should not be interpreted as representing EIA's estimate or projection of the gross generating potential of resources actually projected to be built.

As mentioned above, the costs shown in Table 1 are national averages. However, there is significant local variation in costs based on local labor markets and the cost and availability of fuel or energy resources such as windy sites (Table 2). For example, levelized wind costs for incremental capacity coming on line in 2017 range from $77/MWh in the region with the best available resources in 2017 to $112/MWh in regions where the best sites have been claimed by 2017. Costs shown for wind may include additional costs associated with transmission upgrades needed to access remote resources, as well as other factors that markets may or may not internalize into the market price for wind power.

Table 1. Estimated Levelized Cost of New Generation Resources, 2017

		U.S. Average Levelized Costs (2010 $/megawatthour) for Plants Entering Service in 2017				
Plant Type	Capacity Factor (%)	Levelized Capital Cost	Fixed O&M	Variable O&M (including fuel)	Transmission Investment	Total System Levelized Cost
Dispatchable Technologies						
Conventional Coal	85	64.9	4.0	27.5	1.2	97.7
Advanced Coal	85	74.1	6.6	29.1	1.2	110.9
Advanced Coal with CCS	85	91.8	9.3	36.4	1.2	138.8
Natural Gas-fired						
Conventional Combined Cycle	87	17.2	1.9	45.8	1.2	66.1
Advanced Combined Cycle	87	17.5	1.9	42.4	1.2	63.1
Advanced CC with CCS	87	34.3	4.0	50.6	1.2	90.1
Conventional Combustion Turbine	30	45.3	2.7	76.4	3.6	127.9
Advanced Combustion Turbine	30	31.0	2.6	64.7	3.6	101.8
Advanced Nuclear	90	87.5	11.3	11.6	1.1	111.4
Geothermal	91	75.1	11.9	9.6	1.5	98.2
Biomass	83	56.0	13.8	44.3	1.3	115.4
Non-Dispatchable Technologies						
Wind	33	82.5	9.8	0.0	3.8	96.0
Solar PV[1]	25	140.7	7.7	0.0	4.3	152.7
Solar Thermal	20	195.6	40.1	0.0	6.3	242.0
Hydro[2]	53	76.9	4.0	6.0	2.1	88.9

[1] Costs are expressed in terms of net AC power available to the grid for the installed capacity.

[2] As modeled, hydro is assumed to have seasonal storage so that it can be dispatched within a season, but overall operation is limited by resources available by site and season.

Note: These results do not include targeted tax credits such as the production or investment tax credit available for some technologies, which could significantly affect the levelized cost estimate. For example,new solar thermal and PV plants are eligible to receive a 30-percent investment tax credit on capital expenditures if placed in service before the end of 2016, and 10 percent thereafter. New wind, geothermal, biomass, hydroelectric, and landfill gas plants are eligible to receive either: (1) a $22 per MWh ($11 per MWh for technologies other than wind, geothermal and closed-loop biomass) inflation-adjusted production tax credit over the plant's first ten years of service or (2) a 30-percent investment tax credit, if placed in service before the end of 2013 (or 2012, for wind only).

Source: U.S. Energy Information Administration, Annual Energy Outlook 2012, June 2012, DOE/EIA-0383(2012)

Table 2. Regional Variation in Levelized Cost of New Generation Resources, 2017

	Range for Total System Levelized Costs (2010 $/megawatthour) for Plants Entering Service in 2017		
Plant Type	**Minimum**	**Average**	**Maximum**
Dispatchable Technologies			
Conventional Coal	90.5	97.7	114.3
Advanced Coal	102.5	110.9	124.0
Advanced Coal with CCS	127.7	138.8	158.2
Natural Gas-fired			
Conventional Combined Cycle	59.5	66.1	81.0
Advanced Combined Cycle	56.8	63.1	76.4
Advanced CC with CCS	80.1	90.1	108.5
Conventional Combustion Turbine	91.9	127.9	152.4
Advanced Combustion Turbine	77.7	101.8	122.6
Advanced Nuclear	107.2	111.4	118.7
Geothermal	84.0	98.2	112.0
Biomass	97.8	115.4	136.7
Non-Dispatchable Technologies			
Wind	77.0	96.0	112.2
Solar PV[1]	119.0	152.7	238.8
Solar Thermal	176.1	242.0	386.2
Hydro[2]	57.8	88.9	147.6

[1] Costs are expressed in terms of net AC power available to the grid for the installed capacity.

[2] As modeled, hydro is assumed to have seasonal storage so that it can be dispatched within a season, but overall operation is limited by resources available by site and season.

Source: U.S. Energy Information Administration, Annual Energy Outlook 2012, June 2012, DOE/EIA-0383(2012)