

**VECTREN SOUTH'S RESPONSE
TO STAKEHOLDER COMMENTS ON ITS 2016 IRP**

SUBMITTED JUNE 9, 2017

Southern Indiana Gas and Electric Company d/b/a Vectren Energy Delivery of Indiana, Inc. ("Vectren South") hereby submits this response to comments on its 2016 Integrated Resource Plan ("IRP") submitted by a number of stakeholders including: the Indiana Coal Council ("ICC"), the Citizens Action Coalition of Indiana, Earthjustice, Indiana Distributed Energy Alliance, Sierra Club and Valley Watch (together, the "Environmentalists"), and the Indiana Office of Utility Consumer Counselor ("OUCC"). Vectren South is not responding to every group that filed comments or every comment raised by the stakeholders.¹ Instead, Vectren South has selected issues for this response designed to aid the Director of the Indiana Utility Regulatory Commission's ("Commission") Research, Policy and Planning Division in reviewing the methodology used to develop the 2016 IRP and providing the Director's Report.

I) Executive Summary

For the past two decades, Vectren South like other Midwestern electric utilities has confronted the attack on coal and through significant investments in pollution controls has enabled the continued operation of its baseload coal units (which produce approximately 95% of its energy needs) while greatly improving air quality in Southwestern Indiana (the pollution control equipment has been instrumental in keeping the counties in its service territory in attainment thereby allowing continued economic development). As a result, Vectren South has continued to burn approximately 2 million tons of coal each year (Indiana sourced) and thereby has supported local coal related employment. Recent IRPs have shown that the economics and risks related to the preservation of these small aging coal units, while positive on a net present

¹ For example, the Environmentalists recommend the Commission require utilities to provide an instruction manual for the modeling software it is utilizing. Northern Indiana Public Service Commission has already explained that this recommendation is not possible because the models frequently do not have instruction manuals.

value (“NPV”) basis, have become more challenged. Vectren South’s 2016 IRP presents a preferred plan that would diversify its resource portfolio, reduce risk associated with predominate reliance on one fuel source, continue use of coal over the next seven years at or near historic levels, and preserve ongoing annual use of over 800,000 tons of coal in the long term. Under the Plan, Vectren South invests in and retains its most efficient, best operating coal fired unit (Culley 3). Its remaining coal units are replaced by a combination of a highly efficient combined cycle gas turbine (“CCGT”), solar energy and energy efficiency programs. Culley 3 at 270 MWs would continue to provide approximately 30% of Vectren South’s baseload capacity.

The 2016 IRP represents the most thorough IRP Vectren South has ever conducted, weighing many factors through different portfolios using multiple future scenarios and evaluating how potential portfolios respond to differing future circumstances through stochastic modeling. As a result, the IRP selection process considered both NPV analysis as well as qualitative risk analysis.

The ICC comments point to recent political changes potentially impacting the latest wave of proposed EPA regulations, including carbon regulations under the Clean Power Plan (“CPP”). The comments urge Vectren South to reconsider (or at least delay) its resource diversification plan on the grounds that additional modeling with different environmental regulatory assumptions, will better support the continued operation of its coal units. On the other hand, the Environmentalists have submitted comments urging that all the coal units should be retired as soon as possible and be replace by investments in renewables and energy efficiency (“EE”) instead of CCGT. In support of their anti-fossil fuel agenda, the Environmentalists attack various aspects of Vectren South’s IRP modeling, including the methodology used to consider the appropriate level of EE.

Vectren South acknowledges the reasonableness of the ICC's main point that it makes sense to perform, updated modeling in conjunction with seeking approval of new generation. Such modeling would continue to evaluate a low regulatory scheme (with no carbon restrictions) that was considered as part of a scenario analysis in the 2016 IRP. This update would supplement but not replace the significant analysis conducted to create the IRP.

Vectren South's IRP modeling was heavily influenced by the long term natural gas price forecast. In fact, the low and stable gas prices predicted by almost every expert over the twenty (20) year IRP period in large part drove modeling outcomes that favored an all gas resource portfolio. Based on risk and other considerations, Vectren South instead selected a diverse plan which includes long term reliance on coal (Culley 3). Due to the favorable gas pricing, combined with the attractive heat rates offered by the latest gas turbine technology, Vectren South's coal units (other than Culley 3) were not selected to continue operating. Certainly, environmental compliance costs were an important part of this economic analysis. The Supplemental modeling will further assess compliance costs, such as costs driven by the Clean Water Act ("CWA"). As the longer term viability of the existing units is assessed again, operating costs, unit conditions, heat rates and dispatch projections will be part of this updated analysis. Because the existing units were retired in the early IRP modeling, many of these issues that factor into longer term unit operations were not fully considered.

IRPs are by nature a point in time analysis that use complex modeling to assess many possible future states. Vectren South continues to believe the results of its IRP have been based on sound methodology. The supplemental modeling will be done in a similar robust manner to present well founded resource decisions.

II) **ICC and Other Coal Stakeholder Comments**

A) Supplemental Modeling of Potential Changes to Environmental Regulations Will Consider The Status of All State and Federal Requirements.

ICC contends that the possible elimination of CPP and Environmental Protection Agency's ("EPA") stay of the Effluent Limitations Guidelines ("ELG") rules may substantially reduce the future operating costs faced by coal-fired power plants. Certainly, there is uncertainty now as to the fate of these regulations. Vectren South's ongoing operations must meet existing and potential regulations well into the future as well as permitting requirements, including those which are beyond the scope of the attempted regulatory roll back that has been initiated by the new Administration. For example, certain effluent requirements are contained in Vectren South's wastewater discharge permits (NPDES) recently finalized by the Indiana Department of Environmental Management. And, regardless of the fate of the ELG rule, Vectren South's generating units will continue to need to meet water quality standards applicable to wastewater discharges to the Ohio River set by the Ohio River Sanitation Commission ("ORSANCO"). The Company has also begun groundwater monitoring at its units that could result in similar compliance expenditures related to ash handling as those modeled under the ELG rule. These considerations will be part of the updated modeling used to assess whether short or long term adjustments to the resource planning set forth in the IRP should be considered. Vectren South will be required to act relatively quickly because certain of its National Pollutant Discharge Elimination System ("NPDES") permits expire in 2023 and, to the extent new resources will be requires, lead times to obtain regulatory approvals and commence construction of necessary infrastructure to be completed in a timely manner dictate certain decisions be made.

The Clean Water Act ("CWA") imposes increasingly stringent requirements which impact each unit's water discharge permits issued under Section 402 of the CWA. These discharge requirements are ultimately set forth in NPDES permits. NPDES permits

establish a technology-based floor of performance for dischargers unless these limitations are insufficient to meet applicable water quality standards, in which case a water quality-based effluent limitation is imposed in the permits. Thus, even in the absence of technology based floors established through the ELG rule, it is likely that Vectren South will be required to comply with new applicable limits based upon water quality standards (in its case set by ORSANCO for discharges to the Ohio River). For the units to continue operating beyond 2023, these limits will likely require installation of modern wastewater treatment systems. Thus, these represent an example of compliance costs that even in the absence of the ELG rule still must be modeled in the IRP.

Vectren South, like the ICC, will monitor the Trump Administration's progress as it attempts to undo certain rules. The CPP and ELG rules are final and any rewrite or rollback of the regulation will have to adhere to the federal Administrative Procedures Act, which will require that the new administration compile a new record disputing the prior administration's rule. This effort is a work in progress.

The EPA's administrative stay of the ELG rule has already been challenged in litigation. Challengers are asserting that EPA does not have the authority to stay future deadlines of an already effective rule that was final in 2015. Previous attempts to stay deadlines of effective rules have been met with challenges, and most recently in the case of the air toxic standards for industrial boilers, were largely unsuccessful. *Sierra Club v. Jackson*, 833 F. Supp.2d 11 (D.D.C. Cir. 2012).

Ultimately, Vectren South is responsible for reliable service to its customers. It must assess the operating characteristics of its units and determine the cost effectiveness of those units over time versus the alternatives.

B) Vectren South's Economic Modeling Considered the Potential That CPP Compliance Projected Costs Would Not Be Incurred.

Vectren South must respond to one methodology issue in particular raised by ICC. ICC criticizes Vectren South for conducting modeling that included a carbon price to reflect the CPP, contending that the United States Supreme Court's stay of the CPP and the election of Donald Trump to the presidency of the United States render it unlikely that carbon pricing will be imposed for at least 15 years. The ICC urges Vectren South to update its IRP to reflect no CPP costs in order to reconsider the economics of continued operation of the coal units.

Vectren South developed alternative scenarios designed to identify several low cost portfolios based on different potential future conditions. One scenario was a Low Regulatory Scenario described on pages 186-188 of the IRP. This scenario included no carbon costs over the entire twenty-year period.

ICC also disagrees with the use of an anticipated state implementation plan ("SIP") model for estimating carbon prices, contending the only "road map that could have arguably been used absent a SIP is the Federal Plan." ICC Comments, p. 10. However, the fact that Indiana *stopped* working on a SIP strongly implies Indiana will adopt a SIP if the CPP moves forward, which provides a state far more flexibility than the Federal Plan. Vectren South believes it is sensible to estimate CPP based on an anticipated SIP, even if assumptions about the design of the SIP must be incorporated. Regardless, the supplemental modeling will take a fresh look at the status of CPP and ELG alongside other rules discussed previously and the resulting potential cost impacts on the existing coal fleet.

C. Supplemental Economic Modeling Must Incorporate All Capital Improvements Needed by the Brown Units To Continue To Operate Beyond 2023.

As Vectren South further considers the possibility of operating the AB Brown plant beyond the current planned retirement date (2023), it will assess the likely capital costs to be

incurred over this extended period. One issue to be assessed is the viability of the existing scrubbers.

The Brown plant (both units 1 and 2) relies on scrubbers that are original to the construction of the units (1979 and 1986), and use a dual alkali technology that requires higher variable costs than other scrubber technology. The scrubbers have been operating for 38 and 31 years respectively, both longer than the typical power plant equipment target design of 30 years. Moreover, the operating life of dual alkali scrubbers is uniquely impacted (i.e. reduced) by the acidic and caustic environments they create, resulting in corrosion of the units' structural steel and concrete. For this reason, these are likely the only dual alkali scrubbers remaining in use today at a utility power plant.

By 2023 the original scrubbers will have been in operation 44 and 37 years respectively. It may simply not be feasible to continue to operate the scrubbers beyond 2023 without significant refurbishment or replacement of the original equipment. In addition to the need to replace the basic structural components of the scrubbers, the vintage Brown scrubbers are increasingly challenged to maintain compliance with current emission limits applicable to these units. When these units were originally constructed in 1979 and 1986 the emission limits for sulfur dioxide were much higher than they are today. While the IRP modeling did not select retention of the Brown units and therefore costs beyond 2023 were not modeled, the supplemental modeling that will be done related to possible extended operations will evaluate the scrubber life and operating cost issues. This must be done soon in order to provide Vectren South with the ability to evaluate all potential alternatives and have time to implement the resource strategy.

D. The IRP Included A Reasonable Evaluation of The Unique Conditions Related to Warrick Unit 4 Ownership and Operations.

ICC criticizes the IRP for not considering alternatives concerning Warrick Unit 4, including continued shared ownership with Alcoa or another party, or selling all or a portion of Warrick Unit 4 to a third party. Unlike generating units that are wholly owned by Vectren South, Vectren South's rights with regard to Warrick are governed by both its contractual rights and Alcoa's operation of the facility. As explained below, these contractual obligations and the unique operating characteristics make it difficult to commit to continued reliance on Warrick Unit 4 for IRP purposes.

1) Unit History and 2016 Events. Pursuant to a 1968 Agreement, Alcoa Generating Corporation ("AGC") and Vectren South have owned the Warrick 4 Unit (completed in 1970) as a tenancy in common (the "Warrick 4 Agreement" or "Agreement"). Warrick 4 is a 300 MW coal fired unit located at ACG's Warrick Operations site, together with 3 other AGC owned and operated coal units (Warrick 1-3). Altogether, AGC operates 600 MWs of coal generation at the site (counting its half of Warrick 4). For decades, AGC has used this generation to supply an aluminum smelter (approximately 500 MWs of load) as well as a rolling mill at the site.

As part of the MISO market, Unit 4 has been offered as a must run unit at a minimum output of 228 MWs (114 MWs for Vectren South and 114 MWs for AGC). This matched AGC's need for the generation to support its smelter operations. In early 2016 Alcoa announced (1) closure of its Warrick smelter, and (2) a corporate reorganization where by the end of 2016 it would split its operations into two separate public companies. Alcoa effectuated the split into Alcoa Corp. and Arconic Corp. in November 2016. Ultimately, Alcoa retained ownership of both the rolling mill (approximately 60-90 MW load) and AGC, including its ownership of all of the Warrick Units. The smelter ceased operation in March 2016 and was partially dismantled. Since March 2016, Units 1-3 (150 MWs each) have been used to serve the remaining rolling mill

load with electricity and hot water and steam. Unlike these three smaller coal units, Warrick 4 has never been directly connected to the mill or smelter, and does not provide hot water or steam.

Post- 2016, Alcoa (and AGC) continues to operate Units 1-4 which far exceed the current on-site load. Apart from the nineteen (19) month notice requirement now applicable to the termination of the Unit 4 Operating Agreement, there is no certainty regarding the duration of Alcoa's future need to operate Unit 4. Currently per S&P, ALCOA Corp. has a credit rating of 'BB-', far below investment grade.

2) IRP Considerations Related to Warrick 4.

Balancing IRP economic analysis with risk and other considerations, including an objective of creating greater fuel diversity in its generation, Vectren South concluded customer interests were best served by maintaining some coal facilities in its portfolio. It engaged in both a quantitative and qualitative evaluation of its existing coal units to determine which plants might be retained to reliably and cost effectively serve customers. Based on unit condition and operating costs, the Brown Units and Culley Unit 2 were identified as units to retire, leaving a further evaluation of the attributes of Warrick Unit 4 and Culley 3.

Culley 3 is Vectren South's most efficient unit with a heat rate of approximately 10,700 British thermal units per kilowatt hour ("BTU/KWH") (Warrick 4 averages about 10,800 BTU/KWH). A significant difference between the two units is the historic forced outage rate. Culley 3 has had an average forced outage rate of 5.0 (2006-2015). Warrick 4's forced outage rate is almost double (9.8) over the same time period. In most years, the O&M cost per rated capacity (\$/capacity) associated with Warrick 4 exceeds Culley generating station (Culley 2 and 3 combined) by over 50%. Thus, if Vectren South (as planned) retains a baseload coal unit as part of its long-term portfolio, from an operational standpoint Culley 3 is the clear choice. This

does not even consider the inherent complications of co-ownership of Warrick 4 with AGC, especially as that company continues to go through a period of significant change and uncertainty.

During the course of the IRP process, Vectren South considered when it should exit the joint operations of Warrick 4. While for qualitative reasons Vectren South's IRP set 2020 as the date to retire Warrick 4, a sensitivity analysis showed that closing Warrick 4 two (2) years sooner than 2020 had an economic benefit of approximately \$14 million on a NPV basis.

Warrick 4 must compete with new gas fired combined cycle turbines that have heat rates of 6,340 – 6,540 BTU, making them far more efficient. Continued investment to keep a 47 year old coal unit viable is a significant challenge. Any environmental compliance costs simply add to this challenge. Warrick 4 is also disadvantaged by high operating costs and poor availability. In 2017 Unit 4 has been offline approximately 30% of the time through April 2017 for unscheduled maintenance. The Alcoa operational uncertainty simply makes this picture even more complicated when compared to the ability to build a larger, highly efficient gas unit.

The situation with Alcoa continues to evolve, and Vectren South will further consider Warrick 4 circumstances when it performs its supplemental modeling. The unique ownership issues simply add uncertainty related to the future of the unit.

E. The IRP Used A Proper Mix Of Commodity Price Forecasts As Inputs Into The Model.

ICC claims several shortcomings with Vectren South's commodity price analysis. First, ICC criticizes Vectren South's consensus commodity price because "there was no indication whether the price forecasts had other comparable assumptions such as electricity demand growth, regulations, retirements, natural gas price forecasts, etc." Vectren South developed this consensus price forecast for use in its base analysis to show the most likely outcome. It is a

virtue, not a vice, that the base price forecast utilized forecasts from many different experts with different assumptions. Averaging several of these forecasts helped to moderate the impact of various assumptions to develop a price that is within the range of what experts think is most likely to occur.

ICC notes that stochastic modeling is not helpful in analyzing specific scenarios of concern. Vectren South, recognizing this fact, worked with PACE Global to create/describe five possible alternate futures with logically consistent forecasts for coal, gas, CO₂, technology cost, load, and power prices. Scenario inputs were used to create seven computer generated portfolios (including the base case and base large load addition). Each of these portfolios was optimized to minimize total cost to customers. Each scenario model run selected a large combined cycle gas unit and retired all remaining coal units, including the low regulatory scenario which included no carbon cost and scenarios with high gas prices.

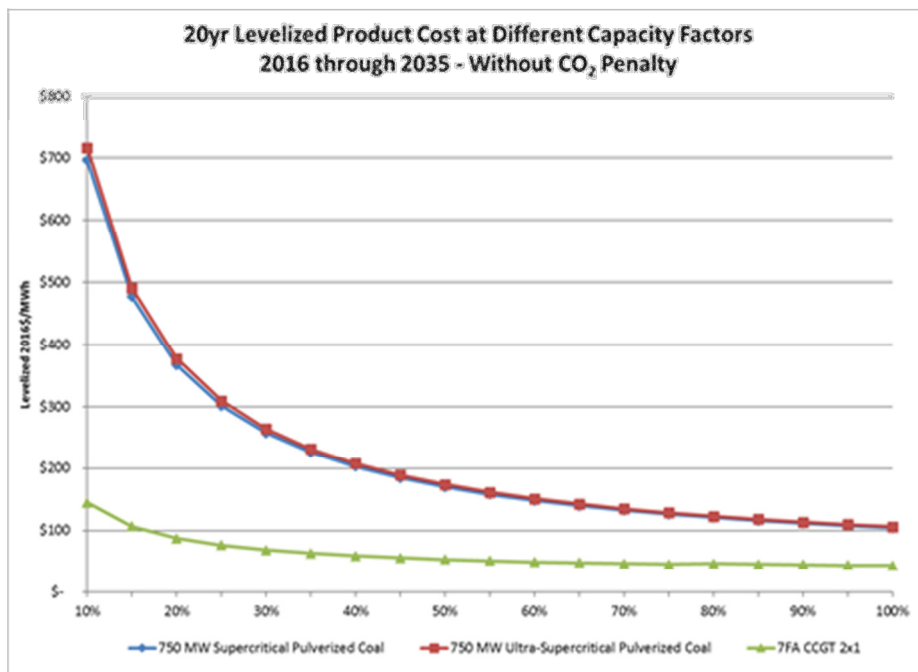
ICC raises particular concern about the natural gas and carbon price forecasts because of the importance of these costs to the economics of a natural gas combined cycle plant. But Vectren South did vet the possibility of a different range of natural gas and commodity prices within each scenario. The IRP incorporated various combinations of gas and coal forecasts. Additionally, CO₂ price ranged from zero in the low regulatory future to an extreme case of approximately \$45.00 by 2036 in the high regulatory scenario. Scenarios are described further in section 6.2 of Vectren South's 2016 IRP. This modeling enabled the IRP to generate multiple portfolios when commodity prices were different from the consensus pricing. In short, Vectren South's IRP used a sound method of evaluating commodity pricing.

F. Other Issues Raised by ICC.

1) Vectren South Reasonably Excluded Modeling of Ultra-Supercritical Pulverized Coal Plants. ICC argues Vectren South failed to reasonably consider coal because it

failed to model ultra-supercritical pulverized coal plants, such as Longview Power facility and Southwestern Electric Power Company's John W. Turk, Jr. Power Plant facility (ICC Comments, pp. 16-17). Vectren South did evaluate supercritical pulverized coal plants which were screened-out early in the process, suggesting ultra-supercritical pulverized coal plants would also be screened out.

In response to the ICC's comments, Vectren South evaluated whether an ultra-supercritical pulverized coal facility would have been selected for further consideration in the IRP had it been included in the initial screening. The results show that the ultra-supercritical pulverized coal facility would not have been considered because of its levelized cost:



The challenges with constructing an ultra-supercritical pulverized coal facility led to the bankruptcy of the owner of one of the two plants identified by the ICC's comments, lending further credibility to Vectren South's conclusions.

2) An IRP Analysis Is Not the Appropriate Forum For Evaluating Sales of a Coal Unit. The ICC criticizes Vectren South for not evaluating selling the Brown Units or Culley

Unit 2 to a third party. The purpose of an IRP is to evaluate a utility's resource needs over a twenty year period, not to address the post-retirement treatment of units. Vectren South may reuse equipment if it builds a CCGT at the Brown site. And, it certainly is amenable to selling Warrick 4 to ALCOA or potentially a third party, if that becomes a viable option. Vectren South will seek ways to support continued coal use.

3) Vectren South's Solicited Public Input. The ICC criticizes Vectren South for not "soliciting input from the Indiana coal industry and related parties . . . until very late in the process." ICC Comments, p. 19. Vectren South conducted a public stakeholder process and held three meetings to discuss its plans—all of which were open to any interested stakeholder. Numerous other groups participated, and Vectren South even modeled two portfolios selected by these groups.

4) The IRP Reasonably Forecast Coal Pricing. Vectren South did not need to solicit flexible coal pricing strategies to provide reasonable coal pricing forecast in its IRP. Soliciting coal producers to provide flexible price forecasts for the IRP would result in highly speculative pricing that may not be representative of actual market pricing available at some future date. Vectren South already has binding coal contracts that provide for periodic market price based re-openers.

The consensus forecast relied upon by Vectren South represents a consolidation of what experts in the field believe is likely. These market prices will surely change over time, but they are a reliable source of information and have a sounder basis than speculative non-binding quotes from individual sellers.

III) Environmentalists Comments

Vectren South's IRP included extensive modeling (of greater complexity than the Company has ever done in the past) combined with robust risk assessment to evaluate how

various proposals would perform under various future scenarios and assumptions. The result is not compromised by “errors or inconsistencies” as the Environmentalists contend. As Vectren South will explain below, the alleged errors and inconsistencies are really areas where (1) Vectren South and the Environmentalists simply disagree on substantive issues or (2) the Environmentalists’ claimed errors or biases do not exist.

A) The IRP Methodology Does Not Improperly Restrict Resource Selection.

The Environmentalists point to several components of the modeling inputs and outputs and claim they have identified improper resource selection restrictions, particularly with regard to renewables and energy efficiency. In most cases, the Environmentalists are simply wrong about the inputs. For example, the IRP methodology did not restrict the choice of solar, wind and demand response resources until 2030 and 2099 as the Environmentalists claim. In the other cases, Vectren South and the Environmentalists simply disagree about inputs and Vectren South continues to believe its inputs are reasonable.

The most fundamental misunderstanding from the Environmentalists is their claim that Vectren South constrained Strategist from selecting certain resource options, particularly renewable, demand response and energy efficiency. Vectren South has updated Table 3 from the Environmentalists comments to show the actual year particular resources were first available to be selected within the 8 model runs performed for each scenario. The cells shown in orange indicate the Environmentalists’ dates with errors in them. Vectren South struck through the incorrect years and added back the first year the identified resources were actually available for dispatch in each scenario.

Resource	Base	High Regulatory	Low Regulatory	High Technology	High Economy	Low Economy	Base + Large Load
200 MW Wind	2099 2019	2030 2019	2099 2019	2099 2019	2024 2019	2099 2019	2025 2019
50 MW Solar	2099 2019	2099 2019	2099 2019	2099 2019	2099 2019	2036 2019	2024 2019
50 MW Wind	2019	2099 2019	2099 2019	2099 2019	2099 2019	2099 2019	2025 2019
9 MW Solar	2019	2099 2019	2099 2019	2030 2019	2024 2019	2035 2019	2025 2019
4 MW DR	2020	2099 2020	2020	2099 2020	2020	2020	2020
EE	2018	2018	2018	2099 2018	2018	2099 2018	2018

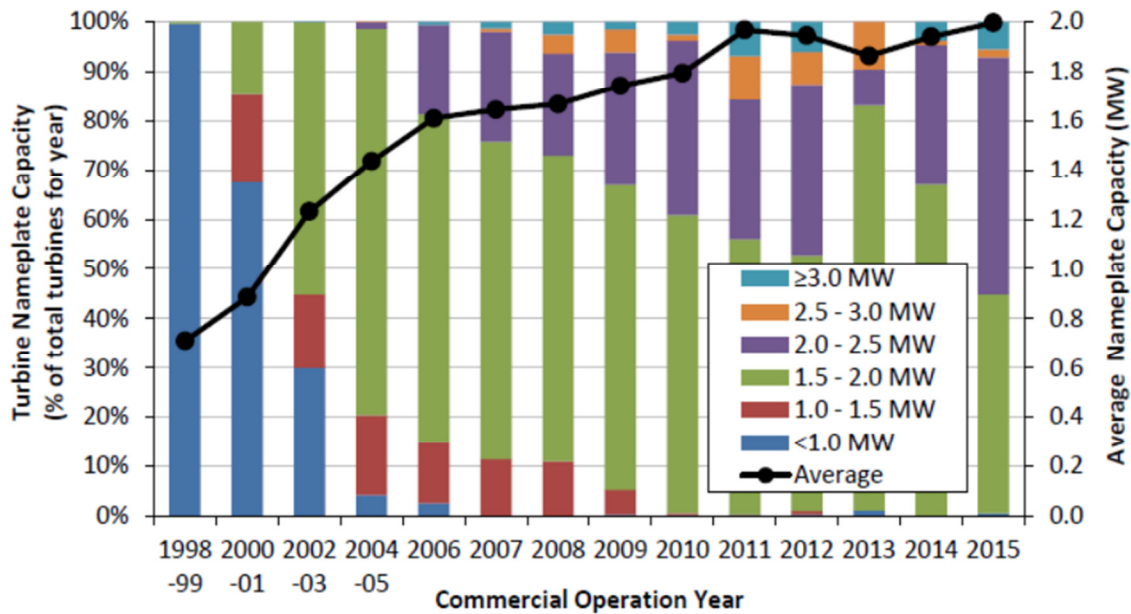
The Environmentalists claim they gleaned this information from the numerous Strategist input and output files Vectren South provided to them, but they do not identify the specific files they rely upon for their conclusion. Vectren South suspects that the Environmentalists reviewed files that represented iterations where restrictions were placed on certain resources, but that does not mean these resources were eliminated from consideration under the specific scenario in other iterations. As Vectren South explained during the stakeholder meetings and in the IRP, it is not possible to consider every single alternative at one time. An iterative approach is necessary to screen resource choices on an economic basis. Starting with a levelized cost of electricity (“LCOE”) comparison outside of Strategist, multiple passes were used in Strategist to consider unit retirements, new supply side, and new demand side alternatives. Any one of the iterations may have eliminated a resource previously screened from consideration to allow the model to consider other alternatives or to evaluate specific resource mixes.

The Environmentalists make three other claims to contend that supply side resource alternatives were not evaluated on a consistent and comparable basis with other supply side

resources. First, they claim the Strategist modeling is biased towards later retirement of coal units. Vectren South assumed the earliest year for coal unit retirements was 2021, the earliest date they could be retired because of the time necessary to build transmission system upgrades required for system reliability should units at either AB Brown (“ABB”) or FB Culley (“FBC”) be retired. Similarly, generation placed at the existing brownfield locations (ABB or FBC) that could avoid the need for transmission upgrades would not be available until 2021. Therefore, due to system reliability and time constraints associated with building replacement capacity, 2021 was assumed as the earliest year for retirement consideration.

Second, the Environmentalists claim that the modeling is biased against renewables. The Environmentalists criticize Vectren South’s assumptions about wind prices, baldly asserting that the industry consensus is that costs will continue to decline. This assertion cannot be squared with known information. Over the past 10-15 years, wind turbine engineers have significantly increased the key technical performance characteristics including nameplate capacity, hub height, and rotor diameter resulting in greater wind swept area. These performance increases, coupled with improvements in production methods, and reductions in supply chain costs, reduced the unit cost of wind turbines rapidly through 2013 but the pace and degree of improvement has slowed since that time. This is apparent from Figure 9 in the Environmentalists’ comments. As a result, installed project costs have remained flat since 2013.

Trends in Turbine Nameplate Capacity



Source: 2015 Wind Technologies Market Report, August 2015, EERE

Onshore wind powered electrical generating technologies have matured. While wind project costs are expected to continue to decline over time, the rates of decline will be much more moderate than seen a few years ago. Furthermore, the expected loss of existing production tax credits for wind will reduce the incentives for investment and potentially curtail development for a period of time. Based on these trends and observations, the IRP relied on Pace Global estimates that 2016 overnight capital costs for an Indiana-based 50 MW wind farm decline by an average of one percent per year through 2030, with a lower decline rate of 0.3% per year thereafter.

The Environmentalists also claim that Vectren South’s initial cost for 50 MWs of solar is too high, pointing to a UBS LCOE model to support their claim. Vectren South also relied on experts to develop its estimates. It isn’t clear that the UBS model included all relevant costs, which would include the costs of PV modules, inverter, civil work, engineering contractor fees and contingency, owner’s cost, owner’s contingency, land, transmission interconnection, and Allowance for Funds Used During Construction. Many LCOE or other cost numbers quoted in

the public arena often exclude one or more of these components due to site specific and owner specific conditions. Additionally, capacity factors utilized in these studies are often not comparable to what could be expected in the Evansville area; therefore, the more refined analysis used to complete Vectren South’s IRP is appropriate.

Third, the Environmentalists claim that Vectren South’s rationale for screening resources was ad hoc. In part, this is based on errors in the Environmentalists reviews, as demonstrated by their results shown in Table 4 of their comments. The following table corrects the errors in their table:

	Section 5.2 Listed	Screened	Approved	Listed in Table 10.14 – New Construction Alternatives of Vectren’s 2016 IRP
CCGT				
240 MW (ABB)	no	yes	no	no
440 MW 1x1 7FA.05	no	yes	yes	yes
750 MW 2x1 7FA.04	no	yes	yes	yes
890 2x1 7FA.05 (ABB)	no	yes	yes	yes
Solar				
4 MW Solar PV	no	no	yes	no
Hydro				
50 MW Lowhead Hydroelectric	yes	no	no	yes
WTE				
50 MW Wood Stoker Fired	yes	no	no	yes

There were several combined cycle gas turbine (CCGT) options included in Figure 5.6 of Vectren South’s IRP. Each option shows the base load and incremental duct-fired net output. The Environmentalists failed to add the two together to represent the total net output of the unit. For example, they say that Vectren South did not list the 890 MW 2x1 7FA.05 CCGT in section 5.2 of Vectren’s IRP. This unit was included and has net base load output of 690 MW and incremental Duct-Fired net output of 199 MW (889 MW total net output). Note that the unfired

CCGT options were not screened or included in the optimizations, but some portfolios included the unfired 2x1 7FA.05 option within the risk analysis. Additionally, they claim that Vectren South did not list the 240 MW conversion of existing gas turbines at AB Brown. This option was discussed in section 5.2.2.3, and details are provided in Technical Appendix Confidential Attachment 1.2 2016 Vectren South Technology Assessment Summary Table. As shown on page 32 of the July 22, 2016 Stakeholder Meeting Deck in Attachment 3.1 Stakeholder Materials, this option was screened out for not being cost effective compared to alternatives. Finally, the Environmentalists show that 4 MW Solar PV was not listed or screened, but was “approved.” As discussed in section 7.1.1.5 on pages 202-203, 4 MWs of solar was included as a proxy for several small solar projects Vectren South intends to complete by 2018 and were included in all portfolios.

B) The IRP’s Energy Efficiency Modeling Assumptions Are Reasonable.

The Environmentalists claim Vectren South’s methodology for modeling energy efficiency is improper and misguided. First, they contend Vectren South’s cost estimates for EE inappropriately reflect increasing expenses resulting from market saturation. While they assert that “they are aware of no reliable evidence for higher energy efficiency market penetration leading to higher efficiency costs” (Environmentalists Comments, p. 35), Vectren South’s own historical experience is that adoption of energy efficiency measures become more expensive once market saturation occurs. This result is logical—more work, and thus more cost, is required to capture the attention of those consumers who have not already taken advantage of energy efficiency measures that have been available for several years. Those consumers are either not initially interested (and require increased marketing to reach) or require an increased incentive to adopt the energy efficiency measure. Many times these challenges lead to redesigning programs or introducing new measures/programs that are more expense (higher cost per unit savings achieved) as market saturation of cost-effective programs occurs. Dr.

Richard Stevie, a noted expert in energy efficiency, prepared a paper establishing that costs increase as the market becomes more saturated. The Environmentalists submitted a critique of Dr. Stevie's analysis which Vectren South will be prepared to respond to in subsequent proceedings. While the IRP is not the appropriate forum to resolve this debate among experts, Vectren South has not acted unreasonably in basing EE costing on its historical experience and analysis by its expert.

The Environmentalists also assert that Vectren South improperly modeled EE blocks, contending that the costs from Dr. Stevie do not match what were modeled in Strategist. Dr. Stevie's EE program costs were incorporated into the Strategist modeling, but they had to be modified so that 1) they are levelized over the weighted measure life, and 2) inflated at 1.6% per year. This was done to more equivalently compare EE programs with supply side resources and matches costs to when the benefits of the program will occur. Levelizing costs over the weighted measure life also mitigates end effects issues. For example, if DSM costs all occurred in the first year of the program then towards the end of the study period there would be costs that are paying for benefits which are not captured in the 20-year time horizon. Vectren South appropriately modeled EE costs and various sections throughout the IRP confirm that Vectren South evaluated supply-side and demand side alternatives on a consistent and comparable basis.

The Environmentalists next criticize Vectren South's avoided cost methodology. Again, their concern results from a misunderstanding of the modeling. Vectren South did not limit its avoided cost calculations to the marginal cost as the Environmentalists claim. Figure 10.13 of Vectren South's IRP shows the various types of avoided costs used in the IRP, which includes system marginal costs, but is not limited to marginal costs. Importantly, Vectren South did not limit or screen out EE programs based on the avoided cost calculations. Strategist selects resources with the primary objective to minimize customer costs.

C) The Risk Assessment Conducted By Vectren South Is Robust.

As it pertains to Vectren South's stochastic modeling the Environmentalists assert that with six independent variables, a full range of possible combinations of variables cannot be represented in just 200 iterations. They suggest that for six uncertain variables, a sampling of 1 million iterations is required. However, any marginal improvement associated with more iterations is limited by the fact that the variables are not truly independent, but instead have shown strong cross correlation. Only a small percentage of all possible permutations of different variable values can be reasonably probable. Examples of strong cross correction are observed between natural gas prices, coal prices and CO2 costs. In a fundamental dispatch model all of these are input variables that directly impact dispatch, power prices and energy costs.

Moreover, running a million iterations would take between 6 and 13 years to run based on typical run times for 200 iterations (12-24 hours). The common practice across much of the industry including many of the biggest utilities in the country is to run as few as 5 to 10 scenarios for their IRPs, and this practice has been accepted for decades. Limited numbers of fully integrated scenarios are accepted in multiple states across the country. Vectren South's risk analysis goes a step further and considers 200 different scenarios which are much better and more accurately captures the uncertainty than the standard practice of 5-10 scenarios traditionally used. Pace Global has been providing simulations using 150-200 iterations using the approach described here for over a decade. It is important to have a complete representation of the risk elements while looking at the future and 200 simulations is sufficient for this purpose.

The key question in the Monte-Carlo analysis is to determine the appropriate number of different permutation of input variables ("simulations") that should be run in order to provide a

sufficiently informative distribution of portfolio performance outcomes. Pace Global evaluated the required number of draws, and concluded two hundred permutations of input variables represent a range that is both consistent with standard industry practices and represent an appropriate balance between meaningful results and cost and time constraints.

Pace Global used the theory of “Statistical Convergence” to estimate the optimal number of simulations required for each of the stochastic variables. First, it performed test runs for the driver variables and analyzed the differences in distribution and mean resulting from different numbers of draws. These tests indicated that 2000 draws provided satisfactory distribution, and further increases in the number of simulations above 2000 did not result in material differences in the output probability distributions (especially looking at the mean values and the tails of the distribution). Parameters observed in the market place such as volatilities, cross-commodity correlations, and mean-reversion, drift and noise terms also greatly influence the width of the resulting distributions. Thus, Pace Global used 2000 simulations for generating the probability distributions for each of the market driver variables.

Second, Pace Global assessed the appropriate number of discrete iterations from the 2000 draws to sample for use by the AURORAxmp® production simulation engine. A sampling technique is used to ensure that both moderate and extreme events (captured by the tails of the distributions) are captured in the input to ensure AURORA results captured the full range of probable outcomes. This ensures that fundamental model runs done in a stochastic fashion will reasonably accurately represent all possible events that can occur in the market. The widths of these distributions are constrained by physical limitations. For example, natural gas prices cannot go below a certain threshold, otherwise the physical infrastructure supporting gas deliveries cannot be sustained. The prices cannot persist at a very high level for longer time periods for the same reason. There can only be short-term spikes. This further limits the number of required simulations.

AURORA uses advanced techniques to simulate the behavior of individual power plants and the power system by solving multiple linear programming problems involving very large numbers of internal variables in a chronological fashion. This technique ensures it captures the complexity of power plant and power system behaviors, but it also makes each simulation time consuming and extremely demanding of computational power. There can be abstractions and simplifications that would speed up the simulation, but at considerable expense to the quality of the simulation. Thus, there is a trade-off between performing a larger number of simulation iterations, and the reliability and quality of each of those iterations. Pace Global performed some test runs for different power market zonal regions across the United States and measured parameters such as market energy prices, margins of assets and the cash-flows generated over the long-term study period etc. These tests indicated that performing 200 simulations would be sufficient for tasks such as resource planning studies, financial valuations and structured deals analysis, which has a good balance between accuracy and run-times.

Having determined the optimal number of simulations, Pace Global used standard sampling techniques to choose the 200 simulations that accurately represent the full 2000 simulations for each variable. For this, Pace Global has instituted the process of “Stratified Sampling” to pick 200 iterations from the actual population of 2000 iterations. This technique makes sure that the distribution tails are captured well. The 200 iterations are to be thought-of as 200 unique states-of-the-world (or “Scenarios”).

The accepted practices of concepts such as statistical convergence and stratified sampling for running the fundamental AURORA model, 200 scenarios accurately captures the range of outcomes that can happen in the market over the 20-year forecast time period. The risk analysis accounts for commodity-specific events such as price spikes, price drops, weather related high and low demand levels, research breakthroughs in costs and regulatory decisions.

D) The IRP's Scorecard Reasonably Depicts The Balancing of Risk.

The Environmentalists claim that the balanced scorecard approach is “black box,” qualitative, opaque and cannot be subjected to rigorous analysis. The purpose of a balanced scorecard is to account for the fact that utilities, stakeholders and customers all have multiple objectives that they are trying to achieve in evaluating alternative portfolios. In the past, IRPs focused solely on least cost portfolios under expected market conditions, and tested very little sensitivity. One can certainly select one objective and subject the portfolios to a “rigorous” analysis of that one variable. But the Commission and many other states have emphasized the importance of accounting for multiple objectives in order to better reflect the real world. Balancing these factors requires some subjectivity. A balanced scorecard approach is widely accepted in the industry and red light, yellow light and green light scorecards are the norm for enterprise risk analysis in the electric utility industry. This approach is appropriate for an IRP that must evaluate portfolio choices against a number of different objectives. Pace Global has used this approach extensively for almost a decade in jurisdictions across the U.S. The scorecard is a reasonable means of explaining this balance.

There are alternative approaches for developing balanced scorecards:

- Weightings of factors can be varied;
- Numerical rather than color coding can be utilized; and
- Factoring differences between the lowest and highest ranked portfolios proportionately can be applied.

The Environmentalists utilized the numerical, rather than color coding approach, in their comments. Pace Global constructed summaries using some of the methodologies identified above, including the Environmentalists' approach. The results of these alternative approaches confirm, rather than contradict, Vectren South's scorecard. The Environmentalists contrary conclusion results from a flawed approach. This exercise demonstrates that a degree of consistency can be achieved using methods that balance multiple competing objectives despite

the fact that the scorecard is not an exact science. The IRP’s scorecard approach achieves overall conclusions that are supported by a range of other unbiased methods.

Pace Global used a color coding basis and then when “averaging” the colors, considered the number of “Red Flags” or red dots to break ties. Below is a comparison of color coded rankings to the numerical rankings used by the Environmentalists in their Figure 17. In this case, though, Pace Global did not round the average to a whole number, as the Environmentalists did.

Color Coded Rankings to the Numerical Rankings

Original Order	Portfolio NPV	Risk	Cost-Risk Trade-Off	Balance/Flexibility	Environment	Local Econ Impact	Actual	Exhibit 18
L	5	4	3	4	4	5	4.17	4
K	5	4	3	4	4	5	4.17	4
M	5	4	3	4	4	5	4.17	4
F	5	4	3	3	4	3	3.67	4
D	5	2	5	2	4	3	3.50	4
O	5	3	3	2	4	3	3.33	3
N	5	3	3	2	4	3	3.33	3
H	5	1	3	2	4	3	3.00	3
E	5	3	1	2	4	3	3.00	3
C	5	3	1	2	4	3	3.00	3
G	5	2	3	1	4	3	3.00	3
I	1	3	1	4	4	5	3.00	3
J	1	3	1	4	5	3	2.83	3
B	5	1	3	1	4	3	2.83	3
A	3	1	1	2	3	5	2.50	3

Source: Pace Global

When the complete number is included in the numerical rankings the Environmentalists used as an alternative, the rankings match up precisely with the order that Pace Global used and the differences between the top three portfolios and the rest are significant. By rounding to the nearest whole number, the Environmentalists made it appear that the rankings were distorted and the stakeholder portfolios were much more closely bunched. In one case where Portfolio I was the same numeric ranking as the four above it, Portfolio I had two red flags and the rest had one.

To account for the relative differences of the lowest and highest rated portfolio in each category, Vectren South calculated a proportional value between the best (a 10) and worst (a 0)

outcomes. This case results in a slightly different order, but the top three remained at the top and were significantly better than the others.

Sample Ranking

Linear Scale	Portfolio NPV	Risk	Cost-Risk Trade-Off	Balance/Flexibility	Environment	Local Econ Impact	Summary	
L	8.9	6.0	5		6.7	7.5	10	7.35
K	9.2	4.8	5		6.8	7.5	10	7.22
M	8.8	5.0	5		6.7	7.5	10	7.17
D	9.6	3.9	10		3.6	7.5	5	6.60
F	8.7	5.1	5		4.2	7.5	5	5.93
I	2.9	5.4	0		8.4	7.5	10	5.71
N	9.2	4.3	5		3.0	7.5	5	5.67
O	9.2	4.0	5		3.0	7.5	5	5.61
H	10.0	3.5	5		2.3	7.5	5	5.54
B	9.9	3.4	5		1.1	7.5	5	5.32
G	9.7	3.0	5		0.7	7.5	5	5.15
E	9.3	5.4	0		3.0	7.5	5	5.04
A	8.4	1.3	0		4.3	5.0	10	4.83
C	8.8	4.7	0		2.8	7.5	5	4.81
J	-	4.3	0		7.4	10.0	5	4.44

Source: Pace Global

Ultimately, the risk analysis is an approach that Pace Global has used for clients across the country in a consistent manner and with wide acceptance. No bias was intended nor deployed.

E) The IRP's Energy Forecast Is Reasonable.

The Environmentalists claim Vectren South did not conduct a historical and forecasted level of peak demand and energy usage, but their comments make clear they simply disagree with the forecast that was utilized. Vectren South's used industry accepted techniques.

The Environmentalists criticize the use of data from Moody's Analytics Economy.Com, asserting "[c]oncerns have been raised in other jurisdictions." They cite only ERCOT, asserting that Moody's "overestimation" of a key driver in ERCOT's forecast, non-farm employment, led to overly optimistic load growth. A review of ERCOT's Report indicates that ERCOT indeed concluded that the low range scenario developed by Moody's proved to be more accurate for Texas (not that Moody's overall data was unreliable) and indicated the organization was

obtaining additional economic data for comparison. However, ERCOT continues to use Moody's data in its forecasts, indicating that the concerns did not lead ERCOT to conclude use of Moody's data was unreasonable.² Moody's is one of the leading providers of near-term and long-term economic forecasts. Its economists often present on current and future economic activity to wide audiences of government, industry, and media. Moody's economists are regularly listed among the best for forecast accuracy by Bloomberg, Pulsenomic, and Market Watch. Itron estimates that roughly half the utilities in the United States use Moody Analytics Economy.Com in developing their sales, energy and demand forecasts.

Without any supporting data, the Environmentalists baldly assert that Moody's projections for non-manufacturing and manufacturing output are too aggressive. At the time of developing the load forecast, there was no reason to believe that near-term non-manufacturing or manufacturing output was unreasonable given 2015 non-manufacturing output increased 2.1% and manufacturing output was up 2.5% with forecasted economic growth peaking in 2016. Moody expected to see economic growth continue to accelerate coming off of the weak economic recovery from the "great recession". Based on Itron's regional forecasting work, Itron reported that Vectren South's economic forecast was consistent with economic forecasts in Indiana and the Midwest.

In its forecast, Vectren South did recognize that there is always uncertainty in any economic forecast. To minimize economic growth uncertainty, Vectren South did not rely upon a single economic concept. The commercial economic driver is weighted between non-manufacturing output (25%), non-manufacturing employment (25%), and population (50%). The growth rate of the economic driver used in the commercial sales model averages 1.1% over the first five years of the forecast (2017 to 2021) compared with 2.4% average annual growth for

² 2017 ERCOT System Planning Long-Term Hourly Peak Demand and Energy Forecast (December 14, 2016) available at http://www.ercot.com/content/wcm/lists/114580/2017_Long-Term_Hourly_Peak_Demand_and_Energy_Forecast.pdf.

non-manufacturing output. The impact of economic growth on forecasted demand is further tempered by end-use efficiency gains (as a result of end-use replacement and new end-use standards), and does not include future DSM impacts (DSM is treated as a supply resource).

Finally, the Environmentalists criticize Vectren South's five year large customer forecast. They criticize basing the forecast on one year's worth of historical sales. In the near-term, sales is more a function of the specific business activity of large industrial customers than macroeconomic indicators. While it is possible to find long-term economic concepts that correlate with the historical data series, the statistical model fit is relatively weak given the large month-to-month variation that is driven by customer-specific activity. The standard approach for addressing this issue is to adjust current sales levels or near-term sales trends for expected business activity by the largest customers. This approach is sometimes referred to as "spot load" adjustments. Vectren South elected to use this forecast approach as its key account managers have excellent relationships with its large customers and have far more specific knowledge of their near-term energy requirements than what would be determined by a simple index of industrial activity. The result is a more refined forecast for the shorter-term, first five years.

F) The IRP Appropriately Utilized a Pre-Tax Discount Rate.

Vectren South modeled the pre-tax discount rate in order to represent portfolio costs, and the expected return on those costs, from a customer perspective. Revenue requirements associated with the NPV of assets is earned at the pre-tax rate of return. The IRP NPV of revenue requirements focused on the costs to the customer, not Vectren South's return. By using the pre-tax discount rate for the fixed carrying charge and the discount rate in Strategist, the modeling reflects the cost to the customer. This was not an error, as the Environmentalists claim—it is the appropriate discount rate to use.

G) The IRP's Appropriately Evaluated Necessary Capacity.

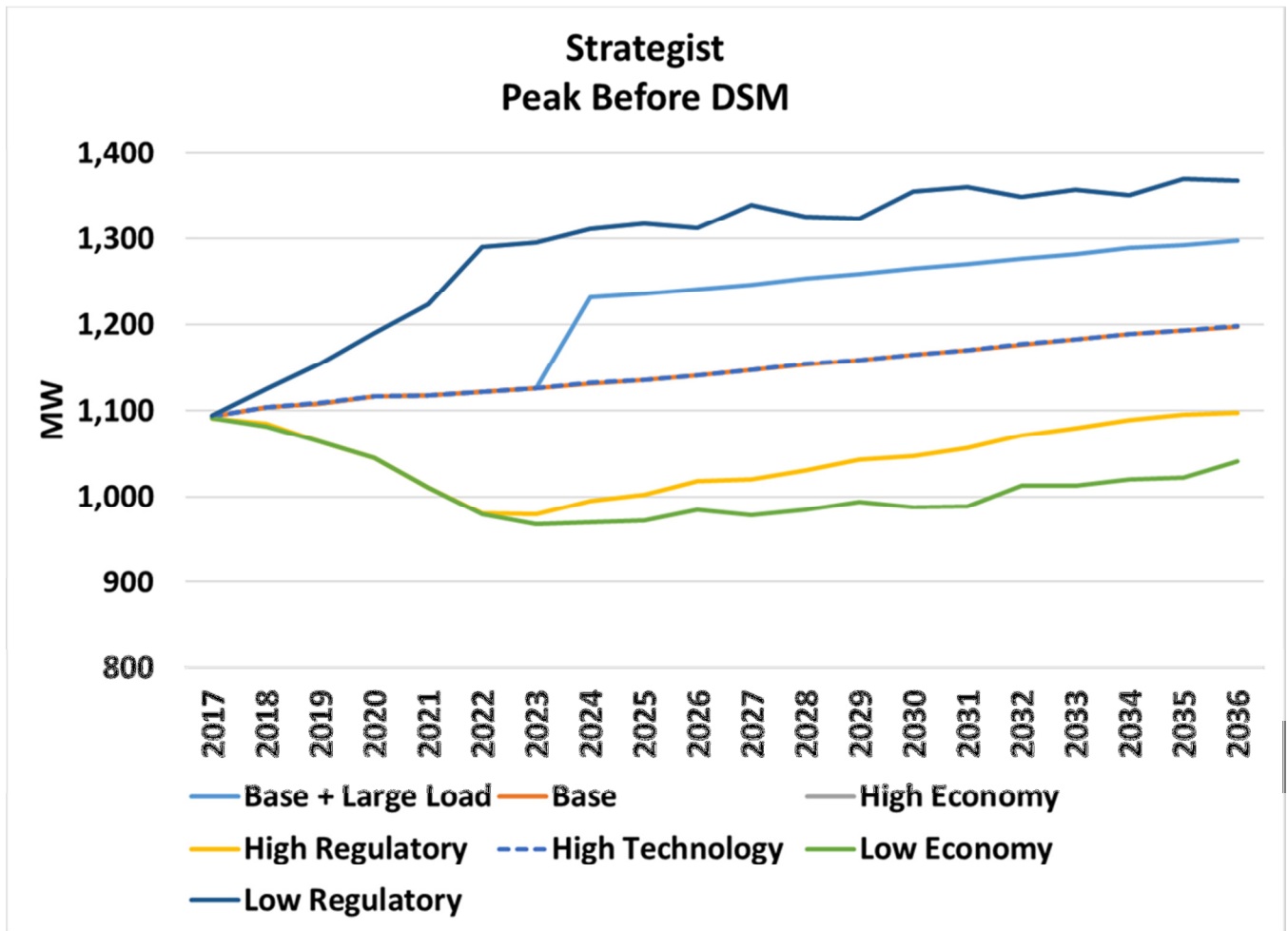
The Environmentalists contend that excess capacity built into the stakeholder portfolios contributed to the large cost gap between these portfolios and Vectren South's preferred portfolio. Because new generation facilities cannot be perfectly shaped to needs, excess capacity frequently occurs when new capacity resources are added. Economies of scale may be lost if demand is exactly met in one year, but more capacity is required in future years. This phenomenon impacted both of the stakeholders' portfolios. In the early years, they contained excess capacity, but by 2025 they resulted in capacity that would only be 25 megawatts ("MWs") more than necessary to satisfy projected peak demand.

Additionally, the Environmentalists complain that Vectren South's preferred portfolio produces excess capacity. As described in the IRP, the preferred plan calls for the new combined cycle gas turbine to be duct-fired, which will replace older, inefficient peaking capacity with much more efficient peaking capability. Depending on set up, duct-firing can provide approximately 200 MWs (installed capacity) of efficient peaking capacity capability through gas burners located within the heat recovery steam generator. These burners can be fired to generate more power during times of high demand. This technology is about half of the cost of a comparable simple cycle gas turbine. A duct-fired plant would allow for back up of further intermittent renewable resources in the long term, enhance opportunities to meet future economic development and can also support wholesale sales which lower customer bills. This low cost peaking capability can only be added in the design phase; it cannot be retrofitted. Regardless, Vectren South may further evaluate the appropriate size of any new generation to minimize excess capacity.

H) The IRP Varied The Peak Load Forecast.

Another false claim made by the Environmentalists is that despite differing limits on the adoption of energy efficiency and demand response, Vectren South’s scenarios use “exactly the same peak load forecast....” Each scenario included a demand forecast that was consistent with the energy forecast. The figure below shows the wide range of peak load forecasts included within optimization modeling. Computer generated portfolios were developed based on scenario assumptions. Later, these computer generated portfolios were modeled and evaluated under the base scenario set of assumptions for comparison purposes and included as an input into stochastic modeling.

Peak Before DSM from the computer-generated portfolios:



l) Vectren South Complied With the IURC Rules.

The Environmentalists argue that Vectren South has not satisfied the IRP rules. Their interpretation of a rule is different from the actual requirement of rule. For example, in their Table 1, the Environmentalists summarized 170 IAC 4-7-4(b)(1) as, “IRP documentation must include inputs, methods and definitions”. The Environmentalists then explain all the documentation Vectren South supposedly failed to provide. However, that provision of the rule actually states, “An IRP must include the following: (1) A discussion of the inputs, methods and definitions used by the utility in the IRP.” A requirement to provide a discussion of the inputs, methods and definitions used by the utility is distinctly different from a requirement to provide the actual inputs, methods and definitions used by the utility in the IRP. Furthermore, the Company freely shared inputs, methods and definitions with the CAC and others after the IRP was completed and the information became available.³ The actual rule states that a utility is required to include a discussion of the inputs, methods and definitions used in the IRP, which Vectren South did throughout the document. The Environmentalists’ contention that Vectren South failed to comply with 170 IAC 4-7-4(b)(1) and other applicable rules is false.

IV. Conclusion

The methodology used in Vectren South’s 2016 IRP is based upon solid modeling and risk analysis and is designed to drive a result that is optimal for Vectren South’s customers. The IRP utilized the most sophisticated and advanced modeling Vectren South has ever employed. Vectren South will update its IRP analysis as it evaluates resource options, but the IRP is sound and serves as a reasonable assessment of Vectren South’s future needs.

³ Vectren South did provide a Strategist input/output report in the tech appendix of the IRP and discussed its methods throughout the document.