March 16, 2017

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Electronically delivered

Re: Public Version of the Comments on IPL's 2016 Integrated Resource Plan

Dear Director Borum, Chief Technical Advisor Pauley, and Assistant General Counsel Comeau,

Pursuant to the Indiana Utility Regulatory Commission's ("IURC" or "Commission") draft Integrated Resource Planning Rule, 170 IAC 4-7,[1] Citizens Action Coalition of Indiana ("CAC"), Earthjustice, Indiana Distributed Energy Alliance ("IndianaDG"), Sierra Club, and Valley Watch (collectively, "Commenters") hereby submit the attached public version of the comments by Anna Sommer with Sommer Energy, LLC, and Elizabeth A. Stanton, PhD, with Applied Economics Clinic on the 2016 IRP submitted by the Indianapolis Power & Light Company ("IPL"). Please note that Commenters filed their unredacted version, under seal in IURC Cause No. 44873, because the filing contained information deemed confidential by IPL and protected as confidential per the Order issued in this Cause. Commenters respectfully reserve the right to challenge IPL's confidential designation of the information. We appreciate the opportunity to comment, as well as Commission Staff's willingness to provide us with extensions of time that allowed us to seek information from IPL through an informal discovery process.

As last year's Electricity Director's Final Report on the 2015 IRPs affirmed, "[w]ith the passage of P.L. 246-2015 (SEA 412-2015) on May 6, 2015, Indiana law now explicitly requires long-term resource planning for the State of Indiana."[2] Anna Sommer with Sommer Consulting, LLC, and Elizabeth A. Stanton, PhD, with Applied Economics Clinic, have organized these comments to address IPL's compliance with the specific informational, procedural, and

[1] All references to the Commission's IRP Rule, 170 IAC 4-7, refer to the revised draft of the Proposed IRP Rule, which the Commission circulated on October 4, 2012 in the IRP rulemaking, RM# 11-07. As explained in the Electricity Director's Final Report on the 2015 IRPs, since 2012 the Commission, utilities, and other stakeholders have followed the requirements of the draft rule (which was negotiated collaboratively, and includes improvements on the prior IRP rule) as if it were in effect. *See* Electricity Director's Final Report: 2015-16 Integrated Resource Plans, at p. 1 (Aug. 30, 2016) (hereinafter "2015 Final Report"), *available at* http://www.in.gov/iurc/files/Consolidated%20IRP%20Report%20for%20DEI%20IM%20IMPA%20and%20WVPA%20-%20Final%208-30-16.pdf.
[2] 2015 Final Report, at p. 1.

methodological requirements of the Commission's IRP rule. Although these comments are not meant to be comprehensive reviews of IPL's IRP process, resource planning practices, or preferred resource plans, the report offers comments in a number of places that have a broader applicability to the IRP process in Indiana. We urge the Commission to consider these comments as it continues its rulemaking process to improve upon the IRP rules for future planning years. Commenters respectfully request that Commission Staff call on IPL and all Indiana utilities to address the informational, procedural, and methodical deficiencies identified in the attached comments both in response to the Director's Report on this year's IRPs and in all future resource planning and decision making.

As an initial matter, Commenters appreciate that IPL took the time to speak with stakeholders one-on-one, in addition to the public stakeholder meetings. As set forth in detail in the attached comments, however, after completing a technical review of IPL's IRP, Commenters have identified numerous informational, procedural, and methodological deficiencies that call into question the validity of IPL's analysis. Many of the issues identified in the attached comments reflect ways in which the actual modeling that IPL did in support of its IRP is not consistent with, or was not adequately documented in, the narrative that IPL presents in its IRP and shared with stakeholders during the public outreach process. The information that Commenters have been able to obtain demonstrates that numerous constraints in IPL's modeling introduce biases that limit the Company's analysis of renewable and demand-side resources. As a result of these deficiencies, IPL's IRP analysis fails to reflect all available, economical demand-side management, distributed generation, and other renewable resource alternatives in their IRP modeling, and it fails to evaluate fairly and transparently the potential benefits to their ratepayers of retiring coal-fired generating units.

Finally, we encountered much difficulty in accessing IPL's complete IRP information for review. This was burdensome for both the utility and us as stakeholders, requiring multiple rounds of discovery, many email communications, and a phone call to obtain the basic information required to do a competent review of IPL's IRP. As such, we endorse the recommendations made by CAC, Indiana Distributed Generation Alliance, the Indiana State Conference of the National Association for the Advancement of Colored People (NAACP), Sierra Club, and Valley Watch in IURC Rulemaking #15-06 to include a "technical appendix" as part of the IRP submissions. Since the utilities already have the files and should be able to provide them to stakeholders (under a nondisclosure agreement, if appropriate), it would likely enhance the quality of comments (if stakeholders have complete information at the outset), reduce the burden on stakeholders to provide comments, and likely reduce the number of requests for extensions on the comment period if stakeholders are able to get the basic modeling information upfront instead of having to ask for it over the course of several weeks, as happened this time around.

Thank you very much for this opportunity. We look forward to the issuance of and opportunity to comment on the Director's Draft Report. Please feel free to contact Jennifer Washburn, Counsel at Citizens Action Coalition, with any questions or concerns.

Respectfully,

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Report on IPL 2016 IRP

Submitted to the IURC on March 16, 2017

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on behalf of CAC, Earthjustice, Indiana Distributed Energy Alliance, Sierra Club, and Valley Watch

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Overview

Our review of the Indianapolis Power & Light Company's 2016 Integrated Resource Plan (IPL's 2016 IRP) is organized in response to IURC guidance on IRP preparation in the IURC's Rule (170 IAC 4-7-4, 4-7-8). Table 1, on the following page, summarizes our findings for each of the eighteen (18) Indiana IRP requirements. More generally, our review raised the following main categories of concerns with regard to the IPL 2016 IRP and how it aligns with the IRP Rule:

- **Failure to communicate core concepts to nontechnical audiences (170 IAC 4-7-4(a)):** IPL's 2016 IRP is missing critical information, is internally inconsistent between sections and attachments, and contains multiple sections that are simply unclear. See Section I of our report below.
- **Incomplete documentation of inputs, methods, and definitions (170 IAC 4-7-4(b)(1)):** IPL failed to produce documentation for both its methods and assumptions. For example, IPL did not provide with its IRP its full set of modeling inputs and the IRP does not offer many details about how key inputs were developed, such as capacity prices. See Section II below.
- **Inconsistencies between modeling descriptions provided by IPL and their consultants (170 IAC 4-7-4(b)(1),(b)(12)):** IPL's IRP narrative is not consistent with the expert report attached to the IRP that detailed the modeling done for IPL. See Sections II and VI below.
- **Modeling errors including modeling of the reserve margin (170 IAC 4-7-4(b)(9)):** IPL's incorrect modeling of the reserve margin—including in 2018 when the future use of the Petersburg units is "optimized"—invalidates its modeling results. See Section IV below.
- **Preferred resource portfolio not selected from candidate portfolios and not described in IRP (170 IAC 4-7-8(a),(b)):** IPL's failure to choose a preferred resource portfolio from among its candidate resource portfolios invalidates its selection of a preferred resource portfolio. In addition, the model used by IPL erroneously uses a much higher required reserve margin instead of the correct 15 percent in the initial years, which has important impacts on resource choices. See Section VII.
- **Biases caused by modelling all scenarios under baseline conditions (170 IAC 4-7-8(a),(b)):** IPL's modeling creates a bias for selection of its Base Case as the preferred portfolio—which was originally selected as the preferred resource portfolio but then replaced with the ad hoc, unmodeled and under-described "Hybrid" preferred resource portfolio. See Section VII below.
- **Biases against renewable resources (170 IAC 4-7-8(b)(3),(b)(4)):** IPL's modeling includes several assumptions that bias resource selection against renewable generation. See Sections IX and X below.
- **Demand-side resources not evaluated on consistent and comparable terms with supply-side resources (170 IAC 4-7-8(b)(3),(b)(4)):** IPL's modeling includes several assumptions that bias resource selection against energy efficiency. See Sections IX and X below.
- **Flawed risk assessment and price forecasting (170 IAC 4-7-8(b)(7)(B)):** IPL's risk and uncertainty assessment is limited in scope, includes technical issues with IPL's Monte Carlo sampling process, and shows troubling inconsistencies in IPL's forecasting of fuel and electricity market and capacity prices, as well as load and RTO requirements. See Section XIV below.
- **Modeling choices lead to baked in lack of flexibility (170 IAC 4-7-8(b)(8)):** Inflated reserve margin settings and limited resources available prior to 2019 constrain IPL's

modeling from selecting the most “economic” choice and lock in retrofitted coal generation and significant excess capacity position for years to come. See Section XVIII below.

Given time and information constraints, our review is as complete as possible. However, we respectfully reserve the right to supplement our analysis in our reply to the Director’s Draft Report and/or in IURC proceedings based upon this IRP.

Table 1. Summary of evaluation of selected Indiana IRP requirements

	Requirement	Findings	Citation
I	The IRP must communicate core IRP concepts and results to non-technical audiences	Not Met	170 IAC 4-7-4(a)
II	IRP documentation must include inputs, methods, and definitions	Not Met	170 IAC 4-7-4(b)(1)
III	The IRP must include a discussion of distributed generation within the service territory and the potential effects on generation, transmission, and distribution planning and load forecasting	Not Met	170 IAC 4-7-4(b)(5)
IV	The IRP must include a description of the generation expansion criteria, including a full explanation of the basis for the criteria selected	Not Met	170 IAC 4-7-4(b)(9)
V	The IRP must include an explanation of the contemporary methods utilized in its development, including model structure and reasoning, and the utility's efforts to develop and improve its methodology	Not Met	170 IAC 4-7-4(b)(11)
VI	The IRP must include an explanation, with supporting documentation, of an avoided cost calculation for each year in the forecasted period	Not Met	170 IAC 4-7-4(b)(12)
VII	Preferred resource portfolio must be selected from among the candidate resource portfolios developed	Not Met	170 IAC 4-7-8(a),(b)
VIII	Preferred resource portfolio must be described, including key variables, standards of reliability, and other assumptions	Not Met	170 IAC 4-7-8(b)(1),(2)
IX	Supply-side and demand-side resource alternatives must be evaluated on a consistent and comparable basis in the selection of the preferred resource portfolio	Not Met	170 IAC 4-7-8(b)(3)
X	Preferred resource portfolio must utilize, to the extent practical, all economical load management, demand side management, technology relaying on renewable resources, cogeneration, distributed generation, energy storage, transmission, and energy efficiency improvements as sources of new supply	Not Met	170 IAC 4-7-8(b)(4)
XI	Targeted DSM programs must be evaluated, including impacts on the utility's transmission and distribution system	Not Met	170 IAC 4-7-8(b)(5)
XII	Financial impact to the utility of acquiring the future resources identified in the preferred resource portfolio must be assessed	Met	170 IAC 4-7-8(b)(6)
XIII	Preferred resource portfolio must balance cost minimization with cost-effective risk and uncertainty reduction	Not Met	170 IAC 4-7-8(b)(7)
XIV	Where possible, assumed risks and uncertainties must be quantified	Not Met	170 IAC 4-7-8(b)(7)(B)
XV	Candidate resource portfolios performance across a wide range of potential futures must be analyzed	Not Met	170 IAC 4-7-8(b)(7)(C)
XVI	Candidate resource portfolios must be ranked by present value of revenue requirement and by risk metric	Met	170 IAC 4-7-8(b)(7)(D)
XVII	An assessment of robustness must factor in to the selection of the preferred resource portfolio	Not Met	170 IAC 4-7-8(b)(7)(E)
XVIII	The preferred resource portfolio must incorporate a workable strategy for reacting to unexpected changes in circumstances quickly and appropriately	Not Met	170 IAC 4-7-8(b)(8)

Source: 170 IAC 4-7-8 amended 10-4-12

Analysis

I. Does the IRP communicate core IRP concepts and results to nontechnical audiences?

No. Although IPL created an 8-page non-technical summary of its IRP analysis, this document is confusing to a nontechnical reader and does not make clear IPL's preferred resource portfolio. In addition, IPL has a responsibility to provide timely, transparent information to the public. We encountered a failure to clearly present basic information in the IRP, difficulties accessing complete IRP information, and errors and inconsistencies in the IRP.

I-A. Failure to clearly present basic information

IPL's executive summary is filled with industry jargon and unexplained terms, which make the document difficult to comprehend for nontechnical stakeholders. A clear communication of core IRP concepts and results to nontechnical audiences requires a simple summary of key IRP findings at the beginning of the IRP. Ultimately, the main finding of an IRP is the utility's preferred resource portfolio. In IPL's 2016 IRP, it appears that the alternative referred to as "hybrid" or "hybrid preferred" is the actual preferred resource portfolio designated by IPL. However, this is never clearly and succinctly stated in the IRP. Moreover, the fact that the hybrid alternative is the preferred course of action is troubling as it was not a candidate portfolio and was never described at the same level of detail as the candidate portfolios.

I-B. Difficulties accessing complete IRP information for review

We filed our first set of informal discovery with IPL on November 9, 2016. We requested all modeling input and output files associated with the IRP. On November 23, 2016, IPL provided its response but it was incomplete. Specifically, the full set of CapEx inputs and outputs was not provided. On December 15 and 22, 2016, we again requested this information. We received follow-up responses regarding these missing CapEx modeling files on December 29, 2016, specifically as it related to the present value revenue requirements and information within the model on DSM cost information. We noted that files were still missing on January 3, 2017, and IPL followed up with additional information on January 5, 2017, but the modeling files in our possession were still not complete. We followed-up again on January 19, 2017, and requested, on January 20, 2017, that we hold a call with IPL's IRP modeling team and ABB. The remaining modeling files were provided on January 30, 2017, and the call with ABB and IPL was held on January 31, 2017. Additional information was requested during that call and we sent a follow-up email to put into writing the requested items. That information was then provided on February 9, 2017. On February 21, 2017, we then asked for another phone call to discuss the information provided about the stochastic analysis. IPL asked that we provide written questions instead, and we sent that on February 23, receiving written responses from IPL on February 28, 2017.

Regardless of the reasons for this extended time period to receive the complete set of modeling files, we recommend that the draft IRP rule be modified so that the expectation is set that this information needs to be provided with the filed IRP.

I-C. Errors and inconsistencies in IPL's 2016 IRP

The errors and inconsistencies in IPL's 2016 IRP presented throughout this report impede the utility's ability to communicate core IRP concepts and results to its audience. Key among these errors and inconsistencies are the following:

- Failure to communicate core concepts to nontechnical audiences (See Section I)
- Incomplete documentation of inputs, methods, and definitions (See Section II)
- Inconsistencies between modeling descriptions provided by IPL and their consultants (See Sections II and VI)
- Modeling errors including modeling of the reserve margin (Section IV)
- Preferred resource portfolio not selected from candidate portfolios and not described in IRP (See Section VII)
- Biases caused by modeling all scenarios under baseline conditions (See Section VII)
- Biases against renewable resources (See Sections IX and X)
- Demand-side resources not evaluated on consistent and comparable terms with supply-side resources (See Sections IX, X)
- Flawed risk assessment and price forecasting (See Section XIV)
- Modeling choices lead to baked in lack of flexibility (See Section XVIII)

I-D. Recommendations for communicating core IRP concepts and results with nontechnical audiences

To best communicate core IRP concepts and results to nontechnical audiences we recommend:

- **An executive summary presenting the candidate and preferred portfolios in clear, simple terms:** IPL's Executive Summary should include a description and/or charts showing the future generation portfolios considered, and IPL's preferred portfolio in multiple years up to and including the end of the study period.
- **A summary table describing the preferred resource portfolio in detail:** Nontechnical readers would greatly benefit from a simple, clear table located at the front of the IRP report and laying out the basic details of the utility's preferred resource portfolio. Key details for inclusion in such a table include, but are not limited to, a load, current resource capability, and a table of the year-by-year planned capacity acquisition of the preferred resource portfolio.
- **A complete submission of all IRP modeling inputs and outputs in machine readable form at the time of IRP submission:** Most capacity expansion models have "standard" input and output files that can be readily exported for review. It is these files that constitute the bulk of this type of submission.
- **Careful fact-checking of all IRP materials for accuracy and internal consistency:** Early release of detailed descriptions and modeling files during the stakeholder process would allow public scrutiny that could aid the utility in identifying errors before the IRP is submitted to the commission.

II. Does IRP documentation include inputs, methods, and definitions?

No, IPL's 2016 IRP documentation does not clearly present inputs, methods, and definitions.

II-A. Complete documentation of inputs and outputs

The term "inputs" should not mistakenly be interpreted to be limited to cost and electric consumption projections such as coal and natural gas price forecasts, the load forecast, combined cycle, solar, and wind costs. The full set of inputs to an IRP is significantly more complex than this and includes a very large number and variety of input assumptions made by the modeler, for example:

- The first year a resource can be added to a portfolio
- The last year a resource can be added to a portfolio
- The size of each resource that can be added
- The minimum and maximum number of units of a particular resource that can be added
- The reserve margin requirement
- The order in which resources must be dispatched
- Forced outage rates
- Heat rate profile
- Fuel delivery charges by unit
- Emissions rates
- Schedule of maintenance outages

Because there are so many inputs to an IRP, the only plausible way to completely document them is to provide the modeling input files in a format that is easily readable (for example, in an Excel spreadsheet) without requiring public interest groups and other intervenors to pay tens of thousands of dollars to license the model. IPL did not provide these input files with its initial 2016 IRP submittal. Indeed, CAC and Earthjustice followed up on their informal discovery request for these input files twice before securing the complete set of inputs four months later.

We recommend that for future resource plans, it would be extremely helpful to a meaningful and cooperative public process to set the expectation that the utility must deliver concurrently with the final IRP all modeling files. We would be happy to work with each individual utility to understand the best compliance pathway given its particular modeling protocols.

It is also worth noting that while this section of the Indiana IRP requirements is specific to "inputs, methods, and definitions", input files must be accompanied by output files for useful third-party review. Output files speak to key aspects of a resource portfolio that provide a deeper level of understanding that just simple charts and graphs can provide.[1]

[1] While Attachment 8.3 provides some confidential information it is not nearly as comprehensive as the output files from the models themselves.

II-B. Ambiguity between IPL's actual methods and its IRP narrative

There was ambiguity and, in some cases, outright conflicts between IPL's modeling methods (as described by the model vendor and IPL's modeling consultant, ABB, in Attachment 2.1 and Confidential Attachment 2.2) and the IPL 2016 IRP narrative:

- In several instances, IPL said that the Quick Transition scenario was modeled in its Capacity Expansion model (IPL 2016 IRP, p.179 and Attachment 2.1, p. 6-45). It was not. When asked to correct two instances of this misstatement, IPL said the statements were in fact correct, but that one was referencing the "Capacity Expansion framework" and the other the "Capacity Expansion selection tools"—a distinction that was not defined (Revised response to CAC 5.1 and Response to CAC 6.1).[2]

  This response does not alleviate confusion. Not only are these two terms unclear, but according to IPL no Capacity Expansion modeling files for the Quick Transition scenario were available because Capacity Expansion was not used at all in developing that scenario so it's not clear how anything related to Capacity Expansion, whether the "framework" or "selection tools" could have been used.
- ABB's list of variables sampled in the stochastic analysis (Attachment 2.1, p.4-15, 4-16) differed from the list provided in IPL's IRP narrative (IPL 2016 IRP, p.149).
- IPL's IRP narrative states that a minimum of 600 MW of gas generation connected to its 138 kV transmission system is required for system reliability (IPL 2016 IRP, p.169).[3] ABB's report (IPL 2016 IRP Attachment 2.1, p.6-45) says the level is 1,200 MW. At the October 21, 2016 stakeholder meeting, IPL said that the level was actually 450 MW of *baseload generation* tied to the 138 kV system *in addition to* the 671 MW Eagle Valley CCGT for a total of 1,171 MW (IPL 2016 IRP, Attachment 1.2, Slide 14, at pdf p.128). These inconsistences suggest that the minimum may be much more flexible than just a single number, but regardless our review of IPL's modeling files found no evidence of additional baseload being added to meet such a requirement.
- IPL's reserve margin requirement was modeled erroneous as a much higher 22 percent instead of the 15 percent MISO Installed Capacity (ICAP) requirement in the initial years (see Section VII-B-1). This discrepancy was not discussed in the IRP narrative.
- Source of capacity price forecast is unclear as described below in Section VI.
- The table of contents to IPL's IRP narrative does not list the attachments to the IRP, which include such essential items as Itron's load forecast report and ABB's modeling results reports. The only place these reports are listed is in the last two pages of the IRP narrative, which gives only the attachment number and title.

II-C. Recommendations for complete documentation of inputs, methods, and definitions

There is no substitute for making the IRP narrative consistent with and comprehensive in summarizing the IRP modeling. In IPL's case, one improvement to consistency would be to have the model vendor directly involved in drafting or otherwise providing quality control to the

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[2] Included as Exhibits 1 and 2.
[3] Note that Petersburg connects to the 345 kV system.

IRP narrative. We do not know whether ABB was involved in drafting the IPL 2016 IRP narrative, but there are unquestionable inconsistencies as (1) ABB's report was submitted as an attachment to the IPL 2016 IRP; and (2) the IPL 2016 IRP narrative differs from the modeling described in the ABB report in at least the following two material ways:

- Discrepancies in the reported reserve margin requirement modeled
- Discrepancies in the minimum level of natural-gas fired generation modeled.

To assure complete documentation of an IRP, we endorse the recommendations[4] made by CAC, Indiana Distributed Generation Alliance, the Indiana State Conference of the National Association for the Advancement of Colored People (NAACP), Sierra Club, and Valley Watch in IURC Rulemaking #15-06 to include a "technical appendix" as part of the IRP submission. The following is a partial list of key items for inclusion in an IRP technical appendix:

- **The input and output files from all models in a readable electronic format**
    - System Optimizer, Planning and Risk, Capacity Expansion: Input and output files should be presented in spreadsheet format.
    - Strategist: Input and output files should be in text format at a minimum. Strategist has the capability to export data into a spreadsheet, which is extremely helpful for review purposes, and we encourage other Strategist users to do as NIPSCO has done and provide us with that information.
    - With any of these models, if stakeholders or Commission staff wish to create their own modeling runs, the executable files also should be made available, but this type of exercise would require licensing fees for model and data and is therefore usually beyond the resources available to an intervenor/stakeholder group.
    - Other models: For most other models, spreadsheet-based input and output files will be of most use. We would be happy to consult with any Indiana utility on the appropriate format to use for a given model.
- **A user guide for each model used:** Indiana utilities use many different models including Strategist, System Optimizer, Planning and Risk, MIDAS, Capacity Expansion model, and Plexos, so having a user guide on hand is essential to a public process so that stakeholders and Commission staff can have an understanding as to how a model works and how to interpret its input and output files.
- **Any files used to "post-process" IRP results in readable electronic format with formulae intact:** For example, NIPSCO and at least one other Indiana utility, Duke, take the results of their modeling and modify the present value of revenue requirements (PVRR) in a spreadsheet.

[4] Public Comments received by the IURC in IURC RM #15-06 are available here: http://www.in.gov/iurc/2844.htm.

III. Does the IRP include a discussion of distributed generation within the service territory and the potential effects on generation, transmission, and distribution planning and load forecasting?

No, while IPL's 2016 IRP includes a High Customer Adoption of Distributed Generation scenario as well as some discussion of distributed generation within the service territory it lacks key information necessary to interpreting IPL's treatment of distributed generation in its modeling.

III-A. Ratio of distributed generation to total generation

The IPL narrative states that in its Distributed Generation scenario, 150 MW of distributed generation (represented as 65 MW of solar, 10 MW of wind, and 75 MW of combined heat and power (CHP)) was added in 2022, 2025, and 2032 (IPL 2016 IRP, p. 168) for a total of 450 MW. This narrative, however, is inconsistent with the Capacity Expansion Model files provided by IPL, which show—[redacted] lus additional resources in subsequent years.

III-B. IPL's acknowledged flaws in modeling distributed generation

IPL's 2016 IRP itself identifies three key flaws in its modeling of the High Customer Adoption of Distributed Generation:

First, the electric dispatch model used by IPL does not adjust electric generation, customer demand, or wholesale sales in response to the adoption of distributed generation, even as the penetration of distributed generation increases to more than 450 MW:

> *A key takeaway is that while the Production Cost model did not adjust IPL's thermal fleet generation in response to customer Adoption of DG, IPL responded to stakeholder feedback and calculated the emission reductions that would result from the Adoption of DG. The Production Cost model, as set up in the 2016 IRP, does not adjust IPL's sale of electricity into the wholesale market for the amount of distributed generation that is added to the system. Stakeholders provided feedback that the adoption trends of DG in the MISO footprint would probably be similar to the adoption of the 450 MW of DG additions in IPL's service territory, which means that IPL would sell less electricity into the wholesale market. (IPL 2016 IRP p.199)*

Second, IPL models no displacement of other generation resources in response to new distributed renewables and combined heat and power, which have very low variable costs and dispatch early in the supply curve. IPL notes that this failure to model fossil generation displaced by new distributed generation makes it necessary for them to do post-modeling adjustments of their CO_2 emission projections. IPL post-hoc adjustments are unreasonable as it would be difficult for IPL to know exactly which units, on an hourly basis, would be displaced by these distributed resources. IPL's approach to this calculation, at best, results in a rough estimate:

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[5] SitesBuiltByYearOut for the High Customer Adoption of Distributed Generation scenario output file provided in response to CAC 1.1

> *IPL used this stakeholder feedback to change its calculation of total CO_2 tons to reflect the CO_2 emissions that are avoided by the adoption of DG wind, solar, and CHP. To do this, IPL assumed that for each MWh of DG wind and solar generation, IPL's portfolio of resources will generate that much fewer MWh and hence emit that much fewer CO_2 tons/MWh. For each MWh of CHP generation, IPL's portfolio of thermal resources will generate that much fewer MWh, but the CO_2 tons/MWh of CHP are still included in the calculation of total CO_2 emissions.*
>
> *As a result of IPL's adjustment to the CO_2 emissions calculation, the Adoption of DG portfolio's 20 year emissions of CO_2 changed from 271,126,254 tons to 264,398,387 tons. 3.2 million tons of CO_2 are avoided by the customer owned DG wind and solar units, and 3.5 million tons of CO_2 are avoided by CHP units. However, even though the CO_2 rate per GWh is lower for the CHP units than IPL's thermal fleet, the CHP units still emit a total of 13.5 million tons of CO_2 during the study period. The Production Cost model also applies a random outage rate to thermal units, including CHP. This random outage rate for each scenario resulted in the Adoption of DG scenario producing more GWh than the Base Case scenario, which results in higher CO_2 for the Adoption of DG scenario than the Base Case emissions even after taking into account the reduction of IPL's thermal fleet generation in response to the addition of DG. (IPL 2016 IRP p.199)*

Finally, IPL identified another post-modeling adjustment that was required but which IPL failed to undertake. Specifically, IPL explains that its PVRR analyses require post-modeling adjustment to account for distributed generation's displacement of other generation and the associated reduction in operational costs, but that IPL has not undertaken this adjustment:

> *IPL did not recalculate the PVRR to reflect change in IPL's thermal generation due to customer adoption of DG, since the PVRR is an output of the Production Cost model. Although the 2016 version of Production Cost model was not set up to adjust the thermal generation as a result of customer adoption of DG, IPL will work to improve this for the next IRP. (IPL 2016 IRP p.199)*

III-C. Recommendations for discussion of distributed generation and its potential effects

For a complete and accurate discussion of distributed generation in an IRP we recommend that a clear rationale be provided and substantiated for the mix of distributed generation types modeled and that the impacts of distributed generation on customer demand, emissions, and displaced generation be represented accurately within the capacity expansion and production cost models themselves and not in post-model corrections.

IV. Does the IRP include a description of the generation expansion criteria, including a full explanation of the basis for the criteria selected?

No. The IPL 2016 IRP narrative does not include a description of the generation expansion criteria including a full explanation of the basis for the criteria selected. IPL's description of generation expansion criteria in its 2016 IRP is incomplete, incorrect, and inconsistent with the explanation given in ABB's two modeling reports (Attachment 2.1 and Confidential Attachment 2.2).[6]

IV-A. Issues in ABB's description of generation expansion criteria

ABB is the model vendor and performed IPL's 2016 IRP analysis. For this reason—and given the inconsistencies between the IRP narrative and ABB report—a review of ABB's report with respect to generation expansion criteria is of particular interest. The Executive Summary of one of ABB's reports states,

> *ABB performed IPL portfolio expansion simulations using its Capacity Expansion Module to model demand and supply side alternatives. The module did a complete numerical simulation of all possible combinations using mixed integer linear programming (MILP) while maintaining a minimum 15 percent reserve margin as required by MISO for the current planning year. The decision criterion or objective function is to minimize the costs to customers presented in terms of present value of revenue requirements (PVRR). Study period was 2017-2036 with end effects through 2046. (IPL 2016 IRP, Attachment 2.1, pdf p.222)*

Based on our review of IPL 2016 IRP modeling files, there are multiple ways in which this description could be improved to enhance clarity and avoid potential misunderstandings:

1. "[W]hile maintaining a minimum 15 percent reserve margin as required by MISO for the current planning year": ABB should make it clear that the reserve margin requirement used was not actually 15 percent in all years modeled but was instead erroneously set at a much higher [redacted] percent for the first five years of the study period (see Section VII-B-1).
2. "[U]sing mixed integer linear programming (MILP)": ABB should explain to the lay audience what mixed integer linear programming means and why this approach is different from and/or better than other IRP modeling techniques.
3. "The module did a complete numerical simulation of all possible combinations": ABB should emphasize that the combinations of resources deemed "possible" were governed by the first-year availability information presented in Attachment 5.1. Not all resources were available in all years of the study period.
4. "The decision criterion or objective function is to minimize the costs to customers presented in terms of present value of revenue requirements (PVRR)." ABB should make explicit some of the key constraints to which the objective function is subject.

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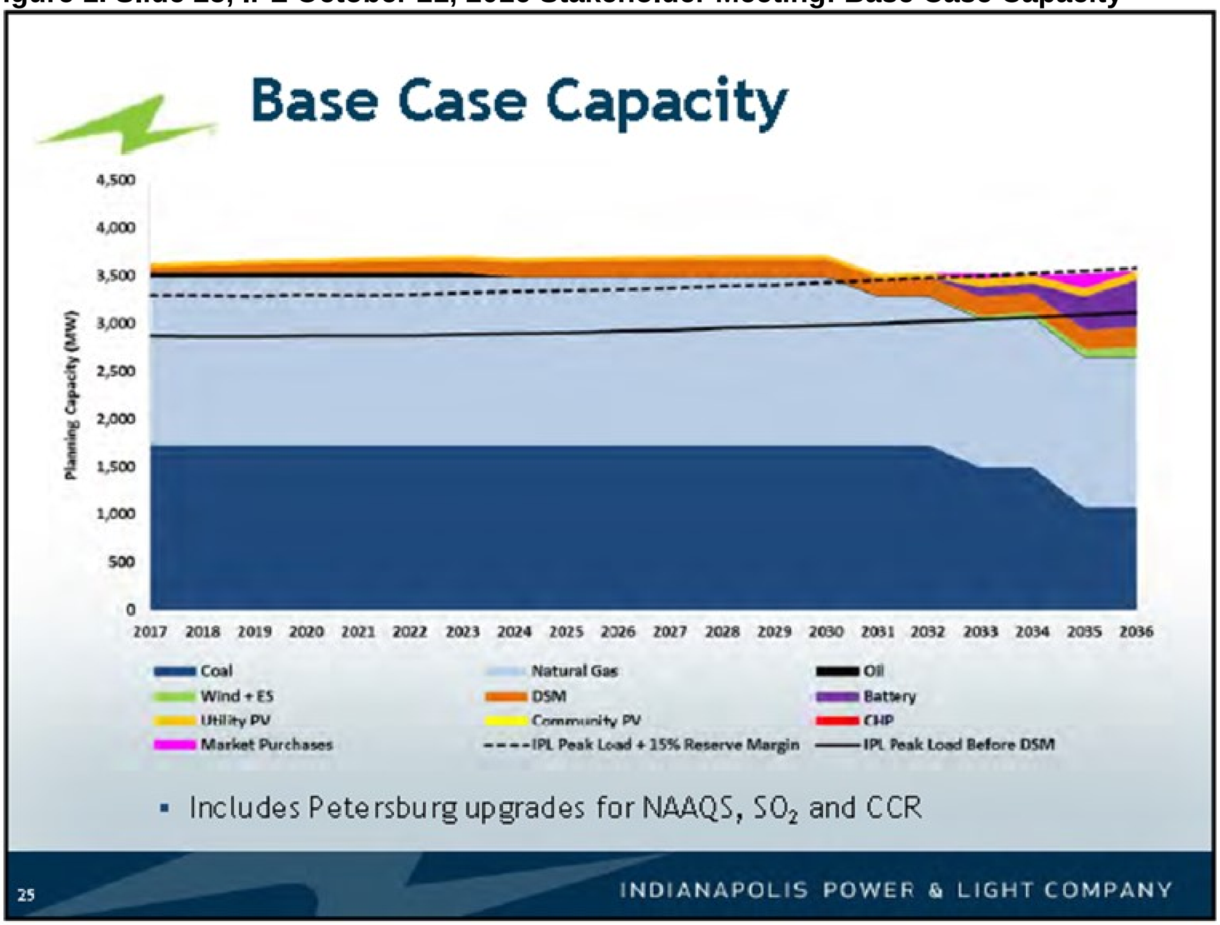
[6] There are two ABB reports attached to IPL's 2016 IRP. One is confidential and one public, but they are not simply the redacted and unredacted versions of each other. It is not at all clear why this would be the case nor is an explanation given for why the information in each report differs in some instances and is the same in others. Indeed, the two reports have to be compared side by side to discern exactly how they differ and whether information in the confidential report is indeed confidential or not.

> Commonly understood constraints include but are not limited to meeting the reserve margin requirement and meeting the load and peak demand forecast but there are often other, scenario specific constraints.

We encourage IPL to be more transparent in its IRP narrative and supporting documents about the factors that have a significant influence on its generation expansion modeling process and results. Simply providing a list of "Scenario Drivers" (Figure 3 of the IPL 2016 IRP Non-Technical Summary) is not sufficient to a cooperative public process and meaningful third-party review of the capacity expansion criteria used in modeling.

For example, when IPL showed the graph reproduced as Figure 1 below at its October 21, 2016 stakeholder meeting, the following information—critical to its accurate interpretation—was omitted: The black dotted line labeled "IPL Peak Load + 15% Reserve Margin" is not the reserve margin requirement that was actually modeled by ABB in IPL's Base Case. The reserve margin requirement modeled by ABB incorrectly starts at a much higher [redacted] percent for the first five years of the period before falling to 15 percent. This discrepancy helps explain the preponderance of excess capacity in this and the other scenarios in IPL's 2016 IRP (see Section VII-B-1).

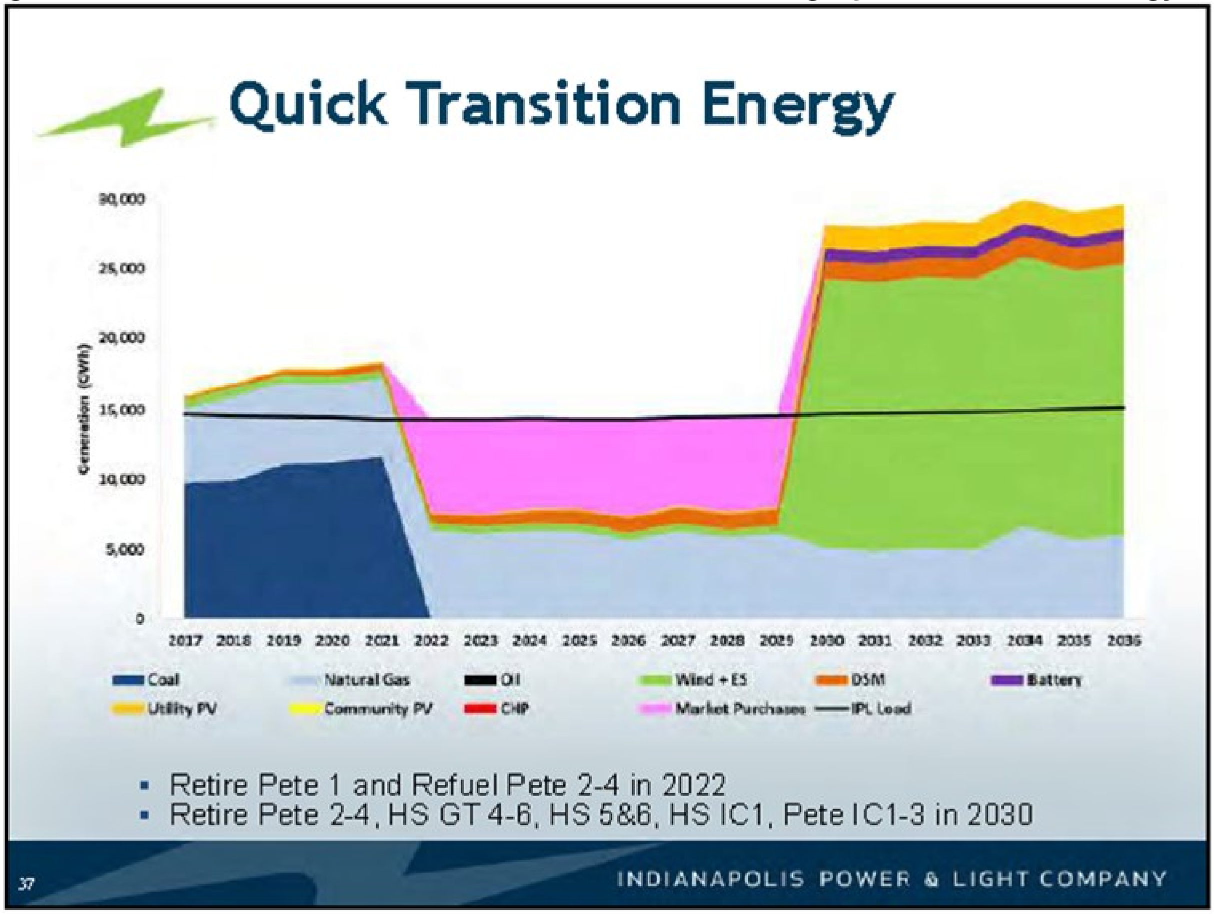
Figure 1. Slide 25, IPL October 21, 2016 Stakeholder Meeting: Base Case Capacity



Similarly, when describing the energy mix of the "Quick Transition" scenario—reproduced below as Figure 2—critical information was again omitted. The IPL narrative states that: "In the Quick Transition scenario, the Capacity Expansion Model was directed to select all of the demand-side management (DSM) bundles that were available (19 EE bundles and 6 DR bundles in both periods of interest)."(IPL 2016 IRP p.179), however, based on our review of IPL modeling files this resource portfolio *was not modeled* in Capacity Expansion.[7] Rather, it was designed and selected by IPL.

As we pointed out to IPL during the October 21, 2016 stakeholder meeting, the level of market energy purchases does not make sense because they are such a significant portion of total energy requirements, nor for that matter does the level of wind purchases late in the study period because they represent so much excess energy. IPL seemed to agree with the former, but declined to change its modeling to represent a more realistic scenario.[8]

Figure 2. Slide 37, IPL October 21, 2016 Stakeholder Meeting: Quick Transition Energy



[7] See also revised response to CAC 5.1 and the response to CAC 6.1 (included as Exhibits 1 and 2).
[8] While IPL characterizes this scenario as based on stakeholder feedback, we do not take that to mean that the stakeholders chose or even had the appropriate information to choose, every resource decision that constitutes this portfolio.

IV-B. Recommendations for generation expansion criteria

For a complete and accurate description of generation expansion criteria in an IRP we recommend that the Commission require utilities to provide when an IRP is submitted, detailed data that is sufficient allow third-party review and a useful public process. This information should include: the type, quantity, and size of capacity available to the model (assuming a model was used) in each year as well as any limitations on resource choices.

In addition, careful review should be made of all narrative descriptions of scenario assumptions and modeling methodologies to ensure that this text is accurate, clear enough to be easily interpreted by a nontechnical audience, and internally consistent across all sections of the IRP and related materials.

V. Does the IRP include an explanation of the methods utilized in its development?

No. IPL's 2016 IRP's explanation of the methods utilized in the development is incomplete regarding the model structure and reasoning used in the model structure's development. Moreover, the IRP does not explain IPL's efforts to develop and improve its methodology.

V-A. Does the IRP include an explanation of the model structure and reasoning?

No. The explanation of the methods used in the development of IPL's 2016 IRP is incomplete and does not fully describe or explain the model structure and reasoning used. These issues are discussed more fully in Sections VII and VIII of this report.

V-B. Does the IRP explain the utility's efforts to develop and improve its methodology?

While the IPL 2016 IRP does include some discussion of the utility's efforts to develop and improve its methodology, these efforts were inadequate. IPL relied on questionable sources to improve its understanding of the IRP process and DSM modeling:

> *IPL conducted extensive research into IRP best practices before undertaking the 2016 IRP. Topics researched include scenario development, methods to model DSM as a selectable resource, key variables for load forecasting, and the use of metrics to compare portfolios. Not only did IPL research publicly available documents from other utility IRPs and MISO to assess the range of possible scenarios and metrics used to compare the scenario portfolios, but IPL staff coordinated a visit, along with the other Indiana IOUs, with the Tennessee Valley Authority to better understand its IRP process and how it modeled DSM as a selectable resource. (IPL 2016 IRP, p.133)*

IPL appears to have modeled its own IRP and DSM efforts in the same manner as Tennessee Valley Authority's (TVA) 2015 IRP. This is problematic because research by Synapse Energy Economics found that TVA overestimated the cost of energy efficiency and imposed excessive constraints on the amount of energy efficiency available in its modeling.[9]

IPL, however, could have improved its methodology by incorporating the TVA 2015 IRP's method of analyzing different resource portfolio alternatives under different scenarios. Instead, IPL used a flawed methodology failed to assess how different resource portfolio performed under different scenarios. ("Scenario" and "resource portfolio" are synonyms under IPL's 2016 IRP.) As a result, each IPL resource portfolio arose from a portfolio-specific scenario but was modeled in a base case scenario. IPL partly describes its "vision" for the IRP as follows: "In the parlance of today, IPL is planning to be antifragile—preparing to meet customers' needs in multiple potential future outcomes. This IRP evaluates resource plans through multiple

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[9] See Takahashi et al. (2015) *Review of TVA's Draft 2015 Integrated Resource Plan* (http://www.synapse-energy.com/sites/default/files/Review-TVA-Draft-2015-IRP-14-022.pdf) and Takahashi (2015) *Searching for Best Practices for Modeling Energy Effficiency in Integrated Resource Planning* (http://aceee.org/sites/default/files/pdf/conferences/eer/2015/Kenji_Takahashi_Session2D_EER15_9.21.15.pdf)

scenarios, which were developed through a public advisory process to cover a broad range of potential futures." (IPL 2016 IRP Executive Summary, p.1) This description fails to reflect the reality of its modeling.[10]

TVA's approach is more robust because it models all of its resource options (called "strategies") against a range of different possible future outcomes (scenarios). TVA defines three key terms as follows:

- *Strategies* represent future business decisions over which TVA has full control. [i.e., which types of energy resources to pursue]
- *Scenarios* represent future conditions that TVA cannot control.
- *A portfolio* is the intersection of a strategy and a scenario and represents a multiyear energy resource plan detailing how TVA intends to meet future power needs. (TVA 2015 IRP, p.12[11])

TVA describes its modeling approach as follows.

> *Together we then developed a series of five scenarios representing alternative plausible futures to help us test the performance of the resource planning strategies under different conditions and, ultimately, to identify the strategy that might represent the most flexible approach to ensuring the lowest cost, most reliable power for our customers.*
>
> *Each scenario can be thought of as a model of a possible future. In one model, the economy might stagnate, fuel prices drop and electricity demand remains flat. In another, strong economic recovery could lead to increased fuel prices and to rapid recovery in electricity sales and long-term demand growth and increase the cost of building generating sources.*
>
> *To better assess the robustness of the strategies evaluated for this IRP, we purposely structured these scenarios to present different challenges to the resource planning strategies. The scenarios differ from each other in key areas, such as projected customer demand, fuel prices and future economic and regulatory conditions. (TVA 2015 IRP, p.13)*

The specific scenarios and strategies employed by TVA are shown in Figure 3 below.

[10] IPL's risk/stochastic analysis is not the same as scenario analysis nor is it a substitute.
[11] TVA (2015) *Integrated Resource: 2015 Final Report* (https://www.tva.gov/file_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/IRP/Documents/2015_irp.pdf

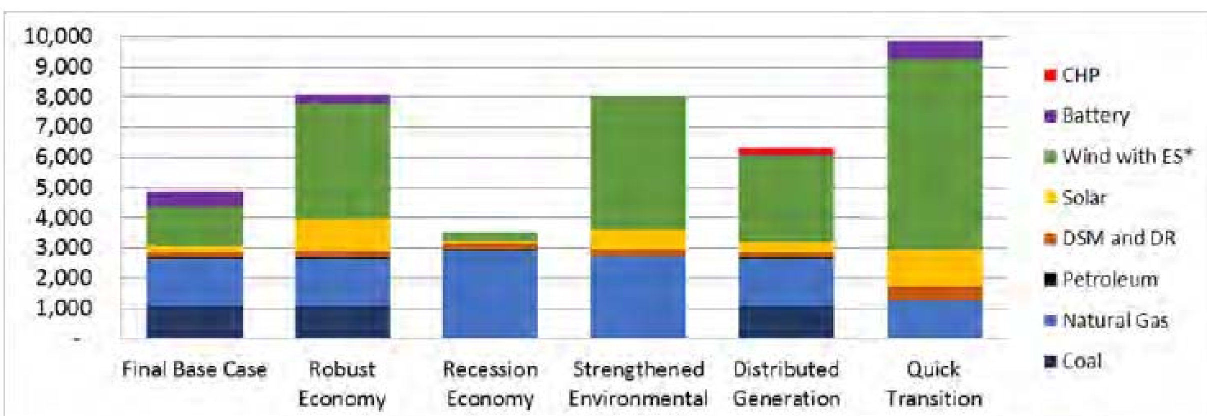
Figure 3. TVA 2015 IRP, Figure 2-1 List of Scenarios and Strategies

Scenarios		Strategies	
1 - Current Outlook	• Current outlook for the future TVA is using for resource planning studies	**A - The Reference Plan**	• Traditional least cost optimization, EE/Renewables optimized
2 - Stagnant Economy	• Stagnant economy results in flat to negative growth, delaying the need for new generation	**B - Meet an Emission Target**	• Resources selected to create lower emitting portfolio based on an emission rate target or level using CO2 as the emissions metric
3 - Growth Economy	• Rapid economic growth translates into higher than forecasted energy sales and resource expansion	**C – Focus on Long-Term, Market-Supplied Resources**	• Most new capacity needs met using longer-term PPA or other bilateral arrangements • TVA makes a minimal investment in owned assets
4 - De-Carbonized Future	• Increasing climate-driven effects create strong federal push to curb GHG emissions: new legislation caps and penalizes CO2 emissions from the utility industry and incentivizes non-emitting technologies	**D – Maximize Energy Efficiency**	• Majority of capacity needs are met by setting an annual energy target for EE (priority resource to fill the energy gap) • Other resources selected to serve remaining need
5 - Distributed Marketplace	• Customers' awareness of growing competitive energy markets and the rapid advance in energy technologies produce unexpected high penetration rates in distributed generation and energy efficiency. TVA assumes responsibility to serve the net customer load (no backup for any customer-owned resources)	**E – Maximize Renewables**	• Enforce near-term and long-term renewable energy targets; targets met with lowest cost combination of renewables • Hydro is included as a renewable option along with biomass, wind and solar

Source: TVA 2015 IRP, p.13

TVA's approach models each scenario with each strategy or set of resource options, for example, how Strategy A fairs under each of the 5 scenarios. IPL, in contrast, would model Strategy A only under Scenario 1. TVA's strategy makes it possible to evaluate whether a given portfolio fairs well under a variety of different possible futures and creates more meaningful apples-to-apples information. A utility's preferred resource plan should perform well under a variety of different scenarios or possible future outcomes. Using TVA's approach, extremes of non-base case scenarios do not force resource decisions that would not test well under base case conditions. Figure E of IPL's Executive Summary, reproduced as Figure 4, illustrates this.

Figure 4. IPL 2016 IRP Executive Summary Figure E: Candidate Resource Portfolios (MW in 2036)



The Robust Economy, Strengthened Environmental, Distributed Generation, and Quick Transition portfolios all have many more MWs of capacity than do the Final Base Case and Recession Economy portfolios. It would be reasonable to expect that the portfolios with more capacity would be more expensive.

This is not to say that the optimization capability of a capacity expansion model should not be used. There is a balance to be reached. The resource optimization can be focused on specific types of resources with adjustments to the resources the model can choose as needed to ensure that the resulting portfolio is reasonable (that it does not, for example, result in unrealistic market purchases or sales).

We address this problem further in Section VII.

In addition, Section 9.3 of IPL's 2016 IRP discusses improvements it plans to make to future IRPs. These items, which are not very specific, include:

1. "Review other IRPs to assess similarities and differences in [DSM modeling] methodologies and potential improvements."(p.224)
2. "Enhance transmission analysis to consider ways to support more renewables."(p.224)
3. "Refine requirements of a new wind asset with complimentary BESS and capacitor assets."(p.224)

These planned improvements point to a misunderstanding of the importance of larger issues related to renewable energy and beg questions such as: Why did IPL find it necessary to couple future wind with battery storage and a capacitor (see Section IX-A-3) when utilities throughout MISO are building and modeling wind in their IRPs without these additional costs?

V-C. Recommendations for explaining methods used in IRP development

Ultimately, the most important question with regards to explaining and improving methods used in IRP development is whether and to what extent IPL intends to address the issues regarding methodology, data quality, and clarity of presentation identified in this report.

VI. Does the IRP include an explanation, with supporting documentation, of an avoided cost calculation for each year in the forecasted period?

No. IPL's explanation of its avoided costs as calculated is confusing and does not include all necessary supporting documents. IPL's 2016 IRP includes a document entitled "Confidential Attachment 5.10 (Avoided Cost Calculation)", but this document does not show IPL's actual calculation. Instead, it reports values for two capacity price forecasts and one market price forecast and an avoided transmission and distribution (T&D) projection. The discussion of avoided cost is given in Section 5.6.4 of IPL's IRP (p.107) but it is incomplete and confusing.

VI-A. Incomplete calculation of avoided costs

The avoided cost calculation presented in IPL's 2016 IRP consists only of a projection of energy costs, a projection of avoided T&D, and two projections of capacity costs, the sources and applications of which are confusing. IPL uses the avoided cost to screen DSM programs. Given this purpose, there is at least one more meaningful way to assess avoided cost. We provide this recommendation at the end of this section.

IPL's approach of screening demand-side measures using simple projections of market energy and capacity prices, even with the inclusion of avoided T&D costs, raises concerns. If this were a true test of how a utility acquires all its energy resources then it should purchase only the energy and capacity that is cheaper than its avoided cost. But this is not the cost metric that is being applied to supply-side resources in this IRP. Rather, portfolios of multiple resource types are being compared on the basis of their present value over 20 years.

VI-B. Avoided capacity cost assumptions are inconsistent and not well-documented

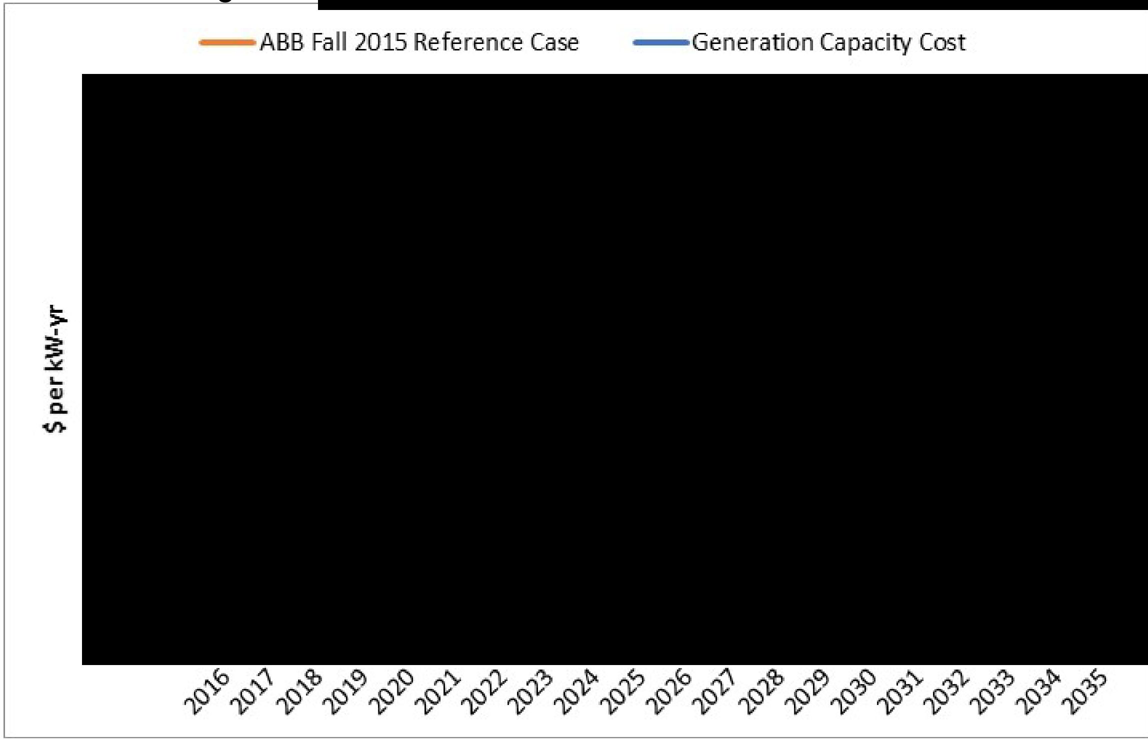
Setting aside the methodological issues with IPL's avoided cost, the price forecasts themselves are not well-documented. In Confidential Attachment 5.10, IPL's two projections of capacity costs are labeled "Avoided Capacity Cost" and "Avoided Generation Capacity Cost":

- Avoided Capacity Cost: The source of IPL's Avoided Capacity Cost is "ABB 2015 Fall Reference Case – MISO-IN"(Confidential Attachment 5.10).
- Avoided Generation Capacity Cost: The source of IPL's Avoided Generation Capacity Cost is "2016 Input Assumptions for 2017 Action Plan Update and [sic] MPS_3_24.xlsx, Capacity Costs NAAQ SO tab, cell C8"(Confidential Attachment 5.10). This citation source references only another spreadsheet, which was not made available to stakeholders, and does not provide an original data source.

IPL's IRP narrative states: "The generation capacity costs are forecasted as a blend of short-term bilateral transactions and the ABB 2015 Fall Reference Case."(p.107) Confidential Figure 5 compares IPL's Generation Capacity Costs to ABB 2015 Fall Reference Case. If IPL's Generation Capacity Costs were indeed "forecasted as a blend of short-term bilateral transactions and the ABB 2015 Fall Reference Case" it would be expected that the two series of values would differ in the "short-term" or first few years of the time period but would converge and have identical values for the remainder of the time period. Instead, Confidential Figure 5 shows values for these series that differ [redacted], indicating that the ABB

2015 Fall Reference Case was “blended” with other values [redacted].

Confidential Figure 5. [redacted]



Source: IPL 2016 IRP, Confidential Attachment 5.10

Note also that the capacity cost data presented by IPL in Confidential Attachment 5.10 as the “ABB Fall 2015 Reference Case” [redacted].” For a comparison of the various capacity costs used in several Indiana 2016 IRPs please see Figure 2 of our *Confidential Selected Summary Report for Indiana 2016 IRPs* [redacted] As a point of comparison for Figure 5, MISO Planning Year 2017/2018 CONE is $94.35 per kW-year.[13]

VI-C. Recommendations for calculating and explaining avoided costs

Our recommendation is to use a more up-to-date model with the capability to choose between a wide variety of resources and simulate scenarios with progressively larger reductions in load. For instance, allow for 0.25 percent decrements to develop proxy avoided costs for that level of

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[12] See MISO Business Practice Manual (BPM) 11, p.89, https://www.misoenergy.org/_layouts/MISO/ECM/Redirect.aspx?ID=19206

[13] See https://www.misoenergy.org/Library/Repository/Tariff/FERC%20Filings/FINAL_Annual%20CONE%20Filing%20letter.pdf

reduction. This would give an additional data point against which to evaluate IPL's next DSM plan since the utility could ask the respondents to its DSM RFP to develop plans that acquire all demand-side measures up to each decrement's avoided cost. This proxy avoided cost information would also have the benefits of making long-term projections of demand-side resource cost and savings unnecessary and would thereby reduce the potential for disagreement about the IRP modeling's impact on the DSM plans. While there is no guarantee that proxy avoided costs would eliminate the possibility of all IRP disagreements, in our opinion this approach would add useful information for formulating the DSM plans. This proxy avoided cost approach complements but does not have to replace modeling DSM as a selectable resource.

VII. Was the preferred resource portfolio selected from among the candidate resource portfolios developed?

No, the preferred resource portfolio was not selected from among the candidate resource portfolios developed. IPL's failure to select a preferred resource portfolio from among its candidate portfolios invalidates the results of its 2016 IRP and flouts the IRP process that was developed over several months with multiple stakeholders, including IPL itself.

VII-A. Proper selection of a preferred resource portfolio

IURC guidance for IRP development (170 IAC 4-7-8 Amended 10-4-12) requires utilities to develop candidate resource portfolios and then select one of these candidates as their preferred resource portfolio:

> *8(a) The utility shall develop candidate resource portfolios from the selection of future resources in section 7 and provide a description of its process for developing its candidate resource portfolios.*
>
> *8(b) From its candidate resource portfolios, a utility shall select a preferred resource portfolio…*

Despite this requirement, IPL's preferred resource portfolio was not one of the candidate resource portfolios but rather a "Hybrid:"

> *In the fourth public advisory meeting, IPL shared the Base Case as the preferred resource portfolio. However, subsequent review and stakeholder discussions, as well as recent evidence of declining technology cost trends for solar and energy storage since the beginning of the IRP modeling process in January 2016, prompted further developments leading IPL to believe the ultimate preferred resource portfolio, designed to meet the broad mix of customer and societal needs, will likely be a hybrid of multiple model scenario results…*
>
> *Following a review and analysis of metric results and scenario assumptions, as well as industry trends, IPL believes future resource mixes are likely to vary. While the Base Case has the lowest PVRR, it also has the highest collective environmental emission results and least amount of DG penetration. The economic variables used to model environmental and DG costs reflect what is measurable today, for example, potential costs for future National Ambient Air Quality Standards ("NAAQS") ozone regulations and an estimate of Combined Heat and Power ("CHP") costs. The model does not include estimated costs for regulations not yet proposed, public policy changes which may occur in the study period or specific customer benefits of DG adoption such as avoided plant operational losses, grid independence or cyber security advantages…*
>
> *IPL recognizes that dynamic conditions across the electric utility industry have driven rapid change in many areas, and IPL believes additional changes may occur even more rapidly than the scenarios modeled. By comparison, the 2014 IRP analysis indicated less than 50 percent of the wind resources selected in this IRP, no solar additions and did not even include energy storage as a selectable option.*
>
> *Given that a blend of variables from the base case, strengthened environmental and DG scenarios appear likely to come to fruition (such as public pressure to reduce emissions, higher customer adoption of DG, and some additional environmental costs), IPL contends that, at this point, a hybrid preferred resource portfolio is a more*

> *appropriate solution. In addition, technology costs may decrease more quickly than the modeled inputs which would likely drive changes in renewable and distributed generation penetration. (IPL 2016 IRP p.8-9)*

Since the Hybrid portfolio was not one of the candidate resource portfolios, IPL's 2016 IRP presents extremely limited information about this portfolio. For instance, there are no modeling results presented for the preferred Hybrid portfolio and modeling inputs are limited to a single simple comparison of capacity by resource across the Final Base, Strengthened Environmental, Distributed Generation, and Hybrid portfolios (IPL 2016 IRP Figure 8.66). Moreover, the description provided by IPL of its preferred resource portfolio is insufficient, as is discussed further in Section VIII.

VII-B. Methodological errors in IPL's development and modeling of is preferred portfolio

Several significant methodological issues also are evident in IPL's design of candidate portfolios, its modeling of multiple base case portfolios, and its comparative modeling across portfolios.

VII-B-1. Use of incorrect reserve margin

We learned during our January 31, 2017 call with IPL and ABB that Capacity Expansion model, i.e., the model that selected portfolios for further stochastic (risk) analysis, will not reach an optimal solution if the reserve margin of the existing portfolio is outside a certain band of the reserve margin requirement (15 percent in this instance). Because IPL has so much excess capacity, ABB, the vendor that performed IPL's modeling, had to artificially increase the reserve margin requirement so that the model would reach an optimal solution. ABB models IPL's reserve requirement at a much higher [redacted] percent for the first five years of the planning period in those scenarios using the Base Case and High Case load forecasts (Base Case, Robust Economy, Strengthened Environmental, Distributed Generation) and [redacted] in the Recession Economy case. This is a full [redacted] above IPL's actual requirement since its system was modeled on an Installed Capacity (ICAP) basis. This modeling error likely prevented the model from selecting a more economic resource plan.

This is because, for example, since IPL modeled a reserve margin well above the actual required 15 percent MISO reserve margin, the Capacity Expansion model erroneously assumes that the retirement of Petersburg Unit 1 in 2018 would create a capacity need (see Figure 7 in Section IX and **Error! Reference source not found.** in Section XIV).

By the time renewables are available for selection in the model there is no reason to add them in the base case (and indeed in most scenarios modeled) since the continued operation of the Petersburg units has already been decided and results in an over-abundance of capacity and energy.

VII-B-2. IPL's choice of the Capacity Expansion model is out of date

IPL's Capacity Expansion model, i.e., the model that selected portfolios for further stochastic (risk) analysis, is out of date with the result that:

- The model will not reach an optimal solution if the reserve margin of the existing portfolio is outside a certain band of the reserve margin requirement.
- The user guide is out of date and unreliable. It was last updated in [redacted], lists output reports that are no longer produced, and says that the model does not have at least one capability that it actually does.
- There is a more updated version of the model, System Optimizer, that IPL apparently was unaware of.[14]

VII-B-3. Confusing method for designing candidate portfolios

In its 2016 IRP, IPL explains that five of its candidate portfolios (Final Base, Robust Economy, Recession Economy, Strengthened Environmental, and High Customer Adoption of Distributed Generation) are designed by varying four categories of drivers in its Capacity Expansion Model:

> *Through the integrated resource planning process, IPL identified candidate resource portfolios to serve IPL customers. IPL derived these portfolios by modeling multiple scenarios to represent the risks of uncertain future landscapes. IPL initially developed five scenarios of future worlds in order to assess how changing certain aspects of those worlds would impact IPL's resource portfolio choice. A cross-functional IPL team identified several drivers that may impact future resource portfolios based upon extensively reviewing previous IPL IRPs, other utility IRPs, the MISO MTEP studies, and previous strategic planning efforts. IPL's research identified uncertainty around these four categories of drivers:*
>
> - *Economics affecting load requirements;*
> - *natural gas and market prices;*
> - *clean power plan and environmental costs;*
> - *the level of customer distributed generation adoption.*
>
> *IPL considered how these drivers may interact in the future to develop specific scenarios. IPL started from a "Base Case" scenario which includes business-as-usual projections for these drivers to trend as currently expected for the study period…IPL also developed four other scenarios of future worlds by varying its projections for the four main categories of drivers list above. IPL titled these four scenarios as follows: Robust Economy, Recession Economy, Strengthened Environmental, and High Customer Adoption of Distributed Generation. (IPL 2016 IRP p.133-134)*

As we describe in more detail in Section V, IPL's development of resource portfolios makes no distinction between the scenario under which a portfolio is developed and the resources of the portfolio itself.[15] For example, Robust Economy is not just a scenario, but also a specific portfolio. As a result, the Base Case portfolio has a critical "baked in" advantage over all other portfolios and the Base Case portfolio appears to be the least costly. In fact, the PVRR values presented are all five cases PVRR when modeled under Base Case circumstances. Naturally, the Base Case outperforms the other portfolios in its own natural environment (that is, Base

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[14] Phone call with IPL and ABB on January 31, 2017.
[15] See Wilson et al. (2015) *Best Practices in Planning for Clean Power Plan Compliance: A Guide for Consumer Advocates*. Section 5.3 for an explanation of these terms. Available at http://www.synapse-energy.com/sites/default/files/NASUCA-Best-Practices-Report-15-025.pdf

Case circumstances). A more correct and more useful analysis (which is absent from IPL's 2016 IRP) would:

1. Develop a set of resource portfolios by targeting specific and plausible resource choices, such as adding significant quantities of renewables and efficiency or retrofitting and continuing to operate coal units;
2. Model each of these portfolios under base case, or most likely, future circumstances; and
3. Evaluate the set of resource portfolios' sensitivity to variations in key uncertain inputs, such as customer demand and commodity prices through sensitivity and/or scenario analysis.

In Section V, we discussed another alternative to this approach: mimicking TVA's scenario, planning strategy, and portfolio approach.

VII-B-4. Modeling of multiple base case portfolios

The resource portfolio described alternatively in IPL's 2016 IRP as the "Base Case" or "Final Base Case" was not developed as described in the text of the IRP. Instead, the IRP's description of the Base Case applies to a Capacity Expansion modeling run labeled "Initial Base" for which no results are reported in the main text of the IRP. The rejection of this Initial Base Case and the addition of modeling constraints to create the Final Base Case are explained only in the ABB report:

> *The Initial Base Scenario had 2,500 MW of Wind without any constraints. IPL consulted its transmission planners to discuss potential issues with meeting voltage stability requirements to comply with NERC reliability standards. The planners recommended a minimum level of ~1200 MW natural gas fired generation on the IPL 138 kV transmission system to meet these requirements. The IRP team reviewed its minimum loading and developed a 1000 MW wind limit to align with min loads. In addition, the team suggested a limit of 250 MW per year based on procurement and construction constraints. (IPL 2016 IRP Attachment 2.1, p.6-45)*

ABB goes on to describe the Final Base Scenario as having the following characteristics:

- *Same assumptions as Initial Base Scenario*
- *Limit of 1000 MW of Wind for study period and 250 MW Year*
- *Minimum ~1200 MW level of natural gas fired generation (IPL 2016 IRP Attachment 2.1, p.6-45)*

The limitations on wind are surprising, particularly since the issues with resource selection, such as the incorrect reserve margin, mean that wind is not added until quite late in the study period when the transmission capabilities of IPL's system could be very different. This is another reason that cost minimization is undermined by these limiting assumptions and the final base case portfolio is not least cost.

VII-C. Recommendations for proper selection of a preferred resource portfolio in an IRP

These fundamental errors in IPL methodology undermine the IRP as a whole. We question whether an IRP can be regarded as having been properly submitted to the commission if its methodology strays so far afield from clear guidance and standard practice. IPL's 2016 IRP methodology is irredeemably flawed for two main reasons:

1. IPL's modeling uses the incorrect reserve margin at the time of the critical decision of whether to retire, refuel, or retrofit the Petersburg units in 2018 (see discussion in Section IX-A-2). We recommend that all utilities use capacity expansion and cost minimization tools that have basic modern capabilities and can perform modeling under an appropriate set of current and expected future assumptions.
2. IPL's preferred resource portfolio is not chosen from among its candidate resource portfolios and as a consequence is not fully described or fully modeled in IPL's IRP process. In accordance with the IURC's guidance, we recommend that all IRPs present a preferred resource portfolio that is selected from among carefully analyzed and described candidate resource portfolios, together with a detailed explanation of why the chosen portfolio is preferred to the other candidates.

VIII. Is the preferred resource portfolio described?

No, the description of the preferred resource portfolio in IPL's 2016 IRP is grossly incomplete, lacking a description of its key variables or an explanation of the standards of reliability or assumptions used to develop it. IPL's preferred resource portfolio is not selected from among its candidate resource portfolios (for which key variables and assumptions are presented) and no separate detailed description of the preferred resource portfolio is provided.

VIII-A. Are the key variables used to develop the preferred resource portfolio described?

No, IPL's 2016 IRP describes key variables used in its candidate resource portfolios but its preferred resource portfolio was not selected from among these candidates, was not modeled in the Capacity Expansion or Production Cost Models, and is not fully described in terms of inputs or outputs in the IRP.

VIII-B. Are standards of reliability used to develop the preferred resource portfolio described?

No, the IPL 2016 IRP raises several questions about reliability that are not adequately explained or addressed.

In IRP modeling, reliability is typically assessed in terms of resource adequacy, that is, the reserve margin requirement. Because the locations of new resources are generally not known and because the specific reliability impacts of retirements are not clear until MISO performs an Attachment Y-2 study (a non-binding study of the reliability impacts from a change in a generator's status, often retirement), reliability concerns are more usefully addressed in the resource acquisition process once a specific location for new resources is identified and/or the MISO Attachment Y-2 process is completed.

IPL's 2016 IRP, however, raises two unique reliability issues in addition to basic resource adequacy. The IPL narrative states that there is an import capability issue associated with the "IPL load pocket" that is "the Indianapolis area load that is supplied by the highly networked IPL 138 kV transmission system."(IPL 2016 IRP, p.29) and that import capability is assumed to be limited to 2,000 MW to "fine tune the base case resource portfolio"(IPL 2016 IRP, p.30). This 2,000 MW limit, however, was not explicitly modeled in Capacity Expansion since IPL's system was represented in the model as a single region with generators and customers grouped together regardless of whether they are located within and outside the load pocket.

In addition, ABB's report (Attachment 2.1 and Confidential Attachment 2.2) mentions but does not fully explain a 1,000 MW limit on wind acquisition over the planning period:

> *The Initial Base Scenario had 2,500 MW of Wind without any constraints. IPL consulted its transmission planners to discuss potential issues with meeting voltage stability requirement to comply with NERC reliability standards. The planners recommended a minimum level of ~1200 MW natural gas fired generation on the IPL 138 kV transmission system to meet these requirements. The IRP team reviewed its minimum loading and developed a 1000 MW wind limit to align with min loads. (Attachment 2.1, p.6-45)*

The IPL 2016 IRP does not provide any evidence that IPL's minimum loads correlate with the peak output of wind farms.

Finally, in its response to CAC Data Request 3.1, IPL states that "the import limitation drives the need for [natural gas] baseload generation to be connected to the 138 kV transmission system". As we mentioned previously, IPL's IRP narrative states that a minimum of 600 MW of gas generation connected to its 138 kV transmission system is required for system reliability (IPL 2016 IRP, p.169).[16] ABB's report (Attachment 2.1, p.6-45) says the level is 1,200 MW. At the October 21, 2016 stakeholder meeting, IPL said that the level was actually 450 MW of *baseload generation* tied to the 138 kV system *in addition to* the 671 MW Eagle Valley CCGT for a total of 1,171 MW (IPL 2016 IRP Attachment 2 at pdf p. 128). The lack of a consistently cited requirement suggests that the true requirement, whatever it may be, is probably much more flexible than any one of these individual statements make it seem.

In addition, as IPL acknowledges in its IRP, "resources connected to the distribution system such as solar facilities reduce the requirements of generation serving the IPL load pocket through the transmission grid."(IPL 2016 IRP, p.29) In fact, if all of these standards are really about import limitations, then IPL's system should be divided into two areas and the model should be able to optimize any resource that can be built within the load pocket.

VIII-C. Are the assumptions used to develop the preferred resource portfolio described?

No, IPL's 2016 IRP describes assumptions used in its candidate resource portfolios but its preferred resource portfolio was not selected from among these candidates, was not modeled in the Capacity Expansion or Production Cost Models, and is not fully described in terms of inputs or outputs in the IRP.

VIII-D. Recommendations for adequate description of the preferred portfolio

For a complete and accurate description of the preferred resource portfolio, a utility must select an IRP's preferred portfolio from among its candidate portfolios. In this way, the assumptions and methodology presented in the IRP are applicable to the preferred portfolios. This practice is necessary for clarity and transparency in IRPs.

Regarding standards of reliability—and assuming the import limitations described in the IRP narrative are in fact modeled in future IPL IRPs—we recommend the following improvements in methodology:

- Include an analysis and description of transmission alternatives that alleviate import limitations.
- Allow the model to select any type of generation resource(s) that can be built within the IPL load pocket, not just natural gas.
- Provide evidence that the peak output of wind farms does indeed correlate with IPL's minimum loads.

[16] Note that Petersburg connects to the 345 kV system.

IX. Are supply-side and demand-side resource alternatives evaluated on a consistent and comparable basis?

No. Supply-side and demand-side resource alternatives are not evaluated on a consistent and comparable basis in IPL's 2016 IRP. IPL's IRP modeling assumptions and methodology create a bias against the adoption of renewable resources. In addition, demand-side resources are not evaluated on a consistent and comparable basis with supply-side resources.

IX-A. Is each supply-side resource alternative evaluated on a consistent and comparable basis with other supply-side resources?

No. The IPL 2016 IRP reflects important biases against renewables, against the retirement of coal-fired generation with replacement by renewables, and against wind capacity more specifically. With these modeling biases, it is not possible for IPL to evaluate renewable resources on a consistent and comparable basis with other supply-side resources.

IX-A-1. Biases against renewables

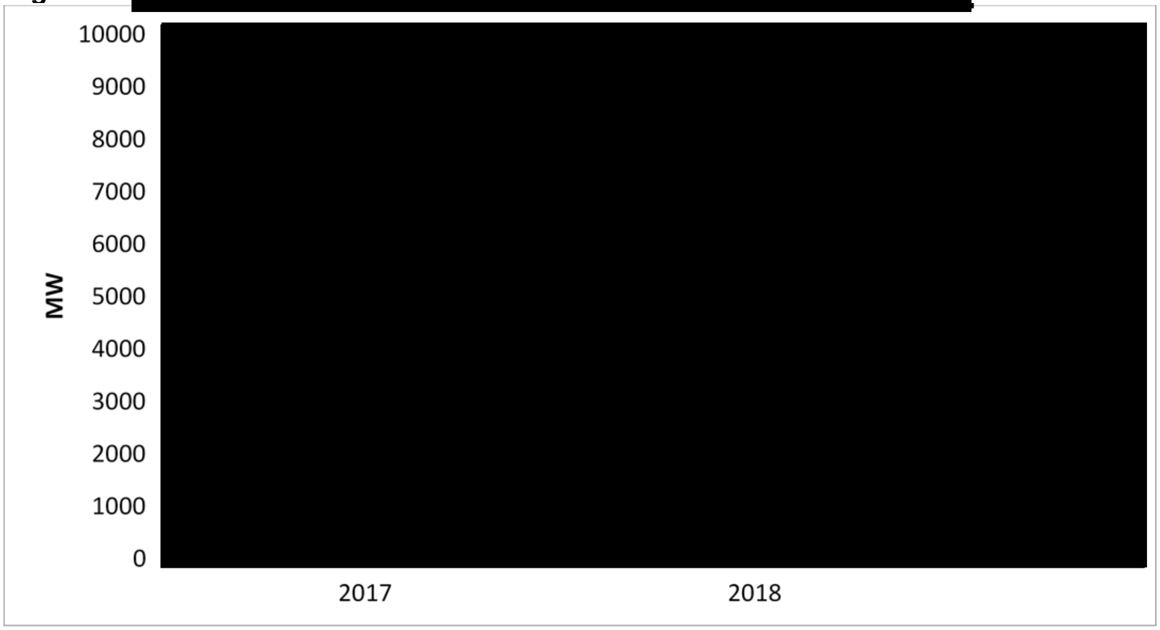
IPL's modeling assumptions and methodology result in a strong bias against renewable resources. First, restrictions on each resource type's "Earliest Feasible Year of Installation" make it impossible for utility-scale solar and wind resources and community solar resources to be brought on line for four years and three years, respectively (IPL 2016 IRP Attachment 5.1). In response to CAC Data Request 1.16, IPL states that the basis for these restrictions on the earliest feasible year of installation is in "IPL experience and business development expertise". It should be noted that Attachment 5.1 is labeled "ABB Midwest Fall 2015 Reference Case Generic Unit Cost and Operating Characteristics" raising questions regarding why a modeling exercise performed by ABB and intended to be used more broadly than just for IPL's purposes would rely in any way on IPL's "experience and business development expertise".

Second, assumptions regarding the earliest feasible year of installation of renewables that have indeed been based on "IPL experience and business development expertise" seem inappropriate for use in IRP modeling. Renewables are often developed by third parties whose very expertise in renewables development may provide a head start on the utilities' efforts to develop their own renewables resources. An assumption that renewables must be developed by the utilities, and not by third parties, would result in feasible years of installation further into the future.

IX-A-2. Biases against retirement of coal-fired generation with renewables as replacement

Delaying the potential for renewable installation until 2019 or 2020 has a critical impact on IPL's IRP modeling because there are no economic resources to bridge that gap. Principally, there is no market capacity purchase option that would allow retirement of one or more of the Petersburg units in 2018 coupled with the addition of wind and solar in 2019 or 2020. With new renewables and market capacity purchases unavailable, the model choices are very limited. Figure 6 shows the resources available to the model in 2017 and 2018; of these, only battery storage is available in sufficient quantity to substitute for retirement of any of the Petersburg units in 2018.

Figure 6. [redacted]



Source: Expansion Options _IRP3.csv provided in response to CAC 1.1a

Because both refueling and retrofitting the Petersburg units is much cheaper than new purchases of battery storage, the model never selects battery storage (see Table 2).

Table 2. Range of expected costs for battery, Petersburg retrofit, and Petersburg refuel

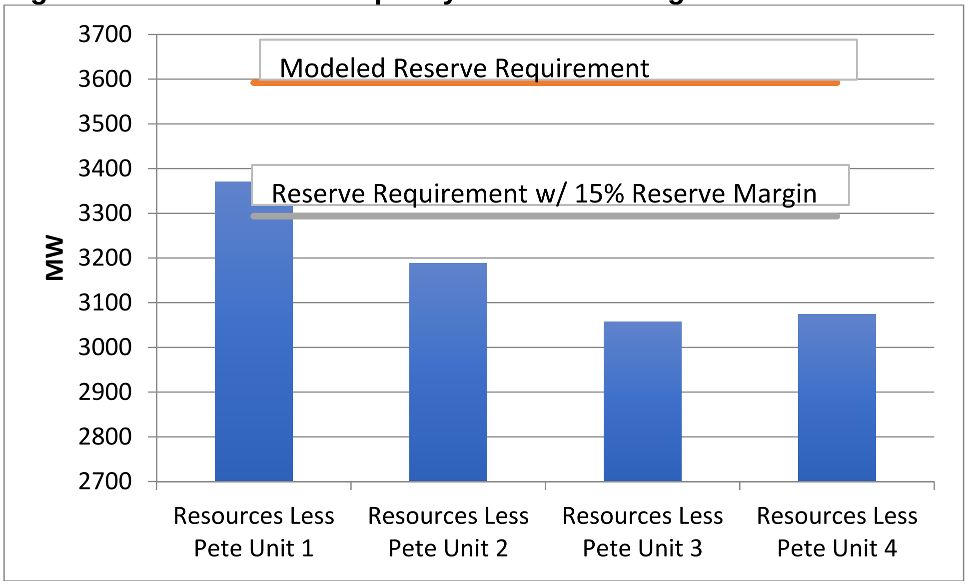
Option	Cost ($/kW)
Battery (20 – 50 MW in size)	[redacted]
Petersburg 1 – 4 Retrofit (234 – 547 MW)	[redacted]
Petersburg 1 – 4 Refuel (253 – 592 MW)	[redacted]

Source: Expansion Options_IRP3.csv provided in response to CAC 1.1

An error in the modeled reserve requirement is an additional source of bias against retirement with replacement by renewables. IPL's modeled capacity need in 2018 with the retirement (individually) of each of the Petersburg units is presented in Figure 7 (where "Petersburg" is abbreviated as "Pete"). The orange/red line in Figure 7 is the reserve requirement as modeled by ABB for IPL and the green line is the reserve requirement using the correct 15 percent reserve margin requirement. If the correct reserve margin requirement had been used in IPL's IRP modeling, Petersburg 1 could be retired in 2018 with no new resources added to replace it.[17]

[17] In the Strengthened Environmental Scenario in which Petersburg 1 is retired, the remaining Petersburg units are refueled to natural gas, which increases their capacity and allows the retirement of Petersburg 1 without the addition of other resources.

Figure 7. IPL's modeled capacity needs in 2018 given various retirement assumptions



Source: "RegCapacityBal" output file from RELIB Scenario (Final Base Case) provided in response to CAC 1.1b[18]

Because IPL modeled a [redacted] percent reserve margin, well above the actual required 15 percent MISO reserve margin, the model erroneously assumes that the retirement of Petersburg unit 1 in 2018 would create a capacity need (see Section VII-B-1 above). Since IPL arbitrarily determined that renewables and market capacity purchases are not available until at least 2019 and 2020, the model could only meet this erroneously created capacity shortfall with batteries, refueling this unit to natural gas, or retrofitting this unit. The model never selects battery storage as it is assumed to be more expensive than retrofitting or refueling.

By the time renewables are available for selection in the model there is no reason to add them in the base case (and indeed in most scenarios modeled) since the continued operation of the Petersburg units has already been decided and results in an over-abundance of capacity and energy.

IX-A-3. Biases against wind capacity

IPL's 2016 IRP modeling is also biased against the adoption of wind throughout the study period. IPL erroneously assumes that wind must be coupled with battery storage and a capacitor (see response to CAC 1.17) to meet FERC Order 827 requiring "reactive power to control system voltage for efficient and reliable operation of an alternating current transmission system" and a pending FERC rulemaking on frequency response (IPL 2016 IRP p. 86). We routinely review IRPs throughout the Midwest—including some conducted by utilities that are actively adding wind to their system—and are not aware of any other utility that interprets these requirements in this manner. Indeed, nothing about these FERC requirements implies that battery storage and a capacitor are needed for wind.

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[18] Peak requirements are modeled on both a "system" and "IPL" basis. When asked about this ABB told us that there was no distinction between the two. The "system" is where the reserve margin requirement is inflated and it does indeed seem to govern resource selection, so this figure is based on "system" data.

There is a significant cost difference between IPL's base wind cost assumption and the added cost to meet the frequency response Notice of Proposed Rulemaking (NOPR) and FERC Order 827. And yet, IPL quotes the specific section of FERC Order 827 that states, "Due to technological advancements, the cost of providing reactive power no longer presents an obstacle to the development of wind generation. The resulting decline in the cost to wind generators of providing reactive power renders the current absolute exemptions unjust, unreasonable, and unduly discriminatory and preferential."[19]

IPL assumes that the combined cost of battery storage and a capacitor add approximately $[redacted] per kW to the cost of wind, an increase of [redacted] percent. It is difficult to see how this cost inflation could be categorized as anything other than "an obstacle to the development of wind generation" and an increase, not a "decrease" in the cost to wind generators of providing reactive power.

The NOPR on primary frequency response would require generators to have controls and operating requirements in a manner allowing the grid to operate within predetermined boundaries above and below 60 Hertz.[20] The NOPR specifically states that no headroom requirement will be imposed which would require "generating facilities to operate below maximum output at all times to ensure sufficient ability to increase their real power output in response to under-frequency conditions."[21] A headroom requirement could be satisfied by installing battery storage or a capacitor so that a generator could move up during frequency events. But again, FERC makes clear that this is not required.

In sum, it does not make sense that IPL would interpret FERC Order 827 and the NOPR on frequency response to require these costly additions to wind.

IX-B. Are supply-side resource alternatives evaluated on a consistent and comparable basis with demand-side resources?

No, as we have previously discussed, IPL's modeling is predicated on a number of assumptions that render its resource selection meaningless. And as we discuss in Section X, demand-side resources available for selection in Capacity Expansion were inappropriately limited in scope.

IX-C. Recommendations for a consistent and comparable resource evaluation

Regarding the evaluation of demand-side resources on a consistent and comparable basis with supply-side resources we recommend a completely new approach. We think the issue of consistency between the IRP and the DSM plan can be made more meaningful by focusing on what the IRP can say about the value of energy efficiency, so that all the complexity and assumptions that go into the market potential study, and, therefore, the efficiency bundles, do

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[19] IPL 2016 IRP, p.87.
[20] FERC News Release (November 17, 2016) "FERC Proposes Revisions of Primary Frequency Response." (https://www.ferc.gov/media/news-releases/2016/2016-4/11-17-16-E-3.asp#.WIaNxLGZMUE)
[21] FERC (November 17, 2016) *Essential Reliability Services and the Evolving Bulk-Power System—Primary Frequesncy Response: 18 CFR Part 35.* (https://www.ferc.gov/whats-new/comm-meet/2016/111716/E-3.pdf), p.42.

not lead to an incorrect answer regarding how much energy efficiency is cost-effective—an occurrence that is of particular concern when the selected bundles do not represent the programs the utility plans to offer.

To focus on the value of energy efficiency, we recommend that utilities use IRP modeling to estimate the value of increasing, zero cost, decrements of load so that an implicit avoided cost for each decrement is developed. This analysis must be predicated on appropriate (and even-handed) selection of supply-side resources. For example, preventing the model from selecting anything other than MISO capacity and energy purchases before 2023 will not give a useful answer about the value of each load decrement.

If utilities instead continue to use the energy efficiency “bundle” approach utilized by IPL in its 2016 IRP, more useful, interpretable results would be achieved by testing generic “portfolio” efficiency bundles with increasing savings over a range of potential cost for each savings level. One of the biggest problems we see with the current energy efficiency bundle approach used by most Indiana utilities is that it assumes perfectly known information about cost and availability of energy efficiency reaching out twenty years into the future, when in fact there are many reasons to dispute this type of “crystal ball” approach to energy-sector forecasting. There is not even a basic sensitivity in which DSM costs less or is more widely available. Even if IPL could plausibly make the case that its analysis of demand-side resources was “comparable and consistent” with supply-side resources—and we do not believe that it can—its modeling methodology would still depend on the hubris of its assumption of perfect foresight.

X. Does the preferred resource portfolio utilize all economical resource alternatives as sources of new supply?

No, the resources included in the IPL 2016 IRP preferred resource portfolio were selected by IPL and not modeled. These resources are not described in detail in the IRP. IPL, however, does describe the candidate portfolios in more detail but these portfolios do not utilize all economical resource alternatives as sources of new supply.

X-A. Does the preferred resource portfolio utilize all economical load management, demand-side management, and energy efficiency improvements?

No, the IPL 2016 IRP does not utilize all economical demand-side management and load management. IPL does not explain or describe the extent to which it relied upon its modeling of its candidate portfolios to determine the economical level of demand-side measures in its preferred portfolio. Nonetheless we have concerns with the information that was made available about the utility's DSM selection. Generally, the improper characterization of IPL's scenarios as discussed above in Section VII particularly through the erroneous use of an inflated reserve margin requirement—renders the model's resource selection meaningless. The subsections that follow present more specific concerns with respect to demand side management

X-A-1. Flawed market potential study

The DSM bundles used in IPL's 2016 IRP modeling were constructed from a 2016 market potential study performed by AEG (IPL 2016 IRP, Attachment 5.6). AEG's market potential study has a number of significant flaws.

First, the study appears to assume that 100 percent of each measure's incremental cost is paid as an incentive. The IRP itself does not explicitly say this but all of the files provided to us, from which the DSM bundle inputs were generated show that program implementation costs are the same under the Utility Cost Test (UCT) and the Total Resource Cost (TRC). The "costs" in the UCT are the costs incurred by the utility whereas the "costs" in the TRC are the costs incurred by the utility plus those incurred by the participant. The only possible way for the UCT and TRC costs to be identical is for all costs to be paid by the utility (that is, 100 percent of incremental costs are paid as an incentive). This assumption would represent a radical shift from IPL's current practice, which, to our knowledge does not pay 100 percent of incremental cost.[22] The functional impact of this assumption is to make energy efficiency more expensive than needed, thereby reducing its chance of selection in cost minimization modeling.

It's possible that in response, IPL might say that it is necessary to pay 100 percent of incremental cost in order to get the highest level of savings, but that rationale should call into question the black box assumptions about customer adoption rates that AEG is making. Again, paying 100 percent of incremental cost to get the same or even less savings than IPL has achieved in recent years is a radical departure from current practice. The onus should be on IPL

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[22] See Cause No. 44792, Petitioner's Exhibit 3, page 3 ("The TRC is differentiated from the UCT by reflecting the full incremental cost of the measure in the denominator, regardless of whether the incremental cost is paid for by the utility, customer, or another third party. Cost effectiveness is achieved when the ratio of benefits to costs is greater than one.")

to demonstrate that this the economical or otherwise appropriate level through its DSM RFP process and subsequent selection of a vendor, rather than restrict DSM in the IRP by making these assumptions.

X-A-2. Incomplete accounting of replacement on burnout measures

Second, the AEG market potential study states that the achievable potential was defined such that "equipment measures" were replaced "when existing units fail" (IPL 2016 IRP Attachment 5.6, p. 16), otherwise known as "replace on burnout." While one of AEG's top twenty residential measures in 2020 is the removal of a secondary Room AC unit (IPL 2016 IRP Attachment 5.6, p.37), the study otherwise seemingly excluded the potential from measures that could be retired or replaced early, i.e., *before* they fail. As the Regulatory Assistance Project documented in its report, *Ten Pitfalls of Potential Studies*, this approach excludes significant savings opportunities, "…failing at least to consider these types of measures in a potential study analysis can lead to a considerable underestimate of achievable savings."[23]

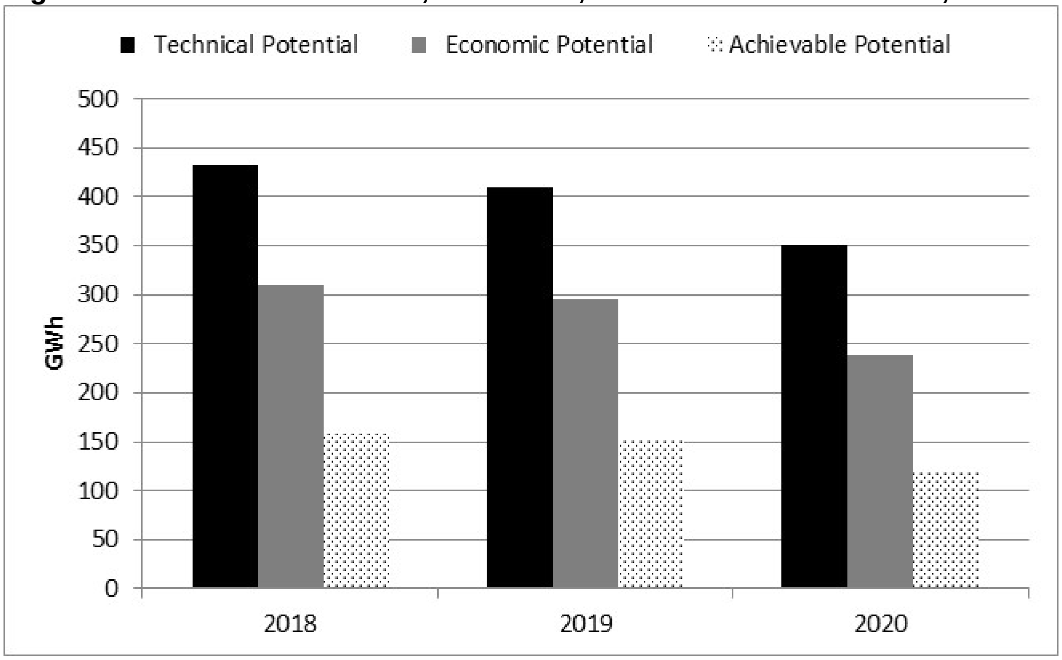
X-A-3. Unsubstantiated assumptions about customer adoption rates

Third, IPL's black-box assumptions about customer adoption rates contribute to a large drop in the 2016 IRP's DSM potential from the economic to achievable categories as shown in Figure 8. In each of the years 2018 to 2020, 49 percent of DSM economic potential is eliminated in screening for achievable potential. Achievable potential represents, in part, the removal of current opt-out customers. But in 2018, for example, excluding those customers would remove just 5 percent of achievable potential.[24] The remaining difference between economic and achievable potential—a 44 percent reduction from economic potential—must therefore result from AEG's adoption rate assumptions, for which IPL has provided reviewers nothing more than a spreadsheet with annual percentages.

[23] Kramer, Chris, and Glenn Reed (2012) *Ten Pitfalls of Potential Studies*. Regulatory Assistance Project and Energy Future Group, (http://www.raponline.org/wp-content/uploads/2016/05/energyfutures-kramerreed-tenpitfallsesdraft2-2012-oct-24.pdf), p.9.

[24] See Attachment 5.6, Table 2-30, which shows that achievable potential in 2018 is with opt-outs is 175 GWh and 159 GWh excluding opt-out customers.

Figure 8. IPL's DSM Technical, Economic, and Achievable Potential, 2018-2020



Source: Table 2-19 of Attachment 5.6, p. 31

IPL argues that, "If customer adoption rates are not considered in the potential used for DSM "bundling" and IRP modeling, then the possibility exists for DSM to get selected at a level that is unachievable in the market."(IPL 2016 IRP, p.111) But this argument simply highlights how critical adoption rate assumptions are to the level of available DSM and the inflexibility of the assumption that the savings present in the IRP must be equal to the savings in the DSM.

X-A-4. Translation of savings and costs from market potential study

Fourth, the translation of savings and cost of the energy efficiency bundles from the AEG market potential study (Attachment 5.6) to Capacity Expansion is flawed: Efficiency costs are erroneously being inflated in a way that is not visible to the reader of the IRP narrative.[25] During our January 31, 2017 call with IPL and ABB we learned that IPL asked Dr. Richard Stevie of Integral Analytics to divide the cost of each energy efficiency bundle into: (1) energy costs; and (2) capacity or capital costs. Total program costs were divided into these two parts based on DSMore's calculation of share of benefits associated with energy savings and share of benefits from capacity savings for each bundle. In our experience with electric-sector energy and capacity modeling, this division of DSM costs into component energy and savings costs is not necessary but would normally have no practical impact on the selection of energy efficiency in modeling, since the model's objective is minimize PVRR and it treats the summation of revenue requirements no differently whether they arise from capacity or energy.

However, IPL's decision to divide DSM costs in this manner does impact the analysis because IPL artificially inflated the costs through certain modeling assumptions. DSM costs are input as "energy" costs or capacity (and therefore input to the model as "capital" costs). ABB said during

[25] We focus on how DSM was modeled in ABB's Capacity Expansion because this is the model that chose the resources in each portfolio.

the January 31, 2017 call that costs associated with energy are equivalent to "as-spent" dollars while costs associated with capital have IPL's rate of return applied. It is this last step that is flawed, since IPL recovers money spent on DSM programs in a tracker, not as capital with a return on and of investment.

The extent to which this incorrect attribution of a rate of return upwardly inflates the cost of energy efficiency depends on the bundle in question. For example, 16 and 34 percent of the cost of residential lighting of up to $30 per MWh in 2018 to 2020 and the cost of residential HVAC up to $30 per MWh, respectively, are input as capital costs.

X-A-5. Built in modeling bias against DSM

Overall, it is of critical importance to note that DSM was unlikely to be selected by Capacity Expansion because, as we discuss in Section VII, IPL's 2016 IRP modeling was constructed so that the utility is long on both energy and capacity by significant margins in each of its portfolios. The result is that there is an extremely narrow window in which DSM is cost-effective. In fact, in the Final Base Case, apart from the retrofit of the Petersburg units, which are essentially forced (see Section VII), no resources other than limited DSM, are added until [redacted], likely because there is such an oversupply of capacity.

Ultimately, these issues suggest two general observations about IPL's approach:

1. Significant disagreement exists between our views of how DSM is properly characterized in a potential study and the manner in which AEG/IPL approached this problem.
2. Assumptions made about incremental costs of measures, avoided costs, customer adoption rates, and the like are assumed by IPL to be static. IPL's 2016 IRP fails to examine the sensitivity of the cost-effective level of DSM to variation in: the cost of energy efficiency measures; the rate of adoption by customers; if its avoided costs are more significant than IPL says; the presence or absence of excess supply-side energy and capacity, etc.

These observations are of concern because IPL, along with several other Indiana utilities, have decided to interpret the IURC requirement that the IRP and DSM plan be consistent to mean that the savings selected in their preferred portfolio must be consistent with the savings in their DSM plans. We would suggest that there are other interpretations of "consistency" that can provide more information about whether the Indiana utilities are achieving all cost-effective DSM and reduce the level of disagreement regarding utilities' modeling approach and assumptions. We would also note that an IRP model does not include the full scope of DSM benefits when it fails to account for avoided T&D benefits.

IPL has already stated that it will not follow its own IRP guidance with respect to the discontinuation of two of its programs:

> *Although neither the ACLM programs nor the Residential Peer Comparison program was selected for the 2018-2020 time frame, IPL expects to continue to offer these programs in 2018-2020 subject to IURC approval. (IPL 2016 IRP, p. 217)*

Would IPL then consider the savings from those programs additional to the savings level already identified as "economic" or would those programs be a component of economic savings? And if the latter, then why should these "uneconomic" programs be included where others are excluded? It is easy to see how limiting this bundle approach can be when it is so focused on trying to exactly estimate the cost of future measures. To achieve consistency, the alternative is to focus instead on the value of DSM through the proxy avoided cost calculation discussed in Section VII.

X-B. Does the preferred resource portfolio utilize all economical technology relying on renewable resources?

No, see Section IX-A.

X-C. Does the preferred resource portfolio utilize all economical cogeneration?

We did not review this aspect of IPL's IRP modeling.

X-D. Does the preferred resource portfolio utilize all economical distributed generation?

No, see Section III.

X-E. Does the preferred resource portfolio utilize all economical energy storage?

Setting aside the fact that the preferred resource portfolio was not based on IPL's candidate portfolios or the results of optimization modeling, IPL's 2016 IRP, unlike that of NIPSCO and Vectren, at least models energy storage as a resource. Because there is very little publicly available information on the cost of battery storage, and battery costs seem to be changing rapidly, we cannot speak to the question of whether all economical energy storage is utilized or not with confidence.

X-F. Does the preferred resource portfolio utilize all economical transmission?

No, see Section VIII-B.

X-G. Recommendations for utilizing all economical resource alternatives

For a complete utilization of all economical resource alternatives we recommend that all resources be modeled with accurate, up-to-date cost information and that any biases be eliminated that would tend to reduce IRP models selection of certain resources for reasons not clearly expressed as the utility's explicit planning goals.

XI. Are targeted DSM programs evaluated, including their impacts on the utility’s transmission and distribution system?

No. IPL 2016 IRP does not evaluate DSM targeted at transmission and distribution system issues.

XII. Are the financial impacts to the utility of acquiring the future resources identified in the preferred resource portfolio assessed?

Yes. IPL uses a Financial Module that appears to assess the financial impacts to the utility of acquiring the future resources identified in the preferred resource portfolio (see IPL 2016 IRP, p.195-8). We have not reviewed this part of IPL's analysis in any detail and cannot comment on its accuracy or thoroughness.

XIII. Does the preferred resource portfolio balance cost minimization with cost-effective risk and uncertainty reduction?

No, IPL's preferred resource portfolio—which has not been properly designated, as explained in Section VII—does not appear to have been subjected to risk analysis. Certainly, IPL has not presented any analysis used to balance cost minimization with cost-effective risk and uncertainty reduction in its preferred portfolio. By IPL's own account, the mix of resources in their preferred resource portfolio is based on expert judgment and not on risk reduction or sensitivity analysis (IPL 2016 IRP p.8-9).

XIV. Are risks and uncertainties quantified, including, but not limited to: regulatory compliance, public policy, fuel prices, construction costs, resource performance, load requirements, wholesale electricity and transmission prices, RTO requirements, and technological progress?

No, risks and uncertainties are not sufficiently or accurately quantified in the IPL 2016 IRP. Particular concerns arising from our review include: the limited scope of the sensitivity analysis, technical issues with IPL's Monte Carlo sampling process, and troubling inconsistencies in IPL's forecasting of fuel and electricity market and capacity prices, as well as load and RTO requirements.

XIV-A. Limited scope of sensitivity analysis

As discussed in Section VII, IPL has made odd and incomplete choices in its selection of deterministic scenarios to model.

More generally, IPL's presentation of its stochastic modeling is not transparent enough for expert reviewers to fully understand, much less a nontechnical audience. IPL's responses to repeated questions regarding the assumptions used in their sensitivity analysis amount to an assertion that all parameters are based on their expert judgment (CAC DR 7). A useful sensitivity analysis in an IRP process is: transparent to a nontechnical audience, clearly and completely documented within the IRP submittal itself, and based on assumptions that can be cited and substantiated. Where possible, assumptions should be documented for stakeholders using publicly available data.

XIV-B. Problems with Monte Carlo sampling

IPL has chosen to use a style of sensitivity analysis referred to as Monte Carlo analysis with Latin Hypercube sampling. In brief, this style of analysis operates as follows:[26]

- Monte Carlo analysis tests out the potential range of PVRR, emissions and other modeling results when modeled using (1) the range of values deemed possible for each uncertain variable, and (2) multiple intersecting uncertainties (this means that more than one variable's value is changing in each modeling run). The more uncertain variables being examined, the more modeling runs (each with a new set of values for the uncertain variables) are needed to get a good sample of the entire range of potential modeling results. Monte Carlo analyses of two or three uncertain variables often involve tens of thousands of modeling runs.
- Latin Hypercube sampling is a short cut that allows analysts to get a good sample of the entire range of potential modeling results with fewer modeling runs. In an analysis with two uncertain variables, for example, good sampling can be thought of as needing to examine locations all across a two-dimensional map. With Monte Carlo analysis, it takes

[26] IPL's response to CAC's Data Request entitled "IPL 2016 IRP CAC 1.31.17 Phone Call and Email Follow Up" provides a partial explanation of this methodology (included as Exhibit 3).

tens of thousands of spots picked randomly on the map to get a good sense of the features all across the map. Latin Hypercube sampling overlays a grid on the map and selects one variable value combination from each cell or box on the grid. Additional uncertain variables can be thought of as additional dimensions in the map: An analysis with three uncertain variables is like a three-dimensional map with Latin Hypercube sampling creating a three-dimensional grid and selecting one variable value combination from each three-dimensional cell.

Monte Carlo analysis both with and without Latin Hypercube sampling is a well-accepted methodology used in sensitivity analysis—although, perhaps not one that it is particularly transparent to a nontechnical audience. The problems with IPL's choice of this methodology result from the number of uncertain variables that they are simultaneously sampling. IPL appears to be testing the sensitivity of modeling results to variables in ten uncertain variables simultaneously (IPL's response to CAC Data Request entitled "IPL 2016 IRP CAC 1.31.17 Phone Call and Email Follow Up").[27] IPL reports that it uses just 50 modeling runs to provide a complete sensitivity analysis. In our opinion, this number of runs cannot be sufficient to provide a good sample of potential modeling results, even with the use of Latin Hypercube modeling.

Here's how the math works assuming that each uncertain variable's range of possible values is divided into 10 parts in the Latin Hypercube sampling grid (in principle, such a grid could be divided into many more parts compounding the problem presented here):

- Two uncertain variables: Two dimensions, each with 10 segments, results in 10x10 or 100 samples (sets of variable value combinations)
- Three uncertain variables: Three dimensions, each with 10 segments, results in 10x10x10 or 1,000 samples
- Four uncertain variables: Four dimensions, each with 10 segments, results in 10x10x10x10 or 10,000 samples
- Five uncertain variables: Five dimensions, each with 10 segments, results in 10x10x10x10x10 or 100,000 samples
- Six uncertain variables: Six dimensions, each with 10 segments, results in 10x10x10x10x10x10 or 1,000,000 samples
- Seven uncertain variables: Seven dimensions, each with 10 segments, results in 10x10x10x10x10x10x10 or 10,000,000 samples
- Eight uncertain variables: Eight dimensions, each with 10 segments, results in 10x10x10x10x10x10x10x10 or 100,000,000 samples
- Nine uncertain variables: Nine dimensions, each with 10 segments, results in 10x10x10x10x10x10x10x10x10 or 1,000,000,000 samples
- Ten uncertain variables: Ten dimensions, each with 10 segments, results in 10x10x10x10x10x10x10x10x10x10 or 10,000,000,000 samples

In contrast, IPL conducts 50 modeling runs for 10 uncertain variables. For this many independent variables, a grid divided into 10 parts would require 10 million modeling runs for good sampling. (A grid divided into 3 parts, requires 59,000 runs, and a grid divided into 100 parts requires 100 million trillion runs.) As a result, Monte Carlo analysis—even with Latin Hypercube sampling—typically includes far fewer than 10 uncertain variables.

[27] Included as Exhibit 3.

In response to CAC Data Request 7.1 asking "On what basis did you establish 50 iterations as the appropriate number for this Latin Hypercube Monte Carlo analysis? Can you please share your calculations or otherwise discuss your methodology demonstrating that 50 iterations provide a sufficient sampling for 10 independent variables?", IPL stated:

> *ABB has performed extensive market price trajectory simulations and has determined that 50 trajectories provides a reasonable balance between the number of scenarios to provide a convergent solution and a manageable number of stochastic scenarios to be applied to many resource plan alternatives. Fifty trajectories also strike a balance between the number of stochastic futures required for a comprehensive solution and a manageable number of simulations. The simulation processing time to create the 50 stochastic market price futures was approximately 9 days.*

In our opinion, this response does not address the concern that insufficient modeling runs have been conducted and that, therefore, the range of potential modeling results has not been adequately represented and IPL's sensitivity analysis is neither sufficient nor correct.

XIV-C. Flawed forecast of fuel and electricity market and capacity prices

In resource planning, key risks are modeled by varying important input assumptions, either one at a time or multiple assumptions together (e.g. the load forecast or the load forecast *and* market prices) to observe the sensitivity of modeling results to these changes. No one approach is appropriate to every utility planning exercise, but starting from reasonable base case assumptions is essential regardless of the model or methodology used.

Regrettably, many of the commodity prices underlying IPL's 2016 IRP modeling are simply unreasonable. They arise from what appears to be a severely flawed modeling exercise performed by IPL's vendor, ABB.[28]

ABB describes this modeling exercise as follows:

[redacted]

[redacted]

[redacted]

[28] To clarify, ABB conducted two distinct modeling exercises discussed in its report. We've previously talked about the modeling runs simulating IPL's system choosing resource expansion portfolios and performing risk analysis. That is not the modeling exercise discussed here. ABB undertook modeling prior to those runs to determine what gas, coal, and market energy and capacity assumptions ought to be incorporated into the runs simulating IPL's system. It is that modeling effort that we discuss here.

> [redacted] *(IPL 2016, IRP, Confidential Attachment 2.2, p.2-11)*

We understand ABB's account of its modeling to mean that the coal, gas, and market energy and capacity forecasts used in IPL's 2016 IRP were developed by analysis that only allows [redacted]—[redacted]—to be built. This strange and troubling modeling choice has the likely effect of distorting IPL's commodity, energy and capacity prices forecasts. This artificial limitation on future resource additions is simply not indicative of how the current energy supply is being built out with renewables representing more than half of all U.S. capacity additions in each of the last three years.[29] This odd assumption also completely ignores the energy efficiency gains made by numerous utilities around the country. We believe that excluding these resources from its analysis almost certainly results in unreasonably high market power and capacity prices.

XIV-D. Load forecasting and RTO requirements

However, what really biases IPL's modeling with respect to need is the fact that the Planning Reserve Margin was set at much higher [redacted] for the first five years of the planning period in those scenarios using the Base Case and High Case load forecasts (Base Case, Robust Economy, Strengthened Environmental, Distributed Generation) and [redacted] in the Recession Economy case (see Section VII-B-1). This is a full [redacted] above IPL's actual requirement since its system was modeled on an Installed Capacity (ICAP) basis. In general, this equates to an excess need of [redacted] MWs" in ABB's Capacity Expansion Modeling of IPL's system in those scenarios using the Base Case load forecast ("RegCapacityBal" output file from RELIB Scenario (Final Base Case) provided in response to CAC 1.1b). This problem alone renders IPL's modeling irredeemably flawed: IPL's model is forced to make choices about retirement and unit construction that are false (see discussion in Section VII).

XIV-E. Recommendations for quantifying risks and uncertainties

For complete quantification of risks and uncertainties our recommendation is to use approaches to risk analysis and energy sector forecasting that are well vetted and relatively transparent, and to apply these techniques to a set of candidate portfolios from which the utility's preferred portfolio will be selected.

[29] U.S. Energy Information Administration (January 10, 2017) *Today in Energy*, "Renewable generation capacity expected to account for most 2016 capacity additions." (http://www.eia.gov/todayinenergy/detail.php?id=29492)

XV. Is the performance of candidate resource portfolios analyzed across a wide range of potential futures?

No. As discussed above in Sections VII and XIV, the IPL 2016 IRP conflates portfolios with scenarios and its candidate resource portfolios are analyzed in a base case future only.

XVI. Are candidate resource portfolios ranked by present value of revenue requirement and by risk metric?

Yes. IPL's 2016 IRP candidate resource portfolios are ranked by PVRR in total dollars and by dollars per kilowatt-hour delivered, and by risk metric.

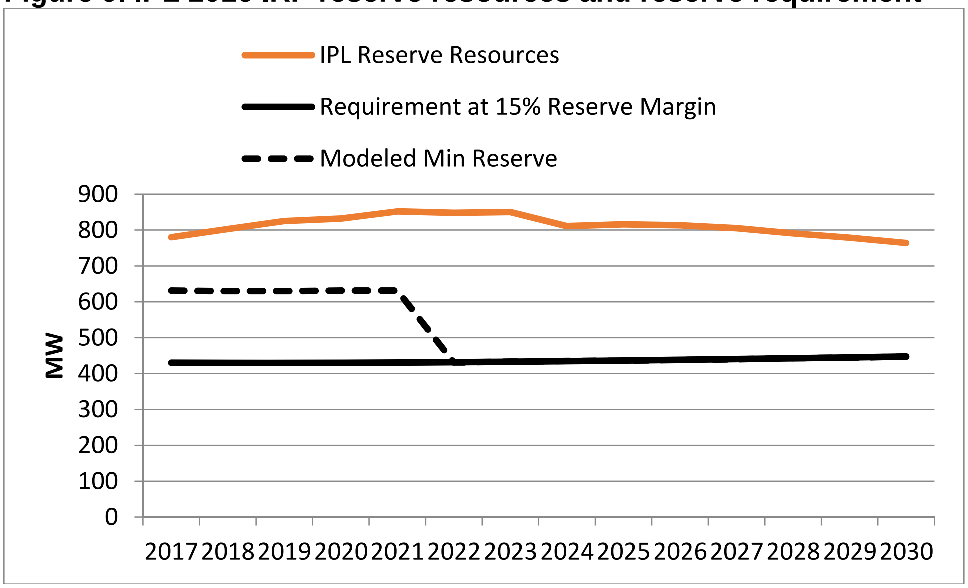
XVII. Does an assessment of robustness factor into the selection of the preferred portfolio?

No. IPL does not factor an appropriate assessment of robustness into the selection of its preferred portfolio. IPL uses the term "robust" to describe its scenario and stochastic analyses, but as we have previously described these analyses are irredeemably flawed and IPL's preferred portfolio is under-described, not selected from among IPL's candidate resource portfolios, and not a product of its IRP optimization modeling.

XVIII. Does the preferred resource portfolio incorporate a workable strategy for reacting to unexpected changes in circumstances quickly and appropriately?

No, the IPL 2016 IRP preferred resource portfolio does not incorporate a workable strategy for reacting to unexpected changes in circumstances quickly and appropriately. One of the most significant decisions facing IPL is the question of whether to retire, retrofit, or refuel the Petersburg units. As discussed previously, because of the inflated reserve margin setting in the first five years of the planning period, as well as the limited resources available before 2019, IPL's model output in any scenario is highly unlikely to reflect the most "economic" choice. Once these units are retrofitted, there is no "flexibility" in IPL's plan, and their continued operation puts IPL in a significant excess capacity position for years to come as shown in Figure 9.

Figure 9. IPL 2016 IRP reserve resources and reserve requirement



Source: "RegCapacityBal" output file from RELIB Scenario (Final Base Case) provided in response to CAC 1.1b

This excess of both capacity and energy is likely to doubly penalize customers by putting them in the position of paying unnecessary costs as well as closing the door to the acquisition of other, more cost-effective resources. This is the exact opposite of "flexibility".

EXHIBIT 1

IPL 2016 IRP Stakeholder Comments
CAC et al. DR Set 5 to IPL
Received: January 19, 2017 (labeled Set 4 by CAC but IPL considers this Set 5)
Response: January 30, 2017
Revised February 9, 2017

5.1 On page 179, IPL states, "In the Quick Transition scenario, the Capacity Expansion Model was directed to select all of the DSM bundles that were available." However, no Capacity Expansion model files have been provided to us, only Strategic Planning/MIDAS (the dispatch model) files have been provided which indicated to us that Capacity Expansion was not used to develop the Quick Transition scenario. Please explain and provide us the missing files if Capacity Expansion model was actually used for this scenario.

Correct. The Quick Transition case did not include the use of the Capacity Expansion selection tools since it was established based upon stakeholder input as described in the Section 1 of the Introduction on Page 4.

5.2 At page 180 of the IRP, the following table is given:

Figure 8.31 – PVRR Results (2017-2036)

Scenario	PVRR ($ Million)
Base Case	$10,309
Robust Economy	$10,549
Recession Economy	$11,042
Strengthened Environmental	$11,989
Adoption of DG	$11,092
Quick Transition	$11,988

We could not match these numbers with the PVRRs in the Capacity Expansion files. The IRP text above this table suggests that the figures incorporate some data from Capacity Expansion but are based on Strategic Planning/MIDAS outputs. However, we could not find these numbers in those outputs either. Please explain exactly how these numbers were derived (including from which Strategic Planning output file if applicable) and provide any spreadsheets, with formulas and links intact that were used for post-processing of the modeling results.

The PVRRs in the table were derived from the Production Cost model runs and shown in the income statement files for each scenario in the column labeled "Base Revenues" based on the capacity expansion model selections. The income statement

output file for each scenario was provided on November 23, 2016 in the folder on Kiteworks labeled 'CAC DR Set 1 – Confidential Attachment 1.1d – Strategic_Planning_Midas_Outputs'. For example, the income statement file for the High Adoption of DG scenario is titled "ADOG Annual Income Statement 20161111.CSV". These annual values are summed to calculate the PVRR for each portfolio. For your convenience, the PVRRs are combined in the file 'Confidential IPL 2016 IRP Charts_v2_CAC DR Set 5.xlsx' located on Kiteworks in the CAC DR Set 5 folder.

EXHIBIT 2

IPL 2016 IRP Stakeholder Comments
CAC et al. DR Set 6 to IPL
Received: February 7, 2017
Response: February 9, 2017

6.1 Following up on IPL Response to CAC et al. DR 5.1, is the text on p.179, therefore, incorrect? And, if so, how does the corrected text read? Similarly, page 6-45 of ABB's public report (Attachment 2.1) states, "The seven future scenarios screened by capacity expansion include the following:…" and Quick Transition is mentioned in that list. How should that text read if it is incorrect?

Both of the referenced statements are correct as written on pages 179 and 6-45.
The Capacity Expansion framework was used to "build" the portfolios for all scenarios. The Capacity Expansion selection tools were not used in the Quick Transition scenario since it was based upon stakeholder input.

Please see the revised response to CAC DR 5.1 which clarifies this.

EXHIBIT 3

IPL 2016 IRP Stakeholder Comments
IPL-CAC 1.31.17 Phone Call & Email Follow Up
Received: January 31, 2017
Response: February 9, 2017

Follow up from 1.31.17 Phone Call – Verbal request for clarification

Q1. Why were the CO_2 emissions higher in the High Adoption of DG Case than the Base Case?

A1. For each scenario, a random forced outage rate is modelled for the thermal generation units which are the same for each scenario. When a thermal generation unit is added to a portfolio, the random forced outage rate draws change.

The Distributed Generation scenario and the Base Case scenario have identical thermal unit portfolios for the period 2017-2021, and those units produce identical GWh and emissions in both scenarios during this period due to identical forced outage rate draws. When the CHP units are added to the Distributed Generation scenario in 2022, the random forced outage rate draws for the thermal units change which causes the thermal units in the two scenarios to produce slightly different amounts of GWh and emissions for the period 2022-2036. The Distributed Generation scenario thermal generation units as a whole ran slightly more than the Base Case thermal units. While this impact is minor, it does cause the Base Case emissions to be slightly lower than the Distributed Generation emissions.

IPL understands the current model limitations do not allow users to use different forced outage draws for various types of generation units. IPL plans to investigate modeling options to enable more flexibility before the next IRP.

Follow up from 1.31.17 Phone Call- Email request for clarification

Q2. A more detailed explanation of how the stochastic analysis was conducted including, but not limited to which variables were included (pdf page 176 of Volume I has a different list from pdf page 250 of Volume II), which variables were correlated to each other, how the variables were divided into bands/buckets for selection in the Latin hypercube sampling, and the parameters of the probability distributions for each variable.

A1. The list of variables in the table below contains a side-by-side comparison of the list of variables in IPL Volume 1 and the ABB Report contains in Volume II (Attachment 2.1).

IPL 2016 IRP Stakeholder Comments
IPL-CAC 1.31.17 Phone Call & Email Follow Up
Received: January 31, 2017
Response: February 9, 2017

IPL 2016 IRP Volume 1, pg. 148	ABB Report, Attachment 2.1, pg. 4-15
Resource technology cost	Note 1
coal prices oil prices	Long-Term Coal Price Long-Term Oil Price
coal unit availability	Mid-Term Coal Unit Availability by Region
gas unit availability	Note 2
natural gas prices	Mid-Term Gas Price Long-Term Gas Price
energy load forecast	Mid-Term Energy by region
peak load forecast	Mid-Term Peak Demand by Region Long-Term Electric Demand Growth
carbon prices	Long-Term CO_2 Price
long-term combined cycle capital cost	Long-Term Combined Cycle capital cost
long-term wind and solar capital cost	Long-Term wind and solar capital cost
long-term utility scale and community solar capital cost	Long-Term utility scale and community solar capital cost
long-term battery storage capital cost	Long-Term battery storage capital cost

Note 1
Resource technology cost is the same as the long-term capital costs

Note 2
Gas unit availability not listed in ABB report, but it was modeled

The file on Kiteworks titled **Confidential Attachment A -"IPL 2016 IRP – Stochastic Parameters"** contains three worksheets:

a) Stochastic Parameters
b) Vectors
c) Correlations

a) Stochastic Parameters –This worksheet contains details of the variable setup in the model, including the probability distribution type (e.g. normal, log-normal, uniform, etc.), the Long-Term and Mid-Term volatility and standard deviation information where applicable, and other variable characteristics and settings.

b) Vectors – This worksheet contains information for the parameters used for variables contained within Transaction Groups in the Eastern Interconnect. For example, cell "Vectors!Y9" contains the standard deviation for January for Transaction Group 3 (which contains Indiana). There are 47 Transaction Groups in the Eastern Interconnect in the ABB model.

c) Correlations – This worksheet contains correlations for variables. Each table contains a scenario variable and one or two correlated variables, along with a listed correlation.

In addition , a PowerPoint presentation titled **Attachment B - "Latin Hypercube Sampling"** is also included. This presentation was provided by ABB (produced by a former group called Global Energy Decisions) and is an overview of the Latin Hypercube process and how it is applied in the model.

Q3. One question I neglected to ask is whether there is an output file from Strategic Planning that shows the PVRRs that were selected in the 50 draws for each scenario?

A3. The Excel file titled **Attachment C - "IPL 2016 IRP – Stochastic PVRRs"** contains PVRRs for each scenario from all 50 stochastic iterations. The PVRRs shown can be cross-referenced in the CSV files in **Confidential Attachment D - "Stochastic Income Statements for 2016 IRP Plans.zip"**. The PVRR value is called 'Total base revenues'.

Q4. A key to which CapEx overlay files correspond to which CapEx scenario.

A4. Please see **Attachment E - "Overlay Files Mapping for Studies"** on Kiteworks for the key.