

STATE OF INDIANA

INDIANA UTILITY REGULATORY COMMISSION

VERIFIED PETITION OF SOUTHERN INDIANA )  
GAS AND ELECTRIC COMPANY D/B/A VECTREN )  
ENERGY DELIVERY OF INDIANA, INC. )  
REQUESTING THE INDIANA UTILITY )  
REGULATORY COMMISSION TO APPROVE )  
CERTAIN DEMAND SIDE MANAGEMENT )  
PROGRAMS AND GRANT COMPANY ) CAUSE NO. 44927  
AUTHORITY TO RECOVER COSTS, INCLUDING )  
PROGRAM COSTS, INCENTIVES AND LOST )  
MARGINS, ASSOCIATED WITH THE DEMAND )  
SIDE MANAGEMENT PROGRAMS VIA THE )  
COMPANY'S DEMAND SIDE MANAGEMENT )  
ADJUSTMENT )

**DIRECT TESTIMONY AND EXHIBITS OF ELIZABETH A. STANTON, PHD,**  
**ON BEHALF OF CITIZENS ACTION COALITION OF INDIANA, INC.**

**Direct Testimony of Elizabeth A. Stanton, PhD  
On Behalf of Citizens Action Coalition of Indiana, Inc.  
Cause No. 44927  
July 26, 2017**

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1 **I. INTRODUCTION**

2 **Q. Please state your name and business address.**

3 **A.** My name is Elizabeth A. Stanton. I am the Director and Senior Economist of the  
4 Applied Economics Clinic, a non-profit consulting group housed at Tufts  
5 University.

6 **Q. Please describe the Applied Economics Clinic.**

7 **A.** The Applied Economics Clinic provides expert testimony, analysis, modeling,  
8 policy briefs, and reports to public interest groups on the topics of environment,  
9 consumer protection, and equity. The Clinic also serves to train the next  
10 generation of expert technical witnesses and analysts by providing applied, on-  
11 the-job training to graduate students in related fields and working proactively to  
12 support diversity among both student workers and professional staff. The Applied  
13 Economics Clinic began operations in February 2017.

14 **Q. Please describe your professional background and experience.**

15 **A.** I am a researcher and analyst with more than 16 years of professional experience  
16 as a political and environmental economist. I have authored more than 120 reports,  
17 policy studies, white papers, journal articles, and book chapters on topics related  
18 to energy, the economy, and the environment.

19 In my previous position as a principal economist at Synapse Energy  
20 Economics, I led studies examining environmental regulation, cost-benefit

1 analyses, and the economics of energy efficiency and renewable energy. I have  
2 submitted expert testimony and comments in Illinois, Vermont, New Hampshire,  
3 Massachusetts, and several federal dockets. My recent work includes extensive  
4 analysis of the EPA's proposed Clean Power Plan, critiquing the analyses used to  
5 support a flawed valuation method for nuclear power plants, developing  
6 testimony on Global Warming Solutions Act (GWSA) compliance for the  
7 Massachusetts Departments of Energy Resources and Environmental Protection,  
8 and analysis of the need for new gas pipelines in New England and the U.S.  
9 Southeast.

10 Prior to joining Synapse, I was a senior economist with the Stockholm  
11 Environment Institute's (SEI) Climate Economics Group, where I was responsible  
12 for leading the organization's work on the Consumption-Based Emissions  
13 Inventory (CBEI) model and on water issues and climate change in the western  
14 United States. While at SEI, I led domestic and international studies  
15 commissioned by the United Nations Development Programme, Friends of the  
16 Earth-U.K., and Environmental Defense.

17 My articles have been published in *Ecological Economics*, *Renewable*  
18 *Climatic Change*, *Environmental and Resource Economics*, *Environmental*  
19 *Science & Technology*, and other journals. I have also published books, including  
20 *Climate Change and Global Equity* (Anthem Press, 2014) and *Climate*  
21 *Economics: The State of the Art* (Routledge, 2013), which I co-wrote with Frank  
22 Ackerman. I am also coauthor of *Environment for the People* (Political Economy  
23 Research Institute, 2005, with James K. Boyce) and co-editor of *Reclaiming*

1           *Nature: Worldwide Strategies for Building Natural Assets* (Anthem Press, 2007,  
2           with Boyce and Sunita Narain).

3           I earned my Ph.D. in economics at the University of Massachusetts-  
4           Amherst, and have taught economics at Tufts University, the University of  
5           Massachusetts-Amherst, and the College of New Rochelle, among others.

6           My professional resume is attached as Attachment EAS-1.

7   **Q. Have you testified previously before the Indiana Utility Regulatory**  
8   **Commission (“Commission” or “IURC”)?**

9   **A.** Yes. I have submitted pre-filed testimony in the currently pending Cause Nos.  
10       43955 DSM 4 (Duke 2018-2020 DSM) and 44872 (NIPSCO CCR).

11 **Q. On whose behalf are you testifying?**

12 **A.** I am testifying on behalf of Citizens Actions Coalition of Indiana, Inc. (“CAC”).

13 **Q. What is the purpose of your testimony?**

14 **A.** The purpose of my testimony is to provide my expert opinion as to whether or not  
15       Southern Indiana Gas & Electric Company’s dba Vectren Energy Delivery’s  
16       (“Vectren” or “the Company”) 2017-2019 energy efficiency plan meets the  
17       definition of “energy efficiency goals” and is reasonable under Indiana Senate  
18       Enrolled Act 412 (2015), which has been codified under Ind. Code § 8-1-8.5-10. I  
19       have concluded Vectren’s plan should be rejected as unreasonable. It is my  
20       opinion that Vectren’s 2016 IRP, including Vectren Witness Stevie’s inputs  
21       provided for the IRP, does not provide an optimal balance of energy resources  
22       that “can only result[] from a well-developed and reasoned IRP that evaluates the  
23       appropriate balance of new supply-side and demand-side resources taking account

1 of risks and uncertainty.” Cause No. 43955 DSM 3, Final Order at 45; *see also*  
2 Final Order, Cause No. 44634 at 34.

3 **Q. Are you submitting any attachments?**

4 **A.** Yes. Attachment EAS-2 is an update to the report written by myself and CAC  
5 Witness Anna Sommer, which was previously submitted to the Commission  
6 through the Vectren IRP stakeholder process on April 17, 2017.<sup>1</sup> This document is  
7 now completely public. Our report comments on a 2015 working paper by  
8 Richard Stevie entitled “Energy Efficiency Program Costs, Program Size, and  
9 Market Penetration”<sup>2</sup> and debunks his claim that there is evidence of “higher  
10 energy efficiency market penetration leading to higher efficiency costs.”<sup>3</sup> Instead,  
11 we show that there is no reliable evidence to support such a claim and that  
12 “[i]mplementing Stevie’s suggestions would lead utilities to the selection of less  
13 energy efficiency than is optimal.”<sup>4</sup>

14 **Q. Please summarize your conclusions and recommendations.**

15 **A.** Vectren’s 2016 IRP, specifically as it relates to DSM cost projections, depends  
16 heavily on an analysis performed by Vectren Witness Stevie. Vectren Witness  
17 Stevie’s projected increase in future energy efficiency costs is based on faulty  
18 data, an incorrect interpretation of statistical results, and a deeply flawed  
19 application of those results to predicted costs.

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<sup>1</sup> The original submission can be found here as Attachment A:  
[http://www.in.gov/iurc/files/Vectren%202016%20IRP--  
Public%20Comments%20by%20CAC%20et%20al--4-17-17.pdf](http://www.in.gov/iurc/files/Vectren%202016%20IRP--Public%20Comments%20by%20CAC%20et%20al--4-17-17.pdf).

<sup>2</sup> Petitioner’s Exhibit No. 2, Attachment RGS-2.

<sup>3</sup> Attachment EAS-2 at 1.

<sup>4</sup> *Id.*

1           Because Vectren’s 2016 IRP depends so heavily on Vectren Witness  
2           Stevie’s flawed cost projections, Vectren cannot demonstrate that its 2016 IRP  
3           arrives at an optimal balance that “can only result[] from a well-developed and  
4           reasoned IRP that evaluates the appropriate balance of new supply-side and  
5           demand-side resources taking account of risks and uncertainty” pursuant to Ind.  
6           Code § 8-1-8.5-10(c). Cause No. 43955 DSM 3, Final Order at 45; *see also* Final  
7           Order, Cause No. 44634 at 34. I recommend against using these findings as they  
8           are inadequate and unreasonable,<sup>5</sup> given that (as Vectren Witness Stevie  
9           acknowledges) no useable prediction of the impact of efficiency market  
10          penetration on program costs exists. Instead, I suggest that the correct assumption  
11          to use in IRP modeling is that inflation-adjusted efficiency costs remain constant  
12          (in real, inflation-adjusted terms) over time.

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<sup>5</sup> Ind. Code 8-1-8.5-10(j) states that under the overall reasonableness evaluation of a Plan, the Commission must consider, among other items, “Comments provided by customers, customer representatives, the office of utility consumer counselor, and other stakeholders concerning the adequacy and reasonableness of the plan, including alternative or additional means to achieve energy efficiency in the electricity supplier’s service territory” and “The electricity supplier’s current integrated resource plan and the underlying resource assessment.”

1 **II. FAILURES AND LIMITATIONS IN VECTREN’S 2016 IRP DUE TO**  
2 **VECTREN WITNESS STEVIE’S UNDERLYING DSM COST**  
3 **ASSUMPTIONS.**  
4

5 **Q. Have you reviewed the testimony of Richard Stevie marked as Petitioner’s**  
6 **Exhibit 2?**

7 **A.** Yes, I have reviewed Vectren Witness Stevie’s testimony and attachments.

8 **Q. On pages 13-17 of Petitioner’s Exhibit 2, Vectren Witness Stevie explains**  
9 **Vectren’s rationale for limiting incremental energy savings to 2 percent of**  
10 **eligible retail sales per year. Please summarize this rationale.**

11 **A.** Vectren Witness Stevie states that—based on various studies of energy efficiency  
12 potential—Vectren chose 40 percent of eligible retail sales for additional  
13 cumulative efficiency savings (starting in 2018) as the total amount of DSM  
14 available or possible to then be an input into Vectren’s 2016 IRP. He offered that  
15 2 percent of eligible retail sales per year, starting in 2018, adds up to 40 percent of  
16 eligible retail sales in total over 20 years:

17 *Vectren South chose to make up to 2% of eligible retail sales as*  
18 *DSM resource options available for selection in the IRP process*  
19 *for each year beginning in 2018. This represents almost 40% of*  
20 *eligible retail sales, far above estimates of even technical market*  
21 *potential.)<sup>6</sup>*

22 **Q. Do you agree with Vectren’s rationale for limiting incremental energy**  
23 **savings to 2 percent of eligible retail sales per year, as described by Witness**  
24 **Stevie?**

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<sup>6</sup> Petitioner’s Exhibit 2 at 17.

1    **A.**    No. The way in which Vectren slowly adds 2 percent per year to eventually reach  
2           the 40 percent maximum is unreasonable, and Vectren Witness Stevie’s testimony  
3           presents no reasoning behind this slow pace of adoption as an input into Vectren’s  
4           2016 IRP. Two percent incremental savings per year is not the only way to add up  
5           to 40 percent additional cumulative savings over time. If Vectren believes that an  
6           additional 40 percent cumulative energy efficiency savings is available and that  
7           energy efficiency has the potential to lower customer costs (in comparison to  
8           generation alternatives), then I can see no reason for slowly adding 2 percent per  
9           year to eventually reach the 40 percent maximum.

10                 Logically, Vectren should offer as much energy efficiency into its IRP as  
11           it can each and every year, with the goal of reaching and exceeding 40 percent  
12           efficiency savings (and getting maximum cost savings to customers) as quickly as  
13           is feasible. By spreading out the 40 percent efficiency savings equally over the  
14           twenty years, Vectren has created an annual ceiling and an artificial, equal  
15           division of savings by year. If there is some other rationale for limiting  
16           incremental efficiency savings to 2 percent per year in this three-year plan,  
17           Vectren Witness Stevie fails to describe or explain it.

18    **Q.**    **Does CAC have an alternative proposal to using savings to judge consistency**  
19           **between the IRP and DSM plans?**

20    **A.**    Yes. Please see the testimony of CAC Witness Sommer, who describes an  
21           alternative method to reconcile IRP and DSM plan savings using the IRP results  
22           to help inform the cost-effectiveness screening that occurs within the DSM plan. I



1 submitted the same proposal in the currently pending case docketed as Cause No.  
2 43955 DSM 4.

3 **Q. Witness Stevie provides Vectren South with a forecast of future energy**  
4 **efficiency prices. Does Vectren Witness Stevie explain his rationale and**  
5 **methodology for this forecast?**

6 **A.** Yes.

7 **Q. Does the current energy efficiency literature provide guidance on how energy**  
8 **efficiency prices will change over time as the size of energy efficiency**  
9 **programs (their “market penetration”) increases?**

10 **A.** I agree with Vectren Witness Stevie that the current literature does not provide  
11 such guidance:

12 *The energy efficiency literature does not provide adequate*  
13 *guidance.<sup>7</sup>*

14 **Q. In the absence of such guidance, what methodology does Witness Stevie**  
15 **utilize in the energy efficiency cost projections used by Vectren in its 2018-**  
16 **2020 DSM Plan at issue here?**

17 **A.** Vectren Witness Stevie created his own, new, un-vetted methodology:

18 *Based upon my research into this issue, I provided Vectren South*  
19 *with a methodology to estimate how the cost to achieve an*  
20 *increment of EE could change as the cumulative EE market*  
21 *penetration rises.<sup>8</sup>*

22 **Q. Vectren Witness Stevie concludes that “The study found that EE program**  
23 **costs per kWh increase as the cumulative penetration of EE increases, as**

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<sup>7</sup> Petitioner’s Exhibit 2 at 18.

<sup>8</sup> Petitioner’s Exhibit 2 at 19.

1           **measured by the percent of retail sales.”<sup>9</sup> and escalates Vectren’s projected**  
2           **energy efficiency costs over time on this basis. Do you agree with his**  
3           **conclusion?**

4   **A.**    No. I do not agree that Vectren Witness Stevie’s study provides evidence that  
5           energy efficiency program costs per kWh increase as cumulative savings as a  
6           percentage of sales increase.

7                         Further, I disagree both with the methodology used by Witness Stevie in  
8           his 2015 study<sup>10</sup> and with his application of that 2015 study’s results to Vectren’s  
9           efficiency cost projections.

10   **Q.**    **Vectren Witness Stevie says that “The primary focus of the research [in his**  
11           **2015 study] was to examine if and to what extent the program cost of EE**  
12           **changes as the available supply (i.e., retail sales) of EE is consumed through**  
13           **implementation of EE programs.”<sup>11</sup> Does Witness Stevie’s 2015 working**  
14           **paper<sup>12</sup> succeed in its purpose?**

15   **A.**    No. While Vectren Witness Stevie’s 2015 analysis examines the relationship  
16           between efficiency cost and cumulative savings, it does not provide new or usable  
17           information and is not an appropriate source for determining expected future  
18           efficiency costs for Vectren.

19   **Q.**    **What critiques do you have of Witness Stevie’s 2015 analysis?**

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<sup>9</sup> Petitioner’s Exhibit 2 at 19.

<sup>10</sup> Petitioner’s Exhibit 2, Attachment RGS-2.

<sup>11</sup> Petitioner’s Exhibit 2 at 19.

<sup>12</sup> Petitioner’s Exhibit 2, Attachment RGS-2.

1 A. In my attached report which updates the one previously submitted to the  
2 Commission through the IRP stakeholder process, I make the following four  
3 critiques of Vectren Witness Stevie's analysis:

- 4 (1) his analysis is not replicable (a fundamental expectation of any such analysis);  
5 (2) he has used incorrect data, and correcting his data changes his results;  
6 (3) correcting his data also renders his results statistically insignificant (that is, not  
7 discernable from happenstance); and  
8 (4) his analysis is not robust (his data are of low quality, and removing inaccurate  
9 entries changes the results).<sup>13</sup>

10 **Q. Please explain your first critique: Witness Stevie's analysis is not replicable.**

11 A. Vectren Witness Stevie's analysis employs a regression methodology. This is a  
12 common, well-understood methodology—so much so that given the same data  
13 and basic description of a regression, anyone with statistical or econometric  
14 expertise should be able to replicate the results of an analysis exactly. If a  
15 regression cannot be replicated, it must be because either the data have been  
16 recorded incorrectly or described incorrectly, and/or the regression methodology  
17 itself was described incorrectly.

18 Witness Stevie creates two regression models—one using 2012-only data  
19 and one using data reported from 2010-2012—and reports that his data for both  
20 models are taken from energy efficiency cost and performance reported in Energy  
21 Information Administration (EIA) Form 861. I was able to replicate Witness

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<sup>13</sup> Attachment EAS-2.

1 Stevie’s 2012-only (Model 2) regression exactly using the data he provides in his  
2 supporting spreadsheets.<sup>14</sup>

3 I was not, however, able to replicate the results of his 2010-2012 (Model  
4 1) regression, even though I was using data provided by Witness Stevie and the  
5 same data specifications used to exactly match the 2012-only regression. I can  
6 only conclude that either the data provided by Witness Stevie was not the data  
7 used to arrive at his findings, or his description of his 2010-2012 regression was  
8 incomplete or inaccurate (see Table 2 below). I would describe the differences  
9 between my replications and Witness Stevie’s findings as small but troubling.

10 **Q. Please explain your second critique: Witness Stevie’s analysis uses incorrect**  
11 **data, resulting in incorrect findings.**

12 **A.** Vectren Witness Stevie provides both (1) sources for his data (in Petitioner’s  
13 Exhibit No.2, Attachment RGS-2) and (2) the data themselves in CAC Exhibit 1,  
14 Attachment EAS-3.

15 In attempting to replicate his regression results using the actual data he  
16 provided—as described in my reply to the previous question—I also checked to  
17 see if the data that he provided matched the data sources that he cited. I found that  
18 many of Witness Stevie’s data points do not match the public sources of data that  
19 he provided, as shown in Table 1:

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<sup>14</sup> Attachment EAS-3 consists of two spreadsheets provided by Vectren Witness Stevie.

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**Table 1. Percentage of erroneous data entries in Stevie data**

	% non-match		
	2010	2011	2012
Program Costs (\$)	65%	27%	4%
Current Year Savings (kWh)	67%	27%	8%
Cumulative Savings (kWh)	65%	24%	6%
Total Revenue (\$)	0%	0%	0%
Total Sales (kWh)	31%	31%	31%

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Given these differences between the data provided and the actual source data, I reran the regressions described in Vectren Witness Stevie’s analysis with the corrected data. I found that changing these data to match the public sources of data that he provided changes the results of the analysis, as compared in Table 2. (“Original” is Witness Stevie’s reported regression results. “Replication” is my attempt to match his results using his data; “Replic\_State” and “Replic\_Year” are two different versions of my replication attempts, differentiated by the type of dummy variable.<sup>15</sup> “Public Data” is the correct public data cited by Stevie. “Clean Data” is a subset of these Public Data, as discussed below.)

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<sup>15</sup> Witness Stevie appears to have assigned “dummy variables” to differentiate results by state. I attempted regression replications that differentiate results by state and, separately, by data year.

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**Table 2. Comparison of regression results**

<b>Model 1</b>						
<b>Results</b>	<b>Original</b>	<b>Replic_State</b>	<b>Replic_Year</b>	<b>Public Data</b>	<b>Clean Data</b>	
<b>Number of Observations</b>	153	153	153	153	105	
<b>Adjusted R<sup>2</sup></b>	0.76	0.76	0.73	0.19	0.57	
<b>Coeff.</b>	<b>(Constant)</b>	-17.82	-18.62	14.72***	1.55	12.92***
	<b>LOG (UR)</b>	2.44	2.15	-	2.92	1.06
	<b>LOG (EE/kWh)</b>	0.61***	0.61***	0.56***	-0.74	0.43*
	<b>LOG (CUMEE/kWh)</b>	0.28**	0.28**	0.28***	0.72	0.39
	<b>LOG (REV*CPI_I/kWh)</b>	-11.98	-11.99	-0.08	-0.21	0.24
<b>Model 2</b>						
<b>Results</b>	<b>Original</b>	<b>Replication</b>		<b>Public Data</b>	<b>Clean Data</b>	
<b>Number of Observations</b>	49	49		51	46	
<b>Adjusted R<sup>2</sup></b>	0.54	0.54		0.08	0.57	
<b>Coeff.</b>	<b>(Constant)</b>	12.02***	12.02***		3.22	12.1***
	<b>LOG (EE/kWh)</b>	0.00	0.00		-0.76*	0.36
	<b>LOG (CUMEE/kWh)</b>	0.90***	0.90***		0.52	0.61*
	<b>LOG (REV/kWh)</b>	-0.84	-0.84		-1.93	-1.16
***P ≤ 0.001 ; **P ≤ 0.01 ; *P ≤ 0.05						

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The adjusted R-squared values estimate the overall statistical significance of the regression (how good of a “fit” the results are to the data). The coefficients (“coeff.”) in Table 1 are Stevie’s main regression result and can be interpreted as for every 1 percent change in Variable X expect a  $\beta$  percent change in Stevie dependent variable, energy efficiency program costs. For example, using the “Original” results from Stevie’s Model 1 would suggest that every 1 percent change in cumulative efficiency savings was associated with a 0.28 percent change in program costs. The asterisks (noted in the footnote to the table as different “P-values”) are indications of the statistical significance of each variable; the more asterisks the better job the coefficient is doing to represent the relationship between the variables. No asterisk or one asterisk suggest that the coefficient does not do a good job of representing relationships between variables.

1 I compared the Original results, reported by Witness Stevie, to the Public  
2 Data results, which use the methodology reported by Witness Stevie but replaces  
3 his flawed data with the correct public data. The Public Data results:

4 • Have much lower “Adjusted R<sup>2</sup>,” indicating a lower overall statistical  
5 significance for these regressions than that reported by Witness Stevie.

6 This means that less import should be assigned to these findings because  
7 the patterns identified by Witness Stevie are difficult to discern from  
8 happenstance.

9 • Have different elasticities (or coefficients) than those estimated by  
10 Witness Stevie for the unemployment rate (UR), percent of incremental  
11 energy efficiency savings (EE/kWh), percent of cumulative energy  
12 efficiency savings (CUMEE/kWh), and electricity price (REV/kWh). The  
13 coefficients from Stevie’s regressions are what is used in Vectren’s  
14 efficiency program cost projections, and correcting his underlying data  
15 changes these results.

16 **Q. Please explain your third critique: Witness Stevie’s analysis uses incorrect**  
17 **data, resulting in findings that are reported as statistically significant but, in**  
18 **fact, are not.**

19 **A.** Using corrected data to run Witness Stevie’s regressions changed not only the  
20 findings but the significance of those findings. Statistical significance can be  
21 thought of as the degree of confidence that should be placed in regression findings.  
22 As shown above in Table 2, correcting Witness Stevie’s data lowers the level of  
23 significance for his explanatory variables (meaning that less confidence can be

1 placed in his results). When the correct data are used for Witness Stevie's  
2 regressions, which are then plugged into project Vectren's energy efficiency costs  
3 in its 2016 IRP, it flips Stevie's result on its head. Rather than saying there is a  
4 significant impact in change of cumulative savings on program costs as  
5 proclaimed by Witness Stevie, the regression performed with the correct data  
6 suggest that no such relationship exists. Based on these corrected regression  
7 results, there is no evidence for greater market penetration resulting in higher  
8 efficiency costs.

9 Witness Stevie's main variable of interest, cumulative energy efficiency  
10 savings, is statistically insignificant when either Model 1 or Model 2 is performed  
11 with corrected data. This means that had Witness Stevie used the correct public  
12 data, he could not have concluded that there was a meaningful relationship  
13 between efficiency program costs and market penetration, which completely  
14 undermines the energy efficiency cost projections he developed for Vectren's  
15 2016 IRP.

16 **Q. Please explain your fourth critique: Witness Stevie's analysis is not robust.**

17 **A.** I took one further step in assessing the quality of Witness Stevie's regression  
18 results: I evaluated the underlying data (from the original public sources) for  
19 quality. Specifically, I rejected data points with the following characteristics with  
20 the goal of examining how sensitive these regression results are to small changes  
21 in the underlying data:

- 22 • I eliminated data points with \$0 or \$1 (that is, one dollar) recorded as  
23 their efficiency costs.



- 1           •       I eliminated data points for which incremental savings were recorded  
2                    as higher than cumulative savings, or where cumulative savings were  
3                    recorded as shrinking precipitously over time.

4           Overall, these eliminations reduced that number of data points in Model 1  
5           from 153 to 105 and in Model 2 from 51 to 46. I reran the regressions described in  
6           Witness Stevie’s analysis with the corrected (from public sources) and “Clean  
7           Data” (with poor quality data points removed), which changed the results of the  
8           analysis, as shown in Table 2 above. It improved the overall significance of the  
9           regression and changed the values (and in some cases signs) of the coefficients,  
10          but did little to improve the statistical significance of individual variables. Vectren  
11          Witness Stevie’s analysis is not robust: Its results depend on the inclusion of  
12          faulty data.

13   **Q.    Given these methodological issues, do you recommend the use of Witness**  
14   **Stevie’s analysis in utility planning?**

15   **A.**    I do not. The analysis needs significant additional refinement to be used as a  
16          source of assumptions for public policy decisions. Furthermore, Vectren Witness  
17          Stevie’s results rely on a data set that is so small as to call into question the value  
18          of regression as a methodology here.

19   **Q.    Based on your rerunning of Witness Stevie’s regressions using improved**  
20   **data as described in Attachment EAS-2, what can you suggest regarding**  
21   **Witness Stevie’s findings and their use in efficiency cost forecasting?**

22   **A.**    My regression analysis was limited to attempts to replicate Witness Stevie’s  
23          results and examination of the sensitivity of his results to data corrections. In my

1 opinion, Witness Stevie's findings, taken together with my own explorations of  
2 his findings, do not amount to evidence sufficient for use in utility planning  
3 decisions.

4 **Q. If Witness Stevie's regression results were replicable, based on both correct**  
5 **data and on high-quality data, would you then support their use in**  
6 **forecasting Vectren's energy efficiency costs?**

7 **A.** No, I would not. In addition to finding fault with the data and methodology of  
8 Witness Stevie's underlying regression analysis, I cannot support the  
9 methodology used by Witness Stevie to apply his regression findings to  
10 predictions of Vectren's expected future efficiency costs. Even if Stevie's  
11 regression analysis had produced a robust estimation of the expected quantitative  
12 relationship between cumulative savings and program costs, the way in which it is  
13 applied to cost projections appears to include several errors that impact the  
14 predicted costs.

15 **Q. What errors have you identified in Witness Stevie's application of his**  
16 **regression findings to efficiency cost projections?**

17 **A.** I have identified four main errors in Witness Stevie's application of his regression  
18 findings to efficiency cost projections (provided to CAC as Base DSM Modeling  
19 File—Confidential.xlsx and included in this submission as CAC Exhibit 1,  
20 Attachment EAS-4-Confidential):

21 (1) the basis for his efficiency cost growth factors are artificially inflated;  
22 (2) he uses his regression results selectively, ignoring certain findings;

1 (3) his 2017 efficiency costs are erroneously based on expected cumulative  
2 savings in 2036; and

3 (4) he confuses the effects of changes over time with the effects of differing  
4 policy choices within a single year.

5 **Q. Please explain your first critique: the basis for Witness Stevie's efficiency**  
6 **cost growth factor is artificially inflated.**

7 **A.** The coefficients for cumulative energy efficiency savings identified by Witness  
8 Stevie in his regression analysis are interpreted as "elasticities", meaning that they  
9 can be interpreted as follows: a 1 percent change in cumulative energy efficiency  
10 savings is assumed to result in an X percent change in program costs, where X is  
11 the reported coefficient from the statistical model. So, for example, according to  
12 Witness Stevie's cost growth factor methodology and assuming his Model 1 were  
13 correct, a 1 percent increase in cumulative energy efficiency savings would  
14 increase program costs by 0.28 percent. Witness Stevie has performed a  
15 regression on three years of data (Model 1: 2010-2012) to estimate this coefficient.  
16 He then repeats this regression on a subset (just one year) of these same data  
17 (Model 2: 2012 only) and identifies a second, higher, coefficient. Finally, Stevie  
18 averages the two coefficients together to get his result.

19 This methodology is non-standard and, frankly, rather surprising. I can  
20 think of no justification for it. This is like finding that the preliminary result for  
21 years A, B, and C is zero (0), but the result for year A alone is ten (10), and  
22 concluding from that, therefore, the correct result for A, B, and C is somehow the  
23 average of zero and ten: five (5).

1                    **ABC = 0**

2                    **A = 10**

3                    **Therefore: ABC = 5**

4                    Witness Stevie’s methodology is not sound. In Vectren’s DSM plan, it  
5                    doubles the rate of efficiency program cost growth used by Vectren as an input  
6                    into the 2016 IRP.

7    **Q. Please explain your second critique: Witness Stevie uses his regression results**  
8                    **selectively, ignoring certain findings.**

9    **A.** Cumulative energy efficiency savings were not the only variable for which  
10                    Vectren Witness Stevie reported a statistically significant relationship to program  
11                    costs, but cumulative energy efficiency savings were the only variable that Stevie  
12                    applied to these efficiency cost growth predictions. Witness Stevie finds a  
13                    significant relationship between incremental efficiency savings and program costs  
14                    in his Model 1, and he finds a significant relationship between electricity prices  
15                    and program costs in both Model 1 and Model 2. In both models, he finds that  
16                    higher electricity prices are associated with lower program costs, but he does not  
17                    apply this finding to his projected program costs. The cumulative savings finding  
18                    is “cherry picked” from among the larger regression and other coefficients.

19                    Electricity prices are expected to rise in Indiana over time. My  
20                    calculations suggested that including this effect on a forecasted growth of electric  
21                    rates ranging from 0.7 percent per year<sup>16</sup> to 3.2 percent per year<sup>17</sup> results in a

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<sup>16</sup> Petitioner’s Exhibit 1, Attachment RHH-1 (Vectren 2016 IRP Attachment 4.1) at 95.

1        decrease in the incremental change in program costs of 4 to 20 percentage points  
2        in each year averaged across Witness Stevie's two models. Put into context, just  
3        this countervailing effect would reduce Witness Stevie's 0.6 percent increase in  
4        efficiency costs due for each 1.0 percent increase in market saturation down to  
5        0.40 to 0.56 percent, without any consideration of the other errors in Witness  
6        Stevie's analysis. I can think of no justification for excluding the expected effect  
7        of changing electricity prices on program costs from Witness Stevie's projected  
8        efficiency costs.

9        **Q. Please explain your third critique: Witness Stevie's 2016 efficiency costs are**  
10       **erroneously based on expected cumulative savings in 2036.**

11       **A.** Witness Stevie applies a different growth rate and starts from a different cost  
12       assumption for savings between 1 and 2 percent of eligible sales. For example, he  
13       projects that the first 0.25 percent of savings would cost \$0.03322 per kWh in  
14       2016, while the fifth block with savings from 1 to 1.25 percent would cost  
15       \$0.07811 per kWh in 2016. The \$0.07811 per kWh cost is based on his assumed  
16       level of savings and costs in 2036 and not on 2016 values.

17                He compounds this same error by calculating 2016 energy efficiency  
18       prices and costs from this growth rate by again using the 2036 efficiency price  
19       (that is, he makes the same error twice in his calculations). I can think of no  
20       justification for this methodology. Witness Stevie has based 2016 energy  
21       efficiency cost growth rates and efficiency costs on the growth rates and costs

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<sup>17</sup> 2016 Residential Bill Survey. Available at:  
[http://www.in.gov/iurc/files/2016\\_Residential\\_Bill\\_Survey\\_Presentation.pdf](http://www.in.gov/iurc/files/2016_Residential_Bill_Survey_Presentation.pdf)

1 reached after an additional 19 percent cumulative savings have been added in  
2 2036. The effect of this error is that the efficiency price per kWh for the fifth  
3 block of savings put into the 2016 IRP is more than double that of the fourth  
4 block of savings.

5 **Q. Please explain your fourth critique: Witness Stevie confuses the effects of**  
6 **changes over time with the effects of differing policy choices within a single**  
7 **year.**

8 **A.** Even if Witness Stevie's model results were accurate and applied properly to the  
9 Vectren system, he is forecasting year-to-year changes in cost as the *annual*  
10 cumulative sum of energy efficiency increases. Despite this, he also applies his  
11 results to intra-annual changes in savings. So the *cost per unit of energy saved*,  
12 not just the total cost of the program, increases as savings increase.

13 For example, if Vectren deployed programs that achieved 1.50% savings  
14 in any given year Stevie assumes that those savings would cost more per unit of  
15 energy saved than if Vectren deployed a program that saved 1.25%. There is no  
16 logical basis for extrapolating his regression results to such effects because he  
17 estimates the relationship between market penetration and program costs from  
18 year to year—not the relationship between incremental annual savings and  
19 program costs within the same year. I can think of no justification for this  
20 methodology.

21 **Q. Given the critiques that you have presented of Witness Stevie's regression**  
22 **analysis and its application, can you recommend the use of these findings in**  
23 **predicting the future cost of energy efficiency?**

1   **A.**    No. I do not recommend using either Witness Stevie’s regression results or his  
2           method of applying regression results to efficiency cost projections—whether  
3           used singly or together. The flaws in the Witness Stevie analysis are serious and,  
4           in my opinion, entirely undermine Vectren’s 2016 IRP and its usefulness in  
5           guiding DSM decisions.

6   **Q.**    **Vectren states that “While they assert that “they are aware of no reliable**  
7           **evidence for higher energy efficiency market penetration leading to higher**  
8           **efficiency costs” (Environmentalists Comments, p. 35), Vectren South’s own**  
9           **historical experience is that adoption of energy efficiency measures become**  
10          **more expensive once market saturation occurs. This result is logical—more**  
11          **work, and thus more cost, is required to capture the attention of those**  
12          **consumers who have not already taken advantage of energy efficiency**  
13          **measures that have been available for several years. Those consumers are**  
14          **either not initially interested (and require increased marketing to reach) or**  
15          **require an increased incentive to adopt the energy efficiency**  
16          **measure.”(Vectren reply, p.19) Does Vectren assertion amount to evidence**  
17          **for the assumption that higher market penetration results in higher program**  
18          **costs?**

19   **A.**    No. Analysis is the way in which historical experience is quantified and  
20           introduced as evidence. Vectren South has not provided any analysis regarding its  
21           historical experience of the relationship between efficiency market penetration and  
22           program costs. Instead, they offer the assertion—without evidence—that such a  
23           relationship exists. If evidence of the asserted relationship exists and is made

1 available to stakeholders, I will review and comment on it. Such an analysis must  
2 control for factors that influence cost like the exclusion of opt-out customers and  
3 the quality of program implementation.

4 **III. CONCLUSION AND RECOMMENDATIONS.**

5 **Q. Please summarize your recommendations.**

6 **A.** Vectren’s 2016 IRP, specifically as it relates to DSM cost projections, depends  
7 heavily on an analysis performed by Vectren Witness Stevie. Vectren Witness  
8 Stevie’s projected increase in future energy efficiency costs is based on faulty  
9 data, an incorrect interpretation of statistical results, and a deeply flawed  
10 application of those results to predicted costs.

11 Because Vectren’s 2016 IRP depends so heavily on Vectren Witness  
12 Stevie’s flawed cost projections, Vectren cannot demonstrate that its 2016 IRP  
13 arrives at an optimal balance that “can only result[] from a well-developed and  
14 reasoned IRP that evaluates the appropriate balance of new supply-side and  
15 demand-side resources taking account of risks and uncertainty” pursuant to Ind.  
16 Code § 8-1-8.5-10(c). Cause No. 43955 DSM 3, Final Order at 45; *see also* Final  
17 Order, Cause No. 44634 at 34. I recommend against using these findings as they  
18 are inadequate and unreasonable,<sup>18</sup> given that (as Vectren Witness Stevie

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<sup>18</sup> Ind. Code 8-1-8.5-10(j) states that under the overall reasonableness evaluation of a Plan, the Commission must consider, among other items, “Comments provided by customers, customer representatives, the office of utility consumer counselor, and other stakeholders concerning the adequacy and reasonableness of the plan, including



1           acknowledges) no useable prediction of the impact of efficiency market  
2           penetration on program costs exists. Instead, I suggest that the correct assumption  
3           to use in IRP modeling is that inflation-adjusted efficiency costs remain constant  
4           over time.

5   **Q.    Does this conclude your testimony?**

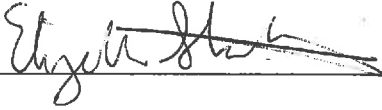
6   **A.    Yes.**

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alternative or additional means to achieve energy efficiency in the electricity supplier's service territory" and "The electricity supplier's current integrated resource plan and the underlying resource assessment."

VERIFICATION

I, Elizabeth Stanton, PhD, affirm under penalties of perjury that the foregoing representations are true and correct to the best of my knowledge, information and belief.



Elizabeth Stanton, PhD

July 26, 2017

Date

# **ATTACHMENT EAS-1**

**Elizabeth A. Stanton, Ph.D.**, Independent Consultant

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**PROFESSIONAL EXPERIENCE**

**Liz Stanton Consulting**, Arlington, MA. *Independent Consultant*, August 2016 – Current.

Providing consulting services on the economics of energy, environment and equity.

**Synapse Energy Economics Inc.**, Cambridge, MA. *Principal Economist*, 2012 – 2016.

Consulted on issues of energy economics, environmental impacts, climate change policy, and environmental externalities valuation.

**Stockholm Environment Institute - U.S. Center**, Somerville, MA. *Senior Economist*, 2010 – 2012; *Economist*, 2008 – 2009.

Wrote extensively for academic, policy, and general audiences, and directed studies for a wide range of government agencies, international organizations, and nonprofit groups.

**Global Development and Environment Institute, Tufts University**, Medford, MA. *Researcher*, 2006 – 2007.

**Political Economy Research Institute, University of Massachusetts-Amherst**, Amherst, MA. *Editor and Researcher – Natural Assets Project*, 2002 – 2005.

**Center for Popular Economics, University of Massachusetts-Amherst**, Amherst, MA. *Program Director*, 2001 – 2003.

**EDUCATION**

**University of Massachusetts-Amherst**, Amherst, MA

Doctor of Philosophy in Economics, 2007

**New Mexico State University**, Las Cruces, NM

Master of Arts in Economics, 2000

**School for International Training**, Brattleboro, VT

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**College of New Rochelle**, New Rochelle, NY

*Assistant Professor*, Department of Social Sciences, 2007 – 2008

**Tufts University**, Medford, MA

*Adjunct Professor*, Department of Urban Environmental Policy and Planning, 2007

**Fitchburg State College**, Fitchburg, MA

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*Adjunct Professor*, Department of Economics, 2003 – 2006

**Castleton State College and the Southeast Vermont Community Learning Collaborative**, Dummerston, VT

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**School for International Training**, Brattleboro, VT

*Adjunct Professor*, *Program in Intercultural Management, Leadership, and Service*, 2004

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*Resume dated August 2016*

# **ATTACHMENT EAS-2**



# **No Evidence for Energy Efficiency Market Saturation Leading to Higher Costs**

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## **Abstract**

A 2015 working paper by Richard Stevie asserts that no other study has illuminated the relationship between energy efficiency program costs and market penetration, and purports to itself demonstrate that market saturation causes higher efficiency program costs. We find that Stevie's study provides no usable evidence of a market saturation-program cost relationship and *ipso facto* no such relationship has as yet been demonstrated. The results of Stevie's working paper have impacted resource decisions proposed by electric utilities in at least three states (Indiana, North Carolina, and South Carolina). Stevie's analysis erroneously suggests that there exists evidence of efficiency market saturation significantly driving up programs costs. We find, in contrast, that the evidence presented is insufficient and inaccurate. We are aware of no reliable evidence for higher energy efficiency market penetration leading to higher efficiency costs. Inclusion of a baseless inflation of efficiency program costs in the name of market saturation results in higher energy efficiency costs than would otherwise be expected. Implementing Stevie's suggestions would lead utilities to select less energy efficiency than is optimal.

## **1. Background**

Projected energy efficiency cost and savings levels are an important input to electric utilities' modeling of future resource additions and retirements. These projections are used in Integrated Resource Plans and other, similar filings submitted to state utility commissions for their approval. Some contend that the future cost of saved energy is influenced both by historical costs and by patterns in the relationship between the cost of saved energy and other factors, including: The amount of new efficiency savings in a given year, and the cumulative amount of savings that has built up over time (after adjusting for efficiency measures that have "sunset" at the end of their measure life).

In many jurisdictions around the United States, projected energy efficiency costs are used to determine utilities' efficient or otherwise optimal investment in energy efficiency and other resources in the next few years. An expectation of high costs, rising costs, or both can reduce investments in energy efficiency. Studies that overestimate the future cost of efficiency programs—and thereby result in lower levels of planned efficiency—deprive electric customers of low (and often least) cost efficiency measures while simultaneously pushing states towards an electric resource mix with higher costs and higher emissions of greenhouse gases and other pollutants.

Richard Stevie's 2015 analysis of these relationships has been used by utilities in Indiana, North Carolina, and South Carolina to justify a future cost of saved energy that rises with higher energy efficiency market penetration (that is, the higher the cumulative efficiency savings, the higher the efficiency cost).<sup>1</sup> The rationale for this purported relationship—as discussed in Stevie's paper—is market saturation and diminishing returns:

*[A]s market penetration increases, energy efficiency implementation costs are expected to rise at higher levels of penetration of the market. The degree of impacts on program costs, from these factors, is a question to be empirically analyzed. (p.9)*

Stevie provides a review of some of the existing literature exploring the relationship between efficiency costs and savings levels and finds it wanting:

*In summary, this review of past studies on the costs of energy efficiency reveals that a significant void exists in our understanding of how the implementation costs of energy efficiency are affected by the level of market penetration. (p.7)*

Having noted this gap, Stevie performs regression analysis using data voluntarily reported by utilities to the U.S. Energy Information Administration (EIA) and concludes somewhat heroically that:

*From the review of other studies, it is apparent that little to no evidence exists on the relationship between program costs, program size, and market penetration. But now, the research conducted in this study provides an initial insight into this relationship...It should be obvious that further research in this area is warranted. As mentioned, this study is the first to investigate how costs can rise with increases in program size and market penetration. The findings point to the existence of cost efficiencies with respect to program size, but rising costs as market penetration increases. (p.21)*

Stevie's regression analysis—and the conclusions drawn from it that have been used to inflate the cost of saved energy—are the subject of this review. We found that Stevie's analysis:

- Is based on highly questionable data sources (Section 2),
- Relies on regression analysis that is sensitive to the inclusion or exclusion of problematic data entries, and seems to depend on unusual choices in variable and model specification (Section 3), and
- Is applied incorrectly and incompletely in the utility filings for which we were able to review workpapers (Section 4).

The result of these errors and omissions is higher energy efficiency costs than would otherwise be expected in utility planning and, consequently, less efficiency chosen in optimal resource planning.

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<sup>1</sup> Stevie, Richard (2015) "Energy Efficiency Program Costs, Program Size, and Market Penetration." Draft Working Paper. Integral Analytics.  
<http://www.integralanalytics.com/files/documents/Projecting%20Energy%20Efficiency%20Program%20Costs%202015.pdf>.

## 2. Data Sources

In regression analysis, variations in the value of one data point or “variable” (here, program costs) are explained through patterns in the values of other related variables. Stevie bases his analysis on the presumption that energy efficiency program costs can be explained using the values of several other variables, which he aggregates to the state level.

The dependent or explained variable in Stevie’s regressions is:

- Program Cost: “the level of direct program spending (dollars) on energy efficiency programs only. Indirect costs are not included.”(p.10); “For the purposes of this study, only the direct program costs including incentive payments to participants will be considered in the analysis.”(p.15); Stevie reports that his data for direct spending on energy efficiency program are taken from EIA Form 861 (p.13).

Stevie’s explanatory variables are:

- Program Size: “the current year achievement of energy impacts as a percent of current year retail kWh sales”(Stevie (2015), p.11); Stevie reports that his data for incremental energy efficiency (or current year annualized impacts) are taken from EIA Form 861 (p.13).
- Market Penetration: “the cumulative achievement of energy efficiency sales as a percent of retail kWh sales”(p.11); Stevie reports that his data for cumulative energy efficiency (called “annual” in the EIA data set) are taken from EIA Form 861 (p.13).
- Electric Rate: “the cost of power (\$/kWh) to customers in an area”(p.11); Stevie reports that his data source for total revenue and total retail sales are taken from EIA Form 861.
- “Unemployment Rate”(p.12): Stevie gives no data source for his unemployment rate measure, instead noting that, “Data on national inflation and unemployment may be found from numerous sources”(p.14), and mentions but does not directly cite a secondary data source for these measures, “See the website Freelunch.com sponsored by Moody’s Analytics for general macroeconomic data including inflation and unemployment.”(p.14, fn.21).

While Stevie relies exclusively on EIA Form 861 for his data on energy efficiency spending, Stevie himself notes that EIA Form 861 data have limitations that impede their ability to correctly characterize the relationship between energy efficiency savings and the cost of saved energy. While Stevie’s list of concerns is not comprehensive, it provides an overview of this data set’s flaws, including: (1) a lack of data on the life of efficiency measures; (2) various known reporting errors (incorrect or mislabeled responses, inconsistent treatment of free riders, inconsistent classification of costs); and (3) changes in reporting requirements and instructions over time (p.14).

With respect to using these data to understand the effect of efficiency market penetration on costs, the most important issue is EIA Form 861’s lack of information on the life of efficiency measures. Without this data point there is no way to measure the cost of saved energy, because this year’s efficiency savings are not the only savings that will arise from this year’s efficiency costs. The best and most commonly used measure for any energy resource cost is a “levelized” cost, which divides a resource’s total fixed and variable costs by the total amount of

energy that it will provide (or save) over its lifetime. EIA Form 861's cost and savings data are simply not sufficient to provide a measure of the levelized cost of saved energy.

Stevie acknowledges these data limitations. His stated solution is to limit his data set to the most recent three years of data available at the time of his study—a remedy that in no way addresses the problem of the mismatch between the cost and savings data available in EIA Form 861:

*For this reason, the analysis conducted here looks at total annual spending relative to the first year impacts. Trying to compute a levelized cost requires knowledge that is just not available. While one might intuit an expected measure life for a portfolio, it is only a guess and could lead to misleading conclusions. In reviewing the EIA data, it is apparent that the reporting is not consistent. For example, kWh could be reported instead of MWh or dollars instead of thousands of dollars as specified in the instructions to the form. For this reason, the study will focus on the last three years of data for the years 2010 through 2012. Use of the most recent data should provide the best quality of data from the data base. (p.14)*

In addition, while EIA's Form 861 data are voluntarily reported by utilities—and are, therefore, available disaggregated by utility—Stevie makes the choice to aggregate these data:

*Finally, to facilitate the research, costs and impact data is [sic] aggregated to a state level. This provides a useful data set for the 50 states plus the District of Columbia. (p.15)*

Stevie's choices to limit his data to three years and aggregate the data to the state level results in a very small dataset for his regression. While Stevie does not follow the convention of reporting the size of his data sets in his working paper, it would appear that his "Model 1" has 153 data points and his "Model 2"—which he further limits to just data for the year 2012—has 49 data points.<sup>2</sup> If this analysis were performed at the utility level, using these same data, its data points would number in the thousands. The small data set used by Stevie limits the reliability of his regression findings and call into question the confidence that can be placed in patterns observed in Stevie's study.

Our replication of Stevie's analysis uses his data and methodology to the greatest extent possible given his omission of some key details regarding variable specification and data sources:

- Program Cost: (dollars) EIA Form 861<sup>3</sup> 2010-2012 aggregated to 50 states plus the District of Columbia:

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<sup>2</sup> Stevie notes in Fn.23 that, "Data for Delaware and Louisiana were deleted since the EIA data indicates [sic] essentially zero cumulative impacts for the year 2012."(p.16)

<sup>3</sup> EIA Form 861 data consists of multiple spreadsheets. For the years 2010 and 2011, "program cost", "program size", and "market penetration" data are taken from Form 3 and from the "dsm\_2012" spreadsheet for 2012. While "electric rate" data are calculated from Form 2 for the years 2010 and 2011 and from the "retail\_sales\_2012" spreadsheet for 2012.

*DIRECTCOSTEEF + INCENTIVEEF*

- Program Size: (%) EIA Form 861 2010-2012 aggregated to 50 states plus the District of Columbia divided by EIA Form 861 2010-2012 aggregated to 50 states plus the District of Columbia states:

*ENERGYEFFINCTOT / Total Sales*

- Market Penetration: (%) EIA Form 861 2010-2012 aggregated to 50 states plus the District of Columbia states divided by EIA Form 861 2010-2012 aggregated to 50 states plus the District of Columbia states:

*ENERGYEFFANNTOT / Total Sales*

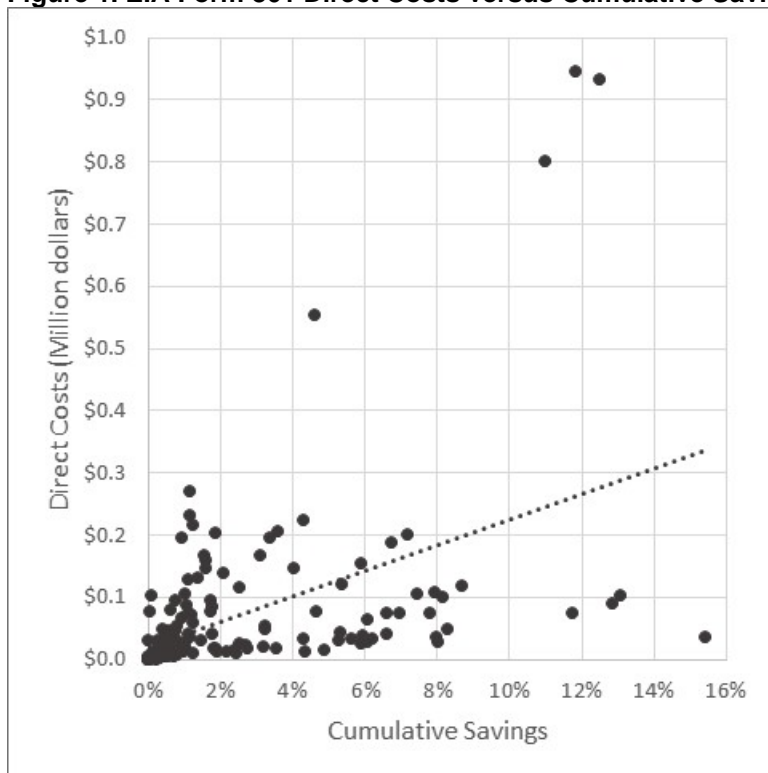
- Electric Rate: (\$/kWh) EIA Form 861 aggregated to 50 states plus the District of Columbia states divided by EIA Form 861 2010-2012 aggregated to 50 states plus the District of Columbia states:

Total Revenue / Total Sales

- Unemployment Rate: (%) U.S. Bureau of Labor Statistics (LNS14000000) Unemployment Rate, U.S. annual average

Using the data gathered from public sources to replicate Stevie's analysis, Figure 1 depicts the relationship between energy efficiency program costs and market penetration that Stevie recommends be used in forecasting future utility efficiency costs, claiming that: "It provides guidance on the expectation that as the market penetration of energy efficiency increases, the unit cost increases."(p.21)

**Figure 1. EIA Form 861 Direct Costs versus Cumulative Savings, 2010-2012**



**Note:** The line shown is a linear trendline, describing the relationship between the two variables: Direct costs and cumulative savings.

Figure 1 provides a snapshot of several critical weaknesses in both Stevie's analysis and the data on which it was based:

- **The positive correlation between direct costs and market penetration (cumulative savings) is weak and appears to be driven by a few outliers.** Figure 1 above shows a dense cloud of data points with a few outliers, and not an obvious trend in which higher costs are associated with greater levels of market saturation. (Note that the data points do not congregate around the trendline but rather are found well above and below these lines.)
- **Larger programs have larger costs, and smaller programs have smaller costs.** Stevie's analysis offers little insight into the relationship between market penetration and the cost of saved energy. Stevie's puzzling choice of program costs in dollars as the dependent variable and percentage savings as the explanatory variable results in a regression analysis that points only to the obvious relationship between program size and program costs while failing to ask pertinent questions about how any one utility's repeated investments in efficiency over many years may impact its program costs.
- **A few years of state-level data cannot reveal an actionable expectation regarding efficiency program costs.** Stevie purports to identify a pattern among states over three years that can be applied to long-term projections of efficiency costs for individual utilities. Not only does Stevie's methodology suffer from well-known reliability issues

arising from very small datasets, it also fails to track individual utilities over time, because his data are aggregated to the state level, and three years of data do not provide a pattern that can be applied to decades of projections. One year of data (as used in Stevie's Model 2) has no information whatsoever about the pattern of changes over time.

### 3. Regression Analysis

We attempted to replicate Stevie's regression analysis results using the data described in the previous section and the two regression equations reported in his working paper:

Model 1:  $\text{ProgCost}_{it} = \text{Intercept} + \beta_1 * \text{ProgSize}_{it} + \beta_2 * \text{MarketPen}_{it} + \beta_3 * \text{ElecRate}_{it} + \beta_4 * \text{Unemploy}_{it} + \varepsilon_{it}$

Model 2:  $\text{ProgCost}_i = \text{Intercept} + \beta_1 * \text{ProgSize}_i + \beta_2 * \text{MarketPen}_i + \beta_3 * \text{ElecRate}_i + \varepsilon_i$

This exercise was successful for Stevie's Model 2 (2012-only) and achieved results that were similar but not identical to Stevie's Model 1 (2010-2012), as shown in Table 1. ("Original" is Stevie's reported regression results. "Replication" is our attempt to match his results using his data; "Replic\_State" and "Replic\_Year" are two different versions of our replication attempts, differentiated by the type of dummy variable.<sup>4</sup> "Public Data" is the corrected version of the EIA Form 861 data cited by Stevie. "Clean Data" is a subset of these Public Data, as discussed below.)

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<sup>4</sup> Stevie appears to have assigned "dummy variables" to differentiate results by state. We attempted regression replications that differentiate results by state and, separately, by data year.

**Table 1. Comparison of regression results**

<b>Model 1</b>						
<b>Results</b>	<b>Original</b>	<b>Replic_State</b>	<b>Replic_Year</b>	<b>Public Data</b>	<b>Clean Data</b>	
<b>Number of Observations</b>	153	153	153	153	105	
<b>Adjusted R<sup>2</sup></b>	0.76	0.76	0.73	0.19	0.57	
<b>Coeff.</b>	<b>(Constant)</b>	-17.82	-18.62	14.72***	1.55	12.92***
	<b>LOG (UR)</b>	2.44	2.15	-	2.92	1.06
	<b>LOG (EE/kWh)</b>	0.61***	0.61***	0.56***	-0.74	0.43*
	<b>LOG (CUMEE/kWh)</b>	0.28**	0.28**	0.28***	0.72	0.39
	<b>LOG (REV*CPI_I/kWh)</b>	-11.98	-11.99	-0.08	-0.21	0.24
<b>Model 2</b>						
<b>Results</b>	<b>Original</b>	<b>Replication</b>		<b>Public Data</b>	<b>Clean Data</b>	
<b>Number of Observations</b>	49	49		51	46	
<b>Adjusted R<sup>2</sup></b>	0.54	0.54		0.08	0.57	
<b>Coeff.</b>	<b>(Constant)</b>	12.02***	12.02***		3.22	12.1***
	<b>LOG (EE/kWh)</b>	0.00	0.00		-0.76*	0.36
	<b>LOG (CUMEE/kWh)</b>	0.90***	0.90***		0.52	0.61*
	<b>LOG (REV/kWh)</b>	-0.84	-0.84		-1.93	-1.16
***P ≤ 0.001 ; **P ≤ 0.01 ; *P ≤ 0.05						

The coefficients (“coeff.”) in Table 1 are Stevie’s main regression result and can be interpreted as for every 1 percent change in Variable X expect a β percent change in Stevie dependent variable, energy efficiency program costs. For example, using the “Original” results from Stevie’s Model 1 would suggest that every 1 percent change in cumulative efficiency savings was associated with a 0.28 percent change in program costs.

After careful review, we believe that three key factors interfere with replication and interpretation of Stevie’s results: unexplained changes by Stevie to EIA Form 861 data; data quality issues in EIA 861 data not properly addressed by Stevie; and Stevie’s specification of the dependent variable.

*3-a. Unexplained changes by Stevie to EIA Form 861 data*

Our review of Stevie’s regression analysis workpapers revealed widespread, large-scale inconsistencies between EIA Form 861 source data and the actual data on which Stevie based his regressions.<sup>5</sup> These inconsistencies take two forms:

1. Stevie’s working paper mentions only one adjustment made to EIA data (the removal of two states in the 2012-only regression). We can offer no possible explanation for a large share of Stevie’s data entries being different from those calculated directly from EIA data as state weighted averages (see Table 2). Still more puzzling is the finding that some of Stevie’s data are exactly identical to EIA data—meaning that whatever factor is causing this inconsistency is only present in some of Stevie’s data extraction. It should also be

<sup>5</sup> We were provided access to Stevie’s workpapers, including his underlying data and regression results, on April 12, 2016, through the IRP stakeholder process.



noted that these data errors were not small in scale: the average error for program costs was 32 percent; current year savings, 34 percent; cumulative savings, 31 percent; and total sales, 31 percent.

**Table 2. Share of erroneous data entries**

	% non-match		
	2010	2011	2012
<b>Program Costs (\$)</b>	65%	27%	4%
<b>Current Year Savings (kWh)</b>	67%	27%	8%
<b>Cumulative Savings (kWh)</b>	65%	24%	6%
<b>Total Revenue (\$)</b>	0%	0%	0%
<b>Total Sales (kWh)</b>	31%	31%	31%

2. Stevie has, without explanation, replaced zero current-year and cumulative savings, and zero program costs with the value 0.00001. This type of change makes it possible to use these data in regression analysis and can be a necessary tactic in logarithmic regressions (since the logarithm of zero is undefined). In this instance, however, data entries with zero savings do not offer information to an analysis of energy efficiency programs and should be removed, as Stevie himself does with such entries in his 2012-only analysis.

Given these serious issues, we reran Stevie’s regressions using the correct public data (“Public Data” in Table 1 above) and found that this correction resulted in changes to both coefficient values and the level of their significance. As shown in Table 1, using corrected data, only one coefficient in one model was significant at the 5 percent level and no coefficients were significant at the 1 percent level. These low levels of statistical significance indicate that the regression findings used by Stevie in various utility dockets represented relationships between the data that cannot be distinguished from happenstance.

*3-b. Data quality issues in EIA 861 data not properly addressed by Stevie*

Stevie’s working paper reports only two data points removed from Model 2 (“since the EIA data indicates [sic] essentially zero cumulative impacts for the year 2012”(p.16)). From this we can infer that all 153 data entries are included in Stevie’s 2010-2012 regression and 49 in his 2012-only regression.<sup>6</sup>

Our review of the 2010-2012 data showed that 25 entries include zero values for current-year savings, incremental savings, or both. State-years without energy efficiency savings cannot offer useful information to the analysis and should be removed. In addition, our review found another 23 data entries with obvious data quality issues: some with \$1 entries in program costs or other obvious errors, and some states where there were unambiguous inconsistencies between reported incremental and cumulative savings (for example, 2011-2012 incremental

<sup>6</sup> Stevie’s workpapers show that out of 153 possible data entries in this analysis, he used 153 in his Model 1 regression and 49 in his 2012-only Model 2 regression.

savings that, when added to 2010 cumulative savings, resulted in a value far greater than the reported 2012 cumulative savings<sup>7</sup>).

These apparently erroneous data comprised the majority of data outliers shown in Figure 1 (above); the remaining high program cost outliers are three-years of program data for California. We reran our “Public Data” regression with this smaller, corrected data set (called “Clean Data”) to examine its sensitivity to changes in the underlying data. In the “Clean Data” regression, coefficient values were dramatically different from those in the “Public Data” regression (see Table 1 above) but the statistical significance of the regression remained very low.

### 3-c. Stevie’s specification of the dependent variable

Program costs in dollars are impacted by the scale of savings, not because of market saturation but—more fundamentally—as a result of the size of the state or utility itself. Program costs on a per kWh basis, however, are far more likely to show meaningful impacts of current year program size and cumulative savings. Using the improved (but very small) dataset described above (“Clean Data”), we examined the sensitivity of Stevie’s results to his unusual choice of dependent variable by comparing (1) the correlation of program costs in dollars to market penetration to (2) the correlation of program costs per kWh to market penetration (see Table 3, which presents the degree of correlation between variables in percentages).

**Table 3. Correlation matrix using EIA Form 861 data with obvious errors removed**

	<i>ProgCost\$</i>	<i>ProgCost\$/kWh</i>	<i>ProgramSize</i>	<i>MarketPen</i>	<i>ElectricRate</i>	<i>UnemploymentRate</i>
<b>ProgCost\$</b>	100%					
<b>ProgCost\$/kWh</b>	60%	100%				
<b>ProgramSize</b>	91%	51%	100%			
<b>MarketPen</b>	94%	57%	90%	100%		
<b>ElectricRate</b>	32%	18%	18%	31%	100%	
<b>UnemploymentRate</b>	27%	22%	28%	26%	24%	100%

Both program size and market penetration are less correlated with program costs in \$ per kWh than they are with program costs in dollars. Any conclusions that might be drawn from that finding should, however, be considered in light of the following caveats: (1) these regression models have too small of a sample size and therefore may not be statistically significant (i.e., discernable from happenstance), and (2) Stevie’s choice to limit his regressions to model just a few years of data makes it impossible to discern data patterns that can have any application to long-term changes in efficiency costs.

Overall, our review of Stevie’s regression analysis calls into question the quality of his data, the significance of his results, and whether or not any results produced using this methodology can be said to add meaningful insight to the projection of future efficiency costs.

## 4. Application of Stevie’s Analysis in Utility Planning

<sup>7</sup> We recognize that some utilities will have correctly adjusted for sunseting measures in their cumulative savings, and for this reason we removed only gross differences between these reported and calculated values.

We also had the opportunity to review Stevie's workpapers in which the results of his regression analysis were applied to an electric utility's 20-year projection of energy efficiency program costs. The coefficients resulting from a logarithmic regression can be interpreted as elasticities, that is, a 1 percentage point change in the value of an explanatory variable can be said to be associated with a  $\beta$  percentage point change in the value of the dependent variable, where  $\beta$  is the coefficient value for the explanatory variable.

In the utility's projection of future efficiency program costs, the coefficients for Stevie's market penetration variable are applied to program costs for a recent historical year such that each incremental 1.0 percent increase in savings has the effect of adding the cost equivalent of 0.6 percent savings (calculated as the average of Stevie's Model 1 and Model 2 coefficients for market penetration: 0.278 and 0.897, respectively). Over the course of 20 years, the utility interprets this as resulting in a more than doubling of the program costs associated with a 1 percent incremental annual savings level: from 3 cents per kilowatt-hour in 2016 to 8 cents in 2036.

In summary, this utility application of regression findings to efficiency cost projections suffers from several errors in substance and logic, any one of which would, by itself, render the study's use in resource decisions inappropriate:

- **Errors, omissions, and misspecifications of data:** Stevie's data are taken—by his own admission—from a deeply flawed dataset, use an illogical combination of dependent and independent variables, are too few in number to provide meaningful results, and do not include the correct variables (or encompass sufficient years) to provide insight into changes to state's or utility's costs over time. In addition, our review of the data used in his regressions found serious unexplained errors and inconsistencies.
- **Weak significance and a lack of robustness in regression findings:** Stevie's overall model significance and significance for his key variable, market penetration, appear to be sensitive to removal of problematic data entries and corrections to his misspecified functional form.
- **Purported impact of electric rates on program costs is excluded from the application of regression findings:** Stevie's regression analysis also finds a significant impact of electric rates on program costs, but this effect is excluded from the utility's projection of future efficiency costs. Our calculations suggest that including this effect on a forecasted growth of electric rates ranging from 0.7 percent per year<sup>8</sup> to 3.2 percent per year<sup>9</sup> results in a decrease in the incremental change in program costs of 4 to 20 percentage points in each year averaged across Stevie's two models. Put into context, just this countervailing effect would reduce Stevie's 0.60 percent increase in annual incremental efficiency costs for each 1 percent increase in market saturation down to 0.40 to 0.56 percent.

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<sup>8</sup> Vectren 2016 IRP Attachment 4.1

<sup>9</sup> 2016 Residential Bill Survey. Available at:

[http://www.in.gov/iurc/files/2016\\_Residential\\_Bill\\_Survey\\_Presentation.pdf](http://www.in.gov/iurc/files/2016_Residential_Bill_Survey_Presentation.pdf)

- **Averaging a coefficient from a full dataset with the same coefficient from a truncated version of the data set:** Stevie’s explanation of the inclusion of Model 2 (which excludes all data entries from 2010 and 2011) is largely rhetorical: He—without substantiation—calls this method “traditional” and notes that it is “extremely useful” because it “provides a view into the long-run since the data contains multiple points along the continuum of experience”(p.16). This approach is neither traditional nor particularly useful, and a regression of data from various states (each unique in program size, market penetration, and electric prices) in the same year in no way provides a view into the long-run and cannot be said to contain multiple points along a continuum of experience. Indeed, the extent to which those multiple data points from various states do predict future performance would be mere coincidence. Averaging the regression result of the 2012 truncation with the full dataset does have one clearly observable result: It increases the assumed addition to program costs from 0.28 percent to 0.60 percent from each 1 percent increase to market penetration.

## 5. Findings and Conclusion

Stevie asserts repeatedly in his working paper that no other study has illuminated the relationship between energy efficiency program costs and market penetration. If this is the case, then that status quo remains unchanged: Stevie’s study provides no usable evidence of such a relationship and *ipso facto* no such relationship has, as yet, been demonstrated.

This area of research is by no means purely scholarly or theoretical. To our knowledge the results of Stevie’s working paper have impacted the resource decisions proposed by electric utilities in no fewer than three states. Stevie’s analysis suggests, erroneously, that there exists evidence of energy efficiency market saturation driving up programs costs that is sufficient to justify a more than doubling of the direct cost per kWh over 20 years.

We find, in contrast, that the evidence presented in his working paper is insufficient and inaccurate. We are aware of no reliable evidence for higher energy efficiency market penetration leading to higher efficiency costs. Inclusion of a baseless inflation of efficiency program costs in the name of market saturation results in higher energy efficiency costs than would otherwise be expected in utility planning and, consequently less efficiency chosen in optimal resource planning.

# **ATTACHMENT EAS-3**

**See Excel spreadsheets**

**ATTACHMENT EAS-4-Confidential**

**See Excel spreadsheets submitted  
under seal**