

Exploring the “How To” of EV Cost-Effectiveness

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ABSTRACT

State legislation created an opportunity for AES Indiana to file with its regulator for approval and cost recovery of a suite of transportation electrification programs through an Electric Vehicle Plan (the EV Plan). Of course, regulatory approval of such a plan relied substantially on proving cost-effectiveness consistent with the jurisdiction’s regulatory rules and practices. The approach to cost-effectiveness (benefit-cost analysis or BCA) for the filing was to examine how principles embodied in the National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources (NSPM) may come to bear and then conduct the standard California Standard Practice Manual for Economic Analysis of Demand-Side Programs and Projects (CSPM) tests as informed by the NSPM.^{1,2} Although the CSPM addresses fuel substitution programs, the last time it was significantly updated in 2001 Elon Musk was six years into his U.S. residency and focused on software and digital finance – electric vehicles were not yet “a thing.” Therefore, although the mathematics of the CSPM tests are straightforward, the input parameters required to assess conversion from internal combustion engine (ICE) vehicles to electric vehicles (EV) are not. For this reason, the NSPM and its principles, fully fleshing out the Resource Value Framework, and full consideration of non-energy impacts, became a critical reference to think through to inform and modify the approach to conducting the CSPM tests.

The paper will quickly introduce the AES context and summarize the CSPM and NSPM background, then focus on what input parameters were developed for the cost-effectiveness testing exercise, and how.

Background

On March 3, 2022, the Indiana House passed House Bill 1221, “An Act to amend the Indiana Code concerning utilities,” as amended by the Senate in February (HEA 1221).³ More commonly known as the “electric vehicles and electricity pricing” bill, the Act was codified in Ind. Code (IC) Ch. 8-1-43 (Chapter 43) and Ch. 8-1-2.5 (Chapter 2.5). The Taft Law Firm, a national law firm with significant focus on energy and having offices in Indianapolis, IN, summarized HEA 1221 at a high level as follows: “HEA 1221 will enable pilot programs that will allow companies to understand best practices for electric vehicle deployment in the state. The pilots will provide the necessary data for stakeholders to refine how to best move forward with these programs in Indiana.”⁴

In deciding to pursue an EV program portfolio, AES Indiana considered both the EV-specific provisions of Chapter 43 and the ratemaking provisions of Chapter 2.5. Chapter 43 allows electric utilities to request approval from the Indiana Utility Regulatory Commission (Commission or IURC) to implement a Public Use EV Pilot Program. Chapter 43 sets forth requirements for these pilot programs and factors for the Commission to consider in approving such a pilot program. Chapter 2.5, the “Alternative Utility Regulation statute,” expressly allows the Commission to approve time-varying pricing structures and tariffs, as well as other alternative pricing structures and tariffs.⁵ AES structured its EV Plan as identifying some programs as developed considering Chapter 43 (the Public Use programs) and consistent with Chapter 2.5 (the alternative rates, tariffs, and pricing structures programs). The Plan was approved by IURC on November 22, 2023.

¹ <https://www.nationalenergyscreeningproject.org/national-standard-practice-manual/>

² https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpuc_public_website/content/utilities_and_industries/energy_-_electricity_and_natural_gas/cpuc-standard-practice-manual.pdf

³ <https://iga.in.gov/legislative/2022/bills/house/1221/details>

⁴ <https://www.taftlaw.com/news-events/law-bulletins/2022-indiana-legislative-wrap-up/>

⁵ See generally pp 6-7 of the testimony of Zac Elliott, AES Sr. Director of Customer Solutions, at:

https://iurc.portal.in.gov/_entity/sharepointdocumentlocation/013046ea-799e-ed11-aad0-001dd8070a7e/bb9c6bba-fd52-45ad-8e64-a444aef13c39?file=_AESIN_Elliott%20Direct%20Testimony_012723.pdf

The term “public use” is not always recognized or commonly understood so inclusion of some specific verbiage on the term, how the law defines public use, and the nature of EV pilots for which utilities may seek approval, all from Chapter 43, has merit.

Public Use

“[P]ublic use EV” means any of the following electric vehicles that is used primarily to serve the public, regardless of whether the electric vehicle (or any associated charging infrastructure) is owned, leased, or operated by, or on behalf of, a governmental or private entity:

- (1) An electric school bus.
- (2) An electric transit bus.
- (3) An electric vehicle that is used by a public or private commercial enterprise primarily to deliver goods or services to the public.”⁶

Public Use EV Pilots

"public use electric vehicle pilot program", or "pilot program", means a limited deployment of:

- (1) charging infrastructure, or
- (2) make-ready infrastructure

that is designed to evaluate the feasibility and design, including the associated costs and benefits, of a larger scale deployment of such infrastructure necessary to support public use electric vehicles.”⁷

Nature of Public Use EV Pilots

“An electric utility may request approval from the commission to implement a public use electric vehicle pilot program to do any of the following:

- (1) Install, own, or operate charging infrastructure or make-ready infrastructure to support public use EVs.
- (2) Provide incentives or rebates to customers to encourage customer investment in public use EVs and in associated EV supply equipment.”⁸

The Portfolio

Referencing Chapter 43, the proposed portfolio included four Public Use EV pilots:

- Bi-directional Charging Pilot: This pilot program will test vehicle-to-grid (V2G) integration and bi-directional power flow with select customers in AES Indiana’s service territory.
- Fleet Solutions: This pilot program will provide planning and advisory services to customers who are transitioning their fleets from traditional fuels to Public Use EVs.
- EVSE Rebates: This pilot program will provide rebates to encourage customer investment in Level 2 and direct current fast charging (DCFC) equipment (EVSE or electric vehicle supply equipment) to serve Public Use EVs.
- EVSE Rebates for Disadvantaged Communities: This program dedicates funds to help ensure that all customers within AES Indiana’s service area have convenient access to charging infrastructure, including in areas that are economically distressed or racially or ethnically diverse.

⁶ IC 8-1-43-6

⁷ IC 8-1-43-7

⁸ IC 8-1-43-8(a)

Turning to Chapter 2.5, the proposed portfolio of alternative rates, tariffs, and pricing structures programs included three residential programs and four commercial and industrial (C&I) programs

Residential:

- Residential Managed Charging: This alternative pricing structure provides incentives to residential customers for allowing AES Indiana to curtail their EV charging during peak hours.
- Off-Peak Incentive: This time-varying pricing structure provides incentives for customers to self-manage their load during peak hours.
- Rate EVX: AES Indiana proposes to close this time-of-use tariff to new participants and instead offer new participants the opportunity to participate in the proposed Managed Charging or Off-Peak Incentive offerings.

C&I, including government/public facilities:

- C&I Managed Charging: This alternative pricing structure provides incentives to C&I customers for allowing AES Indiana to curtail their EV charging during peak hours.
- Rate EVP: This flat-rate per charging session rate would be charged to drivers using AES Indiana-owned Level 2 charging infrastructure.
- Rate DCFC: This alternative rate would provide a new, market-based rate that would be charged to drivers using AES Indiana-owned DCFC charging infrastructure.
- Tariff EVSE: This voluntary, participant-funded alternative tariff will provide charging infrastructure to participating customers for a fixed, monthly fee.

Note that through the course of the proceeding, a Bi-Directional Charging Pilot was deemed too novel and withdrawn from consideration. Therefore, it will not be discussed at length any further.

All programs were proposed as a standalone portfolio, however, explicitly noted as complementing the existing portfolio of energy efficiency (EE) programs. Thematically, and thinking about HEA 1221, AES asserted to its regulator, “AES Indiana has a unique opportunity to address core system reliability and manage rate impact by shaping the associated charging energy and demand in a cost-effective manner.”⁹

Approach to Cost-Effectiveness

Before developing the BCA filed in support of each of the programs in the proposed and ultimately approved portfolio, AES and MCR first reviewed each proposed program to identify whether any of them were not appropriate or feasible to be tested for cost-effectiveness. Because the Bi-Directional Charging Pilot, a vehicle-to-grid pilot, was at the time (2022) so nascent that few, if any, reliable assumptions and inputs to cost-effectiveness testing could be credibly made or developed, no attempt was made to conduct cost-effectiveness testing. Rather, AES decided to include the pilot only if the estimated costs could cost-effectively be borne by the benefits of the remaining pilot programs tested; again, the pilot was ultimately removed from the portfolio in settlement negotiations. In addition, because they are retail rates, not programs, the Rate EVP and Rate DCFC pilots were excluded from cost-effectiveness testing. The pilots subjected to cost-effectiveness testing were:

- Residential Managed Charging
- (Residential) Off-Peak Incentive
- C&I Managed Charging

⁹ See p. 10 of the testimony of Zac Elliott, AES Sr. Director of Customer Solutions, at: https://iurc.portal.in.gov/_entity/sharepointdocumentlocation/013046ea-799e-ed11-aad0-001dd8070a7e/bb9c6bba-fd52-45ad-8e64-a444aef13c39?file=_AESIN_Elliott%20Direct%20Testimony_012723.pdf

- EVSE Rebates
- EVSE Rebates for Disadvantaged Communities
- Fleet Solutions
- Bi-directional Charging Pilot
- Tariff EVS

To conduct cost-effectiveness testing for EV and EVSE, myriad assumptions and directional choices were required since utility intervention in the EV and EVSE markets is distinct from traditional energy efficiency and demand response interventions. With EV and EVSE, we ask not “How much load can we take off the system and customer bills?” but rather “How do we optimize the additional load that will be added to the system and customer bills?” This is an important shift, and it required AES and MCR to come to agreement on many aspects of characterization and quantification, that is the data elements to be included and the basis for them.

Economic assessment of EV and EVSE programs based solely on the traditional primary reference for energy efficiency cost-effectiveness, and the one prescribed as to be the basis for EE cost-effectiveness testing in Indiana, the CSPM, was not entirely appropriate. The emergence and rapid embrace by regulators and energy, environmental, and social justice advocates of the NSPM-DER made it an appropriate resource for thinking through how AES might address many of the issues associated with conversion from ICE vehicles to EV. The NSPM-DER focuses on broadening the lens through which cost-effectiveness is considered—from an energy-only perspective to a holistic one—based on explicit acknowledgement of, and alignment with, the policy drivers in play, the full range of costs and benefits, and symmetrical treatment of costs and benefits.

Honoring standard practice in Indiana, use of the CSPM, the tests ultimately conducted for the AES EV portfolios were the Total Resource Cost (TRC) Test, Societal Cost Test (SCT), Participant Cost Test (PCT), and Rate Impact Measure (RIM) Test as described in the CSPM and Appendix 1 here. However, consideration of the NSPM led to a revision of the specific data elements to be included in quantifying the costs and benefits of EV and EVSE programs.

Referencing the CSPM, the specific equations calculated were:

Total Resource Cost Test¹⁰

TRC Benefit-Cost Ratio = BTRC/CTRC

$$BTRC = \sum_{t=1}^N \frac{UAC_t + TC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{UAC_{at} + PAC_{at}}{(1+d)^{t-1}}$$

$$CTRC = \sum_{t=1}^N \frac{PRC_t + PCN_t + UIC_t}{(1+d)^{t-1}}$$

Equation 1: TRC

Societal Cost Test¹¹

Note that the SCT uses the same equation as the TRC, but with materially different inputs, costs, and benefits.

SCT Benefit-Cost Ratio = BTRC/CTRC, with externalities included

¹⁰ Equation is from p. 22 of CSPM

¹¹ Ibid

$$BTRC = \sum_{t=1}^N \frac{UAC_t + TC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{UAC_{at} + PAC_{at}}{(1+d)^{t-1}}$$

$$CTRC = \sum_{t=1}^N \frac{PRC_t + PCN_t + UIC_t}{(1+d)^{t-1}}$$

Equation 2: SCT

Participant Cost Test¹²

Participant Cost Test Benefit-Cost Ratio = BP/CP

$$BP = \sum_{t=1}^N \frac{BR_t + TC_t + INC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{AB_{at} + PA_{at}}{(1+d)^{t-1}}$$

$$C = \sum_{t=1}^N \frac{PC_t + BI_t}{(1+d)^{t-1}}$$

Equation 3: PCT

Rate Impact Measure Test¹³

Note that the NSPM strongly asserts that RIM answers entirely different questions than BCA and thus should not be used in BCA, rather elsewhere.

RIM Benefit-Cost Ratio = BRIM/CRIM

$$B_{RIM} = \sum_{t=1}^N \frac{UAC_t + RG_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{UAC_{at}}{(1+d)^{t-1}}$$

$$C_{RIM} = \sum_{t=1}^N \frac{UIC_t + RL_t + PRC_t + INC_t}{(1+d)^{t-1}} + \sum_{t=1}^N \frac{RL_{at}}{(1+d)^{t-1}}$$

Equation 4: RIM

Digging into the CSPM sections for each of the tests, the various terms of the equations are defined as:

(1 + d) (1 + d) terms reflect the fact that the tests all consider present values over the estimated useful life of the measures at a discount rate of d

Subscript t References the time period

Subscript at References the alternate fuel

BR Bill reductions experienced by the participant

¹² Ibid, 10

¹³ Ibid, 16

TC	Tax credits received by the participant
INC	Incentives paid to participants
AB	Avoided bills experienced by participants related to alternate fuels
PA	Participant avoided costs associated with measures not chosen
PAC	Participant avoided costs for the fuels not chosen
PC	Participant costs
BI	Bill increases experienced by the participant
UAC	Utility avoided supply costs
UIC	Utility incremental supply costs
RG	Revenue gain to the utility from increased sales
RL	Revenue loss to the utility from decreased sales
PRC	Program costs to the program administrator
PCN	Net participant cost

Cost-Effectiveness Inputs

Given the nature of the EV Plan portfolio, and on behalf of AES, MCR utilized the Beneficial Electrification variant of its Local Energy Efficiency Planning (LEEP-BE) model to conduct the cost-effectiveness testing of the portfolio. Beyond the cost, benefit, and avoided cost, rate, and economic data typically found as inputs to EE cost-effectiveness models, for an EV portfolio, LEEP-BE was configured with numerous additional inputs, largely informed by the NSPM's pillars of policy alignment, non-energy impacts, and cost/benefit symmetry. The inputs included in LEEP-BE for EV cost-effectiveness included:

- CIAC (contribution in aid of construction), or the share of costs related to required infrastructure investment to be borne by the customer.
- Fossil fuel prices, to enable development of energy cost savings to the customer, and at the wholesale level. when switching from ICE vehicle(s) to EV.
- Heat content of Fuels, to enable development of gasoline, diesel fuel, and electricity equivalents for a given number of miles driven.
- Carbon Dioxide values, including pounds per gallon of gasoline and diesel fuel, pounds per mile driven for electricity, and the social cost of carbon.
- Vehicle purchase and annual operations and maintenance (O&M) costs, annual miles driven, and fuel (electricity) efficiency for various classes of vehicle, which for the AES analysis included light duty, medium duty, heavy duty, and bus.
- Federal tax credits, which for the AES analysis were those related to the Infrastructure Investment and Jobs Act (IIJA or BIL – Bipartisan Infrastructure Law).¹⁴
- EVSE (charger) costs, capacity and charging energy load shapes, efficiency, ports per station, and vehicles (by type) serviced by each port.

The full complement of inputs and data assumptions was tabulated in Exhibit EJS-1 of the AES filing (Indiana Utility Regulatory Commission Cause #45843) as follows:

¹⁴ AES articulated on page 17 of the testimony of Edward J. Schmidt, Jr. of MCR on their behalf (https://iurc.portal.in.gov/_entity/sharepointdocumentlocation/b6bbe36-7a9e-ed11-aad0-001dd8070a7e/bb9c6bba-fd52-45ad-8e64-a444aef13c39?file=_AESIN_Schmidt%20Direct%20Testimony_012723.pdf) that inclusion of any provisions or considerations related to the Inflation Reduction Act, or IRA, was premature.

Topic	Term	Value
AESI Line Loss Rate	Combined energy (kWh) and demand (kW)	5.4%
Inflators/Deflators	Inflation	2.16%
	AES weighted cost of capital	6.65%
	Societal discount rate	3.43%
Infrastructure Cost Share	C&I customer cost share	40%
Peak kW Coincidence	Percent of rated kW occurring in the peak billing period	62.50%
Estimates Useful Life (yrs.)	Average of vehicles and chargers	12

Table 1: Economic Inputs

Topic	Term	Value
AESI Retail Rates	Average residential \$/kWh	\$0.1249
	Average C&I \$/kWh	\$0.1315
Fossil Fuel Rates	Gasoline – retail	\$3.81
	Diesel – retail	\$5.51
	Avoidable percentage of retail	92.00%
Heat Content of Fuel	Gasoline BTU/gallon	120,286
	Diesel BTU/gallon	137,381
	Electricity BTU/kWh	3,412
Carbon (CO ₂) Content	Gasoline lbs./gallon	19.37
	Diesel lbs./gallon	22.46
	EV lbs./mile	0.4851
	Social cost of carbon (\$/ton)	\$51.00

Table 2: Fuel and Emissions Inputs

Topic	Term	Value
Vehicle Cost	Light duty fossil	\$46,329
	Light duty electric	\$55,600
	Medium duty fossil	\$50,000
	Medium duty electric	\$67,000
	Heavy duty fossil	\$130,000
	Heavy duty electric	\$220,000
	Bus fossil	\$85,000
	Bus electric	\$125,000
Federal Tax Credit	Residential EV	\$1,567
	Commercial EV	30.00%
Vehicle Miles	Light duty miles/year	14,278
	Medium duty miles/year	23,725
	Heavy duty miles/year	80,550
	Bus miles/year	43,800
Vehicle Efficiency	Light duty fossil miles/gallon	24
	Light duty electric kWh/mile	0.3260
	Medium duty fossil miles/gallon	13
	Medium duty electric kWh/mile	0.5000
	Heavy duty fossil miles/gallon	9
	Heavy duty electric kWh/mile	1.2500
	Bus fossil miles/gallon	7
Vehicle Operation & Maintenance Cost (excludes tires)	Light duty fossil cost/mile	\$0.0610
	Light duty electric cost/mile	\$0.03110
	Commercial fossil cost/mile	\$0.1700
	Commercial electric cost/mile	\$0.1200

Table 3: Vehicle-Related Inputs

Topic	Term	Value
Charger Costs	Level 1 – equipment	\$300.00
	Level 1 – installation	\$0.00
	Level 2 (res.) – equipment	\$700.00
	Level 2 (res.) – installation	\$1,500.00
	Level 2 (C&I) – equipment	\$6,000.00
	Level 2 (C&I) – installation	\$4,000.00
	Level 3 (DCFC) – equipment	\$50,000.00
	Level 3 (DCFC) – installation	\$50,000.00
Charger Efficiency	Level 1	85.00%
	Level 2	95.00%
	Level 3 (DCFC)	99.00%
Charger kW/port	Level 1	1.80
	Level 2	7.20
	Level 3 (DCFC)	150.00
Ports per Charger	Level 1	1
	Level 2 (res.)	1
	Level 2 (C&I)	2
	Level 3 (DCFC)	4
Vehicles Served per Port	Level 1	1
	Level 2 (res.)	1
	Level 2 (C&I)	2
	Level 3 (DCFC)	2

Table 4: Charger and Charging Inputs

Of course, AES avoided costs were also a key input to the LEEP-BE model.

Sources for the data were a mix of AES-provided data and publicly available sources as identified in Exhibit EJS-1 of IURC Cause 45843.

Further Defining Specific Costs and Benefits

While determining the appropriate inputs to the LEEP-BE model, and their values, represented one set of challenges, assumptions and methodological choices were another important set of challenges. Wrestling with inputs, assumptions and methodological challenges comes down to the question of, “How are you going to calculate (solve) the CSPM equations?” This gets to the art of BCA and the reality that qualified practitioners looking at the same situation may very well do things significantly differently and thus arrive at very different answers (benefit-cost ratios, etc.). This is especially true considering NSPM imperatives to align with policy and to maintain cost and benefit symmetry.

Revisiting Tables EJS 1-1 through EJS1-4 from the testimony, and thinking though these various inputs, leads to the following costs and benefits that were applied to calculate the TRC, SCT, PCT, and RIM benefit-cost ratios and net benefits, along with commentary in general and how each was incorporated in MCR’s analysis for AES and its EV Plan filing.

Program Administration (overheads)

This input represents all program-related costs other than rebates and other incentives incurred by the utility in running a program. It was treated as a cost, part of the denominator, in the TRC, SCT, and RIM tests.

Utility Incentives

This input represents dollars provided to the customer, whether directly or indirectly, by the program. It was treated as a cost, part of the denominator, in the RIM test and a benefit, part of the numerator, in the PCT.

Note that for the off-peak incentive and managed charging programs, in addition to one-time enrollment or upgrade (from Level 1 to Level 2 or Level 3 (direct current fast chargers or “DCFC”) chargers as required by the programs) purchase incentives, there is a recurring participation and/or performance incentive that was included as the present value of the stream of the recurring incentives over the duration of participation. MCR modeled this as a fixed amount per participant in each of the 12 years assumed as the average measure life of an EV and EVSE, discounted at the weighted average cost of capital.

Vehicle Supply Equipment

This input represents the incremental cost of EVSE acquired by the participant. It was treated as a cost, part of the denominator, in the TRC, SCT, and PCT.

Note that in the programs in the AES EV Plan, some participants were assumed to enter the program with the required type (level) of charger, some were incentivized to upgrade from Level 1 chargers to Level 2, and some were incentivized to upgrade from Level 2 chargers to Level 3.

Vehicle First Cost

This input represents the incremental cost of an EV versus an ICE vehicle of comparable vehicle class, net of tax incentives (if any). It was treated as a cost, part of the denominator, in the TRC, SCT, and PCT.

Note that netting out the tax incentives was done for modeling convenience.

Note also that for the non-residential programs determination of vehicle first costs required development of a split of participating vehicles between light duty, medium duty, heavy duty, and busses.

Finally, note that to maintain cost and benefit symmetry, and in light of the nascency of the technologies, the incremental cost of an EV versus an ICE vehicle was included in all tests for all participants.

Vehicle O&M

This input represents the cost savings to maintain an EV versus an ICE vehicle, exclusive of tires. It was treated as a benefit, part of the numerator, in the TRC, SCT, and PCT.

Note that data availability dictated that AES consider only light duty O&M costs per mile and commercial vehicle O&M costs per mile.

Note also that O&M is an annual figure and was therefore included as the present value of the stream of O&M costs over the duration of participation. MCR modeled this as over the 12-years assumed as the average measure life, discounted at the weighted average cost of capital for the TRC and PCT, and at the societal discount rate for SCT.

Vehicle Fuel (Energy) Cost

This input is complex in that its treatment varies within the cost-effectiveness tests. In the TRC and SCT that portion of fuel costs avoided at the wholesale level was treated as a benefit.¹⁵ For the PCT, the incremental cost of electricity was treated as a cost and the avoided cost of fuel at retail was treated as a benefit.

Note that fuel (energy) costs are an annual figure and were therefore included as the present value of the stream of fuel (energy) costs over the duration of participation. MCR modeled this as over the 12-year

¹⁵ Only that portion of retail fuel prices that is the cost of fuel to the retailer, plus fuel taxes paid at retail, were considered avoidable since the remaining portion of the retail price is fixed.

assumed as the average measure life, discounted at the weighted average cost of capital for the TRC and PCT, and at the societal discount rate for SCT.

Utility Avoided Costs

This input represents the avoided energy (in the peak and off-peak periods in the summer, winter, and shoulder seasons), capacity, and transmission and distributions costs of kWh and kW not required to be produced and delivered by the utility due to the impact of actively or passively (price signals) managed charging and upgraded (Level 1 to 2 or Level 2 to 3) chargers, where upgrade from Level 2 to 3 brings energy (kWh) savings but increases demand (kW). It was treated as a benefit, part of the numerator, in the TRC, SCT, and PCT

Note that avoided cost is an annual figure and was therefore included as the present value of the stream of avoided costs over the duration of participation. MCR modeled this as over the 12-year assumed as the average measure life, discounted at the weighted average cost of capital for the TRC and PCT, and at the societal discount rate for SCT.

Utility Infrastructure Cost

This term represents the incremental costs to the utility of infrastructure required to provide charging capacity and energy to participants. CIAC was treated as a cost, part of the denominator, in the PCT, and the remainder of utility infrastructure costs was treated as a cost in the RIM test.

Note that AES only proposed to levy CIAC for commercial and industrial customers in other than disadvantaged communities.

Note that, methodologically, since avoided costs essentially represent reduced marginal costs, AES and MCR decided to use the inverse of avoided costs as the incremental utility infrastructure cost.

Carbon Dioxide Emissions

This term represents the reduction in CO₂ emissions for an EV versus a comparable ICE vehicle. It was treated as a benefit, part of the numerator, in the TRC and SCT.

Note that avoided CO₂ emissions is an annual figure and was therefore included as the present value of the stream of avoided CO₂ emissions over the duration of participation. MCR modeled this as over the 12-year assumed as the average measure life, discounted at the weighted average cost of capital for the TRC and at the societal discount rate for SCT.

Note MCR monetized CO₂ using the social cost of carbon as referenced by the US government in the fall of 2022.

Utility Revenue

This term represents the increase in electric revenue due to the charging loads of EV versus comparable ICE vehicles. It was treated as a benefit, part of the numerator, in the RIM test.

Note that incremental electric revenue is an annual figure and was therefore included as the present value of the stream of incremental revenues over the duration of participation. MCR modeled this as over the 12-year assumed as the average measure life, discounted at the weighted average cost of capital.

Conclusion

EV charging is already having an impact on some electric utilities and can be expected to impact virtually all electric utilities in the future as the percentage of vehicle fleet in service that is electric grows. AES Indiana seized an opportunity, created by state legislation, to pilot several EV and EV charging programs to gain

quantitative and qualitative insight into what the impacts would be and how to manage them. However, even as pilots, cost-effectiveness analysis consistent with precedent, rule and the expectations of the regulator was required. MCR and AES collaborated closely to translate existing program designs and budgets into the data required to use four of the five CSPM tests, modified for ICE to EV conversion by applying principles from the NSPM. Ultimately, the AES Indiana EV Plan received regulatory approval and remains active today. Since such cost-effectiveness testing is truly “plowing new ground,” even after standing up to extensive discovery in the regulatory proceeding and receiving approval from the regulator, it remains fair to ask of the cost-effectiveness analyses, “What was done right, what was done wrong, and what could/should have been done differently?”

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APPENDIX 1: CSPM Tests Conducted

The **Total Resource Cost Test, or TRC**, quantifies the costs and benefits of utility energy efficiency, demand response, or fuel substitution interventions (i.e., programs). When applied to a fuel substitution program such as those supporting adoption of EV, the CSPM identifies the TRC as follows: “the test measures the net effect of the impacts from the fuel not chosen versus the impacts from the fuel that is chosen as a result of the program.” (p. 18).

The **Societal Cost test, or SCT**, quantifies the costs and benefits of a utility energy efficiency, demand response, or fuel substitution intervention (i.e., program) from the perspective of society as a whole. The CSPM identifies the SCT as “a measure of the economic efficiency implications of the total energy supply system” (p. 18). It is often recognized as a variant of the Total Resource Cost test that adds to that test monetized non-energy impacts and applies a different, lower, discount rate to present value calculations

The **Participant Cost Test, or PCT**, quantifies the costs and benefits of a utility energy efficiency, demand response, or fuel substitution intervention (i.e., program) from the perspective of utility customers who participate in the program (“participants”). The CSPM identifies the PCT as “a measure of the quantifiable benefits and costs to the customer due to participation in a program” (p. 8) while cautioning that it only addresses quantifiable factors, but consumers make decisions in large part on non-quantifiable ones.

The **Rate Impact Measure, or RIM, test** is also known as the “non-participants” test because it quantifies the costs and benefits of a utility energy efficiency, demand response, or fuel substitution intervention (i.e., program) from the perspective of utility customers who do not participate in the program (“non-participants”). The CSPM identifies the RIM as a measure of “what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program” (p. 13).