**Market Transformation ESRPP Evaluation Protocol - DRAFT**

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# Purpose and Introduction

## Purpose

This protocol provides guidance on the data inputs and methods used to evaluate the ENERGY STAR® Retail Products Platform (ESRPP) market transformation initiative, as required in Attachment C. The procedures outlined in this protocol are based on the ongoing evaluation of ESRPP within the ComEd territory.

## Introduction

ESRPP is a national market transformation initiative, and a collaborative effort of ENERGY STAR, efficiency program sponsors, retail partners, and stakeholders facilitated by the Northwest Energy Efficiency Alliance (NEEA)[[1]](#footnote-2). Coordinating with EPA ENERGY STAR, the platform works directly with corporate-level national retailers to provide mid-stream incentives on qualified energy-efficient products. These incentives influence retail buying and stocking practices, to ultimately drive manufacturing and higher product standards and specifications for a portfolio of energy-efficient products sold through the retail channel. In addition to incentives, NEEA and ESRPP Program Sponsors support development of new products, improve test procedures and advance efficiency standards.

This protocol covers five areas of the ESRPP evaluation.

1. Program Theory, Logic Model, and Market Progress Indicators.
2. Data Sources and Cleaning
3. Natural Market Baseline
4. Unit Energy Savings
5. Annual Savings

Not all aspects of anticipated evaluation activities are finalized as of the publication of this protocol. During CY2022, ComEd’s evaluation team is convening an expert judgement panel to address several critical research questions covering the following topics:

* Natural market baselines for targeted configurations of refrigerators and clothes washers.
* If Illinois retailers are representative of the broader market.
* The similarity between participating and non-participating retailers.
* The influence of downstream programs on the natural market baseline.

The findings from the expert judgement panel and additional evaluation activities should be integrated into this protocol. Additions and modifications to this protocol will be made on an annual basis to ensure that the most recent updates and strategies are described.

# Program Theory and Logic Model

The ComEd ESRPP logic model[[2]](#footnote-3) provides the relationships and connections between the program activities and the anticipated market changes for each product category, separately. These market changes can be observed over short, medium and long term. The logic model for ESRPP includes the connections between the initiative activities, their expected outputs, and the anticipated future outcome. The current ESRPP logic model is shown in Table 1.

Evidence of a program’s influence on its target market is gathered through an assessment of market progress indicators (MPIs) designed to assess whether the program is achieving its intended outcomes. The MPIs for the ESRPP assess progress toward outcomes such as growing the national scale of the program, influencing retailer assortment and sales of qualified products, and influencing ENERGY STAR specifications, test procedures, and Federal standards for products in the ESRPP portfolio. The list of MPIs for ESRPP is shown in Table 2.

|  |
| --- |
| **Manufacturers respond to market changes and build EE into product design, creating permanent change to their process that results in energy savings** **IMPACT**What is the final state of the market after it has transformed?**Mid-Term**We expect that if completed or ongoing, these activities will lead to the following changes in 3-5 years.**Long-Term**We expect that if completed or ongoing these activities will lead to the following changes in 3-5 years.**Outcome X: Change in federal minimum standards for RPP categories****Outcome VIII: Data management system builds sufficient trust with retailers so that access to data is no longer a barrier****Outcome V: Retailers and merchants incorporate incentives into their assortment and marketing decision-making process****Outcome VII: Reliable per unit energy savings values for RRP product categories****Market’s Response****Lack of access to full category sales data inhibits ability to influence formal specification/ standards process and allow for informed program decisions****Participate in extra-regional coordination efforts with program sponsors and retailers to increase program scale****Benefits of energy savings are too small to highly impact most consumers’ choices****Manufacturers are unlikely to respond outside of specification and standards process to increase EE of consumer products****EE is not considered strongly enough by corporate retail buyers****Develop and implement a data management system and market intelligence process for use in program design and related decisions****Develop and execute a portfolio management process that includes protocols for efficiency tiers and on/offboarding of products****Work jointly with market actors to influence specifications, standards, and test procedures****Validated portfolio management process and product strategy documents****Data platform with participating retailer sales data and analysis results****Comment letters supporting changes to codes, standards, specifications, and test procedures****Increase in the number of participating program sponsors and retailers****Barriers****Activities**In order to address our problem or asset, we will conduct these activities**Outputs**We expect that once completed or under way these activities will produce the following evidence**Outcomes****Short-Term**We expect that if completed or ongoing, these activities will lead to the following changes in 1-3 years.**Outcome IV: Reliable market share and portfolio management informs program design and evaluation****Outcome Ill: Data Platform enables effective program operations processes****Outcome Il: ENERGY STAR data and federal test procedures better reflect real world energy consumption****ENERGY STAR® Retail Products Platform Logic Model****Outcome Vl: Increase in ENERGY STAR (or higher tiers) market share for RPP product categories** **Participating retailers are aware of specifications and incentives and receive incentives for selling qualifying products and providing data****Recruit, engage, and provide incentives to retailers****Outcome I: Program achieves sufficient scale of program sponsors, customers, and incentives budgets to influence retailer decision-making****Outcome IX: Increase in ENERGY STAR (or higher tiers) qualifying criteria for RPP product categories****ComEd’s Role****INITIATIVE** Retail Products Platform**PREPARED BY** NEEA**LAST REVISION** Nov. 15, 2021 by Guidehouse**APPROVAL STATUS** Draft |

Table . ENERGY STAR® Retail Products Platform Logic Model

Table . Market Progress Indicators

| Outcome (Timing) | Outcome | Market Progress Indicator | 2020-2023 Target | Data Sources |
| --- | --- | --- | --- | --- |
| I (S) | Program **achieves sufficient scale** of program sponsors, customers, and incentive budgets to influence retailer decision-making. | Portion of US households in ESRPP areas and the related total value of all program sponsor incentive budgets.  | Portfolio-level target:Program represents 25% of nationwide customers and program sponsor incentive budgets grow proportionally. | * EIA-861 Utility Dataset
* ESRPP program documents
 |
| II (S) | ENERGY STAR data and federal **test procedures better** **reflect** real world energy consumption. | 1. Number of products for which RPP provides data to ENERGY STAR
2. Number of products for which test procedures are improved
 | Product-level targets:1. Data provided to ENERGY STAR for two products
2. *There are unlikely to be opportunities to influence federal test procedures for products in ComEd’s RPP portfolio in 2020-2023. We will continue to monitor.*
 | * Longitudinal tracking of RPP engagement with ENERGY STAR revision process (MPI 1)
* DOE rulemaking documents (MPI 2)
 |
| III (S) | Data platform enables **effective program operations processes.** | 1. Data access and accuracy are sufficient to support product-by-product analysis and participation in the ENERGY STAR specification process.
2. Speed with which incentives are paid
3. Number of corrections or data errors
4. Program sponsor confidence in program operations process
 | Portfolio-level target:1. Data access and accuracy continue to be sufficient to support participation in the ENERGY STAR specification process.
2. Incentives are paid on time
3. Correction/data error rates are low
4. All program sponsors report confidence in the program operations process.
 | * Longitudinal tracking of data quality indicators available through the data portal (MPIs 1-3)
* Longitudinal tracking of RPP engagement with ENERGY STAR revision process (MPI 1)
* Qualitative evidence from ENERGY STAR stakeholder interviews (MPI 1)
* Quantitative evidence from program sponsor interviews (MPI 4)
 |
| IV (S) | **Reliable market share** **and** **portfolio management** informs program design and evaluation. | 1. Efficient and transparent portfolio management process
2. Annual savings process and evaluation are efficient and verifiable.
 | Portfolio-level target:1. Portfolio management process continues to be efficient and transparent.
2. Annual savings process and evaluation work are conducted efficiently and can be verified.
 | * Quantitative evidence from program sponsors interviews (MPIs 1-2)
* Quantitative evidence from RPP staff interviews (MPIs 1-2)
 |
| V (S/M) | Retailers and merchants **incorporate incentives into their assortment and marketing** decision-making process. | Retailer consideration of ESRPP qualification in assortment and marketing decisions | Portfolio-level target:All retail partners report using incentives to inform product decisions. | * Quantitative evidence from retailer interviews
* Quantitative evidence from RPP staff communication
* Quarterly presentations and information provided by retailers to ESRPP
 |
| VI (S/M) | Increase in ENERGY STAR (or higher tiers) **market share** for RPP product categories at Participating and Non-Participating Retailers | Market share ESRPP qualified product tiers  | Product-level targets:Measurable increase in market share for at least one product (Note: this shift could have a different pace among different products.) | * Longitudinal tracking of market share and product assortments
* Web scraping of retailer web sites
 |
| VII (M) | Reliable **per-unit energy savings** value for RPP product categories | Number of product categories (bins, tiers, configurations) with reliable energy savings values | Product-level targets:All active products in portfolio have reliable energy savings values. | Longitudinal tracking of measure planning documentation and methodologies |
| VIII (M) | Data management system builds sufficient trust **with retailers** that access to data is no longer a barrier. | 1. Timeliness and completion of retailer uploads
2. Retailer confidence in data warehousing
 | Portfolio-level target:1. Retailer uploads continue to be timely and complete.
2. All retailers report confidence in data warehousing and their contract extensions continue on schedule each year.
 | * Longitudinal tracking of data quality indicators available through the data portal (MPI 1)
* Quantitative evidence from retailer interviews (MPI 2)
* ESRPP program documents (MPI 2)
 |
| IX (M/L) | Increase in **ENERGY STAR** (or higher tiers) **qualifying criteria** for RPP product categories | Number of products for which ESRPP influences an increase in ENERGY STAR (or higher tiers) qualifying criteria apart from expected updates | Product-level targets:*2 ENERGY STAR revision process are expected to begin in 2020-2023 for products in ComEd’s portfolio. We will continue to monitor.* | * Longitudinal tracking of RPP engagement with ENERGY STAR revision processes (MPI 1)
* Qualitative evidence from ENERGY STAR stakeholder interviews (MPI 2)
 |
| X (L) | Change in **federal minimum standards** for RPP categories | ESRPP sponsors inform federal minimum standards for product categories in the portfolio. | Product-level targets:*2 federal standard revision processes are expected to begin in 2020-2023 for products in ComEd’s portfolio. We will continue to monitor.* | Longitudinal tracking of RPP engagement with federal standard revision processes |

# ESRPP Data and Cleaning

There are a variety of data sources required to evaluate ESRPP. The most significant is the data from the national ESRPP sales portal. All program sponsors have access to the monthly sales data from participating retailers in their territory via a data portal that is maintained by ICF. The ESRPP sales portal provides evaluation data reports which contain most of the data required for measuring net market lift. The portal provides separate evaluation data reports for each product category. The evaluation data reports contain the following monthly data:

* Unit sales by model number
* Qualified status of model
* Per-unit incentive
* Retailer (for qualified products)
* Inputs for gross savings (energy factor, capacity, etc.)

Each of the five participating ESRPP MT program retailers provide full category sales data by model number for each product category. The evaluation data reports include sales of each model number by month and the qualified status of each model number in that month. The monthly sales data includes 12 months of pre-program sales data as well as sales from each month the program has been active. ICF also includes the name of the retailer for incentive qualified sales but does not include retailer name for non-qualifying sales[[3]](#footnote-4).

## Data Cleaning[[4]](#footnote-5)

The data from the portal requires additional cleaning and validation to ensure that it is complete and includes the technical information required to calculate unit energy savings (UES). Model specific information should be obtained by comparing model numbers from the sales portal to model numbers in the qualified product lists (QPLs) for ENERGY STAR,[[5]](#footnote-6) the Compliance Certification Management System of the U.S. Department of Energy (DOE),[[6]](#footnote-7) and the California Energy Commission (CEC).[[7]](#footnote-8)

Each QPL has evolved over time, and historical versions of the QPLs are necessary to aggregate current and discontinued models. When a model number is present in multiple iterations of a QPL, the most recent iteration of the QPL should be used. This allows for the possibility of matching products that are no longer produced by manufacturers. In some cases, manufacturers updated the attributes for a model number. When this occurs, the values given in the most recent iteration of the QPL are assumed to be the representative values. Where there are discrepancies among the different QPL sources, the data from ENERGY STAR takes priority, filling in DOE data only when ENERGY STAR matches are unavailable, and filling in CEC data only when neither ENERGY STAR nor CEC matches are available. This prioritization order applies for all attributes except the DOE product class determination, where the DOE data source is prioritized before ENERGY STAR, and the CEC data source is still the last to be referenced.

Once product attributes are known, each model number is assigned one of three tiers based on the efficiency of the product. Table 3 shows a matrix of how the different tiers match to each of the products currently offered through the ESRPP. The product types and tiers within the program can be altered by the program sponsor each year. Evaluators should ensure that the most recent product types, configurations, and efficiency tiers are up to date.

Table . Tier Matrix for Current ESRPP Products

| **Tier** | **Refrigerators** | **Clothes Washers** |
| --- | --- | --- |
| Basic | ENERGY STAR Most Efficient, between 10% and 15% more efficient than federal standards | ENERGY STAR, up to 10% more efficient than federal standards (top-load only) |
| Advanced | ENERGY STAR Emerging Tech, at least 15 % greater efficiency than federal standards | ENERGY STAR Most Efficient, at least 10% greater efficiency than federal standards |
| Non-Qualified | All other models | All other models |

# ESRPP Natural Market Baselines

Market transformation programs aim to transform the entire market for each product category. To estimate savings for the ESRPP MT program, evaluators need to estimate the natural market baseline (NMB) across the entire market. Because the NMB estimates market shares absent any ESRPP MT program influence, the NMB represents expected market shares in both participating and non-participating retailers.

## Data for NMB Determination

The NMB calculation relies on a combination of ESRPP tracking data from participating retailers and historical reported market shares from a prior program sponsor in Wisconsin, Focus on Energy., Focus on Energy. Because the ComEd ESRPP MT initiative began in 2020, only historical data back to 2019 is available for Illinois retailers. Focus on Energy sponsored ESRPP from March 2016 – December 2018, and thus has Wisconsin data from March 2015 – December 2018. Focus on Energy’s ESRPP program ended in December 2018 and ComEd joined in June 2020, so the data series was missing monthly market shares for January through May of 2019 (since participating retailers provided 12 months of historical sales for Illinois once ComEd joined). Market shares from June through December 2019 were assumed to be representative of the entire year.

Supplementing ComEd’s ESRPP portal data with ESRPP reported market shares from Wisconsin Focus on Energy provides a more robust dataset with which to estimate market shares and control for any naturally occurring trends prior to the launch of ESRPP in Illinois. The Wisconsin data also ensures the baseline represents the Midwest regional market. The data from Wisconsin contains all the same fields as the ComEd data since it is an extraction from the same ESRPP data portal.

## Current NMB

The NMB algorithm, in its current form, is a linear forecast based on historical sales data. The actual, annual efficient market shares from 2016 through 2018 are used to derive a linear function to predict the market shares in subsequent years. Equation 1 shows the general form of the NMB that is used for both clothes washers and refrigerators.

Equation . General NMB Algorithm

$$MS\_{n}=a+ \frac{\sum\_{}^{}\left(year\_{i}-\overbar{year}\right)\left(MS\_{i}-\overbar{MS}\right)}{\sum\_{}^{}\left(year\_{i}-\overbar{year}\right)^{2}}\*year\_{n}$$

Where *MS* is the expected annual market share, *year* is the actual year, *i* indicates the years over the baseline period, and *n* is the forecasted year.

As stated in the introduction, a key research question for the expert judgement panel is to provide insight into the appropriate natural market baseline. The results from that panel will inform further refinements to this section of the protocol, which may include updates to the NMB algorithm, or future NMB market share values.

## Criteria for NMB Updates

Over time, there may be circumstances where revisions to the natural market baseline become necessary. Appendix C outlines five different criteria for what might constitute an update to the NMB, all of which are applicable to ESRPP.

* New data available. The addition of program sponsors, or new data features may show the initial forecast of market shares did not follow the actual market conditions at the time.
* New technologies. The introduction of low cost and very efficient technologies, or the inverse with extremely popular higher energy features may alter the energy consumption or characterization of a particular product category.
* Timing of Codes and Standards Change. The delay of codes and standards updates, either by government decision or economic factors.
* Revisions to ENERGY STAR specifications for a product category or configuration which is currently part of the initative.
* Expert Judgement Panel Input. The expert judgment panel slated to convene during 2022 will be asked to provide input regarding the form and trajectory of the NMB. The results of the panel will be incorporated into an updated NMB upon completion.

Updates to the NMB will be made when needed, based on the examination of ongoing sales data and MPI assessments by the evaluators. At least once per plan cycle, the evaluator should review all available data and inputs into the natural market baseline to ensure it remains applicable to the current market conditions, but updates are not required if market conditions are not substantially different from those anticipated when the most recent NMB was constructed.

# Unit Energy Savings (UES)

The unit energy savings (UES) for each model should be calculated using the TRM equations for each product category and configuration. Currently, ComEd’s ESRPP portfolio includes only clothes washers and refrigerators. UES values should be calculated for each model by taking the difference between the efficient unit energy consumption (UEC) and the federal standard UEC. Equation A‑1 is the TRM equation for clothes washer savings[[8]](#footnote-9):

Equation . TRM Clothes Washer Savings

$$∆kWh= Capacity \* (1/IMEFbase - 1/IMEFeff) \* Ncycles $$

where capacity and the efficient integrated modified energy factor (IMEFeff) are provided in the tracking data and IMEFbase and Ncycles default values are provided in the TRM.

The TRM equation for refrigerator savings provides an equation for UECs, with a default constant kWh value for each refrigerator configuration and a parameter for kWh per cubic foot of adjusted volume (volume is provided in the tracking data). UES values are based on the efficiency tier defined by the improvement over federal standard where basic tier is 10% better, CEE Tier 2 is 15% better, and emerging tech are 20% better than federal standard. Table 4 shows the baseline and efficient UEC values from the TRM for each configuration and tier combination[[9]](#footnote-10).

Table . Refrigerator Unit Energy Consumption

| **Product Category** | **New Baseline UECBASE** | **New Efficient****UECEE** |
| --- | --- | --- |
| **ENERGY STAR** | **CEE Tier 2** | **Emerging Tech** |
| 1. Refrigerators and Refrigerator-freezers with manual defrost | 368.6 | 331.6 | 313.3 | 294.9 |
| 2. Refrigerator-Freezer--partial automatic defrost | 430.9 | 387.8 | 366.3 | 344.7 |
| 3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost | 441.7 | 397.4 | 375.4 | 353.4 |
| 4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service | 517.1 | 465.4 | 439.5 | 413.7 |
| 5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service | 545.1 | 490.7 | 463.3 | 436.1 |
| 5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service | 713.8 | 651.0 | 606.7 | 571.0 |
| 6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service | 601.9 | 550.1 | 511.6 | 481.5 |
| 7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service | 652.9 | 596.1 | 554.9 | 522.3 |

# Annual ESRPP Savings

Equation A‑2 is the general equation for estimating ESRPP savings.

Equation . ESRPP Energy Savings

$$ESRPP Savings=(UES x Total Market Units)-(UES x Total Market Units\*NMB)$$

Where:

* *UES* is the difference between sales-weighted average annual kWh for program qualified models and federal baseline models
* *Total Market Units* are the total quantity of qualified model sales from participating retailers plus the estimated quantity of qualified units sold through non-participating retailers
* *NMB* is the forecast natural market baseline market share

## Sales from Non-Participating Retailers[[10]](#footnote-11)

National shipments data from the Association of Home Appliance Manufacturers (AHAM) should be used to estimate non-participating retailer sales that occur within the utility service territory outside of the participating retailers. *Non-Program Sales* are estimated by Equation 3:

Equation 3. Non-Program Sales

$$NPS\_{utility}=NS×\frac{HH×Saturation\_{IL}}{HH×Saturation\_{US}}×\frac{ResC\_{utility}}{ResC\_{IL}}×\frac{PU\_{Class}}{PU\_{Category}}$$

where NPSComEd represents Non-Program Sales in the utility service territory, as calculated by the product of five components:

1. The number of national shipments, NS;
2. The state’s share of the national appliances, represented by HHIL, the number of Illinois households weighted by SaturationIL, the saturation of appliances within Illinois households, divided by HHus, the national number of households weighted by SaturationUS, the saturation of appliances within households nationally;
3. The utility share of the state’s residential customers, represented by ResCutility, the number of residential customer accounts in the utility’s territory divided by ResCIL, the number of residential customer accounts in the state;
4. Configuration split, represented by PUClass, the number of program units per class (e.g. top-loading clothes washers), divided by PUCategory, the number of program units per category (e.g. clothes washers);
5. Share of national annual shipments sold during the analysis period, estimated using PSJune–Dec, the number of program sales between June and December divided by PSJan–Dec, the number of program sales between January and December.

## Savings from Non-participating Retailers

The ComEd evaluation team examined 17 papers discussing inventory management, product substitution and pricing strategies, and optimal retailer stocking levels. Additionally, the team reviewed papers discussing competitive dynamics, strategy and organizational survival, retailer power and market performance, why firms imitate one another, and strategies of low market share businesses.

The literature review found that retailer decision making is complex, and retailers consider many factors when deciding whether to mimic other retailers in the market. For example, firm A may not have the resources to conduct primary research on which products are likely to appeal to consumers over the next buying cycle. In this case, they may copy a competitor, firm B, if firm A believes firm B to have access to better information about trends in consumer demand. Alternatively, firm C may try to differentiate from firms A and B and may decide to purchase a different set of products, especially if firm C believes they do not have the resources to compete directly with firms A or B. Or firm C may use their own information and expectations of what their consumers will demand.

While the literature review was not conclusive, there are certain conditions under which retailers may choose to imitate their competitors. Marketing and stocking behavior was highly structured for smaller retailers. In comparison, larger box stores specialize in higher volume of lower-end washers. However, none of the papers directly supported the claim that non-participating retailers will mirror decisions made by participating retailers. Absent any clear empirical findings, the net lift for non-participating retailers should be set at 50% of the lift observed in participating retailers. Future research, or insights from the structured judgement panel can be used to update the net lift for non-participating retailers in the future.

## Interactions with Other Efficiency Programs

In order to avoid double counting savings from the same piece of equipment, the like-for-like energy and demand savings from other resource acquisition programs (i.e., ComEd’s Appliance Rebate Program) should be removed from the ESRPP savings. Tracking data from resource acquisition programs are likely to differ from the program administrator data portal provided through the ESRPP, which may require additional data cleaning and processing.

Tracking data from other resource acquisition programs should be cleaned and categorized using the same procedures which are applied to the ESRPP sales portal data. Only the net energy and net demand savings from product configurations and efficiency tiers which match the efficiency categories incented through ESRPP should be removed. ESRPP does not apply a NTG ratio as other programs since program savings are only those above the natural market baseline, referred to here as gross ESRPP savings. Verified net savings for ESRPP are then equal to gross program savings less net downstream savings.

1. Program description from the NEEA website. https://neea.org/our-work/programs/rpp. [↑](#footnote-ref-2)
2. The logic model and MPI list are the current working versions form the CY2021 evaluation of ComEd’s ESRPP pilot. They were both developed by the program implementer, NEEA, and reviewed by the Guidehouse evaluation team. [↑](#footnote-ref-3)
3. This is done to protect retailer data privacy. [↑](#footnote-ref-4)
4. The methods for cleaning data, gathering product attributes, and assigning a category were developed by NEEA. These steps were documented and provided to ComEd in the RPP Data Cleaning Memo, dated May 18, 2022. [↑](#footnote-ref-5)
5. <https://www.energystar.gov/productfinder/advanced> [↑](#footnote-ref-6)
6. <https://www.regulations.doe.gov/certification-data/> [↑](#footnote-ref-7)
7. <https://cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx> [↑](#footnote-ref-8)
8. Measure 5.1.2 ENERYG STAR Clothes Washers, Illinois TRM V10. [↑](#footnote-ref-9)
9. These values are current as of version 10 of the Illinois TRM and should be updated regularly to match the values shown in measure 5.1.6, ENERGY STAR and CEE Tier 2 Refrigerator. Emerging Tech values are not included in the TRM and were added to this table by multiplying the UECBASE values by 0.8. [↑](#footnote-ref-10)
10. NEEA Memo to ComEd Regarding Baseline Approaches. September 23, 2021. [↑](#footnote-ref-11)