Vermont Energy Investment Corporation

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December 6, 2013

Ms. Susan M. Hudson, Clerk
Vermont Public Service Board
112 State Street
Montpelier, VT 05620-2701

Re: Analysis of Three Electric Energy Efficiency Scenarios for the 2015 – 2034 Demand Resources Plan
EEU-2013-01

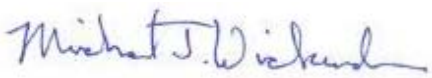
Dear Ms. Hudson:

Please find attached the Vermont Energy Investment Corporation's analysis of three electric energy efficiency scenarios for the *2015 – 2034 Demand Resources Plan.* This document is pursuant to the Board's Order Determining Electric Resource Acquisition Scenarios to be Analyzed and Electric and Thermal Energy and Process Fuel Quantitative Performance Indicator Framework (September 30, 2013).

This document has two parts: (1) a narrative analysis containing an overview of the scenarios, assumptions, and modeling methods—and an Appendix of Modeling Assumptions; and (2) the *Summary Report,* an Excel workbook containing all of the savings and budget results from the modeling files. VEIC also has the supporting modules, screening tools, and other workbooks with more detailed information, and are pleased to provide these files at your request.

VEIC worked collaboratively with the Vermont Public Service Department and the Burlington Electric Department in developing the assumptions. The analyses contained in these documents, however, are solely VEIC's work product. VEIC looks forward to discussing its analysis at the December 19, 2013, Demand Resources Plan Scenario workshop.

Sincerely yours,



Michael Wickenden
Director, Regulatory Affairs

ANALYSIS OF
THREE ELECTRIC ENERGY EFFICIENCY SCENARIOS
FOR THE
2015 – 2034 DEMAND RESOURCES PLAN

Submitted to

THE VERMONT PUBLIC SERVICE BOARD

Pursuant to *Order Determining Electric Resource Acquisition Scenarios to be Analyzed and Electric and Thermal Energy and Process Fuel Quantitative Performance Indicator Framework* (September 30, 2013)

December 6, 2013

EXECUTIVE SUMMARY

This narrative presents three scenarios for electric energy efficiency investment in Vermont for the 20-year period 2015 – 2034. These scenarios support the State's second long-term Demand Resources Plan, and are intended to inform the Vermont Public Service Board's decision-making regarding statewide short- and long-term electric and thermal energy process fuel budgets and goals.

This discussion contains an analysis of the three scenarios, in partial fulfillment of the Vermont Public Service Board Order Determining Electric Resource Acquisition Scenarios to be Analyzed and Electric and Thermal Energy and Process Fuel Quantitative Performance Indicator Framework (September 30, 2013). The narrative and analysis presented here relate only to the Electric Resource Acquisition Scenarios.[1]

Two of the three scenarios make assumptions about pursuing and acquiring all economically achievable resources under different levels of budget constraint, and one scenario makes assumptions about acquiring a predetermined level of annual electricity savings throughout the period. These proposed 20-year scenarios are as follows:

- **Scenario 1: Level Budget with Inflation** (budget constrained). Reflects the Board-approved 2015 budget from the 2012 – 2031 Demand Resources Plan (DRP), inflated to 2015 dollars. For every year beyond 2015, budget values are level with 2015, with a 2% adjustment for inflation, across the remaining years in the 20-year period.

- **Scenario 2: Sustained Growth – Inaugural DRP Extended** (budget constrained). Assumes budget levels that extend the current approved 2012 – 2031 Demand Resources Plan (DRP) through 2034, with the 2032-2034 annual budgets increasing to correspond with the average annual rate of increase for the 2018-2031 period (3% in nominal dollars).

- **Scenario 3: Aggressive Growth – 3% Savings Target** (savings constrained). Assumes ramping up to annual electric energy savings of 3%, relative to annual electric energy use, by 2019, and maintaining that level of savings throughout the remainder of the period (2020 – 2034).

[1] The Vermont Energy Investment Corporation supports the Public Service Department's December 6, 2013, comments on the Thermal Energy and Process Fuel Quantitative Performance Indicator Framework.

The analysis and modeling results are solely VEIC's work product. This analysis also contains *DRP Modeling Assumptions,* as an Appendix.

ANALYSIS OF ELECTRIC ENERGY EFFICIENCY SCENARIOS – 2015 - 2034

1. HOW SAVINGS TARGETS WERE DERIVED FOR THE SCENARIOS

SCENARIO 1: LEVEL BUDGET WITH INFLATION

DESCRIPTION

Budget based. Assumes no change in the current levels for the statewide electric energy efficiency budgets, other than adjustments for inflation, across the 20-year period.

APPROACH

The first step was to inflate the 2015 Efficiency Vermont Resource Acquisition (RA) budget from the 2012-2031 Board-approved DRP. The 2015 budget was inflated from 2012 dollars to 2015 dollars using a 2% annual inflation rate. For purposes of Program Screening Tool (PST) modeling, all years were calculated in 2015 dollars, so no further inflation factor was calculated.

VEIC then subtracted $970,000 for the Customer Credit program budget that operates outside Efficiency Vermont programming. This step informed the *EVT RA [Efficiency Vermont Resource Acquisition] budgets less Customer Credit*.

METHOD APPLIED TO EACH YEAR THROUGHOUT THE PERIOD

Step 2. VEIC multiplied *EVT RA Budget less Customer Credit* by the approved proportional budget splits between Commercial and Industrial (*CI*) and Residential Energy Services (*RES*) to yield each of those market sectors' resource acquisition budgets.

Step 3. VEIC multiplied *EVT RA budget less Customer Credit* by the required 8.9% to establish the budget target for services to low-income customers.

Step 4. VEIC subtracted the resulting low-income (LI) budget figure from the *RES RA* budget to yield the Residential Energy Services budget that does not include non-LI RES budget.

Resulting Budgets

Annual Resource Acquisition budgets for (1) Commercial and Industrial; (2) Residential Energy Services, Low-Income; and (3) Residential Energy Services, Non-Low-Income.

Scenario 2: Sustained Growth – Inaugural DRP Extended

Description

Budget based. Assumes budget levels that extend the current approved 2012 – 2031 Demand Resources Plan (DRP) through 2034, with the 2032-2034 annual budgets increasing to correspond with the average annual rate of increase for the 2018-2031 period.

Approach

The first step was to inflate the 2015 - 2031 *EVT RA* budgets from the 2012 - 2031 Board-approved DRP budgets to 2015 dollars from 2012 dollars, using a 2% annual inflation factor. For purposes of Program Screening Tool (PST) modeling, all years were calculated in 2015 dollars.

VEIC then calculated 2032-2034 targets by taking the average growth rate across the 2018-2031 period (3% in nominal dollars; and 1% in 2015 dollars) and applying it respectively to each of the three years beyond 2031 to yield the budgets for the years through 2034.

Method Applied to Each Year throughout the Period

Step 2. VEIC subtracted $970,000 for the Customer Credit program budget, operated outside Efficiency Vermont programming, to derive *EVT RA budgets less Customer Credit.*

Step 3. VEIC multiplied *EVT RA Budget less Customer Credit* by the approved proportional budget splits between Commercial and Industrial (*CI*) and Residential Energy Services (*RES*) to yield each of those market sectors' resource acquisition budgets.

Step 4. VEIC multiplied *EVT RA Budget less Customer Credit* by 8.9% to establish the required Low-Income budget target.

Step 5. VEIC subtracted the Low-Income budget from *RES RA Budget* to yield the *Non-LI RES Budget*.

RESULTING BUDGETS

Annual Resource Acquisition budgets for (1) Commercial and Industrial; (2) Residential Energy Services, Low-Income; and (3) Residential Energy Services, Non-Low-Income.

SCENARIO 3: AGGRESSIVE GROWTH – 3% SAVINGS TARGET

DESCRIPTION

MWh savings based. Assumes a targeted approach and estimates RA budgets required to ramp up to a 3% *annual savings to annual electric energy usage* ratio by 2019, and maintain 3% thereafter.

The approved ramp-up can be summarized as:

- 2.4% in 2015
- 2.55% in 2016
- 2.7% in 2017
- 2.85% in 2018
- 3.00% in 2019 and beyond

APPROACH

The first step was to obtain forecasts that assume no demand-side / efficiency management programming. Total sales forecasts for the entire state (*TOTAL Vermont*), IBM, and OMYA were provided by Itron (Eric Fox). Burlington Electric Department (BED; Mike Leach) provided its corresponding total sales forecasts.

VEIC subtracted energy forecast values associated with IBM (Self-Managed Energy Efficiency Program participant), OMYA (Customer Credit Program participant), and BED from the *TOTAL Vermont* forecast to yield an *Adjusted EVT Energy Forecast* from 2015 through 2034.

METHOD APPLIED FOR EACH YEAR THROUGHOUT THE PERIOD

Step 2. To obtain 2015 annual savings, the *Adjusted EVT Energy Forecast* was multiplied by 2.4%.

Step 3. For 2016 annual savings, VEIC subtracted the 2015 annual savings from the 2015 *Adjusted EVT Energy Forecast* to yield an energy forecast reflecting demand-side management (DSM) effects. This value was then multiplied by the yearly increase in the *Adjusted EVT Energy*

Forecast (natural rate of growth) and multiplied by 2.55% to obtain 2016 annual savings. This same step was applied to obtain savings targets for 2017, 2018, and 2019 and beyond.

2. Collaboration with Department and BED

VEIC, the Department of Public Service, and BED worked collaboratively to develop the assumptions for the DRP analysis; VEIC continued with the Department in subsequent analysis of the two budget-based scenarios and the single savings-based scenario. Throughout the collaboration, VEIC and the Department worked together to review methods in developing the scenarios.

The analysis and modeling results in this filing are solely VEIC's work product.

3. Modeling Results

VEIC's results are available in an Excel workbook attached to this filing. Known as the *Summary Report,* it contains energy and demand savings (both Summer and Winter), Total Resource Benefit values, and budgets. In the workbook, budgets are presented in 2015 dollars, and in nominal dollars (located in the final three worksheets).

The charts below show graphical comparisons of budgets and savings among the three scenarios.

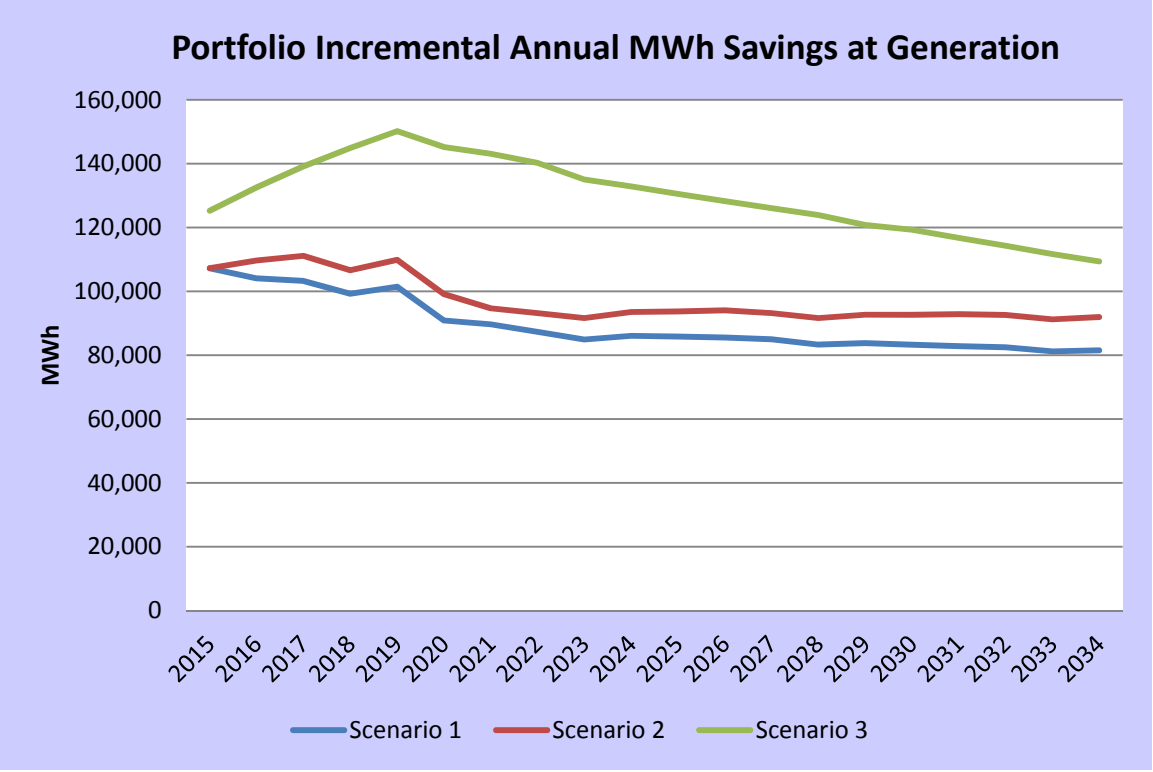


Fig. 1

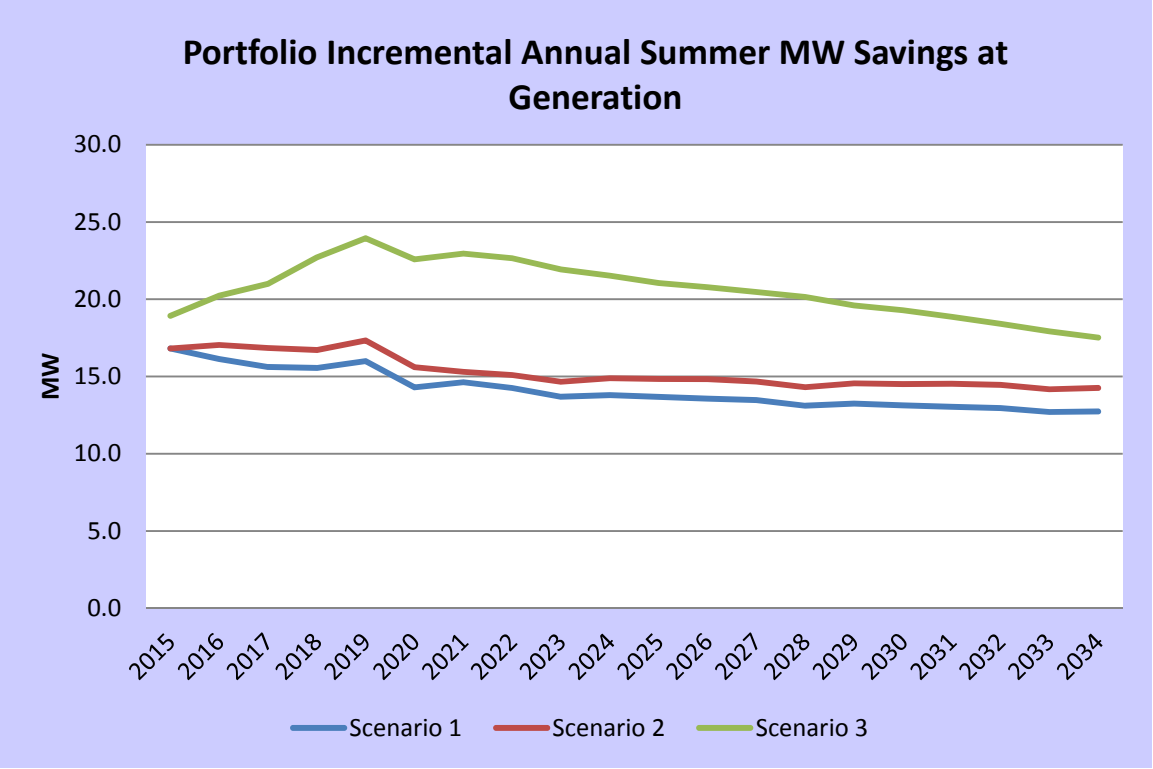
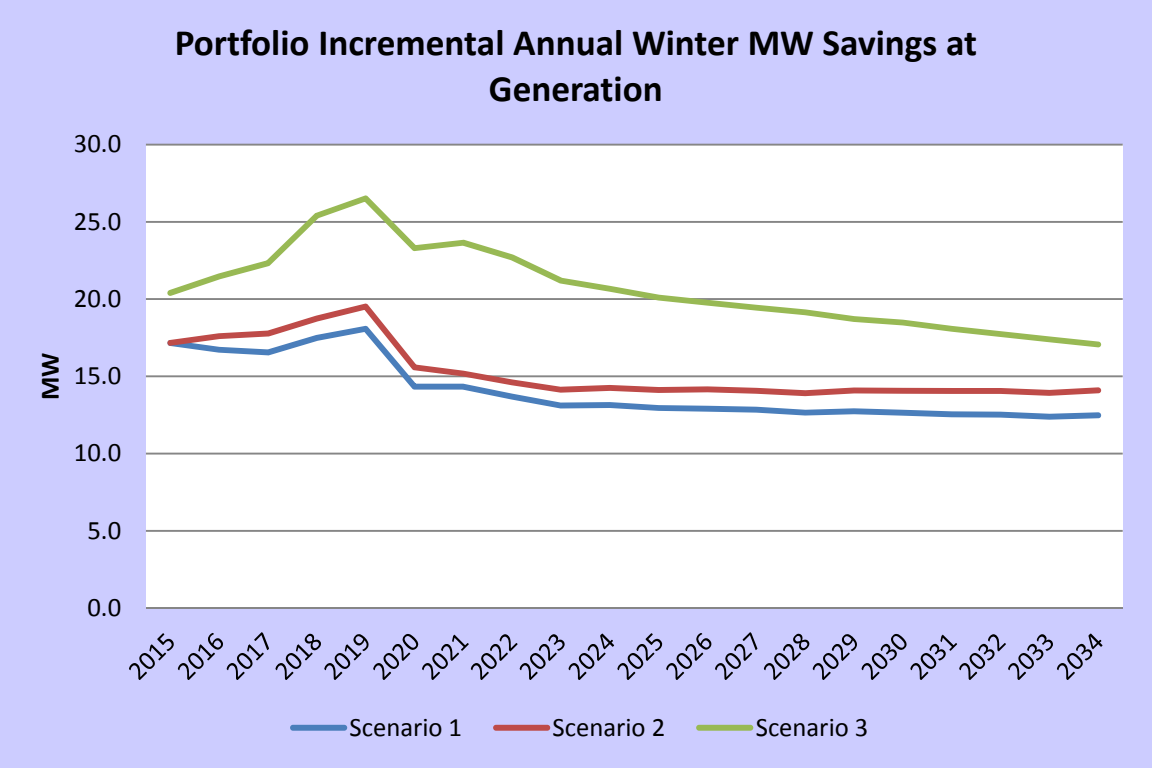

Portfolio Incremental Annual Summer MW Savings at Generation
MW
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034
Scenario 1
Scenario 2
Scenario 3

Fig. 2


Portfolio Incremental Annual Winter MW Savings at Generation
MW
30.0
25.0
20.0
15.0
10.0
5.0
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2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034
Scenario 1
Scenario 2
Scenario 3

Fig. 3

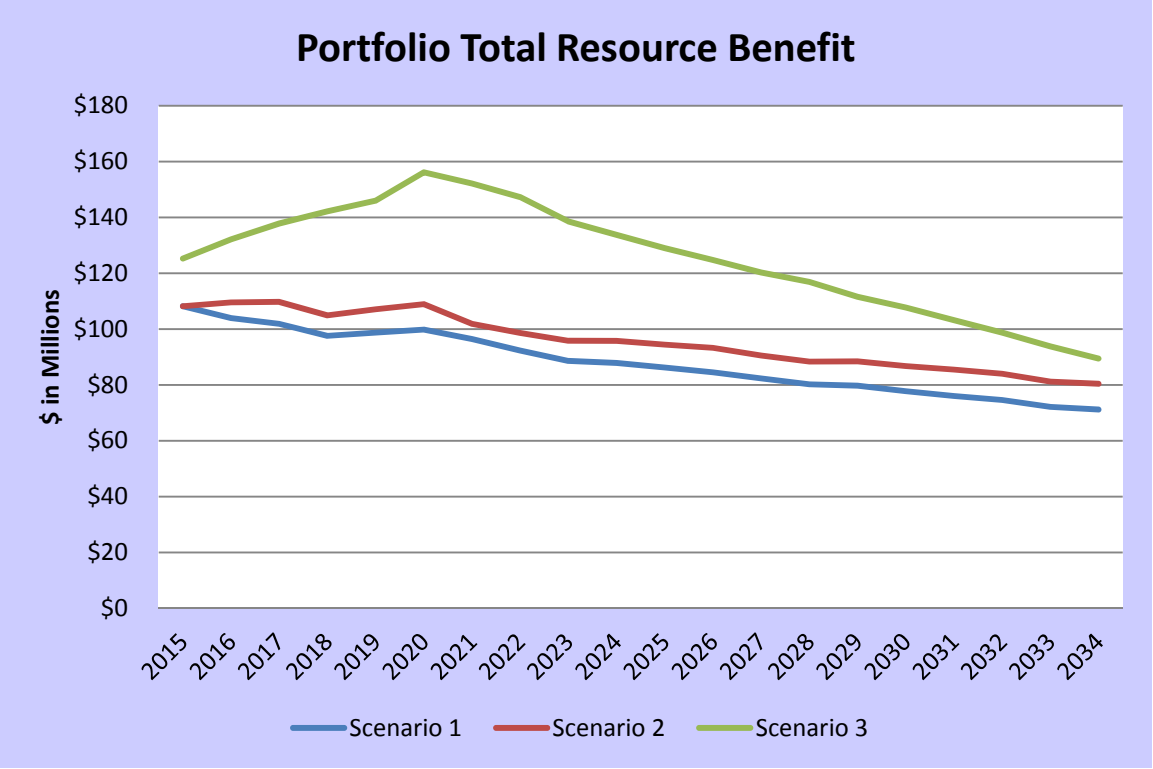
Portfolio Total Resource Benefit
$ in Millions
$180
$160
$140
$120
$100
$80
$60
$40
$20
$0
2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034
Scenario 1
Scenario 2
Scenario 3

Fig. 4

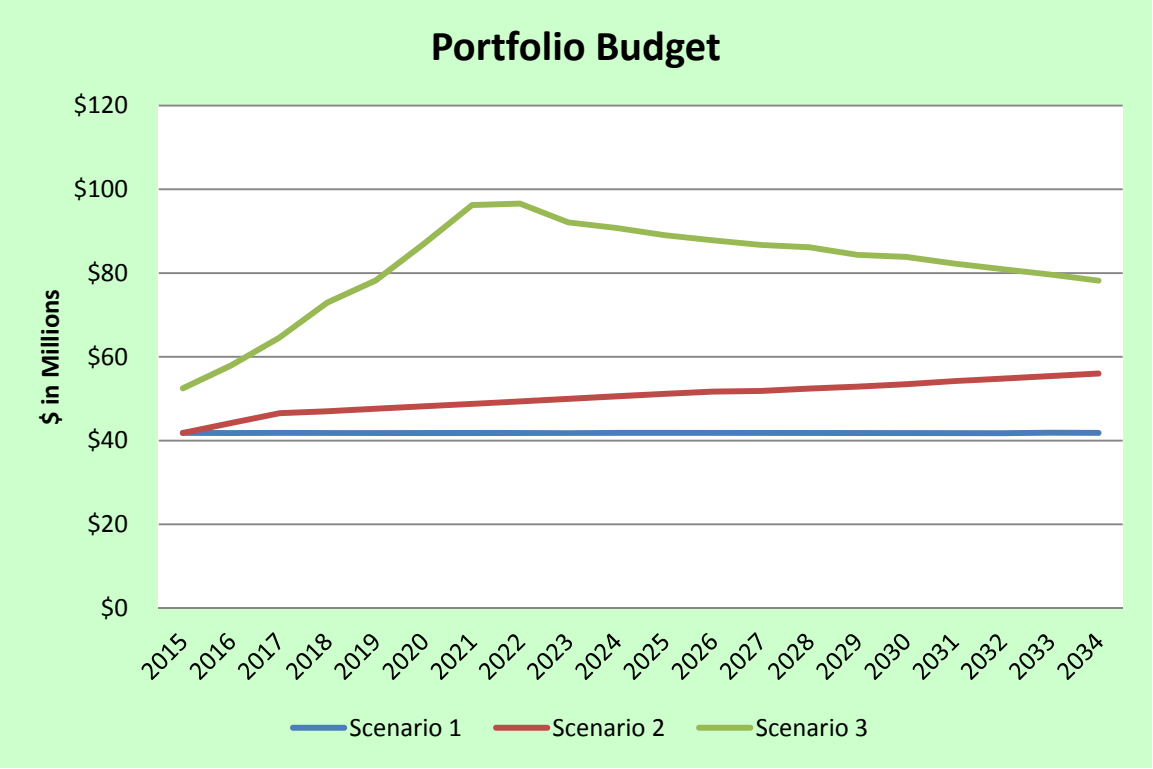
Portfolio Budget
$ in Millions
$120
$100
$80
$60
$40
$20
$0
2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034
Scenario 1
Scenario 2
Scenario 3

Fig. 5

4. Modeling Methods

4.1 Residential Modeling Approach

VEIC used a measure-by-measure savings analysis in its residential modeling in each of the program markets:

- Efficient Products
- Existing Homes (retrofit)
- Low-Income Single Family
- Residential New Construction
- Multifamily New Construction Low-Income
- Multifamily New Construction Market Rate
- Multifamily Retrofit Low-Income
- Multifamily Retrofit Market Rate

First-year characterizations of existing measures were based on the current *Technical Reference Manual* (TRM). For any measure for which there was no characterization in the TRM, VEIC developed a new one, and documented the sources. Adjustments to savings, costs, incentives and net-to-gross factors were applied over the 20-year period where appropriate, according to evaluations or professional judgment. VEIC documented all assumptions and reasons for adjustments in measure tabs at the back of each market module.

Scenario 1: Level Budget with Inflation

This level budget reflects an increase of approximately 41% in total RES funding, in response to the September 30, 2013, Board Order referred to, above, specifying this analysis (EEU-2013-01). That is, the Order stipulates a shift in proportional spending for RES and CI throughout the DRP 20-year period, moving RES spending from approximately 34% of the total budget in 2015 to 48% in 2034. The Board also ordered an assignment of 8.9% of the budget to low-income markets. The remaining RES budget for Year 1 (2015) was split among each remaining program market (listed in *Residential Modeling Approach*), according to averages for the 2010-2012 budget period.

Beginning in 2020, a significant decrease in lighting savings potential is expected. Therefore, VEIC has projected a shift from the dominance of Efficiency Vermont's Efficient Products program market to the Existing Homes retrofit program market. Therefore, the Efficient Products portion of the total budget declines steeply from 48% in 2019 to 36% in 2024 and then continues to decline to 28% in 2034. All other non-low-income markets experience an increase. For example, Existing Homes rises from 12% in 2019 to 32% in 2034.

The budget split for program costs with incentives versus program costs without incentives was also based on averages in the 2010 - 2012 budget period for each program market, and was applied flat, across the 20 years, with two exceptions:

- *Efficient Products.* The model assumes that savings from Efficient Products will require a significant shift from being predominantly driven by incentives to a market in which costs that assume no incentives becomes significantly more dominant. In this program market, VEIC modeled incentives as falling from 76% of total Efficient Products expenditure to 50%.
- *Existing Homes.* The non-incentive costs associated with Existing Homes had not been historically tracked for electrically funded activities and for activities funded by heating and process fuel (HPF) budgets. Therefore, using the established budget split for incentive and non-incentive costs was not appropriate, because it indicated that approximately 13% of total electrically funded activity was ascribed to programming involving incentives. Based on discussions with the program managers, VEIC applied a 50-50 split: 50% would be assigned to programs involving incentives, and 50% to those for which no incentives are used (a 1:1 ratio).

The next step was to develop measure penetrations that produced total incentive levels as close as possible to the targets calculated in the earlier steps. The penetration estimates have been based on historical achievements, input from market managers, professional judgment, and / or evaluations of future trends. Any variance between incentive target and modeled incentive budget was then added to, or subtracted from, the non-incentive budget to ensure 100% of total budget was met.

SCENARIO 2: SUSTAINED GROWTH – INAUGURAL DRP EXTENDED

Scenario 2's target incentive budgets were calculated first, as follows:

- Determination of the percent difference between the Scenario 1 and Scenario 2 total budgets.
- Application of consistent incentive-versus-non-incentive ratios determined in Scenario 1 to Scenario 2.
- For non-low-income markets, incentives were increased by about 50% of the required total budget percentage difference, resulting in penetrations increasing at a similar rate to incentive increases.

  - For example, a 16% increase in the budget was modeled as a 16% increase in the non-incentive budget, an 8% increase in the incentive budget, and an 8% increase in penetrations. The incentive-versus-non-incentive ratio (1:1) remained the same.
- For low-income markets, measures are typically provided at no cost to the customers. Therefore, increasing incentives isn't an appropriate method to drive growth, and so a slight increase in the non-incentive split was applied.
  - The low-income market budgets were therefore modeled with an incremental addition of 10% of the required budget total to the non-incentive budget. For example, a 16% required increase resulted in 17.6% increase in non-incentive budgets [16% + (10% times 16%)]. The remaining budget increase was then assumed to be due to increased participation in low-income programs.
  - Any incentives that were not already at full cost were increased by 50% of the total budget difference, consistent with the non-low-income markets explained above.

For measure penetrations, VEIC uniformly increased them by the required increase in penetration, to produce the total target budget after incorporating the non-incentive budget increase and incentive increases described above.

SCENARIO 3: AGGRESSIVE GROWTH – 3% SAVINGS TARGET

Scenario 3 required MWh targets for each market, so that penetration increases could be applied to meet those targets. These were calculated as follows:

- Determination of the total percentage increase required for Scenario 2 to meet Scenario 3 targets.
- Residential New Construction and Multifamily New Construction markets were designated as "constrained" markets. That is, they are unlikely to be able to produce as large an increase in savings as that of other markets, since incentives are not likely to drive new construction. These markets were limited to a 125% increase over Scenario 2 levels.
- The required percentage savings increase in all other markets was then calculated.
- Initially, all incentives other than those in the low-income program markets or in direct install programs were increased by 125% of the required penetration increase. For example, a 25% increase in incentives would be required to increase penetrations by 20%. These increases were then reviewed, with the result that most measures in which

the incentive had become greater than the incremental / installed cost were capped. This "correction" did not apply to measures in which it was determined that the required growth rate would necessitate significant incentives, or in which incentives were already above incremental costs for other reasons.

- Behavior measures were capped at 150,000 homes. This meant that other measures were selectively increased in some years to make up the resulting shortfall from behavior effects.
- Non-incentive budgets were increased at a constant rate. That is, a 20% rise in penetrations required a 20% rise in non-incentive budgets, with the exception of Efficient Products, in which 75% of required increase was applied to non-incentives.

NOTEWORTHY TECHNOLOGIES AND TRENDS

Lighting. The dip in total residential savings that can be observed around 2020 is entirely due to lighting savings—specifically, the impact of new regulation on bulbs and their baseline assumptions (Energy Independence and Security Act of 2007). As of 2020, the lowest-efficacy bulb that will be able to be shipped or manufactured must be equivalent to a standard 2013 compact fluorescent lamp (CFL). This means that efficiency program support for CFLs will no longer be appropriate (and further, support ramps down significantly before 2020). For other lighting (LEDs, for example) the baseline will shift significantly to limit the savings opportunities from 2020 onward. Not only does this affect first-year savings for lighting after 2020, it also affects the cumulative savings of measures installed prior to 2020. That is, the baseline bulbs require multiple replacements in the lifetime of an efficient measure, and the replacement schedule after 2020 will be the equivalent of the current schedule for a CFL.

Shift from Efficient Products to Existing Homes Retrofit Market. The significant fall in savings potential for lighting will coincide with increasingly stringent codes and standards for new appliances and rapid improvements in energy use from consumer electronics. These factors lead VEIC to predict that Efficient Products will see a significant drop in savings and expenditures over the 20 years, beginning particularly at 2020. Program managers expect to shift programming focus to increasing participation in Existing Homes for customers who are harder to reach. Once engaged with efficiency programs that target these customers, they will receive program support for retrofit opportunities throughout the period.

For Efficient Products, the post-2020 focus will shift to supporting the purchase of more expensive pieces of equipment, rather than the relatively inexpensive lighting products for which there is currently a high sales volume. This shift will require both increases in incentives and more innovative ways to engage with the market, communities, trade allies, and partner agencies. VEIC also expects to see increased attempts to engage in the hard-to-reach and

otherwise underserved populations. Some examples of where Efficiency Vermont has begun to increase this kind of activity can be found in the engagement with the Vermont Refugee Resettlement Program and the Vermont Affordable Housing Coalition. With both organizations, Efficiency Vermont offers lighting and other products directly to refugee and low-income communities. Another potential avenue is Habitat for Humanity, with whom Efficiency Vermont can collaborate to obtain leads for second refrigerator retirement and other efficiency measures in this program market.

The days of cost-effective, high-volume lighting measures are ending, because the market is approaching saturation. In the future, rather than simply providing retail incentives and tracking high-volume sales, VEIC expects higher costs associated with marketing, community outreach, and engaging with market actors. This expected new cost profile explains the significant increase in non-incentive budgets for the Efficient Products program market.

Residential Savings from Behavior Reporting. This model incorporates significant savings from a behavior program that uses energy reporting to engage customers in altering their energy consumption behavior. It is similar to that used in a model designed by OPower. For **Scenario 1**, the savings reflect an assumption that behavioral demand response devices and software will be installed in 100,000 residential homes, accompanied by corresponding services throughout the 20-year period. The assumption in **Scenario 2** is that this measure will increase to a maximum of 120,000 homes, and in **Scenario 3,** 150,000. The penetration of technology is consistent with a nationwide trend toward greater customer engagement with personal energy use. These measures are expected to realize 1.5% savings for non-thermal electric load, plus 1% thermal savings, modeled as becoming increasingly electric through likely expanding sales of heat pumps. These savings rates are relatively conservative, compared to results from most available evaluations, which have documented savings ranging from 1% to 3%. They reflect a savings rate similar to that of other programs implemented in cold climates. A summary of independent evaluations of Opower programs implemented by other utilities shows that National Grid and NSTAR achieved 1.3 to 2.1% energy savings in Massachusetts, and Connexus in Minnesota achieved 2.1 to 2.4% savings through behavioral programs. The number of residential units served is divided into four of the Residential program markets: Existing Homes, Low-Income Single Family, Multifamily Low-Income Retrofit, and Multifamily Market Rate Retrofit. The numbers are based on U.S. Census approximations of the number of households in Vermont.

Heating Electrification. The model also assumes a significant growth in electric heat, due to the increased penetrations of air source heat pumps (ASHPs). This manifests itself directly in three measures, and indirectly in two measures. The direct ASHP measures and their total 20-year

penetrations for each measure in **Scenario 1, Scenario 2,** and **Scenario 3,** are provided respectively in parentheses:

- Retrofit of electric resistance heat to ASHP (1,950 / 2,210 / 3,631)
- Installation of higher-efficiency ASHP over baseline ASHP (16,060 / 18,343 / 39,816)
- Installation of shell measures (insulation / air-sealing) on an electrically heated home (7,028 / 8.017 / 11,108)

The indirect impacts are that electricity savings from Behavior measures assume that the thermal portion of the savings will increasingly come from electric heating. The base assumption is that by 2034, 40% of homes in Vermont will be electrically heated via heat pumps. Second, smart thermostats in this model assume they are installed in electrically heated homes, and so the penetration grows significantly in later years.

Other Measures with Significant Changes across the 20-Year Period. In addition to the measures described above, primary measures that are modeled as experiencing significant change are:

- **Domestic hot water heating**, particularly heat pump water heaters and solar hot water. Note that VEIC has modeled a shift in baseline. Heat pump technology is expected to create a new baseline by 2021, with the replacement of electric hot water tanks of all sizes that are baseline now. Until 2021, VEIC has modeled electric tank to heat pump upgrades, and from that year on, more efficient heat pump models are characterized over a baseline heat pump model.
- **LED lighting.** Efficiency Vermont staff predict a large volume of LED sales in the next five years; therefore, support for this measure will decrease significantly in the early 2020s.
- **Circulator pumps.** This is a new measure for Efficiency Vermont in 2014. The estimate is that there will be a high volume of sales in the early years and then will reduce to a steady rate.
- **Clothes dryers.** A new ENERGY STAR® specification for clothes dryers is expected in 2014. The units expected to come on line in the early years will significantly increase drying time, so purchases are expected to be relatively low. However, around 2020, VEIC predicts that high-efficiency heat pump dryers will become significantly more affordable, and are thus expected to become an important measure for the Residential Energy Services portfolio.

4.2 Commercial and Industrial Modeling Approach

The general approach for analysis of the Commercial and Industrial market sector is a "top-down" method. It starts with an energy sales forecast disaggregated by building type and end

use, and then determines the percentage by which energy use in each subsector can be reduced by the installation of a given efficiency measure. This approach is different from a "bottom-up" method, which typically begins with a fixed number of buildings or equipment installations and considers how many of these items could be addressed by efficiency measures. Calculations in top-down analyses are based on energy consumption, whereas bottom-up analyses have a calculation basis of the number of installed units—whether equipment, technologies (for example, building controls), or "widgets."

In the top-down approach, energy savings potential is assessed by applying several factors to a defined quantity of energy. These factors are applied to the forecasted building type and end use, or to industrial market subsector sales by year, to derive the savings potential of each measure for each year in the analysis period, as shown in the following equation and described in the subsequent bullets.

Energy savings	=	kWh sales	x	*Applicability* factor	x	*Feasibility* factor	X	*Turnover* factor (replace-ment only)	x	*Not complete* factor (retrofit only)	x	Savings fraction	x	Net penetration rate

- **KWh sales** is the total quantity of energy consumed by a particular end use in a particular building type or industrial segment, across the entire market of interest, expressed in kWh (for electricity) or MMBtu (for natural gas or other regulated fuel). In this analysis, VEIC assessed potential in four different zones, described below.
- **Applicability** relates to energy sales by end use (from the sales disaggregation) for each building type or industrial segment. It is the proportion that is attributable to equipment that could be replaced by the high-efficiency measure. For example, for the ambient lighting end use, it would be the portion of the total lighting electrical load consumed by ambient lighting in a given building type.
- **Feasibility** is the fraction of end use sales, expressed as a percentage, for which it is technically feasible to install the efficiency measure. Numbers lower than 100% indicate engineering or other technical barriers that would preclude adoption of the measure. Feasibility is not reduced for economic or behavioral barriers that would reduce penetration estimates. Rather, it reflects technical or physical constraints that would make it impossible or ill-advised for a measure to be adopted in a given application.
- **Turnover** is the proportion or percentage of existing equipment that will be naturally replaced each year due to failure, remodeling, or renovation. This applies to the natural replacement ("replace on burnout") and renovation markets. In general, turnover factors are assumed to be 1 divided by the years of measure life. For example, one

might assume that 10% of the existing stock of equipment (1 piece out of 10) is replaced each year for a measure with an estimated life of 10 years.

- **Not complete** is the percentage of existing equipment that is already considered to be highly efficient. This factor applies only to retrofit markets.
- **Baseline adjustment** decreases the energy savings in future years for early-retirement retrofit measures. This adjustment accounts for the fact that newer, standard equipment efficiencies have higher baselines than older, existing stock.
- **Savings fraction** is the energy savings, expressed as a percentage, from high-efficiency technology, compared to either existing stock for retrofit markets or new baseline equipment for non-retrofit markets. Savings fractions are calculated on individual measure data and assumptions about existing stock efficiency, standard practice for new purchases, and high-efficiency options.
- **Annual net penetrations** are the difference between the base case measure penetration (assuming no efficiency programs) and the measure penetrations that could be achieved with sustained efficiency initiatives. For the resource-constrained economic potential, it is assumed that 100% penetration is captured for all markets, with retirement measures generally being phased in and spread out over time to reflect resource constraints such as contractor availability.

In the top-down approach, measure costs are expressed in the context of energy savings—that is, units of dollars per kWh or MMBtu saved—rather than equipment units. For purposes of estimated potential, total costs in each year are determined by multiplying the measure cost per unit of energy saved by projected energy savings in that year. This same approach is used for other measure impacts such as cost savings on operation and maintenance .

Portfolio Screening Tool

The Portfolio Screening Tool is a combination of CI and Residential measures. Measure level characteristics are entered into the tool, and outputs are generated at the program, sector, and portfolio levels to yield a forecast of achievable savings (expressed as *potential*) and cost estimates. Other analytic results are program and portfolio cost-effectiveness, benefit-cost ratios, and tests such as societal costs, electric system costs, and participant costs. The forecast contains a year-by-year breakdown over the 20-year DRP analysis period, to allow for an in-depth evaluation of savings goals and budgets.

CI High-Level Assumptions and Approach

Major Markets. Measures were modeled in three "programs" by major market:

- New Construction (including major renovation)
- Natural Equipment Replacement (replaced at the time of failure)
- Retrofit

Aggregate Measures. For CI modeling, VEIC looked at 1,224 measures in detail, beginning with characterizations of 72 measures, and modeling them across 12 building types and the 3 major building markets. Although this approach provides a suitable level of detail for analysis across a small number of years, managing this number of measures becomes unwieldy over the full 20-year forecast period.

To simplify the modeling process, VEIC used aggregated measures starting in 2021. A total of 30 aggregated measures were used, with one for each of 10 end uses and the 3 major markets. Each aggregate measure began with corresponding measures within the respective end uses and markets detailed for 2020. That is, if all of the aggregate measures from 2021 onward were given a penetration value of 1, the resulting impacts would be the same as for the detailed measures in 2020. The aggregate measures were then used to model years 2021 through 2034. In general, VEIC assumed that the measure mix in those years would be similar to that of 2020. However, the level of activity by market varied over this time period. Most significant, activity in the Retrofit market increased more than the other markets because of the impact of behavioral measures as a substantial portion of the overall portfolio.

Scenario Modeling. Scenario 2 (**Sustained Growth**) was modeled first, because it falls between **Scenario 1** and **Scenario 3** in terms of annual budgets and savings. VEIC set measure penetrations relative to measure costs and incentive levels to achieve the scenario budget targets. As measure penetrations were adjusted, the model automatically adjusted total measure and incentive costs, and adjusted program non-incentive costs. The measure mix was adjusted as needed to meet expected trends by end use and to meet the targets for overall share of each market.

Once **Scenario 2** was fully balanced, it was used as the starting point for modeling **Scenario 1** and **Scenario 3**. Measure penetration rates were adjusted to meet the budget targets of **Scenario 1**, and the energy savings targets of **Scenario 3**. The measure mix for Scenarios 1 and 3 was generally similar to that developed for **Scenario 2**. For **Scenario 3,** VEIC assumed that the higher levels of savings would come largely from the retrofit market, and that an increasing portion of this would be from behavioral measures.

Major Trends. As a general trend, VEIC expects that it will become more difficult to obtain future efficiency savings because of increasingly efficient baselines. Historically, efficient technologies and practices have generally advanced in step with rising baselines, so that it has

been possible to continue achieving cost-effective efficiency savings despite rising baselines. However, despite high levels of innovation, VEIC expect that the cost of achieving savings will rise over time. In addition, it will be necessary to "go deeper" for energy savings with individual customers, after relatively low-cost measures have been installed.

To capture this long-term trend, VEIC made a general assumption that incremental costs of installed measures would increase by approximately 1.0% per year (in nominal dollars), and that the energy savings would decrease by about 0.5% per year. These assumptions resulted in a trend of generally increasing costs per unit of energy saved over the 20-year period.

Lighting continues to represent the largest share of the overall CI portfolio, but at decreasing levels relative to historical Efficiency Vermont performance. Analysts assumed very limited savings from fluorescent lighting in the first several years, but assumed a transition to LED lighting. Therefore, all energy savings from linear fluorescent high-performance T8 bulbs and ballasts are linked to a standard T8 baseline. VEIC assumed there would be no savings from CFLs.

The heating, ventilation, and air-conditioning / refrigeration (HVAC / R) end use is expected to account for a slightly larger portion of the overall portfolio than it has in the period prior to 2015. VEIC recognizes that the shift to an upstream buy-down implementation model for efficient HVAC equipment accounts for this increase, in part.

Behavioral CI measures are expected to play an increasing role in this 2015 – 2034 period. The key assumptions for behavioral measures are:

- Measure life is 1 year, because they are energy savings from changes in customer behavior only.
- For **Scenario 2** (sustained growth)**,** the behavioral measures represent about 3% of total annual MWh savings in 2015, increasing to 11% of the total annual savings by 2019, and 21% of savings in 2034.
- For **Scenario 1** (level budgets), VEIC assumed a similar level of behavioral measure savings relative to the overall portfolio.
- For **Scenario 3** (aggressive growth), analysts assumed the behavioral measures would account for a somewhat larger proportion of total annual incremental savings, ramping up to approximately 31% of the portfolio in 2034.
- The behavioral measures are modeled as part of the Retrofit market, and are the major driver for an increasing share of that market relative to the other markets throughout the 20-year period.

Assumptions and Methods for Calculating Potential Savings from CI Behavioral Programs

Commercial Program. The potential for statewide commercial behavioral energy savings programs is not well defined, but several programs have demonstrated that significant savings are possible. BC Hydro realized first-year energy savings of 5% from behavior measures and Canada's Ministry of Energy, Mines and Petroleum Resources (MEMPR) realized first-year energy savings of 12%. They achieved this by creating a culture of energy conservation in office buildings.[2] Other programs have shown that energy savings from behavior measures are also possible as part of comprehensive or retrofit efficiency programs.[3]

For the 20-year period, VEIC made assumptions about likely programming that engages businesses that primarily occupy office space. It was assumed that Efficiency Vermont would engage these commercial customers by promoting energy savings through changes in behavior. Successful programs to date have used the following formula:

- Obtain commitment from senior management, to increase the likelihood of changing behaviors among building occupants
- Build internal teams to set goals or a launch a pledge campaign, and create a brand for the effort
- Empower champions to promote the effort
- Use effective communication methods for training and motivating employees
- Use engagement techniques such as peer pressure, feedback, rewards, and competitions to reinforce behavior changes

Assuming that participation will begin slowly and build over time, analysts estimated that participation will increase from about 100 customers in 2015 to approximately 3,700 by the end of 2034. VEIC also assumed that each customer will reduce by 2% its annual energy use through behavioral measures, with a maximum reduction of 10%. The assumptions also took into consideration capital projects, subtracting their effects so that savings would not be double-counted in any of Efficiency Vermont's regular efficiency programs for this market.

VEIC further assumed likely turnover, with some companies dropping out and new customers joining the program. The peak program penetration is estimated to be 8.8% of the total quantity of small and medium-sized commercial businesses.

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[2] Bin, Shui. "Greening Work Styles: An Analysis of Energy Behavior Programs in the Workplace." *Research Report B121* Washington, DC: American Council for an Energy-Efficient Economy. January 2012, p. 7 http://aceee.org/research-report/b121.

[3] Bin, "Greening Work Styles," 10, http://aceee.org/research-report/b121; and Rogers, Ethan, Neal Elliott, Sameer Kwatra, Dan Trombley, and Vasanth Nadadur. "Intelligent Efficiency: Opportunities, Barriers, and Solutions." Report E13J. Washington, DC: American Council for an Energy-Efficient Economy. October 2013.

For this 20-year analysis, VEIC assumed measure life to be 1 year, as with the Residential market. However, in practice, the energy savings from behavioral measures can be repeatedly claimed, and will be subject to verification each year. The cost to engage a company in the program and realize first-year savings accounts for the majority of a behavior program costs. Verifying the persistence or decay of savings in subsequent years will not require as much effort or costs.

Industrial Program. Several Industrial Strategic Energy Management (SEM) programs have been running in the Pacific Northwest for more than five years. Energy Trust of Oregon and Bonneville Power Administration (BPA) are two examples of utilities with established energy management programs. BPA has seen verified first-year savings of 2.7%.[4] SEM is also called *Continuous Energy Management* (CEI), the term VEIC prefers to use.

CEI programs are typically built around the Deming Cycle of: Plan → Do → Check → Act. The International Organization for Standardization (ISO) 50001 defines the management process and documentation required to meet ISO certification for industrial organizations. Unlike other standards, ISO 50001 requires not just conformance to the standard, but also requires some improvement in energy performance. The U.S. Department of Energy (DOE) promotes a program to recognize industrial customers that reduce energy use. The DOE's Superior Energy Performance (SEP) program is built around ISO 50001, and has its own Measurement and Verification protocols.

Efficiency Vermont does not intend to require ISO certification or participation in the SEP program, but it does intend to use the principles of ISO 50001, and the M&V protocols of the SEP program to guide its CEI work. That is, if a Vermont customer wants to pursue ISO or SEP certification, Efficiency Vermont is prepared to support the customer in reaching their goal. This assumption has been applied to the 20-year modeling for the CI market sector.

The modeling also assumes greater penetration among Efficiency Vermont's 140 account-managed industrial businesses, with estimates of average energy reductions totaling 1% annually, up to a maximum of 3% per customer. It is important to note that these customers do not include either IBM or OMYA. It is also assumed that capital projects will not be counted, because of the possibility of double-counting savings claimed through the regular Efficiency Vermont programs.

[4]Ochsner, Heidi, Jim Stewart, Niko Drake-McLaughlin, and Hossein Haeri. *BPA Energy Management Impact Evaluation Report.* Portland, OR: Cadmus Group, February 1, 2013, pp. 20, 25-27. http://www.bpa.gov/energy/n/reports/evaluation/pdf/BPA_Energy_Management_Impact_Evaluation_Final_Report_with_Cover.pdf

VEIC analysts assume that cohorts of approximately 10 customers will be successfully recruited to participate in the Industrial CEI program every three years. This represents a penetration of this market segment of about 21%. Efficiency Vermont also expects to create a separate cohort of approximately 12 municipal wastewater plants.

Because of the nature of CEI, measure life is one year, but savings can be verified each year and claimed repeatedly. The cost to engage a company in CEI programming and to realize first-year savings represents the majority of program costs. Verifying the persistence or decay of savings in subsequent years will require relatively little effort and cost.

5. MODELING ASSUMPTIONS

The full Modeling Assumptions document is presented as the **Appendix.**

GENERAL

The Vermont Public Service Department, Efficiency Vermont, and BED have agreed on the following modeling input assumptions, using two primary categories:

1. Policy assumptions
2. Model input assumptions

POLICY ASSUMPTIONS

Residential: Sector Equity Requirements. The level of residential spending was based on the percentage of resource acquisition (RA) spending used in the first, or inaugural, DRP. The level of spending in the Residential program sector was assumed to be 34% of the VEIC RA budget for 2015, 36% for 2016, and 37% of the RA budgets in 2017. Multifamily program spending is included in Residential sector spending. Currently, the Residential sector contributes approximately 48% of the total Energy Efficiency Charge in VEIC territory. For modeling, the percent spending in the residential sector steadily increases over time.

CI: Sector Equity Requirements. The spending level in the Commercial and Industrial sector in the VEIC and BED models should reflect the inverse of the Residential percentages. This sets the level of spending for Commercial and Industrial combined program spending at 66% of RA budgets for 2015, 64% of RA budgets for 2016, and 63% of RA budgets for 2017.

Low-income: Sector Equity Requirements. Low-income sector equity requirements used for scenario modeling assume that 31% of statewide (non-BED) residential customers qualify as low-income customers. The recommended level for low-income spending is 8.9% of the RA budget for each scenario. The percentage is based on the assumed Energy Efficiency Charge contributions from statewide (non-BED) low-income customers for years 2015-2017 ($15 million) as a percent of RA spending in 2015-2017 ($130 million). In addition, VEIC assumes that an equity constraint of 70%, to determine a minimum spending requirement. Also, an adder of 0.8% is assumed, so that savings are not modeled at the minimum spending requirement. This assumption is relevant for both Low-Income Single Family and Multifamily Low-Income program spending. Therefore:

- ($15,000,000 / $130,000,000) X 0.7 = 8.1%
- 8.1% + 0.8% = 8.9%

Small Business: Sector Equity Requirements. The 2012-2014 performance period "equity for small business" metric involves the minimum number of participating non-residential customers with annual electricity consumption of less than 40,000 kWh. The target in the 2012-2014 performance period for small business participation is 1,950 customers for VEIC. Although this actual target might vary slightly in the future, no significant conceptual changes to this minimum performance requirement are anticipated for the next performance period. In addition, this assumption is expected to have minimal impact on the model.

MODELING INPUT ASSUMPTIONS

Code Changes. The following commercial and residential energy codes and standards assumptions apply equally to VEIC and BED. The impact of updates to energy codes and standards reduces the amount of available electric energy savings potential as indicated below.

Commercial Energy Code, Current commercial energy code is 2011 Vermont Commercial Building Energy Standards (CBES), effective January 2012, based on the equivalent model codes: 2009 International Energy Conservation Code (IECC) and ASHRAE 90.1-2007. This code is expected to remain effective through December 2014.

- The next code revision for Vermont is expected to be effective on January 1, 2015 and will be based on the equivalent model codes: 2012 IECC and ASHRAE 90.1-2010. VEIC modeled an estimated savings impact of 14%, compared to current 2011 Vermont CBES.
- Future code revisions are expected to effective on January 1, 2018, and will be based on the equivalent model codes: 2015 IECC, ASHRAE 90.1-2013 (now in development). The estimated savings impact is still in development, but for modeling purposes VEIC

assumed the expected savings impact value to be approximately 5%, compared to 2012 IECC and ASHRAE 90.1-2010.

Residential Energy Code. Current residential energy code is 2011 Vermont Residential Building Energy Standard (RBES), effective October 2011. It is based on the equivalent model code: 2009 IECC. This is expected to remain in effect through December 2014.

- The next residential code revision is expected to take effect on January 1, 2015, and will be based on 2012 IECC. Since the current version of RBES is already more efficient than 2009 IECC, the estimated savings are expected to be 10%, compared to the 15% expected of a full increase in efficiency between 2009 to 2012 IECC.
- Future residential code revisions expected to take effect on January 1, 2018, will be based on 2015 IECC. Although the code is still in development, the estimated savings impact is expected to be 5%, relative to 2012 IECC.

Stretch Codes. As part of the next code update process, both residential and commercial "stretch codes" will set a higher efficiency requirement for projects that fall under Act 250, criterion 9F. The standards on which these stretch codes will be based have not yet been determined. However, for the scenario modeling, the partners in this scenario modeling agreed that an impact of 5% beyond current code constituted the best professional judgment. If the stretch codes are approved, VEIC assumes that this approval will require buildings that fall under ACT 250 to meet 2015 IECC and ASHRAE 90.1-2013, beginning on January 1, 2015.

Avoided Costs, Budget Targets, and Inflation

The model uses the recently filed *Avoided Energy Supply Costs in New England* (filed August 30, 2013). Avoided costs in the DRP Portfolio Screening Tool (PST) analysis reflect Avoided Energy Supply Costs prepared by the Avoided Energy Supply Component (AESC) Study Group and published on July 12, 2013. The study provides projections of marginal energy supply costs that will be avoided due to reductions in the use of electricity, natural gas, and other fuels. These reductions are generally understood to have resulted from energy efficiency programs offered to customers throughout New England.

It is important to note that these avoided costs, although filed, have not yet been approved by the Board. However, VEIC, with support from the Department, believes these values are appropriate to use for cost-effectiveness screening related to the DRP. VEIC takes into consideration that the AESC study was performed by knowledgeable experts from electric

utilities, gas utilities, efficiency programs, and non-utility entities and their consultants. This group of experts oversaw the design and execution of the report.

It is also important to note again that budgets in the PST are presented in actual dollars, and Board-ordered budgeting is presented in nominal dollars—in this case, VEIC has used 2015 dollars for modeling, with a real discount rate of 3.0% and an inflation rate of 2.0%.

SMEEP and CCP Participant Load. The scenario models assume that IBM will continue to operate in the Self-Managed Energy Efficiency Program (SMEEP), and OMYA will continue to operate in the Customer Credit Program. In addition, it is assumed that no new SMEEP and Customer Credit Program participants will enter the programs. The load for these customers was addressed and documented appropriately in the VELCO / Itron forecast that has been used for this modeling.

Base Appliance and Equipment Energy Levels, Free-Ridership and Spillover Rates, and Measure Life

Base appliance and equipment efficiency levels, free-rider (FR) and spillover (SO) rates, and measure life are all assigned at a detailed measure level in the models. These rates are based either on the values in the current *Technical Reference Manual* or via specific measure characterizations in which TRM values are not available. The EEUs and the Department reviewed existing measures to determine if any anticipated changes to either base efficiency levels, FR and SO rates, or measure life for any particular measures would be significant enough to be identified specifically and adjusted for, in the model. The measures were prioritized on greatest savings impact (kWh, kW, or Total Resource Benefits), quantity installed, risk to portfolio, and magnitude of change anticipated. To date, the following issues have been identified as having significant impact on savings since the last DRP:

1. **EISA impacts.** Specialty CFLs will have a smaller effect because of the reductions in CFL use across the 20-year period.

In the last DRP, specialty CFLs were treated to similar EISA impacts as standard CFLs. Specifically, the first round of adjustments were delayed by 3 years (2015 - 2017), and were equivalent to the 2012 - 2014 adjustments for standard CFLs. Further, the specialty measure lives were reduced to 2020, to account for the "backstop" provision in EISA. A review determined that this adjustment was inappropriate, since most specialty bulbs are exempt from EISA and there is no other legislation (beyond the Energy Policy Act of 2005 [EPAct] legislation on reflector bulbs) that will have an effect.

For this DRP, these measures have therefore been adjusted. The impact of this change might be somewhat reduced by the fact that efficiency program support for CFLs (both standard and specialty) is likely to be reduced significantly over the coming years and be more aggressively replaced by LED measures.

2. **TRM updates.** Upon review, a majority of TRM data used for characterizing Year 1 measure savings in the last DRP have been updated. All these measures have been updated.

3. **Removing trend analysis from modeling for years 7-20.** Efficiency Vermont has changed its methods for characterizing Residential sector savings from 2020 through 2034 (years 7 through 20). In the previous DRP, there was an attempt to create blended, end use bundles. The resulting assumptions underwent a very complex weighting process. The savings were then adjusted over time on a prior "Max Achievable" model that had used measure-by-measure assumptions throughout the 20 years. Very little value accrued from this exercise. In fact, it was not just complex to develop, but also difficult to adjust, and almost impossible to explain under questioning about the results. In light of this, the partners have agreed to revert to a measure-by-measure analysis throughout the entire 20 years.

Vermont Energy Investment Corporation

APPENDIX

MODELING ASSUMPTIONS

In Support of the
Analysis of Three Electric Energy Efficiency Scenarios for the
2015 – 2034 Demand Resources Plan

Efficiency Vermont

Introduction

The Vermont Demand Resources Plan (DRP) identifies short- and long-term budgets and savings goals for the State's energy efficiency utilities, as well as other compensation matters related to the delivery of energy efficiency services. The first DRP was developed during a proceeding by the Vermont Public Service Board (PSB) in 2010 and 2011, and this second Long-Term DRP will follow a similar process for the term of 2013 to 2014. Using a 20-year framework, the DRP establishes savings goals and budgets demand-side electricity and TEPF for both resource acquisition and non-resource acquisition, by calendar year. In addition, the DRP establishes year-by-year savings goals across a 10-year period for thermal energy and process fuels, by calendar year. This document outlines the scenarios, modeling methods, proposed measures, and associated assumptions required to complete the DRP modeling. It serves as a proposed update of the board filing by Vermont Department of Public Service (DPS) on August 15, 2013, *DPS Scenarios Join Assumptions and QPI Frameworks 2013-08-15*, which covered the proposed electric scenario modeling assumptions and frameworks for Quantifiable Performance Indicators (QPIs) and pulls heavily from that original document. It is assumed this same basis will be applied to the load forecast commissioned by DPS for use in scenario evaluation.

Modeling Scenarios

The following EEU territory specific electric three- and twenty- year scenario modeling recommendations for VEIC and BED are anticipated to be approved by the PSB. It should be noted that these scenarios apply only to modeling electric resource acquisition budgets and savings. In addition, it is assumed that no geographically targeted energy efficiency efforts are included in the scenarios.

1. Level Budget with Inflation
    a. This scenario inputs updated modeling assumptions to estimate savings based on the Board approved framework of the inaugural DRP. The Year 2015 resource acquisition budget for VEIC and BED is applied to all years through 2034, plus inflation, to model achievable savings.
2. Sustained Growth – Inaugural DRP Extended
    a. This scenario uses updated modeling assumptions to estimate savings based on the Board approved framework of the inaugural DRP. This scenario uses the projected annual resource acquisition allocations from the inaugural DRP to model the achievable savings for VEIC and BED. Years 2032, 2033, and 2034 are added to complete the twenty-year time horizon with no change to the ramp rate for achieving savings. Year 2032, 2033, and 2034 resource acquisition budgets are estimated based on the 2018-2031 average growth rate.
3. Aggressive Growth – 3% Savings
    a. This scenario uses updated modeling assumptions to estimate resource acquisition budgets required to ramp up to a 3% annual savings to annual electric energy usage ratio for VEIC and BED by year 2019 and maintain this ratio through the end of the analysis period (2034).

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It is expected that these scenarios will be finalized by a Public Service Board (PSB) ruling on September 27, 2013.

Modeling Stakeholders

Organization	Name	Role
Efficiency Vermont	Mike Wickenden	Director Regulatory Affairs
	Mick Hilbert	DRP Project Manager
	Carole Hakstian	Economic and Forecasting Consultant
	Robert Stephenson	Model Project Management
	Jay Pilliod	Model Reviewer
	Erik Brown	Model Reviewer
	Samuel Dent	Residential Model Lead
Optimal Energy (Contractor to EVT)	Steven Bower	C&I Model Lead
Burlington Electric	Chris Burns	
Vermont DPS	Brian Cotterill	
	Barry Murphy	
	Matthew Walker	
	TJ Poor	
	Kelly Launder	
Grimason Associates (Contractor to DPS)	David Grimason	
	Tom Lyle	

Modeling Methodology

Residential Model
The residential modeling methodology involves developing a simple measure by measure savings analysis in each of the program markets:

- Efficient Products
- Existing Homes
- Low Income Single Family
- Residential New Construction
- Multifamily New Construction Low Income
- Multifamily New Construction Market Rate

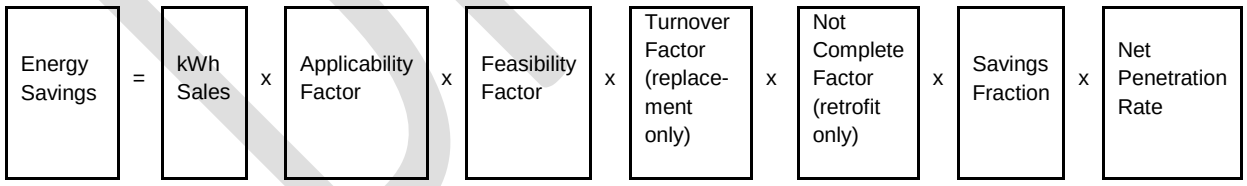
- Multifamily Retrofit Low Income
- Multifamily Retrofit Market Rate

Measures are characterized using the active Technical Reference Manual and include adjustments over time where appropriate. All assumptions and reasons for adjustments are clearly documented in measure tabs at the back end of each market module. For any measure without an approved TRM, a new measure characterization is developed and sources documented.

Penetrations are then developed for each measure. These are estimated based on review of prior program performance, Program Manager input and evaluations providing trend estimates, etc. Ultimately the goal was to adjust penetrations such that the end goal was met. Market opportunity penetrations are based on estimating the number of each item per home over the years, stock mortality and new purchases and ultimately capturing 90% of market share in the program after a few years (for most but not all measures). For existing homes and low income markets, penetrations are based on servicing every home within the 20 years. For RNC, in program homes are ramped up to 90% of new home starts.

Commercial and Industrial Model
The general approach for the Com analysis is "top-down" as opposed to "bottom up." In general terms, the top-down approach starts with a disaggregated energy sales forecast by building type and end-use, and then determines the percentage by which energy use in each "bucket" can be reduced by the installation of a given efficiency measure. This contrasts with a "bottom-up" approach which begins with a fixed number of buildings or equipment installations and considers how many of these items could be addressed by efficiency measures. Top-down analyses, then, work from a basis of energy consumption, while bottom-up analyses work from a basis of the number of units or "widgets."

The assessment of potential proceeds by applying a series of factors to a defined quantity of energy. These factors are applied to the forecasted building-type and end-use or industrial segment sales by year to derive the potential for each measure for each year in the analysis period, as shown in the following equation and described in the subsequent bullets.



- **Sales** is the total quantity of energy consumed by a particular end-use in a particular building type or industrial segment, across the entire market of interest, expressed in kWh or MMBtu. In this analysis, we assessed potential in four different zones, described below. The section titled "Load Forecast and Sales Disaggregation" describes our method for developing these data.

- **Applicability** is the fraction of the end-use level energy sales (from the sales disaggregation) for each building type or industrial segment that is attributable to equipment that could be replaced by the high-efficiency measure. For example, for ambient lighting it would be the portion of total building type lighting electrical load consumed by ambient lighting.
- **Feasibility** is the fraction of end-use sales for which it is technically feasible to install the efficiency measure. Numbers less than 100% reflect engineering or other technical barriers that would preclude adoption of the measure. Feasibility is not reduced for economic or behavioral barriers that would reduce penetration estimates. Rather, it reflects technical or physical constraints that would make measure adoption impossible or ill advised.
- **Turnover** is the number or percentage of existing equipment that will be naturally replaced each year due to failure, remodeling, or renovation. This applies to the natural replacement ("replace on burnout") and renovation markets. In general, turnover factors are assumed to be 1 divided by the measure life (e.g., assuming that 10% (1/10) of existing stock of equipment is replaced each year for a measure with a 10 year estimated life).
- **Not Complete** is the percentage of existing equipment that already represents the high-efficiency option. This only applies to retrofit markets.
- **Baseline Adjustment** adjusts the savings downward in future years for early-retirement retrofit measures to account for the fact that newer, standard equipment efficiencies are higher than older, existing stock efficiencies.
- **Savings Fraction** represents the percent savings (as compared to either existing stock or new baseline equipment for retrofit and non-retrofit markets, respectively) of the high efficiency technology. Savings fractions are calculated based on individual measure data and assumptions about existing stock efficiency, standard practice for new purchases, and high efficiency options. Our estimates of savings fraction and all of the preceding factors are described in the "Measure Characterization" section.
- **Annual Net Penetrations** are the difference between the base case measure penetration (with no efficiency programs) and the measure penetrations that could be achieved with sustained efficiency initiatives. For the resource-constrained economic potential, it is assumed that 100% penetration is captured for all markets, with retirement measures generally being phased in and spread out over time to reflect resource constraints such as contractor availability. We describe our penetration estimates in the "Potential Estimate" section.

In the top-down approach, measure costs are expressed relative to energy savings (i.e., units of dollars per kWh or MMBtu saved) rather than equipment units. For purposes of estimated potential, total costs in each year are determined by multiplying the measure cost per unit energy saved by projected energy savings in that year. This same approach is used for other measure impacts such as operation and maintenance savings.

Efficiency Vermont

Portfolio Screening Tool
The Portfolio Screening Tool (PST) is a combination of C&I and Residential measures. Measure level characteristics are entered into the tool and outputs are generated at the program, sector, and portfolio levels to yield a forecast of achievable potential savings and cost estimates. Other analyses results include program and portfolio cost-effectiveness, benefit cost ratios, and tests such as societal, electric system, participants cost among others. The forecast includes a year by year breakdown over the 20 year DRP analysis period to allow for an in depth evaluation of savings goals and budgets.

Modeling Assumptions

General
The Department, EVT, and BED recommend the Board consider the following available scenario modeling input assumptions. Modeling assumptions are presented in two primary categories:

1. Policy Assumptions and;
2. Model Input Assumptions.

Note that the basis for Low-income spending and Residential and Commercial sector equity splits have been filed with this memo and more detail regarding these assumptions is included in Attachments A and B of the excel spreadsheet titled "20130814 Recommended VEIC_BED Modeling Assumptions and QPI Frameworks.xlsx".

Policy Assumptions

Residential – sector equity requirements

Residential sector equity requirements assumed for scenario modeling are different for VEIC and BED. For both VEIC and BED it was recommended that the level of residential spending be based on the percentage of resource acquisition (RA) spending used in the inaugural DRP. VEIC and BED proposed residential spending as a percent of RA for 2015-2017 are presented below.

- VEIC - The level of residential spending in the model is recommended to assume 34% of the VEIC RA budget for 2015, 36% for 2016, and 37% of the RA budgets in 2017. Multifamily program spending is included as residential sector spending. Currently, the residential sector contributes about 48% of the total Energy Efficiency Charge (EEC) in VEIC territory. For modeling it is recommended that the percent spending in the residential sector steadily increase over time until it is assumed there is little available potential remaining. This residential sector percentage of EEC collections spending in VEIC territory is presented as a "ramp rate over time" in Attachment A of the excel spreadsheet, tab titled "EEC Res Com Split" of the attached excel spreadsheet.
- BED – The level of residential spending in the model is recommended to assume 25% of the BED RA budget for 2015, 25% for 2016, and 25% of the RA budgets in 2017. Multifamily program spending is included as residential sector spending. Currently, the residential sector contributes about 25% of the total EEC in BED territory.

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Efficiency Vermont

C&I – sector equity requirements

The level of commercial and industrial spending in the VEIC and BED models should reflect the inverse of the residential percentages provided above. This sets the level of spending for commercial and industrial combined program spending.

- VEIC - The level of commercial and industrial spending is recommended to assume 66% of RA budgets for 2015, 64% of RA budgets for 2016, and 63% of RA budgets for 2017.5
- BED – The level of commercial and industrial spending is recommended to assume 75% of the RA budget for 2015, 75% for 2016, and 75% of the RA budgets in 2017.

Low-income – sector equity requirements

Recommended low-income sector equity requirements assumed for scenario modeling are different for VEIC and BED.

- BED - It is assumed that 12% of BED's residential customers are low-income. The recommended level of low-income spending to assume for BED scenario modeling is 2.6% of the Resource Acquisition (RA) budget for each scenario. The percentage is based on the assumed Energy Efficiency Charge (EEC) contribution from low-income customers in BED territory for years 2015-2017 ($200,000) as a percent of RA spending in 2015-2017 ($7.5M). The assumption is that no equity constraint is applied to the low-income spending in the model. This includes both single family and multifamily low-income program spending.
    - $200,000/ $7.5M =2.6%
- VEIC – It is assumed that 31% of statewide (non-BED) residential customers are low income. The recommended level of low-income spending to assume for VEIC scenario modeling is 8.9% of the Resource Acquisition (RA) budget for each scenario. The percentage is based on the assumed EEC contribution from statewide (non-BED) low-income customers for years 2015-2017 ($15M) as a percent of RA spending in 2015-2017 ($130M). In addition, it is assumed that an equity constraint of 70% is applied to determine a minimum spending requirement. Also, an adder is applied (0.8%) so not to model savings at a bare minimum spending requirement. This includes both single family and multifamily low income program spending.
    - ($15M/$130M)*0.7= 8.1%
    - 8.1%+0.8%= 8.9%

Small Business – sector equity requirements

The current 2012-2014 performance period "equity for small business" metric is measured by the minimum number of participating non-residential customers with less than 40,000kWH annual consumption. The target in the current 2012-2014 performance period for small business participation is 1,950 customers for VEIC and 158 customers for BED. While this actual target may vary slightly in the future, no significant conceptual changes to this minimum performance requirement are anticipated for the next performance period. In addition, this assumption is expected to have minimal impact on the model. For these reasons it is

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recommended the basis for this assumption be the current "equity for small business" minimum performance requirements as reflected in the EEUs QPIs; specifically a minimum of 1,950 customers for VEIC and 158 customers for BED.

Modeling Input Assumptions

Code Changes

The following commercial and residential energy codes and standards assumptions apply equally to VEIC and BED. The impact of energy codes and standards updates reduces the amount of available electric energy savings potential as indicated below.

Commercial Energy Code

Current commercial energy code is 2011 Vermont Commercial Building Energy Standards (CBES), effective January 2012, based on the equivalent model codes: 2009 International Energy Conservation Code (IECC) and ASHRAE 90.1-2007. This code is expected to remain effective through December 2014.

- Next code revision expected to be effective on 1/1/15 based on the equivalent model codes: 2012 IECC and ASHRAE 90.1-2010. An estimated savings impact of 14% compared the current 2011 Vermont CBES is recommended.
- Future code revision expected to effective on 1/1/18 based on the equivalent model codes: 2015 IECC, ASHRAE 90.1-2013 (now in development). The estimated savings impact is still in development but for modeling purposes is recommended at the expected value which is about 5% compared to 2012 IECC and ASHRAE 90.1-2010.

Residential Energy Code

Current residential energy code is 2011 Vermont Residential Building Energy Standard (RBES), effective October 2011 and is based on the equivalent model code: 2009 IECC. This is expected to remain in effect through December 2014.

- Next residential code revision is expected to be effective on 1/1/15 based on 2012 IECC. Since the current version of RBES is already more efficient than 2009 IECC, the estimated and recommended savings is expected to be 10% as compared to 15% expected of a full increase in efficiency between 2009 to 2012 IECC.
- Future residential code revision expected to be effective on 1/1/18 based on 2015 IECC. Although still in development the estimated and recommended savings impact is expected to be 5% compared to 2012 IECC.

Stretch Codes

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As part of the next code update process, both residential and commercial "stretch codes" will be developed to set a higher efficiency requirement for projects that fall under Act 250, criteria 9F. The standards on which these stretch codes will be based have not yet been determined but for the purposes of the scenario modeling an impact of 5% beyond current code was agreed to be the best professional judgment. If the stretch codes are approved following this assumption, this would require buildings that fall under ACT 250 to meet 2015 IECC and ASHRAE 90.1-2013 beginning on 1/1/2015.

Avoided Costs, Budget Targets, and Inflation

VEIC plans to use the recently filed Avoided Energy Supply Costs in New England report (filed August 30, 2013). Budgets in the PST are represented in real dollars, and board ordered budgets are represented in nominal dollars. VEIC proposes to use 2015 dollars for modeling, with a real discount rate of 3% and an inflation rate of 2.0%.

TEPF

To be determined, concluding consideration of Act 89 impacts.

SMEEP and CCP participant Load

As it relates only to VEIC it is recommended the scenario model should assume that IBM and OMYA will continue to operate in the SMEEP and CCP respectively. In addition, for modeling it is recommended that no new SMEEP and Customer Credit Program participants enter the programs. The load for these customers will be addressed and documented appropriately in the VELCO/Itron forecast prior to modeling the scenarios.

Measure Decay

Treatment of measure decay is recommended to be the same for VEIC and BED. Measure decay is a factor that impacts the DRP load forecast. Assumptions about measure decay should be considered and applied to the DRP load forecast which is used to estimate savings in the DRP. The Vermont System Planning Committee (VSPC) is considering the issue of measure decay in the forecast and how this assumption should be reflected in the savings model. Note, a significant impact of measure decay in the model is reflected in compact fluorescent lighting (CFL) becoming baseline in 2020 (based on the Energy Independence and Security Act of 2007 (EISA)) and how this is handled in both the VELCO/Itron load forecast and the energy efficiency potential modeling is currently being considered by the VSPC. Measure decay in the forecast is not to be confused with the actual "measure life" assigned to each measure, which is discussed below.

Base Appliance and Equipment Energy Levels, Free Rider and Spill Over Rates, and Measure Life

Base appliance and equipment efficiency levels, free rider (FR) and spill over (SO) rates, and measure life are assigned at a detailed measure level in the models. These rates are based on either the values in the current Technical Reference Manual (TRM) or specific measure characterizations where TRM values are not available. The EEUs and DPS are currently reviewing all the existing measures to determine if any anticipated changes to either base efficiency levels, FR and SO rates, and measure life for any particular measures would be significant enough to be identified specifically and adjusted for accordingly in the model. The measures are prioritized based on greatest savings impact (kWh, kW, TRB), quantity installed, risk to portfolio, and

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magnitude of change anticipated. To date the following issues have been identified as having significant impact on savings since the last DRP:

1. EISA impacts - specialty CFLs, impact smaller based on CFL drop off in programs

   In the last DRP, specialty CFLs were treated to similar EISA impacts as standard CFLs - the first round of adjustments were delayed by 3 years (2015-2017) and were equivalent to the 2012-2014 adjustments for standard CFLs and then the specialty measure lives were reduced to 2020 to account for the backstop provision in EISA. Upon review this was inappropriate since most specialty bulbs are exempt from EISA and there is no other legislation (beyond the EPACT legislation on reflector bulbs) that will have this effect. These measures have therefore been adjusted. The impact of this change may be somewhat reduced by the fact that CFL support (both standard and specialty) is likely to be reduced significantly over the coming years and be more aggressively replaced by LED measures.

2. TRM updates

   Upon review, a majority of TRMs used to characterize year one measure savings in the last DRP have been updated since this was last performed. All these measures have been updated.

3. Removing trend analysis from modeling for years 7-20

   EVT have changed the methodology for characterizing residential savings in the 7-20 year period. Last round there was an attempt to create blended end use bundles and the assumptions determined through a very complex weighting process. The savings were then adjusted over time based on a prior "Max Achievable" model that had used measure by measure assumptions throughout the 20 years. It was determined that there was very little value gained in performing this exercise and in fact it was incredibly complex to develop, difficult to adjust and almost impossible to answer questions about reasons for results. In light of this the team has decided to revert to a measure by measure analysis throughout the entire 20 years.

A final list of measures which are determined to significantly impact the modeling results will be available for inclusion in the models by September 27, 2013.

Behavioral Measures, AMI, and other New Measures

Energy efficiency behavior programs address two sets of behaviors: (1) those associated with purchasing and installing energy-efficient technology, and (2) behaviors, decisions, and actions that are considered to be independent of equipment replacement or improvement. In the context of this program plan, EVT refers only to behaviors independent of equipment replacement or improvement, and considers them legitimate energy efficiency measures. Advanced Metering Infrastructure (AMI), commonly referred to as smart metering, is not considered to be a standalone measures by EVT but rather a tool that informs existing efficiency efforts and facilitates behavior change through the use of interval consumption data.

Behavioral measures and AMI-enabled measures are not currently part of the TRM and savings portfolios of VEIC and BED. Per VEIC and BED's current order of appointments behavior savings cannot be claimed in

years 2012- 2014 without renegotiating savings goals with the Department and approval from the Board. The Department's concerns largely revolve around persistence of behavioral savings over time as well as appropriate methods for cost-effectively verifying the realized energy savings from such initiatives. Behavior measures can generically be classified by market sector – residential, commercial, and industrial. VEIC and BED are currently investigating approaches for capturing behavior savings. It is anticipated specific behavior measures will be a part of VEIC and BED savings portfolios starting in year 2015, but specific measures have not yet been identified.

For context, VEIC has two behavior engagement pilots scheduled for 2014. The Department, VEIC, and BED agree that persistence and verification issues become more manageable when isolated to specific behavioral engagement strategies. The Department, VEIC and BED are considering the challenges associated with quantifying persistence and verification of savings primarily within the context of the pilot programs below. In general, the outcome of these behavior pilots will help determine specific behavioral focused initiatives, E,M, and V activities, and saving estimates .

- Continuous Energy Improvement (C&I)

  Strategy: Continuous Energy Improvement

  Continuous Energy Improvement (CEI) is a long-term, comprehensive strategy for maximizing energy productivity. CEI integrates capital upgrades, process improvements, maintenance, and employee engagement to yield deeper, more sustainable savings. CEI is based on the philosophy that on-going, incremental change that benefits an organization is the responsibility of everyone. This strategy has recently been tested in the Energy Leadership Challenge program.

- Residential
  Strategy: Home Energy Reports
  This approach utilizes home energy usage data, individualized reports, customer specific messaging and other tools to encourage behavioral customer engagement.

Measures List

These proposed lists of measures are based on those modeled in the previous DRP with additional measures added where savings opportunities have been identified by VEIC subject matter experts.

Commercial & Industrial
Commercial measures are classified as either market opportunity (market driven) or retrofit and have been broken down into the following end use categories:

- Indoor Lighting
- Outdoor Lighting
- Cooling

- Space Heating
- Ventilation
- Water & Sewer
- Water Heating
- Refrigeration
- Industrial Process
- Whole Building
- Miscelaneous

Please see the attached excel file, *Preliminary Com-Ind Measure List*.

Residential
Residential measures have been broken down by market area as follows, (EVT project tracks in parentheses):

- Efficient Products (6032)
- Existing Homes and Low Income (6036 and 6034)
- Residential New Construction (6038)
- Multifamily Retrofit (6017 and 6020)
- Multifamily New Construction (6018 and 6019)

Please see the attached excel file, *Preliminary RES Measure List*. The first tab includes a combined list of measures with areas for EVT, DPS, and Grimason (DPS Consultant) comments. Measures within these project tracks that actually fall within C&I have been highlighted in yellow. These measures will be included in the residential model and their impacts removed from the C&I model.

Modeling Schedule

Due Date	Time	Key Project Milestone
Ongoing		Document Assumptions from past DRP
8/9/2013		1st draft measure mix provided by EVT
9/18/2013		Final measure mix characterized and approved by EVT
9/20/2013		Draft Measure Mix to BED and DPS/Grimason
9/27/2013		All measure and modeling assumptions updated in model and documented

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Due Date	Time	Key Project Milestone
9/27/2013		Final scenario's selected and defined by PSB
First Draft		
9/30/2013		1st Draft Modeling starts (or sooner if possible)
10/11/2013	12:00 pm	1st Draft C&I and RES outputs to Carole H
10/14/2013	9:00 am	1st Draft Packaged Modeling outputs to DPS/Grimason Meeting to present modeling outputs to EVT and DPS/Grimason with real-time Q&A
10/18/2013	9:00 am	Meeting between EVT and DPS/Grimason to review 1st Draft comments
Second Draft		
10/21/2013		2nd Draft Modeling starts (or sooner if possible)
11/1/2013	12:00 pm	2nd Draft C&I and RES outputs to Carole H
11/4/2013	9:00 am	2nd Draft Packaged Modeling outputs to DPS/Grimason Meeting to present modeling outputs to EVT and DPS/Grimason with real-time Q&A
11/8/2013	9:00 am	Meeting between EVT and DPS/Grimason to review 2nd Draft comments
Final Draft		
11/14/2013	12:00 pm	Final Draft C&I and RES outputs to Carole H
11/15/2013	9:00 am	Final Packaged Modeling outputs to DPS/Grimason Meeting to present modeling outputs to EVT and DPS/Grimason with real-time Q&A
11/19/2013	9:00 am	Meeting between EVT and DPS/Grimason to review 2nd Draft comments, **as needed**
11/22/2013	12:00 pm	Finalized C&I and RES outputs to Carole H
11/25/2013	9:00 am	Final Packaged Modeling Outputs delivered to EVT/DPS/Grimason
11/27/2013		EVT prepares scenario results filing
12/6/2013		Scenario Analysis Results filed with PSB by EVT

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Due Date	Time	Key Project Milestone
7/1/2014		DRP approved

Glossary

The following glossary provides definitions for necessary assumptions needed to calculate measure savings.

Baseline Efficiency (η_{base}): The assumed standard efficiency of equipment, absent an Efficiency Vermont program.

Coincidence Factor (CF): Coincidence factors represent the fraction of connected load expected to be coincident with a particular system peak period, on a diversified basis. Coincidence factors are provided for summer, winter and spring/fall peak periods.

Connected Load: The maximum wattage of the equipment, under normal operating conditions.

Freeridership (FR): The fraction of gross program savings that would have occurred despite the program.

Full Load Hours (FLH): The equivalent hours that equipment would need to operate at its peak capacity in order to consume its estimated annual kWh consumption (annual kWh/connected kW).

High Efficiency (η_{effic}): The efficiency of the energy-saving equipment installed as a result of an efficiency program.

Lifetimes: The number of years (or hours) that the new high efficiency equipment is expected to function. These are generally based on engineering lives, but sometimes adjusted based on expectations about frequency of remodeling or demolition.

Line Loss Factor (LLF): The marginal electricity losses from the generator to the customer – expressed as a percent of meter-level savings. The Energy Line Loss Factors vary by period. The Peak Line Loss Factors reflect losses at the time of system peak, and are shown for three seasons of the year. Line loss factors are the same for all measures. See the Gross-to-Net Calculation section for specific values.

Load Factor (LF): The fraction of full load (wattage) for which the equipment is typically run.

Operating Hours (HOURS): The annual hours that equipment is expected to operate.

Persistence (PF): The fraction of gross measure savings obtained over the measure life.

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Rating Period Factor (RPF): Percentages for defined times of the year that describe when energy savings will be realized for a specific measure.

Spillover (SPL): Savings attributable to the program, but generated by customers not directly participating in the program. Expressed as a fraction of gross savings. All values can be changed as new information becomes available.

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