NAVIGANT

# Energy Efficiency Resource Assessment Report

**Final Report**

**Prepared for:**
**Energy Trust of Oregon**

EnergyTrust of Oregon


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# Executive Summary

## *Introduction and Background*

Energy Trust of Oregon (Energy Trust) engaged Navigant Consulting, Inc. (Navigant) to prepare an energy efficiency resource assessment of its service territory in August 2013. The primary purpose of this energy efficiency resource assessment is to enable Energy Trust to support the Integrated Resource Planning (IRP) planning process of its four funding utilities by providing a 20-year forecast of efficiency resource potential of each utility, as well as informing Energy Trust's strategic program planning, including program development. A primary product of this resource assessment is the Energy Trust Resource Assessment Model, which provides a flexible yet robust platform in which to estimate the technical and cost-effective achievable potential for demand-side resources in Energy Trust's service territory across the residential, commercial, and industrial sectors.

## *Approach*

This section provides a high-level summary of the approach detailed in section 2 of this report.

### Measure Identification and Characterization

Through a review of the previous Energy Trust potential model to identify high impact measures, the Regional Technical Forum (RTF) measures, and measure lists from other Navigant potential studies, Navigant considered over 530 measures across the residential, commercial, and industrial sectors for this resource assessment. Of these, 159 (68 residential, 49 commercial, and 42 industrial) conventional measures were characterized, which are considered to be commercialized technologies with noticeable market penetration and relatively stable price trajectories. Navigant characterized measures for 27 different customer segments across all three sectors. Additionally, Navigant identified numerous emerging technology measures for this study, and ultimately characterized 32 of the measures (10 residential, 17 commercial, and 5 industrial) considered most likely to become commercially available and cost-effective over the study period, and thus contribute to future savings. For all measures characterized, 33 measure inputs across all three customer segments were estimated using a combination of Energy Trust primary data review and analysis,[1] regional secondary sources, and engineering analysis. Navigant also adjusted cost and savings profiles for several measures that are subject to codes and standards, as well as emerging technology measures that are expected to evolve over time without codes and standards.

### Estimation of Technical, Achievable, and Cost-Effective Achievable Potential

The Navigant team built a flexible and robust potential model as part of this resource assessment, which was used to estimate the technical, achievable, and cost-effective achievable potential for electric energy,

[1] Energy Trust measure analyses provide a synthesis of data from the other sources. In many cases, the Energy Trust uses RTF analyses directly. Navigant went to other sources for measure characterization where Energy Trust did not have an analysis or new data, or when an updated analysis had become available since Energy Trust's last update.

peak demand, and gas savings across all sectors. Technical potential was calculated differently depending on whether a measure is a retrofit, end of life replacement, or new construction measure. New construction technical potential is driven by new efficiency opportunities coming into the market due to new building stock and is used to determine the incremental annual addition to technical potential. Technical potential is considered to be "constrained" for Replace-on-Burnout (ROB) measures in that potential is limited by the rate at which baseline measures turn over due to burnout. This view of potential was adopted for consistency with Energy Trust's existing planning framework and program opportunities. For retrofit measures, technical potential is calculated using the entire building stock and is not constrained by any pre-assumed rate of adoption.[2] Achievable potential is specified as a percentage of the technical potential. The percentage of technical potential that is deemed "achievable" is by default 85% based on the Northwest Power and Conservation Council (Council) planning assumptions.[3]

Cost-effective achievable potential was estimated as a subset of achievable potential when limited to only measures that, based on the first-cut analysis incorporated into this study, pass the Total Resource Cost (TRC) test. To account for measures with multiple tiers of efficiency that could compete for the same installation, Navigant employed a tiered "incremental" approach where savings and incremental costs of a competing measure were compared with the measure just below it in ranking, from a TRC perspective. The study also provides an expanded view of emerging technology measures by quantifying the cost, potential, and risks associated with them over the modeling period. Finally, Navigant estimated the risk-adjusted tiered potential by program type, end use, and customer segment, along with cost-effectiveness outputs, including levelized cost of energy and energy efficiency supply curves.[4]

## *Findings*

This section of the executive summary discusses high-level findings of the analysis in addition to providing aggregate electric energy and natural gas savings results. The potential estimates presented in this section and in the main body of the report are estimates of "gross" savings, which represent changes in consumption that result directly from program-related actions taken by consumers that are exposed to the program. Detailed results of the resource assessment including sector level views of potential disaggregated by customer segment, end use, and program type are provided in the main body of this report.

**Electric Energy Potential**

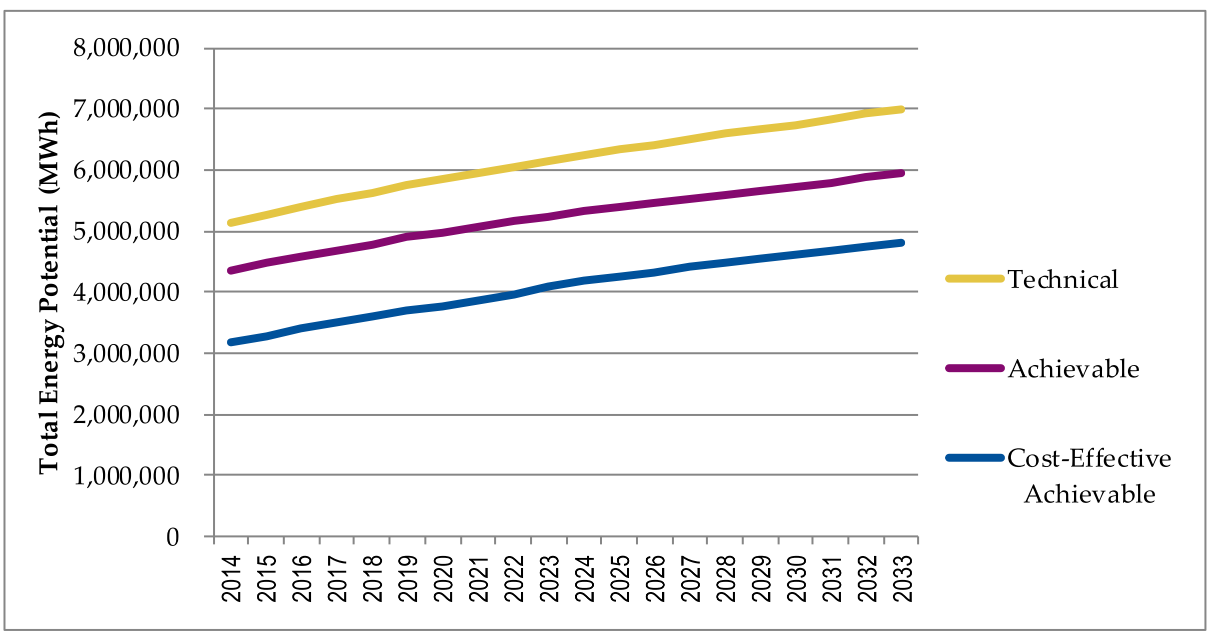
Cumulative technical, achievable, and cost-effective achievable electric energy savings for all sectors are listed in Figure ES-1. This represents potential from conventional measures only and excludes savings from any emerging technologies. Technical and achievable potential at the end of the 20-year forecast

[2] The rate of adoption is considered at a later stage in Energy Trust's planning process.
[3] Achievable Savings – A Retrospective Look at the Northwest Power and Conservation Council's Conservation Planning Assumptions - http://www.nwcouncil.org/media/29388/2007_13.pdf
[4] While tiered potential includes savings from both conventional and emerging technology measures, risk-adjustments were only made to emerging technology measures to account for uncertainty in their ability to reliably produce future savings.

horizon are 6,984,232 and 5,936,598 MWh, respectively. Both forecasts follow similar paths with achievable potential estimated using an 85% achievability factor. Cost-effective achievable potential by 2034 is estimated to be 4,806,536 MWh, which is 80% of achievable potential, thus showing significant cost-effective achievable electric energy potential over the forecast horizon. The overall increase in potential over the time horizon is driven by the projected growth in building stock, lending additional opportunities for savings in new buildings.

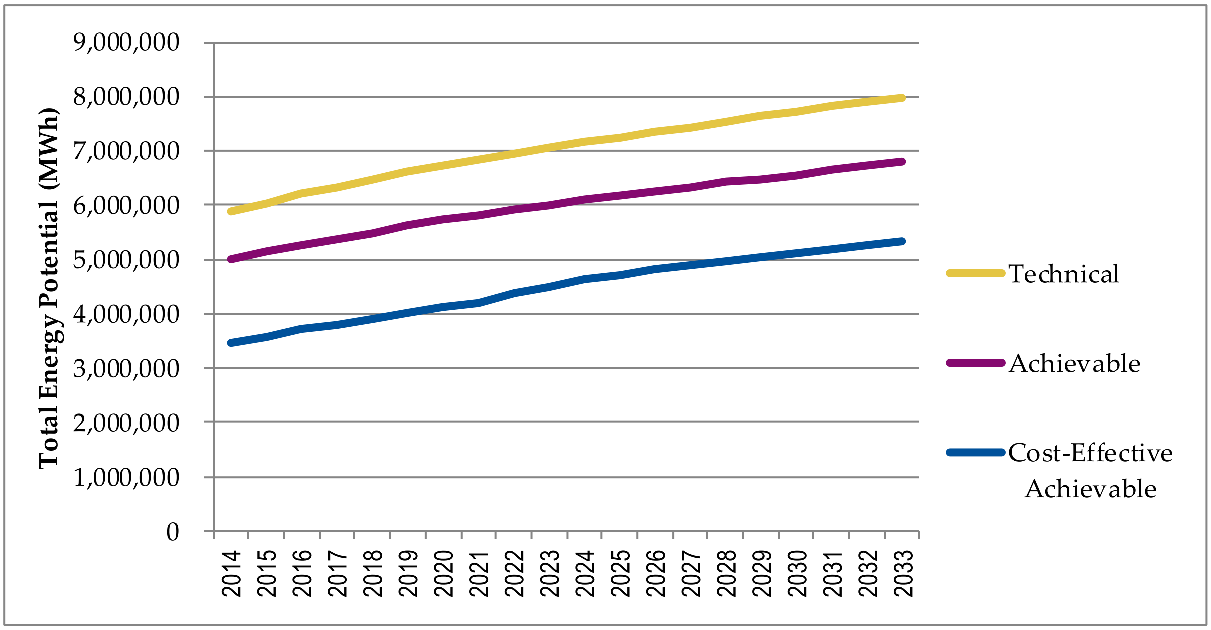
Navigant's modeling approach includes an emerging technology (ET) overlay that enables the model to capture the range of possible savings from ETs due to cost and efficiency improvements over time. Figure ES-2 shows the technical, achievable, and cost-effective achievable potential with the inclusion of emerging technologies. Technical and achievable potential at the end of the 20-year forecast horizon are 7,994,648 and 6,795,451 MWh, respectively. By 2033, cost-effective achievable potential increases to 5,329,351 MWh, after the addition of emerging technologies. Figure ES-3 shows the contribution of emerging and conventional measures toward cumulative risk-adjusted, cost-effective achievable electric savings potential across all three sectors over the study period. By 2033, emerging technologies constitute about 15% of total cost-effective achievable potential. Cumulative cost-effective achievable electric energy potential as a percentage of baseline forecast energy sales (with emerging technology overlay) in 2033 is 11.9%, as shown in Table ES-2**Error! Reference source not found.**. More detail on the key drivers of electric energy savings potential, including on emerging technology savings, are provided in sections 3 and 4 of this report. Table ES-1 shows a summary of electric savings potential in 2033 in units of Average Megawatts (aMW).

**Figure ES-1. Cumulative Electric Energy Savings Potential (MWh) – without ETs**



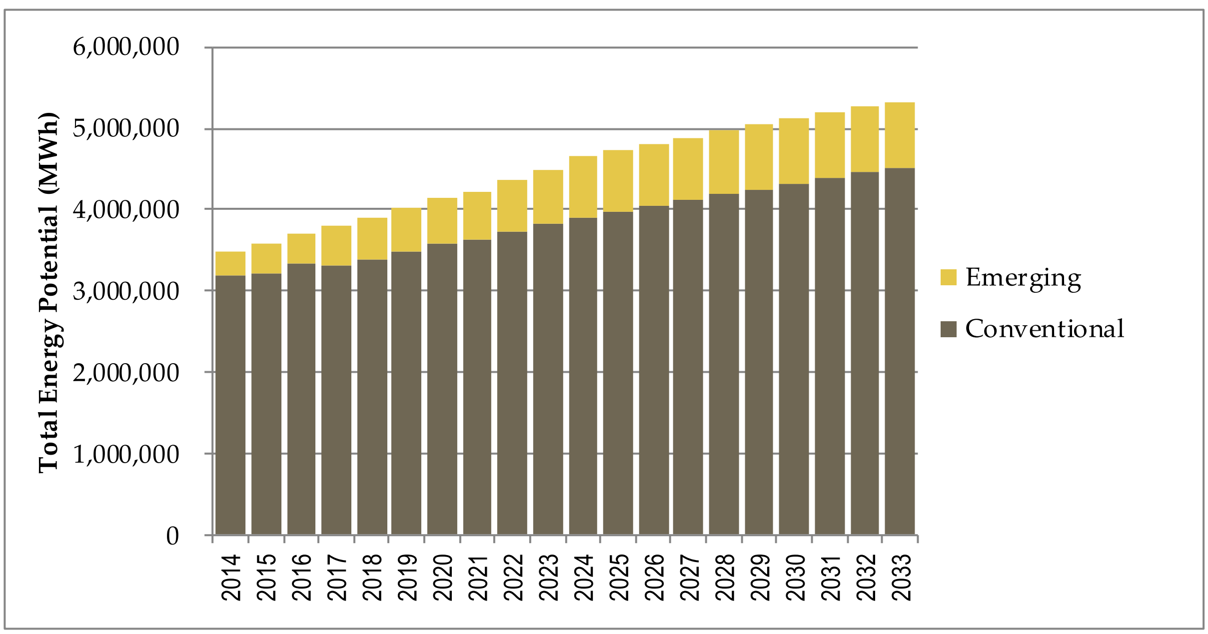

*Source: Navigant analysis, 2014*

**Figure ES-2. Cumulative Electric Energy Savings Potential (MWh) – with ETs**




*Source: Navigant analysis, 2014*

**Figure ES-3. Cumulative Cost-effective Electric Energy Savings - Emerging vs. Conventional**




*Source: Navigant analysis, 2014*

Navigant also estimated peak demand (MW) savings for summer and winter periods as part of this resource assessment. The model estimates peak demand savings using peak demand multipliers for each energy loadshape.[5] Cumulative cost-effective achievable peak demand savings are projected to be 640 and 801 MW by 2033 for summer and winter periods respectively, as shown in Table ES-2**Error! Reference source not found.**.

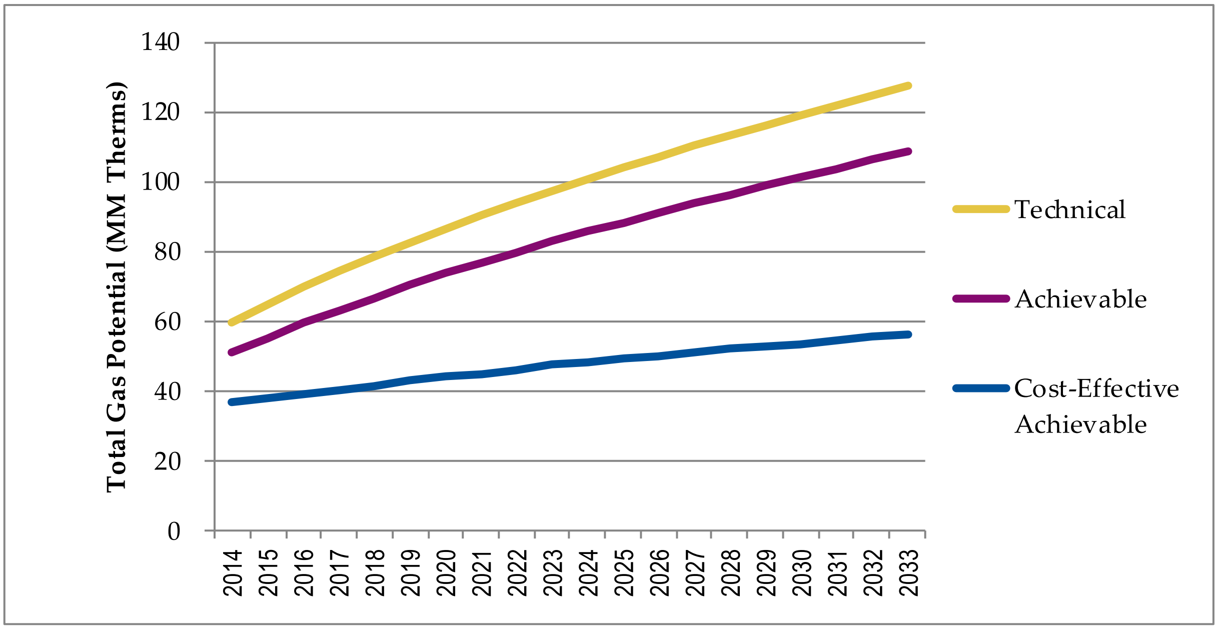
**Natural Gas Potential**

Cumulative technical, achievable, and cost-effective achievable gas savings potential for conventional measures across all sectors are presented in Figure ES-4. Technical potential increases steadily from 60 MMtherms in 2014 to about 128 MMtherms in 2033. This increase in potential is driven by the forecasted growth in building stock within the Northwest Natural (NWN) and Cascade Natural Gas (CNG) service territories. Similar to electric technical potential, gas technical potential also shows a sharp rise over the 20-year forecast horizon as it is driven by future growth in ROB and new construction measures. Cost-effective achievable potential is 56 MMtherms by 2033, which represents about 51% of achievable potential.

Figure ES-5 presents the cumulative gas savings potential with the inclusion of the emerging technology overlay. In this case, technical potential increases from 84 MMtherms in 2014 to about 157 MMtherms in 2033. Cost-effective achievable gas potential increases to 61 MMtherms by 2033 with addition of the emerging technologies. Similar to electric savings, achievable gas savings potential is also estimated using an 85% achievability factor over the forecast horizon. Cumulative cost-effective achievable gas potential as a percentage of baseline forecast gas sales by 2033 is 5.3% (with emerging technology overlay), as shown in **Error! Reference source not found.**. Navigant notes that there is a larger gap between achievable and cost-effective achievable potential for gas savings compared with electric. Low gas cost-effectiveness is driven by low forecasts of future avoided gas costs, which result in relatively low benefits in the TRC calculation. Section 3.1.2 has more details on the drivers of low gas cost-effectiveness. Figure ES-6 shows the contribution of emerging and conventional measures toward cumulative risk-adjusted cost-effective achievable gas savings potential across all three sectors over the study period. By 2033, emerging technology measures contribute up to 19% of total cost-effective gas potential.

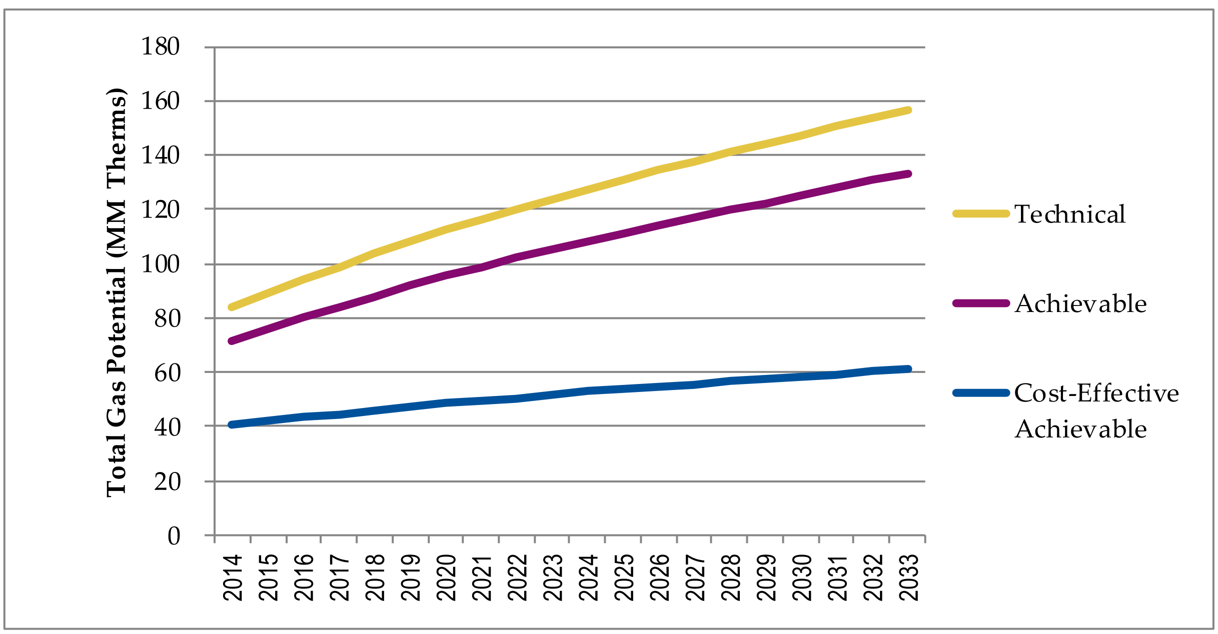
[5] The peak demand multipliers used in this study were calculated based upon the Northwest Power and Conservation Council loadshapes.

**Figure ES-4. Cumulative Gas Savings Potential (MMtherms) – without ETs**



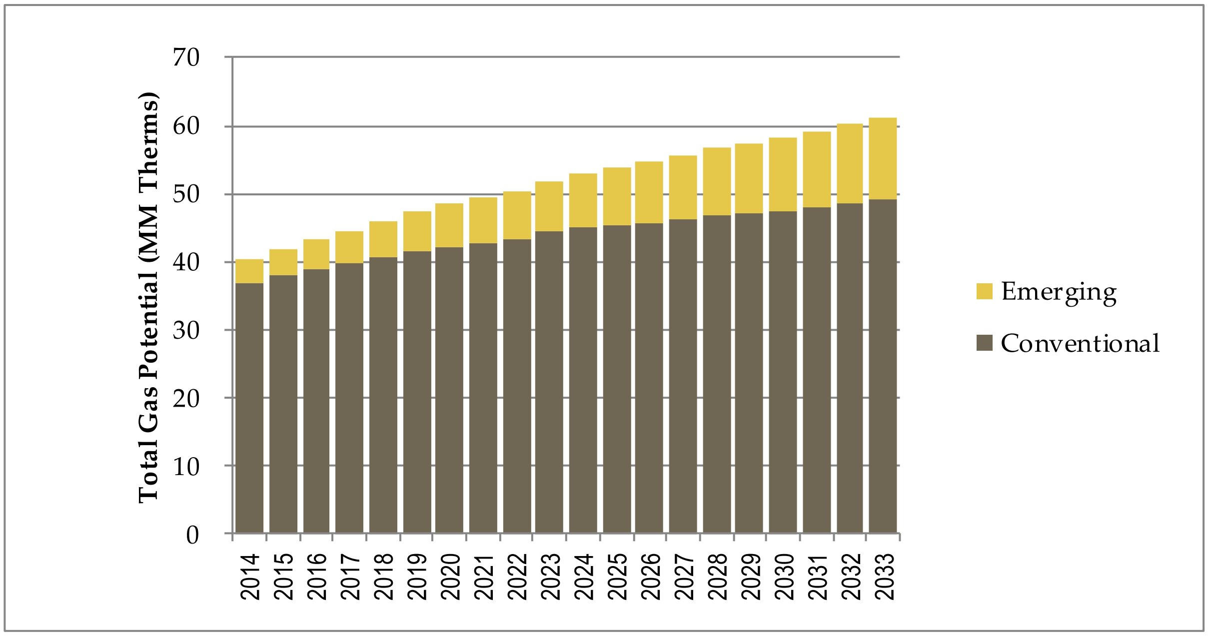

*Source: Navigant analysis, 2014*

**Figure ES-5. Cumulative Gas Savings Potential (MMtherms) – with ETs**




*Source: Navigant analysis, 2014*

**Figure ES-6. Cumulative Cost-effective Gas Savings - Emerging vs. Conventional**




*Source: Navigant analysis, 2014*

**Table ES-1. Summary of Electric Savings Potential in 2033 (Average Megawatts)**

| Sector | Program | Technical | Achievable | Cost-Effective Achievable |
|---|---|---|---|---|
| Residential | New | 81 | 69 | 60 |
| | Retrofit | 155 | 132 | 62 |
| | Replace | 161 | 136 | 105 |
| Commercial | New | 108 | 92 | 77 |
| | Retrofit | 184 | 157 | 118 |
| | Replace | 17 | 14 | 11 |
| Industrial | New | 12 | 10 | 10 |
| | Retrofit | 176 | 150 | 150 |
| | Replace | 19 | 16 | 15 |

*Source: Navigant analysis, 2014*

**Table ES-2. Aggregate Cumulative Cost-effective Achievable Potential - All Sectors**

| Year | Electric Savings MWh | Electric Savings % of Sales | Demand Savings Summer MW | Demand Savings Winter MW | Gas Savings MM Therms | Gas Savings % of Sales |
|---|---|---|---|---|---|---|
| **2014** | 3,477,238 | 10.3% | 442 | 530 | 40.3 | 4.7% |
| **2015** | 3,575,951 | 10.5% | 452 | 544 | 41.8 | 4.8% |
| **2016** | 3,706,599 | 10.6% | 468 | 563 | 43.3 | 4.9% |
| **2017** | 3,802,344 | 10.7% | 478 | 577 | 44.6 | 5.0% |
| **2018** | 3,904,252 | 10.8% | 490 | 591 | 45.9 | 5.1% |
| **2019** | 4,012,545 | 10.9% | 501 | 607 | 47.3 | 5.2% |
| **2020** | 4,137,989 | 11.1% | 513 | 626 | 48.5 | 5.2% |
| **2021** | 4,212,197 | 11.2% | 521 | 637 | 49.3 | 5.2% |
| **2022** | 4,363,789 | 11.4% | 541 | 659 | 50.3 | 5.3% |
| **2023** | 4,478,869 | 11.5% | 551 | 677 | 51.9 | 5.4% |
| **2024** | 4,651,288 | 11.8% | 574 | 702 | 53.0 | 5.4% |
| **2025** | 4,728,601 | 11.8% | 582 | 714 | 53.8 | 5.4% |
| **2026** | 4,810,133 | 11.9% | 590 | 725 | 54.7 | 5.4% |
| **2027** | 4,878,684 | 11.9% | 597 | 736 | 55.6 | 5.4% |
| **2028** | 4,968,898 | 11.9% | 606 | 749 | 56.7 | 5.4% |
| **2029** | 5,043,665 | 11.9% | 614 | 760 | 57.4 | 5.4% |
| **2030** | 5,115,290 | 11.9% | 620 | 770 | 58.3 | 5.4% |
| **2031** | 5,185,445 | 11.9% | 627 | 780 | 59.2 | 5.4% |
| **2032** | 5,266,927 | 11.9% | 635 | 792 | 60.2 | 5.4% |
| **2033** | 5,329,351 | 11.9% | 640 | 801 | 61.1 | 5.3% |

*Source: Navigant analysis, 2014*

**Supply Curves**

Figure ES-7 and Figure ES-8 show traditional efficiency supply curves for all sectors in 2033. The supply curves plot levelized cost of energy saved as a function of cumulative technical potential, for electric and gas savings measures respectively. These supply curves are constructed using individual efficiency measures that are sorted on a least-cost basis,[6] and savings that are calculated on an incremental or tiered basis relative to the measures that precede them. Figure ES-7 shows the supply curve for cumulative energy potential in 2033. Approximately 266,000 MWh are available with levelized cost of energy less than zero. This potential is derived from light-emitting diode (LED) street lights, efficient showerheads, and faucet aerators whose present value of non-energy benefits exceed the upfront equipment costs, resulting in a negative levelized cost. There is an additional 160,936 MWh of potential from LEDs, switched reluctance motors, and high efficiency chillers that can be achieved at almost zero cost. Nearly 5,756,952 MWh of cumulative electric energy potential are available at levelized costs below $0.08 per kWh levelized (in 2014 dollars), which is the lowest forecast of avoided energy costs in 2033.

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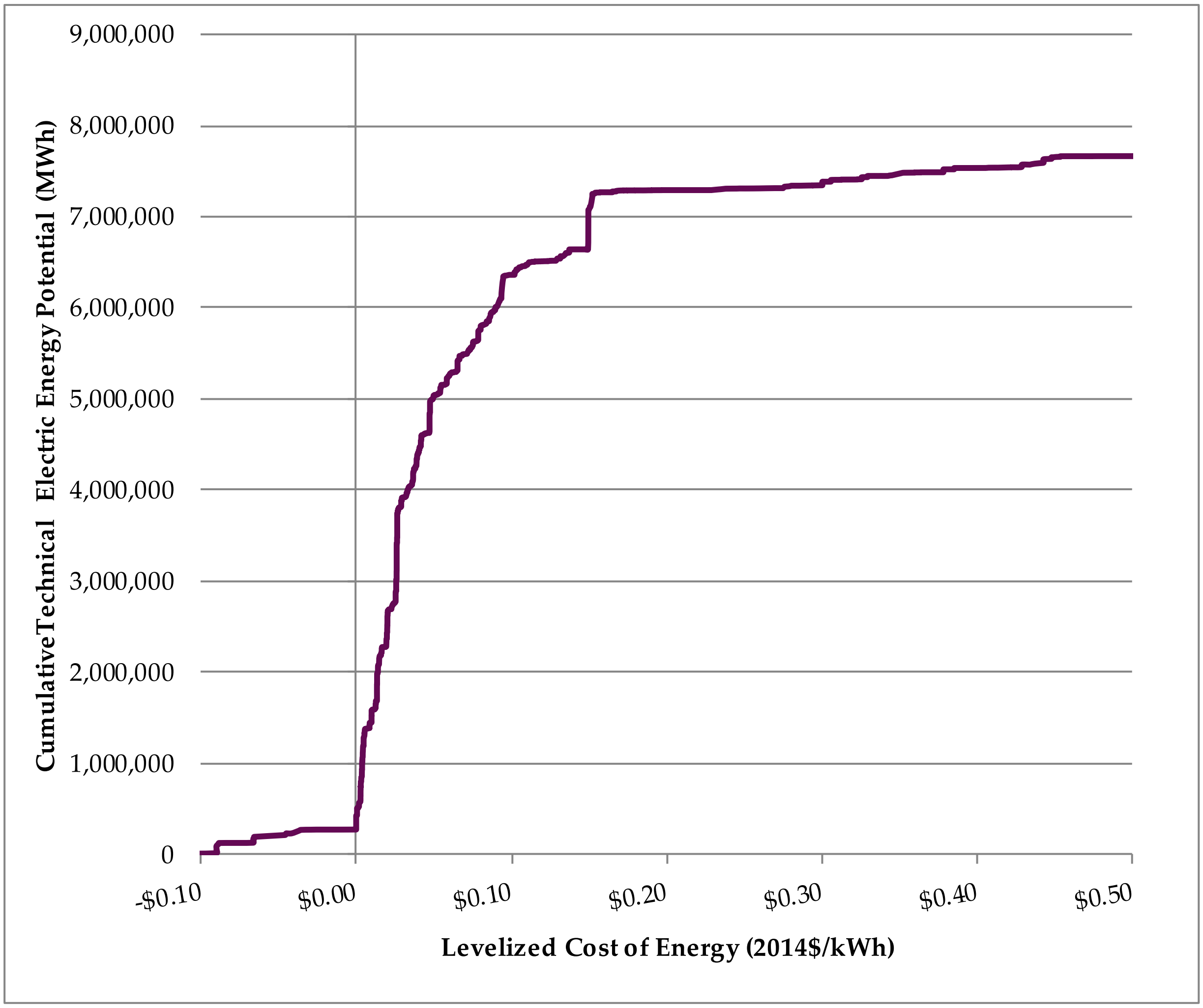
[6] Levelized measure costs were used as the cost basis for sorting the supply curves. To account for competing measures in this process, Navigant estimated an incremental levelized cost relative to the next highest rank within a competition group. Section 2.2.2 offers additional detail on the calculation of levelized costs.

**Figure ES-7. Electricity Savings Supply Curve (2033)[7]**




*Source: Navigant analysis, 2014*

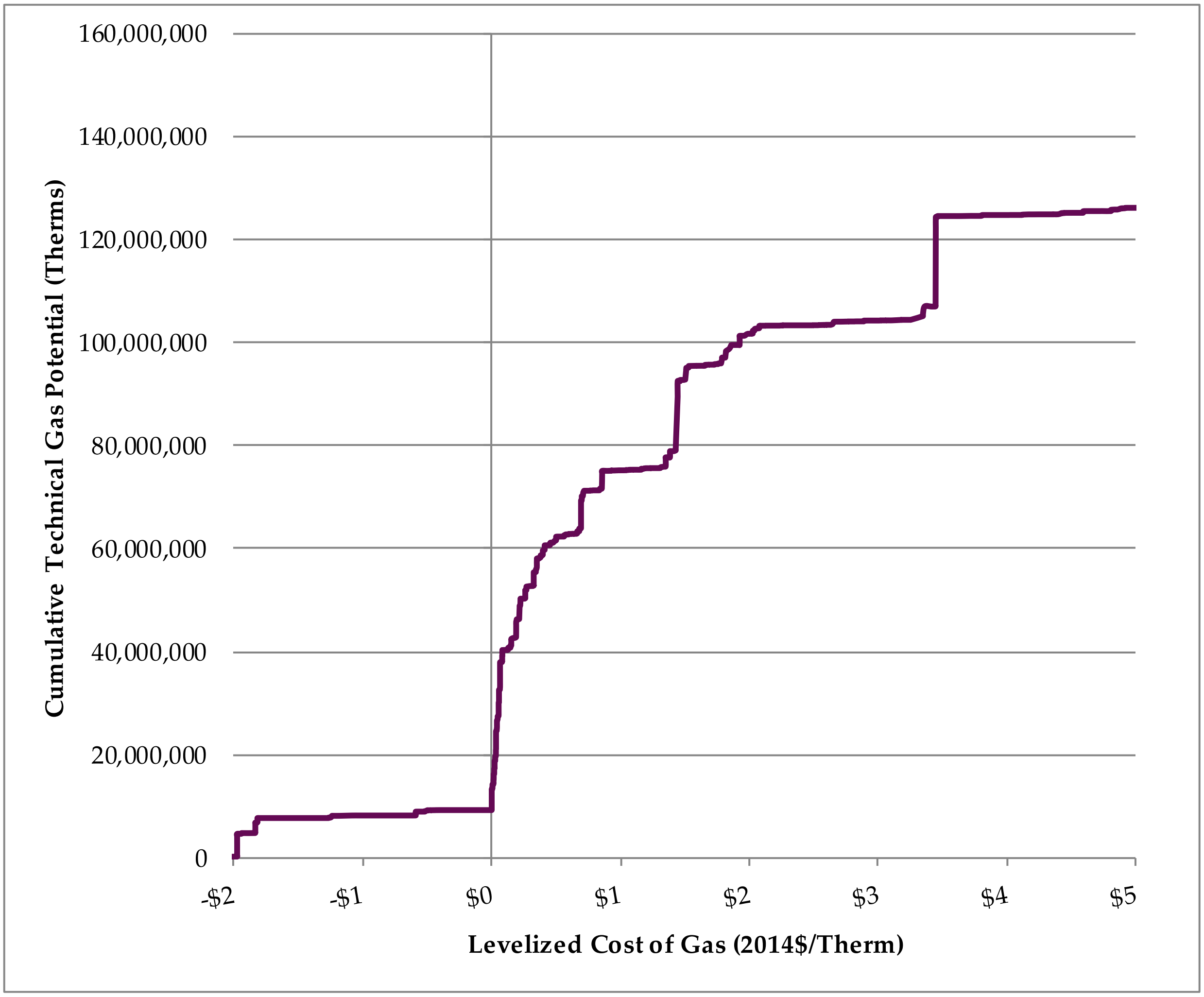
The levelized cost supply curve for cumulative gas saving potential in 2033 is shown in Figure ES-8. Negative-cost measures account for 9.2 MMtherms and are associated with efficient showerheads. Roughly 59 MMtherms of cumulative gas savings can be achieved at costs below $0.40 per therm levelized, which is the lower bound of avoided cost forecasts in 2033. Approximately 147 MMtherms of cumulative gas savings can be achieved at costs below $30 per therm levelized. Beyond 147 MMtherms of potential, costs begin to increase quickly.

It is important to recognize that customers may not view these as zero or negative-cost measures – most have upfront costs that are balanced by savings in replacement equipment costs or operation and

[7] Graph has been scaled to show the area of interest, but additional potential above a levelized cost of of $0.50 per kWh is not shown.

maintenance (O&M) cost, or in non-energy costs such as water, waste treatment, and so on. The supply curve considers all these values together, taking a long-term view.

**Figure ES-8. Gas Savings Supply Curve (2033)[8]**




*Source: Navigant analysis, 2014*

## *Caveats and Limitations*

There are several caveats and limitations associated with the results of this study. The forecasted potential in this study is based on the best estimates of data available today. An important caveat to consider, however, is that uncertainty in the input data used can affect estimates of overall potential. The estimates of achievable potential assume an 85% achievability factor. This sets an upper limit of market penetration in the region over a 20-year period. While this is consistent with regional assumptions and is supported by retrospective research conducted by the NW Power and Conservation Council, there

[8] Graph has been scaled to show the area of interest, but additional potential above a levelized cost of $5 per therm is not shown.

remains uncertainty as to how much of the technical potential is achievable over the modeling period. Furthermore, cost-effective achievable potential in this study is not limited by actual program rollout rates or market acceptance dynamics; rather, it reflects the bucket from which program achievements can draw, at a rate that is to be defined by Energy Trust. The issue of rollout rate is addressed in later stages of Energy Trust's planning process. Finally, the risk associated with future cost and performance of emerging technologies introduces uncertainty into the estimates of future potential. For a full explanation of the limitations of this study, please see section 2.3, "Caveats and Limitations."

# 1 Introduction

## 1.1 Background and Study Goals

Energy Trust of Oregon (Energy Trust) selected Navigant Consulting, Inc. (Navigant) to prepare an energy efficiency resource assessment of its service territory in August 2013. The primary purpose of this resource assessment is to enable Energy Trust to support the Integrated Resource Planning (IRP) planning process of its four funding utilities by providing a 20-year forecast of efficiency resource potential of each utility, as well as informing Energy Trust's strategic and program planning, as well as program design.

An additional focus of this assessment has been to include an "emerging technology" overlay capable of quantifying costs, potential, and risks associated with uncertain, but high-potential energy savings measures. Finally, a key component of this resource assessment is the Energy Trust Resource Assessment Model, which provides a flexible platform in which to estimate the technical and achievable potential for demand-side resources in Energy Trust's service territory. This report does not include utility-specific results. However, the companion model does offer the ability to look at individual results for all four funding utilities (Portland General Electric (PGE), Pacific Power (PAC), Northwest Natural (NWN), and Cascade Natural Gas (CNG).[9]

## 1.2 Organization of Report

This report is organized as follows: Section 2 describes the study approach to estimating potential for energy efficiency savings, including a discussion of measure identification and characterization and the approach to simulating technical, achievable, and cost-effective achievable potential. Section 3 offers the results of the potential study analysis for energy efficiency measures, including a summary of aggregate savings potential. Sections 4, 5 and 6 offer disaggregated savings results by sector, customer segment, end use, and program, as well as a discussion of emerging technologies and the top measures contributing toward potential. Section 7 offers details on energy efficiency potential supply curves.

[9] Utility-specific results will be developed as part of the IRP process at each utility, using the most current utility-specific load forecasts.

# 2 Approach to Electric Energy, Demand, and Gas Savings

This section provides an overview of Navigant's approach to estimating electric energy, demand, and gas savings. Section 2.1 describes the sources of the key inputs to the analysis, including the framework used for the measure identification and characterization process, details on how emerging technologies and code adjustments were treated. Section 2.2 discusses the methodological approach to estimating technical, achievable, and cost-effective achievable potential including details on the calculation of cost-effectiveness and tiered potential savings. Data developed as part of the measure characterization process was imported into the resource assessment model, which employs a combined "bottom-up/top-down" approach to identify and quantify the savings of all energy efficiency measures depending on the sector.

## *2.1 Measure Identification and Characterization*

### 2.1.1 Measure Lists Development

Navigant developed comprehensive measure lists of conventional technologies as the first step in the measure characterization process. Conventional measures are commercialized technologies with noticeable market penetration and relatively stable price trajectories. In developing the conventional measure lists, Navigant reviewed the Energy Trust 2011 potential model and screened electric and gas technologies that contributed approximately 90% of the potential energy savings in the 2011 model. The measure lists were supplemented by additional measures in which Navigant reviewed measures from the Regional Technical Forum (RTF) and measure lists from other potential models that Navigant had developed in the past. Navigant then modified the measure lists to incorporate feedback from Energy Trust, including adding, consolidating, and deleting measures.

Navigant considered over 200 residential measures, 190 commercial measures, and 140 industrial measures. The measures included devices, structured approaches to modifying behavior that save energy, and approaches with both hardware and behavioral components. Ultimately, Navigant characterized 68 residential measures, 49 commercial measures, and 42 industrial measures in the final model. The final selection of measures was driven by the estimated energy savings potential, as well as Energy Trust and regional data availability. The final measure lists can be found in Appendix A.

Navigant characterized each of the residential measures on the final list for three customer segments: single family (SF), multi-family (MF), and manufactured homes (MH). Weather dependent measures were characterized for each of the climate zones. Some examples of weather dependent measures include heat pumps, solar water heaters, insulation and windows, and ENERGY STAR® new homes.

The commercial measures were characterized for all applicable commercial customer segments: office, restaurant, retail, grocery, warehouse, school, college, hospital, other health, lodging, other, data center, and street lighting.

Similarly, Navigant characterized the industrial measures for all applicable industrial customer segments: agriculture, chemicals, cold storage, metal foundries, food products, high technology, pulp & paper, metal fabrication, transportation and equipment, wood products, and other industrial sectors.

### 2.1.2 Measure Characterization Inputs

The measure characterization consisted of estimating or defining 33 measure inputs across customer segments and two climate zones. These parameters are listed and defined[10] as follows:

1. **Measure ID**- Unique identifier of the measure in the model
2. **Measure Char Owner**- Initials of analyst completing the measure characterization
3. **Unique Measure Name**- Name specifying the efficient measure
4. **Zone Applicability**- Specification of the weather zone to which the measure is applicable. Most measures are applicable to both zone 1 and zone 2.
5. **Measure Description**- Detailed description of the efficient measure, including efficacy level
6. **Baseline Assumption**- Specification of the base measure being replaced, including efficacy level
7. **Conventional or Emerging Technology**- Identifier to distinguish if a measure is a conventional technology or an emerging technology
8. **End-Use Category**- Input to map a measure to an end-use category such as space heating and cooling, water heating, lighting, appliance, refrigeration, weatherization, behavioral, and other.
9. **Customer Segment**- Designation of customer segment
10. **Replacement Type**- Characterization of the measure as a retrofit (RET), replace-on-burnout (ROB), or a new construction (NEW) application.[11]
11. **Scaling Basis –** Input to identify the unit basis for density values. For most of the residential measures, the scaling basis is the number of residential homes.
12. **Unit Basis**- Unit basis for cost and savings characterization (e.g., per unit or per square foot)
13. **Base Measure Lifetime**- The effective useful life of the baseline measure in years.
14. **Efficient Measure Lifetime**- The effective useful life of the efficient measure in years.
15. **Base Measure Cost**- Cost of installing the baseline technology in Real 2014 $ per unit basis
16. **Efficient Measure Cost**- Cost of installing the efficient measure in Real 2014 $ per unit basis
17. **Cost Source(s)**- Documentation of the data source(s) for the cost assumptions
18. **Base Energy Consumption**- Annual electricity consumption of the baseline technology in kWh per unit basis
19. **Efficient Energy Consumption**- Annual electricity consumption of the efficient measure in kWh per unit basis
20. **Energy Savings Loadshape**- The relevant electricity savings loadshape of the efficient measure. The loadshape is used to allocate energy savings across time.

[10] The measure characterization template includes detailed descriptions of each of the measure characterization inputs.

[11] ROB is applied to measures where the primary economically feasible opportunity to substitute more efficient equipment occurs at or near the time of equipment failure. Retrofit is applied where it may be economically feasible to replace equipment for efficiency reasons earlier in its life. Some measures have more than one replacement type, for example, if a measure has both new application and replace-on-burn out applications, the replacement type is defined as "NEW and ROB."

21. **Base Gas Consumption**- Annual gas consumption of the baseline technology in therms per unit basis
22. **Efficient Gas Savings**- Annual gas consumption of the efficient measure in therms per unit basis
23. **Gas Savings Loadshape**- The relevant gas savings loadshape
24. **Operation and Maintenance (O&M) Savings**- Indication of non-energy benefits such as water savings and operation and maintenance savings resulting from the installation of the efficient measure in $ per year per unit basis
25. **Savings Source(s)**- Documentation of the data source(s) for savings assumptions
26. **Total Measure Density (Base+EE)**- The measure density (e.g., quantity of measures per home), as the sum of the base and efficient technology densities
27. **Technical Suitability**- The fraction of the total baseline measure which could be replaced with the efficient measure
28. **Baseline Initial Saturation**- The initial saturation of the baseline measure as defined by the fraction of the end-use stock that has the baseline measure installed
29. **Heating Fuel Type Applicability Multiplier**- Designation of the appropriate space heating fuel type to electric or gas-specific measures
30. **Domestic Hot Water (DHW) Fuel Type Applicability Multiplier**- Designation of the appropriate DHW fuel type for electric- or gas-specific measures
31. **Competition Group**- Identifier of measures that are competing for the same installation. Measures in the same competition group share the same baseline technology; therefore, the baseline initial saturation and total measure density are the same for measures in the same competition group.
32. **Density/Applicability Source(s)**- Documentation of the data source(s) for density and applicability factors
33. **Emerging Technology Risk Factor**- Multiplier to account for emerging technology risk

Navigant gave priority to Energy Trust program data and prescriptive costs and savings resources when characterizing the measures.[12] Other regional data sources used in this analysis include the Residential Building Stock Assessment (2011), Commercial Building Stock Assessment (2009), RTF unit energy savings (UES) measure workbooks, the Northwest Power Council 6th Power Plan, and the Energy Trust 2011 residential, commercial, and industrial resource potential models. Navigant used national data sources where regional data were unavailable. Navigant documented the data sources for inputs in the measure characterization input files. The following table summarizes the data sources for key measure characterization inputs.

[12] Energy Trust measure analyses provide a synthesis of data from the other sources. In many cases, the Energy Trust uses RTF analyses directly. Navigant went to other sources for measure characterization where Energy Trust did not have an analysis or new data, or when an updated analysis had become available since Energy Trust's last update.

**Table 2-1. Summary of Measure Characterization Input Data Sources**

| Measure Input | Data Sources |
|---|---|
| Measure Costs, Measure Savings, Measure life, Energy and Gas Savings Loadshapes | » Energy Trust Blessing Memos[13]<br>» Energy Trust 2011 Potential Model<br>» Energy Trust Program Data<br>» Impact Evaluation of Energy Trust's 2009-2011 Production Efficiency Program<br>» RTF measure workbooks<br>» Database for Energy Efficient Resources (DEER)<br>» Engineering Analyses<br>» DOE Appliance Standards Rulemaking Supporting Documents<br>» Northwest Power Conservation Council (NWPCC)<br>» Industrial Assessment Center (IAC) Database |
| Fuel Type Applicability Multiplier, Density, Baseline Initial Saturation, Technical Suitability, End-use Consumption Breakdown | » RBSA 2011<br>» CBSA 2009<br>» Northwest Non-Residential Lighting Market Study<br>» Energy Trust 2011 Potential Model<br>» ENERGY STAR shipment reports<br>» California Potential, Goals, and Target Model<br>» Engineering Assumptions<br>» Manufacturing Energy Consumption Survey (MECS) |
| Codes and Standards Multiplier, Baseline Consumption Multiplier | » Department of Energy Code of Federal Regulations (DOE CFR)<br>» Engineering Analyses |

*Source: Navigant analysis, 2014*

### 2.1.3 Measure Characterization Approaches

Navigant reviewed Energy Trust internal data, regional resources, and Navigant internal resources to determine the appropriate measure characterization approach for each of the measures.

#### *2.1.3.1 Energy Savings and Costs Approaches*

RBSA and CBSA provided building stock measure counts or density proxies enabling Navigant to characterize residential and commercial measures with a bottom-up approach. The bottom-up approach estimates the unit energy savings and costs of each measure and scales the savings potential using measure densities.

Stock assessment data were not available for the industrial sector; therefore, Navigant characterized industrial measures using a top-down approach. Measure savings were calculated as percentages of the customer segment consumption.[14]

[13] "Blessing memos" are cost-benefit analysis and approval memos for Energy Trust prescriptive efficiency measures.

[14] This is common practice for industrial resource assessments.

**Residential and Commercial Energy Savings and Costs Approaches**
Navigant took three general approaches to analyzing residential and commercial measure energy savings and costs:

1. **Energy Trust Primary Data Review and Analysis**- The majority of measures used Energy Trust primary data. Navigant reviewed Energy Trust blessing memos and program data. Some Energy Trust analyses included multiple efficiency tiers; for those instances, the measure characterization team weighted the measure costs and savings by program uptake or measure market share sourced from RBSA or CBSA.
2. **Regional Secondary Resources**- RTF Unit Energy Savings workbooks contained comprehensive regional engineering analyses for several measures such as clothes washers, dishwashers, refrigeration, and window measures. Upon reviewing both Energy Trust and RTF analyses, the RTF input might be chosen if the data vintage was more recent.
3. **Engineering Analysis**- Measures without Energy Trust data or regional analysis were characterized using engineering algorithms.

**Industrial Energy Savings and Costs Approaches**
The savings and costs estimations vary depending on measure data availability. The Industrial Assessment Center (IAC) database, Energy Trust Production Efficiency Program impact evaluation data, and the existing Energy Trusts industrial resource assessment tool were the three main data sources:

1. **IAC Database**[15]: The IAC database collected nationwide industrial facility assessment data including facility energy consumption, efficiency improvements recommendation, savings, and costs of implementation. Navigant extracted relevant measure data from the IAC database by searching for applicable recommendation codes.[16] The percentage energy savings from all relevant entries were averaged to represent the overall measure savings as a percentage of facility consumption and scaled to customer segment consumption. Navigant calculated the measure cost by averaging the $/energy saved of all relevant IAC entries.

2. **Energy Trust Production Efficiency Program Verification and Program Data**: Navigant utilized Energy Trust Production Efficiency Program's verification data to develop measure savings as a percentage of the whole facility consumption. From the same dataset, Navigant calculated the average measure cost in $/energy saved. The savings percentages and measure costs were applied to each of the customer segments.

3. **Energy Trust Industrial Resource Assessment Tools:** The IAC database and Energy Trust's program data do not cover a subset of industrial measures on the measure list; for those measures Navigant relied on secondary sources and the existing industrial tool to populate savings percentages and the measure costs. Using Manufacturing Energy Consumption Survey data, Navigant developed an end-use consumption map disaggregating the percentage end use of the total energy consumption for each of the industrial customer segments for both electricity

[15] The IAC database is available at http://iac.rutgers.edu/database/
[16] The IAC recommendation code mapping is available in the measure input template.

and gas fuel types.[17] Measure savings were estimated as a percentage of end-use consumption and extrapolated to the customer segment level.

#### *2.1.3.2 Density and Initial Saturation*

The RBSA and CBSA served as the primary resource for developing residential and commercial measure total densities and initial saturation factors. Navigant extracted primary data from the RBSA and CBSA and calculated the densities and initial saturation factors by customer segments. For instances where data was not available, Navigant reviewed the existing model and conducted secondary research to estimate the density and initial saturation. One of the goals of the measure characterization task was to best customize measure input data to Energy Trust's resource assessment needs. Therefore, Energy Trust specific data had the highest priority followed by Oregon and region specific data.

Navigant estimated density per home for each residential measure. Density data for most residential measures were available through RBSA. Navigant filled data gaps using applicable regional studies, primary data collected for potential studies completed in other regions, or secondary research.[18]

For commercial measures without unit density data, the efficient measure savings were calculated as a percentage reduction of the baseline measures. Navigant then scaled the energy savings by applying the savings percentages to the end-use energy use intensities (EUI).

Navigant established the baseline EUI for each end use and building type using CBSA whole building EUI estimates and the end-use energy consumption distribution using the NWPCC 6$^{th}$ Power Plan and Commercial Buildings Energy Consumption Survey (CBECS). The EUI approach was applicable to commercial lighting, data center, heating, ventilation, and air-conditioning (HVAC), and water heating measures.

Since Navigant analyzed the industrial measures with a top-down approach, savings were represented by a percentage reduction of the total customer segment consumption; therefore, the default industrial measure density value is 1.

[17] The energy use map by customer segment is included in the measure input template.
[18] Specific data sources are documented in the measure input templates.

#### 2.1.3.3 *Treatment of Bundled Measures vs. Individual Measures in New Construction Applications*

The ENERGY STAR Builder Option Package (BOP) Home measure was a new construction bundle measure, which included multiple individual measures.[19] To avoid double counting technical savings potential, Navigant adjusted the baseline of the individual measures included in the ENERGY STAR BOP measure to reflect minimum ENERGY STAR BOP efficacy levels. In other words, savings and costs of these individual measures under the new replacement type were incremental to the ENERGY STAR BOP measure. The following individual measures were affected:

- Screw-In Compact Fluorescent Lamp (CFL)
- Screw-In Light-Emitting Diode (LED)
- Gas Storage Water Heater
- Solar DHW- Electric
- Solar DHW- Gas
- Tankless Gas Hot Water Heater
- Tier 1 and Tier 2 Heat Pump Water Heater
- Specialty Lights
- Windows (U=0.25)

#### 2.1.3.4 *Tax Credits*

Navigant subtracted Oregon Department of Energy tax credits from the incremental cost of eligible residential measures listed in Table 2-2.[20]

**Table 2-2. Oregon Department of Energy Residential Energy Efficiency Tax Credits[21]**

| Measure | Tax Credit |
|---|---|
| Electric Heat Pump Water Heater Tier 1 | $600 |
| Electric Heat Pump Water Heater Tier 2 | $837 |
| Gas Water Heater .85 Efficiency | $246 |
| Gas Furnace AFUE 95-96.9% | $352 |
| Heat Recovery Ventilation | $225 |
| Air-source heat pump 9.0 | $759 |
| Ductless heat pump (mini-split) | $1040 |

*Source: Navigant analysis, 2014*

[19] A bundle was modeled in this case because it simplified the model and reflected the primary savings opportunity in the market – ENERGY STAR is an important driver in program participation, so the “package” is viewed by much of the market as a discrete choice.

[20] This is consistent with guidance from the Oregon PUC on determining incremental costs for purposes of the Total Resource Cost test. Oregon Department of Energy 2014 Residential energy Tax Credit Rates: http://www.oregon.gov/energy/CONS/docs/2014RETCRates.pdf

[21] Energy Trust has included the Solar Domestic Hot Water Heater Federal and State tax credits in their cost assumptions, therefore the Solar DHW credits are not included in this list.

Navigant completed the tax credit review for all commercial measures. Commercial federal tax credits expired in 2013, and the state tax credits are greatly diminished in value and not as widely available as the previous Business Energy Tax Credit (BETC) program. Therefore, there is no adjustment to commercial incremental cost due to tax credits.

##### *2.1.3.5 Non-Energy Benefits (NEB)*

Clothes washers, dishwashers, showerheads, and faucet aerators yield water savings in addition to energy savings. Navigant included the NEB of these measures under O&M savings. Navigant sourced the values from Energy Trust program resources and RTF measure analysis workbooks.

### 2.1.4 Emerging Technologies

The goal of the Emerging Technologies Overlay is to establish a range of possible savings from emerging technologies. Emerging technology is defined as any technology with *at least one* of the following criteria:

» Is currently not commercially available but expected to become so during the time span of the analysis
» Is expected to achieve significant efficiency or cost improvements over the forecast time horizon

##### *2.1.4.1 Selecting Emerging Technologies*

To select the emerging technologies analyzed, Navigant first identified the end uses within the residential and commercial sectors that account for the largest energy use in the Energy Trust territory. To assess the various energy end uses, we primarily relied on data provided by the previous resource assessment model, utility load forecast, Northwest Conservation and Electric Power Plan, supplemented by national level data from the Energy Information Administration. In the residential sector, end uses considered for emerging technology analysis included the following:

» Domestic Water Heating – Electric
» Domestic Water Heating – Gas
» Space Heating – Gas
» Space Heating – Electric
» Space Cooling – Electric
» Lighting
» Envelope
» Behavioral

In the commercial sector, end uses considered for emerging technology analysis included the following:

» Lighting
» Envelope
» Space Cooling
» Space Heating
» Ventilation
» Refrigeration
» Water Heating

Next, Navigant used the following sources to identify emerging technologies with the highest potential savings in each end use:

- Other resource assessments conducted by Navigant
- NEEA/BPA list of emerging technologies
- Emerging technology scans done by Navigant for other utilities and governments
- Research and development (R&D) and commercialization reports from national research labs, and federal and state governments
- Navigant emerging technology experts

#### *2.1.4.2 Characterizing Emerging Technologies*

Navigant then characterized emerging technologies using similar criteria and resources as conventional technologies, with additional data gathered from the following:

- U.S. Department of Energy (DOE) Building Technologies Prioritization Tool
- DOE R&D reports
- DOE appliance standards analyses
- Historic data of price trends of appliances
- Interviews with Navigant experts

In addition, for each emerging technology, Navigant estimated time-series profiles for several inputs. Navigant developed the following multipliers (where appropriate) to characterize assumed changes in measure characteristics over time:

- Market Availability Profile
    - This value is used to identify whether a product is commercially available (a value of 0 indicates not commercially available; a value of 1 indicates that it is commercially available).
- Energy Consumption Multiplier
    - This value adjusts the efficient technology energy consumption over time to reflect changes due to technology improvement.
- Cost Multiplier
    - This value adjusts the efficient technology cost over time due to predicted declines in technology cost.

Table 2-3 provides an example of an energy consumption time-series profile for solar thermal water heaters. The profile suggests that by 2019 the energy consumption of this measure will be 20% less than its current consumption in 2014. Navigant used similar profiles for all emerging technology measures to capture significant efficiency and cost improvements over the forecast horizon.

**Table 2-3. Illustration of Time-series Profile**

| Emerging Technology Measure | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Solar Thermal Water Heating | 1.00 | 0.95 | 0.91 | 0.87 | 0.84 | 0.80 |

*Source: Navigant analysis, 2014*

#### 2.1.4.3 *Developing a Range of Savings*

The performance and cost characterizations discussed above represent the "Maximum Potential" for emerging technology measures; however, it is important to characterize the likelihood of whether these technologies will meet those targets or even come to market. Instead of trying to produce multiple cost and performance projections for each emerging technology measure, Navigant developed a risk factor for each emerging technology to characterize the inherent uncertainty in the ability for ETs to produce reliable future savings. This risk factor was determined based on qualitative metrics of the following:

- Market risk
- Technical risk
- Data source risk

The framework for assigning the risk factor is shown in Table 2-4. Each ET was assessed within each risk category; a total weighted score was then calculated. Well-established and well-studied technologies (such as LEDs) have lower risk factors while nascent, unevaluated technologies (e.g., Advanced CO2 Heat Pump Water Heater or Supermarket Max Tech Refrigeration) have higher risk factors. This risk factor was then used as a multiplier of the incremental savings potential of the measure.

**Table 2-4. Emerging Technology Risk Factor Score Card**

| | ET Risk Factor | | | | |
|---|---|---|---|---|---|
| **Risk Category** | **10%** | **30%** | **50%** | **70%** | **90%** |
| **Market Risk (25% weighting)** | **High Risk:**<br>» Requires new/changed business model<br>» Start-up, or small manufacturer<br>» Significant changes to infrastructure<br>» Requires training of contractors; consumer acceptance barriers exist | | | **Low Risk:**<br>» Trained contractors<br>» Established business models<br>» Already in U.S. Market<br>» Manufacturer committed to commercialization | |
| **Technical Risk (25% weighting)** | **High Risk:**<br>Prototype in first field tests<br>A single or unknown approach | Low volume manufacturer<br>Limited experience | New product with broad commercial appeal | Proven technology in different application or different region | **Low Risk:**<br>Proven technology in target application<br>Multiple potentially viable approaches |
| **Data Source Risk (50% weighting)** | **High Risk:**<br>Based only on manufacturer claims | Manufacturer case studies | Engineering assessment or lab test | Third party case study (real world installation) | **Low Risk:**<br>Evaluation results or multiple third party case studies |

*Source: Navigant analysis, 2014*

#### 2.1.4.4 *Residential Emerging Technologies Characterized*

The following is a list of the emerging technologies included in the residential sector:

- Solar hot water heater (gas and electric)
- CO2 Heat Pump Water Heater
- Absorption Gas Water Heater
- R-10 Windows
- R-30 Wall Insulation
- R-75 Attic Insulation
- High Efficiency Condensing Furnace
- Advanced Heat Pumps
- LED lighting
- Home Automation/Smart Devices

#### 2.1.4.5 *Commercial Emerging Technologies Characterized*

The following is a list of the emerging technologies included in the commercial sector:

- Advanced Package A/C RTU
- Hybrid Indirect-Direct Evaporative Cooler
- Energy Recovery Ventilator
- Advanced Refrigeration Controls
- Supermarket Max Tech Refrigeration
- Advanced Ventilation Controls
- Absorption Heat Pump
- LED Lighting (multiple applications)
- Wall insulation R-35, Vacuum insulated panels
- Highly Insulated Windows
- Smart/Dynamic Windows
- Absorption Heat Pump Water Heater
- A/C Heat Recovery for Water Heating

#### 2.1.4.6 *Industrial Emerging Technologies Characterized*

The following is a list of the emerging technologies included in the industrial sector.

- Advanced LED Lighting Retrofits
- Wall Insulation – VIP, R0-R35
- Gas-Fired Heat Pump Water Heater
- Switched Reluctance Motors
- Advanced Refrigeration Controls – Industrial

### 2.1.5 Code Adjustments

Measure characterization values are aligned with national and local codes and standards assumptions. As future codes and standards become effective, the energy savings from existing measures subjected to the codes and standards will diminish. Navigant accounted for the impact of codes and standards (C&S) by the C&S multiplier, which reduced the baseline equipment consumption starting from the year when particular codes and standards begin to take effect.

The DOE Technical Support Documents (TSDs)[22] contain information on energy and cost impact of each appliance standard. Typically, the engineering analysis is available in Chapter 5 of the TSDs, energy use analysis is available in Chapter 7, and cost impact is available in Chapter 8. Navigant sourced the C&S multipliers from DOE's analysis and/or assumptions.

In general, Navigant compares the new standard requirements with the current baseline to determine the energy reduction and refer to the relative energy efficiency mark up to determine the cost increase due to codes and standards. Navigant identified the following measures as affected by future codes and standards:

- Tier 1 and Tier 2 Heat Pump Water Heaters
- Gas Storage Water Heater
- Tankless Gas Hot Water Heater
- Advanced CO2 Heat Pump Water Heater
- Absorption Gas Heat Pump Water Heater
- Solar DHW – Electric
- Solar DHW – Gas
- Screw-In Bulbs (CFL and LED)
- High Efficiency Clothes Washers
- Furnace
- Heat Pump
- Gas Hearth
- Advanced Package A/C RTU
- Hybrid Indirect-Direct Evaporative Cooler

[22] Appliance standards rulemaking notices and Technical Support Documents can be found at: http://energy.gov/eere/buildings/current-rulemakings-and-notices

The analysis reduced the baseline technology consumption to align with codes and standards at the effective year of implementation. Due to this approach, savings from the implementation of codes and standards are not included as part of the potential. Table 2-5 summarizes the measures impacted by upcoming codes and standards.

**Table 2-5. Measures Impacted by Upcoming Codes and Standards**

| Affected Measures | Initial Federal Legislation | Effective Date of Last Standard | Issued By |
|---|---|---|---|
| Tier 1 and Tier 2 Heat Pump Water Heaters, Advanced CO2 Heat Pump Water Heater, Solar DHW-Electric | EPACT 1992 | 2014 | DOE |
| Gas Storage Water Heater, Tankless Gas Hot Water Heater, Absorption Gas Heat Pump Water Heater, Solar DHW- Gas | EPACT 1992 | 2014 | DOE |
| High Efficiency Clothes Washers | NAECA 1987 | 2015 | DOE |
| Screw-In Bulbs (CFL and LED) | EISA 2007 | 2020 | U.S. Congress |
| Heat Pump, Advanced Packaged A/C RTU, Hybrid Indirect-Direct Evaporative Cooler | EPACT 1992 | 2015 | DOE |
| HP T8, LED (Troffer) | EPACT 1992 | 2014 | DOE |

*Source: Navigant analysis, 2014*

## 2.2 Approach to Estimating Technical, Achievable, and Cost-Effective Achievable Potential

Navigant estimated the technical, achievable, and cost-effective achievable potential using the resource assessment model, which employs a combined "bottom-up/top-down" approach to identify and quantify the savings of all energy efficiency measures depending on the sector. This modeling approach assumes an energy efficiency measure to be any possible change that can be made to building, equipment or process that could save energy. The residential and commercial sector savings potential were estimated using a bottom-up approach, which considers the potential technical impacts of various demand-side technologies that are aggregated in the model to produce estimates of resource potential at the end use, customer segment, and service territory level. The industrial sector modeling approach is best described as a top-down methodology that begins with the most current utility load forecasts before decomposing them into their constituent end-use components. The model calculates energy savings above a baseline that is determined by a regulatory (i.e., code or standard) or market driver. Figure 1 provides a summary of the key input and output of the model.

**Figure 1. Resource Assessment Model Input and Output**

**Key Input**

- » EE Measure Costs, Savings and Lifetimes
- » Utility Data
  - Electricity Rates, Avoided Costs, Fuel Type Multipliers, Climate Zone Multipliers, Discount Rates
- » Initial Measure Saturation
- » Maximum Measure "Density" (e.g., units/home)
- » NTG Ratios
- » Emerging Technology Risk Factors

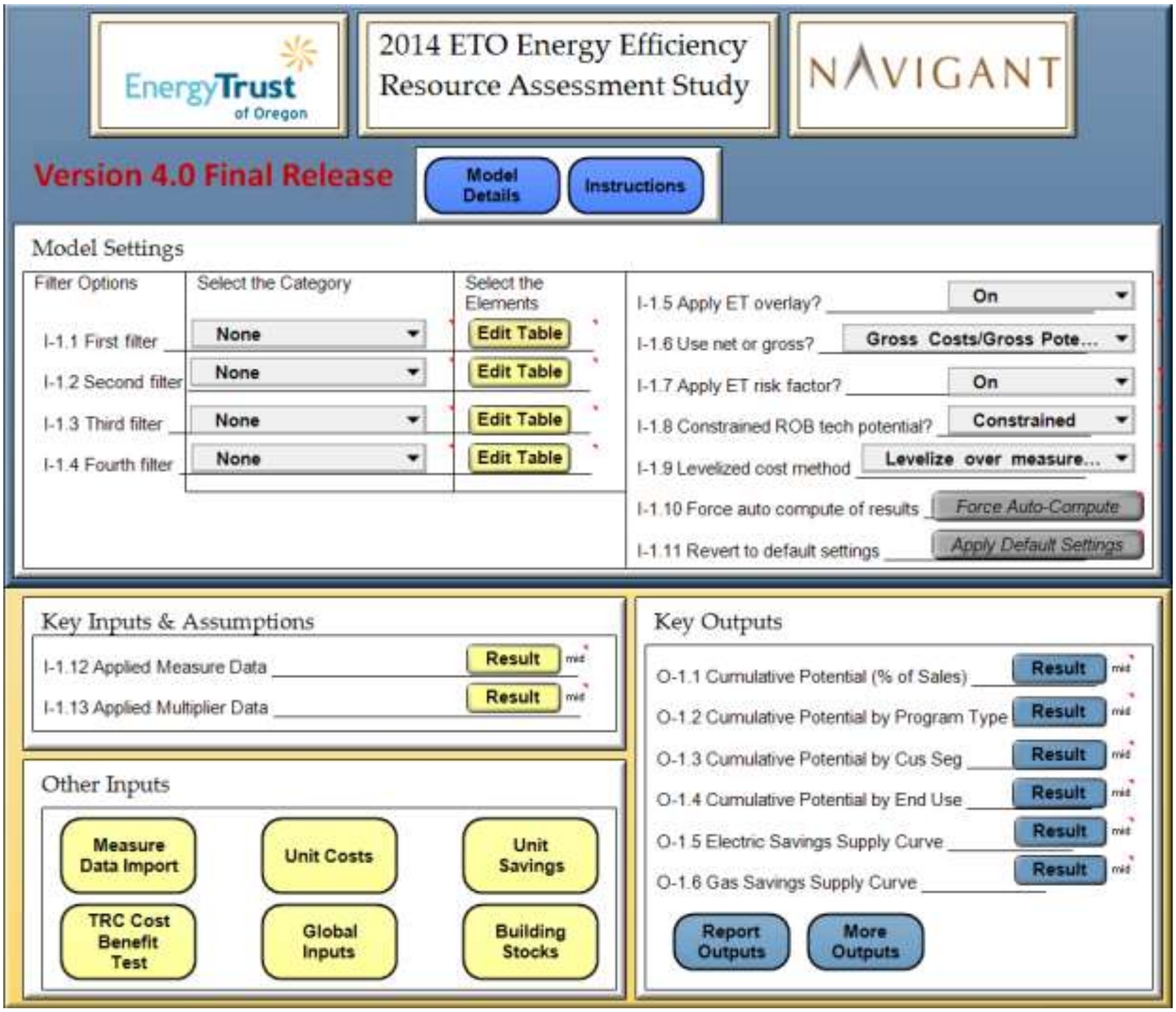
**Key Output**

- » Energy/Demand/Gas Savings (Technical/Achievable/Cost-effective Achievable)
- » Risk-adjusted Tiered Savings
- » Levelized $/kWh and $/therm
- » Total Resource Cost Test
- » Savings as a % of Sales
- » Energy Efficiency Supply Curves

*Source: Navigant analysis, 2014*

Navigant imported input data, developed as part of the measure characterization process, into the model using the graphical user interface displayed in Figure 2. The model interface enables detailed exploration (graphical or tabular) and quality control of all model output at the measure level, across customer segments, utilities, end-use categories, and program types. The model interface also offers the ability to easily turn on or off the ET overlay and risk factor options.

**Figure 2. Base Resource Assessment Model Graphical User Interface**




*Source: Navigant analysis, 2014*

### 2.2.1 Types of Potential

The study calculates three types of energy efficiency potential.

#### *2.2.1.1 Technical Potential*

The calculation of technical potential in this study differs depending on the assumed measure replacement type. Technical potential is calculated on a per-measure basis and includes estimates of savings per unit, measure density (e.g., quantity of measures per home), and total building stock in each service territory. The study accounts for three replacement types, each of which has a specific definition of technical potential as described below.

**1. New Construction (NEW) Measures**
New Construction technical potential is driven by new measures coming into the market each year due to new building stock. New building stock determines the incremental annual addition to technical potential, which would then be added (cumulated) to calculate the cumulative potential in any given year. The equations used to calculate technical potential for new construction measures are provided below.

Annual Incremental Technical Potential (AITP):

$$AITP_{YEAR} = \text{New Buildings}_{YEAR} \text{ (e.g., buildings/year*) X Measure Density (e.g., widgets/building*) X Savings}_{YEAR} \text{ (e.g., kWh/widget) X Technical Suitability (dimensionless)}$$

Cumulative Technical Potential:

$$CTP_Y = \sum_{YEAR=2014}^{YEAR=Y} AITP_{YEAR}$$

* Note: Units for new building stock and measure densities may vary by measure and customer segment (e.g., 1000 square feet of building space, # of residential homes, etc.)

**2. Replace-on-Burnout Measures**
Technical potential for ROB measures is driven by turnover of existing measure stock (1/lifetime of the stock is assumed to burn out each year). This definition of technical potential for ROB measures is considered to be “constrained” in the sense that potential is limited by the turnover rate of inefficient measure stock due to burnout. The model also incorporates the ability to calculate and view “unconstrained technical potential,” which assumes immediate replacement of inefficient measures with efficient measures, regardless of stock turnover constraints. However, the results presented in this study only show a view of constrained technical potential for consistency with Energy Trust’s usage of potential for program planning purposes. The equations used to calculate constrained technical potential for ROB measures are provided below.

Annual Incremental Technical Potential (AITP):

$AITP_{YEAR}$ = Retired Measures $_{YEAR}$ (e.g., measures/year) X Unit Savings $_{YEAR}$ (e.g., kWh/measure) X Technical Suitability (dimensionless)

Where:

Retired Measures $_{YEAR}$ = Remaining Measures $_{YEAR-1}$ X (1/Base Measure Lifetime)

Cumulative Technical Potential:

$$CTP_Y = \sum_{YEAR=2014}^{YEAR=Y} AITP_{YEAR}$$

**3. Retrofit (RET) Measures**

Retrofit measures have a different meaning for technical potential compared with ROB and NEW measures. In any given year, the *entire* building stock is used for the calculation of technical potential and is consistent with Energy Trust's desire not to constrain the calculated technical potential to any pre-assumed rate of adoption of retrofit measures. Code/standard changes from year-to-year could result in potential for a given measure being lower in later years. For retrofit measures, annual potential is equal to cumulative potential thus offering an *instantaneous* view of technical potential. The equation used to calculate technical potential for retrofit measures is provided below.

Annual Potential:

Cumulative Potential = Existing Building Stock $_{YEAR}$ (e.g., buildings*) X Measure Density (e.g., widgets/building*) X Savings $_{YEAR}$ (e.g., kWh/widget) X Technical Suitability (dimensionless)

* Note: Units for new building stock and measure densities may vary by measure and customer segment (e.g., 1000 square feet of building space, # of residential homes, etc.).

#### 2.2.1.2 *Achievable Potential*

Achievable potential is specified as a percentage of the technical potential. The percentage of technical potential that is deemed "achievable" is by default 85% based on the Northwest Power and Conservation Council (Council) planning assumptions.[23] The Council has adopted the 85% value based on the assumptions that the region has 20 years to achieve the 85% goal, that utilities can offer to pay up to the full incremental cost of all cost-effective measures, and that utilities are able to implement state and federal codes and standards over the planning horizon. This definition of achievable potential represents the cumulative upper limit of market penetration over the planning horizon and is not impacted by program rollout rates or market acceptance dynamics. Rather, it represents a bucket of savings from which program achievements can draw, at a rate set by Energy Trust. Although the achievable potential results presented in this study assume a default value of 85%, this is a user-input value in the model, editable at the measure level.

[23] Achievable Savings – A Retrospective Look at the Northwest Power and Conservation Council's Conservation Planning Assumptions - http://www.nwcouncil.org/media/29388/2007_13.pdf

#### 2.2.1.3 *Cost-Effective Achievable Potential*

Cost-effective achievable potential is estimated as a subset of achievable energy efficiency that only includes savings from measures that pass the Total Resource Cost (TRC) test. The TRC for each measure is calculated each year and compared against the measure-level TRC screen threshold (default value of 1.0). If a measure's TRC exceeds the threshold, it is included in the cost-effective achievable potential. For end uses with multiple tiers of efficient measures that could replace the same inefficient base measure, the model uses an incremental or "tiered" approach to calculating cost-effectiveness, which is further described in the next section. The Oregon TRC in particular is determined through the fairly nuanced provisions of Rule UM-551, which includes provisions for exceptions as well as incorporation of quantifiable non-energy benefits. Navigant's analysis took a relatively straightforward approach to the TRC. Cost-effectiveness of many measures may be determined through the rulings in three cost-effectiveness dockets currently underway in Oregon. To the extent that there are exceptions provided in those dockets, or cost-effectiveness is dependent on more detailed analysis of non-energy benefits than are provided in this report, the cost-effectiveness assessments provided in this report are not the "last word" on the subject. Energy Trust will continue to make final cost-effectiveness determinations through its "blessing memos" for prescriptive measures and prescribed calculations, and through site-specific analysis for custom measures. However, we believe that this assessment is at the appropriate detail for estimating the overall conservation resource with one caveat. The potential for savings from gas shell measures in existing single family homes may change significantly based on the Oregon Public Utilities Commission's (PUC's) determinations.

It is also important to note that Washington's Utilities and Transportation Commission's guidance currently relies on a combination of the TRC and the utility cost test. For this reason, adjustments to these results based on program-specific analysis may be warranted for use in Washington.

### 2.2.2 Approach to Calculating Cost-Effectiveness

Cost-effectiveness of energy efficiency measures in this study is defined by the results of the TRC test. The TRC test is a cost-benefit analysis that measures the net benefits of energy efficiency measures from the viewpoint of an entire service territory. The TRC benefit-cost ratio is calculated in the model using the following equation:

$$TRC = \frac{Benefits\ of\ Avoided\ Cost + O\&M\ Savings}{Technology\ Cost + O\&M\ Cost}$$

where:

*Benefits of Avoided Cost* is the monetary benefit of energy and gas savings (e.g., avoided costs of generation, and transmission and distribution investments, as well as avoided fuel costs due to energy conserved by energy efficiency programs).

*Technology Cost* is the incremental equipment cost to the customer.

*O&M Savings* are non-energy benefits including incremental operation and maintenance cost savings and water savings that can be attributed to energy efficiency measures.

*O&M Cost* is the incremental operation and maintenance cost to the customer due to energy efficiency measures.

Navigant calculated TRC benefit-cost ratios for each measure based on the present value of benefits and costs (as defined above) over its useful life. Rebates and bill payments are considered “transfer” payments that stay within the scope of the TRC—the utility system and the customer—and are therefore do not change costs for the TRC calculation. Depending on whether a measure is tiered or not, the model uses different definitions for calculating cost-effectiveness. For individual measures that are not tiered (i.e., they are non-competing measures), a TRC is calculated relative to the measure’s baseline equipment and compared against the measure-level TRC screen threshold (default benefit-cost value of 1). If a measure’s TRC exceeds the threshold, the measure is considered cost-effective. However, for competing technologies used to define competition groups an incremental or “tiered” approach is used, as discussed below.

#### *2.2.2.1 Competition Groups*

Navigant’s modeling approach considers that some efficient technologies will compete against each other in the calculation of potential. The study defines “competition” as efficient measures competing for the same installation as opposed to competing for the same savings (e.g., windows vs. furnaces) or for the same budget (e.g., lighting vs. water heating). For instance, a consumer may install an AFUE 95, AFUE 96, or AFUE 98 furnace, all of which belong to the same competition group, as only one of these would be installed. General characteristics of competing technologies used to define competition groups in this study include the following:

- Competing technologies share the same or similar baseline technology.
- The baseline technology densities, costs, and consumption of competing efficient technologies are the same.
- The total maximum densities of competing efficient technologies are the same.
- Installation of competing technologies is mutually exclusive (i.e., installing one precludes installation of the others for that application).
- Competing technologies share the same replacement type.

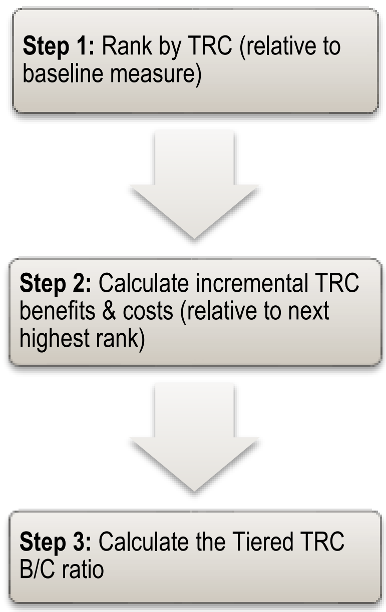
#### *2.2.2.2 Tiered TRC*

Many energy efficiency potential studies explicitly account for market share among multiple efficient technologies that are competing for the same service. This market share can be a direct user input, or it can be calculated by various methods. Energy Trust’s guidance to Navigant was to not assume a given market share and instead to determine cost-effectiveness based on the marginal costs and benefits provided by each measure. Navigant has used “tiered” TRC ratios and tiered levelized cost of energy to capture the marginal cost-effectiveness of each measure.

This method has the advantage that market share, which is a highly uncertain parameter, need not be specified. In addition, the tiered TRC provides insight into the cost-effectiveness of achieving an additional or marginal unit of energy savings. A standard TRC ratio based on full benefits and costs will only provide information about the average cost-effectiveness of a measure relative to an inefficient baseline. In some situations, a measure’s standard TRC (relative to the inefficient baseline) will be greater than 1.0; while it is tiered TRC (relative to the next efficient technology) will be less than 1.0. In such a situation, the tiered TRC is a more informative metric because it suggests the incremental energy provided from that technology (relative to another efficient technology that provides a similar service) may not justify its additional costs. Lastly, the tiered approach ensures that the potential from competing technologies is not double-counted because each technology is only credited with its incremental potential.

For competing measures with multiple tiers of efficiency, a "tiered" approach is employed to evaluate cost-effectiveness. In other words, if several measures could possibly be used to replace a common base measure, the savings (and incremental costs) of a given measure will be compared with the measure just below it in ranking from a TRC perspective.

**Figure 3. Overview of Approach to Calculating Tiered TRC**




*Source: Navigant analysis, 2014*

The following steps describe Navigant's approach to calculating a tiered TRC for measures within a competition group, as summarized in Figure 3.

**Step 1. Rank by TRC**
Competing measures within a competition group are ranked based on each measure's TRC relative to that measure's baseline equipment. These measures are then sorted based on their TRC rank such that the measure with the highest TRC within a competition group is stacked first.

**Step 2. Calculate Incremental TRC Benefits and Costs**
The incremental benefits and costs of the TRC are then calculated relative to the measure with the next highest rank within a competition group. This incremental approach of calculating benefits and costs is only used for measures that belong to a competition group and whose rank is greater than 1. Benefits and costs of measures that are ranked first will be estimated relative to their baseline equipment.

**Step 3. Calculate the Tiered TRC B/C Ratio**

The incremental or tiered TRC for competing measures is then calculated by dividing the incremental benefits by the incremental costs. Figure 4 defines how the TRC is calculated for all combinations of positive and negative incremental costs and benefits. If the incremental benefits and costs are both negative, then the TRC is found by dividing the reduction in costs by the reduction in benefits. In other words, if the reduction in costs for a measure exceeds the reduction in benefits, the measure is still considered to be cost-effective. Also, ranking by the non-tiered TRC ensures that we never have a situation where a measure has positive incremental benefits but negative incremental costs as measures with higher incremental benefits but lower costs would always have a higher non-tiered TRC. Finally, if the incremental benefits of a measure are negative and the incremental costs are positive, then a TRC of zero is assigned to that measure. If both the incremental benefits and costs are negative, the reduction in costs is divided by the reduction in benefits. An incremental measure where the reduction in costs is greater than the reduction in benefits is considered cost effective.

**Figure 4. Rules for Calculating TRC**

| | | PV of Incremental Benefits (B) | |
|---|---|---|---|
| | | Positive (+) | Negative (-) |
| PV of Incremental Costs (C) | Positive (+) | TRC = B/C | TRC = 0 |
| | Negative (-) | Ranking by non-tiered TRC ensures this never occurs, as a measure with incremental benefits but fewer costs would have a higher non-tiered TRC | TRC = C/B |

*Source: Navigant analysis, 2014*

### 2.2.2.3 *Levelized Cost*

Navigant's modeling approach also considers the levelized cost ($/kWh or $/therms) of each measure as an additional cost-effectiveness metric, which is graphed against cumulative potential in the supply curves. The default method calculates levelized cost as the discounted present value cost of the measure annuitized over its life divided by the annual energy savings. The costs included in this calculation are the incremental cost of each measure less any operation and maintenance cost savings. All figures in this report use the default levelization method based on measure lives. Another levelization method is made available within the model that computes costs and savings over a consistent planning horizon for all measures[24]. To account for competition among efficient technologies, Navigant estimated an incremental levelized cost relative to the next highest rank within a competition group, using the same "tiered" approach described above. While the model calculates both levelized cost and TRC as outputs, only the TRC is used to screen for cost-effectiveness.

Similar to the TRC, the value of the levelized cost is determined based on the sign of the costs and the energy savings. Anytime the incremental energy savings are negative, the levelized cost is assigned a value of infinity. Figure 5 defines how levelized cost is calculated for all combinations of positive and negative incremental costs and energy savings.

**Figure 5. Rules for Calculating Levelized Cost**

| | | PV of Incremental Costs (C) | |
|---|---|---|---|
| | | Positive (+) | Negative (-) |
| PV of Incremental Savings (S) | Positive (+) | Levelized Cost = C/S | Levelized Cost = C/S |
| | Negative (-) | Levelized Cost = INF | Levelized Cost = INF |

*Source: Navigant analysis, 2014*

### 2.2.3 Approach to Simulating Tiered Potential Savings

The approach to calculating savings potential follows a methodology consistent with cost-effectiveness. Similar to cost-effectiveness, measures are treated differently depending on whether or not they belong to a competition group. The savings potential for non-competing measures is determined relative to a baseline measure. Potential for competing technologies is determined relative to the measure with the next highest rank within a competition group, following the "tiered" approach.

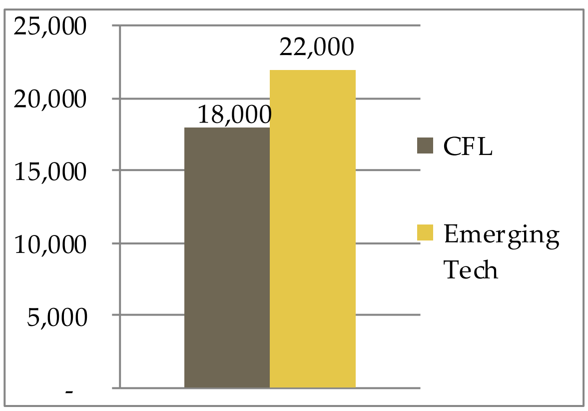
---

[24] The levelization approach based on the same planning horizon, say 20 years, for all measures uses a combination of a true cash flow approach and an annuity approach. For example, a measure having a 5-year lifetime can be installed four times over a 20-year horizon. This means that the cash and energy flows can be repeated exactly four times during that horizon. A measure with an 8-year lifetime is slightly more nuanced. The 8-year measure can be installed twice during the horizon and receive credit for the full 8 years of savings each time. To account for the remaining 4 years in the horizon, the costs over the full measure life are annuitized and assigned to each of the last 4 years. This ensures that the 8-year measure is not penalized with the full incremental costs while only being credited with the 4 years of savings. Once cash streams are determined for all 20 years in the planning horizon, the present value can be annuitized and divided by the annual energy savings to determine the levelized cost of energy.

Savings potential for emerging technologies is also subject to a risk adjustment, which requires a two-stage approach to finding risk-adjusted tiered potential. Risk adjustments are applied to emerging technologies to reflect uncertainty in the ability of those technologies to deliver the assumed savings. The risk adjustments are only applicable to the tiered potential, which for competing measures is incremental to the measure with the next highest rank within a competition group. Calculating risk-adjusted tiered savings potential requires a multi-step process that includes the following steps.

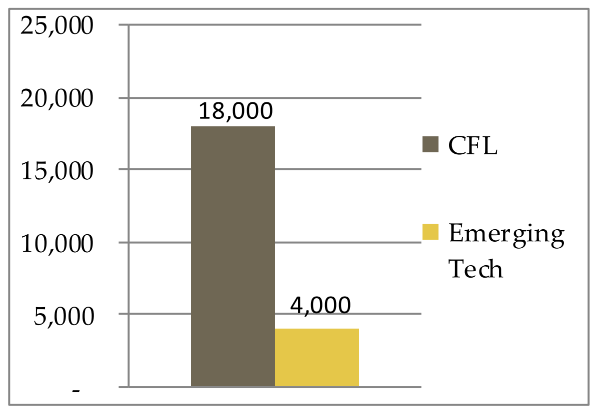
**Step 1. Find Tiered Potential**
For non-competing measures, the savings potential relative to a baseline measure were used. Competing measures are ranked by the TRC (similar to Step 1 of the tiered TRC calculation above) before the incremental potential for each measure in the competition group is calculated (similar to Step 2 of the tiered TRC calculation). Figure 6 shows the potential relative to baseline for a hypothetical competition group that includes a CFL measure and a generic lighting emerging technology. If the CFL has a higher TRC than the ET, then tiered potential for the ET will be incremental to the CFL as is shown in Figure 7.

**Figure 6. Hypothetical Potential Relative to Baseline (kWh/yr)**




*Source: Navigant analysis, 2014*

**Figure 7. Hypothetical Tiered Potential (kWh/yr)**




*Source: Navigant analysis, 2014*

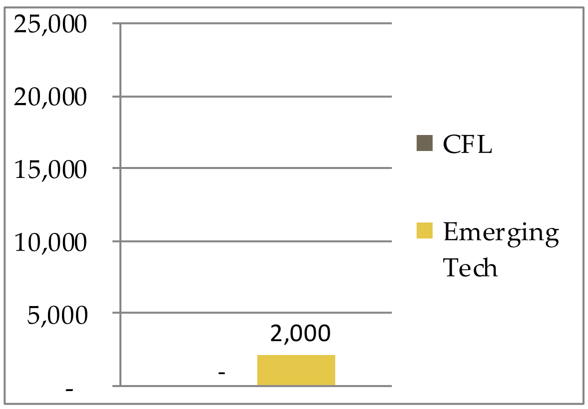
**Step 2. Apply Risk Factors and Determine Reduction in Potential**
The tiered potential for all emerging technologies are multiplied by (1 - *risk factor*) to determine the reduction in potential. The *risk factor* is a value between 0 and 1.0 that reduces the effective savings potential. If the ET in Figure 7 has a risk factor of 0.5, then we would expect a risk reduction of 2,000 kWh/yr, as is shown in Figure 8. No adjustment is made to the CFL, since it is not an emerging technology.

**Step 3. Calculate the Risk-Adjusted Potential Relative to Baseline**
The reduction in potential is then subtracted from the savings potential relative to baseline. Figure 9 shows the resulting difference from subtracting the emerging technology's risk reduction of 2,000 kWh/yr from its potential relative to baseline of 22,000 kWh/yr.

**Step 4. Find the Tiered Risk-Adjusted Potential**

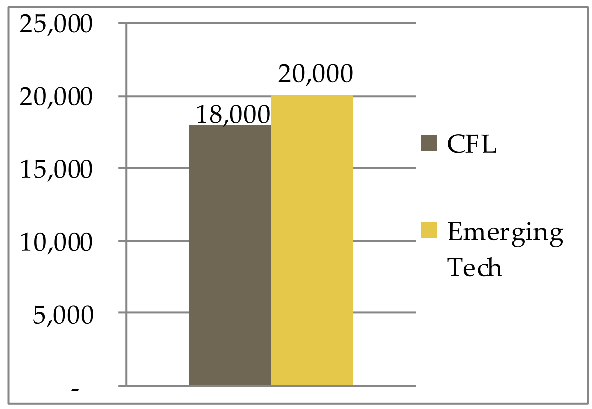
Using the risk-adjusted potential relative to a baseline measure, Step 1 ("Find Tiered Potential") is repeated to find the risk-adjusted tiered potential. When the emerging technology's risk-adjusted potential is tiered relative to the CFL, the resulting risk-adjusted tiered potential is illustrated in Figure 10.

**Figure 8. Hypothetical Reduction in Potential due to Risk (kWh/yr)**



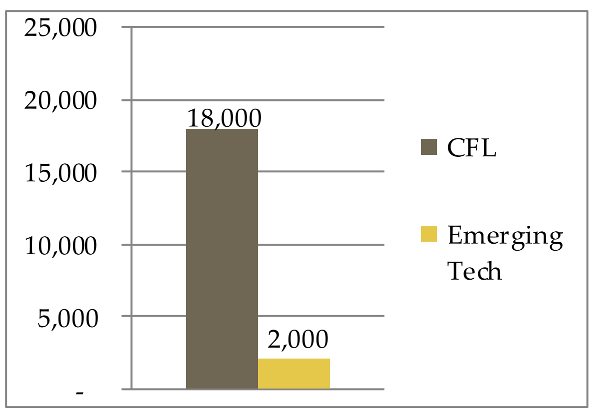

*Source: Navigant analysis, 2014*

**Figure 9. Hypothetical Risk-Adjusted Potential Relative to Baseline (kWh/yr)**




*Source: Navigant analysis, 2014*

**Figure 10. Hypothetical Risk-Adjusted Tiered Potential (kWh/yr)**




*Source: Navigant analysis, 2014*

After the risk-adjusted tiered potential has been computed on an annual basis for every measure, it is then cumulated in accordance with the definitions of NEW, ROB, and RET specified in section 2.2.1.1.

## 2.3 *Caveats and Limitations*

There are a number of important caveats and limitations associated with the results of these forecast and modeling efforts.

### 2.3.1 Data Uncertainties

The Navigant team drew upon many different secondary data sources for estimation of measure energy consumption, incremental cost, market saturation, and emerging technology risk factors. However, inevitable uncertainty in these estimates exists, which can affect estimates of potential. In some cases, national data was used in lieu of regional data. Navigant did not conduct sensitivity or uncertainty analysis on these estimates as part of this study.

### 2.3.2 Market Uncertainties

Several key uncertainties exist regarding the cost-effectiveness of energy efficiency measures. For instance, gas prices are highly uncertain, which in turn drive uncertainty in avoided cost benefits that are a key determinant of cost-effective achievable potential in the model. Additionally, while the study includes risk factors for each ET to characterize natural uncertainty in their ability to produce reliable future savings, there is still uncertainty in the estimation of risk factors for these technologies. While the study accounts for on-the-books and expected codes and standards, it is expected that new standards could significantly reduce the potential savings that may be available for utility programs. However, there are countervailing considerations that provide some assurance.

» The risk factors applied across many emerging technologies can each be wrong individually, and the aggregate estimates of savings reasonably useful if the overall approach taken to risk is balanced in aggregate.
» Codes are not a "competing force" with Energy Trust programs but an integral part of Energy Trust's plans to achieve market transformation wherever this is feasible. The purpose of the study is to estimate overall available savings- if savings come in through new codes and standards, they will still be achieved, but at lower cost to the utility system, and in all likelihood to the consumer also. Therefore, the main hazard is that by not incorporating future codes and standards Energy Trust may be overestimating the long-term cost of some measures, and possibly excluding them from the cost-effective resource potential. Since measures that are not estimated to be cost-effective are rarely incorporated into standards, any exclusion would likely be small and limited in nature.

### 2.3.3 Forecasting under Uncertainty

Cost-effective achievable potential in this study is not limited by actual program rollout or market adoption rates; rather, it reflects the bucket of savings from which program achievements can draw, at a rate that is to be defined by Energy Trust. Forecasts are inherently uncertain. The estimates of future energy efficiency potential included in this study are not a reflection of what *will* happen. Instead, these forecasts are intended as possible futures and provide a view of what *could* be achieved. . The estimates of achievable potential assume an 85% achievability factor. This sets an upper limit of market penetration in the region over a 20-year period. However, there is uncertainty as to how much of the technical potential is truly achievable over the modeling period.

# 3 Energy Trust Energy Efficiency Potential Results

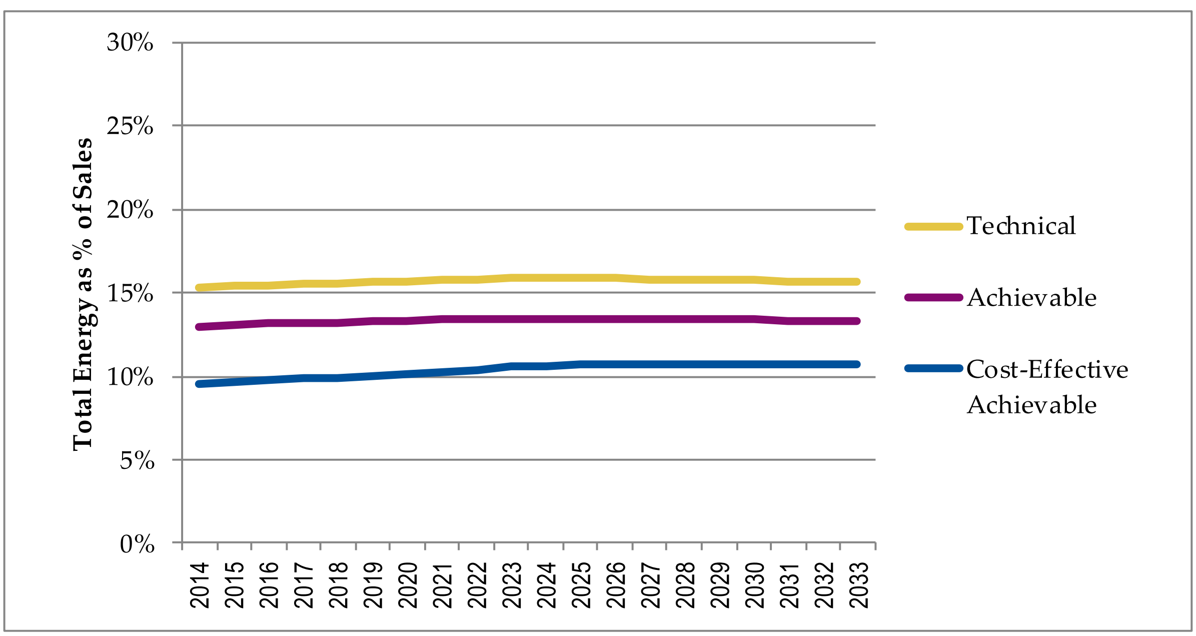
This section provides electric, demand and gas savings potential estimates at an aggregate level. These are estimates of total technical, achievable, and cost-effective achievable potential for all sectors and utilities within the Energy Trust service territory as a percentage of baseline forecast sales. All graphs in this section report a risk-adjusted tiered potential as described in section 2.2.3. These comparisons offer a useful way to compare potential estimates with other studies and past program achievements, while serving as a quality control tool during the study. A more disaggregated view of potential by sector, customer segment, end use, and program are provided in sections 4, 5, and 6, which also include emerging technology results and a discuss of the top saving measures within each sector.

## *3.1 Aggregate Savings Potential*

### 3.1.1 Energy Trust Electric Energy Potential

The cumulative technical, achievable, and cost-effective achievable potential as a percentage of baseline forecast energy sales for all conventional measures (i.e., without emerging technologies) is provided in Figure 11. As seen in this figure, technical potential represents about 15% of baseline energy sales over the 20-year forecast horizon, while achievable potential represents about 13% over the same horizon. Technical potential as a percentage of sales stays relatively flat as it is largely driven by retrofit measures that do not increase over time. Cost-effective achievable potential is about 9%-10% over the forecast horizon. Achievable potential represents an upper bound that is not affected by market adoption rates and program priorities.

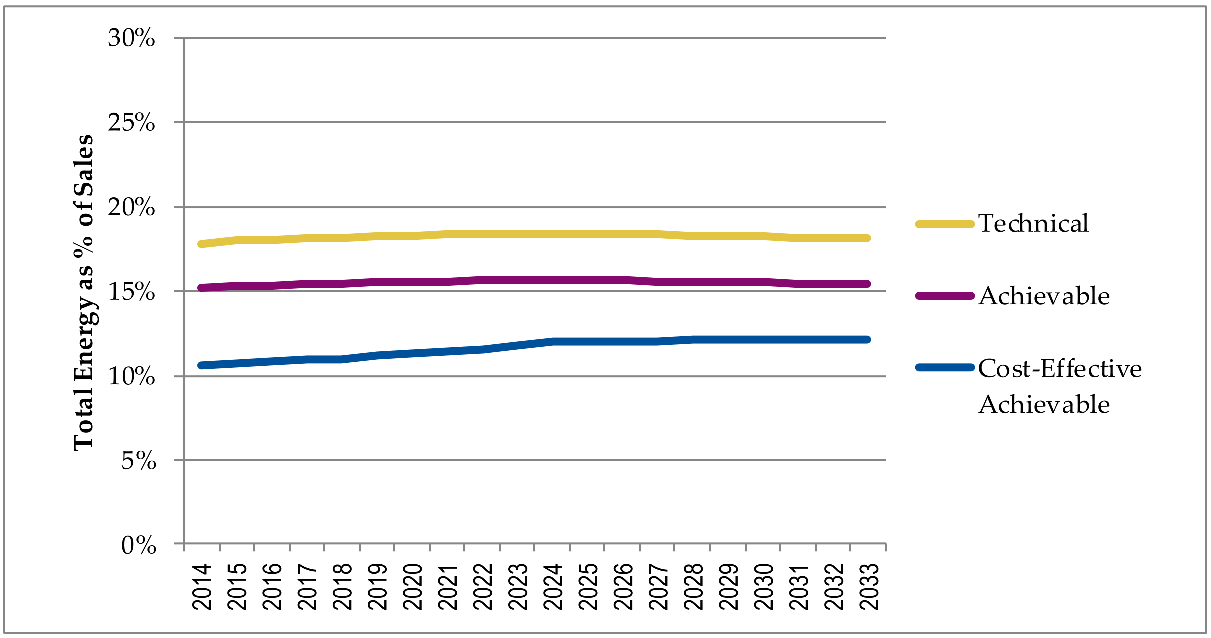
**Figure 11. Cumulative Electric Energy Savings (% of Sales) – without ETs**




*Source: Navigant analysis, 2014*

Figure 12 shows technical, achievable, and cost-effective achievable potential as a percentage of baseline forecast energy sales with the addition of emerging technologies. The inclusion of emerging technologies in the study across all three sectors results in technical potential increasing to 18% of baseline energy sales by 2033, while achievable potential represents 15% of sales over the time horizon. Cost-effective achievable potential is now about 12% over the forecast period, which represents a 2% increase by 2033 due to the addition of emerging technologies. Emerging technology savings in future years are tempered by the inclusion of a risk factor in the calculation of tiered potential savings. Advanced ventilation controls and LED troffers are the largest contributors toward emerging technology savings by 2033. Table 3-1 provides the same information as shown in Figure 12, but in tabular format.

**Figure 12. Cumulative Electric Energy Savings (% of Sales) – with ETs**




*Source: Navigant analysis, 2014*

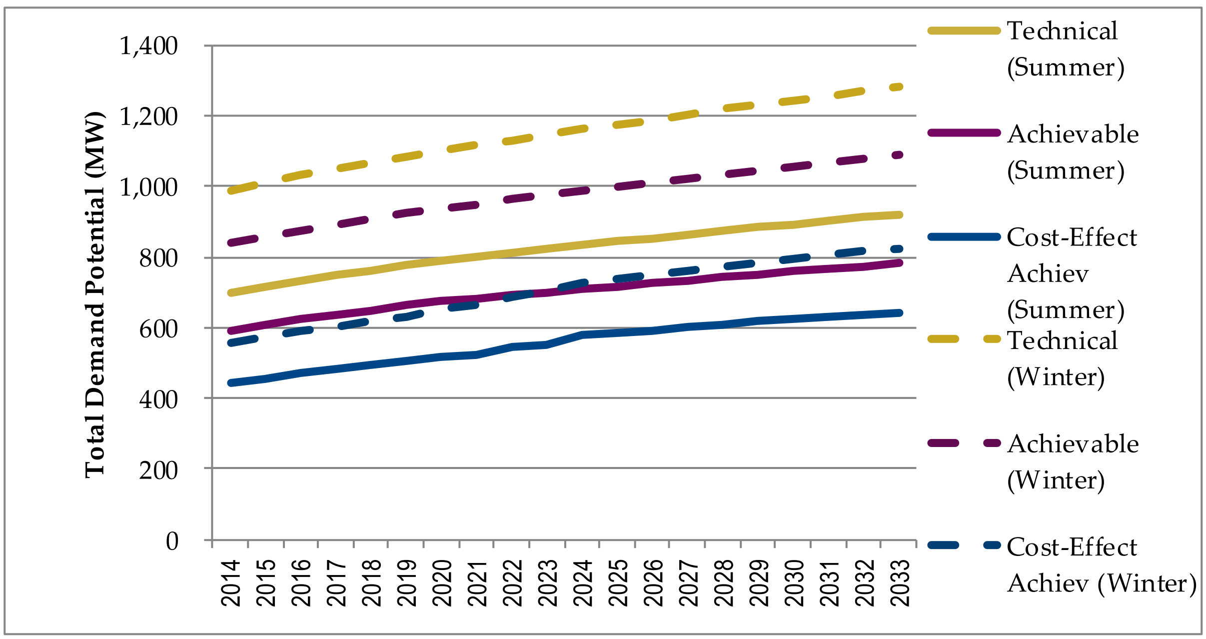
**Table 3-1. Cumulative Energy Savings (% of Sales) – with ETs**

| Year | Technical | Achievable | Cost-Effective Achievable |
|---|---|---|---|
| 2014 | 17.5% | 14.9% | 10.3% |
| 2015 | 17.7% | 15.1% | 10.5% |
| 2016 | 17.8% | 15.1% | 10.6% |
| 2017 | 17.9% | 15.2% | 10.7% |
| 2018 | 17.9% | 15.2% | 10.8% |
| 2019 | 18.0% | 15.3% | 10.9% |
| 2020 | 18.0% | 15.3% | 11.1% |
| 2021 | 18.1% | 15.4% | 11.2% |
| 2022 | 18.1% | 15.4% | 11.4% |
| 2023 | 18.2% | 15.4% | 11.5% |
| 2024 | 18.2% | 15.4% | 11.8% |
| 2025 | 18.2% | 15.4% | 11.8% |
| 2026 | 18.1% | 15.4% | 11.9% |
| 2027 | 18.1% | 15.4% | 11.9% |
| 2028 | 18.1% | 15.4% | 11.9% |
| 2029 | 18.1% | 15.4% | 11.9% |
| 2030 | 18.0% | 15.3% | 11.9% |
| 2031 | 18.0% | 15.3% | 11.9% |
| 2032 | 17.9% | 15.2% | 11.9% |
| 2033 | 17.9% | 15.2% | 11.9% |

*Source: Navigant analysis, 2014*

Figure 13 displays cumulative technical, achievable, and cost-effective achievable demand savings potential for the years 2014 through 2033. This graph shows peak demand savings for both summer and winter peak periods. Although electric and gas savings graphs in this section show potential as a percentage of baseline forecast sales, demand charts include only absolute values for potential. Cost-effective achievable peak demand savings for summer increases steadily from 442 MW in 2014 to 640 MW in 2033, while winter peak demand savings increases from 530 MW in 2014 to 801 MW in 2033. Winter peak demand savings are consistently higher than summer peak demand savings over the study period, which is to be expected since the Northwest region is winter peaking. Table 3-2 presents a tabulated version of the results shown in Figure 13.

**Figure 13. Cumulative Demand Savings (Seasonal Peak MW) – with ETs**




*Source: Navigant analysis, 2014*

**Table 3-2. Cumulative Seasonal Demand Savings (MW) – with ETs**

| | Summer | | | Winter | | |
|---|---|---|---|---|---|---|
| Year | Technical | Achievable | Cost-Effective Achievable | Technical | Achievable | Cost-Effective Achievable |
| **2014** | 693 | 589 | 442 | 956 | 813 | 530 |
| **2015** | 711 | 604 | 452 | 976 | 830 | 544 |
| **2016** | 730 | 620 | 468 | 999 | 849 | 563 |
| **2017** | 745 | 633 | 478 | 1017 | 865 | 577 |
| **2018** | 759 | 645 | 490 | 1035 | 880 | 591 |
| **2019** | 776 | 659 | 501 | 1055 | 897 | 607 |
| **2020** | 788 | 670 | 513 | 1073 | 912 | 626 |
| **2021** | 799 | 679 | 521 | 1087 | 924 | 637 |
| **2022** | 810 | 689 | 541 | 1102 | 937 | 659 |
| **2023** | 821 | 698 | 551 | 1117 | 949 | 677 |
| **2024** | 832 | 707 | 574 | 1133 | 963 | 702 |
| **2025** | 841 | 715 | 582 | 1145 | 974 | 714 |
| **2026** | 851 | 723 | 590 | 1159 | 985 | 725 |
| **2027** | 861 | 731 | 597 | 1173 | 997 | 736 |
| **2028** | 871 | 741 | 606 | 1189 | 1010 | 749 |
| **2029** | 880 | 748 | 614 | 1200 | 1020 | 760 |
| **2030** | 889 | 755 | 620 | 1213 | 1031 | 770 |
| **2031** | 898 | 763 | 627 | 1226 | 1042 | 780 |
| **2032** | 908 | 772 | 635 | 1241 | 1055 | 792 |
| **2033** | 916 | 779 | 640 | 1252 | 1064 | 801 |

*Source: Navigant analysis, 2014*

### 3.1.2 Energy Trust Natural Gas Potential

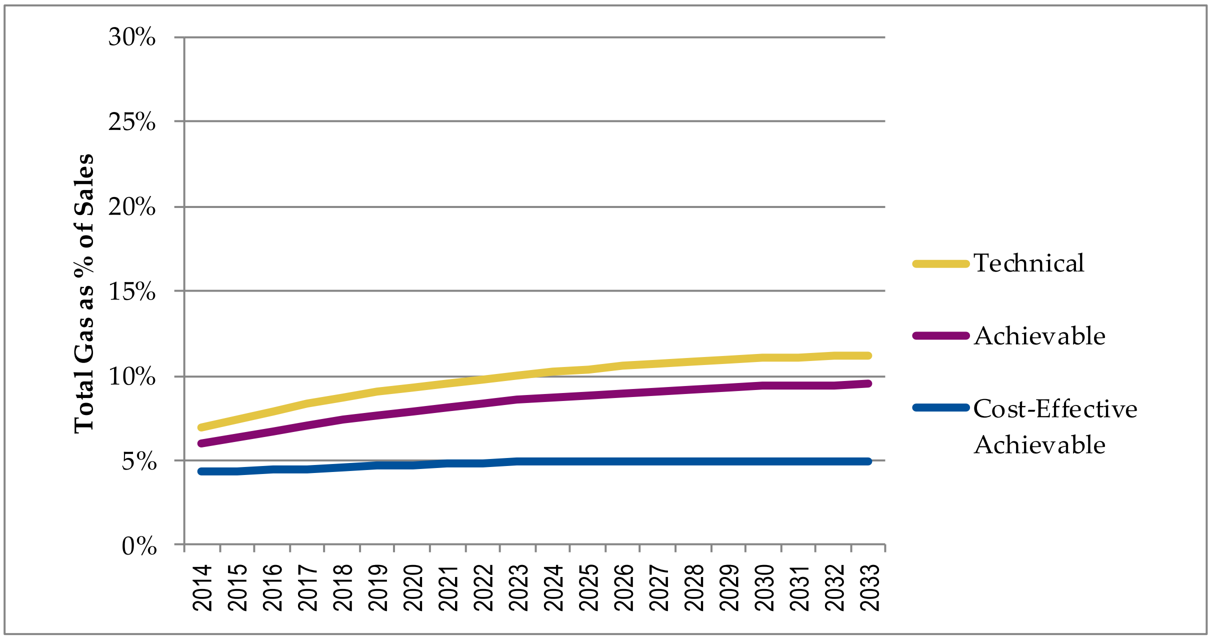
Energy Trust cumulative technical, achievable and cost-effective achievable gas savings potential as a percentage of baseline forecast gas sales for conventional measures (i.e. excluding emerging technologies) is presented in Figure 15. Technical gas potential increases steadily from 7% to 11% over the forecast horizon. This increase in gas technical potential over the 20-year horizon is driven by growth in ROB and NEW gas measures. ROB gas potential increases in the outer years as the baseline stock begins to turn over, creating additional opportunities for savings over time. Cost-effective achievable gas potential rises from about 4.3% in 2014 to 4.9% in 2033. This forecast of cost-effective achievable gas potential is low compared with technical and achievable potential. Currently low natural gas prices result in low gas avoided costs, which result in relatively low benefits in the TRC calculation, making it difficult for gas measures to pass cost-effectiveness. Navigant notes that this phenomenon of low gas prices making it difficult for gas measures to pass cost-effectiveness criteria is a nationwide one[25].

Figure 15 presents the same result as shown in Figure 15, except that it also includes savings from emerging technology gas measures. Technical potential represents 13.7% of gas sales, while cost-effective

[25] See Hoffman I., Borgeson M., and Zimring M., (2013). Implications of Cost Effectiveness Screening Practices in a Low Natural Gas Price Environment: Case Study of a Midwestern Residential Energy Upgrade Program. Clean Energy Program Policy Brief. http://eetd.lbl.gov

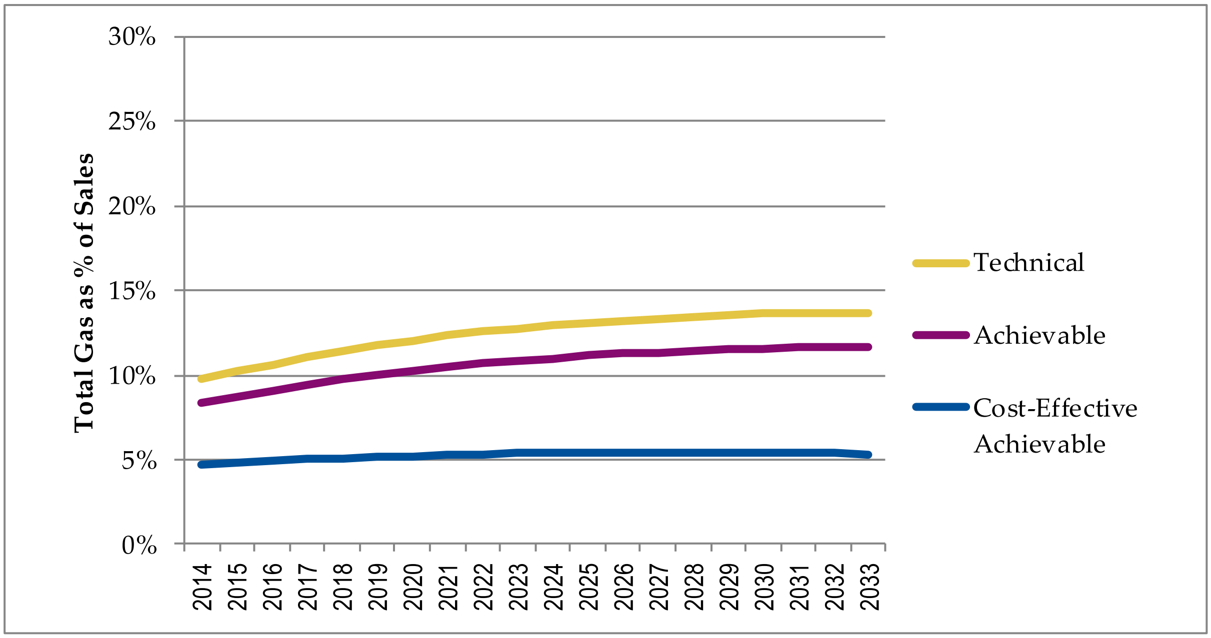
achievable potential represents 5.3% by 2033. Window replacement (U<0.2), gas-fired heat pump water heaters, and smart devices home automation account for the bulk of cost-effective emerging technology gas savings over the study period. Table 3-3 presents a tabulated version of the results shown in Figure 15.

**Figure 14. Cumulative Gas Savings Potential (% of Sales) – without ETs**




*Source: Navigant analysis, 2014*

**Figure 15. Cumulative Gas Savings Potential (% of Sales) – with ETs**




*Source: Navigant analysis, 2014*

**Table 3-3. Cumulative Gas Savings (% of Sales) – with ETs**

| Year | Technical | Achievable | Cost-Effective Achievable |
|---|---|---|---|
| **2014** | 9.8% | 8.3% | 4.7% |
| **2015** | 10.2% | 8.7% | 4.8% |
| **2016** | 10.6% | 9.0% | 4.9% |
| **2017** | 11.1% | 9.4% | 5.0% |
| **2018** | 11.4% | 9.7% | 5.1% |
| **2019** | 11.8% | 10.0% | 5.2% |
| **2020** | 12.0% | 10.2% | 5.2% |
| **2021** | 12.3% | 10.5% | 5.2% |
| **2022** | 12.6% | 10.7% | 5.3% |
| **2023** | 12.8% | 10.8% | 5.4% |
| **2024** | 12.9% | 11.0% | 5.4% |
| **2025** | 13.1% | 11.1% | 5.4% |
| **2026** | 13.2% | 11.2% | 5.4% |
| **2027** | 13.3% | 11.3% | 5.4% |
| **2028** | 13.4% | 11.4% | 5.4% |
| **2029** | 13.5% | 11.5% | 5.4% |
| **2030** | 13.6% | 11.6% | 5.4% |
| **2031** | 13.7% | 11.6% | 5.4% |
| **2032** | 13.7% | 11.6% | 5.4% |
| **2033** | 13.7% | 11.6% | 5.3% |

*Source: Navigant analysis, 2014*

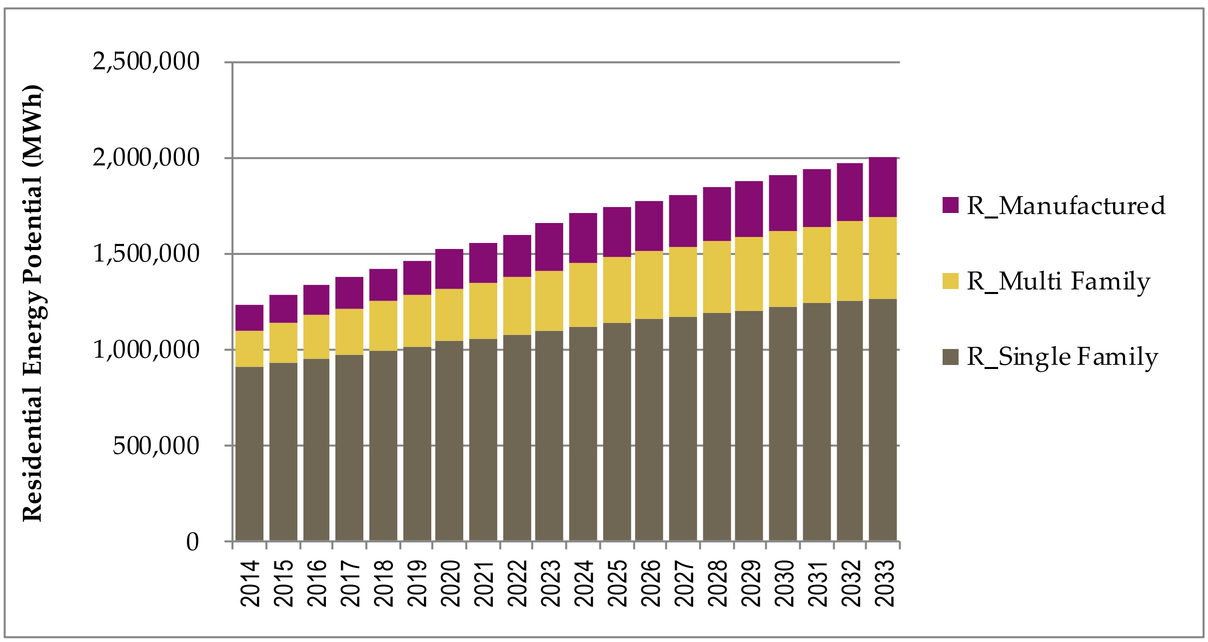
# 4 Energy Efficiency Potential in Energy Trust's Residential Sector

This section provides estimates of energy and gas savings for residential buildings, including SF homes, MF structures, and MH. All the results shown in this section are estimates of risk-adjusted tiered cost-effective achievable potential for the various impact types (i.e., energy, demand, and gas), and include savings potential for both conventional and emerging technology measures.

## *4.1 Residential Cost-effective Achievable Potential – Customer Segment*

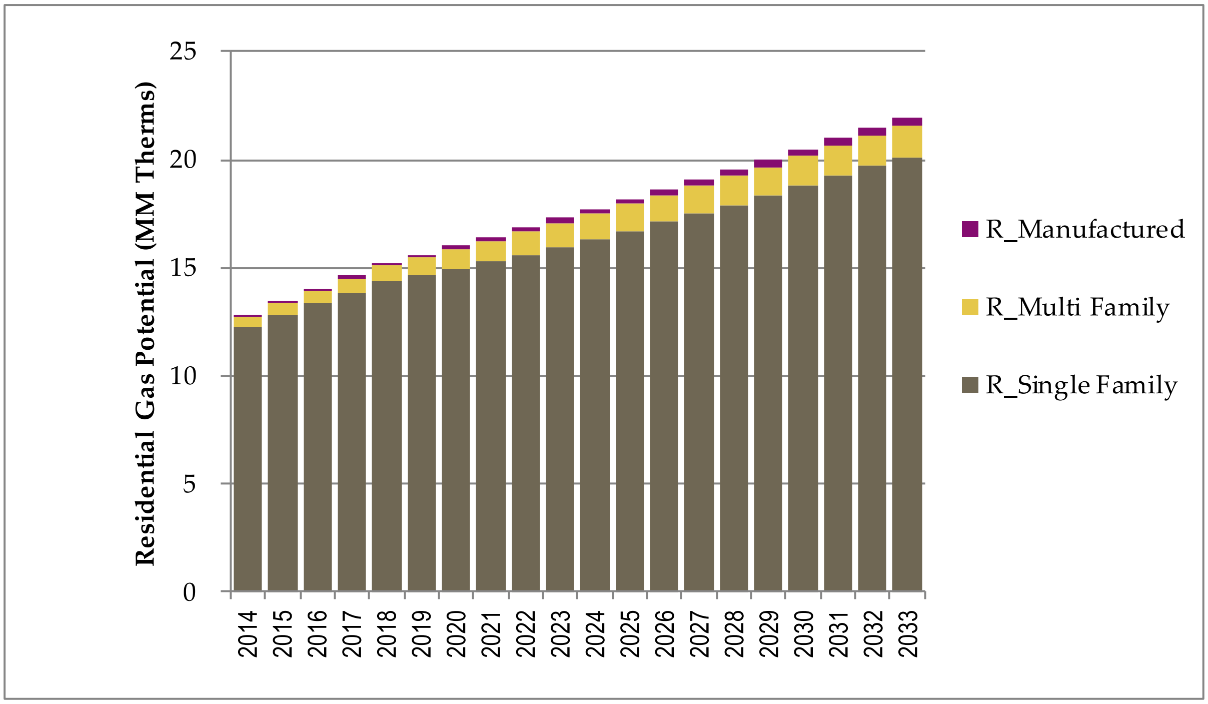
Navigant modeled the savings potential for each measure in each of three different customer segments. Cumulative cost-effective achievable potential for each impact type (i.e., energy, demand and gas savings) is provided in Figure 16 through Figure 17. The majority of residential energy efficiency potential comes from single family homes. For electric energy savings, single family homes account for 63% of cumulative cost-effective achievable potential by 2033, while for gas savings, they account for about 92% of cumulative cost-effective achievable potential. A key reason for this difference is that while the distribution of electric measures between the three segments is more even, the number of gas measures applicable to single family homes is much higher compared with the other two segments.

**Figure 16. Cumulative Residential Cost-effective Energy Savings (MWh) by Customer Segment**




*Source: Navigant analysis, 2014*

**Figure 17. Cumulative Residential Cost-effective Gas Savings (MMtherms) by Customer Segment**




*Source: Navigant analysis, 2014*

## 4.2 *Residential Cost-Effective Achievable Potential – End Use*

Navigant calculated savings potential at the measure level and customer segment level before aggregating these results into six residential end-use categories. End-use categories provide a useful way to categorize and roll-up measure-level savings while also providing a high-level perspective of the measures in that category. As can be seen in Figure 18 through Figure 19, lighting and water heating measures account for a bulk of the residential energy and demand savings potential. By 2033, it is estimated that lighting and water heating measures will contribute up to 58% of cost-effective achievable electric energy potential, with heating and appliance measures contributing about 8% and 9% respectively.

Figure 19 shows the cumulative cost-effective achievable potential for gas energy savings by end-use category for the residential sector. The main drivers of gas savings potential over the forecast horizon are water heating and weatherization measures. In particular, showerheads and window replacement savings contribute significantly toward cost-effective gas potential. Additional detail about the measures that drive overall energy and gas savings results can be found in section 4.4.

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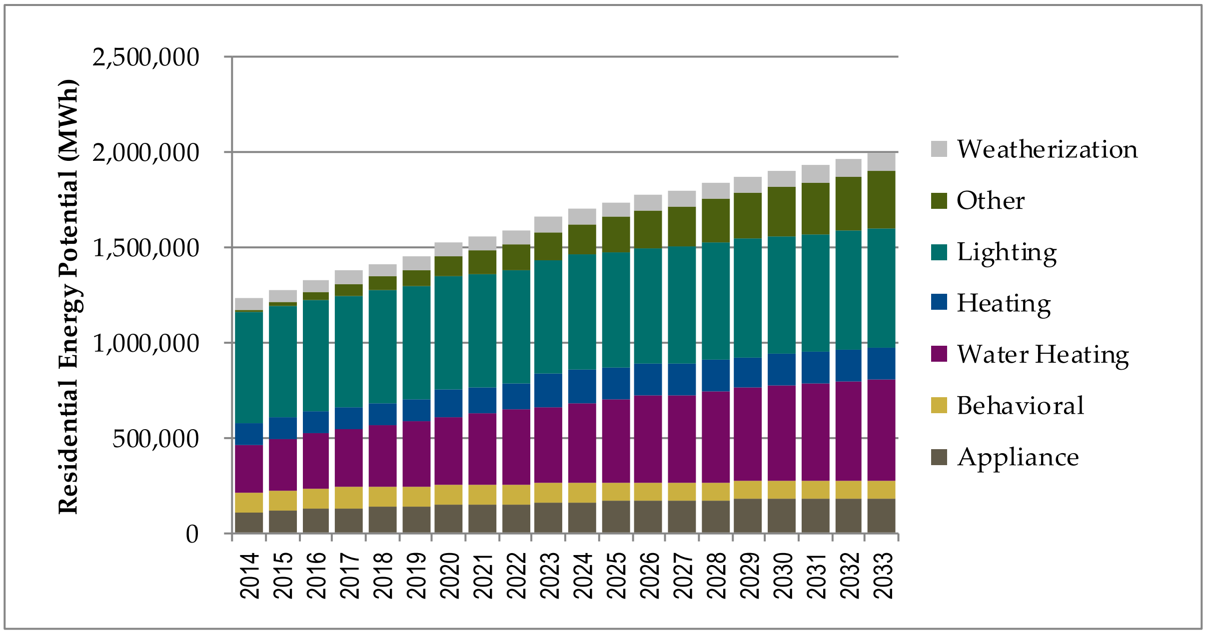
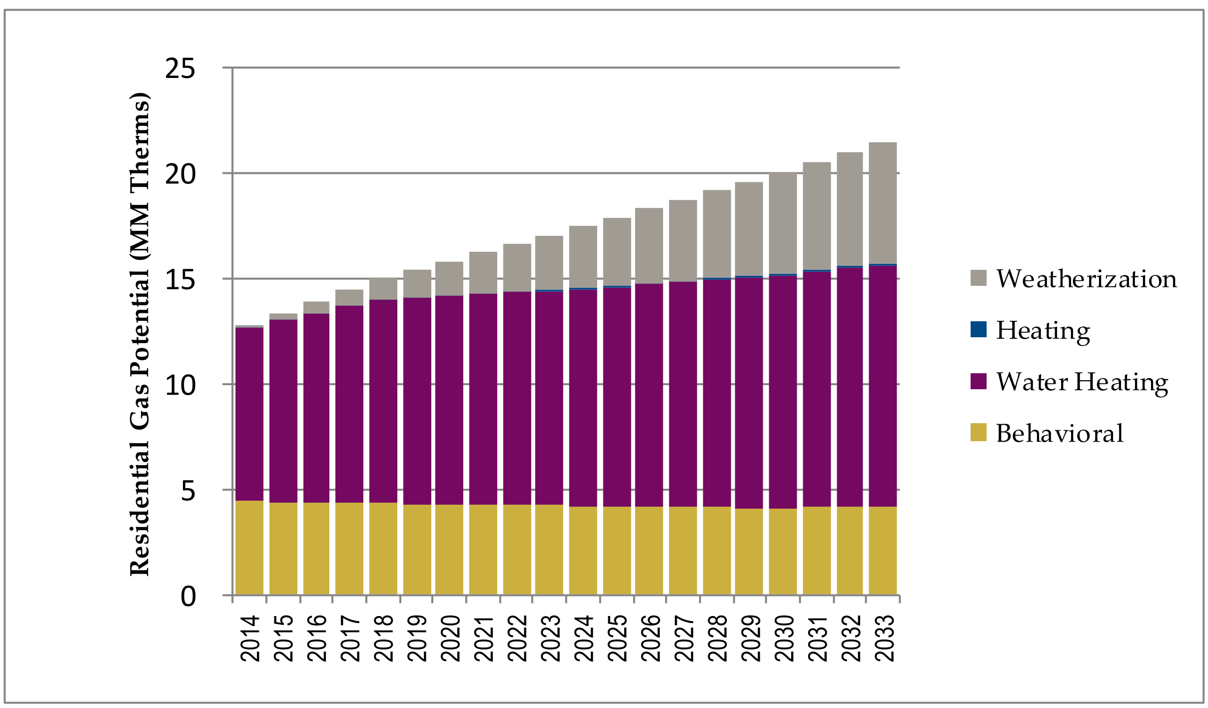
**Figure 18. Cumulative Residential Cost-effective Energy Savings (MWh) by End Use**




*Source: Navigant analysis, 2014*

**Figure 19. Cumulative Residential Cost-effective Gas Savings (MMtherms) by End Use**

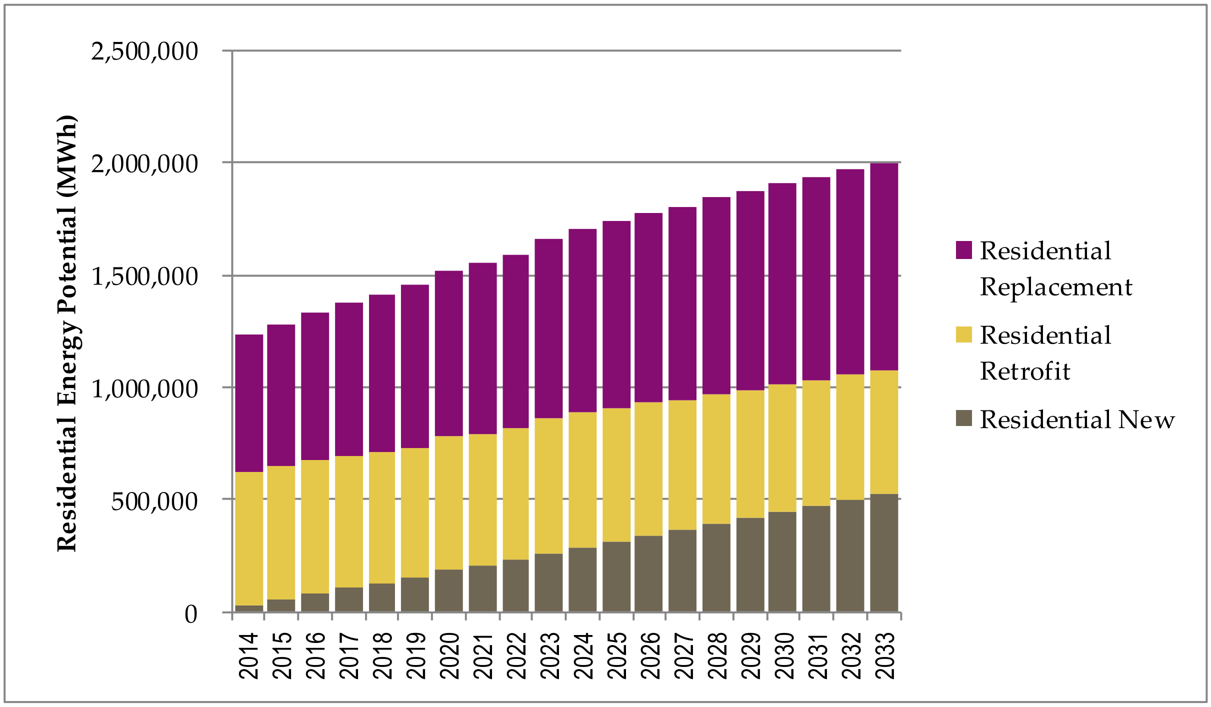



*Source: Navigant analysis, 2014*

## 4.3 *Residential Cost-effective Achievable Potential – Program*

Navigant mapped measure-level output of the model to program types, which are defined by Energy Trust as the combination of sector (e.g., Residential, Commercial, Industrial) and replacement type (e.g., New Construction, Retrofit, Replacement). For example, "Residential Replacement" in Figure 20 shows the cumulative cost-effective achievable potential for ROB measures over the 20-year forecast horizon. Figure 20 shows that the majority of electric energy savings comes from ROB measures. In particular, CFLs and heat pump water heaters dominate ROB electric energy savings potential, while retrofit electric energy savings are driven primarily by showerheads and faucet aerators.

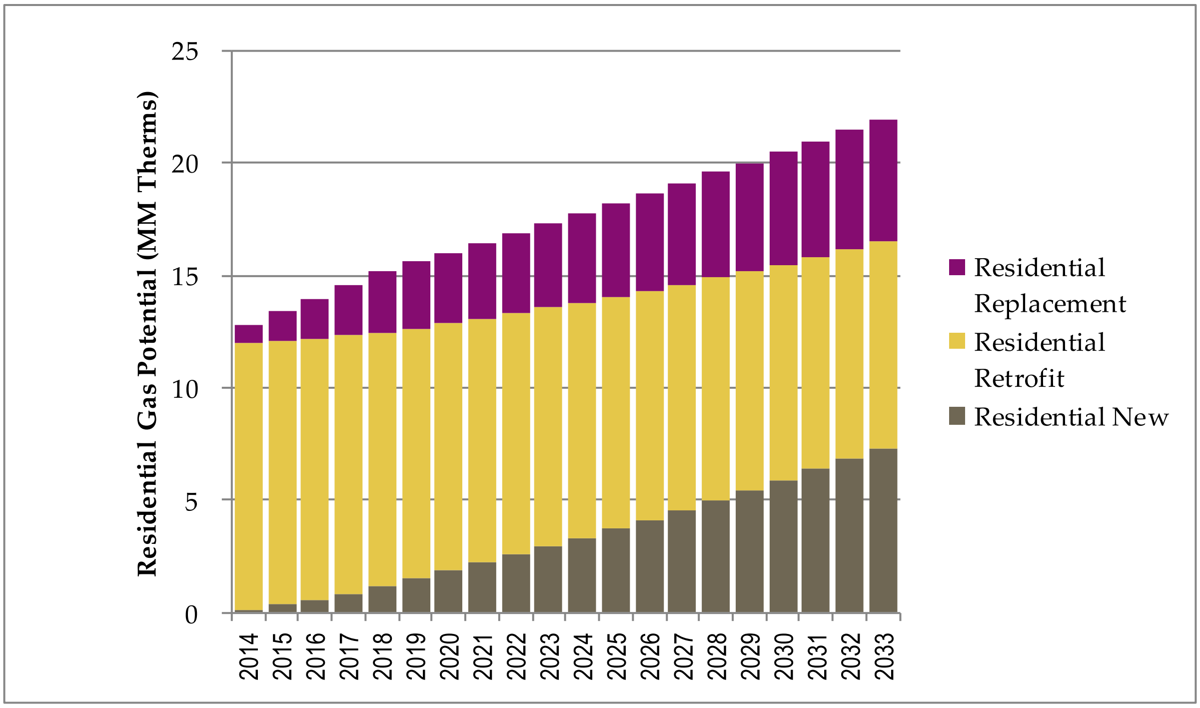
**Figure 20. Cumulative Residential Cost-effective Energy Savings (MWh) by Program Type**




*Source: Navigant analysis, 2014*

Figure 21 shows cost-effective achievable gas potential by program type. This graph shows that while potential in the early years is dominated by retrofit measures (e.g., showerheads, faucet aerators and behavior savings), future potential in outer years is also driven by ROB and NEW measures, especially windows replacements and absorption gas heat pump water heaters. See Appendix B for more measure-level detail of potential by program type.

**Figure 21. Cumulative Residential Cost-effective Gas Savings (MMtherms) by Program Type**

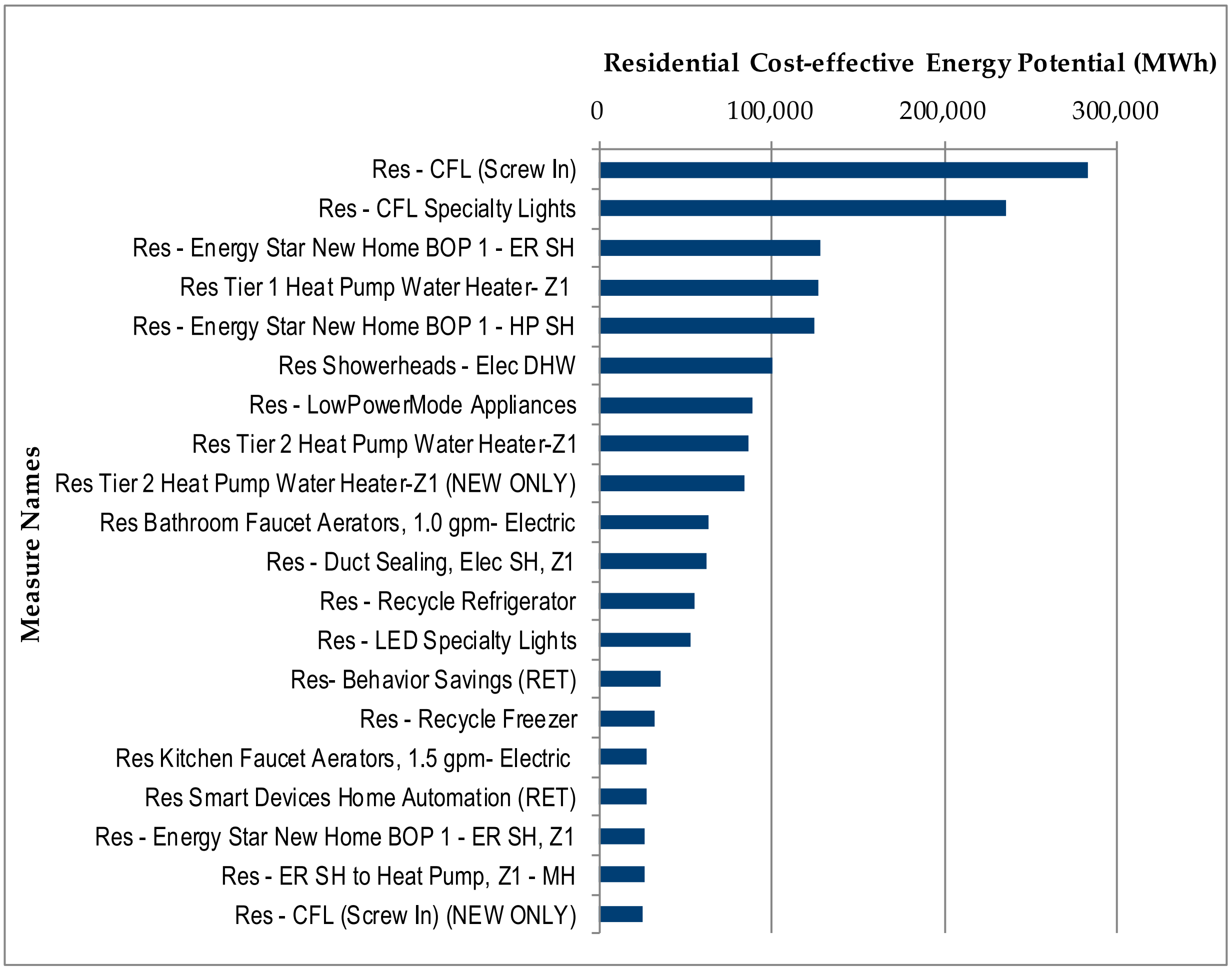



*Source: Navigant analysis, 2014*

### 4.4 *Histograms of Top 20 Residential Measures*

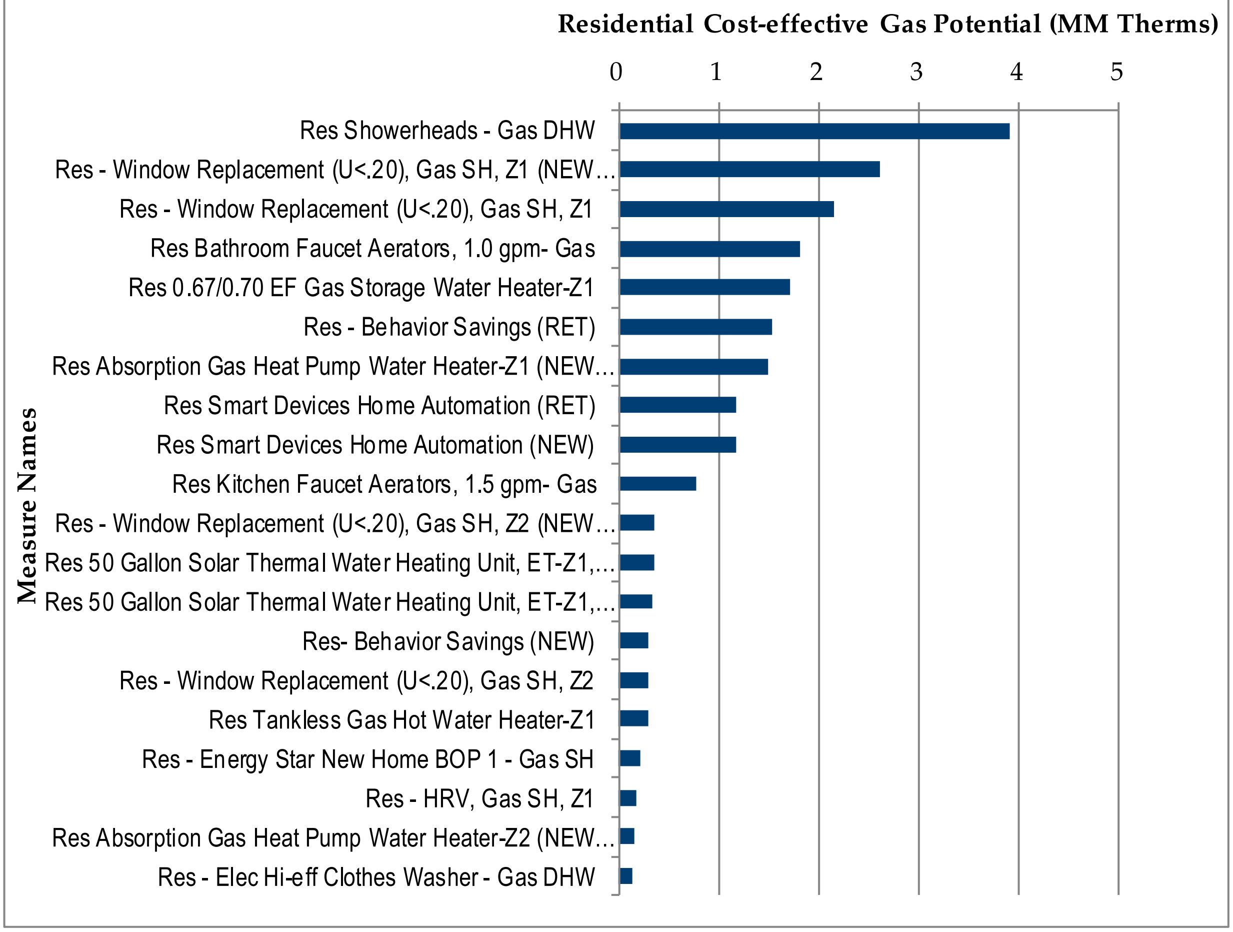
It is common in potential studies for a small number of measures to account for a majority of the savings. Figure 22 and Figure 23 provide a set of histograms showing the cumulative achievable potential by 2033 of the top 20 electric and gas measures in Energy Trust's residential sector. These measures represent over 90% of the total cost-effective achievable potential for both electric and gas measures. For electric potential, the top three measures are residential screw-in CFLs, specialty CFLs and ENERGY STAR New Home BOP – Space Heat. For gas potential, the top three measures are showerheads, window replacement measures, and faucet aerators. For more details on measure-level savings, refer to Appendix B.

**Figure 22. Top 20 Residential Electric Measures by 2033**




*Source: Navigant analysis, 2014*

**Figure 23. Top 20 Residential Gas Measures by 2033**



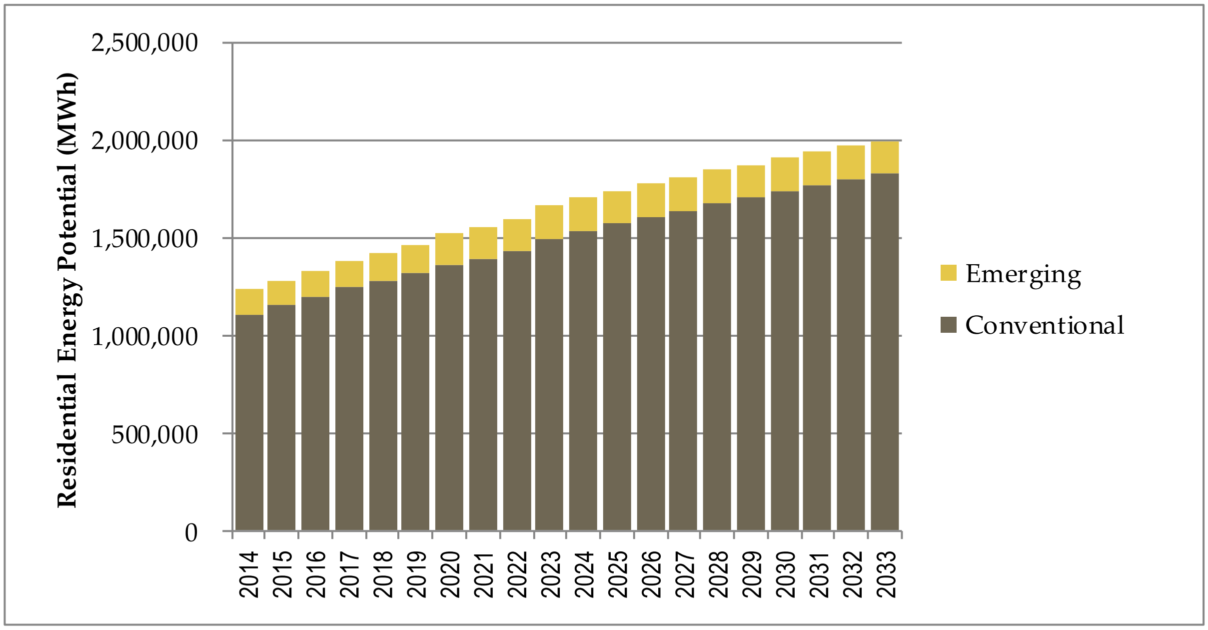

*Source: Navigant analysis, 2014*

## *4.5 Residential Emerging Technology Results*

Navigant's modeling approach includes an emerging technology (ET) overlay that enables the model to capture the range of possible savings from ETs due to cost and efficiency improvements over time. Additionally, the model also accounts for an ET risk factor (see section 2.1 for details on ET measure characterization) to capture the inherent uncertainty in future market development of ETs. As described in section 2.2.3, a tiered approach was used to estimate savings among efficient measures that compete for the same installation. Therefore, ET measures compete with conventional measures within a competition group, and their cost-effectiveness is assessed on an incremental basis relative to the next highest rank within the competition group. Figure 24 and Figure 25 show the contribution of emerging and conventional measures toward cumulative risk-adjusted cost-effective achievable (electric and gas) potential for the residential sector. For electric potential, emerging technology savings over the 20-year forecast horizon are small compared with conventional measure savings; by 2033, ETs contribute about 8% of total cost-effective achievable electric energy potential. There are two reasons for this:

1. Energy saving ETs are incrementally less cost-effective compared with competing conventional technologies. In other words, there is not a lot of incremental (relative to the next most cost-effective measure) cost-effective achievable ET savings in the calculation of tiered potential (since the measure against which it is compared is already more efficient than the baseline measure).
2. The application of ET risk factors (to account for uncertainty in ET savings) reduces the total tiered potential of ETs. The inclusion of a risk factor reduces cumulative cost-effective achievable potential of ETs by 60% in 2033.

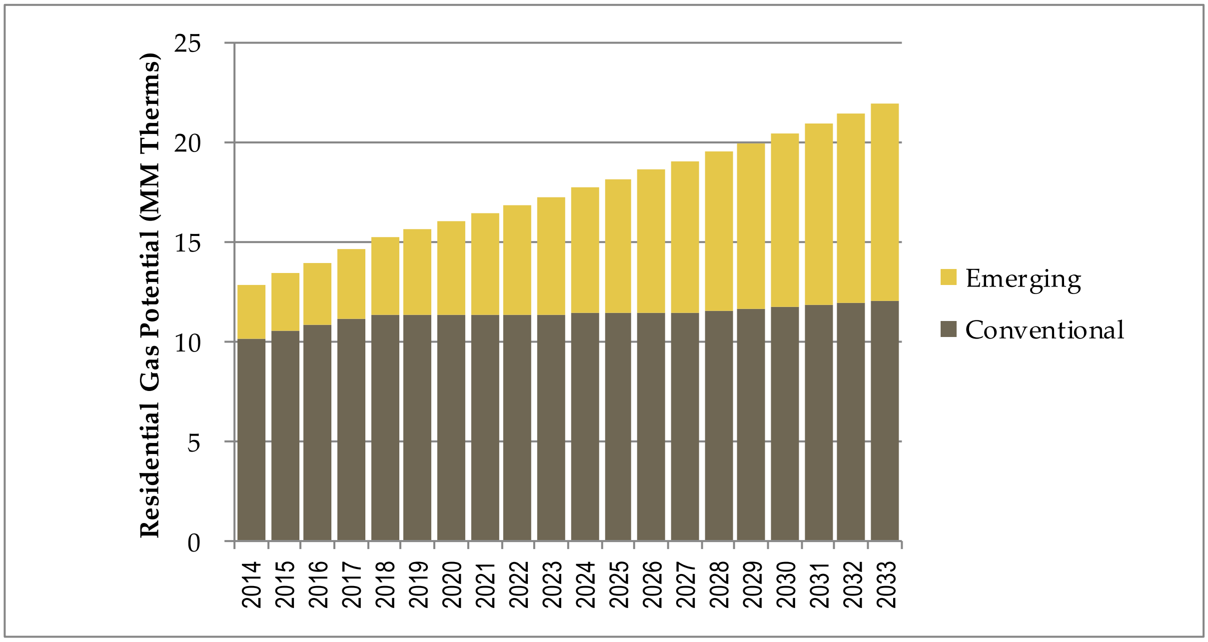
**Figure 24. Cumulative Residential Cost-effective Energy Savings (MWh)-Emerging vs. Conventional**




*Source: Navigant analysis, 2014*

Figure 25 shows that gas ETs have a more significant impact on future gas savings. Smart devices home automation, absorption gas heat pump water heater, and windows replacement measures contribute a bulk of the future gas potential.

**Figure 25. Cumulative Residential Cost-effective Gas Savings (MMtherms)-Emerging vs. Conventional**




*Source: Navigant analysis, 2014*

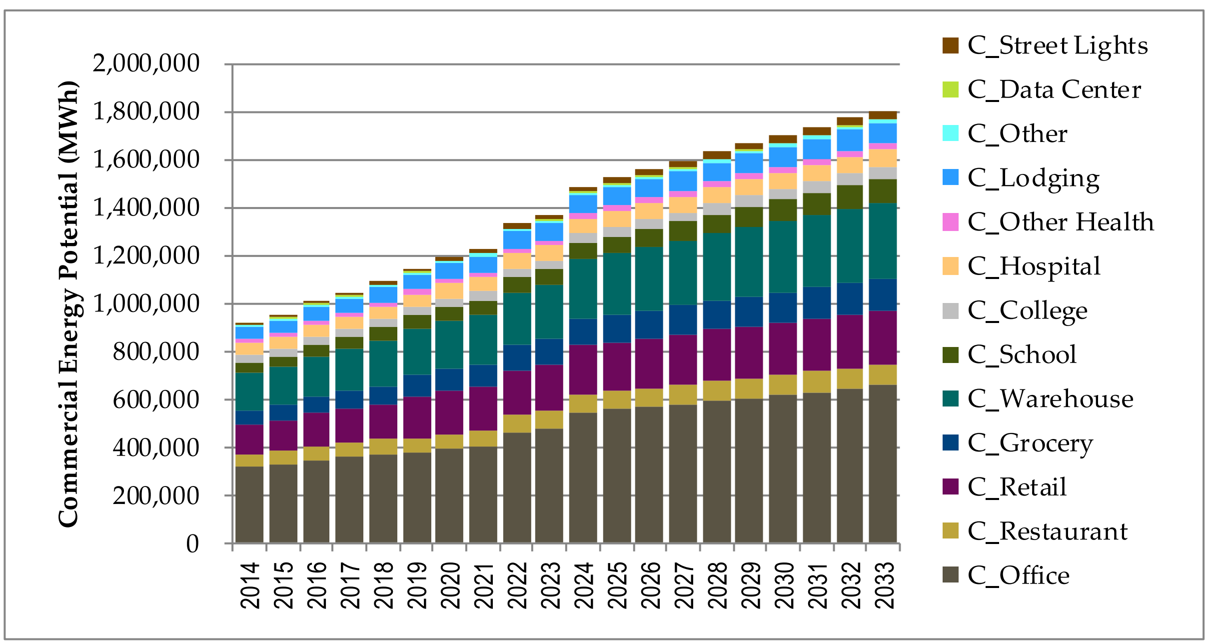
5 Energy Efficiency Potential in Energy Trust's Commercial Sector

This section provides estimates of electric energy and gas savings for all commercial buildings, including existing and new construction buildings. All the results shown in this section are estimates of risk-adjusted tiered cost-effective achievable potential for the electric energy and gas impact types, and include savings potential for both conventional and emerging technology measures.

## *5.1 Commercial Cost-Effective Achievable Potential – Customer Segment*

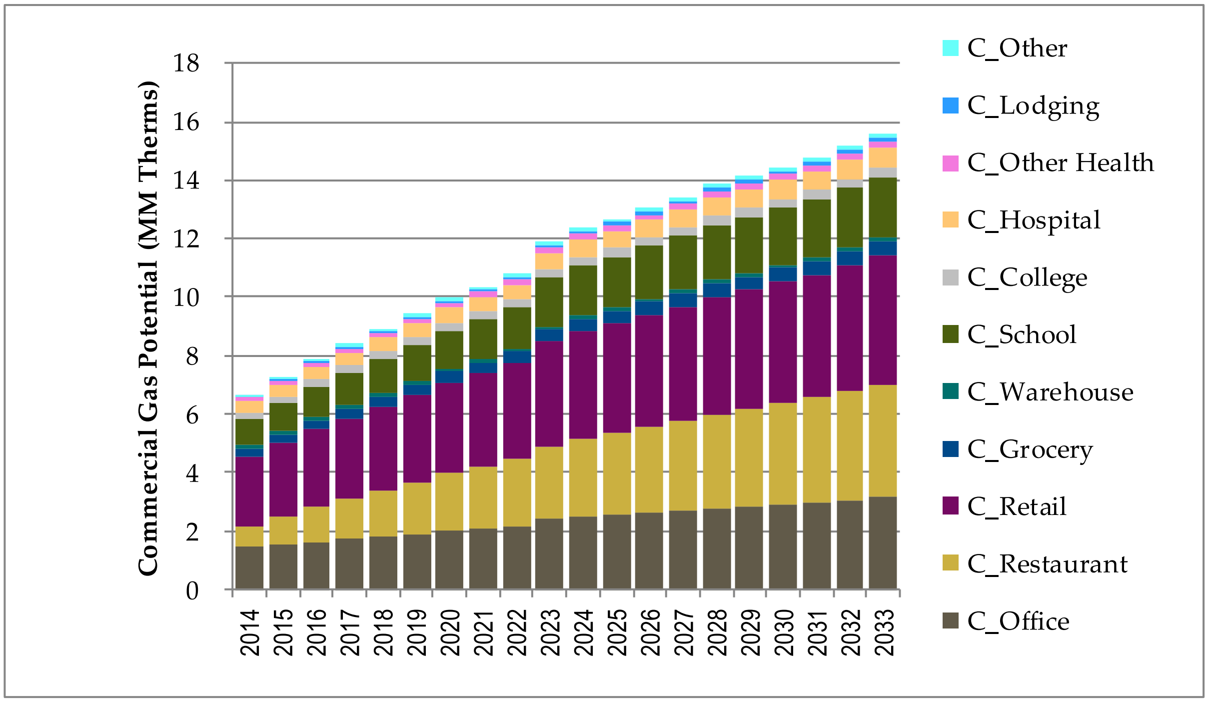
Navigant estimated the savings potential in thirteen different commercial customer segments as shown in Figure 26 and Figure 27. For electric energy savings, commercial offices offer the largest potential for savings accounting for 36% of cumulative cost-effective achievable potential by 2033. Commercial retail and warehouse segments also contribute significantly toward overall potential, accounting for a combined 29% of cost-effective achievable potential by 2033. For commercial gas savings, the retail and restaurant segments show the largest potential for savings contributing 53% of total cost-effective achievable potential by 2033. The bump in gas savings in 2023 is attributable to the commercial wall insulation (R-11) measure becoming cost-effective starting in that year.

**Figure 26. Cumulative Commercial Cost-effective Energy Savings (MWh) by Customer Segment**




*Source: Navigant analysis, 2014*

**Figure 27. Cumulative Commercial Cost-effective Gas Savings (MMtherms) by Customer Segment**

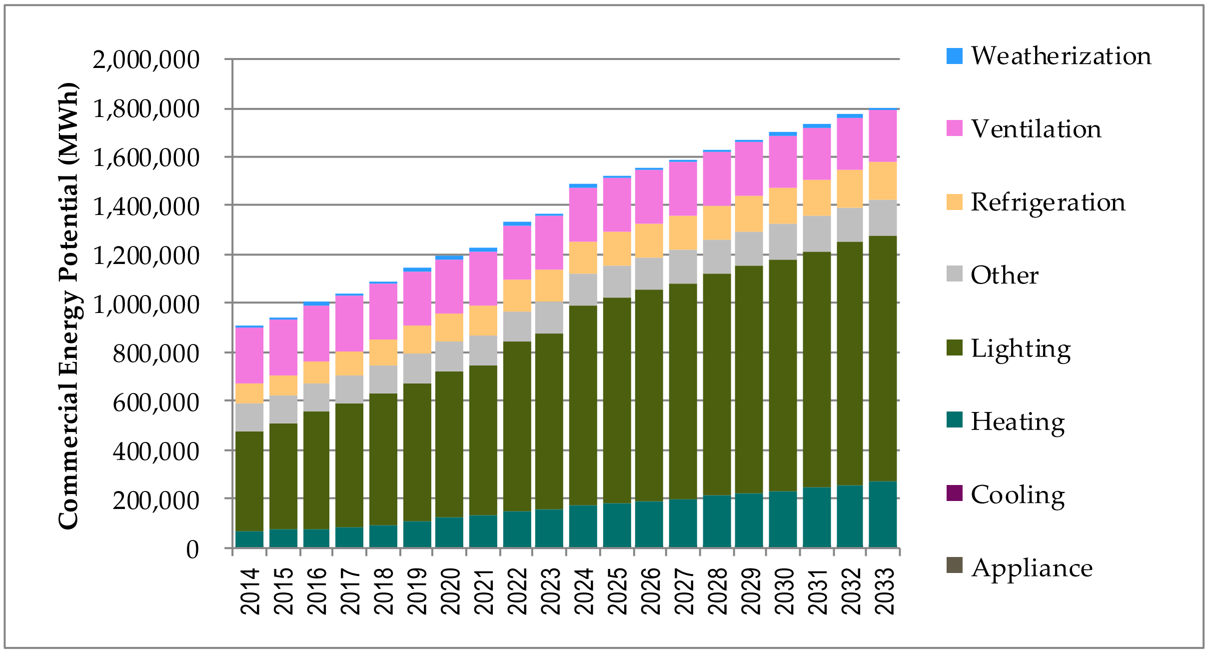



*Source: Navigant analysis, 2014*

## 5.2 *Commercial Cost-Effective Achievable Potential – End Use*

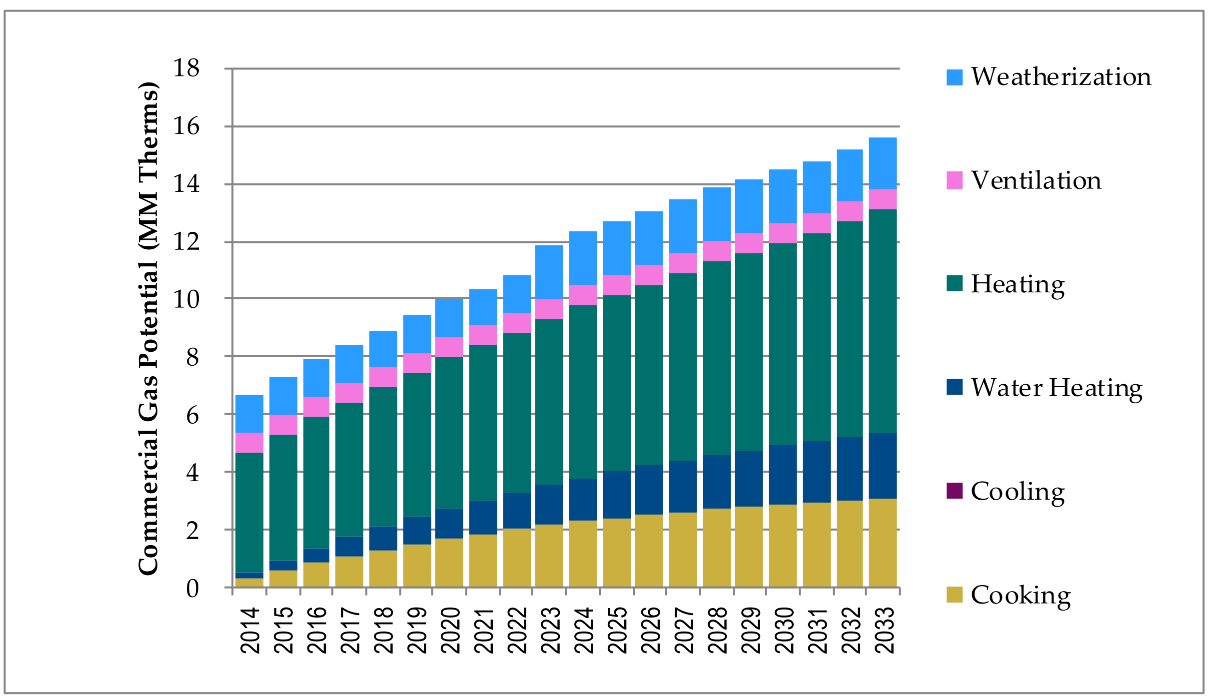
Navigant calculated cost-effective achievable potential at the measure level and customer segment level before aggregating results for the commercial sector into seven different end-use categories. Figure 28 and Figure 29 show the cumulative cost-effective achievable potential for electric and gas savings respectively, disaggregated by end-use category. For electric energy savings, commercial lighting contributes up to 54% of total cost-effective achievable potential by 2033. In particular, commercial lighting savings are driven by CFLs, LED troffers, and exterior LEDs. Ventilation and refrigeration contribute about 20% toward total cost-effective achievable electric energy potential by 2033. For gas savings, heating and cooking measures provide the largest savings opportunity by 2033, driven largely by demand control ventilation, Direct Digital Control (DDC) HVAC controls, and condensing tankless water heaters. Additional detail regarding high impact commercial measures can be found in section 5.4.

**Figure 28. Cumulative Commercial Cost-effective Energy Savings (MWh) by End Use**




*Source: Navigant analysis, 2014*

**Figure 29. Cumulative Commercial Cost-effective Gas Savings (MMtherms) by End Use**

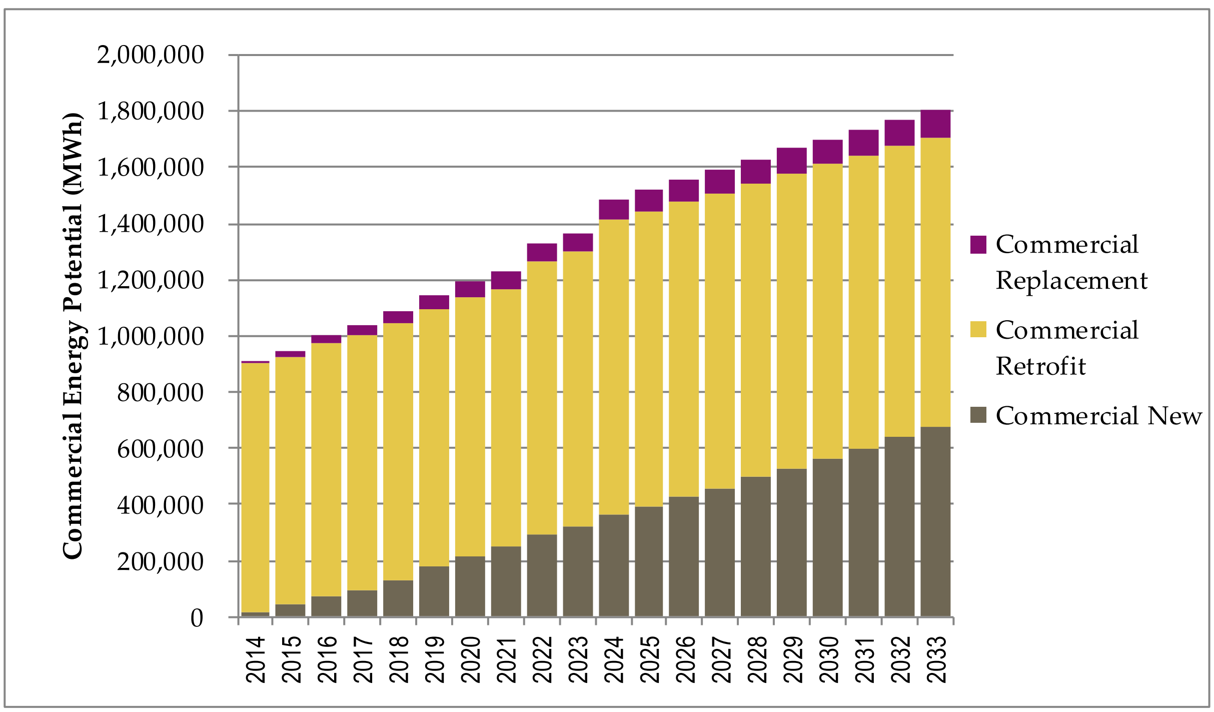



*Source: Navigant analysis, 2014*

## 5.3 *Commercial Cost-Effective Achievable Potential – Program*

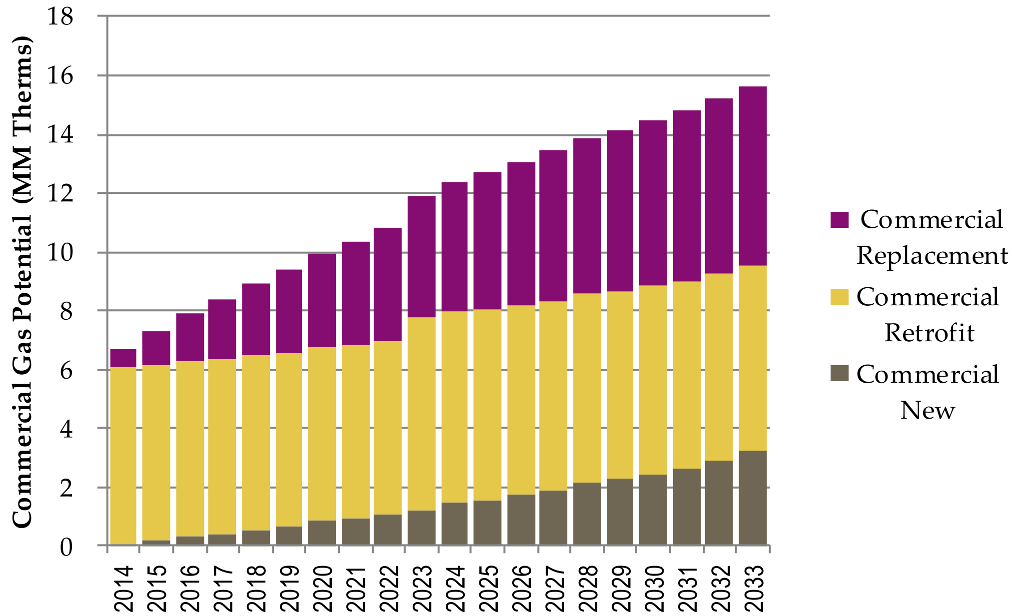
This subsection presents details about commercial electric energy and gas savings disaggregated by program type (e.g., New Construction, Retrofit, and Replacement). Figure 30 and Figure 31 show cumulative cost-effective achievable potential for electric and gas savings measures by program type. Commercial retrofit and new construction measures account for 90% of total cost-effective achievable electric energy savings potential by 2033. In particular, commercial lighting measures, which are characterized as retrofit, account for a bulk of these savings along with demand control ventilation and advanced ventilation controls. The modeling of lighting measures as retrofit implies that, unlike in the residential sector, commercial lighting savings are not constrained by the rate at which the base measure stock turns over. For gas savings, Figure 31 shows that commercial replacement measures contribute significantly toward cost-effective achievable potential by 2033, in addition to retrofit measures. In particular, cooking (e.g., ENERGY STAR fryer) and water heating (e.g., condensing tankless DHW) measures are key drivers of ROB gas savings by 2033, while heating measures (e.g., demand control ventilation) drive retrofit gas savings by 2033. See Appendix B for more measure-level detail of potential by program type.

**Figure 30. Cumulative Commercial Cost-effective Energy Savings (MWh) by Program Type**




*Source: Navigant analysis, 2014*

**Figure 31. Cumulative Commercial Cost-effective Gas Savings (MMtherms) by Program Type**

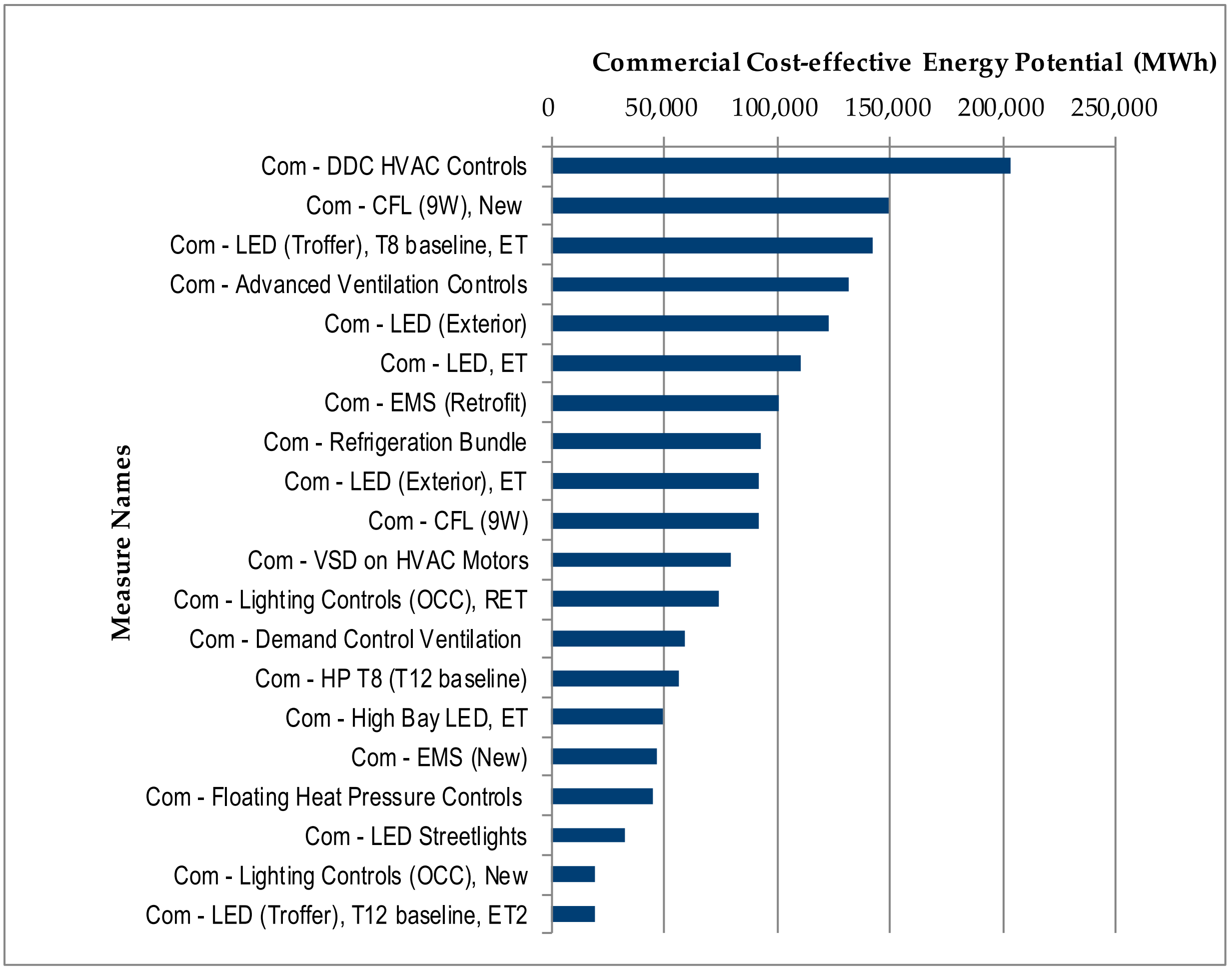



*Source: Navigant analysis, 2014*

## 5.4 *Histograms of Top 20 Commercial Measures*

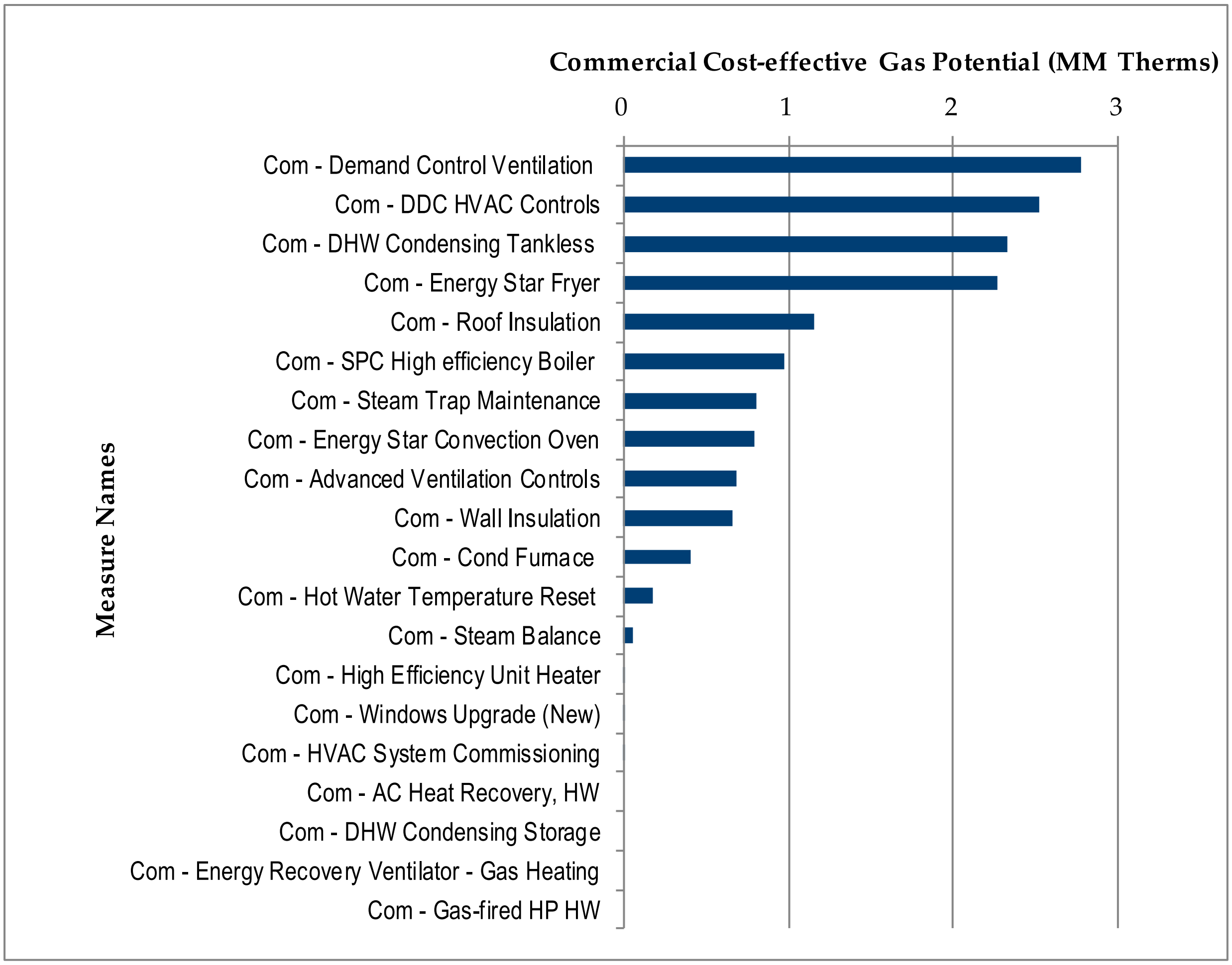
Figure 32 and Figure 33 provide a set of histograms showing the cumulative cost-effective achievable potential by 2033 of the top 20 high impact (electric and gas) measures in Energy Trust's commercial sector. These measures represent over 90% of the total cost-effective achievable potential within the commercial sector. For electric measures, the top three measures are DDC HVAC Controls, CFLs (9W), and LED troffers. Lighting measures have historically been high impact measures in the commercial sector and will continue to do so as LEDs become increasingly cost-effective over the study period. For gas measures, the top three measures are demand control ventilation, DDC HVAC Controls, and DHW condensing tankless water heaters. For more details on measure-level savings, refer to Appendix B.

**Figure 32. Top 20 Commercial Electric Measures by 2033**




*Source: Navigant analysis, 2014*

**Figure 33. Top 20 Commercial Gas Measures by 2033**

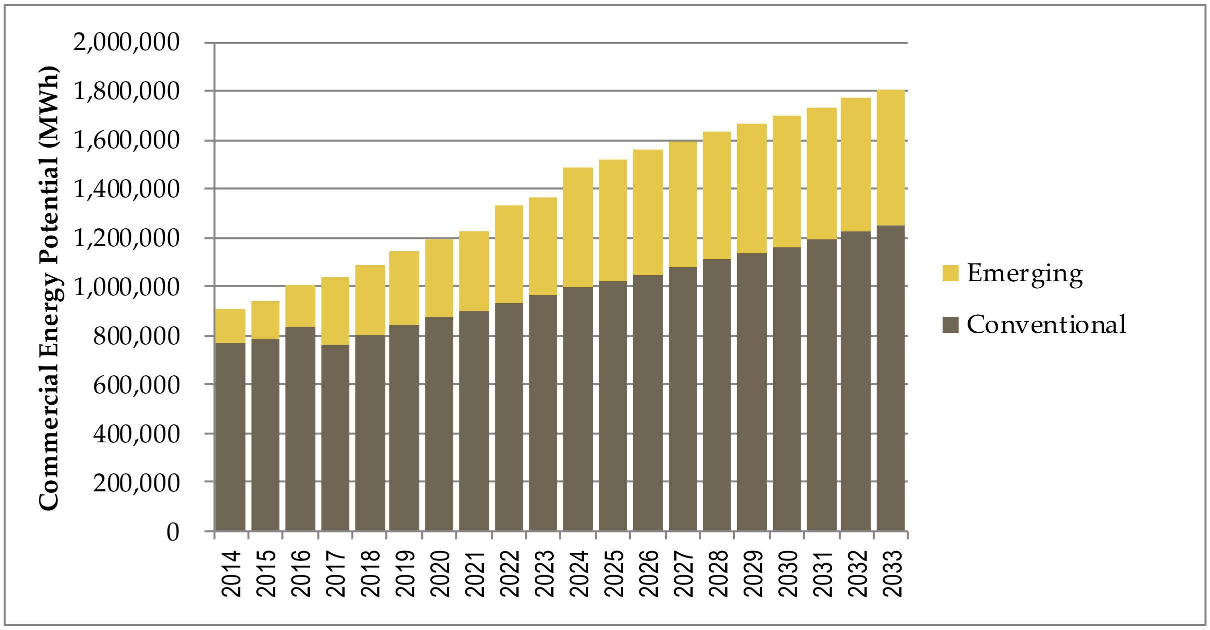



*Source: Navigant analysis, 2014*

## *5.5 Commercial Emerging Technology Results*

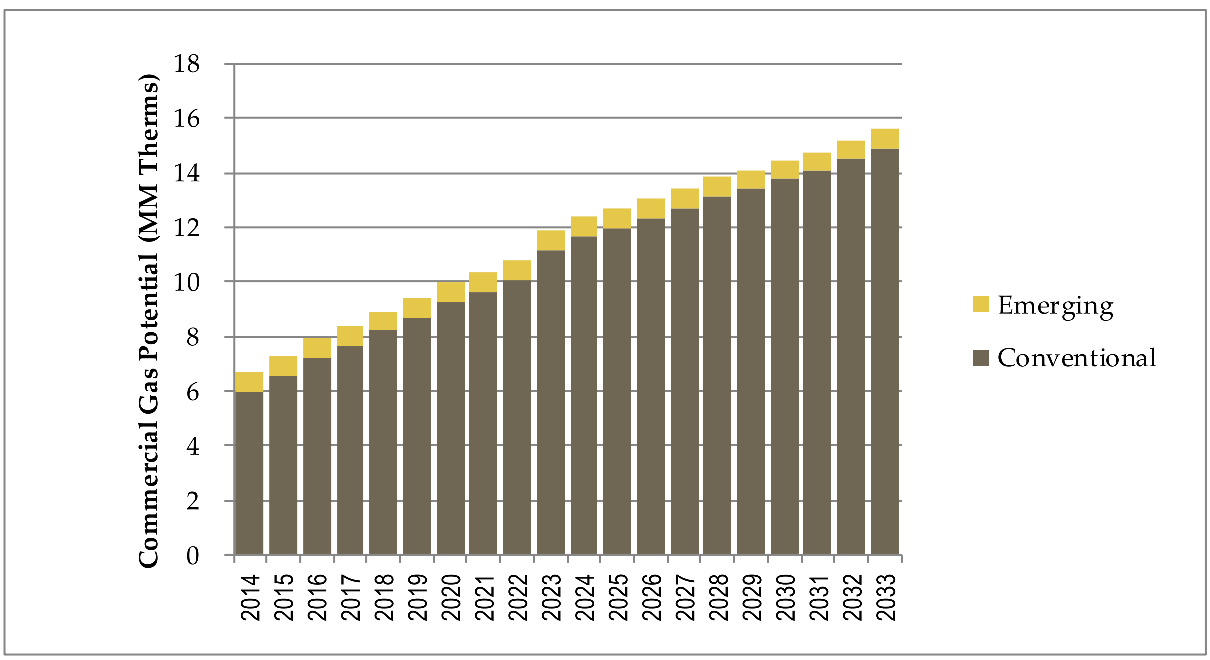
Figure 34 and Figure 35 show the contribution of emerging and conventional measures toward cumulative risk-adjusted cost-effective achievable (electric and gas) potential for the commercial sector. For electric energy potential, emerging technology measure savings are a key contributor toward overall cost-effective achievable potential. By 2033, ETs contribute about 30% of total cost-effective achievable potential, driven primarily by LEDs and advanced ventilation controls. For gas potential, apart from advanced ventilation controls, the emerging technology gas measures characterized by Navigant offer no cost-effective potential over the modeling period. The combination of high incremental costs for gas ETs and low avoided gas costs result in most of the commercial gas ET measures not screening the TRC test. While the costs for gas ETs might decrease over time, Navigant was unable to find any credible data sources that forecast a decrease over the study period.

**Figure 34. Cumulative Commercial Cost-effective Energy Savings (MWh)-Emerging vs. Conventional**




*Source: Navigant analysis, 2014*

**Figure 35. Cumulative Commercial Cost-effective Gas Savings (MMtherms)-Emerging vs. Conventional**




*Source: Navigant analysis, 2014*

# 6 Energy Efficiency Potential in Energy Trust's Industrial Sector

This section provides estimates of electric energy and gas savings for the industrial sector. All the results shown in this section are estimates of risk-adjusted tiered cost-effective achievable potential for the electric energy and gas impact types, and include savings potential for both conventional and emerging technology measures. Navigant used a top-down approach to estimate potential for the industrial sector because of the diversity of end uses and custom nature of projects in the sector. Whereas total potential for the residential and commercial sectors are estimated based on the number of residential homes or square footage of building space, industrial potential is calculated using the load consumption forecast. While the companion Analytica model offers the ability to view disaggregated potential for different industrial customer classes (<1aMW,>1aMW, self-direct etc.), the results in this section show an aggregated view of industrial savings potential.

## *6.1 Industrial Cost-Effective Achievable Potential – Customer Segment*

Navigant calculated the savings potential in eleven different industrial customer segments as shown in Figure 36 and Figure 37. For industrial electric potential, the hi-tech customer segment offers the largest savings accounting for 25% of the cost-effective achievable potential by 2033. This is because the hi-tech customer segment has the largest load consumption forecast over the modeling period across combined electric utilities in the Energy Trust service territory. Similarly, for industrial gas savings, the food products, pulp & paper, and chemicals segments show the largest savings over the study period accounting for 61% of total cost-effective achievable gas potential by 2033. Additional details regarding measures that drive overall electric and gas savings within these segments can be found in section 6.4.

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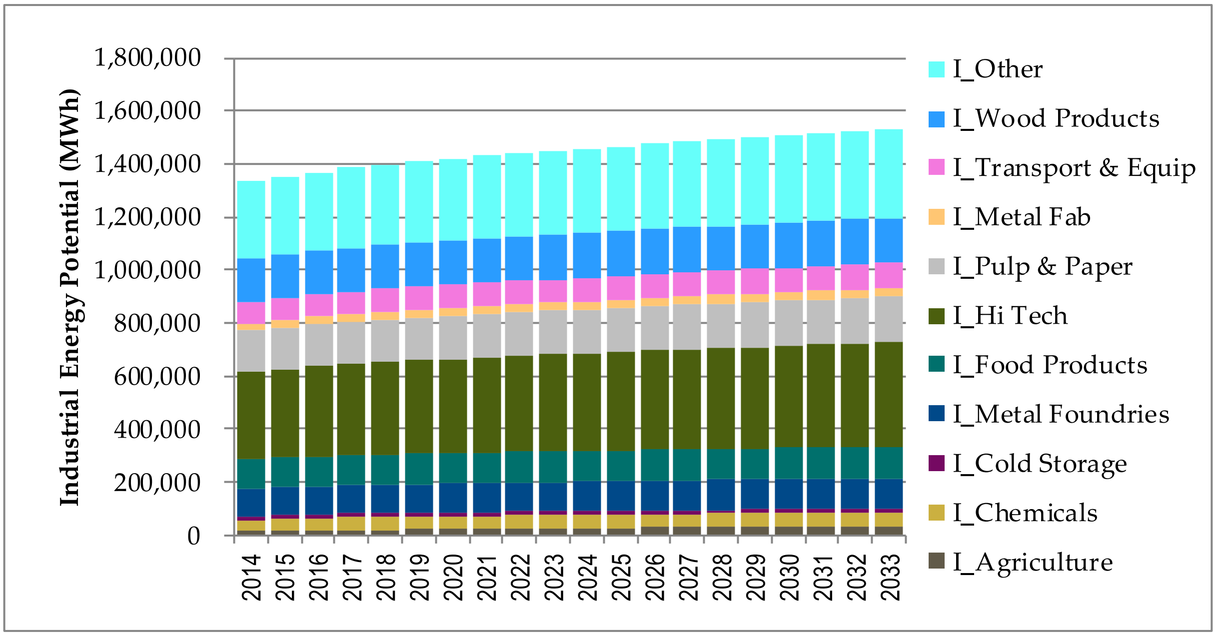
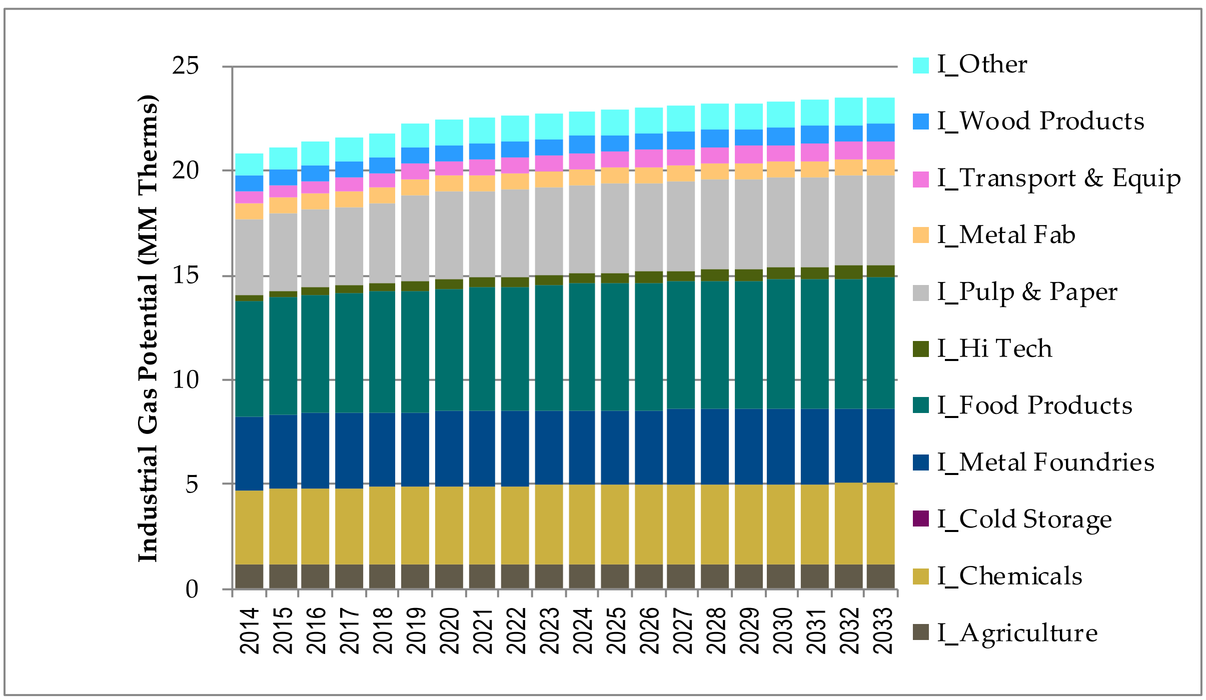
**Figure 36. Cumulative Industrial Cost-effective Energy Savings (MWh) by Customer Segment**




*Source: Navigant analysis, 2014*

**Figure 37. Cumulative Industrial Cost-effective Gas Savings (MMtherms) by Customer Segment**

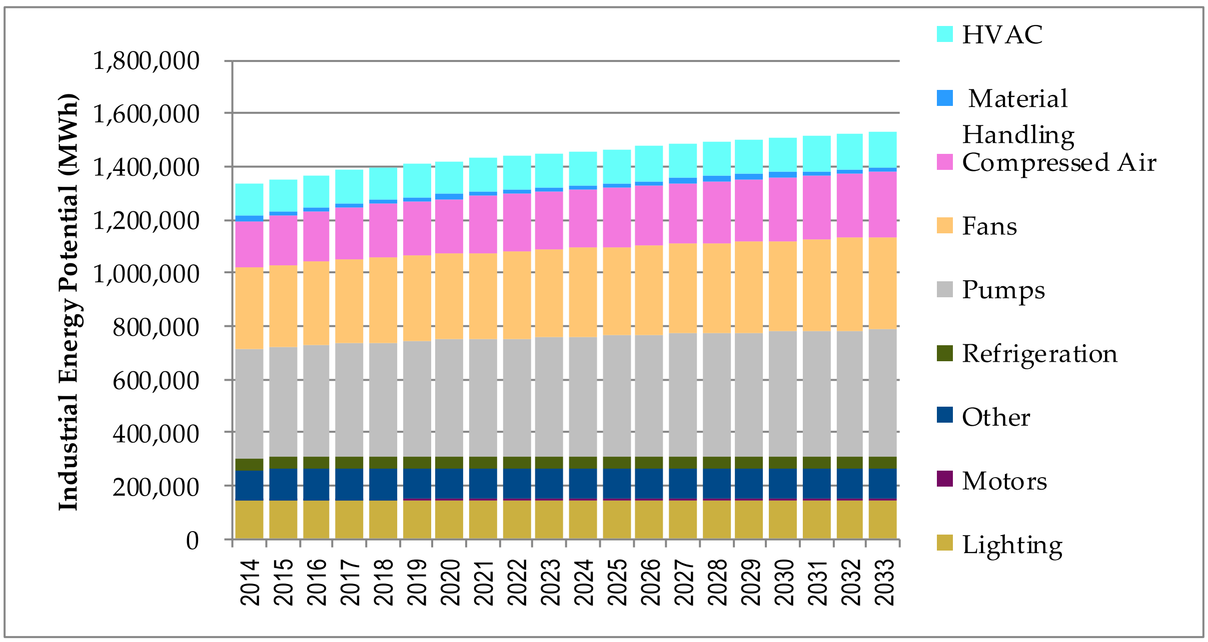



*Source: Navigant analysis, 2014*

### 6.2 Industrial Cost-Effective Achievable Potential – End Use

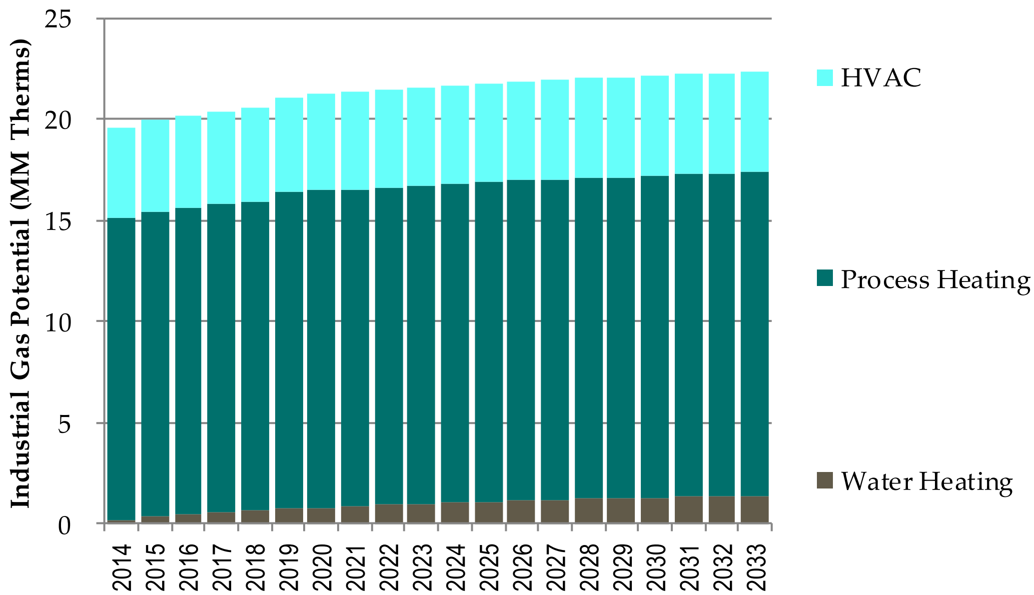
Navigant calculated industrial cost-effective achievable potential at the measure level and customer segment level, which was then aggregated into eleven end-use categories. Figure 38 and Figure 39 show the cumulative industrial cost-effective achievable potential for electric energy and gas savings at the end-use category level. Pumps and fans account for a bulk of the electric energy savings potential, accounting for 54% of total cost-effective achievable potential by 2033. In particular, industrial pump and fan savings are driven by pump and fan variable frequency drives (VFDs), and pump sequencing controls. For industrial gas savings, HVAC and process heating account for over 90% of the cost-effective achievable potential by 2033. Industrial burner upgrades, boiler tune-ups, and roof and wall insulation measures are the biggest contributors toward industrial gas savings over the study period. Further details on measures that drive overall savings can be found in section 6.4.

**Figure 38. Cumulative Industrial Cost-effective Energy Savings (MWh) by End Use**




*Source: Navigant analysis, 2014*

Figure 39. Cumulative Industrial Cost-effective Gas Savings (MMtherms) by End Use

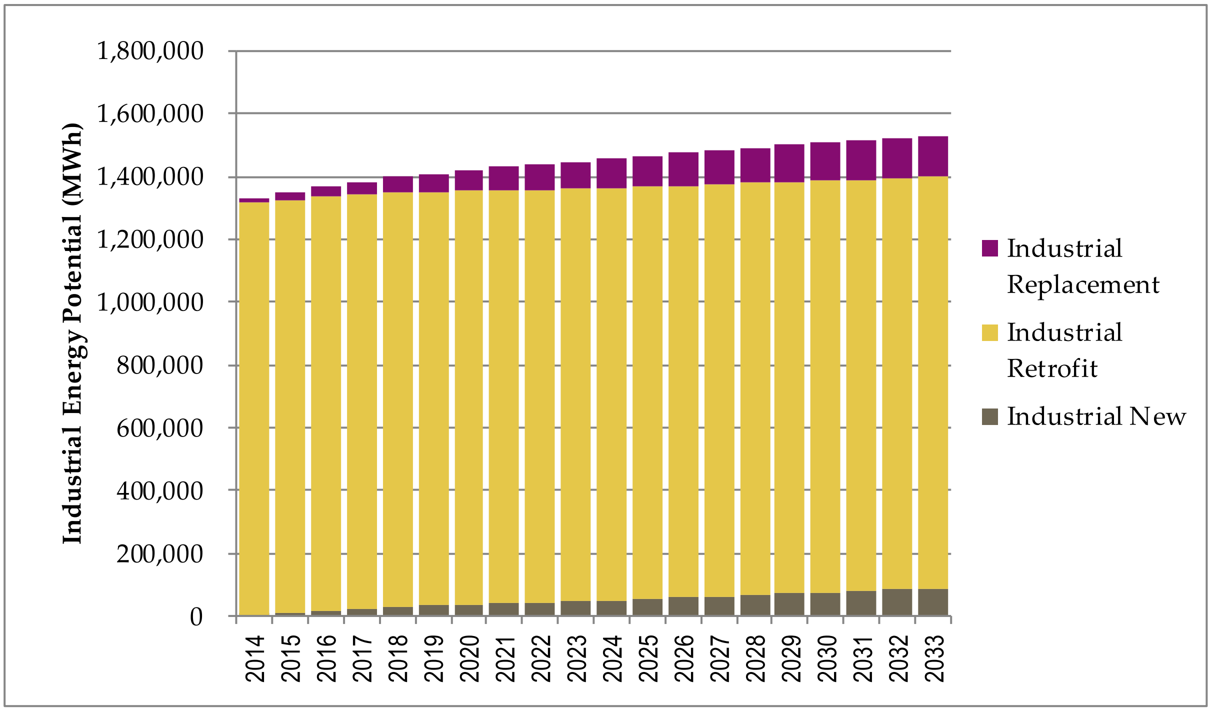



*Source: Navigant analysis, 2014*

## *6.3 Industrial Cost-Effective Achievable Potential – Program*

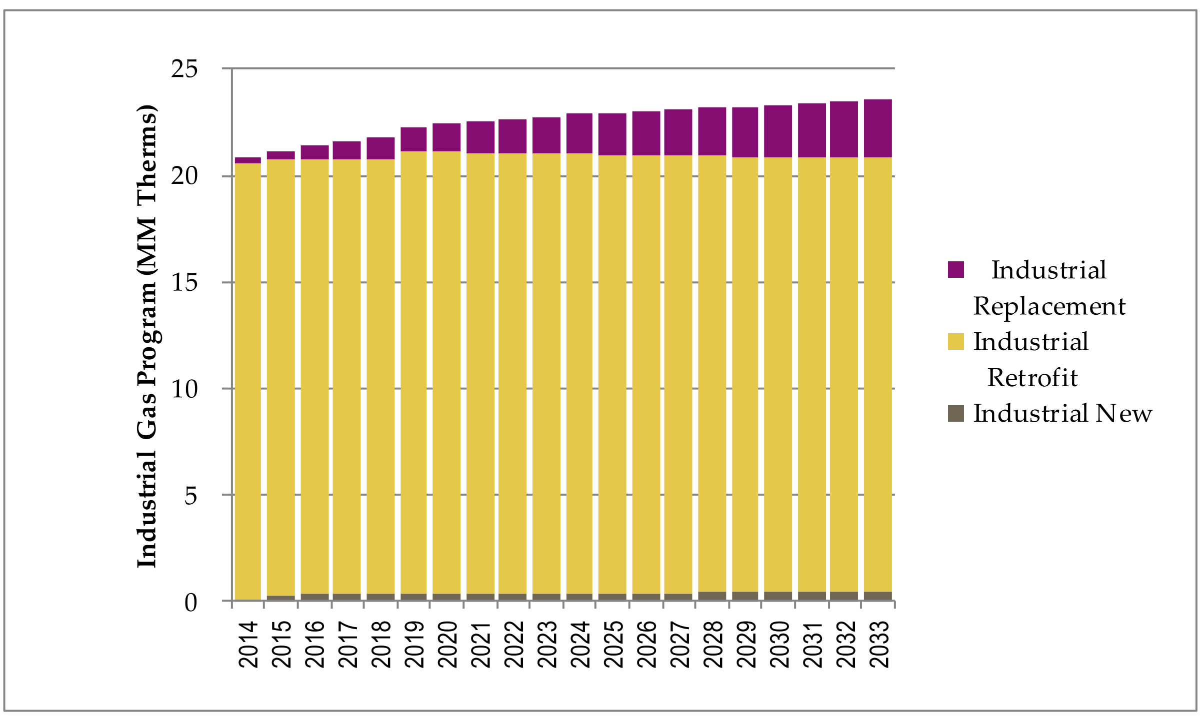
Navigant disaggregated industrial cost-effective achievable potential by program type (e.g., New Construction, Retrofit, Replacement) for electric and gas savings, as shown in Figure 40 and Figure 41. For both electric and gas savings, industrial retrofit measures account for close to 90% of cost-effective achievable potential by 2033. This assumes that most industrial energy efficiency measures (e.g., lighting retrofits or variable frequency drives) are implemented as part of retrofit programs. For ROB and new construction measures, electric savings potential is attributable to equipment (e.g., pump and fan) upgrades while gas savings potential comes from gas-fired heat pump water heaters and high efficiency boilers.

**Figure 40. Cumulative Industrial Cost-effective Energy Savings (MWh) by Program Type**




*Source: Navigant analysis, 2014*

**Figure 41. Cumulative Industrial Cost-effective Gas Savings (MMtherms) by Program Type**

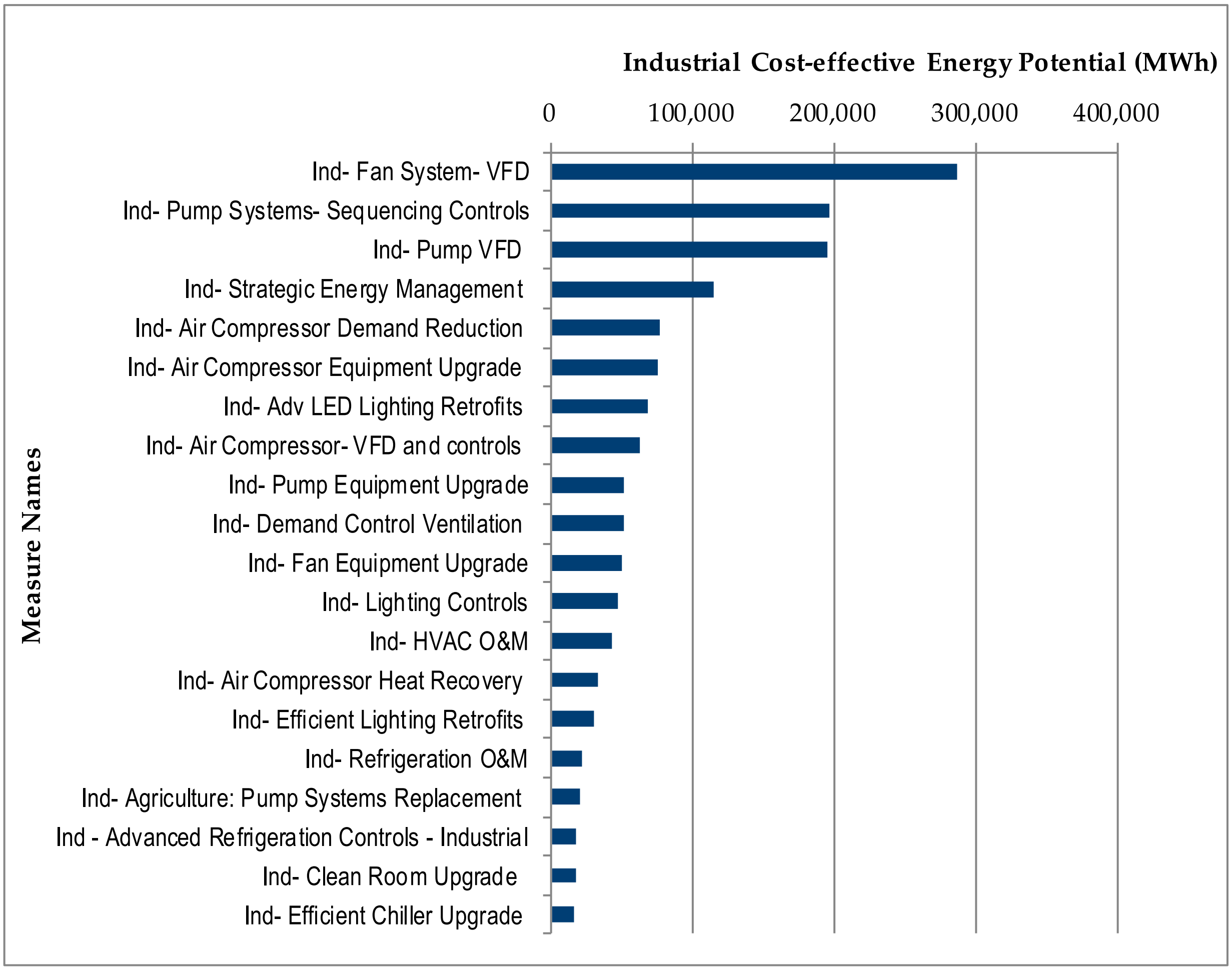



*Source: Navigant analysis, 2014*

### 6.4 *Histograms of Top 20 Industrial Measures*

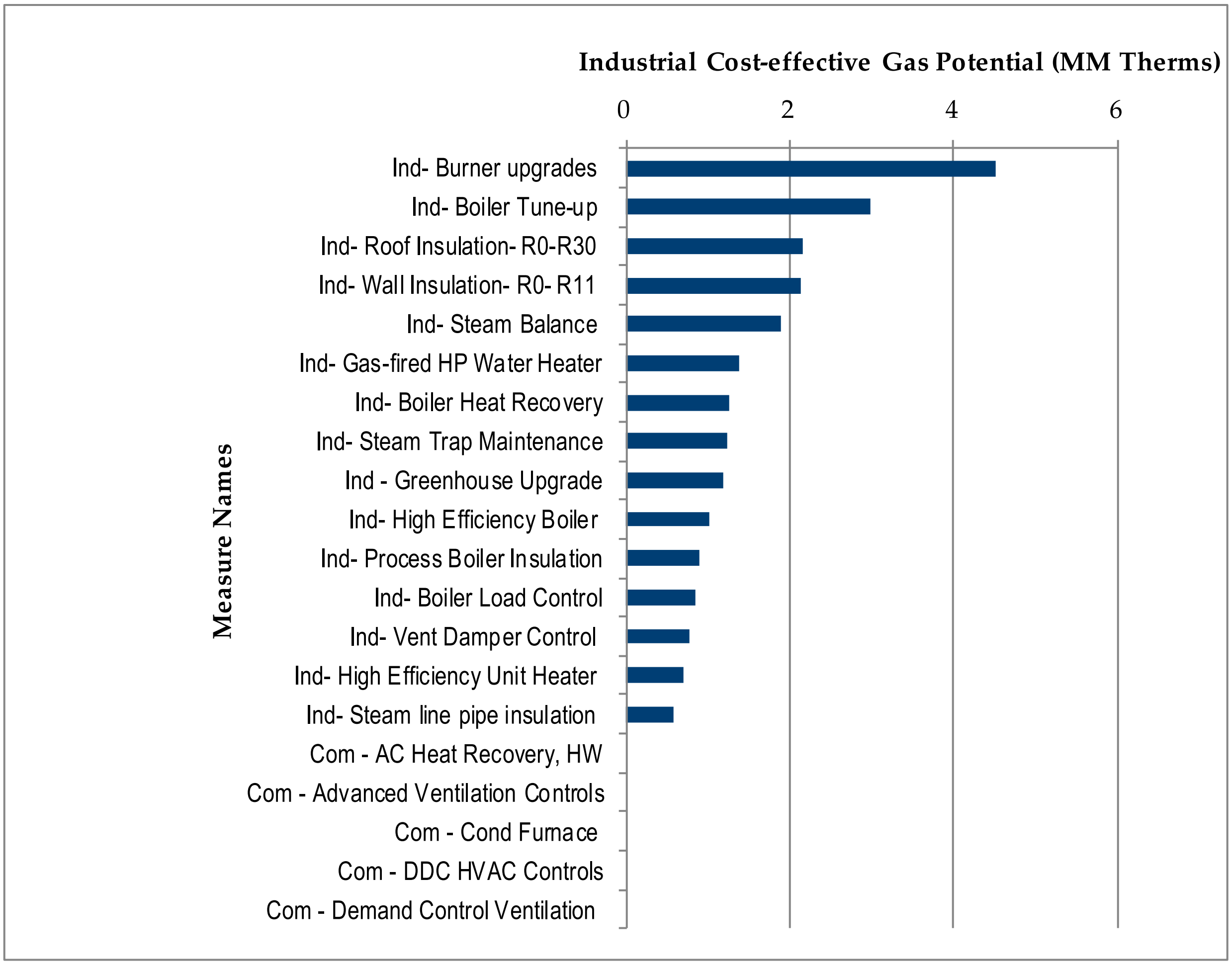
Figure 42 and Figure 43 present histograms showing the cumulative cost-effective achievable potential by 2033 of the top 20 (electric and gas) measures in Energy Trust's industrial sector, which account for over 90% of the savings potential. For electric measures, the top three high impact measures are pump and fan variable frequency drives as well as pump system sequencing controls. The top three high impact gas measures in the industrial sector are burner upgrades, boiler tune-ups, and roof insulation measures. For more details on measure-level savings in the industrial sector, refer to Appendix B.

**Figure 42. Top 20 Industrial Electric Measures by 2033**




*Source: Navigant analysis, 2014*

**Figure 43. Top 20 Industrial Gas Measures by 2033**

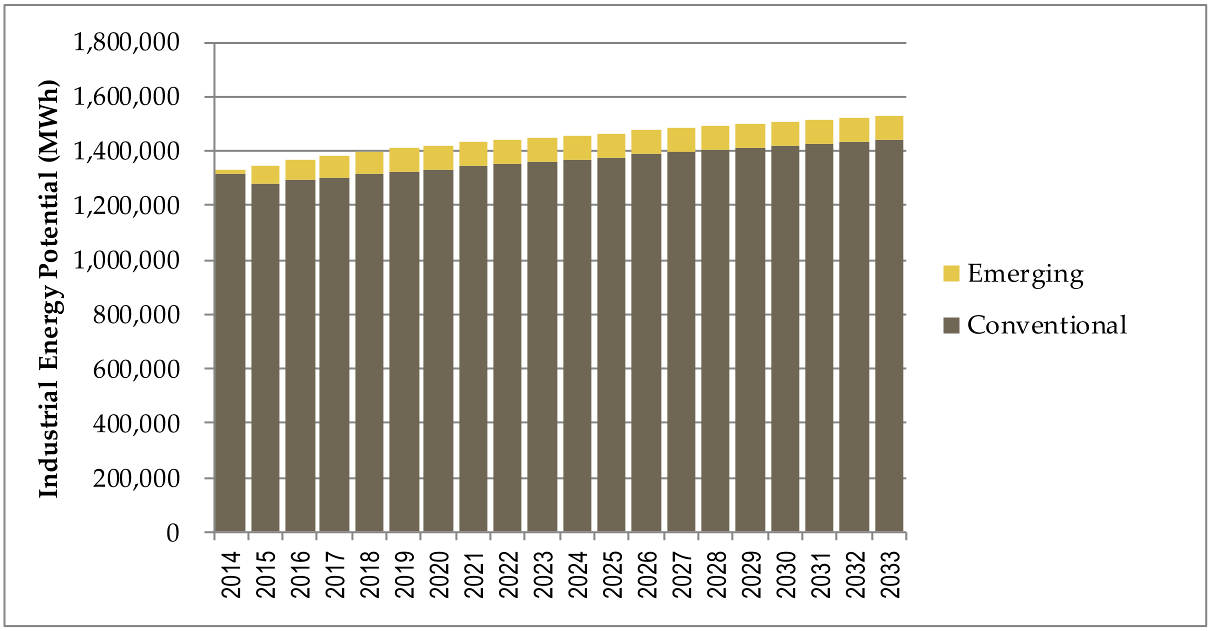



*Source: Navigant analysis, 2014*

## *6.5 Industrial Emerging Technology Results*

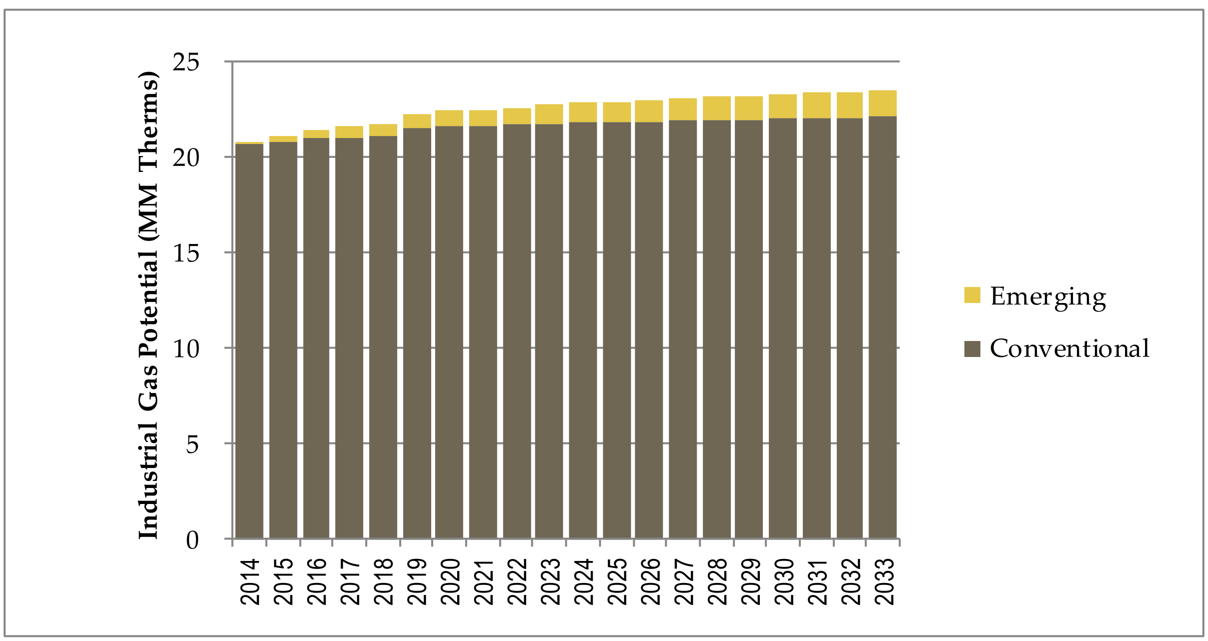
This subsection presents details about the contribution of emerging and conventional technologies toward total cumulative cost-effective achievable potential in the industrial sector. Figure 44 and Figure 45 show the contribution of ETs and conventional technologies toward total cost-effective achievable potential for electric and gas measures respectively. For electric energy savings, ETs contribute about 6% of total cost-effective achievable potential by 2033. Most of the ET energy savings in the industrial sector are attributable to advanced LED lighting retrofits and advanced refrigeration controls. For gas savings, ETs account for about 6% of cost-effective achievable potential by 2033. The main contributors of ET gas savings for the industrial sector are gas-fired heat pump water heaters and wall insulation (vacuum insulated panels).

**Figure 44. Cumulative Industrial Cost-effective Energy Savings (MWh) - Emerging vs. Conventional**




*Source: Navigant analysis, 2014*

**Figure 45. Cumulative Industrial Cost-effective Gas Savings (MMtherms) - Emerging vs. Conventional**




*Source: Navigant analysis, 2014*

# 7 Energy Efficiency Potential Supply Curves

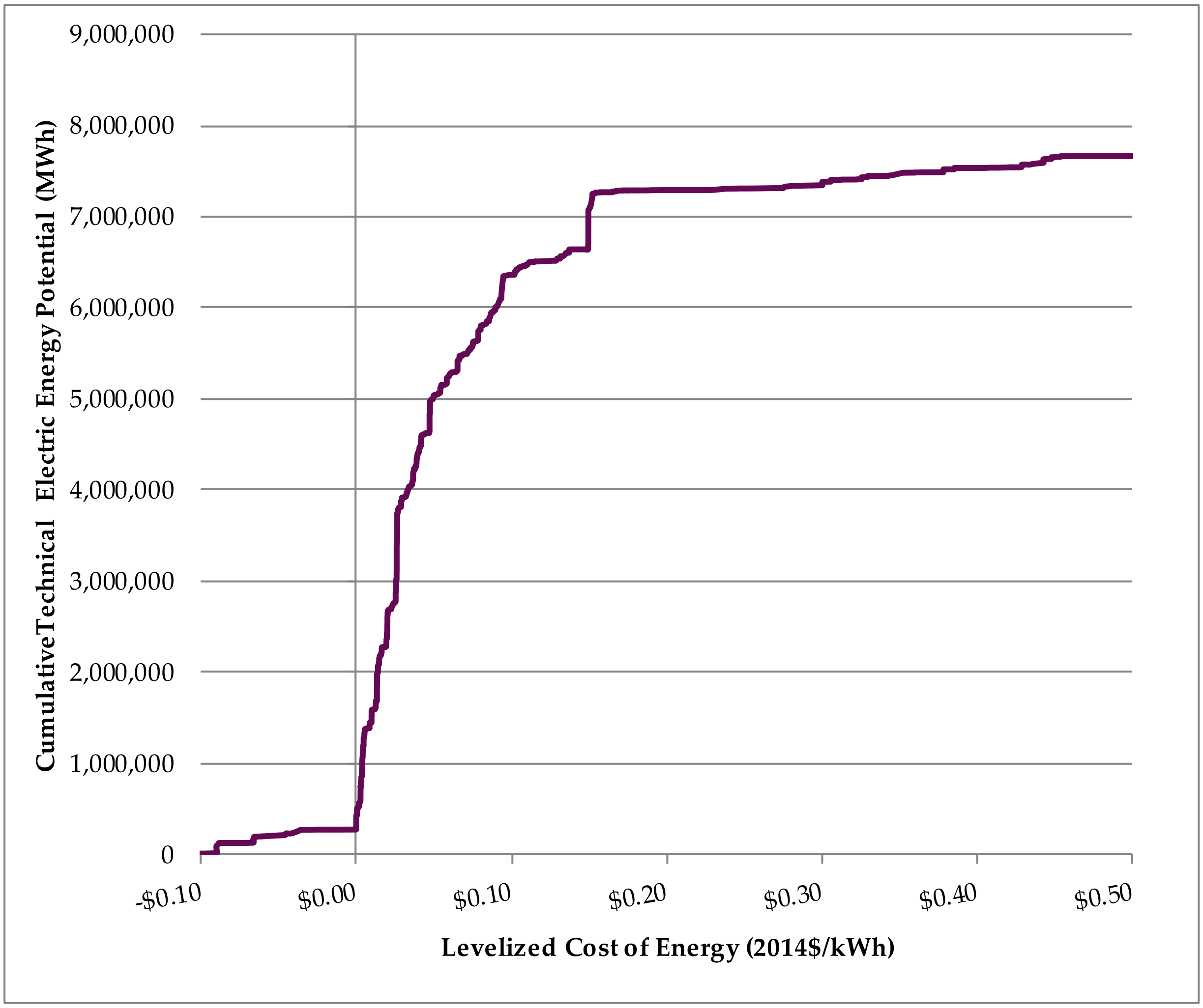
Energy efficiency supply curves offer a useful way to illustrate the amount of energy savings per dollar spent. A supply curve typically consists of two axes – one that shows the cost per unit of savings (e.g., levelized cost per kWh saved) and one that captures the energy savings at each cost level. The curve is constructed using individual efficiency measures differentiated by customer segment, replacement type, and utility, and those measures are sorted on a least-cost basis. Savings are calculated on an incremental basis relative to the measures that precede them.

The levelized cost is the ratio of the present value of equipment and O&M costs (or possibly O&M savings) divided by the present value of energy savings. For this report and under Energy Trust's guidance, all present values are calculated over the lifetime specific to each measure. However, within the potential model, the user can decide whether present values are based on measure-specific lifetimes or a common planning horizon of 20 years.

Lastly, a levelized cost-based supply curve has the potential to show negative levelized cost values. Negative levelized cost values occur when the present value of costs are negative, while the incremental savings are still positive. This can occur when O&M savings or non-energy benefits exceed the upfront equipment costs.

Figure 46 depicts the supply curve for cumulative electric energy potential in 2033. Roughly, 266,000 MWh are available with levelized costs less than zero. This potential is derived from LED street lights, efficient showerheads, and faucet aerators whose present value of non-energy benefits exceed the upfront equipment costs, resulting in a negative levelized cost. Examples of non-energy benefits include avoided water and sewage costs and O&M savings. In effect, these measures are able to provide energy savings *and* cost savings. There is an additional 160,936 MWh of potential from LEDs, switched reluctance motors, and high efficiency chillers that can be achieved at almost zero cost. Nearly 5,756,952 MWh of cumulative electric energy potential are accessible at a levelized cost of energy below $0.08 per kWh (in 2014 dollars), which is the lowest forecast of avoided energy costs in 2033. Costs steeply increase for potential beyond 7,300,000 MWh.

**Figure 46. Electric Savings Supply Curve (2033)[26]**

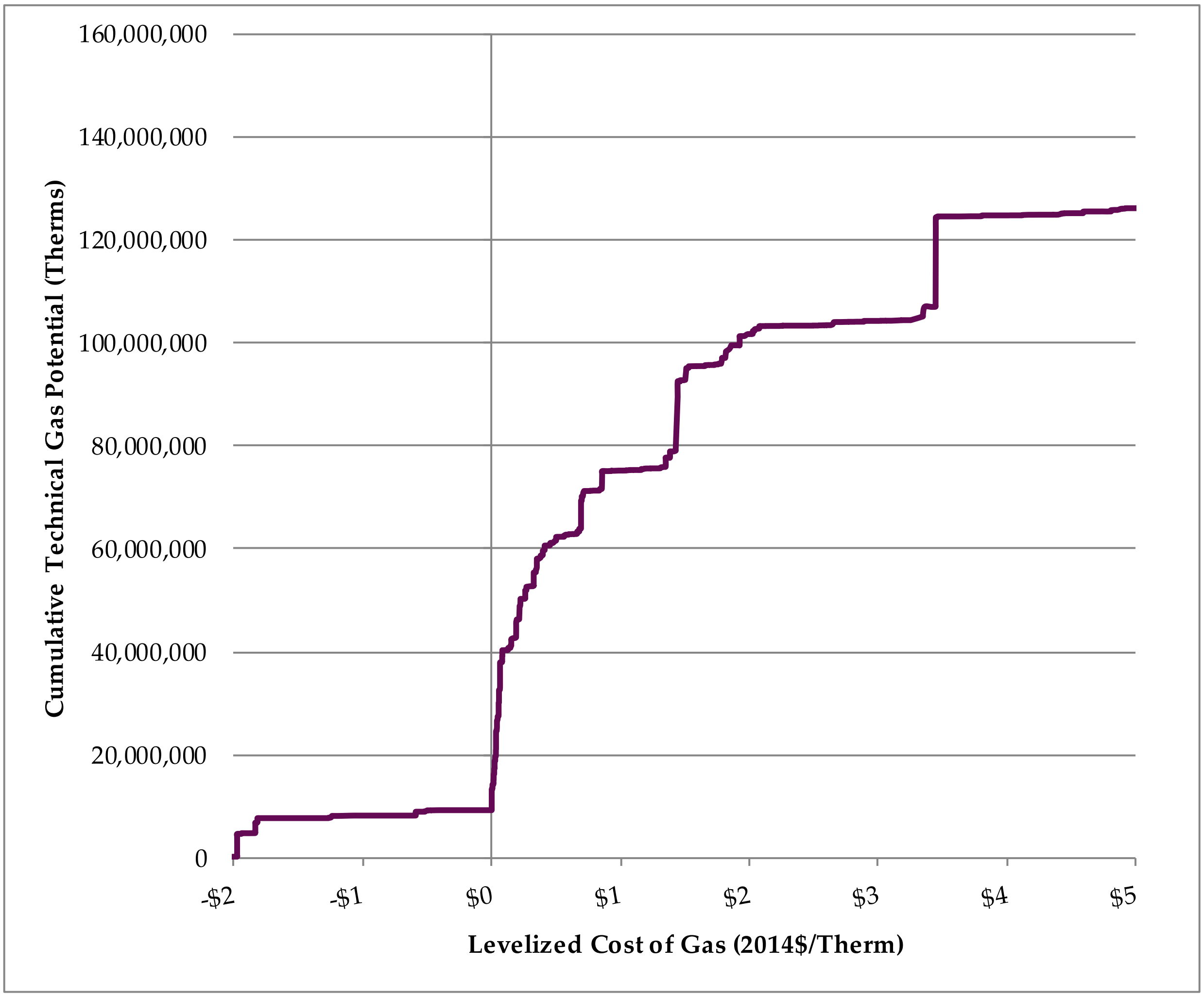



*Source: Navigant analysis, 2014*

[26] Graph has been scaled to show the area of interest, but additional potential above a levelized cost of of $0.50 per kWh is not shown.

The levelized cost of energy supply curve for cumulative gas saving potential in 2033 is shown in Figure 47. Negative-cost measures account for 9.2 MMtherms and are associated with efficient showerheads. These showerheads have negative levelized cost of energy because their non-energy benefits exceed their costs. An additional 31 MMtherms of potential from condensing furnaces and absorption gas heat pump water heaters can be achieved at almost zero cost. Nearly 59 MMtherms of gas potential are available at costs below $0.40 per therm, which is the lower bound of avoided cost forecasts in 2033. Approximately 147 MMtherms of cumulative gas savings can be achieved at costs below $30 per therm. Beyond 147 MMtherms of potential, costs begin to increase quickly.

**Figure 47. Gas Savings Supply Curve (2033)**[27]

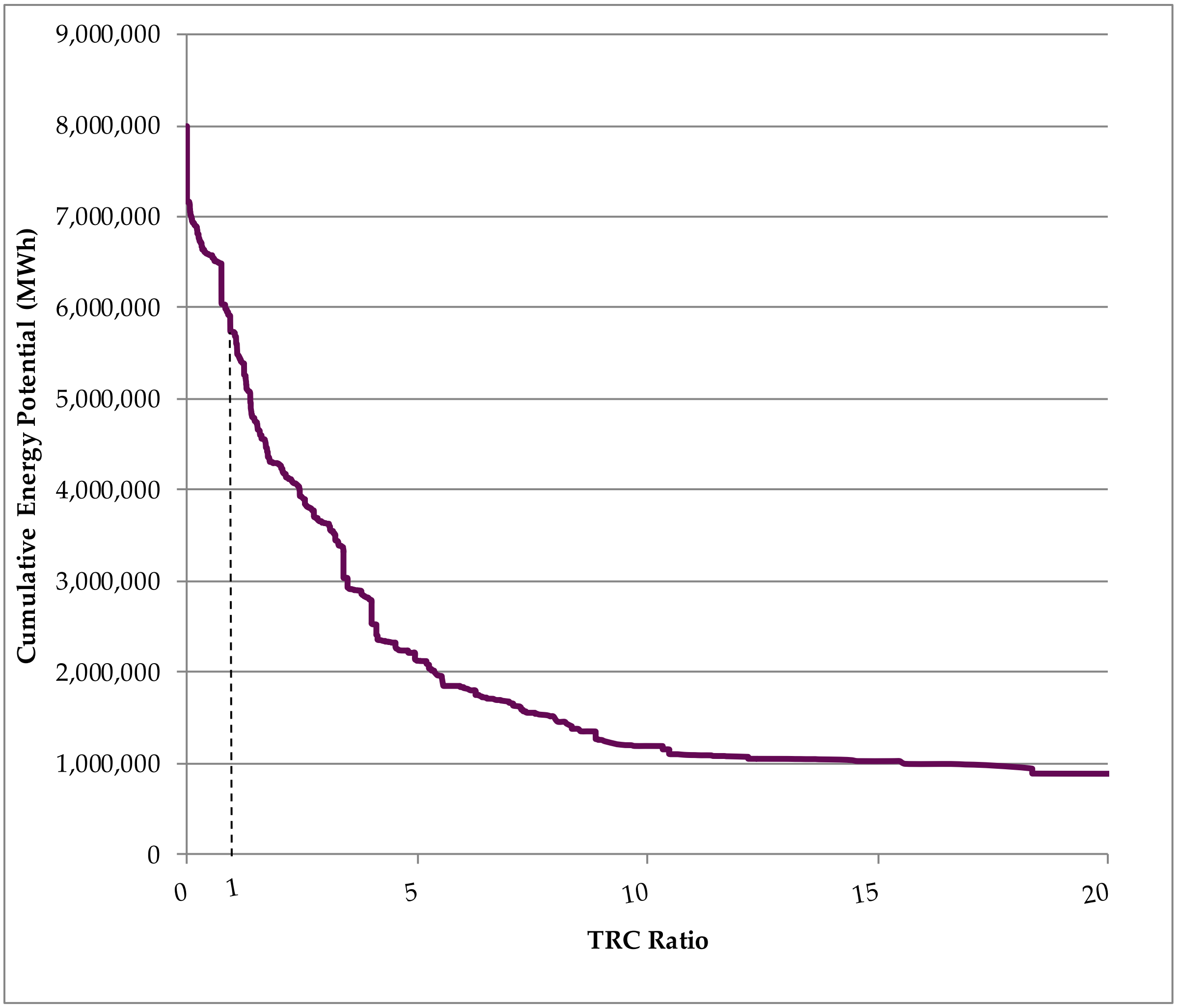



*Source: Navigant analysis, 2014*

[27] Graph has been scaled to show the area of interest, but additional potential above a levelized cost of $5 per therm is not shown.

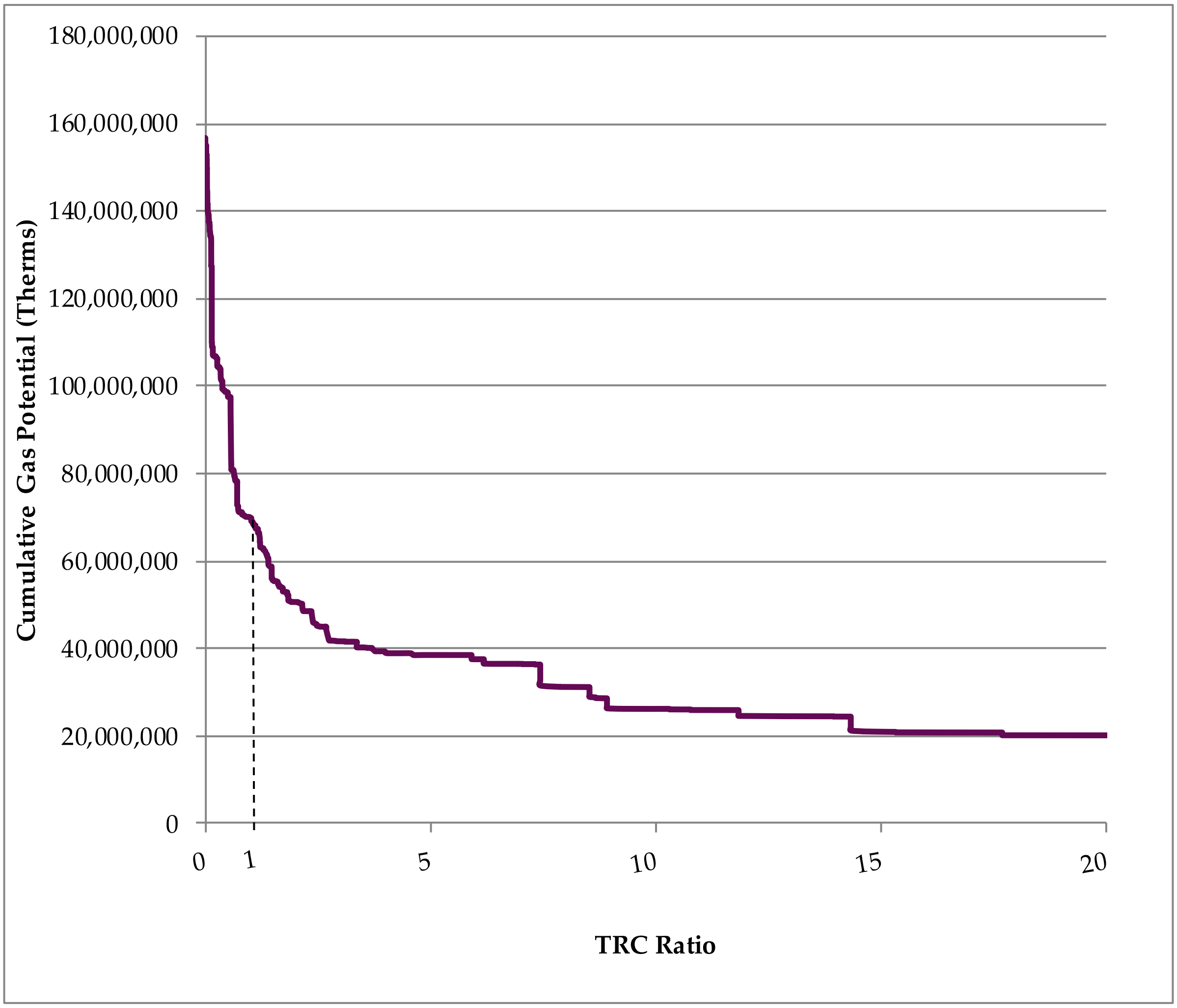
Figure 48 and Figure 49 plot TRC ratio as a function of cumulative technical potential in 2033, for electric and gas savings measures respectively. The curves shown are constructed using individual efficiency measures that are sorted based on their TRC ratio, and savings that are calculated on an incremental basis relative to the measures that precede them. These graphically provide a sense of how much potential is available at different levels of cost-effectiveness. Overall, Figure 48 shows that up to 5,734,340 MWh of cumulative technical potential can be realized as cost-effective potential with a TRC ratio of 1 or above. This reflects the cost-effective part of the curve, while just over 2,260,307 MWh of technical potential is shown to be not cost-effective. In particular, fan variable frequency drives, screw-in CFLs, and specialty CFLs represent the measures, across all sectors with a TRC greater than 1, that offer the largest electric savings. Regarding the gas supply curve, Figure 49 shows that 70 MMtherms, which equates to about 44% of technical potential, is considered to be cost-effective by 2033, and a slight majority of the technical potential lies below the TRC threshold of 1. The gas measures with a TRC greater than 1 that constitute a large portion of the savings across all sectors include burner upgrades, showerheads, and boiler tune-ups. Finally, these curves also offer the ability to gauge the sensitivity of cumulative potential to avoided cost assumptions, a key driver of cost-effectiveness, by way of a first order of approximation.

**Figure 48. Tiered TRC versus Cumulative Electric Savings Potential (2033)**




*Source: Navigant analysis, 2014*

**Figure 49. Tiered TRC versus Cumulative Gas Savings Potential (2033)**




*Source: Navigant analysis, 2014*

# Appendix A Measure Characterization Data

This appendix provides a list of all the conventional and emerging technology measures characterized in this study. Additionally, this appendix is also provided as a set of separate Excel spreadsheets that contain all characterization data (i.e., consumption, costs, and measure lifetimes) for every measure at the customer segment and replacement type level.

## A.1 Residential Measures

| | Conventional Measures | Implementation Type | End Use |
|---|---|---|---|
| 1 | AFUE 95 Furnace, Z1 | ROB/NEW | Heating |
| 2 | AFUE 95 Furnace, Z2 | ROB/NEW | Heating |
| 3 | CFL (Screw-In) | ROB/NEW | Lighting |
| 4 | Heat Pump Controls, Z1 | ROB/NEW | Heating |
| 5 | Heat Pump Controls, Z2 | ROB/NEW | Heating |
| 6 | Duct Sealing, Elec SH, Z1 | RET | Heating |
| 7 | Duct Sealing, Elec SH, Z2 | RET | Heating |
| 8 | Duct Sealing, Gas SH, Z1 | RET | Heating |
| 9 | Duct Sealing, Gas SH, Z2 | RET | Heating |
| 10 | Elec Hi-eff Clothes Washer - Elec DHW | ROB/NEW | Appliance |
| 11 | Elec Hi-eff Clothes Washer - Gas DHW | ROB/NEW | Appliance |
| 12 | Elec Hi-eff Dishwasher - Elec DHW | ROB/NEW | Appliance |
| 13 | Elec Hi-eff Dishwasher - Gas DHW | ROB/NEW | Appliance |
| 14 | ENERGY STAR (0.67 EF) Storage - Gas DHW | ROB/NEW | DHW |
| 15 | ENERGY STAR Manufactured Home | NEW | Heating |
| 16 | ENERGY STAR New Home BOP 1 - ER SH | NEW | Heating |
| 17 | ENERGY STAR New Home BOP 1 - HP SH | NEW | Heating |
| 18 | ENERGY STAR New Home BOP 1 - Gas SH | NEW | Heating |
| 19 | LowPowerMode Appliances | ROB/NEW | Appliance |
| 20 | ER SH to Heat Pump, Z1 | RET | Heating |
| 21 | ER SH to Heat Pump, Z2 | RET | Heating |
| 22 | ER SH to Mini-split ductless heat pump, Z1 | RET | Heating |
| 23 | ER SH to Mini-split ductless heat pump, Z2 | RET | Heating |
| 24 | Faucet Aerators, Bath, Elec DHW | RET | DHW |
| 25 | Faucet Aerators, Kitchen, Elec DHW | RET | DHW |

| | Conventional Measures | Implementation Type | End Use |
|---|---|---|---|
| 26 | Faucet Aerators, Bath, Gas DHW | RET | DHW |
| 27 | Faucet Aerators, Kitchen, Gas DHW | RET | DHW |
| 28 | Heat Recovery Ventilation, ER SH, Z1 | NEW | Weatherization |
| 29 | Heat Recovery Ventilation, ER SH, Z2 | NEW | Weatherization |
| 30 | Heat Recovery Ventilation, Gas SH, Z1 | NEW | Weatherization |
| 31 | Heat Recovery Ventilation, Gas SH, Z2 | NEW | Weatherization |
| 32 | LED (Screw-In) | ROB/NEW | Lighting |
| 33 | Lighting Controls | RET | Lighting |
| 34 | Linear Fluorescent - T8 (Premium Reduced Wattage and 800 Series) | RET | Lighting |
| 35 | OPower/Behavior Savings | RET | Behavioral |
| 36 | Recycle Freezer | RET | Appliance |
| 37 | Recycle Refrigerator | RET | Appliance |
| 38 | Showerheads - Elec DHW | ROB/NEW | DHW |
| 39 | Showerheads - Gas DHW | ROB/NEW | DHW |
| 40 | Solar DHW (50 gal) - Elec DHW | ROB/NEW | DHW |
| 41 | Solar DHW (50 gal) - Gas DHW | ROB/NEW | DHW |
| 42 | Specialty Lights | ROB/NEW | Lighting |
| 43 | Tankless Gas DHW | ROB/NEW | DHW |
| 44 | Tier I Heat pump water heater- Elec DHW | ROB/NEW | DHW |
| 45 | Tier II Heat pump water heater - Elec DHW | ROB/NEW | DHW |
| 46 | Windows, Replacement, (U=.30), Elec SH, Z1 | ROB/NEW | Weatherization |
| 47 | Windows, Replacement, (U=.30), Elec SH, Z2 | ROB/NEW | Weatherization |
| 48 | Windows, Replacement, (U=.30), Gas SH, Z1 | ROB/NEW | Weatherization |
| 49 | Windows, Replacement, (U=.30), Gas SH, Z2 | ROB/NEW | Weatherization |
| 50 | Windows, Replacement, (U=.25), Elec SH, Z1 | ROB/NEW | Weatherization |
| 51 | Windows, Replacement, (U=.25), Elec SH, Z2 | ROB/NEW | Weatherization |
| 52 | Windows, Replacement, (U=.25), Gas SH, Z1 | ROB/NEW | Weatherization |
| 53 | Windows, Replacement, (U=.25), Gas SH, Z2 | ROB/NEW | Weatherization |
| 54 | Wx insulation (ceiling), Elec SH, Z1 | RET | Weatherization |
| 55 | Wx insulation (ceiling), Elec SH, Z2 | RET | Weatherization |
| 56 | Wx insulation (ceiling), Gas SH, Z1 | RET | Weatherization |
| 57 | Wx insulation (ceiling), Gas SH, Z2 | RET | Weatherization |
| 58 | Wx insulation (floor), Elec SH, Z1 | RET | Weatherization |
| 59 | Wx insulation (floor), Elec SH, Z2 | RET | Weatherization |

| | Conventional Measures | Implementation Type | End Use |
|---|---|---|---|
| 60 | Wx insulation (floor), Gas SH, Z1 | RET | Weatherization |
| 61 | Wx insulation (floor), Gas SH, Z2 | RET | Weatherization |
| 62 | Wx insulation (walls), Elec SH, Z1 | RET | Weatherization |
| 63 | Wx insulation (walls), Elec SH, Z2 | RET | Weatherization |
| 64 | Wx insulation (walls), Gas SH, Z1 | RET | Weatherization |
| 65 | Wx insulation (walls), Gas SH, Z2 | RET | Weatherization |
| 66 | Gas Hearth | ROB/NEW | Heating |
| 67 | Heat Pump (HP Upgrade), Z1 | RET | Heating |
| 68 | Heat Pump (HP Upgrade), Z2 | RET | Heating |

*Source: Navigant analysis, 2014*

| | Emerging Technology Measures | Implementation Type | End Use |
|---|---|---|---|
| 1 | Solar hot water heater (gas and electric) | ROB/NEW | Water Heating |
| 2 | CO2 Heat Pump Water Heater | ROB/NEW | Water Heating |
| 3 | Absorption Gas Water Heater | ROB/NEW | Water Heating |
| 4 | R-10 Windows | RET | Weatherization |
| 5 | R-30 Wall Insulation | RET | Weatherization |
| 6 | R-75 Attic Insulation | RET | Weatherization |
| 7 | High Efficiency Condensing Furnace | ROB/NEW | Heating |
| 8 | Advanced Heat Pumps | RET | Heating |
| 9 | LED Lighting | ROB/NEW | Lighting |
| 10 | Home Automation/Smart Devices | RET | Behavioral |

*Source:*

## *A.2 Commercial Measures*

| | Conventional Measures | Implementation Type | End Use |
|---|---|---|---|
| 1 | Hot Water Temperature Reset | RET | Heating |
| 2 | Steam Balance | RET | Heating |
| 3 | Steam Trap Maintenance | RET | Heating |
| 4 | SPC High Efficiency Boiler | NEW/ROB | Heating |
| 5 | ENERGY STAR Fryer | ROB | Cooking |
| 6 | ENERGY STAR Convection Oven | ROB | Cooking |

| | Conventional Measures | Implementation Type | End Use |
|---|---|---|---|
| 7 | DHW High Efficiency Tankless | NEW/ROB | DHW |
| 8 | DHW High Efficiency Tank | NEW/ROB | DHW |
| 9 | DDC HVAC Controls | NEW | Heating |
| 10 | Demand Control Ventilation | RET | Heating |
| 11 | VSD on HVAC Motors | ROB | Ventilation |
| 12 | High Efficiency Chiller | NEW/ROB | Cooling |
| 13 | Condensing Furnace | ROB | Heating |
| 14 | High Efficiency Heat Pump | ROB | Heating |
| 15 | High Efficiency Unit Heater | NEW/ROB | Heating |
| 16 | Economizer Diagnostic, Damper Repair & Reset | RET | Cooling |
| 17 | HVAC System Commissioning | NEW | Heating |
| 18 | Halogen/CFL to 9W CFL | RET | Lighting |
| 19 | Halogen/CFL to LED | RET | Lighting |
| 20 | Ceramic Metal Halide | NEW/ROB | Lighting |
| 21 | Troffer LEDs | RET | Lighting |
| 22 | Exterior LED Lighting | NEW | Lighting |
| 23 | Exit Signs | RET | Lighting |
| 24 | T12 to HP T8 | RET | Lighting |
| 25 | T8 to HP T8 | RET | Lighting |
| 26 | High Bay HID to T8 | RET | Lighting |
| 27 | High Bay HID to T5 | RET | Lighting |
| 28 | High Bay HID to LED | RET | Lighting |
| 29 | LED Street Lights | RET | Street Lighting |
| 30 | Lighting Scheduling/Controls/Occupancy Sensor | ROB/NEW | Lighting |
| 31 | Daylight Control | NEW | Lighting |
| 32 | Efficient Standalone Refrigeration Cases | ROB | Refrigeration |
| 33 | Refrigeration Bundle (ASHC, FHPC, Eff Light, Eff Motor) | ROB/NEW | Refrigeration |
| 34 | Refrigeration Auto Closers (Walk-ins) | RET | Refrigeration |
| 35 | Refrigeration Auto Closers (Reach-ins) | RET | Refrigeration |
| 36 | Floating Head Control | RET | Refrigeration |
| 37 | Roof Insulation - Rigid R0-11 | ROB | Heating |
| 38 | Wall Insulation - Blown R11 | RET | Heating |
| 39 | Windows Upgrade (RET) | RET | Heating |
| 40 | Windows Upgrade (NEW) | NEW only | Heating |

| | Conventional Measures | Implementation Type | End Use |
|---|---|---|---|
| 41 | Window Films | RET | Heating |
| 42 | EMS (RET) | RET | Total |
| 43 | EMS (NEW) | NEW only | Total |
| 44 | Transformers | RET | Total |
| 45 | Desktop/Laptop Power Management | RET | Misc. |
| 46 | Work Station Plug Load Occupancy Sensor | RET | Misc. |
| 47 | Smart Plug Power Strips | RET | Misc. |
| 48 | Server Virtualization | RET | Misc. |
| 49 | Efficient Datacenter | RET | Misc. |

*Source: Navigant analysis, 2014*

| | Emerging Technology Measures | Implementation Type | End Use |
|---|---|---|---|
| 1 | Advanced Package A/C RTU | ROB/NEW | Cooling |
| 2 | Hybrid Indirect-Direct Evaporative Cooler | ROB/NEW, RET | Cooling |
| 4 | Energy Recovery Ventilator | RET | Cooling & Heating |
| 5 | Advanced Refrigeration Controls | RET | Refrigeration |
| 6 | Supermarket Max Tech Refrigeration | ROB/NEW | Refrigeration |
| 7 | Advanced Ventilation Controls | RET | Ventilation |
| 8 | Absorption Heat Pump | ROB/NEW | Heating |
| 9 | ET, Halogen/CFL to LED | RET | Lighting |
| 10 | ET, Troffer LEDs | RET | Lighting |
| 11 | ET, Exterior LED Lighting | NEW | Lighting |
| 12 | ET, High Bay HID to LED | RET | Lighting |
| 13 | Wall insulation R-35, Vacuum insulated panels | RET, NEW | Weatherization |
| 14 | Highly Insulated Windows | RET, NEW | Weatherization |
| 15 | Smart/Dynamic Windows | RET, NEW | Weatherization |
| 16 | Absorption Heat Pump Water Heater | ROB/NEW | Water Heating |
| 17 | A/C Heat Recovery for Water Heating | RET | Water Heating |

*Source: Navigant analysis, 2014*

### *A.3 Industrial Measures*

| | Conventional Measures | Implementation Type | End Use |
|---|---|---|---|
| 1 | Air Compressor- VFD and controls | RET | Compressed Air |
| 2 | Air Compressor Equipment Upgrade | ROB and NEW | Compressed Air |
| 3 | Air Compressor Heat Recovery | RET | Compressed Air |
| 4 | Strategic Energy Management | RET | Other |
| 5 | Green Motor Rewind | ROB | Motors |
| 6 | Fan System- VFD | RET | Fans |
| 7 | Air Abatement | RET | Fans |
| 8 | Fan Equipment Upgrade | ROB and NEW | Fans |
| 9 | Efficient Chiller Upgrade | ROB and NEW | HVAC |
| 10 | Chiller Heat Recovery | RET | HVAC |
| 11 | Clean Room Upgrade | RET | HVAC |
| 12 | HVAC O&M | RET | HVAC |
| 13 | Demand Control Ventilation | RET | HVAC |
| 14 | Efficient Lighting Retrofits | RET | Lighting |
| 15 | Lighting Controls | RET | Lighting |
| 16 | Pneumatic Conveyor | RET | Material Handling |
| 17 | Mechanical Conveyor | RET | Material Handling |
| 18 | Steam Line Pipe Insulation | RET | Process Heating |
| 19 | Process Boiler Insulation | RET | Process Heating |
| 20 | Steam Trap Maintenance | RET | Process Heating |
| 21 | Steam Balance | RET | Process Heating |
| 22 | Boiler Load Control | RET | Process Heating |
| 23 | Pump Equipment Upgrade | ROB and NEW | Pumps |
| 24 | Pump VFD | RET | Pumps |
| 25 | Pump Systems - Sequencing Controls | RET | Pumps |
| 26 | Agriculture: Impact Sprinkler Nozzles | ROB and NEW | Pumps |
| 27 | Agriculture: Pump Systems Replacement | ROB and NEW | Pumps |
| 28 | Agriculture: Replace Ditch with Pipes | RET | Pumps |
| 29 | Agriculture: Gasket Replacement | ROB and NEW | Pumps |
| 30 | Agriculture: Pipe Repair | RET | Pumps |
| 31 | Refrigeration System Upgrade | RET | Refrigeration |
| 32 | Refrigeration O&M | RET | Refrigeration |
| 33 | Roof Insulation - R0-R30 | RET | HVAC |

| | Conventional Measures | Implementation Type | End Use |
|---|---|---|---|
| 34 | Wall Insulation - R0- R11 | RET | HVAC |
| 35 | Burner Upgrades | RET | Process Heating |
| 36 | Boiler Tune-up | RET | Process Heating |
| 37 | Boiler Heat Recovery | RET | Process Heating |
| 38 | Vent Damper Control | RET | Process Heating |
| 39 | High Efficiency Boiler | ROB and NEW | Process Heating |
| 40 | High Efficiency Unit Heater | ROB and NEW | HVAC |
| 41 | Greenhouse Upgrade | ROB and NEW | Other |

*Source: Navigant analysis, 2014*

| | Emerging Technology Measures | Implementation Type | End Use |
|---|---|---|---|
| 1 | Adv LED Lighting Retrofits | RET | Lighting |
| 2 | Wall Insulation - VIP, R0-R35 | RET | HVAC |
| 3 | Gas-fired HP Water Heater | ROB and NEW | Water Heating |
| 4 | Switched reluctance motors | ROB and NEW | Motors |
| 5 | Advanced Refrigeration Controls - Industrial | RET | Refrigeration |

*Source: Navigant analysis, 2014*

# Appendix B Detailed Potential Output

This appendix is provided in a separate Excel file entitled "Appendix B – Detailed Potential Output.xlsm," as well the standalone Analytica model entitled "ETO Resource Assessment Model.ana."