# ENERGY EFFICIENCY AND CONSERVATION MEASURE RESOURCE ASSESSMENT

## Executive Summary of Results

*Prepared for the*

**Energy Trust of Oregon, Inc.**

Final Report

May 4, 2006

By

Stellar Processes

And

Ecotope

Note: Soon after the completion of the resource assessment, Energy Trust received some estimates for an additional measure which is not included in the study. Conservation voltage regulation (CRV) is currently an initiative by the Northwest Energy Efficiency Alliance. This technology is expected to provide 5.4aMW of energy savings within the territory Energy Trust serves by 2015 at a societal cost of 3.07 cents/kWh levelized. Since the amount of savings is relatively small to the overall study potential results, it was not added to the study details but will be used in our analysis of the report.

# Table of Contents

## List of Figures



## List of Tables

## 1. Project Overview

The goal of this project was to provide Energy Trust of Oregon, Inc. (Energy Trust) with the amount and cost of potential energy efficiency and renewable energy measures that could provide electricity and natural gas demand-side savings for Oregon consumers by 2017 within the Energy Trust service territory. This resource assessment is designed to inform strategic planning and the project development and selection process. By 2017, a technical potential of approximately 590 average megawatts (MWa) of electric savings and 106 million annual therms of gas savings were identified in this study[1].

Stellar Processes and Ecotope, Inc. reviewed existing demographic and energy efficiency measure data sources to identify and quantify the resource potential. The contractors created easily updateable planning tools to develop these estimates and for Energy Trust to incorporate in their ongoing planning processes. The tools to evaluate the cost of individual measures and packages of measures considers the measure life, equipment and installation, annual O&M expenses and the discount rate employed by the Energy Trust to produce levelized costs. Levelized costs are useful to compare program options and conservation strategies that have different measure lives on a comparable basis.

It is important to note that program related costs are not included because Energy Trust staff directed that they are outside the scope of this study. It is equally important to note that the levelized costs shown in this study are the entire societal cost of efficiency measures for situations where existing, working equipment is retrofit, and the incremental cost of efficiency when considering new purchases of efficiency versus standard equipment. The incentive costs to the Energy Trust are often only a portion of these "total measure costs". This study provides the basic information on the cost of measures, which the Energy Trust will combine with their knowledge of markets and programs and incentives to develop estimates of total program costs to society and (separately) to the utility system.

While this project was not intended to provide program design, it does identify and quantify estimates of gas and electricity use and measures of activity (such as number and energy use of households or total floor space) in the target markets for the residential, commercial, and industrial / agriculture sectors. Residential savings potential is quantified by housing type for new and existing single family, multifamily, and manufactured homes. Commercial savings are developed on a square footage basis for typical business type designations such as retail, grocery, and large and small office spaces. The industrial analysis quantifies savings and costs by process type such as wood products, food, and electronics.

Determining the applicability of potential measures to sub sectors of the commercial and industrial building stock can be difficult. For these sectors, many "cross cutting" measures such as lighting improvements for commercial applications or motor efficiency

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[1] Electric measure savings are quantified in average MW as well as peak MW savings for summer and winter heavy demand periods. Gas savings are quantified in annual therms.

improvements for industrial customers were analyzed. Cross cutting measures can be applicable across a wide variety of circumstances and building types. In the industrial sector, many measures are relevant for specific applications or processes rather than in discrete building types. The industrial technical potential section discusses the assumptions used to determine measure applicability.

## 2. Methodology

This section describes the general methodology used in this report. More detailed description is provided in the detailed report, and many of the specifics are documented in the calculation spreadsheets.

### 2.1 Establish a Baseline

The first step of the resource assessment is to determine current energy use by sector and housing, business, or process type for new and existing construction. Energy use is then split further by end use such as heating, cooling, cooking, etc. Utility load growth estimates were then applied to the current use to estimate future baseline load conditions, assuming no new energy efficiency measures were implemented. Data sources for creation of the baseline include the 2004 Census for number of houses, PacifiCorp, PGE, Northwest Natural Gas, Energy Trust project data, and a variety of national and regional end use intensity studies.

### 2.2 Compile and Screen List of Measures

Lists of potential efficiency measures were compiled in cooperation with Energy Trust staff for each customer sector. Measures were selected for inclusion on this list based on their ability to meet specific criteria. The measures had to reduce electric or natural gas energy consumption below current standard for that application without significantly reducing service or utility levels to end users. The equipment must currently be commercially available or nearly available and there needs to be a delivery infrastructure in place. We focused on measures with significant savings for a significant portion of the housing, building, or equipment stock in question. The intention was not to represent every possible measure, but represent the available cost and savings by choosing the most significant measures.

For each measure, we attempted to identify and quantify the potential market for which that measure was applicable. To determine the applicability of the measures to Energy Trust service territory and to assess market conditions, economic and census data was collected. While this is relatively straightforward in the residential sector and only slightly problematic in the commercial sector, it is more difficult to provide the same level of detail for a technical potential assessment in the industrial sector.

### 2.3 Measure Data Detail

A wide variety of resources were used to develop measure specific inputs for this study. A literature review was conducted to collect equipment and labor costs and energy benefits. Energy Trust project data and measure cost effectiveness screening models were combined with Northwest Power Planning Council's Regional Technical Forum (RTF) data and other regional sources for measure costs, savings, and non energy benefits assumptions.

### 2.4 Quantify Measure Cost

The incremental cost of the equipment examined in the measures over that required by the relevant energy code was used where applicable in new construction, renovation and replacement[2] markets. The entire cost of substitute equipment was considered in retrofit situations.[3] Where appropriate, differences in operations and maintenance cost and installation costs are also considered.

To compare and prioritize measures, the levelized cost of saved energy was calculated for each measure. The levelized cost calculation starts with the capital cost of a given measure or package of measures as described in the previous paragraph. Any net annual operating and maintenance cost (or benefit) is then added. This cost is amortized over an estimated measure lifetime using a discount rate (in this case a real discount rate of 3 percent/year, which is the standard value used by Energy Trust). This annual net measure cost is then divided by the annual net energy savings (in kilowatt-hours) from measure application (again relative to a standard technology) to produce the levelized cost estimate in dollars per kWh saved.

In dealing with two fuels (electricity and natural gas), we must be aware that there are cross-impacts. For example, a lighting program will save electricity for lighting but increase consumption of electricity and natural gas for space heating. In this case, we compute the Net Present Value (NPV) based on the cost of increased natural gas and electric use and add that value to the O&M component of cost. A more complicated case occurs when the same measure has positive savings for both fuels. In that case, we compute the NPV of avoided cost for both fuels and use the ratio of the NPV to apportion the measure cost between the two fuels. Thus, both fuels would see a reduced levelized cost because they are only "charged" for part of the measure cost.

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[2] A replacement situation is when equipment is normally replaced regardless of energy efficiency opportunities, and there is a choice between less efficient and more efficient replacement units.

[3] A retrofit situation is where working equipment might be replaced with more efficient equipment primarily for energy savings purposes.

## 2.5 Quantify Savings Potential

The resource potential can be considered “technical” or “achievable”. The technical potential is an estimate of all energy savings which could be accomplished immediately without the influence of any market barriers such as cost and customer awareness. As such, it provides a snapshot of everything that could be done. Technical potential does not present what can be saved through programs; it would be impossible to get every customer to install every possible measure. Furthermore, some resources may cost more than the Energy Trust or participants wish to pay. The achievable potential represents a more realistic assessment of what could be expected – taking into account the fact that not all consumers can be persuaded to participate and other real world limitations.

For the technical savings potential analysis, it’s assumed that the measure would be applied to 100% of situations for which it was applicable and for which no related measure was previously applied. For retrofit measures, we assumed that all the population would be addressed. For replacement measures, we first calculated a replacement rate and then assumed that the measure was applied for the cumulative number of replacements up to the target year. For new measures in new home, building, or facilities, we assumed that all of the applicable new construction was treated every year. Growth rates were developed based on utility projections. For replacement and new measures it is important to specify a target year sufficiently into the future that significant new resource will be counted. We utilized the year 2017 as a target year for assessment.

Retrofit and replacement can be in conflict – if one does a retrofit that efficiency opportunity is no longer available to become a replacement candidate later. At the same time, there are measures that occur only as retrofit or only as replacement options. We worked with the measures in various ways to assure that retrofit and replacement would not be “double-counted”. Often, the retrofit is much more expensive because the replacement is only an incremental cost over replacement with a less efficient but otherwise similar piece of equipment. In cases where retrofit was clearly more expensive than grid power and pipe gas, but replacement was feasible, we ruled out the retrofit as not feasible.

Another potential conflict can occur when two technologies could save the same energy for the same equipment. For example, heat pump water heaters and solar water heaters are competing technologies. In these cases, we divided the market between the two options to avoid double-counting. Because the resource assessment quantifies savings from efficiency measures for two fuels, there are other considerations to address. In general, we can develop a supply curve for only one fuel at a time. That is, the gas and electricity supply curves are independent. That does not mean that efficiency opportunities for the two fuels are always independent – many measures save both electricity and gas on the same site (e.g., building energy management system) and many markets can only be effectively approached by a dual fuel program (e.g., new homes). This merely means that the impacts of investment in one fuel on energy use for the other are not captured in the supply curve graph. These impacts are maintained in the output tables and they do influence the levelized cost.

## 3. Summary of Results

The resource potential can be considered "technical" or "achievable". The technical potential is an estimate of all energy savings that could be accomplished immediately without the influence of any market barriers such as cost and customer awareness. As such, it provides a snapshot of everything that could be done. Technical potential does not present what can be saved through programs; it would be impossible to get every customer to install every possible measure. Furthermore, some resources may cost more than the Energy Trust or participants wish to pay. The achievable potential represents a more realistic assessment of what could be expected – taking into account the fact that not all consumers can be persuaded to participate and other real world limitations.

The following figures and tables summarize the results of this analysis for 2017. In providing summary statistics for this section, we limited measure costs to thresholds of $0.055/kWh and $1.70/therm. This provides a summary of the savings potential that has a reasonable chance of being cost effective when compared to avoided energy costs. Although the supply curves do not include the highest cost measures, the tables of measures in the Technical Appendix of the full report lists all measures considered in this study.

### 3.1 Electric Savings Potential

Figure 1 shows the estimated savings from all electricity measures would reduce electricity use by approximately 590 MWa of technical potential for measures with a levelized cost that is less than 5.5 cents/kWh in 2017.

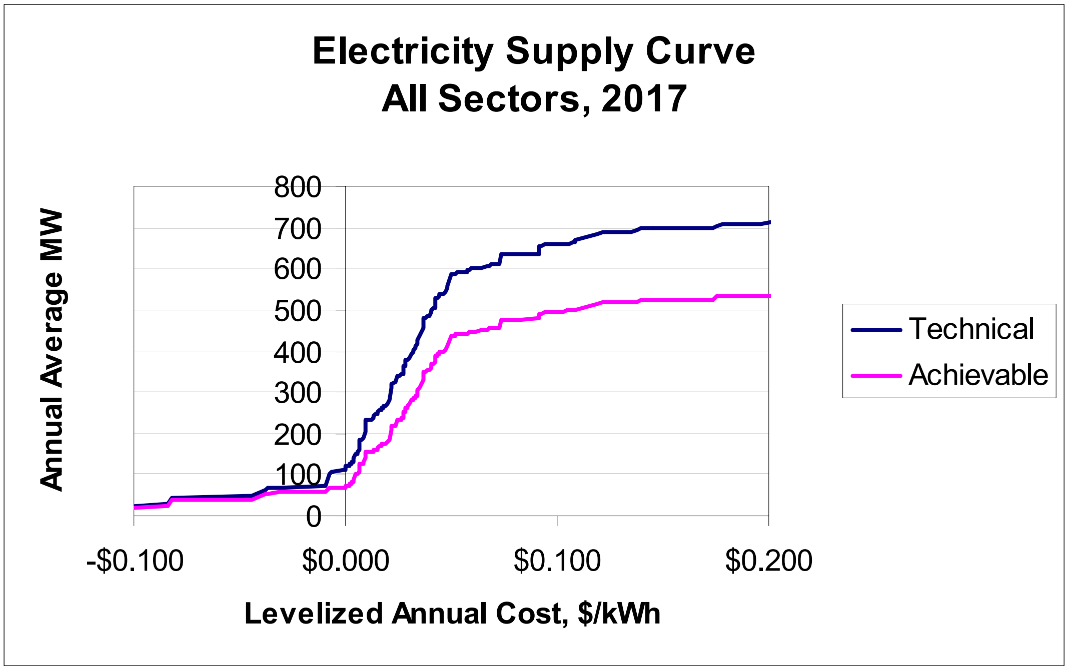


**Figure 1. Electricity Supply Curve**

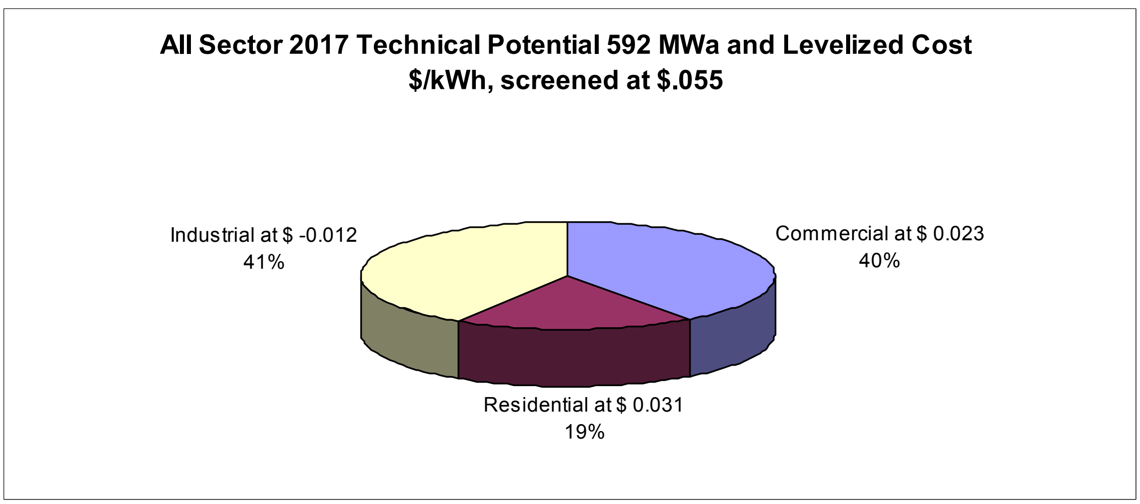


**Figure 2. Electricity Technical Potential**

### 3.2 Gas Savings Potential

Figure 3 shows that natural gas conservation measures could reduce consumption by about 106 million therms at a levelized cost that is less than $1.70 per therm. Note in Figure 4 that the industrial sector is only included in the electricity supply curve, not the gas supply curve. Industrial natural gas customers are not included within Energy Trust mission.

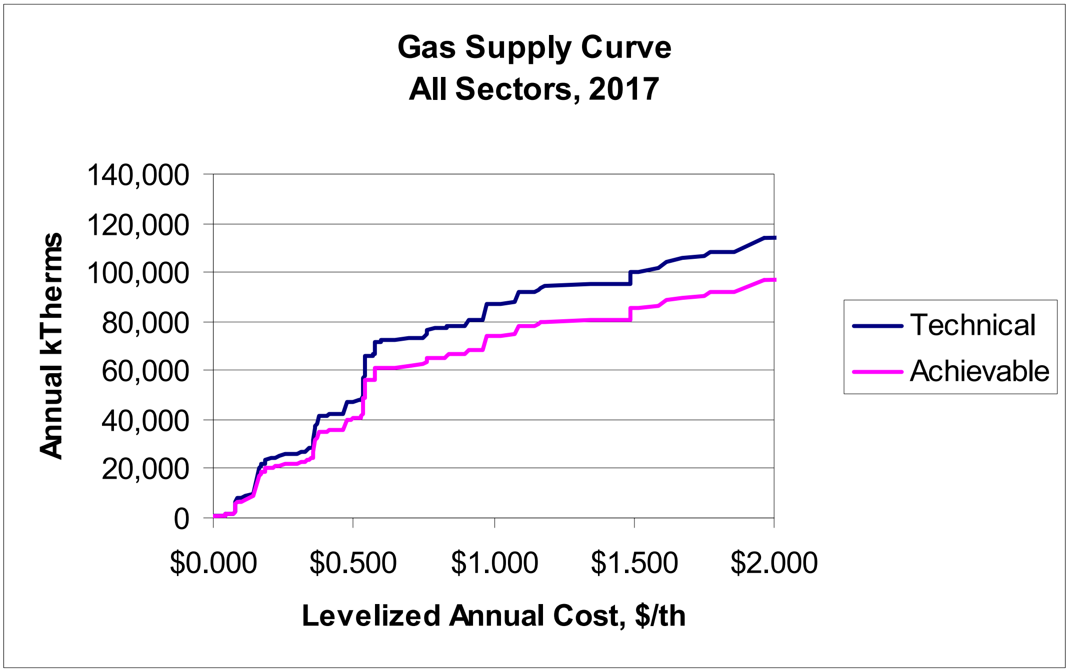


**Figure 3. Natural Gas Supply Curve**

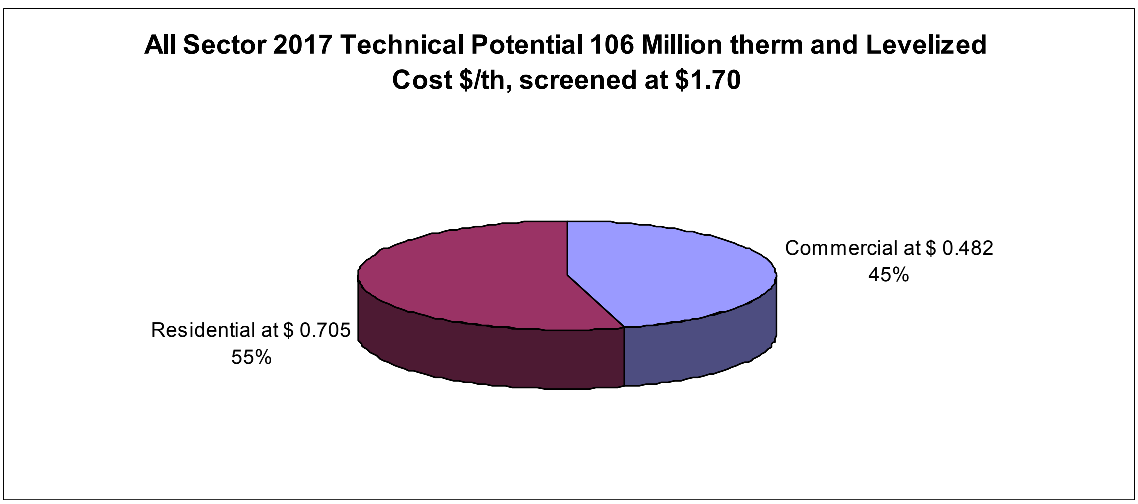


**Figure 4. Natural Gas Technical Potential**

### 3.3 Results by Sector

#### Industrial Sector

Industrial customers of investor owned utilities in Oregon with over 1 MW demand have the option of using their payment to the energy efficiency portion of the public purpose charge to self-direct implementation of efficiency projects. In addition, some industrial customers are transmission customers only for the utilities. For this study, neither of these types of industrial customers were removed – that is, these results apply to all the industries within Energy Trust territory regardless of whether they are currently eligible for Trust programs.

For this sector, measures can be thought of as cross-cutting or process- specific. For example, motors and lighting occur in all segments. However, other measures may be specific to paper manufacture or another process. Because it is so difficult to obtain information on specific facilities, the actual amount of process savings is likely to be much larger than estimated here.

Transformer and motor-related measures as well as lighting opportunities are important cross-cutting measures because of the widespread applicability to virtually all end uses. With this sort of study, it is important that national-level process and end use data by industry type be carefully considered and adjusted for relevance to the local industry. Energy Trust program files provided further information on process opportunities of the existing facilities with Northwest specific characteristics. As a result of this region specific analysis, additional detailed process measures for the electronics, paper and wood products sectors were added. Table 1 summarizes the electric technical potential savings as a fraction of current (2006) sales. This table provides assurance that the estimates are a reasonable savings fraction compared to forecast consumption.

**Table 1 Industrial Sector Savings in 2006, Screened at $.055/kWh**

| Sector | Consumption, MWa | Potential Savings, MWa | Savings Fraction |
|---|---|---|---|
| Computer & Electronic Product Mfg | 200 | 71 | 35% |
| Paper Mfg | 237 | 48 | 20% |
| Primary Metal Mfg | 62 | 9 | 14% |
| Fabricated Metal Product Mfg | 46 | 5 | 11% |
| Food Mfg | 59 | 9 | 16% |
| Wood Product Mfg | 169 | 38 | 22% |
| Agriculture | 39 | 1 | 2% |
| Other Industrial | 114 | 19 | 17% |
| Total: | 927 | 199 | 21% |

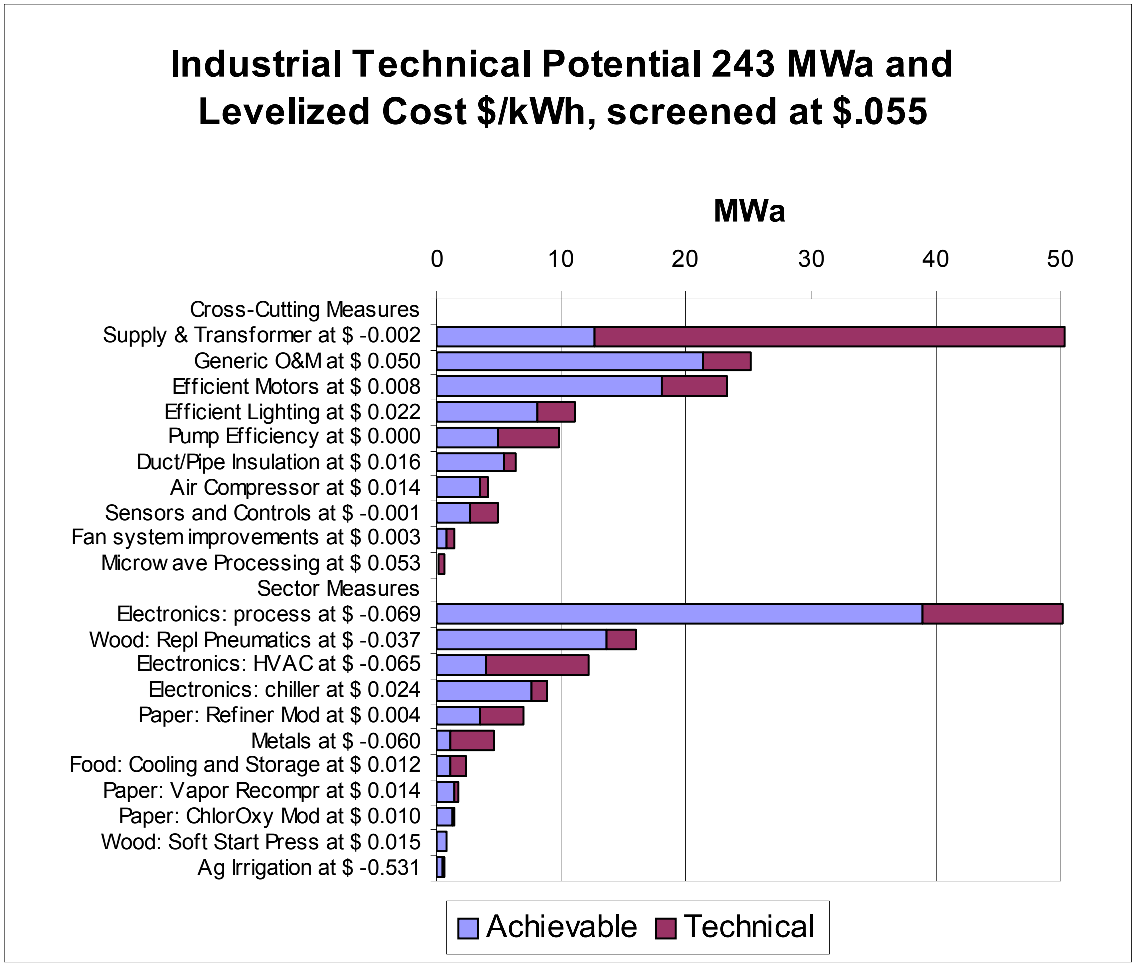


**Figure 5. Major Industrial Measures**

The technical and achievable potential resource shown in Figure 5 by measure is estimated for the year 2017. Supply and transformer measures show the greatest technical potential, however the largest achievable potential is shown for process measures specific to the electronics industry.

**Commercial Sector**

Figure 6 shows the potential for groups of measures in the commercial sector with most significant savings grouped by applicability to existing stock as repair or replacement versus those specific to new construction. 28% or 67 MWa of the 238 MWa technical potential was found for new construction with the balance, 171 MWa, applying to existing construction. In both cases, lighting opportunities dominate. In most cases, achievable potential is estimated as 85% of technical potential. One significant outlier is heat pump water heaters, which have a large technical potential but low achievable potential. Should a low-cost, high applicability model be manufactured, the achievable potential would increase significantly. Details are summarized in Table 2.

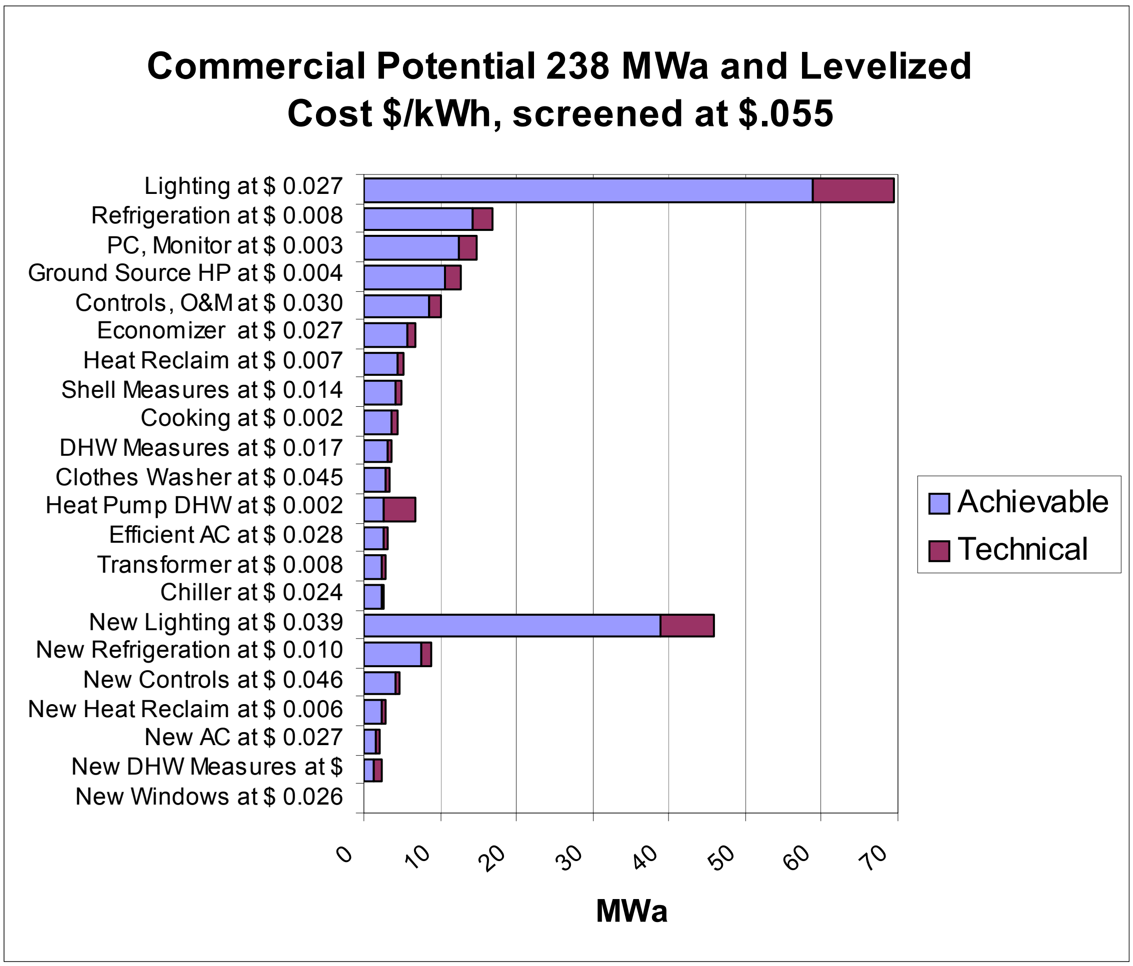


**Figure 6. Major Commercial Sector Measures, Electricity**

Note: Measure category names for new construction begin with New.

**Table 2 Commercial Sector 2017 Electric Technical Potential Savings, Screened at $.055/kWh**

| Measure Category | MWa Savings | Winter Peak Savings, kW | Summer Peak Savings, kW | Level Cost, $/kWh |
|---|---|---|---|---|
| Lighting | 69 | 83 | 108 | $0.027 |
| Refrigeration | 17 | 20 | 27 | $0.008 |
| PC, Monitor | 15 | 15 | 15 | $0.003 |
| Ground Source HP | 13 | 27 | 24 | $0.004 |
| Controls, O&M | 10 | 12 | 11 | $0.030 |
| Heat Pump DHW | 10 | 10 | 10 | $0.002 |
| Economizer | 7 | 14 | 13 | $0.027 |
| Heat Reclaim | 5 | 6 | 8 | $0.007 |
| Shell Measures | 5 | 15 | 1 | $0.014 |
| Cooking | 4 | 4 | 4 | $0.002 |
| DHW Measures | 4 | 4 | 4 | $0.017 |
| Clothes Washer | 3 | 3 | 3 | $0.045 |
| Efficient AC | 3 | 6 | 6 | $0.028 |
| Transformer | 3 | 3 | 3 | $0.008 |
| Chiller | 3 | 5 | 4 | $0.024 |
| New Lighting | 46 | 47 | 60 | $0.039 |
| New Refrigeration | 9 | 14 | 18 | $0.010 |
| New Controls | 5 | 10 | 9 | $0.046 |
| New Heat Reclaim | 3 | 3 | 4 | $0.006 |
| New DHW Measures | 2 | 2 | 2 | $0.043 |
| New AC | 2 | 4 | 4 | $0.027 |
| New Windows | <1 | 1 | <1 | $0.026 |
| **Total** | **238** | **310** | **339** | **$0.023** |

Potential gas commercial conservation opportunities for 2017 are shown in Figure 7 and Table 3. Measures are grouped by similar type and by existing versus new building stock. Of the 48 million therm potential, 21% or 10 million therms apply to new buildings only. O&M and replacement of unit heaters provide the most savings potential in existing construction. Heat reclamation from refrigeration has emerged as significant due to recent regional market research. In new construction, the predominant savings measure is from HVAC controls and new unit heaters and furnaces.

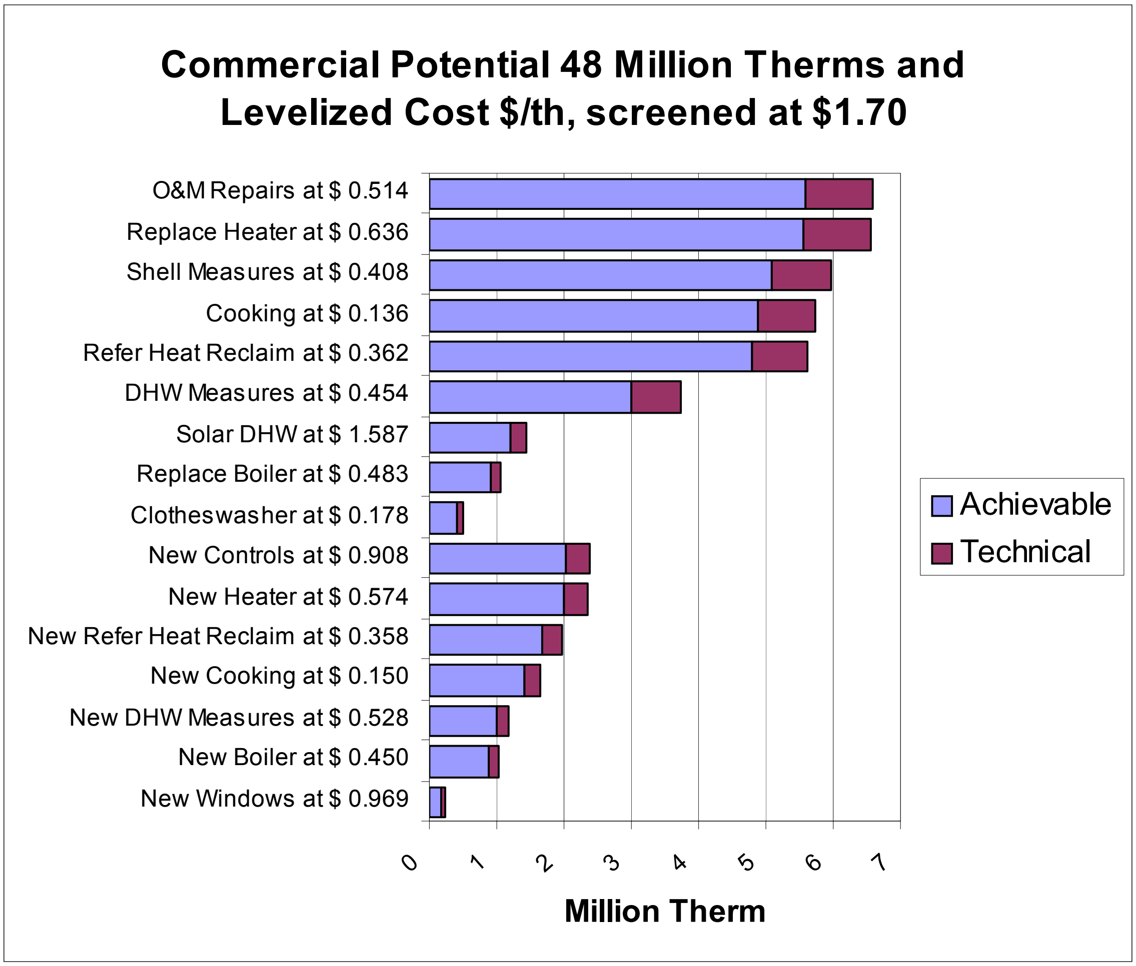


**Figure 7. Major Commercial Sector Measures, Gas**

Note: Measure category names for new construction begin with New.

**Table 3 Commercial Sector 2017 Gas Technical Potential Savings, Screened at $1.70/therm**

| Measure Category | Million therm | $/therm |
|---|---|---|
| O&M Repairs | 6 | $0.136 |
| Replace Heater | 7 | $0.514 |
| Shell Measures | 7 | $0.636 |
| Cooking | 6 | $0.408 |
| Refer Heat Reclaim | 6 | $0.362 |
| DHW Measures | 4 | $0.454 |
| Solar DHW | 1 | $1.587 |
| Replace Boiler | 1 | $0.178 |
| Clothes washer | 1 | $0.483 |
| New Controls | 2 | $0.908 |
| New Heater | 2 | $0.574 |
| New Refer Heat Reclaim | 2 | $0.358 |
| New Cooking | 2 | $0.150 |
| New DHW Measures | 1 | $0.528 |
| New Boiler | 1 | $0.450 |
| New Windows | <1 | $0.969 |
| **Total** | **48** | **$0.482** |

## Residential Sector

Figure 8 shows residential electric potential in 2017 grouped by existing and new. 28 MWa of technical potential is for new construction measures with the balance, 84 MWa, in existing construction. Lighting is the predominant opportunity. There is also significant potential for replacement of lighting and appliances, for weatherization of existing buildings, and for retrofit or replacement of heating systems. In new construction, lighting provides the most savings potential followed by new equipment.[4]

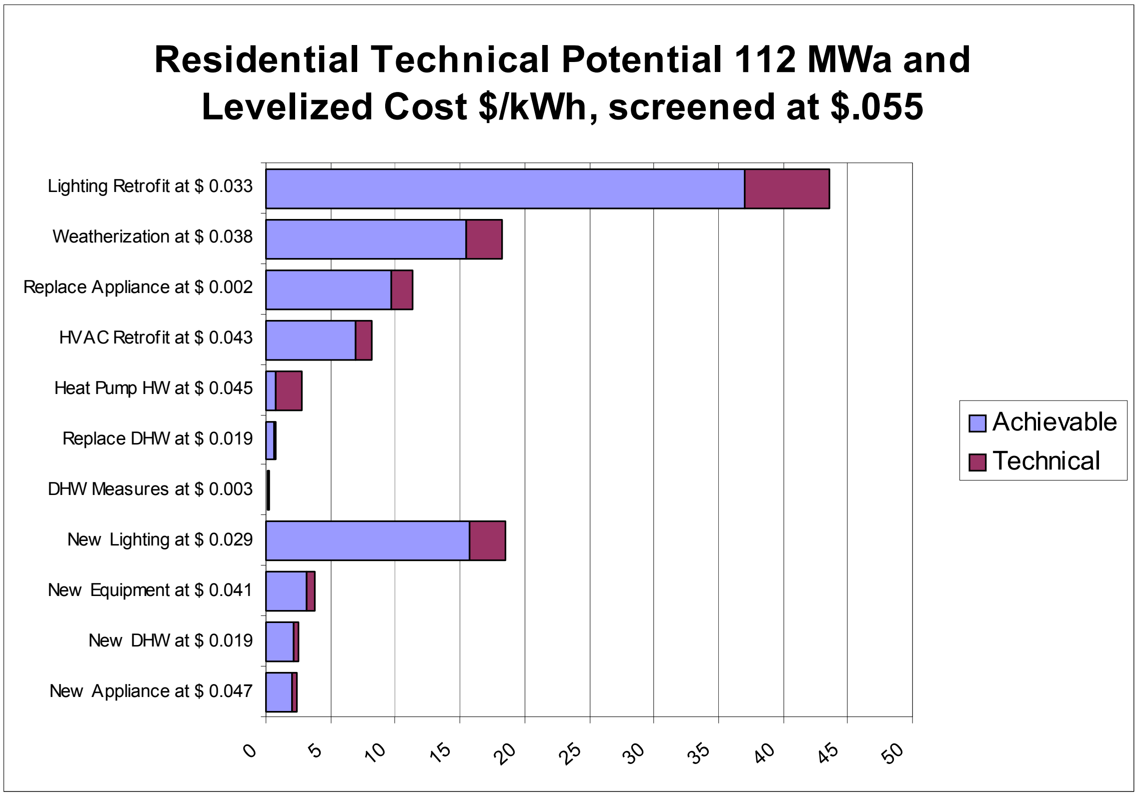


**Figure 8 Major Residential Sector Measures, Electricity**

Note: Measure category names for new construction begin with New.

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[4] The new equipment category includes insulation, heat pumps, and HRV.

**Table 4 Residential Sector 2017 Electric Technical Potential Savings, Screened at $.055/kWh**

| Measure | MWa Savings | Winter Peak Savings, MW | Summer Peak Savings, MW | Level Cost, $/kWh |
|---|---|---|---|---|
| Lighting Retrofit | 40 | 42 | 42 | $0.033 |
| Replace Appliance(1) | 14 | 17 | 15 | $0.002 |
| Weatherization | 18 | 40 | 1 | $0.038 |
| HVAC Retrofit(2) | 8 | 15 | 2 | $0.043 |
| Heat Pump HW | 3 | 4 | 3 | $0.045 |
| Replace DHW | 1 | 1 | 1 | $0.019 |
| DHW Measures | < 1 | < 1 | < 1 | $0.003 |
| New Lighting | 18 | 19 | 19 | $0.029 |
| New Equipment(3) | 4 | 8 | <1 | $0.041 |
| New DHW | 2 | 3 | 3 | $0.019 |
| New Appliance(4) | 2 | 3 | 3 | $0.047 |
| **Total** | **112** | **151** | **88** | **$0.031** |

(1) Clothes washers, dish washers, refrigerator recycle

(2) Heat pumps, commissioning of heat pumps, duct sealing

(3) Insulation, heat pumps, HRV

(4) Clothes washers

For natural gas in new homes, the greatest opportunity lies in increasing the efficiency level of construction. Opportunities during construction include better insulation and windows, duct sealing, high efficiency furnaces[5] and heat recovery ventilation. New construction measures constitute 21 of 58 million annual therms available. The greatest opportunity for gas savings in existing building is in weatherization.

Upgrading to a high efficiency furnace accounts for 6 million therms within the HVAC Retrofit measure category and as an additional measure, the combination of upgrading the furnace with duct sealing contributes another 2.4 million therms.

[5] High efficiency furnaces in new homes contribute 2.3 million therms to the technical potential

**Table 5 Residential Sector 2017 Gas Technical Potential Savings, Screened at $1.70/therm**

| Measure Category | Million Therm | $/therm |
|---|---|---|
| Weatherization Retrofit | 19 | $0.573 |
| Appliance Replace (1) | 10 | $0.896 |
| HVAC Retrofit(2) | 9 | $0.487 |
| New Construction(3) | 13 | $1.012 |
| New Appliance(1) | 8 | $0.545 |
| **Total** | **58** | **$0.705** |

(1) Tankless water heaters, dishwashers and clothes washers

(2) High efficiency furnaces, duct sealing, and duct sealing with furnace upgrade

(3) Insulation, furnaces, windows, HRV

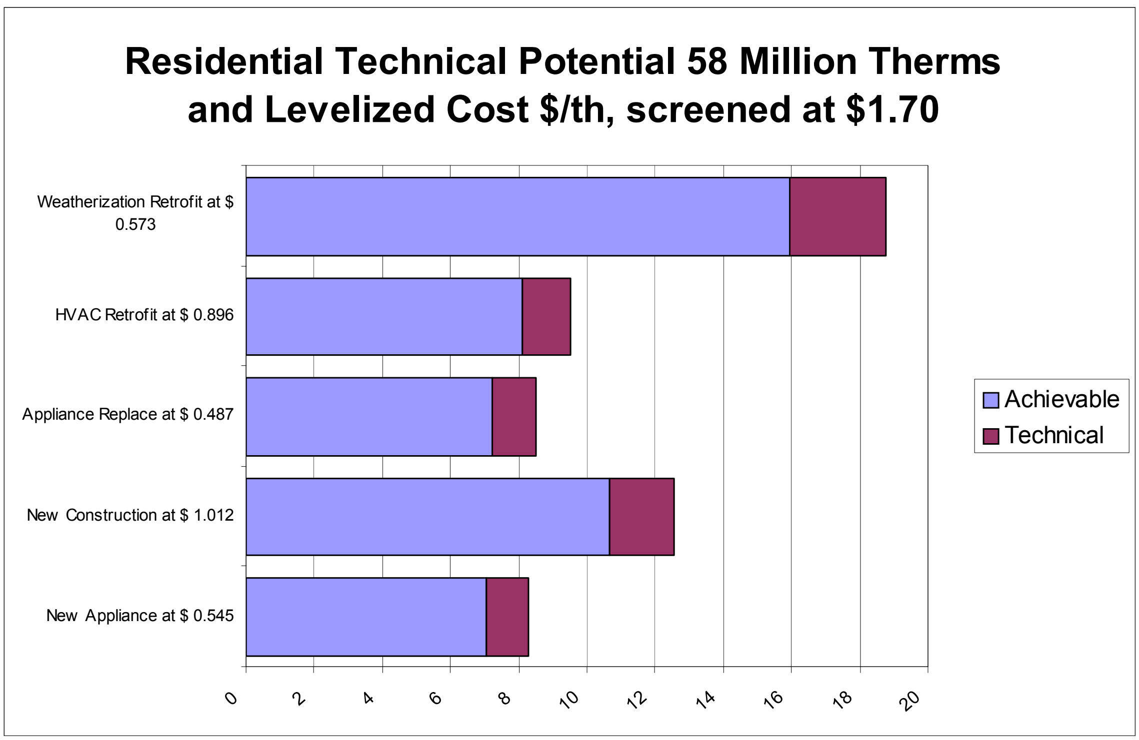


**Figure 9. Major Residential Sector Measures, Gas**

Note: Measure category names for new construction begin with New.

## 3.4 Emerging Technology

Emerging technologies are those that show potential savings but are still not considered mainstream in the industry. A few measures in this category deserve discussion and possible support for demonstration.

Heat reclamation from commercial refrigeration has emerged as a new measure due to recent regional market research. Although still considered emerging, it's recognized as a significant category for gas savings in this study. Heat recovery to DHW is low cost, easy to implement and enjoys wide market acceptance. Heat recovery for space heating is more complicated and, hence, perceived as more risky and less attractive to customers. It is one of relatively few measures with large potential for gas conservation.

Heat pump water heaters are identified as having a large technical potential in both the residential and the commercial sector. However, there is no suitable product currently on the market. There is great potential for development in this area.

Similarly, Heat Recovery Ventilation (HRV) has a large technical potential in both the residential and the commercial sector. In this case, there are products available but local builders are reluctant to adopt them.

## 3.5 Technical Potential Savings Fraction

One perspective on the savings potential is to compare estimated savings to the amount of estimated consumption. Such a comparison may be presented as the expected fraction of end use savings. Note that the amount of consumption for new and existing building stock is quite different due to the inherently different deployment approach to achieve savings.

For existing stock, generally it is more cost-effective to replace old equipment with more efficient equipment as it wears out. We assumed that replacement of existing stock is limited to the turnover rate of the old equipment. In the case of new construction, it is technically possible to change the choice for all the new equipment at the time it is first installed. Thus, for some appliances, the potential savings fraction is higher for new installations merely because of the deployment limitations. On the other hand, because the older stock is less efficient, for some measures the existing stock offers a higher savings fraction that can be addressed.

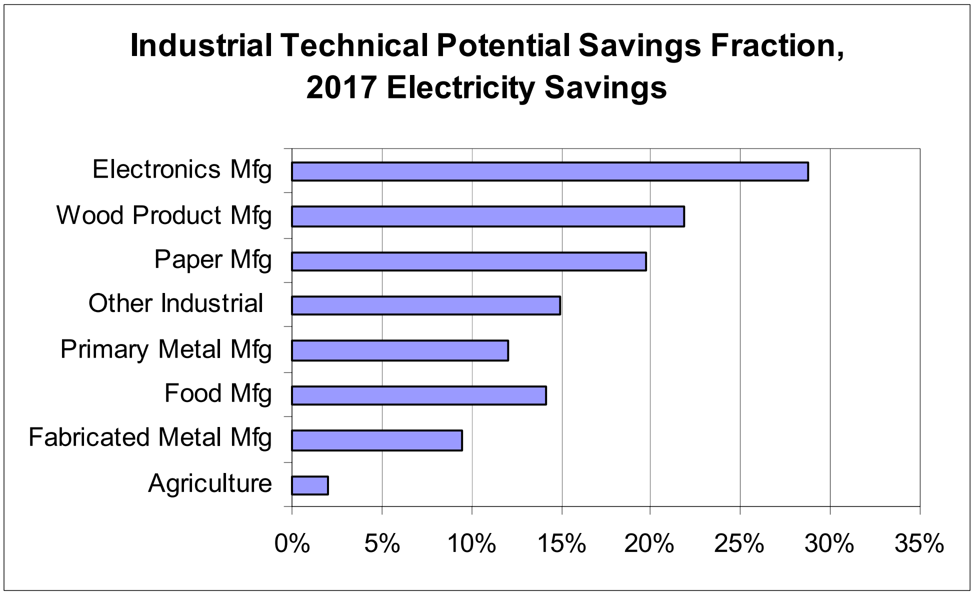


**Figure 10. Savings Fractions for Industrial Sectors**

Figure 10 demonstrates that our analysis focused on the sectors that account for the most energy consumption. The technical potential for the industrial sector is high and, in many cases, the cost is offset by non-energy economic benefits.

Figure 11 shows savings fractions for residential electricity consumption. The higher fraction for new Hot Water is due to the assumption that all new construction could be included while existing stock is limited to a turnover rate. Figure 12 shows savings fractions for residential gas measures.

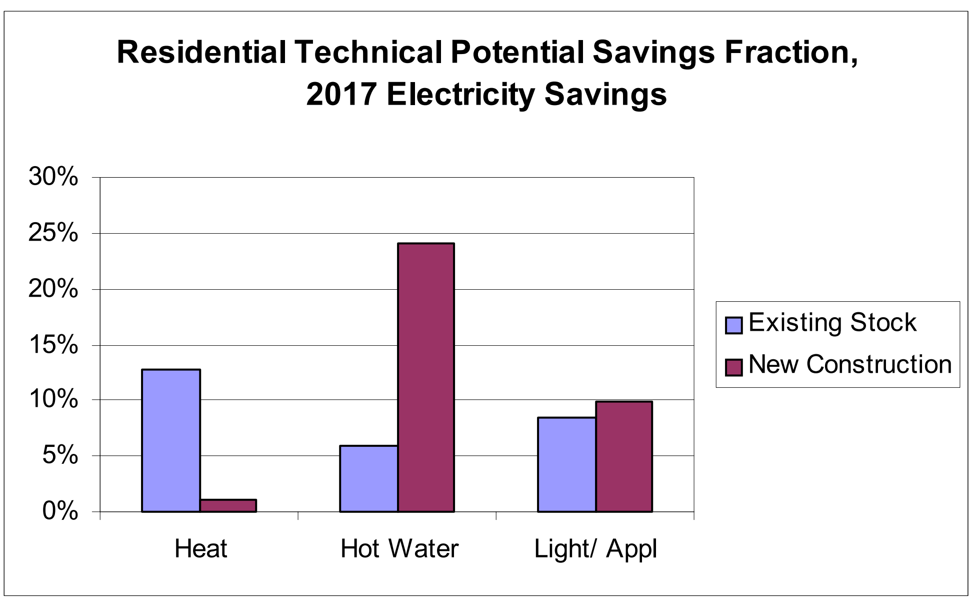


**Figure 11 Residential Savings Fractions by Electricity End use**

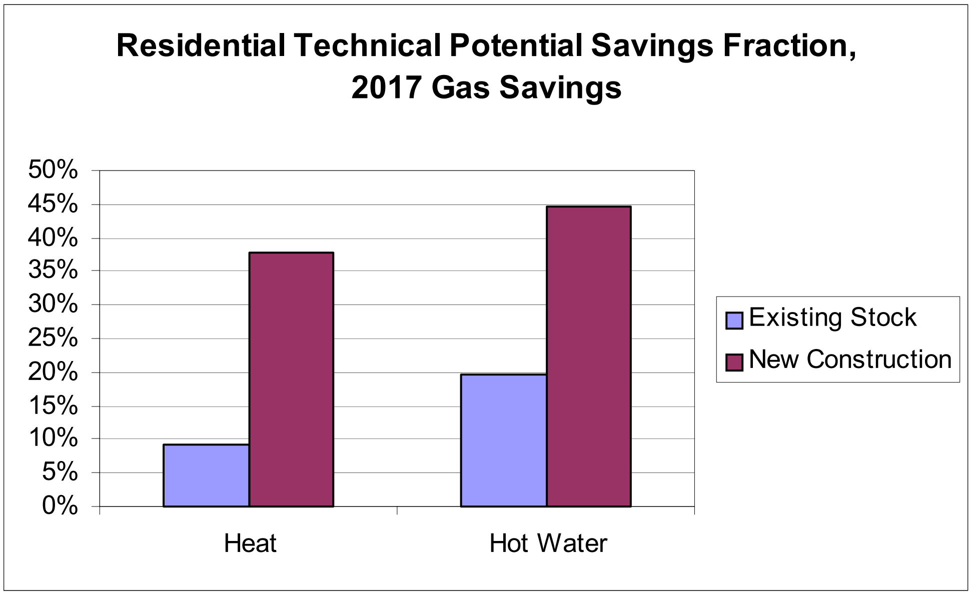


**Figure 12 Residential Savings Fractions by Gas End use**

Savings fractions for commercial sector are high reflecting the opportunity to use heat pumps for space and water heating.

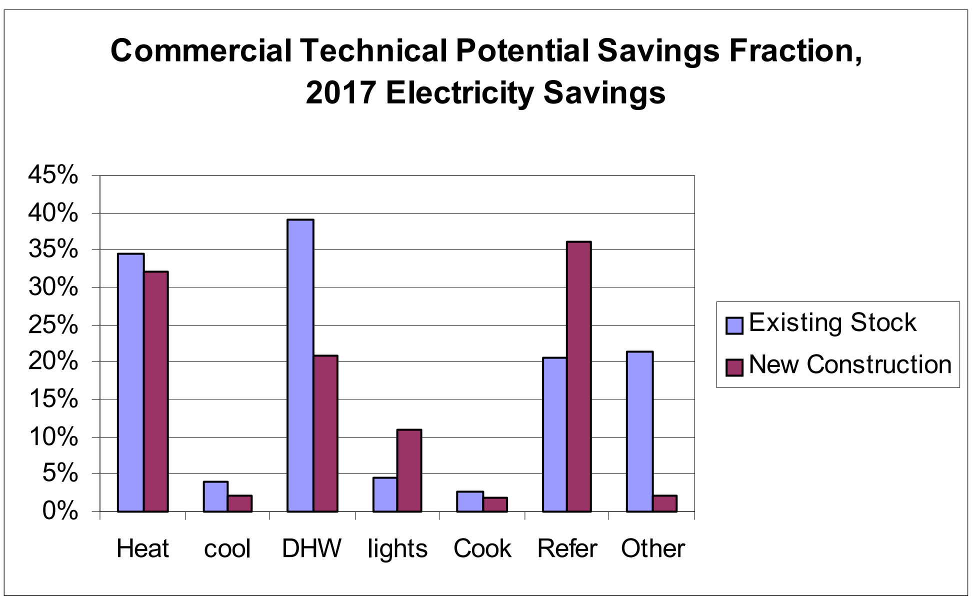


**Figure 13 Commercial Savings Fractions by Electricity End use**

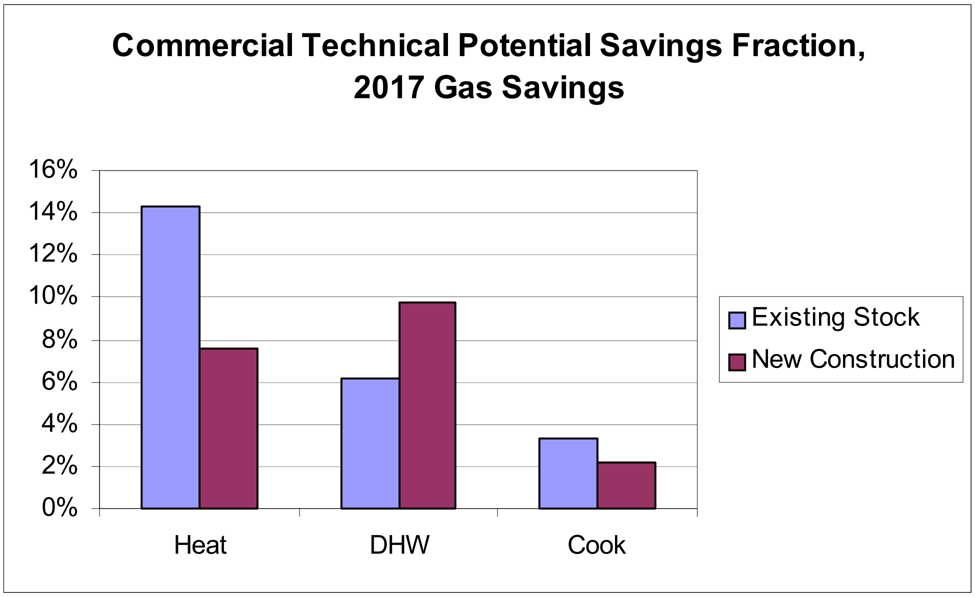


**Figure 14 Commercial Savings Fractions by Gas End use**