Statewide Natural Gas and Electric Energy-Efficiency and Carbon-Saving Potential Study

Methodology and Model Inputs (DRAFT)

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Prepared for

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by:

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Contents

INTRODUCTION

The Minnesota Department of Commerce Division of Energy Resources commissioned this study of statewide energy efficiency (EE) potential to inform electric and natural gas utility Conservation Improvement Program (CIP) development and to guide state energy policy development. The study has been carried out by a consultant team consisting of Center for Energy and Environment (CEE), Optimal Energy (Optimal)and Seventhwave, with consulting support from the American Council for an Energy-Efficient Economy (ACEEE) and E Source.

This report documents the methodology and analytical inputs used for the energy efficiency potential modeling.

STUDY OVERVIEW

This section provides a brief overview of study scope and methodology with more detail provided in the sections below. The analysis includes the following key components:

- A 10-year EE potential study for the period 2020-2029.
- An estimate of the EE potential for electricity and natural gas.
- An estimate of the EE potential for the residential, commercial (including institutional and agricultural), and industrial sectors. The study does not include transportation efficiency.
- Estimates of technical, economic, maximum achievable, and program potential.
- Separate results for each of eleven utilities or groupings of utilities, as follows:
    - Seven groupings of investor-owned utilities (IOUs)[1]
    - Cooperative utilities in Climate Zone 7A[2]
    - Cooperative utilities Climate Zone 6A
    - Municipal utilities in Climate Zone 7A
    - Municipal utilities in Climate Zone 6A
- Two (2) separate reports: one for all electric utilities, and one for all gas utilities.
- Fuel-switching, strategic electrification, and combined heat and power (CHP) opportunities are not considered.[3]

We use an energy-centric, top-down approach as the core of our analysis. The starting point for the top-down approach is each utility's actual loads (residential, commercial and industrial), determined as accurately as possible from utility billing, sales data, and other sources. From there, we proceed to understand how energy is used to meet various end-uses and needs at customers'

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[1] Xcel Energy (gas and electric), Minnesota Power, Otter Tail Power, CenterPoint Energy, Minnesota Energy Resources would all have a separate analysis done, Great Plains Natural Gas and Greater Minnesota Gas would be grouped together.

[2] Climate zones consistent with International Energy Conservation Code (IECC) 2012.

[3] Note that fuel switching for delivered fuels (e.g., customers heating with propane), while not part of the base scope for this study, may be considered as part of an optional scope item.

homes, businesses, and facilities, and how these uses differ from customer to customer. Measure characterizations define the possible means for energy savings, while a cost-effectiveness analysis assesses the economic outcomes of efficiency investments.

The team will conduct the study using a single, integrated study of statewide electric and gas savings potential. This will allow us to better integrate the impacts and potential interactions between electric and gas efficiency measures. However, separate reports will be prepared for electric and gas potential. For reporting, we will apportion the results to individual utility electric and natural gas territories based on their unique geographic territories and building stocks.

This study estimates the technical, economic, maximum achievable, and program potential as defined below:

- Technical potential analysis ignores market barriers and assumes complete adoption of all technically feasible measures regardless of cost-effectiveness.
- Economic efficiency potential includes all efficiency that is considered to be cost-effective according to the Societal Cost Test, under the assumption that society will choose to implement all cost-effective efficiency measures.
- Maximum achievable potential refers to the energy efficiency that is economic from a societal cost perspective that can realistically be captured with well-designed, aggressive, fully-funded efficiency programs.
- Program potential is the efficiency potential possible given specific program funding levels and designs. Often, program potential studies are referred to as “achievable” in contrast to “maximum achievable.” In effect, they estimate the achievable potential from a given set of programs and funding.

STRUCTURE OF THIS REPORT

The report is organized along the lines of the steps we followed to complete the analysis and develop the results presented elsewhere. We begin with an overview of the methodology, including a description of the “top-down” analysis concept. We then discuss four major phases of the analysis.

- Identify and disaggregate the baseline energy sales forecasts
- Develop global study parameters
- Characterize the efficiency measures
- Develop technical, economic, maximum achievable, and program efficiency potentials (including cost-effectiveness screening)

METHODOLOGY OVERVIEW

TOP-DOWN APPROACH OVERVIEW

The general approach for this study is "top-down" as opposed to "bottom up." Top-down approaches have the advantage of being bound by utility load forecasts, and are most commonly used for longer-term potential forecasts across all sectors.[4] In general terms, the top-down approach starts with a disaggregated energy sales forecast, typically by building type and end-use, and then determines the percentage by which energy use in each "bucket" (i.e. combination of sector, building type, and end-use) can be reduced by the installation of a given efficiency measure. This contrasts with a "bottom-up" approach which begins with a fixed number of buildings or equipment installations and considers how many of these items could be addressed by efficiency measures. Top-down analyses, then, work from a basis of energy consumption, while bottom-up analyses work from a basis of the number of units (e.g., households, pieces of equipment, lamps).

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

Figure 1: Fundamental Potential Study Equation

Energy Savings	=	Sales (kWh or MMBtu)	x	Applicability Factor	x	Feasibility Factor	x	Turnover Factor (replace-ment only)	x	Not Complete Factor (retrofit only)	x	Savings Fraction	x	Net Penetration Rate

- **Sales** is the total quantity of energy consumed by a particular end-use in a particular building type in a given analysis year, across the entire market of interest, expressed in kWh or MMBtu (See the "Load Forecast and Sales Disaggregation" section below).
- **Applicability** is the fraction of the end-use level energy sales (from the sales disaggregation) for each building type or industrial segment that is attributable to equipment that could be replaced by the high-efficiency measure. For example, for commercial furnaces it would be the portion of total building type space heating load consumed by gas furnaces.
- **Feasibility** is the fraction of end-use sales for which it is technically feasible to install the efficiency measure. Numbers less than 100% reflect engineering or other technical barriers that would preclude adoption of the measure.

[4] Bottom-up analysis are more appropriate when detailed information is available on building stock and measures, and when there is greater homogeneity of the building and equipment stock to which measures are applied. For a detailed discussion of top-down vs. bottom up, and of potential study methodology in general, National Action Plan for Energy Effi ciency (2007). *Guide for Conducting Energy Efficiency Potential Studies.* Prepared by Philip Mosenthal and Jeffrey Loiter, Optimal Energy, Inc..

Feasibility is not reduced for economic or behavioral barriers that would reduce penetration estimates. Rather, it reflects technical or physical constraints that would make measure adoption impossible or ill advised.

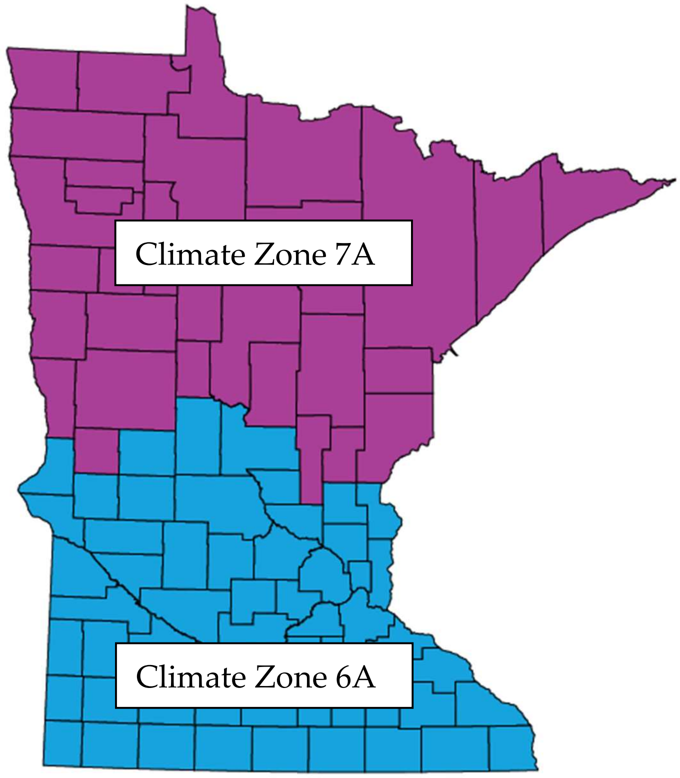
- **Turnover** is the number or percentage of existing equipment that will be naturally replaced each year due to failure, remodeling, or renovation. This applies to the natural replacement ("replace on burnout") and renovation markets. In general, turnover factors are assumed to be 1 divided by the measure life (e.g., assuming that 10% (1/10) of existing stock of equipment is replaced each year for a measure with a 10 year estimated life).
- **Not Complete** is the percentage of existing equipment that does not already represents the high-efficiency option. This only applies to retrofit markets.
- **Savings Fraction** represents the percent savings (as compared to either existing stock or new baseline equipment for retrofit and non-retrofit markets, respectively) of the high efficiency technology. Savings fractions are calculated based on individual measure data and assumptions about existing stock efficiency, standard practice for new purchases, and high efficiency options (See the "Measure Characterizations" section below).
- **Annual Net Penetrations** are the difference between the base case measure penetration (with no efficiency programs) and the measure penetrations that could be achieved with sustained efficiency initiatives (See the "Potential Estimates" section below for a discussion of penetration rates by potential type).

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

REGIONAL ANALYSIS ZONES

Minnesota is large enough to have significantly varying climate, economic, and market conditions across the state. These conditions affect the energy efficiency potential of different technologies and end uses. For example, efficiency measures installed in Minneapolis, with higher average temperatures, relatively speaking, and labor costs, will have different costs and/or savings than the same measures installed in cooler, less urban areas near the Canadian border. We will therefore perform the analysis of efficiency potential separately for each across two climate regions in order to account for these different characteristics. The climate zones used are consistent with the International Energy Conservation Code (IECC) 2012. Each of the seven IOUs will be assigned to either the northern or southern region depending on where the majority of utility sales occur. Similarly, municipal and cooperative utilities will be grouped into those falling in the northern region and those falling in the southern region. The figure below presents the geographical boundaries of the two climate zones.

Figure 2: Climate zones geographical boundaries



INTERACTIONS AND STOCK ADJUSTMENTS

The analysis will account for interactions between measures installed in the same building space. Individual measure savings are not necessarily additive. Because of interactions between measures, the total potential for all measures is less than the sum of individual measure opportunities. For example, building envelope improvements will reduce the cooling load and will thus lower the savings opportunities for high-efficiency air conditioning because the total cooling load has been reduced. The potential estimates take into account all the interactions between measures.The analysis will also account for measures installed in different markets where the markets affect one another. For context, all efficiency opportunities, as applicable, will be characterized by market aligning with standard market and program intervention categories. In general, the two primary "markets" for energy efficiency investments are "market-driven" opportunities and "retrofit" opportunities. Market-driven measures include opportunities due to new construction, renovation, and natural replacement of existing, failed equipment. These are "market-driven" in that some activity is already taking place in the marketplace that presents an opportunity for increased efficiency. This contrasts with retrofit opportunities where no action is immediately necessary, but efficiency opportunities still exist. Retrofit measures include early replacement or retirement of existing, operational equipment, adding controls, or otherwise modifying existing equipment to increase efficiency.

Segmenting the market in this way is important because the costs and savings for the same technology may differ by market. For example, costs and savings for natural replacement measures reflect the incremental difference between current standard practice efficiency and the high efficiency alternative. For early replacement of still functioning equipment, the full labor and equipment costs are incurred; however, the savings are also typically larger because existing older equipment is less efficient. Furthermore, the timing of the opportunities and the year-by-year tracking of building and equipment stocks requires a full understanding of the replacement cycles and size of eligible markets in each year.

A given measure may be characterized in both the market-driven and retrofit markets. For example, a high efficiency boiler could be installed due to a market-driven natural replacement or as an early replacement retrofit. If a boiler is replaced before the end of its useful life, that same opportunity could not then be captured as a natural replacement measure when the existing equipment would have failed. To avoid double counting, our model tracks the eligible stock of equipment over time, based on the measure penetrations for each existing market. For example, if 10% of existing boilers are replaced early with high efficiency models, then only 90% of the original population of boilers remains eligible for efficiency upgrades in non-retrofit markets in that year. However, assuming the boilers had a 20-year measure life, that 10% of boilers replaced early would again become eligible for natural replacement after 20 years. Similarly, once a building is renovated, the opportunity for retrofit is diminished until the end of the measure lives for those measures installed under the market-driven scenarios.

LOAD FORECAST AND SALES DISAGGREGATION

ENERGY SALES FORECAST

The first step in any potential study is defining and forecasting the baseline, or naturally occurring practices and energy consumption, from which the EE potential will be assessed. The starting point is the current and forecasted usage of electricity and gas. Relevant forecast data will be collected from the utilities with the assistance of DER. We will consult the authors of the respective forecasts to better understand how they were developed, and determine the extent to which they account for existing and planned efficiency programs, energy codes and standards, policy issues, the economic outlook, and predictions of future electrification. Once the treatment of these issues is determined, we will make appropriate adjustments to ensure that the baseline forecast truly represents the baseline without new codes and standards or future efficiency embedded, as these will be separately estimated as components of the overall potential. Baseline sales forecasts will be developed for each of the three customer sectors (residential, commercial, and industrial). Establishing the baseline forecasts is an essential step to ensure that all estimates of equipment saturations and impacts are internally consistent between the assumed energy loads and the actual building equipment that produce those loads.

ENERGY SALES DISAGGREGATION

Another early but vital task in the project will be to disaggregate electricity and natural gas sales for each of the 170+ Minnesota utilities by customer segment (typically building type) and end use. As shown in the fundamental equation presented in Figure 1 above, these values are needed as inputs into the overall potential model so that savings estimates are constrained to be an appropriate fraction of total consumption for a given end use in a particular customer segment. The sales disaggregation will also be the basis for later reporting potential estimates for individual utilities or utility groupings. The disaggregation will begin with Energy Information Agency (EIA) data on annual sales by utility and sector. To split total sales by customer segment and end use for the larger IOUs, we will make use of any utility-specific data that can be made available to us on sales by NAICs code or rate class, as well as results from appliance saturation surveys or prior utility-specific potential studies.

For the many COUs that do not have detailed customer data, we will intersect utility service territories with census data on the types of homes and businesses at the ZIP-code level to get an estimate of the number and type of homes and businesses (by NAICs code) in each utility's service territory. We will then use sources such as EIA's Residential and Commercial Energy Consumption Surveys to estimate typical consumption by building type and end use and apportion the known sector-level sales among the customer segments and end-uses.

A top-down disaggregation of the energy sales will be used to split the electricity and natural gas consumption building type and end-use, where appropriate. While the final segmentation is pending collection and review of the available data, the CEE Team anticipates the following segmentation:

Table 1: Building Type Segmentation by Sector

Residential	Commercial	Industrial
Single Family	Small Office	Industrial
Multifamily (2-4 units)	Large Office	
Multifamily (5+ units)	Small Retail	
LI Single Family	Large Retail	
LI Multifamily (2-4 units)	Warehouse	
LI Multifamily (5+ units)	Small Education	
	Large Education	
	Hospitals	
	Lodging	
	Food Service	
	Data Center	
	Public Assembly	
	Agriculture	
	Other	

End use consumption estimates will be corroborated by end use and fuel with a bottom-up modeling of baseline equipment and usage data, where data are available. Energy consumption for each building type will be further disaggregated into the following end uses, by fuel:

Table 2: Electric End-Use Segmentation by Sector

Residential	Commercial	Industrial
Space Heating	Space Heating	Motors
Water Heating	Cooling	- Material Handling
Air Conditioning	Ventilation	- Material Processing
Refrigerators	Water Heating	- Compressed Air
Cooking appliances	Lighting	- Pumps
Clothes washers	Cooking	- Fans & Blowers
Clothes dryers	Refrigeration	- Refrigeration
Dishwashers	Office equipment	- Other Motors
Electronics	Computing	Electro-Chemical
Pools, hot tubs	Other	Process Heating
Lighting		HVAC
		Lighting
		Other

Table 2: Natural Gas End-Use Segmentation by Sector

Residential	Commercial	Industrial
Space Heating	Space Heating	Process Heating
Water Heating	Water Heating	Conventional Boiler
Other	Cooking	CHP/Cogeneration
	Other	Space-heating
	Process	Other, Process
		Other, Non-Process

AVOIDED COSTS, LOAD SHAPES, AND OTHER MODEL INPUTS

Avoided Energy Costs

The CEE Team will collect and review the latest avoided energy cost data, including electric capacity, transmission, and distribution and natural gas costs. The avoided costs will need to extend 34 years into the future (up to 2054), which will accommodate measures installed in year 10 with measure lives up to 25 years. If Minnesota's avoided costs do not extend far enough we will estimate future costs based on projections from the EIA, recent regional avoided cost data relevant to Minnesota, and other sources. We will use a common set of assumptions for avoided costs based on overall costs of the Minnesota electric and natural gas systems. Recognizing that some avoided costs may vary by utility, we will also provide a sensitivity analysis of high- and low-avoided costs to bound the range of economic potential.

Electric Load Shapes

Because the market costs of electric energy vary on an hourly and daily basis, an accurate estimate of the benefits of avoiding electricity consumption must consider the timing of these avoided kilowatt-hours. For ease of analysis, avoided costs are typically expressed in terms of two or more energy costing periods (e.g., summer peak, winter off-peak, etc.) Therefore, load shapes provide the link between annual savings impacts and time-varying avoided costs, which are typically separated into multiple periods. They are also closely related with determining coincidence factors that generate peak load impacts.

With current trends toward increased penetration of intermittent renewable energy sources, efficiency load shapes are more important than ever. We will use the best available data on load shapes, such as the recent study on measure load shapes conducted for the Minnesota TRM. While we will largely rely on these load shapes as the basis for our analysis, we may perform minor additional development work to ensure consistency with our assumptions and methodology.

To the extent that load shapes are not available or gaps exist, we will work with the DER and our team members to determine the most appropriate sources or analysis to complement any available utility data, which could include previous Minnesota potential studies. The analysis will use load shapes for each building type and end-use combination, as well as some measure-specific load shapes where appropriate. In the case of weather sensitive end uses (e.g., cooling and heating), load shapes will be differentiated by climate zone.

Other Inputs

We will also work with the DER and stakeholders to establish other global modeling inputs required for the analysis such as:

- First Year of Analysis
- Initiative (Program) Duration (Years)
- Nominal Discount Rate (NDR)

- Inflation Rate
- Real Discount Rate (RDR)
- Externalities
- GHG Emissions Rates

MEASURE CHARACTERIZATIONS

The next step in the analysis is to describe the efficiency measures that are currently available or are expected to be available over the time frame of the analysis. Measure characterizations describe all of the aspects of an efficiency measure that are specific to that measure, including the amount of energy it saves, its cost, the situations in which is technically feasible, its expected useful operating life, and others. Measure characterizations must always be stated relevant to an appropriate baseline. For example, we must assess how much energy an efficiency measure will save as compared to some other less efficient technology or equipment.

The CEE Team will develop a comprehensive list of efficiency measures necessary to capture all electric and natural gas efficiency opportunities suitable for delivery in Minnesota. This task will also include conventional measures (as determined by the Minnesota TRM custom CIP projects) and emerging technologies or practices, behavioral measures, and load management and demand response approaches.

ENERGY EFFICIENCY MEASURES

Potential studies typically include hundreds of different technologies and thousands of different efficiency measures (treating each building type and market separately). All efficiency opportunities, as applicable, will be characterized by sector, building type, and market (e.g., new construction, natural replacement, and retrofit), aligning with standard market and program intervention categories.

Once we have developed a comprehensive list of efficiency measures, we will perform a qualitative screening to identify any measures that should be screened out of the process. This will ensure that resources are not wasted investigating measures with negligible savings potential or measures that are highly unlikely to pass cost-effectiveness screening. It will also serve to document decisions to omit certain technologies or practices. The vast majority of measures screened will pass the qualitative screening and proceed to the full characterization process. We will also work closely with the DER and the Advisory Committee at this stage to identify any policy or other constraints to be imposed on the analysis.

Measure baseline assumptions will be reviewed for consistency with current building codes, equipment standards, and market trends. In addition, planned revisions to codes and standards will be incorporated to adjust the baselines of measures installed when those revisions are expected to go into effect. For example, for planned or emergency replacements, we will typically assume baselines mandated by the Minnesota building energy codes in effect during the first year of analysis absent any more accurate baseline data. For some areas, such as HVAC equipment, we will rely on proprietary primary Minnesota data tracked and analyzed by team member D+R International. We will also use our knowledge relating to the TRM development to use algorithms, assumptions, and sources from the Minnesota TRM as much as possible.

A typical measure characterization consists of the following parameters, as applicable:

General Inputs:

- Sector

- Primary Fuel and End Use
- Secondary Fuel and End Use
- Measure Effective Useful Life (EUL)
- Baseline EUL (if different)
- % Savings (Primary Fuel, relative to baseline)
- Secondary Fuel Savings (relative to primary fuel savings, MMBtu/kWh or kWh/MMBtu)
- Efficient Equipment Cost
- Baseline Equipment Cost
- Incremental Cost per kWh or MMBtu Saved
- Measure Interactions
- Measure Mutual Exclusion

O&M and Water Inputs:

- Efficient Component Life
- Efficient Component Replacement Cost
- Baseline Component Life
- Baseline Component Replacement Cost
- O&M Levelized Annual Cost
- Water Savings

Early Replacement Retrofit Inputs:

- Baseline Remaining Useful Life (RUL)
- Baseline Cost per kWh or MMBtu Saved
- Baseline Shift Savings Factor

Measure Inputs by Building Type:

- Loadshape and Peak Coincidence Factors
- Applicability
- Feasibility
- Not Complete RET
- % Savings (if variable by building type)
- kWh-kW ratio
- Penetrations

LOAD MANAGEMENT AND DEMAND RESPONSE MEASURES

A DR measure is often a strategy or action taken by the customer in response to a signal at unpredictable times, and it is increasingly being seen as a dispatchable resource influenced by market prices that shift the time of energy use but not the quantity used. By contrast, energy efficiency measures are often equipment or appliances installed in the building with an expected annual energy savings and cost payback for the lifetime of the equipment. Further, the analysis time frame for DR occurs at an hourly interval whereas energy efficiency potential analysis typically is performed on an annual interval. The model will account for the kWh savings potential from DR measures, but is not intended to be an assessment of the potential of DR to meet or manage peak load requirements (that is a separate study).

POTENTIAL ESTIMATES

TECHNICAL POTENTIAL

Technical potential analysis ignores market barriers and assumes complete adoption of all technically feasible measures regardless of cost-effectiveness. While theoretical in nature, the technical potential is useful in determining an upper boundary for future CIP efforts. We will anchor the technical potential as much in reality as possible by limiting it to "reasonable" measures. For example, this might include omitting technically feasible but unrealistic approaches such as stripping buildings to the bare structural level and rebuilding to increase the efficiency of the building envelope. Further, the analysis limits the technical potential to resource-constrained potential which recognizes constraints due to availability of resources such as implementation contractors and efficiency equipment. In general, the resource constraints result in a ramping-up of the penetrations of efficiency measures over the 10 study period such that the entire technical potential is captured by the end of the study period. We believe this presents a much more useful starting point that better aligns with actual economic and achievable potential.

The fundamental equation presented in Figure 1 will be used with measure characterization data, energy forecasts and sales disaggregations, avoided costs and other inputs to generate the technical potential. The resulting potential will be reported both in terms of the physical units of energy (i.e., MWh and MMBtu) and monetized benefits. In addition, the carbon savings associated with the technical potential (and the economic, achievable, and program potentials as described below) will be developed assuming a single set of statewide emissions factors (we may consider breaking this down by utility/groups of utilities if we have the data to support this, although it is not currently in the scope of our study to conduct anything broader than a single state-wide estimate of carbon reductions for each year of the study). The team proposes estimating the carbon savings associated with electric savings using the latest marginal (i.e., annual non-baseload output) electricity emissions factors from the EPA's Emissions & Generation Resource Integrated Database (eGRID) for the MROW subregion, although we are open to other approaches that can be supported by adequate data. In general, the team believes that the marginal emissions factors, rather than the total output emissions rates, are a better indicator of the carbon savings realized by pursuing energy efficiency. For end-use fuels, emissions factors from the latest Inventory of U.S. Greenhouse Gas Emissions and Sinks report will be used.

ECONOMIC POTENTIAL

The economic efficiency potential includes all efficiency that is considered to be cost-effective from a societal perspective, under the assumption that society will choose to implement all cost-effective efficiency measures without the need for efficiency programs. A measure is cost-effective if the benefits derived from its implementation outweigh the costs of that implementation. There are several perspectives from which these benefits and costs can be measured, but in this analysis, we rely on the societal perspective.

The Societal Cost Test (SCT) attempts to represent the overall benefits and costs to the economy from a particular action, regardless of who receives the benefits or incurs the costs.

- The benefits calculated in the Societal Cost Test are the avoided supply costs (both electric and fossil fuels), that is, the reduction in transmission, distribution, generation, and capacity costs valued at marginal cost for the periods when there is a load reduction and any environmental externalities. Environmental externalities represent the economic value of reducing pollutants whose societal costs are not monetized in market prices, such as those paid in the production or use of electricity.
- The costs in this test are the program and measure costs paid by both the utility and the participants. Thus all equipment costs, installation, operation and maintenance, cost of removal (less salvage value), and administration costs, no matter who pays for them, are included in this test.[5] Measure costs were developed as part of the measure characterizations described above.

Measure level benefits and costs are calculated as the net present value of all future benefits and costs. For benefits, this includes the energy savings in each year of its effective useful life, discounted to present dollar terms. For each measure we then calculate the ratio of benefits to costs. When benefits exceed costs, this ratio exceeds a value of one and the measure is considered to be cost-effective and therefore can be included in the economic potential.

Measures that are not cost effective will generally be removed from the analysis. It is not unusual for some measures to be cost effective in some years and not others due to differences in annual avoided costs (and thus the monetized benefits of savings) or changes to cost or savings assumptions for different install years. Because it would be disruptive to markets and programs to constantly start and stop promotion of individual measures, and because some market transformation strategies explicitly require up front investments that will bring measure costs down over time or produce other longer term benefits, we will include measures based on their overall cost effectiveness over the whole study period (even if they may not be cost-effective in certain years), and include or exclude them throughout the whole period. However, it is possible that some measures may not pass cost-effectiveness tests but could still be included for other reasons, such as being nearly cost effective for an emerging technology, if consistent with state policy and desired by the Department. In addition, if measures that likely have substantial potential for energy-savings are not cost effective but are close to being so, we will assess, in consultation with the Department and stakeholders, whether or not the addition of a proxy carbon value or other non-energy benefits would change the results in a meaningful way.

Estimates of economic efficiency potential typically assume immediate installation of all cost-effective measures. To the extent that there are substantial opportunities for retrofit measures, this results in a theoretical potential that far exceeds what is feasible in the short-term, as there would be insufficient resources to implement all retrofits in one year. To generate an economic potential estimate with more relevance for public policy planning, we will prepare a resource-constrained economic potential. This estimate assumes that all market-driven measures (i.e., natural replacement, new construction, and renovation) are implemented at the time they become

[5] Note that for economic potential estimates, administrative costs are typically ignored, because the economic potential represents a theoretical maximum potential that could not be achieved through efficiency program efforts.

available, but that implementation of cost-effective retrofit measures is spread out over several years.

The economic potential analysis prioritizes measures that have the highest energy savings, rather than those that are the most cost-effective. As a result, the economic analysis maximizes the efficiency potential and may not include measures that would be included in an achievable scenario. In other words, the achievable scenario will include a distribution of multiple opportunities competing for the same end-use energy—the analysis does not assume "winner-take-all."

Finally, as mentioned above, multiple scenarios of the economic potential will be developed to test the sensitivity of the results to the avoided costs forecasts. While the team anticipates that a single set of electric and natural gas avoided costs should be sufficient to accurately estimate the potential statewide, even if separate avoided costs are used for one or more of the eleven utility groupings, , we will also assess the economic potential for a "low" and "high" set of avoided costs to estimate the boundaries of what might occur over the analysis period.

MAXIMUM ACHIEVABLE AND PROGRAM POTENTIAL

While technical and economic potential give an upper bound on the theoretical potential available, achievable potential provides a more pragmatic, actionable estimate of potential that can actually be achieved given real world market barriers. It also recognizes the additional non-measure costs that would be necessary to capture the potential. Further, achievable potential estimates build off the estimates of the technical and economic scenarios, as the baseline forecast, avoided costs, measure characterization, and measure screenings do not change from one potential definition to the next. For these reasons, technical and economic potential are often thought of as stepping stones on the way to the more actionable and grounded achievable and program potentials.

Based on a measure's current market saturation, technical potential, market barriers to implementation, supply and delivery markets structure, strategies for promotion, and performance in actual efficiency programs, we will develop a set of penetrations for each measure through the forecast period reflecting the impacts of program intervention in addition to estimates of likely free-ridership and spillover. The team acknowledges that Minnesota does not currently require adjusting for freeridership or spillover when reporting efficiency program savings (i.e., only gross savings are reported). However, taking potential free-ridership and spillover into consideration is a critical issue when developing and analyzing programs, as offering incentives for measures that already have significant market share is an inefficient use of ratepayer funds and the costs of incentives going to free-riders must still be accounted for in program budgets. To adhere to Minnesota's reporting conventions while at the same time providing insight into the net impacts of efficiency, estimates of free-ridership and spillover will be used to estimate actual net savings in addition to gross program efforts and budgets. This proposed approach will be discussed with interested stakeholders, and the final methodology will be subject to the approval of the DER.

We will analyze measures within the context of a portfolio of model programs. The achievable program scenario we envision will assess a model portfolio with aggressive and well-designed programs that cover all opportunities and markets. The maximum achievable scenario will assume all measures are pursued equally aggressively, with 100% measure incremental cost coverage and no budget limitation. This scenario can be used as an upper bound and compared against program potential scenarios with more realistic budgets that optimize for various other metrics. We will work closely with the DER and Advisory Committee to further define this model portfolio. As a result, the program achievable potential scenario will more closely reflect a likely set of goals and budgets that might be pursued by Minnesota utilities and can inform future CIP policy as well as actual utility plans and actions.

ALLOCATION OF POTENTIAL ESTIMATES TO INDIVIDUAL UTILITIES

As noted above, energy efficiency potential for the many municipal and cooperative utilities will be modeled in groups by type of utility and climate region. In order to provide more reporting specificity for these customer-owned utilities, the grouped potential estimates will be back-allocated to individual utilities in proportion to the utility-level energy sales disaggregation described above. This will be done at the sector, segment end-use level. For example, single-family residential space-cooling savings potential can be allocated to individual utilities in proportion to the aggregate estimated space-cooling energy consumption in this segment for each utility. We will also explore employing additional screens and more fine-tuned climate adjustments to account for within-climate-zone variation across these smaller utilities.

Note that this allocation process is not intended to be construed as completely customized potential estimates for each customer-owned utility. The analysis will still rely on group-level estimates of measure market penetration and other model inputs. However, the exercise will provide some customization of potential for known differences in utility customer composition and sales.