Advancements in Modeling Gas DSM as a Resource

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ABSTRACT

Modeling electric demand side management (DSM) programs as part of integrated utility resource plans is a well-tested practice in jurisdictions throughout the United States. Treating gas energy efficiency, and more recently beneficial electrification, as resources on gas utility systems is less common and requires addressing the nuanced differences between the operating characteristics of electric and natural gas systems.

Xcel Energy, a multi-jurisdiction utility in the central U.S., has recently undertaken multiple iterations of modeling gas demand side management programs in gas decarbonization plans, culminating in a comprehensive gas resource planning proceeding where energy efficiency and beneficial electrification are structured similarly to and compared against supply-side options. This approach includes examining the effects on commodity purchases as well as how this information can provide the foundation for considering efficiency and beneficial electrification as possible non-pipes alternatives.

Underpinning this effort is a set of research projects to characterize the potential for adoption of various demand side measures. These studies include traditional potential study scenarios looking at the relationship between customer economics and adoption but also expand the perspective to include necessary information for utility considerations of beneficial electrification programs. The most prominent of these changes is the need to ensure symmetrical modeling assumptions between the electric and gas systems to improve confidence in estimates of expected effects on both systems. This paper will review prior practice, detail the methods used, and describe learnings regarding this maturing practice for both utilities and consultants.

Overview of Integrated Gas Resource Planning

Demand Side Management (DSM) for natural gas is hardly a new field, with decades of experience documented in the literature and in front of regulatory commissions. Yet, like almost any other field, there are some aspects of the industry that remain immature. One such area is integrated gas system planning. Regulators and stakeholders, especially those familiar with integrated planning for electric systems, are increasingly asking gas utilities to perform complex modeling of scenarios exploring how utilities can meet cost management and/or decarbonization objectives. Throughout this paper are key process observations, lessons learned, and preliminary findings from a multi-year, cross-jurisdictional effort.

What is Integrated Resource Planning?

Integrated Resource Planning (IRP) in the context of energy utilities has evolved into a standard practice in numerous states across the US and Canada. LeBel et al. (2025) provided comprehensive background on the genesis of integrated resource planning, especially as it applies to electric bulk system (i.e. generation and transmission) planning where the practice is most common in the United States. In Canada, similarly, multiple provinces examine electric resource planning decisions in a holistic fashion. (Morton, 2025). In addition to analysis of electric bulk system growth, the principles of integrated planning can also be applied all the way down to the local distribution level, which is increasingly of interest to regulators and stakeholders. This shift to looking at localized planning has also enabled evolving conversations about gas resource planning and, especially where policy is encouraging beneficial electrification (i.e. electrification of end uses served by other fuels to drive reductions in bill costs and/or decarbonization) of space heating, the interaction between electric and gas system planning.

From a practical perspective, resource planning is a methodical approach to forecasting changes in demands on an energy system and analyzing multiple approaches to meeting that demand to inform decisions that reduce the total cost to serve energy consumers. Biewald et. Al. (2024) published a guide to resource planning which, though focused on the electric system, outlines the general principles that also apply to gas system planning. The guide includes a checklist, with headings that provide an overview that is helpful for interpreting the discussion in this paper The areas of greatest relevance to this paper are underlined by the author below.

- Stakeholder Engagement
- (Assess) Resource Adequacy
- Develop Model Inputs
  - <u>Load Inputs</u>
  - Supply Side Resource Inputs
  - <u>Demand Side Resource Inputs</u>
  - Market Inputs
  - Fuel and Commodity Inputs
  - Transmission Inputs
- <u>Design Scenarios and Sensitivities</u>
- Run the Model (and Iterate)
- Evaluate Results and Communicate Them
- <u>Integrate the IRP Process with Other Proceedings</u>

Unique Needs of Modeling Gas DSM As a Resource

Gas DSM has a long history dating back many decades. In many cases, the resource planning lens has been foundational from the beginning. For example, the enabling legislation for energy efficiency (EE) programs in Minnesota (what is now referred to as Energy Conservation and Optimization (ECO) programs) provided the following guidance to the Public Utilities Commission when considering how utilities providing either electricity or natural gas should make investments in efficiency:

"The Commission shall not order a utility to make any energy conservation improvement investment or expenditure unless it first finds that the improvement will result in energy savings at a total cost to the utility less than the cost to the utility to produce or purchase an equivalent amount of new supply of energy." (MN 1980 Session Laws, Chapter 579, Section 18)

Though electric and gas DSM have this shared origin of comparing demand and supply side resources to each other, achieving this objective often requires different methods. The drivers for these differences, in no particular order, may vary from one jurisdiction to the next but can be generalized as:

- **Regulatory/legislative context.** This refers to differing requirements between utility types and can be as simple as requirements only being placed on one fuel type and not another or more complex in cases where part of the utility supply chain is deregulated (e.g. retail choice, open capacity bidding into regional markets, etc.)
- **Utility operating characteristics.** Operating characteristics consider both the level of vertical integration as well as when consumption on the system peaks, distribution of customer types, or presence/absence of storage to help manage system operations.
- **Availability of data.** Performing integrated planning is an intensive modeling process that often requires significant amounts of input data and making well-informed assumptions. If insufficient data exists, the value derived from integrated planning is diminished. While the collected data described later in this paper (e.g., through potential studies and program evaluations) are not conceptually new, they receive focus at this early stage in the practice of modeling Gas DSM as a resource because they can be deployed much faster than other data collection tools.
- **Variability in source energy.** When the source of energy is relatively homogenous (e.g. in the case of methane from geologic reserves delivered through pipelines) the potential benefits from integrated planning are lower because there are inherently fewer supply side alternatives that can be compared to demand side solutions.

Many of the recent developments in gas planning have converged in a way that requires more alignment between the electric and gas systems to understand the consumer costs and benefits of changes in the end uses that have traditionally been served by natural gas. There is a myriad of reasons why modeling gas DSM as a resource and performing integrated gas system planning lags behind electric system planning. Though not an exhaustive list, key considerations applicable to the research that will be discussed in following sections include:

- Beneficial electrification (BE) and alternative natural gas sources that create multiple options to model
- Increased access to data, either from meters, connected customer devices, or utility supervisory control and data acquisition (SCADA) systems, and more sophisticated modeling tools, that enable modeling at greater granularity
- Regulatory directives to begin considering effects across both systems simultaneously
- Greater interest in demand side solutions to distribution system constraints
- These shifts suggest when the practices that have been established for electric might be applicable to modeling gas DSM in integrated system planning, but do not consider another topic specific to modeling DSM as a resource—understanding of decisions made by customers and other market actors.

Other Instances of Modeling Gas DSM as a Resource

Neither Colorado nor Minnesota is isolated in exploring how supply- and demand-side initiatives compare in plans that aim to reduce costs and/or emissions resulting from traditional natural gas-consuming end uses. This review of other jurisdictions is not exhaustive, as the effort was focused on identifying the most forward-thinking examples that Xcel Energy was aware of as foundations to build upon with its work.

Quebec, Canada. The partnership between two Canadian utilities, primarily in urban Quebec (Énergir and Hydro-Québec), has garnered attention at conferences and in regulatory proceedings in the US (including recently in Minnesota) due to the unique nature of the relationship between these two different entities. However, an equally important piece of their partnership is the analysis conducted to determine the value of the partnership to consumers. The underpinning proposition is that decarbonization of homes and businesses is optimized when dual fuel solutions are deployed to relieve pressure on a clean electric grid rather than simply = to avoid the challenges of electrifying home heating loads in a cold climate. Through Xcel Energy's work with partners familiar with the context in Quebec, this paper describes some key ways that different cost testing methods and different utility system needs can apply the principles of the Quebec model. While the outcomes in Minnesota may look different than Montreal, the thought process driving the research here remains consistent and can help other utilities understand when it may apply to their customers.

Applying three of the four drivers in the prior section to the Quebec model, a couple of key topics emerge that position both this partnership and application in either Colorado or Minnesota for success, though multiple barriers remain.

- **Regulatory/legislative context.** Decarbonization policies in Quebec apply to both electric and natural gas utilities (Government of Quebec, 2020), driving a symmetry for dual fuel solutions as well as measures that may produce benefits across fuels (e.g. building shell measures that can reduce heating, cooling and ventilation loads year-round).
- **Utility operating characteristics.** A major barrier to applying the Quebec model in other places may lie in the coincidence of peak conditions between the natural gas and electric systems. Unlike Quebec, both Colorado and Minnesota's electric systems are expected to remain summer-peaking for the near term while the natural gas system peak, driven by space heating, occurs in winter. This results in a lower valuation for winter avoided costs on the electric system, making solutions much more sensitive to assumptions about forecasted load growth (e.g. when the system could become winter-peaking) as well as discount rates, inflation rates for supply side construction and commodity costs, etc.
- **Variability in energy source.** Énergir includes electrification, renewable natural gas, and energy efficiency as strategies to reduce customer bills and/or carbon emissions from its system (About, n.d.). This multi-channel approach, like the Commission-stated objectives in both Colorado and Minnesota (CO PUC Decision C22-0760 paragraph 27; MN PUC Docket 23-117, 10/28/2024, Section I), suggests that there is additional value in performing a more robust analysis.

Vermont, United States A useful cautionary case for any utility building DSM into resource planning is Vermont's Clean Heat Standard. The Public Utility Commission, after about 18 months of work, concluded that the standard was "theoretically workable" but "not well suited to Vermont," recommending instead that the state build on its existing thermal-efficiency programs rather than stand up a complex new regulatory layer (VT PUC, 2025) (Page, 2025). The instructive part for modelers is not the political outcome, but why the analysis could not produce a confident decision - and each reason maps onto one of the four drivers of difference between gas and electric DSM modeling identified earlier in this paper.

- **Regulatory/legislative context.** The regulatory/legislative design created its own decision risk: because credits could be generated by a wide menu of measures - weatherization, cold-climate heat pumps, but also wood-pellet stoves, "sustainably sourced" biofuels, and renewable natural gas - the breadth itself drew opposition, including from environmental advocates (Giles, 2024). When the eligible measure set becomes contested, the avoided emissions value of a credit (and therefore the relative ranking of demand-side options against one another) cannot be fixed with confidence.
- **Availability of Data.** Vermont commissioned the kind of demand-side resource assessment this paper recommends — the NV5 Thermal Sector Potential Study, prepared for the Department of Public Service. Its handling, however, illustrates how a potential study fails to de-risk a decision when it is decoupled from the screening analysis it is meant to inform. The study was explicitly not based on a particular program design and was never intended to estimate program costs. The demand-side resource question ("what is achievable") was thus firewalled from the cost-and-comparison question ("what does it cost and how does it rank against the alternative"). (NV%, 2024)
- **Variability in Energy Source.** The variability-in-source dimension cuts the opposite way from the homogeneous-pipeline-gas case described earlier in this paper: Vermont's thermal sector is dominated by delivered fuels such as oil, propane, kerosene, or wood (U.S. Census Bureau, 2024) sold by numerous independent delivered fuel dealers, rather than by a vertically integrated utility, so there was no single regulated entity whose planning model could internalize the trade-off.

The transferable lesson for Xcel Energy's approach is that symmetrical, two-sided cost accounting between the fuels being traded off is not a refinement but a precondition; the bundle-based method described here depends on characterizing the full customer and system cost of each option before the model is asked to choose among them.

Building a Method to Model Gas DSM

Xcel Energy’s main approach for modeling gas DSM is to build bundles of demand side activities that are quantitatively meaningful. In this context, “bundles” means a group of demand side measures that are grouped for the analysis, allowing a modeling tool to treat the demand side and supply side measures similarly. Bundling measures is necessary because the scale of a single measure, implemented in the homes and business of only a fraction of customers, would not result in a significant enough change in the resource planning model’s solution (i.e. the output of resources selected and costs for those resources) to cause the model to consistently select the demand side measures. However, putting all demand side technologies together without considering the measures that make up the portfolio could fail to produce guidance on which measures are most beneficial and should be maximized, as well as which may not be cost effective.

The first bundle type, which Xcel Energy has consistently applied when modeling DSM in electric IRPs, is constructed with the current program design (i.e. “business as usual”) or statutory requirements; this bundle forms the base level of DSM. After the first bundle, Xcel Energy has seen value in two approaches for defining incremental bundles. In short, the decision is to either choose areas of focus to assess the relative value of a certain portfolio strategy (e.g. measure lifetime, peak coincidence, or hours of operation) or to use a more static measure mix and ramp up the level of achievement and investment expected across the entire portfolio. These can be varied together but run the risk of creating too many possible scenarios, with some failing to be material to the modeled outcomes as described above.

In Xcel Energy's experience, the most successful approach to building bundles is to consider what each show while also thinking about larger trends in the energy industry as well as specific policy goals for the demand side portfolio. Figure 1. Two examples for approaches to DSM Bundles in Resource PlansFigure 1 below shows hypothetical examples for two bundle approaches to gas DSM.

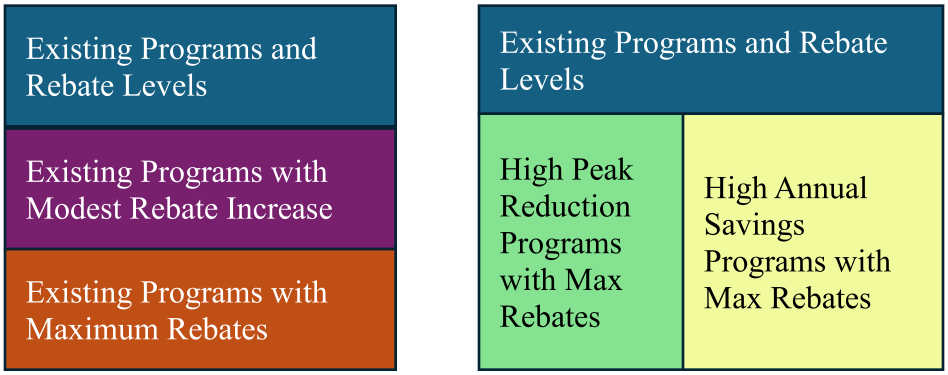

Figure 1. Two examples for approaches to DSM Bundles in Resource Plans

In addition, it may be advantageous to define at least one scenario that is expected to have costs exceeding benefits, so that portfolio design can be considered when the programs may no longer be achieving policy goals. Having steps between bundles that are small enough to observe the trend in increasing/decreasing cost intensity (i.e. $ of program cost per dekatherm of savings) is also a practice that Xcel Energy includes wherever possible.

If either system constraint elimination (e.g. non-pipes alternatives, NPAs[1]) or carbon emission reduction are the exclusive goal of the planning process, it may be advantageous to use the method that focuses on distinguishing whether paying very high rebates for a subset of programs is cost effective. Conversely, if total savings achieved is a goal, the fixed portfolio with increasing investment may be more informative. For example, measures to install high efficiency water heaters may only result in a marginal reduction in system capacity needs but due to the year-round nature of operation, they can have substantial emission reduction benefits.

Based both on the types of natural gas-consuming end uses and the climate in the territory that it serves, Xcel Energy prefers the "stacked" option on the left for gas DSM modeling. This is because key measures (furnaces, boilers, building envelope) with the highest peak coincidence are also among those with the highest annual savings. In the Minnesota Gas IRP this translated into two incremental bundles above the existing programs for BE and three for EE. While the "side by side" approach could have been used, the relatively large effect of a small number of measures (heat pumps in the case of BE and furnaces in the case of EE) might have cause the bundle(s) not including those measures to be too small and, consequently, be

[1] Non-pipes alternatives (NPAs) are a combination of measures on either the supply or demand side to reduce load on a stressed portion of the transmission or distribution system. The intent of and NPA is to defer or permanently avoid a capital upgrade to increase system capacity. Covering the topic of NPAs is not the primary objective of this paper, though NPAs have a role in integrated system planning.

ignored by the model.

Research to Support the Unique Needs of Gas DSM in Resource Plans

Building bundles based on discerning levels of achievement and investment requires sufficient data to predict how customers will respond to the various program designs that exist in the current and/or future DSM portfolio. Adding BE and Load Flexibility (LF) to the traditional EE portfolio adds significant complexity because, though they may be discrete in the eyes of regulators, stakeholders, and utilities, customers make holistic choices that consider both economic and non-economic factors. To build out a better understanding of customer and market actor behavior in two states, Colorado and Minnesota, Xcel Energy relied on six different study efforts over the course of three years:

Table 1 Studies to Inform Gas DSM Modeling

State	Topics	Customer Segments	Title	Key Objectives	Year
CO	LF	Residential	Colorado Conservation Messaging Research	How can voluntary conservation provide relief at times of system stress?	2024
CO	EE, BE	Non-residential	Colorado Business Potential Study	How much energy efficiency and beneficial electrification can be expected from these customer groups with different program designs?	2026
CO	BE	Residential and Small Business	Colorado Heat Pump Market Transformation Evaluation	What would a shift from resource acquisition to market transformation look like for Colorado BE programs?	2026
CO	EE, BE	Residential	Colorado Residential Potential Study	How much energy efficiency and beneficial electrification can be expected from these customer groups with different program designs?	2026
MN	BE	Residential and Commercial	MN BE Study	How much beneficial electrification can be expected from these customer groups with different program designs?	2026

The studies in Table 1, taken together, intended to answer key questions that were necessary to support modeling of DSM in resource plan/clean heat filings, such as:

- Energy Efficiency
    - Updated savings potential from non-equipment measures

  - Estimates of market share for gas equipment measures (both minimum and high efficiency) without rebate programs
  - Capacity reduction from efficiency measures at gas system peak
- Beneficial Electrification
  - Distribution of hybrid vs. all electric systems for end uses where dual fuel is an option
  - Existence of "tipping points" where enough end uses have been electrified to cause customers to fully disconnect from the gas system
  - The typical level of flexibility in the transition between electric and natural gas for dual fuel systems
  - Narrower confidence intervals in the level of adoption for BE measures to improve forecasted change in consumption (both electric and natural gas)
- Load Flexibility
  - Customer willingness to control/curtail non-discretionary natural gas loads such as space or water heating
  - Characteristics of high-confidence behavioral reductions at gas system peak (i.e. behavioral gas DR)

Even where the studies could not conclusively answer the question, meaningful progress has been made in many areas as well as identifying the direction of further research. Specific findings and how they relate to the objectives are further discussed for each platform below.

Energy Efficiency

Accommodating Exogenous Adjustments to Programs Recent directives in both Colorado and Minnesota have directed programs to change methods or measure mix in ways that could reduce or eliminate reliance on savings achievement from gas-consuming equipment and shift toward building envelope measures where feasible. This is consequential because prior potential studies in both states have shown that residential furnaces for space heating are the dominant technology for gas savings opportunities (MN CEE, et. al. 2018, 73-77; Guidehouse 2022, F-26) and evaluations (TRC 2022, 20, 40-41; TRC 2024, 27, 33-34) have indicated that residential HVAC programs materially influence customer and trade partner decision-making. Understanding the degree of durable market transformation that has occurred relative to the risk of backsliding is complex and becomes more consequential in a mixed environment of traditional EE programs and decarbonization policy goals.

While the effect of transformation and a market practice baseline can be easily accommodated in setting energy savings goals by adjusting technical reference manuals or removing measure families when using retrospective analysis of achievements to set future targets, modeling gas as a resource cannot ignore the naturally occurring effects outside of the program. A steady progression of building codes and appliance standards becomes embedded in the econometric forecasting tools used by utilities. However, significant inflection points are not captured in these forecasts until years have passed and must be addressed exogenously. For example, in the case of Minnesota, Xcel Energy elected to model future adoption of furnaces as a load modifier outside of the efficiency bundles using historical adoption data. This was based on two factors: first, there is a relatively consistent turnover rate for the equipment and second, because most heat pump systems currently receiving incentives are dual fuel systems, meaning that the market share of efficient furnaces is not expected to decrease until more research can be performed.

Understanding How Shifts in Measures Affects Bundle Building As described earlier, it is important to balance between the scale of the observed effect and the similarity of measures within the bundles depending on modeling objectives. One such example is how gas EE portfolio savings will be distributed in a portfolio with less reliance on furnace replacements. Though one would expect building shell efficiency measures to grow substantially when equipment measures are removed because program focus shifts, the Colorado Residential Potential Study suggests that this can be more nuanced for a few reasons. The first nuance is how incremental cost, which is usually the full project cost for insulation, both creates “drag” on customer adoption, while increasing the program budget when designing rebates based on a percentage of cost. Second, once the efficient equipment measure has saturated the market, the amount of customer bill savings from building shell efficiency drops because the heating is provided more efficiently.

From a bundle-building perspective, this means that separating building shell from the remaining equipment measures (such as thermostats) or behavioral measures would likely result in maintaining the status quo because the maximum level of building shell potential, which increased to ten times recent achievements but at 40 times the cost, may not be cost-effective in isolation from complementary measures. Using the stacked approach with a comprehensive portfolio including both intermediate and aggressive program tactics and rebates can deliver the most helpful insights.

Pathways Analysis Versus Stock Turnover Modeling While the measures that were characterized in the Colorado Residential Potential Study and the amount of resulting savings were not materially different, the transition from a portfolio that is purely focused on energy to a clean heat portfolio required a new perspective that was not used in prior potential studies. Most notably, the clean heat approach assesses cost effectiveness relative to other carbon reduction strategies rather than using traditional cost effectiveness tests that measure against an assumed supply of geologic natural gas. This type of resource modeling is often referred to as a “pathway analysis”, as it looks at scenarios to achieve a given goal and measures costs and benefits of the scenarios relative to each other. This means that measures or delivery mechanisms that would have previously been non-cost effective may justify additional investigation.

The research conducted in Colorado changed this in two ways to support this pathway analysis. First, at least some achievable scenarios removed the traditional economic potential screening step, resulting in "technical achievable” results that can generate estimates of customer adoption without limitations resulting from utility avoided cost assumptions. See Figure 2 for the distinction between economic, achievable, and technical achievable potential. The areas in gray show successive layers of filtering that occur in each type of potential. For example, technical achievable will only remove measures that are deemed technically infeasible, while the technical achievable, described earlier, eliminates measures that are technically achievable as well as those that are eliminated by Customer and Market Barriers but does not eliminate measures that fail to achieve cost effectiveness criteria as a typical achievable potential would.

The second accommodation was to add more thorough research on conditions of residential building envelopes than can be acquired through typical customer self-report surveys. The enhancement of building data was through blower door test data collected for a nested sample of customers from a larger self-report survey. Initial results suggest that residential customer adoption of additional insulation and air sealing measures may not be limited as much by utility program delivery and instead are a result of customer preferences (both financial and non-financial).

<table>
<tr><td>Technical Potential</td><td rowspan="4">Not Technically Achievable</td><td colspan="3">Technically Achievable</td></tr>
<tr><td>Economic Potential</td><td rowspan="2">Not Cost-Effective</td><td colspan="2">Technically Achievable and Cost-Effective</td></tr>
<tr><td>Achievable Potential</td><td>Customer and Market Barriers</td><td>Attainable Within Assumed Cost-Effective Program Design</td></tr>
<tr><td>Technical Achievable Potential</td><td>Customer and Market Barriers</td><td colspan="2">Attainable Within Assumed Program Design, Ignoring Cost Effectiveness</td></tr>
</table>

Figure 2 Definition of various types of potential, including addition of Technical Achievable

Finally, observed gas system avoided peak capacity requirements due to efficiency remain elusive. A study conducted with Xcel Energy customers in 2024 (Pritchard, 2025) describes research that had started with an attempt to use non-revenue metering devices to directly calculate gas end use consumption. In the end, the devices were unable to deliver data with sufficient confidence and an engineering calculation method (consistent with deemed savings assumptions in prior plans) will continue to be used for the foreseeable future.

Beneficial Electrification

The New DSM Measures on the Block A key driver of value for gas resource planning processes is the recent emergence of beneficial electrification as a viable gas demand side management strategy. The ability to quantitatively estimate the costs of avoided capacity and commodity expenditures on the gas system allows one to consider the optimization between the gas and electric grids, as the "Quebec Model" discussed earlier illustrates. This ability to explore "assumption symmetry"—removing siloes for electric and gas systems and better addressing the demand side technologies that transcend them is both among the core recommendations of LeBel et. al. and aligns with Xcel Energy's motivations to conduct these studies.

The need for this research centers on the paradigm shift that disrupts a relationship that has historically allowed gas forecasts to rely very heavily on weather as the primary variable. Some of the objectives are focused on changing the forecasting method partially (i.e. hybrid beneficial electrification systems) while others intend to shed light on complete shifts (i.e. all-electric conversions) that include predicting customer counts as well as consumption.

Inputs That Drive BE and EE May Diverge. The first finding is that the difference in rates for electric and natural gas, not programs, are the outsized drivers of predicted adoption. The Colorado Residential Potential Study and Minnesota BE Study were conducted by the same research team and generally applied similar assumptions where applicable. The reference scenario in each case showed some overlapping conclusions and some divergence that make the importance of rates very apparent. Foremost among these is that air source heat pumps (ASHP) with a gas furnace back up (i.e. hybrid ASHP systems) are almost always the most cost-effective beneficial electrification retrofit measure from a customer perspective. However, since there are significant differences in the rates for electric space heating in Colorado and Minnesota[2], we can derive additional insights into the role that rates play. At a qualitative level, the initial modeling for Colorado suggest that even substantial rebates may not be sufficient to overcome the bill impacts from electrification, resulting in a long-term project that only a fraction of observed residential BE measure adoption is likely to be cost effective for those customers. Meanwhile, the Minnesota reference case matched observed adoption very closely. This led to a practical conclusion that BE modeling may need to rely more heavily on non-economic "levers" at the early adoption stage if underlying energy prices are not well aligned to encourage BE.

Timing of Measures May Matter More for BE. Concurrent to the Colorado Residential Potential Study, Xcel Energy also worked with a separate team on the Colorado Heat Pump Market Transformation Evaluation. This research included some customer research but, more importantly, helped understand the regional, national, and even global market actors who manufacture, stock, and install heat pump equipment.

The Colorado Heat Pump Market Transformation Evaluation uncovered many complementary insights to the above discussion but also arrived at an additional piece of information that shows the need for nuance when forecasting BE adoption. The specific finding was that trade partners currently see "late life" retrofits as a key market segment where customer awareness is higher. While it's challenging to discern exactly why based on trade partner perceptions, the most logical inference is that the typical replacement on burnout situation involves non-functioning equipment and the trade partner is called in to address that problem. Conversely, a customer who has time to conduct research and learn about options may know more about what they want and request something that the replace on failure customer has had no time to consider.

Translating this into findings about heat pump system replacement, especially a conversion to all-electric systems, means further research into modeling the effects of requiring more time, involvement of more trades, and possibly more permits or inspections—all of which can delay replacement while a customer is enduring a situation that can vary from uncomfortable to crisis—into the adoption model. Absent a massive market shift, a trade partner's natural preference in the replace-on-failure situation will be to help the customer fix a problem faster, which could either result in no heat pump installation at all or installation of a less optimal system to satisfy the customer.

Coordinated Programs as a Forcing Function. Another finding from the Colorado Heat Pump Market Transformation Evaluation relates to the pointing effect of the multiple incentives in the market in Colorado. Analysis conducted by the research team shows that incentives alone do not account for the increase in adoption of heat pumps in communities with one or multiple additional incentives beyond Xcel Energy's rebates. We note that this effect could also apply to energy efficiency programs, but Xcel Energy has not considered assessing this since the BE incentives offered by other entities are much more focused on a set of measures that allow for the

[2] The most prominent difference is that Colorado does not yet have a separate electric rate for customers with any type of electric space heating while Minnesota has a long-running winter-only electric space heating rate that heat pump customers may enroll in as long as electricity provides the majority of their heating. The Minnesota rate applies at the premise level, which means that all electric use is subject to this discount. Furthermore, Minnesota statute exempts payments for the fuel that provides space heating from sales tax in winter months, providing additional benefit beyond the reduction in premise level electric rates.

analysis to be completed. We think that this effect could be one of the reasons why the observed adoption in 2024 and 2025 is higher than projected adoption in the Colorado Residential Potential Study.

In the end, this suggests that customer and trade behaviors may install BE measures but will trend toward lower displacement of natural gas and lower heat pump-driven growth in electric loads in colder climates until electric rates offer a discount even after factoring in the decline in ASHP COP at colder temperatures. It is important to differentiate this customer-driven effect from the least-cost system planning approach. A “system optimized” scenario in the Minnesota study found that solely trying to minimize the cost to serve across the electric and natural gas systems would drive a dramatically different outcome, toward near-universal adoption of Ground Source Heat Pump (GSHP) systems if customer cost were not considered. This is primarily due to the specific cost test used (which omits customer costs but considers many societal costs and benefits and applies to a societal discount rate), but it also comes from the assumption that the Minnesota electric grid will remain summer peaking. This outcome highlights how forecasting studies such as these can easily reach two very different “right answers” depending on the input assumptions or perspective of the analysis.

Load Flexibility

The final aspect of modeling DSM as a resource included in Xcel Energy’s plans is temporary changes in customer consumption, henceforth gas load flexibility (gas LF), akin to what are traditionally called demand response (DR) programs on the electric grid. However, Gas LF is inherently different from DR because of how the gas system operates. Foremost is the relative ease, ubiquity, and cost effectiveness of transporting and storing natural gas. This has resulted in programs that look like demand response, often referred to as interruptible tariffs, focusing on ensuring local system stability and not responding to broader market shortages or economic events. The commodity price surge in February of 2021, colloquially known as “Winter Storm Uri”, changed the conversation in many jurisdictions as maintaining system reliability was not challenged but doing so affordably was a subject of significant debate. The Colorado Conservation Messaging Research was a direct outcome of this event. Not long afterward, Xcel Energy’s first residential gas load flexibility pilot, known as “Heat Savers”, completed its first season in a geotargeted area that was capacity constrained. This combination led to significant utility regulator and stakeholder interest in setting goals and creating programs that could mimic the effects of electric demand response on the natural gas system.

The key objectives of the Colorado Conservation Messaging Research and a forthcoming gas LF study are to improve confidence in estimates of both scale and certainty of customer response to gas load management events. While the effects of California’s FlexAlert notifications show when conservation messaging can work, the research team’s findings through interviews with gas system stakeholders suggest that it comes at the risk of exhausting the impact for economic events and diminishing customer trust in the utility if not used judiciously. As a result, peer utility research found that gas purchasing and/or system operations decisions are not typically made based solely on the effects of voluntary calls for conservation.

With this established, the focus instead shifts to how conservation messaging becomes part of an ecosystem with more formal gas LF programs that can result in measurable impacts though more intentional program design. The specific program structures tested, especially for residential customers, mimic many of the same thought processes used in electric demand response studies. The main differentiator that Xcel Energy and the study teams have recognized is that the resulting behavior from increasing a thermostat set point in summer is not necessarily the same with decreasing it in winter. Pritchard noted that the snapback effect at the end of the event period could drive a peak even higher than the counterfactual peak that was avoided if not managed correctly. Similar to BE, the relatively low adoption of advanced metering infrastructure (AMI) prevents high confidence calculations of observed effects, highlighting an opportunity for future research. In the absence of AMI, the alternative of relying on other devices (e.g. thermostats) combined with engineering calculations remain the best option but could dampen the scale of opportunity when high-confidence scenarios can't be established for modeling. This is especially critical for any future non-pipes alternative analysis, because the consequences of "getting it wrong" are so high.

Conclusions

Though every utility has its own context, the key drivers to consider if and how to model gas DSM as a resource help provide structure and continue to move the industry on a path toward affordable, lower carbon energy while maintaining essential safety and reliability.

- Regulatory/legislative context. Not every utility needs to dive in if the environment doesn't support it. Having defined goals for what gas DSM can achieve when modeling it against supply side measures can help narrow the realm of assumptions and make the outputs more useful.
- Utility operating characteristics. If a gas utility doesn't have sufficient visibility into the electric system, simplifying assumptions about how the grid operates could drive outlier results. Knowing the electric system well doesn't preclude this but it gives better insights into how to adapt modeling to ensure that the goal of optimizing customer costs doesn't get lost.
- Availability of data. Performing integrated planning is an intensive modeling process that often requires significant amounts of input data and making well-informed assumptions. If insufficient data exists, the value derived from integrated planning is diminished. While the collected data described later in this paper (e.g. though potential studies and program evaluations) are not conceptually new, they receive focus at this early stage in the practice of modeling Gas DSM as a resource because they can be deployed much faster than other data collection tools
- Variability in energy source. If a utility is only examining two approaches (e.g. fossil natural gas and energy efficiency), more complex research and planning efforts may not produce much incremental value. At the same time, if there are too many sources (e.g. delivered duels are considered part of the portfolio) it may be necessary to invest significantly in understanding fuels other than natural gas before deciding the correct approach.

Gas demand side management, while not a new concept, could be transformed by the introduction of integrated gas system planning in more jurisdictions across North America. Sharing considerations when designing research to inform these studies and the results that come from them is a critical part of growing literature to support best practices that can achieve acceptance among regulators, stakeholders, and utilities. This is the first phase that will be revisited and improved based on model outcomes and peer utility progress. Xcel Energy's recent experience has taken a few steps forward but not without identifying certain consequential questions that remain unanswered until future research is able to address them.

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AI Disclosure

No AI tools were used by the author while producing this paper. Any AI tools used in the referenced research are cited within the reports for that study.