Towards a More Flexible Gas Future: Emerging Approaches to Residential Gas Load Management

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ABSTRACT

Gas utilities face a variety of emerging challenges including increasingly severe winter storms, policy-driven capacity constraints, a growing focus on energy equity, and the need to reduce greenhouse gas emissions. To maintain reliability and affordability while evolving to meet these challenges, load flexibility will be an increasingly essential non-pipes alternative for many gas utilities. However, the gas system behaves differently from the electric system and has unique needs with regards to peak load management, so gas utilities should be cautious when trying to adapt electric-focused approaches. For instance, issues like post-event snapback that may be manageable for electric utilities may create deeper problems for gas programs. Unfortunately, gas load flexibility pilots have been relatively limited to date, and more research is needed to identify best practices.

To help further the development of effective gas load flexibility initiatives, this paper will draw from the authors' backgrounds in measure evaluation, decarbonization pathway analysis for gas and dual-fuel utilities across North America, and data-driven customer engagement strategies to explore potential approaches that could support scaled residential gas load management. We'll consider potential load reductions, snapback effects, equity impacts, and scalability across various measures including smart thermostats, water heater controls, and behavioral messaging. We'll also conduct a meta-analysis of pilot results to date, and put gas load flexibility into context by exploring different opportunities for the gas system (such as distribution- and supply-side capacity constraints, decarbonization-related challenges, the need to improve equity, and maintaining reliability in extreme weather).

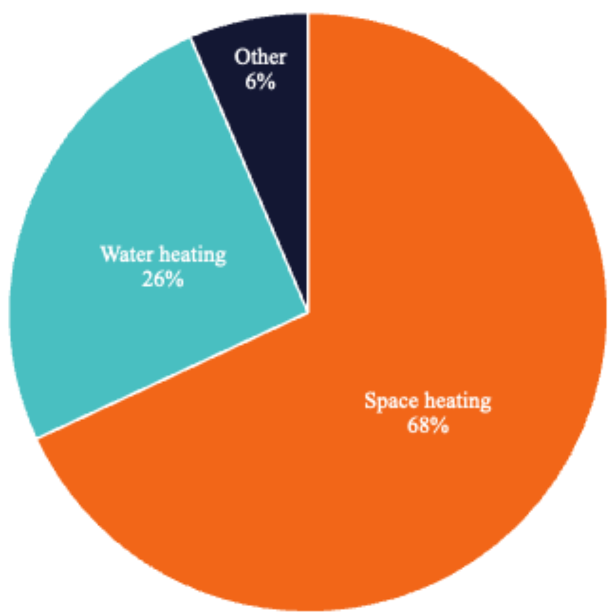
Introduction

Natural gas utilities across the U.S. and Canada are experiencing a variety of emerging challenges, including changing customer trends, new policies that constrain system capacity or limit new infrastructure investments, growing gas demand (particularly in areas where customers are shifting away from propane and fuel oil), increasingly severe winter storms that strain existing distribution networks, and a duty to serve that mandates that all customers can get equitable and reliable access to gas. So-called "non-pipes alternatives" (NPAs), including load flexibility and demand management strategies, offer potential for utilities to help ensure everyone's needs can reliably be met—even under extreme weather conditions—and support an evolving distribution system during the ongoing energy transition. However, making the most of NPAs will require new data sources, innovative program design, and a renewed focus on customer engagement and partnerships.

An immediate need for gas utilities is a more granular understanding of the actual consumption patterns associated with their customers. Due in large part to cost and implementation challenges, many utilities still rely on manual or automated meter reading (AMR) systems that only provide consumption data once a month. That level of granularity is insufficient to support the kind of detailed planning and real-time visibility needed for effective load management, but a variety of solutions now exist. For instance, utilities could explore new opportunities to justify installation of smart meters (also called advanced metering infrastructure, or AMI) given the new potential value streams associated with resolving the emerging challenges they face; they could explore retrofit devices like meter collars that could provide more frequent data collection without replacing the meters themselves; or they could consider fully wireless technologies that enable data collection from existing AMR systems as often as every 30 seconds without any hardware replacements or retrofits.

Once more frequent and granular data is available, a next step is to consider potential load flexibility measures. On the residential side, the U.S. Energy Information Administration suggests that most gas consumption is due to space and water heating (Figure 1). As a result, the most promising load management strategies are likely to be those that can affect these end uses through either automated, control-based measures or behavioral program approaches.

Figure 1: Average U.S. Household Natural Gas Consumption



Source: U.S. Energy Information Administration 2020 Residential Energy Consumption Survey (released June 2023)

While load flexibility will necessarily look different for gas utilities than it will for electric utilities, it's an area rife with opportunity for increased exploration. By identifying new strategies that can enable demand management at scale, gas utilities can help ensure continued reliability and resilience in the face of more extreme climate-driven storms and a range of other emerging challenges.

The Core Challenges: Distribution and Supply Constraints

Broadly speaking, NPAs focused on load flexibility and gas demand response (DR) strategies can be particularly helpful for utilities that are facing either distribution or supply constraints. Distribution constraints represent situations where there's plenty of gas supply, but it can be difficult to get that gas to end-use customers at the rate needed. This can happen in situations where, for example:

- Severe winter storms create a drop in pressure that effectively reduces the amount of gas the system is able to deliver.
- Utilities see rapid expansion in their customer base (e.g. as a result of conversions from propane or fuel oil) but have not yet expanded their distribution pipes.
- Emerging policies aimed at supporting energy decarbonization limit gas utilities' ability to maintain or upgrade existing distribution networks.

In these situations, reducing the rate of demand during peak periods can help ensure that the gas system is able to meet customer needs despite system limitations without losing pressure or risking outages.

Supply constraints occur when there are limitations on the total amount of available gas in the utilities' reserve storage systems. For example, this can happen when prolonged winter storms drive consumption much higher than forecast and create a shortfall in the amount of total gas available to the utility and its customers, or when geopolitical events (such as the ongoing war in Ukraine) limit the overall availability of gas for purchase. In these cases, longer DR events that essentially comprise multi-day conservation efforts have potential to help make existing supplies go further while still meeting essential customer needs.

By helping to alleviate supply and distribution challenges, gas load flexibility—and the data that enables it—can help utilities meet a number of different challenges described below.

Reliability and resilience. Establishing concrete load flexibility strategies offers potential to help utilities better manage gas supplies during extreme cold weather events by limiting the rate of use, or during geopolitical conflicts, like the war in Ukraine that rapidly drove up gas prices, by reducing overall consumption. In addition, a more granular understanding of usage patterns and the various factors that can affect them can help utilities better plan for extreme events to help bolster reliability at a system level.

Decarbonization planning. As emerging decarbonization-focused policies begin to restrict gas distribution capacity, make it harder to invest in existing or new gas infrastructure, or even begin to decommission parts of the gas system entirely, load flexibility can help utilities meet customers' needs in a dynamically changing environment while supporting climate targets, particularly in states where the duty to serve for gas utilities remains in place. Additionally, some utilities are currently considering strategies like blending green hydrogen into the natural gas supply at levels of up to 20% by volume to help meet energy decarbonization goals, but since the energy density of hydrogen is only about 35% that of natural gas (AGA 2022), that could further exacerbate distribution challenges during extreme weather events. Having more granular data on gas demand, in combination with a variety of load flexibility strategies, can help ensure that gas utilities are able to successfully implement these kinds of decarbonization solutions going forward.

Affordability and equity. Since 2010, gas utility infrastructure spending in the U.S. has increased by roughly 3.5 times, even though overall gas consumption has remained relatively flat (AEU 2024), a situation that in combination with other external factors has led to growing gas rates for customers. At the same time, in regions where decarbonization mandates lead to building electrification, gas rates are likely to rise further as fixed gas system costs are reallocated across fewer customers, with estimated increases ranging from 15% to more than 500% over 2023 levels under different decarbonization scenarios (Nadel 2023). Because lower-income households are also less likely to electrify than higher-income households without substantial policy changes and new supportive resources, these impacts could further reduce energy equity and present additional challenges for utilities and regulators. Given these issues, load flexibility—and NPAs broadly—will be essential to help manage system costs through improved planning and system management going forward.

Coordinated gas/electric system planning. As the number of natural gas-fired electric generators have increased, there's a growing focus on coordinating system planning to ensure that gas shortages (e.g. during winter storms) don't lead to either electric or gas outages. For instance, the National Association of Regulatory Utility Commissioners (NARUC) in 2023 announced an initiative called Gas-Electric Alignment for Reliability (GEAR), which will bring together state regulators and stakeholders "to develop solutions to better align the gas and electric industries to maintain and improve the reliability of both energy systems on which our nation depends for power" (NARUC 2023). Similarly, states focused broadly on energy system decarbonization to address climate change will likely need to support improved multi-resource planning to ensure that the energy transition is as cost-effective and equitable as possible while maintaining reliability (Snell and Narbaitz 2022). The kind of data used to support gas load flexibility initiatives can help to provide more insights and apples-to-apples comparisons between systems, and the measures themselves can help reduce the risk that either the electric or gas systems will experience outages as a result of extreme gas demand.

Gas and Electric Load Flexibility are Inherently Different

Unlike the electric grid, where periods of peak demand that might be addressed through load flexibility strategies often last for just a few hours, peak demand on the gas system can last for much longer. In particular, whereas electric utilities are typically aiming to reduce the need to temporarily turn on expensive or emissive peaker plants, or to help with varying power conditions in real-time down to the sub-second level through strategies like frequency regulation, gas utilities facing distribution or supply limitations may need to reduce demand over extended time frames lasting as long as several days. This fundamental difference suggests that utilities, researchers, and program implementers should focus less on instantaneous demand reductions (as is often the case with electric strategies) and more about time-bound energy conservation events focused on reducing net consumption.

The extended duration of gas peak load events can complicate the use of automated measures like smart thermostat-based temperature setpoint adjustments that reduce amenity for end users. Where residential customers, for example, might accept the discomfort of a 4 degree setback for 3-4 hours in the summer, they may be unwilling to accept a winter set-up that lasts for most of a day or overnight, leading to high levels of opt-out. This challenge underscores a need for thoughtful program design and expanded participant engagement and education with gas DR events compared with electric DR events to help ensure positive results.

Additionally, the impact of snapback—a phenomenon where customers temporarily conserve energy during the DR event but then use more energy afterwards as they go back to their usual usage patterns and re-condition their home—has a larger potential to adversely affect gas system benefits than is often the case with electric DR events given the longer event durations. For example, one way to try to avoid customer discomfort over an extended period might be to stagger a larger number of shorter-duration events across the customer base. The problem is that if snapback largely negates net energy savings for each of those events, the gas system as a whole might not realize benefits from the event. Snapback is likely to be a particularly significant challenge in cases where utilities are focused on supply constraints (where net savings across multiple days are essential for success), but even in shorter weather-based events may pose a challenge when problematic peak demand extends beyond several hours.

Finally, gas load flexibility is inherently more constrained from a programmatic perspective simply because there are fewer gas end uses available to be managed than is the case with the electric system. Gas customers don't typically have a large flexible end use like an electric vehicle to turn off or load-shift, so much of the potential for controllability (whether through an automated or behavioral approach) lies in space- and water-heating.

Residential Load Flexibility Measures

To date, there have been relatively few residential gas DR pilots and programs (particularly in comparison with electric DR offerings), and many of the pilots completed so far have centered on smart thermostats using approaches similar to those employed by electric utilities. However, given the significant differences between gas and electric peaks and load-shedding needs described earlier, there's still plenty of room for research and experimentation, and gas utilities may be well-suited to exploring multiple options and incentive strategies.

From a programmatic perspective, potential avenues for gas DR could include such options as non-incentivized behavioral load flexibility, behavioral programs using dynamic monetary incentives that reflect real-time system benefits, or automated demand response via smart connected devices such as thermostats and water heater controls. Each of these requires different enabling technologies, offers different potential system benefits, and varies in scalability and customer impacts. A range of results and lessons learned from existing residential smart thermostat, water heater controller, and behavioral gas DR initiatives are summarized below.

Smart Thermostats

Though SoCalGas initiated the first gas DR pilot over seven years ago, state utility regulators in the U.S. have only approved two full-scale gas DR programs to date. The number of utilities piloting gas DR initiatives is growing, however, and smart thermostat-based DR represents the primary programmatic approach that utilities are exploring as part of these pilots among residential customers in their service territories (Johnson 2024).

National Grid in New York offers one of the two full-scale natural gas DR programs that regulators have approved, and as part of its DR portfolio it operates a bring-your-own-thermostat

(BYOT) residential gas DR program in both its upstate and downstate service territories. Washington Gas is the other utility with an approved gas DR program, a single residential BYOT program called Smart Energy Rewards. But Washington Gas only recently proposed to expand its BYOT offering from a one-year pilot to a full, ratepayer-funded program as part of its demand-side management (DSM) plan for 2024–2026, and the Maryland Public Service Commission didn't approve this DSM plan until December 29, 2023. So the full potential and impact of Washington Gas' full-scale BYOT program remains to be seen.

Besides National Grid New York and Washington Gas, at least six other utilities have operated BYOT gas DR pilots since 2016, though three have since discontinued their pilot offerings:

- Connecticut Natural Gas (CNG) and Southern Connecticut Gas (SCG) (Connecticut): residential BYOT pilot
- DTE (Michigan): residential BYOT pilot
- Eversource (Massachusetts): residential BYOT pilot
- SoCalGas (California): residential BYOT pilot, operated from 2016 to 2019.
- Con Edison (New York): residential BYOT pilot, operated from 2018 to 2022.
- Consumers Energy (Michigan): residential and small business BYOT pilot, operated from 2020 to 2022

Michigan Gas Utilities Corporation has also operated a thermostat-based residential and commercial/industrial DR pilot since 2021. But unlike the BYOT programs highlighted above, this pilot relies on customers manually lowering thermostat setpoints following notification of a DR event via a phone call, text, or email, rather than direct load control (DLC) by the utility.

In addition, at least three utilities plan to develop smart thermostat-based gas DR pilots in their service territories soon, including:

- NYSEG and RG&E—both Avangrid companies—stated in their 2023 Annual Report on Program Performance and Cost Effectiveness of Distribution Level Demand Response Programs that they planned to develop their own gas DR pilots for the 2024–2025 winter season based on the experience of Avangrid's Connecticut utilities, CNG and SCG.
- In Connecticut's 2022-2024 Conservation & Load Management Plan, Eversource stated that it would potentially offer a gas DR pilot in Connecticut based on the results of its BYOT gas DR pilot in Massachusetts.
- NW Natural reported in its 2022 Integrated Resource Plan (IRP) that it had contracted with the Brattle Group to complete a comprehensive DR potential study, highlighting that smart thermostats could be a valuable DR resource and identifying the establishment of a residential and small commercial DR program by 2024 as an IRP action item.

Unfortunately, publicly-reported performance data on the load-reduction impacts of these BYOT DR pilots and programs is limited to (1) National Grid's ongoing BYOT program, (2) the three BYOT pilots that utilities have discontinued, and (3) Washington Gas' one-year BYOT pilot during the winter of 2022-2023. Table 1 highlights the net savings achieved by each of these six DR pilots and programs during their most recent (and for those pilots that have been discontinued, final) winter seasons.

Table 1. Average net savings per event from BYOT gas DR pilots

Utility	Winter season	# of events	# of hours per event	Average # of customers or devices per event[1]	Average event window net savings, including preheat and snapback (Dth per device or customer)[2]	Average total event window net savings, including preheat and snapback (Dth)	Snapback plus preheat losses
National Grid (downstate program)	2022 - 2023	3	4	15,531	0.029	438.85	43%
Washington Gas (pilot)	2022 - 2023	6	3 or 4[3]	3,682	0.036	133.15	48%
Con Edison (pilot)	2021 - 2022	4	4 or 6[4]	4,190	0.025	202.22	54%
Consumers Energy (pilot)	2021 - 2022	10	4	12,927	0.012	155.04	75%
SoCalGas AM events (pilot)	2018 - 2019	24	4	33,895	0.006	207.00	45%
SoCalGas PM events (pilot)	2018 - 2019	5	4	9,208	0.003	31.00	59%

Sources: National Grid 2023; Washington Gas 2023; Con Edison 2022; A. Bickle, et al. 2022; Nexant 2019.

Actual savings vary among the gas DR initiatives featured above, driven by factors inherent to the utility, its geographic location and climate, and its customer base. But snapback usage—the gas required to heat homes back to customers' preferred setpoints after events—and gas used for customer preheating consistently reduced the net load reductions achieved during event hours by 43% - 75%. These high snapback losses speak to the challenge of achieving extended duration (e.g., 24 hour) demand reductions when curtailing heating loads, particularly if a staggered approach is used. And they are also a reason why residential gas DR initiatives

[1] Each utility reported DR event participation using a different metric: National Grid reported the number of dispatched devices; Washington Gas reported the number of devices that participated in an event; Con Edison reported the number of devices enrolled in the pilot at the time of an event; Consumers Energy reported the number of customers participating in an event; SoCalGas reported the number of devices targeted during an event.

[2] National Grid, Washington Gas, Consumers Energy, and SoCalGas all accounted for gas use from both preheating and snapback when calculating net savings. Con Edison accounted only for snapback usage. Two of National Grid's three events were emergency events called on consecutive holiday days (i.e., Christmas Eve and Christmas Day), and participating customers received no preheating for these events.

[3] Washington Gas called two events lasting 3 hours and four events lasting 4 hours.

[4] Events lasted 4 hours for participants who enrolled a Nest thermostat and 6 hours for participants who enrolled a Honeywell thermostat.

focused on heating loads may be best deployed to address short-duration gas distribution constraints that can be resolved by shifting loads to other times of day, when more system capacity may be available. The savings achieved by National Grid and Washington Gas demonstrate that BYOT programs *can* produce net load reductions. But it remains to be seen if the scale of these net savings can–on their own–appreciably alleviate longer-duration supply limitations, such as those caused by known constraints in the capacity of existing pipeline infrastructure or unplanned interruptions to storage facility access.

These pilots and programs also demonstrate that BYOT programs don't necessarily require the presence of AMI at a customer's home, nor the installation of data loggers or any other add-on equipment once a connected thermostat is in place. Both National Grid and Washington Gas collected heating system runtime data from participating customers' smart thermostats and then estimated gas demand reductions during DR events by multiplying runtime data by standardized assumptions around furnace gas consumption rates.

As cataloged in a recent E Source report, there are more than 300 electric and gas utilities and DSM program administrators in U.S. and Canada that offer smart thermostat programs, which provide rebates for smart thermostat installations or instant discounts on online marketplace purchases (McKay 2024). Some utilities have income-qualified smart thermostat offerings as well, which provide increased rebate amounts or free products and installation. Utilities are exerting significant effort to increase the penetration of smart thermostats throughout the market. Provided a home's gas-fired heating equipment is compatible with one or more smart thermostat models, the availability of a wireless network connection to enable utility DLC of thermostat setpoints and the collection of furnace runtime data becomes the greatest technical barrier to wide scale participation across residential customers.

As a result, limitations on the scalability of BYOT gas DR programs exist not so much on the customer side, but instead on the utility side. Not all gas and dual-fuel utilities will face constraints in their gas networks that BYOT programs are well-suited to. Only where utilities face the constraints that BYOT programs can address will the program produce sufficient benefits to justify the costs. And within a utility's gas distribution network, there will generally be a finite geographic area where applicable gas system constraints exist (e.g., low pressure areas during peak demand)

Water Heater Controllers

In general, natural gas DR initiatives that strive to achieve targeted load reductions through control of residential gas-fired water heaters will be limited to storage-type water heating equipment (as opposed to tankless units). This leaves consumers with access to the hot water already in storage tanks during DR events, which makes it possible to shift energy demand for water heating without affecting consumer comfort. Because water heating loads may be curtailed without restricting consumer access to hot water, water heating DR events can be called more flexibly and frequently without concerns that consumer comfort issues will undermine participation—thereby compromising the reliability of load reductions. However, gas used before DR events to pre-heat water in the tanks, or gas that is used later in the day to replenish hot water used or cooled during events (i.e., snapback), will erode the load reductions achieved during DR event hours. As a result, water heater DR initiatives are more appropriate for shifting water heating loads to other times of the day, like gas BYOT programs that shift heating loads. Long-term energy savings are likely to be modest.

In practice, the actual gas demand savings that water heaters can deliver in residential settings remains to be explored through laboratory studies and utility pilots (ICF Canada 2022). The estimates available today are based on modeling studies of limited specificity and precision or a single utility pilot with a small sample size that studied 24-hour DR events. For example, a 2020 case study by the National Renewable Energy Laboratory (NREL) and the U.S. Department of Energy (DOE) investigated the technical potential of residential gas DR during extreme cold events. This study found an upper threshold for demand reductions from gas water heating equal to 5% of total gas loads during cold weather and 12% of total gas loads during a moderate winter. But these levels of load relief could only be reached by eliminating *all* gas water heater demand, and the authors of this study acknowledged that only a fraction of this technical potential could be harnessed as a DR resource in practice (Speake, et al. 2020).

In 2019, Con Edison initiated an 11-month pilot program to study the efficiency savings and DR capabilities of gas-fired residential water heaters retrofitted with an advanced controller manufactured by Aquanta. As part of the pilot, Aquanta controllers were installed in just over 200 single-family homes, and the controllers were programmed to minimize water heating gas use whenever 24-hour DR events were called. On average, these DR events yielded 0.026 Dth of gas savings. But participants also experienced an average of 0.014 Dth of snapback usage on the day following a DR event, the bulk of which occurred during the hour immediately following the end of DR period (West Hill Energy and Computing 2021).

The resulting net savings of roughly 0.012 Dth per household are not directly comparable with those savings achieved by utility BYOT programs. BYOT DR events typically last between 3 and 6 hours while savings in the Con Edison water heater DR pilot accumulated over the course of an entire peak demand day. However, in magnitude if not in method, per-household net savings from Con Edison's gas water heater DR pilot did match the per-customer net savings achieved by Consumers Energy's now-discontinued BYOT pilot during the winter of 2021-2022.

Furthermore, and like BYOT programs, water heater DR initiatives at scale may be able to overcome limited per-unit impacts to produce valuable, aggregate load shifts in the timing of overall gas demand. There is precedence for significant customer participation in water heater DR programs on the electric side. For example, the Hawaii Electric Co. has over 25,000 water heaters enrolled in its residential DLC program, EnergyScout. And as early as 2016, Great River Energy had enrolled 110,000 grid-interactive water heaters throughout Montana in two different load management initiatives. But the potential benefits of the load shifts generated by gas-fired water heaters must be weighed against the potential costs to enable this functionality.

Making water heaters DR-ready by installing control switches and enabling DLC can run several hundred dollars in labor and equipment costs. These costs can be greatly reduced through standardization and the mass production of plug-and-play control devices, like those that can plug into a CTA-2045 socket and which have helped fuel participation in grid-responsive electric water heater programs. But as far as the authors are aware, no manufacturers currently install sockets or ports in gas-fired water heaters that can enable easy installation of controllers that are compliant with CTA-2045 or some other communication protocols. Although some retrofit water heater controls can be self-installed, homeowners may be understandably skittish about DIYing the installation of a control device on a gas-fired appliance. And as an after-market product that is not endorsed by a manufacturer, these kinds of controllers may not receive as much buy-in from manufacturers or consumers as a control device that a water heater was explicitly designed to work with.

Behavioral Load Management

As with water heating, there are currently few available examples of behavioral gas DR pilots or programs with residential customers (Lam et al. 2023). However, one relatively small pilot National Grid completed in January 2022 in partnership with Copper Labs showed promising initial results during an extreme "bomb cyclone" event in New York State (Copper Labs 2022). Due to existing capacity constraints on its gas system, National Grid had been working with Copper Labs to design a behavioral gas DR pilot concept, and this extreme weather event presented a unique opportunity to implement it quickly and demonstrate efficacy with a select group of customers.

In the lead-up to the bomb cyclone, National Grid was expecting an increase in natural gas consumption and decided to run a behavioral DR pilot with customers who already had the Copper Labs hardware and mobile app installed. Together, National Grid and Copper Labs created a DR event to cover a 4-hour peak demand time from 6 to 10 a.m. during the height of the blizzard. In lieu of traditional monetary incentives for customers to reduce demand (such as those used in most BYOT programs), this pilot used a purely behavioral approach in which National Grid simply asked customers to voluntarily reduce their gas consumption via the Copper Labs mobile app. A sample message is as follows:

> *National Grid Gas Peak Event*
>
> *We're expecting cold weather tomorrow AM. Help keep your community warm by limiting gas use tomorrow from 6-10 AM. Hit the bell icon in the Copper Labs app to see tips and track your progress.*

Suggested tips for reducing gas use included turning the heat down a few degrees, postponing hot water use (like a shower), or closing curtains not directly receiving sunlight. Copper Labs advised National Grid on how best to craft impactful messages that would encourage behavior change, and its platform enabled the use of a randomized control trial for the event, with a treatment group that received the targeted messages and a control group that did not. This approach helped ensure that the pilot would deliver meaningful and statistically significant results and provide an apples-to-apples comparison of behavioral DR results with those of traditional thermostat-based strategies.

Using a randomized control trial approach, Copper Labs calculated a reduction of 0.012 Dth per engaged customer over the course of the event, with no appreciable losses associated with preheating or snapback. Copper Labs is currently expanding pilots with National Grid and other gas utilities in the Northeast, and is experimenting with new approaches, such as 24-hour events that have potential to better help with multiple gas system challenges if shown to be successful, and expanded real-time summaries enabling individual participants to compare their performance to the full participant cohort during events.

In comparison with automated DR measures involving controls such as smart thermostats or water heater controllers, behavioral strategies that use messaging and/or monetary incentives may have potential to yield sustained savings over an extended period since they more directly engage customers in order to generate support for the initiative. Because behavioral approaches tend to be a lower-cost measure (since they don't rely on in-home hardware, and in some cases may not even involve monetary incentives), they can often be expanded across a much wider range of customers compared with automated control-based programs, facilitating more rapidly scaled deployments. They may also represent a more equitable way to engage low- to moderate-income households or customers in priority communities since they can avoid the use of expensive smart home devices, and potentially even obviate the need for in-home Wi-Fi depending on the data collection and messaging strategies used. However, granular consumption data collection is essential in order to accurately assess the impacts of load reductions, and rapid data backhaul is important both to help engage customers during the event and for utilities interested in developing performance-based rebates that could potentially improve customer responsiveness and deepen load reductions.

Conclusion

Load flexibility has myriad potential benefits for gas utilities as part of an emerging portfolio of NPAs, from supporting reliability and decarbonization efforts to bolstering affordability and enabling improved multi-resource system planning. However, the approaches and techniques used to implement gas DR and load flexibility should be different from those used by electric utilities given the different system needs, and particular care should be taken to account for the effects of preheat and snapback, along with potential customer impacts. While a number of gas utilities are currently experimenting with automated smart thermostat-based programs and have seen promising results over shorter durations of a few hours (similar to electric DR events), these initiatives face potential challenges when implemented over extended time frames at scale due to preheat/snapback losses, reduction of customer amenity, and potential equity issues given the reliance on in-home equipment supported with robust Wi-Fi networks. Water heater programs also offer some potential for gas load flexibility, but face additional hurdles associated with initial installation and program engagement. Finally, behavioral programs have been relatively little-studied to date, but may offer significant potential by directly engaging customers over different timescales in a scalable and equitable manner, particularly if supported by timely performance-based incentives and established social norming techniques.

Given both the critical opportunities and comparative dearth of generalizable results to date, it’s clear that more research is needed across a variety of residential load flexibility measures and programmatic strategies to better understand best practices for meeting multiple emerging utility needs. Going forward, gas utilities may be well-served by experimenting with both shorter event durations of several hours to help serve as a first step towards weeding out less effective strategies and reducing the potential for any extended customer dissatisfaction, along with longer event durations approaching a full day or more to help better establish which strategies may be most effective in reducing gas peak demand in a deeper and ultimately more beneficial way for the system as a whole. Beyond the measures themselves, gas utilities should also consider different approaches regarding incentives and customer engagement to help ensure that future programs are as effective as possible. Ultimately, as gas utilities race towards an uncertain future that promises significant change on multiple fronts, new NPAs and load flexibility strategies represent a critical and exciting opportunity to help manage the system and continue to meet customer needs.

References

A. Bickle, Wisnefske, M., Kornelis, A., Hicks, A., Lavelle, L., and Ellsworth, A. 2022. *Consumers Energy Smart Thermostat Winter Pilot Program Evaluation Report 2022 Program Year*. Boulder: Cadmus.

AEU. 2024. *A Regulator's Blueprint for 21st Century Gas Utility Planning*. Prepared by Strategen. Washington, D.C.: Advanced Energy United https://www.strategen.com/strategen-blog/aeu-gas-utility-planning.

AGA. 2022. *Net-Zero Emissions Opportunities for Gas Utilities.* Prepared by ICF. Washington, D.C.: The American Gas Association https://www.aga.org/globalassets/research--insights/reports/aga-netzero-emissions-opportunities-for-gas-utilities.pdf.

Con Edison. 2022. *Gas Demand Response Report on Pilot Performance – 2021/2022 Winter Capability Period*. New York Public Service Commission Case 17-G-0606. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={AD51AA7B-5BD2-4A9B-AE57-720C636ED6C0}.

Copper Labs. 2022. *Harnessing Real-Time Data To Keep The Heat On*. Boulder: Copper Labs. https://www.copperlabs.com/harnessing-real-time-data-to-keep-the-heat-on/.

ICF Canada. 2022. *Non-Pipe Solutions Status Update Final Report*. Submitted to FortisBC. Ottawa: ICF Canada.

Johnson, R. 2024. *Gas demand response: Pilot and program design and results*. Boulder: E Source. https://www.esource.com/report/129232rwyj/gas-demand-response-pilot-and-program-design-and-results.

Lam, L., R. Hledik, N. Northrup, and X. Bartone. 2023. "Overview of Gas Demand Response Programs." Memorandum e-filed with the Colorado PUC. Washington, DC: The Brattle Group.

McKay, T. 2024. *Catalog of smart thermostat and demand response programs*. Boulder: E Source. https://www.esource.com/report/1292304pff/catalog-smart-thermostat-and-demand-response-programs.

Nadel, S. 2023. *Impact of Electrification and Decarbonization on Gas Distribution Costs*. Washington, DC: ACEEE. https://www.aceee.org/research-report/u2302.

NARUC. 2023. *Memorandum On the Creation of the Gas- Electric Alignment for Reliability (GEAR)*. Washington, D.C.: the National Association of Regulatory Utility Commissioners. https://pubs.naruc.org/pub/AA9B903D-D6CD-18AE-EA5B-DF611AB4C68C.

National Grid. 2023. *Firm Gas Demand Response 2022-23 Annual Report*. New York Public Service Commission Case 20-G-0086. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={0077C088-0000-C935-9F82-99E9976C45D0}.

Nexant. 2019. *2018-2019 Winter Load Impact Evaluation of SoCalGas Smart Therm Program*. CALMAC Study ID SCG0224.

Snell, E., P Narbaitz. 2022. "Defining the role of gas utilities in a decarbonized energy future". In *Proceedings of the 2022 ACEEE Summer Study on Energy Efficiency in Buildings*. Washington, DC: ACEEE. https://aceee2022.conferencespot.org/event-data/pdf/catalyst_activity_32489/catalyst_activity_paper_20220810190544291_c07b76e8_efdc_4cad_9e34_afd0a4d7dc61

Speake, A., P. Donohoo-Vallett, E. Wilson, E. Chen, and C. Christensen. 2020. "Residential Natural Gas Demand Response Potential during Extreme Cold Events in Electricity-Gas Coupled Energy Systems." *Energies* 13 (19): 5192. https://doi.org/10.3390/en13195192

West Hill Energy and Computing. 2021. *Aquanta Impact Evaluation Final Report*. New York Publish Service Commission Case 15-M-0252. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={2FB97955-7490-441E-A5F2-1F42DA2B402F}.

Washington Gas. 2023. *Goal Assessment Report: Washington Gas Demand Response Pilot*. Maryland Public Service Commission Case No. 9648. https://webpsc.psc.state.md.us/DMS/case/9648.