

Pulling Out All the Stops: Gas Utilities Poised for Best-in-Class Bi-National Market Transformation

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ABSTRACT

North American policy makers are developing aggressive decarbonization targets to equitably reduce greenhouse gas (GHG) emissions while maintaining power reliability, with most current solutions and discussions focused on renewable energy and electrification of homes, businesses, and transportation. Diverse solutions are required to equitably decarbonize the economy, with considerations for local and regional factors, such as consumer preferences, climate type, and existing infrastructure and grid composition. Gas heat pumps are one promising solution that can support decarbonization policy objectives by providing significant energy efficiency improvements, GHG emission reductions, and reductions to consumers' energy bills.

The North American Gas Heat Pump Collaborative is a nonprofit organization founded by 14 North American gas and dual-fuel utilities and energy efficiency program administrators to fight climate change, drive thoughtful decarbonization, and identify innovative solutions to maintain affordability. The Collaborative's purpose is to accelerate the adoption of innovative gas technologies that facilitate the decarbonization of North America's gas network through market transformation initiatives, starting with gas heat pumps (GHPs).

The North American Gas Heat Pump Collaborative was incorporated to advance this technical solution through educational efforts and market transformation activities. The Collaborative will engage manufacturers, develop tools for supply chain actors, develop innovative program designs, and support product specifications to advance the adoption of GHPs in North America in support of decarbonization policy objectives.

Introduction

The North American Gas Heat Pump Collaborative (Collaborative) is a non-profit organization that initially formed in 2020 as a loose collaboration to accelerate the adoption of innovative gas technologies that facilitate the decarbonization of North America's gas network through market transformation initiatives. The Collaborative incorporated in December 2021, with 14 North American gas and dual-fuel utilities and energy efficiency program administrator members.¹ The combined territories of Collaborative members represent more than one-third of all Canadian and US households that use natural gas.

¹ Initial members included: APGA Research Foundation (representing 150 municipal gas utilities), ATCO, Enbridge Gas, FortisBC, Intermountain Gas Company, National Fuel, New Jersey Natural Gas, Northwest Energy Efficiency

The Collaborative seized on the growing consensus that all sectors need to reduce carbon emissions to mitigate the most severe impacts of global climate change from power generation, transportation, and end use consumption. Collaborative members identified a need to accelerate energy efficiency program offerings, and a critical need to go beyond traditional thinking and also address decarbonization in North America. Member organizations are embracing GHG reduction goals and have identified the Collaborative as a valuable forum through which to coordinate, share best practices, and bring the weight of their combined markets.

The group's initial focus is on ramping up the adoption of gas heat pumps (GHPs). GHPs provide a significant improvement in heating efficiency—literally going from efficiencies of less than 100% to efficiencies well above 100% —for residential and commercial buildings. In 2019, GHG emissions from residential and commercial buildings represented approximately 13% of total US GHG emissions (US EPA 1990-2020), and approximately 17% of Canadian GHG emissions (NRCan 2018).

Gas Heat Pumps: Primed to Support Decarbonization

GHPs are a super-efficient technology used for space heating, space cooling, and/or water heating applications in the residential and commercial sectors. They operate similarly to electric heat pumps in that they move heat from one place, “the source,” to another place, “the sink,” using refrigerants and heat exchangers. GHPs use the combustion of natural gas to drive the heat pump system, which allows the heat pump system to capture waste heat from the combustion process to improve the system's overall thermal efficiency. Electric air source heat pumps only use air as the heat source, so when temperatures drop below freezing, electric systems struggle to maintain efficiencies and supply sufficient heat; they often must use supplemental heating, such as electric resistance heat, to properly heat the building (Gilman 2022). The use of natural gas allows GHPs to efficiently operate in cold climates since the systems can maintain high effectiveness even as temperatures drop. Unlike traditional gas furnaces, boilers, and water heaters that can approach but not exceed 100% efficiencies, GHPs typically achieve operational efficiencies of greater than 100% by capturing readily available heat from the ambient air. Figure 1 illustrates how GHPs can achieve these high efficiencies.

Alliance (representing Avista, Cascade Natural Gas, Energy Trust of Oregon, NW Natural and Puget Sound Energy), ONE Gas, Peoples Gas and North Shore Gas, South Jersey Industries, SoCal Gas, Southern Gas Company (representing Atlanta Gas Light, Chattanooga Gas, Nicor Gas, and Virginia Gas), and Spire.

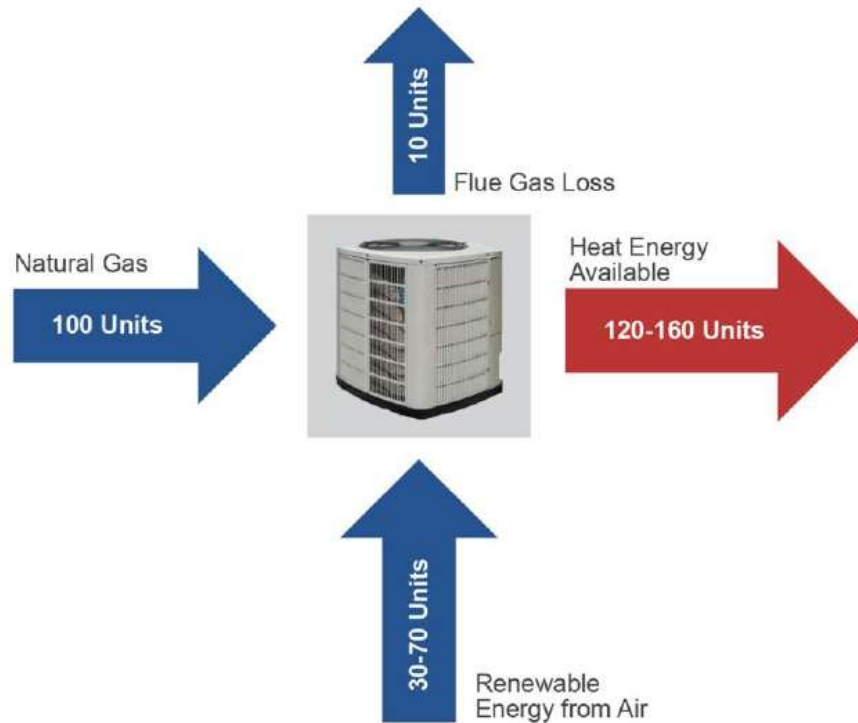


Figure 1. Example how GHPs use natural gas to operate at greater than 100% efficiencies. *Source:* ESC 2021.

In addition to their operational efficiencies, GHPs offer additional advantages (ESC 2021), including:

- Ability to operate on renewable natural gas and hydrogen to further reduce emissions
- Ability to operate using refrigerants with very low or no global warming potential in some configurations
- Adoption does not increase electrical load and therefore does not place additional burden on the electrical grid
- Fewer retrofit barriers than other GHG reduction alternatives
- Lower operating costs than both existing high-performance gas and electric alternatives

Holistic View of Energy Consumption and Associated Emissions. An important, yet under-recognized, decarbonization strategy consideration is the *total* emissions associated with energy-using equipment. Energy efficiency programs primarily measure onsite performance: that is, they count energy savings and associated GHG emissions reductions based on the improvement at the customer’s home or business, known as “*site*” energy/emissions. However, GHGs are also produced in converting raw fuel to electricity or heat, and in transmitting and delivering energy to a site: this is referred to as “*source*” energy/emissions. Promoting onsite energy efficiency improvements, and developing programs focused exclusively on site-level

savings, can have unintended consequences on overall GHG emissions and customer energy costs. A recent U.C. Davis study that modeled the total impact to carbon dioxide emissions from a complete electrification of the residential heating sector showed mixed results (Dichter and Aboud 2020). Using the current grid composition, the researchers found an overall decrease in CO₂ emissions in only 15 US states; in the other 33 states modeled, the researchers found an overall increase in CO₂ emissions when all residential gas heating was converted to electric heating. Another recent study examined the impacts of a variety of gas and electric heating systems on total energy consumption (measured in MMBTUs), customer energy costs, and GHG emissions for a prototypical home in northern Illinois. Table 1 compares these metrics across gas and electric heating systems of varying efficiencies. The table illustrates that while the electric heat pump uses the least site energy of all the systems examined, it uses more source energy, costs more to operate, and emits more than the other systems (Manjarres and Dusault 2020).

Heating System Analysis for a 1,000 ft², 2br Townhome in Rockford, IL				
	80% AFUE Gas Furnace	96% AFUE Gas Furnace	3.8 SCOP Electric Heat Pump	1.4 SCOP Gas Heat Pump
Site Energy* (MMBtu)	42.65	35.68	16.89	24.41
Source Energy (MMBtu)	44.90	37.93	49.50	27.55
Annual Operating Cost (\$)	\$482	\$408	\$641	\$302
Annual CO _{2e} Emissions (tons CO _{2e})	2.71	2.29	3.05	1.67

*NOTE: The electricity required to operate the draft inducer fan, blower fan and refrigerant pump are included in all calculations.

Table 1. Energy consumption, operating costs, and GHG emissions by heating system type. Adapted from Manjarres and Dusault 2020.

The composition of fuel sources that power the electrical grid vary regionally, and the transition to low- or zero-carbon grids across the US will take time. As the power grid transitions away from fossil fuel-based generation, GHPs can provide an effective near- to mid-term solution that lowers overall GHG emissions while also offering a cost-effective solution to customers.

GHPs show tremendous potential to reduce end use consumption, associated GHG emissions, and customer energy costs. They are a promising and necessary solution for cost-effective and prompt decarbonization. However, GHPs are in the early stage of market adoption: several products are expected to enter the market within the next year, and others are near commercialization stage. The market support needed to “mainstream” GHPs aligns well with the Collaborative’s goal of accelerating the adoption of super-efficient GHPs by residential and

businesses customers through market transformation best practices that support energy savings and GHG reduction goals.

More than One Technology Solution: Several types of GHPs are currently, or will soon become, commercially available in the North American market. The different technical solutions provide varying end use applications: some systems are designed solely for space heating systems, while others combine space heating, space cooling, and sometimes water heating. GHP technologies are described below.

Absorption GHPs combust natural gas to heat a solution of water and ammonia or lithium bromide in a sealed absorption circuit. Absorption GHPs are hydronic systems—they transfer heat (or cooling) via the solution to heat (or cool) the air or water—and operate similarly to a vapor compression cycle. Multiple configurations of absorption GHPs are currently available, with different configurations providing heating and/or cooling for different end uses (ESC 2021).

Adsorption GHPs work by boiling a refrigerant and extracting heat from the ambient air. After the refrigerant boils, a salt absorbs the refrigerant vapor, delivering heat to the space through the absorption process. The saturated salt is then dried, or desorbed, by supplying heat to the salt to release the ammonia vapor. As the ammonia vapor condenses, it delivers additional heat to the space (ESC 2021).

Gas engine-driven heat pumps utilize a vapor compression cycle, similar to that used by electric heat pumps, but employ an efficient reciprocating engine fueled by natural gas, instead of an electric motor, to compress the vapor (ESC 2021).

Thermal compression heat pumps are a new type of efficient heating, cooling, and hot water appliance. They use a unique thermodynamic cycle powered by the combustion of natural gas to cycle thermal energy. Thermal compression heat pumps heat helium to increase its pressure, then remove the heat and send it to the space or the water where heating is desired.

As heat is removed from the helium, its pressure drops, which causes a cooling effect. If desired, this “cooling” can be removed and sent to space where cooling is desired. The thermal compression heat pump cycle creates a pressure wave that “pumps” recovered heat from the cold end to the warm end, and this heat pump effect increases the unit’s operating efficiency. Unlike other heat pump technologies, thermal compression heat pumps do not use a substance’s phase change to enable the movement of heat. Further, thermal compression heat pumps do not use any ozone depleting refrigerants (ESC 2021).

Collective Action to Jump Start the GHP Market

The formation of the Collaborative brings together like minded North American gas and dual-fuel utilities and energy efficiency program administrators to work on the advancement of super-efficient gas technologies in support of decarbonization policy goals. The Collaborative aims to transform the North American space conditioning and water heating markets by accelerating the adoption of GHP products by building market demand. Since GHPs are nascent technologies in North America, their accelerated adoption will require comprehensive support. The Collaborative’s plan is to provide some of that support, while also acting as a recognized leader and trusted advocate for highly efficient gas technologies.

The Collaborative’s activities include building awareness, developing messaging on the value proposition, and engaging manufacturers to bring products to the market. The organization

provides a forum to share best practices, develop consistent messaging, and provide a trusted point of contact for key stakeholders, such as GHP manufacturers and HVAC distributors. The Collaborative aims to simplify how the technology is introduced to new actors and customers, and to minimize marketplace confusion about the technology, by developing consistent messaging up and down the supply chain. Member organizations, which together represent almost one-third of residential households in North America, have come together under the Collaborative banner based on the belief that there is strength in numbers when implementing market transformation activities. Members share the costs and findings of market research, marketing, program design, and outreach and engagement. They recognize the need for action and support beyond simple rebate offerings on qualified products and aim to implement activities to reduce or remove barriers to adoption. The organization is conducting activities designed to accelerate adoption of GHPs by proactively priming the market to embrace GHPs. Some of these actions include:

- Consumer market research – targeted market research on consumer decision making to identify potential barriers and opportunities to the adoption of GHPs. These findings will be woven into future actions.
- Stakeholder engagement – holding discussions with stakeholders in a variety of energy efficiency and policy forums to introduce the value of GHPs in meeting decarbonization targets.
- Supply chain outreach and engagement – educating and training supply chain actors to improve their familiarity, understanding, and comfort with GHPs, leading to their embrace of the technology. As trusted resources that can be key to customers' equipment purchase decisions, informed supply chain actors who are knowledgeable and enthusiastic about GHPs are critical to GHPs gaining a significant share of the space conditioning and water heating markets.
- Testing and specification support – since GHPs are new to US and Canadian markets, the Collaborative is supporting required equipment testing and validation to increase stakeholder confidence in their performance and reliability.
- New program designs with consistent offerings – exploring new channels to overcome barriers to customer adoption of GHPs and developing program designs that can be used across member service areas.

The following sections provide more information about select market transformation activities the Collaborative is undertaking to build market demand.

Market Characterization Research: Markets behave differently depending on the product being sold, the geographic market where the product is sold, and the end use for which the ultimate consumer is using the product. Residential buyers' purchase journeys are different from commercial customers' purchase journeys, and there are different intervention points within those journeys. The Collaborative performs product specific market characterization research to better understand purchase decisions, the supply chain, and potential intervention points along the supply chain where interventions can most effectively influence purchase decisions, across the footprint of member organizations. The Collaborative has funded research in residential water heating and residential space conditioning. These studies focused not just on factors

influencing the selection of the final product installed, but also on customer explanations about why a piece of equipment was replaced, general awareness of efficient technology options, and other data points that are useful in constructing a better understanding of how residential customers think about energy efficiency when replacing a mechanical system.

The Collaborative funded four market characterization and supply chain market studies, focused on residential water heating and residential space conditioning.

The residential water heater supply chain market research sought a better understanding of the supply chain and the identification of opportunities through which a new product could gain traction. Researchers interviewed over 20 supply chain actors, including installers, manufacturers, and distributors. The research focused on exploring customer pain points, successful sales techniques, determining the products and features that are most in demand, attitudes towards new technologies, challenges associated with promoting and selling high cost and high efficiency units, the overall supply chain structure, and interactions between supply chain actors. Key findings include:

- Distributors and installers are key influencers in the decision-making process, but have limited exposure or knowledge of high-efficiency options and require tools and education to promote high-efficiency water heaters
- Customer interest in extended warranties is on the rise, especially for high-efficient units
- The high cost of high-efficiency water heaters still creates sticker shock among installers and customers, confirming that cost is still a primary barrier

For the residential water heater consumer market characterization study, researchers interviewed 1,800+ homeowners in Canada and the US to delineate the complete consumer purchase journey, exploring motivations and triggers, pre- and post-installation satisfaction, and garnering a better understanding of the current state of water heater ownership, reasons for replacement, and influences on the purchasing decision. Key findings include:

- Nearly two-thirds of respondents voiced concerns about the cost to purchase and/or install a new water heater, while nearly one-third were concerned with how quickly a new unit could be installed and finding a reputable installer
- Three-fourths of consumers who replaced water heaters considered it to be an emergency and had a new unit in place within 48 hours, while three fifths of those not considering it to be an emergency also had a new unit installed within 48 hours
- Installers had a considerable influence on the final equipment choice, with nearly half of the respondents purchasing their new water heaters directly from a contractor
- While consumers considered a number of features, such as tank size, availability, warranties, and energy efficiency, respondents indicated that price was still the most, or one of the most, important factors
- Awareness of rebates and credits offered by utilities or other organizations was quite limited, with just under 50 percent of respondents indicating no awareness of a rebate or credit associated with a high-efficient water heater

The Collaborative-funded residential space conditioning supply chain market research sought to better understand and document the current landscape for central space heating

systems, current barriers and opportunities with those systems, the purchase path, regional opportunities and barriers, existing market opportunities for combination heating and water heating systems, and supply chain perspectives on the sale and installation of combination systems. Seventy supply chain actors across Canada and the US provided feedback to develop the recommendations and findings. Key findings include:

- Three entities in the HVAC supply chain are key to driving new product adoption: manufacturer representatives, contractors, and wholesalers/distributors
- The typical supply chain model may be evolving, shifting toward a manufacturer direct model
- Immense variability of HVAC systems exists within and between markets, so developing a clear value proposition for a residential combination system is critical
- Combination systems are relatively unknown in the supply chain; socializing the value of combination systems to the supply chain will require significant training and education

For the residential space conditioning consumer market characterization, researchers interviewed 1,000+ homeowners in Canada and the US to delineate the complete consumer purchase journey, exploring motivations and triggers, pre- and post-installation satisfaction, and garnering a better understanding of the current state of space conditioning ownership, reasons for replacement, and influences on the purchasing decision. Key findings include:

- Furnaces are the main type of central heating system consumers consider, get recommendations for, and purchase, with 84% of consumers moving forward with a furnace installation
- Interest in combination systems or dual fuel hybrid systems is low, but generated significantly greater interest among homeowners who currently have an electric-powered system installed
- Three-fifths of homeowners who replaced their heating system did so with the same unit type
- The price of the new equipment and its installation, and length of time required for the installation were the two issues about which respondents expressed the greatest anxiety

Members are using the findings from this research, and will use findings from future Collaborative research, to develop specific intervention strategies for programs in their service territories. The research approach makes this possible because the research was designed to identify regional differences in purchase decision-making and to inform members where to focus their supply chain engagement efforts once products come to market. This research also supports the development of coordinated activities among members, where appropriate, to bring the strength of the Collaborative's combined market to bear.

Manufacturer Opportunity Briefs: To supplement manufacturers' internal business cases for GHPs, the Collaborative developed market research-based summaries and collateral describing the value proposition of GHP products for the North American market. The Collaborative is sharing these opportunity briefs and working with GHP manufacturers to ensure manufacturers recognize the current market demand for high efficiency GHPs, and to highlight

that the demand is forecasted to continue for the foreseeable future. Government and utility drivers of this forecast are described below.

- The Pan-Canadian Framework on Clean Growth and Climate Change outlines Canadian governmental bodies' commitments to reduce GHG emissions. The Canadian government's roadmap to meeting their GHG emissions reduction commitments establishes these goals: 1) by 2025, all fuel-burning primary space heating technologies for sale must meet or exceed 90% condensing efficiency, and 2) by 2035, all space heating technologies for sale in Canada have an energy performance of greater than 100% (NRCan, 2018).
- In the US, state legislatures are debating climate policies that will affect the efficiency requirements of space conditioning equipment for the future. Super-efficient technologies are needed to replace existing space conditioning equipment as baselines and codes increase.
- Canadian and US Collaborative utility members are actively seeking new energy-efficient solutions for their customers that will also fulfill their own energy-efficiency goals.

Manufacturer Engagement: HVAC manufacturers gauge the temperature of the market to inform their research and development and investment decisions for next-generation products. While GHP manufacturers have expressed interest in developing commercialized GHP products and in scaling up production, they are not yet certain that the demand for next-generation gas products will be sufficient to warrant the required investment. Furthermore, major HVAC manufacturers are unaware of the need and role for super-efficient GHP products on the road toward economy wide-decarbonization.

Figure 2 lists manufacturers in the process of certifying residential-size GHP products in the US and Canadian markets. The Collaborative is engaging and building relationships with these and other manufacturers and technology developers to identify the market support they require to justify scaling up production of residential and commercial GHP products. The Collaborative will use the information it gleans through these relationships to identify future funding priorities and activities expected to result in the most effective market interventions.

Manufacturer	Type / Target COP	Primary Sector	Technology Readiness
	Absorption 1.2	Space and DHW heating	Commercially available in Europe
	Absorption 1.2	Space and DHW heating	Commercially available in China
	Absorption 1.2	Space and DHW heating	Available in North America soon
	1.2	DHW heating only	Evaluating Opportunity
	Thermal compression 1.6	Heating, DHW heating and cooling	Available in North America soon
	Thermal compression 1.6	Space and DHW heating	Lab testing

Figure 2. List of manufacturers pursuing certified GHP products.

Supply Chain Engagement: The commercialization of GHPs alone will not accelerate market adoption of this super-efficient technology. Accelerated market adoption also requires market actor awareness, familiarity, and knowledge about the technology so they feel comfortable recommending it to customers. Market actors throughout the supply chain must understand how GHPs operate differently from standard gas heating equipment and that they provide additional benefits. Furthermore, training and education needs will be different for distributors, contractors, and other supply-chain actors.

To that end, the Collaborative is developing market actor-specific messaging and engagement plans that leverage findings from market research and market transformation best practices to proactively engage and support different sets of actors. For example, the contractor engagement plan will be tailored to include the specific types of support and information contractors need to enable them to pivot toward GHPs and away from the HVAC and water heating products they have been recommending to customers and installing for years.

The Collaborative is acting as a “ringmaster” to ensure coordinated and consistent outreach and education about GHPs. Member organizations will coordinate their local outreach and messaging in alignment with the Collaborative. This approach is intended to standardize messaging and engagement around GHPs and to minimize potential market confusion about new GHP products. Consistent GHP nomenclature and terminology should allow similar conversations to happen at national and local levels and set appropriate expectations for the information each market actor needs to incorporate GHPs into their business models.

Program Design and Coordination: The Collaborative is also focusing on developing innovative program designs to support the adoption of GHPs in member service territories. Some members will pursue market transformation initiatives to promote adoption of GHPs in their

service areas. However, other members, cannot fully embrace market transformation activities due to regulatory and/or funding constraints but are able to invest in new implementation avenues to offer GHPs to their customers. The Collaborative is vetting a set of implementation pathways beyond typical rebate offerings—such as bulk purchasing, leasing programs, and on-bill financing—that, taken together, will address the specific needs, regulatory constraints, and funding constraints of all member organizations. This effort involves developing recommended rebate levels by program design, sharing lessons learned and best practices, and developing standardized collateral to educate and inform the market. The Collaborative hopes to act as a central repository of program offerings and activities, as well as serve as a resource for manufacturers looking to partner with utility-sponsored programs across North America. By providing as many resources and solutions as possible, the Collaborative will be a driving force behind the transformation of the North American HVAC and water heating markets.

Conclusions

Now operating as a 14-member—and growing—nonprofit organization, the Collaborative is starting with GHPs in its efforts to advance energy efficiency, fight climate change, and drive thoughtful decarbonization with innovative, affordable solutions. GHPs are a win-win-win for utilities, their customers, and the environment: they have efficiencies that far exceed those of competing gas space conditioning technologies, perform well in all climates, use less total (source and site) energy than competing electric and gas technologies in many locations, reduce customer utility bills, are readily retrofit into existing buildings, can be run on alternative, “greener” fuels, use refrigerants that contribute very little or nothing to global warming, and do not further burden heavily-loaded electrical grids.

The Collaborative is in the initial stages of transforming the residential and commercial sector space conditioning and water heating markets to accelerate and increase their adoption of GHPs. The group’s early work included market characterization and supply chain studies to inform the design of targeted intervention strategies. The group has also engaged with manufacturers and provided them with opportunity briefs showing the growing demand for GHPs, which manufacturers can incorporate into their investment decisions and business plans. To bolster both supply chain and customer awareness and knowledge about GHPs, the Collaborative is drawing on its market characterization findings to develop targeted, consistent outreach messaging about the technology tailored to each set of market actors. The group is supporting member utilities by developing a set of innovative program designs and implementation approaches members can adopt to promote GHPs in their service territories. The Collaborative also provides a wealth of information about GHPs on its website for members and non-members alike. By combining these, and other forthcoming, approaches to understanding and priming the market for GHPs, the Collaborative believes that GHPs will become an important, affordable, and equitable component of North America’s decarbonization strategy.

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