

Getting to Zero: The Critical Role of Demand-Side Management

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ABSTRACT

The race to net zero emissions is on. This paper summarizes the results of a sophisticated, economy-wide modelling exercise that analyzed how Québec, Canada can drive its economy to net zero by 2050, at the lowest cost. In particular, it points to the critical role of demand-side management (DSM) – including conservation, energy efficiency, and beneficial electrification.

Among other critical findings, the study found that to achieve net zero at lowest cost, **DSM has an even greater role to play than new renewable energy supplies.** The renewables buildout itself – required to supply an additional 473 PJ of electricity by 2050 – will of course require significant effort and investment. However, the scale of this build-out is limited by DSM, which enables a decrease in 2050 energy demand of more than 550 PJ. Failure to achieve the full extent of these energy savings could mean up to twice the required investment in renewables, increasing the cost *and risk* associated with attaining net zero.

This paper highlights the central role of DSM in one region's net zero transition, and the scale of effort required. It also points to the need to move far beyond what is cost-effective under current policies and embrace a more aggressive regulatory approach to ensure these energy savings are secured. Due to Québec's unique position as a province with clean electricity and already partially electrified heating, these findings suggest that other regions – which must both replace existing coal and gas *and* grow electricity generation – could stand to benefit even more from DSM efforts.

1 Introduction

The urgency to address climate change through the reduction of greenhouse gas (GHG) emissions is now more apparent than ever. According to the most recent report from the Intergovernmental Panel on Climate Change (IPCC), anthropogenic GHG emissions have already caused warming and rapid changes in the atmosphere, ocean, and on land (IPCC 2021). On the current trajectory, global warming is expected to surpass the 1.5°C target set by the Paris Agreement, and with each additional degree of warming the effects of climate change – including extreme weather events, floods, and increasing ocean acidity – could be even more severe, and significantly impact the planet. However, the IPCC's mitigation pathways project that reaching and sustaining net zero GHG emissions (defined on a 100-year global warming potential) could stabilize temperatures and mitigate the negative impacts of climate change. Within this context, policy makers are beginning to set aggressive emissions reduction targets – including Québec, which announced in 2020 a target of reaching net zero GHG emissions by 2050 (Government of Québec 2020).

In Québec, the energy sector accounted for 70% of overall GHG emissions in 2019 (Environment and Climate Change Canada 2021). Although electricity generation in Québec is >99% non-emitting (including 94% hydro, 5% wind, and <1% others including solar and biomass) (CER 2021), the use of fossil fuel based energy in the transportation, industrial, residential and commercial sectors remains substantial. Therefore, reaching net zero will require a significant transformation of the entire energy system. In other regions where electricity generation also emits GHGs – including the majority of other Canadian provinces and US states – the transformation required will be even more significant.

Although demand-side management (DSM) – including conservation, energy efficiency (EE), and beneficial electrification (BE)¹ – is not always at the center of the conversation regarding the energy transition, reducing the demand for energy services is an essential component in the race to net zero. According to the International Energy Agency (IEA), decreasing energy intensity in a net zero scenario could reduce global energy consumption by more than 1/3rd (IEA 2021b).

While the target of net zero GHG emissions by 2050 is clear, the pathway to achieving this target remains uncertain. Energy systems modelling is a useful tool for policymakers, as it can be used to provide a view of what energy systems could look like in a net zero future, and potential pathways towards this end goal, which can be used to inform policy direction. For example, the International Renewable Energy Agency (IRENA) has collaborated with many regions and decision makers – including the European Commission – to perform analysis using their internally developed energy system model REMap (Renewable Energy Roadmaps), which is used to identify renewable energy technology options and opportunities in all energy sectors and assess their costs and potential for contribution to climate and environmental objectives. The modelling highlighted that the EU had significant opportunities to increase the share of renewables in power generation, and the use of renewables-based heating, cooling and transportation technologies, providing insights for targets and policies to support the EU's decarbonization objectives (IRENA and European Commission 2018).

This paper summarizes the key findings of an economy-wide energy modelling exercise, undertaken in 2021, which analyzed how Québec could achieve its net zero target by 2050 at the lowest economic cost to society. These findings highlight that DSM plays a key role in Québec's lowest cost decarbonization pathway, decreasing energy demand by 26% compared to the reference scenario and reducing the need for new electricity capacity. DSM will be required across all sectors – however, this report focuses specifically on the key role of DSM in the buildings sector, where DSM measures reduce heating demand by 110 PJ.

The following section introduces the energy modelling methodology. Key findings related to the overall energy system transformations – including the role of DSM – are discussed in the subsequent section. This includes a deep dive into the buildings sector, which is shown to have a

¹ Beneficial electrification (BE) refers to replacing direct fossil fuel use with electricity in a way that generates benefits, such as a reduction in overall emissions or costs

high potential for DSM. Potential implications for policy and decision makers are also discussed. The final section summarizes conclusions and critical lessons going forward.

2 Methodology

Modelling was conducted using the North American TIMES energy model (NATEM), a least-cost techno-economic optimisation model which belongs to the TIMES family of models (IEA 2021a). TIMES was developed as part of the IEA's Energy Technology Systems Analysis Program (ETSAP), and continues to be maintained by the program's partners, including contracting parties in 20 countries, the European Commission and two private sector sponsors (IEA-ETSAP 2022a). It is currently used by partners in over 20 countries – including the Austrian Energy Agency, Brazil's Ministry of Mines and Energy, and the Joint Research Centre of the European Commission (IEA-ETSAP 2022b).

TIMES models describe the entire integrated energy system of a region, including various forms of primary energy, conversion technologies which convert primary energy into secondary energy, (e.g., natural gas to power), end-use technologies which transform secondary energy into energy services (e.g. power into vehicle miles travelled), and energy transportation technologies and infrastructure (Figure 1). The model considers the energy service demands of five major sectors – industry, commercial, residential, transportation and agriculture.

Demands for these energy services are defined for the studied time horizon (in this case, between 2016-2050). The time horizon is divided into 2-year (2016-2020) and 5-year (2020-2050) time periods, and each period is divided into sixteen time slices which represent four seasons (spring, summer, fall, winter) and four intraday periods (day, night, morning peak and evening peak). TIMES optimises for an energy system that satisfies the energy service demands of each sector (in each time period and time slice), as well as any imposed constraints (such as emissions reductions), at the least economic cost to society.

The economic cost to society includes all the capital and operating costs of the entire energy system (for example, the capital costs of all infrastructure and technologies, maintenance costs, and resource prices. Energy prices are endogenous to the model and are determined the same way, using capital costs and maintenance costs for extracting/collecting and converting energy). The optimisation is also subject to technical constraints, such as the efficiency of conversion and end-use technologies.

NATEM describes the entire integrated energy system of the 13 Canadian jurisdictions, including Québec. The model is calibrated on a 2016 base year, and for additional years as data becomes available (at the time this study was completed, 2016-2019), using energy supply and demand data from numerous sources, including Statistics Canada and the Office of Energy Efficiency (Office of Energy Efficiency 2020; Statistics Canada 2020a; 2020b).

One set of key inputs to the model are the energy service demands for each jurisdiction. Historical and current demands for energy services are defined for using numerous data sources, such as the Comprehensive Energy Use Database from the Office of Energy Efficiency (OEE) (Office of Energy Efficiency 2020), and projected to 2050 according to macro-economic drivers

such as GDP, population, and household growth. NATEM also includes resource availability and renewables potentials for each jurisdiction. Other key inputs for the model are the techno-economic attributes of technologies, such as investment and operating costs, efficiencies, capacity factors, and emissions factors.² These are included in NATEM's library which contains thousands of actual and future technologies.

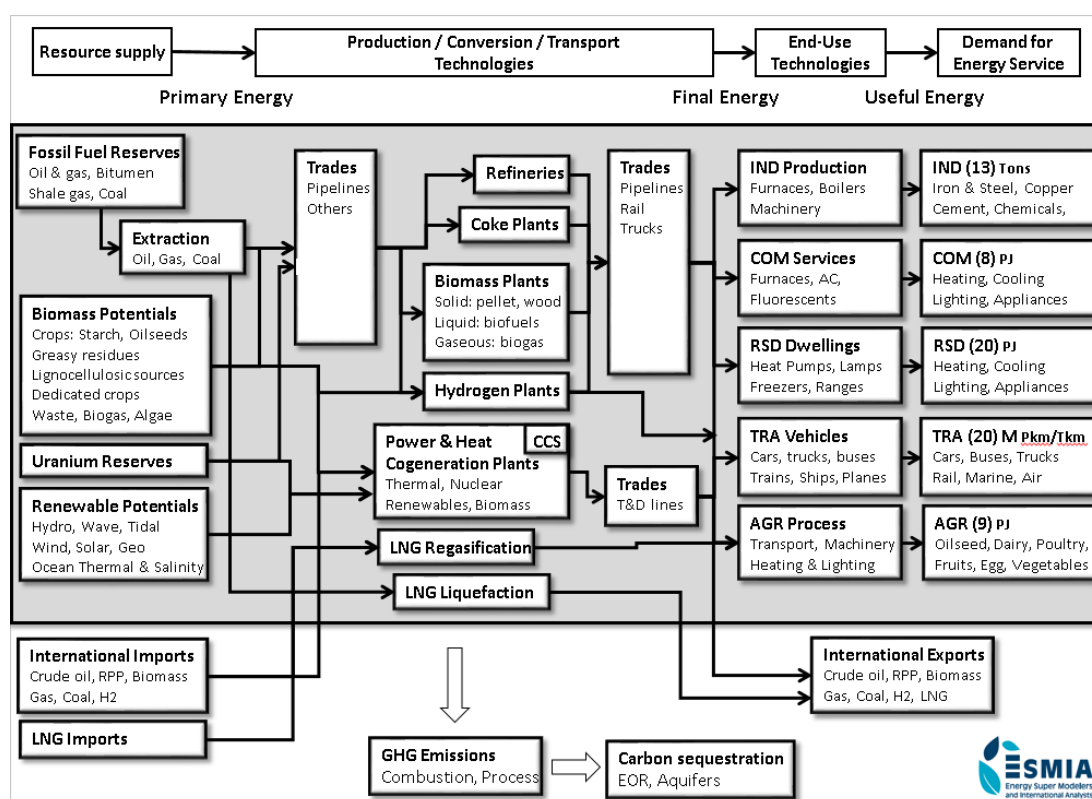


Figure 1 – Representation of an energy system in the North American TIMES Energy Model for a given region (Vaillancourt et al. 2018)

The main outputs of the model include the energy use (TJ) by energy type for each sector/subsector, energy supply by type (i.e., the installed capacity (MW) and generation (MWh) of electricity by energy type, the supply (TJ) of biomass by feedstock type, and the production (TJ) of hydrogen via different production pathways), and the GHG emissions associated with each sector/subsector. Outputs are provided for each time period (2- or 5-year intervals).

In order to model over a long-term time horizon, the model includes assumptions regarding how costs and efficiencies of technologies will evolve over the period modelled (for example, to account for expected improvements in efficiency and falling costs of emerging technologies such as electrolyzers, batteries, etc. between now and 2050). Only documented technological improvements (e.g., forecast of cost reductions for a specific technologies) are included, as opposed to a generic technological improvement affecting all technologies.

² Emissions factors express the amount of GHG emissions (tCO₂e) released to do a given amount of a certain activity. (i.e., tCO₂e/kWh for electricity production from a gas turbine).

As a techno-economic model, it should be noted that market trends and adoption rates are not considered. The modeling results highlight the lowest cost pathway to achieving a given energy system target (in this case, net zero by 2050), assuming that technologies are implemented as soon as they become the least-cost option.³ This is a potential limitation as technology diffusion typically faces significant market (and other) barriers. However, policy and decision makers can use this information to inform the direction of policies and actions aimed at reducing these barriers and meeting this target.

Results are presented for the 2016 base year, as well as two modelling scenarios – a reference scenario (REF) and a decarbonization scenario (NZ50). REF includes the impacts of current policies and regulations, such as the Western Climate Initiative (WCI), North America’s only economy-wide cap-and-trade mechanism, of which Québec is a member, alongside California (Whitmore 2018). This leads to some emissions reductions, but nowhere near the reductions that are required to attain net zero emissions. The NZ50 scenario imposes a constraint on GHG emissions in order to attain net zero by 2050, without relying on the purchase of carbon credits from other regions through the WCI.

3 Key Findings

3.1 The Big Picture: Least-Cost Energy System Transition to Net Zero

Getting to net zero (NZ) at the lowest economic cost will require significant shifts in the energy system. As these findings highlight, DSM has a central role to play in enabling this transition, reducing energy demand by 26% in the NZ50 scenario and limiting the need for build-out of new renewable electricity capacity.

Today, fossil fuels such as natural gas and petroleum products supply half (50%) of Québec’s overall energy consumption, but under the least-cost NZ50 scenario, fossil fuel consumption drops by 80% by 2050. As highlighted by the modelling results, this is because DSM (including conservation, EE and BE), and non-emitting electricity are at the center of the energy system in the net zero scenario. Electricity supplies 71% of overall energy consumption in 2050. DSM, meanwhile, plays the biggest role. Already cost-effective energy savings keep total demand growth to just 0.6%/year in the reference scenario, and additional DSM bends the

³ The model accounts for the lifetime of technologies, with technologies typically being replaced at the end of their useful life. However, if the lowest-cost pathway to achieving the system target (such as net zero by 2050) involves early replacement, some technologies may also be replaced before the end of their useful life.

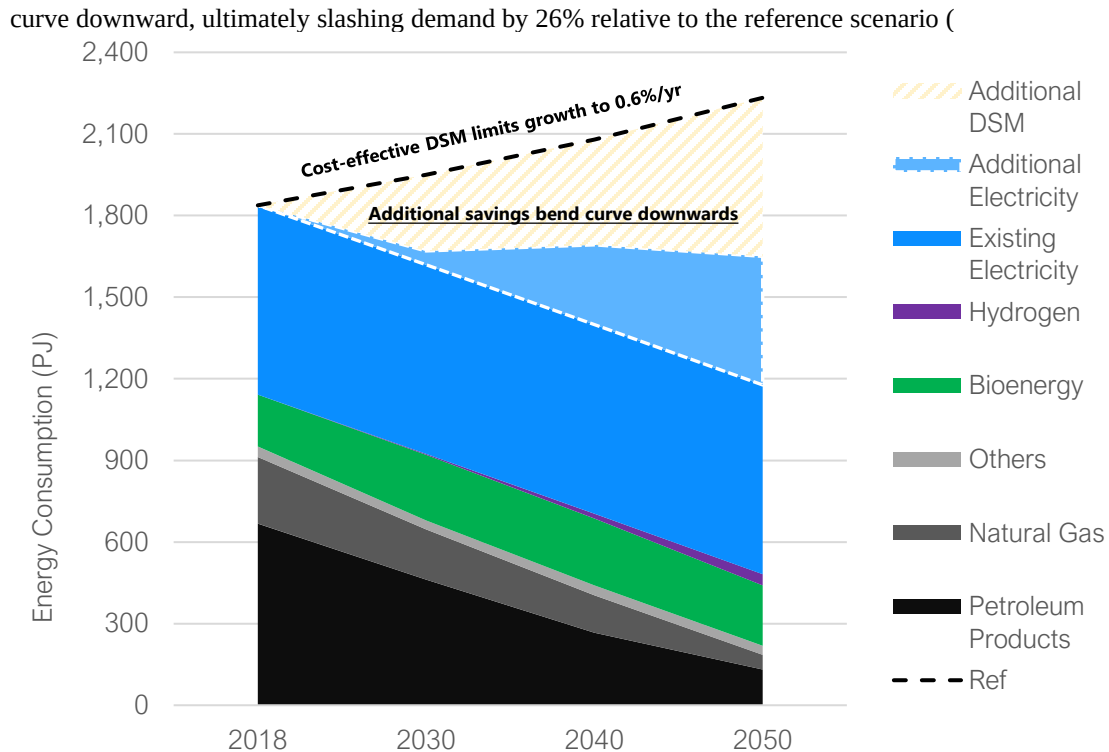


Figure 2Error! Reference source not found.). While these additional savings are not cost-effective under current policies in the reference scenario, they are a key part of the least cost pathway to net zero.

In order to meet increased demand – driven by beneficial electrification in the buildings, transportation, and industrial sectors – electricity supply will need to increase significantly (473PJ increase by 2050). In a net zero world, this electricity must also be non-emitting.

In Québec, current electricity generation is >99% non-emitting (primarily hydroelectricity, along with some wind and other renewables) therefore there is no need to decarbonize the current electricity supply (CER 2021). However, there is still a need for significant build-out of the electricity system to meet the increased demand driven by electrification. Electricity generation would need to increase by 65% (to 348TWh), and installed capacity by 2.3x (to 105GW) by 2050. This is in line with other global, Canada-wide and US-wide net-zero modelling results, which have shown that electricity generation will likely need to increase by 1.5 to >3x and installed capacity by 2 to >4x in a net zero world (EPRI 2021; ETC 2021; IEA 2021b; IRENA 2021; Larson et al. 2021).

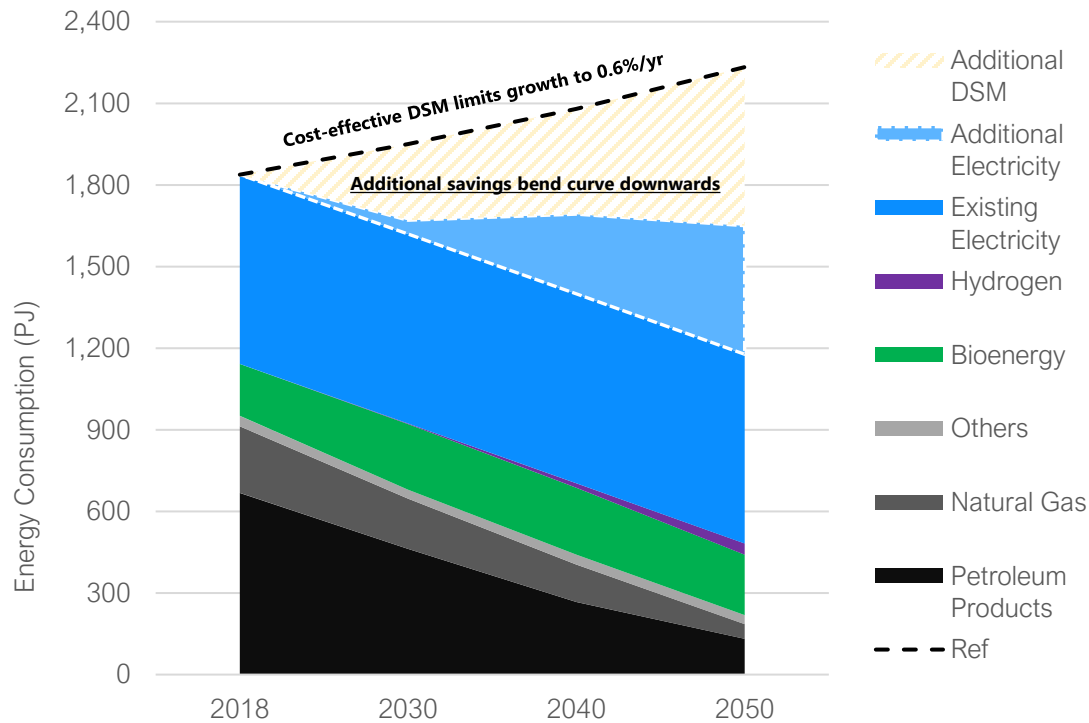


Figure 2 – Evolution of Total Energy Consumption in a Net Zero Scenario

Overall, the *additional* DSM savings reduce energy demand by 583PJ in 2050 compared to the reference scenario. These measures include three main components – EE, conservation (including behavioural changes, such as mode shift), and beneficial electrification. The buildings sector accounts for a significant portion (21%) of additional DSM and will be discussed in more depth in the following section. Further, it must be highlighted that the reference scenario itself is cost-optimized, meaning that it already accounts for all the available DSM savings which are already cost-effective under current policies. In practice, market barriers will impede many of these savings from happening, meaning that even further efforts will be required.

These additional DSM savings are even greater than the increase in electricity generation required. This is a critical take-away: it highlights that any DSM savings which are not achieved will increase the need for new electricity generation – potentially by up to over 2x. This would increase the cost of reaching net zero (given this is a cost optimized scenario), increase the pace of transformation required, and ultimately increase the risk of not reaching the net zero target altogether. Therefore, while DSM may seem to hold less importance in a net zero world where energy is decarbonized, these results highlight that in fact, DSM and emissions-free energy (especially electricity) are complementary, and both will be of key importance in meeting this ambitious target.

While DSM and electricity are most central to the net zero energy system, other energy types also play a supporting role – including bioenergy, which supplies 13% of energy consumption. However, the increase in bioenergy consumption is relatively small (16%), due to limitations on the amount of biomass feedstock that can be sustainably exploited within the province. There is also a strategic but limited role for hydrogen, which supplies only 2.5% of

energy consumption but helps to decarbonize the harder-to-electrify sectors, namely certain segments of heavy-duty freight transport and select industrial processes.

Finally, some fossil fuel consumption remains (11% of overall energy consumption in 2050) – however, where fossil fuels are still used, their emissions will need to be compensated with carbon capture and sequestration – either through direct carbon capture, or negative emissions technologies such as bioenergy with carbon capture and storage (BECCS) (Dunsky Energy + Climate Advisors and ESMIA Consultants 2021).⁴

3.2 Buildings: Electrification + Efficiency Pack a One-Two Punch

As mentioned, over 20% of the DSM savings are achieved in the buildings sector – particularly in space heating, where DSM reduces actual heating needs by 110PJ, and reduces overall energy consumption by 24% (predominantly due to EE and BE savings achieved through increased use of heat pumps).

Today, electric systems – primarily electric resistance systems such as baseboards, along with some air-source heat pumps (ASHPs) – make up the majority of Québec’s space heating technologies. Indeed, electricity currently supplies 55% of total heating demand in Québec and is the main type of energy consumed by buildings (68%). The first two graphs below (Figure 3 and **Error! Reference source not found.**) highlight the changes that would be required in the buildings sector in order to reach net zero, compared to the current situation and the reference scenario.

By 2050, electricity-based technologies supply 99% of heating in the least-cost net zero scenario (NZ50) (Figure 3). ASHPs take the largest market share, supplying 60% of total heating demand and displacing 98% of natural gas systems. Although the penetration of ASHPs also increases in the reference scenario, the change is less significant and more natural gas systems remain. Building energy conservation measures⁵ contribute to reducing overall heating demand by 110PJ, which is two times higher than the already-optimistic reference scenario.

Biomass heating systems are also displaced in the NZ50 scenario. This is primarily because bioenergy with carbon capture and storage (BECCS) becomes required in later years to generate negative emissions and meet the net zero target, and as mentioned above, the availability of sustainable biomass feedstock is limited.

⁴ Bioenergy with carbon capture and storage is a process where biomass is converted into useful energy (e.g. electricity, heat), and the CO₂ emissions are captured and geologically sequestered.

⁵ This includes measures such as retrofits (such as improved insulation) and controls (such as smart thermostats). These are modelled together as one general measure in NATEM.

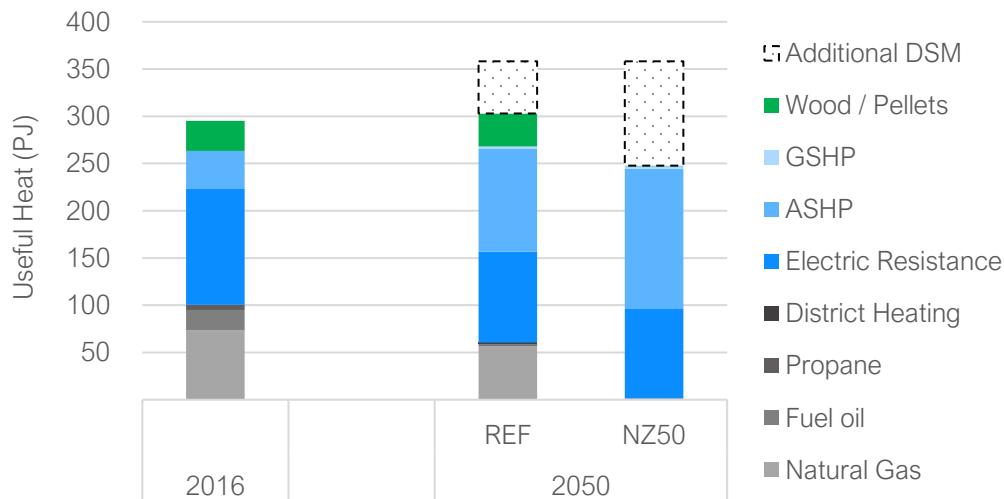


Figure 3 – Total heat delivered by space heating technologies in the buildings sector (residential and commercial buildings)

Overall energy consumption in buildings (including, but not limited to, energy consumed for space-heating)⁶ is significantly lower in the NZ50 scenario compared to the reference, and even slightly lower than it was in 2016 (**Error! Reference source not found.**). This is due to conservation measures which reduce heating demand, as well as due to EE and BE savings, because ASHPs are approximately 3 times more efficient than natural gas or electric resistance systems (Natural Resources Canada 2021). Therefore, less energy is required to supply the same heating demand.

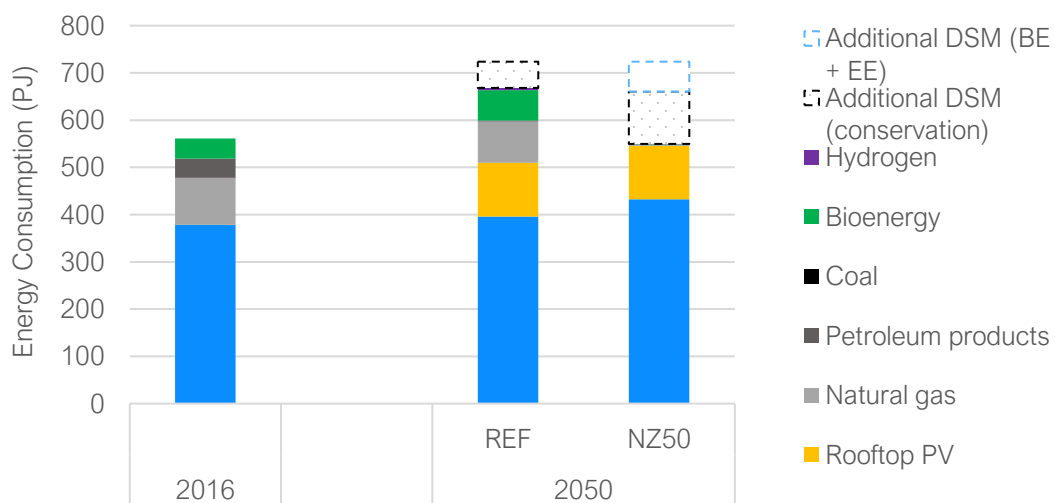


Figure 4 – Total energy consumption by energy type in the buildings sector (residential and commercial buildings)

⁶ Building energy consumption also includes lighting, appliances, and cooling. Although cooling technologies are not directly addressed in this study, it should be noted that heat pumps can also provide efficient cooling and replace air conditioners in many cases (Bertsch and Groll 2008).

When considering energy consumption by energy type, the results demonstrate that the consumption of electricity – particularly from de-centralized rooftop PV systems - does increase as non-electric systems are replaced with electric ones (**Error! Reference source not found.**). Other changes in the types of energy consumed also parallel the changes observed in Figure 3 – for example, the consumption of natural gas and biomass are reduced by 97% and 98%, respectively in the NZ50 scenario), as these heating systems are displaced.

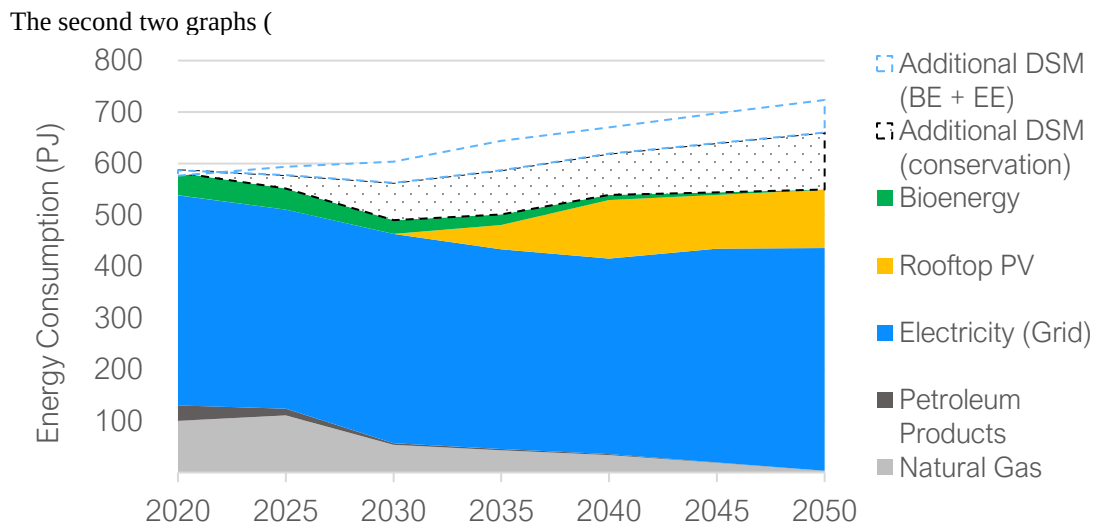


Figure 6 and Figure 7) highlight, specifically for the net zero scenario, how the changes seen by 2050 would evolve over time. As can be seen, the evolution of the space heating technology mix shows that in the short term (by 2030), there is already a significant decrease in both electric resistance and natural gas heating systems (Figure 5). Due to the higher efficiency of ASHPs compared to electric resistance (such as baseboards), replacing these technologies frees up excess electricity, which can then be used to replace non-electric (primarily natural gas) systems with electric systems.

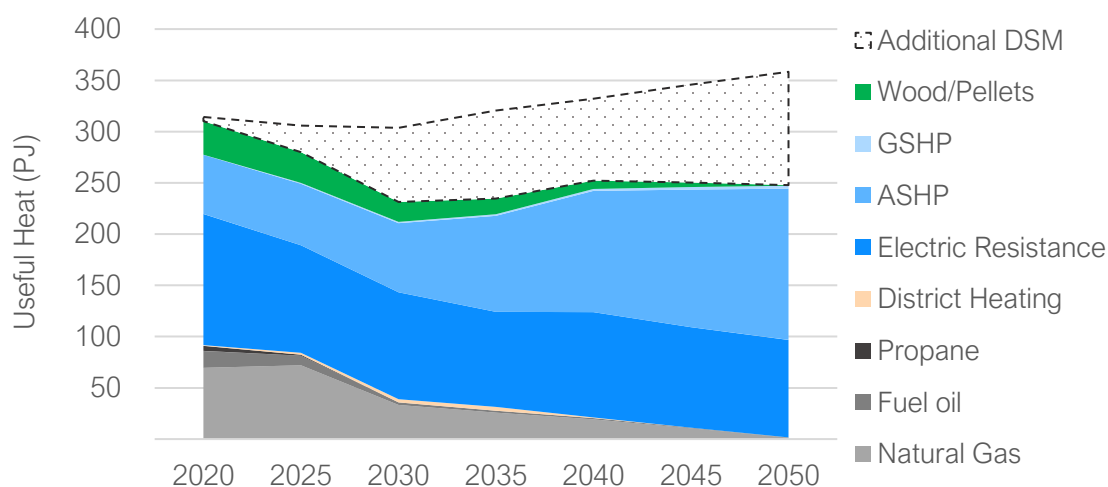


Figure 5 – Evolution of space heating systems in the net zero scenario

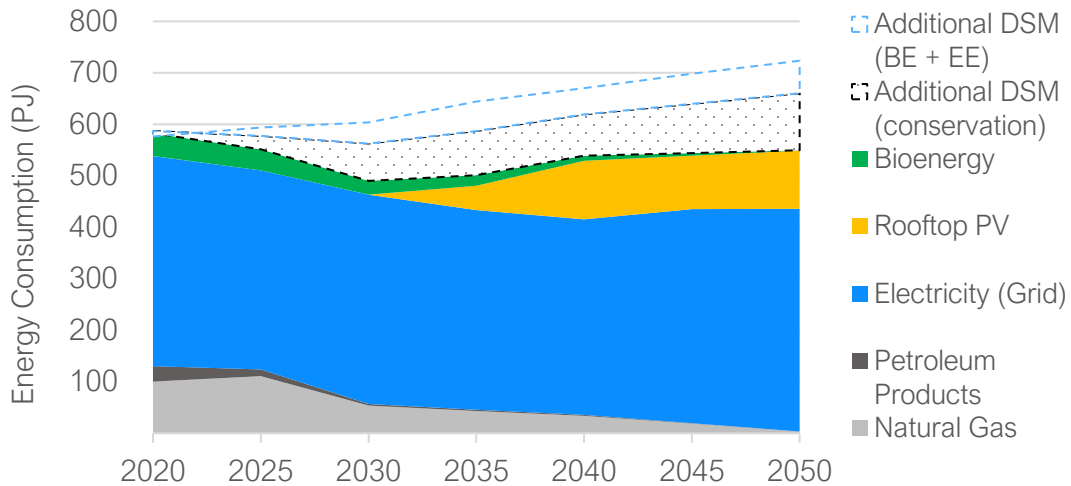


Figure 6 – Evolution of residential and commercial energy consumption by energy type in the net zero scenario

Combined with significant EE and conservation efforts that reduce overall heating and energy demand, this allows the initial electrification of heating to have minimal impact on overall electricity consumption, which increases just 7% between the 2016 reference year and 2030, while the consumption of natural gas and petroleum products decrease by 45% and 92%, respectively (Figure 6). The role of DSM is key in the near-term for allowing electrification of buildings to occur rapidly, while still allowing time for planning and build-out of the electricity supply and enabling short-term emissions reductions.

In the longer term (post 2030), the market share of heat pumps would need to continue increasing, replacing additional electric resistance and natural gas systems. Biomass systems are also replaced to free up biomass feedstock for other requirements such as BECCS, as mentioned.

Heating demand remains significantly lower compared to the reference scenario due to additional DSM savings beyond those which are already cost-effective under current policies (Figure 5), although demand does increase slightly overtime (post 2030) alongside growth in population and heated area. During this period, growth in centralized grid electricity consumption remains relatively low (6% between 2030 and 2050) – however, decentralized rooftop PV generation increases rapidly (

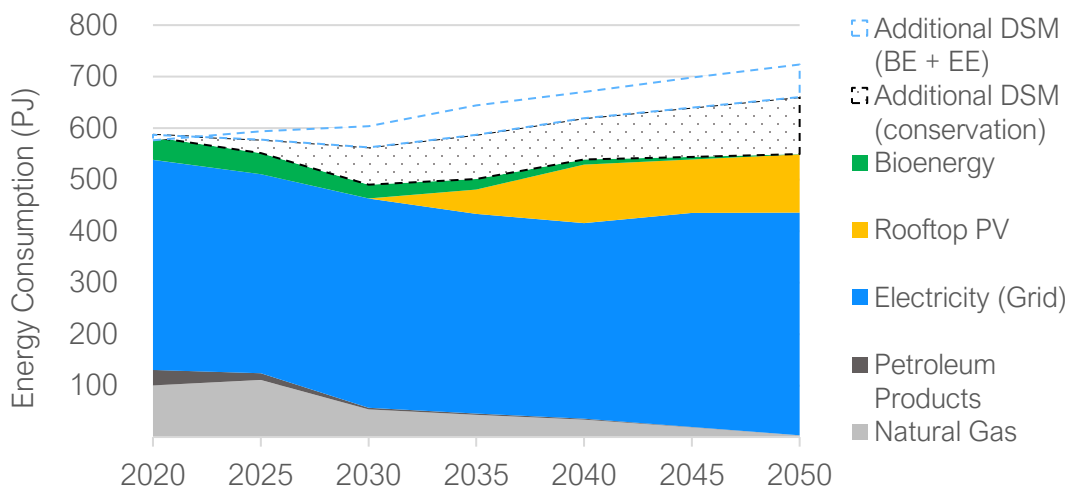


Figure 6). The use of decentralized electricity, also combined with demand response measures, can reduce potential costs associated with transmission and distribution, as well as reduce peak demand for the electricity grid, which becomes important in net zero as all sectors electrify and electricity becomes central to the energy system. By 2050, natural gas consumption in buildings is reduced by 97%.

The Dual Fuel Opportunity

Although not explicitly modeled in NATEM during this study, dual energy systems could play a role in this transition. These are space heating systems with a heat pump as the primary heating system, and a natural gas system (such as a boiler or furnace) as backup. The heat pump provides heating during the majority of the year, but when outside temperatures are too low for the heat pump to operate, the natural gas backup operates instead. Thus, natural gas is only used during the winter peak, significantly reducing natural gas consumption (and GHG emissions), while reducing peak demand and the need for build-out of electricity capacity.

This strategy can also be beneficial for natural gas utilities, which will be impacted by the significant drop in natural gas consumption. For example, in Québec, Hydro-Québec and Énergir (the main electricity and natural gas utilities) recently signed an agreement to offer a dual-energy rate to gas customers who opt to move to electric heat pumps for approximately 70% of their heating needs but retain gas for the remainder. Énergir will receive payment from Hydro-Québec, as compensation for the peak shaving service provided (Energir 2021).

In the near-term, this can enable natural gas customers to transition towards primarily electric heating at minimal additional cost and help accelerate the necessary electrification of heating. However, the long-term viability of this solution in a net zero world is uncertain, given the need to completely decarbonize heating, as well as the likely emergence of other cost-effective peak management solutions such as thermal storage systems and/or electric batteries.

3.3 Commercial vs Residential: Different Transition Pathways

The residential and commercial building sectors⁷ exhibit different transition pathways. Space heating in Québec's residential sector is already primarily (70%) electric, mostly due to electric resistance systems. By 2050, the residential sector's space heating is 99% electrified in the NZ50 scenario, and 80% of these systems are ASHPs. Electric resistance systems also remain non-negligible. DSM is particularly important in this sector, reducing overall energy consumption by 98PJ in NZ50.

Although the space heating demand in the commercial sector is less than half that of the residential sector, 80% of the heating demand supplied by natural gas comes from the commercial sector, and natural gas systems currently supply 65% of heating demand in this sector. In the net zero scenario, commercial space heating is 98% electrified by 2050 – however, the electrified heating is supplied primarily (77%) by electric resistance systems. Although

⁷ Residential includes single family and multi-unit residences (single detached, single attached, apartments and mobile homes).

electric resistance systems take up the largest share, ASHPs also play a non-negligible role in the commercial sector.

The higher penetration of electric resistance systems in the commercial sector is somewhat counter-intuitive, due to the significantly higher efficiencies of heat pumps. Other studies have shown higher adoption of ASHPs compared to electric resistance systems in commercial buildings – however, the penetration of electric resistance systems was also higher in the commercial sector compared to the residential sector by 2050. (Larson et al. 2021). This result merits further analysis in the future.

This being said, while ASHPs have a lower overall energy consumption, they do not necessarily offer any winter peak demand benefits over electric resistance systems in cold climates such as Québec, as they have minimum operating temperatures, typically between -15°C and -25°C (5°F to -13°F) and have significantly reduced heating capacity at cold temperatures. This reduction in capacity means that the cost of a heat pump sized to cover 100% of heating needs at all temperatures would be prohibitive, and the heat pump may not operate efficiently during milder conditions (as it will be oversized and need to cycle on and off to maintain the temperature setpoint). Therefore, heat pumps are typically supplemented by a backup system. In the case of a fully electric system, heat pumps are supplemented with electric resistance elements or electric baseboards.⁸

Therefore, the efficiency benefit of ASHPs alone (without peak benefits) may not be enough to outweigh the higher upfront cost in some cases in the commercial sector. Further, if electric resistance systems are paired with demand response (DR) and storage, their impact on peak demand could be significantly reduced (Baeten, Rogiers, and Helsen 2017).⁹

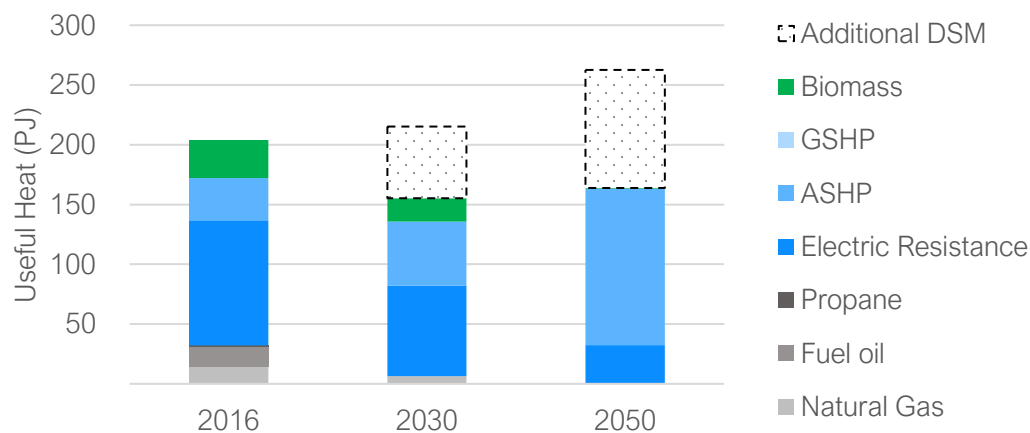


Figure 7 – Space heating technologies in the net zero scenario (NZ50) for the residential sector

⁸ Note that heat pumps may also be supplemented by a gas backup, in which case the system would provide winter peak benefits as no electricity would be used during peak (a dual fuel system, as discussed above)

⁹ Storage and DR can reduce the peak impact of ASHPs with electric resistance backups, as can GSHPs, which maintain a higher efficiency at low outdoor temperatures than ASHPs (Dunsky Energy + Climate Advisors 2020)

Although the number of electric resistance systems used in the commercial sector increases, the decreasing number of these systems in the residential sector is so significant that they are still reduced overall. This, plus the significant residential sector conservation opportunities that reduce overall heating demand, help to offset increased electricity consumption in the commercial sector as natural gas systems are replaced with electric resistance.

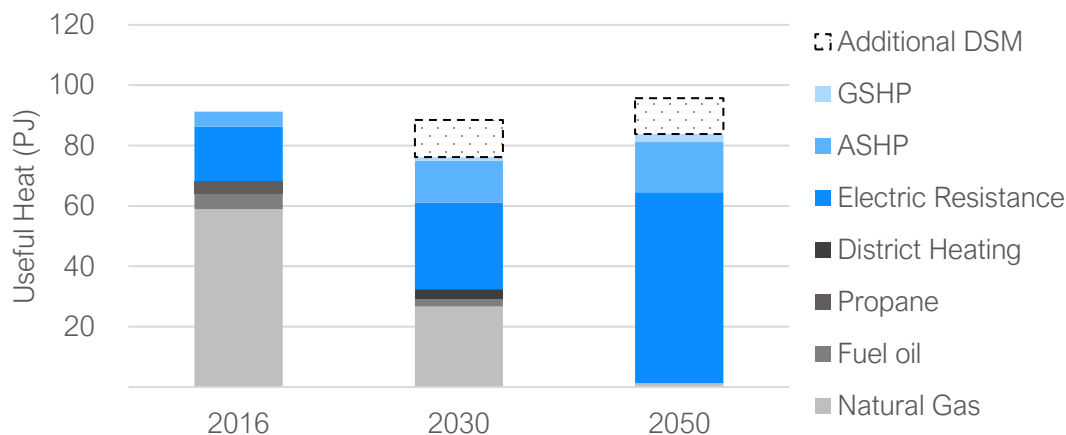


Figure 8 – Space heating technologies in the net zero scenario (NZ50) for the commercial sector

4 Implications: from Incentives to Requirements

The level of DSM (beneficial electrification, energy efficiency and conservation) improvements implied by these modelling results will require significant cost and effort. As discussed previously, these results only highlight additional DSM measures which are not already cost-effective, as 100% of the currently cost-effective DSM is implemented in the reference scenario due to the cost optimisation. The DSM savings discussed here are therefore over-and-above all DSM which is already cost effective under current policies and without imposed GHG constraints.

In reality, not all cost-effective DSM will be implemented under business as usual, and even greater improvements will be required. This likely means a transition away from reliance on voluntary efforts to improve energy efficiency, towards a far greater emphasis on codes, standards, and other regulatory levers. For example, the City of Vancouver recently passed a by-law requiring new low-rise residential space and hot water heating equipment to be zero emission, likely¹⁰ banning natural gas connections in these new homes (City of Vancouver 2022).

Equipment standards prescribing a minimum energy performance for space heating technologies can also benefit the transition. For example, the Government of British Columbia has set a target for all new heating equipment sold in the province to be at least 100% efficient ($COP \geq 1$) by 2030, effectively excluding the majority of natural gas and other petroleum-based

¹⁰ Conceptually, fully decarbonized natural gas (renewable natural gas and/or emissions-free hydrogen) may still meet these regulations.

systems (CleanBC 2021) – with the exception of natural gas heat pumps, for which COPs greater than 1 have been demonstrated (TAF 2018).

Building performance standards which set energy efficiency and emission requirements for buildings, such as those established in New York City in 2019, can also help to ensure targets are met (City of New York 2022). Building codes – both for new and retrofit buildings – can also incorporate energy and/or carbon intensity requirements. The Government of Canada has committed to developing a “net-zero energy ready” building code for adoption by 2030 (Government of Canada 2018).

5 Conclusion: Lessons for Québec and Beyond

Getting to net zero by 2050 will require unprecedented growth in clean electricity. Achieving the requisite scale of growth will, accordingly, present an extraordinary set of challenges, including technical, financial and (not to be underestimated, with public opposition to renewable energy projects becoming more widespread) public acceptance and permitting. In this respect, DSM plays a critical role: not only by reducing the cost of the scaling, but critically, by reducing the risk of the requisite scaling not taking place.

That said, the greater the pace of growth required, the greater these challenges and the associated risk of failure. This modelling found the degree of cost and risk mitigation offered by energy efficiency in Québec to be staggering. Yet it is also important to note that Québec’s unique characteristics – an already decarbonized grid, extremely flexible hydro resources¹¹ and a significant head start on heating electrification (particularly in the residential sector) – make its electrification challenge *less daunting* than elsewhere. Indeed, for the vast majority of U.S. states and Canadian provinces, where the clean power buildout must first replace existing coal and gas plants *and* at the same time grow faster given the lower existing level of electric heating, the cost and risk mitigation value of DSM savings are likely even greater.

Ultimately, decarbonization needs DSM to reduce both cost and, critically, risk – the risk of either needing to pivot to more expensive resources than electricity or, worse, of not achieving net zero at all. We undervalue this resource at our peril.

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¹¹ Québec’s substantial hydropower resources – over 35,000 MW (Hydro Québec 2022) – are unique in that they offer not only hourly and daily flexibility, but indeed seasonal *and even interannual* storage capabilities.

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