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Mind the Gap: The Impact of Budget Constraints on Ontario's Net Zero Plans

Ontario is facing a potential $14.8 billion shortfall between funding for its net zero plans and its goals.

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Mind the Gap: The Impact of Budget Constraints on Ontario's Net Zero Plans

by A. J. Goulding

- Climate change's urgency demands that rigorous cost-benefit analysis be performed on each energy transition expenditure. This publication calculates if there is a potential funding shortfall for Ontario's net zero targets relative to its current cost projections and the available sources to pay for it.
- Under an aggressive adoption scenario, annual available funding in Ontario totals $14.2 billion against an annual need of $29.0 billion – resulting in a potential shortfall of $14.8 billion. Meanwhile, an extreme scenario shows a shortfall of $6.1 billion with available funding for Ontario's net zero goals totaling $19.0 billion against an annual need of $25.1 billion.
- Budget constraints for clean energy investments are real and need to be considered in policy design. This suggests the need for a strong focus on least-cost planning, retaining optionality in system buildout, and sober thinking with regards to the expected pace of heating and transportation electrification.

Introduction

The need for thoughtful investment in net zero carbon emissions initiatives has never been greater. Unfortunately, net zero is not the only funding priority demanding attention from policymakers, who also must consider needs related to healthcare, housing affordability, transit, and education, to name but four. Plans to meet net zero goals require a transition away from unabated use of fossil fuels, including both electrification and carbon capture and storage. Energy transition spending is often accompanied by the claim that "we can't afford not to do it." However, simply making this statement doesn't necessarily cause funding to appear, and the statement is sometimes equally applied to other policy priorities. The urgency of climate change demands that rigorous cost-benefit analysis be performed on each energy transition expenditure, with an eye towards metrics such as the levelized cost of carbon abatement (LCCA) balanced against an

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assessment of the social cost of carbon.[1] Among the worst outcomes for climate change policy are start-stop initiatives (those started with great fanfare and then later modified or paused due to a backlash).[2] Restarting the initiatives often poses greater cost than if the project had proceeded to its initial expected conclusion. Such funding volatility often relates directly to perceptions about affordability.

The purpose of this paper is to assess at a high level the extent to which projected funding needs for energy transition initiatives can be met using existing mechanisms. To test whether there is a potential funding shortfall relative to current cost projections, we focused on Ontario, explored estimates of the cost of reaching a net zero electricity grid,[3] and surveyed the various sources of funding available to pay for it. While our approach is illustrative, it does suggest a significant – though not insurmountable – potential shortfall. Our calculations under an aggressive adoption scenario show annual available funding totals $14.2 billion against an annual need of $29.0 billion, resulting in a shortfall of $14.8 billion. While we are in no way suggesting that the province will choose to fund it, this shortfall represents 7.2 percent of the 2023 provincial budget, which was $204.7 billion (Ontario 2023a, 154). Our calculations under an extreme adoption scenario show annual available funding would total $19.0 billion against an annual need of $25.1 billion, resulting in a shortfall of $6.1 billion. The shortfall in this case is smaller because of higher cost recovery levels due to greater adoption of electrification, among other assumptions. This represents 3.0 percent of the 2023 provincial budget but assumes available federal funding doubles. Doubling federal funding would match US funding per capita under the combined budgets of the *Inflation Reduction Act* (IRA), Bipartisan Infrastructure Law (BIL) and the Creating Helpful Incentives to Produce Semiconductors (CHIPS) programs.

This suggests the need for a strong focus on least cost planning, retaining optionality in system buildout, and sober thinking with regards to the expected pace of heating and transportation electrification. While the funding gap can potentially be overcome, it will be much more difficult to do so if long-run, least-cost planning is not deployed.

Methodology

To determine whether there is a potential shortfall in funding for energy transition needs, we start with high level estimates of future costs from a credible agency. We then subtract current committed federal and provincial funding, which we call taxpayer funded initiatives.[4] We converted the difference to net annual incremental funding needs, bearing in mind a 2050 target date and industry cost of funds. We then identified four categories of funding sources. Incremental funding can come from increases in electricity rates for existing load, which in this paper we limit to consumers willingness to pay (WTP) as drawn from existing research on

1 The LCCA is the average lifetime per ton cost of carbon emissions abatement at an appropriate discount rate (Friedmann 2020, 21).

2 Examples include the recent exemption from carbon tax of fuel oil in the Atlantic Provinces, US states withdrawing (and in some cases rejoining) the Regional Greenhouse Gas Initiative, Ontario's Cap-and-Trade program which began in 2017 and was subsequently cancelled in July of 2018, or the various permutations of the Toronto Eglington subway (now LRT).

3 While a net zero electricity grid does not necessarily equate to a net zero economy, electrification of transportation and heating is one way to address carbon emission concerns. The costs considered in this paper arise due to the need to meet anticipated additional demand from electrification.

4 While there may be some taxpayer funded initiatives at the municipal level, these are not likely to be significant and may be indirectly funded by the province. Some additional funding may be available through other provincial and federal programs, such as for northern development.

Figure 1: Annual Budget for Energy Transition Components

Σ
- Taxpayers via Clean Investment Tax Credits, Canadian Infrastructure Bank etc.
- Annual residential incremental electricity WTP
- Corporate voluntary purchases
- Vehicle electrification
- Heating electrification
- EV fuel cost savings
- Natural rate of replacement embedded in current rates

= Annual budget for energy transition

Source: Author's compilation.

this topic; the purchase of voluntary renewable energy credits (RECs) by industry; payments for incremental load from vehicle and heating electrification; net savings on gasoline from switching to electric vehicles (EVs); and reinvestment of depreciation embedded in existing rates. These are summarized in the bullet points below and discussed in greater detail in subsequent sections.

- *Energy transition costs:* We began by seeking estimates of the cost of energy transition in Ontario by reviewing documents from the Independent Electricity System Operator (IESO). Because electrification is viewed by many as central to decarbonizing, IESO high level cost estimates provide an indication of a large component of the costs of energy transition.
- *Taxpayer funded initiatives:* Next, we reviewed various federal and provincial funding initiatives to determine whether these effectively fund a portion of the projected need.
- *Cost amortization:* To examine need on an annual basis, we amortized the costs over a reasonable asset life using the cost of capital for regulated utilities.
- *Willingness to pay:* We then used willingness to pay (WTP) studies to assess what the potential incremental amount would be that residential customers would be willing to pay for a cleaner electricity sector. For other types of customers, we examined the market for voluntary renewable energy credits (VRECs) as a conservative proxy for corporate willingness to pay.
- *Electrification:* Because both vehicle and building electrification represent incremental load – and thus incremental revenue – to the electricity system, we estimated the additional revenue from each activity at various levels of penetration.
- *Contribution from EV fuel cost savings:* Because EV fuel cost savings are substantial, we assume that a portion of these savings are available to contribute to costs of energy transition, including the aforementioned WTP.
- *Depreciation:* We next examined how much depreciation is embedded in current rates across the value chain, given that this represents funding that can be used for new assets that replenish the rate base. While this includes distribution, given the IESO includes in its estimates a 25 percent contingency[5] which includes funds for wires investment, it is appropriate to include distribution depreciation as a source of funding.

5 According to IESO, "the final totals for both capital investment and annual system cost include a 25 percent contingency. Adding a contingency is a consideration for unknown or unexpected factors and is commonly used for a study of this nature. In addition to capturing general cost uncertainty, which varies by resource type and technology readiness, it is also meant to capture out-of-scope costs (e.g., the build-out of distribution infrastructure, which will be considerable under the Pathways scenario) and the potential for adherence to more stringent reliability criteria, requiring incremental resources." (IESO 2022, 21)

- *Net need:* Finally, we summed the annual availability across all funding sources and compared it to IESO's high level estimates of potential need. A stylized equation is shown above.

Because the IESO scenario anticipates a high level of transportation and heating electrification, we have used what we regard as relatively high levels of adoption in performing the illustrative calculations. However, these levels of adoption are likely lower in the aggressive adoption scenario than those assumed in IESO modeling. Our extreme adoption scenario, discussed in the concluding section, is likely closer to IESO assumptions.

Net Zero Cost Estimates

To illustrate the potential costs of decarbonization, we started with analysis performed by the IESO to inform its "Pathways to Decarbonization" report to the Minister of Energy dated December 15th, 2022. IESO's "Pathways" scenario "focuses on 2050… the time frame in which the Ontario electricity system could be decarbonized." The scenario "assumes the decarbonization of the broader economy, which results in a significantly higher projection for demand based on substantial electrification within other sectors" (IESO 2022, 10.)

IESO emphasizes that the Pathways analysis is high level and is not an integrated system plan (ISP). However, even if it is not an ISP, the analysis is a structured approach to considering potential costs of a high electrification scenario, and is prepared by knowledgeable practitioners. IESO estimates that the cost of new infrastructure under the Pathways scenario would be in the range of $375 to $425 billion in current dollars (IESO, 35); for the purposes of our aggressive adoption scenario in this paper we have chosen to use the mid-point of $400 billion. IESO suggests that resulting system costs per unit of demand could be 20-30 percent higher than they are presently.

Taxpayer financing

Some portion of the costs identified by IESO will be covered by various federal and provincial initiatives. The Canadian federal government has announced over $80 billion in funding for energy transition-related activities, including $60 billion in various Clean Investment Tax Credits, $20 billion in investments through the Canadian Infrastructure Bank (CIB) in the Clean Power and Green Infrastructure priority areas, and $3 billion through Natural Resources Canada for the Smart Renewables and Electrification Pathways program and the Smart Grid program.

CIB investments are not grants; they need to be repaid. As such, the amount of the investment itself is not the contribution to net zero. Because the intended impact of CIB investments is to reduce the cost of capital for proponents, or to make capital available for projects that would otherwise struggle to gain financing, we have assumed the contribution to net zero costs is based on an interest rate discount of 300 basis points, or 3 percent. This means that the CIB loans have an annual value of $0.6 billion.[6] Assuming loans of 20 years,[7] this leads to an undiscounted value of the lower cost of capital of $12.0 billion. Discounted to the present at 5 percent, the value of CIB investments is approximately $7.5 billion.

Thus, for Canada as a whole, total taxpayer funding for net zero initiatives is $70.5 billion ($60 billion in tax credits, $3 billion from Natural

6 Our interest rate discount of 300 basis points is derived from the ICE BofA BB US High Yield Index Effective yield of 7.09 percent, minus the Canadian 20-year bond yield of 3.621 percent, minus 0.47 percent for any applicable fees. This gives us an interest rate reduction of approximately 3 percent, assuming CIB prices at close to its cost of funds.

7 This is less than the 30-year deemed asset life discussed subsequently. This is consistent with conservative lending practices which generally require a "tail" of years of remaining life to provide greater security to the lender in terms of remaining asset value towards the end of the loan.

Resources Canada, and $7.5 billion from CIB). While we would normally apply some further discount to these numbers to reflect the fact that the tax credits will be used over a period of time, not all available funding may be used, and not all projects funded will be successful, for the purposes of this paper we have elected to not apply such discounts as our intent is to determine whether there is sufficient funding under a best-case scenario. However, the numbers do need to be adjusted to reflect that only a portion will be used in Ontario. Using Ontario's gross provincial product as a proportion of Canadian gross domestic product (36 percent), we have assumed that federal funding available to offset IESO costs would be $25.6 billion.

While Ontario has also announced funding for electric vehicle (EV), building retrofit, and home energy efficiency programs, these activities would appear to be more on the consumer side, and thus potentially not a credit against the infrastructure costs estimated by IESO.

In the aggressive adoption scenario, applying the offsetting taxpayer funding to IESO Pathways funding needs of $400 billion reduces the need to $374.4 billion.[8] The extreme adoption case assumes Canadian federal government funding is doubled.

Converting To Annual Amortized Numbers

We converted the total net need to an estimate of annual needs using an indicative average asset life of 30 years and a blend (75/25 percent) of the current weighted average cost of capital (WACC) for Ontario Power Generation (OPG) (6.66 percent) and for local distribution utilities (6.50 percent), as set by Ontario Energy Board's (OEB). This results in a blended WACC of 6.62 percent. The amortization period of 30 years is slightly less than the average Hydro One asset life and consistent with project lives for wind and solar assets. The proportions of 75/25 percent are based on IESO's use of the 25 percent contingency to include required distribution investments. Under Ontario's hybrid market structure, it is likely that many of the energy transition assets that will need to be built will either be under contract with the IESO or placed in OPG's rate base, providing greater predictability of cost recovery and hence a lower WACC.

Applying the blended WACC of 6.62 percent and the deemed 30-year asset life, the indicative annual incremental cost comes to approximately $29.0 billion (OEB 2022).

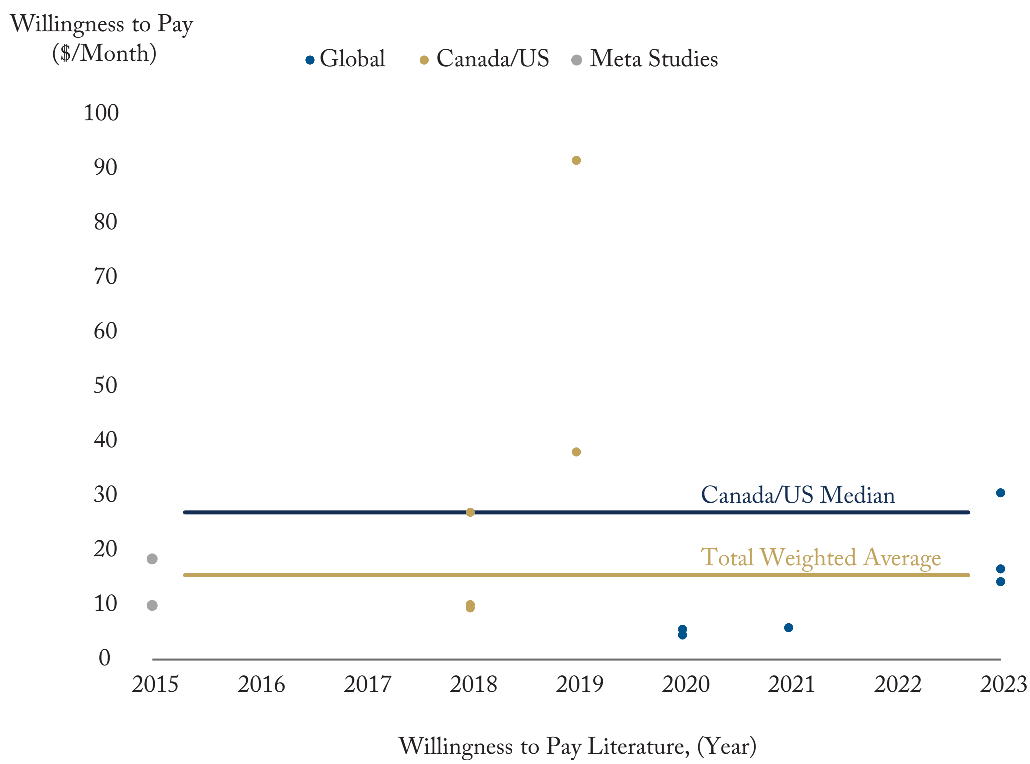
Contribution From Residential Willingness To Pay

After taking into account taxpayer contributions, we turn our attention to the incremental amounts that households may be willing to pay for green or net zero energy. To assess how much might be available from households, in addition to what they are already paying, we reviewed 13 WTP studies dating from 2015 to 2022. Of these, two were meta studies of papers that had been previously published. To calculate an estimate of WTP in Ontario, we used the median of US and Canadian numbers contained in the various papers, consisting of five observations.[9] Observations range from $9 to $92, with a median of $27 per

8 The total tax burden as a proportion of GDP in Canada is 33.2 percent, which is lower than the OECD average of 34.1 percent but greater than the US which has a ratio of 26.6 percent. As a result, there may be little headroom for the government to do more in terms of funding, though Canada is generally in a better fiscal position than some of its peers. (OECD 2021).

9 For full list of sources see bibliography.

Figure 2: Willingness to Pay Studies



Source: Analysis of WTP literature.

month.[10] While this median should be treated with caution, as it represents over 30 percent of the average monthly residential bill, it may be plausible in a world in which households also experience significant savings on gasoline due to transportation electrification, and in which the increases are phased in over time.

WTP studies have a number of limitations, most of which suggesting that the results may overestimate the willingness to pay of the entire population. Studies may suffer from selection bias, where respondents self-select into the study due to their own personal beliefs. Respondents may also have a hypothetical bias, providing what they deem to be socially desirable answers, but which differ from their real-life behavior. The ordering of questions has also been shown to impact WTP values (Stewart et al. 2002). Surveys may not be representative of the distribution of socio-economic status, and may miss lower income respondents who may behave differently (Quevedo et al. 2009). Estimation problems can occur if respondents are

10 All WTP values extracted from the literature were converted to Canadian dollars values at the time of publication using treasury reporting rates of exchange. Following this, they were brought to 2023 present value terms using the Bank of Canada inflation calculator.

Figure 3: Residential WTP Contribution to Energy Transition (aggressive adoption case)

Median WTP from literature	×	Number of months	×	Number of residential and small business customers	=	Ontario annual WTP
$27/month		**12**		**5.3 million**		**$1.7 billion**
WTP literature				Ontario Energy Board		Author calculations

Source: Author's compilation.

not given a choice between alternative uses of funds (Breidert, et al. 2006).

Despite the above concerns, WTP studies at least provide insight into what some customers think they might be willing to pay for cleaner energy. It is clear that there is not in fact a vertical demand curve for electricity; rapid increases in electricity prices were perceived to have contributed to reducing the longevity of two Ontario premiers from two different parties.[11] WTP studies likely represent an upper bound on the extent of politically acceptable price increases.

Taking the monthly median WTP, multiplying this by 12 to develop an annual number, and again multiplying it by the number of Ontario residential and small business customers (5.3 million, according to OEB) yields – under the aggressive adoption scenario – an additional over $1.7 billion to contribute to the annual costs of IESO's Pathways scenario. For the extreme adoption case, the highest observed WTP was used.

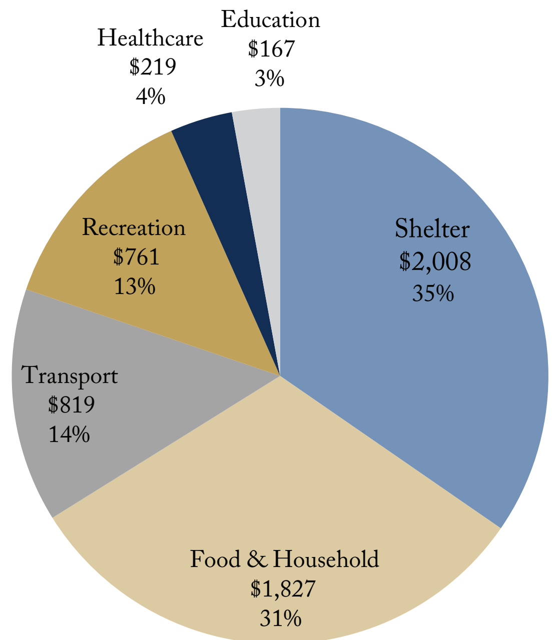
The median WTP of $27 represents 0.5 percent of the average Ontario household's total monthly consumption spend. The average monthly Ontario household's basket of goods according to Statistics Canada is shown below. The largest expenditure categories include shelter (35 percent), food (14 percent), and transportation (14 percent) (Statistics Canada 2023). While WTP amounts could be covered by reducing any of the various categories, these reductions are not "free", in that shifts in consumption also have direct and indirect employment and multiplier effects on the sector in which spending is reduced.

Contribution From Corporate Willingness To Pay

Corporate WTP is difficult to estimate and varies greatly across industries. However, the existence of voluntary renewable energy credit (VREC) markets and virtual power purchase agreements (VPPAs)

11 The defeat of Kathlyn Wynn was largely linked to "skyrocketing electricity prices and high bills" which were seen as a problem "directly tied to the provincial government's policy choices." Toronto City News How Kathleen Wynne ran out of energy with Ontario voters June 7, 2018. Similarly, the defeat of Ernie Eves was blamed on several factors including electricity market changes and perceived resulting costs. *Globe and Mail* Eves leaves Ontario a shameful fiscal legacy. Oct. 30, 2003.

Figure 4: Average Ontario Household Monthly Consumption



Source: Analysis of Statistics Canada data.

for renewable energy demonstrates that there are companies who are willing to pay more for a cleaner energy mix than is being supplied to them by their local utility.[12] Furthermore, some companies are now attempting to match their electricity usage on an hour-by-hour basis with zero emitting energy, signaling an enhanced commitment to reducing emissions. US VREC prices have been rising but are relatively low; prices have yet to exceed US $5 per MWh on a sustained basis. However, the implied VREC prices in VPPAs are likely much higher, and for those firms seeking to match consumption with green energy on an hourly basis there would be an even greater premium. Taking these factors together, we have assigned a value to corporate WTP of $10 per MWh. While this is significantly lower than the cost of compliance RECs in Northeastern jurisdictions, it also reflects the move towards higher quality RECs among those who are buying them voluntarily.

However, we do not assume that all firms are willing to pay. Instead, we start by focusing on the companies who have environmental, social, and governance (ESG) mandates. According

12 Renewable energy credits (RECs) represent the environmental attributes associated with 1 MWh of output from a qualifying renewable energy facility. Compliance RECs are those which electricity retailers are required to purchase on behalf of customers due to a government mandate. By contrast, a voluntary REC is one that companies purchase without being required to do so. Similarly, virtual PPAs are financial transactions between large electricity buyers and renewable generators which allow the buyer to claim the environmental attributes even while the customer is physically served by a traditional utility. While Ontario could do more to facilitate voluntary action by corporate customers, recent changes to community net metering rules and development of the Clean Energy Credit Program are laying the groundwork.

Figure 5: Corporate WTP Contribution to Energy Transition (aggressive adoption case)

% firms with ESG commitments	×	Total Ontario commercial and industrial load	×	Deemed VREC price	=	Potential contribution from corporate customers
38% Science Based Targets	×	**68.8 million MWh** Ontario Energy Board	×	**$10/MWh** Author assumption	=	**$261 million** Author calculations

Source: Author's compilation.

Figure 6: Vehicle Electrification Contribution to Energy Transition (aggressive adoption case)

Annual average kilometers driven	×	Non-EV road vehicle registrations Ontario	×	kWh/km	×	Average residential Electricity cost	×	Rate of EV adoption	=	Contribution to energy transition cost
16,000 Natural Resources Canada	×	**9.4 million** Statistics Canada	×	**0.20** Electric Vehicle Database	×	**0.11/KWh** Author Calculations	×	**80%** Author assumption	=	**$2.6 billion** Author calculations

Source: Author's compilation.

to the organization Science Based Targets, 38 percent of listed companies in G7 indices have disclosed public climate action targets; we apply this proportion against total Ontario commercial and industrial load of 68.8 million MWh (OEB 2022) and multiply this in turn against the assumed WTP of $10 per MWh. This results in a total of $261 million potential additional funding for clean energy initiatives under the aggressive adoption scenario. The extreme adoption scenario assumes both a greater number of companies committing to ESG principles and a higher VREC price.[13]

13 While practical monetization of corporate WTP is challenging, one approach would be to forbid companies operating in Ontario from claiming they are powered by green energy unless they purchase VRECs auctioned periodically by IESO related to production from zero emitting resources in Ontario. Recent rule changes in New York have significantly increased prices of voluntary in-state RECs, for example

Role of Vehicle Electrification

Incremental WTP from all customer classes makes a relatively small contribution to the costs of funding the infrastructure required under IESO's Pathways scenario. Given that the entire premise of the Pathways scenario is increased demand due to electrification, it is reasonable to assume that significant additional revenues will come into the electricity system as a result of this new demand. However, the extent of this incremental income depends on a number of factors, including the pace of adoption and rate design.

While Canada has put in place policies intended to limit sales of conventional gasoline powered cars, and to phase them out entirely by 2035, it is not clear how durable these policies are (Transport Canada 2021). Subsequent governments may reverse them under the banner of "fuel freedom", and concerns about cold weather performance and appropriateness for rural areas may prompt some relaxation. Consequently, instead of assuming 100 percent adoption of EVs in Ontario, we have chosen a rate of EV penetration consistent with Ontario's urban/rural population split. As Ontario's population is approximately 17 percent rural, we have assumed 80 percent EV adoption – allowing for a small portion of urban holdouts.[14]

To calculate the potential contribution from incremental EV demand, we multiply the annual average kilometers driven (from Natural Resources Canada) by the number of non-EV road vehicle registrations in Ontario (from Statistics Canada) by the kWh per mile required (Electric Vehicle Database) by the average residential electricity price across all hours (author calculations from OEB approved rates) by the EV adoption rate.

As distribution rates are currently collected from households using largely fixed charges, we have not assumed any incremental distribution revenue. Because we believe it to be unsustainable, we have also not used the ultra-low overnight electricity rate of $0.028/kWh to calculate incremental revenue. We believe the combination of increased EV charging and heating electrification will ultimately make this rate unfeasible due to increases in overnight load. Instead, we have assumed there is an equal probability that the EV will be charging at any particular time of day, while recognizing that technologies such as managed charging could shift EV charging load to times of day of least system stress.

Based on the above calculations, the incremental annual revenue from EV electrification is $2.6 billion. On an operating basis, EVs can result in savings relative to gasoline costs; for the purposes of this paper, we have assumed that these are a source of the WTP funding discussed earlier. Note as well that charging outside of the home is becoming more expensive and may reduce somewhat the comparative fuel cost advantage. The calculations for both vehicle and heating electrification utilize existing rates before adjusting upwards to capture added WTP. While there may be some residual WTP for electrification, equipment conversion costs also need to be covered.

Allocation of EV Fuel Savings

The savings from moving from gasoline powered vehicles to EV are significant enough to provide additional funding for energy transition activities. At present, the cost of running an EV is cheaper than the cost of running a gasoline powered vehicle. However, as EV owners may incur other non-fuel costs associated with EV ownership, and the savings themselves are an incentive to switch, we assume that only 50 percent of the operating cost savings

14 As rural drivers likely drive more than urban dwellers, kilometers traveled by the electrified fleet may be slightly overstated when using provincial averages for kilometers traveled per vehicle.

Figure 7: Vehicle Electrification Fuel Savings (aggressive adoption case)

((	**Annual average kilometers driven 16,000** Natural Resources Canada	×	**Non-EV road vehicle registrations Ontario 9.4 million** Statistics Canada	×	**Average Canadian litre/km 0.09/km** Canada Energy Regulator	×	(	**Average Ontario gasoline price $1.5/litre** Government of Ontario	−	**Ontario tax per litre $0.9/litre** Government of Ontario	)	×	**Rate of EV adoption 80%** Author assumption	−	**EV electricity cost $2.6 billion** Author calculations	)	×	**EV gas cost savings allocation 50%** Author assumption	−	**Residential WTP $1.7 billion** Author calculations	) =	**Contribution to energy transition cost $4.3 billion** Author calculations

Note: The numbers displayed in the figure may not equate to the calculated contribution to energy transition due to rounding.

Source: Author's compilation.

to EV owners are available to fund the energy transition, and that a portion of that 50 percent funds the household WTP discussed earlier.[15]

To calculate the potential contribution from savings on gasoline we first calculate the annual cost of running vehicles in Ontario on gasoline. This is calculated by multiplying the average kilometers driven (Natural Resources Canada 2008) by the number of non-EV Ontario vehicle registrations, by the average Canadian litres per kilometers (Canada Energy Regulator), by the average Ontario gasoline price (Government of Ontario), minus Ontario tax per litre (Government of Ontario). Taxes are excluded because we believe that ultimately EV owners will be subject to the same levels of taxation for road use as conventional vehicles are currently.

The annual cost of running gasoline-powered vehicles in Ontario is then multiplied by the rate of EV adoption assumed in the EV electrification costs calculation, minus the EV electricity costs previously calculated, multiplied by an EV gasoline cost savings allocation of 50 percent, minus the residential WTP previously calculated.[16]

Role of Heating Electrification

Determining the potential contribution to incremental revenue from heating electrification is challenging. Currently, economics does not favor converting existing natural gas customers to electric heat using conventional technology.[17] Future comparative economics will depend on whether carbon taxes are applied, improvements in the efficiency and efficacy of heat pumps, and the extent of subsidies for switching out existing equipment. IESO notes, when it describes its demand forecast

15 While there is no explicit regulatory mechanism to capture these savings, gradually increasing fees for charging facilities would be one approach, though caution is required if the intent is to maintain economic incentives to switch to EVs.

16 Using post-tax instead of pre-tax gasoline prices, and before allocating any savings to WTP, we calculate savings per non-EV registered vehicle of $1,739 per year from switching to an EV. This is in line with the Ontario Government's estimation of cost savings of between $1,500 and $2,500 (Ontario Government 2023b).

17 The author also sees potential resiliency challenges as transportation and heating electrification increase reliance on a single network (electricity) while allowing complementary natural gas and gasoline distribution networks to atrophy. The pressure that electrification will put on existing networks is discussed by the Canadian Climate Institute in its paper, "The Big Switch: Powering Canada's Net Zero Growth."

Figure 8: Heating Electrification Contribution to Energy Transition (aggressive adoption case)

((**Natural gas residential customers 3.7 million** Government of Ontario	×	**Existing builds rate of adoption 50%** Author assumption	) +	**New electric heating customers 500,000** Author assumption	) ×	**Average sqf of Ontario house 1800 sqf** Statistics Canada	×	**Average winter residential electricity cost 0.11/kWh** Author Calculations	×	**Average heat pump energy use per sqf 5.63 sqf/kWh** EnergySage	=	**Contribution to energy transition cost $2.6 billion** Author calculations

Source: Author's compilation.

for the Pathway scenario (p.25), that it is assuming a transition to heat pumps for new buildings in Toronto by 2030, and for the rest of the province by 2035. IESO also assumes improvements in cold weather heat pump technology. It is unclear whether IESO incorporated conversions from existing buildings in its demand forecast.

Given Ontario government targets of over 175,000 housing starts per year in 2026 and thereafter, we have assumed by the mid-2030s the possibility that there will be 500,000 new electric heating customers (Global News 2023).[18] We also assume that 50 percent of existing gas customers will adopt heating electrification (740,000 households). We multiply this by the current average electricity usage for a heat pump per square foot, by the average square footage of an Ontario home, by the average winter electricity price to estimate the potential contribution to incremental revenues. This totals $2.6 billion.

Asset Replacement Embedded in Rates via Depreciation

Rates on wires and regulated generation assets in Ontario incorporate return of capital in the form of depreciation. Amounts recovered in rates for depreciation can be used to fund replacement assets, all of which will likely be built to current standards and to assist in meeting net zero targets. In 2021, depreciation on Ontario transmission and distribution assets totaled $1.6 billion. Depreciation on OPG assets in 2021 totaled $1.1 billion. The combined total is $2.7 billion.[19]

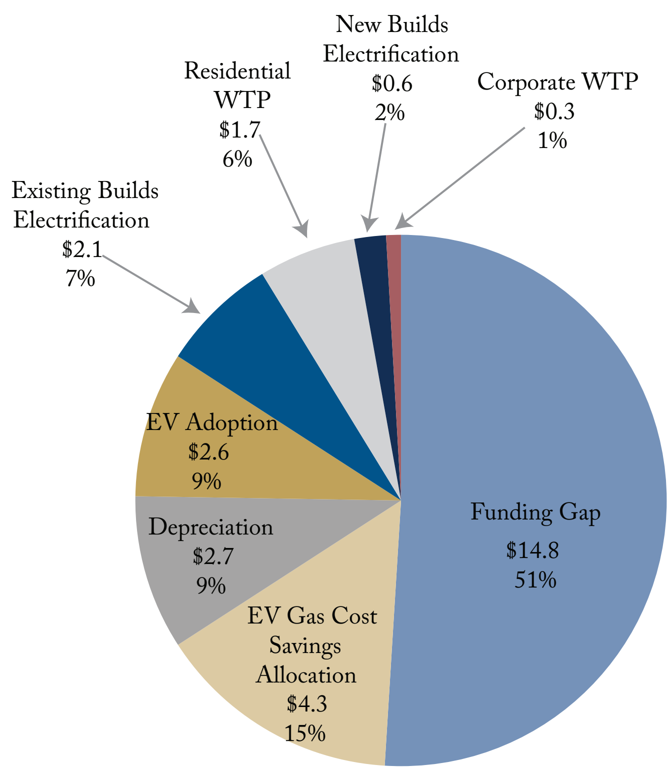
High Level Results

Taking into account the contributions from taxpayers, residential and commercial willingness to pay, vehicle and heating electrification, the EV gasoline cost savings allocation, and asset replacement, annual available funding totals $14.2 billion against an annual need of $29.0 billion. The

18 While this analysis assumes that housing starts slow after the mid-2030s, continued robust housing starts though 2050 would provide additional demand assuming some portion is using electric heat.

19 Note that the net costs of contracted generation are paid for through the Global Adjustment (GA); as contracts expire for existing generation, the GA will decrease (before considering the cost of new contracts), meaning some additional energy transition funding is embedded within the GA.

Figure 9: Annual Contributions to Energy Transition and Funding Gap Under Aggressive Adoption Scenario ($C Billions)



Source: Analysis of Statistics Canada data.

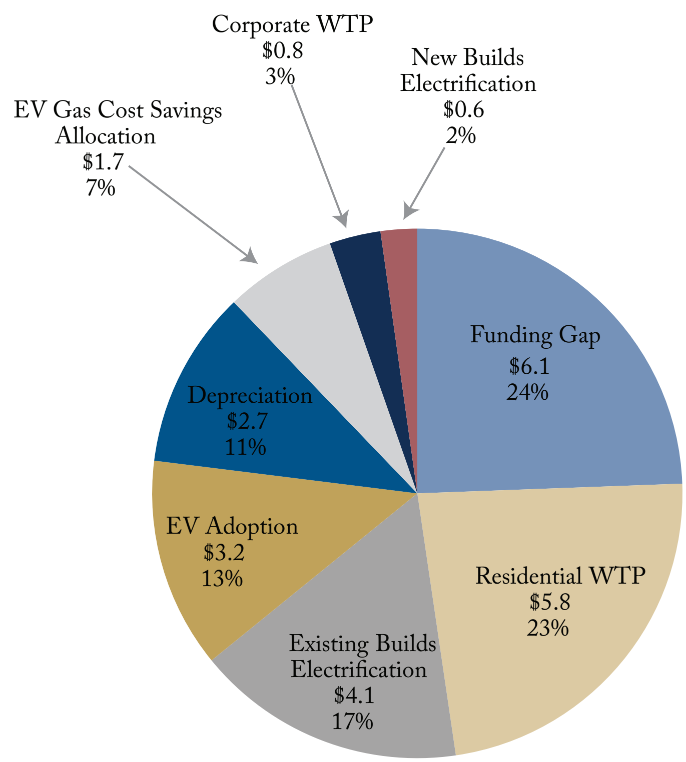
Table 1: Scenario Assumptions

	Aggressive Scenario	Extreme Scenario
Pathway to Decarbonization Cost	$400 billion	$375 billion
Canadian Federal' Government Funding	$25.6 billion	$51.3 billion
Residential WTP*	$27/Month	$92/Month
VREC Price	$10	$15
ESG Commitments	38%	76%
EV Adoption	80%	100%
Heating Electrification Existing Builds Adoption	50%	100%

* Note that this alteration will increase residential WTP in the extreme scenario relative to the aggressive scenario, but it will also decrease the EV gas cost savings allocation in the extreme scenario relative to the aggressive scenario. This is because EV gas cost savings allocation has a component in its calculations requiring the subtraction of residential WTP in order to prevent double counting.

Source: Author's compilation.

Figure 10: Annual Contributions to Energy Transition and Funding Gap Under Extreme Adoption Scenario ($C Billions)



Source: Analysis of Statistics Canada data.

pie chart below shows the potential shortfall of $14.8 billion.

Extreme Adoption Case

We believe the assumptions used to determine illustrative available funding are already aggressive. However, we also examined an extreme adoption case, assuming the factors shown in the table below.

Under such a scenario the annual available funding would total $19.0 billion against an annual need of $25.1 billion. Despite the extreme adoption assumptions, the pie chart below still shows a potential shortfall of $6.1 billion.

Caveats

IESO was constrained by the language of the ministerial direction which prompted the Pathways study. Allowing for technologies such as direct air capture and carbon capture and storage may lower the total cost of meeting the target. Furthermore, as the IESO cautions, the estimates are not the outcomes of an integrated system plan; the outcome of such a plan may be further optimization which would also reduce potential costs. Some additional revenues may also be derived from industrial fuel switching, though these may be offset by stranded costs in the natural gas sector. Increased adoption of mass transit could also decrease demand for electricity for personal transportation.

All calculations presented here are high level and intended to illustrate sources and the magnitude of funding available. Converting these theoretical sources of funding to practical ones will require the design of new funding mechanisms and substantial attention to rate design. Significant additional analysis may be required to confirm the validity of the underlying assumptions, particularly with regards to transportation and heating electrification. As projected adoption rates drive infrastructure investment, it may be that the pace and magnitude of such investment would change if adoption rates were closer to those assumed in the calculations in the aggressive adoption case than was assumed for the Pathways study.

Implications

Our high-level analysis of the potential sources of funding for Ontario's energy transition leads to several recommendations:

- The Ontario government should consider developing a handbook of policy tools (including carbon capture and storage) ranked by the levelized cost of carbon abatement (LCCA Handbook), and assess how to synchronize initiatives to maximize abatement at least cost.
- Given continued technological change and the potential for declining costs, Ontario needs to consider how to stage investments to enable sufficient optionality to take advantage of future cost declines. Such considerations could be included in the LCCA Handbook.
- The Pathways study should be followed by an ISP.[20] Since the Ontario government has already made significant commitments to continuation and expansion of nuclear in the province, the ISP needs to examine how nuclear and other resources will work together, and how best to integrate diverse resources given various demand scenarios.[21] The ISP should relax some of the constraints imposed on the Pathways study, such that the ISP includes all net zero alternatives, including carbon capture and storage.
- As transportation and heating electrification load increases, electricity tariffs will need to be carefully assessed to assure that such loads are paying amounts consistent with their system impact.
- Ontario consumers should be forbidden from claiming that their energy is 100 percent zero emitting unless they have matched their usage with the purchase of an equivalent amount of Ontario-sourced VRECs, proceeds of which would be used to reduce overall net system costs.
- Achieving high levels of electrification will require a suite of policies that will need to be sustained and enforced, which may be unpopular. If the policies are not enforced, system planners may build the system for higher levels of electrification than are attainable, risking significant stranded costs[22] if investments are not granular and lack optionality.

It is important to recognize that, notwithstanding the magnitude of the challenge from climate change, resources are finite. The fact that a resource

20 This is consistent with Recommendation 5 of the Electrification and Energy Transition Panel https://www.ontario.ca/files/2024-02/energy-eetp-ontarios-clean-energy-opportunity-en-2024-02-02.pdf

21 "Getting nuclear right" (including small modular reactors or SMRs) is going to be a key piece of managing energy transition costs. This means avoiding "first of a kind" installations, introducing competition among developers, and ensuring that suppliers share risk for appropriate compensation. That said, claims that renewables are cheaper than nuclear often do not sufficiently account for the costs of intermittency associated with wind and solar. However, Ontario's nuclear announcements to date do not appear to be part of a fully costed plan tested against alternatives, nor does it appear that they will be subjected to independent review. In the absence of a full OEB process, Ontario should consider appointing an independent monitor for the nuclear program.

22 Stranded costs are investments which ultimately cannot be recovered due to insufficient demand.

is zero emitting is not in and of itself sufficient to justify buying it; we need to know that it fits within a least cost, long run approach to addressing the issue.[23] The tendency to pursue industrial policy in the guise of green initiatives,[24] and to favor megaprojects at the expense of distributed energy resources (DERs),[25] may make it more difficult to meet climate goals cost effectively. While the cost gap identified here is not insurmountable relative to provincial budgets, better planning and additional funding will be required. Even if no additional funding is forthcoming given Canada's relatively high tax burden, thoughtful planning can help move Ontario closer to the 2050 target.

23 A least cost approach, while incorporating strict enforcement of existing contracts, should not include abrogation of such contracts if the counterparties are performing.

24 While current policies subsidizing battery manufacturers could be one example of this, the criticism also applies to the former *Green Energy Act*, which failed to take a least cost approach to procuring zero emitting resources in the hopes of establishing a green industrial base in the province.

25 DERs are smaller scale generation or demand response resources, often renewable or batteries, connected at distribution voltages and often behind a customer's meter. They can be aggregated to act as larger resources, or in some cases used to defer transmission or distribution investment. Because they are dispersed, they can provide resiliency benefits. Because they are small, they can be added more gradually in response to increases in demand, but with shorter lead times. While they do not necessarily replace large, central generating stations, they can serve as a complement to them.

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