Direct Economic Benefits of Electric Vehicles to the Province of Ontario

Summary

Low carbon vehicle uptake is part of Ontario's Environment Plan (1), but the only action the Plan proposes to achieve that is to remove barriers for commercial charging. That is good, but probably not sufficient to sell EV's in large numbers, according to recent experience in this province and elsewhere.

This paper shows that each new electric car on the road produces savings for their owners, moderates hydro rates and helps the Ontario economy by keeping more of our energy dollars circulating at home. A strong home market would help related clean technology business. And they don't put unhealthy fumes and greenhouse gases into our sky. Therefore, more effort by the government is amply justified.

A Made-in-Ontario "fee-bate" program is suggested that, at no cost to the tax-payer and miniscule costs to buyers of other types of cars (possibly as low as 1.5% of purchase price), should spur sales of electric cars, e.g. to about 50% of new car sales in the Province by 2024, developing sales momentum such that little further support should be necessary for rapid decarbonization of cars in Ontario. This would "over-achieve" in emissions reduction with respect to the Environment Plan. It needs over-achievement.

Introduction

Last year, we Ontarians emitted 161 million tonnes (CO_2 equivalent) of greenhouse gases (GHG). We must reduce these emissions to zero by 2050 to have a reasonable chance of avoiding totally unacceptable climate change. Everyone in the world must do likewise; but we must take the logs out of our own eyes before pointing out the specks in others' (to paraphrase a prophet, widely revered for His wise advice). What would He do?

Recently, a friend reminded me of another very relevant quote from another prophet (of sorts), Churchill, who, at a critical point in history, told the British people that "sometimes it is not good enough to do our best, we must do what is required".

Difficult? Impossibly costly? I'm sure it's not. There are 100 ways described, and costed, on the website www.drawdown.org, most of which are shown to save money, as will the one I argue for in this paper; for motorists, for hydro rate payers and for the Province as a whole.

Passenger road transportation emitted 30 million tonnes of GHG in Ontario in 2016 (about the same as was saved by shutting down the coal-fired power stations, but that low hanging fruit has long gone). This would be mostly from cars, plus some buses and motor-cycles. This analysis focuses on electrification of cars because they are, doubtless, responsible for the majority of the 30 million tonnes and there is readily available information to assess the direct economic benefits to Ontario of electric cars. There is also now a good selection of electric cars on the market.

The paper describes how a modest, easily justifiable, fee-bate administered by the Ontario government (but hardly costing the taxpayer anything) would accelerate uptake, playing both to this government's Made-in-Ontario Environment Plan and creating direct economic benefits to car owners, tax-payers, hydro rate payers and the Province in general.

This is not to say we couldn't also pursue electrification of buses, motorcycles and indeed trucks, trains, ships and off-road vehicles (construction, mining, farming and forestry). I just don't have information

ready at hand to analyse the direct economic benefits of those and how to effectively incent them. And, of course, we need emission reductions in sectors other than transportation. However, transportation is the biggest emitting sector in Ontario and specific, effective reduction strategies are more obvious than in the others.

This paper is a revision to the version ClimateAction Now kindly published for me under the same title a few weeks ago. That one took a macro-approach, looking top down at electrifying all 8 million light duty vehicles on the road in Ontario. After more research, I've now decided that a more intuitively do-able program can be described for eating this elephant a few cars at a time. Using this bottom up approach, it's easier to see how the economic benefits of each new electric car justifies immediate action this year and for the next few years. Get the train rolling down the track and soon it will move well under its own momentum.

The arithmetic is simple and sources of pertinent data are readily available. For a modest effort, the Province would save money for future electric car owners and hydro rate payers, help the economy by improving the Province's import/export balance, create more opportunity for local clean technology business, clean the air and mitigate climate change. The key to this successful strategy is the opportunity that exists to optimize use of something we already own, and are paying for (and, oh, how we are paying!), the Electricity Grid, as a substitute for buying energy from outside the Province.

***

Savings to New Car buyers

If you want a handle on this, visit the Electric Vehicle Discovery Centre, 1126 Finch Avenue (just west of Dufferin) in North York. It has a selection of electric car models you can see, look under the hood and test drive for free. There are electric car chargers you can handle and knowledgeable staff to talk to. It's run by Plug 'N Drive, a Toronto-based, non-profit, and I highly recommend it.

I took away their booklet, "Electrify Your Drive", which has photographs and key data on all the 13 battery electric (BEV) and 26 plug-in hybrid electric vehicle (PHEV) models available in Ontario. It has summaries of key economic data for both, including the electrical energy in kilowatt-hours (kWh) used per 100 kilo-metres (km). The average for BEV's is 19.5 kWh per 100 km.

According to Natural Resources Canada, NRCan (2), Ontarians drive light vehicles an average of 16,000 km per year. For the illustrative purposes of this paper, therefore, we'll say the annual consumption of electricity by an "average" owner of a BEV is estimated to be 3,120 kWh (19.5 * 160), or 3 Megawatt-hours (MWh).

I focus on the BEV's in this analysis to keep it shorter (the paper is long enough as it is). But most of what I say about BEV's applies, to an extent, to PHEV's, including the feasibility of a fee-bate program. Anecdotal information about PHEV's (including from my daughter, who has had a Chevy Volt for several years) is that some of the owners rarely put gasoline in the tank. Their batteries provide shorter range, but, if this is sufficient for everyday needs, they will create similar economic benefits as I describe for BEV's. It's possible that PHEV's will fade in popularity versus BEV's because it fundamentally doesn't make sense to drag around the weight of an internal combustion drive train when charging stations are easily found everywhere. For example, a quick check on Plug Share (3) shows 90 charging stations already in my neighbourhood (Etobicoke) alone.

So how much would that amount of electricity cost this "average" BEV owner, as compared with gasoline in a comparable internal combustion vehicle (ICV)? Most EV owners I've talked to charge mostly at home, in the off-peak period at night. A BEV owning friend, a professor at Humber College, Lake Shore Campus, does this, albeit topping up for free at the publicly accessible charger in the college parking lot, which is convenient while she is working.

For the sake of a simple analysis, lets forget, for now, about the public chargers and assume all charging is done at home in the off-peak periods. This is quite feasible because, even plugged into a standard wall socket, the Level 1 charger typically gives 8 km of range in one hour. Hence, the full off-peak period at night from 7 pm to 7 am will allow 96 km, which is probably enough for the owner's daily commute.

Those who want more could use a 240-volt receptacle (the type used for stoves and clothes driers), even in a condominium parking space (4). [I'm not sure about apartments; that may need to be addressed under the government's promise in the Environment Plan, page 33, to "improve the rules and remove barriers that block investors from deploying … (refuelling infrastructure to) … increase the uptake of electric … vehicles without government subsidies."] The 240-volt receptacle is needed for a Level 2 charger, which will provide 30 km of range in one hour.

Level 3 chargers are available in public places, like gas stations, and provide 250 km range in one hour, either for free (usually provided by shops for obvious reasons) or for a "service charge" of $15 or $20. But the full hour is unlikely to be required and is billed by the minute – you only pay for what you need (4).

All BEV's can use Level 1, 2 or 3 chargers, while most PHEV's can only take Level 1 or 2.

Assuming the average annual consumption of 3,120 kWh is charged off-peak, at the Ontario off-peak rate of 6.5 cents/kWh this would cost the BEV owner the princely sum of $203 per year. [There may be some minimal additional distribution and regulatory charges per kWh – it varies by location, but they are small enough to ignore for this very high-level analysis].

Contrast that with his, or her, likely, annual fuel cost. The "Electrify Your Ride" booklet lists that, too, against each model for comparable cars with internal combustion engines (ICV's), assuming a fuel cost of $1.20 per litre and annual driving distance of 20,000 km. People who would buy EV's might drive more as they would be aware that the savings are more for higher users. But I tend to use NRCan data, so I'll use their 16,000 km for the average Ontario car driver. On the other side, I'll use the most recent price for regular gasoline in Ontario of $1.30/litre. After making those adjustments, the annual fuel cost of the comparable ICV's would average $2,101.

From the above estimates, the net annual fuel saving for the "average" BEV owner would be about $1,900 ($2,101 minus $203).

I wish I could quantify savings in maintenance costs. I'm no mechanic, but even I know that BEV's have fewer moving parts, no engine oil, transmission, transmission fluid, air filter, spark plugs, belts, muffler, fuel injection system, emission control system, conventional lead acid battery or alternator, and less of a cooling system.

On the other side, there might, eventually, be a cost for battery repair or replacement. This is discussed in more detail towards the end of this paper and is another reason why I submit that an incentive needs

to be applied to the purchase price to get sales moving, before more real-world experience accumulates.

With respect to maintenance costs, a crystal ball would be most useful, but since one is not available to me right now, the most I can say is that the total running cost savings for a BEV versus a comparable conventional car is in the order of $1,900 per year plus maintenance, before considering the possibility of a battery replacement.

Were the government to put that saving clearly within the grasp of Ontarians who need to buy new cars, then (to use words from the Minister's Message in his foreword to the Environment Plan, apparently referring to investments in the Electricity System) that would give some recompense "for the sacrifices they have made and the ones they continue to pay for".

Benefits to Hydro Rate Payers

It might be said this government is now in power because of increasing hydro rates. It behooves the government to do something about this; which they have promised most definitely to do. But what?

Here is a perfect opportunity. The additional revenue that EV's will create for the Electricity System will be nowhere near consumed by incremental costs. In fact, one could argue that, ultimately, with good management, the incremental cost could be negative.

But let's start by being boringly conventional and base the savings on the Hourly Ontario Energy Price (HOEP), as published by the Independent Electricity System Operator (IESO). I'll use this as a close proxy to the incremental cost, even though it appears to be more of an artefact of how the Market Rules effect the bidding strategies of market participants.

The IESO publishes historical monthly averages of HOEP, on-peak and off-peak, from May 2002 (5), conveniently in the form of downloadable Excel spreadsheets, possibly to enable retired geeks like me to amuse ourselves by easily calculating various results, like last year's off-peak average HOEP was 1.7 cents/kWh, the year before 0.9 cents, the year before that 1 cent and the year before that 1.7 cents again. As mentioned above, customers charging their EV's in the off-peak period will pay 6.5 cents/kWh. No additional generators, wires, transformers, switches, or staff, required. Need I say more?

There is more to say. The IESO's 2016 technical report on energy storage (6) noted (Section 3.2, page 18) that "Up to the early 2020's …… SBG will remain at comparable levels to 2014, when Ontario experienced SBG conditions *66% of the time*" (my italics). SBG means Surplus Baseload Generation, which is when market demand (including from neighbouring States) is less than the operating nuclear, river and wind capacity. Steam is dumped, water spilled, wind turbines told to shutoff and neighbouring States paid to absorb the power. A lot of this is seasonal, so EV's cannot be the whole answer. But, even so, it would be advantageous, to manage EV charging to be coincident with SBG to the greatest extent possible, whether or not it happens to be in the official off-peak periods. At these times, EV charging would be saving the Grid money – while contributing revenue.

And I question the qualification "up to the early 2020's". Of course, without that good old crystal ball, no-one can predict Ontario's *exact* supply and demand configuration years ahead. But I imagine most folks will still sleep at night and become active in the day. So, the system will have to provide sufficient capacity to satisfy the day-time demand, which means there will be more than needed at night.

Meanwhile, there has to be limits on GHG emissions. [Which brings up an interesting question. The Environment Plan appears to assume no increase in emissions from the Electricity Sector through 2030. Does this mean the government will constrain the IESO's Market Renewal program to result in no additional use of gas? It should.] Therefore, unless huge progress is made in energy storage and/or carbon capture, it seems inevitable there will continue to be SBG a significant number of hours each year, which EV's could mitigate, albeit not resolve completely.

In summary, every new EV on the road will contribute more to the Electricity System in revenue than it incurs in cost. That should lower hydro rates, or at least keep them from going up so much, for the rest of us. There is an additional longer-term benefit to the Grid potentially from employing used battery packs from vehicles for stationary load management and/or battery to grid technology applied to all those EV's idle most of the time.

Benefits to the Province's Balance of Payments

As calculated above, the "average" owner of an ICV comparable to the now available BEV models forks out in the order of $2,100 per year for gasoline at $1.30 per litre. But how many of these dollars stay in Ontario? How many go to fellow Ontarians, who, in turn, re-spend some in Ontario, some of which will be re-spent again in Ontario and so on (the so-called economic multiplier)?

The Ontario Government has a website (7), which breaks down "What makes up the pump price" into Crude, Wholesale margin, Federal excise tax, and the federal portion of HST, totalling 70 cents per litre, and Retail margin, Ontario tax and provincial portion of HST totalling 50 cents per litre, (when it was at $1.20/litre). From this, I calculate that approximately 58% (0.7 divided by 1.2) of what we spend on gasoline leaves the Province – obviously it's going to vary; as we know, pump prices frequently fluctuate.

This breakdown does not appear to identify refining costs. If it's included in Crude it would still be saved because it can be reasonably assumed that, even if demand declines in the Province, the Ontario refineries would continue in operation supplying the US and/or are fated to be re-purposed anyway.

One objection to reducing gasoline and diesel consumption is that it will reduce government revenue from taxes. But to achieve zero emissions we must. As Churchill might say, it's "required". No-one would say we shouldn't give up smoking so the government wouldn't lose sales taxes. It's recognized that smoking is bad for our health - as are the noxious fumes out of the tail-pipes of ICV's. And the savings in Crude and Wholesale margin are higher than the losses in taxes for the Ontario economy.

The conclusion is that each additional BEV on the road will improve the Province's balance of payments by something close to $1,200 a year ($2,100 * 0.58), $12,000 over a conservative life of 10 years, which will keep accumulating, circulating and multiplying year after year, continually enriching our economy. That may not sound much per car, but don't lose sight of the ultimate potential. We have over 8 million cars, and growing, and let's not forget the buses, motorcycles, and indeed trucks, trains, ships and off-road vehicles (construction, mining, farming and forestry).

StatsCanada (8) reports sales of petroleum products in Ontario in 2017 of 16.9 billion litres of gasoline and 5.5 billion litres of diesel. A little would be for stationary engines; but the bulk would be for mobility. Thus, the potential for displacement by electricity is in the order of 22 billion litres, hereby estimated to be a cash hemorrhage from the Province in the order of $16.6 billion per year (22 * 1.3 * 0.58), at current prices. This is in the same ball-park as the total costs of electricity in the Province, $19

billion in 2014, according to the Office of the Auditor General of Ontario, as reported in the Globe and Mail (9).

The Minister referred to "skyrocketing energy costs that have hurt our economy and our competitiveness" (1). He was likely referring to electricity, or, possibly, also the 4 cents/litre from Cap and Trade, or now the federal greenhouse gas pollution act. But gasoline prices, currently at $1.30/litre, were lower than 70 cents/litre in Toronto before 2003 (10). According to recent news, they are set to jump another 15 cents by this summer (11). That has nothing to do with the carbon tax, but it does illustrate the economic vulnerability of this Province relying so heavily on imported energy. We could strategically alleviate that by smartly getting more utilization out of the Electricity Grid.

Is the Grid up to it? My opinion is yes, but the system planning exercise required to show that in the long-term (with all the changes in technology that are likely to occur) is way beyond the scope of this paper. In the next section, I propose a program designed to put a million EV's on the road in Ontario by 2024. What would be the impact of that on the Grid?

The energy required for 1 million EV's, each at 3 MWh per year is 3 Terawatt-hours (TWh) per year (I promised the arithmetic would be easy). If that load were spread evenly over the 4,380 hours in the night-time (only) off-peak period (i.e. 7 pm to 7 am), forgetting about off-peak time also available during the day on weekends and holidays, [not such a crazy idea given the potential to influence, or stage, when charging is done] it would require 685 Megawatts (MW) of capacity. How much capacity does the Grid have and how much is already used at night-time?

In the summer of 2017, the Grid met a peak demand of 21,786 MW, as reported in the IESO's Ontario Demand Forecast (12). The same report conveniently includes Load Duration Curves for each of the four seasons, which show that, in summer 2017, during the lowest 50% of the time (which would be the night-time, more or less, because seasonal effects are being broken out) the load on the system ranged from 10,000 MW to about 15,000; and the fall of 2017 was about the same, then in the winter of 2017/18 it ranged from 12,000 to about 17,000, then in the spring of 2018 it ranged from 10,000 to just above 14,000. Evidently, an addition of another 685 MW, or even somewhat more, at night-time, would take the load to nowhere near the system's demonstrated recent capacity of at least 21,786 MW.

***

Suggested Program to Achieve "Low Carbon Vehicles Uptake"

The Made-in Ontario Environment Plan (1), page 24, envisages 16% of its target GHG reductions by 2030 to be from "Low Carbon Vehicles Uptake". It would amount to about 750,000 EV's versus a total of around 34,000 on the road in Ontario to-date. A worthy goal. It could be more ambitious, but what action is the government proposing to achieve it? Hardly any. EV sales to-date have been lack-lustre in several jurisdictions without the effective incentives they have in Norway, or Zero Emission Vehicle (ZEV) standards as in California, nine States, British Columbia and Quebec. ZEV standards may seem like a "left-coast" idea to the present Conservative government, given its ideology. Is there anything else effective the Ontario Government could reasonably do? Of course, there is. Read on.

I'm no more car salesman than mechanic so you're invited to critique the following analysis. I identify 5 decision factors that a car buyer would primarily consider: purchase price, running cost, performance, styling and environmental impact. (Cynics might dispute environmental impact, but I'm not saying that

would necessarily be the decisive factor, and if anyone wouldn't think of it, today, they must surely be a recent arrival from another planet.)

I'll split out range as a particular point of performance that has been historically very influential. It was one of the reasons ICV's won out against EV's early last century. But notice something has changed, which is the number of charging stations, now at 4,500 in Canada, and counting. For example, Petro Canada is putting Level 3 chargers at filling stations from coast to coast so that a transcontinental BEV traveller need not go more than 200 km to find a charger. And people have done the "snow-bird thing" (visiting Florida from Canada in winter) in BEV's with no problem finding chargers along the route (13).

The following table shows how I see BEV's stack up against comparable ICV's on the above decision factors.

Decision Factor	Advantage	
	BEV	ICV
Purchase Price		Wins
Running Cost	Wins	
Performance (excl. range)	Wins	
Range		Wins
Styling	Equal	Equal
Environmental Impact	Wins	

I drew up this table to illustrate, at a glance, that if the Purchase Price were made equal, the BEV would (almost) be what Decision Analysis calls a "Dominant Solution", i.e. equal or better in all respects. And I'm suggesting that with three wins (including a "money" factor – running cost), two equals (including the all-important first cost) and one loss (range – which may not matter to a large segment of the population, e.g. who live and work in Toronto) BEV's would sell a lot better than they have to-date in Ontario.

As a corollary, PHEV's with equal purchase price would become a Dominant Solution.

The win for performance (excluding range) is my purely subjective opinion, having now driven both types. The EV was quieter, smoother and had more acceleration (in fact, the lady from the Electric Vehicle Discovery Centre, who accompanied me, expressed fear we might get a speeding ticket at one point). I realize this one might be controversial, but I'd advise all doubters to take a test drive in an EV. It can be done for free at the Electric Vehicle Discovery Centre, with no sales pressure.

In the long-term, I'm not sure what can, or will, be done about range for BEV's. If there were at least one EV in every two-car household in North America that would be progress. It may be cheaper batteries, allowing more on-board storage to be more reasonably priced. But to me it doesn't seem like a sensible solution to pay for and carry around more weight than is needed most of the time. It may be fuel cell vehicles, which are also EV's with a fuel cell/tank instead of batteries. It may just be that the driving public will get used to filling up a little more often. Or it may be that some of them won't and we won't sell 8 million EV's in Ontario, but we could still sell, say, 7 million by 2030, which is about ten times what the Environment Plan is currently assuming. This corresponds to the illustrative scenario I describe below.

In this scenario, I'm projecting 50% of new sales would be BEV's by 2024, which is only what is projected this year in Norway (and they almost made it last year). Again, waiving hefty import and sales taxes has narrowed the price gap in Norway (and, of, course gasoline is about twice our price).

I selected 2024 for sales parity because that is when BEV's will achieve price parity, and be henceforth cheaper, according to Bloomberg New Energy Finance (NEF) (14). But just because they'll likely achieve price parity in 2024 anyway doesn't justify sitting on our fannies until then. According to the UN Intergovernmental Panel on Climate Change, we only have until 2030 to effectively address climate change to avoid unacceptable consequences. We need to get moving today.

What would it take to make the purchase price equal today? Surprisingly little.

An article by Peter Gorrie in Corporate Knights (The Magazine for Clean Capitalism) on April 18, 2019 made a couple of comparisons; specifically, a 2019 Hyundai Kona Electric versus a 2019 Toyota RAV4 XLE and a 2019 Nissan LEAF S versus a 2019 Honda Civic LX. In both cases, the EV had a lower 10-year total cost of ownership, taking into account fuel and maintenance. But this is, evidently, not driving significant sales. And I believe the reason for that is simply the after-HST purchase price was higher for the EV's, by $13,000 and $15,000.

I propose the effective Purchase Price could be made equal in two easy steps, the first of which has already been taken by the Government of Canada.

Step One: the federal government has already committed rebates of $5,000 for zero emission vehicles with manufacturer's suggested retail prices (MSRP) no more than $45,000. Thus, the effective price differential has already been reduced to around $10,000.

Step Two: time for the Province to step up, don't let the feds steal all the glory; but, of course, not on the backs of the long-suffering tax-payer. Enact a "fee-bate" system under the auspices of the Carbon Trust, which is already proposed in the Made-in-Ontario Environment Plan (1). Like the federal rebate, it should be limited to the lower priced models.

As explained in the Environment Plan (page 28), the Carbon Trust will receive income from the amounts paid by industries under the Emission Performance Standards (15), i.e. from those failing to meet the standards. This income will be used to help fund projects that reduce emissions.

In like manner, I propose purchasers of ICV's pay fees to the Carbon Trust that will fund rebates to purchasers of EV's. For simplicity, I'll limit this illustration to BEV's. The fees required per ICV will be considerably less than the required rebate of around $10,000 per BEV (in the first year) so long as the number of BEV's sold are a smaller fraction of the total cars sold. The rebates, and hence the fees, can be scaled down and phased out as the number of BEV's sold approaches 50% of all car sales, and/or the MSRP falls such that the effective after-tax purchase prices equalize, net of federal rebate.

I received info from Plug N' Drive that just 16,814 EV's were sold in Ontario last year (2018). (That might have included PHEV's, but for this illustrative analysis I'll regard it as for BEV's). This was an increase of about 8,000 from the previous year. But remember there was a $14,000 incentive from the previous Ontario government until September 2018. The $5,000 federal incentive started on May 1st, 2019. What will 2019 BEV sales be? For the sake of this illustration, I'll assume about the same as 2018, say 17,000, and that the fee-bate program will kick-in early next year.

Sales of all new motor vehicles in Ontario (as far as I can deduce from Statistics Canada, it's not clear) are in the order of 680,000 per year (16). Let's also assume growth in the overall car sales market of 5% from 2019.

Even effective purchase price parity is still unlikely to convert all new motor vehicle sales into BEV's immediately, due to the usual human and industry inertia (and residual "range anxiety"). A credible illustrative scenario might be a sustained exponential growth until 100% BEV sales are reached. What rate of growth? Just to show how the fee-bate could work out to need only a small fee for ICV purchases, assume growth is such that BEV's would be 50% of all new sales in 2024. This is not a stretch, given the example of Norway (it reported 60% for the month of March 2019).

The point is that next year's BEV sales receiving rebates would then still be only 32,497, funded from an estimated 681,503 ICV sales, so a rebate equalling a price premium of $15,000, less federal rebate of $5,000, would require an average fee of only $477. It's simply the required rebate times the ratio of expected BEV sales over ICV sales, updated at any time modified on experience to date. [To be clear, the Carbon Trust would determine the required rebate for each EV model, but based on external, auditable data. They would also calculate the average fee for any upcoming period, and adjust that from time to time, as necessary, in order to maintain a positive amount in the fee-bate account. They may want to err on the high side to pre-empt the inevitable jibes from right-wing pundits that the scheme somehow fleeces tax-payers.]

OK this now puts the EV lower by $477; it's probably best to leave it with that slight edge for simplicity and transparency. It could be equalized using the Excel Solver add-in – accountants do this kind of "gross up or down" all the time, but I'm not sure it wouldn't create unnecessary confusion. (The average member of the public has no idea what the Excel Solver does.)

If we now also assume the EV price premium falls to zero by 2024, as forecast by Bloomberg NEF, say in equal drops of $3,000 per year, we can project the fees required to fund required rebates: from 2021 through 2024 the fees would be $632, $711, $379 and zero in 2024, when none is required to achieve effective price parity.

The purpose of this exercise is simply to illustrate that the required fees on ICV's would be miniscule in relation to the full, after-tax price of a new car, such that they should not provoke a car buyer revolt. For example, the average price of a conventional car, after HST, in Canada in 2018 was $40,793 (17). Assuming this will be, if anything, a little higher by 2020, the fee would add just over 1%. This is projected to increase slightly for a couple of years then fall, as the effect of falling BEV prices overcomes the effect of increasing BEV sales.

The fees paid by lower priced, more efficient ICV's could be even lower with more loading onto higher priced, less efficient ICV's by making the fee a function of both litres/km and MSRP. But, again, it may be better to keep it simple as a straight % of MSRP, after-HST, which could start at 1.5% building up some capital for stabilization (i.e. possibly avoid future increases). The lower priced ICV's tend to be more efficient anyway, simply because they are smaller

Here is the projection in Excel for any skeptics who wish to check the results.

Year	Car Sales	BEV sales	ICV sales	Ratio BEV/ICV	Premium	Premium less fed rebate	Fee Required	Total Fees	Total Rebates
2020	714,000	32,497	681,503	4.8%	$15,000	$10,000	$477	$324,970,670	$324,970,670
2021	749,700	62,121	687,579	9.0%	$12,000	$7,000	$632	$434,847,973	$434,847,973
2022	787,185	118,750	668,435	17.8%	$9,000	$4,000	$711	$475,001,133	$475,001,133
2023	826,544	227,002	599,542	37.9%	$6,000	$1,000	$379	$227,002,113	$227,002,113
2024	867,871	433,935	433,936	100.0%	$3,000	$0	$0	$0	$0

To be clear, $15,000 is just used here for all the BEV's in 2020 as an example. In practice, the Carbon Trust would continually issue updated applicable rebates, different for each BEV model, based on expert consultation. And the rebate schedule would be dynamic, responding to the changing relative MSRP's – expected to be continually declining, as in the example, as BEV's become more competitive. To keep the car companies honest, the Carbon Trust could base it on MSRP's in, say, Quebec, which has no fee-bate program.

If the above scenario played out, the fee-bate program would have a natural sunset in 2024. The program should not burn too much political capital because: 1) the fees are a small fraction of the total cost of buying new cars, 2) only a fraction of the population buys a new car in any given year, and typically not the "little guys" that this government has stated it wishes to defend, and, 3) the buyers have an obvious alternative at an equivalent price, indeed a lower total ownership cost.

Putting point 3 more pointedly, the program would punish only those who insisted on buying polluting cars when perfectly good non-polluting cars were available for an equivalent effective purchase price and much lower running costs ("you're gonna pollute our sky, endanger my precious grandchildren and millions of other innocent kids and animals, damn-right you're gonna pay!" – there is probably a smoother way to say that when advertising the program).

To elaborate further on point 3) re the defensibility of the program to the typical Conservative supporter; far be it for me to decry carbon pricing, but there is a significant difference in that carbon prices hit all drivers, who mostly bought gas consuming cars when there was not much alternative and are now, essentially, stuck with them for a few years; in contrast, this fee would apply where the buyers would have an immediate, clear, very attractive alternative.

To check what might happen if Bloomberg NEF was proved not quite correct that EV price parity will be achieved in 2024, I ran different numbers. But first recall, it seems only yesterday when the only BEV available was a Tesla Model S for over $100,000, whereas today there are 7 BEV's for around $45,000 or less, and 10 PHEV's, while the average price of new cars is $36,000. But assuming the average premium for BEV's falls by only $2,000 per year (after HST), under the same assumptions as before, the highest fee required is still only 5% of the average price of a conventional car, probably less by then because they will probably increase in price from 2018. But if the government is skittish at any time they can always scale back or terminate the program, after having still provided a significant boost in sales.

Under this rate of growth, there would be 925,000 EV's on the road by 2024 and 7 million by 2030.

Year	Car Sales	BEV sales	ICV sales	Ratio BEV/ICV	Premium	Premium less fed rebate	Fee Required	Total Fees	Total Rebates
2020	714,000	32,497	681,503	4.8%	$15,000	$10,000	$477	$324,970,670	$324,970,670
2021	749,700	62,121	687,579	9.0%	$13,000	$8,000	$723	$496,969,112	$496,969,112
2022	787,185	118,750	668,435	17.8%	$11,000	$6,000	$1,066	$712,501,700	$712,501,700
2023	826,544	227,002	599,542	37.9%	$9,000	$4,000	$1,515	$908,008,450	$908,008,450
2024	867,871	433,935	433,936	100.0%	$7,000	$2,000	$2,000	$867,870,925	$867,870,925

Complementary Actions

This policy complements carbon fee and dividend. And itself may be complemented:

1) Step-up procurement of EV's by government, municipalities, universities, schools, hospitals, police, fire service and other public agencies. This would include buses and trucks, not analyzed in this paper, but with an even greater running cost saving because of higher use.

2) Advertise the program directly AND require car companies to advertise EV's at least to the extent they advertise ICV's.

3) Improve signage to indicate exactly where charging locations are located. Drivers can see roughly where they are on software like PlugShare, ChargeHub and Google Maps, but curbside signs would help finding a particular one for the first time, and also convey to the general public that there are, in fact, already a surprising number of charging locations in their neighbourhood, e.g. about 90 in Etobicoke.

4) Remove regulatory barriers to allow commercial stations to charge per kWh, not just for free or as an hourly service fee (this is already promised in the Environment Plan), and residents to provide their own in condo and apartment parking garages.

***

Conclusion

As detailed in this paper, a fee-bate program for EV's would ease the on-going cash flow for hard-working people who need to drive to work and happen to need a new car (and also for tax-payer funded publicly owned new vehicles), mitigate hydro rates and retain within the provincial economy in the order of $12,000 per electric car sold over 10 years. Thus, the social cost of this GHG reduction measured in dollars per tonne of CO_2 equivalent would be less than zero (oh, and that would be less costly than the federal carbon price).

The (quite likely) positive stimulus to clean technology industries and relevant research and development in Ontario of having a thriving local market for EV's is beyond the scope of this paper. But, as we used to say in Yorkshire, "a nod is as good as a wink to a blind horse"; translation -> if the government can't see that potential, we are in trouble indeed.

***

Questions from an EV Skeptic (skeptic in the "good" sense) and Answers

Q) With current technology, lithium supply will be an issue if EVs really take off. Is there enough and under what circumstances can it be recycled?

A) The 2018 EV Outlook (14) by Bloomberg NEF forecasts 559 million EV's on the road by 2040, with annual sales increasing from 1.1 million worldwide in 2017 to 11 million in 2025 and 30 million in 2030. That will require a dramatic scale-up in the lithium-ion battery supply chain, including for other materials like cobalt. Bloomberg NEF foresees sufficient lithium supply capacity to meet their demand forecast for the next 5-7 years, beyond which further investment will be required. With minerals and chemicals, there is always potential for temporary under-supply, which drives up prices, which, eventually, bring on more supply. This is another reason why Ontario needs to get off the marks quickly, so we don't get left behind and, perhaps, face higher prices just at the time we start to move on this. But, in the longer-term, technology is not static. We constantly learn how to find more, use less, recycle more, develop substitutes, do without.

Recycling will occur when it costs less than primary supply. There are two types of recycling. First, the degraded batteries can be used in stationary applications where "range anxiety" is not an issue. The users will see how much capacity the battery has left and manage it accordingly. Second, the batteries can be processed to extract the materials (this includes manganese, lithium, cobalt, nickel, graphite, aluminium and copper) that can then be used to make new batteries. Each type of recycling can source batteries taken from cars either during or at the end of their lives. It is evident that Nissan, at least, are taking back used batteries for recycling.

The battery manufacturers would be in a perfect position to accept extended producer responsibility because they have business contacts on both sides, i.e. the purchasers of batteries on the downstream and the chemical producers or parts manufacturers on the upstream. Society should monitor how this evolves with a view to enacting regulations enforcing extended producer responsibility if it doesn't evolve naturally.

Q) What is the cost of a battery pack replacement and what are the economics for continued operation?

A) It would vary according to model as different EV's use different sizes and designs of batteries. The only two $ quotes that seem to be readily available are for a Nissan LEAF of $5,500 (US) including installation, with a $1,000 credit for recycling the used battery, and $15,734.29 (US) for a Chevrolet Bolt. The latter is certainly a price shocker. But, as a YouTube video, "Should You Worry About Battery Replacement Costs for Electric Cars?", points out, not a single Chevy Volt (the plug in hybrid but with same type of battery as the newer Bolt) has had to be replaced, after 6 years of experience. This video advises looking at EV battery replacement as akin to replacement of the engine in an ICV. It may be required, but most likely for older cars, which have travelled long distances. And it notes considerable data on Nissan EV battery replacements indicate they are rare and mostly under warranty.

And prices should decrease. According to Bloomberg NEF, lithium-ion battery packs averaged $1,160 per kWh as recently as 2010, reached $176/kWh in 2018 and could drop below $100 in 2024 and also improve in performance.

Since the need to replace batteries is not a certainty, the economic comparison is probabilistic depending on individual aversion to this particular risk. It's another reason why I submit that boosting

EV sales in the near future (which is what we want to do, because the far future would be too little too late) requires an effective incentive, like making the purchase price equivalent to comparable conventional cars. Then a risk averse customer might reckon that he could do no worse than about even, taking into account annual savings of $1,900, or more, from fuel and maintenance.

Q) If battery pack replacement makes no sense and if the car with degraded batteries is worthless, what will be done with the rest of the car? Is this in line with sustainable behaviour?

A) Based on the evidence, we shouldn't assume battery replacement will be necessary or make no sense if it is. And I'm not sure the "degradation" in performance means more than a loss of range, or that it would necessarily end the life of the car. [If any reader knows more about this, please comment]. That might depend on the range the EV provided in the first place ("Electrify Your Ride" lists BEV ranges from 92 to 539 km), how much it dropped and whether that took it below what the owner needed at the time it dropped. For example, a suburban EV buyer might subsequently take another step towards a more sustainable life-style and re-locate residence downtown, or retire, and then not need as much range as when the car was originally purchased. Or, he/she might sell it to an old codger like me, who definitely does not need a lot of range.

At the end of the life of the car, for whatever reason, it will be dealt with like any conventional car. There is a sustainability ethic that says we should make things last longer and be able to easily recycle everything. But that applies to everything, not just EV's. If experience points to a particular sensitivity with batteries typically having a shorter life than the rest of the cars, then, yes, a push should be made to make the batteries easily replaceable at a reasonable cost. Pressure will probably be needed from society on the car companies, because their primary motivation is not aligned with society in this respect, i.e. they just want to sell more cars.

I came across the question on the internet "if EV's require a mid-life battery exchange, costing $10-15,000, how could that proposition be marketed?". The answer that occurred to me was that the initial purchase price, plus the mid-life battery replacement, would have to be competitive. Then, it would be regarded as a deferral of some of the capital, which is a good thing.

But the difference between EV's and regular cars in this respect is, at most, one of degree not fundamental.

Q) Wouldn't you agree that having cars on the road is still a consumption of surface area (roads, parking lots and driveways … etc) so, while EVs are better than regular cars, we still need to promote high occupancy and use of other transit means (walk, bike, public transit).

A) Absolutely.

Author: John Stephenson, M.A.Sc. (Management Sciences), formerly employed for a total of 45 years as a Professional Engineer with Ontario Hydro, Toronto Hydro and FVB Energy Inc, now retired, volunteer with Citizens Climate Lobby Canada, school crossing guard and grandpa; jstephenson806@gmail.com

References:

(1) https://prod-environmental-registry.s3.amazonaws.com/2018-11/EnvironmentPlan.pdf
(2) http://oee.nrcan.gc.ca/publications/statistics/cvs08/chapter2.cfm?attr=0

(3) https://www.plugshare.com/
(4) Make Your Condo EV Ready – 2018 Guide for Condo Owners, Boards and Managers – available from Plug 'N Drive, info@plugndrive.ca
(5) http://reports.ieso.ca/public/PriceHOEPPredispOR/
(6) ww.ieso.ca/Sector-Participants/Energy-Procurement-Programs-and-Contracts/Energy-Storage
(7) https://www.ontario.ca/page/motor-fuel-prices
(8) https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2310006601&pickMembers%5B0%5D=1.7
(9) https://www.theglobeandmail.com/news/national/why-does-electricity-cost-so-much-in-ontario/article33453270/
(10) https://www150.statcan.gc.ca/n1/pub/11-402-x/2010000/chap/ener/tbl/tbl03-eng.htm
(11) https://www.cbc.ca/news/business/gas-prices-carbon-tax-oil-1.5081757
(12) IESO's Ontario Demand Forecast, June 30, 2018
(13) Personal Communication from Plug 'N Drive staff
(14) Electric Vehicle Outlook 2018: Bloomberg NEF
(15) https://ero.ontario.ca/notice/013-4551
(16) Statistics Canada. Table 20-10-0001-01 New motor vehicle sales
(17) https://www.birchwoodcredit.com/blog/average-price-of-a-car-in-canada/