Electric - Powered Transportation

July 2016

The Future is Ahead of You: Summary Report of the Manitoba Government and City of Winnipeg Joint Task Force on Transit Electrification

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Introduction

Formation and Timeframe: In November 2015, the Manitoba government and the City of Winnipeg announced the formation of a joint task force to investigate the potential for broadly implementing electric transit buses, beyond the current pilot project already underway. The task force began working in January 2016 and continued through the spring.

Membership: The task force consisted of eight representatives from the following organizations:

- City of Winnipeg, Transit Department (Winnipeg Transit)
- Manitoba Growth, Enterprise and Trade (GET), Energy Division
- Manitoba Sustainable Development (SD),Climate Change and Air Quality Branch
- Manitoba Hydro
- New Flyer Industries Canada ULC
- Red River College.

The co-chairs of the task force were the director of Winnipeg Transit, and the executive director of the Energy Division. The Energy Division also provided secretariat support for the task force. The task force reported to a steering committee consisting of Manitoba deputy ministers from the departments of GET, Indigenous and Municipal Relations (IMR), and SD, as well as the City of Winnipeg's chief administrative officer (CAO).

Prototype electric transit bus unveiled at Manitoba Legislature

Advanced lithium ion batteries are the distinguishing innovation in modern electric bus technology. Newer electric transit buses that use batteries have all been based on existing diesel bus gliders or involve new configurations that closely resemble conventional buses. In terms of operation, they are more similar to diesel buses than earlier tethered trolleys. Because overhead wiring systems don't need to be constantly energized, battery-based buses also exhibit much higher efficiencies, roughly twice that of older trolleys.

The market for electric buses has become very competitive. Today, in the current North American transit bus industry, there are more suppliers of electric buses than conventional diesel buses. Manitoba-based New Flyer is the largest manufacturer of transit buses of all types in North America, and also is a leader in the development of new technologies, including hybrid transit buses and electric transit buses.

Electric Buses in Manitoba: Electric bus activities in Manitoba began with the signing of a Memorandum of Understanding (MOU) between Manitoba and Mitsubishi Heavy Industries (MHI). The first project, under the MOU, was to develop and demonstrate electric buses.

The prototype electric bus (pictured at left on this page) used New Flyer's advanced Xcelsior glider platform, together with advanced heavy-duty lithium ion batteries from MHI. After initial shake-down testing and parallel completion of the rapid-charging station for on-route recharging, a public demonstration of the prototype electric bus was conducted. This involved shuttling Manitoba Hydro employees between their headquarters building at 360 Portage and their location at 820 Taylor. The rapid-charger was temporarily located at the latter site (see photograph on next page).

With the support of other consortium members, New Flyer applied for and received additional funding from Sustainable Development Technology Canada (SDTC). This funding allowed expansion, adding four new second-generation electric buses to operate in on-route service with Winnipeg Transit over multiple years. The City of Winnipeg also became a new partner.

With transfer of the rapid-charging system to Winnipeg's James Armstrong Richardson International Airport, the multiple electric bus SDTC pilot project began operations in 2014. The four buses continue in service with Winnipeg Transit, all on the #20 ("Watt")

Objectives: The task force's objectives involved:

- looking at the future availability and commercial status of electric transit bus technology
- assessing economic and technical viability of current electric transit bus technology for use in Winnipeg, including identifying infrastructure requirements
- identifying longer-term options for electric buses
- developing a cost benefit analysis to compare electric buses to conventional diesel-powered buses, including emissions profiles and environmental attributes
- identifying components that need to be included in any detailed implementation plan
- preparing a report that captures these assessments

The layout of this final report follows the sequence of objectives.

Status of Technology

Electric bus technology has been advancing rapidly in recent years. The impetus to consider broader use of electric transit was in large part because of the highly successful development and demonstration activities that have taken place in Winnipeg.

Electric Bus Development: Electric public transit systems aren't new. A diverse variety of electric systems are already in place across North America and around the world, including subway, light-rail, tram trolley, and rubber-tire trolley bus systems. In Winnipeg electric tram trolleys were operated until 1955 and rubber-tire electric trolley buses were operated until 1970. While these older technologies continue to evoke a sense of nostalgia, they were neither efficient nor flexible.

route (see photographs of buses throughout).

Results from on-route operation so far have been highly positive. In addition, one of the buses was also engaged for a year in Altoona testing, which involves a suite of accelerated reliability evaluations. Altoona testing is mandatory in the United States for any bus model that wants to be eligible for funding from the Federal Transit Administration (FTA). The bus performed extremely well on the tests, especially compared to competitive models. The full results of the tests are available to the public.*

Rapid-charging system temporarily located at Manitoba Hydro, 820 Taylor

Near-Term Opportunities

From the successes so far, it is clear that, depending on operational circumstances, an electric bus can make sense on a one-to-one basis, compared to a conventional diesel bus. There are multiple benefits to the new electric technology. These include:

- reduced fuel costs
- reduced maintenance costs
- reduced greenhouse gas (GHG) emissions
- reduced smog pollutants
- reduced noise

Electric buses are most beneficial when they can be applied to high-use routes on a dedicated basis, reducing the use of diesel fuel as much as possible. However, in existing transit operations only limited routes currently meet such constraints.

Early on, the task force realized the significant difference between operating a single bus and a larger fleet of buses. Overall, transit system design is based on characteristics of diesel buses, including their ability to operate for extended periods of time untethered to refueling. It is this operational characteristic that permits interlining, the practice of switching buses between route services, allowing buses to be available whenever and wherever they are needed (operating upwards of 22 hours daily or across an entire urban area when and where required). This feature is a cornerstone of existing transit system planning and operation, and must be assessed in greater detail to better understand the implications of using electric buses, with different operating characteristics. The need for such evaluation is discussed later.

The biggest hurdle is not the electric technology in individual buses. Rather, it is the challenge of how to transform an old system, designed around diesel, to a new system of planning, operation and maintenance, based on new electric bus and charging technologies.

Transit authorities throughout North America continue to investigate the potential for electric buses, but with a focus still largely on exploratory small-scale testing (demonstrating one or two buses, typically for a short duration). Some jurisdictions have announced their intention to commit to electric buses, but there have been as yet no large-scale implementations.

An important next step to address integration challenges is to deploy a sufficient number of buses to confirm they can operate in the real world at a large scale. This would involve at least 12 and as many as 20 buses, as part of a single system. For Winnipeg Transit, this would represent in the range of two to three percent of the current fleet. Sufficient operating experience could be gained through this approach, which then could be used as the basis for the next stage (described later). This scale of deployment would provide:

- the ability to plan for a larger integration
- increased knowledge about the technology
- an opportunity to identify and address risk factors
- training for operators and service technicians

For example, the realistic life expectancy of batteries used in transit buses is not entirely certain, and only can be truly confirmed with greater experience.

* Electric bus Altoona results: http://altoonabustest.psu.edu/buses/458

Scenarios for Evaluation: To conduct a quantitative business case analysis, the task force selected two near-term scenarios, comparing costs for a 12-bus deployment of electric buses versus the conventional diesel bus option. These scenarios are termed Peak-Use Buses and High-Use Buses. The main assumptions are outlined in the table on this page.

The task force identified a peak-use buses scenario as a logical introductory approach for electric buses, specifically because it largely avoids costs associated with fleet integration. Individual buses are assigned to a single specific route and they return to a single base. This allows for simplified rapid recharging at a single site, both at mid-day and overnight, as required. At the same time, peak-use, by its nature, results in lower cumulative annual mileage and lower associated diesel fuel reduction.

The high-use buses scenario, on the other hand, represents a better use of electric buses as it maximizes travel and significantly reduces diesel fuel usage. At the same time, based on the current technology, operating high-use buses also imposes significant direct fleet integration costs. This is for redundancy to ensure schedules are fully met.

Charging Infrastructure: An important trade-off for electric buses involves on-board battery capacity versus on-route rapid charging. Increased battery capacity extends range but with a serious weight penalty. Based on the success of the existing pilot project, the task force selected a battery capacity of 200 kilowatt hours per bus, with on-route rapid charging. Determining the number of chargers required to adequately meet schedules requires actual operational experience on a large scale. For analysis, a more conservative number of chargers was assumed, but with optimistic charging assumptions also considered.

Longer-Term Opportunities

The task force's ultimate goal was to consider how a system, like Winnipeg Transit, could be transitioned to being largely electric. The task force determined, as earlier noted, that to understand integration and associated issues, a sufficient deployment of electric buses (in the range of 12 to 20) is required. The next step, over the medium- to long-term, would be to deploy a larger number, in the range of 120 to 200 buses, representing a substantial portion of the buses in an individual fleet. In the case of Winnipeg Transit, this would represent 20 to 30 percent of the total fleet. Again, confirming operability at scale in real world service would be important, including verifying battery-life. After this latter deployment, the final step would be full-scale system roll-out, involving a full electric or nearly full-electric transit fleet.

Benchmarks and Assumptions

Rather than a one-to-one evaluation, the business case, as presented, is based on the implementation of a cluster of 12 buses, corresponding to the scale of a sufficient deployment. As described earlier, this is what would be needed in the near-term to prove the technology is viable. Assumptions are presented in the table on page six for the two defined operational scenarios (Peak-Use Buses and High-Use Buses).

Business Case Results

The summary results for the business case analyses of the two scenarios are presented in the table at the bottom of the next page, including results overall for the 12 bus deployment, and on a per-bus basis.

Evaluation Scenario Descriptions

Name	Assumptions
Peak-Use Buses	Buses operate on dedicated routes for limited time periods in morning and late afternoon, returning to base between peak periods (five to ten hours daily, with expected average of seven hours). Identified as potential introduction point for electric buses.
High-Use Buses	Buses are dispatched on all day runs (go out in the morning and return late the same day or early the next day, and operate as much as 18 to 22 hours daily). Also are used on weekends, involving all-day runs. Such buses are still out of service for preventative maintenance and repairs, so are not operated every single day. Annual mileage in this case translates to approximately 70,000 kilometres.

Peak-Use Buses Scenario:

For the peak-use buses scenario, the additional capital cost for electric buses and all charging equipment, beyond the purchase cost for conventional diesel buses, is about $5.9 million, or roughly $490,000 per bus. For this scenario, the present value cost for the electric bus option over twelve years, including operational savings, is somewhat higher than for diesel. The deficiency represents close to $1.9 million on an overall project basis, or roughly $160,000 on a per-bus basis. A breakdown of cost contributions is presented on page eight in the upper figure for this scenario.

Second-generation electric bus on Graham Transit Mall during mid-Summer

High-Use Buses Scenario: For the high-use buses scenario, the additional capital cost for electric buses and all charging equipment, beyond the purchase cost for conventional diesel buses, is about $7.6 million, or roughly $630,000 per bus. The higher cost here is due to the larger number of rapid chargers involved. For this scenario, the present value cost for the electric bus option over twelve years, including operational savings, is also still somewhat higher than for diesel. The deficiency represents just over $1.5 million on an overall project basis, or roughly $130,000 on a per-bus basis. A breakdown of cost contributions for this scenario is presented on page eight in the lower figure.

Implications: For both scenarios, the total incremental short-falls from the business case analyses are relatively similar, and while significant, are not overwhelming. The comparison of electric versus diesel buses involves the classic trade-off between an option heavy on capital costs (electric) versus an option heavy on operating costs (diesel).

Addressing the deficiency and reaching break-even could be achieved through a capital cost reduction in the range of 12 to 16 percent, assuming no changes in any other factors. This level of cost reduction is realistic, given current developments and the increasing deployment of battery buses and associated charging equipment. Electric buses are essentially at the cusp of readiness. Their already lower operating costs (fuel and maintenance), combined with anticipated future capital cost reductions, suggest the longer-term advantage is toward electric buses.

The future of diesel is problematic, as it is difficult to predict future diesel fuel prices. They could vary extensively from being not much different than today to being significantly higher. The latter aspect includes implications for a future price on carbon within Canada and Manitoba, as discussed in the next section.

Summary Results of Business Case Analysis

Scenario	Incremental Capital	Net Present Value Deficiency	Per-Bus Deficiency
Peak-Use Buses	$5.9 million	$1.9 million	$160,000
High-Use Buses	$7.6 million	$1.5 million	$130,000

Summary of Assumptions for Electric Bus Business Case Analysis

Variable	Peak-Use Buses	High-Use Buses
Equipment Life	12 years for buses; 20 years for rapid-charging systems.	
Discount Rate	4.35 percent (nominal basis) with 2019 treated as base-year.	
Currency Conversion Rate	0.85 U.S. dollars per Canadian dollar, with value of only 0.70 for sensitivity.	
Bus Purchase Cost	Basic bus costs for both standard diesel and electric buses (latter equipped with 200 kWh battery pack consistent with pilot buses) based on 2019 delivery, but not including any specialized options such as automated vehicle location.	
Charging Infrastructure Cost	Four buses per rapid charger.	Three buses per rapid charger.
Annual Travel per Bus	35,000 kilometres annually.	70,000 kilometres annually.
Fuel Consumption	For diesel buses, fuel consumption is 62 Litres per 100 kilometres, consistent with Winnipeg Transit experience, plus additional diesel exhaust fluid (DEF) for Tier-4 engine requirements. For electric buses, electricity consumption is consistent with experience in the pilot project, plus a small amount of diesel fuel for auxiliary heating. More specialized renewable fuel could be used but creates handling and logistics issues, whereas standard diesel is readily available at all transit operations.	
Fuel Cost	Diesel prices are consistent with retail fuel price projections of the U.S. Energy Information Administration forward Outlook 2015, and including: reference (expected) case, at $1.10 per Litre; high oil price case, at $1.65 per Litre; and low oil price case, at $0.90 per Litre. DEF is assumed to have the same price as diesel. Electricity prices are consistent with forward projections outlined to the Manitoba Public Utilities Board (PUB). Differential load factors are considered in the two scenarios, based on experience to date.	
Maintenance (Non-Battery)	Electric buses are assumed to have a range of lower maintenance costs than conventional diesel buses.	
Battery-Related Costs	Electric bus batteries are assumed to last for a full 12-year period without any significant additional incremental battery costs incurred.	
Direct Integration Costs	No direct integration costs.	Direct integration costs are included to provide redundancy.

GHG-Related Impacts

A Cost Benefit Analysis (CBA) is often employed by governments with the intent to reflect and explicitly monetize a variety of health, social, environmental and infrastructure impacts (benefits or costs beyond explicit operating and capital costs that are included in a business case). In this report only one factor, greenhouse gas (GHG) emissions, is evaluated in this way.

GHG Emissions Profile: As part of the earlier analysis supporting the SDTC application by New Flyer, it was estimated that an electric bus operating in a clean-grid jurisdiction, like Manitoba, could result in full-cycle GHG reductions of approximately 160 tonnes per bus annually. Such analysis also includes reductions in upstream emissions associated with the exploration, extraction and refining of fossil fuels (full-cycle).

For this report, GHG emissions analysis only includes those emissions occurring directly in Manitoba, that would be counted against Manitoba under Environment and Climate Change Canada's National Inventory Report. This latter approach reflects how Manitoba is judged under the current emissions allocation rules. The differences in methodology are important to note in explaining any apparent differences in results.

Conventional diesel bus emissions are dominated by diesel fuel consumption itself, with diesel emission fluid (DEF), which is associated with Tier-4 emissions controls, also contributing emissions. The active constitute in DEF is urea, which incorporates some fossil-fuel carbon. On the other hand, electric bus emissions include grid-mix based emissions for electricity as consumed, and a small amount of diesel fuel for auxiliary heating during winter.

Price on Carbon: Both the federal and Manitoba governments have indicated policy positions that may put a price on carbon. The greatest uncertainty still at issue is the extent to which different mechanisms may be applied in different provinces (whether it is a per unit emission-fee, tradable emission permit, or some other system).

For analysis, a simple emission-fee approach is assumed, with a value of $30 per tonne of GHG by 2018, continuing to escalate in real terms thereafter. Based on the implementation of 12 buses over 12 years, the total present value cost of such carbon pricing is about $250,000 for the peak-use buses scenario, and about $500,000 for the high-use buses scenario.

The costs associated with a price on carbon, as compared to other explicit capital and operating costs, are material, but still relatively smaller. They can help make up for the deficiencies in both scenarios, but alone, they will not make electric buses economically viable. As a result of a price on carbon, the deficiency is reduced to about $135,000 per bus for the peak-use buses scenario, and to about $90,000 per bus for the high-use buses. The high-use scenario is more positively affected, given higher mileage and a larger reduction in diesel-use.

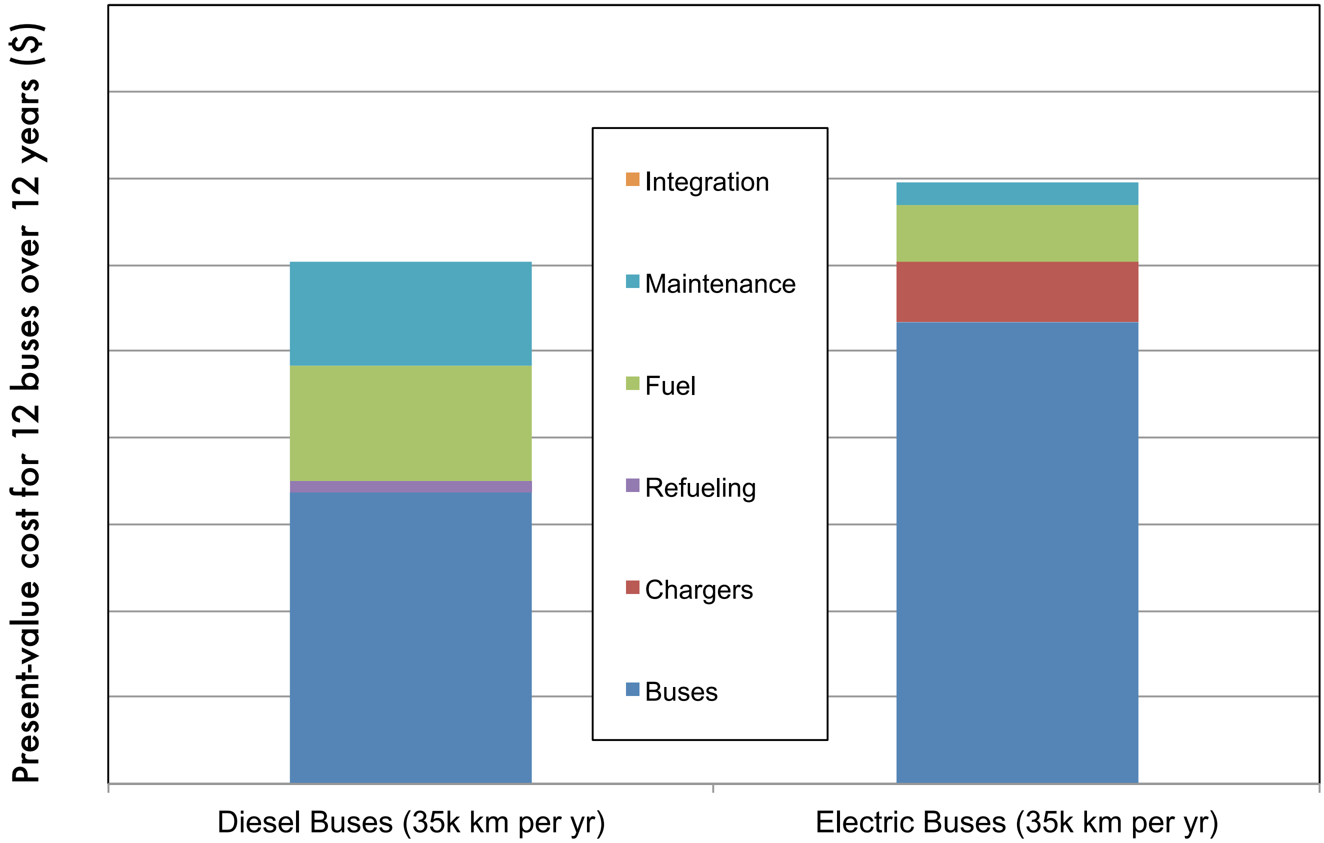
Additional Factors

An important future cost is staff safety training related to implementation of electric vehicles. The present value of this cost is identified as about $150,000. However, this cost is not directly included in the business case, as it likely could be amortized over a longer period of time. A variety of other items were identified as relevant benefits or costs, but without attempting to monetize associated values.

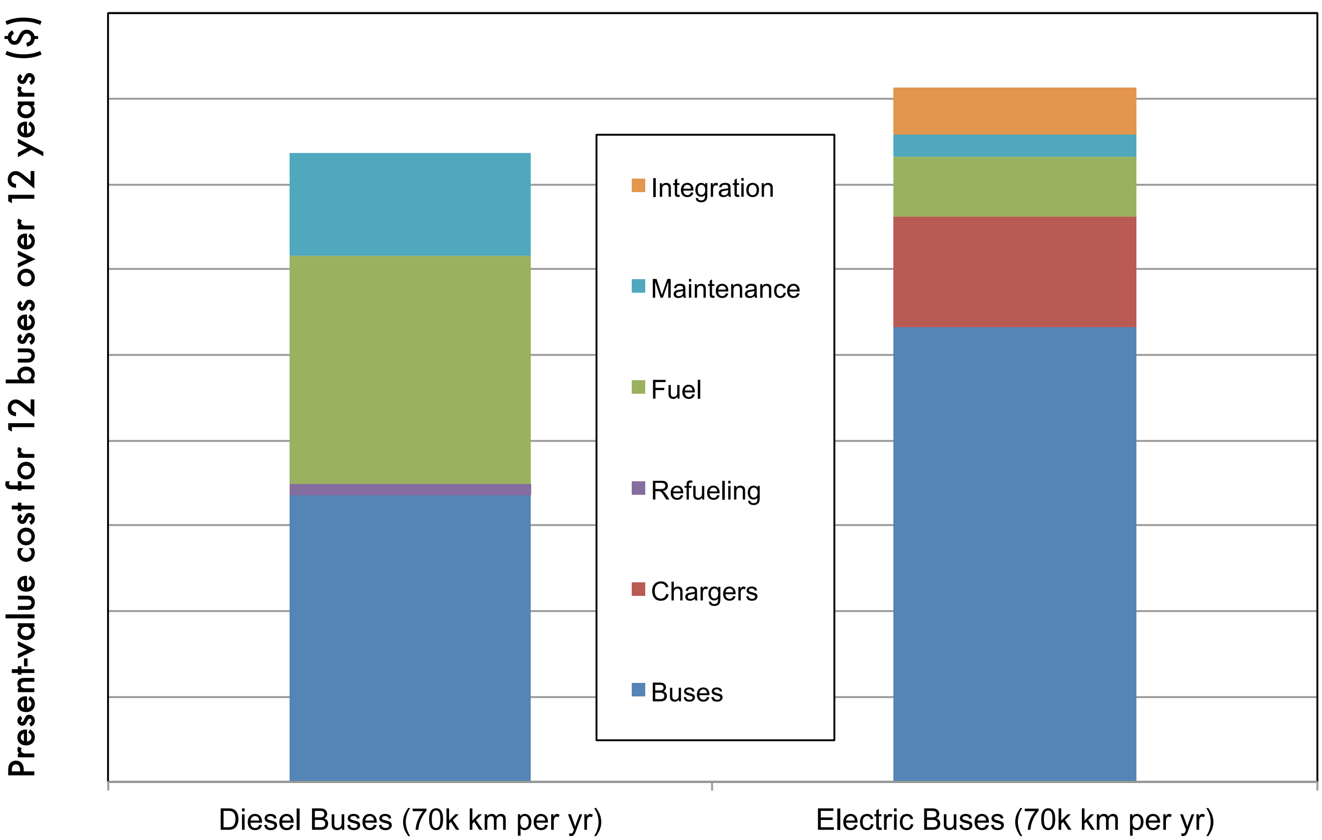
Resulting GHG emissions for the diesel bus option translate to 165 kilograms per 100 kilometres, while those for the electric bus option translate to only 3 kilograms per 100 kilometres. This means the annual GHG reduction that results by moving from diesel to electric buses is about 57 tonnes per bus annually for peak-use buses, and 113 tonnes per bus annually for high-use buses. For either scenario this represents a reduction of more than 98 percent compared to diesel.

Second-generation electric bus on Graham Transit Mall during late Winter

Summary Breakdown of Business Case Analysis for Peak-Use Buses



Summary Breakdown of Business Case Analysis for High-Use Buses



Sensitivity Analysis

Three major aspects are considered in terms of sensitivity. The first is the relative importance of changes in the cost variables on the overall viability for electric buses. The second is to examine more-optimistic assumptions related to charging. Last is integration.

Relative Variable Sensitivity: The results of a quantitative analysis are presented in the table at the bottom of this page, and show a clear priority order of importance in terms of sensitivity to changes in variables. Changes in purchase price or currency conversion are most important. Changes in diesel fuel price or annual travel distance are next most important, followed by changes in the level of maintenance savings, and lastly, changes in the price of electricity or bus electricity consumption.

Currency conversion is highly important in terms of impact on the viability of electric buses, because purchase prices for transit buses are directly related to costs in U.S. dollars. A currency conversion of 0.85 is assumed, but if it were to drop as low as 0.70, which had occurred in the past year or so, the net deficiency for the electric options increase significantly on a per-bus basis to the range of $200,000 to $225,000. Currency conversion cannot be directly controlled. This emphasizes the importance of both reducing capital cost to enhance the viability of electric buses, and of seeking potential co-funding in the short-term.

The viability of electric buses is quite sensitive to changes in the price of diesel. However, future diesel prices are highly uncertain and cannot be directly controlled. The anticipated, reference price for diesel fuel is about $1.10 per Litre, ranging from a low-price value of about $0.90 per Litre to a high-price value of about $1.65 per Litre. Importantly, the sensitivity analysis results for diesel fuel price apply consistently to variations in travel distance (at a constant fuel price, increases in travel will increase diesel consumption for the diesel option, since fuel consumption rates remain relatively consistent). This emphasizes the importance of achieving a high mileage for electric buses to displace as much diesel fuel as possible.

Break-even diesel prices were also determined, translating to: $1.60 per Litre for peak-use buses and $1.40 per Litre for high-use buses. These prices are higher than the reference price case, as noted, but less than the high-price case for diesel. As such, although relatively high, they are not unrealistic.

Upward or downward variations in the price of electricity have only a relatively small effect. This also applies consistently to variations in electricity consumption by electric buses (a constant electricity price but higher or lower electricity consumption per kilometre). This means fairly wide swings in electricity price or in electricity consumption can be readily tolerated. More important in terms of impacts on overall viability are the costs of charging infrastructure (capital) and load factors.

More Optimistic Charging: The task force recognizes that deliberately conservative approaches are embedded into the cost estimates. To a significant extent, this is because of the lack of experience in the field with electric buses. An area of particular importance is the amount of rapid charging infrastructure that is necessary.

Conservative assumptions are included to make sure that buses would be sufficiently charged so they can meet schedule requirements. To evaluate sensitivity, more optimistic charging is also evaluated, with the main assumptions: six buses per rapid charger and high load factors. This directly reduces the deficiency for the electric buses by 60 to 80 percent compared to diesel on a per-bus basis. The resulting deficiencies are reduced to about $70,000 per bus for peak-use buses, and about $20,000 per bus for high-use buses. The only way to confirm the true requirements and the practical limits for rapid charging infrastructure is through gaining extensive in-service experience. This emphasizes the need for staged deployments, as outlined earlier.

Sensitivity Evaluation Results

Rank	Variables
#1	Bus Purchase Price; or Currency Conversion Rate
#2	Diesel Fuel Price; or Annual Travel Distance
#3	Relative Maintenance Savings (for Electric Buses)
#4	Electricity Price; or Bus Electricity Consumption

Major Steps for Electric Bus Deployment

Step	Description
#1	Sufficient deployment in the range of 12 to 20 buses, which for Winnipeg Transit would represent roughly two percent to three percent of the fleet
#2	Large deployment in the range of 120 to 200 buses, which for Winnipeg Transit would represent roughly 20 percent to 30 percent of the fleet
#3	Final full system-wide deployment

Components for Electric Bus Deployment

Item	Brief Description
Transit route planning	Determining how to best integrate electric buses into transit service
Transit physical infrastructure planning	Determining how physical and transportation (civil) works are affected by electric buses
Electrical infrastructure location and implementation	Optimizing from electrical service and transit operation perspective where to place rapid charging infrastructure
Bus technology availability and status evaluation	Determining what technology capabilities and limits are likely to be in place by the time of realistic implementation
Charging standards status and compliance	Confirming the status of common-based standards for bus-related charging
Maintenance planning	Confirming the nature of maintenance savings and maintenance requirements for electric buses
Maintenance facilities modifications	Determining what modifications are necessary, particularly from a safety perspective
Training requirements	Confirming the nature and extent of training, and which staff need to be involved
Project team coordination	Coordinating overall activities toward transit electrification

Greater Integration Cost: The direct integration cost used for the high-use buses scenario is based on a preliminary analysis, and could be potentially greater. To understand the impacts of this cost, a much higher level of direct integration cost is also evaluated, with electric bus availability assumed to be fully constrained by charging activities for 90 minutes each day (a very high level, requiring a much higher level of redundant back-up).

The impact on the high-use buses scenario is dramatic, with the cost deficiency in this case increased from $130,000 to about $580,000 per bus. The peak-use buses scenario is unaffected because it was deliberately designed to largely avoid costs of integration. The deficiency remains at about $160,000 per bus.

Increased levels of integration cost shift the relative advantage to the peak-use buses application. Although achieving high-mileage usage of buses is important for enhancing economic viability, through diesel fuel cost avoidance, it is equally important to address and minimize direct integration costs for electric transit buses. Just as previously noted regarding the extent of rapid charging infrastructure required, a true cost for electric bus integration can be only understood through gaining more extensive in-service experience. Again, this emphasizes the need for deploying buses in stages.

Future Directions

Given the need to address integration issues, the task force found that a gradual transition toward electrification, based on a few buses at a time, would not be meaningful. Instead, a series of larger step-by-step changes are necessary. Three main steps are identified, as summarized in the upper table on the opposite page.

At each step, proof of operability and cost effectiveness need to be confirmed. The costs associated with these step-by-step changes will be significant, but to validate the effectiveness of the technology and be able to move forward, progress will ultimately be needed by the North American transit industry as a whole. Given the advanced status of activity and the extensive practical experience already achieved here, Winnipeg represents a good site to begin the paradigm shift.

As part of its work, the task force identified a series of components that would need to be addressed as part of a detailed implementation plan for a 12 to 20 bus deployment. Relevant components are summarized in the lower table on the opposite page.

Conclusions

Key conclusions from the work of the task force are as follows:

- Electric buses show significant future promise in addressing multiple, pressing societal concerns.
- Benefits of electric buses include:
  - reduced operating costs, most significantly for fuel but also for maintenance
  - reduced environmental impacts, in particular regarding GHG emissions
  - enhanced energy security and price predictability
- Given the still relatively high capital cost for electric buses and associated charging infrastructure, the task force analysis shows the electric bus option to be somewhat more costly overall than diesel buses for the evaluated scenarios.
- Although a gap exists to achieve economic viability, the gap is neither overwhelming nor insurmountable, with the longer-term advantage leaning toward electric buses. This is because of declining costs for batteries, and uncertain but likely higher costs for diesel fuel, including the effects of a price on carbon.
- Considering only the capital costs for purchasing electric buses and charging infrastructure, bridging the gap can be achieved if capital costs can be reduced in the range of 12 to 16 percent, which is quite realistic over time.
- A major necessity for electric buses that also represents a significant associated cost factor is their integration into existing complex transit networks. This important finding has not been previously identified as an issue for electric buses. The focus so far across North America has been on small-scale testing to evaluate the technology, rather than looking at large-scale integration.

Second-generation electric bus and rapid-charging system at Winnipeg's James Armstrong Richardson International Airport (photograph courtesy of New Flyer)

- The task force recognizes that significant inherent conservatism has been built into costs for the electric option. This is simply because of a lack of sufficient field experience with electric bus technology.
- Sensitivity analysis shows a clear priority order in the importance of changes to cost variables that can affect bottom line viability:
  - changes in purchase price or currency conversion are most important
  - followed by changes in diesel fuel price or annual travel distance
  - followed by changes in the level of maintenance savings
  - followed lastly by changes in electricity price or bus electricity consumption.
- As outlined in this report, one of the most advanced electric bus demonstrations in the world is well underway in Winnipeg. This means that the level of practical experience with electric buses here is already high, making Winnipeg an ideal site for deploying electric buses on a larger-scale.

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