NO LITTLE PLAN:

Electrifying GO Transit

Greg Gormick

clean train coalition
TRANSIT FOR A HEALTHY CITY

Transport Action Ontario

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NO LITTLE PLAN: ELECTRIFYING GO TRANSIT

BY

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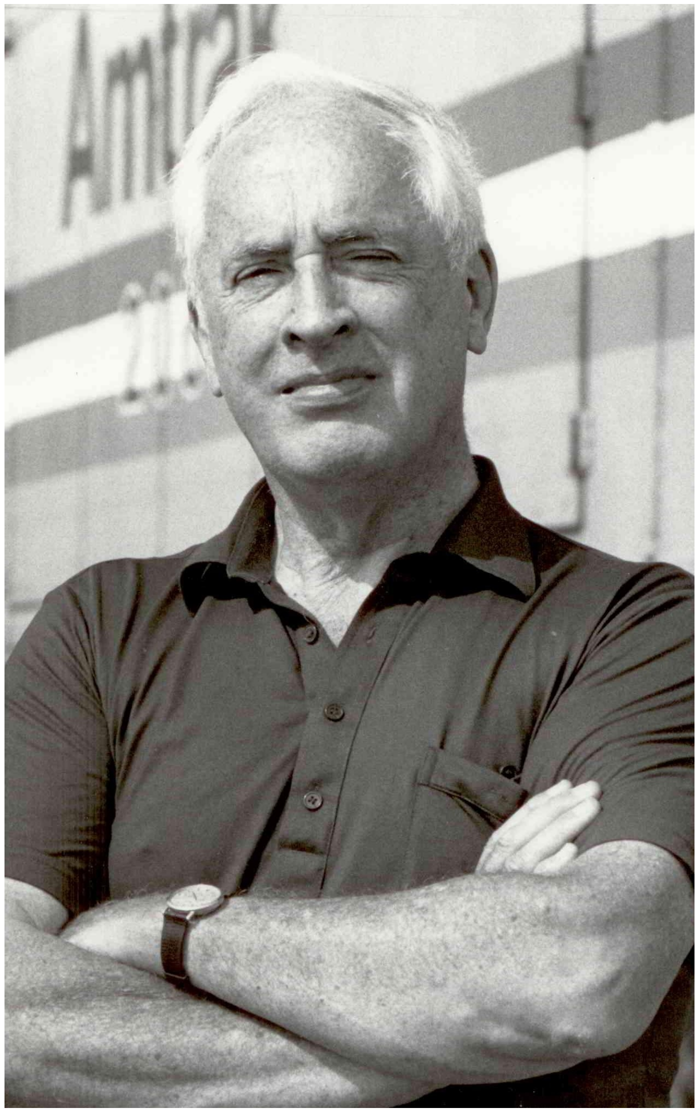
Dedication



This report is dedicated
to the memory of the late John Bruce McCullum,
President of Transport 2000 Ontario (now Transport Action Ontario)
from 1988 to 1992.

Visionary, ecologist, and sustainable transportation advocate.

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Foreword

As readers of this report will find, the electrification of GO Transit has a long history. Following the innovative establishment of GO's commuter rail service in 1967, electrification was studied seven times, most recently with the Metrolinx GO Electrification Study that was released on January 19, 2011.

All these studies identified many positive attributes to electrification. However, not one centimetre of electrified commuter rail infrastructure has to date been built. The situation today remains perplexing and frustrating. Despite identifying many positive features, the most recent Metrolinx study recommends what can only be described as a leisurely implementation of electrification on two corridors only.

As readers will also find, the GO Electrification Study and the Air Rail Link plan both contain assumptions and omissions that must be challenged. In our minds, the worst issue is the difference between the 2021 reference case used in the Electrification Study and the 2031 vision in the Metrolinx Regional Transportation Plan, better known as *The Big Move*. It includes high-frequency, day-long express rail service, similar to that provided by the impressive urban rail systems in European cities like Paris and Berlin. This can only be accomplished with electrification. But the study doesn't quantify the benefits, alternatives and costs to attain this vision, sticking only to the 2021 scenario of modest service increases. It also under-emphasizes the very likely ability of electrification to reduce the required scope of Union Station's capacity increase and the magnitude of the planned Yonge subway capacity expansion.

We commissioned this report, *No Little Plan: Electrifying GO Transit*, to prod the Government of Ontario to look at the longer term – the period from 2031 onward – and commit promptly to an accelerated, expanded electrification plan. Written by Greg Gormick, an experienced and visionary transportation commentator who has written extensively about the transformational potential of electrification, this report identifies the key next steps to maintain momentum. His exploration of worldwide electrification experience demonstrates the lengthy implementation plan can definitely be shortened.

The need for a European urban rail approach is even more intriguing as a result of recent events in the City of Toronto. With the cancellation of planned LRT lines and the reduced coverage provided by proposed subways, a "surface subway" concept using electrified GO integrated with other transit lines is an important cost-effective option to consider.

We urge decision makers to read this report carefully and start down the implementation path now. We are greatly concerned that another opportunity to transform GO and our region-wide public transit network – and thereby improve the economic, social and environmental health of the Greater Toronto and Hamilton Area – is once again slipping through our fingers.

Peter Miasek
President
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May 16, 2011

Executive Summary

Introduction

GO Transit was launched by the Government of Ontario in 1967 as North America's first new commuter rail service in decades. It was an immediate success. Today, it is difficult to imagine what the Greater Toronto and Hamilton Area (GTHA) would be without the GO system. And GO's success has inspired other cities. There are now 10 commuter rail systems in other North American cities that are carbon copies of GO.

But GO and the region are at a crossroads. GO is slated to play a key role in altering the commuting habits and land development patterns in the GTHA. Vastly expanded GO service with more trains on more lines and quicker schedules are among the cornerstones of the Metrolinx Regional Transportation Plan (RTP), better known as *The Big Move*. To do this, the current provincial government is going to have to commit to a decision as bold as the launch of GO in 1967. There is compelling evidence to suggest that the only way to achieve the provincial goals is to progressively and aggressively convert GO to clean, quiet and cost-effective electric operation. This is the course that other large and medium-sized urban regions have followed worldwide.

This report has been commissioned to encourage the Government of Ontario to commit fully to an accelerated electrification plan now, thus avoiding the ongoing penalties on the region's economy, environment, public health and long-term sustainability.

1.0 Rail Electrification's History of Excellence

Rail electrification in North America is not new technology. The first application on a main line railway was in 1895 in Baltimore. The first example of "taking wealth from the air" by exploiting development rights over electrified lines was achieved above New York's Park Avenue in 1906. The first use of self-propelled electric multiple unit (EMU) cars for fast, frequent commuter rail service was implemented in New York at the same time. The first electrification of a major intercity network was undertaken by the Pennsylvania Railroad (PRR) from New York to Washington and Harrisburg, Pennsylvania, in 1928.

All these installations proved four advantages of electrification: lower emissions and noise, tunnel operation without massive ventilation systems, its superiority in conquering steep grades and its ability to squeeze more capacity from the same track and station infrastructure.

After World War Two, rail electrification continued in Europe, but stalled in North America. The main reason was the perfection of diesel-electric locomotives, which use onboard diesel engines to power electric traction motors. This had some of the benefits of the electric locomotive and lower upfront capital costs compared to electrification. In the 1950s and '60s, some aging electric lines were scrapped, especially short tunnel operations, such as CN's St. Clair River Tunnel electrification at Sarnia, Ontario. These were replaced by diesel operations with new ventilation systems to clear the tunnels of fumes.

But one major railway maintained its commitment to electric traction. On the PRR, studies concluded diesels still couldn't compete with electric operation. The result was renewal of the fleet with new EMUs for commuter service and high-horsepower electric locomotives for freight.

In the early 1970s, as a result of the OPEC oil crisis, several North American railways re-examined electrification, including Canadian Pacific. But once the OPEC crisis passed, oil prices stabilized and the rail industry returned to its pro-diesel stance.

Today, North America has re-awakened to electrification's potential. Part of this renewed interest revolves around the spate of high-speed rail projects now proposed in the U.S. Also, faced with automobile-fed urban sprawl, rising energy costs, uncertain future oil supplies and continued environmental degradation, there is a growing public call for the expanded rail electrification. There are currently 19 commuter rail electrification projects and proposals under way in North America.

2.0 GO Electrification Studies: 1980-2001

The benefits and the means of electrifying GO have been studied on numerous occasions in the past. Each of the previous studies contains data still relevant to the issue today.

The first series of studies was carried out in 1980-1982 and concluded, *"The province should prepare for future change by completing current planning studies and carrying our detailed design of financial implementation studies needed to validate and implement electrification of the Lakeshore portion of the GO Transit commuter rail network."*

A detailed implementation plan followed. However, the plan was derailed by the Province's insistence that GO use the unproven, made-in-Ontario Advanced Light Rail Transit (ALRT) technology. By the time it was determined that the cost of ALRT was excessive, the momentum for electrification had been lost.

In 1992, another comprehensive study clearly spelled out the virtues of electric traction. Electric multiple units (EMUs) vis-à-vis electric locomotives received serious study. It was concluded it was not possible to convert GO's non-powered bi-levels to self- propelled EMU operation, as there was little under-floor space for traction equipment. It was suggested that new motorized driving cars could be paired up one-for-one with the existing bi-levels. The study team recommended the preferred traction power system to be +/-25,000 volts AC (now known as 2x25 kV). The report also dealt extensively with emissions and noise, demonstrating that electrification would result in significant reductions in both types of pollutants.

Exhaustive though it was, nothing came of the 1992 study, even though the government of Premier Bob Rae was philosophically supportive. The global economy had receded and there were no provincial funds available to move forward.

The GO electrification issue slumbered until 2001, when an opportunity arose to purchase surplus electric locomotives from Mexico. A study confirmed the incremental capital and operating costs for electrification from 2004 to 2021 would be less than $100 million. This did not account for the significant health, environmental and ridership benefits. Although GO electrification had never been more affordable, the government of Premier Mike Harris did not act.

3.0 Enter Metrolinx

Metrolinx is the provincial government agency established in 2003 to plan and coordinate transportation within the Greater Toronto and Hamilton Area (GTHA). A takeover of provincially-owned GO Transit was later added to its mandate.

In 2007, prior to release of the Metrolinx Regional Transportation Plan, *The Big Move*, the Premier released his Move2020 plan, an $11.5 billion commitment to 52 priority transit projects in the GTHA, including *"increasing speed and reducing emissions by electrifying the GO Lakeshore line and expanding capacity on all GO lines".*

The government's endorsement of electrification escalated in 2008 with its acceptance of *The Big Move*. Express rail, defined as *"high speed trains, typically electric, serving primarily long-distance regional trips with two-way all-day service"*, was a cornerstone of the plan. *The Big Move* proposed express rail on GO's Lakeshore and Brampton lines within 15 years and on the Milton and Richmond Hill lines within 25 years. Additional express rail service was identified for beyond the 25- year planning horizon.

The inspiration for this program was provided by the electrified, high-frequency urban rail systems of Western Europe, such as the Paris RER and the German S-Bahnen, which are much like high-capacity surface subway systems serving suburban and inner-urban passengers.

Metrolinx then commissioned a follow-up study for the Lakeshore. Electrification of the full line was pegged at $4 billion, including contingency. This large price tag seemed to discourage Metrolinx and electrification started to fade away once again.

Electrification was revived soon thereafter as a result of the Air Rail Link (ARL) project. Conceived as a diesel multiple unit (DMU) service, it would operate up to 150 trains between Union Station and Pearson International Airport daily. Added to the expansion plans of GO and VIA Rail, this would result in more than 400 diesel trains passing through well-developed neighbourhoods daily. In 2005, the Weston Community Coalition addressed the issue and then spearheaded the 2009 formation of the Clean Train Coalition (CTC). Composed of residents' associations along the line, the CTC dedicated itself to presenting citizen concerns and advocating improvements, including electrification. The urgency increased when the diesel-powered ARL was attached to Toronto's bid for the Pan Am Games, to be held July 10-26, 2015.

In May, 2009, under pressure from the CTC, local politicians and MPPs, the McGuinty government announced it would undertake a $4 million "comprehensive review" of GO electrification.

4.0 The Metrolinx GO Electrification Study

The 1,705-page GO Electrification Study Final Report was released January 19, 2011. Observers were pleasantly surprised that a phased electrification plan was recommended for the ARL/Georgetown and Lakeshore corridors, with the former as the first priority. The two-route plan was approved unanimously by the Metrolinx directors one week later and, within minutes of the board's decision, Minister of Transportation Kathleen Wynne announced the initiation of the Environmental Assessment process.

The decision was based on a combination of journey time savings, operating and maintenance cost savings, anticipated future ridership growth and electrification's contribution to the long term goals of *The Big Move.*

The estimated cost was $1.6-1.8 billion. It was recommended that the implementation be phased in over 21-24 years. This time line struck many as extremely slow when compared with the implementation schedules of other railways around the world.

CORRIDOR SEGMENT	COMPLETION
Union Station-PIA and Willowbrook (EA and Design)	2011-2015
Union Station-PIA and Willowbrook (Construction)	2018-2020
Airport Spur Junction-Brampton Mount Pleasant	2020-2022
Union Station-Oshawa	2024-2026
Willowbrook-Oakville	2026-2028
Oakville-Hamilton James Street	2028-2030
Oshawa-Bowmanville	2030-2032
Brampton Mount Pleasant-Kitchener	2032-2035

Perhaps the most useful revelation in the report concerned the cost of GO electrification. The estimated cost to electrify the full GO system was $3.7-4.2 billion, much lower than previous estimates.

Although the report was generally positive, there were a number of contradictions, false assumptions and omissions that still need to be challenged:

1. The Reference Case selected was GO's 2021 benchmark consisting of a limited amount of service expansion using diesel-hauled bi-level trains of 10-12 cars, except for the ARL which assumed single-level diesel-motorized units. The result is that electrification was assessed against a case that falls far short of what was envisioned in *The Big Move*, which contemplated high-frequency, all-day service in both directions on all routes. This results in a report that views electrification as far less of a system development tool that it should be.

2. Tier 4 diesel motive power was assumed to be available and it was against this form of traction that electrification was compared. Tier 4 aims to significantly reduce particulate and nitrogen oxide emissions versus today's diesel engines. However, no manufacturer has yet produced a commercially viable Tier 4 diesel.

3. The equipment selected was electric locomotives rather than EMUs, largely because the study concluded EMUs would have higher total costs over the 30-year life cycle. However, many senior railroaders feel these costs were overstated, especially in view of the superior performance of EMUs. A bi-level EMU strategy should have been studied in detail. For example, the 1992 GO Electrification Study found the design of existing bi-levels could be adapted to create bi-level EMU power cars capable of hauling existing GO bi-level coaches.

4. Health, environmental, social and community benefits were undervalued. The study claimed these benefits are small. To make this case stick, Metrolinx reported the benefits in the context of GO's anticipated emissions on a regional basis, not directly on the affected corridors. This contradicts the opinion of Toronto's Medical Officer of Health.

The beneficial economic impact of electrification is substantial. Using accepted industry multipliers, it is estimated electrification of the ARL/Georgetown and Lakeshore corridors would generate $5-7 billion in economic benefits. Electrification of the full GO system would generate $11-17 billion. Much of this activity would occur in Ontario.

It is difficult to fathom how electrification of two GO corridors could possibly require the 21-24 years proposed by Metrolinx. There are numerous techniques and technologies around the world to make it happen quicker and without unduly disrupting existing rail traffic. Metrolinx must be encouraged to study this issue in much greater detail and move in concert with other planned infrastructure investments.

The most controversial aspect of the report was the recommendation to proceed with the ARL as a diesel service to be completed in time for the two-week Pam Am Games in July, 2015, with future conversion of the units to EMUs. If the approved plan is followed, the ARL will be electrified by 2018-2020 and some further reduction in the level of diesel-powered GO service on the Georgetown Corridor will occur by 2020-2022. The complete elimination of diesel-based service on the line will not occur until 2032-2035.

It has become clear that the 2015 start-up of the ARL as a diesel-powered service is a "done deal". The contract with Japan's Sumitomo for 12 diesel multiple unit (DMU) rail cars was signed on March 29, 2011.

Still, many issues and concerns remain:

- There is doubt the passenger volumes and automobile trip replacements predicted for the ARL will materialize.
- With its low projected ridership, the diesel-powered ARL may actually increase fuel consumption and emissions vis-à-vis the automotive trips it will allegedly replace.
- The future conversion of the DMUs to EMUs is risky and highly unlikely.
- The ability of the Sumitomo DMUs to meet Tier 4 emission standards is unknown.
- The final price for the Sumitomo DMUs is surprisingly high when compared to the price paid by the Sonoma-Marin Area Rail Transit District.

- The addition of more station stops should be explored in the context of using the large investment in the ARL as a springboard for a high-frequency urban rail service.
- GO's questionable decision to spend $400 million to build a fourth track on the Weston Subdivision to protect for the construction of electrification infrastructure after ARL diesel service begins requires further investigation and justification.
- Delaying the ARL until electric service can be launched from the start ("do it once, do it right") would avoid this $400 million expenditure. Other green transportation alternatives can be put in place for the two-week Pan Am Games.

5.0 Conclusions and Recommendations

Despite initiation of the Environmental Assessment process, the fight for GO electrification has not yet been won. As with many other Ontario transit programs that were supposedly assured, there has been far too much talk and too little action.

If GO electrification is to be implemented as promised, there are measures that need to be taken soon:

- **Accelerated and Expanded Electrification Program**: The leisurely timelines must and can be accelerated. The scope of the lines to be converted can be increased.

- **International Peer Input**: This will advance the implementation in the most expeditious and cost-effective manner possible.

- **Freight Railway Consultation:** Most of the track for the approved plan is owned by freight railways. The involvement and approval of these railways is critical to successful implementation.

- **European Urban Rail Concept:** In *The Big Move*, a vision was presented that transformed GO into a higher speed, higher frequency urban rail service. Electrification is critical to such a plan, along with high-performance EMUs, full fare integration and numerous physical connections with other transit lines. Some have termed this a "surface subway" or "overground" system.

  The implementation of an urban rail strategy should be accelerated within the City of Toronto. With the cancellation of Toronto's Transit City LRT plan and the reduced coverage to be provided by the proposed subway alternatives, a fully-integrated GO rail system providing subway-like service on existing and re-aligned rights-of-way is an attractive option. A failure to embark on such a project will only condemn the GTHA to more gridlock, lost productivity, environmental degradation, excessive automobile dependency and a loss of global competitiveness.

- **Public Scrutiny and Oversight:** GO electrification only became an issue because of public scrutiny and advocacy. If electrification is to be implemented as promised by the current government, and even expanded, then the public will need to keep up the campaign. And if the government is sincere in its stated desire to involve citizens in this process, it should maintain and strengthen the stakeholder workshop process that was in place throughout the one-year GO Electrification Study. Few of the public recommendations made in those sessions were investigated, let alone incorporated into the final plan.

Introduction

"Make no little plans; they have no magic to stir men's blood and probably will themselves not be realized."

Daniel Burnham

In the late 1950s, the Government of Ontario faced a daunting challenge. The rapid growth of Toronto had placed tremendous pressure on the region's existing transportation system. Major choices about its future direction had to be made. As with many North American cities that boomed in those heady postwar years, most of the growth beyond the boundaries of the old, transit-dependent city was being fuelled by the automobile.

How would the province respond? There was pressure from many quarters to follow the example of U.S. cities such as Los Angeles, Houston, Atlanta and Detroit by recasting this urban region as one whose transportation destiny would be surrendered to the automobile. A few lonely voices argued for a response that leaned heavily on transit expansion and urban development policies designed to support it.

Both Premier Leslie Frost and his successor, Premier John Robarts, remained unconvinced that automobiles and highways alone should define the future of the Metropolitan Toronto Region. The cost and consequences of the land acquisitions for a highway-based transportation system would have been staggering. Cities that had done so, such as Los Angeles, were already drowning in the cars that merely continued to feed the sprawl and consumed all new highway capacity.

On May 19, 1965, Premier Robarts announced his bold plan. Ontario would create an 84-kilometre experimental commuter service over the upgraded Canadian National line from Pickering to Toronto Union Station and on to Oakville and Hamilton. It would be called GO Transit and it would be North America's first new commuter rail service in decades. The public hailed the premier's decision, even while many highway-minded civil servants and planners scoffed at it.

Launched on May 23, 1967, with Premier Robarts at the controls of the first train, GO was – to paraphrase the legendary Chicago architect and planner, Daniel Burnham – "no little plan." The impact of the initial Lakeshore Line on the communities it served was swift and dramatic. The two-year ridership targets were reached within six months. A visiting delegation of politicians, civil servants and planners from New Jersey declared GO to be "Toronto's transportation triumph: The right thing, done at the right time and in the right way."

The two Ontario premiers who believed in rail transit and committed their governments to build it: John Robarts (far left) and Leslie Frost (second from right), at the 1963 opening of the TTC's University subway.

Today, it is difficult to imagine what the Greater Toronto and Hamilton Area (GTHA) would be without the expanded GO rail system. Not only has it helped shape this region, it has inspired other cities to follow Toronto's example. There are now 10 GO carbon copy commuter rail systems operating in cities as diverse as Vancouver, Miami, Dallas, Albuquerque and Los Angeles. Others have emulated major aspects of GO.

But GO and the region are at a crossroads once again. They are facing a challenge as daunting today as that which confronted Premier Robarts back in 1965. In the years since he launched his visionary commuter rail system, there has been a failure to bolster and increase the public commitment to GO and the transit-oriented principles which compelled its creation. At best, successive governments have been stingy in their treatment and funding of GO. At worst, they have ignored and neglected it, underestimating its power to help shape this region's urban form and functioning. The publicly-funded highway system has continued to grow, fuelling the gridlock and urban sprawl that GO was designed to prevent.

Now, the opportunity has arisen to recommit to GO and fully embrace its ability to bring about decisive change to the commuting habits and land development patterns of the GTHA. One of the cornerstones of the 2008 plan wrought by the Government of Ontario's regional transportation agency, Metrolinx, is vastly expanded GO service. More trains, on more lines, operating on quicker schedules, seven days per week.

To do this, the current provincial government is going to have to commit to a decision as bold as that made by Premier Robarts 45 years ago. There is compelling evidence to suggest that the only way to make GO one of the healthiest, most efficient and sustainable arrows in the Province's regional transportation quiver is to progressively and aggressively convert it to clean, quiet and cost-effective electric operation. This is the course that other major city regions have chosen worldwide.

Make no mistake about it: this will be no little plan. It involves a steady and assured stream of capital funds if it is going to deliver its full benefits. But – measured by the performance of the great electric commuter rail systems around the world – that investment will repay itself many times over in health, environmental, social and economic benefits.

This report has been commissioned to encourage the Government of Ontario to commit fully to an accelerated electrification plan now. The growing pressures on the GTHA and its transportation system suggest that delaying it will only inflict ongoing penalties on this region's economy, its environment, the health of its citizens and the long-term economic sustainability of its regional transportation system.

The time for accelerated GO Transit electrification is now.

1.0 Rail Electrification's History of Excellence

"Electricity is the natural medium for the application of motive power. Its supply is unlimited. It is everywhere. It is to movement what the sun is to growth."

The Western Electrician, 1899

To appreciate the advantages of rail electrification, it is necessary to understand how and why it was developed. It is a saga of continuous development and evolution that has produced a form of high-productivity transportation that is risk-free, economically superior, environmentally sustainable and unchallenged by any other type of motive power.

The development of the railway was one of the world-changing events of the 19th century. The concept of low friction steel wheels rolling on steel rails altered the world's perception of time and distance. Steam trains made possible rapid, all-weather communication and commerce between cities and towns that had been at the mercy of uncertain and expensive water and wagon road transportation. Inside those cities and towns, horse-drawn streetcars were the first step towards affordable mass transportation for the growing urban population in countries transformed by the steam-powered Industrial Revolution.

As revolutionary as these early forms of transport were, they had limitations. Horsecar systems required large numbers of animals to power them and equally large workforces to tend them. Steam locomotives were dirty, noisy, labour intensive and limited by the capacity and efficiency of their fireboxes and boilers.

It is little wonder that numerous inventors tried to improve railroading as early as the 1830s by marrying it with another wonder of that century: electricity. Early attempts using battery power were unsuccessful. But by the last quarter of the 19th century, the advances in electrical technology resulted in numerous demonstrations of small, generator-powered electric rail vehicles in North America and Europe.

Inventors such as Werner von Siemens, Charles J. Van Depoele, Frank Sprague and others at Thomas Edison's Menlo Park labs were among those who built experimental electric trains using direct current (DC) transmitted by ground-level rails or overhead wires. The first was demonstrated in Berlin in 1879 by von Siemens. Another was constructed in 1883 at the predecessor of the Canadian National Exhibition.

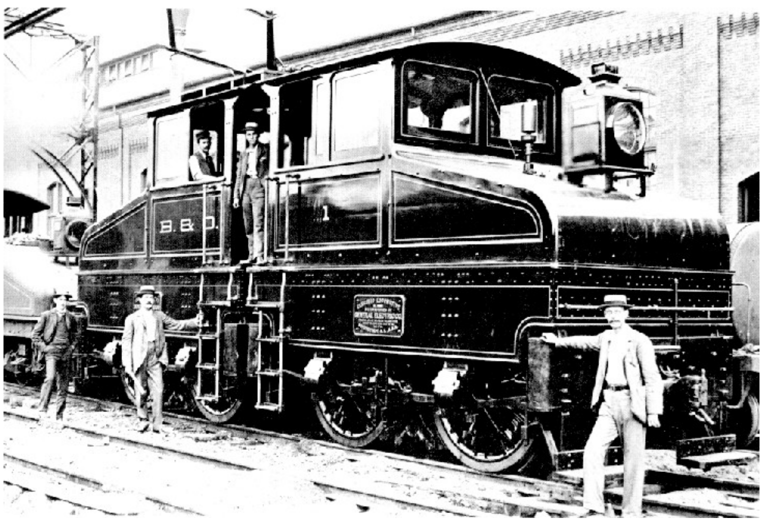
"Our electric train is creating quite a stir," Werner von Siemens proudly wrote to his brother on June 12, 1879. His experimental electric train – generally regarded as the world's first successful design – was demonstrated to eager Berliners 132 years ago.

By the 1880s, commercial applications finally appeared, drawing heavily on the numerous advances that had been made in electrical generation, transmission and motor design. The first beneficiaries were the horse-drawn street railways, which were electrified with low voltage DC power supplied to the streetcars via wires strung over the tracks or in conduits buried between the running rails.

Next, it became possible to electrically power the larger and heavier rolling stock used on elevated rapid transit systems in cities such as New York and Chicago, which had been powered by steam engines that showered the streets with smoke, soot and hot cinders. Electrification also made possible underground or subway rapid transit systems. Attempted with limited success in London using complex condensing steam locomotives, subways were impractical until it became possible to power them electrically.

1.1 Harnessing 'White Coal'

Finally, in 1895, electricity was first applied to main line railroading. When the Baltimore & Ohio Railroad (B&O) built its 5.5-kilometre Baltimore Belt Line, it required a 2.3-kilometre tunnel under the city with a steep climb at its northern end. The city was opposed to any scheme that would vent smoke and cinders on to the streets from the tunnel. As well, the steep grade would have required a reduction in the train lengths or "double-heading" with two steam locomotives and crews. Electrification was the answer.



The B&O contracted with General Electric (GE) for the locomotives, power generation station and a rigid DC overhead power rail system. When the line opened on June 27, 1895, it was heralded as the dawn of a new era in transportation. Small and specialized as it was, the B&O's line demonstrated it was possible to move heavy intercity trains reliably with electricity. Because of its clean, quiet qualities compared to the coal-fired steam locomotives, electrification advocates called this new motive power source "white coal" and said a trip on an electric train was like riding "on a streak of chained lightning."

Rail electrification – in lockstep with the entire electrical industry – advanced rapidly. Other North American and European railways studied its application for tunnels, heavy grades and dense urban operations, such as the Gare d'Orsay in Paris, which became the world's first fully-electrified underground railway complex when it opened in 1900. But it was a tragedy that gave electric railroading its biggest boost and led to three projects that decisively proved its applicability and reliability.

The New York Central Railroad (NYC) was the only line to directly serve Manhattan, which it did via a four-track route that required 3.2 kilometres of tunnels under Park Avenue to reach Grand Central Station at 42nd Street. On January 8, 1902, a commuter train in the tunnel was rear-ended by another whose crew couldn't see the smoke-obscured signals, killing 15 people. The New York State Legislature decreed that steam locomotives would be prohibited in Manhattan as of July 1, 1908.

Based on the success of the B&O operation and facing the legislated deadline, the NYC's managers embarked on a crash program of electrification and modernization. The old station was replaced by a new Grand Central Terminal consisting of 67 tracks on two levels below the city's streets. Using a DC third rail system similar to those applied to subway and elevated transit lines, the NYC electrification ultimately embraced three routes and 800 track-kilometres.

The first phase of this landmark project was inaugurated ahead of schedule in late 1906. All the work had been undertaken while the existing steam-powered commuter and intercity passenger and freight services kept rolling. At its peak, the NYC's electrified zone handled more than 800 trains daily, almost all of them funnelled through the four-track tunnel under Park Avenue. It continues today as the state-owned Metro-North Commuter Railroad, which carried more than 79 million passengers in 2009 – nearly 300,000 on a typical weekday.

1.2 Taking Wealth from the Air

One large benefit of the NYC electrification was the world's first air rights development project. Without the need to vent smoke from the steam locomotives, it was possible to build over a railway line. The project's chief designer described it as "taking wealth from the air." His visionary Park Avenue development plan – combined with the reduced rail operating costs – helped pay the $80 million cost of the electrification and the monumental Grand Central Terminal. Thanks to electrification, air rights development has occurred hundreds of times over in major cities around the world.

The reputation of electricity as a form of propulsion capable of meeting the heavy demands of urban railroading was solidified by the NYC project and boosted by its major competitor, the Pennsylvania Railroad (PRR). Its tracks from the west ended at the Hudson River, placing it at a competitive disadvantage.

The PRR's answer was a 21.5-kilometre line under the Hudson to its new 21-track Pennsylvania Station in Manhattan. An East River tunnel extended the electrification to a connection with its subsidiary Long Island Railroad (LIRR), North America's first commuter railway. The only way to operate this vast underground complex was electrically. The PRR chose a 600 volt DC third rail system, which it also applied to six LIRR commuter lines, all of which remained in service as they were electrified. Completed in 1910, the $113 million PRR New York Tunnel and Terminal Project dramatically improved passenger transportation in New York and spurred transit-oriented development on Long Island.

The third player in this electrification revolution was the New Haven Railroad (NH). To reach uptown Manhattan, the NH had trackage rights on the NYC's Grand Central line for its New England trains, including its Connecticut commuter service. To continue using that track, the NH adopted the NYC's third rail DC scheme. But east of the junction, 11,000 volt alternating current (AC) was supplied by an overhead wire catenary system to roof-mounted pantographs on the trains, which switched from one system to the other while running at speed.

The NH decision to use AC power came at the height of the "War of the Currents." Championed by GE, DC power had a tremendous effect on everyday life, bringing with it widespread electrification of street and household lighting, street railways and industry. It was hailed as the Second Industrial Revolution. But the subsequent perfection of AC by GE's rival, Westinghouse, offered advantages just as revolutionary. In railroading, too, AC power had a lasting impact.

AC can be transmitted at high voltages over long distances with little energy loss and fewer substations than DC. Catenary, which can also be used for DC current, is safer and less prone to weather disruption than a third rail, which can't handle higher-voltage AC current. AC reduced rail electrification costs, as was proved when the NH's first segment opened in 1907. It eventually encompassed 245 route-kilometres and 1,050 track-kilometres, including a new line to connect with the electrified PRR line into Penn Station.

The success of the three New York electrification projects sparked a wave of planning in North America and Europe. It was apparent that electrification had set a new gold standard for high-efficiency railroading.

1.3 The EMU: A Whole Train in One Car

Although there were technical differences, the three New York systems shared many principles and characteristics. The most visible was the motive power and rolling stock. All three used electric locomotives to haul the passenger and freight trains that originated or terminated outside the electrified zones behind steam engines. But for fast, frequent commuter service within those zones, the three railways selected self-propelled, subway-like electric multiple unit (EMU) cars.

Many first and second generation North American EMUs delivered reliable and cost-effective service for decades. Typifying this longevity were the Blueliners of the Philadephia-area commuter service of the Reading Company, which entered service in 1931 and weren't completely replaced until 1990. Photo from the Joe Testagrose Collection.

The key to this EMU concept was hardwired electrical control technology, which couldn't be duplicated with steam traction. It enabled any number of electric cars or locomotives to be coupled and controlled by one person from cabs at the front or rear of any train. This yielded one of the tremendous operating cost advantages of electrification, eliminating the need to power long and heavy steam trains with extra, individually-controlled locomotives operated by separate crews.

EMUs offer many advantages over locomotive-hauled operation, including:

- Even distribution of motors and brakes throughout a train, yielding uniform performance no matter how short or long the train, allowing for greater speed and density of service, and with fewer cars than required by locomotive haulage;
- A reduction of the heavy forces exerted downward into the track and bridges by locomotives, with the weight distributed evenly throughout an EMU train;
- Elimination of the need to move the locomotive from one end to the other or turn the entire train on special trackage, saving time, crew costs and infrastructure;
- Ease of maintenance, thanks to under-slung motors and other gear accessible from the sides or through trap doors in the car floors; and
- Substantial reductions in labour and energy costs.

Most importantly, the three New York projects validated electrification's superiority in solving four broad challenges facing railroaders worldwide.

1.4 Electrification’s Advantages

1.4.1 Emissions and Noise Abatement

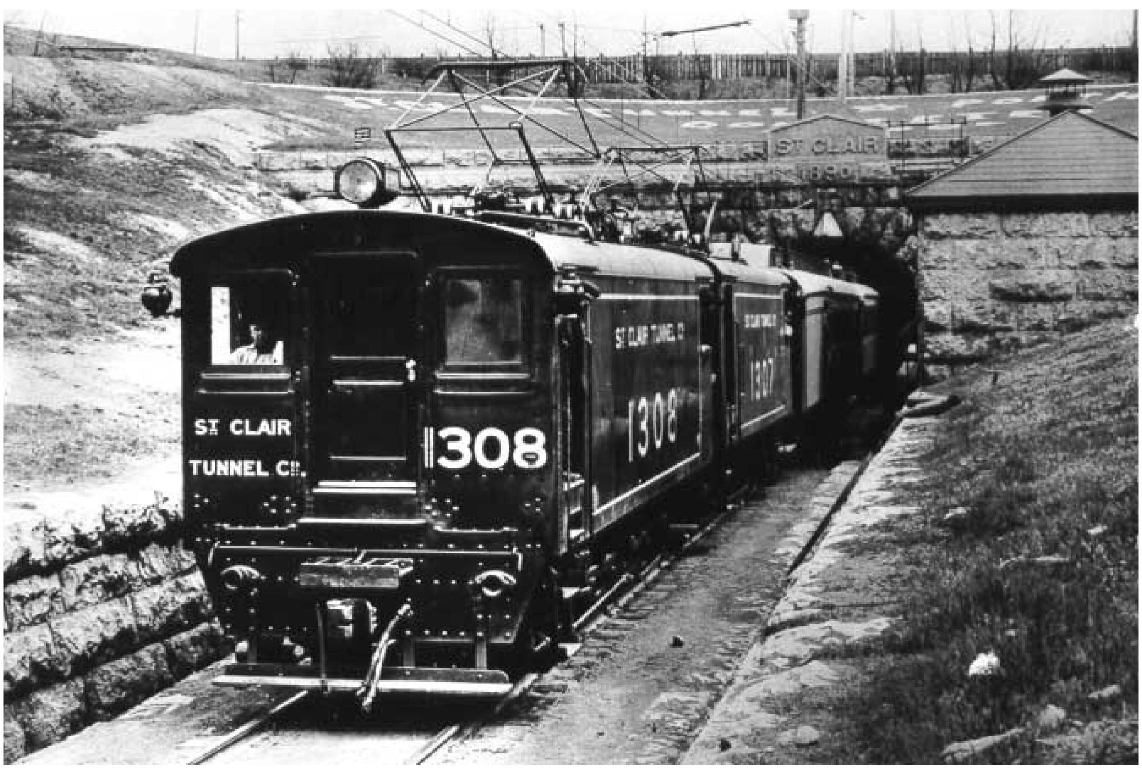
In urban areas, the emissions and noise from steam engines was, at best, a nuisance and, at worst, a health hazard. Electrified urban railways rid cities of online pollution and reduced noise considerably.

Critics point out that pollution is still created at offline generating stations, which in North America were generally coal-fired thermal plants during electrification’s early years. However, even early grid-connected systems converted more of the energy in the coal into productive horsepower than was possible with multiple steam locomotives of varying degrees of combustion efficiency. As a result, electric rail lines consumed less coal per horsepower and produced less pollution.

Cleaner power generation methods, particularly hydro, reduced the carbon footprint of many electrified rail operations. It also freed them from dependence on a single energy source. This provides strategic policy benefits for those railways using renewable, non-fossil fuel sources. For example, shortages of imported coal forced a reduction in the steam-hauled services of the Swiss Federal Railways during the First World War. An aggressive postwar electrification program made Switzerland’s railways independent of foreign energy by adopting domestic power sources for virtually all of its routes.

1.4.2 Tunnels

The drawbacks to operating steam locomotives in long tunnels are obvious. Where it was done, it often had life-threatening consequences for train crews and passengers alike, as was demonstrated by the NYC’s Park Avenue Tunnel collision. Just as electrification resolved the problem on that line, so it did for other tunnel operations, as well as making long tunnels on several new lines feasible.



Grand Trunk’s St. Clair River Tunnel electrification was the first in Canada, opening in 1908. It replaced a dangerous and inefficient steam operation between Sarnia, Ontario, and Port Huron, Michigan.

Three examples were found in Canada, two of them destined to become important components of the Canadian National Railways (CNR) after the Crown corporation was formed to rescue certain bankrupt private railways. The first was the Grand Trunk's St. Clair River Tunnel between Sarnia, Ontario, and Port Huron, Michigan, which was retrofitted as a DC catenary operation in 1908. The Canadian Northern line from downtown Montreal to the railway-planned suburbs to the north was opened in 1918 and its operation was only possible because of the DC catenary electrification of the five-kilometre Mount Royal Tunnel. As well, the New York Central's Detroit River Tunnel between Windsor, Ontario, and Detroit, Michigan, was opened in 1910 as a third rail DC electric operation.

Electrification was an even greater boon to the operation of Europe's long tunnels under the Alpine passes, including the Simplon (19.8 km), Gotthard (15 km), Lötschberg (14.6 km) and Arlberg (10.25 km). It later made possible the construction of even longer subterranean railway tunnels, such as Japan's Seikan (53.85 km) between the islands of Honshu and Hokkaido, the Chunnel (50.5 km) linking England and France, and the new Gotthard Base Tunnel (57 km), which will be the world's longest when it opens in late 2017.

1.4.3 Steep Grades

As the original B&O Baltimore Belt Line and several early European operations proved, electric locomotives are capable of conquering steep grades that would be difficult or even impossible for steam and other forms of motive power.

Electric locomotive and EMUs are able to deliver high and constant tractive effort through a wider speed range than steam or diesel locomotives. From a standing start through to high speeds, the electric output converted to actual pulling power is high and delivered continuously. Passengers on electric trains often comment on the smooth, rapid departures from stations and the seemingly effortless ascent of steep grades. The result is what railroaders often refer to as the "jack rabbit" acceleration qualities of electric trains.

Furthermore, electric motors have high short-term or overload capabilities. For short periods, electric traction systems can be overloaded to as much as twice their long-term continuous output rating. Unlike other forms of motive power, the electric is not limited by the capacity of an onboard power plant, such as a diesel engine or a steam boiler, but only by the high capacity of its traction system and the amount of electricity being fed to the trains from offline generating stations.

As a result, electrification was adopted by many railways serving mountainous territory, such as the Norfolk & Western and Virginian railroads in the Appalachian Mountains, and the Milwaukee Road's western transcontinental line, which crossed five mountain ranges on its route to Puget Sound.

The Milwaukee Road also introduced an innovation that remains a key advantage of electrification. Known as regenerative braking, it converts the train's traction motors into generators when braking or descending a grade, feeding electricity into the catenary to help power other trains and reducing wear on the air brake systems. Regenerative braking can recover more than 10 per cent of a train's power intake.

1.4.4 Capacity Expansion

The early New York City projects and others in Europe and the U.K. demonstrated electric trains make better use of track and station capacity than other forms of rail traction, thanks largely to their rapid acceleration and braking characteristics. This is especially true with EMUs, which make it possible for trains to easily reverse direction at their end terminals merely by having the engineer or motorman move from one end of the train to the other.

These capacity-building advantages grew with the development of automatic couplers. With the push of a button in the cab, EMUs can be quickly coupled or uncoupled. This reduces time and labour costs, and makes it easy to alter train lengths to meet fluctuations in demand. This helps to reduce the time that trains tie up tracks and platforms in end terminals with marshalling and switching movements.

These advantages were not lost on the Pennsylvania Railroad (PRR), which faced a major congestion problem at its Broad Street Station in Philadelphia at the same time it was gaining experience with its New York Penn Station project. Broad Street was handling more than 500 daily trains by 1913 and further expansion was impossible. Nor was the noise and pollution from this steam traffic appreciated by Philadelphians. The answer was electrification. Beginning in 1915, the PRR progressively electrified this dense commuter service with an 11,000 volt AC catenary system and improved EMUs.

As PRR managers knew, electrification also yielded higher speeds out on the main lines. The average speed of the New York Central's commuter trains increased 50 per cent with electrification, thanks to the higher acceleration and braking rates it made possible. Furthermore, the speed capabilities of electric trains had already been explored extensively in Germany. On a test track near Berlin, an experimental electric car set a speed record of 210.2 km/hour in 1903.

1.5 The Pennsylvania Railroad: Mother Road of Electrification

It was for all of these reasons that the PRR committed itself to what would become the largest and most influential electrification of the pre-Second World War period. In 1928, the PRR began electrifying the entire intercity passenger, commuter and freight operation on its four-track "broad way" from New York to Washington, as well as its main line from Philadelphia to Harrisburg. This was reputed to be the world's busiest railway system and, with the $250 million electrification and improvement project, it would eventually be considered the world's finest.

The PRR electrified with the 11,000 volt AC catenary system and developed several new, high-powered locomotives, including 139 of the sleek GG1s, some of which ran daily at up to 160 km/hour for more than 50 years. As well, more than 400 EMUs were built for commuter service in New York, Philadelphia, Baltimore and Washington, D.C.

Under a rolling implementation plan, the PRR's electrification project faltered only when the Great Depression descended in September, 1929. Because of electrification's proven ability to quickly repay its capital costs from operating savings, the U.S. government rode to the rescue and the project was completed in 1938. A huge benefit was the creation of 45 million man-hours of employment during its construction.

The undisputed monarchs of pre-war electrification were the Pennsylvania Railroad's 139 sleek, swift and strong GG-1s, many of which remained in 160 km/hour service for nearly half-a-century. Photo from the Joe Testagrose Collection.

At its peak, the PRR electric operation covered nearly 1,100 route-kilometres and 3,200 track-kilometres. It was so successful that the PRR was able to repay the government loans earlier than expected from the operating savings. U.S. Secretary of the Interior Harold Ickes called these loans the best the government ever made, especially in light of the tremendous volume of traffic this intensive railway plant later handled during the Second World War. Had not wartime rationing and manufacturing priorities intervened, the electrification most likely would have been carried west 400 kilometres on the steeply-graded, four-track main line over the Allegheny Mountains from Harrisburg to Pittsburgh.

The company-published *Centennial History of the Pennsylvania Railroad* noted the conversion to electric operation occurred smoothly, even under the tremendous traffic that had to continue moving on the main lines and through the complex terminal facilities during construction. It also noted that electric traction is so fundamentally different from other forms of motive power "that a revision of operating practices and methods in many respects was necessary on the electrified lines" in order to ensure a trouble-free conversion that did not interfere with day-to-day operations. In the end, electrification "soon tended to show a performance even better than the engineers had envisaged."

Inspired by the success and the breadth of the PRR project, electrification flourished overseas in this period, too. As on the PRR, electrification overseas covered all aspects of operations: commuter, intercity passenger, freight and even yard switching.

Electrification's effect on commuter service was especially impressive. In the period between the world wars, substantial electric commuter services were developed in major cities in the U.K., Europe, Asia and Australasia. In each case, they not only reduced operating costs and improved service, but also resulted in a phenomenon evocatively known as the sparks effect, being found to have a public appeal that "sparked" higher-than-expected ridership and revenue.

1.6 Electrification in Perspective

But electrification was not a panacea. Its principal drawback was its initial capital cost. Right from the start, railroaders made it clear that electrification could only be justified by large volumes of revenue-producing traffic. In 1913, one of the deans of electrification said it cost almost as much to electrify an existing line as to build one from scratch. This partially resulted from the tendency to use electrification as an opportunity to make other upgrades, in essence building all-new railways on the old rights-of-way.

Therefore, a combination of operating constraints, traffic density and other conditions had to be present for a line to be a candidate for electrification. Light density lines were rarely converted unless they could be "wired" economically as part of larger projects. But where these favourable factors existed, electrification demonstrated its ability to revolutionize a rail service physically and financially by generating operating benefits and substantial cost savings. Electrification didn't cost, it paid, especially on dense suburban commuter rail networks. In general, electric trains:

- Increased service speed, which made increased train frequency possible;
- Increased capacity and often made physical expansion unnecessary;
- Increased reliability, being less vulnerable to severe weather than other forms of traction;
- Reduced maintenance costs, being comparatively simpler machines;
- Improved asset utilization by requiring less maintenance and no down time for fuelling, making diesels more available for revenue-producing service; and
- Reduced life cycle costs because of their robustness and longevity.

1.7 Post-War North America: Running Out of Juice

After the Second World War, rail electrification continued its rise throughout Europe, but it stalled in North America. The reason was simple: the diesel-electric locomotive. The diesel had been under development almost as long as the electric locomotive, but progress was slow. In the late 1920s, through the research efforts of General Motors (GM) and GE, the marriage of a lightweight diesel engine with the control and traction gear of electric trains yielded results.

Although a diesel can't deliver the same performance as an electric, it had some competitive advantages in postwar North America. First and foremost, diesels were fuelled by plentiful, relatively inexpensive oil. As well, by using a diesel engine to drive an onboard electrical generator, they offered some of the benefits of the electric locomotive and performance improvements over steam. The diesel's control systems used MU technology, reducing labour costs by enabling operation of two or more locomotives with one crew. It also provided higher availability than steam with reduced maintenance labour costs.

The diesel's key advantage was its lower upfront capital cost compared to electrification. It required only modification or replacement of existing steam maintenance facilities, not a whole electrical transmission system and revisions to other facilities, such as "immunization" of signal systems. It also reduced – but didn't eliminate – emissions problem.

It was no contest. In the post-war years, North America's for-profit railways were in financial trouble. All levels of government had undermined the self-sufficiency of the railways with large investments in other modes and without requiring users to pay their full costs directly. Highways, ports, waterways, aviation facilities and state-owned airlines bloomed with this public funding. As these modes diverted an increasing amount of traffic and revenue, the railways were weakened. None could contemplate a massive, long-term investment such as electrification at a time when their existence was being jeopardized.

The situation was completely different in Europe and it explains why electrification is one of the mainstays of railroading on that continent today.

1.8 Post-War Europe: Electrification's New Valhalla

At the end of the Second World War, much of the European rail network was in ruins, bombed by the Allies and sabotaged by retreating Axis troops. One of the first orders of business for the Allies was the resuscitation of the industries and the economy of Western Europe, which required reliable, high-volume transportation. Railways – not highways and aviation – were the answer. Often with U.S. Marshall Plan and United Nations recovery funds, the state-owned railways were rebuilt. Electrification had been applied to the busiest lines, so their rebuilding was a priority. Rail electrification was considered so strategic that the U.S.S.R. stripped the East German railways of their electric motive power, rolling stock, catenary, substations and related gear, shipping it east to be redeployed on the Soviet Railways.

The Second World War spurred unprecedented technical development in all industrial sectors, including electronics. The rebuilding of Western Europe's electrified rail systems wisely took full advantage of these advances. This produced rail electrification options more sophisticated than those in North America, where research focused on diesel motive power. Western Europe's lack of domestic oil and its abundance of coal and hydro-electric power also drove plans to expand electrification of the continent's main rail lines.

Working with visionary electrical manufacturing giants, the publicly-owned railways of Western Europe wrought a second revolution in electric railroading. One major advance was the development of AC systems of 15,000 and 25,000 volts at commercially-available frequencies of 50 or 60 cycles. This made it easier to draw current directly from utility companies without expensive rectification and conversion gear, as had previously been the case. As well, higher-voltage AC was more efficient, cost-effective and reliable than previous systems. It was used widely as electrification accelerated from the 1950s onward in Europe. As well, the Soviet Union, Australia, South Africa and India undertook large electrification projects, often with the 25,000 volt AC catenary system.

In a 1958 statement, the International Union of Railways said:

"For its outstanding characteristics – availability, suitability for high speeds, heavy loads and long non-stop runs, robust construction, low maintenance – the electric locomotive is the master card of the European railways in the modernization of the large systems...."

A Swedish State Railways night train to Narvik, Norway, pulled by an ABB Rc-series electric locomotive. These powerful, pint-sized European locomotives can lay claim to being the most successful electric motive power of all time. They have served in their native Sweden, Norway, Austria, the former Yugoslavia, Turkey and Iran, as well as on the U.S. Northeast Corridor. Photo by David Gubler.

Through all this, rail electrification in North America was at low ebb. The conversion of the main line railways from steam to diesel was complete by 1960. The diesels also doomed some of the short but aging electric operations of the past. This included numerous electric tunnel operations, where diesels were substituted, but only through the construction of massive ventilation systems required to clear the tunnels of diesel fumes after the passage of each train. CN's St. Clair River Tunnel was but one example, being dieselized in 1958.

On the PRR – the electric operation viewed as the pace-setter – studies in the 1950s concluded diesels couldn't compete. The result was renewal of the fleet with new EMUs for commuter service and high-horsepower locomotives for freight; the existing passenger motive power fleet soldiered on. The sturdy PRR electrification also made possible America's first higher-speed service with the 1969 launch of the 200-km/hour New York-Washington Metroliner EMU trains.

On the other electric commuter railways in New York, Philadelphia and Chicago, a limited amount of modernization and expansion occurred in the 1960s and '70s because diesels had still not proved themselves capable of bettering the performance of the electric trains and infrastructure, which were then more than 30 years old and still incredibly robust.

1.9 The 1973 Energy Crisis

The outlook for North American electrification changed dramatically in the early 1970s thanks to a world event that demonstrated one of the risks inherent in an oil-dependent transportation system. In October, 1973, the Organization of Petroleum Exporting Countries (OPEC) announced a 70 per cent rise in the price of oil and a drastic cut in exports. As oil prices rose and supplies dropped, the global economy was thrown into turmoil and the dangerous oil addiction of many nations – especially Canada and the U.S. – became apparent. Government policies were enacted to combat the situation, including the encouragement of alternate energy sources. The crisis was resolved in March, 1974, but the effects lasted for many years.

One result was that several North America railways re-examined electrification. Canadian Pacific (CP) was one that looked closely, going so far as to conduct winter tests in Sweden, Norway and Switzerland using state-of-the-art electric locomotives and erecting a catenary section in B.C.'s Selkirk Mountains to determine the effects of extreme winter weather. The test catenary withstood three major snow slides.
But the predicted North American electrification renaissance didn't happen. Once the OPEC crisis passed, oil prices stabilized and even declined in relative terms. The opportunity was lost and, with the exception of some electric commuter extensions, the rail industry returned to its pro-diesel stance.

Not so in Europe and emerging industrial nations, such as China and India, where the conversion from steam and diesel to electric increased. Several factors drove this movement, particularly public policies aimed at energy self-sufficiency. Another was the quest for speed. Testing of internal combustion designs – such as a preliminary gas turbine version of France's electric Train à Grande Vitesse – confirmed the superiority of electric operation for high-speed service. Electrification has triumphed in Europe; the remaining non-electric mileage is declining annually.

Electric racehorses at rest at the Gare du Nord in Paris. From left to the right, two of the Eurostars that provide service through the electrified Channel Tunnel, a Thalys trainset used on the Paris-Brussels/Cologne/Amsterdam routes and a first-generation SNCF Train à Grande Vitesse, one of the speedsters that launched the European high-speed electric rail revolution on the Paris-Lyon route in 1981. Photo by Mathieu Costecalde.

1.10 Electrification Today

Today, North American passenger railroading has once again awakened to electrification's potential. Part of this renewed interest revolves around the spate of high-speed rail projects now proposed in the U.S. The one notable electrification project of the post-OPEC oil embargo period was Amtrak's 1999 extension of the catenary east from New Haven to Boston for its Acela Express higher-speed service.

Now, faced with automotive-fed urban sprawl, rising energy costs, uncertain future oil supplies and continued environmental degradation, there is a growing chorus of voices calling for rail expansion – particularly electrified rail service – across North America.

An Amtrak Acela zips through the Ruggles commuter station on its way to Boston's South Station, oblivious to the weather. Built in Canada by Bombardier and combining advanced North American and European technologies, the Acelas are this continent's only high-speed trains, achieving a maximum speed of 240 km/hour on portions of Amtrak's electrified Northeast Corridor.

North American Commuter Rail Electrification Projects – 2011

PROJECT	ROUTE	ROUTE-KM.	STATUS
Montréal AMT Lakeshore Line	Lucien-L'Allier-Vaudreuil	38	Under study
Montréal AMT Delson Line	Montreal West-Candiac	21	Under study
Montréal AMT Blainville Line	East Junction-Saint-Jérôme	48	Under study
Connecticut DOT Danbury Branch	South Norwalk-Milford	61	Under study
Connecticut DOT Hartford Corridor	New Haven-Springfield	101	Under study
Long Island East Side Access	Sunnyside-Park Avenue Tunnel Junction	5	Under construction
Long Island Main Line Extension	Ronkonkoma-Yaphank	16	Under study
Long Island Port Jefferson Branch	Huntington-Port Jefferson	37	Under study
Long Island Montauk Branch	Babylon-Speonk	56	Under study
Long Island Central Branch	Babylon-Bethpage	10	Under study
SEPTA Schuylkill Valley Metro	Philadelphia-Reading	99	Under study
SEPTA Quakertown Extension	Lansdale-Shelly	30	Under study
SEPTA Wawa Extension	Elwyn-Wawa	5	In design
Denver RTD East Line	Union Station-Denver International Airport	37	Under construction
Denver RTD Gold Line	Union Station-Wheat Ridge	18	In design
Denver RTD Northwest Line	Pecos-South Westminster	5	In design
Caltrain Peninsula Commute Line	San Francisco-San Jose	83	In design
Mexico El Tren Suburbano Line 2	Martin Carera-Jardines de Morelos	19	In design
Mexico El Tren Suburbano Line 3	Chalco-La Paz	11	In design
TOTAL		**700**	

2.0 GO Electrification Studies: 1980-2001

"As diesel locomotive operators, we are the prisoners of a single fuel; a fuel that is fast becoming a pawn on the chessboard of international politics. One does not need sophisticated techniques for predicting the future to form the view that, whatever else happens, its price is bound to rise."

Keith Campbell
Vice-President, Administration
Canadian Pacific Railway
1972

The benefits and the means of electrifying GO have been studied on numerous occasions in the past by GO, the Government of Ontario and qualified outside parties. Each of the previous studies contains data still relevant to the issue today. Indeed, many of the answers have been sitting on government bookshelves for decades and, from the start, it has struck many informed observers that the recent Metrolinx exploration of the issue is merely an expensive re-ploughing of old ground.

Electric commuter rail service was no mystery to GO Transit staff when they launched the service in 1967. Some were former CN staffers with experience on that railway's Montreal electric line, which had run from downtown through Mount Royal to the northern suburbs since 1918. Others had worked on electrified rail and transit operations elsewhere before joining GO. But the early days of GO were no time for electrification dreams. With slim budgets and a growing call for expansion of the Lakeshore service to other lines, GO had to stretch its provincial funding thin. The OPEC oil embargo encouraged management to keep a watch on electric rail developments, but little else.

That situation changed for a reason unrelated to electrification. On November 10, 1979, an eastbound CP freight train with several tank cars of dangerous commodities derailed near Mavis Road in Mississauga. The fear of a chlorine cloud from a ruptured tank car resulted in the evacuation of 200,000 residents. The public and the media were whipped into a frenzy. The provincial government of Premier Bill Davis announced the formation of the Ontario Task Force on Provincial Rail Policy to investigate the state of the railways, explore their potential and "safeguard the public interest." The group was led by MPP Margaret Scrivener and backed by a panel of planners, academics and senior Ontario bureaucrats.

Although rail matters had always been largely federal responsibilities, the Province had several reasons for wading into the fray. First, the public and the media wanted to know what the Province was going to do about the perceived deterioration of the railways, even though they weren't under Ontario's legislative control.

As well, GO was enmeshed in tough negotiations with CN over its operating agreement, which had expired in 1977. CN wanted a substantial fee increase. It also insisted GO-related improvements be totally funded by Ontario and all upgraded infrastructure was to be the railway's property. The Province was eager to resolve this issue.

Finally, the government had created the Urban Transportation Development Corporation (UTDC) in 1975 in the backwash of praise it received for halting Toronto's controversial Spadina Expressway and committing itself to transit alternatives. UTDC intended to revolutionize the global transit market with Ontario-grown innovations.

Some critics noted that established manufacturers already had designs to meet the industry's current and future needs. Rejecting this rationale, the Province lavished funds on UTDC and co-opted various transit projects to showcase its wares. The rail policy review would be yet another opportunity to trumpet UTDC's capabilities.

If nothing else, the Scrivener Task Force accomplished one worthy goal by kick-starting serious consideration of electrification.

2.1 The 1980 Electrack Study

This altered political landscape started a wave of serious and credible studies of the benefits, technical requirements and costs of electrifying GO's Lakeshore Line from Pickering to Hamilton, as well as considering its application to other lines in the growing commuter system. The first of these studies was delivered in June, 1980, by the specialized U.S. consulting firm, Electrack, Incorporated.

Swedish-designed AEM-7 electric locomotives became the mainstay of Amtrak's popular and fast Northeast Corridor intercity passenger services beginning in 1979. The AEM-7 and it successor ALP-44 also found homes on the commuter rail systems of NJ Transit, Philadelphia's SEPTA and Baltimore's MARC. Photo by Joseph Barillari.

The report spelled out the technical details and benefits of GO electrification, many of which remain valid 30 years later. It clearly established:

> *"[The] technical feasibility of electrifying the GO Transit Rail Services, provisionally at a voltage of 25 kV, 60 Hz. The initiation of the Phase I electrification proposal would be a natural first step, making use of the existing bi-level passengers cars, for introduction of electrified service on the Oakville-Pickering Lakeshore route.*
>
> *"Subsequent introduction of electrified service to other branches and to Hamilton would be appropriate if service were expanded to an all-day regular interval operational format, contingent upon purchase of additional passenger cars and locomotives."*

First and foremost, Electrack declared an electrified GO would please commuters with its "quiet, clean and more reliable service. The public benefit would be further enhanced in the event that the extent and frequency of service was increased above existing levels." The report noted electrification's "sparks effect" in attracting new riders who weren't using the existing, infrequent GO diesel services.

The expanded operation would use GO's new Hawker-Siddeley (now Bombardier) bi-level rolling stock and state-of-the-art motive power, such as the GE E60C or the Swedish-designed, GM-built AEM7. Rated at 6,000 and 7,000 horsepower, respectively, both were in daily service on Amtrak's former PRR Northeast Corridor.

Phase I would electrify the Pickering-Oakville Lakeshore Line and Phase II would extend it to Hamilton, as well as convert the Georgetown, Richmond Hill and Milton services. The estimated costs, including motive power and rolling stock, were:

Phase I	$ 80.8 million
Phase II	$168.1 million
Total	$248.9 million

Phase I required five years from negotiation of agreements through to training and testing. Proceeding directly to Phase II added only two more years, resulting in a completely electrified GO rail system in seven years. The study noted:

> *"After recovery of initial design and tooling-up costs, the capital cost per mile for subsequent railway electrification projects will progressively reduce in real terms, to the extent that Phase II unit cost rates could prove to be less than those for Phase I."*

The financial findings were based on the demonstrated savings realized by other electric commuter operations around the world.

Looking forward, the report pointed out the capital value depreciation of electric installations and locomotives would occur over at least a 35-year period, as compared with the 18 to 25 years for diesel. As well, a move to longer GO trains would require two of the current diesel locomotives per train, while the electric option required only one, which would have a longer service life. The cost ratio of an electric locomotive was estimated at only 40 per cent of a diesel due to its extended life and reduced maintenance.

Electrification would reduce GO's energy costs significantly due to several factors, including the elimination of energy consumption during locomotive coasting and idling and the lower cost of electrical energy. The costs involved with refuelling operations would be totally eliminated. Furthermore, maintenance costs would be reduced by approximately 30 per cent by virtue of the relative simplicity of electrics.

In answer to the government's stated policy to make Ontario less dependent on imported oil, the report emphasized that electrification would achieve a saving in oil imports by reducing GO's energy consumption and cutting automobile and GO bus mileage. The increased service frequencies possible with electrification would boost ridership further.

The projected Ontario employment and industrial benefits were large:

> *"The initiation and carrying through of a railway electrification project resulting in a more economic and reliable transportation service will make an effective contribution to the economy of the Province of Ontario.*
>
> *"Such a project creates a number of temporary and permanent industrial and economic impacts on both local and national spheres of activity as well as on the railroad organization involved. It also creates a number of business and employment opportunities, some of which are new technology areas which are likely to be in increasing demand in future years.*
>
> *"When a manufacturing capability has been established, Ontario firms will be able to compete more effectively for electrification business in other provinces and even outside Canada.*
>
> *"Many standard components and assembly designs are available to Canadian suppliers from European manufacturers on a royalty or licensing basis. This type of arrangement avoids unnecessary repetition of research and development work already accomplished in other countries, and it also provides opportunities for two-way improvement of designs and manufacturing techniques."*

Still, the Province would not take the 1980 Electrack report at face value and more studies began under the Scrivener Task Force. One was undertaken by Queen's University's Canadian Institute of Guided Ground Transport (CIGGT) and another by the Ministry of Transportation and Communication (MTC).

2.2 Alternate Ontario Rail Policy Task Force Studies

The CIGGT study looked at the entire Ontario rail network – commuter, intercity passenger and freight – and provided an academic endorsement of electrifying GO's Lakeshore Line only, as well as a crazy quilt of other CP and CN freight and passenger lines.

The MTC study looked at rail electrification, TTC trolley bus network expansion, new trolley bus systems for Hamilton, Ottawa and conversion of GO's bus services to electric. It was moderately supportive of GO rail electrification and negative on all of the electric bus proposals.

Updating the Electrack data, the MTC report pegged the cost of GO Phase I (Pickering-Oakville) at $91.9 million. Electrification would be achievable within five years, would require 40-42 kWh of electricity (0.4% of Ontario's total) and eliminate 12.8-13.6 million litres of diesel fuel (0.8% of Ontario's transportation consumption). The project would create 1,225 man years of employment, of which Ontario's share would be 1,022.

Phase I's estimated net saving in annual operating costs was $683,000 to $834,000, paying back the capital investment within 15 years of the service launch.

MTC estimated the cost of Phase II (Hamilton Extension, Georgetown, Milton and Richmond Hill lines) at $114.4 million, but did not calculate the operating and energy cost savings. Phase II would result in 1,597 man years of employment, of which Ontario's share would be 1,378.

In light of recent statements by Metrolinx regarding the time required to electrify any of the GO lines, one section of the MTC report stands out:

> *"The technology is well proved, although substantial lead times are required for construction.... It is, however, quite feasible, given speedy attention and cooperation by the parties involved, to have Phase I electrification in operation five years after authorization to proceed is given.*
>
> *"Some reduction of the time-span would be feasible if negotiation of project agreements could be accomplished in less time or concurrent with engineering work; if engineering and construction were undertaken consecutively by a single contractor; or if longer track-possession time could be provided by the owning railroad.*
>
> *"Typical catenary construction rates achievable in medium-level commuter and freight-rail territory are between 80 and 240 track kilometres per year, dependent primarily upon the amount of installation equipment mechanization, and the ratio of off-track and on-track accessibility to the tracks to be electrified."*

In its 1980 interim report, the Scrivener Task Force called rail electrification "a course well worth exploring." Its final report of August, 1981, recommended:

> *"The Province should prepare for future change by completing current planning studies and carrying out detailed design and financial implementation studies needed to validate and implement electrification of the Lakeshore portion of the GO Transit commuter rail network."*

2.3 Electrification Derailed

The GO board was sufficiently encouraged to approve a study management plan leading to an electrification implementation plan. Delivered in May, 1982, it was the work of engineering consultants DeLeuw Cather International, its Canadian subsidiary, DelCan, and Electrack, which had by then established a Toronto office in anticipation of approval of the GO project. A major contributor on motive power and rolling stock issues was Philadelphia-based Louis T. Klauder & Associates (LTK).

The plan proposed a rolling investment program that would begin with the launch of the Lakeshore Line in 1990 and full GO system electrification by 2020. This would have spread the capital requirements to a palatable annual level for the Province.

LTK analyzed three types of service-proven equipment: GE E60C locomotives, GM-ASEA AEM7 locomotives and the latest generation of Silverliner EMUs then being operated by Philadelphia's Southeast Pennsylvania Transportation Authority commuter rail system. The latter was included as an alternative to a frequently-advanced argument by the Province that the Ontario-built, diesel-hauled GO bi-level cars could and should be converted to EMUs. The report said:

> *"At present, the consultant teams understand that they are to investigate the feasibility of converting the existing bi-level cars now in service on the Lakeshore Line to EMU operation. The consultant feels that there is a strong case to be made for eliminating this alterative and we are prepared to submit a summary report and recommendations on this matter.... EMU operation can still be considered with new vehicles while the existing bi-levels remain in use for their service life."*

It appeared that GO electrification was finally on track. But it was not to be.

A Silverliner EMU train of the Southeastern Pennsylvania Transportation Authority approaching Philadelphia's Temple University station. Photo by Adam E. Moreira.

The explanation is buried in the Throne Speech of April 21, 1981, which noted "design work for electrification of the GO commuter rail system from Oakville to Pickering is under way." But it also sketched out the future of Crown-owned UTDC:

> *"My government has every confidence that the development of an intermediate capacity transit system by the Urban Transportation Development Corporation is but the beginning of an auspicious future for the industry. Additional investments in UTDC will allow for production facilities in Ontario. A feasibility study for an Intermediate Capacity Transit system for the City of Hamilton is expected to be ready by this fall, and negotiations will begin with Metropolitan Toronto for an ICTS line in this area."*

The unproven ICTS helped undo the GO electrification plan. UTDC predicted it would revolutionize transit worldwide and produce a stream of orders, but it needed a showcase for such sales. Because of its large contributions to transit capital and operating costs since the early 1970s, the Province convinced the TTC to substitute ICTS for the conventional light rail technology slated for its new Scarborough RT line.

Eager to promote its wares, UTDC then proposed a modified version of ICTS known as GO-Advanced Light Rail Transit (GO-ALRT) using enlarged versions of the rolling stock for the Scarborough RT, which opened in 1985. GO-ALRT would dispense with the ICTS's linear induction motors and DC third rail power supply system, evolving into a more conventional, 25,000 volt AC catenary rail system.

GO-ALRT was selected for the proposed Lakeshore Line extensions from Pickering to Oshawa and Oakville to Hamilton, as well as a new northern Pickering-Oakville line serving the Scarborough Town Centre, North York City Centre, Pearson International Airport and Mississauga City Centre. A north-south route would connect the Port Credit and Brampton GO stations via Hurontario Street.

In addition to showcasing GO-ALRT for sale outside Ontario, this plan was motivated by the high cost of the renegotiated CN-GO operating agreement. GO-ALRT was also viewed as a system that could parallel and replace the existing Lakeshore and other rail services operated on CN lines, producing a system entirely owned and operated by the Province.

Another wrinkle was added by the Province's interest in hydrogen as an Ontario-developed power source for rail and transit operations, which the Scrivener report highlighted and endorsed. Nearly 30 years later, a practical design has still not been produced.

GO's electrification plan was halted. All attention focused on meeting commuter demand with slightly increased GO rail service and more parallel diesel bus services. Engineering and land acquisition began for GO-ALRT's Pickering-Oshawa line.

Three years later, GO-ALRT was shelved when the costs escalated and CN – facing new, passenger-friendly federal legislation – lowered its charges for GO. There was no need to proceed. But the electrification momentum had vanished and the time lost to the aborted GO-ALRT project resulted in yet more unserved demand for GO's services. This had to be met with expanded diesel operation and more diesel buses.

2.4 The 1992 CPCS Study

Wisely, GO established a practice of periodically reviewing plans that had not been funded. In 1992, Canadian Pacific Consulting Services (CPCS) updated and expanded the earlier electrification work with input from Hatch Associates.

> *"Although electric railways have been in existence for over 100 years, significant technological advances have been made in recent decades and will continue to be made in the future. These technological advances have resulted in reduced fixed equipment cost, reduced maintenance costs and increased energy efficiency. The accelerating development of technologies makes it appropriate to review the economics of electrification on a regular basis."*

Additional impetus came from the accelerated rail and transit electrification program under study in Los Angeles, including its new Metrolink commuter system. GO had assisted Metrolink with the design of this copycat system, which used Ontario-built bi-level rolling stock. The push for electrification resulted from the stringent air quality management regulations being imposed throughout Southern California.

The 1992 CPCS study was a tour de force that took into account recent developments in motive power and rolling stock, as well as changes in capital, operating and maintenance costs. The team included some who had conducted CP's extensive electrification testing in the 1970s. These experienced railroaders spelled out the virtues of electric traction.

DIESEL BENEFITS	DIESEL DRAWBACKS
Unlimited route and assignment choice	Limited hotel (lighting/air conditioning/heating) and standby power
Compatibility with other equipment in all corridors	Cost and time lost servicing and overhauling diesel engines
Mechanical breakdowns confined to one train	Health concerns from noise, fumes, oil and fuel dispersion
Low first cost	Limited per-unit horsepower
	Slow acceleration
	Shorter economic life
	Limited categories of usable fuels
	Non-revenue moves to refuelling points
	Powerful cleaning agents required to remove of oily residue
	Contributes to CO2 emissions
	Fuel not available from Ontario sources
	Susceptible to fuel cost and supply fluctuations

ELECTRIC BENEFITS	ELECTRIC DRAWBACKS
Reduced maintenance cost and time	Equipment confined to electrified lines
Choice of primary energy source	Reduced available clearance envelope
Fumes and oil dispersion eliminated	Signal system modernization required
Reduced main line operation noise	Cost of catenary maintenance
Reduced noise at yard and layover sites	Train immobilization by catenary damage or power failure
Greater per-unit horsepower	Supplementary operating/safety rules
Greater acceleration	Reduced mobility for work equipment
Shorter headways	Visual intrusion of catenary
Higher traffic capacity	High first cost
Greater energy efficiency	
Partial recovery of braking energy	
Over-track air rights development	
Ample hotel and standby power	
Wayside power requirements eliminated	
Lower energy costs	
Less prone to energy price fluctuations	
Not dependent on energy sources outside Ontario	
Large economic and job creation benefits	

Based on GO's long-range plans, the CPCS study assumed the Oshawa-Hamilton Lakeshore trains would operate every 10 minutes during peak hours and every 30 minutes off-peak. The other lines would operate every 20 minutes during peak periods and 60 minutes off-peak. These operations were compared under four 10-car equipment scenarios:

(1) Diesel locomotives with bi-levels system-wide;
(2) Electric locomotives with bi-levels on the Lakeshore and diesels on the Milton, Georgetown, Bradford, Richmond Hill and Stouffville lines;
(3) Electric locomotives with bi-levels system-wide; and
(4) Electric locomotives on the Lakeshore and 10-car EMUs elsewhere.

The equipment types used for the economic analysis were the GE E60C locomotive used in previous studies and the Asea Brown Boveri (ABB) ALP44, a more advanced, commuter-specific version of the previously-studied AEM7. As well, the X10 single-level EMUs that ABB had recently built for the Swedish State Railway's regional passenger services and Stockholm Transport's commuter rail operations were examined. The study compared the benefits and drawbacks of EMU operation.

EMU BENEFITS	EMU DRAWBACKS
Trains easily sized to suit passenger load variations	More motor equipment to inspect and maintain
Frequent off-peak service maintained while most rolling stock is receiving servicing	Inspection time increased, requiring more inspection trackage in yards or more manpower
Frequent off-peak service at lower energy cost	
Very high power-to-weight ratios	
Higher acceleration due to power being distributed throughout the train	
More rapid deceleration due to greater braking power distributed throughout train	
Less stress on track structure due to even distribution of weight and traction motors	

The suitability of EMUs vis-à-vis locomotive-hauled electric trains received serious study. While the performance of the recent European EMUs went into the comparisons, the suggestion was not made that they could simply be operated as-is on GO's lines. There are substantial differences in the standards for railway equipment in North America and Europe, the principal one being the mandatory end-strength or buff-load requirements. The higher North American standards, as set by the U.S. Federal Railroad Administration (FRA), reflect the greater equipment weights and lower level of crash-preventive train control systems. Because of the inter-connected nature of the North American rail system, the FRA standards apply in Canada and Mexico, too.

What was investigated as part of the 1992 study was the possibility of converting the non-powered GO bi-level coaches and cab cars to self-propelled EMU operation. It had long been assumed that the squeezed ends of these distinctive cars had been designed to accept the pantographs to collect power from the catenary if GO electrified and converted them to EMUs. However, the study team reported:

> *"The most significant design feature [of the bi-levels] is the drop floor (or well) construction between the trucks. This permits an upper floor level to be added over the well.... The well-style of the bi-level coach leaves no underfloor space for traction equipment. In addition, the GO cars leave very little space for traction motors. The Consultant considers that the car design is efficient and harmonious for its current purpose, but conversely is not suited to 'conversion' to an EMU traction power car....*
>
> *"The only 'conversion' scenario suggested here, and in later economic comparisons, is the purchase of new driving motorized cars to be paired up one-plus-one with existing bi-levels. The new motor-cars would be built to harmonize with the existing cars but sacrifice some seating to structural differences over the trucks and in the lower body sides. Assume a 40 seat loss. All four axles of the motor-car are assumed to be motorized up to modern motor design horsepower for EMUs."*

The report introduced another new concept in GO electrification. The study team affirmed the earlier selection of a 25,000 volt (25 kV) AC traction power system, but they took this a step further with the recent, service-proven autotransformer system using a voltage of +/- 25 kV (now known as 2 x 25 kV). In simple terms, it reduces the substation requirements and provides the same benefits of more powerful 50,000 volt (50 kV) AC without the costs and problems it would entail, such as increasing the height of bridges and station roofs.

A Swedish State Railways X10 EMU in Stockholm commuter service. This rolling stock was examined in detail by the authors of GO's 1992 electrification study and was rated highly for consideration, in modified form,as part of any plan to electrify all or portions of the GO system.

On the selection of the traction power system, the authors reported:

> *"The +/- 25 kV system has, therefore, a transmission capability close to that of a 50 kV supply, but without the problems of increased clearances appropriate to 50 kV. It also offers the benefits of reduced electro-magnetic interference in parallel communications circuits.... From this viewpoint, the system performance is similar to a simple 25 kV system with booster transformers."*

The study team reported the all-in capital costs of four equipment options, including the new bi-level EMU design, as:

(1)	Diesel locomotives system-wide	$ 708.5 million
(2)	Electric locomotives on Lakeshore and diesel elsewhere	$ 809.2 million
(3)	Electric locomotives system-wide	$1,109.8 million
(4)	Electric locomotives on Lakeshore and EMUs elsewhere	$1,171.3 million

In summary, the 1992 study team concluded:

> *"As would be expected due to the high capital cost of electrification infrastructure, Scenarios 3 and 4 – the two full electrification scenarios – have a significantly higher economic cost than Scenario 1 – full dieselization – and Scenario 2 – dieselization of the branchlines and electrification of the Lakeshore Line only. The differences between the present values of Scenarios 2, 3 and 4 from the base [diesel] case are: +9.7%, +28.8% and +32.3%....*

"For practical purposes, however, the increase in the economic cost of Scenarios 2, 3 and 4 [electric] over that of Scenario 1 – continued full diesel operation – could be viewed as the cost of environmental benefits and service improvements and evaluated in that context."

Exhaustive though it was, nothing came of the 1992 study, even though the government of Premier Bob Rae was philosophically supportive. The global economy had melted down and there were no provincial funds available to move forward. In fact, several GO route extensions and off-peak service additions were discontinued.

2.5 Opportunity Lost: The 2001 Lakeshore Line Study

The GO electrification issue slumbered until 2001, when a golden opportunity appeared. The state-owned National Railways of Mexico had begun to realign, rebuild and electrify its main Mexico City-Guadalajara trunk route in the early 1980s; 39 GE E60C-2 electric locomotives built in Erie, Pennsylvania, were delivered in 1983-1984. But then the Mexican government decided to privatize and split up its state railway. The new owner didn't want the electrification, partially because the catenary wires prevented the use of extra-high double-stack container cars, which came into service after the electrified plant had been built. The bulk of the Mexican electrification system was for sale – cheap.

A 2001 study by Hatch Mott Macdonald, in association with CPCS Technologies, examined the feasibility of electrifying the Oshawa-Hamilton Lakeshore Line with the surplus Mexican equipment. All analysis was done on the basis of GO's service expansion plans for the period from 2004 through 2025 and the acquisition of 20 of the GE locomotives, 11 of which had never entered revenue service in Mexico. These would be updated with more efficient AC traction systems to haul 10- and 12-car Bombardier bi-level consists. As well, much of the Mexican electric traction power system would be included without charge and additional materials would be obtained inexpensively from a recently decommissioned electric freight line in northern British Columbia.

National of Mexico GE E60C-2 electric power in freight service in 1996. In 2001, these locomotives were available to GO at a fraction of their new or replacement cost, as well as the electrical infrastructure from the 218-kilometre double-track line. Photo by Raymundo Collada

A comparison of the electric and diesel options revealed that capital costs over the 21-year planning horizon would be $454 million for electric and $208 million for diesel. Because of their higher acceleration, higher average speeds and greater availability, electric locomotives would have enabled GO to avoid the purchase of 24 additional bi-level cars required under the diesel scenario, saving $62.4 million.

The combined capital, operating and maintenance costs over the 21-year study period yielded a net present value for the electric option of -$445 million vs. -$348 million for diesel – a difference of $97 million. Although described as “significant,” the study team was unable to quantify the health and environmental benefits of electrification or the expected “sparks effect” on ridership and revenue.

GO electrification had never been more affordable. But these were the last days of Premier Mike Harris’ government, which had eliminated virtually all provincial support for urban transit. GO’s funding was in disarray and it was impossible to embark on even a cut-rate electrification project that would have reduced the commuter railway’s operating and capital expansion costs dramatically.

Rail electrification in Toronto remained a dormant issue until the provincial government changed in 2003 and new players came on the scene.

3.0 Enter Metrolinx

> ***"Studies cause delay and enable government officials to in turn delay making decisions; in this, they are sometimes welcomed by those government officials...."***
>
> ***Minister of Transport's Rail Passenger Action Force, 1985***

GO electrification might have remained just a wistful "what if" scenario if not for the actions of two Liberal governments – one federal and the other provincial – and the response of a group of affected Torontonians. More than anything else, it was this citizen reaction that put electrification back on the table.

When the Liberal government of Premier Dalton McGuinty swept to power in October, 2003, it carried with it many campaign promises to rein in urban sprawl, protect undeveloped land around Ontario's cities and promote transit options to lure commuters from their cars. Among the various legislative initiatives was the creation of the Greater Toronto Transportation Authority in April, 2006. Renamed Metrolinx later that year, it was charged with planning and coordinating transportation within the Greater Toronto and Hamilton Area (GTHA). A takeover of provincially-owned GO Transit was later added to its mandate, much to GO management's chagrin.

Staffed largely with former politicians and provincial bureaucrats without real-world transportation experience, Metrolinx was eager to impress the public and its political masters with a series of "early wins." As a result, the agency floated numerous visions for GTHA transportation improvements. One was electrification of GO's Lakeshore, Georgetown, Milton and Richmond Hill lines under labels such as SuperGO and Express Rail. Metrolinx early on announced this would be studied as part of its Regional Transportation Plan (RTP), due for delivery in late 2008.

3.1 MoveOntario 2020

Before the delivery of the RTP, the Premier released his MoveOntario 2020 plan on June 15, 2007, four months prior to the provincial election. Bypassing his new agency, McGuinty made an $11.5 billion commitment to 52 priority projects for the GTHA. At the top of the list were 17 GO projects, including Lakeshore, Georgetown and Milton service expansion and line extensions. Number five was "increasing speed and reducing emissions by electrifying the GO Lakeshore line and expanding capacity on all GO lines."

In the press release issued by the Premier's Office, McGuinty said:

> *"The time to make this sort of ambitious but realistic investment is now. Our economy demands it," McGuinty said. "What's more, our families deserve it, because gridlock not only saps strength out of our economy, it steals time from our families."*
>
> *To cite one example, with electrification of the GO Lakeshore line, a commuter will get from Toronto to Hamilton 15 minutes faster.*
>
> *"That's an extra half-hour a day. And that can make the difference between missing your daughter's first goal at soccer – or seeing it," McGuinty said.*

Under priority subway and other rapid transit projects, the Premier also identified a Pearson Air-Rail link to Union Station.

The release from the Premier's Office qualified these recommendations so as to not appear to totally pre-empt his new agency, adding in fine print, "Projects subject to the review of the Greater Toronto Transportation Authority." Many critics asked publicly if there could be a clearer sign that Metrolinx was just going to be a rubber stamp for any politically-motivated decisions from the Premier's Office.

3.2 The Big Move

But the government's endorsement of electrification didn't stop here. It escalated with the September, 2008, release of the draft of the Metrolinx RTP, which it labelled *The Big Move* when it was accepted and endorsed by the board in November. Among the transit technologies woven into this grand plan were:

> ***Express Rail**: High-speed trains, typically electric, serving primarily longer-distance regional trips with two-way all-day service. Regional Express service could have a capacity of 25,000 to 40,000 passengers per hour in the peak direction with trains operating in completely separated rights-of-way, with as little as 5 minutes between trains. Average speed: 50 to 80 km/h with stations two to five km apart. Example: Paris Region Réseau Express Regional (RER).*
>
> ***Regional Rail**: Diesel-electric or electric trains serving primarily longer-distance regional trips; approximate capacity at 10-minute headways of 5,000 to 20,000 passengers per hour peak direction; service can be enhanced by electrification, enabling better train performance (acceleration) and therefore higher average speeds even with relatively close station spacing. Average speed: 30 km/h with two km station spacing; 50 km/h with wider station spacing or electrified trains. Example: GO Transit rail system.*

The Big Move set out a series of investments spread out over a 25-year timeframe and with options for afterward, which would be subject to a comprehensive review at that time. Among the top transit priorities within the first 15 years were Express Rail on the Lakeshore Line from Hamilton to Oshawa and a Union Station-Pearson International Airport rail link:

> *"The GTHA's first Express Rail service will provide significantly faster and higher capacity service to commuters travelling along the GO Lakeshore Line, connecting several of the Growth Plan urban growth centres: the downtowns of Hamilton, Burlington, Oakville, Toronto, Pickering and Oshawa. Collectively, these six centres are forecast to accommodate significant growth over the next 25 years, and new Express Rail service will make transit an attractive alternative.*
>
> *"Express Rail will also be extended to Downtown Brampton, along with more frequent, two-way all-day Regional Rail service to the urban growth centres of Downtown Milton, Richmond Hill/Langstaff Gateway, Markham Centre and Etobicoke Centre."*

In years 16-25 of *The Big Move*, additional GO investments would "consolidate and strengthen the 15-year network described above." These would include:

- Express Rail service to Cooksville on the Milton Line and to the Richmond Hill/Langstaff Gateway on the Richmond Hill Line; and.
- Improvements to existing GO Rail services and extension to Bowmanville.

The GO expansion program was expected to continue beyond the 25-year timeframe of *The Big Move* with priority projects including:

- A direct Express Rail link between Mississauga City Centre and Union Station via Cooksville;
- Additional capacity on the Yonge subway or the Richmond Hill Express Rail corridor to relieve the Yonge subway;
- East-west Express Rail connecting Oakville, Mississauga, Vaughan, Richmond Hill, Markham and Pickering; and
- Extension of all-day two-way regional rail service to additional communities.

The inspiration for this rolling program of GO investments, according to one Metrolinx senior staff member, was provided by the electrified, high-frequency urban rail systems of Western Europe, such as the Parisian Réseau Express Regional (RER) and the S-Bahn networks of several German, Swiss and Austrian urban regions (see Appendix A).

Bi-level EMU equipment of the Réseau Express Regional, the electrified urban rail system of Paris, which initially inspired some Metrolinx staff and led them include mention of a Toronto version in their 2008 regional master plan, *The Big Move*.

Further encouragement came from the longstanding Caltrain plan to transform its San Francisco commuter service with electrification and service-proven European bi-level equipment designs and operating concepts (see Appendix B).

The Caltrain plan had only recently become known to Metrolinx staff and it obviously impressed some of them. In the April 19, 2008, edition of *The Toronto Star*, Metrolinx general manager of strategic investments and initiatives, John Howe, said of GO electrification, "It's not just about stringing wires over the tracks. It opens up all sorts of opportunities, just like that Caltrain project. We are re-examining the whole GO Lakeshore service in terms of equipment and frequency to make it a cornerstone of our regional transportation plan. We want it to be transformational."

3.3 Restudying Studies

As part of its initial interest in electrification, Metrolinx commissioned Hatch Mott Macdonald (HMM) to revise the 2001 Lakeshore Line study to reflect:

- The used locomotives and other electrification materials from Mexico and B.C. were no longer available, having been sold to other operators or scrapped;
- Performance data was available on Bombardier's new ALP-46A electric locomotives, which were in service on New Jersey Transit;
- GO had begun planning for 12-car bi-level trains on the Lakeshore; and
- Capacity expansion programs had increased the amount of track that would have to be electrified.

HMM's April, 2008, electrification study reported:

> *"The 2001 study update had concluded that diesel operation demonstrated a clear economic advantage over the introduction of electrification on the Lakeshore corridor....*

"The results of this study are less conclusive in demonstrating a clear advantage for continued diesel operation. For the base case scenario over the 2008-2033 study period, using current energy costs and considering an annual escalation of 3% and discount rate of 6%, the net present value is -$765 million for the electric option and -$578 million for the diesel option (all net present values are negative on account only cost streams have been considered).

"The case for electrification is compelling when only operating costs are considered. For all sensitivity analyses, the electric operation advantages range from a low of $150 million to a high of $453 million over the study period, depending on which sensitivity cases are being compared.

"Although the environmental implications of electrification are reviewed in this study, an economic analysis of the environmental benefits of electrification has not been quantified. Clearly, if outside economic justification can be brought to bear to offset the high capital cost of electrification (such as capacity improvements when done in concert with other plant improvements) then the economic benefits accrued to GO Transit will continue in perpetuity."

Just prior to the release of *The Big Move* plan in September, 2008, Metrolinx hired HMM again to expand on this work. Among the additional issues explored was the time saving possible through the use of bi-level EMUs similar to Alstom's Coradia Duplex equipment, as used in Sweden. No analysis of the costs involved in substituting bi-level EMUs for electric locomotive-hauled trains occurred. Another new item in this so-called addendum to the April, 2008, study was the provision of background information on positive train control (PTC) and other automatic train stop systems.

The most useful element in the two HMM studies was the cost updating. The all-in Lakeshore Line electrification capital cost was now pegged at $2.619 billion without contingency, to be spread over the 2016-2031 period, or $4.086 billion with an extremely large contingency.

Alstom's Coradia Duplex bi-level EMU received superficial analysis as part of the 2008 Metrolinx updating of the 2001 GO Lakeshore Line study. The high-capacity electric rolling stock has been purchased by several European operators. Coradia trainsets of the national railways of France (left) and Luxembourg (right) are shown here at rest at Luxembourg Central Station.

At this stage, Metrolinx seemed to chill on the electrification of any portion of the GO system. Observers have suggested that in its eagerness to please the public and its political masters, Metrolinx had endorsed the idea without knowing what it entailed. As well, Metrolinx had promoted other big-budget projects and the tally was obviously higher than the Province was prepared to fund in a first round of transportation improvement projects.

3.4 GO 2020

Before negative comments on electrification began emanating from Metrolinx, GO waded into the situation. With its shotgun marriage to Metrolinx looming, GO management released its own strategic vision plan, GO 2020, on December 12, 2008. In common with the Premier's Move Ontario2020 program and *The Big Move*, this plan also raised the probability of electrification as part of a slew of rail improvements to be undertaken by 2020. The plan noted that "introducing electric trains on the Lakeshore corridor, and the Georgetown corridor if appropriate, will offer travel time savings and environmental benefits."

Now, three plans and two studies from the Government of Ontario and its agencies had placed electrification on the table in the space of 18 months. But what set the issue on fire was another project that, like electrification, had been smoldering away.

3.5 The Airport Rail Link Factor

For decades, there had been talk about a rail link to serve Pearson International Airport. These public and political calls for action grew as many European cities began working with their nationalized railways, airport authorities and airlines to seamlessly connect and integrate their air and rail passenger systems with rail links to their major international airports.

In May, 2003, the talk finally produced a plan, but a controversial one. The federal government invited f our pre-qualified private consortia to submit business cases for the project, following a request for expressions of interest issued in April 2001. On November 13, 2003, it was announced that Union Pearson AirLink Group (UPAG) had been selected as the successful respondent. UPAG was owned by SNC-Lavalin Engineers & Constructors Inc., a member of the SNC-Lavalin Group of Companies.

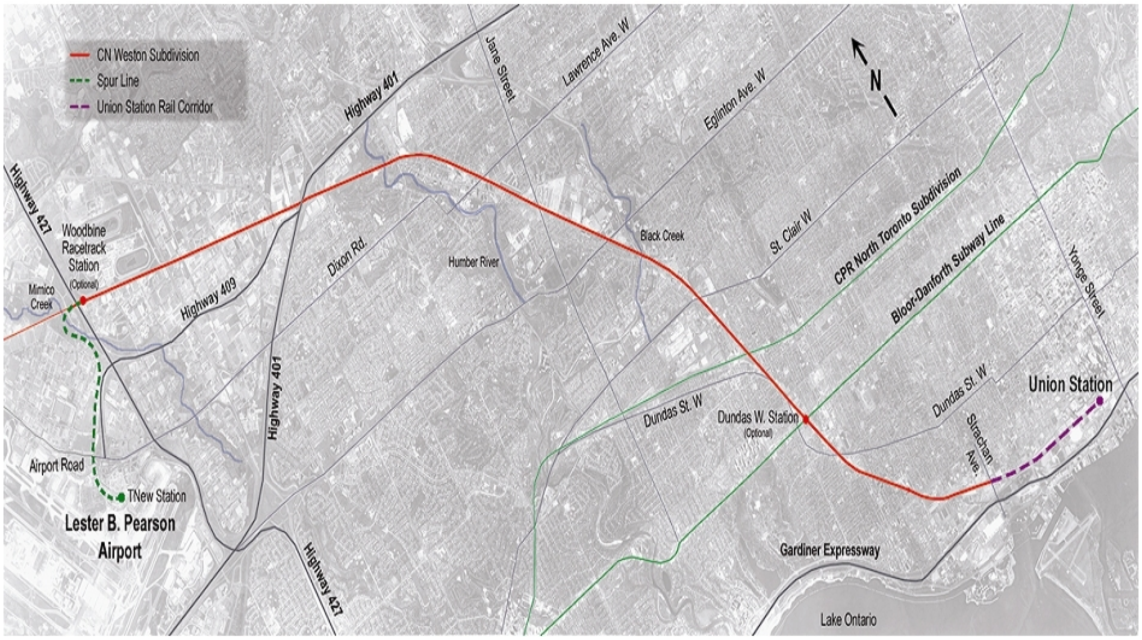
The project was a pet of then Don Valley East MP and Minister of Transport David Collenette. At the time of the announcement, he said there wouldn't be a nickel of public money spent on the project. That has proven untrue.

To be known as Blue 22, the project would use CN's Weston Subdivision from Union Station to a 3-km spur to be built into the new terminal slated for construction at Lester B. Pearson International Airport. Service would be provided by a fleet of retired VIA Budd rail diesel cars (RDC), remanufactured by Industrial Rail Services, Inc., of Moncton, N.B. The name was derived from the running time of 22 minutes between the end terminals with one intermediate stop at Bloor Street West. The one-way fare would be $20.00.

The announcement of Blue 22 started many residents of Weston pondering the implications for their community. Bisected by the busy CN Weston and CPR MacTier Subdivisions that share a wide corridor slightly east of and parallel to Weston Road, the community had endured decades of disruption by the trains that passed over the grade crossings on four east-west residential streets.

Largely under the guidance of resident Mike Sullivan (now MP for York South-Weston), residents began asking questions of Transport Canada, GO Transit (which used the Weston Subdivision for its Georgetown service) and CN. The answers they received were not encouraging. Blue 22 would require the closure of some of the grade crossings, cutting access to TTC services and shopping on Weston Road. The air rail link proponents next suggested building full-scale road-rail grade separations, which would have required the demolition of more than 100 homes.

Union-Pearson Air Rail Link



As well, with a service frequency of 15 minutes in each direction for 19 hours daily, questions were asked about the resulting noise and diesel-generated pollution, especially in light of the long-discussed expansion of service on GO's Georgetown Line and the VIA Toronto-London service that share the route.

The lack of satisfactory answers from the Blue 22 proponents and GO led to the formation of the Weston Community Coalition as "a grassroots, non-partisan organization comprised of a voluntary group of residents, business owners, and representatives from community associations, schools and faith groups. The group was formed in early 2005 to protect the Weston community from the threat of a privately run Air Rail Link, but is also actively involved in seeking the betterment of the greater Weston area through other initiatives."

The Weston residents and others further south along the entire line to Union Station were galvanized into action by the multiple GO expansion plans flung out by Premier McGuinty, Metrolinx and GO. Simple math told the residents they could be dealing with more than 400 Blue 22, GO, VIA, CP and CN diesel-powered trains on a portion of the corridor. The result was the creation of the Clean Train Coalition in early 2009 to represent the interests of all the citizens along the line.

After much confrontation in so-called "inclusive consultation" sessions, a proposal came forward on the grade crossing issue and an agreement to place the expanded rail corridor in a trench below street level. Later, SNC Lavalin switched its equipment choice from the remanufactured Budd RDCs of the original Blue 22 proposal to new, diesel-powered self-propelled cars under the renamed Airport Rail Link (ARL). SNC Lavalin said these unspecified new cars would allegedly meet the Tier 4 emissions standards that would come into effect in 2015 and would be "convertible" from diesel to electric traction at a later date.

Stoked by the discussions of electrification that had been initiated by the Premier, Metrolinx and GO, the WCC and CTC both advocated the adoption of this form of traction. They quite correctly pointed out that Tier 4 diesels did not exist and the manufacturers admitted it was going to be difficult to produce them by the 2015 deadline set by the U.S. Environmental Protection Agency, which has also been accepted by the equivalent regulatory authorities in Canada.

Furthermore, the two citizens groups pointed out they were not saying "not in my back yard," but "yes, in my back yard – if done properly." The residents all welcomed improved transit service to their communities, which are transit deficient. The fact that the ARL would be a premium-priced service with only one intermediate station stop did not endear it to the online residents. The SNC consortium finally bowed to protest and added a Weston station stop to its plan.

In fact, the ARL had run into trouble. With the change of government in Ottawa in 2006, the ARL lost its federal champion. Responsibility slowly migrated to the Province and it announced on December 15, 2008, that it would become the main proponent of the project. Sources at Queen's Park revealed Premier McGuinty chose it as one of his legacy projects and had it attached to Toronto's bid for the Pan American Games, to be held between July 10 and 26, 2015, and billed as the world's "greenest" sporting event ever. Word was the Premier had ordered the ARL completed in time for the games without fail.

Adding to the frustration of the residents was the way Metrolinx and GO seemed to change their facts and arguments constantly regarding the number of trains, the number of tracks and the performance of the trains in terms of noise and emissions. Their distrust of the provincial consultation process only grew when the *Globe & Mail* published excerpts from a Metrolinx internal strategy paper in February, 2009. The document advised staff:

> *"Our consultation period needs to be tightly structured and telescoped. The last thing we need is for this to be hijacked by nimbies or local politicians on the make. These should be mainly informational briefings. We should salt the sessions with supporters. An orgy of consultation will mire this in controversy and delay."*

The strategy paper also advised staff to "de-emphasize maps, which require precision we cannot yet offer and make us vulnerable to discrediting when an error or inconsistency is identified."

3.6 The Study to End All Studies

Finally, under pressure from the WCC and CTC, and with support from numerous local politicians, NDP MPPs and even members of its own caucus, the Liberal provincial government announced on May 26, 2009, that it would embark on a $4 million "comprehensive review" of GO electrification, although the ARL was not initially included in the terms of reference.

Like all the other consultations on the rail expansion that would affect the corridor northwest of Union Station to Malton and beyond, the GO Electrification Study got off to a shaky start. Participants complained that the deck already seemed to be stacked against electrification. For example, graphics chosen for presentation and publication invariably showed the heaviest, ugliest examples of catenary, not the light and unobtrusive systems that many foreign railways use today.

Metrolinx staff has called it "ugly," but modern catenary can be designed and built unobtrusively, as demonstrated in this recent shot of an Austrian States Railways Vienna-Budapest Railjet zooming through Biatorbágy, Hungary. Photo by Ligeti Gábor.

Worse were comments made by the staff members, many of whom admitted they had never even ridden on an electric train, let alone had any experience building, managing or operating electric railway systems. Typical were those by the team leader Karen Pitre and Metrolinx executive vice-president and GO managing director Gary McNeil, as quoted in the June 5, 2010, edition of the *National Post*:

> *"In order electrify a system, it's hundreds of millions, or in the case of our whole system it would be in the billions of dollars to electrify and that doesn't really get any more capacity," said Mr. McNeil...*
>
> *[Ms. Pitre] said a lot of people call the catenary system, in which a web of overhead wires power trains, a mixed blessing. For one thing, "it's ugly," she said, and for another, it's not especially conducive to windy or snowy conditions.*
>
> *And while electric trains do not spew out pollutants, there are other environmental costs, said Ms. Pitre, like using more power.*

In answer to these specious claims, this author replied in a July 21, 2010, article in *The Toronto Star*:

> *Metrolinx executive vice-president Gary McNeil has argued that electrification doesn't add any capacity to rail lines. Wrong. That was one of the principal reasons commuter railways in New York, Philadelphia and Chicago electrified nearly a century ago. Electric trains accelerate faster than diesels and allow for more runs without track expansion. When traffic soars, as it has on many GO routes, electrification creates carrying capacity.*
>
> *Metrolinx study team leader Karen Pitre has said that electric trains use more power than diesels. Also wrong. In fact, when they apply their brakes, they send electricity back into the overhead wires to help power other trains. Pitre has also questioned the ability of overhead wires to withstand our winter weather. This will, no doubt, shock the railway managers of Scandinavia and Russia. The latter's 9,288-kilometre Trans-Siberian route is fully electrified, traversing some of the world's coldest and snowiest terrain.*

An EMU trainset on Basel's five-line S-Bahn, unaffected by the snow and low temperatures that seem to concern Metrolinx staff.

After two fractious stakeholder workshops, the mood improved marginally as some useful materials arrived from one of the study team's nine consultants, LTK Engineering Services, one of the few North American firms with any electrification experience. LTK managed to eliminate ridiculous options such as unproven hydrogen-powered conventional rail equipment – which had previously been promoted by Premier McGuinty – and overpriced and inappropriate magnetic levitation technology. LTK also recommended the use of the proven 2 x 25 kV AC traction power system, as had already been established in the 1992 GO electrification study.

The study team's documents are all available on the GO Transit website, so repetition of their myriad details is unnecessary. They have contributed little except to update the previous cost figures. The validity of this massive research project is also questionable given the fact that members of the study team revealed their role was not to make recommendations; the ultimate decision would be made at the highest political levels, principally by Minister of Transportation Kathleen Wynne and Premier McGuinty.

So, the advocates of GO electrification awaited the delivery of a report they expected would yield little. Their expectations were not dashed.

4.0 The Metrolinx GO Electrification Study

"I don't want to pre-empt the discussion with Metrolinx, but we've said all along that the reason we wanted the electrification study was because we believe that it's an important thing to consider, that the electrification of the system is something that is an aspirational goal."

Hon. Kathleen Wynne
Minister of Transportation of Ontario
January 19, 2011

When Metrolinx released its 1,705-page its GO Electrification Study Final Report on January 19, 2011, the headline on the website of veteran transit advocate and commentator Steve Munro summed it up best: "Not Quite Greased Lightning: GO Transit to Electrify, Eventually."

After all the negativity experienced in the workshop sessions, it surprised many of the participants when the study team recommended electrification of the ARL/Georgetown and Lakeshore corridors, with the former as the first priority. The two-route plan was approved unanimously by the Metrolinx directors exactly one week later and, within minutes of the board's decision, Minister of Transportation Kathleen Wynne announced the initiation of the Environmental Assessment process.

The GO Electrification Study Team reached its decision based on a combination of factors, including:

- Journey time savings;
- Operating and maintenance cost savings;
- Anticipated future ridership growth, which would increase the cost savings; and
- Electrification's contribution to the long-term attainment of the objectives of *The Big Move*.

At an estimated cost of $1.6-1.8 billion, the implementation of electrification on the two corridors would be on a lengthy, staged basis:

CORRIDOR SEGMENT	COMPLETION
Union Station-PIA and Willowbrook (EA and Design)	2014-2015
Union Station-PIA and Willowbrook (Construction)	2018-2020
Airport Spur Junction-Brampton Mount Pleasant	2020-2022
Union Station-Oshawa and Eastern Maintenance Yard	2024-2026
Willowbrook-Oakville	2026-2028
Oakville-Hamilton James Street	2028-2030
Oshawa-Bowmanville	2030-2032
Brampton Mount Pleasant-Kitchener	2032-2035

Although advocates welcomed the decision to partially electrify GO, the final report struck many as an underwhelming endorsement that matched the lack of enthusiasm displayed by the Metrolinx study team at the public workshop sessions. In fact, the report seemed to damn electrification with faint praise. The timeline for the implementation seemed a farce when compared with the schedules being implemented by other railways now or soon to be engaged in electrification around the world.
As Munro commented on his website following the release of the study:

> *Whether Metrolinx (and more importantly GO) has actually embraced this concept, or will mutter disparagingly to anyone who will listen, remains to be seen. I cannot help noticing an analogy to the TTC where, for a time, LRT was embraced as a viable technology, only to be eclipsed when its political sponsor left office. Will electrification suffer a similar fate if the Liberals are defeated in fall 2011?*

While the final report made some valid points in favour of electrification, these had all been contained in previous GO-funded studies based on real-world input from established electric commuter rail operators, leading one to wonder why so much time and public money needed to be spent restudying these issues. The most notable positive findings of the Metrolinx final report were:

- Electrification unit costs drop as the size of the network expands (the “network effect”);
- Electrified rail services attract more riders and revenue than diesel (the “sparks effect”); and
- Electrification yields substantial operating and maintenance savings.

On the latter point, the study found full GO network conversion would yield annual operating and maintenance savings in 2021 of almost $53 million, escalating to $79 million by 2031. For the combination of the ARL/Georgetown and Lakeshore lines, the annual savings would be $33 million in 2021 and $48 million in 2031, assuming diesel fuel costs will increase at twice the rate of electricity.

Perhaps the most useful revelation was regarding the cost of GO electrification. In the run-up to the report’s release, Metrolinx staff up to and including Chair Rob Pritchard portrayed electrification as overly expensive and probably unaffordable by the Government of Ontario. They estimated electrification of the full GO system at up to $7 billion. Instead, the study pegged the price at $3.7-4.2 billion.

But mixed in with the few positive points in the final report, there were also the contradictions, false assumptions and myths Metrolinx staff raised in the workshop sessions. Given the appearance of propriety by virtue of their publication in the study, these negative points could play a role in delaying or even derailing the GO electrification plan at a later date. They should not go unchallenged.

4.1 The Reference Case

"To ensure that only those costs and benefits associated with electrification were included, the Study assessed the incremental costs and benefits of electrifying the GO rail network."

The slightly expanded system that would be in place in 2021 as a result of the GO 2020 plan was the reference case on which analysis was performed. This was the subject of much debate at the Metrolinx electrification workshop sessions. Many participants requested that electrification be assessed in the context of how it could assist in the transformation of GO into a high-frequency, all-day service, as promised in *The Big Move*. But Metrolinx took the view that the assessment should be on the basis of a 2021 benchmark using diesel-hauled bi-level trains on all lines except the ARL, where single-level diesel and electric multiple unit rolling stock would be compared.

The result is electrification has been assessed on a one-for-one replacement basis mixed with a limited amount of service expansion and the ARL as a tack-on project. On the bulk of the system, electrification would occur slowly as GO gradually adds hourly off-peak, two-way service over a number of years.

This falls far short of what many advocates feel is vital if the GTHA is going to experience a significant modal shift. As was envisioned in *The Big Move*, there is a demand and need for the conversion of GO into a European-style urban rail service with higher day-long frequencies in both directions on all routes. Only with such an approach can GO divert a large number of commuters to transit, especially within the boundaries of Toronto. As has been proved elsewhere, electrification is essential to this objective.

While the Electrification Study failed to view electrification in the context of GO's future service model, others at Metrolinx haven't been so blinkered. Another study team has acknowledged electrification's transformational properties, especially in the context of Union Station's capacity constraints.

According to the final electrification study report, Union Station can handle the doubling of traffic as contemplated under the GO 2020 expansion plan it used as its reference case. But the current rebuilding of the facility will not be capable of handling the additional traffic generated if all the expansion plans embodied in *The Big Move* are carried through to completion and the Union Station's traffic quadruples.

An October 20, 2010, stakeholder presentation on the Metrolinx Union Station Study and the Downtown Rapid Transit (DRT) Study acknowledged that electrification could have a significant bearing on the course pursued for Union Station. It identified the electrified services in Melbourne and Sao Paulo as "examples of rapid transit expansion being achieved by upgrading electrified commuter rail lines to a metro/subway standard, using rapid transit equipment, to dramatically increase the extent of rapid transit services into the growing hinterlands."

The presentation went even further into the realm of GO electrification and its benefits – indeed, its necessity – in the examination of one option:

- *What if the required resources for the DRT were used to provide a high speed tunnel connecting selected GO Rail lines directly to the centre of the downtown core (along Queen or King streets or somewhere in between) rather than continuing to operate to/through Union?*
- *We are assuming this would require the type of electrified commuter rail services operated in Melbourne and Sao Paulo using rapid transit equipment, consistent with the Super GO concept assumed in the RTP [The Big Move] for selected corridors.*

Whether this monumental project is ever undertaken is not as important as the fact that its mere contemplation indicates at least some members of the Metrolinx team can see the transformational capabilities of GO electrification. It would have been more productive if the members of the electrification study team had been as equally forward looking. Unfortunately, they weren't and the result is a report that views electrification as far less of a system development tool than it should be.

Sao Paulo EMU commuter train in the city's new Brooklin financial district on the Emerald Line. The system carries about 1.2 million riders every weekday.

4.2 Tier 4 Diesel Traction

"The Reference Case also assumed that Tier 4 Diesel MP40 rolling stock will be in operation as GO Transit has committed to convert to Tier 4 emission standards.... This is therefore the rolling stock against which other technologies were compared in the study."

The Metrolinx study team placed boundless faith in the ability of new Tier 4 diesel locomotives to deliver major environmental and health benefits at reasonable cost. Mandated by the U.S. Environmental Protection Agency (EPA) for introduction on all locomotives produced in the U.S. as of 2015 and accepted as the new voluntary standard for the locomotives GO will purchase after that date, Tier 4 aims to reduce particulate matter by 70 per cent and oxides of nitrogen (NOx) by 76 per cent.

There's just one problem: No manufacturer has yet been able to produce a commercially viable Tier 4 diesel. In rebuttal, Metrolinx maintains that manufacturers have previously been able to meet the standards mandated by previous EPA emission reduction orders, but that's far from reassuring. And there are major concerns within the railway industry concerning the financial and operation effects of these new standards, if they can be attained.

The two largest suppliers of diesel locomotives – General Electric (GE) and Electro-Motive Diesel (EMD) – are attempting to develop new diesels to meet the Tier 4 standards, but neither has been successful so far. Reports on their efforts are not encouraging. In an article in the September, 2008, edition of the trade magazine, *Railway Age*, EMD's manager of emissions compliance, David E. Brann, outlined the financial impact of Tier 4, including:

- *Tier 4 locomotives will be more expensive. The after-treatment devices are likely to cost as much as or more than the diesel engine itself, driven by large size, low volumes, and the platinum-group metals used in catalyzed particulate filters.*
- *Operating costs of Tier 4 locomotives will increase. The reagent for selective catalytic reduction devices is an additional fluid that will have to be replenished....*
- *Maintenance costs will increase. Locomotives will be even more tightly packed with equipment than they are now. There are packaging concerns, and space now empty will be filled with after-treatment components, making maintenance more difficult and time-consuming. Periodic cleaning and replacement of after-treatment catalyst elements will also add cost.*
- *The technical expertise necessary to overhaul and maintain locomotives in certified configuration will increase. Suppliers will be required to produce higher technology versions of emissions-critical components such as pistons, rings, cylinder liners, turbochargers, and fuel injectors.*

Metrolinx has verified the impact of Tier 4 – provided the manufacturers can even attain the standards – on its future capital costs. The 57 Motive Power Industries MP40PH-3C diesel-electric locomotives in GO's current fleet were built to the previous Tier 2 standards and cost the agency $5.5 million each in 2009. The proposed Tier 4 MP40 equivalents are estimated to cost $7.8 million – a 40 per cent increase.

Despite all the drawbacks and unknown variables, Metrolinx accepted Tier 4 as the benchmark against which electrification would be judged. In so doing, the study team violated its own criteria. At the beginning of the study, the team set out three standards by which all equipment should be assessed:

- Is the technology proven?
- Is the technology commercially viable?
- Is the technology compatible with the reference case service levels?

Tier 4 diesel technology is neither proven nor is there evidence it will be commercially viable, making it incompatible with the Metrolinx reference case service levels. It is, at best, a high risk technology. Electrification meets all three criteria. Despite the final report's claim that "the magnitude of the transformation to electrification presents significant risks," it is a risk-free technology, as proved by the millions of train-miles racked up annually by electric railways worldwide.

4.3 Motive Power and Rolling Stock Selection

> ***"While the electric locomotive was used in the detailed evaluation, the Study notes that electric multiple units (EMUs) over the long term will be able to take the GO Rail system closer to The Big Move vision for Express Rail with significant journey time savings."***

The question of what type of equipment would be selected for high-level evaluation resulted in much debate at the workshop sessions. Before the final report was delivered, Metrolinx revealed that staff had rejected the use of self-propelled EMUs except possibly for the ARL. The study team said this was due to cost, estimating that the selection of EMUs versus the diesel option for anything other than the ARL would result in "around 40% more in capital costs, while over the 30-year life cycle they were around 2.5 times more expensive, meaning a significantly larger capital and operating budget would be required."

However, senior railroaders with extensive experience on other North American commuter rail systems who were consulted by this writer felt these costs were overstated, especially in view of the superior performance of EMUs and their effect on system operating costs over an extended period. Yes, bi-level EMUs would cost more initially. But their superior acceleration, deceleration and operational flexibility give them a considerable edge over locomotive-hauled train operation. The Metrolinx study even admits they would offer time savings twice or greater than those achievable with electric locomotive haulage of the existing bi-level coach fleet. It is this level of performance that has led the majority of electric commuter rail operators worldwide to select EMUs in preference to locomotive-hauled rolling stock.

When the issue of bi-level EMUs was raised at the stakeholder workshops, Metrolinx fell back on the argument that an FRA-compliant bi-level EMU does not currently exist. They rejected the use of the FRA-compliant EMUs employed in Chicago. Although known on those electric systems as bi-levels, they are actually gallery cars that can be best described as partial bi-levels, with lower capacity and poor passenger flow compared with the Bombardier full bi-levels used by GO and 12 other North American commuter railways. Testing and rejection of this gallery design in the mid-1970s led GO to develop the current full bi-level design in cooperation with Bombardier predecessor, Hawker-Siddeley.

As well, Metrolinx rejected suggestions they consult with their counterparts on the San Francisco Caltrain electrification project, which will make use of North America's first fleet of non-FRA-compliant, European bi-level EMUs, which is covered in detail in Appendix B. However, Metrolinx consultant LTK did note:

> *Caltrain has worked with the FRA and has recently secured a waiver to allow the operation of proven, European design, non-FRA-compliant vehicles intermixed with its current diesel LHC fleet and limited freight. This waiver required years of technical review, including sophisticated computer simulations of train-to-train and train-to-highway vehicle collisions to argue that an equivalent level of passenger safety would be maintained between compliant and non-compliant rolling stock. Metrolinx should not underestimate the effort required to obtain their own approval, particularly since they are under jurisdiction of Transport Canada rather than the FRA.*
>
> *The European EMU design ... takes advantage of crash energy management features, such as engineered crush zones. It is believed that a 25 kV, European-derived multi-level EMU may be a feasible and commercially viable alternative for Metrolinx's consideration.*

A possible bi-level EMU fleet strategy was not carried forward for detailed evaluation by Metrolinx because GO remains wedded to locomotive-hauled operation of its existing bi-level coaches and cab cars. Using electric locomotives with this rolling stock protects GO's past investment and leaves its current 10-year fleet strategy untouched. While this makes some financial sense, it is short-sighted and unnecessary.

A Sydney CityRail H-series EMU train arriving in Scarborough – New South Wales, that is.

The 1992 GO Electrification Study examined the possible conversion of the non-powered GO bi-level cars into FRA-compliant EMUs. The study team found the existing cars couldn't be easily converted, but the design itself could be adapted to create new, Thunder Bay-built bi-level EMU power cars capable of hauling existing GO bi-level coaches, producing two-car sets that could be marshalled into trains of any length. This would use of all of GO's current bi-level fleet and protect its sunk cost. It could also open up new markets for Bombardier, the manufacturer of the highly-successful, Thunder Bay-built bi-levels.

Furthermore, with four of GO's seven existing lines remaining as diesel operations under the Metrolinx electrification scenario, the existing bi-level fleet will be amply employed until its retirement is physically and financially desirable.

The EMU issue needs to be revisited. Given the leisurely schedule on which Metrolinx intends to electrify, new rolling stock will not be required until at least 2024. This is more than enough time for Metrolinx to cooperatively develop an Ontario-built EMU version of the Bombardier bi-level coach or develop a plan for the introduction of proven, non-FRA-compliant bi-level EMUs, similar to that in progress on Caltrain.

4.4 Health, Environmental, Social and Community Benefits

> ***"There are transportation and economic benefits to electrification. There are also small environmental, social and community benefits. Health benefits are expected to be marginal."***

These findings stand in stark contrast with what has been reported by other railways investigating electrification. For example, in the U.K. Department for Transport's 2009 report, *Britain's Transport Infrastructure: Rail Electrification*, which led to the current £1.3 billion commitment to electrify numerous lines for commuter, intercity passenger and freight service, the government agency reported:

> *Electric trains generally perform better than equivalent diesel vehicles even on the basis of the current electricity generation mix. Typically an electric train emits 20–35% less carbon per passenger mile than a diesel train. This advantage will increase over time as our power generation mix becomes less carbon intensive....*
>
> *Electric trains have zero emissions at the point of use, which is of particular benefit for air quality in pollution 'hot-spots' such as city centres and mainline stations. Electrification reduces rail's reliance on imported diesel fuel. Electric trains are quieter than diesel trains, and virtually silent when waiting at stations.*

In San Francisco, Caltrain has repeatedly stated that electrification results in a 90 per cent reduction in emissions, not to mention the fact that "electric trains are significantly quieter, a plus for neighbours living and working near the corridor."

Transportation library bookshelves are lined with reports delivering the same verdicts on these issues. But Metrolinx has presented the evidence on the multiple health, environmental, social and community impacts of electrification in such a way as to imply either a strange sense of logic on its part or a deliberate effort to downplay the benefits. This specifically applies to what Metrolinx describes as the marginal health benefits. To make this case stick, Metrolinx has reported those benefits in the context of GO's anticipated emissions on a regional basis, not directly on the affected corridors:

> *By electrifying larger sections of the GO Transit Rail network, greater GHG [greenhouse gas] reductions can be achieved – electrifying the entire network would deliver a 94% reduction of GO Transit Rail's future contribution to GHG emissions, although this reduction would only be a small fraction (0.32%) of the overall region's emissions. Nevertheless, all options with the exception of Option 1 (the electrification of the Georgetown line) meet or exceed the Big Move's Regional Transportation Plan strategic target of reducing GHG emissions per passenger by 25%.*
>
> *Electric trains do not emit CAC [critical air contaminant] from the locomotives, but rather at the source of electricity generation. The impacts of CAC on the local community and adjacent sensitive receptors were considered, and the more the network is electrified, the more people benefit from improved air quality. However,*

analysis of the concentrations of air contaminants such as particulate matter (PM2.5), NOx and SOx with Tier 4 Diesel locomotives shows that the impact of the Reference Case service levels would already be well below the stringent World Health Organization standards. As more corridors are electrified, the local air quality improves, but the health benefit associated with electrification is likely to be relatively small.

However, the City of Toronto's Medical Officer of Health examined the data using a different yardstick. In his report, Dr. David McKeown wrote:

Metrolinx estimates that GHG emissions from the GO rail system would be more than twice as high with Tier 4 diesel as they would be if the Georgetown and Lakeshore corridors were electrified (338,000 tonnes of GHGs each year, measured in carbon dioxide equivalents (tonnes CO2e/year), compared to 151,000 tonnes CO2e/year). Furthermore, GHG emissions from a Tier 4 system would be approximately 18 times higher than from a fully electrified system (19,000 tonnes CO2e/year).

The GHG emissions reductions that could be achieved by upgrading Tier 4 diesel to electric trains on the Georgetown and Lakeshore corridors would enable Metrolinx to reach its target of 21 percent GHG reduction per passenger for their operations. It would also be an important contribution to the Ontario government's target of 6 percent GHG emissions reductions from freight and diesel transportation as set out in the Move Ontario 2020 plan.

The health, environmental, social and community benefits of electrification are large. The minimization of these benefits by Metrolinx only served to make the final report look skewed in favour of sticking to GO's Tier 4 diesel strategy, which remains a chimera at this point. The issue needs to be revisited, particularly because it has implications for the other lines in the GO system that the study rejected for electrification.

In this regard, it is worth noting Dr. McKeown's recommendations to the members of the Board of Health:

1. The Board of Health urge the Minister of Transportation to provide secure and dedicated funding to electrify the GO Transit rail service as soon as possible, starting with the Georgetown and Lakeshore corridors; and
2. The Board of Health request the Government of Ontario commit to electrification of the entire GO Transit rail service.

These recommendations were adopted by the Board of Health on February 2, 2011.

4.5 Economic Impact

"Electrifying the GO Transit Rail network is expected to generate economic benefits during construction (due to construction employment) and in operation (due to faster commutes, less congestion), which in turn increase the economic output."

Yes, but this misses the mark by quite a distance, as previous GO electrification studies proved in their detailed assessment of the numerous benefits in terms of economic spinoff and job creation. Throughout North America, as governments of all levels have awakened to the benefits of improved and expanded rail service, attention has been devoted to quantifying those benefits. In general, it is recognized that rail investment has a substantial impact on numerous aspects of a region's economy, including:

- Diversion of traffic from other publicly-subsidized modes of transportation, such as highways;
- Job creation during the construction or equipment manufacturing phases;
- Ongoing jobs and economic spin-off from the operation;

- Savings in health care costs due to diversion of traffic from less safe modes and reductions in emissions that affect the public's health;
- Savings in national energy costs, given the higher energy efficiency and reduced fuel requirements of rail, especially if it is electrified; and
- Residential and/or commercial development and economic activity in the areas surrounding the stations and other facilities.

The U.S. Department of Commerce (USDOC), the Association of American Railroads (AAR), the American Public Transportation Association (APTA) and States for Passenger Rail (S4PR) have produced a series of calculators that may be used to arrive at rule-of-thumb figures on the potential impact of any rail investment program. Applying these multipliers to the financial requirements of the various GO electrification options reveals the following benefits:

GO Electrification Economic Benefits

NETWORK OPTION	COST ESTIMATE (BILLIONS)	USDOC[1] (BILLIONS)	APTA[2] (BILLIONS)
ARL/Georgetown	$0.783-0.886	$2.349-2.758	$3.132-3.544
Lakeshore	$1.142-1.293	$3.426-3.879	$4.568-5.172
ARL/Georgetown + Lakeshore	$1.619-1.831	$4.857-5.493	$6.476-7.324
ARL/Georgetown + Lakeshore + Milton	$1.921-2.163	$5.763-6.489	$7.684-8.652
ARL/Georgetown + Lakeshore + Milton + Barrie	$2.468-2.772	$7.404-8.316	$9.872-11.088
Full GO System	$3.755-4.202	$11.325-12.606	$15.020-16.808

[1] U.S. Dept. of Commerce (USDOC) Formula: $1.00 investment = $3.00 in economic activity

[2] American Public Transportation Association (APTA) Formula: $1.00 investment = $4.00 in economic activity

GO Electrification Job Creation Benefits

NETWORK OPTION	COST ESTIMATE (BILLIONS)	AAR[1] (JOBS CREATED)	S4PR[2] (JOBS CREATED)
ARL/Georgetown	$0.783-0.886	15,660-17,772	23,490-27,580
Lakeshore	$1.142-1.293	22,840-25,860	34,260-38,790
ARL/Georgetown + Lakeshore	$1.619-1.831	32,380-36,620	48,570-54,930
ARL/Georgetown + Lakeshore + Milton	$1.921-2.163	38,420-43,260	57,630-64,890
ARL/Georgetown + Lakeshore + Milton +Barrie	$2.468-2.772	49,360-55,440	74,040-83,160
Full GO System	$3.755-4.202	75,100-84,040	113,250-126,060

[1] Association of American Railroads (AAR) Formula: $1 million investment = 2,000 jobs

[2] States for Passenger Rail (S4PR) Formula: $1 million investment = 3,000 jobs

These benefits are substantial and must be considered in any project of the magnitude of GO electrification. Furthermore, they need to be assessed in terms of their local impact, a point on which the Metrolinx study was silent. Previous GO electrification studies analyzed the local impact and found considerable regional benefits that would flow to a wide range of Ontario manufacturers equipped to provide the required goods and services.

The electrification of BC Rail's Tumbler Ridge freight branch in the 1980s resulted in 89 per cent of all the catenary materials being procured locally, as well as the production of the electric locomotives at the General Motors (now Electro-Motive Diesel) plant in London, Ontario. That this study didn't investigate Ontario sourcing and stimulus opportunities in detail is a glaring omission.

4.6 Implementation

"The implementation of the Electrification Options on the existing GO network that is an operating railway presents a number of challenges."

In the 1880s, the Canadian Pacific Railway built the world's first transcontinental railway under a single management. In four years, eight months and 19 days, the company completed the construction of more than 4,700 route-kilometres of railway, traversing the rugged Canadian Shield, spanning the Prairies and conquering four mountain ranges with technology that was crude by today's standards. It is, therefore, difficult to fathom how the electrification of 235 route-kilometres of existing railway could possibly require the 21 to 24 years proposed by Metrolinx.

In other countries, electrification proceeds at a much faster pace. Part of the reason is these rail operators, anxious to reap the benefits of converting to electric traction, have devised techniques and technologies to make it happen quickly and without unduly disrupting existing rail traffic. In its July, 2009, report, *Britain's Transport Infrastructure: Rail Electrification*, the U.K. Department for Transport observed:

> *Network Rail has developed proposals for an electrification process to minimise disruption. These proposals involve construction techniques which make extensive use of overnight closures of not more than eight hours. The application of modular techniques and the deployment of rapid delivery systems to improve the rate of production will be of key importance. The proposed methodology is designed to operate within normal 'rules of the route' possessions. To achieve this it is expected that construction techniques which are capable of working with the adjacent line open to traffic will be required.... [For] straightforward stretches of line between major junctions and complex stations Network Rail's work suggests the use of 'factory trains'. This will enable standardisation as far as possible. The factory trains will be flexible units, capable of working individually or in combination, and as such, could play a useful on-going role in the efficient maintenance of the electrified network.*

It is obvious that other operators are far ahead of GO in the implementation of electrification. As a complete novice in this field, GO should be calling upon and learning from those railroaders who are capable of electrifying their railways in a fraction of the time Metrolinx has proposed. Furthermore, even Metrolinx suggested a method for advancing its electrification plan more expeditiously and at lower cost:

> *The available time for construction is limited by the level of service and therefore if the Reference Case service level increases were delayed until the electrification construction work has been completed on each corridor there would be savings in construction schedule and cost.*

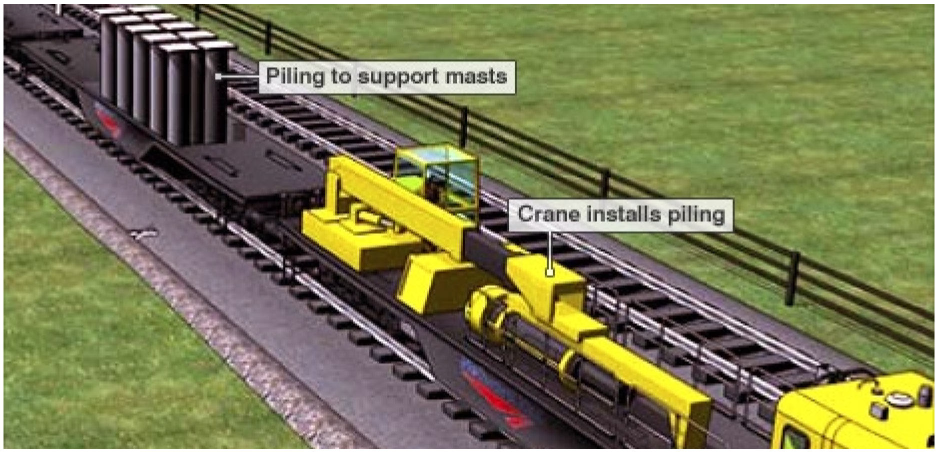
Despite this valid observation, the plan remains to first proceed with the infrastructure and service expansion contained in the GO 2020 reference case and deal with electrification afterward, thus inflicting time and cost penalties. Metrolinx needs to be directed to study this issue in much greater detail and, with the benefit of real-world input of other electric railroaders worldwide, reduce both its electrification timelines and cost estimates.

In yet another example of contradiction found within the final report, Metrolinx advises:

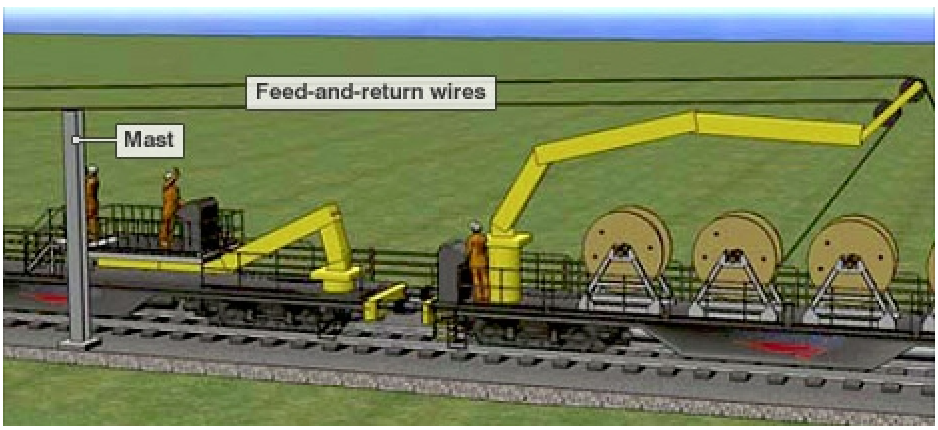
> *The conversion to electrification of Option 3 is a long-term investment. To wait until expanded future services are in place would increase both the time and the cost of implementation. Commencing a phased approach now, while service levels are lower, minimizes construction disruption and ensures that the electrification infrastructure is in place as ridership grows.*

Metrolinx would do well to heed its own advice on this issue.

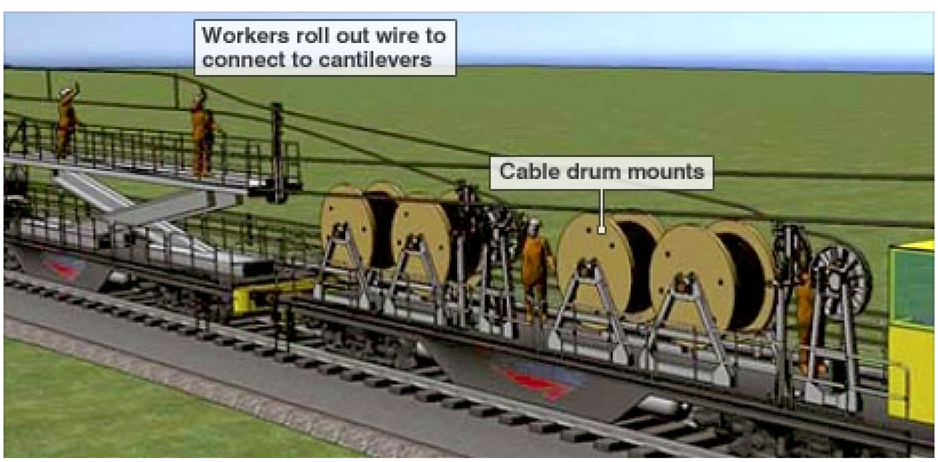
U.K. Catenary Factory Train



A factory train can install 1.5 km of cable in an eight-hour shift. First, it drills piles beside the track to support the overhead catenary wires.



The factory train moves along unravelling wire at a steady pace. The feed-and-return wires are attached to the masts to supply the catenary wires with electricity.



Workers attach the cantilever support arms to the masts and wires to the cantilevers. Finally, essential grounding and safety inspections are carried out.

4.7 The ARL Project

> ***"In the case of the ARL, it is assumed that the initial deployment of DMUs will be replaced by EMUs if the Georgetown line is electrified either in part or in full.... These EMUs could be conversions of the DMUs or new vehicles with the DMUs redeployed to other GO corridors."***

Without a doubt the most controversial and questionable aspect of the GO Electrification Study was the recommendation to proceed with the ARL as a "convertible" diesel service to be completed in time for the two-week Pan Am Games in July, 2015. Metrolinx has stated that all infrastructure work for the diesel incarnation of the ARL and the expansion of GO's Georgetown service will be "electrification compatible."

In fact, the decision to proceed with the ARL as a diesel-first service wasn't a recommendation based on detailed study. It was a directive from Premier McGuinty. On several occasions, members of the study team revealed to the participants in the workshops that construction of the ARL as a convertible diesel service was a "given" because it was allegedly impossible to electrify the 35.6 route-km. from Union Station to the airport and Willowbrook Yard by 2015. No concrete proof of this has ever been provided and one suspects it is merely Metrolinx staff's opinion. Nonetheless, staff maintained the delivery of the ARL was locked in by the Province's commitment to the Pan Am Games.

Proof that the ARL would proceed as a diesel-first project was provided by Metrolinx on November 16, 2010, more than two months before the Electrification Study was released, when the agency announced negotiations were under way with Sumitomo Corporation of America for the untendered purchase of 12 to 18 DMUs. Construction of the carshells and initial assembly will take place at the plant of Sumitomo's rail manufacturing partner, Nippon Sharyo, Ltd., at Toyokawa in south central Japan. Each car will then be shipped for final assembly at Nippon Sharyo's new plant in Rochelle, Illinois, which still hasn't been completed.

Metrolinx has said it is investigating the possibility of some Canadian content in the DMUs, but this is not required under the contract with Sumitomo, sidestepping the Government of Ontario's usual domestic content rules for publicly-funded transit equipment. Metrolinx says these rules do not apply to the purchase of "heavy locomotives," although it would be difficult to qualify this lightweight rolling stock as such.

Artist's rendering of the Sumitomo DMUs for the Sonoma Marin Rail Transit District, which will serve as the base order on which the Metrolinx ARL equipment is being purchased without competitive bidding.

The Sumitomo DMUs will be purchased using an option on a base order placed by the Sonoma-Marin Area Rail Transit District (SMART). The 18-car base order for this troubled San Francisco Bay Area project included options for up to 196 additional cars, which could be exercised by other North American transit agencies.

This has become a favourite tactic of manufacturers eager to avoid multiple competitive bidding processes. Having secured the first competitively tendered order, the potential purchaser in another jurisdiction attempts to make the case that a new tendering process is unnecessary because the original one proved the superiority of the equipment technically and financially. This is exactly what has occurred with the ARL equipment order.

In an attempt to tamp down any public and alternate manufacturer opposition to this curious deal, Metrolinx had the former Integrity Commissioner of Ontario, Justice Coulter Osborne, Q.C., examine the transaction and he pronounced it fair. However, it is apparent to anyone with experience in the rail equipment field that Justice Osborne may not have been provided with all the facts. One aspect of his report is especially puzzling.

Canada's Bombardier Transportation was asked to bid on this order, but declined due to its small size and low potential profit margin. Germany's Siemens Mobility was interested and entered into discussions with Metrolinx, but was ultimately rejected, as stated in Justice Osborne's report. The company has remained quiet about this, but industry sources report Siemens was perplexed by the whole process. The company has North American credentials in this field, having supplied 12 married pairs of the diesel version of its highly-successful DMU/EMU Desiro self-propelled cars to San Diego's North County Transit District for use on its Oceanside-Escondido Sprinter service.

What was not addressed in Justice Osborne's report – likely because he was never informed – was the willingness of the Moncton, New Brunswick, firm, Industrial Rail Services, Inc. (IRSI) to bid on the project. IRSI was the supplier connected with the original SNC Lavalin Blue 22 version of the ARL, slated to deliver fully-remanufactured ex-VIA stainless steel Budd rail diesel cars equipped with all-new diesel engines of a proven European design and meeting high emissions standards.

Given that GO and Metrolinx executives have confessed that the Sumitomo convertible DMUs will probably not be converted, but redeployed to other lines and replaced with new EMUs when the ARL is electrified, there is every reason to believe IRSI could have supplied a thoroughly acceptable fleet at a significantly lower cost. These remanufactured Budd cars would have a high Canadian content and a longer service life due to the documented longevity and sturdiness of the stainless steel carbodies. Justice Osborne's report and Metrolinx are mute on this issue.

In the end, the contract with Sumitomo was signed on March 29, 2011. By a strange coincidence, the oft-delayed SMART project then reduced its order from 18 to 12 DMUs immediately after Metrolinx signed its contract. At SMART's April 20, 2011, board meeting, the directors approved the reduction and it was noted this was only possible because another buyer had been found to enable the agency to exercise an escape clause in its contract with Sumitomo. That buyer is, of course, Metrolinx.

It should also be noted that SMART is relying heavily on LTK Engineering Services, which also served as a consultant on the Metrolinx Electrification Study. The company has so far billed SMART for $4,202,190 in design engineering and management operations services and an LTK staff member has been appointed as the agency's acting operations director. At the April 20 SMART board meeting, approval was given to increase LTK's contract to a total of $4,833,864.

No matter which equipment manufacturer was ultimately selected and how that decision was reached, the issue of the impact of a high-frequency DMU service remains unchanged and it is of great concern to online residents. It was a similar type of diesel service under the original Blue 22 proposal in 2003 that spurred these residents into action and led to the creation of the Weston Community Coalition and the Clean Train Coalition (CTC).

The current version of the service – even if it can be built to the promised Tier 4 standards – is hardly an improvement. With the ARL operating every 15 minutes in both directions from 5 a.m. to 1 a.m., residents will have to contend with the emissions and noise from 140 trains daily. In addition, there will be the expanded GO Georgetown service (29 trains daily by 2015 with more to follow) plus VIA, CN and CP traffic. In total, this will result in 206 diesel trains on the corridor between West Toronto and Weston daily.

Under the approved electrification implementation plan, some relief will be provided if the ARL is converted as promised between 2018 and 2020. A further reduction in the level of diesel-powered service will occur between 2020 and 2022 if implementation of the two-phase Georgetown electrification plan occurs, but diesel-hauled GO service won't be totally eliminated until sometime between 2032 and 2034. As the CTC points out, that's a long time to endure an intensive diesel-powered rail service.

Another controversial aspect of this plan is the so-called Weston Tunnel, which remains under discussion and design. In reality, it is a concrete-walled trench that will carry the GO Weston Subdivision underneath John, King and Church streets in Weston. The latter two will remain open to vehicular traffic, but John Street will be a pedestrian-only crossing. As well, the parallel CP MacTier Subdivision will remain at its present level with grade crossings at these three locations. Further south, the Denison Avenue grade crossing over both rail lines will be replaced with a full road underpass.

It is apparent to all who have slogged it out through the stakeholder consultation process that the ARL is a "done deal." The intervention of the Premier and his Cabinet has assured that. Still, many questions remain and the public has a right to some straight answers.

Q. Is the ARL really the transportation and environmental benefit that this government has touted?

Premier McGuinty has said the ARL will immediately replace 1.2 million trips by car annually. That translates to 3,287 daily, although Metrolinx has boasted the service will carry 5,000 daily within five years. With 140 frequencies daily, that means the 126-seat ARL trains will handle an average of 23 passengers per train at the start of service and 35 per train within five years. To put this in perspective, the TTC's King streetcar carries about 56,000 passengers every weekday.

Frankfurt International Airport's long distance rail passenger station. A second station serves two commuter and three regional rail routes.

Five million trips are made annually between downtown Toronto and Pearson, so 5,000 per day would account for 36 per cent of all those trips. That's an ambitious goal. Major airports in Europe with multiple high-quality transit connections have difficulty attaining that rate of passenger capture.

Zurich's Kloten Airport, for example, is served by intercity and commuter trains, two streetcar lines and buses. These services combined handle 46 per cent of all air passengers. In fact, the Zurich Airport Authority is mandated by the government to reach 42 per cent in order to receive funding. This is an unusually high passenger capture rate.

By comparison, Frankfurt International – the third busiest airport in Europe and the ninth globally – is served by two intercity rail passenger routes, five regional and commuter rail lines, and buses, all of which capture about 26 per cent of air passengers.

Q. Why maintain the fiction concerning the conversion of the DMUs to EMUs?

Numerous Metrolinx staff members have already said the agency will most likely buy new EMUs if and when the ARL is electrified; the DMUs will be redeployed to other light-density GO services. The conversion of self-propelled rolling stock from one mode of traction to another is a rarity in the railway world. The few operators that have gone this route have ultimately regretted it for financial and mechanical reasons. Experienced railroaders in the U.S. and Europe who were consulted for this report see this equipment conversion plan as high risk.

Q. How can the public be reassured that the Sumitomo DMUs for the ARL will actually perform as promised, as well as meet Tier 4 emissions standards?

As of the writing of this report, Metrolinx is still unable to answer many technical questions regarding the DMUs. They can't even say which make and model of diesel power plant will be used in the cars or even its exact horsepower rating. This is hardly reassuring, especially given the difficulties the world's largest diesel manufacturers are having in attaining the promised Tier 4 emissions standards.

Q. What is the final price tag for these DMUs and are they proper value for money?

While the Metrolinx study made much of the risks of GO electrification, it seems to have not been as concerned when it came to the ARL. Sumitomo's carbuilding partner, Nippon Sharyo, has delivered a total of 302 DMUs of 18 different designs for 12 clients, but the company has never built an FRA-compliant DMU for a North American operator, let alone one that is convertible to electric operation.

It must also be asked just what penalties the modifications to the original SMART design to create a convertible version for Metrolinx has inflicted on the cost of the rolling stock. The SMART DMUs will cost $6.2 million per two-car pair. The Metrolinx versions will cost $9.2 million per pair, not including taxes and import duties. Conversion to EMUs will cost $3.2 million per two-car set. Although the ARL cars will have slightly different interiors than the SMART cars, it is difficult to account for a cost difference of $3 million per two-car set.

One might also ask why is it necessary to buy six two-car sets when only four sets are required for the service. The plan is to use four two-car trains in service daily, another pair as a spare to fill in when one of the assigned sets is out of service for maintenance and yet another two-car set as a "hot standby" that can be quickly placed in service should one of the regularly-schedule trains fail. A 50 per cent spare ratio is more than twice as high as the accepted industry standard. This is a function of operating with such a small and specialized fleet dedicated to the ARL only. If Metrolinx was ordering a common fleet of EMUs for the ARL and all other electrified GO services, it would be unnecessary to maintain such a large spare ratio. With a larger, common fleet pool, it would be possible to have a reasonable number of spares that could be tapped to replace assigned equipment used on any electrified service that failed or was removed from revenue service for scheduled preventive maintenance.

North American FRA-Compliant Commuter Rail Equipment Costs

MODEL/TYPE	BUYER	ORDER PLACED	COST (MILLIONS CDN)
LOCOMOTIVES			
Siemens ACS-64 Cities Sprinter Electric	Amtrak	2010	$6.3
Bombardier ALP-46A Electric	NJ Transit	2008	$8.3
Bombardier ALP-45DP Dual-Mode	AMT	2008	$10.8
MPI MP40PH Tier 2 Diesel	GO Transit	2009	$5.5
MPI MP40PH Tier 4 Diesel (proposed)	GO Transit	(2014)[1]	$7.8[1]
BI-LEVEL LOCOMOTIVE-HAULED CARS			
Bombardier BiLevel Coach	GO Transit	2011	$2.5
Bombardier BiLevel Coach	GO Transit	2009	$3.0
Bombardier BiLevel Cab Car	GO Transit	2009	$3.2
Sumitomo Gallery Coach	Virginia Rail Express	2008	$2.2
SINGLE-LEVEL DIESEL MULTIPLE UNIT CARS			
Sumitomo	GO Transit ARL	2011	$4.6
Sumitomo	SMART	2010	$3.1
Colorado Railcar (company now defunct)	Portland Westside Express	2005	$4.0
Siemens Desiro VT-642	San Diego NCTD Sprinter	2004	$2.0
SINGLE-LEVEL ELECTRIC MULTIPLE UNIT CARS			
Sumitomo (with DMU-EMU conversion)	GO Transit ARL	2011	$6.2[2]
Kawasaki M8	Connecticut DOT	2006	$2.9
Rotem Silverliner V	SEPTA Philadelphia	2006	$2.6
BI-LEVEL ELECTRIC MULTIPLE UNIT CARS			
Sumitomo Gallery High-Liner	Chicago Metra	2010	$3.4
Sumitomo Sharyo Gallery Bi-Liner	NICTD South Shore	2007	$3.3

[1] GO Electrification Study Final Report, Appendix 8B

[2] GO Electrification Study Final Report, Appendix 8B (DMU-to-EMU conversion @ $1.6 million per car)

Foreign Non-FRA-Compliant Electric Multiple Unit Equipment Costs

MODEL/TYPE	BUYER	ORDER PLACED	COST (MILLIONS CDN)
SINGLE-LEVEL			
Alstom X'Trapolis	V/Line Melbourne	2009	$2.2
Alstom-Bombardier ET-430	DB Stuttgart S-Bahn	2009	$2.1
Bombardier SMU260	Queensland Rail	2009	$2.5
Siemens Desiro	First ScotRail	2008	$2.0
Stadler FLIRT	NSB Oslo S-Rail	2008	$2.7
BI-LEVEL			
Stadler KISS	BLS Berne	2010	$4.6
Alstom-Bombardier TER-2N	SNCF/CFL	2009	$4.6
Reliance Rail "A" Set	Sydney CityRail	2006	$4.8
Skoda CityElefant	Czech Railways	2006	$3.9
Siemens Desiro	SBB Zurich S-Bahn	2003	$3.7

Q. Why can't a more rapid transit-style "surface subway" operation, with additional station stops, be part of the ARL/Georgetown South Service Expansion plan, especially if the line is being rebuilt with four tracks?

Participants in the Metrolinx workshops asked that such a service be seriously considered, especially in light of the fact that the ARL project is now being funded totally by the taxpayers of Ontario. There is no evidence that an exploration of this option has been undertaken by Metrolinx. Given that the area served by the GO Weston Subdivision, especially north of Bloor Street West, is poorly served by public transit, this would make perfect sense.

Q. Is it really necessary to inflict more than $400 million in extra infrastructure costs on the ARL electrification plan?

The electrification study revealed that GO intends to build a fourth track on the Weston Subdivision and a tunnel under Highway 401 in order to protect for the construction work required to implement electrification after ARL diesel service begins in 2015. This is a large price to pay for what GO says is necessary track capacity during construction. GO has no experience in electrification and is not yet fully aware of the techniques employed by other railways to minimize track occupancy time for construction and keep the existing rail services moving. This $400 million-plus decision is especially questionable and it needs to be investigated thoroughly before such a large commitment of public funds is made.

Q. If this additional, expensive infrastructure is so necessary to the conversion of the ARL after its launch as a diesel service in 2015, why not just delay the project until it can be done properly?

Members of the CTC and Transport Action Ontario have asked this question repeatedly. The answer they have received is that the ARL is a requirement of Ontario's bid for the Pan Am Games. The fact that the current government tacked this requirement on to the original bid has been curiously forgotten. There is no reason to believe that not delivering the ARL in time for the games would in any away affect or jeopardize Ontario's successful bid if an adequate and environmentally friendly alternative were to be substituted. The CTC has suggested that a fleet of Ontario-built "green" hybrid or biodiesel buses providing express service from Pearson International Airport to Union Station and other points across the GTHA would more than fit the bill for a two-week sporting event. This suggestion has fallen on deaf ears at Queen's Park and Metrolinx headquarters.

Nor have Metrolinx and Premier McGuinty been willing to heed the advice of seemingly more influential outside parties. A motion on this issue went before Toronto City Council on March 8, 2011, moved by Councillor Frances Nunziata (Ward 11 – York South-Weston) and seconded by Councillor Doug Ford (Ward 2 – Etobicoke North). The recommendations were:

1. That City Council request that the Minister of Transportation consult with international rail experts to determine whether electrification of the Airport Rail Link can be completed by 2015.

2. That City Council request that if rail electrification experts are of the opinion that the Air Rail Link cannot be built to operate as electric in time for the Pan Am Games, alternative transportation plans be made to transport people from the airport to Union Station for the duration of the Games to avoid the added costs of converting from diesel operation to electric.

This motion was passed by City Council on March 9. Still, the Province refused to consider altering its diesel-first stance for the ARL.

Obviously, the Premier's directive to Metrolinx to deliver the ARL in time for the Pan Am Games is unstoppable. The result is that taxpayers will pay for a service that is far less than it could be at the time of its launch. They will also pay a high price to later convert it into something that will still fall short of delivering the maximum transportation benefits to the greatest number of users.

5.0 Conclusions and Recommendations

"Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will not die."

Daniel Burnham

The public perception is that the battle for GO electrification has been won and its advocates can rest easy. That's far from the truth.

The Government of Ontario and Metrolinx were highly successful in their public relations efforts following the January 26, 2011, approval of the two-line electrification plan. The media reported the decision in positive terms and the public generally believed it. But the Metrolinx board decision was little more than a paper victory for the advocates of electrification. As with many other Ontario transit projects that were supposedly assured, there has been far too much talk and too little action. The fact that this plan calls for the construction of the ARL as a diesel-first service provides ample reason for cynicism and concern.

This is not a new situation. Throughout the citizens' campaign for GO electrification, the advocates faced both political and bureaucratic intransigence. Anyone who has campaigned for improved transit or rail service knows this situation all too well. Transportation planner and former Toronto City Councillor Howard Levine has gone so far as to describe it as "rigid incompetence cloaked in know-it-all arrogance."

True, Metrolinx did conduct a public consultation process that was extensive (and no doubt expensive), but it often appeared to be window dressing. The revelations in 2009 of an internal Metrolinx report spotlighting the need to co-opt and control the public consultation process did little to reassure those who were attempting to make the case for electrification.

It is, therefore, understandably difficult for these citizens to accept the provincial government's commitment to electrify portions of the GO system as firm. At best, it is loose enough to provide many opportunities to bail out before it is implemented.

Nonetheless, the authorization to proceed with the electrification of the ARL/Georgetown and Lakeshore corridors has been received and preliminary work in preparation for the Environmental Assessment process has begun. This is more than has ever been accomplished in the past, when it appeared on numerous occasions that GO electrification was imminent.

Still, this is a far different situation than the one facing Ontarians back in the mid-1960s. Then, Premier John Robarts applied his own sense of logic and fairness to the issue of mobility in what was then known as the Metropolitan Toronto Region. He not only spoke sincerely in favour of, but fully committed his government to what became a landmark in North American transportation: the creation of GO.

Now, it remains for another premier to honour a commitment to a plan just as momentous. If GO electrification is going to be implemented as promised, there are measures that must be taken – and soon.

5.1 Accelerated and Expanded Electrification Program

It has been eight years since some residents of Weston proposed electrification as a solution to the neighbourhood-disrupting problems that would arrive with a diesel-powered ARL. Even using the luxurious timelines proposed by Metrolinx today, had a positive decision been rendered back in 2003, an electrified ARL could be in service now. That obviously didn't happen.

Worldwide experience proves the timelines for GO electrification are unreasonably lengthy. It is true that foreign railways with extensive experience in electrification can do it much faster because of the expertise they have acquired from previous projects. These railways have assembled teams of planners, designers, suppliers and builders who can swing deftly from one project to another, all of them experienced in bringing about electrification collaboratively in the swiftest and most cost-effective manner.

Still, the one element that is present in those electrification projects elsewhere and lacking at Metrolinx is commitment and enthusiasm. It is imperative that the political masters who command the bureaucrats who will be entrusted with making GO electrification a reality should now hold their feet to the fire. Ways must be found to expedite the process and even expand it. There is still a case to be made for electrification of more of the GO system, especially the Milton and Richmond Hill lines, the latter as part of a long overdue realignment and expansion of the route. With a proper approach, there is reason to believe there are strong operating, financial and environmental benefits to be gained by including other lines in the project.

Above all, this must be done with alacrity. Past experience proves that delaying or stretching out a GO electrification plan only provides opportunities to kill it further down the way.

5.2 International Peer Input

One of the key failings of the Metrolinx study process was the absence of international expertise in the construction, implementation and operation of electrified railways, especially commuter lines. Metrolinx and Minister of Transportation Wynne have argued otherwise and pointed to consultants ARUP and LTK as proof. However, these two firms – while headquartered outside Canada – do not have the real-world manufacturing, implementation and operating experience to qualify them as international experts capable of making meaningful contributions to the implementation plan.

The input of professional railroad manufacturers and operators who have dealt with electrification on functioning railways in Europe, the U.K. and elsewhere is very much needed if the Metrolinx-approved plan is going to be advanced in the most expeditious and cost-effective manner possible.

In recent conversations this writer has had with senior GO operating personnel, it has become apparent that part of their reluctance to embrace and accelerate electrification is largely based on fear arising from a lack of knowledge of how electric railroading works and how it can be undertaken without seriously disrupting current operations. One senior GO staffer admitted he wasn't aware most of the world's electrified railway infrastructure had been built to convert existing lines previously operated with steam or diesel locomotives and the work had been carried out without shutting down these railways. This is common knowledge in the railway world.

The way to quell this GO managerial fear and resistance is through the involvement of those professionals elsewhere who implement electrification programs regularly. The engagement of these real-world electric railroaders is vital if the approved GO program is going to occur as promised.

5.3 Freight Railway Consultation

Throughout the consultation and study process, Metrolinx chose to portray electrification as high risk and Tier 4 diesel as low risk, while the opposite is true. However, there is one risky element of the plan and that is the approval of the freight railways, which own large segments of the GO routes to be electrified.

GO is a tenant of CN, CP and the American-owned Goderich-Exeter Railway on about 40 per cent of its current route network. But of the 243.4 route-kilometres included in the approved Option 3 plan, only 93 route-kilometres are owned

by GO. That means the ownership ratio is reversed and about 60 per cent of the trackage earmarked for electrification remains completely under freight railway control.
As a result, the involvement and approval of the freight railways is critical to implementing four phases of the seven-phase electrification program. Past anti-electrification statements by two of these railways should be of considerable concern. As well, the freight railways have in the past insisted that any works erected on their rights-of-way become their property, even if constructed by and for government passenger agencies. This cannot be the situation today if electrification is to proceed.

Metrolinx does have recourse to the amended *Canada Transportation Act,* which could compel the freight railways to cooperate with a passenger-driven electrification program and under fair financial terms (see Attachment H). However, it would be preferable if they were willing partners, avoiding a lengthy and antagonistic legal battle before the Canadian Transportation Agency.

Metrolinx needs to resolve any conflicts with the freight railways now, before any serious implementation work is undertaken. A failure to do so could not just delay, but ultimately kill some portions of the current GO electrification plan.

5.4 The European Urban Rail Concept

In *The Big Move*, much was made of the plan to evolve GO beyond its traditional morning-in/afternoon-out weekday service primarily focused on moving suburban commuters in and out of Union Station. What is desperately needed is the transformation of GO into a day-long service with higher speeds and frequencies on all routes, emulating successful urban railways such as the more than 30 S-Bahn systems of Europe, the Parisian RER network, London's recent Overground project and similar operations in cities such as Sydney, Melbourne and Sao Paulo. Electrification is a crucial element in such a plan, along with the use of high-performance EMUs, full fare integration and numerous connections with other transit lines.

The positive implications of such a transformation and expansion of GO's rail system are massive, as has been proved in those urban centres that have taken this route. Even Metrolinx's own studies have validated this approach. This should be a prime objective of Metrolinx, the Government of Ontario and the municipal and regional governments throughout the GTHA.

The implementation of a GO urban rail strategy should especially be accelerated within the boundaries of the City of Toronto. With the cancellation of Toronto's Transit City LRT plan and the reduced coverage to be provided by the subways proposed under the current civic administration's transportation plan, a fully-integrated GO rail system providing above-ground, subway-like service on existing and selectively realigned rights-of-way is one of the few options available. A failure to embark on such a project will only condemn Toronto and the entire GTHA to yet more gridlock, lost productivity, environmental degradation and excessive automotive dependency. It will also leave us uncompetitive with those regions in North America and overseas which are moving or have already moved in this direction.

5.5 Public Scrutiny and Oversight

GO electrification only became an issue because of public scrutiny and advocacy. There is ample proof that this issue wouldn't be on the table now if not for the efforts of the residents in Weston who placed it there eight years ago and then maintained a vigil, never taking "no" for an answer from politicians and bureaucrats who seemed determined to derail the issue. If implementation is to occur, these same members of the public are going to have to remain vigilant and even aggressive in their pursuit of GO electrification.

As those who participated will attest, the Metrolinx public consultation process frequently seemed hollow. This was not helped by the revelation of the *Globe & Mail* of the internal document that encapsulated the agency's views on how to co-opt and control all of its consultation processes. Though its author has departed Metrolinx, nothing that has occurred since has convinced many members of the public who have participated in various consultations that the situation has changed.

What remains now for those citizens who have fought so hard to make GO electrification happen is a level of scrutiny and activism equal to that which they have applied to the issue since it began in earnest with the announcement of the ARL eight years ago. Various organizations that advanced this cause – especially the CTC – proved adept at building bridges to the public, key members of the media, transportation professionals worldwide and politicians of all stripes at all three levels of government.

If GO electrification is to be implemented as promised by the current government and even expanded to provide greater benefits to residents of the GTHA – benefits this government has repeatedly said it seeks to achieve – then the public will need to keep up the campaign. And if this government is sincere in its oft-stated desire to involve citizens in this process, then the least it can do is maintain and improve the stakeholder workshop process that was in place throughout the one-year GO Electrification Study.

Appendix A: The European Urban Rail Concept

The history of commuter railroading may be divided into three eras of development. The first began as soon as the original steam-powered railways of the 19th century connected the central business districts of large cities with the surrounding countryside. Intercity trains scheduled to arrive in a city in the morning and depart in the late afternoon allowed workers to live in towns outside the crowded cores of the business capitals of the industrialized world. Soon, trains dedicated to this sole purpose appeared. The era of the pure suburban or commuter train began.

The next era arrived with the implementation of electric service early in the 20th century. Electrification improved the speed and efficiency of the original steam-powered services dramatically, but it didn't significantly alter the service pattern, which usually remained a morning-in, afternoon-out weekday operation linking the growing suburbs with the central business districts of major cities in the U.K., Europe, the eastern U.S. and elsewhere.

The third era of commuter railroading began in 1924 with a sea change in the operation of the heavily-used suburban system in Berlin. This new approach gave rise to the concept of the urban railway, known in Germany as the Stadtschnellbahn ("fast city rail") or S-Bahn.

A.1 German S-Bahn Systems

Berlin's railway system was developed in the 19th century by eight separate companies. All operated suburban service on the usual morning-in/afternoon-out service pattern, but using six separate and disconnected main terminals on the edge of the city's core. The first improvement came in the 1870s with the construction of the Ringbahn, a loop line encircling the city. Commuter, intercity passenger and freight services all used this connection between the main terminals and yards. The line's commuter service was electrified with a third rail DC system in 1926 by the state-owned Deutsche Reichsbahn, which unified the disjointed national rail system after the First World War.

To provide a more direct route through the city, the 14-km. Stadtbahn was opened in 1882, cutting east-west across the city's core. Built as a four-track line on a viaduct, the Stadtbahn handled through passenger and freight trains connecting between the eight different rail systems, as well as high-frequency commuter service to a number of new intermediate stations within the city. Two tracks were dedicated to this commuter service and electrification was completed in 1928.

In 1924, the commuter services on the Stadtbahn, the Ringbahn and other routes radiating out of the city were unified as the Berlin S-Bahn to provide a high-frequency service connecting seamlessly at numerous points with the city's extensive subway (Űntergrundbahn or Ű-Bahn) and streetcar (Strassenbahn) systems, as well as regional and intercity trains. A new north-south tunnel route through the city's core was completed in two stages between 1936 and 1939.

The Berlin S-Bahn progressively established principles and concepts that converted key lines of the city's commuter rail system to increase inner city transportation benefits. These characteristics include:

- High-frequency, fixed-interval service, usually 5-10 minutes in the city centre and 15-20 minutes beyond;
- Extended service hours, running from approximately 5 a.m. until after midnight;
- Numerous stations within the city's boundaries, allowing for intra-city journeys;
- Often a central ring line around the city's core and connecting with other rail services radiating outward;
- A central east-west and/or north-south section through downtown, often underground or elevated;
- Dedicated tracks when running alongside main lines used for intercity and regional rail service;
- Elimination of all grade crossings;
- Dedicated rolling stock, usually larger than but similar to that used on city metro or subway lines;

- Integration with other urban transit services in terms of ticketing and physical connectivity; and
- A distinctive and readily-identifiable logo at every station, such as the green “S” used in Germany.

Disrupted by the severing of some routes and a complicated operating arrangement during the Soviet partition of the city between 1961 and 1989, the S-Bahn has since been reunified and placed under the management of the city’s public transportation authority, the Berliner Verkehrsbetriebe (BVG), and operated under contract by Deutsche Bahn (DB), the government-owned national rail system.

The separate double-track lines of the Deutsche Bahn regional system (left) and the S-Bahn service at the Hackescher Markt S-Bahn station in Mitte, Berlin.

The Berlin S-Bahn now consists of 15 routes with a 331-km. route network serving 166 stations connected with the city’s web of 10 Ű-Bahn, 22 streetcar and 149 bus lines, as well as the extensive network of regional commuter, regional express and intercity passenger trains operated by DB. Daily ridership on the S-Bahn exceeds one million, accounting for 26 percent of the 1.4 billion annual public transportation journeys within Berlin.

The S-Bahn is fully integrated with all other BVG services and fares are charged on the basis of a three-zone system encompassing all the modes. The S-Bahn’s Ringbahn around the city’s core forms Zone 1 of this system.

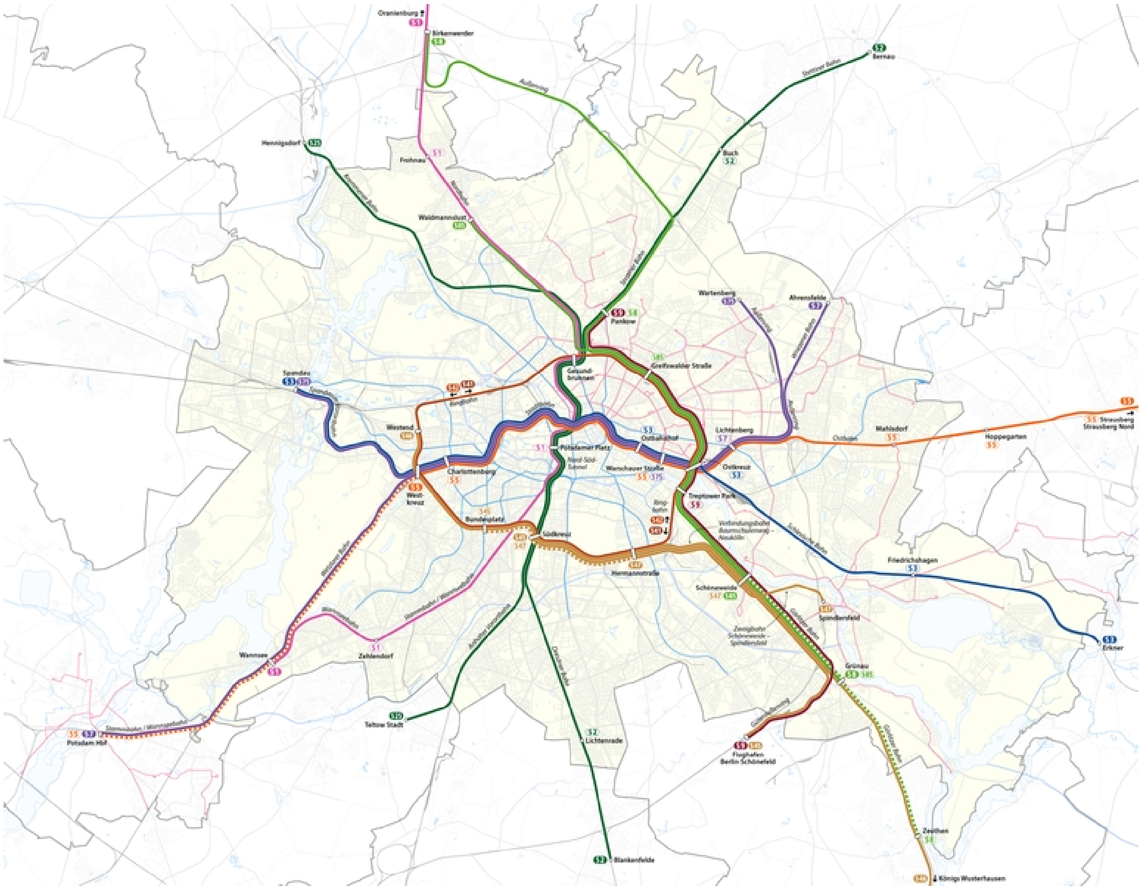
The creation of the Berlin S-Bahn was followed closely by the successful 1934 application of the concept to the dense commuter operation in Hamburg, where electrification of the component lines began in 1907. The Second World War and post-war reconstruction delayed the implementation of other planned S-Bahn systems in Germany, but the movement resumed in the 1960s and continues today. S-Bahn systems are now in operation or soon will be launched in 15 major German urban regions.

As well, the success of the German systems inspired the creation of urban rail networks in other European cities, all of which have adopted some or all of the S-Bahn principles. These include Vienna, Zurich, Paris, Copenhagen, Milan, Budapest, Prague, Warsaw, Madrid and Barcelona. The S-Bahn influence is also apparent in urban rail systems in London, Liverpool, Dublin, Melbourne, Sydney and Sao Paulo. All of these systems are electrified, although a few lighter density diesel-powered lines temporarily remain on some of the systems. In each case, electrification is planned in the near future.

CITY/REGION	ROUTES	ROUTE-KM.	STATIONS
Augsburg (under construction)	8	266	76
Berlin	15	331	166
Bremen	4	259	56
Dresden	3	103	38
Hamburg	6	144	68
Hannover	8	385	74
Leipzig-Halle	3	33	47
Magdeburg	1	39	18
Munich	10	442	148
Nuremberg	4	229	75
Rhine-Main (Frankfurt-Mainz-Wiesbaden)	9	303	108
Rhine-Neckar (Ludwigshafen-Mannheim-Heidelberg-Karlsruhe)	6	290	77
Rhine-Ruhr (Cologne-Ruhr Metropolitan Region)	13	676	124
Rostock	3	58	24
Stuttgart	7	190	75

Deutsche Bahn Class BR 485 EMU train at the Ostbahnhof on the Berlin S-Bahn's Route S9 to Schönefeld International Airport. Other DB regional commuter routes also serve the airport. Photo by Johannes Fielitz.

Berlin S-Bahn



Map courtesy of Maximilian Dörrbecker

The newest trains on the Berlin S-Bahn are the Bombardier Class 481 EMUs, shown here at the Hauptbahnhof (Central Station), which is also served by numerous DB intercity and regional routes, as well as the Berlin Ű-Bahn.

A.2 Paris Réseau Express Régional

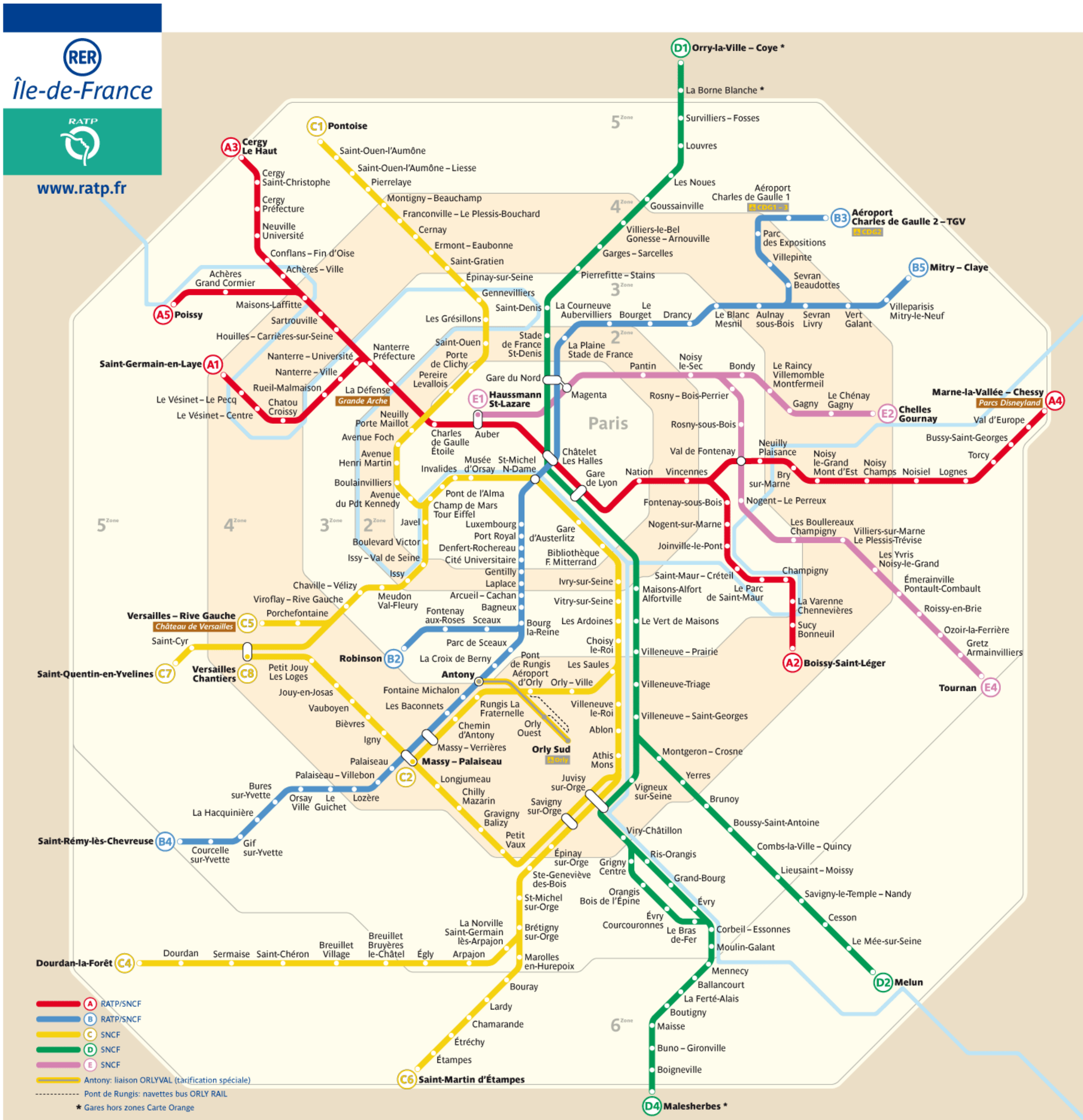
The Réseau Express Régional (RER) of Paris has been used as a touchstone for North American commuter rail improvement proposals ranging from the Caltrain 2025 electrification plan to Metrolinx's regional transportation blueprint, *The Big Move* – and for good reason. The RER is considered by many rail and transit professionals to being the fullest flowering of the urban rail concept pioneered in Germany.

The RER's roots go back to a 1936 plan by the Parisian transit authority to build a fast and frequent railway equivalent of its Métro or subway system, but using higher-capacity equipment built to main line railway standards. Like the underground Métro, this system's lines would pierce the heart of the city and it would operate on tracks isolated from the main line system of the Société Nationale des Chemin de Fer français (SNCF). As in Berlin, the Second World War and post-war reconstruction delayed this plan until the 1960s, when it was revived by the Île-de-France's transit authority, the Régie Autonome des Transports Parisiens (RATP).

The first line to be completed was the east-west Line A. This involved the RATP's takeover of the disconnected SNCF Saint-Germain-en-Laye and Vincennes commuter lines, which terminated at stub-ended stations on the western and eastern fringes of the business district on the Left Bank. The two lines were electrified and stitched together via a new line partially in a tunnel with six underground stations. Construction from both ends extended the two old lines toward each other station by station, with the final connection made at the underground station in the city's core at Châtelet-Les Halles. Line A opened on December 9, 1977.

At the same time, the southern leg of the north-south Line B was added to the operation, initially connecting Châtelet-Les Halles with the Gare du Luxembourg to the south. The line was progressively extended north under the Seine to the Gare du Nord and beyond to Paris-Charles de Gaulle Airport, not only creating numerous additional connections to the RATP transit system and the air terminal, but also with other SNCF commuter, regional and intercity rail services.

A dual-voltage bi-level EMU train arrives at the underground Haussmann St-Lazare station on the RER's Line E.



Standards were set in the construction of the first two RER lines that have been maintained throughout the network's growth. First and foremost has been the size of the tunnels, which are much higher and wider than those found on the RATP Métro system, allowing for both the overhead catenary system and the use of high and wide bi-level EMU rolling stock. Advanced train control systems have also been employed to provide an extremely high peak frequency service.

One complication was the electrification. The first phase of SNCF electrification prior to the Second World War was generally undertaken with 1,500 volt DC catenary. But the French pioneered the use of 25 kV AC catenary after the war and that has become the standard for both their high-speed TGV lines and recent electrification of conventional lines. Consequently, the RER has from the start used a fleet of EMUs known as *Materiel d'Interconnexion*, which has been built as both single-level and bi-level variants. The trains are equipped to automatically switch from one traction power system to the other while running at speed.

The RER has been progressively expanded by making use of dedicated and electrified tracks on existing SNCF rights-of-way and additional new line segments, largely tunnelled, to connect all the lines into a seamless and comprehensive system serving large sections of the Île-de-France that were previously transit deficient or served by overloaded RATP Métro and bus lines. The RER now consists of:

Number of lines:	5
Number of stations:	257
System length:	587 km.
Annual ridership:	782,900,000

It should be noted that the five RER lines include numerous branches at their outer ends and some alternate routes within the core of the city. Line E is a likely candidate for further extension and the building of a new Line F has long been considered. However, Parisian transit expansion is now focused on a substantial expansion of the RATP tramway system, three Métro extensions and the long-planned Tangentielle Nord line of the SNCF's 30-route Transilien commuter rail system, which serves points beyond the Île-de-France.

The RER is operated by both RATP and SNCF, with the former owning and operating Line A and Line B south of the Gare du Nord. The other lines are owned and operated by SNCF, but completely integrated physically and through the fare structure with the rest of the RER and the RATP Metro, tramway and bus systems. Nine of the stations on the RATP-owned RER lines A and B provide direct connections with other SNCF-operated RER lines and its Transilien commuter rail network, which carries more than 600 million passengers annually.

The main hub of the RER is the deep underground station at Châtelet-Les Halles, which serves three of the system's routes and four Métro lines. It is reputedly the largest and busiest underground railway station in the world, handling a daily average of 750,000 passengers every weekday, of which 493,000 are RER users. At peak period, it serves as many as 120 RER trains per hour.

A bi-level EMU train at Mèe-sur-Seine on the southern end of the five-route Paris RER's Line D.
Photo by Romain Martin.

One striking feature of the RER has nothing to do with its grand scale and technical excellence. The RER's construction was a key factor in the passage of a funding measure that continues to fuel the public transportation system of the Île-de-France. It is a small fee levied on all Parisian businesses and employers as a regional transport contribution, the rationale being that these firms benefit directly from the vast labour market they can tap thanks to the RER and other RATP services. This levy came into force in June, 1971, and has been a permanent source of revenue for transport investment ever since. Incredibly, there was very little public debate or opposition to this funding tool when it was introduced. Nor has it ever been seriously challenged since.

The impact and success of the RER cannot be understated. Its introduction slashed journey times, particularly on east-west and north-south routes. As well, it has made suburb-to-suburb trips of a diagonal nature easy and fast, thanks to the cross-platform connections between lines at Châtelet-Les Halles and other stations. This ease and directness of travel has led to the RER exceeding its planners' traffic forecasts. Ridership of 55,000 or more passengers per hour in each direction on Line A make it the busiest transit line in the world outside of East Asia. This traffic volume has led to a frequency of more than one train every two minutes during the rush hours, as well as the installation of digital signalling in 1989 and the use high-capacity bi-level EMU trains since 1998.

The RER has also wrought a social revolution, bringing residents of the suburbs into central Paris for shopping and leisure activities and aiding in the re-integration of the core with its outskirts. This is most evident in the Châtelet-Les Halles neighbourhood, which is crowded with suburbanites on evenings and weekends.

The success of the Paris RER has inspired the current construction of a sister system in Brussels.

Number of lines:	9
Number of stations:	120
Length:	350 km.
Projected ridership:	25 million annually
Frequency per line:	15 minutes maximum
Cost:	€2.173 billion.

The objective of the Brussels RER is to create a high-frequency electric service within a 30-km. radius of the city's core and improve cross-city journey times. Additionally, the new service will cut the journey time between the European Quarter neighbourhood and the city's international airport, which already possesses an electrified rail connection.

The Brussels RER will open in 2016 and make use of single-level EMU rolling stock drawn from a new fleet of 305 three-car Desiro ML trains purchased from Siemens by the publicly-owned Société Nationale des Chemins de fer Belges for use on this system and other regional passenger services.

Among the numerous components of this ambitious project are:

- Quadruple-tracking of sections of existing lines to segregate RER and intercity trains;
- Construction of a 1.25-km. double-track tunnel in the city's northeastern sector;
- Reconstruction of 28 existing stations and widening of numerous road overpasses;
- Construction of park-and-ride lots at most stations; and
- Construction of noise barriers along several sensitive line segments.

The Brussels RER is scheduled to open in 2016.

A.3 London Overground

Although it is the newest addition to the growing global family of urban rail systems, the London Overground makes use of some of the world's oldest commuter rail routes, including a 142-year-old tunnel line formerly operated as part of the London Underground subway system. Its launch as a new, improved and integrated operation within the City of London in 2007 occurred largely out of desperation resulting from the misguided privatization of the nationalized British Railways by Prime Minister John Major's government in 1994, which U.S. transportation commentator Yonah Freemark has accurately described as "a racket designed to transfer profits into the private sector and force the public sphere to absorb losses."

The privatization scheme established a separate infrastructure owner, Railtrack (now Network Rail), and franchised all the former British Railways commuter, intercity passenger and freight services to an initial collection of 23 concession operators. The subsequent service, safety and funding disaster this scheme wrought is well known to those in the railway industry, not to mention British users who had to suffer through it. Some improvement has occurred in recent years, but it has taken tremendous effort and even more public funding than formerly flowed to the publicly-owned British Railways.

One of the initial franchise operators was Silverlink, which took over a rag-tag collection of lines radiating out from and encircling London, which it designated as its County and Metro routes, respectively. These were part of a misguided approach to franchising that distributed the plethora of London commuter services among several private operators . It was far from satisfactory, doing little to improve service frequency or quality.

In 2003, the City of London's transportation agency, Transport for London, implemented a scheme to market these diverse and disjointed services under one umbrella. This led to the agency's proposal to the infrastructure owner, Network Rail, and the Association of Train Operating Companies (National Rail) to take over the Silverlink services within London. The city's plan was not to just improve the services and integrate them seamlessly with its subway, bus and tram lines, but to build new links – often on long abandoned railway rights-of-way – to create a whole new service that would plug gaps in the city's public transportation system. The London Underground's East London Line would be part of this new sub-system, reconstructed to accommodate electric railway equipment of higher capacity.

The objective was to serve 20 of London's 33 boroughs, placing 30 per cent of Londoners within a walk of less than 15 minutes from an Overground station. The new system would have 17 direct connections with other commuter and intercity rail services, 14 with London Underground, two with the London Docklands Railway and one with the Croydon Tramlink, as well as numerous connections with bus services throughout its wide service area. To do this, Transport for London created a five-route system consisting of the East London, West London, North London, Watford DC and Gospel Oak-Barking (or Goblin) lines. All except the latter would be electrified using the two different traction power systems already in place on portions of the network. The Gospel Oak-Barking Line remains operated with self-propelled diesel multiple unit (DMU) equipment, although the plan calls for its electrification.

Only the Watford DC Line enters the city's core, terminating at Euston Station, which is an important terminus for electrified intercity, regional and commuter trains. Euston is also directly served by London Underground's Victoria and Northern subway lines, and is within a five-minute walk of the Metropolitan, Circle and Hammersmith & City lines. It is slated to become the London terminus of the High-Speed 2 intercity passenger line, which will provide electrified 400 km/hour service to the Midlands, the North of England and Central Scotland.

London Overground Class 378 Capitalstar dual-system EMU at Haggerston on the East London Line. The train is drawing DC current from the third rail system and its roof-mounted pantographs for AC catenary power collection on other lines are locked down. Note the proximity of the apartment building to the left of the station platform.

Much of the Overground passes through less affluent areas around the fringe of London. A key objective was to assist in regenerating these neighbourhoods by providing a frequent, affordable, high-quality transit service. The neighbourhoods along the North London and Goblin lines were particularly transit deficient.

There has been substantial investment in London Overground since Transport for London took over and re-launched service on November 12, 2007. These include:

- New high-capacity, air conditioned trains;
- New and extended lines;
- More frequent service (four trains per hour minimum in each direction);
- Refurbished stations; and
- Better customer information.

Some of these improvements are being delivered as part of the Olympic Transport plan, which was a condition of London's winning bid for the 2012 Olympic Summer Games. These investments will leave an important transport and regeneration legacy to East London.

In 2012, an extension of South London Line will be opened between Clapham Junction and Dalston Junction via Surrey Quays, providing a quick link between southwest and southeast London. This extension will link the new route to the existing London Overground and National Rail networks, with trains running in both directions every 15 minutes. Trips to West Croydon and Crystal Palace will also be possible with a cross-platform connection between trains at Surrey Quays. The extension will complete the London Overground orbital railway around the Capital.

The former Underground station at Shadwell on the Overground's East London Line, refurbished and branded with Art Deco signage identical to that found on Transport for London's Underground system.

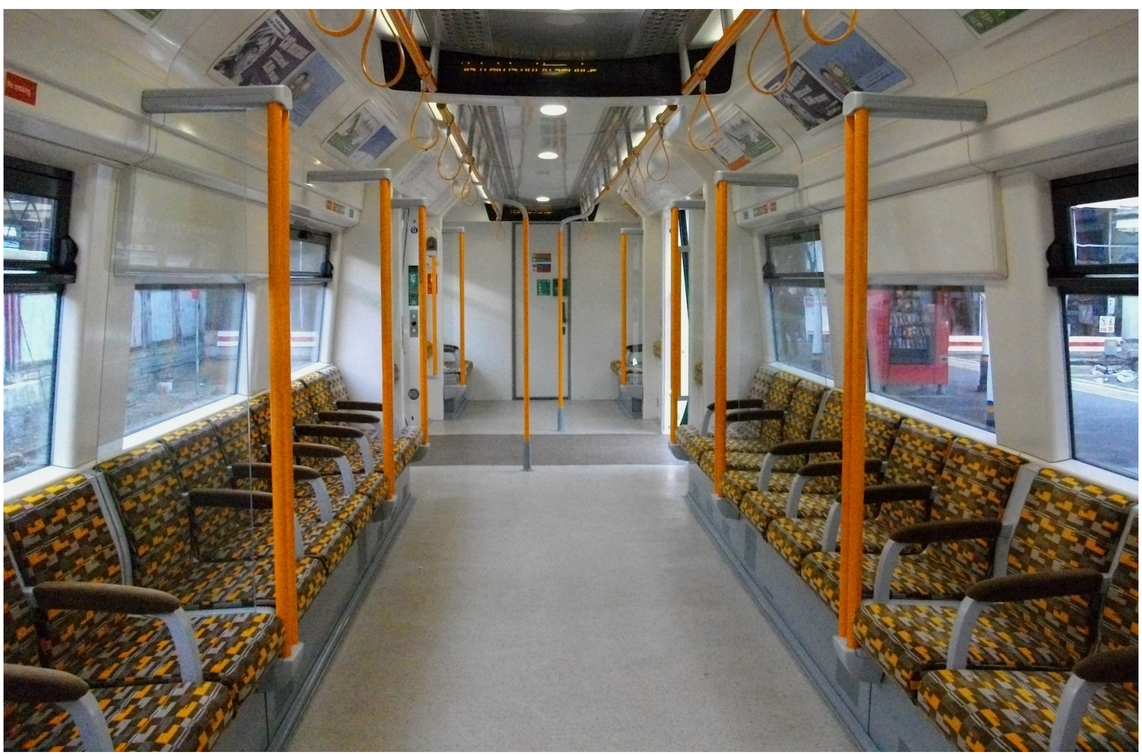
The Overground's fare system is shared with all of Transport for London's other services and is based on a seven-zone structure. Fare payment may be made with cash, conventional paper tickets, multi-ride passes (daily, weekly or monthly) or the Oyster pay-as-you-go smart card.

Canada's Bombardier Transportation has been a major contributor to the success of the London Overground. The company built the fleet of 57 four-car Class 378 Capitalstar EMU trainsets at its Litchurch Lane Works in Derby, England, as well as the eight two-car Class 172 Turbostar DMUs used on the Gospel Oak-Barking Line. This new equipment provides a level of performance and comfort unheard of with the older equipment it replaced. The dual-system EMUs are equipped to operate on both the 750 volt DC third rail and 25 kV AC catenary lines of the Overground.

The Capitalstars are part of Bombardier's Electrostar family of EMUs. The company has built nearly 500 sets of these trains in various configurations of up to five cars for service in the U.K. As well, the Electrostar design was used for the production of the 24 four-car EMU sets for use on South Africa's new Johannesburg-Pretoria-OR Tambo International Airport electrified rail service, the Gautrain, which opened in 2010 in time for the Fédération Internationale de Football Association World Cup.

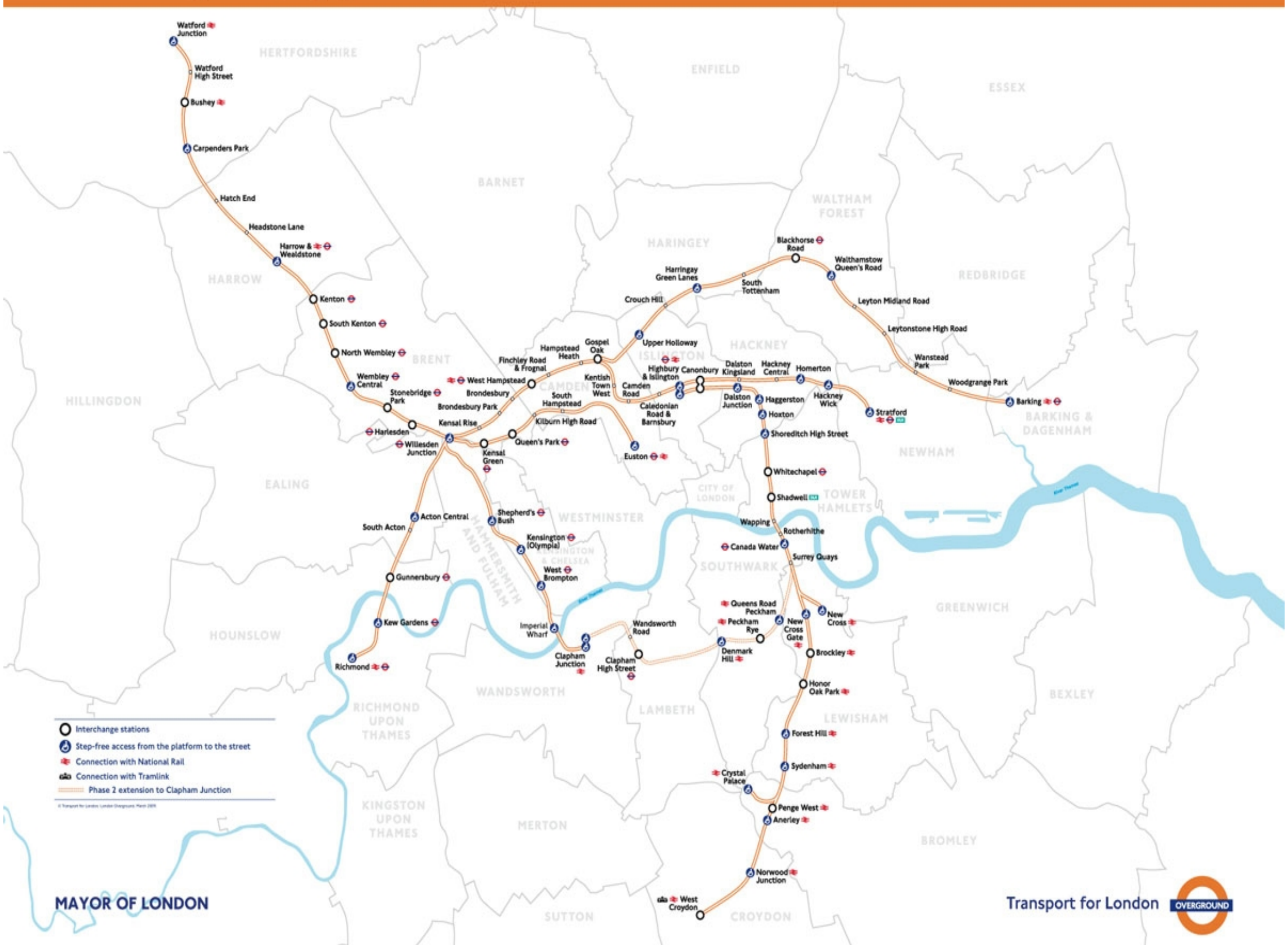
Built on the bones of several deteriorated and generally unloved railways, the 78-station London Overground now carries about 30,000 passengers daily. Further expansion is planned.

A Bombardier Class 378 Capitalstar EMU train calls at the new London Overground Imperial Wharf station on the West London Line on opening day, September 27, 2009.



Interior of a Bombardier Class 378 Capitalstar EMU with longitudinal seating similar to that found on the “tube” trains of the London Underground. Photo by Peter Skuce.

London Overground geographic map 2012



Appendix B: U.S. Commuter Rail Electrification Projects

Every railway approaches electrification in its own way, tempered by its physical, operational and fiscal environment. At the same time, there are common threads that run through every electrification program. Acquiring knowledge from by these experienced electric railroaders must be a key component of any GO electrification plan.

In fact, there appears to have been little outreach by Metrolinx to experienced electric rail operators and manufacturers in North America or Europe. This is shocking considering the magnitude of the GO electrification project and the willingness of seasoned operators to share their knowledge with others. Proof of the latter is contained in this report, which has benefited tremendously from the data and guidance received from active and retired railway professionals in North America and Europe.

A favourite response by Metrolinx to suggestions that European experience may have relevance on this continent is that conditions are so different as to make any comparisons impossible. But Bombardier and Siemens are increasingly adapting European technology to meet North American needs for a wide variety of clients. This includes the $280 million rebuilding of the Union Station Rail Corridor with a Siemens "European architecture" rail traffic control system and the use of advanced Bombardier and Siemens electric locomotives of European design by New Jersey Transit and Amtrak.

Even accepting the increasingly hollow argument that European solutions won't work in North America, there are 11 electric rail passenger operators in North America. The GO Electrification Study Team made contact only with Montreal's AMT, which operates a single, 31-kilometre electric commuter line from downtown Central Station to suburban Laval.

In an October 21, 2010, e-mail response to this author regarding electrification initiatives elsewhere, Metrolinx president and CEO Bruce McCuaig wrote, "We absolutely should look at other case studies and see what might be applicable to our situation here, but should not assume that there is a 1:1 comparison."

If Metrolinx is truly willing to learn from working examples elsewhere, then they should be liaising with the two North American operators currently engaged in designing and building new electric commuter rail services: San Francisco's Caltrain and Denver's Regional Transportation Authority.

North American Electric Rail Passenger Systems

CITY OR MAIN LINE ROUTES	OPERATOR	ROUTES	ROUTE-KM.	TRACTION POWER
Northeast and Keystone Corridors	Amtrak	2	895	12/25 kV AC catenary
Montreal	AMT	1	31	25 kV AC catenary
New York	Metro-North/ Connecticut DOT	2	131	12 kV AC catenary/ 750 V DC third rail
New York	Metro-North	2	130	750 V DC third rail
New York	Long Island RR	10	237	750 V DC third rail
New York	NJ Transit	6	240	12/25 kV AC catenary
Philadelphia	SEPTA	13	224	12 kV AC catenary
Baltimore	MARC	1	120	12 kV AC catenary
Chicago	Metra	3	62	1.5 kV DC catenary
Chicago	South Shore Line	1	118	1.5 kV DC catenary
Mexico City	El Tren Suburbano	1	27	25 kV AC catenary
		42	**2,223**	

B.1 Caltrain 2025 Plan

B.1.1 Background

Caltrain is the San Francisco equivalent of GO Transit. The 125-kilometre San Francisco-San Jose-Gilroy commuter operation harks back to the line's opening in 1864. Under the private ownership of the Southern Pacific Railroad, ridership peaked during the Second World War and then began a long decline as the San Francisco Bay Area, in common with all major American cities, sprawled and became more dependent on automotive commuting. Service quality rose and fell many times, even after the State of California agreed to subsidize and modernize the operation in 1980, rebranding it as Caltrain. Even this failed to revive it decisively.

In 1982, a group of commuters, independent transit planners and environmentalists founded the advocacy association Peninsula Rail 2000 (becoming the BayRail Alliance in 2001) because they were concerned "Caltrans lacked vision to realize the full potential of the Caltrain service." They devised a five-point plan to transform Caltrain into a frequent rapid transit system. Their objectives were:

- The formation of a new transit district to own and operate Caltrain;
- Extend service further downtown with a new terminal on Market or Mission streets;
- Increase frequency and service hours to approach or match those of BART;
- Implement self-service, proof-of-payment (POP) ticketing; and
- Convert the operation from diesel to electric.

A California Senate study determined these measures would more than double ridership and improve cost recovery. Although political and bureaucratic foot dragging has led to many delays, the BayRail Alliance's dogged determination has aided immeasurably in producing an impressive list of improvements.

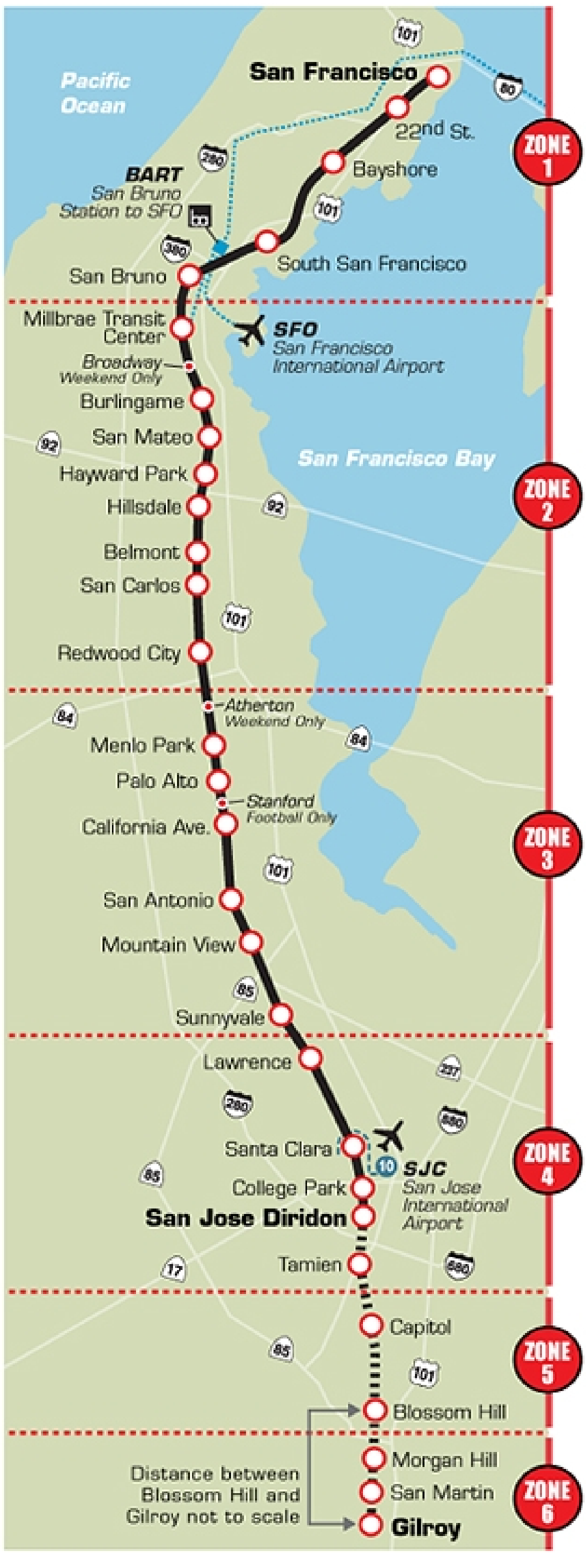
Now owned and operated by a public agency, the Peninsula Corridor Joint Powers Board, Caltrain posted average daily ridership of 36,778 in 2010 – a 74 per cent increase over 1992. While this is still far from realizing the BayRail Alliance's full vision of converting Caltrain into a European-style urban rapid railway similar to the Paris RER or the German S-Bahns, it is impressive. Also encouraging is that advocates and managers have found ways to work together to realize improvements for the benefit of all.

B.1.2 Commitment to Electrification

Although construction has yet to begin, electrification as far south as San Jose is at the top of the "to do" list for Caltrain. This has been a key element of the BayRail Alliance's agenda since its founding. In 1992, the group succeeded in getting Caltrain electrification included in Santa Clara County's T2010 transportation plan and in the Measure A half-cent sales tax, as well as convincing San Mateo County voters to support its vision for electrified "rapid rail" Caltrain service in preference to the expensive BART subway construction option.

It took time, but the group finally got Caltrain's directors on board. In 1999, the Peninsula Corridor Joint Powers Board voted to drop their staff's "go-slow" approach and made electrification a near-term priority. The BayRail Alliance also successfully campaigned that year to convince San Francisco voters to approve a ballot measure that included Caltrain electrification.

With this board and voter support, Caltrain staff bowed to the inevitable and committed to electrification. The result was Caltrain's 2025 Plan, which has three key objectives:



- Electrification;
- Electric multiple unit (EMU) rolling stock; and
- Positive train control for safety and capacity expansion.

The rationale behind the adoption of the 2025 program is:

> *... to attract and retain the maximum level of future ridership by "unconstraining" the Caltrain system (capacity) while providing a measurably safer transportation network in the most financially effective manner. To achieve this goal, Caltrain is pursuing a methodical, holistic approach in developing safety enhancement strategies that not only consider rail passengers, but the entire transportation environment....*
>
> *Between the years 2009 and 2014, the Capital Program will be focused on the most significant systems enhancements to date – primarily a new signal system and electrification – that will add even more capacity and enable the use of high-performance rolling stock. In order to achieve these stated objectives and maximize the benefits of the 2025 Program, Caltrain is focused on using proven methods and technologies that reduce the risks and costs associated with implementing the improvements and operating the system.*

Under Caltrain's 2025 Plan, the service from San Francisco to San Jose will be electrified and completely re-equipped at a cost of \$1.3 billion. Of this amount, \$785 million is for the infrastructure, including catenary, transformer stations and distribution system. The 48-km. section of the route south from San Jose to Gilroy will remain diesel operated for the foreseeable future using the locomotives and Bombardier bi-level rolling stock now employed in the Baby Bullet Express service.

The commitment to the 2025 Plan set Caltrain staff on a worldwide investigation of electric traction technology and the means of implementing it in a cost-effective manner to deliver maximum financial, service, safety and environmental benefits. The research has been both exhaustive and evolutionary.

Unlike Metrolinx, the planners and consultants began with no preconceived assumptions or bias towards any one technology or technique. They relied extensively on the evidence of other operators of electrified services and then sought to adapt their best practices to Caltrain's environment, market and finances. To their credit, Caltrain staff hasn't been afraid to modify some of their original opinions.

B.1.3 Rolling Stock Selection

The flexibility of Caltrain staff is particularly apparent in their analysis and selection of rolling stock. At the outset of their studies, much like the GO Electrification Study team, Caltrain staff and its consultants examined the locomotive-hauled and self-propelled EMU concepts alongside diesel to determine which would provide the maximum benefits. Originally, locomotive-hauled operation with existing and/or new bi-level rolling stock was favoured. But further investigation revealed so many long-term benefits to bi-level EMUs that it has now become the preferred option.

Caltrain's oft-stated reasons for selecting of bi-level EMUs are:

- Each EMU set has its own power supply, so trains stop and start quicker, reducing travel time.
- Without the need for a locomotive, train sets are more flexible and easier to interchange.
- Much like today's automobiles, EMUs are designed to absorb energy in a collision, increasing safety for train crews and passengers.
- The switch from diesel locomotives to EMUs will reduce air pollutant emissions from trains by up to 90 per cent and decrease power consumption significantly.

In the Caltrain studies, the role models have been the electrified, high-frequency urban rail systems of Europe, such as the German S-Bahns and Paris RER cited previously in this report and detailed in Appendix A. However, the use of proven, off-the-shelf European designs brings with it regulatory and safety challenges. That Caltrain's directors and staff would take on this complex and groundbreaking project is the highest tribute that can be paid to their commitment to electrification.

An artist's rendering of what Caltrain will be following electrification and the adoption of European-style bi-level EMUs engineered with crash energy management technologies. Courtesy of Clem Tillier, BayRail Alliance.

B.1.4 Crashworthiness and Advanced Train Control

The complication in Caltrain's proposed use of European rolling stock centres on the design standards applied by North America railways versus the rest of the developed world. North American equipment is built to regulations set by the U.S. Federal Railroad Administration (FRA), many of which pertain to crashworthiness, aimed at minimizing damage and injury in case of an accident. In Europe, these crashworthiness standards allow for much lighter equipment.

In North America, it is assumed accidents will happen and motive power and rolling stock are designed accordingly. This makes them much heavier than in Europe, where the supposition is that technologies and techniques will be employed to ensure accidents don't happen. A key component of this European strategy is advanced rail traffic control, particularly systems that automatically apply a train's brakes if its crew does not respond to the signals governing the movement of their train.

This is not the case throughout North America, where most rail traffic control systems are rudimentary by comparison with those found on the main lines of Europe because they are fully dependent on the proper observance of signal and radio commands by the crews. A train that passes a stop or restricting signal because of crew failure is, quite simply, a runaway. Only on Amtrak's Northeast Corridor and a few densely-trafficked U.S. lines that host passenger trains at speeds of more than 79 mph is any form of automatic train stop (ATS) or positive train control (PTC) to be found.

One of the additional benefits of such technologies is that they improve operational efficiency and boost line capacity. But the implementation of advanced rail traffic control systems lagged for more than 80 years in the U.S. It was mandated by the Interstate Commerce Commission in the 1920s, but the railways found ways to avoid implementation on a cost basis. Only where passenger trains operated in excess of 79 mph was ATS mandated and installed.

On September 12, 2008, this changed forever when the locomotive engineer of a Los Angeles Metrolink commuter train ran past a yellow cautionary signal and then a red stop signal, crashing head-on into a Union Pacific freight train near Chatsworth. The accident killed 25 and injured 135. This was the third major Metrolink accident that involved loss of life and might have been prevented with ATS or PTC. It unleashed a raft of changes throughout the U.S. rail industry. One of these was the legislated requirement by the U.S. government that PTC be adopted for all lines hosting passenger trains and/or dangerous goods traffic by 2015. This is expected to cost the railways as much as $10 billion.

North America's first commuter rolling stock incorporating crash energy management technologies are these Hyundai-Rotem bi-level coaches and cab cars for the Los Angeles Metrolink service. Image © 2010 by cz17.

Rather than resist this capital intensive add-on to its system, Caltrain has embraced it. By adopting PTC, they are now proposing to make use of North America's first fleet of non-FRA-compliant, European-designed bi-level rolling stock. This equipment will employ crash energy management (CEM), which prescribes that a car's structures crushes in a controlled manner and absorbs energy, significantly improving crashworthiness. CEM cars have energy-absorbing retractable couplers, a controlled crumple zone and interior fittings designed to minimize passenger injuries in the event of a sudden stop. An EMU with CEM features is more crashworthy than a conventional locomotive-hauled train.

Caltrain's proposed combination of electrification, PTC and CEM rolling stock will create North America's first advanced, European-style urban railway. The implications are massive, producing benefits impossible to achieve without such "out of the box" thinking that includes a commitment to maximum service and safety. The GO Electrification Study team rejected such a game-changing approach to electrification and future equipment design.

It is true Caltrain enjoys certain benefits many other commuter operators don't, including GO. Caltrain has to deal with but one line and owns the San Francisco-San Jose portion of it; only the light-density segment south to Gilroy operates on a line owned by a freight railway. While some freight trains are allowed on Caltrain's portion of the line to serve local industries, they do so at its discretion under a technique known as temporal separation. This allows freight trains to have track access only when the commuter trains aren't operating, preventing commuter and freight trains from ever being in close proximity to each other.

A contributing factor in this package of electrification, revised equipment standards and advanced operational practices is the fact that Caltrain will also provide the San Francisco gateway for the upcoming California high-speed rail passenger service linking San Diego, Los Angeles, San Francisco and Sacramento. It, too, will be an electrified, PTC-equipped system employing rolling stock built to non-FRA European crashworthiness standards using CEM. The electrification will allow both Caltrain and high-speed intercity trains to use a 2.1-km. tunnel under downtown San Francisco to the new multi-modal Transbay Transportation Center, which its proponents refer to as "the Grand Central Terminal of the West."

Although there are some differences between Caltrain and GO, they are not altogether dissimilar. While it is true Caltrain is dealing with a line largely under its own ownership, the 2025 plan does not eliminate FRA-compliant equipment from the mix. The commuter trains operating south of San Jose will remain diesel hauled and equipped with existing FRA-compliant Bombardier bi-level rolling stock. On May 27, 2010, Caltrain received an FRA waiver to pursue this plan, subject to nine conditions.

B.1.5 Moving Electrification Forward

Moving Caltrain electrification forward has not been easy and the journey is far from over. It has been complicated by state funding problems, objections to aspects of the California High-Speed Rail Authority (CHSRA) intercity passenger project and other issues. Originally scheduled to be fully implemented by 2014, the $1.3 billion plan is now slated for completion by 2020 in conjunction with the high-speed project, which will cover $516 million of its costs.

The electrified Caltrain Regional Rail plan will result in a weekday schedule of 172 trains with peak service operated on five-minute headways. The EMU trains will operate at up to 150 km/hour on an electrified corridor shared with the CHSRA trains, which will be fully grade separated from intersecting streets and highways.

It should be noted that all work will be undertaken with the Caltrain corridor under full traffic. Work blocks on the line will be arranged so as to keep commuter traffic flowing to the maximum extent possible.

Caltrain management asserts this plan will be implemented. In fact, the agency says the alternative is to shut down Caltrain altogether because the current diesel operation is financially unsustainable. Without electrification, Caltrain's deficit at the current service level would exceed the available funding by 2019. With electrification, the deficit will be a manageable $27 million and will drop to $14 million by 2035.

Caltrain's executive officer for public affairs, Mark Simon, says:

> *"We've maximized out the way we run Caltrain and the only way it's going to survive is if we change the way we run it – if we electrify it. Without these improvements, the service that we provide today – the service that keeps 37,000 daily commuters off our already congested freeways – is at risk. An electrified Caltrain will be a Caltrain for the next generation – entirely new and able to accommodate future job and population growth in the region."*

Caltrain proves that electrification of a diesel commuter system that has reached a mature and robust level of service and traffic – much lower than what now or will soon exist at GO – is not only feasible, it is desirable financial, operationally and environmentally. The difference is that Caltrain's directors and managers are thoroughly committed to electrification. It would be difficult to make the same claim of Metrolinx and GO management.

B.2 Denver RTD FasTracks Project

B.2.1 Background

That San Francisco should have finally embarked on a program to improve, expand and electrify its historic Peninsula Commute service does not surprise many long-time rail and transit observers. San Franciscans are noted for their high reliance on and commitment to – even affection for – their transit systems.

Not so in Denver, Colorado. Beginning in 1950 with the abandonment of the last streetcar lines, its began a long slide that made it one of the poster children for public transit deterioration and urban planning stupidity. By the 1980s, Denver was at its nadir in every respect. But a wide array of residents, politicians, planners and businessmen were not willing to accept the depressing status quo. One of the urban renewal visions that finally gained traction was the recreation of Denver's rail-based electric transit system in modern guise as LRT. Between 1994 and 2006, RTD opened four modern LRT lines totalling 40 kilometres.

The successful application of LRT to Denver's transportation needs led to the current and highly ambitious $6.5 billion FasTracks project. This will expand the system through the Denver-Aurora and Boulder metropolitan areas with seven new lines totalling 192 km. using LRT, electric commuter and diesel commuter technology. It also includes the $300 million reconstruction of historic Denver Union Station as the multi-modal heart of the region, LRT extensions, expansion of the current LRT stations, 21,000 additional station parking spaces and increased bus service. Denver's first four conventional commuter rail lines will be supported by a maintenance facility located on the Northwest Corridor.

When commuter rail was selected for these routes, it was assumed they would be built – as with every other North American light-density, start-up system – with diesel locomotives hauling single-level coaches or self-propelled diesel multiple unit (DMU) cars. All options were fully investigated by RTD.

ROUTE	TERMINALS	LENGTH (KM)	COST ($ MILLIONS)	COMPLETION DATE
East Corridor	Union Station-Denver Int'l. Airport	38	1,140.0	2016
Gold Line	Union Station-Wheat Ridge	12	552.5	2016
Northwest Corridor	Union Station-Longmont	66	684.4	2016
North Metro	Union Station-Broomfield	45	637.2	2017
TOTAL		**161**	**3,014.1**	

However, RTD's financial consultants subjected the traction power and equipment options to the same unbiased analysis that led to the selection of commuter rail instead of LRT or bus rapid transit on these routes. RTD reports:

> *"Decisions on rail technology are based on several factors, including the length of the corridor, projected ridership, the characteristics of the vehicles, cost, technical and environmental feasibility, and public input. These factors help determine which mode will be the most operationally efficient, cost-effective and feasible for each corridor."*

The result of this rigorous examination led to the selection of electric traction for the East Corridor and Gold Line with diesel for the two other lines. As well, the first 8.4 km. section of the Northwest Corridor will also be electrified and operated as a short-turn service augmenting the diesel operation over the route's full 66 km. The primary factors in selecting electric operation with EMUs were the long-run operating and maintenance cost reductions, as verified by RTD's financial advisors, Goldman Sachs and J.P. Morgan.

RTD fully explored its equipment options, spending much time analyzing electric rolling stock that was or would soon be on order by other North American electric commuter rail operators. With specifications in hand, RTD called for bids on a 50-car EMU order. The winner was Korea's Hyundai-Rotem, which had previously received a $275 million order for 120 single-level Silverliner V EMUs from Philadelphia's Southeastern Pennsylvania Transportation Authority (SEPTA). The firm also landed equipment orders for Vancouver's electric intermediate capacity Canada Line and the Los Angeles' Metrolink commuter rail system. Rotem was required to establish U.S. assembly facilities to meet the 60 per cent Buy America content requirements attached to any projects involving Federal Transit Administration (FTA) funds.

B.2.2 Denver's Airport Rail Link

On August 26, 2010, RTD and its partners broke ground at Denver International Airport on the $1.14 billion East Corridor project, the first phase of the region's commuter rail project. Built largely along an existing freight railway right-of-way, the 38-km. line will serve seven stations and seamlessly connect at Union Station with the other RTD commuter rail, LRT and bus services, and Amtrak's daily intercity passenger service, the Chicago-Oakland *California Zephyr*.

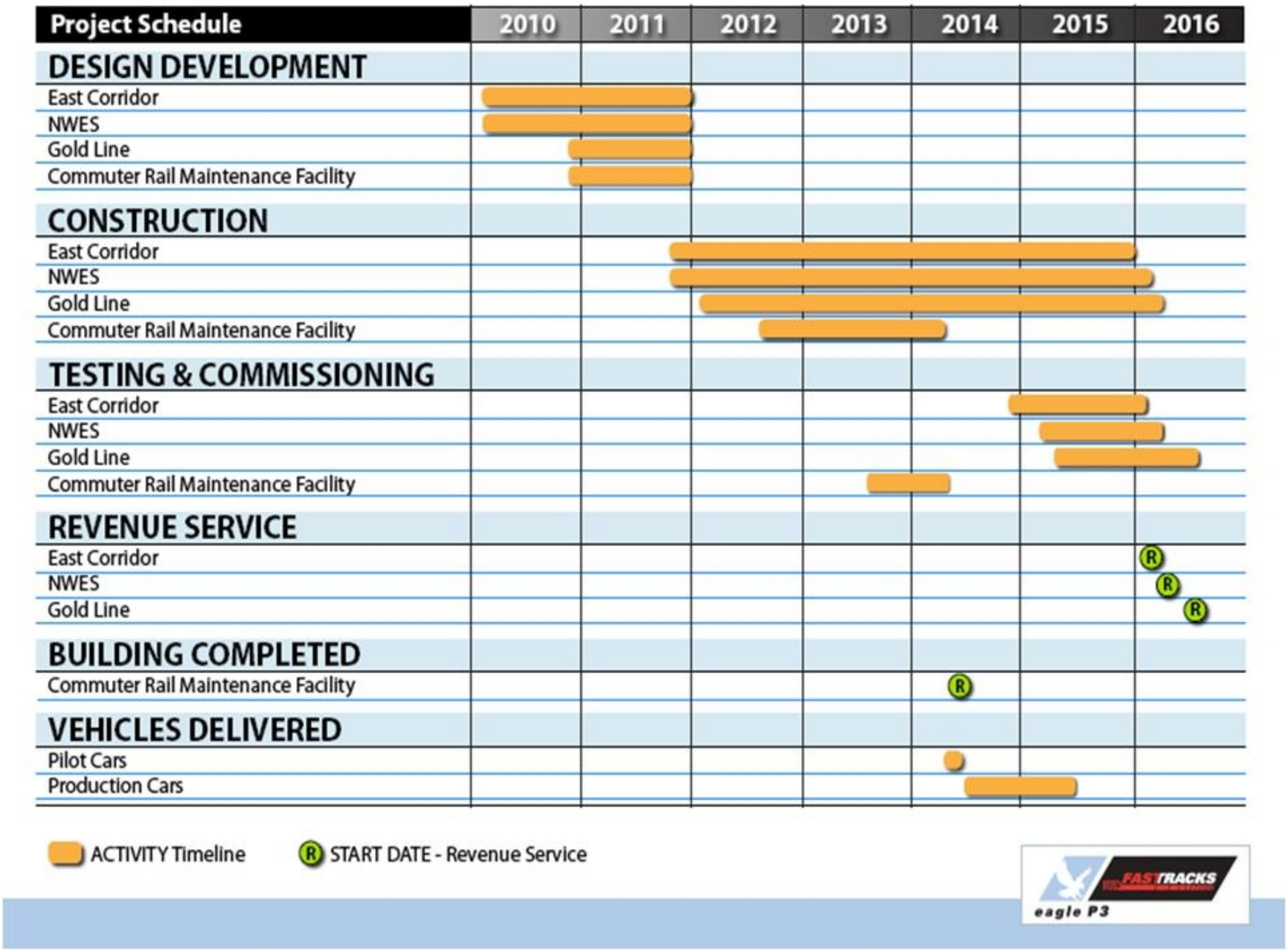
Unlike Metrolinx's ARL, the East Corridor will not be a premium-priced service, but will operate as a component of the RTD network and within its regular fare structure to provide direct and intermediate service between Denver Union Station and Denver International Airport. Completion is scheduled for 2016.

The East Corridor, the other two electrified lines and the commuter rail maintenance facility – which will also stable and maintain the diesel equipment for the Northwest and North Metro lines – are being built under a public-private partnership known as the Eagle P3 Project, which is a component of FasTracks.

Denver Transit Partners (DTP), led by Fluor Corporation, will design, build, operate, maintain and finance the Eagle P3. DTP has arranged $452 million in private funding. The contract stipulates a six-year design-build phase with a 30-year period of operations and maintenance. Fluor has a 50 per cent share of the engineering, procurement and construction contract, a 33 per cent share in the operations and maintenance contract, as well as a 10 per cent equity share in the concession's "special purpose vehicle," which raised the financing to fund the project. The DTP team includes a group of global suppliers, including electrification specialist Balfour Beatty Rail and carbuilder Hyundai-Rotem USA.

While Denver's Eagle P3 appears to be working well and will deliver the city's electrified airport rail link in January, 2016, two to four years before Torontonians may be riding on their equivalent electrified service, one note of caution should be sounded. As is typical with P3 projects, it is contingent on a large percentage of public sector funding. On May 2, 2011, the FTA sent a Full Funding Grant Agreement for $1.03 billion for the East Corridor and Gold Line projects to Congress for its mandatory 60-day review prior to approval. This is approximately 60 per cent of the full cost for the two lines.

Denver RTD FasTracks Commuter Rail Implementation Timetable



Airport Rail Links

Compiled by Daniel Hammond, Transport Action Ontario

CITY/AIRPORT	TYPE OF RAIL SERVICE*	MOTIVE POWER
EUROPE		
Amsterdam	Commuter and Intercity	Electric
Athens	Commuter	Electric
Barcelona	Commuter	Electric
Berlin	Commuter and Intercity	Electric
Brussels	Commuter and Intercity	Electric
Budapest	Commuter and Intercity	Electric
Cologne	Commuter and Intercity	Electric
Copenhagen	Commuter and Intercity	Electric
Dresden	Commuter	Electric
Dusseldorf	Commuter and Intercity	Electric
Frankfurt	Commuter and Intercity	Electric
Friedrichshafen	Commuter	Electric
Geneva	Commuter and Intercity	Electric
Hamburg	Commuter and Intercity	Electric
Helsinki	Commuter (opens 2014)	Electric
Kiev	Commuter (opens 2012)	Electric
Krakow	Commuter	Electric
Leipzig-Halle	Commuter and Intercity	Electric
Lyon	Intercity	Electric
Lübeck	Commuter and Intercity	Electric
Malaga	Commuter	Electric
Milan	Commuter and Intercity	Electric
Moscow Sheremetyevo International	Commuter	Electric
Moscow Domodedovo International	Commuter	Electric
Moscow Vnukovo	Commuter	Electric
Munich	Commuter	Electric
Oslo	Commuter	Electric
Paris Charles de Gaulle	Commuter and Intercity	Electric
Paris Orly	Commuter	Electric
Palermo	Commuter	Electric
Pisa	Commuter and Intercity	Electric
Rome	Commuter and Intercity	Electric
Sochi	Commuter and intercity (opens 2014)	Electric
Stockholm	Commuter	Electric
Strasbourg	Commuter	Electric
Stuttgart	Commuter	Electric
Trondheim	Commuter and Intercity (to be electrified)	Diesel
Vienna	Commuter and Intercity	Electric
Warsaw Frederic Chopin	Commuter	Electric
Warsaw Modlin (under construction)	Commuter (opens 2012)	Electric
Zurich-Kloten	Commuter and Intercity	Electric

**Does not include numerous airports worldwide served by electric light and heavy rail transit*

Airport Rail Links

CITY/AIRPORT	TYPE OF RAIL SERVICE*	MOTIVE POWER
UNITED KINGDOM		
Birmingham	Commuter and Intercity	Electric
Glasgow	Commuter	Electric
London Heathrow	Commuter	Electric
London Gatwick	Commuter	Electric
London Luton	Commuter	Electric
London Stansted	Commuter	Electric
Manchester	Commuter and Intercity	Electric
Southampton	Commuter	Electric
AFRICA		
Johannesburg	Commuter	Electric
ASIA		
Bangkok	Commuter	Electric
Chennai	Commuter	Electric
Delhi	Commuter	Electric
Hong Kong	Commuter	Electric
Izmir	Commuter	Electric
Kuala Lampur	Commuter	Electric
Nagoya	Commuter	Electric
Osaka	Commuter and Intercity	Electric
Sapporo	Intercity	Electric
Soeul Gimpo	Commuter	Electric
Soeul Incheon	Commuter	Electric
Taipei	Commuter (opens 2013)	Electric
Tel Aviv	Commuter (to be electrified)	Diesel
Tokyo Narita	Commuter	Electric
OCEANIA		
Brisbane	Commuter	Electric
Sydney	Commuter	Electric
NORTH AMERICA		
Anchorage	Tourist/Special Events (intermittent)	Diesel
Baltimore-Washington International	Commuter and Intercity	Electric
Burbank	Commuter and Intercity	Diesel
Chicago O'Hare	Commuter (with bus connection)	Diesel
Dallas-Fort Worth International	Commuter (with bus connection)	Diesel
Denver	Commuter (opens 2016)	Electric
Miami	Commuter (with bus connection)	Diesel
Milwaukee	Intercity (with bus connection)	Diesel
New York Kennedy International	Commuter (with airport circulator)	Electric
Newark	Commuter (with airport circulator)	Electric
Philadelphia	Commuter	Electric
Providence	Commuter and Intercity	Electric and Diesel
South Bend Regional	Commuter	Electric
Toronto Pearson International	Commuter (opens 2015)	Diesel

**Does not include numerous airports worldwide served by electric light and heavy rail transit*

Appendix D: Canada Transportation Act (S.C. 1996, c. 10)

DIVISION VI.1
PUBLIC PASSENGER SERVICE PROVIDERS
Dispute Resolution

Application

152.1 (1) Whenever a public passenger service provider and a railway company are unable to agree in respect of any matter raised in the context of the negotiation of any agreement concerning the use of the railway company's railway, land, equipment, facilities or services by the public passenger service provider or concerning the conditions, or the amount to be paid, for that use, the public passenger service provider may, after reasonable efforts to resolve the matter have been made, apply to the Agency to decide the matter.

Application

(2) Whenever a public passenger service provider and a railway company are unable to agree in respect of any matter raised in the context of the implementation of any matter previously decided by the Agency, either the public passenger service provider or the railway company may, after reasonable efforts to resolve the matter have been made, apply to the Agency to decide the matter.

2007, c. 19, s. 44.

Amount to be fixed

152.2 (1) If, pursuant to an application made under subsection 152.1(1), the Agency fixes the amount to be paid by the public passenger service provider for the use of any of the railway company's railway, land, equipment, facilities or services, that amount must reflect the cost associated with the public passenger service provider's use of that railway, land or equipment or those facilities or services.

Factors

(2) In determining that amount, the Agency must take into consideration, among other things,

(*a*) the variable costs incurred by the railway company as a result of the public passenger service provider's use of the railway company's railway, land, equipment, facilities or services, including, but not limited to, its variable costs incurred to maintain safe operations and to avoid congestion and undue delay;

(*b*) the railway company's cost of capital, based on a rate set by the Agency, applied to the net book value of the assets to be used by the public passenger service provider, less any amount to be paid by the public passenger service provider in respect of those assets;

(*c*) the cost of any improvements made by the railway company in relation to the public passenger service provider's use of the railway company's railway, land, equipment, facilities or services;

(*d*) a reasonable contribution towards the railway company's constant costs; and

(*e*) the value of any benefits that would accrue to the railway company from any investment made by the public passenger service provider.

2007, c. 19, s. 44.

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About the Author

The CTV television program, *W5*, described Greg Gormick as a Toronto consultant “with a client list that reads like a *Who’s Who* of Canadian transportation.”

A member of the fourth generation of his family to work in Canada’s railway industry, Gormick has served as a writer, researcher, strategic analyst and policy advisor in the railway and transit fields since his 1978 graduation from Ryerson Polytechnical Institute’s School of Journalism. He has reported on, for and to these industries extensively and contributed his knowledge to numerous public agencies and the officials connected with them.

The basis of Gormick’s expertise is a solid grounding in real-world operations, planning and policy, gained from those veterans of the rail and transit industries who have tutored him throughout his career. His affiliation with these professionals results from frequent and lengthy assignments with the Canadian Pacific Railway, Canadian National Railways, VIA Rail Canada, the Toronto Transit Commission, the Electro-Motive Division of General Motors, Bombardier and Skoda Transportation.

As a reporter and commentator, Gormick has used his experience to inform the public and the media on transportation developments and opportunities. For 21 years, he served as Canadian contributing editor of the trade magazine, *Railway Age*, which included his production of the *Passenger Rail Planner’s Guide*, an annual review of every rail-based passenger system in North America. He is also a frequent contributor to *The Toronto Star*.

One of Gormick’s most notable public sector roles was as transportation policy advisor to Toronto City Council, Mayor Art Eggleton and the Coalition of Corridor Mayors, providing strategic guidance on intercity rail passenger, commuter rail and urban transit issues. Most recently, Gormick has served in a similar role for Dean Del Mastro, MP for Peterborough and chair of the House of Commons All Party Rail Caucus. His work has included the concept plan for the re-establishment of the CPR’s Toronto-Havelock-Blue Mountain route as a municipally-managed short line railway and restoration of Toronto-Peterborough passenger service.

Gormick is the author of the Toronto Railway Club’s 75th anniversary book, *Wheels of Progress: Toronto Moves by Rail*. His next book will be *The Canadian: The Life and Times of the Last Streamliner*.

clean train coalition

TRANSIT FOR A HEALTHY CITY

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DJC 2010