Appendix 8H

Economic Impacts

December 2010

METROLINX
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EXECUTIVE SUMMARY

Electrification of the GO Transit network is expected to affect transit operating performance, which in turn will have economic impacts for users, non-users and the broader Provincial economy. This account measures the annual economic impacts of six scenarios for the years 2021 and 2031 relative to the reference case, as well as one-time impacts from construction for project options 1, 2 ,3 11, 15 and 18. These impacts are reported in terms of GDP, the change in jobs and the change in the associated labor income, and are stated in 2010 $. Results reflect how the electrification of Metrolinx will (a) directly affect households and businesses in the regional economy and, and (b) total Provincial economic impacts that are derived by applying multipliers designed for Ontario to derive indirect effects of employment, wages and GDP generated by the direct impacts of construction and improvements to the Metrolinx network. These impacts include goods and services purchased by firms directly working on construction projects to support this work and impacts of household expenditures from the income earned by workers in directly or indirectly affected industries. The range of impacts is as follows:

- Annual economic impacts range from approximately 130 jobs for Option 1 and 800 jobs for Option 18 in 2021 and 160 jobs for Option 1 and 1,000 jobs for Option 18 in 2031.
- Additional annual Provincial and Federal tax revenues in 2021 will range from $3.5 million (Option 1) to almost $23 million (Option 18), and from $4.4 million to more than $28 million in 2031.
- Moderate land use changes in suburban locations will likely be triggered due to increased speed and better reliability realized by the electrification options that attracts more users and increases mobility to suburban station areas, where there is developable land and some reductions in noise and air pollution
- Temporary construction impacts that will generate between 900 to more than 6000 direct jobs depending on alternative and actual levels of local purchases.

DOCUMENT DEFINITIONS AND GLOSSARY OF TERMS

Term	Definition
TREDIS	Transportation Economic Development Impact System. A web based economic analysis tool.
GTA	Greater Toronto Area
Output	Gross business revenue incorporating business sales, (unsold) inventory for goods producing industries and budget expenditures for non-profit or public sector agencies.
GDP	Gross Domestic Product. Business revenues minus cost of goods purchased and transportation.

NOTE: Use hereafter of the terms “we”, “our” or similar means “Delcan/Arup Joint Venture team”.

1. OVERVIEW

Electrification of the GO Transit network is expected to affect transit operating performance, which in turn will have economic impacts for users, non-users and the broader Provincial economy. Analyzing the nature of these effects involves a mixture of quantitative and qualitative techniques. In addition, the temporary economic impacts associated with construction of electrification of the GO Transit Network are presented.

The quantitative analysis of operational impacts begins with ridership projections for 2021 and 2031 for Options 1,2,3,11,15 and 18 that are described in Section 2. These projections are provided as net incremental changes from the "reference case" for the two analysis years, and provide estimates of new transit demand, diversions of automobile trips to transit, and potential time savings for highway and transit travelers.

Section 3 describes the translation of the transit and highway impacts of the electrification options to economic benefits for 2021 and 2031. This is done by applying the Transportation Economic Impact System (TREDIS) calibrated to the GO region and Ontario to capture widespread economic multiplier (or spinoff) effects. The methodology associated with the analysis of the operational economic impacts of electrification is reviewed in Section 8.

Section 4 presents the qualitative analysis developed to estimate localized station and land use effects and uplift that can be expected from electrification. This analysis was fashioned from a review of local and regional land use plans, parcel level reviews of land use, land use regulations by potential station areas, municipal policies and the review of additional literature.

Estimates of construction impacts are presented in Section 5, and are presented as ranges. The level of economic affect from construction will vary based on the option that is implemented; the amount of contingency budget that is spent and the specific line- items that would require contingency spending; and expenditures that are local, in Ontario, or purchases made in other provinces or nations.

Potential provincial and federal tax revenue impacts of the six options are described in Section 6. The key taxes analyzed are the Harmonize d Sales Tax and Income Tax, on both Federal and Provincial levels.

Section 7 presents the literature review conducted in support of this economic analysis. The review supports the economic impact framework described in Section 3 as well as the land use impacts described in Section 4.

2. QUANTITATIVE CALCULATIONS

2.1. General Model of Impact Factors

The six general categories of transportation economic impacts included:

- Faster and more convenient service for current transit users.
- Travel time and costs savings accruing to travelers who switch modes and re-investment of this value elsewhere in the regional economy.
- Travel time and cost savings accruing to travelers who do not switch modes, but enjoy lower levels of congestion due to the overall modal diversion on the networks, and the associated use of the savings to purchase other consumer products and services as desired (and have more leisure time).
- Business productivity gains due to reduced delay, improved reliability and improved locational advantage for people and goods on the network.
- Expanded access to workers and goods through increased access to a larger geographic labor and commodity market.
- Direct effects on business growth occur as the greater productivity and changes in consumer spending lead to more business sales and attraction of new business activity. There are further impacts as the directly-affected businesses that grow also buy more from suppliers within the region ("indirect economic effects"), and the additional worker income is re-spent on more consumer purchases within the region ("induced effects").
- Additional benefits are realized from greater efficiency due to the switch from diesel fuel to electric power. This not only reduces demand for foreign imports of petroleum products in favor of electric energy generation, but also reduces air pollution and greenhouse gas emission and yields lower operating costs of train service on a continuing basis (though enabled by higher up-front capital cost for installation of new infrastructure and locomotives).

Additional economic development benefits occur in the form of enhanced regional income and job creation occurring in the *short-run* due to construction and equipment purchases, and in the *long run* due to efficiency, productivity and spending shifts. The long run economic benefits can all be traced to five key factors:

2.2. Baseline Transportation Changes

Electrification is expected to lead to travel time and reliability savings. These are likely to be result from:

1) The number, distance and duration of trips affected by the change (including those using the service that is electrified as well as any that may divert to or from other modes);
2) The comparative acceleration and deceleration cycles of diesel to electric vehicles, and
3) Improvements in reliability associated with the use of new vehicles included in the electrification project.

The data used to develop this aspect of economic impact for each alternative include the following data elements pertaining to costs associated with travel distance, travel time and reliability:

- The number of person-trips, person-hours, vehicle trips, vehicle kilometers of travel (VKT) and vehicle hours of travel (VHT), by mode that will be affected by the change (before and after the change).
- The comparative average per-vehicle kilometer operating costs, by technology.

Travel cost savings are determined by applying the vehicle operating costs to the number of trips (vehicle kilometers or stops) affected by the change. Travel time savings are determined by applying any change in travel time per trip (based on changes in reliability or acceleration/deceleration cost and per-kilometer costs) to the number of trips affected. These cost savings are then projected over the life of the project and expected to accrue to households and businesses in the region

Table 1 - 2021 Comparison of Metrolinx Regional Transportation Changes Between Reference Case and Project Options

Description	Unit	Reference Case	Incremental 2021 Results					
			Option 1	Option 2	Option 3	Option 11	Option 15	Option 18
Transit demand	trips	76,983,704	594,905	1,768,165	2,363,071	2,792,250	3,098,743	3,418,574
Transit travel time savings (existing users)	minutes		32,906,328	94,530,715	127,437,043	150,306,711	173,220,331	202,604,576
Transit travel time savings (new users)	minutes		1,018,634	2,475,662	3,494,296	3,943,452	4,392,559	5,250,433
Highway demand (trips removed)	trips		(495,755)	(1,473,471)	(1,969,225)	(2,326,875)	(2,582,286)	(2,848,812)
Highway travel time (minutes removed - decongestion benefits)	user minutes		(4,041,776)	(15,275,077)	(19,316,854)	(22,388,857)	(25,933,540)	(28,273,098)
Highway distance (car kms removed)	vehicle km		(5,816,080)	(21,980,698)	(27,796,778)	(32,217,363)	(37,318,129)	(40,684,732)

These savings are calculated through transportation changes in 2021 and 2031 that are expected as outcomes of electrification, and are summarized in Exhibits 1 and 2, below.

Table 2 - 2031 Comparison of Metrolinx Regional Transportation Changes Between Reference Case and Project Options

Description	Unit	Reference Case	Incremental 2031 Results					
			Option 1	Option 2	Option 3	Option 11	Option 15	Option 18
Transit demand	trips	93,529,000	743,972	2,043,143	2,808,888	3,319,036	3,718,394	4,079,716
Transit travel time savings (existing users)	minutes		41,151,710	118,217,400	159,369,110	187,969,260	216,624,376	253,371,470
Transit travel time savings (new users)	minutes		1,273,875	3,095,991	4,369,866	4,931,568	5,493,209	6,566,041
Highway demand (trips removed)	trips		(619,976)	(1,842,680)	(2,462,657)	(2,909,923)	(3,229,333)	(3,562,643)
Highway travel time (minutes removed - decongestion benefits)	user minutes		(7,486,417)	(28,293,401)	(35,779,818)	(41,469,963)	(48,035,634)	(52,369,101)
Highway distance (car kms removed)	vehicle km		(7,273,423)	(27,488,431)	(34,761,853)	(40,290,110)	(46,668,982)	(50,879,158)

By investing in new transit vehicles and infrastructure, the GO electrification project has the potential to change the relative attractiveness of transit in relation to other modes travelers. While modal shifting due to the reliability and time savings described in preceding sub-section 2.1 is likely to be a small share of overall GO trips, the change could result in some level of improved economic efficiency. Rate of modal diversion is derived from time and reliability savings.

The above inputs will be critical both for rail (with vs. without electrification) in comparison to passenger car (or other modes from which passengers may divert). The data needed to derive economic impacts from the cost savings due to modal shifting in the proposed GO methodology include:

- The data inputs about person-trips, person-hours, vehicle-kilometers, vehicle-hours and operating costs by mode; and
- The differences in demand and cost between modes both with and without the electrification project provide the basis for understanding cost savings at the system level, and deriving economic efficiencies.

3. ANNUAL ECONOMIC IMPACTS DUE TO OPERATING PROJECT OPTIONS

Impacts to the economy are due to regional competitiveness for metro-area businesses that are expected to have lower costs of doing businesses, including access to larger labour market improved productivity because workers have easier commutes and less congestion on roadways because people are choosing to use the improved Metrolinx system instead of driving. Each industry on the Metrolinx region that experiences part of the direct economic benefit will have a unique response in terms of how much a better functioning public transportation system affects their business outlook.

3.1. Direct Impacts

Direct impacts in the Metrolinx region are composed of direct cost savings expected due to electrification and improve market access for labour and firms.

Direct cost savings accruing to businesses and households are calculated per alternative for the Metrolinx region. The cost savings due to modal diversion is computed by summing the vehicle operating costs and travel time costs (by mode) for the affected mix of modes both with and without electrification. These cost savings are then projected over the life of the project and expected to accrue to households and businesses in the region.

Market Access impacts are distinct from those that arise through travel cost savings. Travel cost savings apply to the current pattern of economic activity of households and businesses (as reflected by trip-making behavior). With a transportation investment, these trips can be satisfied less expensively. In contrast, market access impacts arise because transportation investments can also enable new economic linkages, as well as increase the potential for knowledge sharing and growth in the city as a whole. Exhibits 3 and 4 report the direct economic benefits to Metrolinx region in 2021 and 2031. Note that "Toll & Fare" costs rise in these years above the reference case and are "dis-benefits" in terms of economic impact. However, the negative costs to households represent anticipated new revenues to Metrolinx.

Table 3 - 2021 Value of Direct Transportation Savings per Electrification Option Compared to Reference Case (Millions of 2010 $s)

	Option 1	Option 2	Optio n 3	Option 11	Option 15	Option 18
Passenger Benefit - Net Local	$13.41	$39.67	$53.09	$62.41	$71.92	$83.43
Crew Benefit - Net Local	$0.08	$0.32	$0.40	$0.47	$0.54	$0.59
Freight Benefit - Net Local	$0.05	$0.19	$0.24	$0.28	$0.32	$0.35
Reliability Benefit - Net Local	$0.37	$1.45	$1.81	$2.16	$2.51	$2.56
Vehicle Operating Benefit - Net Local	$2.91	$10.99	$13.90	$16.11	$18.66	$20.34
Toll & Fare Cost - Net Local	($3.57)	($10.61)	($14.18)	($16.75)	($18.59)	($20.51)
Safety Benefit - Net Local	$1.00	$3.77	$4.77	$5.53	$6.41	$6.98
Environmental Benefit - Net Local	$0.12	$0.44	$0.56	$0.64	$0.75	$0.81
Local Value of Travel Impacts:	$14.37	$46.23	$60.59	$70.85	$82.52	$94.57

Table 4 - 2031 Value of Direct Transportation Savings per Electrification Option Compared to Reference Case (Millions of 2010 $s)

	Option 1	Option 2	Option 3	Option 11	Option 15	Option 18
Passenger Benefit - Net Local	$17.64	$52.86	$70.50	$82.81	$95.45	$110.35
Crew Benefit - Net Local	$0.16	$0.59	$0.75	$0.86	$1.00	$1.09
Freight Benefit - Net Local	$0.09	$0.35	$0.45	$0.52	$0.60	$0.65
Reliability Benefit - Net Local	$0.50	$1.97	$2.47	$2.93	$3.41	$3.84
Vehicle Operating Benefit - Net Local	$3.64	$13.74	$17.38	$20.15	$23.33	$25.44
Toll & Fare Cost - Net Local	($4.46)	($12.26)	($16.85)	($19.91)	($22.31)	($24.48)
Safety Benefit - Net Local	$1.25	$4.72	$5.97	$6.92	$8.01	$8.73
Environmental Benefit - Net Local	$0.15	$0.55	$0.70	$0.81	$0.93	$1.02
Local Value of Travel Impacts:	$18.95	$62.53	$81.35	$95.08	$110.43	$126.65

It was assumed that the local market access impact of electrification of the GO Transit system will be limited to the increased accessibility offered to the core trade area of the GO region by faster and more reliable transit service due to the direct transportation enhancement described section 2, above. Therefore, market access was calculated based on the levels of induced ridership by alternative that would be attracted to the Metrolinx system as a consequence of electrification. Induced ridership was used as the basis for market access change because, by definition, it reflects new economic linkages above the reference case enabled by implementing one of the build alternatives, and lends itself to a conservative approach for growth without risk of double-counting benefits from travel cost savings. The scale of expected business output to be generated due to improved market access by 2021 and 2031 is shown in Exhibit 5.

Table 5 - Business Output Estimated due to Improved Market Access by Option (Millions of 2010$s)

Project Option	2021	2031
Option 1	$5.42	$5.76
Option 2	$16.98	$22.63
Option 3	$22.67	$37.86
Option 11	$26.80	$31.76
Option 15	$29.73	$40.98
Option 18	$32.69	$43.80

3.2. Provincial Economic Impact

Provincial economic impact will accrue based on transportation cost savings for businesses and individuals. The Provincial-wide impact is expected to be triggered by the direct transportation impacts described in the preceding section, and carried forward at the regional level to reflect: (1) impacts to suppliers of goods and services purchased in the Province by firms that benefitted from direct effects; and (2) workers of directly and indirectly affected businesses will purchase consumer goods and services from businesses in Ontario from wages earned as a consequence of the direct and indirect business transactions.[1] Essentially, it is expected that the cost savings accruing to households and businesses in Ontario due to the improved efficiency of electrification will be passed on from sector to sector in the GO region (with “Place of Work” data from Statistics Canada and Canadian data on “inter-industry purchasing patterns” from OECD[2]), resulting in a total overall regional impact significantly beyond the direct impacts.

The overall regional economic impacts are expected to grow annually as ridership of the chosen electrification alternative increases over the reference case. The result is annual changes to Metrolinx in improved productivity to businesses and out of pocket savings to consumers (as reported above in Section 3.1) and annual jobs wages and GDP that will accrue within the Province. Exhibit 6 summarizes the direct economic impacts of the six alternatives that are expected to be realized by the year 2021 and Exhibit 7 summarizes the expected impacts of alternatives by 2031.

Table 6 - Economic Impacts in 2021 Derived from Proposed Metrolinx Electrification Options

	Total Economic Benefits		
	GDP (Millions $2010)	**Jobs (Rounded to “10”)**	**Wages (Millions $2010)**
Option 1	$12.13	130	$10.53
Option 2	$39.69	400	$34.40
Option 3	$51.52	530	$44.68
Option 11	$60.18	620	$52.21
Option 15	$70.18	710	$60.82
Option 18	$78.40	800	$67.95

Table 7 - Economic Impacts in 2031 Derived from Proposed Metrolinx Electrification Options

	Total Economic Benefits in 2031		
	GDP (Millions $2010)	**Jobs (Rounded to “10”)**	**Wages (Millions $2010)**
Option 1	$14.94	160	$12.98
Option 2	$48.93	500	$42.42
Option 3	$63.52	660	$55.10
Option 11	$74.21	770	$64.38
Option 15	$86.51	890	$74.98
Option 18	$96.85	1000	$83.96

1These larger Provincial wide impacts are often referred to as “multiplier” effects.
[2] Organization for Economic Co-operation and Development

4. LOCALIZED STATION LAND USE EFFECTS

Land use changes due to electrification of the GO network are facilitated by multiple factors, including actual or perceived noise reductions/air quality improvements at station areas and along rail lines, developable land parcels near stations, land use policies that enables/encourages development and new riders boarding or alighting at stations. Minimal positive changes in noise and air quality may encourage some housing or other noise-sensitive land uses (such as schools and religious institutions). The likelihood is that the limited noise reduction and minor air quality changes that are now being forecast will not in themselves encourage most development types, such as retail, commercial service storefronts, office space, health services, public sector uses and (possibly) above ground level apartments. Higher land values may be expected from the following three-part dynamic, any one of which may bid-up the price of land:

- More demand for services by station areas from additional riders of Metrolinx will lead to development or expansion of commercial and retail services that cater to these needs
- Opportunities due to improved market access (discussed in Section 2) may increase the development potential of land near station areas.
- Noise and air quality improvements that occur, or are perceived, as part of electrification, will be particularly encouraging for housing development, as well as other noise sensitive land uses.

4.1. Development Potential

Land near existing stations close to the economic center of a region tends to be built-out. Though opportunities for redevelopment may exist, the cost of redevelopment is usually high, and may include the opportunity cost of demolishing something that is viable, though less than highest-and-best-use. In contrast, stations farther out towards suburban and suburbanizing areas tend to have less densely developed station areas, with land available for development and fewer barriers to re-development.

Thus, land area by the current termini of transit lines, as well as near, will tend to experience the greatest impacts, as they are generally located on the outskirts of the metropolitan region where existing development is less dense, and in those areas where rail service is being introduced. The greatest opportunity for significant lands use change lies by planned new Metrolinx stations. However, the new stations are part of the reference case, and just the incremental ridership forecast at these new stations will be applicable to land use impacts of electrification alternatives.

The most significant land use changes are found near station areas with land available for development and/or where redevelopment is economically feasible and significant numbers of new riders are attracted for passenger boardings and alightings. Development patterns can be expected to respond to electrification of existing service to the extent that the technology shift renders service to and operation of existing stations less intrusive (quieter, lower emissions). However, the most significant land use changes occur when new transit stations are established, and the changes are brought about by the introduction of transit service itself. The nature and magnitude of land use shifts will depend primarily on:

- The success of the new service in attracting ridership;
- The degree of change in noise, congestion (vehicle/foot traffic), and emissions (real or perceived);
- Regional job and population growth and related factors driving market demand for housing, retail

and employment space;

- The availability and cost of vacant land, or underutilized land available for redevelopment in 400 to 800 meter radii from stations; and
- Regional and municipal land use plans and zoning regulations that allow, support and direct new development patterns.

To the limited extent that electrification makes Metrolinx operations quieter, it may induce land use changes along the tracks, beyond station areas. For example, in quiet suburban areas, residential development may become feasible closer to the tracks where it was previously considered too noisy. Quieter operation may reduce the amount of buffer space and lot size, allowing for more intense development. If additional residential density increases population, additional local-serving retail development may be induced. As with station area development, impacts would be greater in suburban areas, as more urbanized areas tend to have land uses compatible with noise and emissions (office, retail, high density residential, institutional) and less likely to benefit from reduced noise and emissions from Metrolinx. It is important to note that development near rail stations are usually a mix between new economic development for a region or municipality, and existing jobs that are being relocated to take advantage of transit oriented development opportunities that have been created.

In 2006, the Government of Ontario released its “Growth Plan for the Greater Golden Horseshoe”, which outlines the regional land use strategy for growth management. The document identifies 25 “Urban Growth Centers”, existing or emerging downtown areas with minimum density targets and other policies to encourage more intense land use and downtown revitalization. In other words, regional growth is being directed towards these Urban Growth Centers and conversely, away from other areas in the region. It should be noted that the plan does not expressly limit growth in other areas, but since demand for growth is finite, directing growth to certain area leaves less growth to occur in others.

A number of Urban Growth Centers are also in communities with Metrolinx endpoints, or with proposed new stations/endpoints, including:

- Downtown Barrie
- Downtown Guelph
- Downtown Hamilton
- Downtown Kitchener
- Downtown Milton
- Downtown Oshawa
- Richmond Hill/Langstaff Gateway
- Downtown St. Catharines

To the extent that existing and future stations are located within these target areas the station areas can be expected to experience greater land use impacts than stations in non-growth target areas.

Municipal Official Plans, zoning regulations, targeted area land use plans (such as downtown and waterfront plans), and municipalities’ online land use mapping applications where available provided significant information regarding zoning, as well as some general information regarding existing and future land use and densities. Documents from some municipalities identified vacant parcels suitable for development and underutilized parcels suitable for redevelopment. For example, the Richmond Hill Downtown Design & Land Use Strategy (2009) indicated a number of developable and re-developable parcels in the downtown area within a 5-10 minute walking distance of the Richmond Hill GO Station, the current endpoint of the Richmond Hill (F) line. Similarly, Georgetown GO Station Land Use Study (2008) identifies parcels suitable for station-related redevelopment in four areas surrounding the station (the current end of the Georgetown (D) line).

Other municipalities may also have vacant and/or re-developable land in their station areas that was not readily apparent from the information available online. For example, an amendment to the Town of Lincolnville's bylaws indicates that the land surrounding the station area that is reserved for station-related employment development (Lincolnville station is the current end of the Stouffville (G) line). However the document does not indicate whether the area is vacant or currently developed for another use. Land use documents from the Town of Innisfil, which lies just south of the Barrie South station (the current end of the Barrie (E) line), indicate large parcels of land south of the station area reserved special agricultural development. It is unclear whether this land might be available for station-related development.

None of the studies reviewed contained specific amounts (hectares) of land available for development/redevelopment or how many units of residential/square meters of retail/office/industrial could be accommodated. To determine station area development potential in more concrete terms, the next step would be to conduct site visits of station areas, meet with local planning officials to determine whether additional data or studies exist, and interview local commercial real estate brokers knowledgeable about regional and local real estate market trends.

5. CONSTRUCTION IMPACTS

Construction impacts are temporary shocks to an economy that will occur during the spending of the construction budget for Metrolinx electrification projects. Construction impacts follow the budget. In general, the more expensive the alternative, the greater construction investment is required, and therefore the economic impacts from construction are larger. This varies slightly by the mix of materials and services per alternative, and the amount of spending that is likely to occur in the GGH versus elsewhere in Canada or the world. Construction impacts are shown as gross numbers of annual job-years, meaning, for example, if 500 jobs were involved with an alternative in each year, the gross construction year jobs would be 1000 for two years, 1500 for three years and 2000 for years, further assuming an even allocation of spending per year. Lastly, impacts are provided on a total jobs bases, including part-time and full-time jobs, and are not shown on a "full-time equivalent" basis.

As planned, Options 1, 2 and 3 are anticipated to cost between $886 million and $1.5 billion and costs of Options 11, 15 and 18 are expected to be between $1.7 billion and $3.2 billion, including contingencies. Construction associated with the electrification options will generate direct impacts of $155 million to nearly $1 billion in GDP, supporting 900 to 6000 direct (but temporary) jobs associated with construction that will pay $$59 million to $400 in aggregate wages. In addition, total regional impacts including spin-off effects is expected to account from $275 million to $1.8 billion of additional GDP in the GGH over the spans of the construction periods of the various alternatives. The direct impacts and full regional impacts from construction of the six alternatives are shown below in Exhibit 8.

Table 8 - Economic Impacts Anticipated During Construction Period

Scenarios	Direct Impacts			Regional Impacts Including Multipliers		
	Employment – person years (in 100s)	Wages ($mill)	GDP ($mill)	Employment – person years	Wages ($mill)	GDP ($mill)
Option 1	900-1,500	$59.2-97.2	$154.9-$256.2	2,100-3,500	$121.4-$203.6	$274.5-$460.4
Option 2	1,000-1,600	$67.8-105.5	$180.7-$278.6	2,400-3,800	$138.9-$218.0	$317.5-$494.8
Option 3	1,600-2,400	$113.8-$160.1	$290.0-$420.5	3,600-5,800	$211.4-$333.8	$478.6-$753.3
Option 11	1,900-2,800	$124.2-$186.0	$323.1-$486.3	4,500-6,800	$256.6-$387.9	$576.6-$873.0
Option 15	2,200-3,400	$147.0-$226.5	$382.7-$591.0	5,200-8,200	$302.2-$471.2	$681.0-$1060.8
Option 18	4,100-6,200	$265.2-$400.0	$657.0-$999.0	9,700-14,800	$554.8-$844.2	$1210.8-$1848.9

The low ends of the ranges assume no contingency spending. The high ends of the ranges assume that all contingency budgets are expended.
Calculations by EDR Group based on data from Statistics Canada, input/output framework of the Organization for Economic Cooperation and Development and the Minnesota IMPLAN Group.

Construction impacts were calculated on the basis of an input/output model developed by EDR Group and Minnesota IMPLAN Group for GGH and based on OECD (Organisation for Economic Co-operation and Development) industry to industry purchasing tables for Canada. The key difference between construction impacts and the annual impacts discussed above is that the former are temporary and reflect the expenditure of the construction budget for the each alternative.

Direct construction impacts reflect initial spending of the construction budget in the region. The construction / investment phase (assessed for regional-level economic impacts) are based on the following assumptions of regional purchases derived from comparing the regional economy to the economies of Ontario and Canada:

- Power Distribution Equipment will include an estimated 8.1% of local purchases (the proportion of the total demand for a commodity that is supplied by producers located within the region) and 91.8% purchases from outside the region (international and the rest of Canada)
- To be conservative, this analysis assumes the contract for Rolling Stock will be awarded to a manufacturer outside of Ontario, leaving 3.5% direct local purchases from the line item budget for items such as transport, and that 96.5% of the budget for Rolling Stock will be spent outside of the Province. If a contract is awarded to a company in Ontario, then job estimates will increase based on the amount of actual production constructed in the Province. For example, if 100% of production occurs in the Province, then additional direct jobs expected will range from 240 (Option 1) to 1,700 (Option 18). These impacts would be scaled down if less than 100% of production in the Province.
- Construction of Power Supply Infrastructure will include 87.8% local purchases and 12.2% purchases from outside the region
- Sitework, maintenance and layover facilities will be purchased 100% from within the region
- Overhead Structure will include 68.3% local purchases and 31.7% purchases from outside the region
- Professional Services will include 83.3% local purchases and 16.7% purchases from outside the region

6. PROVINCIAL/FEDERAL TAX IMPACTS

The key tax impacts analyzed are Harmonized Sales Tax (HST) and Personal Income Taxes, which reflect the purchases of goods and services and wages that are expected to be generated due to economic impacts of the electrification options. Depending on Project Option, estimated Federal and Provincial tax revenues range from $3.5 million (Option 1) to almost $23 million (Option 18) in 2021, and from $4.4 million to more than $28 million in 2031. Provincial and Federal Tax impacts by alternative are shown in Exhibit 9 for 2021 and Exhibit 10 for 2031

The rates of both taxes have been recently changed. As of July 1, 2010, the HST has been set at 13%, consisting of an 8% Ontario rate and 5% national rate. Secondly, the lowest bracket in the Ontario income tax schedule has been lowered from 6.05% to 5.05% this year. As a result, there is not a body of research at the Provincial or National level to allow for a clear estimate of effective tax rates based. Tax impacts are calculated based on data reported by the Canadian Revenue Agency and the Ontario Ministry of Finance and then adjusted to approximate the new tax rates. Consequently, these data should be viewed as a reasonable order of magnitude. The approach used for tax calculation is as follows:

- **HST.** HST was calculated based on regional GDP. There are non-taxable items including, groceries, agriculture products, prescription drugs and medical devices. Using Statistics Canada data and TREDI S sector specific calculations, it was estimated that approximately 3% of GDP will fall into these categories.
- **Provincial Income Tax.** There are three Provincial tax brackets:
  - First $37,106 of income was taxed at 6.05% and is now taxed at 5.05%
  - Second $37,106 of income is taxed at 9.15%
  - Everything above $74,212 is taxed at 11.16%

Calculations consisted of the following steps:

- First, using income and tax revenue data from 2008-2009, an effect tax rate of slightly more that 7% was calculated taking tax exemptions into account.
- Second, Provincial income taxes were calculated for the average wage of the economic impacts of the Project Options. The average wage gross wage from each Option was approximately $83,000. However, after being adjusted for tax exemptions (based on 2008 CRA data)[3], taxable income was slightly less than $75,000 per worker
- Third, this wage calculated on the basis of the new tax brackets and applied to reduce the effective tax rate in step one.

[3] Canadian revenue Agency, 2010 Interim Table 1: General statement by province and territory of taxation for tax Year 2008

Table 9 - Estimated Provincial and Federal Tax Impacts by Option in 2021 (Millions of 2010$)

	Income Tax		HST		Total Provincial	Total Federal	Total Provincial/Federal
	Provincial	Federal	Provincial	Federal			
Option 1	$0.70	$1.31	$0.94	$0.59	$1.64	$1.90	$3.54
Option 2	$2.29	$4.28	$3.08	$1.92	$5.37	$6.20	$11.57
Option 3	$2.97	$5.56	$4.00	$2.50	$6.97	$8.06	$15.02
Option 11	$3.47	$6.49	$4.67	$2.92	$8.14	$9.41	$17.55
Option 15	$4.04	$7.56	$5.45	$3.40	$9.49	$10.97	$20.46
Option 18	$4.52	$8.45	$6.08	$3.80	$10.60	$12.25	$22.85

Sources: Canadian Revenue Agency and Ontario Ministry of Finance. Calculations by EDR Group based on estimated economic impacts of Options

Table 10 - Estimated Provincial and Federal Tax Impacts by Option in 2031 (Millions of 2010$)

	Income Tax		HST		Total Provincial	Total Federal	Total Provincial/Federal
	Provincial	Federal	Provincial	Federal			
Option 1	$0.86	$1.61	$1.16	$0.72	$2.02	$2.34	$4.36
Option 2	$2.82	$5.28	$3.80	$2.37	$6.62	$7.65	$14.27
Option 3	$3.66	$6.85	$4.93	$3.08	$8.59	$9.93	$18.53
Option 11	$4.28	$8.01	$5.76	$3.60	$10.04	$11.61	$21.64
Option 15	$4.99	$9.32	$6.71	$4.20	$11.70	$13.52	$25.22
Option 18	$5.58	$10.44	$7.52	$4.70	$13.10	$15.14	$28.24

Sources: Canadian Revenue Agency and Ontario Ministry of Finance. Calculations by EDR Group based on estimated economic impacts of Options

7. LITERATURE REVIEW

7.1. Literature Review for Economic Impact

There is a significant base of studies documenting the ways in which rail system changes from diesel to electric power lead to economic, operational and environmental impacts. The most significant body of this research comes from the United Kingdom though some also comes from North America. A short synopsis of key research is described here.

- Roden (2009)[4] examined plans by Network Rail, a British infrastructure manager, for major expansion of electrification on key routes across the United Kingdom. While 40% of British rail network (in track-km) is currently electrified, it carries around 5% of freight train-km and just under half of passenger train-km. Unveiled in April, the plans, when compared with the cost of existing diesel operation maintenance, should in some instances save money. In addition to costs, discussion includes rolling stock and environmental concerns.
- Hope (2010)[5] examined the case that electric trains inflect less track damage, are cheaper to maintain, enhance line capacity, and meet climate change objectives better than diesel traction trains. The author reviews the history of electric traction trains in western Europe, outlines the controversies and problems encountered thus far, considers the support of the Department of Transportation (DfT), explains how regenerative braking works, and summarizes some of the political hurdles that had to be overcome. One sidebar describes the Network Rail factory train concept. Also on rail electrification in the UK in 2010, Berton (2010)[6] further describes electrification plans for rail services in the UK.
- Aurelius (2010) [7] presented factors which should be considered in the early phases of an urban circulator project. In Aurelius' view, urban circulators are a specialized version of light rail, operating over relatively short distances in dense, built-up areas. Differences in performance expectations and technical requirements for electrification in different settings were considered.
- Starcic (2009)[8] described benefits of transit electrification including: reduced greenhouse gas emissions, faster acceleration and top speeds, better braking and easier to maintain engines. According to this research, the primary drawback is its startup cost, due to the type of infrastructure required. The study selected several transit agencies making the switch, however focused primarily on California's Caltrain, a commuter rail which runs on one line of track between San Francisco and Gilroy. Though costly, the train is estimated to reduce air pollutant emissions by nearly 90 percent.

7.2. Use of Transferrable Case Studies

Three other studies have explicitly analyzed electrification initiatives of the type considered by GO Transit at this time. Each of these studies involved the use of the TREDIS transportation economic

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[4] Roden, Andrew, "Network Rail Makes the Case for Electrification," *International Railway Journal*, Volume 49, Issue 7, 2009, pp. 35-38.

[5] Hope, Richard, "Network Rail Strives to Catch Up on Electrification," *Railway Gazette International*, Volume 166, Issue 4, 2010, pp. 50-53

[6] Burton, Alan De, "Network Rail's route plans for Control Period 4 2009-2014 25 KV A.C. electrified lines in England," *Electric Railway*, Volume #55, Issue 325, 2010, pp. 3-6

[7] Aurelius, John P, "Urban Streetcars – Electrification," *Transportation Research Board 89th Annual Meeting – Compendium of papers* (Report #10-0436), 2010.

[8] Starcic, Jana, "Rail Systems Flip the Switch on Electrification" *Metro*, Volume 105 Issue 7, 2009-8, pp. 52-54

impact framework within the context of an overall methodology for assessing the economic impacts of a transit program including electrification. These comparison studies are:

- **Durham, Ontario Regional Transit.** For the Regional Municipality of Durham, electrification was examined as part of a broader examination of the public transport options for the long-term strategy plan. Three aspects of economic impacts are evaluated for each alternative in the Durham study relative to the Business as Usual (BAU) case. These include impacts from:

  (1) *Construction Effects* (the total for all years in which construction is undertaken);

  (2) *Annual Traveler Time and Cost Effects* realized from operating and maintaining (O&M) each of the alternatives after construction is completed; and

  (3) *Annualized Access and Mobility Impacts* derived from the combination of improving mobility for residents of Durham (both transit users and auto users), and improved market access to businesses in Durham.

  These impacts are reported in terms of Gross Domestic Product (GDP), the change in jobs relative to the BAU case, and the change in the labour income associated with these net new jobs. All dollar amounts are stated in 2008 dollars. The results of the study show how the proposed improvements to mobility, effects of congestion education, and capital investments in DRT's LTTS are likely to affect households and businesses in the regional economy. Total Provincial economic impacts are derived by applying multipliers applicable to Ontario to derive indirect effects of employment, wages and GDP. Assessments of the incremental impacts the options will have on land values and land development in the corridor are not included.

- **Metrolinx Transit Improvements.** Metrolinx performed an economic impact analysis for various transit alternatives, some of which include electrification.[9] The economic impact approach to this modeling entailed complementary modeling and "on the ground" work to elucidate the complete and holistic expected impact by integrating models and local knowledge to: (1) observe and calculate central tendencies of complex information; and (2) adjust assumptions in the modeling to take local conditions into account. Potential economic development benefits for each transit alternative were assessed through a series of analytical steps in coordination with municipal and Provincial growth plans. The steps are organized so that each provides clear and usable findings by itself, and together they provide a comprehensive and constant comparison of economic impacts projected for each alternative. The elements of the Metrolinx analytical framework encompass:

  - *Regional economic perspective* - The study incorporated relevant development and land use studies in areas directly related to the project and their effects on potential utilization, contingent development and other factors influencing the economic impact of the transit improvements.

[9] These studies include Dundas Street Rapid Transit; Durham-Scarborough Bus Rapid Transit (BRT); Hurontario-Main Rapid Transit; Hamilton B-Line Rapid Transit; Sheppard-Finch LRT; GO Lakeshore; Yonge Subway North Extension; Scarborough Rapid Transit; VIVA- York Region rapid transit system; Sheppard East LRT; Eglinton Crosstown LRT; Finch West LRT and Scarborough Rapid Transit. Each of these studies evaluated the relative merits and costs of alternative project options, which included variations in the alignments and technologies.

- *Benefits of transit ridership.* The study derived significant benefits from the time savings, cost savings and other comparative benefits of transit ridership per project alternative, including passenger savings from using rail rather than automobile for commuting and personal trips. The overall potential impacts of those savings were then estimated with methods for quantifying the overall re-circulation of transportation savings into the regional economy as consumer expenditures. Further network data were used to calculate benefits from improved safety and, lessened roadway congestion. The breadth of the approach also encompassed all known and quantifiable savings associated with transit investment, including affordable mobility benefits such labour access, low-income transportation benefits, and related benefits.

- *Environmental Costs.* Carbon costing (using 'full social costs' for carbon, not market rates) and benchmarks for other emissions such as particulates are quantified in the Metrolinx study. Innovative approaches were considered for quantifying the public health impacts of the project bundles/alternatives. Factors such as the impacts of hospital visits of improved air quality, and the health benefits of increased walking activity which may accompany transit were also taken into account.

- *Land Use and economic development opportunities.* Quantifying the value of transit investment on adjacent land use is the subject of extensive research. In practice, higher order transit investment is often a catalyst for development, not a net generator of new development. In the Metrolinx study, analysis of local and regional market conditions and trends, interviews with realtors, local planners, businesses, financial institutions, and other stakeholders, and by reviewing local comprehensive plans and land use regulations all contributed to a qualitative understanding of potential for local real estate development near stations by alternative. Lessons from relevant literature were also applied in this analysis.

- **South Coast Rail Corridor Development Study (Massachusetts).** Rather than electrifying an existing commuter rail line, this study examined the implications of alternative electric and non-electric modal alternatives for transport along a commuter corridor. That made its overall approach particularly pertinent to the GO Electrification study methodology. The South Coast Rail study included a comparative analysis of economic impacts arising from different passenger rail transportation options involving changes in modal shares, station-area development potential and overall transportation efficiency.

The study examined how transportation changes resulting from proposed South Coast Rail Alternatives would translate into economic benefits for the region and state. The modeling approach provided a comprehensive forecast of total economic impacts (direct +indirect +induced) as measured by changes in business output, employment, and household income attributable to the proposed transportation investments. These were distinguished from land-use impacts which are treated separately. The impacts fell into six categories. All six of these impacts are benefits to residents and businesses within the region, and were discussed in findings of the report.

- *Public Transport Time Savings* - Some existing transit riders who now travel along the study corridor can benefit from faster travel and more convenient service.

- *Mode Switching* - New rail and rapid bus travelers who switch from car travel can save time and they can also save money, as the new transit option costs them less than what they currently spend on car operating costs (tires, fuel, oil and parking), and they can use that additional money to purchase other consumer products and services as they desire.

- *Automobile Congestion Reduction* - Travelers who continue to drive or ride in cars, as well as truck drivers, can also benefit from reduced peak period traffic congestion, which leads to direct savings in vehicle operating costs. Households can use the savings to purchase other consumer products and services as desired (and have more leisure time).

- *Business Productivity* - Insofar as traffic congestion gets reduced along the corridor, some businesses can gain productivity from fewer late arrivals due to traffic delay, and reduced need to pay higher wages or accept shorter work hours to attract workers in those congested areas. The net effect is a reduction in the cost of doing business.

- *Labor Market* - Businesses can also gain productivity as a result having access to larger labor markets with more diverse and specialized skills. That can allow businesses to draw on a better match between available workers and required skill needs, and it can also allow some industries to achieve greater economies of scale. Reduction in the growth of traffic congestion can also enable more productive truck deliveries.

- *New Business Growth* - effects on business growth occur as the greater productivity and changes in consumer spending lead to more business sales and attraction of new business activity. There are further impacts as the directly-affected businesses that grow also buy more from suppliers within the region ("indirect economic effects"), and the additional worker income is re-spent on more consumer purchases within the region ("induced effects").

• ***Other Studies – British Columbia and Alberta.*** Similar types of impact categories were also evaluated (using the same TREDIS framework) in studies economic impact of the multi-modal Gateway Transportation Plan for Vancouver (which included expansion of electric (light rail) public transport, freight rail and road improvements), and Economic impact of proposed high speed rail for the Edmonton-Calgary corridor.

7.3. Additional Land Use Literature[10]

The issue of land use changes resulting from a transition from one rail transit technology to another is not specifically addressed in the literature covering the broader body of research on the impact of rail transit on land use (including type, values, and density). However, the findings of that broader research have implications useful for understanding the likely impacts of such a change.

The key driver of impacts is change in transportation accessibility/cost, followed by significant market factors and policy interventions. Thus if the new technology increases speed/frequency of service or reliability, and the change occurred in a supportive policy environment with favorable demand for increased density, land use changes are likely to occur. Key Findings are:

- Suburban locations experience greater impacts than central city locations (due to greater changes in accessibility in the former versus relative saturation of access in the latter). (Dyett and Castle 1978; Fajans 1978; Flacke 1978a; MTC 1979; Boyce 1972; SANDAG 1984)
- "Transit systems potentially impact development in two ways, just as highways do: by reducing transportation costs and by changing relative accessibilities."(Handy 2005)
- Commuter rail has a greater impact than light rail due to higher speeds and greater regional access ("greater sphere of influence") (Cervero 1984)
- Factors influencing success:
- Healthy real estate market, availability of capital and demand for high density development (Knight and Trygg 1977), and high growth region – "almost exclusively, transit system's impacts on land use are limited to rapidly growing regions with a healthy underlying demand for high-density development" (Vesalli 1997)

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[10] Boyce, D., et. al., 1972. Impact of Rapid Transit on Suburban Residential Property Values and Land Development Analysis of the Philadelphia-Lindenwold High Speed Line. Wharton School, University of Pennsylvania, November.

Cervero, R. (January 01, 1984). Light rail transit and urban development. *Journal of the American Planning Association, 50,* 2.) Diaz, R. B. (January 01, 1999). Impacts of rail transit on property values. Proceedings of the 1999 Commuter *Rail/rapid Transit Conference.*

Handy, S. (January 01, 2005). Smart Growth and the Transportation-Land Use Connection: What Does the Research Tell Us? *International Regional Science Review, 28,* 2, 146-167.

Knight, Robert L. and Lisa L. Trygg. 1977. Land Use Impacts of Rapid Transit: Implications of Recent Experience. Prepared for the U.S. Department of Transportation. San Francisco, CA: DeLeuw, Cather & Company.

Vessali, K. V. (January 01, 1997). Land use impacts of rapid transit: A review of the empirical literature. *Berkeley* Planning Journal, 11.

The Effect of Rail Transit on Property Values: A Summary of Studies. Project 21439S, Task 7, NEORail II, Cleveland, Dyett, Michael V. and Gilbert H. Castle, III. 1978. Study of the Housing Industry. Working paper, BART Impact Program. Berkeley, CA. Metropolitan Transportation Commission. April.

Fajans, Michael H., Michael V. Dyett and David M. Dornbusch. 1978. Study of Development Patterns. Working SANDAG (San Diego Association of Governments). 1984. San Diego Trolley: The First Three Years (November).

- Supportive land use policies (density bonuses, joint development, air rights, region-wide growth control policies; parking restrictions; and public sector assistance with infrastructure or land assembly (Pill 1988) and provision of a high performance regional transit system.
- Studies are mixed on how the income level of the neighborhood influences the impact. Diaz reconciles conflicting evidence: “rail transit imparts value to residential property in districts where the population values the access provided by that transit service the most, regardless of the income of the district”.

7.4. Public Policy Documents

EDR Group reviewed municipal Official Plans, zoning regulations, targeted area land use plans (such as downtown and waterfront plans), and utilized municipalities’ online land use mapping applications where available. These documents provided significant information regarding zoning, as well as some general information regarding existing and future land use and densities.

Documents from some municipalities identified vacant parcels suitable for development and underutilized parcels suitable for redevelopment. For example, the Richmond Hill Downtown Design & Land Use Strategy (2009) indicated a number of developable and re-developable parcels in the downtown area within a 5-10 minute walking distance of the Richmond Hill GO Station, the current endpoint of the Richmond Hill (F) line. Similarly, Georgetown GO Station Land Use Study (2008) identifies parcels suitable for station-related redevelopment in four areas surrounding the station (the current end of the Georgetown (D) line).

Other municipalities may also have vacant and/or re-developable land in their station areas that was not readily apparent from the information available online. For example, an amendment to the Town of Lincolnville’s bylaws indicates that the land surrounding the station area that is reserved for station-related employment development (Lincolnville station is the current end of the Stouffville (G) line). However the document does not indicate whether the area is vacant or currently developed for another use. Land use documents from the Town of Innisfil, which lies just south of the Barrie South station (the current end of the Barrie (E) line), indicate large parcels of land south of the station area reserved special agricultural development. It is unclear whether this land might be available for station-related development.

None of the studies reviewed contained specific amounts (hectares) of land available for development/redevelopment or how many units of residential/square meters of retail/office/industrial could be accommodated. To determine station area development potential in more concrete terms, the next step would be to conduct site visits of station areas, meet with local planning officials to determine whether additional data or studies exist, and interview local commercial real estate brokers knowledgeable about regional and local real estate market trends.

8. MODELING AND METHODOLOGY

The Transportation Economic Development Impact System (TREDIS) was the framework to estimate how the transportation changes resulting from proposed GO Electrification Options will translate into economic benefits. This computerized framework has been successfully used in the past to calculate economic impacts for other Metrolinx system improvements, for evaluation of options for Durham Regional Transit, and for multi-modal impacts of both GTA West and Niagara GTA transportation corridors for the MTO. It was also used for evaluating the economic impacts of multi-modal investments in Vancouver, BC. The distinguishing aspects of this framework is that it is multi-modal, provides both economic impact and benefit/cost accounting, and it provides a generally accepted reporting format for many of the desired outputs. A comprehensive forecast of total economic impacts (direct +indirect +induced) as measured by changes in business output, employment, and household income attributable to the proposed transportation investments. These are distinguished from land-use impacts which are treated separately, and in a qualitative manner.

The process for data calculation relies significantly on readily-available ratios and relationships, which can be derived from (1) general per-vehicle or per-person cost assumptions related to travel time and travel operating costs, (2) travel demand and transportation system performance estimates of the type that can be generated by a travel demand model, (3) inter-industry and household spending patterns, (4) general ratios and multipliers associating output with GDP, jobs and wages, and (5) energy-related ratios regarding per-vehicle electricity use, gallons of diesel saved per unit of electricity and the costs of the electrification process itself.

Local and Provincial economic modeling using TREDIS evaluated the following: (1) the economic structures of the Metrolinx region based on Statistics Canada data, (2) implications of travel demand changes for different industries in the region, depending on their reliance on commuting and business travel, and (3) information on the inter-industry purchasing and implications for generating indirect and induced economic activities by industry. Effects on relative costs and productivity for various industries were also evaluated in generating total economic growth impacts. Overall impacts were calculated using an input-output model for Ontario based on Statistics Canada data and the inter-industry purchasing patterns from Organization for Economic Cooperation and Development to trace how changes in household spending patterns and business costs flow through the economy, together with econometric equations to represent industry growth responses to price and cost changes ("elasticities"), and effects of regional changes in travel time reliability and labor market access on business productivity over time.

8.1. Steps in the Analysis Process

The analysis process involved three steps:

Step 1: Translate the information regarding electrification Options into specific transportation user changes. Projections of employment and population for the GO region and system improvement/service plans developed in association with the electrification alternatives form the starting basis for this analysis. These projections will incorporate regional growth including growth induced by improved market access. The results of travel demand modeling analysis of these socio-economic and network changes, will form the basis for demand and utilization inputs to the TREDIS framework. With this input for each alternative, this framework will be used to assess time changes (and the value of that time) for forecast on-the-clock and commuter traffic by auto or transit.

Step 2. Analyze the User Impacts to Determine Monetized Costs. The changes in vehicle-hours and vehicle-kilometers of travel are translated into changes in travel time, vehicle operating cost and other out of pocket expenses (transit fares). Ultimately, all of these changes involving either rail or motor vehicle traffic affect business travel, commuting trips and personal trips. Those effects are then translated into changes in the dollar value of total user (time and operating) costs.

Step 3. Derive Economic Impacts from Changes in Costs for the GO study area. Input-Output ratios factors are used to identify how the user impacts are allocated to the regions' households and the regions' industries (as the business cost and productivity implications are differentially incurred). In addition to transportation efficiency cost savings, the direct increases in output or employment associated with land use opportunities at stations will be incorporated at this point. The allocated cost impacts are used to estimate resulting changes throughout the economy in jobs and associated changes in levels of labor income and business output. The economic input-output model will then be used to calculate potential total direct, indirect, and induced business supplier and consumer sales that occur in the rest of the GO Region that stem from the impacts of electrification alternatives. An overview of the framework is presented in Exhibit 11, and a more detailed flow chart is shown below as Exhibit 12.

Table 11 - Overview of TREDIS Framework Components

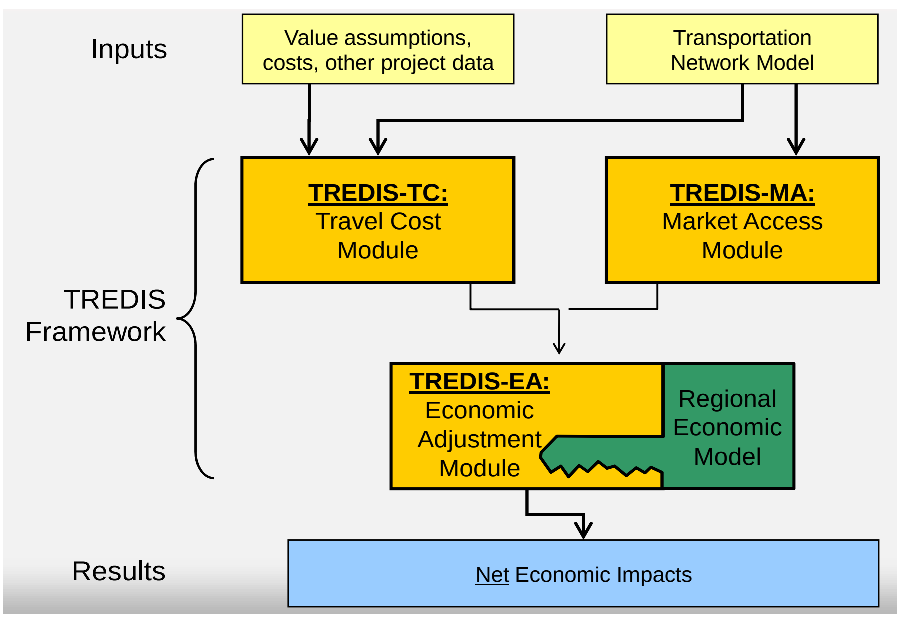

Table 12 – Flow Chart of Transportation Economic Development Impact System (TREDIS)

Access and Cost Pre-Processor
Policy Input: change in Trips, Vehicle-Hours of Travel, Vehicle-Miles (or km) of Travel and accidents; also identification of corridor (directions of access) affected

Given Data: mix of time of travel (peak, off-peak), mode of travel (bus, rail, car, light truck, heavy truck, rail, sea); and spatial patterns of area population & employment (from GIS), mix of commodity flows (optional)

↓

Cost Shift: change in Aggregate Annual Costs of operation by Industry (including household sector)

Access Shift: change in travel time to air, sea, rail terminals, plus change in market size (population, employment within 45-90 min. access)

Other benefits: value of change in personal time & other non-money benefits

↓

Cost Response Module
Input: change in operating cost for existing businesses, by industry
Calculation: change in self-investment, passed on savings to other sectors

Market Access Impact Module
Input: change in size of labor, materials and customer markets, by industry
Calculation: change in operating costs, scale and productivity

↓

Indirect, Induced and Dynamic Impacts Module
Input: direct impacts on business activity, adjusted for double counting
Calculation: indirect impacts from business supplier orders,
induced impacts from worker re-spending of additional wages

↓

Impact/Benefit Post-Processor
Input: change in business sales, jobs & payroll, by industry; also non-money benefits
Calculation: separation of money and non-money impacts on travelers, other users and beneficiaries, and spatial distribution of impacts

8.2. Default Factors used in TREDIS

Factors used in TEDIS calculations are itemized in Exhibit 13.

Table 13 - Economic Factors Used To Model Electrification Options

Economic Impact Modeling Factor	Default Value
Crew Time Cost ($/hr per crew member) – the business cost of labor for professional drivers and paid crew (including cost of wages plus fringe benefits). <See NOTE A>	**Car: $21.60** **Truck: $25.02** **Bus: $22.31** **Rail-transit: $30.84** **Rail-freight: $33.42** **Aircraft: $77.84** **Ship: $42.33**
Average Crew Size (number) **– including professional driver/ pilot and supporting paid crew. (This should be customized for the applicable location and type of vehicles.)** <See NOTE B>	**Car: 0.0** **Truck: 1.2** **Bus: 1.0** **Rail-transit: 2.0** **Rail-freight: 2.0** **Aircraft: 4.7** **Ship: (no default)**
Passenger Time Cost ($/hr per occupant) – the business opportunity cost, or user valuation, of the average passenger's time. This is in addition to the passenger vehicle operating cost per hour. The same values apply for in-vehicle and out-of-vehicle time (except for transit OVTT = out-of-vehicle). <See NOTE C>	**<u>Ground Transport:</u>** ***(car-truck-bus-rail)*** **On-the-Clock: $27.50** **Commute $21.20** ***=user benefit $10.60*** ***+wage premium $10.60*** **Personal: $10.60** ***(transit OVTT $21.20)*** **<u>Air Transport:</u>** **Business $40.10** **Commute $33.30** **Personal $33.30**
Buffer Time Cost ($/hr) – the business opportunity cost, or user valuation, of lost scheduling time due to unreliable travel conditions (i.e., effect of "schedule padding"). <See NOTE D>	**<u>Passenger Modes:</u>** ***Same as above*** **<u>Truck Freight:</u>** **non-mfg goods $0.75** **Non-durable mfg: $2.25** **Durable mfg.: $5.00**

Economic Impact Modeling Factor	Default Value
Average Passenger Occupancy (number) – the total number of occupants excluding professional **driver and supporting paid crew.** (Note: in most cases, the car driver is counted as an occupant and not a crew member.) <See NOTE E>	**Car: 1.5** **Truck: 0** **Bus: 10.5** **Rail-pass: 120** **Rail-freight: 0** **Aircraft: 105** **Ship: (no default)**
Freight Logistics Time Cost ($/hr. per ton) – business opportunity cost of freight delay, including shipper inventory, dock handling & consignee schedule disruption. <See NOTE F>	<u>**Truck & Air only**</u> **non-mfg goods: $0.75** **Non-durable mfg: $1.50** **Durable mfg.: $2.50**
Average Freight Cargo (tons) **– the total number of tons of freight per vehicle** <See NOTE G>	**Truck: non-mfg: 1.0** **Truck: mfg goods: 17.5** **Rail-freight: 3,024** **Aircraft: 4.6** **Ship: 14,000**
Vehicle Mileage-based Operating Cost: Free Flow ($/kilometer) – the average per-mile cost of vehicles' fuel, tires, maintenance, and depreciation for travel in free-flow conditions. <See NOTE H>	Car $0.36 Truck $0.73 Bus $0.90 Train $5.10 Air $10.22 Ship $15.53
Vehicle Mileage-based Operating Cost: Congested ($/kilometer) – the per-KM costs of roadway vehicles operating under congested roadway conditions. <See NOTE I>	Car $0.40 Truck $0.91 Bus $0.96
Vehicle Time-based Operating Cost: ($/hour) – the average per-hour cost of vehicles' fuel, tires, maintenance, and depreciation for travel. <See NOTE J>	**Air: $3,650.00** **Ship: $260.00**
$ per Accident <See NOTE K>	<u>**Cars and Trucks:**</u> **Prop Damage $ 3,160** **Pers. Injury $ 83,520** **Fatality $ 6,000,000** *4)* ***Econ cost $1,221,500*** 5) ***Social adder $4,778,500***

Economic Impact Modeling Factor	Default Value
***Accident Rates*: All rates shown are per 100m Vehicle Kilometers Traveled** <See NOTE L>	Passenger Car /Truck: Prop Damage 128 /198 Pers. Injury 56/7 Fatality 0.93 /0.25 Public Transit: Pers. Injury 364 Fatality 5 Air Travel: Pers. Injury 0.114 Fatality 0.007
Environmental Cost: Mileage-Based ($/vkt) — cost of air pollution and greenhouse gases per vehicle-kilometer of travel ***<see NOTE M>***	**Car: $0.02** **Truck: $0.03**

Note A: Crew wages are drawn from the BLS National Compensation Survey (issued June 2007) for applicable transport occupations, with 40% added for fringe benefits (national average in those occupations). Values for truck drivers, bus drivers and train engineers are published BLS values for those occupations, plus fringe benefits. Values for aviation are based on weighted average of $34.11/hr. for flight attendants and $94.47/hr. for pilots, plus fringe. Values for marine (ferry or freighter) are based on weighted average of $13.11 for sailors and $30.04 for ship engineers, plus fringe. Source: http://www.bls.gov/ncs/ocs/sp/ncbl0910.pdf

Note B: Default crew size for all modes are drawn from typical values for New York City, San Francisco and Chicago, as reported in Chester, Mikhail, Institute of Transportation Studies, UC Berkeley, 2008.

Note C: Values of time shown here are generally consistent with methods for valuing *user travel time benefits* as followed by HERS and BCA.Net software, as well as CUTR and USDOT guidance. However, values have also been updated to reflect 2007 wage rates (average of all occupations, not just transport occupations), based on BLS wage data. Also, additional long-term business costs (beyond the user value of travel time) have been added in the form of fringe benefit costs for "on-the-clock travel" and wage premiums paid by employers for commuting in higher-cost congested areas. As a result, car/light truck "on-the-clock" travel time is calculated as a business cost valued at 100% of the national average wage rate plus 30% fringe. Both commuting and personal travel time are treated as a non-money user benefit with a value set at 50% of the wage rate (no fringe added). For economic impact analysis only, there is an additional allowance for the effect of higher commuting cost on employer cost in the form of a wage rate premium valued at another 50% of the wage rate per hour without fringe (per research by Zax et al.). For public transit, the wider range reflects possible variation in riding conditions, as noted by CUTR: "*Transit travel time should be valued at 25-35 percent of prevailing wage under comfortable conditions (when sitting), but can be significantly higher for crowded transit vehicles (100% of wage rate) or for waiting under unpleasant conditions (up to175% of wage rate)*." For out-of-vehicle transit time, TREDIS uses 100% of the wage rate, but allows for a wider range of values.

Note D: The costs of travel time variability (non-recurring delay) is calculated using the concept of "buffer time", which is defined as the additional schedule time needed to ensure an on-time arrival 95% of the time (19 out of every 20 trips) versus the average travel time. For example, If a weekday commute normally (i.e., on average) takes 30 minutes to complete, but unplanned congestion causes 5% of trips (about 1 per month) to take 45 minutes, then the commuter must schedule 45 minutes for the trip on the average day to ensure an on-time arrival (even though it is likely to only to take 30 minutes). This trip therefore requires 15 minutes of "buffer time". For passenger travel, buffer time has been shown to be valued similarly to travel time unless a schedule constraint exists (see CUTR). For Freight Trucks, the value of buffer time can vary widely for carrier types and commodity, but is generally higher than passenger travel (relative to travel time). USDOT reports that the value of reliability can vary from 20% to 250% of "standard" delay (http://ops.fhwa.dot.gov/freight/documents/improve_econ.pdf).

Note E: Typical passenger loadings for all modes are drawn from typical values for New York City, San Francisco and Chicago, as reported in Chester, Mikhail, Institute of Transportation Studies, UC Berkeley, 2008.

Note F: Freight logistics cost is estimated on the basis of values assigned for recurring travel time delay from HEAT documentation, based on literature review and additional research by Cambridge Systematics and EDR Group. These logistics cost values, added to crew cost and vehicle operating cost, yield total freight costs per hour in line with TTI congestion studies.

Note G: Typical Cargo loadings for trucks come from the USDOT Comprehensive Truck Size and Weight Study; data for rail is from the Association of American Railroads www.aar.org/PubCommon/Documents/AboutTheIndustry/Statistics.pdf ; data for water transport is based on 1000 TEUs per ship at 14 tons per TEU from InfoMare and NY/NJ port; data for air transport from Bureau of Transportation Statistics.

Note H: Vehicle operating cost per mile: for free flow conditions is defined for cars as an average of small, medium and large cars and SUV; source AAA. Truck cost is based on FHWA Truck Size and Weight Study, with cost/mile ranging from $1.03 - $1.38 depending on speed. Converted to kilometers.

Note I: Vehicle operating cost per mile: for congested road conditions is based on auto fuel consumption estimates from US EPA and truck fuel consumption estimates from Berwick and Farooq (2003), using an assumptions of stop-and-go travel conditions (as defined by US EPA at www.fueleconomy.gov and with a long-term (30-year) fuel cost of $4.00 per gallon. Converted to kilometers

Note J: Per hour operating cost is to be used for modes where vehicle operating cost is most easily measurable on a time-basis (air and marine). The operating cost/hour for water freight cost/mile ranges from $242/hour for 11,000 ton vessel to $491/hour for 265,000 ton vessel; default represents a 90,000 ton vessel. 2008. Airline costs are from www.airlines.org/economics/cost+of+delays/

Note K: Accident costs are derived from the following sources: total fatality cost including both money costs and social value of lost life (lifetime earnings) is from "Treatment of the Economic Value of a Statistical Life in Departmental Analysis – 2009 Annual Revision," USDOT, Memorandum to Modal Administrators, March 18, 2009.
http://ostpxweb.dot.gov/policy/reports/VSL%20Guidance%20031809%20a.pdf

Detailed values for injury and property damage are drawn from Blincoe, L. et al. (2002). *The Economic Cost of Motor Vehicle Crashes, 2000* (Table 2) and then updated from 2000 dollars to 2008 dollars by the CPI change (25%). http://thedesignstate.com/wp-content/uploads/2009/04/economicimpact2000.pdf The difference between total fatality valuation and fatality cost is attributed to social valuation of lost life.

Note L: Accident rates are from Bureau of Transportation Statistics: Converted to kilometers http://www.bts.gov/publications/national_transportation_statistics/#chapter_2

Note M: Environmental costs per VMT can include a wide variety of air pollution, water pollution, noise pollution and land quality/use impacts. However, the default values shown here include only costs associated with air pollutants defined by the Clean Air Act (NOx - nitrogen oxides, SO_2 - sulfur dioxide, PM - particulate matter and VOC - volatile organic compounds) plus greenhouse gases .

For the Clean Air Act pollutants, the total cost per VMT is estimated to be 1.1c for cars and 3.9c for large trucks (source: FHWA: *1997 Federal Highway Cost Allocation Study Final Report Addendum*, Federal Highway Administration, USDOT, 2000, Table 12. For greenhouse gases, the total cost per VMT is estimated to be 1.7c for cars and 2.4c for trucks based on Littman (Todd Littman: "Climate Change Emission Valuation for Transportation Economic Analysis," VTPI, 2009 and drawing from *Transportation Energy Data Book*, Oak Ridge National Laboratory, 2008). Also shown in Table 5.10.7-2 of Littman: Transportation Cost and Benefit Analysis II – Air Pollution Costs, Victoria Transport Policy Institute, updated 2009. Note that there are also some studies that have derived values based on changing market values for emission credits; these sources have been used to derive estimates as high as 5c per VMT for cars and 26c/vmt for trucks. Converted to kilometers.