ELECTRIFYING TORONTO'S TRANSPORTATION: SOONER AND LATER

Richard Gilbert

Presentation to the
Greater Toronto Transportation Conference
November 26, 2010

Enquiries to mail@richardgilbert.ca
More information about the presenter is at
www.richardgilbert.ca

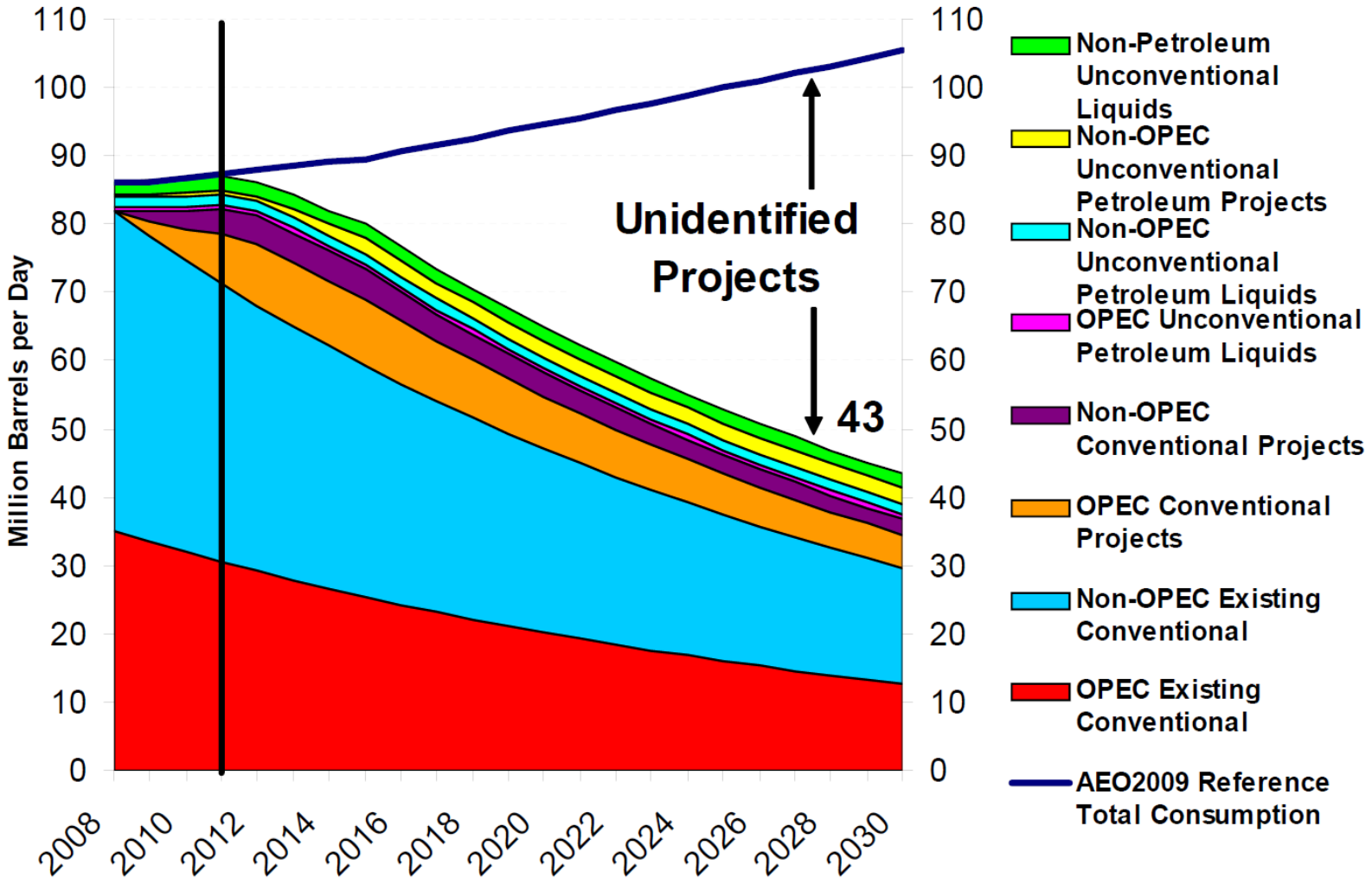
SOONER AND LATER?

‘SOONER’ REFERS TO A PROPOSED REFASHIONING OF TRANSIT CITY TO ACHIEVE MORE ELECTRIFICATION WITHIN THE SAME BUDGET.

‘LATER’ REFERS TO THE LONGER LOOK AT ELECTRIFICATION THAT CONCLUDES THIS PRESENTATION.

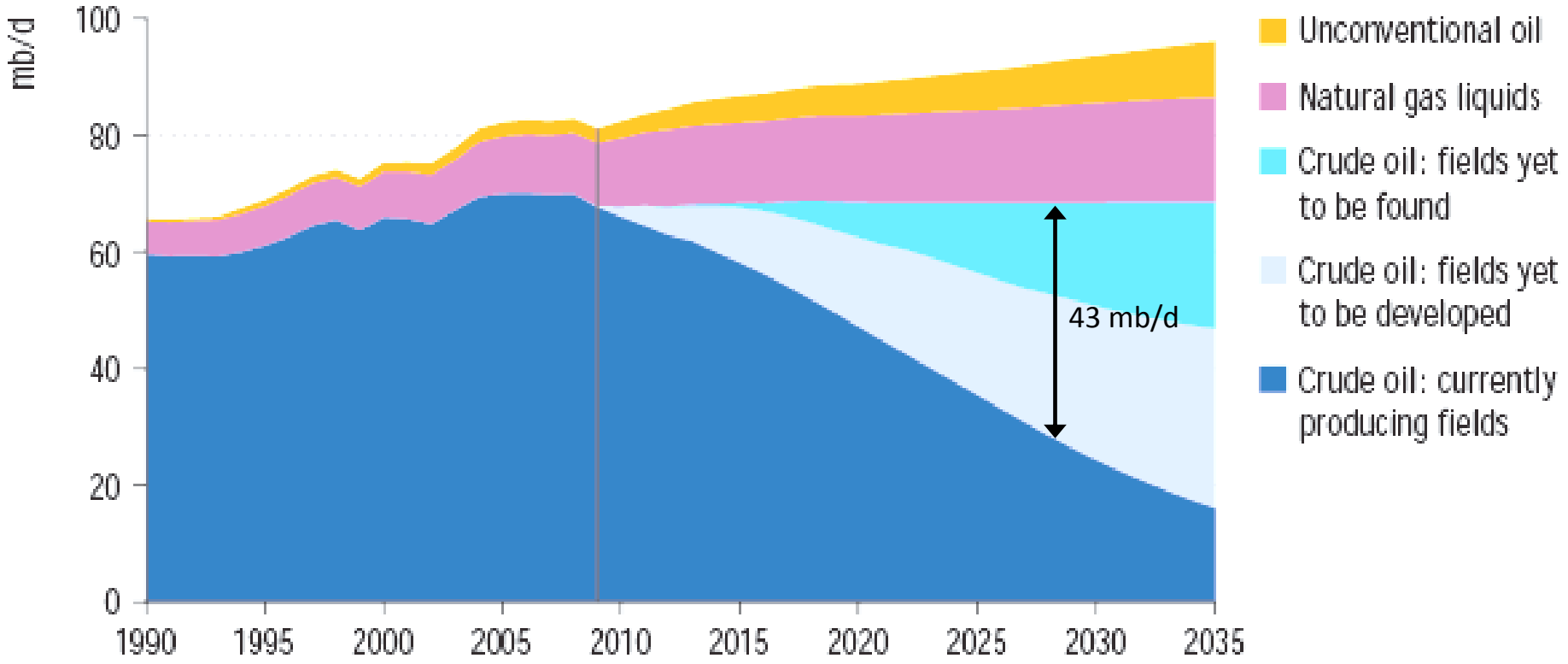
FIRST, SOME REMINDERS OF OUR OIL PREDICAMENT

FIRST OF TWO SIMILAR INDICATIONS THAT THE WORLD OF OIL IS ABOUT TO CHANGE:
a huge gap in anticipated supply in relation to expected demand



Source: US Energy Information Administration, April 2009

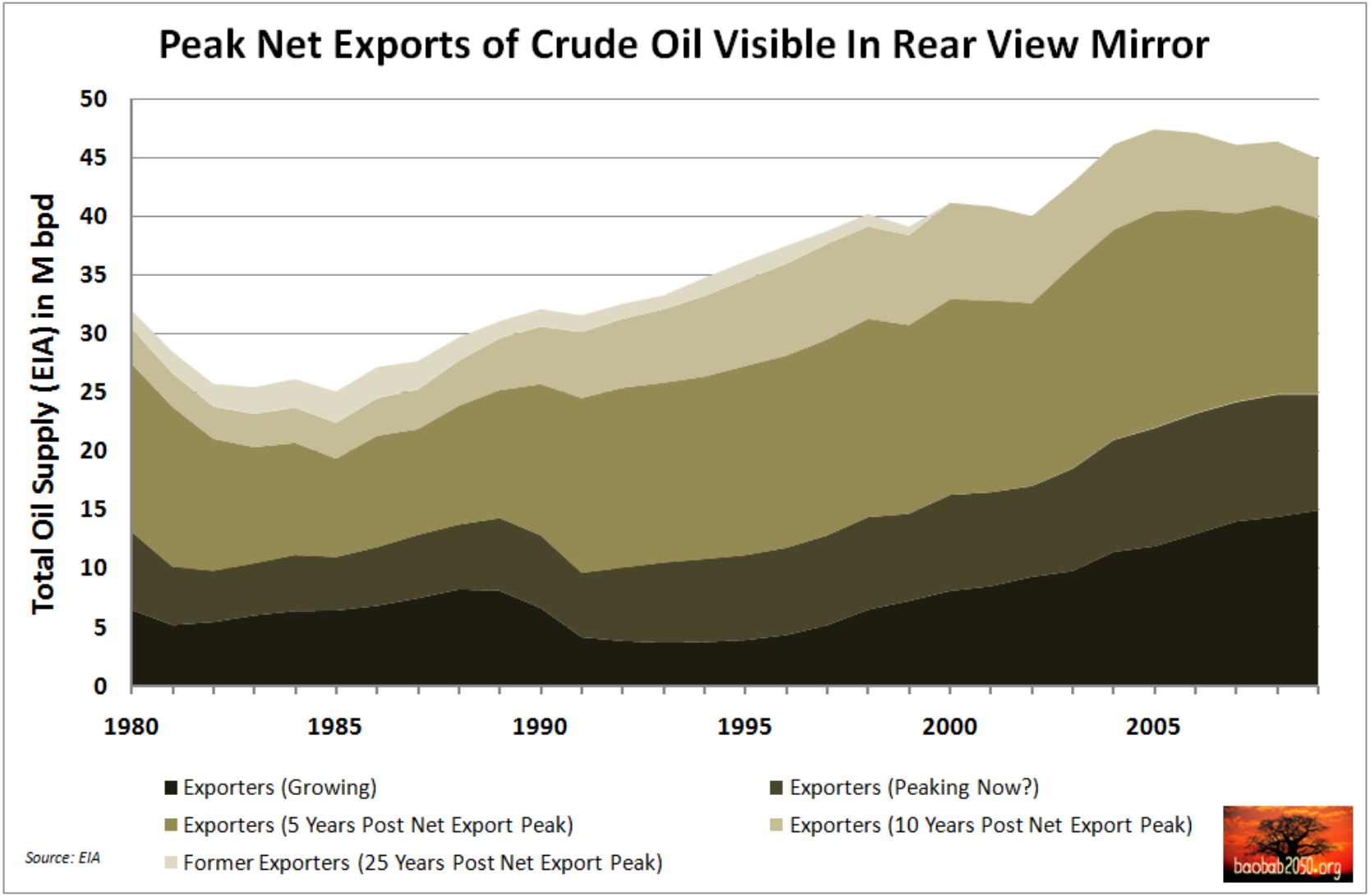
SECOND SIMILAR INDICATION THAT THE WORLD OF OIL IS ABOUT TO CHANGE:
a huge gap in anticipated supply in relation to expected demand



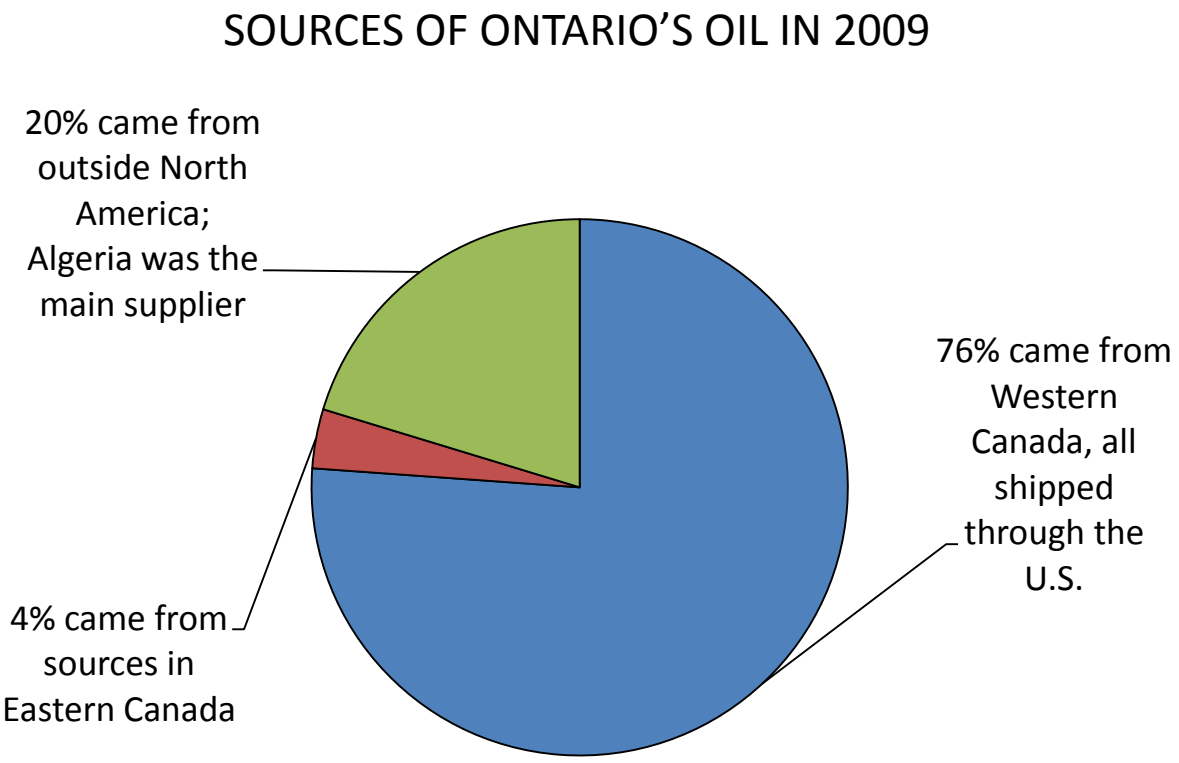
Source: International Energy Agency, World Energy Outlook, 2010 (Figure 3.19)

Shortfalls in millions of barrels per day: 43 in 2028; 45 in 2030; 52 in 2035

A THIRD INDICATION THAT THE WORLD OF OIL IS ABOUT TO CHANGE: production of petroleum liquids may not have peaked yet, but exports have



A special oil challenge for Ontario



Ontario has no stockpiled oil

Every nation except Canada maintains substantial stockpiles of oil to protect against interruptions in supply

There is always optimism

The New York Times

Tuesday, November 16, 2010

There Will Be Fuel

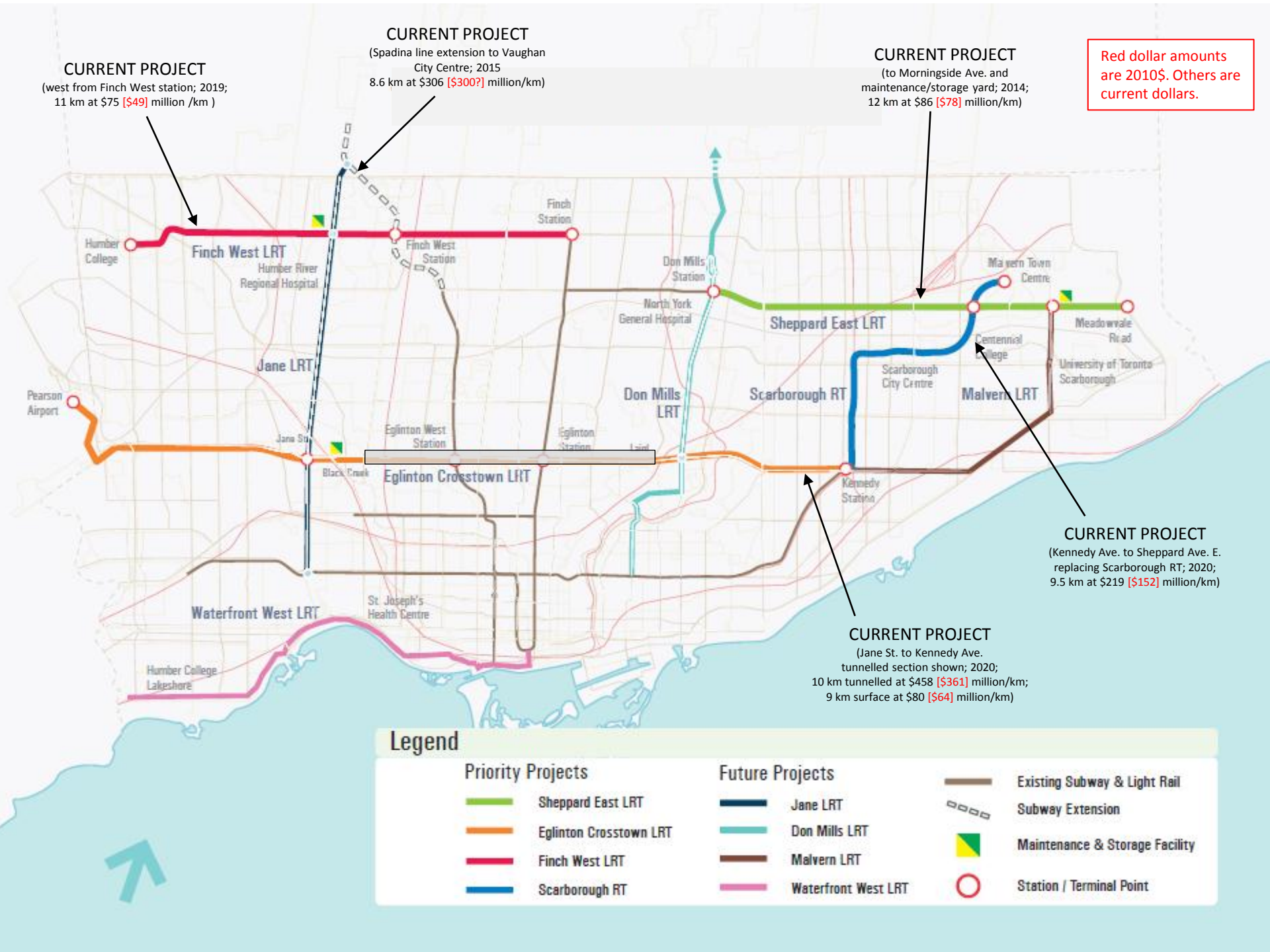
NO SHORTAGE A Chesapeake Energy natural gas well near Burlington, Pa. Experts say the nation has gas reserves for 100-plus years.

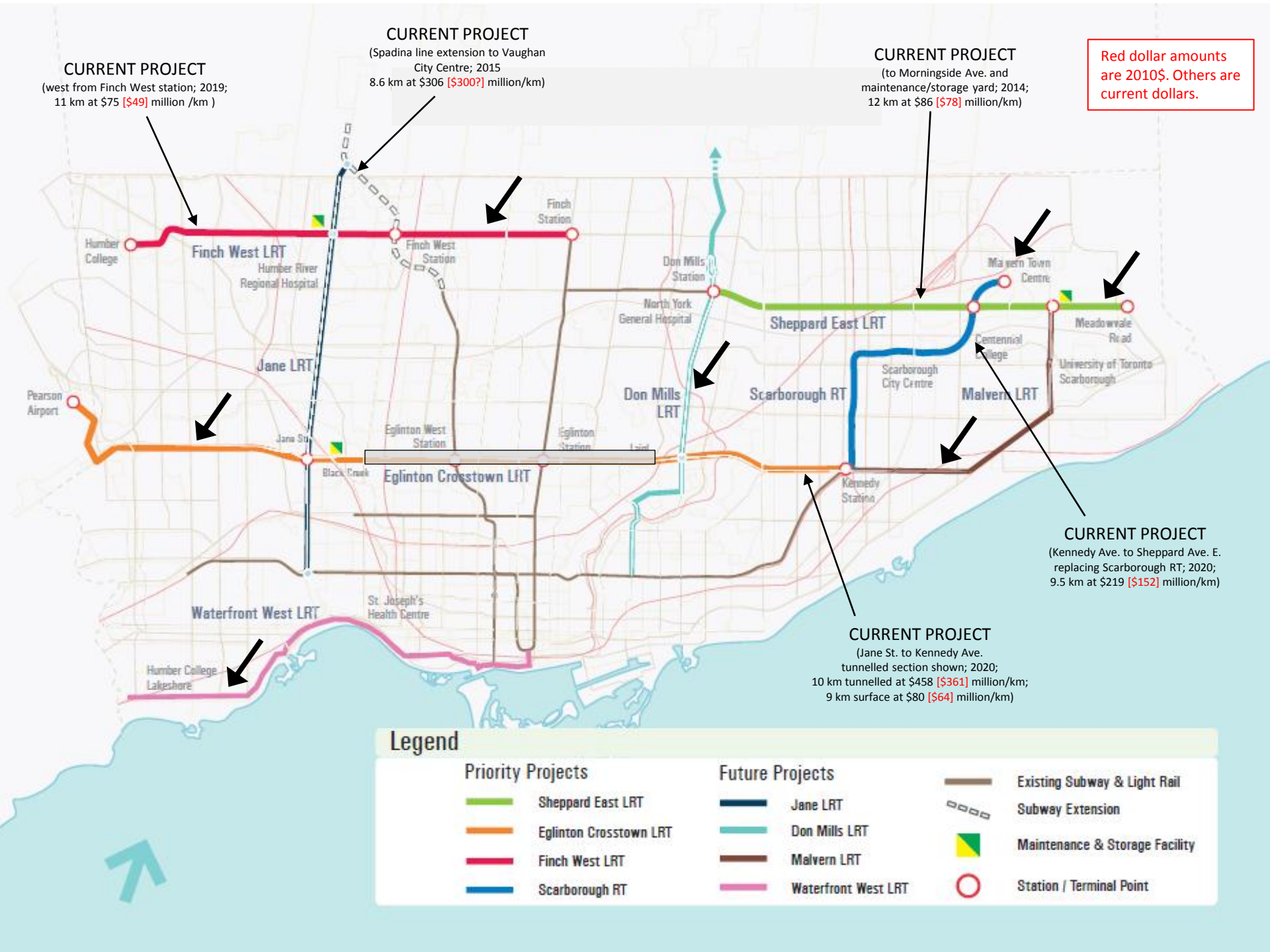
Ralph Wilson/Associated Press

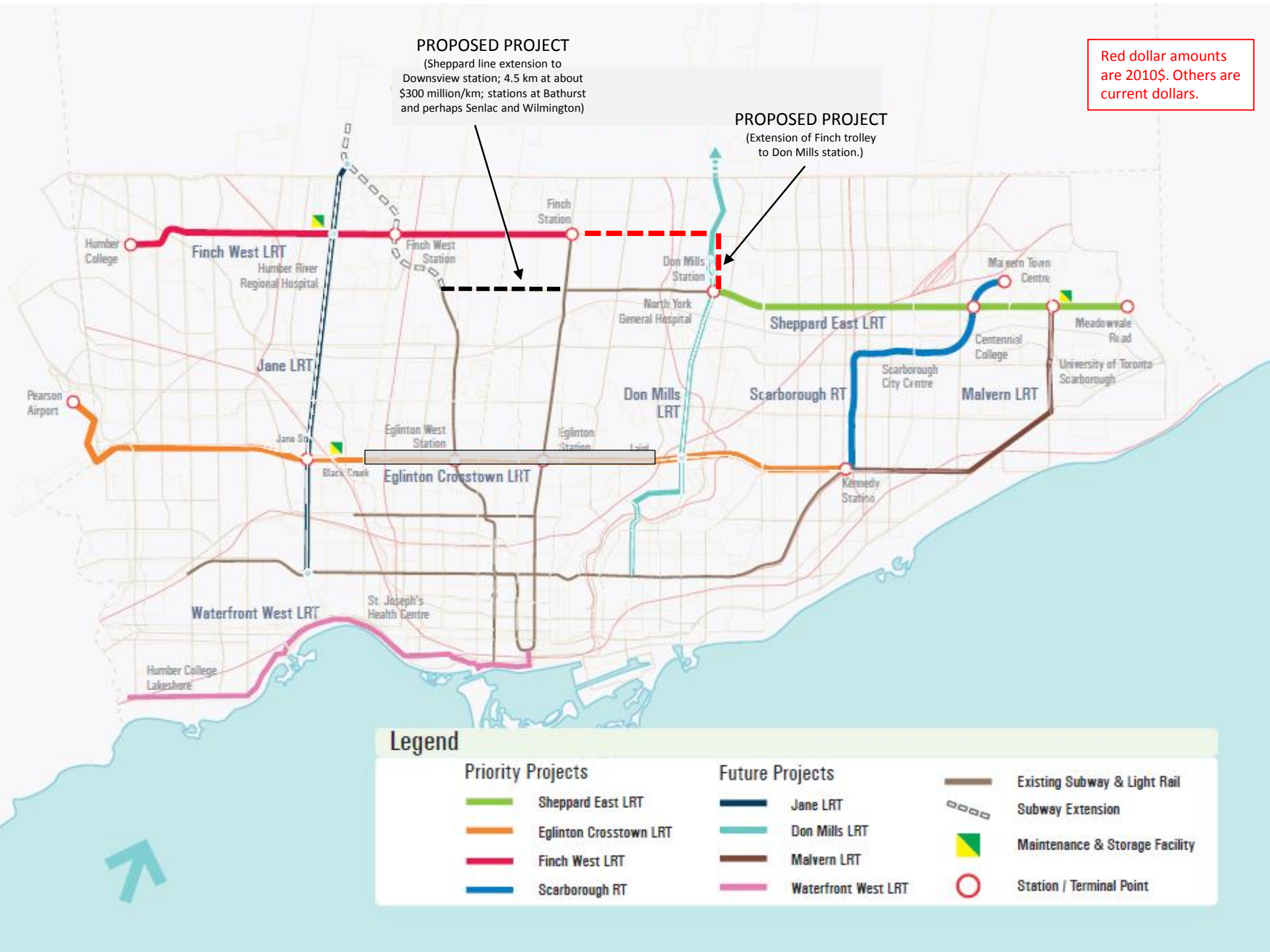
By CLIFFORD KRAUSS

NEW OIL SUPPLIES Pipes await use at the Devon Jackfish oil sands drilling project, left, under construction in Alberta, Canada. The country's oil sands supply more oil for North America than Saudi Arabia does. THREE summers ago, the world's supertankers were racing across the oceans as fast as they could to deliver oil to markets growing increasingly thirsty for energy. Americans were grumbling about paying as much as $4 a gallon for gasoline, as the price of crude oil leapt to $147 a barrel. Natural gas prices were vaulting too, sending home electricity bills soaring.

ELECTRIFYING TORONTO'S TRANSPORTATION SOONER: REFASHIONING TRANSIT CITY


CURRENT PROJECT
(west from Finch West station; 2019;
11 km at $75 [$49] million /km)
CURRENT PROJECT
(Spadina line extension to Vaughan
City Centre; 2015
8.6 km at $306 [$300?] million/km)
CURRENT PROJECT
(to Morningside Ave. and
maintenance/storage yard; 2014;
12 km at $86 [$78] million/km)
Red dollar amounts are 2010$. Others are current dollars.
Humber College
Finch West LRT
Humber River Regional Hospital
Finch West Station
Finch Station
Don Mills Station
North York General Hospital
Sheppard East LRT
Malvern Town Centre
Meadowvale Road
Centennial College
Scarborough City Centre
University of Toronto Scarborough
Jane LRT
Pearson Airport
Don Mills LRT
Scarborough RT
Malvern LRT
Jane St.
Eglinton West Station
Eglinton Station
Black Creek
Eglinton Crosstown LRT
Kennedy Station
CURRENT PROJECT
(Kennedy Ave. to Sheppard Ave. E.
replacing Scarborough RT; 2020;
9.5 km at $219 [$152] million/km)
Waterfront West LRT
St. Joseph's Health Centre
Humber College Lakeshore
CURRENT PROJECT
(Jane St. to Kennedy Ave.
tunnelled section shown; 2020;
10 km tunnelled at $458 [$361] million/km;
9 km surface at $80 [$64] million/km)
Legend
Priority Projects
Sheppard East LRT
Eglinton Crosstown LRT
Finch West LRT
Scarborough RT
Future Projects
Jane LRT
Don Mills LRT
Malvern LRT
Waterfront West LRT
Existing Subway & Light Rail
Subway Extension
Maintenance & Storage Facility
Station / Terminal Point


CURRENT PROJECT
(west from Finch West station; 2019;
11 km at $75 [$49] million /km)
CURRENT PROJECT
(Spadina line extension to Vaughan
City Centre; 2015
8.6 km at $306 [$300?] million/km)
CURRENT PROJECT
(to Morningside Ave. and
maintenance/storage yard; 2014;
12 km at $86 [$78] million/km)
Red dollar amounts are 2010$. Others are current dollars.
Humber College
Finch West LRT
Humber River Regional Hospital
Finch West Station
Finch Station
Don Mills Station
North York General Hospital
Sheppard East LRT
Meadowvale Road
Centennial College
Scarborough City Centre
University of Toronto Scarborough
Jane LRT
Pearson Airport
Don Mills LRT
Scarborough RT
Malvern LRT
Jane St
Eglinton West Station
Eglinton Station
Black Creek
Eglinton Crosstown LRT
Kennedy Station
CURRENT PROJECT
(Kennedy Ave. to Sheppard Ave. E.
replacing Scarborough RT; 2020;
9.5 km at $219 [$152] million/km)
Waterfront West LRT
St. Joseph's Health Centre
Humber College Lakeshore
CURRENT PROJECT
(Jane St. to Kennedy Ave.
tunnelled section shown; 2020;
10 km tunnelled at $458 [$361] million/km;
9 km surface at $80 [$64] million/km)
Legend
Priority Projects
Sheppard East LRT
Eglinton Crosstown LRT
Finch West LRT
Scarborough RT
Future Projects
Jane LRT
Don Mills LRT
Malvern LRT
Waterfront West LRT
Existing Subway & Light Rail
Subway Extension
Maintenance & Storage Facility
Station / Terminal Point


PROPOSED PROJECT
(Sheppard line extension to Downsview station; 4.5 km at about $300 million/km; stations at Bathurst and perhaps Senlac and Wilmington)
PROPOSED PROJECT
(Extension of Finch trolley to Don Mills station.)
Red dollar amounts are 2010$. Others are current dollars.
Humber College
Finch West LRT
Humber River Regional Hospital
Finch West Station
Finch Station
Don Mills Station
North York General Hospital
Sheppard East LRT
Meadowvale Road
Centennial College
Scarborough City Centre
University of Toronto Scarborough
Jane LRT
Don Mills LRT
Scarborough RT
Malvern LRT
Pearson Airport
Jane St
Eglinton West Station
Eglinton Station
Black Creek
Eglinton Crosstown LRT
Kennedy Station
Waterfront West LRT
St. Joseph's Health Centre
Humber College Lakeshore
Legend
Priority Projects
Sheppard East LRT
Eglinton Crosstown LRT
Finch West LRT
Scarborough RT
Future Projects
Jane LRT
Don Mills LRT
Malvern LRT
Waterfront West LRT
Existing Subway & Light Rail
Subway Extension
Maintenance & Storage Facility
Station / Terminal Point

One of Vancouver's 228 new trolleybuses

(made in Winnipeg; 40 are articulated)

Trolleybus capital costs per two-way kilometre

(based on the system installed in Landskrona, Sweden, in 2003)

Item	Actual cost/km in millions of Swedish krona in 2003	In 2010 Can$ (tripling bus capacity)
Wires and poles	5.6	1.1
Substation	1.2	0.2
Vehicles*	5.1	3.1
Other	1.7	0.3
Totals	**13.6**	**4.7**

*Landskrona initially provided one single-unit (29 seated, 41 standing, low-floor) trolleybus per two-way route-km, enough for an average 8.5-minute headway. The proposal for Toronto would provide three times this capacity.

A new plan for Transit City that stays within the current budget, adds two subway lines, and completes the whole program (rather than less than half of it) by 2020

Current implementation 2010-2020	Cost in mill. of 2010$		Proposed implementation 2010-2020	Cost in mill. of 2010$	Note
Sheppard LTR (Ph. 1)	1,030		Sheppard LRT	1,240	Both phases
Eglinton LTR (tunnelled)	3,610		Eglinton subway	3,000	Use Spadina per-km cost
Eglinton LRT (surface, Ph. 1)	576		Eglinton trolleys (east, west)*	115	All phases
Scarborough LRT (Ph. 1)	1,445		Scarborough trolley*	50	LRT is too much per km
Finch LRT (Ph. 1)	535		Finch trolley*	110	To Don Mills station
			Sheppard subway extension	1,410	Use Spadina per-km cost
			Jane trolley*	85	
			Don Mills trolley*	90	
			Malvern LRT	720	Use Finch per-km cost
			West Waterfront LRT ?	376	Balance of funds
Total	**7,196**		**Total**	**7,196**	

*Trolleybus system costs have been estimated at $5.0 million per route-kilometre, following previous slide

How has this been done?

Unchanged: Sheppard E. LRT (Ph. 1) including yard (12 km)

Delete: Eglinton LRT, Finch LRT, Scarborough LRT (40 km).....-$6,166 mill.

Add: Sheppard E. LRT (Ph. 2), Malvern LRT,
and West Waterfront LRT (27 km).....+$1,306 mill.

Add: Sheppard West subway, Eglinton subway (14 km).....+$4,410 mill.

Add: Eglinton (E. and W.) trolleys, Scarborough trolley,
Finch trolley (to Don Mills), Jane trolley,
Don Mills trolley (83 km).....+$450 mill.

TOTAL CHANGE.....$0

Note: Cost of trolleybus maintenance and storage yards is not included.
(Existing bus yards can be converted at relatively little cost.)

Issues in refashioning Transit City

Too many LRT vehicles are on order.
Negotiate with Bombardier to replace some of these with subway cars.

Tunnelling machines ordered for Eglinton.
To be bored to subway specifications anyway.

Tunnelling machines needed for the Sheppard extension.
Use the machines being used for the Spadina extension.

Trolleybuses take up roadway.
But perhaps less roadway than LRT, even on own rights-of-way.

Parts of Eglinton and Sheppard must be massively redeveloped to justify a subway.
True. Start now; be very generous to neighbourhoods and property owners. (Some redevelopment should in any case be planned to justify LRT.)

The provincial government won't agree to a change in plan.
The province will likely agree with what Toronto wants unless it costs more, is less cost-effective or results in undue delay.

Capital costs can be huge

Current estimated cost of Eglinton LRT is $4.186 billion in 2010$.

Annual ridership along Eglinton is projected to be 52 million/year.

Annual cost of $4.186 billion over 35 years at 4% is about $222.2 million.

Thus, capital cost per Eglinton LRT ride is about $4.25. (Plus an operating cost of perhaps $2.00/ride.)

With installation of a subway, *and appropriate development*, the capital cost per ride could perhaps be reduced to about $1.00 per ride (presumes about four times the ridership).

Development must be subway-related

There is much recent and ongoing development along Sheppard Avenue East.

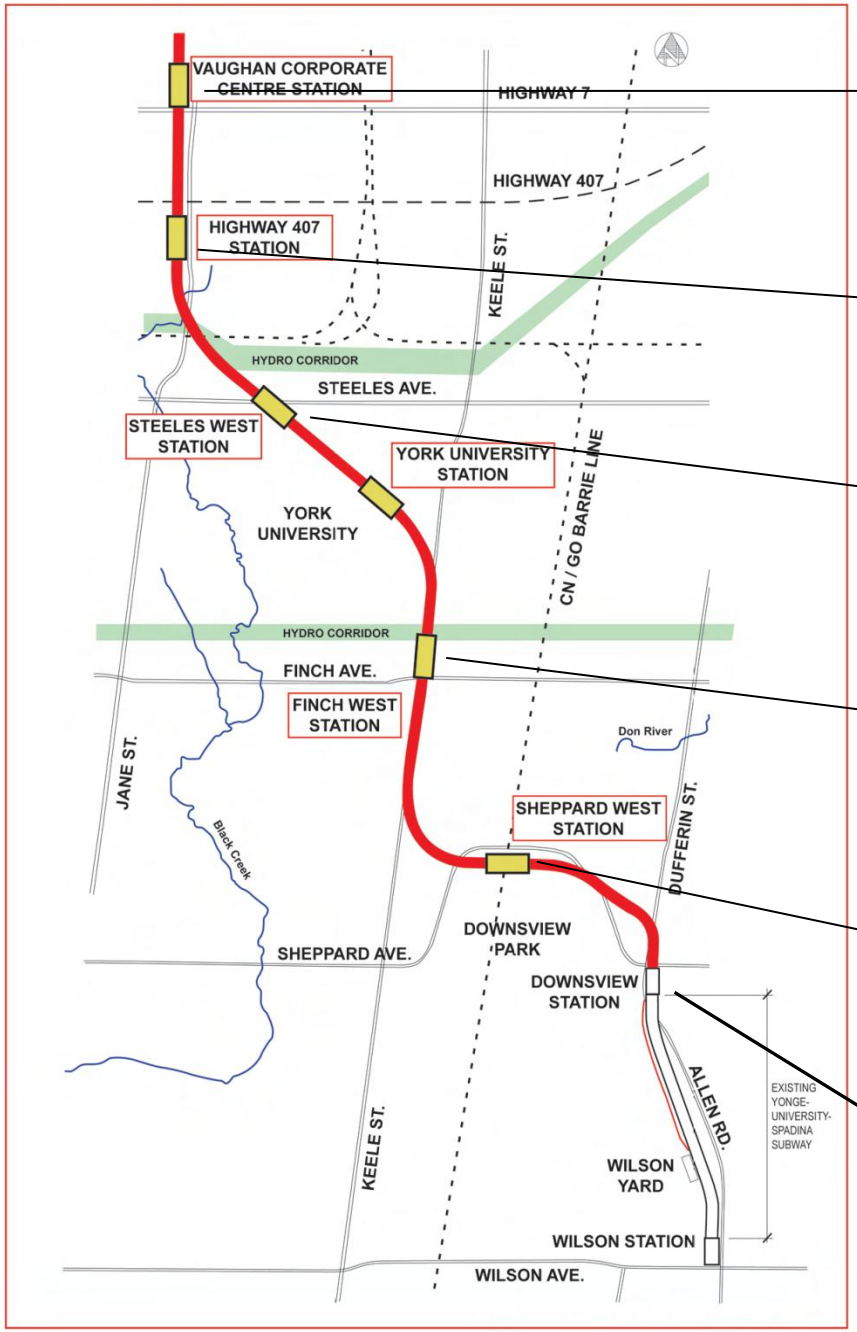
Relative ridership on the Sheppard line is not increasing.

It was 4.0% of the ridership on the YUS and BD lines in 2007-2008.

It was 3.9% of the ridership on these lines in 2009-2010.

For the most part, the new development is not subway-related.

Along the Spadina extension

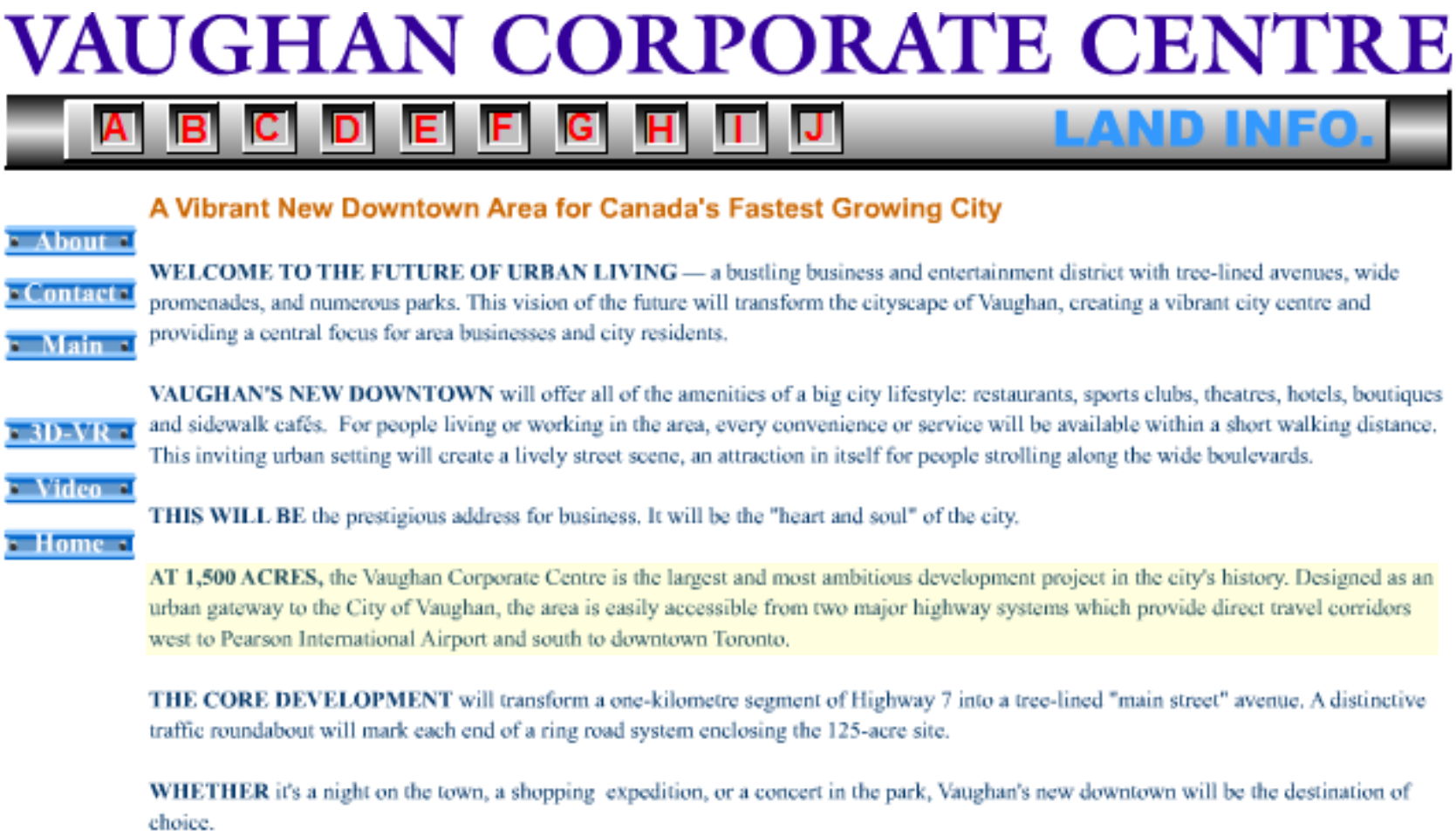


Toronto-York Spadina Subway Extension

Vaughan Corporate Centre station location

click here to return to slide show

Development at Vaughan Corporate Centre ignores the subway



VAUGHAN CORPORATE CENTRE

A B C D E F G H I J LAND INFO.

A Vibrant New Downtown Area for Canada's Fastest Growing City

About
Contact
Main
3D-VR
Video
Home

WELCOME TO THE FUTURE OF URBAN LIVING — a bustling business and entertainment district with tree-lined avenues, wide promenades, and numerous parks. This vision of the future will transform the cityscape of Vaughan, creating a vibrant city centre and providing a central focus for area businesses and city residents.

VAUGHAN'S NEW DOWNTOWN will offer all of the amenities of a big city lifestyle: restaurants, sports clubs, theatres, hotels, boutiques and sidewalk cafés. For people living or working in the area, every convenience or service will be available within a short walking distance. This inviting urban setting will create a lively street scene, an attraction in itself for people strolling along the wide boulevards.

THIS WILL BE the prestigious address for business. It will be the "heart and soul" of the city.

AT 1,500 ACRES, the Vaughan Corporate Centre is the largest and most ambitious development project in the city's history. Designed as an urban gateway to the City of Vaughan, the area is easily accessible from two major highway systems which provide direct travel corridors west to Pearson International Airport and south to downtown Toronto.

THE CORE DEVELOPMENT will transform a one-kilometre segment of Highway 7 into a tree-lined "main street" avenue. A distinctive traffic roundabout will mark each end of a ring road system enclosing the 125-acre site.

WHETHER it's a night on the town, a shopping expedition, or a concert in the park, Vaughan's new downtown will be the destination of choice.

The above is from the City of Vaughan Web site, November 2010

click here to read shaded paragraph

Description from the City of Vaughan's Web site

AT 1,500 ACRES, the Vaughan Corporate Centre is the largest and most ambitious development project in the city's history. Designed as an urban gateway to the City of Vaughan, the area is easily accessible from two major highway systems which provide direct travel corridors west to Pearson International Airport and south to downtown Toronto.

At 1,500 acres, the Vaughan Corporate Centre is the largest and most ambitious project in the city's history. Designed as an urban gateway to the City of Vaughan, the area is easily accessible from two major highway systems which provide direct travel corridors west to Pearson International Airport and south to downtown Toronto.

click here to return to slide show

Metrolinx has estimated residents or jobs at three Spadina extension stations in 2031 (adjusted to within 600-metre radius of station)

Station	Residents or jobs
Vaughan Corporate Centre	15,000
Steeles West	12,000
Finch West	12,000

My rough estimate of residents/jobs needed within 600 metres of each station for a subway line to pay its way ≈ 40,000 (per km^2).
(See 2006 *Toronto Star* article in next slide.)

Also see Lo et al (2008, p46): "Our rough estimate was that a minimum population density of 31,500/km^2 was essential to achieve breakeven operations."

TORONTO STAR
www.thestar.com

Building subways without subsidies

Aug. 28, 2006. 01:00 AM
RICHARD GILBERT

Transit subsidies are relatively new. The TTC functioned without capital subsidies until the 1960s, and without regular operating subsidies until the 1970s. The initial section of the Yonge line, opened in 1954, was funded almost entirely from the fare box, as were much of the University line and the initial section of the Bloor-Danforth line, opened in 1966.

Now, operating subsidies are expected, and so are even larger capital subsidies, especially for new subway lines.

Several things have changed. The most important is that, compared with the 1950s, the TTC now provides twice as much service for every 100 passengers it carries (about 47 vehicle-kilometres of service in 2004, compared with 23 in 1954).

In the 1950s, service was mostly in the denser, inner parts of Toronto. Since then, it has

Hong Kong shows that subways can be built and operated without subsidy (if densities are high enough).

Familiar image of Hong Kong

But, much of it is like this (no subway here)

Or like this

click here to return to slide show

Opportunities for development along an Eglinton subway line

Eglinton and Keele

Opportunities for development along an Eglinton subway line

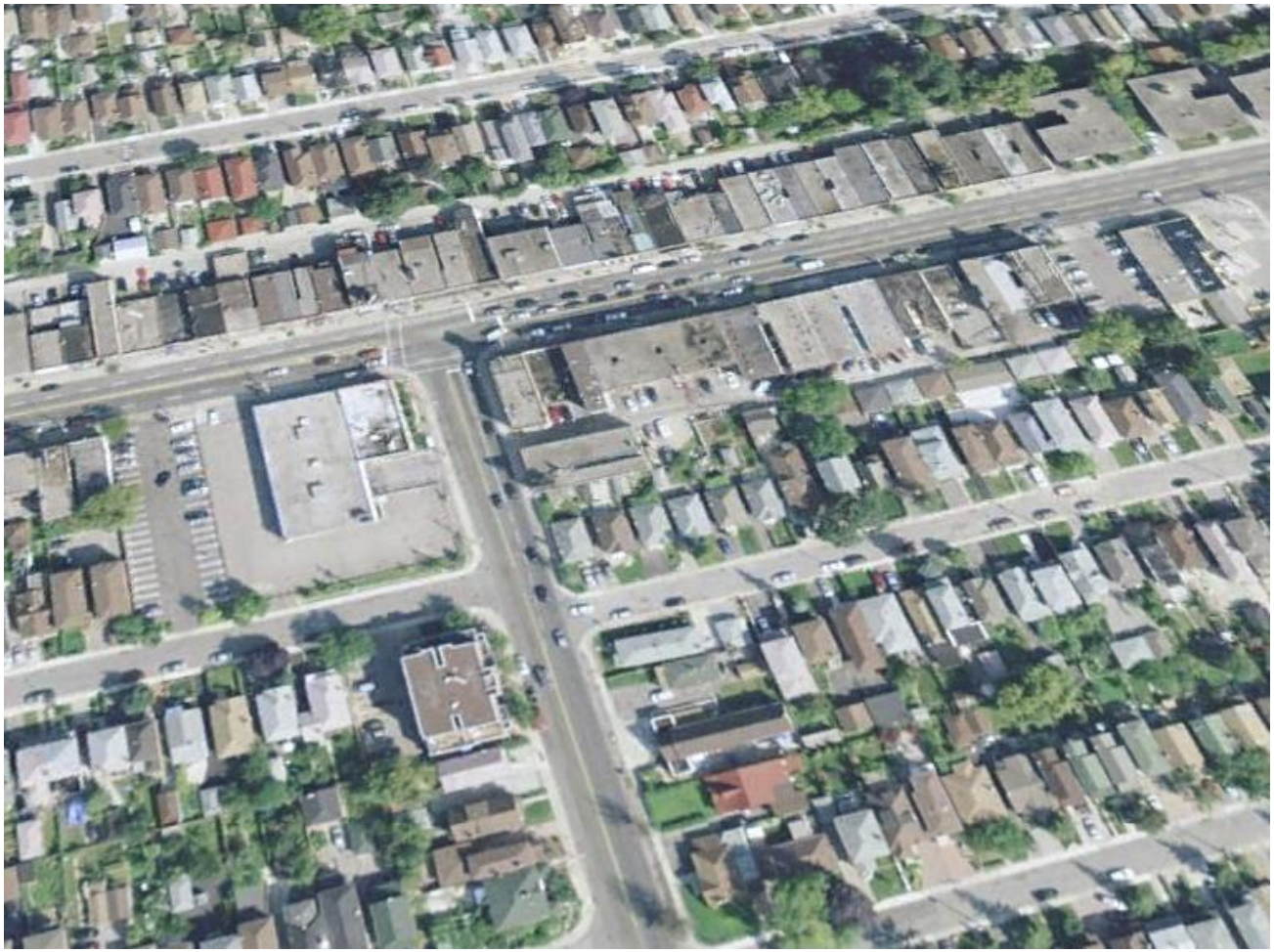
Eglinton and Caledonia

Opportunities for development along an Eglinton subway line

Eglinton and Dufferin

Opportunities for development along an Eglinton subway line

Eglinton and Oakwood

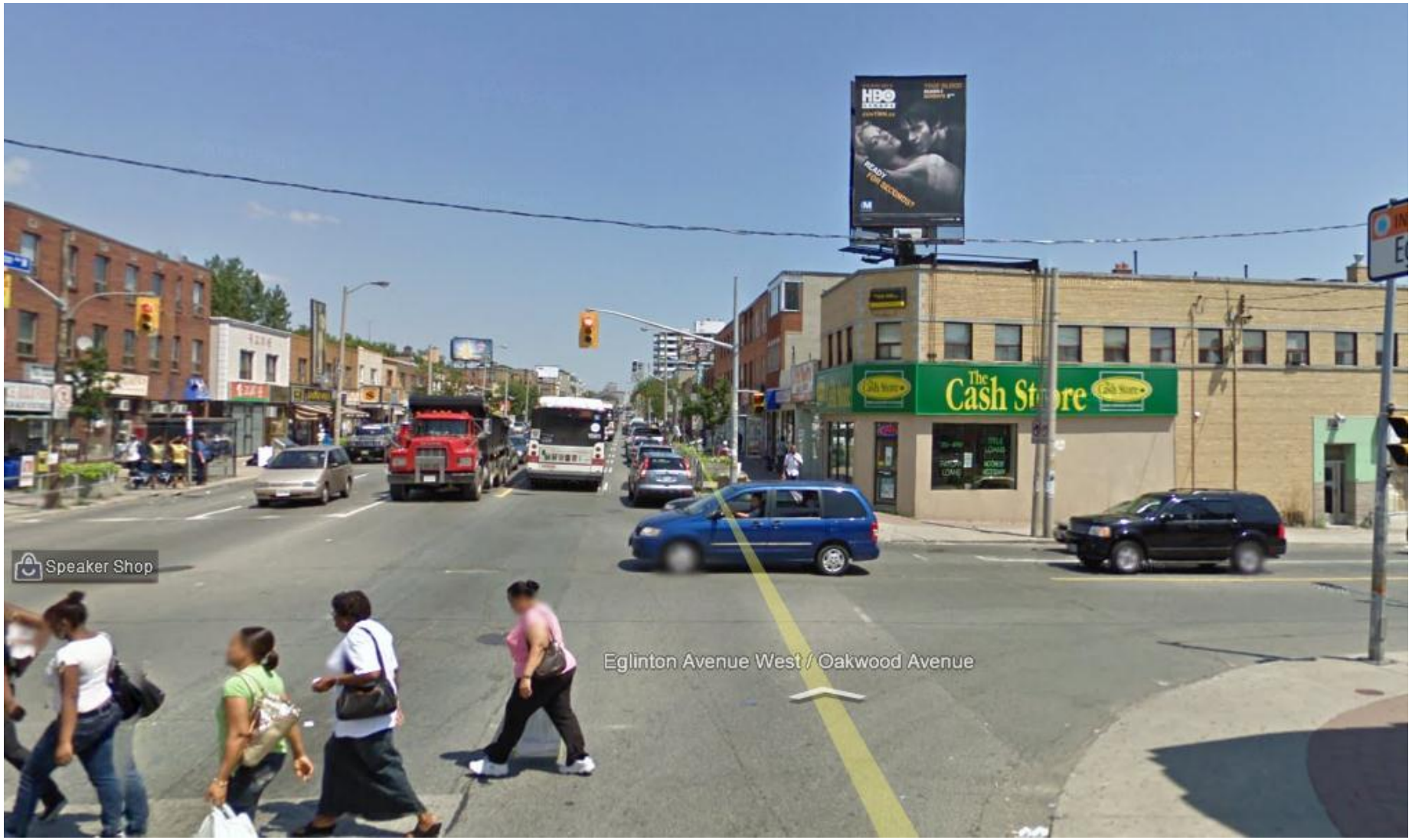


Opportunities for development along an Eglinton subway line

Eglinton and Oakwood (looking south)

Opportunities for development along an Eglinton subway line

Eglinton and Oakwood (looking east)



Opportunities for development along an Eglinton subway line

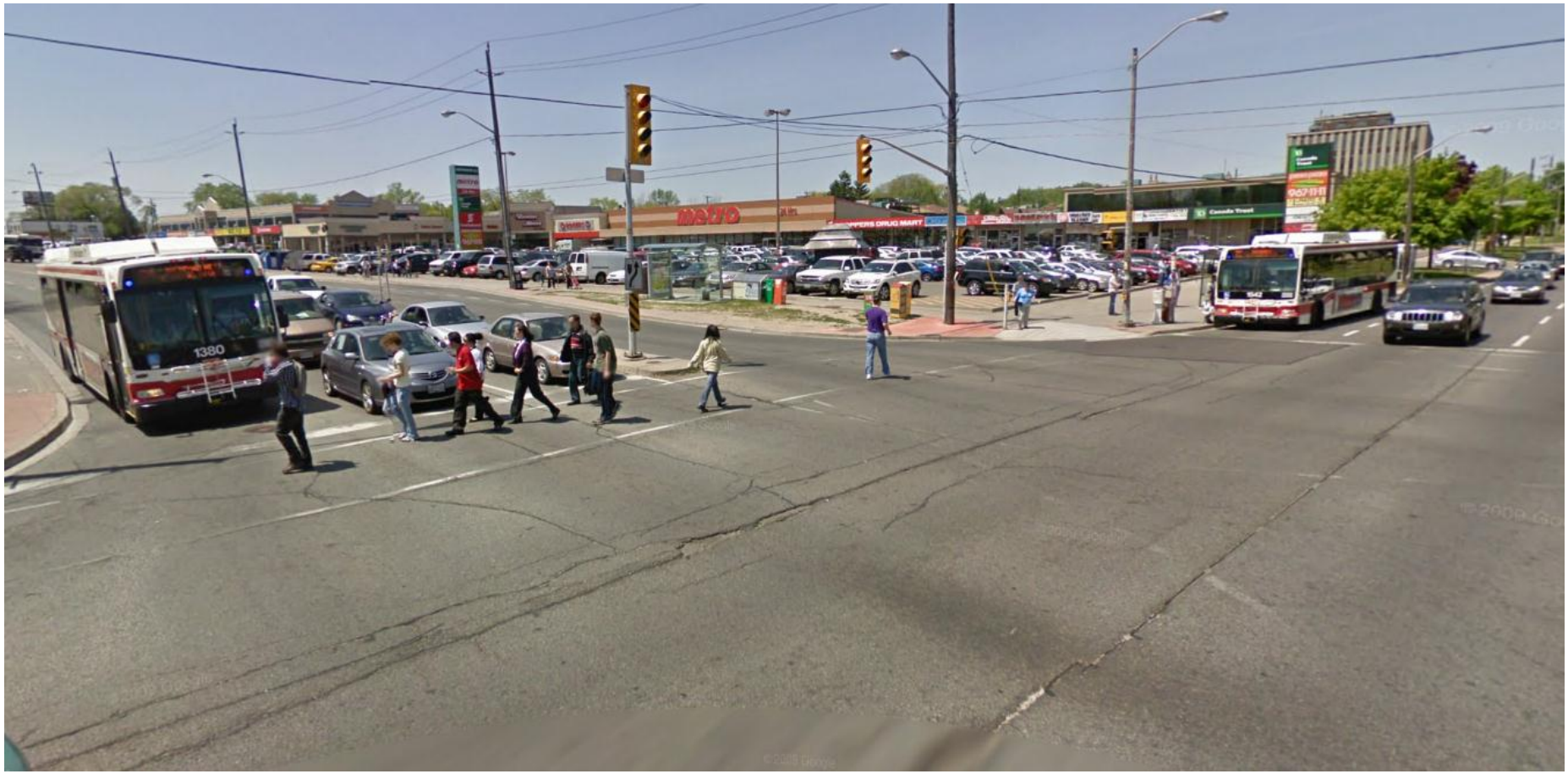
Eglinton and Oakwood (looking west)

Opportunities for development along an Eglinton subway line

Eglinton West station

Opportunities for development along a Sheppard W. subway line

Sheppard W. and Bathurst



Opportunities for development along a Sheppard W. subway line

Sheppard W. and Wilmington

Why build Sheppard W. subway (4.5 km) when another 270 km of trolleybus route could be added with the same funds?

Main reason could be to provide test of proposition that subways can be built without subsidies (if built in conjunction with appropriate development).

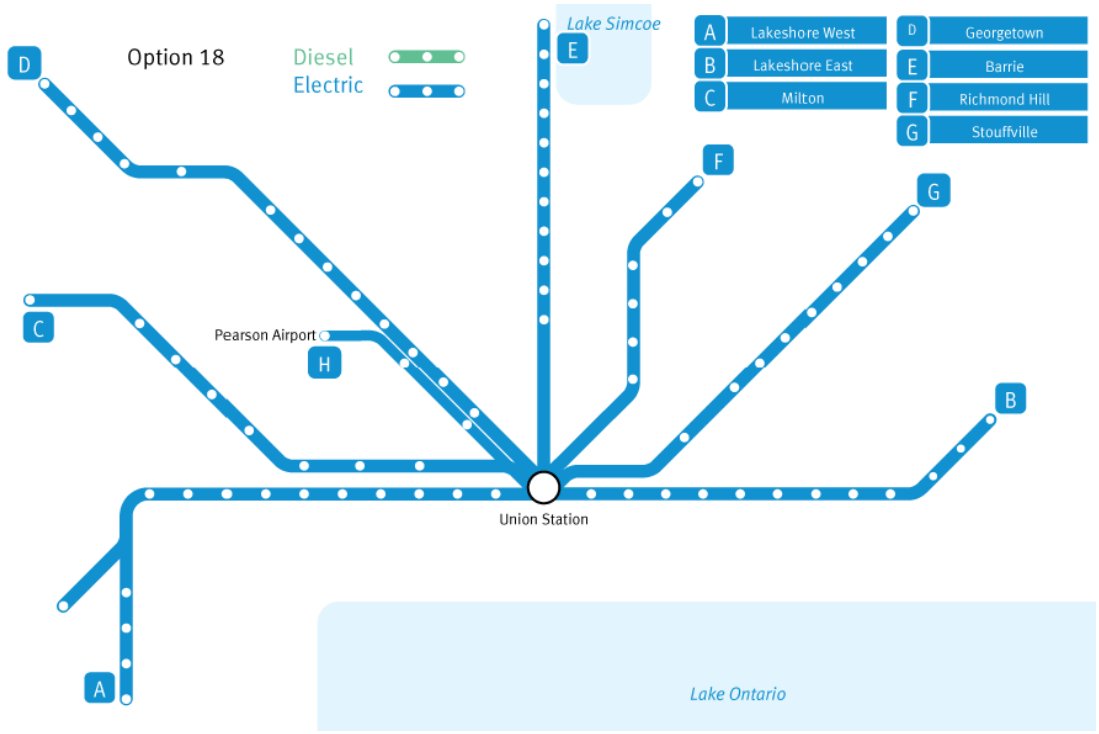
Also, could another 270 km be accommodated?

Encouraging news from GO TRANSIT

Preliminary findings from GO's Electrification Study:

1. Electric locomotives – at right – are the most cost effective (vs. diesel, dual mode, electric multiple, maglev, etc., etc.)

2. Six options remain under consideration, include electrifying entire system (at right)



Encouraging news from Quebec

Accueil > Actualités > Québec / Canada > Un monorail Montréal-Québec?

Publié le 13 novembre 2010 à 15h42 | Mis à jour le 13 novembre 2010 à 19h12

Un monorail Montréal-Québec?

Agrandir

Une capsule de 80 places, suspendue dans les airs au-dessus de l'autoroute 20, qui filerait à 250 km/h vers la capitale nationale.

PHOTO FOURNIE PAR L'IREC

Gabriel Béland
Cyberpresse

Imaginez-vous un instant assis dans une capsule d'un peu moins de 80 places, suspendue dans les airs au-dessus de l'autoroute 20, et qui file à 250 km/h vers la capitale nationale.

Ce projet n'a rien d'un scénario de science-fiction. Il est plutôt le fruit d'une étude de l'Institut de recherche en économie contemporaine (IREC) sur la

Disney World monorail

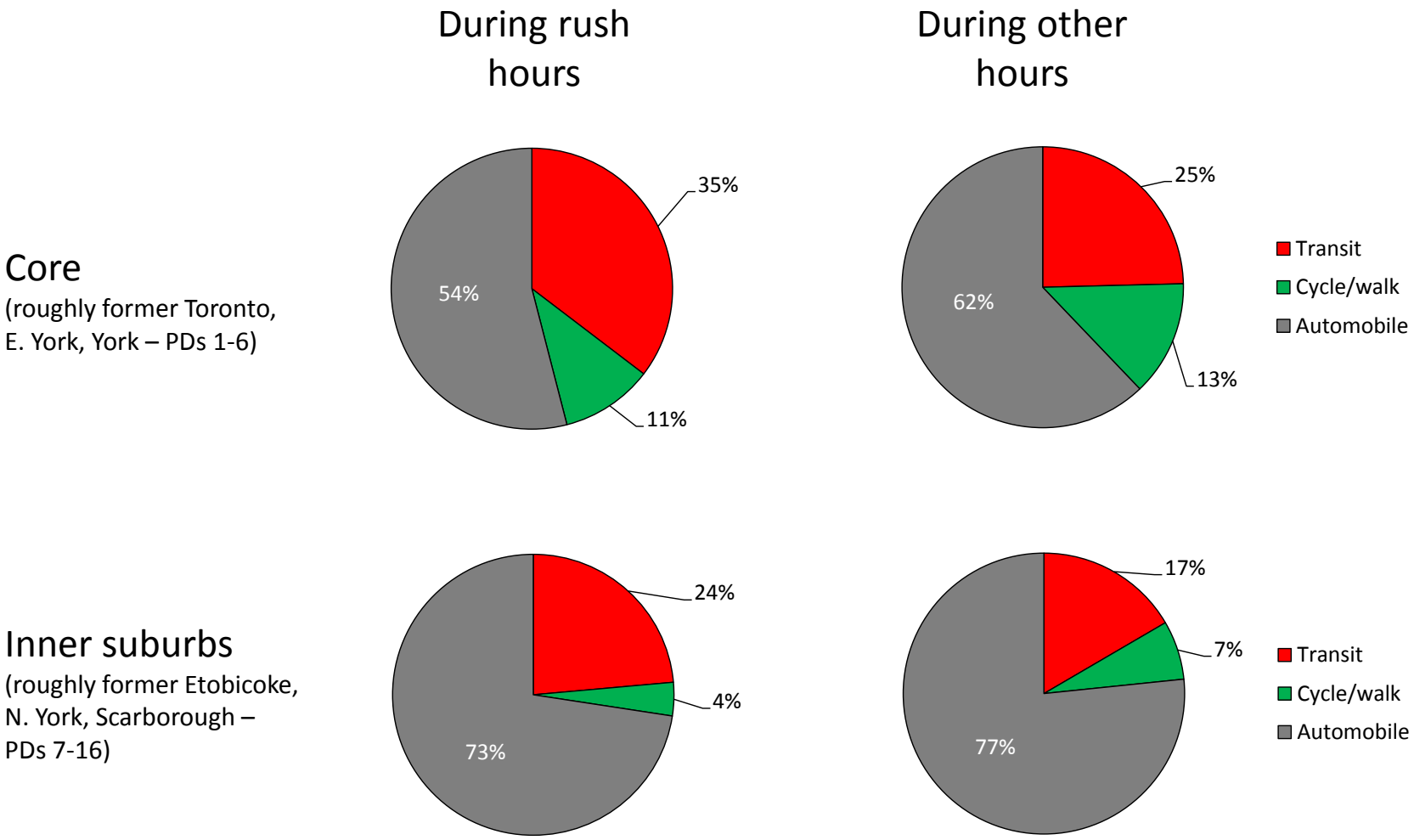
(since 1971; trains by Bombardier)

Wuppertal Schwebebahn

(since 1898)

ELECTRIFYING TORONTO'S TRANSPORTATION LATER: BUBBLES AND BEAMS?

Most trips by Toronto residents are made by car, even residents of the core during rush periods



Congestion confusion 1

There is frequent overstatement of how bad things are for drivers. For example, *Globe and Mail* reports on IBM's May 2010 international survey of "commuter pain" included the following:

- "Five North American cities were polled and Toronto (surprise) topped the list of most unhappy commuters"
- "Torontonians are more aggravated by their daily commute than residents of New York, Los Angeles or Montreal."

The survey actually showed that respondents in the Toronto region:

- mostly (67%) have a commute time of less than 30 minutes, with only 4% over 45 minutes;
- are able to leave for work later on average than in other North American regions;
- are less inclined than in other regions to switch to transit when fuel prices rise; and
- are *less* inclined to report travel stress than residents of Los Angeles and Montreal.

Congestion confusion 2

What surveys show depends on the questions you ask.

If you ask “Is congestion a problem in your city (area, community, neighbourhood, etc.)?” up to 90% respond “Yes.”

If you ask “Is congestion a problem *for you*?”, up to 90% respond “No.”

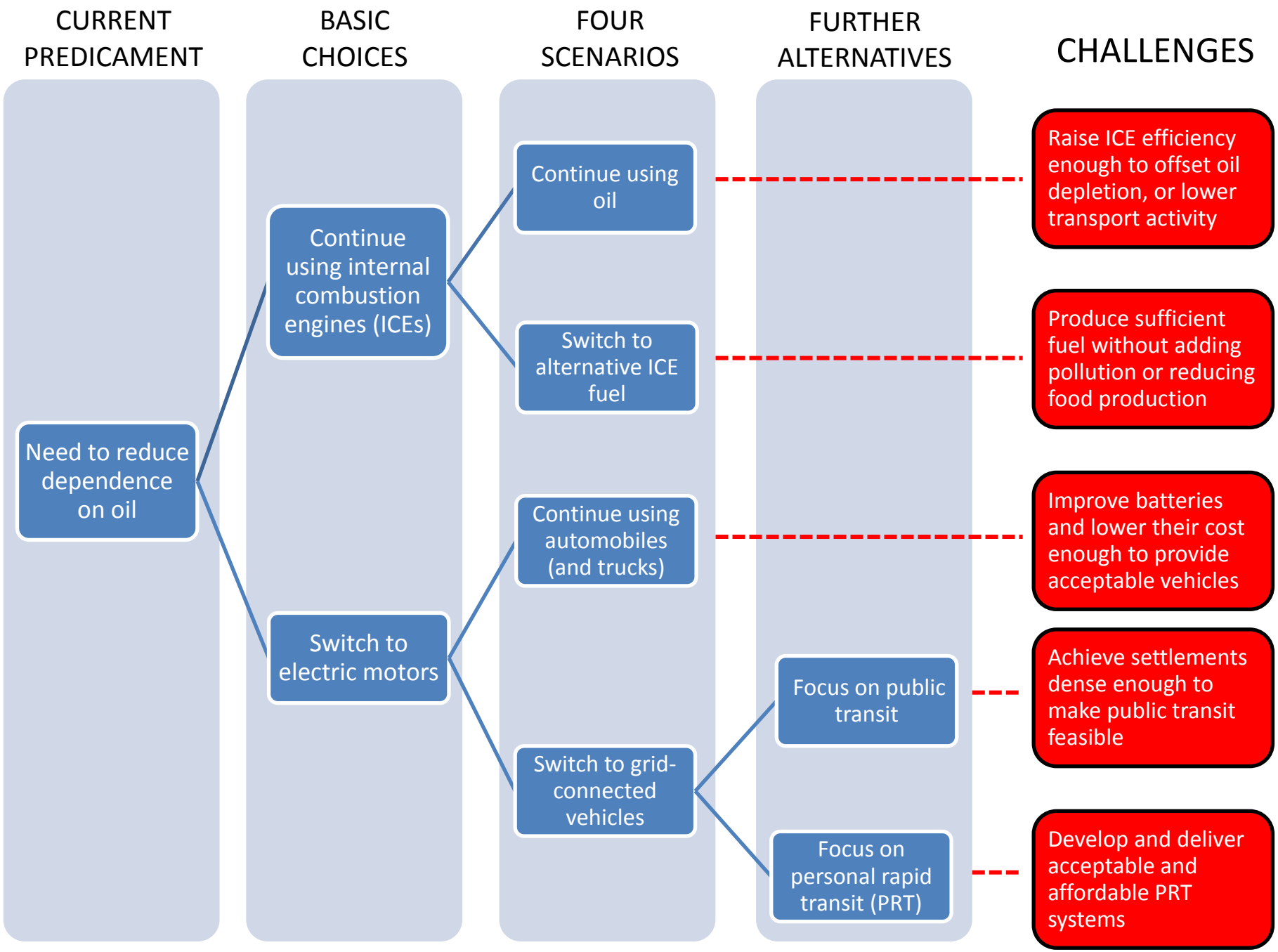
Similar differences in results occur when you ask about crime.

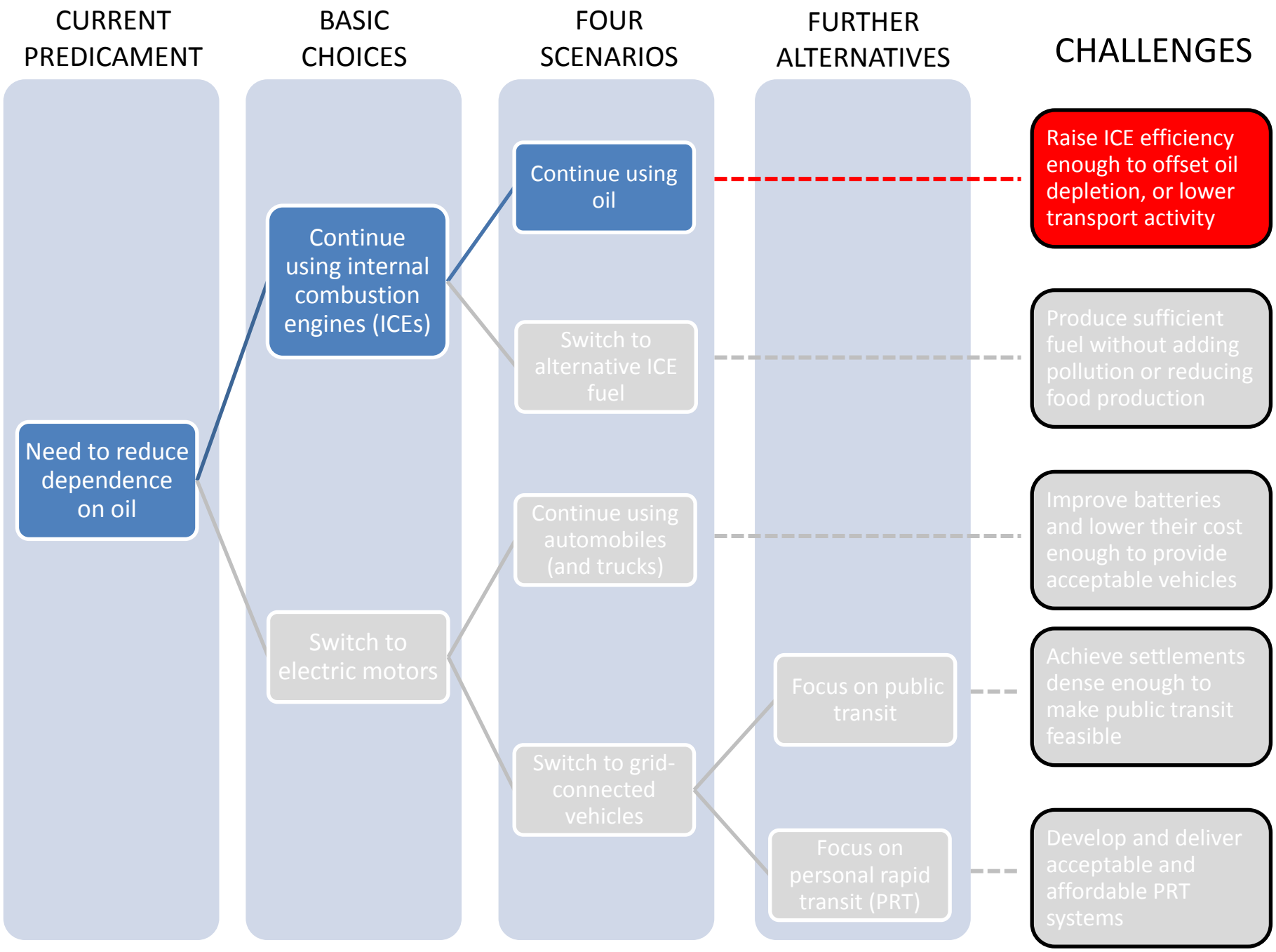
Only bright feature of car use

Driving by the Toronto region's 16- to 20-year-olds fell by more than a third per capita between 1986 and 2006.

Possible causes: (1) graduated permit; (2) high insurance rates; (3) greater interest in electronics.

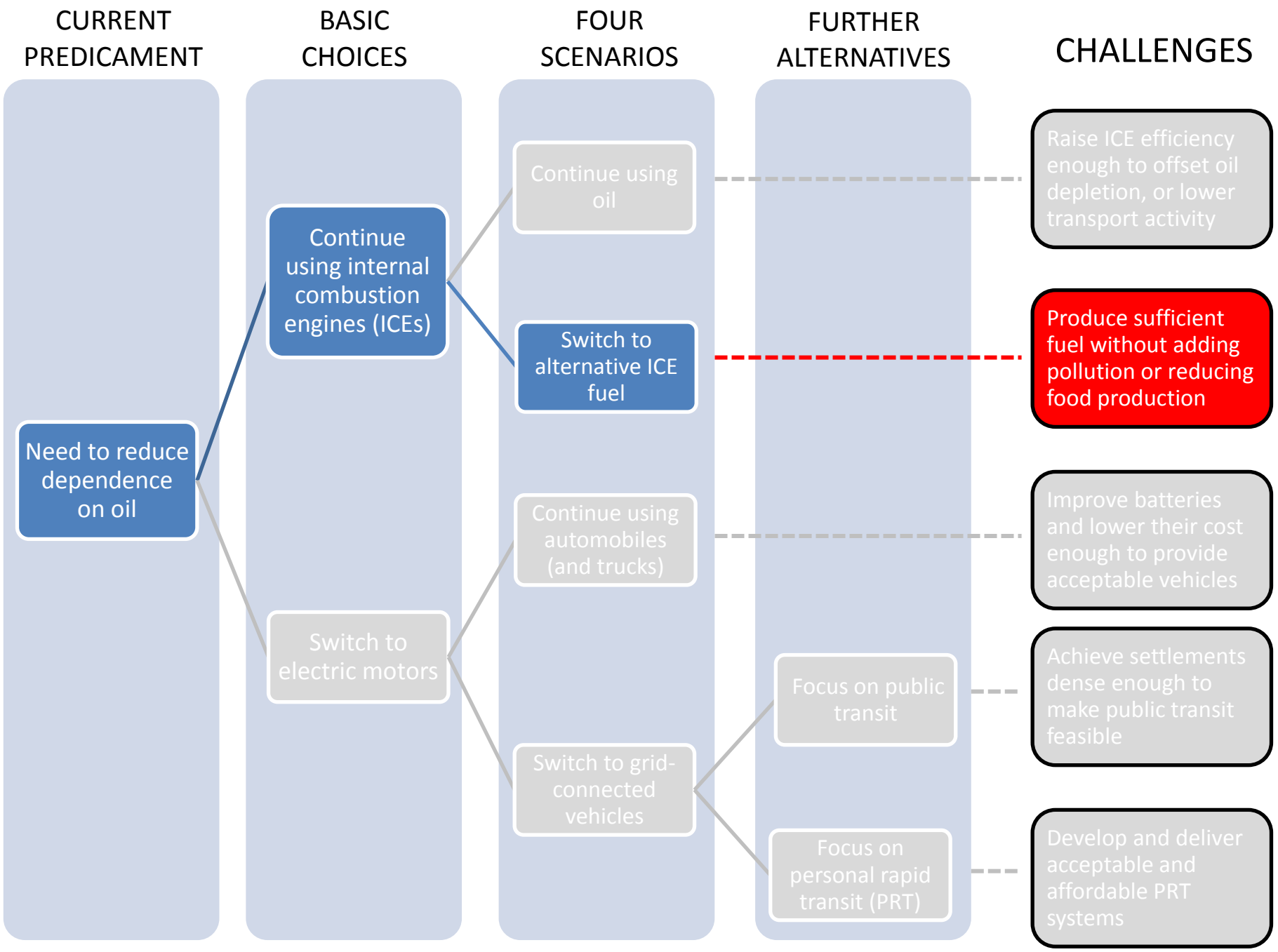
How can this be used to change a culture of automobile dependence?

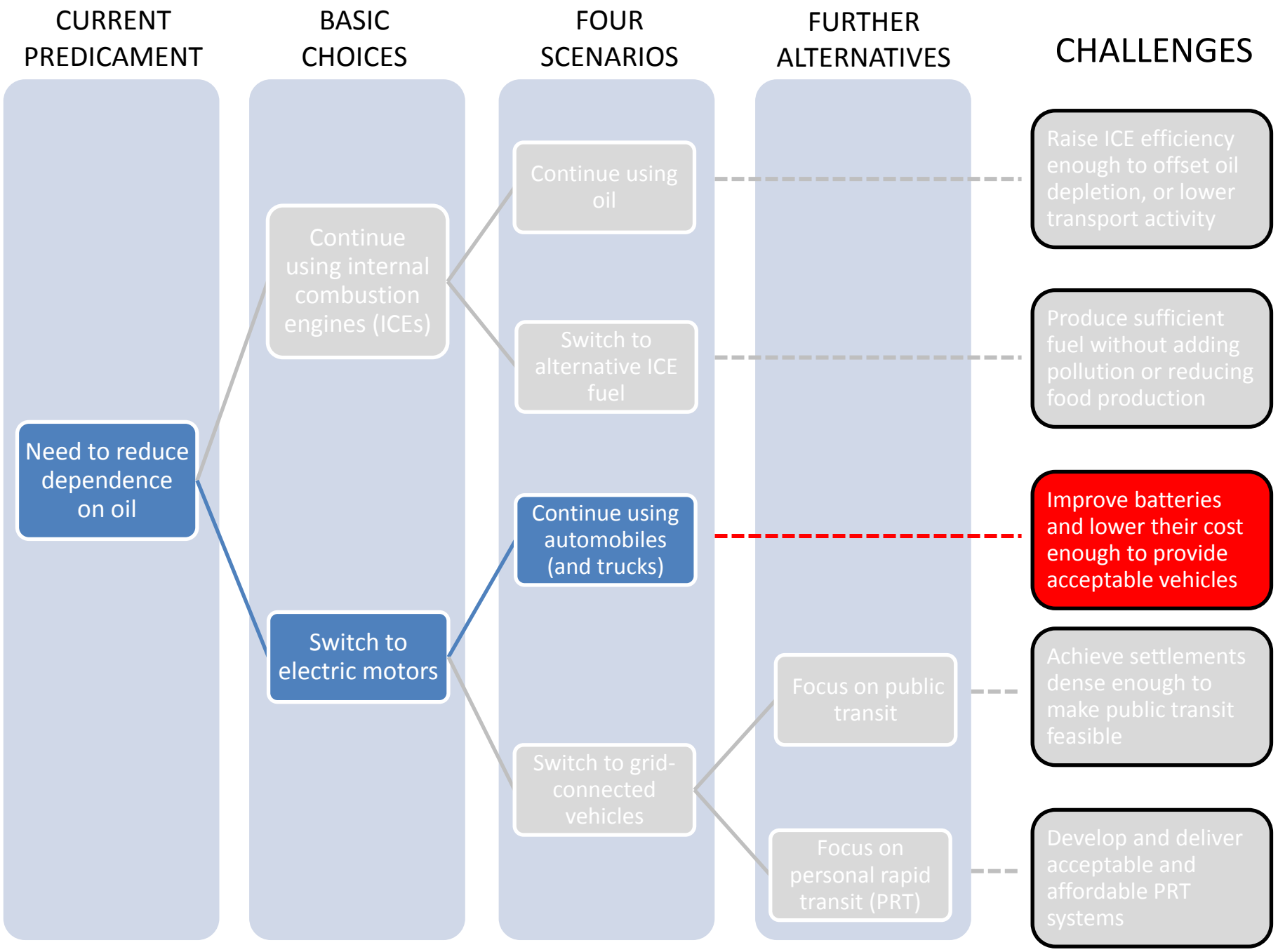

CURRENT PREDICAMENT
BASIC CHOICES
FOUR SCENARIOS
FURTHER ALTERNATIVES
CHALLENGES
Need to reduce dependence on oil
Continue using internal combustion engines (ICEs)
Switch to electric motors
Continue using oil
Switch to alternative ICE fuel
Continue using automobiles (and trucks)
Switch to grid-connected vehicles
Focus on public transit
Focus on personal rapid transit (PRT)
Raise ICE efficiency enough to offset oil depletion, or lower transport activity
Produce sufficient fuel without adding pollution or reducing food production
Improve batteries and lower their cost enough to provide acceptable vehicles
Achieve settlements dense enough to make public transit feasible
Develop and deliver acceptable and affordable PRT systems


CURRENT PREDICAMENT
BASIC CHOICES
FOUR SCENARIOS
FURTHER ALTERNATIVES
CHALLENGES
Need to reduce dependence on oil
Continue using internal combustion engines (ICEs)
Switch to electric motors
Continue using oil
Switch to alternative ICE fuel
Continue using automobiles (and trucks)
Switch to grid-connected vehicles
Focus on public transit
Focus on personal rapid transit (PRT)
Raise ICE efficiency enough to offset oil depletion, or lower transport activity
Produce sufficient fuel without adding pollution or reducing food production
Improve batteries and lower their cost enough to provide acceptable vehicles
Achieve settlements dense enough to make public transit feasible
Develop and deliver acceptable and affordable PRT systems

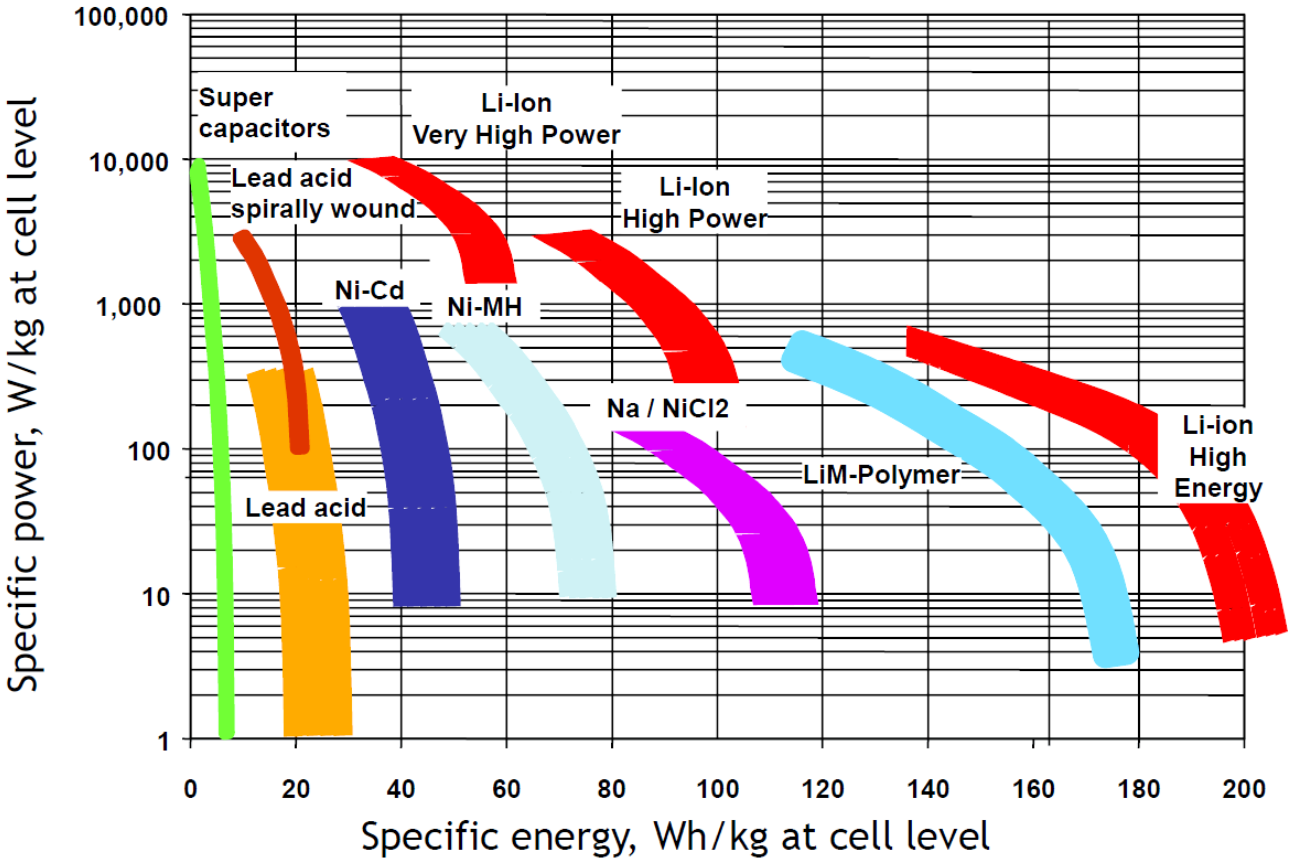
New-LDV fuel economy (CAFE) standards are set to rise by 2025

- Will fall from 9.2 to 6.6 L/100km, 2010-2016 (25.5 to 35.5 mpg)
- *May* fall from 6.6 to 3.7 L/100km, 2017-2025 (35.5 to 62.0 mpg)
- Result *if activity level and fleet turnover rates are unchanged* would reduce oil consumption for LDV vehicle use by about 40% by 2025
- This is consistent with possible oil depletion by 2025: about 40%
- But may not allow for maintenance of more essential uses (aviation, pharmaceuticals, plastics, fertilizers, pesticides)
- And fuel economy often has perverse effects (Jevons Paradox)


CURRENT PREDICAMENT
BASIC CHOICES
FOUR SCENARIOS
FURTHER ALTERNATIVES
CHALLENGES
Need to reduce dependence on oil
Continue using internal combustion engines (ICEs)
Switch to electric motors
Continue using oil
Switch to alternative ICE fuel
Continue using automobiles (and trucks)
Switch to grid-connected vehicles
Focus on public transit
Focus on personal rapid transit (PRT)
Raise ICE efficiency enough to offset oil depletion, or lower transport activity
Produce sufficient fuel without adding pollution or reducing food production
Improve batteries and lower their cost enough to provide acceptable vehicles
Achieve settlements dense enough to make public transit feasible
Develop and deliver acceptable and affordable PRT systems


CURRENT PREDICAMENT
BASIC CHOICES
FOUR SCENARIOS
FURTHER ALTERNATIVES
CHALLENGES
Need to reduce dependence on oil
Continue using internal combustion engines (ICEs)
Switch to electric motors
Continue using oil
Switch to alternative ICE fuel
Continue using automobiles (and trucks)
Switch to grid-connected vehicles
Focus on public transit
Focus on personal rapid transit (PRT)
Raise ICE efficiency enough to offset oil depletion, or lower transport activity
Produce sufficient fuel without adding pollution or reducing food production
Improve batteries and lower their cost enough to provide acceptable vehicles
Achieve settlements dense enough to make public transit feasible
Develop and deliver acceptable and affordable PRT systems

Lithium is not good enough; what about barium titanate (EEStor), zinc air? — there is little evidence of feasibility

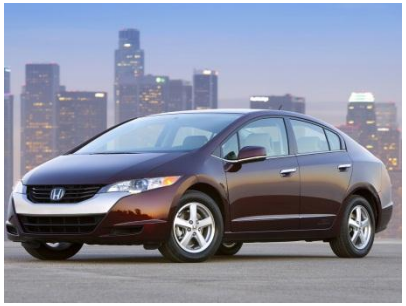


The specific energy of both gasoline and diesel fuel is about 12,500 Wh/kg, more than 60 TIMES the maximum value shown here. Thus, even if electric motors are five times as efficient, and batteries improve by a factor of three, there will still be more than a 4:1 difference in effective energy storage.

A fuel-cell solution is impracticable because of reliability, cost and, above all, high energy losses

50% loss

50% loss



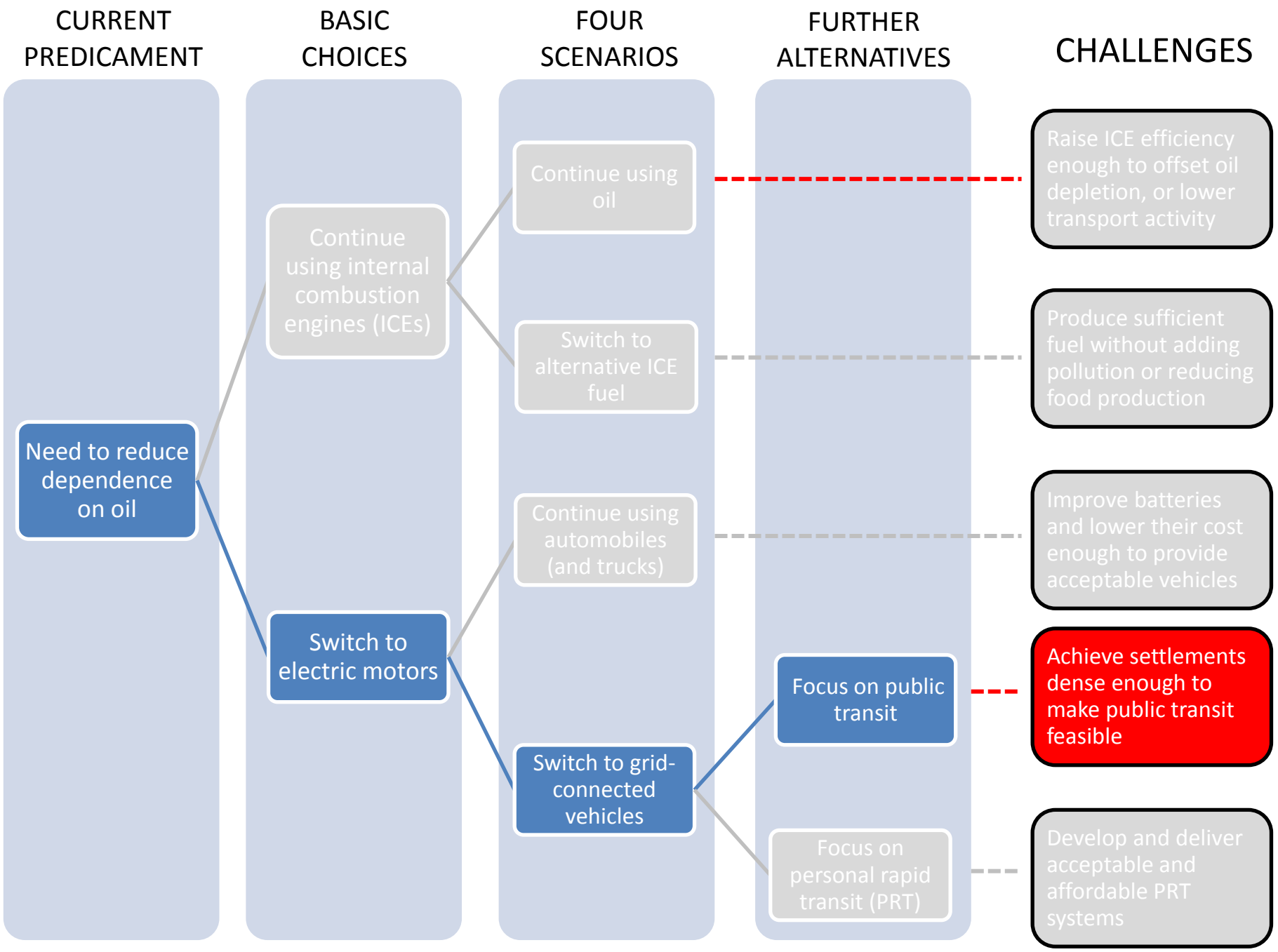
HONDA FUEL-CELL CAR (FCX)

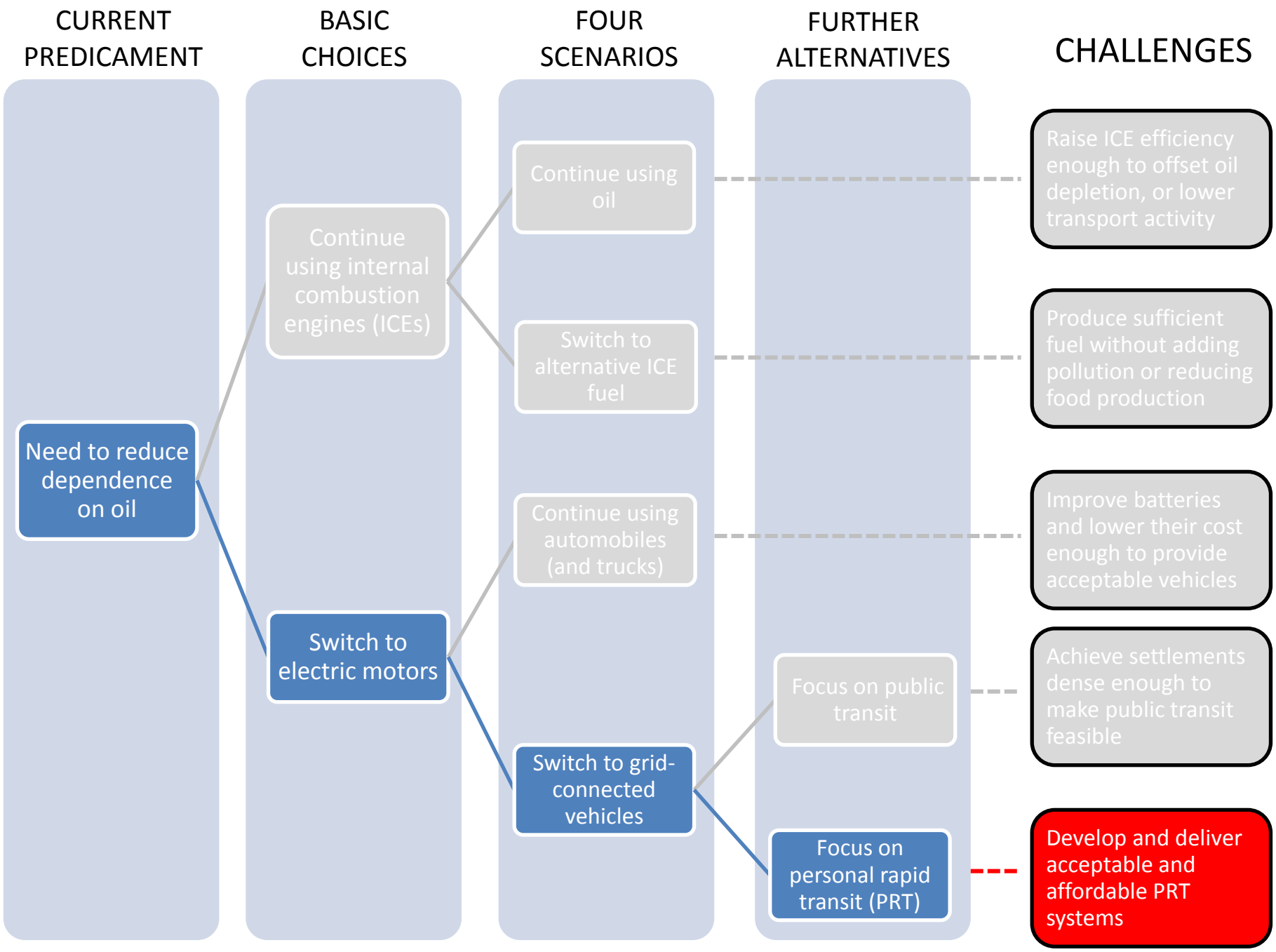
Total energy loss from turbine to motor ≈ 75%

(80% if hydrogen is liquefied for distribution)

CALGARY LIGHT-RAIL TRAIN

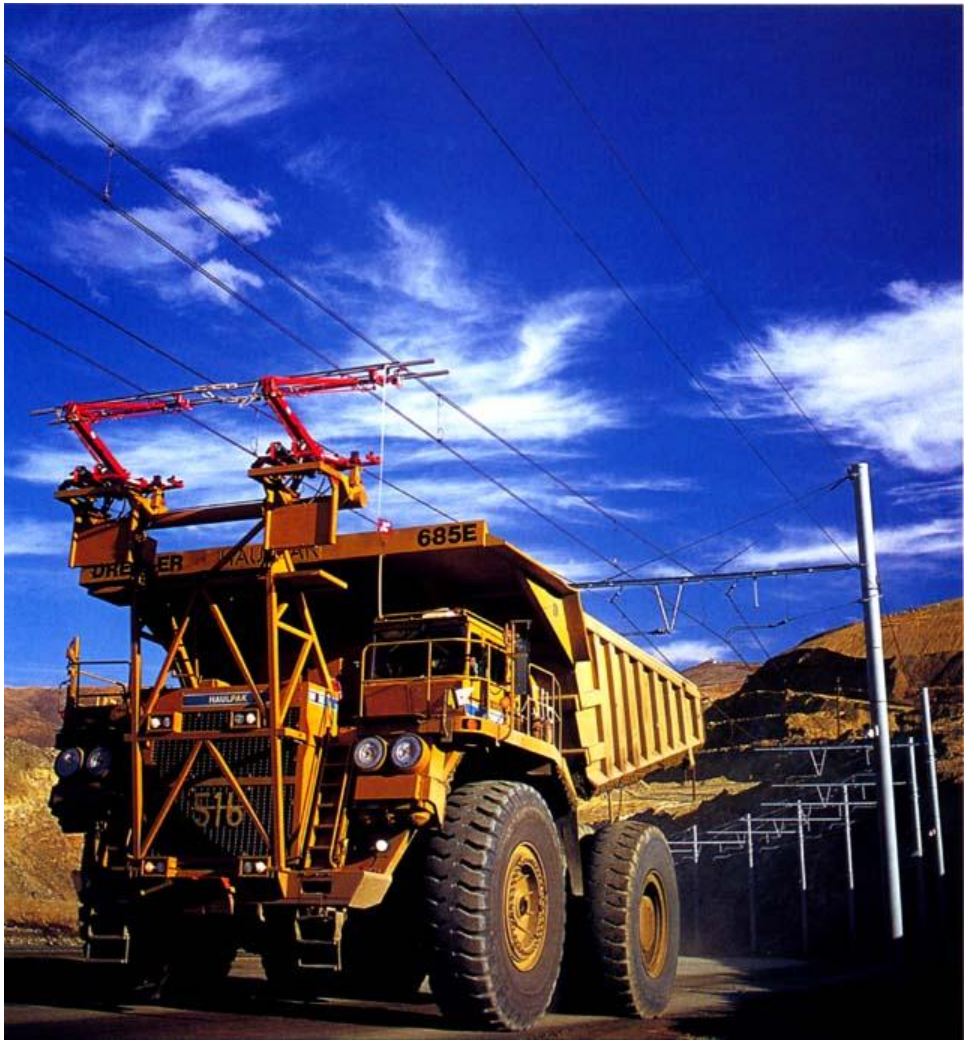
Total energy loss from turbine to motor with direct connection via the grid ≈ 10%


CURRENT PREDICAMENT
BASIC CHOICES
FOUR SCENARIOS
FURTHER ALTERNATIVES
CHALLENGES
Need to reduce dependence on oil
Continue using internal combustion engines (ICEs)
Switch to electric motors
Continue using oil
Switch to alternative ICE fuel
Continue using automobiles (and trucks)
Switch to grid-connected vehicles
Focus on public transit
Focus on personal rapid transit (PRT)
Raise ICE efficiency enough to offset oil depletion, or lower transport activity
Produce sufficient fuel without adding pollution or reducing food production
Improve batteries and lower their cost enough to provide acceptable vehicles
Achieve settlements dense enough to make public transit feasible
Develop and deliver acceptable and affordable PRT systems

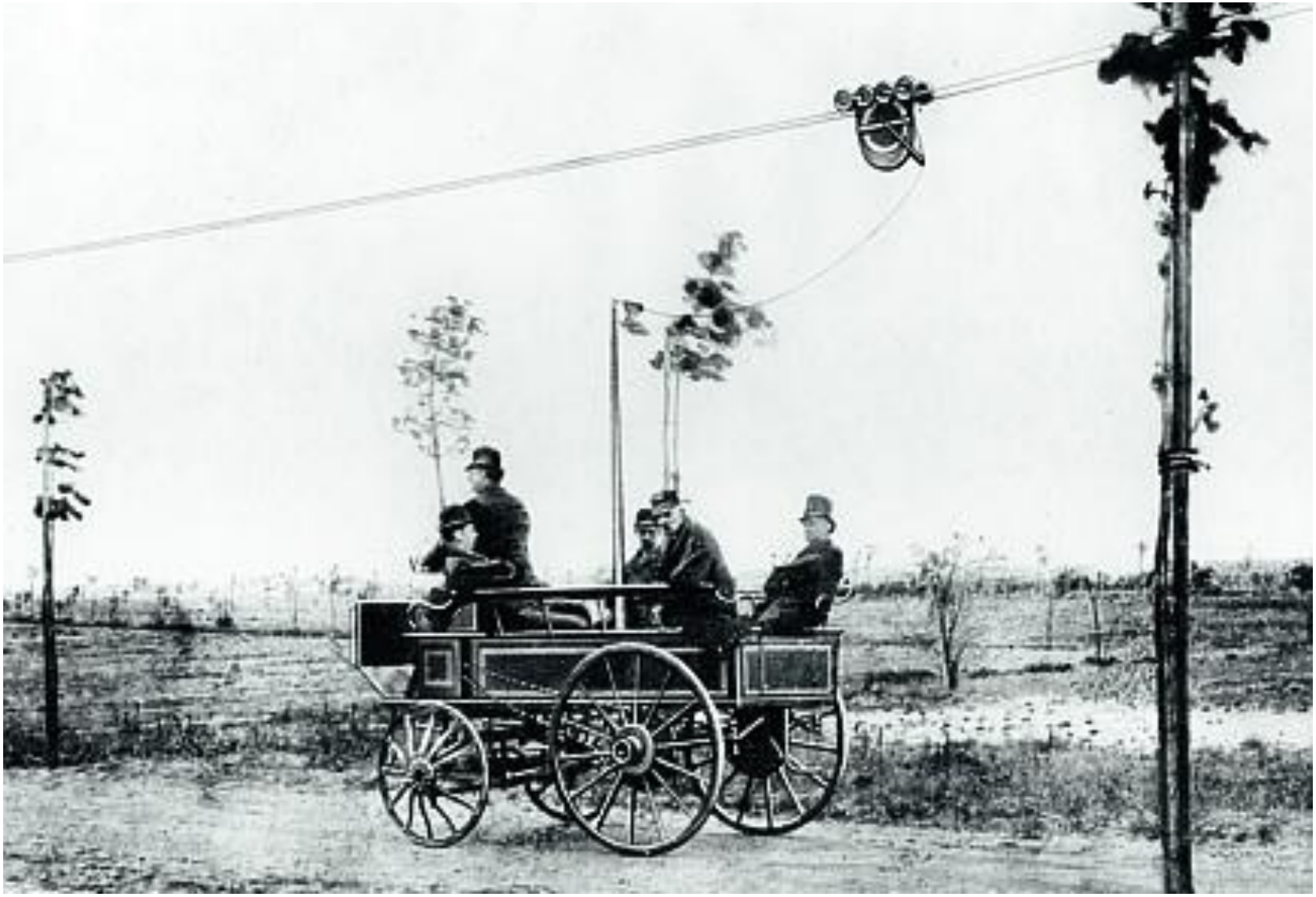

CURRENT PREDICAMENT
BASIC CHOICES
FOUR SCENARIOS
FURTHER ALTERNATIVES
CHALLENGES
Need to reduce dependence on oil
Continue using internal combustion engines (ICEs)
Switch to electric motors
Continue using oil
Switch to alternative ICE fuel
Continue using automobiles (and trucks)
Switch to grid-connected vehicles
Focus on public transit
Focus on personal rapid transit (PRT)
Raise ICE efficiency enough to offset oil depletion, or lower transport activity
Produce sufficient fuel without adding pollution or reducing food production
Improve batteries and lower their cost enough to provide acceptable vehicles
Achieve settlements dense enough to make public transit feasible
Develop and deliver acceptable and affordable PRT systems

Trolley trucks are already in frequent use

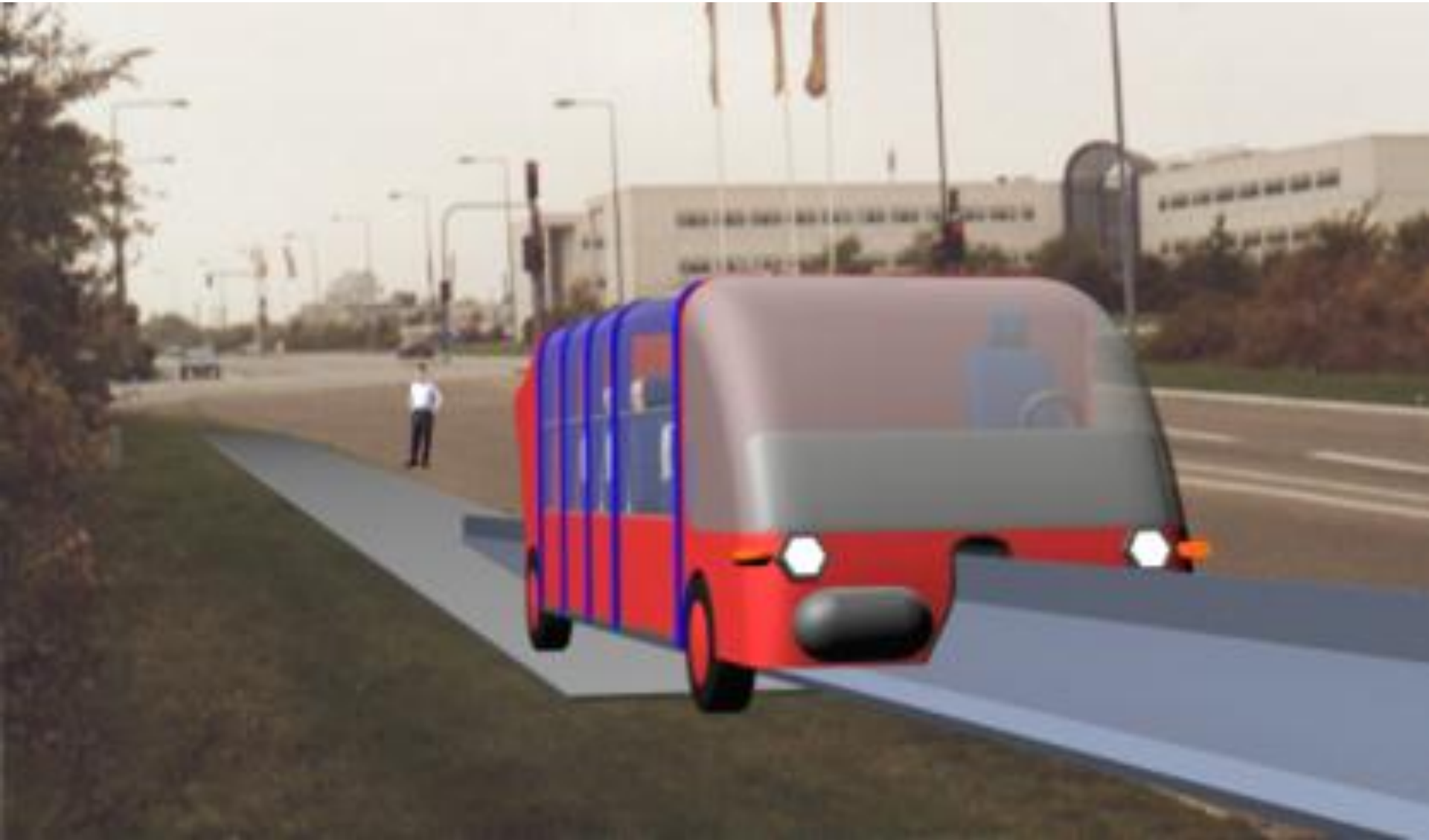
(Siemens-made, Barrick's Goldstrike Mine, Nevada)



Grid-connected automobile in 1882 (Siemens, near Berlin)



Another suggestion for grid-connection



But PRT pods captive to guideways may be the best way to go.

This is an artist’s impression of what is being installed at Heathrow Airport, London UK.

Here’s a PRT station at Heathrow’s Terminal 5 car park.

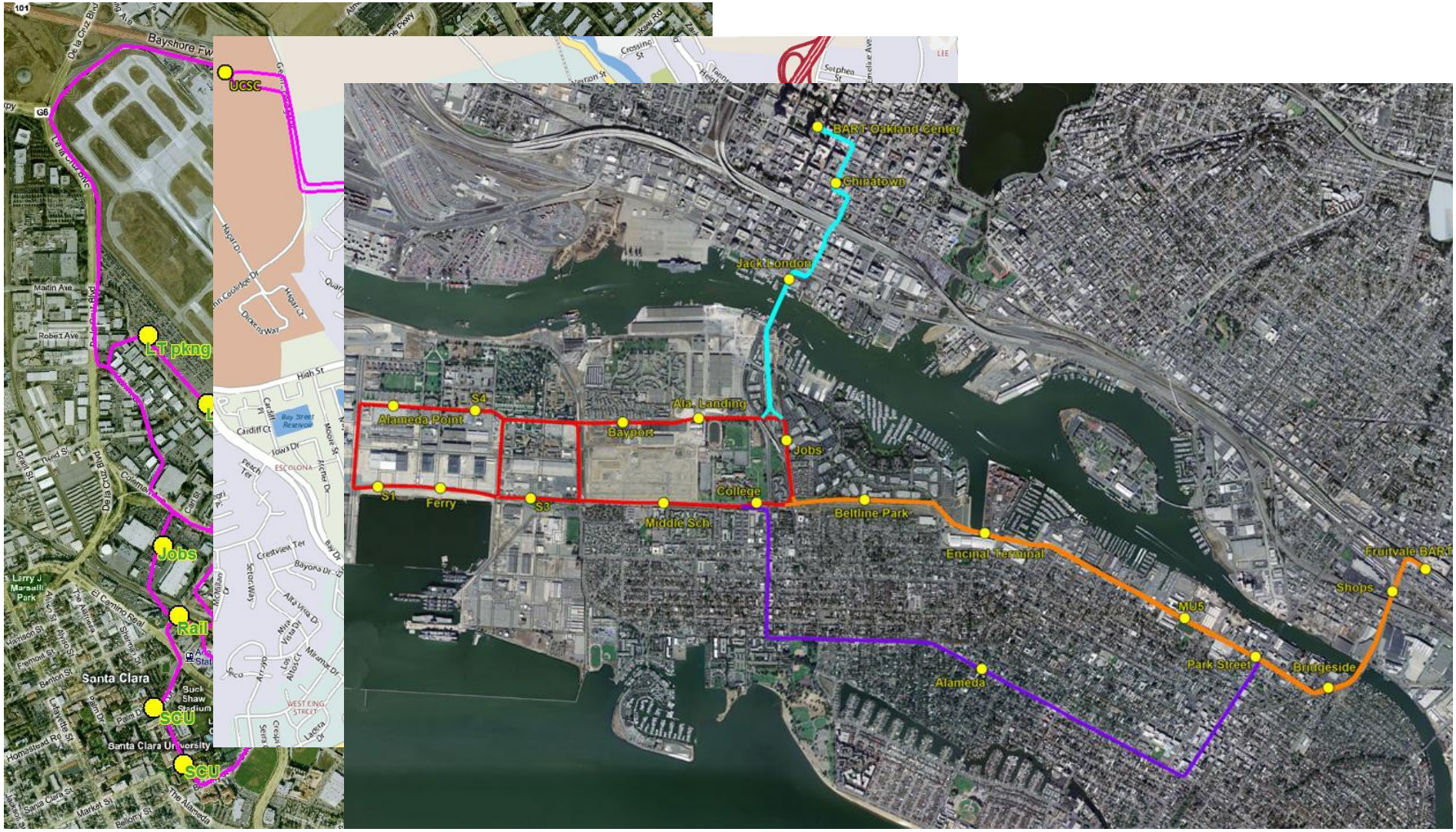
Such a system is being considered for the airport at St. Louis, Missouri.

Similar too is the Vectus PRT system, undergoing trials at the test track in Uppsala, Sweden.

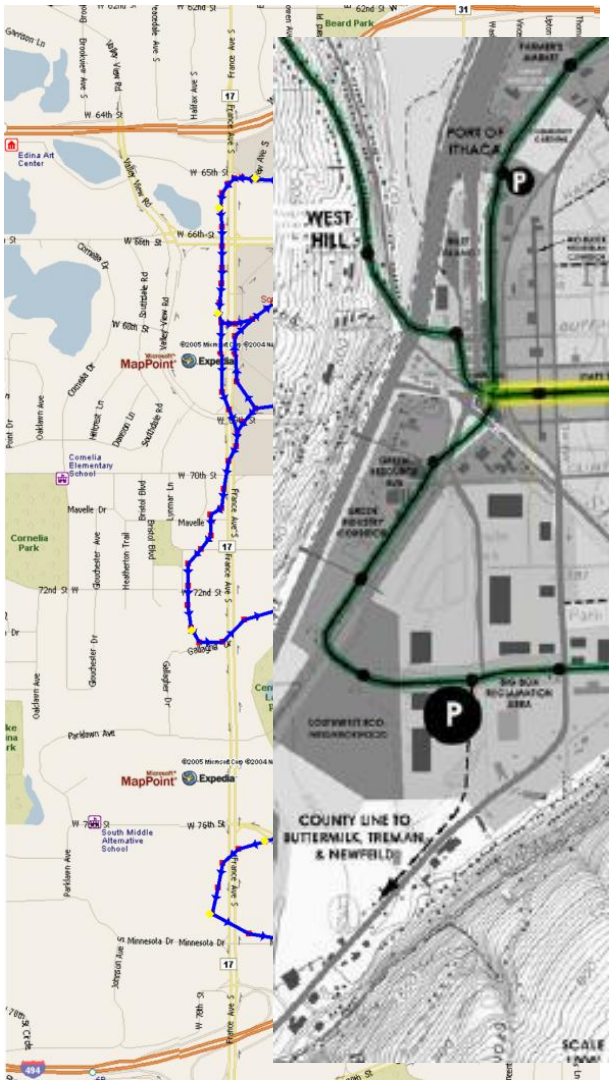
A system in which dedicated pods are hung from the rail could be better, such as this proposal for Seattle, Washington

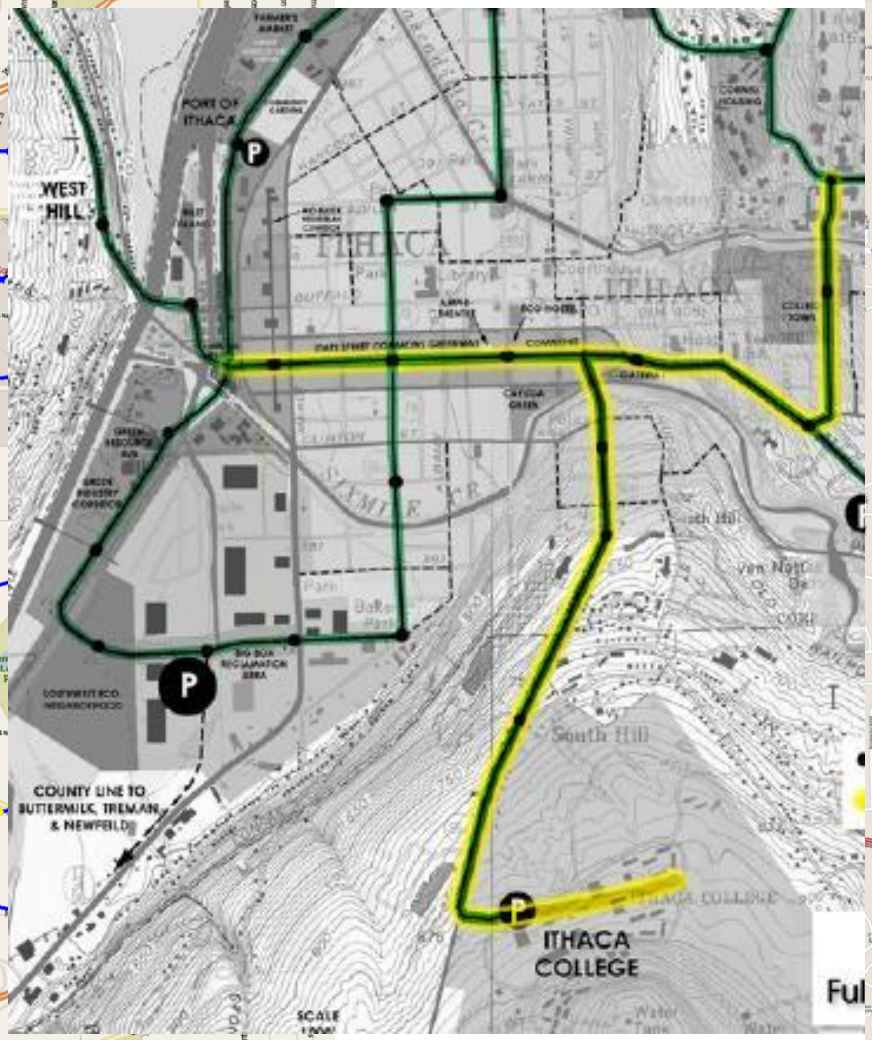
And this proposal for Götgatan, Stockholm, Sweden.

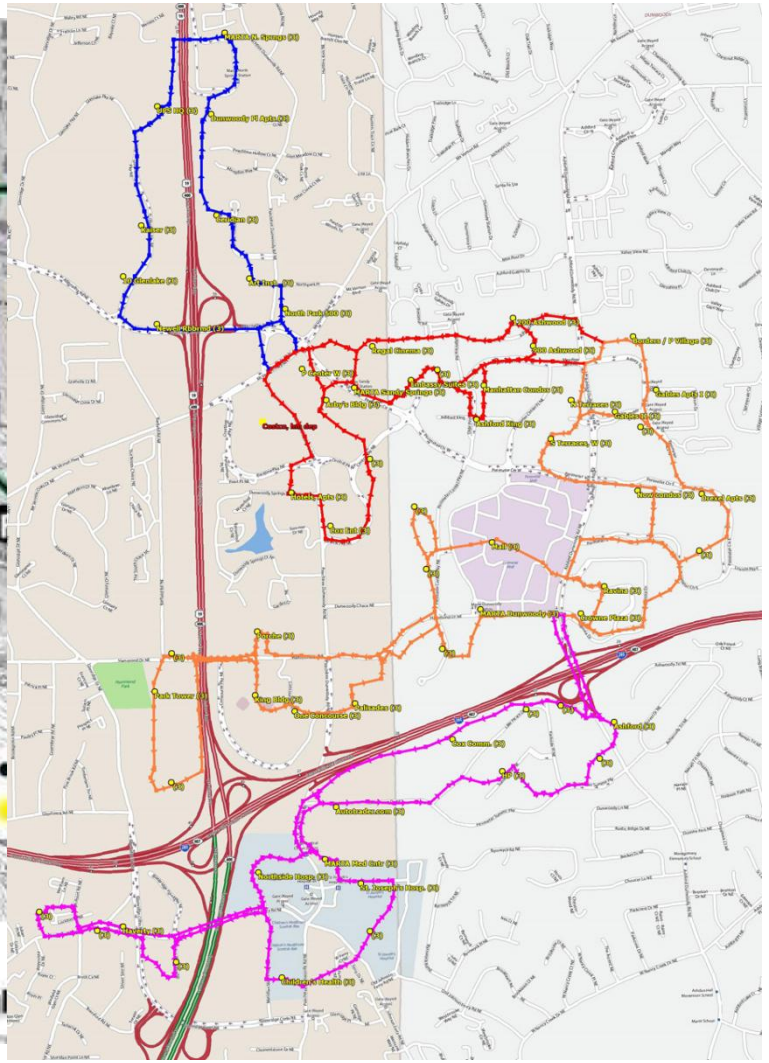
There are PRT proposals for San Jose airport, Santa Cruz, and Alameda, all in California.



Proposals for Edina (a suburb of Minneapolis), Ithaca, New York, and Perimeter Center, Atlanta.







Virginia is interested.

Interest and development of PRT appears to be growing around the world. With the inevitable construction of at least two systems and the testing underway of several others … **it can be argued that PRT is proving to be a feasible technology**.

December 2008 report from the Virginia Department of Rail and Public Transportation to the Governor and General Assembly (State Legislature)

From a comparative analysis done for the State of New Jersey

	Time for a 6.4-km direct trip in minutes	Time for a 12.8-km trip, one transfer, in minutes	Average capacity persons/ hour/ direction	Yearly millions of person-kilometres for each two-way km of service	Capital cost per person-kilometre in dollars	Operating cost per person-kilometre in dollars	Total cost per person-kilometre in dollars	Total cost compared with PRT
Subway	15.0	35.0	14,400	189.2	0.10	0.25	0.35	1.05
LRT subway	19.0	43.0	3,300	43.4	0.45	0.42	0.87	2.59
LRT surface	19.0	43.0	3,300	43.4	0.10	0.42	0.52	1.56
PRT (two-way)	11.4	21.9	4,100	53.9	0.04	0.30	0.34	1.00

Main source: Carnegie & Hoffman, *Viability of PRT in New Jersey*, Report to the Governor and Legislature, February 2007

We might have had PRT instead of Google

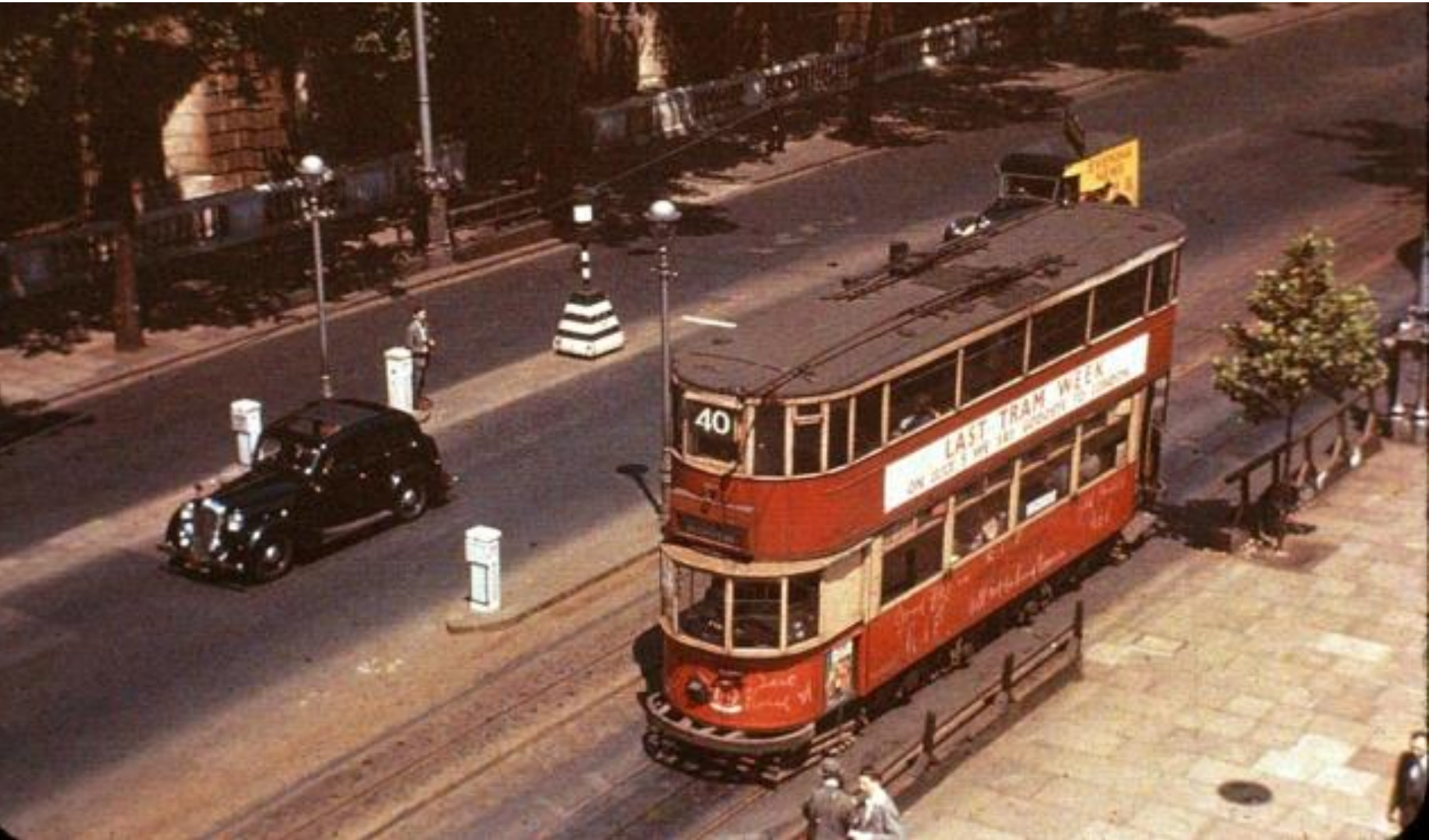
When I was here at Michigan … I wanted to build a personal rapid transit system on campus to replace the buses. It was a futuristic way of solving our transportation problem. I still think a lot about transportation -- you never loose a dream, it just incubates as a hobby. …

I think it is often easier to make progress on mega-ambitious dreams. I know that sounds completely nuts. But, since no one else is crazy enough to do it, you have little competition.

Commencement Address by Larry Page, co-founder of Google, at the University of Michigan, May 2, 2009

Objections to PRT (and streetcars and trolleybuses) include visual pollution, addressed by the ground-level powering of the Tramway de Bordeaux.

The trams of my London childhood, withdrawn in 1952, had optional underground powering (and double-ended operation).



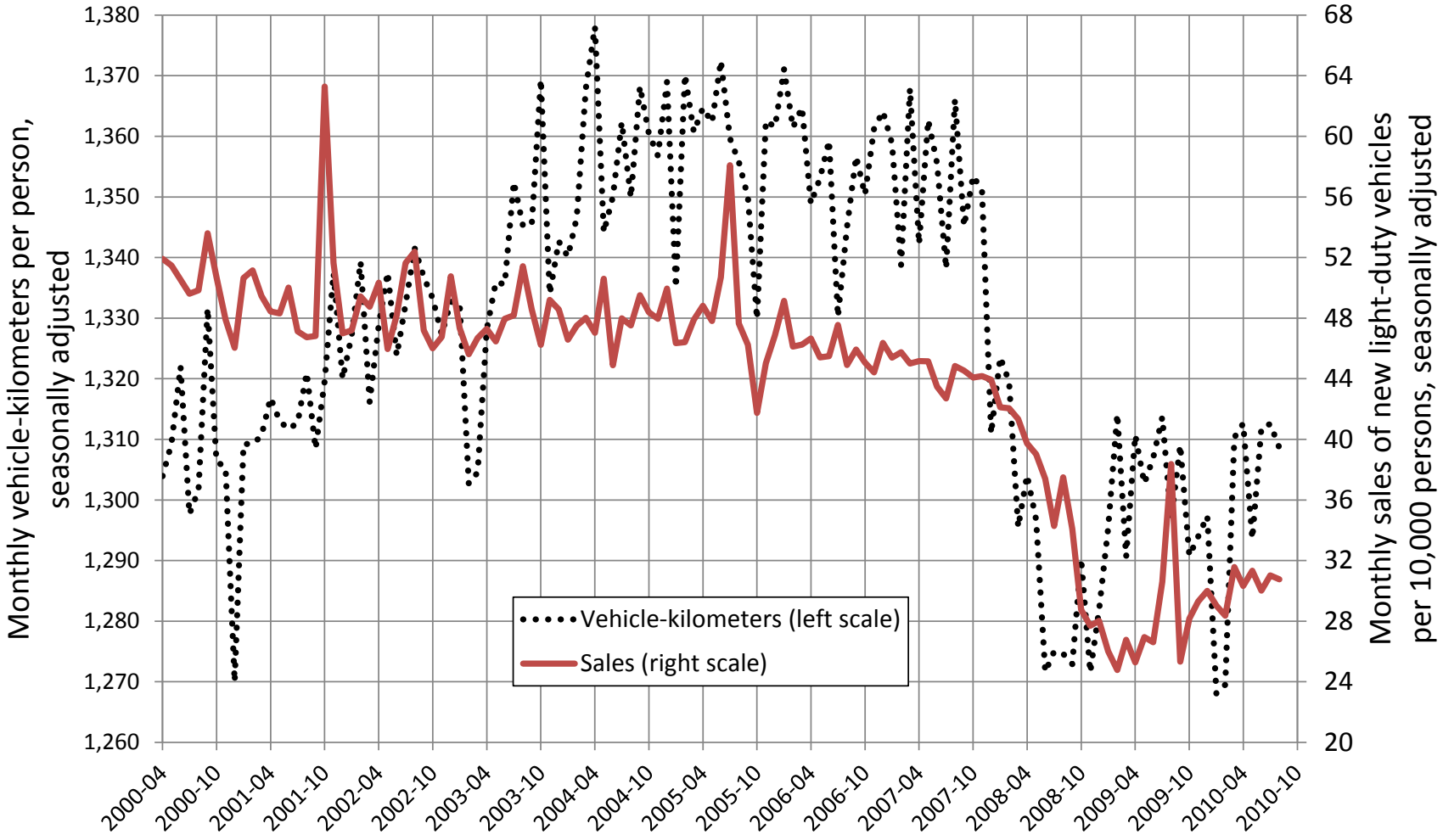
Trams with underground powering had been in operation for decades. Here is a shot from 1919. Note the exposed operator.

At this point, a brief video is shown
‘Bubbles and Beams: A Convenient Future’

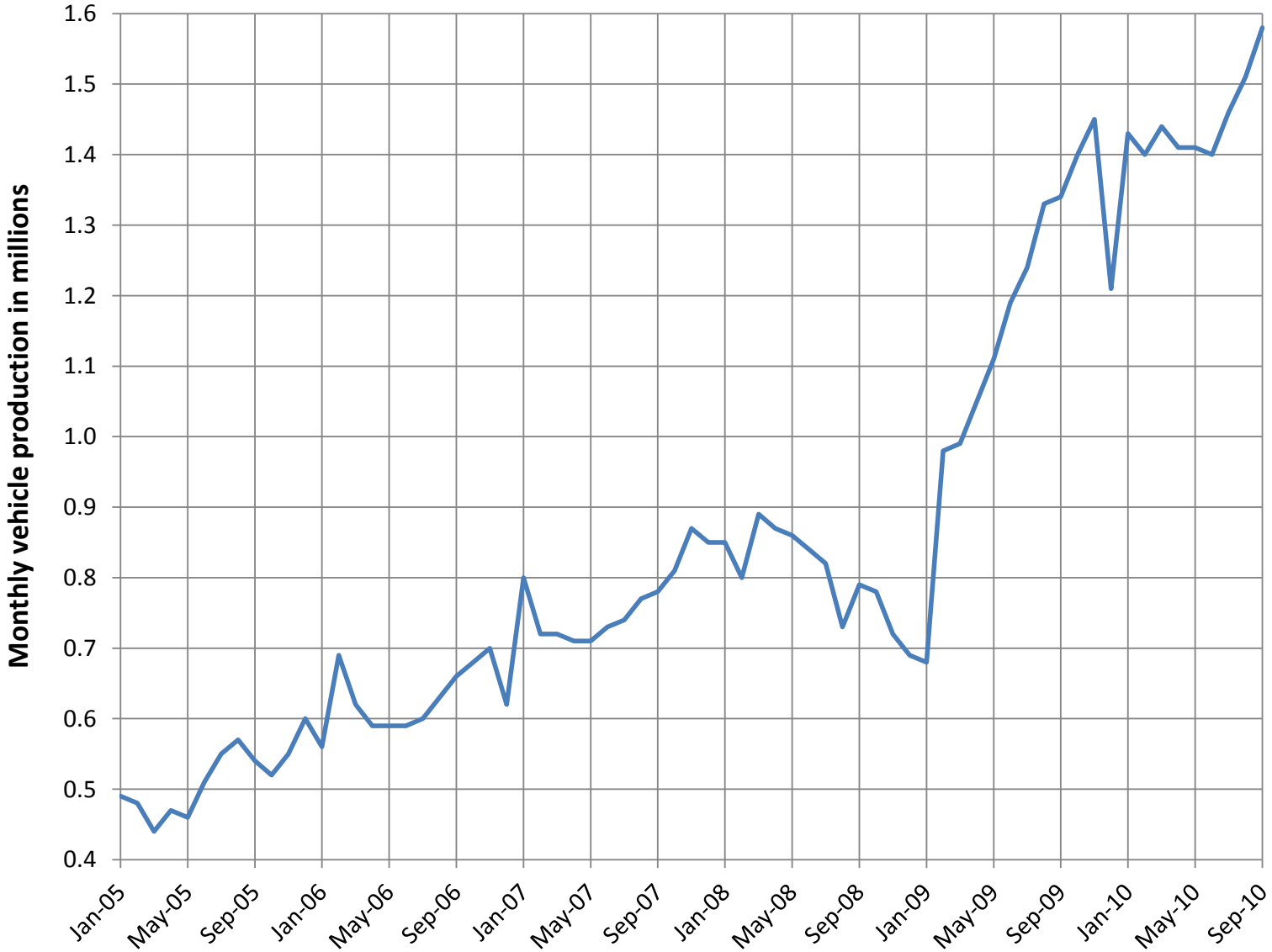
To view the video, click here

Signs that a
TRANSPORT REVOLUTION
is under way

Per-capita vehicle movement and sales in the US, 2000–2010



Monthly vehicle production in China, 2005–2010, seasonally adjusted (≥ 4 wheels)
(now mostly ICE-based; EM-based coming see next slide)



China 'to focus on promoting electric cars'

Agence France-Press, Thu Oct 28, 6:48 am ET

BEIJING (AFP) – Chinese authorities have agreed to promote electric cars to address the country's intensifying energy and pollution concerns, as auto sales surge, an official said Thursday.

Warren Buffett (left) and Bill Gates celebrate the nationwide launch of Chinese electric vehicle BYD

The Ministry of Industry and Information Technology and other government agencies have studied the future of China's auto industry, Zhu Hongren, the ministry's spokesman, told reporters.

"The basic consensus is to take electric cars as the main strategic direction for the transformation of China's auto industry," Zhu said.

Efforts will be made to develop better batteries, engines and electric control technology with the aim of mass producing electric vehicles and plug-in hybrid cars, he said.

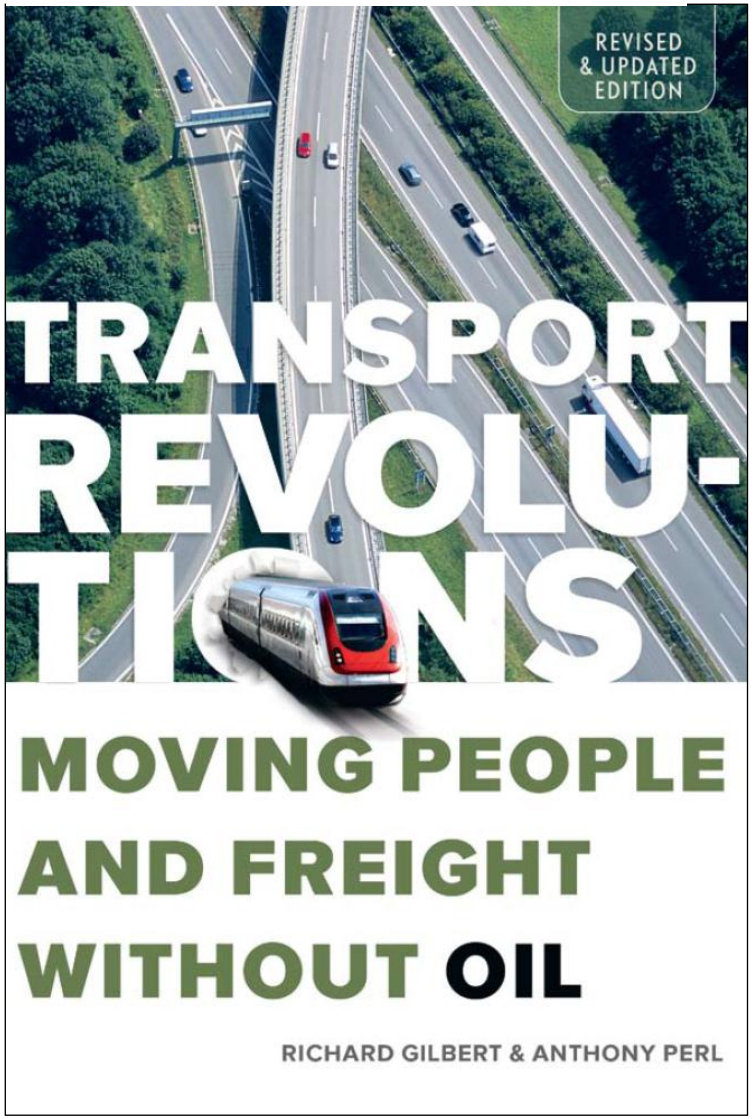
China overtook the United States last year to become the world's largest auto market in terms of units sold. ....

High-speed (200+ km/h) and very high speed (300+ km/h) routes under const-ruction in China

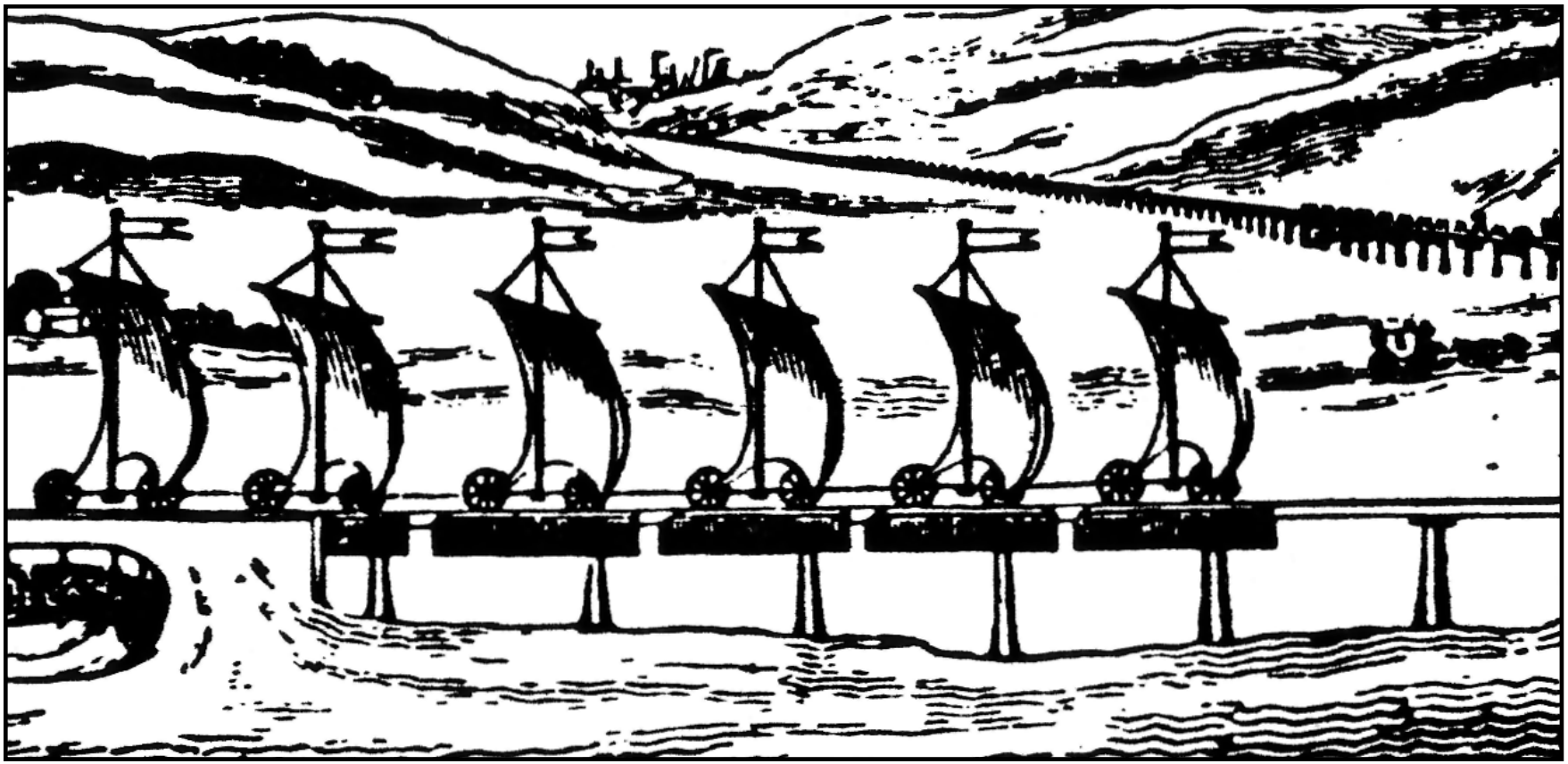
Bombardier 380-km/h, 16-car train for the Beijing-Shanghai route (2014)

For more information about *Transport Revolutions*, visit www.transportrevolutions.info

SECOND EDITION PUBLISHED IN MAY 2010



Monorail using sails proposed by Henry Palmer in 1828



Source: Marshall (1938) via Nakićenović (2006)

THANKS FOR YOUR INTEREST!