

MARON

E-BUSES IN OPTIMIZED TRANSIT FLEET

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THANK YOU MR. MODERATOR FOR YOUR INTRODUCTION. IT WILL BE QUITE A CHALLENGE TO COVER MY TOPIC IN 15 MINUTES BUT I WILL DO MY BEST.

Starting Point

- ⦿ Public transit in Canada
 - ❑ 2 billion passenger-trips / year
 - ❑ 1.2 billion kilometers / year
 - ❑ Over 18,000 vehicles across the country
 - ❑ More than 55,000 employees
- ⦿ Energy consumption by Canadian Transit
 - ❑ Diesel (incl. bio): 450 million litres
 - ❑ Natural gas: 2.3 million cubic metres
 - ❑ Electricity: 793 million kilowatt-hours

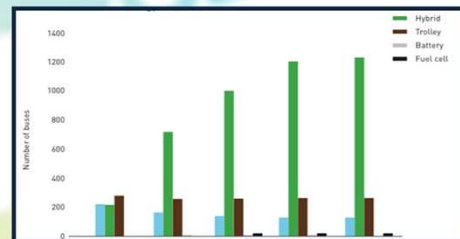
CANADA IS A YOUNG COUNTRY AND THE SECOND LARGEST LAND MASS IN THE WORLD. WITH ONLY 35 MILLION PEOPLE, IT DOES NOT HAVE A STRONG TRADITION OF PUBLIC URBAN TRANSIT BUT THINGS ARE CHANGING.

YOU CAN SEE HERE A VERY BRIEF PROFILE OF THE CANADIAN TRANSIT INDUSTRY.

THE CNG CONSUMPTION REPRESENTS ONLY PART OF ONE MEDIUM SIZE TRANSIT SYSTEM, AND THE ELECTRICITY CONSUMPTION IS DONE MAINLY BY CANADA'S 3 LARGEST TRANSIT SYSTEMS IN TORONTO, MONTREAL AND VANCOUVER.

Where do e-buses stand ?

- ❖ Buses: the backbone of the Canadian Transit Fleet – 84% of vehicles
- ❖ Hybrids are the fastest growing alternate fuel option
- ❖ Still less than 7% of fleet
- ❖ Many disappointments



DESPITE THE FACT THAT WELL OVER 50% TRIPS ARE COMPLETED BY DIESEL BUSES, THERE HAS BEEN A TREND TO REPLACE THESE BUSES WITH E-BUSES. THE SECOND MOST POPULATED PROVINCE IN THE COUNTRY, QUEBEC, HAS VOUCHERED TO ELECTRIFY 90% OF ITS TRANSIT VEHICLES BY 2030.

UNFORTUNATELY, PAST ATTEMPTS AT ELECTRIFICATION HAVE OFTEN LEAD TO DISAPPOINTING RESULTS

What's wrong ?

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Canada Ottawa Photo Galleries

City could pay to turn hybrid buses into diesel buses

Pilot project in draft 2013 budget earmarks \$550K to retrofit 5 of city's 177 hybrid buses
CBC News Posted: Oct 25, 2012 8:08 PM ET | Last Updated: Oct 28, 2012 2:44 PM ET

TOP STORY



CITY

TTC Hybrid Buses: The Better Way?

Posted by Dennis Marciniak / AUGUST 22, 2009 38 Comments



Why are e-buses not meeting expectations in the field?

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AS THESE NEWS CLIPPINGS INDICATE, E-BUSES FAILED TO MEET EXPECTATIONS ON SEVERAL OCCASIONS, EVEN IN LARGE SYSTEMS. AT PRESENT, THIS IS AN IMPORTANT ISSUE BECAUSE THE COST OF NATURAL GAS IS HANGING AROUND AN ALL TIME LOW AND SUPPLIES OF SHALE GAS ARE SO ABUNDANT THAT CNG BUSES ARE TURNING HEADS IN TRANSIT SYSTEMS ACROSS THE COUNTRY.

Some Mistakes

BIG PROMISES

- ❖ Fuel savings based on dyno data
- ❖ Little mention of the impact of duty cycles on bus performance
- ❖ E-Bus price nearing that of diesel buses as sales volume builds up

HIGH EXPECTATIONS

- ❖ Fuel cost savings in the order on 30-35%
- ❖ No change in bus affectation practices in the field
- ❖ Provincial government grants encouraging the adoption of these buses in hope of rapid drop in their cost of acquisition

In short, overpromised and under-delivered

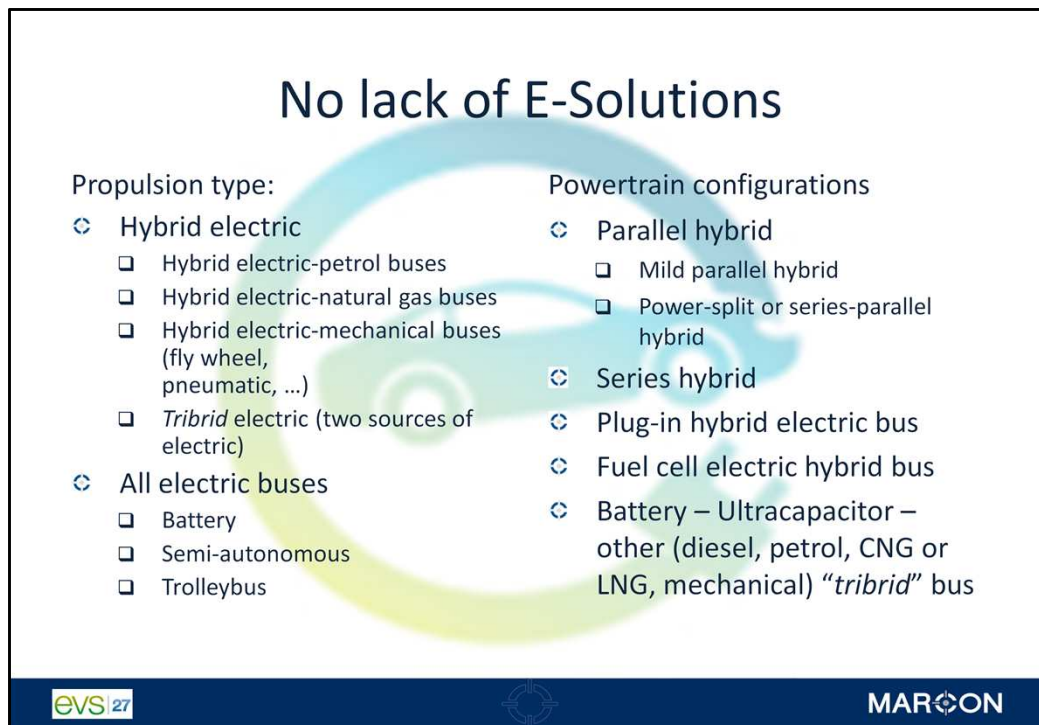


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THESE UNMET EXPECTATIONS WERE OFTEN CREATED BY EXAGGERATED PROMISES FROM MANUFACTURERS AND UNREALISTIC EXPECTATIONS ON THE PART OF OVER-EAGER TRANSIT OPERATORS.

FUEL SAVINGS ESTIMATES LOOKED REALLY GOOD BUT WERE BASED ON DYNO DATA, NOT ON RELIABLE FIELD DATA. THE SELLING PRICES OF E-BUSES WERE SUPPOSED TO DROP QUICKLY, NEARING THAT OF DIESEL BUSES AS SALES VOLUME BUILDS UP.

WELL, REALITY IN NORTH AMERICA IS QUITE DIFFERENT WITH SALES OF CNG BUSES OUTPACING THOSE OF E-BUSES BY 300% DEPITE THE WIDE RANGE OF OPTIONS ON THE MARKET



THERE IS INDEED A WHOLE ARRAY OF BUS TECHNOLOGIES OUT THERE, BUT MANY HAVE NOT YET BEEN PROVEN TO THE SATISFACTION OF TRANSIT OPERATORS, A CROWD THAT IS RATHER ENCLINED TOWARDS CONSERVATISM.

ONE MUST UNDERSTAND THAT SERVICE IMPERATIVES ARE RATHER STRINGENT FOR TRANSIT SYSTEMS, WHILE BUDGETS ARE OFTEN VERY TIGHT. AND, OF COURSE, THERE ARE ALWAYS THE POLITICAL IMPERATIVES OF ELECTED OFFICIALS WANTING TO SHOW THEIR GREEN SIDE BECAUSE ... WELL FRANKLY, IT BRINGS IN VOTES.

Hybrid electric (partially electric bus where, the motor is

electric, but the on-board energy source is not):

- o Hybrid electric-petroleum buses (such as diesel-electric buses, the most commercially popular)
- o Hybrid electric- natural gas buses (where the ICE is powered by either CNG or LNG)
- o Hybrid electric- mechanical buses (with a mechanical device [pneumatic, flywheel. ...] acting as a second source of power)
- o Tri-Hybrid electric (two sources of electric power) buses (such as fuel-cell / battery or fuel-cell/ultracap/supercap buses)
- o Trolleybuses (where the source of power is not, for the most part, on board the bus)
- o All electric buses (that have a single source of electric power such as batteries or fuel cell)

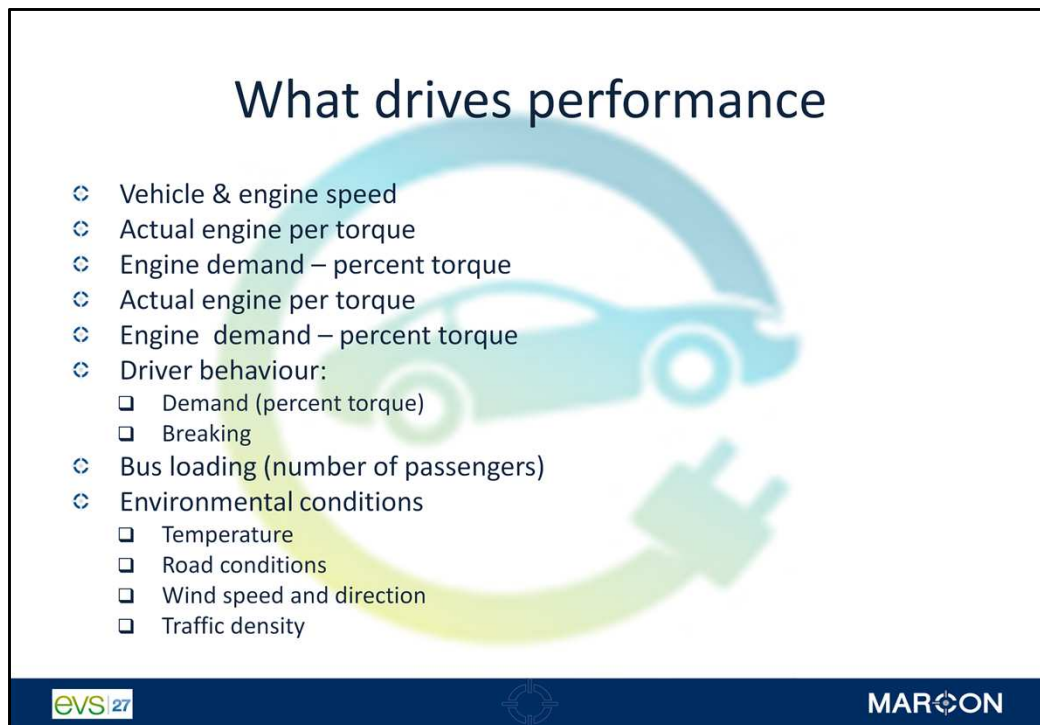
Conduction charge at the depot (plug-in);

Induction charge

Rapid conduction charge

Exchange of batteries

Hydrogen on board



SO SELECTING A BUS TECHNOLOGY, THE **RIGHT BUS TECHNOLOGY**, WILL BECOME MORE RATHER THAN LESS COMPLEX IN THE FUTURE.

PERFORMANCE IS ONE IMPORTANT ISSUE TO CONSIDER, BUT UNFORTUNATELY, NOT AN EASY ONE TO ASSESS.

WITHIN A TRANSIT FLEET, THERE ARE USUALLY MANY ROUTES AND THEY CAN BE VERY DIFFERENT FROM ONE ANOTHER. IN ADDITION, BUSES ARE NOT ALLOCATED TO THE SAME DRIVERS DAY AFTER DAY. ADD TO THIS THE FACT THAT THE CLIMATE IN OUR CITIES VARIES WIDELY WITH VARIATIONS IN TEMPERATURES RANGING FROM -40C TO +35C WITHIN A GIVEN YEAR, AND TRAFFIC CONDITIONS ONLY SERVE TO MAKE THINGS EVEN MORE UNPREDICTABLE.

BETWEEN TRANSIT SYSTEMS, THIS IS THEREFORE ALMOST NO COMPARISONS POSSIBLE. AND WITHIN THE SAME SYSTEM, COMPARING ONE ROUTE TO ANOTHER IS OFTEN FUTILE AS WELL.

SO HOW DOES ONE DETERMINE IF AN E-BUS IS THE RIGHT CHOICE FOR HIS OR HER TRANSIT SYSTEM ?

The Solution

- ① Procuring accurate data
- ② Forecasting fuel consumption
- ③ Identifying all costs
- ④ Using a lifecycle cost model to compare cost of all options

- ✦ MARCON'S TLC BU\$™
- ✦ MARCON'S TLC TRUCK™
- ✦ MARCON'S TLC AUTO™
- ✦ FleetCarma Loggers
- ✦ FleetCarma Web Portal
- ✦ FleetCarma Fuel Consumption Predictor



WELL, WE ARE SUGGESTING FOUR STEPS CONCLUDING WITH A LKIFECYCLE COST ANALYSIS THAT WILL ALLOW A FAIR COMAPRAISON ON THE BASIS OF A COMMON YARDSTICK – MONEY

MARCON AND ITS PARTNER, FLEET CARMA, HAVE PACKAGED A SERIES OF PRODUCTS TO MAKE THIS TASK FASTER AND MORE ACCURATE THAN EVER

STEP 1: Procuring Accurate Data



UP TO VERY RECENTLY, PROCURING ACCURATE DATA WAS TIME CONSUMING, RELATIVELY COMPLICATED IN TERMS OF THE QUANTITY AND TYPE OF EQUIPMENT REQUIRED ONBOARD VEHICLES AND THEREFORE COSTLY.

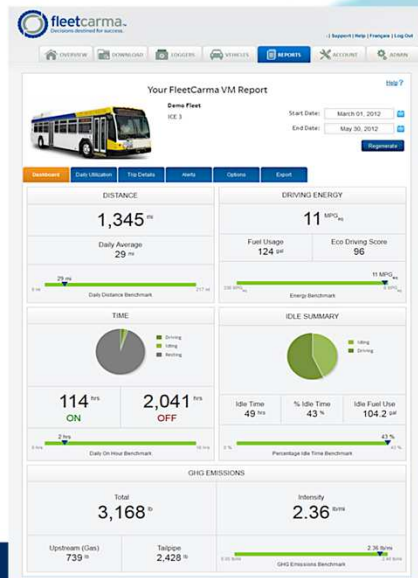
NEW DATA LOGGING TECHNOLOGY DEVELOPED BY FLEETCARMA GREATLY SIMPLIFIES THE INSTALLATION AND REDUCES THE COST OF COLLECTING ACCURATE DATA. A SIMPLE MODULE IS PLUGGED INTO ANY VEHICLE'S AVAILABLE OBD-II / J1939 PORT WITH (OR WITHOUT) THE USE OF AN ADAPTOR AND RELAYS KEY INFORMATION ABOUT THE VEHICLE VIA CELLULAR NETWORK. FURTHERMORE, THIS INFORMATION CAN BE SYNCHRONIZED WITH THE THE GEOLOCATION OF THE VEHICLE IN REAL TIME WHILE IT PERFORMS ITS STANDARD DUTY. WHILE A LITTLE MORE EXPENSIVE THAN THE BASE INSTALLATION (WITHOUT MODEM AND GPS), THE FULL INSTALLATION SAVES THE MAINTENANCE CREW THE TIME REQUIRED TO UNPLUG AND UPLOAD THE INFORMATION ON A DAILY OR WEEKLY BASIS.

HERE, YOU CAN SEE:

- A COMPACT DATA LOGGER CLIPS IN OBD-II PORT
- A MODEM THAT MONITORS VEHICLE LOCATION (GPS) AND UPLOADS DATA THROUGH CELL NETWORK
- J1939 ADAPTER

THIS EQUIPEMNT IS COMPATIBLE WITH MOST BUSES TO MEASURE FUEL USAGE & TRACK VEHICLE LOCATION, INCLUDING PLUG-IN ELECTRICS AND HYBRIDS. DATA CAN BE AUTOMATICALLY (AND WIRELESSLY) UPLOADED TO FLEETCARMA'S DATABASE.

FleetCarma Web Portal

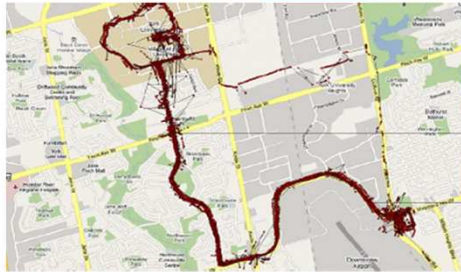


- Distance traveled
- MPG / LP100Km
- Fuel usage
- Driving behaviour
- Idle statistics
- Utilization data
- Tailpipe and upstream emissions

THIS EQUIPMENT PROVIDES ACCURATE INPUT TO THE LIFECYCLE COST ANALYSIS PROCESS AS WELL AS THE ADDED BENEFIT THROUGH A WEB PORTAL VIEWABLE BY ANYONE IN CLIENT ORGANIZATION WITH PROPER LOGIN CREDENTIALS.

SUPPLIES INFORMATION REGARDING REAL-WORLD ANALYTICS AS SOON AS THE DATA LOGGER IS SYNCHORNIZED WITH THE PORTAL ON A BUS BY BUS BASIS GPS DATA ANALYSIS ON VEHICLE LOCATION ALSO AVAILABLE

STEP 2: Forecasting Fuel Consumption



- ❖ Pilot project at Toronto Transit Commission
- ❖ No reconfiguration of the routes
- ❖ GPS used to capture most urban, average, and least urban routes

Date	2010-02-02
TTC Route Travelled	106 York University
Time of Record (hour)	12.5
Distance Travelled (km)	241.9
Total Number of Stop	1748.0
Total Travel Time (hour)	8.6
Total Stop Time (hour)	4.0
Average Speed (kph)	19.3
Average Number of Stop (/km)	7.2

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THIS ER INSTALLATION WAS USED AT THE TORONTO TORONTO TRANSIT COMMISSION (TTC), THE LARGEST URBAN TRANSIT FLEET IN CANADA, OUR STUDY DID NOT INVOLVE THE RECONFIGURATION OF THE ROUTES DESIGNED BY TTC PLANNERS. IT SIMPLY ASSUMED THAT SUCH ROUTES HAD ALREADY BEEN OPTIMIZED FOR SERVICE DELIVERY PURPOSES.

GPS RESULTS WERE USED TO IDENTIFY WHICH ROUTE WAS BEING REPEATED FOR EACH DAY AND WE DROVE BOTH CONVENTIONAL DIESEL BUSES AND DIESEL ELECTRIC HYBRID BUSES

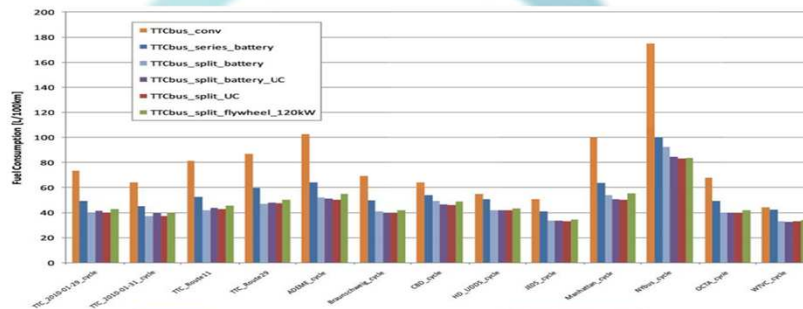
USING THE DATA PROVIDED BY THE FEET CARMA INSTALLATION, OUR SIMULATION BASED MODEL PROVIDED A FORECAST THAT YIELDED LESS THAN 3% ERROR ON AVERAGE FROM REALITY

BY EXPANDING THIS HIGH FIDELITY VEHICLE MODELING BASED APPROACH TO DIFFERENT VEHICLE POWERTRAIN CONFIGURATIONS, FLEETCARMA IS ABLE TO ACCURATELY PREDICT HOW DIFFERENT TECHNOLOGIES WOULD PERFORM ON DIFFERENT "REAL-LIFE" TTC

ROUTES AS WELL AS HOW THEY WOULD PERFORM ON “STANDARD”
DRIVE CYCLES.

Results

- ⦿ Different drive cycles have a substantial impact on a vehicle's fuel consumption

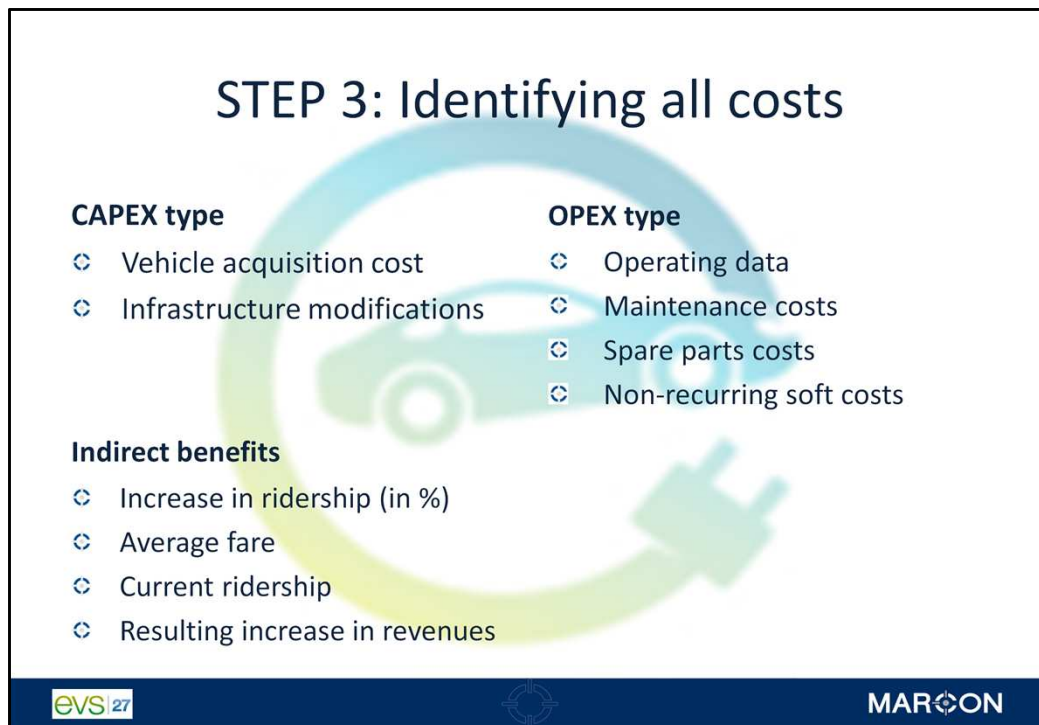


- ⦿ High fidelity simulated fuel consumption of different bus powertrain types on different “real-life” TTC routes and some “Industry Standard” drive cycles

AS SHOW IN THIS DIAGRAM, SWITCHING TO HYBRID BUSES CAN YIELD IMMENSE FUEL SAVINGS ON CERTAIN ROUTES WHILE THEY CAN BE NEGLIGIBLE ON OTHER ROUTES.

THE MOST IMPORTANT LESSON TO BE RETAINED HERE IS THE IMPORTANCE OF DOING DATA ACQUISITION ON THE ROUTES OF INTEREST PRIOR TO MAKING ANY PREDICTIVE CALCULATIONS.

- TAKING SOMEONE ELSE’S INFORMATION AND ASSUMING THAT IT APPLIES TO THE CASE AT HAND IS A RECIPE FOR DISASTER.
- NOT USING DATA GATHERED DIRECTLY ON THE FLEET UNDER INVESTIGATION GUARANTEES THAT FUEL CONSUMPTION NUMBERS WILL EITHER BE TOO LOW OR TOO HIGH.
- THIS ERROR CAN OFTEN COMPLETELY SKEW THE RESULTS OF AN ANALYSIS.
- IN THE CASE OF A LARGE TRANSIT FLEET, THIS CAN EASILY LEAD TO BAD DECISIONS COSTING HUNDREDS OF MILLIONS OF DOLLARS
- MUCH MORE THAN IF PROPER DATA LOGGING AND SIMULATIONS HAD BEEN PERFORMED PRIOR TO THE DECISION PROCESS.



ALTHOUGH IMPORTANT, **THE COST OF FUEL** IS BUT ONE COMPONENT THAT MUST BE CONSIDERED IN THE PROCESS OF OPTIMIZING A FLEET. NEWER TECHNOLOGIES (THAN THE INCUMBENT DIESEL BUS) ARE NOTORIOUSLY MORE EXPENSIVE TO PURCHASE AND OFTEN REQUIRE OTHER CHANGES WITH EITHER POSITIVE, OR NEGATIVE IMPACT ON THE OVERALL COST OF RUNNING A FLEET. THESE “OTHER COSTS” CAN BE CRITICAL TO THE SELECTION OF A BUS PROPULSION TECHNOLOGY, AND, AT THE VERY LEAST, THE FOLLOWING ITEMS MUST BE TAKEN INTO CONSIDERATION:

- VEHICLE ACQUISITION COST: BASE PRICE FOR BUSES, WARRANTY CONDITIONS, SHARE OF PRICE COVERED BY OUTSIDE AGENCY (MAY VARY FROM ONE TECHNOLOGY TO THE OTHER) AND RESALE VALUE
- INFRASTRUCTURE MODIFICATIONS: BUILDINGS, GARAGE DOORS, WASHING FACILITIES, ROOF CLEARANCE, BATTERY ROOM (FOR LEAD-ACID BATTERIES ONLY), ADDITIONAL SPARE PARTS SPACE, SAFETY / LEAK DETECTION EQUIPMENT
- EQUIPMENT: LIFTS, BATTERY CONDITIONERS, OTHERS (EX. BATTERY HANDLING)
- STATIONS AND OTHER ASSETS: TRANSIT WAY STATIONS, BUS STOP SHELTERS, PRIVATE PROPERTY COMPENSATION

- OPERATING DATA: ENERGY STORAGE LIFE EXPECTANCY (YEARS), FUEL PRICES (CURRENT AND FORECASTED)
- MAINTENANCE COSTS: ENERGY STORAGE REPLACEMENT (PER BUS), NON-SCHEDULED ENERGY STORAGE SYSTEM REPLACEMENT (PER BUS), ANNUAL PREVENTIVE MAINTENANCE (POWER PACK), ENERGY STORAGE SYSTEM DISPOSAL COSTS (PER BUS), POWER INVERTER MODULE (PIM), POWER TRAIN (INCL: TURBOCOMPRESSOR), ENGINE REPLACEMENT, TRANSMISSION REPLACEMENT,
- PREVENTIVE MAINTENANCE (ANNUAL), STARTER, FRAME, STEERING AND SUSPENSION (ANNUAL PER BUS) ANNUAL BRAKE MAINTENANCE (PER BUS),
- OTHER TRANSIT SYSTEM SPECIFIC COST: SPARE PARTS COSTS (FLEET), ADDITIONAL INVENTORY REQUIRED, ANNUAL CARRYING COST OF INVENTORY
- NON-RECURRING SOFT COSTS: FEASIBILITY STUDY, PROJECT MANAGEMENT, PREVENTIVE MAINTENANCE REPROGRAMMING, TRAINING OF MAINTENANCE EMPLOYEES, DRIVERS AND OTHERS, MODIFICATIONS TO SERVICE PLAN, TOOLING (EX. ENERGY STORAGE SYSTEM SERVICING), ADVERTISING & PROMOTION
- INDIRECT BENEFITS: INCREASE IN RIDERSHIP (IN %), AVERAGE FARE INCREASE

OBVIOUSLY, I CANT SHOW THE WHOLE SPREADSHEET BECAUSE WE WONT BE ABLE TO READ IT BUT ALL PREVIOUSLY MENTIONED ELEMENTS ARE TAKEN INTO CONSIDERATION

STEP 4: Lifecycle Cost Modeling

- ⦿ TLC BU\$™ model used at OC Transpo
- ⦿ Comparison of several propulsion options for the purchase of 226 buses
- ⦿ Acquisition value: from 90M\$ to 140M\$ for vehicles alone
- ⦿ Technologies assessed:
 - ❑ Compressed natural gas (CNG)
 - ❑ Diesel-electric hybrid (DEH)
 - ❑ Conventional diesel

BUT HERE IS A QUICK EXAMPLE: OC TRANSPOR , THE TRANSIT FLEET SERVING THE NATION'S CAPITAL INTENDED ON REPLACING 226 BUSES WITH A BUS EQUIPPED WITH A CLEANER TO SATISFY THE REQUIREMENTS OF THE CITY'S GREEN PLAN. THE MANAGEMENT WAS FIRMLY INTENT ON PROCURING DIESEL-ELECTRIC HYBRID BUSES BUT WAS CHALLENGED BY AN INTEREST GROUP WITH INFLUENCE IN THE REGION.

MARCON WAS CALLED TO ARBITRATE THE SITUATION BY CONDUCTING A STUDY OF THE FINANCIAL AND ENVIRONMENTAL IMPACT OF SEVERAL ALTERNATE PROPULSION TECHNOLOGIES INCLUDING METHANE AND HYDROGEN FUEL CELL BUT FOCUSED MAINLY ON CNG AND DEH BUSES

Lifecycle Cost Analysis Results

Capital Investment Costs at OC Transpo			
	DIESEL	CNG	DEH
Capital Investment Costs			
Bus acquisition	90 108 581	95 366 244	139 816 714
Building and Infrastructure cost	0	50 207 748	1 763 264
Other soft, non-recurring costs	0	692 074	955 283
Total capital costs	90 108 581	146 266 066	142 535 262

Forecasted Fuel Costs at OC Transpo	
Diesel (fleet average)	\$161.2M
Diesel (low speed/high stop)	\$223.8M
CNG (general allocation)	\$112.1M
DEH (low speed/high stop allocation)	\$163.4M

AFTER 3 MONTHS GATHERING COSTS DATA WITHIN OC TRANSPOR AS WELL AS OBTAINING REFERENCE DATA FROM FLEETS ALREADY OPERATING WITH THESE ALTERNATE TECHNOLOGIES, MARCON WAS READY TO REVEAL THE RESULTS OF ITS ANALYSIS PERFORMED WITH ITS TLC BUS MODEL.

CAPITAL EXPENSES COSTS ARE THE HIGHEST FOR NATURAL GAS AS NEW COSTLY FUELLING INSTALLATIONS WERE REQUIRED. BUT FUEL COSTS WERE MUCH LOWER THAN THOSE OF DIESEL (USING HYBRIDS OR NOT) EVEN IN THIS CASE WHERE OPERATORS WERE NOT ALLOCATING BUSES TO ROUTES WHERE THEY COULD PERFORM BEST. I ALSO DRAW YOUR ATTENTION TO THE FACT THAT THE PRICE OF NATURAL GAS AT THAT TIME WAS STILL RELATIVELY HIGH AT CAD 6,35/MMBTU COMPARED TO A TYPICAL 2013 PRICE OF LESS THAN 4\$.

IN THIS CASE, FUEL COSTS WERE NOT, BUT IDEALLY SHOULD BE SUPPLIED BY CROSSCHASM IN THE WAY DESCRIBED EARLIER.

Average Fleet Allocation		DIESEL	CNG
Capital Investment Costs			
Bus acquisition		90,108,581	95,366,244
Building and infrastructure cost		0	50,207,748
Other soft, non-recurring costs		0	692,074
Total capital costs:		90,108,581	146,266,066
Operating Costs			
O&M cost (excluding fuel)		192,698,598	193,902,965
Fuel cost		161,193,810	112,051,396
Electricity (compressor)		0	6,293,399
Total operating costs:		353,892,408	312,247,760
Non-Discounted Total Cost		444,000,989	458,513,826
Discounted Total Cost		302,108,366	333,267,256

Lifecycle costs		
Low Speed / Frequent Stops	DIESEL	DEH
Capital Investment Costs		
Bus acquisition	90,108,581	139,816,714
Building and infrastructure cost	0	1,763,264
Other soft, non-recurring costs	0	955,283
Total capital costs:	90,108,581	142,535,262
Operating Costs		
O&M cost (excluding fuel)	246,834,752	182,890,809
Fuel cost	223,774,936	163,361,122
Battery replacement cost	0	25,481,952
Other costs	0	5,078,268
Total operating costs:	470,609,689	376,812,151
Non discounted Total Cost	560,718,269	519,347,413
Discounted Total Cost	373,459,512	365,250,148

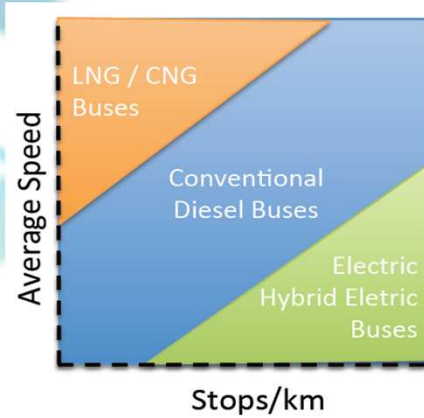
SO, IN THIS CASE, THE CONCLUSION WAS THAT OVER THE LIFE OF THE BUSES, THIS NEW DEH FLEET WOULD PERFORM BETTER THAN THE INCUMBANT DIESEL BUSES WHERE CNG BUSES WOULD NOT. BUT THIS WAS NOT REALLY A FAIR COMPARISON.

CNG BUSES USED IN THEIR OPTIMAL DUTY CYCLE WOULD PERFORM BETTER THAN DIESEL AS WELL BUT REMEMBER, THE OPERATORS WERE NOT WILLING TO MAKE PROPOER ALLOCATIONS FOR CNG BUSES, WHERE THEY CLAIMED THEY WOULD DO SO FOR DEH BUSES. AND UNDERSTANDEDBLY, A MIXED FLEET WITH 3 TYPES OF BUSES WAS NOT AN OPTION.

NEVERTHELESS, THE OC TRANSP0 CASE ALLOWS US TO DRAW VALUABLE LESSONS.

Lessons Learned

- Each technology has a “sweet spot”
- Using E-Buses where they cannot outperform other technologies only serves to uselessly discredit E-technologies
- Garbage in, garbage out
- Lifecycle cost analysis is the only way to get the whole picture



1. EACH TECHNOLOGY HAS A “SWEET SPOT”
- 2 USING AN E-BUS, INDEED ANY BUS TECHNOLOGY, WHERE IT CANNOT OUTPERFORM OTHER TECHNOLOGIES ON THE FIELD ONLY SERVES TO DISCREDIT THEM
3. WHERE ANALYSIS DATA IS CONCERNED, NO BIG SURPRISE: GARBAGE IN, GARBAGE OUT
4. LIFECYCLE COST ANALYSIS IS THE ONLY WAY TO GET THE WHOLE PICTURE