Informing Transition Strategies to Alternative Fuel Vehicles Technologies in Developing Countries

Marc HADDAD
Center for Mobility Systems
Lebanese American University

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Outline

Part I	**Overview of sustainability challenges in developing countries:** *The case of Lebanon's Greater Beirut Area (GBA)*
Part II	**Assessment of mitigation strategies:** *What can be done with what's readily available*
Part III. a	**Prioritization of alternative fuel and vehicle technologies:** *What can be done with what's not readily available yet*
Part III. b	**Vehicle mix model:** *How to arrive at the most beneficial vehicle mix for the lowest costs*
Part IV	**Fleet management modeling:** *How to maximize fleet energy efficiency by managing on-board energy use*

Road transport in the Middle East region

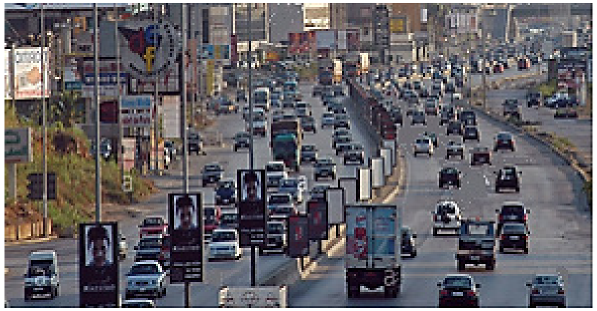
existing conditions

- Region’s annual population and economic growth (1.5% and 3.9%) higher than global averages (0.9% and 3.2%)
- Consumption of oil in transport almost doubling in two decades (67.1M tons in 2000, 124.6M tons in 2014)
- Forecast of 1.9% annual increase in transport energy consumption until 2040, almost double the rate for Europe
- Significant challenges in readiness of infrastructure, age of vehicle fleet, modal share of public transport, awareness of sustainability, and GDP per capita

source: “Global Transport Scenarios 2050”, World Energy Council, 2011

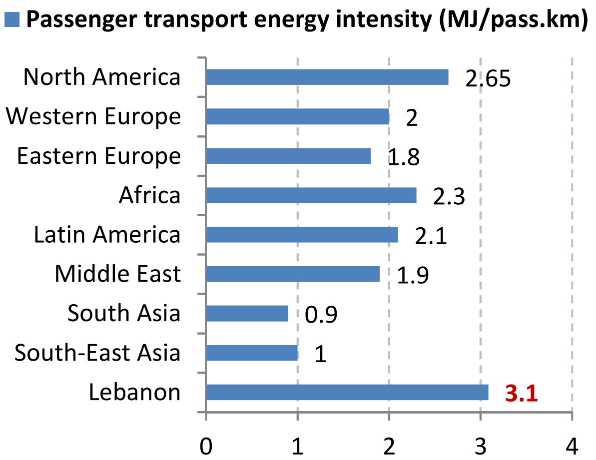
Road passenger car transport in Lebanon:
existing conditions in Greater Beirut Area (GBA)

Off-Peak Traffic in 2000

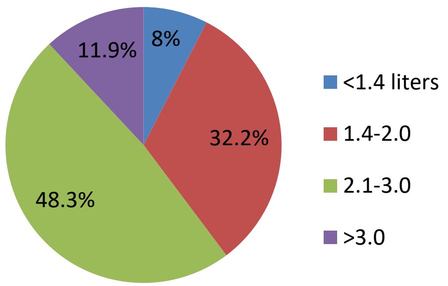


Off-Peak Traffic in 2015

- > 40% of Lebanese population (~ 2M people)
- > 5M daily passenger trips in 2015
- > 1.75 million passenger cars registered in 2017
- Occupancy rate of 1.2 pass/veh. (25% < world average)
- Old vehicle fleet (71% older than 10 years, 63% older than 20 years)
- Oil-based fleet (99.2% on gasoline, 62% of total oil consumption)
- 2nd biggest emitter of GHG (1.4 times world average)



Inefficient fleet: **60% of engines > 2.1 liters**



Engine displacement distribution (2007)

GHG	25% of all GHG Emissions (% of all sectors)
CO_2	+114% in 2011
CO	94%
NOx	59%
NMVOC	66%

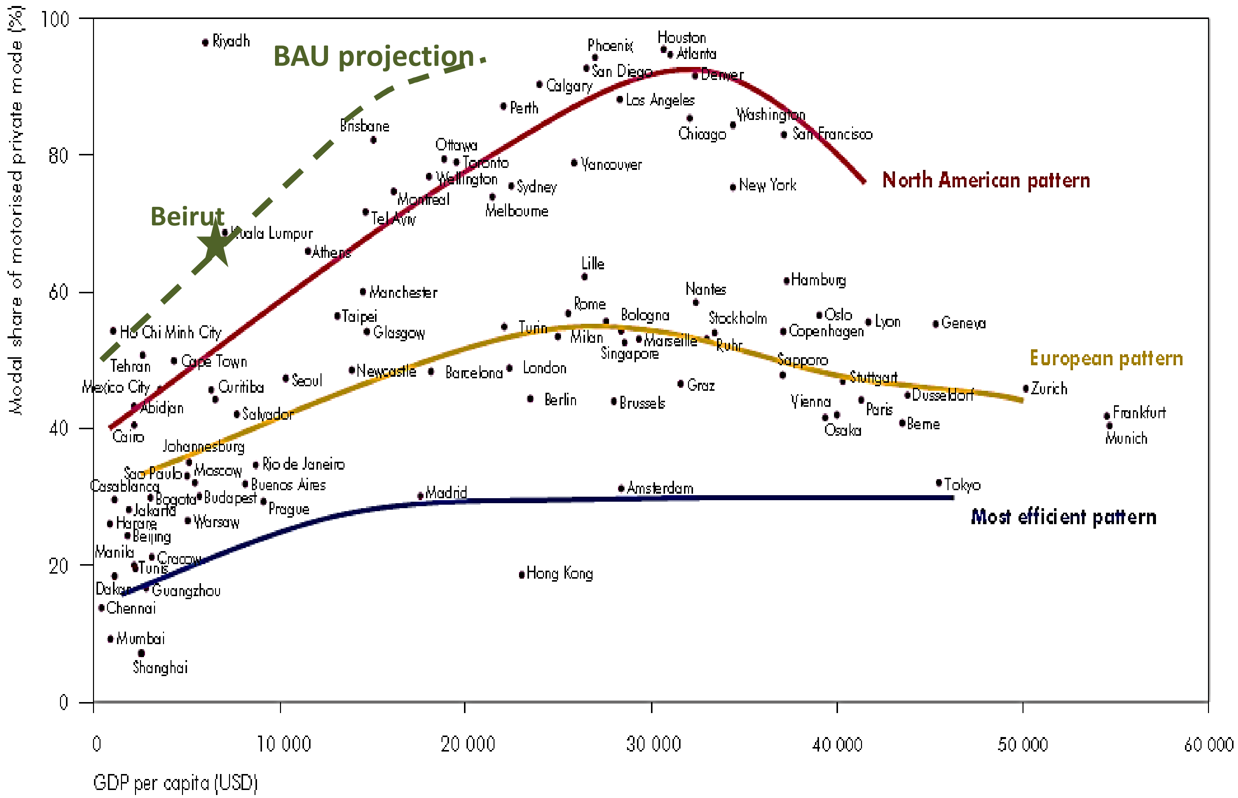
Public transport in Lebanon:

existing conditions in GBA

< 30% market share in GBA

Low vehicle occupancy

Modal share of passenger cars (%) vs. GDP/capita (USD)



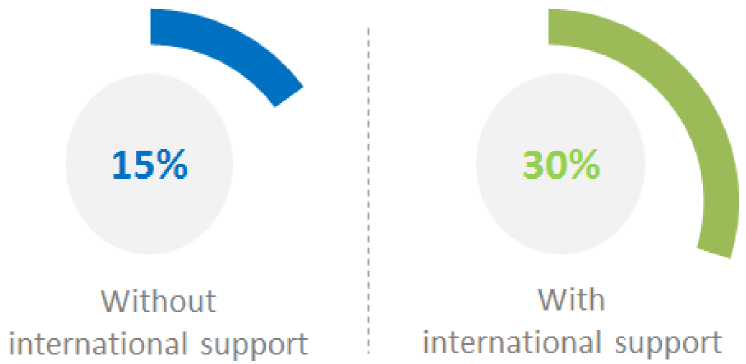
Overdependence on passenger cars similar to North American cities, but:

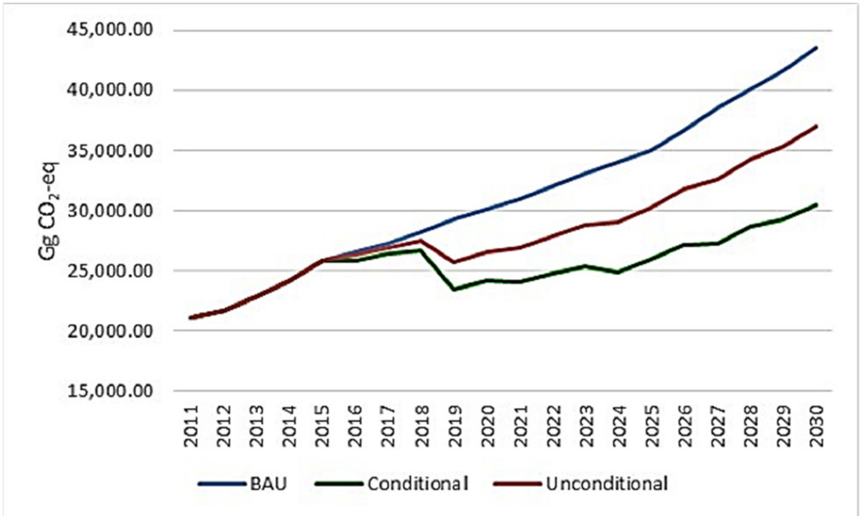
- ***without the equivalent GDP/capita***
- ***without any strategy towards sustainability in the horizon***

INDC Commitments and Discovery of Natural Gas

Towards sustainability

- Lebanon signed the Paris Agreement of the UNFCCC for mitigation of transport GHG





- Agreement's INDC targets by 2030
  - Revive the role of public transport
  - Achieve a share of 20% fuel-efficient vehicles by 2030
- Discovery of large reserves of natural gas:
  - How to use feasible alternative fuels in transport?

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Mitigation scenarios

Input Data and Assumptions

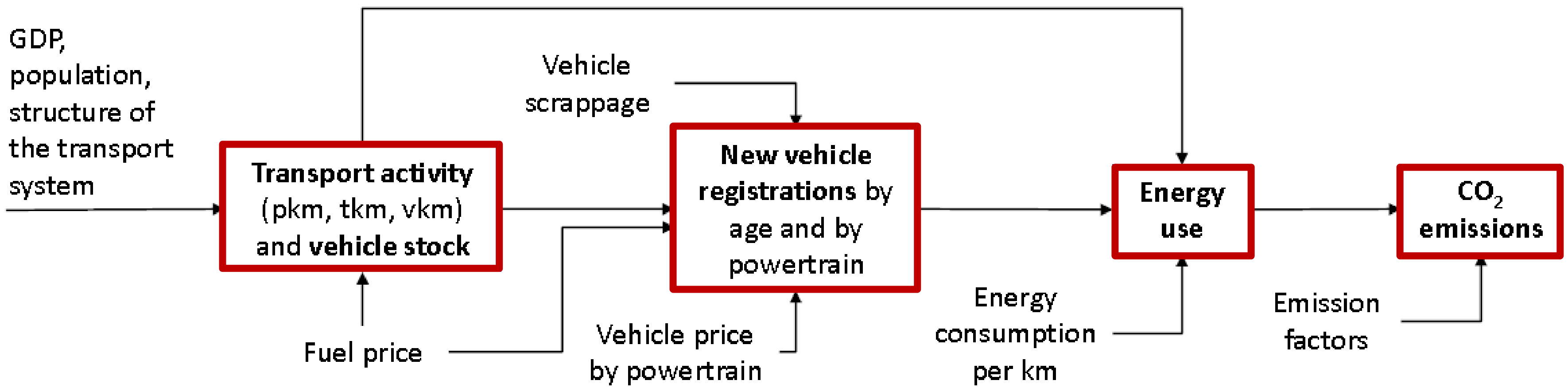
	Socio-economic assumptions (2010 – 2040)	Passenger transport system index	Passenger LDV powertrain shares (2010 – 2040)	
			Conventional	Hybrid
Baseline scenario: *Business As Usual scenario*	- Fuel prices up by 50% - Population up by 22% - GDP up by 4 times	36% of pkm on public transport	11.8% small, 54.9% midsize, 33.3% large vehicles	0%
Mitigation option 1: *Increase share of Fuel Efficient Vehicles (FEV)*	constant	constant	35% small, 55% midsize, 10% large vehicles	constant
Mitigation option 2: *Increase share of FEV and Hybrid vehicles*	constant	constant	35% small, 55% midsize, 10% large vehicles	10% of new registered vehicles by 2040
Mitigation option 3: *Increase share of mass transport*	constant	53% (emulating European cities)	constant	constant

Dynamic Assessment of INDC Mitigation Strategies

UNECE's "For Future Inland Transport Systems" (ForFITS) Model

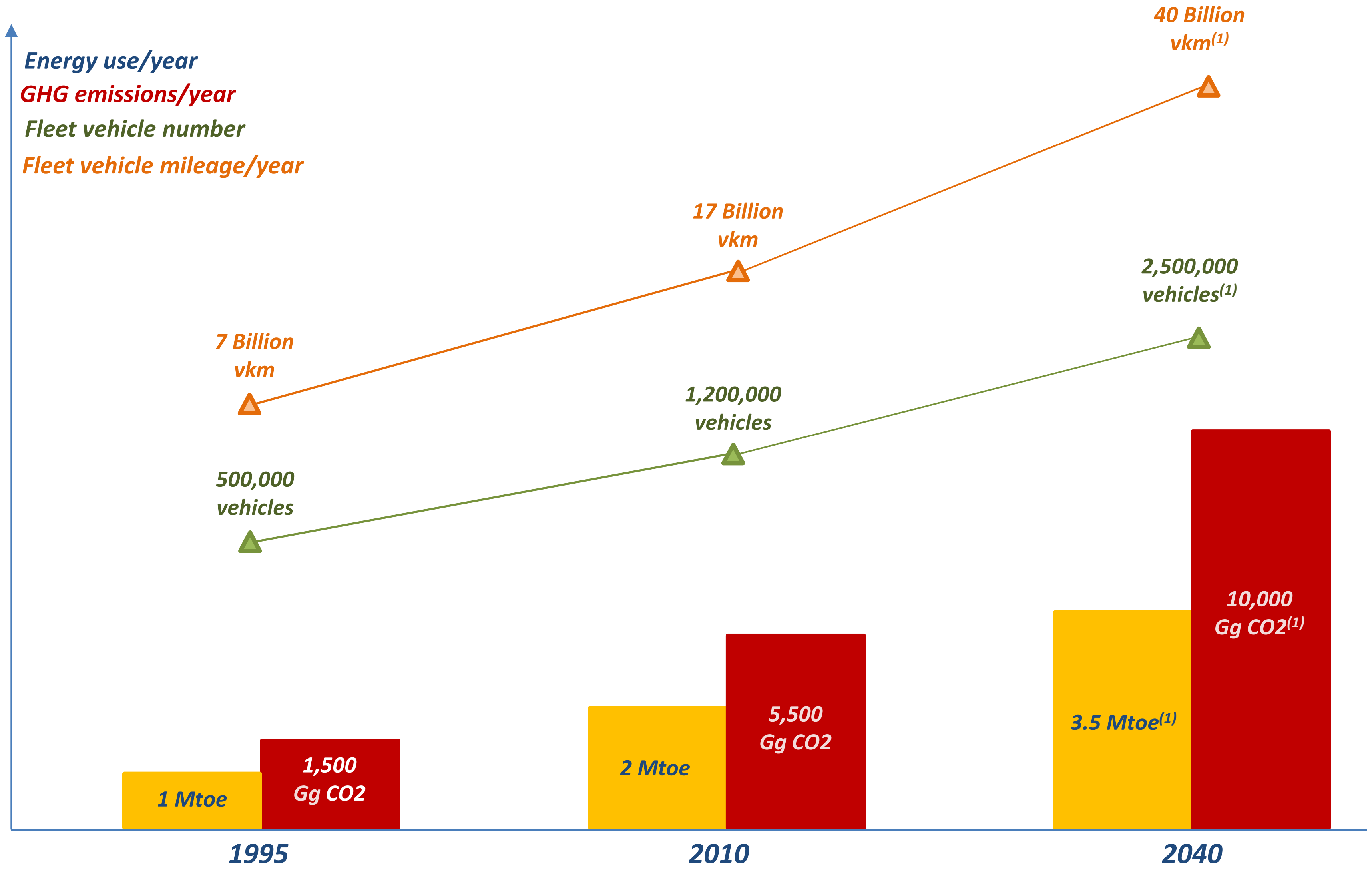
- Determine impact of INDC mitigations strategies on:
  - vehicle stock, transport activity, energy use, CO_2 emissions
  - by 2020 and 2040
- ***ForFITS*** uses demographic and socio-economic data and assumptions, with limited policy inputs, to model transport activity and estimate fuel consumption and CO2 emissions

ForFITS (2012) Calculation Methodology



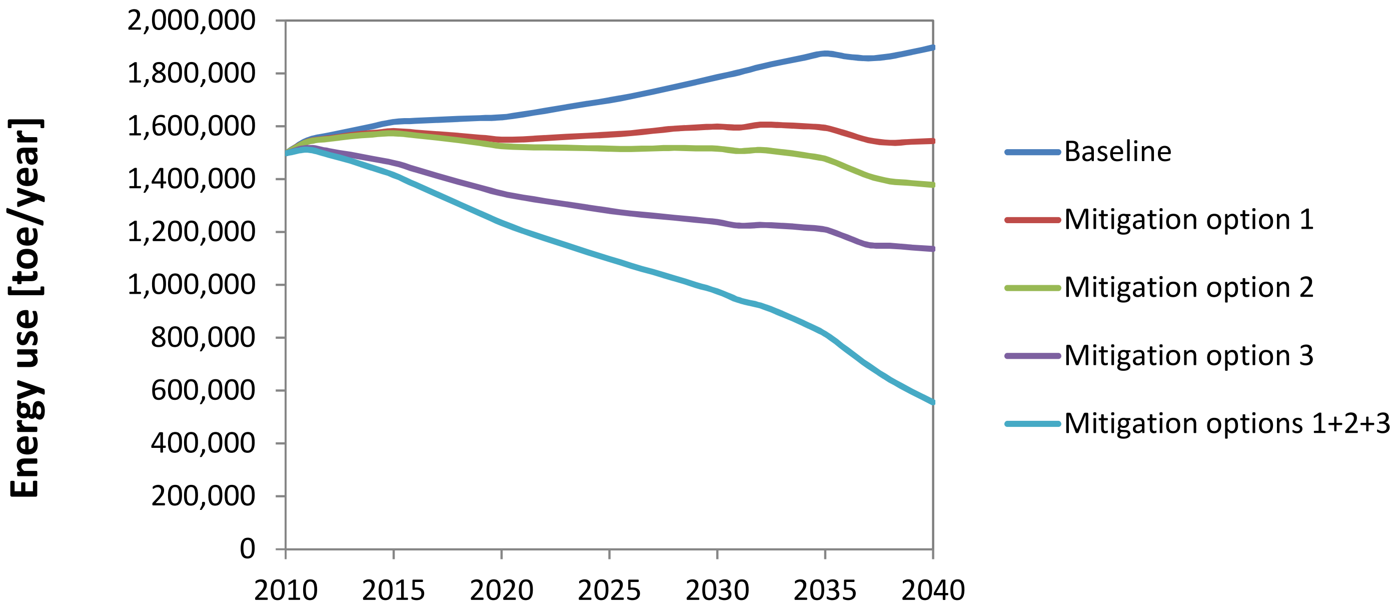
Baseline BAU projection

significant growth



Mitigation results

The whole is greater than the sum of the parts



- Increasing FEVs to 35% in 2040 stabilizes energy use and emissions
- Adding 10% HEVs to the mix by 2040 gives 11% additional savings
- Increasing bus pkm to 45% in 2040 reverses growth trends
- Combining all three strategies leads to 63% reductions in 2040 compared to 2010, more than their cumulative savings

Policy Incentives

Increase the market share of alternative fuel vehicles

Type	Priority sequence	Measures		
Economic and financial measures	**1 Create market** *Give incentives*	Exemption from custom and excise fees, registration fees, and road usage fees at registration.	Payment of min salvage value (2500 USD) as down payment for car loan> Extension of loan period to 8-years. Reduce loan interest.	Reduce gradually max age of imported pre-owned vehicles to 3-years with mileage lower than 100,000 km.
	2 Stop the bleed	Adopt a Bonus-Malus tax policy where polluters pay more annual road-usage fees, and where taxes like the road usage fees are reconsidered according to fuel efficiency and/or emissions rather than engine displacement.	Create a car scrappage program based on swapping current passenger cars with hybrid and fuel efficient cars	
Market development	**3 Remove old cars**	Create a car termination plant that deals with the car termination process after the swap in the scrappage program		
Policy, legal and regulatory	**4 Regulate car imports**	Update decree 6603/1995 relating to standards on permissible levels of exhaust fumes and exhaust quality to cover all types of vehicles	Update the vehicle inspection program requirements taking into consideration special requirements for hybrid cars' inspection, in addition to mandating the presence of catalytic converters on conventional gasoline vehicles	
Institutional/ organizational capacity	**5 Close the tap**	Set up a mechanical inspection unit at the port of Beirut in charge of checking up the emissions and safety standards of imported pre-owned cars before entering the country		
Social awareness	**6 Reform wrong perception**	Establish awareness campaign		
Project monitoring and validation	**7 Monitor the progress**	Create Mobility Monitoring Indicators (MMI) framework		

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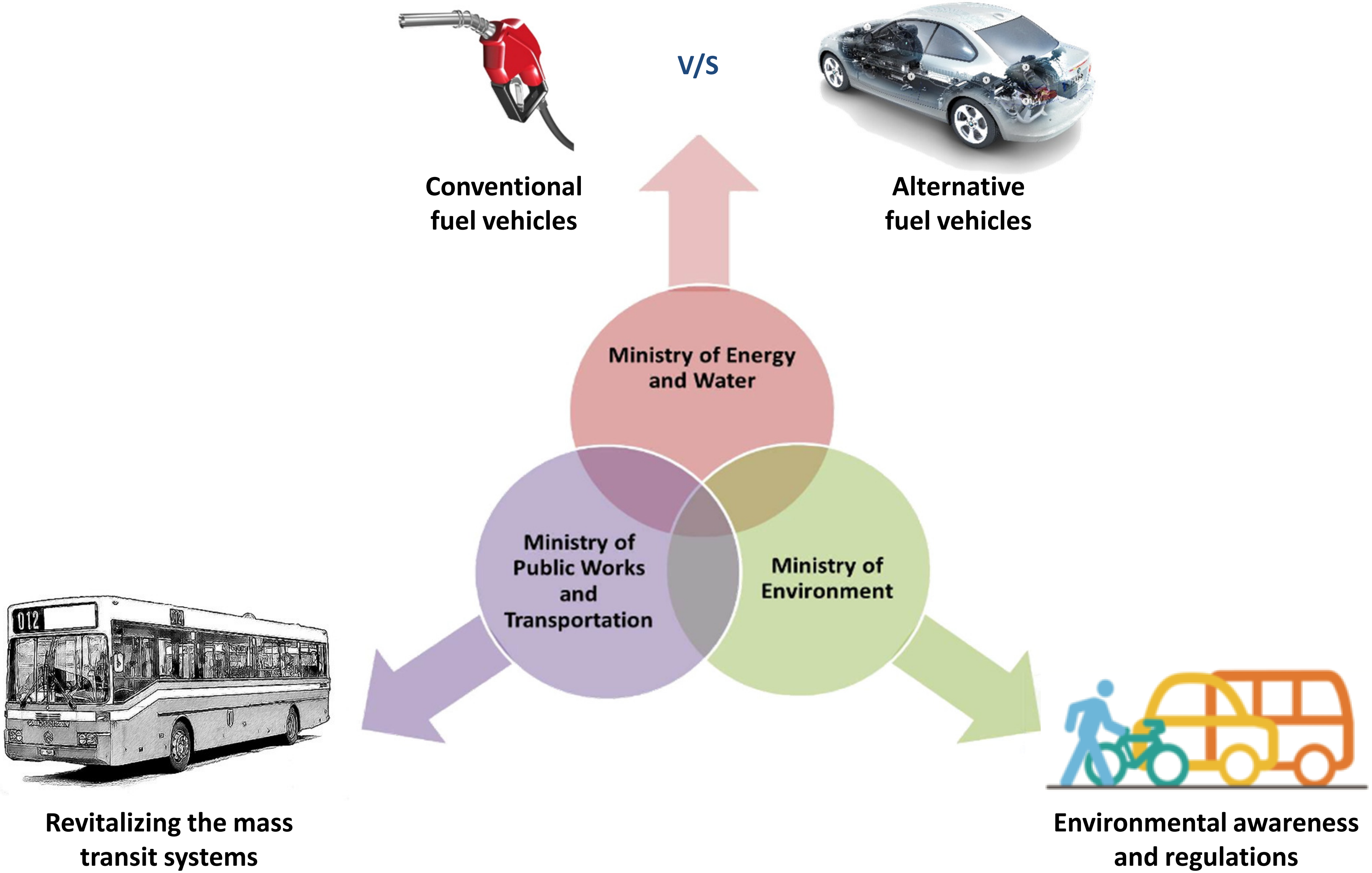
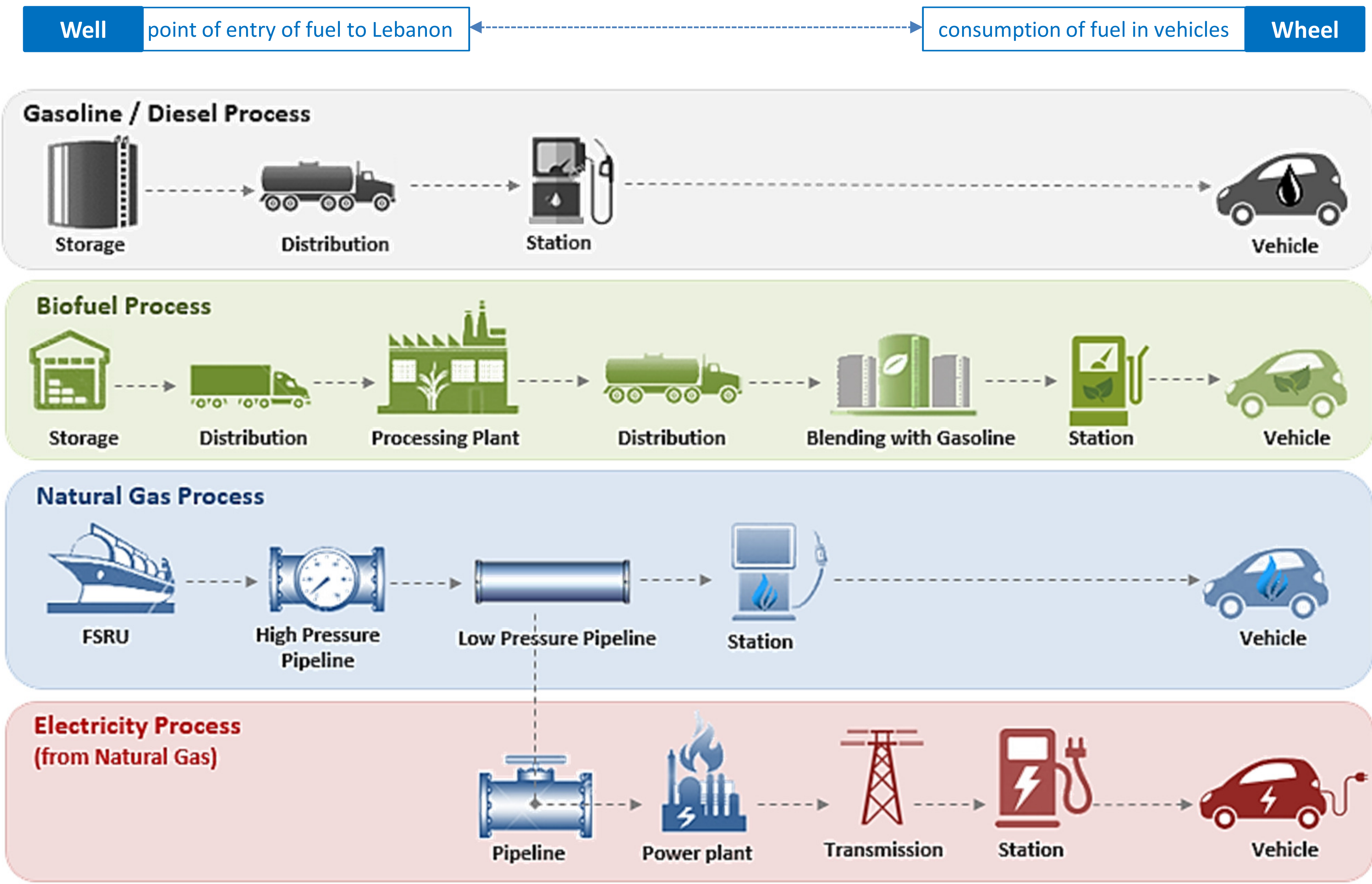
Exploring alternative fuels and vehicle technologies

Minimize energy use and GHG emissions for lowest costs



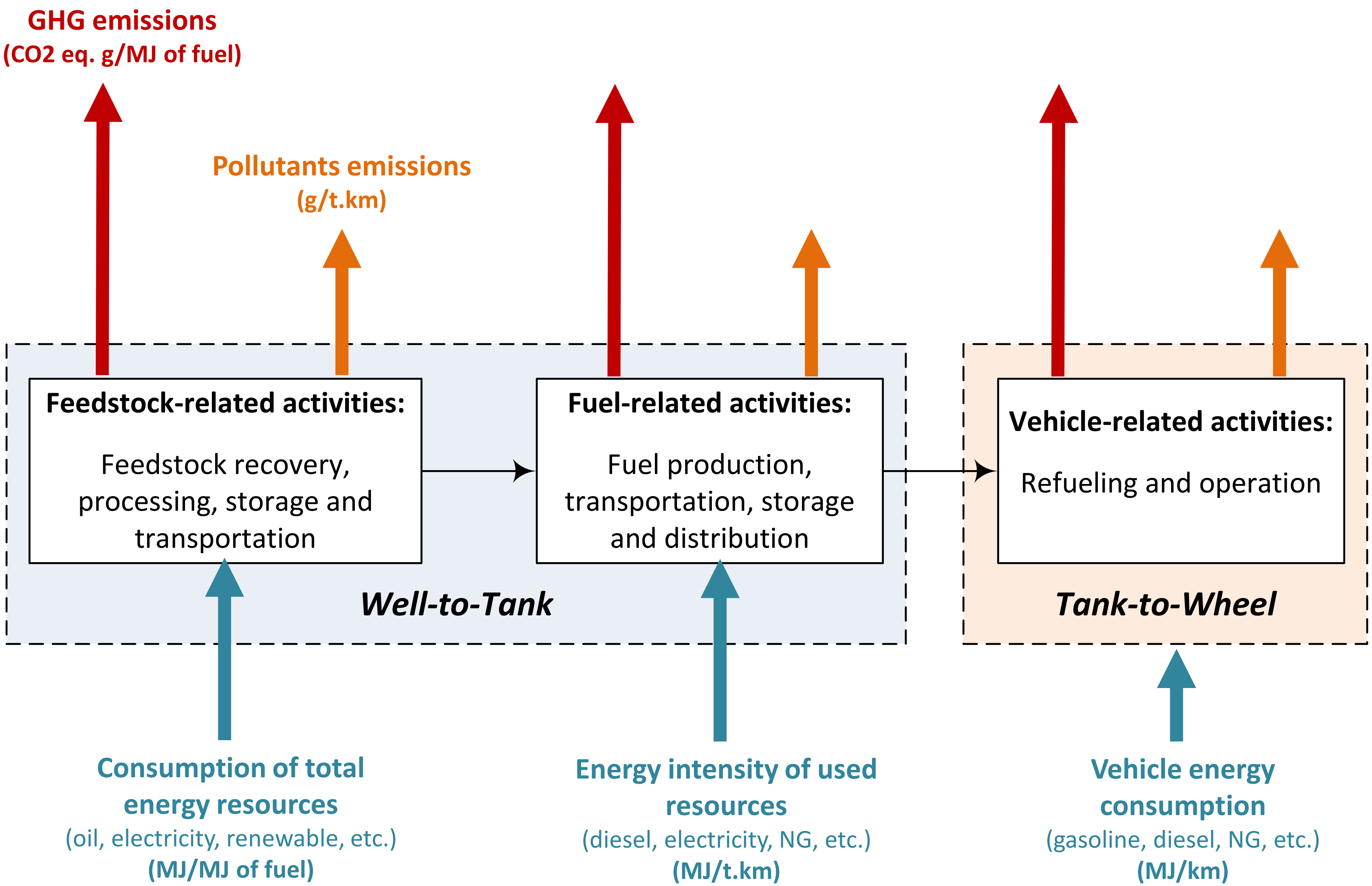
Well-to-wheel assessment

fuel use, emissions and costs of vehicle technologies in Lebanon



Assessment framework

Argonne's GREET



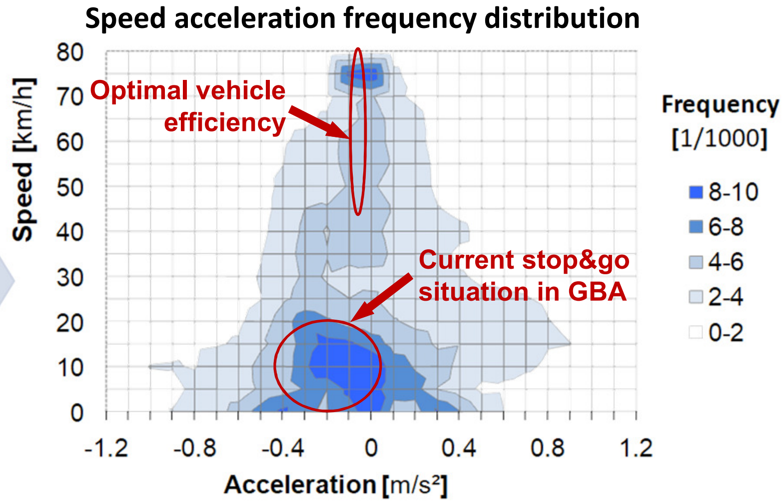
Tank-to-wheel assessment

fuel use, emissions and costs of vehicle technologies in Lebanon

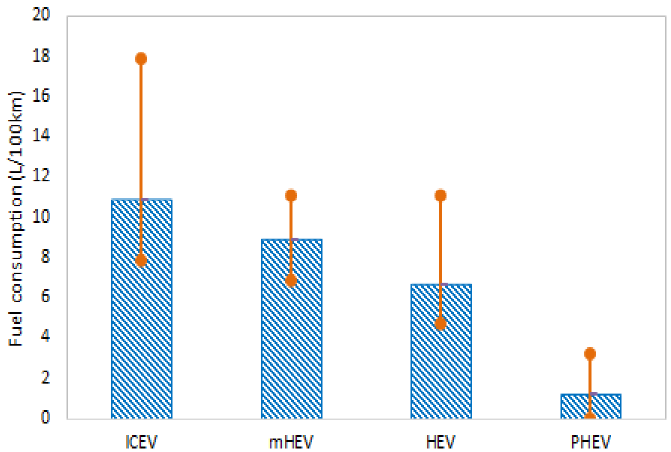
On-board measurements to develop GBA driving cycles

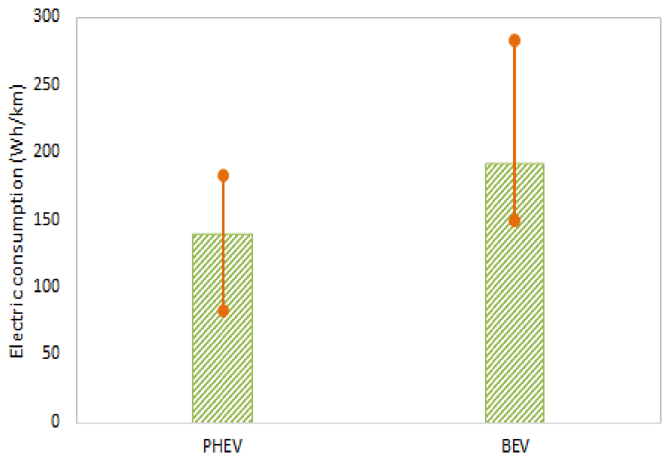
10,300 km - 850 hrs

- 50% of trips < 5 km
- 50% of stops < 5 sec
- Stop time > 15% of trip time



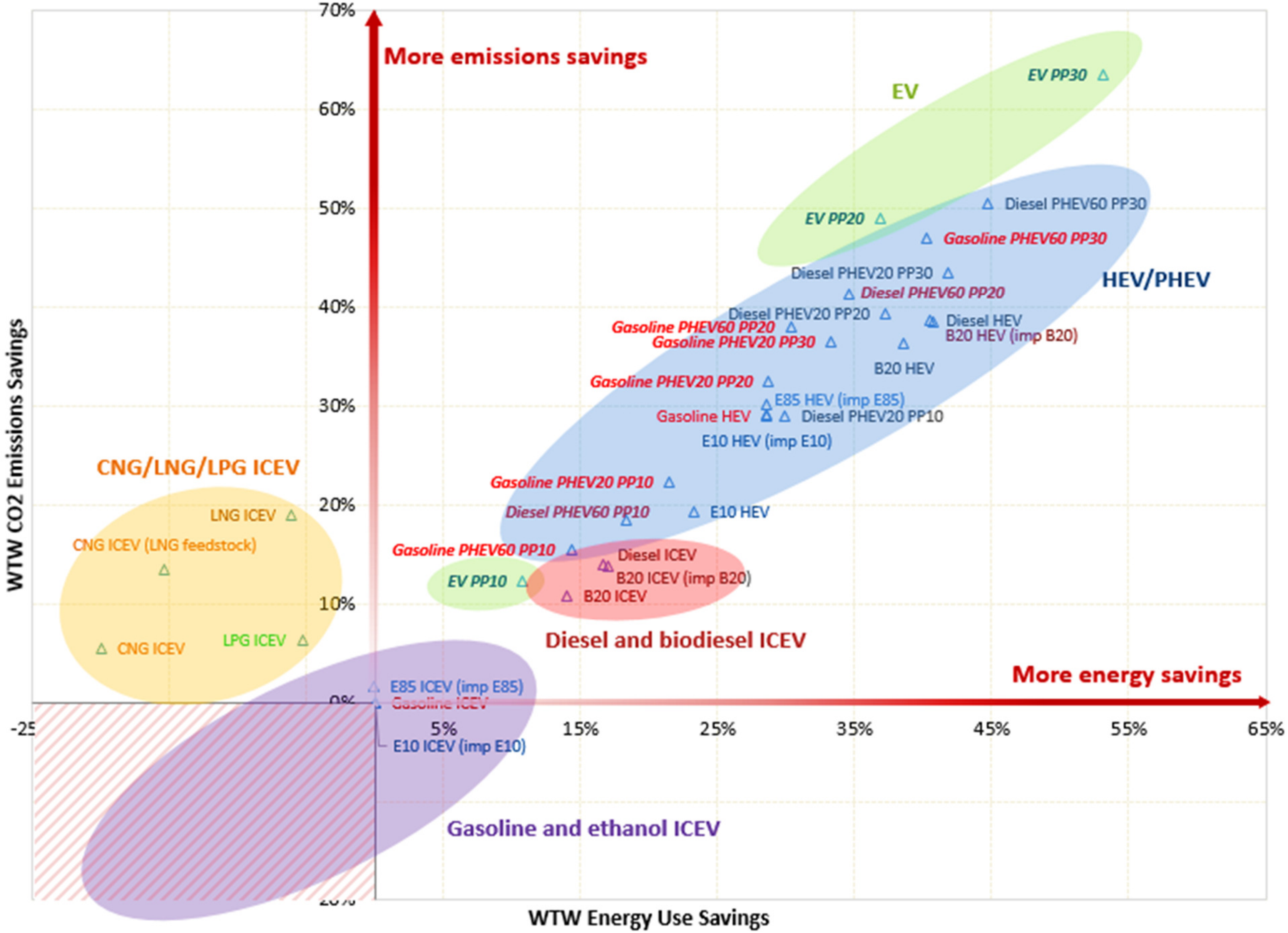
Autonomie simulation results by vehicle type on 20 representative driving cycles for the GBA





Benefits of assessed fuel-vehicle technologies

EV's and PHEV's best if electricity mix is clean, NG clean but energy consuming



Cost methodology

User, government and private sector costs over near, medium and long terms

Vehicle total costs for users:

Vehicle ownership cost
- Vehicle purchase cost
- Vehicle depreciation
- Insurance fees
- Custom and excise fees
- Registration
- VAT
- Road usage fees
- Financing charges

Vehicle operating cost
- Energy consumption cost
- Maintenance and repair costs
- DPF and Battery costs

Operation subsidies

Environmental-to-cost performance
in (USD/veh.km) of each fuel-vehicle technology relative to the baseline 2016 gasoline ICEV

Government foregone revenues
GHG abatement cost by fuel-vehicle technology in (USD/tonne CO2 eq.)

Public sector infrastructure cost
v/s WTW GHG emissions reduction of each fuel-vehicle technology

Infrastructure and government costs:

Infrastructure capital cost
- Distribution infrastructure
- Transportation infrastructure
- Fuel production plant

Infrastructure operating cost
- Distribution infra. O&M
- Transportation infra. O&M

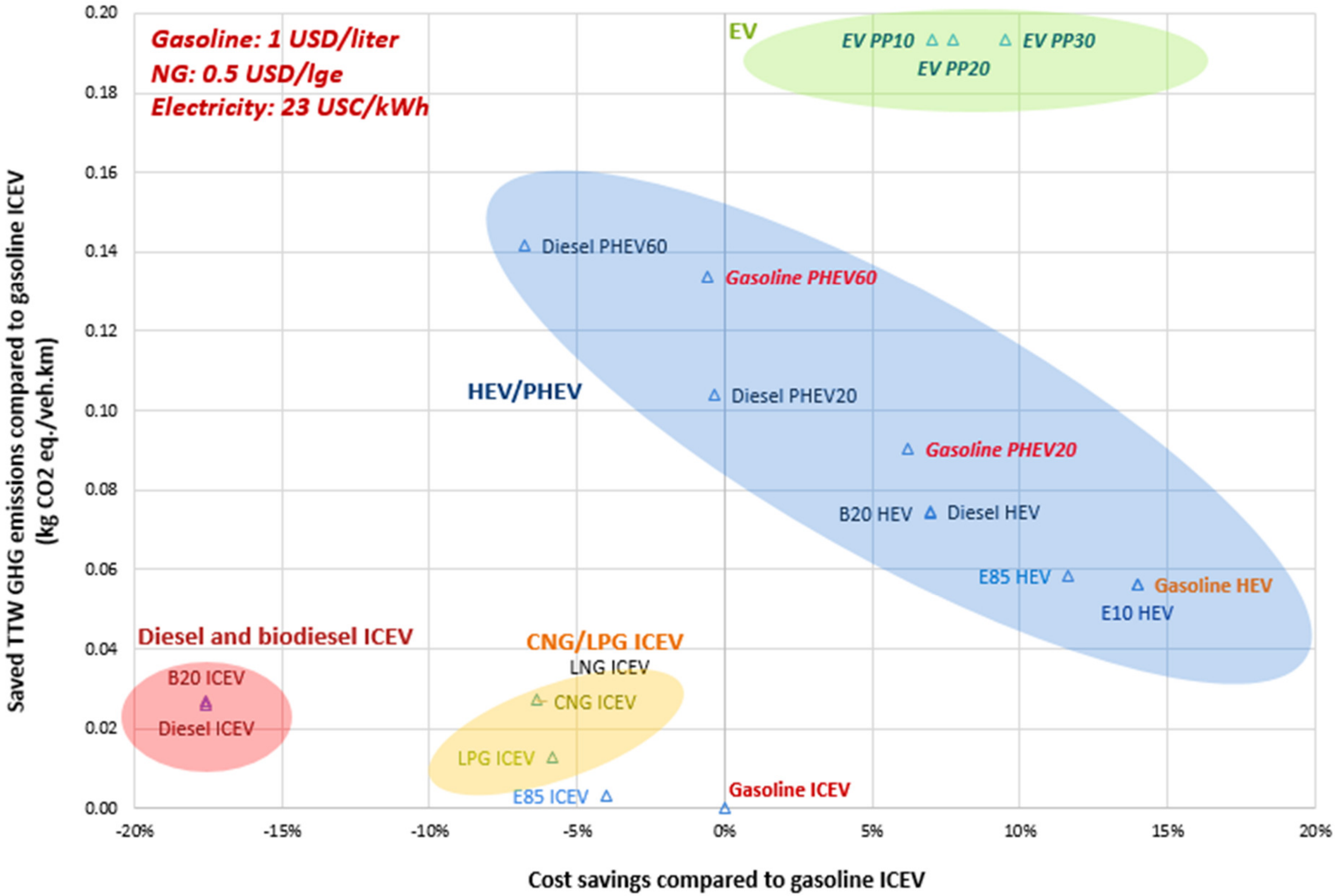
Subsidy foregone revenues

Foregone fuel tax revenues

Near-term 2018-2020 — Medium-term 2018-2030 — Long-term 2018-2040

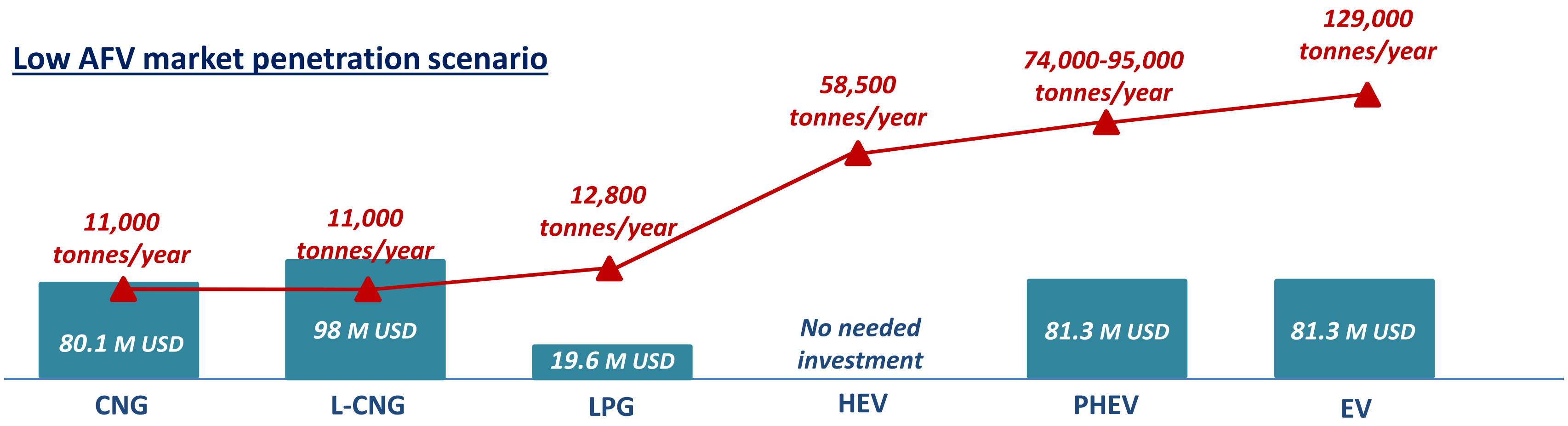
Technology attractiveness from users' perspective

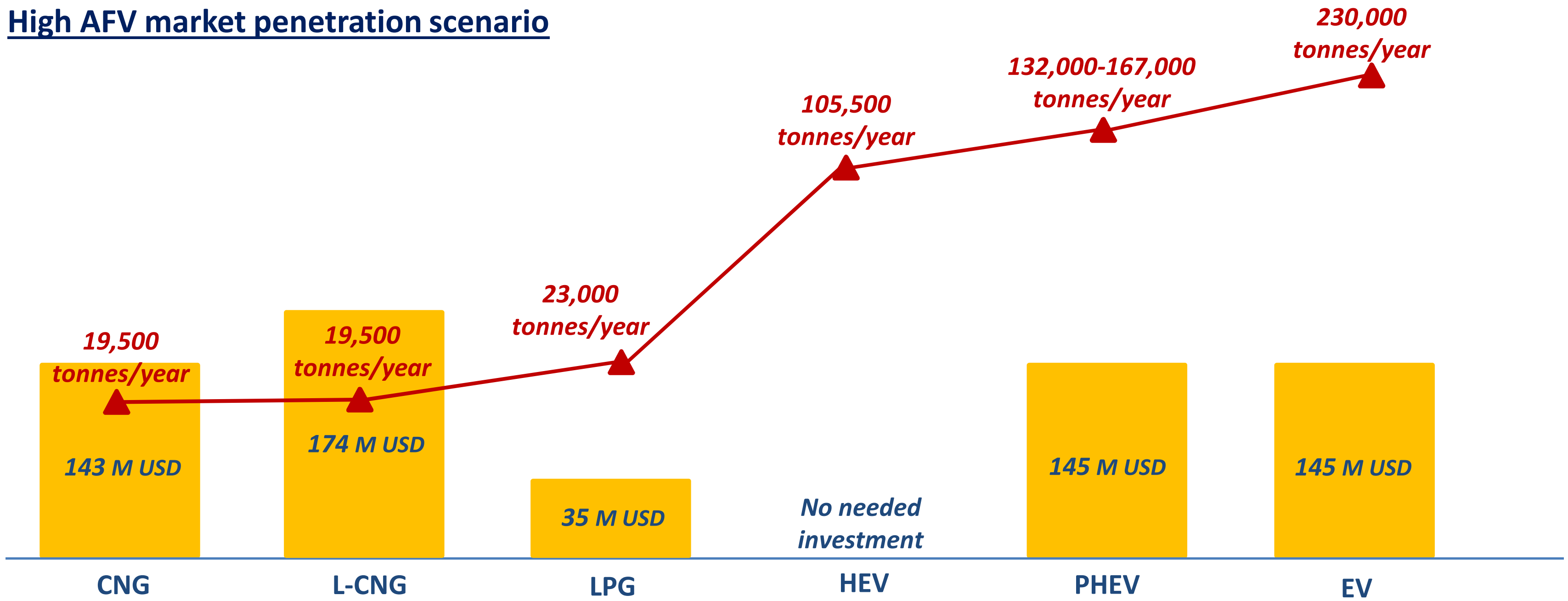
Environmental-to-cost performance for yearly mileage of 12,000 km



Infrastructure investment costs by market penetration rate

per saved WTW GHG emissions





Transition strategy to alternative fuel vehicles

Roadmap

2030 – 2040

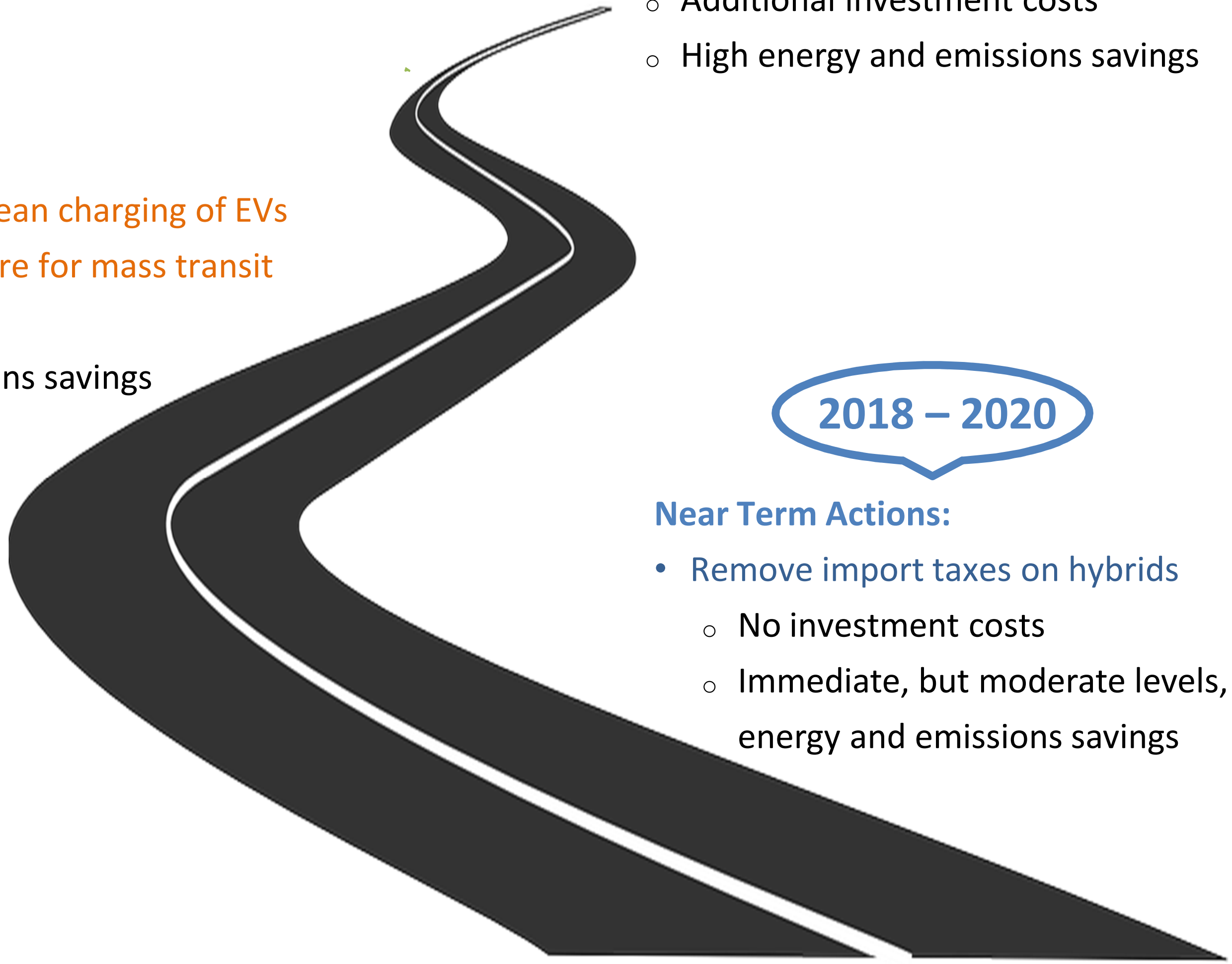
Long Term Actions

- Expand electricity charging infrastructure
  - Additional investment costs
  - High energy and emissions savings

2020 – 2030

Medium Term Actions

- Convert power plants to NG for clean charging of EVs
- Build small-scale CNG infrastructure for mass transit
  - New investment costs
  - Additional energy and emissions savings



2018 – 2020

Near Term Actions:

- Remove import taxes on hybrids
  - No investment costs
  - Immediate, but moderate levels, of energy and emissions savings

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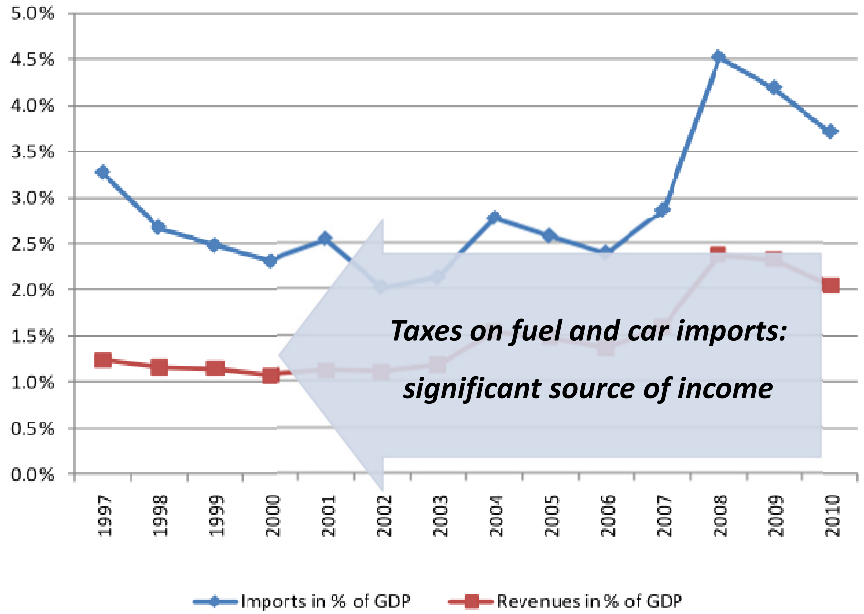
Vehicle-mix model

Towards a beneficial mix of alternative fuel vehicles for lowest infrastructure cost

Infrastructure
(completely unavailable backbone and refueling)

Government
(within cons



Taxes on fuel and car imports: significant source of income

Fuel-Vehicle Class and Type
(gasoline/diesel/biodiesel ICEV, HEV, PHEV, CNG, BEV, small, medium, large)

User Adoption by Group
(normal user, service fleet, taxi fleet)

Adoption dynamics for user groups vs individual user under cost restrictions

Vehicle-mix model

SD model outline

Model Inputs

- User groups
- Costs: vehicle, fuel, infrastructure
- Vehicle: driving range, tech exposure, WTW emissions
- Infrastructure construction time
- Government policies
- Constraints: INDC targets, tax revenues, personal income

Model Calculations

Adoption =
Attractiveness of vehicle tech
(relative utility {emissions, costs, range, infra availability})
×
User willingness to switch to vehicle tech (tech exposure)

where:

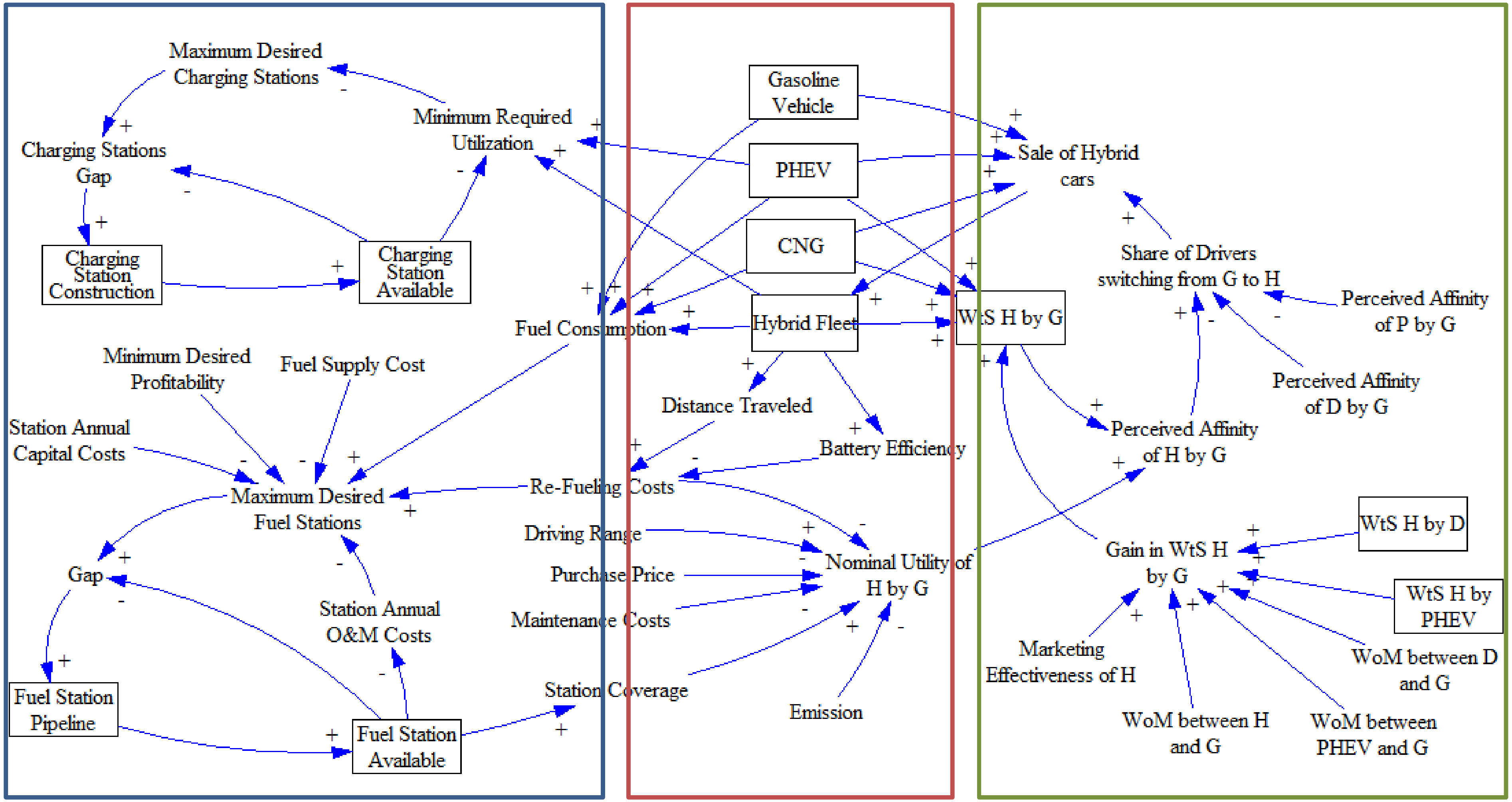
Infra availability (profitability, utilization)

Model Outputs

- % vehicle sales for each vehicle tech
- Infrastructure construction

Vehicle-mix model

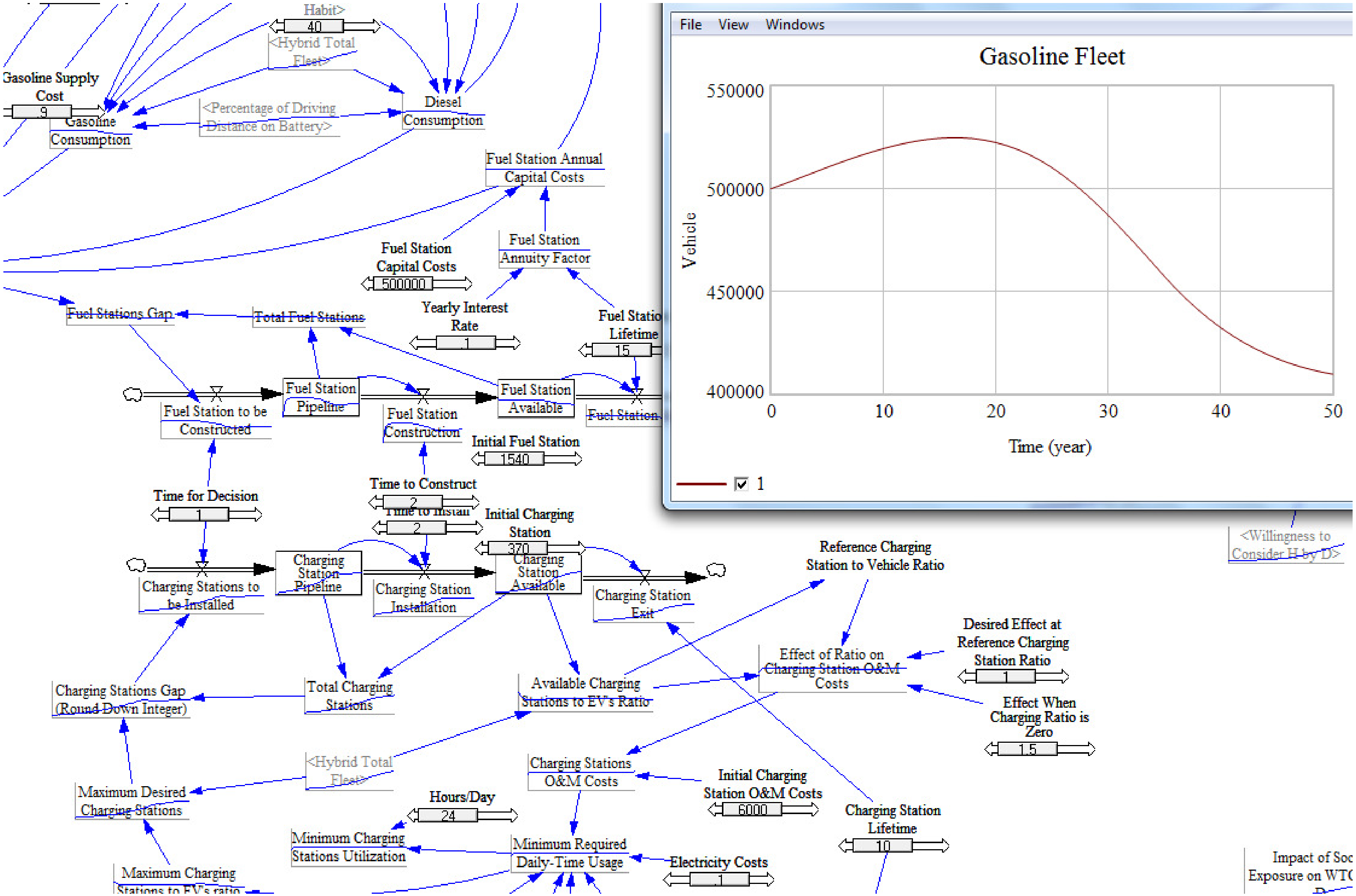
Causal Loop Diagram



Infrastructure Vehicles User Adoption

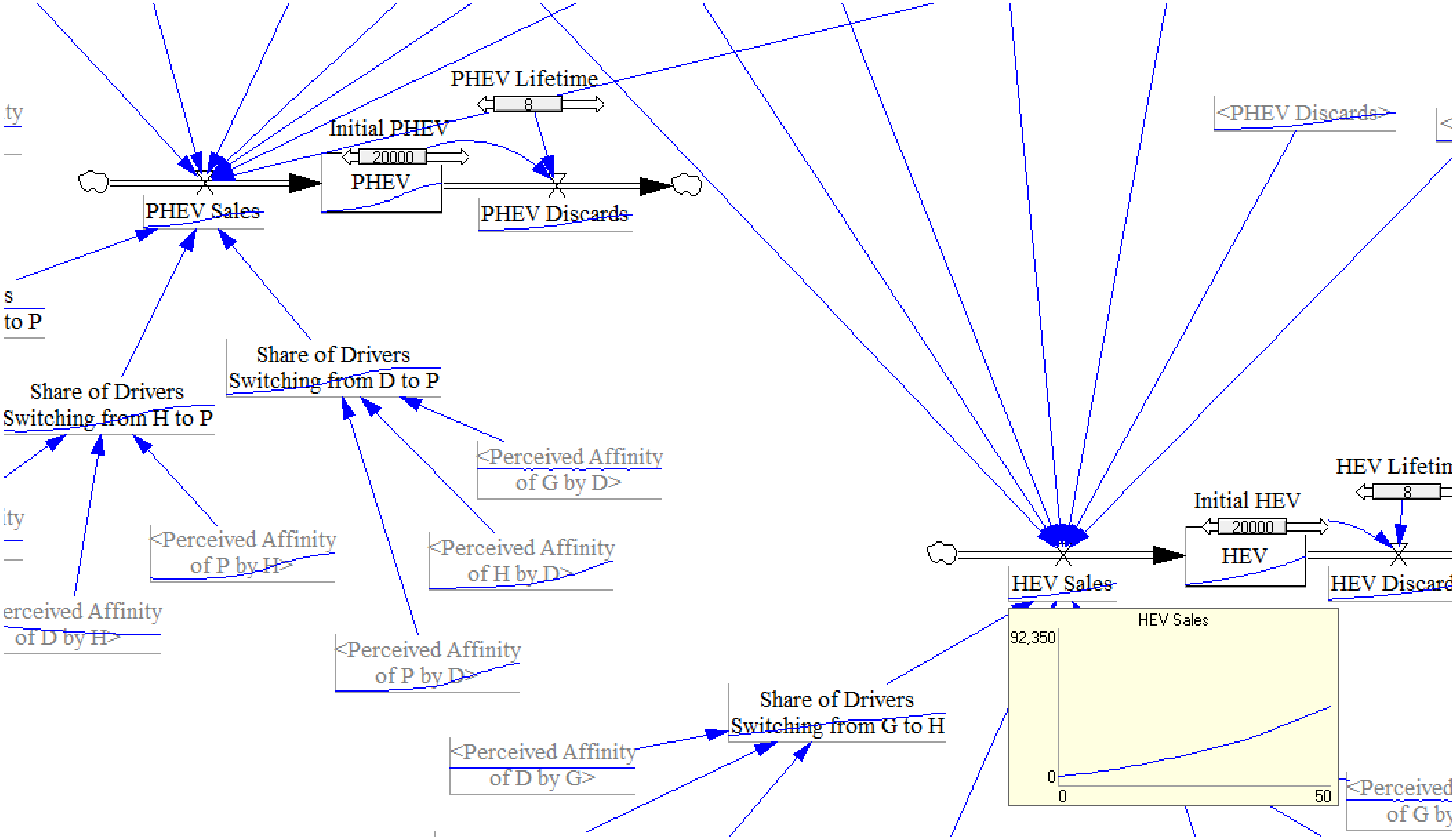
Vehicle-mix model

SD Model in-progress



Vehicle-mix model

SD Model in-progress



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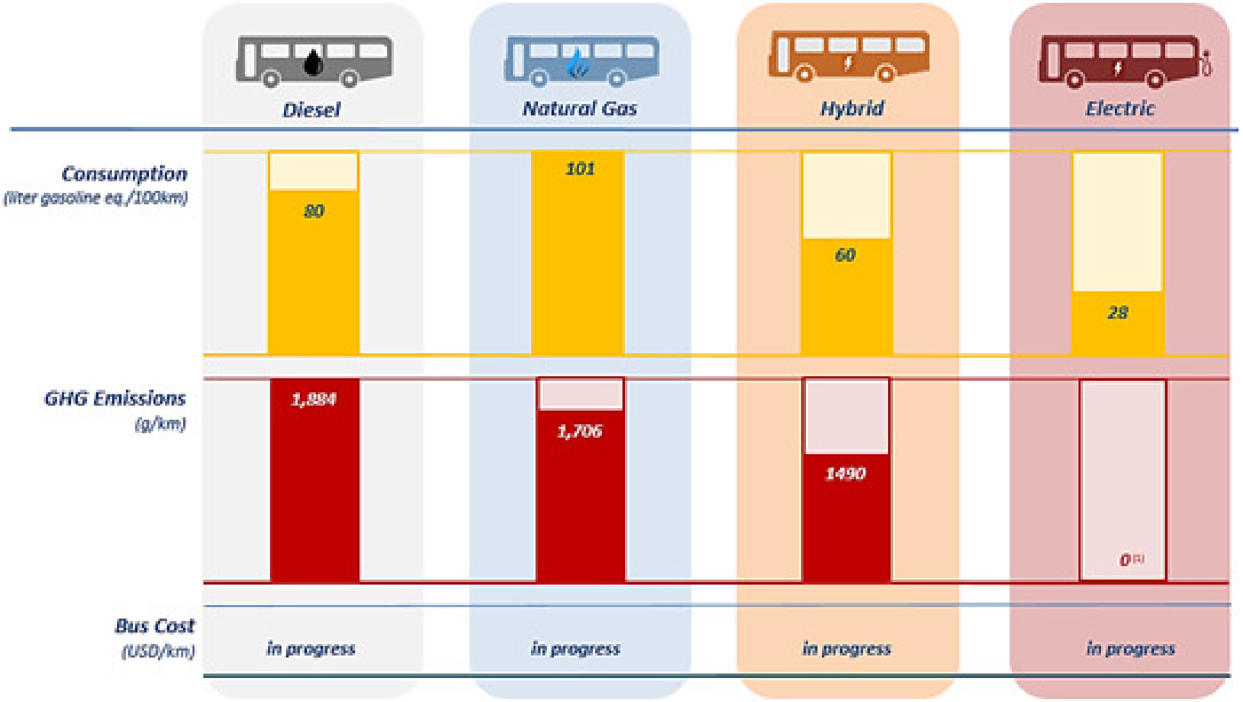
Fleet management modeling

Future work

- World Bank funding for BRT system approved
- Repeating previous exercise for bus-fuel technology
  - Assessment of bus fuel-technology needs
  - Assessment of the impact of electrified buses on electricity demand, and definition of optimal location of charging strategies and charging stations

Preliminary results



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