SUSTAINABLE OIL AND GAS DEVELOPMENT IN LEBANON

Transport Sector

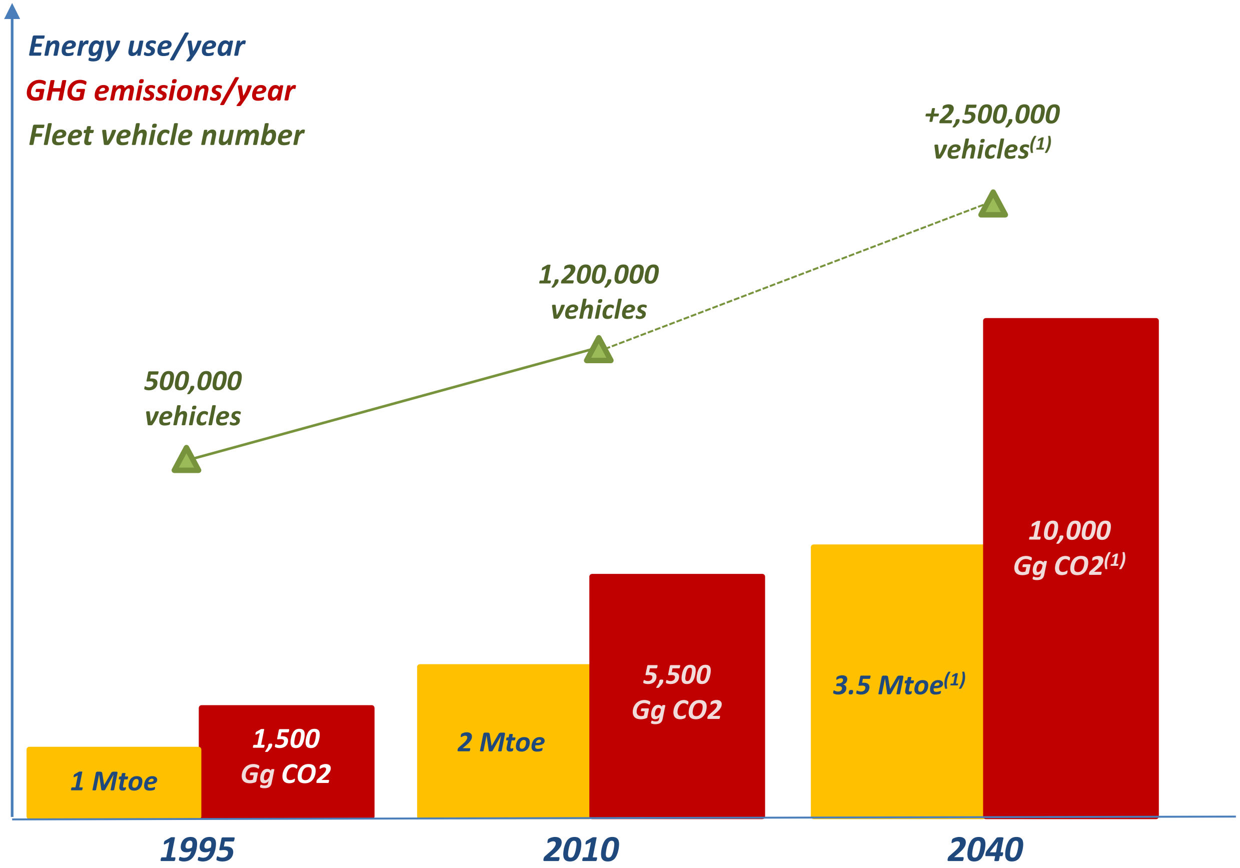
Innovative Vehicle and Bus Technologies Needed for Sustainable Mobility in Greater Beirut Area

Transport Experts:
Marc Haddad, PhD
Charbel Mansour, PhD

Project Managers:
Rola Sheikh, UNDP
Michel-Ange Medlej, MOEW

International Beirut Energy Forum
September 26, 2018

Current state and projection of transport energy use in Lebanon: *significant growth*



According to the business as usual projection of Lebanon's energy use and emissions:

- Energy consumption and emissions expected to double by 2040 as compared to levels of 2010.
- Gasoline is the dominant fuel with 83.5%.
- Lebanon's vulnerability to energy security will increase due to additional need to import gasoline and diesel.
- Lebanon will not be able to meet the INDC commitment to the UNFCCC to reduce its GHG emissions.

(1) Forecasted numbers are calculated using a model developed for Lebanon, based on the population and GDP growth (*Source: Mansour et al. 2015, National Greenhouse Gas Inventory Report and Mitigation Analysis for the Transport Sector in Lebanon*).

Current proposals for shifting to sustainable mobility

SODEL Project 2017:
MOEW, UNDP, LPA

Assess the use of alternative fuel-vehicle technologies

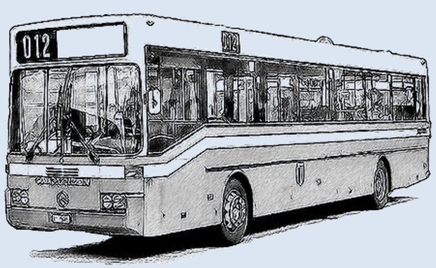
v/s

Conventional fuel vehicles

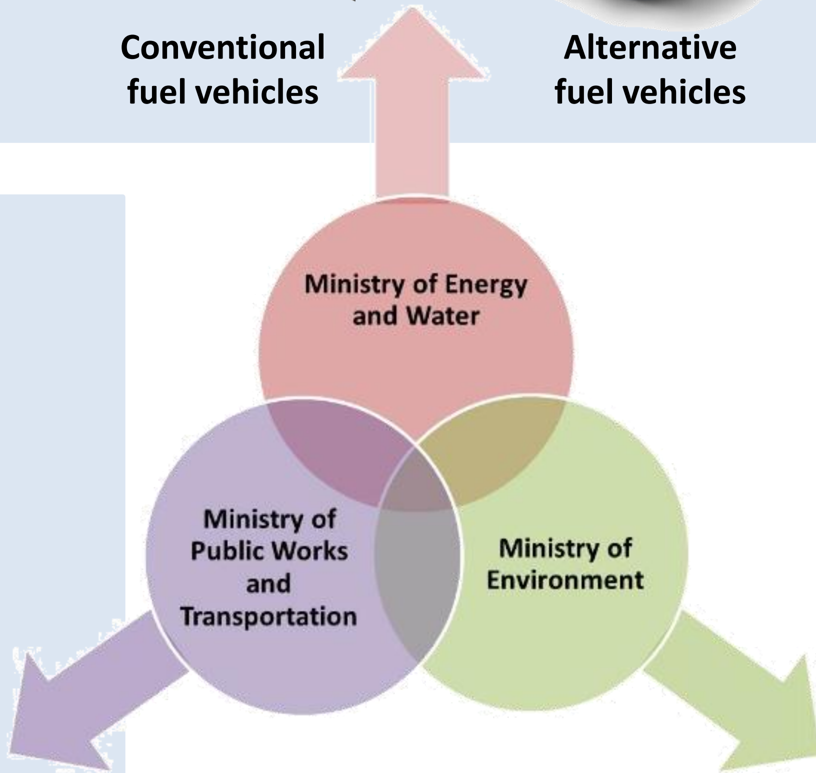
Alternative fuel vehicles

SODEL Project 2018:
MOEW, UNDP, LPA

Assess the use of alternative fuel-bus technologies



Revitalizing the mass transit systems



Environmentally sound technologies

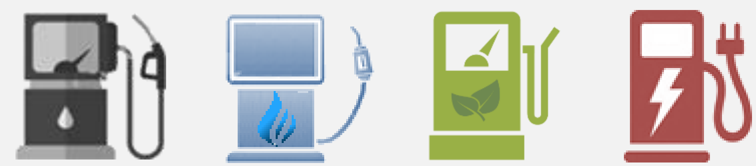
Objectives of the SODEL Study

1 What is the best way to use Lebanon’s natural gas in the transport sector?

- Directly in passenger cars, taxis and buses?
- Indirectly in power plants to generate electricity for electric vehicles?
- A mix of both strategies?

2 Which other fuels can also be feasible for Lebanon’s transport sector?

- Oil-based?
- Natural-gas?
- Biofuels?
- Electricity?



3 Which vehicle and bus technologies is the cleanest and cheapest for Lebanon?

- Gasoline and diesel vehicles?
- Compressed natural gas (CNG) vehicles?
- Ethanol and biodiesel vehicles?
- Hybrid, plug-in hybrid and electric vehicles?

4 What should the government strategy be?

- Laws and regulations?
- Incentives and disincentives?
- Action plan?

Project outline

I. Assessment of alternative fuel-bus and fuel-vehicle technologies

- Define the various options for the use of natural gas and other low-carbon fuels as applicable to the Lebanese transport sector.
- Identify the corresponding bus and vehicle technologies.

II. Infrastructure assessment

- Assess the existing and potential fuel-supply infrastructure relevant to the identified bus and vehicle technologies.

III. Environmental assessment

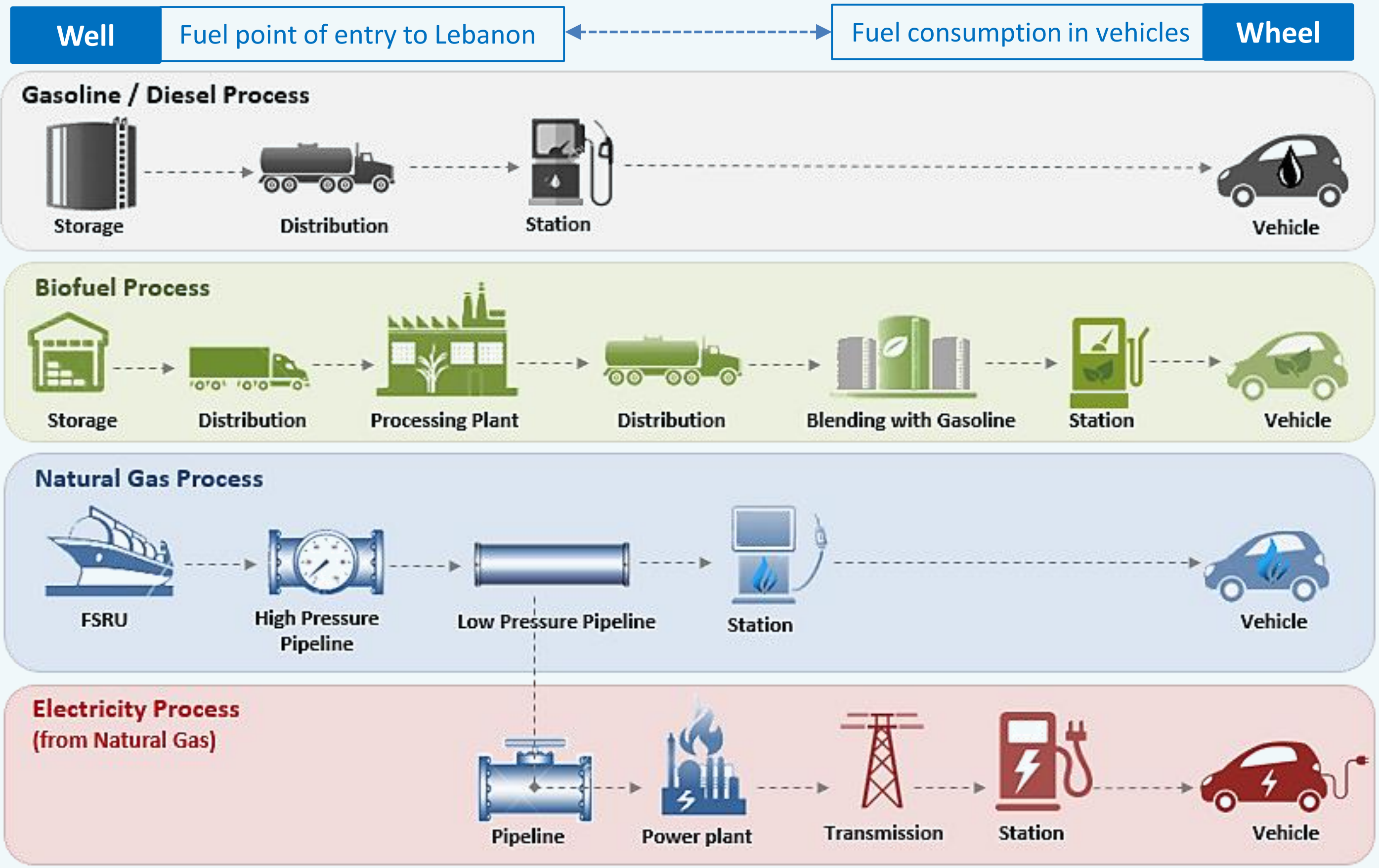
- Conduct a Well-To-Wheel energy and emissions analysis for the identified energy chain pathways.

IV. Cost-benefit analysis

- Identify the cost value of the identified bus and vehicle technologies in order to support setting a beneficial transport policy, favoring cleaner over more polluting technologies.

Study Methodology: Energy consumption and emissions at all stages of each fuel process

A well-to-wheel assessment of fuel and vehicle technologies in Lebanon is conducted. The objective is to evaluate their fuel use, environmental impacts and costs.



Calculation of total energy consumption for each process

Calculation of total emissions for each process

Study Methodology: Costs

A cost-benefit assessment is carried out to evaluate the economic impacts of the fuel-vehicle technologies on the car users, the government and the private sector, for the near- (2020), medium- (2030) and long-terms (2040). Following are the cost components considered.

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

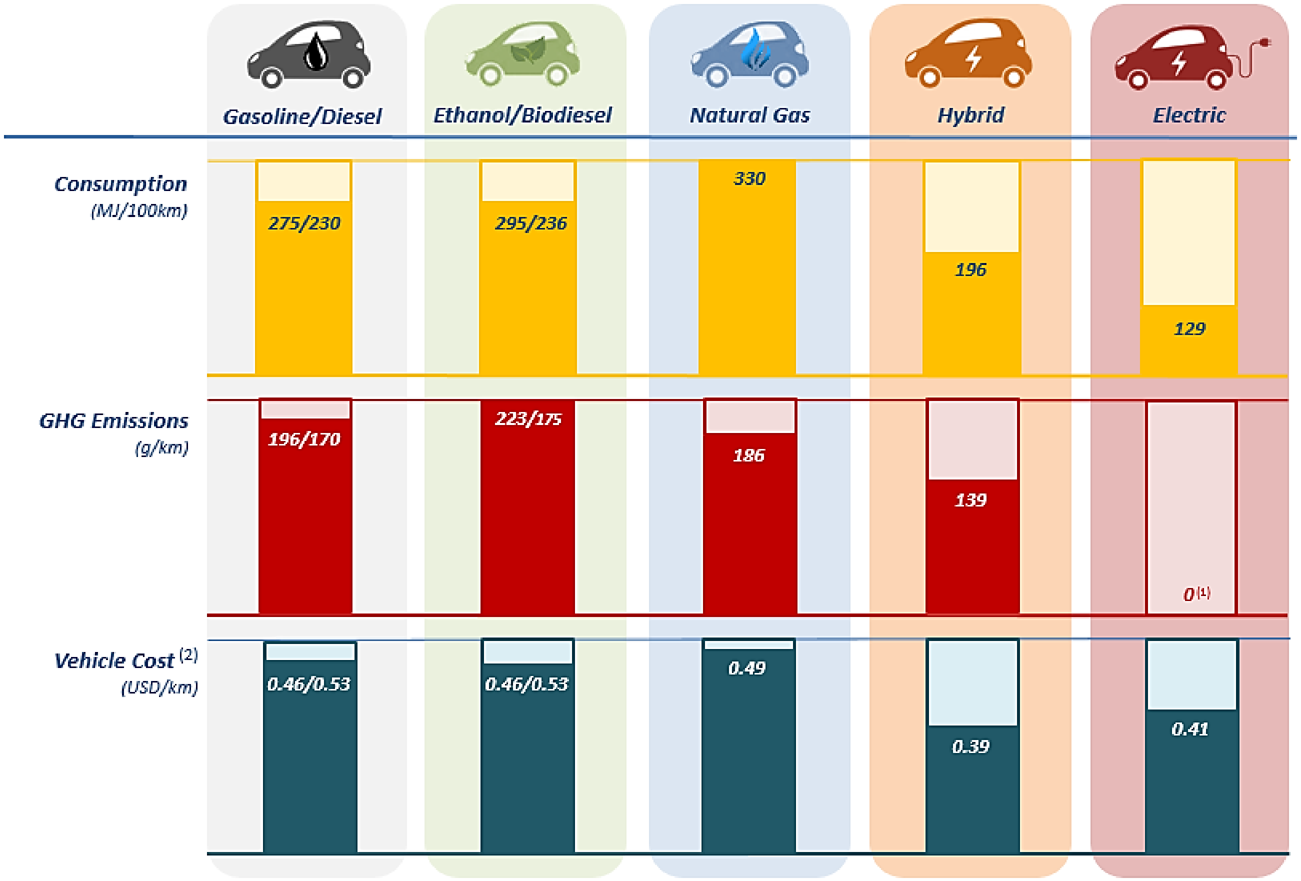
- Distribution infra. O&M
- Transportation infra. O&M

Subsidy foregone revenues

Foregone fuel tax revenues

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

Results for cars: Consumption, emissions and costs of each fuel and vehicle technology

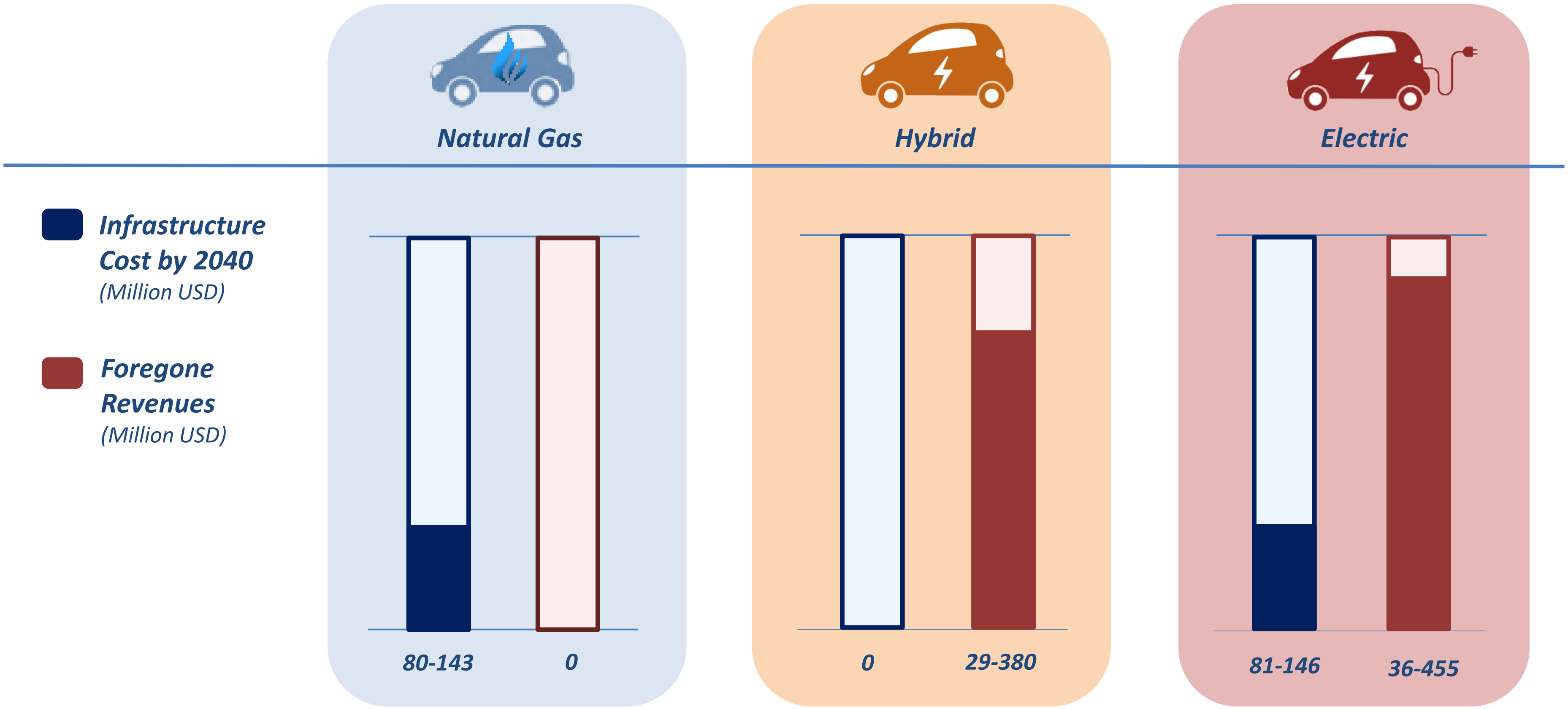


Electric and hybrid vehicles are the best performers:

- Electric vehicles save 53% of energy consumption compared to gasoline vehicles if natural gas is used to produce clean electricity in power plants.
- Electric vehicles contribute to improve air quality in urban areas with their zero emissions.
- Hybrid vehicles save 28% of fuel consumption and emissions.
- If tax incentives are given to buy electric and hybrid vehicles, users can save 10% to 15% of total vehicle cost over the 10-year vehicle lifespan.

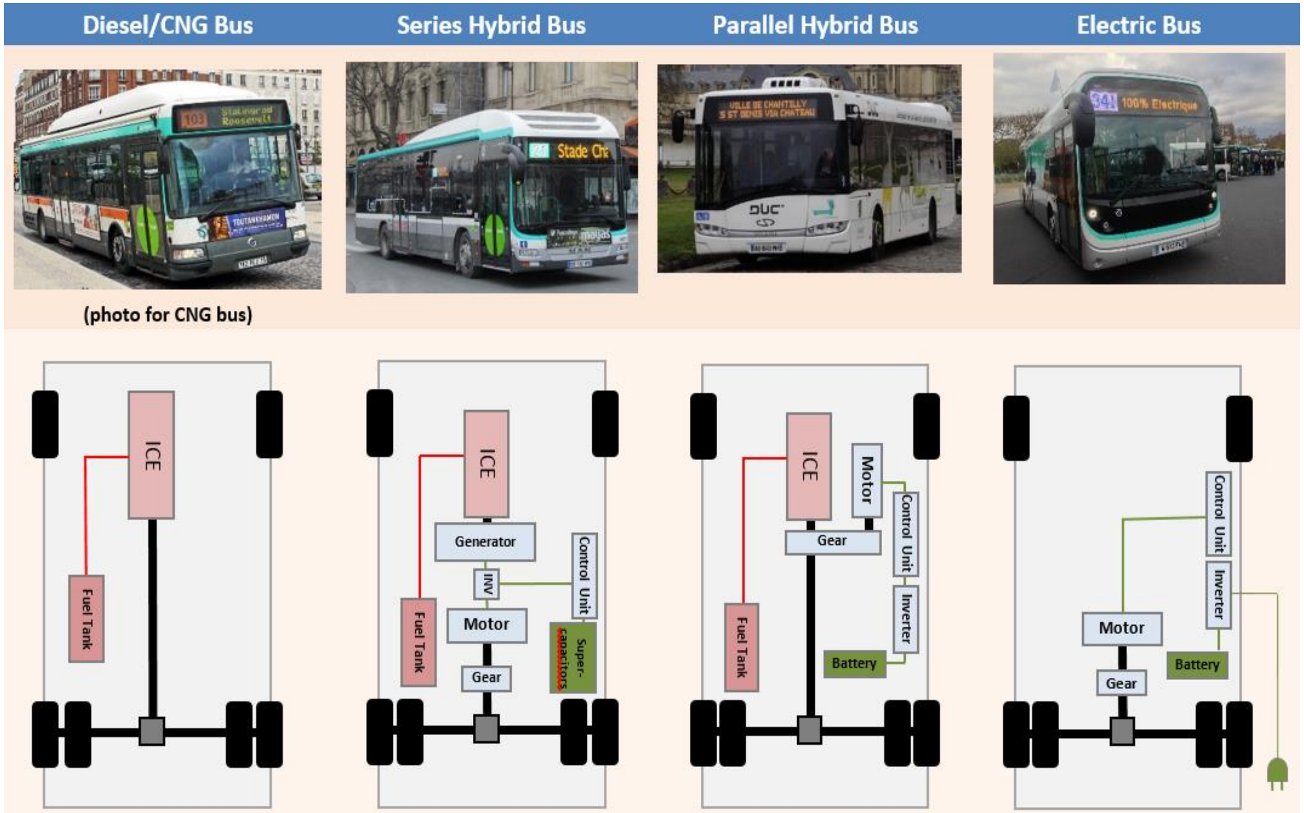
(1) 72 g/km of GHG emitted from the power plant, using natural gas as fuel.
(2) Vehicle cost includes vehicle ownership cost, operating cost and operation subsidy.

Results for cars: Infrastructure costs and foregone revenues



- Infrastructure cost for natural-gas vehicles and electric vehicles are of comparable scale (USD 80-146 M), which means it is more effective to develop an infrastructure for electric vehicles since they provide superior energy, emissions and cost savings for users, the same infrastructure investment cost.
- Natural gas vehicles are of interest only for mass transit services.
- Hybrids are the vehicle technology of choice if no infrastructure investment is to be made.
- Electric are preferred when it comes to maximizing energy and emissions savings, making them the preferred fuel-vehicle technology in the medium and long term

Potential bus technologies as applicable for the Lebanese transport sector



	Auxiliaries power excluding climate control auxiliaries	Climate control auxiliaries power
Diesel and CNG buses	9,000 W	13,400 W
Hybrid and electric buses	5,250 W	14,000 W

- Severe congestion conditions

  avg. velocity: 6 km/h
  idle time: 67% of trip time

- Peak traffic conditions

  avg. velocity: 11 km/h
  idle time: 36%
  with frequent acceleration and deceleration

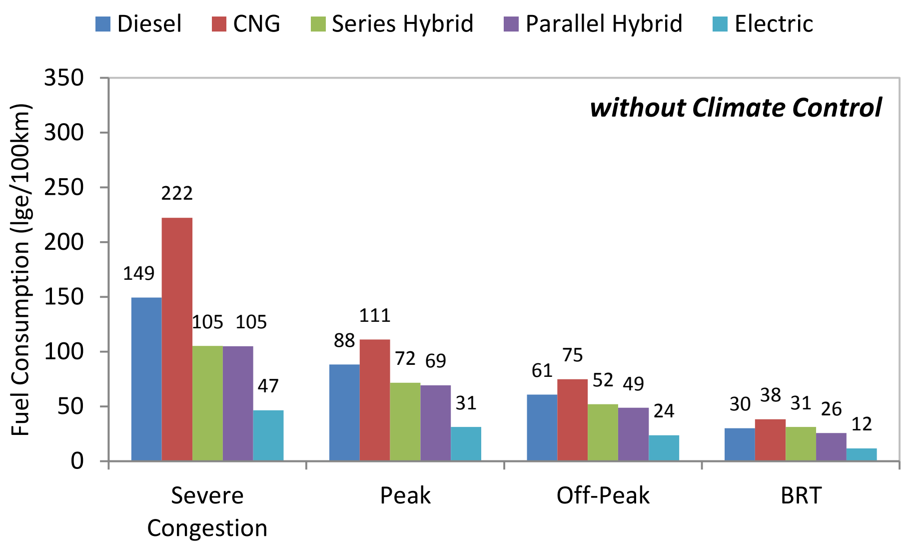
- Off-peak traffic conditions

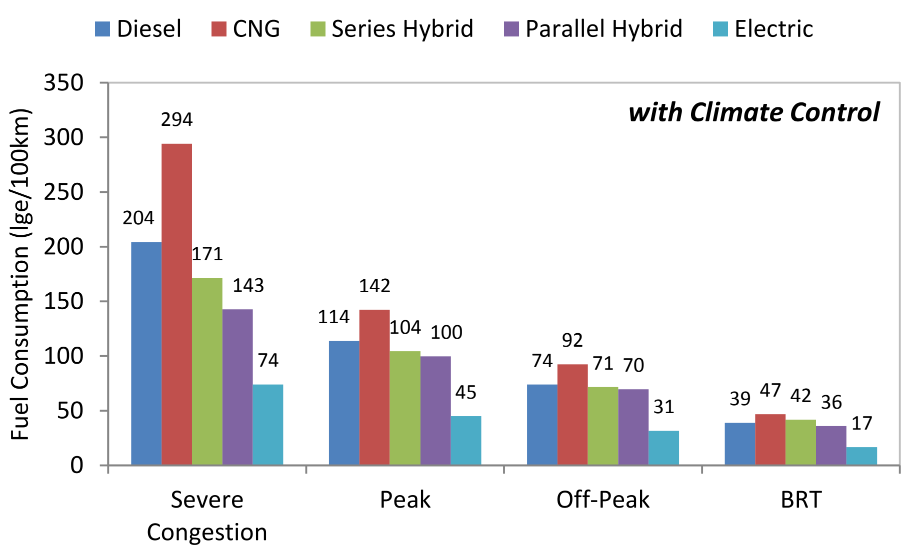
  avg. velocity: 20 km/h
  idle time: 21%

- BRT service conditions

  avg. velocity: 36 km/h
  idle time: 23%

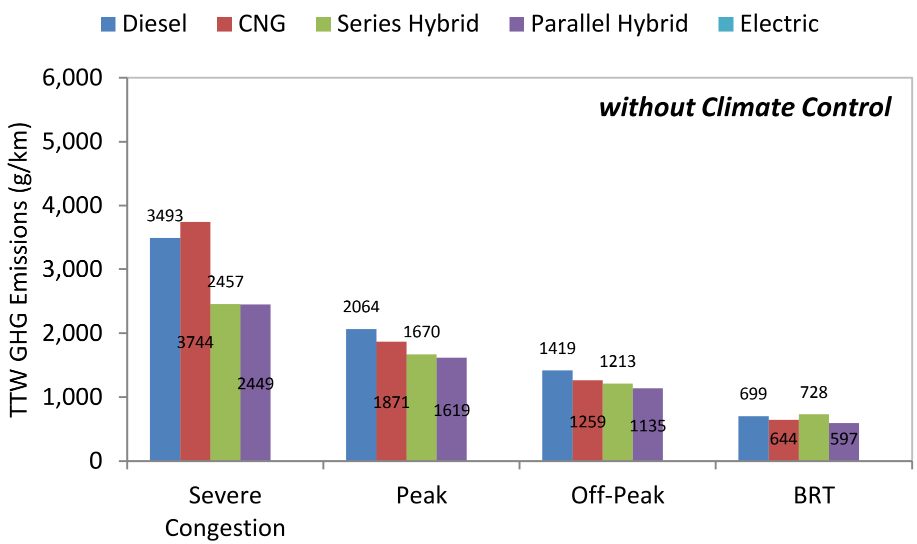
Results for buses: Consumption



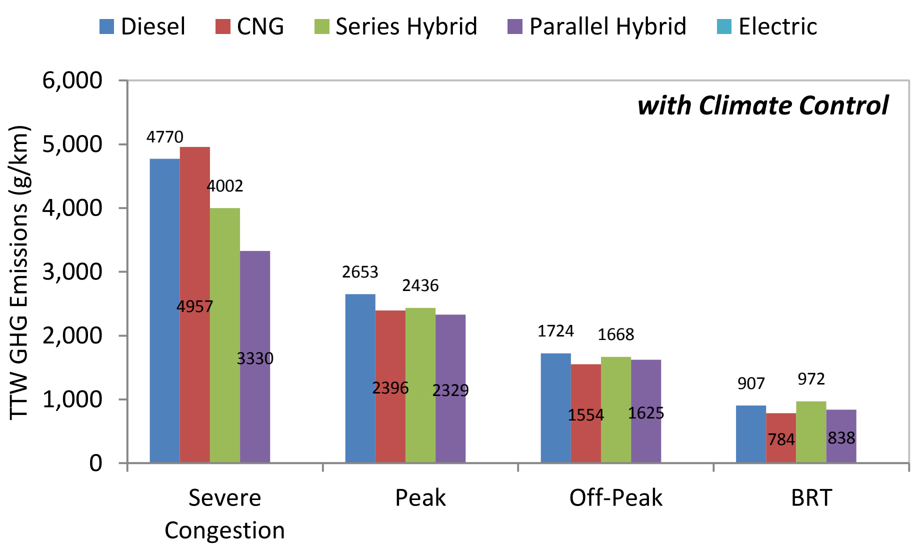


Results for buses: GHG Emissions

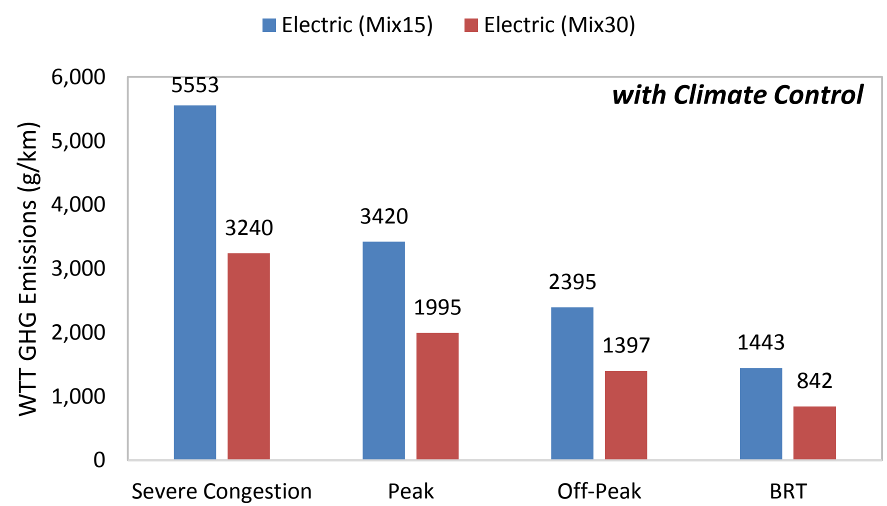
TTW GHG emissions without use of climate control auxiliaries.



TTW GHG emissions with use of climate control auxiliaries.

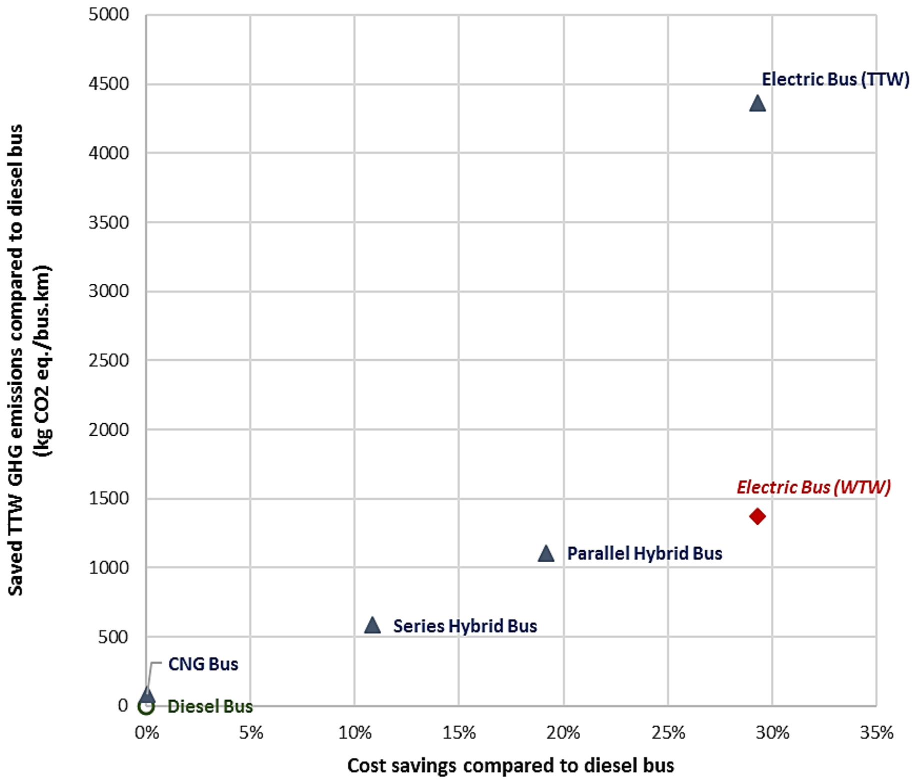


WTT GHG emissions of electric bus technologies under the 2015 and 2030 electricity mixes.

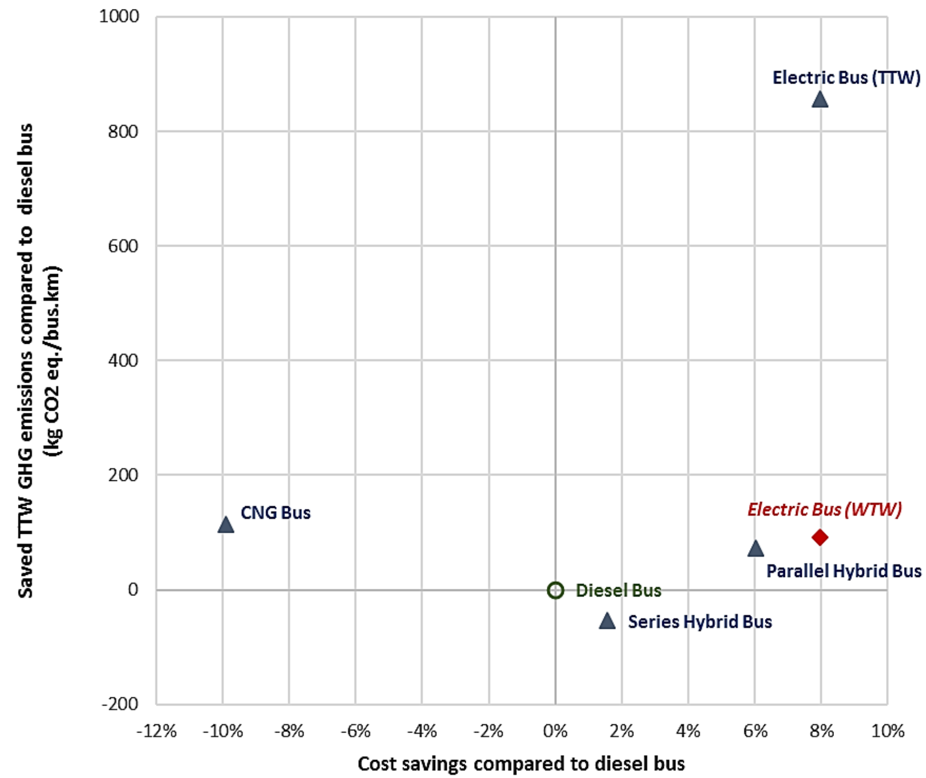


Results for buses: Environmental-to-cost performance of bus technologies relative to diesel bus

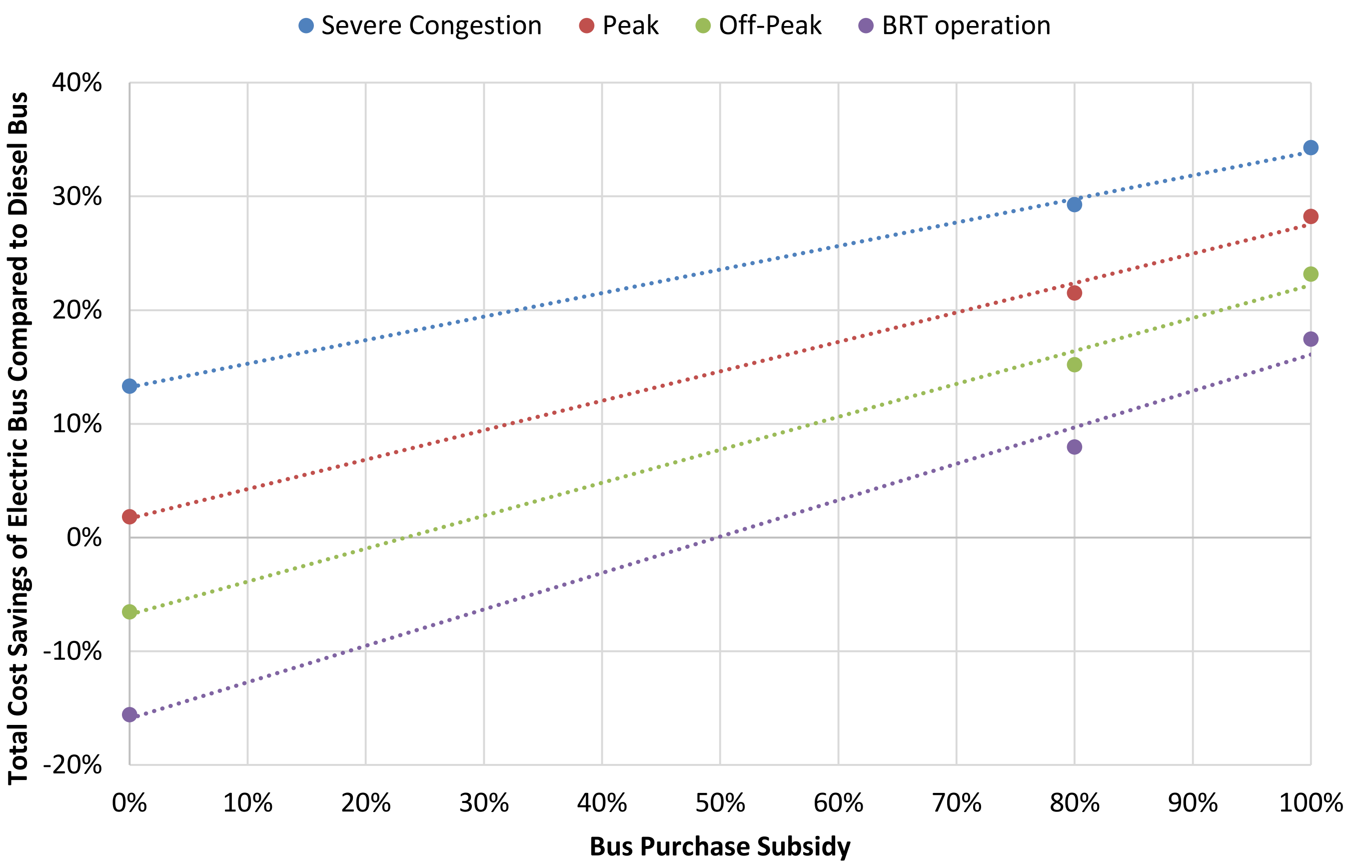
SEVERE CONGESTION OPERATION



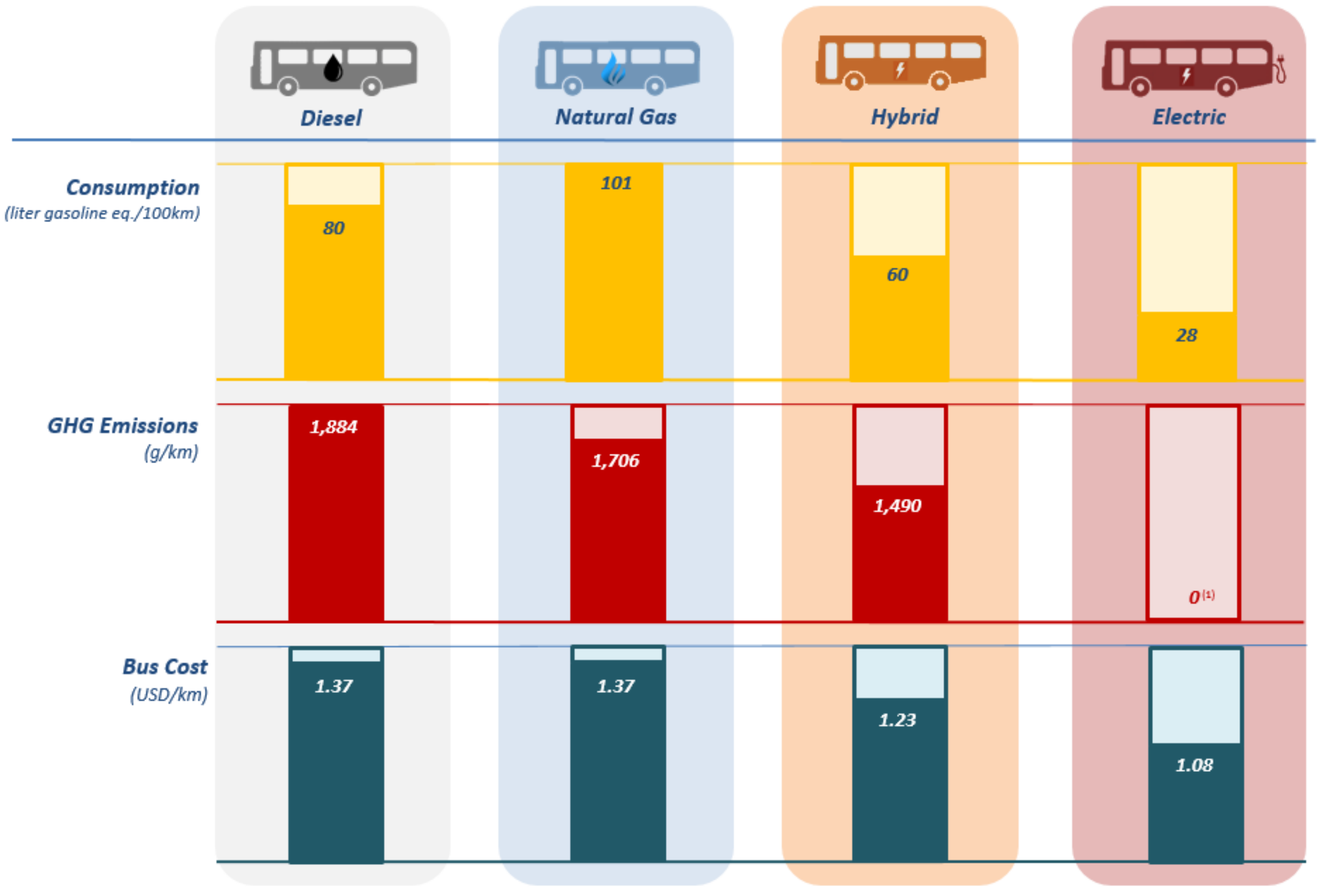
BRT OPERATION



Results for buses: Costs



Results for buses: Consumption, Emissions and Costs of each fuel and bus technology



Similar to passenger cars, electric and hybrid buses are the best performers:

- Electric buses save 65% of energy consumption compared to diesel buses if natural gas is used to produce electricity in power plants.
- Electric buses contribute to improve air quality in urban areas for their zero emissions.
- Hybrid buses saves 25% of fuel consumption and 21% of emissions.
- If incentives on bus purchase cost are given to bus operators, electric bus can save between 8% and 30% compared to Diesel bus over the 12-year bus service life, depending on the bus average velocity.
  (*30% inside Beirut under severe congestion, 8% under BRT operation*)

(1) 1,259 g/km of GHG emitted from the power plant, using natural gas as fuel.

Strategy Roadmap

2030 – 2040

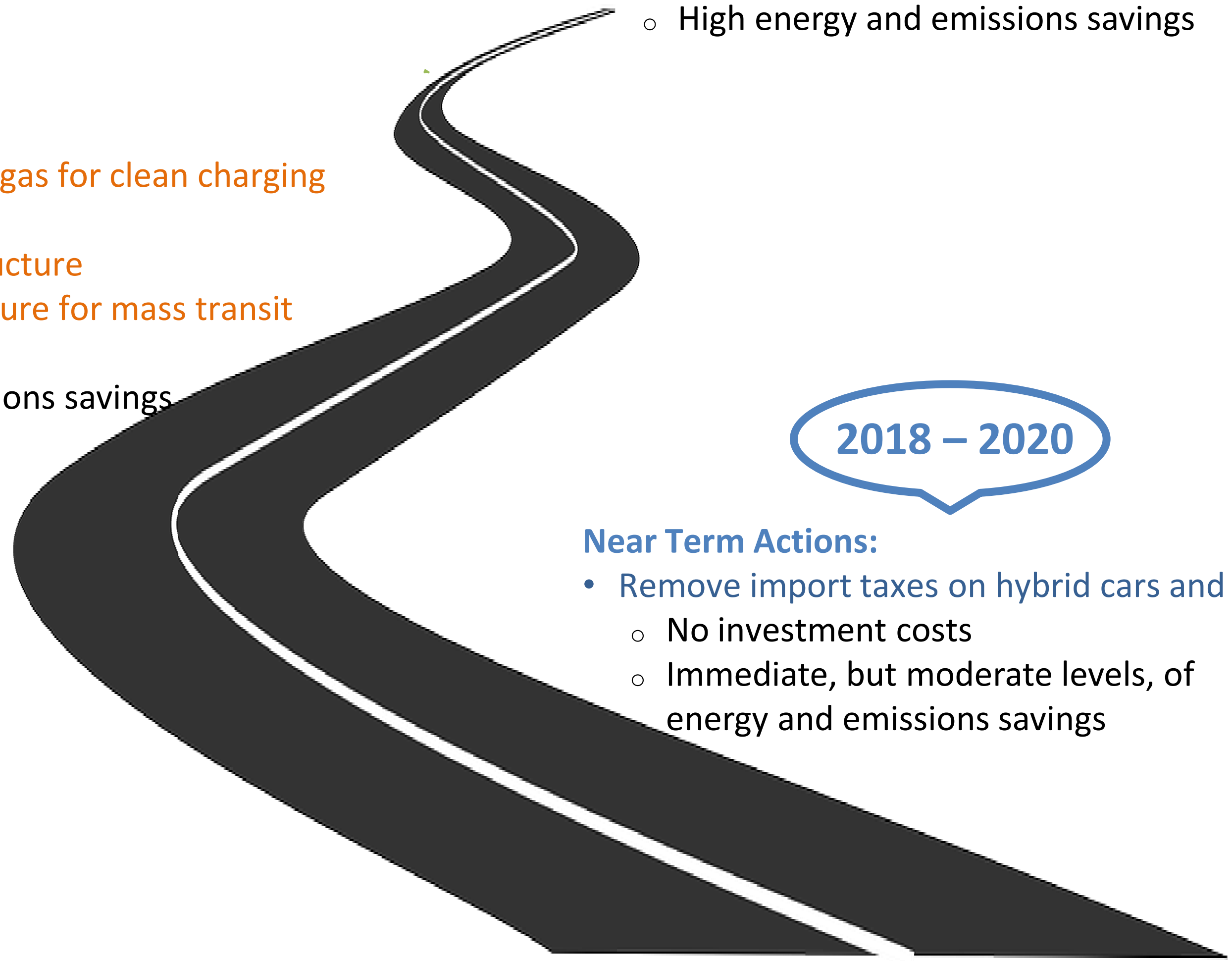
Long Term Actions

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

2020 – 2030

Medium Term Actions

- Convert power plants to natural gas for clean charging of electric vehicles and buses
- Build electivity charging infrastructure
- 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 hybrid cars and buses
  - No investment costs
  - Immediate, but moderate levels, of energy and emissions savings

Thank you for your attention

Marc HADDAD mhaddad@lau.edu.lb
Charbel MANSOUR charbel.mansour@lau.edu.lb

Strategy Roadmap in Detail

2018-2020 — **2020-2030** — **2030-2040**

Near Term Actions (2018-2020):

Remove import taxes on hybrids

Invest	Infrastructure: No new investment	Foregone Revenues: $29-$380 M	
Save	Fuel: 28.6%	Emissions: 29%	Costs: 14%

Medium Term Actions (2020-2030):

1. Build electricity charging infrastructure and use NG to generate electricity.

Invest	Infrastructure: $25-$57 M	Foregone Revenues: $36-$455 M	
Save	Fuel: 53%	Emissions: 64%	Costs: 7.8%

2. Build small-scale CNG infrastructure for mass transit (taxi, bus)

Invest	Infrastructure: $26-57 M	Foregone Revenues: zero	
Save	Fuel: -20%	Emissions: 5.6%	Costs: 3.7%

Long Term Actions (2030-2040):

Expand electricity charging infrastructure

Invest	Infrastructure: $56-$89 M	Foregone Revenues: zero	
Save	Fuel: 53%	Emissions: 64%	Costs: 9.5%

Policy Recommendations
Action plan for transition to fuel efficient passenger cars in the Lebanese Transport sector

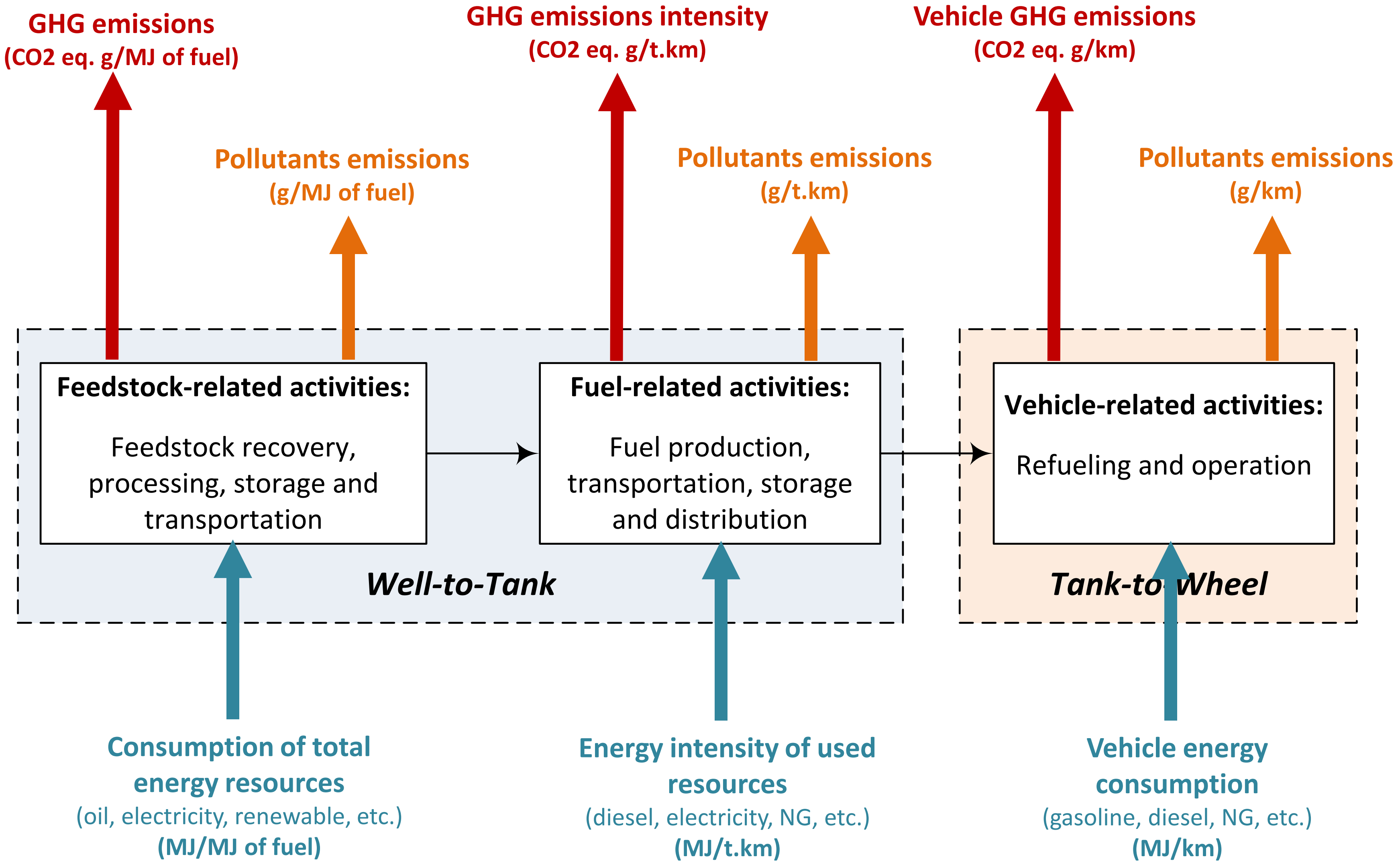
Type	Priority sequence	Measures		
Economic and financial measures	1 Create market *Give incentives*	Exemption from custom and excise fees, registration fees, and road usage fees at registration.	Extend loan period and reduce loan interest.	Create a car scrappage program based on swapping current passenger cars with hybrid and electric vehicles
	2 Transition *Put Restrictions*	Adopt a Bonus-Malus tax policy where polluters pay more annual road-usage fees, and where taxes are estimated based on fuel efficiency and/or emissions rather than engine displacement.	Reduce gradually maximum age of imported pre-owned vehicles and maximum mileage.	
Market development	3 Dispose of old cars	Create a car termination plant that deals with the car termination process after the swap in the scrappage program	Create an industry for recycling car parts and components	
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 with special requirements for inspection of hybrid cars, and mandate catalytic converters on conventional gasoline vehicles	
Institutional/ organizational capacity	5 Plug the leaks	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 Educate	Establish awareness campaign to educate about new technologies & correct old perceptions		
Initiative monitoring and validation	7 Monitor the progress	Create Mobility Monitoring Indicators (MMI) framework		

Policy Recommendations

Action plan for deployment of efficient mass transit system in the Lebanese Transport sector

Type	Priority sequence	Measures			
Economic and financial measures	**1 Develop supply chain**	Design a bus network covering all boroughs within GBA and reserve lanes for bus operation	Ensure sufficient number of transit buses with proper powertrain technology	Exempt mass transit buses (and spare parts) from custom/excise fees, and registration fees	Create employee package for taxi drivers including social benefits, insurance, retirement plans, etc.
	2 Shift travel demand	Establish smart card ticketing schemes with appropriate reduced tariffs			
Market development	**3 Deploy effective infrastructure**	Optimize the operation management of the bus transit system: conserve a clear and regular bus operation, implement real-time information system, deploy personalized travel planning tools, implement transit signal priority, set up stringent maintenance and cleanliness program , construct relevant maintenance and repair workshops			
Policy, legal and regulatory	**4 Set regulatory framework**	Set clear regulations specifying the operation maneuvers of private bus operations and taxi owners	Draft new amended laws for increasing parking space and reserving lanes for buses		
Institutional/ organizational capacity	**5 Manage demand**	Develop technical expertise among TMO staff and high level management			
Social awareness	**6 Stimulate passengers demand**	Provide information on CO_2, fuel and cost savings comparing to passenger cars			
Project monitoring and validation	**7 Monitor the progress**	Create Mobility Monitoring Indicators (MMI) framework			

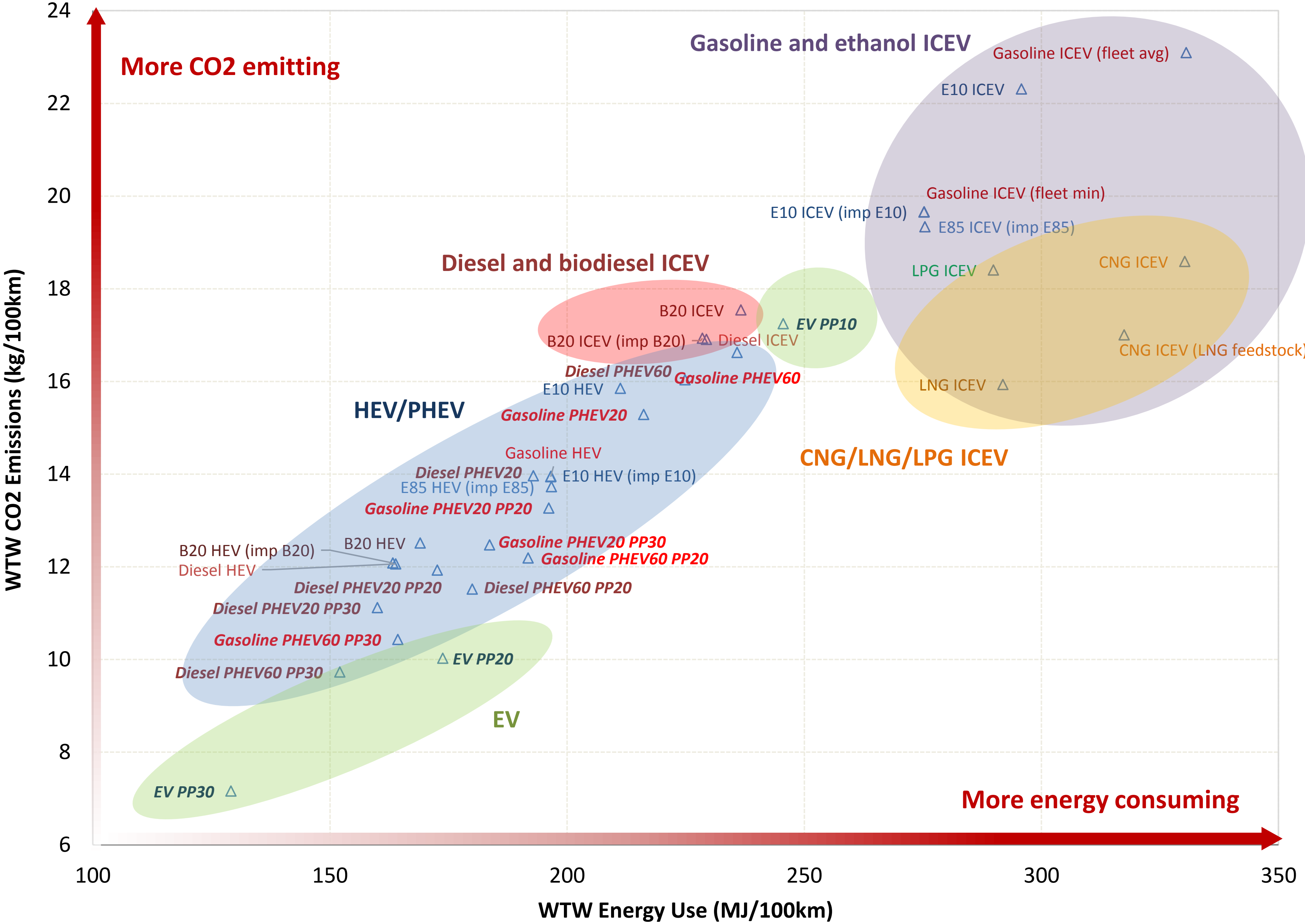
Assessment framework for the identified fuel-vehicle technologies



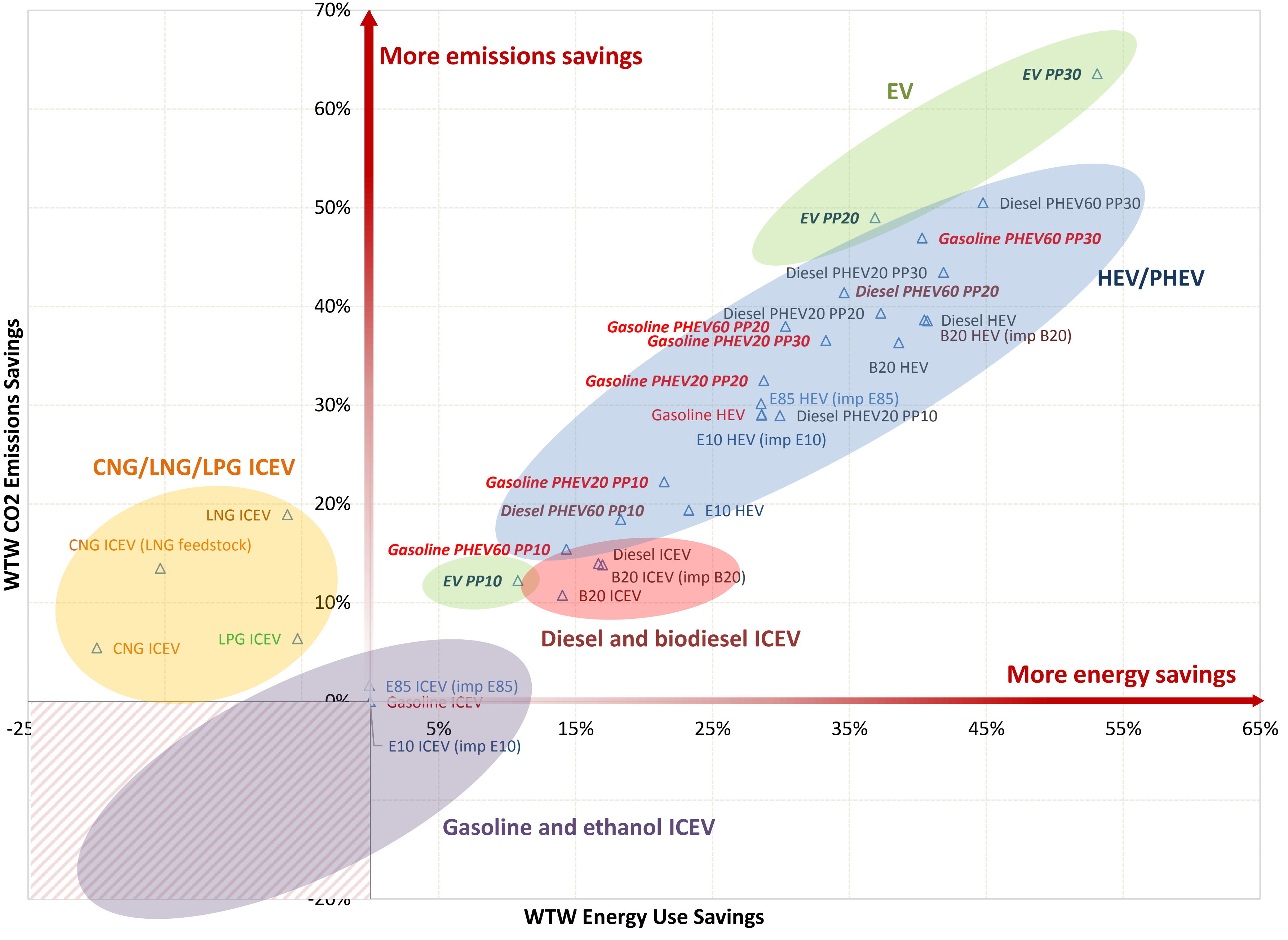
Evaluated GHG emissions: CO_2, CH_4 and N_2O

Evaluated pollutants emissions: VOCs, CO, NOx, PM10, PM2.5, SOx

CO2 emissions versus energy use of the assessed fuel-vehicle technologies

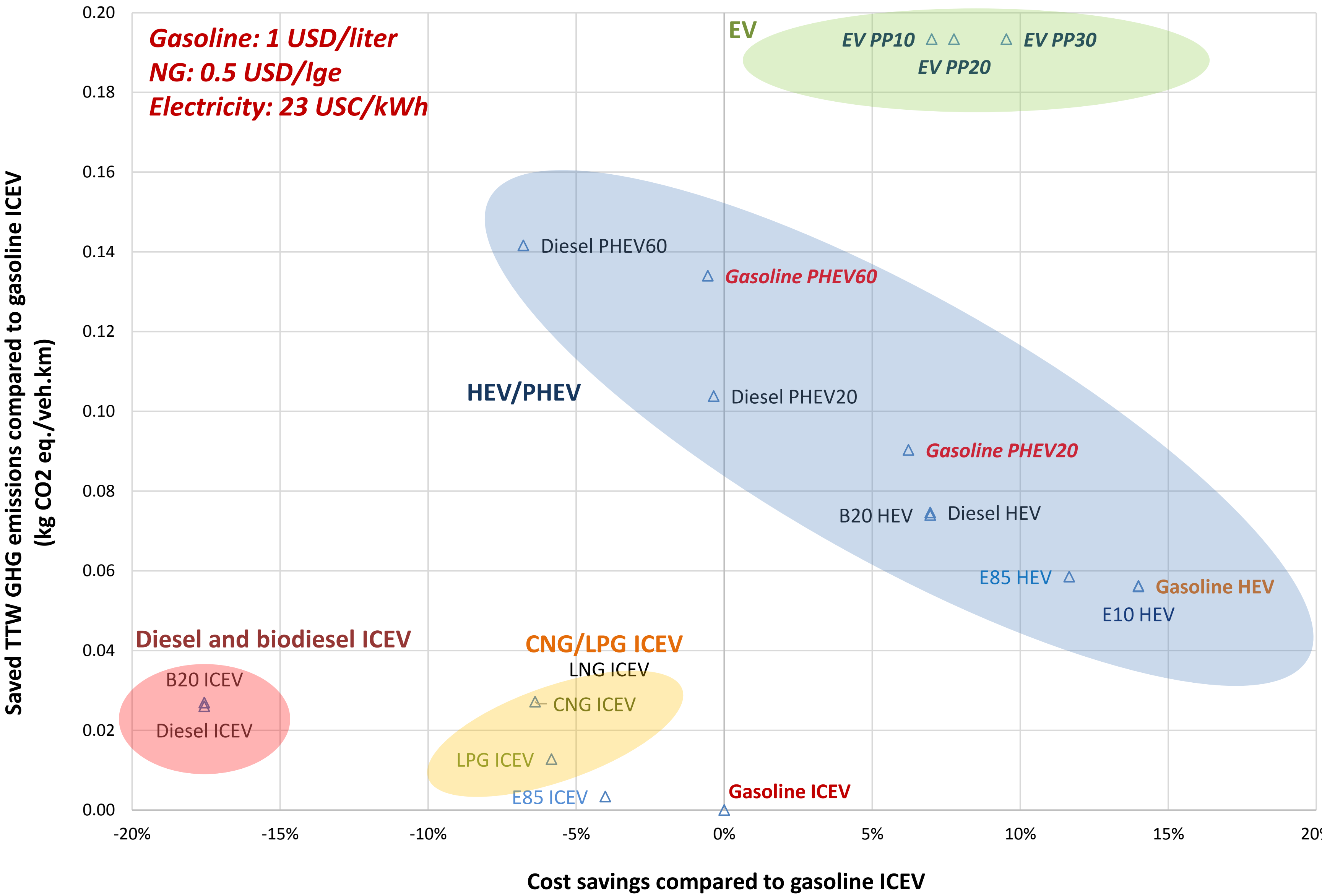


CO2 emissions versus energy use savings of the assessed fuel-vehicle technologies



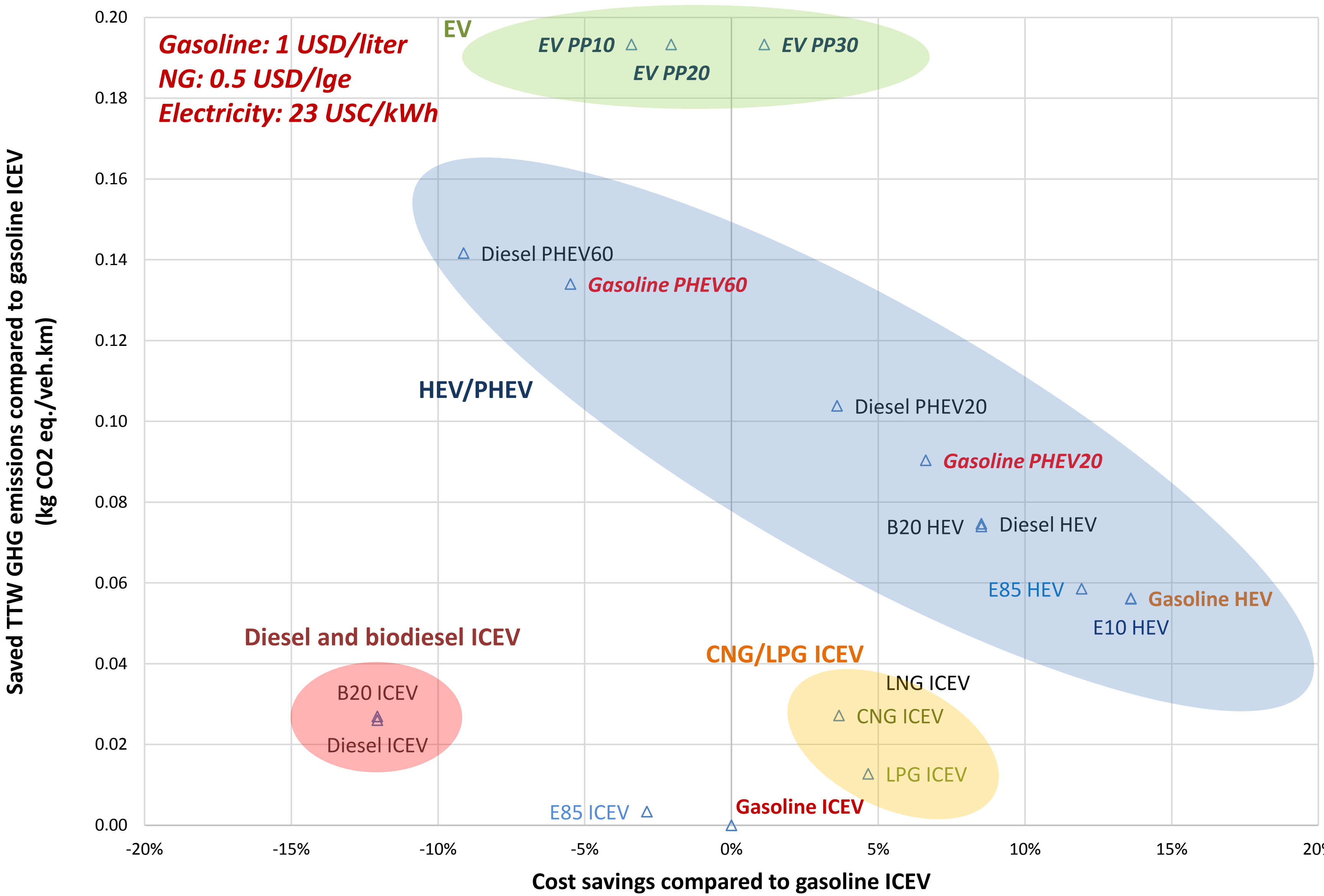
Costs and benefits from the car users' perspective:

Environmental-to-cost performance of fuel-vehicle technologies relative to gasoline ICEV for yearly mileage of ***12,000 km***



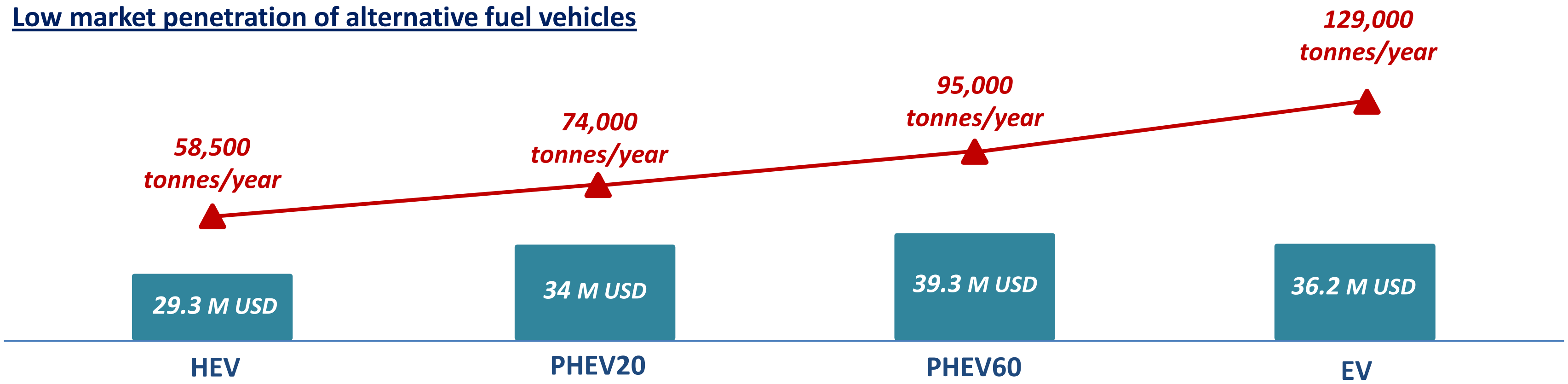
Costs and benefits from the car users' perspective:

Environmental-to-cost performance of fuel-vehicle technologies relative to gasoline ICEV for yearly mileage of ***30,000 km***

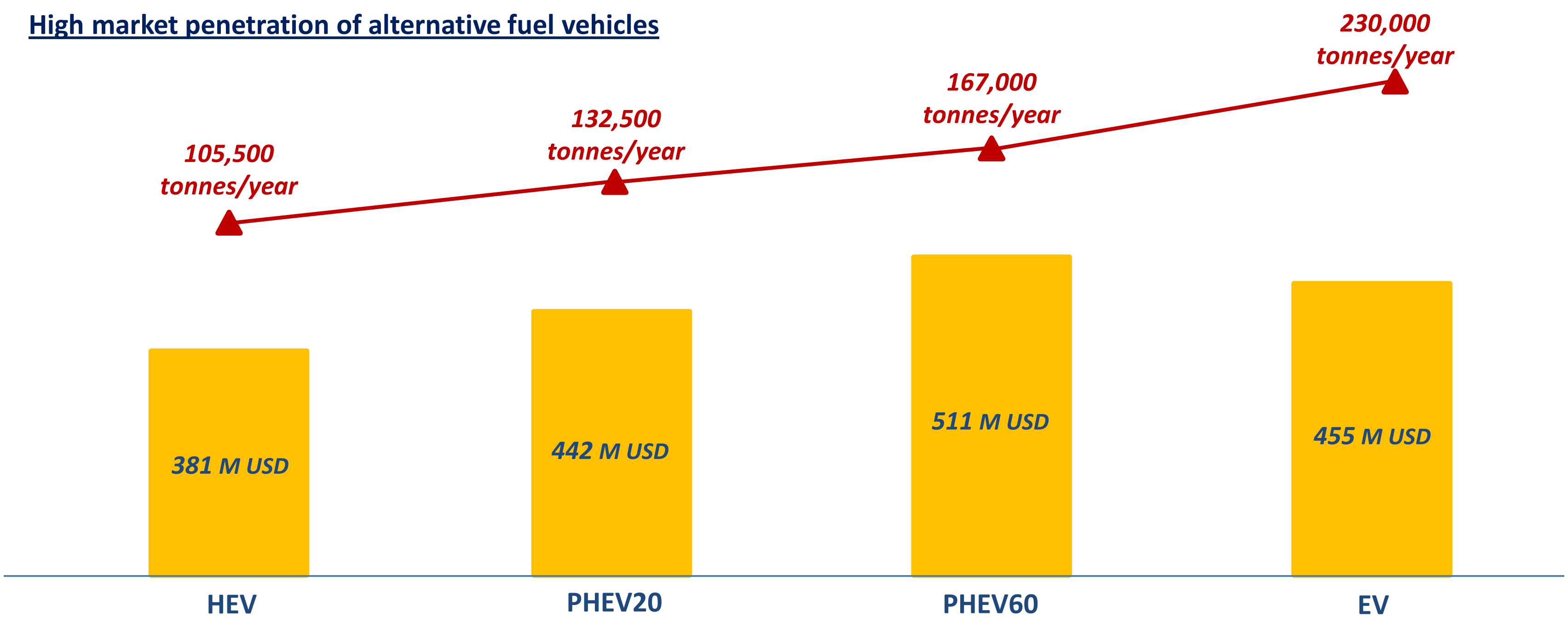


Government foregone revenues and saved WTW GHG emissions over the near, medium and long-terms

Low market penetration of alternative fuel vehicles



High market penetration of alternative fuel vehicles



Infrastructure investment costs and saved WTW GHG emissions over the near, medium and long-terms