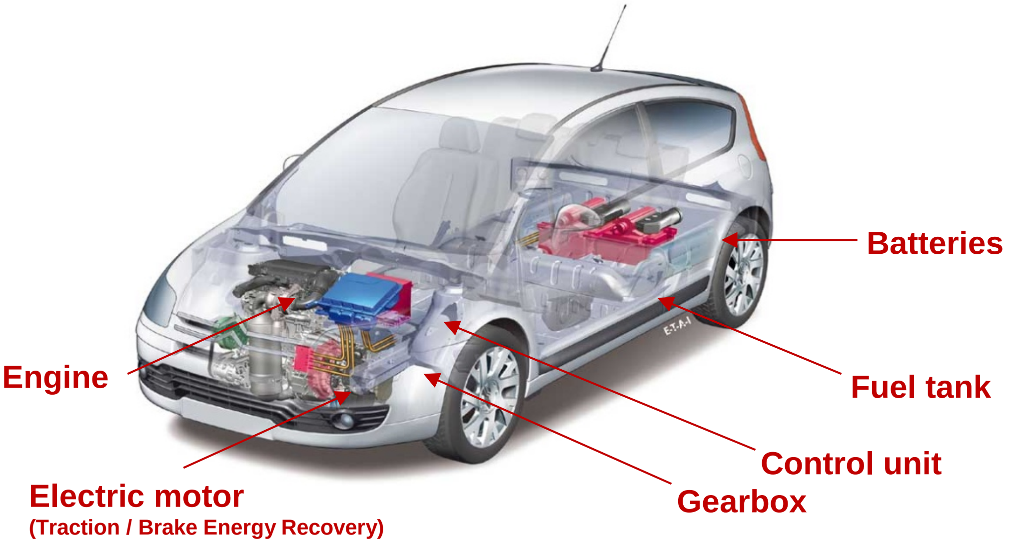
Technology Fact Sheet for Mitigation

J. Hybrid Electric Vehicles[i]

Sector : Transport	
Subsector : Advanced powertrains for passenger cars	
Technology characteristics	
Introduction	Hybrid Electric Vehicles (HEVs) combine an electric motor and battery pack to the internal combustion engine (ICE) found in conventional vehicles (figure 1). The batteries in HEVs are lighter and smaller than those in electric vehicles because the ICE produces most of the power to operate the vehicle. The ICE can be designed to run on gasoline, diesel, or an alternative fuel. The battery pack stores excess energy generated from braking to use for quick acceleration. There are three configuration types of HEVs: parallel, series and series/parallel. · In parallel HEVs, the gas tank supplies fuel for the ICE, and the batteries provide power to the motor. Both power the transmission, which turns the wheels. · In series HEVs, the ICE does not directly power the vehicle but instead turns a generator, which sends power to either the motor or the batteries. · Series/parallel hybrids have the flexibility to operate in either series or parallel mode. They present maximum fuel savings at the expense of additional costs. The main idea behind HEVs is the extra flexibility offered by the electric motor, which allows the engine to operate more efficiently. At low demand, the motor drives the vehicle using battery power. The ICE engages when needed to drive the wheels or recharge the battery. At full acceleration, the battery adds power; when the vehicle idles, the ICE shuts off.  Figure 1. Configuration of HEV powertrain. HEVs are also classified as micro-hybrid, mild-hybrid, full-hybrid, plug-in hybrid and range-extender electric vehicles. They are differentiated by the fraction of electric power added onboard; consequently, the ability to achieve more hybrid functions, as summarized in figure 2. Note that the more electric energy is available onboard, the more fuel reduction will result, at the expense of additional control complexity.

<table>
<tr><td></td><td>(Plug-in hybrid and Range-extender EV will not be considered in this fact sheet, they will be assessed seperately).

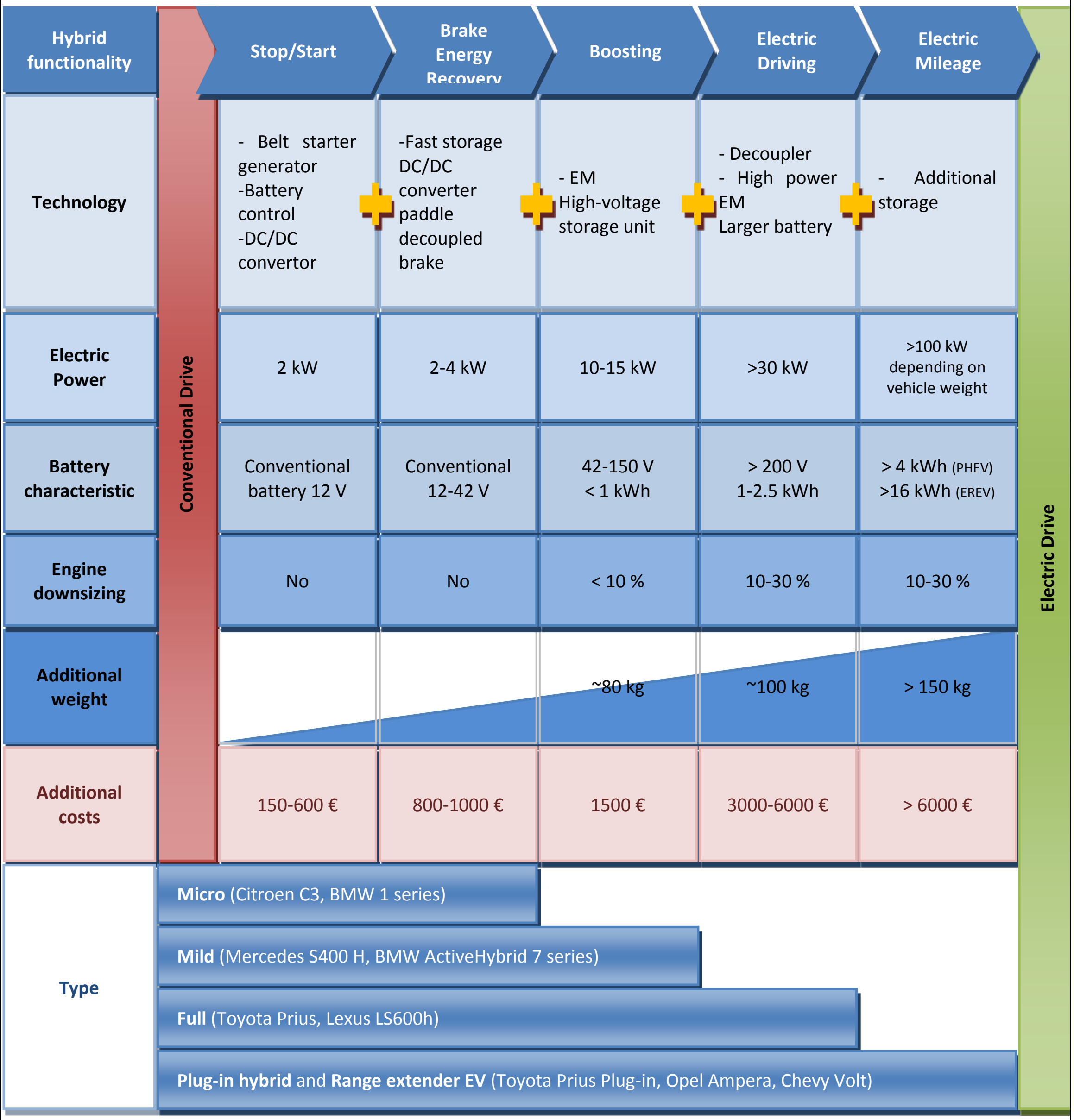
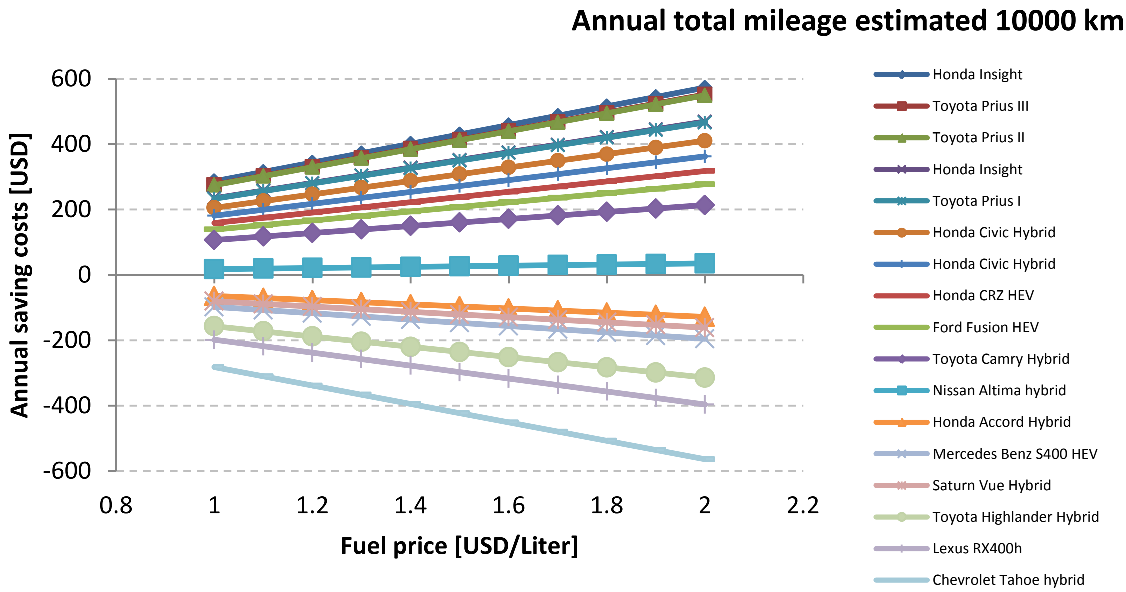


Figure 2. Power classification of existing electrified vehicles.</td></tr>
<tr><td>Technology characteristics</td><td>Conventional vehicles present a lot of energy losses within their power trains. HEVs logic is to bring a solution to each source of energy losses:
· Engine stop to prevent from idling
· Brake energy recovery to prevent losing kinetic energy of the vehicle while braking
· Engine downsizing and electric boosting during acceleration
· Management of engine operating points
· Electric drive mode
Therefore, HEV technologies improve the operation of ICE vehicles by optimizing their operation modes. 10-30% of fuel consumption can be saved with such technologies relative to that of comparable gasoline powered vehicles, in addition to reducing CO2 and pollutant emissions.</td></tr>
<tr><td>Operation and maintenance</td><td>· HEVs differ little from conventional vehicles when it comes to routine maintenance items: the systems that control the on-board storage batteries and the additional</td></tr>
</table>

	electric drive motor must be checked out regularly. · Maintenance costs of HEVs are lower than those of conventional vehicles, due to less use of the engine; therefore, less change of oil, spark plugs, air filter, fuel filter, brake pads, etc. According to an end-of-life study performed by the USDOE on 2002 Toyota Priuses, the maintenance cost ranged between 0.01 and 0.03 USD/mile, where the average maintenance cost for conventional vehicles from the same vehicle segment is 0.042 USD/mile. · HEVs may need a battery change over the vehicle life. Current batteries of HEVs are under warranty for 160000 km or 8 years (case of Toyota). A large number of HEV Li-Ion and NiMH batteries have exceeded 280000 km without been replaced or any significant performance deterioration. These batteries are designed to last for at least 10+ years and 7000+ charge cycles.
Endorsement by experts	· HEVs are endorsed by automotive manufacturers, in order to avoid paying excess emissions penalties.
Advantages	The improved efficiency of HEVs makes hybridization especially worthwhile for urban passenger cars. They offer several advantages compared to conventional vehicles: · They recover braking energy for recharging the batteries, while this energy is lost with conventional gasoline vehicles · They require fewer fill ups and are more economical to run, getting up to 50 miles per gallon (4.7 l/100 km) of fuel. · Some have a driving range of about 960 km, twice that of conventional vehicles (and six times that of electric vehicles). · HEVs emit fewer tailpipe pollutants because of their electric powertrains and efficient ICEs. · In conventional vehicles, ICEs are designed to meet peak power needs (e.g., when the vehicle needs to climb a hill or accelerate). In HEVs, the engines can be smaller, lighter, cleaner-running, and designed to operate efficiently when meeting average power needs because the battery intervenes when extra energy is required. · Maintenance costs for HEVs are lower than those for conventional vehicles. A great deal of progress has been made in improving the batteries so they will last for a vehicle lifetime of 150000 miles or more. · They do not require any additional infrastructure investments.
Disadvantages	· Cost more to buy · Have expensive batteries that might wear out before vehicle does · Less safe than conventional vehicles (batteries may pose a danger to people unfamiliar with them, like mechanics or rescue workers at an accident scene) · Create hazardous waste (used batteries need to be recycled or disposed of in a safe manner) · Encourage use of private passenger cars if intelligent taxation policies are not adopted
Capital costs	
Additional cost to implement mitigation technology, compared to "business as usual"	Additional costs depends on the level of hybridization and the taxation policies: Table 1. Additional costs of HEVs per country.

	France	USA	Lebanon
Micro hybrid	150-1000 Euros	500 USD	*Not Available*
Full hybrid	2800-4800 Euros	5000 USD	20000-30000 USD

Development impacts, direct and indirect benefits	
Cost benefits	Figure 3 illustrates the operating cost savings of different HEVs, compared to the average new vehicle fleet operating cost of 2005. The total vehicle kilometers traveled per year is estimated 10000km. With the current fuel price trend (~1.2 USD/liter), savings range between 150 and 350 USD/year with small and medium sedan hybrid cars comparing to the average fuel consumption cost of the 2005 world new car fleet. Note that additional savings are achieved by comparing to the average fuel consumption cost of the whole 2005 Lebanese car fleet, since the average consumption far exceeds the 2005 world average of 8.07 l/100km.  Figure 3. Annual operating saving costs of HEVs comparing to 2005 new fleet world average, as function of fuel price, with an annual mileage estimated 10000 km.
Environmental benefits	According to an end-of-life study on hybrid vehicle fleets, done by the USDOE (the office of Energy Efficiency and Renewable Energy): · Consumption and CO_2 savings range between 17 and 35% for small and medium sedan hybrid cars. · However, large sedan hybrid cars and SUVs present consumption figures above the world average, but lower than similar gasoline car models.
Local context	
Status	Almost no HEVs are available in the Lebanese car fleet. Only Toyota is proposing in its show rooms the Prius for +50000 USD, largely above the average of its segment (~25000 USD). Note that the Prius is sold in the USA at 26000 USD and France at 26000 Euros, with 2000 Euros subsidy from the government. Some initiatives are taken from independent car dealers, whom are importing hybrid vehicles from the US, mainly Toyota Prius MY2004-2009, and selling them at a price range between 14500 USD and 21000 USD, depending on the model, the vehicle status and its mileage.
Timeframe	**Short term implementation** HEVs’ implementation could start immediately. No specific infrastructure is requested.

	However, adequate taxation policies and car fleet renewal scheme can improve the implementation of these technologies. Many examples can be consulted worldwide, notably the "bonus-malus"/"prime à la casse" French programs, the "Umweltprämie" German program and the "US CARS" US program.

[i] **This fact sheet has been extracted from TNA Report – Technology Needs Assessment Reports For Climate Change Mitigation – Lebanon. You can access the complete report from the TNA project website http://tech-action.org/**