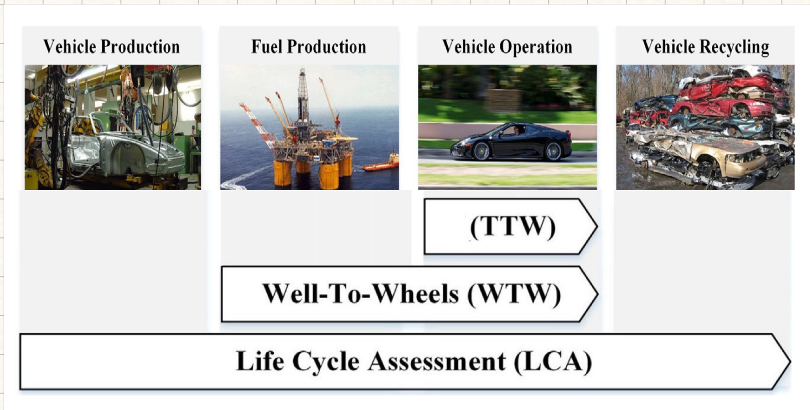
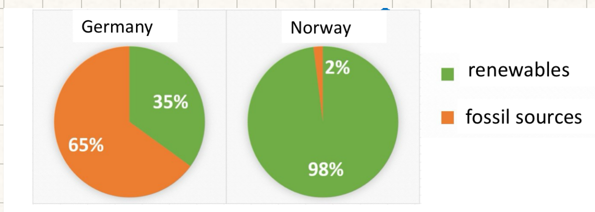
Electric Vehicles

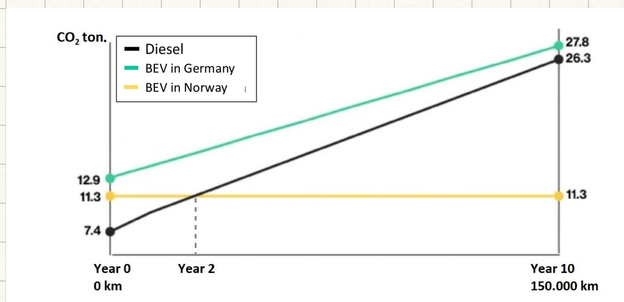
Scientists POV

three possible approaches:

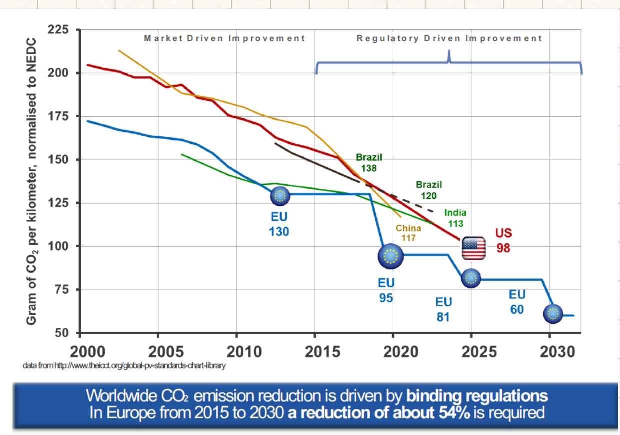


Tank-to-Wheel





Vehicle Manufacturers POV

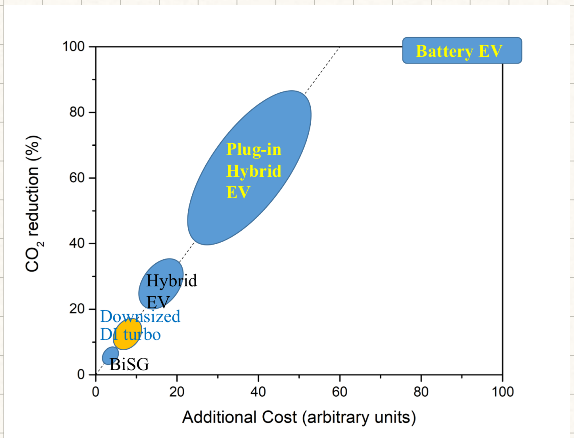


Regulation on passenger cars CO_2 emission:

- 95 g/km of CO_2 for 2020 for the new car fleet for the average car mass (1379,88 kg)
- For every 100 kg additional vehicle weight, the emission of 3,33 g/km more CO_2 is allowed
- Excess emission premium for manufacturers failing to meet their emission target: €95 for every g/km of excess emission per vehicle

- ICE techical evolution is not sufficient for CO_2 compliance
- Powertrain electrification is mandatory to fulfill CO_2 limits
- Multiple electrification solutions are available;
    - Mild
    - Full-hybrid
    - Plug-in-hybrid
    - Battery Electric Vehicle (BEV)

with different complexity, cost and CO_2 performance



Final User POV

Advantages:

- Improved performance (fun-to-drive), features and comfort
- Lower operation costs and environmental impact
- Access to city centers

Disadvantages

- Novelties in driving habits may not be welcomed by everyone
- Increased purchasing cost is unavoidable
- Charging problems for PHEV and BEV

Electrified Configurations

	Electrified Vehicle Types				
Functions	Micro	Mild (MHEV)	Full (FHEV)	Plug-in (PHEV)	Battery Vehicles (BEV)
Idle stop/start	✓	✓	✓	✓	
Electric torque assistance (fill-boost)		✓	✓	✓	✓
Energy Recovery (regenerative braking/coasting)	✓	✓	✓	✓	✓
Electric driving			✓ 1÷2 →15 km	✓ 30÷70 km	✓ >100_km
Battery charging (during driving)	✓	✓	✓	✓	
battery charging (from the grid)				✓	✓

Two major cost drivers:

- Impact on the existing power-train components
- High voltage battery

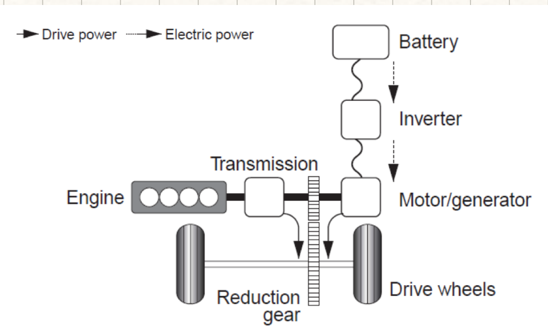
To minimize integration cost, the vehicle and transmission architecture should be kept the same as for a conventional vehicle. The easiest way is to integrate the 12-48 V electric machine into the already existing engine accessories belt drive, by replacing the 12 V alternator.

4 Basic configurations:

- Parallel
- Series
- Combination of series and parallel
- Electric (BEV)

Parallel Hybrid System

Power can flow to the wheels from either the ICE, an electric motor or from both in parallel



Advantages:

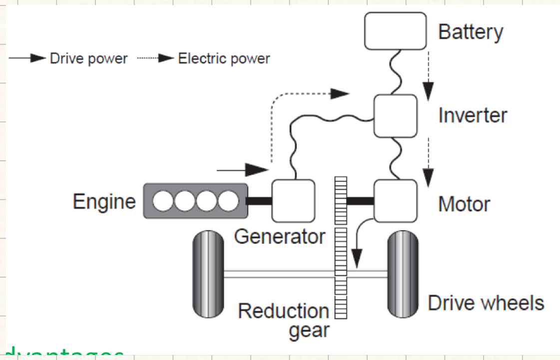
- Significant reuse of base powertrain components can reduce investment
- Many choices for the location of the electric machine(s)
- Battery power can be directly added to the base powertrain for increased performance

Disadvantages

- Independent speed control of the ICE not possible
- Losses inherent in base transmission remain
- Additional gearing adds to mechanical losses

Series Hybrid System

Power from ICE used to generate electrical power which then flows serially to an electric traction motor.



Advantages:

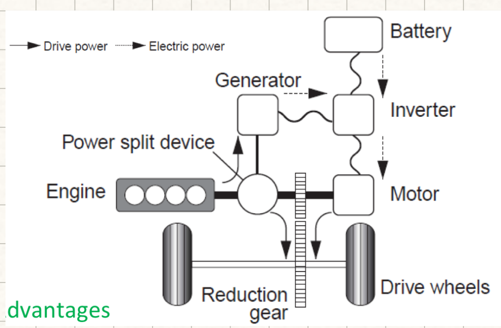
- Typically sized to provide the customer with full EV experience in charge depleting mode
- Large amount of electrical power in combination with independent speed and torque control of the ICE result in very efficient city driving

Disadvantages

- Inefficient charge sustaining highway driving due to lack of mechanical path
- High cost system due to high level of electrical power in addition to maintaining the ICE
- Sizing of the ICE is a trade-off between vehicle performance in charge sustaining mode, cost

Series Parallel

Power flows in series through electrical path, power flows in parallel through mechanical path



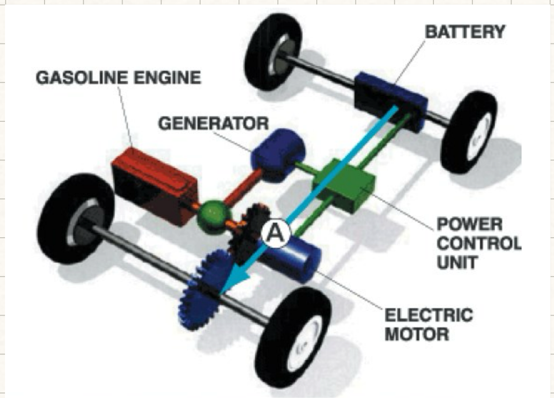
Advantages

- Independent speed and torque control of ICE
- Simplified gear train and lack of clutches and valve bodies minimizes the mechanical system losses
- Typical packaging allows for efficient motor designs that can deliver significant electric drive power
- Typically the most efficient powertrain for combined city and highway driving cycles

Disadvantages

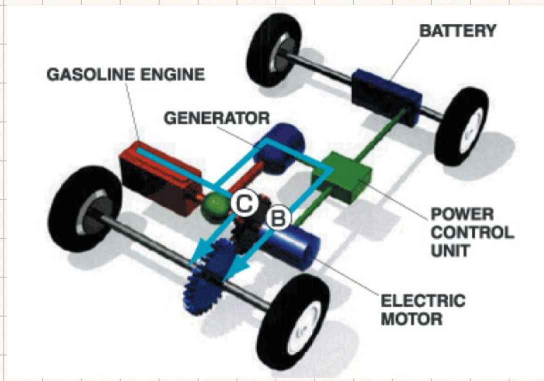
- Power split ratio selection can lead to high electrical losses during high speed operations (> 120 km/h)
- Typically cannot deliver peak electrical and mechanical power at the same time
- Reverse is electric drive only

1) Start and low to mid-range speeds:
The engine stops when in an inefficient range, such as at start-up and low to mid-range speeds. The vehicle runs on the motor alone



2) Driving under normal conditions:

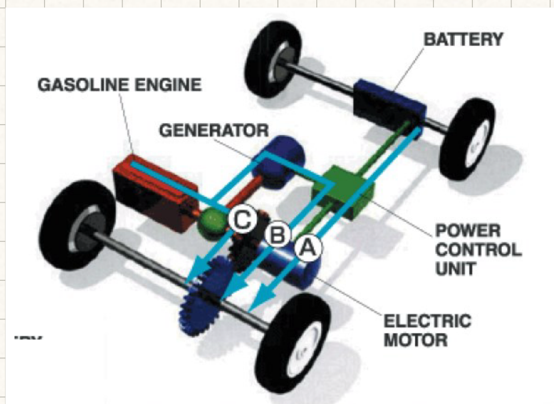
Engine power is divided by the power split device. Some of the power turns the generator, which in turn drives the motor (B).



The rest of the power drives the wheels directly (C). Power allocation is controlled to maximize efficiency.

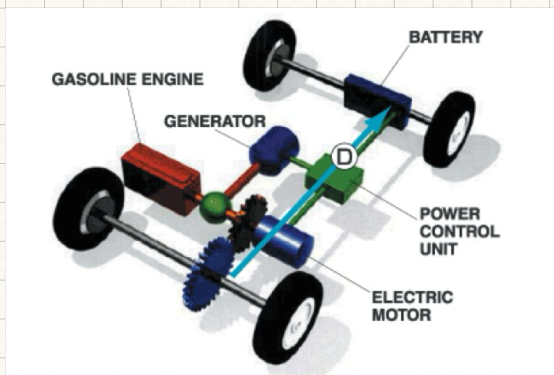
3) Sudden acceleration:

Extra power is supplied from the battery (A), while the engine and high-output motor provide smooth response (B+C) for improved acceleration characteristics.



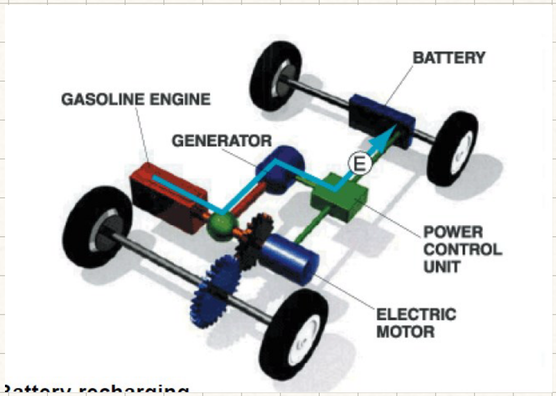
4) Deceleration, braking:

The high-output motor acts as a high-output generator, driven by the vehicle's wheels. This regenerative braking system recovers kinetic energy as electrical energy, which is stored in the high-performance battery (D).



5) Battery recharging:

Battery level is managed to maintain sufficient reservos. The engine drives the generator to recharge the battery when necessary (E).



6) At rest:

The engine stops automatically.