Electric Vehicles

Adam Opel AG





Rising Energy Demand Worldwide





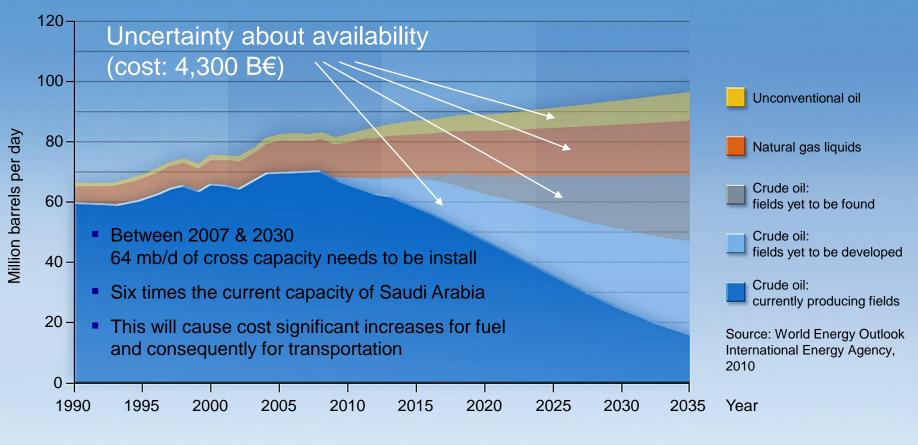


The Petroleum Age "Like a Candle in the Night"





Future Petroleum Demand Economics Will Drive Customer Behavior

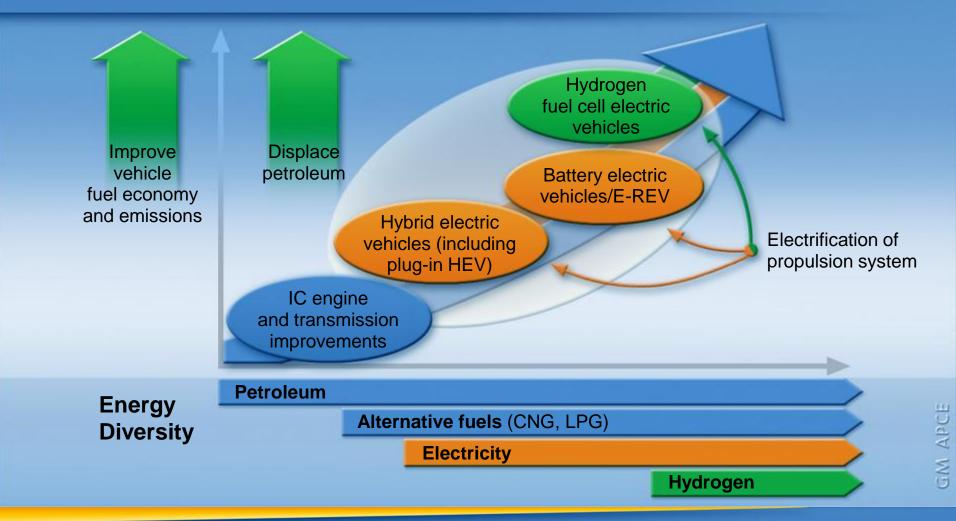






IM APCE

Opel's Advanced Propulsion Technology Strategy

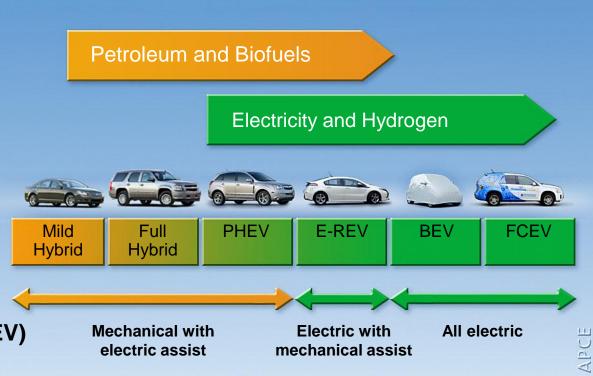






Vehicle Electrification

- Mild HybridsHybrid-System
- Full Hybrids2-Mode Hybrid System
- Plug-in Hybrids (PHEV)
 Modified 2-Mode Hybrid
 System
- Extended-Range
 Electric Vehicles (E-REV)
 Voltec System
- Battery Electric Vehicles (BEV)
- Fuel Cell Electric Vehicles (FCEV)





Electric Mobility Wish List: Vision Or Illusion? Public Perception According to Market Research

Range

- > 300 km
- Reliable & predictable

Charging

- In less than 30 min.
- At household electricity price
- Everywhere and wireless

Cost

- On-cost per vehicle < 5,000 €</p>
- Negligible operation cost

Performance

- Like a "real" car?
- Comfort, safety, capacity
- Fun to drive





On-Board Energy Storage

Weight and Volume of Energy Storage System for 500 km Range

Diesel

Compressed hydrogen 700 bar 6 kg H₂ = 200 kWh chemical energy

Lithium ion battery 100 kWh electrical energy

System Fuel

System Fuel

System Cell



43 kg 33 kg



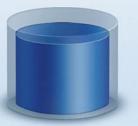
125 kg 6 kg



830 kg 540 kg



46 L 37 L



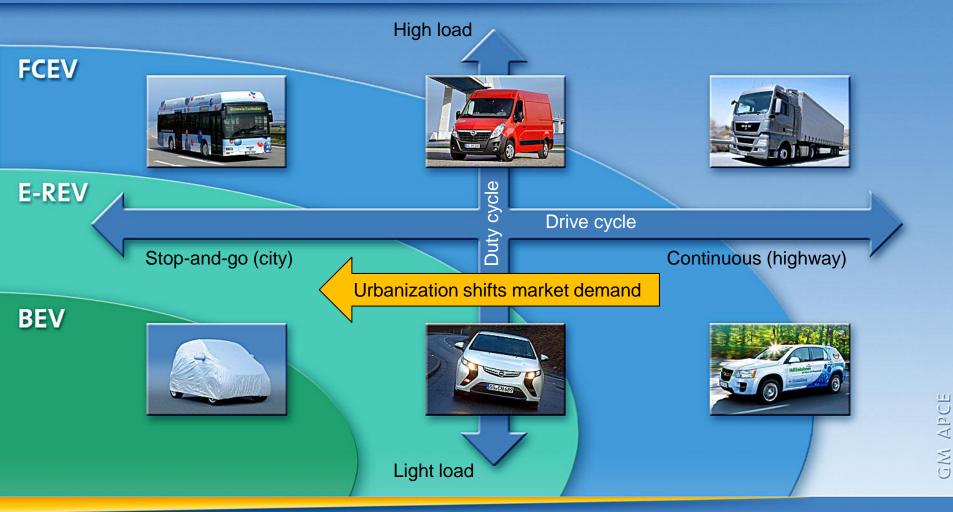
260 L 170 L 670 L 360 L





GM APCE

The Application Map Our Answer to Concurrent Development Targets





Electric Propulsion System Development

1966 GM Electrovan



New materials for FC membranes



2000 Opel HydroGen1 2007 Opel HydroGen4



1966

1972

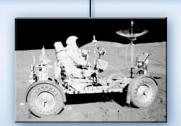
1990

1996

2000

2007

2010



1972 Lunar Roving Vehicle



1990 Opel Impuls



1996-1999 GM EV1



2010 Chevrolet Volt 2011 Opel Ampera

Space technology

- Low performance
- Huge systems
- Lack of suitable materials

E-hype & ZEV mandate

- Limited range
- Long recharging time
- Range anxiety
- Poor battery life
- Too expensive

E-hype & Li-ion batteries





E-REV as a New Propulsion Category

PHEV

Plug-in Hybrid Electric Vehicle Limited Performance in EV-Mode

BEV

Battery Electric Vehicle Limited Range



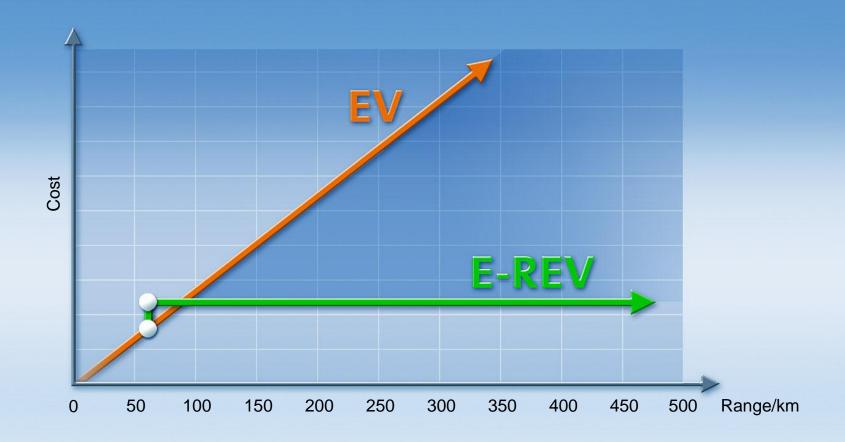
Extended-Range Electric Vehicle Full Performance in EV-Mode





GM APCE

Range and Cost







GM APCE

Range and Recharging Time

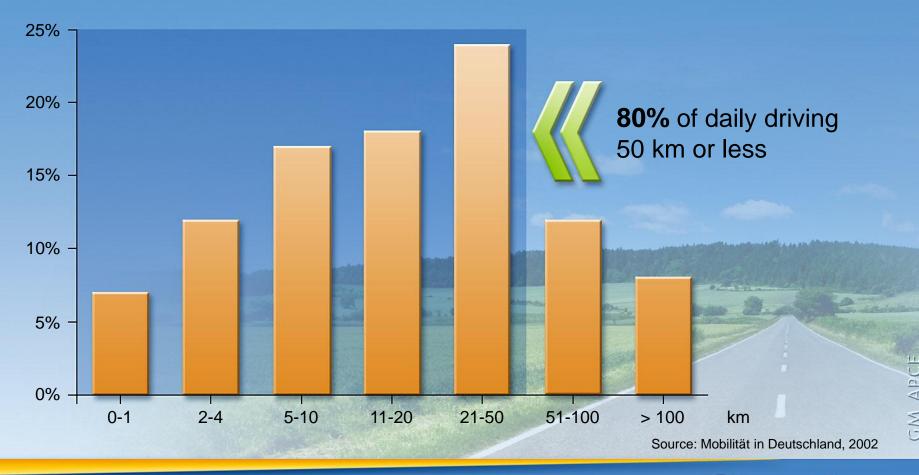


→ The same is valid for mass and volume





Typical Daily Mileage







Opel Ampera A Fully Capable Electric Vehicle

40-80 km

Battery-electric driving



Full usability:

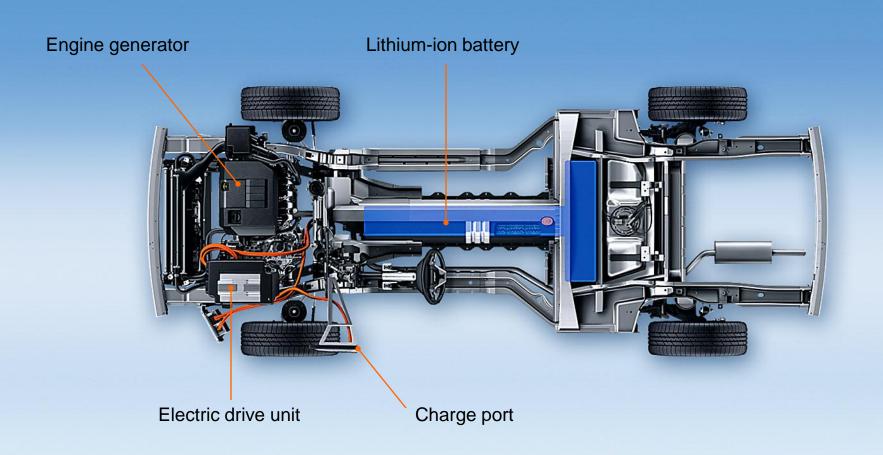
Performance and refueling like conventional vehicles





GM APCE

Opel Ampera Propulsion System







Li-ion technology

Pouch cells

Liquid cooling

360 V nominal voltage

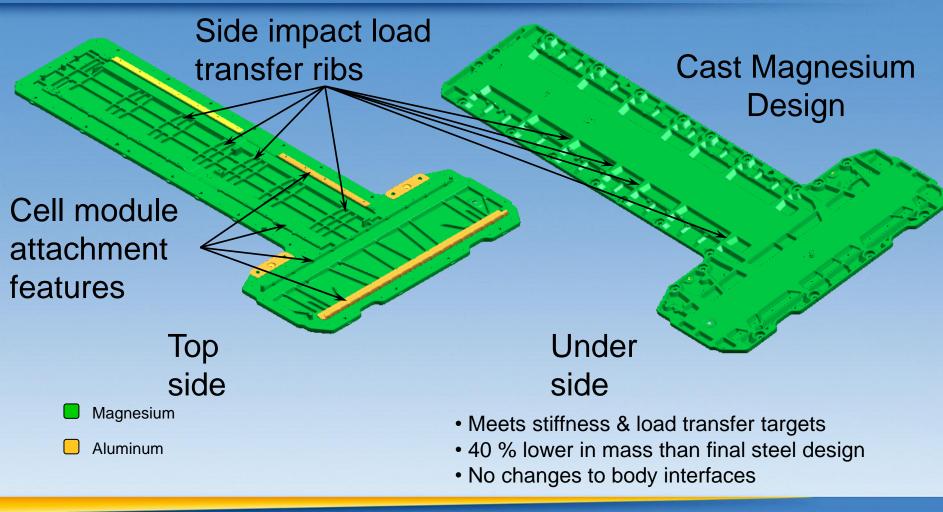
180 kg system weight







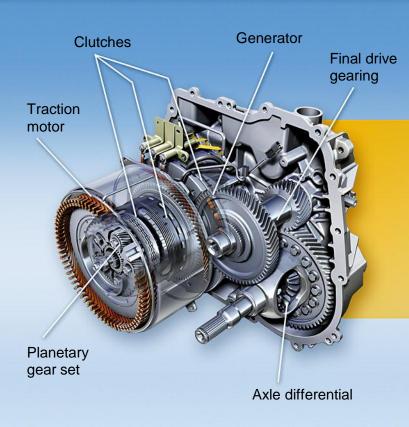
Opel Ampera Battery Pack Tray







Opel Ampera Drive System



On-axis electric drive

Two electric motors

Traction: 111 kW, 370 Nm

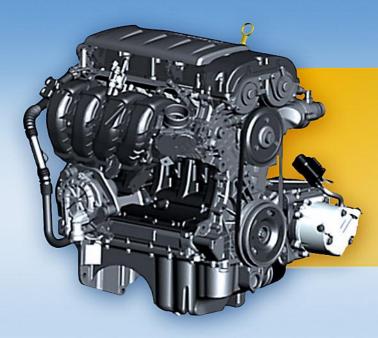
Generator: 54 kW

- One planetary gear
- Geared final drive
- Three clutches





Opel Ampera Drive System



1.4L DOHC I-4 engine

Power: 63 kW @ 4800 rpm

Max. engine speed: 4800 rpm

Displacement: 1.4 L

Compression ratio: 10.5 : 1





Opel Ampera Electric Drive System

Four different operating modes:

- Electric driving
 - low speed (1-motor)
- Electric driving
 - high speed (2-motor)
- Extended-range driving
 - low speed (1-motor series)
- Extended-range driving
 - high speed (2-motor combined)

Operation strategy:

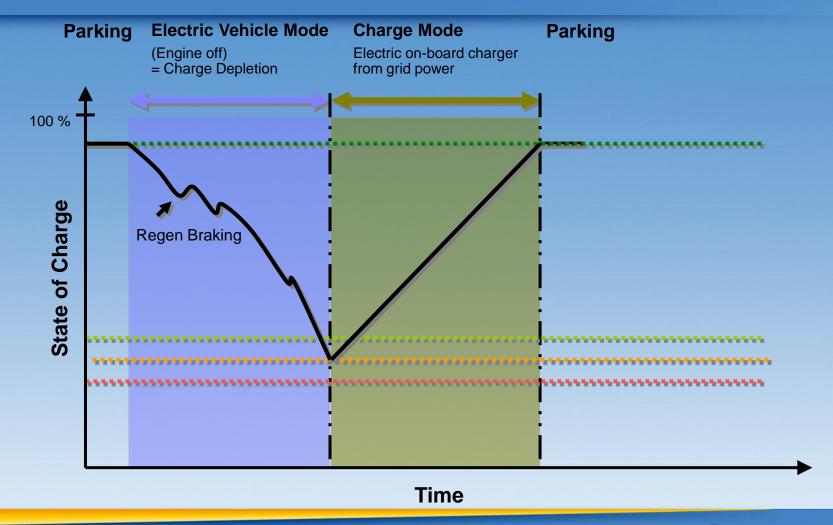
- Maximum battery-electric range (electric driving)
- Maximum efficiency







Opel Ampera Electric Drive System

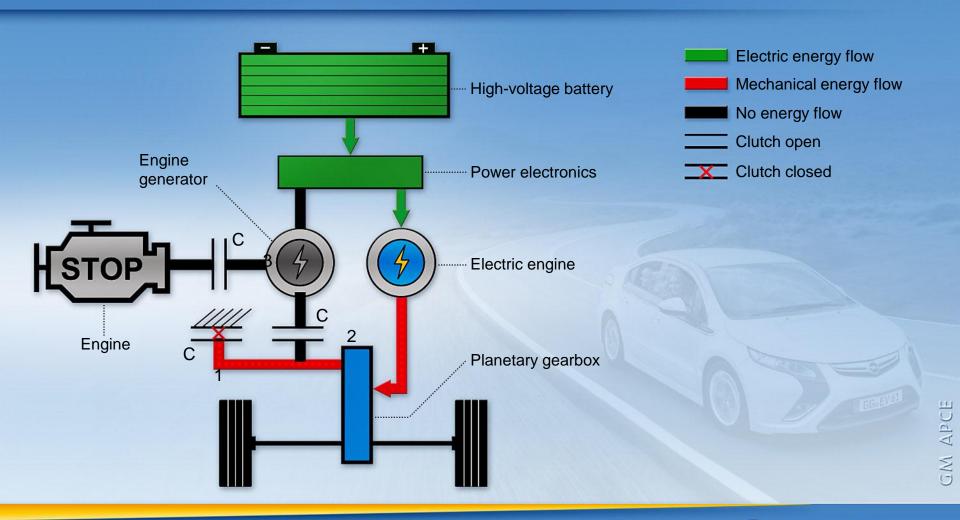






Ampera Electric Drive System

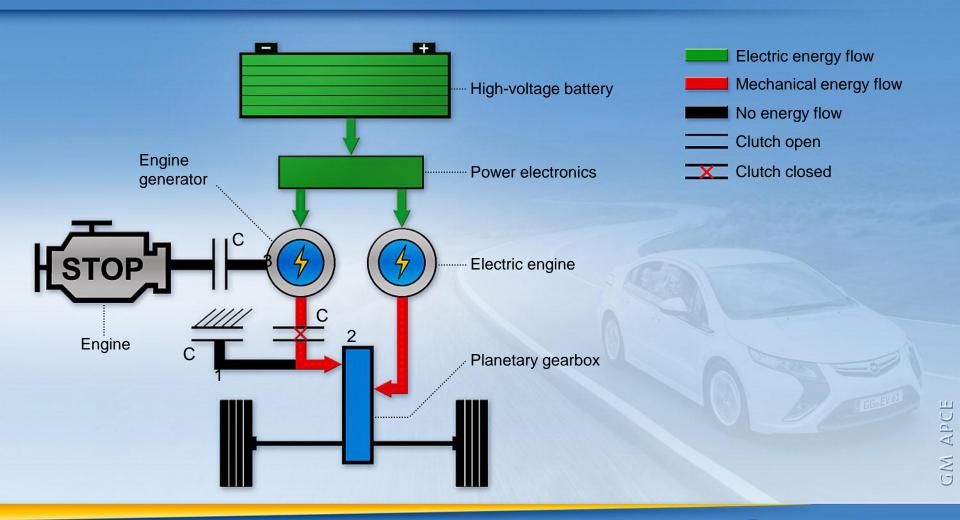
Electric Driving (Low Speed)





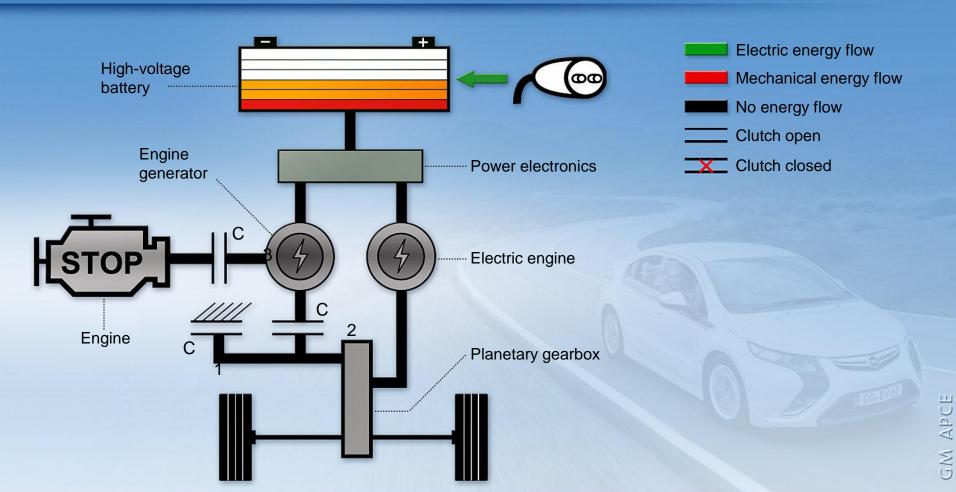
Ampera Electric Drive System

Electric Driving (High Speed)





Ampera Electric Drive System Charging







Important: Independence from Specific Infrastructure Solutions

- Recharging of Ampera possible at European power outlet (standard household installation)
- Recharging at home or workplace
 - → Will account for more than 85% of all charging events in the future





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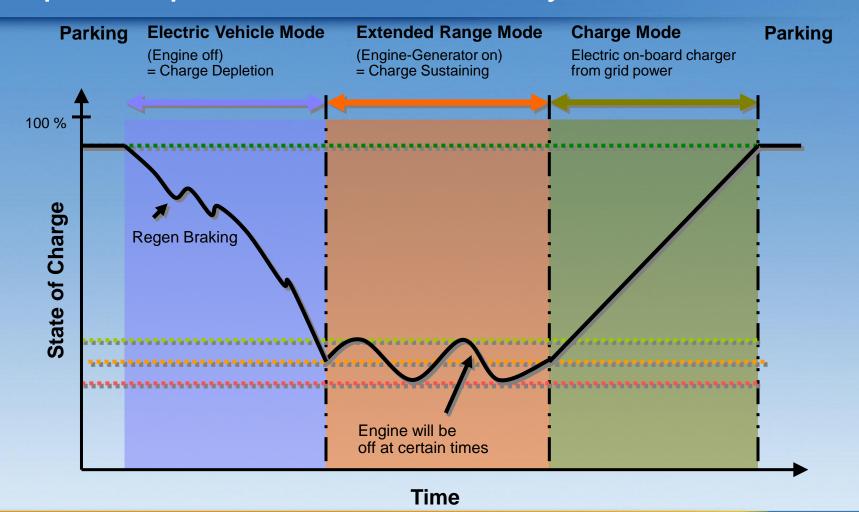
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Opel Ampera Electric Drive System

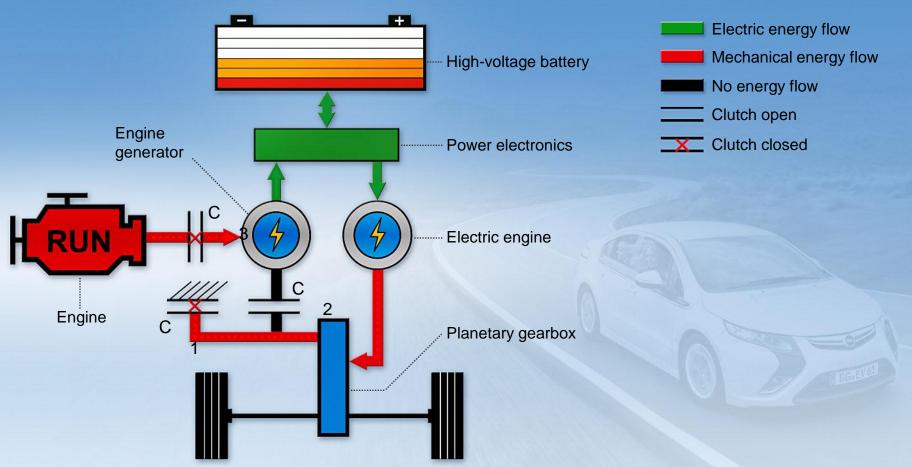






Ampera Electric Drive System

Extended-Range Driving (Low Speed)

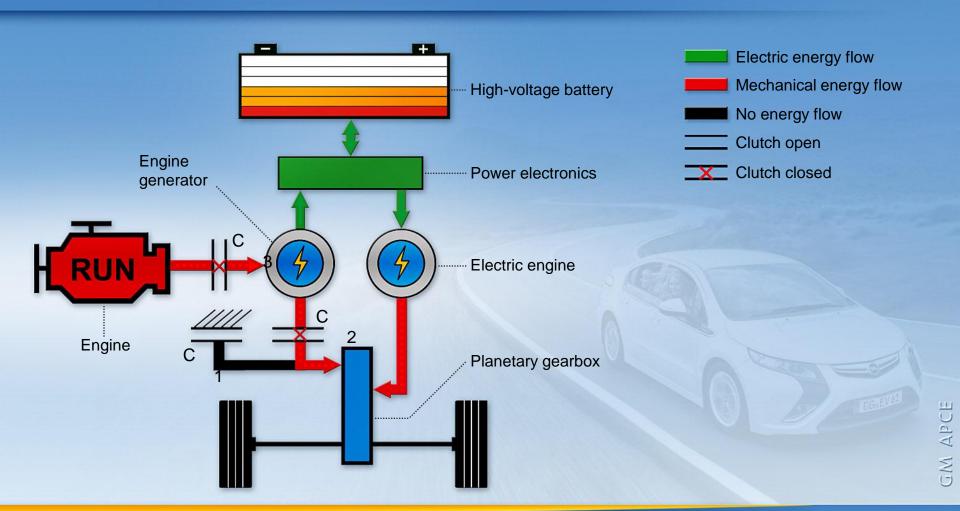




GM APCE

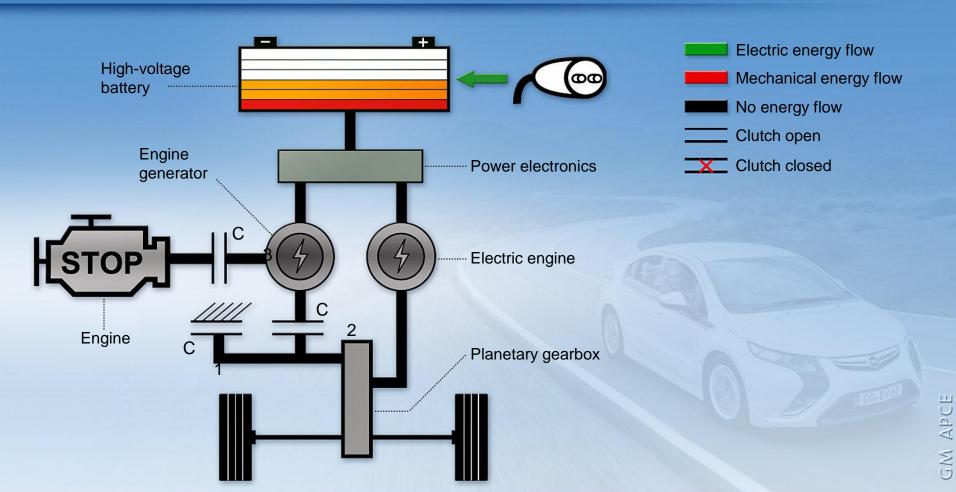
Ampera Electric Drive System

Extended-Range Driving (High Speed)





Ampera Electric Drive System Charging







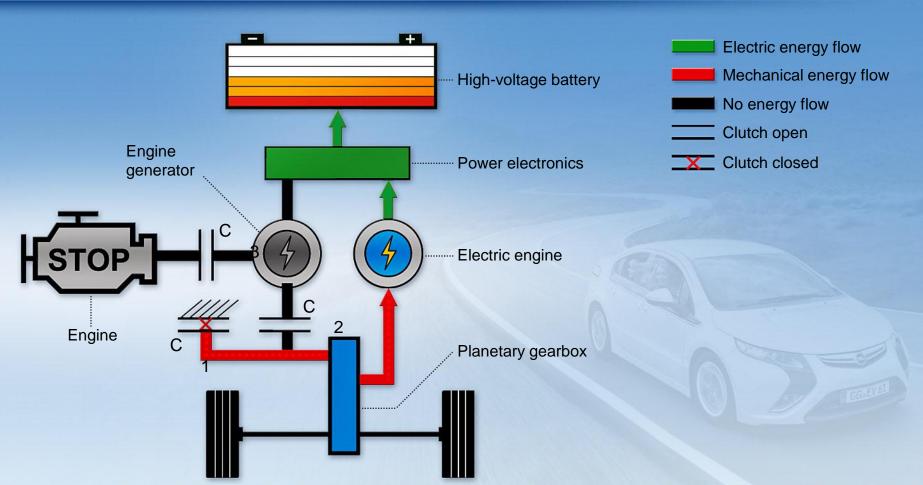
Ampera Electric Drive System Animation





Ampera Electric Drive System

Regenerative Braking

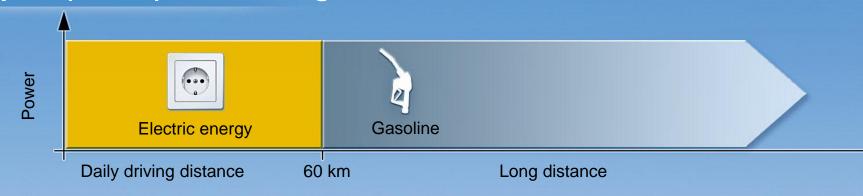




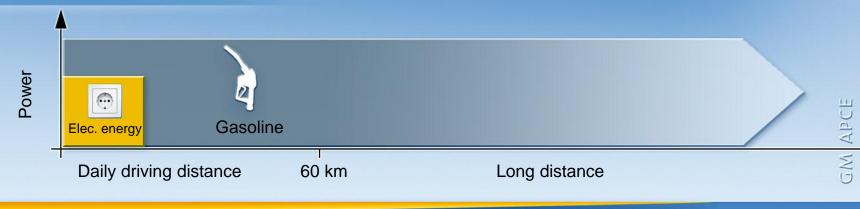
SM APCE

Opel Ampera vs PHEV Propulsion System. What's the Main Engine?

Ampera (E-REV): Master Engine = Electric Motor



Plug in Hybrids (PHEV): Master Engine = Combustion Engine



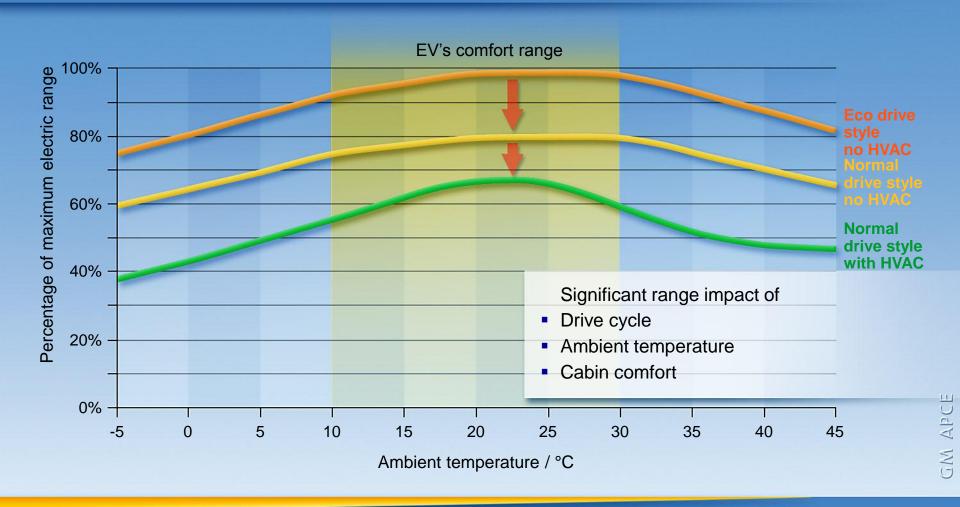


Reliability in Daily Use





EV Range: A "Reliable Uncertainty"







Spirited Gas-Free Performance

- 111 kW of power
- 370 Nm of torque
- 160 km/h top speed
- 0-100 km/h in about 9 seconds

Breaking the paradigm ...
Now GREEN
and FUN TO DRIVE
can go together





Opel Ampera – Making EVs Relevant

- Large volume production solution
- Capable of being first and only vehicle
- Independent of public charging infrastructure
- Predictable performance
- Fun-to-drive
- Affordable
- Safe







Opel Ampera <u>A Real Volume Product – Not a Demo Vehicle</u>





Opel Ampera Program Timeline – Chevrolet Volt & Opel Ampera





Opel Ampera Architecture Concept

Carryover vs. New Components

Material Breakdown

Structural Performance

Mass Considerations

Aero

Battery Pack Tray

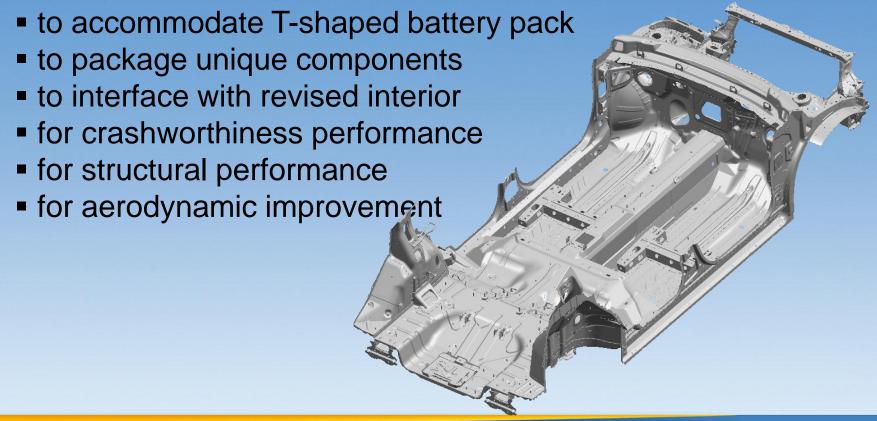




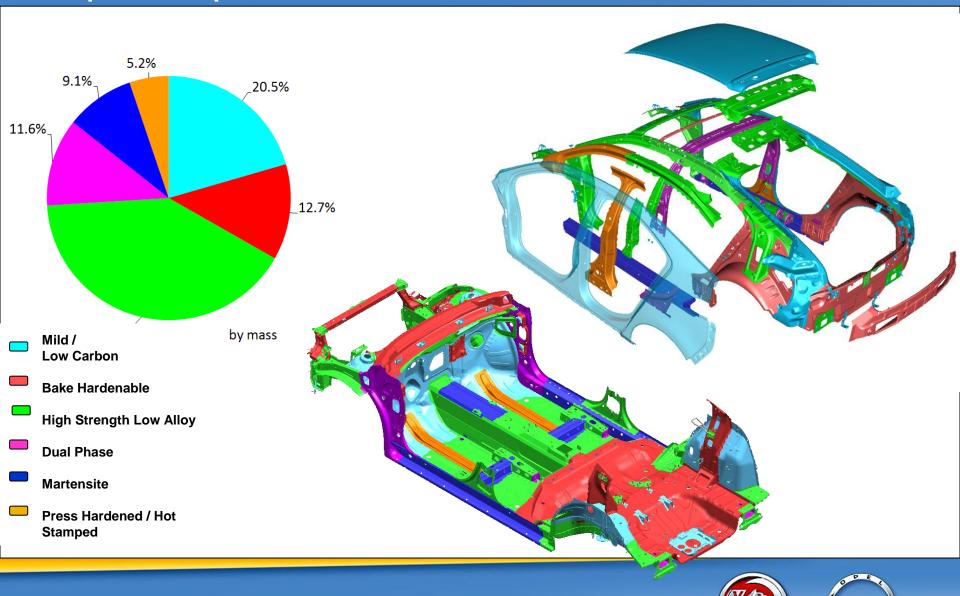


Opel Ampera Architecture Concept

Ampera Lower Structure is based on a global compact 5-door hatchback design, revised as follows:

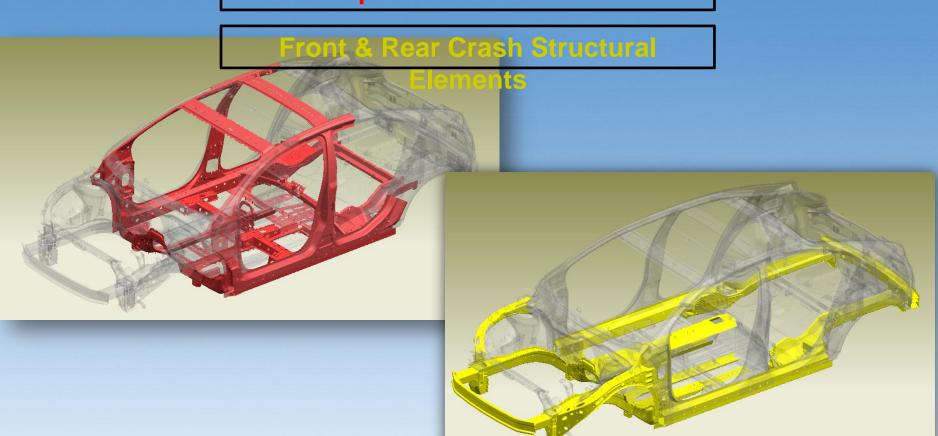






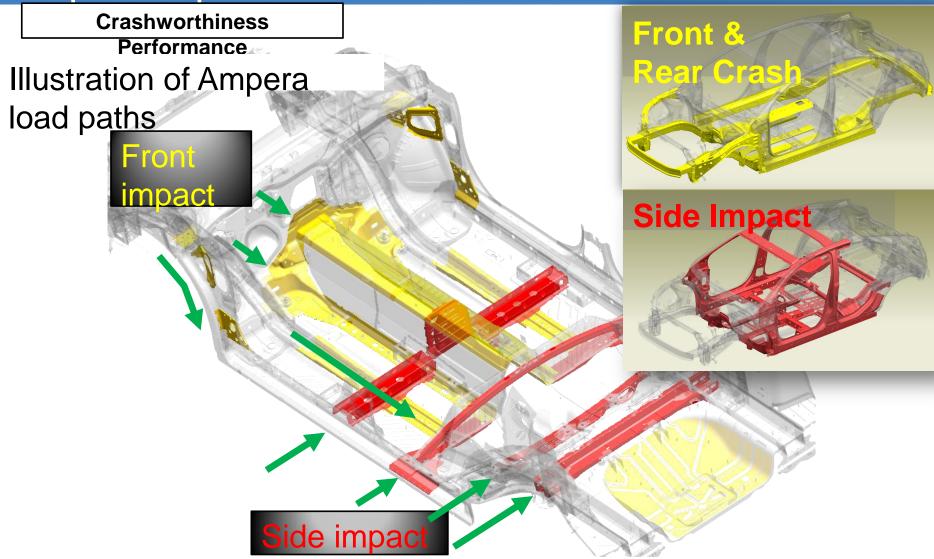
Opel Ampera Passive Safety Concept

Side Impact Structural Elements

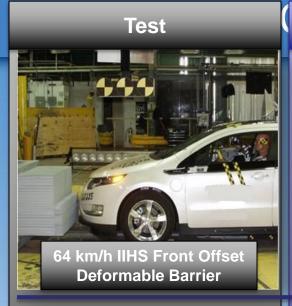








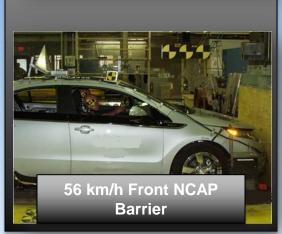


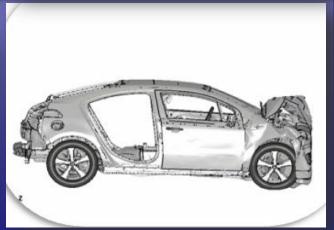


CAE Model















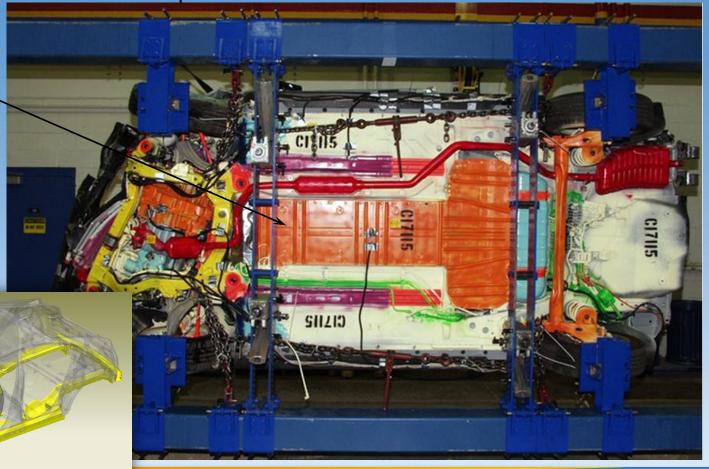
Opel Ampera Passive Safety Concept

Euro NCAP – 40% Overlap Front Offset Deformable Barrier – 64.37 km/h

Battery Pack Tray

Front &

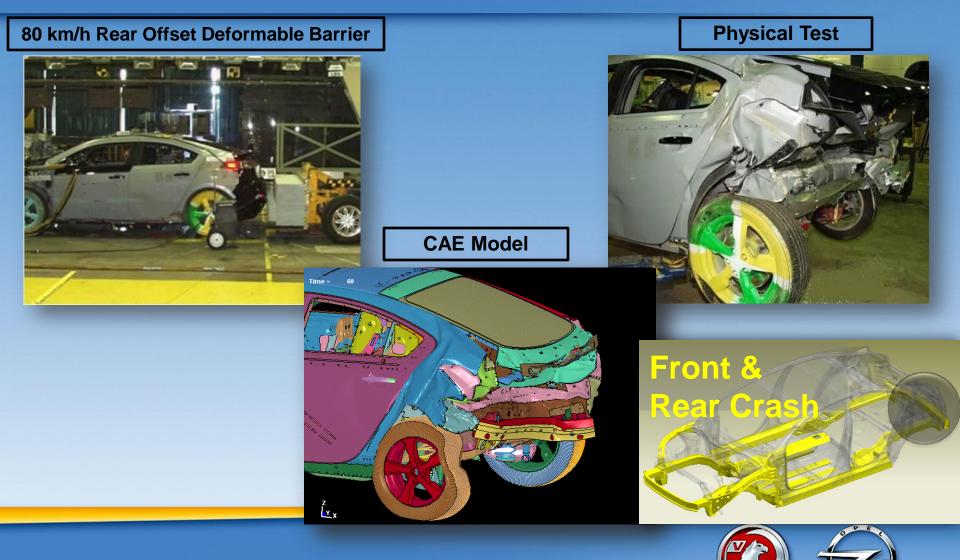
Rear Crash







Opel Ampera Passive Safety Concept



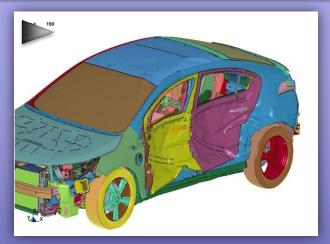
Test

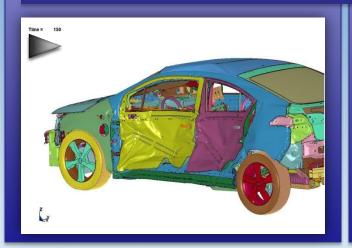


50 kph IIHS Side Impact Deformable Barrier

CAE accurately predicts physical test

CAE Model



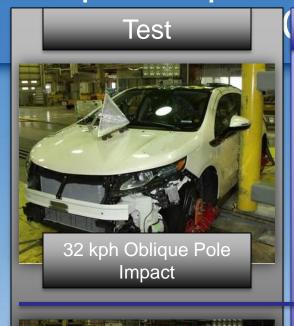




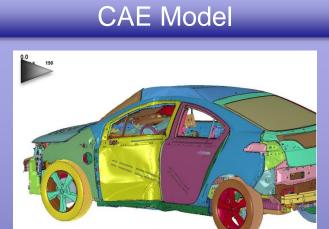








62 kph Crabbed Deformable Barrier



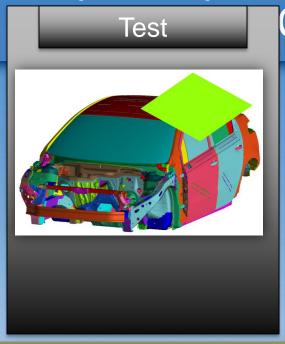




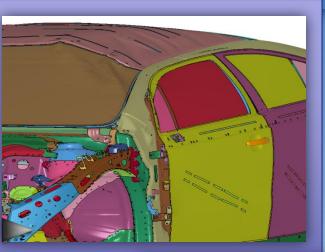






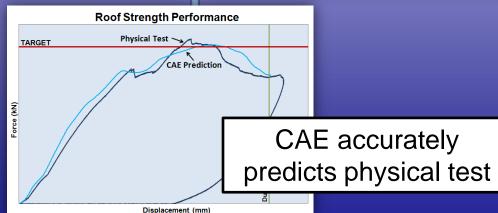








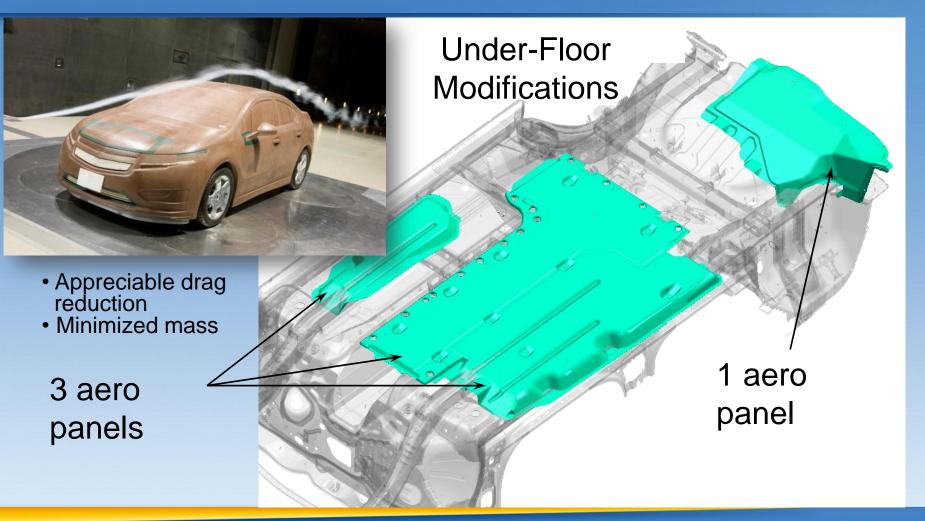








Opel Ampera Aerodynamic Improvement Concept





Thanks for your Attention







E-REV



FCEV

Opel. Wir leben Autos.



