Fun with Electric Cars: What INL Automotive Engineers Do All Day

BYU-I student visit to INL

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www.inl.gov

Idaho National Laboratory

Personal Background

Living the dream

- BSME from BYU (Provo), 2001
- Numerous internships before and during undergraduate program

- Ford Motor Company 2001 – 2007
  - Product design engineer
  - Powertrain Product Development

- Idaho National Laboratory 2007 – present
  - Vehicle test engineer
  - Energy Storage and Transportation Systems

Advanced Vehicle Testing Activity (AVTA)

- Part of the U.S. Department of Energy's Vehicle Technologies Program
- INL and ECOtality N.A. conduct the AVTA's light-duty vehicle testing, with Argonne National Laboratory performing dynamometer testing

AVTA Goals

- Determine actual petroleum displacement and overall operating cost of advanced technology vehicles through *testing* and *real-world demonstrations*
- Provide benchmark data to industry and government research and development programs
- Assist fleet managers and consumers in making informed vehicle purchase and operating decisions

AVTA Testing by Technology

- Plug-in hybrid electric vehicles (PHEV)
  - 12 models, 259 vehicles, 1.5 million test miles
- Hybrid electric vehicles (HEV)
  - 18 models, 47 vehicles, 5 million test miles
- Full-size battery electric vehicles (BEVs)
  - 40 EV models, 5+ million test miles
- Neighborhood & Urban electric vehicles
  - 26 models, 1.2 million test miles
- Hydrogen internal combustion engine vehicles
  - 7 models, 500,000 test miles

The EV Project

- INL is a principle participant with ECOtality N.A. in largest electric vehicle charging infrastructure demonstration ever undertaken
- 5,700 Nissan Leaf BEVs
- 2,600 Chevrolet Volt EREVs
- >14,000 Level II EVSE charging units
- >300 DC fast chargers
- 7 market areas in:
  - Oregon, Washington, California,
  - Arizona, Tennessee, D.C.

Charging Infastructure Locations

- > 40 project partners, including electric utilities

www.theevproject.com

Project Supporter

U.S. DEPARTMENT OF ENERGY

ecotality NORTH AMERICA

NISSAN

GM

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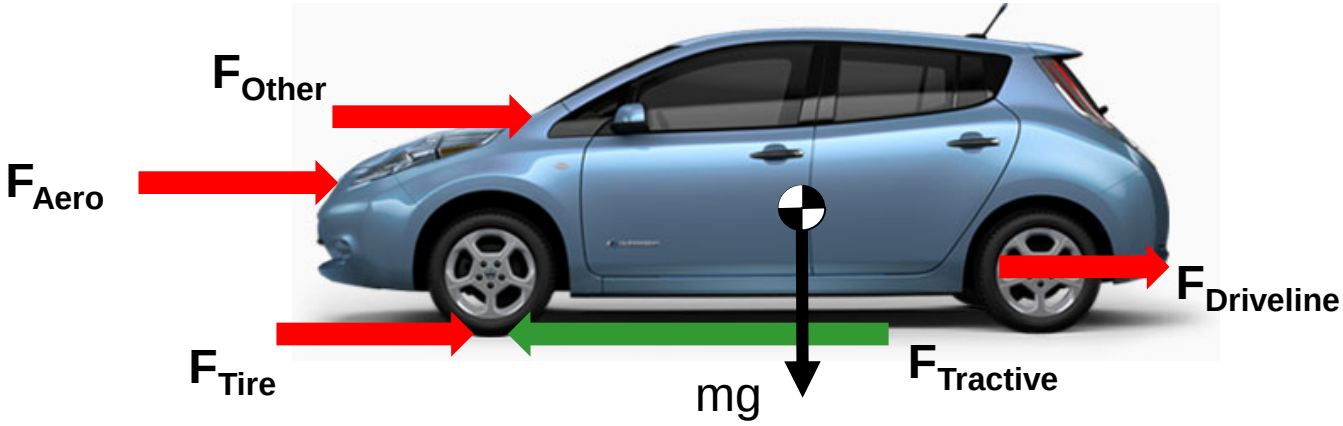
Underlying Physics Principles

- Conservation of energy – it has to come from somewhere
- How much energy does it take to get from point A to point B?



Find the power (P) required to maintain a speed of V

$F_{inertial\ accel} = m_{vehicle} * a_{vehicle}$

$F_{aero} = \frac{1}{2} C_D A_{frontal} \rho_{air} (V_{vehicle})^2$

$F_{driveline\ rolling\ resistance} = C_{RR}\ m_{vehicle}\ g$

$F_{tractive} = F_{inertial\ accel} + F_{aero} + F_{driveline} + \ldots + F_{other}$

$P_{wheel} = F_{tractive} * V_{vehicle}$

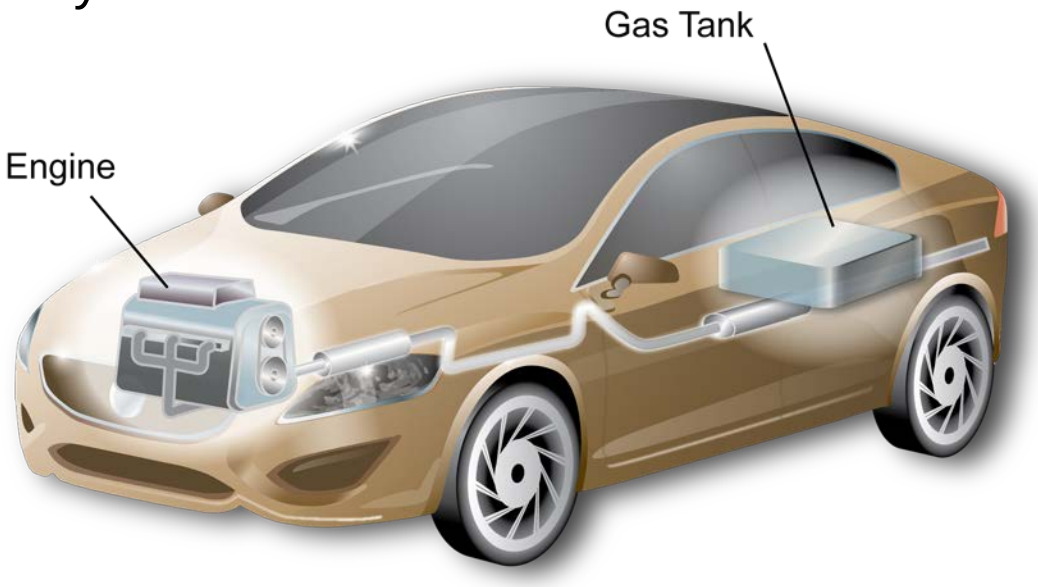
Find energy required to get from point A to point B

$$E_{wheel} = \int_a^b P_{wheel}\, dt$$

*** Assume Rotational Inertias are negligible**

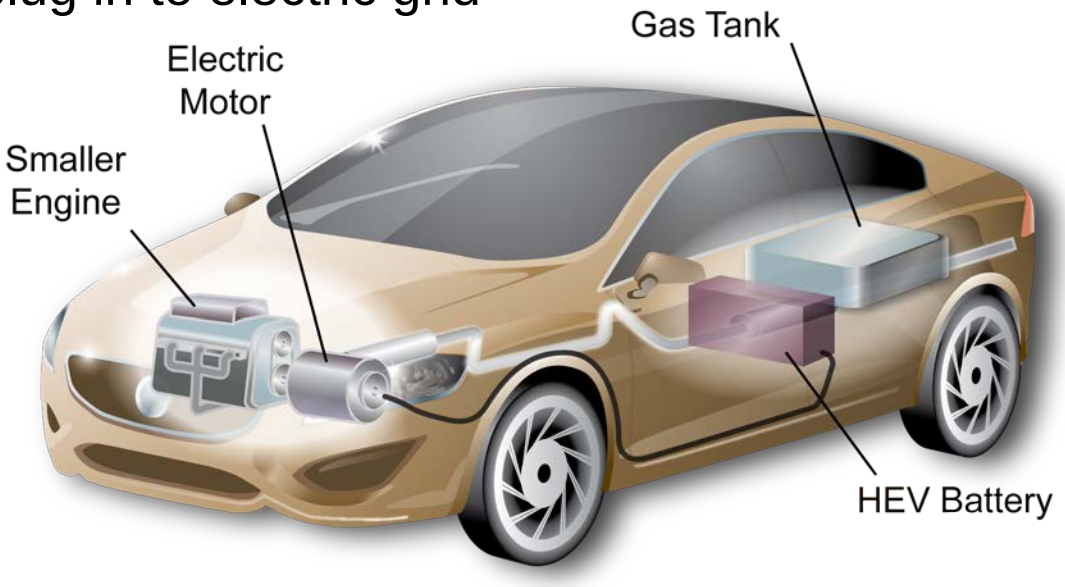
Comparison of Vehicle Technology

Conventional vehicle with internal combustion engine (ICE) only



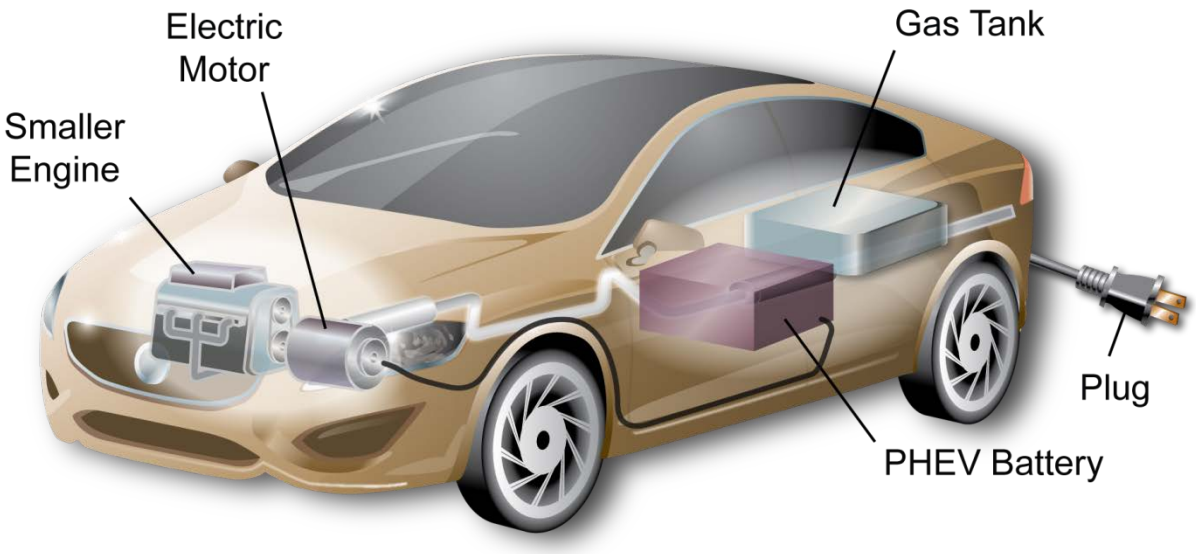
Comparison of Vehicle Technology

- Hybrid Electric Vehicle (HEV) with ICE and electric drive
- Does not plug in to electric grid



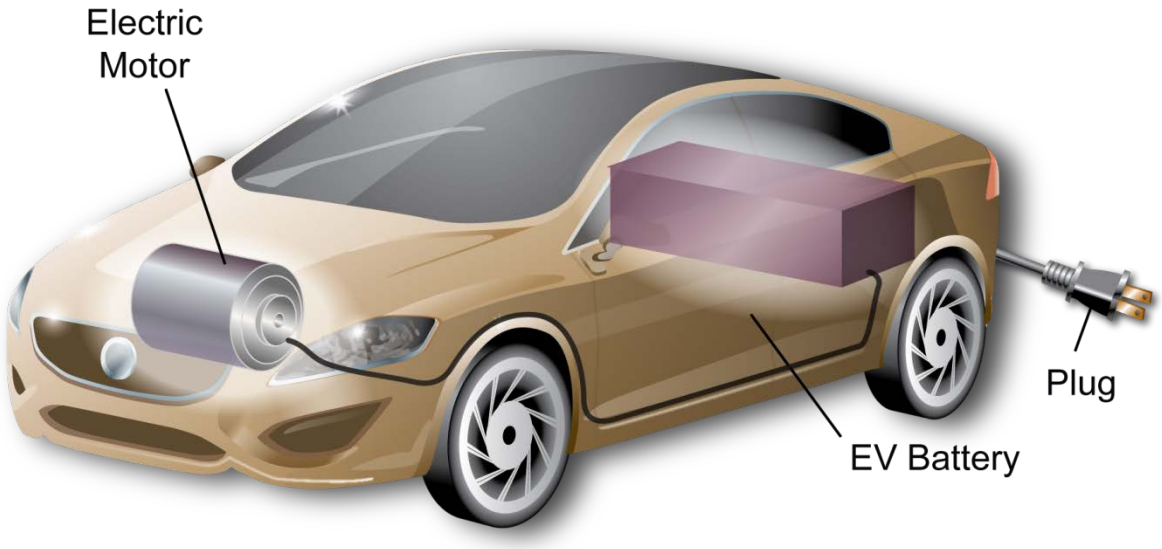
Comparison of Vehicle Technology

- Plug-in Hybrid Electric Vehicle (PHEV) with ICE and electric drive



Comparison of Vehicle Technology

- Battery Electric Vehicle (BEV) with electric drive only



Some Exciting Electrified Vehicles in Production or Announced for Production Soon

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HEVs

PHEVs

Toyota Prius PHEV

Ford TBD
C-size sedan

Extended Range Electric Vehicle (EREV)

Chevrolet Volt

Battery Electric Vehicles (BEVs)

Mitsubishi iMiev

Tesla Roadster

Nissan Leaf

What Do Engineers Do All Day?

- Communicate
- Paper work
  - Conduct business processes for project management, safety, procurement, budgeting, etc.
- Engineering
  - Define, design, analyze, create, test/verify, iterate
  - Create models based on first principles (what you go to school to learn how to do)
  - Create models based on experimentation/testing and past experience (institutional knowledge)
  - Use models to create something
  - Verify it works (… it probably won't…) and figure out why not
- Logistics
- Reporting

It's all about problem solving!

Automotive Engineering Challenges

- Increasing product complexity
- Pressures on:
  - Minimizing cost
  - Decreasing time to market
  - Continuously improving quality
- High volume
- All done in an extremely large business enterprise

But the test drive makes
it all worth it!

Opportunities for You in the Auto Industry

Auto companies and suppliers are aggressively recruiting engineers with specialized skills in:

- Design, integration, and testing of
  - High voltage power electronics
  - Electric motors
  - Batteries
  - Auxiliary electric systems (electro-hydraulic regenerative braking systems, electric power steering, etc.)
- Controls development and verification
- Noise, vibration, and harshness (NVH) systems integration and testing
- Vehicle network communications protocols
- Anything related to BATTERIES!

How to Develop These Skills

- Undergraduate coursework and projects
  - Mechatronics
  - Analog and digital controls
  - Embedded controls programming
  - Vehicle design projects that involve electrical and mechanical systems
- Graduate courses focused on electric vehicles and grid integration
- Student competitions

There's no substitute for hands-on experience (with proper safety supervision!)

Acknowledgement

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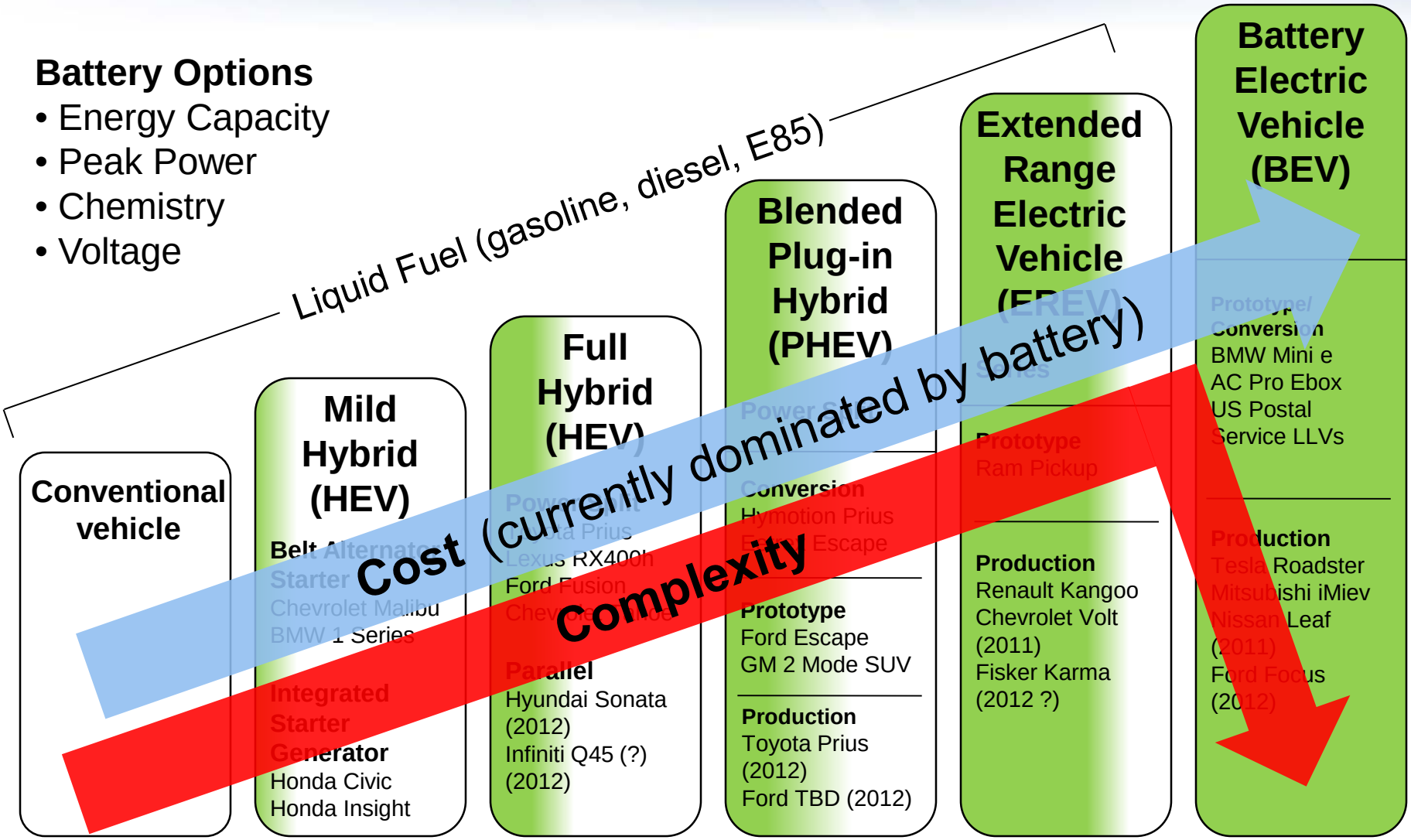
Additional Information

http://avt.inl.gov
or
http://www1.eere.energy.gov/vehiclesandfuels/avta/

Electrified Vehicle Powertrain Architectures

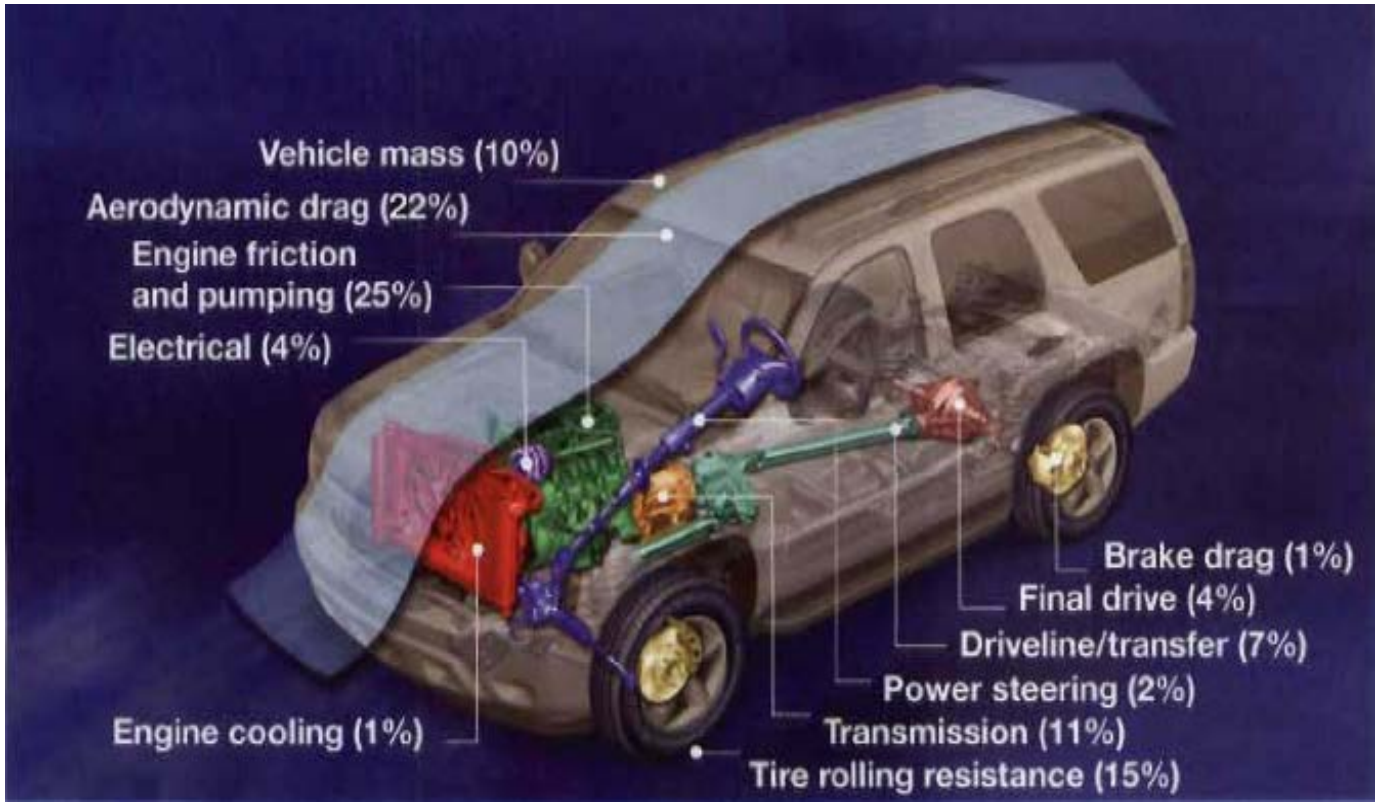
Battery Options
- Energy Capacity
- Peak Power
- Chemistry
- Voltage



Dates given are announced target years for start of production

Vehicle Losses

Example: Chevrolet Tahoe (non-hybrid)



Source: Automotive Engineering International, March 2010