eAssist™ to EVs

Electrification Technologies for the future

Bill Wallace
Director – Global Battery Systems Engineering

GM
PETROLEUM SUPPLIES...

35% of world’s energy

96% of transportation energy
64 mb/d of gross capacity needs to be installed between 2007 & 2030 – Six times the current capacity of Saudi Arabia.

Source: IEA World Energy Outlook, 2010
ENERGY CONSERVATION AND DISPLACEMENT
USING ELECTRIFICATION TECHNOLOGIES TO REDUCE CONSUMPTION
AND DISPLACE PETROLEUM

Petroleum and Biofuels
(Conventional and Alternative Sources)

Electricity and Hydrogen
(Zero Emissions Energy Sources)

- eAssist™
- Full Hybrid

- Extended Range Electric
- Battery Electric
- Fuel Cell Electric

CONSERVATION

DISPLACEMENT

Increasingly Electrified Powertrains
HYBRIDIZATION

eAssist™ – Technology to Watch in 2011

Hybridization
- EV Operation
- Load Shifting
- Regeneration
- Stop/Start

Improvements in Conventional Powertrain

Toyota Prius IV
Ford Fusion
Buick LaCrosse eAssist™
Honda Insight
Opel Astra
Volkswagen Passat Bluemotion
Chevrolet Tahoe Hybrid
Chevrolet Silverado Hybrid
Chevrolet Silverado Hybrid

Hybridization Upper Bound
Conventional Upper Bound

Efficiency
Technology Implementation
LaCROSSE SEDAN WITH eASSIST™

EPA Estimated Label FE (MPG): 25 City/36 Highway
eASSIST™ – DELIGHTING CUSTOMERS WITH FUEL EFFICIENCY

Consumption reduction at the lowest cost

- Engine idle stop – and smooth starts
- Lower power regeneration (15kW)
- Grade based assist (10kW, 50Nm)
- Reduced engine and driveline losses
- Selected aero improvements
- Low rolling resistance tires

Base powertrain in the 2012 Buick LaCrosse

- Optional on Regal, Alphaneon (Korea), LaCrosse (China) and 2013 Chevrolet Malibu
**ELECTRIFICATION**

- **Hybridization**
  - EV Operation
  - Load Shifting
  - Regeneration
  - Stop/Start

- **Improvements in Conventional Powertrain**

- **Conventional Upper Bound**

- **Hybridization Upper Bound**

- **Displace Petroleum**
  - Grid connection

- **Technology Implementation**

- **Cars**
  - Chevrolet Volt
  - Toyota Prius IV
  - Ford Fusion
  - Buick LaCrosse eAssist™
  - Opel Astra
  - Volkswagen Passat Bluemotion
  - Chevrolet LaCrosse eAssist™
  - Chevrolet Tahoe Hybrid
  - Chevrolet Silverado Hybrid
  - Honda Insight
  - BEV

- **Efficiency**
Based on OmniStats Data posted by the U.S. Bureau of Transportation
## Creating a New Propulsion Category

<table>
<thead>
<tr>
<th>HEV</th>
<th>Electric Vehicle</th>
<th>BEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid Electric Vehicle</td>
<td>With Extended-Range</td>
<td>Battery Electric Vehicle</td>
</tr>
<tr>
<td>Petroleum</td>
<td>Electricity + Petroleum</td>
<td>Electricity: Limited Range</td>
</tr>
</tbody>
</table>
EXTENDED-RANGE Electric Vehicle

25–50 miles BATTERY Electric Driving

25–50 HUNDREDS of miles EXTENDED RANGE Driving

VOLT
EV driving characteristics
- 111 kW EV power
- 100 mph top speed
- EV responsiveness

Acceleration
- 0-60 mph in about 9 seconds

Extended range
- >300 ER miles eliminates "range anxiety"
- Smooth transitions
- EV feel preserved even in ER driving
TECHNOLOGY in TRANSITION

A PERIOD OF TRANSITION WITH COMBINED ELECTRICITY AND LIQUID FUELS
HAPPENING NOW – IN 2011

- Petroleum and Biofuels
  (Conventional and Alternative Sources)
- Electricity
  (Zero Emissions Energy Sources)

Era of Liquid Fuels
Era of Transition
Era of Electricity

eAssist™ coming in 2011
EREV – In Production Now
CHEVROLET SPARK EV
eASSIST™ TO EVs

PRACTICAL PETROLEUM CONSERVATION AND DISPLACEMENT

Electrification technologies for 2011

- eAssist™
  - Lower cost, practical efficiency extension of base powertrains
  - 2012 Buick LaCrosse – 37MPG Highway
- EREV
  - Practical petroleum displacement
  - 2011 Chevrolet Volt – 25-50 miles EV range

Factors for EREV and EVs in path to energy diversity

- Customer expectations for vehicle utility
  - No compromise of vehicle utility with eAssist™, HEVs, EREVs
  - EVs are ideal for urban environments and for those with predictable commutes
- Economics of durable energy storage in petroleum/electricity
Electrification Has Changed GM

“Beginning in 2011, General Motors will add 1,000 engineers and researchers...

...over the next two years to significantly expand its vehicle electrification expertise to lead in the development of electric vehicles from hybrids to electric vehicles with extended-range capability, like the 2011 Chevrolet Volt.”

— Dan Akerson, GM Chairman and CEO

- New skill sets
- New academic curricula
- New ENTHUSIAM for one of the biggest global growth industries
INVESTING IN MICHIGAN’S GREEN ECONOMY

- Detroit-Hamtramck: $336M - Volt Assembly Plant
- Flint Engine South: $202M - Engines
- Brownstown Township: $43M - Battery Assembly Facility
- Bay City: $37M - Cam Shafts and Connecting Rods
- Grand Blanc: $30M - Tooling
- Warren: $27M - Battery Systems Lab
- Flint Tool & Die: $23M - Stamping
- Flint Metal: $2M - Stamping

$700 MILLION