EVS 23

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SUSTAINABILITY:
THE FUTURE OF TRANSPORTATION

ANAHEIM, CALIFORNIA USA

Realizing the Power of Plugging-in…
Can we commercialize PHEV's?

Nancy Gioia

Director of Sustainable Mobility Technologies & Hybrid Vehicle Programs
Ford Motor Company

HOSTED BY:

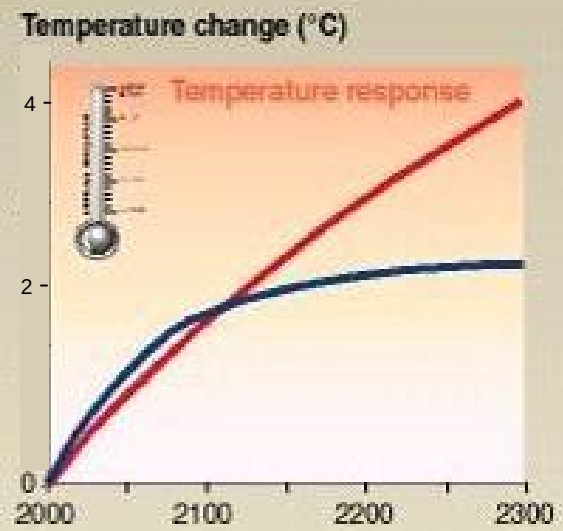
EDTA
Electric Drive Transportation Association

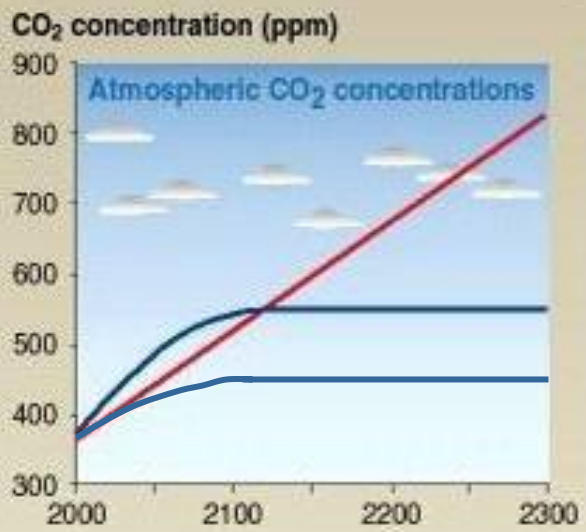
In partnership with the World Electric Vehicle Association (WEVA)

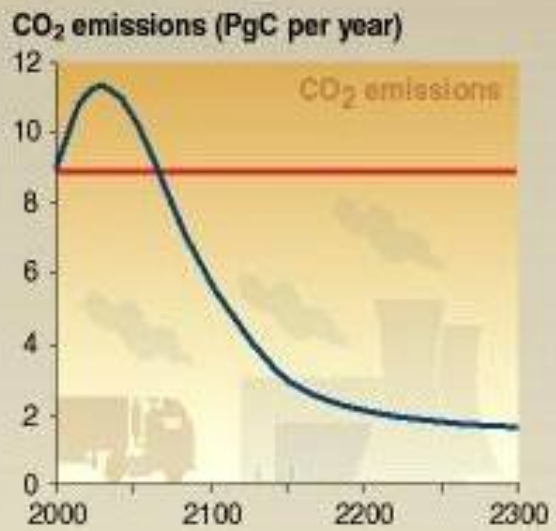
Can we Commercialize???
New Business Paradigms Are Needed…

- Climate change and energy security are real
  - Vehicle, Fuel and Utility Technology Solutions needed
    … for a new shared customer
- Potential vision of New Business Paradigms
  - Today: World of independent solutions
  - Opportunity: Convergence of technologies and industries
  - Future: Transportation and Utilities become interdependent
- Goal: Accelerate the production of PHEVs and V2H technologies that delight customers and provide a reasonable rate of return
- Two key challenges:
  - Technical: battery, vehicle system interface, V2H enablers
  - Business case: customer/company affordability, new value streams, two independent industries

Ford Motor Company is committed to the exploration of new ideas with the potential to create a cleaner, greener world



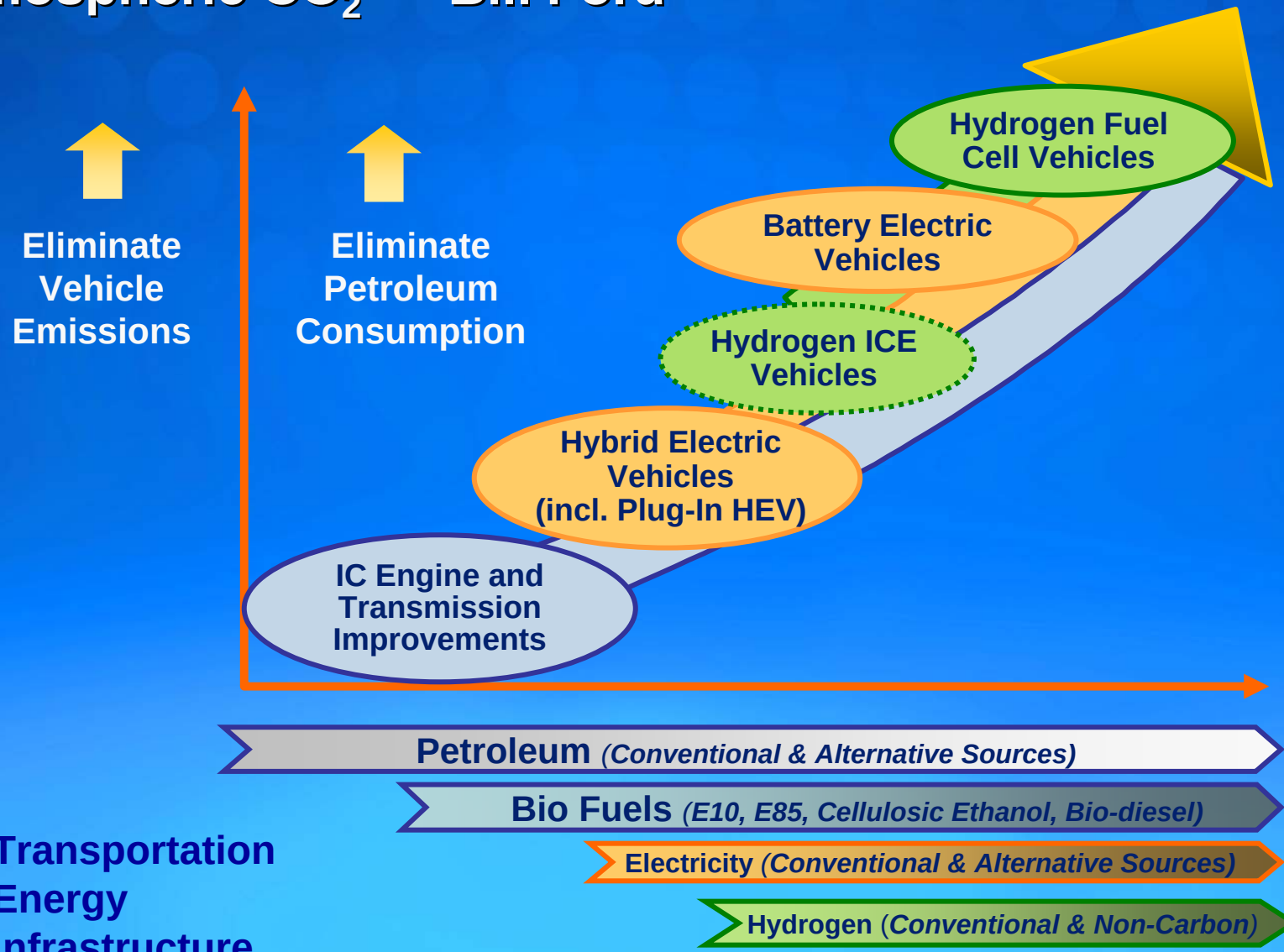




Constant CO2 emissions at 2000 level — Emissions path to stabilise CO2 concentration at 550ppm & 450ppm

Alan Mulally: *" ...we are at an inflection point in the world's history as it relates to climate change and energy security. The time for debating whether climate change is real has past. We now are working hard to find solutions."*

"No single technology on the horizon will enable our industry to play its full part in stabilizing levels of atmospheric CO_2" – Bill Ford



PHEVs represent a potential opportunity to reduce our petroleum fuel consumption – closing the gap until more advanced technologies and renewable fuels become readily available

Ford presently has two PHEV projects underway ..

The Ford HySeries Drive

- Series Hybrid
- Hydrogen Fuel Cell Drive Train
- Plug-In Hybrid functionality
- High Capacity Lithium-Ion Battery

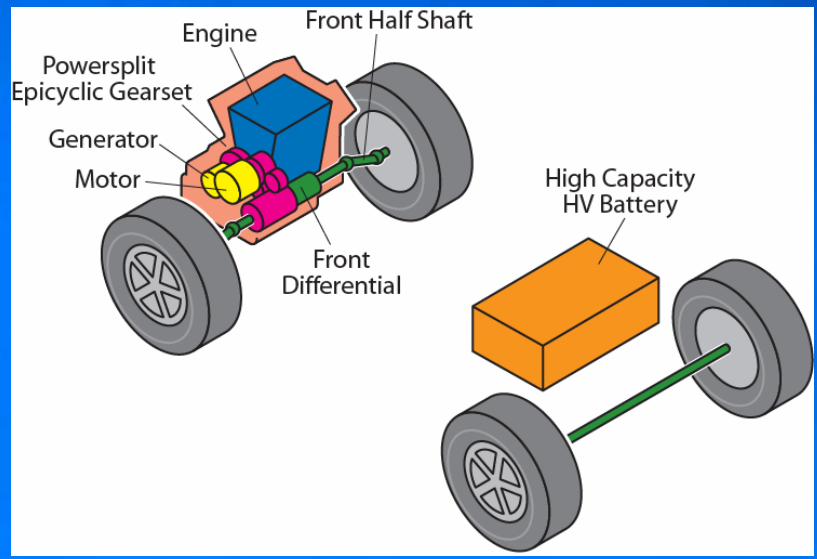
The Ford Escape Plug-In Hybrid

- Parallel Hybrid Electric Vehicle
- Plug-In Hybrid functionality
- High Capacity Lithium-Ion Battery

Ford Escape PHEV delivers reduced fuel consumption via a high capacity battery that can be charged from a standard 110V electrical outlet and then discharged during driving

Specifications

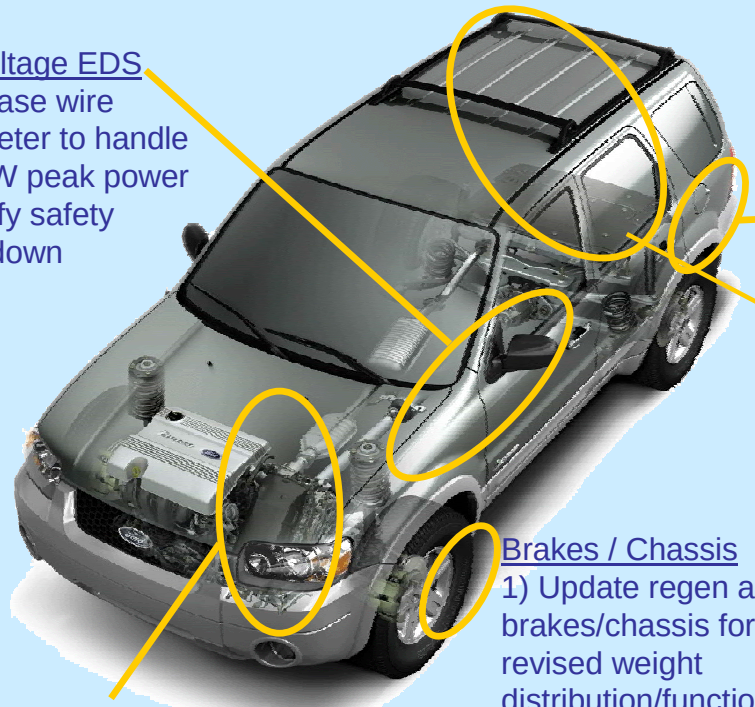
- Engine: High Efficiency 2.3L Atkinson cycle
- High Energy Li-Ion Battery: 10 kW-hr
- Fuel Capacity: 15 gal
- Seating: 5-passenger
- Weight: 3900 llbs
- Max Speed: 102 mph
- Acceleration (0-60 mph): 10.3 sec



Attributes

- Superior fuel economy – up to 120 mpg
- Overnight recharging from standard home outlet
- Two thirds less trips to gas station
- Regenerative braking
- All electric mode during low speed driving
- Interactive vehicle energy management display
- Capless fuel filler

In addition to the high capacity battery, the Ford Escape PHEV has significant vehicle and system upgrades



High Voltage EDS
1) increase wire diameter to handle 60 kW peak power
2) Modify safety shutdown

110 V AC plug-in door

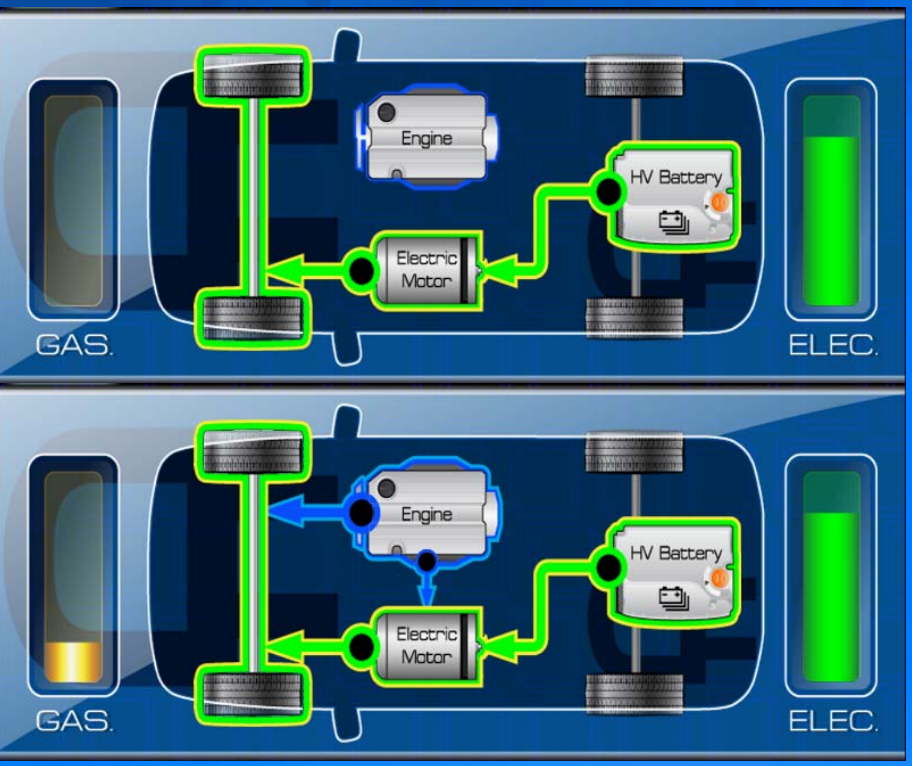
Rear Cargo Area
1) replace production high voltage battery with high energy Li-Ion battery
2) add battery charger
3) add gateway module for plug-in control
4) revise rear structure for added weight and safety performance
5) redesigned suspension for added weight

Brakes / Chassis
1) Update regen and brakes/chassis for revised weight distribution/function

Transaxle/Engine Compartment
1) modify transaxle oil lubrication/cooling circuit for extended engine-off durability
2) add oil to air heat exchanger to increase continuous operating capability of electric machines

Other Areas
1) Emissions - need revise strategy to meet PZEV w/extended engine off time
2) Climate control - need new approaches for heating vehicle and defrosting during extended engine off time

A fully charged Ford Escape PHEV operates in two modes – Electric Drive and Blended Electric/Engine Drive



ELECTRIC DRIVE

At urban speeds, the high-capacity plug-in hybrid battery allows for extended battery-only driving distance, shifting a significant amount of the energy used for vehicle propulsion from petroleum to electric generation resources

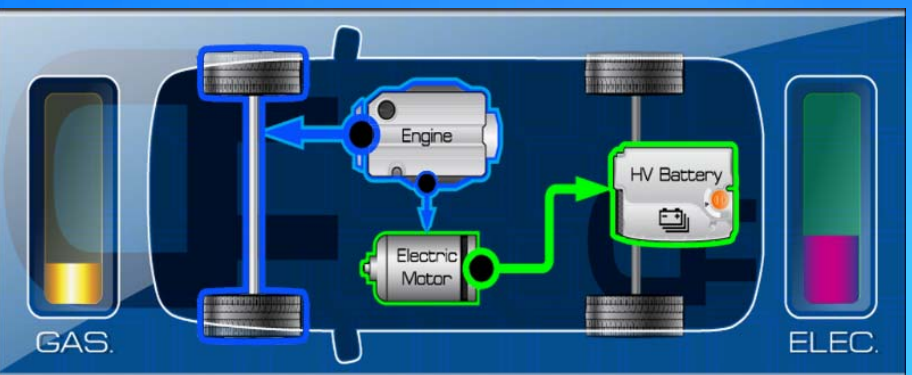
BLENDED ELECTRIC/ENGINE DRIVE

At higher power demands and vehicle speeds, the vehicle automatically switches to blended electric/engine mode, providing propulsion using both the engine and the high-capacity battery, thereby further reducing fuel consumption

During Electric Drive and Blended Electric/Engine Drive the charge of the PHEV battery is depleted as it is applied to power the vehicle – providing the potential for superior fuel economy– up to 120 mpg

Once the charge of the high capacity battery has been partially depleted to a set limit state of charge, the vehicle continues to operate as a standard hybrid electric vehicle

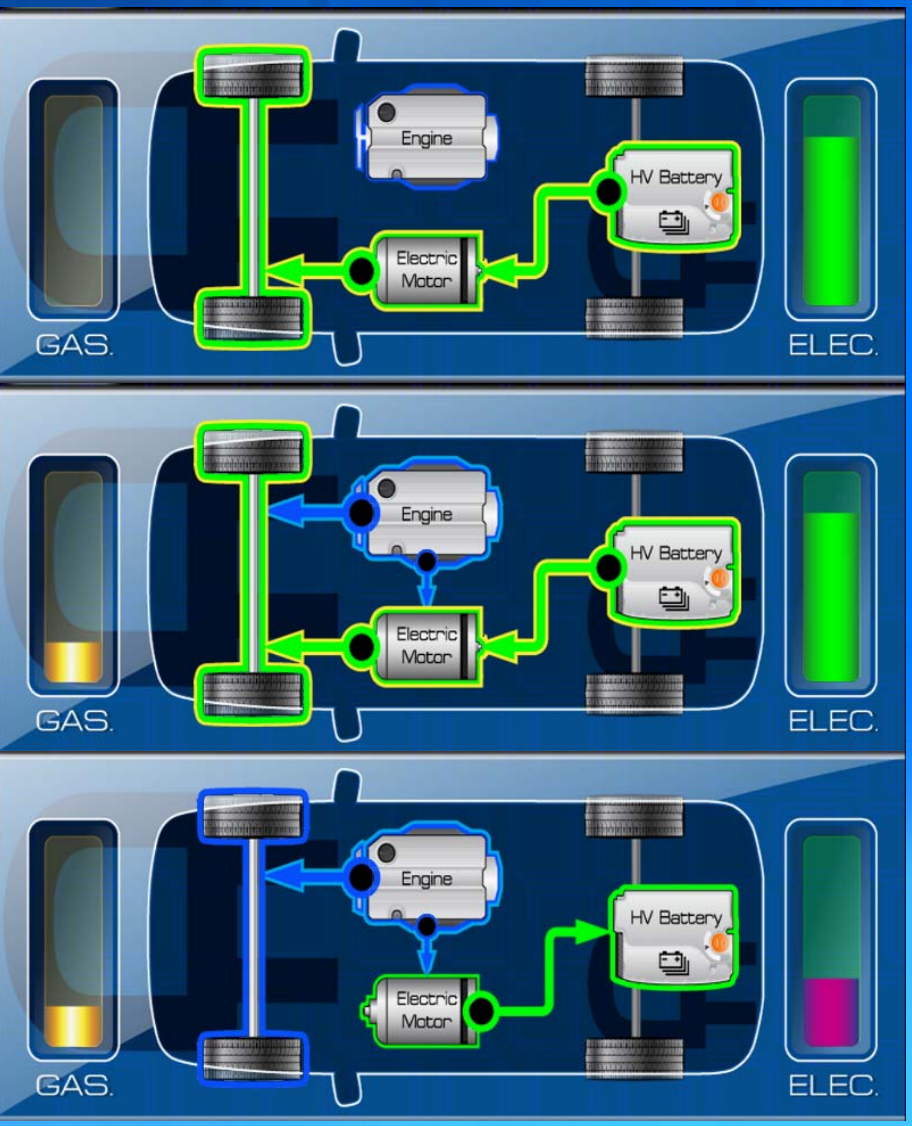
After "Charge Depletion" , the PHEV battery operates in "Charge Sustaining" mode –



HYBRID DRIVE

In hybrid drive mode, the vehicle continues to operate as a standard hybrid electric vehicle, with significant fuel economy improvement in city driving over a non-hybrid vehicle

It is important to understand the role PHEV Battery Charge Depleting (Electric and Blended Drive) and Charge Sustaining (Hybrid Drive) will play under typical driving



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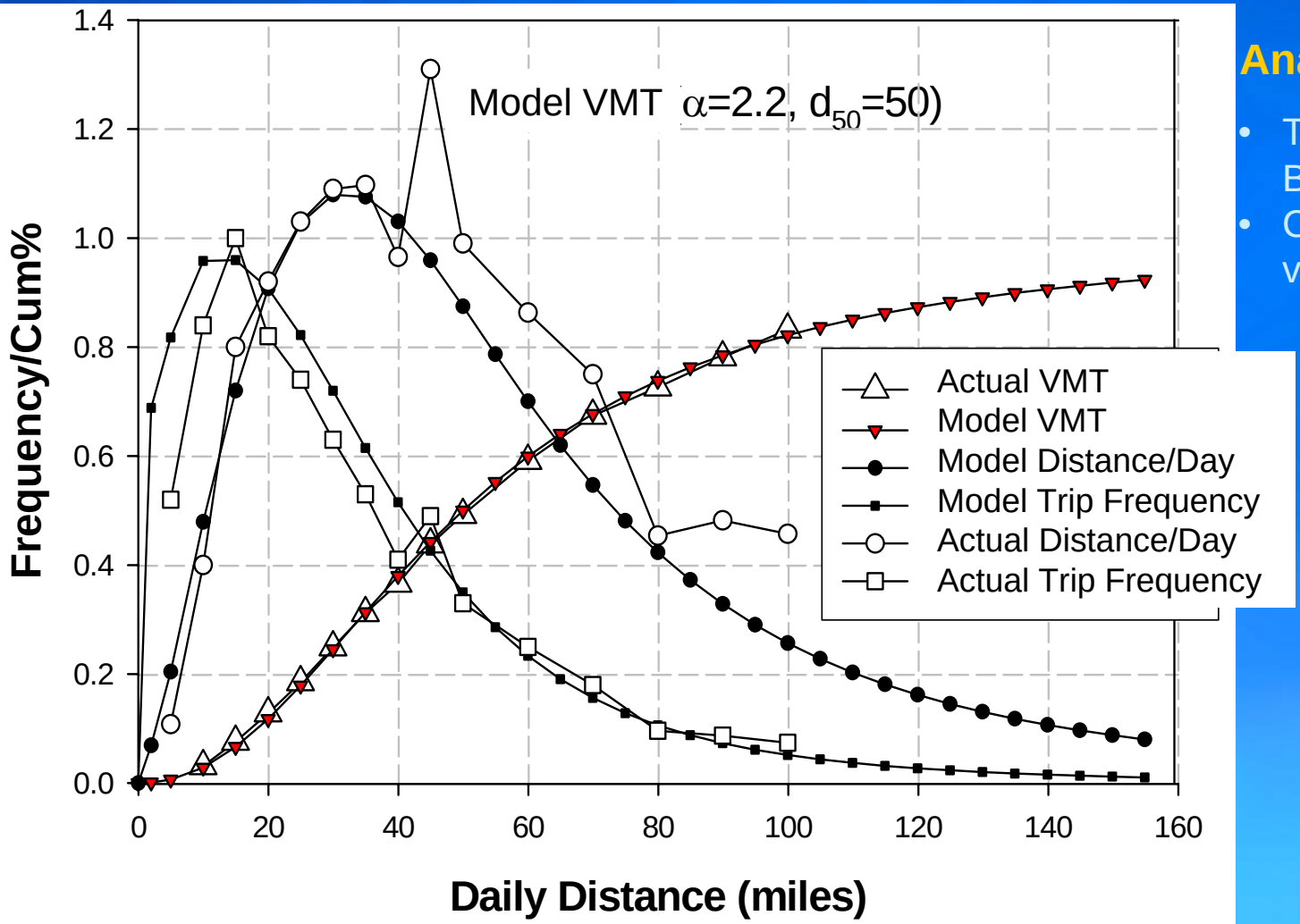
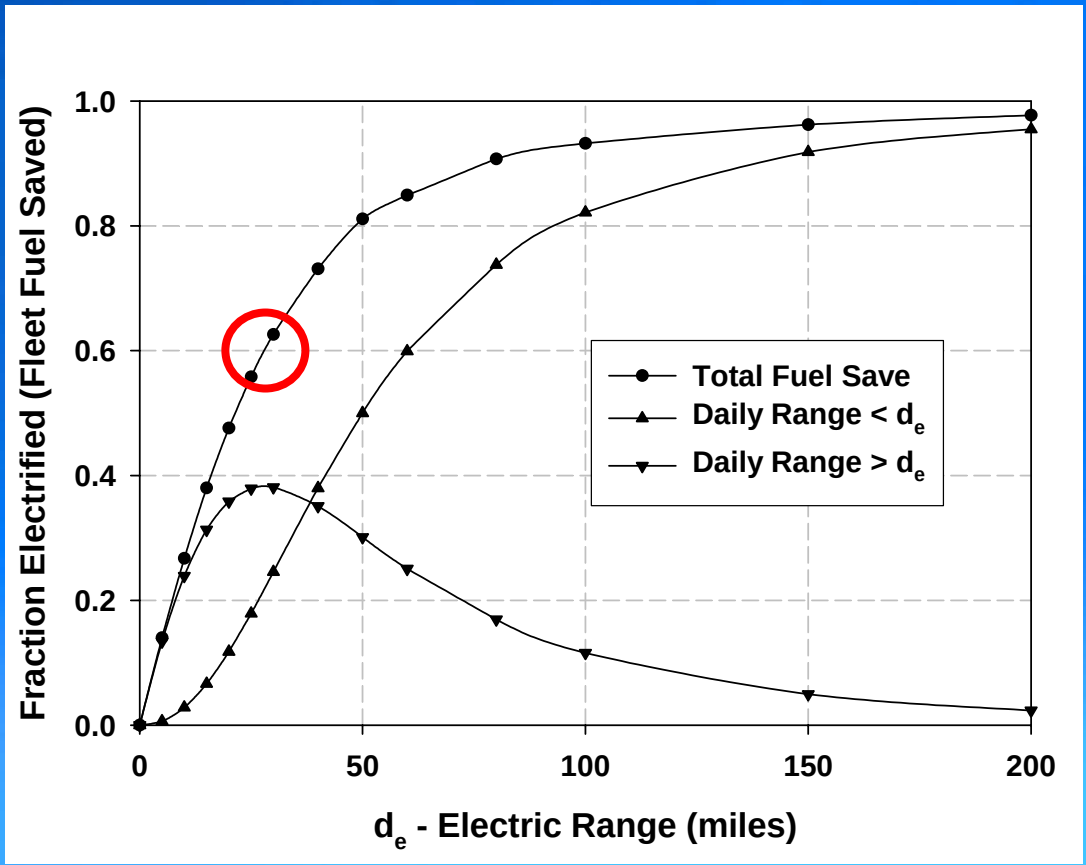
VMT study indicates that the most frequent actual distance driven per day is ~ 15 miles and that the most mileage is racked up by people driving ~ 30 miles per day



Analytical Study

- Three Cities: Atlanta, Baltimore, Spokane
- Compared actual data versus modeled data

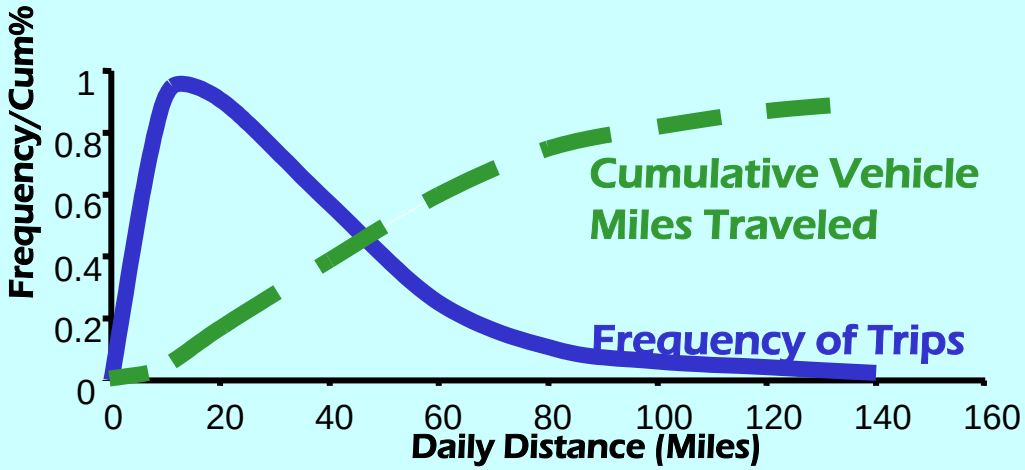
Comparing the consumer PHEV drive data to fleet fuel saved indicates that 30 miles of electric range can displace about 60% of fleet petroleum fuel consumption



Fuel Savings Potential

- 30 miles electric range can displace about 60% of fleet fuel consumption
- For modest electric ranges, people that drive the battery to full depletion by the end of their daily driving get better fuel economy / value utilized from battery investment

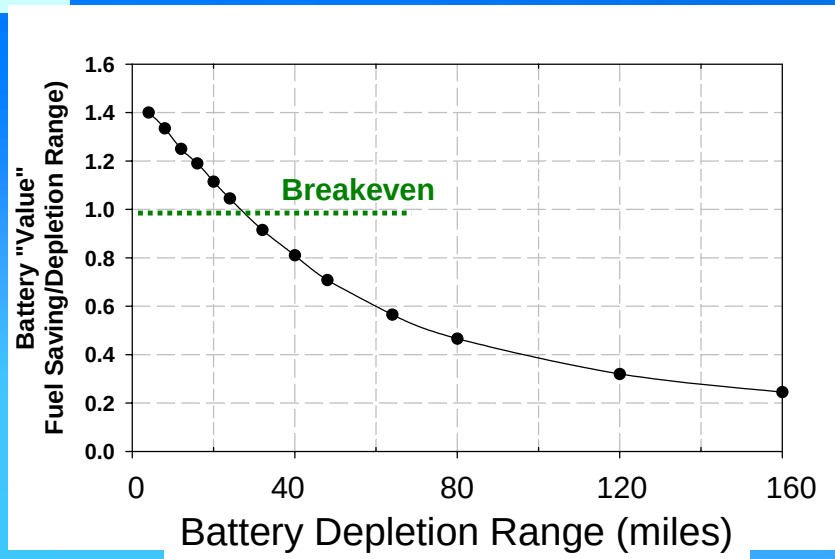
The greatest potential for fuel economy improvement is when the capacity of the PHEV battery is used – greater battery range is expensive and is rarely used by most households



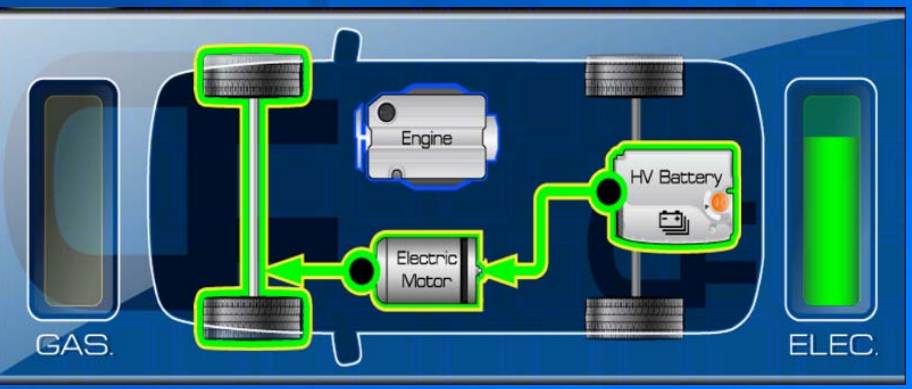
To sustain breakeven, battery cost on a $/kWh basis must drop with increasing range

Relative to a battery that delivers 30 miles electric range

- **A 100 mile electric range battery must deliver a $/kWh that is 2.5 times less expensive**
- **A 400 mile battery must deliver a $/kWh that is 10 times less expensive**



Ford's Escape PHEV battery provides ~30 miles of "Charge Depletion" (Electric and Blended) range



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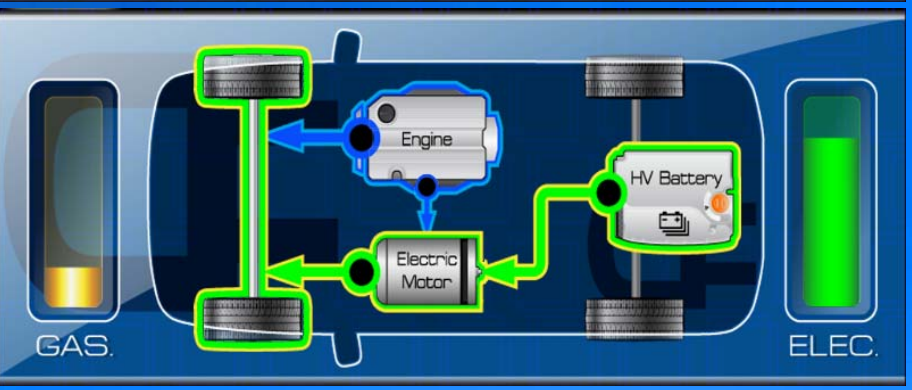
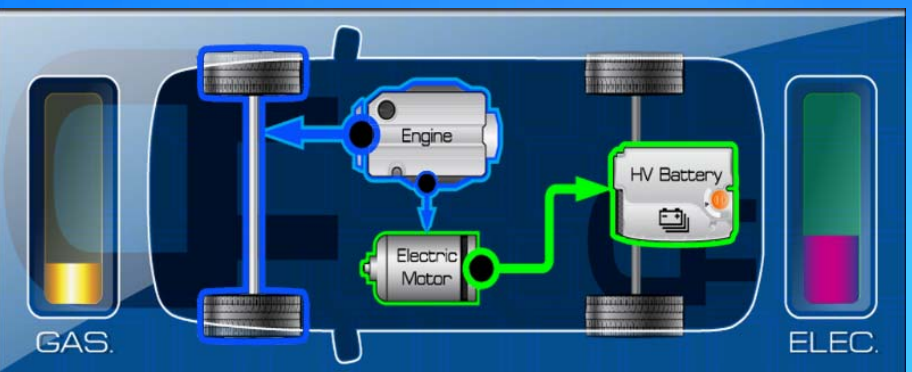


BLENDED ELECTRIC/ ENGINE DRIVE

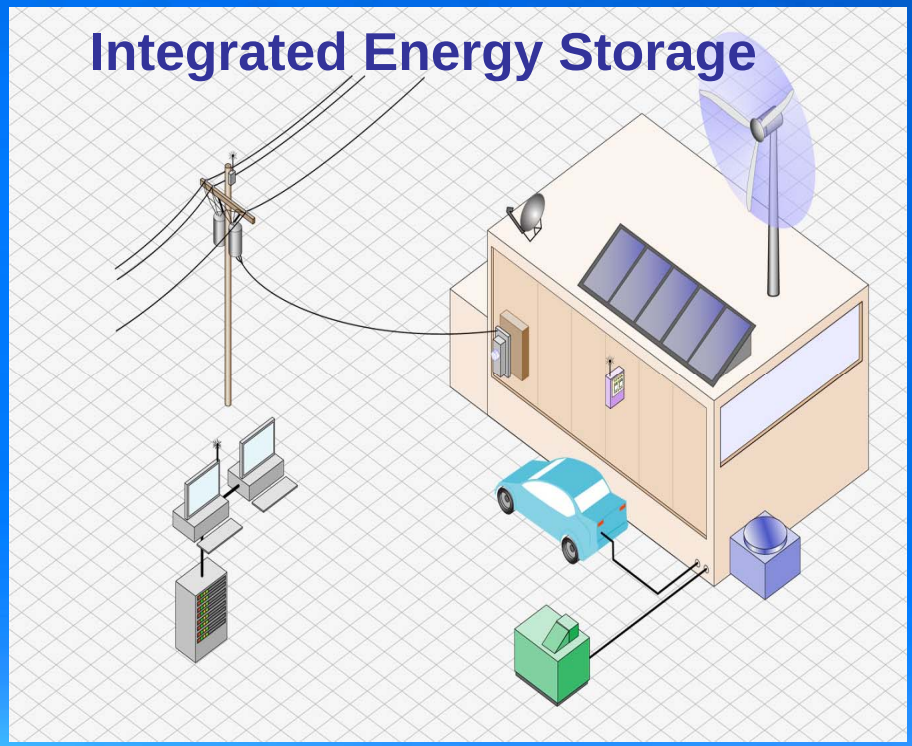
Opportunity for superior fuel economy - - up to 120 mpg



HYBRID DRIVE

Typical Hybrid FE improvements versus non-hybrid vehicles

In order to deliver the superior fuel economy of our PHEVs to the consumer - at a value that is not cost prohibitive - we are seeking new ways of doing business that deliver sustainable solutions for all stakeholders



Key Message: New Vision requires Three Main Pillars:

- ***Renewable Energy Sources***
- ***Energy Storage Unit and Energy Storage Market***
- ***Interactive Wireless Communication between Utility , Transportation, Customer***

In July 2007, Ford Motor Company and Southern California Edison (SCE) announced an innovative, new partnership to develop and deliver PHEV/Grid solutions

FORD/SCE COLLABORATION GOALS

- Creation of New Business Models
  - Collaborate to explore entire relationship of PHEVs and the electric grid
  - Develop/data/understanding that leads to creation of new business and ownership models
  - Seek other partnerships such as utilities, suppliers, OEM's and government
- Development of open architectures, standards and specifications
  - Collaborate to lead development of standards and specifications
  - Help accelerate the introduction of PHEVs to the US Market
- Create Customer Demand
  - Communicate what is possible to the marketplace / realistic expectations
  - Design Consumer value streams/opportunities to jumpstart demand

Two industries connected by a common fuel, changing our transportation and energy future…

Ford / SCE Collaboration Workstreams

Technology Advancement

Ford/SCE Collaboration

- **Standards**
  - Interface to Home/Grid
  - Communication Vehicle to Home
  - Vehicle (Plug/wall, HMI/Icon's),
- **Energy Storage**
  - Mobile/Stationary Battery Arch.
  - Range/weight/reliability/safety

Ford R&A

- **Other Technical Challenges**
  - Vehicle Emissions (PZEV/Evap)
  - Safety/Crash Integrity
  - Vehicle dynamics

NRL Project

- Climate control with extended engine off - NREL's Vehicle Ancillary Loads Reduction Project

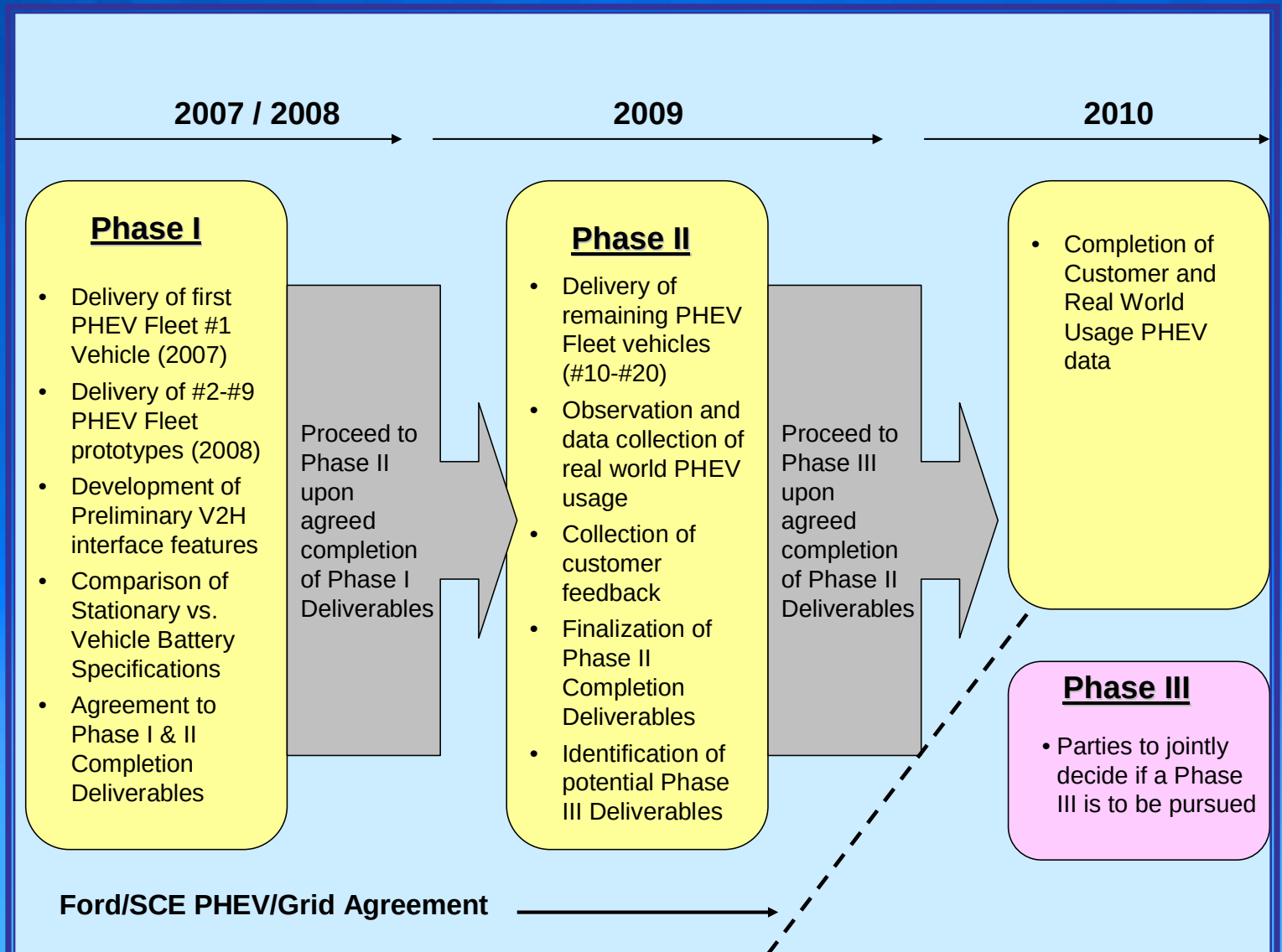
Business/Value Proposition - based on product (PHEV vehicles/batteries/smart connect)

Ford/SCE Collaboration

- **Value Streams**
  - Direct: OEM, Customer, Utilities
  - Indirect: Battery Suppliers, Insurance, Residuals,
- **Battery Ownership**
  - OEM, Utility, Third Party
  - Leasing vs Owership
  - New stationary batteries or secondary use market
- **Business Modeling**
  - Identification of New Value Streams
  - Holistic approach to commercialization of PHEV

= Areas for 3rd party collaboration: progression of standards and development of business value proposition

Phases I & II include the development and evaluation of PHEV/Grid solutions via 20 Ford PHEVs, battery bench testing and creation of new business models



Our next steps include the continuation of our PHEV/Grid study with SCE and seeking of new ways of doing business

Our overall objective is to progress the development and delivery of PHEV/Grid solutions – projects include, but are not limited to these areas;

- Battery Value Stream (commonality with stationary use, secondary use value, etc.)
- Vehicle Attributes
- Grid Interface (V2H connectivity and long term….V2G)
- Utility Energy Management (off-peak charging, access to grid, etc.)
- Customer Needs and Expectations (accessibility to charging, impact on energy costs, vehicle residual values, monthly payment, etc.)
- Environmental/Energy Security Impact
- Specifications Development – what industry standards are required
- Communciations – Getting the facts out
- Government Policy – removing barriers to improve PHEV business case

We are seeking new levels of cooperation and new relationships between all stakeholders

Potential 3rd Parties

- **Utilities**
- **Suppliers**
- **Battery Manufacturers**
- **Research**
- **Policy Makers**
- **Others**


Ford