AFS TRINITY
POWER CORPORATION

# Future Trends in Energy, Technology & Transportation

*Discovery Institute - Cascadia TransTech Leadership Forum Series*

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## World's Nations are collectively facing a crisis . . .

We are like people on a boat in the middle of the ocean who have enough water for everyone to survive for ten days . . . . . but shore is 20 days away

Do you want to be on that boat?

News Item: You *are* on that boat

How much oil is left?

However you answer this question. . . Everyone agrees

That the global oil supply is not limitless and

*Global oil demand is outpacing supply*

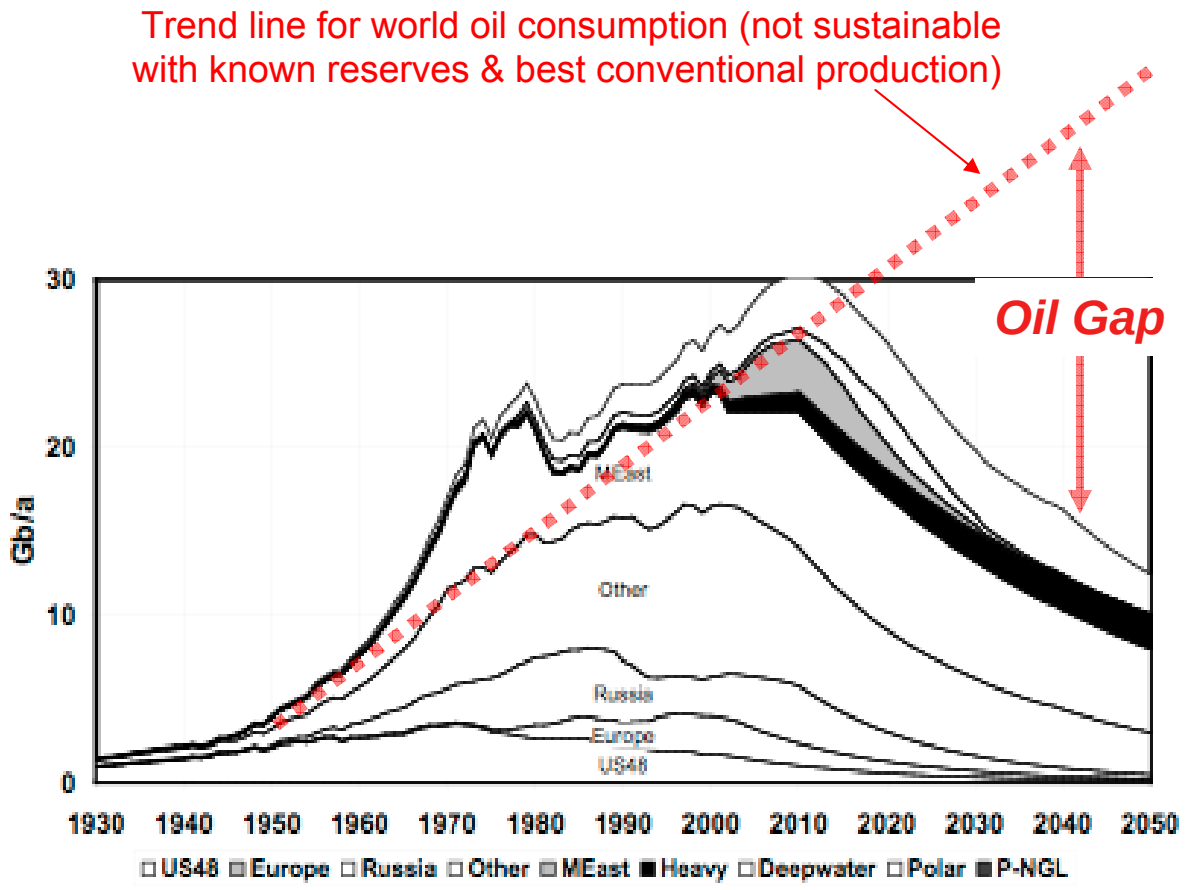
As China and India become vehicular societies …

There will not be enough oil for all of us.

The result will be competition—potentially war—to secure supply or drastic cutbacks in vehicular and aircraft use….. Or both

What can we do?

# The Big Shortfall - Oil & Gas Production vs Demand




Base graph from: C.J.Campbell and Anders Sivertsson, "Updating the Oil Depletion Model", 2005.

*What Are Our Options?*

a. *Reduce oil use for power generation? (Irrelevant - only < 2% used for electricity)*
b. *Seek new unconventional oil?* (Deep water, tar sands, oil shale, coal gasification all extremely expensive)
c. *Hydrogen* ? (20-40 yrs away)
d. *Flexfuels?* (inefficient from corn and/or incapable of satisfying enough demand used *alone*)
e. *Conservation? (*aggressive CAFÉ, big new gas tax, rationing . . . some other other form of mandated reduced useage) OR

d. *Much more fuel-efficient cars*

## (Options Review)

a. *Reduce oil use for power generation? (Irrelevant - less than 2% of oil consumption is for electricity generation)*

b. *Seek new unconventional oil/gas supplies? (*Deep water drilling, tar sands, oil shale, coal gasification are all extremely expensive)

c. *Hydrogen fuel cells? (*Require hugely expensive new infrastructure and still would be 20 to 40 years away from reality)

d. Ethanol and Biodiesel? (They can help, however, they accentuate the need for more fuel-efficient vehicles)

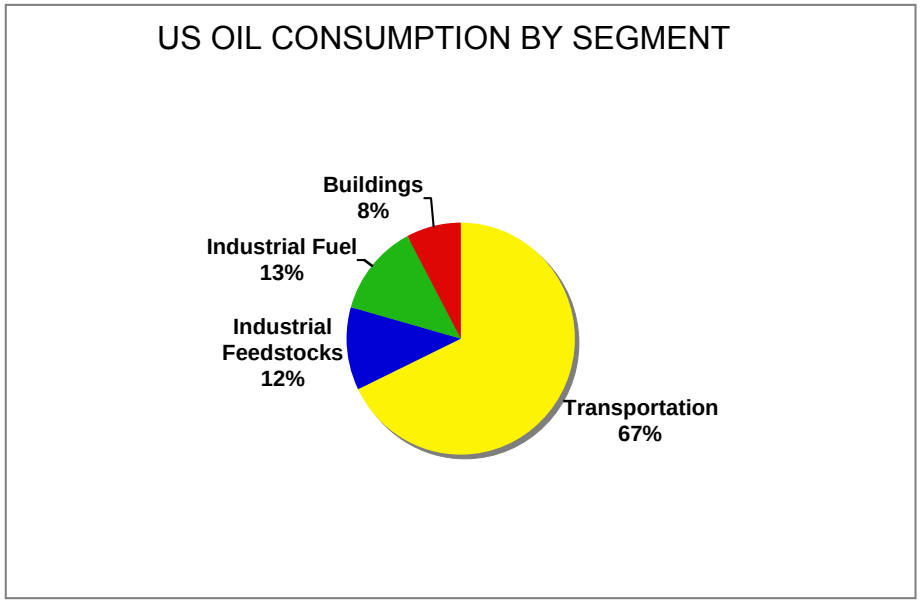
e. *Conservation? (*Big gasoline tax, aggressive new CAFÉ regs, rationing . . . some other form of mandated reduced consumption. . . *these would work* . . . *But painfully*) OR

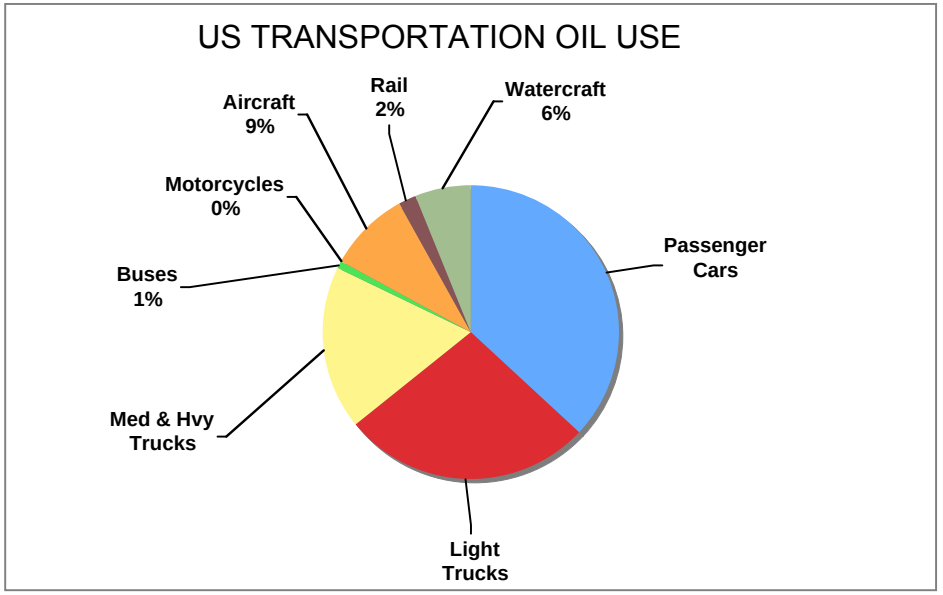
f. *We can build much more fuel-efficient vehicles*

The likelihood is that some combination of these options will be needed to successfully address the energy challenge

# *Transportation* Drives U.S. Oil Consumption

(It's also responsible for 1/3 of all $CO_2$ emissions)




US Highway Vehicles Oil Use in 2004

- 236,761,000 vehicles on the road
- 12,141 miles driven per year per vehicle
- 21.0 MPG average for all vehicles
- 10.9 MBD oil used (includes gasoline & diesel)

*Oil for power generation or industrial use isn't the problem*

# It's *Transportation* that Drives Oil Consumption

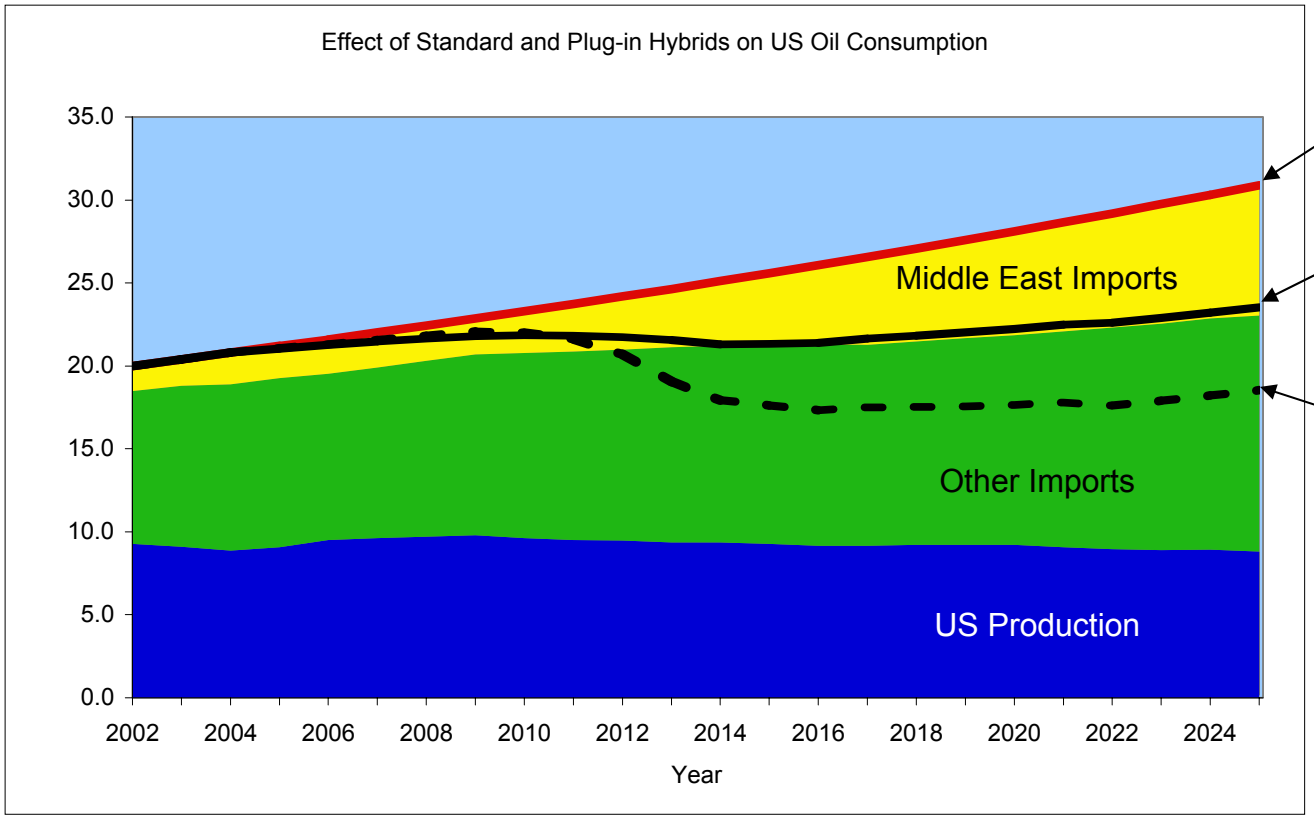
# The Extreme Hybrid™ (XH™) Option

150 - 250 MPG Plug-in Hybrid Electric Vehicle (PHEV) that will use *electricity, not oil, as its primary energy source* and which will also be flexfuel-capable to reduce gasoline use even more

Previous Plug-in Hybrids have been plagued by battery durability and cost issues, forcing them to minimize their electric-only operation

The Extreme Hybrid™ is a Plug-in Hybrid whose batteries *will last* because its Fast Energy™ storage technology solves the energy storage issues that still plague other plug-ins

# XH™ Plug-in Hybrids Will Reduce Oil Consumption




- Today's hybrids (Prius, Civic, Escape) do not reduce oil consumption enough
- PHEVs will reduce oil consumption more
- XH™ PHEVs could virtually eliminate the need for Middle East oil imports

The AFST Oil Model shows potential impact of Extreme Hybrid™ PHEV on North American Oil Consumption

# How The XH™ Plug-in Can Achieve 250MPG* ...

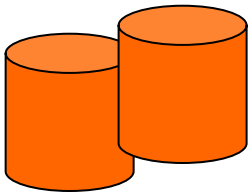

AFS Trinity
Concept Car
Side View

*80% Electricity* + *20% Hybrid* = > 250 MPG*

*(∞ MPG)* *(50 MPG)*

Power Grid

ICE + Batteries



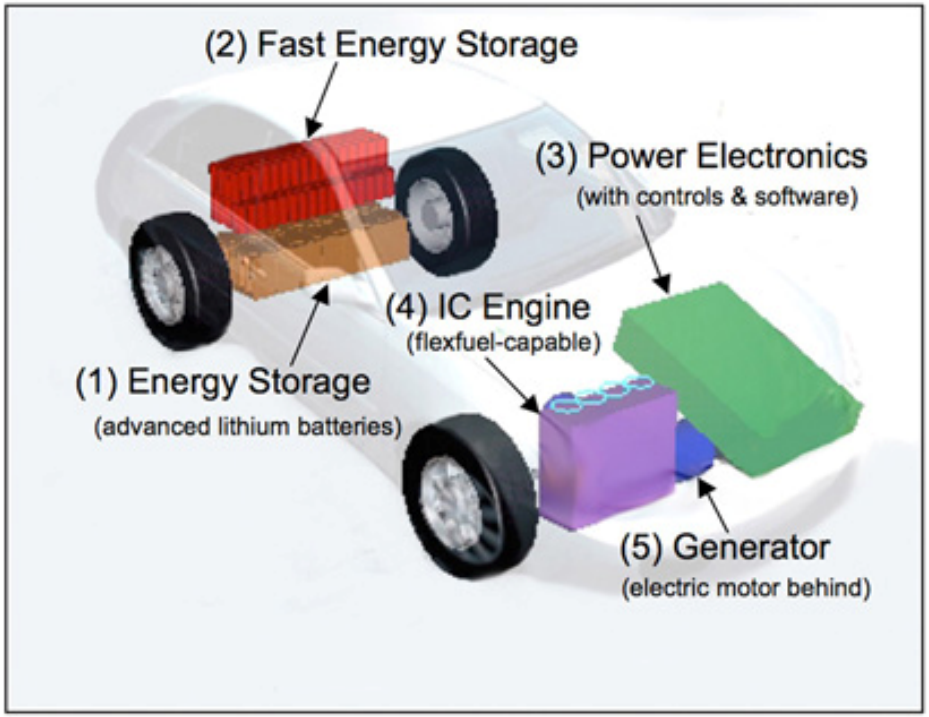
gasoline or flexfuel

## 80% of Americans drive less than 40 miles/day

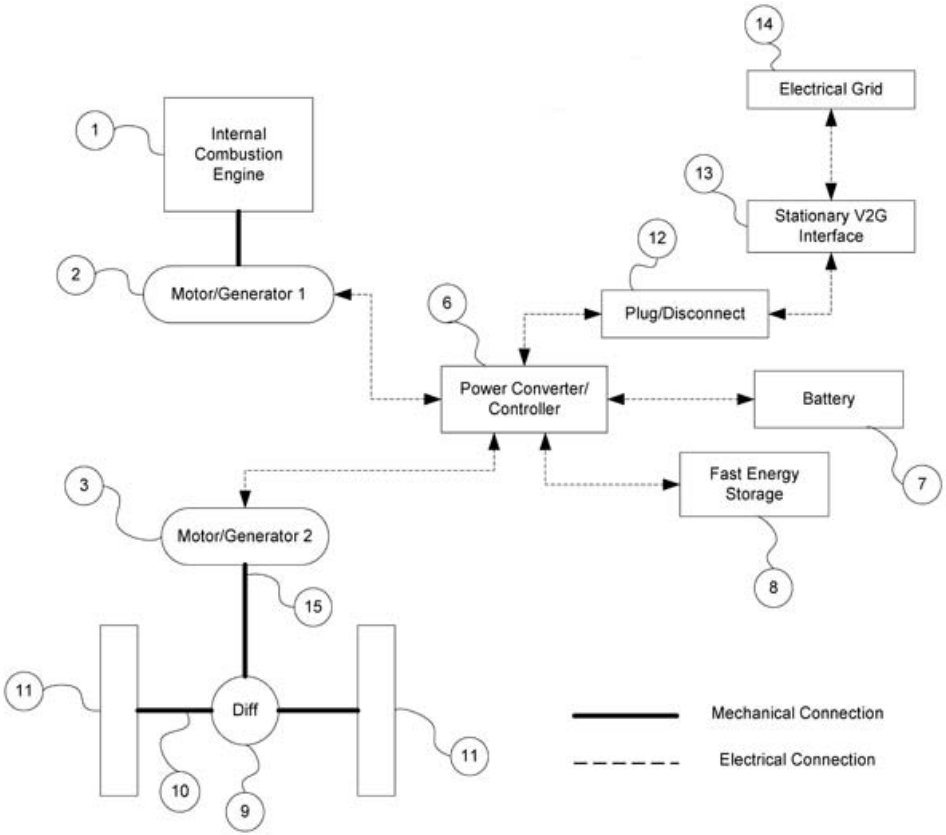
*All mpg figures represent miles per petroleum gallon

# Extreme Hybrid™ Drive Train

(cutaway view)



# AFS Trinity Drive Train Schematic
# from Patent Filing May 4, 2006





Left - Figure #4 of 9 of Patent Filing, "Plug-in Hybrid with Fast Energy Storage", May 4, 2006

Above - AFS Trinity Concept Car (Rear View)

# The Problem with Previous Plug-in Designs

For conventional batteries, delivering or absorbing high currents when deeply discharged amounts to suicide, therefore the batteries of other hybrid and other plug-in hybrid vehicles are only shallow-discharged

But shallow-discharging requires much larger battery packs that add too much weight and volume

XH™ Technology with Fast Energy Storage™ Buffers & protects the batteries, saving and extending their useful lives and enabling exceptional all-electric performance

# What will set the Extreme Hybrid™ apart from other hybrids and PHEVs?

- Much more durable, with a >150,000+ mile 10 year battery life, enabling use of lithium batteries
- Electric-only operation will include same top speed, acceleration, passing and high speed driving requirements of a conventional high performance HEV
- Greater electric-only range (40 miles) with full highway speed capability in all-electric mode, but still with an extended range in HEV mode of 500 miles
- Acceleration of 0-60mph in 7-9 secs with 110 mph sustainable top speed
- For high speed driving, will operate continuously in cycle US06 (federal test cycle for high speed, high engine load driving)
- Much greater regenerative braking
- Drive train enables vehicle design flexibility and reduced drive train weight
- Gradeability: Hwy. 7.2% @ 50mph for 30 minutes; low speed of 15%-25% @ 30mph
- 1580 kg towing capacity

## The Extreme Hybrid™ will deliver dramatically better fuel economy, performance and lower cost of ownership

# Ricardo Strategic Partnership

*AFST & Ricardo* have signed an exclusive 3-year Technology Partnership to develop the Extreme Hybrid™

*Ricardo* is already a preferred service provider to OEMs worldwide, including GM and Ford, with 1750 consultants and engineers focusing on drive trains and new technologies

**Engine**
Refinement, Design, Development, Testing, Calibration...

**Vehicle**
Refinement, Packaging, Testing, Calibration...

**Transmission**
Design, Analysis, Manufacture, Testing...

**Motorsport**
Transmission, Software, Engine, Vehicle...

**Control & Electronics**
Embedded Technology, Systems Engineering, Rapid Prototyping...

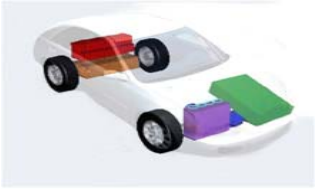
**Software**
Design, Analysis, WAVE, VECTIS, CAMSPRING...

***Ricardo*** delivers world class strategy, engineering and technology programmes (engine, transmission, vehicle and whole vehicle integration) to the leaders in the global automotive industry always focusing on customer profitability

- Corporate, business unit and product strategy
- Powertrain, vehicle, electronics and systems integration engineering
- Research
- Advanced programmes
- MY programmes and post SOP support
- Process and business re-engineering
- Niche manufacture
- Volume passenger car
- Niche performance
- Motorcycle
- Motorsport
- Off highway and Heavy duty vehicles
- Mobility enabling local delivery and management
- Global coverage enabling location to match product cycle
- Global coverage to assist with client geographical expansion
- Core centres and critical mass of expertise
- Leading edge technology, support and programme delivery
- Focus on delivering great products while reducing time and cost

1750 consultants and engineers in UK, Paris, Stuttgart, Wolfsburg, Prague, Turin, Detroit, Chicago, Tokyo and Shanghai

# XH™ Mileage and Cost Comparisons (Sedan)



| | Average U.S. Sedan | Toyota Prius Hybrid** | XHR Plug -in Hybrid Sedan |
|---|---|---|---|
| High speed driving | Engine Only | Engine and electric motors | Electric only up to battery range, engine and electric motor(s) beyond battery range |
| Electric range | 0 mi | 0 mi | 40 miles |
| Fuel use* | 12 gal. | 6 gal. | 1.2 gal. |
| Electricity use* | 0 kWh | 0 kWh | 63.3 kWh |
| Weekly energy cost* | $34.20 | $17.10 | $7.22 |
| Mileage* | 24.6 mpg | 50 mpg | 250 mppg** |

*Based on 300 mile/week; mixed urban/highway drive cycle, Gasoline @ $2.85/gal; Electricity priced at PG&E E9A rate for off peak charging of EVs. Currently 6 ¢/kWh.
** Fuel economy in an OEM SUV estimated to be 154 mppg with weekly operating cost substantially lower than non-XHR ve rsion.

Baseline configuration defined as Series hybrid architecture. Initial XHR sedan component sizing complete for Battery, Fast Energy StorageR , Engine, and Traction motors

# XH™ Mileage and Cost Comparisons (SUV)

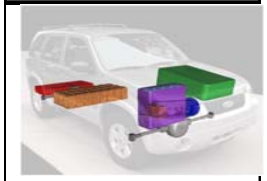
| | Lexus RX330 Conventional SUV | Lexus RX400h Hybrid SUV** | XHR Plug -in Hybrid SUV |
|---|---|---|---|
| High speed driving | Engine Only | Engine and electric motors | Electric only up to battery range, engine and electric motor(s) beyond battery range |
| Electric range | 0 mi | 0 mi | 40 miles |
| Fuel use* | 13.26 gal. | 11.2 gal. | 2.0 gal. |
| Electricity use* | 0 kWh | 0 kWh | 96 kWh |
| Weekly energy cost* | $37.80 | $31.90 | $11.40 |
| Mileage* | 23 mpg | 27 mpg | 154 mppg** |



*Based on 305 mile/week; mixed urban/highway drive cycle, Gasoline @ $2.85/gal; Electricity priced at PG&E E9A rate for off peak charging of EVs. Currently 6 ¢/kWh.
** Fuel economy in an OEM sedan estimated to be 250 mppg with weekly operating cost substantially lower than non-XHR version.

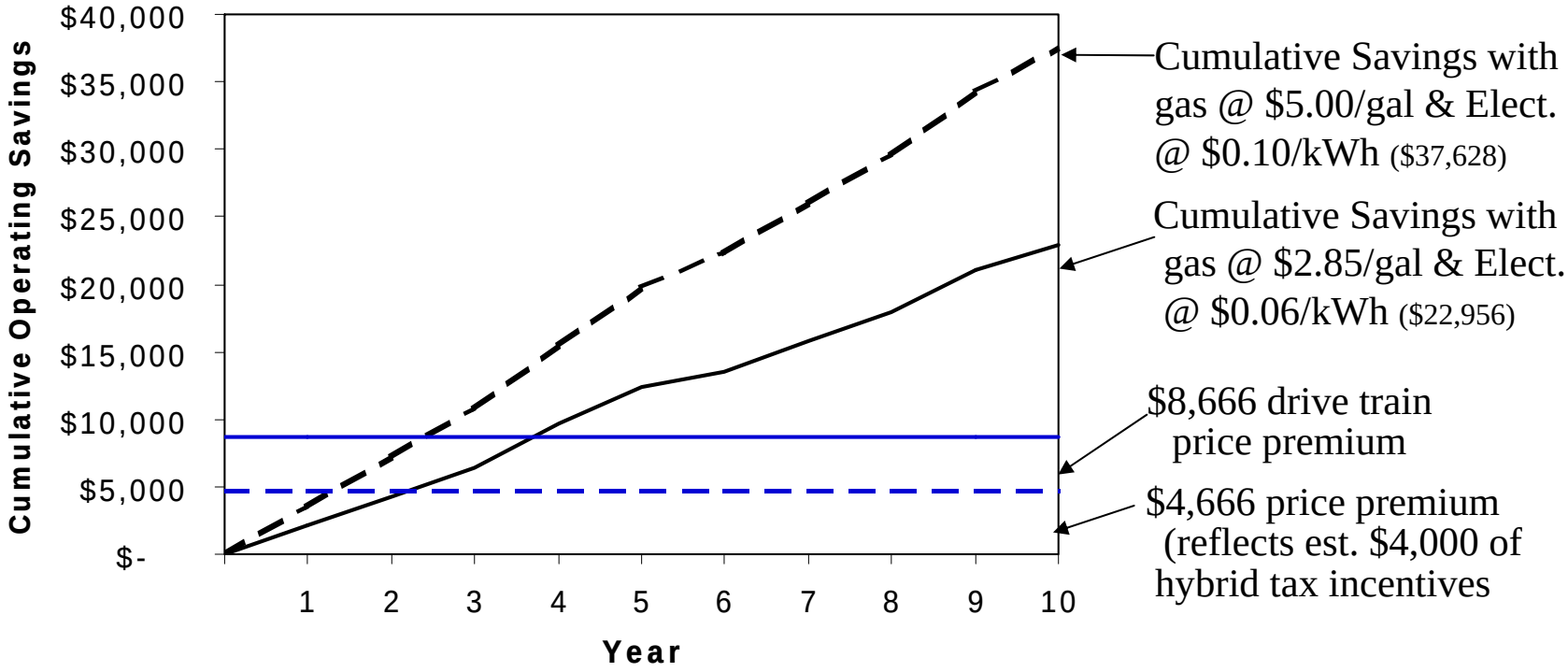
Baseline configuration defined as Series hybrid architecture. Initial XHR SUV co mponent sizing complete for Battery, Fast Energy StorageR, Engine, and Traction motors

# XH™ Life Cycle Cost Comparisons (SUV)

| | Vehicle Model (1) | Price Premium for Hybrid Drive train | 5 Yr. Cumulative Op. Cost (2) | 10 Yr. Cumulative Op. Cost (2) |
|---|---|---|---|---|
|  | Lexus RX330 (conventional drive train) | Baseline | $18,625 | $39,364 |
|  | Lexus RX400h (hybrid) | $7,045 (Calculated based on todayÕs component costs) | $14,440 Savings of $4,145 vs RX330 | $30,933 Savings of $8,431 vs RX330 |
|  | AFST XHR (plug in hybrid) | $8,666 (Calculated based on projected 2015 reductions in component costs - tax credits would reduce this further) | $6,181 Savings of **$12,444** vs RX330 | $16,408 Savings of **$22,956** vs RX330 |

1. Comparisons are based on luxury mid-sized SUV. Trade Study of a 250 MPG XHR sed an is in process
2. Operating costs include energy cost, maintenance and repairs. Fuel costs and electric costs were held constant at $2.85/gal & $.06/kWh. Operation was based on 305 miles per week (15,860 miles per year), mixed urban/highway drive cycle.

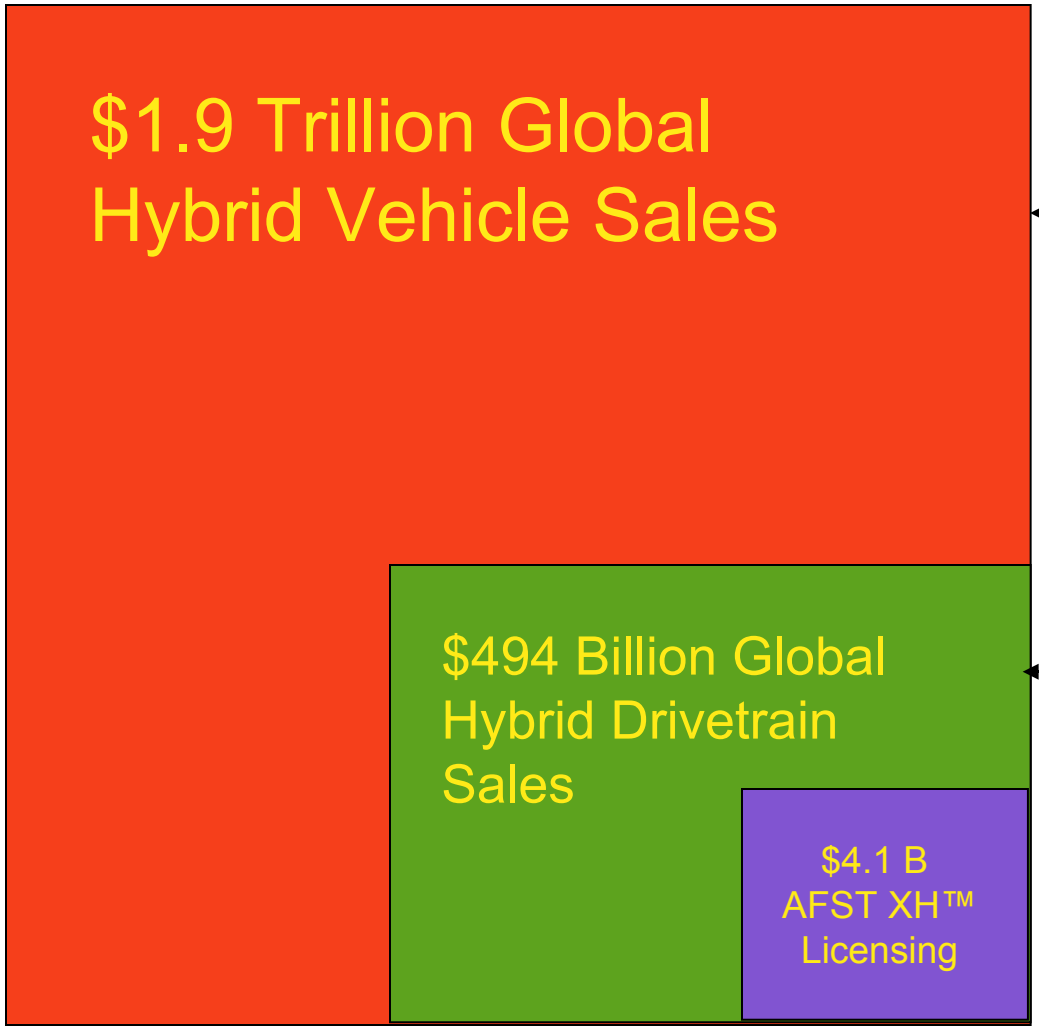
# XH™ Payback Analysis




1. Operating costs (energy, maintenance & repairs) based on 305 mi/wk (15,860 mi/yr) in a mixed urban/highway drive cycle.
2. Payback analysis does not include finance charges, registration, insurance, etc.
3. XH™costs, based on a high performance SUV platform, could be reduced in a smaller car optimized for lower cost. Performance would be less ambitious, but still be attractive compared to a comparable conventional vehicle.
4. Adding V2G capability would reduce monthly charging costs, further improving and accelerating payback.

## XH™ Operating Cost Savings Provide Rapid Payback

# Hybrid Vehicles Market Size - 2016




Based on 80% penetration of hybrid technology as projected by Booz Allen Hamilton in 2004 when oil prices were $35/bbl

Hybrid drivetrain includes traction motor(s), energy storage, power conversion, wiring, and control software. Market value based on wholesale drivetrain sales as calculated in AFST trade study


Thank you.

# AFS TRINITY
## POWER CORPORATION

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