







Electrified Vehicles

Concepts, Specifics, Examples

Stanford University – January 2011

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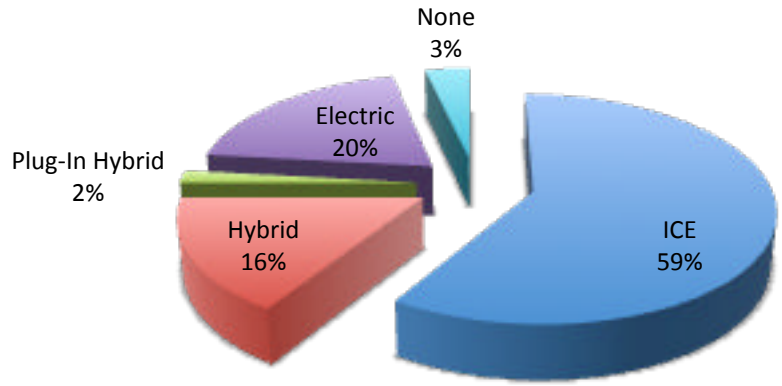
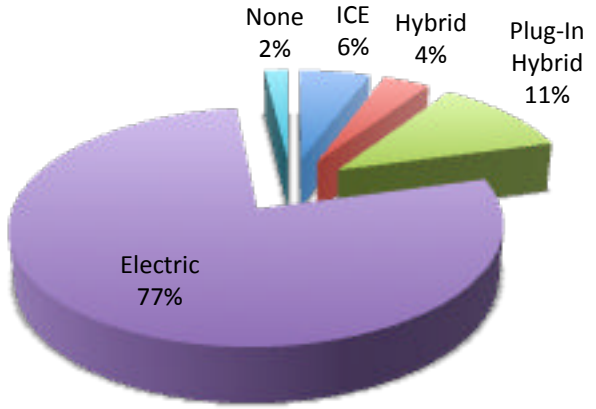
How Do You Feel About Electric Vehicles?

A spontaneous poll in class: ME302 / CS523 - Jan 5, 2011 – total of 54 students

1. What powertrain concept will you buy as your next car?

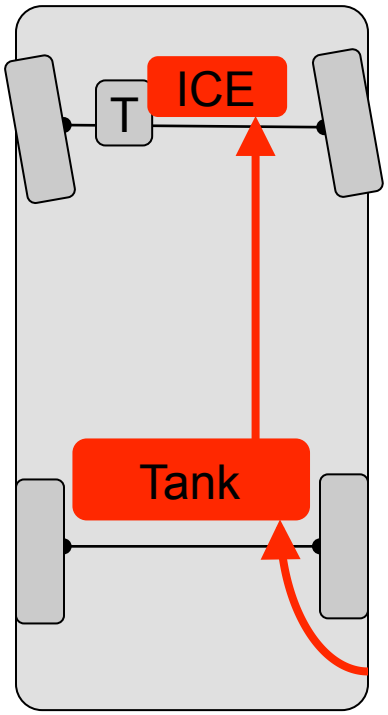


2. Which car would you choose for a test drive next weekend?



Concepts of Electrified Vehicles

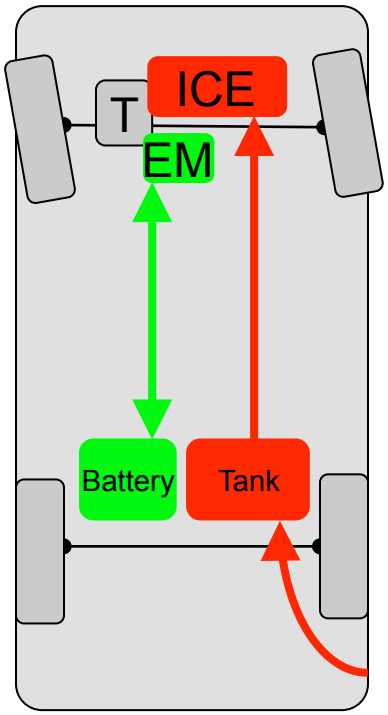
Conventional



Non-Electric Vehicle

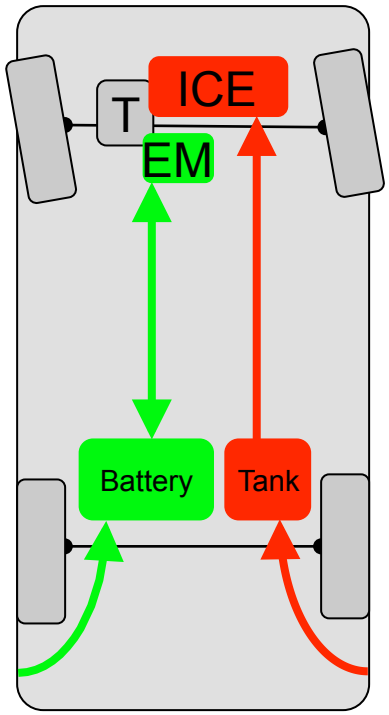
Large range
Low cost
Convenient

Electrified



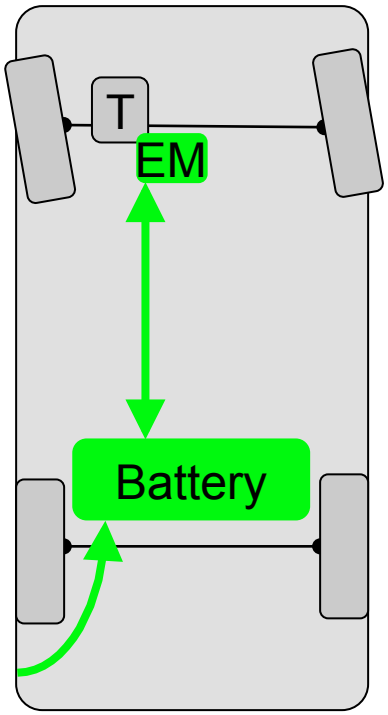
Hybrid Electric Vehicle (HEV)

Large range
Optimized efficiency
Partially “zero emission”



Plug-In Hybrid Electric Vehicle (PHEV)

Large range
Optimized efficiency
Extended “zero emission”

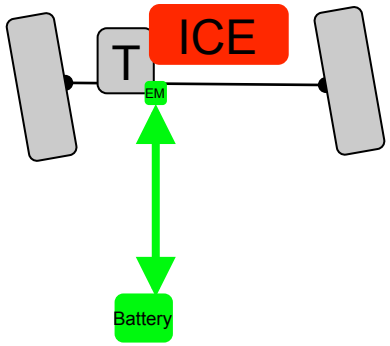


Battery Electric Vehicle (BEV)

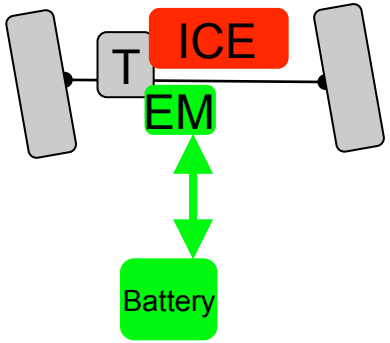
Full “Zero emission”
“No petroleum”
Simplified design

Concepts of Hybrid Electric Vehicles

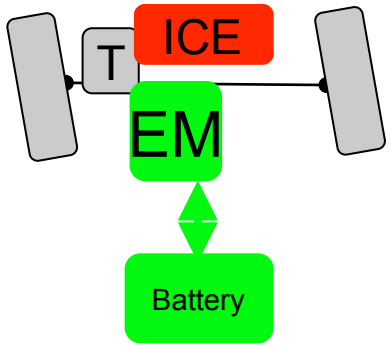
Level of Hybridization



Micro Hybrid
slight efficiency improvements
e.g. BMW 3 Efficient Dynamics

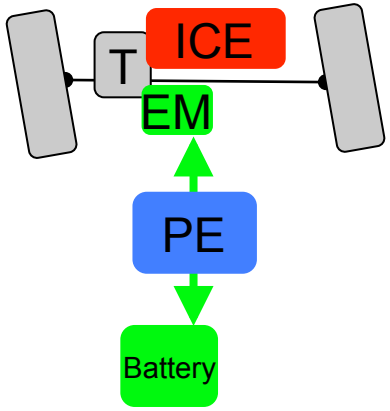


Mild Hybrid
greater efficiency improvements
e.g. Saturn Vue Hybrid

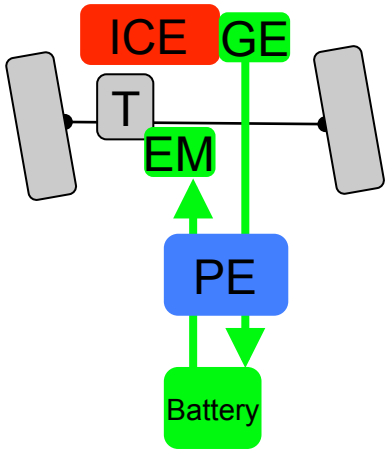


Full Hybrid
optimized efficiency
e.g. Toyota Prius

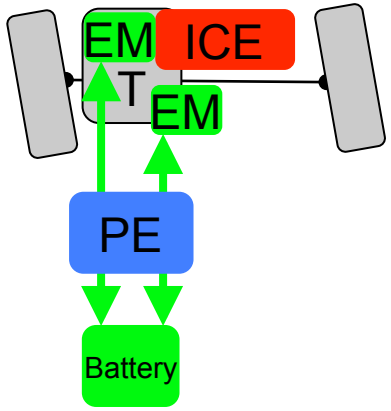
Hybridization Concept



Parallel Hybrid
engine start-stop, no e-drive
e.g. Honda Civic, Insight

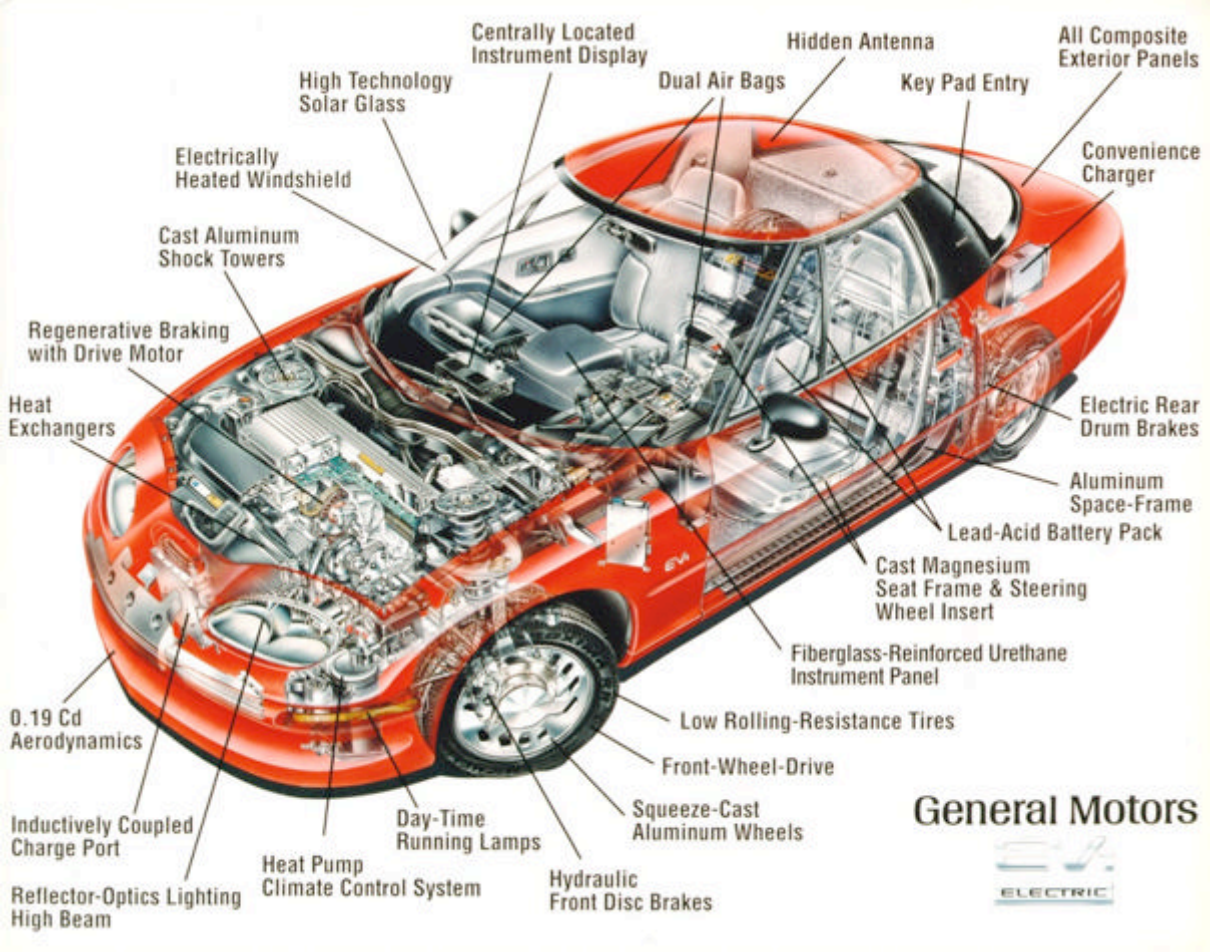


Series Hybrid
all e-options, no mech linkage
e.g., Volvo C30, Hybrid Busses



Power-Split Hybrid
all e-options, relatively complex
e.g. Toyota Prius, BMW X6

1990's Battery Electric Vehicles



Example

Model:	GM EV1
Concept:	BEV
Body:	Coupe, 2 seats
E-Range:	55-150mls
Weight:	3,000 lbs
Output:	137 hp
Battery:	Lead-Acid, 19 kWh NiMH, 26 kWh
Units:	1,117 (1996-1999)
Price:	lease $300-575 (per month)

Similar: Toyota RAV 4 EV (1997-2003)

Noteworthy

- Customer reaction to the EV1 was positive (see "Who Killed the Electric Car?")
- GM believed that electric cars occupied an unprofitable niche (800 units, $1b)
- EV1 program was subsequently discontinued in 2002, all cars were repossessed

Data source: http://en.wikipedia.org/wiki/General_Motors_EV1 Picture: http://www.autolinedetroit.tv/journal/?p=797

Production Hybrid Electric Vehicles

Example

Model:	Toyota Prius
Concept:	HEV (full, pwrsplt)
Body:	Mid-size, 5 seats
Mileage:	50 mpg, US comb.
Weight:	3,000 lbs
Output:	134 hp
Battery:	NiMH, 2 kWh
Units:	2m (Sep 2010)
Price:	$23k
Similar:	Ford Escape Hybr. Honda Insight*, many others…

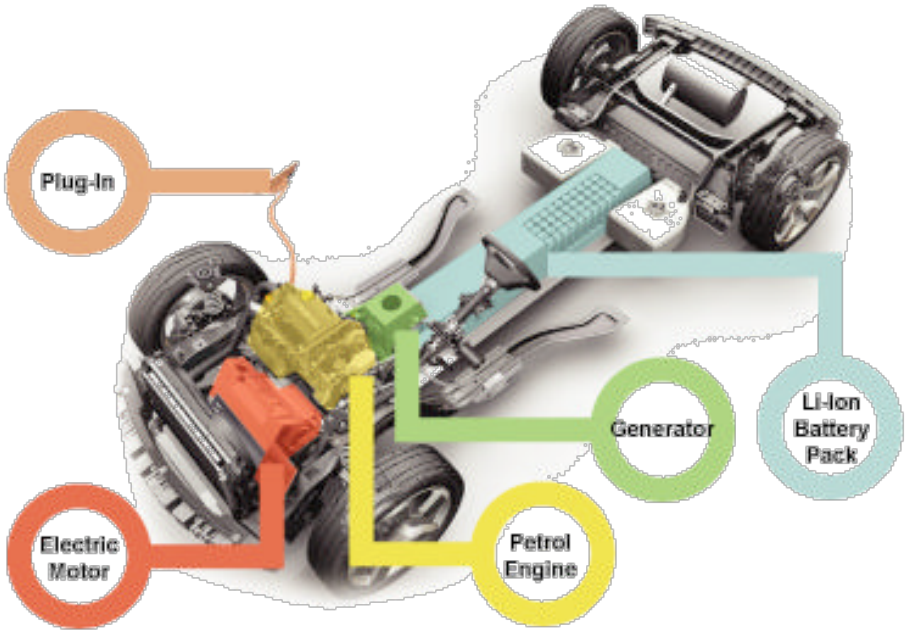
* Honda Insight is parallel hybrid

Noteworthy

- recently surpassed by the Chevy Volt as most fuel efficient gasoline car sold in US
- sold in 70+ countries, became Japan's best selling vehicle in 2009
- buying motivation: 57% “makes statement about me,” 36% “mainly fuel economy”

Data source: http://en.wikipedia.org/wiki/Toyota_Prius Picture: http://www.comparecontracthire.com/blog/wp-content/uploads/2009/04/new-prius2.jpg

Plug-In Hybrids, “Range Extended Electric Vehicles”



Example

Model:	Chevrolet Volt
Concept:	PHEV (full, pwrsplt)
Body:	Mid-size, 5 seats
E-Range:	25-50 mls
Mileage:	93 / 37 mpg (e / c)
Weight:	3,800 lbs
Output:	149 hp
Battery:	Li-Ion, 16 kWh
Units:	60k p.a. (’12 plan)
Price:	$40k
Similar:	Toyota Prius (‘12), Ford C-Max (’12), Fisker Karma (’12)

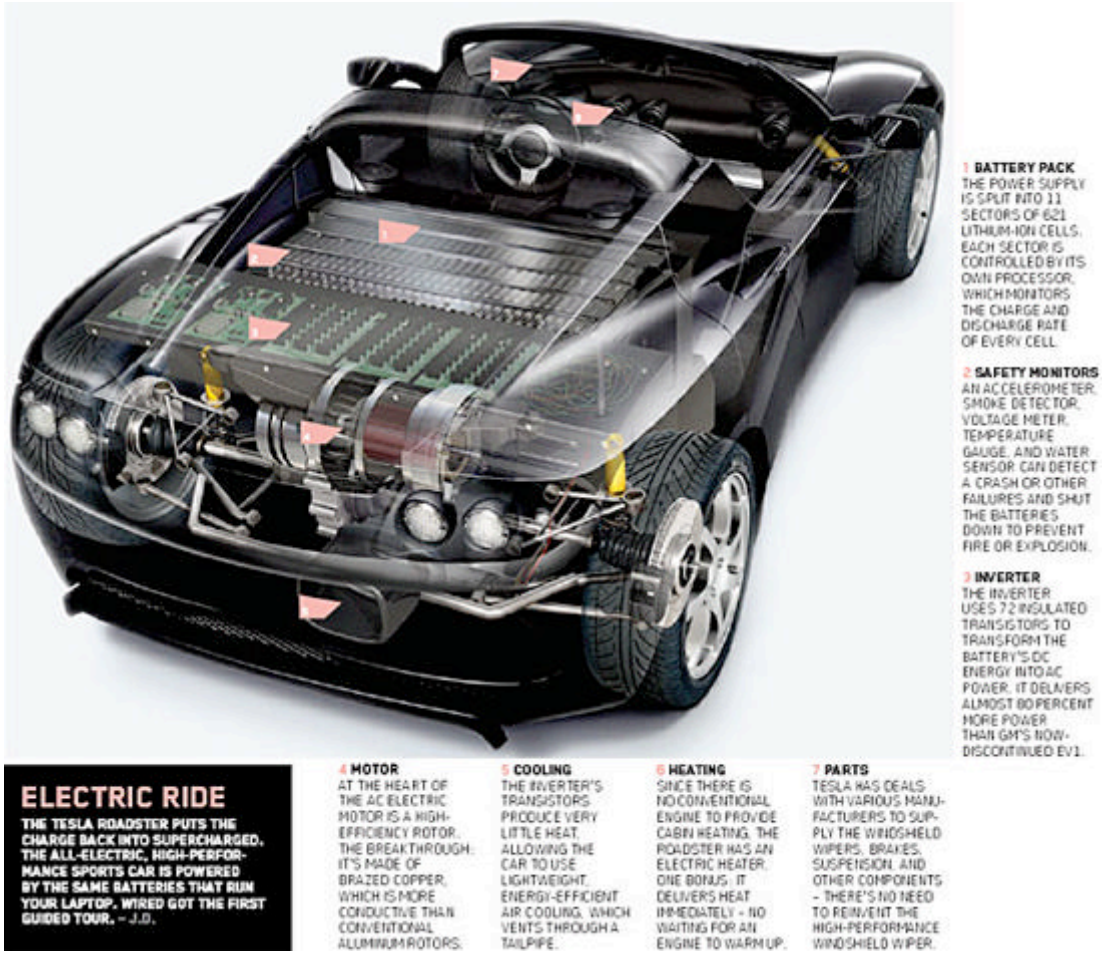
Noteworthy

- first vehicle delivered Dec 2010, sold initially only in CA, D.C., MI, TX, NY, NJ, CT
- phone app to check fuel efficiency as well as the vehicle's current electric range
- Car & Driver Magazine for first time included electrically powered car in 10 best cars

Data source: http://en.wikipedia.org/wiki/Chevy_Volt

Picture: http://movementbureau.blogs.com/photos/uncategorized/gm_volt_analysis2.png

Battery Electric Vehicles “Performance Pioneers”



Example

Model: Tesla Roadster
Concept: BEV
Body: Roadster, 2 seats
E-Range: 244 mls
Weight: 2,700 lbs
Output: 248 hp
Battery: Li-Ion, 53 kWh
Units: 1,400 (Dec 2010)
Price: $109k

Similar: Tesla S (‘12)

Noteworthy

- first highway-capable all-electric production vehicle in the U.S., “EV Pioneer”
- to be discontinued 2012, due to tooling changes at Lotus' assembly plant in the UK
- unique charging connector, conversion to SAE J1772 standard announced

Data source: http://en.wikipedia.org/wiki/Tesla_roadster

Picture: http://stadium.weblogsinc.com/autoblog/videos/HiRezPics/FF_162_tesla3_f.jpg

Battery Electric Vehicles “Pilot Tests”

Example

Model:	MINI Electric
Concept:	BEV
Body:	Compact, 2 seats
E-Range:	100 mls
Weight:	3,300 lbs
Output:	204 hp
Battery:	Li-Ion, 40 kWh
Units:	800 total
Price:	lease $600-850 (per month)
Similar:	Ford Focus, Honda Jazz (’12)

Noteworthy

- most applicants well-educated, well-off males over 35, affinity for new technology
- regenerative braking controlled via accelerator pedal (not break pedal)
- powertrain components by AC Propulsion (CA)

Data source: http://en.wikipedia.org/wiki/Mini_E

Picture: http://evworld.com/images/bmw_mini-e_seethru.jpg

Battery Electric Vehicles "Small Cars"

Example

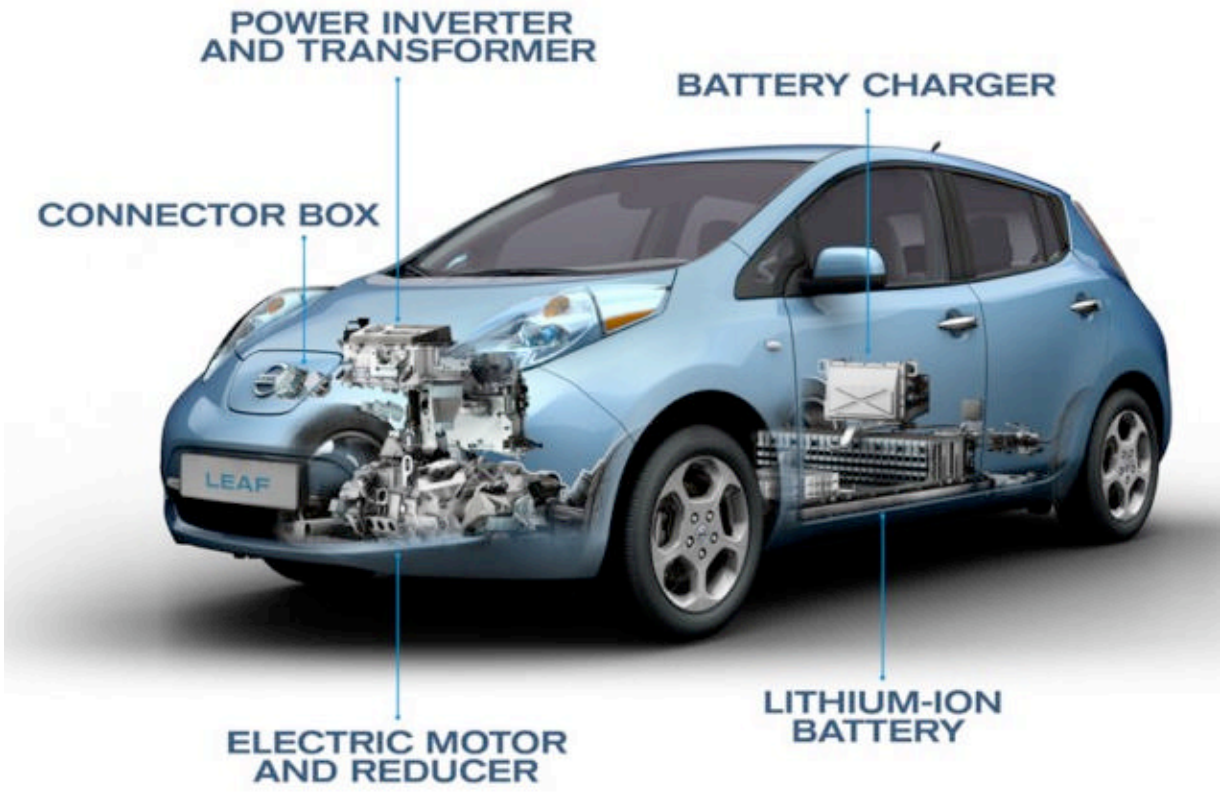
Model:	THINK City
Concept:	BEV
Body:	Micro, 2+2 seats
E-Range:	100 mls
Weight:	2,300 lbs
Output:	34 kW
Battery:	Li-Ion, 24 kWh
Units:	2500+ (in Europe)
Price:	$34k
Similar:	Mitsubishi iMiev, Smart Electric, CT&T, Zap

Noteworthy

- 20 year old Norwegian company, formerly owned by Ford
- Ener1 (IN) owns 31%, supported by $118.5 million federal grant
- delivery mainly to fleets, key markets CA, NY, D.C., IN

Data source: http://www.plugincars.com/think-city/review, Think website Picture: http://www.pluginamerica.org/vehicles/think-city

Battery Electric Vehicles "Mass Market"



Example

Model:	Nissan Leaf
Concept:	BEV
Body:	Mid-size, 5 seats
E-Range:	73 mls
Weight:	3,400 lbs
Output:	110 hp
Battery:	Li-Ion, 24 kWh
Units:	150k p.a.(plan '12)
Price:	$33k
Similar:	Ford Focus ('12), Mitsubishi iMiev, Coda Sedan ('11)

Noteworthy

- first vehicles delivered in United States and Japan Dec 2010 (11th, 22nd)
- telematics: displays range + charging stations on a map, online driving statistics
- EPA rated combined fuel economy at 99 mpg gasoline equivalent

Data source: http://en.wikipedia.org/wiki/Nissan_leaf

Picture: http://2.bp.blogspot.com/_E2zkF4aPcRc/TMhX1-Psf7I/AAAAAAAABog/ZgcwDXAIf1A/s1600/NISSAN+LEAF+2.jpg

Battery Electric Vehicles "New Asian Entries"

Example

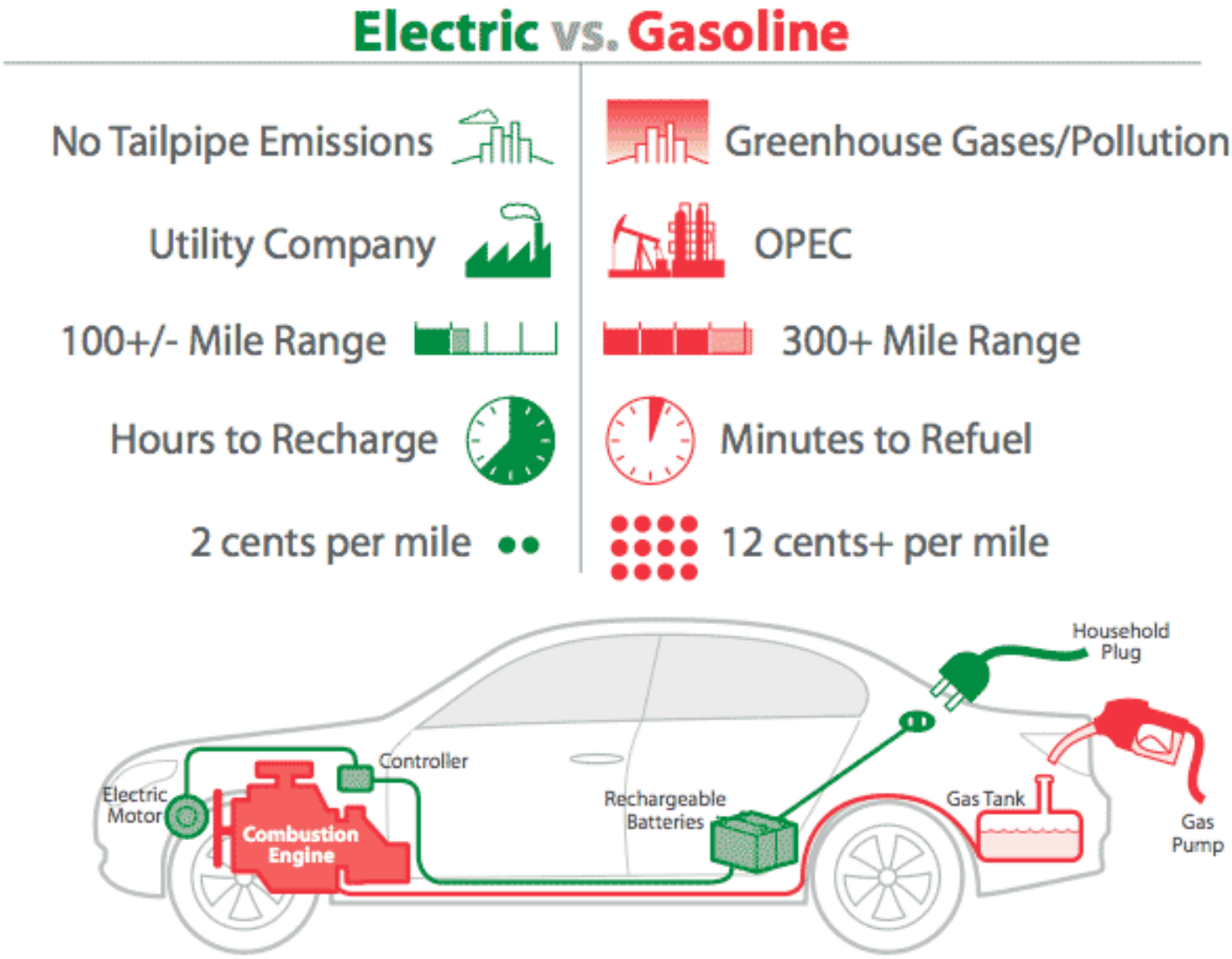
Model:	BYD e6
Concept:	BEV
Body:	MPV, 5 seats
E-Range:	186 mls
Weight:	4,500 lbs
Output:	up to 215+54 hp
Battery:	Li-Ion, 48 kWh
Units:	40 (May '10)
Price:	$40k
Similar:	Geely, Tata

Noteworthy

- BYD is one of the largest battery manufacturers worldwide
- plans for mass production postponed, instead field test with taxis in China
- 50 vehicles for fleets in CA by end of 2011, sale to private buyers planned for 2012

Data source: http://en.wikipedia.org/wiki/BYD_E6 Picture: http://www.autolinedetroit.tv/journal/?p=797

Summary – Is It Really That Simple?



Source: http://www.gravitycontrol.org/blog/wp-content/uploads/2009/07/gas-electric-v6.gif