

Should You Buy an Alternative Vehicle for Economic and/or Environmental Reasons?



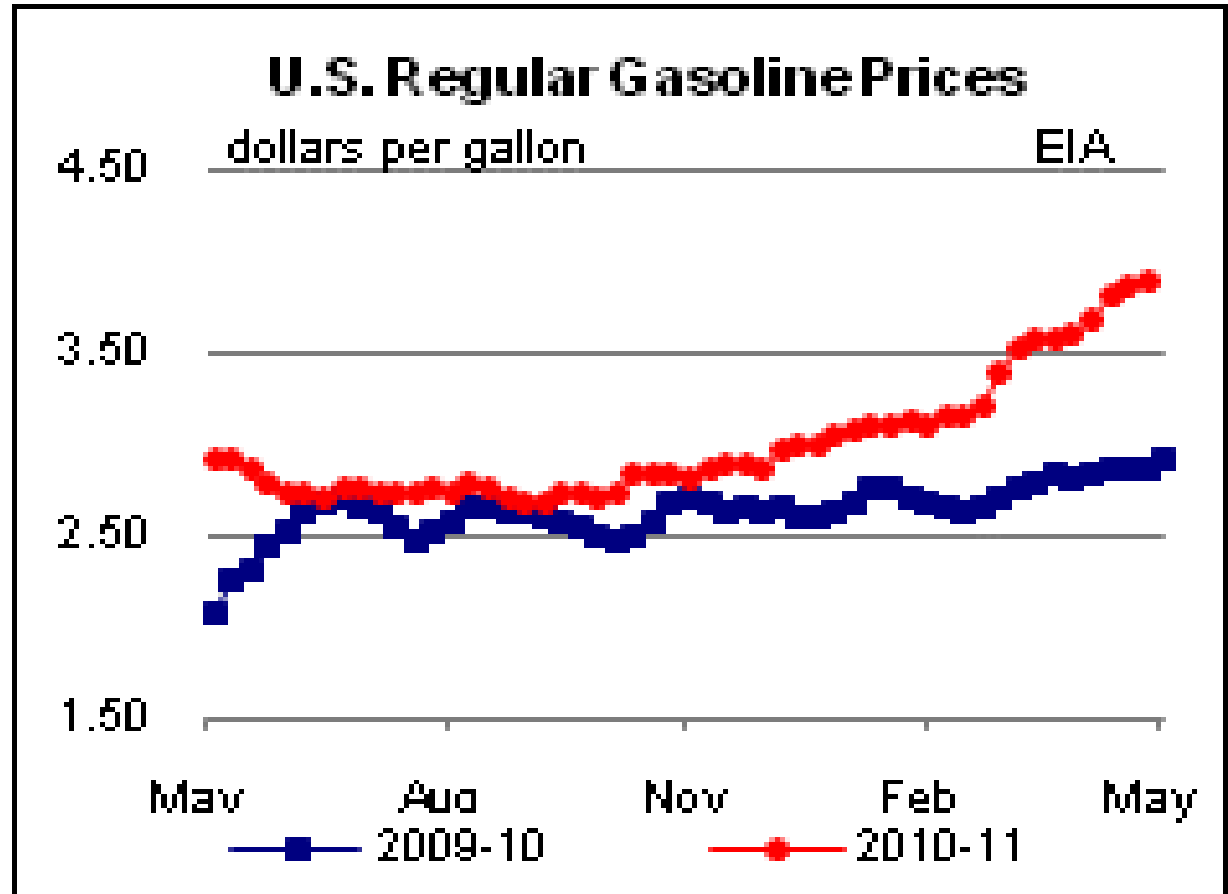
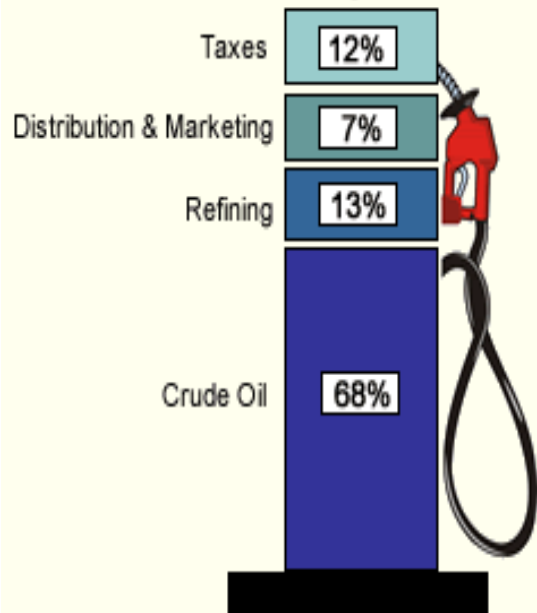
Photo credit: Michael Graham
Richard/TreeHugger

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Rochester, Minnesota
April 26, 2011

UNIVERSITY OF MINNESOTA
EXTENSION

U.S. Retail Gasoline Prices: Up over \$1.00 in past year

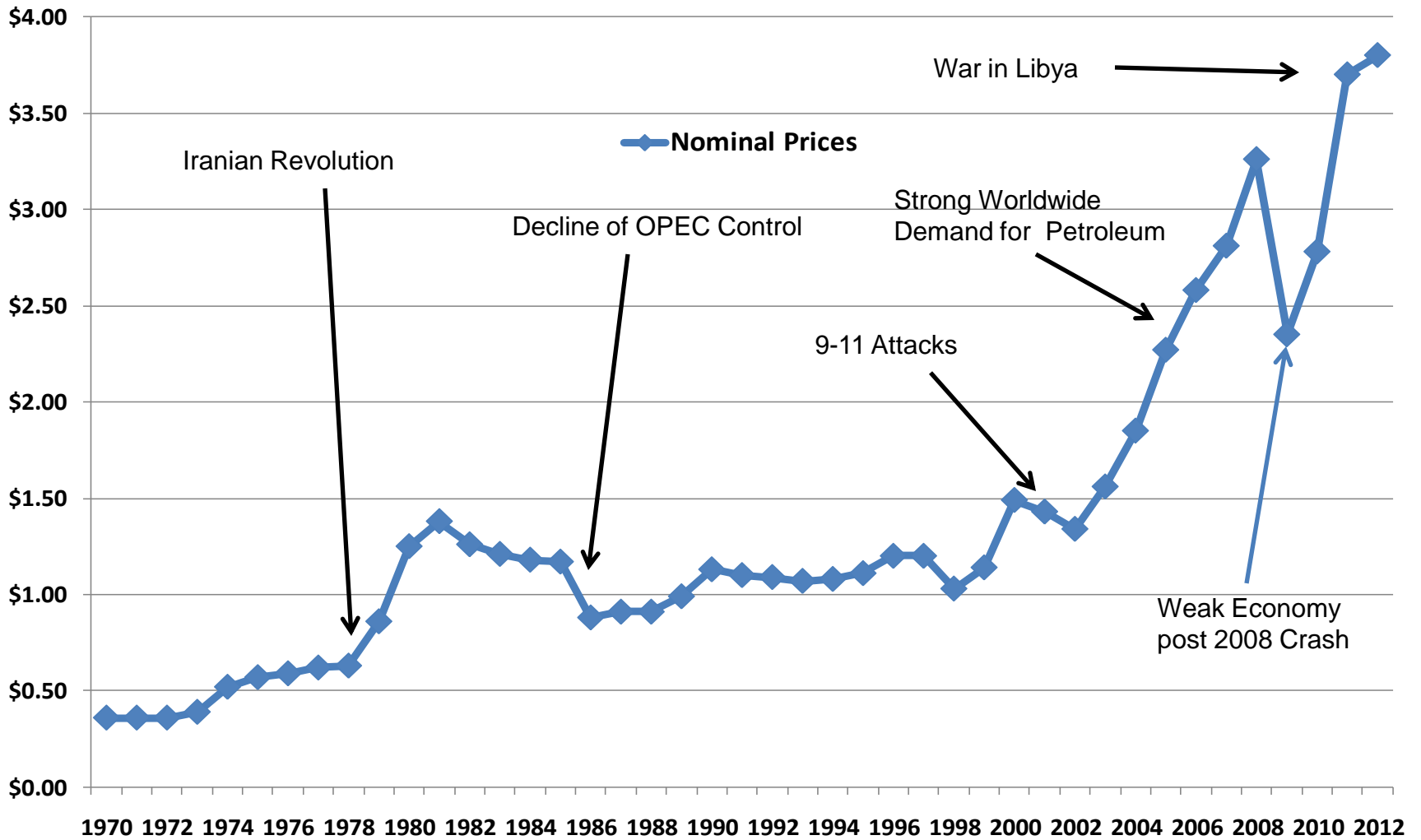
What We Pay For In A Gallon Of Regular Gasoline
(March 2011)
Retail Price: \$3.56/gallon



Source: EIA. <http://www.eia.doe.gov/oog/info/gdu/gasdiesel.asp>

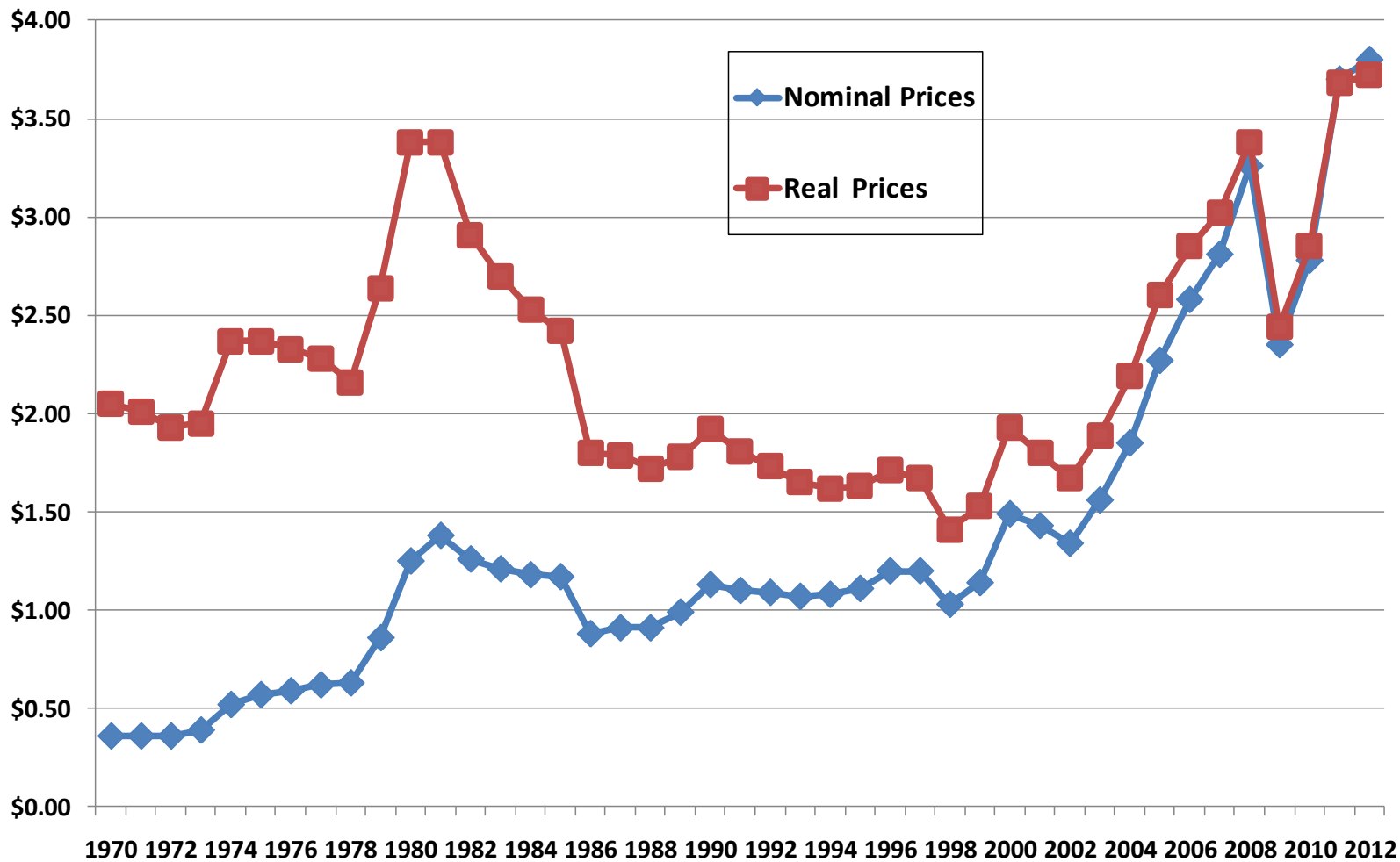
History of U.S. Retail Gasoline Prices, 1970-2012*

Source: Energy Information Agency, U.S. DOE. *Projected



History of U.S. Retail Gasoline Prices 1970-2012*

Source: Energy Information Agency, U.S. DOE *projected



Plan for Today's Talk

- Discuss capabilities of four vehicles
 - Conventional Vehicles (ICE)
 - Hybrids (HEV)
 - Electric Vehicles (EV)
 - Extended Range Electric Vehicles (PHEV)
- Demonstrate a consumer decision tool to anticipate consumer behavior
- Determine Costs of Ownership and Operation
- Compare GHG emissions of the four cars

Toyota Prius– Hybrid Electric Vehicle (HEV)

- Experience: 11 years in production, 1 million sold in U.S.
> 2 million sold world
- Uses Regenerative Braking to Charge Battery--generates power as the vehicle is slowed by braking
- Battery Assists during acceleration
- Gasoline Engine starts and stops as needed --- delivering 48 MPG
- Excellent streamlining of car
- **Price = \$23,750 before credits**
- Battery Longevity –no problem
- In 2012 Prius Hybrid with 12 mile range on charge will be available (PHEV)



Source: JDPower.com



Source: Toyota.com Australia

Nissan Leaf--- Electric Vehicle (EV)

- Available in U.S. market in Dec. 2010,
20,000 have been reserved
- Up to 100 mile range
- Lithium Battery Packs under the floor
- Can charge in 16 hours @120 Volts
- Can charge in 8 hours @ 240 Volts
- Rapid re-charge in 30 minutes@ 480 Volts
- Battery Pack has 100,000 mile warranty
- Rapid acceleration, 90 mph possible
- Can direct heating /cooling with cell phone, while plugged in
- Typically-- 4 miles per kiloWatt-hour
- **Price = \$34,780 with charge station**
- Warning: You can't drive non-stop to Grandma's House for Thanksgiving in Duluth.



Lithium Ion Battery Packs, Charging Equipment

- New Plant Built in Smyrna, Tennessee

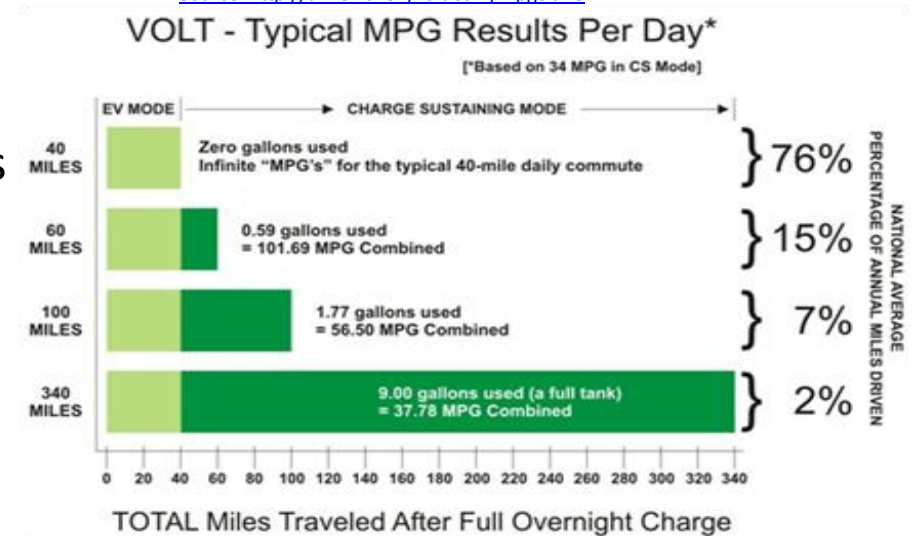


Chevrolet Volt-Extended Range Electric Vehicle, a PHEV (plug-in hybrid electric vehicle)

- Most expensive car in analysis **\$41,000 + \$2,000 for 240V charging station**
- 40 miles of travel in “charge-conserving mode”
- 300 miles possible when generator is running on premium gasoline--- gets 34 miles per gallon of gas
- Generator does not re-charge battery, but produces power to turn the wheels
- Warranty on battery is 100,000 miles



Source: <http://allnewchevyvolt.com/mpg3.JPG>



Toyota Matrix - Internal Combustion Engine (ICE)

- 1.8 Liter Engine
- Matrix is the Hatchback version of the Corolla
- Most Popular car in the world
- About 30 MPG
- **Cost is about \$20,000**



COURTESY: TOYOTA MOTOR CO.



Economic Analysis Used

- Determine Accumulated Discounted Value of Expenditures Made Over Life of the Car
- What is a car, but a series of expenditures that one assumes for the life of the vehicle?
- Focused on expenditures for ownership, fuel, engine maintenance, battery replacement, assume rapid charging stations in the home---"points of difference"
- Ignored depreciation, license fees, insurance, storage
- Users experiment with flat projections of fuel cost for life of the vehicle
- Force consumers to identify their discount rate

Building up Assumptions

- Assumed 15,000 miles per year for Minnesotans
 - (12,000 miles per year assumed by EPA)
- Battery Replacement Cost in Year 8 –a very conservative estimate--- 100,000 mile warranty (150,000 in CA)
 - Battery life hasn't been a big issue with hybrids
- Cost of Gasoline Engine Maintenance per 3,000 miles ---- oil change, muffler, anti-freeze, filters for oil, air, and gasoline, starter battery and starter-- \$60.84 per 3,000 miles
- Price of residential electricity
 - For U.S. 11.26 cents per kWh in 2009
 - MN equaled 9.74 cents per kWh in 2009
 - Source: <http://www.eia.doe.gov/fuelelectric.html>

GHG Emissions from Gasoline and Electricity

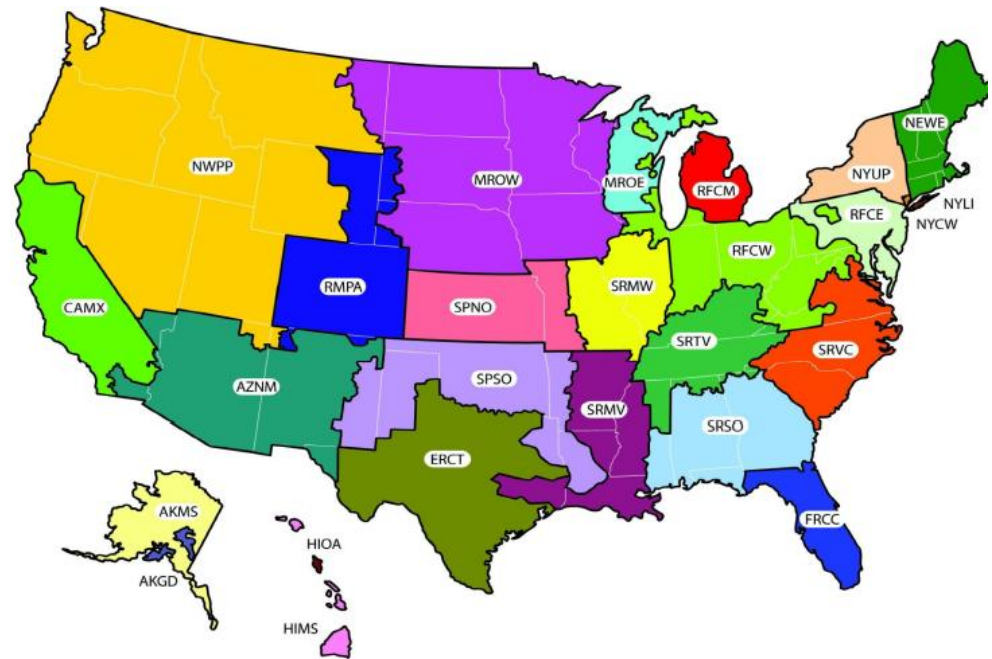
- 10% ethanol blend is most gasoline
 - Gasoline is $92\text{g CO}_2\text{e} \times 121\text{ MJ/gal} = 24.52\text{ lb./gal}$
 - Ethanol is $42\text{ g. CO}_2\text{e} \times 89\text{ MJ/gal} = 8.23\text{ lb. / gal.}$
- (Liska et al., Journal of Industrial Ecology, 13,58-74 (2009))

Therefore, E10 equals 22.89 lb. CO₂ e/ gal.

http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2010V1_0_year07_SummaryTables.pdf

• U.S. electricity typically emits 1306.18 lb/ MWh

• MN electricity emits 1781.44 lb/ MWh (36% > national avg.)



Input—Assumptions in Yellow Cells

1	Alternative Vehicle Analysis		Copyright by Douglas G. Tiffany		18-Apr-11	
2						
3	Car Pricing & Performance Assumptions		Conventional Vehicle	Hybrid Vehicle	Electric Vehicle	Extended Range Electric
4	Negotiated Purchase Price (plus charging station*)		\$ 20,000	\$ 23,750	\$ 34,780	\$ 43,000
5	Down Payment (if financed) or Total Purchase Price		\$ 5,000	\$ 5,000	\$ 5,000	\$ 5,000
6	Enter months of car loan		60	60	60	60
7	Enter interest rate on car loan		5.00%	5.00%	5.00%	5.00%
8	Income Tax Credits for Hybrid, Electric & Charging Station			\$ -	\$ 8,500	\$ 8,500
9	Cost of Battery Service Assumed in Year 8			\$ 2,000	\$ 8,000	\$ 8,000
10	Miles per Gallon of Gasoline		30	48		34
11	Miles per kiloWatt-hour of Electricity				4.0	4.0
12	Expected Miles per Year	15,000				
13	Annual Miles from Grid Electricity (less or equal to above figure)					8,000
14	Gasoline and Electricity Prices, Greenhouse Gas Emissions Rates and Discount Rate					
15	Gasoline (E10) Price for life of car	\$3.80				
16	Addl. Cost of Premium Gasoline Per Gallon	\$0.25	(Affects Fuel Cost of Extended Range Electric only)			
17	Electricity Price (Grid) per kWh for life of car	\$0.0974				
18	Gas Engine Maintenance Per 3000 miles	\$60.84				
19	Personal Discount Rate Applied to Costs	6.00%				
20	GHG Emissions per MWh of Electricity (Tons)	1781.44	Pounds per MWh		(See attached page.)	
21	GHG Emission per Gallon of Gasoline (E10)	22.89	Pounds per Gallon		(See attached page.)	

Calculated Values

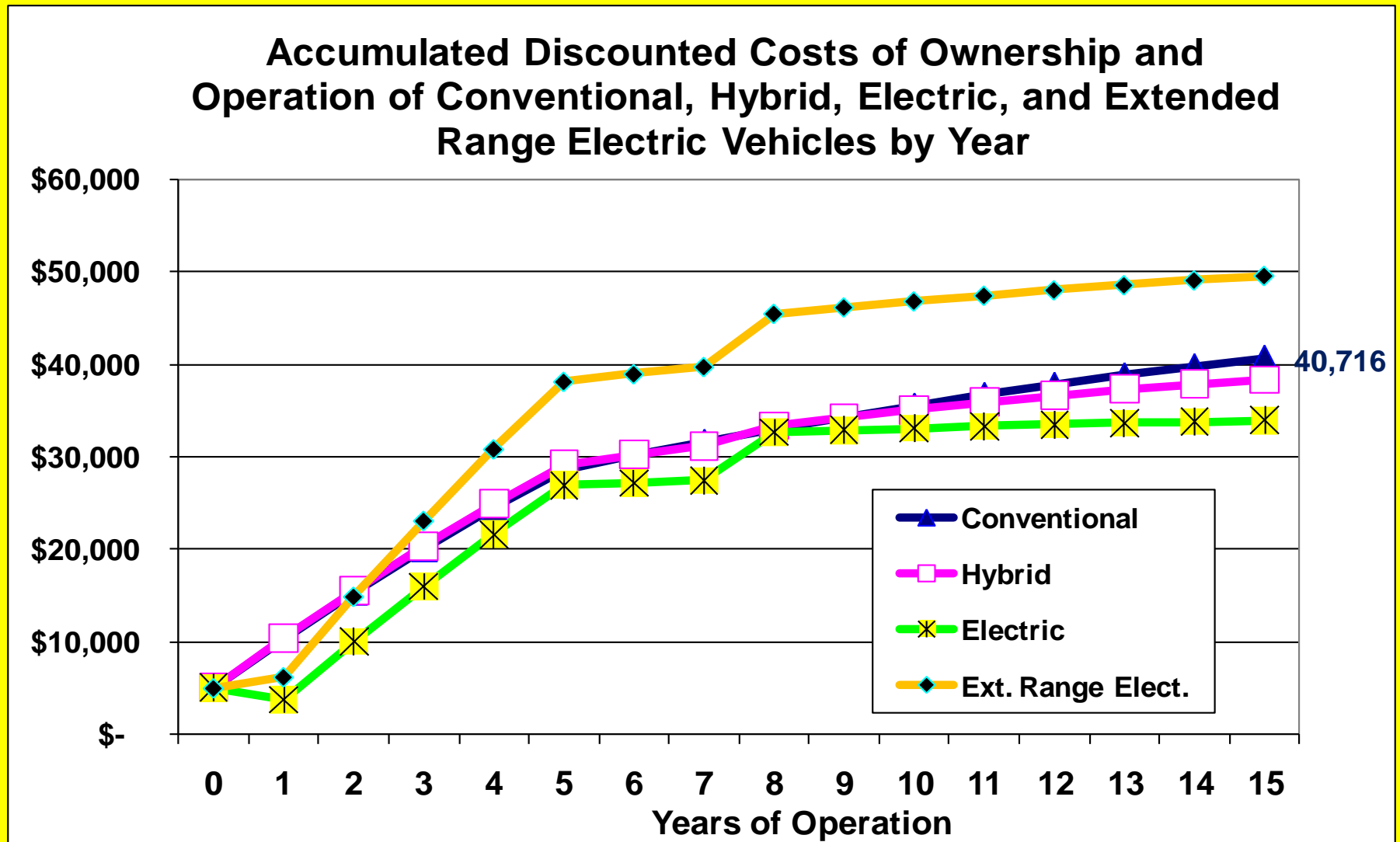
Compare Monthly Fuel Costs

Monthly Payments, Gas Usage and GHG Emissions in First Five Years				
	Conventional Vehicle	Hybrid Vehicle	Electric Vehicle	Extended Range Electric
Monthly Car Payments (if financed)	\$ 283.07	\$ 353.84	\$ 420.32	\$ 575.44
Monthly Opportunity Cost of Down Payment or Purchase	\$ 25.00	\$ 25.00	\$ 25.00	\$ 25.00
Average Monthly Gasoline Payments	\$ 158.33	\$ 98.96		\$ 69.49
Average Monthly Engine Maintenance Costs	\$ 25.35	\$ 25.35		\$ 11.83
Average Monthly Electrical Payments			\$ 30.44	\$ 16.23
Monthly Costs (ownership, fuel, engine maint.)	\$ 491.75	\$ 503.14	\$ 475.76	\$ 697.99
Difference in Monthly Payments in first 5 years vs. Conventional		\$ 11.39	\$ (16.00)	\$ 206.24
Annual Greenhouse Gas Emissions				
Annual Gasoline Usage (gal.)	500.0	312.5		205.9
Annual Electricity Usage from Grid (kWh)	-	-	3,750	2,000
Annual GHG Emissions from Gasoline Usage (lb. of CO2 equiv.)	11,445	7,153	-	4,713
Annual GHG Emissions of Electricity Source (lb. of CO2 equiv.)	-	-	6,680	3,563
Total Annual GHG Emissions (lb. of CO2 equivalent))	11,445	7,153	6,680	8,276
Annual GHG Reduction in Metric Tonnes per Year	-	1.947	2.161	1.438
Effective CO2 Tax Charged to Self by Owning Alternative Vehicle per Metric Tonne		\$ 6	(7)	\$ 143

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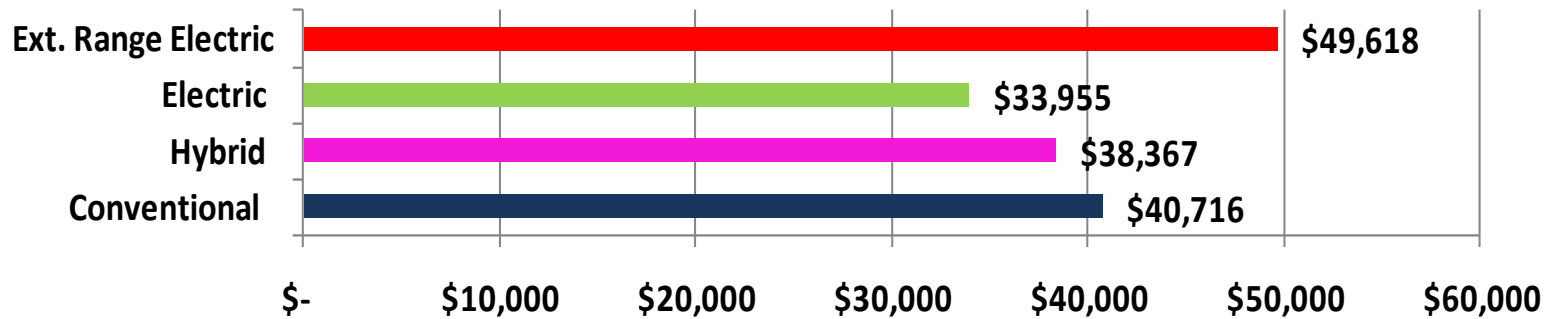
See the CO2 Tax on the Extended Range Electric Vehicles

Baseline Graph, assuming \$3.80 gas, 15k miles, 9.74 cent electricity

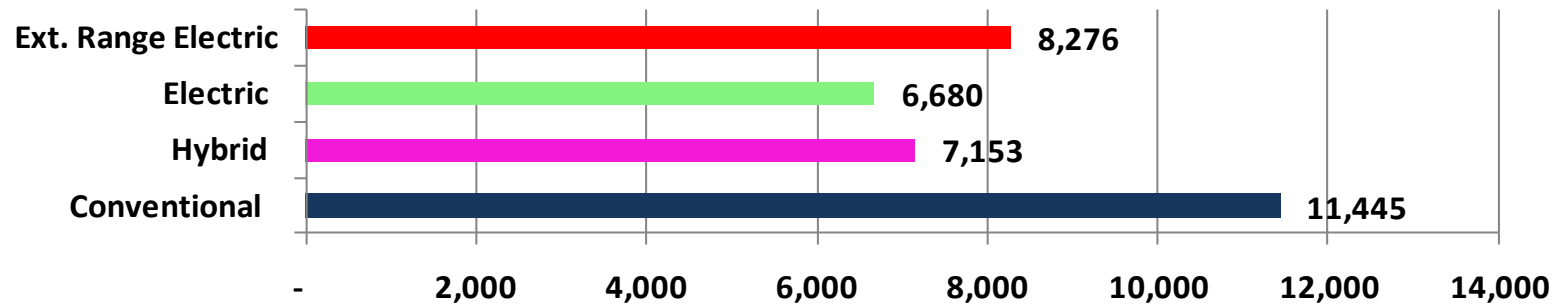


Graphs of Accumulated Discounted Costs and GHG Emissions

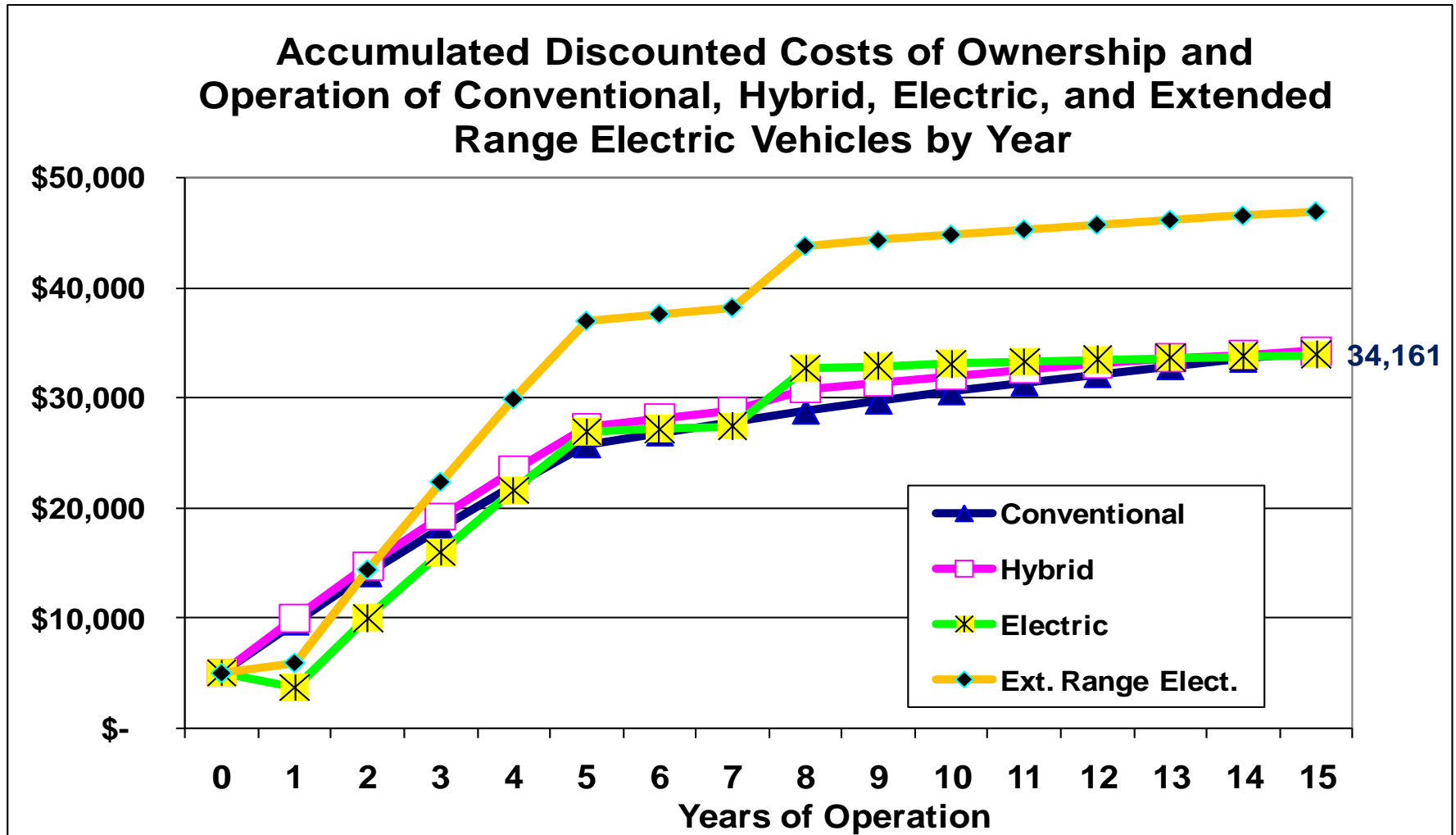
Accumulated Discounted Costs of Ownership & Operation in Year 15



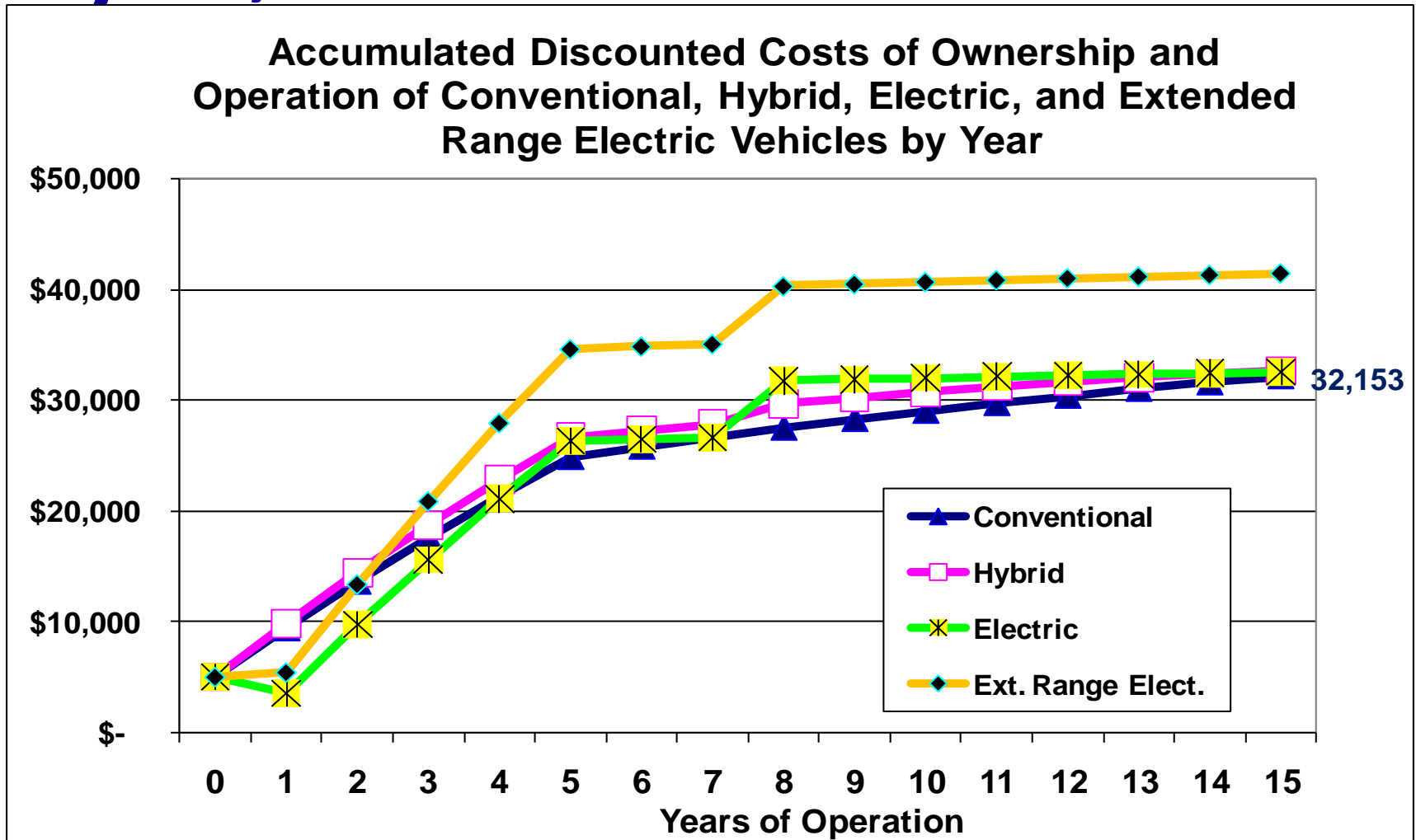
Annual GHG Emissions (lb.)



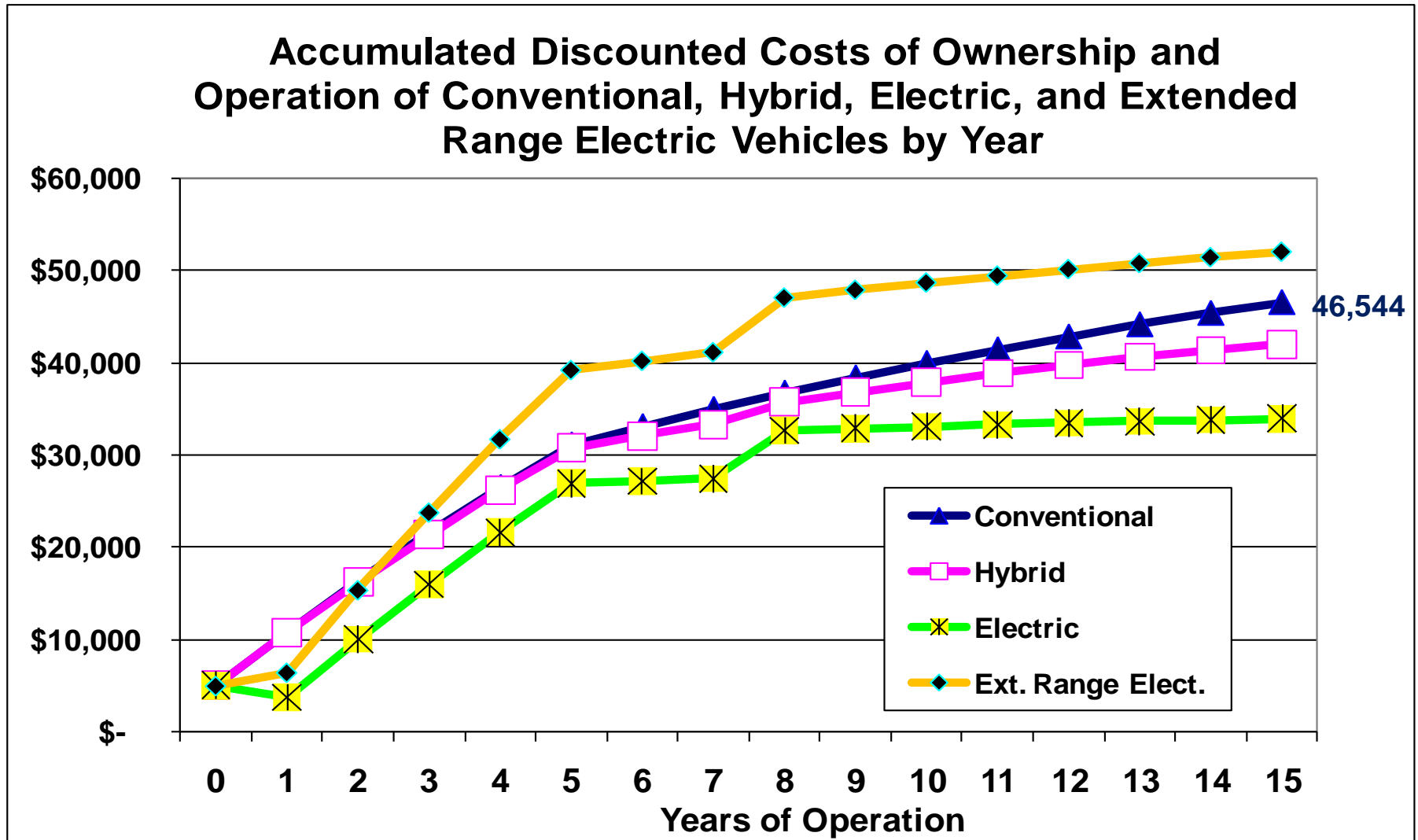
Electric Car is Still Lowest for life of Vehicle down to \$2.45 per Gal. Gasoline



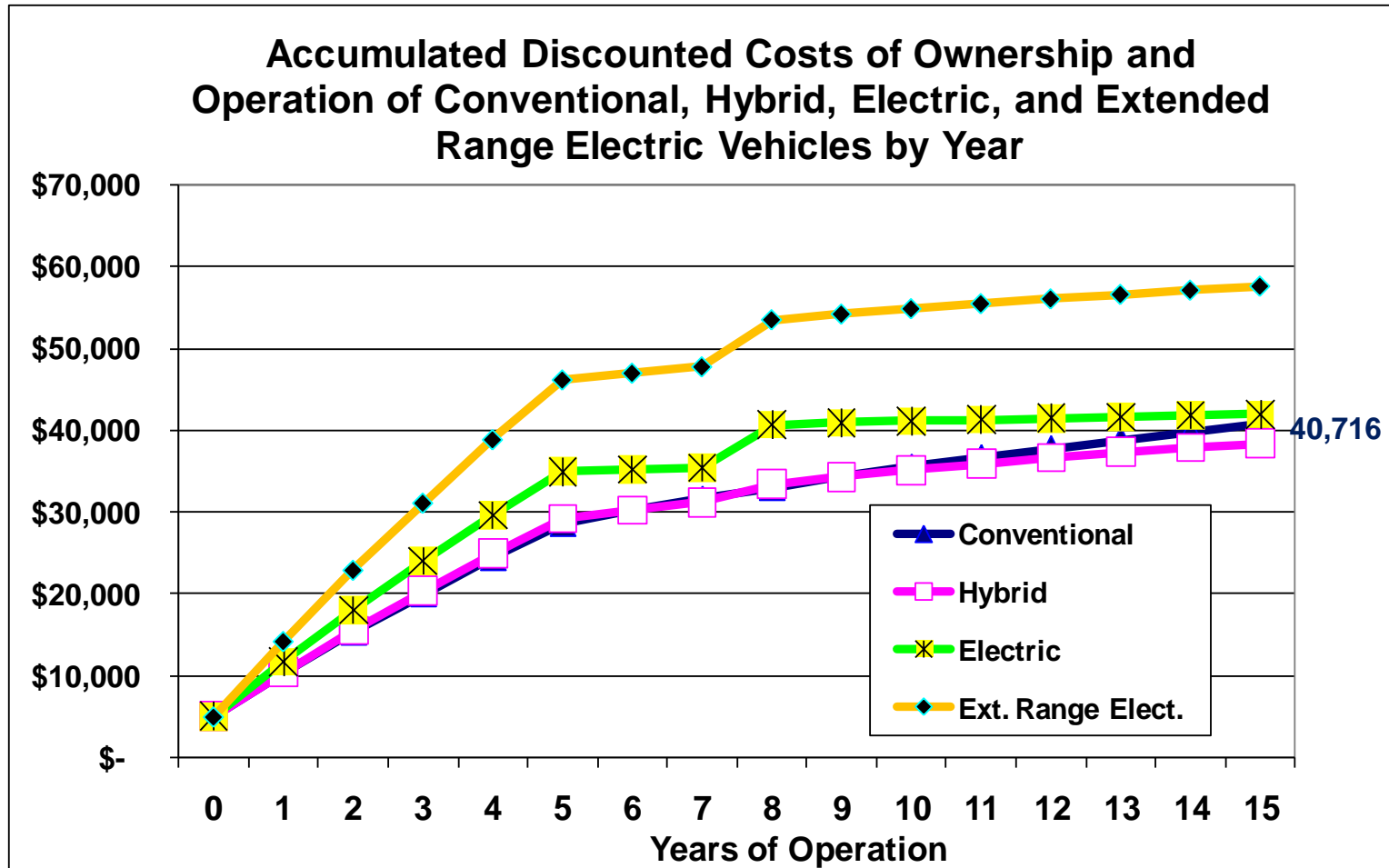
If the Cars are driven 9,000 miles / year, the conventional car wins



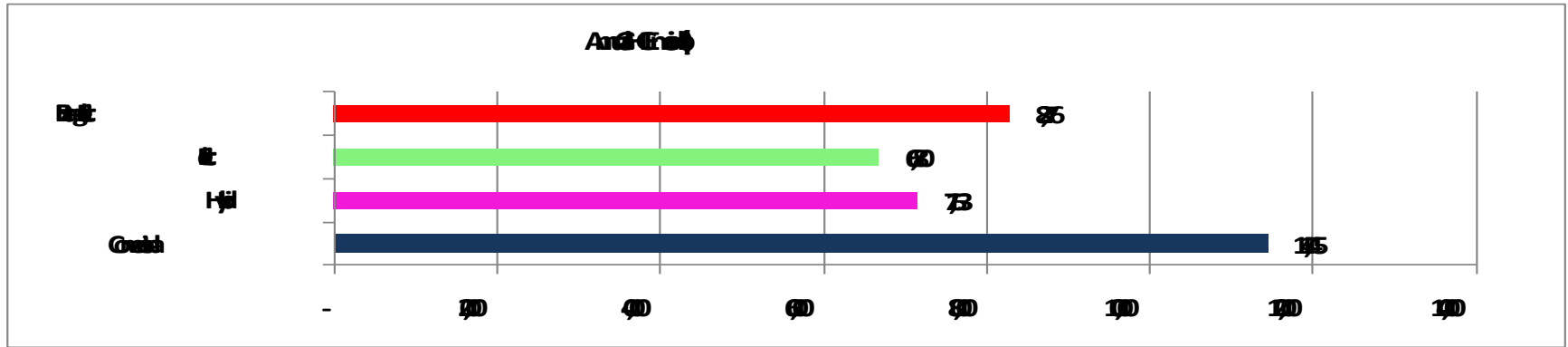
If Gasoline Goes to \$5.00 per Gallon, Electric Vehicles Become Very Attractive



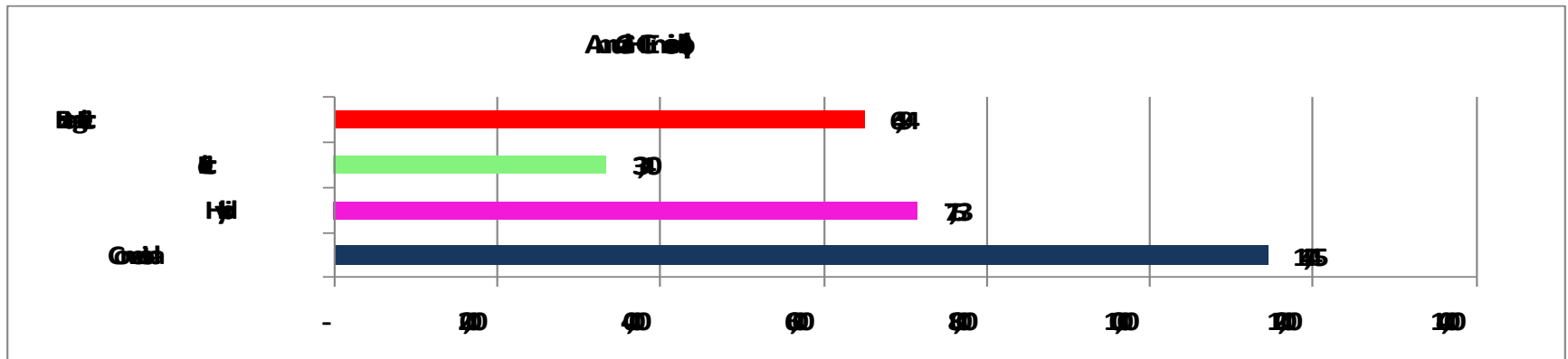
What Happens to Electrics and Ext. Range Electrics when Tax Credits End with \$3.80 gas and 15k mpy?



If Consumer buys 50% windpower, what happens to GHG emissions at 15K mpy for MN drivers?



To



Conclusions

- Alternative vehicles cost more, but can be cost-effective while reducing GHG emissions if you drive enough miles.
- Emissions of electric vehicles can be cut further when utilities increase the proportion of renewables in their portfolio.
- Electric Vehicles are the newcomers, with the shortest operational record, but are very efficient in converting energy.
- Electric Vehicles are cost-effective choices with tax credits, if the consumer can tolerate range issues.
- EVs may be well-suited as fleet vehicles around a city.
- Lots of operational experience is available with hybrids.
- If annual miles driven are low, more expensive vehicles are hard to justify.
- Power pricing plans of utilities may make EVs even more economical if consumers charge at off-peak hours.

Thanks!

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