

Lightweight Materials Enhance PEV and PHEV Efficiency

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on behalf of

The Aluminum Association,

Aluminum Transportation Group (ATG)

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About The Aluminum Association's Aluminum Transportation Group (ATG)



www.aluminumtransportation.org

Lightweight Materials - PEV and PHEV

AIV Technology **reduces** PEV and PHEV Cost:

<u>Battery System Cost *</u>	<u>Cost Savings **</u>
Today: @ \$ 1,250 /KWh	\$ 1,375 - \$ 3,750
Future: @ \$ 750 /KWh	\$ 825 - \$ 2,250

* Including cooling and control systems

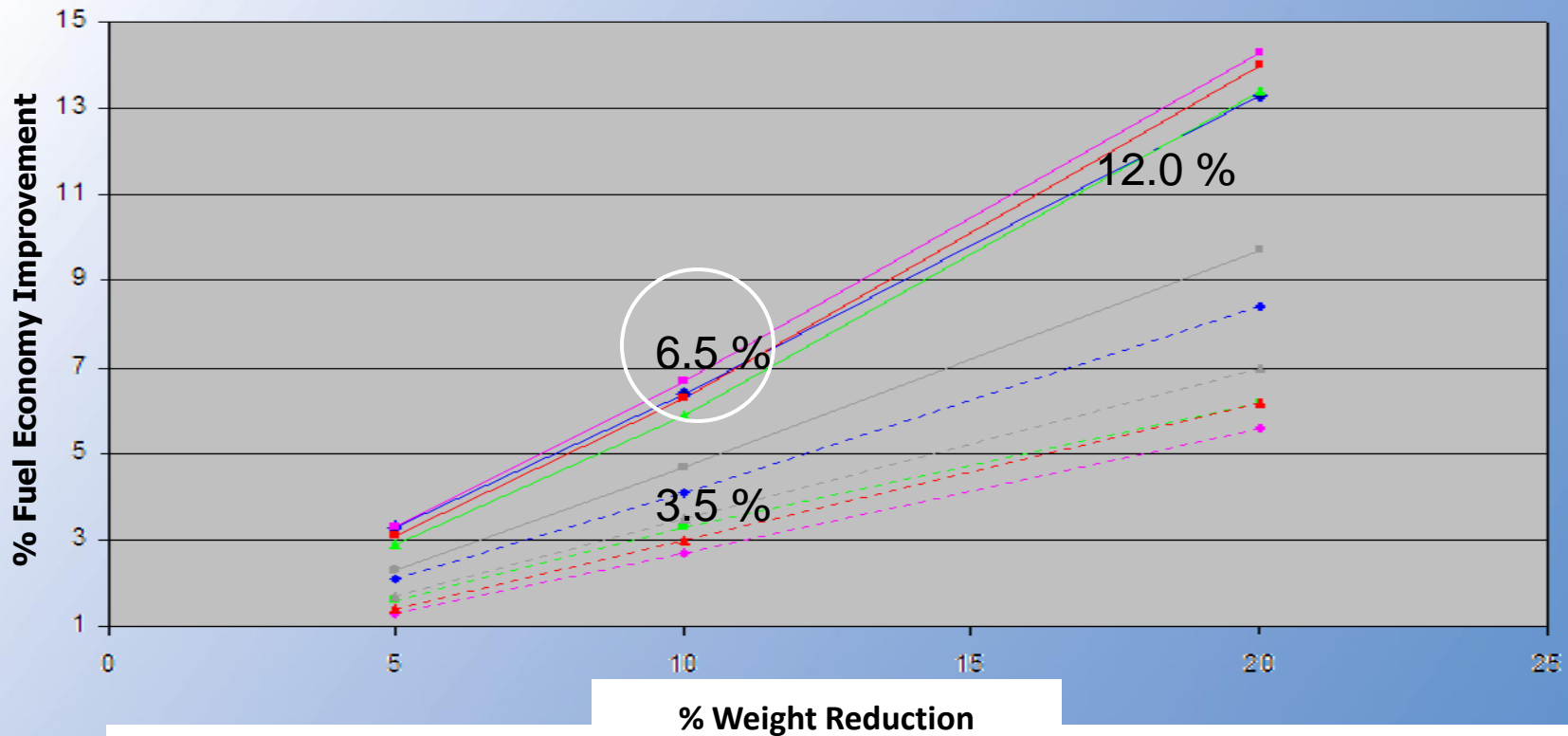
** Varies with vehicle size and EV range

Lightweight Materials - PEV and PHEV

Outline:

- **Weight Reduction vs. Energy Consumption**
- **Weight Reduction Trade-offs**
Structure cost vs. Battery cost

Weight Reduction vs. Fuel Economy - Conventional Vehicles



- Small Car - Resized Engine
- Large SUV - Resized Engine
- Mid Size Car - Resized Engine
- Small SUV - Resized Engine
- Truck - Resized Engine
- Small Car - Baseline Engine
- Large SUV - Baseline Engine
- Mid Size Car - Baseline Engine
- Small SUV - Baseline Engine
- Truck - Baseline Engine

Lightweight Materials - PEV and PHEV

Electric Vehicle Optimizatin Study:

- Analytical Model (Ricardo)

Easy 5 simulation - Ricardo vehicle and component models

- Vehicles – converted to PEV/PHEV

Small car – typ. BMW Mini

Small SUV – typ. Saturn Vue

- Performance

Range: 40 / 80 miles - Full electric mode (**Battery Size**)

Acceleration: 10 sec. 0-60 MPH, FTP75 (**Motor Size**)

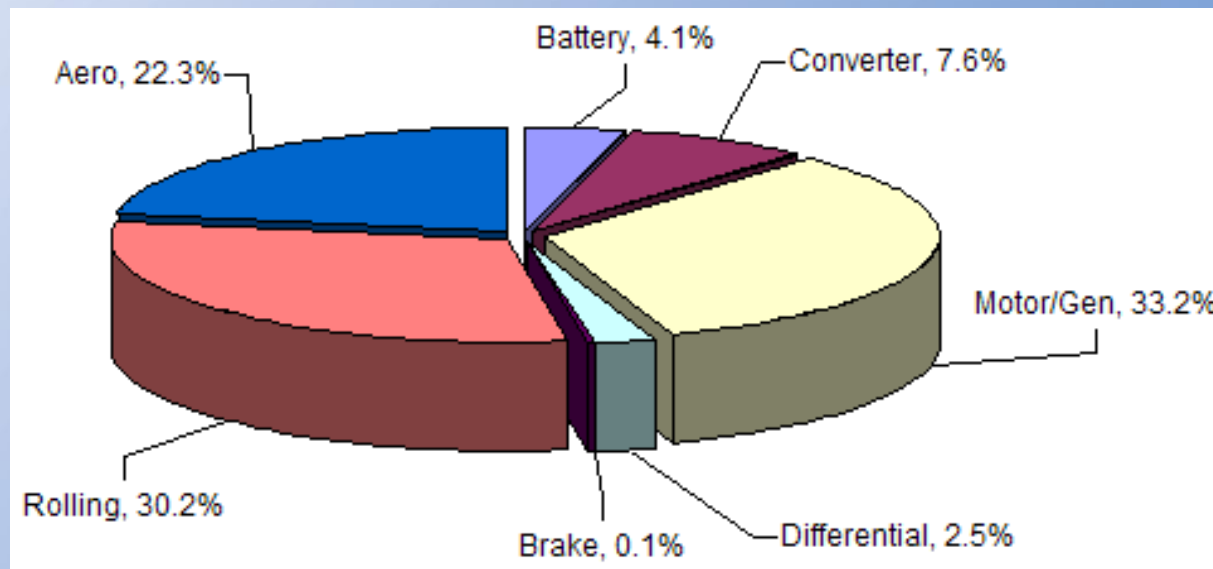
Top speed: 100 MPH

Lightweight Materials - PEV and PHEV

Small Car – Energy Usage

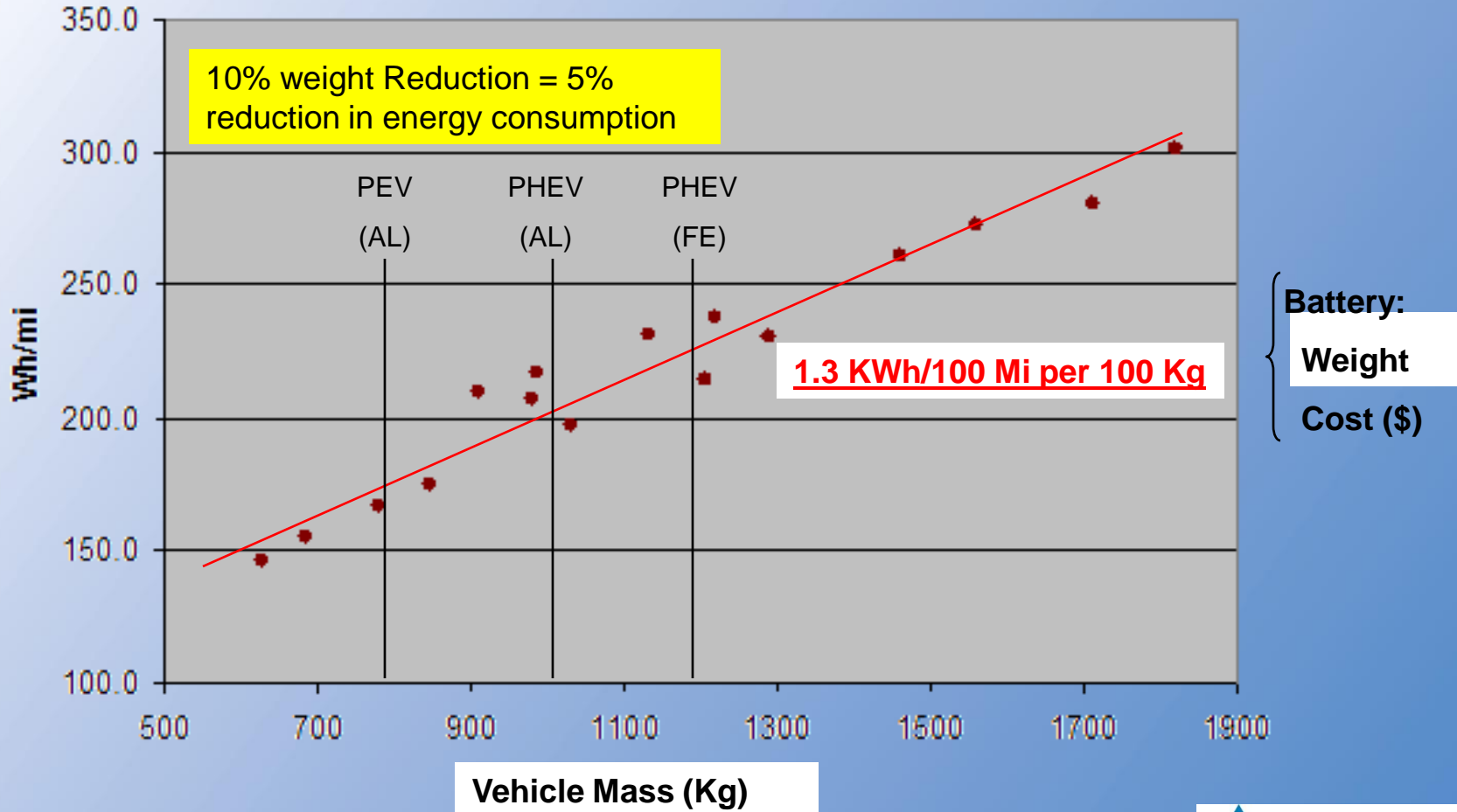
PHEV (Fe): 1205 kg

[**Regen = 20.9%**]



Schedule (FTP75)

Vehicle Mass vs. Energy Consumption



Lightweight Materials - PEV and PHEV

Vehicle Weight Analysis – Small Car:

Base (<u>Gas, Fe</u>)	1,304 Kg	(R=375 Mi)
- Powertrain system	(571) Kg	
+ Hybrid charging	348	
+ e Powertrain	<u>124</u>	
	(99)	
PHEV (Fe)	1,205 Kg	(R=375 Mi, 40 e)
- <u>Light Weighting (AlV)</u>	<u>(147)</u>	<u>(12% reduction)</u>
PHEV (AL)	1,071 Kg	(R=375 MI, 40 e)
- Hybrid charging	(348)	
- Structure design (PT)	(52)	
- e Powertrain	<u>(36)</u>	
	(576)	
PEV (AlV, Full EV)	627 Kg	(R=40 Mi)

Lightweight Materials - PEV and PHEV

AIV Technology – Small Car:

	Reductions (Kg)
BIW	96 Kg
Closures	28
Chassis	<u>23</u>
Total	147 Kg *

* 1.1 KWh battery reduction (40 mi range)

\$ 1,375 reduction @ \$1,250 /KWh

Lightweight Materials - PEV and PHEV

Light Weighting –

- Cost / Benefit Evaluation

Aluminum Vehicle Structure - System Cost Analysis

	Baseline Steel		Baseline Aluminum		Differentials			
	Mass (kg)	Cost (\$)	Mass (kg)	Cost (\$)	Mass (kg)	Cost (\$)	Mass (%)	Cost (%)
Body	433	\$2,665	270	\$3,295	163	-\$630	37.58%	-23.63%
Engine	257	\$2,535	219	\$2,160	38	\$375	14.78%	14.78%
Energy Storage	18	\$53	16	\$45	3	\$8	14.78%	14.78%
Transmission	79	\$1,177	67	\$1,151	12	\$26	14.78%	2.22%
Driveshaft/Diff/Axle	110	\$1,397	99	\$1,304	11	\$93	9.59%	0.00%
Cradle	36	\$83	21	\$134	15	-\$51	41.70%	-60.75%
Corner Suspension	48	\$220	40	\$198	8	\$22	15.96%	10.16%
Braking System	49	\$420	41	\$377	8	\$43	16.37%	10.13%
Steering System	28	\$580	22	\$491	7	\$89	23.45%	15.36%
Fuel PV Cost	0	\$9,342	0	\$8,071	0	\$1,272	0.00%	13.61%
TOTAL MANUFACTURING	1,564	\$14,871	1,288	\$14,974	275	-\$103	17.61%	-0.69%
RETAIL PRICE	0	\$23,819	0	\$23,964	0	-\$144	0.00%	-0.61%
TOTAL OWNERSHIP	0	\$51,520	0	\$50,344	0	\$1,176	0.00%	2.28%



Manufacturing and Lifecycle Analysis of
Aluminum Vehicle Structures
July 2007



Lightweight Materials - PEV and PHEV

Summary:

- **10% mass reduction: 4 – 6% reduction in battery size**
- **Low Mass Aluminum Structure Achieves:**

EV weight reduction potential: 147 Kg (12 %)

Reduce future battery cost @ \$750/KWh \$ 800 - \$2,250

Expected aluminum structure cost premium \$ 630

Net cost savings \$ 170 – 1,620

Reduced Energy Consumption: 1.3 KWh / 100 Mi per 100 Kg

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The Natural Ally of
Efficient Transportation

Thank You

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Small Car Results

PHEV (Fe)

PHEV (AI)

PEV (Fe)

PEV (AI)

PHEV (Fe)

PHEV (AI)

PEV (Fe)

PEV (AI)

		40 MILE RANGE				80 MILE RANGE				
Small EV	Units	Case 1	Case 2	Case 3	Case 4	Case 1	Case 2	Case 3	Case 4	
Base Weight	kg	1304	1142	684.6	539.2	1304	1142	684.6	539.2	
ITERATION 1	Battery Size [Total]	kWh	12.9	11.8	10.5	9.4	25.8	23.7	20.6	18.8
	Motor Size	kW	110	110	110	110	110	110	110	110
	Battery Weight	kg	73	67	59	53	146	134	117	106
	Motor + Controller Weight	kg	50	50	50	50	50	50	50	50
	E-Powertrain Weight	kg	123	117	109	103	196	184	167	156
	Weight Iteration 1	kg	1205	1037	794	642	1278	1103	851	695
ITERATION 2	Battery Size [Total]	kWh	13.8	12.6	11.1	10.2	28.3	26.0	22.8	20.8
	Motor Size	kW	110	110	110	110	110	110	110	110
	Battery Weight	kg	78	71	63	57	160	147	129	117
	Motor + Controller Weight	kg	50	50	50	50	50	50	50	50
	E-Powertrain Weight	kg	128	121	113	107	210	197	179	167
	Weight Iteration 1	kg	1210	1041	797	647	1292	1117	863	707
OPTIMIZATION	Motor Size	kW	101.0	88.0	73.0	70.0	107.0	93.0	80.0	70.0
	FDR		5.37	5.34	5.37	5.20	5.32	5.37	5.34	5.31
	Rated Speed		0.58	0.58	0.61	0.70	0.58	0.58	0.62	0.58
	Battery Size [Total]	kWh	13.6	12.2	10.3	9.1	28.2	25.4	21.5	19.1
	Battery Weight	kg	77	69	58	51	159	17	121	108
	Motor + Controller Weight	kg	47	43	38	37	49	44	40	37
	Optimized Weight	kg	1,205	1,031	781	627	1,290	980	846	684
	HWFET Range	mi	37	36	35	33	76	74	69	67
	45 mph range	mi	41	41	39	37	82	81	77	74
	70 mph range	mi	28	26	24	21	57	54	49	46
	0-30 mph Accel Time	s	4.8	4.9	4.8	5.0	4.9	4.9	4.8	4.9
	0.60 mph Accel Time	s	9.9	10.0	10.0	9.9	10.0	10.0	10.0	10.0
	Top Speed	mph	100	100	100	100	101	100	100	100