

**Table II-29**  
**Passenger Car and LDT1: Incremental Cost of a ULEV II Compared to a ULEV I Vehicle**

Emission Control Technology	4-cylinder				6-cylinder				8-cylinder			
	Tech. cost est. (in dollars)	Tech. on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)	Tech. cost est. (in dollars)	Tech. on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)	Tech. cost est. (in dollars)	Tech. on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)
Universal exhaust gas oxygen sensor (a)	10.00	50	50	0	20.00	50	50	0	20.00	50	50	0
Air-assisted fuel injection (b)	8.00	50	50	0	12.00	50	50	0	16.00	50	50	0
Individual cylinder fuel control (c)	0	50	100	0	0	50	100	0	0	50	100	0
Retarded spark timing as start-up (c)	0	0	100	0	0	25	100	0	0	100	100	0
Low thermal capacity manifold (upgrade)	20.00	25	75	10.00	40.00	25	75	20.00	40.00	25	75	20.00
Greater catalyst loading (d)	13.59	0	100	13.59	22.02	0	100	22.02	36.59	0	100	36.59
Imp. double layer washcoat & 600 cpi cell density	1.80	0	100	1.80	2.92	0	100	2.92	4.86	0	100	4.86
Engine modifications (e)	0	0	0	0	10.00	0	100	10.00	15.00	0	100	15.00
Air injection (electric) (f)	50.00	0	0	0	65.00	0	50	32.50	65.00	25	75	32.50
<b>Total incremental component cost</b>				<b>\$25.39</b>				<b>\$87.44</b>				<b>\$108.94</b>

(a) Only the front oxygen sensor in an UEGO type sensor

(b) Air assisted fuel injection requires minor redesign of the idle air control valve at no additional cost and the addition of an adaptor to each injector at a cost of \$2 each

(c) Individual cylinder fuel control and retarded spark-timing at start-up constitute software changes only, at no additional hardware cost.

(d) Catalyst volume on a ULEV II vehicle is estimated to be virtually the same as on a ULEV I vehicle.

(e) Types of engine modifications may be less uniform throughout the industry and may include items such as additional spark plug per cylinder, addition of a swirl control valve or other hardware needed to achieve cold combustion stability, improved mixing and better fuel injector targeting.

(f) Cost of air injection includes an electric air pump with integrated filter and relay, wiring, air shut-off valve with integral solenoid, check valve, tubing and brackets

**Table II-30**  
**Light-Duty Truck (3751 lbs. LVW- 8500 lbs. GVWR): Incremental Cost of a ULEV II Compared to a ULEV I Vehicle**

Emission Control Technology	4-cylinder				6-cylinder				8-cylinder			
	Tech. cost est. (in dollars)	Tech. on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)	Tech. cost est. (in dollars)	Tech. on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)	Tech. cost est. (in dollars)	Tech. on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)
Universal exhaust gas oxygen sensor (a)	10.00	50	50	0	20.00	50	50	0	20.00	50	50	0
Air-assisted fuel injection (b)	8.00	25	50	2.00	12.00	50	50	0	16.00	50	50	0
Heated fuelinjectors	12.00	0	0	0	18.00	0	0	0	24.00	0	50	12.00
Individual cylinder fuel control (c)	0	25	100	0	0	25	100	0	0	0	100	0
Retarded spark timing as start-up (c)	0	0	100	0	0	25	100	0	0	100	100	0
Low thermal capacity manifold	20.00	25	75	10.00	40.00	25	75	20.00	40.00	25	100	30.00
Increaseed catalyst volume	0	0	100	0	55.50	0	100	55.50	35.10	0	100	35.10
Greater catalyst loading	21.15	0	100	21.15	34.03	0	100	34.03	49.66	0	100	49.66
Imp. double layer washcoat & 600 cpi cell density	2.81	0	100	2.81	4.52	0	100	4.52	6.59	0	100	6.59
Engine modifications (d)	0	0	0	0	10.00	0	100	10.00	15.00	0	100	15.00
Air injection (electric) (e)	50.00	0	0	0	65.00	0	50	32.50	65.00	50	100	32.50
<b>Total incremental cost</b>				<b>\$35.96</b>				<b>\$156.54</b>				<b>\$180.85</b>

(a) Only the front oxygen sensor in an UEGO type sensor

(b) Air assisted injection requires minor redesign of the idle air control valve at no additional cost and the addition of an adaptor to each injector at a cost of \$2 each

(c) Improved precision fuel control envisioned here and retarded spark timing at start-up constitute software changes only, at no additional cost

(d) Types of engine modifications may be less uniform throughout the industry and may include items such as an additional spark plug per cylinder, addition of a swirl control volve or other hardware needed to achieve cold combustion stability, improved mixing and fuel injector targeting.

(e) Cost of air injection includes an electric air pump with integrated filter and relay, wiring, air shut-off valve with integral solenoid, check valve, tubing and brackets

**Table II-31**  
**Medium-Duty Vehicle (8500-10000 GVW): Incremental Cost of a ULEV II Compared to a ULEV I Vehicle**

Emission Control Technology	8-cylinder and higher			
	Tech. cost est. (in dollars)	Tech.on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)
Universal exhaust gas oxygen sensor (a)	20.00	0	0	0
Air-assisted fuel injection (b)	16.00	0	0	0
Heated fuelinjectors	24.00	0	0	0
Individual cylinder fuel control (c)	0	0	100	0
Retarded spark timing as start-up (c)	0	100	100	0
Low thermal capacity manifold	40.00	0	0	0
Increased catalyst loading	39.65	0	100	39.65
Greater catalyst loading	42.07	0	100	42.07
Imp. double layer washcoat & 600 cpi cell density	7.44	0	100	7.44
Engine modifications (d)	20.00	0	100	20.00
Air injection (electric) (e)	75.00	0	0	0
<b>Total incremental cost</b>				<b>\$109.17</b>

(a) Only the front oxygen sensor in an UEGO type sensor

(b) Air assisted injection requires minor redesign of the idle air control valve at no additional cost and the addition of an adaptor to each injector at a cost of \$2 each

(c) Improved precision fuel control envisioned here and retarded spark timing at start-up constitute software changes only, at no additional cost

(d) Types of engine modifications may be less uniform throughout the industry and may include items such as an additional spark plug per cylinder, addition of a swirl control valve or other hardware needed to achieve cold combustion stability, improved mixing and fuel injector targeting.

(e) Cost of air injection includes an electric air pump with integrated filter and relay, wiring, air shut-off valve with integral solenoid, check valve, tubing and brackets

**Table II-32**  
**Passenger Car & LDT1: Incremental Cost of a SULEV Compared to a ULEV I Vehicle**

Emission Control Technology	4-cylinder				6-cylinder			
	Tech. cost est. (in dollars)	Tech.on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)	Tech. cost est. (in dollars)	Tech. on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)
Universal exhaust gas oxygen sensor (a)	10.00	50	100	5.00	20.00	50	100	10.00
Air-assisted fuel injection (b)	8.00	50	100	4.00	12.00	50	100	6.00
Individual cylinder fuel control (c)	0	50	100	0	0	50	100	0
Retarded spark timing as start-up (c)	0	0	100	0	0	25	100	0
Abbreviated engine start-up (d)	10.00	0	25	2.50	10.00	0	25	2.50
Low thermal capacity manifold (upgrade)	20.00	25	100	15.00	40.00	25	100	30.00
Close-coupled pipe catalyst(s) (e)	14.78	0	100	14.78	23.94	0	100	23.94
Greater catalyst loading	20.38	0	100	20.38	33.03	0	100	33.03
Imp. double layer washcoat & 900 cpi cell density	4.33	0	100	4.33	10.56	0	100	10.56
Engine modifications (f)	10.00	0	100	10.00	10.00	0	100	10.00
Air injection (electric) (g)	50.00	0	0	0	65.00	0	50	32.50
<b>Total incremental cost</b>				<b>\$75.98</b>				<b>\$158.53</b>

(a) Only the front oxygen sensor in an UEGO type sensor

(b) Air assisted fuel injection requires minor redesign of the idle air control valve at no additional cost and the addition of an adaptor to each injector at a cost of \$2 each

(c) Improved cylinder fuel control and retarded spark-timing at start-up constitute software changes only, at no additional cost

(d) Abbreviated engine start-up utilizes a higher speed starter or integral starter/alternator system to achieve quicker engine cranking at start-up.

(e) Catalyst volume on a SULEV is estimated to be 20 percent greater than that on a ULEV I vehicle.

(f) Types of engine modifications may be less uniform throughout the industry and may include items such as an additional spark plug per cylinder, addition of a swirl control volve or other hardware needed to achieve cold combustion stability, improved mixing and fuel injector targeting.

(g) Cost of air injection includes an electric air pump with integrated filter and relay, wiring, air shut-off valve with integral solenoid, check valve, tubing and brackets

**Table II-33**  
**Light-Duty Truck (3751 LVW-8500 GVW): Incremental Cost of a SULEV Compared to a ULEV I Vehicle**

Emission Control Technology	4-cylinder				6-cylinder			
	Tech. cost est. (in dollars)	Tech. on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)	Tech. cost est. (in dollars)	Tech. on 2003 MY ULEV I (%)	Proj. Tech. on ULEV II (%)	Inc. Cost (in dollars)
Universal exhaust gas oxygen sensor (a)	10.00	50	100	5.00	20.00	50	100	10.00
Air-assisted fuel injection (b)	8.00	25	100	6.00	12.00	50	100	6.00
Heated fuel injectors	12.00	0	0	0	18.00	0	0	0
Individual cylinder fuel control (c)	0	25	100	0	0	25	100	0
Retarded spark timing as start-up (c)	0	0	100	0	0	25	100	0
Abbreviated engine start-up (d)	10.00	0	25	2.50	10.00	0	25	2.50
Low thermal capacity manifold	20.00	25	100	15.00	40.00	25	100	30.00
Close-coupled pipe catalyst(s) (e)	23.00	0	100	23.00	92.50	0	100	92.50
Greater catalyst loading	31.73	0	100	31.73	51.04	0	100	51.04
Imp. double layer washcoat & 900 cpi cell density	6.74	0	100	6.74	10.84	0	100	10.84
Engine modifications (f)	10.00	0	100	10.00	10.00	0	100	10.00
Air injection (electric) (g)	50.00	0	50	25.00	65.00	0	50	32.50
<b>Total incremental cost</b>				<b>\$124.97</b>				<b>\$245.38</b>

- (a) Only the front oxygen sensor in an UEGO type sensor
- (b) Air assisted fuel injection requires minor redesign of the idle air control valve at no additional cost and the addition of an adaptor to each injector at a cost of \$2 each
- (c) Improved cylinder fuel control and retarded spark-timing at start-up constitute software changes only, at no additional cost
- (d) Abbreviated engine start-up utilizes a higher speed starter or integral starter/alternator system to achieve quicker engine cranking at start-up.
- (e) Catalyst volume on a SULEV is estimated to be 20 percent greater than that on a ULEV I vehicle.
- (f) Types of engine modifications may be less uniform throughout the industry and may include items such as an additional spark plug per cylinder, addition of a swirl control valve or other hardware needed to achieve cold combustion stability, improved mixing and fuel injector targeting.
- (g) Cost of air injection includes an electric air pump with integrated filter and relay, wiring, air shut-off valve with integral solenoid, check valve, tubing and brackets

**Table II-34  
Increased Catalyst Cost Estimates for LEV II Vehicles**

		<b>Sales Wtd. Eng. Disp. (liter)</b>	<b>Proj. ULEV I Cat. Vol. (liter)</b>	<b>Proj. ULEV II Cat. Vol. (liter)</b>	<b>Inc. Cat. Vol. Cost (a) (dollars)</b>	<b>Inc. Rh. (b) (grams)</b>	<b>Add. Rh Cost (c) (dollars)</b>	<b>Higher cpi coct (c) (dollars)</b>
<b>Passenger Cars</b>								
ULEV II compared to ULEV I	4-cylinder	2.0	1.5	1.5	0	0.626	13.59	1.80
	6-cylinder	3.2	2.4	2.4	0	1.015	22.02	2.92
	8-cylinder	4.5	4.0	4.0	0	1.686	36.59	4.86
<b>Light-duty trucks (0-8,500 lbs. GVWR)</b>								
ULEV II compared to ULEV I	4-cylinder	2.3	2.3	2.3	0	0.975	21.15	2.81
	6-cylinder	3.7	2.6	3.7	55.50	1.568	34.03	4.52
	8-cylinder	5.4	4.7	5.4	35.10	2.288	49.66	6.59
<b>Medium-Duty Vehicles (8500-10000 GVW)</b>								
ULEV II	8-cylinder	6.1	5.3	6.1	39.65	2.585	42.07	7.44
<b>Passenger Cars</b>								
SULEV compared to ULEV I	4-cylinder	2.0	1.5	1.8	14.78	0.939	20.38	4.33
	6-cylinder	3.2	2.4	2.9	23.94	1.522	33.03	7.01
<b>Light-duty trucks (0-8,500 lbs. GVWR)</b>								
ULEV II compared to ULEV I	4-cylinder	2.3	2.3	2.8	23.00	1.462	31.73	6.74
	6-cylinder	3.7	2.6	4.4	92.50	2.352	51.04	10.84

(a) Catalyst cost is estimated to be approximately \$50/liter

(b) Assumes increase in rhodium loading of 12 g/ft<sup>3</sup> for ULEV II and 15 g/ft<sup>3</sup> for SULEV

(c) Cost of rhodium = \$675 per troy ounce.

(d) Assumes ULEV II vehicles use 600 cpi catalysts and SULEVs use 900 cpi catalysts. Cost of 600 cpi catalyst compared to 400 cpi catalyst is 2 cents/in<sup>3</sup> in large volumes. Corresponding cost for 900 cpi catalyst is 4 cents/in<sup>3</sup>.

**Table II-35  
SUPPORT COSTS**

**(A) Engineering Development Cost of Advanced Vehicle Technology (Research)**

Emission Control Technology	Eng. Staff for Tech. Dev.		Eng. Staff Cost (a) (in dollars)	Dev. Vehicle Cost (in dollars)	Addtl. Equipment (in dollars)	Cost/Vehicle (c) (dollars/veh.)
	(Person yrs.)	(Person hrs.)				
Catalyst evaluation	4	8,320	499,200	400,000	0	1.12
Engine modifications	6	12,480	748,800	500,000	0	2.19
Individual cylinder fuel control	4	8,320	499,200	500,000	0	1.87
Heated fuel preparation	3	6,240	374,400	400,000	0	1.47
EHC + HC adsorber eval. (D)	10	20,800	1,248,000	500,000	0	2.81
Low thermal capacity manifold	4	8,320	499,200	400,000	0	1.12
<b>Total</b>						<b>\$10.59</b>

**(B) Legal and Administrative Costs**

	No. Of Staff	Number of years	Staff Cost (in dollars)	Cost/Veh. (c) (dollars/vehicle)
Legal	0	0	0	0
Administrative	0	0	0	0

- (a) Development cost includes personnel, overhead and other miscellaneous costs at a total rate of \$60/hr.
- (b) Prototype development vehicles are estimated to cost \$100,000 each.
- (c) Cost has been distributed over 100,000 vehicles per year for 8 years.
- (d) For advanced engineering work in contrast to vehicle calibration/certification effort.

**Table II-36**  
**Passenger Car: Incremental Consumer Cost of a ULEV II Compared to a ULEV I**

		<b>4-cylinder (in dollars)</b>	<b>6-cylinder (in dollars)</b>	<b>8-cylinder (in dollars)</b>
Variable costs	Component	25.39	87.44	108.94
	Assembly	0.00	1.00	1.00
	Warranty	0.00	0.08	0.08
	Shipping	0.00	0.13	0.13
Support costs	Research	10.59	10.59	10.59
	Legal	0.00	0.00	0.00
	Administrative	0.00	0.00	0.00
Investment recovery costs	Mach & equipment	0.00	0.00	0.00
	Assembly plant changes	0.00	0.00	0.00
	Vehicle development	0.00	0.00	0.00
Capitol recovery		2.16	5.95	7.24
Dealership costs	Operating costs	1.14	3.16	3.84
	Capitol recovery	0.59	1.63	1.99
<b>Total incremental cost to consumer</b>		<b>\$39.87</b>	<b>\$109.98</b>	<b>\$133.81</b>

**Light-Duty Truck (0-8500 lbs. GVWR): Incremental Consumer Cost of a ULEV II Compared to a ULEV I**

		<b>4-cylinder (20%) (in dollars)</b>	<b>6-cylinder (59%) (in dollars)</b>	<b>8-cylinder (21%) (in dollars)</b>
Variable costs	Component	35.96	156.54	180.85
	Assembly	0.00	1.00	1.00
	Warranty	0.00	0.08	0.08
	Shipping	0.00	0.13	0.13
Support costs	Research	10.59	10.59	10.59
	Legal	0.00	0.00	0.00
	Administrative	0.00	0.00	0.00
Investment recovery costs	Mach & equipment	0.00	0.00	0.00
	Assembly plant changes	0.00	0.00	0.00
	Vehicle development	0.00	0.00	0.00
Capitol recovery		2.79	10.10	11.56
Dealership costs	Operating costs	1.48	5.38	6.13
	Capitol recovery	0.77	2.77	3.17
<b>Total incremental cost to consumer</b>		<b>\$51.58</b>	<b>\$186.56</b>	<b>\$213.50</b>

**MDV (8500-1000 GVW): Incremental Consumer Cost of a ULEV II Compared to a ULEV I**

		<b>8-cylinder (in dollars)</b>
Variable costs	Component	109.17
	Assembly	1.00
	Warranty	0.08
	Shipping	0.13
Support costs	Research	10.59
	Legal	0.00
	Administrative	0.00
Investment recovery costs	Mach & equipment	0.00
	Assembly plant changes	0.00
	Vehicle development	0.00
Capitol recovery		7.26
Dealership costs	Operating costs	3.85
	Capitol recovery	1.99
<b>Total incremental cost to consumer</b>		<b>\$134.06</b>

**Table II-37**  
**Light-Duty Truck (0-8500 lbs. GVWR): Incremental Consumer Cost of a SULEV Compared to a ULEV I**

		4-cylinder (in dollars)	6-cylinder (in dollars)
Variable costs	Component	75.98	158.53
	Assembly	0.50	2.00
	Warranty	0.00	0.08
	Shipping	0.00	0.13
Support costs	Research	10.59	10.59
	Legal	0.00	0.00
	Administrative	0.00	0.00
Investment recovery costs	Mach & equipment	0.00	0.00
	Assembly plant changes	0.00	0.00
	Vehicle development	0.00	0.00
Capitol recovery		5.22	10.28
Dealership costs	Operating costs	2.77	5.45
	Capitol recovery	1.43	2.82
Total incremental cost to consumer		<b>\$96.50</b>	<b>\$189.87</b>

**Light-Duty Truck (0-8500 lbs. GVWR): Incremental Consumer Cost of a SULEV Compared to a ULEV I**

		4-cylinder (in dollars)	6-cylinder (in dollars)
Variable costs	Component	124.97	245.38
	Assembly	1.50	2.00
	Warranty	0.08	0.08
	Shipping	0.13	0.13
Support costs	Research	10.59	10.59
	Legal	0.00	0.00
	Administrative	0.00	0.00
Investment recovery costs	Mach & equipment	0.00	0.00
	Assembly plant changes	0.00	0.00
	Vehicle development	0.00	0.00
Capitol recovery		8.24	15.49
Dealership costs	Operating costs	4.36	8.21
	Capitol recovery	2.26	4.25
Total incremental cost to consumer		<b>\$152.12</b>	<b>\$286.13</b>

**Table II-38  
Incremental Cost of a LEV II Vehicle Compared to a LEV I Vehicle**

Emission Category	LEV I Vehicle Category	New Vehicle Fleet Composition 4-cyl/6-cyl/8-cyl			Composite Incremental Cost (dollars)
		4-cyl	6-cyl	8-cyl	
ULEV	PC	58%	33%	9%	71.46
	LDT1	91%	9%	0%	46.18
	LDT2	4%	85%	11%	184.13
	MDV2	0%	21%	79%	207.85
	MDV3	0%	17%	83%	208.92
	MDV4	0%	0%	100%	134.06
SULEV	PC	63%	37%	0%	131.05
	LDT1	91%	9%	0%	104.90
	LDT2	5%	95%	0%	279.43

**Cost-Effectiveness of LEV II Vehicle Compared to ULEV I Vehicles**

Emission Category	LEV I Veh Category	Incremental cost to consumer (dollars)	Emission Reduction 120K miles			Cost-effectiveness		Inc. Cost-effectiveness	
			ROG (lbs.)	CO (lbs.)	Nox (lbs.)	ROG+NOx (\$/lb.)	ROG+CO/7+NOx (\$/lb.)	ROG+NOx (\$/lb.)	ROG+CO/7+NOx (lbs.)
ULEV	PC	71.46	0.0	48.4	67.3	1.06	0.96		
	LDT1	46.18	0.0	51.5	69.3	0.67	0.60		
	LDT2	184.13	2.3	171.2	159.7	1.14	1.10		
	MDV2	207.85	10.6	662.4	156.1	1.25	1.14		
	MDV3	208.92	13.3	796.8	244.0	0.81	0.56		
	MDV4	134.06	11.0	78.4	94.3	1.27	1.15		
SULEV	PC	131.05	5.8	205.5	81.6	1.50	1.12	2.96	1.40
	LDT1	104.90	5.9	216.0	83.9	1.17	0.87	2.85	1.33
	LDT2	279.43	7.7	335.7	174.4	1.53	1.32	4.76	2.19