

# Future is Electric Transportation

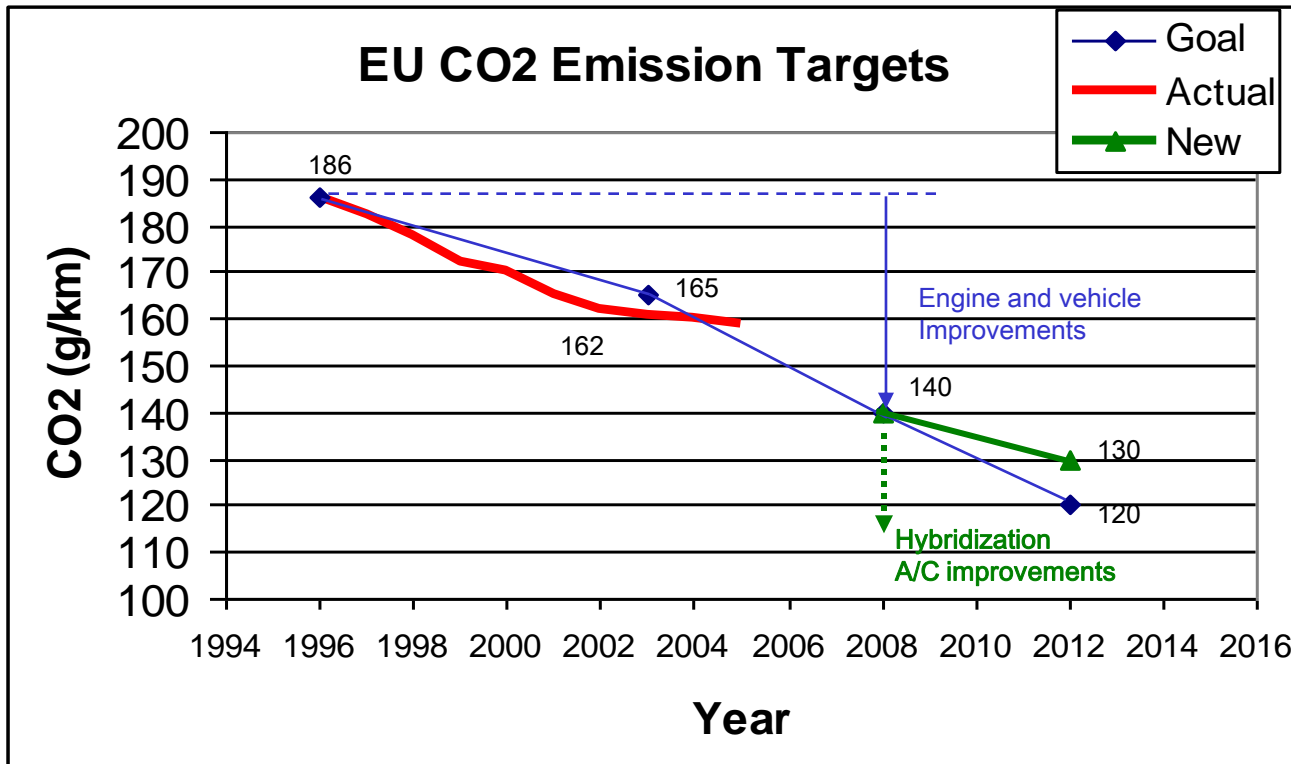
presented to:

**Jump Start to a Secure, Clean Energy Future  
Conference, Microsoft Campus**

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- Home energy consumption .....22%
  - Personal transportation.....28%
- Total energy consumption: ~50% U.S. energy
- Improvements in personal transportation must be our focus in total CO<sub>2</sub> reduction.
    - Per DOE EIA, 124M detached homes in U.S.
    - Home heat demand is 46 GJ/yr..... 3.68 ton
    - Home electricity consumption 12MWh/yr...10.16 ton
    - Personal vehicle (CAFÉ veh) 81GJ/yr..... 6.46 ton
- Home + personal veh CO<sub>2</sub>/year.....20.3 ton

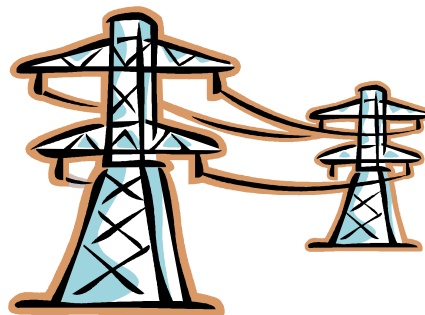
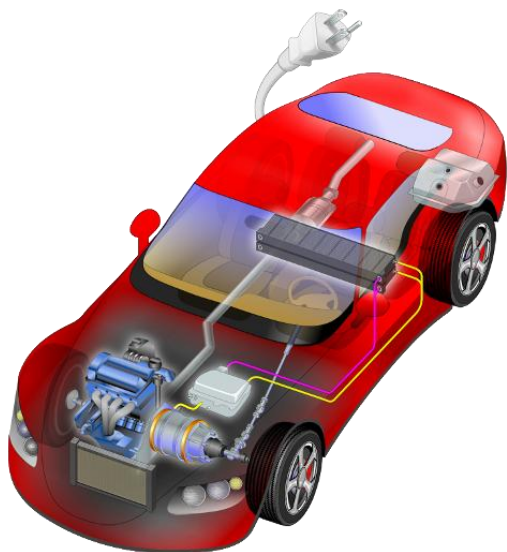
- Initial GHG targets were voluntary, grass roots A.C.E.A.
- In 2008 EU will set a 130 g/km target for 2012



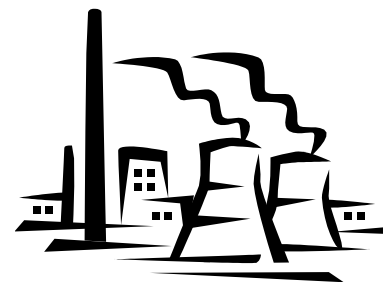
Vehicle	g/km	Ton/yr
Maybach	512	14
F250 Truck	460	12
VW Touareg	353	9.4
Grand Cherokee	310	8.2
Corolla	188	5
Camry Hyb	171	4.6
Civic Hyb	134	3.6
Prius	120.4	3.2
VW Tandem 1lit/	26	0.6

- For plug-in hybrids to make sense their gross CO2 emissions must be lower than conventional gasoline or diesel fueled HEV's.

PHEV @ 4 mi/kWh



T&D @ 90% eff.



A) 950g CO2/kWh for pulverized coal plant  
B) ~150g CO2/kWh IGCC & sequestration

A)  $1005\text{g CO}_2 / (4 \times 1.6\text{ km}) = 157\text{g CO}_2/\text{km}$   
=> Clean-up coal plant first  
B)  $167\text{g CO}_2 / (4 \times 1.6\text{ km}) = 26\text{g CO}_2/\text{km}$   
=> Introduce PHEV first

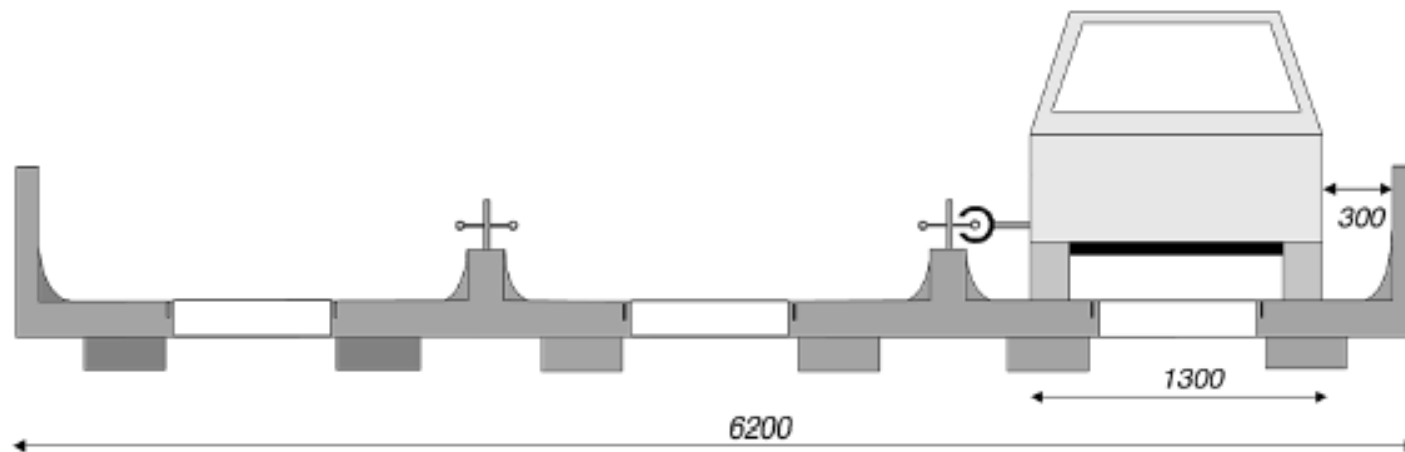
- Europe: ACEA goal is 120g CO2/km (currently at 140g CO2/km)
- Clean coal enables widespread PHEV introduction.

- Lithium for energy storage systems continues to displace nickel metal hydride technology.
- Ultracapacitor technology must improve its cost picture – for energy, and for energy throughput (Wh-cycles). AltairNano claim is <5x MXWL.

ESS Component	Specific Energy (Wh/kg)	Energy specific cost (\$/Wh)	Power specific cost (\$/kW)	Cycle Capability at 80% DOD # Cycles (Wh-cycles)
Ultracap	5	16 (3000F cell at module level)	12	>10 <sup>6</sup> 4x10 <sup>6</sup>
VRLA	30	0.12	80	3*10 <sup>2</sup> 7x10 <sup>3</sup>
NiMH	44	0.65	75	4*10 <sup>3</sup> 1.5x10 <sup>5</sup>
Lithium	70	0.50	75	JCS 2.5*10 <sup>3</sup> 1.4x10 <sup>5</sup> A123 5*10 <sup>3</sup> 2.8x10 <sup>5</sup> AltairNano 15*10 <sup>3</sup> 8.4x10 <sup>5</sup>

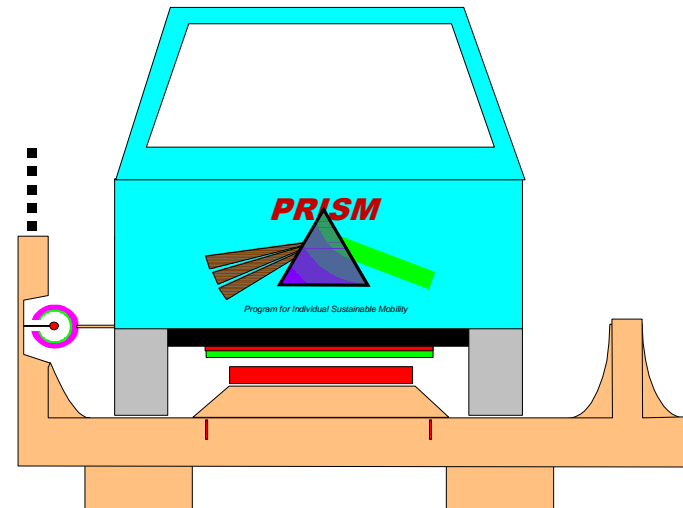
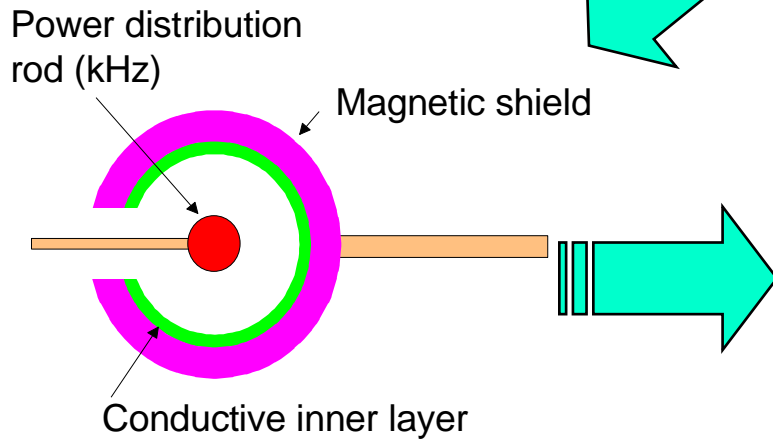
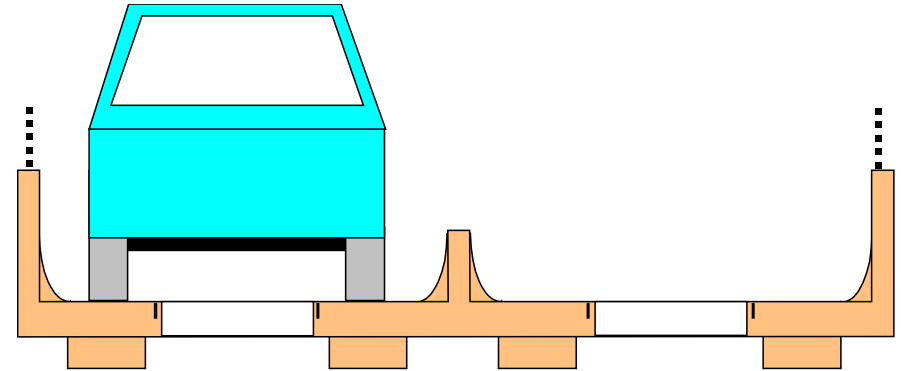
- Now seeing evidence of revived interest in electrified highway.
- Illustration of the guideway concept
  - City/highway mode: conventional hybrid vehicle performance and economy
  - Guideway mode: extra high speed, autonomous travel

**Figure 2** Cross section of PRISM guideway, including inductive power distribution (dimensions in mm)



Source: Excerpted from A Program for Individual Sustainable Mobility, Craig H. Stefan, John M. Miller, L. Craig Davis  
Int'l Journal Vehicle Autonomous Systems, Vol 2 Nos 3/4 2004

- Components of PRISM
  - Wheeled vehicle on guideway
  - Autonomous control
- Add in power coupling
  - Coaxial winding transformer
  - Inductive coupling ~20kHz, up to 200 kW and higher



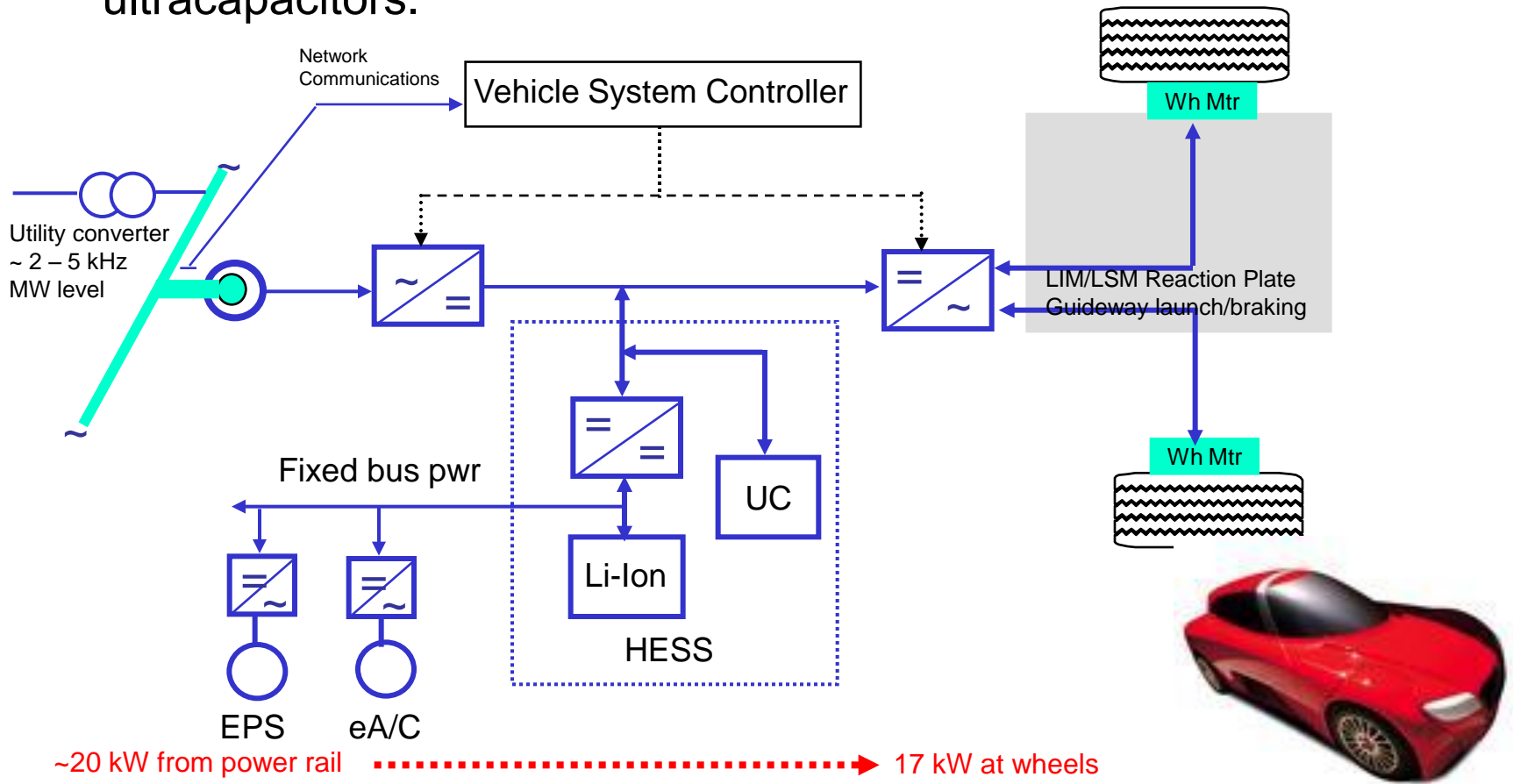
- Narrow (1200 mm) wide vehicles having extraordinary fuel economy are not new.
- VW developed the Tandem in 1999 having a single cylinder, 0.3 liter, CI engine to realize 1lit/100km.
  - 12 kg single cylinder CI engine, 6.3 kW (@ 4500), 18 Nm (@2000)
  - 120 kph top speed, 650 km range on single fill-up



An illustration of a tandem Vehicle that has already been proven capable of 235 mpg!



- Illustration of on-guideway power flows
  - Coupled with clean coal, modern power electronics and energy storage technologies – high energy battery and high power ultracapacitors.



- Present 380ppm CO<sub>2</sub> is rising rapidly to 450ppm
  - Global commitment could clamp at 500-600ppm.
- Climatic changes are positively tied to CO<sub>2</sub>
- Electrification of U.S. transportation will have the equivalent impact of 400 Gen IV nuclear plants
- More focus on carbon free renewables will enable sustainable mobility without resorting to more nuclear.
  - Need much more emphasis on electrics and PHEV
  - Which now means Energy Storage Technologies.