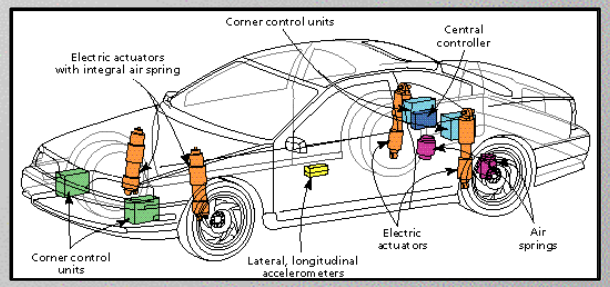
Transportation Market Potential of ThermoElectric Devices (TED)

Sam Ciray
ArvinMeritor
Air & Emissions Technologies

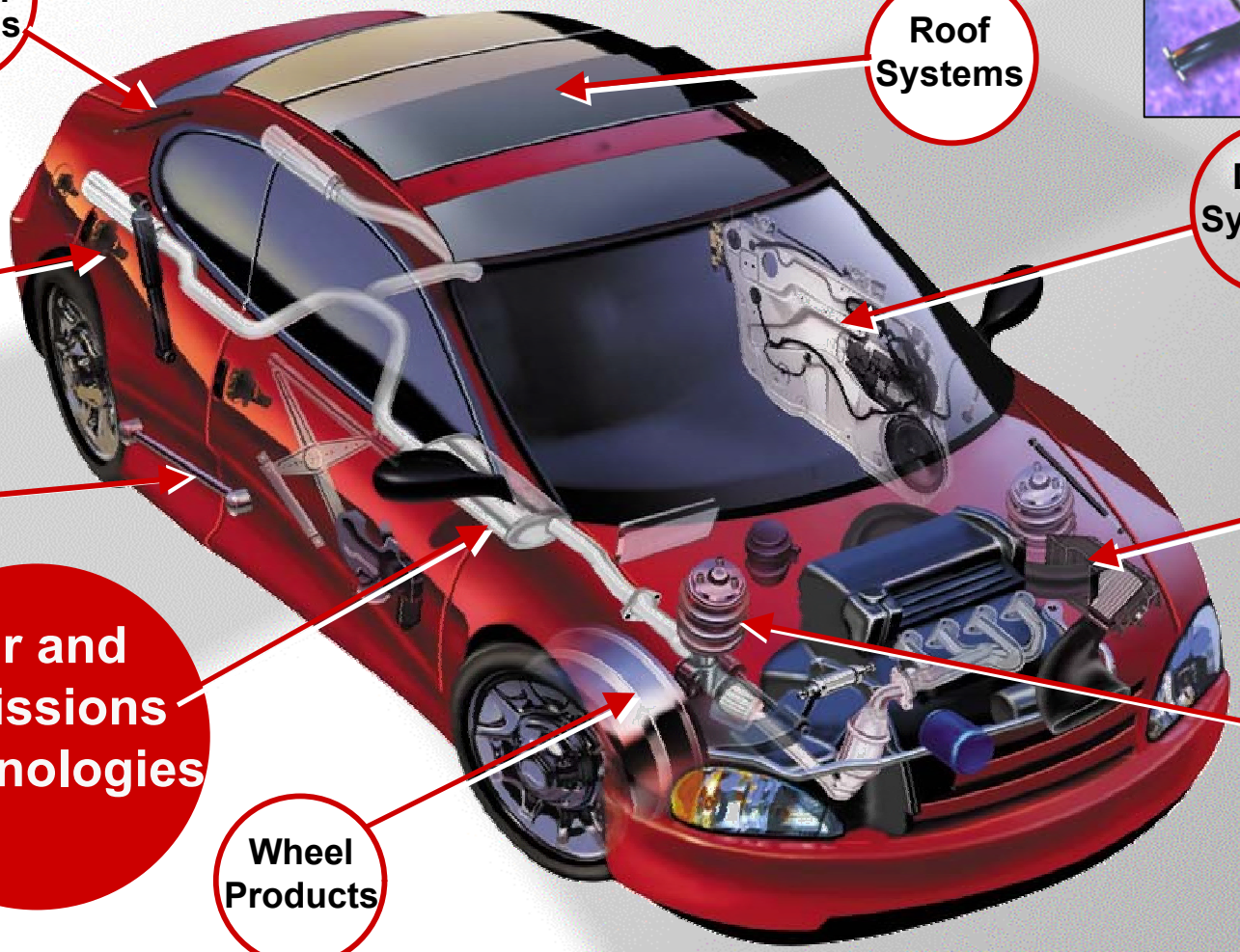


Who is ArvinMeritor?

ArvinMeritor Inc. is a premier $7-billion global supplier of a broad range of integrated systems, modules and components to the motor vehicle industry. The company serves light vehicle, commercial truck, trailer and specialty original equipment manufacturers and related aftermarkets. In addition, ArvinMeritor is a leader in coil coating applications. The company is headquartered in Troy, Mich., and employs 33,000 people at more than 150 manufacturing facilities in 27 countries.

Light Vehicle Systems

Original Equipment and Aftermarket



Motion Control Systems

Roof Systems

Door Systems

Access Controls

Coil Coating

Filtration Systems

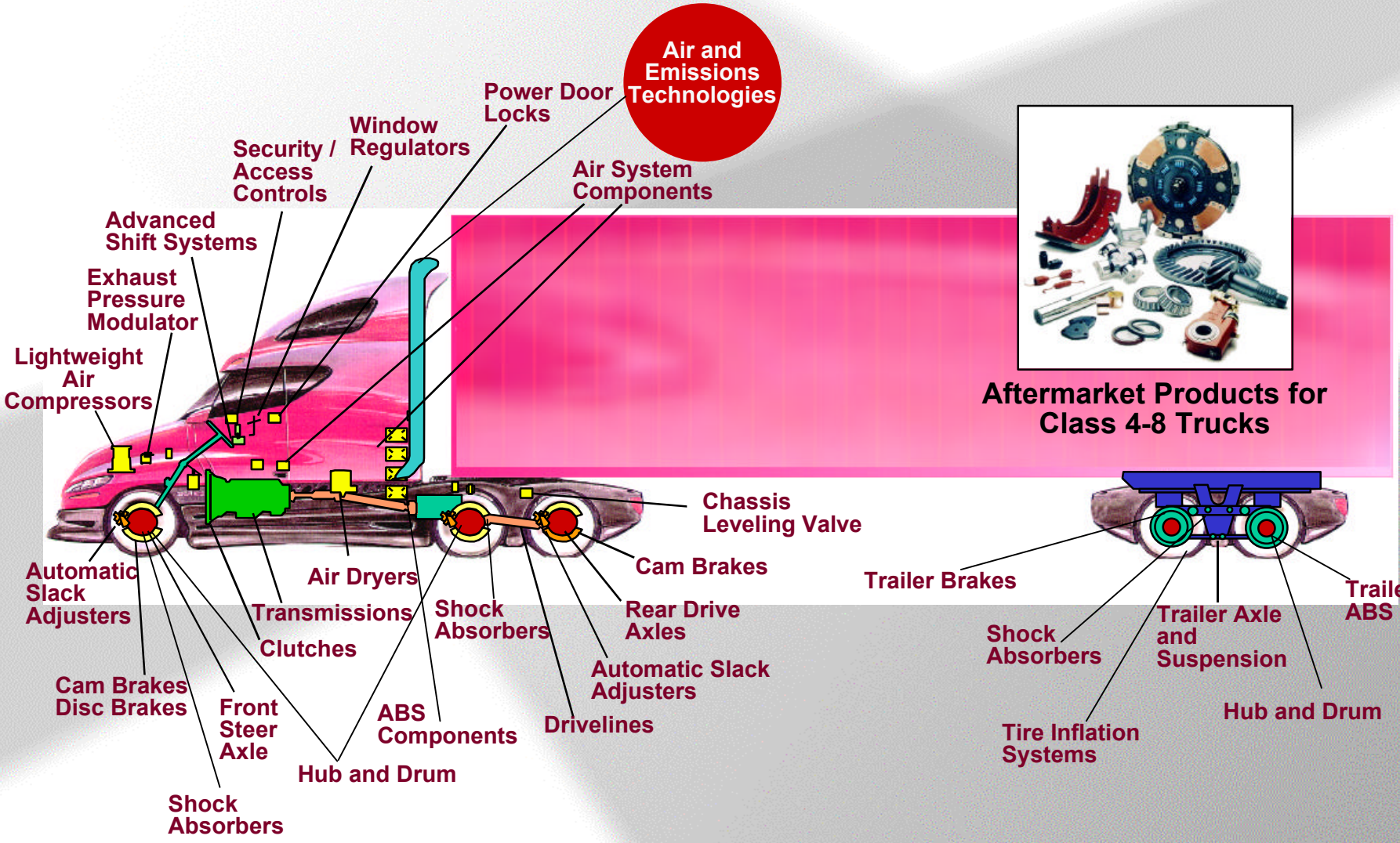
Air and Emissions Technologies

Modular Suspension Systems

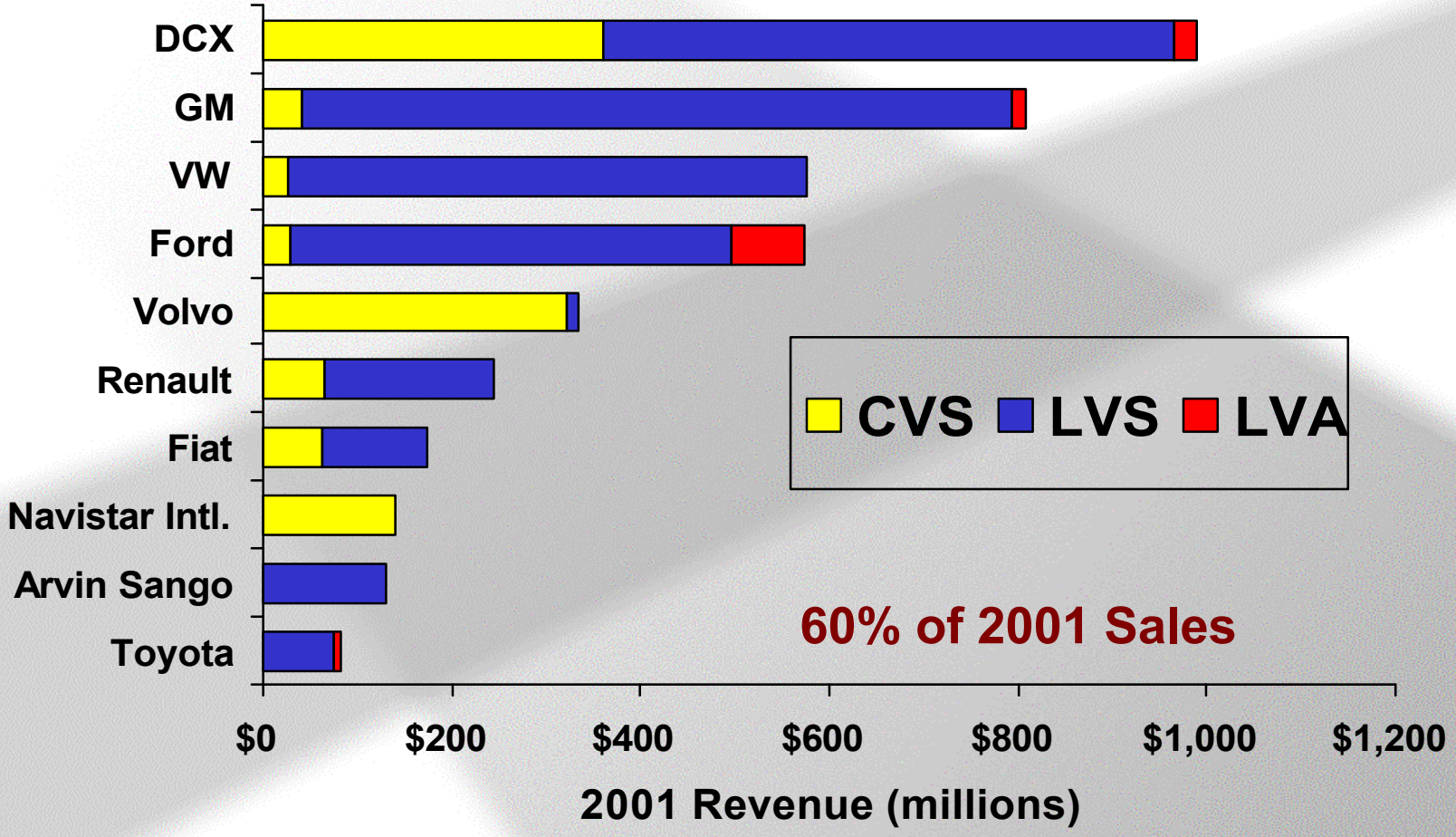
Wheel Products

Commercial Vehicle Systems

Original Equipment and Aftermarket



Customer Diversity



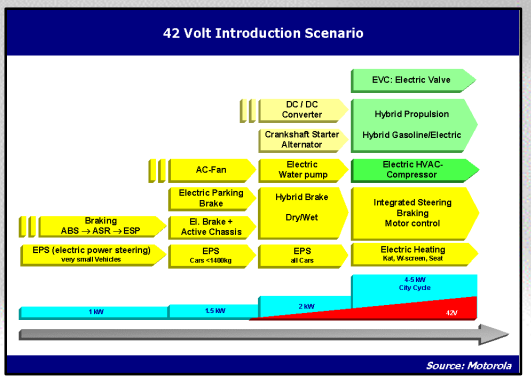
Significant Relationships with Major Vehicle Producers

ArvinMeritor and TED Technology

- **Why is ArvinMeritor interested in TEDs?**
  - ✓ Future demand for increased automotive electric power
  - ✓ Exciting new technology with exciting potential for growth
  - ✓ Waste heat recovery from automotive exhaust systems
  - ✓ Strategic direction to improve powertrain efficiency that will result in a reduction of harmful emissions
  - ✓ We have a clear channel to market given our relationships with automotive and HD truck OEM's

Automotive Electric Power Trends (Auxiliary Loads)

- Today's average vehicle operates at power levels of ~ 1– 2 kW. Although there are alternative views, 2010 vehicles could require between 3 - 4 times that level!
- Vehicle electrical system requirements have more than doubled over the last 30 years and are expected to continue to increase at a rate of 5% annually.
- The creation of an additional 1 kW could result in a fuel savings of 10 – 15% on a medium-sized vehicle.



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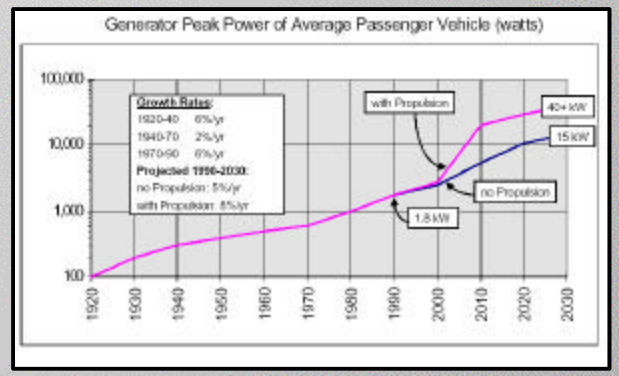

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Driving Factors for Transportation Electric Power

*** Reduction of fuel consumption * Emission reduction * * Improved safety * Improved comfort ***

These factors can be achieved with the introduction of new electronic systems, and/or the replacement of mechanically driven systems with electrical ones.

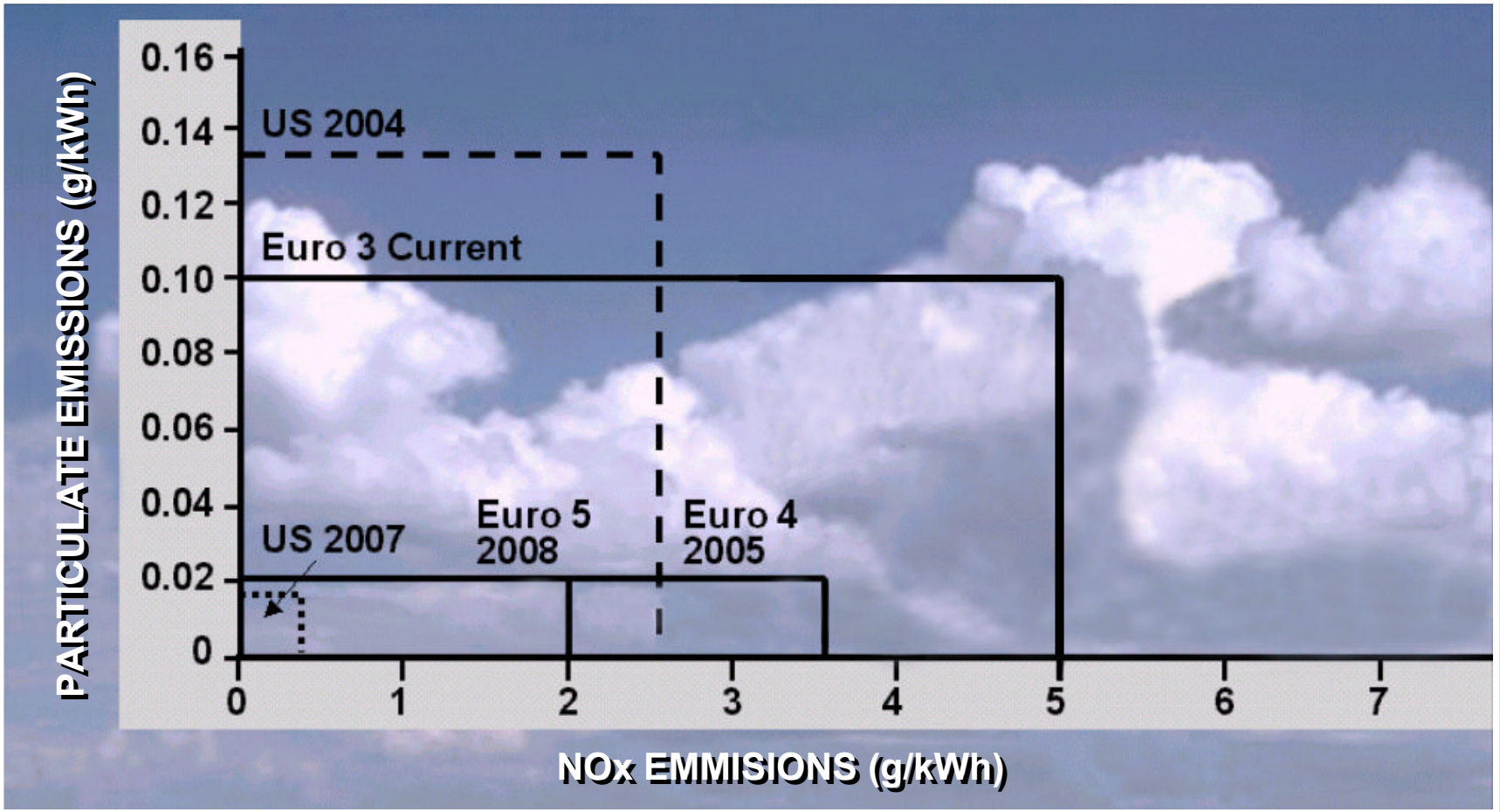
Electrical Loads	
Component	**Peak, Watts**
ABS pump	600
Active suspension	12000
Air pump	400
Brake by wire	2000
Catalyst	3000
Electric A/C compressor	4000
Electric fan	800
Engine coolant pump	500
Heated front seats	2000
Heated steering wheel	120
Heated windshield	2500
Infotronics	100
Lights	600
Power door locks	400
Power seats	1600
Power sunroof	200
Power Windows	700
Rear defrost	1500
Rear wiper	90
Steer by wire	1800
Trunk closer	200
Valve control	3200
Winshield pump	100
Wipers	300

TOTAL PEAK ELECTRIC DEMAND

35.9 kW

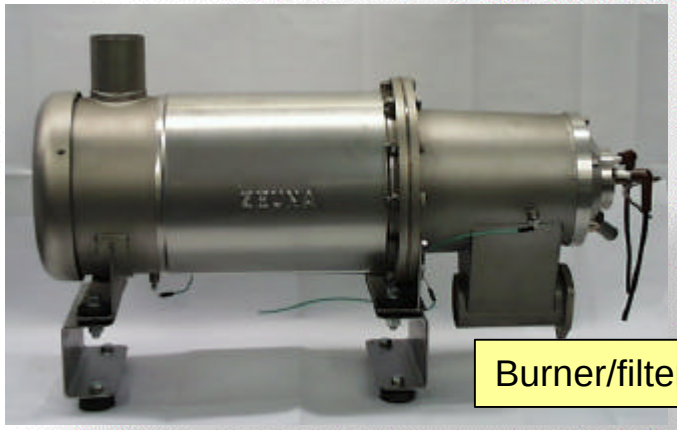
Source: SAE International – 42 Volt Systems

Commercial Vehicle Emissions Potential



- Leadership position in emissions technology
- $1.6 Billion Market Opportunity

ARM CVE Applications



Burner/filter

Cat/filter/burner muffler fitted to Volvo at Warton

Cat/filter/burner

Alternate (Competing) Technologies

- There will be various technologies competing to supply the additional electronic needs of the future
  - TED's
  - Fuel Cells
  - Advanced Alternators
  - Advanced Batteries
  - Ultra-capacitors
  - Flywheels Technology

Potential APU Markets

- Luxury Vehicles
- Recreational Vehicles
- Heavy Duty Trucks
- Short Haul Trucks
- Passenger Vehicles

$800/kW → $400/kW → $100/kW

However, the technologies will need to be cost effective!

Source: U.S. Department of Energy – Pacific Northwest National Laboratory

TED vs. Current Technologies

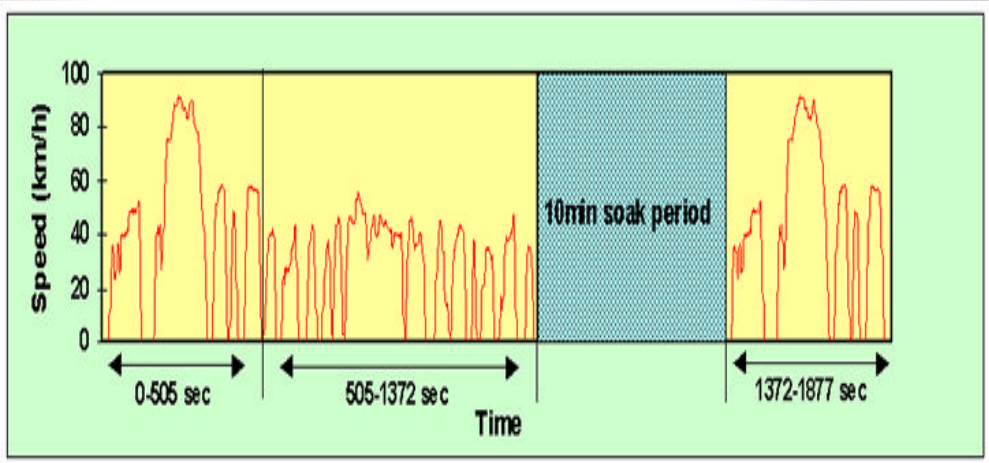
	Conversion Efficiency	Cost	Power Density	Life Span
	%	$ / kW	kg / kW	years
TED	30%+	$0.30 - $0.50	?	?
Fuel Cell APU	30 - 40%	$0.40 - $0.80	10	5 - 10
Alternator	50 - 80%	$0.05 - $0.10	2 - 3	4 - 8
	Energy Efficiency			
Battery (lead acid)	80%	$0.12 - $0.15	150 - 400	5 - 10
Battery (Lithium ion)	95%	$0.20	200 - 300	7 - 12
Battery (Ni-MH)	70%	$0.20 - $0.35	200 - 300	10+
Ultra-Capacitor	85 - 98%	?	< 10,000	?
Flywheel	80%	?	2000 - 8000	20+

TED vs. Current Technologies

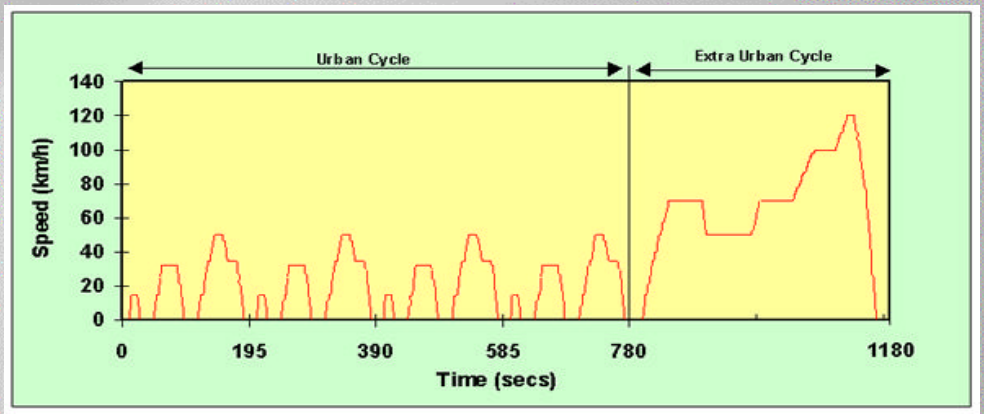
- **Unaccounted cost benefits of TEDs**
  - **How do we quantify the emissions benefits to?**
    TED's will be able to augment the existing shaft driven alternator, resulting in significant fuel savings. Additionally, the impact of TED technology could lead to a reduction in overall engine size, and therefore, result in lower emissions.
  - **Same with solid-state benefits in warranty $$?**
    No moving parts means that the lifetime of the TED should exceed that of the vehicle. If TED technology leads to total replacement of the alternator, warranty costs related to alternator replacement can be avoided.

Technical Challenges

- Efficiency vs. Package Size
  - Temperature Differential
  - Air vs. Water cooling on the cold side
- Availability of waste heat
  - Cold start (how long until TED generates sufficient electrical power)
  - US FTP vs. European ECE drive cycles

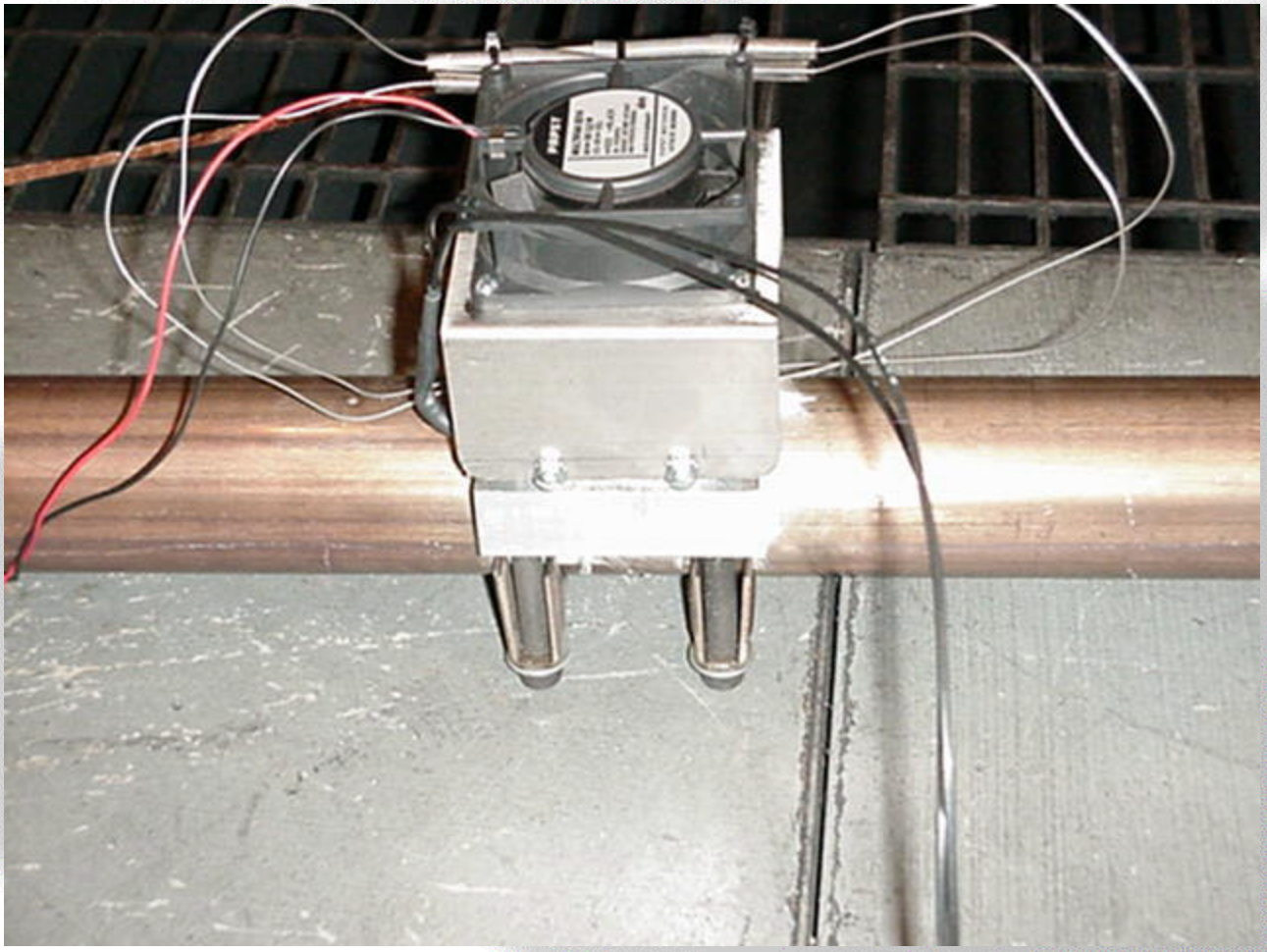


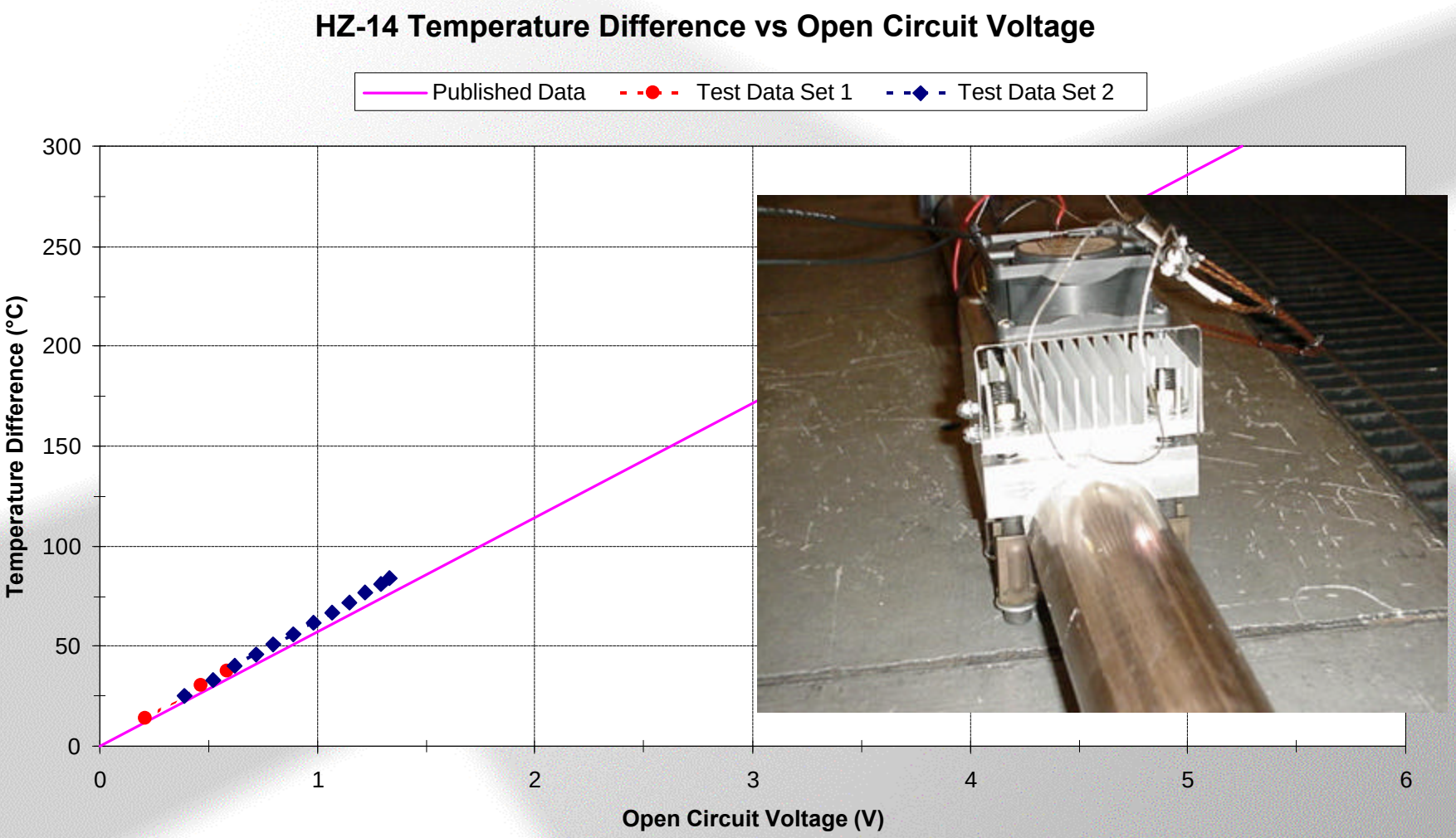
US FTP-75



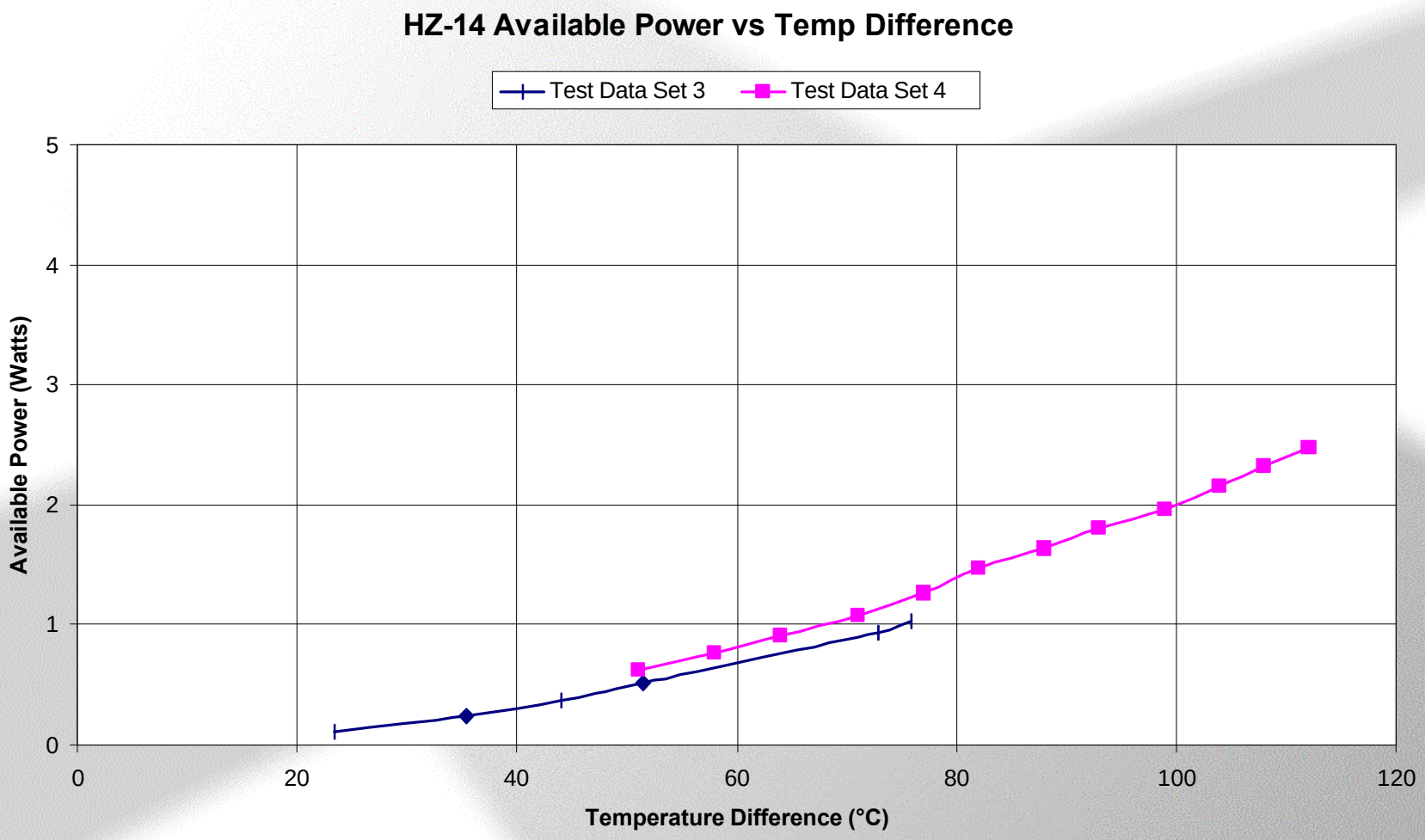
Euro 20% cycle

Preliminary TED Testing on Exhaust Pipe



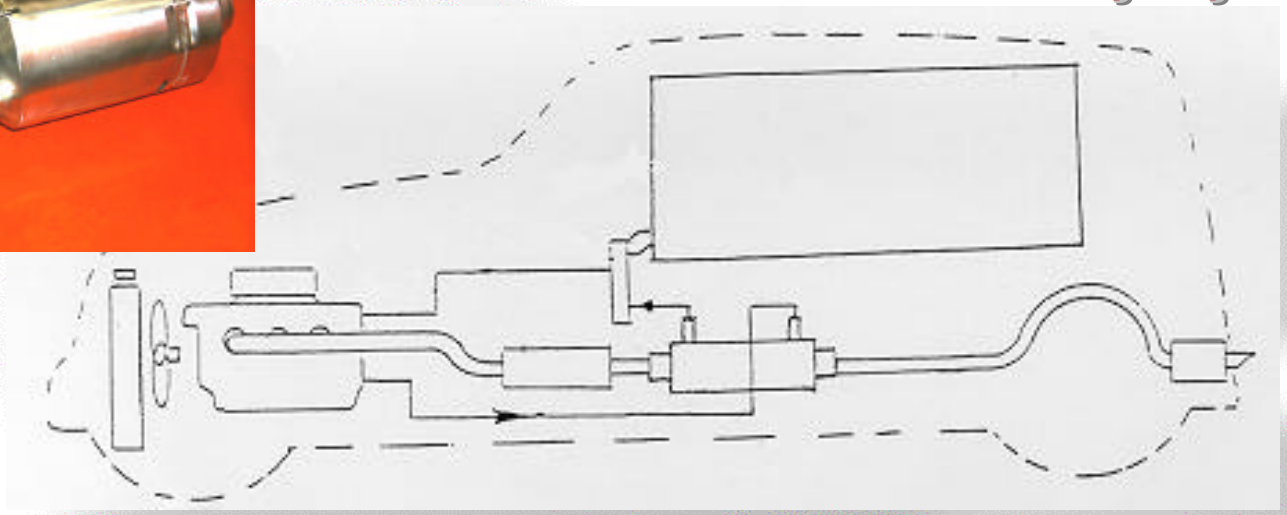


ArvinMeritor Test Data



ArvinMeritor Test Data

Exhaust Heat Recovery System

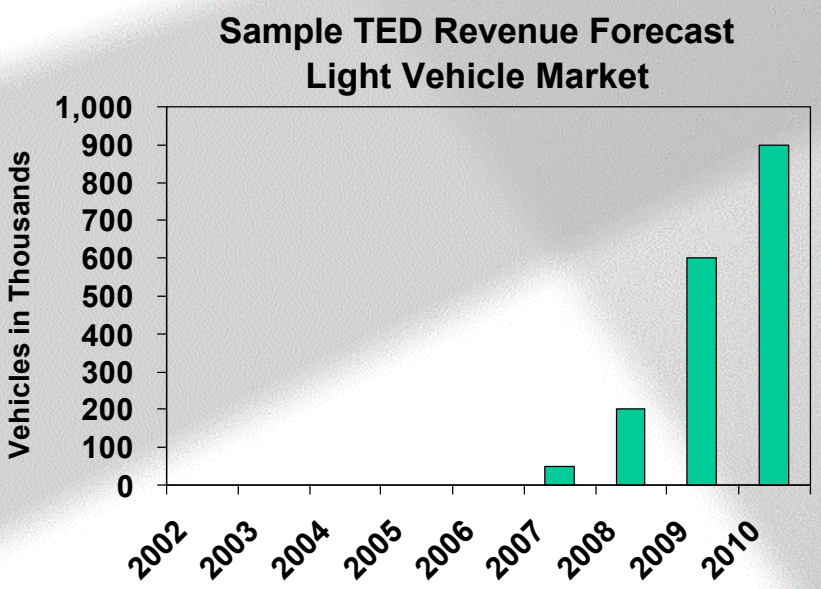


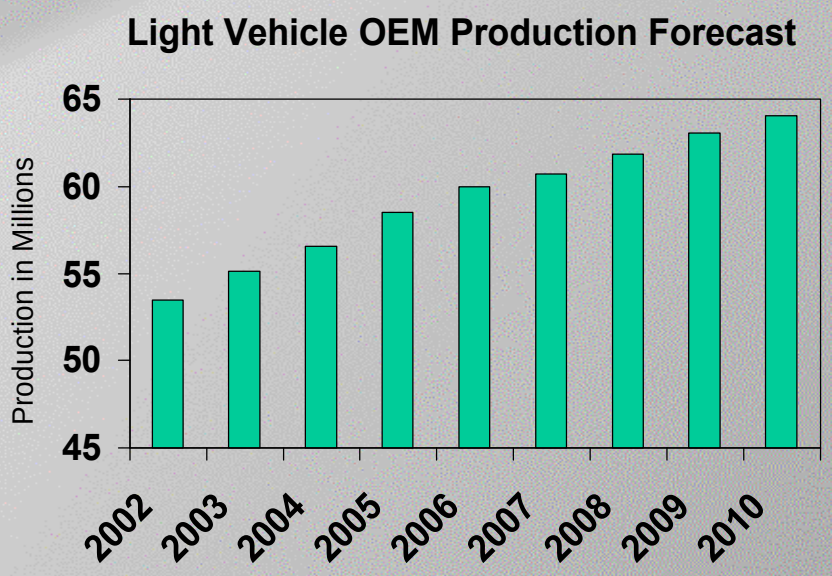
BENEFITS –

- **FAST WARM-UP: Small hybrid vehicles and modern DI turbo diesel vehicles using engine coolant heaters can not supply heat quickly. An exhaust heat exchanger can be used to quickly warm-up the passenger compartment.**
- **CONTINUOUS EXTRA HEAT: For cold climates and for larger vehicles (Vans & SUV's) which have higher heating requirements. Good for diesels in the European market.**
- **IMPROVING EMISSIONS: This type of auxiliary heating of engine coolant should improve engine cold-start response**

TED Market Potential Automotive Focus

- TED technology can quickly be applied to the heavy-duty truck market in the recovery of exhaust heat. The result will be increased in fuel savings - given their annual idling fuel consumption of ~ 1,230 gallons/year. (source: Argonne National Laboratory)
- We believe that the light vehicle market penetration rates for TED technology will be very similar to that of 42V technology. This assumption translates into a 10% penetration in 5-6 years and 25-35% in 10 years [after introduction to market]. (source: Darnell Group)



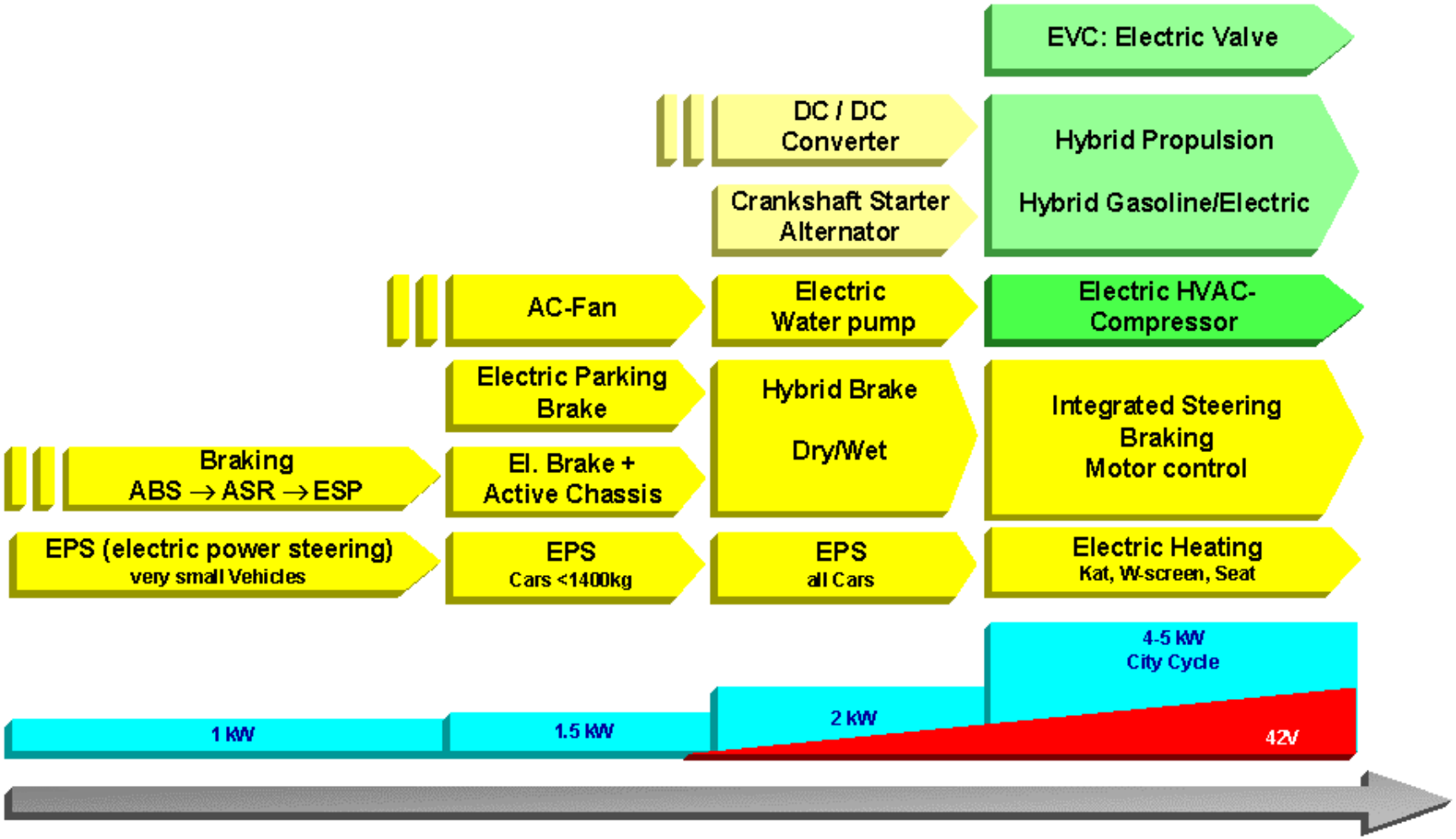


Our Vision for TED Technology

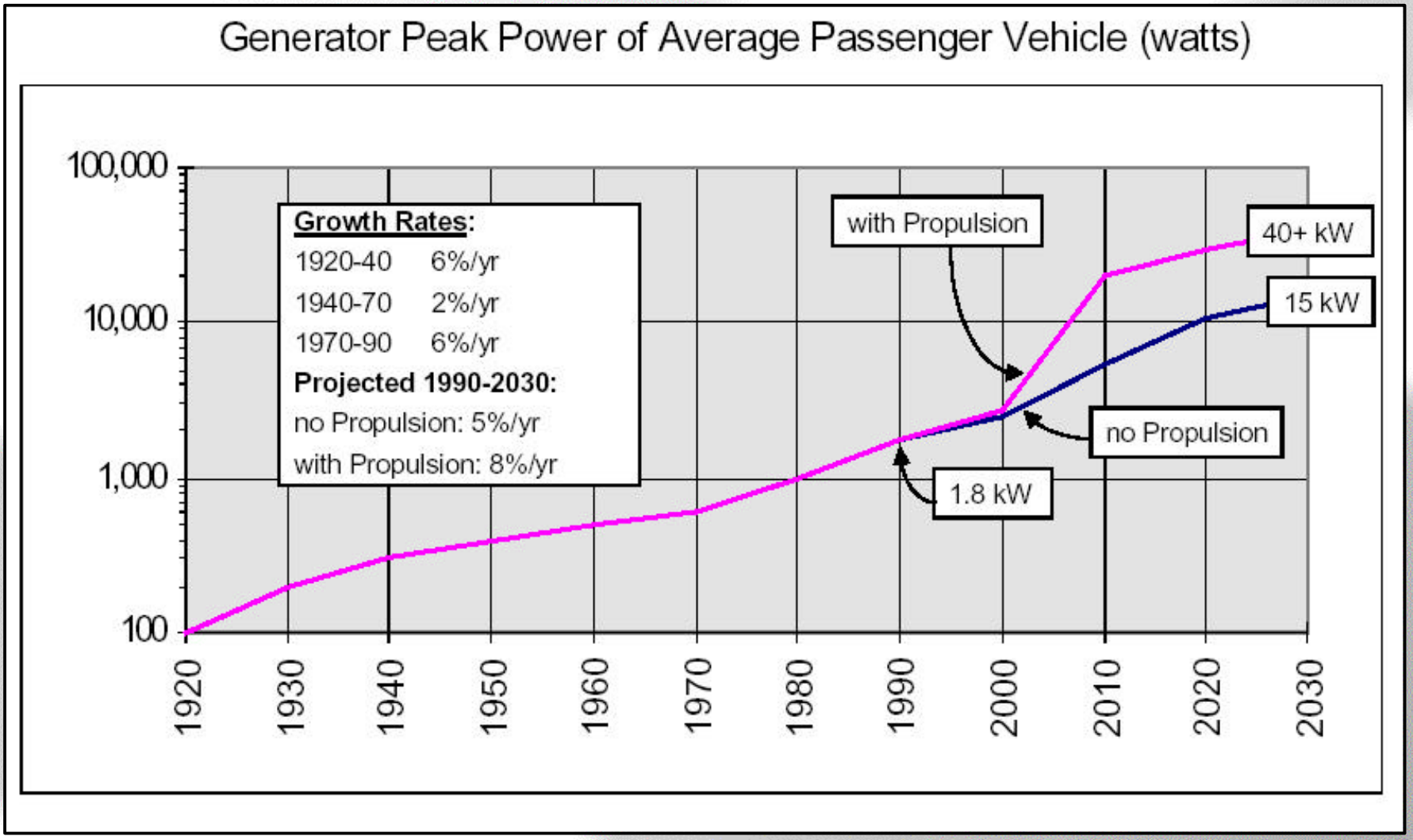
- TED technology represents an opportunity for strong growth in the automotive market.
- Capitalizing on recovery of exhaust waste heat will be our initial focus.
- TED's can not currently cost-competitive with the batteries and alternators.
- TED's must be able to compete in terms of $/W in order to be a viable technology.
- Additional funds will be required to further develop this technology.

THANK YOU

42 Volt Introduction Scenario



Source: Motorola


Generator Peak Power of Average Passenger Vehicle (watts)
100,000
10,000
1,000
100
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
Growth Rates:
1920-40 6%/yr
1940-70 2%/yr
1970-90 6%/yr
Projected 1990-2030:
no Propulsion: 5%/yr
with Propulsion: 8%/yr
with Propulsion
40+ kW
15 kW
no Propulsion
1.8 kW