Toyota and the Environment

EEP 142

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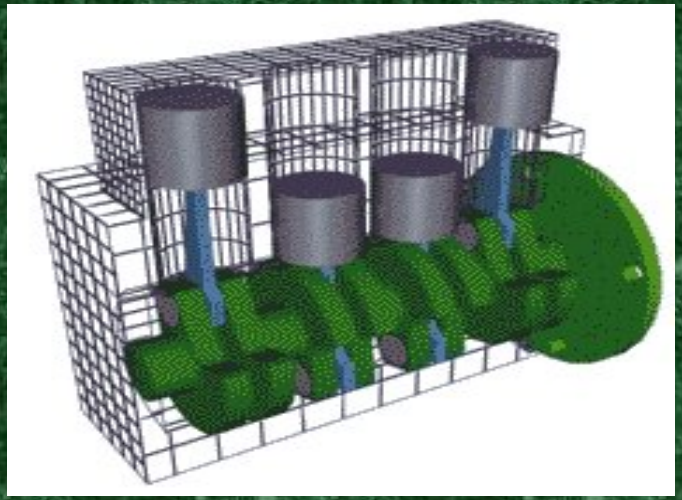
The Prius

- Gas-Electric Hybrid
- 1.5 L 76 hp@ 5000 RPM, I4 ICE engine
- 500V electric motor 67 hp@ 1200-1540 RPM
- Net system power 110 hp (82 kW)
- Hybrid Synergy Drive ® System : Power Split Device
- mpg estimates: 60(city)/51(highway)/55(combined)
- Super Ultra Low Emissions Vehicle (SULEV) in CA



Basic G-E Hybrids

- ***Parallel Design***: This drivetrain includes a fuel tank to power the ICE engine as well as batteries to power the electric motor. Both the electric motor and ICE engine connect to the transmission, which means both can provide propulsion power independently or simultaneously.

- ***Series Design***: The ICE engine turns a generator which in turn can either charge the batteries or power the electric motor to propel the vehicle (ICE engine does not directly power the vehicle.

Hybrid Synergy Drive®

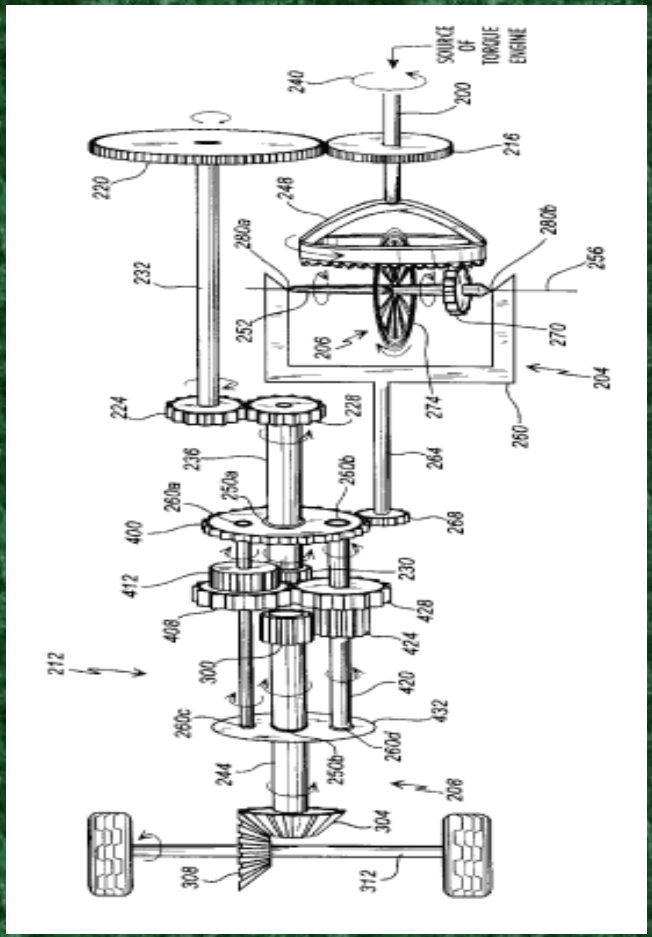
- ***Full hybrid system*** is capable of operating in either gas or electric modes, as well as operating under both engine and electric mode

- Major improvement with new HSD from 1997 Prius by designing more efficient drivetrain to increase duration of electric-mode driving as well as the peak power delivered electrically

- ***Triangular mono-form shape*** gives it a Drag Coefficient of 0.26 (measures how aerodynamic a vehicles design is) reducing the force needed to act against air resistance thus improving fuel efficiency ($F_d = 0.5C_d\rho Av^2$)

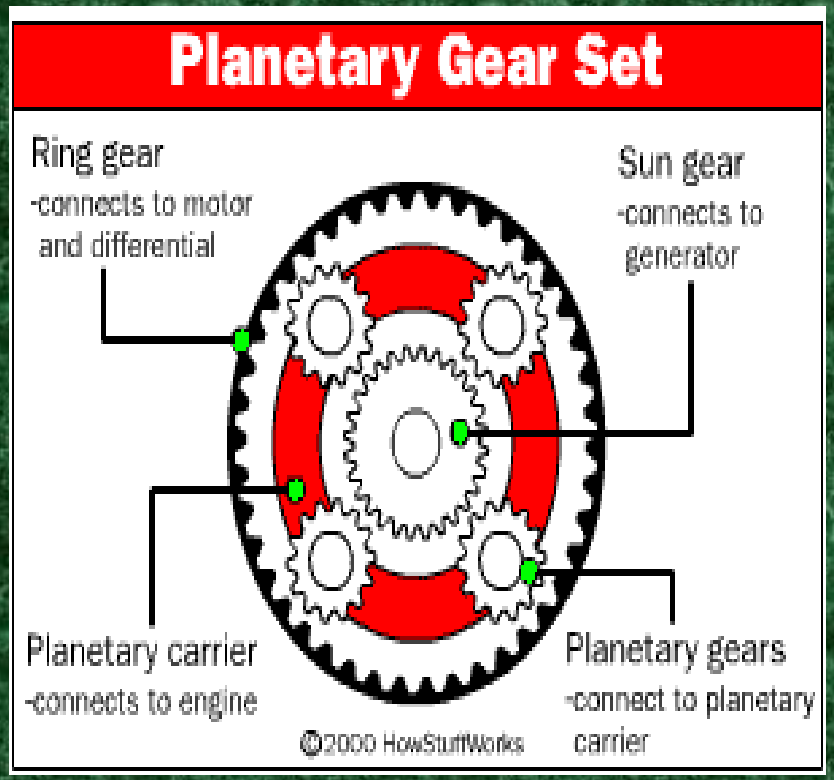
Continuously Variable Transmission (CVT)

- *Electronically controlled*-CVT (EVCT) is a system that makes it possible to vary progressively the gear ratio so that the transmission can select infinite numbers of ratios.
- Improves fuel efficiency by always allowing the engine to operate at its optimum RPM.



The “Power Split Device”

- Planetary Gear Set in ECVT is a gearbox that connects the engine, generator, and electric motor
- Under initial acceleration the electric motor and batteries provide all the power to spin the ring gear (planet carrier stationary when engine is not running)
- As vehicle accelerates the generator spins until it reaches a threshold speed (approx 25 mph) in which the ICE engine then turns the planetary gears.



Do G-E Hybrids need to be plugged in?

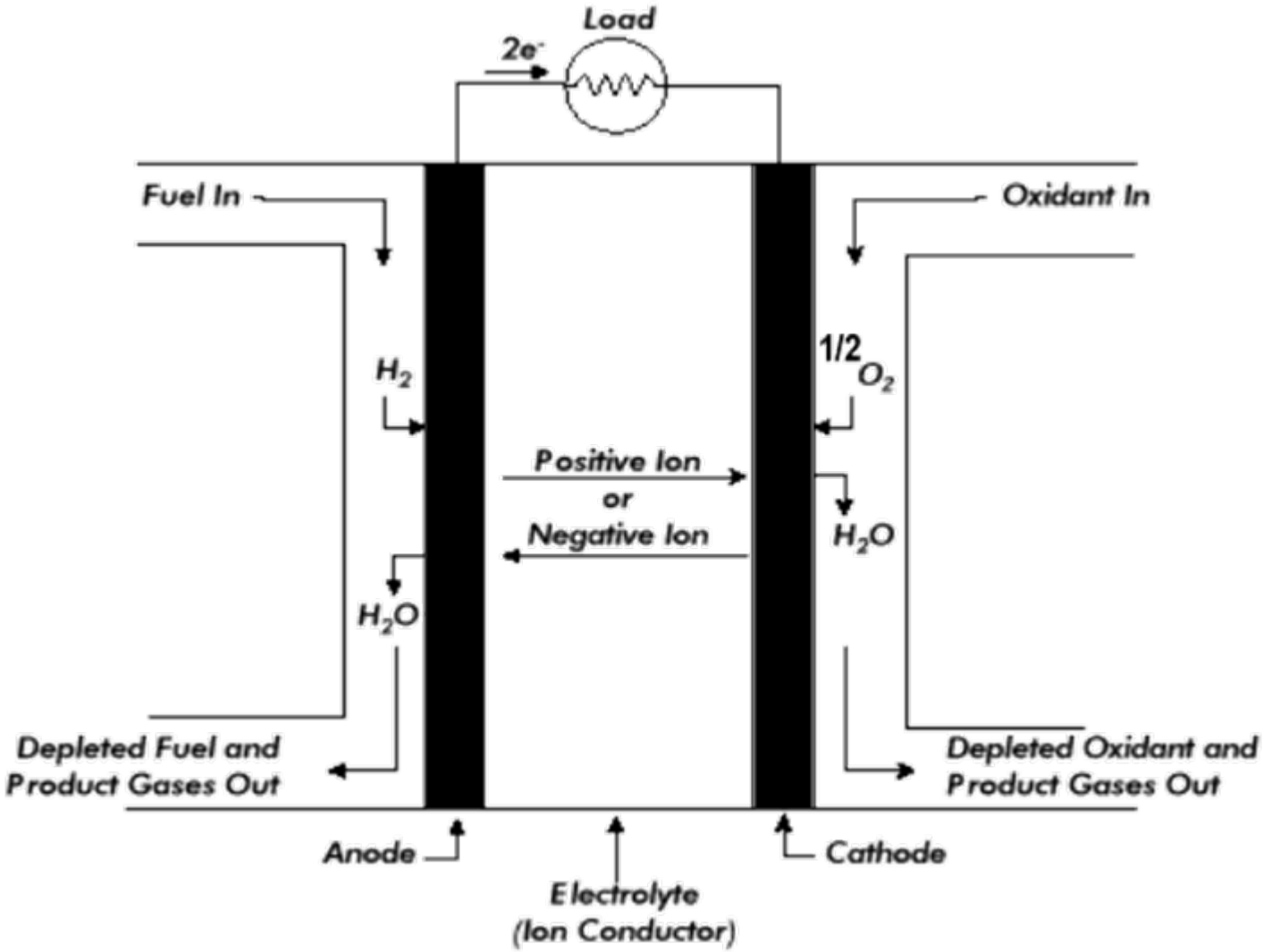
- The Prius doesn't need to be plugged in to be recharged, the onboard generator automatically maintains proper level of charge in the batteries (never full or empty)

- *Regenerative braking system* allows heat energy from braking to be used in recharging the nickel-metal hydride (Ni-MH) batteries.

What do space ships and Toyota vehicles have in common?

- Fuel-Cell Hybrid Vehicles (FCHV-3) methanol-reformer for on-board creation of hydrogen for fuel cell stack (1997)
- Fuel cell is comprised of four main components: methanol storage tank, methanol reformer to create hydrogen, fuel cell stack, and permanent-magnetic electric motor.
- $CH_3OH + H_20 \rightarrow 3H_2 + C0_2$ … $\Delta H > 0$ (endothermic)
- Fuel is mixed with water , pumped into the reformer, heated, and converted to hydrogen and carbon dioxide in a catalyst bed. Most of the hydrogen is removed from the reformed gases using a purification membrane. The leftover hydrogen and the carbon dioxide (referred to as raffinate) is sent to a burner to provide heat.

Schematic of Individual Fuel Cell



Fuel-Cell Hybrid Vehicle (FCHV-4)

- FCHV-4 system uses 4, 5000-psi hydrogen fuel tanks rather than on-board hydrogen formation (based on Highlander SUV)
- Problem with direct hydrogen through hydrogen-absorbing alloy tank and safety of carrying high pressure flammable Hydrogen on board?
- Methanol (CH_3OH) is a liquid fuel and can be stored in existing underground gas station tanks and dispensed at minimal equipment costs versus high infrastructure cost for establishing of hydrogen fueling stations.
- Not zero-emission vehicle since CO, HC, and NOx are by-products of fuel-cell reformation process.

FCHV Specifications

Base platform	Kluger V [Highlander]
Dimensions	4,685 x 1,825 x 1,720 mm
Maximum speed	Higher than 150 km/h
Cruising distance	More than 300 km
Seating capacity	5 persons
Fuel cell type	Polymer electrolyte fuel cell stack
Output	90 kW
Motor Type	Synchronized permanent magnet
Maximum output	80 kW
Maximum torque	260 Nm
Fuel Type	Pure hydrogen
Storing method	Hydrogen-absorbing alloy tank
Secondary battery Type	Nickel-metal hydride battery

How safe are hybrids in the case of an accident?

- High-voltage cables are located away from areas emergency workers might access, painted orange, are shrouded in metal and have specific automatic disablement mechanisms to ensure the lines have no voltage in the case of an accident.

Aren't Diesels just as fuel efficient as hybrids?

- While some diesel vehicles get high fuel mileage, it is important to look at emissions when considering a vehicle's impact on the environment.
- The best diesels on US roads today are allowed more than 17 times more smog-forming emissions than the Prius.
- A *Rebound Effect* if mpg declines and VMT increases?

Toyota Recycle Vision Goals (initiated in 2003)

- 1.Improve vehicle recovery rates
- 2.Increase use of renewable resources and recycled materials
- 3.Promote distribution of re-used parts
- 4.Reduce use of substances of environmental concern

- “At Toyota, our concern for the environment starts when a car is born and continues until its useful life is over.” Quote from Toyota website
- What makes Toyota’s plan unique is its consideration of recycling at various stages in the entire life cycle of cars from development/design, dealers, and end-of-life vehicles.

Development/Design Stage

- Four Key Points in this stage:
- 1.Adoption of technologies that are environmentally considerate
- 2. Attention to dismantlement
- 3.Reduction of substances of environmental concern
- 4. Reduction of polyvinyl chloride (PVC) resin usage

1.Adoption of technologies that are environmentally considerate

- a. A molecular design technology based on a new crystallization theory for production of TSOP (Toyota Super Olefin Polymer)
- b. A technology that makes it possible for paints of bumpers to be easily decomposed; this technology cuts off the strong bonding of molecules of paints

2.Attention to dismantlement

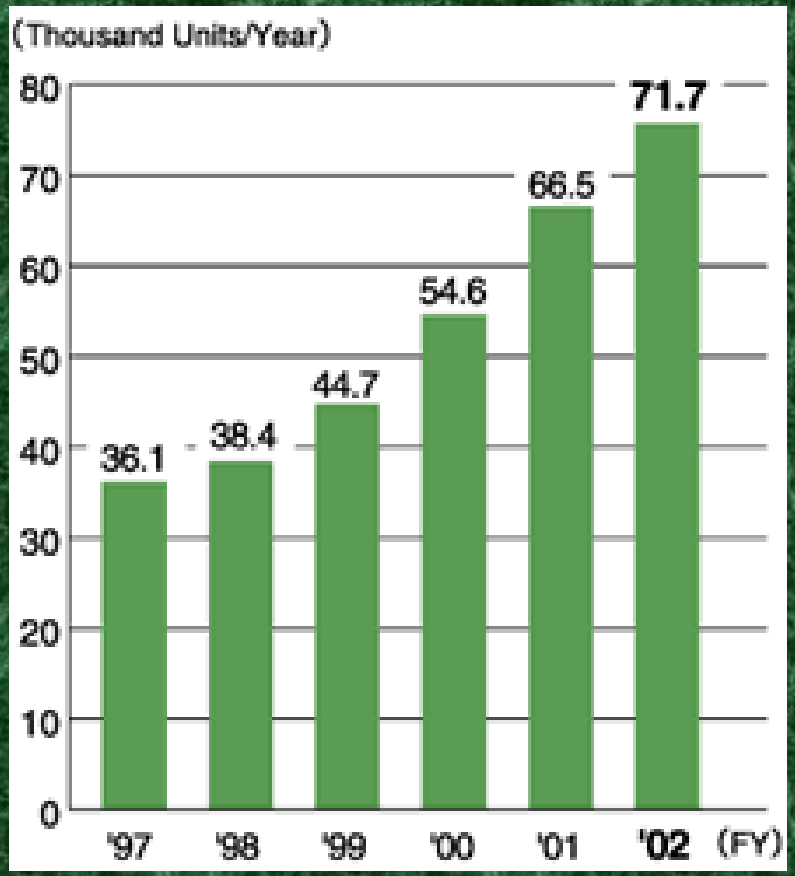
- Toyota has succeeded in designing easy-to-dismantle cars and cutting
  dismantling time by 30 percent. The specific steps for making this possible:
- a. Structures that allow fastened areas to come apart when pulled hard
  b. Use of clips instead of screws for securing components whenever possible
  c. Parts integration
  d. Avoidance of composite materials (eliminating the need for separating and sorting during dismantling)

Reduction of substances of environmental concern

- This leads to decrease the volume and increase the quality of ASR (automotive shredder residue) generated from end-of-life cars.
- 4 main substances of environmental concern: Lead, Mercury, Cadmium, and Hexavalent chromium.

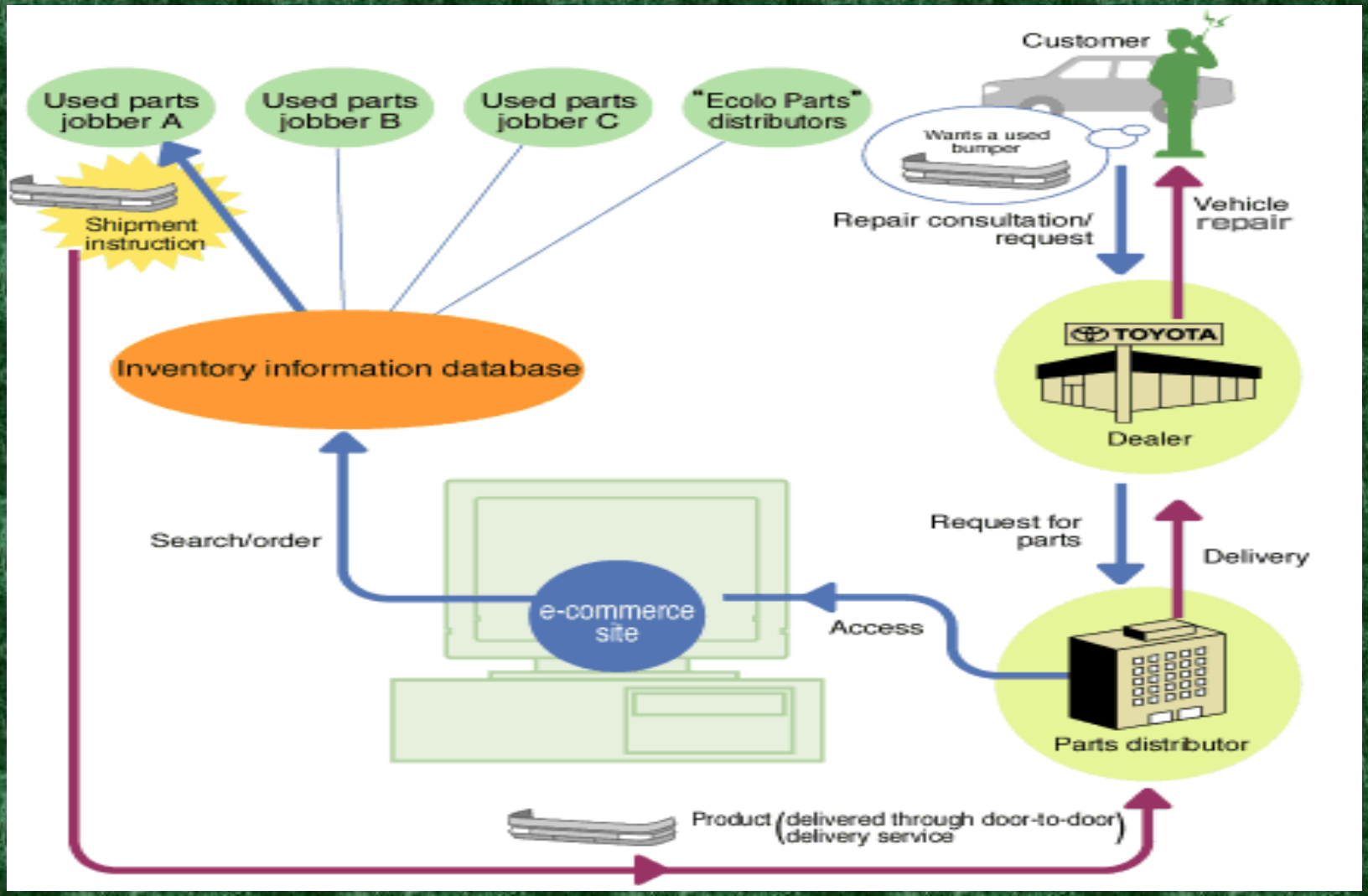
Dealers: Recycling of recyclable materials

- Collecting bumpers: According to statistics in 2002, 76 percent of bumpers generated at dealers were collected and recycled into bumpers or some other automotive parts



Establishment of a system of supply of used parts through e-commerce

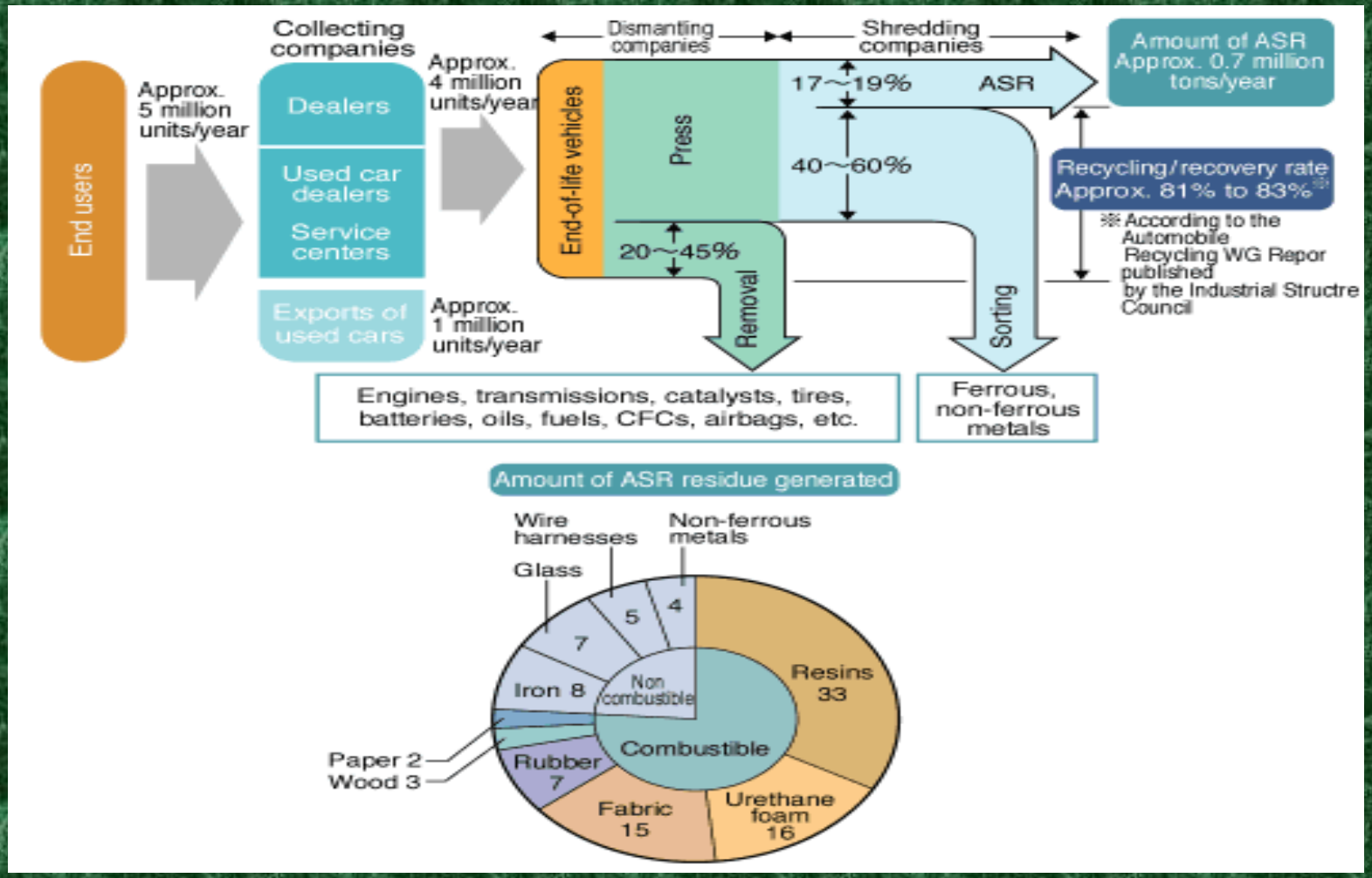
(This makes faster and cheaper supply of used parts possible)



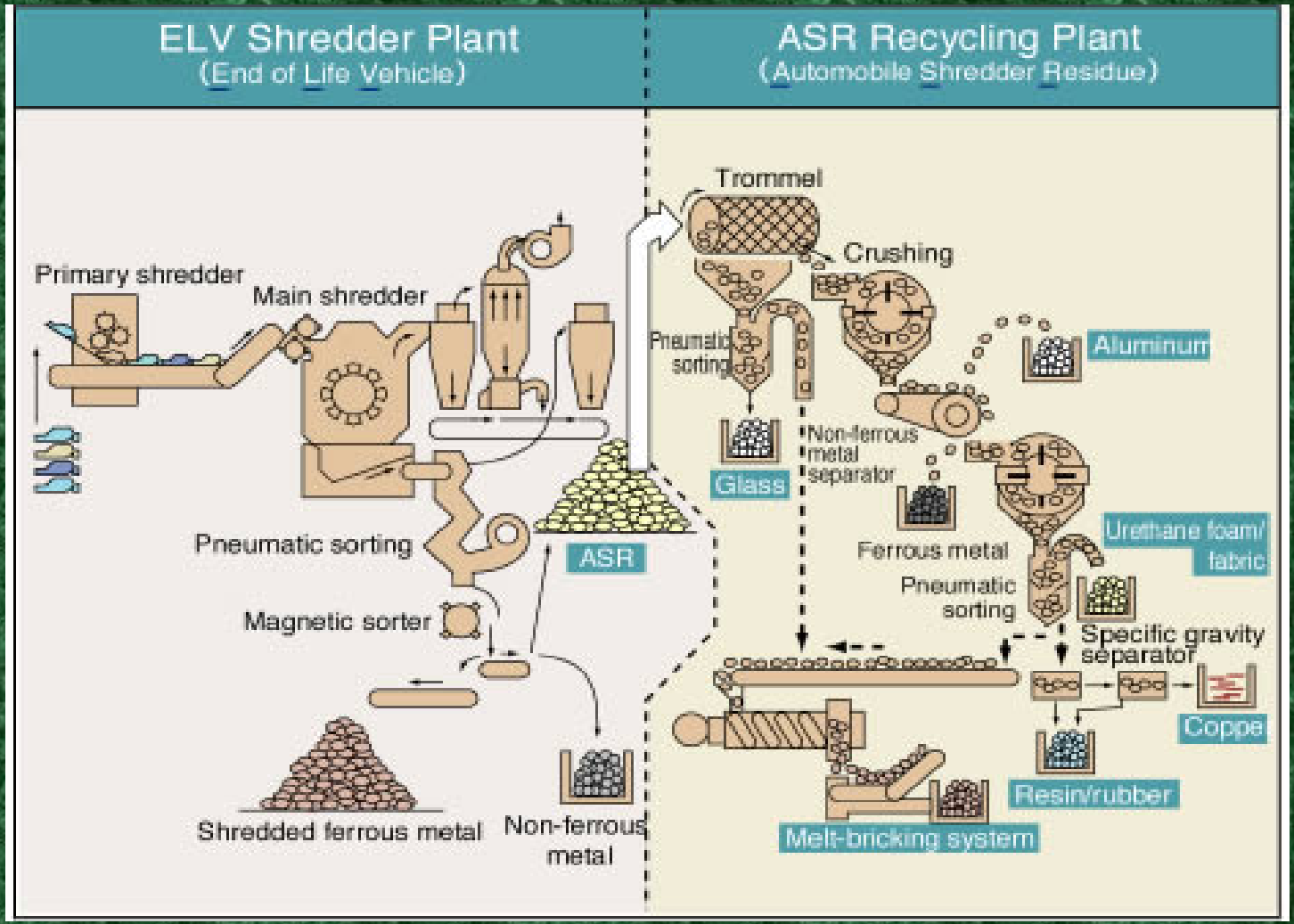
What happens to End-of-life cars?

- 1.Removal of relatively easy-to-recycle parts: engine, oil, and tires
- 2.Crushing and sorting out ferrous and non-ferrous metals for recycling
- 3. ASR is recycled through the new technology for effective utilization of shredder residue which had been thought to be virtually impossible to recycle and disposed of as waste in landfill.

Disposal route for end-of-life vehicles (Japan)



ELV shredder plant and ASR recycling plant.



EMISSION STANDARD LEVELS (listed from least clean to cleanest)

T1	Tier 1	The least stringent EPA (Federal) standards
TLEV	Transitional Low Emission Vehicle	More stringent than Tier 1 standards for hydrocarbons (HC)
LEV	Low Emission Vehicle	More stringent than TLEV standards for both hydrocarbons (HC) and oxides of nitrogen (NOx) than Tier1
ULEV	Ultra Low Emission Vehicle	More stringent than LEV standards HC
SULEV	Super Ultra Low Emission Vehicle	Even more stringent standards than ULEV for both HC and NOx
ZEV	Zero Emission Vehicle	The strictest emission standard, permitting no emissions

What is the emissions rating of Prius?

- The standards for a Super Ultra Low Emission Vehicle (SULEV)
- produce nearly 90% fewer smog-forming pollutants than the average new car.
- designed to be an Advanced Technology Partial Zero Emission Vehicle (AT-PZEV), a standard created by the California Air Resources Board and adopted by other states.
- AT-PZEV certification means the Prius has near-zero tailpipe emissions, zero evaporative emissions.
- special extended warranty on emission control components.

More FAQs

- **Do I need to use special gasoline?**
  No. Prius can be fueled with ***regular 87 octane gasoline***, saving you money at the pump.

- **Can Prius run on electricity when it runs out of gas?**
  No. Though Prius can operate in electric-only mode when gasoline is in the tank, it is not designed to run without gasoline. So drivers should be sure to keep gas in the tank at all times.

- **How often does Prius need to be serviced?**
  Prius needs no more servicing than a conventional car

FAQ's (Cont'd)

- **Bluetooth™ [1]**
  The Bluetooth™ technology available in Prius allows wireless connections between the car and a Bluetooth-capable mobile phone, allowing for easier and more convenient hands-free use while driving

- **What tax or other incentives are available upon purchasing a Prius?**
  A hybrid can get you a $2,000 federal income tax deduction. That's set to decline to $1,500 next year

Details on Prius warranty

As taken from the 2004 Toyota Prius Owner's Warranty Booklet Information :

- New Vehicle Limited Warranty:

  Basic: 36 months / 36,000 miles
  Hybrid Vehicle System: 96 months / 100,000 miles
  Powertrain: 60 months / 60,000 miles
  Corrosion Perforation: 60 months / unlimited miles
  Restraint Systems: 60 months / 60,000 miles

- Emission Control Warranty:

  Federal, Performance: 24 months / 24,000 miles
  Federal, Performance Specific Components: 96 months / 80,000 miles
  Federal, Defect: 36 months / 36,000 miles
  Federal, Defect Specific Components: 96 months / 80,000 miles
  California (t), Performance: 180 months / 150,000 miles
  California (t), Defect: 180 months, 150,000 miles
  California (t), Hybrid Battery Pack: 120 months / 150,000 miles

(t) = Also applies to Maine, Massachusetts, New York and Vermont vehicles equipped with a California Certified Emission Control System. Vehicles covered by this warranty are also covered by the Federal Emission Control Warranty.

Fuel Cost Savings

How much can you expect to save (given ~12 gallon tank and gas mileage of 60city/51highway/combined 55)?

How much do you usually pay for a gallon of gas?	$2.89 per gallon	
How many miles do you generally travel?	40 miles/day	
What is the highway gas mileage of your current vehicle?	20 mpg	
Estimated savings:	Over 1 yr	Over 5 yrs
Amount you would spend on gas for your vehicle:	$2109.69	$10,548.50
Amount you would spend on gas for the Prius :	$767.16	$3,835.82
Amount you would save with Prius :	**$1342.53**	$6712.68

Price and Product Differentiation

General Pricing			
	Prius Sedan	**Civic** Sedan Hybrid	**Jetta** Sedan
MSRP	**$20,295**	$19,650	$20,740

Fuel Economy			
	Prius Sedan	**Civic** Sedan Hybrid	**Jetta** Sedan
City (mpg)	60	46	38
Highway (mpg)	51	51	46

Product Differentiation

Engines & Power			
	Prius Sedan	**Civic** Sedan Hybrid	**Jetta** Sedan
Standard Engine	1.5L 76 hp I4	1.3L 85 hp I4	1.9L 100 hp I4
Horsepower	76 @ 5000 RPM	85 @ 5700 RPM	100 @ 4000 RPM
Torque (lbs-ft)	82 @ 4200 RPM	87 @ 3300 RPM	177 @ 1800 RPM
Valves	4	2	2
Displacement (cc)	1497	1339	1896

Conclusion

- Toyota’s goals are to meet these objectives; to achieve the world's highest level of environmental performance by advanced hybrid technology, improved fuel efficiency, reduced emission and advanced recycling processes