

AC Propulsion Products, Politics, and Plans

AC Propulsion, Inc.

San Dimas, CA

March, 2005

<http://www.acpropulsion.com>



AC Propulsion History

- Alan Cocconi developed the drive system for the General Motors Impact EV prototype in 1989, setting a new standard for EV performance.



- Cocconi founded AC Propulsion in 1992 to develop electric vehicle technology.

AC Propulsion Today

- A full-function R&D facility located in San Dimas, California, dedicated to building electric vehicles that people want to buy



- Power electronics lab
- Battery test lab
- 200-hp electric dynamometer
- Electronics assembly
- Machine shop
- Fabrication shop
- Composite shop
- Automotive service bays

Honda Civic EV Conversion - 1994



200 hp

0-60 mph in 6.2 seconds

0-125,000 miles in 10 years

0 emissions

Electric Land Speed Record - 1999



**Two AC-150 drive systems
400 hp
245.5 mph**



VW Beetle “The Plug Bug” - 2001

- Bi-directional charger
- Vehicle-to-grid demo 2002



- Discharge to grid
- Power any AC load

Los Angeles City Hall Shuttle - 2002



Two AC Propulsion bus upgrades in service:

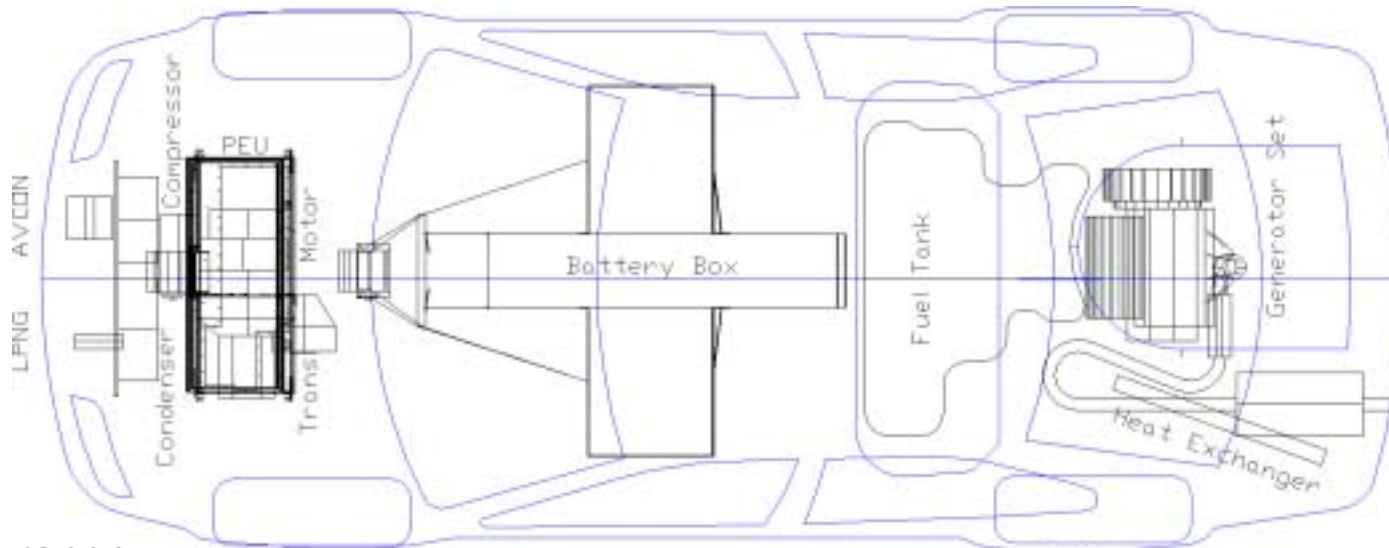
- 1st bus – since June, 2002
- 2nd bus – since January, 2003

AC Propulsion Plug-in Hybrid Prototype - 2003

100 kW drive system with bi-directional AC power interface

4-passenger
35 mile battery range
0-60 in 8.5 sec
87 mph top speed
3750 pounds

Project Sponsors:
SCAQMD
CARB
VW
NREL
EPRI

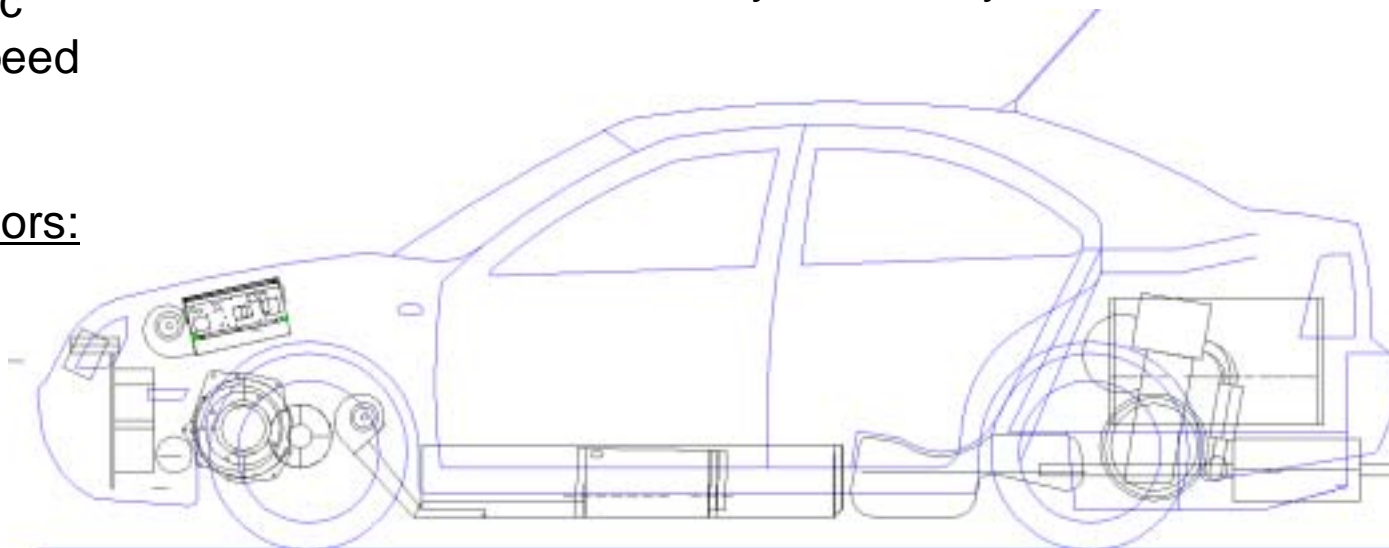


8 kWh lead-acid hybrid battery

Auxiliary power unit
1.4L engine,
inverter-
controlled
alternator

35 kW
APU output
on gasoline
for driving

15 kW on
natural
gas for
stationary
generation



APU Development



- Stand-alone, self-contained unit
- Adaptable to other engines, power levels, applications

Jetta: Hybrid vs Conventional

	<u>Project Vehicle</u>	<u>VW Jetta 2.0L auto.</u>
0-60 mph acceleration	8.7 secs ¹	12.0 secs ²
Top Speed	87 mph ³	>100 mph
City fuel economy	27 mpg ⁴	23 mpg ⁵
Highway fuel economy	34 mpg ¹	29 mpg ⁵
EV range	30 miles	0 miles
Max Range	540 miles	435 miles

1 measured

2 *Consumers Reports* test data

3 Governed by control system

4 CARB test result depreciated 10%

5 EPA label value

On-track: Challenge Bibendum 2003



Jetta leads
Courrèges La Bulle °r
Infineon Raceway
September, 2003

Automakers Say:

Use Gasoline Only and Be Proud of It

- “Remember, Prius never needs to be plugged in.”
– 2004 Toyota Prius Product Reference Guide
- “The Civic Hybrid’s gas-electric powertrain works seamlessly and automatically as you drive.
So you **never plug it in.** (emphasis in original)
– 2004 Honda Car & Truck product brochure
- “Do I have to plug it in?”
“No. Not once. Not Ever. Plug-in vehicles are strictly electric, not hybrids.”
– Lexus brochure for 2005 RX 400h

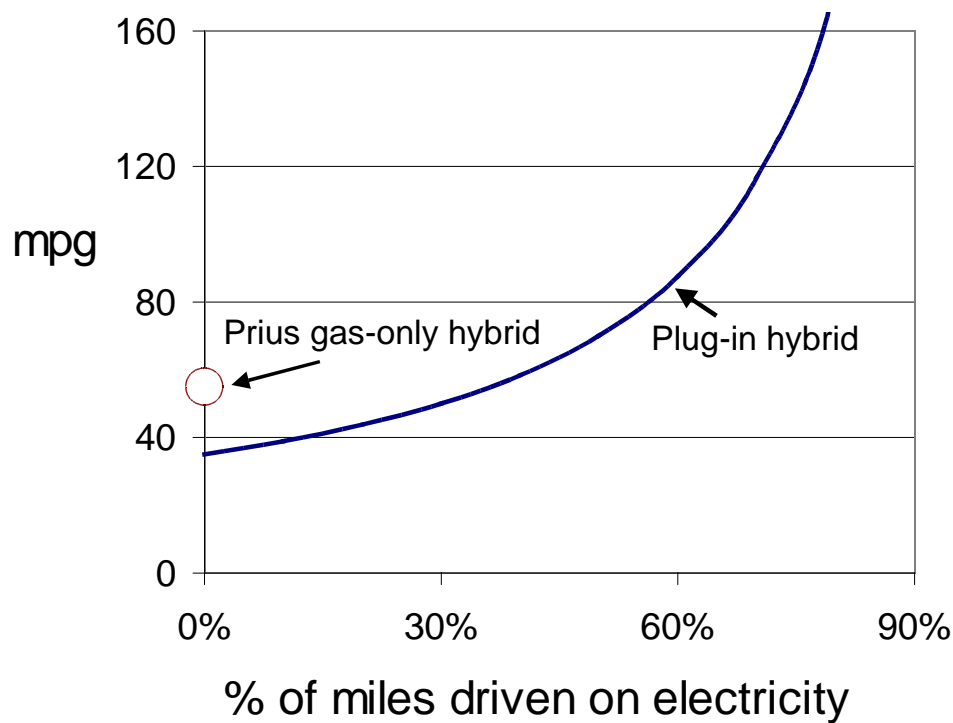
Plug-in Hybrid vs Plugless 2004 Prius



Engine	1.4 liter 35 kW	1.5 liter 56 kW
Generator	30 kW	20 kW (est)
Traction Motor	110 kW	50 kW
Transmission	Fixed ratio	Planetary
Battery	PbA 8 kWh 650 lb	NiMH 2 kWh 100 lb (est)
Charger	20 kW (V2G)	none
Charge port	conductive	none

Plug-In Hybrids Use Gas and Electricity

- Have enough EV range for daily driving
- Plug in at home
- Charge while you sleep
- Go on trips - 450 miles per tank

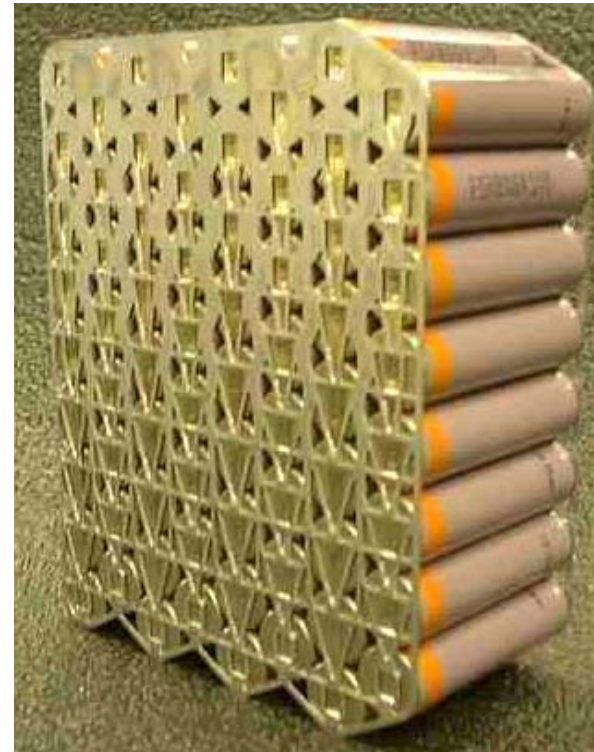
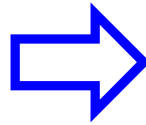


- Reduce petroleum imports
- Get better mpg
- Use domestic energy
- Use renewable electricity
- Reduce cold start emissions
- Kick the gasoline habit

Plug-In Hybrids: 2005 and Beyond

- ACP – upgrade Jetta, Li-polymer battery, 55 mi EV range
- Energy CS – Plug-in Prius to show at EVS-21 in Monaco
- CalCars – Development, promotion, policy support
- EPRI – Demonstration of DaimlerChrysler Sprinter hybrid

AC Propulsion Assembly of Li Ion Cells



- 18650 cells
- 190 Wh/kg
- \$400/kwh

- 30 to 80 in parallel block
- 100 blocks in a string
- 150 Wh/kg in assembly

Li Ion pack for *tzero*



- 6,800 cells
- 68P100S
- 370 V
- 50 kWh
- 165 kW
- 350 kg

Proof of Concept - Lilon

tzero

0-60 mph in 3.6 sec



On Tuesday September 9, 2003 in a series of acceleration tests, the tzero repeatedly accelerated 0-60 in under 4 secs. Alan Cocconi achieves the best time - 3.6 secs. Writer Chris Dixon gets 3.7 secs and reports it in the *New York Times*.

300 mile range



On Thursday October, 3, 2003, Tom Gage drove the tzero 302 miles, from Sunnyvale to Santa Barbara, without charging. Average speed was 58 mph.

2003: 1st Place Michelin Challenge Bibendum



AC Propulsion results:

- tzero - 1st overall, 6 trophies
- Jetta – 19th overall, 3 trophies



tZero vs VIPER



tZero

vs VIPER



tZero

vs VIPER



tZero

vs VIPER



2004: Three New EV Concepts



Courrèges Design EXE
(Paris)



Volvo 3CC
(California)



Venturi Fétish
(Monaco)

Courrèges Design EXE EV Concept



La Bulle °r

EXE

EXE: A Basic Platform, Advanced Ideas



- AC Propulsion drive system and BMS
- 68P100S Li Ion battery underfloor
- Front wheel drive, 2-seater
- 2004 Challenge Bibendum, Shanghai



Volvo 3CC EV Concept

- Front-wheel drive
- Battery in floor
- Two-plus-one seating



- 2004 Challenge Bibendum, Shanghai
- 2005 NAIAS, Detroit
- 2005 Geneva Auto Show

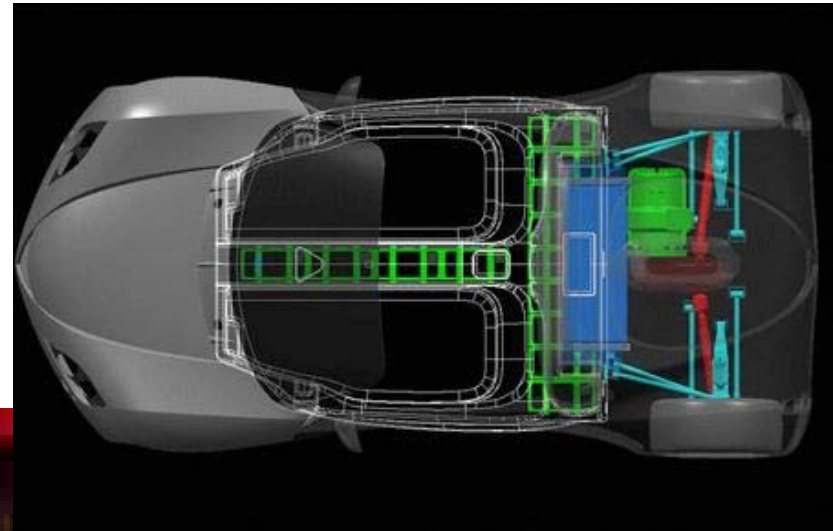
Volvo 3CC: A Sustainable Mobility Concept



- Designed by Volvo Monitoring and Concept Center, Camarillo, CA
- AC Propulsion drive system, battery system
- Built entirely California

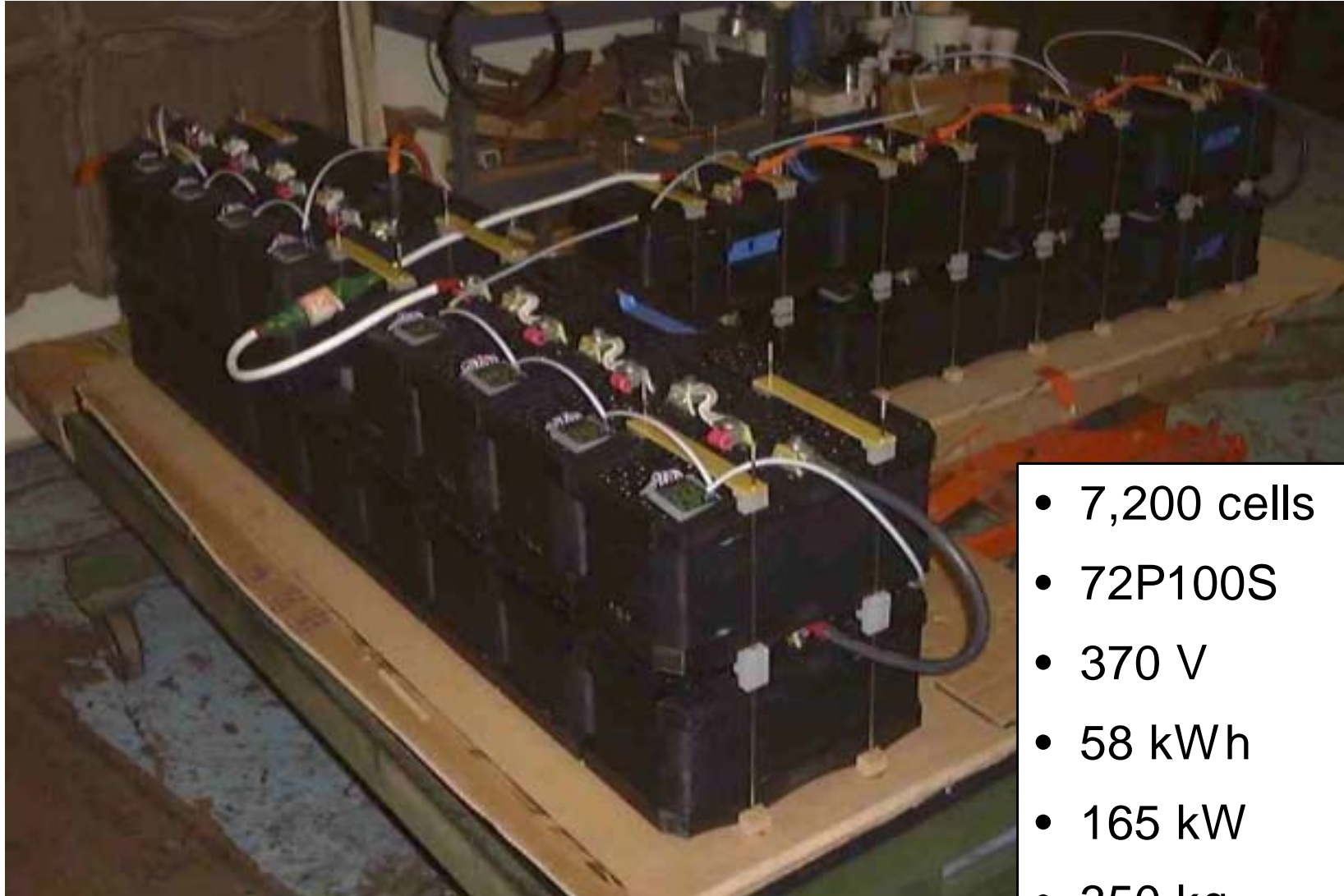
Venturi Fétish EV Prototype

- AC Propulsion drive system
- Li Ion cell assemblies with AC Propulsion BMS
- Mid-motor, rear wheel drive



- 2004 Paris Motor Show world debut
- 2005 LA Auto Show US debut
- Planning for limited production
- \$660,000

Fétish Battery: T-Pack for Good Balance



- 7,200 cells
- 72P100S
- 370 V
- 58 kWh
- 165 kW
- 350 kg

2004 Michelin Challenge Bibendum Results



Madame
Courrèges

Monsieur
Michelin

2004 Michelin Challenge Bibendum Results

Volvo 3CC: 3rd overall



Tomorrow Dawns in Shanghai, China



Sunrise at Challenge Bibendum

World Population

Region	population millions	% of world population
World	6,396	100%
China	1,307	20%
India	1,087	17%
US	294	5%
EU	381	6%
Japan	128	2%
ROW	3,200	50%

source: Population Reference Bureau

Crude Oil Consumption

Region	population millions	% of world population	Crude Oil Use, Total		
			million tonnes	% of world	per cap vs world
World	6,396	100%	3,413	100%	1.0
China	1,307	20%	228	7%	0.3
India	1,087	17%	115	3%	0.2
US	294	5%	764	22%	4.9
EU	381	6%	571	17%	2.8
Japan	128	2%	200	6%	2.9
ROW	3,200	50%	1,535	45%	0.9

source: International Energy Agency

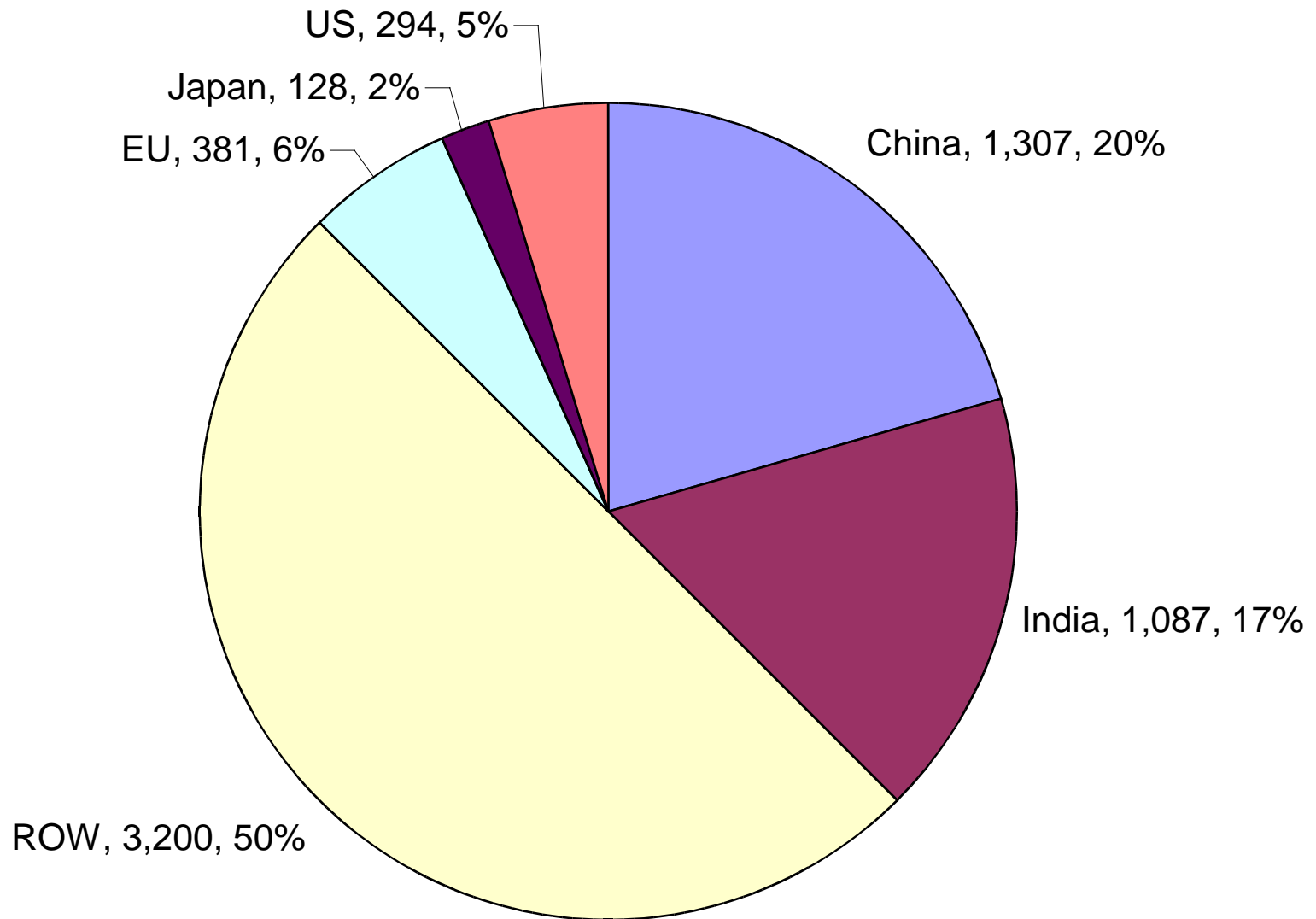
Gasoline Consumption

Region	population millions	% of world population	Gasoline Use, Transport		
			million tonnes	% of world	per cap vs world
World	6,396	100%	846	100%	1.0
China	1,307	20%	36	4%	0.2
India	1,087	17%	8	1%	0.1
US	294	5%	371	44%	9.6
EU	381	6%	108	13%	2.2
Japan	128	2%	44	5%	2.6
ROW	3,200	50%	278	33%	0.7

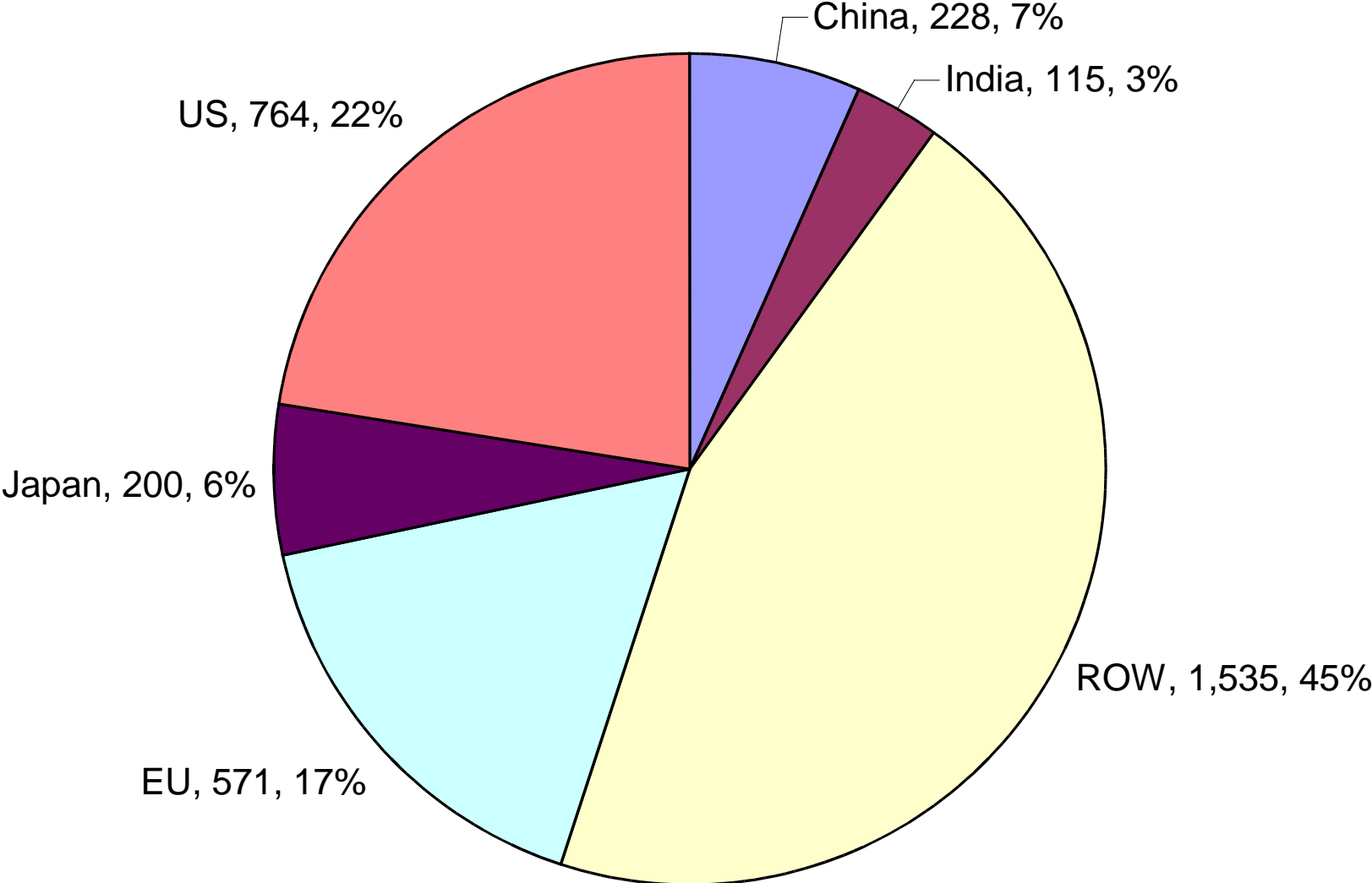
source: International Energy Agency



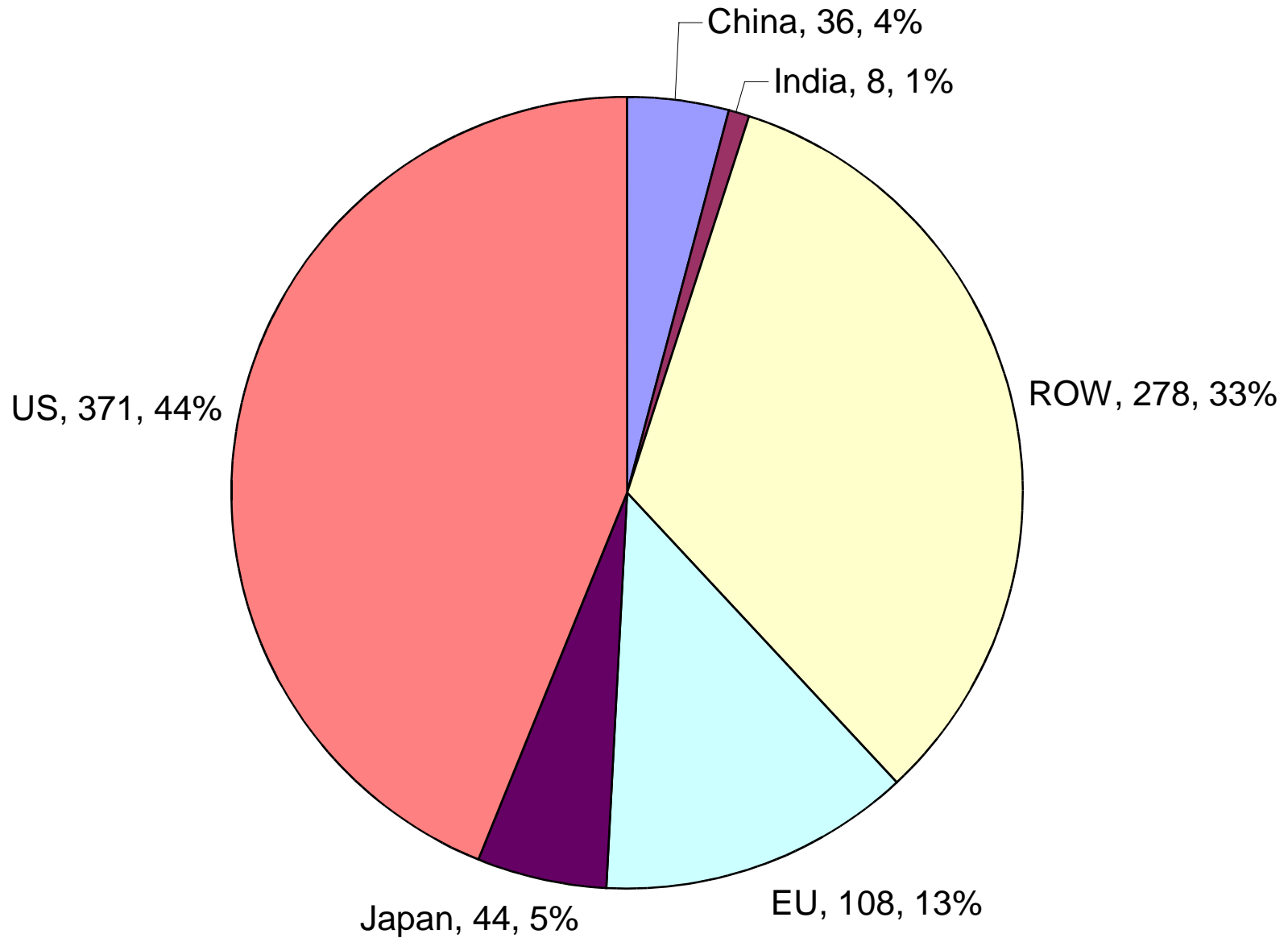
Population



Crude Oil Consumption (mil tonnes)

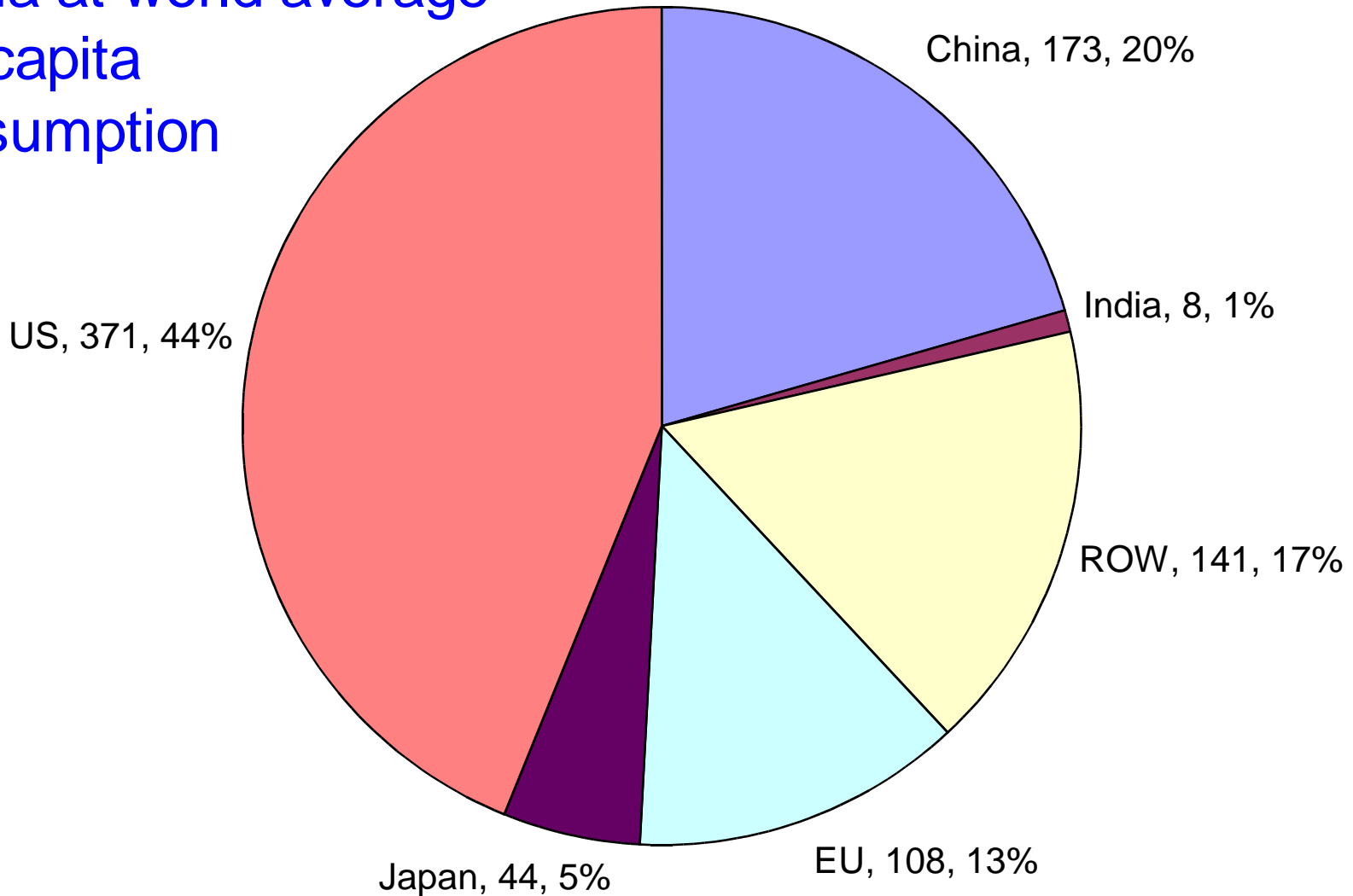


Motor Gasoline Consumption (mil tonnes)



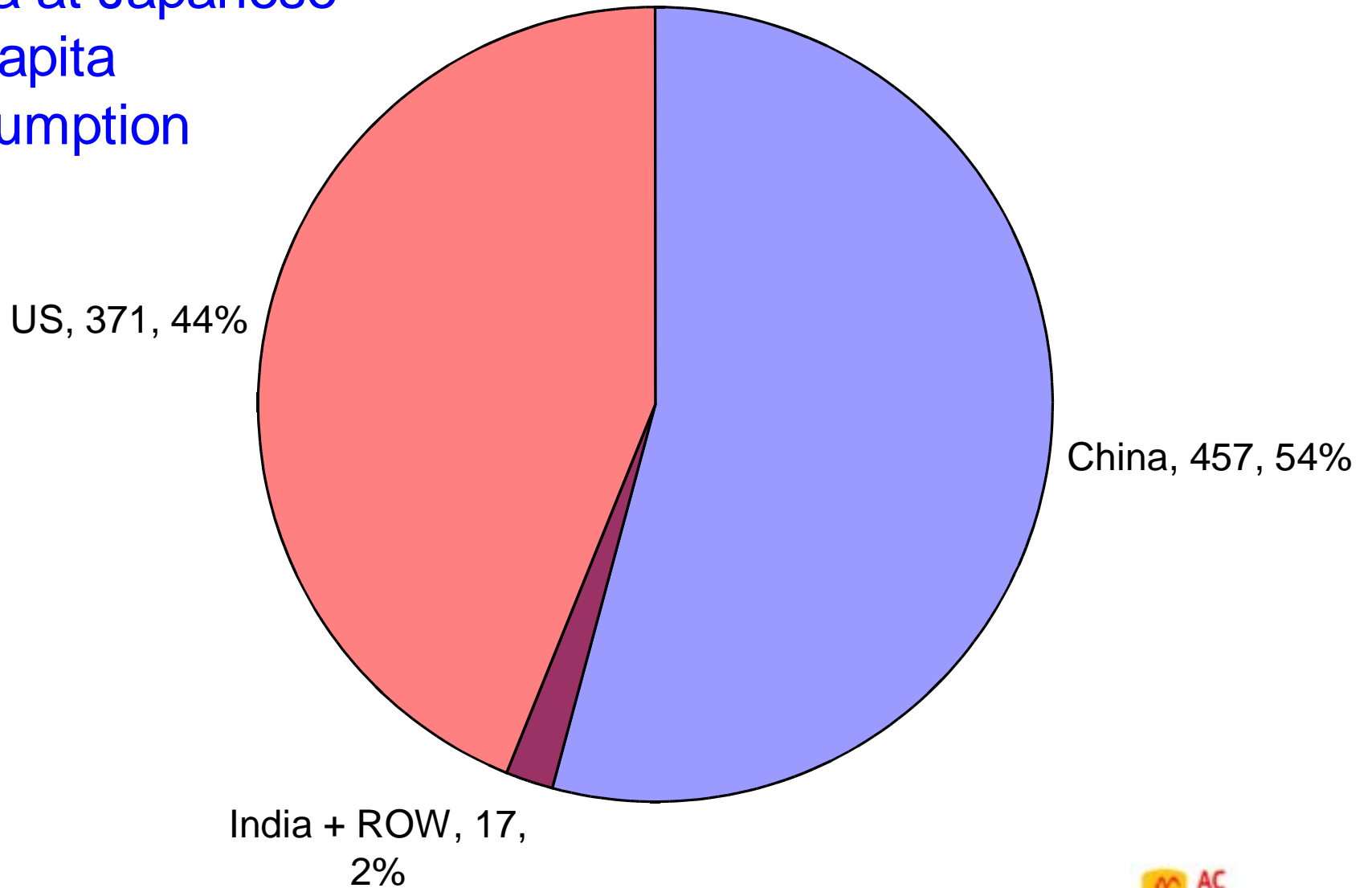
Motor Gasoline Consumption (mil tonnes)

China at world average
per capita
consumption



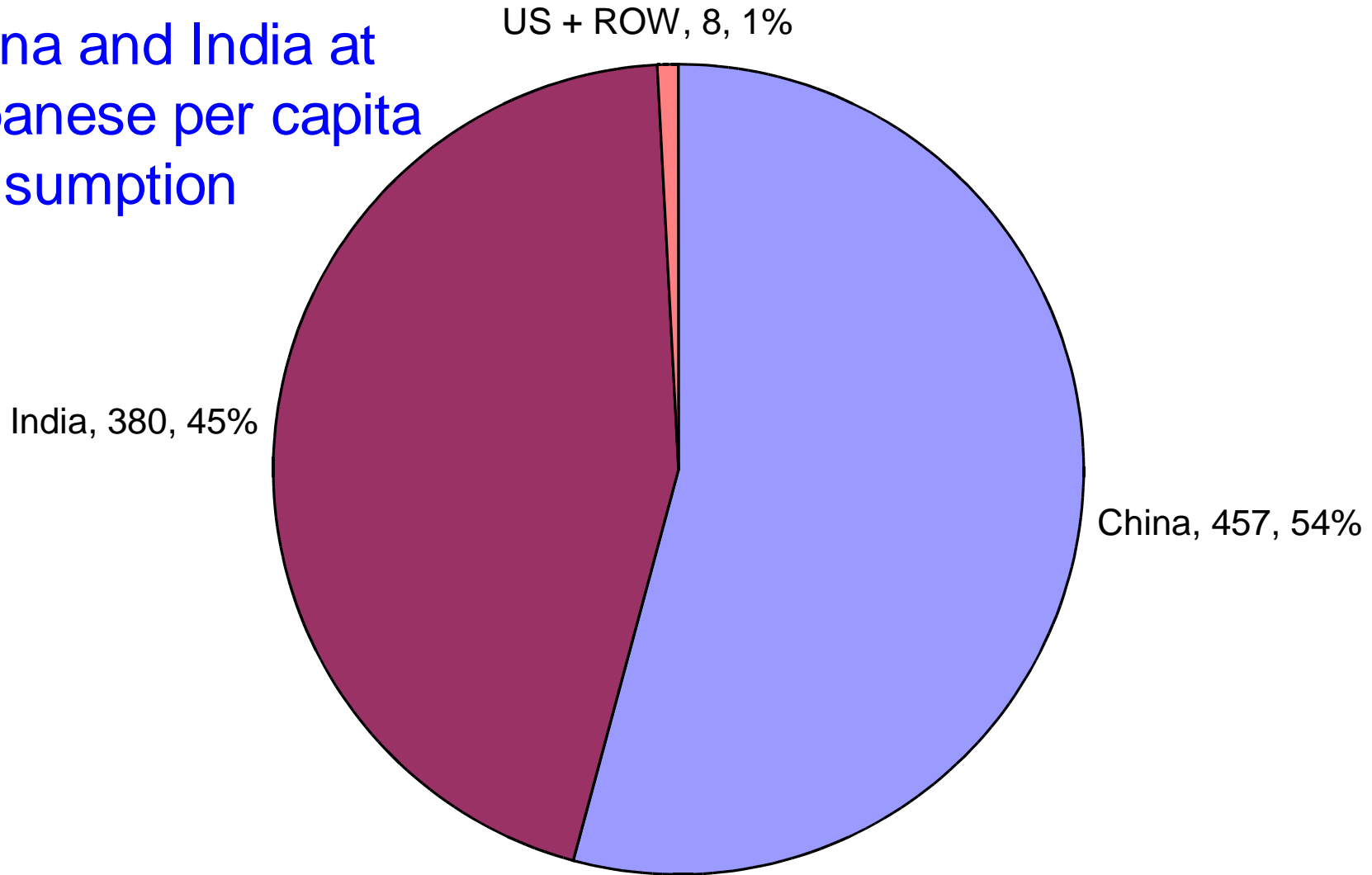
Motor Gasoline Consumption (mil tonnes)

China at Japanese
per capita
consumption



Motor Gasoline Consumption (mil tonnes)

China and India at
Japanese per capita
consumption



Petroleum Demand Will Surpass Supply

- The total spare capacity of all 11 countries in OPEC is 330,000 bpd (down from 6 million bpd in 2002).
 - International Energy Agency
- There is no spare refinery capacity, demand has outstripped all expectations.
 - Deborah White, Societe Generale Bank, Paris
- Venezuelan president Hugo Chavez has offered China wide-ranging access to the country's oil reserves. Venezuela - the world's fifth largest oil exporter - (now) sells about 60% of its output to the United States.
 - BBC, 12/24/04

Petroleum: A Hierarchy of Value

1. Aviation
2. Petrochemicals
3. Maritime shipping
4. Long haul trucks
5. Rail transport
6. Long trips by car
7. Commuting
8. Picking up the kids
9. Driving a Hummer

California's Electric Power Mix - 2003

Natural Gas	37%
Large Hydro	16%
Coal	21%
Nuclear	15%
Eligible Renewables	11%
Petroleum	0%
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	100%

source: California Energy Commission

**Electric Vehicles:
Transportation Without Petroleum**

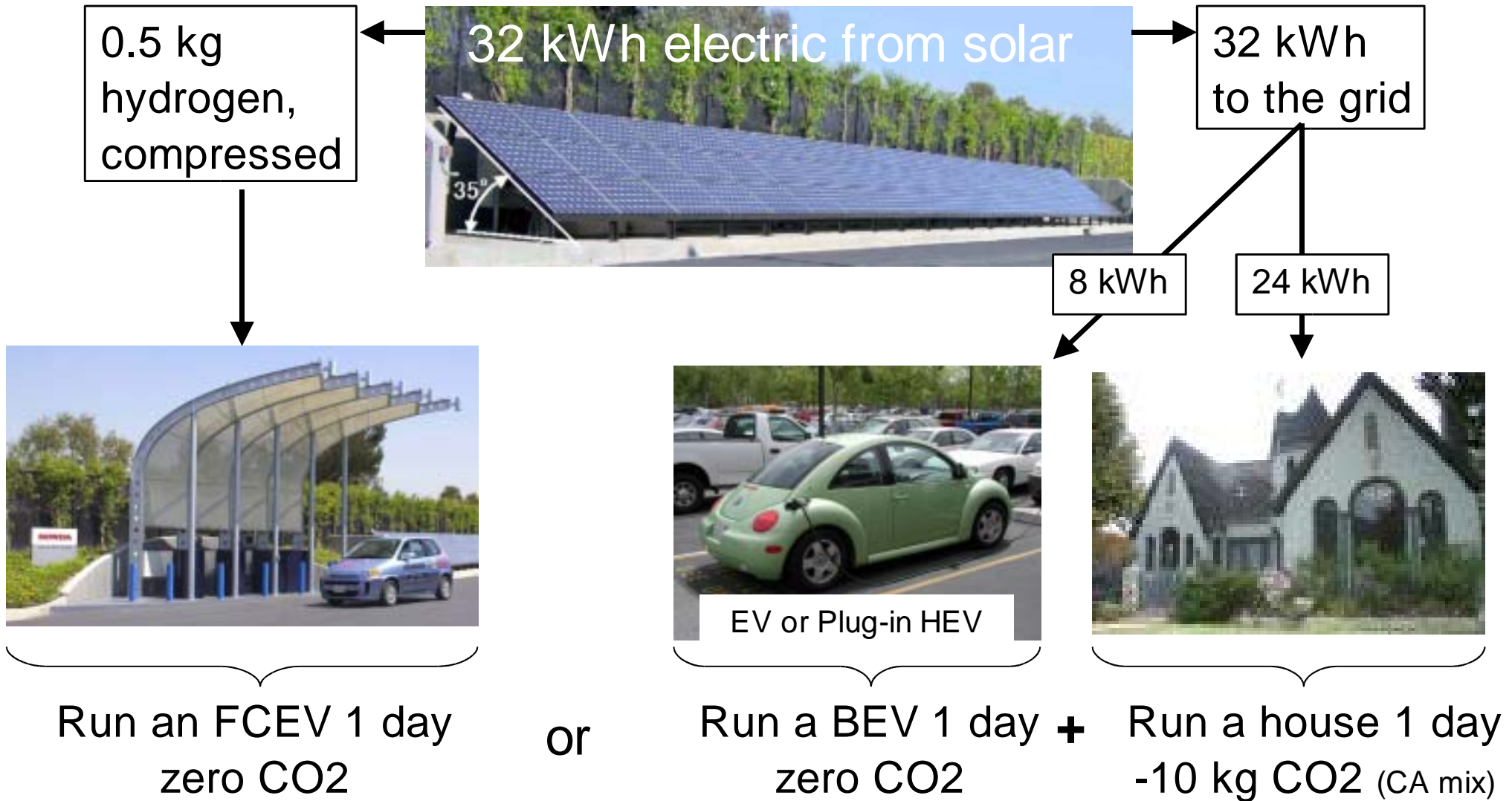
Electricity: Already a Great Fuel for Cars

- Low Pollution
- Low Greenhouse Gas Emissions
- Available and sustainable
- Diverse domestic resources
- Efficient in generation and use
- Established infrastructure
- Complementary with existing uses
- Synergistic with solar and wind resources

Other Fuels Can Substitute Too

- ✓ Natural gas
- ✓ Bio-diesel
- ✓ Ethanol
- ✓ Methanol
- x Hydrogen

Hydrogen Increases CO2 Emissions



Automakers Pursue Perverse Agenda



Automakers produced over 5000 EVs from 1997 through 2002. Most are being systematically recalled, hauled away, and destroyed.

EV1: The Electric Car is ~~Here~~ Gone

Burbank, CA
March 14, 2005



photos: www.saveEV1.org

Destination: Destruction



photo: www.saveEV1.org

Death Row in the Desert



photo: www.saveEV1.org

The Crusher



photo: www.saveEV1.org

Appalling Aftermath



photo: www.saveEV1.org

Business as Usual?



“... flattening the vehicle so it can go through the various mechanics of recycling,”
- Dave Barthmuss, General Motors, quoted in *Washington Post*, March 10, 2005

photo: www.saveEV1.org

Or Obliteration of History?



photo: www.saveEV1.org

GM: Generally Misguided

(with fuel cells) ... “we can give our customers absolutely everything they aspire to have”

- Larry Burns, General Motors VP, quoted in *Fleets & Fuels*, March 14, 2005

GM: Generally Misguided

(with fuel cells) ... “we can give our customers absolutely everything they aspire to have”

- Larry Burns, General Motors VP, quoted in *Fleets & Fuels*, March 14, 2005

“In the first two months of 2005, GM's sales in this country fell 9.9% and its market share hit a record low of 24.4%. GM's shares were hammered, dropping 14% to their lowest price in 10 years.”

- Los Angeles Times, March 17, 2005

Plan for Production of Electric Vehicles

- Sell systems and technology licenses to EV manufacturers
- Build EV conversions, low volume
- Support V2G development and demonstration
- Develop one or more suppliers of EV batteries
- Reduce cost of drive system
- JV with automakers, medium to high volume

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People Like Electric Vehicles

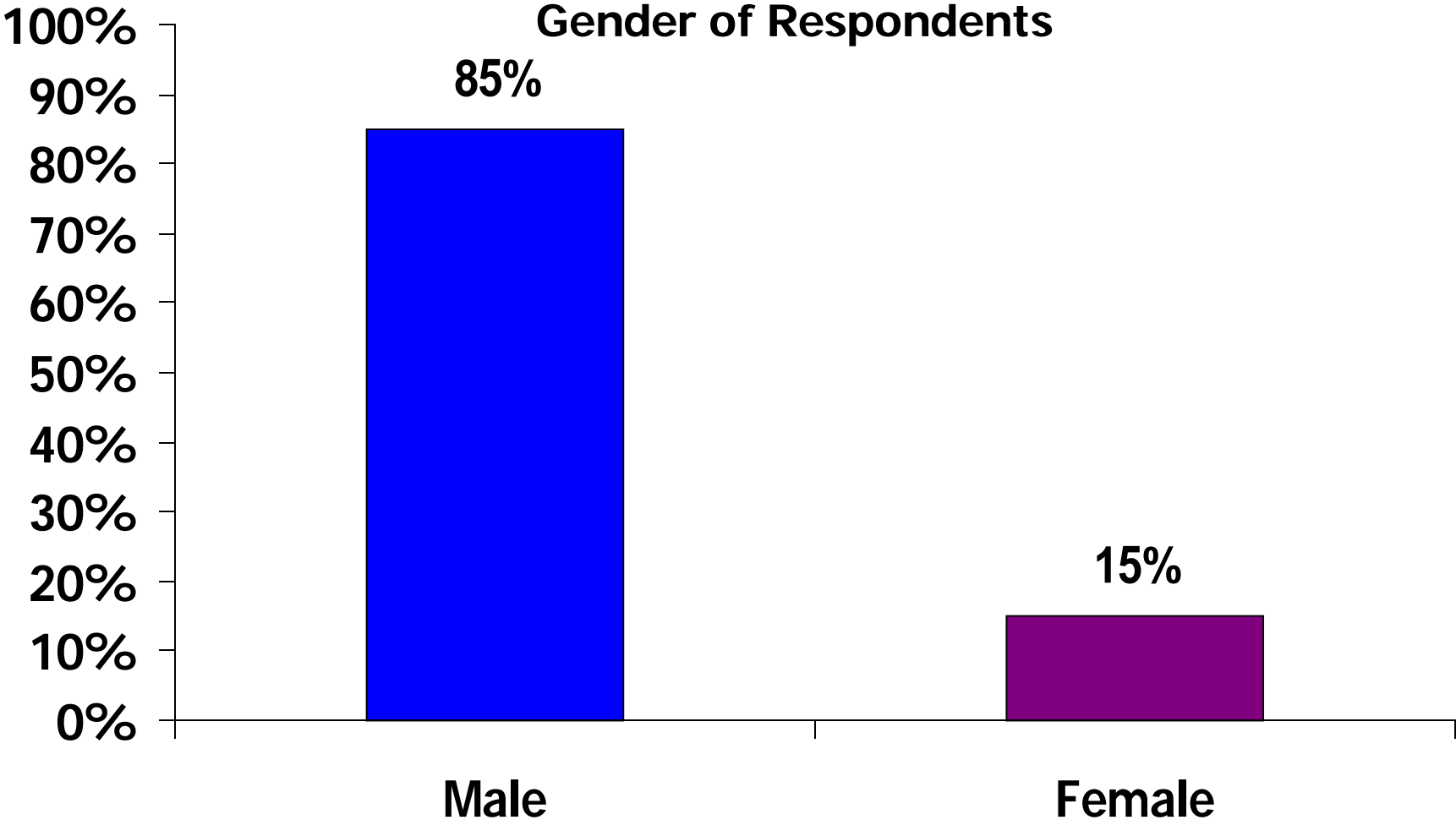
Quotes from drivers who tested an AC Propulsion conversion at EVS-20, Long Beach, November 2003

- “very good acceleration, quite good, actually better than my car”
- “I do like the strong regen(enerative braking). I didn’t think I would. You really have much more control”
- “I like this one, you have full accel and decel on one pedal”
- “really amazing power, no shifting”
- “wow, wow, wow-wow-wow, it really goes. I’m amazed, wow, like a race car, unbelievable”
- “It’s definitely the strongest EV I’ve ever driven”
- “it just drives beautifully”

Electric Vehicle Survey

- Survey Objective:
 - To understand what people want and need in a modern Electric Vehicle
- Online Survey Launched on January 1, 2005
- 635 Respondents as of January 19, 2005
- Response Rate exceeds 100%
- Survey conducted by Nadine Weil

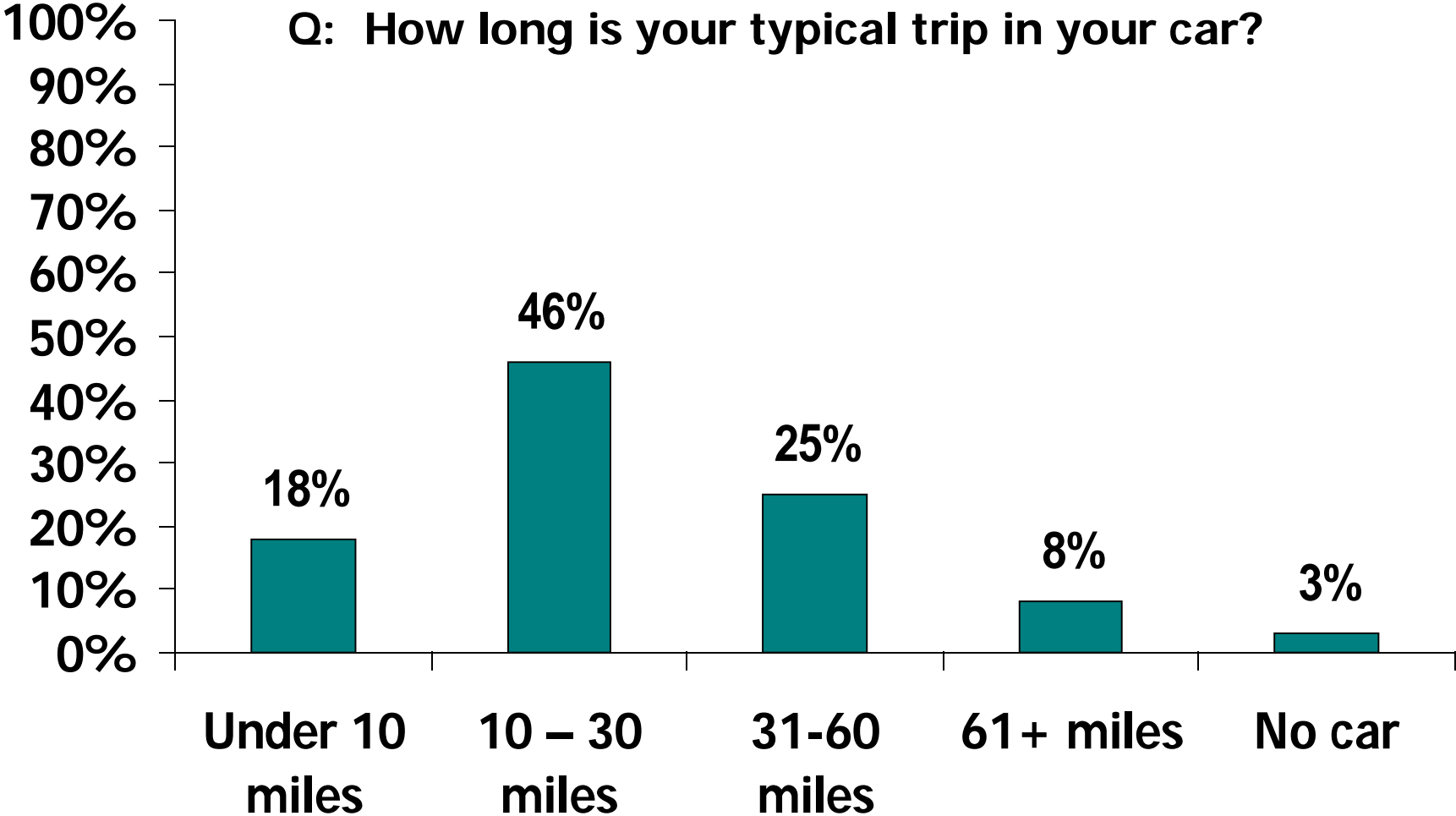
The majority of respondents were men



Source: EV Survey. 582 Respondents



64% of all car trips are 30 miles or less

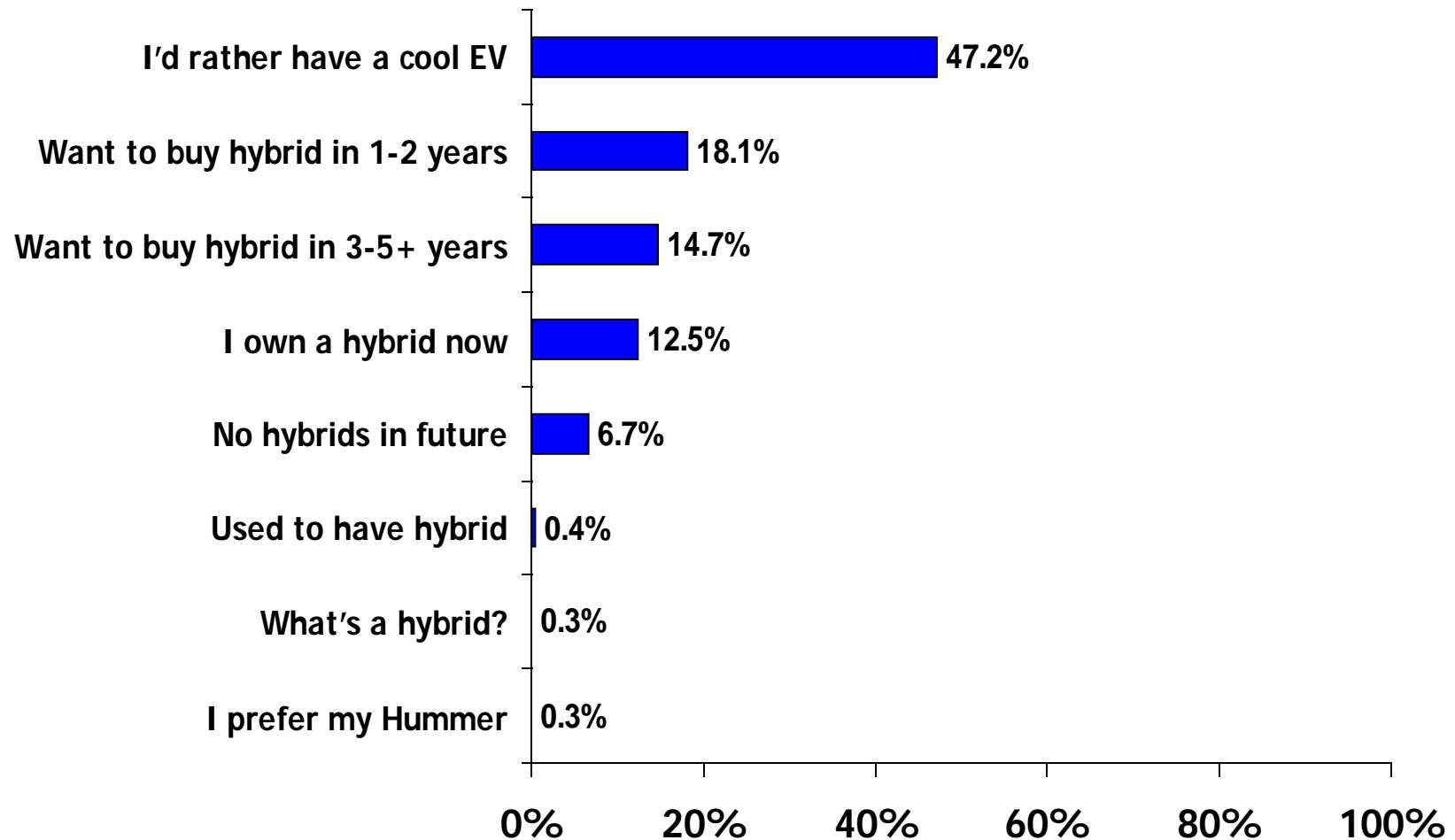


Source: EV Survey. 625 Respondents



45% either own a hybrid now or want to buy one, while 47% also prefer EVs

Q: What do you think of hybrid cars?

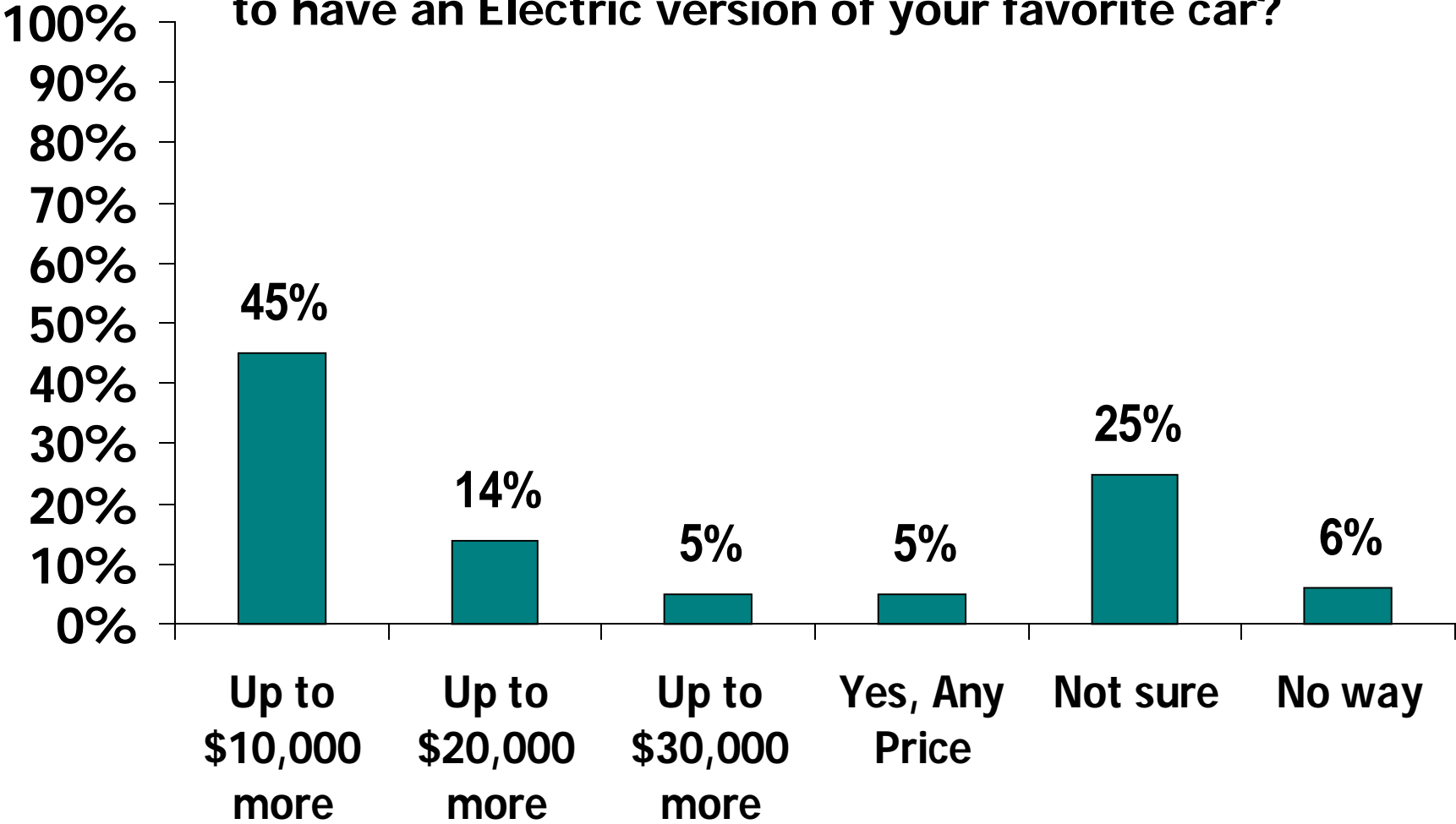


Source: EV Survey. 778 Total Responses



59% would pay up to \$20K more for EV

Q: Would you consider paying a small price premium to have an Electric version of your favorite car?

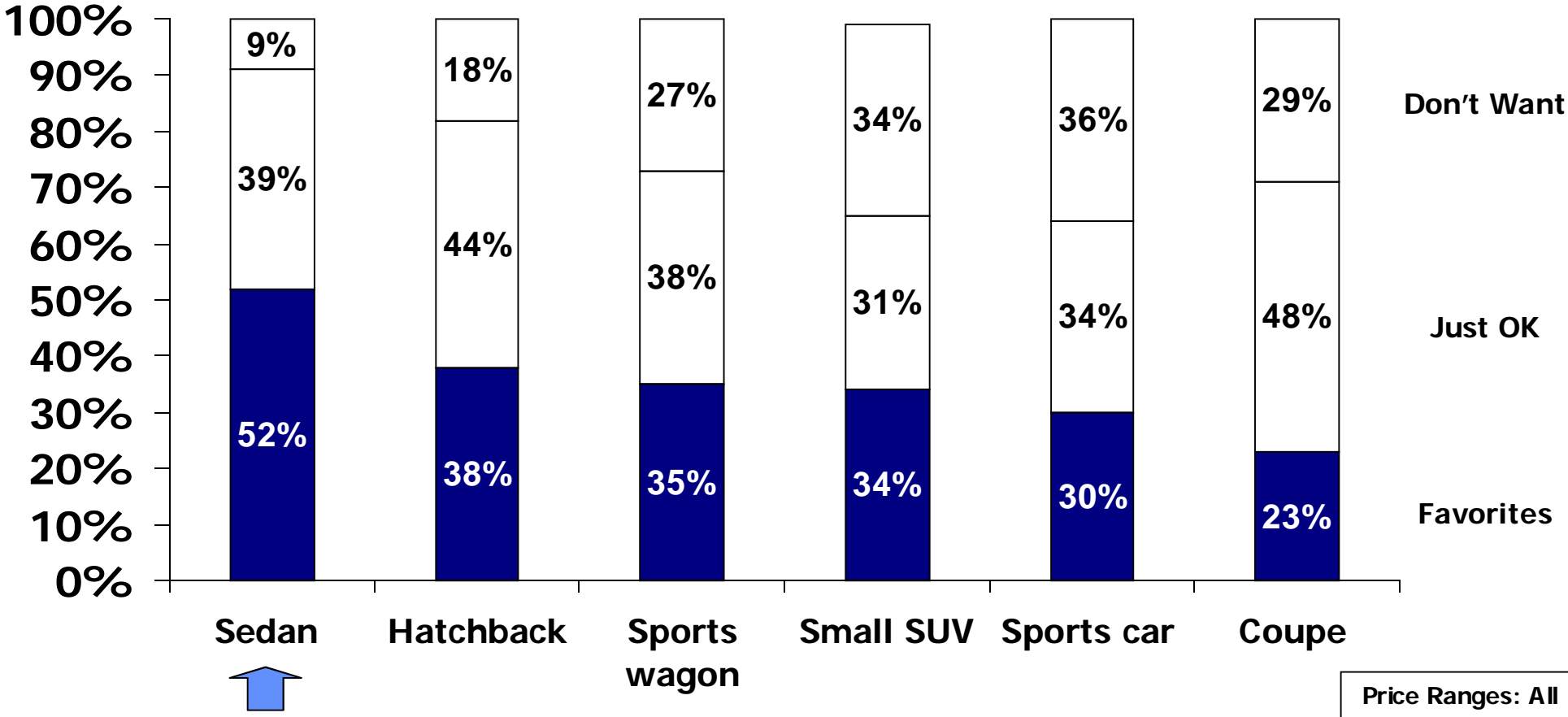


Source: EV Survey. 607 Respondents



The Sedan is the favorite body style, and the hatchback is the 2nd favorite

Q: If you could design your ideal modern EV, which BODY STYLE would you choose?



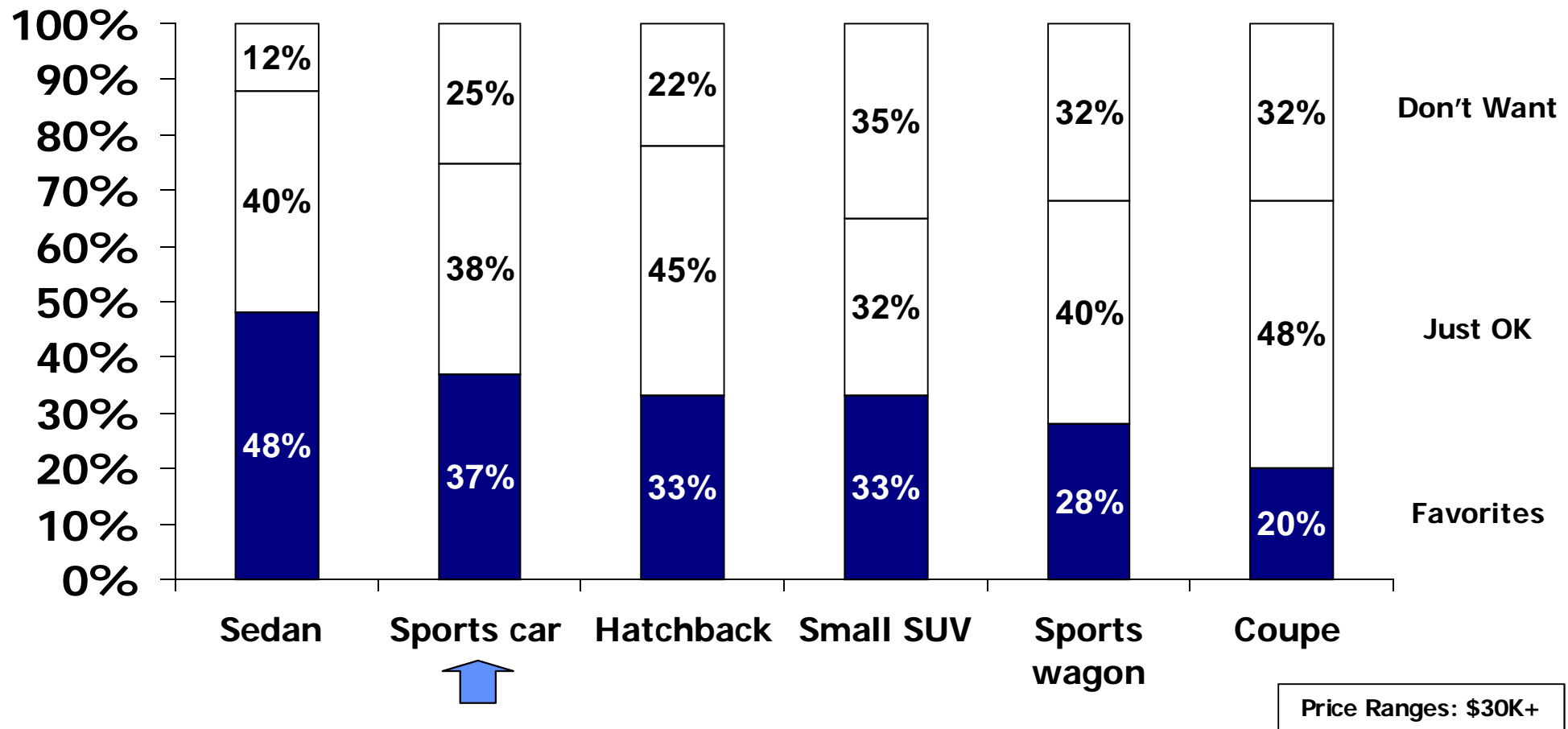
Source: EV Survey. 609 Respondents

In order of "Favorites" Left To Right



However, less price-sensitive buyers also prefer sports cars

Q: If you could design your ideal modern EV,
which BODY STYLE would you choose?
(Price Segment **\$30K+**)



Source: EV Survey. 59 Respondents

In order of "Favorites" Left To Right

Price Ranges: \$30K+



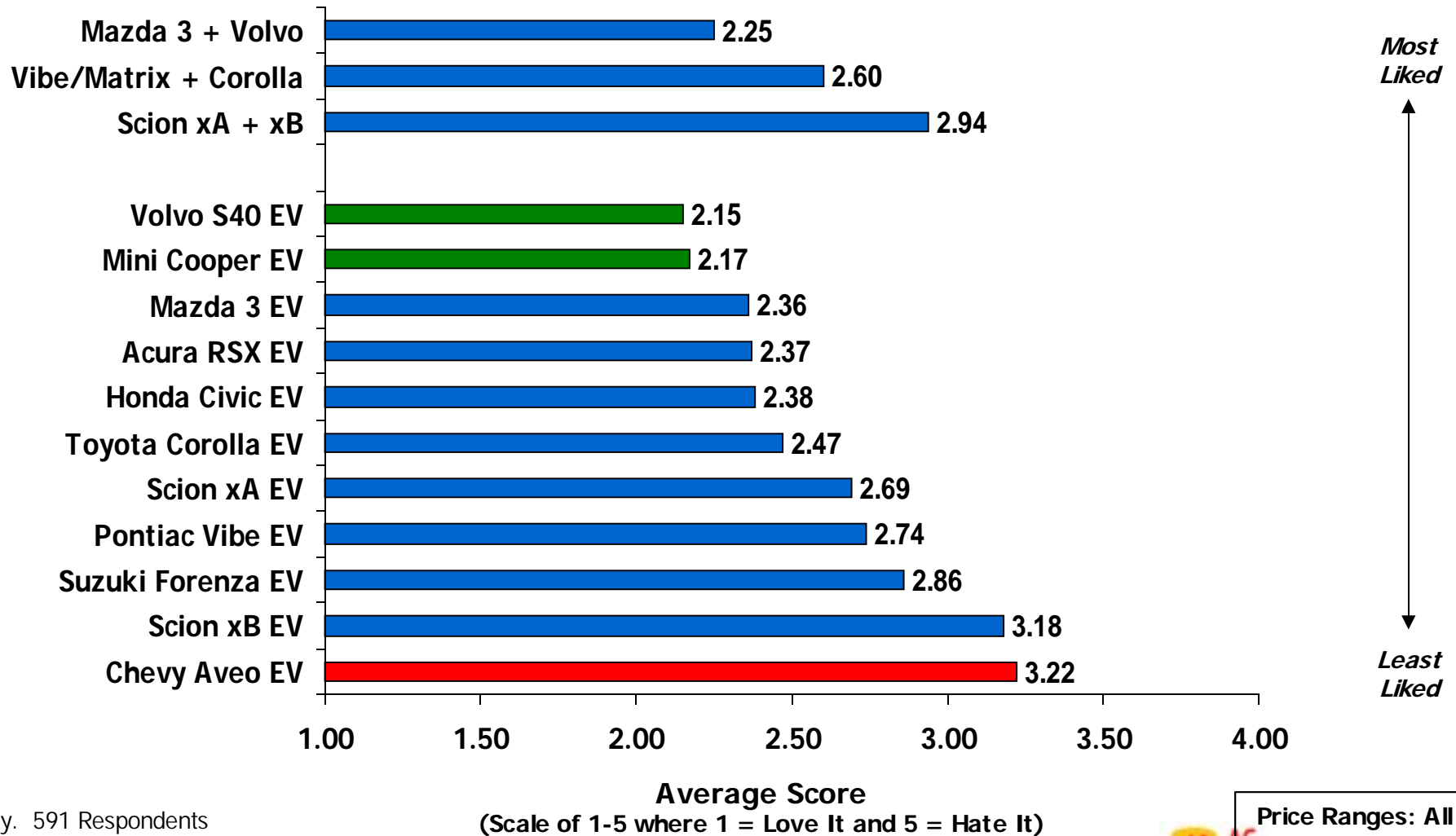
The Car Candidates

			
Acura RSX EV	Chevy Aveo EV	Honda Civic EV	Mazda 3 EV
			
Mini Cooper EV	Pontiac Vibe EV	Scion xA EV	Scion xB EV
			
Suzuki Forenza EV	Toyota Corolla EV	Volvo S40 EV	Venturi Fetish EV

Rankings of EV Car Candidates

Q: What do you think of the following EVs?

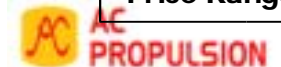
Average Score of All Segments



Source: EV Survey. 591 Respondents

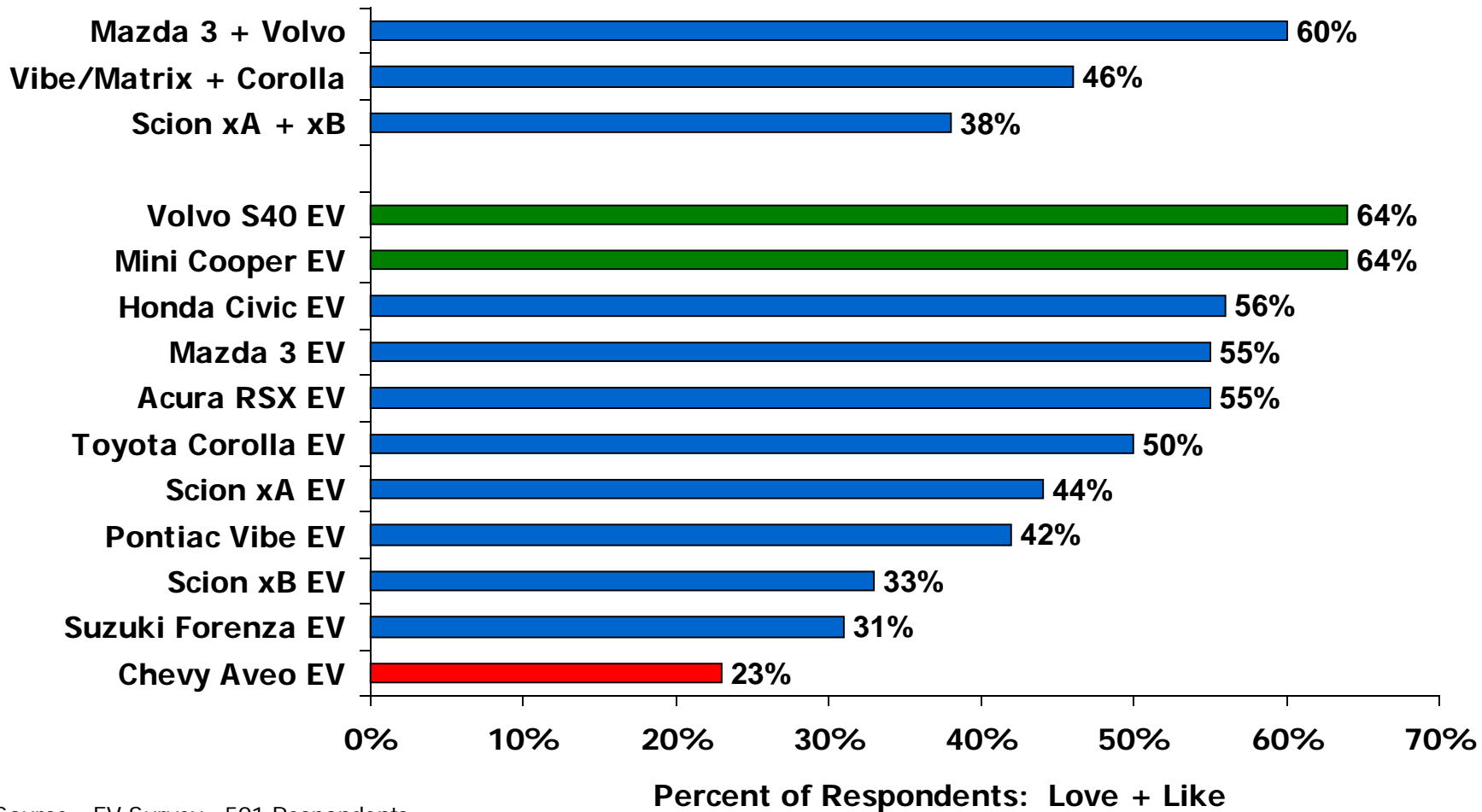
Average Score
(Scale of 1-5 where 1 = Love It and 5 = Hate It)

Price Ranges: All



Rankings of EV Car Candidates

Q: What do you think of the following EVs?
"Love It" Plus "Like It"



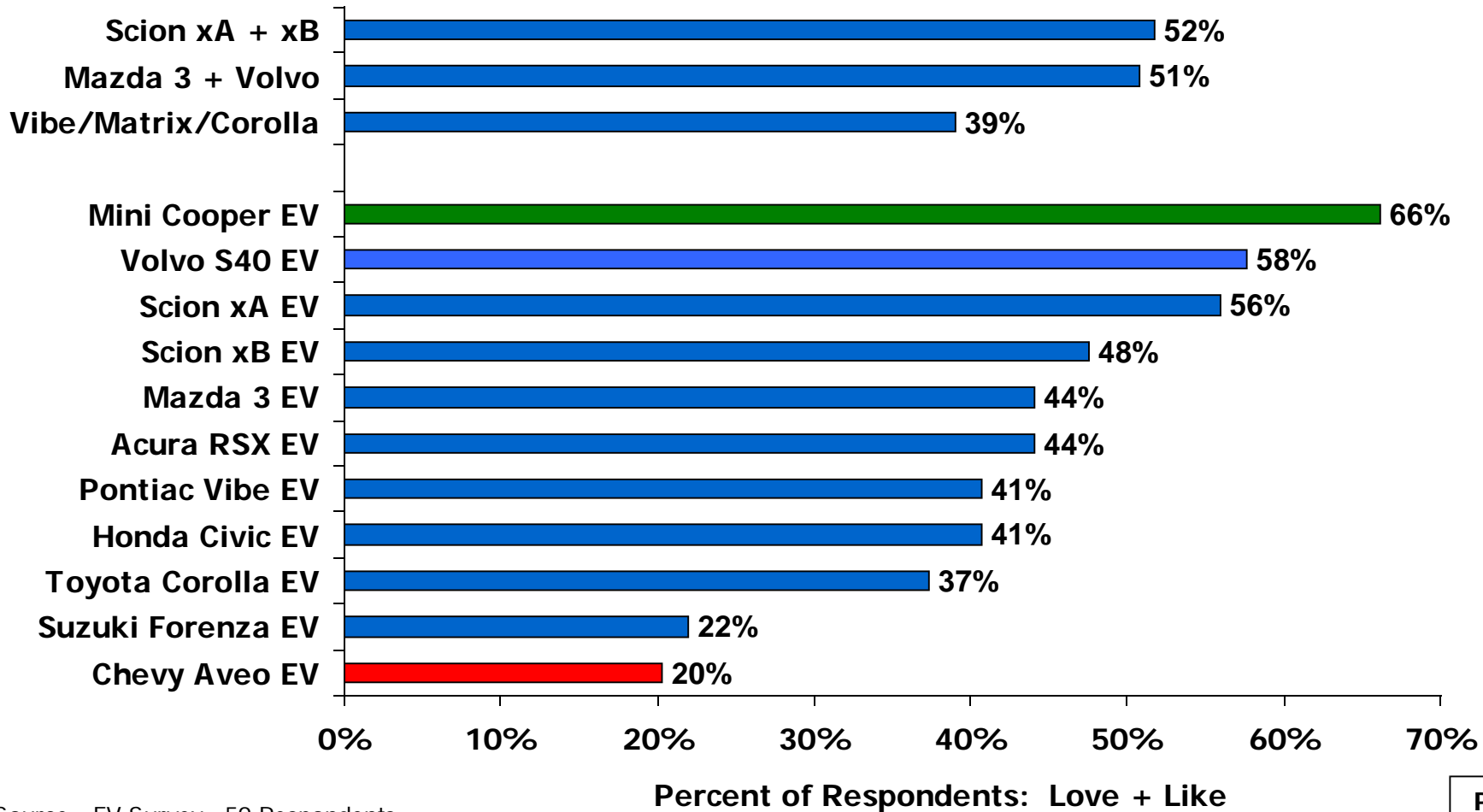
Source: EV Survey. 591 Respondents

Price Ranges: All



Rankings of EV Car Candidates

Q: What do you think of the following EVs?
"Love It" Plus "Like It" for Price Segment **\$30K+**



Source: EV Survey. 59 Respondents

Price Ranges: \$30K+



But Two Factors Prevail

1. Price
2. Range

Economics of Range

Cell Cost \$6/cell, assembled in pack, now
 ÷ 8 Wh/cell, now
 = 0.75 \$/Wh

Range Cost 200 Wh/mi, typical for efficient EV
 x 0.75 \$/Wh
 = \$150/mi of range

Battery Cost 100 mile battery: \$15,000
 300 mile battery: \$45,000

Cost Reduction 50% in 3-5 years

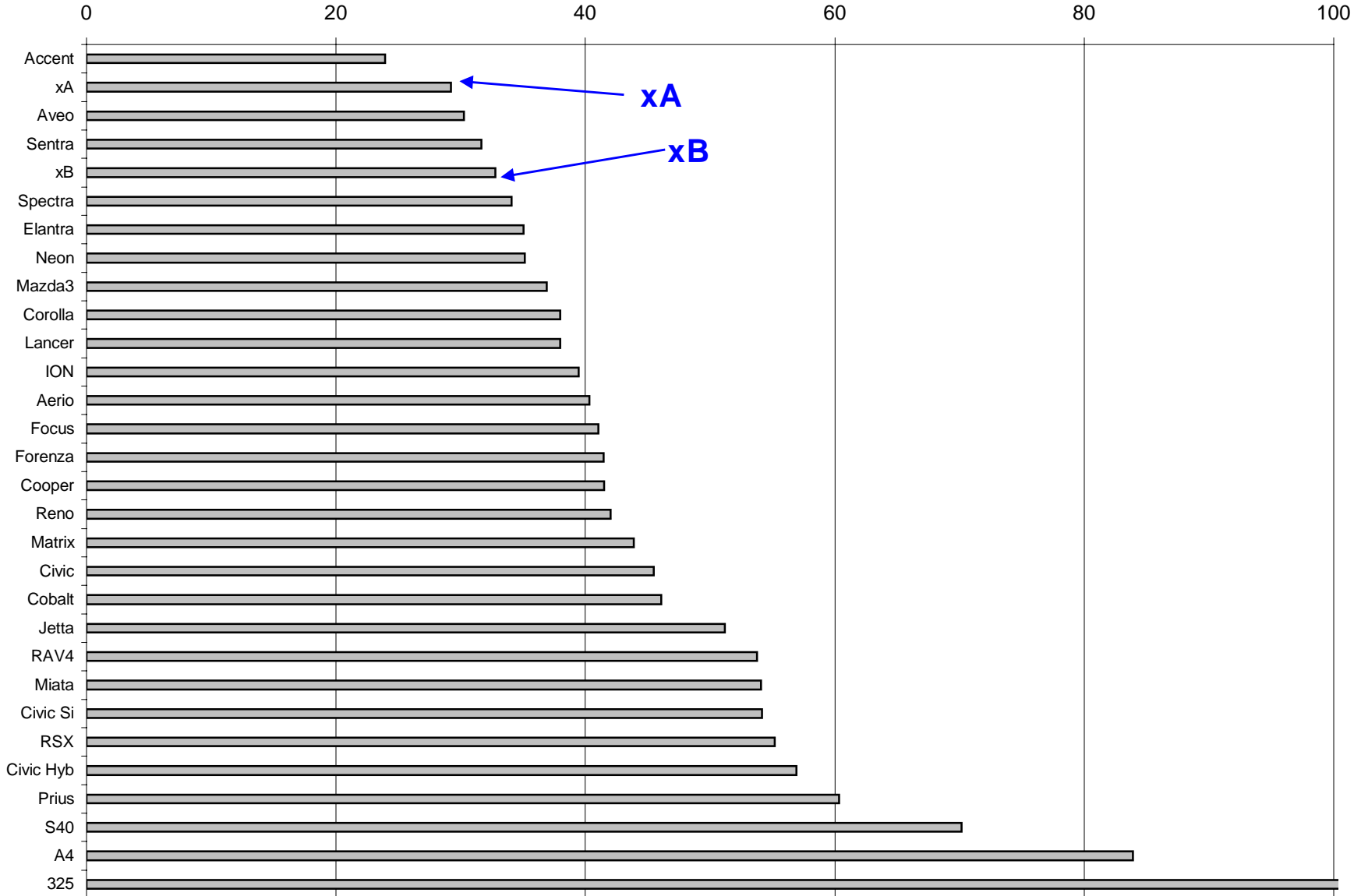
Economics of Efficiency

Range Cost \$150/mi of range

Weight 10% weight decrease
 10% range increase
 ⇒ ~ \$7/lb

Aero speed is biggest factor
 Cd and frontal area secondary

Car Comparison: Price x Weight



The AC Propulsion EV

FMVSS-certified EV conversion of Scion xA and xB



Scion xB



Scion xA

Features

- AC Propulsion drive system
- Li Ion battery
- Fast charging
- Regenerative braking
- Onboard battery diagnostics
- A/C, full power

Performance

- 100 mile range (180 mi option)
- 0-60 <10 sec (<7 sec option)
- 90 mph
- 1 mile per minute charging



FAQs

1. How much?

2. When?

3. ?

Check <http://www.acpropulsion.com> for updates