



**Powering Autos to 2020:
The Era of the Electric Car?**
Press Briefing

Detroit, June 14, 2011 – *Embargoed until 12:00pm EDT today*

THE BOSTON CONSULTING GROUP

Welcome to BCG

Today's speakers

Xavier Mosquet



Senior Partner

Global leader of BCG's Automotive practice
Managing Director of BCG's Detroit office

Lead author of *Powering Autos to 2020: The Era of the Electric Car?*

BCG Detroit

+1 248 688 3450

mosquet.xavier@bcg.com

Marco Gerrits



Partner

Head of BCG's Automotive practice in Greater
China

Coauthor of *Powering Autos to 2020: The Era of the Electric Car?*

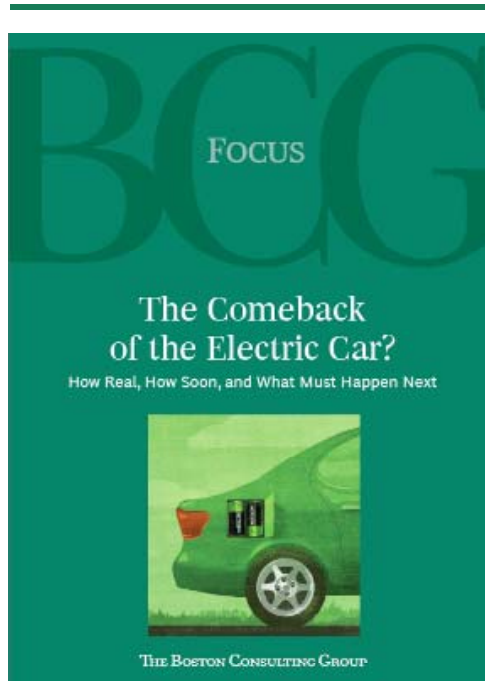
BCG Beijing

+86 10 8527 9007

gerrits.marco@bcg.com

BCG presents third study on automotive propulsion and electric car adoption

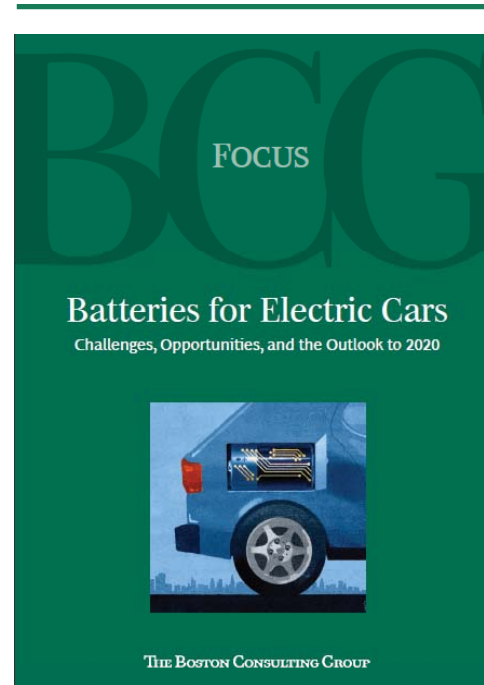
2009



Focus areas

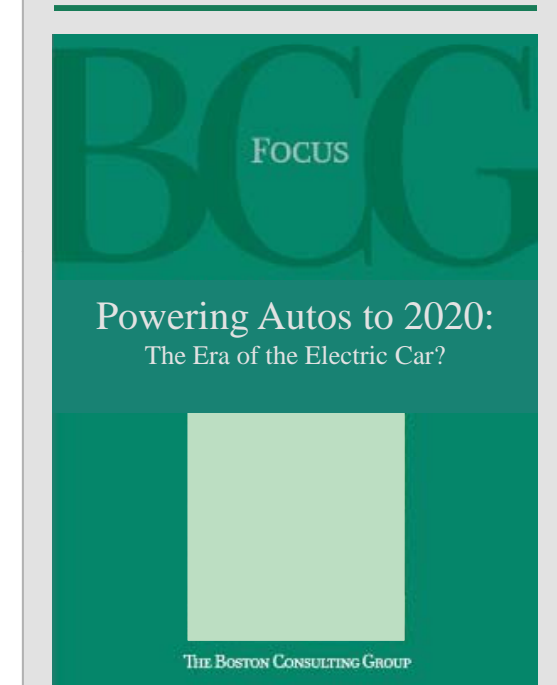
- Carbon-cost tradeoffs
- Total costs of ownership (TCO)
- Volume forecasts

2010



- Battery technology and industry overview
- Battery cost analysis
- Total costs of ownership (TCO) revisited

2011



- Potential of ICE technologies
- Consumer perspective
- Updated volume forecasts
- Go-to-market challenges

***Powering Autos to 2020* integrates major market drivers: regulation, technology, total cost and consumers**

The automotive market environment is quickly evolving

- Strict emission targets being enacted in all major markets
- First EVs¹ on the street and government incentives in place

We would like to offer an updated perspective on the main market drivers ...

- Emission targets and the improvement potential of different technologies
- Total Cost of Ownership – purchase costs, operating costs and terminal values
- Consumer's perspective on different technologies and their willingness to pay

... and discuss possible scenarios and their likely implications for key stakeholders

- Powertrain mix in US, Europe, Japan and China under different scenarios in 2020
- Implications for OEMs, suppliers and regulators

1. EVs include pure battery, range-extended, and plug-in hybrid electric vehicles

Agenda

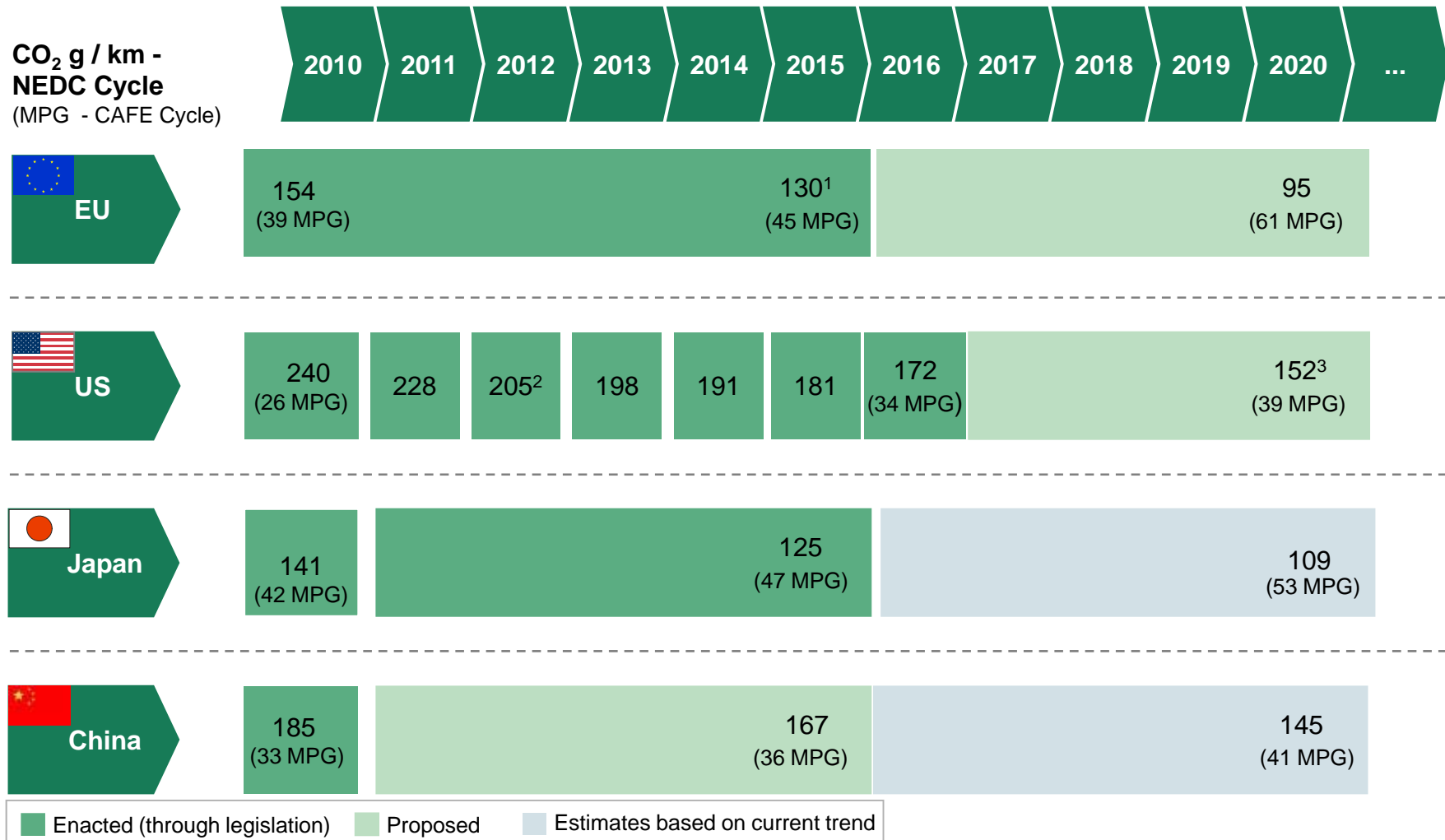
Technology, costs and emissions

Consumer perspective

Market forecast and implications

Q&A

Automotive CO₂ emission standards are becoming more stringent worldwide



1. From motor vehicle technology only. EU plans to reduce emissions by another 10 CO₂ g/km from other improvements (e.g. air conditioning technology) and biofuels


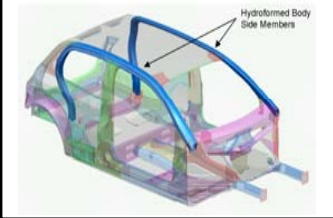

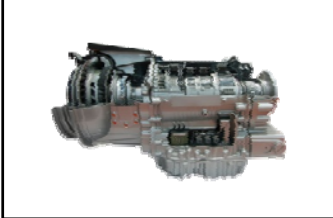

2. For 2012-2016, California agreed to conform to the Federal Standards, before California had enacted stricter legislation

3. Based on released scenarios of a 47-62 mpg target for 2025 – 47 mpg expected to be the more likely

Note: All targets are expected to be phased in

Source: ICCT, EPA, The Motor Industry of Japan 2010, Asahi Shimibun press search

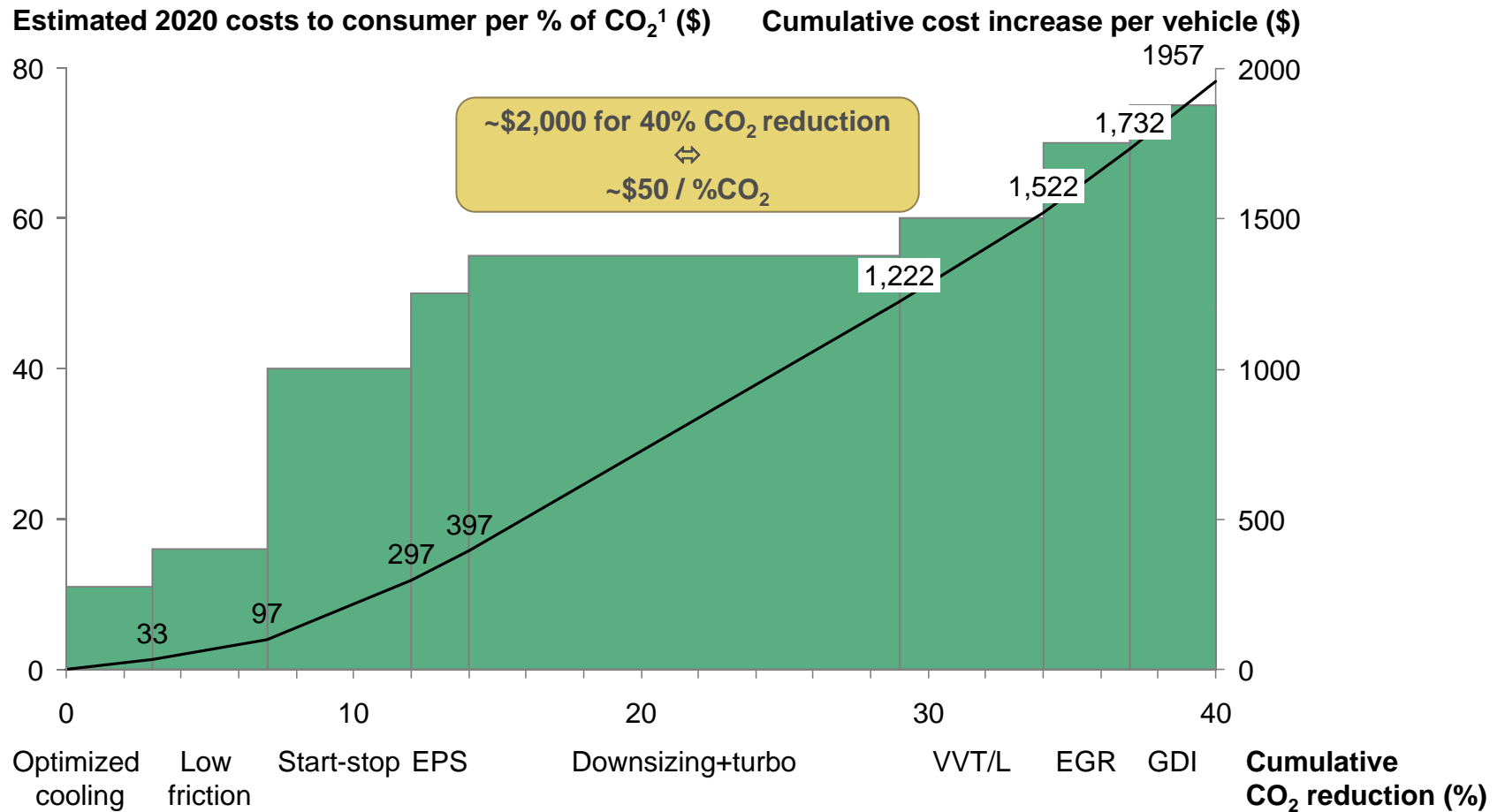
Conventional technologies with high CO₂ reduction potential; ICE has the most potential

	Aerodynamics	Vehicle mass	ICE technology	Transmissions	Power management
					
Levers	<ul style="list-style-type: none"> Optimized design (drag coefficient and frontal area) Optimized tires 	<ul style="list-style-type: none"> Lightweight material New manufacturing technologies Content optimization Downsizing 	<ul style="list-style-type: none"> Vaporization and combustion optimization Energy losses reduction (pumping, friction, heat) Weight reduction 	<ul style="list-style-type: none"> Improved automatic transmissions control Continuously variable transmissions Dual clutch 	<ul style="list-style-type: none"> Switch from mechanical to electric accessories Optimization of accessories' electric consumption
Impact on CO₂ emissions	1% CO ₂ reduction for ~0.01 drag coefficient reduction	3-4% CO ₂ reduction for 10% mass reduction	From 1 to 20% CO ₂ reduction per technology	From 1 to 7% CO ₂ reduction per technology	From 1 to 2% CO ₂ reduction per technology
2020 max potential %CO₂ red	~5%	~5-6%	~40% ⁴	~5-10%	~3-5%
Cost to consumer/car¹	~\$100/veh or ~\$20/%CO ₂ ²	~\$500/veh ² or ~\$100/%CO ₂ ³	~\$2,000-2,500/veh or ~\$50-60/%CO ₂ ⁵	~\$100-200/veh or ~\$20-40/%CO ₂ ⁶	~\$150-250/veh or ~\$50/%CO ₂

1. Vehicle price increase before VAT 2. Cost for avg. weight reduction of 250 lbs 3. New materials show potential for weight reduction up to 37% at cost of \$2,100, i.e. ~\$160/%CO₂ 4. 30-35% for Diesel 5. Average for gasoline and diesel: individual technologies vary from \$20 to \$100+ per %CO₂ 6. Replacement of 5-speed automatic gearbox with dual clutch transmission on compact car
Source: Expert interviews, BCG analysis

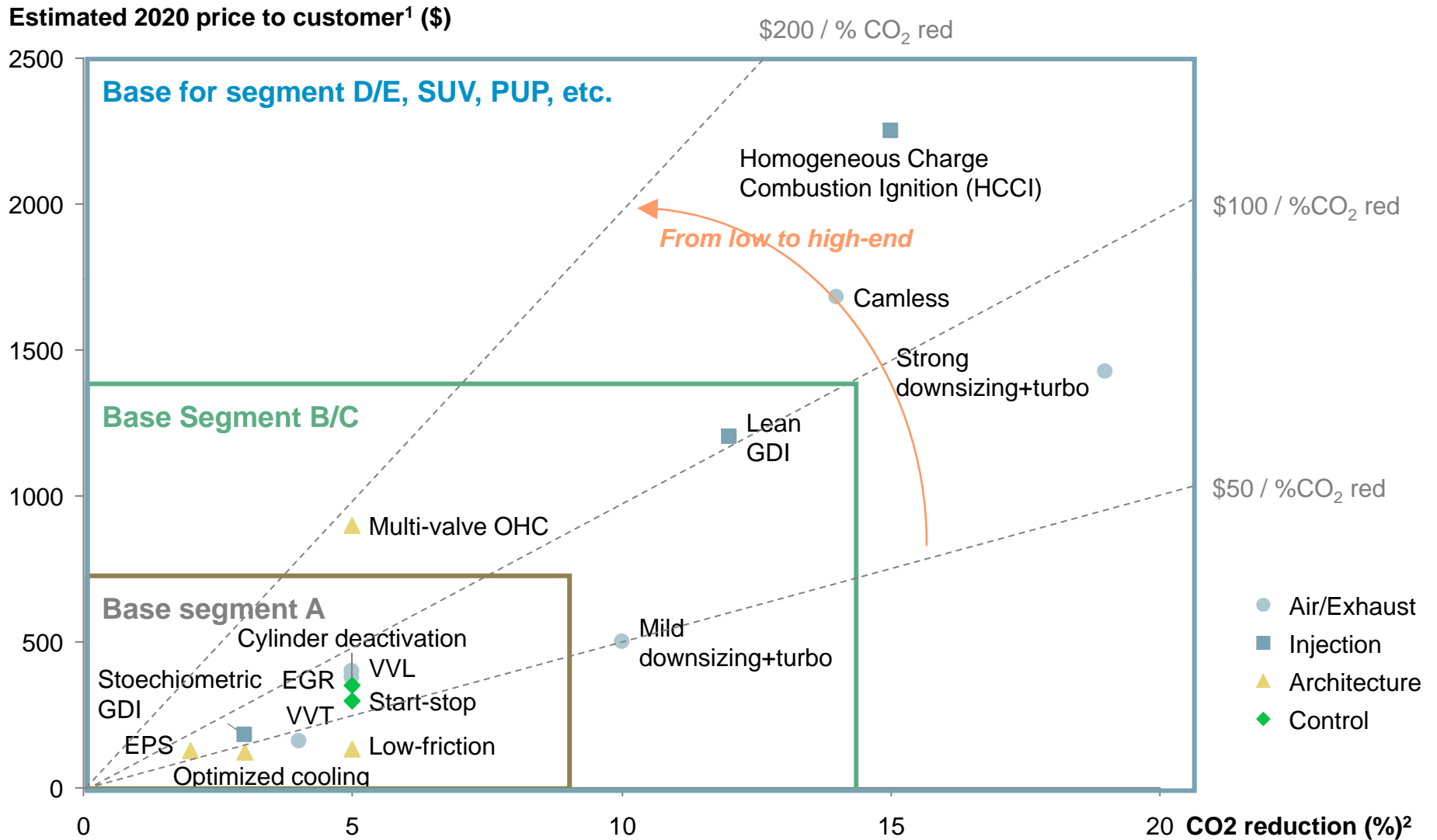
ICE technologies alone can reduce emissions by 40%

At a cost of \$50 per percentage of CO₂ reduction: approx. \$2,000 per vehicle to the consumer



1. Estimated 2020 price to customer before VAT. Assume 1% decrease in manufacturing costs from 2010 to 2020 and OEM mark-up ranging between 50 to 100%; shown for D segment in North America. Expect minor variances by segment and region

Performance-cost tradeoffs lead to potential range of technology options by segment



1. Estimated 2020 price to customer before VAT -- Assume 1% decrease in manufacturing costs from 2010 to 2020 and OEM mark-up ranging between 50 to 100% 2. Max plausible potential for CO2 reduction Source: Expert interviews, BCG analysis

Comparison of different technologies

North America 2020 view – average passenger car

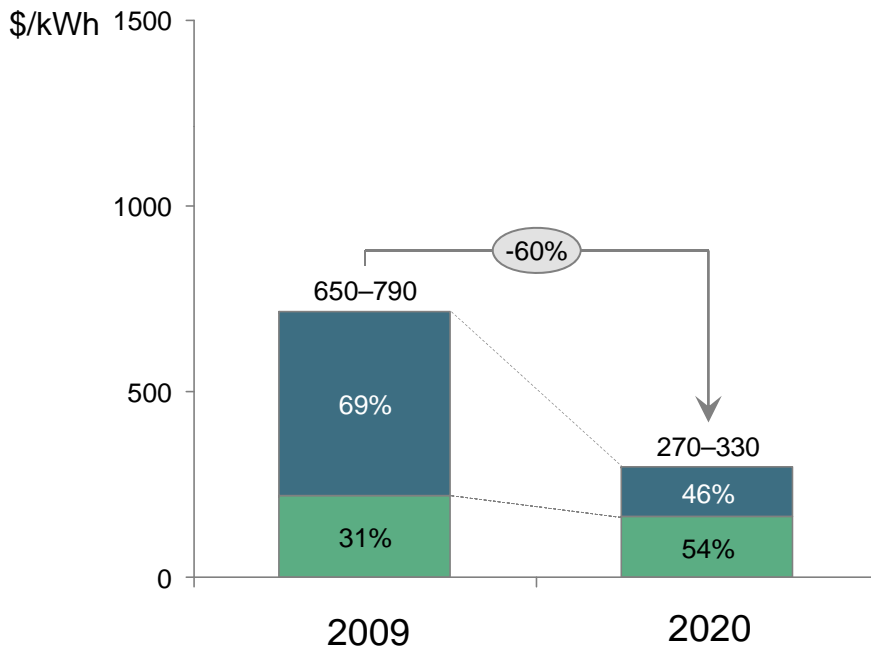
	Gasoline ICE	Diesel	CNG	Hybrid	EV
Tailpipe CO₂ Emissions Reduction vs. '10 gasoline ICE	-40%	-40%+	-60%	-65%	-100%
Price Increase vs. '10 vehicle price	\$2,000	\$4,000 (Includes \$1,500 cost of post treatment)	\$5,000	\$5,000	\$10,000
Price per % CO₂ reduction	\$50	\$100	\$85	\$80	\$100

Source: BCG

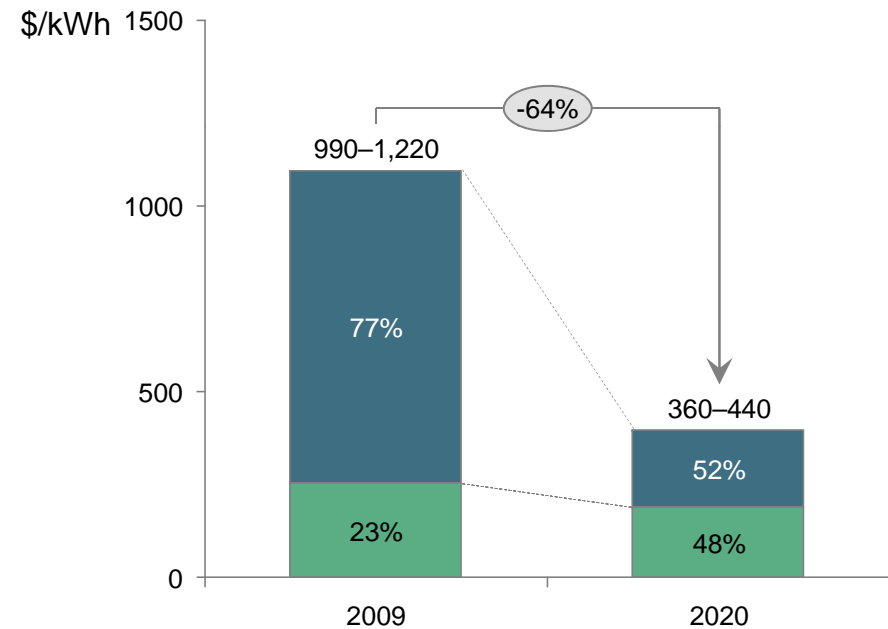
BCG expects pack costs for OEMs will fall to ~\$360-440 per kWh by 2020



Cell cost per kWh



Pack cost per kWh



■ Battery volume dependent costs ■ Battery volume independent costs

Notes: Assumes annual production of 50,000 cells and 5,000 batteries in 2009 and 73 million cells and 1.1 million batteries in 2020. Numbers are rounded.
 Source: BCG Batteries Tier 1 report January 2010 (BCG interviews, BCG analysis, Argonne); OEM interviews in Jan 2011

Agenda

Technology, costs and emissions





Consumer perspective

Market forecast and implications

Q&A

BCG conducted consumer research on green auto technologies in four regions

Customer survey in four key regions

Market	Sample
 USA	1,027
 Europe	5,016 (Top 5 countries ¹)
 Japan	746 <i>Data from previous survey used for market model</i> <i>Most recent survey not conducted due to tsunami</i>
 China	550 (Top 20 cities ² , vehicle owners & intenders)

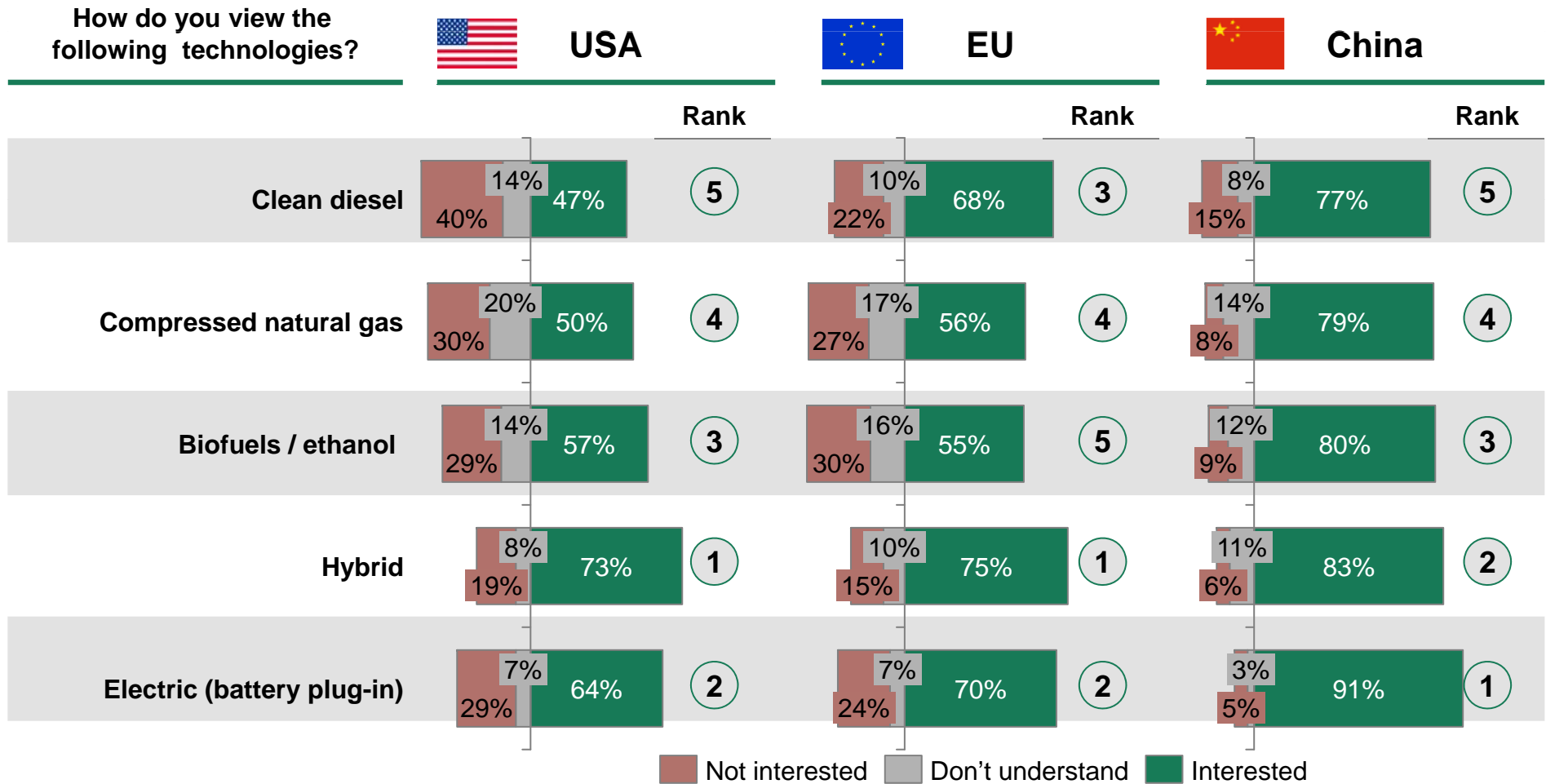
Questions on green automotive technologies

- 1 Attitude toward different green automotive technologies**
 - Level of interest and knowledge
 - Reasons for interest in technology
- 2 Willingness to pay for green technologies**
 - General willingness to pay more upfront or over the life of the vehicle
 - Amount willing to pay more upfront
 - Amount willing to pay more over the life of the vehicle
 - Payback expectations

1. Germany, France, UK, Italy, Spain 2. Online car buyer survey: weighted to be representative of car buyer population and actual car price ranges by market
Source: BCG Consumer Barometer March 2011, N = 1,027 in US, N = 5,016 in Europe; BCG Automotive Survey of car owners and intenders in China N = 550

Car buyers are most interested in hybrid and electric

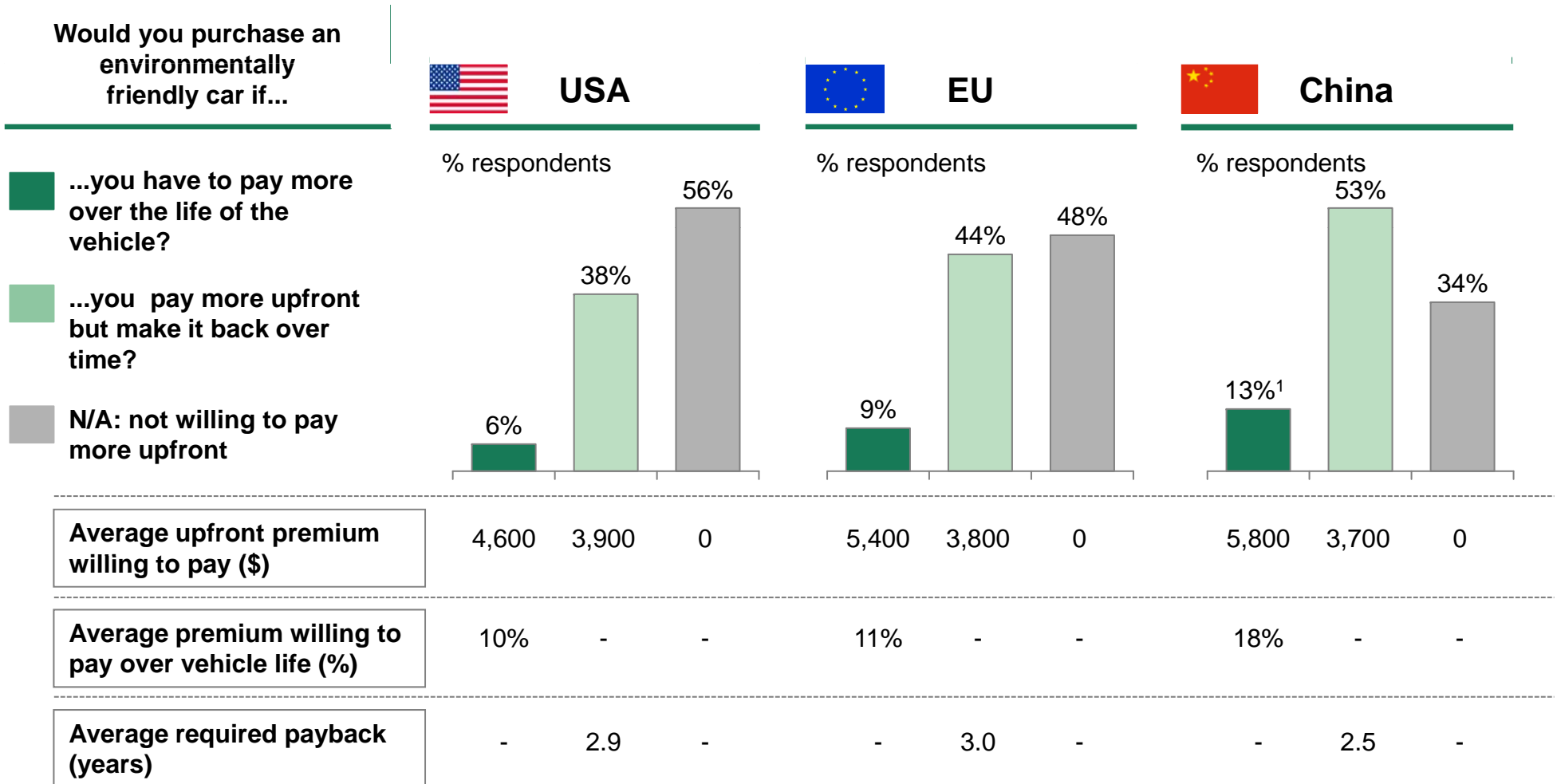
Chinese car buyers show a preference for electric



Note: EU is weighed 28% Germany, 19% Italy, 10% Spain, 24% France and 20% UK by 2010 vehicle sales.

Source: BCG Consumer Barometer March 2011, N = 1,027 in US, N = 5,016 in Europe; BCG Automotive Survey of car owners and intenders in China N = 550

6% of US and 9% of EU consumers are willing to pay more over the life of the vehicle for green cars; ~50% are unwilling



1. Step down by city size – 31% in top 10 cities, 23% in cities 11-20, 14% beyond top 20; weighted average of vehicle owners and intenders / first-time car buyers
 Note: EU is weighed 28% Germany, 19% Italy, 10% Spain, 24% France and 20% UK by 2010 vehicle sales.
 Source: BCG Consumer Barometer March 2011, N = 1,027 in US, N = 5,016 in Europe; BCG Automotive Survey of car owners and intenders in China N = 550

Green consumers and those seeking payback are willing to pay \$4,000-\$6,000 more upfront

How much extra would you be 'willing' to pay upfront



USA



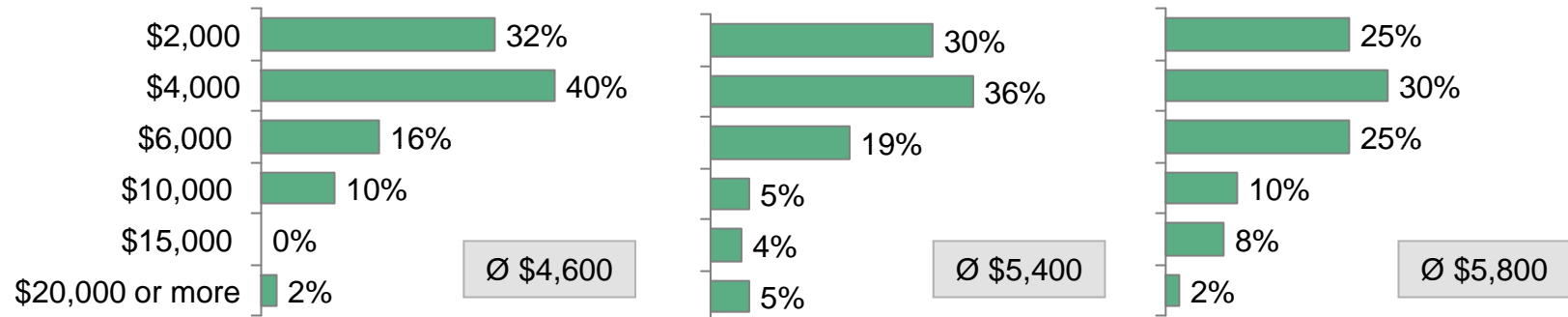
EU



China¹

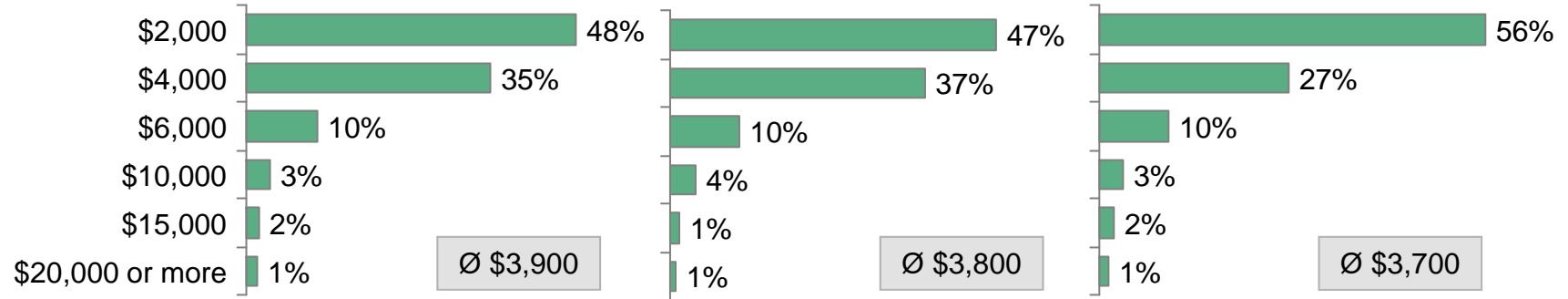
Consumers willing to pay more over the life of the vehicle

% respondents, of those willing to spend more over vehicle life



Consumers expecting payback over time

% respondents, of those willing to spend more if paid back over time



1. Weighted average of vehicle owners and intenders / first-time car buyers

Note: EU is weighed 28% Germany, 19% Italy, 10% Spain, 24% France and 20% UK by 2010 vehicle sales.

Source: BCG Consumer Barometer March 2011, N = 1,027 in US, N = 5,016 in Europe; BCG Automotive Survey of car owners and intenders in China N = 550

Green consumers are willing to pay 10-20% more over the life of the vehicle

How much would you be 'willing' to spend more over vehicle life



USA

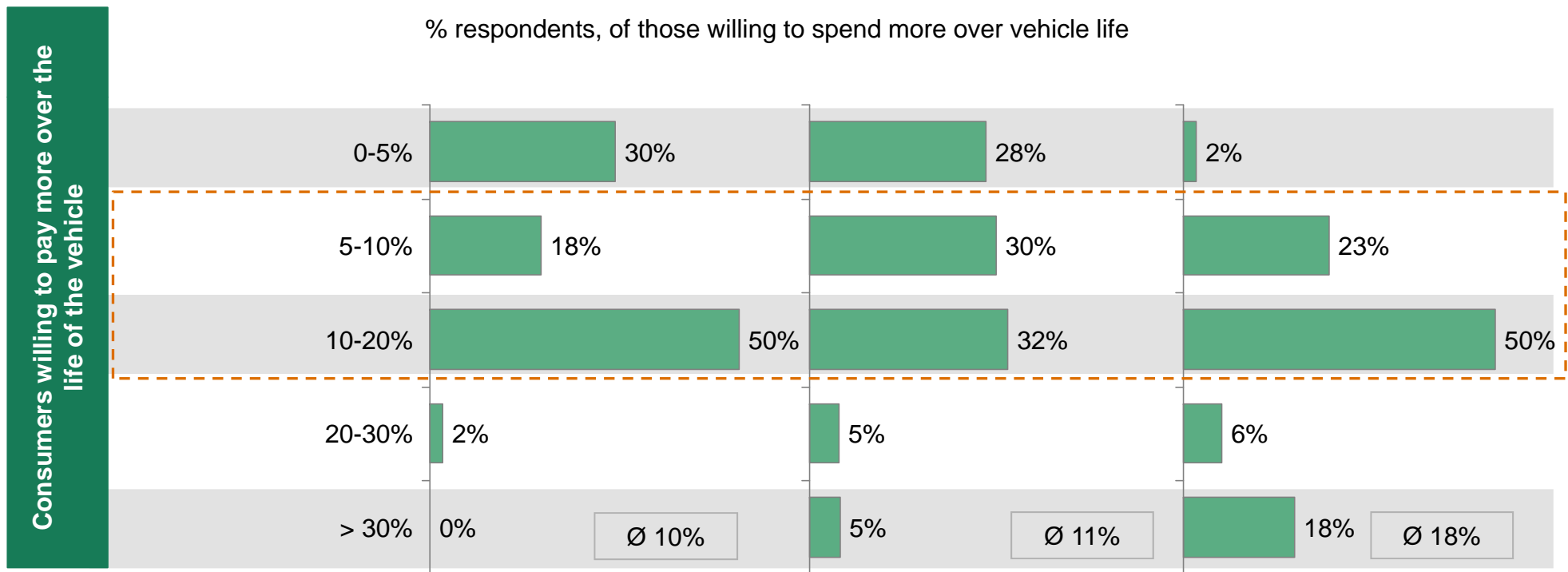


EU



China

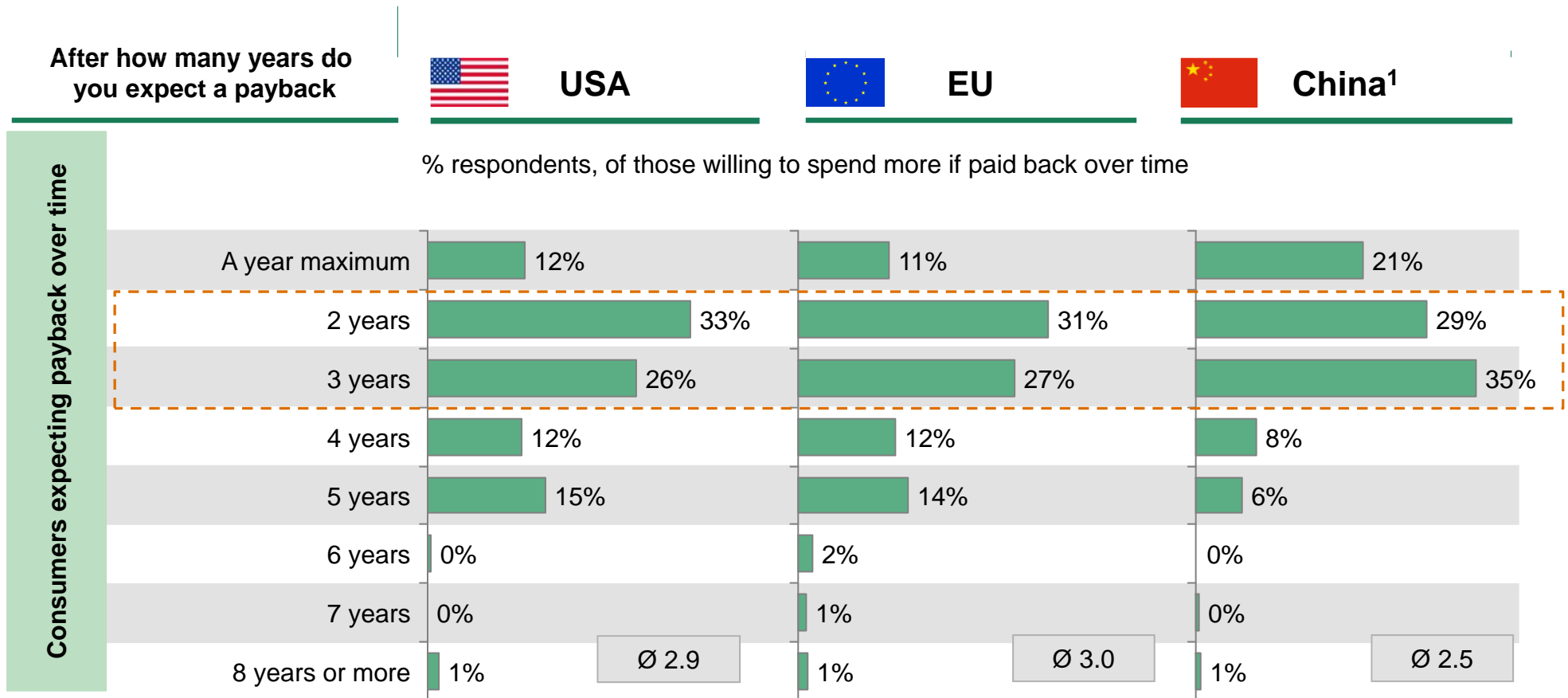
% respondents, of those willing to spend more over vehicle life



Note: EU is weighed 28% Germany, 19% Italy, 10% Spain, 24% France and 20% UK by 2010 vehicle sales.

Source: BCG Consumer Barometer March 2011, N = 1,027 in US, N = 5,016 in Europe; BCG Automotive Survey of car owners and intenders in China N = 550

But those seeking payback expect their upfront investment to be amortized within 2-3 years



1. Weighted average of vehicle owners and intenders / first-time car buyers

Note: EU is weighed 28% Germany, 19% Italy, 10% Spain, 24% France and 20% UK by 2010 vehicle sales.

Source: BCG Consumer Barometer March 2011, N = 1,027 in US, N = 5,016 in Europe; BCG Automotive Survey of car owners and intenders in China N = 550

Agenda

Technology, costs and emissions

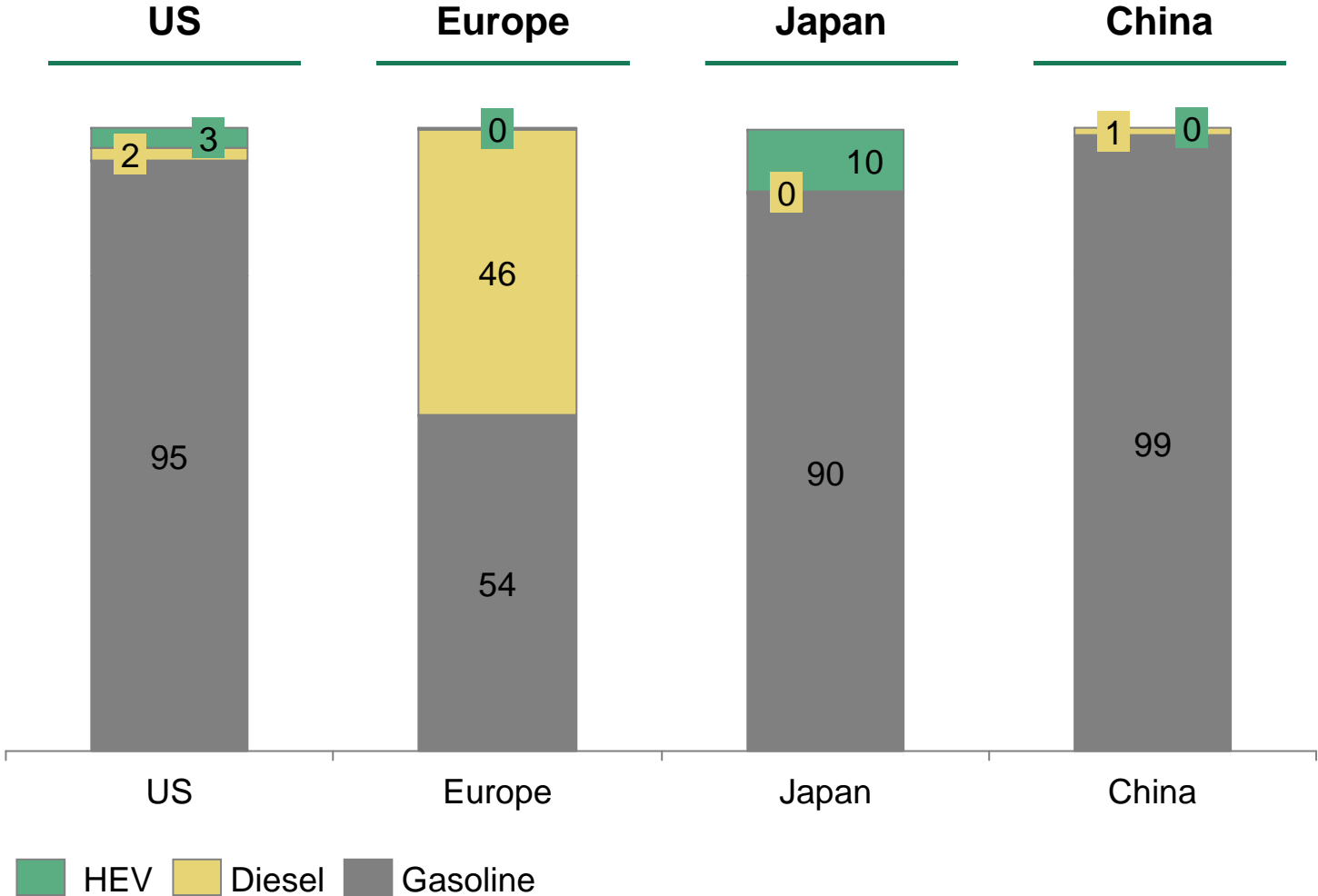
Consumer perspective

Market forecast and implications

Q&A

Starting position: 2010 powertrain mix

Percent of passenger car sales

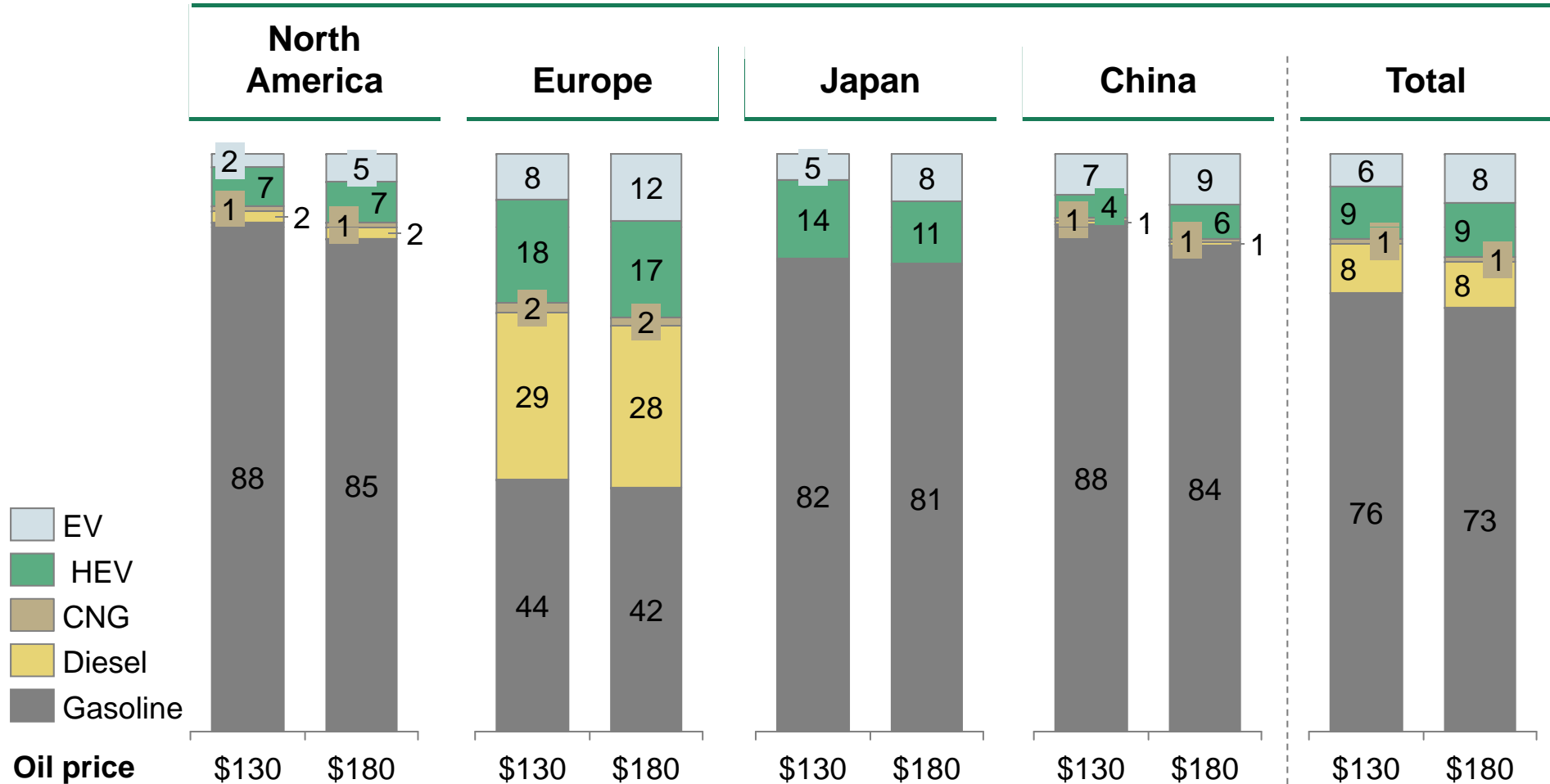


Source: BCG analysis, Edmunds, ACEA, Autonews, The Daily Yoimuir

ICE will still dominate global passenger car sales in 2020

Europe and China will be the largest markets for EVs in 2020

Powertrain projections (% of 2020 passenger car sales)



Note: EV=Pure battery electric vehicle, RE (range extender), and plug-in HEV; HEV=Hybrid (mild and full, incl. diesel HEVs); CNG=compressed natural gas; gasoline includes micro hybrids and flex fuel
Source: BCG analysis

Greener scenarios could increase EV penetration by 6%

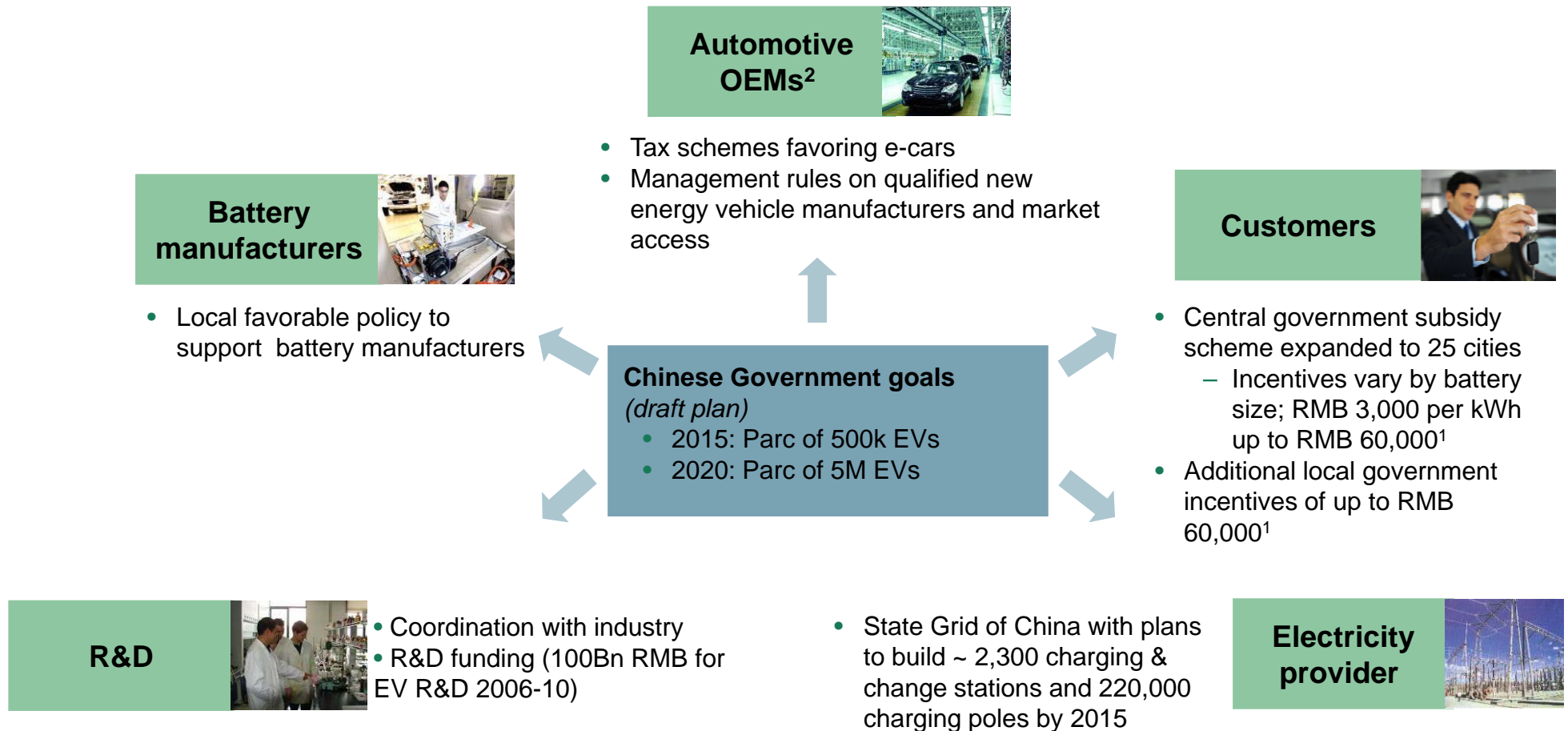
Either through a combination of peak oil with incentives or lower battery costs

				Change Top 4 region penetration (percentage points)		
	Drivers	Base Value	Sensitivity Value	Gas & diesel	HEV	EV/RE/PHEV
Individual levers	Oil prices	\$130 / barrel	\$180 / barrel	-3.0	0.4	2.6
	EV incentives	0	\$2,000	0.0	-2.2	2.2
	Battery costs	\$400 / kWh	\$300 / kWh	-0.6	-1.7	2.4
Combined scenarios	Oil price + EV incentives	\$130 / barrel 0	\$180 / barrel \$2,000	-3	-3	6
	Oil price + battery costs	\$130 / barrel \$400 / kWh	\$180 \$300 / kWh	-4	-2	6

Source:: BCG

China will be a major wildcard for EV sales

Market success will be highly dependent on continued government support



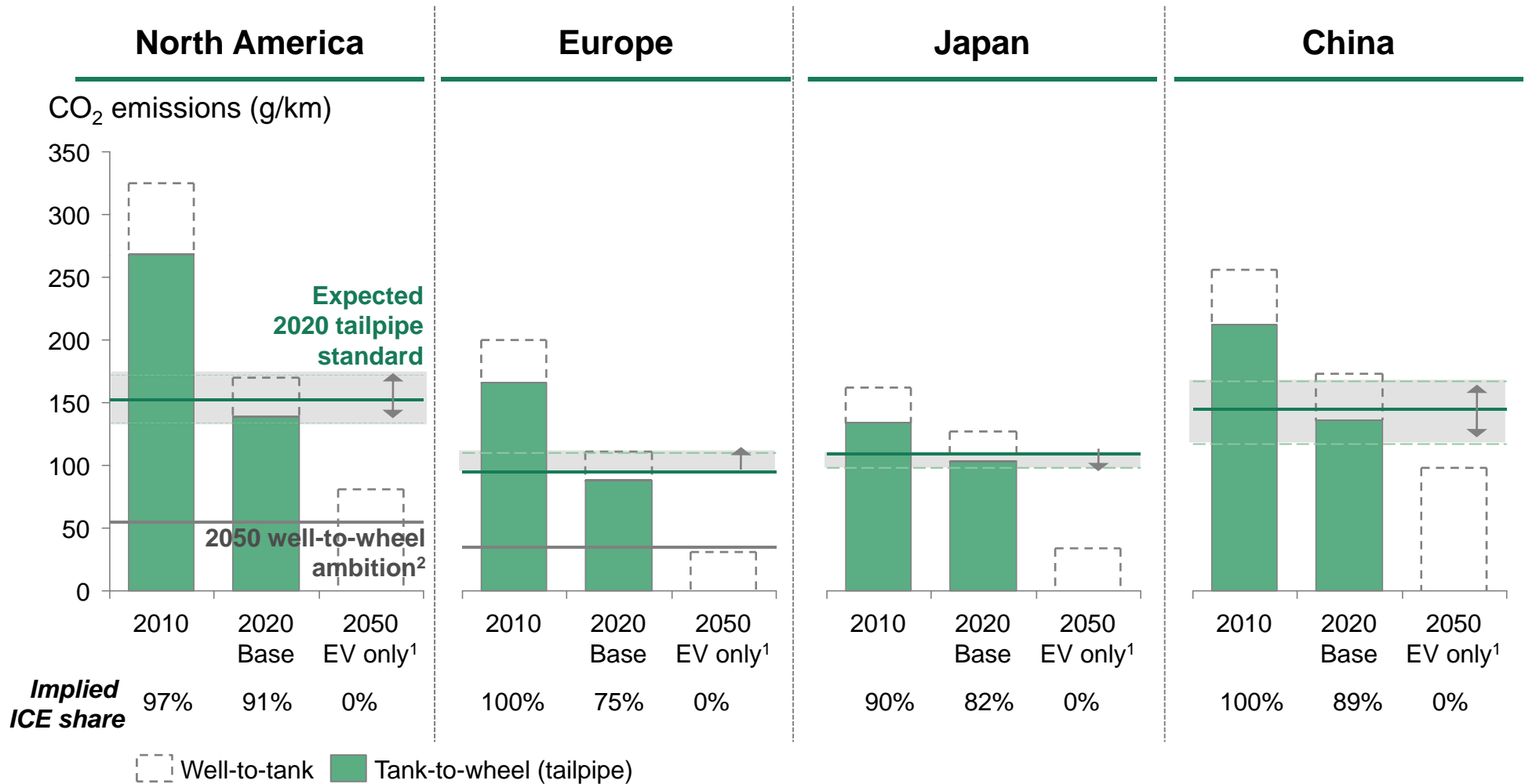
Government established SASAC alliance – a cross functional initiative of OEMs, battery manufacturers and utilities

1. Most incentives are for lower values

2. Financial support for OEMs is strict: FAW, SAIC and Yutong were granted support but budget unknown, DFM got 50Mn Rmb interest discount, Chery got 10Mn Rmb, Source: BCG analysis, press clippings, government websites

OEMs should meet 2020 standards through ICE advancement

Meeting 2050 ambitions will require electrification



1. 2050 power mix, assumes mix per region changes at same rate between 2035 and 2050 as between 2020 and 2035 2. US and Europe have stated ambitions to reduce GHG emissions by 90% from 1990 levels
Source: BCG analysis

We can imagine at least three different paths forward

High degree of uncertainty

The Pragmatic Path



- Energy independence and economic considerations prevail
- Well-to-wheel CO₂ emissions drive environmental decisions
- Oil prices remain at \$100 per barrel or below
- Advanced ICEs and hybrids dominate; moderate EV share as hedge against rising oil prices

The Breakthrough Path



- Battery technology improves significantly to cost \$250 per Kwh or below
- Oil prices remain in line with market expectations of \$130 per barrel
- EVs including plug-ins for longer ranges ultimately take a significant share of the market (10-30% by 2020)

The Green Path



- Oil prices surge to over \$250 per barrel
- Governments invest in EVs and clean sources of electricity
- A mix of small-model EVs and larger-model HEVs could capture up to a third of the market by 2020
- If prices decouple from oil, CNG/LPG can represent a larger share of the ICE market

Navigating among possible paths

Implications for OEMs, suppliers and regulators

All market participants have to prepare for and retain the flexibility to switch among the different paths the industry could take

OEMs have to learn to manage more complex and dynamic technology portfolios

- How to reduce variance and complexity in mature technologies?
- Where to partner and where to develop proprietary intellectual property?
- When and where to invest in manufacturing capacity for batteries and e-motors?
- What go-to-market model to choose for e-cars – basic (car only), extended (services, infrastructure)?

Suppliers have to review their current technology portfolios

- How to be best positioned for new growth areas (advanced ICE, EV and HEV components)?
- What is the value proposition compared to OEMs and new players (e.g. chemical companies, start-ups)?

Regulators have to be clear on roadmap and reduce uncertainty for new technologies

- How to weigh goals of emissions reduction, energy independence and support of domestic industries?
- How to bring, and sustain, new technologies at sufficient scale to lower costs?
- How to best incentivize desired consumer behavior?

Agenda

Technology, costs and emissions

Consumer perspective

Market forecast and implications

Q&A

Appendix

Definitions

Internal-Combustion-Engine Vehicles (ICEs)

- Fueled by gasoline, diesel, compressed natural gas, or biofuels
- Includes micro-hybrids (i.e. simple start-stop automatic)

Hybrid Electric Vehicles (HEVs)

- Have both an internal-combustion engine and an electric motor but no external charging.
- Includes mild (e.g. Honda Insight) and full hybrids (e.g. Toyota Prius)

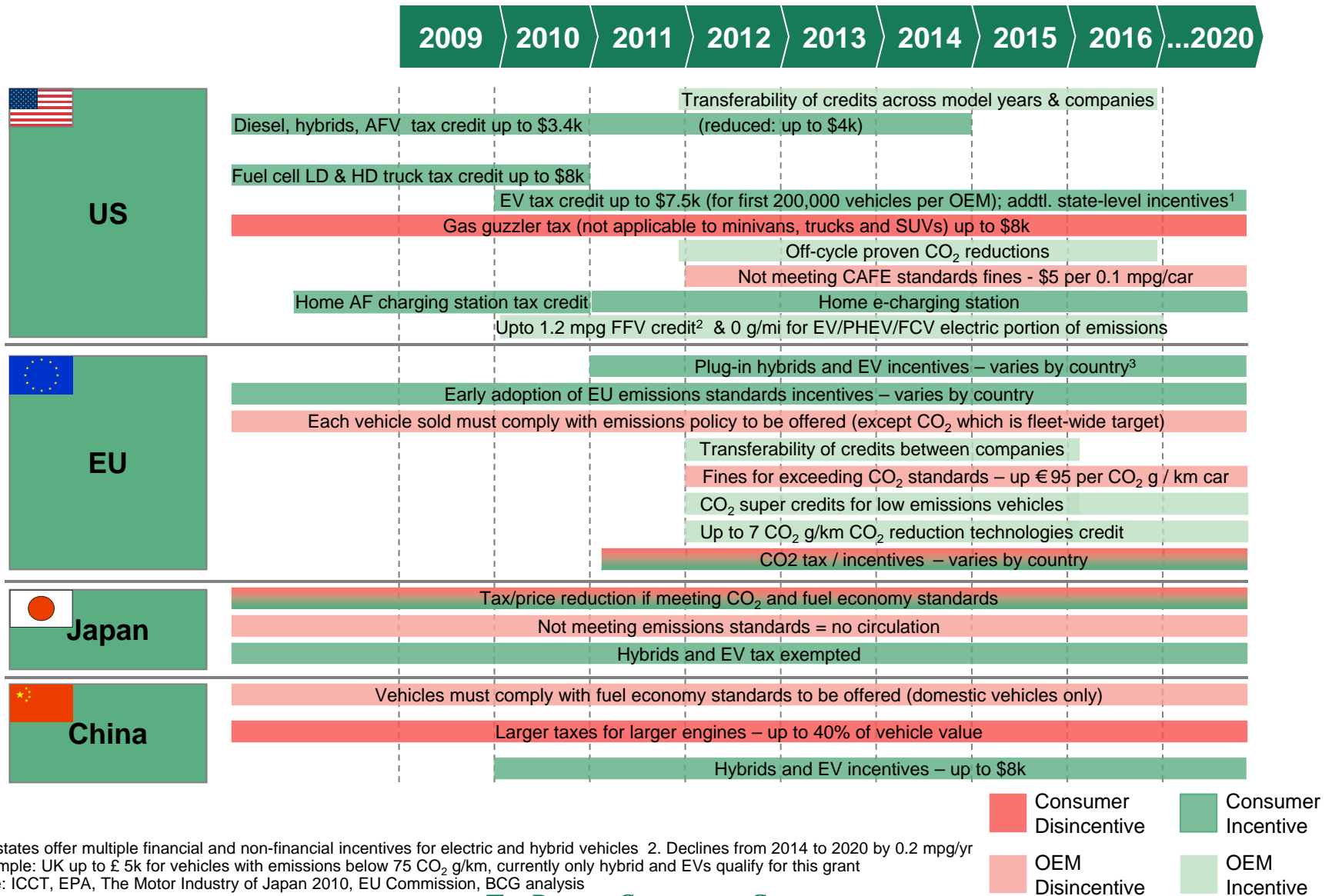
Electric Vehicles (EVs)

- Have an electric motor and can be charged externally
- Includes pure battery, range-extended (RE), and plug-in hybrid electric vehicles (PHEVs)

Glossary

Abbreviation	Description
NEDC Cycle	New European Driving Cycle
CAFE Cycle	Corporate Average Fuel Economy Cycle
EPS	Electric power steering
VVT/L	Variable valve timing / variable valve lift
EGR	Exhaust gas recirculation
GDI	Gasoline direct injection
Multi-valve OHC	Multi-valve overhead camshaft
CNG	Compressed natural gas
LPG	Liquefied petroleum gas

Governments using taxes, incentives to drive consumer uptake of EVs, hybrids; but many set to expire before 2020



1. US states offer multiple financial and non-financial incentives for electric and hybrid vehicles 2. Declines from 2014 to 2020 by 0.2 mpg/yr
 3. Example: UK up to £ 5k for vehicles with emissions below 75 CO₂ g/km, currently only hybrid and EVs qualify for this grant
 Source: ICCT, EPA, The Motor Industry of Japan 2010, EU Commission, BCG analysis