quarterly analysis review

16.2

2Q 2016

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ta engineering	jim moore, charles taylor

23 may 2016

topics

1 energy markets

automotive markets

technologies studies

environmental studies

consumers & opinion surveys

policy & business studies

qar

outline

1 energy markets

gasoline prices

> EIA: Summer retail gasoline prices expected to be lowest in a decade
> FOTW: Gas prices still relatively high historically

oil markets/production

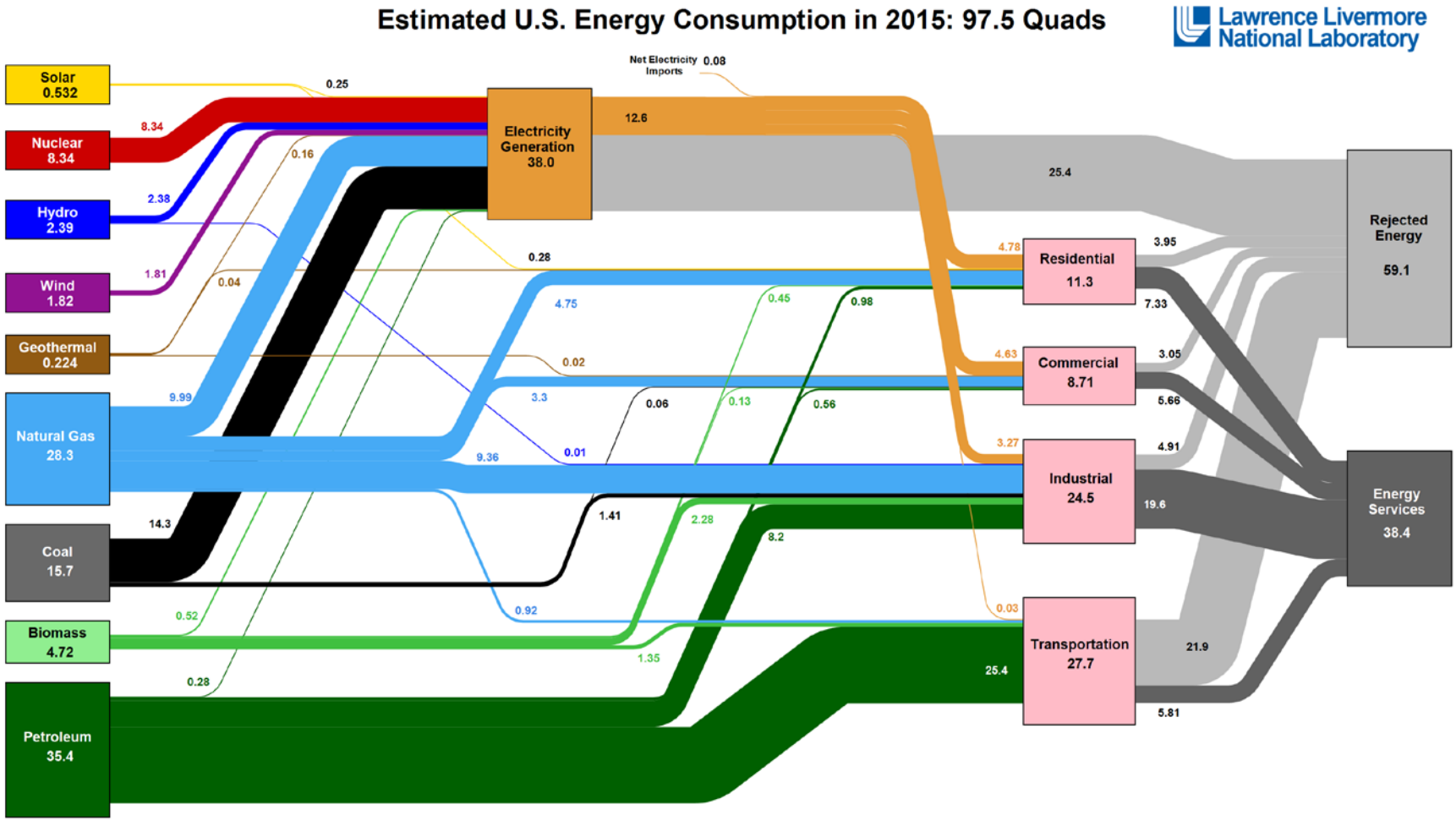
> EIA: Crude projected to stay cheap for a while
> EIA: Most domestic crude oil comes from new wells
> Goldman Sachs: Faster to drill new wells than ever before
> Bloomberg: Reduced demand for petroleum for transportation will keep prices down in the long term

energy projections

> EIA/OPEC/ExxonMobil/BP: Growth in (transportation) energy usage and demand over next 3 decades will be driven by developing countries and increased shipping

energy usage

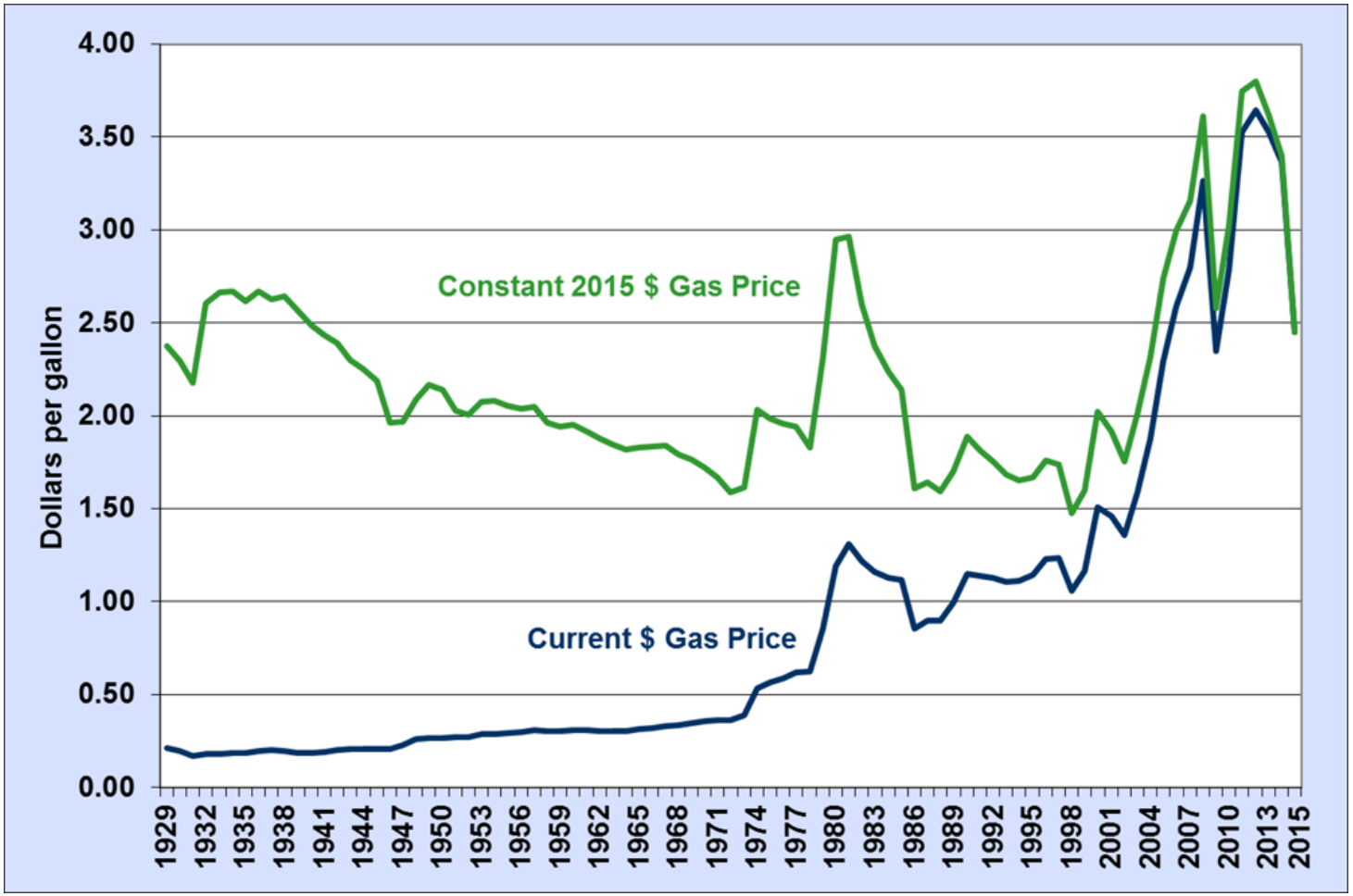
LLNL: National energy usage down 1%, transportation energy and petroleum usage up 2% in 2015



Source: https://flowcharts.llnl.gov/

gasoline prices

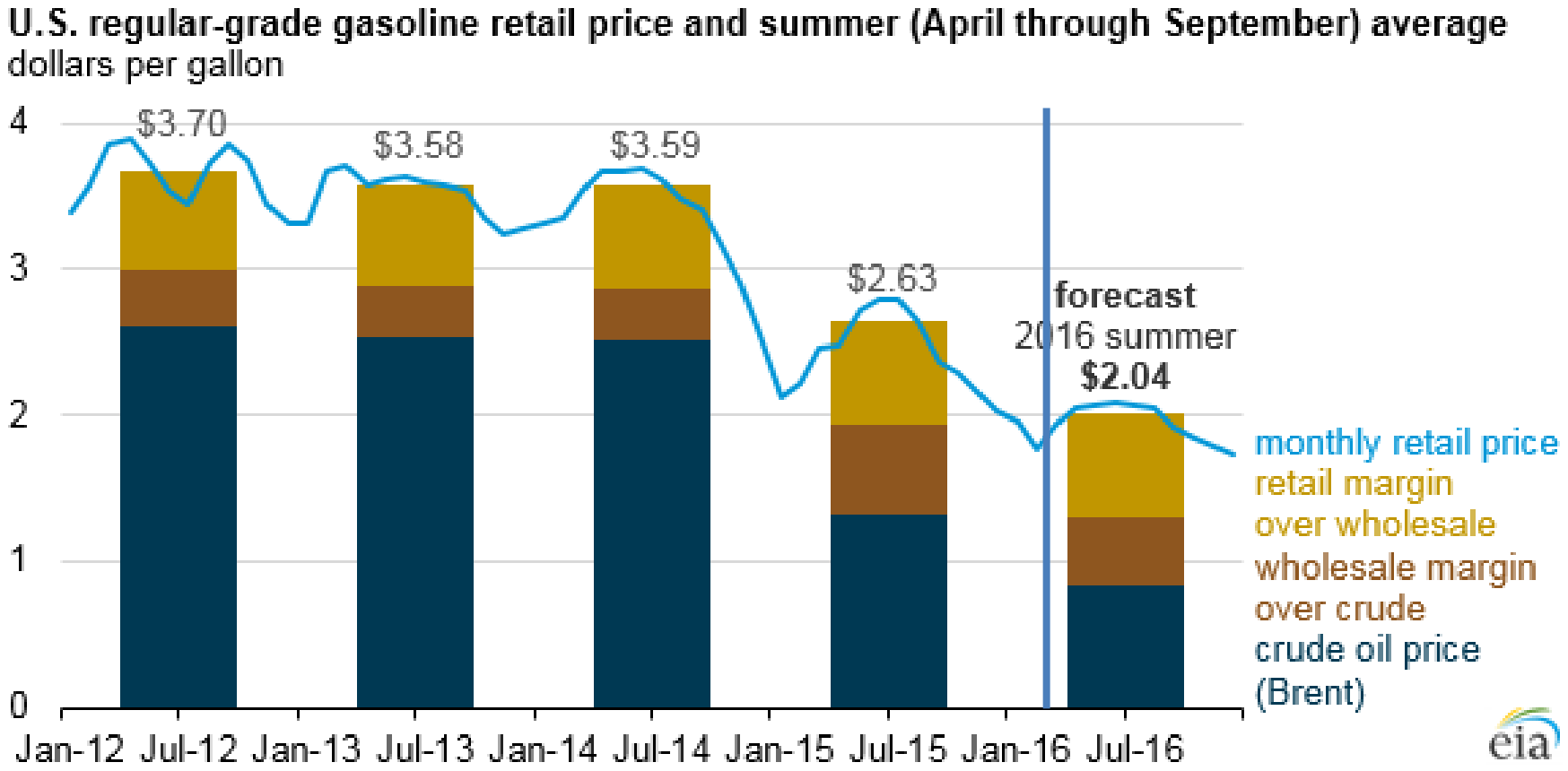
FOTW: Gas prices still relatively high historically, even after recent price drops



Source: http://energy.gov/eere/vehicles/fact-915-march-7-2016-average-historical-annual-gasoline-pump-price-1929-2015

gasoline prices

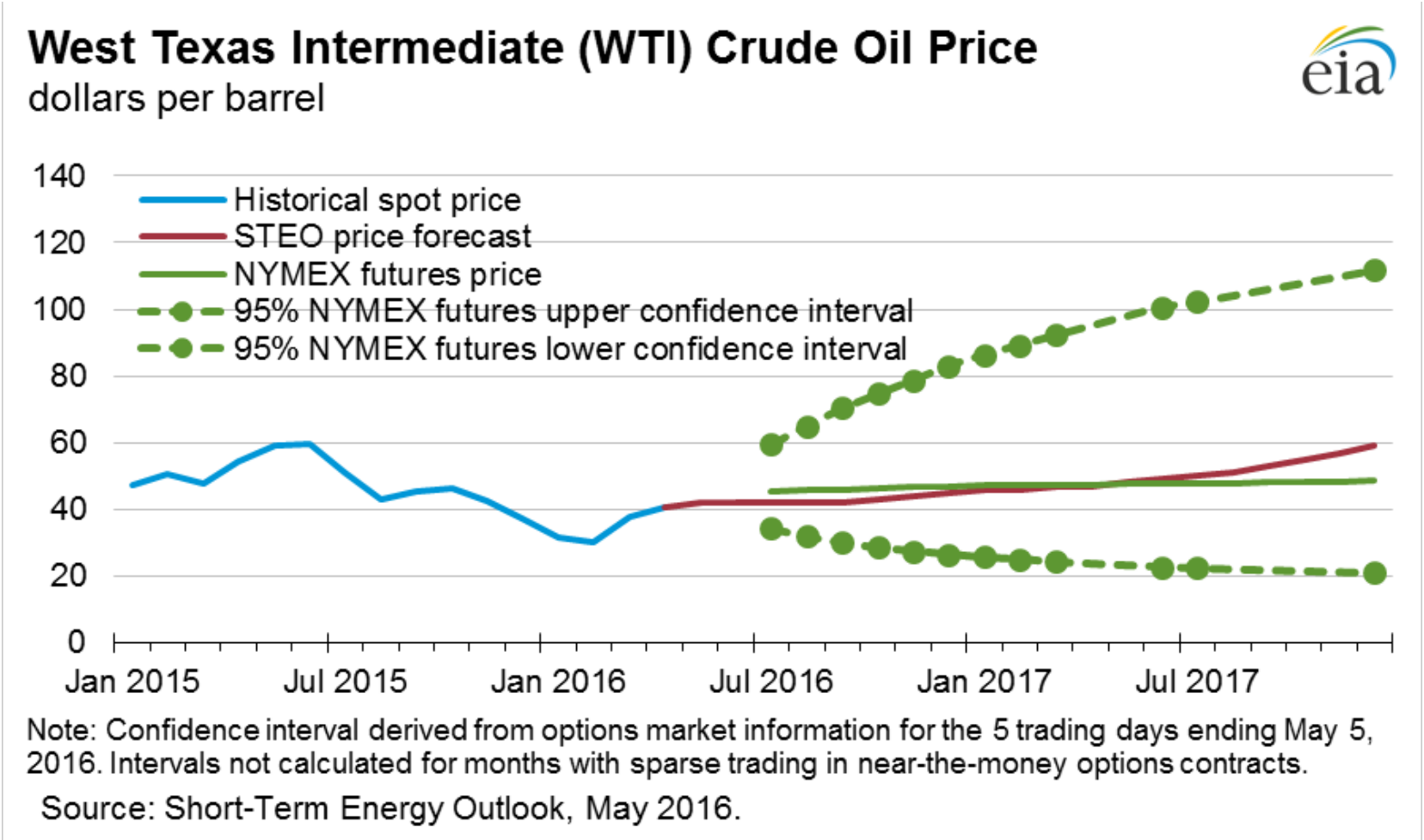
EIA: Retail gasoline prices this summer expected to be lowest since 2004



Source: http://www.eia.gov/todayinenergy/detail.cfm?id=25792

oil markets

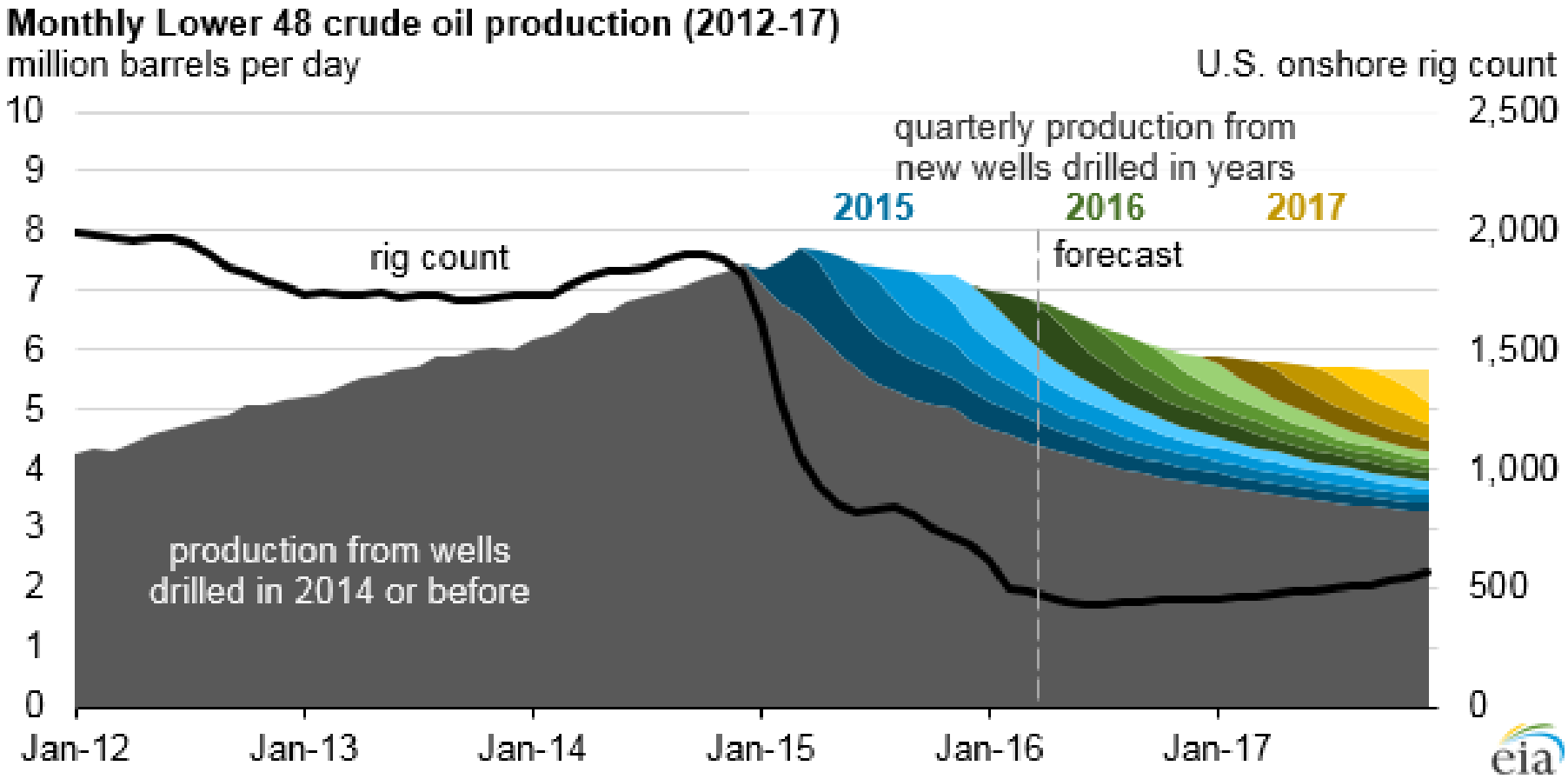
EIA: Oil prices are forecast to remain steady for the next couple of years



Source: http://www.eia.gov/forecasts/steo/report/

oil production

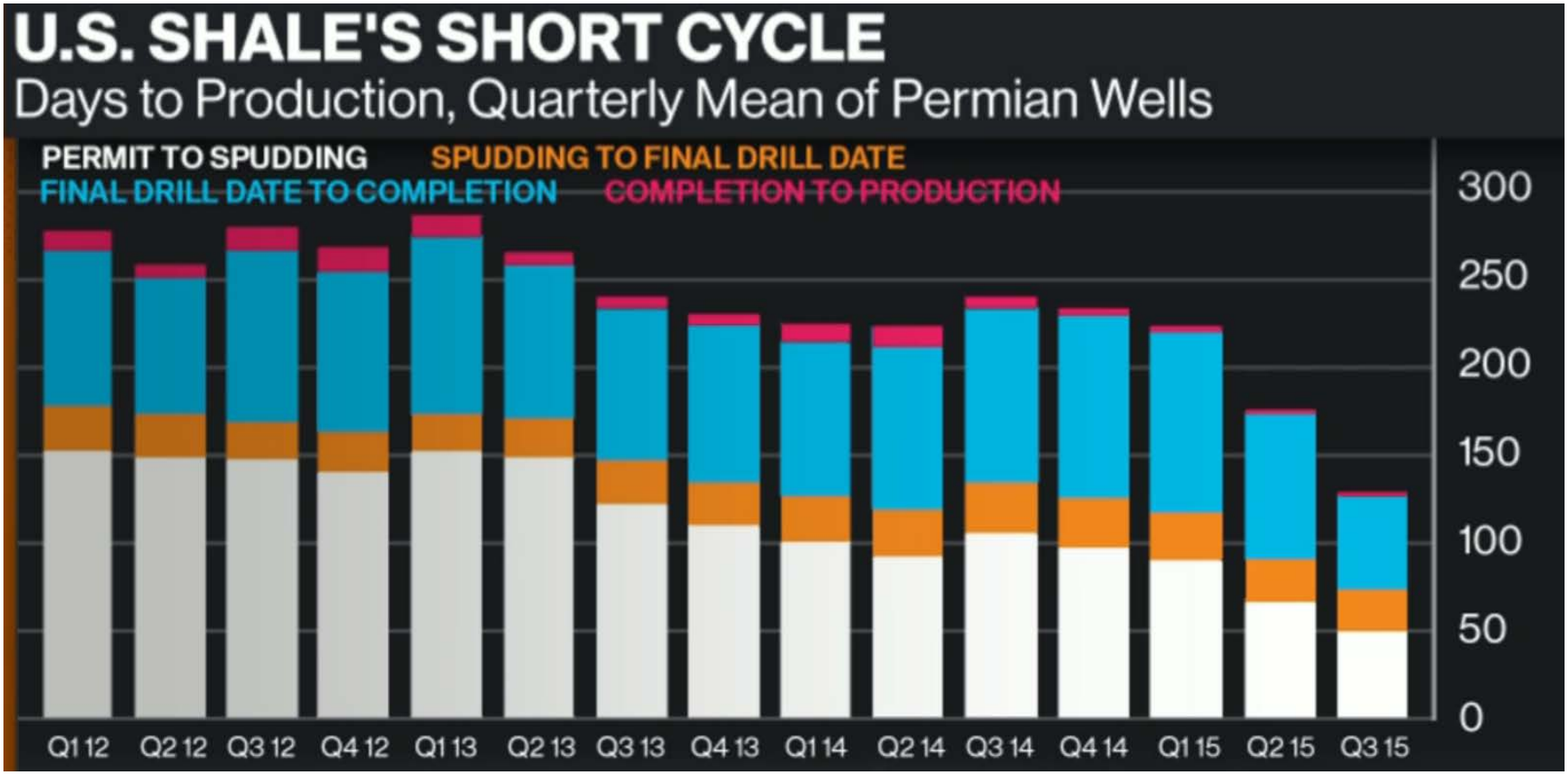
EIA: Large fraction of U.S. oil production comes from newly drilled wells



Source: http://www.eia.gov/todayinenergy/detail.cfm?id=25892

oil production

Goldman Sachs via Bloomberg: Domestic shale oil production capable of starting up faster than ever

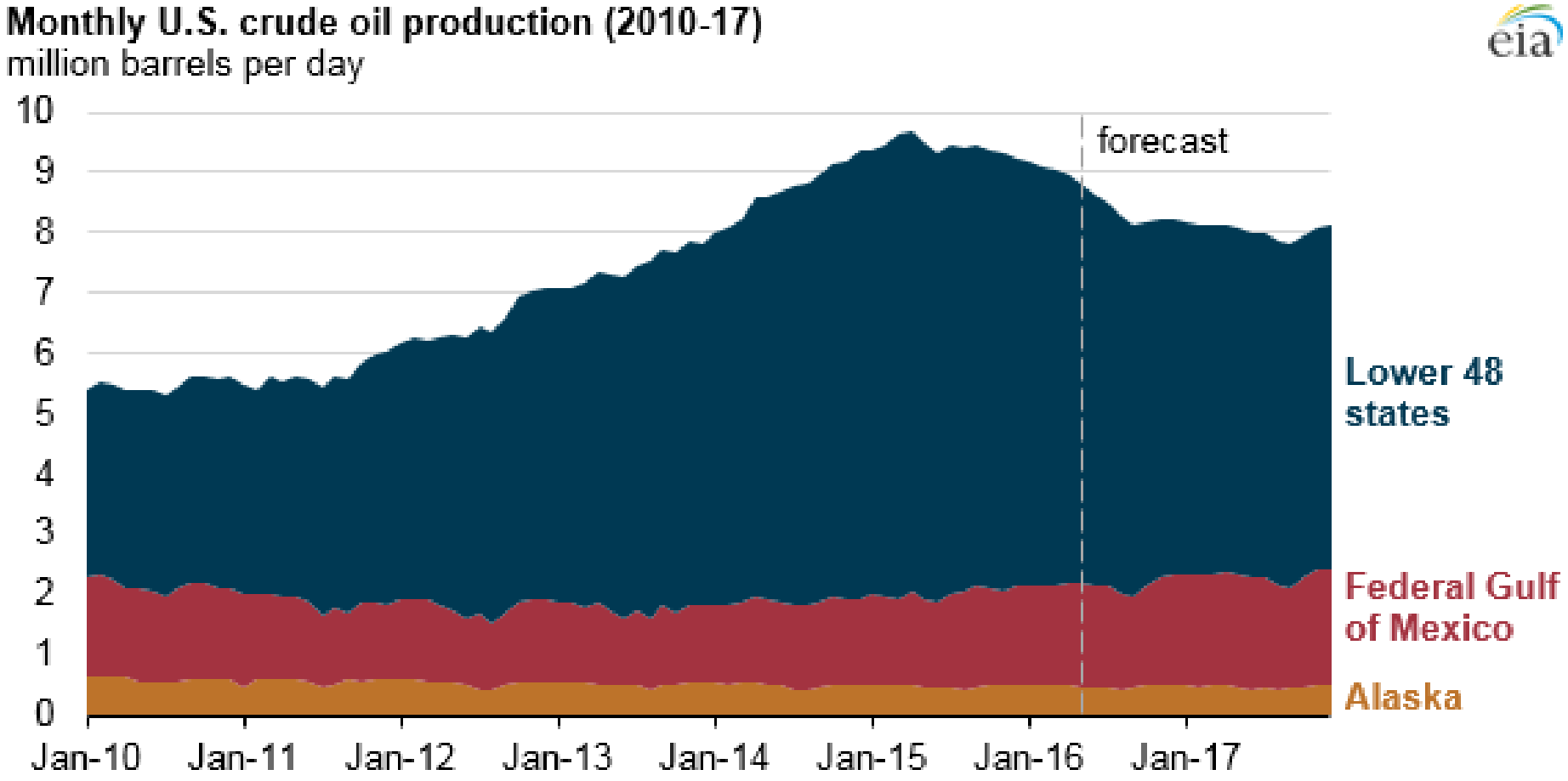


Note: Spudding refers to the initial drilling for an oil well

Source: http://www.bloomberg.com/news/videos/2016-02-16/why-an-opec-production-cut-wouldn-t-make-much-of-a-difference

oil production

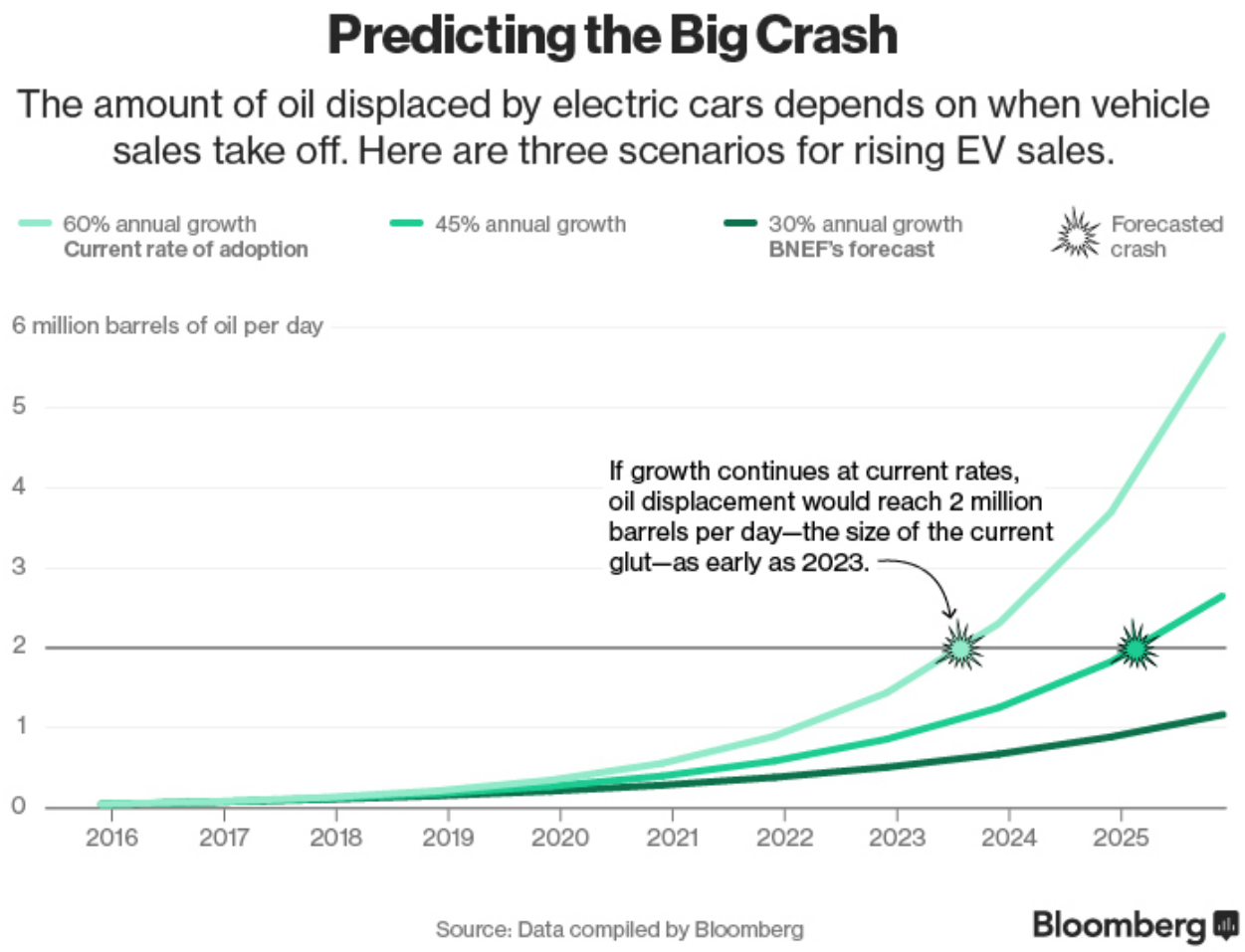
EIA: Oil production in lower 48 states projected to decrease, Gulf of Mexico production to continue climb



Source: http://www.eia.gov/todayinenergy/detail.cfm?id=25892

oil markets

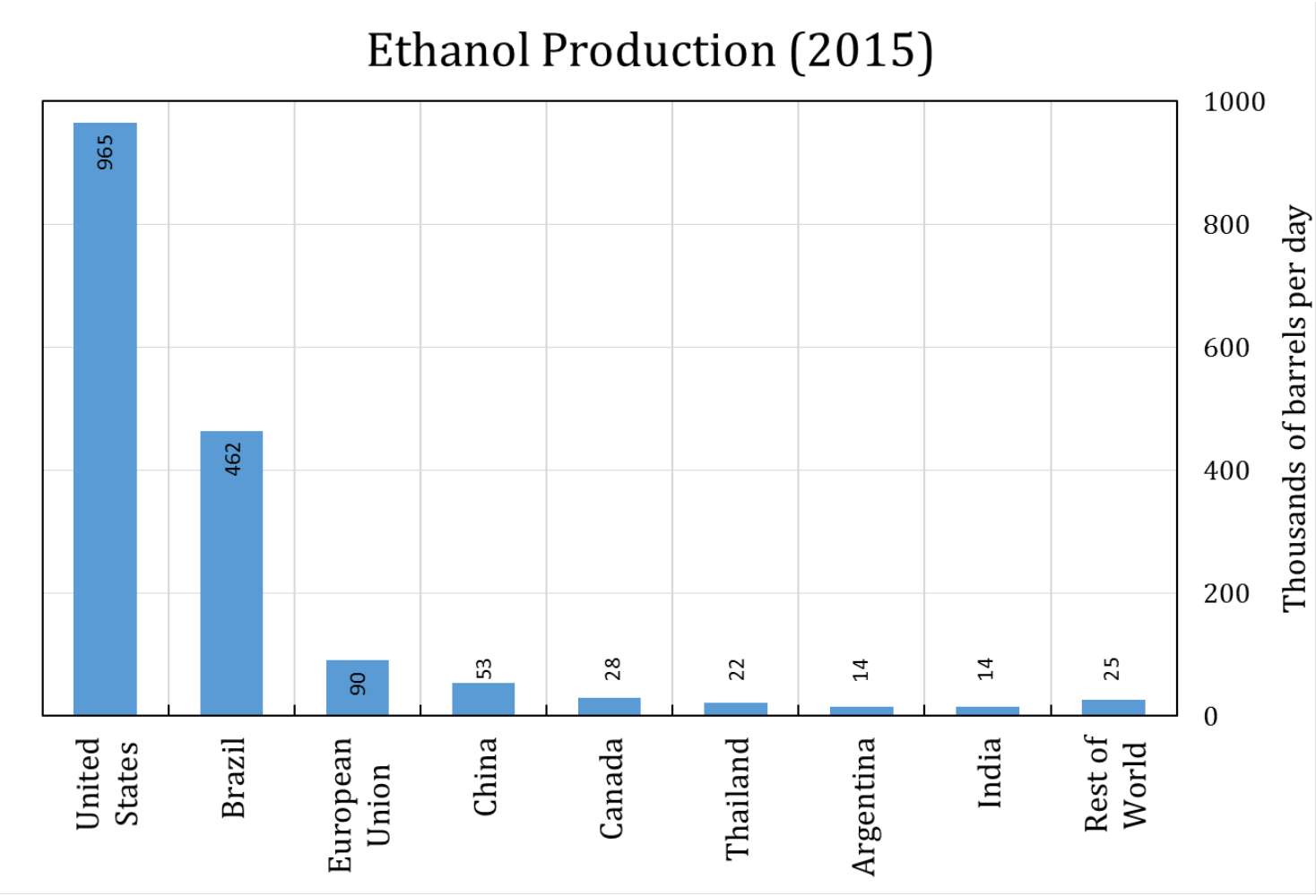
Bloomberg: Oil displaced by EVs will lead to 2 million bpd oil glut around 2028



Source: http://www.bloomberg.com/features/2016-ev-oil-crisis/

oil markets

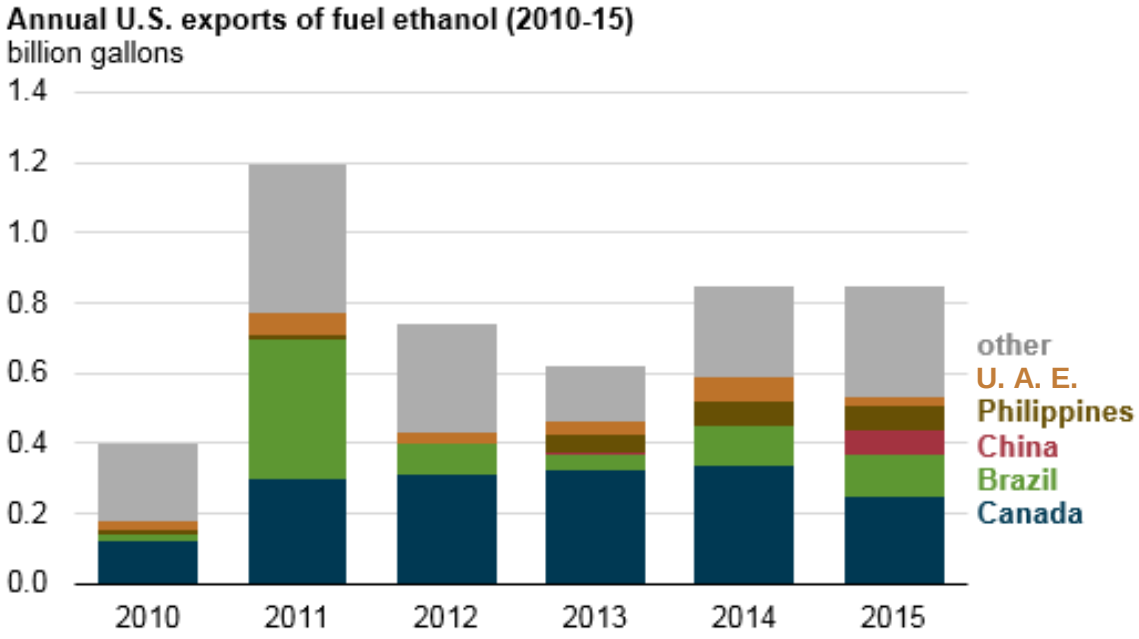
RFA: U.S. and Brazil are the world's largest ethanol production markets

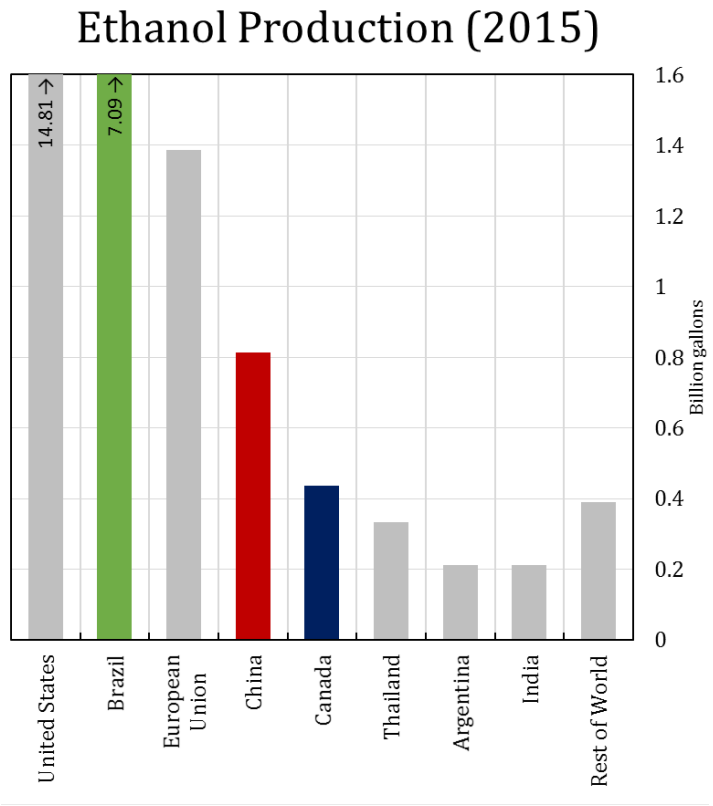


Source: http://www.ethanolrfa.org/resources/industry/statistics/#1454098996479-8715d404-e546

oil markets

EIA/RFA: U.S. ethanol exports are sizeable portion of world market



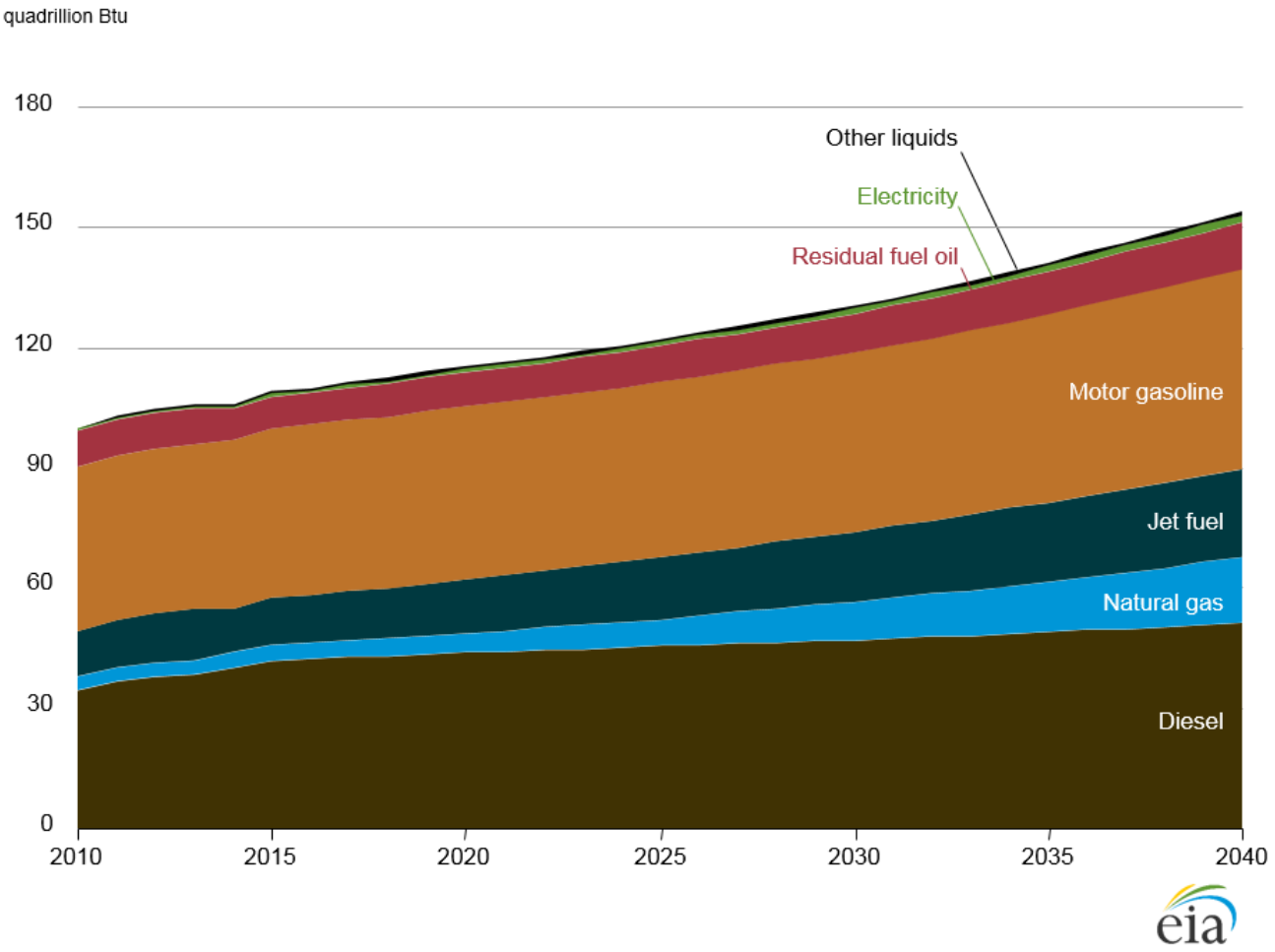


Sources: http://www.eia.gov/todayinenergy/detail.cfm?id=25312 and http://www.ethanolrfa.org/resources/industry/statistics/#1454098996479-8715d404-e546

energy usage

EIA: Transportation energy use from many fuels expected to grow worldwide

Figure 8-2. World transportation sector delivered energy consumption by energy source, 2010–40

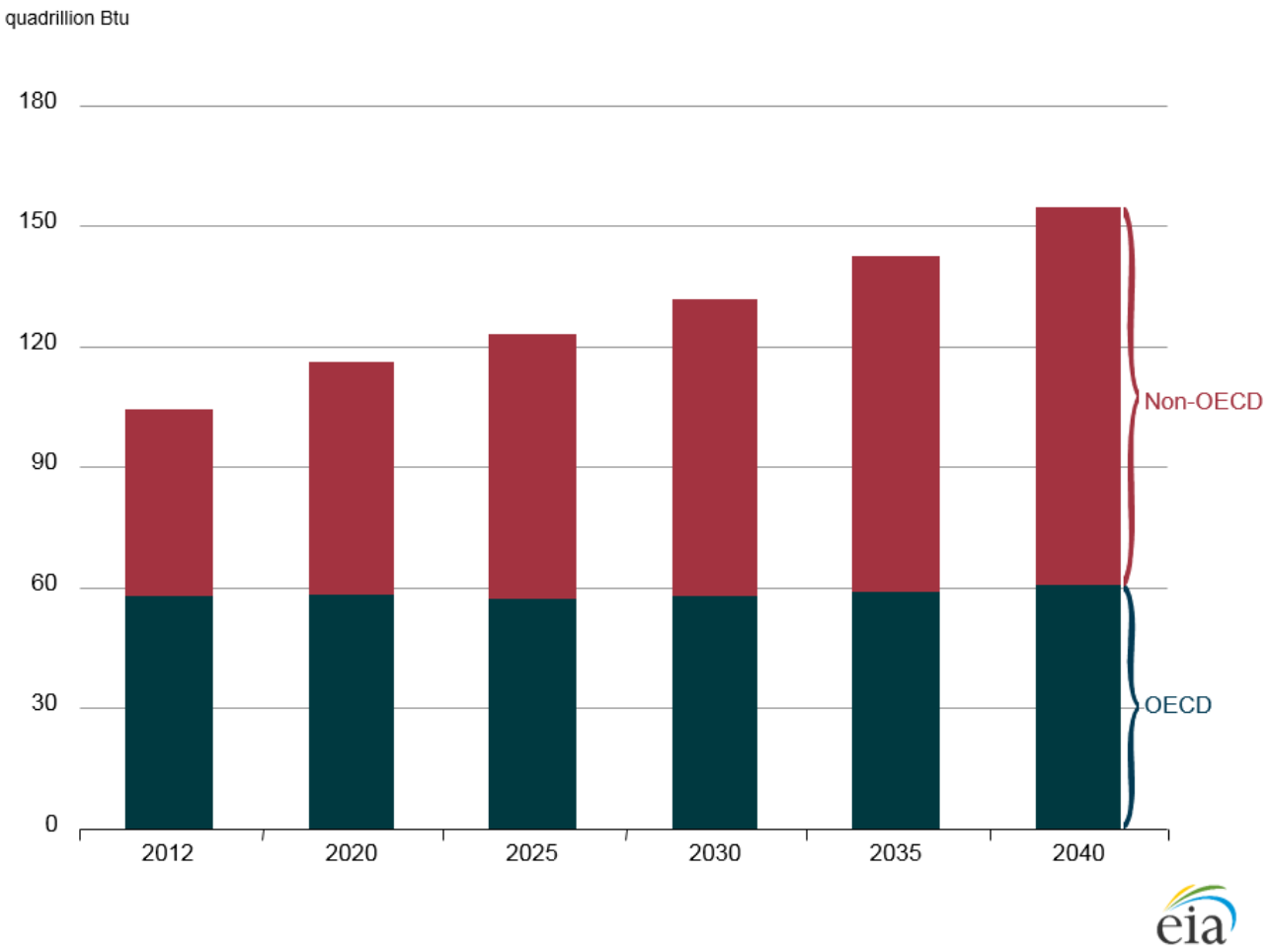


Source: http://www.eia.gov/forecasts/ieo/transportation.cfm

energy usage

EIA: Transportation energy use expected to be flat in developed countries, double in non-OECD countries

Figure 8-1. Delivered transportation energy consumption by country grouping, 2012–40



Source: http://www.eia.gov/forecasts/ieo/transportation.cfm

energy usage

OPEC: Road transportation oil demand expected to decrease in most-developed countries, and increase, but slow, in developing countries

Figure 2.17
Growth in road transportation oil demand, 2014–2040

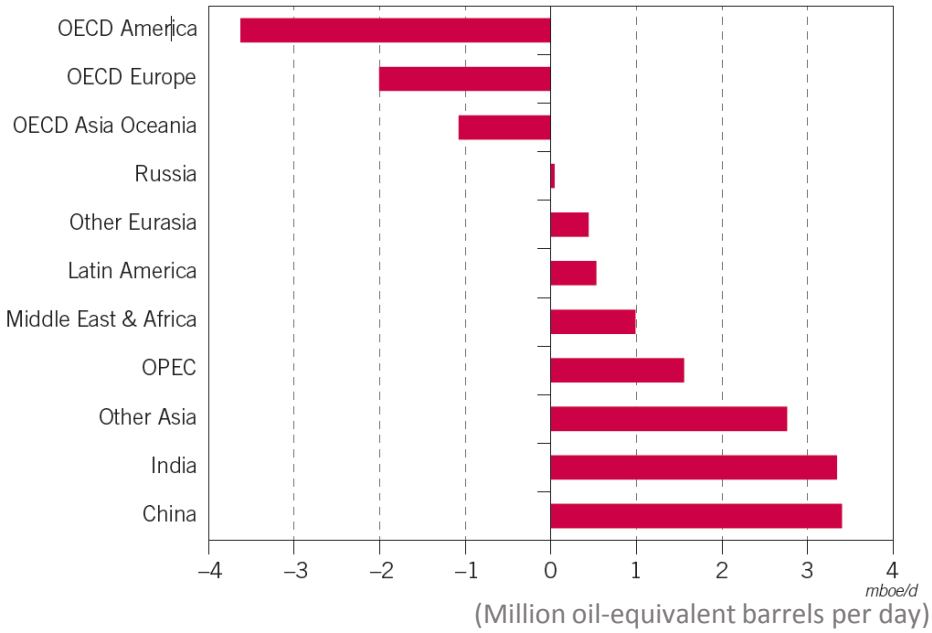
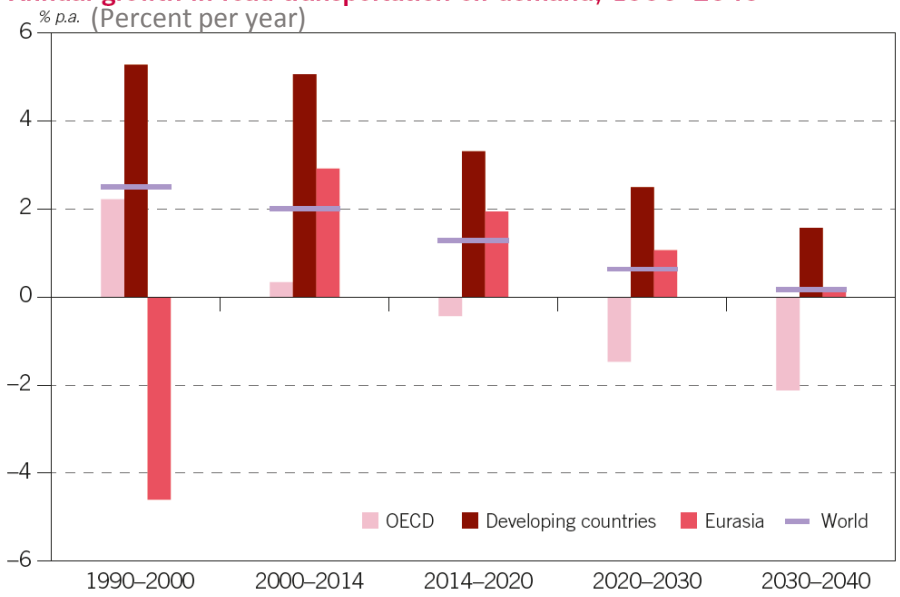


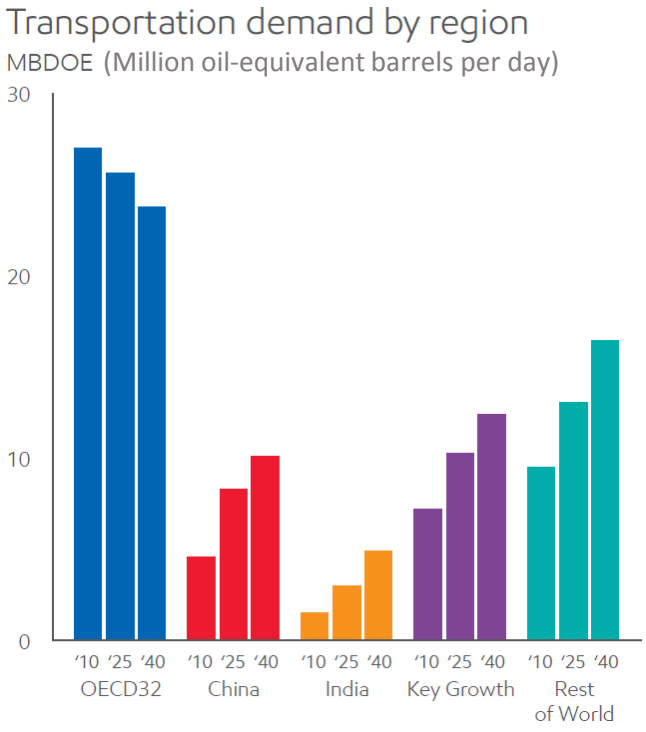
Figure 2.18
Annual growth in road transportation oil demand, 1990–2040

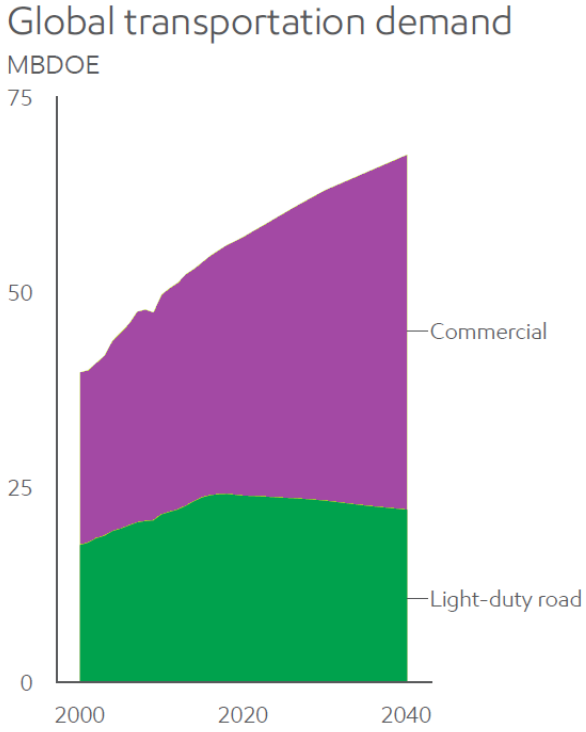


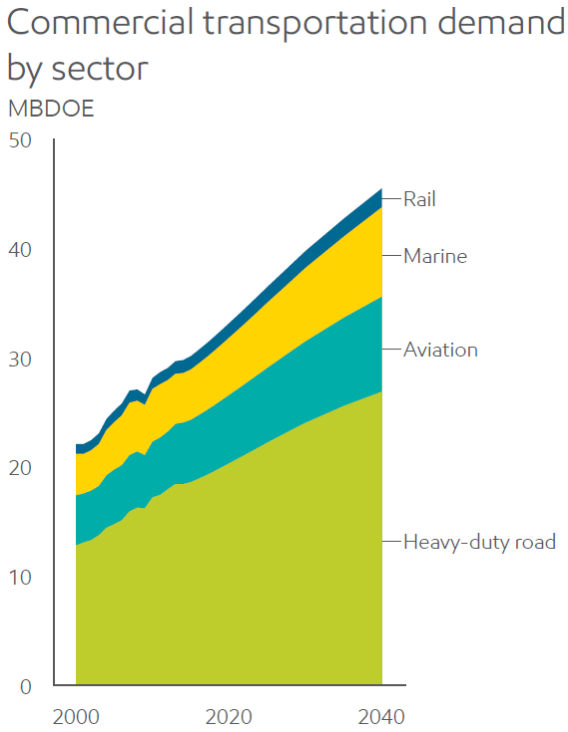
Source: http://www.opec.org/opec_web/en/publications/340.htm

energy usage

ExxonMobil: Transportation demand expected to decline in OECD countries and increase elsewhere, mostly driven by commercial shipping







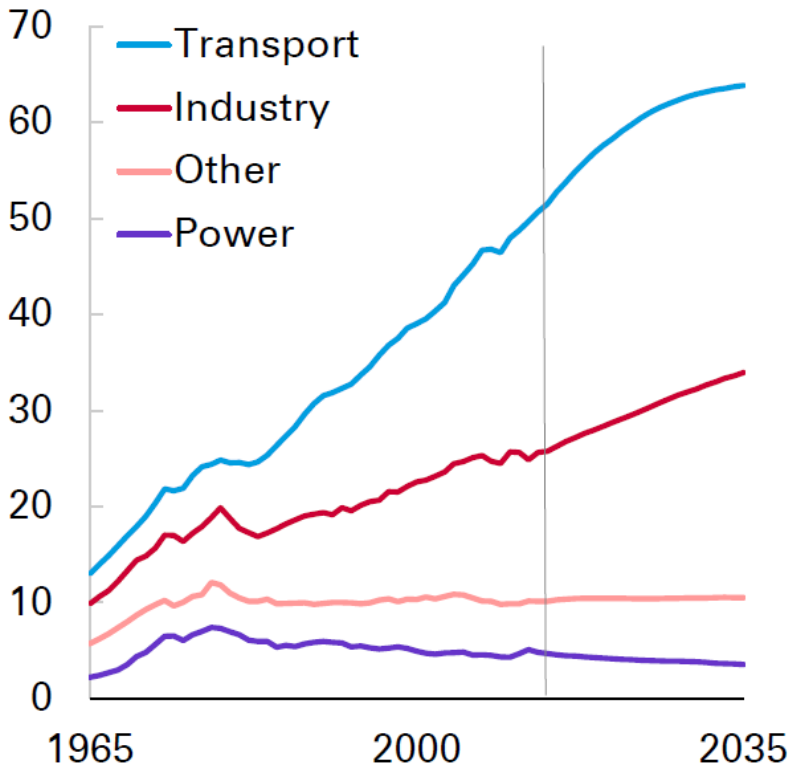
Source: http://corporate.exxonmobil.com/en/energy/energy-outlook

energy usage

BP: Transportation energy use expected to be flat in developed countries, double in non-OECD countries

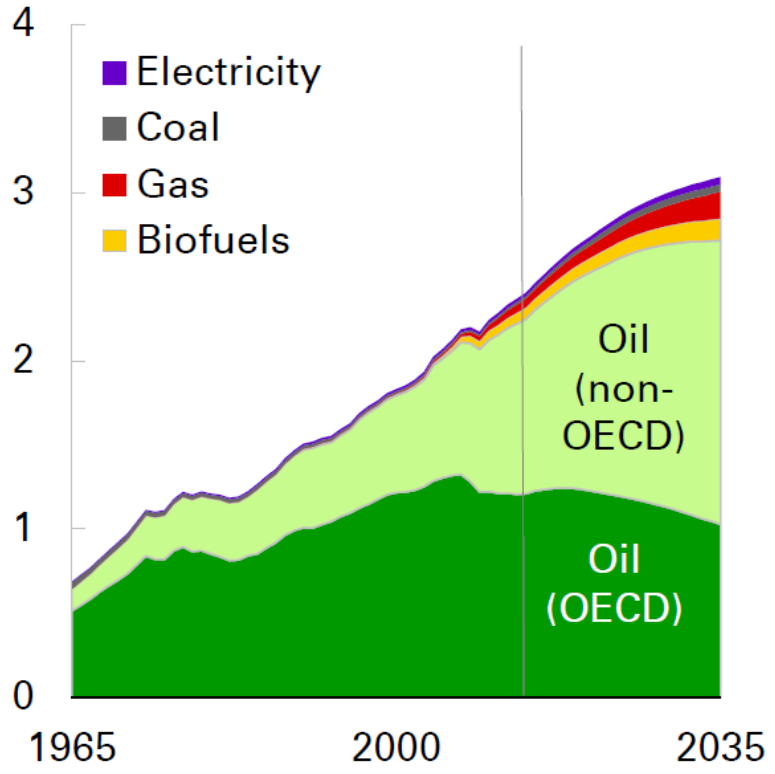
Liquids demand by sector

Mb/d (Million oil-equivalent barrels per day)



Transport demand by fuel

Billion tonne of oil equivalent (toe)



Source: http://www.bp.com/en/global/corporate/energy-economics/energy-outlook-2035.html

topics

2

energy markets

automotive markets

technologies studies

environmental studies

consumers & opinion surveys

policy & business studies

qar

outline

2 automotive markets

LDV market

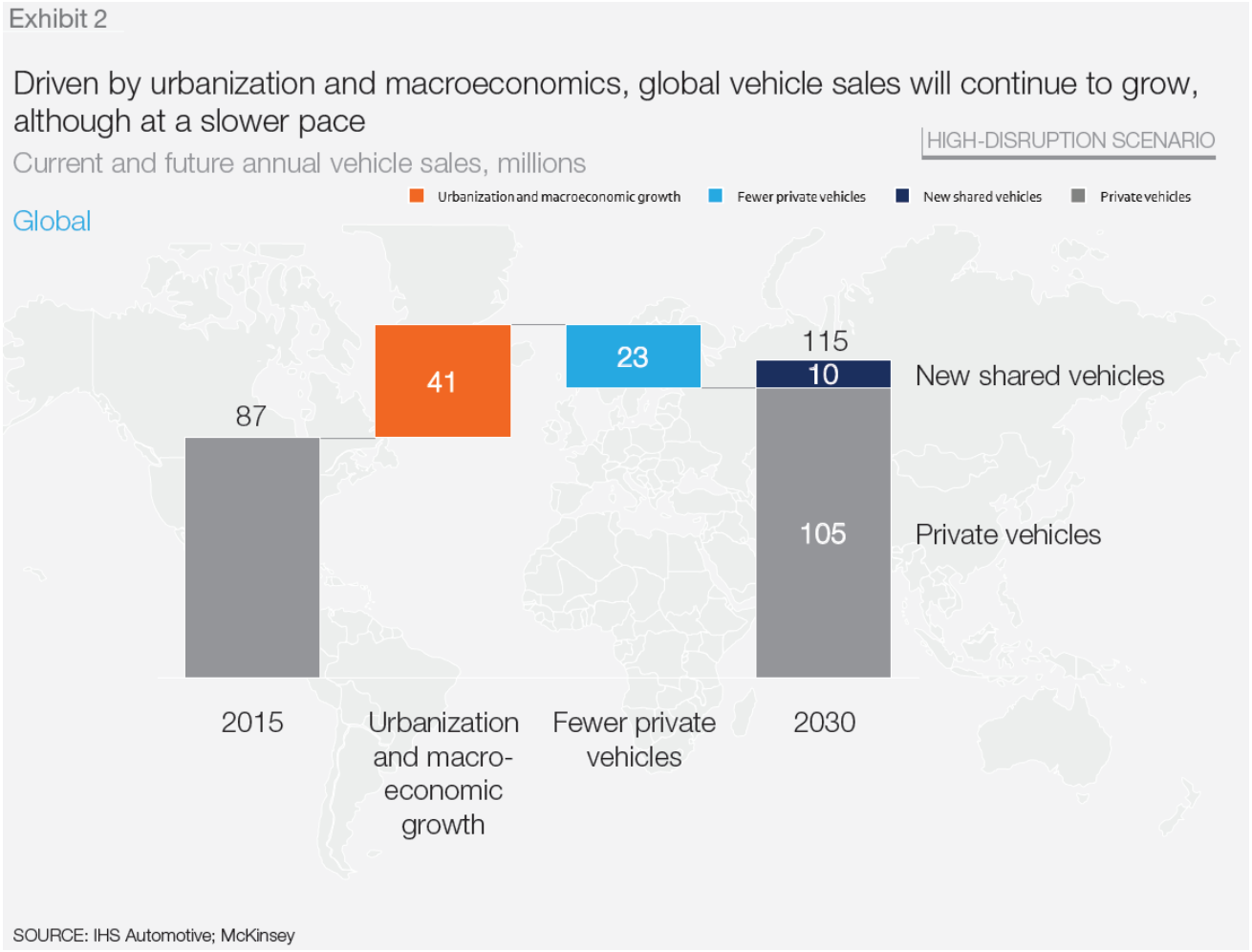
> McKinsey: Urbanization will drive vehicle sales, but ride sharing can reduce total sales
> ANL: More diverse PEV models than HEVs
> ANL: HEV sales correlate well with gasoline prices, EV sales do not
> Bloomberg: BEVs will make major impact in LDV market over next two decades

PEV market

> Tesla: Over 300,000 pre-orders in the first week
> ANL: Worldwide EV sales up in 2015

global vehicle sales

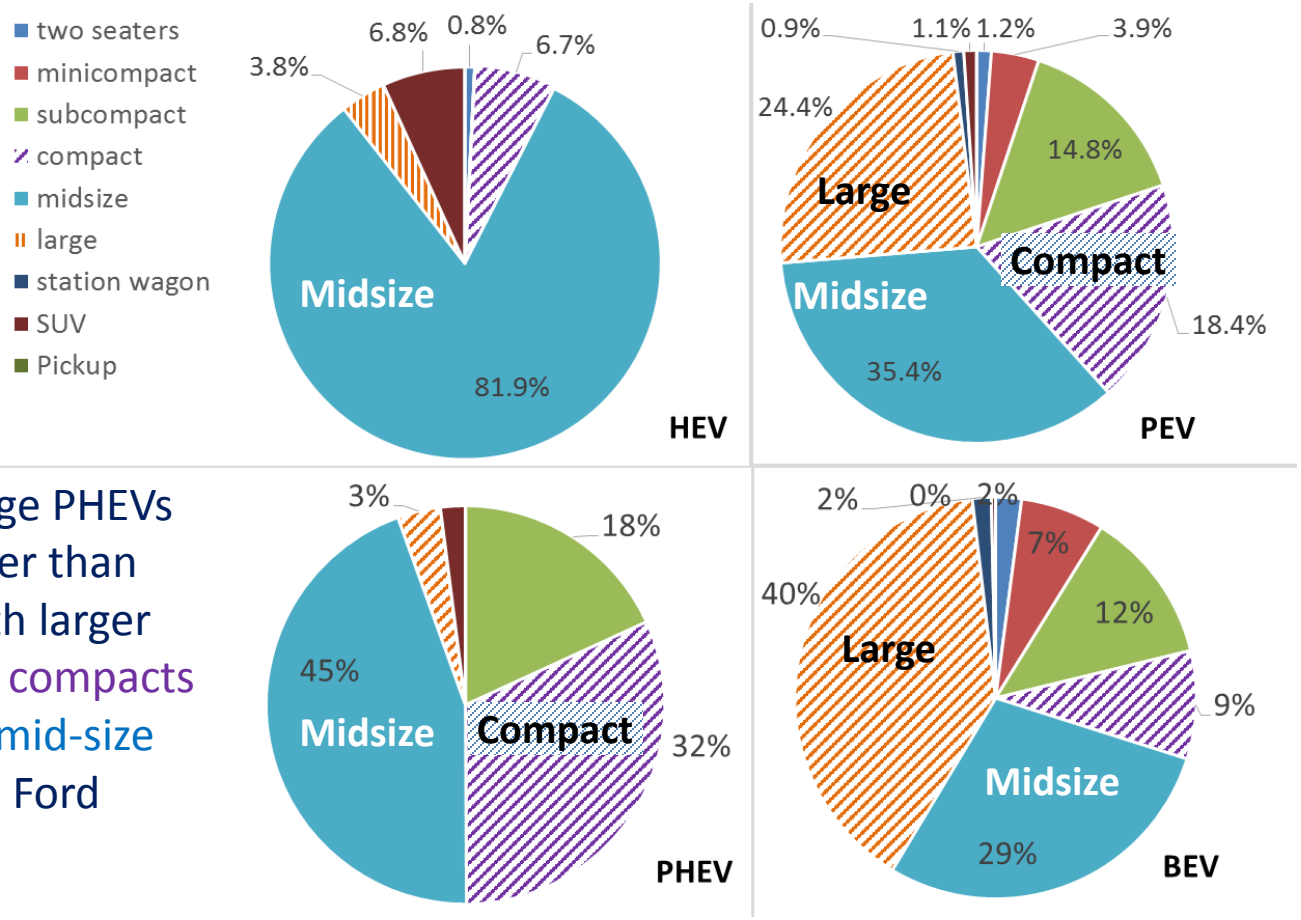
McKinsey: Urbanization and economic growth will boost global vehicle sales, ride-sharing can be factor



Source: http://www.mckinsey.com/industries/high-tech/our-insights/disruptive-trends-that-will-transform-the-auto-industry

LDV markets

ANL: PEVs available in more diverse models than hybrids



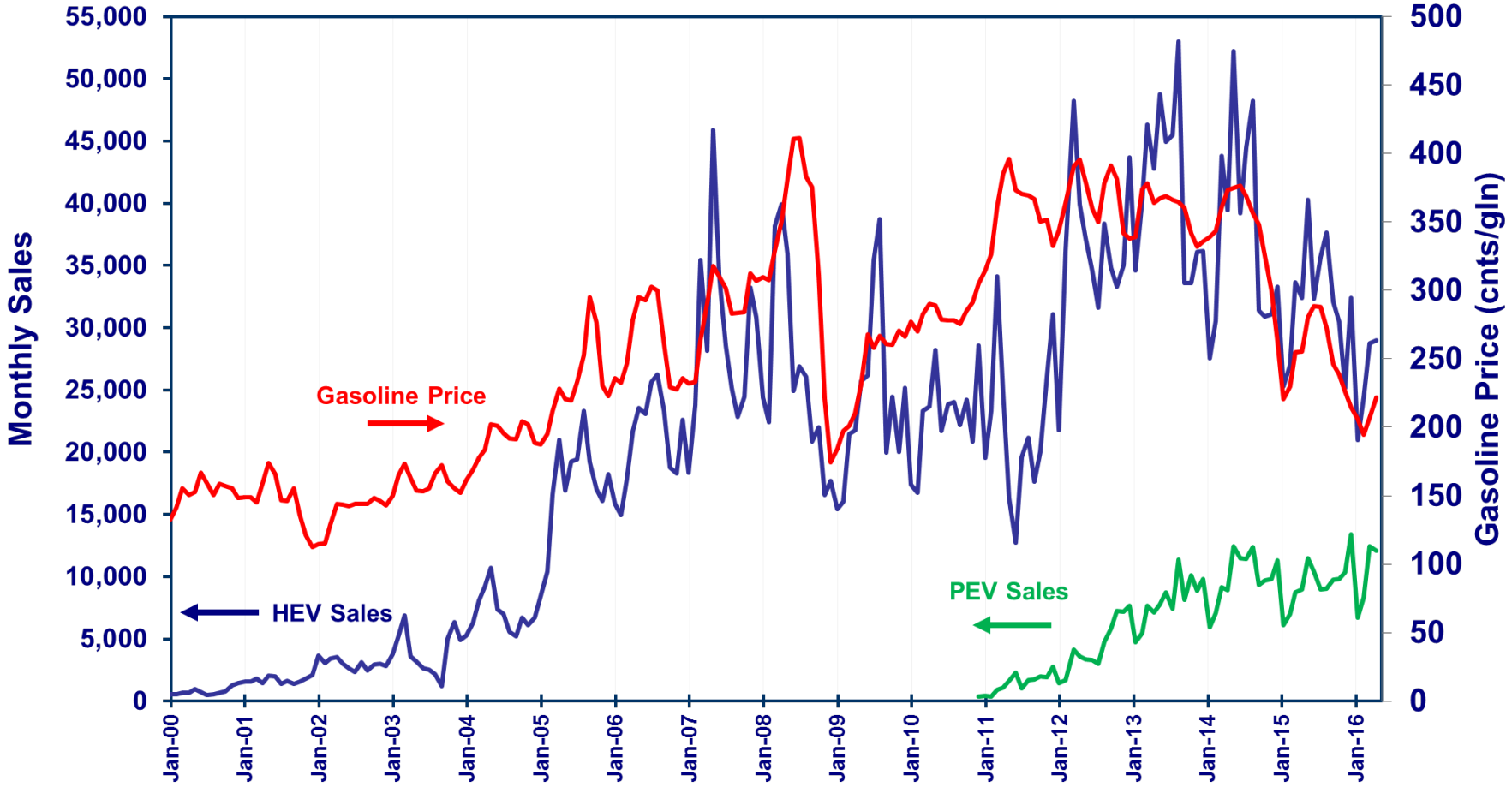
On average PHEVs are smaller than HEVs, with larger shares of compacts Volt and mid-size Prius and Ford Energi

BEVs are larger on average than PHEVs (due to success of the large Tesla Model S and the mid-size LEAF)

Source: Y. Zhou, Argonne National Laboratory

LDV markets

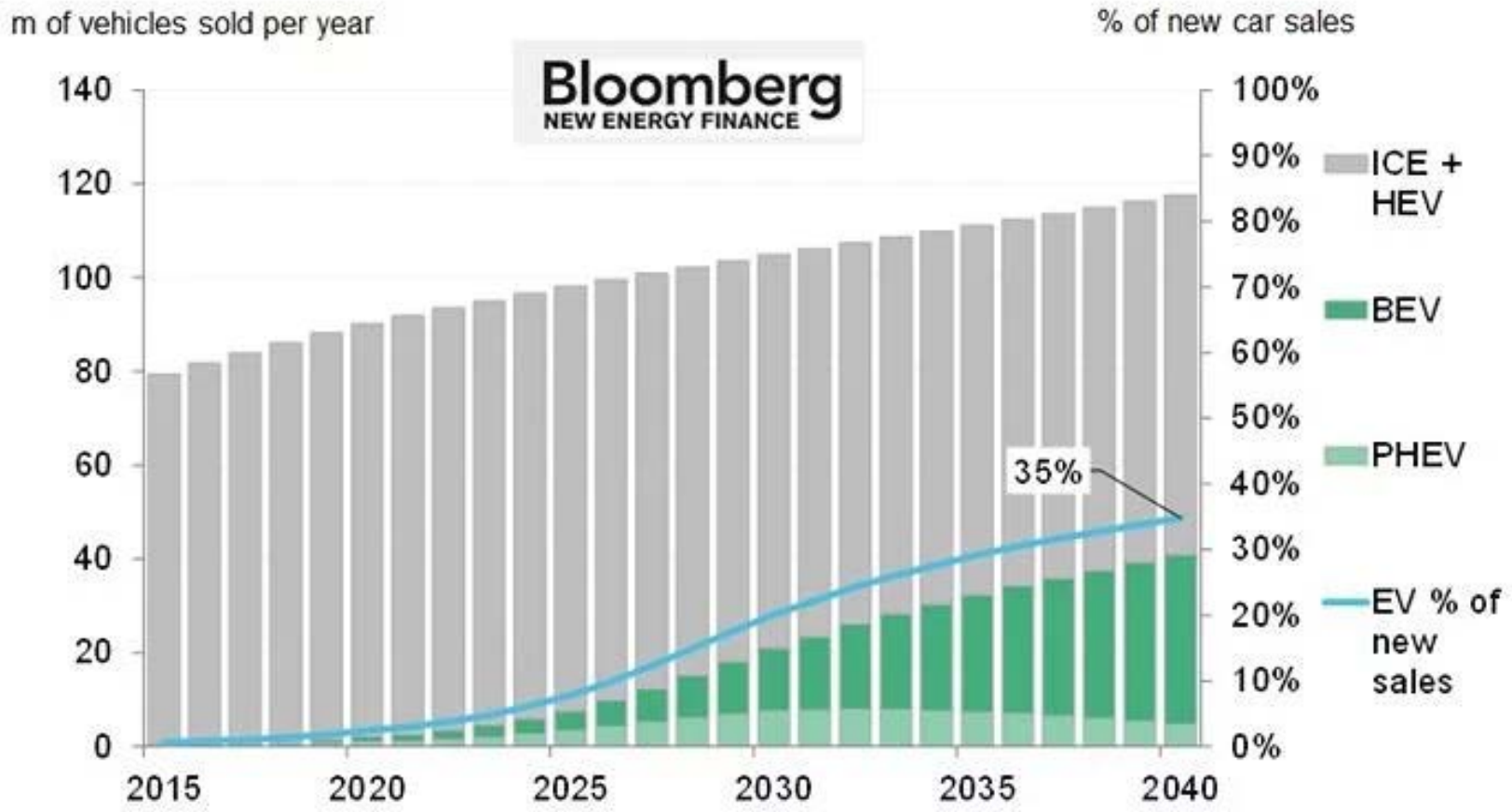
ANL: Hybrid electric (HEV) and Plug-in electric (PEV) vehicle sales correlate differently to gasoline price



Source: Y. Zhou, Argonne National Laboratory

LDV markets

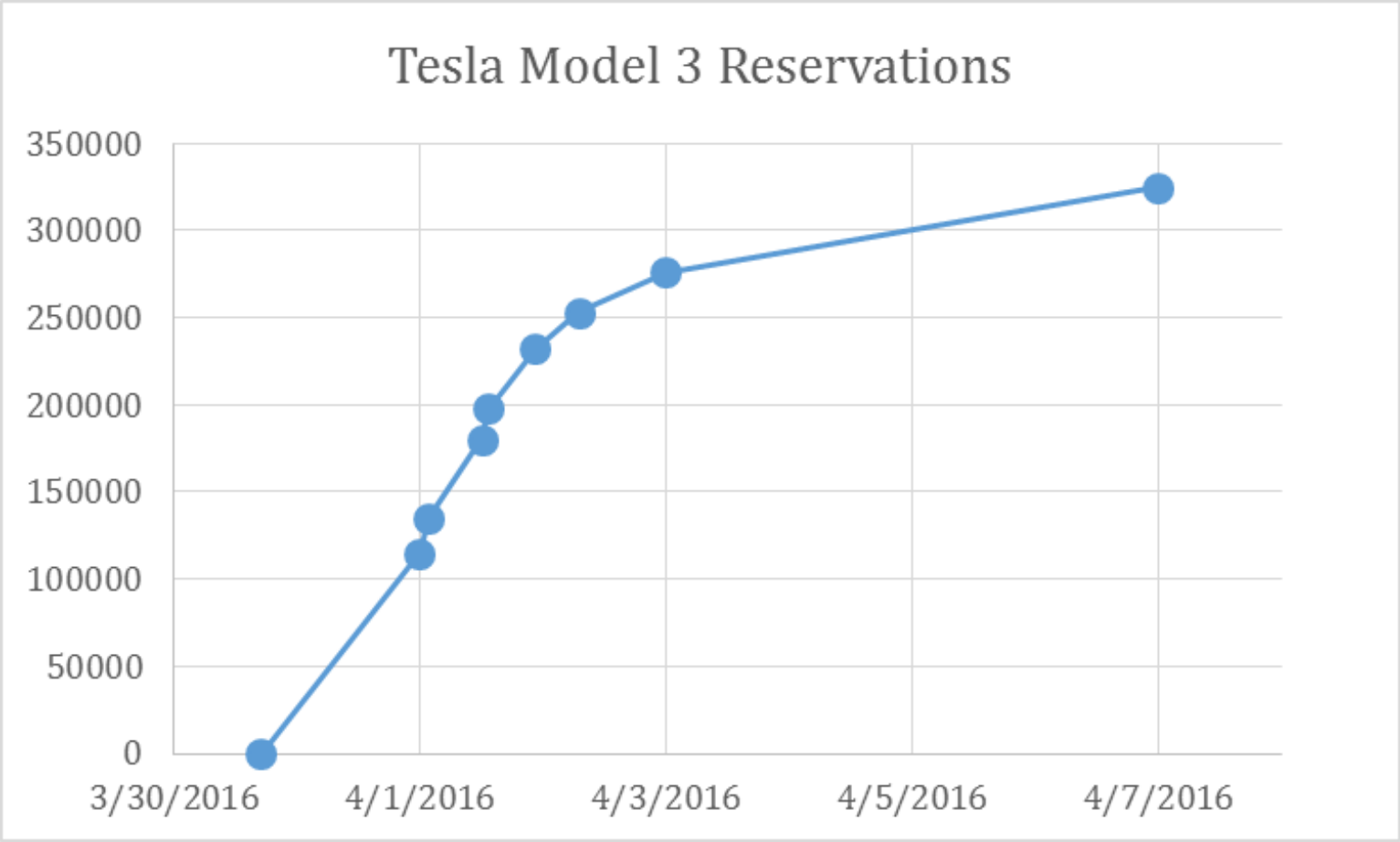
Bloomberg: BEVs will take more of the global LDV market over the next 2 decades



Source: http://about.bnef.com/press-releases/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040/

PEV markets

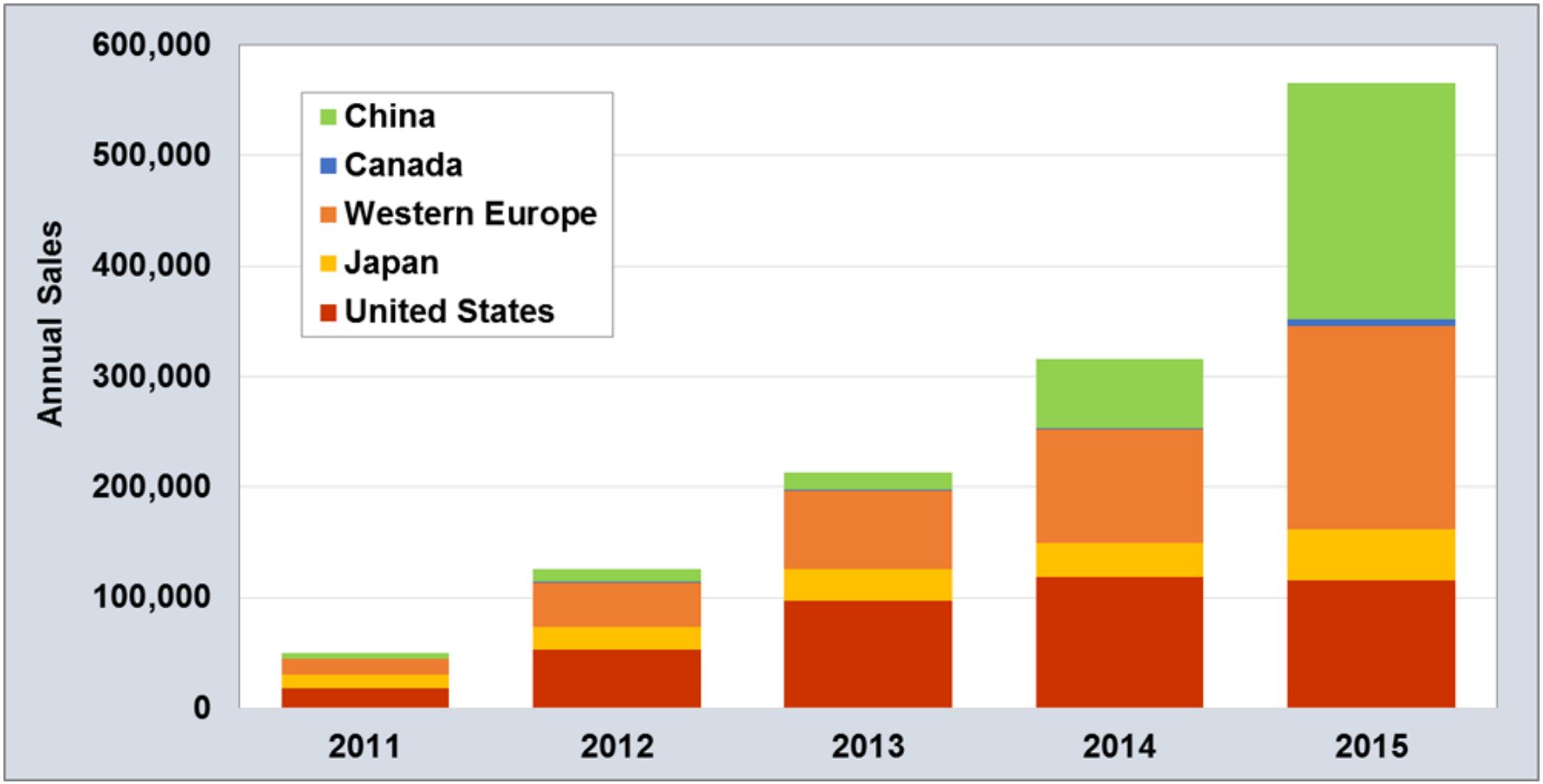
Tesla: Over 300,000 Tesla Model 3s were pre-ordered in the first week



Sources: https://twitter.com/elonmusk/ and http://www.forbes.com/sites/markrogowsky/2016/03/31/live-teslas-model-3-is-shown-off-to-the-world-after-thousands-reserve-a-spot-to-get-one/ and http://www.forbes.com/sites/aarongold1/2016/04/02/tesla-model-3-why-the-details-dont-matter/

PEV markets

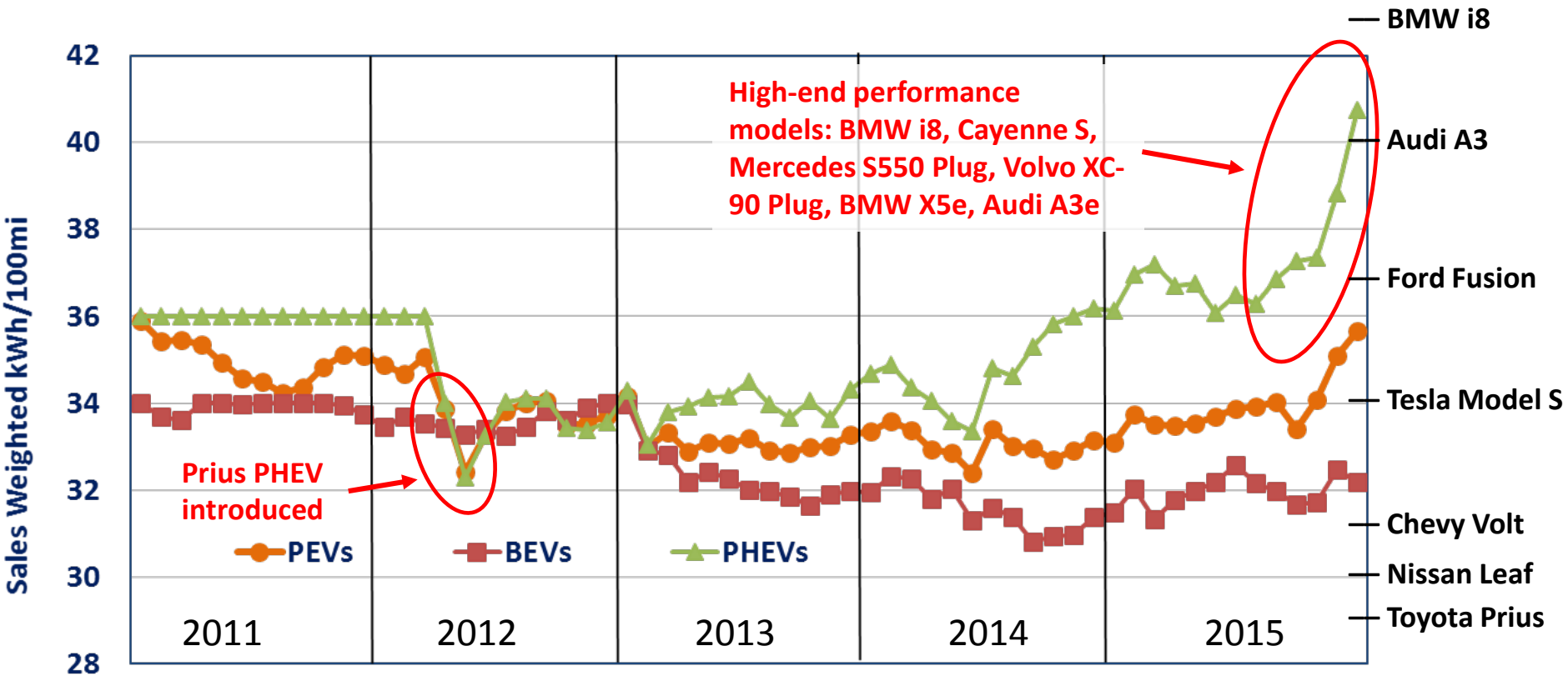
FOTW/ANL: Global light vehicle PEV increased by 80% in 2015



Source: http://energy.gov/eere/vehicles/fact-918-march-28-2016-global-plug-light-vehicle-sales-increased-about-80-2015

PEV markets

ANL: EV fleet efficiency improved over time, but decreasing recently due to success of large and high-performance models



Sources: Y. Zhou, Argonne National Laboratory and http://www.fueleconomy.gov

topics

energy markets

automotive markets

3 technologies studies

environmental studies

consumers & opinion surveys

policy & business studies

qar

outline

3 technologies studies

battery manufacturing

> Bloomberg/CEMAC: Battery manufacturing will increase and prices will drop, increasing demand

vehicle reliability

> FOTW: EV warranties are similar throughout industry
> Ricardo: People are owning cars longer

infrastructure

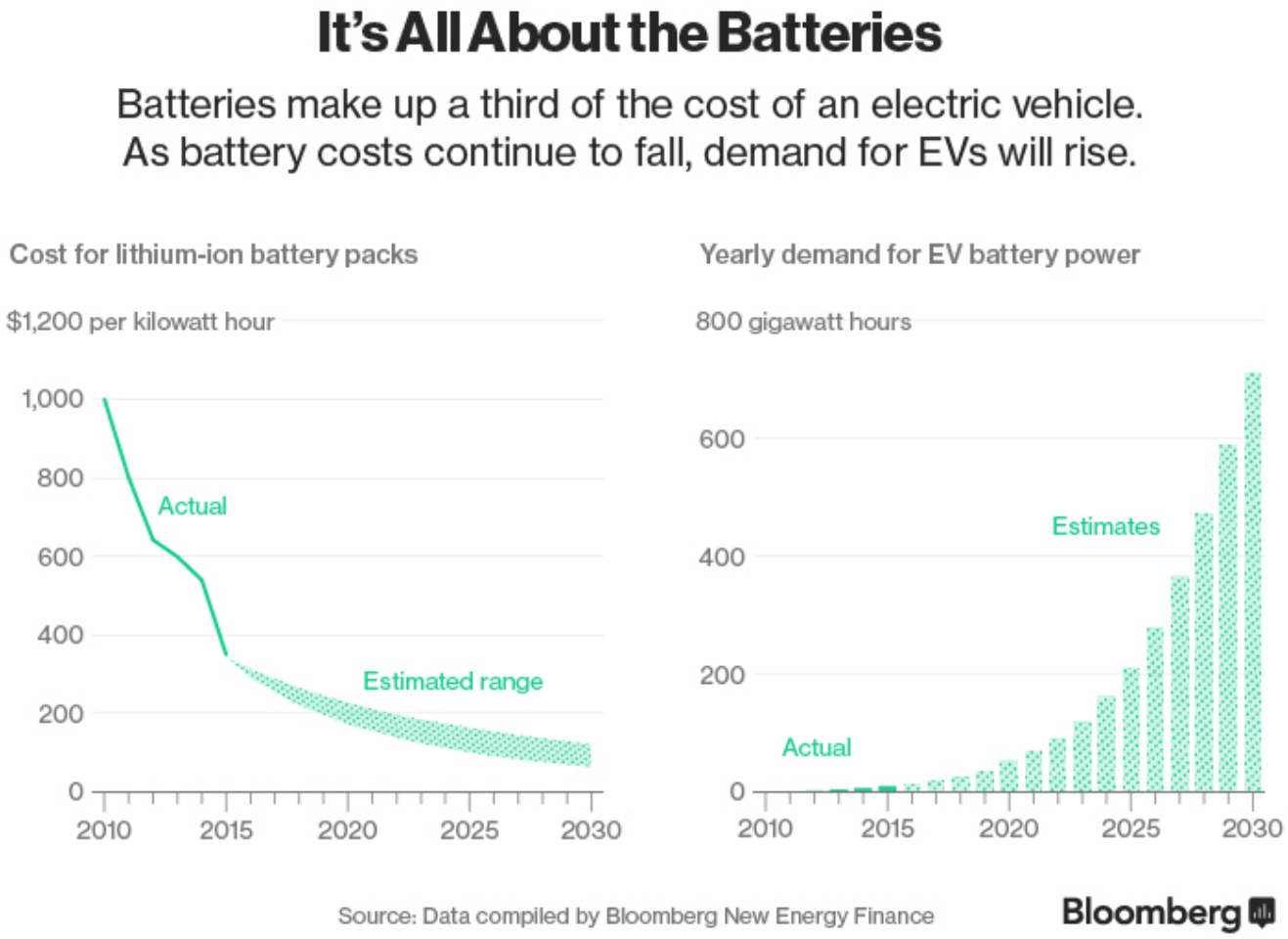
> Electric Avenue/FOTW: EV charging demand is important and vehicle OEMs use different standards for chargers
> EIA/RFA/USDA: High-octane fuel demand and options are growing

vehicle technologies

> ORNL: Advanced tech is being rapidly incorporated into new vehicles
> Leeds: CAVs can have major energy implications

battery manufacturing

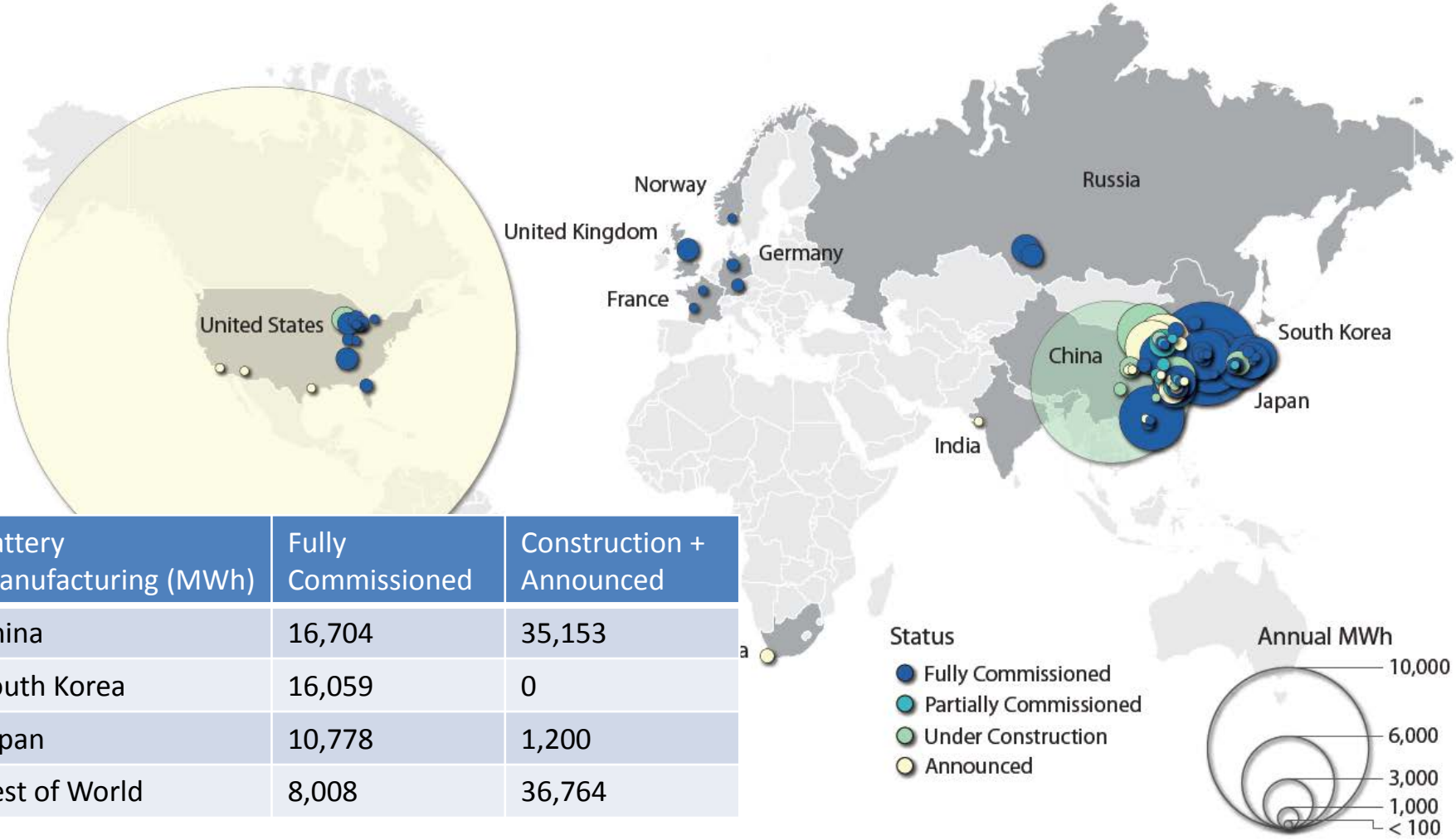
Bloomberg: Battery prices will drop and EV demand will rise



Source: http://www.bloomberg.com/features/2016-ev-oil-crisis/

battery manufacturing

CEMAC: Li-ion battery manufacturing concentrated in Asia, though Gigafactory could alter status quo



Battery Manufacturing (MWh)	Fully Commissioned	Construction + Announced
China	16,704	35,153
South Korea	16,059	0
Japan	10,778	1,200
Rest of World	8,008	36,764

Source: http://www.manufacturingcleanenergy.org/products.html

vehicle dependability

FOTW: Most electric vehicles offer at least 8-year, 100,000-mile warranties

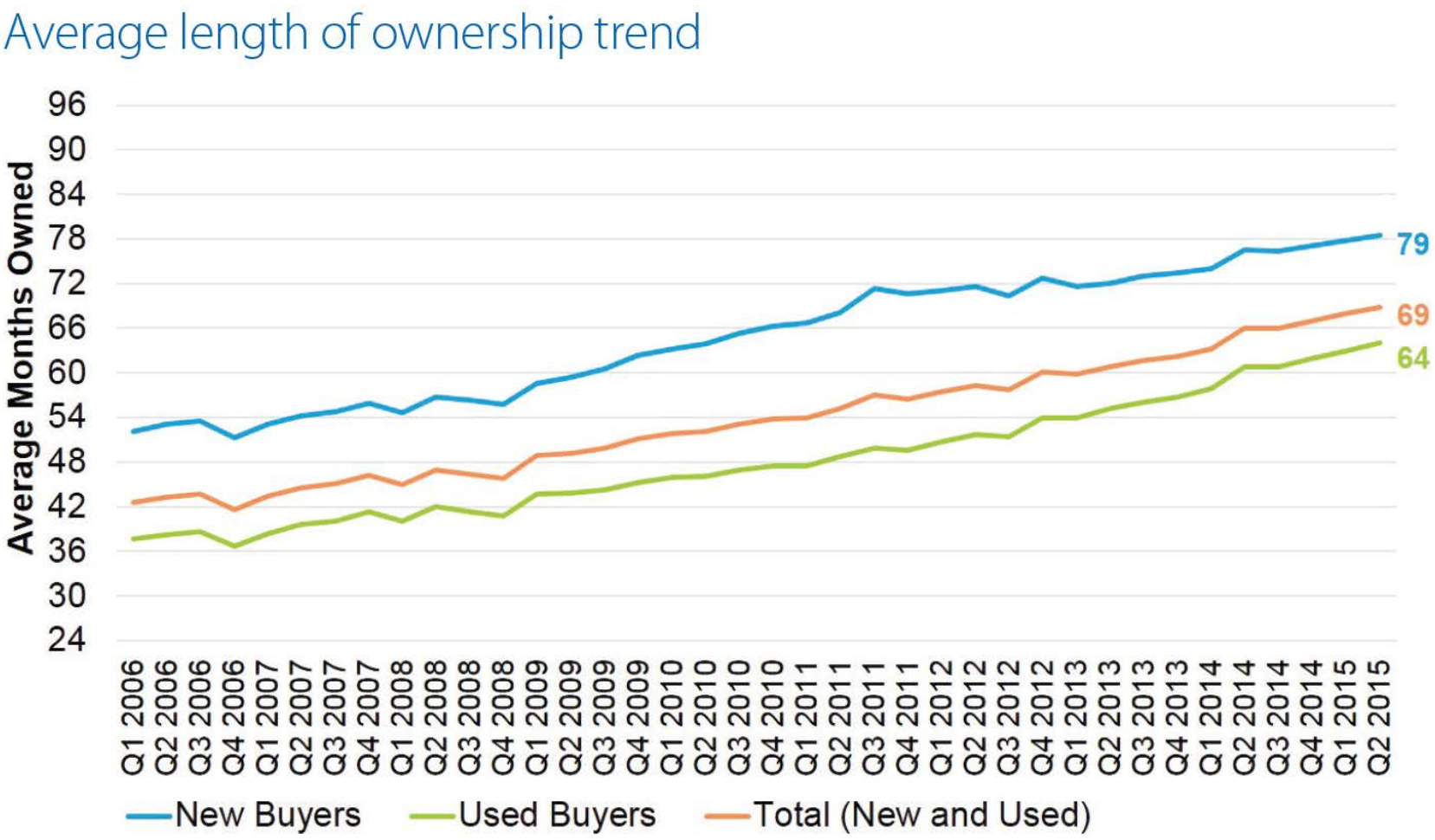
Make and Model	Warranty Years	Warranty Miles
Model Year 2016 Electric Vehicles		
BMW i3 BEV	8	100,000
BMW X5 xDrive40e	8	100,000
Chevrolet Spark EV	8	100,000
Fiat 500e	8	100,000
Ford Focus Electric	8	100,000
Mercedes-Benz B250e	8	100,000
Mitsubishi i-MiEV	8	100,000
Nissan Leaf	8	100,000
Volkswagen e-Golf	8	100,000
Tesla Model S (60 kW-hr battery pack)	8	Unlimited
Tesla Model S (85 kW-hr battery pack)	8	Unlimited
Tesla Model S AWD - 70D	8	Unlimited
Tesla Model S AWD - 85D	8	Unlimited
Tesla Model S AWD - 90D	8	Unlimited
Tesla Model S AWD - P85D	8	Unlimited
Tesla Model S AWD - P90D	8	Unlimited
Kia Soul Electric	10	100,000
BYD e6	10	Not specified*
smart fortwo electric drive	10	Not specified*

Make and Model	Warranty Years	Warranty Miles
Model Year 2016 Plug-In Hybrid Vehicles		
Audi A3 e-tron ultra	8	100,000
Mercedes-Benz S550e	15	150,000
Porsche Cayenne S e-Hybrid	6	Not specified*
Porsche 918 Spyder	7	Not specified*
Porsche Panamera S E-Hybrid	7	70,000
BMW i3REX	8	100,000
BMW i8	8	100,000
Cadillac ELR	8	100,000
Chevrolet Volt	8	100,000
Ford C-Max Energi Plug-In Hybrid	8	100,000
Ford Fusion Energi Plug-In Hybrid	8	100,000
Hyundai Sonata Plug-In Hybrid	Lifetime**	Unlimited
Volvo XC90 AWD Plug-In Hybrid	4	50,000

Source: http://energy.gov/eere/vehicles/fact-913-february-22-2016-most-common-warranty-plug-vehicle-batteries-8-years100000

vehicle dependability

Ricardo/IHS: People are owning both new and used vehicles for longer



Source: http://www.ricardo.com/en-GB/News--Media/Events/TransitionServices/TransitionServicesForm/TransitionServicesWhitepaper/

infrastructure demands

FOTW: Electric vehicle charging options and speeds vary considerably

	Level 1	Level 2	DC Fast Charger	Tesla Supercharger
Examples of Charging Stations				
Electrical Current Type	AC	AC	DC	DC
Range per Charge Time	2-5 miles/ 60 minutes	10-20 miles/ 60 minutes	50-70 miles/ 20 minutes	170 miles/ 30 minutes
Vehicle Charge Ports	J1772	J1772	J1772 combo CHAdeMo	Tesla combo

Manufacturers typically support Level 1 and Level 2 charging.

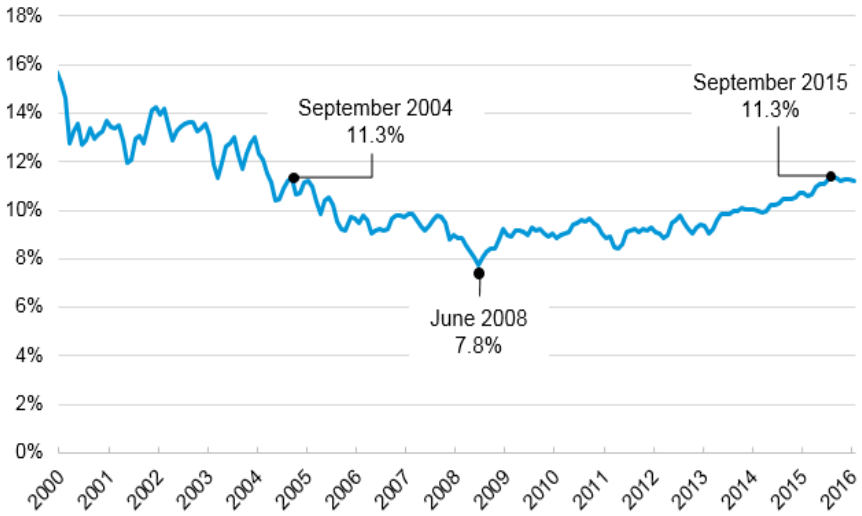
BMW and Chevrolet use J1772 standard for DC Fast Charging, and Nissan, Mitsubishi, and Toyota use CHAdeMO. Tesla offers support for each through an adapter.

Source: http://energy.gov/eere/vehicles/fact-919-april-4-2016-plug-electric-vehicle-charging-options-and-times-vary

infrastructure demands

EIA: Engine design trends lead to increased demand for higher-octane gasoline

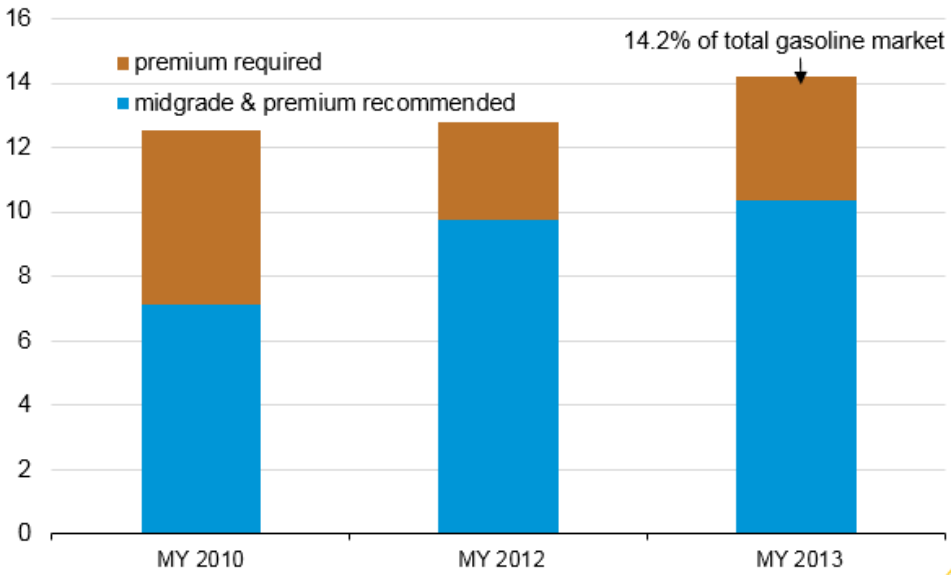
Figure 1. Premium gasoline sales as a percent of total motor gasoline sales



Source: U.S. Energy Information Administration, *Prime Supplier Report*, March 2016.

Figure 3. Percentage of vehicles sold that recommend or require higher octane fueled gasoline sales

percent of sales of vehicles with gasoline engines

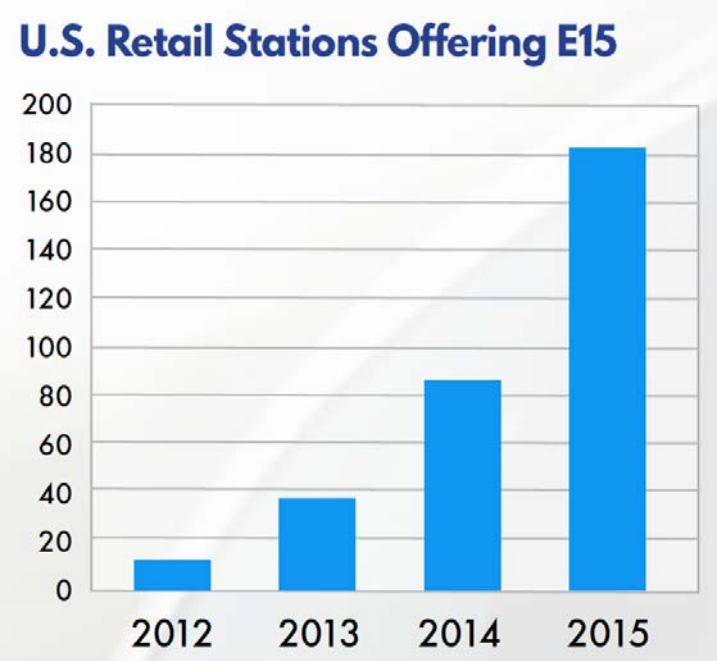


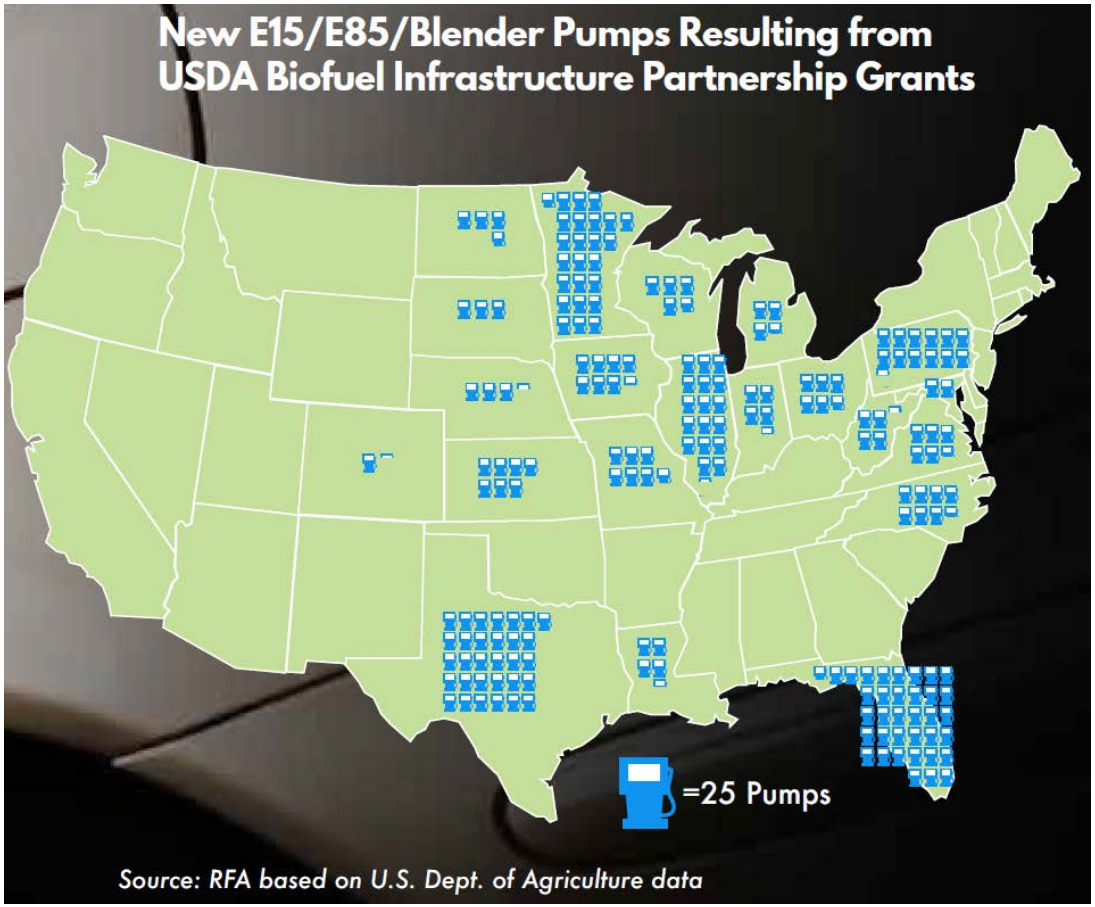
Source: U.S. Energy Information Administration, estimated based on various data sources.

Source: http://www.eia.gov/petroleum/weekly/archive/2016/160330/includes/analysis_print.cfm

infrastructure demands

RFA/USDA: E15 availability growing nationwide; USDA funding additional 5000 pumps at 1400 stations

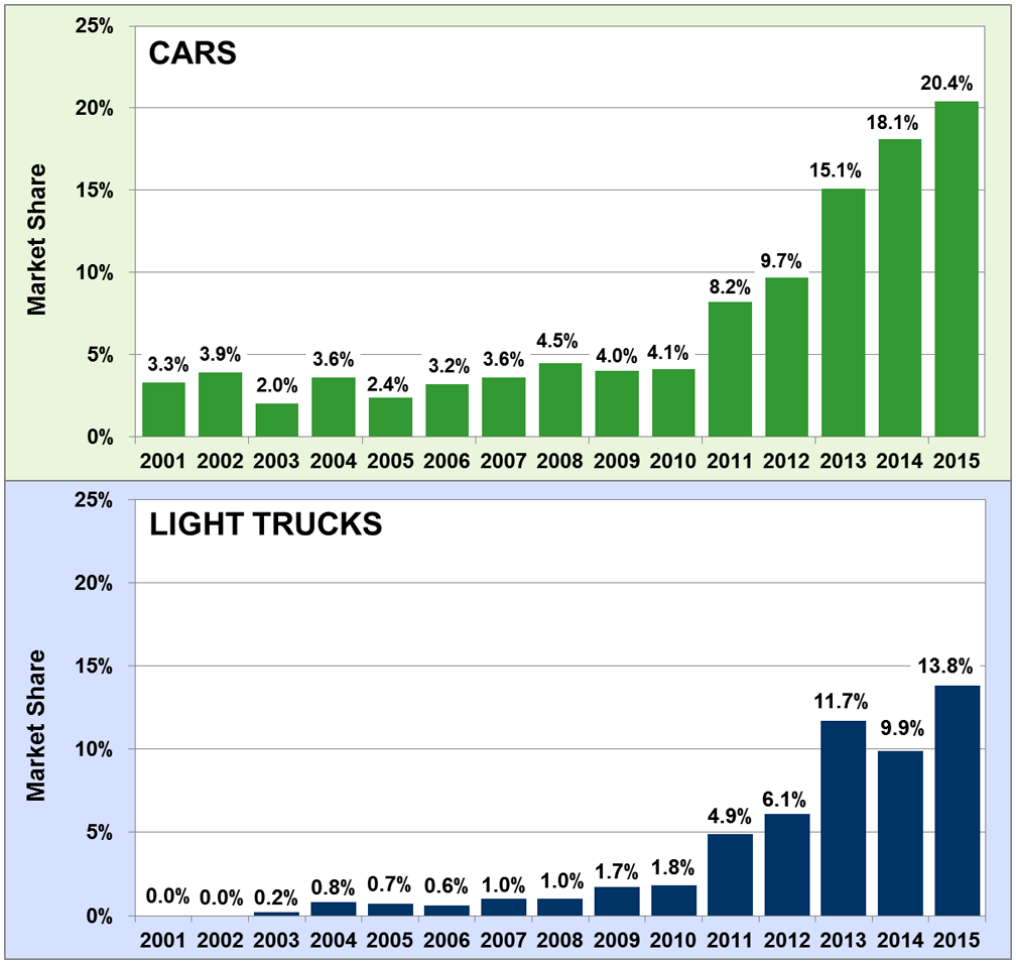




Sources: http://www.ethanolrfa.org/wp-content/uploads/2016/02/RFA_2016_full_final.pdf
http://www.usda.gov/wps/portal/usda/usdahome?contentid=2015/10/0300.xml

vehicle technologies

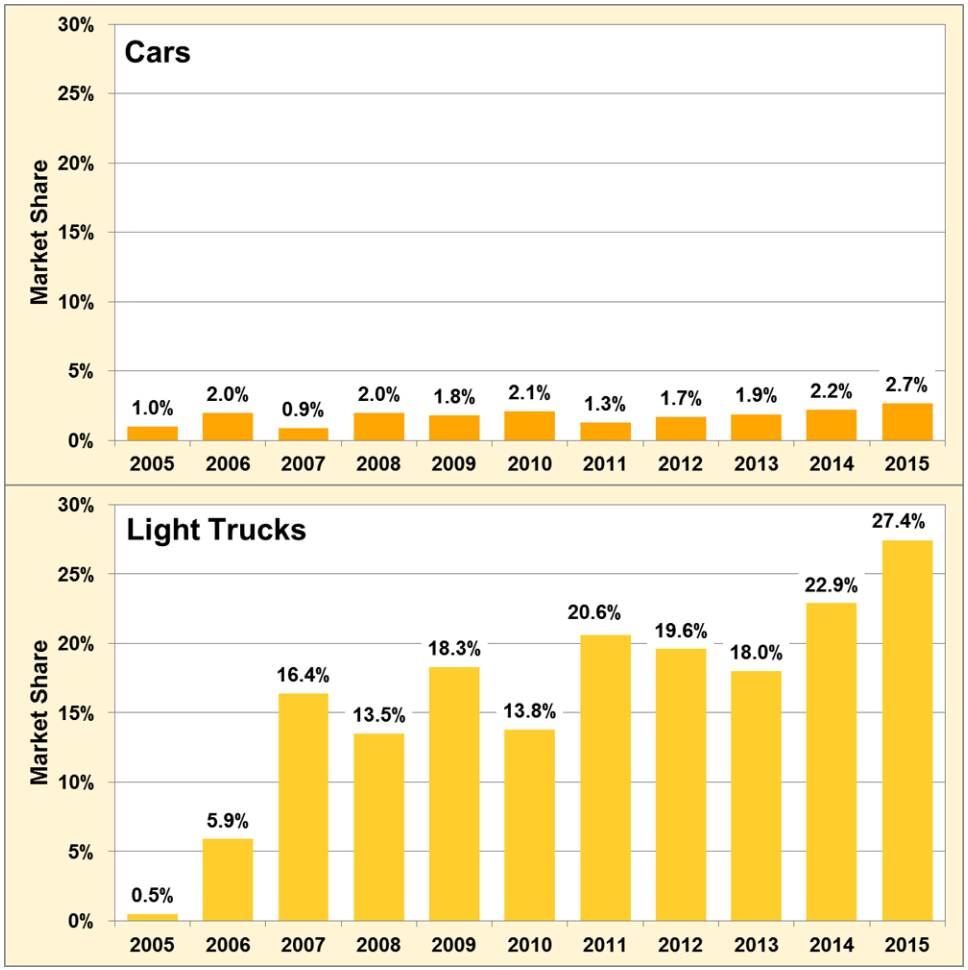
FOTW/ORNL: Twenty percent of new cars in 2015 had turbochargers



Source: http://energy.gov/eere/vehicles/fact-924-may-9-1916-twenty-percent-new-cars-2015-had-turbochargers

vehicle technologies

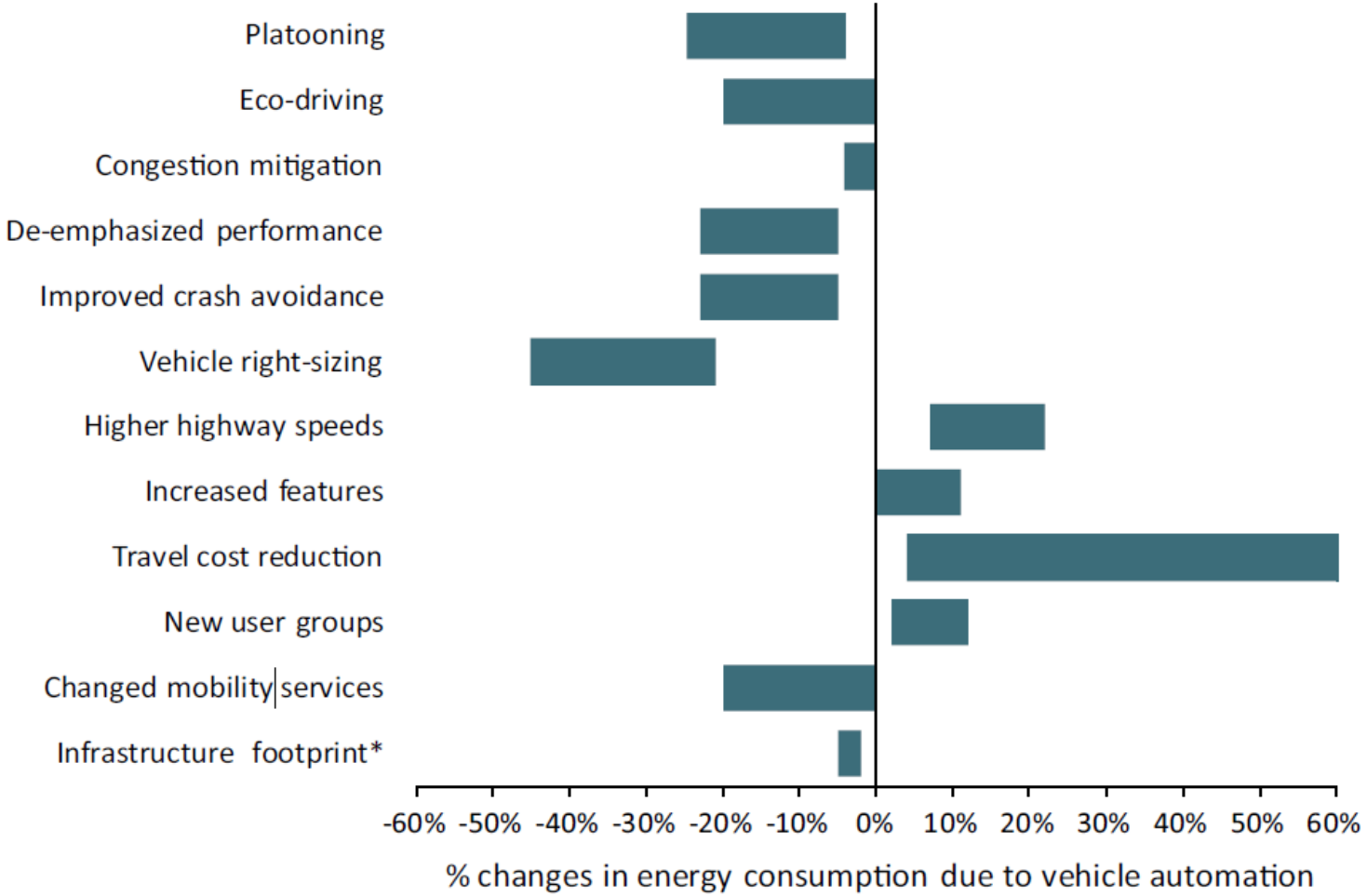
FOTW/ORNL: Cylinder deactivation was used in over 25% of new light trucks produced in 2015



Source: http://energy.gov/eere/vehicles/fact-923-may-2-1916-cylinder-deactivation-was-used-more-quarter-new-light-trucks

vehicle technologies

Leeds/UW/ORNL: Many aspects of connectivity and automation can have impacts on energy consumption



Source: http://dx.doi.org/10.1016/j.tra.2015.12.001

topics

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policy & business studies

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gasoline consumption

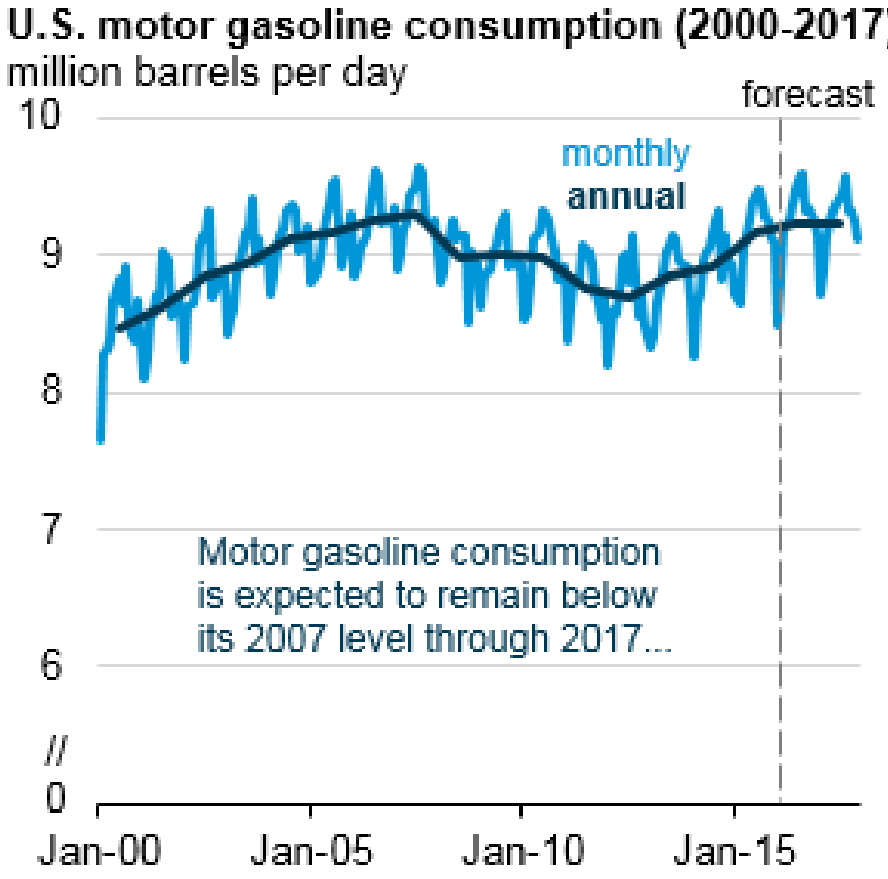
> EIA: Motor gasoline consumption to remain below peak levels in 2015
> Navigant: 100 millions gallons of gasoline usage displaced by EVs from 2011 to 2014

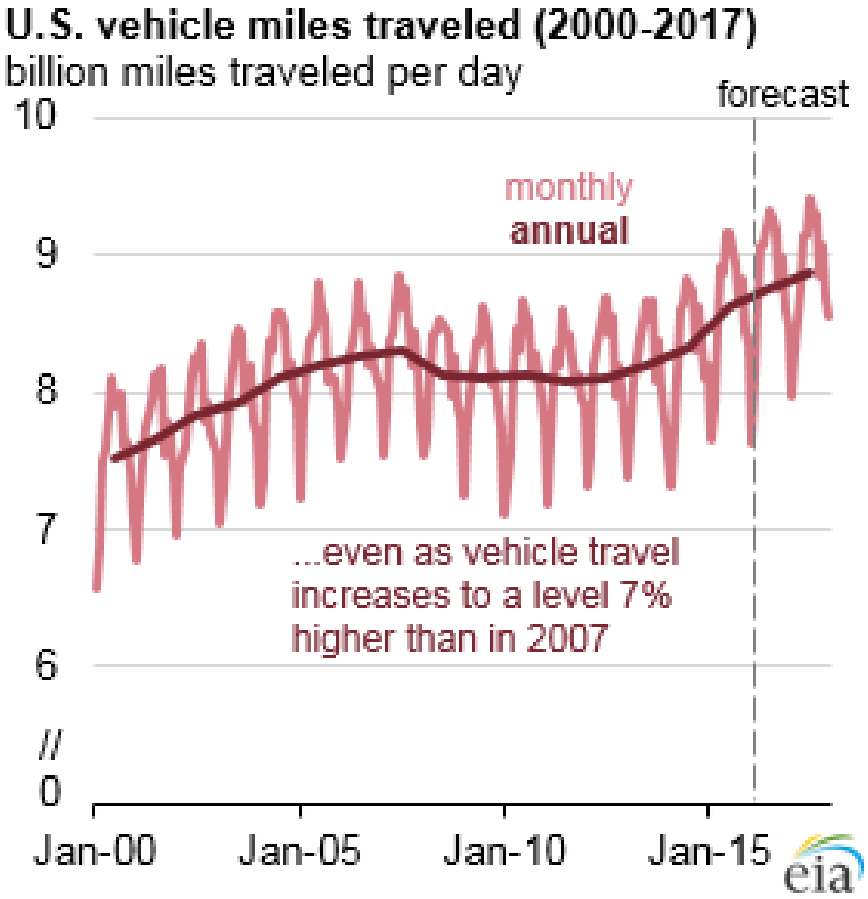
emissions

> EIA: U.S. CO_2 emissions continue to decline in all sectors

gasoline consumption

EIA: Motor gasoline consumption expected to remain below 2007 peak despite increase in travel



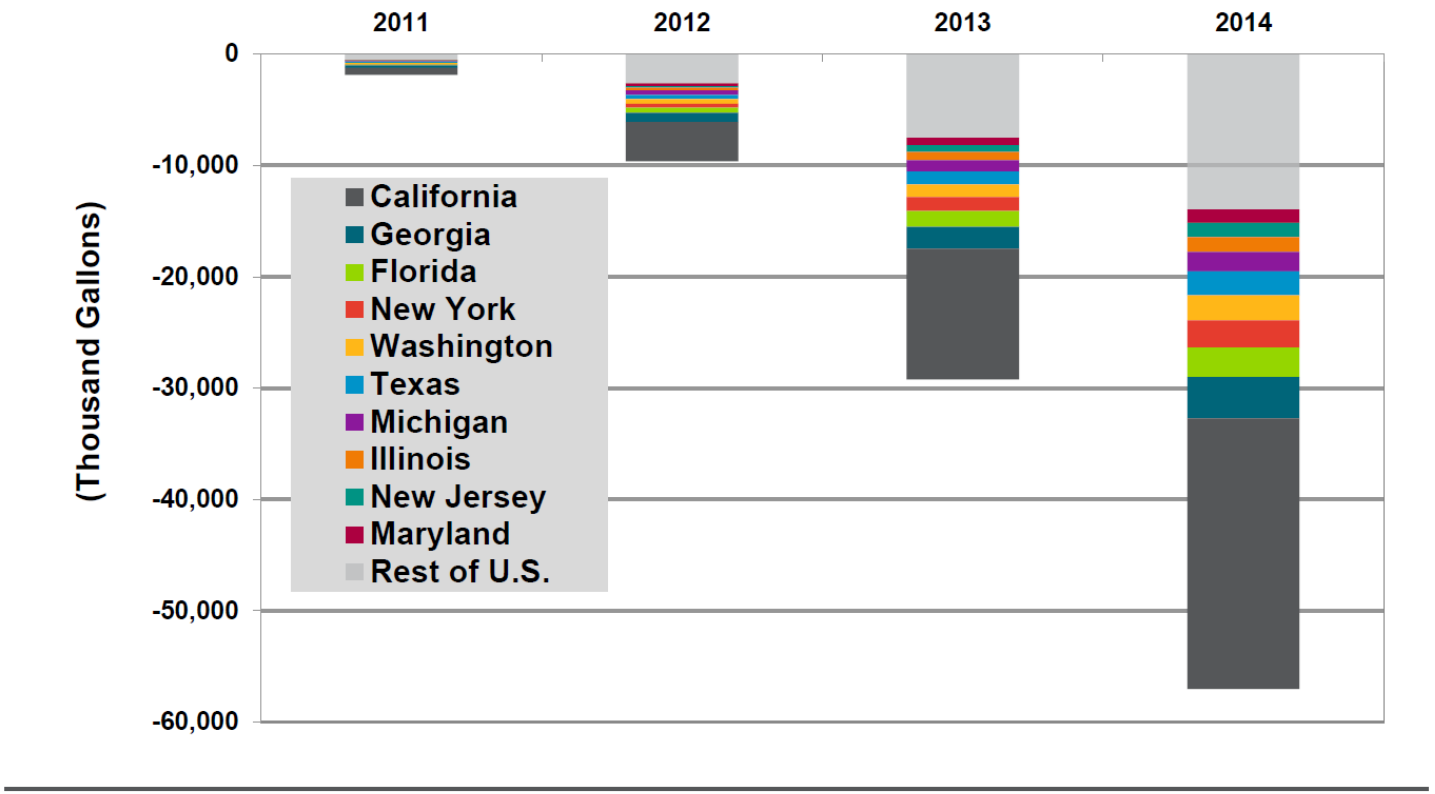


Source: http://www.eia.gov/todayinenergy/detail.cfm?id=25072

gasoline consumption

Navigant: EVs displaced nearly 100 million gallons of gasoline from 2011 to 2014

Chart 2.7 Plug-In Electric Vehicle Gasoline Fuel Displacement by Top 10 States, United States: 2011-2014

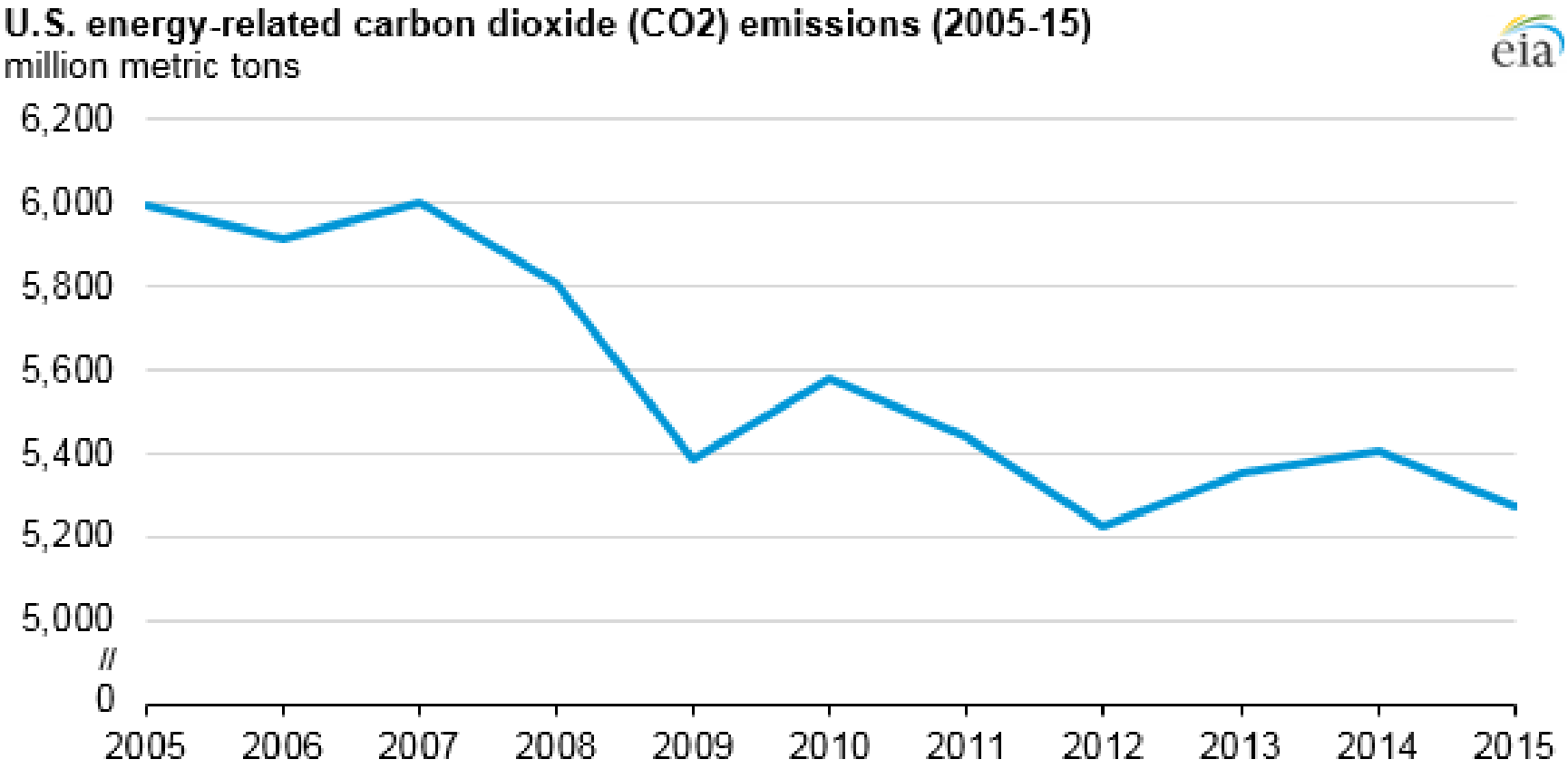


(Source: Navigant Research)

Source: *U.S. Electric Vehicle Energy Consumption: 2011-2014*, Navigant Research

emissions

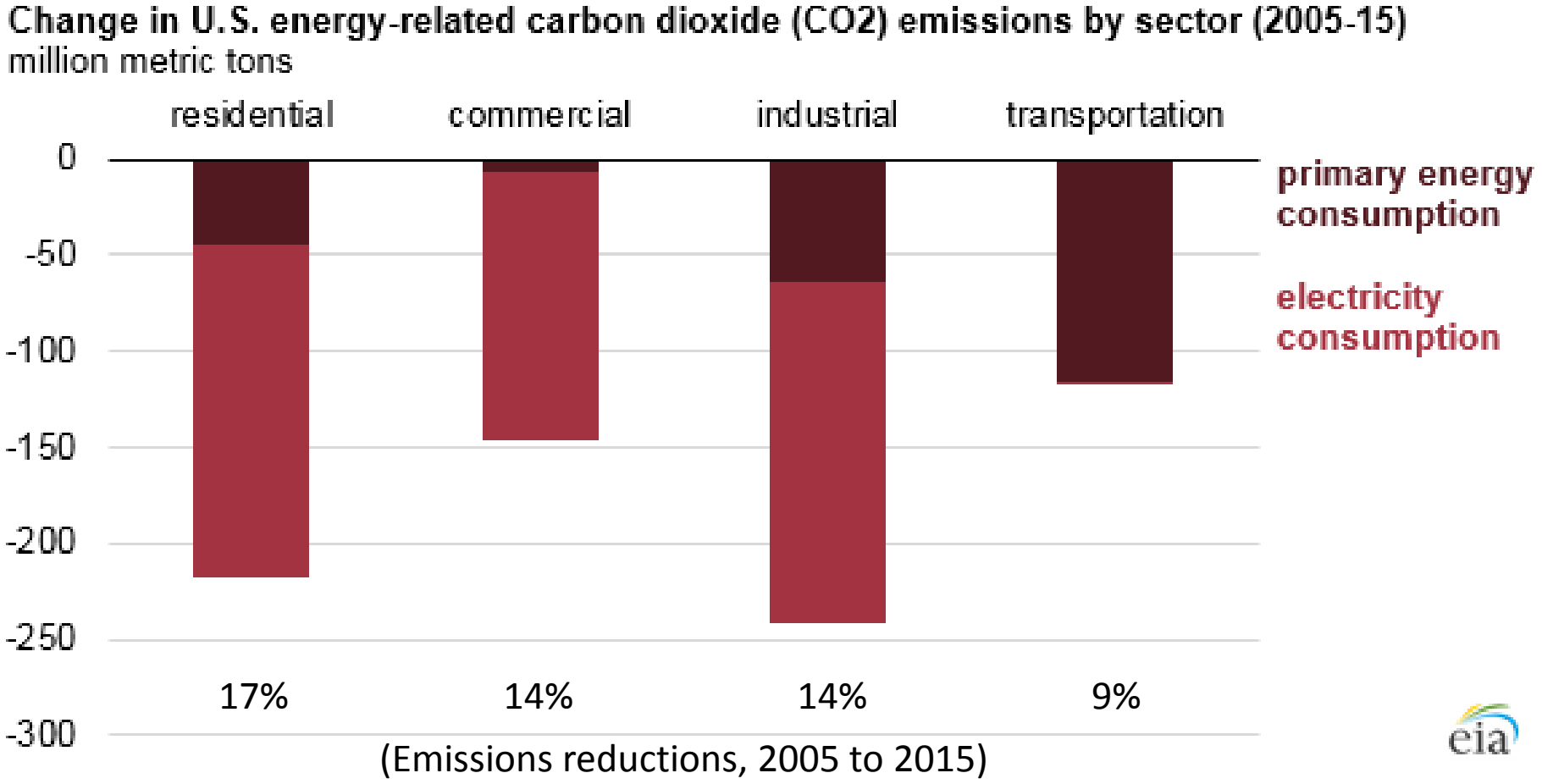
EIA: U.S. energy-related CO_2 emissions 12% below 2005 levels last year



Source: http://www.eia.gov/todayinenergy/detail.cfm?id=26152

emissions

EIA: CO_2 emissions from transportation decreased over 100 million metric tons compared to 2005 emissions



Source: http://www.eia.gov/todayinenergy/detail.cfm?id=26152

topics

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5 consumer & opinion surveys

consumer sentiments

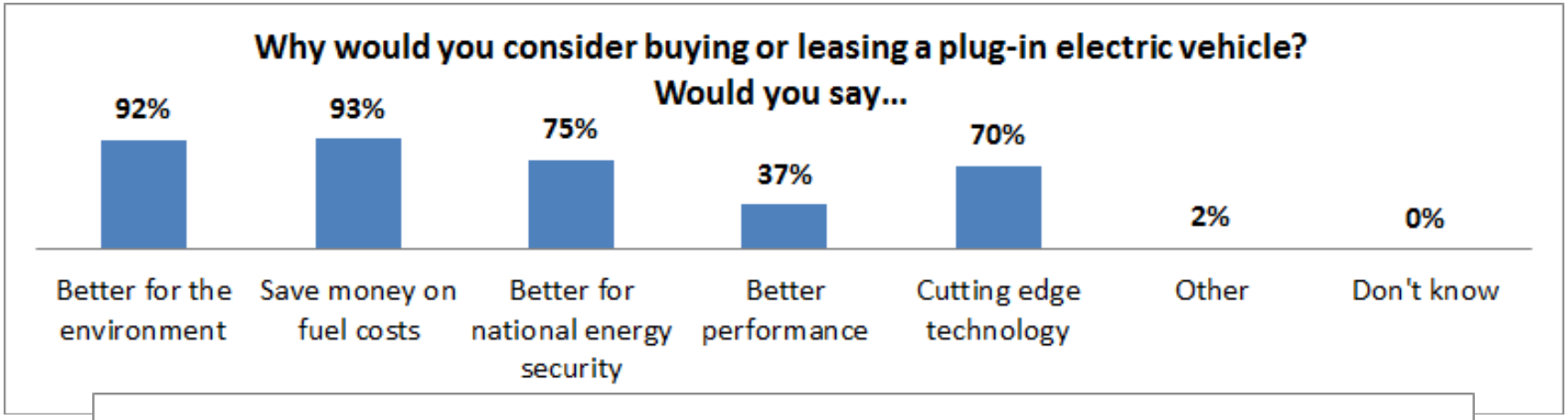
> NREL/INL: Consumers have many reasons to like EVs, awareness is a major factor if they will consider purchasing
> AAA: People are wary of (semi-)autonomous vehicles

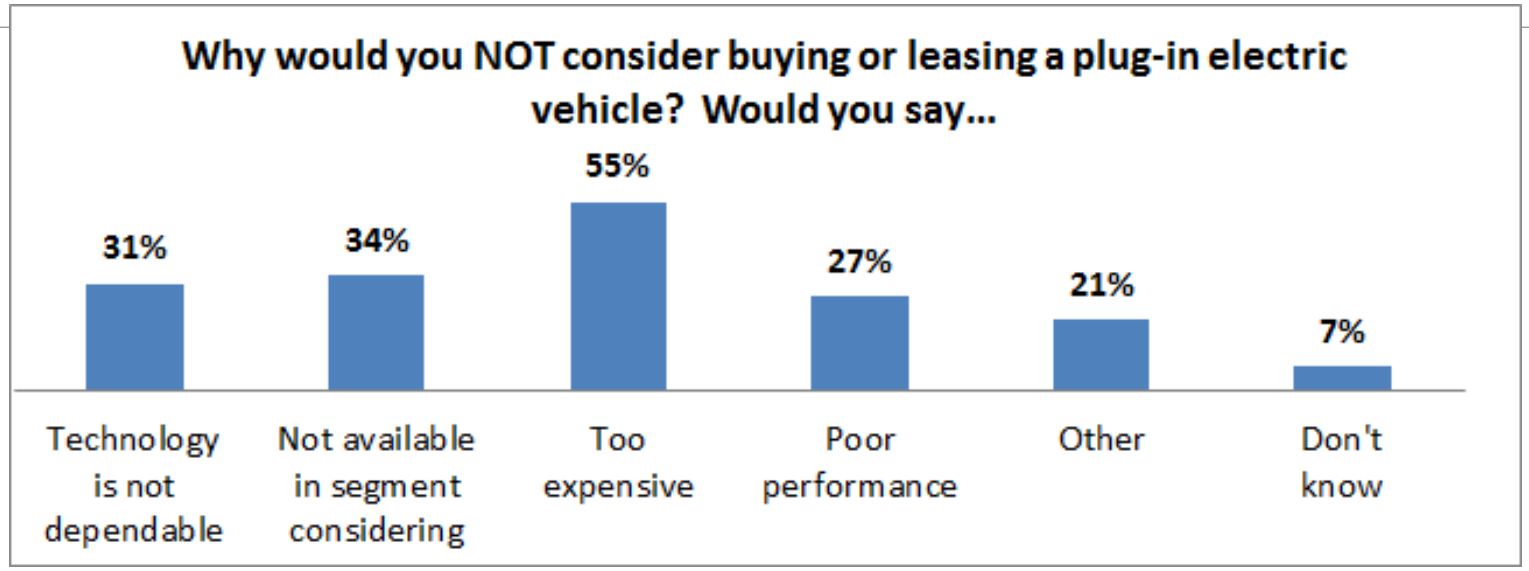
travel behavior

> WMATA: Severe weather affects commute modes
> APTA: Ride-sourcing can replace personal vehicles, but currently mostly popular evenings and weekends
> EIA: U.S. more car-centric than most other countries

consumer sentiments

NREL: Consumers have many reasons for considering PEVs; price and availability largest detriments

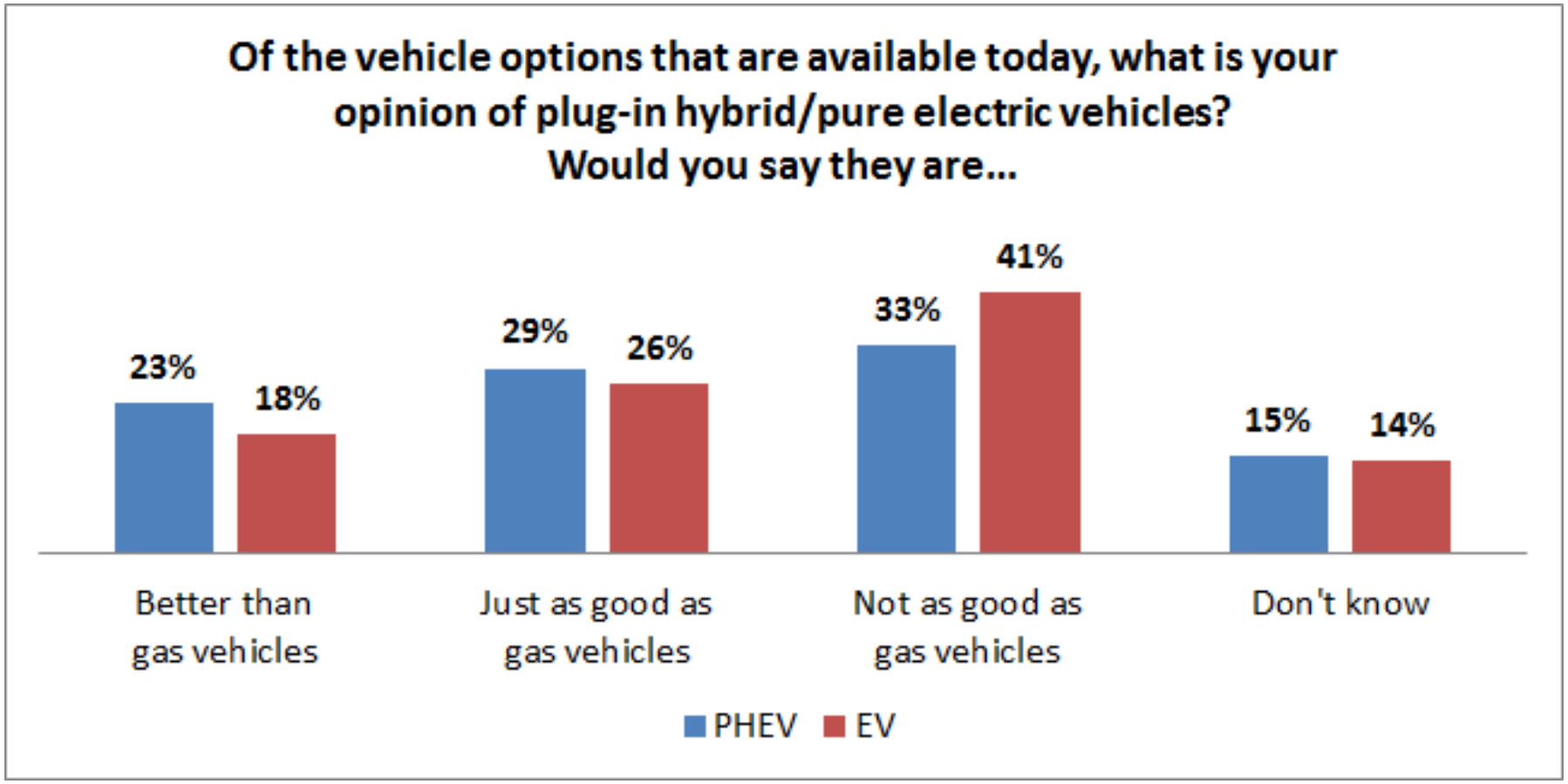




Source: http://www.afdc.energy.gov/uploads/publication/consumer_views_pev_benchmark.pdf

consumer sentiments

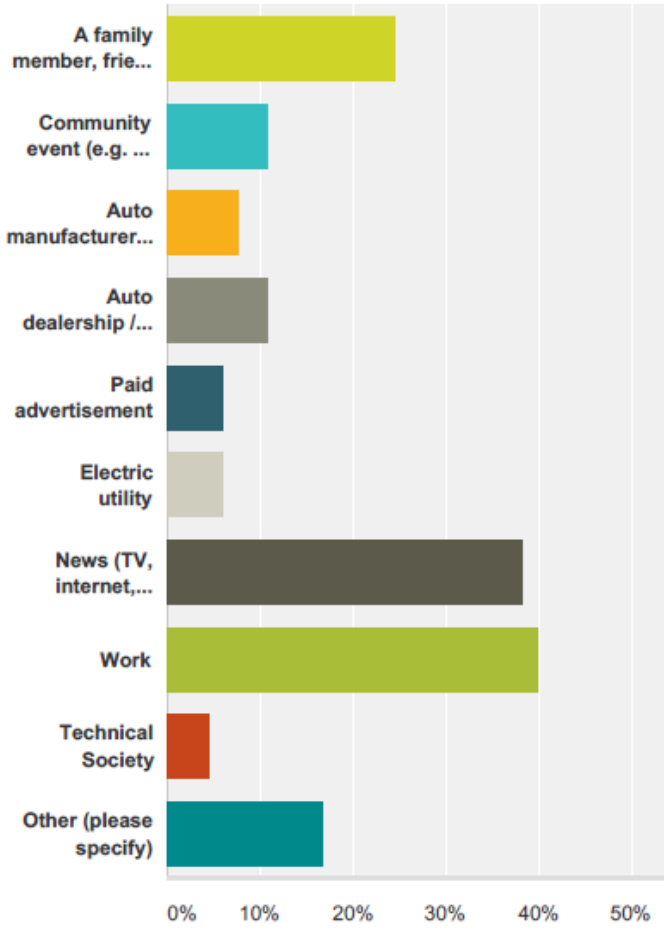
NREL: Broad range in opinions on PHEVs among consumers…



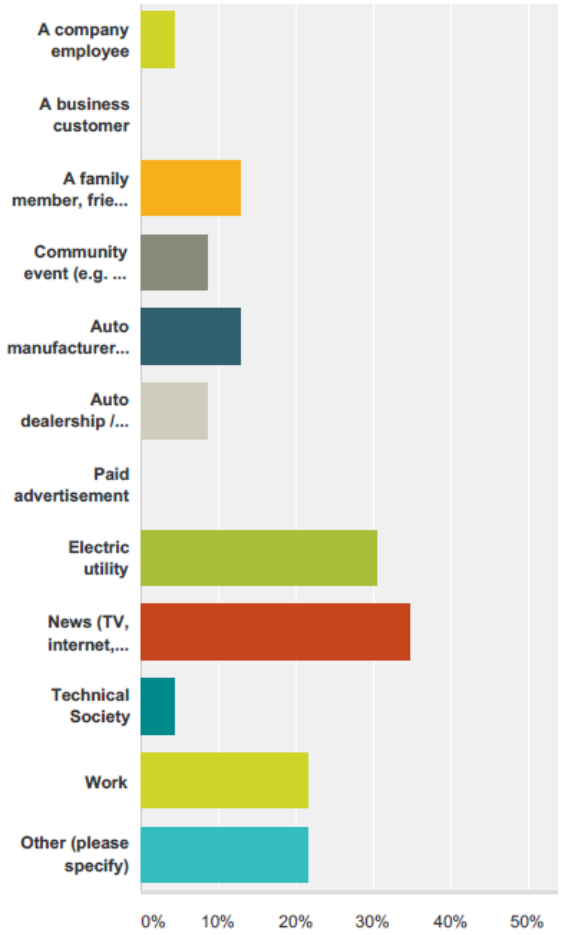
Source: http://www.afdc.energy.gov/uploads/publication/consumer_views_pev_benchmark.pdf

consumer sentiments

INL: Number of factors to create awareness and interest of PEV and EVSE



EV awareness



EVSE awareness

Source: https://avt.inl.gov/sites/default/files/pdf/evse/DriveElectricVermontCaseStudyMarch2016.pdf

consumer sentiments

AAA: Drivers might not want semi-autonomous features on their vehicles

61% of U.S. drivers want at least one of these semi-autonomous features on their next vehicle:

NewsRoom.AAA.com

Among drivers who **WANT SEMI-AUTONOMOUS FEATURES** on their next vehicle, their primary motivation is:

- 84% safety
- 64% convenience
- 46% reducing stress
- 30% wanting the latest technology

NewsRoom.AAA.com

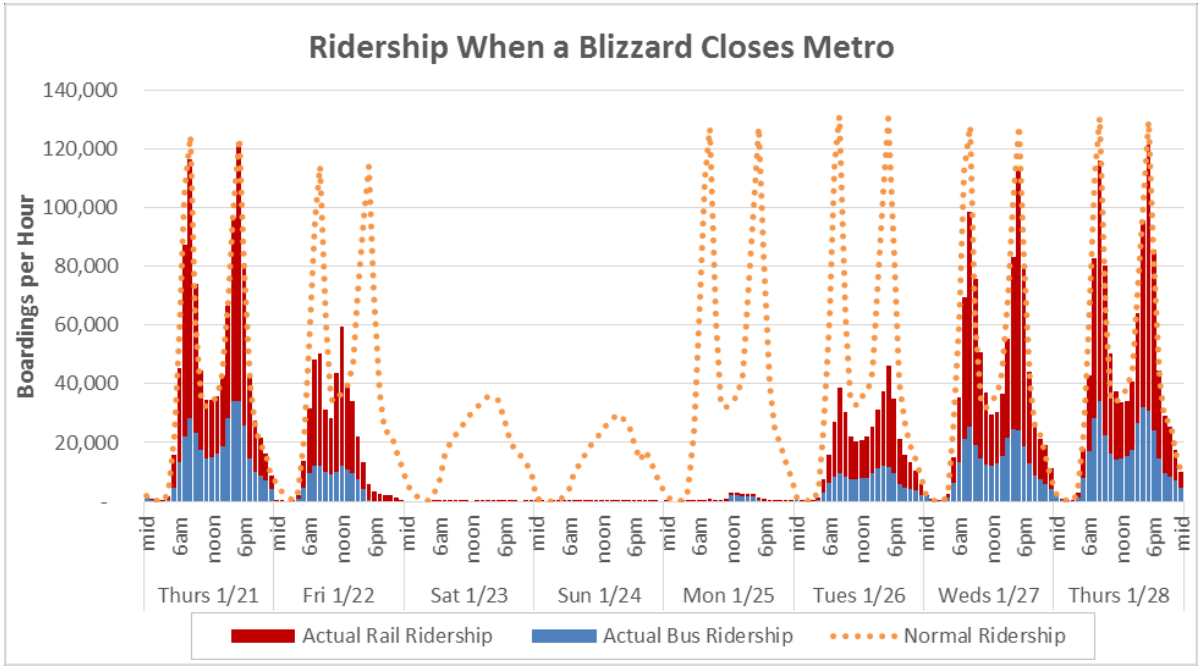
Among drivers who **DO NOT WANT SEMI-AUTONOMOUS FEATURES** on their next vehicle cite the following reasons:

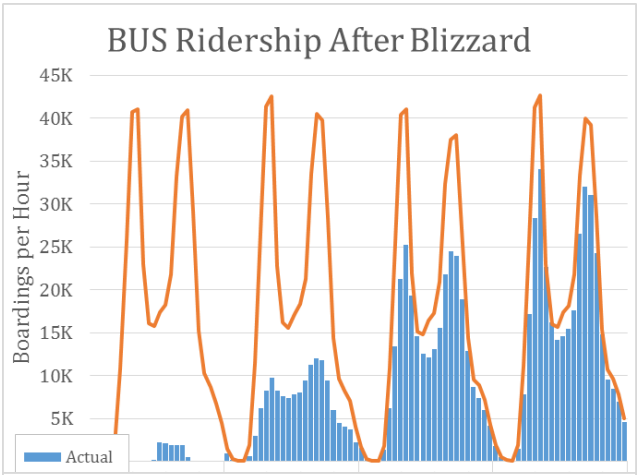
- 84% trusting their driving skills more than the technology
- 60% feel the technology is too new and unproven
- 57% not wanting to pay extra for it
- 50% do not know enough about the technology
- 45% find it annoying

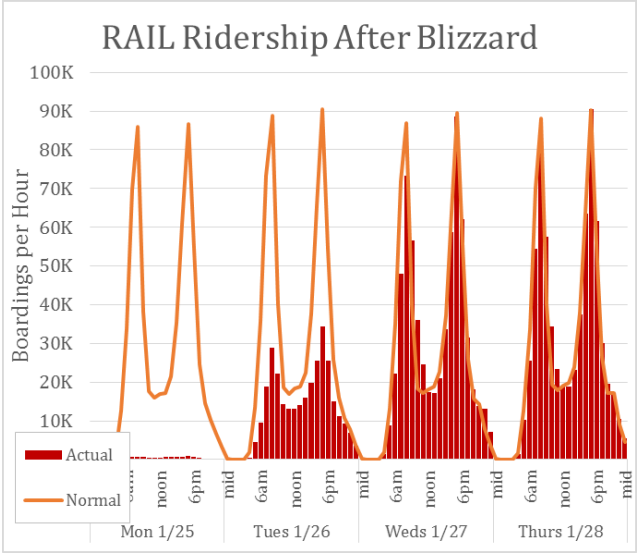
Source: http://newsroom.aaa.com/2016/03/three-quarters-of-americans-afraid-to-ride-in-a-self-driving-vehicle/

weather and public transit

WMATA: Public transport greatly reduced during blizzard; rail recovered faster after blizzard than bus



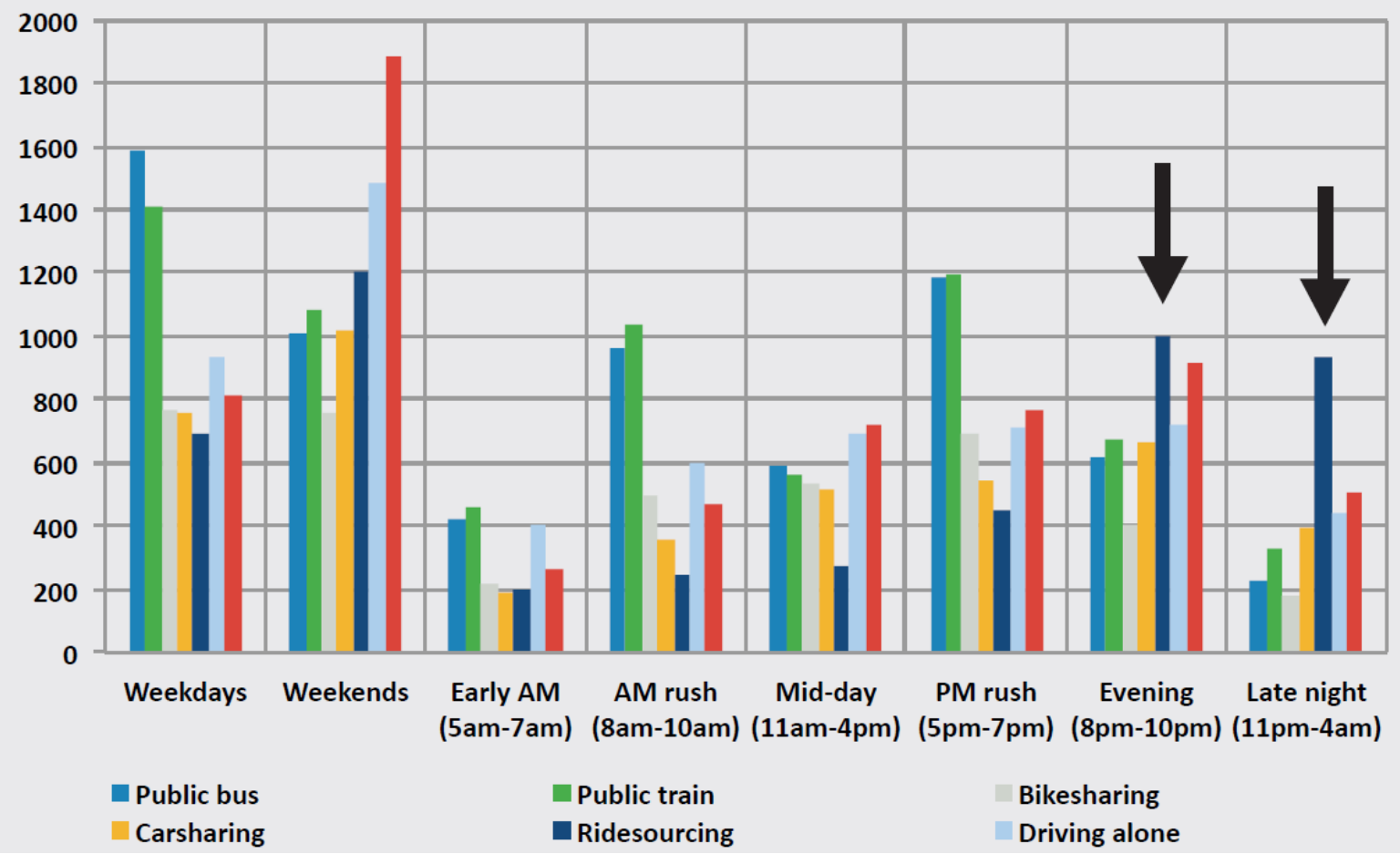




Source: http://planitmetro.com/2016/02/22/ridership-before-and-after-the-blizzard-of-2016/

travel behavior

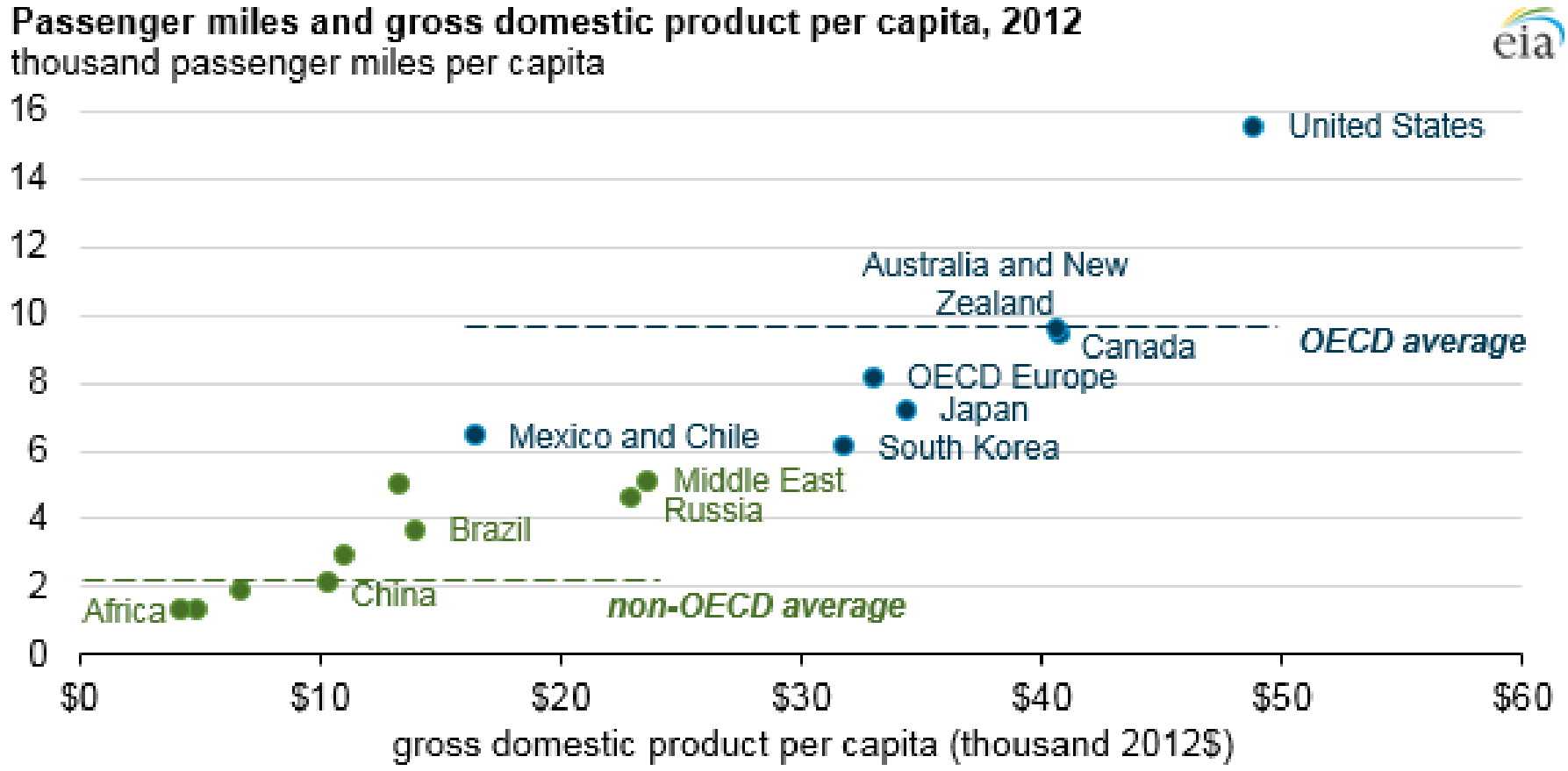
APTA: Ridesourcing (e.g. Lyft/Uber) most popular evenings and nights, least popular other times



Source: http://www.apta.com/resources/hottopics/Pages/Shared-Use-Mobility.aspx

travel behavior

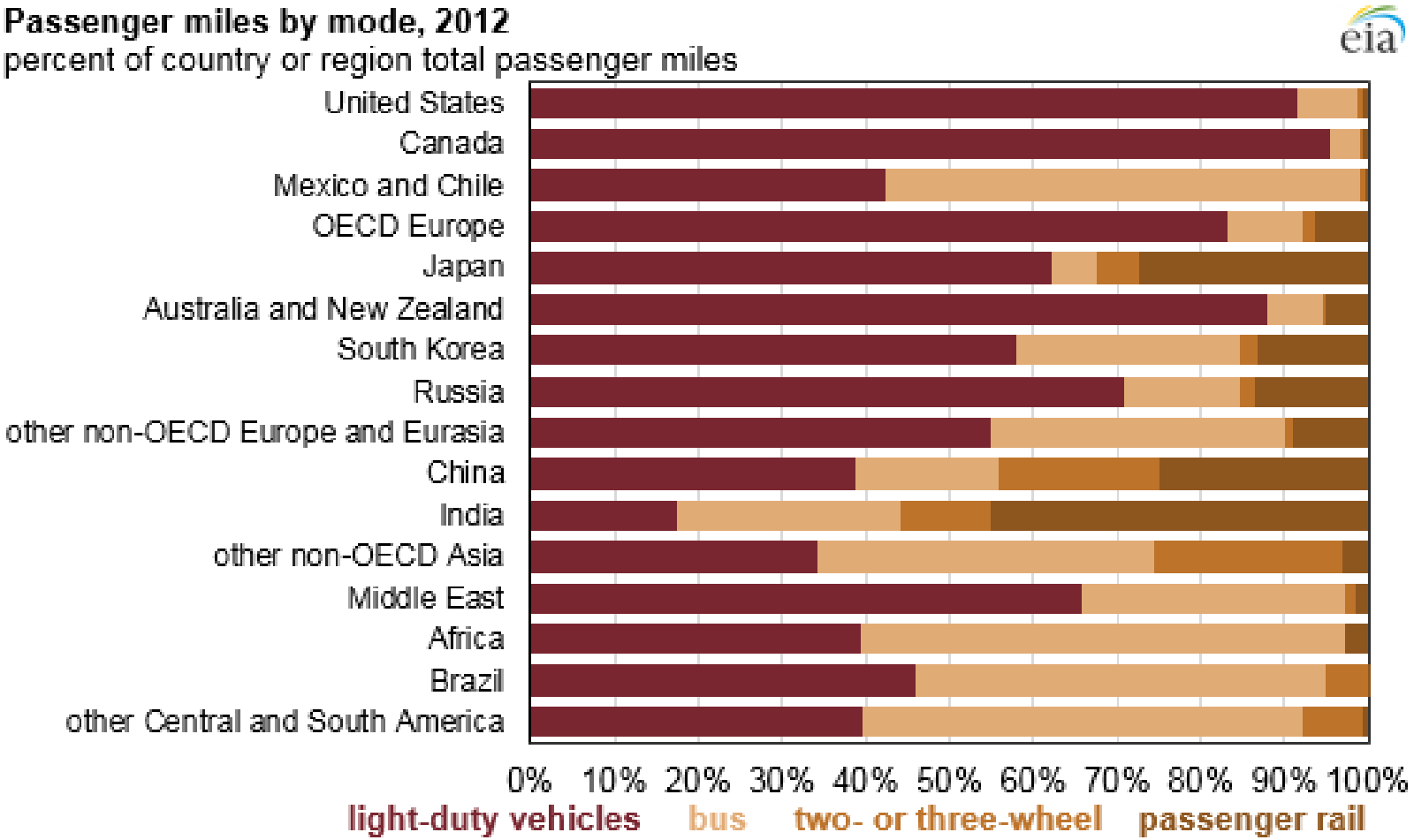
EIA: Annual passenger travel tends to increase with income



Source: http://www.eia.gov/todayinenergy/detail.cfm?id=26192

travel behavior

EIA: U.S., Canada, and Australia more car-centric than other countries



Source: http://www.eia.gov/todayinenergy/detail.cfm?id=26192

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EV markets

> ANL: EV sales vary by state, can be driven by state incentives
> Bloomberg: Federal EV incentive phase-out on horizon

fleet idling

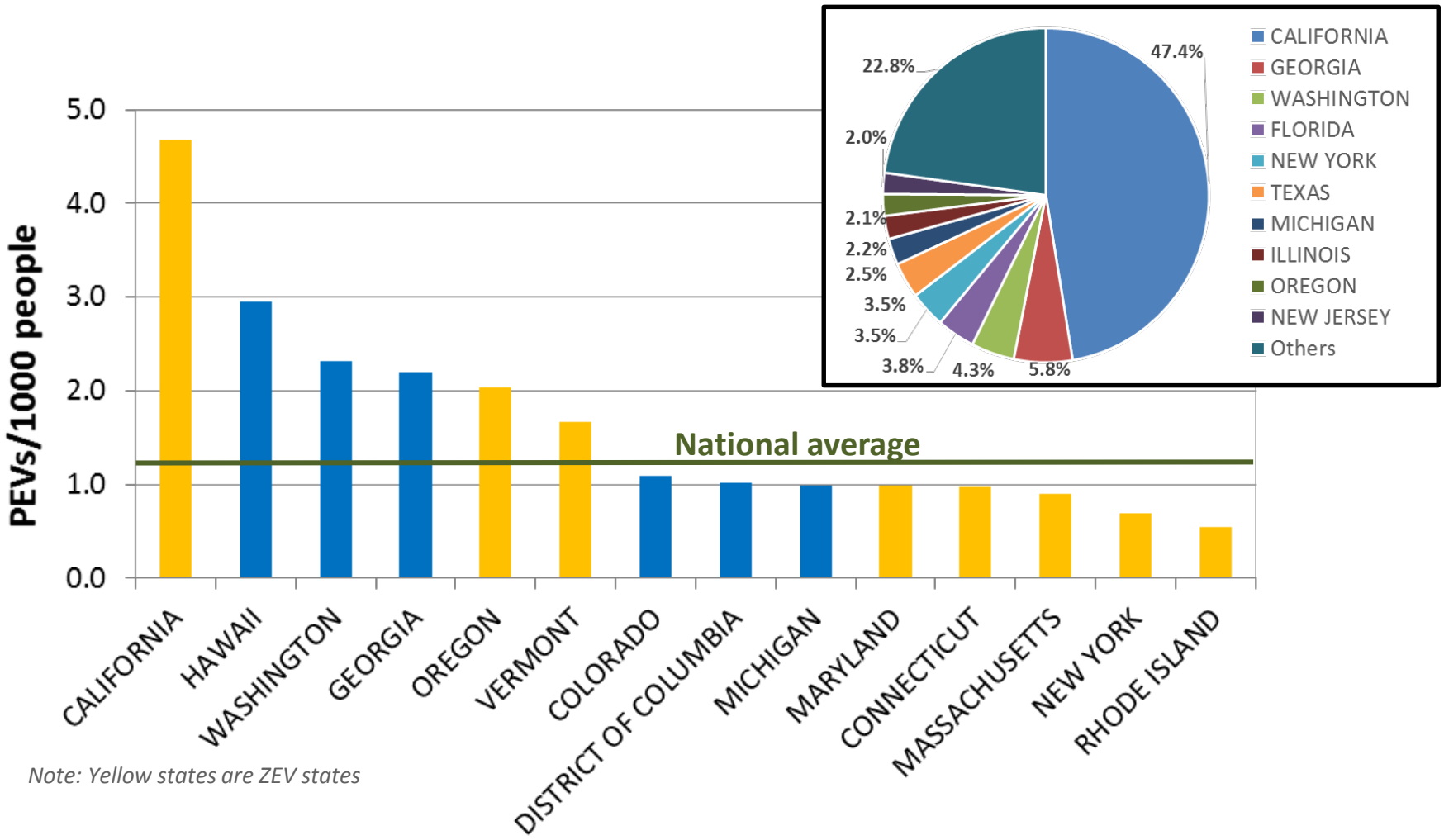
> FOTW/NTEA: Different industries idle differently
> FOTW/NTEA: Fuel savings and emissions reductions drive idle-reduction technologies

disruptive technology

> WSJ/KPMG/McKinsey: Automakers now expecting major changes in industry, including CAVs

PEV markets

ANL: EV sales vary widely by state, nearly half of EVs sold nationwide are in California

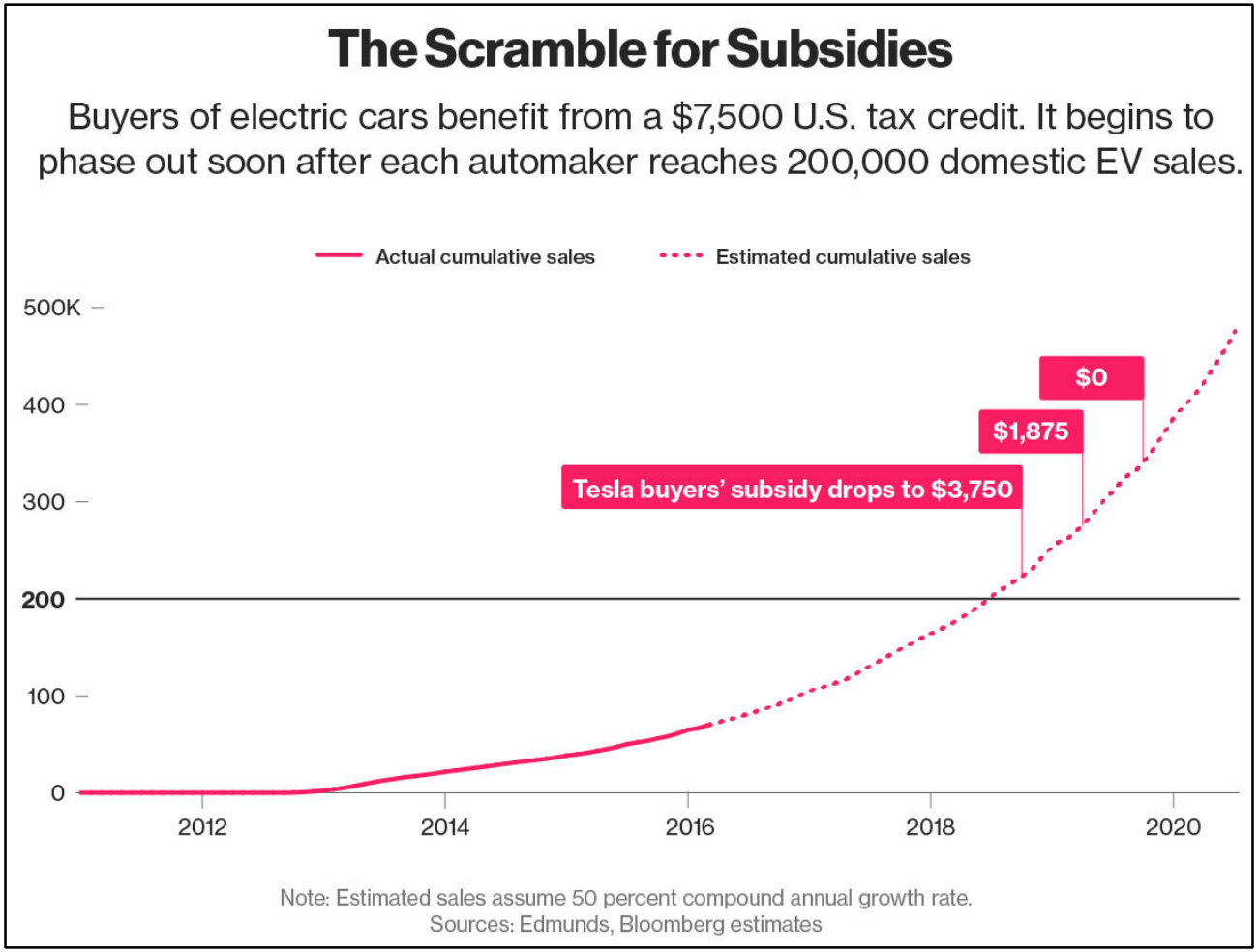


Note: Yellow states are ZEV states

Source: Y. Zhou, Argonne National Laboratory

PEV markets

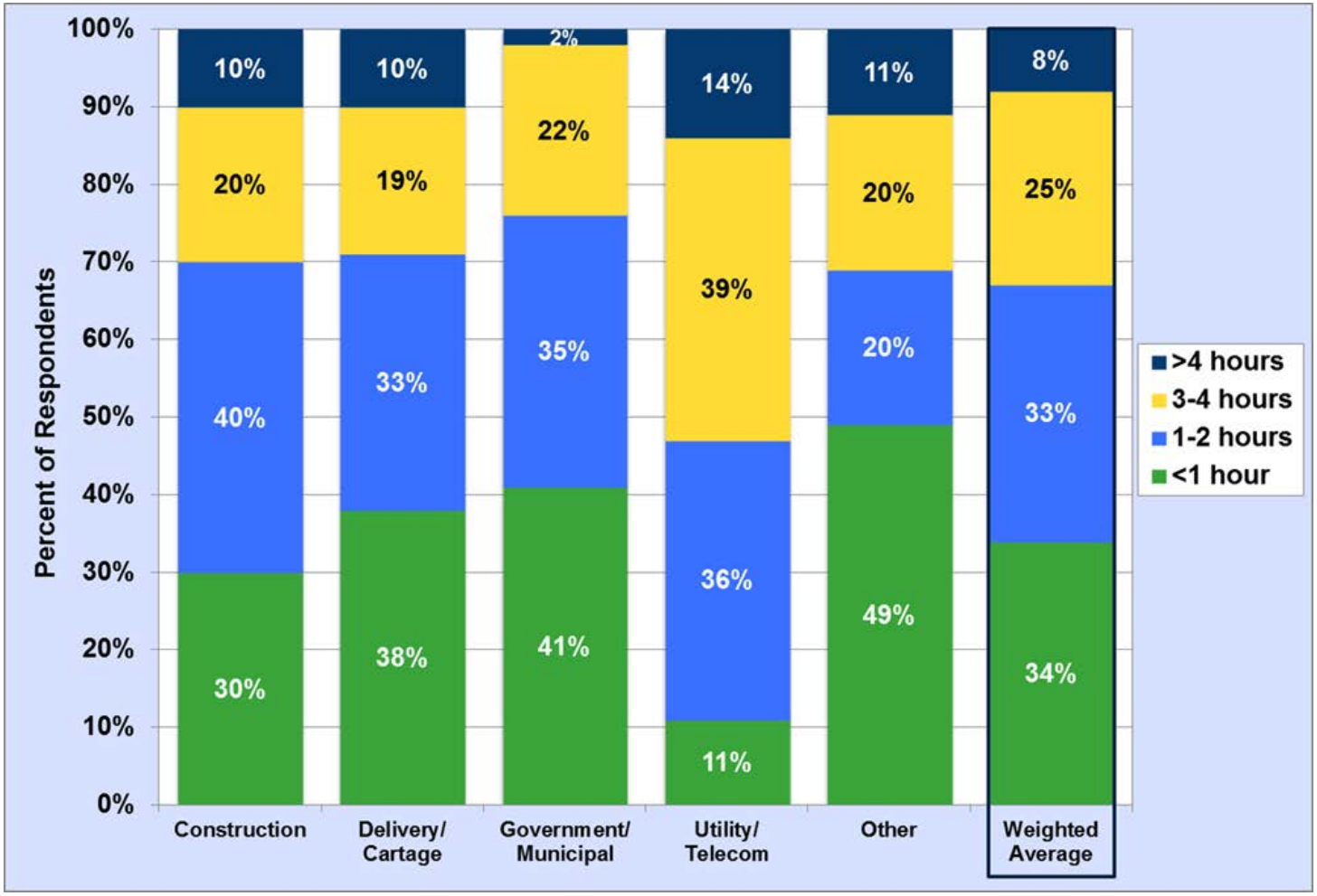
BNEF: High sales for Tesla Model 3 will coincide with phase out of $7,500 federal tax credit



Source: http://www.bloomberg.com/news/articles/2016-05-04/two-tesla-production-chiefs-to-leave-ahead-of-biggest-challenge-yet

idle reduction

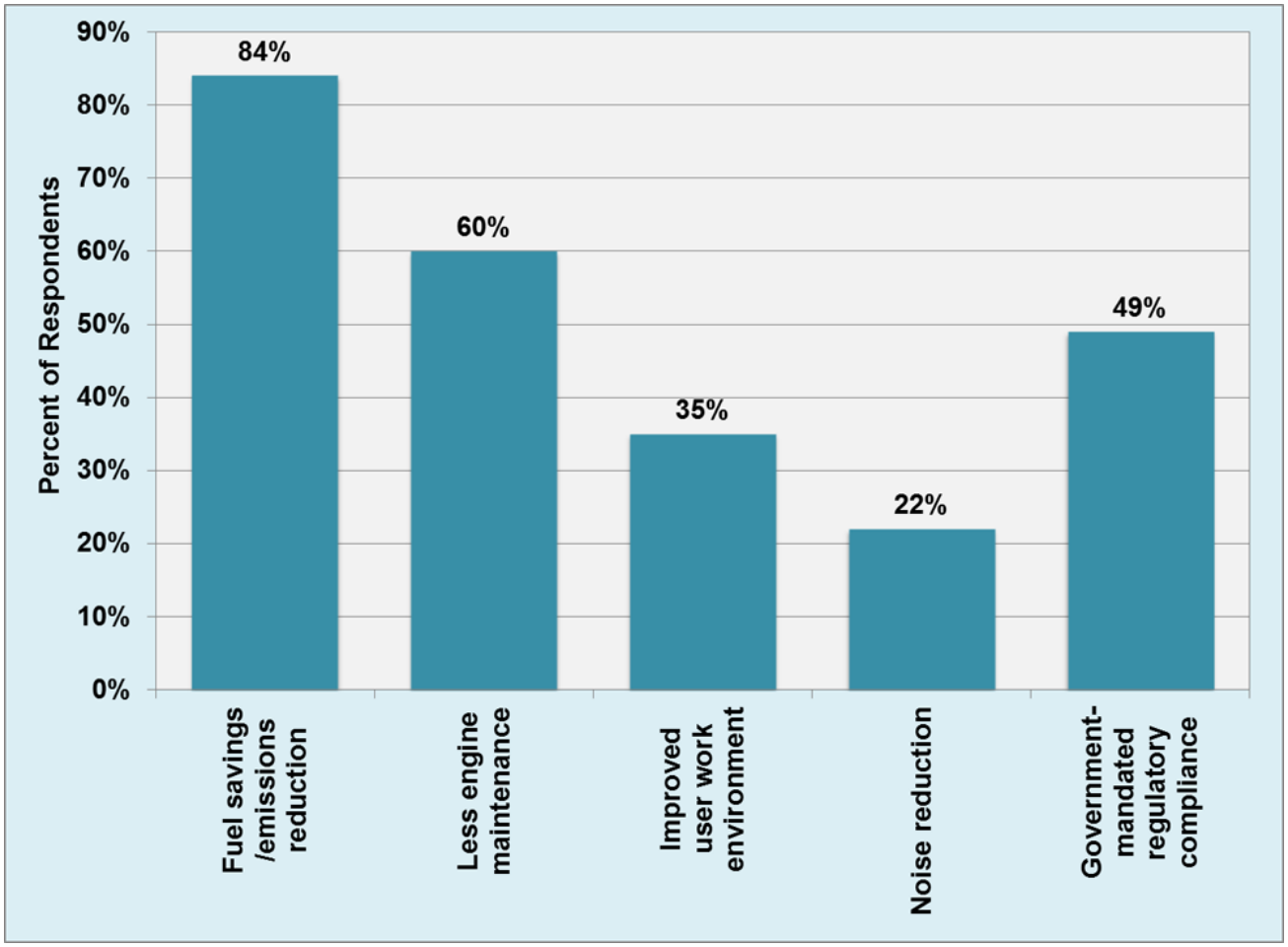
FOTW/NTEA: Different industries idle differently



Source: http://energy.gov/eere/vehicles/fact-917-march-21-2016-work-truck-daily-idle-time-industry

idle reduction

FOTW/NTEA: Fuel savings and emissions reductions top reason fleets adopt idle reduction technologies

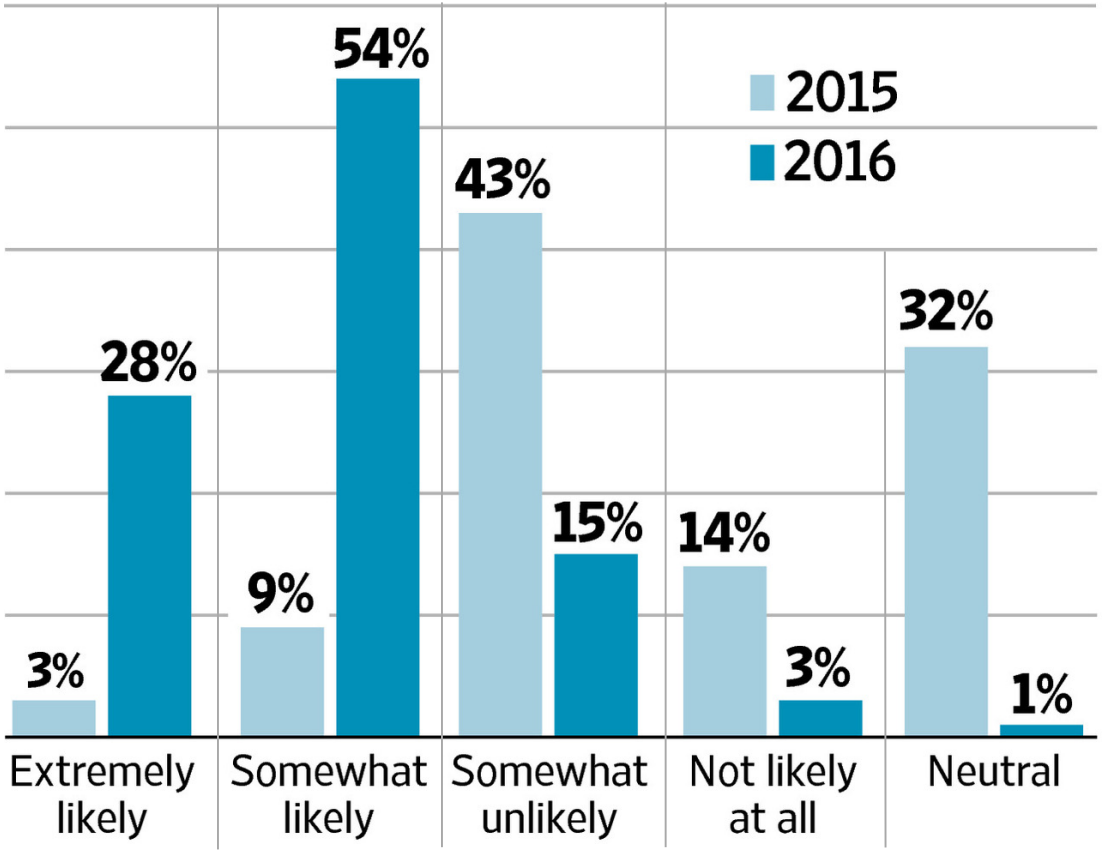


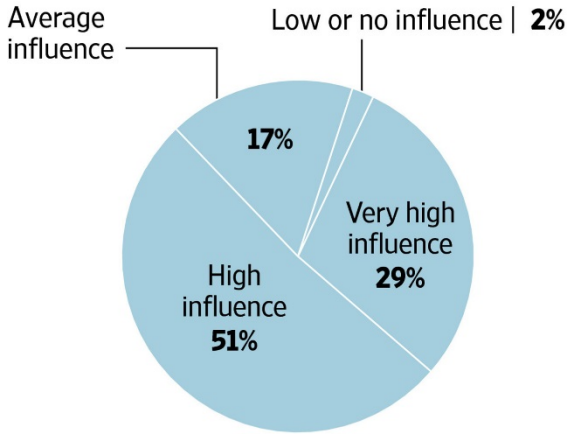
Source: http://energy.gov/eere/vehicles/fact-916-march-14-2016-fuel-savingsemissions-reduction-was-top-reason-cited-truck

disruptive technology

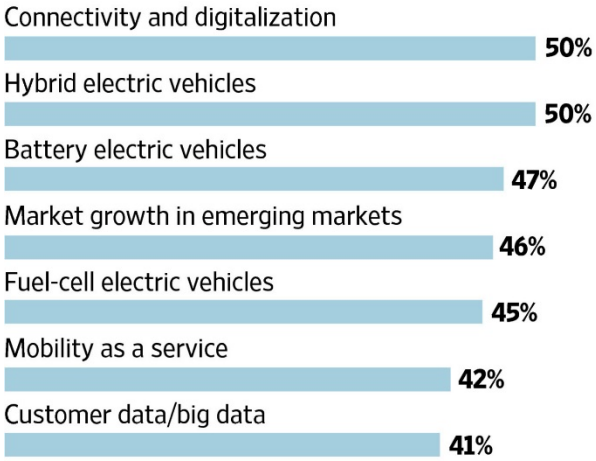
KPMG via WSJ: Auto executives starting to expect major business-model disruption

How likely is a major business-model disruption in the next 5 years?





Legislative and regulatory influence



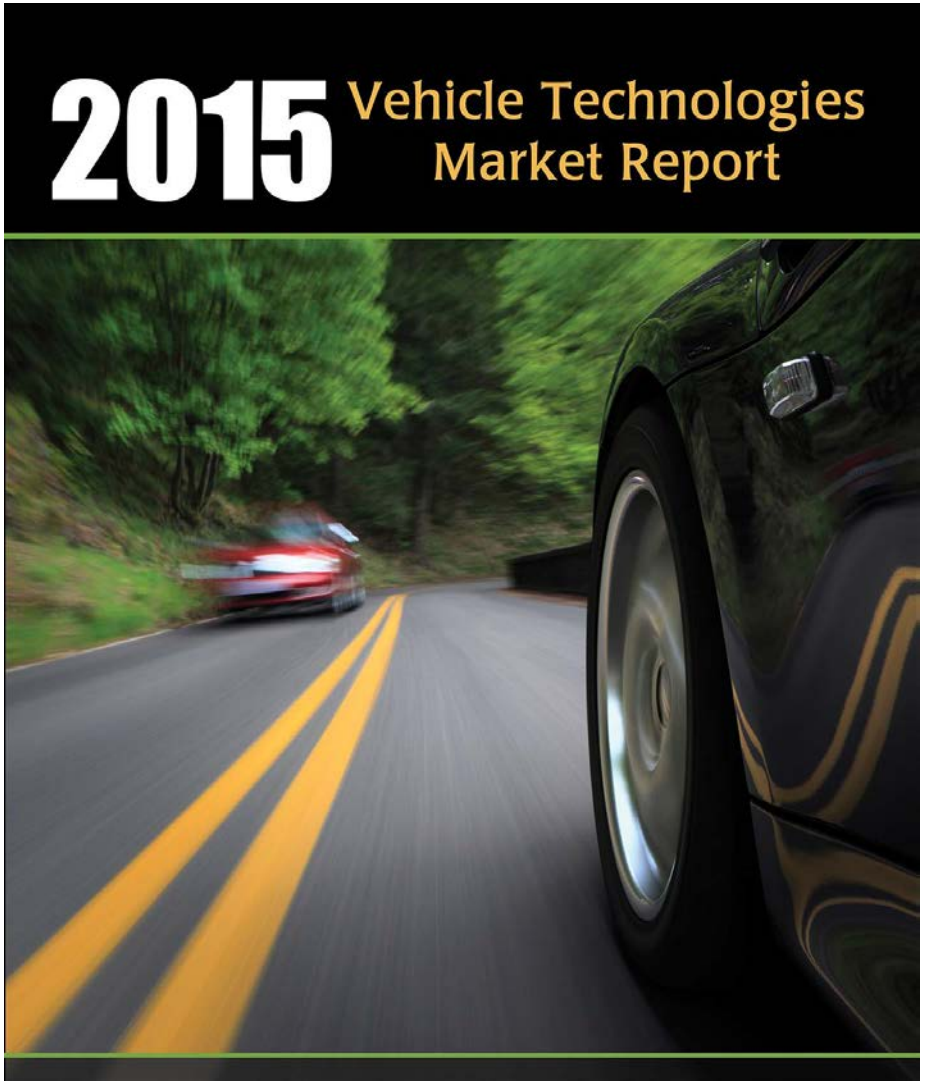
Important trends

Source: http://www.wsj.com/articles/ceo-mark-fields-maps-fords-future-1460502908

publication

ORNL: Release of 2015 Vehicle Technologies Market Report

The *Vehicle Technologies Market Report* details the major trends in U.S. light-duty vehicle and medium/heavy truck markets as well as underlying trends. This report is supported by the U.S. Department of Energy's Vehicle Technologies Office, and, in accord with its mission, pays special attention to the progress of high-efficiency and alternative-fuel technologies.



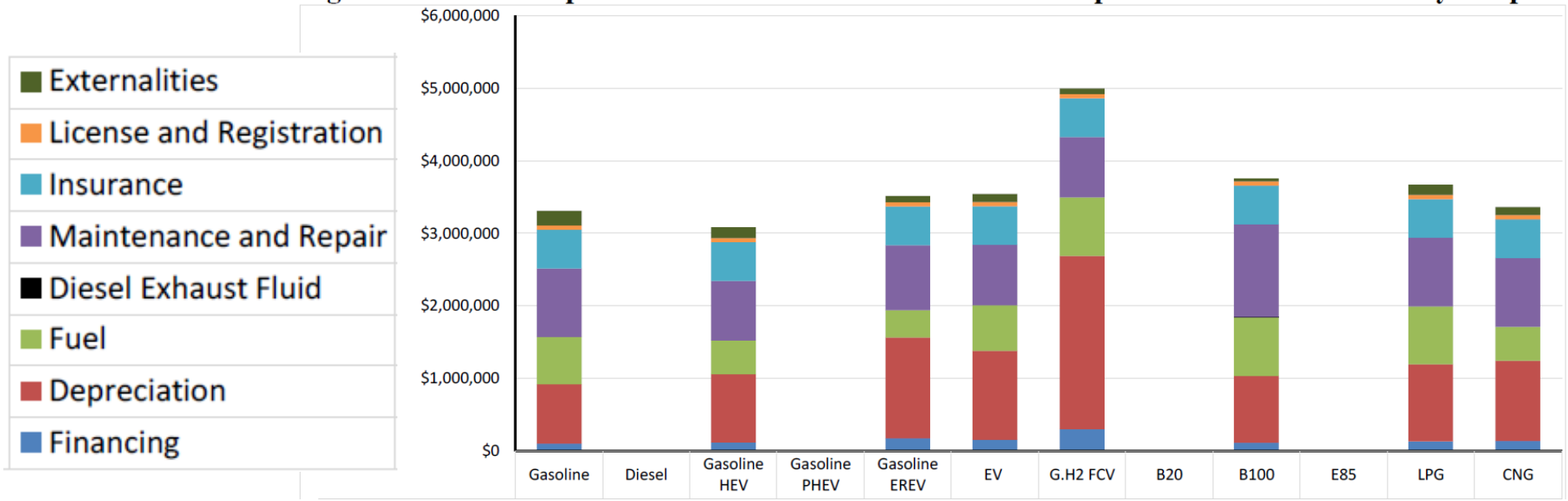
Source: http://cta.ornl.gov/vtmarketreport/index.shtml

publication

ANL: Release of AFLEET Tool 2016

Argonne has developed the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool for Clean Cities stakeholders to estimate petroleum use, greenhouse gas emissions, air pollutant emissions, and cost of ownership of light-duty and heavy-duty vehicles using simple spreadsheet inputs.

Figure 34. TCO Outputs Sheet – LDV Total Cost of Ownership w/ Externalities Summary Graph

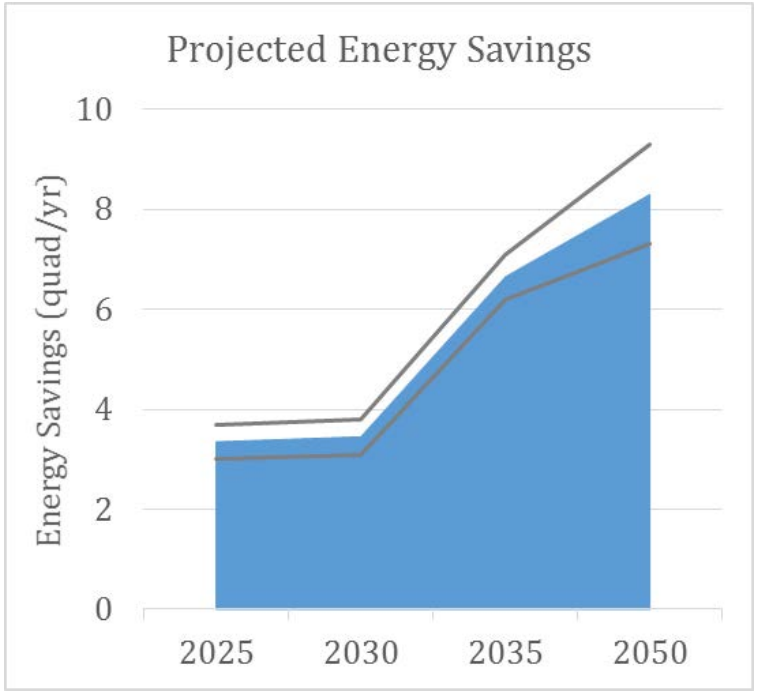


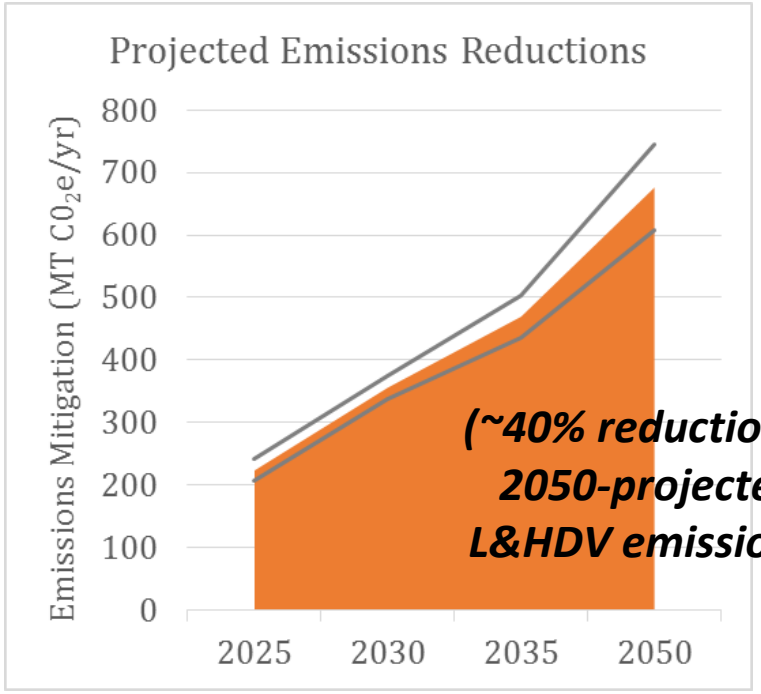
Source: https://greet.es.anl.gov/afleet_tool

publication

ANL: Release of VTO program benefits analysis

This report estimates the benefits of successfully developing and deploying these technologies (a “Program Success” case) relative to a base case (the “No Program” case). The Program Success case represents the future with completely successful deployment of Vehicle Technologies Office (VTO) and Fuel Cell Technologies Office (FCTO) technologies.





Source: http://www.anl.gov/energy-systems/project/prospective-benefits-assessments-vehicle-technologies

summary observations

energy Gasoline prices are still low; long-term transportation energy use will be driven by developing countries

automotive Third-party EVs sales projections higher than previous projections; worldwide sales will be driven by urbanization

tech/enviro Automakers are including advanced technologies to improve fuel economy and reduce CO_2 emissions; CO_2 emissions continue to fall in United States

opinion/policy Increased EV awareness makes consumers more likely to consider purchasing; disruptive technologies increasingly expected to play a major role in the auto industry

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2Q 2016

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summary