Is the Car of the Future Electric?

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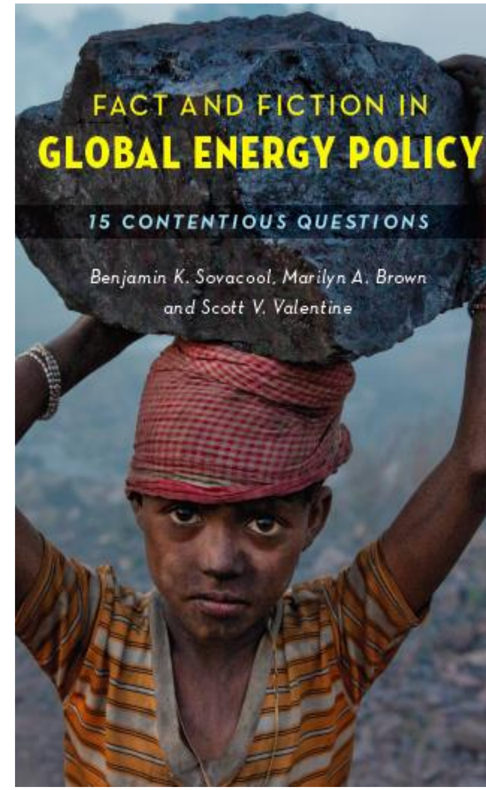

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Sociotechnical Systems, Not Isolated Technology

Energy systems are far more than technological packages: they are sociotechnical systems.

Viewed as a sociotechnical system, a car includes:	
Roads & traffic signals	Emissions testing
Oil companies & refineries	Registration offices
Fuel stations	Insurance companies
Car & parts manufacturers	Research centers
Dealerships & maintenance	Police & legal networks

With EV charging and vehicle-to-grid support, the transportation and electricity “systems” are converging.

Source: Sovacool, Brown, and Valentine. 2016. *Fact and Fiction in Global Energy Policy* (Johns Hopkins Press).

Why is there so much inertia (“lock-in”)?

“the current low functionality and high cost of alternatives, and low gasoline taxes are endogenous consequences of the dominance of the internal combustion engine and the petroleum industry, transport networks, settlement patterns, technologies, and institutions with which it has coevolved.”

(MIT Management Professors: Struben, J., &, J. D. Sterman, 2008).

Vested interests make change difficult.

Dialecticism, Not Monologue

The Future of Electric Vehicles (EVs) and the Common Ground

Is the car of the future electric?

ONE SIDE: EVs are more carbon- and fuel-efficient, can displace costly petroleum dependence, save owners money, and improve the reliability of electricity infrastructure.

OTHER SIDE: EVs produce their own toxic pollution, continue to lock in private motorized modes of transport, are costly and limited in range, and cannot displace the use of liquid fuels in many applications.

EVs offer pollution and carbon benefits

EVs can reduce or eliminate tailpipe pollution and curtail greenhouse gas emissions, but the extent of the gains depends on the type of EV and the carbon intensity of the electricity used to recharge the batteries.

EVs shift the generation of air pollution away from urban areas and toward rural communities, which host fossil fuel-fired powered power plants that recharge EV batteries.

EV penetration can enhance energy security

Of the top ten net oil exporters, only two can be viewed as politically stable suppliers - Norway (ranked number three as a net oil exporter) and Mexico (ranked number ten).

Exports from these two nations pale in significance to exports from nations such as Saudi Arabia, Russia, Iran, and the United Arab Emirates.

The supply of oil can be interrupted during times of political upheaval.

Terrorism is linked to revenues from oil: the wealth of Osama Bin Laden’s family came from government construction contracts that were financed by oil money. ISIS is fueled by oil revenues.

EVs can save money

Consumers can profit from the use of EVs because electricity is cheaper than gasoline for equivalent distances traveled.

Most travel times and distances are relatively short, which suggests that for many commuters the current technology should suffice. Given that about 60 percent of vehicles travel less than 30 miles per day, EV technology is not far from being able to effectively service the travel needs of most motorists

At 2014 gasoline prices, when compared to an ICE that gets 35 miles per gallon, a $21,000 investment in a Nissan Leaf will yield gas savings of almost $750 per year based on 12,000 miles driven per annum

EVs can improve electricity reliability

If EVs draw power from the grid at off-peak times, vehicle recharging could take place today without any substantial expansion of electricity generation capacity

Many electricity generators and electricity grids operate in a sub-optimal fashion because there is a great deal of slack capacity in the system to deal with demand peaks and troughs.

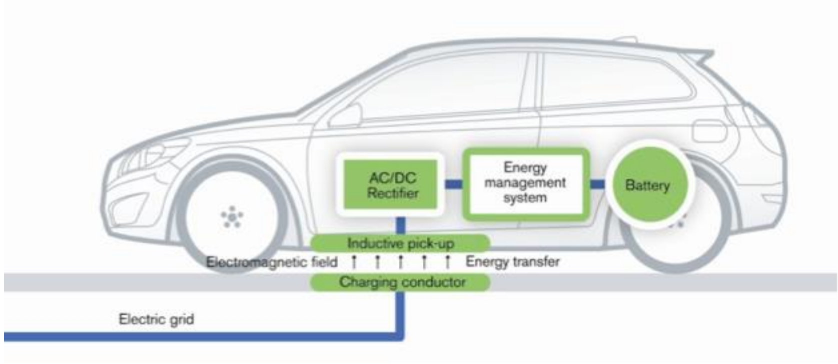
Replacing a relatively small 100 MW peaking gas-turbine unit would require about 30,000 BEVs, each supplying 6.6 kW (assuming an availability of 50%).

EV technology is advancing rapidly

In 2007, even the most advanced BEVs had limited charge ranges of about 100-160 km, long recharge times of 4 or more hours, and high battery costs leading to noncompetitive vehicle retail prices.

A mere 7 years later, the 2014 Tesla Model S comes equipped with a battery supercharger that can provide 170 miles of range in as little as 30-minutes.

The future may involve wireless inductive charging systems replacing the need to “plug in.”



The other side: EVs are no better than conventional cars

EVs depend upon an assumption that transportation should be private, rather than public, and motorized, rather than human-powered. Yet, private, motorized transport gives rise to a host of problems.

It leads to increased congestion, a greater risk of accidents, and elevated demands on scarce natural resources.

Also, those that rely on private transport walk less: they have higher rates of diabetes, cardiovascular disease, and obesity than those who walk or take public transport

Cost and range anxiety will constrain EV Growth

A key criticism of current EVs is that they are expensive and range limited: the cost and storage capacity of lithium-ion batteries has limited the range of travel per charge

The IEA found that buyers expect vehicle efficiency improvements to pay for themselves in the first three years or less. With gasoline at $3.50 per gallon, it would take 12 years for the operational savings attributed to the Focus EV to offset the cheaper retail price of the ICE Focus.

The 2014 Nissan Leaf has a range of only 84 miles before requiring a recharge.

Opponents of EVs argue that this state of anxiety is amplified by EVs because charging time is far more onerous than stopping in to a local gas station.

EVs engender sizable environmental externalities

EVs give rise to a host of environmental ills. Most notable are greenhouse gas emissions from electricity use, toxic pollution from battery manufacturing and disposal, and elevated water consumption.

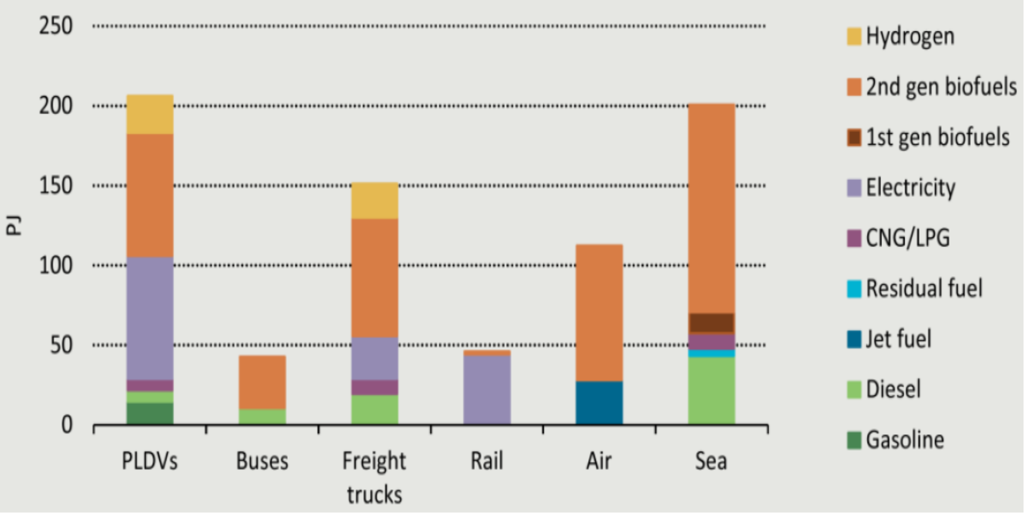
The transition of LDVs from internal combustion engines to electric power is likely to increase consumption of electricity, and thus exacerbate water scarcity in some regions.

This is because fossil fuel and nuclear power plants – which dominate the electricity generation sector – require large amounts of water for the production of steam and for cooling processes.

Liquid fuels lack substitutes

EVs, because they run on electricity, are constrained by the reach of electricity networks. The added water intensity associated with EVs makes it difficult to electrify transport in regions where water is scarce – e.g., Africa.

Buses, freight trucks, long distance trains, and airplanes will most likely continue to operate on jet fuel, biofuel, diesel, and gasoline – at least over the next few decades.



Expected Transportation Fuel Mixes and Modes in a Low-Carbon Nordic Region, 2050

EVs still risk injury, congestion, and physical inactivity

The paradigm of private vehicle ownership, not the technology of private vehicles, needs to be changed. EVs depend upon an assumption that transportation should be private, rather than public, and motorized, rather than human-powered.

Traffic congestion caused urban Americans to waste 5.5 billion hours (equivalent to the time US businesses and citizens spend each year filing their taxes).

Private motorized vehicles of any sort contribute to less physical activity.

Synthesis

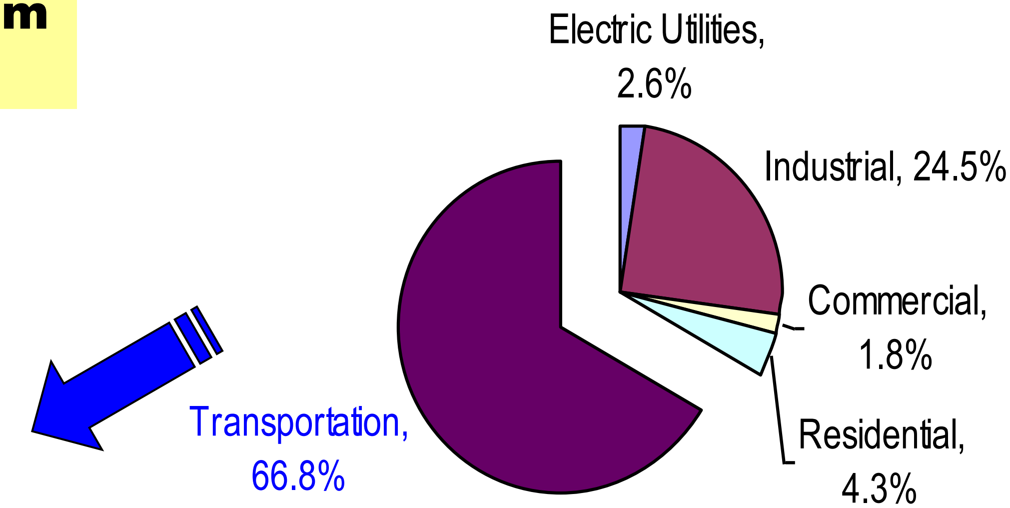
- In the end, the pace and scale of EV diffusion depends on further technological breakthroughs in batteries, charging equipment, support infrastructure, consumer attitudes, societal conceptions of mobility, and policy support.
- EVs might represent the transport platform of the future, but much development is still needed for them to become dominant.
- This gives ICE stakeholders time to wage a competitive market defense that might confine EVs to specialized market niches for some time to come. Thus, the outcome is uncertain.

Extra Slides

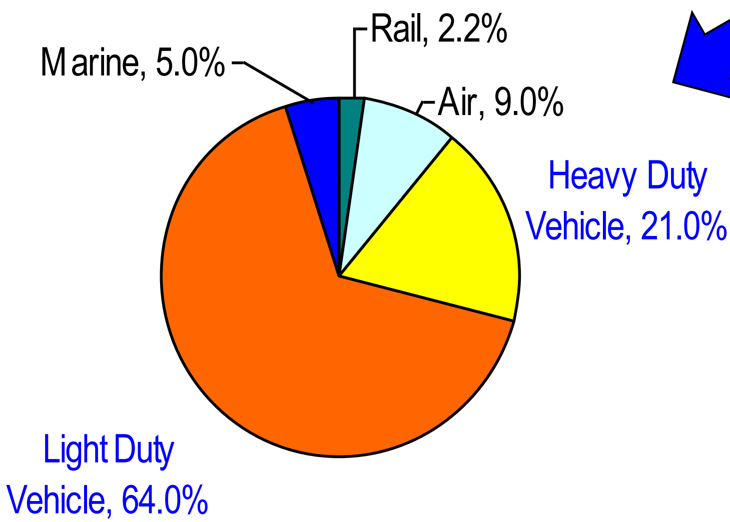
Introduction

The transportation sector accounts for 67% of the oil use in the U.S. and is the fastest growing petroleum consuming sector.

Petroleum Consumption by End-Use Sector



Transportation



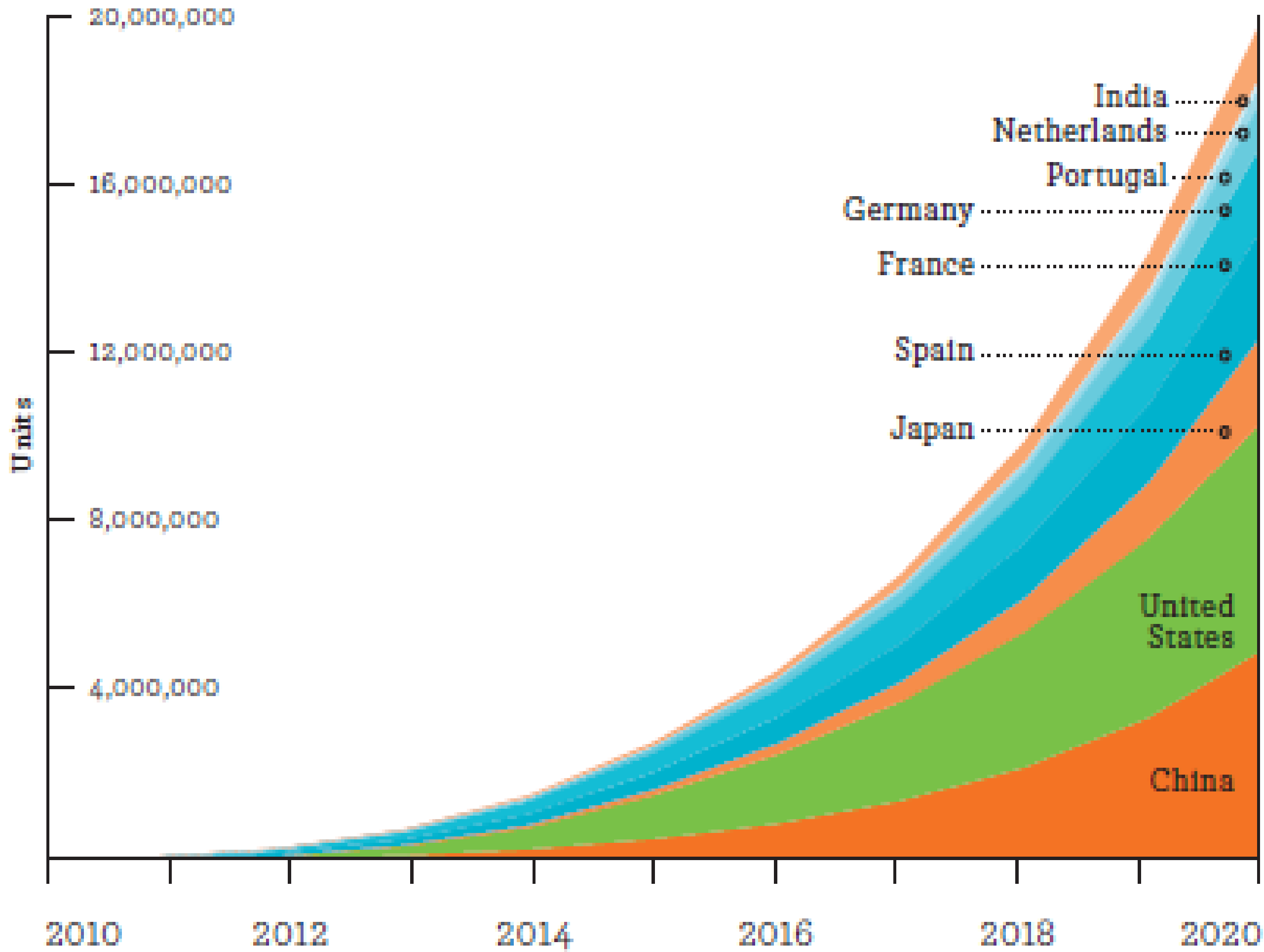
Source: TEDB No. 26

Attributes of Electric Vehicles

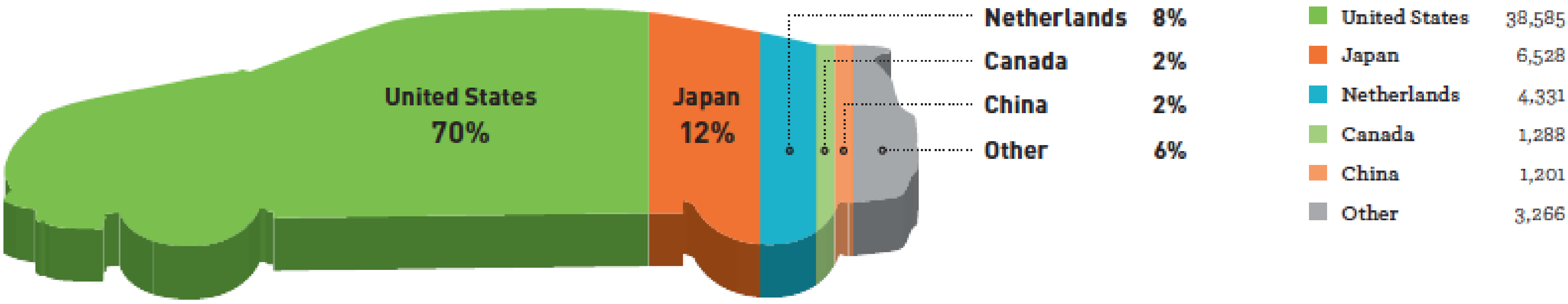
	Type of Propulsion Energy and Emissions	Technology Readiness	Infrastructure Requirements
Hybrid electric vehicle (HEV)	• Propulsion energy from both consumable fuels and a battery. • The battery is recharged by regenerative breaking and through the ICE.	• Numerous car models exist in the market today.	• HEVs are compatible with existing refueling infrastructure.
Plug-in hybrid electric vehicle (PHEV)	• An HEV with a means of recharging its battery from an external power source. • Pollution benefits depend on the driving cycles and the energy resources used to generate electricity.	• A number of models exist in the market; however, recharging equipment needs to be cheaper.	• PHEVs are compatible with existing grids in most industrialized countries.
Battery electric vehicle (BEV)	• Propulsion energy drawn entirely from a battery. • There are no tailpipe emissions, but total pollution benefits depend on the energy resources used to generate electricity.	• Battery improvements are needed to extend driving ranges and shorten recharging times; in addition, battery costs must be cut.	• Substantial market penetration could exacerbate peak demand, requiring new power plant or solar PV investments, especially if smart grid technologies and pricing policies are not able to concentrate recharging into off-peak periods.

Source: Sovacool, Brown, and Valentine. 2016.
Fact and Fiction in Global Energy Policy (Johns Hopkins Press).

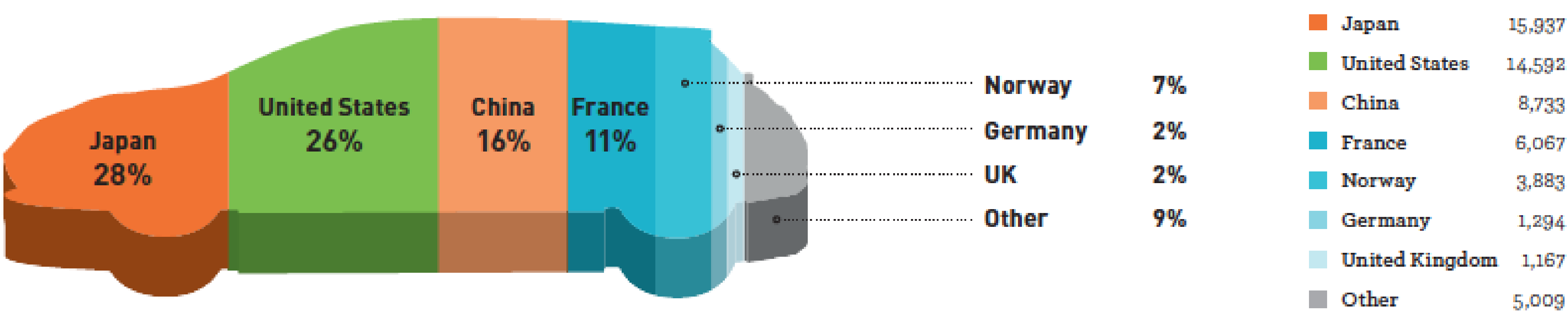
The EV Market is Booming



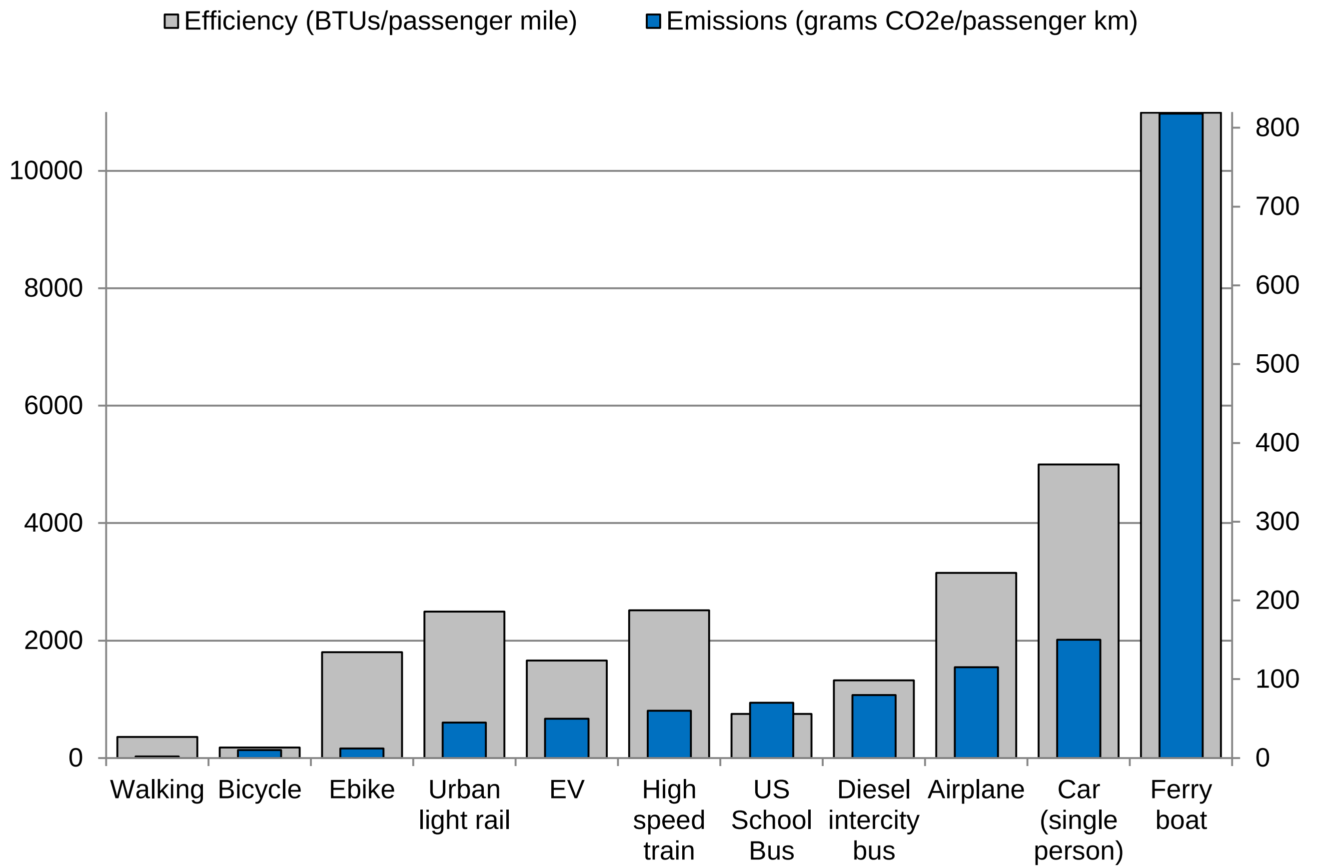
World PHEV Sales by Country



World BEV Sales by Country



IEA, 2013. Global EV Outlook



Delft, in the Netherlands, a “living street” lacks traffic lights, stop signs, lane dividers or even sidewalks because motorized vehicles are either prohibited or access is limited to public transport. Streets of this type encourage human interaction and exercise

Although most major automobile manufacturers have released EVs, they also market an array of increasingly fuel efficient models propelled by blended fuels or hybrid technology.

Technology	Description
▪ Variable valve timing and lift	Improves engine efficiency by optimizing the flow of fuel and air into the engine
▪ Cylinder deactivation	Saves fuel by deactivating cylinders when they are not utilized
▪ Turbochargers and superchargers	Allows manufacturers to downsize engines without sacrificing performance or to increase performance without lowering fuel economy
▪ Integrated Starter/Generator Systems	Automatically turns the engine off when vehicle is idling
▪ Direct Fuel Injection	Delivers higher performance with lower fuel consumption
▪ Continuously Variable Transmissions	Employs an infinite number of “gears” to provide seamless acceleration and improved fuel economy
▪ Automated Manual Transmissions	Combines the efficiency of manual transmissions with the convenience of automatics

Technologies That Improve Conventional Motor Vehicle Efficiency (each offering 5-12% efficiency improvement)