Why the
Palm Beach County Transportation Planning Agency Governing Board should locally support the White House goal of 50% of all new light vehicles sold in 2030 be powered by clean energy

by

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Executive Summary

There are over one million light duty vehicles (car, pickups, and delivery vans) registered in Palm Beach County. Each year the heat and pressure of internal combustion engine (ICE) piston chambers render 5.25 million tons of breathable oxygen useless to sustain life as it combines with the hydrogen and carbon atoms of 1.65 million tons of gasoline. Each year from the Palm Beach County ICE light duty vehicle tail pipes spew newly formed molecules of over 1.9 million tons of water (steam) and over 5 million tons of carbon dioxide gas. Carbon dioxide (CO_2) is a stable molecule which once formed will linger in the atmosphere between 300 to 1,000 years. Therefore nearly all of the carbon dioxide produced from fossil fuels burned over the last century is still in our atmosphere. The carbon dioxide made on I-95 today will add to the amount CO_2 in the air until at least the year 2322 and possibly the year 3022.

Carbon dioxide and atmospheric water are both major greenhouse gases. The EPA estimates 17% of the USA greenhouse gas pollution comes from light duty vehicles. Due to the lack of heavy industry, Palm Beach pollution percentages are different from the national average. Of the amount of pollution Palm Beach County generates it is likely 20% or higher of the total amount comes from ICE cars.

Global warming is and will have a greater impact on Palm Beach County than nearly any other area of the country because we are a low elevation, sub-tropical county with its most expensive infrastructure built near the Atlantic Ocean. The Atlantic Ocean has risen 12 inches in the last century and it will rise another 12 inches in less than 30 years. For the best outcome for the citizens of Palm Beach County, the political leadership must be proactive in this silent, invisible, touchless, odorless, tasteless, slow acting but implacable crisis.

On August 5th, 2021 President Biden signed the "Executive Order on Strengthening American Leadership in Clean Cars and Trucks" which states in part: "…Section1. Policy. America must lead the world on clean and efficient cars and trucks. That means bolstering our domestic market by setting a goal that 50 percent of all new passenger cars and light trucks sold in 2030 be zero-emission vehicles, including battery electric, plug-in hybrid electric, or fuel cell electric vehicles."

Actively assisting this goal lies within the mandate of the Palm Beach County Transportation Planning Agency. MPO enabling legislation states in part "In developing the long-range transportation plan and the transportation improvement program required under paragraph (a), each M.P.O. shall provide for consideration of projects and strategies that will: …. Increase the safety and security of the transportation system for motorized and nonmotorized users;…. Protect and enhance the environment, promote energy conservation, and improve quality of life;…. Promote efficient system management and operation;…"

More specifically at the March, 2022 PBC TPA Citizen Advisory Committee meeting TPA staff presented, "a MOTION TO RECOMMEND ADOPTION of 2022 Legislative and Policy Positions" which included the policies 1.d "Mandate adaptive cruise control, lane assistance, and collision avoidance systems on new vehicles." and policy 4. "Provide funding to advance autonomous, connected, and electric vehicles and infrastructure."

Achieving the "goal that 50 percent of all new passenger cars and light trucks sold in 2030 be zero-emission vehicles, including battery electric, plug-in hybrid electric, or fuel cell electric vehicles" is possible. Norway accomplished this between the years 2011 and 2018. Now in early 2022, 96% of all new cars sold in Norway are plug-in vehicles.

The estimated number of new cars in 2030 equaling 50% of those sold in PBC is over 52,000. If in 2030 new car sales are 50% plug-ins, this will cumulatively total only 13% of the cars on the road. Therefore 87% of light duty vehicles on the road will still be gasoline and diesel powered. Based on the Norway curve, in 2034 it is likely 100% of new light duty vehicles sold will be plug-ins. In 2034 still 62% of the cars on the road will be the older ICE propelled. Except for registered antiques, all cars on the road in 2042 will likely be plug-ins. When this happens here greenhouse gas pollution from Palm Beach County will have decreased by at least 1/5th.

Government planning at any level which stops the release of carbon dioxide will lower the heat peak and may shorten the negative effects on the planet by decades. Secondly, the infrastructure for ICE cars is a major pillar of the USA economy. The changeover from ICE to BEV will be highly disruptive but government intervention may help ease the transition for many to the new economy.

The actions requested of the PBCTPA Governing Board are:

1) Task the Technical Advisory Committee to perform an in depth review of the coming disruptive switch from ICE to BEV light duty vehicles and make recommendations as needed.

2) Form a sub committee headed by Governing Board members and composed of representatives from Agency staff, the Technical Advisory Committee and the Citizen Advisory Committee to consider the future direction of the Transportation Planning Agency with regards to Global Warming.

3) Make an inter-Agency request to the Florida Department of Highway Safety and Motor Vehicles that an accessible report be maintained categorizing PBC vehicle registrations by make, model and propulsion type.

4) The Governing Board wearing their other hats as City Commissioners, Mayors and County Commissioners should reactivate the initiative to establish an accurate accounting of the amount of greenhouse gas pollution generated by Palm Beach County.

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Palm Beach County and Global Warming

Palm Beach County is low lying, coastal, subtropical with most of its expensive real estate infrastructure built within a few miles of the Atlantic Ocean. Therefore we will suffer earlier and more extensive damage from a warming planet than nearly any other place in the United States. The Atlantic Ocean has risen 12 inches in the last 100 years. In just 28 years, by 2050, the Atlantic Ocean is projected to rise another 10 to 14 inches on the East Coast[1]. The likelihood of a hurricane developing into a major one of Category 3 or higher is increasing by about 8 percent a decade[2].

Floridians are well aware of the potential existential damage from hurricanes. September 2019 Hurricane Dorian pounded the Bahamas with sustained winds of 185mph and videos show 20 feet storm surges in Freeport. Freeport is only 84 miles east of the TPA offices in West Palm Beach. What happens if the next Category 5 hurricane does not veer away?

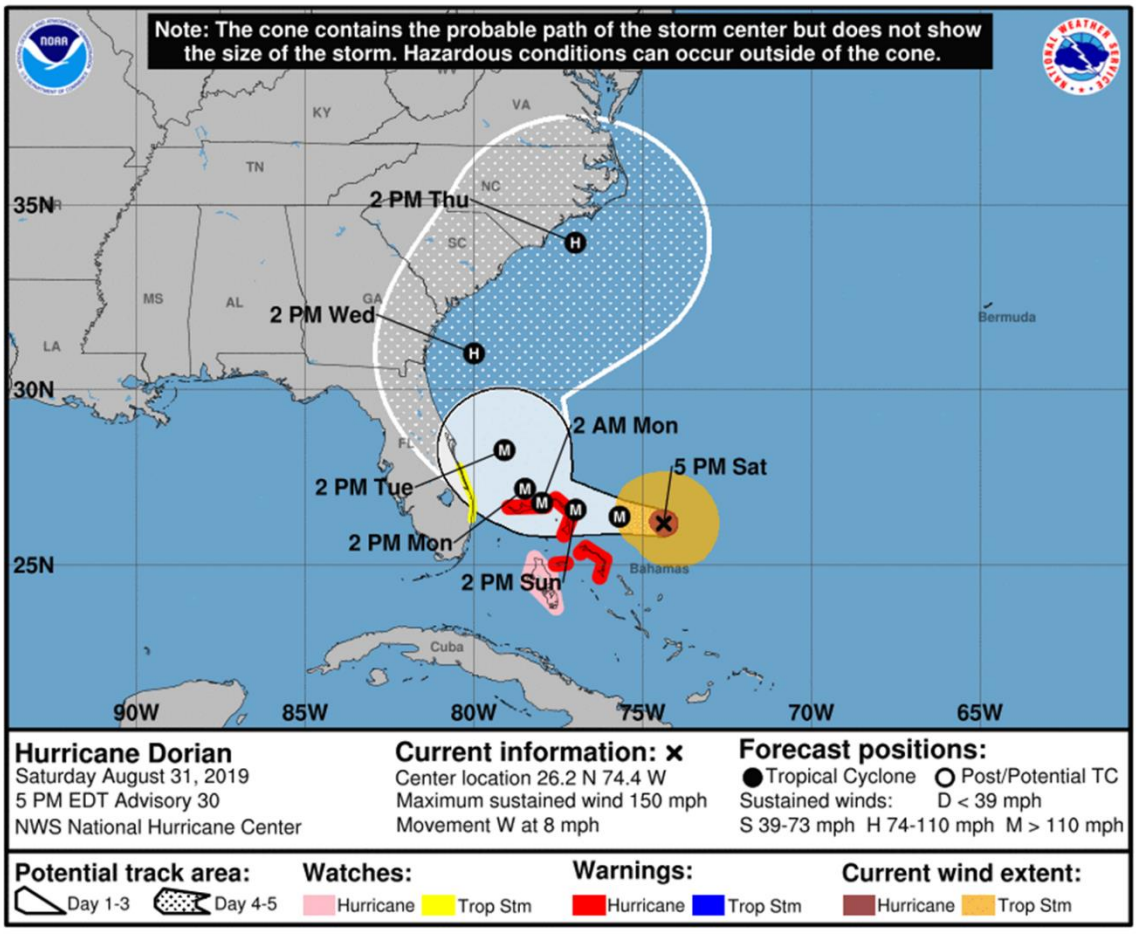


Figure 1 https://www.nhc.noaa.gov/data/tcr/AL052019_Dorian.pdf

[1] https://oceanservice.noaa.gov/hazards/sealevelrise/sealevelrise-tech-report.html#step1
[2] https://www.nytimes.com/2020/05/18/climate/climate-changes-hurricane-intensity.html

Floridians are starting to understand the harm and costs of King Tides and salt water intrusion. Less understood by Floridians is how a warming ocean retains lower levels of oxygen. Many species of fish will have to leave our coast or be smothered. Coral reefs are also dying at an accelerated rate.

Evolving strategies to reverse Global Warming and its effects fall in to two categories: mitigation and adaptation. Mitigation strategies reduce greenhouse gas emissions from development, and adaptation strategies make communities more resilient to the effects of a changing climate[3].

How much greenhouse gas pollution does Palm Beach County produce?

The EPA does a good job of laying out the sources of Green House Gas (GHG) emissions[4]. "The transportation sector is one of the largest contributors to anthropogenic U.S. greenhouse gas (GHG) emissions. According to the *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2019* (the national inventory that the U.S. prepares annually under the United Nations Framework Convention on Climate Change), transportation accounted for the largest portion (29%) of total U.S. GHG emissions in 2019. Cars, trucks, commercial aircraft, and railroads, among other sources, all contribute to transportation end-use sector emissions."

[3] https://www.epa.gov/smartgrowth/smart-growth-and-climate-change

[4] For more information on U.S. GHG Emissions from Transportation and what the numbers in these pie charts represent, please see: Fast Facts: U.S. Transportation Sector GHG Emissions (PDF) (5 pp, 289 K, June 2021, EPA-420-F-21-049)

2019 U.S. GHG Emissions by Sector

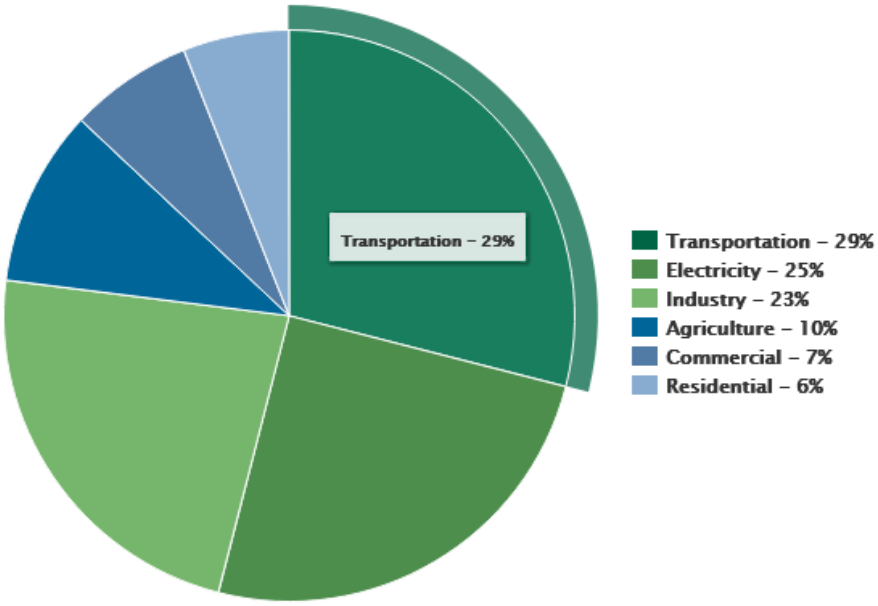


Figure 2 Transportation - 29% Electricity - 25% Industry - 23% Agriculture - 10% Commercial - 7% Residential - 6%

2019 U.S. Transportation Sector GHG Emissions by Source

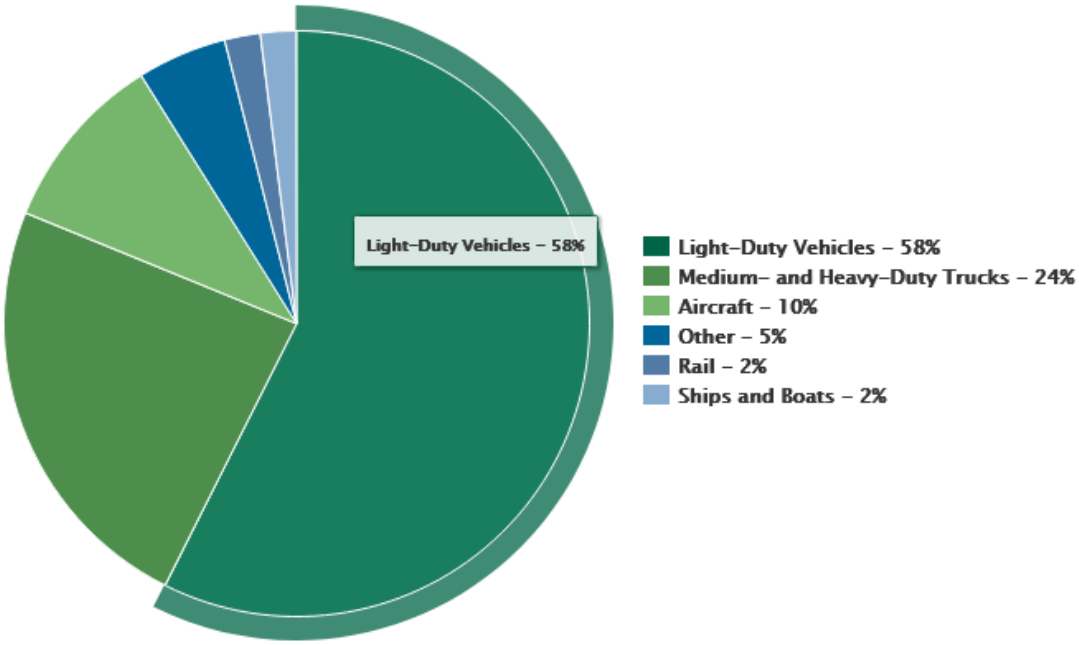


Figure 3 Light-Duty Vehicles - 58% Medium- and Heavy-Duty Trucks - 24% Aircraft - 10% Other - 5% Rail - 2% Ships and Boats - 2% Note: Totals may not add to 100% due to rounding. Transportation emissions do not include emissions from non-transportation mobile sources such as agriculture and construction equipment. "Other" sources include buses, motorcycles, pipelines and lubricants

Using the data from these two charts together we can see light-duty vehicles (the subject of President Biden's Executive Order) account for 17% of the nation's greenhouse gas pollution (.29×.58=.1682) .

A rumor is three years ago a committee was gathering the data to create similar pie charts in Figures 3 and 4 specifically for Palm Beach County. For unspecified reasons this initiative was abandoned. For Palm Beach County the percentage of pollution from light-duty vehicles is most likely 20% or higher of our total because we have so little industry.

The most accurate way to determine how much pollution is produced by light-duty vehicles is to determine how many gallons of gasoline and diesel fuel are sold and burned per year in Palm Beach County. It should be possible to derive this number by the amount of gas tax money generated by Palm Beach County. Unfortunately, how gas tax money is handled is a complex and opaque process. Therefore this information is not available to the Palm Beach County Transportation Planning Agency.

An alternative method to determine the amount of CO_2 pollution in Palm Beach County from light duty vehicles is use the EPA's average values for cars. The average ICE car gets about 22.0 miles per gallon and drives around 11,500 miles per year[5]. This means a car burns about 523 gallons of gasoline per year (11,500 / 22) .

The weight of one gallon of gasoline is 6.3 pounds. Therefore the average ICE burns 3,295 pounds (523 x 6.3 lbs.) of gasoline per year. This weight is 1.65 tons (3,295 lbs. / 2,000).

The weight of a gallon of gasoline (6.3 lbs.) is the total of the weight of carbon atoms (5.5 lbs or 87%) plus the weight of hydrogen atoms (0.8 lbs or 13%). Air is sucked through the carburetor of an internal combustion engine (ICE) into the piston chambers where atomized gasoline is burned using the oxygen component of air. In the heat and pressure of a piston chamber, the 5.5 pounds of carbon atoms (C) and the 0.8 pounds of hydrogen atoms (H) combine with 21 pounds of oxygen atoms (O). After combustion, this 27.3 pounds of atoms per gallon of gasoline reforms to become new molecules of 20 pounds of carbon dioxide (CO_2) and 7.3 pounds of water (H_2O) which is spewed from the engine tailpipe into the atmosphere[6].

To recap:

Every year the average ICE car burns 1.65 tons of gasoline using 5.25 tons of breathable oxygen (O_2) which is chemically transformed into 5 tons of carbon dioxide (CO_2) and 1.9 tons of water (H_2O).

[5] https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle#typical-passenger

[6] Appendix 3: How can 1 gallon of gas produce 20 pounds of CO_2?

There are over 1 million light duty vehicles registered in Palm Beach County (see Figure 12).

Therefore **the light duty vehicles of Palm Beach County every year are sucking out of the air over 5.25 million tons of breathable oxygen to burn over 1.65 million tons of gasoline which then spews over 5 million tons of carbon dioxide back into the air.**

Carbon dioxide is a stable molecule. These new molecules will stay in the atmosphere between 300 to more than 1,000 years. They will not recycle to breathable oxygen again until a process such as photosynthesis in a living plant uses the energy of sunlight to break the chemical bonds to obtain the carbon for cell structure and release the oxygen back into the atmosphere. The only way to return to the weather patterns of the 1950's is return the atmosphere to the atmospheric chemistry of the 1950's. The first step to do this is stop new greenhouse gas pollution[7].

Towards this end August 5th, 2021 President Biden released a White House Executive Order.

[7] https://news.climate.columbia.edu/2021/02/25/carbon-dioxide-cause-global-warming/

Executive Order on Strengthening American Leadership in Clean Cars and Trucks

BRIEFING ROOM

Executive Order on Strengthening American Leadership in Clean Cars and Trucks

AUGUST 05, 2021 • PRESIDENTIAL ACTIONS

By the authority vested in me as President by the Constitution and the laws of the United States of America, and in order to promote the interests of American workers, businesses, consumers, and communities, it is hereby ordered as follows:

Section 1. Policy. America must lead the world on clean and efficient cars and trucks. That means bolstering our domestic market by setting a goal that 50 percent of all new passenger cars and light trucks sold in 2030 be zero-emission vehicles, including battery electric, plug-in hybrid electric, or fuel cell electric vehicles. My Administration will prioritize setting clear standards, expanding key infrastructure, spurring critical innovation, and investing in the American autoworker. This will allow us to boost jobs — with good pay and benefits — across the United States along the full supply chain for the automotive sector, from parts and equipment manufacturing to final assembly.

It is the policy of my Administration to advance these objectives in order to improve our economy and public health, boost energy security, secure consumer savings, advance environmental justice, and address the climate crisis.

....

JOSEPH R. BIDEN JR.

THE WHITE HOUSE
August 5, 2021.

Figure 4 (for complete Executive Order see Appendix 6)

Questions for the PBC TPA Governing Board

Is implementing a local initiative for President Biden's executive order on clean cars and trucks in the purview of the PBC TPA?

From Florida State Statutes 339.175 Metropolitan planning organization. (See Appendix 5 for the complete Statute)

6) POWERS, DUTIES, AND RESPONSIBILITIES.—The powers, privileges, and authority of an M.P.O. are those specified in this section or incorporated in an interlocal agreement authorized under s. 163.01. Each M.P.O. shall perform all acts required by federal or state laws or rules, now and subsequently applicable, which are necessary to qualify for federal aid. It is the intent of this section that each M.P.O. shall be involved in the planning and programming of transportation facilities, including, but not limited to, airports, intercity and high-speed rail lines, seaports, and intermodal facilities, to the extent permitted by state or federal law.

(a) Each M.P.O. shall, in cooperation with the department, develop:

1. A long-range transportation plan pursuant to the requirements of subsection (7);
2. An annually updated transportation improvement program pursuant to the requirements of subsection (8); and
3. An annual unified planning work program pursuant to the requirements of subsection (9).

(b) **In developing the long-range transportation plan and the transportation improvement program required under paragraph (a), each M.P.O. shall provide for consideration of projects and strategies that will:**

1. Support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity, and efficiency;
2. **Increase the safety and security of the transportation system for motorized and nonmotorized users;**
3. Increase the accessibility and mobility options available to people and for freight;
4. **Protect and enhance the environment, promote energy conservation, and improve quality of life;**
5. Enhance the integration and connectivity of the transportation system, across and between modes, for people and freight;
6. **Promote efficient system management and operation**; and
7. Emphasize the preservation of the existing transportation system.

Expanding on the sections emphasized in bold print:

Increase the safety and security of the transportation system for motorized and nonmotorized users Quality BEVs have computers which are connected to multiple cameras and radar devices. The computers are also connected to the steering, acceleration, and braking systems of the vehicle. Increasing the percentage of BEVs on our roadways increases the safety of both drivers and pedestrians. (See Appendix 1, sub heading Safety).

Protect and enhance the environment, promote energy conservation, and improve quality of life;

Protect and enhance the environment, …As previously explained the switch from ICE and diesel engine vehicles to plug in vehicles will stop the release of over 5 million tons of the greenhouse gas CO_2 into the skies of Palm Beach County per year. This is likely 20% or greater of all greenhouse pollution produced in Palm Beach County.

…promote energy conservation,… -- The energy stored in the chemical bonds between carbon and hydrogen atoms in a gallon of gasoline are about 120,286 British Thermal Units (Btus)[8]. This amount of energy converts to 35.2 Kilowatt hours (kWhs)[9]. The average car's fuel economy is 22 miles per gallon[10]. Therefore per 100 miles the average car burns 4.5 gallons of gasoline. This 4.5 gallons of gasoline is the energy equivalent of 160 Kilowatt hours.

The average electric car uses 34.6 Kilowatt hours per 100 miles[11]. This is 460% more efficient than the average ICE powered car. The most energy efficient car currently is the 2021 Tesla Model 3 Standard Range Plus RWD Automatic which uses 24kWh per 100 miles[12]. This is 666% more efficient than the average ICE powered car.

There are also other energy costs which need to be addressed for a true comparison of energy conservation. In producing gasoline the refining process adds an additional 10% of energy used. For this paper it is unknown how to calculate the energy cost of transporting a gallon of hydrocarbons from thousands of feet underground to your local gas station.

When charging an electric car nothing is physically moved. The movement of electrons on high powered electric lines is virtually instantaneous and friction free. Electric motors convert 77% of electrical energy from the grid into spinning wheels[13]. The conservation of energy of electric cars over ICE powered cars is even more glaring when calculated for a commuter who charges their car with electricity from solar panels on their home.

…and improve quality of life; The American Lung Association has released a report [14] which states a shift to 100% sales of zero-emission passenger vehicles by 2035 plus widespread adoption of renewable energy solutions would result in over $1.2 trillion in

[8] https://www.eia.gov/energyexplained/units-and-calculators/
[9] https://www.boilerstoves.co.uk/convert-btu.asp
[10] See Appendix 3.
[11] https://ecocostsavings.com/average-electric-car-kwh-per-mile/
[12] https://www.fueleconomy.gov/feg/Find.do?action=sbs&id=43821
[13] https://www.fueleconomy.gov/feg/evtech.shtml
[14] https://www.lung.org/clean-air/electric-vehicle-report

public health benefits by 2050 (such as nearly 3 million fewer asthma attacks, 110,000 fewer premature deaths, and over 13 million fewer lost work days) plus over $1.7 trillion in avoided global climate damages.

Promote efficient system management and operation

The State of California and the European Union with their clear directives on reducing global warming emissions have created enough certainty in the future business climate so that the more creative auto manufacturers (Tesla, Volkswagen, Ford, GM, Hyundai) have committed their futures to manufacturing BEVs rather than ICE powered vehicles. The rest of the car manufactures will have to follow their lead or go bankrupt.

It would be inefficient system management for the PBCTPA not to be involved locating easy access and adequate charging stations for visitors passing through PBC or stopping here. It would be inefficient system management if the PBCTPA did not plan for the contingency that some gas stations may be abandoned without first removing their in ground gasoline tanks. Do elected officials have a duty to help mitigate the problems facing citizens resulting from a disruptive technology change?

The safe braking distance for sixty miles per hour is 359 feet.

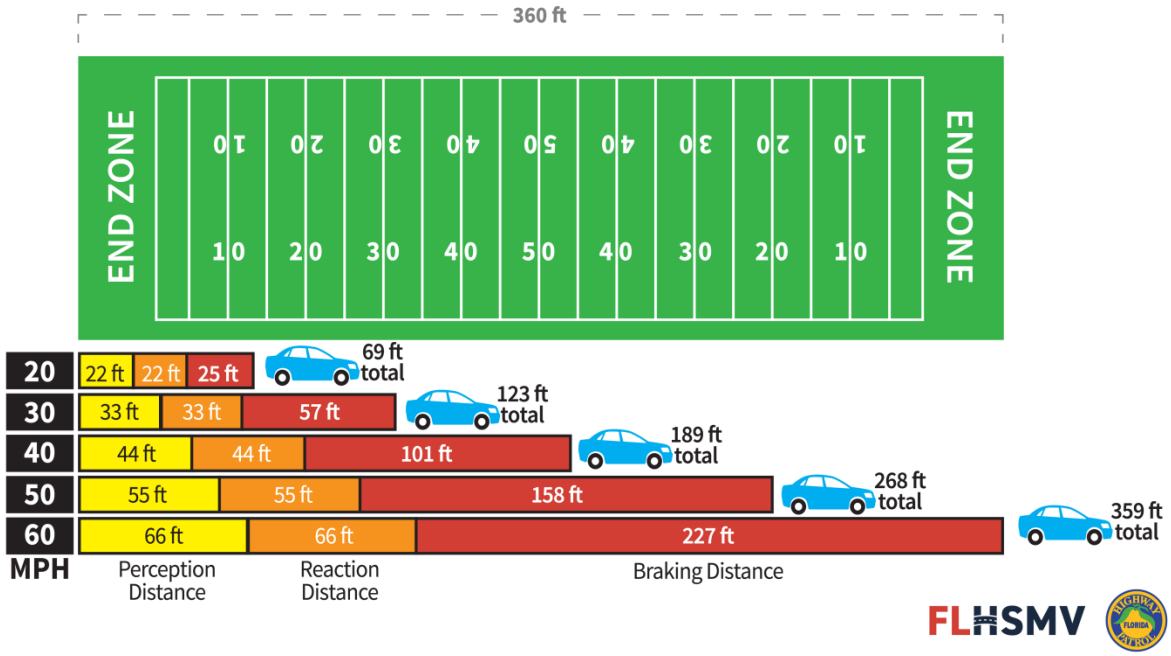


Figure 5 https://www.flhsmv.gov/safety-center/driving-safety/distracted-driving/

Still in the realm of science fiction, but probably less than a decade away from becoming science fact, BEVs will increase the efficiency and carrying capacity of the road network by communicating with other computer controlled vehicles so convoys may form and safely travel tightly together at high speeds. Energy efficiency may even improve from drafting.

Figure 6 When all cars have motion cameras and communicate with each other it will be possible to safely platoon them closely together as they accelerate, brake, and swerve to avoid road hazards in unison.

When a semi tractor trailer tire blows, the cars' artificial intelligences will be able compute avoidance routes and cars a mile back will brake in unison. The semi will slow down and limp to the breakdown lane as cars flow around it like schooling fish.

The PBCTPA staff officially supports this vision. At the March 2, 2022 Citizen Advisory Committee board meeting Agenda item 2.A was a MOTION TO RECOMMEND ADOPTION of 2022 Legislative and Policy Positions. This motion was passed by the CAC. Among the listed "actions consistent with its vision" were policy 1.d. "Mandate adaptive cruise control, lane assistance, and collision avoidance systems on new vehicles." And policy 4. "Provide funding to advance autonomous, connected, and electric vehicles and infrastructure."

PALM BEACH
TRANSPORTATION PLANNING AGENCY
2022 LEGISLATIVE & POLICY POSITIONS

2.A

The Palm Beach TPA collaboratively plans, prioritizes, and funds the transportation system of Palm Beach County and supports the following actions consistent with its vision.

SAFE

1. Change state and/or federal law to:
   a. Regulate distracted driving[1] and failure to obey crossing guards as primary offenses,
   b. Allow automated speed enforcement/citations[2],
   c. Require helmets for all bicyclists[3], scooters and motorcyclists[4], and
   d. Mandate adaptive cruise control, lane assistance, and collision avoidance systems on new vehicles[5].
2. Enhance education to include:
   a. Annual pedestrian and bicycle safety curriculum in Elementary and Middle Schools[6],
   b. Driver education[7] curriculum in High School, and
   c. Knowledge of pedestrian, bicycle, and motorcycle laws to obtain a driver's license[8] and to renew it every 5 years, and
   d. Roadway safety information distributed to rental car companies for customers.
3. Revise state and local roadway design standards based on context classification, including setting a target speed based on context instead of existing speeds[9] and establishing context-based criteria for installation of vehicle or pedestrian crossing treatments at mid-block and unsignalized locations.

EFFICIENT

4. Provide funding to advance autonomous[10], connected, and electric vehicles[11] and infrastructure.

Figure 7: Top half of page 14 of the 2MAR2022 PBC TPA CAC agenda & backup packet.

If sufficient Federal funding is authorized to successfully address the ills of global warming, what is the best way to locally distribute this money?

So far not enough Americans have shown they possess the attributes of wisdom, delayed gratification, and a basic understanding of science for the USA to successfully solve a crisis which can not be seen, smelled, felt, heard, tasted and while implacable, has taken decades to start manifesting itself. If in the future the country decides to stop global warming, this will take massive amounts of Federal money which will need to be distributed to the local level.

The PBC TPA web site states Metropolitan Planning Organizations were created with the passage of the Federal-Aid Highway Act of 1962. In the subsequent 60 years, while far from perfect, MPOs have developed policy for the efficient, inclusive, and low graft distribution of Federal funds for local infrastructure projects. Clearly the MPO bureaucratic structure is the most logical template for the distribution of State and Federal funds to build local infrastructure projects. The TPA Governing Board template is the most inclusive and therefore fairest way to set policy countywide.

In the optimistic future scenario, who will oversee and administer the Federal funds for Global Warming infrastructure projects such as seawalls or wiring parking garages for BEV charging? There are two basic choices. Graft additional duties and responsibilities onto existing MPOs or create a new agency.

Perhaps a new organization with a similar Governing Board or even the same governing board as existing MPOs is the best choice. Separate meetings would be required in much the same way elected City Commissioner meet as the City Commission and also separate meetings as CRA commissioners. Trying to graft Global Warming initiatives beyond transportation issues into the current MPO/TPA structure may be counter productive. The current TPA structure is a smooth running organization which moves through the budget year with very predictable and familiar rules, tasks, expectations, and deadlines. It is a well worn road for transportation projects from inception to completion. On the other hand, a government agency implementing Global Warming mitigation and adoption projects is likely to attract employees who are true believers with a sense of impending doom. The policies issuing from the State and Federal levels are likely to be works in progress with many gaps. The overall goal would be to bend the arc to lessen the peak damages caused by Global Warming.

What will replace the gas tax?

Per gallon gas taxes are a major funding source for transportation. As the percentage of ICE vehicles declines, so will the amount of gas tax revenue. How much money is at stake for Palm Beach County? Unfortunately, the PBCTPA staff does not know how many gallons of gasoline and diesel fuel are sold in the County.

There is no clear consensus of how to start making up this currently small, but increasing loss of tax revenue. In every case making up the difference by imposing a driving tax on electric vehicles is a stupid idea. This is the moral equivalent of taxing attendees to Alcoholic Anonymous meetings to make up for a drop in booze tax revenues. Or taxing nicotine patches to make up for a drop in cigarette excise taxes . The big picture is every ICE vehicle is destroying the world by generating on average five tons of CO^2 per year. This societal cost far outweighs the societal cost of a decreasing gas tax.

Is the goal of selling 50% of all new light duty vehicles as plug in vehicles by 2030 realistic and achievable?

For the year 2021 Norway's new car sales of plug in vehicles was 87% of total new cars sold. BEVs were 65%, plug in hybrids 22%, non plug in hybrids 6%, ICE cars only 4%(!) and diesel

4%.[15] Norway reached the 50% market share for new plug in vehicles in 2018, twelve years before our leadership hopes the USA can achieve this goal.

Norway is not a fluke. Sweden crossed the 50% new car sales for plug ins in 2021[16]. New car plug in sales for November 2021 in Germany were 34%.[17]

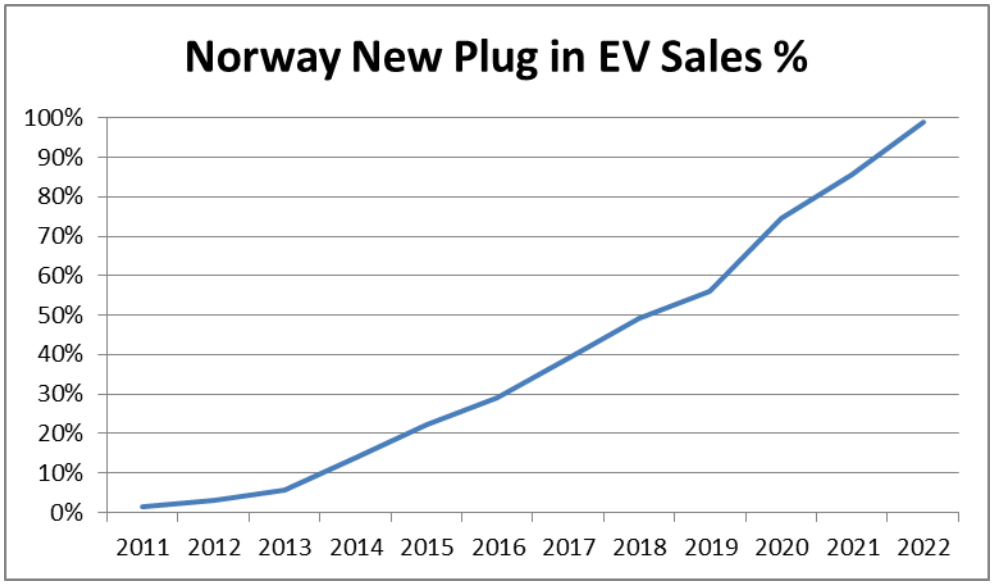


Figure 8 Norway's curve of new light duty vehicles which were plug-ins.

By shifting Norway's historical curve so the 50% sales mark centers on the year 2030 it is apparent Norway's success could be duplicated in the USA:

[15] https://www.reuters.com/business/autos-transportation/electric-cars-take-two-thirds-norway-car-market-led-by-tesla-2022-01-03/
[16] https://cleantechnica.com/2021/12/02/most-autos-sold-in-sweden-are-now-plugin-evs-over-54-in-november/
[17] https://cleantechnica.com/2021/11/04/germanys-plugin-ev-share-jumps-above-30-an-unstoppable-force/

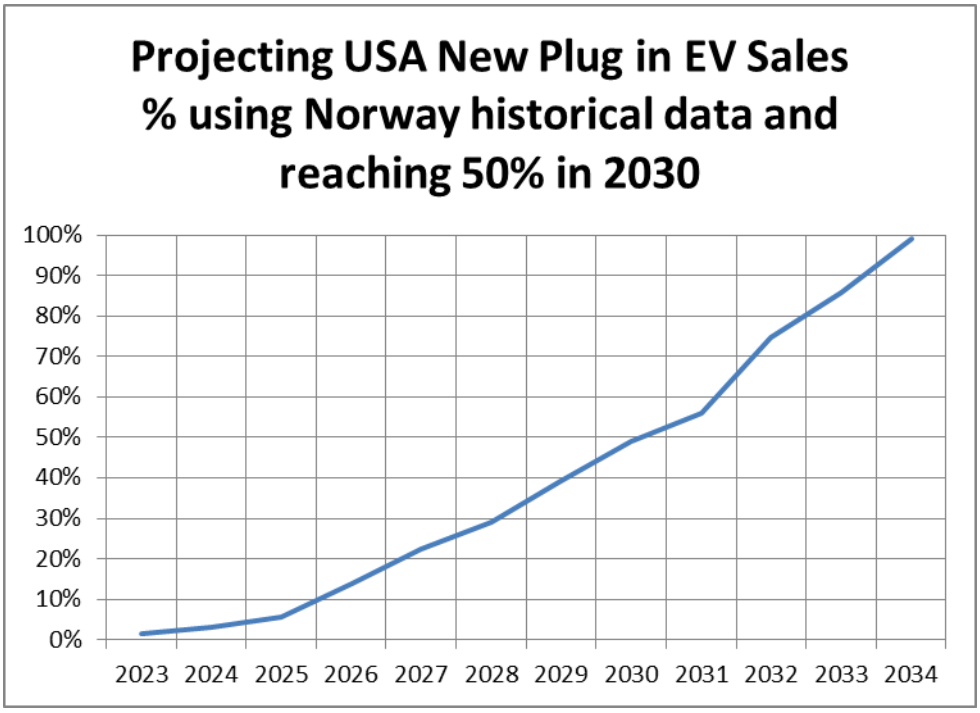


Figure 9 A projection of a USA possible rate of transition from ICE light duty vehicles to plug in LDVs created by shifting the actual Norway transition curve so the year Norway achieved 50% new car sales of plug-ins is centered on the year 2030.

The average age of cars in the USA fluctuates around 12 years. To maintain this average age, 1/12th of the fleet are replaced with new cars every year. In August 2021 the registered number light duty vehicles in Palm Beach County was 1,082,257 (See Fig. 9). The following chart is a rough guess of the number of new plug-ins needed to be bought by PBC residents to reach the goal of 50% new light-duty vehicles sold in 2030

Projecting PBC New Plug -In Sales numbers using Norway historical data to reach 50% in 2030				
Year	PBC Registered light duty vehicles	Total new car sales as % of registerd cars	% of new light duty vehicle sales that are plug-ins	Estimated # of plug-ins vehicles sold each year
	est. increase 20,000 per year	1/12= 8.5%	Norway's curve	Col 2*Col 3*Col 4
2023	1,120,000	8.5%	1.60%	1,523
2024	1,140,000	8.5%	3.10%	3,004
2025	1,160,000	8.5%	5.60%	5,522
2026	1,180,000	8.5%	13.80%	13,841
2027	1,200,000	8.5%	22.40%	22,848
2028	1,220,000	8.5%	29.10%	30,177
2029	1,240,000	8.5%	39.20%	41,317
2030	1,260,000	8.5%	49.10%	52,586

Figure 10 A guess at the number of new plug-ins needed to be bought and sold to reach the White House goal in PBC.

If in 2030 new car sales are 50% plug-ins, this will cumulatively total only 13% of the cars on the road. Therefore 87% of light duty vehicles on the road will still be gasoline and diesel powered. Based on the Norway curve, in 2034 it is likely 100% of new light duty vehicles sold would be plug-ins. In 2034 still 62% of the cars on the road will be the older ICE propelled. Except for registered antiques, all cars on the road in 2042 will likely be plug-ins.

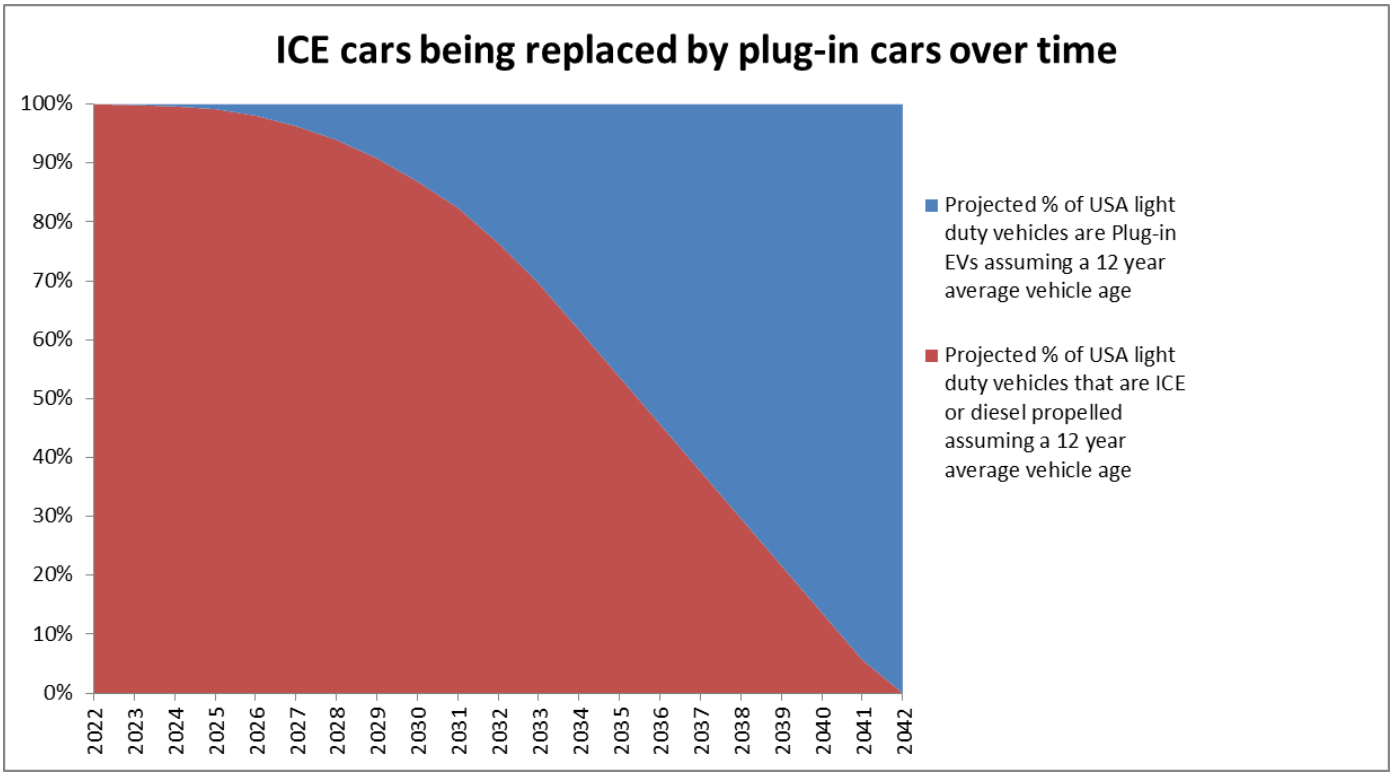


Figure 11

A current report[18] states 69 percent of US consumers expect their next vehicle to be ICE powered, 22 percent some sort of hybrid and only five percent are interested in buying a BEV. As estimated on the graph, by the time the 27 percent of the US consumers who want plug in vehicles actually have them, ten years will have past and it will be 2032. The coming decade will be ten years of increasing global warming and environmental destruction, and ten years of improving BEV technology. Therefore in ten years it is likely 100% of US consumers will expect their next car to be a BEV.

As ICE cars disappear from our roads so does the greenhouse gas pollution they spew. The curve of the Fig. 10 graph also represents how today's Palm Beach County's 5 million tons per year of CO2 pollution generated by cars could go to zero in 20 years.

Fossil fuel advocates make the assertion switching from ICE propulsion to BEVs does little to reduce greenhouse gas emissions because the electricity used to charge the batteries in light vehicle is generated by dirty fossil fuels power plants and therefore all that is happening is the source of pollution has been shifted, but not reduced. Therefore there is no point in establishing government policy to speed up the switch to BEVs and other plug-ins. This argument is pure sophistry. The technology to rebuild the electric grid completely fossil fuel

[18] https://www.roadandtrack.com/news/a38698676/does-anyone-want-an-electric-car/

free is here. It is not happening quickly because of politicians such as Senator Joe Manchin(DEM WVa) who are slow walking change apparently to protect the owners of fossil fuel assets (such as his son) from losing money from "stranded resources." Nevertheless, the economic reality that electricity produced by solar and wind power with battery backup is cheaper and more reliable than electricity produced by fossil fuels is slowly winning out[19]. This year (2022) 14.9 gigawatts (GW) of electric generating capacity is scheduled to be retired. Of this amount 85% are coal-fired power plants and 8% natural gas.[20] By the time significant numbers of plug-ins are on the roads, a significant amount of the electricity they use will be from fossil fuel free sources.

Where Palm Beach County is now

Number of Plug-In light duty vehicles

Determining the number of plug-in vehicles currently on the road in Palm Beach County is difficult. The State of Florida provides no citizen accessible information.

Current Registered Vehicles
Based on registrations having no expiration date or expiring on/after August 01, 2021
Update Frequency: Monthly
Data Refreshed: 8/8/2021

	Vehicle Type Desc									
County Name	AUTOS & PICKUPS	HEAVY TRUCKS	MOTORCYCLE	BUS	TOOLS	VESSEL	VEHICLE TRAILER	TRAVEL TRAILER	MOBILE HOME	Grand Total
Grand Total	16,212,272	1,701,797	638,883	58,423	6,483	928,153	2,032,876	218,219	1,084,929	22,882,035
ALACHUA	176,837	19,061	7,326	990	90	9,897	28,930	2,665	13,120	258,916
BAKER	18,409	4,156	688	194	7	2,102	5,970	853	4,722	37,101
BAY	134,750	22,046	7,610	406	66	15,102	30,700	3,650	13,321	227,651
BRADFORD	18,229	4,324	822	119	11	1,980	7,059	675	4,944	38,163
BREVARD	476,837	48,379	26,999	1,236	210	32,761	64,070	8,387	25,266	684,145
BROWARD	1,555,047	113,824	41,917	5,303	554	43,295	73,282	4,987	20,272	1,858,481
PALM BEACH	1,082,257	88,725	31,974	2,968	247	38,078	78,138	6,223	19,266	1,347,876
PASCO	403,464	40,832	19,335	1,143	91	23,002	55,596	11,954	47,724	603,141
PINELLAS	712,890	60,248	31,477	2,478	321	48,230	70,421	8,473	51,821	986,359

Figure 12 Generic Vehicle registration data available on the Florida Department of Highway Safety and Motor Vehicles website. No spreadsheets by make, model, propulsion, or new monthly registrations.

[19] Not in the scope of this report. This is one representational source. https://cleantechnica.com/2022/01/12/happy-hours-energy-storage-could-support-the-grid-every-hour-of-the-day-all-year-long/

[20] https://cleantechnica.com/2022/01/11/coal-will-equal-85-of-u-s-electric-generating-capacity-retirements-in-2022/

This graph from the US Department of Energy is the kind of data needed. Unfortunately the data has not been updated for two years and is not broken down by counties.

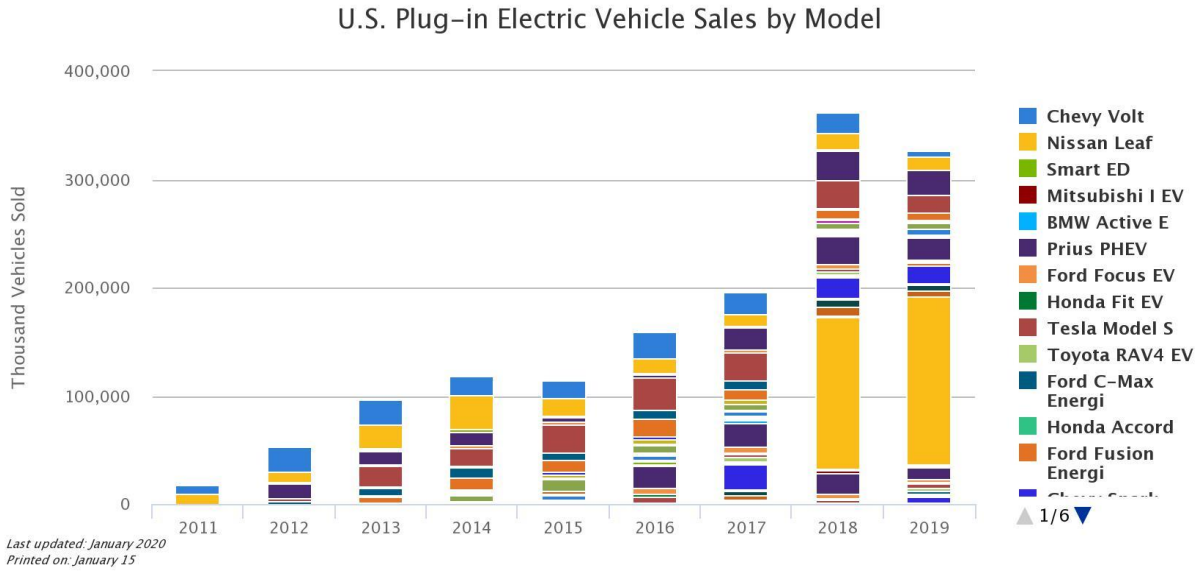
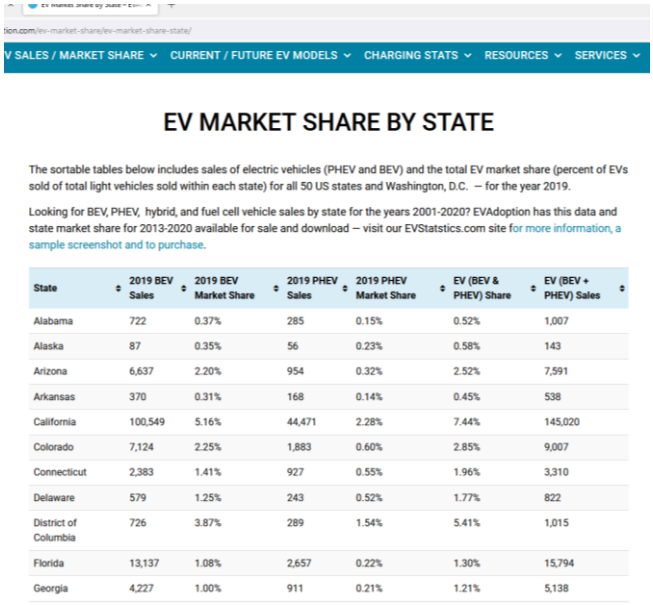


Figure 13 The type of information needed for accurate measurements in PBC. From the US Department of Energy Alternative Fuels Data Center. Last updated two years ago. https://afdc.energy.gov/data/ The big yellow segment causing the 85% total sales jump in 2018 is 139,782 Tesla Model 3s.

The company evadoption.com may sell you the information:



State	2019 BEV Sales	2019 BEV Market Share	2019 PHEV Sales	2019 PHEV Market Share	EV (BEV & PHEV) Share	EV (BEV + PHEV) Sales
Alabama	722	0.37%	285	0.15%	0.52%	1,007
Alaska	87	0.35%	56	0.23%	0.58%	143
Arizona	6,637	2.20%	954	0.32%	2.52%	7,591
Arkansas	370	0.31%	168	0.14%	0.45%	538
California	100,549	5.16%	44,471	2.28%	7.44%	145,020
Colorado	7,124	2.25%	1,883	0.60%	2.85%	9,007
Connecticut	2,383	1.41%	927	0.55%	1.96%	3,310
Delaware	579	1.25%	243	0.52%	1.77%	822
District of Columbia	726	3.87%	289	1.54%	5.41%	1,015
Florida	13,137	1.08%	2,657	0.22%	1.30%	15,794
Georgia	4,227	1.00%	911	0.21%	1.21%	5,138

Figure 14 Screenshot from https://evadoption.com/ev-market-share/ev-market-share-state/

Atlas EV HUB seems to be trying to plug the information hole of State and Federal agencies: "One of the objectives of the Atlas EV Hub is to demonstrate the effectiveness of collaboration. We believe that through crowdsourcing and other data sharing practices, organizations can be more effective by spending their time on consuming and interpreting data rather than collecting it.

Through the Open Vehicle Registration Initiative, Atlas is working with states directly to make data on electric vehicle registrations publicly accessible. This page contains the data from states participating in the initiative in some form. If you're interested in learning more or helping out, please send an email to info@atlasevhub.com." Quote from https://www.atlasevhub.com/materials/state-ev-registration-data/

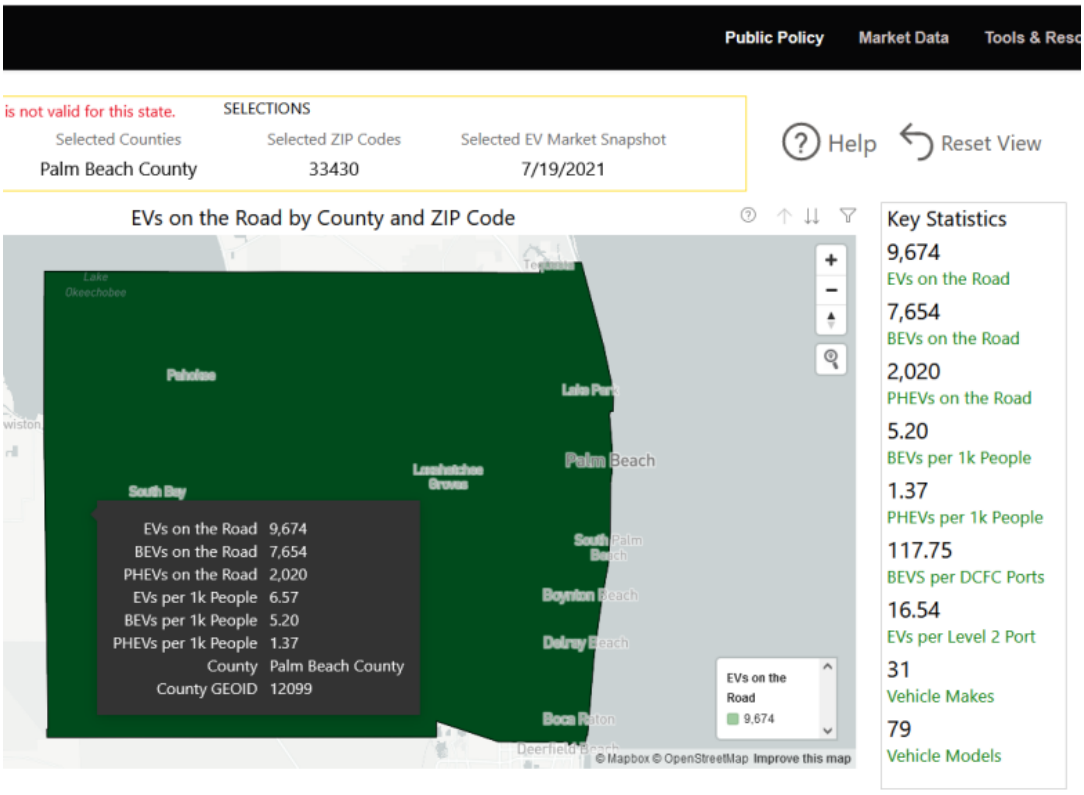


Figure 15 Current number of Plug-in vehicles in PBC is about 9,700

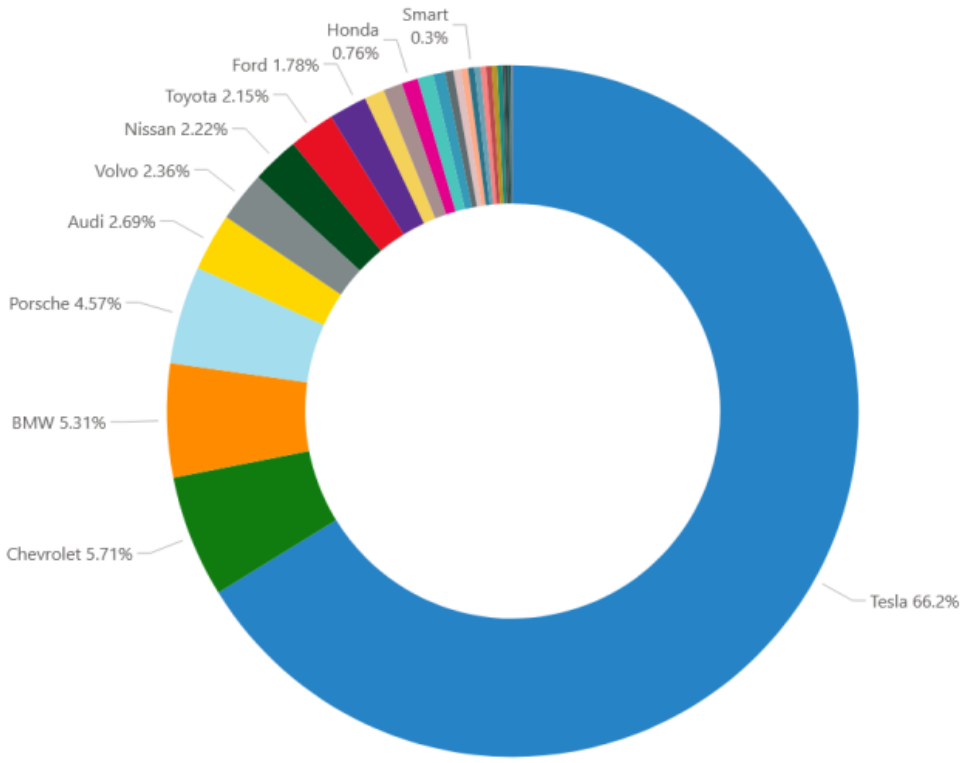


Figure 16 2/3s of plug in vehicles in PBC are Teslas

Number of public/private charging stations

The number of plug-in charging stations in PBC is hard to estimate. If you google "electric vehicle charging stations" you will likely end up with a map:

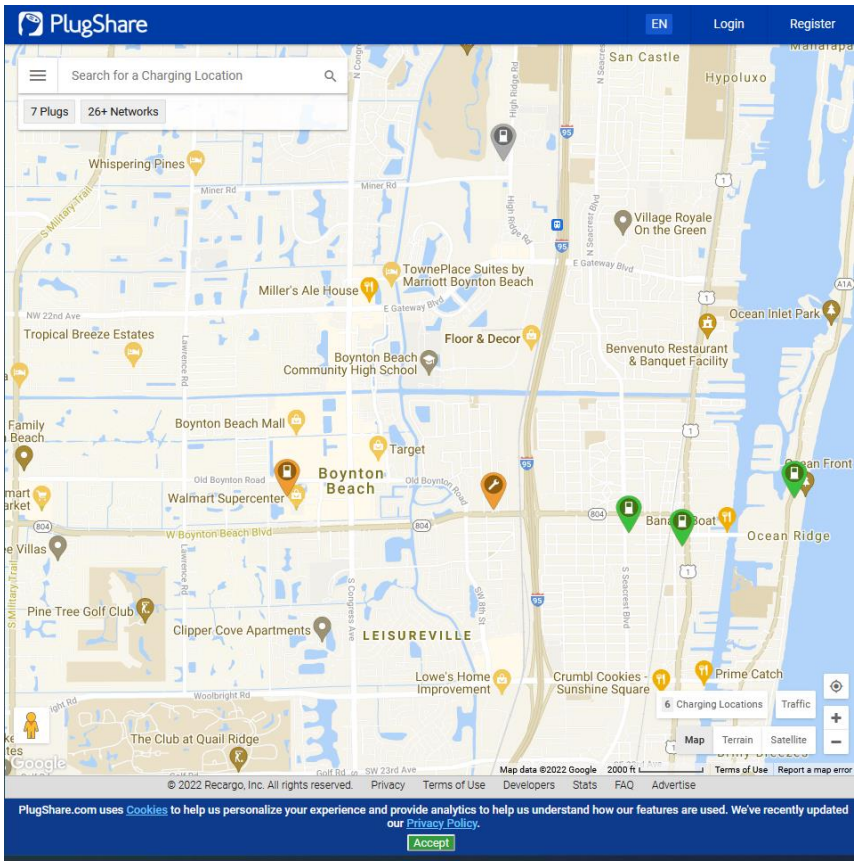


Figure 17 The results of an internet search for public BEV charging stations

The Lake Worth Turnpike Service Plaza is probably the largest charging station in Palm Beach County. It has eight Tesla charging stations and six FPL charging stations for a total of fourteen. As the Googlemap screenshot shows, the charging location is well positioned for easy expansion to the north. A consideration is the safety of placing high DC voltage near gasoline fumes. The EV charging stations are at least 60 feet from the Gulf service station gasoline pumps. On a different subject concerning Global Warming sea rise and hurricane storm surges. According to Google Earth this service plaza is 8.5

miles inland from the Atlantic Ocean and the drainage ditches are still only 20 feet above sea level.

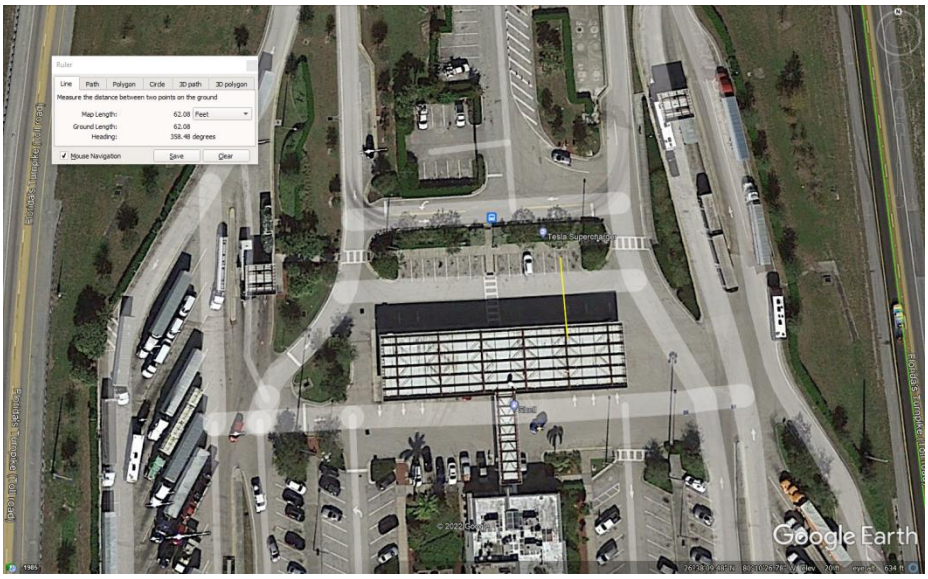


Figure 18 BEV charging station at the Florida Turnpike Lake Worth service plaza Picture source: Google Earth

Figure 19 Plug in charging station at Florida Turnpike Lake Worth Service Plaza on the east side looking west

Figure 20 BEV charging station Florida Turnpike Lake Worth service plaza west end looking east.

Figure 21 Electrical equipment for BEV charging station at Florida Turnpike Lake Worth service plaza from north side looking south. This area could easily be used to double the charging stations when needed. Gulf service station in the background with gasoline pumps approximately 60 feet away.

Proactive Local Government Plug-In Policy

Boynton Beach is establishing BEV charging points and provides rebates to City residents of $250 to $500 for home installations of an EV charger.

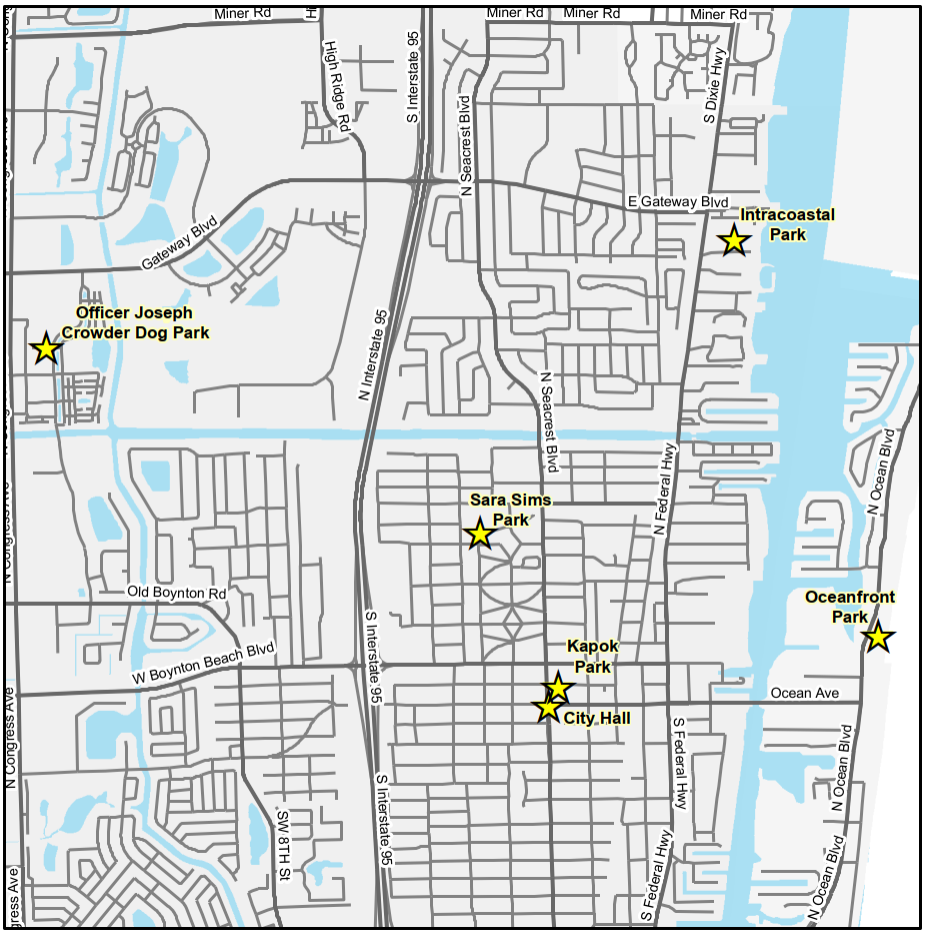


Figure 22 City of Boynton Beach BEV charging stations on City property. Note the Fig 16 map does not show the same charging stations.

Ideas for Municipalities and the County Commissions

The Southern Alliance for Clean Energy has written an on line manual titled "Electrify The South: Policy Toolkit for Local Governments to Accelerate Electric Vehicles[21]" Its sections include:

1) Create an Overarching Transportation Electrification Plan
2) Establish EV Municipal Fleet Goals

[21] https://docs.google.com/document/d/1I7Lok_3g1_J-ZqdsHdIIHq28Q7v2HWEjLuCPX3aF7mU/edit#

   A. Procurement Goals
   B. Model Green Fleets
   C. The Climate Mayor's EV Purchasing Collaborative
3) Establish EV Public Transportation Goals
   A. Electric Transit Buses
   B. Electric School Buses
   C. New and Emerging Shuttle Services with EVs
   D. Consult with your Local Utility
4) Promote EV Charging Access & Infrastructure
   A. Applications of City/County-Owned Charging Infrastructure
   B. Policies to Enable Private Sector Charging Infrastructure Deployment
   C. Best Practices to Support Charging Infrastructure
5) Establish Education and Outreach Initiatives
   A. Consumer Education and Informational Materials
   B. Outreach Events
6) Promote Economic Development by Investing In Electric Transportation
   A. City EV Charging Station Incentives
   B. Engage Economic Development Offices
   C. Strategic Charging Incentives for EVs
   D. EV Group Buy Program
7) Expand Equity and Access
   A. Charging Access for Frontline Communities
   B. Outreach Events in Frontline Communities
   C. Prioritize Frontline Communities for Electrification
   D. Voucher, Low-Interest Financing, Point of Purchase Rebates, and Used EV Rebates for Low-Income Drivers
   E. Carshare Programs
8) Engage Your Local Utilities
   A. EV Charging Infrastructure
   B. Utility Incentives
   C. Utility EV-Friendly Rates
   D. Utility EV Charger Programs
9) State Actions
   A. Leading by Example Master Planning
   B. State Policies
   C. Best Practice Standards
10) Case Studies
   A. Columbus, Ohio
   B. Seattle, Washington
   C. Denver, Colorado
   D. Minneapolis, Minnesota

The overall length of the manual is 30 pages. However, there are many links to further information and case studies. Several links are to initiatives and projects in Florida including two from Palm Beach County: Palm Beach and Boynton Beach.

In the Southern Alliance for Clean Energy comprehensive manual there is a conspicuous omission. The most effective strategy Norway used to increase plug-in sales was to manipulate the tax code so with comparable car models the plug-in version was slightly cheaper than the ICE version (see Appendix 2). The most effective lever of this type Palm Beach County has would be to waive the PBC 1% sales tax for Plug-in light duty vehicles. Similarly the State of Florida could waive the 6% sales tax (as it already does for school supplies, food, medicine, etc.). On a national level a carbon tax on the 5 tons of CO^2 each ICE vehicle produces per year would be equitable.

Conclusion and recommendations

Global warming is regarded as a ghost crisis because it does not register on our senses and its affects appear long after the causes. Therefore a united response commiserate to its existential threat to our way of life has yet to occur.

The Palm Beach County Transportation Planning Agency or a similarly configured agency is the best positioned political entity in Palm Beach County to coordinate a response to Global Warming. Recommendations to the Governing Board:

1) Task the Technical Advisory Committee to perform an in depth review of the coming disruptive switch from ICE to BEV light duty vehicles and make recommendations as needed. An example of this would be to develop recommendations for City governments on how to start buying BEVs for their fleets by using piggy back contracts and 3rd party leasing to qualify for Federal incentives.
2) Form a sub committee headed by Governing Board members and composed of representatives from Agency staff, the Technical Advisory Committee and the Citizen Advisory Committee to consider the future direction of the Transportation Planning Agency with regards to Global Warming including consider changing the Agency name back to the more broadly construed Metropolitan Planning Organization or start planning for a new agency.
3) Make an inter-Agency request to the Florida Department of Highway Safety and Motor Vehicles that an accessible report be maintained categorizing PBC vehicle registrations by make, model and propulsion type.
4) The Governing Board wearing their other hats as City Commissioners, Mayors and County Commissioners should reactivate the initiative to establish an accurate accounting of the amount of greenhouse gas pollution generated by Palm Beach County.

Appendix 1: BEV vs ICE

Acceleration

A *Car and Driver* magazine article from January 2021 highlights the $3 million dollar Bugatti Chiron as the new holder of the world record for the quarter mile with a time of 9.4 seconds[22].

In June 2021 the Bugatti Chiron record was broken by…Jay Leno. He drove the quarter mile in 9.247 seconds with a tri-motor Tesla Model S Plaid[23]. This car retails for at $130,000 which means for the same $3 million dollar cost of a Bugatti Chiron, a person could buy 23 faster Teslas.

And of course it trickles down from there. Dodge recently announced it is ending its Hellcat production. Muscle cars are losing to Teslas on every drag strip in the country.
https://www.youtube.com/watch?v=u2Ps06tS5Lg
https://www.youtube.com/watch?v=Nn4VO9iVVgg

SPACE

An ICE car is built around the huge engine and transmission. Electric cars have much more flexibility because the electric motor is much smaller. This allows the electric motors to be tucked in with the skateboard design which has a much more flexible design and feels roomier than ICE cars with the traditional transmission and drive train hump.

Figure 23 Classic ICE V8 Source: https://www.proformanceunlimited.com/shop/chevy-engines/454-ci-bbc-crate-engine-550hp/

[22] "Bugatti Chiron Is Now the Quickest Car We've Ever Tested: It's never been easier to join the 200-mph club" by Tony Quirog published January 1, 2021 (https://www.caranddriver.com/news/a35105452/bugatti-chiron-tested-quickest-car-ever/

[23] https://www.roadandtrack.com/news/a36715189/jay-leno-production-quarter-mile-record-tesla-model-s-plaid/

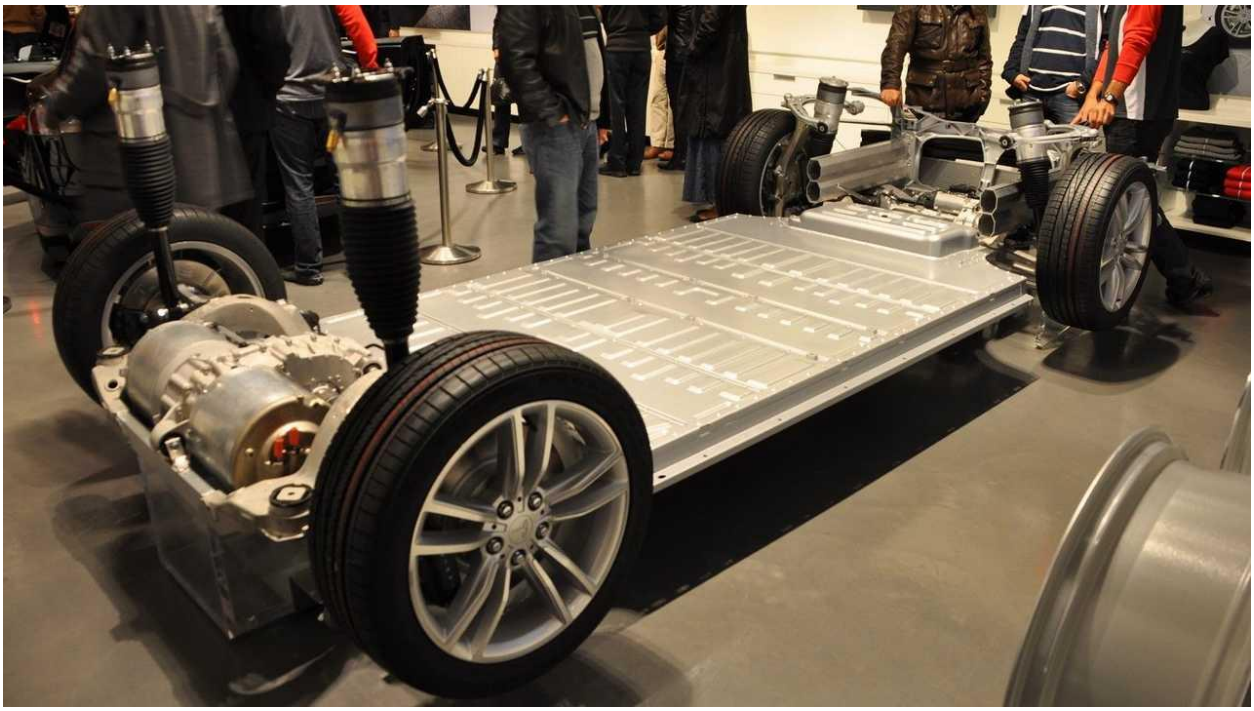


Figure 24 One example of the BEV skateboard design. Source: **https://insideevs.com/news/450534/tesla-leaves-skateboard-design-new-structural-battery-packs/**

Electric car designs for even more usable room are being researched. One idea is integrate the battery pack into the frame by using battery components as load bearing structures[24].

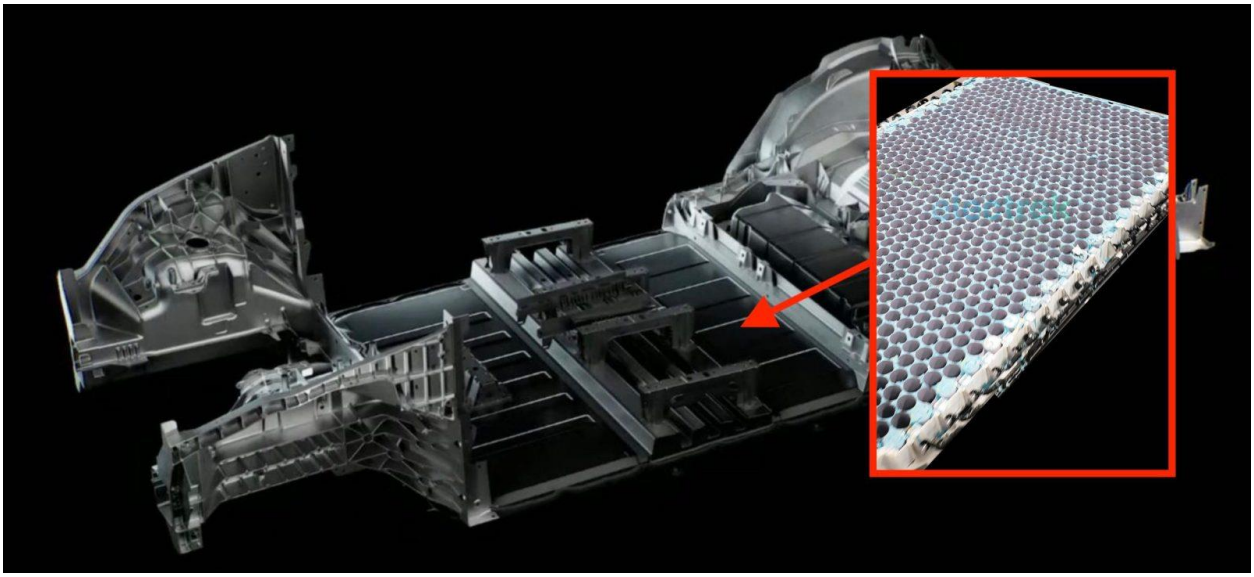


Figure 25 **https://electrek.co/2021/01/19/tesla-structural-battery-pack-first-picture/**

[24] https://www.reuters.com/business/autos-transportation/next-step-evs-design-batteries-strengthen-car-extend-range-2021-07-23/

Handling

Electric cars typically handle better than ICE cars because their center of gravities are lower to the ground (skateboard battery packs vs high and bulky IC engines).
https://www.autoblog.com/2018/11/24/tesla-model-3-137-mph-spinout-bonneville/

Cornering

This article (https://policedriver.com/the-difference-between-handling-and-cornering/) explains the orthodox definition of cornering : "When testing vehicles, most car magazines measure cornering capability by driving a vehicle around a skid pad, which is a circle with a known radius. The driver will increase the vehicle's speed until they cannot keep the vehicle centered on the radius."

Skid pad video: https://www.youtube.com/watch?v=xhe3UIH3Wak This video starts out a little cheesy and some may find it offensive. However, the author really knows how to drive and the video ends with clear examples of how cornering works.

The definition of cornering will have to be rewritten for electric vehicles. The computers which run the cars allow so much more. The GMC Hummer EV introduces "crabwalk", has four wheel steering, and a new extraction mode which raises the body 6 inches to clear obstacles (will the Humvee be able to do low rider bouncing?).
https://www.youtube.com/watch?v=rzGlVG75kUM

The companies Elaphe and Protean Electric are developing in wheel electric motors. With a motor in each wheel the phrase, "turns on a dime" becomes a reality as wheels on one side of the car spin forward and the opposite spin backwards. Elaphe accurately named this "tank turn": https://www.youtube.com/watch?v=al_NZHnuu0g
A recent video with great visuals explaining in-wheel electric motors.
https://www.youtube.com/watch?v=yS3w2IjkzxU
Viewing a youtube video from a document seems to be a two step process. Clicking on the link may only open a tab for youtube, but not the specific video. To view the correct video copy the link and paste it into the youtube tab.

Maintenance

https://www.motortrend.com/news/government-ev-ice-maintenance-cost-comparison/

https://www.consumerreports.org/car-repair-maintenance/pay-less-for-vehicle-maintenance-with-an-ev/

Fuel cost

To compare apples to apples and make it easier for citizens to understand costs, the Federal Department of Energy's Office of Energy Efficiency and Renewable Energy has developed the eGallon tool[25] which "represents the cost of driving an electric vehicle (EV) the same distance a gasoline-powered vehicle could travel on one (1) gallon of gasoline." It does not seem to have the most latest costs on record[26].

Perhaps a clearer explanation is the average electric car uses 34.6 kiloWatt hours (kWh)to travel 100 miles[27].
FPL charges 10.99 cents per kwh for residential accounts[28].
If an electric vehicle is charged at home and the home has no solar panels, the fuel cost per 100 miles is

$$34.6\ kWh\ per\ 100\ miles\ \times \frac{\$.1099}{kWh} = \$3.80\ per\ 100\ miles$$

A 25 miles per gallon sedan uses 4 gallons of gasoline to travel 100 miles[29].
Current gas prices in Palm Beach County are approximately $3.35 per gallon[30].

$$4\ gallons\ of\ gasoline\ per\ 100\ miles \times \frac{\$3.35}{gallon\ of\ gasoline} = \$13.40\ per\ 100\ miles$$

Therefore, if you charge an EV at a residence using FPL supplied electricity, the savings in fuel cost is $9.6 per 100 miles.
If an EV is charged at a home which has enough solar panels, then the daily commute fuel costs are zero.
If you charge an EV on a road trip the kWh cost from a vendor is hard to reliably estimate at this time. One source lists $0.28 per kWh for Tesla Supercharger stations.[31]

[25] https://www.energy.gov/maps/egallon
[26] https://www.energy.gov/eere/vehicles/articles/fotw-1186-may-17-2021-national-average-cost-fuel-electric-vehicle-about-60
[27] https://ecocostsavings.com/average-electric-car-kwh-per-mile/
[28] https://www.fpl.com/content/dam/fpl/us/en/rates/pdf/res-may-2021.pdf
[29] https://www.edmunds.com/fuel-economy/the-truth-about-fuel-consumption.html
[30] https://www.gasbuddy.com/gasprices/florida/boynton-beach
[31] https://www.motorbiscuit.com/how-much-does-it-cost-tesla-supercharger/

Range

Driving range between charges is not a concern for those who actually own and drive BEVs. It still seems to be a concern for ICE car owners who are contemplating getting a BEV. The steadily increasing range of BEVs:

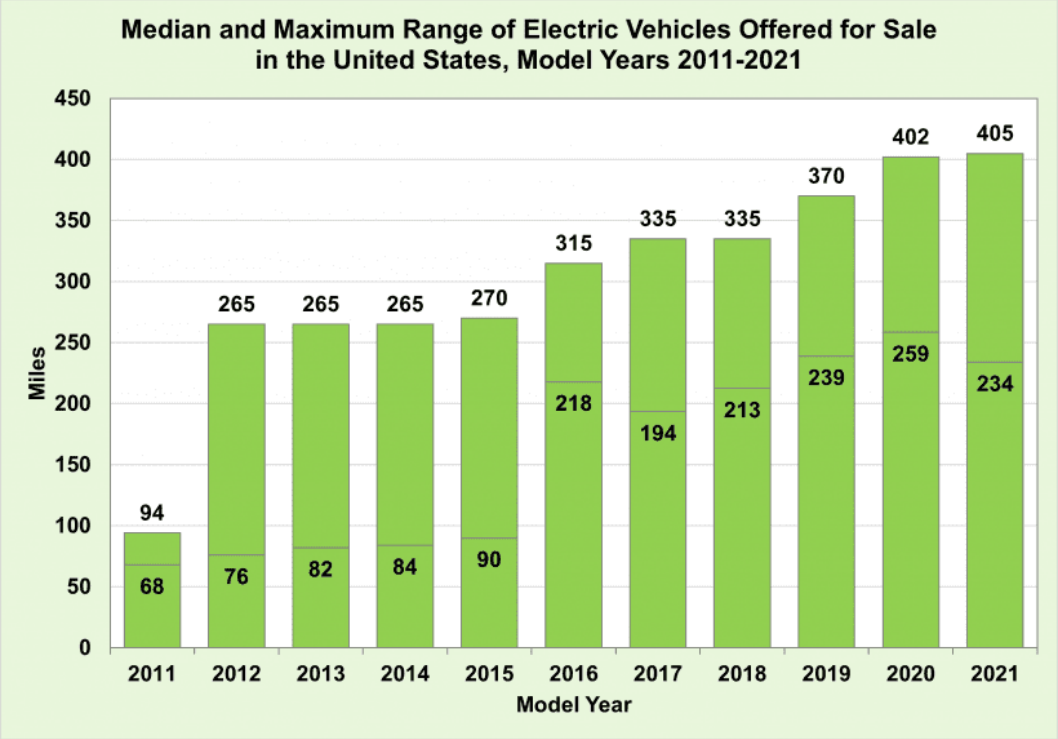


Figure 26 When modern all-electric vehicles (EV) were introduced in model year (MY) 2011, there were four models available with ranges spanning from 63 to 94 miles, with a median range of 68 miles. Over time, the number of models and the ranges of EVs have increased. By MY 2021 the maximum range of an EV had more than quadrupled to 405 miles on a single charge, while the median range was 234. Source: https://cleantechnica.com/2022/01/10/in-2021-electric-vehicle-model-in-usa-with-longest-range-was-rated-405-miles-on-a-single-charge/

The longest range cars in 2020:

2020 Model S Long Range — 402 miles
2021 Model X Long Range — 371 miles
Tesla Model 3 Long Range — 322 miles
Tesla Model Y AWD — 316 miles
Tesla Model 3 Performance — 299 miles
Tesla Model Y Performance — 291 miles
Chevy Bolt — 259 miles
Hyundai Kona Electric — 258 miles

Tesla Model 3 Standard Range Plus — 250 miles
Kia Niro EV — 239 miles
Nissan LEAF PLUS — 229 miles
Source: https://cleantechnica.com/2020/10/15/which-electric-vehicles-have-the-longest-range/

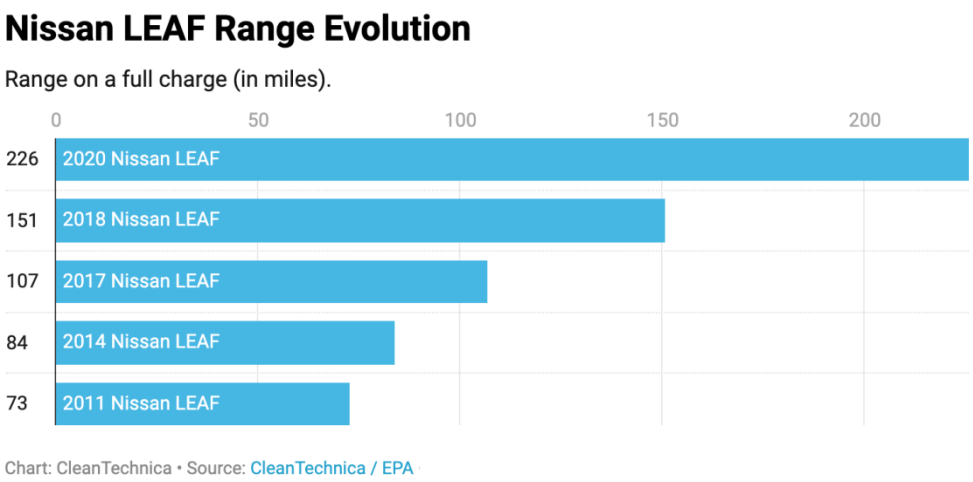


Figure 27 The tripling in range of the Nissan Leaf from 2011 to 2020 is an example of the steady evolution of EV battery packs. Source: https://cleantechnica.com/2020/10/15/which-electric-vehicles-have-the-longest-range/

The one charge range performance will continue to improve. However, car makers are now looking for a sweet spot of an optimum range so smaller battery packs can be installed to reduce the sale price.

Examples of continuing research and improvements:

1. Our Next Energy (ONE), a two-year-old Michigan startup, retrofitted a Tesla Model S with its batteries and drove 752 miles on a single charge. https://www.caranddriver.com/news/a38668912/750-mile-ev-battery-michigan-startup-our-next-energy/
2. Another battery advance from the State of Michigan. Lithium-sulfur batteries potentially have 4 times the energy density of the current Lithium-Ion batteries. But sulfur chemistry batteries degrade too quickly. This is an article on how the material from recycled Kevlar

Safety

Tesla autopilot dodging cars, trucks, a wild pig, and a mountain lion (not a large bobcat).
https://www.youtube.com/watch?v=bUhFfunT2ds
https://www.youtube.com/watch?v=2On4Msc2yNA

This is a biased sales video. It gives a sense of the dynamic flux and creativity going on in the BEV industry right now and foreshadows how BEVs are safer and will continue to get safer when compared to ICE cars. https://jalopnik.com/watch-teslas-and-audis-and-other-cars-smack-into-fake-k-1848316218

A British take on Tesla Model X with some thoughts on safety.
https://www.youtube.com/watch?v=0ssucYoYtYE

Electric school buses are safer than ICE school buses
https://insideevs.com/news/553225/electric-school-bus-moose-test/

House/BEV battery storage

When poor electric grid maintenance plus global warming induced droughts resulted in gigantic wildfires many homes in California lost power. A couple of people figured out how to hack their Tesla battery to provide electric power to their home. This is now becoming a feature for BEVs. This video has a little tongue-in-cheek. Buy a Ford Charge Station Pro… Pick up truck included.
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=video&cd=&cad=rja&uact=8&ved=2ahUKEwjwwfnm5J32AhXTVTABHQE8A3gQtwJ6BAgFEAI&url=https%3A%2F%2Fmedia.ford.com%2Fcontent%2Ffordmedia%2Ffna%2Fus%2Fen%2Fnews%2F2022%2F02%2F02%2Ff-150-lightning-power-play.html&usg=AOvVaw2hYdG3o6WtfX9dyovjwcIH

Of course Tesla was there first. https://insideevs.com/news/569986/tesla-home-charger-tops-jdpower/

Battery primer

While the White House Executive Order lists "….zero-emission vehicles, including battery electric, plug-in hybrid electric, or fuel-cell electric vehicles.", an underlying assumption of this paper is by 2030 the only rival to ICE vehicles left standing will be Battery Electric Vehicles. There are many shortcomings ICE proponents tout about EV batteries: inadequate energy density resulting in less than desirable range, expensive materials, the source of some scarce materials is in countries with corrupt and unstable governments, flammability (as a retired Fire Lieutenant/Paramedic I can emphatically state this is a case of the pot calling the kettle black), reduced energy in cold climates, recyclability and the length of charging time are the most repeated issues.

Every issue listed is either a myth or based on outdated knowledge. Each concern is being addressed by multiple players around the world and solutions in the laboratory are being fast tracked for commercial utilization. By the time other options such as hydrogen powered ICE cars are commercially competitive for the 2022 type market, BEVs will have moved the goal posts. The amount of research on batteries going on around the world is a quantum leap more than research on all the alternatives combined.

These recent news articles are a sample of evolving battery dominance:

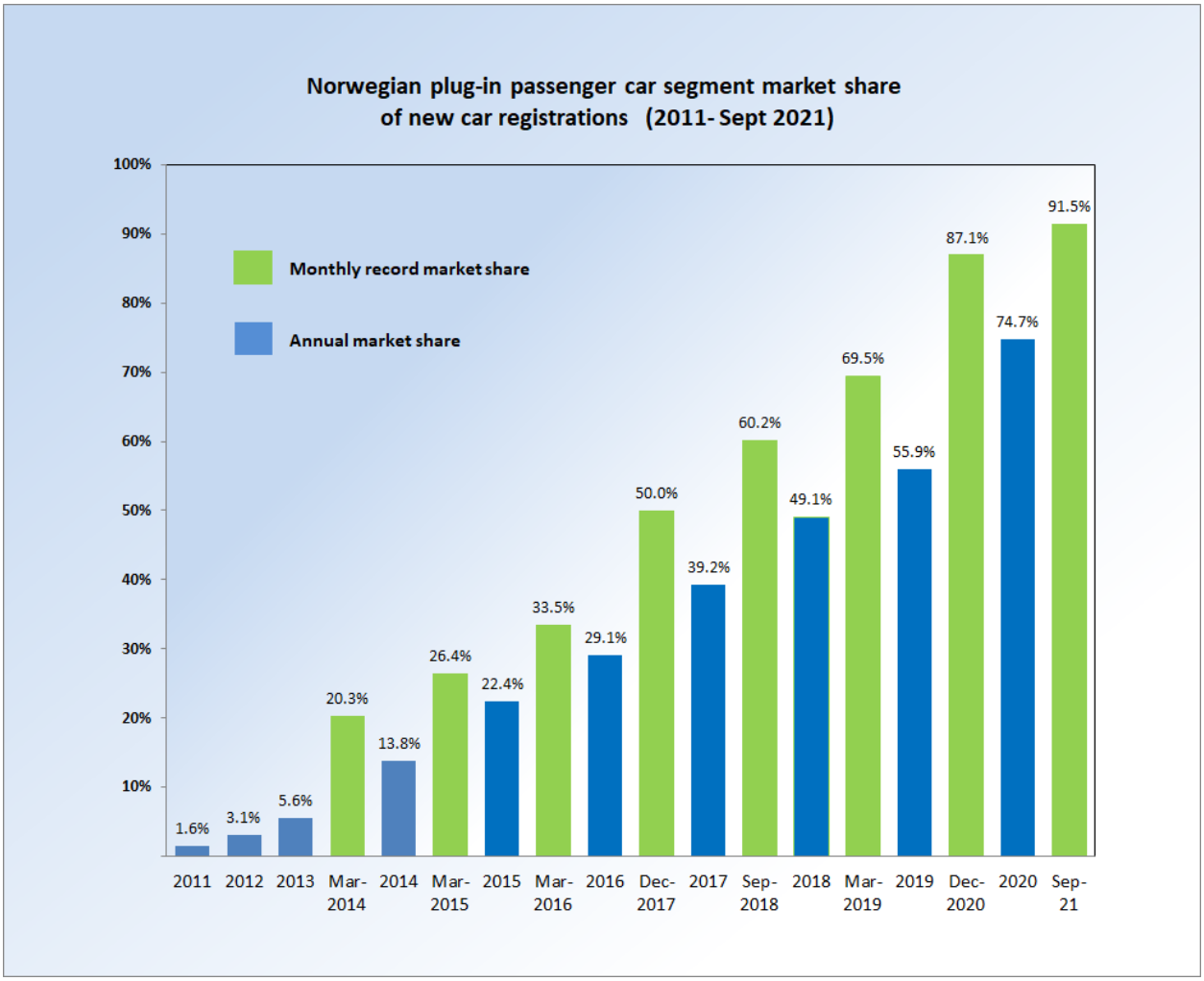
https://carnewschina.com/2022/01/13/catl-new-patent-allows-anode-free-sodium-ion-battery-density-to-go-above-200wh-kg/
https://www.caranddriver.com/news/a38668912/750-mile-ev-battery-michigan-startup-our-next-energy/
https://www.caranddriver.com/news/a38668912/750-mile-ev-battery-michigan-startup-our-next-energy/
https://insideevs.com/news/557776/tesla-2000miles-using-ea-chargers/
https://newatlas.com/energy/best-battery-energy-breakthroughs-2021/
https://www.torquenews.com/14093/tesla-18650-2170-and-4680-battery-cell-comparison-basics
https://www.pv-magazine.com/2022/02/11/a-4000-cycle-lithium-sulfur-battery/
https://www.autoweek.com/news/technology/a39001430/mercedes-benz-prologium-solid-state-battery/
https://cleantechnica.com/2022/02/07/calculating-better-solid-state-batteries/
https://www.motortrend.com/features/structural-battery-composites-automotive-ev-energy-storage/
https://www.quantumscape.com/resources/blog/white-paper-a-deep-dive-into-quantumscapes-fast-charging-performance/
https://www.teslarati.com/panasonic-tesla-4680-electric-vehicle-battery-production-investment/
https://insideevs.com/news/564017/lucid-air-usable-battery-capacity/
https://www.nanalyze.com/2022/01/ev-battery-stocks/
https://d1softballnews.com/jeff-dahn-and-teslas-million-mile-battery-goes-beyond-electric-cars-technology-hybrids-and-electrics/
https://www.inceptivemind.com/new-electrolyte-solid-state-lithium-ion-batteries/23385/
https://www.resilientdesign.org/portable-battery-power-and-resilience/
https://electriccarfaqs.com/how-to-select-battery-for-electric-car/
https://electrek.co/2022/01/27/storedot-which-makes-ultra-fast-tesla-like-4680-battery-cells-develops-tech-to-extend-batteries-first-and-second-life/
https://electrek.co/2022/01/25/gm-lg-giant-new-50-gwh-battery-cell-factory-us/
https://batteriesnews.com/nanograf-energy-density-milestone-lithium-ion-battery-material-energy-dense/
https://www.teslarati.com/tesla-battery-recycling-redwood-materials-100-gwh-goal/
https://www.independent.co.uk/life-style/gadgets-and-tech/quantum-battery-breakthrough-paves-way-for-revolution-in-energy-storage-b1995425.html
https://www.goodnewsnetwork.org/scientists-revitalize-batteries-bringing-dead-lithium-back-to-life/
https://www.wired.com/story/the-us-inches-toward-building-ev-batteries-at-home/
https://cleantechnica.com/2022/01/10/in-2021-electric-vehicle-model-in-usa-with-longest-range-was-rated-405-miles-on-a-single-charge/

https://techxplore.com/news/2022-01-rubber-material-key-long-lasting-safer.html
https://abcnews.go.com/International/wireStory/tesla-inks-deal-key-battery-component-china-82293464
https://www.mining.com/recycling-plant-aims-to-turn-us-coal-country-into-rare-earth-powerhouse/
https://cleantechnica.com/2022/01/17/battery-resourcers-recycling-facility-will-open-in-august/
https://cleantechnica.com/2022/01/11/the-role-of-annealing-in-improving-all-solid-state-lithium-battery-performance/
https://cleantechnica.com/2022/01/16/stelco-will-recycle-ev-batteries-at-its-ontario-factory/
https://www.inceptivemind.com/battery-breakthrough-membrane-quintuple-electric-vehicle-ranges/22945/
https://carnewschina.com/2022/01/13/catl-new-patent-allows-anode-free-sodium-ion-battery-density-to-go-above-200wh-kg/
https://investorplace.com/2022/01/sldp-stock-is-an-extremely-risky-wager-on-unique-ev-batteries/
https://www.motortrend.com/features/long-range-cheap-quick-charging-ev-future/
https://newatlas.com/energy/best-battery-energy-breakthroughs-2021/
https://www.torquenews.com/14093/tesla-18650-2170-and-4680-battery-cell-comparison-basics
overview of solid state batteries https://www.lexology.com/library/detail.aspx?g=b8b7684c-e0aa-4b0d-93e3-e24009859043
https://www.energy-storage.news/norways-freyr-battery-signs-us3-billion-off-take-deal-with-energy-storage-industry-customer/
https://www.cnn.com/2021/12/17/politics/lithium-mining-energy-climate/index.html
https://www.tesmanian.com/blogs/tesmanian-blog/permanent-magnet-motor-with-wrapping
https://insideevs.com/news/550025/lucid-air-fast-charging-review/
And these links are representative of the dynamic improvements as BEVs pull away from ICE vehicles (there is some duplication of links already mentioned):
https://www.marketwatch.com/story/electric-vehicles-hit-a-pivot-point-as-battery-prices-fall-and-governments-get-behind-the-new-technology-11645105486
https://www.visualcapitalist.com/comparing-the-carbon-footprint-of-transportation-options/
https://cleantechnica.com/2022/02/08/january-german-plugin-ev-share-22-fiat-500-in-top-spot/
https://cleantechnica.com/2022/02/07/nissan-to-end-internal-combustion-engine-development-sort-of/

https://thetechxp.com/how-to-find-a-tesla-supercharger-and-tesla-supercharger-map/?_gl=1*nn6wtp*_ga*Nm0tRVNSeUhxRHFfUVBndDQxYzJwUGMtZ1cySDRUd1diaGFKR3ZMcGFaak5yQ2pHaC1EUkRNNjJCNE9zZFVWUA
https://www.cnet.com/roadshow/news/how-much-range-you-really-need-in-an-electric-car/
https://www.motortrend.com/news/ree-automotive-boards-corners-ces/
https://www.motortrend.com/events/3-cool-new-electric-motor-technologies-ces-2022/
https://cleantechnica.com/2020/10/15/which-electric-vehicles-have-the-longest-range/
https://www.tesmanian.com/blogs/tesmanian-blog/tesla-model-y-body-built-for-structural-battery-pack-with-4680-cells-again-spotted-at-giga-texas
https://insideevs.com/news/561034/tesla-models-plaid-accelerates-171mph/
https://cleantechnica.com/2022/01/14/tesla-cold-weather-experiment-in-22f-31f-temperatures/
https://www.roadandtrack.com/news/a38698676/does-anyone-want-an-electric-car/
https://cleantechnica.com/2021/08/10/when-do-fossil-fuel-car-sales-collapse/
https://insideevs.com/news/557776/tesla-2000miles-using-ea-chargers/
https://cleantechnica.com/2021/02/27/electric-vehicle-market-share-trends-in-uk-netherlands-norway-china-germany-france-sweden/
https://cleantechnica.com/2021/12/19/one-man-behind-the-white-house-effort-to-convert-federal-fleet-to-electric-vehicles/
https://chargedevs.com/newswire/resonant-link-says-its-wireless-charging-tech-achieves-5-10-times-lower-power-losses-than-others/
https://www.cnet.com/roadshow/news/brightdrop-opens-first-dealership-los-angeles/
https://insideevs.com/news/553225/electric-school-bus-moose-test/
https://jalopnik.com/watch-teslas-and-audis-and-other-cars-smack-into-fake-k-1848316218
https://cleantechnica.com/2022/01/06/swedens-plugin-ev-share-breaks-new-records/
https://www.caranddriver.com/news/a38668912/750-mile-ev-battery-michigan-startup-our-next-energy/
https://insideevs.com/news/558447/norway-plugin-car-sales-december2021/
https://insideevs.com/news/553225/electric-school-bus-moose-test/
https://cleantechnica.com/2021/12/03/norway-again-over-90-plugin-ev-share-in-november-legacy-ice-at-record-low-5/
https://cleantechnica.com/2021/10/26/how-many-jobs-will-disappear-with-switch-to-electric-cars/
https://www.teslarati.com/rivian-amazon-delivery-van-official-name-specs/
https://cleantechnica.com/2021/03/04/three-truths-about-electric-vehicles/
https://www.bloomberg.com/news/features/2021-10-22/the-ev-disruption-that-nobody-s-talking-about
https://finance.yahoo.com/news/more-expensive-charging-electric-vehicle-150723451.html

Appendix 2: The Norway success story

What President Biden has proposed for the USA by 2030, Norway achieved this benchmark in 2018. This beats the USA goal by 12 years.



By Mariordo (Mario Roberto Durán Ortiz) - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=48177838

How the Norwegians did it. The following is copied from https://elbil.no/english/norwegian-ev-policy/ :

The Norwegian success story is first and foremost due to a substantial package of incentives developed to promote zero-emission vehicles into the market. The incentives have been gradually introduced by different governments and broad coalitions of parties since the early 1990s to speed up the transition.

The Norwegian Parliament has decided on a national goal that all new cars sold by 2025 should be zero-emission (electric or hydrogen). By the end of 2020, there were more than 330.000 registered battery electric cars (BEVs) in Norway. Battery electric vehicles held a 54 % market share in 2020. The speed of the transition is closely related to policy instruments and a wide range of incentives.

The current Government has decided to keep the incentives for zero-emission cars until the end of 2021. After 2021 the incentives will be revised and adjusted parallel with the market development. The VAT exemption for zero-emission vehicles in Norway has been approved by the EFTA Surveillance Authority (ESA) until the end of 2022.

The 50 % rule

Since 2017 it has been up to the local governments to decide the incentives regarding access to bus lanes and free municipal parking. The Parliament has agreed on implementing a 50 % rule, which means that counties and municipalities can not charge more than 50 % of the price for fossil fuel cars on ferries, public parking and toll roads. The 50 % rule is already in function on county ferries and state ferries but will also be implemented on toll roads in the course of 2019. A rule of maximum 50 % parking fee at public parking for zero-emission cars is expected to be implemented by many municipalities from 2019.

Charging infrastructure

For longer distance trips, a well-organized charging network has to be in place. As of January 2021, we have more than 330.000 EV’s and 3.200 cars that can fast-charge at the same time. Even if EV owners are charging at home and manage without fast charging daily, they think it is essential to have the option to fast charge when needed.

Consumers are willing to pay a higher price for the service of fast charging. On average three times more than they pay for electricity at home.

By 2017 the Norwegian Government launched a program to finance the establishment of at least two multi-standard fast charging stations every 50 km on all main roads in Norway.There has successfully been established fast charging stations on all main roads in Norway.

The Norwegian car tax system

The overall signal from the majority of political parties is that it should always be economically beneficial to choose zero and low emission cars over high emission cars. This is obtained with «the polluter pays principle» in the car tax system. High taxes for high emission cars and lower taxes for low and zero-emission cars. Introducing taxes on polluting cars can finance incentives for zero-emission cars without any loss in revenues.

The Norwegian Parliament has decided on a goal that all new cars sold by 2025 should be zero (battery electric or hydrogen) emission vehicles. This is a very ambitious but feasible goal with

the right policy measures. The Parliament will reach this goal with a strengthened green tax system, not a ban.

The purchase tax for all new cars is calculated by a combination of weight, CO2 and NOx emissions. The tax is progressive, making big cars with high emissions very expensive. For the last years, the purchase tax has been adjusted gradually to have more emphasis on emissions and less on weight.

The following example compares an EV model with a similar petrol model to illustrate how the Norwegian tax system makes EVs competitive in the market.

The Norwegian EV incentives:

- No purchase/import taxes (1990-)
- Exemption from 25% VAT on purchase (2001-)
- No annual road tax (1996-2021). Reduced tax from 2021.
- No charges on toll roads or ferries (1997- 2017).
- Maximum 50% of the total amount on ferry fares for electric vehicles (2018-)
- Maximum 50% of the total amount on toll roads (2019)
- Free municipal parking (1999- 2017)
- Parking fee for EVs was introduced locally with an upper limit of a maximum 50% of the full price (2018-)
- Access to bus lanes (2005-).
- New rules allow local authorities to limit the access to only include EVs that carry one or more passengers (2016)
- 50 % reduced company car tax (2000-2018).
- Company car tax reduction reduced to 40% (2018-)
- Exemption from 25% VAT on leasing (2015)
- Fiscal compensation for the scrapping of fossil vans when converting to a zero-emission van (2018)

Volkswagen Golf vs. e-Golf

	Volkswagen Golf	Volkswagen e-golf
Import price:	22 046	33 037
CO2 tax (113 g/km)	4 348	-
NOx tax:	206	-
Weight tax:	1 715	-
Scrapping fee:	249	249
25% VAT:	5 512	-
Retail price:	34 076 €	33 286 €

The progressive tax system makes most EV models cheaper to buy compared to a similar petrol model, even if the import price for EVs are much higher. This is the main reason why the Norwegian EV market is so successful compared to any other country.

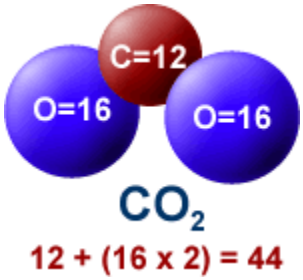
Appendix 3: How can 1 gallon of gasoline produce 20 pounds of Carbon Dioxide?

How can a gallon of gasoline produce 20 pounds of carbon dioxide?

It seems impossible that a gallon of gasoline, which weighs about 6.3 pounds, could produce 20 pounds of carbon dioxide (CO_2) when burned. However, most of the weight of the CO_2 doesn't come from the gasoline itself, but the oxygen in the air.

When gasoline burns, the carbon and hydrogen separate. The hydrogen combines with oxygen to form water (H_2O), and carbon combines with oxygen to form carbon dioxide (CO_2).

A carbon atom has a weight of 12, and each oxygen atom has a weight of 16, giving each single molecule of CO_2 an atomic weight of 44 (12 from carbon and 32 from oxygen).



Therefore, to calculate the amount of CO_2 produced from a gallon of gasoline, the weight of the carbon in the gasoline is multiplied by 44/12 or 3.7.

Since gasoline is about 87% carbon and 13% hydrogen by weight, the carbon in a gallon of gasoline weighs 5.5 pounds (6.3 lbs. x .87).

We can then multiply the weight of the carbon (5.5 pounds) by 3.7, which equals 20 pounds of CO_2!

Data Sources https://www.fueleconomy.gov/feg/contentincludes/co2_inc.htm
Physical and chemical properties of gasoline: Department of Energy (DOE), Alternative Fuels Data Center (AFDC), Properties of Fuels.

From the EPA Green Vehicle Guide:
"What are the average annual carbon dioxide (CO2) emissions of a typical passenger vehicle?

A typical passenger vehicle emits about 4.6 metric tons of carbon dioxide per year.

This assumes the average gasoline vehicle on the road today has a fuel economy of about 22.0 miles per gallon and drives around 11,500 miles per year. Every gallon of gasoline burned creates about 8,887 grams of CO2.[32] "

[32] https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle#typical-passenger

Doing the math using the above DOE and EPA websites:

$$\frac{11{,}500\ miles\ per\ year}{22.0\ miles\ per\ gallon} = 523\ gallons\ of\ gasoline\ per\ year$$

$$523\ gallons\ of\ gasoline\ per\ year\ \times 8{,}887\ grams\ of\ CO2\ = 4{,}648\ kilograms\ of\ CO2$$

1 kilogram = 2.2 pounds
2,000 pounds = 1 American ton
4,648 kilograms = 10,225 pounds = 5 American tons

Each typical passenger vehicle emits over 5 American tons of carbon dioxide per year.

Using the same steps the DOE used to calculate the weight of CO_2, the weight of water created and breathable oxygen used from burning a gallon gasoline can also be calculated.

A hydrogen atom has an atomic weight of 1, and each oxygen atom has an atomic weight of 16, giving each single molecule of H_2O an atomic weight of 18 (2 from hydrogen and 16 from oxygen).

Therefore, to calculate the amount of H_2O produced from a gallon of gasoline, the weight of the hydrogen in the gasoline is multiplied by 18/2 or 9.

Since gasoline is about 87% carbon and 13% hydrogen by weight, the hydrogen in a gallon of gasoline weighs 0.82 pounds (6.3 lbs. x .13).

We can then multiply the weight of the hydrogen (0.82 pounds) by 9, which equals 7.3 pounds of H_2O!

The amount of oxygen in an amount of CO_2 from the atomic weights is 44/32 or 1.375. Therefore the weight of oxygen in 20 pounds of CO_2 is 14.5 pounds (20/1.375).

The amount of oxygen in an amount of H_2O from the atomic weights is 18/16 or 1.125. Therefore the weight of oxygen in 7.3 pounds of H_2O is 6.5 pounds (7.3/1.125)

Adding these two results together is 21 pounds of oxygen. Every time one gallon of gasoline is burned, 20 pounds of CO_2 and 7.3 pounds of water is added to the atmosphere where it remains for 300 to 1,000 and 21 pounds of breathable oxygen is removed from the skies of Palm Beach County for the same length of time.

Using the same 523 gallons per year per car the weight of water produced is 3,818 pounds (7.3 pounds x 523). Converting to tons this is 1.9 tons of water per car per year from their tailpipes (in the form of steam).

Appendix 4: What do greenhouses have to do with carbon dioxide?

Categorizing carbon dioxide, water and methane as "greenhouse gases" may make sense to scientists as a very accurate and useful analogy or metaphor. Unfortunately, the point is lost because a large percentage of the USA population have no idea why a glass greenhouse warms up.

The earliest known European Orangery was built around 1545 in Padua, Italy. As the name implies the purpose was an enclosure so orange trees and other warm weather plants could grow in colder climes. The first ones were made from brick or stone and warmed with a fire. Commercial plate glass casting was perfected in France in 1688. The Crystal Palace was built in 1851 at Hyde Park, London for the Great Exhibition . After that, glass greenhouses were built for the rich and famous and spread out from there.

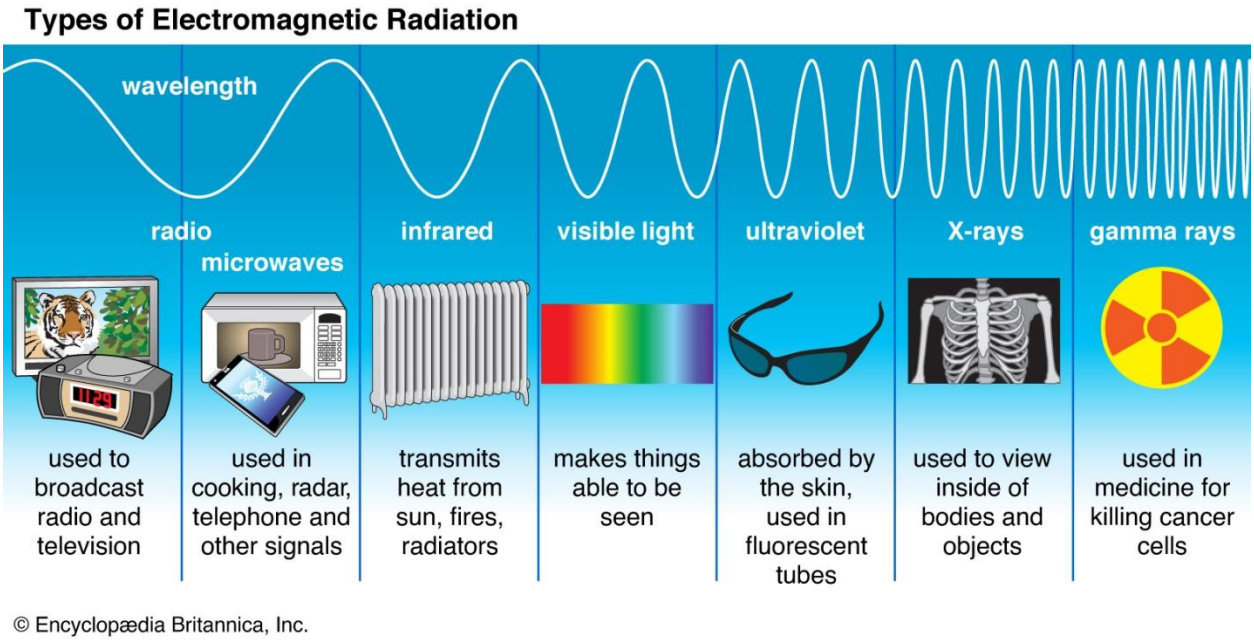


Figure 28 Source: https://www.britannica.com/science/electromagnetic-spectrum

Glass greenhouses work (being warmer than the surrounding air) because of properties of the electromagnetic radiation spectrum. Frequency is the number of wavelength periods per second. Wavelengths are the number of periods per meter. As can be seen in the graph gamma rays have the most wavelength periods per meter. This is 10,000,000,000 wavelength periods per meter. Radio and TV waves are at the lower end of the spectrum. For Very High Frequency (VHF) each wave length is between one and ten

meters long per period. Ultra High Frequency (UHF) have wave lengths between one and $1/10^{th}$ meter per period.

Between the extremes of gamma and radio waves is sunlight: radiant energy from the sun. Sunlight has a range of wavelengths from infrared (the lower end is 1,000 wavelength cycles per meter) to ultra violet light (top end is 10,000,000 wavelength cycles per meter). Visible light, the wavelengths of radiation our eyes can see, is between the ranges of 1,428,000 wave length cycles per meter (top of infra red) to 2,630,000 wavelength cycles per meter (bottom of ultra-violet).

Glass is nearly invisible to us because visible light wavelengths are so tight they zip right through the nuclei of the glass molecules with no interaction. As do the ultra-violet rays. However, the wider wavelength infra red rays bump and interact with the glass molecules. The infrared rays either bounce back up towards Space or the energy from the ray of sunlight is absorbed by the glass molecule. The rays of sunlight which easily penetrate the glass of a greenhouse (visible and ultraviolet light) hit the surface of the objects in the greenhouse. The sunlight energy is absorbed into the objects. Energy can neither be created or destroyed. After an object has some time in sunlight, it can no longer store any more energy and energy must leave the object. One method is re-radiating the energy into the electromagnetic spectrum. However, this energy leaves the objects in the greenhouse in longer wavelengths. The former sunlight energy is now infrared light or heat rays. This wavelength does no zip through glass. This energy is bounced back from the glass into the greenhouse getting a second chance to warm the air and objects. The air and objects in a greenhouse heat up.

Water, carbon dioxide, and methane molecules share this characteristic of glass. Therefore scientist for ease of understanding, have classified them as greenhouse gases. Releasing billions of tons of greenhouse gases into the atmosphere has the same effect as seeding the sky with trillions and trillions of floating, teeny tiny shards of glass. Some pieces will be angled to reflect heat rays into Space, and some pieces will be angled to reflect heat rays back to Earth. Enough greenhouse gas molecules are reflecting heat rays back to Earth to cause Global Warming. Not as accurate, but perhaps for better understanding… water, carbon dioxide, and methane could have been labelled “down comforter” gases.

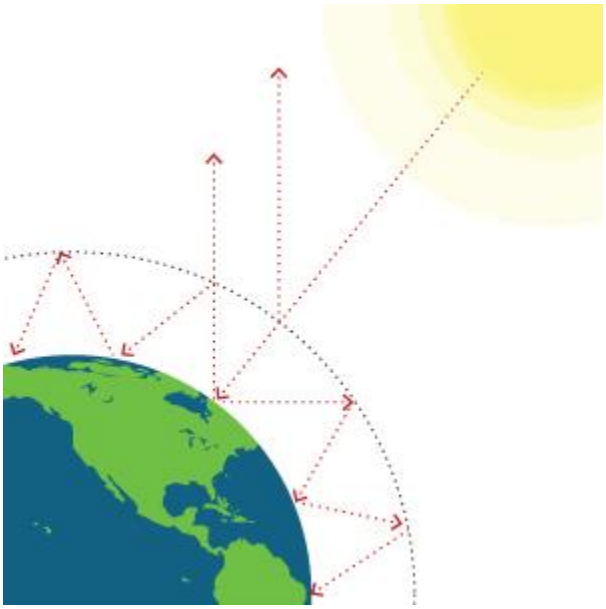


Figure 29 Source: https://www.fondriest.com/environmental-measurements/parameters/weather/photosynthetically-active-radiation/

Figure 30 Source: https://droneservicestx.com/drone-services/aerial-thermal-imaging/

Nearly every frontline fire engine in the USA has a thermal imagery device to make invisible infra red/heat rays visible to firefighters which aids in locating the seat of the fire. In Figure 30 notice the correctly serpentined charged hoseline is black because of the cool water (why nobody is on the nozzle of a charged hoseline is another question). The interior of the open front door and the broken out

windows to its right glow yellow from the fire within. Above the two firefighters on the left are two windows. The frames around the windows are radiating heat represented by the yellow color. But the windows themselves are nearly as dark as the solid walls. This visually shows the greenhouse effect as the window glass reflects back into the fire enough heat rays to be nearly as cool as a solid wall.

Bill Nye the Science Guys has some thoughts on carbon dioxide. To get to Youtube videos copy the link, click on the link. This will open a tab for Youtube. Paste the copied link into Youtube search.
https://www.youtube.com/watch?v=16ywJDBM27o

A good explanation of many Global Warming/Climate Change misconceptions. Use the same steps as the Bill Nye link. https://www.youtube.com/watch?v=OWXoRSIxyIU

Appendix 5 Gasoline Primer

Gasoline Source

By The Editors of Encyclopaedia Britannica |

Siberia, Russia: oil well
Key People:Benjamin Silliman
Related Topics: fracking heavy oil and tar sand tar sand light oil rock oil

crude oil, liquid petroleum that is found accumulated in various porous rock formations in Earth's crust and is extracted for burning as fuel or for processing into chemical products.

Chemical and physical properties

Crude oil is a mixture of comparatively volatile liquid hydrocarbons (compounds composed mainly of hydrogen and carbon), though it also contains some nitrogen, sulfur, and oxygen. Those elements form a large variety of complex molecular structures, some of which cannot be readily identified. Regardless of variations, however, almost all crude oil ranges from 82 to 87 percent carbon by weight and 12 to 15 percent hydrogen by weight.

Crude oils are customarily characterized by the type of hydrocarbon compound that is most prevalent in them: paraffins, naphthenes, and aromatics. Paraffins are the most common hydrocarbons in crude oil; certain liquid paraffins are the major constituents of gasoline (petrol) and are therefore highly valued. Naphthenes are an important part of all liquid refinery products, but they also form some of the heavy asphaltlike residues of refinery processes. Aromatics generally constitute only a small percentage of most crudes. The most common aromatic in crude oil is benzene, a popular building block in the petrochemical industry.

Because crude oil is a mixture of such widely varying constituents and proportions, its physical properties also vary widely. In appearance, for instance, it ranges from colourless to black. Possibly the most important physical property is specific gravity (i.e., the ratio of the weight of equal volumes of a crude oil and pure water at standard conditions). In laboratory measurement of specific gravity, it is customary to assign pure water a measurement of 1; substances lighter than water, such as crude oil, would receive measurements less than 1. The petroleum industry, however, uses the American Petroleum Institute (API) gravity scale, in which pure water has been arbitrarily assigned an API gravity of 10°. Liquids lighter than water, such as oil, have API gravities numerically greater than 10. On the basis of their API gravity, crude oils can be classified as heavy, medium, and light as follows:

A natural oil seep. *Courtesy of Norman J. Hyne Ph.D.*

- Heavy: 10–20° API gravity
- Medium: 20–25° API gravity
- Light: above 25° API gravity

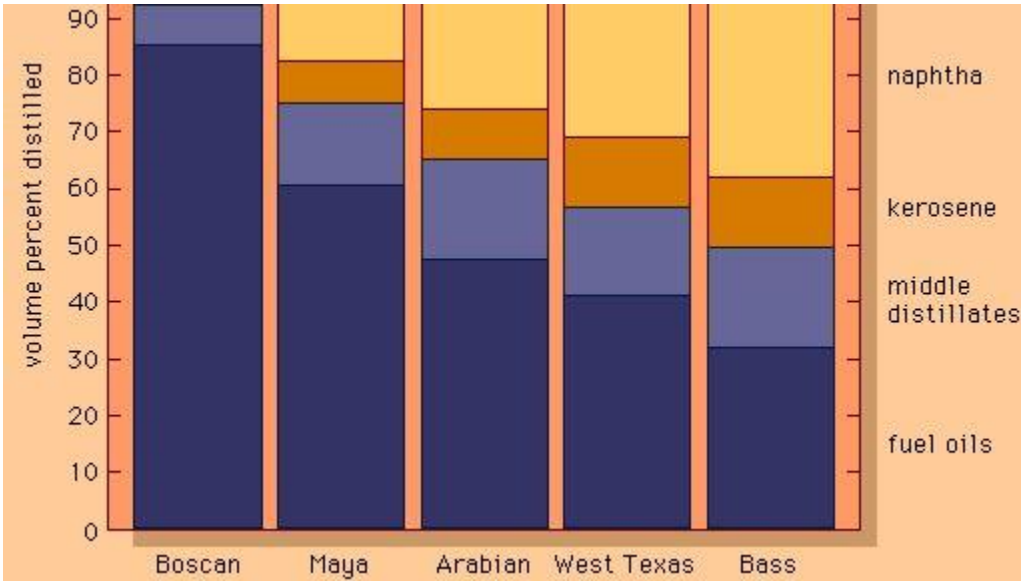
Crude oil also is categorized as “sweet” or “sour” depending on the level of sulfur, which occurs either as elemental sulfur or in compounds such as hydrogen sulfide. Sweet crudes have sulfur contents of 0.5 percent or less by weight, and sour crudes have sulfur contents of 1 percent or more by weight. Generally, the heavier the crude oil, the greater its sulfur content. Excess sulfur is removed from crude oil during refining, because sulfur oxides released into the atmosphere during combustion of oil are a major pollutant.

Extraction and processing

Crude oil occurs underground, at various pressures depending on depth. It can contain considerable natural gas, kept in solution by the pressure. In addition, water often flows into an oil well along with liquid crude and gas. All these fluids are collected by surface equipment for

separation. Clean crude oil is sent to storage at near atmospheric pressure, usually aboveground in cylindrical steel tanks that may be as large as 30 metres (100 feet) in diameter and 10 metres (33 feet) tall. Often crude oil must be transported from widely distributed production sites to treatment plants and refineries. Overland movement is largely through pipelines. Crude from more isolated wells is collected in tank trucks and taken to pipeline terminals; there is also some transport in specially constructed railroad cars. Overseas transport is conducted in specially designed tanker ships. Tanker capacities vary from less than 100,000 barrels to more than 3,000,000 barrels.

The primary destination of crude oil is a refinery. There any combination of three basic functions is carried out: (1) separating the many types of hydrocarbon present in crude oils into fractions of more closely related properties, (2) chemically converting the separated hydrocarbons into more desirable reaction products, and (3) purifying the products of unwanted elements and compounds. The main process for separating the hydrocarbon components of crude oil is fractional distillation. Crude oil fractions separated by distillation are passed on for subsequent processing into numerous products, ranging from gasoline and diesel fuel to heating oil to asphalt. The proportions of products that may be obtained by distillation of five typical crude oils, ranging from heavy Venezuelan Boscan to the light Bass Strait oil produced in Australia, are shown in the figure. Given the pattern of modern demand (which tends to be highest for transportation fuels such as gasoline), the market value of a crude oil generally rises with increasing yields of light products.



crude oils Product content of five major crude oils. *Encyclopædia Britannica, Inc.*

In the United States, the conventional practice for the petroleum industry is to measure capacity by volume and to use the English system of measurement. For this reason, crude oil in the United States is measured in barrels, each barrel containing 42 gallons of oil. Most other areas of the world define capacity by the weight of materials processed and record measurements in metric units; therefore, crude oil outside the United States is usually measured in metric tons. A barrel of API 30° light oil would weigh about 139 kg (306 pounds). Conversely, a metric ton of API 30° light oil would be equal to approximately 252 imperial gallons, or about 7.2 U.S. barrels.

The Editors of Encyclopaedia Britannica This article was most recently revised and updated by Melissa Petruzzello.

Hydrocarbons

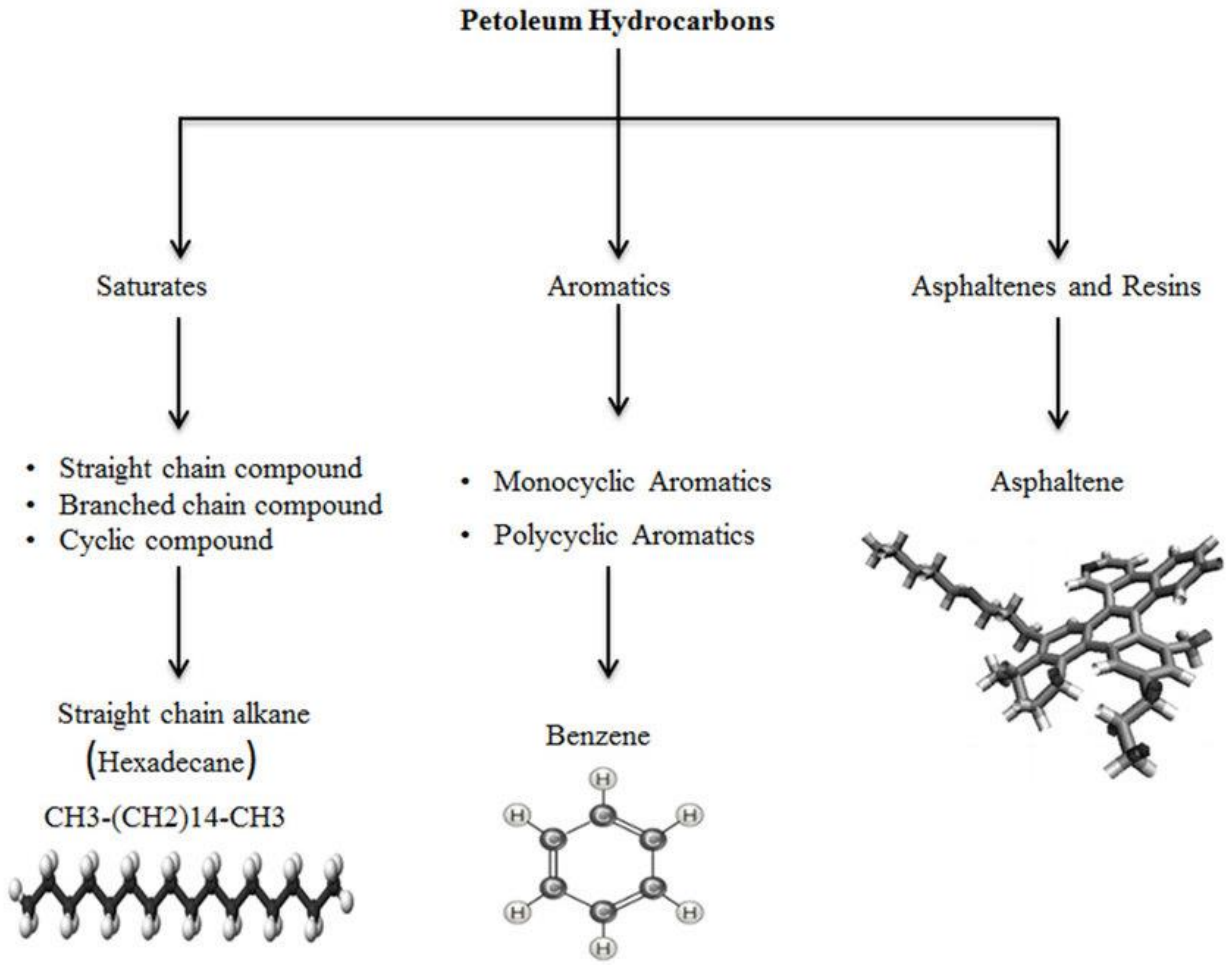


Figure 31 Diagram by Eman Koshlaf PhD, RMIT University, Australia| RMIT · Department of Applied Science

From the University of Calgary, Canada https://energyeducation.ca/encyclopedia/Hydrocarbon :

The term **hydrocarbon** refers to the most basic type of organic molecules. As suggested by their name, they are comprised of only 2 elements: hydrogen and carbon.[1] Hydrocarbon molecules have one or more central carbon atoms in a branched or chain-like structure, surrounded by hydrogen atoms. There are four main categories of hydrocarbons: Alkanes, Alkenes, Alkynes, and Aromatic hydrocarbons.[2]

Structure

The simplest hydrocarbons are called alkanes. Alkanes are made exclusively with **single bonds** between the carbon atoms. Figure 1 shows some small alkane molecules - notice that all the C-C bonds are single bonds. This means that all carbons in an alkane have a tetrahedral geometry. The examples in Figure 1 are all "straight chain" alkanes, where the central carbons form a single linear chain. Alkanes may also be branched [3] or cyclic [4], and can contain any number of carbon atoms.

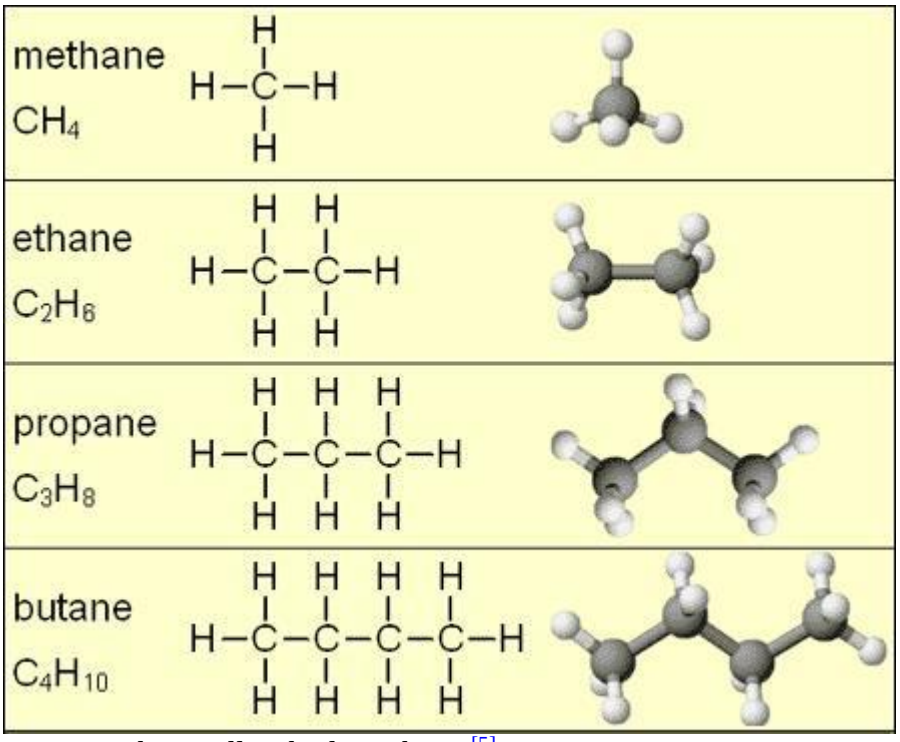


Figure 1 The smallest hydrocarbons.[5]

Similar in structure to alkanes, alkenes are hydrocarbons where the central carbon chain contains at least one double bond between carbon atoms, and alkynes contain at least one triple bond. Also commonly seen are hydrocarbon derivatives, where atoms other than carbon or hydrogen are present.[1] For example in an **alkyl halide**, a hydrogen from an alkane is replaced by a halogen atom such as chlorine or bromine.

Hydrocarbons and their derivatives are the main constituents of fossil fuels, and release energy through combustion. Besides their fuel applications, hydrocarbons are also used in chemical synthesis and are major components of lubricating oils, greases, solvents, fuels, wax, asphalts, cosmetics, and plastics.[6] These non-fuel applications of hydrocarbons can be of great importance to society and the economy.

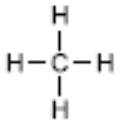
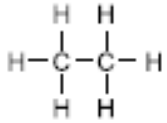
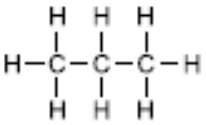
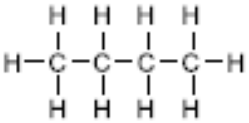
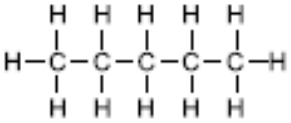
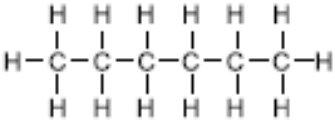
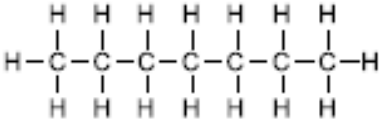
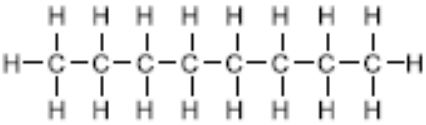
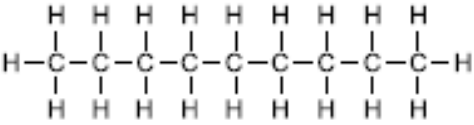
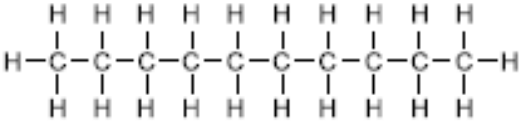
Name	Molecular Formula	Condensed Formula	Structural Formula
Methane	CH_4	CH_4	
Ethane	C_2H_6	H_3CCH_3	
Propane	C_3H_8	$H_3CCH_2CH_3$	
Butane	C_4H_{10}	$H_3C(CH_2)_2CH_3$	
Pentane	C_5H_{12}	$H_3C(CH_2)_3CH_3$	
Hexane	C_6H_{14}	$H_3C(CH_2)_4CH_3$	
Heptane	C_7H_{16}	$H_3C(CH_2)_5CH_3$	
Octane	C_8H_{18}	$H_3C(CH_2)_6CH_3$	
Nonane	C_9H_{20}	$H_3C(CH_2)_7CH_3$	
Decane	$C_{10}H_{22}$	$H_3C(CH_2)_8CH_3$	

Figure 32 List of the first 10 hydrocarbons, the compounds found in gasoline Illustration source: https://sites.google.com/site/csetstudyguidechemistry/home/6-1c-organic-chemistry-biochemistry---ten-simplest-hydrocarbons

Gasoline data sheet

3. CHEMICAL AND PHYSICAL INFORMATION

3.1 CHEMICAL IDENTITY

Gasoline is a refined product of petroleum consisting of a mixture of hydrocarbons, additives, and blending agents. The composition of gasolines varies widely, depending on the crude oils used, the refinery processes available, the overall balance of product demand, and the product specifications. The typical composition of gasoline hydrocarbons (% volume) is as follows: 4-8% alkanes; 2-5% alkenes; 25-40% isoalkanes; 3-7% cycloalkanes; l-4% cycloalkenes; and 20-50% total aromatics (0.5-2.5% benzene) (IARC 1989). Additives and blending agents are added to the hydrocarbon mixture to improve the performance and stability of gasoline (IARC 1989; Lane 1980). These compounds include anti-knock agents, anti-oxidants, metal deactivators, lead scavengers, anti-rust agents, anti-icing agents, upper-cylinder lubricants, detergents, and dyes (IARC 1989; Lane 1980). At the end of the production process, finished gasoline typically contains more than 150 separate compounds although as many as 1,000 compounds have been identified in some blends (Domask 1984; Mehlman 1990). Information regarding the chemical identity of gasoline is located in Table 3-l.

3.2 PHYSICAL AND CHEMICAL PROPERTIES

Information regarding the physical and chemical properties for the gasoline mixture is located in Table 3-2. In cases where data are not available for gasoline, ranges are given to indicate the different values for the individual components.

TABLE 3-1. Chemical Identity of Gasoline

Characteristic	Information	Reference
Chemical name	Gasoline	RTECS 1990
Synonyms	Casing head gasoline; motor fuel; motor spirit; natural gasoline; petrol	HSDB 1993
Registered trade name(s)	No data[a]	
Chemical formula	No data[a]	
Chemical structure	No data[a]	
Identification numbers:		
CAS registry	8006-61-9	RTECS 1990; Sax and Lewis 1989
NIOSH RTECS	LX3300000	RTECS 1990; SANSS 1986; Sax and Lewis 1989
EPA hazardous waste	No data	
OHM/TADS	7217073	OHM/TADS 1991; SANSS 1986
DOT/UN/NA/IMCO shipping	UN1203, UN1257	RTECS 1990
HSDB	No data	
NCI	No data	

[a]Gasoline is a mixed compound consisting of hydrocarbons, blending agents, and additives.

CAS = Chemical Abstracts Services; DOT/UN/NA/IMCO = Department of Transportation/United Nations/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemicals Substances; SANSS = Structure and Nomenclature Search System

TABLE 3-2. Physical and Chemical Properties of Gasoline

Property	Information	Reference
Molecular weight	108[a]	Anonymous 1989
Color	Colorless to pale brown or pink	Sax and Lewis 1989; Weiss 1986
Physical state	Liquid	Sax and Lewis 1989
Melting point	No data	
Boiling point	Initially, 39°C After 10% distilled, 60°C After 50% distilled, 110°C After 90% distilled, 170°C Final boiling point, 204°C	Budavari et al. 1989; OHM/TADS 1991; Sax and Lewis 1989
Density	0.7-0.8 g/cm^{3}[b]	IARC 1989
Odor	Gasoline odor	Weiss 1986
Odor threshold	0.025 ppm[c]	Weiss 1986
Solubility:		
Water at 20°C	Insoluble	OHM/TADS 1991; Sax and Lewis 1989
Organic solvent(s)	Absolute alcohol, ether, chloroform, benzene	Budavari et al. 1989; Sax and Lewis 1989
Partition coefficients:		
Log K_{ow}	2.13-4.87[d]	Air Force 1989
Log K_{oc}	1.81-4.56[d]	Air Force 1989
Vapor pressure[e]		ASTM 1989
at 60°C	465 mmHg	
at 56°C	518 mmHg	
at 51°C	593 mmHg	
at 47°C	698 mmHg	
at 41°C	773 mmHg	
Henry's law constant:		
at 20°C	4.8×10^{-4}-3.3 m^{3}/mol[d]	Air Force 1989
Autoignition temperature	280-486°C	NEPA 1986; Sax and Lewis 1989; Weiss 1986
Flashpoint	-46°C	Sax and Lewis 1989
Flammability limits	1.4-7.4%	Weiss 1986

TABLE 3-2. Physical and Chemical Properties of Gasoline (*continued*)

Property	Information	Reference
Conversion factors	No data	
Explosive limits	1.3-6.0%	Budavari et al. 1989; Sax and Lewis 1989

[a]Average molecular weight
[b]Temperature not specified
[c]Not specified whether data for air or water
[d]Since data are not available for gasoline, ranges are given indicating different values for the individual components.
[e]The American Society for Testing and Materials (ASTM) has established guidelines on compositions of gasoline that will permit satisfactory performance under varying conditions. These guidelines define five volatility classes that vary by seasonal climatic changes. The values given for vapor pressure at the given temperatures are based on these volatility classes.

TABLE 3-3. Major Components of Gasoline[a]

Component	Percentage Composition[b]	Component
n-alkanes		Other possible components
C_5	3.0	octane enhancers
C_6	11.6	methyl t-butyl ether (MTBE)
C_7	1.2	t-butyl alcohol (TBA)
C_9	0.7	ethanol
C_{10}-C_{13}	0.8	methanol
total of *n*-alkanes	17.3	antioxidants
		N,N'-dialkylphenylenediamines
branched alkanes		2,6-dialkyl and 2,4,6-trialkylphenols
C_4	2.2	butylated methyl, ethyl and dimethyl phenols
C_5	15.1	triethylene tetramine di(monononylphenolate)
C_6	8.0	metal deactivators
C_7	1.9	*N,N'*-disalicylidene-1,2-ethanediamine
C_8	1.8	*N,N'*-disalicylidene-propanediamine
C_9	2.1	*N,N'*-disalicylidene-cyclohexanediamine
C_{10}-C_{13}	1.0	disalicylidene-N-methyl-dipropylene-triamine
total of branched	32.0	ignition controllers
		tri-o-cresylphosphate (TOCP)
cycloalkanes		icing inhibitors
C_6	3.0	isopropyl alcohol
C_7	1.4	detergents/dispersants
C_8	0.6	alkylamine phosphates
total of cycloalkanes	5.0	poly-isobutene amines
		long chain alkyl phenols
olefins		long chain alcohols
C_6	1.8	long chain carboxylic acids
total of olefins	1.8	long chain amines
		corrosion inhibitors
aromarics		carboxylic acids
benzene	3.2	phosphoric acids
toluene	4.8	sulfonic acids
xylenes	6.6	
ethylbenzene	1.4	
C_3-benzenes	4.2	
C_4-benzenes	7.6	
others	2.7	
total aromatics	30.5	

[a]Adapted from Air Force 1989
[b]Percent by weight

Appendix 6: State of Florida MPO laws

339.175 Metropolitan planning organization.—
(1) PURPOSE.—It is the intent of the Legislature to encourage and promote the safe and efficient management, operation, and development of surface transportation systems that will serve the mobility needs of people and freight and foster economic growth and development within and through urbanized areas of this state while minimizing transportation-related fuel consumption, air pollution, and greenhouse gas emissions through metropolitan transportation planning processes identified in this section. To accomplish these objectives, metropolitan planning organizations, referred to in this section as M.P.O.'s, shall develop, in cooperation with the state and public transit operators, transportation plans and programs for metropolitan areas. The plans and programs for each metropolitan area must provide for the development and integrated management and operation of transportation systems and facilities, including pedestrian walkways and bicycle transportation facilities that will function as an intermodal transportation system for the metropolitan area, based upon the prevailing principles provided in s. 334.046(1). The process for developing such plans and programs shall provide for consideration of all modes of transportation and shall be continuing, cooperative, and comprehensive, to the degree appropriate, based on the complexity of the transportation problems to be addressed. To ensure that the process is integrated with the statewide planning process, M.P.O.'s shall develop plans and programs that identify transportation facilities that should function as an integrated metropolitan transportation system, giving emphasis to facilities that serve important national, state, and regional transportation functions. For the purposes of this section, those facilities include the facilities on the Strategic Intermodal System designated under s. 339.63 and facilities for which projects have been identified pursuant to s. 339.2819(4).
(2) DESIGNATION.—
(a)1. An M.P.O. shall be designated for each urbanized area of the state; however, this does not require that an individual M.P.O. be designated for each such area. Such designation shall be accomplished by agreement between the Governor and units of general-purpose local government representing at least 75 percent of the population of the urbanized area; however, the unit of general-purpose local government that represents the central city or cities within the M.P.O. jurisdiction, as defined by the United States Bureau of the Census, must be a party to such agreement.
2. To the extent possible, only one M.P.O. shall be designated for each urbanized area or group of contiguous urbanized areas. More than one M.P.O. may be designated within an existing urbanized area only if the Governor and the existing M.P.O. determine that the size and complexity of the existing urbanized area makes the designation of more than one M.P.O. for the area appropriate.
(b) Each M.P.O. designated in a manner prescribed by Title 23 of the United States Code shall be created and operated under the provisions of this section pursuant to an interlocal agreement entered into pursuant to s. 163.01. The signatories to the interlocal agreement shall be the department and the governmental entities designated by the Governor for membership on the M.P.O. Each M.P.O. shall be considered separate from the state or the governing body of a local government that is represented on the governing board of the M.P.O. or that is a signatory to the interlocal agreement creating the M.P.O. and shall have such powers and privileges that are

provided under s. 163.01. If there is a conflict between this section and s. 163.01, this section prevails.
(c) The jurisdictional boundaries of an M.P.O. shall be determined by agreement between the Governor and the applicable M.P.O. The boundaries must include at least the metropolitan planning area, which is the existing urbanized area and the contiguous area expected to become urbanized within a 20-year forecast period, and may encompass the entire metropolitan statistical area or the consolidated metropolitan statistical area.
(d) In the case of an urbanized area designated as a nonattainment area for ozone or carbon monoxide under the Clean Air Act, 42 U.S.C. ss. 7401 et seq., the boundaries of the metropolitan planning area in existence as of the date of enactment of this paragraph shall be retained, except that the boundaries may be adjusted by agreement of the Governor and affected metropolitan planning organizations in the manner described in this section. If more than one M.P.O. has authority within a metropolitan area or an area that is designated as a nonattainment area, each M.P.O. shall consult with other M.P.O.'s designated for such area and with the state in the coordination of plans and programs required by this section.
(e) The governing body of the M.P.O. shall designate, at a minimum, a chair, vice chair, and agency clerk. The chair and vice chair shall be selected from among the member delegates comprising the governing board. The agency clerk shall be charged with the responsibility of preparing meeting minutes and maintaining agency records. The clerk shall be a member of the M.P.O. governing board, an employee of the M.P.O., or other natural person.

Each M.P.O. required under this section must be fully operative no later than 6 months following its designation.

(3) VOTING MEMBERSHIP.—
(a) The voting membership of an M.P.O. shall consist of not fewer than 5 or more than 19 apportioned members, the exact number to be determined on an equitable geographic-population ratio basis by the Governor, based on an agreement among the affected units of general-purpose local government as required by federal rules and regulations. The Governor, in accordance with 23 U.S.C. s. 134, may also provide for M.P.O. members who represent municipalities to alternate with representatives from other municipalities within the metropolitan planning area that do not have members on the M.P.O. County commission members shall compose not less than one-third of the M.P.O. membership, except for an M.P.O. with more than 15 members located in a county with a 5-member county commission or an M.P.O. with 19 members located in a county with no more than 6 county commissioners, in which case county commission members may compose less than one-third percent of the M.P.O. membership, but all county commissioners must be members. All voting members shall be elected officials of general-purpose local governments, except that an M.P.O. may include, as part of its apportioned voting members, a member of a statutorily authorized planning board, an official of an agency that operates or administers a major mode of transportation, or an official of Space Florida. As used in this section, the term "elected officials of a general-purpose local government" shall exclude constitutional officers, including sheriffs, tax collectors, supervisors of elections, property appraisers, clerks of the court, and similar types of officials. County commissioners shall compose not less than 20 percent of the M.P.O. membership if an official of an agency that operates or administers a major mode of transportation has been appointed to an M.P.O.

(b) In metropolitan areas in which authorities or other agencies have been or may be created by law to perform transportation functions and are performing transportation functions that are not under the jurisdiction of a general-purpose local government represented on the M.P.O., they shall be provided voting membership on the M.P.O. In all other M.P.O.'s where transportation authorities or agencies are to be represented by elected officials from general-purpose local governments, the M.P.O. shall establish a process by which the collective interests of such authorities or other agencies are expressed and conveyed.
(c) Any other provision of this section to the contrary notwithstanding, a chartered county with over 1 million population may elect to reapportion the membership of an M.P.O. whose jurisdiction is wholly within the county. The charter county may exercise the provisions of this paragraph if:
1. The M.P.O. approves the reapportionment plan by a three-fourths vote of its membership;
2. The M.P.O. and the charter county determine that the reapportionment plan is needed to fulfill specific goals and policies applicable to that metropolitan planning area; and
3. The charter county determines the reapportionment plan otherwise complies with all federal requirements pertaining to M.P.O. membership.

Any charter county that elects to exercise the provisions of this paragraph shall notify the Governor in writing.

(d) Any other provision of this section to the contrary notwithstanding, any county chartered under s. 6(e), Art. VIII of the State Constitution may elect to have its county commission serve as the M.P.O., if the M.P.O. jurisdiction is wholly contained within the county. Any charter county that elects to exercise the provisions of this paragraph shall so notify the Governor in writing. Upon receipt of such notification, the Governor must designate the county commission as the M.P.O. The Governor must appoint four additional voting members to the M.P.O., one of whom must be an elected official representing a municipality within the county, one of whom must be an expressway authority member, one of whom must be a person who does not hold elected public office and who resides in the unincorporated portion of the county, and one of whom must be a school board member.
(4) APPORTIONMENT.—
(a) The Governor shall, with the agreement of the affected units of general-purpose local government as required by federal rules and regulations, apportion the membership on the applicable M.P.O. among the various governmental entities within the area. At the request of a majority of the affected units of general-purpose local government comprising an M.P.O., the Governor and a majority of units of general-purpose local government serving on an M.P.O. shall cooperatively agree upon and prescribe who may serve as an alternate member and a method for appointing alternate members who may vote at any M.P.O. meeting that an alternate member attends in place of a regular member. The method shall be set forth as a part of the interlocal agreement describing the M.P.O.'s membership or in the M.P.O.'s operating procedures and bylaws. The governmental entity so designated shall appoint the appropriate number of members to the M.P.O. from eligible officials. Representatives of the department shall serve as nonvoting advisers to the M.P.O. governing board. Additional nonvoting advisers may be appointed by the M.P.O. as deemed necessary; however, to the maximum extent feasible, each M.P.O. shall seek to appoint nonvoting representatives of various multimodal forms of transportation not otherwise represented by voting members of the M.P.O. An M.P.O. shall

appoint nonvoting advisers representing major military installations located within the jurisdictional boundaries of the M.P.O. upon the request of the aforesaid major military installations and subject to the agreement of the M.P.O. All nonvoting advisers may attend and participate fully in governing board meetings but may not vote or be members of the governing board. The Governor shall review the composition of the M.P.O. membership in conjunction with the decennial census as prepared by the United States Department of Commerce, Bureau of the Census, and reapportion it as necessary to comply with subsection (3).

(b) Except for members who represent municipalities on the basis of alternating with representatives from other municipalities that do not have members on the M.P.O. as provided in paragraph (3)(a), the members of an M.P.O. shall serve 4-year terms. Members who represent municipalities on the basis of alternating with representatives from other municipalities that do not have members on the M.P.O. as provided in paragraph (3)(a) may serve terms of up to 4 years as further provided in the interlocal agreement described in paragraph (2)(b). The membership of a member who is a public official automatically terminates upon the member's leaving his or her elective or appointive office for any reason, or may be terminated by a majority vote of the total membership of the entity's governing board represented by the member. A vacancy shall be filled by the original appointing entity. A member may be reappointed for one or more additional 4-year terms.

(c) If a governmental entity fails to fill an assigned appointment to an M.P.O. within 60 days after notification by the Governor of its duty to appoint, that appointment shall be made by the Governor from the eligible representatives of that governmental entity.

(5) AUTHORITY AND RESPONSIBILITY.—The authority and responsibility of an M.P.O. is to manage a continuing, cooperative, and comprehensive transportation planning process that, based upon the prevailing principles provided in s. 334.046(1), results in the development of plans and programs which are consistent, to the maximum extent feasible, with the approved local government comprehensive plans of the units of local government the boundaries of which are within the metropolitan area of the M.P.O. An M.P.O. shall be the forum for cooperative decisionmaking by officials of the affected governmental entities in the development of the plans and programs required by subsections (6), (7), (8), and (9).

(6) POWERS, DUTIES, AND RESPONSIBILITIES.—The powers, privileges, and authority of an M.P.O. are those specified in this section or incorporated in an interlocal agreement authorized under s. 163.01. Each M.P.O. shall perform all acts required by federal or state laws or rules, now and subsequently applicable, which are necessary to qualify for federal aid. It is the intent of this section that each M.P.O. shall be involved in the planning and programming of transportation facilities, including, but not limited to, airports, intercity and high-speed rail lines, seaports, and intermodal facilities, to the extent permitted by state or federal law.

(a) Each M.P.O. shall, in cooperation with the department, develop:

1. A long-range transportation plan pursuant to the requirements of subsection (7);
2. An annually updated transportation improvement program pursuant to the requirements of subsection (8); and
3. An annual unified planning work program pursuant to the requirements of subsection (9).

(b) In developing the long-range transportation plan and the transportation improvement program required under paragraph (a), each M.P.O. shall provide for consideration of projects and strategies that will:

1. Support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity, and efficiency;

2. Increase the safety and security of the transportation system for motorized and nonmotorized users;
3. Increase the accessibility and mobility options available to people and for freight;
4. Protect and enhance the environment, promote energy conservation, and improve quality of life;
5. Enhance the integration and connectivity of the transportation system, across and between modes, for people and freight;
6. Promote efficient system management and operation; and
7. Emphasize the preservation of the existing transportation system.

(c) In order to provide recommendations to the department and local governmental entities regarding transportation plans and programs, each M.P.O. shall:

1. Prepare a congestion management system for the metropolitan area and cooperate with the department in the development of all other transportation management systems required by state or federal law;
2. Assist the department in mapping transportation planning boundaries required by state or federal law;
3. Assist the department in performing its duties relating to access management, functional classification of roads, and data collection;
4. Execute all agreements or certifications necessary to comply with applicable state or federal law;
5. Represent all the jurisdictional areas within the metropolitan area in the formulation of transportation plans and programs required by this section; and
6. Perform all other duties required by state or federal law.

(d) Each M.P.O. shall appoint a technical advisory committee, the members of which shall serve at the pleasure of the M.P.O. The membership of the technical advisory committee must include, whenever possible, planners; engineers; representatives of local aviation authorities, port authorities, and public transit authorities or representatives of aviation departments, seaport departments, and public transit departments of municipal or county governments, as applicable; the school superintendent of each county within the jurisdiction of the M.P.O. or the superintendent's designee; and other appropriate representatives of affected local governments. In addition to any other duties assigned to it by the M.P.O. or by state or federal law, the technical advisory committee is responsible for considering safe access to schools in its review of transportation project priorities, long-range transportation plans, and transportation improvement programs, and shall advise the M.P.O. on such matters. In addition, the technical advisory committee shall coordinate its actions with local school boards and other local programs and organizations within the metropolitan area which participate in school safety activities, such as locally established community traffic safety teams. Local school boards must provide the appropriate M.P.O. with information concerning future school sites and in the coordination of transportation service.

(e)1. Each M.P.O. shall appoint a citizens' advisory committee, the members of which serve at the pleasure of the M.P.O. The membership on the citizens' advisory committee must reflect a broad cross-section of local residents with an interest in the development of an efficient, safe, and cost-effective transportation system. Minorities, the elderly, and the handicapped must be adequately represented.

2. Notwithstanding the provisions of subparagraph 1., an M.P.O. may, with the approval of the department and the applicable federal governmental agency, adopt an alternative program or mechanism to ensure citizen involvement in the transportation planning process.
(f) The department shall allocate to each M.P.O., for the purpose of accomplishing its transportation planning and programming duties, an appropriate amount of federal transportation planning funds.
(g) Each M.P.O. shall have an executive or staff director who reports directly to the M.P.O. governing board for all matters regarding the administration and operation of the M.P.O. and any additional personnel as deemed necessary. The executive director and any additional personnel may be employed either by an M.P.O. or by another governmental entity, such as a county, city, or regional planning council, that has a staff services agreement signed and in effect with the M.P.O. Each M.P.O. may enter into contracts with local or state agencies, private planning firms, private engineering firms, or other public or private entities to accomplish its transportation planning and programming duties and administrative functions.
(h) In order to enhance their knowledge, effectiveness, and participation in the urbanized area transportation planning process, each M.P.O. shall provide training opportunities and training funds specifically for local elected officials and others who serve on an M.P.O. The training opportunities may be conducted by an individual M.P.O. or through statewide and federal training programs and initiatives that are specifically designed to meet the needs of M.P.O. board members.
(i) A chair's coordinating committee is created, composed of the M.P.O.'s serving Hernando, Hillsborough, Manatee, Pasco, Pinellas, Polk, and Sarasota Counties. The committee must, at a minimum:
1. Coordinate transportation projects deemed to be regionally significant by the committee.
2. Review the impact of regionally significant land use decisions on the region.
3. Review all proposed regionally significant transportation projects in the respective transportation improvement programs which affect more than one of the M.P.O.'s represented on the committee.
4. Institute a conflict resolution process to address any conflict that may arise in the planning and programming of such regionally significant projects.
(j)1. The Legislature finds that the state's rapid growth in recent decades has caused many urbanized areas subject to M.P.O. jurisdiction to become contiguous to each other. As a result, various transportation projects may cross from the jurisdiction of one M.P.O. into the jurisdiction of another M.P.O. To more fully accomplish the purposes for which M.P.O.'s have been mandated, M.P.O.'s shall develop coordination mechanisms with one another to expand and improve transportation within the state. The appropriate method of coordination between M.P.O.'s shall vary depending upon the project involved and given local and regional needs. Consequently, it is appropriate to set forth a flexible methodology that can be used by M.P.O.'s to coordinate with other M.P.O.'s and appropriate political subdivisions as circumstances demand.
2. Any M.P.O. may join with any other M.P.O. or any individual political subdivision to coordinate activities or to achieve any federal or state transportation planning or development goals or purposes consistent with federal or state law. When an M.P.O. determines that it is appropriate to join with another M.P.O. or any political subdivision to coordinate activities, the M.P.O. or political subdivision shall enter into an interlocal agreement pursuant to s. 163.01, which, at a minimum, creates a separate legal or administrative entity to coordinate the

transportation planning or development activities required to achieve the goal or purpose; provides the purpose for which the entity is created; provides the duration of the agreement and the entity and specifies how the agreement may be terminated, modified, or rescinded; describes the precise organization of the entity, including who has voting rights on the governing board, whether alternative voting members are provided for, how voting members are appointed, and what the relative voting strength is for each constituent M.P.O. or political subdivision; provides the manner in which the parties to the agreement will provide for the financial support of the entity and payment of costs and expenses of the entity; provides the manner in which funds may be paid to and disbursed from the entity; and provides how members of the entity will resolve disagreements regarding interpretation of the interlocal agreement or disputes relating to the operation of the entity. Such interlocal agreement shall become effective upon its recordation in the official public records of each county in which a member of the entity created by the interlocal agreement has a voting member. This paragraph does not require any M.P.O.'s to merge, combine, or otherwise join together as a single M.P.O.

(7) LONG-RANGE TRANSPORTATION PLAN.—Each M.P.O. must develop a long-range transportation plan that addresses at least a 20-year planning horizon. The plan must include both long-range and short-range strategies and must comply with all other state and federal requirements. The prevailing principles to be considered in the long-range transportation plan are: preserving the existing transportation infrastructure; enhancing Florida's economic competitiveness; and improving travel choices to ensure mobility. The long-range transportation plan must be consistent, to the maximum extent feasible, with future land use elements and the goals, objectives, and policies of the approved local government comprehensive plans of the units of local government located within the jurisdiction of the M.P.O. Each M.P.O. is encouraged to consider strategies that integrate transportation and land use planning to provide for sustainable development and reduce greenhouse gas emissions. The approved long-range transportation plan must be considered by local governments in the development of the transportation elements in local government comprehensive plans and any amendments thereto. The long-range transportation plan must, at a minimum:

(a) Identify transportation facilities, including, but not limited to, major roadways, airports, seaports, spaceports, commuter rail systems, transit systems, and intermodal or multimodal terminals that will function as an integrated metropolitan transportation system. The long-range transportation plan must give emphasis to those transportation facilities that serve national, statewide, or regional functions, and must consider the goals and objectives identified in the Florida Transportation Plan as provided in s. 339.155. If a project is located within the boundaries of more than one M.P.O., the M.P.O.'s must coordinate plans regarding the project in the long-range transportation plan.

(b) Include a financial plan that demonstrates how the plan can be implemented, indicating resources from public and private sources which are reasonably expected to be available to carry out the plan, and recommends any additional financing strategies for needed projects and programs. The financial plan may include, for illustrative purposes, additional projects that would be included in the adopted long-range transportation plan if reasonable additional resources beyond those identified in the financial plan were available. For the purpose of developing the long-range transportation plan, the M.P.O. and the department shall cooperatively develop estimates of funds that will be available to support the plan implementation. Innovative financing techniques may be used to fund needed projects and programs. Such techniques may include the assessment of tolls, the use of value capture financing, or the use of value pricing.

(c) Assess capital investment and other measures necessary to:
1. Ensure the preservation of the existing metropolitan transportation system including requirements for the operation, resurfacing, restoration, and rehabilitation of major roadways and requirements for the operation, maintenance, modernization, and rehabilitation of public transportation facilities; and
2. Make the most efficient use of existing transportation facilities to relieve vehicular congestion and maximize the mobility of people and goods.
(d) Indicate, as appropriate, proposed transportation enhancement activities, including, but not limited to, pedestrian and bicycle facilities, scenic easements, landscaping, historic preservation, mitigation of water pollution due to highway runoff, and control of outdoor advertising.
(e) In addition to the requirements of paragraphs (a)-(d), in metropolitan areas that are classified as nonattainment areas for ozone or carbon monoxide, the M.P.O. must coordinate the development of the long-range transportation plan with the State Implementation Plan developed pursuant to the requirements of the federal Clean Air Act.

In the development of its long-range transportation plan, each M.P.O. must provide the public, affected public agencies, representatives of transportation agency employees, freight shippers, providers of freight transportation services, private providers of transportation, representatives of users of public transit, and other interested parties with a reasonable opportunity to comment on the long-range transportation plan. The long-range transportation plan must be approved by the M.P.O.

(8) TRANSPORTATION IMPROVEMENT PROGRAM.—Each M.P.O. shall, in cooperation with the state and affected public transportation operators, develop a transportation improvement program for the area within the jurisdiction of the M.P.O. In the development of the transportation improvement program, each M.P.O. must provide the public, affected public agencies, representatives of transportation agency employees, freight shippers, providers of freight transportation services, private providers of transportation, representatives of users of public transit, and other interested parties with a reasonable opportunity to comment on the proposed transportation improvement program.
(a) Each M.P.O. is responsible for developing, annually, a list of project priorities and a transportation improvement program. The prevailing principles to be considered by each M.P.O. when developing a list of project priorities and a transportation improvement program are: preserving the existing transportation infrastructure; enhancing Florida's economic competitiveness; and improving travel choices to ensure mobility. The transportation improvement program will be used to initiate federally aided transportation facilities and improvements as well as other transportation facilities and improvements including transit, rail, aviation, spaceport, and port facilities to be funded from the State Transportation Trust Fund within its metropolitan area in accordance with existing and subsequent federal and state laws and rules and regulations related thereto. The transportation improvement program shall be consistent, to the maximum extent feasible, with the approved local government comprehensive plans of the units of local government whose boundaries are within the metropolitan area of the M.P.O. and include those projects programmed pursuant to s. 339.2819(4).
(b) Each M.P.O. annually shall prepare a list of project priorities and shall submit the list to the appropriate district of the department by October 1 of each year; however, the department and a metropolitan planning organization may, in writing, agree to vary this submittal date. Where

more than one M.P.O. exists in an urbanized area, the M.P.O.'s shall coordinate in the development of regionally significant project priorities. The list of project priorities must be formally reviewed by the technical and citizens' advisory committees, and approved by the M.P.O., before it is transmitted to the district. The approved list of project priorities must be used by the district in developing the district work program and must be used by the M.P.O. in developing its transportation improvement program. The annual list of project priorities must be based upon project selection criteria that, at a minimum, consider the following:

1. The approved M.P.O. long-range transportation plan;
2. The Strategic Intermodal System Plan developed under s. 339.64.
3. The priorities developed pursuant to s. 339.2819(4).
4. The results of the transportation management systems; and
5. The M.P.O.'s public-involvement procedures.

(c) The transportation improvement program must, at a minimum:

1. Include projects and project phases to be funded with state or federal funds within the time period of the transportation improvement program and which are recommended for advancement during the next fiscal year and 4 subsequent fiscal years. Such projects and project phases must be consistent, to the maximum extent feasible, with the approved local government comprehensive plans of the units of local government located within the jurisdiction of the M.P.O. For informational purposes, the transportation improvement program shall also include a list of projects to be funded from local or private revenues.
2. Include projects within the metropolitan area which are proposed for funding under 23 U.S.C. s. 134 of the Federal Transit Act and which are consistent with the long-range transportation plan developed under subsection (7).
3. Provide a financial plan that demonstrates how the transportation improvement program can be implemented; indicates the resources, both public and private, that are reasonably expected to be available to accomplish the program; identifies any innovative financing techniques that may be used to fund needed projects and programs; and may include, for illustrative purposes, additional projects that would be included in the approved transportation improvement program if reasonable additional resources beyond those identified in the financial plan were available. Innovative financing techniques may include the assessment of tolls, the use of value capture financing, or the use of value pricing. The transportation improvement program may include a project or project phase only if full funding can reasonably be anticipated to be available for the project or project phase within the time period contemplated for completion of the project or project phase.
4. Group projects and project phases of similar urgency and anticipated staging into appropriate staging periods.
5. Indicate how the transportation improvement program relates to the long-range transportation plan developed under subsection (7), including providing examples of specific projects or project phases that further the goals and policies of the long-range transportation plan.
6. Indicate whether any project or project phase is inconsistent with an approved comprehensive plan of a unit of local government located within the jurisdiction of the M.P.O. If a project is inconsistent with an affected comprehensive plan, the M.P.O. must provide justification for including the project in the transportation improvement program.
7. Indicate how the improvements are consistent, to the maximum extent feasible, with affected seaport, airport, and spaceport master plans and with public transit development plans of the units of local government located within the jurisdiction of the M.P.O. If a project is located

within the boundaries of more than one M.P.O., the M.P.O.'s must coordinate plans regarding the project in the transportation improvement program.
(d) Projects included in the transportation improvement program and that have advanced to the design stage of preliminary engineering may be removed from or rescheduled in a subsequent transportation improvement program only by the joint action of the M.P.O. and the department. Except when recommended in writing by the district secretary for good cause, any project removed from or rescheduled in a subsequent transportation improvement program shall not be rescheduled by the M.P.O. in that subsequent program earlier than the 5th year of such program.
(e) During the development of the transportation improvement program, the M.P.O. shall, in cooperation with the department and any affected public transit operation, provide citizens, affected public agencies, representatives of transportation agency employees, freight shippers, providers of freight transportation services, private providers of transportation, representatives of users of public transit, and other interested parties with reasonable notice of and an opportunity to comment on the proposed program.
(f) The adopted annual transportation improvement program for M.P.O.'s in nonattainment or maintenance areas must be submitted to the district secretary and the Department of Economic Opportunity at least 90 days before the submission of the state transportation improvement program by the department to the appropriate federal agencies. The annual transportation improvement program for M.P.O.'s in attainment areas must be submitted to the district secretary and the Department of Economic Opportunity at least 45 days before the department submits the state transportation improvement program to the appropriate federal agencies; however, the department, the Department of Economic Opportunity, and a metropolitan planning organization may, in writing, agree to vary this submittal date. The Governor or the Governor's designee shall review and approve each transportation improvement program and any amendments thereto.
(g) The Department of Economic Opportunity shall review the annual transportation improvement program of each M.P.O. for consistency with the approved local government comprehensive plans of the units of local government whose boundaries are within the metropolitan area of each M.P.O. and shall identify those projects that are inconsistent with such comprehensive plans. The Department of Economic Opportunity shall notify an M.P.O. of any transportation projects contained in its transportation improvement program which are inconsistent with the approved local government comprehensive plans of the units of local government whose boundaries are within the metropolitan area of the M.P.O.
(h) The M.P.O. shall annually publish or otherwise make available for public review the annual listing of projects for which federal funds have been obligated in the preceding year. Project monitoring systems must be maintained by those agencies responsible for obligating federal funds and made accessible to the M.P.O.'s.
(9) UNIFIED PLANNING WORK PROGRAM.—Each M.P.O. shall develop, in cooperation with the department and public transportation providers, a unified planning work program that lists all planning tasks to be undertaken during the program year. The unified planning work program must provide a complete description of each planning task and an estimated budget therefor and must comply with applicable state and federal law.
(10) AGREEMENTS.—
(a) Each M.P.O. shall execute the following written agreements, which shall be reviewed, and updated as necessary, every 5 years:

1. An agreement with the department clearly establishing the cooperative relationship essential to accomplish the transportation planning requirements of state and federal law.
2. An agreement with the metropolitan and regional intergovernmental coordination and review agencies serving the metropolitan areas, specifying the means by which activities will be coordinated and how transportation planning and programming will be part of the comprehensive planned development of the area.
3. An agreement with operators of public transportation systems, including transit systems, commuter rail systems, airports, seaports, and spaceports, describing the means by which activities will be coordinated and specifying how public transit, commuter rail, aviation, seaport, and aerospace planning and programming will be part of the comprehensive planned development of the metropolitan area.
(b) An M.P.O. may execute other agreements required by state or federal law or as necessary to properly accomplish its functions.
(11) METROPOLITAN PLANNING ORGANIZATION ADVISORY COUNCIL.—
(a) A Metropolitan Planning Organization Advisory Council is created to augment, and not supplant, the role of the individual M.P.O.'s in the cooperative transportation planning process described in this section.
(b) The council shall consist of one representative from each M.P.O. and shall elect a chairperson annually from its number. Each M.P.O. shall also elect an alternate representative from each M.P.O. to vote in the absence of the representative. Members of the council do not receive any compensation for their services, but may be reimbursed from funds made available to council members for travel and per diem expenses incurred in the performance of their council duties as provided in s. 112.061.
(c) The powers and duties of the Metropolitan Planning Organization Advisory Council are to:
1. Enter into contracts with individuals, private corporations, and public agencies.
2. Acquire, own, operate, maintain, sell, or lease personal property essential for the conduct of business.
3. Accept funds, grants, assistance, gifts, or bequests from private, local, state, or federal sources.
4. Establish bylaws and adopt rules pursuant to ss. 120.536(1) and 120.54 to implement provisions of law conferring powers or duties upon it.
5. Assist M.P.O.'s in carrying out the urbanized area transportation planning process by serving as the principal forum for collective policy discussion pursuant to law.
6. Serve as a clearinghouse for review and comment by M.P.O.'s on the Florida Transportation Plan and on other issues required to comply with federal or state law in carrying out the urbanized area transportation and systematic planning processes instituted pursuant to s. 339.155.
7. Employ an executive director and such other staff as necessary to perform adequately the functions of the council, within budgetary limitations. The executive director and staff are exempt from part II of chapter 110 and serve at the direction and control of the council. The council is assigned to the Office of the Secretary of the Department of Transportation for fiscal and accountability purposes, but it shall otherwise function independently of the control and direction of the department.
8. Adopt an agency strategic plan that provides the priority directions the agency will take to carry out its mission within the context of the state comprehensive plan and any other statutory mandates and directions given to the agency.

(12) APPLICATION OF FEDERAL LAW.—Upon notification by an agency of the Federal Government that any provision of this section conflicts with federal laws or regulations, such federal laws or regulations will take precedence to the extent of the conflict until such conflict is resolved. The department or an M.P.O. may take any necessary action to comply with such federal laws and regulations or to continue to remain eligible to receive federal funds.
(13) VOTING REQUIREMENTS.—Each long-range transportation plan required pursuant to subsection (7), each annually updated Transportation Improvement Program required under subsection (8), and each amendment that affects projects in the first 3 years of such plans and programs must be approved by each M.P.O. on a recorded roll call vote, or hand-counted vote, of a majority of the membership present.
History.—s. 1, ch. 79-219; s. 1, ch. 82-9; s. 219, ch. 84-309; s. 3, ch. 84-332; s. 30, ch. 85-55; ss. 1, 2, ch. 87-61; ss. 1, 2, ch. 88-86; s. 1, ch. 88-163; s. 6, ch. 89-301; s. 79, ch. 90-136; s. 4, ch. 92-152; s. 60, ch. 93-164; s. 502, ch. 95-148; s. 54, ch. 95-257; s. 53, ch. 96-323; s. 25, ch. 97-280; s. 70, ch. 98-200; s. 9, ch. 99-256; ss. 33, 103, ch. 99-385; s. 20, ch. 2000-266; s. 23, ch. 2002-183; s. 8, ch. 2003-286; s. 4, ch. 2004-366; s. 6, ch. 2005-281; s. 22, ch. 2005-290; s. 40, ch. 2007-196; s. 70, ch. 2008-4; s. 30, ch. 2008-227; s. 240, ch. 2011-142; s. 55, ch. 2012-174.
Note.—Former s. 334.215.

Appendix 7: Complete White House Executive Order

BRIEFING ROOM

Executive Order on Strengthening American Leadership in Clean Cars and Trucks

AUGUST 05, 2021 • PRESIDENTIAL ACTIONS

By the authority vested in me as President by the Constitution and the laws of the United States of America, and in order to promote the interests of American workers, businesses, consumers, and communities, it is hereby ordered as follows:

Section 1. Policy. America must lead the world on clean and efficient cars and trucks. That means bolstering our domestic market by setting a goal that 50 percent of all new passenger cars and light trucks sold in 2030 be zero-emission vehicles, including battery electric, plug-in hybrid electric, or fuel cell electric vehicles. My Administration will prioritize setting clear standards, expanding key infrastructure, spurring critical innovation, and investing in the American autoworker. This will allow us to boost jobs — with good pay and benefits — across the United States along the full supply chain for the automotive sector, from parts and equipment manufacturing to final assembly.

It is the policy of my Administration to advance these objectives in order to improve our economy and public health, boost energy security, secure consumer savings, advance environmental justice, and address the climate crisis.

Sec. 2. Light-, Medium-, and Certain Heavy-Duty Vehicles Multi-Pollutant and Fuel Economy Standards for 2027 and Later.

(a) The Administrator of the Environmental Protection Agency (EPA) shall, as appropriate and consistent with applicable law, consider beginning work on a rulemaking under the Clean Air Act (42 U.S.C. 7401-7671q) to establish new multi-pollutant emissions standards, including for greenhouse

gas emissions, for light- and medium-duty vehicles beginning with model year 2027 and extending through and including at least model year 2030.

(b) The Secretary of Transportation shall, as appropriate and consistent with applicable law, consider beginning work on a rulemaking under the Energy Independence and Security Act of 2007 (Public Law 110-140, 121 Stat. 1492) (EISA) to establish new fuel economy standards for passenger cars and light-duty trucks beginning with model year 2027 and extending through and including at least model year 2030.

(c) The Secretary of Transportation shall, as appropriate and consistent with applicable law, consider beginning work on a rulemaking under EISA to establish new fuel efficiency standards for heavy-duty pickup trucks and vans beginning with model year 2028 and extending through and including at least model year 2030.

Sec. 3. Heavy-Duty Engines and Vehicles Multi-Pollutant Standards for 2027 and Later. (a) The Administrator of the EPA shall, as appropriate and consistent with applicable law, consider beginning work on a rulemaking under the Clean Air Act to establish new oxides of nitrogen standards for heavy-duty engines and vehicles beginning with model year 2027 and extending through and including at least model year 2030.

(b) The Administrator of the EPA shall, as appropriate and consistent with applicable law, and in consideration of the role that zero-emission heavy-duty vehicles might have in reducing emissions from certain market segments, consider updating the existing greenhouse gas emissions standards for heavy-duty engines and vehicles beginning with model year 2027 and extending through and including at least model year 2029.

Sec. 4. Medium- and Heavy-Duty Engines and Vehicles Greenhouse Gas and Fuel Efficiency Standards as Soon as 2030 and Later. (a) The Administrator of the EPA shall, as appropriate and consistent with applicable law, consider beginning work on a rulemaking under the Clean Air Act to establish new greenhouse gas emissions standards for heavy-duty engines and vehicles to begin as soon as model year 2030.

(b) The Secretary of Transportation shall, as appropriate and consistent

with applicable law, consider beginning work on a rulemaking under EISA to establish new fuel efficiency standards for medium- and heavy-duty engines and vehicles to begin as soon as model year 2030.

Sec. 5. Rulemaking Targets. (a) With respect to the rulemaking described in section 3(a) of this order, the Administrator of the EPA shall, as appropriate and consistent with applicable law, consider issuing a notice of proposed rulemaking by January 2022 and any final rulemaking by December 2022.

(b) With respect to the other rulemakings described in section 2 and section 4 of this order, the Secretary of Transportation and the Administrator of the EPA shall, as appropriate and consistent with applicable law, consider issuing any final rulemakings no later than July 2024.

Sec. 6. Coordination and Engagement. (a) The Secretary of Transportation and the Administrator of the EPA shall coordinate, as appropriate and consistent with applicable law, during the consideration of any rulemakings pursuant to this order.

(b) The Secretary of Transportation and the Administrator of the EPA shall consult with the Secretaries of Commerce, Labor, and Energy on ways to achieve the goals laid out in section 1 of this order, to accelerate innovation and manufacturing in the automotive sector, to strengthen the domestic supply chain for that sector, and to grow jobs that provide good pay and benefits.

(c) Given the significant expertise and historical leadership demonstrated by the State of California with respect to establishing emissions standards for light-, medium-, and heavy-duty vehicles, the Administrator of the EPA shall coordinate the agency's activities pursuant to sections 2 through 4 of this order, as appropriate and consistent with applicable law, with the State of California as well as other States that are leading the way in reducing vehicle emissions, including by adopting California's standards.

(d) In carrying out any of the actions described in this order, the Secretary of Transportation and the Administrator of the EPA shall seek input from a diverse range of stakeholders, including representatives from labor unions,

States, industry, environmental justice organizations, and public health experts.

Sec. 7. General Provisions. (a) Nothing in this order shall be construed to impair or otherwise affect:

(i) the authority granted by law to an executive department or agency, or the head thereof; or

(ii) the functions of the Director of the Office of Management and Budget relating to budgetary, administrative, or legislative proposals.

(b) This order shall be implemented consistent with applicable law and subject to the availability of appropriations.

(c) This order is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

JOSEPH R. BIDEN JR.

THE WHITE HOUSE
August 5, 2021.