

LOW-CARBON FUEL (LCF) VEHICLE OWNERS

JANUARY 2023 ONLINE QUALITATIVE STUDY

REPORT PREPARED MAY 18th, 2023

CONSUMER REPORTS® SURVEY GROUP

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INTRODUCTION

Consumer Reports conducted an online discussion board on vehicles that run on low carbon fuel from January 30-31, 2023. Schlesinger Group (now Sago) hosted the study using its QualBoard platform. Consumer Reports conducted this qualitative study to learn more about the experiences and views of thirty-one Americans who own vehicles that can run on low-carbon fuels (LCFs) besides electricity—that is, not hybrid or electric vehicles, but those that run on ethanol, biodiesel, hydrogen fuel cells, and so on.

REPORT HIGHLIGHTS

- Most people in this study feel that low-carbon fuels (LCFs) are better for the environment than conventional diesel or gasoline.
- Familiarity with LCFs varies widely even among respondents, and most say that they feel the general public does not know much—or anything—about LCFs.
 - Suggestions for improving people’s familiarity with the idea of LCFs include greater advertising and more information from dealerships when people are shopping.
 - Some did not know their vehicle was capable of using LCFs when they purchased it, or did not really know what that meant. One didn’t realize it until she was asked to join this study.
- Some got LCF-capable vehicles specifically with environmental protection in mind. Others chose their vehicles for other reasons but view the environmental protection as a nice benefit.
- Many mention having trouble finding low-carbon fuel in their area at least sometimes, so while their vehicles *can* take LCFs, they do not always use them. Some never do.
 - For some, the flexibility is a benefit, as it means they can use environmentally-friendly fuels when possible but fuel with “regular” fuel when that isn’t available.
 - Others worry that changing between fuel types would damage the engine and avoid doing so.
 - Exception: seven people in this study use vehicles that run on hydrogen fuel cells, which can *only* take that kind of fuel. For them, running out of fuel is a real concern that limits how far and where they can drive.
- Many are unsure which type of fuel is best for the vehicle (or whether some could harm it) and whether switching between different types of fuel might be bad for the engine/vehicle.
- While most have not had any engine trouble or issues with the longevity of their vehicles—which are at most four years old—many mention concern that LCF vehicles might require more intensive or more expensive maintenance than those that run on conventional fuels.
- Common reasons that people got their own vehicles and circumstances they think would encourage others to get LCF-capable vehicles include financial incentives; dependable **availability of LCFs at fueling stations; and the availability of vehicles that fit a person’s general needs and just happen to be capable of running on LCF.**
 - Convenience seems to be the key for those less motivated by the environmental aspect. If a vehicle otherwise meets their needs and they can fuel it with LCF for about the same cost as conventional fuels, they will do so, but they do not purchase a vehicle specifically because it can take LCFs and will not drive out of their way to a different fuel station.
 - Contrast that with some others (especially those who drive hydrogen-powered vehicles) who are primarily motivated by protecting the environment.

- Many seem to consider LCF vehicles as an intermediate step toward an even more environmentally-friendly future. They anticipate their next vehicle being fully electric, or the vehicle landscape in the US gradually shifting to predominantly electric.

PROFILE OF LCF VEHICLE USERS IN THIS STUDY

FUEL TYPES USED

We asked the owners of LCF-capable vehicles what types of fuel they used. Around a fifth of the participants in the study, seven people, drive hydrogen fueled vehicles, most of them ($n = 6$) Toyota Mirais. Vehicles that run on hydrogen take it exclusively and cannot use any other form of fuel. However, the rest of the vehicles in the study appear capable of running on multiple types of fuel—biodiesel or diesel, gas or ethanol, etc.—and the bulk of the remaining participants switch between fuels at least sometimes. The most common fuel type drivers in this study mentioned was biodiesel (11 people use it at least sometimes), followed by gasoline (9 use it at least sometimes). Six use ethanol at least part of the time; the same is true for diesel. See Appendix C, page 36.

Most of the gas and diesel users appear to use that fuel sometimes and a LCF other times. Only five say they never use any kind of LCF. Two would like to, but have trouble finding it, and another didn't know her vehicle could.

- "I have not tried using biodiesel yet. Have not seen that as an option in my local gas stations which is why I have stuck with regular gas." – Francis
- "I like the option it's just difficult finding a station where it [biodiesel] is present." - Jonathon
- Kristen is also in a similar position. She implies there are more EV charging stations than fueling stations carrying ethanol in her area: "I have looked into this option of putting ethanol into my truck but I do not see that as a convenient because I can never find any resources for it. I see more options for plug in cars more than anything in my hometown."

On the other hand, Jocelyn did not know her Range Rover could run on anything besides gasoline until she was invited to participate in this study. It was a gift from her parents, and "I had little involvement in the selection process of the vehicle. I had no idea that I could use any other fuel than gasoline. When I asked my parents, they were also unaware that this particular truck could consume low-carbon fuels."

Some people who do not use LCFs appear to have been advised against using them. While Jerry says that ethanol played a role in his decision to get the vehicle he did, and that the dealership told him his vehicle could run on it, he uses only "premium unleaded gas" because someone at the dealership advised that instead. (For more, see page 21.) Similarly, while it is possible that Christine 2¹ uses biodiesel sometimes, she says she will "usually fill the car up with diesel gas because it runs best on that."

¹ There are two Christines in the study, so in the absence of permission to use last initials, I have distinguished them as Christine 1 and Christine 2. In this report, you will also see quotes from "Anonymous A" and "Anonymous B," who did not give permission for their first names to be used.

While those five (Francis, Jonathon, Kristen, Jocelyn, and Jerry) never use LCF, three others say they rarely use LCF. All three probably would use it more, but have encountered barriers.

- Similar to how Jerry was told to use only premium unleaded gas, Sally isn't sure which fuel is right to use, though she used a few different ethanol fuels at different times. She reports conflicting information **in her truck's user manual** that makes her unsure whether it runs **best on a certain kind of fuel and, if so, which**: "What really confuses me right now is the owners manual saying to keep a 87 or higher octane level. How do you accomplish that if the ethanol product is only a 85? [...] Is the ethanol blended unleaded as low carbon as the E85?"
- For Madison, the issue is access, because she is not willing to go out of her way to fill up; there is only one station, on the way to visit family, that she ever uses to fuel with LCF.
- For Veronique, it is an issue of both access and cost: "Biodiesel is always a bit more expensive than regular gas, but ethanol (E85) is cheaper for now, but not all fuel stations offer it readily, and they're not always on my way."

Seven sometimes use LCF. Availability and price tend to affect what they use. Some of these people will actively seek out LCFs, while others do not. Three usually use LCF. Finally, eleven say they always or almost always use LCF. This includes the seven who drive hydrogen fuel cell vehicles, which cannot take any conventional fuel.

Please note that the divisions between "rarely," "sometimes," and "usually" are blurry. Some people gave more detail on their situations than others, and some may have used more forceful language than others who were actually in a similar situation.

For the people who switch between different types of fuel—that is, everyone except the five who "never" use LCF and the eleven who "always" do—Martyna summarizes: "Sometimes the price difference and sometimes the convenience. For instance if there is no low-carbon fuel where I am and need to fill up, I won't go look for the gas station that has it because I simply don't have too much time for that." Similarly, Ryan writes, "The decision that I make to use either diesel or biodiesel is usually dependent on what I have access to at that time, and if both are equally available which one is more cost effective."²

WHAT PEOPLE DO WITH LCF-CAPABLE VEHICLES

People use their LCF-capable vehicles for all kinds of purposes, from commuting to hauling. Exactly what depends on the type of vehicle itself and, sometimes, the type of fuel they have it in it at a given time.

² "Cost effective" can be a complex analysis, weighing fuel cost and fuel economy for different types of fuel. Chrissy, for instance, can go further on a tank of ethanol fuel than biodiesel—see top of page 16. Or consider Ryan's quote in more context: "When I purchased the truck I originally did not make a big consideration out of the biodiesel fuel but the more that I use the truck the more I realized that I could save money on expenses by using diesel instead of gasoline and that it lasted longer and resulted in more fuel savings for me. Although the diesel itself is more expensive the fuel efficiency ended up being very valuable to me and my family." When asked about choosing between biodiesel and regular diesel, he says availability and cost both play a role: "Based on availability at the different fuel stations that I use I could use biodiesel in place of regular diesel if regular diesel either wasn't available or if biodiesel was less than the actual diesel fuel. These decisions between gasoline and Diesel and biodiesel always end up being economical for me and I'm trying to use the fuel cost and the fuel efficiency when I make my decisions as to which fuel to use and purchase."

For example, people who drive LCF-capable pickups mention towing:

"I use this for trip[s] to my dad's ranch in Roseville, CA. He has many animals and also hauls a lot of stuff back and forth because he is rebuilding his main home. I drive [it] on the weekends mostly when I'm working on Dad's farm." - Roan on his Silverado

"I use it for everything because it has great cabin space and good towing capacity. We hook up the boat to it on the weekends and toss the bikes in the back for weekly mountain biking." -Chrissy on her Silverado

"We use it to do heavy lifting and towing types of jobs that you would typically do with a pickup truck." -Ryan on his Dodge Ram

While most people (with the exception of those who drive hydrogen fueled vehicles) do use their vehicles for long trips, some people change the fuel they use when they do so. For some people, these are the only opportunities they have to actually use LCF, because there are no places to fuel with it near their homes. Ken says that "We normally put regular diesel fuel in the truck as that is what is available where we live. I will look for biodiesel when we are traveling outside of our local area."

For others, though, long travel means leaving known sources of LCF. They either use other fuels while traveling or use a different vehicle to travel. This is especially salient for who drive hydrogen-fueled cars. Since these can only run on hydrogen, most avoid using them for lengthy travel or outside the areas they know have hydrogen fueling stations. Christine 1, who has a Mirai, says "I usually use it for running errands since I don't have to travel very far in my day-to-day." On the other hand, another Mirai driver, Gina, does use it for road trips, along with commuting. For more, see "Barriers and Problems" section, page 16.

Of course, some don't change their fuel at all. Crystal, who uses her truck for "everything from running errands to road trips," only uses biodiesel; people who only use conventional fuel do not switch either.

When asked, no one mentioned using different kinds of fuel for different purposes. Instead, what kind of **fuel people use seems to be driven by availability, cost, and the driver's level of interest in** low-carbon fuels.

Similarly, when asked what they like and dislike about their vehicles, fuel simply **didn't come** up for some people. Instead, they people mention things like how well the vehicle runs, how much it tows, its comfort, size (cargo/passenger space, but also the difficulties of finding a parking spot), their attitudes toward the brand, and so on. Those who mention the fuels usually mention them in an environmental context:

- "I think that it's a great vehicle if you care about the environment" – Rachel
- "I don't like that they don't sell LCF at all gas stations and that gas stations stop selling LCF even though customers are used to buying it. I like that I'm making a difference in our environment and leaving a smaller carbon footprint. I also like how you get more mileage per gallon of gas." -Crystal

LCF AWARENESS

Part of this study focused on how much people know about LCFs, when they became aware of them, and what they think other people (those who don't own LCF-capable vehicles themselves) think or know about them. Awareness of the variety and uses of LCFs varied widely even among the respondents, with some people not aware that their vehicle *could* use LCFs until after they had purchased it, while others purchased it specifically for that reason.

KNOWING WHETHER YOUR OWN VEHICLE CAN TAKE LCF

Jocelyn is the only person in this survey who appears to not have known that her vehicle could take LCFs until she screened into the survey. However, quite a few found out sometime after making the purchase, and others didn't know when they bought their LCF-capable vehicle exactly what that meant. Some say the dealership didn't stress or explain that information enough; **some still have questions and had to figure out a lot on their own.**

"I actually didn't know about the low carbon fuel until we had already signed for the car," Kristen writes: "I learned from the salesman what my truck can do after I had already purchased it. I don't mentioned it being brought up when I was looking."

Crystal says that "I actually did know that it could take low-carbon fuels. [But] I didn't know all of the low-carbon fuels that it could take. [...] Initially, I heard that it took biodiesel fuel. I then learned from car shopping and research that it also takes E85 and high octane fuels as well."

Sometimes, people are first exposed to LCFs or steered in that direction at a dealership. (For more on the role of dealerships in promoting familiarity with LCFs, see page 21.) These people **knew their vehicle could use LCFs when they bought them, but did not come in looking for LCF-capable vehicles.**

- Christine 1, who wanted to buy an eco-friendly vehicle and ideally a Toyota, expressed her interest in hybrid or electric vehicles to a salesperson, who mentioned the Mirai.
- Madison was already looking at her vehicle "because of the exterior and color. I then learned about the specs, such as biodiesel capabilities, from the salesman."
- Tomario was looking for a larger vehicle: "I went to the dealership and they showed me all of the options for the Chevy Tahoe, and they told me a lot about the low-carbon fuel Tahoe vehicles they had available. And I was skeptical at first but they told me more information, and I was able to test drive the vehicles."
- Justin "got a lot of information from the spokesperson," but knew LCFs were an option beforehand.

But some people seem to know a lot; these tend to be people who wanted to purchase an environmentally-friendly vehicle and did research to land specifically on their LCF vehicle. Some people were explicitly looking for a low carbon fuel vehicle. Roan "initially saw this vehicle being showcased at a car and truck trade show back in 2018/2019." Mark "was looking for a vehicle that could be used for lowering my carbon footprint on the environment. I did a little bit of research online and then ended up from that research online selecting a couple vehicles I was interested in. I started out going to the Ford dealership in my area and they were able to guide me through the process."

FIRST HEARING ABOUT LCFs IN GENERAL

As those quotes show, for some people, the dealership is their first experience hearing about LCFs at all. Several people found out about LCFs **in the process of shopping for this vehicle.**

- "first heard about low carbon fuels when I was purchasing this vehicle." – Ryan
- "first heard about LCF vehicles during my online car search. I was initially searching for car dealerships that sell electric vehicles but a few LCF vehicles popped up in my search as well."
-Crystal
- Richard wrote that a friend discussed LCFs with him, "which I found interesting and chose to give it a try. When we got to the dealership, they gave reasons and expertise advice, which has been [beneficial]."
- "After the dealer explained to me that I could buy a pickup truck that took low carbon fuel, I started researching and was surprised that there were far more cars than I realized that offered it. And cars I would not expect." -Chrissy

Still others did not even know LCFs existed, let alone that their vehicles could use LCFs, until *after* they bought them! Michael writes that "I've heard about LCFs fairly recently as it pertains to passenger vehicles. A few years ago when I found out my impala was able to use E85 fuel. [...] I found out when I saw a small e85 sticker in my rear passenger window. [...] Several months after I bought it!" Similarly, Sally writes that she first heard about LCFs "In the owner's manual of [her current] vehicle" and she "found the info to be quite confusing at first." (For Sally's full experience, see box on page 9.)

On the other hand, some had been aware of LCFs for a long time. Jocelyn "first heard of low-carbon fuels such as natural gasses and biofuels in high school and college when discussing the Earth's resources for a science project." Others had heard about it due to [an interest in cars in general](#):

- "a blog about cars as I oftentimes read them" -Rachel
- A family member who works for GM mentioned it (Martyna)
- Stumbling upon it "when I was doing some reading on electric cars I was considering at the time" -Ken
- Gina, too, was looking into EVs when she heard about hydrogen-powered vehicles.
- Adolfo had been aware of LCFs for a while, but "They didn't really excite me because of the pollution levels. I heard about how VW had an issue with their emissions as it related to diesel. I heard about ethanol and the damage it could cause to engines. In my mind they were not real environmental options and did not feel as if I was detaching from fossil fuels." It was not until he received a promotional package in the mail from Toyota, and was invited to be a test driver for the first-generation Mirai, that he considered getting one.

[Several people heard about LCFs from their friends](#), especially friends who owned LCF vehicles.

- "A friend of mine was talking about his low-carbon fuel vehicle, and my curiosity is piqued." - Mark
- "A close friend that has one and talked us into it" -Melody
- "From my friends that had compressed natural gas (CNG) and hydrogen fuel cell electric vehicles (FCEV)" -Al
- Edin had heard of LCFs generally at some point, but found out about his specific vehicle (Mirai) from "my friend circle," in which people had gotten hybrids and EVs before, and possibly LCF-capable vehicles as well.

A few people learned about LCFs in general from [ads](#): "I heard about low carbon fuels when I watched tv commercials, but I did not really understand what they were until I went to visit the dealership," Tomario says. Anonymous B mentioned "Social media and targeted ads."

Sally's Experience

Sally's response, while lengthy, is evocative of the confusion some people have over their LCF-capable vehicles.

The dealership labeled it under flex fuel. Very minimal was discussed beyond that.

In reading the manual I learned the following:

1. The gas cap is yellow to identify the vehicles flex fuel and LCF capability.

(There's also a little removable tag on the cap retainer that says to see the manual)

2. While the vehicle is capable of operating with different fuels, including LCFs; continuous switching from one to the other is NOT recommended.

(Still researching why)

3. With the different fuel type capability, the lowest octane should be 87.

That's where the confusion really began. I've just read about the flex fuels and some of them only have an 84 to 86 octane, now I'm reading I shouldn't use those?

What?

So, do I have to buy additives to carry with me to insure proper octane?

If the truck can use E85, do I have to use only E85?

(Manual says don't switch back and forth)

Recapping the thought process...the truck is flex fuel and can operate on the ethanol to non ethanol spectrum.

Yet, I am to pick one and stay using just that one? Doesn't that contradict the whole flex fuel concept?

Again, where I live, the fuel choices can come down to diesel or gas. That would mean switching from a LCF that I might find in a big city or while traveling. (Refer to owners manual saying not to switch back and forth).

THOUGHTS ABOUT LCFs

*"I generally think about vehicles that can take LCFs as an equal to **better versions of normal vehicles**. [...] I believe efficiency and reduced carbon footprint will improve in the near future." -Michael*

I asked people think beyond their own vehicle and tell me their overall impressions of LCF-capable vehicles. In general, responses were glowing and **focused on the environmental benefits of low-carbon fuel**. In a typical response, Ryan writes that "I have a very good impression of vehicles that take low carbon fuels because I can appreciate the innovation in advancement in this area and I think it's a noble effort to be looking for gasoline alternatives."

- "I feel it's safer, useful and makes me think higher of them." -Melody
- "I absolutely love the approach to reducing carbon emissions in vehicles" – Sally
- "I believe these vehicles are extraordinary invention, for number of different reasons. They provide meaningful, very comfortable alternative means of transportation while being environment friendly." -Edin.

Some, like Chrissy and Crystal, also say they get better mileage (“and in some instances lower fuel prices,” Crystal adds).

A few are not so bubbly.

“My impression is that most other LCFV [that is, not hydrogen-fueled] are just as bad as the gasoline cars as it comes to exhaust issues.” -Adolfo

“Overall impression is that the low-carbon fuels are not as efficient / can potentially harm engines. but they are also better for the environment and generally costs less per gallon of gas.” -Justin

“I think that they are comparable to other vehicles. However, my fear is that the low carbon aspect is more of a tactic to purchase a higher price vehicle when users might purchase standard gasoline more because it is readily available.” -Mark

As far as other impressions go, “They tend to look sleeker and usually are made by foreign (especially Japanese and Korean car manufacturers). Those cars also more reliable in general,” Chrissy says. Christine 1 writes that LCF-fueled vehicles are “pretty luxurious and high-tech feeling,” though that could be based on her own experience with a Mirai.

OTHER PEOPLE'S THOUGHTS ABOUT LCFs

Next, I asked what impression (if any) these LCF-capable vehicle owners thought people in general have of LCF-capable vehicles. Many said that people **just don't know much about them**, and several suggested that that unfamiliarity makes people opposed to getting one. Quite a few mentioned that companies should advertise their vehicles more to promote familiarity with the concept!

“I don't think that people know that they exist at all honestly. I haven't heard anyone talk about them, whether that's in my social circle, amongst my family members, or even online/social media” - Christine 1

“I would say that most of my friends / general in public are still uneasy about low carbon fuels. They question the harm the engine takes by running something that can be infiltrated with water more regularly. [...] I feel like they are uneasy because they are not as well informed about them. Getting commercials out there to raise better awareness. Having informational booths at auto shows and tech shows. I feel like you gotta get people super excited about it before car companies will start to push more of these types of vehicles into production.” -Justin

“I feel that a lot of people are not well educated about low-carbon fuel vehicles, because they are not talked about much on social media nor seen on the commercials or newspapers.” -Tomario

“In my area they are so new that very few realize or know enough information about them.” -Jon

“I think people know less about the alternative of low-carbon fuel vehicles because they are also more standard, it is hard to see the difference, because they look like normal cars, but the Teslas, etc, have had more media coverage because of their owner. So it is mostly media coverage, I would say.” -Veronique

“Most do not have any idea what it is. I had to explain it.” -Jonathon

“I'd say probably futuristic and high tech since they're still pretty new to the market and normally the EV ones take all the shine. I believe that companies should do a better job promoting them.” - Rachel

"I think not enough people are educated about LCF vehicles and the ones that are educated aren't thoroughly educated. They think it's high maintenance and require extra money for fuel, repairs, etc. Consumers also aren't always aware that you can get fuel from some regular gas stations." -Crystal

"Most people have no idea what the car is, and think it's a regular gas car--they don't understand where hydrogen stations are, and it's not widely advertised even in a metro city like San Francisco. I have to explain it and they most likely don't understand, but I think they get my car doesn't take gas. They ask a lot about the range and how much it costs, but that is about the limit to the questions." - Gina (who drives a hydrogen-fueled vehicle)

"They are afraid, mainly due to the fueling infrastructure and the limited range" - Anonymous B (also a hydrogen-fueled vehicle, thus the 'range' comment)

On the other hand, Jerry "think[s] they are well know[n] and advertising seen by most people[.] I believe in the dealership people tell them as well."

For those who know about LCFs, the attitudes they hold may be mixed:

- "For people who know about them, I think the impression is they are better for the environment, but come with a higher price tag and the risk of not being able to find the right fuel. I think people also see them as more futuristic and maybe a slight status symbol." - Chrissy
- "In the conversations I've had it seems to be 50/50. One side doesn't like the idea of low carbon fuels due to the cost and availability. The other side believes we should only use low carbon fuel because it reduces our carbon footprints and we should do whatever in our power to do so." -Anastasia

Martyna offered family and friends a chance to test drive her vehicle: "They couldn't tell much difference."

We asked a few people if they think awareness of LCFs compares to awareness of hybrid or electric vehicles:

- "Absolutely not!!! I didn't even know about them until after talking to a friend of mine who owns one and helped talk us into it. I was blown away with the lack of knowledge out there and even how dealers don't talk about it!" -Melody
- "In my experience, they are less well-known than EVs and Hybrids. I think Tesla is the reason why EVs have gained so much traction and before that Hybrids were making headway. Toyota and Hyundai made a name for themselves in the Hybrid department. Most of the people who know about the LCFV if they are in the market for buying a newer car or have recently bought one." -Chrissy

Sally on Others' Views of LCF

Again, Sally's response is lengthy, illustrative, and evocative. It is included in full here.

Wow, that's a 4 coffee pot question.

To stay at just one, I will take the (popular in my area) generational perspective in a story type format.

Rancher "Doc" has his grandpa's old truck that once used regular gas. This truck is iconic in town and super dependable on the ranch. No, it doesn't smoke or leak fluids, and it is considered more of a family member than a vehicle. Doc has his own 20 year old diesel truck. Doc swears it's more dependable and cost effective than anything you can buy today.

A conversation about LCFs and carbon footprints will lead to a very firm discussion about...yes, you guessed it...the government and the environmentalists who he feels have no clue what it takes to put a steak in the grocery store. Like many older americans whose vehicles are daily workers, the thought of stepping into the new technology is akin to falling into an empty pit. They stick to the tried and true that has served them well for generations. In their world, hard work, dirty hands and astounding dedication has produced a life they love. Anyone with ideas to upset that wagon without having done the hardwork is in for a battle. Doc repairs his own equipment when it breaks and can't imagine the extra costs of having "a new-fangled computerized " piece that requires a waste of his time to take to town for repairs. (Remember that time away from the ranch equals work not done and money lost).

Part two:

Now that you have Doc's story, we move on to his son "John", who left the ranch with his big plans and a smart phone.

John comes to visit in his new LCF car.

The father and son vehicle conversation ensues. By the end of the conversation, John has presented his vehicle in a manner that would make any manufacturer proud. Doc just shakes his head in dismay as he thinks the tech world has stolen his son. (There goes Doc's dreams of John taking over the ranch).

This may sound far fetched or perhaps you know someone who stands on the tried and true of older quality equipment workmanship. Either way, there is a percentage of the population that sees an almost alien influence barreling towards them. Without any real proof of quality, dependability or previous experience, the LCF vehicle world is not welcomed. Some of these same people have already had to meet government enforced environmental guidelines at their own expense.

As the younger generations evolve, the technological advancements in vehicles are becoming more accepted and desired.

Good, bad or indifferent, there are and will be various mindsets towards LCFs.

I believe that knowledge and understanding will promote a wider acceptance of the LCFs in the near future.

Interviewer: Thank you! You've drawn a really great picture of how people think about these vehicles. Now, a hopefully shorter question--half a cup of coffee, not four pots: In your experience, have people heard of low-

carbon fuel vehicles before this conversation in your story happens? Doc is aware of "computerized" new vehicles, but has he heard of things that run on something other than gas or diesel before his son shows up?

If you don't know, that's fine too; just curious.

Like most of us raised in truly rural areas, most of what is known about LCF vehicles could be considered what we call, scuttlebutt. Information that comes in tidbits during social gatherings or over coffee at the cafe.

Some is drawn from magazine articles or radio and tv programs.

Doc is aware of alternative fuel vehicles but says he has about as much interest in them "as the brown residue on his workboots."

REASONS FOR GETTING AN LCF-CAPABLE VEHICLE

CHOOSING THEIR CURRENT VEHICLES

For some people in this study, the low-carbon fuel capability was a key reason they chose their vehicle. Some were driven by environmental protection, others by potential cost savings.

"Last few years, we became alarmed about our environment. We live in a part of the country experiencing extreme drought and heat waves, so climate change, for us at least, was real. We implemented few changes in our daily behavior and since we needed new vehicle, going EV or hybrid, was almost no brainer. It happened, around the same time, gas prices was around \$6 around here so . . . We put 2 and 2 together and made a decision to switch from gas powered vehicle to low carbon." -Edin

He later adds, "We were thinking about EV but my wife didn't exactly like available models."

"The fuel was a huge part of the reason I chose my current vehicle. The price and fuel efficiency for a truck are a tough thing to get so I thought being able to use this fuel would be an advantage and still do. [...] Trucks are not known for good gas mileage and that was something I wanted to get the best value in that I could to offset fuel costs. [...] I considered electric but I don't feel like they are tested and proven yet." - Justin

"Environmental aspects were really a big thing to me." – Martyna

"I chose a Tahoe because it's a low-carbon fuel vehicle and I wanted to 'do my part' and get something that was good for the environment. I also never had a truck before so it was a win-win situation." -Crystal

"I chose it because I always wanted a pickup truck and the low-carbon fuels aspect was a huge factor in decision making. Other pickup trucks have horrible range and with the high costs of gas today, this has been a boon for me and my family." -Chrissy

"I chose it because of environmental reasons / lower carbon emissions, being better for the environment. It makes me feel better about my carbon footprint, and I want to do what I can to be a good human being, but obviously within my budget constraints." -Christine 1

Anastasia makes a vague reference to regulations in the state she and her father live in or used to live in, saying that it requires low-carbon fuels. (The vehicle in question is her father's pickup, which he usually fuels with biodiesel.)

For others, LCF capability was just one factor among many. A few people mentioned positive experiences with other vehicles in that brand or model line.

- Jon is an excellent example: "I have had multiple Ford Explorers and honestly the fact that this one had the low carbon fuels option just happened to be [an] accident. I have however grown to see the multiple advantages."
- In another common sentiment, Veronique lists her other reasons and then adds, "The fact that it can handle some ethanol is a plus, as I am trying to reduce my environmental footprint."
- "I'm a big Toyota fan girl, since my first car (Camry) was a Toyota, and so I turned to Toyota when I was on the hunt for my next car after graduating school and moving to SF. [...] I was open to a hybrid or EV which I communicated to my salesperson, and he proposed the Mirai. he really sold me on it based on the environmental factors and the financial incentives to buying one." -Christine 1
- Jerry likes other Fords he's had and other features of this vehicle: "trusted brand in my opinion. I also like the strong engines for quick acceleration, rear-wheel-drive, and for handling and towing if I'm going on trip with family or hiking. Great safety features." He says that the fact it can take ethanol also played a role in his decision, even though he doesn't currently fuel with it: "Ethanol also has a higher octane number than gasoline, giving my vehicle increased power and performance. I would think fewer miles per gallon, clean, renewable energy."

Some mention incentives, like sales, tax breaks, or free fuel, for buying LCF-capable vehicles. Mirai drivers, in particular, seem to have benefitted from a suite of incentives from Toyota and from the state of California as well a federal tax credit. (Toyota apparently gives three years of free hydrogen fuel to Mirai purchasers, especially valuable as the price of hydrogen is increasing.) Not all of these incentives are financial: Gina returned to the fact that she can use the car pool lane on her commute several times across the course of the interview.

"We get a car pool lane sticker which saves our commute times in half, which is the reason we did it. We also save so much time not going to the gas station and makes road trips easier with kids. Also, the 3 years of free fuel was a big selling point, as hydrogen is kind of pricey." --Gina

"I looked at the financial aspect and the Mirai came out on top. Toyota provides for great incentives." -Adolfo

"And they had a great price on the vehicle, and I could help the environment, and save money." --Tomario

"That particular [vehicle] that takes low-carbon fuel had [a] few thousand dollars discount on it so that kind of made me make that decision. [...] I think the discount was related to no one buying the car at that time and it was sitting at the lot for couple of months." -Martyna, describing a discount that may not have been related to the vehicle being LCF-capable.

"Discounts, rebates, and tax credit. [...] I believe it added up to \$8000-\$9000. If I remember correctly, government credit was about \$7000 and rest was available through manufacturer. \$20000 [possibly typo for \$2,000] Toyota discount, \$4500 CA clean fuel rebate, \$8000 federal tax credit for

fuel cell vehicle." Elsewhere, he writes, "We got them because of the vehicle incentives, the fuel incentives and the cars build quality, not to mention that they are environmentally friendly." -- Anonymous B

"Definitely being fueled by hydrogen and emitting water was a primary reason for me to purchase this vehicle. Also Toyota had great deals on the Mirais around the timeframe (March 2021) I was buying the vehicle." – Anonymous A

Some did not mention the LCF capability at all or said it played no part in their decision. For example, for Ken, the main factors were interest in a GM pickup with good towing capabilities. "In this case the ability to use low carbon fuels did not play a factor, however if given a choice between biodiesel or regular diesel I will choose biodiesel and I do make an effort to try and find it."³

Other examples of people who chose their vehicles for reasons other than LCF capability:

- Jonathon, who has never used LCFs—he is interested, but doesn't have access locally—said that the primary reason he bought his vehicle was "the lower load floor and new rear suspension, and the rear seats feel more spacious and the ride is smoother. We also enjoy the driver-assistance aids, including the adaptive cruise control, blind-spot monitoring, rear cross-traffic alert, reverse automatic emergency braking, a rear-camera mirror, lane-changing assist, park assist and a head-up display."
- "I chose to get this vehicle not necessarily because of the low carbon fuels but because it's an excellent pickup truck and I needed one that was a little heavier than the other Ram that we also own." -Ryan

ADVANTAGES OF LCF

These themes carry over from the vehicle purchase process to current thoughts and attitudes. When we asked LCF-capable vehicle owners **what they liked about their vehicles, many listed off factors unrelated to the LCF itself**. For instance, Anonymous B writes that his Mirai's "features are that of a luxury vehicle which we didn't expect at all," and Kristen likes feeling up high and protected in her F150. Others like the towing capability and interior technology in their vehicles.

As for LCF itself, as discussed elsewhere (e.g., page 9), **many people appreciate the environmental friendliness** of these fuels. **But LCF emerges as something people like for less abstract reasons, too, especially cost and range**. Chrissy sums up: "Pros of owning a low carbon fuel vehicle: Reduced Emissions, Tax Breaks, low operating costs and eco-friendly."

Other people have similar positive observations about LCFs saving money or having better range:

- "The few occasions where I've been able to obtain biodiesel it's either been the same price, or no more than .20 cents more (which is about the price I'm willing to spend to "feel good" about the fuel I'm putting into my truck :-)" -Ken
- Crystal says that biodiesel prices are lower than she expected, "and I can drive a lot longer on a full tank."
- "If I put in biodiesel, I can get about 550 miles per tank. If I put in ethanol, I can get a range of as much as 1000 miles. I prefer to use ethanol for obvious reasons. . . . I love how I get such a long range when use E85 (ethanol) and I prefer that over other biodiesel because it is

³ Elsewhere, Ken writes, "While I am low carbon fuel vehicle aware, that did not influence my decision to purchase this truck. It is a nice "bonus" for me and gives me a certain amount of "feel good factor" to know this huge truck is a low carbon fuel vehicle."

slightly cheaper. Almost every gas station near me offers E85, which is very convenient.” - Chrissy, who gets better range with LCFs than conventional fuels, but especially ethanol, as described here.

Richard says he also saves money on maintenance costs: “Regular fuel and gasoline have a way of making my car heated and I spend more on repairs, unlike biodiesels, which has great and enormous friendly usage.”

BARRIERS AND PROBLEMS

CONCERNS: HOW FUEL AFFECTS MAINTENANCE AND COSTS

Many people say they had no concerns related to LCF when they got their vehicles. Among those who did, one common theme is **whether it is bad for the vehicle to switch between fuels**. Another, related theme is **not being certain which fuels are best for the vehicle**.

“My main concern was how my vehicle would react to using biodiesel and maybe using regular fuel if I couldn’t afford biodiesel at times. I was also concerned if there was any added maintenance and/or repairs because my vehicle takes different fuels.” -Crystal

“I had some concerns about what gas stations would have the low carbon fuels and also if it would matter if I mixed gas types because I did not want to damage the engine. For example, I envisioned a scenario where I would be driving across the state and needing to top off my gas before embarking on a long stretch of road where there would be no gas stations. I was concerned that if I had a half tank of low carbon fuel in the gas tank, but the only had access to a gas station that sold regular gas, how would that affect the car? [...] I do make sure to monitor the ratio of different fuel types and I use different tanks for each fuel type. I am still concerned about this scenario happening, but that is why I take extra caution.” -Chrissy

“Does using low carbon fuel protect the vehicles engine and parts better over using regular fuel?” -Frances

Jocelyn, who just found out her vehicle can take other types of fuel, is concerned that she may have damaged hers by running it on premium gasoline only: “I am now wondering how premium gasoline is affecting my car. Which fuel is best for my engine long-term etc.? I don’t have any concerns about maintenance and repair because I get my car checked on with the dealership at its designated times and they handle all maintenance. I would add that who will be responsible if my car engine fails because of my choice of fuel?”

While some people were uncertain which type of fuel was best for their vehicle, others confidently said that one type was best—but these were not the same for everyone. Of course, different vehicles may have different optimal fuels, but clearly there is both confusion and conflicting advice among LCF owners. Some examples of conflicting views on which fuels are best for vehicles:

- “The fuel [biodiesel] is what is safe and right for my car and engine to keep it in top shape or running its best.” – Melody
- “I usually fill the car up with diesel gas because it runs best on that.” -Christine 2
- “We tend to purchase the high premium gasoline to maintain the engine.” – Jonathon

Another related theme is concern about **longevity and repair**.

“For the low-carbon, I think my greatest worry is that it would upset the cylinders and reduce engine life, or use up the spark plugs more quickly.” -Veronique

“I currently have new concerns about longevity and how the LFC will effect internal engine components in the long term. Will I have the same low maintenance costs? What problems do LCF vehicles have?” --Sally

Christine 1 has a similar concern about **how long her vehicle will last and what repairs will cost**. “I’m also concerned about the longevity of my Mirai, how long it’ll last/run for, and how much maintenance will add up over the years.”

For those who drive hydrogen vehicles, cost is a problem—or, for Mirai owners still using their three years’ worth of free fuel from Toyota, a concern for the future. There is also **range anxiety**, like with other EVs—see box below.

“Cost of the fuel- it’s pricey and we hope it goes down as this becomes more popular.” -Gina

“I had a concern about the access to hydrogen stations in long trips. I also had a concern about the price of hydrogen.” Both of these concerns have been borne out: “Yes, there has been times when I go to fuel hydrogen and the station is down. Moreover, the price of hydrogen is almost 27 dollars and it takes about 119 to fill up the car. I am concerned that if process do not drop the alternative fuel may not be around for long. A lot of difficulties with delivery of the fuel. [...] I pumped hydrogen approximately 15 times. Of those times there was a time when the hose was broken. So I went to the other station. That pump was also broken. I returned home and the following day I checked, internet search, to see of the pumps were on line and they were. The other time I had to wait approximately 20 mins so that the pump came back on line. The point of sale system was not working properly and I called the company. They said they would send a tech but it came back on line after a few minutes.” – Adolfo

“Even when you can find Hydrogen, cost to consumers have doubled in less than 3 months, with no sign of decreasing.” – Anonymous A

“Probably the biggest thing someone can be missing about the experience of owning a vehicle that can use low-carbon fuels is that hydrogen supply chain issues are real, and it really does affect you. I think there’s a hydrogen shortage right now, so the prices are kind of insane.” -Christine 1

When LCF Means Range Anxiety

Some LCF-capable vehicle drivers suffer from similar constraints as EV drivers: range anxiety and concern about finding charging stations. Those whose vehicles can also take standard fuel can find diesel or gasoline if necessary; some have a strong preference for LCFs, but even they have used that as a fallback occasionally. Chrissy, for instance, says, “I have tried to use only low-carbon fuels with the exception of maybe 3 or 4 times when I had no alternatives because I was on empty and needed whatever gas was available.”

However, people whose vehicles run on hydrogen are more constrained. One can think of hydrogen-fueled vehicles as a special kind of EV, one that generates its own electricity through hydrogen fuel cells rather than by plugging in to charge. However, that hydrogen has to come from somewhere, and hydrogen fueling stations are even rarer than charging stations. Christine 1 has to plan trips around limited access to hydrogen fuel stations: “I don’t have difficulty finding a fueling station in the nearby area since I’m in the bay, but if I had to do a bay to SoCal trip, that can get tricky.” Adolfo

agrees: “we typically use it to commute and running local errands. No road trips at this time and none are planned because of the lack of a stable and expansive infrastructure.”

Edin says “it’s used for city drive, 100%.”

Anonymous A says: “I primarily drive this vehicle for running errands. As much as I would like to make it my primary car, and drive it everywhere I go, I am limited by Hydrogen availability.”

Elsewhere, he writes about range anxiety and how he cannot count on the few hydrogen fueling stations there are to be open: “For sure the environmental benefit was the primary driving factor in my decision to purchase the Mirai about 22 months ago. Having said that, as much as I would like to always drive it, it gets less than 25% of my overall driving, due to the lack of stable and abundant hydrogen fueling infrastructure.[...] If I was comfortable with Hydrogen availability, I would always drive my Mirai. Unfortunately that is seldom. Hydrogen fueling stations or down on and off. My neighboring station has been up for less than 50% in the last six months. Between San Francisco and Los Angeles, there is just 1 Hydrogen fueling station in Coalinga/Harris Ranch on Interstate I-5, which is down at times too. I drive often between San Francisco and Los Angeles and always take my gasoline vehicle.”

PROBLEMS WITH THE VEHICLE

Most people in this study say they haven’t had any problems with their vehicles yet. (Note that these are new vehicles—the oldest are model year 2020.) Mark is typical in that the only maintenance issues he’s had have been “just replacing minor parts. It is not a cost thing with that really. It is just more the fear of having to do something that is very costly in the future involving the engine.” Chrissy writes that the cons of owning a low carbon fuel vehicle are “expensive upkeep, more expensive initial cost, limited availability and lack of compatibility.” The only person who seems to have needed major repairs is Sally, whose pickup has engine trouble even though she has owned it less than a year.

On the other hand, Roan mentions that “I just needed to change [mechanics], because my former mechanic was resistant towards using alternate **fuels/electric...** He has no desire to learn about it, so I fired him. I just want to have a mechanic who is thoroughly well versed in all fuel types, alternative and otherwise.”

Instead, the most common problem people mention is difficulty finding LCFs.

PROBLEMS WITH FUEL

When we asked people who do not always use LCFs why not, the most common issue (among those who were interested) was availability: **LCFs are not available everywhere, or they are not as affordable as traditional fuels.** Martyna sums it up nicely: “Sometimes the price difference and sometimes the convenience. For instance if there is no low-carbon fuel where I am and need to fill up, I won’t go look for the gas station that has it because I simply don’t have too much time for that.”

“I wish I could say that I have more access to low carbon (biodiesel) fuel than I do. The local dealer/convenience store stopped selling biodiesel shortly after I bought my truck. I do make an effort when traveling outside of my normal “footprint” to find biodiesel. I have owned several diesel vehicles as an adult and generally prefer them so looking for biodiesel is not new to me and it’s just something I do.” –Ken

“Limited availability in the mountains where I live.” –Sally

"At first I didn't use LCF because I didn't know where to get it from in my area so my father would do it. I've since found a gas station in my area." -Crystal

"I fuel with gas because it's hard to find stations that offer biodiesel here." -Frances

"I try to use the low carbon one as much as possible. It just needs to be available or convenient for me to get." -Mark

Expense can factor in as well as availability: "Biodiesel is always a bit more expensive than regular gas, but ethanol (E85) is cheaper for now, but not all fuel stations offer it readily, and they're not always on my way. I try also not to drive for nothing, that saves up even more than fueling up."
- Veronique

ENCOURAGING LCF USE

In one part of the study, we asked "What do you think would encourage people to use low-carbon fuels?" People replied both with *information* they think would encourage people to use LCF and with *changes* that might encourage people to get EVs, such as wider availability of LCFs at more fuel stations.

Many replies involved an element of education—the idea that first, people have to know LCFs exist and what they are.

- "Educating them about the availability and the benefits." -Chrissy
- "A better understanding of the LCF systems" would be one way to encourage people to get them. – Sally
- "I was hesitant to purchase but after really getting to know about the fuel and how it can help environmentally I was sold." - Justin, speaking of his own experience

In fact, **familiarity with the idea of LCFs** is a common theme from both people like Anastasia, who did not know much about LCFs before this study, and people like Anonymous A, who got his hydrogen-fueled vehicle in part because of the LCF.

- "Education on low carbon fuels needs to be implemented more!!! It's a choice that doesn't change the quality of the vehicle. The only issue would be availability and I feel if we demand it, it would be in supply more" -Anastasia
- "Education on benefits of LCFs, Rewarded being "Trailblazers" - Tax credits/incentives, transparency about vehicles and fueling infrastructure." -Anonymous A

Advertisements are a common suggestion for achieving greater awareness.

- "Maybe to get them to know them more by the commercials because people are usually afraid of things they are not familiar with." -Martyna
- "I think more professional/universal advertising. Get people in front of the general public that can speak to the benefits." -Justin
- "[I]f people don't know what they are they won't research and they need to be marketed as I only see ads for electric cars." -Gina
- "I feel that if consumers had more social media and tv presence showing the benefits of the vehicles. And showing what companies make them, and what low-carbon fuel means, and show if they are cheaper to use versus 87 gas and higher octane vehicles. Then I feel that

would catch the attention of other consumers, and if there was a tax break that might also catch people's attention." -Tomario

Kristen, however, suggests word of mouth: "I think being informed is the most important factor. If people don't know then they may or may not want to adventure that route on their own to find out about. Word of mouth is the best advertisement."

Others list **improvements in manufacturing and infrastructure that would help**:

- "We need LCF to be more widely available, have better fuel economy, require less maintenance." -Jonathon
- "Wider availability of low-carbon fuel." -Mark
- Roan mentions an array of "nudges" already happening in the Bay Area, where he lives, to get people off fossil fuels: "The nudge is (aggressive ads on tv, billboards, politicians pushing it, social media mass marketing, slogans, incentives etc) What would draw people toward low-carbon: health benefits/clean air, saves money, is better for the car itself, is good for vehicle performance, etc."

Financial incentives are also a common theme. Here are just some of many mentions:

"I think most people would be incentivized to try low-carbon fuels based on the financial incentives available to them so it really needs to be clear and strong enough that there are Financial wins to be had to merit somebody buying a new vehicle and also investing in new fuel sources." -Ryan

"Definitely some tax incentives would encourage people as well as being able to find the low carbon fuel in many gas stations." -Frances

"I really think that the biggest draw for them is that tax incentive / fueling credit, and if those were no longer available, people would not be encouraged to use low-carbon fuels/cars..." -Christine 1

"Incentives, absolutely, more than anything else. Quite a few of my friends/colleagues used government incentives for purchase of electric vehicles in the years past. [A] few actually mentioned they weren't actually ready to jump the ship if it wasn't for credits." -Edin

"Government subsidies would definitely help, a program that would show the advantages and drawbacks, and more fueling stations for every kind of low-carbon fuel vehicles." – Veronique

"Financial incentives. Many people virtue signal about alternative fuels but do not act if the cost is greater." - Michael

Like Michael, Ken talks about smoothing the path for the transition to alternative fuels: "Make it seamless. I also think to not make a big deal about it being low carbon. I think there is a small percentage of folks that will buy a vehicle based on the fact that it is low carbon. If it fits their needs, and is in their price range they are going to buy it. If it happens to be a low carbon fuel vehicle all the better."

The Role of Dealerships in LCF Education and Purchasing

Several people mentioned the role dealerships played in their purchasing process. Others also raise questions about the buying process and wish that dealerships had told them more. Dealerships play a key role, and clearly some handle it very differently from others.

For some people, dealers were a source of information and some even persuaded them to get LCF-capable vehicles. For instance, Tomario writes that "I heard about low carbon fuels when I watched tv commercials, but I did not really understand what they were until I went to visit the dealership. And the dealership salesman Mike was able to breakdown what low-carbon fuels are and how they help the environment and myself."

Chrissy is one of those who heard about LCFs for the first time while shopping for a new vehicle. "I wanted a pickup truck, but was not aware of the low carbon fuel options. When I went to the dealer to test drive some trucks, I learned about the low carbon fuel options. After learning about this, but before I pulled the trigger on my Chevy, I researched some other low carbon fuel trucks and SUVs." Jonathon writes that "We primarily purchased the vehicle for its of reasons: comfort, spacious, technology and then the salesman talked about the biodiesel option which gave us a reason to buy the car." (However, he primarily fuels it with gasoline "to maintain the engine.")

On the other hand, some dealers seem averse to low-carbon fuels, or uninformed themselves. Edin writes that "we weren't exactly sure about couple of things" after owning the vehicle for a while and "took it to dealership to ask around. I realized then that maintenance personnel could've been provided with better training themselves." In addition, when I asked Jerry why he fuels his vehicle with gasoline rather than ethanol, he replied "The online research and was convinced by dealership." He confirmed that the dealership advised him to use gas. I asked if he remembered what advantages they said gas had over the low-carbon fuels; he said, "I remember the salesman trying to push me on the sale to sell me different models. I seen a jeep wrangler, sedan, and I'm thinking he didn't care."

Melody writes that "I didn't even know about them until after talking to a friend of mine who owns one and helped talk us into it. I was blown away with the lack of knowledge out there and even how dealers don't talk about it!"

Sally writes, "I would encourage dealerships and manufacturers to clarify ALL cost/benefit parameters so a consumer can truly make an informed choice." (In her shopping experience, "The dealership labeled it under flex fuel. Very minimal was discussed beyond that.")

Finally, Adolfo observes, "At the dealerships dealers are trying to shake you down for more money so if they can sell you the vehicle with more bells and whistles and disiade [typo, possibly for dissuade] you from the LCFV then the costumer will likely walk out without a LCFV. What dealers do and don't makes a huge difference in the costumers' choice."

*I find it interesting but not very knowledgeable about low-carbon fuels and I have a lot of questions. For example, how can switching fuels now affect my engine? Also, **why was this information not spotlighted during the buying process?***

-Jocelyn, who just found out through this study that her vehicle can run on LCF

LCF GROWTH OPPORTUNITIES

For several drivers in this study, what they think would encourage others to use LCFs mirrors their own experiences. *Many of those who use LCFs in their vehicles only sometimes seem open to doing so more often if they had access, or if prices were more comparable to other fuels.* These people's descriptions of their driving habits echo Ken's observation about the importance of making the transition to alternative fuels "seamless."

Several of these drivers seem to use LCFs because they *might as well*—they won't put in much work to seek them out, either in purchasing a vehicle or fueling it, but will use them if it is convenient. "The low-carbon fuels were a perk," Veronique writes, "and I have a few stations nearby that offers this so I can fuel up on this easily." Madison, who got her vehicle based on its price, appearance, and fit for her needs, writes that the fact it can run on biodiesel "really didn't play much of a role. I like the idea of helping the environment as much as I can so I liked the sounds of it but really wasn't too concerned."

Others express similar sentiments or say they felt that way at first and *came to really appreciate the LCF capabilities, especially if that saved them money.* For instance, Ryan "bought this pickup truck because I was looking for something that was more functional and more heavy duty than the pickup truck that my family currently owns and in that case the low carbon fuel consideration was not a main factor in my decision-making actually. I would be interested to know how many people bought vehicles that use low carbon fuels and then discovered the fuel economy and savings of them when they purchased a vehicle for completely **different reasons.**" He says he "ultimately end[ed] up using the biodiesel more than I anticipated because of how fuel efficient the fuel is while using the vehicle." Similarly, Tomario says, "I feel that for me I have always loved Chevy Tahoe vehicles, but I feel that the low-carbon fuel did play a slight role. Because I found out that I could help the environment, but *get better mileage and have an engine that runs smoother and more clean.*" In other words, *if people get a vehicle that they like that just happens to be LCF-capable, and there are LCFs available and affordable in their area, they will use those fuels.*

Of course, affordability also depends a bit on fuel economy. Ryan fuels based on what he has access to and, if he has a choice, which one goes farther: "I'm the type of person that votes with my dollars, so if diesel ends up being less expensive and more fuel efficient than biodiesel at that time I'm obviously going to buy diesel and the same is true for biodiesel."

Another stumbling block is access to LCFs. As mentioned elsewhere, many drivers of hydrogen-fueled vehicles would be happy to use their vehicles for longer trips if the infrastructure would allow it.

- Michael writes that "I put regular diesel in my truck primarily because LCFs are not readily available in my area"; later, he writes, "unfortunately it's not even remotely convenient to obtain."
- "I live in rural Appalachia so mostly I use regular gas."⁴ - Jon
- Martyna, who usually uses regular diesel in her vehicle, does put in biodiesel when it is available but won't go out of her way to a station specifically because it has biodiesel: "I'm not going to drive around in traffic just to find the biodiesel fuel."

⁴ When asked if this was due to availability or other considerations, like performance when driving on mountain roads, he confirms the issue is availability.

It seems access is expanding in some areas, at least. Jon writes that “Accessibility is the issue. As I said live in rural Appalachia and many stations currently don't offer. However, as time is progressing many are moving toward the availability.”

There may be other unexpected benefits of using LCF as well; Anastasia writes that “My dad says when he’s using low carbon fuel for long periods his car is more silent and runs smoother.” Mark writes that he isn’t “getting the full benefit of the low carbon aspect of the vehicle” because “I am not using the low carbon type of fuel because of the lack of availability.” It is unclear what benefit he had in mind—to himself, the vehicle, or possibly the environment.

WOULD YOU GET IT AGAIN?

Most people in this study, when asked, said they would get their vehicle again—though usually their satisfaction or dissatisfaction with the vehicles was based on factors other than its LCF capability. The exceptions all drive hydrogen fuel cell vehicles. Anonymous B, as a Mirai owner, liked that he got free fuel; Christine 1 liked the tax rebates and other financial incentives; and Adolfo is not pleased with the rising cost of hydrogen fuel. He would get the same car, he writes, but he would lease it instead of buying it.

LCF AND LIFESTYLE

WHAT PEOPLE SHOULD KNOW

We asked LCF-capable vehicle owners what they think people should know before buying or leasing a vehicle that can use LCFs, and whether there is anything they wish they had known before getting theirs.

The most common theme was [awareness of whether or where LCF might be available](#):

- “That not every gas station has that kind of fuel available if you really bought the car to use that certain fuel type.” -Martyna
- “I think they have to know the area they live in and how close they are to stations” -Gina
- “They should have the expectation to most likely buy standard fuel as opposed to the other options” due to “difficulty finding low-carbon fuel.” -Mark
- “They should check for the availability of fuel and the proximity.” -Richard
- “If none around you then doesn't make too much sense to buy one.” -Kristen

Those who own hydrogen fuel cell-powered vehicles also mention being aware of [range](#)—see Gina’s comment above.

Another, closely-related theme was [research](#):

- “Make sure it is actually something that fits your needs” -Edin
- “I think they should know about the locations where they can obtain biodiesel as well as the range and benefits for the environment and the vehicle while using biodiesel fuel. Also it would be nice to know if the vehicle comes with any special incentives or tax breaks” -- Frances

[Cost](#) comes up too. Chrissy says, “I would tell them to be prepared to pay a little more up front, but then the costs over the long run, in terms of gas/fuel/energy, will be much less, so it is worth it.”

Tomario also mentions [fuel cost, as well as availability](#): “I feel that people should know that low-carbon fuel vehicles give you a smooth ride, but at times there are a lot of places that do not sale

E85 fuel. And at the same time they need to know that some places will charge you more than regular 87 to fuel your vehicle. And also low-carbon fuel vehicles are not thought of in small towns, and may be hard to fuel."

A few also mention EVs and hybrids, perhaps on the assumption that someone considering LCF would be considering other environmentally-friendly vehicles.

- "Suggest an apples to oranges comparison of an LCF vehicle to a fully electric or even a hybrid. Balance the personal needs to what vehicle you'll want." – Michael
- "Drivers have a better understanding of ho[w] to maintain a low-carbon vehicle as compared with an electric vehicle." -Veronique

Finally, several mentioned that **people should know LCFs are better for the planet**. Crystal frames this in terms of heading off potential concerns people might have about maintenance or cost (see Barriers and Problems section, page 16): "They should know that yes, it's reducing your carbon footprint but not high maintenance and very economical." Roan mentions that he had to change mechanics because his didn't want to work on alternate fuel vehicles, and this is something others may want to keep in mind—but "they should know that in the end, you are saving the planet, and doing your part!"

RECOMMENDING LCF

Next, we asked whether these people would recommend using low-carbon fuels to a friend or family member, and whether there are certain people or uses that they would recommend it to more than others. Some said they would recommend them to anyone, like Melody: "I feel it's best for anyone wanting to make a change and difference and doing something better for our environment. That's why we switched besides just needing a new car and the quality. I'd recommend it to anyone!"

Only a few said they would not recommend LCFs at all. All of those people said they would recommend fully electric vehicles instead.

- "I would not recommend it because essentially I am not seeing the major benefits of using low-carbon fuel at this moment. There are not a lot of gas stations with low-carbon fuel near my friends or family either so they would be left to use mixed gasoline and low-carbon when they can find it or complete gasoline, which defeats the point. I would honestly suggest going completely electric." – Jocelyn (the one who did not know her vehicle could take non-gasoline fuels until she was asked to join this study)
- "I don't think I'd really recommend to a friend or family member to get a low-carbon fuel car as I think it wouldn't make sense for them given the accessibility of electric vehicles and electric charging stations & the current discounted prices on the Teslas right now." -Christine¹
- "I personally would recommend an electric vehicle instead of a low carbon fuel vehicle. To me it's more convenient to just get home and plug my car in and not have to worry about stopping at a gas station to cold weather to get fuel." -Frances⁵

Many people take **logistics** into account when considering whether they would recommend LCF.

⁵ However, when asked if there are any situations where she thinks a low-carbon fueled vehicle would be a better fit, she said, "I would say probably more of a better option for road trips if they don't want to stop as much to charge like they would with an electric vehicle."

"I would [recommend it] just because I like to make that little impact for our environment but I know it might not be a good idea for people that have long commutes and live in the area where it's harder to get that type of fuel." -Martyna

"I would absolutely recommend anyone consider a low carbon fuel vehicle and in my case, a diesel powered vehicle. I have always been a fan of diesel power and now and for the past 20 or so years diesels have gotten quieter and perform better to the point that they often outperform their gasoline powered models. I would tend to recommend diesel powered vehicles to folks I know who drive longer distances where the diesel economy and drivability really shines." -Ken

"I believe that I would advise anyone of the benefits of LCF vehicles in suburban and urban areas. While I might discuss what I know and have learned about them in my situation to those in comparable rural areas. There's more to consider than just believing you are helping the environment by buying one. Fuel sources are much more readily available in urban areas. Owning a flex fuel vehicle gives you options but again if the supply of any fuel is limited than the low carbon footprint would seemingly go right out the window." - Sally

"I would recommend equally to everyone, because if it is a first car, you will be immersed already in that more environmentally-friendly fuel alternatives. I think rural or city, it is similar, because it is a matter of availability, so I think city-dwellers have an advantage... Those who like road trips, I would recommend because this kind of truck would reduce their overall fuel bill... as long as they have a good Google map to guide them to fuel stations who have these options." -Veronique

Michael would recommend vehicles that can use LCF, but can also use other types of fuel. "I would recommend an LCF vehicle to anyone. It's a cost effective and environmentally friendly vehicle, with not many limitations. [...] I would recommend my type of vehicle to all potential buyers since it is able to use normal and LCFs. However, a vehicle specifically made to use only LCFs I would only recommend to those who have accessibility to that fuel."

Some also consider [personality](#):

"The right person is [...] looking to try something different and new not just traditional fuels and wants to be environmentally friendly." -Jerry

"I would only recommend a LCF vehicle to anyone who is trying to reduce their carbon footprint. Most people aren't going to want to find a gas station or place to fill up. I would suggest that they do their research and make sure it's what they really want." -Crystal

"For more open-minded and experiential [possibly typo for *experimental*] types of friends and family I would definitely recommend low carbon fuel vehicles. However I have many friends and family who are not as open-minded and not interested in new experiences and I would not recommend a hybrid or electric or low carbon fuel vehicle to them necessarily, unless they brought it up to me and at that point I would engage in a discussion with them" -Ryan

Note: Throughout the study, some respondents seemed to equate "low-carbon fuel" with "vehicles that have a low carbon footprint"—something to keep in mind for future research. Edin's response to the question about recommending low-carbon fuels, for instance, is this: "I already recommend low carbon vehicles, if and when asked for advice. I'd advise them to perhaps choose hybrid at first, as their first low carbon vehicle and then perhaps, later switch completely. [...] However, if someone plans on using these vehicles for lots of road trips, well then, that begs for consideration. Sometimes it can be hard to find places to re-charge or find mechanical help, if something happens."

VIEWS OF LCF, HYBRID, AND ELECTRIC VEHICLES

In a few questions, we probed at the connections people make between hybrid, electric, and LCF-capable vehicles to see if people see them as related (for instance, all environmentally friendly) or not. People came down on both sides. Many (though by no means all) seem to think of EVs as the ideal, most environmentally friendly form of vehicle—though with some practical drawbacks, such as expense and charging infrastructure—with hybrids and LCFs as a kind of in-between stage, better for the environment than fully gasoline-powered vehicles but also more convenient than EVs.

SIMILAR

"I do think that low carbon fuel vehicles are comparable to electric vehicles and hybrid vehicles because they're both trying to make use of alternative fuel sources other than gasoline and they're both exploring fuel economy for fuels other than gasoline" -Ryan

"I do think they are comparable since they accomplish the same goal of reducing our carbon footprint." - Anastasia

"From my perspective, there are more similarities than differences. Intake in both cases are non-gasoline based and emission cleaner." – Anonymous A

"They still offer the same "better for environment" aspect but it's still a different type [of] fuel." - Melody

"In my eyes, they are all low carbon vehicles. I believe we were all as owners motivated by [the] same thing, or at least it played a role in our decision to purchase low carbon vehicle and that is to reduce our carbon footprint. We just take a different route, that's all." – Edin

"I think they are comparable. While the tech is different the end result is similar, reducing the carbon footprint and making the most of the fuel used." - Michael

DIFFERENT

Chrissy makes a distinction based on **range and range anxiety**: "I think low carbon fuel vehicles get better range, in general, compared to most EVs on the market today. I consider hybrids to be more in the same category as low carbon fuel vehicles."

Gina points to the option to **fuel at home** as a dividing line: "I think they are comparable as they don't use gas, but I think the way you power them is another thing- most people with electric cars charge at home, which is a huge plus."

"I think of [LCF] as being different than the other two. I think it allows more flexibility when it comes to fuel options." -Mark

Christine 1 thinks that **LCFs stand apart from both hybrids and EVs, on the one side, and traditional gas and diesel vehicles on the other**: "I think they're pretty different, especially in terms of the technology. Low carbon fuel vehicles are still burning fossil fuels as I understand it, right? and so there is still nonrenewable resources being consumed at a rate that the earth can not replenish them, it's still emitting like toxic carbon/fumes into the air, but just at a much less "terrible" rate than traditional fuels; so I don't think that they're comparable to traditional gas/diesel cars or electric/hybrid cars at all."

“Personally I view them as separate types of vehicles. While utilizing a low carbon fuel is better for the environment there is still processing of fuel being done. You still utilize the same standard gas stations and emissions are more comparable to regular gasoline. Whereas electric is a much different concept. Charging a vehicle and operating electric does not emit the same fumes, however, someone is making the electricity and most likely they are putting up fumes into the environment. At this time I also think fuel is much more reliable; I am still uneasy about electric being the sole form of power.” – Justin

Crystal says that hybrids are comparable to both EVs and LCF-capable vehicles, but “I don’t think LCF vehicles are comparable [to EVs] because they still take fuel. They still omit [probably typo for *emit*] emissions.”

Jocelyn’s view is similar to Crystal’s: “I believe that low-carbon fuel is more closely related to hybrid vehicles than electric ones. I view low-carbon vehicles as options as to hybrids. Meaning the owner can choose what fuels they choose to consume and with a hybrid, you can choose fuel or to charge the car. Mostly, I don’t know enough about Hybrids or low-carbon fuel cars to say in what ways they compare or differ. I do know electric cars completely lower the carbon footprint while the others differ in levels. Electric cars also could save the owner hundreds of dollars a year in fuel costs as well as a hybrid. I view low-carbon vehicles as completely separate from electric vehicles.”

“I believe that LCF, electric and hybrid are completely separate classifications of vehicles. [...] EV has charging stations, very high cost battery replacement, time and logistics investments for distance and charging. A hybrid offers a crossover feature not available to the EV. The LCF expands the operating parameter (like flex fuels) that appears to offer more convenience of fueling options. For me, each vehicle is different, much like an F250 and a VW difference. Even though these two very different vehicles might share an electric operating system classification in the future.” – Sally

“I see electric and [missing word, or possibly ‘and’ should not be there] different from low carbon fuels. Hybrids are not quite one or the other in my mind. The EVs and the LCFVs are different in two areas: 1. The LCFVs are trying to be like combustion engines with a fuel that burns cleaner. 2. The EVs are a departure from combustion engines and seek their “fuel” from electric charging of a battery. In that case, the EVs appear to be more environmentally friendly as they do not spell out smog that most other LCFVs expel when they are driven. With the exception of hydrogen cell cars.” - Adolfo

Ken puts full electric vehicles in a category of their own, and **highlights the difference between gas and diesel**: “I think of them all more or less as the same things. More specifically I think of all vehicles that take liquid fuels that can be bought at the corner gas station to be about the same. As I mentioned yesterday, I do prefer and enjoy diesel powered vehicles when it makes sense for me to own one. I think of hybrids (gas/electric for now anyway) to be in the same category-I find them similar. Electric only cars I do place in a category of their own and I probably will own one someday. I am in favor of electric vehicles once we have enough charging stations and charging can be as quick as getting gasoline is today.”

Elsewhere, Adolfo even makes an argument for distinguishing further among LCFs: “I think that each LCF has its own advantages and disadvantages. Each has different environmental impact. I think that the clumping of all of them into one category is not a good way to determine how people select each LCFV. The major issue in selecting these cars is how they compare to gasoline combustion engines and what incentives are available to the consumer. [...] I surely would not have bought [my] car [without financial incentives] and I don’t think that other LCFVs would be desirable for my needs as compared to other gasoline cars.”

CHOOSING BETWEEN HYBRID, EV, AND LCF

Some people described their decision to get a low-carbon fuel vehicle over an EV or hybrid.

Jerry, whose household also contains a hybrid, writes that he has both because he **likes having options**: “I like hav[ing] many options [...] I wanted something new, not two hybrids.” Similarly, Gina’s family has an EV as well as hydrogen-fueled vehicle. They initially intended to get another EV, “but when looking, we saw the Mirai and liked the long range. [...] We wanted a different fuel source—we **wanted more choices than just home chargers.**”

Anonymous A also owns a plug-in hybrid and a fully gas-powered vehicle, and got an LCF **to have a vehicle that took no gasoline at all**: “To be gasoline-free, I bought the Mirai Hydrogen FCEV (over a Battery Electric Vehicle (BEV), such as a Tesla).” However, he adds that “in hindsight and in my opinion today, PHEV with a decent range on electric is in the ‘sweet spot.’”

Finances, of course, also play a role.

- “I think environmental wise they are similar however the maintenance on them moneywise could be way different. I think the hybrid/electric vehicles can get expensive to use. ... I don’t want an electric vehicle just because there is not much to choose from and I don’t like how most of them look like. Also, I think in a long run the maintenance costs more. The hybrid wasn’t an option when I was buying a car and the LCF truck I got had a great deal at that time.” -Martyana
- “the \$15000 fuel credit played a major factor on the purchase” of a Mirai (presumably that three-years-free incentive Toyota offers). In comparison, there was no fuel credit for EV or hybrid vehicles: “Only state and federal incentives but they were also much lower.” -Anonymous B

For some, the choice was driven by **environmentalism first, then by other preferences**.

- “I wanted to make a transition out of fossil fuels and out of combustion engines. The electric cars require charging that takes longer and the hydrogen fuel cell cars are much faster. That was an appeal.” -Adolfo
- “We were set on purchasing low carbon vehicle, that much was clear. [...] No real preference on EV, biodiesel, hydrogen and such. We had a chance to try coupe of EV’s our friends drove and kinda liked them, but nothing to get excited about. [...] Then we had a chance to drive and fell in love with the car. Being hydrogen powered vehicle wasn’t all that important to us. It was that we loved THIS car and car was still environment friendly.” -Edin
- “I believe that they fall into the same category which is the environmentally friendly” but chose to get an LCF because of concerns over the safety of EVs—specifically, Tesla’s Autopilot feature. “Lots of people got into accidents due to its malfunction.” -Rachel

Some plan to switch from LCF to electric in the future. Jocelyn, who just found out through this study that her vehicle could run on LCF, says, “I feel I would ultimately love to use low-carbon fuels that would be better for the environment but ultimately I am interested in going fully electric in the next few years.” Similarly, when asked if she’d get the same vehicle again, Christine 1 writes, “Probably not. I’d go for an EV.”

FUTURE OF LCF

We asked LCF-capable vehicle owners whether they think vehicles that can use LCFs will become widespread or remain relatively less common. **Many feel they will be a transitional phase between gas-powered vehicles and something more environmentally friendly, such as EVs, but others envision a more diverse future fuels landscape, with gas vehicles becoming less common but no one alternative dominating.**

Madison writes, "I think they will remain less common. I think people are going **straight to electric.**" Others agree:

- "I don't think that they'll become widespread honestly, and they'll stay pretty invisible as people just jump from traditional fueled cars to electric."
- "Unless there is a large shift away from electric tech, I think LCF vehicles will remain in the background." -Michael
- Gina points out the convenience of charging EVs at home: "I think electric will be the way of the future, as people love to charge at home and it's very popular. I don't think people will want to go a gas station at all whether it's for gas or hydrogen."

Veronique thinks **a shift to LCFs (and possibly other alternative fuels) will be driven by fuel prices:** "If the price of gas remains as high as it is now, I think more people will look for the alternatives, especially if they offer fuel economy as well. [...] But if the government made its subsidies program clearer, it might attract more people. Same with the companies, give more incentives to switch. [...] I am guessing with the problems of full electrics, those who want to save up a bit will go for low-carbon, or hybrids, and still have the reliability of normal trucks." Ryan, too, talks about LCF, hybrid, and electric vehicles becoming more common if the cost of gasoline rises.

Several people say that **people need to know more about LCFs and/or the infrastructure has to develop (two related issues) for them to be more common:**

- "There are a lot of unanswerable questions in the LCF arena currently. Perhaps when father time has had a chance to provide us with those answers, the LCF vehicles will become a viable majority." -Sally
- "If there is not easier access to low carbon fuel, then it will not surpass hybrid or electric vehicles" -Mark
- "If the circumstances change as far as availability and education I think it could become widespread." -Anastasia
- "With more options such as makes/models more people will lean towards purchasing these vehicles." -Crystal

Jocelyn points out that environmental friendliness and luxury are often intertwined, but more so with EVs than LCF-capable vehicles: "many car manufacturers are utilizing resources in developing tech-driven electric cars. My range rover cost \$100,000, if I wanted to be environmentally friendly while keeping luxury then I would spend that money on a Tesla and I feel a lot of people agree."

Tomario thinks LCF vehicles are **already becoming less common, giving way to fully electric vehicles:** "E85 fuel is more rare, because so many places are pushing electric vehicles everywhere. [...] I feel that electric is taking the place of E85 fuel vehicles, and I feel that something will replace electricity one day. Because the world wants vehicles that provide a clean carbon footprint, and maybe one day something that is helpful to the environment and low cost." Elsewhere, he writes that LCFs "will be the knock off name brand that had a chance, but they never showed us really what

special power they had but they never rose to the top. I feel that low-carbon fuel vehicles are a great option to move towards all electric vehicles, but they are not talked about or seen in the media barely."

Al uses a similar metaphor, saying that the fueling infrastructure has to be in place for hydrogen fuel cell vehicles to become more common: "Otherwise, it will go the way as the video recording technologies of Betamax and VHS!" On the overall future of different fuel types, he sees "Battery Electric Vehicles (BEVs) have the momentum today to replace ICE, and will coexist [with] hybrid, PHEV, LCFs (Hydrogen Fuel Cell and others). Till ICE vehicles are phased out, perhaps due to legislation, PHEV with 50+ miles in electric IMHO will be the "sweet spot"."

On that note, some people anticipate a mixed fuel future, at least until one environmentally-friendly mode wins out over others.

- "Low-carbon fuels and full electric cars will be even more common by 2024, and I believe will eventually surpass gas vehicles in total sales by 2024 that's how fast it's moving in my eyes." - Roan
- "I think [there will be] a bit of an arms war/race between EVs and alternative fuel vehicles. But I definitely think the standard gasoline fueled cars are going to be less common. There are so many factors contributing to the growth and advancement of these new modes of fueling/powering cars. The main one has to do with the infrastructure (e.g. ease and cost of producing and supplying/delivering the necessary form of fuel/power to make vehicles go and the convenience of repairing them). [...] It will depend on how the different types of alternative fueled vehicle manufacturers get ahead of the curve and handle the demand." - Chrissy

Justin suggests "putting something together where a vehicle can run off of LCF & electricity. Give people an opportunity to start getting use to electricity but also utilize a fuel that is more eco friendly." In other words, he recommends combining the two "stepping stones" (LCF and hybrid) to create a hybrid vehicle where the non-electric fuel is some kind of LCF rather than gasoline.

Finally, some see low-carbon fuels as the predominant fuel type of the future. Mark writes that he chose an LCF-powered vehicle "because it would leave a lower footprint on the environment." When asked what drew him to LCF rather than an EV or a hybrid, he explains, "I don't know how sustainable the other two [EVs and hybrids] are. Meaning that there are a lot of people that use conventional gas, and are unwilling or don't want to switch. I am thinking along the lines that the other two may be phased out at some point." Crystal thinks LCFs will eventually "become more popular and common than both LCF [probably means EV] and hybrid vehicles. They're less maintenance, the fuel costs less and you don't have to wait for your char to charge in order for you to drive it."

"A Good Start"

Just as people tended to describe hybrid and LCF-capable vehicles as comparable because both are stepping stones between gas and EVs, some describe LCFs as a stepping stone between the present and an all-electric future. "I feel that low carbon fuel vehicles are a good start in reducing carbon emissions and trying to go green. They are not EVs but they do their part in keeping the environment safe and reduce pollution," writes Frances. Madison agrees: "I think they are a good alternative to a traditional vehicle but with better impacts on the environment but not quite as cutting edge as a fully electric vehicle." Similarly, Michael describes them as "better versions of normal vehicles." Christine 2 calls them "a step in the right direction."

SUMMARY

The drivers in this study vary in their approaches to low-carbon fuel vehicles. Most agree that LCFs are better for the environment than conventional fuels like gasoline or diesel. Some, especially those whose vehicles are powered by hydrogen fuel cells, sought out this power source specifically to minimize their environmental impact, while others see the environmental benefits of the vehicle as a "bonus" (Ken) or "perk" (Veronique). For many of the latter group, LCF capability did not affect their choice of which vehicle to purchase, but they are pleased that the vehicle they otherwise would have purchased also happens to have this capability.

Most drivers in the study suggest that LCFs are a more convenient way of being eco-friendly than BEVs and that switching to LCFs is a smaller transition than switching to an EV. People like this convenience. They also say that incentives--tax breaks, free fuel, access to carpool lanes, etc.--affected their own choice to purchase an LCF-capable vehicle or suggest these as ways to encourage more people to use LCFs. There is a strong consensus that if LCFs became more widely available and better-known--two deeply interconnected processes--people would be more likely to use them. Indeed, several people in this study would like to fuel with LCFs more often than they do, but LCFs are not available in their area. For some, LCFs are available but more expensive than conventional fuels, so they rarely use them. They are happy to use LCFs and feel good about their environmental impact when using them is convenient and affordable, but will not bother when it adds much hassle or expense.

On the other hand, figuring out what LCFs are is a hassle itself for some people. Dealers can play a make-or-break role here in educating people about LCF: while some people in this study learned about LCFs from their dealer, several others said their dealer had not mentioned the vehicle's LCF capability or had said very little about it. At least one person said the dealership informed him of the vehicle's LCF capability but advised him to fuel with gasoline instead. Several people have questions about the proper use of their LCF-capable vehicle. Quite a few wonder whether gasoline or LCF is better for the engine, or if using the "wrong" fuel--or switching back and forth between fuel types--could damage their vehicle. They also express concern over the longevity of LCF vehicles in general, since they are fairly new to the market.

Overall, these LCF-capable vehicle drivers are satisfied with their vehicles and excited about the potential of LCFs in general, even those who do not use them much personally. They see LCFs as a convenient way to be more environmentally friendly.

METHODOLOGY

Respondents were recruited from Qualboard's panel. In the screening process, potential respondents were shown a list of vehicles (provided by CR) that are capable of running on LCFs. Only those who indicated they owned or leased at least one of these vehicles were invited to join the study. Please note that this does not mean all participants in the study *used* LCFs; many vehicles that are capable of running on LCFs can also run on traditional fuels. For instance, a vehicle may be capable of running on biodiesel or regular diesel. Indeed, some participants indicated elsewhere on the screener that they did not know their vehicle was capable of running on LCF until they were asked a question about how often they use it. One of the themes of this study, in fact, is how widely familiarity with LCFs varies even among those whose vehicles are designed to run on LCFs.

The questionnaire used for screening in also covered demographics and frequency of using LCF (including awareness that one’s vehicle could use it). Recruitment was designed to get a mix of demographic backgrounds, such as age, genders, incomes, and race/ethnicity, as well as a range of LCF use, from people who only use LCF in their vehicles to those who never do.

All but two gave permission for their first names to be used. The others will be referred to as “Anonymous A” and “Anonymous B.” There are two Christines, so in the absence of permission to use last initials, I have distinguished them as Christine 1 and Christine 2.

Quotes used in this report have been edited for readability, mainly to correct punctuation and spelling errors.

Note: This is an opt-in panel and respondents are compensated generously for their time. People who participated in this study are not representative of all people who own or lease LCF-capable vehicles. This panel may provide a starting point for future research. However, given that this is a vanishingly small subpopulation, a survey would be impractical—recruiting even these 30 was difficult.

DEMOGRAPHICS

The participants in this study are:

- 15 female, 15 male
- Two high school graduates; three with some college education; most have at least a BA.
- Ages range from 22 to 60.
- The majority give their racial/ethnic background as white or Caucasian ($n = 17$); four as Asian; three as Black or African-American; one as Hispanic; and the rest gave multiple answers or “other.”
- None have an annual household income below \$25,000, and most have at least \$100,000:

Income level	Number of participants
\$25,000 to \$49,999	3
\$50,000 to \$74,999	3
\$75,000 to \$99,999	4
\$100,000 to \$124,999	7
\$125,000 to \$149,999	4
\$175,000 to \$199,999	4
\$200,000 or more	4

APPENDIX A: PARTICIPATION

Thirty-two people began the board on the first day. Thirty people began the second day and all thirty finished. One person answered the first question of the first day and nothing else, and did not return for the second day. Another participated in the first day, but did not own an LCF-capable vehicle and appeared to have screened in by mistake. (This person shared a first name with someone who did qualify, but did not participate; perhaps the wrong one was invited.) This person did not participate the second day and is not included in any of the results in this report.

APPENDIX B: DISCUSSION BOARD SCRIPT

Day One: Your LCF-Capable Vehicle

INTRO/Q1: Hi there and welcome! I appreciate you taking the time to tell me about your vehicle that can take low-carbon fuel, such as biodiesel, ethanol, propane, or hydrogen fuel cells. Some of you might have vehicles that can take low-carbon fuels but you generally use regular fuel (gasoline or diesel). **That is totally fine. I still want you to be part of this study!** I'll ask you slightly different questions depending on whether you generally use low-carbon fuels or traditional fuels.

Before we get started, please tell me a bit about yourself. How do you think your friends and family would describe you and what do you think is important for me to know about you? (I'll ask about your vehicle and driving in a moment, but for now, just tell me about you as a person.)

Please also take a moment to upload a photo of yourself. I'm doing a lot of these interviews--it helps me keep track of who's who if I can put a face with the name!

Q2: Please tell me about all the vehicles you or your household currently own or lease. I'm especially interested in the fuel type for each: you have one that can take low-carbon fuels, we know, but I'm interested in what fuel the others take, if you have any others. *Also, if you are considering getting another in the next few years, please tell me what kind you think you'd get. Again, it doesn't have to be a specific model, but if you're thinking a pickup truck or an SUV; a hybrid vehicle or some other specific fuel type; or a specific feature that is a must-have, or even if you have a particular color in mind, please tell me!*

Q3: Now, please tell me a little bit about the vehicle you have that can take low-carbon fuels. This is the one you answered questions about to qualify for this survey, the [piped in]. For starters, I would like to know what kind of fuel you put in it, how long you have had it, and what you typically use it for: commuting, road trips, running errands, etc.

Q4: *Why did you choose to get this vehicle? If the fact that it can take low-carbon fuels played a role in your decision, I'd love to hear about that. Again, it's fine if it didn't; lots of times people get a vehicle because they are interested in some features and don't care one way or another about others.*

Q4B: [ALTERNATE VERSION, SHOWN TO PEOPLE WHO SAID IN THE SCREENER THAT THEIR VEHICLE COULD NOT USE LCF] *Why did you choose to get this vehicle? If the fact that it can take low-carbon fuels played a role in your decision, I'd love to hear about that. Again, it's fine if it didn't; lots of times people get a vehicle because they are interested in some features and don't care one way or another about others. My records of the questions you answered earlier show that you did not know your vehicle could take low-carbon fuels until you were asked to be part of the survey. Please let me know if I'm mistaken.*

Q5A: [ONLY SHOWN TO PEOPLE WHO DID NOT KNOW THEIR VEHICLE COULD USE LCFs] According to my records of the screener questions you answered to qualify for this survey, you own a vehicle that can use low-carbon fuels, but you didn't know that it could until you started this study. **I'd like to know how you feel about the idea of using low-carbon fuels now that you know it's a possibility.**

Q5B: [ONLY SHOW TO PEOPLE WHO KNEW THEIR VEHICLE COULD USE LCFs] Now I'm interested in learning *how* you found this vehicle and how you decided how to fuel it the way you do. Please tell me how you got your information and walk me through your decision-making process. *For example, if you decided you wanted to buy a vehicle that could use low-carbon fuels, how did you narrow down to this particular one? Were there many options available at dealerships near you, or did you have to hunt a bit to find what you wanted, or get something a little different from what you wanted? Or if you didn't seek it out because it could use low-carbon fuels, what did you do when you realized it could: did you look up ways or places to fuel it with those, or was that not really a big deal to you?* **You might have told me a little bit about this in the previous question. You don't need to repeat yourself if you did, but I'd love more details if you can think of them.**

Q6: If you had any concerns when you got this vehicle, please tell me about them. *For this study, I'm mostly interested in concerns you had related to the low-carbon fuel it could use or how that could affect the vehicle. I'm also interested in concerns you might have had about maintenance and repair of the vehicle.*

Q7: Has what you were concerned about actually happened? If it has, or if there have been other difficulties that you *didn't* expect, please tell me about them.

Q8: On the flip side, please tell me if there are any benefits or perks to having this vehicle, **especially ones you didn't expect.** *For instance, if it performs better than you expected or costs less to fuel than you thought it would, I'd love to know about that.*

Q9A: [SHOW TO PEOPLE WHO SAID ON SCREENER THAT THEY "NEVER" USE LCF BUT THEY DID KNOW IT COULD] You have a vehicle that can take low-carbon fuels, but you said that **that's not the fuel you usually put in it. Please tell me a little about why not.** *For instance, please tell me if you would like to but there's something getting in the way, like high prices, you can't find the right kind of fuel, or things like that. Or if you're not comfortable with the idea, or just not interested, please tell me more about that.*

Q9B: [SHOW TO PEOPLE WHO SAID ON SCREENER THAT THEY USE LCF "SOMETIMES"] You have a vehicle that can take low-carbon fuels, and you said that you use them sometimes, but not always. Please tell me more about that. *Are there any specific reasons or occasions you use one kind of fuel rather than another?*

Q10A: [SHOW TO PEOPLE WHO SAID ON SCREENER THAT THEY DID NOT KNOW THEIR VEHICLE COULD USE LCF] Vehicles that can take low-carbon fuels are still fairly unusual. How did you first hear about low-carbon fuels? You told us earlier that you didn't know your vehicle was capable of using low-carbon fuels until you qualified for this study. That's fine too—just let me know if or when you heard about low-carbon fuels in general before this!

Q10B: [SHOW TO PEOPLE WHO SAID ON THE SCREENER THAT THEY USE LCF] Vehicles that can take low-carbon fuels are still fairly unusual. How did you first hear about low-carbon fuels? I'm interested in both where you heard that they exist and where you heard that these are options for something you can actually buy.

Q10C: [SHOW TO PEOPLE WHO SAID ON THE SCREENER THAT THEY NEVER USE LCFS, BUT THEY KNEW THEIR VEHICLE COULD] Vehicles that can take low-carbon fuels are still fairly unusual. How did you first hear about low-carbon fuels?

Q11: Please tell me what you like and dislike about this vehicle overall.

Day Two: LCF-Capable Vehicles in General

Q1: Welcome back! Yesterday, I asked you questions about getting and using your vehicle that can use low-carbon fuels.

Today's questions are a little more general.

Some people think of low-carbon fuel vehicles and electric or hybrid vehicles as similar: they promise to reduce your carbon footprint, they use cutting-edge technology, it can be more difficult to find a place to charge them than to charge a gasoline or diesel vehicle, and so on. Do you think that low-carbon fuel vehicles are comparable to either electric vehicles or hybrid vehicles, or do you think of them as different things? *Please explain.*

Q2: How do you think about vehicles that can take low-carbon fuels, in general? What is your overall impression of them? *If you don't really have an overall impression and really just know about your own vehicle, that is fine too—tell me so—but please take your best shot.*

Q3: What impression, if any, do you think people in general have of vehicles that can take low-carbon fuels? *For instance, do you think people think they're high-tech; weird; a status symbol; futuristic; either better or worse for the environment than cars that take traditional fuels; that they have limited range or would be hard to fuel; and so on? If you think most people haven't heard of them or don't know they're available for sale, tell me that too!*

Q4: Do you think vehicles that can use low-carbon fuels will become widespread, or do you feel they will remain less common? *Please explain.*

Q5: What do you think people should know before buying or leasing a vehicle that can use low-carbon fuels? *Is there anything you wish you had known before getting yours?*

Q6: What do you think would encourage people to use low-carbon fuels?

Q7: Given your experience with your current vehicle and anything else you now know about low-carbon fuels, please tell me whether you would recommend a friend or family member getting a vehicle that can take low-carbon fuels *and using those low-carbon fuels* if they were considering a new vehicle purchase. *Please tell me what else would factor into your recommendation. For instance, are there certain people or uses you would recommend it for more than others?*

Q8: The point of this study is to learn about people who have vehicles that can use low-carbon fuels: **why they got those vehicles, what it's like to own (or lease) one, what they know about low-carbon fuels in general, what they think are the pros and cons of using them, and so on.** What am I missing about the experience of owning a vehicle that can use low-carbon fuels? What other question(s) should I ask if I do this again? *Please answer them, too!* 🗣️

APPENDIX C: FUEL TYPES USED

This appendix shows who uses which type(s) of fuel in their LCF-capable vehicle, based on their answers during the study.

Biodiesel: 11

- Melody G.
- Veronique (along with ethanol)
- Roan (along with ethanol)
- Madison (sometimes)
- Ryan (sometimes)
- Michael (sometimes)
- Ken (sometimes, implied)
- Jonathon, probably (“I like the option it’s just difficult finding a station where it is present” implies it gets used at least occasionally.)
- Crystal
- Anastasia’s father (Anastasia answered the questions speaking about her father’s vehicle, because she answered the screener for all vehicles in the household)
- Richard

Gasoline: 9

- Mark (usually)
- Veronique
- Frances
- Jon (“mostly”—unclear what else, or if “mostly regular 87 octane” means sometimes a different form of gasoline or sometimes a LCF)
- Jonathon (“generally” uses premium 93 octane; see above for implication that he uses biodiesel occasionally as well)
- Jerry
- Jocelyn
- Kristen
- Sally

Hydrogen fuel cells: 7

- Mirai: 6
 - o Christine 1
 - o Anonymous A
 - o Adolfo
 - o Edin
 - o Gina
 - o Anonymous B
- Nexo Blue 2022 Hyundai: 1
 - o Rachel

Ethanol: 6

- Veronique (along with biodiesel)
- Roan (along with biodiesel)
- Mark (E85 sometimes)
- Justin

- Tomario
- Sally

Diesel: 6

- Madison
- Ryan
- Michael (sometimes)
- Ken (usually)
- Melody sometimes, possibly—unclear if she *usually* or *always* uses biodiesel
- Christine 2 (“I usually fill the car up with diesel gas because it runs best on that”)