



California Public Utilities Commission

# The Case for Diesel Cars in California

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# CALIFORNIA PUBLIC UTILITIES COMMISSION

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The Case for Diesel Cars in California

# **The Case for Diesel Cars in California**

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## Executive Summary

California has adopted the aggressive goal of reducing its greenhouse gas emissions to 1990 levels by 2020.<sup>2</sup> To achieve this goal, the state is transforming its largest source of emissions, the transportation sector, by promoting the switch from gasoline-powered vehicles to cleaner alternative fuels, such as electricity, and is contemplating substantial infrastructure investments to support this transition.<sup>3</sup> However, as California considers the appropriate measures to make investments to promote electric vehicles, there is an alternate path that should be considered alongside deployment of electric vehicles and associated infrastructure. Diesel and biodiesel-powered vehicles, which are substantially cleaner and more fuel-efficient than conventional gasoline-powered vehicles, can be integrated into California's fleet in a short time frame, using existing infrastructure and technologies, with minimal state-sponsored investment. They increase the range of economic and environmentally beneficial options for consumers.

## Introduction

The Global Warming Solutions Act (AB 32) calls for the maximum feasible reduction of greenhouse gases emitted by passenger vehicles.<sup>4</sup> California is pursuing a variety of long-term strategies to achieve this goal, including the phasing in of a fleet of passenger vehicles that relies on electricity, rather than gasoline.<sup>5</sup> The electric vehicle industry is promising, but still nascent, and will require substantial infrastructure

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<sup>2</sup> California Health and Safety Code § 38550 (AB 32).

<sup>3</sup> California Air Resources Board, *Greenhouse Gas Inventory Data – Graphs*, May 28, 2010, <http://www.arb.ca.gov/cc/inventory/data/graph/graph.htm> (accessed October 7, 2010). California Air Resources Board, *Climate Change Scoping Plan*, December 2008, at 40, [http://www.arb.ca.gov/cc/scopingplan/document/adopted\\_scoping\\_plan.pdf](http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf).

<sup>4</sup> Assembly Bill (AB) 1493 (Pavley, 2002) and AB 32 (Pavley, 2006) amongst others.

<sup>5</sup> Senate Bill (SB) 626 (Kehoe, 2009), amongst others

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investments in the form of a widespread, inter-connected charging system. Moving to an electricity-fueled transportation system as a strategy for greenhouse gas emissions reductions will also require commensurate investments in, and development of, clean energy technology in the energy generation sector which is currently California's second largest source of emissions.<sup>6</sup> Therefore, while an electric vehicle system is promising, its development is a long-term proposition.

Existing technologies could, however, enable California to begin reducing its transportation sector emissions in the short term. This paper considers diesel and biodiesel as a transportation fuel, and provides evidence showing that California could capture significant environmental benefits, in a relatively short timeframe by using existing infrastructure, and by relying on vehicles that are already familiar to consumers. Recent technological developments have made diesel-fueled vehicles an appealing alternative to comparable gasoline-fueled vehicle for the passenger and light-duty sector. Diesel vehicles are

- less polluting than gasoline-fueled vehicles,
- more fuel efficient than gasoline-fueled vehicles,
- available for rapid deployment without substantial infrastructure investment,
- widely marketed and sold in other major auto markets, and
- a viable alternative for consumers with “range anxiety” in an electric vehicle-oriented market.

### **Emissions**

Diesel cars pollute less than comparable gasoline-fueled vehicles. Greenhouse gas emissions associated with diesel's fuel cycle from “well” to “wheels” , or the total emissions, from extraction of the energy-bearing resource (“well”) through combustion

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<sup>6</sup> 2008 ARB Scoping Plan

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(“wheels”), are 15 percent lower than emissions from comparable gasoline-fueled vehicles. Table 1 presents the well-to-wheels emissions for conventional gasoline vehicles, diesel-fueled vehicles, hybrid electric vehicles, and plug-in hybrid electric vehicles. While conventional diesel-fueled vehicles emit less overall greenhouse gas emissions than traditional gasoline fueled vehicles, they emit more overall greenhouse gas emissions than plug-in hybrid vehicles. Vehicles fueled by biodiesel may produce fewer emissions than plug-in hybrid vehicles, depending upon the energy source used to power the grid from which the plug-in hybrid car is charged.

**Table 1: Total Well-to-Wheels Cycle Direct Greenhouse Gas Emissions for Various Vehicle Types, 2010 (Grams per Mile)**

Fuel Type	Vehicle Type				
	Conventional	Hybrid Electric	<i>U.S. Grid</i>	<i>Plug-In Hybrid Electric Northeast U.S. Grid</i>	<i>California Grid</i>
<b>Gasoline</b>					
E10 <sup>7</sup>	476	322	340	312	289
E85 <sup>8</sup>					
<i>Corn</i>	389	263	302	274	250
<i>Cellulosic</i>	171	116	203	175	151
<b>Diesel</b>					
Diesel Fuel	405	305	328	301	277
B20 <sup>9</sup>	334	230	279	251	227

*Source: Results taken from the Argonne National Laboratory’s Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model Version 1.6b; Light-Duty Diesel Vehicles: Market Issues and Potential Energy and Emissions Impacts*

It is important to note that while diesel engines produce less carbon monoxide and hydrocarbons than gasoline-fueled engines, they emit relatively more nitrogen oxide and particulate matter, which are regulated by the United States Environmental Protection

<sup>7</sup> E10 is a blended fuel containing 90 percent gasoline and 10 percent ethanol.

<sup>8</sup> E85 is a blended fuel containing 15 percent gasoline and 85 percent ethanol.

<sup>9</sup> B20 is a blended fuel containing 20 percent biodiesel and 80 percent diesel fuel.

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Agency's "Tier 2" emission standards. For many years, these emissions standards limited the expansion of diesel-fueled vehicles in the U.S. market, because meeting the standards requires more advanced and complicated emissions control technology.<sup>10</sup> Over the past few years, automakers have developed emissions-reducing technologies that have reduced nitrogen oxide and particulate matter emissions by 80 to 90 percent.<sup>11</sup> These improvements mean that diesel vehicles which have been principally produced for European markets, are now largely in compliance with the U.S. Environmental Protection Agency's (EPA) standards, as well as with the more stringent regulations in California.

### **Efficiency**

Diesel vehicles are considerably more efficient than those fueled by gasoline. The U.S. EPA publishes fuel economy ratings that demonstrate that diesel vehicles are 20% to 40% more efficient than comparable gasoline vehicles.<sup>12</sup> This is coupled with the fact that diesel as a fuel itself inherently has an energy content that is 11% greater per gallon than gasoline.

Diesel engines are also much more efficient than engines that use a mix of gasoline and ethanol.<sup>13</sup> They tend to be less efficient than hybrid electric vehicles, though they seem to be able to out-perform comparable hybrid electric vehicles.<sup>14</sup>

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<sup>10</sup> Light Duty Diesel Vehicles report, 14.

<sup>11</sup> Light Duty Diesel Vehicle report, 15; C. Morey and J. Mark, "Disel Passenger Vehicles . . . [www.sae.org/technical/papers/2000-01-1599](http://www.sae.org/technical/papers/2000-01-1599) .

<sup>12</sup> "Light-Duty Diesel Vehicles: Efficiency and Emissions Attributes and Market Issues" Report #: SR/OIAF(2009)02

<sup>13</sup> Office of Integrated Analysis and Forecasting, Energy Information Admin., U.S. Dep't of Energy, Report No. SR/OIAF/2009-02, Light-Duty Diesel Vehicles: Market Issues and Potential Energy and Emissions Impacts 10 (2007).

<sup>14</sup> See Nicholas Rufford and Jason Dawe, Toyota Prius Proves a Gas Guzzler in a Race with the BMW 520d, The Sunday Times, March 16, 2008, [http://www.timesonline.co.uk/tol/driving/used\\_car\\_reviews/article3552994.ece](http://www.timesonline.co.uk/tol/driving/used_car_reviews/article3552994.ece); Eric Loveday, Passat BlueMotion enters record books after going 1,527 miles without refueling; that's 74.8 mpg, Oct. 4, 2010,

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Table 2 compares diesel and gasoline on-road efficiencies. Four vehicles were selected: Ford Focus, Honda Civic, VW Jetta TDI, and Mercedes C-class. All four are available in gasoline- and diesel-powered models, and are familiar to consumers in California, as well as across the United States. The table shows the fuel efficiency of each type of fuel measured in miles per gallon. The chart represents an average of each car's city and highway mileage.

**Table 2: Comparison of Gasoline and Diesel efficiency and GHG emissions across four different vehicles**

<b>Engine Type</b>	<b>Ford Focus<sup>15</sup></b>	<b>Honda Civic<sup>16</sup></b>	<b>VW Jetta TDI<sup>17</sup></b>	<b>Mercedes C<sup>18</sup></b>
	Both diesel and gasoline are 1.6L	1.8L gasoline, 2.2L diesel	Both diesel and gasoline are 2.0L	1.6L gasoline, 2.1L diesel
<b>Gasoline</b> <i>Miles Per Gallon<sup>19</sup></i>	35.1	35.6	30.5	36.2
<b>Diesel</b> <i>Miles Per Gallon</i>	61.8	46.1	42.8	42.8
<b>% Change between gasoline and diesel</b>	43.2%	22.7%	28.7%	15.4%
<b>Gasoline GHG emissions</b> <i>(g CO<sub>2</sub>e/mile)</i>	256	245	291	154
<b>Diesel GHG emissions</b> <i>(g CO<sub>2</sub>e/ mile)</i>	159	216	217	144
<b>% Change between gasoline and diesel</b>	37.8%	11.8%	25.4%	6.5%

Assuming that the average vehicle travels 12,000 miles annually,<sup>20</sup> and that for every diesel car introduced an equivalent gasoline car is removed, the result of one driver switching from the gasoline-powered to the diesel Ford Focus would result in a reduction

<http://green.autoblog.com/2010/10/04/passat-bluemotion-enters-record-books-running-1-527-miles-without/>).

<sup>15</sup> <http://www.ford.co.uk/Cars/Focus/FuelEconomyandCO2Emission>

<sup>16</sup> <http://www.honda.co.uk/cars/civic5door/#fullspecification>

<sup>17</sup> <http://www.volkswagen.co.uk/#/new/jetta/which-model/engines/fuel-consumption>

<sup>18</sup> [http://www2.mercedes-](http://www2.mercedes-benz.co.uk/content/unitedkingdom/mpc/mpc_unitedkingdom_website/en/home_mpc/passengercars/home/new_cars/models/c-class/w204/technical_data.html)

[benz.co.uk/content/unitedkingdom/mpc/mpc\\_unitedkingdom\\_website/en/home\\_mpc/passengercars/home/new\\_cars/models/c-class/w204/technical\\_data.html](http://www2.mercedes-benz.co.uk/content/unitedkingdom/mpc/mpc_unitedkingdom_website/en/home_mpc/passengercars/home/new_cars/models/c-class/w204/technical_data.html)

<sup>19</sup> The Miles Per Gallon are combined cycle, meaning the average of city and highway mileage

<sup>20</sup> Utilizing the EPA's commuter model using 1997 Oak Ridge Laboratory data

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of 1.164 tons of carbon dioxide emissions per year.

Though like Hybrid Electric Vehicles, diesel-powered cars are more efficient than gasoline-powered cars, they are typically more expensive. The premium for a diesel vehicle over a similarly-equipped gasoline model ranges from \$1,000 to \$7,195.<sup>21</sup> Diesel engines are generally more durable than their gasoline-powered counterparts and tend to have higher resale values. Moreover, vehicles with diesel engines have lower operating costs over the life of the vehicle, which tends to offset their higher initial cost. Additionally, diesel prices in the United States have been comparable to gas prices; whereas in Europe, where diesel vehicles make up a much larger share of the passenger vehicle market (over 50 percent), diesel is heavily subsidized.

The efficiency gains, among other reasons, have led the U.S. Energy Information Administration (EIA) to predict the diesel share of total light-duty vehicle sales to grow, from 1.7% of total vehicles sold in 2007 to 10% in 2030.<sup>22</sup>

### **Infrastructure**

Diesel cars employ existing fuel-delivery infrastructure with fuel already at the pumps and ready for use, and this translates to a minimal need for additional investment as more diesel cars are incorporated into the fleet. As California begins to integrate the price of GHG emissions into its economy, diesel vehicles represent an immediate, cost-effective strategy to reduce GHG emissions. This is important for the California electricity sector in two ways. First, it allows for the electric vehicle infrastructure rollout to be done on a timeline that accounts for a variety of critically important considerations

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<sup>21</sup> “Light-Duty Diesel Vehicles: Efficiency and Emissions Attributes and Market Issues” Report #: SR/OIAF(2009)02

<sup>22</sup> “Light-Duty Diesel Vehicles: Efficiency and Emissions Attributes and Market Issues” Report #: SR/OIAF(2009)02

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in addition to the State's 2020 emissions reductions goals. Second, since the electricity sector faces the largest share of GHG reductions in the CARB Scoping Plan, any non-electricity sector source of reductions will help reduce pressure on electric rates.

### **Economics**

Partially due to fuel efficiency, as well as tax and price differentials, Western Europe has seen a dramatic growth of diesel passenger car sales in the past decade, climbing from 28.4% to 52.2% for the region as a whole. This number is as high as 70% in France, Spain, and Belgium due to incentive programs.<sup>23</sup>

Because the technological improvements are already “on the shelf,” the same companies already building cars for the European market can easily supply cars for the American market (which in some cases are simply diesel-powered versions of U.S. models). Therefore, companies like Ford, GM and Toyota, for example, can manufacture, market, and sell cars for California with small, efficient turbo-diesel engines. This lends itself to extraordinarily low development costs because these manufacturers can shift production using known processes, materials and supply chains to the American and more specifically the California market.

In a 2009 comparative-cost study of alternative energy vehicles, Intellichoice, a car comparison website, analyzed the costs of ownership for alternative fuel vehicles, using factors including, “depreciation, financing, fuel, insurance, maintenance, repairs, and state fees.” Notably, the study included clean diesel technology for the first time.<sup>24</sup> The survey ranked the VW Jetta TDI first in light of the aforementioned criteria over the Toyota Prius, demonstrating that while both hybrid electric vehicles and diesels maintain

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<sup>23</sup> Ibid.

<sup>24</sup> [http://images.intellichoice.com/intellichoice\\_2009\\_hybrid\\_clean\\_diesel\\_survey.pdf](http://images.intellichoice.com/intellichoice_2009_hybrid_clean_diesel_survey.pdf)

price premiums over comparable gasoline-powered cars, the long-term savings often justify the high up-front cost.

### **Drivability**

A diesel car also may be an attractive option for a consumer who is looking for a satisfying driving experience. Many small turbo-diesel cars are as efficient as hybrid-electric vehicles, but are more suited to the habits of the average driver. The inherent torque-biased character of diesel engines compared to their gasoline counterparts allows smoother, easier to modulate, and more economical operation. Diesel cars have a greater level of torque at lower revolutions per minute (RPM), which means they are better suited to starting from idle, when the engine consumes energy in the least efficient manner. This is a major advantage over gasoline cars, particularly in urban areas. The Ford Focus specified in Table 1, for example, produces its optimum torque figure in gasoline form, 110 lbs/ft, at a relatively high 4000 RPM.<sup>25</sup> The turbo-diesel model produces 160 lbs/ft at 1750 RPM, with only a 10 percent drop in horsepower, while using less fuel and emitting less carbon dioxide.

### **Biodiesel**

A major advantage of diesel passenger cars is that they can easily be converted to run on biodiesel. This fuel switch can use the same technology inherently present in a diesel engine, but can further increase fuel economy and reduce greenhouse gas emissions. Unlike earlier iterations, modern technology has allowed the fuel switch to occur without the replacement of filters, seals, or any other engine components.

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<sup>25</sup> [http://www2.fordconnection.com/fordconnection/multimedia/gbr\\_en/001/yyb/gbr\\_en001yybfuelspc.htm](http://www2.fordconnection.com/fordconnection/multimedia/gbr_en/001/yyb/gbr_en001yybfuelspc.htm)

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Biodiesel refers to a fuel made from plant, animal, or waste feedstocks. This biodiesel can be blended with traditional diesel in different proportions to create various low-emissions fuel options. Moreover, engines that use B20 produce 18 percent less greenhouse gas emissions than Ultra Low Sulfur Diesel (ULSD) fuel, and 30 percent less than a comparable gasoline-powered vehicle.<sup>26</sup>

As is the case with traditional diesel vehicles, accommodating larger numbers of biodiesel-powered vehicles would not require substantial infrastructure investment. Biodiesel can be transported using existing pipeline and tanker infrastructure systems, and unlike other biofuels such as ethanol, requires no special sealants or additives to prevent corrosion.

Biodiesel offers a large reduction in emissions because during the “feedstock” phase (i.e. during extraction of the energy-producing resource) biodiesel is a “carbon sink.” This means it produces negative carbon dioxide emissions, because the organic matter from which biodiesel is refined absorbs carbon dioxide when it photosynthesizes.

However, there are some concerns about the implications of expansive biodiesel production. For example, placing a higher value on land used for producing biodiesel could displace food crops. Additionally, while biodiesel production results in lower emissions when compared with extraction and refinement of other fuels, this figure doesn't take into account the opportunity cost in emissions if the land would have been used for an even less emissions-intensive purpose.

Developments in non food-crop derived biodiesel products have increased the commercial viability of biodiesel considerably. For example, algae-based biodiesel has

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<sup>26</sup> For example, B5 is 5% biodiesel and 95% diesel. Modern turbo-diesel engines can use blends up to B100 (100 percent biodiesel) with minimal modifications to the engine.

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produced high yields of B100 by using photo bio-reactors and specialized growing ponds. Depending on the size of the pond system and the efficiency of the photo-bioreactors, these systems have produced hundreds of thousands to millions of gallons of biodiesel in a year.<sup>27</sup> These algae can grow quickly, and require less space than other biodiesel sources. According to U.S. Department of Energy (DOE) Aquatic Species Program Report, biodiesel equivalent to one quadrillion BTUs of energy can be cultivated on approximately 494,000 acres, about 0.5% of California's total geographical area.<sup>28</sup> One quad of B100 biodiesel corresponds to approximately 8.5 billion gallons.

While algae represent a promising avenue of biodiesel development, one of the greatest advantages of biodiesel production is the diverse array of sources, which protects the industry from the price fluctuations and shocks to particular parts of the industry. According to the EIA Light-Duty Diesel Vehicles Report, the biodiesel industry has production capacities varying from less than one million to up to fifty million gallons per year.

### **Diesel and Biodiesel Hybrids**

Diesel and biodiesel also can aid in reducing emissions in hybrid electric vehicles and plug-in hybrids. The amalgamation of electric and diesel or biodiesel drivetrains<sup>29</sup> can compound fuel efficiency and emissions advantages. Hybrid engines are better suited to an urban environment, where “stop and go” traffic patterns are more pervasive. Although diesel-electric hybrid cars have not yet reached mass-production in passenger cars, diesel-electric drivetrains are already in use in trains and buses around the world as well as right

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<sup>27</sup> See the Aquatic Species Program Report, July 1998, located at <[http://www1.eere.energy.gov/biomass/pdfs/biodiesel\\_from\\_algae.pdf](http://www1.eere.energy.gov/biomass/pdfs/biodiesel_from_algae.pdf)>

<sup>28</sup> <http://www.epa.gov/otaq/renewablefuels/420r10006.pdf>

<sup>29</sup> Drivetrain is defined as the group of components that generate power and deliver it to the road surface. In automobiles this is defined as the engine, transmission, driveshafts, differentials, and drive wheels.

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here in California, operated by MUNI in San Francisco<sup>30</sup> and CityBus of Santa Rosa.<sup>31</sup> In 2006 the San Joaquin Regional Transportation District led a consortium of eleven transportation agencies from California, Arizona, and Nevada in purchasing 157 such vehicles.<sup>32</sup>

### **Policy Recommendations**

California should complement its current policies in favor of electric vehicles with similar policies that would promote the use of diesel and biodiesel vehicles. A major factor in the success of any attempt to expand the use of diesel vehicles will be consumer education; it is critical to differentiate modern, clean turbo-diesel technology from the unrefined cars that once typified this market sector. Demonstration of the considerably lower emissions than gasoline cars will be necessary, though the greater durability and high resale value of diesel-powered vehicles should also be stressed. Because the CPUC will be playing a major role in the electrification of passenger vehicles, understanding how other emerging technologies and fuel interact with those investments will ensure that ratepayers receive the best possible outcome. While specific incentives are not recommended at this time, further support of this technology should be pursued in order to reap the near-term benefits from its wider implementation. One option is to include diesel and biodiesel vehicles under the heading of alternative fuels in the Energy Policy Act of 2005,<sup>33</sup> as this would create a further financial stimulus for the adoption of diesel vehicles. Similarly, funding in the form of research grants to spur continued development of biodiesel represents a cost-effective way to simultaneously

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<sup>30</sup> <http://www.sfmta.com/cms/ccac/MTACACEMSCJuly112007minutes.htm>

<sup>31</sup> <http://ci.santa-rosa.ca.us/news/Pages/SantaRosaCityBusHybrid.aspx>

<sup>32</sup> <http://sanjoaquinrtd.com/hybrid/default.php>

<sup>33</sup> [http://www.epa.gov/oust/fedlaws/publ\\_109-058.pdf](http://www.epa.gov/oust/fedlaws/publ_109-058.pdf)

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increase energy independence and encourage GHG reductions while creating “green” jobs. The California Energy Commission, CARB, and CPUC should consider hosting a workshop, as part of the Commission’s ongoing alternative fueled vehicle rulemaking (R.09-08-009) in order to more fully understand how diesel and biodiesel vehicles can serve as a complementary avenue to reduce GHG emissions in the transportation sector. In addition, California’s energy agencies should coordinate in order to consider what other options are available to assist in the deployment of diesel and biodiesel vehicles.

### **Conclusion**

California’s electric grid is already among the cleanest in the country, and the state’s long-term switch from a transportation system reliant on gasoline to one powered by that grid will keep California as a leader in climate policy. This switch will require significant, long-term investment.

Diesel- and biodiesel-powered vehicles can ease the transition to this new system by helping the state make initial reductions towards its goal of decreasing greenhouse gas emissions to 1990 levels by 2020. With diesel fuel already flowing at filling stations throughout the state, extensive diesel infrastructure is in place and requires no additional investment. The inherent efficiency of diesel engines in vehicles has already been proven in numerous markets worldwide, and therefore the technology needs no new research or development before it is ready for California’s roads. Diesel vehicles can be easily converted to biodiesel, a renewable fuel source that can be made within the state or the nation, and that affords consumers considerable choice.