# A MODEL OF THE U.S. START-STOP VEHICLE MARKET

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## 1. INTRODUCTION

Start-Stop vehicles, which shut off the engine at idle and restart the engine when the driver's foot leaves the brake pedal or presses clutch, have been commercially available for several years and have achieved noticeable market penetration in Europe. However, they have only very recently become available in the United States. Given different vehicle preferences, traffic conditions, regulatory environment and fuel prices in the U.S. market, there have been questions about the viability of Start-Stop vehicles in that market. Hybrid electric vehicles, plug-in hybrids and battery electric vehicles have all been introduced in the U.S., but none have achieved significant market penetration. Current Start-Stop vehicles offer 5 to 10 percent fuel savings at a far lower purchase price point than other powertrains. This paper describes research that was undertaken and a model developed to estimate the future U.S. market penetration of Start-Stop and hybrid-electric vehicles.

## 2. BACKGROUND

A variety of technologies are available for improving the fuel efficiency / CO2 emissions of vehicles. Many of these technologies use more advanced electrification in some form to complement or substitute for the conventional internal combustion engine. At one extreme, fully-electric vehicles replace the internal combustion engine with an electric motor. Hybrid and plug-in hybrid vehicles use electric motors to complement an internal combustion engine. While all of these vehicle configurations can provide substantial improvements in fuel efficiency, they have not had significant impacts on the overall fuel efficiency of vehicle fleets because they have not been widely adopted by consumers.

Start-Stop vehicles use advanced functionality similar to hybrid vehicles to turn off the internal combustion engine when it is stopped and then restart it when the driver releases the brake pedal or engages the clutch. The electronics, a more robust battery, and other components used in these vehicles have incremental costs to consumers of approximately £300 to £800 and deliver fuel savings of between 5 percent to10 percent.

In response to increasing environmental requirements, auto manufacturers began introducing Start-Stop configurations to improve their fleets' fuel efficiency and CO2 emissions. Start-Stop technology was offered as an individual option or bundled with other fuel saving and environmentally-friendly features. The technology has taken off in the past few years, and industry analysts estimate 70 percent of new cars manufactured in Europe will include Start-Stop technology by 2016.

Despite the rapid adoption in Europe, auto manufacturers have only very recently begun to introduce the Start-Stop feature in vehicles sold in the United States. The research described in this paper was designed to determine how consumers in the U.S. market are likely to respond to the newly-introduced Start-Stop vehicles.

There have been several studies conducted to understand how U.S. consumers make choices among alternative vehicle configurations (see, for example, Hess, et al, 2012 and Bhat, et al, 2012). However, all of the previous published work in the U.S. has focused on the choice between conventional and electric powertrains and does not directly address the market potential for Start-Stop configurations. While the development of the European market is instructive, different conditions exist in the U.S. market. For example, fuel prices at the time of the U.S. study were approximately £0,57 per liter and with no direct CO2 requirements for automakers. One key unanswered question is whether U.S. consumers are generally less focused on fuel efficiency when they decide which type of vehicle to purchase. As a result, additional primary research was needed to support estimates of how Start-Stop vehicles might fare in the U.S. market.

## 3. STUDY APPROACH

The work that was undertaken for this study included both qualitative research in the form of focus groups and a quantitative survey of U.S. consumers who intended to buy a new vehicle in the next two years. The focus groups addressed the participants':

- General vehicle needs and preferences
- New vehicle purchase considerations
- Awareness and knowledge of alternative vehicle powertrains and configurations
- Reactions to alternative configurations and
- Specific reactions to Start-Stop options

The focus groups were held in four U.S. metropolitan markets: Boston, Atlanta, Chicago and Los Angeles.

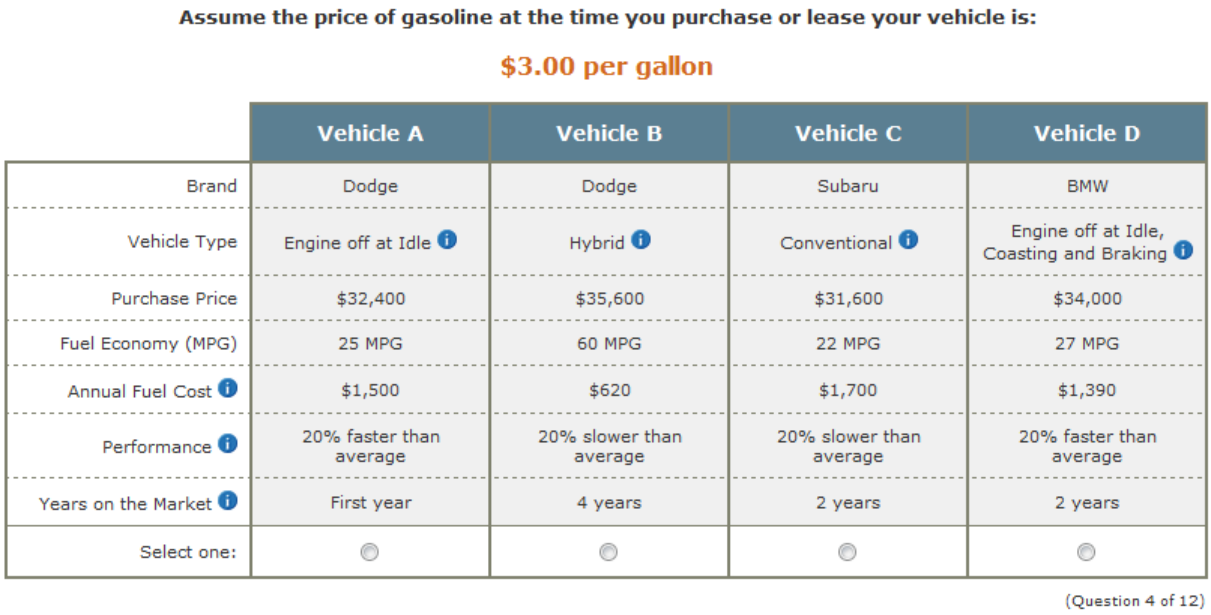
The quantitative survey included a set of questions to establish respondents' current vehicle experience and best-worst experiments to understand their high-level needs. Respondents were then shown text that described the types of options they would be asked to evaluate, including general descriptions of the different vehicle configurations. The options included conventional, Start-Stop, advanced Start-Stop (higher costs and higher fuel savings) and hybrid-electric vehicle configurations.

The stated choice experiments included eight vehicle attributes:

- Manufacturer
- Power train configuration
- Purchase price
- Annual fuel cost
- Fuel economy
- Payback period
- Performance/acceleration
- Years on the market

These attributes were constructed to mimic the information shown on new car stickers at U.S. dealerships. Fuel price was also shown and varied among the stated choice screens and also shown as constant across vehicle options on a set screen. There are two important interactions involving fuel price: annual fuel cost is a function of fuel price and fuel economy; and the payback period is a function of annual fuel cost savings and purchase price. The figure below shows an example stated choice experiment. The survey was administered via the web and the information circles shown in Figure 1 were constructed as hover-overs that provided respondents with definitions of the vehicle features shown on the screens.

**Figure 1 - Example Stated Choice Experiment – (Data Not Actual)**



**Assume the price of gasoline at the time you purchase or lease your vehicle is:**

**$3.00 per gallon**

| | Vehicle A | Vehicle B | Vehicle C | Vehicle D |
|---|---|---|---|---|
| Brand | Dodge | Dodge | Subaru | BMW |
| Vehicle Type | Engine off at Idle | Hybrid | Conventional | Engine off at Idle, Coasting and Braking |
| Purchase Price | $32,400 | $35,600 | $31,600 | $34,000 |
| Fuel Economy (MPG) | 25 MPG | 60 MPG | 22 MPG | 27 MPG |
| Annual Fuel Cost | $1,500 | $620 | $1,700 | $1,390 |
| Performance | 20% faster than average | 20% slower than average | 20% slower than average | 20% faster than average |
| Years on the Market | First year | 4 years | 2 years | 2 years |
| Select one: | | | | |

(Question 4 of 12)

The survey was administered in December 2011 to a nationally-representative sample of over 1.200 individuals who intended to purchase a new vehicle in the near-term.

## 4. RESEARCH FINDINGS

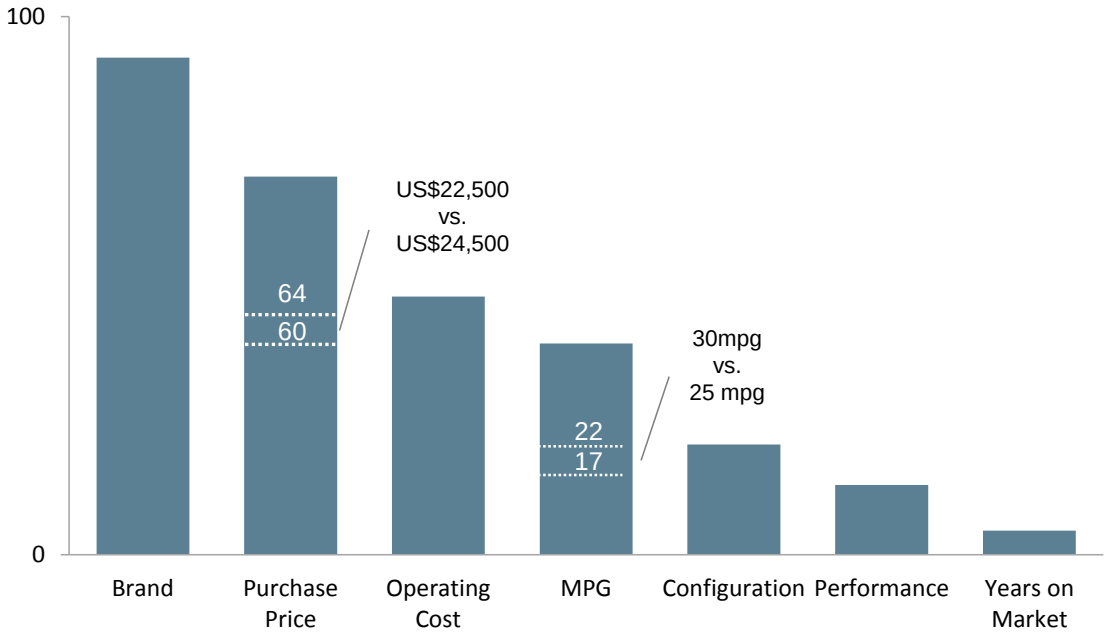
Most of the focus group participants were aware of hybrid and electric vehicle alternatives but few understood how they worked. Most said that they had not considered these vehicles because they did not like their unique styling and the additional costs were too great. Although there had been some press coverage of the impending introduction of Start-Stop vehicles in the U.S., focus group participants were almost totally unfamiliar with this concept. However, most participants indicated that they would consider this option if it were available at a cost of US$500 to US$1.000 over a conventional vehicle and if the technology worked as described.

Data from the stated choice experiments were used to develop vehicle choice models.[1] That work found, as expected, that there are important segments of the market in which fuel efficiency is a key driver. However, there are also significant market segments in which consumers focus on other priorities.

[1]Latent choice modeling was used to assist in developing an appropriate set of model specifications and to identify key consumer segments. The utility function coefficients of similarly-specified logit-form models were also estimated using hierarchical Bayes methods, which allows full heterogeneity in preferences at the individual level.

Figure 2 below shows the differences in the strength of preference[2] between the most favored and least favored levels tested for each attribute. The values were calculated assuming a "base" fuel price equivalent to current U.S. price levels.

**Figure 2 - Relative Importance of Vehicle Attributes**




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Top of Bar** | Most Preferred Brand | <US$15k | US$150/yr | 60mpg | ICE/S-S | 20% higher | 4 yrs |
| **Bottom of Bar (0 level)** | Least preferred Brand | US$55k+ | US$2.500/yr | 12mpg | Hybrid | 20% lower | 1 yr |

This figure confirms that there are very strong brand effects in the U.S. market – with certain brands having significant perceived value compared to those that are not as well regarded. However, U.S. consumers are clearly sensitive to fuel efficiency both directly and as reflected in the fuel-related operating costs. The trade-offs between fuel economy (measured in this figure as mpg -- miles per gallon) and purchase prices are illustrated by the values that are highlighted in those bars, with five miles per gallon equivalent to approximately US$2.000 price differential for the average U.S. consumer.

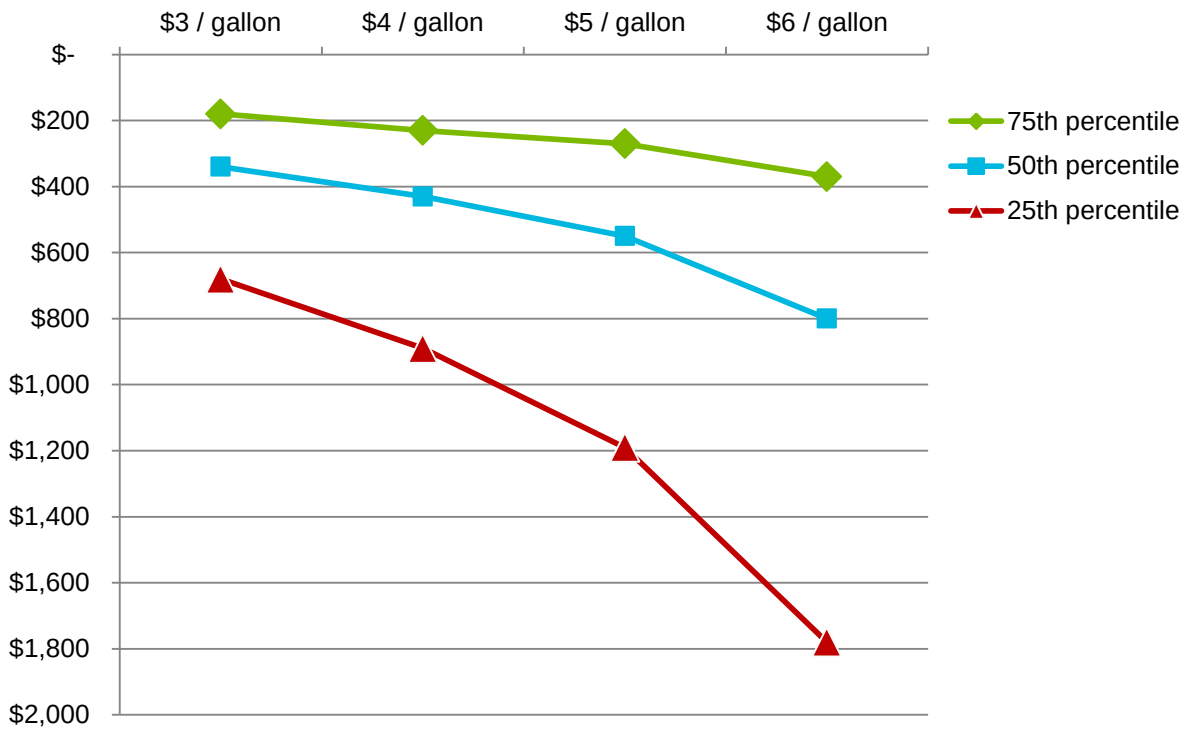
Figure 2 also indicates that internal combustion engines (ICE) and Start-Stop vehicles are generally preferred to hybrid vehicles in this market. No significant difference was found between consumers' reactions to Start-Stop configurations vs. conventional

[2]In this figure, the estimated utilities were normalized to a scale of 0 to 100 for each individual and then those normalized values were averaged across all individuals in the sample.

vehicles outside of the price and fuel efficiency effects. This was an important finding as some have speculated that U.S. consumers might be averse to adopting this new technology. There is some sensitivity to vehicle performance (as measured by acceleration rate), suggesting that the acceleration performance of the Start-Stop technology will be important to its acceptance in the U.S. And, finally, individuals in general prefer technologies that have been tested in the marketplace for some period of time (as measured by years on market), again a factor that could affect the speed of adoption of this technology in the U.S.

Figure 3 below shows a more complete illustration of the trade-off between purchase price and fuel efficiency in the U.S. market.

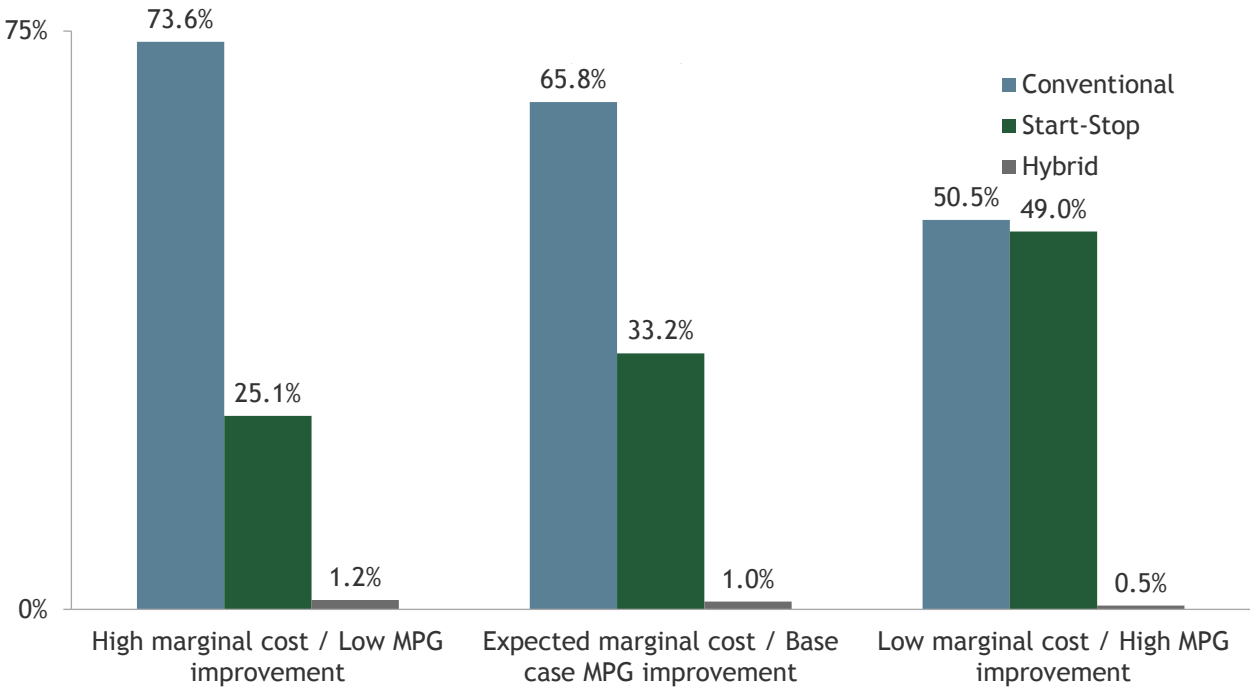
**Figure 3 - Willingness to Pay for a 5% Fuel Efficiency Improvement**




This figure shows U.S. consumers' willingness to pay at different fuel prices for the 5 percent fuel efficiency improvement typical of a basic Start-Stop vehicle compared to its counterpart without that technology. The top line in this graph shows that 75 percent of consumers are willing to pay about US $200 for this improvement at then-current fuel prices (~US$3.50/gallon); 50 percent are willing to pay US $400 and 25 percent are willing to pay US $800 for a 5 percent fuel efficiency improvement.

A vehicle market simulation model[3] was developed and calibrated so that it accurately reflects market shares by vehicle size classes and power train configurations. This simulation model was then used to estimate the effects on market shares of different Start-Stop vehicle price and efficiency levels. Figure 4 below shows a sample result from this simulation model.

**Figure 4 - Start-Stop Market Penetration Under Different Scenarios**




This figure shows the estimated market penetration for Start-Stop vehicles, including both basic Start-Stop and more advanced Start-Stop technologies, under three scenarios. The bars to the left assume a relatively lower-than expectedStart-Stop efficiency improvement with an accompanying higher cost than currently expected. Under that scenario, Start-Stop vehicles account for approximately one-quarter of new vehicles purchased. The middle set of bars represents the currently-expected Start-Stop efficiency and price points and shows those vehicles capturing one-third of new vehicle sales. The set of bars to the right assumes a very optimistic price-performance point and shows that, under those conditions, almost half of new vehicles could be chosen with Start-Stop configurations.

## 5. CONCLUSIONS

The work described in this paper included a program of qualitative research, quantitative research and simulation modeling that all suggest that there will be

[3]The vehicle choice models were implemented in a sample enumeration-based market simulation model.

significant demand for Start-Stop vehicles in the U.S. The European experience to date has demonstrated that consumers are in general satisfied with this technology and are positively inclined toward re-purchase. The qualitative research showed that U.S. consumers almost universally do not know about Start-Stop vehicles. However, they are much more inclined to accept Start-Stop technology than they have been to accept hybrid or electric vehicles.

Despite the significant differences that exist between the U.S. and European markets, the quantitative research showed that many U.S. consumers are willing to pay the expected additional cost of Start-Stop technology in order to get the fuel savings that that technology can provide. The research also highlighted that consumers are much more inclined to select a vehicle powertrain that is complimentary to known performance levels and technology than more exotic options.

## REFERENCES

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