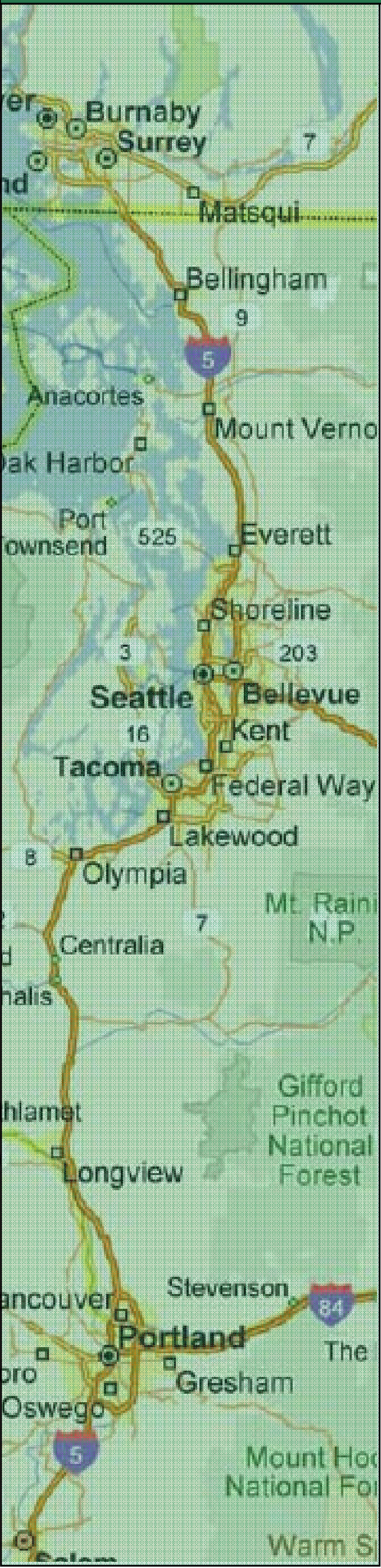

Alternative Fuels Corridor Economic Feasibility Study

Final Report

January 23, 2009

Prepared For:

Washington State Department of Transportation

Office of Public/Private Partnerships

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List of Acronyms

Acronym	Description
AF	Alternative Fuels
AFV	Alternative Fuel Vehicle
ASTM	American Society Testing and Materials
ATM	Automated Teller Machine
ATV	Advanced Technology Vehicle
B&O	Business & Occupation
B2	2% Biodiesel, 98% Petrodiesel
B3	3% Biodiesel, 97% Petrodiesel
B5	5% Biodiesel, 95% Petrodiesel
B20	20% Biodiesel, 80% Petrodiesel
B99	99% Biodiesel, 1% Petrodiesel
B100	100% Biodiesel
BC	British Columbia
BEV	Battery Electric Vehicle
BP	Better Place (Company)
CAFE	Corporate Average Fuel Economy
CCS	Carbon Capture and Sequestration
CFCP	California Fuel Cell Partnership
CFFP	Clean Fuel Fleet Program
CMAQ	Congestion Mitigation and Air Quality
CNG	Compressed Natural Gas
COGS	Cost of Goods Sold
CTED	Dept. of Community, Trade, and Economic Development
DCTED	DLA Center for Training, Education & Development
DOE	Department of Energy
DOT	Department of Transportation
E10	10% Ethanol, 90% Gasoline
E20	20% Ethanol, 80% Gasoline
E30	30% Ethanol, 70% Gasoline
E85	85% Ethanol, 15% Gasoline
E95	95% Ethanol, 5% Gasoline
EIA	Energy Information Administration
EV	Electric Vehicle
FCV	Fuel Cell Vehicle
FHWA	Federal Highway Administration
ft^2	Square Feet
Gal	Gallon
gCO_2	Grams of Carbon Dioxide
GHG	Greenhouse Gas
H_2	Hydrogen Gas
H2A	Hydrogen Analysis Project
HEV	Hybrid Electric Vehicle
HEVDP	Hawaii Electric Vehicle Demonstration Project
HOV	High Occupancy Vehicle
hr	Hour
I-5	US Interstate 5
IRR	Internal Rate of Return
kg	Kilogram
kg/d	Kilogram per day
kW	Kilowatt
kWh	Kilowatt-hour
LEV	Low Emission Vehicle

Acronym	Description
LH2	Liquid Hydrogen
LNG	Liquid Natural Gas
MGY	Million Gallons per Year
MMBTU	Million British Thermal Units
MW	Megawatt
NACS	National Association of Convenience Stores
NAS	National Academy of Sciences
NB	Northbound
NCDC	National Clean Diesel Campaign
NEV	Neighborhood Electric Vehicle
NFCBP	National Fuel Cell Bus Technology Development Program
NG	Natural Gas
NGV	Natural Gas Vehicle
NREL	National Renewable Energy Laboratory
OCS	Outer Continental Shelf
OR	Oregon
P&R	Park & Ride
PB	Parsons Brinckerhoff
PEHV	Plug-in Electric Hybrid Vehicle
PNNL	Pacific Northwest National Laboratory
PRD	Pressure Relief Device
psi	Pounds per Square Inch
psia	Pounds per Square Inch Absolute
PV	Photovoltaic
QAFMV	Qualified Alternative Fuel Motor Vehicle
R&D	Research & Development
RCW	Revised Code of Washington
RFS	Renewable Fuel Standard
RPS	Renewable Portfolio Standard
SB	Southbound
SEP	State Energy Program
SF/YR	Square Feet per Year
SG&A	Sales, General, and Administrative
SMR	Steam Methane Reformer
SOI	State of the Industry
TPY	Tons per Year
TRAC	Transportation Research Center
UCD	University of California, Davis
US	United States
USA	United States of America
USCAR	United States Council for Automotive Research
USDA	United States Department of Agriculture
USDOE	United States Department of Energy
USDOT	United States Department of Transportation
VALE	Voluntary Airport Low Emission
VAPG	Value-Added Producer Grants
VEETC	Volumetric Ethanol Excise Tax Credit
VMT	Vehicle Miles Traveled
WA	Washington
WSDOT	Washington State Department of Transportation
ZEV	Zero Emission Vehicle

Executive Summary

The U.S. transportation sector is heavily dependent on petroleum-based gasoline and diesel, as these fuels provide about 95% of U.S. transportation energy needs. Vehicles using alternative fuels are being developed by private industry to serve a growing market of people, businesses, and the public sector, but a limited retail market through which to purchase these fuels has, to some degree, constrained the use of these vehicles.

The Washington State Department of Transportation, through its Transportation Partnerships Office has commissioned a study to examine the underlying economics of the retail alternative fuel industry to see how it could, through the use of State-owned land at rest areas, incentivize station operators to begin selling alternative fuels in the Interstate-5 corridor. I-5 has also been designated by USDOT as one of the "Corridors of the Future" and has received funding in order to promote the use of alternative fuels. This Final Report presents the research effort and results of the economic analysis, providing background information on the fuels' supply chains and station costs as well as estimates of potential demand and revenues from operations.

Analysis Framework

The consultant team developed a framework based on a typical gasoline fuel station that projects capital and operating business metrics including costs of goods sold, station operating costs, and revenues.

The majority of the data used in the traditional gasoline station model was obtained through the Association for Convenience and Petroleum Retailing, and was supplemented by a survey of fuel stations currently operating in the I-5 corridor. This data revealed that the retail gas station industry operates on very thin margins, earning only five to eight percent profit on each gallon of gasoline sold. The many gasoline retailers sell gasoline simply to get customers to their store in hopes they will purchase other sundry items or service that carry a higher profit margin more typical of retail sales. The average convenience store in 2007 (across the US) sold approximately 1.6 million gallons of fuel, yielding $4.1 million in revenue and gross profits of about $233,000 (6%). Non-fuel sales for the same period averaged $1.4 million in revenue with gross profits of $440,000 (31%).

The cost to open a retail gas station in 2007 averaged between $2.0 and $2.4 million depending on the location. Land and building represented the majority of costs at about $790,000 and $710,000, respectively. The capital costs of fueling, food service, and merchandising equipment round out the total station costs, accounting for about $730,000. Average annual operating costs for a convenience store and gas station were approximately $423,000 in 2007, not including credit card fees which amount to about 2% of revenues.

This framework was subsequently used to analyze conceptual retail stations selling alternative fuels, given assumptions of specific alternative fueling equipment capital costs, cost of goods sold, and revenues estimated to be earned in the I-5 corridor. This framework provided a mechanism to forecast cash flows from operations over time. These cash flows were then used in a conceptual lease-based transaction between the State and the operator where the costs of station development may be shared as well as revenues from the operation, depending on the division of risk. The results of this analysis (the Alternative Fuels Operating Feasibility), where ethanol, biodiesel, electricity, and hydrogen were evaluated, are discussed below.

Supply Chain Overview

The supply chain network for gasoline and diesel has evolved and expanded over the past century into a complex and interconnected system that ties together oil production, distribution, refining/processing, and distribution to customers. Decades of infrastructure and system development have resulted in a supply chain network that usually works efficiently to distribute oil and finished products throughout the country.

The supply chain analysis considered potential barriers and opportunities in the supply chain network for five alternative fuels: ethanol, biodiesel, compressed natural gas, electricity, and hydrogen. Although various incentives are available to promote the use of all of these alternative fuels and infrastructure development, supply chain barriers are, in some cases, limiting the degree to which alternative fuels can compete with petroleum-based fuels. The following are some of the key supply chain barriers for these alternative fuels:

Ethanol (for the purposes of this study, E85 is implied):
- Rail / barge / truck feedstock transport is expensive (lack of pipelines similar to petroleum);
- Lack of blending and storage facilities in the Northwest.

Biodiesel:
- Feedstock cost and availability;
- Cost to transport feedstocks (lack of pipelines, terminals, blending facilities);
- Competition with petroleum-based diesel (substitutes compete on price).

Compressed Natural Gas:
- Non-renewable fuel;
- Limited domestic natural gas resources for expanded transportation use;
- Additional pipelines and LNG terminals needed for increased imports.

Electricity:
- Few electric cars currently available although plug-in hybrid vehicles expected to be in production within a couple of years;
- Lack of public / on-the-road charging facilities;
- Increased demand for low-carbon power generation.

Hydrogen:
- Fuel-cell vehicles are likely to need at least another 10-15 years of research, development, and demonstration before major deployment efforts can begin;
- Lack of hydrogen delivery and refueling station network (pipelines, etc.);
- Need for increased capabilities for low-carbon hydrogen production.

While these supply chain challenges are taken into consideration in the estimation of potential demand for alternative fuels in the I-5 corridor, they are presented in detail in Chapter 2 of this report to provide background on why certain fuels are likely to be more or less successful penetrating the market in Washington. Generally, biodiesel and ethanol must compete on price with traditional diesel and gasoline (as they are considered substitutes), therefore unit production costs must be reduced. Electricity and hydrogen have a different set of challenges associated with technology development and vehicle availability. All fuels noted above will likely be incorporated into a “cap and trade” or “carbon tax” framework at some point in the future, which will impact their relative cost competitiveness, though these potential impacts were not estimated as part of this analysis.

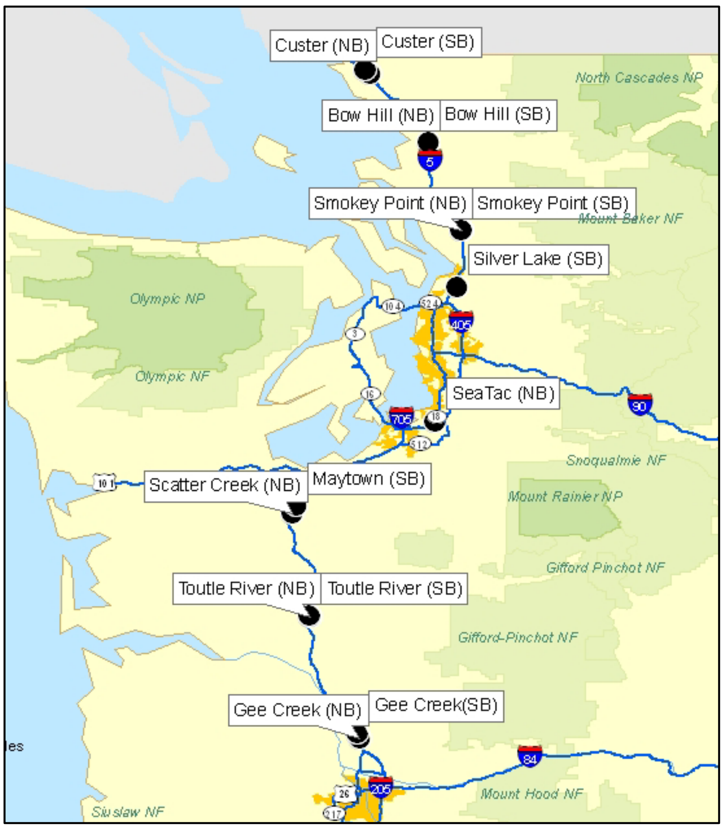
Station Spacing Analysis

The total investment by WSDOT and the potential success or failure of the program depends on the I-5 corridor's ability to provide a sufficient number of fueling stations to ensure drivers can use the corridor for inter-city travel. The station spacing analysis, presented in Chapter 3 discusses the driving range of vehicles and the number of rest areas that should be considered for the various alternative fuel station scenarios to complete a viable network of fueling options. The number and spacing of stations in the inter-regional context (focusing on vehicles traveling on I-5) is dictated by the range of the vehicles and the reliability of the stations. The table below compares the average range of each vehicle.

ES1: Vehicle range by technology

Technology	Range
Gasoline (reference)	> 350 miles
Biodiesel	> 400 miles
Ethanol	> 250 miles
Hydrogen	120 - 300 miles
Electricity	60 -200 miles

I-5 in Washington spans 275 miles from the Canadian border to the Oregon border. Clearly a motorist using just about any of the technologies listed in the table above could traverse the State with one or less refueling events, but a level of redundancy is necessary for safety and convenience. If one station fails (is for whatever reason unable to provide fuel on a given day or week), travelers should feel confident that another station will be available within a reasonable distance to accommodate them before they run out of fuel. Therefore, station locations should be frequent enough that a failure of one station should not affect a traveler's ability to move efficiently within the I-5 corridor. On the other hand, the stations contemplated in this study are not meant to compete with existing or future stations on non-state owned land (although this is inevitable to a degree). As such, a limited number of rest area stations in more rural locations is preferable.



Although not a perfect solution because sites are not equally accessible from both sides of the freeway, the comprehensiveness of the rest area network is a major advantage. The map (right) shows the rest area network in the I-5 corridor noting directional access (NB = Northbound, SB = Southbound).

In the case of hydrogen and fast charge electric vehicles, rest area locations would represent a vital corridor connecting regions together. A conservative limit of 120 miles between stations can be easily accommodated by the rest area network enabling both hydrogen and fast charge electric vehicles to travel between regions and throughout the I-5 corridor. A minimum of two stations and a maximum of seven stations at rest areas provide the ability to travel through the state using either fuel. The minimum case assumes stations would be in place in Vancouver, BC; Seattle, WA; and Portland, OR and thus the only stations located on State land would be those in the “gaps” between these major cities. It should also be noted that the drivers may have to turn around and head in the opposite direction in order to reach a fueling station before running empty under the minimum scenario.

For biodiesel and ethanol, there are stations currently operating in the corridor, but there are gaps in the station networks of the two fuels. To avoid directly competing with established private operators, stations should be sited at rest areas in these gaps. Since both fuels are compatible with existing fuels, it is not necessary to create a comprehensive network. However, to provide adequate availability, gaps in the networks suggest that 3 biodiesel and 4 ethanol stations could be initially used to provide access throughout the corridor. If biodiesel and ethanol are co-located, a total of 5 stations would be needed. A minimum scenario would require one combination station to fill the gap in the existing station network for these fuels.

The table below summarizes the minimum, maximum, and suggested number of stations located along the I-5 corridor by fuel.

ES2: Number of Stations Needed in the I-5 Corridor

Fuel Type	Minimum	Maximum	Preferred
Hydrogen	2	7	5
Fast-Charge Electricity	2	7	5
Ethanol and Biodiesel	1	6	5

Alternative Fuels Operating Feasibility

Chapter 4 outlines the feasibility analysis of operating the conceptual alternative fuel stations at rest areas in the I-5 corridor. Forecasts for cost and revenue data are presented for the following four retail fuel combinations that were screened and evaluated in the operating framework discussed above and presented in Chapter 1.

1. Electricity (standalone): For this service offering, facilities for electric vehicles (plug-in electric hybrid vehicles are expected to be the primary patron group but regular fully electric vehicles could also use the facilities) would be provided on a slimmed down retail format that would not include the convenience store component, which is part of the other three service platforms. A kiosk interface, similar to an ATM, would be provided which would require minimal capital and operating costs outlays. It was assumed that high power fast chargers would be used to allow travelers to charge a typical PHEV battery in 10 to 15 minutes. The electricity infrastructure required for the

fast charge equipment would be compatible with a battery swapping approach, though additional building infrastructure and personnel would also be needed for this type of operation. Battery swapping facilities were not modeled in any scenarios.

2. Electricity paired with Hydrogen: A full service convenience store would be provided in a standard gasoline station layout with a portion of the service station footprint dedicated to the electricity kiosks described in #1. Hydrogen would be delivered regularly to the station by truck and stored in tanks located on the property (as opposed to on-site production). Typical convenience store revenues are included with hydrogen and electricity sales.
3. Biofuels: A full service convenience store would be provided in a standard gasoline station layout. Both ethanol (E85) and biodiesel (B99) would be sold. Typical convenience store revenues are included with biofuel sales. The station configuration would not provide for heavy truck / semi refueling and the convenience store is not envisioned to provide the types of services to truckers offered at traditional truck stops. This deliberate rest area station platform was conceived to minimize the competitiveness of the rest area stations with truck stops in the I-5 corridor.
4. Biofuels paired with Electricity: This station concept would be identical to #3 while also providing electricity charging kiosks as outlined in #1.

While land is a considerable cost component of the traditional gas station model (about one third of the cost), land is assumed to be provided at no cost to the concessionaire, depending on the expected return, as outlined below. Net income from the operating model was used in a concession framework that was developed to help judge and compare the feasibility of the fuel station scenarios. This framework focuses on the internal rate of return (IRR) of the alternative fueling station. The IRR is calculated from an annual stream of cash flows, represented by total net income after estimated federal and state taxes, from an individual station for a given demand scenario. Cash flows over 15 years were examined as well as a longer 30-year structure.

A 15% IRR target was established as a minimum reasonable return and is expected to represent the lower bound of what a concessionaire would likely require for a venture of this type. The calculated IRR of each fuel station's cash flows was adjusted upward or downward to achieve a targeted 15% overall return to the concessionaire. In situations where the base IRR was below 15%, the IRR was adjusted upward by modeling an up front State capital contribution that could be used to offset some capital costs of station implementation. Alternatively, if the base IRR was initially above 15%, it was adjusted downward by modeling an annual land rent that would be paid by the concessionaire to the State in the form of a percent-of-revenue fee.

The exhibit presented below is a comparison of the alternative fuel scenarios' concession IRRs. Scenarios which fail to meet the target IRR may still be viable if the State is willing to provide contributions to enhance the cash flow for the concessionaire in the early years while the technology is being adopted by consumers. Conversely, scenarios which produce excess IRR may provide an opportunity for the State to share in revenues generated by the concessionaire in the form of a rent-sharing program. This rent share would be a fixed percentage of revenue which the concessionaire would be required to pay on a regular basis (i.e. - annually). These rent share payments would effectively lower the concessionaires IRR to the target level while providing income for the State in return for the use of the land.

ES3: Estimated IRR for 15- and 30-Year Concession: Base Case

Fueling Station Offering	15-Year Concession IRR	30-Year Concession IRR
Electricity Kiosk (Standalone)	0% to 15% IRR	> 15% IRR
Hydrogen / Electricity Kiosk	< 0% IRR	0% to 15% IRR
Biofuels (Standalone)	0% to 15% IRR	> 15% IRR
Biofuels / Electricity Kiosk	> 15% IRR	> 15% IRR
All Fuels Combined	> 15% IRR	> 15% IRR

Generally, the biofuel scenarios were the strongest due to the fact that vehicles are already being sold and used in the I-5 corridor. As such, these concessions are expected to have a positive cash flow after only five to six years, while the stand alone electricity and hydrogen scenarios are expected to lose money in each of the first 8 to 10 years of operation. While the biofuels scenarios have the benefit of momentum in the market, they are also hindered by the price competition with regular gasoline and diesel, which are considered substitutes. As such, the biofuels must be priced competitively, which means slim unit profit margins of less than 10%. Operating with such slim margins creates a situation where the IRR can range widely, with relatively small shifts in capital and operating costs and unit profitability.

The scenario showing biofuels paired with electricity provides a return to the concessionaire in excess of 15% while making three alternative fuels available. The electricity kiosks are not expected to have strong profit potential in the early years due to the low number of electric cars on the road today, though these kiosks are expected to grow in use in the latter years of the forecast period and provide substantial profits due to the low costs of the operations and high unit margins. The excess revenues earned by the concessionaire could be shared with the State through a land rent agreement generating over $4 million over the course of a 30-year concession.

If all four fuels were offered, the station would still be expected to yield an IRR greater than 15%, though not as strong as the biofuel / electricity scenario, due to the slow penetration hydrogen vehicles and the high cost of operations related to hydrogen equipment.

Convenience revenues are included in all scenarios except the standalone electricity kiosk scenario. The team performed a limited analysis on the contribution that the convenience store made to the overall operation and concluded that removing the convenience operations would have a clear negative impact on the concession performance. The total net income earned over the 30-year concession period would be expected to fall by 25% to 35%. This would cut the 30-year IRRs stated in the tables above roughly in half and cause many of the 15-year IRRs to turn negative. In all scenarios, the State would need to provide an up-front capital contribution to help the concessionaire achieve the target 15% IRR.

Alliance Opportunities

Alternative fuels and vehicles have been successfully introduced in small demonstration programs with personal users, in public and private fleets (e.g. municipal, state, federal, regional trucking, taxis) and in niche markets (e.g. airports, school buses, transit vehicles) where vehicles, fuels and fueling infrastructure were made available to users concurrently. While some fundamental technological and economic challenges remain, the primary challenge to alternative fuel (AF) commercialization is how to "build a market simultaneously for new vehicle technologies, new fuels, and new infrastructure to support them."

The decision-making problem is highly complex as it requires decisions to be made in parallel by a large number of stakeholders who pursue separate goals, respond to different incentives, and are each facing decisions of a different nature:

1. Governmental bodies making public policy decisions,
2. Private companies making capital investment decisions, and
3. Users making consumer choices.

In other words, automotive manufacturers would not distribute alternative fuel vehicles (AFV) (even in demonstration programs) within a given market where refueling stations are not available; fuel producers, distributers and stations owners would only invest in support infrastructure if enough AFVs are in circulation to support the demand for the fuels they produce and distribute; and users would not purchase vehicles they cannot refuel conveniently.

A wide array of stakeholders from the public and the private sectors have already expended a vast amount of resources in promoting alternative fuels and have a vested interest in helping the new technologies take these last steps toward larger market implementation. These stakeholders form a heterogeneous body of individuals, governmental and not-for-profit entities, and small and large corporations, each with their own goals and responding to different sets of incentives.

Private stakeholders include wide-ranging types of organizations that are primarily motivated by economic profit, including: automotive industry, petroleum-based fuel producers and distributers, alternative fuel producers and distributers (most of which are specialized on a single fuel source), public and private utility companies, fuel station owners and concessionaires, infrastructure and station builders, and private vehicle fleet owners.

Public stakeholders include policy-makers as well as State, regional and local government and agencies concerned with the implementation of policies and enforcement of regulations. Public agencies concerned with transitioning to an alternative fuel economy are found at all levels of government and providing leadership, resources, and experience. Public agencies also own large vehicle fleet that can provide a customer base to a new AF station.

All stakeholders are poised to benefit eventually from the transition from petroleum-based fuels to alternative fuels; but for those benefits to be realized, these decisions must be coordinated. At the current stage of development, industry stakeholders concur that the adequate availability of alternative fuel stations is the major barrier to a commercial transition toward AF technologies, though several public and private stakeholders are working, generally in parallel, to reduce dependency on traditional petroleum fuels.

Industry and public stakeholders alike are mindful of the necessity of coordinated action and a general consensus has been developing around the primary elements that a successful alliance strategy would need to address to transition successfully to an alternative fuel future. These include:

- Policy leadership and consistency of the political message, based on coordinated policy, regulations, and incentives for all branches of government, public and industry outreach initiatives, and strategic planning.

- Regulatory framework adapted to the AF industry including building codes for AF stations, fuel quality and emissions standards, testing procedures, to metering standards required for retail activity.

- Any initiative focusing on AF deployment must realistically consider the expectation for profit of the private industry and the level of risk associated with initial capital investment as well as long-term operation of AF fueling infrastructure. Financial incentives, including direct subsidies and tax breaks, are a key component to reduce the financial risk of private stakeholders, but must be guaranteed over a long-enough period of time to secure the necessary return on investment.

- Large-scale infrastructure projects cannot be built on the "build it and they will come" premise. Past experience with alliances and public-private partnerships in AF demonstration programs have highlighted the importance of obtaining the upfront commitment of automotive manufacturers to produce and deliver AFVs in the market.

- Deployment strategies must remain focused on the end user. Surveys highlight that individual users are in general very sensitive to convenience (availability of station, fueling process, and vehicle maintenance), cost, vehicle and fuel performance, reliability and safety, and are generally unfamiliar with or misinformed about most AF and AFV technologies. Successful alliances must therefore focus on overcoming these barriers. In that respect, public outreach, education programs, and financial incentives are instrumental.

- Numerous coalitions, leadership, technology and resource centers, and programs aimed at fostering the transition to alternative fuels exist at the local, state, and federal levels. Through a limited number of interviews, most have expressed interest in supporting WSDOT by sharing knowledge, industry contacts, and in providing active support.

Introduction

The Washington State Department of Transportation (WSDOT) and other agencies of the State of Washington (the State) are taking part in a number of initiatives to allow people to become less reliant on traditional gasoline and diesel-based transportation, including the passenger cars and trucks driven on State highways every day. The transition from a primarily gasoline and diesel-based system to a diversified system incorporating alternative fuels is expected to be both challenging and rewarding. Both public and private involvement will be needed to overcome what is considered by WSDOT to be one of the first major hurdles: establishing alternative fuel stations to provide the fuel supply in advance of the public's investment in the automobiles and trucks that use these fuels.

WSDOT, along with state agencies in Oregon and California, is using the Interstate-5 (I-5) corridor as a test bed for this analysis as part of USDOTs "Corridors of the Future" program. WSDOT, through its Office of Public Private Partnerships has commissioned a study of the economic feasibility of such fuel stations in the I-5 corridor with the hypothesis that some form of public support will be necessary to implement the retail fuel stations, at least initially. Once enough people adopt the technologies that use the fuels, creating sufficient demand, the public subsidy will no longer be needed and regular market operations will dictate the supply and demand dynamics that determine the sustainable number of profitable alternative fuel retailers.

WSDOT selected a consultant team led by Parsons Brinckerhoff (PB) and supported by alternative fuel subject matter experts from Parsons Brinckerhoff (PB) and the University of California, Davis Institute for Transportation Studies (UCD) (together the Team) to perform the analysis. The Team engaged in the study at roughly the same time as teams doing somewhat different but complementary work for the states of Oregon and California, which are also examining I-5 alternative fuel opportunities.

A summary of the full scope for this Alternative Fuels Corridor Economic Feasibility Analysis is presented in the following bullets.

1. Task 1: Develop Traditional Fuel Station Business Model: Develop an operational analysis tool using information for a traditional gasoline & diesel fuel station in the I-5 corridor. Use capital and operating statistics to establish benchmarks that can be compared to the conceptual pro formas developed for alternative fuel stations using the same model. This gives the Team an understanding of the current industry standard practices and expectations from a retailers perspective. This also provides a benchmark to compare future analysis against.
2. Task 2: Supply Chain Overview: Perform a conceptual supply-chain overview including a background review of each of the relevant fuel types, how and where each fuel is produced, and how the fuel is delivered to the retail stations. The supply chain is an integral part of the potential success or failure of the fuel. The supply chain can add significant infrastructure costs and limit the fuel's potential use, lowering its viability compared to other alternative fuel choices. WSDOT does not want to invest in a technology with a low chance of long-term viability.
3. Task 3: Station Spacing Analysis: Using existing models that estimate fuel station network requirements, estimate the adequacy of providing State-owned rest areas and other public land to incentivize and establish an initial network of alternative fuel stations in the I-5 corridor. This analysis will be extended to other non-State-owned locations if rest areas are found to be insufficient to provide the quantity and distribution of station locations. Both "minimum necessary"

and "ideal" station network configurations will be estimated. The location and number of alternative fuel locations is essential to the success of the project. If the alternative fuel network does not meet the minimum requirements for a driver to be able to drive from one end of the corridor to the other, the corridor will be underutilized. The number of fueling locations also affects the total commitment and investment by WSDOT.

4. Task 4: Alternative Fuels Analysis: Extending the work performed in Task 1 and incorporating insights from tasks 2 and 3, evaluate the strength of various alternative fuels from a financial perspective, given assumptions of demand in the market for each fuel. The goal of this Task is to assess, in relative terms, the operating viability of each alternative fuel option and estimate the value to the operator of the State providing incentives, such as land at rest areas to locate the fuel station. This analysis provides some understanding of how profitable, and therefore how attractive, a potential concession for a concessionaire may be. This analysis also provides some insight as to the expected potential long-term viability of each alternative fuel.
5. Task 5: Alliance Opportunities: This task will illuminate who the public and private stakeholders are and which amongst this group could potentially be interested in participating, either financially or otherwise, in the development of an alternative fuel corridor. Stakeholders identified here may have a future role in the program, helping to make I-5 an alternative fuels capable corridor.

Chapter 1: Traditional Gasoline Station Model

In order to understand how alternative fuel stations may operate and perform financially, the Team developed a model to simulate operations of a typical fuel station. This model is based on a traditional gasoline / diesel fuel station, using industry average data for the capital cost to construct a station as well as operating costs and revenues to develop profitability metrics. Both fuel and non-fuel items and services were analyzed and included in the model.

This model will be used as a template for analysis of the alternative fuel stations. It was developed to be flexible and allow inputs and assumptions to be adjusted as necessary to accommodate slightly modified operations associated with the alternative fuels. We have assumed that any alternative fuel station operated by a private entity will offer similar non-fuel services to what is offered at a traditional gasoline station, and possibly multiple fuels. Non-fuel products and services are expected to be important to the profitability of the station, especially in the long-term as margins from alternative fuel sales become thin due to competition, as has happened with gasoline. That said, the focus of this analysis is on fuel sales and does not focus on the specific mix of other services a fuel station/convenience store operator chooses to offer.

The model is built to reflect an average, single-location fuel station operating in the I-5 corridor. Inputs to the model are discussed in the next section, followed by an overview of the model results and analysis framework. The average station is contains 3-6 fueling islands as well as an attached convenience store. The industry average store has a sales area of 2,768 square feet, with an average total lot size of approximately 1.2 acres. Hours of operation vary from 18 to 24 hours per day, usually requiring at least one attendant at any given time. The majority of the traditional fueling station's revenue is fuel sales, however petroleum-based fuels have low profit margins, so in-store sales provide a majority of the gross profit although they account for a smaller percentage of revenue. In essence, traditional fueling stations sell fuel to attract customers to the convenience store.

Traditional Fuel Station Model Information Sources

The majority of the data used in the traditional gasoline station model was obtained through the Association for Convenience and Petroleum Retailing (NACS). The NACS is an international trade association representing 2,200 retail and 2,000 supplier company members, which publishes industry data annually in its State of the Industry Report (SOI).

The SOI is the compilation of financial and performance data reported by 122 firms from across the United States representing the 13,618 retail stores in the 2008 survey year.[1] Figures used from the NACS reflect the national weighted averages unless otherwise noted.

To supplement the NACS data, a survey of fuel stations currently operating in the I-5 corridor was conducted by the Team. The short written survey was administered in July of 2008 to 59 fuel stations, and had a response rate of about 12%. While the response rate was somewhat low, enough responses were received to provide a local perspective and validate the NACS statistics used in the traditional fuel operating model.

[1] Data is generally presented as averages for all stores reporting a given line item, such that totals do not always equal the sum of the parts.

There are two notable differences between the NACS and I-5 survey data:

1. The NACS data reflects national averages with a very large sample size while the I-5 survey data is for a much smaller sample of fuel station/convenience stores located in a discrete corridor within one state.
2. The NACS data reflects an entire year of statistics for 2007 while the I-5 survey data was for a single month, May 2008.

The average volume of gasoline sales and total store sales calculated from the I-5 surveys were generally in line with data obtained from the NACS. The survey respondents data extrapolated to annual figures would average $4.175 million in fuel revenue and 1.112 million gallons sold. This translates into a price of $3.75 per gallon in May 2008. The data obtained from the NACS reports a national average of $4.126 million in fuel revenue and 1.610 million gallons sold per store in 2007, inferring an average price per gallon of $2.56. A comparison of the I-5 survey data and NACS data is shown in Exhibit 1.

Exhibit 1: NACS and PB Survey Statistics Comparison

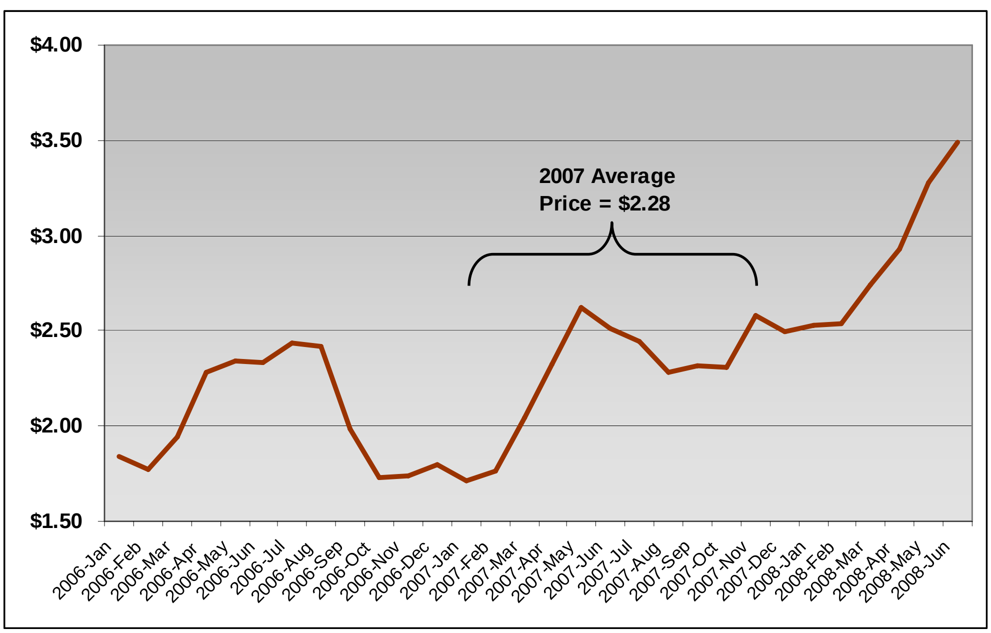
	2007 Industry Average	2008 WA Survey Responses
Gallons Sold	1.610	1.112
Fuel Revenue	$4.126	$4.175
In-Store Revenue	$1.361	$1.028
Total Revenue	**$5.487**	**$5.203**

all figures in millions

Fuel was much more expensive in Washington State in May of 2008 than the national average over all months of 2007.

Exhibit 2 shows a graph of national average gasoline prices by month between January 2006 and June 2008. The average price of gasoline in 2007 according to the Energy Information Administration was $2.27 per gallon, but the price rose to about $3.50 per gallon by mid 2008. Total annual store sales for survey respondents averaged 5.203 million (monthly revenue annualized), whereas the national average for 2007 was 5.487 million, about 5% higher. A full summary of the survey results is contained in Appendix A.

Exhibit 2: Monthly Retail Gasoline Prices, 2006 to 2008

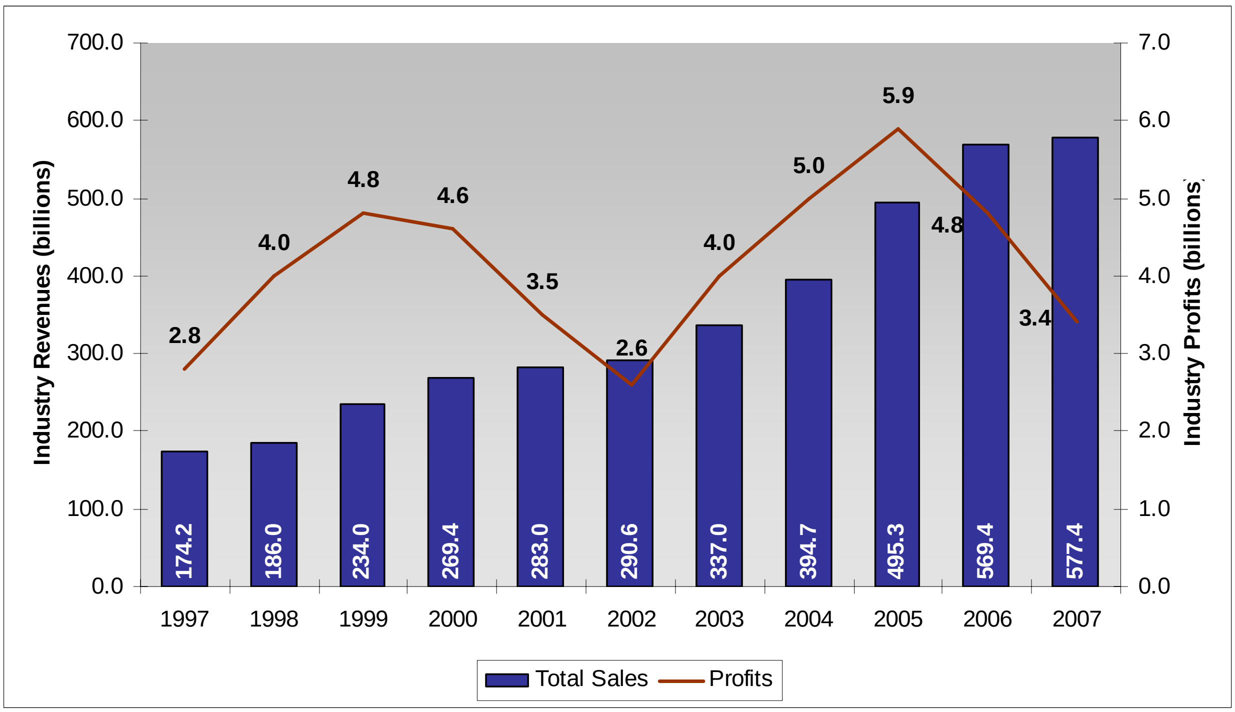


Current State of the Fuel Station Industry

Using NACS SOI data, the following sections inform the underlying drivers of gasoline station profitability. The convenience store industry experienced declining growth rates of motor fuel sales, total sales, and pretax profits in 2006 and 2007 compared to the four prior years. Industry sales as a whole were up by only 0.8% in 2007 over the 2006 level. The blue vertical bars in Exhibit 3 show annual revenues.

While revenue growth slowed, profitability actually declined in 2006 and 2007 as shown by the red line in Exhibit 3. Pretax profits were $3.4 billion in 2007 down from $4.8 billion in 2006 and $5.9 billion in 2005. The NACS states that declining profitability has resulted from the rising costs of credit card fees and the increased use of credit cards to purchase fuel, as well as general changes to consumer behavior due to increasing fuel costs.

Exhibit 3: Convenience Store Industry Total Sales and Pre-Tax Profits 1997 - 2007



Operating Revenue

Traditional fuel station income can be categorized into two general sources: fuel revenue and in-store revenue. Fuel revenue consists of all fuel types and in-store revenue consists of all other sales including but not limited to beverages, food, tobacco, car washes, and automotive parts and repair services. Exhibit 4 shows the average total sales per station in 2006 and 2007. In both years, revenues were consistently distributed 75% / 25% between fuel and in-store sales, respectively.

Exhibit 4: Total Operating Revenue

Categories	Category as % of Total		Average Sales	
	2006	**2007**	**2006**	**2007**
Fuel Sales	75%	75%	3,619,600	4,126,200
In-Store Sales	25%	25%	1,233,900	1,360,500
Total Sales	**100%**	**100%**	**4,853,500**	**5,486,700**

Average total fuel revenue for a single station/convenience store was $4,126,200 in 2007, as detailed in Exhibit 5. Ethanol and other fuels are not shown as they represented less than 1% of total gallons sold. Regular gasoline accounted for close to 70% of sales, followed by diesel fuel at 16%. The only significant changes in sales from 2006 to 2007 were a slight increase (3%) in mid-grade gallons sold and a decrease (6%) in the gallons of diesel fuel sold. Despite a 1% overall decline in the total number of gallons sold between 2006 and 2007, revenues increased by 14% due to higher average prices per gallon.

Exhibit 5: Fuel Sales and Revenue

Fuel Type	Gallons Sold		Fuel Type as % of Total Gallons		Revenue	
	2006	**2007**	**2006**	**2007**	**2006**	**2007**
Regular	1,101,800	1,104,500	68%	69%	2,463,300	2,829,900
Mid-Grade	147,800	152,400	9%	9%	329,500	390,600
Premium	93,100	91,300	6%	6%	207,600	233,800
Diesel	277,700	262,200	17%	16%	619,200	671,900
TOTAL	**1,623,400**	**1,610,400**	**100%**	**100%**	**3,619,600**	**4,126,200**

In-store revenues are divided into four categories: tobacco, alcohol, foodservice, and general merchandise. As shown in Exhibit 6, the largest contributor to in-store sales in 2007 was tobacco sales, accounting for over 40% of revenues. Total in-store sales increased by 11% between 2006 and 2007, though the distribution of sales remained relatively constant. For purposes of alternative fuels analysis and comparison of operating performance between fuels, in-store sales are assumed to remain constant despite the mix of products that may be offered at a particular location.

Exhibit 6: Average Single-Location In-Store Revenue

Categories	Category as % of Total Sales		Average Sales	
	2006	**2007**	**2006**	**2007**
Tobacco	43%	42%	528,900	569,700
Alcohol	14%	14%	176,900	191,500
Foodservice	17%	17%	210,800	232,800
All Other	26%	27%	317,300	366,500
Total Sales	**100%**	**100%**	**1,233,900**	**1,360,500**

Costs of Goods Sold

Fuel Cost of Goods Sold (COGS) was calculated using NACS-reported average gross profit for fuel (cents per gallon) by type and is expressed in the model as a percentage of revenue. The formula below shows this calculation and Exhibit 7 presents the resulting statistics for each fuel type.

Fuel Cost of Goods Sold = Revenues – (Gallons Sold x Gross Profit per Gallon)

Exhibit 7: Fuel Cost of Goods Sold

Type	Gallons	% of TOTAL	Revenue	Gross Profit / Gal	COGS $ Annual	COGS as % Rev	Gross Profit
Regular	1,104,500	69%	2,829,900	$0.14	2,678,100	95%	151,800
Mid-Grade	152,400	9%	390,600	$0.18	362,400	93%	28,200
Premium	91,300	6%	233,800	$0.20	215,400	92%	18,400
Diesel	262,200	16%	671,900	$0.13	637,200	95%	34,700
Total	**1,610,400**	**100%**	**4,126,200**	**$0.14**	**3,893,100**	**94%**	**233,100**

Although fuel is by far the largest revenue stream for convenience stores, motor fuels COGS averaged 94% in 2007, leaving about 6% of fuel revenue as gross profit. Regular gasoline sales are the highest of all the fuel types sold, followed by diesel, though these types have the smallest gross profit margins at about $0.13 per gallon, or about 5%.

Profit margins for alternative fuels are expected to be higher than gasoline because they have not yet been commoditized by ubiquitous competition. Because gasoline is widely available and the differences between brands are nearly nonexistent, people generally choose the location where they purchase gas based on the price. With price being the sole factor with which operators can compete, prices (and profit margins) are driven down to increase sales. Alternative fuels are not as widely available as gasoline; therefore higher profit margins can be expected by operators for some period until such time that the combination of a growing market and relatively high gross margins have attracted a sufficient number of new retailers to result in competitive price and margin reductions.

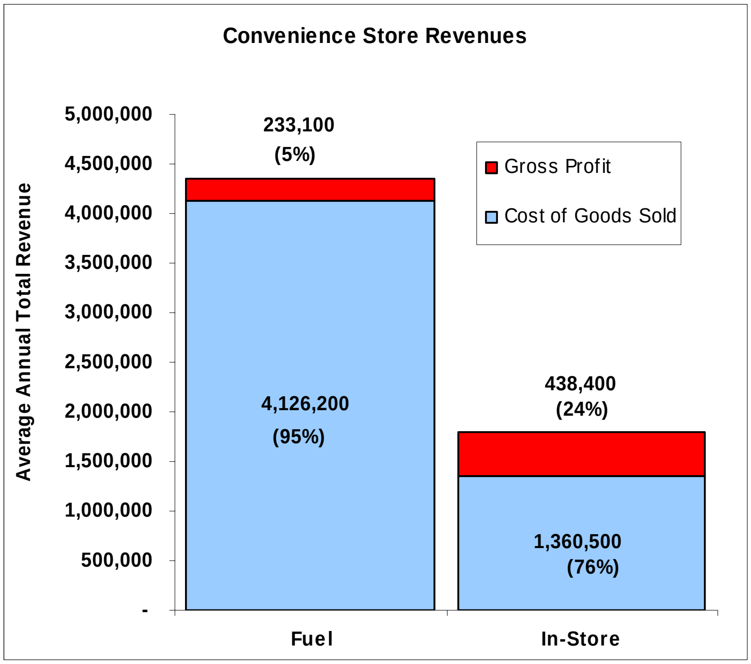
Fuel stations rely on fuel sales to generate traffic through the station store and generally make the majority of profits on in-store sales. In-store COGS is also expressed in the model as a percentage of revenue but was derived by subtracting average gross profit from average revenues for each in-store category, as shown in Exhibit 8 below. Aside from fuel, tobacco and alcohol have the highest costs (and lowest profit margins) and together accounted for close to 70% of in-store inventory costs for an average store, approximately $630,000 per year.

Exhibit 8: In-Store Cost of Goods Sold in 2007 Dollars

In-Store Revenue Categories	Revenue	Cost of Goods Sold	COGS as % of Rev	Gross Profit
Cigarettes/ Other Tobacco	569,400	476,100	84%	93,300
Foodservice	232,800	117,900	51%	114,900
Alcohol	191,900	153,500	80%	38,400
General Merchandise	366,400	174,600	48%	191,800
Total	**1,360,500**	**922,100**	**68%**	**438,400**

As shown in Exhibit 9, revenues from fuel sales are three times that of in-store sales, but fuel gross profit only accounts for one-third of the gross profit for the business.

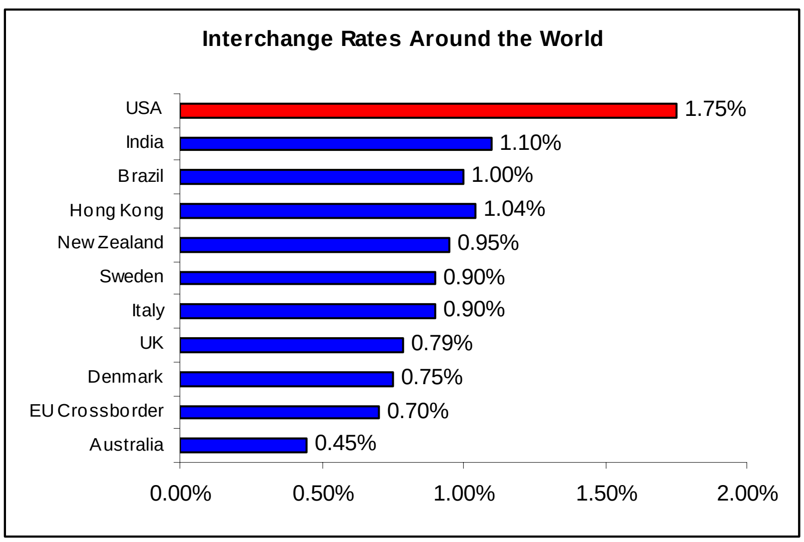
Exhibit 9: Convenience Store Revenues by Source



Credit Card Fees

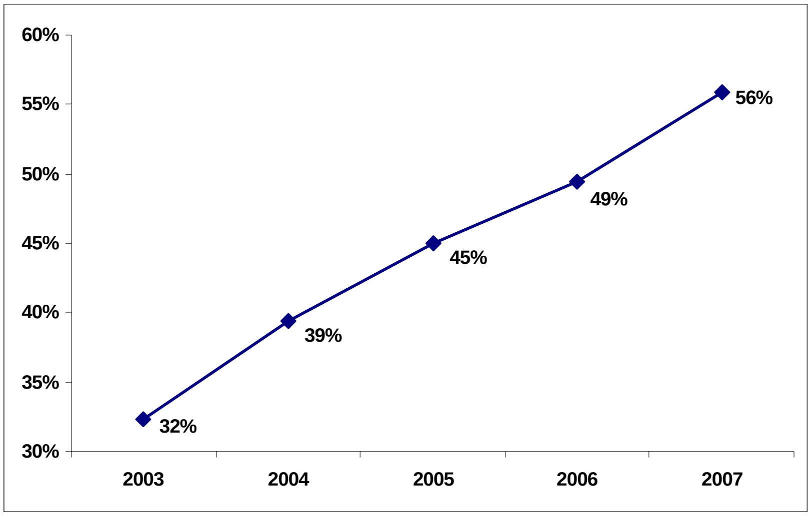
Credit card fees are a major cost component for convenience stores, accounting for at least 1.75% of revenues from purchases made with credit cards and similarly branded debit cards. Some industry groups, including NACS, argue that the fee levels in the U.S. are unfairly high. Exhibit 10 compares fees charged in the U.S. with other countries. Our assumption is that the 1.75% rate continues for the length of the forecast period.

Exhibit 10: Select Credit Card Interchange Rates



The percentage of customers using credit cards for fuel purchases increased from 32% in 2003 to 56% in 2007 as shown in Exhibit 11. Increasingly higher fuel prices, which would otherwise require customers to carry larger amounts of cash, combined with a declining number of merchants willing to accept personal checks are roots of this trend which is assumed to continue until 85% of transactions are by credit or debit card, expected by 2015.

Exhibit 11: Percentage of Transactions at Convenience Stores Using a Credit Card



Sales, General, and Administrative Costs

Exhibit 12 lists average Sales, General, and Administrative (SG&A) expenses for a fuel station/ convenience store. Wages and benefits accounted for almost half of these costs which totaled about $422,900 in 2007. All of these expenses are expected to be borne by any fuel station operator regardless of the type of fuel they sell.

Exhibit 12: Industry Average Sales, General, and Administrative Expenses, 2007

Cost Category	
Wages & Benefits	207,000
Advertising & Promotion	7,300
Utilities	41,300
Property Taxes, Licenses, and Other Taxes*	17,800
Business Insurance	6,300
Equipment Rent	4,200
Communications	5,500
Repairs and Maintenance	32,100
Royalty/Franchise Fees	12,300
Branded Foodservice Franchise Fees	8,200
Supplies	12,600
Cash Short/Over & Drive-Offs	4,700
Bank Charges (ex. CC Fees)	3,300
Internet Expenses	14,800
Other Expenses not Listed	45,500
Total Sales, General, and Administrative Costs	**422,900**

*This line reflects an industry average and is not specific to Washington.

Taxes

Business and Occupation Tax

The State does not assess a traditional income tax on business income; rather it levies a Business and Occupation (B&O) Tax on gross revenue. All businesses operating in Washington State (including not-for-profit organizations) are taxed using this approach. As with income taxes, there are different rates, credits, and exemptions for the B&O tax depending on the business, but convenience stores, are taxed at a rate of 0.471% of gross revenue.[2] The Team assumes that the fuel stations will incur this tax as a retail business without any credits, and assumes no change from the current tax rate.

Other Taxes

Federal and State Motor Fuel taxes are included in the fuel COGS. Other taxes, such as payroll and property taxes, are included as an expense within the Sales, General, and Administrative section of the income statement. Federal income taxes are not calculated in the PB Model, and no special federal or state tax exemptions or deductions are assumed for any one specific alternative fuel that are not available for all fuel stations.

Capital Costs

The capital cost to construct a traditional fuel station was estimated in order to give a basis of comparison for the alternative fuel station model. The NACS reports the average investment required for both urban and rural locations.[3] Since most state rest area locations are located along I-5 in somewhat rural settings, the team focused on the rural station site capital cost statistics. New rural stations were on average 19% less costly to develop than urban stations in 2007. Most of the variation in the cost is due to higher land costs in urban areas. Exhibit 13 shows the capital cost assumptions provided for both rural and urban stations.

Exhibit 13: Average New Gas Station Capital Investment, 2007

Property	**Rural**	**Urban**
Land	645,900	927,200
Building	702,600	712,100
Total Property	*1,348,500*	*1,639,300*
Equipment		
Foodservice Equipment	116,000	116,600
Motor Fuels Equipment	379,800	409,100
Merchandise Equipment	155,100	212,600
Technology Equipment	36,400	35,900
Total Equipment	*687,300*	*774,200*
Total Capital Costs	**2,035,800**	**2,413,500**

The price of land accounted for about one third of the average required investment for a new rural area station in 2007 if the facility was purchased outright. Assuming this purchase approach, a discounted sale of State land at rest areas to an operator could be an effective incentive should WSDOT be able to provide sizable locations in areas with adequate visibility,

[2] Convenience stores fall in to the "retail only business" rate category.

[3] In the past five years the capital cost growth of new rural stations has outpaced that of urban stations mainly due to land, building and fueling equipment cost growth, though land areas and building sizes were roughly the same. Interviews with NACS revealed that sample sizes from year to year impacted the data in certain years but that trends shown in the data were believed to be accurate. To reduce the impacts of sample size variations year to year, annual data for the five years reported (2003 to 2007) was smoothed (averaged) and escalated to 2007 year terms.

signage and traffic flow.[4] However, the provision of rest area land to a potential alternative fuel retailer via a zero-cost or below market lease agreement would also provide a tangible economic incentive to help jump start a fledgling network of alternative fuel sites without a change in land ownership.

This raises two important questions regarding how the transaction might be structured.

1. **With the State's goal for the project to jump start the use of alternative fuels, would it consider a sale of the land to the station operator?** If such a parcel were offered for sale at a State rest area, it would likely come with restrictions designed to confine its use to the retail sale of alternative fuels. Land so encumbered would fetch a lower sales price than a comparable site with no such use restrictions, since it would attract a wider range of buyers, including traditional fuel station retailers.
2. **If the State retains ownership of the land, who will pay for the building and other land improvements**? For toll road rest area concessions, often the state or toll authority typically pays for some on site infrastructure (parking lots and signage), the building shell, and the fuel tanks. The operator is then responsible for the installation of fuel pumps and other fuel-related equipment, canopies, and interior improvements.[5] While this has been the norm, there is precedence for the concessionaire paying for all improvements to the site, but this would only work if the returns to the concessionaire on the business venture were sufficient to cover the costs.

With the specific structuring of the potential concession outside the scope of this work, some assumptions were made regarding the above two questions so that potential operator investment costs could be estimated.

Due to lack of available funds for WSDOT to invest in rest area infrastructure development, the base scenario was established where the concessionaire would pay for the installation of the building and infrastructure, and receive rights to operate on the State owned land at no costs. The State may participate further by contributing funding for station site development or receiving excess revenue from the concessionaire if a target return is exceeded.

The profit sharing mechanism could be based on a "percentage of gross revenue" land lease transaction. This approach provides a realistic method for an operator to conduct business on State owned land while providing the State levers to incentivize the operator and allow a fair rate of return. Depreciation, consideration of lending terms, and the value of State owned land are not considered in the calculation of occupancy cost under this approach.

This approach is uncommon but could be plausible if risk-mitigating options or other buy-back provisions that provide for risk sharing or an exit strategy for the operator are incorporated in the concession agreement. Even with such provisions, this position may have considerably higher risk, especially considering uncertainties regarding technology adoption and competition from other operators who may have more attractive locations and service offerings. The concession structure is explored further in Chapter 4 of this report.

[4] The average property size for a new rural store opening in 2007 was 53,000 square feet. The average building size for a new rural store opening in 2007 was 4,400 square feet.

[5] Interviews with industry experts revealed that this approach was commonly used on toll roads in New Jersey, Pennsylvania and New York to structure concession agreements with rest area operators.

Chapter 1 Conclusions

Exhibit 14 shows a summary profit and loss statement for the traditional fuel station as modeled using industry averages discussed above. This framework will be used to evaluate alternative fuel station profitability, under shifting assumptions for key operating variables including fuel revenue, fuel COGS, land, and fueling equipment costs.

Revenues from certain alternative fuels that have not been substantively adopted, such as hydrogen, are expected to be low at first but grow over time. Assumptions for demand and price of each alternative fuel will be developed as part of Task 4 and play an important part in the operating forecasts for those station types.

Exhibit 14: Pro-Forma Profit and Loss for Example Traditional Fuel Station[6]

Fuel Revenue	4,126,200
Other Revenue	1,360,500
Total Revenue	***5,486,700***
Fuel COGS	3,893,100
In-Store COGS	922,100
Total Cost of Goods Sold	***4,815,200***
Gross Profit	671,500
SG&A	(422,900)
Lease cost	(110,880)
Fueling Equipment Cost	(42,849)
Other Equipment Cost	(34,695)
Estimated B&O Tax Due	(25,842)
Net Income before Federal Taxes	***34,333***

After subtracting COGS from Gross Revenue, about $672,000 remains to pay the expenses of the business. SG&A is by far the largest expense, followed by the cost of the lease, which in this case is calculated as a 4,400 square foot facility at $25.20 per SF/YR as detailed in the Capital Costs section above.[7] Annual fuel and other equipment costs are assumed to be paid for using borrowed funds with favorable loan terms of 5% interest for 12 years. The net income for this fuel station is positive but close to zero relative to revenues. It is important to reiterate that this financial picture assumes industry average revenues and costs. Actual net income could vary widely, depending on location, overall convenience, cleanliness, brand recognition, lease terms, the operator's ability to control costs, and other factors.

The location of a fuel station is the most important factor in assessing its value. Locations along I-5 at rest areas have both positive and negative characteristics that will impact the viability of operations. On the

[6] Sales, General and Administrative Expenses (SG&A) represent all operating costs of the business except for the COGS, capital costs, and taxes.

[7] The lease cost for the gasoline station example is calculated as if located on non-state property under typical commercial terms available in the I-5 corridor. Other lease options that may be suitable for rest area concessions will be further explored as part of Task 4.

negative side, the customer base for a rest area fuel station is somewhat limited to people already using I-5 (often in a single direction) as it would likely be inconvenient for someone to drive onto the Interstate to a rest area from a local road for the sole purpose of purchasing fuel.

Another potential disadvantage of being located at a rest area is the limited options for other services, such as food, that might be available compared to a regular exit off of the Interstate. Many people prefer to stop for fuel and food at the same time and if the fuel station located at the rest area is limited to sundries, it may be a less attractive alternative if a similar fuel station is located at a nearby exit where there are several food alternatives.

These potential location disadvantages are offset by the convenience and generally very good highway visibility of rest areas. Stopping at a rest area generally takes much less time than an exit since there are no traffic signals and the rest area itself is physically close to the highway. These and other aspects of the rest areas' competitive advantages will be discussed in more detail as part of the station spacing analysis in Chapter 3.

Chapter 2: Supply Chain Analysis

Introduction

This chapter provides an overview of the supply chain issues for alternative fuels on the I-5 corridor, which will help inform WSDOT of potential barriers and actions that may affect the feasibility of an alternative fuels corridor. This chapter describes:

- The supply chain for gasoline and diesel
- Alternative fuels considered in the analysis
- Feedstocks for each fuel
- How the alternative fuel or energy is produced
- How the fuel is or will be delivered to retail stations
- Supply chain issues
- Potential strategies to overcome or address supply chain issues.

Overview of Gasoline/Diesel Supply Chain

This section briefly describes the supply chain for gasoline and diesel. This overview is provided to help provide possible insights into potential supply chain issues for alternative fuels, and to demonstrate the magnitude of change and infrastructure development that may be required over the coming decades to transition to alternative fuels.

Overview of Gasoline and Diesel

The U.S. transportation sector is heavily dependent on petroleum (in the form of gasoline and diesel), as it provides about 95 percent of U.S. transportation energy needs[8]. The supply chain network for gasoline and diesel has evolved and expanded over many decades into a complex and interconnected system that ties together oil production, distribution, refining/processing, and distribution to customers. For example, the first oil pipeline was built in 1879. During the 1920s, pipeline mileage grew to over 115,000 miles, pipelines expanded further in the wake of World War II, and in the 1970s the Trans Alaska Pipeline System was built.[9] Decades of infrastructure and system development have resulted in a supply chain network that usually works very efficiently to distribute oil and finished products throughout the country.

From Oil Underground to Refineries

Oil is composed of compressed hydrocarbons — aquatic plant and animal remains that were covered by layers of sediment. Over millions of years of extreme pressure and high temperatures, these plants and

[8] U.S. DOE, Transportation Energy Data Book Edition 27, p. 2-4.
[9] Pipeline 101 Home, History of Pipelines, http://www.pipeline101.com/History/timeline.html

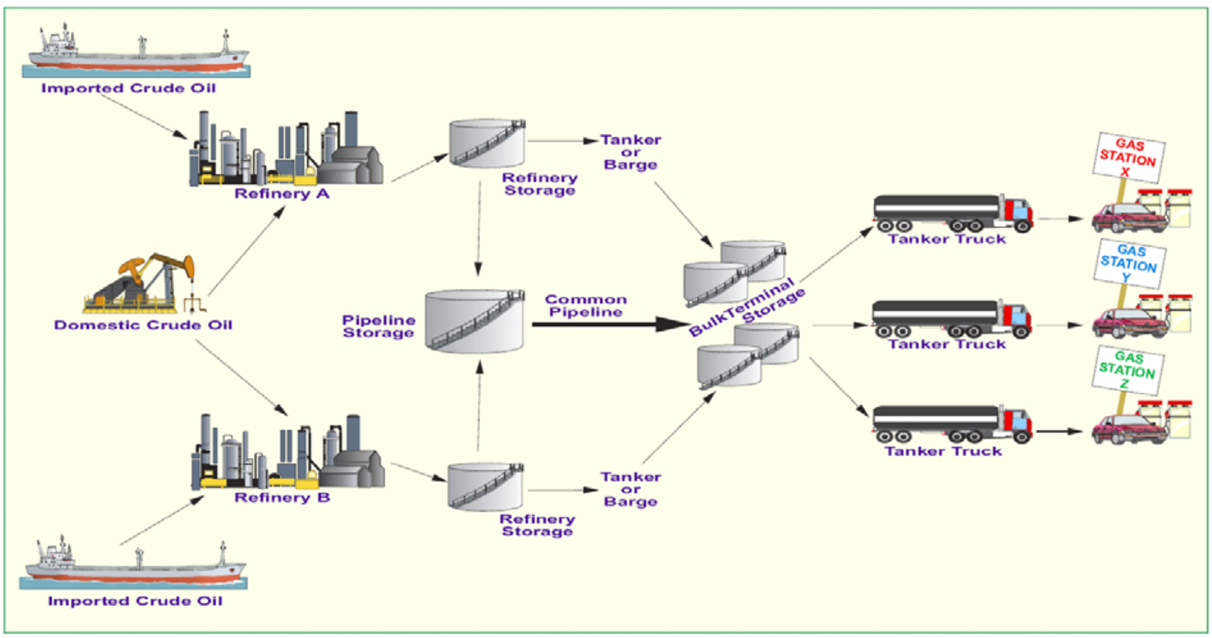
animal remains became the mix of liquid hydrocarbons that we know as oil, with deposits accumulating in underground reservoirs.[10] Wells are drilled into these reservoirs to extract (produce) the oil.

Once the oil is produced, it must be transported to refineries usually via oil pipelines, ships, or barges. Currently, there are about 150 petroleum refineries in the U.S.[11] For the U.S. as a whole, pipelines are critical for quickly moving oil, especially for long distance transport. In the year 2000, pipelines moved virtually all of the crude oil between different regions within the country.[12] A schematic of the distribution of oil, gasoline, and diesel is shown in Exhibit 15.

From Refineries to Gas Stations

At refineries, oil is processed into gasoline, diesel, and other petroleum products. At the refineries, both the incoming crude oil and the outgoing final products need to be stored in large tanks. Usually, pipelines carry the final products from the tank farm near the refinery to other storage tanks across the region or country. For long distance transport of fuels, pipelines are particularly critical. In the year 2000 pipelines moved about 70 percent of the gasoline, diesel, and other refined products between different regions within the country.[13] Gasoline and diesel are also transported by barges and tanker trucks.

Exhibit 15: Distribution of Oil, Gasoline and Diesel



Source: Energy Information Administration.

Along the west coast of the United States, the energy infrastructure is logistically separate from the rest of the country. Washington State is almost entirely dependent on oil delivered via tankers and barges to

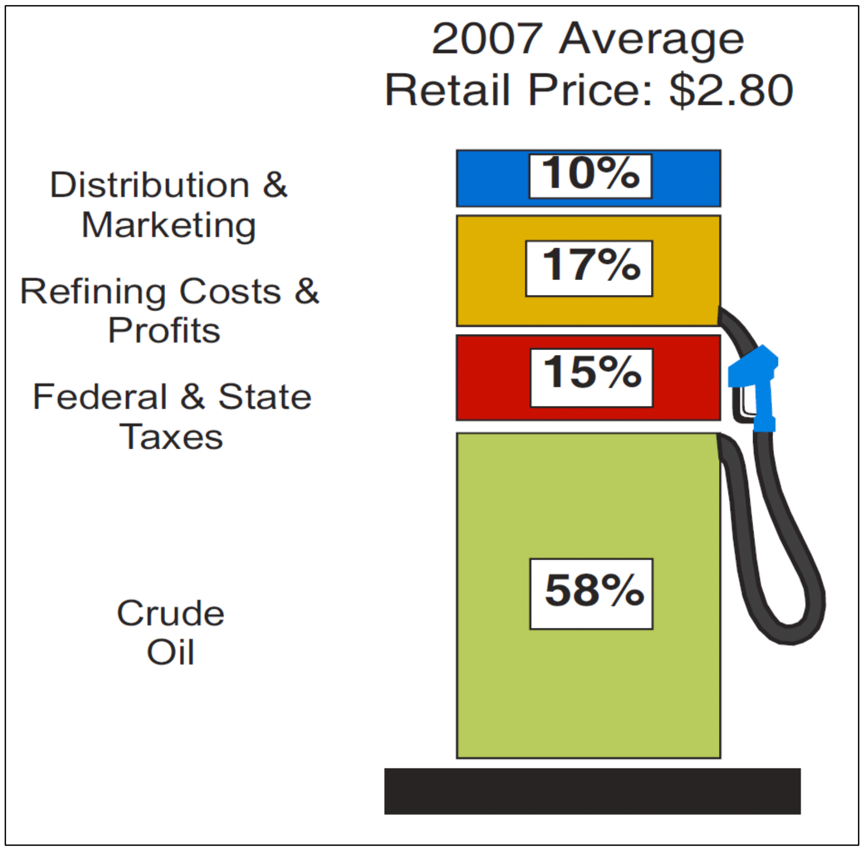
[10] Source: Energy Information Administration, Oil Market Basics, http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/oil_market_basics/supply_text.htm#Oil%20Production
[11] Source: U.S. Energy Information Administration, Basic Petroleum Statistics, http://www.eia.doe.gov/basics/quickoil.html
[12] Allegro Energy, *How Pipelines Make the Oil Market Work –Their Networks, Operation and Regulation*, Memorandum Prepared for the Association of Oil Pipe Lines And the American Petroleum Institute's Pipeline Committee, December 2001.
[13] Allegro Energy, *How Pipelines Make the Oil Market Work –Their Networks, Operation and Regulation*, Memorandum Prepared for the Association of Oil Pipe Lines And the American Petroleum Institute's Pipeline Committee, December 2001.

refineries within the state, and oil from the Trans Mountain Pipeline from Canada. For the distribution of gasoline and diesel, Washington State relies on the Olympic pipeline, barges, and trucks. The Olympic pipeline delivers fuel to major terminals or tank farms throughout western Washington.

At the bulk storage terminals, the gasoline and diesel are loaded into tanker trucks destined for various retail gas stations. When the tanker truck reaches a gas station, the truck operator unloads each grade of gasoline or diesel into the appropriate underground tanks at the station, where it is then ready to be sold to customers.

As shown in Exhibit 16, the primary component of the retail cost of gasoline is the cost of crude oil, which in 2007 accounted for 58 percent of the cost of crude oil.

Exhibit 16: Components in Retail Price of Gasoline[14]



Alternative Fuels Included in Supply Chain Analysis

Most energy and policy experts now agree that the U.S. must transition from petroleum-based transportation fuels to alternative transportation fuels or energy sources in the coming decades. The alternative fuels or energy sources considered as part of this alternative fuels analysis are:

- Ethanol
- Biodiesel
- Compressed Natural Gas
- Electricity
- Hydrogen

Ethanol Supply Chain

Overview of Ethanol

In the transportation sector, ethanol is the most widely used liquid biofuel in the world. In the U.S. ethanol is primarily made from the sugars and starch in corn. Because ethanol is made from plants, it is a renewable fuel. In other parts of the world, sugar cane and sugar beets are the most common ingredients

[14] Source: U.S. Energy Information Administration, *A Primer on Gasoline Prices*, May, 2008.

for ethanol. An emerging process which breaks down cellulose in woody fibers results in cellulosic ethanol. Cellulosic ethanol can be made from trees, grasses, and crop wastes. Cellulosic ethanol has several potential advantages over corn-based ethanol, such as less energy required to produce the feedstock and lower greenhouse gas emissions.

Ethanol can be used as a total or partial replacement for gasoline. Gasoline containing ten percent ethanol (E10) is used in many urban areas that don't meet clean air standards, and all vehicles that run on gasoline can use E10 without making changes to their engines. Over 99 percent of the ethanol produced in the United States is mixed with gasoline to make E10.[15] A blend of 85 percent ethanol and 15 percent gasoline is called E85, and this type of fuel can be used by vehicles specifically manufactured as flexible fuel vehicles. E85 has about 27 percent less energy per gallon than gasoline. E85 typically costs less than gasoline on a gallon-for-gallon basis but more than gasoline on an energy-equivalent basis.[16]

Greenhouse gas emissions attributed to ethanol varies considerably, and depends, among other things, on the feedstock and energy used to produce the ethanol. For example, analysis by the Argonne National Laboratory indicates that greenhouse gas emission impacts from corn-based ethanol can vary significantly—from a 3 percent increase compared to gasoline if coal is the process fuel to a 52 percent reduction if wood chips are used.[17] According to the Argonne study, corn-based ethanol currently results in GHG emissions that are on average about 19 percent lower than gasoline. On the other hand, cellulosic ethanol may reduce GHG emissions by 86 percent, according to the U.S. Department of Energy.[18]

However, recently there has been an increase in concern regarding the potential negative impacts of an increased use of biofuels on food prices, and also some concerns that some biofuels may reduce GHG emissions less than studies suggest. For example, a recent study by Tim Searchinger, Fellow with the German Marshall Fund of the United States, indicates that previous analyses of the GHG emissions impacts of biofuels have failed to count the carbon emissions that occur as farmers worldwide respond to higher prices and convert forest and grassland to new cropland. New analysis shows that the loss of greenhouse gases from direct and indirect land use changes exceeds the other benefits of many biofuels over decades. This analysis points out that some biofuels, such as those produced from municipal, industrial and agricultural waste, remain viable ways of reducing greenhouse gases since they do not trigger significant land use change.[19]

Overview of Ethanol Supply Chain

Transportation is typically the third highest expense to an ethanol producer-after energy and feedstock. The most common mode of transporting feedstock to an ethanol plant is by truck and rail. Corn primarily from the Midwestern U.S. is the most common feedstock. As corn production increases, transportation demand would normally be expected to increase. In a study by USDA for 5 years (2000-2004), it showed

[15] Energy Information Administration, Ethanol – A Renewable Fuel, http://www.eia.doe.gov/kids/energyfacts/sources/renewable/ethanol.html

[16] Source: U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, Ethanol E85, http://www.eere.energy.gov/afdc/ethanol/e85.html

[17] Source: Wang, Michael; Wu, May; and Huo, Hong; Argonne National Laboratory, *Life-cycle energy and greenhouse gas emission impacts of different corn ethanol plant types*, May, 2007.

[18] Source: U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, Ethanol Greenhouse Gas Emissions, http://afdc.energy.gov/afdc/ethanol/emissions.html, Accessed September 22, 2008.

[19] Source: Searchinger, Tim, The Impacts of Biofuels on Greenhouse Gases: How Land Use Change Alters the Equation. http://www.gmfus.org//doc/SearchingerBiofuelBrief_Final2-28.pdf

that railroads ship approximately 31 percent of corn to export locations and 30 percent to domestic locations; barges-68 percent to export and 2 percent to domestic locations; and trucks-2 percent to export locations and 67 percent to domestic locations.

Railroads, trucks and barges transport most ethanol from production, or import locations, where it is blended with gasoline at or near the point of retail distribution. Rail is the primary ethanol product mover, shipping 60 percent of the product, followed by 30 percent moved by truck and 10 percent by barge.

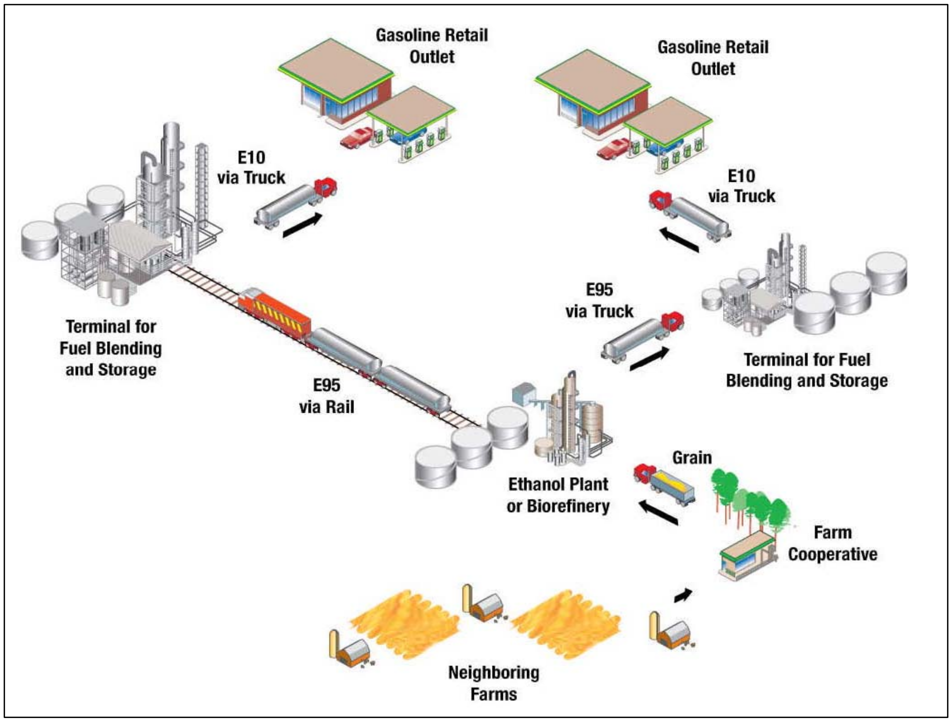
Once the ethanol has been blended at storage sites or petroleum storage sites, it is move primarily by trucks to the end user and fuel station franchisees.

Ethanol Supply Chain Issues

Current Supply Chain Issues

Several supply chain issues could inhibit growth in the ethanol industry. The efficiency of the ethanol transportation system may begin to depend on the ability of the blending market to accommodate additional quantities of ethanol. Presently, there are not enough facilities available for blending ethanol with gasoline. For ethanol use to increase substantially, more blending/storage facilities would be required. Understanding the flow of the product to the market is important. Exhibit 17 below illustrates how this is accomplished. Corn or other feedstocks are transported to an ethanol plant or biorefinery most often by truck or rail. From the refinery, E95 is transported to fuel blending and storage facilities by rail, truck or barge. From the fuel blending and storage facilities, ethanol blended with gasoline is transported to fuel stations.

Exhibit 17: Rail and Truck Ethanol Distribution System



Source: USDA Ethanol Transporter Background, Citing National Bioenergy Center, September, 2007.
E95 is fuel ethanol (ethanol blended with 5 percent gasoline).

All three modes of transportation for the ethanol industry — rail, barge, and truck — are at or near capacity. According to a report from the U.S. Department of Transportation, total rail freight is forecast to increase from 1,879 million tons (in 2002) to 3,525 million tons by 2035, an increase of nearly 88 percent.[20] The Federal Highway Administration (FHWA) projects truck freight to almost double from 2002 to 2020, and driver shortages are projected to reach 219,000 by 2015 (for reference, in 2004, there were 1.3 million long-haul heavy-duty truck drivers).[21]

Construction of more short line rail spurs at destination blending and storage terminals — mostly owned by blenders, refiners, and third-party providers — may become a key to the efficiency of rail ethanol transportation. Factors that may be contributing to a slower rate of infrastructure development include its capital-intensive nature as well as the sometimes lengthy permitting process.

The other option that is being explored is the use of pipelines. In the petroleum industry, it has proven to be the safest and most efficient way to move fuel. Kinder Morgan has built an ethanol pipeline in Florida and hopes to expand within the United States.[22] Although the success of the Kinder Morgan pipeline is encouraging, a complete pipeline system does not exist yet. The ethanol industry would have to build a separate pipeline infrastructure in order to fully utilize the benefits of a pipeline transport system.

Technologies that May Reduce Supply Chain Barriers

When fuel station franchisees start to sell alternative fuels, one of the new technologies they may want to consider is the blender pump. Blender pumps utilize two underground tanks that dispense the particular fuel mixture desired by the customer. For ethanol blender pumps, one tank holds E85, the other holds unleaded gasoline, and these two fuels can be mixed to deliver mid-range ethanol blends such as E20, E30, E40, or just regular unleaded fuel. Blender Pumps are in use throughout North and South Dakota, Minnesota, and Iowa.

The blender pump can provide several advantages:

- The franchisee does not have to expend capital to provide a special pump for the alternative fuel, as the pump can provide fuel for:
    - Non-flex-fuel vehicles that can use lower grades of mixed fuel, in the form of E20 and E30.
    - True flex fuel vehicles that can use E85, and
    - Non-flex-fuel vehicles that use regular unleaded gasoline.
- The franchisee can deal directly with ethanol producers to fill the “alternative fuel tank” and avoid paying the capital cost for a petroleum company to blend it.

Technologies or Policies to Help Overcome Supply Chain Barriers

Several pieces of legislation have been enacted to assist and promote the use of alternative fuels. The most prominent is the Renewable Fuels Standard, which has been adopted by the State of Washington. Engrossed Substitute Senate Bill 6508, an act relating to developing minimum renewable fuel content

[20] U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, 2006.
[21] Federal Highway Administration; “The U.S. Truck Driver Shortage: Analysis and Forecasts.” Global Insight, May 2005.
[22] Source: http://www.ethanolproducer.com/article.jsp?article_id=5149, January, 2009.

requirements and fuel quality standards, was signed into law by Governor Gregoire in 2006. This act applies to ethanol and biodiesel, and guiding principles of the Act include:

- Establishing a market for alternative fuels in Washington.
- Reducing dependence on imports of foreign oil.
- Improving the health and quality of life for Washingtonians.
- Stimulating creation of a new industry in Washington that benefits our farmers and rural communities[23].

Fourteen states have some type of retail pump incentives for ethanol for E10 and/or E85 fuel. Washington State's Biofuels Advisory Committee, in their report to the Director of the Washington State Department of Agriculture on *Implementing the Minimum Renewable Fuel Content Requirements* (August 2007) recommends consideration of several incentives to promote biofuel use in Washington State, and the state currently offers some incentives for biofuel retailers. One of the recommendations for incentives from the report include consideration of federal and/or state support and incentive programs to aid profitable biofuels feedstock crop production systems. Programs might include crop price incentives or insurance premium assistance.

In addition, Washington State University was directed to analyze and recommend models for possible implementation of biofuel incentive programs. Incentives to be studied include market incentives and research grant preferences. Finally, by the year 2015, all state agencies and local government subdivisions of the state must satisfy 100 percent of their fuel needs for all vessels, vehicles, and construction equipment from biofuels certified by the DCTED as having been produced from recycled materials or Washington feedstock to the extent practicable.

Below are some examples of incentive programs adopted federally or by other states.

State Incentive Programs:

Following are examples of incentive programs implemented by other states. Each state's exact requirements will vary:

Renewable Fuel Retailer Incentive

A licensed retail motor fuel dealer may receive a quarterly incentive for selling and dispensing renewable fuels, including biodiesel. Qualified motor fuel dealers are eligible for up to $0.065 for every gallon of renewable fuel sold and up to $0.03 for every gallon of biodiesel sold, if the required threshold percentage is met. The threshold percentage for the incentive payment will increase on an annual basis from 10 percent for renewable fuel and 2 percent for biodiesel in 2009 to 25 percent for each fuel type.

Regional Biofuels Corridor

Nebraska has joined Indiana, Iowa, Kansas, Michigan, Minnesota, North Dakota, South Dakota, and Wisconsin in adopting a cooperative initiative under the Energy Security and Climate Stewardship Platform Plan (Platform). The Platform establishes a regional biofuels corridor program and directs state

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[23] Source: Text of bill: http://apps.leg.wa.gov/documents/billdocs/2005-06/Pdf/Bills/Senate%20Passed%20Legislature/6508-S.PL.pdf; and Washington State Biofuels Advisory Committee Report to the Director of the Washington State Department of Agriculture, *Implementing the Minimum Renewable Fuel Content Requirements*, August 2007.

transportation, agriculture, and regulatory officials to develop a system of coordinated signage across the Midwest for biofuels and advanced transportation fuels and to collaborate to create regional E85 corridors. The program requires standardized fuel product coding at fuel stations as well as increased education for retailers about converting existing fueling infrastructure to dispense E85.

Alternative Fuel Vehicle (AFV) and Fueling Infrastructure Loans – State Incentive

The Nebraska Energy Office administers the Dollar and Energy Saving Loans Program (Program). The Program makes low-cost loans available for a variety of alternative fuel projects, including: the replacement of conventional vehicles with AFVs; the purchase of new AFVs; the conversion of conventional vehicles to operate on alternative fuels; and the construction or purchase of a fuel station or equipment. Dedicated AFVs are eligible, and loans may go towards a portion of the cost of dual-fuel vehicles. The maximum loan amount is $150,000 per borrower, and the interest rate is 5 percent or less.

Federal Incentive Programs:

Following are examples of incentive programs implemented by other states:

Tax Credit for E85 Infrastructure

The Energy Policy Act of 2005 (EPAct 2005, P.L. 109-58) created a 30 percent federal income tax credit, up to $30,000 maximum, to establish alternative fuel infrastructure. The provision permits taxpayers to claim a 30 percent credit for the cost of installing clean-fuel vehicle refueling property to be used in a trade or business of the taxpayer or installed at the principal residence of the taxpayer. Under the provision clean fuels are any fuel at least 85 percent of the volume of which consists of ethanol, natural gas, compressed natural gas, liquefied natural gas, liquefied petroleum gas, and hydrogen and any mixture of diesel fuel and biodiesel containing at least 20 percent biodiesel.

Prohibition on Franchise Agreement Restrictions Related to E85 Infrastructure

Section 241 of The Energy Independence and Security Act of 2007 (P.L. 110-140) amends the Petroleum Marketing Practices Act to prohibit for a franchisor (i.e. oil company) to restrict a franchisee from installing E85 infrastructure through a franchise agreement.

Infrastructure Development Grants for Mid-level Blends of Ethanol

Section 244 of The Energy Independence and Security Act of 2007 (P.L. 110-140) authorizes the Secretary of Energy to establish a new program for making grants and providing assistance to retail and wholesale fuel dealers for the installation, replacement, or conversion of fuel storage and dispensing equipment for renewable fuel blends greater than E10 but less than E85. Funding assistance is subject to appropriations from Congress.

More information on some of the incentive programs can be found at the Department of Energy's Alternative Fuels and Advanced Vehicles Data Center website:

http://afdc.energy.gov/afdc/incentives_laws.html

Biodiesel Supply Chain

Overview of Biodiesel

Biodiesel is produced from renewable sources such as new and used vegetable oils and animal fats, and is a cleaner-burning replacement for petroleum-based diesel fuel. Biodiesel contains about 8 percent less energy per gallon than petroleum diesel.

Biodiesel can be blended with petroleum diesel in any percentage; B20 is a blend containing 20 percent biodiesel and 80 percent petroleum diesel, and B100 for 100 percent biodiesel. B20 is the most common biodiesel blend in the United States. B20 can be used in nearly all diesel equipment and is compatible with most storage and distribution equipment. B20 and lower-level blends generally do not require engine modifications. Some foreign biodiesel suppliers blend pure biodiesel with a very small amount of U.S. petroleum diesel in order to qualify for a federal blending subsidy (sometimes referred to as "splash and dash" transactions), although federal legislation is being proposed to narrow this loophole.[24]

B100 or other high-level biodiesel blends can be used in some engines built since 1994 with biodiesel-compatible material for parts such as hoses and gaskets.[25] However, as biodiesel blend levels increase significantly beyond B20, a number of concerns come into play, such as low-temperature gelling, solvency/cleaning effect if regular diesel was previously used, and microbial contamination.[26]

Recently, with an increase in the cost of diesel this past year, biodiesel has been costing about the same as petroleum-diesel on an energy equivalent basis, and depending on the feedstock the GHG emissions of biodiesel is generally lower than petroleum diesel.[27] However, as described in the section on ethanol, recently there has been an increase in concern regarding the potential negative impacts of an increased use of biofuels on GHG emissions and food prices. Some biofuels, such as those produced from municipal, industrial and agricultural waste, may be viable ways to reduce greenhouse gases through there is some debate as to whether they trigger significant land use change or affect food prices.[28]

Overview of Biodiesel Supply Chain

The majority of biodiesel is made from virgin seed oils (predominately soy oil in the United States). Soybeans are grown across much of the middle of the U.S. The rest is produced from recycled restaurant grease, animal fats, or other lipid resources that are available at a low cost. The feedstock supply chain depends on the feedstock – seed oils are harvested, transported to crushing facilities usually via rail or barge, crushed, and the oil is then transported via rail or barge to the biodiesel plant where it is converted to biodiesel. Biodiesel is then distributed from the point of production via truck, train, or barge to biodiesel blending and fuel distribution terminals or directly to the fuel stations. Pipeline distribution of biodiesel,

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[24] An example of an article describing proposed legislation can be found here: http://www.allbusiness.com/government/government-bodies-offices-us-federal-government/11465976-1.html
[25] Source: U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.eere.energy.gov/afdc/fuels/biodiesel_alternative.html
[26] Source: U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.eere.energy.gov/afdc/fuels/biodiesel_alternative.html
[27] Source: http://www.eere.energy.gov/afdc/pdfs/afpr_july_08.pdf
[28] Source: Searchinger, Tim, The Impacts of Biofuels on Greenhouse Gases: How Land Use Change Alters the Equation. http://www.gmfus.org//doc/SearchingerBiofuelBrief_Final2-28.pdf

which would be the most economical option, is still in the experimental phase. For long distances, distribution is primarily by rail car, while for shorter distances tanker trucks are most often used.

Biodiesel is sold as either a blend with petroleum diesel (e.g., B20) or as B100, which is 100 percent biodiesel. Blends are created either on the truck at fuel distribution terminals, known as "splash blending," or at the fuel station. In Washington, there are more than 25 fuel stations that offer biodiesel in B99 or B100 form.

Biodiesel Supply Chain Issues

The major barrier to increased biodiesel production is the cost of feedstock, which affects the demand for the product. The costs of production are driven by the cost of the feedstock, which makes up approximately 80 percent of the delivered cost of the fuel. The industry operates significantly below capacity (22 percent in 2007) in part due to expected demand growth but also due to market conditions that cause tight margins.

Biodiesel is consumed primarily as a substitute to petroleum diesel and consequently is in direct price competition with diesel. As an example of how this competition plays out, the cost of soy biodiesel can be compared to petroleum diesel. Operating costs of production beyond feedstock are approximately $0.59/gallon. The co-products return about $0.08/gallon of biodiesel produced. On average 7.6 pounds of soy bean oil is required to make 1 gallon of biodiesel and the price of soy bean oil on the Chicago Board of Trade has fluctuated between 50 cents/lb and 65 cents/lb during 2008 (up from less than 25 cents/lb for the period between 2000 and 2004). This results in production costs ranging from $4.31 to $5.45/gallon without returns on capital or transportation costs[29]. Transportation costs add about 10 percent and federal subsidies currently discount this cost by $1.00/gallon. With the federal subsidy, biodiesel was competitive with petroleum diesel over the course of the year when national average diesel prices ranged from $3.25 to $4.75/gallon.

The excess operating capacity in the biodiesel industry means that the tight margins are likely to persist. The industry will increase production as soon as the feedstock cost drops below the price that makes biodiesel competitive with petroleum diesel. The increased demand for seed oil places upward pressure on the price. The biodiesel industry operates in a precarious position with highly volatile feedstock costs and highly volatile prices available for its product.

Another issue effecting biodiesel demand is the use of higher blends of biodiesel (>B20) in most vehicles will void the engine manufacturers' warranty. This discourages consumer acceptance of the alternative fuel. Vehicle manufacturers are beginning to remove this restriction as industry standards for biodiesel quality become established.

Washington State is not currently large producer of seed oils with less than 15,000 acres planted in 2007. Mustard and canola are the main oil seed crops in Washington as they are good rotational crops with the major cash crops of the region. Canola is a promising biodiesel feedstock in Washington due to high yields, high oil content and a co-product (the meal) that can be used as animal feed. Current low levels of production are due largely to a historically declining market.

A low cost alternative to seed oils is waste grease. It is estimated that waste grease in Washington could produce between 12 and 24 MGY of biodiesel. Waste grease is generated predominately at restaurants

[29] Source: Carriquiry and Babcock, A Billion Gallons of Biodiesel: Who Benefits?, Iowa Ag Review Online: Winter 2008

that are small point sources that must be aggregated in a reverse distribution system. There are services that distribute grease from source to refinery; however the high cost of transporting the grease to remote refineries may make this option less desirable.

Biodiesel production capacity in Washington is currently 131.5 MGY with projects in permitting/proposal stages to expand that to 380 MGY. The majority of the current production capacity comes from the 100 MGY Gray's Harbor facility that came online in August 2007. There are currently four operational plants with approximately 24,255 TPY in total capacity. Expansion of crushing capacity has been targeted with almost $9 million in state funding through the Energy Freedom Program. Full realization of planned expansion would bring the crushing capacity up to 427,000 TPY[30].

Potential Changes in Technology

The biodiesel industry is relatively young and fast growing (from 0.5 million gallons per year [MGY] in 1999 to 400 MGY in 2007). The industry has begun to diversify by building flexible production facilities that can handle multiple different feedstocks depending on the market conditions. These facilities and dedicated recycled oils and animal fat-based facilities increase the quantity of biodiesel produced from low value feedstock.

Future technologies in renewable diesels using algae or cellulosic material as a feedstock hold promise for significantly increasing the potential supply, and lowering the cost if the technologies develop as their proponents envision. In addition, at fuel stations, blending pumps could reduce the cost of delivering blended fuels (see discussion of the blender pump in the ethanol section, which could be used for biodiesel as well.)

Policy Context

The market for biodiesel has been spurred by government incentives both federal and state. The State of Washington has 17 laws and incentives to promote the use of biodiesel. Most prominently is the Renewable Fuel Standard (RFS) requiring a B2 blend increasing to B5 as the in-state feedstock and crushing capacity are equivalent to a B3 level[31].

State Incentive Programs:

Following are other State incentive programs:

- The Energy Freedom Program – funds projects converting farm products, wastes, cellulose or biogas into electricity, biofuel, and/or other coproducts. A supplemental capitol budget in 2006 provided $23 million to explicitly fund bioenergy projects.
- Tax Incentives – Buildings, equipment and land used in producing biodiesel is exempt from state and local property and leasehold taxes for a period of 6 years; exemption of sales and use tax for purchase of equipment used in retail sales of biodiesel; reduction of B&O tax for biodiesel manufacturers
- State Agency Fleet Requirements - By the year 2015, all state agencies and local government subdivisions of the state must satisfy 100 percent of their fuel needs for all vessels, vehicles, and

[30] Source: Yoder and Wandschneider, Economics and Policy for Washington State Biofuel Markets: Interim Report, December 1, 2007.
[31] Per RCW 19.112.110

construction equipment from biofuels certified by the DCTED as having been produced from recycled materials or Washington feedstock to the extent practicable.

Federal Incentive Programs:

The major Federal incentives for biodiesel are:

- Small producer biodiesel tax credit – Part of the Energy Policy Act of 2005, gives a 10 cent per gallon tax credit for each gallon of agri-biodiesel (biodiesel from seed oils) produced by a single producer up to 15 MGY. The credit is set to expire at the end of 2008.
- Biodiesel tax credit – Originally part of the American Jobs Creation Act of 2004 and extended by the Energy Policy Act of 2005, gives a $1.00 per gallon tax credit to producers of agri-biodiesel and $0.50 per gallon tax credit to producers of waste-grease biodiesel. The credit is set to expire at the end of 2009.
- Credit for installing alternative fuel refueling property – Part of Energy Policy Act of 2005, gives a tax credit of 30% of the cost of installing biodiesel refueling equipment for biodiesel blends of at least B20. The credit will expire at the end of 2010.
- Renewable Fuel Standard – Part of Energy Independence and Security Act of 2007, requires the consumption of 500 MGY of biodiesel in 2009 increasing to a billion gallons a year in 2012.

Many of the federal incentives are set to expire December 31, 2008, reducing federal subsidy of biodiesel by $0.50-$1.10/gallon depending on the producer. In absence of these continuing incentives the biodiesel industry will become significantly less competitive with petroleum diesel. More information on some of the incentive programs can be found at the Department of Energy's Alternative Fuels and Advanced Vehicles Data Center website: http://afdc.energy.gov/afdc/incentives_laws.html.

Potential Strategies to Overcome/Address Biodiesel Supply Chain Issues

Following are additional strategies to overcome or address biodiesel supply chain issues:

- Increase incentives and programs to expand biodiesel refueling and distribution infrastructure (such as pipelines, blending facilities and terminals, etc).
- Provide incentives to spur production of in-state oil seeds. This could take the form of a tax credit or a loan payment program for biodiesel feedstocks to provide a price floor and reduce the risks faced by farmers.

Compressed Natural Gas Supply Chain

Overview of Compressed Natural Gas

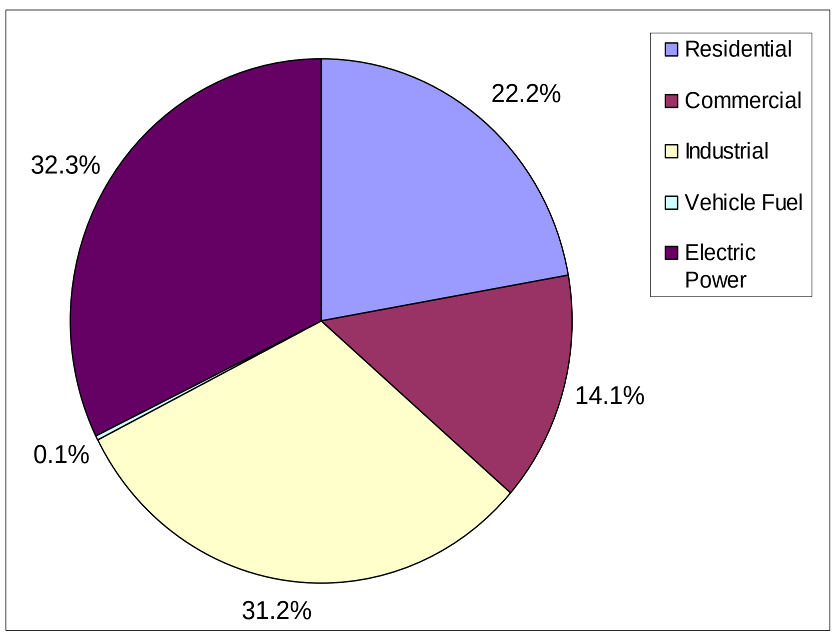
Natural gas is formed underground in the same way that oil is. It is composed of compressed hydrocarbons — aquatic plant and animal remains that were covered by layers of sediment. Over millions of years, extreme pressure and high temperatures changed some of this organic material into natural gas. Natural gas is considered an alternative transportation fuel, but like oil it is not a renewable fuel (i.e., it is finite in quantity).

The U.S. has an extensive natural gas distribution system, consisting of 300,000 miles of transmission pipelines, which can quickly and economically distribute natural gas throughout the lower 48 states. As shown in Exhibit 19, natural gas is used for a wide variety of energy and other needs in the U.S., including power generation, residential heating, and in commercial and industrial applications. Currently, only about one tenth of one percent of natural gas is used as a transportation fuel.

Vehicles can use natural gas as either a liquid or a gas, but most vehicles use the gaseous form compressed to pressures above 3,100 pounds per square inch. Compressed natural gas (CNG) is natural gas under pressure. The primary advantages of natural gas over petroleum based fuels include its clean-burning qualities, and the domestic resource base for natural gas (the U.S. currently imports about 65 percent of its petroleum[32], but only about 20 percent of its natural gas[33]).

However, It is far from clear whether domestic production of natural gas could support an increased use of natural gas as an alternative transportation fuel. Exhibit 18 presents data from the U.S. Energy Information Administration on historical U.S. natural gas production, as well as forecast domestic natural gas production to the year 2030. As shown in Exhibit 19, domestic natural gas production is forecast to remain relatively flat to the year 2030. Therefore, unless other sectors were to dramatically decrease their use of natural gas, the forecasts suggest limitations for substantially increasing the use of domestically produced natural gas as a transportation fuel.

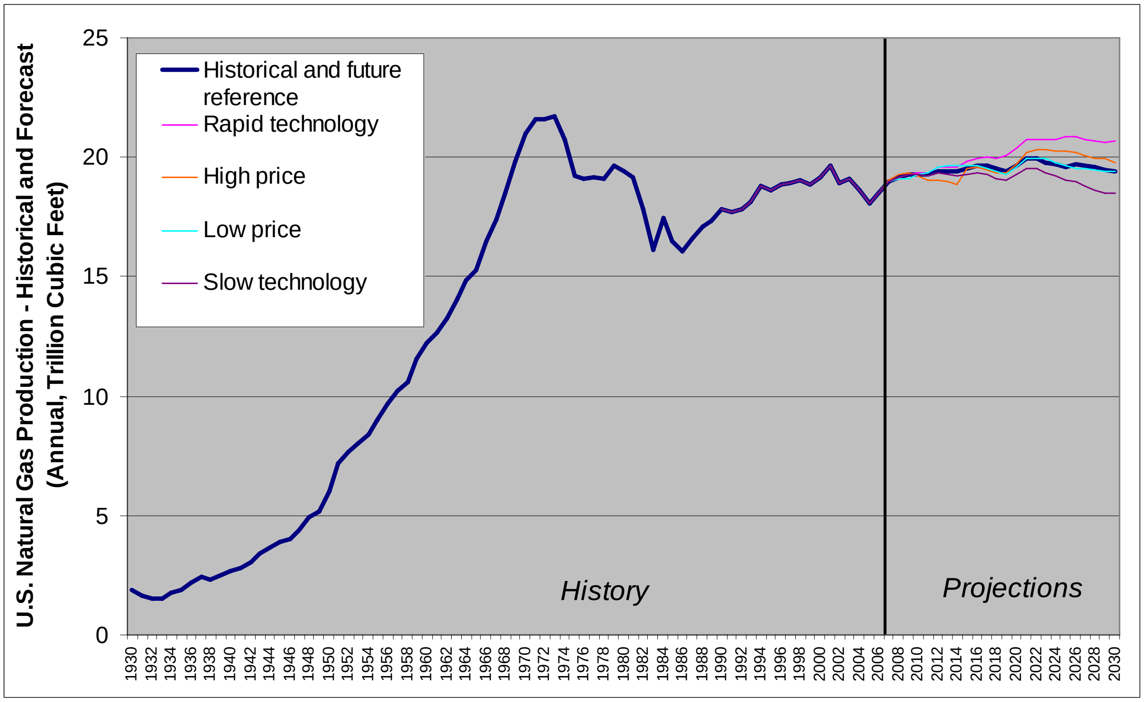
Exhibit 18: U.S. Natural Gas Consumption, 2007, By End Use[34]



Currently there are about 150,000 natural gas vehicles (NGVs) operating in the U.S. These vehicles include transit buses, trucks, vans, and cars.[5] Natural gas vehicles have generally been significantly cheaper to fuel than conventional gasoline vehicles. In general NGVs are well suited for fleets since fueling costs are less than for gasoline and fleet vehicles can fuel at one central facility. Presently a major concern for NGVs is the limited range, which is typically between 100-200 miles. In addition, since production levels are still modest, economies of scale have not been reached, and vehicle costs are significantly higher than for gasoline vehicles.

[32] Source: U.S. Energy Information Administration, Petroleum Navigator, U.S. petroleum annual imports and annual products supplied, http://tonto.eia.doe.gov/dnav/pet/hist/mttimus1a.htm and http://tonto.eia.doe.gov/dnav/pet/hist/mttupus1a.htm
[33] Source: U.S. Energy Information Administration, Natural Gas Navigator, U.S. natural gas annual imports and annual consumption, http://tonto.eia.doe.gov/dnav/ng/hist/n9140us2a.htm and http://tonto.eia.doe.gov/dnav/ng/hist/n9100us2A.htm
[34] Source: U.S. Energy Information Administration, Natural Gas Consumption by End Use, http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm

Exhibit 19: U.S. Natural Gas, Historical and Forecast Production, 1930 to 2030 (Annual Trillion Cubic Feet)[35]



Overview of CNG Supply Chain

Increases in natural gas usage for electrical power, heating, residential, commercial, and industrial could lead to interruptions in supply and delivery. While the U.S. and Canada have significant resources of natural gas, there are potential problems in ensuring that supply will meet increased demand.

Domestic production of natural gas could increase from two major sources – Alaska and the Outer Continental Shelf (OCS). Exhibit 20 shows the estimate for technically recoverable undiscovered natural gas resources in the OCS of the lower 48 states. Unavailable areas are those places that are legally off limits to development. Even if these areas were made available for drilling, the EIA estimates only a 1.8% increase in production through 2030.

An Alaskan pipeline is planned for operation around 2018, and EIA's forecast assumes that the Alaskan pipeline begins transporting natural gas to the lower 48 states in 2020.[36] There are, however, several potential concerns that could disrupt the pipeline project including the physical configuration, ownership of the pipeline, and natural gas production taxes. Any or all of these could cause delays or cancellation of the pipeline. The increase of natural gas prices from $2.19 per thousand cubic feet in 2000 to $7.52 per thousand cubic feet in 2005 increase the probability that a significant natural gas capital project will be undertaken.[6]

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[35] Source: U.S. Energy Information Administration, U.S. dry natural gas production; and Annual Energy Outlook 2008 forecast of U.S. natural gas production to 2030. http://tonto.eia.doe.gov/dnav/ng/hist/n9070us2a.htm; http://www.eia.doe.gov/oiaf/aeo/gas.html

[36] Source: U.S. Energy Information Administration, Annual Energy Outlook 2008, forecast of U.S. natural gas production by source.

Without developing new supplies, there are certain mitigation measures currently being used to increase supply security. These measures include storing more gas, constructing alternative pipelines, increasing the capability to use other fuels, and increasing pipeline coordination.

Another supply option is importing more liquid natural gas (LNG). This option will require additional LNG terminals. Unfortunately, imported LNG leaves the U.S. with economic and political problems similar to those experienced with oil.

Exhibit 20: Technically Recoverable Undiscovered Natural Gas Resources in the Outer Continental Shelf (OCS) of the Lower 48 States

Outer Continental Shelf Areas	Natural Gas Reserves (Trillion cubic feet)
Available areas	
Eastern Gulf of Mexico	10.1
Central Gulf of Mexico	113.6
Western Gulf of Mexico	86.6
Total Available	**210.3**
Unavailable	
Washington-Oregon	2.28
Northern California	3.58
Central California	2.41
Southern California	9.75
Eastern Gulf of Mexico	22.16
Atlantic	36.99
Total Unavailable	77.17

Policies That Provide Incentives or Support for CNG Vehicles

State Incentive Programs:

- Following are state programs, some of which include incentives, for CNG:
- Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (HEV) Tax Exemption
- Alternative Fuel Grant and Loan Program
- Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (HEV) Emission Inspection Exemption
- Clean Fuel Vehicle Purchasing Requirement
- Clean School Bus Funding
- Fleet Action Plan - Seattle
- Natural Gas Technical Assistance

More information on these state programs can be found at the Department of Energy's Alternative Fuels and Advanced Vehicles Data Center website (Washington State natural gas programs: http://afdc.energy.gov/afdc/progs/view_ind_mtx.php/tech/NG/WA/0).

Federal Incentive Programs:

Several federal incentives for alternative fuel vehicles or infrastructure include natural gas as an alternative fuel. This includes the following programs[37]:

- Air Pollution Control Program
- Congestion Mitigation and Air Quality (CMAQ) Improvement Program
- Clean School Bus USA
- Clean Construction USA
- Clean Ports USA
- Clean Fuels Grant Program
- Alternative Fuel Excise Tax Credit
- Clean Cities
- SmartWay Transport Partnership
- Alternative Fuel Infrastructure Tax Credit
- Qualified Alternative Fuel Motor Vehicle (QAFMV) Tax Credit
- Energy Independence and Security Act of 2007 Signed Into Law
- Alternative Transportation in Parks and Public Lands Program
- Voluntary Airport Low Emission (VALE) Program
- Clean Agriculture USA
- Aftermarket Alternative Fuel Vehicle (AFV) Conversions

More information can be found on incentive programs at the Department of Energy's Alternative Fuels and Advanced Vehicles Data Center website: http://afdc.energy.gov/afdc/incentives_laws.html.

CNG Supply Chain Issues

Overall, additional infrastructure, such as LNG terminals or gas pipelines, will be critical to natural gas supply, especially if natural gas is used increasingly as an alternative transportation fuel. These would primarily enable an increase in imports of natural gas. Investments in long term rather than short term infrastructure would need to become available in order to avoid supply disruptions.

[37] Source: US Department of Energy, Energy Efficiency and Renewable Energy, Technology Type Table, Federal Incentives for natural gas, website accessed September 26, 2008; http://afdc.energy.gov/afdc/progs/tech_matrx.php

Electricity Supply Chain

Overview of Electricity

Electricity is an energy carrier, meaning it moves energy in a usable form from one place to another. We use electricity to move the energy chemically released in coal, natural gas, uranium, and other energy sources from power plants to homes and businesses. We also use electricity to move the energy in flowing water from hydropower dams to consumers.

Electricity can be used to power electric and plug-in hybrid electric (PHEV) vehicles directly from the power grid. Vehicles that run on electricity produce no tailpipe emissions, although they are attributed with emissions related to electric power generation. Some electric vehicles are available on the market, primarily for lower speed, short distance travel. Several automobile manufacturers have indicated they will be producing PHEVs within the next few years. PHEVs strive to combine the benefits of pure electric vehicles and traditional gasoline-powered vehicles on the road today. Like electric vehicles, they plug into the electric grid and can be powered by the stored electricity alone, but they also have engines that enable greater driving range and battery recharging.

Some states, such as California and Hawaii, have taken steps to develop infrastructure to support electric vehicles and PHEVs. Hawaii, for example, through it's Hawaii Electric Vehicle Demonstration Project (HEVDP), has initiated a project to install rapid charging infrastructure throughout the island of Oahu. This project is a joint venture involving the Hawaiian Electric Company and Hawaii Electric Vehicles, Inc. The project involves installing rapid charging systems throughout the entire State of Hawai'i. Rapid chargers will also be installed on the neighbor islands in the upcoming years. More information can be found on the project's website at http://www.htdc.org/hevdp/projects.html.

Overview of Electricity Supply Chain

Because the electric power grid is well-developed, there should be few if any major impediments to distributing electricity from the grid to battery charging stations for battery powered (BEVs) and plug-in hybrid vehicles (PHEVs)[38]. A key issue is the magnitude of the power (kW or MW) required to operate the battery charging stations. The power required will depend on the charging times provided and the number of vehicles to be charged at the same time. Most BEVs are charged at home by their owners with charging times of 6-8 hours. These charging times are not practical for public charging used by travelers.

A more widespread use of BEVs would likely require fast charging at charging stations (charging times less than one-half hour). For example, for a vehicle with a 30 kWh battery, the electrical power to the charger would be at least 70 kW and to charge five vehicles simultaneously would require about 350 kW. This is a rather high power requirement for individual charging stations. For fast charging, the high power is maintained during most of the charging period as the taper period near the end of the charge is minimized.

Battery charging equipment capable of charging batteries in one-half hour or less is being tested in Japan and China and similar chargers should be available for use in this project. These high power chargers are relatively expensive being in the range of at least $30K to 40K for a station having a maximum power of less than 100 kW.

[38] Improvements and capacity enhancements have been made to the national electricity grid over the past 30 years and these types of improvements are assumed to continue in the future as electricity demand grows.

The spacing of the charging stations will depend on the range (miles) of the BEVs. It seems likely that most of the BEVs that would be using the charging stations in this project will have a range of at least 100 miles so the spacing of the charging stations initially could be about 50 miles. This would require the drivers of the BEVs to be attentive to the state-of-charge of their batteries, but it should be possible without an undo hardship other than the need to plan for additional travel time required for recharging every 100 miles. Initially, it may be possible to co-locate battery charging facilities with gasoline fuel station (especially where extra parking is available). This would minimize the cost of site preparation and other facilities. Alternatively, battery charging facilities could be co-located with restaurants, coffee-shops, or shopping centers, so drivers' vehicles' can recharge while shopping or eating. Electric vehicle charging locations are available at a number of public locations in California.[39] For example, recharging stations are at stores, banks, hotels, tourist attractions, government facilities, university parking lots, park-and-ride locations, airports, and libraries.

Charging batteries in plug-in hybrids requires less power because the batteries are smaller and store much less energy. For example, batteries in PHEVs are likely to store 5-10 kWh so charging those batteries in one-half hour would only require 10-20 kW. Unlike BEVs, PHEVs do not require immediate recharging when the battery is fully discharged. PHEVs can use gasoline to achieve ranges of greater than 400 miles and refuel with gasoline when the tank runs low. The actual range of PHEVs batteries is not well defined since PHEVs may not operate on batteries alone but rather using both battery power and the engine. It seems likely that the numbers of PHEVs will greatly exceed that of BEVs in the near term, especially in charging stations between city centers. Battery charging equipment for these lower power chargers is readily available, because such equipment was provided in California during implementation of the ZEV Mandate (1998-2005).

The major barrier to providing facilities for battery charging is the high cost of the battery charging equipment and providing the high power grid connection. This is particularly the case for BEVs with large batteries if fast charging (times less than one-half hour) is to be provided. Before proceeding with the construction of charging stations, it is necessary to carefully assess the demand for such stations. The cost of the charging stations is likely to be much higher than a gasoline fueling station. Another barrier could be the lack of national and international standards for charging equipment and connecting devices. However, this problem is well recognized the United States and other countries and international committees are at work to develop standards for both low and high power charging of batteries for BEVs and PHEVs.

Presently most BEVs or PHEVs allow charging from conventional outlets, but this problem must eventually be solved. Automakers might include the ability to charge from standard outlets along with another connection. Without a standard, there could be compatibility issues especially for fast charge stations.

Electricity Supply Chain Issues

The electric power system produces and delivers electricity to its customers in the residential, commercial and industrial sectors. The electricity is produced by power plants of different sizes and types, which can be fueled by a number of energy sources. The structure of the electric power system has evolved because of the need to balance the generation of electricity with the demand for electricity. Unlike liquid fuels, electricity is difficult and expensive to store and as a practical result, virtually all electricity must be generated at the time of use and distributed to the point of use.

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[39] http://www.eere.energy.gov/afdc/progs/ind_state.php/CA/ELEC

The current electricity supply chain consists of primary energy transport, electricity generation, and transmission and distribution. Electricity is currently used in a wide range of sectors (e.g. residential, commercial and industrial) and only very minimally for transportation. However, the supply chain is expected to be the same for transportation-related electricity demands. Because of the well-established infrastructure for supplying electricity already exists, there will likely be no fundamental shifts in how transportation electricity is provided. There can be, however, some important impacts in the economics and operation of the electric utilities if substantial vehicle charging takes place. The piece of the supply chain for EVs that is not currently used in any significant way is the charging interface with vehicles (either at the consumers' homes or at public or fleet charging locations). As a result, most of the barriers for supplying electricity result from this lack of public charging infrastructure. This will be less of an issue in the near-term for PHEV adoption, as PHEVs can liquid fuels as the back-up power source.

The electric industry in Washington is composed of several large investor owned utilities (Avista, Pacific Power and Light and Puget Sound Energy). The typical demand for electricity varies on multiple timescales: daily and seasonal. Demand varies throughout the day because of the changing needs for lighting, heating/air conditioning, industrial demands, and other appliance and electrical equipment use throughout the day. Lighting and other appliances have specific times they are typically used. Also, seasonal effects influence the need for electricity, given that heating is needed in the winter months and air conditioning in the summer months. As a result, the demand for electricity varies throughout the year on an hourly basis.

In the future, electricity production could increasingly become more distributed using renewable energy sources, with less reliance on a centralized production system. For example, rooftop solar photovoltaic (PV) power at a home, office, or elsewhere could be connected to the electricity grid. If the building has excess power generation, the electricity could go back into the grid.

Primary Energy Transport to Power Generating Facilities

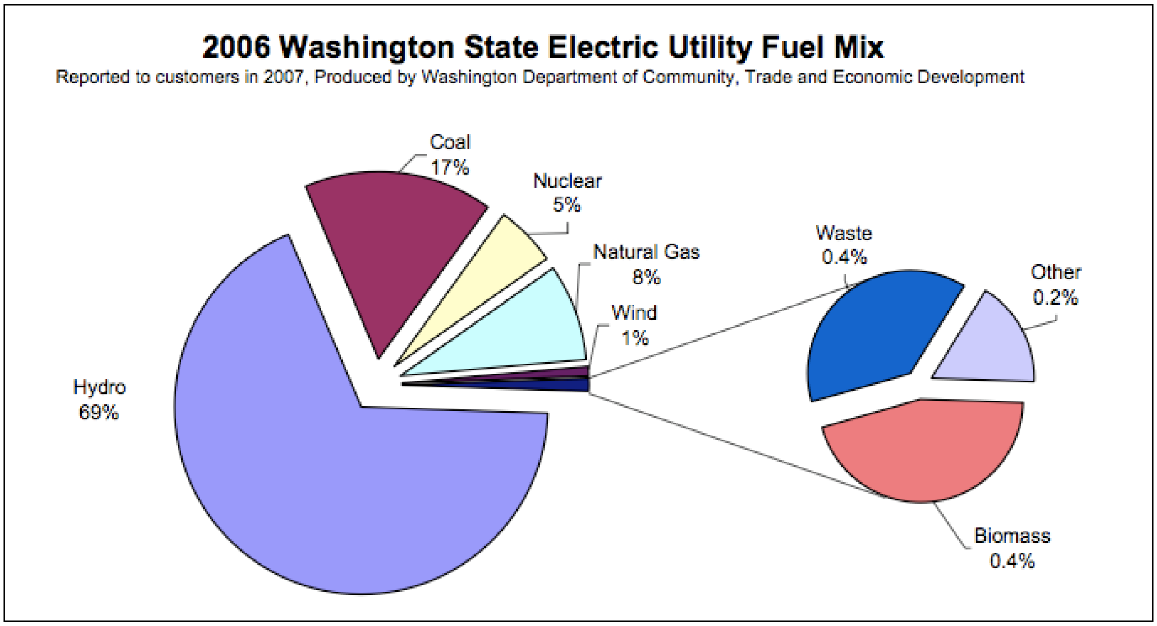
There is a well-established network for transport of primary energy resources to power plants, which varies by the type of fuel used for electricity generation. Natural gas is transported to Washington plants by pipeline, mainly from Canada. There has also been some discussion for LNG terminals in Washington to supplement the supply of natural gas. Coal is transported primarily by rail from the southeast. Waste materials and biomass are transported by truck to processing and electric power facilities. Nuclear plants require uranium fuel, which is produced in several locations in the Western U.S. and transported by rail and truck to the power plant. Other types of electricity generation in the state, mainly renewable, do not require transport of primary energy resources. Wind, solar and hydro plants extract energy from the resources where they occur. The availability of these renewable resources can vary on a daily and seasonal basis.

Electricity Generation

Because electricity demand varies on an hourly basis and little electricity can be stored, power plants must generate electricity in real-time to meet the demand. This requirement affects the structure and operation of the system of electrical generation power plants. There are a number of different types of power plants that are commonly used to generate electricity, which are shown in the table. This collection of power plants operating with various types of technology and fuels is often referred to as the "grid mix".

Exhibit 21 shows the distribution of energy resources that are used to generate electricity in Washington. Washington State is unusual in that the majority of electric generation is supplied from hydropower, which is a very clean and comparatively low cost energy resource. Used in transportation, electric vehicles running on an average grid mix will be significantly cleaner than conventional gasoline vehicles.

Exhibit 21: 2006 Washington State Electric Utility Fuel Mix [40]



A number of different technologies are used to generate electricity. Thermal power plants (steam turbines, gas turbines and combined cycle plants) use heat to power a fluid thermal power cycle. This heat can be achieved from burning hydrocarbon and biomass resources such as coal, natural gas, biogas, oil, biomass and waste, or non-combustion sources such as nuclear fission or solar concentration. Another method of electricity production is the use of a mechanical turbine using either gravitational energy from water behind a hydro dam and tides or from energy in the wind. Photovoltaic conversion of sunlight into electricity is another method for electricity generation.

Because of the variation in the demand for electricity, not all power plants need to be operating at full capacity all the time. Excess electricity generation that is not used cannot be stored efficiently and is thus wasted, so generation is carefully managed to make sure that there is the correct amount of generation occurring. Different types of power plants have different capital and operating costs associated with them, and there is a tradeoff between high capital cost generation that has low operating costs and low capital cost generation with high operating costs. Renewable resources, such as hydro, biomass and wind also have resource constraints that limit the timing and amount of generation. The current renewable portfolio standard (RPS) in Washington is 15 percent by 2020, which will increase the amount of biomass, wind and solar generation.

[40] Source: CTED 2008 2006 Fuel Mix Disclosure. State of Washington, Community, Trade and Economic Development. Accessed 9/1/08. http://www.cted.wa.gov/site/539/default.aspx

Large-scale charging of electric vehicles will impact the current electric grid in different ways depending upon the timing of charging. Charging vehicles primarily at night will have very different implications than charging vehicles primarily during the day because different power plants will be operated on the margin.

Based on data from Washington State CTED, average CO_2 emissions from the electric sector in Washington in 2006 was 210 gCO_2/kWh[41], which is quite low compared to the U.S. average electricity (over 600 gCO_2/kWh). This is due to the high fraction of electricity that is generated from hydro resources and the fact that only about 25% of electric generation came from fossil fuels (coal and natural gas). This means that the greenhouse gas emissions per mile of travel in an electric or plug-in hybrid electric vehicle (EV or PHEV) will be quite low (60-200 gCO_2/mile). The low end of the range (60 gCO_2/mile) corresponds with an EV or a PHEV that is operated primarily in all-electric mode, while the high end of the range (200 gCO_2/mile) corresponds with a PHEV where only 1/3 of the miles come from electricity. These numbers compare quite favorably to the GHG emissions from driving a conventional gasoline vehicle (~400 gCO_2/mile).

Transmission and Distribution

Once electricity is generated, it must be transported to the point of use, via transmission and distribution. This infrastructure is widespread and in general is not likely to be overly burdened by additional electricity demands for charging vehicles. There may be specific points along some distribution lines that face congestion if patterns and quantities of electricity demand change significantly in the face of additional vehicle demand. Also, RPS requirements will increase the use of some renewable resources such as solar and wind, which may require additional transmission lines since the resource distribution may not coincide with population centers.

EV Impacts on Electric Utilities

The demand profile for electricity varies significantly over the course of the day, typically with peaks in the afternoon and evening and low demand in the middle of the night. EVs, including PHEVs, can improve the operation of the electric grid by adding demand during the periods of low demand. The electricity grid is designed to meet the varying demand for electricity with different types of power plants. Power plants that are designed to operate continuously (large thermal power plants such as coal and nuclear) are the lowest cost to operate and provide inexpensive electricity. Power plants that are designed to cycle on and off to deal with peak demands (typically natural gas turbines) are the most expensive to operate.

Adding additional electricity demands at night by charging vehicles with off-peak electricity can improve the cost of electricity and operation of the electric grid, mainly by better utilizing existing generation resources. However, hydroelectric power plants are able to ramp up and down quite quickly in response to changes in electricity demands and the high fraction of hydroelectric power will reduce (but not eliminate) the benefits associated with adding demand at night, relative to a power grid that has much less hydroelectric power. A recent study by the Pacific Northwest National Laboratory (PNNL) found that existing capacity in the current electricity generation grid (Pacific Northwest region) is enough to power 18% of current vehicles with

[41] Source Washington State CTED, total CO2 from electric power generation divided by total electric power generation: http://www.cted.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=4696&MId=863&wversion=Staging ; http://www.cted.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=4697&MId=863&wversion=Staging

baseload and intermediate generation.[42] This is significantly lower than most other regional power grids, because of the high fraction of hydroelectric power generation, which is limited by energy rather than power capacity.

Utilities will be motivated to have consumers recharge their EVs during the nighttime hours and may need to provide the proper incentives (e.g. time of use charging tariffs) to have them do so. The widespread use of vehicle charging that can be controlled by the utility can also enable the penetration of intermittent renewable resources such as solar and wind into the generation mix. Because these intermittent renewables cannot be controlled, the ability to control load (using smart grid technologies) on a vehicle can help minimize the backup generator (reserve margin) requirements for the grid operator, thus lowering the cost of integrating these intermittent renewable generation resources.[43]

Policies and Incentives to Address Barriers to Electricity as a Transportation Fuel

A number of policies and incentives already exist to promote the development or use of electricity as a vehicle fuel.

State Incentive Programs:

Following are state incentive programs for electricity as an alternative transportation fuel[44]:

- Tax exemption for alternative fueled vehicles (AFVs) and hybrid electric vehicles (HEVs) – new passenger vehicles are exempt from state sales and use tax (NG, propane, H_2 and electricity). Valid 1/1/09 to 1/1/11. (Reference Revised Code of Washington 82.08.809 and 82.08.813).
- Alternative fuel grant and loan program – low-interest research loans and grants for renewable and alternative fuels, energy sources, infrastructure, facilities and technologies. Expires 6/30/16. Department of Community, Trade, and Economic Development (CTED). Energy Freedom Program and the Green Energy Incentive Program. (Reference Revised Code of Washington 43.325).
- EV and PHEV demonstration program grants – Public agency grants for the purchase or conversion of PHEVs and BEVs for agency fleet applications. Department of Community, Trade, and Economic Development (CTED). (Reference Revised Code of Washington 43.325.110)
- Exemption for AFV and HEV emissions inspection. Vehicles running on electricity, natural gas or LPG and hybrids that have greater than 50 mpg fuel economy are exempt. (Reference Revised Code of Washington 46.16.015)
- EV charging at State Buildings – vehicles that are used for state business or conducting business with the state may be recharged at State buildings and locations. "…authorizes the purchase of power at state expense to recharge privately and publicly owned plug-in electrical vehicles at state office locations where the vehicles are used for state business, are commute vehicles, or where the

[42] Source: Pacific Northwest National Laboratory, *Impacts Assessment of Plug-In Hybrid Vehicles On Electric Utilities and Regional U.S. Power Grids. Part 1: Technical Analysis*, November 2007.
[43] Source: Yang, Christopher. Carbon Emissions and Grid Impacts of Using Electricity to Charge PHEVs in California. Presentation at the Plug-In 2008 Conference, San Jose, California. July 22-24, 2008.
http://steps.ucdavis.edu/research/Thread_2/fuels_electricity/3B_Yang_UCD-PHEV-Final.ppt
[44] Source: US DOE Alternative & Advanced Fuels Data Center, Washington Electric Laws and Incentives, Accessed 9/10/08.
http://www.eere.energy.gov/afdc/progs/ind_state_laws.php/WA/ELEC

vehicles are at the state location for the purpose of conducting business with the state." (Reference Revised Code of Washington 43.01.250)

- Alternative fuels mandate – all state and local government agencies using public vehicles must use biofuels or electricity for 100% of fuel needs to the extent practicable. Effective 6/1/15. (Reference Revised Code of Washington 43.19.648)
- Clean vehicle purchasing requirement – at least 30% of all vehicles purchased through state contract must be clean fuel vehicles, and the requirement will increase 5% each year. (Reference Revised Code of Washington 43.19.637)
- Medium speed and neighborhood electric vehicles (NEVs) access to roadways with speed limits up to 35 mph. (Reference Revised Code of Washington 46.04.295, 46.04.357 and 46.61.723 through 46.61.725)
- Clean school bus program – Funding program to retrofit school buses with exhaust control devices or alternative fuel infrastructure. (Reference Revised Code of Washington 70.94.017)

Federal Incentive Programs:

Several federal incentives for alternative fuel vehicles or infrastructure include electricity as an alternative fuel. A few federal programs include:[45]:

- Air Pollution Control Program
- Congestion Mitigation and Air Quality (CMAQ) Improvement Program
- Clean Construction USA
- Clean Ports USA
- Clean Fuels Grant Program
- State Energy Program (SEP) Funding
- Clean Cities
- Vehicle Incremental Cost Allocation
- Energy Independence and Security Act of 2007
- Alternative Transportation in Parks and Public Lands Program
- Voluntary Airport Low Emission (VALE) Program
- Clean Agriculture USA

More information can be found on incentive programs at the Department of Energy's Alternative Fuels and Advanced Vehicles Data Center website: http://afdc.energy.gov/afdc/incentives_laws.html.

[45] Source: US Department of Energy, Energy Efficiency and Renewable Energy, Technology Type Table, Federal Incentives for Electric Vehicles, website accessed September 26, 2008; http://afdc.energy.gov/afdc/progs/tech_matrx.php

Potential Strategies to Overcome/Address Electricity Supply Chain Issues

- Tax credits for charging infrastructure and provide special/subsidized electricity tariffs for charging vehicles
- Additional state government role as an early adopter of EVs (BEVs and PHEVs) and charging infrastructure, such as at rest areas, park-and-ride lots, and government office buildings (already underway). See a list of charging infrastructure available in California, for example (http://www.eere.energy.gov/afdc/progs/ind_state.php/CA/ELEC).
- Identify potential hotspots or problem zones in electricity distribution infrastructure if widespread vehicle charging is implemented
- Establish procedures to streamline public charging infrastructure
- Develop public/private partnerships for rapid electric vehicle charging infrastructure, such as the project being developed for the Hawai'i EV Ready State project.
- Education and outreach to consumers and businesses

Hydrogen Supply Chain

Overview of Hydrogen

Hydrogen (H) is the most plentiful gas in the universe. However, hydrogen is not found by itself on earth, and rather it is found in compound form with other elements. For example, when hydrogen is combined with oxygen, it creates water. When hydrogen is combined with carbon, it creates hydrocarbon compounds such as methane, coal, petroleum, and biological materials. Hydrogen is also found in all growing things.

Similar to electricity, hydrogen is an energy carrier. Because hydrogen gas does not occur naturally on earth in large quantities, it must be made from something else, such as natural gas, coal, wood, or water electrolysis powered by wind. Hydrogen can be transported and stored on vehicles, where it is converted into electricity in a fuel cell to run motors that turn the wheels. So hydrogen is the intermediary (or energy carrier) that lets you take the energy from natural gas, coal or wood and turn it into motive power at the wheels of your car. However, unlike electricity, large quantities of hydrogen can be stored until it is needed, at a relatively low cost.

Hydrogen powered fuel cell vehicles (FCV) and the hydrogen infrastructure to fuel them are in an early stage of development. Like electric vehicles, fuel cell vehicles use electricity to power motors located near the vehicle's wheels. In contrast to electric vehicles which rely on batteries, fuel cell vehicles produce their primary electricity using a fuel cell. The fuel cell is an electrochemical device that combines hydrogen and oxygen in air to produce electricity, heat and water. Fuel cells have very high conversion efficiency, and produce no emissions of pollutants or greenhouse gases.

Although important progress has been achieved in improving FCV technologies, FCVs are likely to need at least another 10-15 years of research, development, and demonstration before major deployment efforts can begin.[46]

[46] Source: International Energy Agency, Energy Technology Perspectives 2008: Fact Sheet – The BLUE Scenario, 2008, http://www.iea.org/textbase/techno/etp/fact_sheet_etp2008.pdf.

Overview of Hydrogen Supply Chain

Since hydrogen doesn't exist on earth as a gas (H_2), it must be separated from other elements. As described previously, hydrogen atoms can be separated from water, biomass, or natural gas molecules. Hydrogen can be produced from a variety of feedstocks including fossil fuels (natural gas, petroleum coke, coal), renewable energy (wind, solar, biomass or hydropower), and nuclear energy. Like electricity, hydrogen can be produced at a range of scales, from the household level to central hydrogen production plants serving a large city.

Hydrogen for vehicles can be produced "onsite" at fuel stations via small scale reforming of natural gas or water electrolysis. Alternatively, hydrogen can be produced in large central plants and delivered to users in trucks (either in compressed gas tube trailers or liquefied hydrogen tankers), or in gas pipelines. At the fuel station, the hydrogen is further compressed to high pressure (350-700 atmospheres) for dispensing to vehicles.

Currently, hydrogen is not widely available as a fuel, although there are about 70 demonstration hydrogen fuel stations in the U.S. The best choice for hydrogen supply (either produced onsite at fuel stations, or from large central plants) depends on the scale of hydrogen demand, density of demand, local energy prices, delivery distances, and other factors.[47]

Hydrogen Supply Chain Issues

Current Hydrogen (H_2) Supply Technology

Well-established, commercially available technologies are available for producing hydrogen at large scale from fossil fuels and delivering it to users as a compressed gas (at 70 to 700 atmospheres) or cryogenic liquid (at -253ºC). Large quantities of hydrogen are produced for industrial uses, such as oil refining and ammonia production. In the U.S., about 9 million tons per year are produced, enough to fuel about 20 to 30 million fuel cell vehicles. Most hydrogen in the U.S. (about 95 percent) is made via large scale steam reforming of natural gas, which is generally the lowest cost method. (Hydrogen can be produced from natural gas at a cost equivalent to $1.50/gallon gasoline; however, delivery to vehicles would add several additional dollars per gallon of gasoline equivalent) Water electrolysis is used where low cost electricity is available and accounts for a few percent of hydrogen production. (Hydropower is the usual source for electrolytic hydrogen today, but in theory any source of electricity could be used, including renewable sources such as wind or solar power.)

Although we know how to make low cost hydrogen at large scale from fossil fuels, a key issue for establishing a sustainable hydrogen transportation system is developing low-cost, zero-carbon hydrogen supplies. Hydrogen fuel cell vehicles have zero tailpipe emissions. However, emissions of greenhouse gases (GHG) and air pollutants can occur during hydrogen production and delivery. Because there is increasing recognition of the need to reduce GHG emissions while we transition to alternative fuels, it is important to consider the GHG implications of transitioning to hydrogen as an alternative fuel source. As with electric vehicles, it is important to consider the whole fuel cycle from "well to wheels." If hydrogen is produced from natural gas and used in a fuel cell vehicle, "well to wheels" greenhouse gas (GHG)

[47] Source: Yang, C., and Ogden, J. "Determining the lowest-cost hydrogen delivery mode." International Journal of Hydrogen Energy, 32(2), 268-286., 2007.

emissions are roughly half of those for a comparable gasoline vehicle.[48] But to gain the full GHG benefits of a hydrogen transportation system, near-zero carbon hydrogen supplies are needed for the long term (e.g. biomass gasification, fossil hydrogen with carbon capture and sequestration, or renewable electrolysis).

Near to Mid-Term H_2 Supply Technology

Several technology developments are likely to help enable introduction of hydrogen fuel over the next 5-15 years.

- Small scale reformer technology (for reforming natural gas or biofuels) is advancing rapidly and is becoming attractive for onsite hydrogen production at fuel stations.
- The technologies to produce hydrogen from biomass are advancing and could be employed in the near to mid-term.
- When hydrogen is made from hydrocarbons like natural gas, coal, or biomass, it is possible to capture the carbon, and sequester it underground in deep geological formations. Carbon capture and sequestration (CCS) is being tested at an industrial scale at several sites globally, and if successful, could eventually allow hydrogen production from plentiful, cheap fossil sources like coal, without emitting CO_2 into the atmosphere. However, CCS may not be widely used for a number of decades. For example, the International Energy Agency, in it's optimal technology BLUE map scenario to 2050 (which assumes the whole world participates fully in technology development and implementation), the estimation is that about 19 percent of global GHG reduction in 2050 (from baseline) results from CCS.[49]
- Renewable powered electrolysis is technically feasible and can be produced locally at a fuel station, or at large central plants; the issue is bringing down the cost of electricity. Advances in wind power, and integration of intermittent renewables into the grid might make this more economically attractive.

Long term H2 Supply Technology

Research is ongoing on a variety of advanced low carbon processes to make hydrogen, such as thermo-chemical cycles driven by high temperature nuclear or solar heat and biological hydrogen production. All are far from large-scale commercial application.

Hydrogen Storage

Unlike liquid fuels such as gasoline or biofuels, in order to achieve high energy densities for transport and onboard vehicle storage, hydrogen must be stored at either high pressure (70-700 atmospheres) or low temperature (-253ºC). Hydrogen storage and delivery is more capital and energy intensive than storage and delivery of liquid fuels. Finding alternative hydrogen storage methods that could reduce costs and energy requirements is a major focus of the USDOE's Hydrogen R&D program.

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[48] Source: National Research Council, *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*. 2004, National Research Council - Board on Energy and Environmental Systems: Washington DC. p. 394.

[49] Source: International Energy Agency, Energy Technology Perspectives 2008: Fact Sheet – The BLUE Scenario, 2008, http://www.iea.org/textbase/techno/etp/fact_sheet_etp2008.pdf.

Logistics Issues for Hydrogen Supply

Hydrogen can be delivered to fuel stations in trucks or pipelines. The three main delivery options are:

1) **Truck delivery of compressed gas.** Hydrogen is compressed at the production plant to 70-150 atmospheres and stored in a "tube trailer." The tube trailer a special truck trailer fitted with a bank of long pressure tubes holding hydrogen. Tube trailers are an economical way to deliver small quantities of hydrogen short distances. (The total capacity of the tube trailer is typically 100-300 kilograms of hydrogen, enough to refuel 20-60 fuel cell cars.) The tube trailer can be fitted with its own compressor and dispenser, and is termed a "mobile refueler." Vehicles can be filled directly from this self-contained, mobile, mini hydrogen station. In the very early stages of hydrogen vehicle adoption, mobile refuelers could be a convenient and flexible way to offer hydrogen at fuel stations. The mobile refueler could be parked at the station (which might offer other fuels like gasoline or biofuels in addition to hydrogen), serving a small population of early hydrogen cars. When empty, the mobile refueler could be returned to the central plant for refilling.

2) **Truck delivery of liquid hydrogen.** At the central plant, hydrogen is brought to very low temperatures (-253 C), using an energy intensive liquefaction process. Liquid hydrogen has much higher density than compressed gas hydrogen, allowing relatively compact and low cost bulk storage. Liquid hydrogen tanker trucks are filled from bulk LH2 storage tanks at the central plant, and travel to fuel stations. Liquid hydrogen delivery is used to transport larger quantities of hydrogen over longer distances than compressed gas trucks. A typical LH2 truck carries 3000 kg of hydrogen, roughly 10 times the capacity of a tube trailer. At the fuel station, LH2 is transferred to a liquid hydrogen tank located at the station. The LH2 tank can store 3000 kg or more, enough for many days refueling. During refueling, the liquid hydrogen is pumped to high pressure and then gasified under pressure and used to fill gaseous storage tanks onboard the vehicle at 350-700 atmospheres.

3) **Pipeline delivery of gaseous hydrogen.** Pipeline delivery of large quantities of hydrogen is a well-established practice in the chemical and refining industries, and there are hundreds of miles of high pressure hydrogen pipelines in operation in the U.S. today. Hydrogen vehicle fuel would be compressed at the central plant (to 20-70 atmospheres), and fed into a gas pipeline system that delivers hydrogen to a network of fuel stations throughout an urban area. (This system is somewhat analogous to a local natural gas utility system, although it would be much "sparser" network, since hydrogen would be delivered to a limited number of fuel stations, rather than to every house). Recent studies of hydrogen delivery systems suggest that ultimately pipeline delivery will be the lowest cost way of bringing hydrogen from central plants to urban fuel stations. Hydrogen pipelines are expensive, costing perhaps $1-1.5 million per mile in urban areas, but at high levels of hydrogen use, the delivered cost is lowest on a $/kg basis. (Pipelines might become competitive when 25-50 percent of cars in a densely populated urban area use hydrogen). It has been proposed that hydrogen could be piped through the existing natural gas system, saving the cost of building new pipelines, but this would not give an optimal flow rate, and would require careful checking for materials compatibility. It is more likely that dedicated hydrogen lines would be built. However, it is unlikely that extensive hydrogen energy pipelines will be built for several decades, until large, geographically concentrated demand builds up.

With onsite production via small scale natural gas reforming, the existing natural gas system should be adequate to provide natural gas for hydrogen production. In some cases, it may be necessary to upgrade the grid connection and electric distribution lines for onsite electrolysis.

Hydrogen Fuel Stations

All new alternative fuels, including hydrogen, face the so-called "chicken and egg" problem. Consumers will not buy vehicles unless fuel is readily available, and fuel providers won't build stations unless vehicles are there to use them. Early hydrogen infrastructure will be expensive, so a key question is how to build a viable network of stations that will allow consumers adequate access to fuel. Recent research at U.C. Davis suggests that an initial "sparse" network of strategically placed hydrogen stations might provide adequate convenience for consumers.[50] Coordinating early infrastructure and vehicle placements in focused areas geographically, and carefully timing the rollout of stations and cars will help to gradually introduce hydrogen as an alternative energy source for transportation. As the scale of hydrogen use increases, hydrogen delivery costs should decrease.

Because hydrogen is a new and relatively unfamiliar fuel, siting and permitting hydrogen stations are key issues. Hydrogen stations can require more land area than gasoline stations, because fuel storage takes up more space, which can make siting more difficult than with liquid fuels.

Incentive Programs

A number of state and federal incentive programs are available for the use of hydrogen as an alternative transportation fuel.

State Incentive Programs:

Washington State has established an incentive programs for the purchase of alternative fuel vehicles, including hydrogen powered vehicles. The Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (HEV) Tax Exemption begins January 1, 2009. Under this law new passenger cars, light-duty trucks, and medium-duty passenger vehicles that are dedicated AFVs are exempt from the state sales and use tax. This includes vehicles that operate on hydrogen. In addition, the Alternative Fuel Grant and Loan Program awards low-interest loans and grants for research and development of new and renewable energy and biofuel sources; renewable energy and alternative fuel infrastructure, facilities, and technologies; and research and development to develop markets for alternative fuel byproducts. Funding for the Program is provided by the Energy Freedom Loan Account and the Green Energy Incentive Account. The Program expires June 30, 2016.

Construction of new alternative fueling facilities as well as upgrades and expansion of existing fueling infrastructure offered to the public are eligible for funding of up to $50,000 per fueling infrastructure project. Funding for fueling infrastructure projects will only be awarded if the project is located within a 'green highway zone' in the state, which is a designated area within reasonable proximity of Washington Interstates 5, 90, and 82. Although projects are eligible for funding, no money has been appropriated for the Green Highways grant fund at the time of this writing.

Federal Incentive Programs:

[50] Sources: Nicholas, Michael A., Susan L. Handy, Daniel Sperling (2004) Using Geographic Information Systems to Evaluate Siting and Networks of Hydrogen Stations. Transportation Research Record (1880), 126 – 134; Nicholas, Michael A. and Joan M. Ogden (2007) Detailed Analysis of Urban Station Siting for California Hydrogen Highway Network. Transportation Research Record 2006 (1983), 129 – 139.

Most hydrogen incentives or programs are at the federal level. Some of the federal programs for hydrogen as an alternative transportation fuel include[51]:

- Air Pollution Control Program
- Congestion Mitigation and Air Quality (CMAQ) Improvement Program
- Clean Construction USA
- Clean Ports USA
- Renewable Energy Systems and Energy Efficiency Improvements Grant
- Clean Fuels Grant Program
- Alternative Fuel Excise Tax Credit
- Clean Cities
- Vehicle Incremental Cost Allocation
- Fuel Cell Motor Vehicle Tax Credit
- Alternative Fuel Infrastructure Tax Credit
- Qualified Alternative Fuel Motor Vehicle (QAFMV) Tax Credit
- Energy Independence and Security Act of 2007 Signed Into Law
- Alternative Transportation in Parks and Public Lands Program
- National Fuel Cell Bus Technology Development Program (NFCBP)
- Voluntary Airport Low Emission (VALE) Program
- Clean Agriculture USA
- Alternative Fuel Tax Exemption

More information can be found on incentive programs at the Department of Energy's Alternative Fuels and Advanced Vehicles Data Center website: http://afdc.energy.gov/afdc/incentives_laws.html.

Possible State Actions to Address Barriers to Hydrogen Infrastructure

A number of additional possible state actions could help address some of these supply chain barriers for the use of hydrogen as an alternative transportation energy source. These include:

- State government role as an early adopter of hydrogen technologies (including state agency fleets), if these vehicles and infrastructure can be purchased at reasonable costs or in partnership with vehicle/technology developers.
- Establish procedures to help streamline permitting of hydrogen stations.

[51] Source: US Department of Energy, Energy Efficiency and Renewable Energy, Technology Type Table, Federal Incentives for Hydrogen/Fuel Cells, website accessed September 26, 2008; http://afdc.energy.gov/afdc/progs/tech_matrx.php

- Help streamline permitting of hydrogen delivery infrastructure, such as pipelines.
- Help coordinate introduction of stations and vehicles in focused "lighthouse cities"/regions. A lighthouse city is a city that automakers and energy companies will focus on during the early stages of fuel cell vehicle commercialization. Since hydrogen infrastructure is expensive, it will be much easier to provide hydrogen stations in and around a small number of cities than for the country as a whole. These cities will then have the infrastructure necessary to support the early introduction of commercial fuel cell vehicles. Essentially, focusing on a small number of cities allows the automakers and energy companies to reduce the "chicken and the egg" problem. The term "lighthouse" refers to cities that will "lead the way" for others to follow.
- Provide support and incentives for early hydrogen suppliers.
- Identify good sites for hydrogen station development; provide incentives to receptive communities.
- Hold workshops for state fire marshals and first responders to acquaint them with hydrogen technologies.
- Education and outreach to consumers.
- Provide incentives for alternative fuel production that meets certain criteria (e.g. locally produced, provides local jobs, low greenhouse gas emissions, renewable, etc.)

Summary of Supply Chain Issues

Each of the five alternative fuels analyzed in this chapter have some supply chain issues. Exhibit 22 summarizes the feedstock, transport, refining, and supply chain issues for each alternative fuel. All of the alternative fuels have supply chain issues that generally result in the cost of the alternative fuel being higher than gasoline or diesel, making it hard to compete with gasoline and diesel. Most alternative fuels also have infrastructure supply chain challenges (lack of pipelines, terminals, or other infrastructure).

Exhibit 22: Summary of Supply Chain Issues for Alternative Fuels

Alternative Fuel Sources	Feedstock or Fuel Source	Transport of Feedstocks (or Fuel Source)	Refining/Production Method	Transport of Finished Product to Fuel Stations	Supply Chain Barriers/Issues
Ethanol	Corn currently. In future cellulose, other biomass, etc.	Truck, rail, barge.	Ethanol refineries.	Rail, truck, or barge.	Lack of pipelines for transport; lack of blending and storage facilities for ethanol; GHG and potential food price impacts of corn-based ethanol.
Biodiesel	Soybeans, other vegetable oils, animal fats. In future algae, biomass.	Truck, rail, barge	Biodiesel refineries.	Barge, rail, truck.	Feedstock cost and availability. Cost to transport feedstocks. Lack of pipelines, terminals, blending facilities. Competition with petroleum-based diesel.
CNG	Natural gas	Pipelines, LNG terminals	Processed at natural gas processing plant.	Pipelines and tanker trucks.	Limited domestic natural gas resources for expanded transportation use. Additional pipelines and LNG terminals for increased imports.
Electricity	Hydroelectric power, natural gas, coal, nuclear, wind, etc.	NA for hydroelectric power and wind power; pipeline for natural gas; rail, barges for coal.	Electric power generation.	Transmission lines from power grid (from power generating facilities to recharging facilities). In future, possibly more distributed power generation from renewables.	Lack of public/on-the-road charging facilities.
Hydrogen	Fossil fuels, renewable energy, or nuclear power.	Electric power for electrolysis is delivered via the grid or from a dedicated power system; pipeline for natural gas; rail, barges for coal; trucks, rail for biomass.	Produced in large central plants via large scale steam reforming of natural gas. Also be produced "onsite" at fuel stations via small scale reforming of natural gas or water electrolysis.	Pipeline or by road using tube trailers and cryogenic liquid hydrogen tankers.[52] For on-site hydrogen production, natural gas or electricity would need to be transported to fuel stations.	Lack of hydrogen delivery and fuel station network (pipelines, etc.).

[52] Source: DOE Hydrogen Program, http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/doe_h2_delivery.pdf

Chapter 3: Station Spacing Analysis

The prospect of using Washington State rest areas as potential locations for alternative fueling is explored in this chapter. This section also describes using WSDOT maintenance sites and park and ride facilities for public refueling if the network of available rest areas is not sufficient to meet the goals of WSDOT.

WSDOT-owned rest areas are arranged in a comprehensive network, providing services where there generally are very few. As they are typically sited away from other services, land availability is an advantage, though from a commercial perspective their isolation is both a benefit and a challenge. Rest areas are usually remote, and in areas generally underserved by traditional automobile services located at exits. Therefore, they present an opportunity for the State to play an important role connecting regions together. However, because of their remote locations, they would not generally be used by vehicles making local trips, which represent a large portion of overall auto trips. Rest areas stations should be seen as an integral part of a larger system, but not the complete system itself.

Conversely, sites such as publically owned fleet maintenance facilities may be more conveniently located for use by local traffic, but in most cases were not intended to provide the general public with fueling services and face safety and security constraints to general public access. For this reason, the main focus of this analysis is on the suitability of rest areas as alternative fueling station locations, with some coverage of maintenance facilities for consideration if rest area sites are found to be insufficient in number or placement.

Another category of State-owned land that could be suitable for alternative fueling station locations is park and ride facilities. As opposed to maintenance facilities, they already allow public access. Park and ride locations are generally selected for their convenient access to the freeway or other high capacity roads.

Park and ride facilities target commuters; an auto user market segment considered a likely early adopter of alternative fuel vehicles due to their relatively high consumption of fuels (and associated cost) and regular travel and refueling patterns. The drawback to using park and ride facilities as station locations is that many are small and depending on the alternative fuel being considered, adding a station would significantly reduce the number of parking spaces, or a simply may not fit. Because of these difficulties, specific park and ride facilities are not recommended in this report, but along with maintenance facilities some analysis is provided.

The study is restricted to the main north south corridor of I-5 as it connects some of the most populous regions in the state, and has a greater potential to be part of a larger corridor connecting Mexico to Canada with alternative fuel availability.

Goals and Methodology

The introduction of alternative fuels is part of the solution to a transition to a cleaner more sustainable transportation system. However, the lack of infrastructure to support a transition to these fuels creates a significant barrier to their adoption by consumers. Alternative fuels are initially more expensive than gasoline due to low volumes in both production and delivery of the fuel and in some cases new refueling technology and equipment. (especially in the case of hydrogen and electricity). Therefore, infrastructure expansion by for-profit companies is likely to be slow absent assistance by government.

In the case of the WSDOT, a strategy of providing sites at little or no cost to the retailer to build stations has been suggested. The fuels considered in this analysis are hydrogen, ethanol, biodiesel, and electricity. As mentioned earlier, rest areas are the preferred sites due to their current function as a service to the public, lack of other services in the I-5 corridor, and their generally ample land area.

Inter-regional vs. Intra-regional sites

Rest areas, park and ride facilities, and maintenance facilities fall into two categories of sites: inter-regional and intra-regional. The two types of sites highlight two different refueling functions: inter-regional refueling for trips between regions, and intra-regional refueling for local travel.

The vast majority of refueling is of the intra-regional variety, but both are necessary for a functioning refueling network. Inter-regional refueling would most likely be the role for stations at WSDOT rest areas. However this network of inter-regional stations must be accompanied by intra-regional stations. In some cases rest stops may work in this capacity, but they are generally not ideal for home based refueling since they must be accessed from the freeway. Park and rides and maintenance sites could fill the role of intra-regional stations and are analyzed on the same metrics as rest stops to highlight the differences in site types.

Inter-regional Siting Strategy

The number and spacing of stations in the inter-regional context is dictated by the range of the vehicles and the reliability of the stations. The range varies widely depending on the alternative fuel considered. Exhibit 23 compares the current ranges of vehicles using each technology type under consideration.

Exhibit 23: Estimated Vehicle Range by Technology

Technology	Range
Gasoline (reference)	> 350 miles
Biodiesel	> 400 miles
Ethanol	> 250 miles
Hydrogen	120 - 300 miles
Electricity	60 -200 miles

Distance between refueling locations should not exceed the range of the vehicles and so the refueling site spacing should, at a minimum, be determined by the vehicle ranges mentioned above. The two fuels with the least range are electricity and hydrogen. Because of the generally lower range of electric vehicles, a benchmark of 60 miles between stations is used, and a distance of 120 miles is used for hydrogen vehicles.

Although, distance between stations is important, a level of redundancy is necessary. If one station fails (is for whatever reason unable to provide fuel on a given day or week), travelers should feel confident that another station will be available within a reasonable distance to accommodate them before they run out of fuel. Therefore, station locations should be frequent enough that a failure of one station should not affect a traveler's ability to move efficiently within the I-5 corridor.

Suitability of Rest Areas as Refueling Locations

Rest area sites present some interesting challenges when looking at station placement. Typically, a rest area consists of two locations, one on each side of the highway. Each is only accessible from its respective side such that if a station were placed one side, it could not be used easily by vehicles traveling in the opposite direction. Therefore distance on the same side of the freeway will be used to evaluate adequate distances between stations.

However, stations on opposite sides of the highway are not treated as totally independent. As rest areas usually come in pairs, one in the northbound direction and one in the southbound direction, two stations would not be on opposite sides of the freeway at the same rest area. Stations were instead staggered so that in the hydrogen case, for example, there would be no more than 120 miles between stations on one side of the highway, but in case of emergency or shut down, one could double back to the other side of the freeway and get fuel at least every 60 miles. This helps provide the redundancy discussed briefly above.

I-5 is considered a reasonable test bed for these technologies for two main reasons. First, it provides access to Oregon, California, and British Columbia, all of which have expressed interest in promoting the use of alternative fuels in this corridor. Hydrogen in particular will be highlighted during the Vancouver Winter Olympic games in 2010 and having hydrogen stations in Washington State will create the possibility of leveraging the activity in Vancouver. Secondly, I-5 is a densely populated corridor with many commuters, translating into the ability to serve a greater proportion of Washingtonians and educate and encourage more people to adopt cleaner, more sustainable auto transport technology.

Intra-Regional Siting Strategy

Because the focus of this analysis is on siting stations at rest areas, there will be little opportunity to provide access to fuel for local travel. However, where possible, rest area sites that function as both a link in the inter-regional chain of stations, and provide good intra-regional accessibility will be favored for selection. Should WSDOT decide to provide locations specifically for intra-regional siting in the future, performance metrics on maintenance facilities and park and ride lots are included.

Station Spacing Analysis Results

Hydrogen Station Placement Strategies

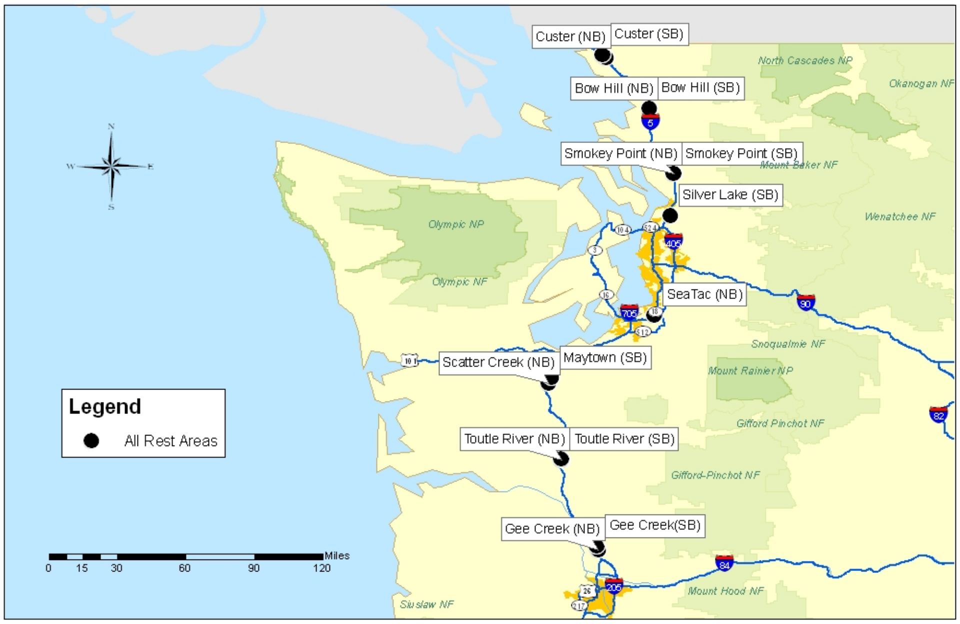
Hydrogen stations located at WSDOT rest areas would be positioned as part of an inter-regional strategy. The market for these stations would be travelers already using I-5, and the few people who live near rest areas. A rest area strategy could be seen as WSDOT providing the backbone of a system with the expectation that other entities would pursue the placement of stations and vehicles in populated areas.

An inter-regional rest area only scenario is developed as a baseline and can be considered the first phase. A second phase or possibly concurrent with the first phase would build off the backbone network created by rest areas. In this phase, park and rides and/or maintenance facilities could be used to site stations in populated areas where appropriate thereby expanding the market of travelers served. A general measure of attractiveness can be represented by the amount of population surrounding a site (see supplemental comparison of population and traffic near rest areas in Appendix A).

Rest Area Scenario (Baseline)

For this scenario, only rest areas will be considered as potential sites. The entire rest area network is shown in Exhibit 24. In the figure callouts, NB signifies northbound, and SB signifies southbound. There are 14 rest areas along I-5 in Washington.

Exhibit 24: All rest areas along I-5



Appendices B and C rank rest area attractiveness based on population and traffic in proximity to the location, respectively. Based on these parameters, the most attractive rest areas are at SeaTac and Silver Lake locations. As they have the potential to provide service to the greatest proportion of the auto-traveling public, these sites were obvious first choices from the pool of rest areas.

Using the two stations at SeaTac and Silver Lake as first selections in the network, other stations were selected in relation to those to enable inter-regional travel along I-5. As stated earlier, the lower limit of range for hydrogen vehicles is estimated at 120 miles, so stations should not be spaced farther apart than that on each side of the freeway. A map of the distances between stations in each direction is shown in Exhibits 25 and 26. These figures show that it is not necessary to have hydrogen stations at all rest areas if the 120 mile between stations criterion is used.

Exhibit 25: Rest Areas in the Northbound Direction

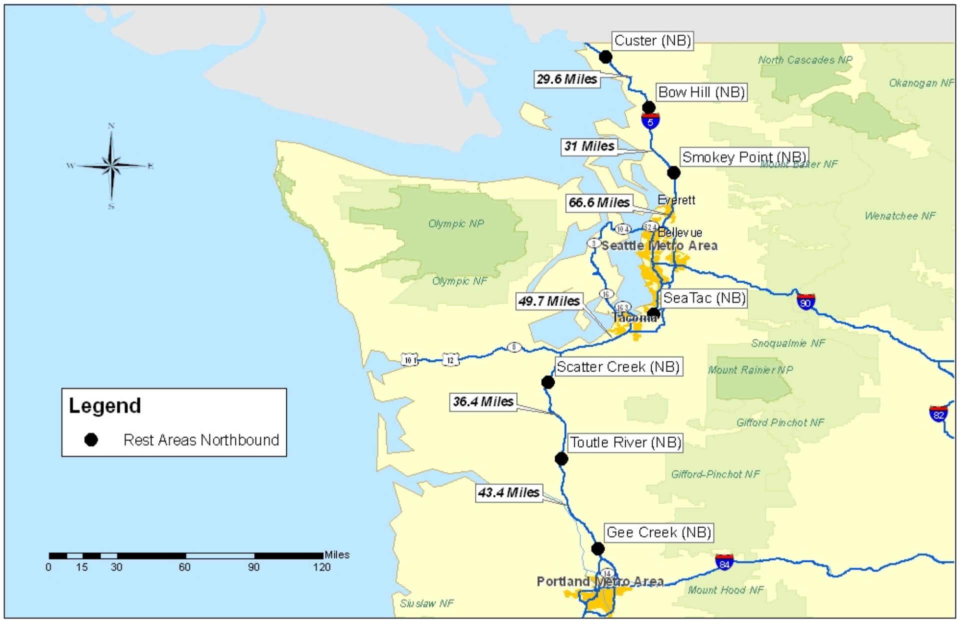
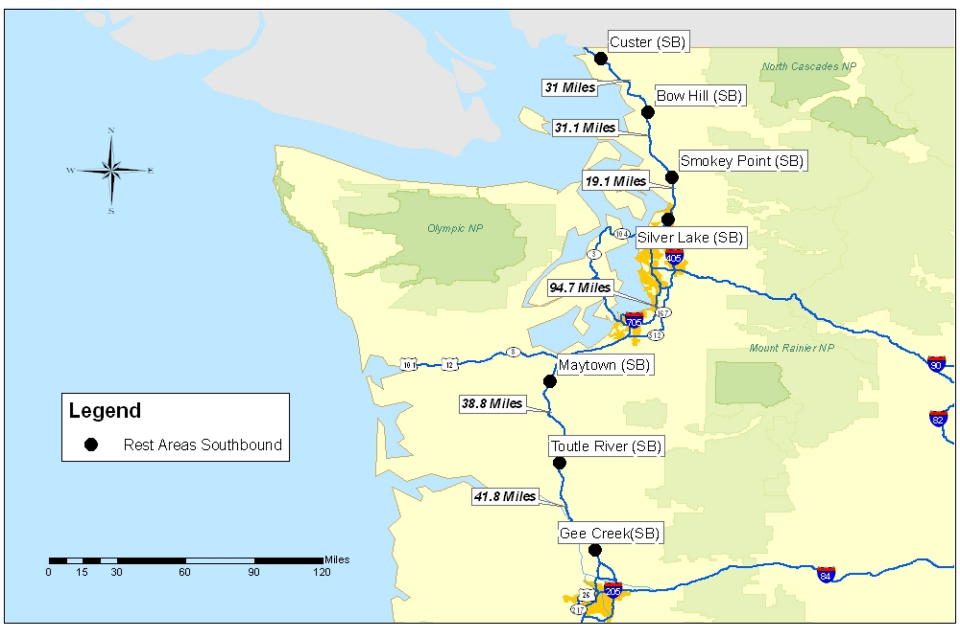


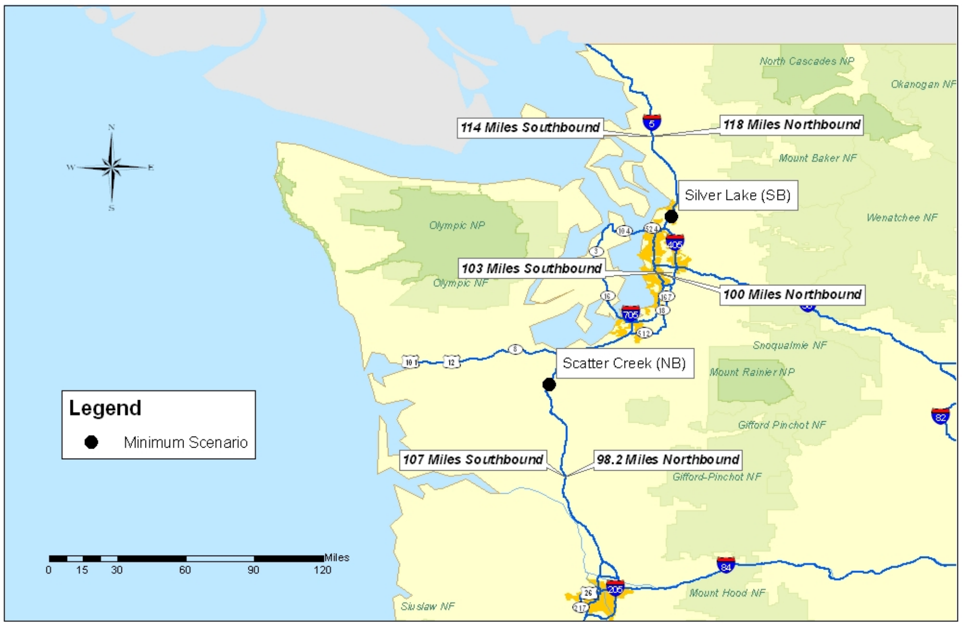
Exhibit 26: Rest Areas in the Southbound Direction



Minimum Hydrogen Scenario

If the goal is to simply move vehicles through the State from Oregon to Canada, the minimum number of stations is two as shown in Exhibit 27. This assumes that the Portland area will have fuel available along the I-5 corridor, and the planned Vancouver, British Columbia airport station is operational. Notice that because the customer has to double back to refuel the northbound and southbound distances are different.

Exhibit 27: Minimum Hydrogen Scenario



Siting stations at Scatter Creek Northbound and at Silver Lake Southbound would enable travel through the state. Using these two sites would necessitate southbound bound travelers to detour 3.4 miles to refuel at Scatter Creek, and then detour another 11.6 miles to return to the same exit they had originally got off of to refuel. Traveling north, customers would have to make a similar detour to access the southbound Silver Lake facility. One possible modification of this would be to use a park and ride facility near Sliver Lake called the South Everett Freeway Station instead of Silver Lake. This would mean that only southbound travelers would have to detour to access fuel. This minimum plan leaves no recourse if a station is down and may leave customers stranded.

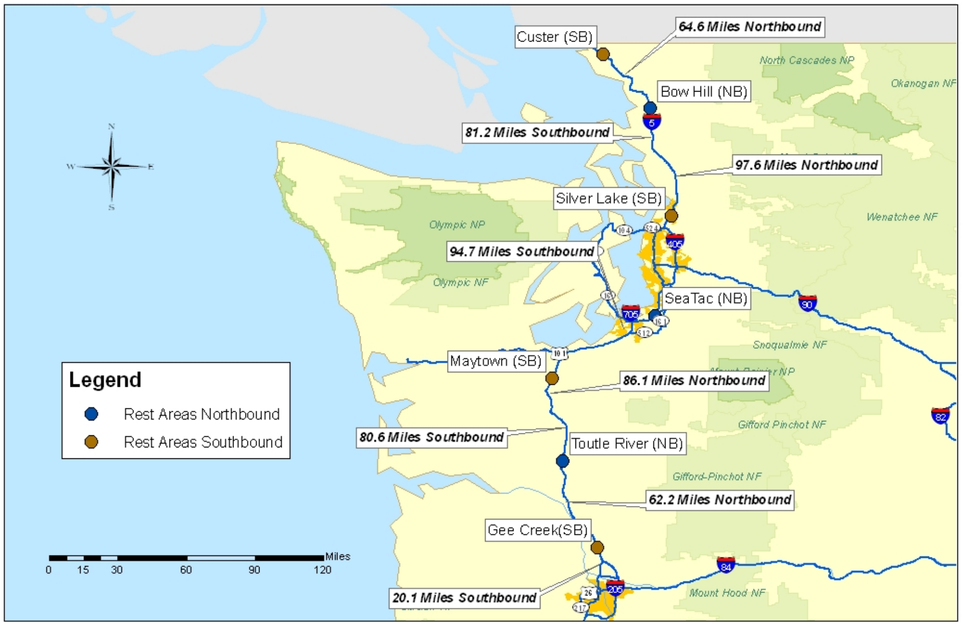
Applying the siting criteria of having no more than 120 miles between stations on the same side of the freeway reveals a self contained Washington State scenario, enabling travel along I-5 regardless of fuel availability in Oregon and Canada. Again using both Silver Lake and SeaTac as the first sites selected, the other sites selected are shown in Exhibit 28.

If Portland and Vancouver, B.C. have fuel, both Custer and Gee Creek can be omitted from the network shown in Exhibit 28 and still provide fuel at least every 120 miles on the same side of the freeway.

If the South Everett Freeway Station were used instead of Silver Lake, this would provide access to both sides of the freeway and would obviate the need for a station at the Bow Hill rest area.

Although this scenario would leave a 120 mile gap in the network, there is little traffic going by Bow Hill (Appendix C). This scenario provides a reasonable level of redundancy and ease of use with only four stations: Toutle River (NB), Maytown (SB), SeaTac (NB), and the South Everett Freeway Station.

Exhibit 28: Washington-Contained Hydrogen Network



Electric Charging Station Placement

Electric vehicles present an interesting situation for siting at rest areas. Currently, the dominant technology is slow charging and with this technology, obtaining a full charge could take 8 hours. Customers making inter-regional trips could charge for only a few hours, but this would likely be enough to get them to get to the next charger. This may be acceptable to an intrepid few, but spending long periods of time at a rest area is not likely to catch on for the majority of EV drivers.

Recently, there has been significant interest in fast charging, and the battery technology seems to be progressing to meet this interest. Fast charging is a much more practical solution for the rest area locations. If 50 kilowatt chargers are used, and it is assumed that 25 kilowatt hours enable a vehicle to travel 100 miles, 30 kilowatt hours will have a range of 120 miles, similar to the spacing criteria for hydrogen vehicles. Using these assumptions, the inter-regional siting scenarios for hydrogen stations can be used for pure electric vehicles. The minimum number of stations is 2, and the maximum is 7 for interregional refueling. The number can be altered based on the actions of Canada, and Oregon, and also on whether South Everett Freeway Station can be used instead of Silver Lake.

Plug-in Hybrid Vehicle Charging Station Placement

The advantage of plug-in hybrids is that electricity customers are not bound to stay until the battery is full. Customers can leave at any time and choose to use the gasoline engine in lieu of electric operation. This said, the goal is to eliminate or significantly reduce the need for petroleum in PHEV travel in the I-5 corridor. If we assume a battery pack range of 2 to 10 kilowatt hours, the charge time using a 50 kilowatt charger would take from 3 to 12 minutes to charge a battery. Only customers who are stopping at a rest area for normal reasons are likely to use a rest area charger.

Since fast chargers can be used for both plug-in hybrids and pure electric vehicles, a compromise solution may be to site charging stations based on the limitations of electric vehicles with the added benefit of those stations being available for plug-in hybrids. Tying plug-in hybrids to the limitations of electric vehicles and hydrogen vehicles yields a minimum number of charging stations of 2 and a maximum need of 7, as stated above.

Biodiesel and Ethanol

Both biodiesel and ethanol are compatible with existing diesel and gasoline, so creating a comprehensive network is not critical for movement through the corridor with vehicles that can use these fuels. Given this reality, the goal of WSDOT is to promote the use of fuels using less petroleum, and as such, minimum necessary and convenience and redundancy scenarios are presented that would allow travel in the corridor without reliance on traditional diesel and gasoline use. However, some ethanol and biodiesel stations currently exist in the I-5 corridor. The existing stations that do not require a special refueling card and are near the freeway are shown in Exhibits 29 and 30.

Exhibit 29: Map of existing ethanol stations and suggested rest areas

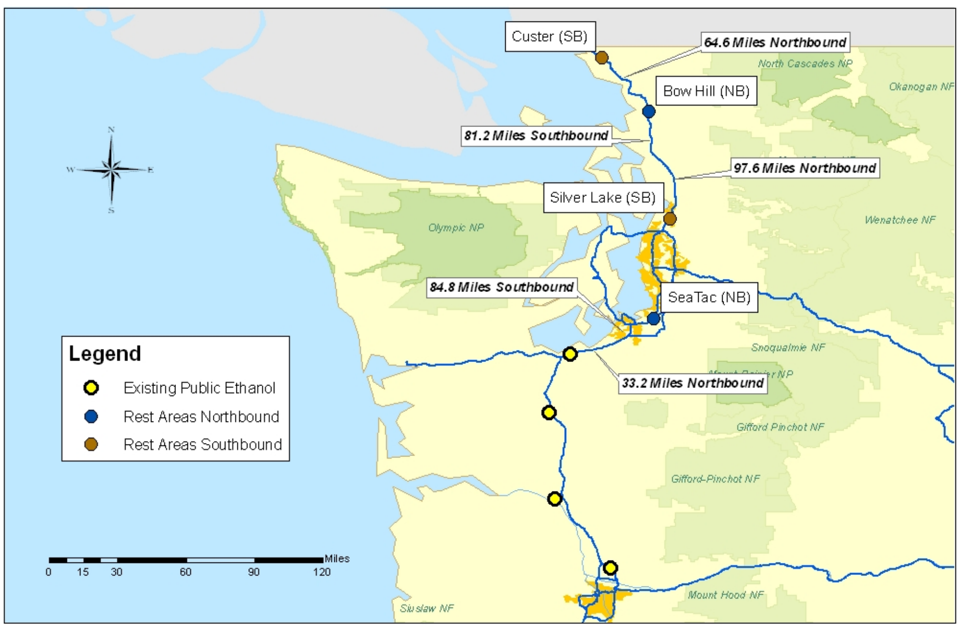
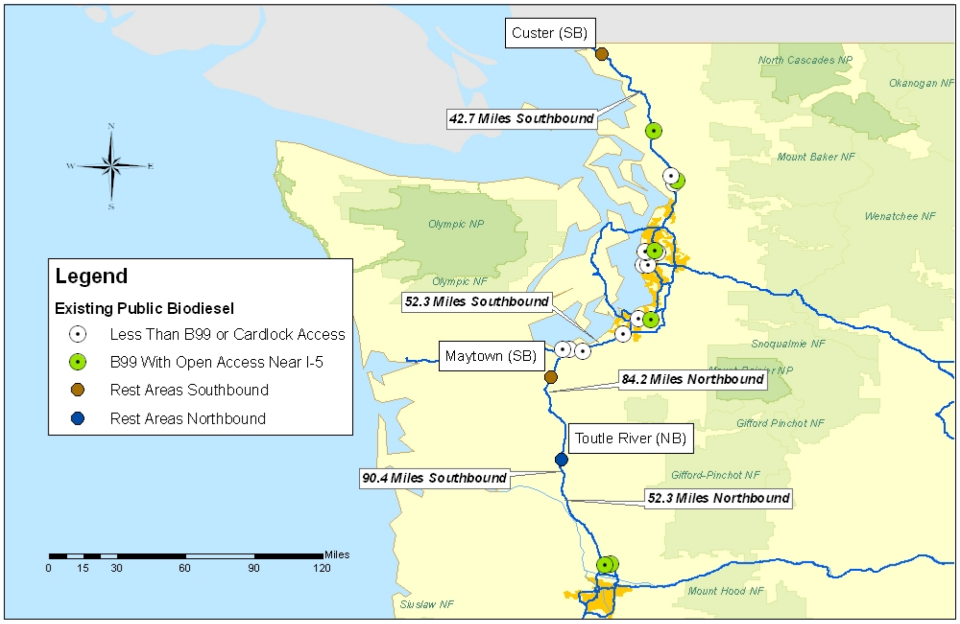


Exhibit 30: Map of existing biodiesel stations and suggested rest areas



Both fuels are present in the corridor but opportunities exist to fill in gaps in the network. Station sites are chosen using the same criterion for station spacing as stated above for hydrogen and electricity- no more than 120 miles between stations on the same side of the freeway. This spacing approach is clearly for convenience rather than necessity. Suggested rest areas are shown in Exhibits 29 and 30, above, and the distance between refueling opportunities on the same side of the freeway are indicated. Existing stations are assumed to have bi-directional access (since they are located at exits).

In the biodiesel case, decisions on the whether to use the northbound or southbound rest area is arbitrary. For example, Toutle River southbound could be substituted for Toutle River northbound. Scatter Creek northbound could be substituted for Maytown southbound if Toutle River northbound were used.

A strategy of co-locating ethanol and biodiesel has been proposed and is discussed in the following chapter. If locations for ethanol and biodiesel are sited separately, significant redundancies in capital and operational costs would exist (for example, two buildings instead of one, a doubling labor needs would occur). Since the coverage areas of Ethanol and Biodiesel do not match, the limitations of both need to be taken into account. The area around the Custer rest area does not have access to either fuel. Ethanol is poorly represented in the major metropolitan areas of Seattle and Tacoma, representing the opportunity to locate stations at two rest areas in that span of I-5. Biodiesel is not available around Toutle river rest area. If a strategy of co-location is pursued a total of 5 combination stations would be preferable. Due to the long range of the vehicles, a minimum scenario would entail one ethanol or combination station at silver lake/South Everett Freeway Station.

Station Spacing Conclusions

Using rest areas as alternative refueling locations would enable travel through the State of Washington. Although not a perfect solution because stations are not accessible from both sides of the freeway, the comprehensiveness of the rest area network is a major advantage.

In the case of hydrogen and fast charge PHEVs, rest areas represent an important means of connecting regions together. A conservative limit of 120 miles between stations was easily accommodated by the rest area network enabling both hydrogen and fast charge electric vehicles to travel between regions and throughout the I-5 corridor. A minimum of two stations and a maximum of seven stations at rest areas provide the ability to travel through the State using either fuel.

For hydrogen, a network of stations along I-5 should not be viewed as a network in isolation. The users of these rest area stations will most certainly come from the metropolitan regions of Portland, Vancouver, Olympia, Tacoma, Seattle, and Vancouver BC. Plans for a rest area network should happen in conjunction with the deployment of vehicles in at least one of these areas. Otherwise, there will be very few users of stations. Other entities besides the Washington State DOT could site stations in a metropolitan region. As a first step the Washington state DOT could search for an appropriate site with good access along the I-5 corridor near a populated area. The best initial candidates are the Silver Lake Rest Area/South Everett Freeway Station or the SeaTac Rest Area. This station could be used in the beginning as a place where people surrounding the station could refuel and in a concurrent or later stage, could be a link in the I-5 corridor.

For biodiesel and ethanol, the relative merits of a location can be seen in both the population surrounding a location (Appendix B) and the amount of traffic generated near a location (Appendix C). Exhibits 29 and 30 above show that there are gaps in the station networks of the two fuels. To avoid competing with other operators, stations should be sited in these gaps. Since both fuels are compatible with existing fuels, it is not necessary to create a comprehensive network. However, to provide adequate availability, gaps in the networks suggest that 3 biodiesel and 4 ethanol stations could be used to provide access throughout the corridor. If both fuels are co-located, a total of 5 stations are needed. A minimum scenario would require one combination station to fill the gap in the existing station network for these fuels.

Exhibit 31 below summarizes the minimum, maximum, and suggested number of stations located along the I-5 corridor by fuel type.

Exhibit 31: Number of Stations Needed in the I-5 Corridor

Fuel Type	Minimum	Maximum	Preferred
Hydrogen	2	7	5
Fast-Charge Electricity	2	7	5
Ethanol and Biodiesel	1	6	5

Chapter 4: Alternative Fuels Economic Feasibility

The previous sections of this report outlined the background research and analysis that was conducted to establish the framework for performing the economic feasibility analysis. For the economic feasibility analysis, an operating model was developed that could be used to evaluate rest stop fueling and concession retail operations. The parameters used to populate and analyze various combinations of alternative fuel offerings at retail stations are described in this chapter. The feasibility of each alternative fuel scenario is assessed by analyzing the financial results from the operating model for the various alternative fueling scenarios. The alternative fueling scenarios have been framed as conceptual station lease (or concession) transactions.

Approach and Methodology

The general approach used in this analysis was the application of a gas station operating model using conceptual cost and demand data. This model was used to estimate an annual operating pro-forma for each alternative fuel scenario. The capital and operating costs for each station concept were then forecast on an annual basis and subtracted from estimates of annual revenue. Annual revenue estimates for each fuel were estimated using the most recent guidance on current and future alternative fuel vehicle availability and use in the I-5 corridor, standard metrics for average consumption per vehicle, and expected wholesale and retail costs per unit of fuel. The estimation of these metrics is described later in this chapter.

Once costs were netted from revenues, annual net income after estimated federal and state taxes was used as a proxy for cash flow in a concession framework where a single operator would develop and operate the alternative fuel retail station (or stations) under certain terms, and be allowed to retain a fair return on investment (targeted at a 15% internal rate of return). The results, which are detailed later in this chapter, show, in relative terms, which fuel station concepts, were most likely to yield a fair return on investment to a potential concessionaire. The return on investment assumes State incentives that would be extended in the form of exclusive, discounted operating rights at WSDOT-owned rest areas.

Alternative Fuel Screening

The Team used a screening process to assess the reasonableness of carrying each alternative fuel through the economic portion of the analysis. This screening process also resulted in potential pairing scenarios that would provide the most insight into the relative success of varying alternative fuel retail offerings.

Natural gas (in both CNG and LNG form) was not carried forward from further analysis and consideration as a result of this screening process. Natural gas was dropped because there was a general consensus among the research team that, as a non-renewable fossil fuel, natural gas was less “alternative” than other options being considered.

Natural gas is commercially available today for both light duty vehicles and transit buses. While the number of light duty vehicles has not increased as much as some expected, many transit agencies have adopted natural gas as their primary fuel. There are significantly fewer natural gas fueling stations than conventional gasoline stations; nevertheless, the natural gas infrastructure is relatively widespread. Given the already well-established commercial status of natural gas, including its widespread use in power generation, government assistance may be less warranted for this fuel than for some of the other alternative fuels.

Most work on alternative fuel vehicles has involved fuels that can reduce pollutants, greenhouse gases, and dependence on foreign energy sources. Renewable fuels are considered desirable because they have the capability to vastly reduce greenhouse gases and increase energy security more than other fuels. In addition, hydrogen and electricity can both be produced using renewable energy sources, one of which is natural gas. Natural gas can reduce pollution and greenhouse gases somewhat, and the US does have significant quantities of natural gas. However, the fuels chosen for this study are expected to have a much greater effect on all of these issues in the mid- and long-term.

Pairing of Remaining Fuels

The remaining fuels: hydrogen, electricity, and biofuels ("biofuels" in this analysis refers to ethanol (E85) and biodiesel (B99) together) were retained for further economic analysis. Four specific service station offerings were developed using combinations of these fuels. They were:

Scenario 1: Electricity (standalone): For this service offering, facilities for electric vehicles (most likely PHEVs) would be provided on a slimmed down retail format that would not include a full service convenience store, which is part of the other three service platforms. A kiosk interface, similar to an ATM, would be provided which would require minimal capital and operating costs outlays. It was assumed that high power fast chargers would be used to allow travelers to charge a typical PHEV battery in 10 to 15 minutes.

Scenario 2: Electricity paired with hydrogen: A full service convenience store would be provided in a standard gasoline station layout with a portion of the service station footprint dedicated to the electricity kiosks described in #1. Hydrogen will be delivered regularly to the station by truck and stored in tanks located on the property (as opposed to on-site production). Typical convenience store revenues are included with hydrogen and electricity sales.

Scenario 3: Biofuels: A full service convenience store would be provided in a standard gasoline station layout. Both ethanol (E85) and biodiesel (B99) would be sold. The station configuration would not provide for heavy truck / semi refueling and the convenience store is not envisioned to provide the types of services to truckers offered at traditional truck stops. This deliberate rest area station platform was conceived to minimize the competitiveness of the rest area stations with truck stops in the I-5 corridor. Typical convenience store revenues are included with biofuel sales.

Scenario 4: Biofuels paired with electricity: This station concept would be identical to #3 while providing electricity charging kiosks as outlined in #1.

Estimating Demand and Revenue

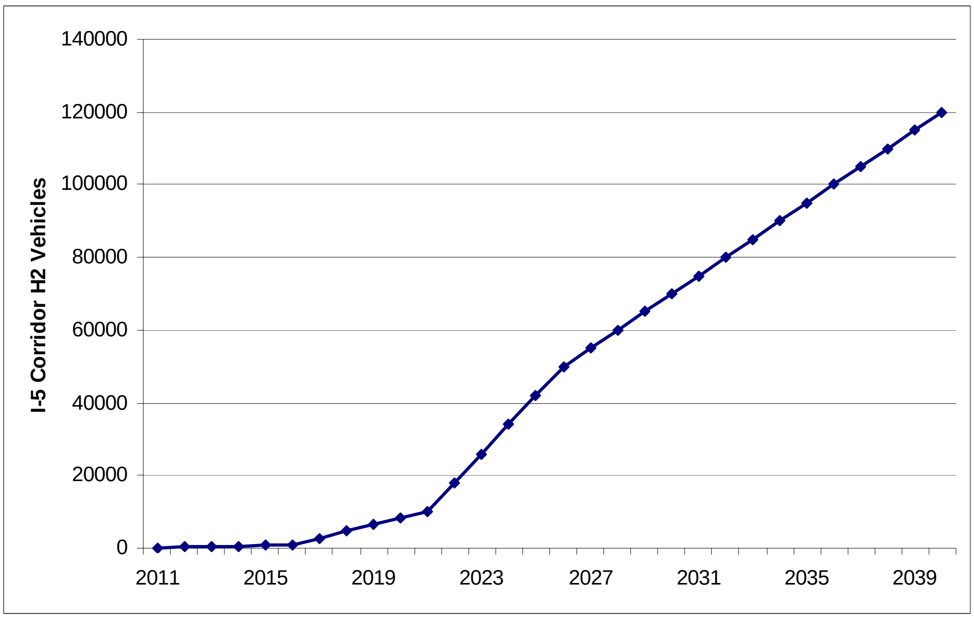
Demand and revenue were estimated separately for each of the alternative fuels. The following sections outline the demand potential of each fuel type individually (demand for the specific fuel combinations outlined above are not estimated). The resulting revenues from each fuel's estimated demand are later combined in the operating model to simulate the overall fuel revenue from each of the four scenarios listed above.

As noted in Chapter 3, the alternative fuel stations envisioned in this analysis will be located at State rest areas, which typically serve intercity travelers moving longer distances along I-5. It would generally be inconvenient for people making local trips (Intra-city) to get on the Interstate to refuel due to the spacing, rural locations of rest areas and the fact that most rest areas are accessible only from a single direction on the Interstate. As such the demand forecasts discussed herein have been tailored to apply only to intercity trips, leaving local travel fueling demands to be met by other providers in locations on non-State land.

Hydrogen

For this study, we used expected vehicle quantities and timing of California pilot programs for hydrogen vehicle rollouts by auto manufactures as guidance. Because these pilot programs are already planned for areas of southern California, we assumed that the adoption of FCVs will proceed more slowly in Washington. Exhibit 32 shows our scenario for the number of hydrogen FCVs in the State, near the I-5 corridor between 2010 and 2040. We assume that 100 FCVs are introduced in 2010, building up to a total fleet of 1,000 FCVs by 2015. After 2015, thousands of new FCVs are introduced each year, reaching a total of 10,000 by 2020 and 50,000 by 2025. This is based on a ZEV adoption rate analogous to that proposed for California.

Exhibit 32: Number of H2 FCVs in the I-5 Corridor of Washington



The timing and adoption rate of this vehicle rollout scenario assumes that refueling stations are made available in the I-5 corridor such that Washington could take part in any auto manufacturer pilot rollout of FCVs similar to what is expected in southern California. The implementation of such stations at State rest areas is assumed to be sufficient to make the I-5 corridor a reasonable candidate market for a portion of the FCV pilots expected in the US between 2010 and 2015.

I-5 Corridor Hydrogen Demand Estimate

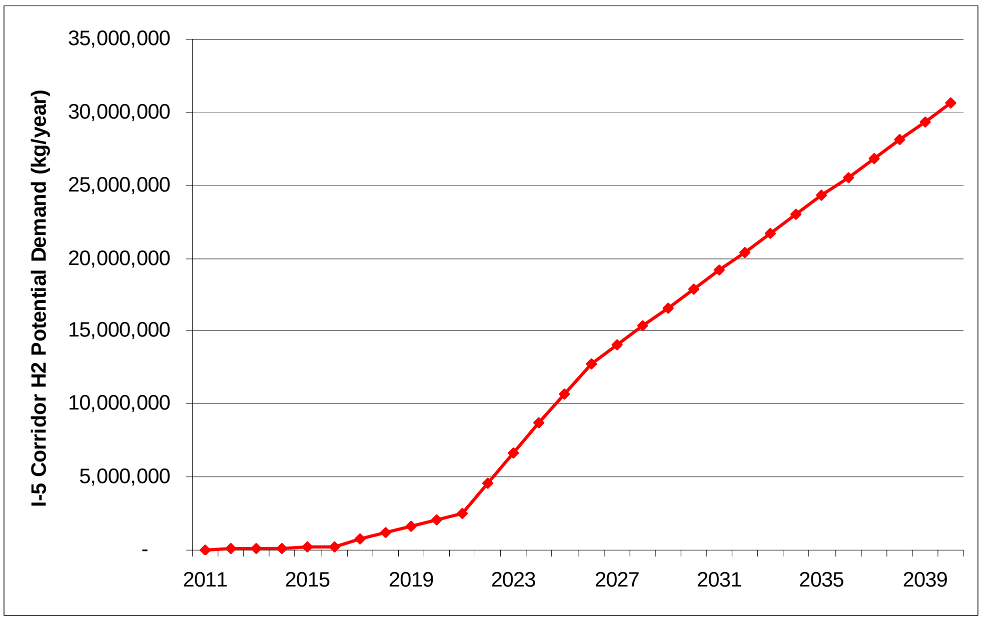
Based on the number of hydrogen vehicles expected in the Washington portion of the I-5 corridor, the hydrogen demand potential can be estimated assuming:

1) Distance - each vehicle drives an average of 15,000 miles per year, and

2) Fuel Economy - each vehicle has a fuel economy of 60 miles per kilogram of hydrogen fuel.[53]

As a result, each hydrogen car is expected to use about 250 kilograms of hydrogen per year or about 0.7 kg hydrogen per day. This translates into a potential corridor demand of 255,000 kg per year in 2015 and close to 2.5 million kg per year in 2020. The total hydrogen demand potential is plotted in Exhibit 33.

Exhibit 33: I-5 Corridor Potential Annual Demand (kg)



Hydrogen Station Numbers

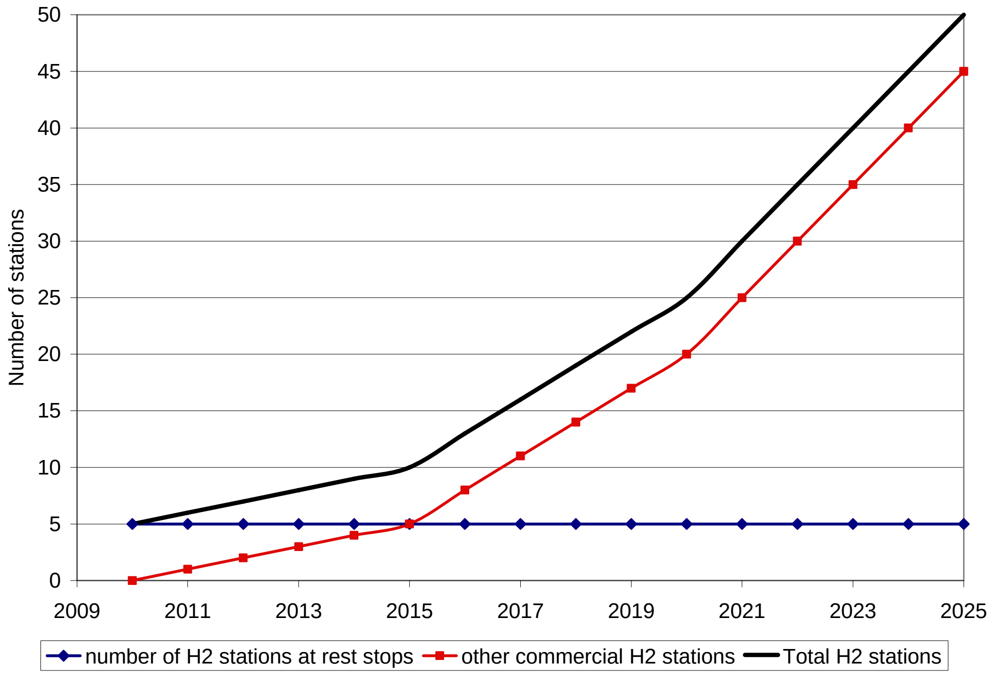
To attract the interest of vehicle manufacturers to deliver vehicles to Washington and create the early demand for hydrogen suggested above, we assume that 5 stations are opened at I-5 rest areas in 2010. These five stations would constitute the project and be the initial fueling options for drivers of hydrogen powered vehicles in Washington.[54] Within the first year, private stations are expected to begin to appear at non-state locations to supplement the network of rest area locations. The non-rest area stations are expected to be located in more urban settings and capture mostly intra-city demand, though an equal proportion of total corridor demand has been allocated to each station regardless of whether they are at a rest area or not. Non-rest area stations are expected to be added as demand grows.

The average demand per station per day is expected to grow from less than 100 kg per day in 2015 when about 10 total stations are expected in the corridor to over 600 kg per day by 2025. The non-rest area stations combined with the rest area stations build to a total network 50 stations (45 off of I-5 and 5 at I-5 rest areas) by 2025. As such, in 2025, the five rest area stations will be

[53] One kilogram of hydrogen has approximately the same energy content as one gallon of gasoline, so the FCVs are assumed to have roughly twice the fuel economy of a comparable gasoline car.
[54] This approach represents a departure from hydrogen vehicle pilot programs expected in southern California which will be in urban areas as opposed to along highway corridors.

providing about 10% of the total retail hydrogen supplied in the I-5 corridor. Expected station growth is shown in Exhibit 34.

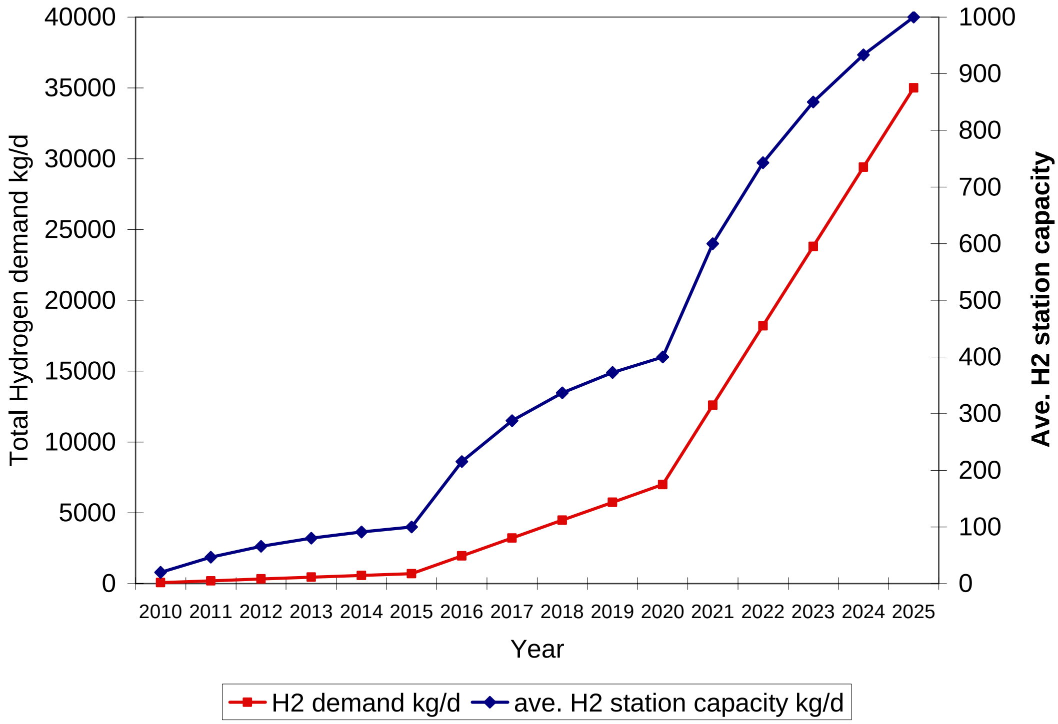
Exhibit 34: Assumed Hydrogen Stations in I-5 Corridor



Overall corridor demand, as noted above, is proportionally divided between all stations regardless of location. Each station is assumed to have the capacity to sell the level hydrogen demanded, therefore station pump and holding capacities at rest area stations are increased with demand. We assume that the capacity factor of each station is 70%[55]. The potential hydrogen demand per station and the average required capacity per station are shown in Exhibit 35. From this exhibit we see that in the time period 2010 to 2015, stations with 100 kg/day capacity could meet demand (blue line). Beyond 2015, the required station capacity grows rapidly, reaching 1,000 kg/day in 2025. We assume that the rest area stations are upgraded in 2015 to 1,000 kg/day capacity.

55 The station dispenses 70% of maximum amount of hydrogen that could be provided if the station operated at full capacity all the time. So a 1000 kg/day capacity station would dispense 70% x 1000 kg/d = 700 kg/d

Exhibit 35: Total Hydrogen Demand and Average Station Capacity kg/day



Electricity Vehicle Demand

To estimate the expected electricity demand at alternative fuel stations we begin with an estimate of electric vehicle sales. While both PHEVs and BEVs will contribute to electricity demand, we assume that BEVs will constitute a very small percentage of charging on the I-5 corridor. Due to the limited range and relatively long charge times of BEVs, we assume few BEVs will travel significant distances. The overwhelming majority of BEVs will be charged at home or perhaps at work, but not on the highway. The electricity demand will then come primarily from PHEVs.

To estimate the number of PHEVs as a function of time we assumed that PHEVs will have a similar market penetration to that of conventional hybrids. Data from the first 8 years of hybrid vehicle sales in the US were used to estimate the initial market for PHEVs.[56] The Energy Information Administration has projected conventional hybrid sales in the year 2030 (roughly 30 years after year one sales) at 2,000,000 vehicles.[57] We assumed a generally smooth curve between the initial sales and the 30 year projection as shown in Exhibit 36.

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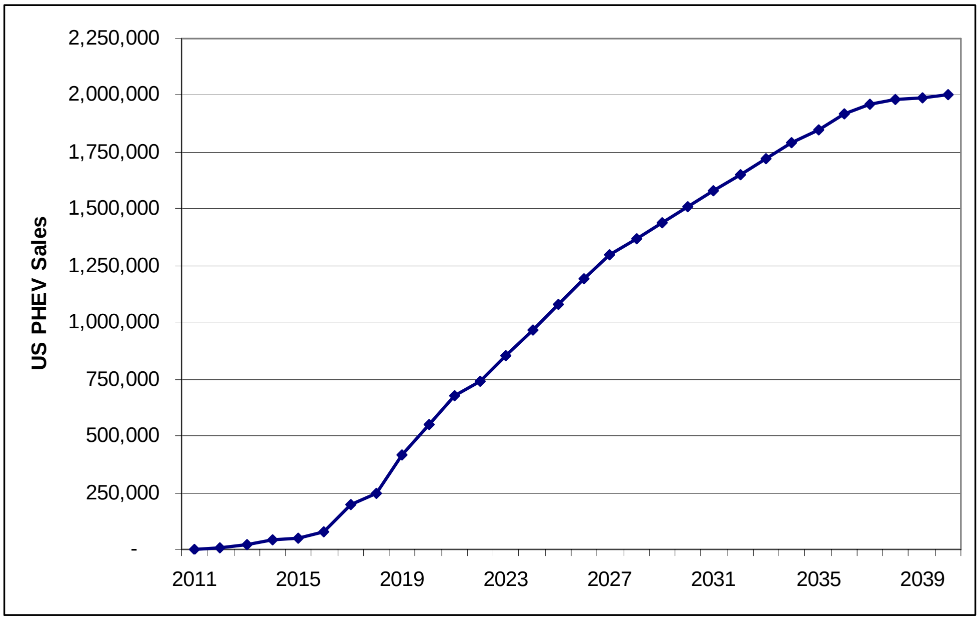
[56] http://www.hybridcars.com/market-dashboard/oct06-us-sales.html. Year 8 is a projection from sales through October.

[57] Annual Energy Outlook 2007 with Projections to 2030 (Early Release) – Overview, Energy Information Administration, http://www.eia.doe.gov/oiaf/aeo/key.html

Exhibit 36: Expected US PHEV Sales

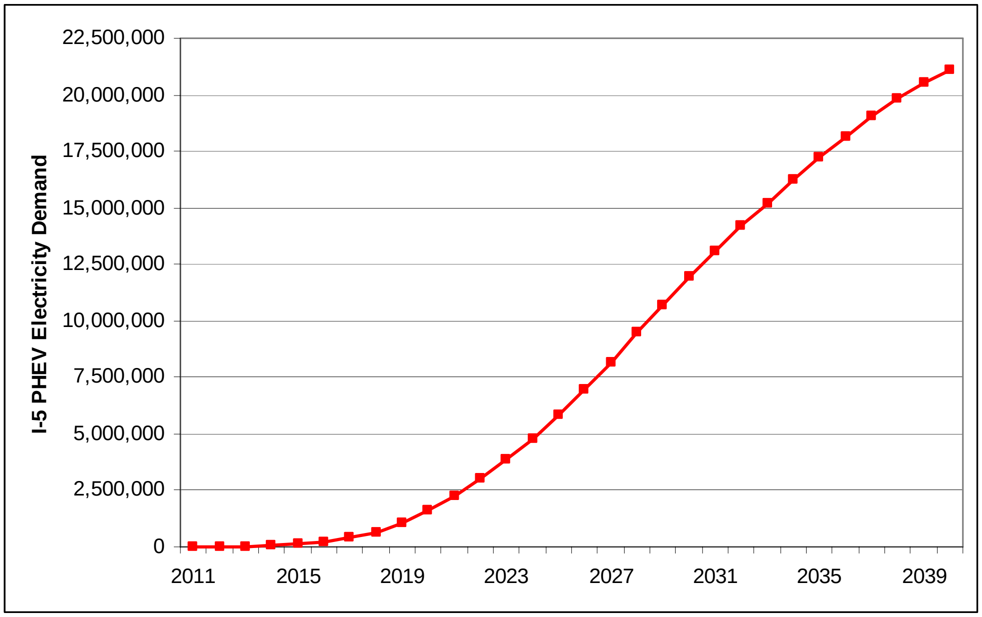


To determine the number of vehicles sold in the state of Washington we normalized our national estimate based on the percentage of the US population in Washington (2.11%). We further assumed that PHEVs would remain in the Washington fleet for 12 years. Roughly 60% of the population of Washington lives near the I-5 corridor, and vehicles far from the corridor are unlikely to contribute significantly to the electricity demand at I-5 corridor stations. As such, approximately 1,500 of the 50,000 PHEVs estimated to be in use in the US in 2015 are expected to be used in the I-5 corridor of Washington.

Not all vehicles owned by people living near the corridor will actually use stations on the corridor to charge. Many people will charge at home, or perhaps at work, or simply use gasoline when their electric capabilities run low. We assumed roughly 30% of PHEV owners living near the corridor will use fast charging stations on occasion. Therefore, we multiplied the Washington state I-5 corridor fleet by 0.3 to determine the pool of PHEVs that are expected to drive on I-5 somewhat regularly and are likely to charge on at the rest area stations. This equates to about 450 vehicles per year in 2015.

Given the fact that PHEVs can travel long distance without charging, it is unclear how often owners will choose to utilize fast charge stations. We maintain the assumption that most of the regular I-5 corridor users will still use home or work as the primary charging location, but occasionally these users will stop to charge at a rest area. We assumed each of these vehicles will charge at a station once per week and that each charge is 5 kWh. The result of these assumptions is that in 2015 a single station will provide about 3,300 charges (450 cars, once per week, divided between five rest area stations and two non-rest area stations). By 2020, we expect there to be just over 6,000 PHEVs regularly using the I-5 corridor and consuming about 1.6 million kWhs per year, equating to about 32,000 charges per year per station. The graph in Exhibit 37 shows the total demand in kWh in the I-5 corridor expected between 2011 and 2040.

Exhibit 37: Total Annual Electricity Demand in the I-5 Corridor of Washington (kWh)



Similar to the hydrogen example, this analysis assumes that five rest areas are equipped with charging equipment and that the private sector supplies additional charging capacity as demand increases. By 2020 five non-rest area stations are expected to be put in place on exits in the I-5 corridor providing a total of ten stations to serve the PHEV market. Each rest area and non-rest area station is allocated the same portion of corridor demand, and the stations are expected to add capacity to meet demand until the station is able to accommodate about 300 charges per day. By 2040 the total number of stations in the I-5 corridor is expected to grow to 40 (5 rest area stations and 35 non-rest area stations), each charging about 300 vehicles per day.

Biofuel (Ethanol and Biodiesel)

Biodiesel

As standards have now been established for certain biodiesel blends, these fuels are expected to be usable in all new diesel vehicles entering the market. As stated above, our analysis assumes that only B99 or higher biodiesel is sold at rest area stations.

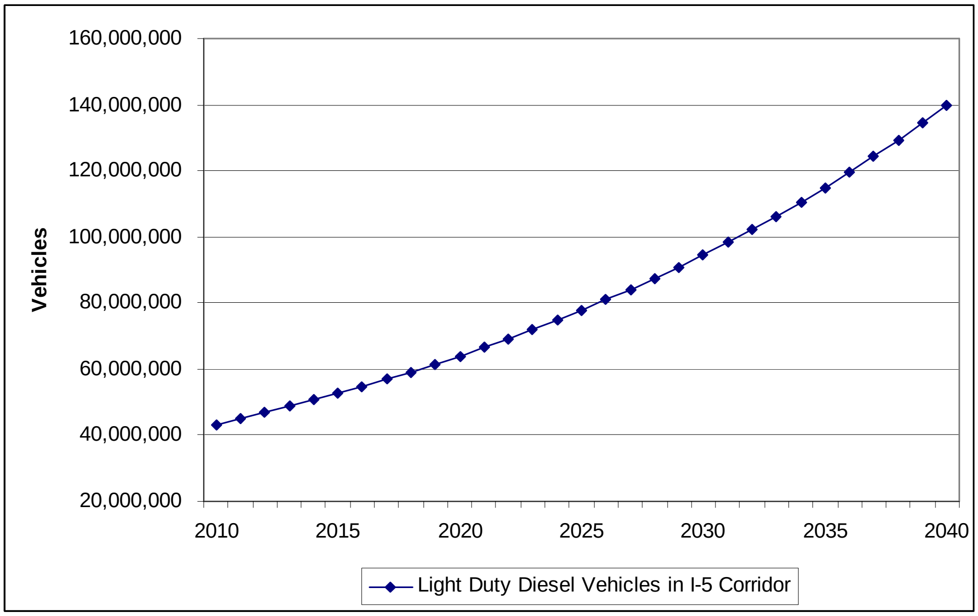
Nationwide approximately 4.27 million diesel light trucks and 300,000 diesel cars were on the road in 2006[58]. Assuming Washington follows national averages on vehicle sales there should be approximately 60,000 light duty vehicles (mostly large trucks and SUVs) that operate on diesel in the I-5 corridor. The vehicles should have an average fuel economy of approximately 22 mpg and travel on the order of 15,000 miles per year. This results in a total I-5 diesel fuel demand for light duty vehicles around 40 million gallons per year. Currently very few of these vehicles operate on biodiesel.

[58] Davis, Stacy C., Susan W. Diegel and Robert G. Boundy. (2008) Transportation Energy Data Book: Edition 27. Oak Ridge National Laboratory. cta.ornl.gov/data

Automakers have plans to offer more diesel vehicles in the near future relative to the recent past, given increased demand for efficient vehicles and recent advancements in emissions control. The EIA projects that as much as 13% of new vehicle sales in 2030 will use diesel fuel[59].

Exhibit 38 shows that the number of light duty diesel vehicles in the I-5 corridor are expected to grow from roughly 40 million currently to close to 140 million in 2040.

Exhibit 38: Projected growth in diesel vehicles and biodiesel demand in the I-5 corridor



This analysis does not consider heavy truck / semi vehicle diesel demand. We expect that heavy duty vehicles will refuel at truck stop stations and are not part of the market for the rest stop stations.

To develop a projection of biodiesel demand along the I-5 corridor and for the five rest area stations, we have made the following assumptions.

- The fleet of diesel light duty vehicles will grow at a 4% annual rate.
- The share of all light duty diesel sales filled by biodiesel is assumed to grow from 3% in 2008 to 35% in 2040.
- Private stations offering biodiesel in the I-5 corridor will increase from the current approximately 15 stations to approximately 50 stations in 2040.
- Consumers are equally likely to refuel at a location off of an exit or at a rest area station (corridor demand is equally allocated to all stations in the I-5 corridor).
- Biodiesel remains price competitive with regular petroleum diesel.

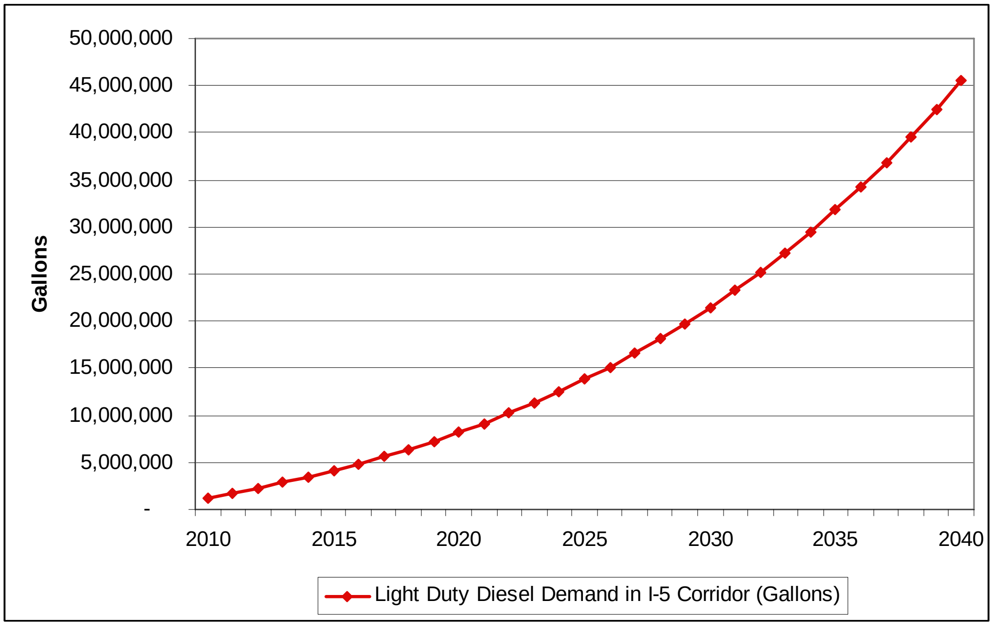
Considering these assumptions, the total annual I-5 corridor light duty vehicle biodiesel demand is expected to be about 5 million gallons by 2015, representing a 10% share of total diesel. With the expected total number of fueling station along the I-5 corridor estimated at 22 in 2015 (five rest

[59] Energy Information Administration (EIA). (2008) Annual Energy Outlook 2008 with Projections to 2030.

area stations and 17 non-rest area stations), this equates to annual per station demand of roughly 225,000 gallons per year. As diesel use and the share of the total captured by biodiesel retailers grows, potential annual per station demand is expected to grow to about 360,000 gallons by 2020 and close to 600,000 gallons by 2030.

Exhibit 39 shows the resulting total potential biofuel demand from light duty vehicles in the I-5 corridor. It is expected to grow from about 1.2 million gallons per year in 2010 to over 45 million gallons by 2040.

Exhibit 39: Biodiesel Demand in the I-5 Corridor



Ethanol

Establishing the future use of E85 fuel along the I-5 corridor, or any other area in the United States, is directly connected to the number of Flex Fuel vehicles that are in use. The number of current flex fuel vehicles establishes the current demand potential, of which only a portion will actually be E85 sales, since gasoline is a substitute. The forecast includes variables that fluctuate based on consumer's awareness, convenience, and the price of fuel. The criteria for the demand were based on the following statistics and assumptions.

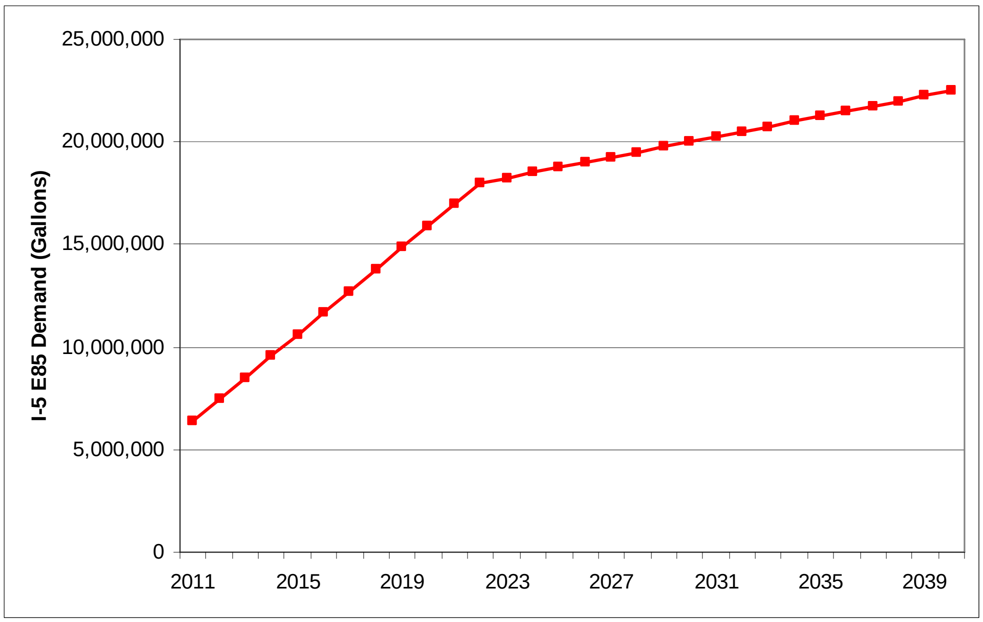
- As of 2007, there were 4.2 million passenger vehicles in the state of Washington and 64,500 of these were flex fuel vehicles capable of using E85 fuel (1.5% of the licensed cars)[60]
- 633,000 vehicles, on an average day, travel the I-5 corridor and assuming the ratio of Flex Fuel vehicles in the state holds, this equates to 9,500 Flex Fuel vehicles driving in the I-5 corridor daily[61]

[60] Washington State Department of Licensing, 2007
[61] WSDOT 2007 Annual Traffic Report

- Considering average annual vehicle use of 15,000 miles and efficiency of 12 miles per gallon, this equates to the potential for about 11.9 million gallons of E85 to be used in the corridor per year.[62]
- Since gasoline is a substitute for E85, we assume that drivers of Flex Fuel vehicles only fill up with E85 about half the time based on convenience, and only half of those fill-ups occur at stations immediately along the I-5 corridor.

Using these assumptions, the potential corridor demand for E85 is approximately 3 million gallons per year. Assuming in 2010 there are five rest area stations and two competitive non-rest area stations in the I-5 corridor, this equates to a per station potential demand of about 425,000 gallons per year. Exhibit 40 shows expected I-5 corridor demand.

Exhibit 40: Ethanol Demand in the I-5 Corridor



The demand for E85 is present and could increase if the fuel is recognized by the consumer as a viable alternative. Both price and the inconvenience of more frequent fill-ups due to the lower efficiency of E85 are factors. E85 contains less energy per gallon that gasoline, yielding 17-20% lower gas mileage. Therefore, the spread between the price of unleaded and E85 must be enough to entice the consumer to use the product. When the price of regular unleaded fuel drops substantially, the refueling stations could see a drop in demand. Another significant market variable affecting the long term outcome is the wholesale availability of E85 fuel along the corridor.

[62] Flex Fuel vehicles tend to be the larger vehicles (light duty trucks, such as pickup trucks and large SUVs). However, car manufacturers are increasing their stock of sedans and smaller cars that can use E85 such that the relatively low MPG could increase over time.

Expected Station Revenue

The demand estimates outlined above were converted into station fuel revenue by dividing annual demand by the number of stations in the corridor and multiplying this by the retail price assumption for each fuel. As demand grows over time, the estimated number of competing stations is assumed to grow as well. Retail prices were assumed to grow annually from levels assumed today at the rate of inflation, estimated at 2.8% based on the regional Consumer Price Index.

Exhibit 41 shows the unit prices for the alternative fuels assumed for 2007. Prices of hydrogen and electricity were not available from reported sources and were based on unit costs and a reasonable profit margin per unit that equated to roughly a 35 mile per gallon-dollar equivalent. Ethanol and Biodiesel unit costs were taken as reported by the US Department of Energy Clean Cities Alternative Fuel Price Report for July 2008.

Exhibit 41: Assumptions for Unit Prices of Alternative Fuels

	Unit	Price (2007$)	
Hydrogen	Kilograms	$	7.00
Electricity	kWh	$	1.00
Ethanol	Gallons	$	3.40
Biodiesel	Gallons	$	4.90

Alternative Fueling Station Costs

Capital Costs

Capital costs vary by fuel type due to the different containment and pumping equipment needed for each of the fuels. The following outlines the costs related to the various fuels and identifies the costs assumed in the operating analysis.

Hydrogen Capital Costs

Due to the low initial demand for hydrogen fueled vehicles and subsequent ramp-up, it is assumed that the fuel station will have a 100kg capacity for the first five years of operation. Additional equipment with a capacity of 1,000kg will need to be purchased in 2015 to accommodate expected demand. All equipment is expected to have a useful life of 15 years though some additional equipment will be needed to keep up with demand.

Due to the desire for low up front capital costs of the stations, the hydrogen configuration selected uses on site tanks that are refilled on a regular basis by delivery trucks. The cost for the equipment for this configuration is expected to decrease dramatically as the technology becomes more refined. Exhibit 41 below shows that the equipment that would be needed in order to keep pace with demand in 2015 is expected to cost a fraction of what is paid for much less capacity equipment in 2010. Additional information on other possible hydrogen station configurations is available in Appendix E.

Exhibit 42: Hydrogen Capital Cost Needs (2008$)

Year of Purchase	Cost in 2007$	Useful Life	Capacity
2010	318,000	15 years	100Kg
2015	262,000	15 years	1,000Kg
2040	262,000	15 years	1,000Kg

Electricity Capital Costs

Recharging Equipment Background

Our assumption is that fast charging facilities (Level 3) will be employed at I-5 rest areas. As noted earlier, the rest area charging facilities will focus on service to PHEVs, which take less time to charge than BEVs but would still require Level 3 chargers to maintain the convenience of very short charge times. Exhibit 43 describes categories of charging which differ mainly in their power requirements and cost of equipment. This demonstrates that there is a real trade-off between different power levels of charging with respect to time to charge.

Exhibit 43: EV Charging Categories (Morrow 2008, PG&E 1999)

Level	Typical Specifications	Charge Times (hrs)	Cost[1]
Level 1	Most common outlets in US (broad access) 120 V, 12 A => 1.4 kW, single phase	BEV: 10-20 PHEV: 4-10 NEV: 8-12	Low
Level 2	Primary residential and commercial charging 240V, 32 A => 7.7 kW, single phase	BEV: 4-6 PHEV: 1-3 NEV: 2-4	\$2-4K
Level 3	"Fast Charge" 480V, up to 400A => up to 200 kW, typically 60 – 120 kW, three phase	Greater than 50% charge in 10-15 minutes	\$35-80K

[1]http://www.pge.com/includes/docs/pdfs/shared/environment/pge/cleanair/ev4pt2.pdf

The major barrier to providing facilities for battery charging is the high cost of the battery charging equipment and providing the high power grid connection. This is particularly the case for BEVs with large batteries if fast charging (times less than one-half hour) is to be provided. Additionally, there are currently no national or international standards for charging equipment and connecting devices. However, this problem is well recognized in the United States and other countries and international committees are at work to develop standards for both low and high power charging of batteries for BEVs and PHEVs.

For the rest area analysis, two "Fast Charge" (Level 3) chargers per fueling station are expected to provide enough capacity to service demand for the first 5 years of operation, with an additional units added as needed. The cost for these units is estimated to be \$50,000 each in 2010, the assumed first year of operations. Each recharging station would have four outlets, so 8 vehicles would be able to charge at any given time, although operating all outlets simultaneously could adversely affect charging times. These chargers would also need to be connected to a high voltage grid; therefore capital costs associated with this expense have been included.

Recharging Stations

It is assumed that battery recharging can be provided at any refueling station (such as gasoline, biodiesel, ethanol, or hydrogen) due to the relatively small space needed for the facilities. Charge times for PHEVs are expected to be in the range of 10 to 15 minutes for most customers given the fast charge equipment employed. As such, charging could be done while travelers rest, eat, use rest rooms, etc.). The charging stations will have to accommodate a range of battery designs – chemistries, voltage, cell amp hours, and pack kWh. The total initial capital cost of the installation would be about 247,000 for the charging equipment, the high power line and transformer as detailed in Exhibit 44.

Exhibit 44: Electricity Kiosk Initial Installation Capital Cost

480 Volt Line (1/4 mile)	132,000
Transformer	15,000
Standard Charger (2)	100,000
Initial Capital Costs	247,000

Biofuel (Ethanol and Biodiesel) Capital Costs

Biodiesel fueling stations will require dedicated tanks and pumps. The equipment costs are not significantly different from petroleum fueling equipment outlined in Chapter 1. For this analysis, the same costs associated with pumping equipment for traditional gasoline fueling stations are assumed, though the number of pumps and tanks has been scaled to the expected demand of the biofuel stations (half the number of pumps are expected to be needed). The biofuel equipment capital costs are estimated at $127,000 and are expected to need replacement after every 10 years.

Operating Costs

General and administrative costs for each station offering except the electricity standalone kiosk (scenario 1) were generally similar, totaling about $420,000 annually (2008$), since they all include a full convenience store. The hydrogen station has higher electricity costs due to the demands of the fueling storage and dispensing equipment.

The standalone electricity kiosk has much lower operating costs due to the absence of the convenience store and general service station buildings. Some costs for operating the business are incurred including transaction processing costs and other costs representing the need for one employee to periodically visit each location, inspect the kiosks and keep financial records. These annual costs are outlined in more detail below as part of the operating pro-forma presentation, but total roughly $80,000 annually (2008$).

Operating Pro-Forma

To establish the bottom line financial metrics (a proxy for cash flow) to use in the concession analysis, an income statement-style calculation was made for a single station under each scenario. This section illuminates this calculation and provides a basic pro-forma operating statement for each of the scenarios presented above. An explanation of each of the line items is listed below, followed by a series of tables that provides an estimate of major business expense line items at five-year increments.

Fuel Revenue – Revenue generated by fuel sales. Revenues are highly dependent on the demand schedule estimated for the respective fuels.

In-Store Revenue – Revenue derived from all non-fuel sales, generally sundry items from the convenience store. These estimates were developed based on averages in traditional fueling stations across the country as outlined in Chapter 1.

Gross Revenue – The sum of fuel and in-store (non-fuel) revenue.

Fuel Cost of Goods Sold (COGS) – The COGS is the delivered price of the fuel to the retailer for all fuel sold. The COGS for each fuel type differs widely due in part to the availability of the fuels in the vicinity of the I-5 corridor. Transportation costs are a significant component of both hydrogen and biofuels. The technology used to produce and store hydrogen impacts the cost as well. As discussed earlier, there is a tradeoff between the high capital costs for on-site production equipment (which renders a lower cost of goods sold) and the lower capital cost of having the hydrogen shipped to the station by truck and stored in tanks (which increases the unit cost of the hydrogen to the retailer).

In-Store Cost of Goods Sold (COGS) – The wholesale cost to the retailer of all non-fuel items sold, based on national averages outlined in Chapter 1.

Total Cost of Goods Sold (COGS) – The sum of fuel and in-store COGS.

Net Revenue - Gross revenue less total cost of goods sold.

Sales, General, and Administrative (SG&A) Expense – This expense, generally referred to as "overhead," includes all expenses directly related to the operation of the business that are not the cost of the actual product, including labor, utilities, maintenance, transaction, fees and supplies.

Annual Equivalent Capital Costs – Capital costs for equipment and building listed in the above sections are converted to annualized costs assuming they are purchased with borrowed funds and paid back over their useful lives. The land cost in this analysis is assumed to be zero as an incentive for potential concessionaires. The annual capital cost varies due to equipment costs, as some fuels use common and widely available technology to contain and pump the fuel and others use equipment still being developed.

Taxes – Both state and federal expected tax liabilities are included. For state taxes, the Washington B&O tax was calculated based on gross revenues. For federal taxes, it was assumed that the business paid taxes at the corporate rate ranging up to 39%, depending on income levels.

Net Income – Estimated amount cash remaining after all business operations are paid for.

The following are the scenarios considered and resulting pro-forma outputs:

1. Electricity (standalone): This scenario is the only one under consideration without the convenience store, thus none of the associated revenues or expenses are included. The station would open with eight outlets per station, which provides ample capacity based on demand estimates. The COGS for electricity is relatively small. With a reasonably strong expected demand over the life of the concession and only moderate capital costs, this scenario has a positive net income after nine years.

Exhibit 45: Electricity Kiosk Pro-Forma

	2015	2020	2025	2030	2035
Fuel Sales	20,737	217,271	673,467	947,124	1,012,065
In-Store Sales	-	-	-	-	-
Gross Sales	20,737	217,271	673,467	947,124	1,012,065
Fuel Cost of Goods Sold	(1,659)	(17,382)	(53,877)	(75,770)	(80,965)
In-Store Cost of Goods Sold	-	-	-	-	-
Total Cost of Goods Sold	(1,659)	(17,382)	(53,877)	(75,770)	(80,965)
Net Revenue	19,078	199,890	619,589	871,354	931,100
Sales, General, & Administrative	(97,090)	(111,083)	(128,939)	(144,080)	(156,115)
Capital Costs	(32,380)	(32,380)	(32,623)	(21,659)	(21,901)
Taxes	(98)	(1,023)	(155,729)	(239,909)	(256,048)
Net Income After Taxes	(110,490)	55,403	302,298	465,706	497,035

2. **Electricity paired with Hydrogen:** Hydrogen has low expected demand and high capital costs, making net revenues negative for a large period of the concession. Hydrogen on its own as a source of revenue does not do well compared to the other alternative fuels considered. This is due to low demand early in the life of the concession period and relatively high costs. For this scenario, electricity sales and in-store sales are also sources of revenue and help negate some of the negative and low earnings of hydrogen sales, especially early in the life of the concession. Under this scenario, the store would be expected to have a positive net income in year 11.

Exhibit 46: Hydrogen with Electricity Kiosk Pro-Forma

	2015	2020	2025	2030	2035
Fuel Sales	200,245	832,780	2,638,266	3,996,317	5,122,099
In-Store Sales	1,430,423	1,594,033	1,757,644	1,921,254	2,084,864
Gross Sales	1,630,667	2,426,813	4,395,910	5,917,571	7,206,964
Fuel Cost of Goods Sold	(144,126)	(566,943)	(1,808,163)	(2,798,264)	(3,750,638)
In-Store Cost of Goods Sold	(940,820)	(1,048,430)	(1,156,041)	(1,263,651)	(1,371,261)
Total Cost of Goods Sold	(1,084,946)	(1,615,373)	(2,964,203)	(4,061,915)	(5,121,899)
Net Revenue	545,721	811,440	1,431,707	1,855,656	2,085,065
Sales, General, & Administrative	(541,847)	(612,891)	(701,383)	(783,219)	(861,600)
Capital Costs	(152,967)	(184,620)	(185,834)	(157,031)	(168,863)
Taxes	(7,680)	(11,430)	(129,850)	(311,238)	(358,564)
Net Income After Taxes	(156,773)	2,498	414,640	604,168	696,037

3. **Biofuels:** Vehicles using biofuels are commonly available today and it is expected that biofuels will become nearly direct substitutes for traditional petroleum-based fuels in the near future. As such, the extended market ramp-up period expected for electricity and hydrogen vehicles does not detract from biofuel revenues in the early years. The infrastructure costs are similar to that of a traditional fueling station and therefore relatively low. Despite high competition, a station selling biofuels is expected to have positive net income after the sixth year of operation.

Exhibit 47: Biofuel Standalone Pro-Forma

	2015	2020	2025	2030	2035
Fuel Sales	3,212,327	4,219,536	5,226,793	6,243,895	7,248,771
In-Store Sales	1,430,423	1,594,033	1,757,644	1,921,254	2,084,864
Gross Sales	4,642,750	5,813,569	6,984,437	8,165,149	9,333,635
Fuel Cost of Goods Sold	(2,987,464)	(3,924,168)	(4,860,918)	(5,806,822)	(6,741,357)
In-Store Cost of Goods Sold	(940,820)	(1,048,430)	(1,156,041)	(1,263,651)	(1,371,261)
Total Cost of Goods Sold	(3,928,285)	(4,972,599)	(6,016,958)	(7,070,473)	(8,112,618)
Net Revenue	714,465	840,970	967,479	1,094,676	1,221,017
Sales, General, & Administrative	(586,651)	(663,269)	(739,887)	(816,652)	(893,234)
Capital Costs	(110,652)	(110,652)	(116,456)	(132,701)	(138,505)
Taxes	(21,867)	(27,382)	(43,343)	(56,676)	(73,818)
Net Income After Taxes	(4,706)	39,667	67,793	88,647	115,460

4. **Biofuels paired with Electricity:** This scenario is also expected to return profit for the concessionaire after about six years, although combining these two fuels creates a different shaped revenue curve compared to biofuels alone due to the added costs in the early years of the concession period and the considerably higher revenues in the later years.

Exhibit 48: Biofuel with Electricity Kiosk Pro-Forma

	2015	2020	2025	2030	2035
Fuel Sales	3,233,064	4,436,807	5,900,260	7,191,018	8,260,836
In-Store Sales	1,430,423	1,594,033	1,757,644	1,921,254	2,084,864
Gross Sales	4,663,487	6,030,840	7,657,904	9,112,272	10,345,701
Fuel Cost of Goods Sold	(2,987,464)	(3,924,168)	(4,860,918)	(5,806,822)	(6,741,357)
In-Store Cost of Goods Sold	(940,820)	(1,048,430)	(1,156,041)	(1,263,651)	(1,371,261)
Total Cost of Goods Sold	(3,928,285)	(4,972,599)	(6,016,958)	(7,070,473)	(8,112,618)
Net Revenue	735,202	1,058,242	1,640,945	2,041,799	2,233,083
Sales, General, & Administrative	(586,960)	(666,501)	(749,905)	(830,740)	(908,289)
Capital Costs	(137,114)	(137,114)	(142,918)	(148,199)	(154,003)
Taxes	(21,965)	(99,304)	(254,362)	(361,373)	(398,069)
Net Income After Taxes	(10,837)	155,322	493,761	701,488	772,722

Results of Economic Viability Tests

Lease or concession contracts to provide fueling and food services at public rest areas are commonly used to help operators of limited access transportation facilities (such as toll roads) provide necessary services to the traveling public. Research on these transactions yielded several examples that were used to frame the terms of a conceptual concession to provide the alternative fueling services described above at state rest areas. The legality of such transactions and operations at Washington State rest areas has not yet been determined, and as such this concession framework is offered only as a conceptual example and means of comparing the economic viability of the alternative fuel scenarios evaluated.

Analysis Framework: Concessions Models and Internal Rate of Return

The concession framework developed for this analysis uses the internal rate of return (IRR) of the alternative fueling station to judge the economic feasibility of each fuel type. The IRR is calculated from an annual stream of cash flows, represented by total net income after taxes, from an individual station. Cash flows over 15 years were examined as well as a longer 30-year structure. The longer concession timeframe was established based on other concession examples examined and the approximate useful life of buildings and certain other improvements that would be made by the concessionaire. The 15 year concession was selected simply for comparison purposes to demonstrate the value that longer concessions provide in allowing the operator to counter balance the unprofitable early years of the operation with profitable later years.

The IRR of the series of cash flows was calculated for each station platform and then adjusted upward or downward to achieve a targeted 15% overall return to the concessionaire. In situations where the base IRR was below 15%, the IRR was adjusted upward by modeling an up front State capital contribution that could be used to offset some capital costs of station implementation.

Alternatively, if the base IRR was initially above 15%, it was adjusted downward by modeling an annual land rent that would be paid by the concessionaire to the State in the form of a percent-of-revenue fee. The 15% IRR target was established as a minimum reasonable return and is expected to represent the lower bound of what a concessionaire would likely require for a venture of this type.

The following series of tables shows the results of the financial and concession analyses for each refueling station platform for a single station. These concession outputs make use of the net income established for each station scenario in the previous section. The concession IRR summary for each station scenario is presented, showing the target IRR (15%), the "Standalone" or Base IRR[63], and the profit share or state contribution to the station's startup that would be required to bring the Standalone IRR in line with the target IRR.

Two "cases" were considered in this analysis. The base case uses the demand potential outlined earlier while a low case was also analyzed which assumed a 20% reduction in the base case demand. This low case is used as a test to better understand how sensitive profitability is to the underlying demand.

Electricity – Standalone Kiosk

Exhibit 49 outlines the analysis results for the electricity kiosk scenario. As previously mentioned, this scenario is the only one under consideration which does not include plans for a convenience store on site. This lowers the overall capital cost of the project as well as revenues, especially in the early years, as convenience revenues adds stability to the overall revenue stream and has much less ramp-up. This scenario is potentially viable for the 30-year concession option, but would require an investment by the State if a 15-year concession is considered.

The base case, 30-year concession scenario yields an internal rate of return of 15.6%; just above the target IRR of 15%. With this scenario, the state could potentially charge a land rent on gross revenues of 3.2%, which would give the concessionaire an IRR of 15% and yield approximately $570,000 dollars in revenue for the state over the 30-year life of the concession. The low case yields a 13% IRR which would require the State to pay an upfront contribution to the concessionaire of approximately $308,000 at the beginning of the concession for the concessionaire to reach the target IRR.

For the 15-year concession option, a contribution by the State to the concessionaire would be required in both the base case and the low case. In the base case, the IRR is estimated to be 1.8%, requiring a State contribution of $575,000 for the concessionaire to reach a 15% IRR. For the low case, an IRR of negative 2.8% is expected which would require an up front State contribution of $707,000 in order to meet the target IRR.

[63] The Base IRR is the internal rate of return if no state funding or state lease collections are implemented for the project. It represents the station as a standalone financial entity.

Exhibit 49: Electricity Kiosk Analysis Results

	Low Case	Base Case
30-Year Concession		
Target IRR	15.00%	15.00%
Standalone Concession IRR	12.90%	15.60%
State Contribution to Reach Target	$ 308,000	NA
State Land Rent to Reach Target (%)	NA	3.20%
State Land Rent to Reach Target ($)	NA	$ 570,000
15-Year Concession		
State Contribution	15.00%	15.00%
Standalone Concession IRR	-2.80%	1.80%
State Contribution to Reach Target	$ 707,000	$ 575,000
State Land Rent to Reach Target (%)	NA	NA
State Land Rent to Reach Target ($)	NA	NA

Full Service Hydrogen with Electricity Kiosk

Exhibit 50 outlines the analysis results for the full service hydrogen with an electricity kiosk scenario. This scenario is the only one to include hydrogen as an alternative fuel.

All cases situations analyzed resulted in an IRR lower than the target IRR. The base case, 30-year concession is expected to yield an IRR of 13.3%. The State would need to supplement this station configuration with about $428,000 to achieve an IRR to 15%. The low case for the 30-year concession yields a 10.6% IRR which would require a State contribution of over one million dollars for the concessionaire to reach 15%. The 15-year concession yields negative IRRs in both the base and low cases.

Exhibit 50: Full Service Hydrogen and Electricity Kiosk Analysis Results

	Low Case	Base Case
30-Year Concession		
Target IRR	15.00%	15.00%
Standalone Concession IRR	10.60%	13.30%
State Contribution to Reach Target	$ 1,030,000	$ 428,000
State Land Rent to Reach Target (%)	NA	NA
State Land Rent to Reach Target ($)	NA	NA
15-Year Concession		
State Contribution	15.00%	15.00%
Standalone Concession IRR	-10.80%	-3.40%
State Contribution to Reach Target	$ 1,380,000	$ 1,138,000
State Land Rent to Reach Target (%)	NA	NA
State Land Rent to Reach Target ($)	NA	NA

Full Service Biofuel

Exhibit 51 outlines the concession analysis results for the full service biofuel scenario. As noted above the established population of vehicles and demand for the fuel makes this station scenario break even early in the concession and yield returns that exceed the target IRR of 15% in the base case 30-year concession scenario. The biofuels station format, similar to gasoline stations, is very sensitive to operating costs and profit margins on fuel. For example, if the profit on a gallon of biodiesel increases from 8% to 10%, the IRR could increase by double digit percentages. As such, we assume a profit per gallon of roughly 8% must be achieved on average over time to make the numbers shown in the exhibit below.

As sensitive as this business model is to changes in net income, it is also sensitive to capital infusions. Under both low demand forecast scenarios, and the 15-year base scenario, the State would have to contribute relatively small capital amounts ranging from 87,500 to $530,000 for the concessionaire to achieve the 15% IRR target.

Exhibit 51: Full Service Biofuel Analysis Results

	Low Case	Base Case
30-Year Concession		
Target IRR	15.00%	15.00%
Standalone Concession IRR	4.40%	16.50%
State Contribution to Reach Target	$ 530,000	NA
State Land Rent to Reach Target (%)	NA	0.76%
State Land Rent to Reach Target ($)	NA	$ 161,000
15-Year Concession		
State Contribution	15.00%	15.00%
Standalone Concession IRR	-22.90%	8.75%
State Contribution to Reach Target	$ 423,000	$ 87,500
State Land Rent to Reach Target (%)	NA	NA
State Land Rent to Reach Target ($)	NA	NA

Full Service Biofuel with Electricity Kiosk

Exhibit 52 below outlines the analysis results for the full service biofuel with an electricity kiosk scenario. This scenario yields an IRR for the concessionaire above the target for all cases under consideration except the low case 15-year scenario. The performance of this case is due to the strong electricity revenues in the latter part of the forecast.

For the 30-year concession the IRR for the base and low case are 29.2% and 21.3%, respectively. To bring the IRR down to the target, rent share for the base case would need to be 2.0% of gross revenues and would yield approximately $4.7 million. For the low case, the rent share would be 1.2% and yield $2.24 million over the course of the concession.

The 15-year concession under the base scenario would yield an IRR of about 23%, while the low scenario would need a State contribution of about $136,000 to help the concessionaire achieve the target 15% return.

Exhibit 52: Full Service Biofuel and Electricity Kiosk Analysis Results

	Low Case	Base Case
30-Year Concession		
Target IRR	15.00%	15.00%
Standalone Concession IRR	21.30%	29.20%
State Contribution to Reach Target	NA	NA
State Land Rent to Reach Target (%)	1.15%	2.00%
State Land Rent to Reach Target ($)	$ 2,240,000	$ 4,670,000
15-Year Concession		
State Contribution	15.00%	15.00%
Standalone Concession IRR	11.40%	22.90%
State Contribution to Reach Target	$ 136,000	NA
State Land Rent to Reach Target (%)	NA	0.56%
State Land Rent to Reach Target ($)	NA	$ 425,000

Analysis Conclusions

The analysis and results discussed above are conceptual, but provide many useful insights into the operations of fueling stations offering the various alternative fuels. One striking takeaway, one that is not completely apparent from the tables above is that fueling stations, once they begin to reach equilibrium, operate on very slim margins. This was the case for the biofuels. Despite their infancy in demand relative to gasoline and traditional diesel fuel, E85 and biodiesel are substitutes, respectively, and as such must be price competitive to appeal to the masses.

Hydrogen and electricity, on the other hand, have been modeled from technology introduction, though ramp-up, and into market penetration. The profit margins on these fuels could vary widely depending on the cost to produce and transport the fuel, the cost and availability of the vehicles, and the efficiency of the vehicles and resulting cost to operate them relative to vehicles using other fuels.

Exhibit 53 below provides a summary comparison of the fuel scenarios and concession lengths using the IRRs discussed considering the base potential demand. The scenarios are generally put into three categories; (red) having an IRR less than zero, (yellow) having an IRR between zero and the target of 15%; and (green) having an IRR expected to exceed the 15% target under the conditions set forth in the analysis.

Scenarios which fail to meet the target IRR may still be viable if the state is willing to provide an upfront contribution to the concessionaire in the early years of the business while the technology is being adopted by consumers. Conversely, scenarios which produce excess IRR may provide an opportunity for the state to share in revenues generated by the concessionaire in the form of a rent-sharing program. This rent share would be a fixed percentage of revenue which the concessionaire would be required to pay on a regular basis (i.e. - annually). These rent share payments would effectively lower the concessionaires IRR to the target level while providing some amount of income for the state in return for the use of the land.

As noted above there are many assumptions regarding demand potential, prices, operating and capital costs, and technology availability that play a part in these estimates. Movement of any one of these variables could have a material impact on the expected IRR of any of these scenarios.

Clearly the hydrogen scenarios are the weakest due to the expected slow adoption of the fuels and the relatively high capital costs to install and operate the equipment. The electricity kiosks on a standalone basis exceed the target IRR in the 30 year scenario because they have healthy profit margins resulting in strong income levels in the latter half of the 30-year concession period once the number of PHEVs in use becomes significant. The biofuel scenarios, both standalone and with electricity, look promising, but as discussed earlier are highly dependent on fuel profit margins staying above the 8% level on average over the concession period.

One additional scenario is listed in the table; "All Fuels Combined." This includes all of the fuel operations combined at one station, and yields healthy returns, similar but slightly less than the results for the biofuels / electricity kiosk scenario, as expected.

Exhibit 53: Estimated IRR for 15- and 30-Year Concession: Base Case

Fueling Station Offering	15-Year Concession IRR	30-Year Concession IRR
Electricity Kiosk (Standalone)	0% to 15% IRR	> 15% IRR
Hydrogen / Electricity Kiosk	< 0% IRR	0% to 15% IRR
Biofuels (Standalone)	0% to 15% IRR	> 15% IRR
Biofuels / Electricity Kiosk	> 15% IRR	> 15% IRR
All Fuels Combined	> 15% IRR	> 15% IRR

Finally, the team performed some analysis on the operations of the fueling stations if no convenience store operations were included as part of the concession. In these cases, the operations and capital costs were reduced along with revenues. While a complete set of sensitivities was not performed, the team concluded that removing the convenience operations would have a clear negative impact on the concession performance. The total net income earned over the 30-year concession period would be expected to fall by 25% to 35%. This would cut the 30-year IRRs stated in the tables above roughly in half and cause many of the 15-year IRRs to turn negative. In all scenarios, the State would need to provide an up-front capital contribution to help the concessionaire achieve the target 15% IRR.

Chapter 5: Alliance Opportunities

Introduction: Problem and Opportunity

> **AF/AFV Commercial Deployment Cycle**
>
> - Laboratory testing
> - Demonstration and early adoption
> - Transition to commercial market
> - Large-scale commercial deployment

Alternative fuels (AF) and vehicles (AFV) have been successfully introduced in small demonstration programs with personal users, in public and private fleets (e.g. municipal, state, federal, regional trucking, taxis) and in niche markets (e.g. airports, school buses, transit vehicles) where vehicles, fuels and fueling infrastructure were made available to users concurrently. While some fundamental technological and economic challenges remain, the primary challenge to AF commercialization is how to "build a market simultaneously for new vehicle technologies, new fuels, and new infrastructure to support them" (Melendez, 2006).

The decision-making problem is complex as it requires decisions to be made in parallel by a large number of stakeholders who pursue separate goals, respond to different incentives, and are each facing decisions of a different nature:

1. Governmental bodies making public policy decisions,
2. Private companies making capital investment decisions, and
3. Users making consumer choices.

For instance, automotive manufacturers would not distribute AFVs (even in demonstration programs) within a given market where refueling stations are not available; fuel producers, distributers and stations owners would only invest in support infrastructure if enough AFVs are in circulation to support the demand for the fuels they produce and distribute; and users would not purchase vehicles they cannot refuel conveniently.

Most stakeholders are poised to benefit from the transition from petroleum-based fuels to alternative fuels; but for those benefits to be maximized, these decisions must be coordinated. At the current stage of development, industry stakeholders concur that the adequate availability of alternative fuel stations is the major barrier to a commercial transition toward AF technologies (Melendez, 2006, Melaina and Bremson 2008).

To kick start the industry in Washington State, WSDOT has taken the initiative to address the primary concern of the industry and help create favorable conditions for investment in fueling infrastructure within a well-defined geographic area, the I-5 corridor. To be successful, this initiative must build broad alliances and partnerships among the numerous public and private stakeholders involved in the AF transition process. In turn, successful alliances are based on strategies that align the goals and incentives of its partners so that the each partner benefits from the coordinated actions of the group. Developing successful alliance strategies therefore requires:

1. Identifying the stakeholders and the "critical decision-makers,"
2. Understanding the goals and incentives of each group (including the State),

3. Identifying the tools at the disposal of the State of Washington to advance its public policy objectives, and
4. Focusing on alliances where all stakeholders benefit from coordinated action.

This analysis indentifies the public and private stakeholders and their respective goals and incentives, informs WSDOT about the major barriers to the development of AF retail stations, identifies the policy tools available to the State of Washington, and outlines potential alliance opportunities to overcome these barriers.

The Team built on prior literature review; a collection of feedback from experts, and interviews with public and private stakeholders conducted by the National Renewable Energy Laboratory (NREL) in 2006 and 2007[64] as well as industry knowledge from our Team to develop a base understanding of the barriers to development and the dynamics at play among the stakeholders. This information was supplemented by a limited number of interviews to gauge the interest in potential alliances to further the development of AF stations in the I-5 Corridor. The last part of this analysis proposes potential bundling of retail products and services with the AF retail stations to improve the economics as well as the "green image" of the stations.

Stakeholders: Barriers, Goals and Incentives

A wide array of stakeholders from the public and the private sectors have already expended a vast amount of resources – monetary as well as political and intellectual capital – in promoting alternative fuels and have a vested interest in helping the new technologies take these last steps toward larger market implementation. These stakeholders form a heterogeneous body of individuals, governmental and not-for-profit entities, and small and large corporations, each with their own goals and responding to different sets of incentives.

This section proposes a taxonomy of the major stakeholders according to their common goals, and discusses their incentives. Although the boundaries among these groups may sometimes overlap, stakeholders can be grouped according to the nature of the goals they pursue so as to identify alliance strategies where each stakeholder benefits from the coordinated actions of the alliance. This section however starts with a review of the barriers that may prevent their coordinated actions. Any alliance should focus strategies to remove these barriers as well as aligning the incentives of all stakeholders.

The question of risk allocation among public and private stakeholders – central to public-private partnerships for infrastructure development – is considered far less relevant to the deployment of retail AF stations in the I-5 Corridor, and is discussed at the end of this Section.

[64] Expert opinions form the NREL engineers and scientists and Clean Cities Coordinators reported in Melendez 2006, and industry feedback on experience with alternative fuel deployment gathered from 39 experts from the public and private sectors – including technology developers, auto makers, alternative fuel providers, technology advocates, fleet and non- fleet customers, and policy-makers – during the "Lessons Learned Meeting" by the NREL on July 20, 2006 and reported in Melendez, Theis, and Johnson 2007.

Barriers to AF Technology Deployment

Melendez (2006) lists the primary barriers to deployment of AF technologies based on literature review and interviews with NREL experts and Clean Cities Coordinators. These barriers and associated ranking are summarized below:

1. Availability of alternative fuel refueling infrastructure
2. High costs of constructing refueling infrastructure
3. Availability of AFVs
4. Inconsistency in public policy and leadership messages
5. Lack of economic incentives
6. Competition against conventional fuel economies of scale
7. High costs of purchasing AFVs (compared with conventional vehicles)
8. Lack of customer awareness and market acceptance
9. Lack of AFV service and maintenance training and technicians
10. Lack of trained fueling station operators
11. Poor perceived or actual performance of AFVs (safety, power, attributes, range, reliability, etc.)
12. Alternative fuel availability
13. Low oil prices
14. Poor fuel properties of alternative fuels
15. Inconsistent codes and standards

Melendez' analysis further showed that out of the top eight barriers (i.e. the top 50%), the following five barriers were consistently cited. In particular, the lack of AF fueling infrastructure was the number one barrier identified by each group:

1. Availability of alternative fuel refueling infrastructure
2. High costs of constructing refueling infrastructure
3. Availability of AFVs
4. Inconsistency in public policy and leadership messages
5. High costs of purchasing AFVs (compared with conventional vehicles)

While the ranking may differ, the Team concurs that these issues constitute the primary barriers to AF deployment. Any alliance to promote the use of AF in the I-5 corridor should therefore focus on strategies to alleviate or remove these barriers.

Private Stakeholders

Private stakeholders include wide-ranging types of organizations that are primarily motivated by economic profit. Profit can be realized from:

- Economic value created by capital investment in AF infrastructure or AFV research and development (R&D) programs or being an early adopter/implementer in new technologies or fuels (e.g. Toyota's early effort in hybrid vehicles),
- Production, transport, and distribution of AFs,
- Cost savings resulting from switching from petroleum-based to AFs,
- Increased sales of other commercial products due to a greener company image, as evidenced by the adoption of AF technologies.

Depending on the type of economic actor, profit is measured over shorter or longer periods of time (e.g. investment in retail fuel station vs. investment in AFV R&D). This group also includes special-interest and industry lobbying groups whose primary concern is to defend and advance the commercial interests of its private members.

Automotive Industry

As stated earlier, the concurrent availability of AFVs along with the fueling infrastructure is a key component to successful deployment in a specific market (such as the I-5 corridor). Therefore, any alliance strategy must include a combination of AFV manufacturers to ensure adequate availability of vehicles in the market.

Today, most major vehicle manufacturers have AFV programs in demonstration and pre-commercialization phase. Given their high-level of refueling convenience, hybrid-electric vehicles, followed by flex-fuel or hybrid vehicles, are the most advanced in the commercialization phase. As no single technology as emerged as the most likely to replace petroleum-based technology in the short-term, most vehicle manufacturers (as well as other private stakeholders such as energy companies – see below) are developing several AF technologies simultaneously. The Department of Energy lists approximately fifty AVF personal vehicle and light truck models available to individuals and fleets. However, most of these models (but for electric hybrid vehicles) are only available in small quantities within targeted geographic markets. Compared to over 1,000 personal vehicle models operating on petroleum fuels available nationwide, the limited consumer choice is one of the forces limiting the acceptance of AFVs by consumers. However, the success of the Toyota Prius, for instance, shows that when the needs of individual users are addressed, large-scale distribution of a single AFV model is achievable.

The following vehicle manufacturers (in alphabetic order) are the most active in the AFV market:

- Chrysler
- Daimler
- Ford
- General Motor
- Honda
- Hyundai
- Mazda
- Mercedes-Benz
- Mitsubishi
- Nissan
- Toyota
- Volkswagen

Vehicle manufacturers have formed alliances to look at many issues necessary to market acceptance and deployment, including the need for support infrastructure. The Department of Energy's FreedomCAR and Fuel Partnership programs, for example, bring together companies such as Daimler, Chrysler, Ford, and GM (as well as oil and gas companies such as Chevron).

Stakeholders in the automotive industry include not only vehicle manufacturers actively engaged R&D programs and early commercial applications of AFVs but also automotive technology developers and manufacturers providing specialized components for AFVs (e.g. Automotive Fuel Cell Cooperation focusing on hydrogen fuel cells). Automotive technology providers usually work in partnership with vehicle manufacturers.

Vehicle dealers are independent of vehicle manufacturers and, at the present retail volumes, have few incentives to invest in a specialized labor force to sell and maintain AFVs. AFV manufacturers have recognized that the lack of AFV service and maintenance and the lack of customer awareness as to the performance of vehicles are impediments to deployment. Consequently, most are placing their vehicles directly and are offering leasing programs for vehicles that include all maintenance services. Some demonstration programs include leases that are offered at significant discount to the actual cost incurred by the manufacturers. For example, the Honda FCX Clarity, powered by hydrogen fuel cells, is estimated to cost approximately $300,000 to manufacture and is offered for lease in California at around $600 per month (including collision insurance and maintenance).[65]

While investing in vehicle research and development is part of the vehicle manufacturers' business, investing in support infrastructure is not. AFV manufacturers may participate in some infrastructure development in the demonstration phase, but infrastructure costs in the commercialization phase would have to be born by the fuel producers, transporters, and stations owners. As demonstrated in Chapter 4, such costs may be too high to be born by the private sector alone.

Petroleum-Based Fuel Producers and Distributers

Oil and gas companies have reasons to promote alternative fuels and alternative fuel vehicle (AFV) and related infrastructure, despite the possible negative financial impacts from competition with their traditional petroleum based products. On one hand, these companies have hundreds of billions invested in fixed infrastructure designed for the extraction, refining, and distribution of petroleum products and derive almost all their profits from these activities. However, they are also fully aware of the energy, economic, and environmental security concerns of consumers. These companies are competing for leadership in alternative fuels, and they are looking for strategic investments that would give them a competitive advantage. On the other hand, these companies may potentially have interest in only some types of alternative fuel. For example, these companies already produce natural gas (used in CNG and also most typically used to produce hydrogen), but are currently less involved in biofuels or electrically powered transportation efforts (although they do sell natural gas for power generation at some facilities).

The Corridors of the Future designation of the I-5 corridor could provide them with a high-profile opportunity to showcase their technological leadership and improve their brand image. As opposed to specialized AF producers, oil and gas companies are actively engaged in R&D and distribution demonstration and commercialization of multiple fuel sources simultaneously. The most active oil and gas companies (in alphabetic order) include:

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[65] USA Today, "FCX Clarity: Bring on the Hydrogen Stations," November 23, 2007

- BP
- Chevron
- ConocoPhillips
- Exxon Mobil
- Shell

When dealing with AF, petroleum-based fuel producers and distributers face similar constraints as specialized AF producers and distributers. The large size of their organizations however allow them to take on more risky investments or even treat development of AF station as R&D programs; which smaller and specialized AF producers and distributers cannot do. However, the new brands created by petroleum-based fuel producers and distributers to produce and deliver some AF (e.g. Shell Hydrogen) is indicative of the maturity of the market, now closer to commercialization.

Alternative Fuel Producers and Distributers

Because production technologies differ widely among AF sources, most producers and dealers of AFs (other than oil and gas companies) focus their business on one fuel source. Having invested capital in research and development, manufacturing, and storage equipment, they have direct financial interest in the establishment of alternative fueling facilities to promote the widespread use of their own fuel products. These stakeholders are therefore discussed separately below, after an introduction highlighting barriers and goals common to most AF producers and distributors.

For fuel producers and transporters, profit is driven by distribution costs, price and volume of fuel sold. Over the past couple of years, AF prices have been driven higher by record-high petroleum-based fuel prices (until the most recent significant drop in oil prices). However, even with relatively high prices tracking the price of conventional fuels, AFs cannot currently achieve the type of economies of scale enjoyed by conventional fuel producers and distributers.

Moreover, AFs require specialized transportation modes and/or dedicated infrastructure, leading to generally higher transportation costs. The availability of specialized infrastructure and the cost to transport different type of AF from production sites to stations are therefore additional impediments to the deployment of fueling stations as AFs (as noted in the supply chain discussion in Chapter 2). Such additional costs are reflected in lower operational margins or higher prices at the pump, which could be offset by fuel price subsidies either directly to users, to distributers, or station owners.

AF producers face additional challenges in providing fuels at the quantity and quality required for commercial-grade use. Quantity is affected both by the availability of production facilities and by the availability of raw material.

Consistency in quality in the production of alternative fuels is also necessary to commercial application. From the individual user perspective as well as from the AFV manufacturers' perspective, quality must be guaranteed and be widely-accepted (preferably established by or endorsed by the State or the federal government). In the case of biodiesels, the American Society for Testing and Materials (ASTM) has developed a standard (ASTM D 6751) for B20; however, no standard yet exists for higher biodiesel blends. The necessity for standards extends to all alternative fuel types. In Washington State, the Revised Code of Washington (RCW), Title 19, Chapter 19.112, defines "alternative fuels"[66] for transportation and defines fuel

[66] ""Alternative fuel" means all products or energy sources used to propel motor vehicles, other than conventional gasoline, diesel, or reformulated gasoline. Alternative fuel includes, but is not limited to, liquefied petroleum gas, liquefied natural gas, compressed natural gas, biodiesel fuel, E85 motor fuel, fuels containing seventy percent or more by volume of alcohol fuel, fuels

standards including air pollution standards and standards for biodiesel fuel and fuel blended with biodiesel fuel. Similar standards exist in other States and have proved instrumental to early AF deployment: for instance, in California, the designation of hydrogen as a transportation fuel and the subsequent development of standards (although still not complete) had proved essential to the initial deployment of hydrogen fueling stations in the State.[67]

Quality standards are particularly relevant for individual users as vehicle manufacturer warranties do not extend to engine defects caused by fuels (outside of demonstration programs). Until widely-accepted standards are developed, AF producers could potentially offer fuel warranties in partnership with AFV manufacturers or on their own to help overcome the lack of market acceptance and perceived low performance of AFs and AFVs. This is an area where strong State leadership could have a high impact.

The development of fuel standards is not only an area of potential collaboration among AFV manufacturers and AF producers but also an area where leadership at the State level is instrumental to move the industry forward.

Biodiesel Producers, Distributers, and Retailers

Biofuel producers, distributers, and retailers may be interested in forming an alliance with WSDOT along the I-5 corridor to increase sales of their products. According to BioEnergy Washington, in its June 2008 report Biofuel Development in Washington, as of June there were 7 biodiesel production facilities in Washington State, with a combined capacity of 135 million gallons per year (MGY). The report notes that over the last year, a number of other biodiesel projects have been put on-hold or have been cancelled, with high feedstock costs cited as the major concern. Finally, the report indicates that 1.7 million gallons of biodiesel (or 0.70 % of total diesel sales) were sold in Washington during the 3 month period from January, 2008 through March, 2008.

Biodiesel production facility operators in Washington State include (in alphabetic order):

- Central Washington Biodiesel
- Columbia BioEnergy
- Gen-X Energies
- Imperium Renewables/Seattle Biodiesel
- Standard Biodiesel
- Washington Biodiesel

A number of biofuel projects by these organizations and others are underway in Washington State.[68]

Biodiesel distributers and retailers may also be interested in potential alliance opportunities with WSDOT. A list of retail biodiesel establishments can be found at the National Biodiesel Board website:

http://www.biodiesel.org/buyingBioDiesel/retailfuelingsites/showstate.asp?st=WA

The State today counts 66 biodiesel fueling stations, shown in Exhibit 54, many if which are located close to the I-5 Corridor. Biodiesel distributors can also be found on the National Biodiesel Board website:

http://www.biodiesel.org/buyingbiodiesel/distributors/showstate.asp?st=WA

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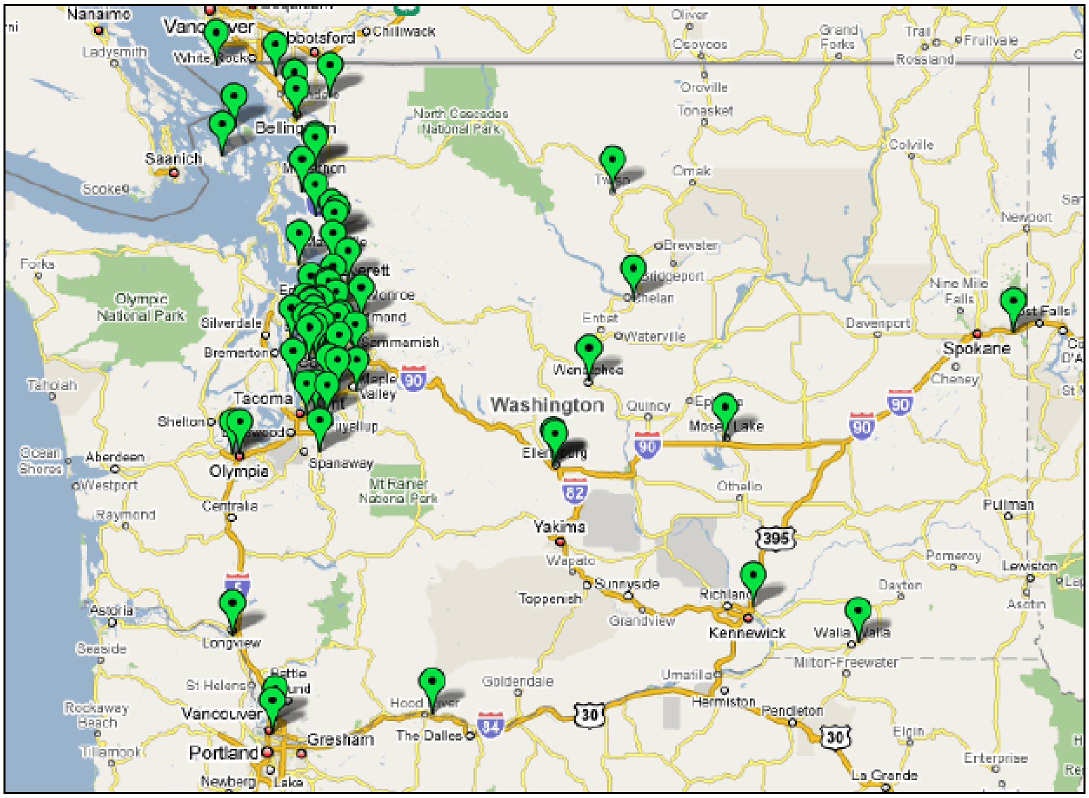
that are derived from biomass, hydrogen fuel, anhydrous ammonia fuel, nonhazardous motor fuel, or electricity, excluding onboard electric generation."

[67] Interview with the Fuel Cell Partnership (CAFCP), December 2008.

[68] BioEnergy Washington, Biofuel Development in Washington, June 2008, http://www.bioenergy.wa.gov/documents/biofuelactivities.pdf.

Exhibit 54: Existing Biodiesel Stations



An organization that could be critical in helping provide outreach to potential alliance partners (producers, distributors, retailers, etc.) is the Northwest Biofuels Association/Northwest Environmental Business Council, which is a non-profit trade association structured to represent the business interests of its members while supporting the development of the biofuels industry as a whole in Idaho, Montana, Oregon, and Washington. Industry members consist of the producers, brokers, distributors, and retailers of biodiesel and ethanol, along with the firms providing services to these entities (engineers, consultants, contractors, law firms, financers, etc.).

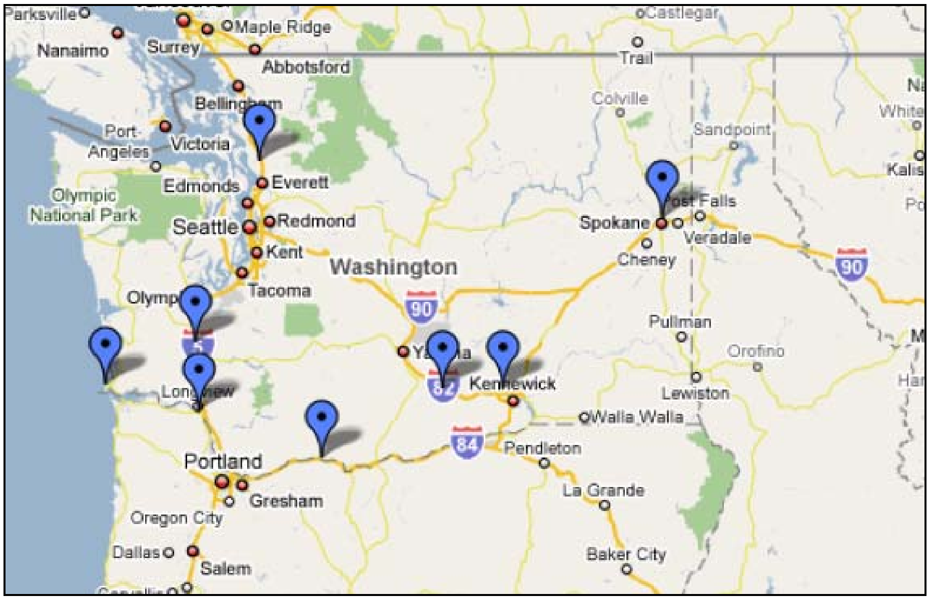
Finally, WSDOT could consider, as part of the current initiative, a "Freeways to Fuel" type project, whereby fuel crop feedstock are grown in the rights-of-way of the I-5 Corridor and other Interstate and/or State-owned right-of-way. One state looking at this type of program is Utah. The Utah Department of Transportation (UDOT) has partnered with Utah State University to research the possibility of growing biodiesel producing plants such as canola, safflower and perennial flax alongside of the state highways. UDOT is hoping that this program might eventually be able to fuel its entire fleet from "homegrown biodiesel," save on maintenance costs, and aesthetically improve its right of way.[69] Biodiesel partners for WSDOT's alternative fueling station effort (including research institutions, producers, state and federal partners) could be involved in any potential freeways to fuel initiative as well.

[69] Source: Utah Department of Transportation, UDOT Freeways to Fuel Initiative: http://www.udot.utah.gov/main/f?p=100:pg:2410893841748515:::1:T,V:1376

Ethanol Producers, Distributers, and Retailers

In Washington State, there are more than 100,000 flexible fueled vehicles (FFVs) capable of operating on blends of ethanol and gasoline varying from 0% ethanol and 100% gasoline up to 85% ethanol and 15% gasoline (E85).[70] However, there are only eight stations serving E85 to the general public in the State, including three in the I-5 Corridor, as shown in Exhibit 55.[71]

Exhibit 55: Existing Ethanol Stations



Moreover, there is currently no ethanol production facility in the State. Washington State University, in its June 2008 report Biofuel Development in Washington lists five facilities totaling 280 MGY project currently on-hold, three more in feasibility and planning stage (175 MGY), as well as three other projects totaling 235 MGY have been canceled over the past year.

The State of Washington has rich and diverse agricultural land producing over 200 varieties of crops. In 2007, approximately 2.4 million acres of corn, barley, and wheat were planted in the State. These crops have the potential to produce approximately 450 million gallons of ethanol. However, with such a wide-array of crops that can be produced, cultivating feedstock for production biofuels and ethanol in particular is in competition with many high-yield crops. Crops with higher sugar yield, such as sugar beet, could be used as a competitive crop. There is also non-traditional cellulosic feedstock available in the State for producing biofuels including by-products form the forestry industry (mill waste, wood construction material debris, paper, etc.).

[70] http://www.bioenergy.wa.gov/BioFuelAvailability.aspx
[71] http://www.nwbiofuels.org/biofuels_locator

Hydrogen and Fuel Cells Producers, Technology Providers, Distributers, and Retailers

Hydrogen is seen by many experts as a long-term solution to petroleum-based fuels and many countries around the world, led by Iceland relying on its geothermal energy for the production of hydrogen, have launched large scale programs aimed at developing a hydrogen economy.[72] Internationally, there are four major producers of hydrogen (in alphabetic order): (1) Air Liquide, (2) Air Products, (3) Linde, and (4) Praxair.

In the U.S., research efforts are currently focusing of fuel storage, codes and standards for hydrogen fueling stations. The State of California is a leader in the deployment of hydrogen technology and counts over 26 hydrogen fueling stations used in demonstration programs, primarily clustered in the San Francisco and Los Angeles metropolitan areas (developed through the California Fuel Cell Partnership, see discussion below).

According to a recent survey conducted by Washington State University, there have been relatively few coordinated efforts in the State of Washington to promote hydrogen as a viable alternative fuel. However the State hosts a number of very active stakeholders in the hydrogen industry. [73]

- Production: two plants have current production capabilities: (1) Air Liquide (Kalama, WA) and (2) BP West Coast Products LLC (Ferndale, WA). Hydrogen can be produced through electrolysis using renewable energy sources available within the State and research is also underway to produce hydrogen from biofuels. Moreover, the State's five oil refineries currently use hydrogen for their own production processes.
- Technology: the State counts a growing number of fuel cell and production/storage technology companies at various stages of development form R&D, start-ups, to companies in commercialization stage, including: ReliOn (www.relioninc.com), EnerG2 (www.energ2.com), Genesis Fueltech (www.genesisfueltech.com), Alumi-Fuel Power, Inc. (based in Seattle), InnovaTek (www.tekkie.com), Neah Power Systems (www.neahpower.com/index.html)
- Research: the University of Washington is generally active in alternative energy research, including hydrogen. Similarly, the Pacific Northwest National Laboratory (PNNL) has a strong focus on hydrogen fuel cell and storage technology development.
- Safety: The Volpentest HAMMER Training & Education Center (Richland, WA) is one of the premier training facility for training workers and first responders involved with new technologies and hazardous material, including hydrogen (HAMMER - Hazardous Materials Management and Emergency Response)

[72] www.hydrogen.energy.gov/international.html.
[73] This list is reported in Sjoding, D., and Hamernyik, E., "Overview of Hydrogen and Fuel Cells in Washington State," Washington State University, September 2008

Private and Public Energy Utilities

About two-thirds of electric power in Washington State is sold by public sector agencies,[74] but two of the top five retailers of electricity in Washington State (Puget Sound Energy and Avista Corporation[75]) are investor-owned utilities that are traded on the New York Stock Exchange. However, only Puget Sound Energy, a private entity, sells electricity along the I-5 corridor in Washington State.

Puget Sound Energy provides electricity in Thurston County and King County (other than within the City of Seattle and areas to the north and south, where electricity is provided by Seattle City Light). Puget Sound Energy also provides electricity in Skagit and Whatcom Counties on the northern part of the State. Exhibit 56 lists the power utilities providing electricity in WSDOT rest areas along the I-5 corridor.

Investor-owned public-sector energy utilities may be interested in forming an alliance with WSDOT to increase the use of electricity for transportation. In Hawaii, for example, the Hawaii Electric Company (an investor-owned energy utility) is a participant in a joint venture, the Hawaii Electric Vehicle Demonstration Project (HEVDP), to install rapid charging infrastructure throughout the Island of Oahu. WSDOT may want to consider a similar alliance with Puget Sound Energy or an alliance with a public-sector utility.

As an example of a local public sector utility partnership, the Snohomish County PUD has been part of a partnership for a tidal energy exploration project. For this project the Snohomish County PUD is partnering with the U.S. Dept. of Energy, the Electric Power Research Institute, the University of Washington/NW National Marine Energy Center, Devine Tarbell & Assoc., the National Renewable Energy Lab, and Pacific Northwest National Labs Marine Sciences Laboratory. In this case the project is funded by the public sector: from the U.S. Department of Energy ($1.2 million), as well as the Bonneville Power Administration ($500,000).[76]

It should be noted however that an increase in demand for electricity could increase prices to consumers and necessitate additional investment in electric power generating capabilities for the State. Chapter 2 describes several issues with the electricity supply chain and the potential of large-scale charging of electric vehicles on the current electric grid (charging vehicles primarily at night will have very different implications than charging vehicles primarily during the day because different power plants will be operated on the margin).

There are many aspects of a partnership or alliance that utilities could be involved in, such as standardization, smart metering, and smart grid work, among others. For instance, utilities may be interested in the provision of hardware and communication/information technology that will be needed to appropriately manage these new loads, and the standardization of those technologies.

In addition, depending on the constraints at particular stations it may also be possible to use solar power to augment existing power sources, which power utilities may have interest in. For example, the Oregon Department of Transportation (ODOT) is engaging in a public private partnership to install solar panels along highway rights-of-way for a solar power demonstration project. According to the demonstration project's website, "This is an 'all Oregon' project – Oregon companies will supply materials, design and

[74] Washington State Department of Community Trade and Economic Development, 1999 Biennial Energy Report Section 2, http://www.cted.wa.gov/energy/archive/BR99/.

[75] Source: U.S. Energy Information Administration, Washington State electricity profile: http://www.eia.doe.gov/cneaf/electricity/st_profiles/sept03wa.xls.

[76] Source: Craig Collar, PE, Snohomish County PUD, Presentation on Tidal Energy Exploration in Puget Sound, http://www.snopud.com/renewables.ashx?p=3546#

install this collaborative project, showcasing what can be accomplished through creative, responsible partnering in the public and private sectors."[77]

Exhibit 56: Private and Public Power Utilities Servicing I-5 Rest Area Locations

Rest Area	Power Utility	Type Utility
Gee Creek	Clark Public Utilities	Public
Toutle River	Cowlitz County PUD	Public
Scatter Creek	Puget Sound Energy	Investor-Owned
Maytown	Puget Sound Energy	Investor-Owned
SeaTac	Puget Sound Energy	Investor-Owned
Silver Lake	Snohomish County PUD	Public
Smokey Point	Snohomish County PUD	Public
Bow Hill	Puget Sound Energy	Investor-Owned
Custer	Puget Sound Energy	Investor-Owned

Fuel Station Owners/Concessionaires

Fuel station owners range from single location stores owned and operated locally to multinational oil companies. Current fueling retailers are likely candidates to be the concessionaires for the alternative fueling stations under consideration. These traditional fueling station business owners have many incentives to pursue alternative fuels: knowledge of the economics of fuel retail may be a competitive advantage in this emerging business; potential increase in market share; possible decline of sales of congenital fuels (in the long-term) if AF are not distributed; and image enhancement (in the short-term), among others. Because these business owners are familiar with fuel retail industry, they may find that adding alternative fuels stations to their current operation presents similarities and can create synergies with their current business. However, owners of conventional fuel stations may also oppose incentives and grants offered by WSDOT and its State partners on the ground that it creates unfair subsidies.

Depending on the strategy pursued by WSDOT, this industry knowledge may offer more or less benefit for the retailer who is familiar with current business practices. As explained in the previous chapters, traditional fueling stations generally receive approximately 75% of their revenue from fuel sales, although this accounts for only about 35% of income. Gasoline and diesel is generally sold at a very low profit margin because it is a commoditized item with very little difference perceived between brands by consumers. Convenience stores attached to gas stations generally have higher profit margins and these are where most fuel retailers make a majority of their income.

The AF business models studied in the previous section differ from the traditional fueling station model. Whereas the traditional model relies on high volumes of fuel sales with low operating margins, the AF business model would be, initially, low volumes and higher operating margins. However, with low initial volumes, higher operating margins are not anticipated to be enough to generate a profit in the early years.

[77] Source: Oregon Department of Transportation: http://www.oregon.gov/ODOT/HWY/OIPP/inn_solarhighway.shtml

AF owners and concessionaires are therefore likely to be responsive to incentives that would mitigate the risks of operating losses.

Biofuel and E85 stations would operate very similarly to traditional fueling stations, and prior knowledge of fuel distribution would be a competitive advantage. Stations that would sell hydrogen and electricity however would initially have less in common with the traditional fueling station business model (at least until AFs become commoditized).

As presented in Chapter 1, land costs are a large part of the initial capital investment. With the uncertainty in demand, reducing or eliminating land cost would greatly improve the economics of the station over the life-cycle of the concession and decrease the initial risk.

This initial risk can also be mitigated by increasing the coordination with AFV manufacturers to ensure that AVFs are made available in the market concurrently with the station to fleets or individual users located within a short driving distance form the station. WSDOT could play a significant role in facilitating this coordination as detailed below in the Alliance Strategies.

Infrastructure and Station Builders

The builders of conventional and alternative fuel infrastructure and stations would benefit most directly from increased business linked to new construction. In Washington State, Saybr Contractors, for instance, has developed specific expertise in the alternative fuels arena and is already partnering with the Puget Sounds Clean Cities Coalition to develop natural gas fuel facilities.

Beyond the direct benefits to contractors and operators, such construction activity would also bring larger economic benefits to the State including employment and revenue from sales taxes. The State could facilitate the activity of such local firms or the implantation of new firms dedicated to AF infrastructure by facilitating the creation of new businesses and providing short-term tax incentives.

Private Vehicle Fleet Owners

To date, most AF deployment programs have focused on fleets (public and private) as vehicles and stations can be most conveniently provided concurrently. Fleet owners switching to AF do so for environmental and health concerns as well as economic benefits resulting from the combination of savings at the pump (when oil prices are high enough), and subventions and tax incentives (while government agencies, may switch to alternative fuel vehicles for their fleet in response to a regulatory requirement).

While fleets generally have a limited number of vehicles, they account for large volumes of fuel sales for an AF station and could represent a significant competitive advantage to the economics of a retail station. However, targeting fleets may have some constraints as part of this project. For example, fleet customers generally prefer to have sole access to the station for security reason; and prefer to be able to locate their maintenance facility and fueling station in the same location.

Other Private Companies That Are Not Direct Industry Participants

With environmental concerns influencing consumer decisions, many companies are investing in enhancing their "green image." Recently in California, the "Green Power Group- California Affiliates" was formed, including companies such as Advanced Micro Devices, Apple, Cisco Systems, and eBay. Though this partnership surrounds purchasing and developing new sources of renewable energy, similar partnerships could be developed for alternative fuel by building on the desire of their company to be seen as environmentally-friendly, hence providing additional financial support to the I-5 Corridor initiative. This is already the case in Washington, where Starbucks Coffee Company is a sponsor of the Puget Sound Clean Cities Coalition.

In addition, if solar power is included at the alternative fueling stations, private sector companies involved in the manufacture or installation of photovoltaic systems may be interested in a partnership or alliance on this project much like the public-private partnerships in place in Oregon as part of its solar highway demonstration project. [78]

Public Stakeholders

Public stakeholders include policy-makers as well as state, regional and local government and agencies concerned with the implementation of policies and enforcement of regulations. Government bodies are mainly concerned with the making and implementation of public policy including public health (including air quality), environmental preservation, energy security, and national, state and/or local economy. Policy-makers, at the federal and state levels, have numerous policy tools at hand to "push" or "pull" the transition toward alternative fuels. By enacting laws and regulations mandating emission standards or fuel blends for instance policy-makers can mandate incremental changes ("push" strategy); and by providing incentives and subsidies (including in-kind subsidies) policy-makers can improve the financial return for early investors producing, transporting, and distributing AFs as well as AVF manufacturers and distributers ("pull" strategy).

Federal Government

The federal government provides wide-reaching incentives and programs in support of AFV ownership and AFV infrastructure investments. Some of the major agencies involved in promoting alternative fuels include the U.S. Department of Energy, Department of Agriculture, the Department of Transportation, the Environmental Protection Agency, the Department of Defense, as well as the Internal Revenue Service.

Washington State has already demonstrated its ability to partner with the federal government as I-5 has been designated as part of the USDOT Corridors of the Future Program. Possibilities for partnering with the federal government abound. One example would be for WSDOT to leverage the new status of the I-5 corridor by proposing to use it as a pilot corridor for AFV infrastructure implementation. WSDOT could take advantage of numerous existing programs such as the Department of Energy's FreedomCAR and Fuel Partnership, the EPA's National Clean Diesel Campaign, the SmartWay Transport Partnership, and the Department of Agriculture's various programs to encourage bioenergy production, to name but a few.

Resources for AF technologies and infrastructure and AFVs are centralized at the federal level and can be accessed from the DOE's Alternative Fuels and Advanced Vehicles Data Center's website at: http://www.afdc.energy.gov/afdc/

[78] Source: Oregon Department of Transportation: http://www.oregon.gov/ODOT/HWY/OIPP/inn_solarhighway.shtml

State Government

Washington State governmental bodies can support WSDOT's initiative by offering land parcels or linear right of way, tax incentives, direct grants (with or without the federal assistance), or by enacting laws and regulations to establish standards and foster investment and partnerships. At the State level, the Energy Policy Division of the Washington State Department of Community, Trade and Economic Development (CTED) provides information and analysis in support of economically and environmentally sound energy programs and projects, including alternative fuels for transportation. Through the CTED, the State provides direct financial assistance and tax incentive programs, which could be used to help fund AF infrastructure projects (such as the Energy Freedom program).[79] Although the mechanisms for financial assistance are in place, the programs have not yet been used in infrastructure projects and their funding is subject to renewed commitment from the Legislature next year.

State Agencies are already organized in special working groups to promote the development of AF, such as BioEnergy Washington, which includes the Department of Agriculture, the Department of Ecology, and WSDOT, to name a few.[80] This group's agenda includes promoting a BioEnergy economy in the State by making policy recommendations and distributing funds to support industry growth.

State government agencies could also increase their usage of alternative fuel vehicles, and potentially encourage the use of alternative fueling stations in the I-5 Corridor.

Regional and Local Governments and Agencies

In Washington, strong leadership is driving the transition to AF at the local and regional level. The Cities of Seattle, Tacoma, Olympia, as well as King County Metro Transit, Snohomish County, Pierce Transit, and the Port of Seattle, among others, have already implemented AF programs targeted at their fleets of vehicles. Regional agencies are also involved in the process: the Puget Sound Clean Air Agency for instance promotes the use of AF through education, incentives, and enforcement through such program as Diesel Solution aimed at reducing emissions for public and private fleets.[81]

Mandates to reduce emissions have greatly contributed to the distribution of AFVs in public fleets over the past ten years. However, unless the specific objections of fleet owners/operators are addressed, they may not be willing to have their fleets become consistent customers of I-5 alternative fuel stations (see discussion of private fleet owners). The experience of the State of New York in that respect may be valuable. As par of its Alternative Fueled Vehicles Program, in 2003 the State of New York opened eight State-owned CNG stations to the general public. The State subsequently entered into a public-private partnership with Clean Energy (one of the largest provider of vehicular natural gas in North America) to take over operations and management of these State-owned, high-volume CNG stations and to construct additional new stations open to local governments, municipalities, and the general public. Clean Energy currently operates twelve stations, ten of which are serving the State fleet as well as non-State entities and the public.[82]

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[79] http://www.cted.wa.gov/site/526/default.aspx
[80] http://www.bioenergy.wa.gov/
[81] http://www.pscleanair.org/programs/dieselsolutions/fuels/biodiesel.aspx
[82] http://www.ogs.state.ny.us/supportservices/vehicles/cleanfuel/infrastructure.html
and http://www.cleanenergyfuels.com/stations/newyork.html

Neighboring States and Province

The concept for the "Alternative Fuels Corridor" includes AF stations traversing the length of Interstate 5 from British Columbia through Washington and Oregon to Baja, California. In September 2008, Washington, Oregon and California signed a tri-state Memorandum of Understanding (MOU) to foster the use of alternative fuel vehicles by developing the distribution network for alternative fuels throughout the I-5 Corridor. The memorandum lays out common goals, a work plan and activities designed to further the development of this alternative fuels corridor. June, 2008, Washington and British Columbia also signed an MOU, in which the State and Province have agreed to work together to develop a strong and viable alternative fuels network.

Not-For-Profit

Not-for-profit organizations include research institutions such as universities or national laboratories, which focus on providing solutions to specific scientific, technologic, policy, and economic or business questions related to the transition toward AF. Not-for-profit organizations also include volunteer coalitions such as Clean Cities that provide a collaborative platform, information and technical resources upon which to build public-public and public-private partnerships in support of alternative fuel (these existing coalitions are discussed in the Existing Alliances section).

A few examples of Washington State not-for-profit organizations that may be interested in forming alliances with WSDOT, or being involved in development or promotion of an alternative fuels corridor include (in alphabetic order):

- Climate Solutions
- Northwest Biofuels Association
- Pacific Northwest National Laboratory (PNNL)
- Puget Sound Clean Cities Coalition (now housed within the Puget Sound Clean Air Agency)
- Sightline Institute
- Transportation Choices Coalition
- Washington State Transportation Research Center (TRAC)
- Washington State University, the University of Washington and other Universities

PNNL, for example, may be interested in some involvement since PNNL has conducted research on the impact of plug-in hybrid vehicles (PHEVs) on the electric grid, has conducted research in fuel cells, and has a Bio-based Products Research Group. At the national level, the Oak Ridge National Laboratory (ORNL) and the National Renewable Energy Laboratory (NREL) have also been conducting extensive research in AF technologies and AF deployment in general and on hydrogen in particular. The ORNL has partnership programs in place to foster collaboration.

The Puget Sound Clean Air Agency and the Northwest Biofuels Association may be able to work with WSDOT to engage stakeholders and potential private sector partners in the alternative fuels industry.

The Puget Sound Clean Cities Coalition, Transportation Choices Coalition, Climate Solutions, and Sightline Institute may be critical alliance partners to engage in the sustainability implications of an alternative fuel corridor.

Universities/Colleges

Universities, community colleges, and technical colleges may also be interested in partnerships or alliances with WSDOT. Washington State University, for example, already plays a major role in education and outreach for alternative fuels in the state and has broad research programs for alternative fuels.

The development of AF fueling stations could be coordinated with education and/or training programs, where professionals and/or students could be trained to operate and maintain AF station infrastructure and AFVs. However, designing and operating a station to serve simultaneously as a training center would likely increase development and operating costs of the station.

Individual Users

Adoption of AF technologies by individual users can be motivated by very different goals varying from technological innovation, to environmental concerns, to economic benefits (tax incentives and reduced fuel costs). These three basic goals also provide a segmentation of the market for temporal deployment of AF technologies as users seeking technological edge or with a high degree of concern for the environment are likely to be early adopters even at a premium, while users seeking cost savings are more likely to adopt the new technology when the economic advantages are more clearly defined.

As emphasized in the previous sections, alliance strategies must focus on the coordinated deployment of AF infrastructure and AFVs; but such strategies must also remain focused on the users. In the particular case of the I-5 Corridor, individual users are all the more important to successful deployment as it is unclear whether fleet users could be enticed to use stations located on the Interstate.

Adequate refueling availability is fundamental to individual users. Given the sparse location of AF stations, AFV owners may have to drive more than conventional-fuel vehicle owners to refuel. While owners of flex-fuel or bi-fuel vehicles may be less sensitive to station availability, dedicated AFVs rely entirely on the availability of the stations providing the fuel they need.

Surveys[83] highlight that individual users are in general very sensitive to convenience (availability of station, fueling process, and vehicle maintenance), cost, vehicle and fuel performance, reliability and safety. The surveys also reveal that users are generally unfamiliar with or misinformed about most AF and AFV technologies and place little trust in “untested” technologies. On the other hand, the success of the Toyota Prius underlines that individual users respond favorably to tax incentives.

Strategic Alliances

Existing Alliances

Stakeholders promoting the transition toward AF technologies have organized in various forms of alliances such as:

- Private joint ventures, e.g. United States Council for Automotive Research (USCAR), among DaimlerChrysler, Ford, and General Motors;
- Trade associations, e.g. the National Biodiesel Board;
- Resource and leadership centers to foster collaboration among stakeholders and provide direct assistance, e.g. Clean Cities; and

[83] Melendez, Theis, and Johnson, 2007, and Plax and Kearney, 2006.

- Alliances among public and private entities, e.g. the California Fuel Cell Partnership.

In this section we focus on the resource and leadership centers and public-private partnerships, in which WSDOT and its state and local public partners could play a significant role in aligning the objectives and coordinating the actions of the stakeholders to kick-start the deployment of AF in the I-5 Corridor. This section presents a few examples (among many) of successful programs and alliances, highlighting the primary contribution to success.

Clean Cities

Established in 1993 in response to the Energy Policy Act (EPAct) of 1992, Clean Cities is a network of approximately 90 volunteer coalitions coordinated at the local level, which help "develop public-private partnerships to promote alternative fuels and advanced vehicles, fuel blends, fuel economy, hybrid vehicles, and idle reduction."[84]

Clean Cities focuses on strategies that ensure the coordinated action of stakeholders and supports the public, private and public-private initiatives by providing technical data and information and access to funding resources from the DOE. Clean Cities also offers technical assistance to local coordinators as they work to develop infrastructure and market strategies and partnerships.[85]

The local Clean Cities coalition for Washington State is the Puget Sound Clean Cities Coalition (now housed within the Puget Sound Clean Air Agency).[86] Since 1999, the Coalition and its members have been demonstrated successes in obtaining grants to assist in the implementation of alternative fuel projects; among recent examples:

- In 2006, Sound Refining received Clean Cities grant funds to support the installation of in-line rack blending infrastructure for biodiesel.
- In 2005, Alternative Fuel Werks received a Clean Cities grant to expand retail biodiesel fueling infrastructure throughout the Puget Sound region.

California Air Resource Board's Zero Emissions Vehicle Program

The California Air Resource Board's zero emissions vehicle program (started in 1998) is considered successful[87] largely because it has enabled the development of agreements among and between stakeholders and has been providing incentives aimed at the coordinated action of stakeholders. The program:

- Established an agreement with vehicle manufacturers to ensure the placement of 1,300 vehicles with individuals and fleets;
- Provided manufacturers access to public fleets;
- Provided assistance for infrastructure development;
- Provided financial incentives to users up to $5,000 per vehicle (incentive in place until March 2009) and assistance for installation of home rechargers;

[84] http://www1.eere.energy.gov/cleancities/
[85] Clean Cities, "Fact Sheet," September 2008, Accessed online November 2008, http://www1.eere.energy.gov/cleancities/
[86] 1904 Third Avenue - Suite 105, Seattle, WA 98101, Coordinator Mark Brady, 206-689-4055, www.pugetsoundcleancities.org
[87] According to the participants to the Lessons Learned Meeting as reported in Melendez, Theis, and Johnson (2007).

- Established environmental performance standards (and test procedures) along with clear standardized labels intended to inform users;
- Provided training to emergency respondents. [88]

California Fuel Cell Partnership

Started in January 1999, two state government agencies (the California Air Resources Board and the California Energy Commission) joined with six private-sector automotive and energy companies to form the California Fuel Cell Partnership (CFCP). The CFCP is:

> a "collaboration of organizations, including auto manufacturers, energy providers, government agencies and fuel cell technology companies, that work together to promote the commercialization of hydrogen fuel cell vehicles. Automotive members provide fuel cell passenger vehicles that are placed in demonstration programs, where they are tested in real-world driving conditions. Energy members work to build hydrogen stations within an infrastructure that is safe, convenient and fits into the community. Fuel cell technology members provide fuel cells for passenger vehicles and transit buses. Government members lay the groundwork for demonstration programs by facilitating steps to creating a hydrogen fueling infrastructure." Members also "collaborate on activities that advance the technology, such as first responder training, community outreach and agreeing on protocols while standards are being developed." [89]

The coalition is an example of broad-based partnership and has 33 members including automotive manufacturers, energy companies, fuel cell technology companies, and government agencies. It works through a consulting firm hired jointly by the first 8 members. To date, it has brought to market 26 hydrogen fueling stations clustered in Northern and Southern California (Sacramento, San Francisco, San Jose, greater Los Angeles, San Diego and Palm Springs) and over 200 light duty vehicles as part of fleet or other limited customer demonstration programs. While the CFCP has been focusing on demonstration of the hydrogen technology, its goal for the next five years is to explore strategies to move into commercialization.

Better Place

Funded in 2005, Better Place is private company based in Palo Alto, California, that proposes an innovative business model for electric vehicles. Under the Better Place model, individual users could either buy or lease an electric car and then buy miles on their electric car batteries from Better Place the way cell phone users pay "minute-by-minute access to cell towers connected together in cellular networks."[90]

To work, this business model needs to be implemented in partnership with local, state or national governments, utility companies, and vehicle manufacturers. Better Place recently announced its partnership with the state of Hawaii, following similar agreements with Israel, Australia, Denmark, and the San Francisco Bay area. Better Place also secured commitment from French automaker Renault and Japanese manufacturer Nissan and the first electric cars are scheduled for delivery in Denmark and Israel in 2011.[91]

Better Place is active in California and in the Pacific Northwest and could play a major role in the deployment of electric charging and battery exchange stations, in the I-5 Corridor and elsewhere in the

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88 http://www.arb.ca.gov/msprog/zevprog/zevprog.htm
89 http://www.fuelcellpartnership.org/aboutus.html
90 http://www.betterplace.com/our-bold-plan/business-model/
91 Thomas Friedman, "While Detroit Slept," New York Times, December 9, 2008

State. The Better Place platform is flexible and could easily be combined with any of the station layouts inclusive of electricity charging equipment that are proposed as part of this study. With the high voltage power supply that is part of the infrastructure plan, both car charging equipment, using Better Place plug adapters, and battery swapping facilities could be possible.

A Word on Risk Allocation

The question of risk allocation among public and private entities is in general central to forming public-private partnerships in developing infrastructure and providing related services. In the case of the deployment of AF retail infrastructure in general, and in the I-5 Corridor in particular, the distinction need to be made among:

- The delivery of the building structures and infrastructure for the fueling stations;
- The provision and installation of fueling technology (and finishing of the building); and
- The provision of the AVFs required to building the market in the Corridor.

In designing alliances and partnerships among public and private entities, in order to reduce risks, responsibilities need to be allocated to the parties best able to manage them. Therefore, in the I-5 Corridor, incentives provided by WSDOT and its State partners need to focus not only on the coordination of the actions of the stakeholders (as discussed above) but also on the mitigation of risks for these stakeholders.

WSDOT does not currently have the capability or the intention of providing AF technologies or AFVs. On the other hand, there are private companies dedicated to developing that market if they can make a profit doing so. For the provision of AF technologies and AFVs, the primary question therefore is not to know who should fill the demand of the market, but how public stakeholders can help private stakeholders build this market (and why they should do so).

The allocation of risks among the private partners also falls within the realm of the existing capabilities and specialties of each partner (e.g. vehicle manufacturers are not in the business of building infrastructure). However, given the necessity of coordinated deployment of vehicles and stations, alliances must rely on a common agreement to provide vehicles (with fleet and individual users) as stations are being developed. WSDOT can play a significant role as a catalyst in developing such agreement and coordinating the investment of the respective stakeholders in the I-5 Corridor.

As discussed above, The California Air Resource Board's zero emissions vehicle program (see below) was considered successful in large part because it established such an agreement with the vehicle manufacturers to provide vehicles alongside with assistance for investment in infrastructure so as to coordinate the actions of the private stakeholders. In another example, in the late 1990's the State of Hawaii, through the Hawaii Center for Advanced Transportation Technologies (HCATT) (formerly known as the Hawaii Electric Vehicle Demonstration Project, HEVDP) initiated the deployment of electric-charging stations that were originally intended for public use. Although several manufacturers were producing electric vehicles that could have been charged at these stations, such vehicles were not distributed to individual users in the State. The stations were eventually used by government and commercial fleets and used as part of demonstration programs. While from the perspective of the HCATT, which focuses on the development and demonstration of electric-drive technology, the program was eventually a success, it did not result in the provision of electric-charging infrastructure accessible to the general public because commitments from vehicle manufacturers were not secured upfront.

The question of risk allocation between public and private partners is of particular importance with the question of technological choice. As WSDOT and its State partners decide on the type of incentives to provide to help building the market, the type of incentives should be carefully designed to ensure that the state public policy objectives are met without substituting for the market in choosing a particular technology (i.e. as long as such technology meets the public policy objectives).

Last is the question of allocation of responsibilities (i.e. risks) between public and private sector in the delivery of the building structures and infrastructure for the fueling stations. As discussed in Chapter 1, WSDOT could either:

- Grant the use of the land to the concessionaire at little or no cost without paying for the development of building and infrastructure; or
- Grant the use of the land to the concessionaire at little or no cost and fund (at least in part) the development of building and/or infrastructure, and lease the facility to the operator.

Given the economics of the AF retail station, early assistance with in the development of the infrastructure and buildings would constitute a strong economic incentive for AF station owners/concessionaires and considerably reduce the risk of the capital investment. However, given the limited choices in locating the stations (in the I-5 Corridor), capital assistance to facilitate investment in the Corridor may not be sufficient if other locations are considered more attractive for initial commercialization.

Public Policy Tools

The State of Washington is one of the most active in the country with 29 laws, regulations and incentive programs on the books as of November 2008 (second behind California with 55) in addition to 57 such programs and laws at the federal level. Nationwide, as of November 2008, the alternative Department of Energy's (DOE's) Fuels and Advanced Vehicle Data Center lists[92] 417 federal and State incentive programs and 489 laws and regulations, highlighting the great diversity of existing public policy tools to encourage the development of alternative fuels, vehicles and infrastructure, air quality, fuel efficiency, and other transportation-related topics aimed at reducing the use and of petroleum-based fuels. A list of the incentive programs and laws for the Federal Government and the States of Washington, Oregon, and California is provided in Appendix F for reference.

[92] http://www.afdc.energy.gov/afdc/incentives_laws.html accessed November 2008

Exhibit 57: Domestic Incentive Programs and Regulations in place as of November 2008[93]

State	Incentives	Regulations	Total
Federal US	43	14	57
California	39	16	55
Washington	13	16	29
Illinois	12	16	28
New York	14	13	27
Indiana	14	12	26
Tennessee	8	18	26
Iowa	10	15	25
New Mexico	11	14	25
Minnesota	4	20	24
Texas	15	8	23
North Carolina	13	9	22
Oregon	10	12	22
Florida	7	13	20
Missouri	9	11	20

The focus of these programs varies widely. While a large number of incentives nationwide are designed to cover all AF types, most incentives are technology-specific designed to push or pull one type of technology. On the beneficiary side, incentives cover the entire supply chain of AF and AFV. As the development of AF technology has historically been focused on fleets a very large number of programs are still in place to benefit fleet owners and managers. An increasing number of incentives and laws are also designed for individual vehicle owners and drivers, reflecting the desire for a market shift form fleets to individual users.

Exhibit 58: Domestic Incentive Programs and Regulations by Technology and Beneficiary Type[94]

Technology	
Alternative Fuel - All	174
Biodiesel	411
Ethanol	407
Natural Gas	314
Liquefied Petroleum Gas (LPG)	271
Electric Vehicles (EV and NEV)	279
Hydrogen/Fuel Cells	250
Blends	164
Hybrid Electric Vehicles (HEV)	110
Emissions Based	112
Fuel Efficiency	56
Idle Reduction	76

Beneficiary	
Individual Vehicle Purchaser/Driver	230
Fleet Purchaser/Manager	426
Fueling/Recharging Station Builder or Operator	159
Alternative Fuel Producer	175
Alternative Fuel Dealer	149
Alternative Fuel Purchaser	131
Alternative Fuel or AFV Researcher	68
Electrified Truck Stop Builder/Operator	10
AFV Manufacturer/Retrofitter	67

Incentives and laws may apply to more than one technology or more than one type of beneficiary

[93] Ibid
[94] Ibid

The following sections look at the type of laws, regulations, and incentive programs and their respective effectiveness as perceived by various stakeholders.

Laws and Regulations

The DOE's Alternative Fuels and Advanced Vehicle Data Center regroups laws and regulations in the following broad categories:

- Acquisition Requirements
- Fuel Taxes
- Idling Restrictions
- Registration Requirements
- Fuel Production Standards
- Vehicle Driving Restrictions
- Energy-Based Economic Development Plans
- Vehicle Emissions Inspections
- Renewable Fuel Standard
- Renewable Fuel Mandate
- Fuel Use Requirement

According to the participants to the Lessons Learned Meeting,[95] while many regulations and laws were seen as effective, their effectiveness is in general undermined by the "mismatch between the mandates and the availability of alternative fuels, infrastructure, and vehicles, as well as the lack of enforcement (e.g. Energy Policy Act).

Incentives

The DOE's Alternative Fuels and Advanced Vehicle Data Center regroups incentive programs in the following broad categories:

- Grants
- Tax Incentives
- Loans and Leases
- Rebates
- HOV Lane Access
- Exemptions from Requirements/Restrictions
- Fuel Discounts
- Technical Assistance

The participants to the Lessons Learned Meeting[96] generally agreed that incentives were more successful than regulations in promoting development and deployment of AF technologies. Tax incentives and HOV lane access have been reported as widely used by hybrid vehicle owners/drivers.

Related Laws and Regulations

Other laws and regulations can also foster the development of AF, such as air quality mandates and commuter programs. In 2006, the Washington State Legislature passed the Commute Trip Reduction

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[95] Melendez, Theis, and Johnson 2007
[96] Ibid

Efficiency Act, which requires local governments in those counties experiencing the greatest automobile-related air pollution and traffic congestion to develop and implement plans to reduce single-occupant vehicle trips. Although the program does not currently include goals specifically indicating an increased use of alternative fuels, the increased use of low-emitting fuels could support two of the goals of the CTR program, namely reducing energy consumption and air pollution (RCW 70.94.547).

Conclusion

Successful transition of the transportation industry to alternative fuels (AF) hinges on the coordinated actions of a wide range of stakeholders necessary to "build a market simultaneously for new vehicle technologies, new fuels, and new infrastructure to support them" (Melendez, 2006). To solve this conundrum, alliances among public and private stakeholders must be built that align the various goals and incentives of the stakeholder groups.

Industry and public stakeholders alike are mindful of this necessity and a general consensus has been developing around the primary elements that a successful alliance strategy would need to address. These include:

Policy Leadership and Consistency of the Political Message

Policy motivations for transitioning away from petroleum-based transportation fuels cover multiple areas from environmental and ecological concerns to economic and energy security. While the involvement of diverse political bodies at all level of government is essential to establish a broad support base for AF, it also adds to the complexity of the problem by establishing different set of priorities (such as a particular emphasis on one source fuel, for instance) and different implementation strategies to "push" (e.g. by enacting laws and regulations) or "pull" (e.g. by providing incentives and subsidies) the transition toward alternative fuels.

Consistency in the policy message requires coordinating policy, regulations, and incentives for all branches of government as well as public and industry outreach initiatives. It also requires that incentives and programs are established with long-term visibility. This could be done for instance through a single State agency (created for this very purpose or using an existing group within a State Department) and provided with a clear charter and in charge of a strategic plan establishing goals, milestones, and implementation steps in the short-, medium-, and long-term. Such an agency could also play a significant role in coordinating with private stakeholders, including alternative fuel vehicle (AFV) manufacturers to ensure that AVFs are made available in the market concurrently with the stations.

Regulatory Framework

As the industry evolves and moves into early commercialization phase industry stakeholders often mention the lack of codes and standards as an impediment to deployment. Necessary codes and standards range from building codes for AF stations, fuel quality and emissions standards, testing procedures, to metering standards required for retail activity. This is an area where state leadership is instrumental and could have the greatest impact.

Economics

Private stakeholders include wide-ranging types of organizations that are primarily motivated by economic profit. Any initiative focusing on AF deployment must realistically consider the expectation for profit of the private industry, whether such profit is measured over a shorter or longer time period.

Given level of risk and the large sums of capital required upfront for the construction of AF stations, economic incentives are an essential part of any deployment strategy. The operating economics of the stations being also uncertain, financial incentives (including direct subsidies and tax breaks) should not be limited to the initial capital investment phase but extend into operations. Incentives must also be guaranteed over a long-enough period of time to secure the necessary return on investment.

Other types of assistance can also be brought to bear to improve the operating economics of stations and decrease risk. One issue of primary concern to AF station owners is the availability of insurance policies: such policies are either not available or prohibitively expensive (depending on the type of fuel). This problem will eventually resolve itself as more AF stations are introduced in the market. In the interim it can be alleviated by the creation of insurance pools, potentially secured by government back-stop guarantees.

Ultimately the primary operating risk is related to demand. Through a limited number of interviews, some stakeholders, while realizing how valuable land-subsidies would be to a new station, have expressed reservations about a deployment program limited to the I-5 Corridor, as opposed to a dense urban areas where users can conveniently and locally refuel their vehicles. To address in part the demand risk, large volumes of AF sales could be secured from a single fleet. However, fleet customers have particular concerns and requirements (including security and collocation of fueling and maintenance facilities) that would need to be specifically addressed to secure their participation.

Further enhancements to the operating economics can also be added by including ancillary, revenue-producing activities, including conventional fueling station retail, photovoltaic panels on site, and collocation of AFVs service and maintenance facilities for users.

Alternative Fuel Vehicle Availability:

Large-scale infrastructure projects cannot be built on the “build it and they will come” premise. Past experience with alliances and public-private partnerships in AF demonstration programs have highlighted the importance of the commitment of automotive manufacturers to produce and deliver AFVs in a given market. Coalitions such as the California Fuel Cell Partnership as well as private companies involved in AF infrastructure deployment such as Better Place have secured upfront commitment from major automotive manufacturers. Such upfront commitment is seen as an essential piece of a successful strategy.

Focus on the End User

Surveys highlight that individual users are in general very sensitive to convenience (availability of station, fueling process, and vehicle maintenance), cost, vehicle and fuel performance, reliability and safety. The surveys also reveal that users are generally unfamiliar with or misinformed about most AF and AFV technologies and place little trust in “untested” technologies. Successful alliances must therefore focus on overcoming these barriers. In that respect, public outreach and education programs are instrumental, and so are financial incentives making the cost of vehicle and the cost of AF competitive with petroleum-based technologies.

To the extent that fleet users can also be part of such programs, the specific needs of fleet owners and users should also be considered in the design of the station as well as in outreach programs.

Leveraging Existing Coalitions, Resource Centers, and Programs

Numerous coalitions, leadership, technology and resource centers, and programs aimed at fostering the transition to alternative fuels exist at the local, state, and federal levels. Through a limited number of interviews, most have expressed interest in supporting WSDOT by sharing knowledge, industry contacts, and in providing active support.

Appendix A: Gasoline and Diesel Station Survey

WSDOT Alternative Fuels Corridor

Survey Response Analysis

Introduction

The first step in assessing the economic feasibility of an alternative fuels corridor along I-5 was to develop an operational analysis of traditional fuel stations, as described in Chapter 1. In doing so, a survey was conducted to extract general operating information, and to establish a better understanding of the traditional fuel station business model. Information obtained via surveys was primarily meant to supplement data from the National Association of Convenience Stores (NACS), and to serve as a comparison against industry standards.

The target audience of this survey included fuel station owners and managers in the I-5 corridor, and between the cities of Castle Rock and Bellingham. Stations in major urban areas including Seattle, Tacoma, and Everett were excluded from the survey analysis because these areas are generally not served by State rest areas due to the widely available private services at nearby Interstate exits.

To simplify distribution of surveys throughout the I-5 corridor, packets containing a one-page survey, letter of explanation, and prepaid return envelope were compiled in advance. Of the 59 total surveys distributed to stations, 49 were delivered in-person, while the remaining 10 were sent by mail.

In all, seven surveys were returned with complete or partial information. This represents a response rate of about 12%. In some cases, not all information was included in the survey analysis. As the summary tables detail below, sample sizes vary by question and category depending on how the information was provided, and whether the responses were consistent with other categories within the survey. For instance, some respondents provided a combined figure for gasoline and diesel costs, and failed to differentiate between the two. As a result, the response was excluded from the gasoline and diesel cost breakdown, but included in the combined fuel costs summary. Additional details for individual questions are provided in the tables below. The full surveys received are provided at after the summary results.

Survey Questions and Summary Results

Question 1: Station Hours

Please indicate the normal weekday and weekend operating hours of your business, excluding holidays.

Of the returned surveys, five out of seven stations operate weekdays from early morning to late evening, while only two stations are open 24 hours per day. Weekend operating hours for all stations were identical to the weekday responses.

Table A1 –Business Hours

	24 Hours	Early Morning - Late Evening	Closed	Other
% of Respondents	29%	71%	0%	0%

Question 2: Types of Goods & Services

Please indicate the types of goods and services that you provide at your fuel station from the list below (check all that apply).

Table A2 shows that all respondents sell gasoline and snack food/drink items and that most also sell diesel fuel. A limited number of stations incorporate fast food franchises or auto repair services. All respondents specified the "other" services as car washes.

Table A2 – Types of Goods and Services Sold

	Gasoline	Diesel	Snack Food/Drink	Fast Food Franchise	Repair Service	Other
% of Respondents	100%	86%	100%	26%	14%	29%

Question 3: Fuel Sales

How many gallons of the following fuels did you sell during the month of May 2008? (If May data is not available or if your record keeping covers a time period other than one month, please answer for the most recent month or time period available)

Table A3 displays average monthly fuel sales by type. Based on this sample, an average store sells over four times more gasoline than diesel fuel. On an annual basis, total fuel sales amount to 1.1 million gallons.

Table A3 – Monthly Fuel Sales

	Gasoline	Diesel	Total Average Fuel Sales
# of Respondents	7	6	-
Average Montly Sales per Station	75,367	17,806	93,173
Annualized Sales	904,409	213,670	1,118,079
% of Total Average Fuel Sales	81%	19%	100%

Question 4: Monthly Gross Revenues

Please indicate your gross revenues for the month of May 2008 in the following categories: non-fuel sales, gasoline sales, and diesel sales.

According to this sample, revenue generated by fuel products is approximately four times that of non-fuel goods and services. Total annual revenues amount to $5.2 million.

Table A4 – Monthly Fuel vs. Non-fuel Gross Revenues

	Fuel	Non-fuel	Total Average Revenues
# of Respondents	5	5	-
Average Monthly Sales per Station	$347,982	$85,624	$433,606
Annualized Sales	$4,175,786	$1,027,483	$5,203,270
% of Total Average Revenues	80%	20%	100%

Question 5: Monthly Business Costs

Please fill in the following information about your May 2008 costs of doing business.

Table A5 and A6 shows cost information for COGS and general expenses. Gasoline COGS is by far the largest cost at close to $300,000 per station in the month of May, more than all other costs combined. The total costs if annualized amount to over $6.0 million, which exceeds the average annual sales shown in Table A4 above.

Table A5 – Monthly Business Costs

	Non-fuel Goods &	Gasoline	Diesel	Labor	Rent, Lease, or Mortgage	Taxes, Credit Card Fees, & Other	Total Average Costs
Sample Size	5	5	4	4	5	5	-
Average Costs per Station	$55,921	$292,981	$89,396	$16,750	$11,180	$41,230	$507,458
% of Total Average Costs	11%	58%	18%	3%	2%	8%	100%

Table A6 - Monthly Fuel vs. Non-fuel Costs

	Fuel	Non-fuel	Total Average Costs
Sample Size	5	4	-
Average Costs per Station	$382,377	$125,081	$507,458
% of Total Average Costs	75%	25%	100%

Question 6: Monthly Net Income

Please indicate the range of monthly net income (profit) after all expenses generated by your business.

Profits did not exceed $10,000 for any of the surveyed fuel stations. More than half of these stations had profits less than $4,000 per month.

Table A7 – Monthly Net Income Range

	Less than $4,000	$4,000 to 6,999	$7,000 to 9,999	More than $10,000
% of Respondents	60%	20%	20%	0%

Question 7: Number of Stations Owned

Do you own more than just one station? If so, how many?

Table A8 – Number of Stations Owned

	One Station	More than One Station
% of Respondents	57%	43%

Appendix B: Population within five minutes of a potential refueling location

Legend:	Government Fleet Fueling Facility	Rest Area	Park & Ride

NAME	Population	Facility Type	Latitude	Longitude
Chehalis WSDOT (Fuel)	402	Fuel Facility	46.6117740	-122.9083710
Toutle River (NB)	498	Rest Area	46.3509058	-122.9043190
Toutle River (SB)	499	Rest Area	46.3523303	-122.9079778
Bow Hill (SB)	512	Rest Area	48.5846693	-122.3465330
Bow Hill (NB)	541	Rest Area	48.5823305	-122.3443140
Toledo (Fuel)	717	Fuel Facility	46.4493670	-122.8644620
Maytown (SB)	1,072	Rest Area	46.8710956	-122.9703582
Scatter Creek (NB)	1,388	Rest Area	46.8353494	-122.9852501
Stanwood I P&R	1,868	Park & Ride	48.2388240	-122.2440260
Toledo-Winlock P&R	2,043	Park & Ride	46.4747444	-122.8810863
Ridgefield P&R	2,055	Park & Ride	45.8167310	-122.6831500
Custer (SB)	2,112	Rest Area	48.9266689	-122.6461821
Lake Samish P&R	2,135	Park & Ride	48.6891980	-122.4006580
Woodland (Fuel)	2,255	Fuel Facility	45.9140480	-122.7526450
Woodland P&R	2,688	Park & Ride	45.9064399	-122.7414429
Gee Creek(SB)	3,036	Rest Area	45.7991472	-122.6806075
Custer (NB)	3,160	Rest Area	48.9091279	-122.6220304
Olympia WSP (Fuel)	3,383	Fuel Facility	46.9623530	-122.9133440
Kelso (Fuel)	3,610	Fuel Facility	46.1148670	-122.8906470
Stanwood II P&R	4,484	Park & Ride	48.2398480	-122.3478960
Gee Creek (NB)	5,442	Rest Area	45.7770803	-122.6695372
Cook Road P&R	5,736	Park & Ride	48.5076090	-122.3371380
Smokey Point (SB)	6,323	Rest Area	48.1691077	-122.1942775
Arlington P&R	6,613	Park & Ride	48.1960920	-122.1289120
Smokey Point (NB)	6,777	Rest Area	48.1688486	-122.1888685
Bellingham (Fuel)	6,998	Fuel Facility	48.7874150	-122.5277970
Marysville WSP (Fuel)	8,148	Fuel Facility	48.1003730	-122.1944870
SR 432 P&R	8,354	Park & Ride	46.1063426	-122.8795503
I-5 & SR 6 P&R	8,581	Park & Ride	46.6607504	-122.9764212
Burlington WSP (Fuel)	9,237	Fuel Facility	48.4872160	-122.3382820
I-5 & Hwy 531 P&R	10,530	Park & Ride	48.1522514	-122.1917355

Tumwater (Fuel)	10,723	Fuel Facility	46.9854100	-122.9122240
Chuckanut P&R	10,828	Park & Ride	48.4847292	-122.3373360
Chehalis WSP (Fuel)	11,292	Fuel Facility	46.6701090	-122.9806670
Ferndale Station P&R	11,342	Park & Ride	48.8468950	-122.5760590
Lake Stevens Transit Center P&R	12,868	Park & Ride	47.9974733	-122.1029756
Tumwater(Mottman) (Fuel)	13,140	Fuel Facility	47.0253400	-122.9392090
Marysville II P&R	14,387	Park & Ride	48.1001290	-122.1850350
Mellen Street P&R	14,455	Park & Ride	46.7115406	-122.9769393
Woodinville P&R	14,869	Park & Ride	47.7572290	-122.1528440
Fairhaven P&R	15,139	Park & Ride	48.7200970	-122.5115400
Kent (Fuel)	15,656	Fuel Facility	47.3645300	-122.2490800
Lake Geneva (Auburn) (Fuel)	16,507	Fuel Facility	47.2934430	-122.2865130
Auburn P&R	17,038	Park & Ride	47.3208709	-122.2277600
Marysville Ash Avenue P&R	17,557	Park & Ride	48.0536670	-122.1836780
Mount Vernon (Fuel)	18,378	Fuel Facility	48.4064100	-122.3299390
SeaTac (NB)	18,952	Rest Area	47.2711335	-122.3145569
Tacoma WSP (Fuel)	19,678	Fuel Facility	47.1547910	-122.3957950
Marysville I P&R	20,438	Park & Ride	48.0500080	-122.1832460
George Hopper P&R	21,906	Park & Ride	48.4520510	-122.3356090
Allen Street P&R	22,670	Park & Ride	46.1450783	-122.8964882
Mount Vernon P&R	22,710	Park & Ride	48.4174710	-122.3330640
Peasley Canyon P&R	22,953	Park & Ride	47.3017520	-122.2572230
Vancouver Admin (Aces) (Fuel)	24,671	Fuel Facility	45.6588060	-122.5597840
Brier P&R	25,050	Park & Ride	47.7919059	-122.2719652
Canyon Park P&R	25,326	Park & Ride	47.7943571	-122.2107595
Federal Way/S 320th ST P&R	26,023	Park & Ride	47.3124733	-122.3005083
Northwest Avenue P&R	29,517	Park & Ride	48.7824520	-122.5022920
Kent / James ST P&R	30,764	Park & Ride	47.3867300	-122.2432490
South Kirkland P&R	32,353	Park & Ride	47.6430010	-122.1971330
Redmond Interim P&R	32,937	Park & Ride	47.6794894	-122.1275669
Twin Lakes P&R	33,123	Park & Ride	47.2935300	-122.3610030
Renton Highlands P&R	33,291	Park & Ride	47.5062340	-122.1856410
Bothell P&R	33,683	Park & Ride	47.7597570	-122.2014662
Federal Way Transit Center P&R	34,601	Park & Ride	47.3177160	-122.3032090
South Federal Way P&R	34,996	Park & Ride	47.2898700	-122.3229870
South Bellingham P&R (West)	35,012	Park & Ride	48.7145255	-122.4751916
South Bellingham P&R (East)	35,523	Park & Ride	48.7134019	-122.4738960
South Bellevue P&R	36,216	Park & Ride	47.5865487	-122.1902297

Kenmore P&R	36,538	Park & Ride	47.7574080	-122.2436870
Salmon Creek Park & Ride	36,753	Park & Ride	45.7183260	-122.6527760
Mercer Island P&R	37,075	Park & Ride	47.5884140	-122.2317160
Belleuve WSP (Fuel)	37,247	Fuel Facility	47.5843420	-122.1326990
Renton (Fuel)	37,665	Fuel Facility	47.4869880	-122.1824740
Newport Hills P&R	40,065	Park & Ride	47.5562310	-122.1892030
Bellevue WSDOT (Fuel)	40,402	Fuel Facility	47.6410090	-122.1956390
Kent Station Transit Center P&R	41,884	Park & Ride	47.3833527	-122.2324134
Burien Transit Center P&R	42,369	Park & Ride	47.4686800	-122.3389280
Overlake P&R	43,071	Park & Ride	47.6327668	-122.1366555
BPA Park & Ride	43,352	Park & Ride	45.6602760	-122.6568690
Olson Place & Myers Way P&R	43,786	Park & Ride	47.5224010	-122.3348180
99th St P&R	44,562	Park & Ride	45.6922780	-122.6642510
Overlake Transit Center P&R	45,150	Park & Ride	47.6442177	-122.1333024
Lakeview (Fuel)	45,355	Fuel Facility	47.1593400	-122.4872590
Mariner P&R	46,321	Park & Ride	47.8786180	-122.2394730
South Renton P&R	47,119	Park & Ride	47.4717240	-122.2123520
S Seattle WSP (Fuel)	47,941	Fuel Facility	47.4688000	-122.2870690
Silver Lake (SB)	48,762	Rest Area	47.9024510	-122.2155729
Wilburton P&R	49,327	Park & Ride	47.6025100	-122.1854370
Seattle (Corson) (Fuel)	49,485	Fuel Facility	47.5456780	-122.3222640
Tukwila P&R	49,644	Park & Ride	47.4827441	-122.2689647
Renton Transit Center P&R Garage	50,252	Park & Ride	47.4812560	-122.2078190
Parkland Transit Center P&R	50,817	Park & Ride	47.1475380	-122.4344090
Eastgate P&R	50,820	Park & Ride	47.5803059	-122.1523944
Tacoma Dome Station P&R	51,032	Park & Ride	47.2411120	-122.4249430
Vancouver (Fuel)	51,178	Fuel Facility	45.6520210	-122.6672870
Houghton P&R	54,654	Park & Ride	47.6680352	-122.1853503
Kent-Des Moines P&R	54,801	Park & Ride	47.3923747	-122.2874974
Southwest Spokane ST P&R	55,120	Park & Ride	47.5714817	-122.3653663
SR 908/Kirkland Way P&R	55,281	Park & Ride	47.6792300	-122.1878560
McCollum Park P&R	55,899	Park & Ride	47.8803180	-122.2196590
Redondo Heights P&R	56,402	Park & Ride	47.3552533	-122.3100492
Center Street P&R	59,861	Park & Ride	47.2339792	-122.4968928
Aurora Village Transit Center P&R	60,843	Park & Ride	47.7749282	-122.3414652
Star Lake P&R	61,470	Park & Ride	47.3579060	-122.2997670
I-5 / SR 512 P&R	62,306	Park & Ride	47.1641560	-122.4834210

Kingsgate P&R	64,079	Park & Ride	47.7184350	-122.1876190
Everett (Fuel)	64,333	Fuel Facility	47.9099300	-122.2226080
Edmonds P&R	64,580	Park & Ride	47.8056143	-122.3301429
Ash Way P&R	65,213	Park & Ride	47.8498190	-122.2608140
72nd St. Transit Center P&R	66,840	Park & Ride	47.1919730	-122.4525325
Shoreline P&R	68,254	Park & Ride	47.7677680	-122.3459000
Lynnwood Transit Center P&R	68,933	Park & Ride	47.8157000	-122.2950980
Seattle (Ballinger) (Fuel)	71,349	Fuel Facility	47.7775600	-122.3406020
South Everett Freeway Station P&R	71,804	Park & Ride	47.8968636	-122.2156130
Eastmont P&R	74,138	Park & Ride	47.9138030	-122.2069730
Mountlake Terrace P&R	89,408	Park & Ride	47.7848875	-122.3152166
Fifth Ave NE/NE 133rd St P&R	104,306	Park & Ride	47.7260796	-122.3236866
North Jackson Park P&R	108,809	Park & Ride	47.7361475	-122.3235500
Airport & Spokane P&R	111,942	Park & Ride	47.5714060	-122.3227700
Signals (Fuel)	112,467	Fuel Facility	47.5705430	-122.3213730
North Seattle P&R	136,182	Park & Ride	47.7013650	-122.3284720
Northgate Transit Center East P&R	138,449	Park & Ride	47.7031651	-122.3258454
Northgate Transit Center P&R	151,823	Park & Ride	47.7031460	-122.3285110
Greenlake P&R	171,680	Park & Ride	47.6758530	-122.3200300

Appendix C: Vehicle miles traveled within five minutes of a potential refueling location

Legend:	Government Fleet Fueling Facility	Rest Area	Park & Ride

NAME	VMT	Facility Type	Latitude	Longitude
Arlington P&R	0	Park & Ride	48.1960920	-122.1289120
Stanwood II P&R	0	Park & Ride	48.2398480	-122.3478960
Twin Lakes P&R	0	Park & Ride	47.2935300	-122.3610030
Lake Stevens Transit Center P&R	9,786	Park & Ride	47.9974733	-122.1029756
Chehalis WSDOT (Fuel)	57,687	Fuel Facility	46.6117740	-122.9083710
Toledo (Fuel)	148,032	Fuel Facility	46.4493670	-122.8644620
Fairhaven P&R	175,734	Park & Ride	48.7200970	-122.5115400
Redmond Interim P&R	216,399	Park & Ride	47.6794894	-122.1275669
Custer (SB)	234,699	Rest Area	48.9266689	-122.6461821
Olympia WSP (Fuel)	252,459	Fuel Facility	46.9623530	-122.9133440
Custer (NB)	265,051	Rest Area	48.9091279	-122.6220304
Bellingham (Fuel)	330,695	Fuel Facility	48.7874150	-122.5277970
Ferndale Station P&R	387,297	Park & Ride	48.8468950	-122.5760590
Kenmore P&R	402,331	Park & Ride	47.7574080	-122.2436870
Burien Transit Center P&R	405,925	Park & Ride	47.4686800	-122.3389280
Lake Samish P&R	410,350	Park & Ride	48.6891980	-122.4006580
Tacoma WSP (Fuel)	413,008	Fuel Facility	47.1547910	-122.3957950
Kelso (Fuel)	423,083	Fuel Facility	46.1148670	-122.8906470
Bow Hill (SB)	425,707	Rest Area	48.5846693	-122.3465330
Bow Hill (NB)	428,063	Rest Area	48.5823305	-122.3443140
Toledo-Winlock P&R	470,991	Park & Ride	46.4747444	-122.8810863
Toutle River (SB)	476,507	Rest Area	46.3523303	-122.9079778
Toutle River (NB)	484,109	Rest Area	46.3509058	-122.9043190
South Bellingham P&R (West)	491,267	Park & Ride	48.7145255	-122.4751916
South Bellingham P&R (East)	503,533	Park & Ride	48.7134019	-122.4738960
Maytown (SB)	537,179	Rest Area	46.8710956	-122.9703582
Woodland (Fuel)	553,296	Fuel Facility	45.9140480	-122.7526450
Cook Road P&R	559,596	Park & Ride	48.5076090	-122.3371380
Scatter Creek (NB)	568,770	Rest Area	46.8353494	-122.9852501
Northwest Avenue P&R	575,376	Park & Ride	48.7824520	-122.5022920
George Hopper P&R	588,451	Park & Ride	48.4520510	-122.3356090

Kent (Fuel)	590,613	Fuel Facility	47.3645300	-122.2490800
Vancouver Admin (Aces) (Fuel)	593,549	Fuel Facility	45.6588060	-122.5597840
I-5 & SR 6 P&R	594,445	Park & Ride	46.6607504	-122.9764212
Burlington WSP (Fuel)	598,022	Fuel Facility	48.4872160	-122.3382820
Woodinville P&R	604,815	Park & Ride	47.7572290	-122.1528440
Chehalis WSP (Fuel)	607,936	Fuel Facility	46.6701090	-122.9806670
Allen Street P&R	609,192	Park & Ride	46.1450783	-122.8964882
SR 432 P&R	620,024	Park & Ride	46.1063426	-122.8795503
Chuckanut P&R	633,126	Park & Ride	48.4847292	-122.3373360
Smokey Point (SB)	635,961	Rest Area	48.1691077	-122.1942775
Mellen Street P&R	638,755	Park & Ride	46.7115406	-122.9769393
Woodland P&R	644,192	Park & Ride	45.9064399	-122.7414429
Kent Station Transit Center P&R	657,513	Park & Ride	47.3833527	-122.2324134
Smokey Point (NB)	658,339	Rest Area	48.1688486	-122.1888685
Mount Vernon (Fuel)	667,871	Fuel Facility	48.4064100	-122.3299390
Mount Vernon P&R	675,732	Park & Ride	48.4174710	-122.3330640
Stanwood I P&R	682,242	Park & Ride	48.2388240	-122.2440260
Tumwater(Mottman) (Fuel)	688,302	Fuel Facility	47.0253400	-122.9392090
BPA Park & Ride	689,839	Park & Ride	45.6602760	-122.6568690
Auburn P&R	693,420	Park & Ride	47.3208709	-122.2277600
Ridgefield P&R	719,718	Park & Ride	45.8167310	-122.6831500
Parkland Transit Center P&R	746,130	Park & Ride	47.1475380	-122.4344090
Marysville WSP (Fuel)	766,092	Fuel Facility	48.1003730	-122.1944870
Tumwater (Fuel)	770,345	Fuel Facility	46.9854100	-122.9122240
Gee Creek(SB)	780,756	Rest Area	45.7991472	-122.6806075
Vancouver (Fuel)	803,688	Fuel Facility	45.6520210	-122.6672870
I-5 & Hwy 531 P&R	828,281	Park & Ride	48.1522514	-122.1917355
Kent / James ST P&R	860,882	Park & Ride	47.3867300	-122.2432490
Gee Creek (NB)	883,884	Rest Area	45.7770803	-122.6695372
Olson Place & Myers Way P&R	917,188	Park & Ride	47.5224010	-122.3348180
Overlake Transit Center P&R	918,011	Park & Ride	47.6442177	-122.1333024
99th St P&R	954,423	Park & Ride	45.6922780	-122.6642510
Marysville II P&R	989,433	Park & Ride	48.1001290	-122.1850350
Renton Highlands P&R	994,916	Park & Ride	47.5062340	-122.1856410
Marysville Ash Avenue P&R	1,003,414	Park & Ride	48.0536670	-122.1836780
Aurora Village Transit Center P&R	1,036,109	Park & Ride	47.7749282	-122.3414652
Overlake P&R	1,038,365	Park & Ride	47.6327668	-122.1366555
Canyon Park P&R	1,089,210	Park & Ride	47.7943571	-122.2107595

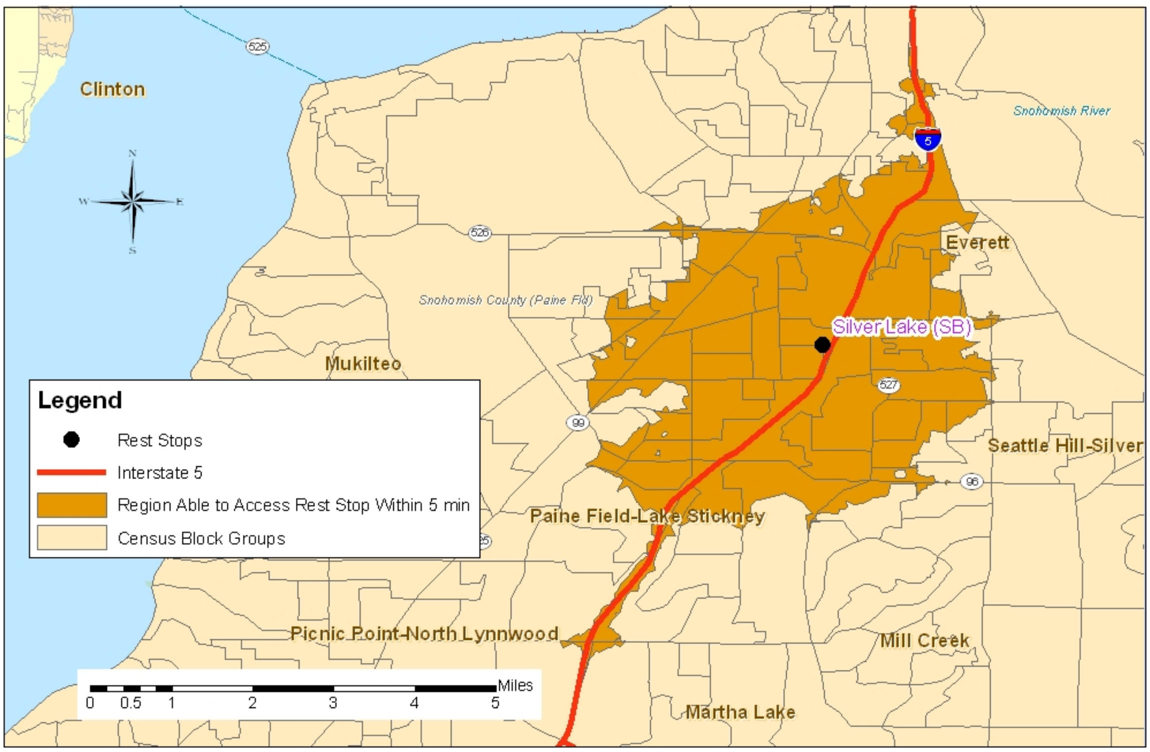
Edmonds P&R	1,093,869	Park & Ride	47.8056143	-122.3301429
Salmon Creek Park & Ride	1,107,581	Park & Ride	45.7183260	-122.6527760
Marysville I P&R	1,114,191	Park & Ride	48.0500080	-122.1832460
Shoreline P&R	1,170,257	Park & Ride	47.7677680	-122.3459000
Renton (Fuel)	1,173,972	Fuel Facility	47.4869880	-122.1824740
Federal Way/S 320th ST P&R	1,202,012	Park & Ride	47.3124733	-122.3005083
Bothell P&R	1,209,623	Park & Ride	47.7597570	-122.2014662
Redondo Heights P&R	1,226,538	Park & Ride	47.3552533	-122.3100492
Seattle (Ballinger) (Fuel)	1,231,854	Fuel Facility	47.7775600	-122.3406020
Center Street P&R	1,418,102	Park & Ride	47.2339792	-122.4968928
Peasley Canyon P&R	1,428,510	Park & Ride	47.3017520	-122.2572230
Federal Way Transit Center P&R	1,485,869	Park & Ride	47.3177160	-122.3032090
Silver Lake (SB)	1,549,909	Rest Area	47.9024510	-122.2155729
Lakeview (Fuel)	1,556,119	Fuel Facility	47.1593400	-122.4872590
Everett (Fuel)	1,604,009	Fuel Facility	47.9099300	-122.2226080
South Federal Way P&R	1,607,129	Park & Ride	47.2898700	-122.3229870
Kingsgate P&R	1,646,117	Park & Ride	47.7184350	-122.1876190
SeaTac (NB)	1,657,080	Rest Area	47.2711335	-122.3145569
72nd St. Transit Center P&R	1,706,138	Park & Ride	47.1919730	-122.4525325
Mariner P&R	1,720,960	Park & Ride	47.8786180	-122.2394730
Southwest Spokane ST P&R	1,724,406	Park & Ride	47.5714817	-122.3653663
Lake Geneva (Auburn) (Fuel)	1,733,929	Fuel Facility	47.2934430	-122.2865130
Tacoma Dome Station P&R	1,797,246	Park & Ride	47.2411120	-122.4249430
McCollum Park P&R	1,825,122	Park & Ride	47.8803180	-122.2196590
I-5 / SR 512 P&R	1,918,509	Park & Ride	47.1641560	-122.4834210
Star Lake P&R	1,921,940	Park & Ride	47.3579060	-122.2997670
Belleuve WSP (Fuel)	1,935,772	Fuel Facility	47.5843420	-122.1326990
SR 908/Kirkland Way P&R	1,993,462	Park & Ride	47.6792300	-122.1878560
Eastmont P&R	2,009,223	Park & Ride	47.9138030	-122.2069730
Renton Transit Center P&R Garage	2,106,638	Park & Ride	47.4812560	-122.2078190
Kent-Des Moines P&R	2,119,972	Park & Ride	47.3923747	-122.2874974
South Everett Freeway Station P&R	2,161,374	Park & Ride	47.8968636	-122.2156130
South Kirkland P&R	2,177,185	Park & Ride	47.6430010	-122.1971330
Lynnwood Transit Center P&R	2,178,263	Park & Ride	47.8157000	-122.2950980
Mountlake Terrace P&R	2,280,054	Park & Ride	47.7848875	-122.3152166
Houghton P&R	2,300,385	Park & Ride	47.6680352	-122.1853503
Mercer Island P&R	2,344,618	Park & Ride	47.5884140	-122.2317160

S Seattle WSP (Fuel)	2,373,043	Fuel Facility	47.4688000	-122.2870690
Fifth Ave NE/NE 133rd St P&R	2,421,924	Park & Ride	47.7260796	-122.3236866
South Bellevue P&R	2,424,537	Park & Ride	47.5865487	-122.1902297
North Jackson Park P&R	2,487,027	Park & Ride	47.7361475	-122.3235500
Ash Way P&R	2,501,921	Park & Ride	47.8498190	-122.2608140
South Renton P&R	2,525,873	Park & Ride	47.4717240	-122.2123520
Bellevue WSDOT (Fuel)	2,531,867	Fuel Facility	47.6410090	-122.1956390
Newport Hills P&R	2,581,888	Park & Ride	47.5562310	-122.1892030
North Seattle P&R	2,594,081	Park & Ride	47.7013650	-122.3284720
Northgate Transit Center East P&R	2,609,034	Park & Ride	47.7031651	-122.3258454
Seattle (Corson) (Fuel)	2,649,097	Fuel Facility	47.5456780	-122.3222640
Eastgate P&R	2,736,457	Park & Ride	47.5803059	-122.1523944
Northgate Transit Center P&R	2,869,000	Park & Ride	47.7031460	-122.3285110
Tukwila P&R	3,038,410	Park & Ride	47.4827441	-122.2689647
Wilburton P&R	3,045,906	Park & Ride	47.6025100	-122.1854370
Greenlake P&R	3,186,731	Park & Ride	47.6758530	-122.3200300
Airport & Spokane P&R	3,503,314	Park & Ride	47.5714060	-122.3227700
Signals (Fuel)	3,523,945	Fuel Facility	47.5705430	-122.3213730

Appendix D: Analysis of Individual Station Sites

To help establish the potential value of each rest area location from a fueling station viability perspective, traffic and population surrounding the potential station was analyzed. Population within five minutes driving time to a facility was used as a proxy to estimate the potential for the station to be used by local drivers. Exhibit D1 shows a map of the area around the Silver Lake southbound rest area and provides a visual depiction of the potential watershed for fueling station use from that area by local traffic. The shaded area represents population that could reach the rest area within a five minute drive. The higher than average population within a five minute drive makes the Silver Lake rest area a relatively attractive choice for the location of alternative fueling facilities.

Figure D1: Population within Five Minute Drive of the Silver Lake Rest Area



Studies show that a large percentage of consumers refuel within 5 minutes of their home[1]. Due to this factor, the number of people close to the potential rest area station determines its value to the surrounding community. Although, motivated alternative fuel customers may live more than five minutes from their nearest station, in general, demand decreases from surrounding zones as distance increases.

Another way to determine the economic viability of a rest area location is to see how much traffic surrounds the station, particularly I-5 traffic. Similarly to how population was totaled for census block groups in the shaded region in Figure C1, vehicle miles traveled (VMT) based on national highway planning network data were totaled. VMT near a station gives a sense of how many people pass by a station. Since all of the rest area stations are along I-5, the VMT numbers are relatively high. The results from both the traffic and population summations can be seen in Exhibit D2 and Exhibit D3.

Figure D2: Population within Five Minute Drive to Rest Area

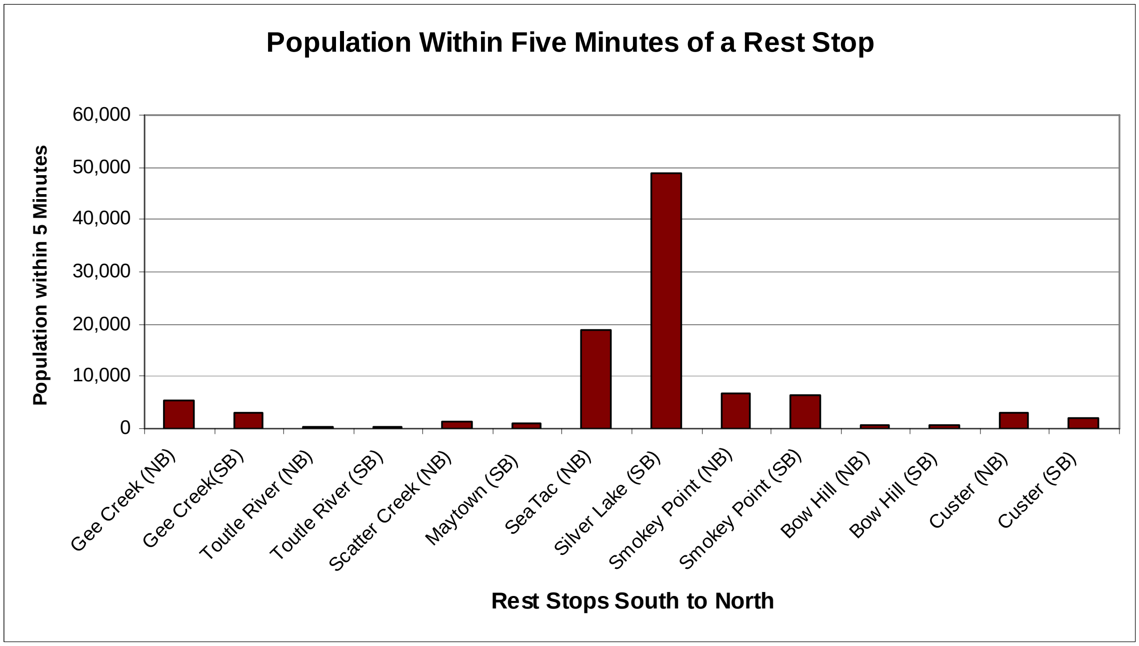
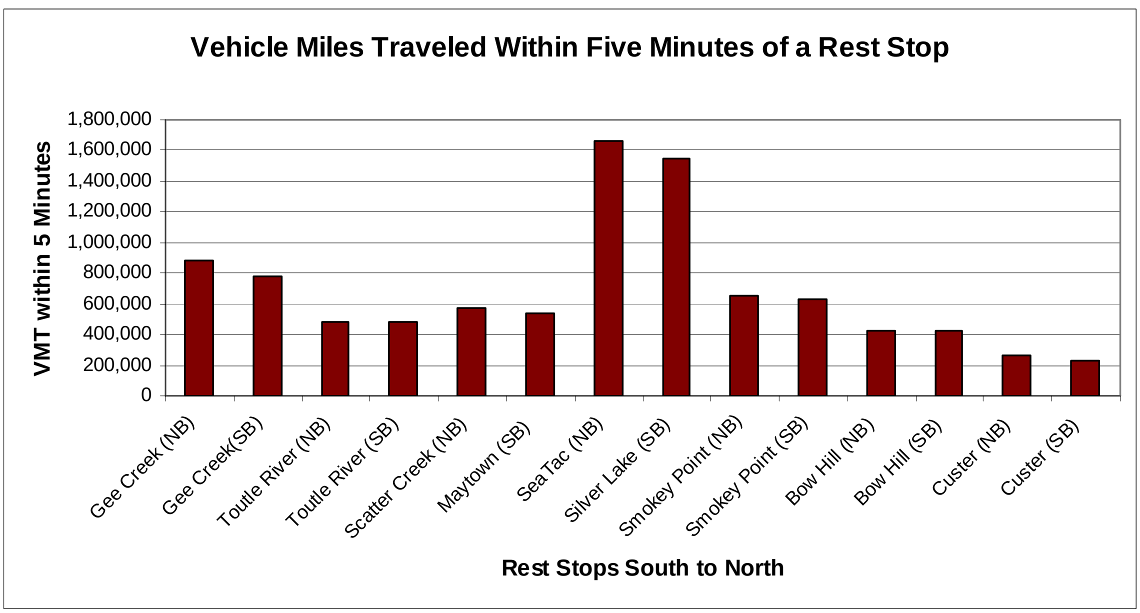


Figure D3: Traffic within Five Minute Drive to Rest Area



The salient feature of Exhibit D2 is that population surrounding a site is not very large except for the SeaTac and Silver Lake rest areas. This indicates that only those two may serve any appreciable amount of local traffic. Conversely, due to the high volume of traffic on I-5, VMT is relatively large surrounding rest stops (Exhibit D3). This indicates that there is a good potential to serve inter-regional travel. To put these numbers in context, Exhibit D4 and D5 compare the rest stop values to maintenance fuel facilities which are in a more urban setting.

Exhibit D4: Comparison of Rest Areas and Maintenance Fuel Facilities (Population)

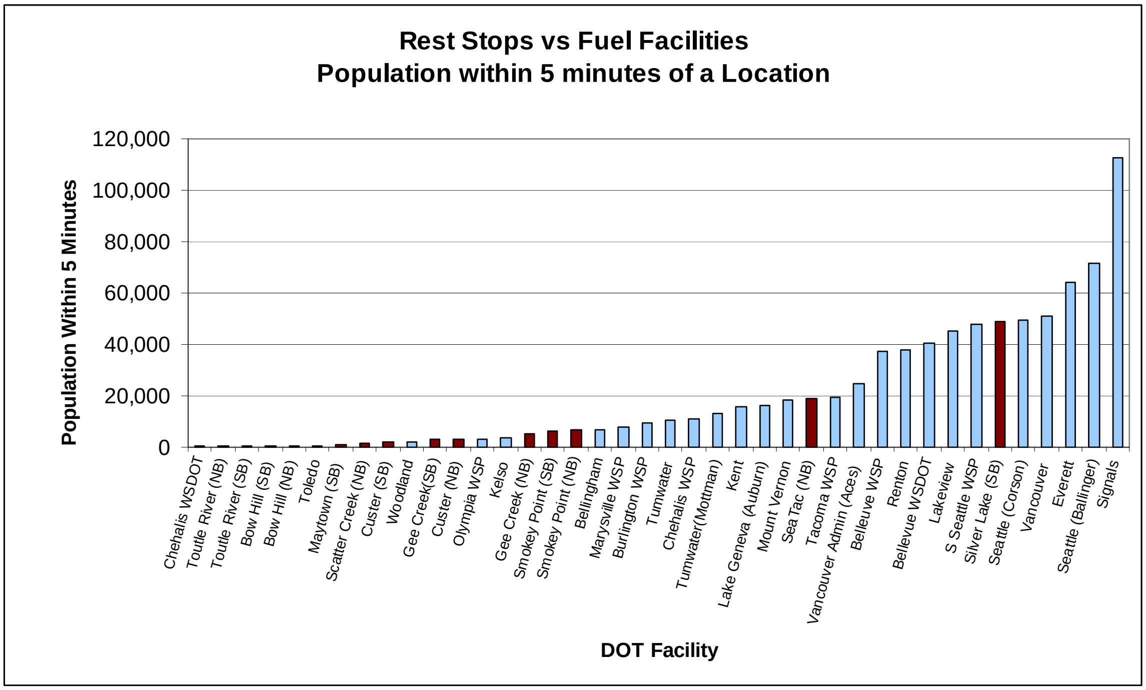
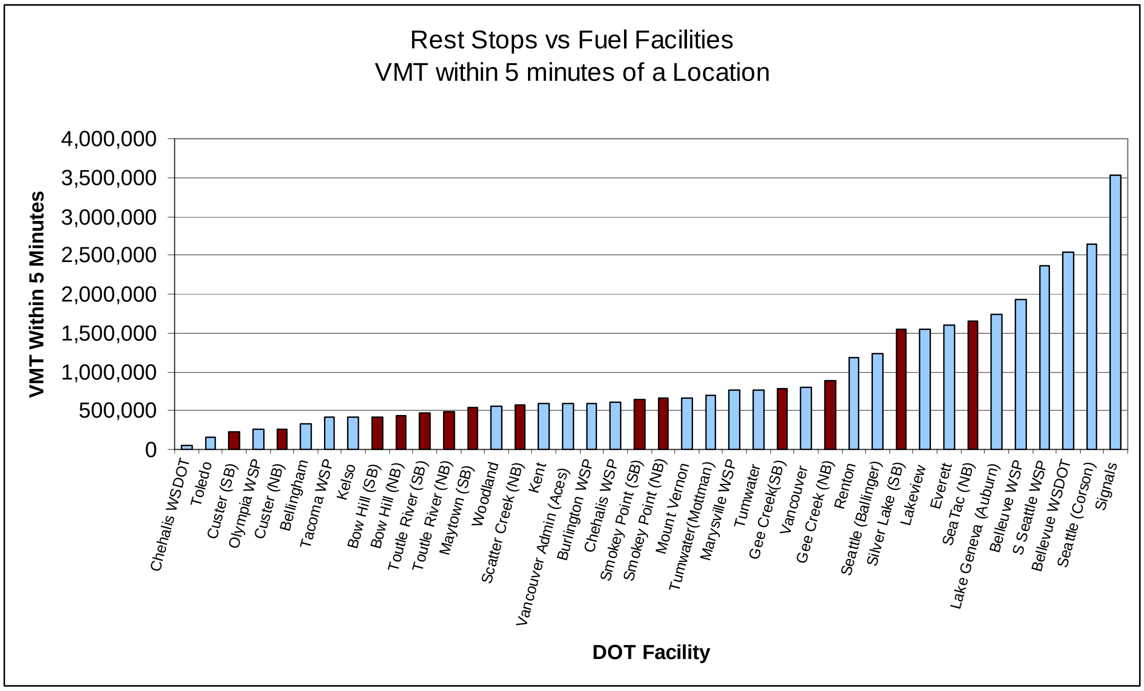


Exhibit D5: Comparison of Rest Areas and Maintenance Fuel Facilities (VMT)



The facilities are listed ordinally from smallest to largest. Notice that maintenance facilities (lighter bars) are generally located near larger population centers, implying they may better the home based (local) traffics' fueling needs. Exhibit D4 shows that rest areas do indeed rank low in the number of people in the immediate proximity indicating that rest area locations will not be the main station for many people. Looking at VMT (Exhibit D5) however, the rest areas rank relatively higher compared to the figure ranking population. This indicates that there is a good potential to serve customers who may pass through and are far from home. Park and ride facilities are very similar in access characteristics to maintenance fuel facilities. A full list of all facility types and the metrics that describe them are in Appendices B and C.

Appendix E: Hydrogen Refueling Equipment Supplement

There are several refueling station technologies that could be employed. For 2010-2015, we consider 100 kg/day stations; from 2015-2025, 1000 kg/day stations.

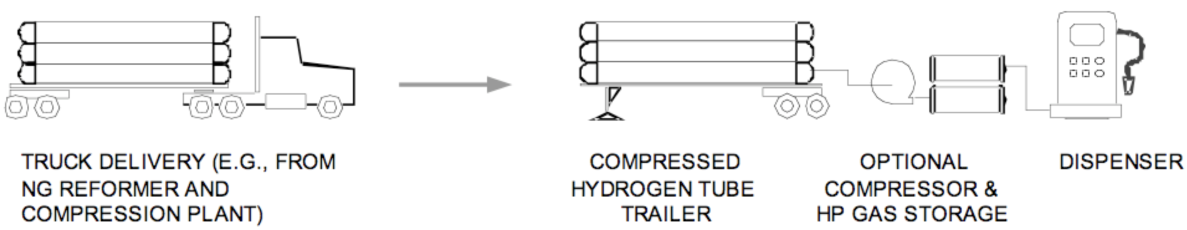
Three types of stations are considered in this analysis (with potential station sizes):

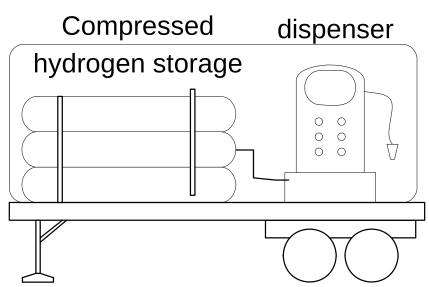
- Mobile refueler stations (100 kg/d)
- Liquid H_2 stations with truck delivery (100 kg/d; 1000 kg/d)
- Onsite Steam Methane Reforming (SMR) stations (100 kg/d; 1000 kg/d)

Mobile Refueler Stations

This is the simplest type of hydrogen refueling station. It consists of high-pressure gaseous hydrogen storage and a dispenser, mounted into a mobile trailer. The refuelers are towed to and from hydrogen production facilities so that the hydrogen tank can be refilled when needed. This type of hydrogen supply is being used in several sites in California. This is a very flexible type of station since they do not need to have any permanent fixed equipment and everything is self-contained on the truck trailer (see Exhibit E1). This allows refueling sites to be added or changed as the need arises.

Exhibit E1: Types of Mobile Refuelers





Hydrogen Mobile Refuler

Equipment costs for mobile refueler stations have been estimated for 10 kg/day units by Weinert and Lipman. To estimate costs for a 100 kg/day unit, we adapt information from the H2A delivery model. We assume that a truck trailer is delivered to the station site, and attached to a dispenser. Two types of mobile refuelers are shown. In the first, compressed gas is delivered at 2700 psi, and a compressor at the station brings it to the required pressure for dispensing to compressed gas vehicles. In the second, we show a costs for a higher pressure mobile refueler (7000 psia), which requires no compressor. Note that we have added the capital cost of the tube trailer to the mobile refueler total. If the state contracted with a hydrogen supplier, this cost could be avoided and it would become part of the cost of delivered hydrogen instead.

Exhibit E2: Compressed Tube Trailer H_2 station equipment costs [H2A current technology]

Source	H_2 compressor	H2 Storage	Truck Trailer (incl. H_2 storage tubes)	Dispensers	Controls, safety	Other (engineering, permitting, etc.	TOTAL CAPITAL COST ($)
H2A - 100 kg/d 2700 psia tube trailer delivery; compression at station to 7000 psi	$39,573 Max rate 100 kg/day	$31,084 38 kg @ $899/kg	$165,000 9 gas tubes; 280.3 kg of deliverable H2 @ 2700 psi)	1 @ $26,880 each	$22,320	$26,968	$292,583
H2A - 100 kg/d 7000 psia tube truck delivery, no compressor needed.	-		$350,000 (1 gas tube holding 420 kg of deliverable H2 @ 7000 psi)	1 @ $26,880 each	$22,320	$26,968	$403,848

Typical operating costs include rent for land, electricity for compression (for the 2,700 psia case, cost for purchasing compressed hydrogen to fill the truck plus truck operating costs (the purchase price is assumed here to be $10/kg) and fixed O&M costs equal to 13% of the capital cost (see Exhibit E3). The footprint of a mobile refueler station would be modest, about 2,206 sq. ft. [H2A 2007]. These mobile refueler stations do not provide a good value in terms of cost per unit of hydrogen relative to other methods, but they do have low capital costs and provide the flexibility for siting and potentially moving smaller stations that may be needed for connectivity and reliability even if they are underutilized.

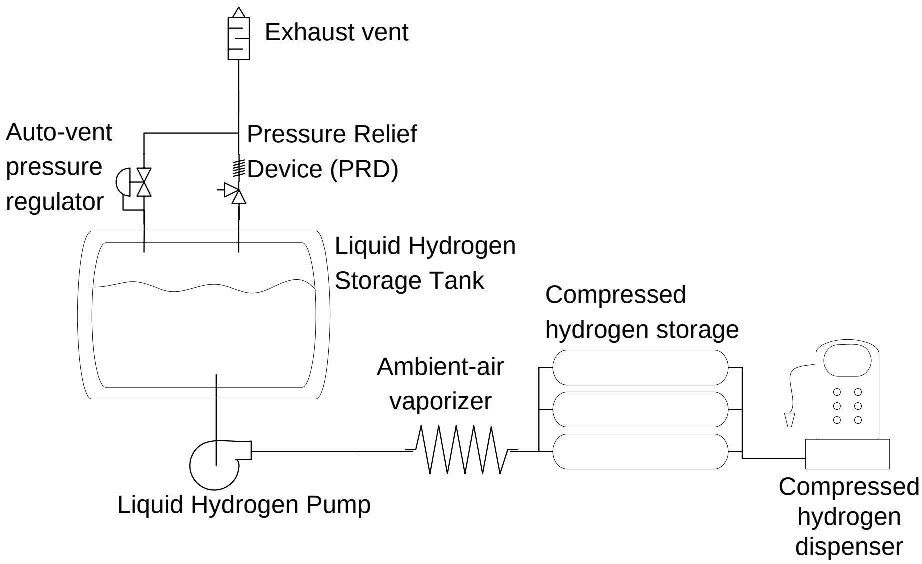
Exhibit E3: Operating Costs for Mobile Refueler Hydrogen Station ($/yr) [Adapted from (H2A 2007)]

Station Type	Station Capacity kg/d	Land (2206 sq. ft; $0.5/sq.ft/mo.)	Purchased compressed gas H2 (25,550 kg/y @$10/kg)	Electricity (2.15 kWh/kg; $0.08/kWh)	Fixed O&M (13% of capital cost)	TOTAL O&M
Mobile Refueler station – 2700 psi delivery	100	$13,236	$255,500	$4,395	$38,036	$311,166
Mobile Refueler station – 7000 psi delivery	100	$13,236	$255,500	-	$52,500	$325,631

Liquid H_2 stations with truck delivery

Liquid H_2 (LH_2) refueling stations that take delivery of liquid hydrogen have the possibility of dispensing either liquid or compressed hydrogen. Most current stations have liquid delivery and storage, and dispense fuel as compressed H_2. A typical configuration of a LH_2 station that dispenses compressed H_2 is shown in Figure 6 below. Liquid H_2 is used for delivery and storage because of its relatively higher density than compressed H_2. It is converted to compressed H_2 since most current and planned fuel cell vehicles use compressed gas at either 350 or 700 bar storage pressure.

Exhibit E4: Liquid hydrogen station dispensing compressed gas.



The key components of the system are the LH_2 storage tank with safety equipment to prevent overpressures from boiloff, and the cryogenic hydrogen pump and vaporizer, which conserve energy by pumping a liquid to pressure before vaporizing rather than compressing a gas. Once hydrogen is vaporized, it can be compressed further before dispensing onto a compressed gas vehicle. Exhibit E5 shows a site plan for a 100 kg/day liquid hydrogen system located within a gasoline station (H2A 2007).

Exhibit E5: Site Plan for Liquid Hydrogen System at Gasoline Station (H2A 2007; Weinert and Lipman 2006).

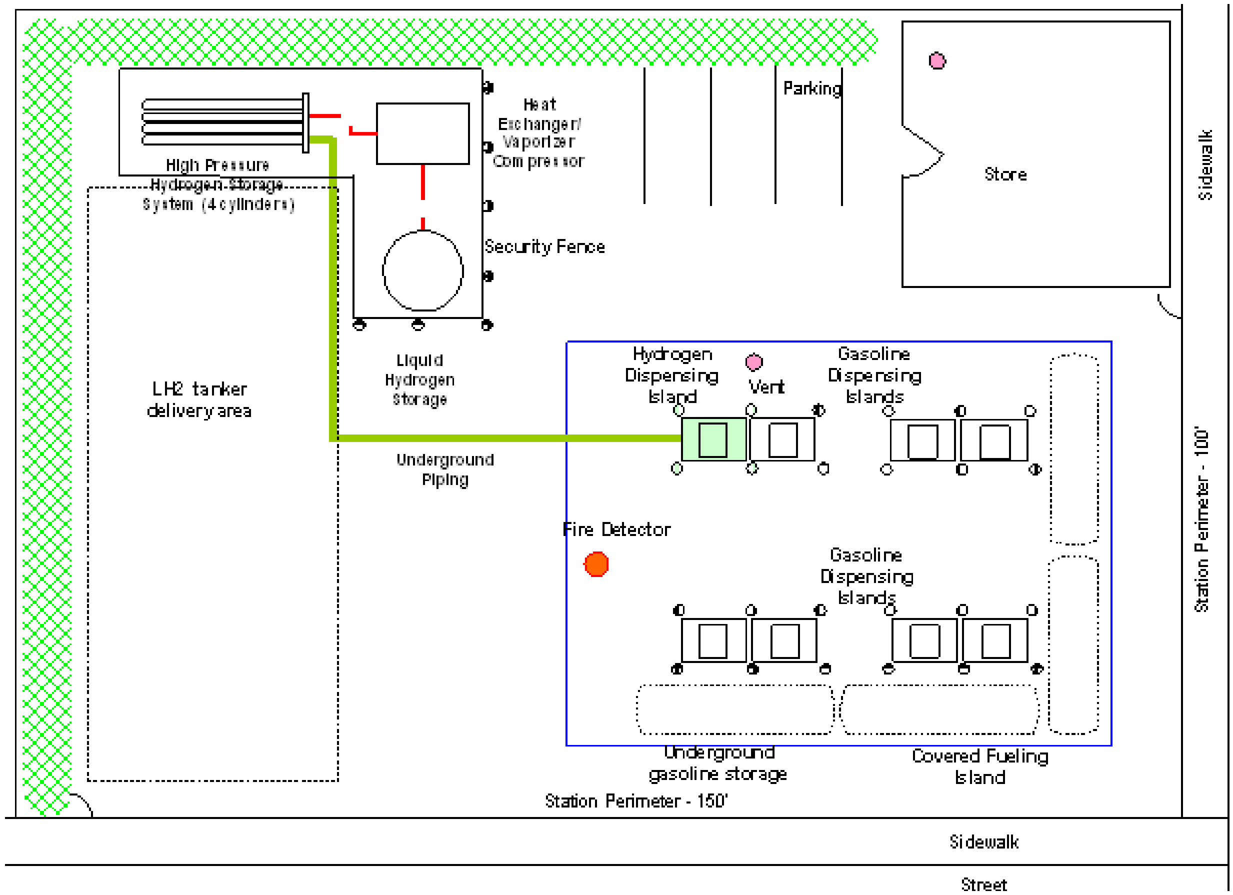


Exhibit E6 gives a capital cost breakdown for LH_2 refueling station equipment from several recent studies. Exhibit E7 shows operating costs from these studies. In Exhibits E6 and E7, we have adapted these studies to estimate station costs for 100 kg/day stations using current technology, and 1000 kg/day stations using current and future (2015) technologies. Liquid hydrogen is a useful method of storing and transporting hydrogen to a refueling station. It has high density so that it is possible to transport approximately 10 times more hydrogen on a truck than when using compressed gas. This can significantly lower the delivered cost of H_2, especially when transport distances are moderate or long. In the longer term (beyond the scope of this project timeframe), pipelines will also be a competitive method for transporting hydrogen, and can significantly lower costs and energy use associated with transporting hydrogen if large volumes (associated with supplying hundreds or thousands of stations) are needed (Yang and Ogden 2007).

Exhibit E6: Liquid H_2 station equipment installed costs [1, 2, 6, 7]

Source	LH_2 storage	LH_2 pump	Compressed H_2 storage	Dispensers	Safety equipment, controls, site prep. engineering	Life
H2A 1500 kg/day (2015 technology)	$40/kg 4488 kg H_2	$29,638 100 kg/hr	$899/kg 358 kg H_2	3 @ $26,880 each		20 yrs
H2A 100 kg/day (current tech)	1576 kg $176,504	2 pumps (7 kg/h each) + evaporator $90,428 + 7920	38 kg H2 $31,084	1 @$26,880	22,320 + 79,906	20 years
Yang and Ogden 500-3000 kg/day (2015 technology)	$226866\left(\frac{size[kg]}{8219.2}\right)^{0.7}$ 200% of daily flow	$60820\left(\frac{Flow[kg/hr]}{114}\right)^{0.7}$ 100% of station flow	$592/kg 10% of daily flow	$44,400 each 1 per 500 kg/day capacity		15 yrs, 10 yr for pump
Weinert 1000 kg/day Current technology	$463,681 3400 kg H_2	$218,507 1000 kg/day	$1,102,748 667 kg H_2	$127,130 for 3		15 yrs
NAS – current 1800 kg/day	$531(size[kg])^{0.7}$	$377,251 1800 kg/day	$288,065 405 kg H_2	4 @ $15,000 each		14%[1]
NAS – future 1800 kg/day	$206(size[kg])^{0.7}$	$226,350 1800 kg/day	$144,032 405 kg H_2	4 @ $8,000 each		14%[1]

[1]Lifetime not specified, only equipment capital cost

Exhibit E7: Liquid H_2 Station Operating Costs

Source	Yang and Ogden	NAS	Weinert	H2A
Land	[15000 + $S_{station}$] ft^2 $0.50/$ft^2$/month	--	1200 ft^2 $0.50/$ft^2$/month	15000 ft^2 $0.50/$ft^2$/month
Fixed	7.5% of capital cost	8% of capital cost	8% of capital cost	11% of capital cost
Electricity	0.81 kWh/kg	0.8 kWh/kg	0.8 kWh/kg	0.33 kWh/kg

Exhibit E8: Summary of LH_2 Station Equipment Capital Costs

Station Type	Station Capacity kg/d	H_2 storage	LH_2 pump	H_2 compressor and gas storage	H_2 dispensing	Other (engineering, installation, permitting, etc.)	TOTAL STATION CAPITAL ($)
LH2 truck delivery (H2A current tech)	100	1576 kg $110,315	2 pumps (7 kg/h each) + evaporator $90,428 + 7920	38 kg H2 $31,084	1 disperser @$26,880	$87,333	$353,960
LH2 truck delivery (Weinert - current tech)	1000	$463,681 3400 kg LH2 storage	$218,507 1000 kg/d pump capacity	$1,102,487 667 kg compressed gas storage	$127,130 3 dispensers	-	$1,911,805
LH2 truck delivery (2015 tech - Yang and Ogden)	1000	$84,355 (2000 kg LH2 storage)	$30,065 (1 LH2 pump 42 kg/h)	$59,200 100 kg compressed gas storage	$88,800 (2 dispensers)	-	$262,420

Exhibit E9: Summary of Operating Costs for LH_2 stations

Station Type	Station Capacity kg/d	Footprint of H_2 related equipment	Land rent ($0.5/sq/ft/ month, for 15,000 sq. ft. station	Purchased LH_2 (assuming $5/kg price for LH_2 truck delivered to station)	Electricity (0.81 kWh/kg; 8 cents/kWh)	Fixed (7.5% of capital cost/yr)	TOTAL O&M $/year
LH2 truck delivery (H2A current tech)	100	2206 sq. ft	$90,000	$127,750	$1,635	$31,530	$250,915
LH2 truck delivery (Weinert - current tech)	1000	1200 sq. ft	$90,000	$1,277,500	$16,352	$152,944	$1,536,796
LH2 truck delivery (2015 tech)	1000	7200 sq. ft	$90,000	$1,277,500	$16,352	$19,682	$1,403,534

Onsite Steam Methane Reforming (SMR)

Several recent studies indicate that distributed (or onsite) production of hydrogen from natural gas at refueling stations is an attractive option for early hydrogen supply to vehicles. Hydrogen can be produced in a small-scale Steam Methane reformer (SMR) located at the station, avoiding the cost and complexity of hydrogen delivery. Alternatively, distributed production requires less capital investment than central production, which would be useful during a transition to hydrogen vehicles. Similar H_2 compressors, storage tanks, and fuel dispensing equipment would be included at each site regardless of SMR or delivery approaches.

A number of companies have developed small SMR systems ranging in size from tens to several hundred kilograms per day. It is likely that larger onsite reformers in the range of 1000-1500 kg/d will become available over the next 5 years.

Exhibits E10 – E12 show a sketch of an onsite SMR system, and site plans for integrating small and large SMRs into gasoline stations.

Exhibit E10: Hydrogen refueling station employing a small-scale steam methane reformer

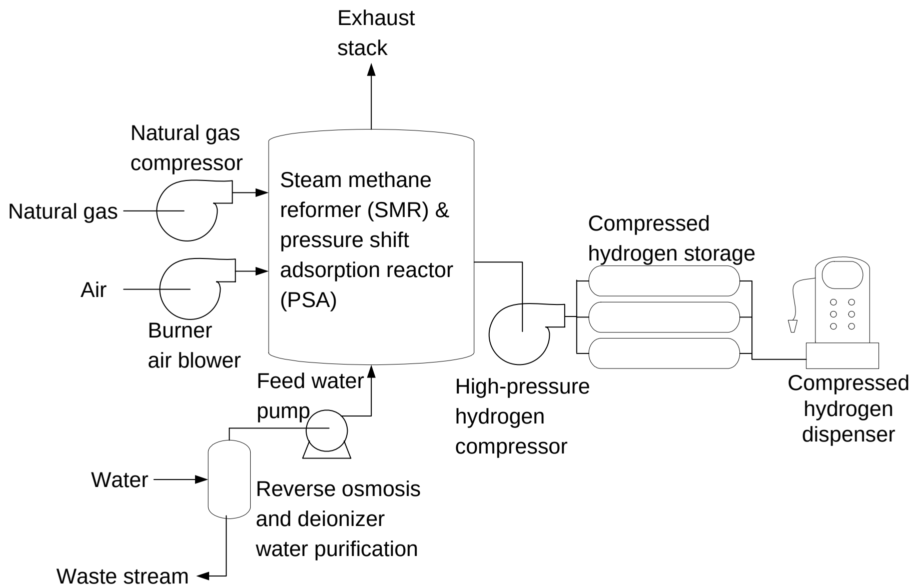


Exhibit E11: H2A Site Plan diagram for 100 kg/day reformer station

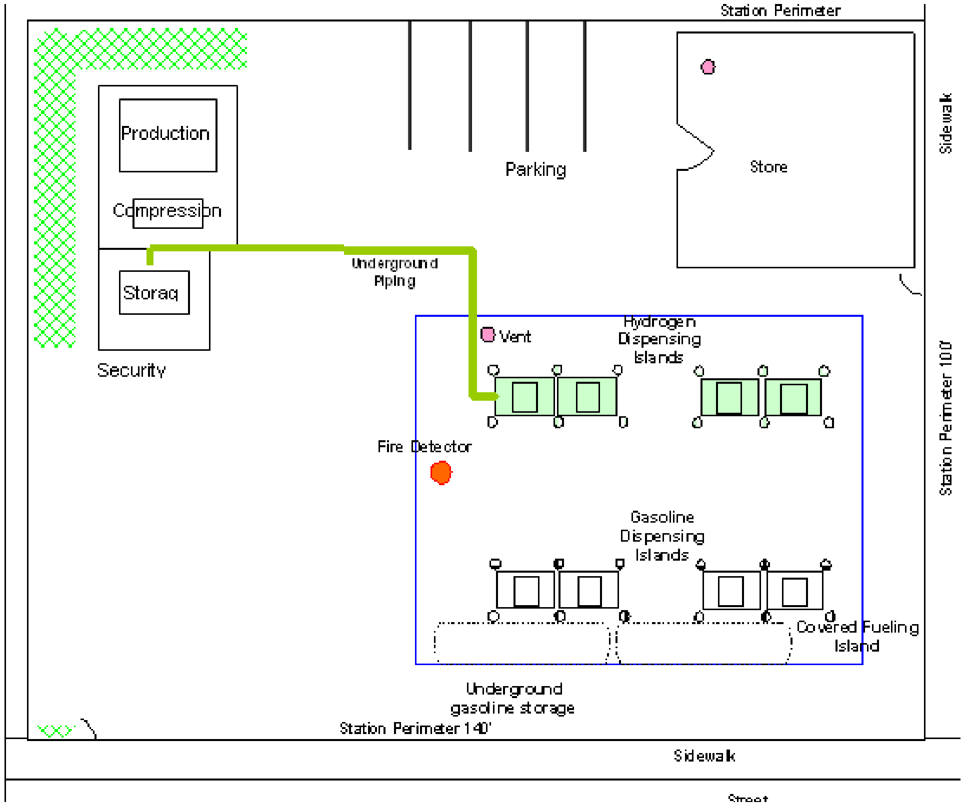
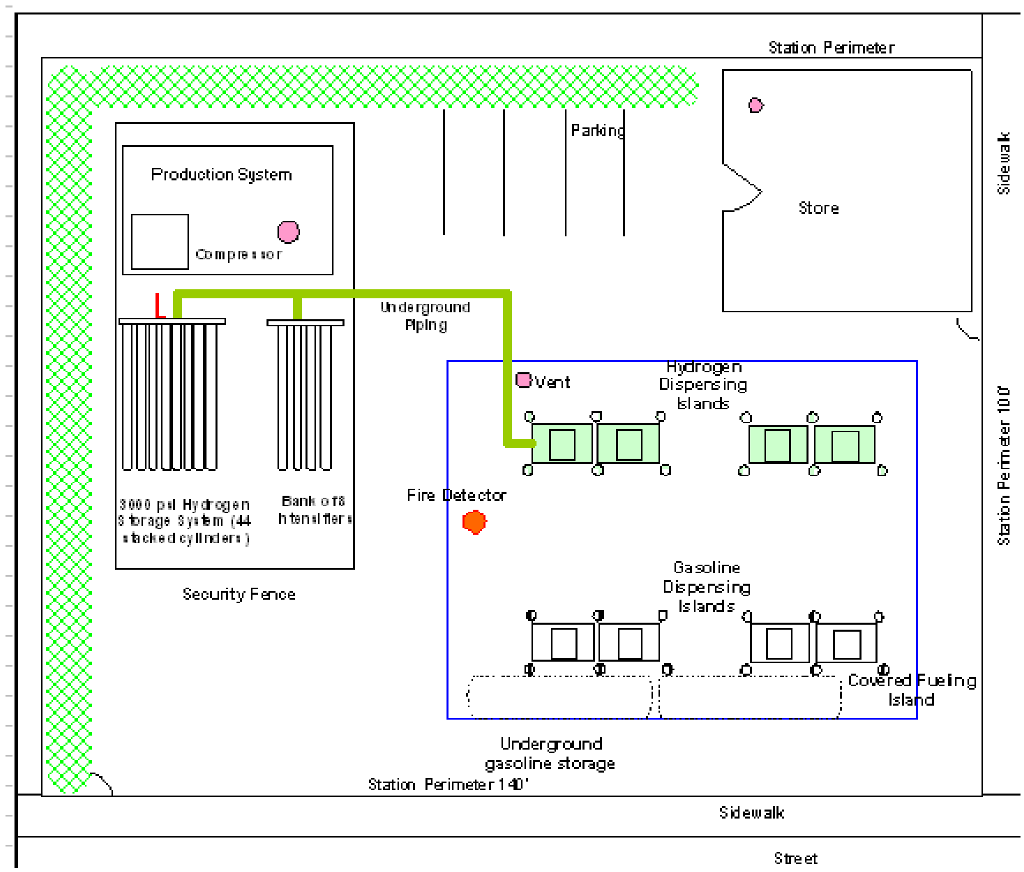


Exhibit E12: H2A Site Plan diagram for 1500 kg/day reformer station



Exhibits E13 and E14 give performance and cost data for onsite SMR systems from several recent studies. In Exhibits E15 and 16 we have adapted these estimates for 100 and 1,000 kg/day stations. Large stations could also require natural gas lines to be upgraded, resulting in additional costs, not included in these tables.

Exhibit E13: Energy Inputs for Small Scale Onsite Natural Gas Steam Reforming

Literature Source	NG use (MMBTU/kg H_2)	Electricity use[1] (kWh/kg H_2)	System Efficiency
H2A 2005	0.17	2.9	63%
NAS Current	0.19	2.2	58%
NAS Future	0.16	1.7	69%

1. Electricity use for distributed SMR includes compression and station operation needs.

Exhibit E14: The Small-scale reformer system costs from DOE H2A model.

System	Reformer size [kg H_2/day]	Reformer station cost[1] [$]	Fixed non-fuel O&M[2] [%cap/yr]
SMR, near-term	100	$473,381	10%
SMR, near-term	1500	$3,225,136	6%
SMR, med-term	100	$396,724	11%
SMR, med-term	1500	$2,178,099	7%

1. Station cost does not include land costs
2. Land rental included in fixed O&M cost

Exhibit E15: Capital Costs for Onsite SMR Stations

Station Type	Station Capacity kg/d	H_2 production	H_2 storage	H_2 compressor	H_2 dispensing	Other (engineering installation)	TOTAL CAPITAL ($)
Onsite SMR (Weinert -current tech)	100	$382,000	$197,000	$52,000	$42,000	$375,000	$1,048,000
Onsite SMR (Weinert - current tech)	1000	$1,467,000	$2,372,000	$171,000	$127,000	$998,000	$5,135,000
Onsite SMR (2015 tech; Yang and Ogden, adapted from H2A)	1000	$787,994	$338,268	$274,085	$64,344	$216,603	$1,681,295

Exhibit E16: Operating Costs for Onsite SMR stations ($/yr).

Station Type	Station Capacity kg/d	Land	NG	Electricity	Fixed O&M	TOTAL O&M
Onsite SMR (Weinert current tech)	100	$90,000	$31,439	$5,928	$78,600	$205,966
Onsite SMR (Weinert - current tech)	1000	$90,000	$314,389	$59,276	$385,125	$848,790
Onsite SMR (2015 tech)	1000	$90,000	$306,600	$59,276	$118,919	$574,795

Natural gas use in onsite reformers is assumed to be 1.35 GJ natural gas/GJ hydrogen produced (Yang and Ogden 2007).

Fixed costs are assumed to be 7.5% of capital costs per year. (Yang and Ogden 2007)

Electricity use is 0.8 kWh/kg for compression.

Appendix F: List of Incentives and Laws at the Federal Level and For the States of Washington, Oregon, and California[97]

Federal Incentives and Laws

Incentives

Advanced Technology Vehicle (ATV) Manufacturing Incentives

Alternative Fuel Excise Tax Credit

Alternative Fuel Infrastructure Tax Credit

Biobased Transportation Research Funding

Biodiesel Income Tax Credit

Biodiesel Mixture Excise Tax Credit

Biomass Research and Development Initiative

Fuel Cell Motor Vehicle Tax Credit

Heavy-Duty Hybrid Electric Vehicle (HEV) Tax Credit

Improved Energy Technology Loans

Light-Duty Hybrid Electric Vehicle (HEV) and Advanced Lean Burn Vehicle Tax Credit

Qualified Alternative Fuel Motor Vehicle (QAFMV) Tax Credit

Qualified Plug-In Electric Drive Motor Vehicle Tax Credit

Renewable Energy Systems and Energy Efficiency Improvements Grant

Small Agri-Biodiesel Producer Tax Credit

Small Ethanol Producer Tax Credit

Value-Added Producer Grants (VAPG)

Volumetric Ethanol Excise Tax Credit (VEETC)

Laws and Regulations

Aftermarket Alternative Fuel Vehicle (AFV) Conversions

Alternative Fuel Definition

Alternative Fuel Definition - Internal Revenue Code

[97] Source: http://www.afdc.energy.gov/afdc/incentives_laws.html accessed Novembre 2008

Alternative Fuel Tax Exemption

Clean Air Act Amendments of 1990

Corporate Average Fuel Economy (CAFE)

High Occupancy Vehicle (HOV) Lane Exemption

Idle Reduction Equipment Excise Tax Exemption

Idle Reduction Facilities Regulation

Import Duty for Fuel Ethanol

Renewable Fuel Standard (RFS) Program

Tier 2 Vehicle and Gasoline Sulfur Program

Updated Fuel Economy Test Procedures and Labeling

Vehicle Acquisition and Fuel Use Requirements for Federal Fleets

Vehicle Acquisition and Fuel Use Requirements for Private and Local Government Fleets

Vehicle Acquisition and Fuel Use Requirements for State and Alternative Fuel Provider Fleets

Vehicle Incremental Cost Allocation

Programs

Air Pollution Control Program

Alternative Transportation in Parks and Public Lands Program

Biobased Products and Bioenergy Program

Clean Agriculture USA

Clean Cities

Clean Construction USA

Clean Fuel Fleet Program (CFFP)

Clean Fuels Grant Program

Clean Ports USA

Clean School Bus USA

Congestion Mitigation and Air Quality (CMAQ) Improvement Program

National Clean Diesel Campaign (NCDC)

National Fuel Cell Bus Technology Development Program (NFCBP)

Pollution Prevention Grants Program

SmartWay Transport Partnership

State Energy Program (SEP) Funding

Voluntary Airport Low Emission (VALE) Program

Washington State Incentives and Laws

State Incentives

Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (HEV) Tax Exemption

Electric and Plug-In Hybrid Electric Vehicle Demonstration Grants

Biofuels Retail Tax Exemption

Biofuels Tax Deduction

Biofuels Production Tax Exemption

Idle Reduction Tax Incentives

Alternative Fuel Vehicle (AFV) Annual Fee

Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (HEV) Emission Inspection Exemption

State Laws and Regulations

Renewable Fuel Standard

Biofuels Standards Program

E85 Definition

Biodiesel Definition

Biodiesel Storage

Low Emission Vehicle Standards and Sales Requirements

Idle Reduction Weight Exemption

Alternative Fuel Vehicle (AFV) Identification Requirement

Medium-Speed and Neighborhood Electric Vehicle (NEV) Access to Roadways

Electric Vehicle (EV) Recharging at State Buildings

Biodiesel Use Requirement

Alternative Fuel Use Requirement

Clean Fuel Vehicle Purchasing Requirement

State Fleet Petroleum Reduction

Biofuels Production Contracts

Clean School Bus Funding

Climate Change and Reduced Petroleum Dependence Initiative

Regional Climate Initiative

Global Warming Mitigation Initiative - King County

Fleet Action Plan - Seattle

Utilities/Private Incentives

Natural Gas Technical Assistance

Oregon Incentives and Laws

State Incentives

Biofuels Use Tax Credit

Biofuels Production Property Tax Exemption

Alternative Fuel Production Facility and Fueling Infrastructure Tax Credit

Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (HEV) Tax Credit

Alternative Fuel Loans

Idle Reduction Incentives

Biofuels Production and Distribution Grants - Portland

Portland Biofuels Fueling Infrastructure Grants

State Laws and Regulations

Renewable Fuels Mandate

Biodiesel Quality Testing Procedures

Biofuels Program Impact Studies

Idle Reduction Weight Exemption

Low Emission Vehicle (LEV) Standards

Vehicle Registration Requirement

Hydrogen Promotion

Global Warming Mitigation Initiative

Alternative Fuel Vehicle (AFV) Acquisition and Fuel Use Requirements

Pollution Control Equipment Exemption

Electric Vehicle (EV) and Hybrid Electric Vehicle (HEV) Registration Fees

Low-Speed Vehicle Access to Roadways

Portland Renewable Fuels Mandate

Portland Biofuels Use Requirement

Utilities/Private Incentives

There are currently no known utility or private incentives offered in Oregon.

California Incentives and Laws

State Incentives

Idle Reduction Incentives

Alternative Fuel Incentive Development

Alternative Fuel Vehicle (AFV) Rebate Program

Alternative Fuel Research and Development

High Occupancy Vehicle (HOV) Lane Exemption

Funding for Emission Reductions

Alternative Fuel Vehicle (AFV) and Refueling Infrastructure Grants and Loans

Lower-Emission School Bus Grants

Alternative Fuel Research and Development

Vehicle Emission Reduction Grants - Sacramento

Funding for Heavy-Duty Vehicle Emission Reductions - Sacramento

Funding for Air Quality Improvement Programs - Ventura County

Alternative Fuel Vehicle, Refueling Infrastructure and Idle Reduction Grants - San Joaquin Valley

Low-Emission Vehicle Incentives and Technical Training - San Joaquin Valley

Funding for Emission Reductions - South Coast

Technology Advancement Funding - South Coast

Natural Gas Vehicle Home Fueling Infrastructure Incentive - South Coast

Alternative Fuel and Advanced Technology Vehicle and Infrastructure Incentives – Vacaville

Electric Vehicle (EV) Parking Incentive - Sacramento

Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (HEV) Parking Incentive - Los Angeles

Clean Vehicle Parking Incentive - Hermosa Beach

Hybrid Electric Vehicle (HEV) and Zero Emission (ZEV) Vehicle Parking Incentive - San Jose

Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (HEV) Parking Incentive - Santa Monica

Electric Vehicle (EV) Parking Incentive - Los Angeles Airport

State Laws and Regulations

West Coast Global Warming Mitigation Initiative

Low-Carbon Fuels

Emission Reduction Requirements

Alternative Fuels Plan

Alternative Fuel Vehicle (AFV) Acquisition Requirements

Truck Idle Reduction Requirement

School Bus Idle Reduction Requirement

Hydrogen Energy Plan

Hydrogen Specifications

Biofuels Use

Biofuels Specifications

Biofuels Production Mandate and Alternative Fuel Use Study

Alternative Fuel Vehicle (AFV) Program Support

Zero Emission Vehicle (ZEV) Production Requirements

Alternative Fuel Vehicle (AFV) License

Alternative Fuel Tax

Low-Speed Vehicle Access to Roadways

Emission Reduction Non-Attainment Fee

Biodiesel Blend Use Requirement - San Francisco

Heavy-Duty Idle Reduction Requirement - Sacramento

Emissions Reduction Requirements - San Joaquin Valley

Public Agency Fleet Emissions Reduction Requirements - South Coast

Neighborhood Electric Vehicle (NEV) Access to Roadways - Placer County

Utilities/Private Incentives

City of Riverside Employee Vehicle Purchase Incentives

Alternative Fuel Vehicle (AFV) and Hybrid Electric Vehicle (AFV) Insurance Discount

Compressed Natural Gas (CNG) Taxi Incentive

Electric Vehicle (EV) Recharging Rate Reduction

Electric Vehicle (EV) Recharging Rate Reduction - Los Angeles

Southern California Edison Rate for Electric Vehicles (EV)