Scenarios Analysis
For Penetration of XTL Fuels

Ver: 5/30/2007

ABSTRACT

This paper presents California Energy Commission (Energy Commission) staff's analysis of the value of future development of three synthetic diesel fuel blends as replacements for and supplements to conventional petroleum-based diesel for California's transportation fuels market to the year 2050. Collectively referred to as XTLs, the blends include gas-to-liquid (GTL), coal-to-liquid (CTL), and petroleum coke-to-liquid (PTL). This paper employs the AB 1007 Full-Fuel Cycle Analysis results and quantifies the emissions implications with the various XTL scenarios evaluated.

Staff analyzed the effects of monetary and non-monetary incentives and mandates, their cost-effectiveness in obtaining petroleum and emissions reductions, and the sufficiency of consumer demand and expected XTL supply. Based on numerous findings, staff concluded that XTL fuels have the potential to significantly displace petroleum demand and to reduce emissions and, thus, are worthy of further exploration. Staff generated price supply curves for scenarios where XTLs were mandated or incentivized to displace 10 to 40 percent of diesel demand by 2030 – 2050.

Key Words: XTL, XTLs, GTL, CTL, PTL, gas-to-liquid, coal-to-liquid, petroleum coke-to-liquid, diesel fuel blends, synthetic diesel fuels, synthetic diesel blends.

INTRODUCTION AND OVERVIEW

This paper presents California Energy Commission (Energy Commission) staff's analysis of the value of future development of three synthetic diesel fuel blends to replace and supplement conventional petroleum-based diesel for California's transportation fuels market to the year 2050. Collectively referred to as XTLs, the blends include gas-to-liquid (GTL), coal-to-liquid (CTL), and petroleum coke-to-liquid (PTL). This paper employs the AB 1007 Full-Fuel Cycle Analysis results and quantifies the emissions implications with the various XTL scenarios evaluated.

Staff analyzed five scenarios, including the effects of monetary and non-monetary incentives and their cost-effectiveness in creating a market for XTL fuels to obtain petroleum and emissions reductions. Staff also considered whether consumer demand is sufficient to create a premium diesel market. Three fuel price scenarios (Low, Reference, and High) were evaluated based on the *Energy Information Agency's 2007 Annual Energy Outlook*.

Based on detailed analyses of the five scenarios, staff concluded that:

- Government incentives and/or mandates would be necessary to encourage XTL use above 5 percent diesel displacement in California.
- By 2022 and 2050 XTLs can displace 1.5 – 2 billion gallons of petroleum-based diesel and 1.5 – 3.0 million tons of greenhouse gas (GHG) respectively[1] at a competitive incentive cost, with emissions reductions and using the existing infrastructure, while retaining performance standards for diesel vehicles and equipment.[2]
- By 2030 and 2050, XTLs (and renewable diesels) <u>each</u> can displace 26–33 percent of diesel demand (+/- 2 percent) before reducing petroleum diesel demand below 2007 levels. This represents 2.7 – 4 billion gallons per year respectively, for each fuel type. Reaching these levels may require incentives up to $1.00 per XTL gallon.[3]
- Over the next decade, the California market is not expected to grow enough to support a premium diesel market.

Recommended State Actions

Based on its research and analyses, staff perceives XTLs to be an alternative fuel option with significant promise. XTLs' potential to displace petroleum-diesel, to improve emissions, to blend with all grades of diesel, and to displace either petroleum or upgrade crude, as well as its consequent economic benefits to refineries in terms of production flexibility, its eventual availability in volume, and its transparency to consumers, present strong argument for further exploration. Consequently, staff identifies the following impediments and offers recommendations to address those impediments to XTLs' use:

---

[1] A 10% GHG benefit is assumed on a Full-Fuel Cycle Analysis basis. Final FFCA results were not available as of May 22, 2007.

[2] For the reference fuel price scenario. The Low or High fuel price scenarios have lower and higher values, respectively.

[3] Excluding GTL from XTLs would reduce volumes by 50 and 40 percent by 2030 and 2050, respectively.

1. Near Term (within three years): Lack of bulk storage facilities sufficient to receive XTLs shipments (and renewable diesels) from abroad and keep bulk XTLs segregated.
    - The State Legislature should enhance government oversight of improvements to the state's transportation fuel supply infrastructure. The Legislature should empower the Energy Commission to oversee and facilitate the permitting process of transportation fuel supply infrastructure improvements. The Legislature must ensure that construction at ports or inland is done in a timely manner and that it is responsive to environmental and other state concerns. Staff envisions that this step will support all XTLs, renewable diesels, and petroleum supplies imported to California.

2. Near Term: Lack of sufficient market demand for XTLs.
    - The Governor should direct the Department of General Services to establish 10-year off-take contracts from domestic or in-state XTL plants. Staff envisions that this step will assist with financing of the first PTL, coal, and biofuel plants.
    - The state should support federal appropriations for the authorizations contained in EPAct 2005 that involve production of XTL transportation fuel.

3. Near Term: Uncertainty about greenhouse gas sequestration mitigation.
    - The state should evaluate and demonstrate carbon management, including additional infrastructure to transport carbon dioxide (CO_2) to locations for enhanced oil recovery and other beneficial uses. Staff envisions that this step will support a PTL plant ideally located in the Bakersfield area.
    - Government needs to establish a sequestration framework, i.e., regulation that provides regulatory certainty upon which CTL and PTL plants could be built. Establishing a GHG reduction monetization value would be helpful. This development would enable industry to determine when and if CTL and PTL plants can be economic and to develop compliant GHG sequestration process.

4. Mid-Term Issue (3–10 years): High risk of building PTL, coal, and bio-fed plants in California.
    - The State Legislature should provide domestically produced XTL fuels with a state fuel tax credit worth 50 cents per gallon for 20 years. Eligible plants must mitigate their GHG emissions where, on a full fuel cycle basis, they are at conventional petroleum refining GHG emissions. The tax credit applies to volumes produced when California source crude oil prices are below $50 per barrel (bbl). Staff envisions this action to assist the development of in-state PTL (and perhaps co-feed coal and bio-co-feed plants), which are expected to be smaller and thus less competitive with large petroleum refining plants.
    - The Legislature should establish an accelerated depreciation tax rate for XTL plants built in California. Eligible plants must mitigate their GHG emissions where, on a full fuel cycle basis, they are equivalent to conventional petroleum refining GHG emissions. Staff envisions this action to assist in the financing of the first petroleum coke, coal, bio-fueled plants.

- o The Legislature should enact an 80 percent project XTL loan guarantee, with eligible projects to include new PTL plants. Eligible plants must mitigate their GHG emissions where, on a full fuel cycle basis, they are equivalent to conventional petroleum refining GHG emissions. Staff envisions that this action will assist with the financing of the first PTL, Coal, and Biofuel plants.
- o The state should support revision and/or extension of EPAct 2005 tax credits, federal appropriations for the authorizations in EPAct, and federal/private sector investments in XTL plant construction.
- o The state should support demonstrated and proven CO_2 management strategies and significantly reduced cost for CO_2 management.
- o The state should establish streamlined permitting process for Integrated Gasification Combined Cycle (ICGG) CTL, PTL, and bio-fed plants.[4]
- o The state should support/endorse clean diesel cars and light trucks as a greenhouse gas emission reduction strategy, which also builds demand for XTLs fuels.

5. Long-Term Issue (more than 10years): Uncertainties on greenhouse gas sequestration mitigation.
   - o The State Legislature should provide funding to adequately research GHG sequestration technologies and approaches amenable for use in California.
   - o The state should support strategic development of an XTL fuel infrastructure, including production, refining and transport, which are secure and reliable, displacing at least 15 percent of California's refined petroleum requirements.
   - o The state should encourage consumer and industry incentive to use CTL-derived fuel, particularly in the transportation industry.
   - o The Governor should direct the Energy Commission to research the feasibility of building small-scale XTL plants using the petroleum coke that can also co-process biomass feedstock.

Assumptions for XTL Fuel Analysis Scenarios

Using as a foundation the findings from initial research and analysis, staff employed the following assumptions to analyze five potential scenarios:

- While GTL is in short supply currently, new production facilities ensure greater quantities beginning in 2007, with significant volumes by 2012, and expansions expected through 2050.
- XTLs give refineries production flexibility resulting in lower price volatility.
- XTLs allow refineries to produce more of a given commodity based on market demand, thus potentially offsetting the higher initial cost of an XTL fuel.
- Based on XTL fuels', superior fuel stability, cetane, sulfur, and aromatic specifications, XTLs are considered higher quality fuels than petroleum-based diesel.
- Finished XTL fuel blends are not segregated from conventional diesel and use the same diesel infrastructure: XTL is compatible with pipelines, community storage, retail

[4] Per Rentech: Co-locating a CTL facility with an IGCC power plant will allow for the more efficient use of both project's assets and lower capital costs for each project, allowing higher project availability as well as providing an opportunity for both parties to optimize the fuels and commodity markets.

stations, and diesel vehicles. (In certain cases initially, bulk segregated delivery XTL storage may be required.)

- On a Btu-basis, XTL diesel blend performance is similar to that of petroleum-based diesel fuels.
- In mature conditions, XTL fuel was assumed to have a market value price $4.20 to $12.60 per barrel higher refinery acquisition cost (10 to 30 cents per gallon) than conventional petroleum diesel.
- Manufacturers, refiners, and retailers accept XTL blends between zero and 50 percent; for analysis, staff used a nominal average 30 percent XTL blend for all on-road and off-road diesel fuel.
- For XTL fuel blends to be used in large volumes, it is necessary for the XLT to be retailed at the same price as diesel. Various incentives were evaluated bounding the potential XTL California market demand.
- Consumer behavior is unchanged; for at least one decade there is insufficient consumer demand willing to pay more at the retail level for premium diesel.
- Prohibitively high market cost thresholds for small GTL volumes necessitate large demand volume to lower the incremental cost.

Background for Supply and Demand Assumptions

All AB 1007 analyses were done using three fuel price scenarios. Table 1 shows the projected crude oil price scenarios based on the Energy Information Association's (EIA's) 2007 Annual Energy Outlook Price Forecast adjusted to reflect the typical California grade and priced crude.

Table 1. Fuel Price Scenario Crude Oil Prices

Crude Oil Price Scenario	2007	2012	2017	2022	2030	2050
High	63	70	83	90	99	121
Reference	63	49	48	51	55	64
Low	63	37	31	31	31	31

Prices are dollars per barrel, in constant 2007 dollars

Table 2 lists the anticipated XTL supply volume and timing assumptions used for this analysis for the three fuel price scenarios. All options and volumes were vetted with various XTL industry representatives in 2007. GTL volumes represent expected new worldwide capacity, CTL represents expected national capacity, and petroleum coke supply represents expected in-state capacity. The un-shaded boxes represent published estimates at this time for the Reference and or High fuel price scenarios.

The Low and High fuel price scenarios were adjusted relative to the Reference case. The percent change is shown on the left of the tables. The percent adjustments are based on staff and stakeholder's judgment.

Table 2. Assumed XTL Supply Volumes per Fuel Price Scenario

(Billion gallons/year)

Gray areas are placeholder estimates.

Supply in a Low Fuel Price Scenario

Percent of Reference Volume	Supply Options	2012	2017	2022	2030	2050
70%	GTL	1	2	2	8	11
10%	CTL	0	0	1	1	2
60%	PTL	0.0	0.0	0.1	0.1	0.2
	Total	1	2	3	10	13

Supply in a High Fuel Price Scenario

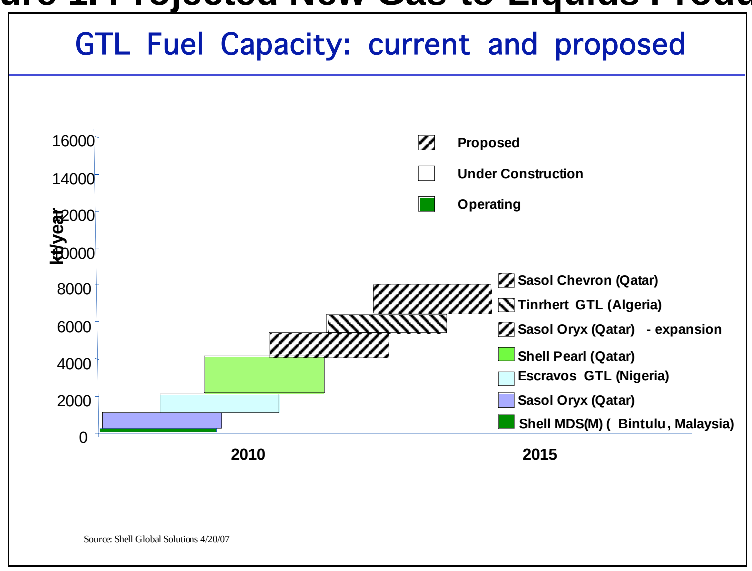
Percent of Reference Volume	Supply Options	2012	2017	2022	2030	2050
130%	GTL	1	3	4	16	20
155%	CTL	0	0	21	26	31
125%	PTL	0.0	0.0	0.2	0.3	0.4
	Total	1	4	25	42	51

Supply in a Reference Fuel Price Scenario

Supply Options	2012	2017	2022	2030	2050
GTL	1	3	3	12	15
CTL	0	3	8	12	20
PTL	0.0	0.0	0.2	0.2	0.3
Total	1	6	11	24	35

The plant capacities of worldwide new gas-to-liquid (GTL) plants were estimated in Figure 1 based on published industry estimates. The anticipated GTL capacities are assumed relevant to the Reference Fuel Price scenario and assumed to increase by 30 percent in the High Fuel Price Scenario[i]. Conversely, they are reduced 30 percent in the Low Fuel Price Scenario. Staff has no reliable projections of GTL production after 2017. GTL and petroleum coke volumes beyond 2017, shown in Tables 2, are speculative and presented for illustrative purposes.

Figure 1. Projected New Gas-to-Liquids Production Capacity



Coal-to-liquid plant capacity was estimated based on the Energy Information Administration's 2006 Annual Energy Outlook projection that by 2030 70 MBbl/day and 1,690 MBbl/day in the reference and high oil price cases, respectively is built. Staff assumed in the *Low Price Scenario* that effectively no significant coal to liquid plants are build –CTL plants are assumed to not be competitive or built with crude below $40-50 per barrel. There are currently 16 CTL projects proposed by developers to be built by 2017 in the United States, totaling approximately 360,000 barrels per day (5.1 billion gallons/year) of estimated diesel CTL capacity.[ii] Realistically, only a fraction will be built and only if significant federal and state policies are developed to support this new capital-intensive domestic supply.

Staff has a prior Commission Staff paper that estimated California's Pet-Coke supply potential, but has no significant information to project the timing of PTL production.

As a base, staff used the Energy Commission's *2005 Integrated Energy Policy Report* (*Energy Report*) demand forecast, a very high price demand scenario for diesel fuel that assumes the regulation of vehicle greenhouse gas emissions according to AB 1493 (Pavley 2002).The *2005 Energy Report* forecasts demand through 2030; linear extrapolation was used to extend the forecast through 2050 (Table 3). Off-road diesel demand was added to the on-road demand forecast. Off-road diesel demand was determined via Energy Information Association data for 2003 and extrapolated maintaining its ratio to on-road diesel demand for all future years.

Table 3. Supply and Demand Assumptions for XTL Diesel Analysis

(Million gallons/year)

	Year				
	2012	2017	2022	2030	2050
California on-road diesel demand (2005 IEPR)	3,468	4,017	4,611	5,455	7,376
Estimated off-road diesel demand	1,370	1,587	1,822	2,155	2,900
Sub-Total diesel demand (rounded off)	4,800	5,600	6,400	7,600	10,300
Max Case - Diesel Car and Light Truck Demand	0.9	20	280	1,400	2,200
Total diesel demand (rounded off)	4,801	5,620	6,680	9,000	12,500
Percent of XTL world supply California would use	13%	13%	20%	15%	19%
World supply of XTL-diesel	740	3,000	3,000	12,000	15,000
Assumed California XTL diesel demand (rounded off)	100	400	600	1,800	2,800
XTL volume relative to California diesel demand (%)	2%	8%	9%	20%	22%

Additional diesel demand from light-duty diesel cars and light trucks (SUVs, vans, pick-up trucks) were included, as part of the sensitivity analysis, to evaluate a Maximum high diesel demand scenario. For this Max Case scenario, staff assumed that diesel car sales resume in California in 2009, and take 20 years to reach their maximum penetration. Diesel car sales are assumed to reach European levels; 45 percent of new vehicle car sales and 57 percent for light trucks. This Max Case diesel demand scenario represents the European diesel car expansion experience 1998-2007.

Staff assumed California's market and any incentive would not overwhelm worldwide or national markets; consequently, staff constrained California's GTL demand volumes below 15 percent of the expected new worldwide GTL supply. California's CTL demand was constrained to a nominal 12 percent of national supply – based on California's diesel fuel demand proportions to national demands.

Starting in 2007, GTL fuel may be available to refineries at a 10 to 30 cents-per-gallon higher price and with a 5 cents-per-gallon higher arbitrage cost over conventional, petroleum-derived diesel. This cost premium is expected to decline as additional GTL capacity is built and most conventional refineries worldwide are configured to produce ultra-low-sulfur diesel fuel. This declining cost was not analyzed.

Figure 3 graphically illustrates the aggregate on- and off-road diesel fuel demand assumed for the AB 1007 analysis also shown in Table 3. Given that most on-and off-road diesel fuel is commingled in California prior to final sale, staff performed the XTL analysis for the aggregate volumes of off- and on-road diesel markets. The XTL Supply (or Demand) is the preliminary XTL estimate evaluated for differing incentives. Note the Max Diesel Demand sensitivity is shown and that aggressive diesel car penetration cars do not materially influence diesel fuel demand until after 2022.

Figure 3. Demand Assumptions for Diesel and XTL used in Analysis

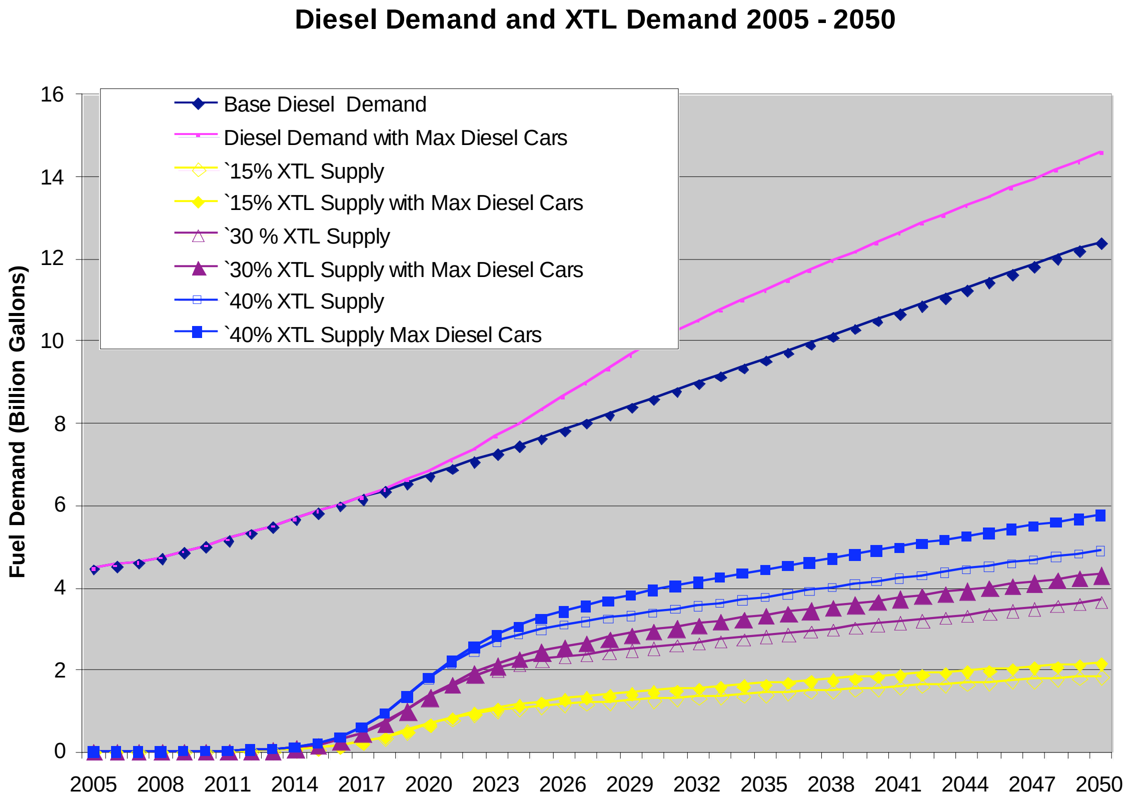


Table 4 shows the assumed supply response to various incentives (cents/gallon) for each of the three fuel price scenarios. Staff judgment and vetting with industry stakeholder rs was used to arrive at the supply response to incentives. The colored region of each table represents the percent of supply shown earlier in Table 2. Each table has two grey boxes, one in the *Low* and one in the *High* Fuel Price Columns. These values represent the percent supply change from the Reference case. For example, from the GTL Table; the 70% and 130% values adjust the Low and High price Scenario volumes respectively from the Reference case. The GTL Reference case shows that a $1.00 per gallon incentive could pull 26 percent of worldwide 2030 supply to California. However, in the Low Price Scenario a $1.00 per gallon incentive is estimated to pull 18 percent (70%x26%)of world supply, and in the High case pull 34 percent (130%x26%).

Table 4. 2030 Assumed XTL Supply Response to Incentives (per gallon)

	CTL Analysis		12%
Incentive	Low	Reference	High
0	0%	0%	0%
`25¢	0%	2%	3%
`50¢	0%	4%	6%
`75¢	1%	7%	10%
$1.00	1%	7%	11%
	10%		155%

	GTL Analysis		
Incentive	Low	Reference	High
0	1%	2%	3%
`25¢	6%	8%	10%
`50¢	14%	20%	26%
`75¢	17%	24%	31%
$1.00	18%	26%	34%
	70%		130%

	Pet Coke Analysis		
Incentive	Low	Reference	High
0	6%	10%	13%
`25¢	15%	25%	31%
`50¢	30%	50%	63%
`75¢	45%	75%	94%
$1.00	60%	100%	125%
	60%		125%

Retail Price Scenarios

For the XTLs analysis staff assumed 1) elevated retail diesel prices are associated with mandated XTL use or 2) governmental incentives (at equal value to the higher fuel prices in #1) enable the XTLs to retail at the same price as petroleum diesel. In the mandated scenario the elevated retail fuel prices evaluated were: 0, 3, 6, 9, 15, 25, 30 cents per gallon at an assumed 30 percent blend level. This is equivalent to 10, 20, 30, 50, 80, 100 cents per neat XTL gallon incentive, which was used in the Governmental incentive scenario. See Table 5.

Table 5 shows a parametric chart of incremental XTL fuel blended price and the percentage blended impact on price. Based on extensive interactions with the GTL industry, staff expects 10 to 30 cent-per-gallon higher value / price for the neat GTL when large GTL plants are built by 2012 (refer to the unshaded areas in the table). However, higher values are shown to evaluate other possibilities. For example, if the GTL (or XTL) fuel had 20 cents per gallon higher cost and was blended at 30 percent it would raise the cost of the finished fuel 6 cents per gallon.

Table 5. Incremental Blended Cost of the XTL Fuel Relative to Diesel

	Incremental neat XTL fuel cost (¢/gallon) relative to diesel							
	10	20	30	40	50	60	80	100
% Blend	**Elevated Fuel Prices (cents/gallon)**							
5%	0.5	1	1.5	2	2.5	3	4	5
10%	1	2	3	4	5	6	8	10
15%	1.5	3	4.5	6	7.5	9	12	15
20%	2	4	6	8	10	12	16	20
25%	2.5	5	7.5	10	12.5	15	20	25
30%	3	6	9	12	15	18	24	30
40%	4	8	12	16	20	24	32	40
50%	5	10	15	20	25	30	40	50

[1] Refer to *Final Retail Price Analysis*, Appendix X, for calculations of the incremental price.

Staff developed California-specific highway transportation fuel price forecasts for regular-grade gasoline and diesel based on the U.S. Energy Information Administration's (EIA) *2007 Annual Energy Outlook* crude oil price forecast cases for use in the Energy Commission's AB 1007 alternative fuel penetration analyses. The High, Reference and Low fuel price cases correspond in name and in underlying crude oil price assumptions to the EIA's 2007 High, Reference and Low crude oil price cases using the U.S. refiner acquisition cost of imported crude oil index. These cases use differing assumptions for crude oil prices, crude oil to rack fuel price margins, and rack price to retail price margins. For greater detail see the Staff Paper titled Overview of Proposed Transportation Energy Analyses for the 2007 Integrated Energy Policy Report May 8, 2007.

The High Diesel Retail Price Case starts at $3.05 in 2007 and increases to $4.53, by 2050. The Reference Case starts at $2.99 in 2007, dips to $2.60, in 2015 and ends at $3.01 in 2050. The Low Case starts at $2.90 in 2007 and drops to $2.07 by 2030-2050. All prices used in this work are in 2007 dollars, using the 5/30/06 Energy Commission deflator series, unless otherwise specified. Figure 5. shows the context of historic U.S. diesel retail prices relative to the three future fuel price scenarios.

Figure 5. Retail Price Forecasts for AB 1007 Analysis

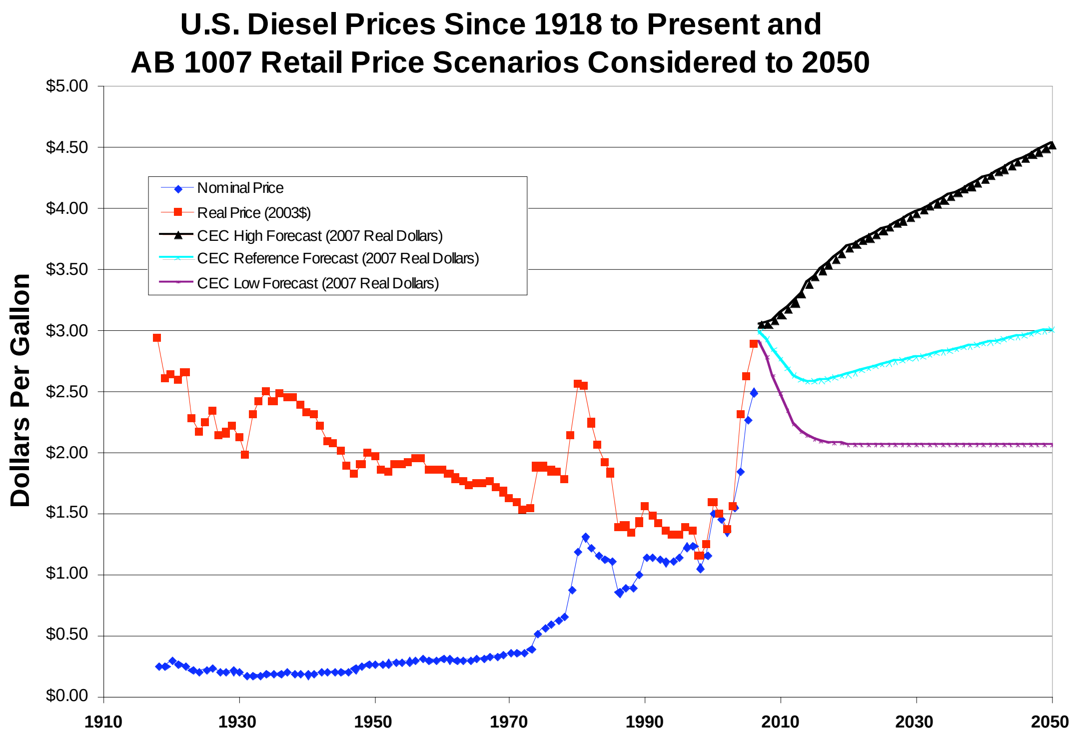


Table 6. shows the percent of California diesel demand displacement based on Table 4 and Table 2 assumed supply and responses to incentives. Table 5 illustrates the percent of California diesel demand potentially displaced with the assumed incentives in 2030. These are subject to change – based on Industry stakeholder feedback. Other responses are easily modeled and will be with additional industry inputs. However, working with the above assumptions the Tables reveal how disproportionate XTL supplies sources are expected be from the same incentive per gallon. The XTL supply is anticipated in proportion to each fuel source supply-which is disproportionately.

Table 6. Potential Percent of California 2030 Supply by XTLs

GTL Supply Response to Incentives

Incentive per gallon	Low	Reference	High
0	1%	3%	8%
`25¢	5%	11%	32%
`50¢	14%	27%	79%
`75¢	16%	32%	95%
$1.00	18%	35%	102%

Pet Coke Supply Response to Incentives

Incentive per gallon	Low	Reference	High
0	0.1%	0.2%	0.4%
`25¢	0.2%	0.6%	0.9%
`50¢	0.4%	1.2%	1.8%
`75¢	0.6%	1.7%	2.7%
$1.00	0.8%	2.3%	3.6%

CTL Supply Response to Incentives

Incentive per gallon	Low	Reference	High
0	0%	0%	0%
`25¢	0%	2%	8%
`50¢	0%	5%	17%
`75¢	0%	9%	31%
$1.00	0%	10%	34%

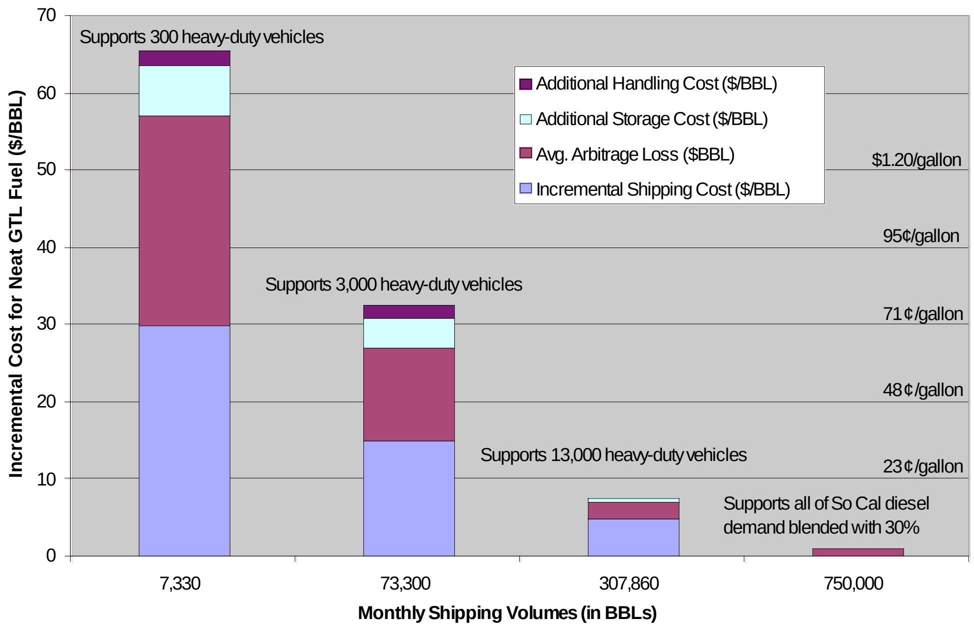
Background for GTL Landed Cost Analysis

GTL represents the first opportunity to use the XTL fuels in California. One Scenario evaluated as a first step assisting the infrastructure development to land GTL fuels from abroad. Figure 6 illustrates staff's understanding of the relationship between GTL shipping volumes and the incremental cost expected absent market price influences. This illustration captures the significant higher shipping and storage cost associated with small volumes of fuel as a preliminary estimate. The illustration is based on GTL volumes from Qatar and other distant countries and does not consider the potential higher market price of the fuel at the producer location. It illustrates the initial and temporary market entry hurdle for GTL fuels.

Staff used this information to illustrate that small GTL volumes brought to California have prohibitively high market cost thresholds. Consequently, for GTL fuels to compete in the market, they must quickly secure greater than 300K BBLs demand volumes to lower their incremental cost. Sufficient GTL fuel may be available by the fall of 2007 and certainly after the second GTL plant goes on line by the end of the decade.

Staff does not anticipate that European diesel fuel markets will have these incremental costs due to their, greater diesel demand vs. gasoline, market conditions and proximity to supply. Staff did not have sufficient information to reliably estimate CTL and PTL cost at this time.

Figure 6. Illustration of GTL's Incremental Cost to Market



Staff estimated the ratio of XTL diesel blended with a U.S. Environmental Protection Agency (EPA) diesel fuel or lesser sub-quality diesel to comply with California Air Resources Board (ARB) specifications for an alternative diesel formulation. Table 7 shows typical values for the total aromatic content and cetane numbers for GTL fuel and EPA diesel. Based upon these specifications and a finished blended diesel with 20 percent aromatic content and a cetane number of 55, the ratio of GTL diesel to be blended with EPA diesel is 1:2 (one gallon of GTL is blended with two gallons of EPA diesel). The resulting mixture can be called GTL33. The desired aromatic and cetane values are within the ranges for ARB alternative diesel formulation specifications.[iii]

Table 7. Diesel Fuel Specifications and XTL Price Example

Component	**Percentage**	**Aromatic Content, %**	**Cetane No.**
Sub-Quality Diesel	66.7	30	42.5
XTL Fuel	33.3	0	80
Blended Diesel (XTL33)	100	20	55
ARB Diesel		20	55

If the suitable blending ratio of XTL fuel to a sub-quality diesel is 1:2, a XTL value as a blendstock can be calculated from the sum of two parts sub-quality diesel and one part XTL fuel versus three parts ARB diesel fuel. For this incremental-priced example, the calculated XTL diesel is assumed to have 20 cents per gallon higher value, relative to CARB diesel prices, and is blended with two parts of a 10 cent per gallon lower value diesel fuel, relative to CARB diesel fuel prices. The resultant three gallons of CARB fuel would have cost equal CARB diesel.

Table 8. Illustration of XTL Blending Value as a 2 to1 Blend

	Value Relative to CARB Diesel (cents/gallon)	Blend Ratio	Value (price)
XTL Diesel	+.20	1	+.20
EPA Diesel	-.10	2	-.20
CARB Diesel	0	3	Sum of incremental cost = 0

Table 8 illustrates that the blending value of XTL fuels may lower some or all of the XTL fuels' higher cost shown in Table 6. Table 8 shows the blending value of a 33 percent XTL fuel and its ability to take a lower value (sub-quality diesel) and blend up to a higher value ARB diesel fuel.

Refineries using XTL fuels may benefit with some lower refining cost, less severe hydro treating or ability to blend other lower quality streams to produce higher quality diesel fuel and greater volumes. However, staff took a conservative approach and ignored these possible cost savings as potential offsetting plant expenses.

Scenario Analyses

Using the assumptions listed earlier in this paper, staff developed five scenarios to explore outcomes:

- A "base line" scenario without monetary incentives or government mandate or commitment.
- A government mandate to use an annual-average 10-30 percent XTL blend.
- A monetary incentive to encourage 10-30 percent market demand.
- State government commitment to use XTL fuel. (not modeled)
- Creating consumer demand for XTL versus premium diesel.

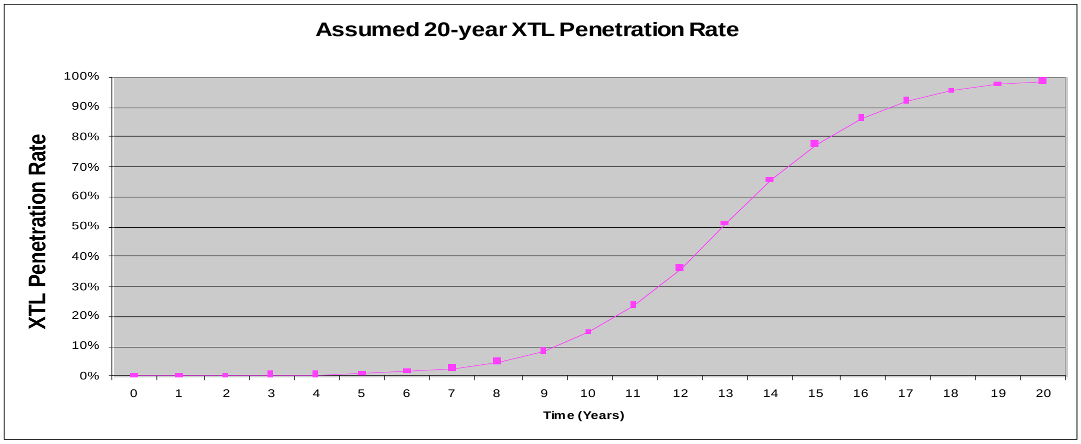
Base Line

This scenario assumes that all GTL, CTL, and PTL fuels produced are sold in their local markets and occasionally small volumes are used in California from 2007 to 2050 for plant turnarounds and, on rare occasion, as backup for conventional petroleum-based diesel supply. GTL fuel is typically sold to Europe, Asia, and China where their diesel demand is growing significantly faster than in California. CTL fuel is sold to the local state markets; PTL is not produced in state; petroleum coke continues to be exported to Japan or other Asian countries for use as a solid fuel. Consequently, XTLs are assumed to not be used beyond 5 percent of diesel demand.

Government Mandate to Sell XTL-Blends

This scenario assumes the state government mandates the sale of an annual average (10-30 percent) XTL fuel blend for on- and off-road diesel fuel demands. This mandate would be phased in starting in 2012 and require 10-30 percent XTL blends by 2032. Figure 7 shows the assumed 20-year phase-in rate assumed for all XTL displacement volumes. Flexibility for a mandated XTL fuel blend is assumed where XTL percentage would vary between 0% and 50% on any day due to; changing crude prices, XTL prices, and local market conditions. However, on a yearly-averaged basis they would meet the percent blend goal. Any higher cost associated with using the XTL-blended fuels, are assumed to be passed on to customers. For analytical purposes, staff evaluated 3,6,9,15,25 and 30 cents per gallon higher retail prices in response to a state mandated XTL blends. At this time, staff does not have a strong analytical basis for determining the price premium beyond the blended cost ratio. This approach tends to overestimate the retail prices due to ignoring potential refining cost savings from: avoided hydro treating cost, and a refiners ability to blend lower quality feeds into higher value diesel fuels.

Figure 7. Assumed XTL Penetration Rate Schedule



Government Provides Monetary Incentive to Create Market Demand

This scenario assumes the state government provides 25, 50, 75 and 100 cents per gallon incentive to XTL fuels. The incentive is assumed to ensure that the retail price of XTL fuels would be the same as petroleum diesel fuel. Incentives greater than 50 cents per gallon were evaluated to illustrate a plausible a price / supply analytical relationship and not necessarily as a recommended strategy. An annual-average goal was assumed to allow XTL fuel blends to vary between 0% and 50% due to changing world crude prices, XTL prices, and local market conditions. Allowing for market flexibility is important in addressing market price volatility.

CTL has a $.50 per gallon federal incentive which expires in 2009 and has little value to XTL industry unless extended by the Federal Government, for this scenario. Staff assumed that this federal incentive was extended to a more meaningful 30-year term. Consequently, CTL would not receive the additional state incentives until state incentives reached above 50 cents per gallon.

The XTL goal would be set to an annual-averaged 10-30 percent XTL fuel blend for on- and off-road demands. The incentive scenario would follow the same mandate scenario phased schedule discussed earlier and shown in Figure 7. Incentives would be granted to only XTL plants that demonstrate GHG emissions equal to refining petroleum diesel on a Full-Fuel Cycle Basis.

Should the incentive be applied to GTL, CTL, or Pet-Coke volumes? Cost effectiveness analysis was done in aggregate for the fuel options. However, each option's full fuel cycle emissions attributes may result in different emissions cost effectiveness values. Further discussion will be presented as these results are available.

State Government Commitment to Use XTL Fuels

The State of California could take a number of actions to foster XTL plant construction and use XTL fuels, including:

- Endorse use of XTL fuels.
- Commit to 10-year purchase contracts.
- Provide loan guarantees.
- Offer preferred state bids for XTL fuels.
- Accelerate depreciation rates for XTL in-state plants.

Realistically, staff envisions the state to support only petroleum-coke, perhaps with coal assisted-fed, due to the zero-chance of citing GTL plants in California. Staff did not relate a production volume to any of the potential actions listed above. Rather, staff qualitatively evaluated these actions as prerequisites to building new PTLand CTL plants to help lower the risk to the financial community.[5] One industry stakeholder indicated a 10-20k bbl/day (150-300 million gallons/year) plant is feasible using California Pet-Coke and sequestering emissions in the Bakersfield area.

Today the state's vehicle fleet uses nine million gallons of diesel fuel[iv]; staff assumed that one-third of this would be substituted with XTL fuel. Staff also assumed that the state fleet use of XTL fuels would have at least a 10 cent-per-gallon higher purchase price than conventional diesel fuel. The Department of Transportation, however, incurred on average 50 cents per gallon and up to a $1.50 per gallon higher cost to transport ultra-low sulfur diesel ahead of the statewide rollout due to the small volumes and remote locations in 2002. This experience should serve as a caution to anticipate higher cost if the state government were to require using XTLs too soon as a single course of action. Staff also expects significantly higher shipping and handling costs if the state pursues this approach first and as a sole action. Consequently, staff does not consider requiring the state fleet to use XTL to be a practical stand-alone option. However, it could be a part of a larger concerted effort to hasten the use of XTL fuels production and use.

Creating Consumer Demand for XTL versus Premium Diesel

Staff assumes that sufficient consumer demand to create a premium diesel market will not occur for at least two decades. There is uncertainty as to what a future premium diesel will be with regard to engines meeting 2010 heavy-duty diesel exhaust standards. For more than eight years, diesel engine manufacturers have been researching homogeneous charged combustion ignition (HCCI) as an emissions attainment technology. HCCI engines would define "premium" diesel fuel qualities differently than they are defined for today's diesel engines. For example, today's diesels consider a high cetane number to be a key "premium" fuel quality; however, HCCI engines would be insensitive to cetane numbers.

---

[5] Rentech indicated a 10-20k bbl/day (150-300 million gallons/year) plant is feasible using California Pet-Coke and sequestering emissions in the Bakersfield area.

Light duty diesel vehicles are considered key for developing a premium diesel market. Premium diesel fuels supplied via XTL blends are not considered a viable option before 2022 due to the limited light-duty diesel vehicle population and the time required for new diesel demand to justify a segregated diesel retail infrastructure. The oil retail industry characterizes current diesel light-duty retail station use as underutilized due to the limited light-duty diesel vehicle population's fuel demand. Using the Scenario model, Staff evaluated a hypothetical and aggressive scenario in which light-duty diesel vehicle sales increase by 2.5 percent per year, and light-duty vehicles account for 30 percent of diesel demand in 10 years. This aggressive scenario illustrates the length of time required before light-duty diesel penetration could justify a premium diesel fuel. Of this vehicle population, staff envisions that only a small fraction would use or need premium diesel.

At this time, staff believes that a premium diesel retail market is not a likely XTL driver and consequently did not evaluate this scenario further. However, staff welcomes alternative perspectives and would consider evaluating this option further if compelling evidence is provided that supports the greater likelihood of a viable premium diesel market.

Evaluation Metrics

XTL diesel and Renewable diesel analysis were both done directly from the Energy Commission's projected diesel demand assuming some percentage relationship to Renewable diesel volumes. A Scenario Model was constructed that allow quantifying petroleum reduction consumer and governmental cost and quantified criteria and GHG emissions. An Environmental Benefits spreadsheet was used to quantify emissions changes and to later enable cost-effectiveness analysis associated with proposed policy strategies. The Scenario model incorporates the full fuel-cycle (GREET-derived), emission factors, cost effective, and emission calculations. The model compares the Energy Commission's diesel demand forecasts for California, with alternative fuels projected scenarios.

The current version of the model quantifies reduced transportation fuel demand, costs, and emissions; many of the input emission values were vetted through the AB 1007 Full Fuel Cycle Analysis process, with stakeholders including the California Air Resources Board staff. As such, the current version of the model represents a snapshot of technologies today and may evolve as updates and facts change over time.

Base Assumptions for Analysis

For the Scenario analysis, staff assumed that for each of the incentives evaluated (for example, 0.25, 0.50, 0.75 and $1.00 per gallon), resulted in a range of XTL total available supply reaching California's market in the Reference fuel price scenario. For the High and Low price scenarios the response was assumed to vary +/- 20 percent to account for the range in fuel price scenarios.

Results and Discussion

Figure 8 shows the results of the Scenario Model petroleum reduction volumes over time. Note the range of supply anticipated, the results are specific to the Reference Price case.

Figure 8. Price Supply Curve for XTLs - Reference Fuel Price

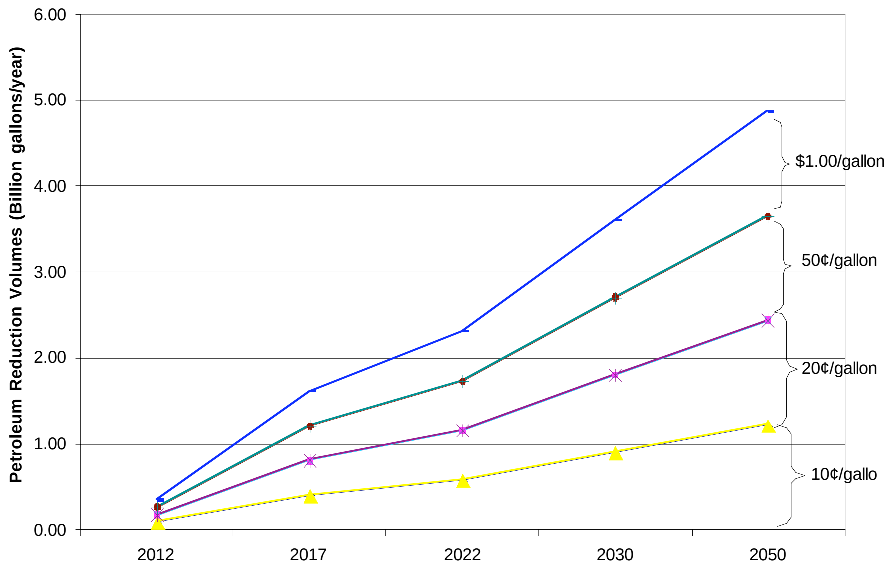


Table 9 shows the emission reductions in tons/year found relative to the full fuel cycle emission assumptions determined by TIAX report and staff's assumed penetration levels and rates described earlier. Off-road emissions are not captured in these values.

Table 9. XTL Emissions and Petroleum Reductions with $1.00 per Gallon Incentive

Single Year	NOx	CO	NMOG	Toxics	Particulate Matter	GHGs	Reduction (billion gallons)
2012	2	0	1	0	0	16,698	0.024
2017	39	1	15	11	1	302,857	0.437
2022	162	6	65	47	4	1,267,670	1.829
2030	218	8	90	64	6	1,759,078	2.538
2050	294	11	129	86	9	2,540,212	3.665

Price Supply Curve Results

In Figure 9 shows the estimated Price Supply Curves for petroleum reduction generated from the Scenario Model based on the assumptions listed herein. The range in values reflect +/- 20 percent supply response assumed from the Reference fuel price values, to represent the low and high fuel price scenarios. Figure 10 shows the estimated Price Supply Curves for GHG reductions using the same 20 percent tolerance for the low and high fuel price scenarios.

Figure 9 Potential XTL Petroleum Reduction vs Fuel Price Scenario vs Incentive

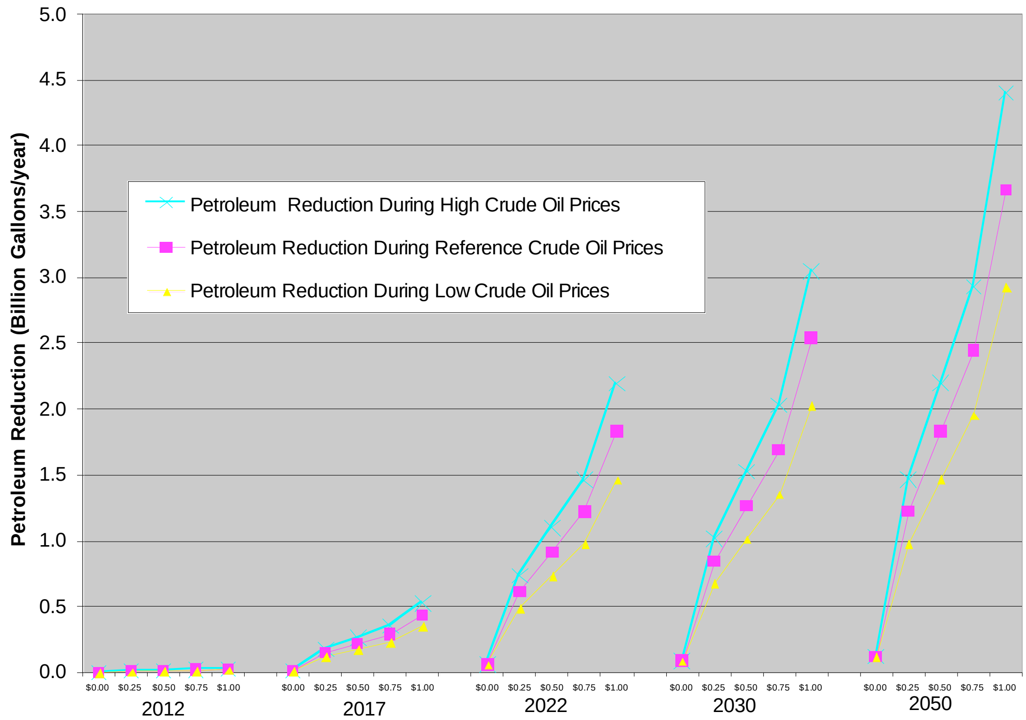
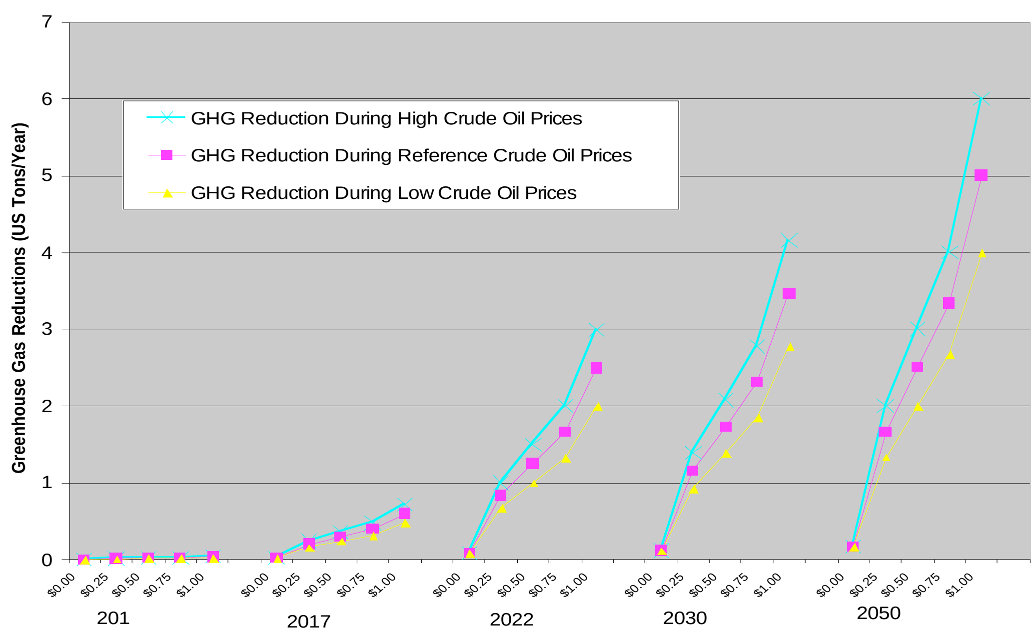


Figure 10 Potential XTL Petroleum Reduction vs Fuel Price Scenario vs Incentive



General Findings:

By 2022 and 2050 plausible petroleum reductions of 1.5 – 2 billion gallons, and 1.5 – 3.0 million tons of Greenhouse Gas Reductions respectively was determined. The Petroleum Reduction cost effectiveness was in direct proportion to the assumed incentive. The maximum Petroleum Reduction cost effectiveness evaluated was $1.00 per gallon per reduced diesel gallon.

Emissions Discussions

See the Full Fuel Cycle analysis.

Health and Safety Considerations

See the Full Fuel Cycle analysis.

Consumer Reaction to XTLs

It is envisioned that with proper branding by companies that use GHG mitigation in manufacturing plus bio-mass components that XTL will be well accepted by the consumers since they have to do nothing different but use a more environmentally acceptable fuel.

The same diesel infrastructure system would dispense XTL-blended fuels and petroleum fuels in California. With sufficient incentives, XTL-blends would not differ from petroleum diesel in terms of; cost, power, torque or fuel economy. The final XTL diesel blend is no different from the consumer's perspective, similar to today's 5.7 percent ethanol gasoline blends. Consequently, consumer acceptance of XTL fuel blends is not a limiting factor due to the expectation that the consumer would not have a choice but would buy the available diesel fuel, which may contain XTL-blends from 0 - 50 percent.

The prerequisite for using XTL blends hinges on either mandating its use or applying sufficient incentives to lower its cost to competitive levels. Where the burden falls will likely guide the choice of incentive or a mandate. The mandate assumes that all incremental cost is passed on to the customer; whereas, with an incentive, it is the state that assumes the loss in excise tax revenue. The consumer would not see an increase in retail price. The policy makers must decide whether the incentive is applied to GTL, CTL, or PTL for reasons of domestic supply, their different environmental burdens, or other considerations.

---

[i] Updated April 20, 2007, by Shell Global Solutions.

[ii] EIA 2007 Annual Energy Outlook

[iii] *Certified Alternative Diesel Formulations*, February 2002. [http://www.arb.ca.gov].

[iv] *California State Vehicle Fleet Fuel Efficiency Report: Volume II*, April 2003. California Energy Commission. CEC 600-03-004.