Assessment of Pennsylvania Natural Gas Price Support Program Candidates

Prepared for the Pennsylvania Natural Gas Development Group as an entry in the 2012 USAEE Case Competition

by

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Executive Summary

This report analyzes two proposed options for increasing natural gas demand and bolstering prices in the state of Pennsylvania: (1) construction of the Allegheny Pipeline to transport gas to the New York market, and (2) increasing penetration of Compressed Natural Gas (CNG) Dual-Fuel (DF) passenger vehicles in the state through manufacturer incentives and fueling station subsidies.

We find that the rapid increase in production anticipated from Marcellus Shale means that the increase in consumption of PA gas resulting from either of these measures will not have a substantial short-term effect on price. However, in some cases other benefits result from these programs.

For the dual-fuel vehicle option, the proposed financing incentive will substantially increase the number of consumers likely to purchase DF vehicles, leading to between 16,000 and 22,000 on the road after two years. These vehicles would consume between 1 and 2 million MMBTU of natural gas annually, though this additional consumption would cause PA natural gas prices to be, on average, 0.024% higher than they would otherwise be. However, these vehicles create consumer benefits due to fuel savings of between $46 and 259 million and social benefits due to decreased pollution of between $3 and $5 million. Plug-in electric vehicles (PEVs) do not constitute a compelling alternative, as they have even less of an effect on natural gas price.

The pipeline has a greater impact on prices, causing prices to be 7% higher than they would be without its construction. However, the pipeline would represent an economic loss to PA consumers due to higher prices of $400 million on average. We believe that supporting a pipeline that would raise energy costs for voters and businesses in Pennsylvania represents a significant political risk for the Governor.

Other options are not explicitly studied, although existing research suggests that conversion of municipal transit buses to CNG fuel systems may create a more significant price support than either of these options.

We recommend:

- Encouraging American Motors to proceed with the DF vehicle rollout, as there is no real cost to the state to do so. “Station-in-a-box” fueling stations should not require state subsidy to be cost-effective, although such incentives might help accelerate adoption of these vehicles;
- Creating a program to continue CNG/DF vehicle incentives after the expiration of American Motors’ financing offer to continue to build consumer demand;
- Not attempting to move ahead with the pipeline construction; and,
- Exploring other options, such as municipal fleet conversion to CNG.

1. Introduction

In an effort to support the Pennsylvania natural gas industry during a time of low prices, the Pennsylvania Natural Gas Development Group is lobbying the Governor to support programs to bolster demand for the state's Marcellus Shale gas production.

Two specific proposals have been put forward: (1) construction of the Allegheny Pipeline to transport gas to the New York market, and (2) increasing penetration of Compressed Natural Gas (CNG) Dual-Fuel (DF) passenger vehicles in the state through manufacturer incentives and fueling station subsidies. This report analyzes these programs and determines the effect they are likely to have on gas demand and price in the state of PA. We also examine a few other alternatives—such as increasing Plug-in Electric Vehicle (PEV) deployment.

The Development Group is primarily interested in *short-term* price support to maintain the pace of development in the shale gas industry through the economic downturn. Therefore, our focus is on benefits that will accrue within the next two years. However, we also discuss longer-term benefits that may enter into program selection.

Sections 2 and 3 of this report analyze the effectiveness of the two proposed initiatives—the Allegheny Pipeline project and the CNG program, respectively. Section 4 discusses other possibilities for affecting demand. Section 5 summarizes the conclusions and offers policy recommendations.

2. Pipeline Analysis

Natural gas demand in PA was 2.4 bcf per day (EIA 2012b). Even assuming a 5% annual increase in consumption (the rate over the last decade has been 3%), the demand in 2016 would be 3.2 bcf per day. Based on the survey conducted by Considine et al. (2011), the production from the Marcellus shale alone is expected to reach 13 bcf per day. Assuming that the state continues to produce 0.5 bcf per day of conventional gas, it will have a surplus of over 10bcf per day by 2016. Figure 1 shows that the utilization of pipelines designed to supply peak demand New York State, for example, would need to operate at about 60% of capacity on average. If the calculation were based on peak-day or peak-week, the rate would be even lower.

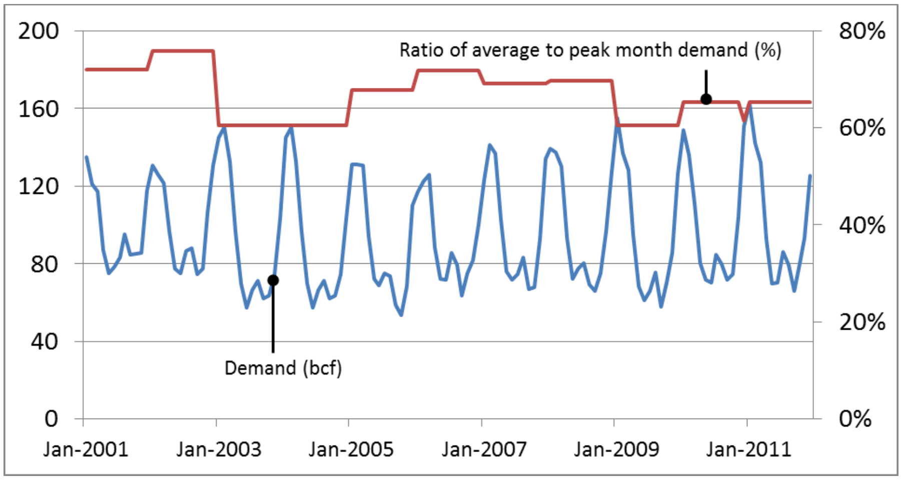

Figure 1: New York state demand and ratio of average to peak-month demand. This can be used as an estimate of pipeline utilization. If a pipeline were sized to cater to peak-month demand, it would have been used at only about 60% capacity in 2009-11.

We will see in subsequent analyses that the utilization of a pipeline is a crucial determinant of its economic viability.

Pipeline-Induced Price Increase

We assume that, with the Governor's help, the pipeline will take two years to receive approval, and that will be another two years before it is operating at capacity. As such, we perform calculations for the year 2016—four years out.

We use the same approach as Considine et al. (2011, p.21) to estimate the impact of the pipeline on the price of gas in Pennsylvania.

We first calculate the increase in the price of gas due to Marcellus production, assuming that no pipeline is built. Based on EIA data, we estimate the expected percentage increase in the supply of gas into the United States from 2015 to 2016. We then calculate the net percent increase in the supply of gas in Pennsylvania in those years, which is the increase in supply (assumed to be entirely due to the Marcellus shale) less increase in demand. We use estimates of the production from the Marcellus shale given in Considine et al. (2011, p.iv).

We assume that demand in the residential, commercial, and industrial sectors stays flat, and that all growth comes from the power sector. This growth is estimated by using data from PJM's active generation queues (PJM 2012a), and assuming that new natural gas power plants operate at an efficiency of 50% and a load factor of 40% (EIA 2012d).

The percentage increase in demand is multiplied by the expected share of Marcellus shale gas in total US production in 2016. This gives us an estimate of how much of the increase in total US supply comes from Marcellus. Using the price elasticity for demand of natural gas (again, taken from Considine et al. 2011), we arrive at an estimate of the percentage change in price that can be expected from this net increase in Marcellus production.

The entire calculation is then repeated assuming that the Allegheny Pipeline is built, and reduces the net supply available to Pennsylvania. This proposed pipeline has a capacity of 750 mmcf per day, and we assume that it operates at 60% capacity as discussed above.

We then compare the anticipated price in the pipeline and non-pipeline scenarios. Our calculations show that **the pipeline increases prices by about 7% over what they would have been without the pipeline.** It is important to note that this is not necessarily an increase in price over today's levels. The large anticipated volume of Marcellus production discussed above may continue to drive prices down, in which case the pipeline would mitigate this price decline somewhat. On the other hand, gas production may get marginally more expensive as the cheaper wells are exhausted, forcing prices upward. Absolute gas price projections depend on a variety of factors and are beyond the scope of this analysis. Here, we are simply projecting a relative price increase between a scenario with the Allegheny Pipeline and a counterfactual scenario in which the pipeline is not built.

We recognize that the assumptions we have made are uncertain. In order to account for this uncertainty, we run a Monte Carlo simulation with the key parameters varied and triangularly distributed as shown in Table 7 (Appendix). Throughout this report, we use the term *nominal* or *base case* to mean the average, or most likely, simulated scenario.

Our simulation indicates that the **median price increase due to the pipeline in 2016 is 7% compared to that it would have been without the pipeline, with a 90% chance that it will lie between 5-11%.**

Feasibility of Allegheny Pipeline

From the point of view of a private investor, would the Allegheny Pipeline be profitable? Smith (2010) puts the capital cost of a Pennsylvania-New Jersey pipeline at about $700 million, including the cost of compression. We amortize this cost over 30 years, assuming a seven per cent cost of capital. We assume that a private investor would have a 12 percent minimum acceptable rate of return (MARR) on the investment. The pipeline has a capacity of 750 mmcf per day and a we assume 60% annual load factor. It takes 18 months to construct, with half the capital spent in the first 12 months, and half in the next six. Finally, we assume that the pipeline is available for of half the second year: it carries half the gas in that year than it otherwise would have.

The pipeline's revenues are calculated by multiplying the gas transported each year—a product of capacity and load factor—by the tariff. The total costs are the amortized cost of capital, and operating expenses, estimated at 35% of revenues based on FERC Form 6 data for the Tennessee Gas Pipeline Co.

We solve this simple model to produce tariff that would yield a NPV of zero, assuming a discount rate equal to our MARR. This model suggests that tariffs would have to be $0.70 per mmbtu for the pipeline to generate an adequate return, which is far in excess of the $0.47 to $0.57 premium associated with prices in New York compared to those in Pennsylvania (IFC 2012, p.25). We suggest that one would only build a pipeline if the tariff were less than or equal to the premium between the two markets.

We recognize that our assumptions are subject to uncertainty, and a sensitivity analysis was done to identify the variables that have the most bearing on the tariff needed for the pipeline to break even. Figure 2 (Appendix) summarizes the results of this analysis and indicates that the required tariff is most sensitive to utilization rates and the cost of capital.

We also calculate the value of each of the most sensitive parameters at which the break-even tariffs fall within the range of premiums available in the New York market. Table 1 summarizes the results of that exercise.

Table 1: What would it take for the pipeline to achieve the MARR?

	NY - PA Premium	
	$0.47	*$0.57*
Capex (millions of dollars)	460	560
Cost of capital	3%	5%
Utilization	74%	67%

We note that a relatively small increase in utilization could cause the pipeline to break even. This could be achieved, for example, by contracting to supply power plants. High air-conditioning-driven demand for electricity (and therefore natural gas) in the summer could increase the utilization of power plants. Furthermore, the premium in New York could be much higher in the winter: as a regulatory report (FERC 2009) noted, “pipeline utilization remains highly seasonal; major regional pipelines often operate at high load factors during the winter resulting in basis differentials to upstream liquid trading points that may greatly exceed firm transportation tariff levels.”

In summary, the existing pipeline outflow capacity in Pennsylvania significantly exceeds the volume of gas the state will have available for export. Even with no new build, the average annual utilization of the existing network is likely to be less than 70%. **Any new pipeline would only make sense if the shippers undertook to made special arrangements to ensure higher utilization, or were willing to pay a high tariff in order to capture large seasonal premiums as and when they arose.**

Who Gains and Who Loses from the Pipeline?

If the pipeline reaches the 65-75% utilization required for it to make a 12% return, the net present value of the cash flows from it (discounted at 7%, the cost of capital), is roughly $13 million. This is the gain to a private investor, if the pipeline is built and can be run efficiently.

From the point of view of consumers, the pipeline would be expected to raise prices for consumers in Pennsylvania and cause prices to fall for consumers in New York and New Jersey. We try to estimate what the effect on consumers in Pennsylvania might be.

We start with the demand in Pennsylvania in 2010 (available from the EIA), and assume that it grows at the same rate in the next four years as it did in the ten from 2001 to 2010. We assume that city gate prices in Pennsylvania in 2016 will be $5.76 per mmbtu, as is suggested in the report prepared by IFC (2012) for the City of New York. We also assume that prices in Pennsylvania rise by 7%, which is our median estimate.

The rise in price multiplied by the total demand gives an estimate of what consumers in Pennsylvania lose. Clearly, we are assuming that *all* demand is impacted by the price rise. This may not be the case. Some customers might have locked in lower prices.

Given the inherent uncertainty in our assumptions, we varied key parameters as shown in Table 8 (Appendix), and ran a simulation to estimate the distribution of consumer losses in Pennsylvania. We find that if the change in price induced by the pipeline is greater than 6%, there is a net loss to consumers. At 6%, consumers in Pennsylvania lose, while those in New York and New Jersey gain.

The simulation indicates that the most likely outcome is a total net loss to consumers of $400 million. There is a 90% chance that the losses to consumers in Pennsylvania will lie between $640 million and $240 million. (See the Appendix for an analysis of whether the losses sustained by consumers in Pennsylvania are offset by gains for consumers in New York and New Jersey. This determination is likely not of interest to the stakeholders within PA, though it may be of use if federal input on the project is required.)

We assume that the supplies from Pennsylvania to the east coast do not constitute additional production: the producers simply get a higher price for the gas that they would have produced anyway. However, as noted in the Appendix, any gain to suppliers is likely to be offset by losses to Pennsylvania consumers. Note that we ignore any changes in demand resulting from the price movements: Considine et al. (2011) suggest that the demand for gas is inelastic.

As such, the total gain from the pipeline is likely to be $13 million for the private investor, and whatever the consumers in New York and New Jersey gain from potentially lower prices in those states.

Ultimately, **we do not believe that the Governor would be willing to expend political capital on a pipeline that would raise energy costs for voters and businesses in Pennsylvania.**

3. CNG Dual-Fuel Vehicle Program Analysis

The Compressed Natural Gas/Dual Fuel (CNG/DF) vehicle program rollout can be broken into two halves: incentivizing the purchase of DF vehicles and ensuring that fueling station capacity exists for this fleet. While the two components are obviously related, we can treat them separately to begin with. We first look at the vehicle sales problem, assuming that the availability of fueling stations is not a concern to customers—i.e., that there exist enough CNG stations in the target markets to meet demand.

Vehicle Sales: Consumer Choice

In this section, we derive a picture of consumer preferences comparing each of the two DF vehicle models to their standard counterparts. As discussed in the market report provided by American Motors, the decision between a DF and standard version will likely be reduced to a financial one for most consumers, since the former provides more flexibility in fuel choice with little downside other than increased cost. We therefore calculate the Net Present Cost (NPC) of each option.

The NPC of each vehicle is simply the discounted series of loan payments for the vehicle purchase less the discounted expected fuel savings. Standard versions are financed for five years at 4%, while DF versions are financed over the same period at 0% interest. The consumer's discount rate for financing expenditures is 7%. While the financing portion of the NPC is relatively simple, the value of fuel savings depends on the vehicle's fuel economy, annual mileage, the proportion of that mileage driven using CNG vs. gasoline, the price differential between the two fuels, and the implicit discount rate at which consumers value future fuel savings. Each of these variables, except for fuel economy, has rather large uncertainties associated with them. To handle these uncertainties, we run a Monte Carlo simulation in which we parameterize each of these input variables across its range. Throughout this report, we use the term *nominal* or *base case* to mean the average, or most likely, simulated scenario. We observe the cost performance of each DF model against its standard counterpart. Table 9 (appendix) contains the distribution parameters used for each of these variables.

Thus, in the nominal case, a DF Sentinel with 29 combined MPG drives 9,600 miles (80% $\times$ 12,000 mi.) each year on CNG, using 331 GGE. If the gasoline-CNG price differential is $2, then this vehicle will save around $660 per year in fuel costs. Using similar logic, the 12-MPG DF Admiral will use 800 GGE of CNG, saving $1600 per year. These annual savings are discounted at the implicit discount rate (50% in the most likely case) to provide a NPV associated with the fuel savings over the assumed 10-year life of the vehicle.[1]

Figure 3 (appendix) shows the simulation results for the differential between the standard version and the DF version of each model. We make several important observations. First, the presence of the 0% financing offer from American Motors for DF vehicles makes a big difference. **When this program is in place (top graph), 69% of Sentinel buyers and 98% of Admiral buyers would view the DF version as less expensive. In contrast, when the standard 4% financing is offered (bottom graph), only 4% of Sentinel buyers and 42% of Admiral purchasers find the DF version to be cheaper.** These results reflect uncertainty and variability in consumer preferences for saving fuel and driving habits as well as fuel price

[1] We recognize that many drivers will not keep their cars for a decade. However, high discount rates mean that fuel savings in the out years do not contribute much to the NPV.

differentials. A sensitivity analysis showed that the discount rate applied to fuel savings and the gasoline-CNG price differential were the biggest drivers in the amount of savings. (See Figure 4 in the appendix.)

Our second observation is that the favorable NPV of the DF Admiral pickup truck against the standard version is more robust to this variability than is the DF Sentinel. This finding is due to lower gas mileage and correspondingly higher consumption of the pickup truck compared to the sedan, which effectively provides a greater opportunity for savings. In short, **Admiral buyers should be more inclined to go with the DF version that should Sentinel buyers due to the comparatively greater savings potential.**

Vehicle-Induced Gas Demand

Having established that DF vehicles are appealing to at least some consumers—especially in the presence of manufacturer incentives—we now estimate sales volume in the target markets. We note that the proposed rollout is to be "centered on Philadelphia and Pittsburgh,"[2] areas in which a few CNG stations already exist. We make the assumption that this program will focus on expanding CNG vehicle penetration in these metro areas. Scaling AM's statewide sales figures based on population, [3] approximately 4,000 Sentinels and 8,500 Admirals are currently sold annually the target market.

Despite AM's enthusiasm for the new DF models, it would be overly optimistic to assume that DF models will constitute all 12,500 vehicle sales after the program rollout. The simulation discussed above showed that buyers may continue to purchase standard models due to driving habits or high discounting of fuel savings. Furthermore, it is likely that some buyers will reject the DF technology due to its novelty. For these reasons, we predict that DF versions constitute 25% to 70% of Sentinels sold and 70% to 98% of Admirals sold.[4]

We simulate these ranges using triangular distributions and determine the number of each vehicle type sold. In the average case, **by year two, there are 4,500 DF Sentinels and 14,500 DF Admirals on the road consuming 13 million GGE yearly, or 1.5 million MMBTU of gas. There is a 90% chance that additional consumption from this program will lie between 1 and 2 million MMBTU.** On average, each DF vehicle consumes 75 MMBTU gas annually.

Table 2: Effects of dual-fuel vehicle program on PA gas market after two years

	Nominal (Most Likely)	5th percentile	95th percentile
Number of new DF Vehicles	18,600	16,600	21,300
Yearly Gas Cons. by DF Vehicles (MMBTU)	1,400,000	1,000,000	2,000,000
Δ Gas Price over today's levels (%)	0.024%	0.016%	0.033%

2 PNGDG memo.

3 See Table 11 in the appendix for county list and populations of this target market.

4 According to our simulation, 69% and 98% represent the maximum possible penetration for DF versions of Sentinel and Admiral, respectively. These rates would occur if all buyers maximize NPV. However, as discussed above, this is not likely the case—we anticipate adoption rates to be lower. A 25% adoption rate for the DF Sentinel implies a premium of $750 placed on the standard version. A 70% adoption rate for the DF Admiral implies a premium of $1250 on the standard version.

What effect does this consumption have on PA gas prices? Using a similar calculation to the pipeline analysis, **we found** (see Table 2) **only a 0.024% increase in prices over the business-as-usual counterfactual in the nominal case, with a 90% chance that the increase will be between 0.016% and 0.033%.**

In this section, we have analyzed the consumer side of this program, finding that DF vehicles—particularly pickup trucks, can be compelling choices to consumers when financing incentives are in place and finding a positive though negligible effect on the natural gas prices.

CNG Fueling Stations

We now turn to the supply side of the program to determine the costs and feasibility of deploying CNG stations to serve the new fleet of vehicles. We first consider the economics of a conventional CNG filling station, making the following assumptions regarding costs, financing, and operation.

Station construction capital expenses (CAPEX) are $1 million, which can be borrowed at 5%.[5] The bonds mature at the end of 10 years, when both capital and interest must be paid back. The operator is allowed to depreciate the facility over 10 years using a straight line method. The price of compressed natural gas is $2/GGE, that the gas tax is $0.18/GGE, and that the gas is purchased at $8/MMBTU, which is the cost of gas for industrial users in Pennsylvania (EIA 2012c). Operating expenses are based on figures from America's Natural Gas Alliance (ANGA n.d.): electricity costs $0.25/GGE and annual administration and maintenance costs are 5% of CAPEX. Credit card fees are 2% of sales.

We assume that each station serves 100 cars. This is the current ratio of cars to stations in the US (The Economist, 2012). The ratio is much higher in other countries (e.g., 950 vehicles per station in Brazil). In our case, we assume that over 10 years, the ratio doubles to 200 cars per station. From the analysis in the previous section, each car consumes about 75 MMBTU of fuel each year in the nominal case.

We assume that Federal and State tax rates are 35% and 10% respectively; and that a declining State tax credit is available so that 100% of annualized CAPEX is deductible in the first year, 90% in the second year, and so on. The minimum acceptable rate of return for a private operator is 7%.

An analysis of the cash flows makes it clear that, so long as operators are allowed to deduct depreciation expenses from income, they only have a taxable income in and after the ninth year of operation. As such, the tax credit is of very little value. The ten-year NPV of the cash flows is a *negative* $500,000. We assume that this loss would have to be covered by a subsidy. This number is comparable to the $700,000 in subsidy that the state if Pennsylvania had to give operators of CNG filling facilities to get started (Allegheny Conference on Community Development 2012, p.9).

Clearly, there is uncertainty in our variables, and we analyze the impact of variation on the cost per vehicle served, which is the ten-year NPV of the required subsidy (private loss and tax credit) divided by the average number of vehicles served each year. The results of this sensitivity analysis are shown in Table 3.

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[5] This is the rate at which Allegheny County borrows. We are, in effect, assuming that the State allows station operators to finance their facilities with municipal bonds.

Table 3: Sensitivity analysis of subsidy in dollars needed per car served for conventional CNG stations. The shaded regions represent those values for which it would be cheaper to buy each user a home CNG filling station.

		CAPEX	CNG Price	Cars per station in Year 1	MMBTU per car	Maintenance cost
	Base values:	*$1,000,000*	*$2/GGE*	*100*	*75*	*5% of CAPEX*
Change in Base Value	-100%	0	12,000	-	7,700	1,100
	-80%	0	9,900	34,000	6,800	1,500
	-60%	0	8,200	15,000	5,900	1,900
	-40%	430	6,500	8,200	4,900	2,300
	-20%	1,700	4,800	5,000	4,000	2,700
	--	**3,100**	**3,100**	**3,100**	**3,100**	**3,100**
	20%	4,600	1,700	1,900	2,300	3,500
	40%	6,100	440	1,100	1,600	4,000
	60%	7,700	0	580	930	4,400
	80%	9,200	0	180	320	4,900
	100%	11,000	0	0	0	5,400

It is clear from Table 3 that for even slight deviations in any of the parameters from our default assumptions, it would be cheaper simply to buy CNG vehicle-owners a $4000 home filling station (see Krupnik 2011, p.6) than to subsidize a public filling station.

Table 3 also shows that a public filling station would be viable if the capital expenditure could be cut by 60%. As it happens, the station-in-a-box concept makes this possible. We repeat the calculations done above for a station in a box, with the following key changes: CAPEX is $300,000, and the station consumes 20% of the gas it sells to run the compressor. Analysis shows that the net present value of the cash flows of such a station would be $280,000, of which $46,000 would come from the tax credit. As such, the station would be profitable even without a tax credit.

We run the same sensitivity analysis for the station-in-a-box.

Table 4: Sensitivity analysis of subsidies required for station-in-a box. The conclusion that these stations would not require any subsidy appears robust: the regions shaded in grey are the ones where no subsidy would be required to make the station viable.

		Capex	CNG Price	Cars per station	MMBTU per car	Maintenance
	Base values:	*$300,000*	*$2/GGE*	*100*	*75*	*5% of CAPEX*
Change in base value	-100%	$0	$6,400	-	$2,300	$0
	-80%	$0	$4,700	$7,100	$1,400	$0
	-60%	$0	$3,000	$1,600	$600	$0
	-40%	$0	$1,300	$40	24	$0
	-20%	$0	$30	$0	$0	$0
	--	**$0**	**$0**	**$0**	**$0**	**$0**
	20%	$0	$0	$0	$0	$0
	40%	$0	$0	$0	$0	$0
	60%	$0	$0	$0	$0	$0
	80%	$269	$0	$0	$0	$0
	100%	$100	$0	$0	$0	$0

The results, in Table 4, confirm that the assumption is, indeed, robust: under most circumstances, the station-in-a-box will not require a subsidy over and above the tax credit. Note that the numbers in Table 4 assume that the declining tax credit is available to the operator. In most cases, the station would be viable even without this credit.

Net Economic Benefit

We have analyzed the localized effects of this program on the natural gas market. The net economic benefits of this program will reflect changes in producer and consumer surplus due to demand changes as well as the costs of any subsidies necessary for the program to work. We assume that the program is in place for two years, but we incorporate benefits gained over the ten-year life of each vehicle sold in those two years.

American Motors provides a subsidy to DF vehicles in the form of an interest-free loan. This subsidy represents AM's absorption of the higher costs associated with the DF vehicles to bring approximate price parity with the standard versions of the cars. The difference between the NPV of each DF car sold under the 0% financing plan and the NPV of the car had it sold under the regular financing plan is about $2,000 for each Sentinel and $2,200 for each Admiral in the nominal case. **Depending on sales, AM's financing offer costs the company between $34 and $44 million**.

Natural gas industry producer benefits result from the increased sales of gas. Using the simulated ranges of additional consumption and factoring in costs of production, royalties, selling price, and federal and state taxes, we estimate **producer benefits due to vehicle consumption are between $25 and $130 million.**

Consumer and social benefits in the form of fuel cost savings and reduced airborne pollution can result from deployment of DF vehicles and perhaps offset this subsidy. We first look at the value of fuel savings. While consumers have relatively high implicit discount rates on this savings when making the purchase decision as discussed above, these savings are nonetheless real dollars and should be discounted at the same rate when determining *actual* benefit to consumers. Using the 7% discount rate used throughout this analysis, the nominal per-vehicle NPVs of fuel savings are $3,700 and $9,000 over a 10-year vehicle lifetime for Sentinel and Admiral, respectively. **We find that the benefits received by consumers from lifetime fuel cost savings are comparatively high compared to the AM subsidy, ranging from $46 million to $260 million.**

We now calculate social benefits due to reduced pollution, assuming that Sentinel and Admiral vehicles are driven 12,000 miles a year. We use Argonne National Laboratory's (ANL) GREET model to calculate greenhouse gas (GHG) emissions. For the emissions of the other pollutants (NO_x, $PM_{2.5}$ and PM_{10}), emissions data are only available in terms of grams of pollutant per vehicle mile. While the data on GHG emissions from the GREET model are authoritative, we have multiple sources for data on all other pollutants. As such, we define a high and low case for the three pollutants. The emissions in each case are shown in Table 12 in the appendix.

We now value the reduction in emissions, assuming that the social benefit from avoiding a ton of GHG emissions is $14 (Matthews & Lave 2000);[6] a ton of NO_x emissions, $1200; a ton of PM_{10}, $450; and a ton of $PM_{2.5}$, $15,000 (USEPA, in Muller & Mendelsohn 2009). Like fuel savings benefits, emission reduction values are calculated over the 10-year lifetimes of two years' worth of car sales at a discount rate of 7%.[7] We find the social benefit from avoided pollution from the implementation of the DF vehicle program to be between $3 million and $5 million.

Summary results of benefits and subsidies are shown in Table 5. We find that net economic benefits for the dual-fuel vehicle program are positive, ranging from **$179 million to 350 million.** The value of fuel savings for consumers outweighs the cost to American Motors, and the social benefit from avoided pollution, while much smaller, is not insignificant.

Table 5: Breakdown of Net Economic Benefit for two-year CNG/DF Vehicle Program ($millions)

	Nominal (Most Likely)	**5th percentile**	**95th percentile**
American Motors Subsidy	(39)	(34)	(44)
Consumer Fuel Savings	149	46	259
Natural Gas Industry Benefit	65	25	130
Social Pollution Benefit		3 to 5	
Net Economic Benefit		**178 – 350 million**	

[6] Matthews and Lave report the costs of pollution in 1992 dollars. Given the uncertainty surrounding these values (they report a range of $2 to $23 per tonne of emissions avoided), we report all costs per tonne in the nominal values we find in the referenced study; i.e., we do not inflate them to 2012 dollars.

[7] We note that the appropriate discount rate for avoided pollution is perhaps even more uncertain than the implicit discount rate consumers place on fuel savings. For this net benefit analysis, however, we take the position that once converted to dollar values, the various benefits should be discounted equally.

4. Other Options

Other options for increasing natural gas demand in Pennsylvania exist. We briefly discuss several of them here.

Plug-In Electric Vehicles

Plug-in Electric Vehicles (PEVs) should support the natural gas market by increasing demand for power. Due to the market conditions and regulatory environment, it is likely that new power plants in the state will be gas plants rather than coal. We assume that electricity demanded by PEVs will be met by gas power generation, and we perform an analysis similar to that used for evaluating the DF vehicles.

We use the Nissan Leaf as a prototype PEV. Its standard-fuel substitute is the Nissan Versa Hatchback. The Leaf is priced $18K higher than the Versa.[8] If Nissan offers the same 0% financing offer as American Motors, this differential would decrease to around $12K, assuming the Versa is financed over five years at 4% in the nominal case. Factoring in anticipated fuel cost savings further reduces this differential to $10K, again in the nominal case where fuel savings are highly discounted around 50%. An existing $7,500 federal tax credit would need to be supplemented with a $2,500 tax credit at the state level to bring the effective cost of the Leaf down to the cost of the Versa.

However, these calculations incorporate the same variability and uncertainties in driving habits and consumer preferences present in the DF vehicle analysis. Again using Monte Carlo simulation (this time varying the gasoline-electricity GGE differential between -$1.00 and $1.30), we find that one in two Vesta purchasers will instead choose the PEV the presence of these subsidies. A 50% penetration rate is likely an optimistic scenario, as new technology likely needs an initial ramping period. This scenario also presumes that consumers have high enough tax liability to utilize the entire $10K worth of credits.

How might this program affect natural gas demand in PA? The Nissan Versa holds a 24% market share in the subcompact market and sold 100K units in 2011. Scaling the national figure to PA, we estimate that 4,000 Versas are sold annually in the state. If we assume 20%-50% penetration, subsidized Leaf sales could reach between 800 and 2,000 per year in this state. For reference, Nissan sold around 10K of the model in 2011 and just over 4K during the first three quarters of 2012,[9] so this project would be ambitious.

Based on the EPA rated 99 MPG equivalent, a PEV in our nominal case uses 4.1 MWh/year. Assuming 10% transmission losses and 50% plant efficiency, 800 PEVs would require electricity generated by 25,000 MMBTU of gas per year. Two thousand PEVs would increase generation consumption of gas by 62,000 MMBTU per year. It is clear that these low levels would have a negligible impact on demand and price in PA, given our analysis of the other programs. At the end of two years, the total subsidy cost (tax credits plus financing) would be between $21 million and $52 million, with 24% of that subsidy paid by the manufacturer in the form of interest-free financing, 19% paid by state tax credits, and the remaining 57% covered by the federal tax credit..

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[8] Edmunds.com was used for prices and MPG estimates for each of these vehicles.

[9] http://www.detroitnews.com/article/20120904/AUTO01/209040402/1361/Nissan-Leaf-sales-continue-to-fall--20-000-sales-target-unlikely

Municipal Fleet CNG Conversion

The benefits of switching a vehicle from diesel or gasoline fuel to CNG depend on how much of the former is used in the first place. Furthermore, the switch requires the large capital expenditure associated with building new filling stations. This logic suggests that large, fuel-guzzling fleets of municipal vehicles are good candidates for conversion. The filling facilities for such vehicles can be concentrated at a few depots, reducing capital expense for filling stations. Furthermore, the fleets usually operate in urban areas where the benefits from lower emissions of particulates and NO_x are likely to be of greater value.

The issue has been studied in detail (Johnson 2010), and we do not repeat the analysis. One conclusion from the study was that, even without any government subsidy, a large (100 vehicles or more) fleet of diesel-fuelled transit buses could recoup its investment in a switch to CNG within four years. The study reports that the average lifetime of a transit bus is 15 years (Johnson 2010, p.4).

Transit buses travel, on average, 35,000 miles each year and have a fuel economy of 3.02 miles per gallon gas equivalent. As such, each bus would consume 0.1bcf per year of gas. Assuming 15-year lifetime, the Southeastern Pennsylvania Transportation Authority (SEPTA) operates 90 buses that are due to retire this year, and an additional 250 that are due to retire over the next five years (SEPTA 2012).

If we replaced all 340 with CNG buses, the increase in demand would be about 0.1 bcf per day, greater than the capacity of the Allegheny Pipeline. The 4,500 Sentinels and 14,500 Admirals that we assume can be put on the roads by the second year of American Motors' roll-out of the models would create and additional demand that year of 0.004 bcf per day. Switching a quarter of Philadelphia's buses to CNG would create 25 times that demand, at no additional cost.

5. Conclusions & Recommendations

Table 6: Summary of the different programmes considered: while the dual-fuel program is worth considering if AM are willing to subsidize the vehicle, using CNG in municipal fleets is more effective and requires no subsidy.

Program	Δ Gas Demand in PA	Δ Gas Price over no action	Subsidy Required	Net Social Benefit in PA
	million mmbtu/yr	%	$ million	
Dual-Fuel Vehicle Program (2014)	1 - 2	0.016 – 0.033	34 - 44	178 - 350
Pipeline (2016)	110–220	5-11	None	~ 0[10]
Plug-in electric vehicles	0.03 – 0.06	~0	21 - 52	Not estimated
Replacing municipal transit fleets	1 *per bus*	Not estimated	None	Not estimated

Allegheny Pipeline

While we do expect the Allegheny Pipeline to raise prices in Pennsylvania if built, any net benefit from it will accrue to gas consumers in New York and New Jersey. The Governor's constituents in Pennsylvania are likely to face higher energy bills, and – as such – we do not think we can count on his support for it.

Importantly, even with the Governor's support, the pipeline will be operational only in about four years. It would do very little to raise prices in the short term, and we do not recommend that it we aggressively pursue it at this point of time.

CNG Dual Fuel Vehicle Program

If American Motors is willing to provide the $40 million subsidy to get this program going, the benefits that accrue from this program (largely in terms of consumer cost fuel savings) significantly exceed the costs. The benefits from reduced pollution are relatively small.

We anticipate that 80 new filling stations would be needed each year. Conventional stations would each need a subsidy of $0.5 million per year to make them viable, and would tip the program into being a net loss. The station-in-a-box concept requires no subsidy to be viable, and we recommend that this concept be pursued.

Other alternatives

If incentivized through financing offers and tax subsidies to such an extent that the PEV effective purchase price is on par with standard-fuel equivalents, they would increase gas consumption by between 25,000 and 62,000 MMBTU per year by year 2 of the incentive program. This increased consumption, however, would have a negligible impact on gas prices. Other options are more effective.

[10] Benefits to producers balanced out by losses to consumers. Gains to the pipeline operator uncertain and small.

We note that replacing retiring municipal transit buses with CNG vehicles is an investment that would pay for itself in less than four years, provided the fleet in question is sufficiently large. About 90 of Philadelphia's transit buses are due to retire now, and another 250 over the next five years. Replacing this entire fleet would raise demand by a greater amount than building the Allegheny pipeline, and would require no subsidy. Using CNG in cities – where the fleet is likely to operate – is also likely to yield benefits in terms of lower missions of pollutants such as NO_x and $PM_{2.5}$, both of which are highly detrimental to human health.

As such, we suggest that perhaps the most cost-effective and socially responsible way of increasing demand for natural gas is to push for municipal transit fleets to be replaced by CNG vehicles.

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7. APPENDIX

The appendix contains explanation, figures, and tables that provide more details on the calculations performed in this report.

UNCERTAINTY RANGES IN SIMULATION PARAMETERS

The tables in this section catalogue values used for simulation input variables.

Table 7: Distribution parameters for variables in calculations for projected price increase due to new pipeline

Variable	Nominal (Most Likely)	Min.	Max.	Notes
Load factor on power plants	40%	9%	60%	EIA data show that the lowest load factor for gas plants in PA was 9% (in 2003), and that it was 40% in 2010. We assume a maximum load factor of 60%, because PA gets a lot of its power from nuclear reactors, which run at a very high load factor. As such, gas generation must provide flexibility.
Pipeline utilization	60%	40%	100%	New pipelines might lower the premium and make it seasonal (so it exists only in the winter), resulting in low (~40%) utilization.
Marcellus production in 2016 (bcf/day)	13	12	14	The most likely, minimum and maximum values are the projections Considine et al. (2011) have for 2016, 2015 and 2017 respectively. We assume that production might be a year ahead or a year behind current projections.
New power plant build in 2016 (MW)	2000	0	4000	PJM data indicate that 4GW of capacity is queued to come online in 2016. However, we recognize that many of these projects might fall by the wayside and assume that it is likely that only half of them will be built. In the worst case, none get built. In the best case, all get built.[11]

[11] (PJM 2012b) data also indicate that no natural gas plants in PA are set to close in the near future.

Table 8: Parameters used to simulate consumer losses in PA due to pipeline

		Base	High	Low	Remarks
PA demand in 2010	million mmbtu	880			
Growth rate in demand to 2016	per year	3%	0%	6%	3% was the average growth in demand from 2001-10, 6% was the growth from 2009-10[12]
Base price in 2016	$ per mmbtu	5.3	3.92	6.71	$3.92 is the average 2011-15 price for PA considered estimated by IFC (2012), and $6.71 was the 2006-10 price.
Change in price		7%			We assume the same distribution of prices as was obtained from the simulation
New price	$ per mmbtu	5.7			
Change in consumer surplus	$ millions	-$410			

Table 9: Distirbution parameters for variables in fuel savings calculation. (Triangular distributions used unless otherwise noted.)

Variable	Nominal (Most Likely)	Min.	Max.	Notes
Annual Mileage (mi)	12,000	8,000	16,000	
Mileage Proportion CNG	80%	50%	100%	
Gasoline - CNG Price Differential ($/GGE)	$2	$0	$3	$2 is the current differential: reg. gasoline in PA is around $4/gal., while CNG prices are around $2/gallon gas equivalent (GGE)[13]
Fuel Savings Discount Rate	50%	5%	100%	Provided in American Motors market study.

[12] This was likely due to a cold winter, and this growth rate is unlikely to be repeated.

[13] http://www.cngprices.com/station_map.php

Simulation Results

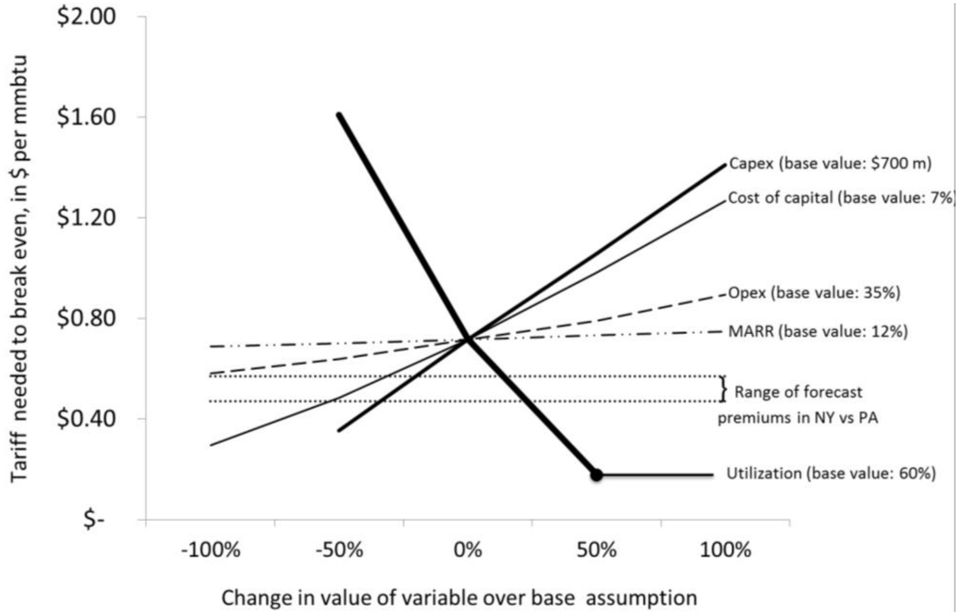

Figure 2: Sensitivity results for pipeline simulation. The required tariff is most sensitive to utilization rates, followed by CAPEX and the cost of capital.

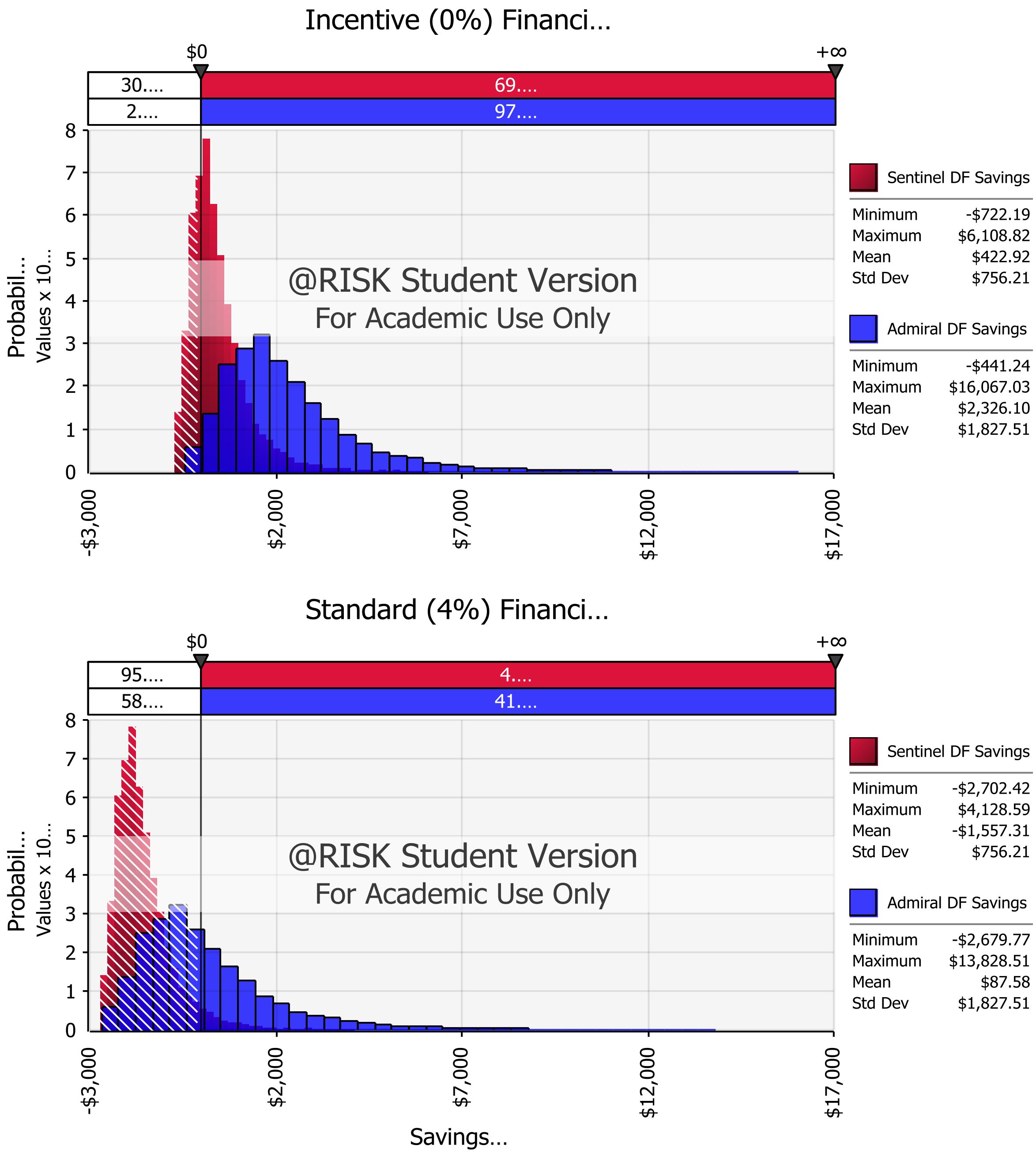

Figure 3: Simulation results for vehicle NPV show strong impact of zero-percent financing incentive (top graph) on attractiveness of dual-fuel vehicles and relatively greater fuel savings for the Admiral pickup compared to the Sentinel sedan. Positive values on the horizontal axis indicate scenarios where the DF version is less expensive in consumers' eyes than the standard version in NPV terms

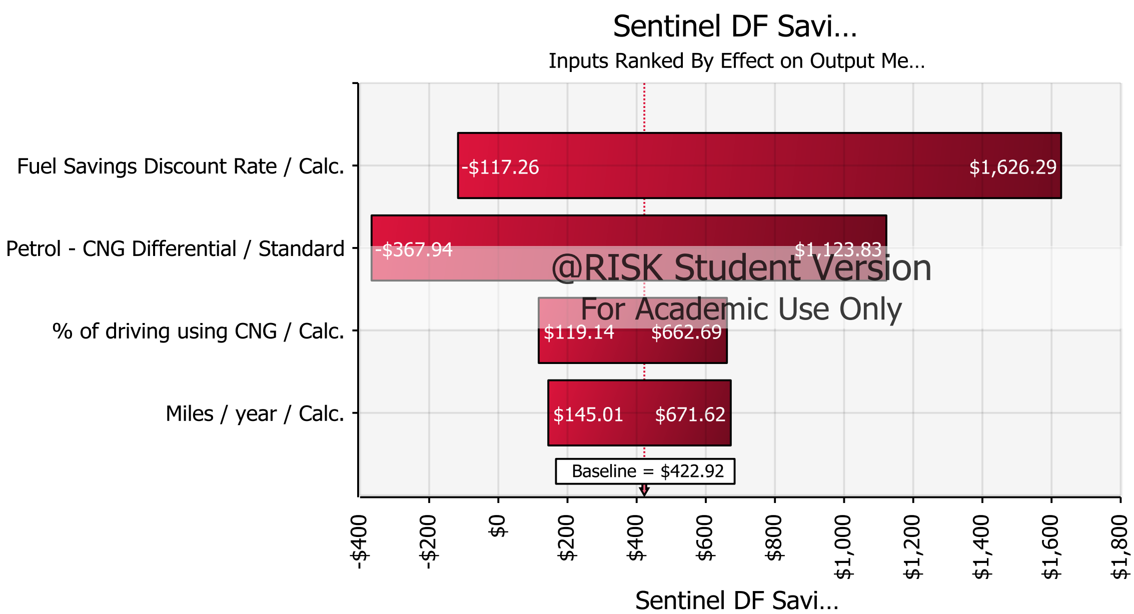

Figure 4: Sensitivity analysis for Sentinel DF NPV savings shows that implicit discount rate and gas price are the largest drivers. The same analysis for the Admiral models showed similar results.

Analysis of Pipeline Benefits to NY/NJ

We check to see if the losses sustained by consumers in Pennsylvania are offset by gains for consumers in New York and New Jersey. We estimate 2016 demand in both states by starting with the demand in 2010, and assuming that in increases at the same average rate as it has in the last 10 years to arrive at demand in 2016. We assume that the base price in New York in 2016 is $5.76 (IFC 2012), and that the price in New Jersey is the same. We also assume that the fall in prices on account of the pipeline is the same in both NY and NJ. Again, we assume that the reduction in price applies to the total demand in both states. The total consumer gain from the pipeline is total demand times the fall in price.

The consumer gain is calculated for each combination of a range of price changes in the three states. In each case, we impose the restriction that the price in New York and New Jersey cannot fall below the price in Pennsylvania. If this were to happen, the gas would simply stop flowing.

With these somewhat stylized assumptions in place, we calculate the total loss or benefit to consumers in all three states – this is consumer gain in New York and New Jersey, less the loss in Pennsylvania. The results are shown in Table 10.

Table 10: Total gain (loss) to consumers, in millions of dollars. If the rise in prices in Pennsylvania exceeds 5%, there will be an overall loss to consumers in all three states. The 'X's mark combinations of price changes that are not allowed: in these cells, the prices in New York and New Jersey would fall below those in Pennsylvania.

Price change in Pennsylvania	Price change in New York and New Jersey: 0%	-1%	-2%	-3%	-4%	-5%	-6%	-7%	-8%	-9%	-10%
0%	0	110	230	340	450	570	680	790	900	920	X
1%	-56	57	170	280	400	510	620	740	760	X	X
2%	-110	0.9	110	230	340	450	570	600	X	X	X
3%	-170	-55	58	170	280	400	440	X	X	X	X
4%	-220	-110	2	110	230	280	X	X	X	X	X
5%	-280	-170	-54	59	120	X	X	X	X	X	X
6%	-340	-220	-110	-37	X	X	X	X	X	X	X
7%	-390	-280	-200	X	X	X	X	X	X	X	X
8%	-450	-360	X	X	X	X	X	X	X	X	X
9%	-520	-520	X	X	X	X	X	X	X	X	X
10%	-680	X	X	X	X	X	X	X	X	X	X

Miscellaneous

Table 11: Pennsylvania CNG vehicle target market area. These areas already have some limited CNG fuel station deployment.

City/County	Metro Area	Pop.	% PA Pop.
Allegheny	Pittsburgh	1,200,000	9.4%
Washington	Pittsburgh	210,000	1.6%
Philadelphia	Philadelphia	1,540,000	12.1%
Chester	Philadelphia	500,000	3.9%
Delaware	Philadelphia	560,000	4.4%
Montgomery	Philadelphia	800,000	6.3%
		4,810,000	**37.7%**

Table 12: Calculating emissions and emission indices for the two vehicles

Pollutant	Fuel			Remarks
		Sentinel	*Admiral*	
Fuel life-cycle GHG (tons $C0_2e$ per car per year)	Gasoline	4.6	11.1	Based on the GREET model (ANL 2010)
	CNG	3.7	9.0	
	Reduction	**0.9**	**2.1**	
		Low	*High*	
NOx (grams per vehicle mile)	Gasoline	0.3	0.3	(ANL 1999, p.41)
	CNG	0.3	0.01	(ANL 1999, p.42) assumes no reduction, Honda Civic claims 95% reduction (Shuldiner 2012)
	Reduction	**0.0**	**0.3**	
PM10	Gasoline	0.01	0.11	(ANL 1999, p.41) for base value; (Gillies et al. 2001) for high value
	CNG	0.00	0.02	(ANL 1999, p.42) assumes 80% reduction
	Reduction	**0.010**	**0.089**	
PM2.5	Gasoline	0.0	0.1	(ANL 1999, p.41) for base value; (Gillies et al. 2001) for high value
	CNG	0.0	0.0	(ANL 1999, p.42) assumes 80% reduction
	Reduction	**0.0**	**0.1**	