The Importance of Pricing Transportation Fuels within California's Cap-and-Trade Program

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California's goal of reducing greenhouse gas (GHG) emissions 80 percent below 1990 levels by 2050 will require deep cuts in GHG emissions from the transportation sector. These reductions can come from a variety of channels, including: increases in new-vehicle fleet fuel economy; increases in existing-vehicle fleet fuel economy; reductions in vehicle-miles-traveled; an increased penetration of low carbon fuels; and, reductions in upstream emissions associated with existing gasoline and diesel fuels.

To summarize this memo, *not* including transportation fuels within the cap will lead to the following:

1. Require more reductions either from other sectors or from upstream emissions associated with transportation fuels, increasing the price of allowances.
2. Steepen the cap-and-trade market's marginal abatement cost curve, increasing volatility and allowance-price risk faced by firms and consumers.
3. Make reaching the goals in SB375 more costly.
4. Reduce the market opportunities for low-carbon fuels, thereby increasing the costs associated with the Low Carbon Fuel Standard (LCFS), as well as LCFS credit prices.
5. Reduce the criteria-pollutant emission, congestion, and accident co-benefits associated with AB32.
6. Set a bad precedent for future cap-and-trade programs in other states, nationally, or globally.

How fuels in the program are included is just as important. If allowances are given freely based on past production it not only removes the ability to use the revenues to offset any regressive aspects of the program, but also creates an implicit production subsidy. This subsidy will deaden the price signal, which is at the heart of the efficiency improvements resulting from cap and trade. And, while some might be tempted to pursue allocation using output-based updating as a strategy to reduce

wealth transfers and achieve cost-containment, this is counterproductive as it deadens the price signal that is at the heart of what makes cap-and-trade efficiency. Ultimately, output-based allowance allocation reduces the abatement achieved from the sector, and makes the program more costly. Furthermore, free allocation of allowances to firms, of any type, can lead to large wealth transfers from energy consumers to energy firms.

In the remainder of this memo, I discuss why cost-effective greenhouse gas emission reductions require including transportation fuel within the cap, how including transportation fuels within the cap will aid in cost attainment associated with the cap-and-trade program, and the large co-benefits associated with including transportation fuels within the cap.

1. Cost-Effective Reductions in Greenhouse Gas Emissions

Few topics in economics garner as much agreement among economists than the cost effectiveness of reducing "externalities," such as greenhouse gas emissions, through putting a price on the externality. When consumers and firms do not face the external costs of their decisions, greenhouse gas emissions will be inefficiently high. Eliminating the price signal will:

1. Reduce the incentive to shift to more fuel-efficient vehicles.
2. Increase the incentive to keep older fuel-inefficient vehicles on the road longer.
3. Lead to increases in vehicle-miles-traveled, making SB475 more costly to implement.
4. Reduce incentives to decrease upstream emissions associated with existing gasoline and diesel fuels refining.

It is also important to note that alternatives to pricing greenhouse gas emissions, while making improvements in one of these channels, can actually increase emissions through other channels. For example, when not combined with pricing greenhouse gas emissions, fuel-economy standards reduce consumers' cost of driving. This leads to more miles traveled. This rebound, as it is known, reduces the net reductions coming from the increased fuel economy and can exacerbate other externalities associated with transportation, such as criteria-pollutant emissions, congestions, and accidents. Holland, Hughes, and Knittel (2008) show that Low Carbon Fuel Standards, while reducing the average carbon intensity of fuels can reduce fuel prices, also leading to more miles traveled because low-carbon fuels are implicitly subsidized in the market.

Some have questioned the impact pricing greenhouse gas emissions might have in the transportation sector. These arguments typically fall under one of two general categories: (a) the size of the demand elasticity for gasoline, or (b) the existence of other market failures.

The Demand Elasticity for Gasoline

Some have cited the near-zero elasticity of demand for gasoline a reason for not pricing greenhouse gas emissions. It is true that the ***short***-run demand elasticity of gasoline is likely very small. Hughes, Knittel, and Sperling (2008) estimate the "one-month gasoline demand elasticity" relying mostly on changes in gasoline prices driven by changes in oil prices and find that the elasticity is smaller than 0.1, suggesting a 10 percent increase in gasoline prices reduces demand by less than 1 percent. But, there is also recent evidence that the short-run elasticity is larger when the source of the price change is perceived to be more permanent, such as coming from changes in gasoline taxes. Muehlegger, Linn, and Li (2012) find that consumers are nearly three times more sensitive to price changes that are more permanent (e.g., changes in gasoline taxes) compared to more transitory price movements (e.g., changes resulting from changes in oil prices).

The focus on short-run elasticities is misguided, however. By definition, short-run elasticities shut off many of the channels through which reductions in consumption can occur. The time frames typically analyzed to estimate short-run elasticities, eliminate a number of behavior changes that consumers make the longer is the price change. For example, a paper might estimate how consumption changes within the first month of a price change. It is best to think of the elasticity of demand as a continuum, varying by the length the price change has existed. Within a month, consumers can eliminate discretionary trips, perhaps improve fuel economy through inflating tires or tuning up engines. Over the course a year or two, consumers may establish carpool relationships and some consumers will replace their vehicle with a more fuel-efficient model either on their previous replacement schedule, or slightly ahead of schedule. Over the very long run, consumers may change commute patterns, firms will offer a different mix of vehicles, and new technologies may develop.

While short-run elasticities are fairly straightforward to estimate, estimating long-run elasticities present a challenge for researchers. The ideal "experiment," where we observe a permanent change in prices, holding constant other factors that influence the demand for gasoline, does not exist in the data. Nevertheless,

estimates of long-run elasticities exist. These typically rely on estimating a "partial-adjustment" model of demand, where demand depends on both the current price and lagged prices. The presence of the lagged prices allow for consumers to change their current consumption because prices in the past were high, reflecting the fact that some behavioral changes may take more than one period to implement. These sorts of models likely understate long-run elasticities because consumers may not implement certain behavioral changes if they believe the price change to be temporary.

Estimates of long-run demand elasticities tend to average roughly 0.8, but vary considerably. Graham and Glaister (2002, Table 4)) provide fairly up-to-date review of the literature. The average of the long-run elasticities that they report is roughly 0.8.[1]

A large literature exists focusing on specific components of the long-run elasticity, for example estimating how short-run price changes affect vehicle demand. Li, Timmins, and von Haefen (2009) and Busse, Knittel, and Zettelmeyer estimate how changes in gasoline prices affect new-vehicle fuel economy. Knittel and Sandler (2012) estimate how gasoline prices impact VMT over two-year periods. They estimate a VMT-elasticity of roughly 0.15. Knittel and Sandler also document VMT shifts from fuel-inefficient and high criteria-pollutant emission vehicles to more fuel-efficient and lower criteria-pollutant emitting vehicles *within* a household. Blake (2012) shows that gasoline prices affect home values in bedroom communities, likely reflecting long-run changes in commute and land-use patterns.

Table 1 reports abatement in terms of millions of metrics tons of CO2 equivalent from the on-road transportation sector for a variety of elasticities and allowances prices. The table assumes a fuel price of $4 per gallon and a baseline emissions rate of 160 millions of metric tons. The table suggests that abatement can be substantial. If we take an elasticity of 0.75, roughly equal to the average elasticity reported in Graham and Glaister (Table 4), an allowance price of as little as $10 per ton achieves reductions equal to the targets under SB 375.[2] Alternative, if the elasticity is 0.25, an allowance price of $30 achieves these targets.

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[1] The existence of fuel-economy standards will, in principle, reduce the long-run demand elasticity associated since the fuel-economy standard will mute some of the fleet fuel economy increase relative to business as usual, which includes the fuel-economy standards and as fuel economy increases the price of fuel becomes a smaller component of the marginal cost of driving. However, because the fleet takes so long to turn over the effect of fuel-economy standards on the elasticity of demand is likely to be small for quite some time. In addition, many of the estimates reported in Graham and Glaister used data from a time period where Corporate Average Fuel Economy standards were initially being implemented.

[2] http://arb.ca.gov/cc/sb375/mpo.co2.reduction.calc.pdf.

Finally, it is also important to note that a small elasticity does not imply putting a price on greenhouse gas emissions is not cost effective; efficiency dictates a price on the externality for any non-zero elasticity.

Elasticity	Allowance Price			
	$10	$20	$30	$40
0.10	0.4	0.8	1.2	1.6
0.25	1.0	2.0	3.0	4.0
0.50	2.0	4.0	6.0	8.0
0.75	3.0	6.0	9.0	12.0
1.00	4.0	8.0	12.0	16.0
1.25	5.0	10.0	15.0	20.0

Table 1: Abatement under different elasticity and allowance price assumptions from the on-road transportation sector. (MMTCO2e/year)

Existence of Other Market Failures

The second argument often raised against pricing greenhouse gas emissions is that other market failures may exist, in addition to the negative externality associated with climate change. For example, consumers may exhibit "myopia" when it comes to investing in fuel efficiency for a variety of reasons. That is consumers invest too little in fuel economy at the time of purchase. Or, there may be market failures associated with research and development for alternative fuels or vehicle technologies, such as learning-by-doing spillovers or an incomplete patent system.[3]

Two things are worth noting in regards to the existence of other market failures.

First, their existence does not eliminate the need to price the externality for cost-effectiveness. Additional market failures open the door for additional policies, such as R&D subsidies or fuel economy standards, but efficiency policy requires pricing greenhouse gas emissions.

[3] Learning by doing refers to the case where the marginal cost of a product decreases the more a firm has produced in the past. For example, the cost of building the new Boeing Dreamliner likely falls the more Boeing has produced in the past. Learning by doing, by itself, does not constitute a market failure. Learning-by-doing *spillovers* do lead to market failures, referring to case where firm Y's costs fall the more firm X produces. Because firm X does not profit from the benefits of it production on firm Y's costs, firm X will produce below the efficient outcome, leading to too little learning.

Second, the evidence supporting additional market failures in the transportation market is incomplete. Using data on individual new and used car transactions, Busse, Knittel, and Zettelmeyer (2013a) find no evidence that consumers behave myopically when purchasing vehicles. In fact, they find implied discount rates that are similar to the interest rates the same consumers are paying for the vehicles. Allcott and Wozny (2011) estimate that consumers use an implied discount rate of 0.16 in the used car market, not far from the interest rates paid within the data. In addition, I know of no literature documenting learning-by-doing spillovers within the transportation sector.

2. Cost Containment within the Cap-and-Trade Program

Not including fuels within the cap will have adverse effects on the price of allowances. This can occur in one of two ways, depending on whether the cost of reductions from pricing greenhouse gas emissions within transportation fuels are below or above the allowance price. (In practice, given the large number of channels reductions may come from, the impacts are likely to be a combination of these two.)

Figure 1 illustrates a stylized marginal abatement cost curve when reductions from the transportation sector are below the allowance price, so they are inframarginal. In this case, not including transportation fuels will shift the marginal abatement cost curve to the left by size of the transportation "step." This will move the MAC curve from what is represented in the top panel to the one in the bottom panel. The level of abatement required under the cap will not change in the two panels because abatement under the cap is dictated by the reductions required after accounting for reductions under the complementary programs within AB32 in order to reach California's abatement goals. Because of this, if transportation fuels are not included within the cap, allowance prices will shift from P_{with} to $P_{w/o}$.

Figure 2 illustrates the second case---when reductions from the transportation sector are above the allowance price. In this case, not including transportation fuels within the cap does not change the equilibrium price. It does, however, steepen the marginal abatement cost curve just to the right of the cap. If there is uncertainty with respect to either other components of the marginal abatement cost curve or the required abatement, then leaving fuels out of the cap will increase allowance price volatility and the risk associated with investments in abatement technologies.

3. Co-Benefits and Costs

Not including fuels within the cap will reduce the co-benefits associated with AB32. Pricing greenhouse gas emissions will have several key co-benefits. These include, a reduction in criteria-pollutant emissions, a reduction in congestion, and a reduction in the negative externalities associated with traffic accidents. Recent work suggests that the co-benefits are much larger than previously thought.

Knittel and Sandler (2013) find that "dirtier" vehicles---measured by either their criteria-pollutant emissions, fuel economy, or size---are much more responsive to changes in fuel prices than cleaner vehicles. This implies that, for a given change in fuel prices, the reduction in these externalities are much larger than what the simple average level of externality would suggest. Knittel and Sandler find that accounting for this effect---that dirtier vehicles are more responsive---increases the co-benefits associated with just criteria-pollutant emissions by 90 percent during their sample (1998 to 2008). They also find that over this time period, the reduction in criteria-pollutant emissions alone, from a $1.00 gasoline tax, are roughly equal to the cost of such a tax. Accounting for other externalities would make such a large tax even more attractive.

These co-benefits also work to undo some of the regressivity issues associated with increases in fuel prices. Knittel, Miller, and Sanders (2011), for example, find that the negative effects of transportation emissions on infant health fall disproportionately on low-income communities. This alone, however, is probably not enough to make such a policy progressive throughout the income distribution. Working with national data, both Poterba (1991) and Busse, Knittel, and Zettelmeyer (2013b) find that gasoline taxes are initially progressive (through roughly income deciles one to four) and then regressive after this.

The regressivity of including transportation fuels within the cap is certainly something that policy makers should be cognizant of and take steps to overcome. This creates a strong argument for auctioning off allowances and distributing the funds from this auction in a progressive manner. This can be accomplished in a number of ways.

The importance of using allowance-auction revenue to undue the regressivity of the cap-and-trade program relates to another issue with respect to transportation fuels and the cap: it is not only important to include them, but equally it is important *how* California include them. In particular, it is important to note that free allocation of allowances that is based on past production will undo many of the efficiency and cost-effectiveness benefits discussed above.

Allocating allowances based on past production creates an implicit production subsidy. Simply put, it creates an added benefit from selling fuel---obtaining more free allowances. This deadens the price signals faced by firms and consumers, which is at the heart of the efficiency improvements from putting a price on greenhouse gas emissions.

While it is tempting to believe that output-based updating of free allowances is a cost-containment mechanism, because it leads to a smaller price signal, it is not---quite the opposite. Output-based updating of free allowances will reduce the ultimate abatement from the transportation sector, increase vehicle miles traveled, reduce the co-benefits, and move some abatement from transportation from being inframarginal to "out of the money." These changes will ultimately make the program more costly. In contrast, allowance allocations that are based on parameters that cannot be influenced by firm decisions once the cap-and-trade program is initiated, such as allocation schemes based on production prior to AB32, or the auctioning off of allowance, do not suffer from this.

More generally, free allocation of allowances of any form shifts valuable wealth away from alternative uses, such as distributing funds to consumers to overcome issues of regressivity or public investments, to the firms receiving the allowances. The typical rationale for free allocation is a response to the likely occurrence that firms' costs will increase. However, it is equally important to realize that the prices that consumers face will also increase, increasing consumers' "costs." In some cases this price response is large enough to actually increase industry profits, even in the absence of any free allowances (see, for example, Holland, Hughes, Knittel, and Parker (2013)).

Free allowance allocation is essentially equivalent to allocating tax revenues to firms within a tax policy. In the standard textbook model of externalities (e.g., one period, no uncertainty, etc.) a cap-and-trade program is equivalent to a Pigouvian tax on the externality. The tax program generates tax revenues equal to the level of the tax times the amount of generated emissions. These tax revenues are equivalent to the value of allowances within the cap-and-trade program. That is to say, if the government were to auction off all of the allowances, the proceeds in the auction would equal the tax revenues collected in the tax program. Therefore, giving allowances for free is equivalent to giving away the equivalent share of the tax revenues. Just as the tax revenues might be used to reverse the regressivity of a given energy tax, the same arguments hold for using allowance value to do the same.

Summary

To summarize, including transportation fuels within the cap is justified on efficiency grounds, but also provides a number of co-benefits. These co-benefits not only include the traditional co-benefits such as reductions in criteria-pollutant emissions, but also the benefits such a decision will have on the general performance of the cap-and-trade program. Including transportation fuels will tend to decrease allowance prices and their volatility. Finally, their inclusion will serve as a positive model for other cap-and-trade programs.

References

Blake, Thomas C. 2012. "What's Exile to the Exurbs Worth? Commuting Costs and Geographic Sorting in the Housing Market," mimeo Ebay Research Laboratory.

Busse, Meghan, Christopher R. Knittel, and Florian Zettelmeyer. 2013a. "Are Consumers Myopic? Evidence from New and Used Car Purchases," *The American Economic Review*, 103(1).

Busse, Meghan, Christopher R. Knittel, and Florian Zettelmeyer. 2013b. "Stranded Vehicles: How Gasoline Taxes Change the Value of Households' Vehicle Assets," mimeo MIT.

Li, Shanjun, Christopher Timmins, and Roger von Haefen. 2009. "How Do Gasoline Prices Affect Fleet Fuel Economy?" American Economic Journal: Economic Policy, 1(2).

Holland, Stephen, Jonathan Hughes, and Christopher R. Knittel. 2009. "Greenhouse Gas Reductions under Low Carbon Fuel Standards?," *American Economic Journal: Economic Policy*, 1(1).

Holland, Stephen, Jonathan Hughes, Christopher R. Knittel, and Nathan Parker. 2011. "Some Inconvenient Truths About Climate Change Policy: The Distributional Impacts of Transportation Policies," NBER Working Paper, 17386.

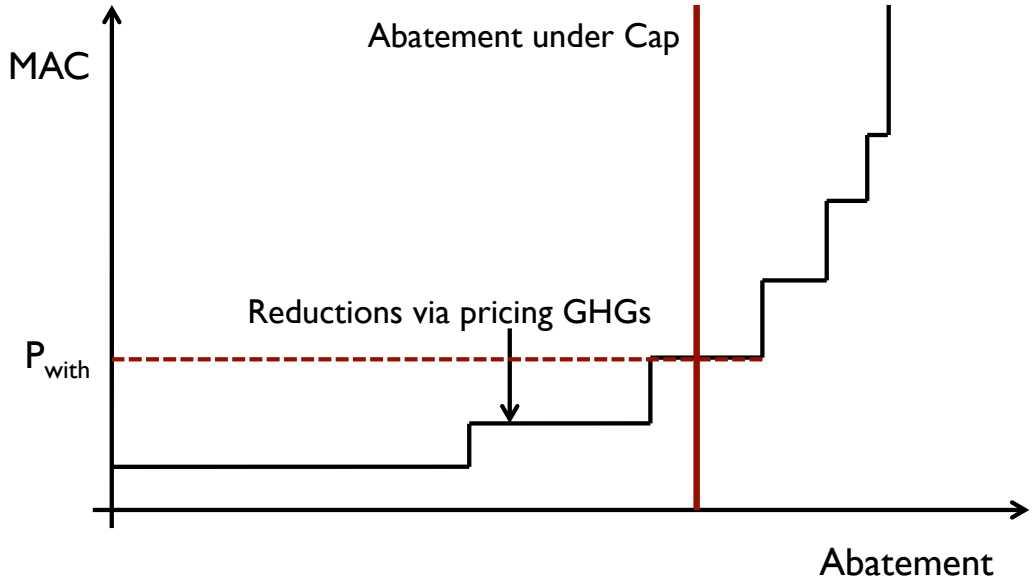
Hughes, Jonathan E., Christopher R. Knittel, and Daniel Sperling. 2008. "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand." *Energy Journal* 29 (1).

Muehlegger, Linn and Li. 2012. "Gasoline Taxes and Consumer Behavior," working paper, Harvard University.

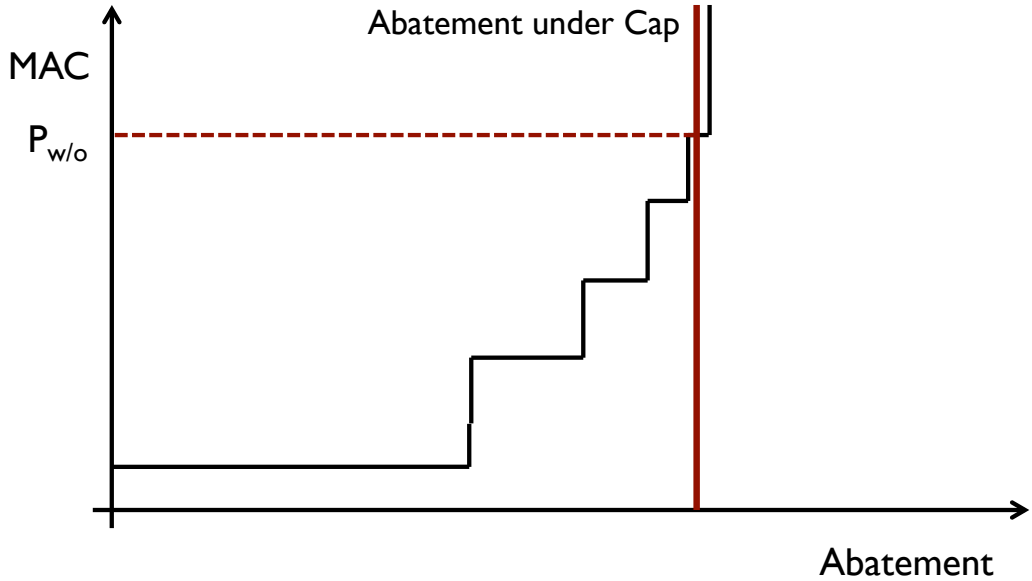
Poterba, James M. 1991. "Is the Gasoline Tax Regressive." *Tax Policy and the Economy* 5, pp. 145–164.

Daniel J. Graham and Stephen Glaister. 2002. "The Demand for Automobile Fuel: A Survey of Elasticities," Journal of Transport Economics and Policy, Vol. 36, No. 1 (Jan., 2002), pp. 1-25

Figure 1: Case 1: Reductions from pricing greenhouse gas emissions in transportation are inframarginal

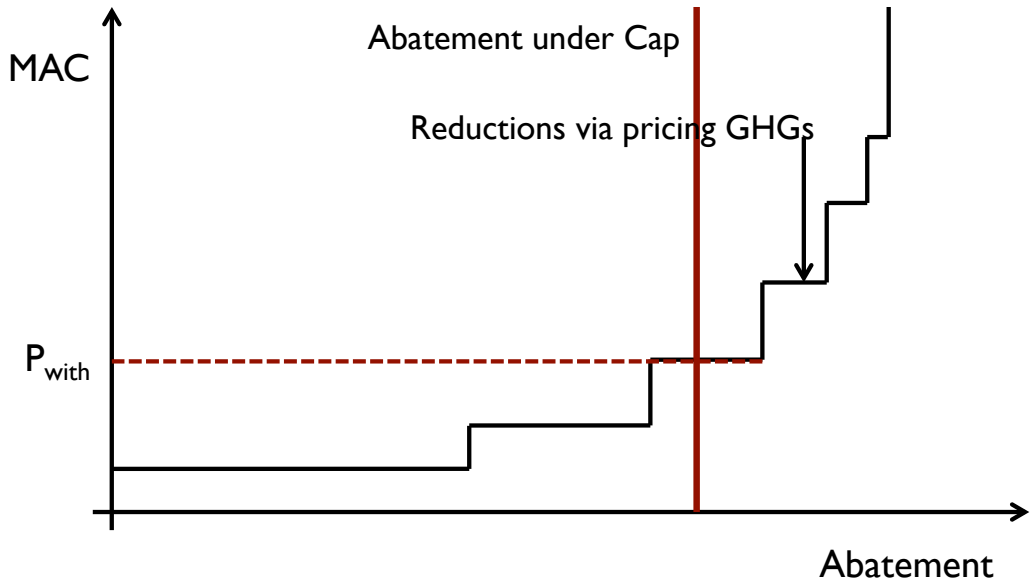


Case 1: With fuels under the cap

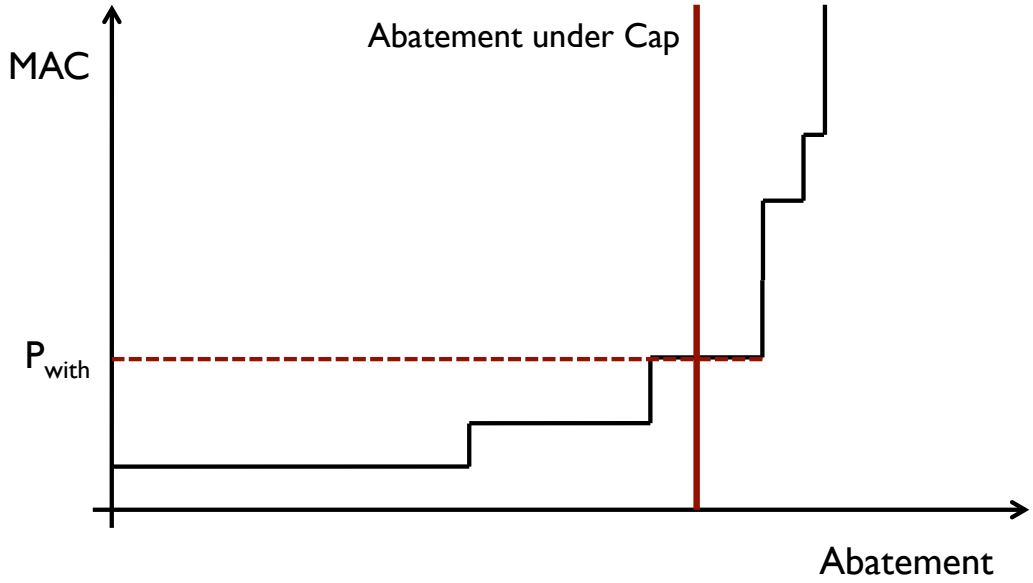


Case 1: Without fuels under the cap

Figure 2: Case 2: Reductions from pricing greenhouse gas emissions in transportation are more costly than allowance price



Case 2: With fuels under the cap



Case 2: Without fuels under the cap