Pathways to Decarbonize the PVC Value Chain in 2050

Appendix 5

A Simplified Discounted Cash Flow Model to Explore the Impacts of Costs on the Pace of Implementation of Abatement Technologies

Authors: Francis Brown and Ronald Whitfield

Corporations typically evaluate technology investments based on such criteria as alternate uses for the funds involved, the technical merit of the technology, its financial attractiveness, and the operational and business risks involved.

The business-as-usual case that we have developed for the PVC chain defines the expected emissions from the process plants and the grid over time. As a thought experiment we can assume that all sites would abate CO2 emissions either by installing CCS systems or switching to hydrogen as a fuel. This would generate cost curves for the sites and estimates of the percent abatement achievable over the 2030–2050 time period. However, this would not be a realistic picture of how the chain might be decarbonized over time.

The decision of which technology to employ, and when to deploy it at a given site, would be made in consideration of the factors enumerated above as well as the impacts of the policy or regulatory regime in place. Because it is a definable, tractable option we have assumed that a tax would be imposed on emissions from a site at a level that would incentivize some operators to make an investment decision to abate emissions while others would prefer to pay the tax and avoid making the investment. We assume further that the tax would be indexed to increase at a rate of 5% per year and would be in place in time to impact projects operating in 2030. If site-specific abatement costs were much higher than the tax an operator might elect to pay the tax rather than invest in the technology, especially if there were an expectation that abatement costs might be reduced in the future.

The investments can take place over time, the abatement facilities will have long operating lives, and the tax will increase steadily. Consequently, an economic evaluation of the decision to abate, or not, must account for the time value of money. We address this by the use of a simplified discounted cash flow model that examines the cash flow profiles for two options at each site at each time period: invest in and operate the decarbonization facility at the current time or pay the tax on unabated emissions and defer the decision to invest. With investment and operating costs, the project life, abatement efficiencies, and the initial tax rate known, the present value of the decarbonization option can be calculated at any stipulated discount rate. Then, a separate calculation can find the present value of the costs of imposing the tax on the unabated emissions over the same time period. If the present value of the cost of installing and operating a decarbonization system exceeds the present value of the tax on unabated emissions, the operator could elect to pay the tax, at least until such time as the technical and economic parameters were improved.

The parameters that drive model results are as follows:

- **Investment Period:** 1–3 years, depending on the level of investment required.
- **Investment Schedule:** 10/60/30% for three-year engineering/design/construction; 40/60% for two-year E/D/C. Planning and permitting activities would precede this and are sunk costs.
- **Operating Costs:** Cash cost of decarbonization in 2020 dollars, constant throughout the project life.
- **Start up:** 100% capacity obtained in the first year of operation and maintained throughout.
- **Project Life:** 20 years of operation.
- **Terminal Value** of the project: Zero.
- **Emissions Profile:** Unabated amount during E/D/C, then constant at the abated amount throughout.
- **Tax Rate:** Either $50 or $75/t CO2 for projects initiated for 2030, then escalating at 5%/yr. thereafter.
- **Discount Rate:** 7.4%

The major simplifications imbedded in the model are the assumptions of instantaneous start up and of constant values for operating costs and the amount of abated emissions. The examples summarized below illustrate how the model was used to evaluate the possible extent of decarbonization over time, either by CCS or use of hydrogen as a fuel, for the cases evaluated. These examples are taken from the low-tax, low-gas-price case of decarbonization by lower cost CCS (Reference Case utilities costs and a $50/t initial tax on CO2 emissions). They represent conditions in the 2030-time frame.

	Example 1	Example 2
Site Size for its Type	Very Large	Large
Site Type	Fully Integrated	Intermediates Production Only
Operations on Site	Production of Ethylene, Chlorine, EDC, VCM and PVC with a CHP plant	Production of EDC and VCM
Inputs to Site	EPB naphtha cracker feedstock, brine for Cl2 production, additional EDC, O2	Ethylene, chlorine, O2, HCl
Site Products	Ethylene, chlorine, PVC, HCl	EDC, VCM
Decarbonization CapEx, $MM	1580	186
Decarbonization Cash OpEx, $MM/yr.	473	43.9
Unabated Emissions, MMt/yr. CO2	7.993	0.626
Abated Emissions, MMt/yr. CO2	0.911	0.071
Cost to Abate, $/t CO2 Treated	79.0	99.8
Present Value with Abatement at $50/t Tax, $MM	−282	−140
Tax Required to Produce a Present Value of Zero, $/t CO2	52.6	66.6
Abate in 2030 Time Frame?	Yes	No

For Example 1, an initial tax of $50/t on emitted CO2 would be insufficient to induce commitment to decarbonization since the present value of the costs to abate over the project's life would exceed the costs of paying the tax by $282 million. However, at a tax of $52.6/t, which would occur just one year later (i.e., 2031), there is no difference between the options and at any higher tax rate abatement would be the preferred option. Therefore, we assign the site in Example 1 as abating in the 2030-time frame, along with two other sites whose present values dictate the advantages of the investment to abate.

In the case of the site of Example 2, it would take almost six years for the initial $50/t tax to be high enough to justify abating rather than paying the emissions tax, so we assign that site to be abating in the 2040-time frame. By 2040 the estimated capital and energy requirements of CCS systems would have been reduced by 35%, and all but the three smallest PVC production sites could justify abating with that technology. These assignments are based solely on the costs and emissions data provided to the model, the model parameters, and the assumed initial tax rate. They assume that all the infrastructure necessary to support CCS operations will be in place when required, that the sites can accommodate the installations, which will be quite large, and that the permitting and regulatory regimes to support these activities will be in place in time to support decision making for a 2030 project. None of these assumptions is assured.