
Atlantic Coast Pipeline Benefits Review

Chmura and ICF Economic Benefits Reports

Southern Environmental Law Center

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EXECUTIVE SUMMARY

In September 2014, Dominion Resources—together with its partners Duke Energy, Piedmont Natural Gas and AGL Resources—announced their joint investment in the 550-mile interstate Atlantic Coast Pipeline (ACP). The proposed pipeline would bring natural gas from West Virginia through Virginia and into eastern North Carolina.

The Southern Environmental Law Center commissioned Synapse Energy Economics (Synapse) to review two reports—one by ICF International and one by Chmura Economics & Analytics—released by Dominion and its partners that assessed the projected economic, job, and tax benefits associated with building and operating the ACP. Synapse identified a number of problems with the reports' conclusions. Importantly, neither report accounted for any of the environmental and societal costs that the pipeline may impose on local communities. Without consideration of these costs, the ICF and Chmura reports can only present an incomplete accounting of the pipeline's net benefits.

Regarding the results of the ICF International report, Synapse concluded that ICF likely overestimates the economic benefits of the pipeline for the following reasons:

- ICF's assumption of a large difference between Henry Hub and Dominion South natural gas prices may not be justified based on available price data.
- The study's method of allocating electric savings to Virginia customers from the ACP is inadequately explained and seems unlikely given regional electric-market dynamics.
- The conclusion that all energy savings to businesses from the ACP will be used to create new jobs is not supported by evidence.
- ICF's characterization of jobs stimulated by energy savings from the ACP as "permanent" is not supported.
- The ICF study does not make clear whether or not it has included costs to build new natural gas generation—a key component in calculating the net economic impacts of the pipeline.
- The report erroneously presents reliability impacts not relevant to Virginia and North Carolina.
- Finally, the study inaccurately conflates wholesale electric price volatility with retail electric rate volatility.

It is worth noting that even if we accept ICF's numbers, the ACP would not produce net benefits until 2027, almost ten years after its construction.

Furthermore, Synapse's review found both the ICF report and the Chmura report to be largely inauditable, meaning they lack the transparency and verifiable data necessary for independent review. Such reports, funded by companies with a financial interest in building the ACP, do not provide the



useful, objective tools necessary to inform a public decision-making process meant to ensure the public good. Analyses that are included in a productive public discourse should be defensible and have well-defined methodology and assumptions, combined with the use of publicly available information. For these reasons, we recommend that elected officials, agency staff, and the public view the conclusions of the ICF report and the Chmura report with skepticism. The wholly transparent analysis described here is necessary before it can be determined what, if any, economic benefits will result from the ACP.

The following report provides additional details of the Synapse review.

1. REVIEWING ICF'S ACP ANALYSIS

In February 2015, ICF International released a report prepared for Dominion Transmission entitled, *The Economic Impacts of the Atlantic Coast Pipeline*.¹ The purpose of the report was to assess the ACP's impacts on the economies and natural gas and electricity markets within North Carolina and Virginia. The study broadly concluded that over the next 20 years, the two states combined could expect the ACP to generate \$7.5 billion in energy cost savings, nearly 45,000 job years, and billions in labor income, in addition to increased reliability, reduced price volatility and state economies enhanced by over \$4 billion collectively. Based on the flaws that were identifiable in the report, it is likely that the results overestimate the benefits of the pipeline. Furthermore, our review found that ICF produced a report using data that are not publicly available and therefore not auditable without the release of additional information. That is, the lack of details on the assumptions, data inputs, and methodologies used by ICF in their analysis greatly impedes adequate third-party review of the study.

ICF's assumption of large difference between the Henry Hub and Dominion South natural gas prices may not materialize. ICF does not make available the Henry Hub and Dominion South natural gas price forecasts used in its study. Instead, it reports the projected difference between these two price points. While Henry Hub prices were generally higher than Dominion South prices in 2014, price spreads between the two points as recent as the week of February 11, 2015 have been as low as 2 cents.² On average in 2015, the price spread has been 81 cents.³ The average spread and the volatility of the price

¹ ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc.

² EIA Natural Gas Weekly Update (February 11, 2015). Available here: http://www.eia.gov/naturalgas/weekly/archive/2015/02_12/index.cfm

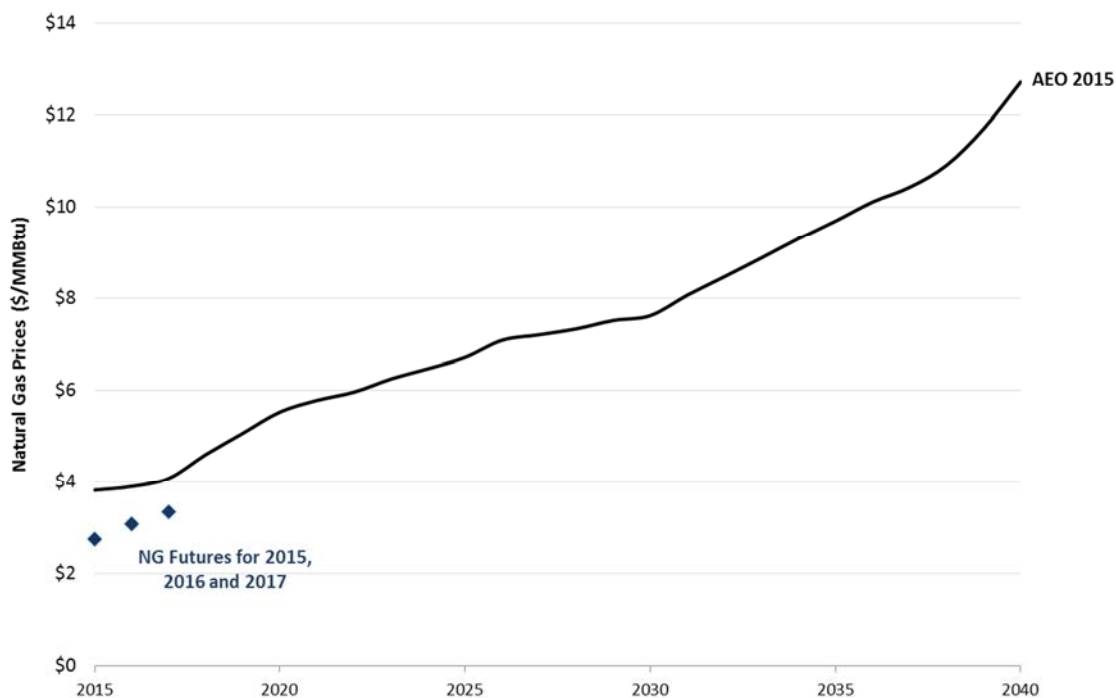
³ EIA Natural Gas Weekly Update. Average of 14 weeks of price data available in 2015. Data is available here: <http://www.eia.gov/naturalgas/weekly/archive/>



spread calls into question whether ICF’s predicted spread of between \$1.50 and \$1.75 will actually materialize.⁴

In addition, the short-term outlook for prices (using NYMEX futures) remains low—as depicted in Figure 1. The short-term expectations for Henry Hub prices in 2015, 2016, and 2017 are lower than the projections in the most recent EIA long-term forecast. The study’s results depend on the continuing divergence of Dominion South and Henry Hub prices. If these price points are actually converging, the implied savings—and resulting economic impacts—would decrease or perhaps disappear. Again, it is unclear how publicly available price projections compare to ICF’s assumptions, but the study should incorporate more up-to-date expectations for Henry Hub and Dominion South prices. The report also, confusingly, switches between using Henry Hub and Transco Zone 5 prices to compare to Dominion South prices. It is not clear which price spread is more valid: 1) Dominion South compared to Henry Hub in ICF’s Exhibit 6, or 2) Dominion South compared to Transco Z5 in ICF’s Exhibit 8.

Figure 1: EIA natural gas price forecast and NYMEX futures



Source: EIA Annual Energy Outlook 2015 (Reference Case), available here: <http://www.eia.gov/oiaf/aeo/tablebrowser/>. NYMEX Futures are averages of monthly settlements (pulled on April 15, 2015), available here: <http://www.cmegroup.com/trading/energy/natural-gas/natural-gas.html>

⁴ ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc. Exhibit 6.

ICF determined economic impacts based on its estimate of cost savings from accessing natural gas from Dominion South in southwestern Pennsylvania instead of Henry Hub in Louisiana. The bulk of the savings would arise from the reduced costs of generating electricity by burning natural gas, with additional savings to direct natural gas customers. ICF's savings estimates, however, rest on the insufficiently documented expectation that Henry Hub prices will continue to be significantly higher than Dominion South prices.⁵ As discussed above, these prices may be converging.

Even accepting ICF's assumptions about the spread of gas prices, there appear to be no annual net savings from the ACP until 2027.⁶ In Exhibit 8, ICF presents the "projected price spread" per MMBtu (i.e. the savings from switching from Transco Z5 to Dominion South), along with the "demand charge" which is the unit cost associated with the pipeline per MMBtu. The savings from switching gas sources would have to outweigh the costs of the pipeline for the project to generate net savings. The exhibit shows that the lines representing the price spread and cost of the pipeline cross in 2027. This means, using ICF's assumptions about gas prices and the other information presented, it appears that the price spread *per MMBtu* does not begin to cover the additional pipeline expense *per MMBtu* until 2027.⁷ The study does not present estimated savings in terms of *total dollars*, making it impossible to determine at what point the total cost of the pipeline is projected to break even.

The study's method of allocating electric savings to Virginia customers from the ACP is inadequately explained and seems unlikely given PJM market dynamics. ICF estimates projected natural gas savings for direct gas customers and pass-through savings to electricity customers due to lower natural gas plant generating costs. ICF appears to assume that lower natural gas prices would mean that Virginia utilities' cheaper electricity would—due to the state's membership in the PJM capacity and energy markets—suppress energy prices throughout the PJM region by \$0.94/MWh over the analysis period.⁸ ICF expected price suppression would seem to require that Virginia natural gas plants are on the margin in PJM (i.e. set the regional wholesale electric price) for a significant share of hours in a year. PJM includes part or all of 13 states and the District of Columbia. A reduction in generating costs for natural gas power plants in Virginia may have a small impact on wholesale costs for the entire region to the extent that the marginal price of energy is reduced. However, since Virginia generators are serving load throughout the PJM region, any price suppression would affect the region at large, and not be captured by Virginia customers alone. It is unclear if ICF allocated savings across the PJM region or assumed that any savings in Virginia power generation would only affect Virginia customers. If it is the latter, the

⁵ ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc. Exhibit 6.

⁶ ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc. Exhibit 8.

⁷ ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc. Exhibit 8.

⁸ ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc. Page 11.

study's economic impacts on Virginia are significantly overstated—even after assuming that ICF's price spread materializes.

The conclusion that all energy savings to businesses from the ACP will be used to create new jobs is not supported by evidence. ICF's economic impact estimates depend on residents and businesses in Virginia and North Carolina re-spending net energy savings. According to ICF, businesses' electric and gas savings generate "more than 2,200 permanent, full-time jobs across the two states" which are "driven mainly by large energy savings for the commercial sector and increased residential consumption expenditures."⁹ The study did not provide any underlying data to support this claim. Critical inputs and assumptions—such as the assumed direct energy savings by sector—are necessary to satisfactorily review this finding. While not explained explicitly, it is possible that ICF assumed that all commercial and industrial energy savings would translate into new job creation. While it is reasonable to assume that residents would re-spend most or all of their energy savings within the state, applying this same assumption to businesses' savings would be difficult to support.¹⁰ Some of businesses' savings on energy bills may go to support hiring more employees, while the remainder may be invested in capital or materials, or returned to owners as profit. Business investment and profit are unlikely to support new in-state jobs in the same way as an increase to consumer spending. Therefore, economic impacts resulting from commercial and industrial savings may be overstated.

ICF's characterization of jobs stimulated by energy savings from ACP as "permanent" is not supported. The study estimates 44,600 job-years over a 20-year period, or approximately 2,225 annual jobs on average over that period, but these are not necessarily long-term jobs.¹¹ If energy savings fluctuate by year, then so will the resulting job impacts. Unfortunately, the study shows neither energy savings nor job impacts on a year by year basis. Therefore, it is impossible to verify how the job impacts are sustained over time. Policymakers should have access to information such as whether the job impacts are more pronounced in the early years, later years or evenly distributed in order to better plan for the long-term well-being of their constituencies.

The study inaccurately conflates wholesale electric price volatility with retail electric rate volatility. The ICF study claims that the ACP will protect consumers against "extreme electricity price spikes and

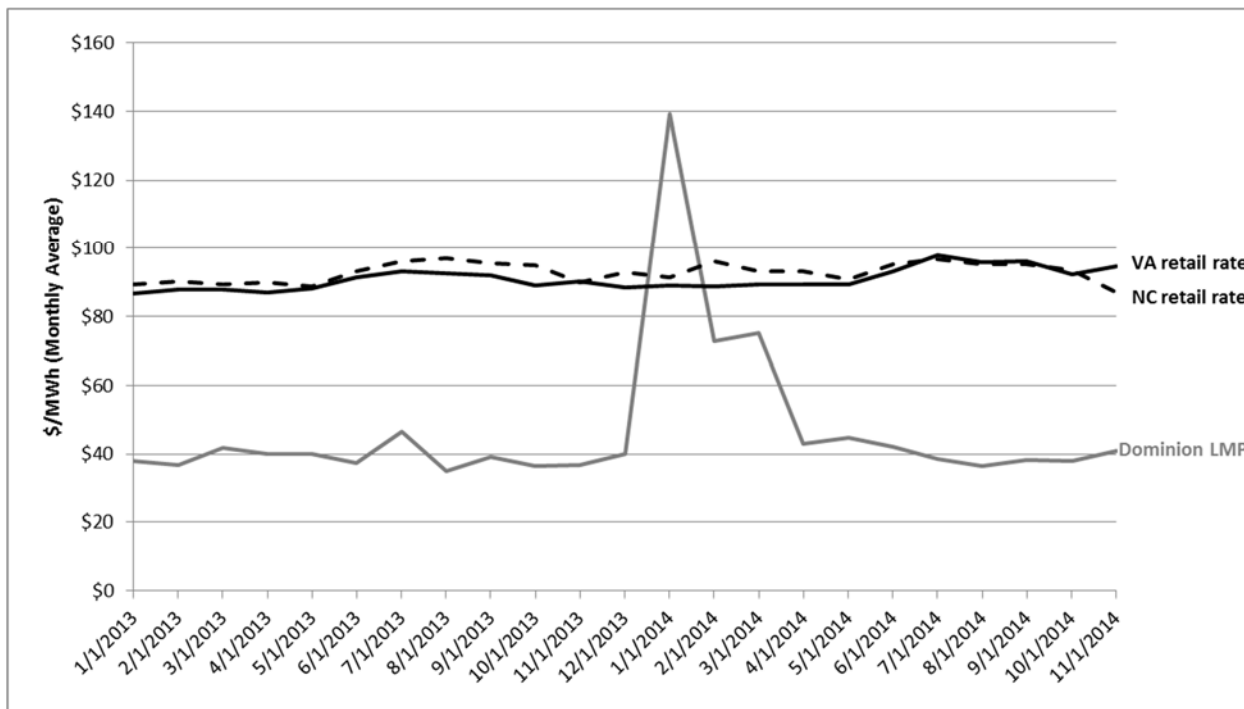
⁹ ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc. Page 12.

¹⁰ While the U.S. average personal savings rate is currently approximately 5 percent (<https://research.stlouisfed.org/fred2/data/PSAVERT.txt>), many studies evaluating economic impacts from energy efficiency assume that 100 percent of residential energy savings is re-spent on household goods. See Bower, S., S. Huntington, T. Comings, W. Poor. 2012. *Economic Impacts of Efficiency Spending in Vermont: Creating an Efficient Economy and Jobs for the Future. Optimal Energy*, Synapse Energy Economics, for the Vermont Department of Public Service and American Council for an Energy-Efficient Economy (ACEEE). Available here: http://synapse-energy.com/sites/default/files/SynapsePaper.2012-08.ACEEE_Economic-Impacts-of-EE-in-VT.S0073.pdf.

¹¹ ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc. Exhibit 12.

volatility.”¹² Retail electric prices faced by consumers, however, do not track wholesale price movements and are largely insulated from abrupt price fluctuations in the wholesale electric market. For example, volatile wholesale electric prices in the eastern United States in January 2014 did not result in price spikes for retail customers, as shown in Figure 2.

Figure 2: Wholesale (LMP) versus retail electric prices (\$/MWh monthly average)



Source: EIA “Average Retail Price of Electricity Monthly”, available here: <http://www.eia.gov/electricity/data/browser/#/topic/7?agg=0>. Wholesale prices are based on Dominion LMP, available here: <http://www.pjm.com/markets-and-operations/energy/real-time/monthlylmp.aspx>

A wholesale price spike over several hours or even days does not translate into higher electric charges in customers’ monthly bills. Rather, it may result in a smaller increase in rates for all hours of the year, usually after a long delay. Regulated utilities’ fuel and energy costs are not immediately passed through to customers; instead, they are typically “trued up” on an annual or biannual basis.

The ICF study does not make clear whether or not it has included costs to build new natural gas generation—a key component in calculating the net economic impacts of the pipeline. The study presents the economic impacts of new natural gas electric generation that would be built as a result of the ACP. However, the costs to construct these facilities would be passed through to ratepayers, most directly in North Carolina. In Virginia, the costs of new facilities would have to be recovered by the

¹² ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc. Page 6.

revenues on the PJM markets; these costs would be socialized throughout the PJM region. In both cases, for accuracy, the costs of construction that flow through to customers should be accounted for in this study, if they are not already reflected in ICF's electricity bill impacts. If these costs are not included, then the electricity savings to customers is overstated.

The report erroneously presents reliability impacts not relevant to Virginia and North Carolina. ICF claims that the pipeline “enhances electric reliability in the region” yet does not present any direct evidence or quantification of this benefit.¹³ ICF presents electric reliability impacts based on a Pepco filing in Maryland.¹⁴ (Note that the study claims that Pepco serves parts of Virginia, but that is not the case.¹⁵) Savings from improved reliability, such as those presented by Pepco, are often based on customers' willingness-to-pay to avoid an outage and not on dollars that would actually flow in the economy. For instance, if a residential customer were willing to pay \$20 to avoid the trouble of an outage, that does not mean that the outage actually costs them \$20. Avoiding an outage is beneficial but does not necessarily translate to money in hand. Moreover, ICF implies that reliability would be improved through the additional natural gas plants assumed in their modeling. However, these new plants would be built in response to “regional load growth and capacity needs under the market assumptions used in this analysis”—not directly due to the ACP. ICF has not presented a reliability impact related to the ACP. Therefore, its claim that the pipeline improves reliability is unfounded.

ICF's study of the ACP lacks the transparency necessary for third party review and verification. The study does not provide critical data needed to confirm or critique its results. In an economic and jobs benefits analysis, a complete set of modeling assumptions, inputs, and outputs would typically include—in addition to the projected job and gross domestic product impacts provided by ICF—the following key data points:

a) Modeling inputs:

- Natural gas price forecasts: ICF does not provide natural gas price forecasts for Henry Hub and Dominion South, making it impossible to determine whether the study's expected gas price savings are reasonable. While historical and projected Henry Hub prices are available from other sources—including the U.S. Energy Information Administration (EIA)—projected Dominion South prices are not publicly available and historical prices are only available on an intermittent basis in EIA's “Natural Gas Weekly Update.”

¹³ ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc. Page 14.

¹⁴ ICF International. 2015. *The Economic Impacts of the Atlantic Coast Pipeline*. Fairfax, VA: ICF International for Dominion Transmission, Inc. Exhibit 15.

¹⁵ Pepco serves parts of Maryland and all of the District of Columbia, none of Virginia: <http://www.pepco.com/my-business/builders-and-inspectors/resources/service-area-map/>.

- Load forecasts: ICF does not provide their projections of how the region’s electric demand will change over time.
- Annual electric generation capacity build-out: ICF does not provide their assumptions regarding what types and sizes of energy generation facilities will be built in the region (or, in the case of Virginia, in the greater PJM region) and in what years these generators will be built.
- Conversion rate of gas to electric savings: ICF does not provide their assumptions regarding the gas-burning efficiency of the region’s electric generators.
- Rate impacts of new gas plants: ICF does not provide their assumptions regarding how much electric ratepayers will pay for new generation facilities and in what years.
- Annual pipeline construction and operation costs: ICF does not provide annual pipeline construction and operation costs.

b) Modeling outputs:

- Annual gas and electric cost savings: The study focuses on the economic impacts modeled in IMPLAN, the underlying economic assumptions of which are reasonably available and auditable. The inputs to IMPLAN used by ICF, however, are developed using its own proprietary Gas Market Model (GMM) and Integrated Planning Model (IPL), and have not been made available for review.
- Allocation of gas and electric savings by state: ICF does not provide a break-down of what gas and electric savings are projected to occur in what states.
- Annual economic and job impacts by sector: Economic impacts are not provided by year or by customer sector (residential, commercial and industrial) in the ICF study. Therefore, it is not possible to trace how purported savings are distributed over time and throughout the economy.

2. REVIEWING CHMURA’S ACP ANALYSIS

Synapse conducted a review of a 2014 analysis by Chmura entitled *The Economic Impact of the Atlantic Coast Pipeline in West Virginia, Virginia, and North Carolina*.¹⁶ The Chmura analysis studied selected potential economic benefits of the ACP, during the expected construction phase and also after construction. The study estimated benefits such as tax revenue and job creation throughout the three-state region. As previously noted, this study is inadequate to inform a public decision-making process.

¹⁶ Chmura Economics & Analysis. 2014. *The Economic Impact Of The Atlantic Coast Pipeline In West Virginia, Virginia, And North Carolina*. Richmond, VA: Chmura Economics & Analysis for Dominion Resources.

We found that the accuracy of the Chmura study cannot be assessed without additional information on their modeling assumptions and data inputs. In particular, a third-party audit of the Chmura report requires the release of detailed information on the expected spending categories and magnitude for building and operating the pipeline.

Neither Chmura in its report nor Dominion and ACP in their background materials offer an appropriate level of detail regarding capital and operations spending for the pipeline. In the absence of critical assumptions and inputs to Chmura’s modeling, we can only make inferences from observing the results of their economic analysis. Without detailed capital and operations spending assumptions provided either by Chmura or ACP, it is not possible to satisfactorily verify or critique these economic projections.

The Chmura study provides detailed tax revenue benefits for three states, but fails to provide any underlying data or assumptions for these tax revenue calculations. Chmura notes that it uses some IMPLAN assumptions to calculate total employment spending and business profits from total annual capital expenditures. For example, the study assumes that 34.5 percent of total revenue is paid as employment compensation while 1.4 percent is profit. However, the study provides no information regarding specific employment and business profit dollar values. Without this information, it is impossible to assess the accuracy of Chmura’s income and corporate tax calculations benefits. For income tax calculations, critical assumptions not provided in the study include what average wages and, therefore which income brackets and tax rates, have been assumed. Furthermore, Chmura neglects to provide either the method for calculating the cumulative tax revenues or the assumed interest rate. Without these critical details it is impossible to assess the accuracy of Chmura’s findings or to evaluate the expected job impacts of the ACP.

3. HIDDEN COSTS OF THE ACP

The ICF and Chmura reports do not include discussion of many serious costs associated with pipeline construction and operation. The ACP will pass through hundreds of communities and natural ecosystems, and the resulting impacts can be difficult to value in terms of dollars and cents. Pipeline construction and operation will involve real costs—in terms of public safety, human health and welfare, and impacts to property and natural resource values—which have been ignored in these reports. Below, we highlight a few of these hidden costs.

- **Very large, high-pressure natural gas transmission pipelines like the one proposed by Dominion pose substantial public safety risks to nearby residents.** The proposed 42-inch ACP would be one of the largest interstate natural gas pipelines in the United States. Accidents at natural gas transmission lines are particularly dangerous because the distance between shut-off valves is significant, meaning a rupture or leak would be fed by great quantities of gas even after being shut-down. Despite the passage of the Pipeline Safety Improvement Act in 2002, there have been more than 3,000 significant accidents, causing more than 150 fatalities, hundreds of injuries, and billions of dollars

in property damage,¹⁷ including four major incidents in North Carolina, Virginia, and West Virginia in the last few years.¹⁸ One of the most infamous recent accidents occurred on a 30-inch pipeline in San Bruno, California where the blast killed eight people, destroyed 38 homes, and registered as magnitude 1.1 earthquake.

- **The ACP project could have detrimental effects on property values in communities where the pipeline will be located.** The 550-mile, 42-inch pipeline will pass through 26 counties and hundreds of communities. Research by Boxall, et al. (2005) and Hansen, et al. (2006) show nearby pipelines may have negative impacts on property values, particularly following catastrophic events like the explosions cited above.¹⁹ The Forensic Appraisal Group, LTD, found that the negative impact on property values could be “up to 30% or more of the whole property value.” Resale value is also a concern, particularly in states that require disclosure of potentially hazardous conditions. Reduced property values would lead to lower assessed real estate values and, therefore, lower tax revenues.
- **The presence of a 42-inch, high pressure natural gas pipeline like the ACP may lead to insurance and mortgage issues.** With increased media coverage of catastrophic events like the recent explosions in West Virginia and California, there is concern that insurance underwriters may already be increasing rates or even denying coverage for properties located near natural gas transmission lines.²⁰
- **The construction of the ACP could lead to an increase in natural gas drilling in areas along the pipeline route that were not previously developed, including the George Washington National Forest, which is located on the southern edge of the Marcellus Shale formation.** Increased drilling activity brings with it a host of negative socio-economic impacts, such as air pollution, degradation of surface and groundwater, noise, significant heavy truck traffic, and damage to local roads and infrastructure, the burden for which falls on local residents and taxpayers. Further, interstate pipelines require compressor stations—typically located every 40-100 miles along the line—to move the

¹⁷ See *Pipeline and Hazardous Materials Safety Administration’s Significant Incident Files*. Available at: <http://www.phmsa.dot.gov/pipeline/library/data-stats>.

¹⁸ In September 2008 in Appomattox, VA, the 36-inch Transco pipeline ruptured. The explosion burned an area 1,125 feet in diameter. Twenty-three families were evacuated, two homes were destroyed, and five people were hurt. In late 2012, an explosion on a 20-inch gas pipeline in Sissonville, WV destroyed several homes and a section of Interstate 77 in both directions. A large explosion on a 12-inch pipeline in Asheville, NC in January 2014 damaged several homes and vehicles as well as two local businesses. At the beginning of 2015, an explosion at a 20-inch pipeline in Brooke County, WV sent two families from their homes.

¹⁹ Boxall, P. C., W. H. Chan and M. L. McMillan. “The impact of oil and natural gas facilities on rural residential property values: a spatial hedonic analysis.” *Resource and Energy Economics*, 2005, 27:248-269; Hansen, J. L., E. D. Benson and D. A. Hagen. “Environmental Hazards and Residential Property Values: Evidence from a Major Pipeline Event.” *Land Economics*, 2006, 82:4, 529-541.

²⁰ See Pipeline Safety Trust’s “Landowners Guide to Pipelines,” 2014. Available at: http://pstrust.org/wp-content/uploads/2014/07/pst_LandOwnersGuide_2014_forweb.pdf.

gas from West Virginia to North Carolina.²¹ Compressor stations can be noisy and produce air pollutants such as nitrogen oxides, hydrogen sulfides, and formaldehyde.

- **In addition to water impacts from increased gas development in the area, the construction of the pipeline itself could lead to water quality impacts.** Run-off and sedimentation during construction and chemical additives used to keep rights-of-way clear can impact local surface waters. Blasting and excavation could also affect aquifers and water tables. Gas companies are not subject to the Safe Drinking Water Act, and therefore are not required to disclose any chemicals that are in the gas they transport. Chemicals are used mainly for preventing corrosion of the pipeline and can include desiccants, coolants, and biocides for inhibiting microbial growth.²² These chemicals could potentially leak into groundwater.
- **Pipeline construction may damage productive farmland and forest land.** Construction of the ACP will require land and forest clearing, with an estimated total land requirement of 4,600 acres. The pipeline operator will need to keep rights-of-way clear, and construction equipment may lead to soil compaction, which can affect crop production. Further, many trees will be removed to make way for the pipeline and access roads.
- **Pipeline construction and maintenance can have detrimental impacts on wildlife through habitat loss and fragmentation.** The ACP will cut through forests, wetlands, and other important wildlife habitat, putting pressure on native species' ability to survive. According to the U.S. Fish and Wildlife Service: "ROWs [rights-of-way] and other linear developments like transmission lines, roads, seismic lines and trails can increase human access into new areas, displace wildlife from their habitat, act as barriers to wildlife movement and affect migration routes. ROWs may cross different ecosystems and can fragment habitat, lead to the clearing of sensitive vegetation and create pathways for the spread of invasive species. ROW stream crossings can result in significant biological and engineering problems."²³
- **Pipeline construction could affect the natural beauty and recreational value of areas like the Blue Ridge Mountains, Monongahela National Forest, and the George Washington National Forest.** Landscapes will be permanently scarred by pipeline rights-of-way, which could have significant impacts on tourism and the aesthetic value of these protected areas.

²¹ See *The Transportation of Natural Gas*. Available at: <http://naturalgas.org/naturalgas/transport/>.

²² Thompson, Neil G. "Gas and Liquid Transmission Pipelines." Available at: http://www.dnvusa.com/Binaries/gasliquid_tcm153-378807.pdf

²³ <http://www.fws.gov/ecological-services/energy-development/pipelines.html>