
Report Analyzing CarbonPath's Methodology According to IPCC Guidelines

Prepared for Carbon Path Group
by the Honors College Carbon Markets Research Group
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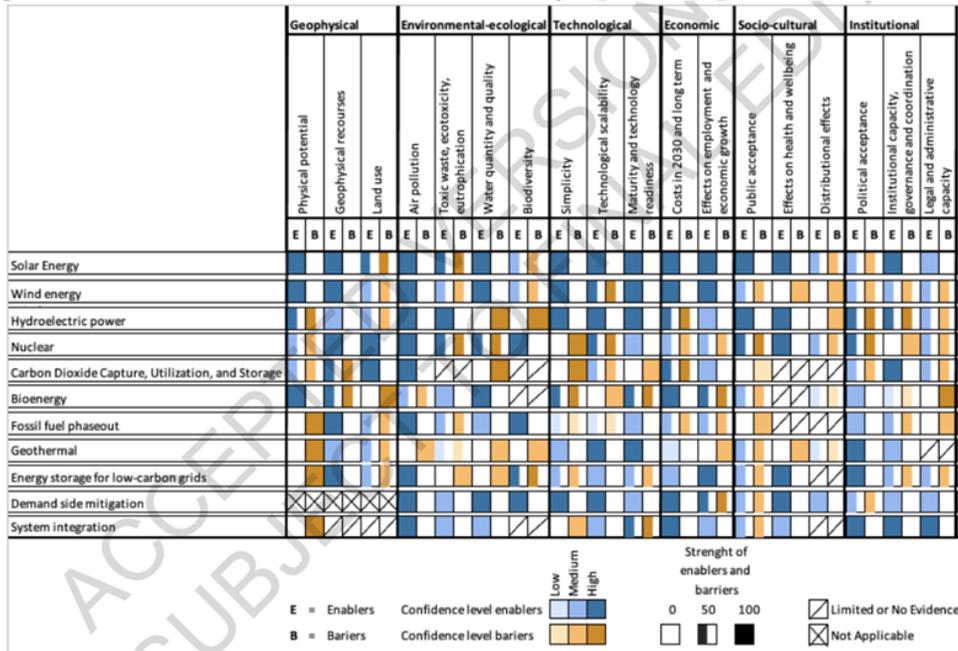
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Introduction

This report is the second document produced for CarbonPath by the Honors College Carbon Markets research team. Our team was asked to evaluate CarbonPath’s methodology according to the guidelines laid out in Chapter 6 “Energy Systems,” of the IPCC WGIII AR6. The IPCC examines eleven different energy systems¹ according to a number of different categories and subcategories to determine each system’s capacity to contribute to the goal of limiting global warming to 1.5°C. The team used Figure 6.19 as our starting point (reproduced below). The IPCC uses a qualitative measure of confidence, which reflects the confidence the author team has in both the validity of their finding (reflecting the quality and consistency of the evidence) and the degree of agreement within the team. Our team aimed for the same qualitative measure of confidence and our evaluation is based on agreement within the team and the quality of the supporting evidence we were able to evaluate. As part of our process, we sought to isolate the independent impact of issuing carbon credits for the plugging and abandonment (P&A) of low-producing and abandoned wells on the IPCC’s goal of limiting global warming. We were not attempting to capture the cradle-to-grave impact of a well from drilling to P&A since Carbonpath’s methodology applies to existing wells that are already in production, and which would eventually be subject to P&A later in their lifecycle.”We wanted to remain focused on CarbonPath’s model of issuing carbon credits to companies that follow existing P&A practices prior to what would normally serve as the end of a well’s production curve. To make our assessment, we looked at how the IPCC report scored each energy system within each category and sub-category as laid out in Figure 6.19. We followed the same guidelines and made our determinations within the six categories and the included subcategories outline in Figure 6.19. Once we had a better understanding of how the IPCC determined their levels of confidence, we evaluated CarbonPath’s methodology according to the categories laid out by the IPCC. In chapter 6, the IPCC outlines that the effort to limit warming to below 2°C will require “rapid and deep reductions in energy systems CO₂ and GHG emissions” (6-3). This will require several changes including reducing fossil fuel consumption, increasing the use of alternative energy, and increasing the production from low-and zero-carbon energy sources (6-3). Within this context, the team found that CarbonPath’s methodology fits well within the IPCC’s overall framework and has strong potential to contribute positively to the IPCC’s overall goals.

¹ The systems evaluated by the IPCC include solar energy, wind energy, hydroelectric energy, nuclear energy, carbon dioxide capture, utilization, and storage, bioenergy, fossil fuel phaseout, geothermal energy, energy storage for low-carbon grids, demand side mitigation, and system integration.

Figure 6.19 Summary of the extent to which different factors would enable or inhibit the deployment of mitigation options in energy systems. Blue bars indicate the extent to which the indicator enables the implementation of the option (E) and orange bars indicate the extent to which an indicator is a barrier (B) to the deployment of the option, relative to the maximum possible barriers and enablers assessed. An X signifies the indicator is not applicable or does not affect the feasibility of the option, while a forward slash indicates that there is no or limited evidence whether the indicator affects the feasibility of the option. The shading indicates the level of confidence, with darker shading signifying higher levels of confidence. Appendix II provides an overview of the factors affecting the feasibility of options and how they differ across context (e.g., region), time (e.g., 2030 versus 2050), and scale (e.g., small versus large), and includes a line of sight on which the assessment is based. The assessment method is explained in Annex II.11.



From Clarke, L., Y.-M. Wei, A. De La Vega Navarro, A. Garg, A.N. Hahmann, S. Khennas, I.M.L. Azevedo, A. Löschel, A.K. Singh, L. Steg, G. Strbac, K. Wada, 2022: Energy Systems (pp. 6-68). In IPCC, 2022: *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [P.R. Shukla, J. Skea, R. Slade, A. Al Khouradajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.008

Summary of the IPCC's guidelines including CarbonPath's methodology

	Geophysical						Environmental-ecological						Technological						Economic				Socio-Cultural						Institutional							
	Physical Potential		Geophysical Resources		Land Use		Air Pollution		Toxic Waste, ecotoxicity, eutrophication		Water quantity and quality		Biodiversity		Simplicity		Technological scalability		Maturity and technological readiness		Costs in 2030 and long term		Effects on employment and economic growth		Public Acceptance		Effects on health and wellbeing		Distributional effects		Political acceptance		Institutional capacity		Legal and administrative capacity	
	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B		
CarbonPath Methodology	Blue	Yellow	Blue	Yellow	50	Yellow	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow			
Solar Energy	Blue	Yellow	Blue	Yellow	50	50	Blue	Yellow	50	50	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow				
Wind Power	Blue	Yellow	Blue	Yellow	50	50	Blue	Yellow	50	50	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow				
Hydroelectric	50	50	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow				
Nuclear	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	50	50	50	50	Blue	Yellow	Blue	Yellow	50	50	Blue	Yellow	50	50	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow				
Carbon Dioxide Capture, Utilization, and Storage	50	50	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow				
Bioenergy	Blue	Yellow	50	50	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	50	50	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow				
Fossil fuel phaseout	Blue	Yellow	Blue	Yellow	50	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	50	50	50	50	Blue	Yellow	50	50	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow					
Geothermal	Blue	Yellow	Blue	Yellow	50	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow					
Energy storage for low-carbon grids	Blue	Yellow	Blue	Yellow	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	50	50	50	50	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow					
Demand side mitigation	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	50	50	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow				
System integration	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	50	50	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow	Blue	Yellow				

E = Enablers Confidence level enablers
 B = Barriers Confidence level barriers

Low Medium High

Strength of enablers and barriers

Limited or no evidence
 Not applicable

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Evaluation of CarbonPath’s methodology according to the categories laid out by the IPCC in Chapter 6

Geophysical

The first category used by the IPCC is geophysical, asking the overarching question, are the required resources available? Our team assigned a level of confidence to each of the three sub-categories within the Geophysical category.

1. Physical Potential (evaluating the physical constraints to implementation) – **High Confidence**

- a) The physical potential for CarbonPath comprises two portions: verifying the review process for the plugging and abandonment of the wells and facilitating a carbon credit system on the blockchain. We separated our analysis into 1) the carbon emissions verification and capping process, and 2) the use of the blockchain system to deliver carbon credits and financing. According to a 2019 estimate by the Environmental Defense Fund, the 565,000 marginal producing wells represent a super majority of US oil and gas wells, but account for barely more than 5% of production volume, representing significant operation and maintenance cost to regulatory agencies and producing facilities (Winn, 2021). The U.S Energy Information Administration estimates that the number of producing wells in the United States was 936,943 in 2020 and of those wells, 80% were producing less than 15 BOE/d. (1). Furthermore, marginal well ownership is clustered into small ownership (1-100) for 23% and large ownership (100+) for 77% which matches CarbonPath’s focus on targeting large producers operating marginal wells (Winn, 2021). Based on CarbonPath’s plugging and abandonment review process and US marginal well demographics, we have **high confidence** in the physical potential for facilitating early well capping and delivering better financial returns for well owners by freeing up investments in the form of carbon credits. We have possible agreements with CarbonPath’s process presentation regarding short term appeal for the carbon credit system and probable avenue for limits on its physical potential. In the short and mid-term, there is **high confidence** in CarbonPath’s methodology for awarding carbon credits due to a mandatory capping procedures required under US regulations. Producing facilities are required to properly review and cap wells at the end of operations which aligns with CarbonPath’s process. In addition, CarbonPath offers a way to remove company liabilities with earlier in hand assets in the form of carbon credits for future transactions in the blockchain system which is appealing to companies barely making a profit on marginal wells as well as other high expenditure wells. Strengthening the carbon credit system’s success, CarbonPath offers quantifiable carbon offsets that have model guidelines in US government and third-party verification processes for negative carbon emissions against a business-as-usual schedule. In the long term, CarbonPath’s provides capital redeployment which may serve as potential leakage. Carbonpath’s initial pricing model for credits roughly equates to the costs associated with P&A, so the capital available for redeployment is largely a matter of timing, rather than a windfall to fund future exploration. Only if carbon credits were to become significantly more valuable would this alter the leakage risk.

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- 2) Geophysical Resources (evaluating the availability of resources needed to implementation) – **High Confidence**
- a) CarbonPath mainly is an additional carbon credit verifier for carbon emissions reduction in the oil and gas industry. There is **high confidence** and good evidence that CarbonPath’s well plugging and abandonment process require no significant additional geophysical resources due to the established nature of the plugging and abandonment industry standard, which minimizes pollution and uses less resources than the continued operation of marginal wells. Additionally, CarbonPath’s methodology appears to offer quantifiable offset using existing technology, at least in the US. The geophysical potential for CarbonPath’s P&A process and carbon credit awarding scales with the number of operating wells and companies willing to conduct the business to cap and remediate early rather than cap and remediate later following US legislation H.R. 2415 on orphaned wells. The long-term geophysical potential is low but varies highly depending on the profitability of operating wells compared to early close-out using carbon credit system offered by CarbonPath to resolve company liability. Overall, there is **high confidence** in meeting CarbonPath’s goals to reduce carbon emissions using market forces with sustainable geophysical resource use.
- 3) Land Use (evaluating claims on a land where an option would be implemented) – **Medium to High Confidence**
- a) The plug and abandonment process used by Carbon Path does not use new land for any purpose. The process happens on land that is already being used to generate oil, which adds carbon dioxide to the atmosphere. The construction that must take place to plug and abandon a well should be studied on a case-by-case basis, analyzing each jobsite for the best way to minimize land destruction and promote biodiversity. Through this process, the land use will be improved compared to its previous state and will minimize the amount of land affected by oil drilling. It is also important that the plug and abandonment process complies with the state and federal regulation standards set in place by the government to ensure proper sealing. Depending on landowner preferences, there is potential for land use to contribute in positive ways to clean energy production and increased biodiversity. Carbon Path uses a blockchain process to verify the credits, which uses energy and land to function. CarbonPath plans to use a carbon negative blockchain, Celo, to mitigate the overall carbon footprint of their processes. Though the land used is likely nowhere near a jobsite, there will be space taken somewhere in a server room that accounts for the overall land use of Carbon Paths methodology. There is **Medium to High Confidence** that the Carbon Path methodology will have a positive effect on land use.

Environmental-Ecological

The second category used by the IPCC is Environmental-Ecological, asking the overarching question, what are the wider environmental and ecological impacts of the option? Our team assigned a level of confidence to each of the four sub-categories within the Environmental-Ecological category.

- 1) Air Pollution (evaluating Increase or decrease in air pollutants such as NH₄, CH₄ and fine dust) – **Medium to High Confidence**.
 - a) Carbon Path uses an oil well plug and abandon technology which is mature and effective. The plug and abandonment process uses cement to cap off oil wells, which produces carbon dioxide during the production process. In 2019, cement production worldwide accounted for around 5% of the global greenhouse gas emissions. Though there are other aspects of the plug and abandonment process such as jobsite transportation that produce carbon dioxide and other greenhouse gases, they are negligible in comparison to the carbon dioxide emissions that come from cement production. If Carbon Path were to use carbon sequestering cement technology, they would have the potential to break even in terms of material and jobsite emissions if implemented properly. This technology has the potential to capture more carbon than it emits, which could potentially make up for other processes that make up the entire plug and abandonment process. Though plugged wells do produce methane emissions, oil wells that produce less than 15 barrels of oil a day are some of the highest producers of methane leaks. According to Resources for the Future (RFF), the EPA estimates that abandoned wells produce approximately 280,000 metric tons of methane per year (this estimate is uncertain) (Raimi 2022, 2).² RFF estimates that decommissioning 62,000 wells a year would result in a methane emissions reduction of 217,000 metric tons over fifty years (Raimi 2022, 2). Therefore, wells plugged under state regulatory oversight should have a net-negative effect on methane emissions relative to either low-production or abandoned wells. The plug and abandonment process does help to mitigate methane production significantly, but it does not completely mitigate methane leaks.
- 2) Toxic Waste, Ecotoxicity, Eutrophication – **High Confidence**
 - a) The plug and abandonment process is a solution to a problem (oil field production) that has clear negative environmental impacts. The potential for leaking oil wells negatively affects the environment, and the plug and abandonment process can remove these potential hazards. To do this, careful attention must be paid in the plug and abandonment process to ensure that leakage will not occur. After the process is completed, jobsite monitoring must be used to confirm that no leaks occur after the work is done. Using the plug and abandonment process is a great solution to keeping oil out of both land and water, so there is **high confidence** that Carbon Path can positively affect the environment.

² A 2021 article by Williams, Regehr, and Kang found that methane emissions from abandoned wells in Canada and the United States have been underestimated by 150% and 20% respectively. This underestimation suggests that methane emissions from abandoned wells might be an ever-larger contributor to global warming than previously thought and more significant study of methane emissions from abandoned wells is needed.

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- 3) Water Quantity and Quality (evaluating changes in the amount of water available for other uses) – **High Confidence**
- a) The plug and abandonment process used by Carbon Path does not use excessive amounts of water and is not normally conducted near a body of water (reducing any potential contamination issues). Though runoff from leaking oil wells has the potential to destroy the water quality of a pond, lake, or river, water contamination can be mitigated through the P&A process outlined by CarbonPath’s methodology. The greatest risk to groundwater comes from wells that were either poorly constructed or nonproducing wells that have been left unplugged or were improperly plugged, which can lead to migration of pollutants to the surface and/or the atmosphere (Ho et al. 2016). According to Ho et al., “Leakage pathways include the migration of methane from producing or nonproducing hydrocarbon formations, or sometimes from aquifers to the atmosphere; of brine from saltwater zones to freshwater aquifers, surface water, or surface soils; of oil and gas from hydrocarbon formations to freshwater aquifers, surface water, or surface soils; or of pollutants in surface runoff into freshwater aquifers (API 1993)” (2016). The authors note that proper well design is the first step towards mitigation of groundwater contamination and that proper P&A can help ensure that the risk to groundwater is minimal (Ho et al. 2016). If the plug and abandonment process is conducted properly and with care, according to individual state standards, and the site is monitored after the work is done, there should be no issues with the quantity and quality of water, with a very small chance of leakages affecting the water table. The process will only benefit water quality and quantity in the long run, giving CarbonPath’s methodology a **high confidence** rating regarding water health.
- 4) Biodiversity (evaluating changes in conserved primary forest or grassland that affect biodiversity, and management to conserve and maintain land carbon stock) – **High Confidence**
- a) The creation of oil wells destroys biodiversity and alters the natural state of the land being used for oil production. CarbonPath uses a methodology that prioritizes returning the land back to its natural state (according to the wishes of the landowner) which will benefit biodiversity. To ensure that this happens, a non-destructive construction method must be used with as little impact to the surrounding land as possible. If this happens, biodiversity can likely be restored to the original state – this will look different for each well site, but the job can be tailored to the preferences of each landowner.

Technological

The third category used by the IPCC is Technological, asking the overarching question, can the required option be upscaled soon? Our team assigned a level of confidence to each of the three sub-categories within the Technological category.

- 1) Simplicity (evaluating is the option technically simple to operate, maintain and integrate) – **Medium to High Confidence**
- a) CarbonPath was evaluated on two aspects of the process: 1) the industrial process of plugging and abandonment, and 2) blockchain technology. First, we evaluated Carbonpath’s indirect role in the physical act of plugging and abandonment for orphan wells or marginal wells. CarbonPath plays a direct role in facilitating the carbon credit

assessment process and the financial transactions and credits on the developed blockchain system. There is **high confidence** on the simplicity of initiating the plugging and abandonment process. P&A technology is well-established and there are clear state and international regulatory standards. There is **high confidence** that the actual plugging process using physical resources will be simple because there is a well-established industry procedure for plugging and maintaining the proper environment for orphaned or marginal wells during the close-out procedures. Furthermore, the technology required for plugging is available and operators can be trained relatively quickly on how to plug wells. One contributor to the **high confidence** in the technology for the physical process is also due to clustering in the companies that offer well plugging services or the technological depth available for large producing companies mentioned in the physical potential clustering. There is **medium confidence** in the simplicity of the blockchain system due to it being a relatively new financial system and technology without the full backing by US government. In addition, it is likely for the initial blockchain system to act as a potential barrier due to the relatively high possibility of introducing government regulation on a system that is compatible with internal ESG reporting. However, it is possible for CarbonPath's methodology to increase simplicity on the blockchain system for availability in government ESG reporting and company portfolios by increasing transparency and quantifying commission values, insurance costs and reinvestment potential of proceeds from the sale of carbon credits.

- 2) Technological Scalability (evaluating the ability of the option to be scaled up) – **High Confidence** (Distributed Risk on blockchain system and insurance withholding)
 - a) There is **high confidence** in CarbonPath's methodology and system to offer on-site review and quantification for carbon emissions offset due to the collaborative nature of the process, which can be distributed across regions and companies using a structured guideline and initial consultation process. There is **high confidence** in the scalability of the blockchain system due to its contents and units being stored on the Cloud and not locally stored, reducing the impacts of possible cyber security threats and energy shortages in server locations. However, there is insufficient information and cases to offer a substantial view on the viability of the blockchain system adoption or buy-in by producing companies in the long-term. Furthermore, there is insufficient detail in CarbonPath's methodology and industry data to properly assess blockchain system scalability functions for the effects of insurance withholding, leaking effects on both the value of carbon credits and the physical amount of carbon emissions offset, and the relative growth for alternative energy production systems.
- 3) Maturity and Technological Readiness (evaluating R&D and the time needed to implement the option) – **Medium to High Confidence** (High confidence on emissions review and capping, medium on financial blockchain system)
 - a) As a collaborator and reviewer for the physical plugging of wells and abandonment process, CarbonPath indirectly participates in the remediation process for both the producing wells and orphaned wells. We evaluate CarbonPath's maturity and technological readiness on the physical process of plugging wells and remediating well sites as well as the initialization, maintenance, and facilitation of the developed

blockchain system. There is **high confidence** in the maturity and technological readiness for the plugging and abandonment process following industry experience in preparing wells for P&A. Due to the maturity of the physical process, there is **high confidence** in CarbonPath's methodology for verifying carbon emissions and well conditions. Furthermore, it is likely that CarbonPath will contribute or enable a preferable condition for well operating companies by transferring liabilities into assets for immediate or near immediate use by the companies. There is **medium confidence** in the maturity and technological readiness for mass adoption of the blockchain system in the use for speculative trading. Some contributors for **medium confidence** in CarbonPath's methodology on the blockchain system is the lack of sufficient data to analyze the potential and application for the system in current market, administrative costs per instance or application of the system going forward, and the distribution of physical and human resources by CarbonPath, US government, and participating companies for the use of funds generated or transferred in the blockchain.

Economic

The fourth category used by the IPCC is Economic, asking the overarching question, what economic conditions can support or inhibit the implementation of the option? Our team assigned a level of confidence to each of the two sub-categories within the Economic category.

- 1) Costs in 2030 and beyond (evaluating Investment costs, costs in USD tCO₂-eq⁻¹) – **High Confidence**
 - a) The comparison and evaluation of the revenue and the costs for CarbonPath moving into 2030 is **high confidence**. The costs of CarbonPath are very low relative to the revenue generating potential. CarbonPath's only economic burden is the technology, and the costs of the maintenance and expansion of their blockchains and databases, with a cost of 0.00017 cents to process a blockchain transaction. They take on none of the costs associated with plugging the well or restoring the land at the behest of the landowner. Instead, it is the operator's responsibility to plug the well correctly, and restore the land, and afterwards to receive a verification and sign-off from the local state that the land was sufficiently reclaimed. CarbonPath's only costs are their verification technology which evaluates how much oil was left in the well, and the costs of maintaining their blockchain, and marketing their offsets as a solution to operators. An important point to consider in CarbonPath's verification methodology is that blockchain is a new technology, and there are no clear future predictions for how it will be legislated and developed. A blockchain is a system which records transactions such as carbon credit purchases and trades, across a network. Legislation could have potential negative impacts, like restricting access to the blockchain, to the data that is shared within it, and the extent of the availability of information on blockchains, similarly to some of the data protection laws implemented in the European Union, namely the GDPR restrictions. All these scenarios would impair CarbonPath's methodology for storing transactional data, impacting the confidence of the analysis. However, such aggressive legislation is not likely to be passed, particularly in the United States. In contrast, the revenue stream for CarbonPath is guaranteed if the demand for carbon offsets exists, and if the market does not price oil such that future revenues generated from oil production would be higher than the costs of plugging the well, in which case it

would make no economic sense for a firm to cease production. CarbonPath takes 20-25% of the value of the carbon credit acquired by an operator as their validation fee. This means that as the price of carbon credits continues to increase into the future, their revenues will rise exponentially. According to the CarbonPath forecasts, at \$30/ ton of CO₂, their cumulative revenue potential is \$72 billion given the 400,000 wells producing 1-15 bbls per day with an estimated 6,000 tonnes of CO₂ per well, based on the MT pilot project (EIA). In addition, the initial, go-to-market, price of the credits that Carbon Path issues is based on the costs of plugging the well, however, the price thereafter would be market-driven. Thus, the transaction means that the market reaches equilibrium and breakeven point where MP~0 for the market, however, for CarbonPath as an individual firm MP~20-25%.

In addition, assuming the implementation of a National Carbon Market with a fixed price above \$30/ ton of CO₂, CarbonPath will stand to benefit and increase revenues.

Economic theory suggests that a ton of CO₂ should be priced around \$60, for the market to function correctly, which would double CarbonPath's revenues to \$144 billion.

Another issue to consider relating to price, are the costs of plugging each well, and how they compare to the market price of CO₂. According to a report by Resources for the Future and the Center on Global Energy Policy at Columbia University, costs of plugging an orphaned wells are anywhere between \$67 to \$170 per ton of CO₂-equivalent, depending on how long the well-plugging process takes (Bordoff et al., 2020). In comparison with a carbon credit that sells at \$60/ ton of CO₂ on the free market, it might not be profitable for firms to plug their wells for offsets without regulation forcing them to do so. However, this report is not directly relevant as it focuses on a widespread federal effort to plug wells. On a smaller scale, and for individual firms, the cost-benefit analysis will look differently.

CarbonPath does not bear any of the upfront costs of the P&A, which minimizes their costs to just the operational costs of the blockchain and their technology. As a result, revenues highly exceed costs. Given the costs are not predicted to rise significantly in the future and given that the revenue potential is predicted to rise as CarbonPath expands their customer base, if a global carbon market is implemented with a carbon price exceeding \$30/ ton of CO₂, the evaluation of CarbonPath's costs and revenue economic has **high confidence**.

- 2) Effects on Employment and Economic Growth (evaluating decrease or increase in job and economic welfare) – **Medium Confidence**
 - a) The evaluation on the employment and economic growth impacts is of **medium confidence**. On the one hand, CarbonPath can be beneficial to a community whose revenue stream is centered on oil and gas, and who is going through what Daniel Raimi an economic “bust”. When oil and gas prices are too low, or local reserves run out, oil and gas companies move out of the area taking employment opportunities with them. In such cases, and assuming that there are opportunities elsewhere, for example the company has other operations with lower cost margins or finds a new reserve in a different region, those employees must either follow the gas company to a different location or find other employment. In this situation, plugging and abandonment of oil and gas wells could provide an alternative source of employment without forcing the employees to relocate. The average national cost of plugging and abandoning a well is

\$24,000. Plugging 10 wells requires 2.4 person years of work at a wage of \$100,000 per job. In addition, CarbonPath's incentive to plug orphaned wells creates a revenue opportunity for firms and employees for plugging some of the 2.1 million abandoned and unplugged wells in the United States (EPA). P&A of low-performing wells would also allow operators to redeploy labor to other projects that may be a better fit for their skills. According to a report by Resources for the Future and the Center on Global Energy Policy at Columbia University, a federal effort to plug 500,000 orphan wells to which CarbonPath would contribute, could create 120,000 jobs (Bordoff et al., 2020). The report also highlights that a significant pool of labor from the oil and gas industry could be deployed towards and benefit from such a program (Bordoff et al., 2020) However, the re-skilling of workers to P&A is controlled by the well operator company, not directly by CarbonPath. Nonetheless, by encouraging the oil and gas companies to plug their wells CarbonPath can have a positive impact on the local economy and employment. The COVID-19 pandemic and the loss of more than 76,000 industry workers in early 2020, has invigorated the discussion of potential job growth in the P&A of low producing and abandoned wells (Bordoff et al 2020). There is robust discussion of federal investment in the P&A of orphan wells. For example, North Dakota used CARES Act funding to help accelerate its already existing cleanup program, which sought to plug 239 abandoned oil wells and reclaim 2,000 acres of land (Bolstad, 2020). The Bureau of Land Management also recently announced that it would invest funds from the Bipartisan Infrastructure Law in the P&A of abandoned wells on federal lands. In addition, over \$4.4 billion will be made available to states and Tribes to reclaim orphan wells on state, Tribal, and private lands (BLM, 2022). This suggests that there is potential for job market growth in this area and an increased public recognition of the need to invest in the P&A process.

Another issue to consider is the secondary labor markets, including restaurants, hotels, and other services. In *The Fracking Debate*, Daniel Raimi highlights the negative impacts of an oil bust on the workers who are not directly involved in the oil industry, instead providing services for its workers. According to the same Resources for the Future report, a downturn of oil and gas activity in the Permian Basin, Marcellus, Bakken as well as other states, affected funding for schools, infrastructure, public safety and more (Bordoff et al., 2020). Although many of the wells CarbonPath targets are low performing wells which do not have a substantial impact on the level of employment in a region, this will still contribute to a negative trend of customers moving away from services. In short, it is difficult to estimate what this project means for secondary services in the area.

The situation becomes complicated if the price of carbon offsets and the prices of gas or oil along with external factors, make it more profitable for a company to plug the well rather than keep drilling. In this case, the well's employees will transition to P&A sooner, making their life cycle of employment at this well shorter, with an overall negative impact on employment. However, this situation is unlikely in the close future, given the high demand for oil and gas which is predicted to continue even during the Energy Transition.

Moreover, CarbonPath's business model does not require many employees, and there will be little scaling of employment even once they reach their peak operational capacity. In

addition to their management team, the firm will only be hiring blockchain and CarbonPath technology operators. However, their involvement in and stimulation of the carbon market will contribute to the emergence of more "green" jobs and higher potential in P&A, in addition to spurring more blockchain related jobs for the continued development of this technology. Investment in blockchain technology and cryptocurrency continues to be a growth area for both tech and finance. According to a LinkedIn report, cryptocurrency and blockchain related job postings increase 395% between 2020 and 2021 (Pandey 2022). This suggests that there is scope for CarbonPath to contribute to secondary labor market growth in this area.

However, CarbonPath is also working with orphan wells that do not have any employees. In this case, the impact on the economy will be purely positive, as the natural resources in the well will be monetized and their value will be injected into the economy as carbon credits. The uncertainty in decreased physical, on-site, employment and increased "green" job potential results in a **medium confidence** evaluation of CarbonPath's employment and economic impacts in the current moment.

Socio-Cultural

The fifth category used by the IPCC is Socio-Cultural, asking the overarching question, what social conditions could support or inhibit acceptance, adoption, and use of the option? Our team assigned a level of confidence to each of the three sub-categories within the Socio-Cultural category.

- 1) Public Acceptance (evaluating the extent to which the public supports the option and will change their behaviour accordingly) – **High Confidence**
 - a) The evaluation of the public acceptance of CarbonPath's operations is of **high confidence**. Recently, carbon capture projects have entered the public sphere of interest and understanding. Strong opinions exist both for and against the validity and impact of various carbon capture methodologies. However, due to CarbonPath's scope of dealing with abandoned wells and low-capacity wells, it is likely that public acceptance will be stronger for these projects as they will mitigate existing emissions (as opposed to point-source projects that allow for the expansion of the fossil fuel industry). CarbonPath specifically intends to target methane emissions, which is the most potent greenhouse gas contributing to climate change. Methane is referred to as a super-polluter. Methane reduction projects tend to have strong public support, which suggests that CarbonPath's efforts will be supported as well. Carbon Path has also shared their intentions of potential partnerships with NGOs take existing cleared lands post-capping and adapt the land into renewable energy projects. If implemented, these efforts would likely be highly favored by the public.
- 2) Effects on health and well-being – **Uncertain**
 - a) The current evaluation of Carbon Path's effects on health and well-being is uncertain. Orphaned and abandoned wells do have the potential to pose serious health hazards. These wells may leak chemicals into surrounding soil and groundwater and emit high amounts of methane, which highly flammable and toxic in enclosed spaces (Turrentine), which pose a clear threat to health and safety. According to Raimi et al, unplugged wells can also pose health hazards through the emissions of air pollutants like

benzene, hydrogen sulfide, or volatile organic compounds (VOCs) (2021). While the authors note that these air pollutants pose a health risk, they also note that the exposure pathway of these pollutants have not been well-studied in the literature (Raimi et al, 2021). This suggests that more research is needed to truly understand the health impacts posed by unplugged wells. Capping these wells will likely have a positive impact on health and well-being to some degree, as it will reduce the chances of future hazards. However, it is difficult for us to evaluate this category currently as we do not know what the long-term health impacts are even after the well has been capped. Communities that are currently struggling with health impacts may not see immediate relief. Evaluation of this category will become easier as more data from CarbonPath's projects become available (will be able to help quantify the improvement once wells are capped) and we have a better understanding of the long-term impact and treatment of health hazards related to orphaned and abandoned wells. However, according to a report by Resources for the Future and the Center on Global Energy Policy at Columbia University, a widespread federal effort to plug orphaned and abandoned oil and gas wells would reduce local air pollution, safety risks, and greenhouse gas emissions for local communities (Bordoff, 2020). This suggests that health and safety would not be negatively impacted by CarbonPath's methodology.

- 3) Distributional Impacts (evaluating equity and justice across groups, regions, and generations, including energy, water, food security, and poverty) – **Uncertain (too early to assess properly)**
 - a) The evaluation of Carbon Path's distributional effects is uncertain at the moment. Plugging wells may have a distributional effect of supporting environmental justice in the communities where these wells are located. According to a January 2022 release from the White House, "Many of these orphaned wells are located in rural communities, environmental justice communities and communities of color that have suffered from years of divestment. Plugging these wells will not only reduce methane emissions and stop dangerous pollution, but it will create good-paying, union jobs and spur economic revitalization, especially in hard-hit energy communities" (White House Briefing). This has the potential to improve access to energy and water and improve economic conditions in the area. Carbon Path's operations are assumed to be relatively small-scale and rapid for each site, so it is difficult to speculate on their specific economic impact. As CarbonPath continues to scale, there is potential for plans to partner with local organizations that could result in positive distributional impacts.

Institutional

The sixth category used by the IPCC is Institutional, asking the overarching question, what institutional conditions could support or inhibit the implementation of the option? Our team assigned a level of confidence to each of the three sub-categories within the Institutional category.

- 1) Political Acceptance (evaluating the extent to which politicians support the option) – **Medium to High Confidence**
 - a) The evaluation of the political acceptance for Carbon Path is of **medium-high confidence**. It is unlikely that there will be changes that would prevent their methodology

from operating. This would require severe legislation of the blockchain on the national level, and changes in the requirements for plugging and abandonment, and land reclamation on the state level.

The political support on the national level is dependent on the policies of the ruling party, so it is likely to succeed under a president like Biden or an administration that is more open to climate change mitigation. However, CarbonPath is politically neutral as it does not directly penalize oil producers, but simply encourages them to redirect human capital to revenue generating projects rather than unprofitable wells. Nonetheless, political support in implementing a mandatory "cap-n-trade" system would be helpful, albeit not necessary, in the growth of an American carbon market and in increasing the number of participants in this market. This would stimulate the demand for CarbonPath's offsets. However, a mandatory national carbon market could also be harmful to CarbonPath, depending on the price of carbon that is set by the market, and depending on any price ceilings and floors set by the government. If the price is set or reaches equilibrium below a level that is profitable for CarbonPath, the firm's revenues could fall significantly and make the company unsustainable in the long run. However, this is not likely to happen as it would affect all verification and offset-trading firms in the market, and in the long term the market would reach a different equilibrium through either shifting the price or the quantity.

Recent polling from Pew Research Center (conducted May 2nd to 8th, 2022) indicates high levels (79%) of bipartisan support for tax credits and other instruments for encouraging businesses to develop technology to capture and store carbon emissions. In addition, a smaller plurality (53% to 45%) of those surveyed thought that stricter environmental laws were worth the potential costs to the economy and jobs. This suggests that CarbonPath's methodology, which focuses on producers and businesses would be supported by the public (in contrast to something like a carbon tax which directly impacts producers and would be passed along to consumers, as has been observed in other systems where "cap-n-trade" was implemented, namely the EU ETS and the European energy market.

The confidence is of a **medium level** also due to the potential for lobbying from other groups, including property owners, or mineral rights owners who will be impacted by CarbonPath. However, as CarbonPath currently focuses on smaller wells and orphaned wells, these lobbyists are unlikely to be highly influential. This would also be state-dependent since lobbying would be different in each state legislature.

Finally, the price of gasoline is another determinant of the confidence level. Depending on how valuable oil becomes due to supply or demand shocks, the general public and by extension the political sector might not agree with "oil being left in the ground" instead of being extracted and contributing to the global supply.

- 2) Institutional capacity, governance, and coordination (evaluating the capability of institutions to implement and handle the option) – **Medium Confidence**
 - a) The evaluation of the institutional capacity is of **medium confidence** and focuses on the capacity of institutions to implement and handle CarbonPath's methodology and functioning. Although institutional acceptance might be higher, coordination and governance are complex and involve a lot of stakeholders. As mentioned in the political acceptance confidence evaluation, there might be lobbying from both sides- from the pro-CarbonPath side which would benefit from increased development in the carbon market,

and from other groups such as property owners, or mineral rights owners, who would not want their wells to be capped by operators and their revenues to be cut. This makes it difficult to evaluate anything relating to institutional capacity, governance and coordination at a high confidence level.

In terms of coordination, it would be helpful for CarbonPath to connect with other green energy companies and lobbyists, to ensure continued neutrality or support from the government. In addition, increased coordination in terms of communicating with the public would be helpful, to make sure that the public is aware of what CarbonPath's projects mean directly for them (or what it does *not* mean for the groups it does not impact directly). CarbonPath aims to "allow corporations, individuals, and governments to offset pollution securely and efficiently", which requires trading between all of these sectors in the carbon market within the CarbonPath blockchain. It also requires the public, the government, and the private sector to have an accurate understanding of CarbonPath and the blockchain, to increase confidence in both.

However, CarbonPath can largely operate in the private sector with little support or cooperation from the institutional sector. Their clients are well operators, and the only direct interaction with any state or legal legislation is the planning approval, and the oversight and approval for the plugging and abandonment process, both of which come from the State. These approvals, however, are not as vulnerable to changes in party politics. Therefore, CarbonPath is largely protected from short-term political fluctuations.

3) Legal and administrative capacity – **Medium to High Confidence**

- a) The evaluation of the legal and administrative capacity is of **medium confidence** in terms of the long-term future of Blockchain technology. It is dependent on the procedures of each individual state that CarbonPath operates in. The Resources for the Future and the Center on Global Energy Policy at Columbia University report indicates that one challenge of a large effort to plug orphaned wells would be the state regulatory offices would need to scale up their administrative capacity to oversee such programs (Bordoff et al., 2020). This could potentially slow down the certification of the P&A process that CarbonPath requires in order to issue credits. However, CarbonPath is not likely to operate at such a large scale, especially in the beginning. The evaluation is also **medium confidence** around the potential for the blockchain technology and the carbon market mandatory regulation, both of which are recent developments with a difficult to predict future.

However, the methodology of CarbonPath does not require the state to implement any new policies or take any new steps, which means that its ability to work within existing legal frameworks is of **high confidence**. Carbon Path's methodology relies on the state to issue the same certification they have always issued in order to issue credits against any well. This reduces the coordination and capacity load on the state and makes the evaluation more reliable.

Conclusion

This report evaluated the methodology of CarbonPath according to the guidelines laid out in Chapter 6 “Energy Systems,” of the IPCC WGIII AR6. Overall, the team found that CarbonPath’s methodology performed very well according to IPCC guidelines receiving high and medium confidence levels in almost every category. The team had high confidence in the ability for CarbonPath’s methodology to work within existing structures to help address climate change through reductions in carbon dioxide and methane emissions. Utilizing well-established P&A technology and state-level certification of the process gave the team high confidence in the ability of CarbonPath to issue high quality carbon credits. By working within existing institutional and regulatory frameworks related to certification, CarbonPath does not require additional legal or regulatory changes to be made for them to begin issuing credits. Blockchain is a rapidly growing technology that continues to gain widespread and mainstream acceptance. The team found no issues with the use of the blockchain itself and the choice of a carbon negative blockchain, Celo, fits within CarbonPath’s overall goals of reducing carbon emissions. Our only hesitation came from the relative newness of the technology and the possibility of uncertainty within the regulatory environment related to the blockchain. As the technology continues to mature, these hesitations will be addressed. CarbonPath’s model presents opportunities for economic growth. CarbonPath’s costs are very low relative to their potential to generate revenue. CarbonPath’s methodology has the potential to positively impact the communities in which the low-performing and abandoned wells are located. This includes potential growth in the green jobs sector and the redeployment of oil and gas workers. Our only hesitation as it relates to employment is the need to see how the green job sector continues to develop as more resources are put into employment that directly targets climate change; however, that uncertainty falls outside the scope of CarbonPath’s direct impact. Overall, the team believes that CarbonPath’s methodology holds its own, and in some areas outperforms, the other energy sources that the IPCC includes in its analysis.

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