Regional-scale GHG utilization strategies for enhanced shale oil recovery and sustained carbon management

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The rapid development of unconventional resources has transformed the US energy landscape over the past decade, but has largely outpaced efforts to manage associated emissions that pose significant environmental risks. Regulation of greenhouse gas (GHG) emissions has largely been driven by economics and logistics; however, with a projected reliance on shale oil and gas for decades to come, new proactive strategies will be crucial to minimize adverse environmental and social impacts. Here, we explore opportunities to improve long-term GHG management from both industry and environmental perspectives through a regional case study in the Eagle Ford shale, currently the leading producer of unconventional oil in the United States.

Managing natural gas (CH₄) co-produced with shale oil, referred to as ‘casinghead gas,’ presents challenges and controversy. In the Eagle Ford, most of this gas is flared because the cost of building out pipeline and processing infrastructure exceeds potential revenue in the current natural gas market. Although this approach reduces GHG emissions relative to venting, flaring wastes energy, increases CO₂ emissions, and raises public concerns such as local health impacts and reduced property values. Furthermore, Eagle Ford wells are characterized by high gas:oil ratios that tend to increase as the wells age. Based on compiled historic oil and casinghead gas production data, we project that co-produced gas volumes will continue to increase over the next decade, even as drilling and completion rates drop. Given this localized availability of significant gas volumes and the low primary recovery rates of shale oil, we propose that on-site capture and utilization of casinghead gas for enhanced oil recovery (EOR) could be a more economically and environmentally attractive long-term management strategy. Based on recent studies of CO₂- and CH₄-EOR potential in unconventional reservoirs, we estimate the incremental recovery potential associated with projected gas streams would be profitable with respect to capital investments based on current and future market trends. We also discuss how costs and risks to industry could be mitigated in the absence of a carbon market through demand assurance, pricing floors, and private-public cost-sharing options for capital infrastructure. This approach avoids unnecessary GHG emissions and lost revenue, as recycled CH₄ could be brought online if the natural gas market rebounds.

Although CO₂-EOR has been applied extensively to conventional plays in this region, CO₂ is primarily sourced from natural deposits, missing significant opportunities to reduce anthropogenic CO₂ emissions and jumpstart geologic carbon storage efforts. In addition to providing added profit as primary oil production slows, investing in CH₄-EOR infrastructure in shale oil plays could provide a gateway to permanent sequestration of GHG emissions from nearby anthropogenic sources, such as natural gas processing plants where nearly pure co-produced CO₂ streams are currently vented in the absence of storage incentives. For instance, the nearby Haynesville shale produces gas with high (2.5-7.5%) CO₂ content, and the CO₂ separated in acid gas removal units would require little additional processing to be sequestered instead of emitted. Through high-level geospatial and economic
analyses, we demonstrate how strategically building out infrastructure to convert depleted production wells into storage repositories for CO₂ emitted by natural gas processing plants could achieve appreciable emission reductions in the Eagle Ford region. The potential to reduce near- and long-term emissions associated with shale oil and gas production by introducing appropriate carbon market schemes that internalize GHG emissions is also discussed, along with associated social benefits. We conclude by generalizing our case study to national and regional policy frameworks incentivizing a push towards “closing the loop” between production and emissions in shale resource development.