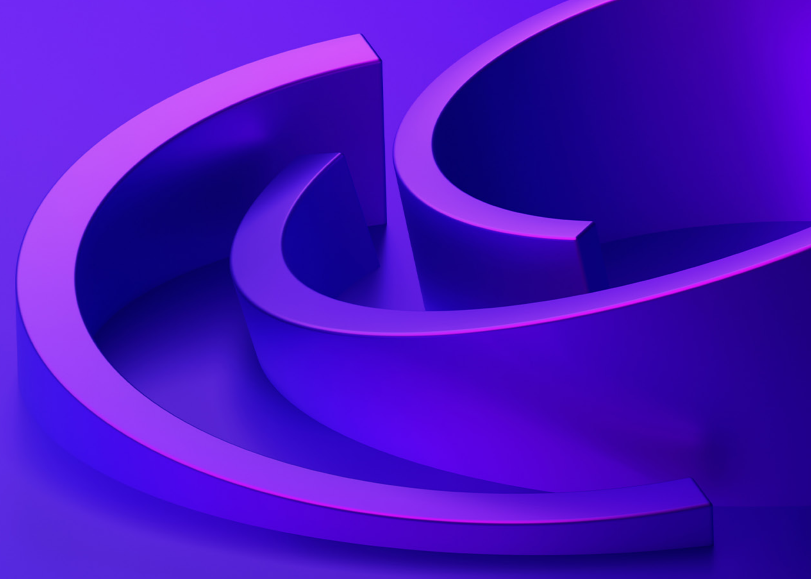


Profitable paths to decarbonization

A robust, quantitative approach to understanding investment trade-offs in upstream unconventional operations

Unconventional oil and gas (O&G) companies consider a wide range of interdependent factors and constraints to fully understand the economics of their development and operational decisions. But one factor is increasingly gaining prominence in the economic equation: emission reductions.

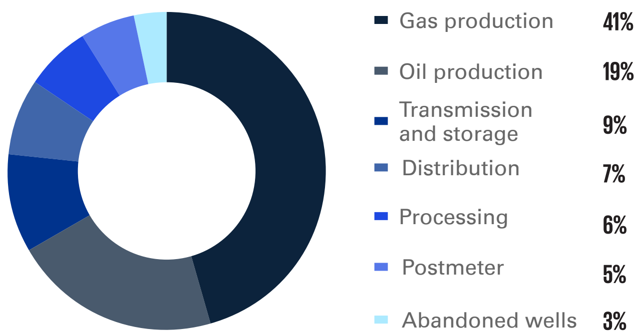
Given increasing regulatory disclosure requirements and public pressure on companies to reduce emission footprints, O&G operators are challenged to develop a full appreciation of the trade-offs between these emerging stakeholder expectations, traditional development decisions, and operational constraints.

Dollars per oil equivalent barrel ($/OEB), once a primary profitability metric, is being replaced by dollars per oil equivalent barrel per equivalent tons of carbon dioxide ($/OEB/eTCO2), at both an individual asset level and across a portfolio of opportunities.

The analysis of the trade-offs between environmental impact and profitability often exhibit confirmation bias, potentially reducing overall return given increasingly stringent requirements. In the past, quickly ramping up production generally maximized value. Now, increased emissions scrutiny—and economic penalties such as the methane fee introduced in the Inflation Reduction Act—means that going fast without commensurate abatement spend can result in emission increases and actually erode profitability.

U.S. oil and gas emission sources

U.S. O&G operators are trying to maximize profitability while reducing emissions, two-thirds of which result directly from hydrocarbon production.



Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990—2020, U.S. EPA, April 2022

Whereas optimizing $/OEB was a primary metric of the past, we are now in an era of optimizing $/OEB/eTCO2, both at an individual asset level and across a portfolio of opportunities.

Increasingly sophisticated analysis for portfolio management

To protect profitability while reducing their carbon footprint, upstream O&G operators will need to do more than meet basic emissions reporting requirements from the U.S. Securities and Exchange Committee (SEC) and other governing bodies.

Operators must increase the sophistication of their analysis by factoring in the potential environmental costs both on an individual asset basis and across their portfolio. The resulting analysis will produce more insightful outputs, including multiple-scenario analysis, a full view of the portfolio, and a better understanding of the most profitable path to net zero.

To face new regulatory and profitability challenges, operators need to become more and more sophisticated in their decision-making.

Emissions analysis maturity scale

The ability to conduct more sophisticated emissions analysis depends on three factors:

- Access to relevant and trusted data at the correct granularity
- Ability to develop credible pricing and investment scenarios
- Capacity to build dynamic economic models that can be quickly optimized

Ability to do increasingly sophisticated analysis

	Primary function	Required input data	Sample output
Analytics and optimization	Portfolio optimization	Full access to dynamically linked economic models that include cost-of-carbon considerations	Full portfolio view, with ability to optimize across the portfolio in real time
	Asset optimization	Dynamic economic model-type data for an asset, including cost-of-carbon and mitigation levers	Asset-level-trade-off curves, correlograms, efficient frontier displays, sensitivity analysis, etc.
Investment analysis	Incremental investment scenario analysis	Low-, base-, and high-side scenarios and investment optionality at the asset or piping and instrumentation Diagram (P&ID)-tag level	Multiple scenario abatement curves and possible incremental abatement “surfaces” providing a view on pathway options
	Basis ESG investment decision-making	Greenhouse gas (GHG) mitigation cost-benefit data at the P&ID, pad, and/or asset level; possible programmatic grouping across multiple assets	Traditional abatement curve displays, potentially augmented with data from basic visualization and monitoring applications
Reporting and monitoring	Monitoring	Asset or P&ID-tag level time-series data on emissions, production, etc.	GHG intensity monitoring
	Reporting and visualization	Asset or P&ID-tag level data on emissions, production, location, etc.	GHG intensity monitoring

Insights through accurate modeling and intuitive simulation

In supporting upstream operators, KPMG has developed a suite of modeling tools based on the fundamentals of O&G development and operational planning. More recently, these tools have been extended to include emissions and abatement considerations. The underlying model has an emphasis on accuracy and the ability to quickly run simulations rather than the pursuit of precision or high-fidelity projections. This allows operators to gain an intuitive sense of how parameters behave, including the balance between economic and environmental factors.

Pathway from problem framing to actionable insights

Situational analysis and framing of the question

Understanding the question being asked so the quantitative model is aligned with the business drivers

Model construction and simulation

Building the quantitative model with a focus on accuracy versus precision and keeping it as simple as possible

Parameter space exploration and scenario analysis

Running multiple models at the asset or portfolio levels to understand the trade-offs among key variables

Synthesis and business insight

Taking the insights from the models and the understanding of the trade-offs and turning them into operational advantage

With this approach, operators can use the models to make decisions in real time based on multiple scenarios. This is in contrast to more conventional approaches that take longer to run for a precise, often singular and deterministic, output.

For our models, traditional inputs provide the “bottom-up” basis for the simulations. Additionally, if a variable is unknown or subject to optimization, then a range of values can be used for a parameter space exploration exercise to understand the impact of potential decisions and uncertainties (e.g., ranging drilling costs +/-20 percent, or allow carbon cost to vary).

Model inputs

Our quantitative simulation requires input in the following areas for a complete economic picture of the development:

Financials	Land and subsurface (type curves)	Development schedule and facilities	Capex costs (per well)	Opex costs (per BOE)	Carbon abatement
Oil price (monthly)	Bonus (per acre)	Max # drilling rigs and DUCs	Drilling tangible	Compression and gathering	Cost of carbon ($/MT)
Gas price (monthly)	Asset location (State)	# Days per well	Drilling intangible	Transportation oil	Emissions intensity (MT/boe)
NGL price (monthly)	Drillable acreage	Max # completion rigs	Completion tangible	Transportation gas	Abatement spend per year
Model start date	Working interest	# Days per completion	Completion intangible	Transportation NGL	Abatement projects for abatement curve
Inflation rate	Well spacing (acres)	Appraisal delay	Capex expensed (total)	Processing oil	Methane fees
Discount rate	Oil production (monthly)	Ramp-up schedule	Capex capitalized (total)	Processing gas	
	Wet gas production	Total takeaway constraint (BOE)		Produced water disposal	
	Wet gas composition	Gas constraint		Produced water rate	
	Produced water	Facilities cost		Fixed opex (per well/month)	
	Exploration cost	Construction time (delay)			

Model simulations allow operators to quickly understand important complexity and potential outcomes, with nuance that could otherwise be missed.

The model itself begins with the definition of the subsurface parameters and drilling and completions schedules. These variables are convolved and result in the overall production profile for the various flow streams tracked (liquid, gas, water, emissions, etc.).

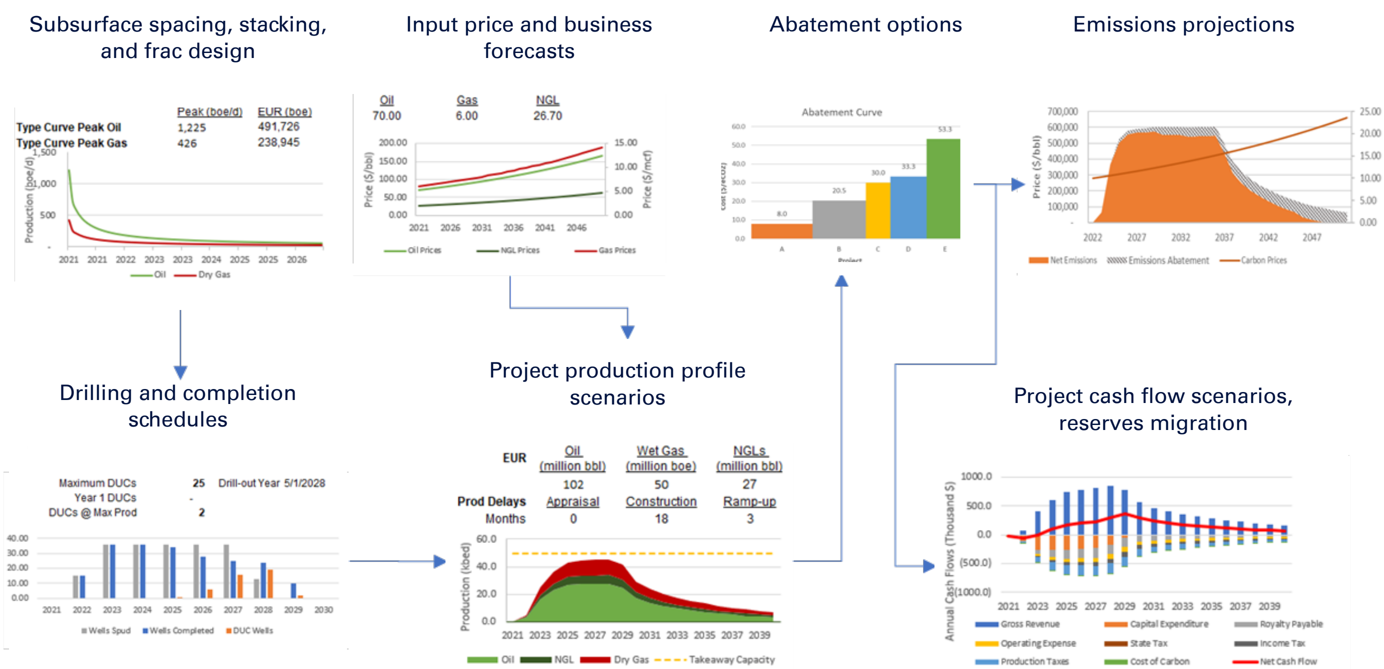
With baseline flow streams, including emissions, established, abatement options can be considered. Abatement project dependencies or sequencing can be included, but generally individual abatement opportunities are ordered and executed in increasing cost per CO2 or methane reduction.

Of particular note, abatement modeling and optimization is highly dependent on the type of abatement projects considered, and they often must be bespoke to the asset or assets being modeled. For example, short-term abatement associated with a particular unconventional well that is shut in after five years will have a limited impact on a long-life project, compared to a facilities or pipeline abatement project that may have a decades-long lifespan. This time dependence is an important consideration in the modeling.

Once flow streams are established, and emissions both emitted and avoided are calculated, traditional project cash flows and economic metrics can be finalized.

Visualization of general modeling workflow

Quantitative model construction and simulation for three use cases



Sample applications and simulations

Our modeling approach is flexible enough to allow for a wide range of applications. These applications generally fall into three distinct classes of use cases:

1

Discrete scenario analysis

Single asset and input sensitivity analysis

Detailed view of single asset value levers, including cost, pace, takeaway capacity, abatement options, and GHG cost

2

Parameter space exploration

Efficient frontier modeling

Full comprehension of development decision, constraint trade-offs, and resulting financial metrics

3

Portfolio optimization

Portfolio analysis and management

Individual asset models can be linked and simulated simultaneously to model portfolio value and capital efficiency

Discrete scenario analysis

A single discrete analysis, for example, is useful for isolated decision-making and "what if" scenario analysis. Alternatively, an efficient frontier modeling approach is useful when exploring the parameter space of a decision with uncertainty, such as development pace or drilling costs.

Once a single model is created, building a portfolio simulation—essentially a "model of models"—is straightforward. These types of simulations are particularly useful for quantitative portfolio optimization, such as capital distribution across multiple investment opportunities.

The following hypothetical cases illustrate these distinct use cases and represent a spectrum of business challenges that upstream unconventional O&G organizations face. Note that while the examples refer to U.S. unconventional assets, the tools and techniques described are easily extended to other upstream asset types and locales.

Operators need to consider a wide range of interdependent factors and constraints to fully understand the economic and environmental trade-offs of their development and operational decisions.

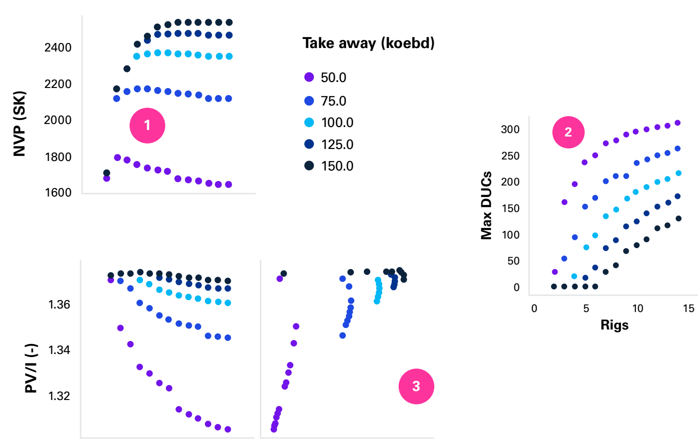
Parameter space exploration

An operator with a large acreage position in West Texas wants to understand the trade-off between development pace and takeaway capacity that maximizes key economic metrics, such as net present value (NPV) and capital efficiency as measured by present value over investment (PV/I) for the opportunity.

With estimated subsurface data and cost parameters, the "optimum" or "efficient frontier" (NPV versus PV/I, for example) can be mapped. As the figure illustrates, as takeaway capacity increases, value is increased by increasing the pace (e.g., # of drilling and completion rigs) 1 and minimizing the number of drilled but uncompleted (DUC) wells 2 .

For the asset, however, the relationship (the efficient frontier) between NPV and capital efficiency (PV/I) is nonlinear 3 , reflecting the balance of pace, idle wells, and field over capitalization.

Business question: What is the balance of development pace versus takeaway capacity that maximizes NPV and PV/I? What is the "efficient frontier?"



Emissions cost, development pace, and opportunity profitability

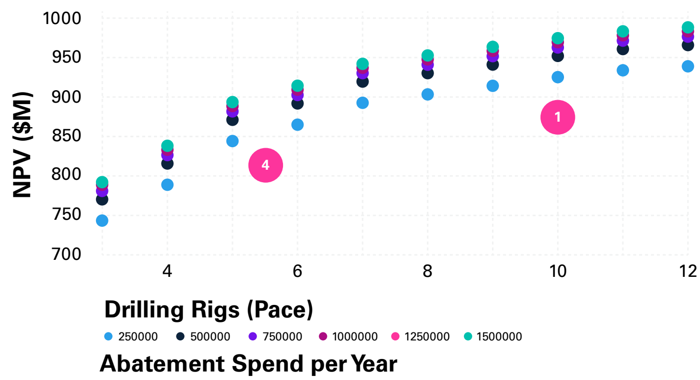
The same opportunity in West Texas now has an assumed cost of carbon and unlimited takeaway capacity (e.g., ullage). The operator now wants to understand the trade-offs between production ramp-up, abatement spend, avoided emissions, and opportunity value.

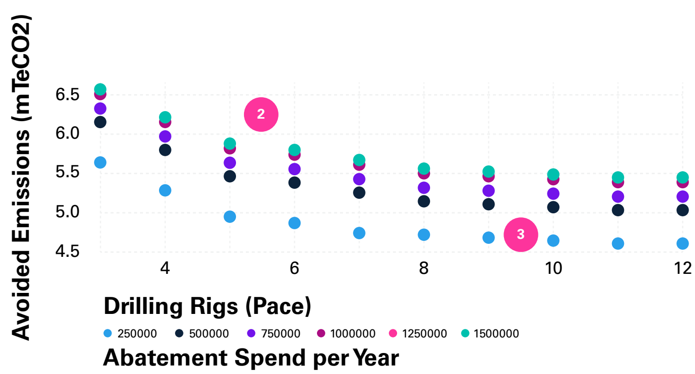
As described, the operator must understand the abatement options available to both existing operations and new development. Abatement curves are specific to individual assets and reflect the varying states of equipment, technical parameters, and operational philosophies. These options are then provided to the simulation as described in the workflow above.

Combining multiple variables in this example, as the pace of development increases, the value of the project increases 1. And, generally, the amount of avoided emissions decreases 2 since the abatement program and spend cannot keep up with production ramp-up.

However, as the abatement spend increases, the amount of avoided emissions increases 3 and is better able to keep pace with increasing production. Interestingly, in a high-cost-of-carbon scenario, spending more per year increases NPV by offsetting long-term carbon costs 4.

Business question: For a given asset and high cost of carbon, in an unconstrained system, what are the trade-offs between production, abatement spend, avoided emissions, and value?





Portfolio optimization

Optimum distribution of capital across a portfolio of opportunities

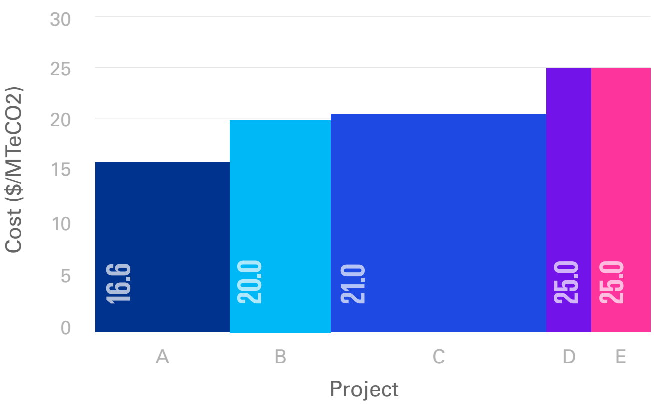
In our final example, an operator with a hypothetical portfolio of three assets is looking to allocate capital to reduce emissions across its portfolio while maximizing portfolio profitability. The business challenge is optimizing the trade-off between profitability and abatement spend.

The operator has an overall budget of $2 million per year to invest among three assets, each with individual abatement curves. The cost of carbon is uncertain, so two scenarios are simulated.

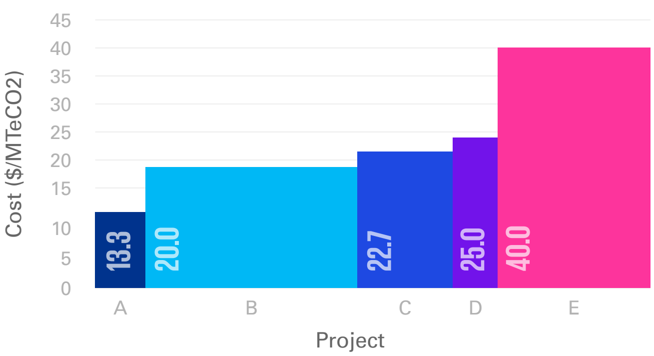
Business question: How much abatement investment in each of the three assets will optimize the portfolio tradeoff between profit and emissions reduction? The portfolio has an overall budget of $2M per year to invest among three assets with varied abatement curves.

Asset abatement curves and scenario analysis

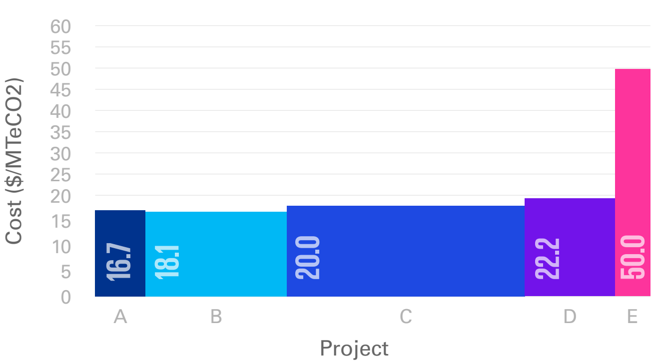
Eagle Ford asset



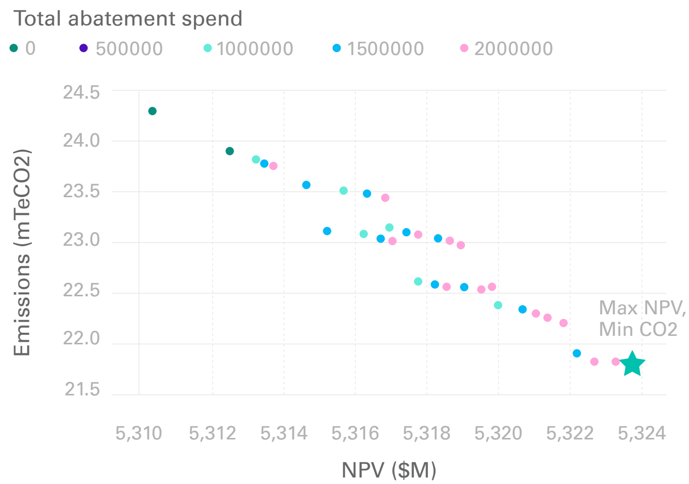
Anadarko asset



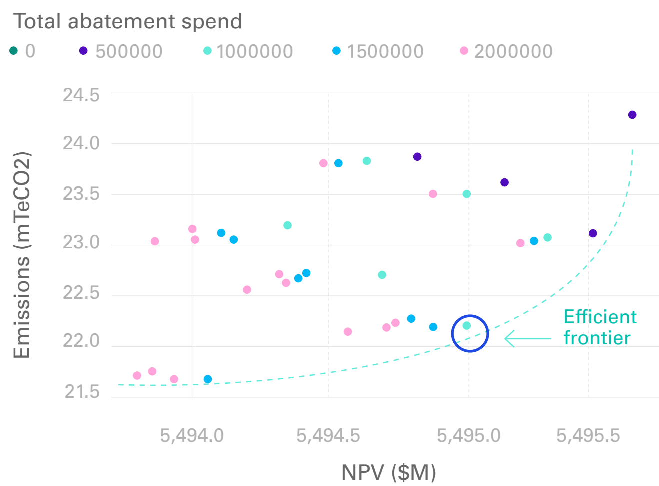
Wolfcamp asset



High cost of carbon scenario: cost of carbon: $60



Low cost of carbon scenario: cost of carbon: $30



As illustrated, in a high-carbon-price scenario, investing the maximum budget in the largest abatement projects results in both maximum NPV and minimum emissions (see star). In a low-carbon-price scenario, however, various investment strategies form an efficient frontier of options that balance maximizing NPV and minimizing emissions.

The blue circle represents one portfolio investment scenario that balances NPV with total emissions. In this case, the "optimum" abatement spend per year was $500,000, $1,000,000, and $500,000 in the Eagle Ford, Anadarko, and Wolfcamp assets, respectively, reflective of the asset base profitability and available abatement options.

In summary

The model and workflow described are flexible and can be tailored to address a specific operator's needs or uncertainties, and we have found that real-world simulations provide the insights clients require to quickly understand complexity and nuance in their decisions.

As the assets become more diverse and the mix of existing operations and greenfield development is included in the simulations, understanding the operational picture becomes more complicated. For example, in the analysis of a particular brownfield asset with a facilities constraint, a remaining 30-year life, and overcapitalization limits, the trade-offs between further development pace, total emissions, and key value metrics can be complex. In this example, we have seen:

- Macro and micro trends in the PV/I/NPV relationships
- "Efficient frontier" relationships between NPV, pace, and total emissions for any given cost of carbon, carbon intensity, and methane fee
- Varying profitability along the paths to "net zero," all with different capital efficiencies
- Abatement spend and emission reductions that actually increase capital efficiency

Armed with a flexible model that includes emissions and abatement considerations, upstream operators can map the most profitable path to net zero.

How KPMG can help

Oil and gas operators are under significant pressure to demonstrate both commitment and action toward net zero or decarbonization goals. Not all paths to net zero have the same pace, cost, or impact on profitability. Faced with an imperative to "act," it is challenging for operators to define what the "right path" for their decarbonization journey looks like as well as to have confidence that their investments are advancing in this direction.

The tools and capabilities outlined in this paper can help operators explore their choices; select the path that provides the desire set of strategic or economic outcomes; and have increased confidence as they move into execution.

KPMG professionals understand these and other upstream operator challenges. Using our deep industry knowledge and experience, we help deliver regulatory, tax, portfolio modeling, and operational knowledge to assist oil and gas companies optimize their businesses.

We look forward to working with you to add value to your operations.

About our Authors

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Dave, a principal and practice leader for KPMG Energy Solutions, has more than 20 years of experience supporting upstream oil and gas clients as well as power and utility organizations. His exposure to a diverse client mix has allowed him to develop and bring leading practices to improve performance, address complex challenges, and navigate the energy transition.

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Jim brings 10 years of experience working in energy and trading, including upstream, downstream, power, and renewable credits. His time in industry includes various positions with Shell modeling risk/return for portfolios of physical and financial assets. Jim's experience includes financial due diligence, digital transformation, and change management.

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Zack has consulted the oil and gas industry for 10 years, leveraging extensive experience to help operators frame, evaluate, and develop plans for strategic upstream businesses. He also has a leadership role on the Energy Solutions team, working with clients to evaluate the economic and environmental trade-offs of CCUS, hydrogen, and other new business ventures.

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