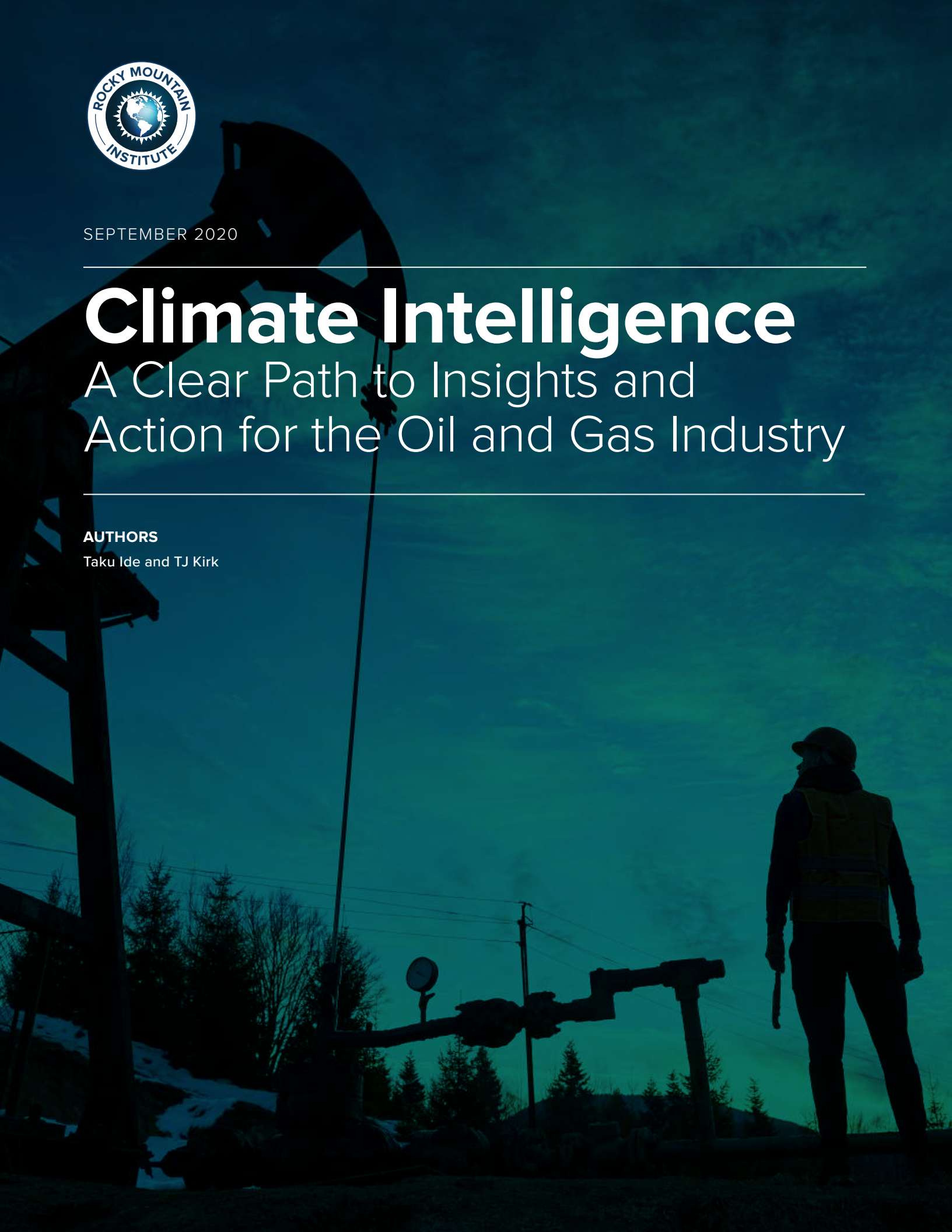

SEPTEMBER 2020

Climate Intelligence

A Clear Path to Insights and Action for the Oil and Gas Industry

AUTHORS

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An Urgent Problem

Our ability to reduce 41 gigatons (Gt) per year of human-caused carbon dioxide emissions in the next several decades is critical to avoiding a self-accelerating chain of climate events toward a hotter earth.[1] Modeling results to date show that if greenhouse gas emissions remain unchecked, climates near the equator will become uninhabitable by humankind as early as the second half of this century. Supply chains will become disrupted, as rising sea levels and more frequent and severe storms flood infrastructure critical to export and import of goods and energy, and large populations are forced to shift to more habitable regions, putting stress on limited infrastructure and resources.

At our current emissions rate, we have approximately 10–15 years left in the global carbon budget to limit global warming to 1.5°C–2°C.[2] Over half of global energy-related carbon dioxide equivalent emissions come from the production, transport, and use of oil and gas products.[3] And the oil and gas industry is under increasing scrutiny and pressure to reduce emissions by regulators, buyers, investors, and the general public. As the urgency to cut global emissions to net zero by 2050 grows, oil and gas companies are at the crossroads of two potential futures: one in which they successfully evolve to a greener future, or one in which they risk the financial consequences of business as usual.

To curb greenhouse gas (GHG) emissions, we must transition toward a low-carbon energy future. Of the fossil fuel energy sources, natural gas has some potential to be an important transition energy source, especially to phase out coal in areas where renewable sources of energy are not readily available or fit for end-use purpose. However, for natural gas to have any credible role as a transition fuel, we must dramatically reduce and aim to eliminate methane emissions that are associated with the natural gas supply chain.

Methane is a short-lived, but powerful, climate pollutant,[i] and the natural gas sector is responsible for nearly 41 megatons of methane emissions per year,[4] equivalent to 3.2 Gt of CO_2 equivalent (CO_2e) emissions per year over a 20-year timeframe.[ii] That methane is released into the atmosphere when gas is extracted, moved through pipelines, and distributed into homes and businesses.

[i] Methane is a relatively short-lived greenhouse gas that has a global warming potential (GWP) equivalent to 28 times that of CO_2 over 100 years, but 84 times that of CO_2 for 20 years. Thus, the warming impact of methane is concentrated early in its lifespan and is a serious threat to our shrinking carbon budget in the near-term.

[ii] Current CO_2e emissions of 41 Gt/y include methane emissions from the oil and gas sector, although methane emissions are converted to CO_2e in GWP100.

Toward a Greener Future

To curb these emissions, companies, investors, and policymakers need irrefutable, real-time climate data and a trusted climate intelligence resource to aggregate this information. This will enable stakeholders to use the data to inform decision-making, and over time determine if actions are having an impact.

At its core, successfully reducing methane emissions and risks associated with prolonged emissions requires actionable insights, which are built atop three key elements:

1. First, we need sensors that can detect methane—whether as a concentration anomaly or emissions rate. These sensors can be mounted on satellites, fixed wing airplanes, stationary flux towers, vehicles, and fence posts. Various sensing techniques and instruments can be combined to cover a wide range of geospatial, temporal, and concentration or emissions rate resolutions.

2. Second, the methane emissions data must be integrated with other streams of data, such as oil and gas asset information, ownership status, related physical/technical characteristics, location, operational performance history, financial performance history, and related party interests.

   Our partnership with Spherical Analytics allows automated, machine-learning-enabled ingestion of both measured and modeled methane emissions data, together with any relevant asset, market, and environmental data. This data is then cleaned and assigned to assets, elevating it to asset grade data (AGD). AGD is data that is highly pedigreed, provenanced, auditable, and immutable, allowing it to be integrated into myriad existing and new systems.

3. Third, the integrated AGD set must be analyzed to generate insights. Specifically, methane emissions must be tied to health, safety, and economic drivers that motivate operators, investors, regulators, and the public to take action. For example, methane emissions data that is presented in isolation may provide awareness, but often may not lead to any concrete actions to reduce those emissions. However, if methane emissions can be tied to adverse impacts on community health,[5] actions to reduce emissions become imperative. These abatement actions are much more likely to occur, in a much shorter timeframe.

Toward a Greener Future

The Climate Action Engine (CAE), an initiative developed by Rocky Mountain Institute (RMI) in partnership with Spherical Analytics, weaves together the three elements above under a single data and analytics platform. It is a system that is uniquely positioned to meet and respond to the industry's need to make methane emissions reduction actionable. For example, the CAE will:

- Enable operators to ensure that they are prioritizing emissions reduction initiatives that have the largest methane emissions reduction potential;
- Track emissions reduction initiatives to ensure changes before and after their implementation;
- Report emissions in line with various reporting guidelines such as those stipulated by the Taskforce on Climate-related Financial Disclosures (TCFD), Sustainability Accounting Standards Board (SASB), Global Reporting Initiative (GRI), and CDP; and
- Allow users to explore what-if scenarios such as identifying sub-economic assets under a carbon tax scenario, and flagging potential stranded asset risks in the context of climate change like more frequent and severe floods and hurricanes.

The CAE has been, and will continue to be, designed with end-users in mind to address their greatest needs.

EXHIBIT 1
The Climate Action Engine Workflow

Use-Case Development in the Near Term

In the short term, the CAE will focus on identifying opportunities to reduce methane emissions that are under operational control in Texas. The intended primary audience of our work includes operators, service providers, and financial institutions.

Some specific use cases in development with input from users include, but are not limited to:

- Improving accuracy and confidence around flaring activities
- Streamlining and enhancing accuracy in GHG reporting
- Enhancing operations and maintenance scheduling based on higher resolution, higher frequency, and more accurate environmental performance analyses
- Highlighting operators' assets available to produce low-emissions gases that can be certified and marketed as low-emissions intensity products
- Enriching operators' proof of environmental performance for myriad reporting, marketing, and risk/finance applications

These use cases will be developed by deriving insights from dozens of sources including the following:

- **Environmental Instrumentation**
  - Satellite/space-based instrumentation
    - VIIRS (a satellite instrument that produces data that can be used to identify flare activities)
    - TROPOMI (a methane-sensing satellite instrument that can identify large methane emissions concentration anomalies)
  - Airborne instrumentation
    - Fixed-wing flyovers using hyperspectral sensors that can measure elevated methane concentrations with high spatial resolution
    - UAV (unmanned aerial vehicle)/drone-based instrumentation sorties
  - Terrestrial remote instrumentation (from public and private monitoring stations as available)

- **Compliance Reports**
  - Historical production data (water, oil, gas)
  - Greenhouse gas emissions data as reported to the US Environmental Protection Agency by operators
  - Reported flare data
  - Reported environmental accidents like spills

- **Other Publicly Available Inputs**
  - Asset permits
  - Equipment specifications/engineering documents
  - Asset ownership/interested party reports
  - Financial/market performance reports
  - Environmental risk reports
  - Flood risk reports

Use-Case Development in the Near Term

Reconciling Reported and Actual Flares

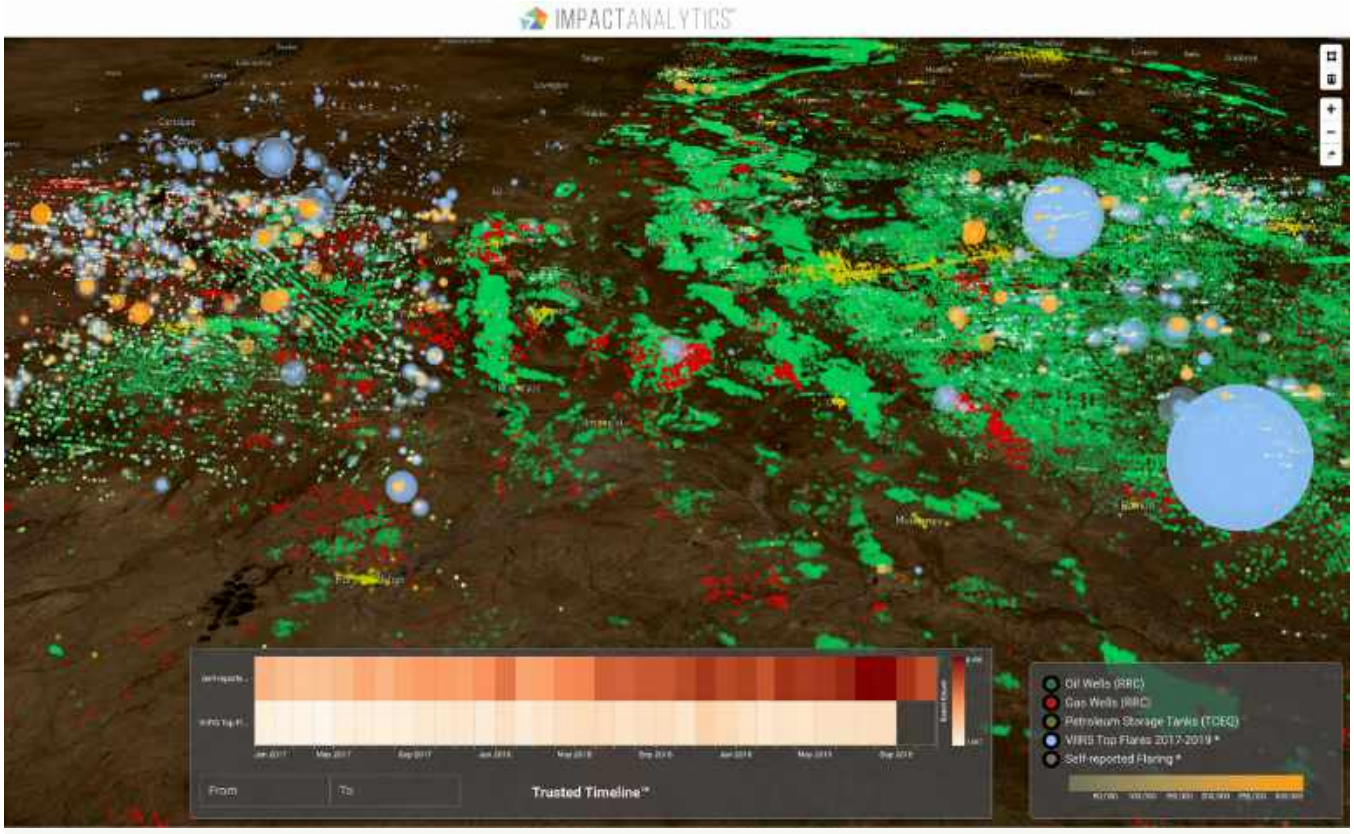
Today, the simplest way to assess a flare's operating efficiency is by using audio, visual, and olfactory techniques, and methane emissions quantification from flares are rarely performed, especially for older systems.[6] The CAE can help improve this along two fronts. First, the VIIRS satellite can track the status of flares for any given operator to determine monthly changes in flare status (lit or unlit). Additionally, VIIRS data can be analyzed to quantify the volume rate of gases flared. Thus, asset-contextualized VIIRS data can enable comparison between the observed volume of flared gases and the reported volume of flared gases.

- For operators, the ability to demonstrate alignment between reported flare data and observed flare data is valuable to gain market acceptance of reported data and to increase confidence in externally reported numbers.

- For flare service providers, month-to-month flare status, when coupled with changes to production rates in the same region, can serve as a valuable business lead generation tool. Analysis of VIIRS data can also be used to delineate regions where old, inefficient flares are deployed. Flare manufacturers with highly efficient flare systems can use this data to see areas of opportunity for their improved flare systems or other flare gas utilization projects.

EXHIBIT 2

Comparison of VIIRS vs. Self-Reported Flaring



Note: VIIRS data is displayed for the Permian Basin; Self-reported flare data is summed from the entire state of Texas.

Use-Case Development in the Near Term

RMI and the Climate TRACE Coalition

In July 2020, RMI was one of nine founding members in conjunction with former Vice President Al Gore to launch the Climate TRACE coalition.[7] Climate TRACE is on a mission to make meaningful climate action faster and easier by mobilizing the global tech community. The coalition is harnessing satellite data, artificial intelligence, and the collective expertise of each member organization to track human-made greenhouse gas emissions from all major sectors, in as close to real-time as possible. While this is no small task, the emissions product generated by Climate TRACE will afford unprecedented action by reaching decision makers across numerous target sectors. The CAE will be a powerful home for highly spatially and temporally resolved emissions data from Climate TRACE.

- For investors, it may be valuable to compare between flare intensities (as defined by volume of observed flares or produced oil or gas) across different operators and assets, so that they can invest where flare intensities are lowest.

- For regulators, the ability to quantify discrepancies between reported and observed flare data can ensure that they write regulations and policies to curb methane emissions from flares based on representative numbers.

Streamlining Reporting

Oil and gas companies are responsible for reporting to several different standards including CDP, TCFD, GRI, SASB, and more. They typically gather data for these reports manually, which is a labor-intensive task. Using a common data platform like CAE can allow for the automatic generation of verified quantitative information needed to report to each standard. Users can then analyze trends in disclosures to make informed decisions to improve operations and make investments.

- For operators, automated reporting processes can minimize human errors. In addition, a digital collation of emissions data—as opposed to emissions data that is manually compiled in an Excel spreadsheet—can more quickly identify areas where emissions can be reduced. Lastly, efficiency gained can allow resources to be reallocated from reporting activities toward activities that can tangibly reduce emissions.

- For investors and regulators, automated and streamlined reporting can help increase confidence in numbers reported by operators.

Supporting a Differentiated Gas Market

Differentiated gas—gas distinguished from the conventional commodity by attributes such as methane emissions performance—is one tool that oil and gas producers, buyers, investors, and regulators can use to credibly make their methane emissions footprint more transparent. The Methane Emissions Standard for natural gas, like the one RMI and Systemiq are

Use-Case Development in the Near Term

developing in their Global Methane Solutions (GMS) partnership,[8] can differentiate gas on the basis of its methane emissions performance, including emissions mitigation and monitoring measures at the facility level. The CAE can support a differentiated gas market in multiple ways:

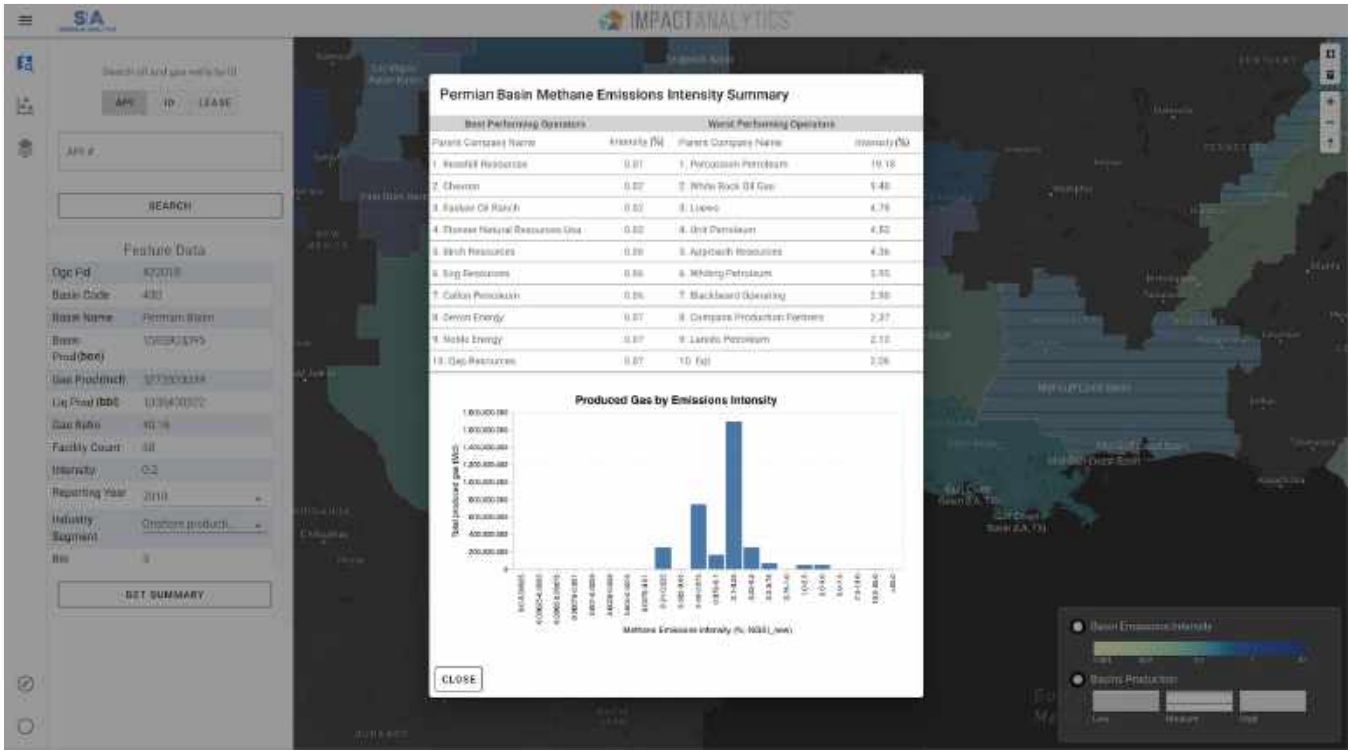
- By directly integrating a standard's criteria that grades gas volumes on their methane emissions performance, the CAE will be able to highlight facilities and operators that are qualified to produce certifiable gas. This insight can help operators themselves identify opportunities to participate in differentiated gas markets, help gas buyers identify differentiated gas suppliers, and aid regulators and investors in determining how companies in their jurisdictions or investment portfolios are performing.

- The CAE can help quantify and communicate the emissions reduction and economic opportunities that differentiated gas presents to various stakeholders—whether they supply, buy, regulate, or invest in natural gas.

- The CAE can also help a standard itself improve over time, through data analysis that can inform the method for evaluating the methane footprint of a gas, and a standard's expansion to other geographies and new supply chain segments over time.

EXHIBIT 3

Methane intensity of the Permian Basin



Use-Case Development in the Mid to Long Term

In the mid to long term, the CAE will go beyond providing insights to reduce methane emissions from existing assets. The CAE is being designed to enable quantification of both physical and transition risks that are associated with climate change for operators, investors, and purchasers of oil and natural gas. Physical risks such as flooding, extreme heat and weather events (e.g., hurricanes), and water shortages can damage assets and disrupt supply chains.

RMI and Spherical Analytics completed initial steps to quantify physical risks to assets. For example, a floodplain map of Texas was analyzed together with asset location and production data in order to determine which assets are at risk from anticipated flood events.

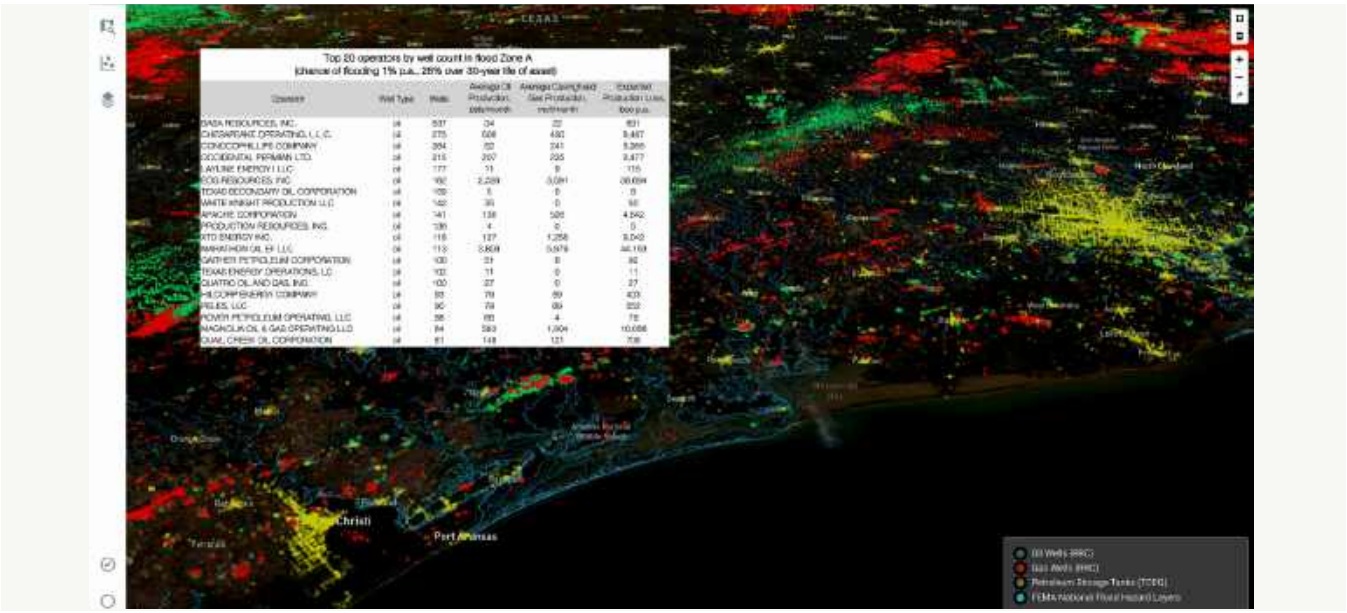
Assets at high risk can now be catalogued by variables such as operator, asset type, and age. Furthermore, by combining first-order cost estimates of operation data, such as those compiled by Rystad, and decline curve analyses to project future production, it is possible to calculate at-risk values of assets.[9] Similar analyses can be undertaken to understand impacts from hurricanes and other anticipated extreme weather events.

The CAE can also assess exposures of assets to transition risk, such as changes in regulations, enactment of a carbon tax, and changes in market demand (e.g., lower demand for fossil fuels leading to lower unit prices). By leveraging asset grade data, it is possible to quickly assess which assets are most exposed to transition risks so that proper actions can be taken.

For operators, exposure to physical and/or transition risks may mean choosing not to operate in areas where physical risks are highest, or where compliance with tighter emissions regulations leads to increased lifting costs that make a development sub-economic. For investors, it may mean choosing to invest in operators whose assets are best protected from physical risks.

EXHIBIT 4

Oil wells (green) and gas wells (red) in FEMA elevated flood hazard regions



Process of Developing Use Cases

We will develop all use cases described above, short, mid, and long term, with input from end-users of the outputs from the CAE. As we do not have a long lead time to reduce methane emissions, ensuring that insights from the CAE can be readily integrated into end-users' existing decision-making framework is a necessary criterion to achieve adoption and scale.

To start, we are engaging with operators, service providers, financial institutions, and regulators to define metrics that can inform actions to reduce emissions. We are beginning with bilateral conversations to identify the needs of each individual player. If there are common needs that are expressed across all players, we will form a consortium for users to share common emissions-related metrics.

The Big Picture of Greenhouse Gas Emissions

The challenge to reduce greenhouse gas emissions and avert the worst impacts of climate change is a complex problem, one that is entwined with every aspect of our lives and every corner of the economy. The potential solution space is equally as complex. Shifting toward a greener future requires the transformation of economic systems and technologies around the world, while also supporting continued human and economic development. Moreover, climate change does not recognize political, economic, or market boundaries, but these boundaries represent critical constraints in the solution space. The urgency of the challenge requires us to move quickly to reduce emissions at the source, and we don't have time for ineffective strategies.

Addressing challenges that are this complex requires good data, reliable and timely information, and deep insight to guide action. And since we can't manage what we can't measure, having accurate, timely, and actionable data on global GHG emissions is essential to limit warming to 1.5°C. Our work to bring transparency and action on methane emissions from the oil and gas industry in Texas is just the first step in addressing this challenge by enabling a trusted global ecosystem of "climate intelligence" to bear on the challenge.

By bringing data, intelligence, and people together onto one single platform, RMI and partners like Climate TRACE are enabling climate solutions that work for the benefit of the climate, companies, countries, and people. With extensive connections into a comprehensive and growing ecosystem of climate-relevant data and partners, the CAE can go beyond just methane emissions from the oil and gas industry in Texas. We hope the CAE will be the go-to for high-value insights across all anthropogenic sources of GHG emissions across all geographies and sectors.

To learn more, email **methane-contact@rmi.org** or visit **www.rmi.org/CAE**

Endnotes

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