Research Article

Fast Action on Methane Emissions as a Climate and Energy Security Imperative

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Abstract: Ambitious methane emission reductions are an integral part of any realistic climate agenda. Indeed, the Paris targets are out of reach without such reductions. Fortunately, many are cost effective and/or technically feasible. The IEA estimates that G20 countries account for 63 per cent of anthropogenic methane emissions. The G20 has already taken a leadership role; acknowledging in 2021 that methane emissions represent a significant contribution to climate change, promoting several initiatives. Furthermore, the climate consequences of methane emissions might be exacerbated as G20 countries through hydrogen emissions inhibit the breakdown of methane in the atmosphere.

Introduction

One challenge with reducing CO_2 emissions is that they are the result of the primary process of generating useful energy. In contrast, industrial emissions of methane and hydrogen are side effects in most sectors. They are waste streams that can potentially be eliminated or greatly reduced, with relative ease. Both gases have a very strong warming effect, many times stronger that CO_2 but with shorter duration, and the emissions have a great impact on warming. But targeted reduction requires more precise data on source of the emissions. Most scientific work has historically been focused on assessing the global or regional volume of emissions of various greenhouse gases. Local emissions have overwhelmingly been estimated using emission factors, not empirical measurements. This has hindered progress on mitigation, as actual localised data is imperative to efficiently allocate efforts and investments towards reductions by those individuals with the potential agency to tackle them.

Investments in empirical science studies over the past decade are starting to pay off in several sectors, most notably the energy sector where the largest reduction potential lies (UNEP/CCAC Global Methane Assessment, 2021). It has now become possible for site managers to effectively measure methane emissions, to direct their mitigation efforts rapidly and effectively. Enabling local empirical emission measurements that advance mitigation is nothing less than a data revolution for climate action on methane: from global empirical data with local estimates, to local empirical data that is reconciled with the global picture This ensures that the whole of the emissions are the proverbial sum of the parts.

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The Figure 1 shows the current best estimate of methane emissions in various sectors of G20 countries. However, this does not include emissions embedded in imported products, which would substantially increase especially the EU in the energy sector.

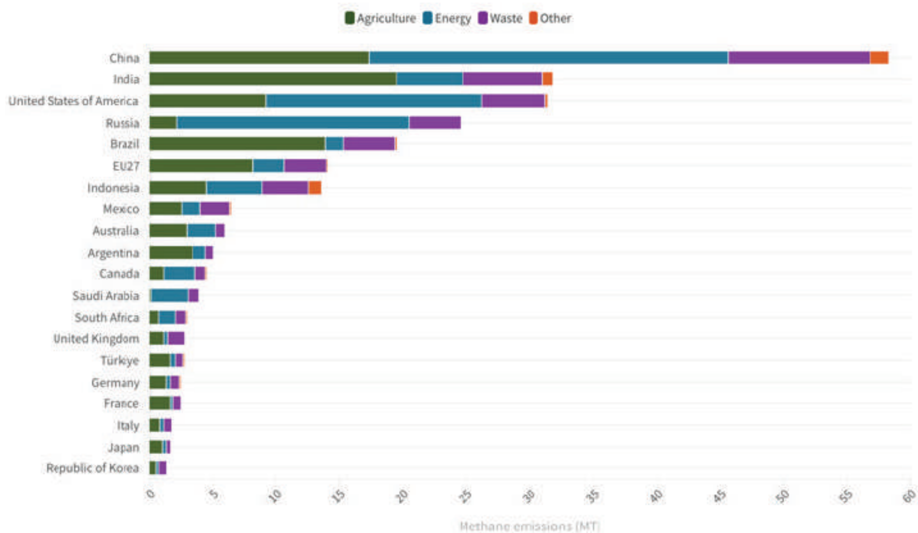
While the greatest reduction potential undoubtedly lies in the energy sector in the coming years rapid progress is expected in the availability of local data on emissions from the other sectors such as livestock, rice, solid waste and water. As described below, the mitigation potential, methods and agency varies greatly between sectors, and each should be considered separately. In contrast, for hydrogen, the scientific work is just starting.

Methane: Over 80 Times More Potent than CO_2

To stay on track to reach the Paris Agreement goal of limiting climate change to 1.5°C, the world needs to almost halve greenhouse gas emissions by 2030. The Intergovernmental Panel on Climate Change notes that if the world is to achieve the 1.5°C temperature target, deep methane emissions reductions must be achieved over this time:

"As highlighted by IPCC, if the world is serious about avoiding the worst effects of climate change, we need to cut methane emissions from the fossil fuel industry. But this is not a get-out-of-jail free card: methane reductions must go hand in hand with actions to decarbonize the energy system to limit warming to 1.5°C, as called for in the Paris Agreement".

Figure 1: Estimates of Methane Emissions from Anthropogenic Souces Among G20 Members



Source: IEA's Global Methane Tracker 2022 https://www.iea.org/reports/global-methane-tracker-2022
UNFCCC GHG inventory (2020 data for the EU27 and Türkiye only) https://di.unfccc.int/

Methane released directly into the atmosphere is more than 80 times as potent as CO_2 over a 20-year time horizon. However, as methane's atmospheric lifespan is relatively short at 10 to 12 years, actions to cut methane emissions can yield the most immediate reduction in the rate of warming, while also delivering air quality benefits.

Mitigating methane emissions is entirely compatible with the push for net zero and the Paris climate targets.

Box 1: Green Hydrogen, Climate Change, and the Energy Transition

Governments and the private sector are showing great interest in "green hydrogen", particularly for the so-called hard to abate sectors. The IPCC (2022) notes that for "almost all basic materials – primary metals, building materials and chemicals – many low- to zero-GHG intensity production processes are at the pilot to near-commercial and in some cases commercial stage, but they are not yet established industrial practice. Low-emissions hydrogen could also reduce CO_2 emissions from shipping, aviation, and heavy-duty land transport if production process improve and costs decline. (IEA, 2019, 2021; IRENA, 2021; The Economist, 2020). Hydrogen, however, slows the destruction of methane in the atmosphere and therefore has an indirect global warming effect. Any push toward hydrogen must therefore take into consideration the negative environmental consequences of this shift to a new energy carrier.

Green hydrogen is produced through electrolysis, the process where electricity from renewable energy sources is used to separate water into hydrogen and oxygen molecules. If the energy comes from net additional renewable sources, the process itself does not release any carbon into the atmosphere.

Almost all 90 million tons of hydrogen production today involves fossil fuels. The main uses are in oil refining, the production of ammonia and methanol, and direct reduction of iron in steel production (IEA, 2021). The IEA estimates that at present fossil gas accounts for around three-quarters of the annual global dedicated hydrogen production, using around 6 per cent of global fossil gas use. Coal comes next, due to its dominant role in China: it accounts for an estimated 23 per cent of global dedicated hydrogen production and uses 2 per cent of global coal use (IEA, 2021; IEA, 2019; IRENA, 2021).

The cost of hydrogen produced using fossil fuels and CO_2-free alternatives is at present significant, but is projected to fall to fossil fuel parity by 2050. Given these cost trajectories, the Hydrogen Council and McKinsey estimate that $500 billion will be invested in hydrogen production infrastructure by 2030.

A massive build out of renewable energy infrastructure is required to achieve net zero emissions, so until there is a net surplus of renewable electricity, producing green hydrogen will prolong the operating life of fossil power plants. Another consideration is that in many developing countries new renewable energy production might arguably be better used to meet basic energy needs, particularly in sub-Saharan Africa where the global goal of universal access to electricity is far from being attained.

An important environmental consideration regarding hydrogen's role in our energy future is its role as a greenhouse gas. Hydrogen leaks easily and reacts with tropospheric hydroxyl radicals so that emissions of hydrogen to the atmosphere act to prolong atmospheric concentrations of methane and ozone. Hydrogen is therefore an indirect greenhouse gas with a global warming potential that is estimated to be 33 over a 20-year time horizon (Warwick *et al.*, 2022; Colombia University, 2022; Ocko and Hamburg, 2022, Frazer-Nash, 2022; Falko *et al.*, 2021). Arguably the 20-year GWP is appropriate because of the relatively short atmospheric lifetime of hydrogen compared with CO_2.

Estimates of hydrogen's GWP and great uncertainties regarding fugitive emissions rates point to the need for exercising caution. Most measurement and detection protocols are designed with safety as an objective, not environmental consequences. In this regard hydrogen is similar to methane and only now is the industry monitoring emissions, reducing them, and reporting. The same needs to be done for hydrogen, in addition to undertaking more research and modelling. Considering realistic estimates of both methane and hydrogen emissions, green hydrogen has the potential to be less climate intensive than the fossil fuel it replaces, but it will not have zero climate impact (Ocko and Hamburg, 2022).

Under any decarbonization scenario, substantially reducing methane emissions has a great climate benefit. In fact, without it, the target are all but unattainable. Consequently, ambitious methane reductions are an integral part of any realistic climate agenda. There are also no real trade-offs between mitigation of methane and carbon dioxide, and they should be pursued concurrently. China had drafted its own methane strategy to control emissions in the energy, agriculture and waste treatment sector (Reuters, 2022).

Upside Opportunities for G20 Action on Methane

Recalling that cutting human-caused methane by 45 per cent this decade would keep warming beneath a threshold agreed by world leaders, G20 Italy summit in 2021 acknowledged that methane emissions represent a significant contribution to climate change, and welcome the contribution of various institutions, including the establishment of the UNEP International Methane Emissions Observatory (IMEO).

UNEP's IMEO catalyzes the collection, reconciliation, and integration of empirically based near real time methane emissions data, to provide unprecedented climate transparency and the information required for action. Closely involving and partnering with many other players in methane mitigation such as energy companies, the Global Methane Hub (GMH), satellite providers, and NGOs, it is one of the implementation partners for the Global Methane Pledge (GMP).

The GMP engages over 150 participating countries across sectors and needs a sectoral delineation of commitments. Also, as noted above the private sector has a critical role to play in reducing emissions from the energy sector in the short-term. As part of its implementation role under the GMP, UNEP's IMEO developed a robust framework for engaging the oil and industry that has established itself as the gold standard of transparency for the sector. The Oil and Gas Methane Partnership 2.0 (OGMP 2.0) commits energy companies to measuring, reporting and mitigating their emissions; but progress is uneven. There is great potential upside for methane mitigation by the G20 members. Two years after its launch, fewer than half (9/20) of G20 members have national companies as members of OGMP 2.0, although a higher share (14/20) of domestic assets is reported to UNEP through their foreign holdings. Only three G20 members have engaged in IMEO, notwithstanding the majority (15/20) being members of the Global Methane Pledge. There is an opportunity for climate action on methane with G20 countries aligning their commitments on methane emission abatement.

G20 countries account for approximatively 63 per cent of global oil and gas production, but OGMP 2.0 currently has merely 29 per cent coverage of G20 countries' oil and gas production. For countries outside G20, it has 50 per cent coverage. Overall, 37 per cent of global oil and gas production is covered by OGMP 2.0. This underrepresentation of industry in the G20 countries represents a clear opportunity for progress.

Collective Action is Needed for Solving Complex Problems

As in many environmental issues, the concept of LiFE (Lifestyle For Environment) is applicable to the behavioural aspects of tackling methane emissions. To mitigate methane emissions, it is action by individuals that are required to enact change and the idea of LiFE is to develop ways to change behaviour at scale (Government of India, Ministry of Environment, Forest and Climate Change, 2022). For methane, the world is rightly focused on regulatory and policy measures, but these government frameworks shape the context that guides individual behaviour. India has demonstrated this in several sectors such as the Ujjwala Scheme to increase LPG use in the home or the Swachh Bharat Mission to construct toilets in rural areas. Collective action is not an alternative to regulatory measures, but the mechanism through which action is delivered.

For methane, the collective action required is often not by consumers, but it still concerns individuals, such as asset managers of oil and gas installations, government shareholders who approve capital allocation for mitigation, steel company procurement managers who specify the methane content of coking coal, investors who are not satisfied with estimates and require empirical emissions data, individuals who make dietary choices, rice farmers who change their flooding practice, citizens who separate organic matter from waste, among others. All these actors need to evolve their behaviour for a collective outcome.

In the instance of methane emissions, three aspects require attention to drive this collective action:

First, there is awareness of the seriousness of the issue and opportunity for climate action. It is still relatively recent that attention has focussed beyond CO_2. Since 2012, the Climate and Clean Air Coalition (CCAC) has highlighted the importance of short-term pollutants as part of an effective climate policy.

Second, there is empirical data for measurement data. Without quantification of emissions, it is not possible to prioritise actions and investments towards the largest sources. Critically, the data must be direct measurement data, not generic emission factors and tailored to the scale of the individuals who are able to take action at the facility or site level.

Third, it is to ensure that individuals who are in a position to act have the agency to do so. In the energy industry, most often these will be asset or site managers. As in all LiFE campaigns, this means that they must change behaviour from what they were in the past. Social norms must change in the sector to make methane mitigation a priority, such as safety. This requires a combination of motivation, empowerment or sometimes even compulsion. Involving the individuals at the site level in the direct measurements and providing information on the impact of emissions can help motivate them. A supportive environment that gives these individuals access to the means to act and recognises them for doing so is imperative. This will be strengthened by rules and regulations that make mitigation more compulsory.

Elaborating Experiences and Approaches

Partnerships in the Energy Sector

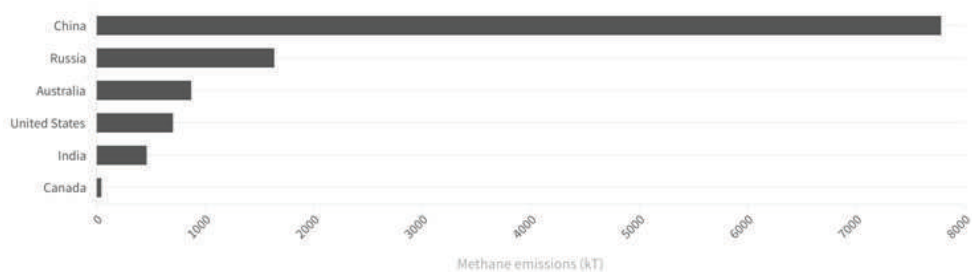
Lifestyle for Environment, introduced by Prime Minister Modi at COP26, encourages a focus on mindful and deliberate utilisation of resources and encourages individuals to adopt simple changes in their daily life that can contribute to climate change. Consistently with the LiFE approach, UNEP has developed partnerships with the individuals who have the agency to mitigate emissions in methane assets. These partnerships also function to develop and agree a global Measurement, Reporting and Verification (MRV) standard for the different sectors.The Oil and Gas Methane Partnership 2.0 (OGMP 2.0) currently brings together over one hundred companies from five continents, representing over a third of oil and gas production. Member companies strive for a defined Gold Standard level of measurement, reporting and mitigation. UNEP assesses the reports for consistency and quality and reports the results to the public. A similar initiative focus on methane emissions from mining metallurgical coal used in producing steel, a "hard to abate" industrial sector, having the potential to reduce the carbon footprint of steel production by up to one third. This could make material difference on G20 emissions considering its members represent the vast majority of steel demand and metallurgical coal production.

For the oil and gas sector, methane emissions are a consequence of extraction, processing, and delivery, either intentional (venting and flaring) or unintentional (equipment leaks). Methane is emitted because of a combination of design choices in equipment, operational practices and equipment failures or leaks. As such, many mitigation measures can be readily engineered, without impacting the main processes of producing oil and gas. An additional benefit is that often by reducing methane emissions, the captured product can be sold, offsetting some of the cost.

Consequently, oil and gas operations that target near-zero methane emissions (for example, a methane intensity target of 0.2 per cent) are entirely plausible without greatly affecting operational activities, although potentially adding some cost and obviously not addressing the impact of consuming the product. The primary agents of change are the asset managers, who must plan, implement, and monitor the changes in equipment or process. To prioritize mitigation actions cost-effectively, asset managers need to have a comprehensive understanding of the scope and scale of emissions across infrastructure. They need access to the required resources from the company capital allocation process. They also need to be encouraged by company priorities, the regulatory context, as well as the social norms of their industrial community.

Metallurgical coal is used to produce steel. During mining operations methane is released from the coal seams and primarily managed for safety concerns. Emissions can fluctuate widely as they result from processes such as the displacement of natural soil layers or microbiological activities. Mitigation actions must not affect safety in any way, which means that the methane is diluted as quickly as

Figure 2: Estimates of Methane Emissions Coking Coal Mining in G20 Countries



Source: IEA's Global Methane Tracker 2022 https://www.iea.org/reports/global-methane-tracker-2022 and IMEO's own calculations
G20 countries account for >90% of worldwide coal mine methane emissions from coking coal.

possible during underground operations. The main mitigation option is drainage of the methane from the mine before production, which both increases safety and delivers higher-concentration streams of gas that can be destroyed or monetized. The other important mitigation option is destruction of Ventilated Air Methane (VAM), a technology that is already operational in several mines around the world and needs to be substantially scaled up.

While a substantial reduction in the emissions of the steel sector by lowering the methane emissions in its supply chain appears technically realistic, the incentive structure is more complicated than it it for oil and gas sectors. As with the oil and gas sector, participants in the metallurgical coal sector have ready access to capital and knowledge, and the asset managers generally have a high degree of agency over their emissions.

Better Actionable Data

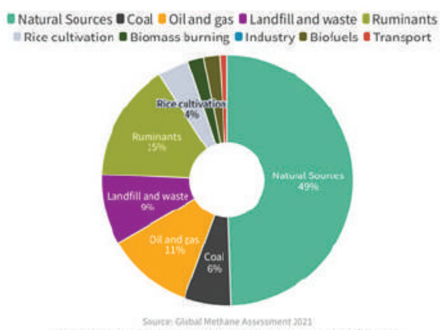
To deliver the Global Methane Pledge and remain within the envelope of global temperature rise, requires reliable actionable data for the individuals who act to reduce 150 Mt of methane emissions across all sectors by 2030. UNEP launched IMEO at the G20 for this purpose. Working with research institutions and companies, UNEP's IMEO assembles and integrates emissions data from multiple sources at the site and regional levels, into a public data set – diligently noting their uncertainty range.

A prominent example of this effort is IMEO's Methane Alert and Response System (MARS) launched at COP27. This integrates detections from multiple satellites into a comprehensive and consistent view, and generates alerts to the emitters, while registering subsequent mitigation results. The success of the system is predicated on clear focal points for each major asset, at each oil and gas company and for each government concerned. Having a dedicated MARS focal point in each G20 country is a small and necessary implementation step.

Beyond Energy

Beyond the energy sector, livestock, rice and waste are estimated to represent almost two-third of anthropogenic methane emissions. It is recognized that the greatest short-term mitigation potential is in the energy sector, but reductions will be required to meet GMP aims. While there are many organisations and individuals that are already involved in mitigation action for these sectors, assembling a global dataset of measured emissions is a necessary step to focus and direct the collective action required in these sectors.

Figure 3: Share of Different Methane Emission Sources (Estimates)

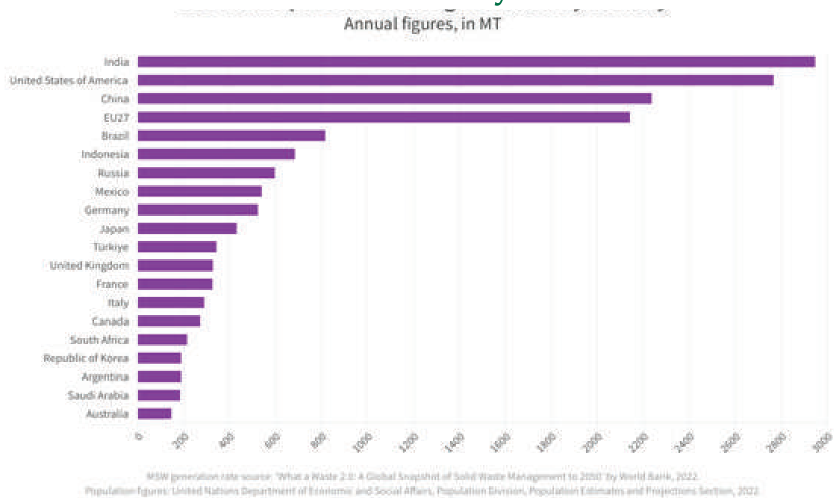


In the solid waste sector, methane emissions stem exclusively from the organic component of the waste, which comprises 30-50 per cent of waste streams. Organic waste in anaerobic conditions is decomposed by bacteria, which produces methane that escapes into the atmosphere if not captured. Globally, around 37 per cent of municipal solid waste is disposed of in some type of landfill, 33 per cent is openly dumped, 19 per cent undergoes materials recovery through recycling and composting, and 11 per cent is treated through modern incineration (World Bank, 2018). These systems are highly diverse, ranging from highly managed facilities to unmanaged dumps.

Upstream mitigation, such as the separation of organic and non-organic waste at the household or commercial level, can reduce methane emissions if the organic waste is properly managed (through anaerobic digestion, composting, combustion, etc.). In principle, targets for near-zero methane emissions are technically possible, but they are harder to achieve.

The solutions to mitigate methane emissions from rice production are relatively well established. The source of emissions is anaerobic decomposition of organic matter in flooded rice paddies. Mitigation can be accomplished through management practices such as alternate wetting and drying, direct seeding, using short-duration varieties and shifting to different crops. However, it is important to ensure that the interplay between methane and nitrous oxide is also considered, given that in reducing one of these greenhouse gases, it is easy to inadvertently increase the other. How these emissions vary over space and time is not well understood.

Figure 4: G20 Municipal Solid Waste Generation by Country



This is a sector where the LiFE approach holds promise, as the key is behavioral change by a large number of individual farmers. Livestock produce methane both through the digestion of feed in ruminant animals (i.e., enteric fermentation in cattle, buffalo, sheep) and the operations through the handling and storage of liquid manure. Unsurprisingly, emissions vary greatly by animal type, feed quantity and quality, and environmental context. These emissions are part of meat and dairy supply chains. As such, the methane footprint of livestock is deeply interconnected with food security, cultural and behavioural patterns of food consumption, and, in many parts of the world, rural livelihoods.

The livestock sector is further complicated because concentrating and intensifying livestock production can reduce enteric methane emissions per unit of output but increase absolute emissions of methane. Concentrated livestock facilities also have animal welfare and health implications, such as contributing to increased antibiotic resistance (UNEP, 2023). There is a need for better quantification of methane emissions in intensive and extensive livestock systems, especially in low- and middle-income countries.

In all five sectors, it is essential to establish a public record of empirical data, collected through state-of-the-art scientific methods. This allows for a characterization of uncertainty and provides the various actors of the methane ecosystem with a sound basis for action.

Conclusion

Mitigating methane from the main emitting sectors of fossil fuels, waste, livestock and rice should be a priority under any climate strategy. The most cost-effective and highest degree of agency exists in the oil and gas, as well as metallurgical coal sectors. A trusted set of empirically verified emissions data is essential for any collective action, and UNEP's IMEO has been designed for this purpose. Individual behavioral change programs, such as LiFE should be part of the solution, as action ineluctably is taken by individuals in any instance. We also draw attention to take early action in the growing hydrogen industry, to learn from the lessons of methane mitigation and make the climate consequences of hydrogen emissions an integrated component of the sector.

The G20 has demonstrated a strong focus and concern with limiting methane emissions in its declarations in Article 26 of the 2021 Rome summit communiqué, notably enabling the launch of UNEP's IMEO. In the last two years much progress has been made, and there is an opportunity to do more to accelerate climate mitigation.

The following is a list of five suggested short-term actions by the G20.

- As stated in the EU Joint Declaration from Energy Importers and Exporters on reducing Greenhouse Gas Emission from Fossil Fuels, fossil fuel energy producers can implement projects and support measures to significantly reduce emission across fossil fuel energy operations.
- A G20 statement underscoring the essential role of empirical data at the granularity of the entity that has the agency to mitigate the emissions, is both essential and highly innovative in climate policy. Most data efforts have been global or regional, and achieving higher precision and granularity coherent with agency is an important statement. Two years after its launch fewer than half (8/20) of G20 members have national companies as members of OGMP 2.0. If G20 countries would encourage their national oil and gas companies to join OGMP 2.0, this would increase global coverage from 35 per cent to 80 per cent of production.
- At the Rome summit, the G20 facilitated the IMEO launch and encouraged members to support the initiative. To date, only three G20 members have contributed funding to IMEO, notwithstanding the majority (15/20) being members of the Global Methane Pledge.

Since the Pledge was created after the Rome G20 summit, there is an opportunity for climate action on methane with G20 countries aligning their commitments on methane emission abatement by supporting IMEO directly.

- Steel production accounts for seven percent of global CO_2 emissions. Under any realistic decarbonisation pathways, mitigating methane emissions from the metallurgical coal production can reduce the climate footprint of steel by up to one third. Reducing emissions in the steel industry and its supply chain should be a priority. Steel companies are called on to include methane emissions from metallurgical coal in their environmental considerations.
- To avoid offsetting gains in reducing methane emissions, avoiding hydrogen emissions from the very start is imperative to the contribution of the gas in the energy transition. Hydrogen emissions are potentially large and have a strong warming effect.

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