TRENDS IN SOUTHEAST ASIA

GLOBAL METHANE PLEDGE

A Review of Data, Policy and Transparency in Reducing Methane Emissions in Malaysia

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FOREWORD

The economic, political, strategic and cultural dynamism in Southeast Asia has gained added relevance in recent years with the spectacular rise of giant economies in East and South Asia. This has drawn greater attention to the region and to the enhanced role it now plays in international relations and global economics.

The sustained effort made by Southeast Asian nations since 1967 towards a peaceful and gradual integration of their economies has had indubitable success, and perhaps as a consequence of this, most of these countries are undergoing deep political and social changes domestically and are constructing innovative solutions to meet new international challenges. Big Power tensions continue to be played out in the neighbourhood despite the tradition of neutrality exercised by the Association of Southeast Asian Nations (ASEAN).

The **Trends in Southeast Asia** series acts as a platform for serious analyses by selected authors who are experts in their fields. It is aimed at encouraging policymakers and scholars to contemplate the diversity and dynamism of this exciting region.

Global Methane Pledge: A Review of Data, Policy and Transparency in Reducing Methane Emissions in Malaysia

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EXECUTIVE SUMMARY

Malaysia is a signatory of the Global Methane Pledge, but the implications for national action on methane emissions remain unclear. We reviewed publicly available literature and data, arriving at the following key findings:

1. *There is no clear national plan for methane action yet*. Since signing the Pledge in 2021, there has been no demonstrable government initiative focusing on joined-up methane action at the national level. Malaysia does not have a methane strategy or policy, and sector-specific regulations focusing on methane emissions are either not present, vague, or publicly inaccessible.
2. *There are indications emissions are falling due to positive corporate action*. Effective methane reduction initiatives exist in Malaysia's top two methane-emitting sectors, oil and gas and palm oil, and key players have committed to net zero pathways with methane reductions central to progress to 2030. Emissions should be expected to rapidly fall further if action can be scaled across all industry players.
3. *Quantifying reductions with confidence remains challenging*. Different reporting approaches and incomplete information on assumptions and uncertainties in quantification approaches, make independent analyses of reported emissions challenging. Wider

deployment of measurement-based emission quantification is a key option to improve confidence in progress.

4. *Improvements in corporate Monitoring, Reporting, and Verification (MRV) in the coming years are expected*. While some corporate standards remain confidential, key companies have joined international frameworks featuring transparency and MRV measures like the Oil and Gas Methane Partnership 2.0 and, in a broader climate context, the evolving Science Based Targets initiative. Improved corporate MRV should enable improved national emissions reporting.
5. *Methane reduction is a "low-hanging fruit"*. Methane is a major initial lever to reduce greenhouse gas emissions up to 2030 in the climate plans of leading Malaysian industry players. Action to improve methane-related processes in the key oil and gas and palm oil sectors thus presents a valuable opportunity for Malaysia to contribute to global climate mitigation within its long-term national interests. Therefore, decisive methane action is needed even while plans for further crucial greenhouse gas emission reductions are developed and articulated in more detail.

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By Matthew Ashfold, Helena Varkkey, Yong Jie Wong, Anjulie Razak, Shareen Yawanarajah, Mark Lunt and Emily Oi Yen Tse[1]

1. METHANE AND CLIMATE CHANGE

The concentration of atmospheric greenhouse gases (GHGs) is steadily increasing, with the 2021 levels of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) 49 per cent, 162 per cent and 24 per cent, respectively, above pre-industrial levels.[2] Due to continually rising GHG concentrations, the past eight-year period (2015–22) is likely the warmest on record at around 1.1°C above the pre-industrial temperature. Associated climatic extremes such as heatwaves and flooding[3] are already causing "widespread adverse impacts and related losses and damages to nature and people".[4] Despite ongoing global efforts to address climate

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[2] World Meteorological Organization (2022a).

[3] World Meteorological Organization (2022b).

[4] Intergovernmental Panel on Climate Change (IPCC) (2023).

change, such as the Paris Agreement, which aims to keep global warming well below 2°C, cross-cutting challenges mean GHG emissions are not falling and leave climate change unresolved.[5] Additional strategies are needed to slow the warming induced by GHG emissions.

Among the GHGs, methane is gaining increasing attention as a significant shorter-term driver of warming. Although there is around 200 times less methane than CO_2 in the atmosphere, the global warming potential (GWP) metric[6] indicates each unit of methane causes around 80 times more warming than a unit of CO_2 over twenty years. The increasing methane concentration has made the second-largest contribution to observed global warming, after CO_2.[7] Due to its warming potency and its shorter atmospheric lifetime (about twelve years) than CO_2 (usually assessed as hundreds to thousands of years), rapid reductions in methane emissions have great potential to slow climate change in the coming decades.[8] Unfortunately, methane concentrations are rising at an increasing rate, with a record increment of 18 parts per billion (ppb) in 2021.[9] While the precise reasons for recent records are the subject of ongoing research,[10] methane is known to be emitted from several anthropogenic sectors, including waste (e.g., from wastewater), energy (e.g., from oil and gas (O&G) production) and agriculture.[11] Importantly, owing to methane's role in producing global surface ozone pollution, reductions in methane emissions should also yield air quality improvements and associated health and crop productivity benefits.[12]

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[5] Ibid.

[6] Intergovernmental Panel on Climate Change (IPCC) (2021a).

[7] Intergovernmental Panel on Climate Change (IPCC). (2021b).

[8] Ocko, Sun, Shindell, et al. (2021); United Nations Environment Programme (UNEP) (2022).

[9] World Meteorological Organization (2022a).

[10] Peng, Lin, Thompson, et al. (2022).

[11] Saunois, Stavert, Poulter, et al. (2022).

[12] United Nations Environment Programme (UNEP) (2021a); Intergovernmental Panel on Climate Change (IPCC) (2021b).

Launched by the United States and the European Union in 2021 during the 26th Conference of the Parties (COP26) of the United Nations Framework Convention on Climate Change (UNFCCC), the Global Methane Pledge (GMP) aims to catalyse global anthropogenic methane emission reductions of at least 30 per cent by 2030, relative to 2020 levels. By November 2022, more than 150 countries have joined the pledge.[13] These countries represent approximately 50 per cent of global anthropogenic methane emissions, with some major emitters yet to join. To contribute to the collective goal, participating nations commit to voluntary actions to reduce national methane emissions and to improve the accuracy and transparency of reporting on emissions.[14] In relation to the Paris Agreement, most nations include methane within the scope of GHG emission reduction targets in their Nationally Determined Contributions (NDCs).[15] However, so far only around 10 per cent of NDCs, which largely predate the GMP, contain targets specifically for methane emissions.[16]

Malaysia, an upper-middle-income nation in Southeast Asia, is among the GMP signatories. Notably, its largest methane emitting sectors are reported[17] to be O&G and palm oil, which are among the country's most strategically and economically important sectors. However, the implications for national action of Malaysia signing the GMP remain unclear. In this study, we thus aim to provide a comprehensive and policy-relevant analysis of progress, opportunities and challenges in Malaysia's implementation of the GMP. The GMP recognizes that improving the quality of methane emissions data is central to "ambitious and credible action", so we review both data and literature that was publicly available before 30 June 2023. We (i) evaluate and compare the available methane emission datasets for Malaysia to establish uncertainties and

[13] Volcovici (2022).

[14] Climate and Clean Air Coalition (CCAC) (2023).

[15] US Department of State (2022).

[16] World Resources Institute (WRI) (2022).

[17] Qiu and Wong (2022); Government of Malaysia (2022a).

opportunities for more transparency; and (ii) assess the status of methane emission governance and policy, by government and by industry, with a focus on the crucial O&G and palm oil sectors.

2. DATA AND UNCERTAINTIES ON METHANE EMISSIONS IN MALAYSIA

In this section, we first outline the major approaches to quantifying methane emissions. We then describe various publicly available estimates of Malaysia's methane emissions, considering estimates for the national total and from key sectors. Finally, we compare these available estimates, aiming to identify major areas of uncertainty and opportunities for improved transparency.

2.1 Approaches to Quantifying Methane Emissions

Approaches to quantifying emissions of methane and other gases are often divided into "top-down" and "bottom-up" methods. Both approaches have their strengths and weaknesses, and a combination of approaches is typically required to gain a comprehensive understanding of emissions. Here we outline the differences between the approaches to provide context for subsequent sections.[18]

Bottom-up approaches rely on multiplying an emission factor, the average emission rate for a given source or activity (e.g., emissions per cow), by the amount of that activity (e.g., the number of cows). Emission factors for a specific source can be estimated using measurements at the source scale. Importantly, in the simplest application of this approach, which remains common, "default" emission factors are assumed to be widely suitable for the same-source category in different countries and across many years. However, without local measurements to assess their

[18] For further details, UNEP provides a commentary on quantification approaches within an overview of the status of global methane emissions. Refer to United Nations Environment Programme (UNEP) (2022).

wider applicability, such "default" emission factors may not account for differing country and site-specific contexts that affect local emission rates. Activity data are often obtained from global and national statistical databases and are also subject to uncertainty. Bottom-up approaches underlie many methane emission inventories produced by the scientific community and governments reporting to the UNFCCC,[19] as covered in section 2.2. While subject to uncertainties, they hold significant value in enabling estimates of emissions across countries, and because they are based on emitting processes, can be directly related to emission reduction strategies.

Top-down approaches rely on atmospheric methane measurements, from ground-based, airborne, and remote-sensing platforms, and often require complex atmospheric modelling to estimate emissions using measured information.[20] As such, top-down approaches can only be applied if suitable measurements—which can be costly and technically challenging—and expertise exist. Additionally, while recent scientific advances have been rapid,[21] both measurement technologies and modelling approaches are subject to uncertainties. Within the top-down approaches, some enable longer-term national-scale emission estimates, whereas others—e.g., using observations from aircraft campaigns—provide source and sector-specific estimates at selected times and locations. Continuous measurements can also underpin emission estimates with higher temporal resolution than is typically possible via the bottom-up approach.

As noted above, combining both approaches is necessary to increase confidence in emission quantification and gain a comprehensive

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[19] Intergovernmental Panel on Climate Change (IPCC) (2006); Intergovernmental Panel on Climate Change (IPCC) (2019).

[20] Shen, Zavala-Araiza, Gautam, et al. (2021); Maasakkers, Varon, Elfarsdóttir et al. (2022).

[21] Additionally, there are studies synthesizing information on advances in methane measurement technologies leading to new opportunities to improve top-down quantifications. Refer to Erland, Thorpe, and Gamon (2022); and Jacob, Varon, Cusworth, et al. (2020).

understanding of methane emissions. Emphasis is also increasingly placed on improving methane emission quantification approaches to inform mitigation action.[22] New measurement technologies can assist in developing improved emission factors, more applicable to a local context for the bottom-up approach. Additional measurements can also support the wider use of top-down estimates, providing opportunities to boost transparency through independent verification of emissions reported on a bottom-up basis.[23]

2.2 Methane Emission Datasets

We now review information and data on methane emissions in the Malaysian context, available by 30 June 2023. We collate estimates of national total emissions, the most relevant number when considering Malaysia's overall contribution to the GMP aim, as well as estimates for the key sectors contributing to the national total. Information is obtained from global emission datasets developed by the international scientific community,[24] from the Malaysian government's reports to the UNFCCC, and from disclosures of major companies operating in Malaysia (Table 1). We first summarize key information about these datasets before assessing their consistency and exploring whether differences can be understood.

2.2.1 United Nations Framework Convention on Climate Change

Malaysia's most recent national GHG inventory reports annual emissions from 1990 to 2019 and is contained within the Fourth Biennial Update Report (BUR4) submitted to the UNFCCC in 2022.[25] As is required for reports to the UNFCCC, a bottom-up methodology was followed, using

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[22] United Nations Environment Programme (UNEP). (2022).

[23] Ibid.

[24] For more detailed global-scale reviews, see Saunois, Stavert, Poulter, et al. (2022); and International Energy Agency (IEA). (2022a).

[25] Government of Malaysia. (2022a).

Table 1: Overview of Information Available for Malaysia in Selected Methane Emission Datasets

	UNFCCC[1]	*IEA*[2]	*EDGAR*[3]	*CEDS*[4]	*Petronas*[5]	*SDP*[6]
Spatial information, resolution	No	No	Yes, 0.1° × 0.1°	Yes, 0.5° × 0.5°	No	No
Temporal coverage	1990–2019	2021–2022	1970–2021	1970–2019	2017–22	2020–21
National total reported	Yes	Yes	Yes	Yes	No – corporate report	No – corporate report
O&G sector detail	IPCC category 1B2 and process sub-categories	Multiple sub-categories	IPCC category 1B2	Working sector 1B2 "Fugitive-petr-and-gas"	Yes	No
Wastewater sector detail	IPCC category 4D2 and industry contributions	No	IPCC category 4D	Working sector 5D "Wastewater-handling"	No	Yes

Notes:

1. Government of Malaysia. (2022a). Malaysia Fourth Biennial Update Report Under the United Nations Framework Convention on Climate Change. Retrieved from https://unfccc.int/documents/624776
2. International Energy Agency (IEA). (2022a). Global Methane Tracker 2022. Retrieved from https://iea.blob.core.windows.net/assets/b5f6bb13-76ce-48ea-8fdb-3d4f8b58c838/GlobalMethaneTracker_documentation.pdf
3. Emissions Database for Global Atmospheric Research (EDGAR). (2022). GHG database version 7.0. Retrieved from https://edgar.jrc.ec.europa.eu/emissions_data_and_maps
4. O'Rourke, Patrick. R, Smith, et al. (2021). CEDS v_2021_04_21 Release Emission Data (v_2021_02_05). Zenodo. https://doi.org/10.5281/zenodo.4741285
5. Petronas. (2022a). Petronas Integrated Report 2021. Retrieved from https://www.petronas.com/integrated-report-2021; Petronas. (2023a). Petronas Integrated Report 2022. Retrieved from https://www.petronas.com/integrated-report-2022
6. Sime Darby Plantation (SDP). (2022a). Sustainability Report 2021. Retrieved from https://www.insage.com.my/Upload/Docs/SIMEPLT/SDP%20SR%202021_20220429.pdf#view=Full&pagemode=bookmarks

the IPCC Guidelines for National Greenhouse Gas Inventories (2006). Below, we outline salient information from the BUR4 pertaining to the emission factors and activity data selected for quantifying methane emissions.

IPCC default emission factors (i.e., a "Tier 1" method, subject to larger uncertainties) were applied for most inventory elements, including methane emissions from the O&G sector. These emissions lie within the IPCC category 1B2 for "Fugitive Emissions", defined broadly to include methane emissions from O&G infrastructure through venting (intentional operational release), flaring (incomplete combustion of methane) practices, and unintentional leaks. This broad UNFCCC/IPCC definition differs from other reporting frameworks, where "fugitive" refers to unintentional leaks only. Reported methane emissions from the O&G sector are disaggregated into multiple sub-categories (e.g., 1B2ai, venting from oil production). Overall, the BUR4 indicates the 1B2 category as a major contributor to uncertainty in Malaysia's reported emissions, with large (200 per cent or more; see Table A27b) uncertainties in emission factors.

The BUR4 explains that the estimates of emissions in category 1B2 benefit from newly available data on gas volumes vented and flared during oil production, and flared during natural gas production, provided by Malaysia Petroleum Management (MPM, the national industry regulator) and covering 2012–19. For these three sub-categories, the IPCC's default emission factor is applied (e.g., 0.66 kilotonnes, or kT, methane per million m^3 of vented gas, for sub-category 1B2ai).

Emissions from other 1B2 sub-categories, covering different stages of the value chain, are estimated using energy statistics, such as gas production, and emission factors "at the lower 10 per cent of the default [Tier 1] emission factor range of the developing countries in the 2006 IPCC Guidelines". The use of relatively low emission factors (yielding lower estimated emissions) is justified based on information from Petronas that "fugitive emissions from their operations would be comparable to those of developed countries", though there is no elaboration in the BUR4 on supporting evidence.

For the IPCC's "Industrial Wastewater" category (4D2), the dominant reported contribution (99 per cent) to Malaysia's methane emissions is from Palm Oil Mill Effluent (POME; see section 3.2.2). The BUR4 indicates estimates of POME emissions using an emission factor of 0.225 kilogrammes of methane per kilogramme of Chemical Oxygen Demand (COD), along with conversion factors relating COD to wastewater volume and then to crude palm oil production.[26] These values are derived from published studies conducted within the Malaysian palm oil industry and from the Malaysian Palm Oil Board's (MPOB) production statistics,[27] representing a country-specific (i.e., Tier 2, comparatively less uncertain) approach.

2.2.2 International Energy Agency

The International Energy Agency (IEA) is an intergovernmental organization that provides policy recommendations, analysis and data on the global energy sector. It estimates national methane emissions from the supply or use of fossil fuel energy, including oil, gas and coal, available in their Global Methane Tracker (GMT).[28] The IEA also quantifies national total emissions by incorporating estimates for non-energy sectors from other datasets.

For O&G sector operations, emissions are disaggregated by fuel (oil or gas), segment (upstream or downstream), production type (e.g., onshore, offshore) and emission process (e.g., venting, incomplete flaring, and a separate "fugitive" category for unintentional leaks). These categories do not align exactly with Malaysia's UNFCCC inventory. In the IEA's bottom-up methodology, emission factors developed for the United States are re-scaled for other countries based on auxiliary data on national governance and industry-related indicators (e.g., age of infrastructure). For Malaysia, the IEA's scaling factors range from 0.6 (downstream categories) to 1.2 (upstream oil categories). The country-scaled emission factors are then applied to national production and

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[26] Ibid.

[27] Loh, Mei, Ngatiman, et al. (2013); Malaysian Palm Oil Board (MPOB) (2022).

[28] International Energy Agency (IEA) (2023a); International Energy Agency (IEA) (2022a).

consumption (i.e., activity) data. We report a "Total O&G" methane emission, which excludes a small emission of 2 kT from a coal category.

The latest version of the GMT dataset contains emissions for 2022. However, we focus on the previous version of 2021 emissions[29] to enable comparison with other available datasets and because there is little change (3 kT, or <1 per cent, for "Total O&G") in the estimates for Malaysia.

While the IEA emission estimates also aim to consider top-down information on larger methane sources detected by satellite, such information is not yet reliably available in tropical regions such as Malaysia, where retrievals are more challenging.

2.2.3 Emission Database for Global Atmospheric Research

The Emission Database for Global Atmospheric Research (EDGAR) has been developed and maintained by the Joint Research Centre of the European Commission since the 1990s. EDGAR contains anthropogenic GHG emissions data, including methane and other air pollutants.[30] It provides global coverage, national-level and sector-specific emissions, and is used widely by the scientific community. We use the latest version 7.0, which quantifies emissions up to 2021.[31]

EDGAR uses a bottom-up methodology aligned with the IPCC emission categories, though not to the level of disaggregation found in Malaysia's UNFCCC inventory. For example, in addition to a national total, data for the overall 1B2 and 4D (wastewater) categories for methane emissions in Malaysia are available and reported here. To provide global consistency, EDGAR uses standardized emission factors, which are unlikely to reflect the diversity of country and site-specific variations in emissions, and thus subject to significant uncertainties (approximately ±100 per cent, for both categories 1B2 and 4D).[32] For

[29] Ibid.

[30] See Janssens-Maenhout, Crippa, Guizzardi, et al. (2019).

[31] Emissions Database for Global Atmospheric Research (EDGAR) (2022).

[32] Solazzo, Crippa, Guizzardi, et al. (2021).

activity data, uncertainties in statistics for the O&G sector in developing countries are expected to be smaller (approximately 20 per cent).[33] The spatial allocation of emissions in EDGAR grid maps also depends on proxy activity data (e.g., light detected at night by satellites for flaring activity) rather than direct measurements of the emitted pollutant. Overall, a "very low" confidence is reported for the EDGAR estimate of Malaysia's methane emissions in category 1B2, corresponding to an uncertainty of >100 per cent.[34]

2.2.4 Community Emissions Data System

Like EDGAR, the Community Emissions Data System (CEDS) is a global database of GHG and air pollutant emissions, including methane.[35] Similarly, CEDS provides global coverage, national-level and sector-specific emissions, and grid maps of spatially allocated emissions. Malaysia's CEDS methane emission estimates are constructed using data from "primary" emission datasets such as EDGAR,[36] Regional Emission Inventory in Asia (REAS) version 2,[37] and flaring emissions data.[38]

CEDS emissions are reported in working sectors comparable to the EDGAR categories. These include 1B2 "Fugitive-petr-and-gas" and 5D "Wastewater-handling" (assumed equivalent to the IPCC's 4D). We use CEDS v_2021_04_21, which provides emission values up to 2019.[39] Given the connections between EDGAR and CEDS, uncertainties for CEDS methane emissions in Malaysia are likely similar to those for EDGAR, though we are unaware of any formal quantification.

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[33] Ibid.

[34] Solazzo, Crippa, Guizzardi, et al. (2021).

[35] Hoesly, Smith, Feng, et al. (2018); Common Education Data Standards (CEDS) (2022).

[36] Andrew (2020).

[37] Kurokawa, Ohara, Morikawa, et al. (2013).

[38] Klimont, Kupiainen, Heyes, et al. (2017).

[39] O'Rourke, Smith, et al. (2021).

2.2.5 Petronas

In addition to nations, various entities, including companies, publicly report their GHG emissions. Accordingly, we also analyse emissions data reported by two prominent Malaysian companies in key sectors linked to Malaysia's methane emissions. Here we focus on methane emissions data, with more information on the broader climate strategies of these companies provided in section 3, focused on policy.

Petronas, Malaysia's national O&G company, reports GHG emission data in various public documents, including its disclosure to the Methane Guiding Principles (MGP) initiative, its Integrated Reports, and a booklet on its Pathway to Net Zero Carbon Emissions 2050.[40] Our overall analysis of these documents largely reflects information published in 2022, though we add further information from the Integrated Report 2022, which was published in June 2023.

In the 2022 Integrated Report, GHG emissions are reported using multiple metrics, with disaggregation by Scopes,[41] specific greenhouse gases, and specific Scope 1 sources. Emissions are also disaggregated by business segments and between Malaysian and International sources. The interactions among the disaggregated categories (e.g., methane emissions, from venting sources, within Malaysia) are not available, meaning we are unaware of a definitive statement of Petronas' methane emissions within Malaysia only, that would be most comparable with the other datasets considered. In Table 2, we report Petronas' total methane emissions, presumably including small contributions from operations outside Malaysia, with values for 2019 and 2021 from the 2022 Integrated Report and the value for 2017 calculated from the information in the 2021 Integrated Report.

Detailed methodological information (e.g., specific emission factors) is not available. However, the various international principles, frameworks and standards that inform Petronas' approaches to GHG

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[40] Petronas (2022a, 2022b, 2022c, 2023a).

[41] An introductory note on the meaning of Scopes 1, 2 and 3 is provided from Greenhouse Gas Protocol (2022).

emission quantification are described in the Integrated Report 2022. Emission quantification methodologies are also described in the MGP disclosure, largely under Principle 3: Improve accuracy of methane emissions data. This section reports "improvement of emissions factors" based on selected site-level measurements, plus "plans to pilot satellite technologies to measure methane emissions from onshore facilities and plans to compare the accuracy against ground measurements". An internal standard to govern Petronas' practice on methane emissions quantification and reporting is mentioned, which is elsewhere in the document reported as "aligned to the Oil and Gas Methane Partnership (OGMP) 2.0 Framework". This MGP disclosure predates the announcement in November 2022 of Petronas joining OGMP 2.0 (discussed further in section 3.2.1).

2.2.6 Sime Darby Plantation

Sime Darby Plantation (SDP) is the world's largest listed palm oil company based on plantation area and fresh fruit bunch production. SDP also reports GHG emission data in publicly available documents, including its Sustainability Report 2021[42] and corporate presentations uploaded to web pages describing SDP's Net Zero emissions commitment.[43] As with Petronas, there is no exact statement of SDP's methane emissions in Malaysia. The Sustainability Report provides total emissions reported for Scopes 1 and 2 in CO_2-equivalent units, along with the breakdown among countries in which SDP operates, including Malaysia and Indonesia, and a breakdown by source type, including "methane emissions from treating effluent mainly from mill processes".

Overall, these methane emissions are reported as contributing 1,853 kT CO_2e, or 66 per cent of SDP's total Scope 1 and 2 emissions in 2021. There does not appear to be a specific statement on methane emission mass, so with the Sustainability Report stating adherence to recognized international standards, we assume the use of a GWP value

[42] Sime Darby Plantation (SDP) (2022a).

[43] Sime Darby Plantation (SDP) (2023).

for methane from an IPCC assessment report based on a 100-year timeframe. Accordingly, the methane emissions value in Table 2 assumes GWP_{CH4} = 25 and includes emissions from outside Malaysia.

Since publishing its latest Sustainability Report, SDP has announced a revision of emissions data, adding Scope 3 emissions. This update is linked to the announcement of a Net Zero emissions commitment and the associated submission of emission reduction targets to the Science Based Targets initiative (SBTi). This does not appear to have had any material effect on reported methane emissions in Scopes 1 and 2.[44]

2.3 Comparison of Methane Emission Estimates for Malaysia

We have developed Table 2 to contribute an up-to-date and detailed comparison of estimated methane emissions in Malaysia as a national total and for the two major sectors of interest. We focus on three specific years, 2017 (the earliest year in Petronas' reporting), 2019 (the latest year in Malaysia's UNFCCC inventory and the baseline year for Petronas' near-term methane reduction targets), and 2021 (the most recent available year in several other datasets). In Figure 1, we present similar information, for selected datasets, over a longer period.

Table 2 shows that Malaysia's national total methane emission is estimated to be slightly above 2,000 kT in 2019 in each of the three available datasets: UNFCCC, EDGAR, and CEDS.[45] For the O&G sector, the 2019 estimates in these three datasets vary from 714 kT (or 35 per cent of the total) in UNFCCC to 886 kT (39 per cent) in CEDS

[44] Ibid.

[45] As stated previously, most international standards describe methane's GWP within a 100-year period (GWP 100) at 25 instead of 84–87 within a 20-year timeframe (GWP 20). The standard use of GWP 100 values may underplay the short-term impact on warming of reported methane emissions. For example, the contribution of methane to Malaysia's total emissions reported to the UNFCCC using GWP 100 is about 15 per cent, while if recalculated using GWP 20 it will be more than a third.

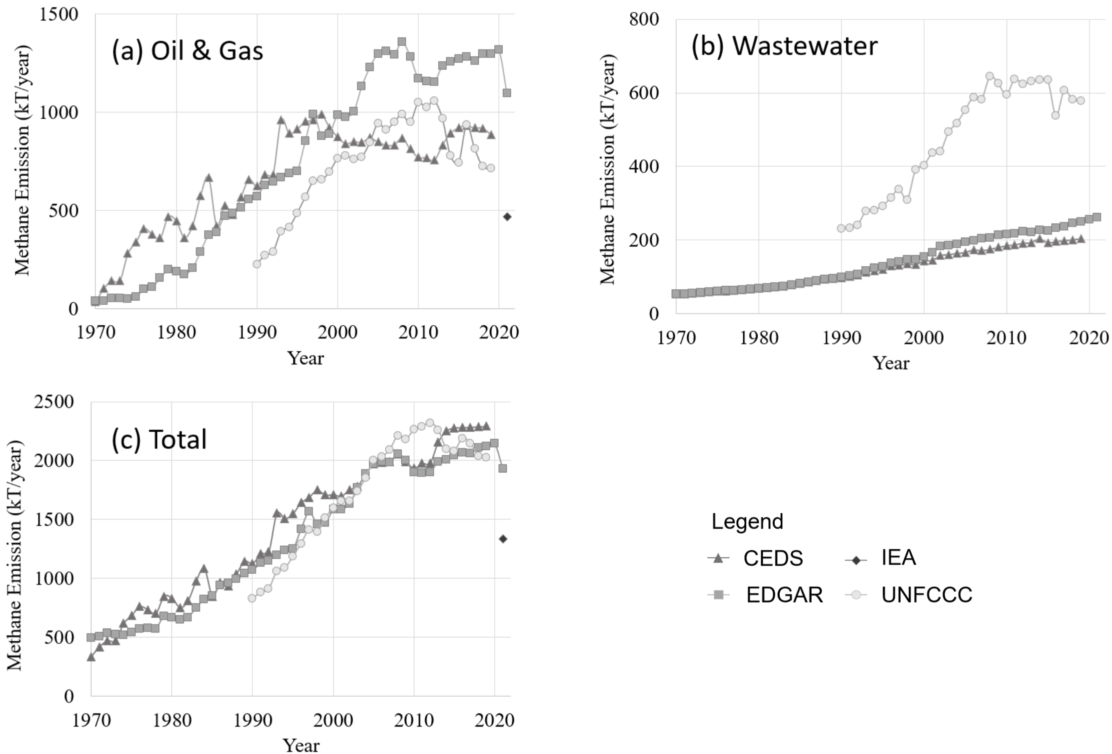
Table 2: Summary of Methane Emission Estimates for Malaysia for 2017, 2019, and 2021

Source	*Detail*	*2017*	*2019*	*2021*
		kT CH_4	*kT CH_4*	*kT CH_4*
Total				
UNFCCC		2,145	2,029	—
EDGAR		2,061	2,120	1,934
CEDS		2,285	2,294	—
IEA		—	—	1,333
O&G				
UNFCCC	IPCC Category 1B2	814	714	—
EDGAR	IPCC Category 1B2	1,261	1,296	1,096
CEDS	Working sector 1B2 – Fugitive-petr-and-gas	920	886	—
IEA	"Total O&G"	—	—	466
Petronas[1]	Scope 1 and 2 operations	606	414	232
Wastewater				
UNFCCC	IPCC Category 4D2 (99% POME)	607	579	—
EDGAR	IPCC Category 4D	237	251	262
CEDS	Working Sector 5D – Wastewater-handling	199	204	—
SDP[2]	Effluent, assumes GWP_{CH4} = 25	—	—	74

Notes:

1. Petronas reports for the organization rather than Malaysia, including 7 per cent of total GHG emissions in 2022 occurring in other countries. Within Malaysia, we have not found public information on the exact contribution of individual operators to the national production of O&G.
2. SDP reports for the organization rather than Malaysia, including emissions occurring in other countries such as Indonesia and Papua New Guinea.

Figure 1: Malaysia's Methane Emissions for (a) O&G, (b) Wastewater, and (c) Total



and 1,296 kT (61 per cent) in EDGAR. For the wastewater sector, there is a significant difference between the 2019 estimate in UNFCCC of 579 kT (29 per cent) and the estimates of EDGAR (251 kT, 12 per cent) and CEDS (204 kT, 9 per cent). This is despite the EDGAR and CEDS values representing a broader category (4D) that includes both industrial and domestic wastewater emissions. Together, this comparison of 2019 estimates demonstrates substantial differences, for both key emitting sectors, between the UNFCCC inventory, and the EDGAR and CEDS scientific datasets (which are not entirely independent of one another). These differences indicate the large uncertainties in these approaches using predominantly Tier 1 emission factors. Nevertheless, the substantial differences between the two sectors act in opposite directions, resulting in similar national total estimates in all three datasets.

2.3.1 Comparisons of Sector-Specific Estimates

Across the recent years (2017–21) considered in Table 2, there are declines in estimated methane emissions from Malaysia's O&G sector. There is a modest reduction in the UNFCCC inventory, from 814 kT in 2017 to 714 kT in 2019, and the IEA estimate for the O&G sector in 2021 is even lower at 466 kT. The reduction is most striking for Petronas, with operational methane emissions, predominantly within Malaysia, reported as declining from 606 kT in 2017 to 232 kT in 2021, with substantial venting reductions highlighted as a key lever.[46] Section 3 provides further discussion on these reductions.

Emission estimates are also available for sub-categories of the O&G sector in the UNFCCC inventory and the IEA dataset. While the sub-categories are not identical, comparisons can be made and do reveal inconsistencies. By comparing the most recent UNFCCC data (for 2019) with the nearest available IEA data for 2021, we first note that in the UNFCCC inventory, 60 per cent of emissions are from oil categories and 40 per cent from gas, whereas the contributions are close to the opposite in the IEA dataset (40 per cent oil, 55 per cent gas, 5 per cent

[46] Petronas (2022b).

undifferentiated). Further, venting from oil makes the largest contribution (57 per cent) to methane emissions in the UNFCCC inventory, whereas no emissions are reported for venting from gas (sub-category listed as "Not applicable"). In contrast, venting from oil and venting from gas each contributes 27 per cent to the IEA estimate.[47]

For the wastewater sector estimates including POME, no major trends are apparent between 2017 and 2021. The much lower emission from wastewater reported in the EDGAR and CEDS datasets may be due to the use of generic Tier 1 emission factors, potentially underestimating emissions from POME, a high-emitting wastewater source. Corporate emissions reported by SDP in 2021 are significantly lower than the national estimates in the other estimates. One lens for understanding this difference is that there are fewer methane-emitting palm oil mills operated by SDP in Malaysia and other countries (~70)[48] than the overall number of mills in Malaysia (~450).[49] Most mills, both operated by SDP and nationwide in Malaysia, do not yet have facilities for capturing methane, though, in section 3, we discuss progress in this area.

[47] To illustrate the complexity in understanding such inconsistencies, consider venting from oil production. In the UNFCCC inventory sub-category 1B2ai (venting from oil production) contributes emissions of 404 kT. This is calculated by multiplying two values listed in the BUR4: the vented gas volume provided by MPM, 612 million m^3, and the IPCC's default emission factor of 0.66 kT per million m^3. In the IEA's GMT the "offshore oil, vented" sub-category contributes emissions of 130 kT. The relevant emission factor for Malaysia is 0.468 per cent (default 0.39 per cent scaled by a factor of 1.2), in units of mass of methane per mass of oil produced. The activity data, annual oil production, is not provided directly in the GMT, but can be inferred as 27.8 million tonnes. This comparison demonstrates there are differences between the datasets in sub-category definitions, in both the type and availability of activity data, and in the emission factor units. There is additionally a difference in the reporting years. Finally, as noted elsewhere, beyond reporting complexities there are large technical uncertainties in the emission factors.

[48] Sime Darby Plantation (SDP) (2023).

[49] Malaysian Palm Oil Board (MPOB) (2023).

2.3.2 Importance of Transparency in Quantifying Methane Emissions

As evidenced above, the available datasets are challenging to compare, with methodologies not fully documented or transparent, with differences in reporting boundaries (e.g., national versus corporate) and emission categories. All datasets considered rely on a bottom-up approach to quantifying emissions. The UNFCCC, EDGAR, and CEDS datasets rely predominantly on default emission factors which are highly uncertain and unlikely to reflect actual site-specific variations in Malaysia. These approaches are generally consistent with Tier 1 in the IPCC guidelines (IPCC, 2006),[50] representing a lower level of methodological complexity. As noted above, in Malaysia's UNFCCC inventory, some O&G emission categories are estimated using emissions factors selected from the lower end of the default IPCC ranges based on country-specific guidance from Petronas. However, the basis for this judgement is unclear in the BUR4. It is also unclear whether the approach is suitable for the wider O&G sector in Malaysia, including other operating companies.

The IEA GMT approach involves the development of country-specific emission factors, though with only limited transparency in the methodology and without the use of local methane measurements. In a slightly more complex approach, Malaysia's UNFCCC inventory reports POME emissions using emission factors developed from country-specific measurements (i.e., Tier 2), and Petronas reports "[improving] emissions factors" based on site-level measurements. Generally, Malaysia's BUR4 notes that "a National GHG Inventory Improvement Plan for emission factors had been launched in 2021 under the 12th Malaysia Plan (2021–2025)". More widespread use of site-specific emission calculations for key emitters would be characteristic of the IPCC's (highest) Tier 3.

Internationally, various agreements and frameworks support, and increasingly require, enhanced transparency in monitoring, reporting and verification (MRV) of methane emissions. For example, the Enhanced

[50] Intergovernmental Panel on Climate Change (IPCC) (2006).

Transparency Framework of the Paris Agreement includes new reporting and review requirements for developing countries like Malaysia, notably through a Biennial Transparency Report (BTR) containing a GHG emissions inventory and reporting on progress towards NDCs. Signatory countries to the GMP commit to

> moving towards using the highest tier IPCC good practice inventory methodologies, consistent with IPCC guidance, with particular focus on high emission sources, in order to quantify methane emissions; as well as working individually and cooperatively to continuously improve the accuracy, transparency, consistency, comparability, and completeness of national greenhouse gas inventory reporting under the UNFCCC and Paris Agreement, and to provide greater transparency in key sectors.

There is currently little top-down information related to methane emissions in Malaysia.[51] Such information could enable verification of the varying bottom-up emission estimates and provide more granularity in both spatial (e.g., facility level) and temporal (e.g., daily) dimensions. For instance, a top-down approach involving satellite observations indicated methane emissions from the O&G sector in Mexico are double the reported bottom-up estimate in the national GHG inventory.[52] Additional global top-down studies highlight the importance of intermittent "super-emitter" events that are unaccounted for in bottom-up estimates, which assume constant emissions over the assessment period.[53]

Global studies employing the top-down approach indicate that satellite and ground-based methane observations currently provide limited information for Malaysia, compared to many other countries.[54] A

[51] For example, no studies from Malaysia are reported in this recent review: Yang, Kuru, Zhang, et al. (2023).

[52] Shen, Zavala-Araiza, Gautam, et al. (2021).

[53] Lauvaux, Giron, Mazzolini, et al.

[54] Scarpelli, Jacob, Grossman, et al. (2022); Worden et al. (2022).

recent study used satellite observations to develop national-level methane emission estimates that can inform the Global Stocktake of the Paris Agreement, and also highlighted the scientific challenges in reconciling top-down and reported bottom-up emission estimates.[55] More local top-down research relevant to Malaysia is scarce, with one study reporting ship-based methane measurements close to offshore O&G infrastructure in the South China Sea, and identifying emissions in locations not featured in the bottom-up EDGAR inventory, though with substantial (>±100 per cent) reported uncertainties in emission amounts.[56]

Overall, the differences in the existing sectoral emission estimates indicate an opportunity to greatly improve confidence in Malaysia's methane emission quantification. This will require more detailed bottom-up approaches and significantly more measurements that can support top-down approaches. Increased transparency in reporting emissions and the associated methodologies would also improve understanding of the identified differences among datasets. While the existing emission estimates hint at a trajectory (e.g., recent reductions in methane emissions in Malaysia's O&G sector), improved quantification approaches will be needed to track progress towards both organizational and national targets, to assess consistency between corporate and national methodologies, and to demonstrate with confidence the effectiveness of actions taken to reduce methane emissions.

3. STATUS OF METHANE EMISSION POLICY AND GOVERNANCE IN MALAYSIA

This section assesses the status of methane emission management and policy by the Malaysian government and industry players by contextualizing the Malaysian climate policy and governance framework within the GMP commitments. It then compares the methane emission governance progress of the Malaysian O&G and palm oil sectors and

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[55] Ibid.

[56] Nara, Tanimoto, Tohjima, et al. (2014).

explores opportunities for cross-sector learning. Figure 2 illustrates the relationships between global and national governance structures and intra-country governance hierarchies. Note that while climate governance is housed under the Ministry of Natural Resources, Environment, and Climate Change (MNRECC), the two key methane-emitting sectors are governed under separate ministerial arrangements.

3.1 Aligning National Governance to the Global Methane Pledge

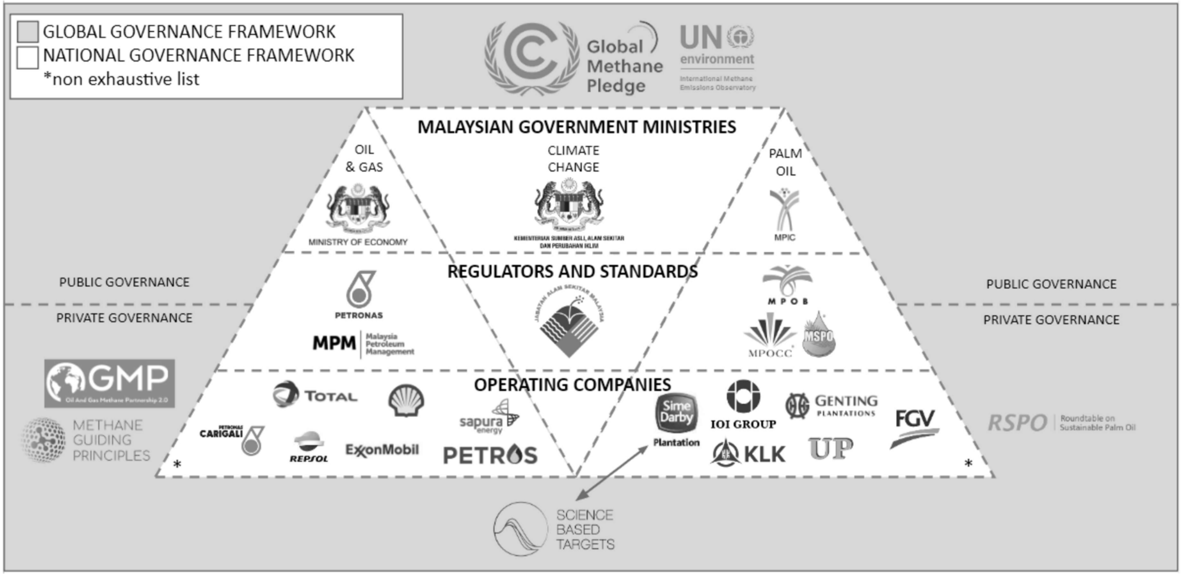
Overall, the GMP's global direction within the context of the Paris Agreement goals requires substantial, immediate action on methane emissions by all. The GMP calls for signatories to "take comprehensive domestic actions to achieve that target, focusing on standards to achieve all feasible reductions in the energy and waste sectors and seeking abatement of agricultural emissions". In this vein, several GMP signatories, including developing countries, have released specific policies or action plans to tackle methane. These include Vietnam's Action Plan for Methane Emission Reduction by 2030, Brazil's National Programme for the Reduction of Methane Emissions – Zero Methane, and Mexico's General Law of Climate Change, which prioritizes eliminating or reducing fugitive methane emissions.[57]

As a fellow developing country GMP signatory, Malaysia would also be expected to commit to comprehensive domestic actions on methane emissions. To the authors' knowledge, Malaysia has no laws governing methane emissions or reporting. Malaysia's guiding policy document for climate change is the National Policy on Climate Change (NPCC), published in 2009. This policy identifies methane as a major cause of climate change, alongside CO_2 and N_2O. However, specific policies on methane reduction are absent.[58] This fourteen-year-old document may not reflect new knowledge in the fast-evolving field of climate science, but it is currently under review.

[57] International Energy Agency (IEA) (2022b).

[58] Government of Malaysia (2019).

Figure 2: Schematic of the Global and National Governance Framework Related to Methane Emissions in Malaysia



Whilst important, policies may change depending on the administration. Malaysia does not yet have a Climate Change Act (CCA) institutionalized and regulated within its legal system to ensure continuity. A draft of the CCA was announced in 2018,[59] yet following several administration changes, the tabling of the Act may still be three years away.[60] Environmental civil society organizations highlighted a lack of transparency around the drafting process and requested specific reasons for the delay.[61] The GMP signatories should "commit to maintaining up-to-date, transparent, and publicly available information on our policies and commitments". The limited transparency surrounding the NPCC review and CCA draft makes it difficult to determine if Malaysia is making substantial adjustments to its climate governance framework in response to recent developments like signing the GMP.

The GMP signatories also "commit to support existing international methane emission reduction initiatives … to advance technical and policy work that will serve to underpin Participants' domestic actions". Initiatives such as the Climate and Clean Air Coalition (CCAC) mentioned in the GMP often highlight the air quality and health benefits arising from methane emission reductions, adding supplementary benefits to climate action. While methane does not directly damage human health,[62] sources of methane are usually also sources of health-damaging air pollutants such as particulate matter.[63] Anthropogenic methane emissions also contribute to the formation of tropospheric ozone, a harmful air pollutant, causing around 500,000 premature deaths worldwide annually.[64] In principle, methane action is therefore relevant to agencies focused on air quality, such as the Department of Environment within the NRECC in Malaysia. However, at this point, we are not aware of governance integration aimed

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[59] Sim (2018).

[60] Soo (2023).

[61] Ibid.

[62] Mar, Unger, Walderdorff, and Butler (2022).

[63] Michanowicz, Lebel, Domen, et al. (2021).

[64] United Nations Environment Programme (UNEP) (2021a).

at realizing climate and air quality co-benefits coherently.[65] Currently, the National Malaysian Ambient Air Quality Standards (and the measured average concentrations of key pollutants) remain above the universal Air Quality Guidelines recommended by the World Health Organization,[66] and methane is not explicitly considered in the Environmental Quality (Clean Air) Regulations 2014.

The GMP signatories "resolve to review progress towards the target of the GMP on an annual basis until 2030 by means of a dedicated ministerial meeting". We are unaware of any specific government initiative aligned with the GMP to focus on and track joined-up methane action. As noted above, methane is included in Malaysia's NDC. However, the NDC refers to overall GHGs, and the targeted 45 per cent intensity reduction is probably insufficiently challenging to compel stringent methane action. Some existing methane reductions are mentioned as mitigation measures implemented in the BUR4, as detailed elsewhere. One forward-looking perspective is provided in Malaysia's third National Communication (NC3) to the UNFCCC, submitted in 2018,[67] with GHG emissions between 2020 and 2030 projected in three scenarios: "Business as usual", "Planning", and "Ambitious". Even the "Ambitious" scenario envisaged in 2018 does not include methane emission reductions, with O&G sector emissions unchanging between 2020 and 2030, and at a level higher than emissions subsequently reported, for 2019, in BUR4. Similarly, for the industrial wastewater sector, the "Ambitious" scenario projects a slow increase in methane emissions from 2020 to 2030, at a higher level than emissions reported for 2019.

There are, however, upcoming opportunities for the government to update forward-looking information relevant to contributing to the GMP. Multiple reporting documents to the UNFCCC are due soon: the Long-Term Low Emission Development Strategy (LT-LEDS) (2023), the NDC Roadmap (2023), the National Communication 4 (NC4) (2023), and

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[65] See, for instance, the USA's Clean Air Act from the Environmental Protection Agency (2022).

[66] Centre for Research on Energy and Clean Air (CREA) (2022).

[67] Government of Malaysia (2018).

the first BTR (2024). The Roadmap document should provide a more detailed pathway for actions to achieve Malaysia's NDC emissions intensity target. The NC4 would be expected to include projections more consistent with the GMP. However, these would not necessarily constitute firm targets for methane emission reductions. With the NPCC and Environmental Quality Act (EQA) 1974 currently under review, aligning these documents with the GMP and these various reporting documents would enable Malaysia to reaffirm its commitments to the GMP and UNFCCC while the CCA continues to be refined.

3.2 Emissions Governance in Key Methane-Emitting Sectors

The O&G and palm oil (wastewater) sectors are expected to be Malaysia's major methane-emitting sectors and, at the same time, are key economic sectors to Malaysia. The O&G sector contributes around 8 per cent to the Malaysian economy,[68] while the palm oil sector contributes around 3 per cent.[69] In addition, these sectors are politically important. Petronas is wholly owned by the Malaysian government and accounts for more than 15 per cent of government revenue.[70] Malaysia is the world's second-largest palm oil producer, and the crop continues to function as an engine of rural development and poverty alleviation.[71] Hence, the sustainable development of both sectors in the face of climate change is of exceptional importance to Malaysia.

3.2.1 Methane in the Malaysian O&G Sector

Action on methane in the O&G sector is fundamental to achieving the GMP goal and related climate mitigation efforts. For example, the IEA's Net Zero Emissions by 2050 Scenario states:

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[68] Statista (2023a).

[69] Statista (2023b).

[70] Fitch Ratings (2021).

[71] Varkkey and O'Reilly (2019).

> methane emissions from fossil fuel operations fall by around 75 per cent by 2030. This results mostly from the rapid deployment of emission-reduction measures and technologies, including a stop to all non-emergency flaring and venting and universal adoption of monthly or continuous leak detection and repair programmes.[72]

Understanding the governance structure of Malaysia's O&G sector is crucial in evaluating the feasibility of this scenario for the country. Flaring and venting, the two main operational practices (with "fugitive emissions" being unintended leaks) contributing to methane emissions in this sector, are not publicly regulated in any national jurisdictions in Malaysia but are governed by commitments of the national O&G company, Petronas.[73]

In Malaysia, Petronas is the hydrocarbon resource owner for the whole country.[74] Section 2 of the Petroleum Development Act 1974 gives ownership and exclusive exploration and development rights over all O&G in the country to Petronas under the direction of the Prime Minister. Other investors may participate in exploration and production activities in Malaysia by applying to Petronas for a Production Sharing Contract (PSC). These investors are known as Petroleum Agreement Contractors (PACs). There are currently thirty-eight PACs, including large foreign O&G companies like Shell and ExxonMobil. The MPM within Petronas oversees all PACs and is responsible for all Malaysian upstream regulations (self-described as a "regulator with a commercial mindset"), including aspects of environment and sustainability.[75] MPM

[72] International Energy Agency (IEA) (2023b).

[73] The World Bank (2022).

[74] Petros gained full ownership to supply, sell, and distribute domestic natural gas through the Miri and Bintulu pipeline effective January 2020. However, O&G production in Sarawak is still under PSC. See Lim How Pim (2022).

[75] Another agency, the Malaysian Petroleum Resources Corporation (MPRC) under the Ministry of the Environment, oversees Oil and Gas Services and Equipment (OGSE, or "PAC minus one") companies, of which 85 per cent are SMEs. MPRC is currently developing a Sustainability Roadmap to support OGSE companies to meet higher sustainability requirements in the sector over time.

also advises the Malaysian government on O&G matters, regulations, and incentives for upstream investment.[76]

The MPM regulates PACs with the guidance of the Petronas Procedures and Guidelines for Upstream Activities (PPGUA). Through the PPGUA, MPM sets annual flaring and venting limits, authorizes flaring and venting activities with adequate justification, and receives monthly reports of flaring and venting volumes from PACs.[77] The PPGUA is a corporate guideline and not, however, a formal national regulation. Petronas and MPM are also guided by minimum environmental standards, but these standards are not publicly available. Similarly, Petronas' Integrated Report 2022 explains that MPM rolled out "requirements on methane emissions measurements, quantifications, and reporting by all upstream operators that are operating in Malaysia", but these do not seem publicly available. It is also unclear if Petronas' operations are regulated at the same standards as PACs. For example, a report by the World Bank indicates that standards related to gas venting and flaring are detailed in confidential documents related to production and operations procedures and guidelines, PACs licensing arrangements, and risk service contracts.[78] Therefore, it is difficult to assess expectations to limit methane-emitting venting and flaring across the Malaysian O&G sector.

Petronas has, however, announced its Pathway to Net Zero in November 2022.[79,80] The pathway includes several targets for the period up to 2030, though less detail for the further period to 2050 when net zero is to be achieved. The targets (see Figure 3) include Scopes 1 and 2 GHG reductions and more specific methane emission reductions. The baseline year is set as 2019, with Petronas subsequently confirming in the 2022 Integrated Report that the baseline reference for the 2030 GHG emissions target is 54.9 Megatonnes (Mt) of CO_2e using an equity share

[76] Petronas (2023b).

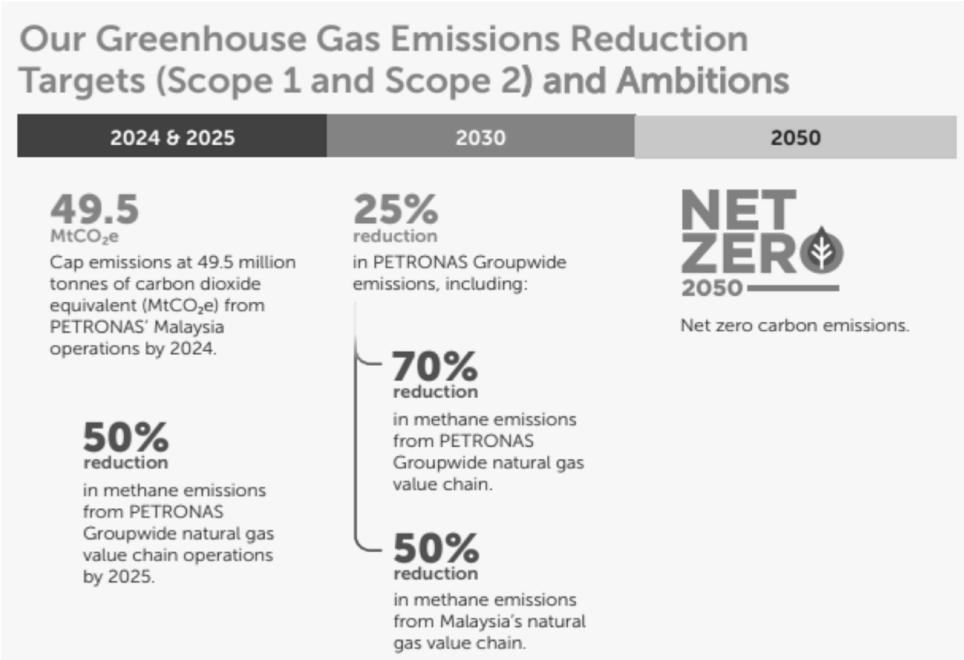
[77] World Bank. (2022).

[78] Ibid.

[79] Petronas (2022c).

[80] Petronas (2022d).

Figure 3: Petronas Pathway to Net Zero Targets (from Petronas 2022c)



approach. The 2022 Integrated Report also provides emissions data for the "Petronas Groupwide Natural Gas Value Chain" metric used in methane-specific targets. The 2019 baseline is 399 kT (96 per cent of the total in Table 2), with emissions reported as almost halving to 200 kT in 2022, essentially in line with the 2025 methane target.

The information provided also allows some assessment of interactions among the targets. For example, meeting the "70 per cent by 2030" methane target would contribute around half (7.0 of 13.7 MtCO2e) of the necessary reductions to meet the "25 per cent by 2030" Scope 1 and 2 GHG target, underscoring the importance of methane to near-term progress. However, without providing a baseline 2019 emission for Malaysia's natural gas value chain, it is hard to fully assess the requirements of other operators to meet the nationwide "50 per cent by 2030" methane target.

Tracking such commitments necessitates transparent MRV, and additional relevant transparency measures are emerging. The OGMP 2.0 and the MGP initiative provide standardized frameworks for O&G companies to report publicly on methane action, and for detailing improvements in emission quantification approaches. More broadly, there is increasing scrutiny of corporate net zero pledges and targets. New guidance emerging from the United Nations (UN) emphasizes a principle of "radical transparency in sharing relevant, non-competitive, comparable data on plans and progress", along with expectations for immediate action consistent with longer-term net zero pledges.[81]

Petronas emphasizes the value of transparency to meet the needs of stakeholders, including investors and consumers, in their Net Zero Pathway: "we believe transparency of our strategy, performance, emissions profile and how we engage in policy and standards development is critical in earning trust with stakeholders ...."[82] Petronas is currently a signatory member of both the OGMP 2.0 and the MGP. Petronas is expected to report under the OGMP 2.0 for the first time

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[81] United Nations (2022).

[82] Petronas (2022c).

later in 2023, with the framework requiring reporting to include both operated and non-operated joint ventures at the local and international scale.[83] Petronas already reports publicly against five MGP principles (continually reduce methane emissions, advance strong performance across the gas supply chain, improve the accuracy of methane emissions data, advocate sound policy and regulations on methane emissions, and increase transparency).[84] Petronas has also endorsed the World Bank Zero Routine Flaring by 2030 initiative and the recommendations of the Taskforce on Climate-Related Financial Disclosure (TCFD), with initial disclosures expected in 2023.[85]

Petronas' key position as the national O&G company and regulator for all other sector investors in Malaysia can facilitate progress with the country's GMP commitments. Currently, in Malaysia's BUR4, venting and flaring gas volume data are provided by Petronas MPM, presumably representing a nationwide figure across all operators. However, mitigation via reduced venting and flaring is presented in BUR4 for Petronas, rather than the national O&G sector overall, and in units of CO_2 equivalents, without a specific value for methane. Looking forward, and linking to the discussion in section 2.3.2, the BUR4 Improvement Plan mentions efforts to improve "the completeness of activity data and emission factors for fugitive emissions from the oil and gas sector". These efforts seem aligned with Petronas' commitments to the OGMP 2.0, MGP, and the World Bank initiative. Taken together with potential independent top-down measurement studies, Petronas' MRV data covering both operations and the entire sector, and by extension Malaysia's data feeding into the future UNFCCC submissions, there is much potential to better reflect the reality of year-by-year progress in the O&G sector in Malaysia.

However, the current structure of the Malaysian O&G sector may limit the application of other tried and tested approaches for lowering methane emissions from O&G. For example, several countries have

[83] Mineral Methane Initiative (2023).

[84] Petronas (2022b).

[85] Petronas (2023c).

successfully included leak detection and repair requirements, technology standards, and bans on non-emergency flaring and venting in their national regulations.[86] Going further, the Environmental Defense Fund, in its submission to the Global Stocktake of Paris Agreement, proposed a set of policy options for producer countries anchored on a price per unit of methane emissions, implemented as either a methane fee, an emission trading system, or a methane performance standard.[87] These policy options require independent quantification and reporting mechanisms to verify compliance. In the Malaysian context, such independent verification may be challenging, as Petronas is both the largest producer and regulator of the sector. Despite Petronas taking steps towards transparency to align its efforts with Malaysia's GMP, confidentiality clauses continue to govern PSCs, potentially limiting the transparency of the wider Malaysian O&G sector. In the context of demonstrating methane reduction, it is hoped that Petronas' recent commitments to transparency will also encompass its regulatory arm, MPM.

3.2.2 Methane in the Malaysian Palm Oil Sector

Around 85 per cent of global palm oil production is concentrated in Indonesia and Malaysia. Understandably, there is less worldwide interest in methane emissions from wastewater in the palm oil sector. However, that sector makes the second largest contribution (28 per cent) to Malaysia's reported methane emissions (Table 2). This therefore presents an opportunity for Malaysia to create a niche producer role for a specific aspect of sustainability: methane emission actions from POME wastewater.

In palm oil extraction, mills generate POME when sterilizing fresh fruit bunches, clarifying extracted crude palm oil, and pressing empty fruit bunches. For every tonne of fresh fruit bunches processed, mills

[86] International Energy Agency (IEA) (2021a).

[87] United Nations Framework Convention on Climate Change (UNFCCC) (2022b).

discharge 0.7–1 m^3 of POME. An open ponding system is a popular and cost-efficient treatment method for POME. This process must comply with environmental standards for water discharge, yet there are no equivalent standards for methane emitted during organic decomposition in ponds. Relevant mitigation technology exists, however; a methane capture and flaring system (labelled 1 in Figure 4) can reduce methane emissions by a reported 82 per cent, whereas methane capture and electricity or heat generation (labelled 2 and 3) is reported to avoid 90 per cent of methane emissions.[88] Hence, with the right incentives, there is potential for Malaysia to rapidly cut methane emissions from POME using existing technology, while enhancing diversity in renewables generation.

Palm oil is a highly regulated sector in Malaysia. Industry players are subject to more than 15 laws and regulations.[89] All Malaysian palm oil producers are furthermore required by law to adhere to the Malaysian Sustainable Palm Oil (MSPO) certification scheme. Producers can also apply for Roundtable for Sustainable Palm Oil (RSPO) certification if they meet its standards. MSPO and RSPO certifications allow qualifying products to use the respective labels on product packaging to reflect the sustainability commitments of downstream processors, traders, and manufacturers, encouraging consumers to make sustainable purchasing decisions.

Methane-specific principles and criteria do not exist in current versions of the MSPO and RSPO guidelines. Within the RSPO, Criterion 7.10 under Principle 7: Protect, Conserve, and Enhance Ecosystems and the Environment, states that

> GHG emissions are identified and assessed for the unit of certification. Plans to reduce or minimize them are implemented, monitored through the Palm GHG calculator and publicly reported.

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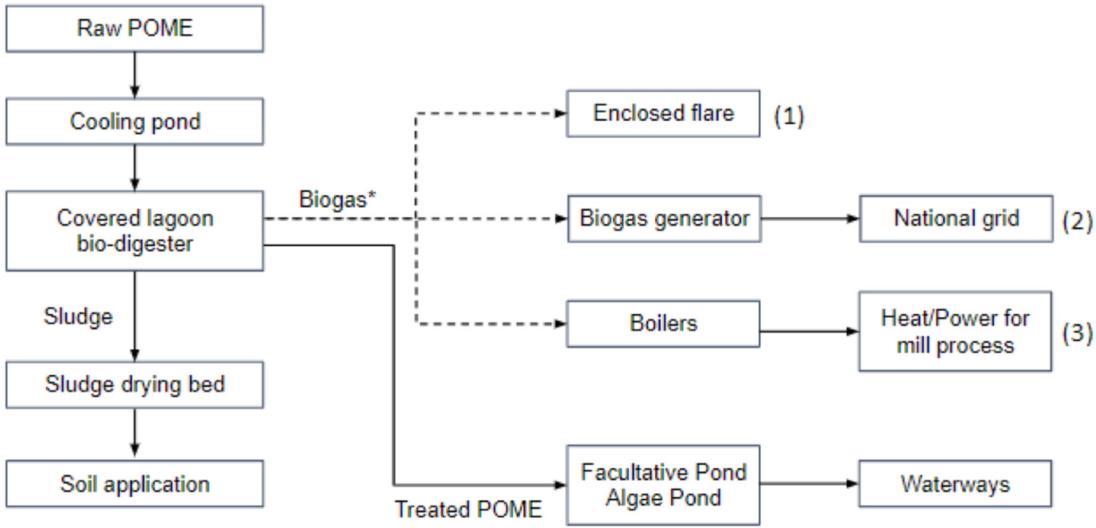
[88] Roundtable on Sustainable Palm Oil (RSPO) (2018).

[89] Malaysian Palm Oil Council (MPOC) (2023).

Figure 4: Illustrative Flowchart of POME Treatment, Including Methane Capture (Raman et al. 2019)



*In an anaerobic environment, the biogas produced consists of approximately 60% methane (NNFCC, 2016).

The dashed lines indicate that biogas infrastructure is not always present in mills, and without it, biogas is released into the atmosphere.

While methane emission avoidance systems are not specifically required, the principles and criteria include guidance on how

> plans prepared by the unit of certification should specify actions to be taken to reduce GHG emissions including for example, adopting low-emission management practices for both mills (e.g., better management of palm oil mill effluent (POME), efficient boilers etc.)" and "the feasibility of collecting and using biogas should be studied where relevant.

In the MSPO Part 4: General Principles for Palm Oil Mills, methane emission avoidance is not a requirement, but Indicator 4.5.5.2 states that "where open discharge of POME into water course is practised, mills should undertake to gradually phase it out in accordance to the applicable state or national regulations".

However, the Malaysian government and palm oil-producing companies recognize methane capture from POME as a major strategic action for reducing GHG emissions. The BUR4 indicates that "for the industrial wastewater treatment and discharge sub-category, improvement on the estimation of biogas generated and captured from POME at each facility is being undertaken". In the document, Malaysia reports an increase in the number of mills with biogas capture, from 104 in 2017 to 125 in 2019 (which roughly matches values from MPOB[90]), leading to an estimated avoidance of 150 kT methane emissions in 2019.

The Ministry of Plantation and Commodities cited 2021 MPOB data that 135 mills (30 per cent) have installed biogas systems, 15 are being constructed, and 130 are in the planning stage. The National Agricommodity Policy mentions a 2014 MPOB mandate for new and expanding palm oil mills to install methane capture infrastructure, which would serve to accelerate this transition,[91] though further details are publicly unavailable. Emphasizing the long-standing availability of

[90] Loh, et al. (2020).

[91] Ministry of Plantation Industries and Commodities (2021).

this technology, historic methane emission avoidance activity through Clean Development Mechanism (CDM) investments is also highlighted in the BUR4: "collectively, oil palm-related project activities accounted for 77.9 per cent of Malaysia's CDM pipeline of registered projects, contributing to more than 90 per cent of the total potential emission reduction". Many of these projects include capturing methane from POME. Bursa Malaysia's inaugural Voluntary Carbon Market auction further demonstrated that biogas recovery from wastewater treatment qualifies under the Verified Carbon Standard (VCS) method (or, similarly, under the Clean Development Mechanism methodology AMS-III.AO). This provides an opportunity for economic incentives from methane-reducing actions.[92]

SDP, the world's largest palm oil plantation company headquartered in Malaysia, currently has fourteen out of seventy mills (ten in Malaysia, two in Indonesia, and two in Papua New Guinea) equipped with biogas capture.[93] According to the SDP Sustainability Report 2021,[94] biogas plants installed at SDP facilities in 2021 avoided 20 kT of methane emissions (compared to 2021 total emissions of 74 kT; Table 2), and there is an ambition to accelerate deployment: "Five biogas plants are under construction and will be operational by 2022, and we have plans to commission an additional 16 by 2025, half of which should be completed by 2023. We aim to have 68 plants in operation by 2030—or at least one at every mill we operate".

SDP announced in December 2022 its 2050 Net Zero Commitment and Roadmap. The roadmap includes a broadening of emissions under consideration relative to the most recent Sustainability Report,[95] adding Forest, Land, and Agriculture (labelled "FLAG") and Scope 3 emissions. The roadmap reports around 70 per cent of non-FLAG Scope 1 and

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[92] Bursa Malaysia (2023).

[93] Sime Darby Plantation (SDP) (2023).

[94] Sime Darby Plantation (SDP) (2022a).

[95] Ibid.

Scope 2 emissions come from methane-emitting POME. One of the three strategic areas in the SDP Net Zero roadmap is "Acceleration in renewables" through bioenergy and solar, positioning SDP as a player in the renewable energy market in Malaysia. SDP thus aims to avoid methane emissions through an increase of biogas plants and is entering into agreements with renewable energy companies to achieve this target.[96] The co-benefits of establishing biogas plants could serve as a driving incentive for the palm oil industry. Given the various existing business models, the sector could benefit economically by saving on mill energy costs where fuel is scarce or expensive, while becoming a potential attraction for local or international investments.

Further, there is a commitment to tackle methane emissions in the wider sector through engagement with other mill operators in SDP's supply chain. To demonstrate meaningful emission targets, SDP has submitted near and long-term targets to the Science Based Targets Initiative (SBTi) for validation. The SBTi provides rigorous and comprehensive external assessment, validation and approval of companies' targets.[97] SDP would only be likely to reveal details of specific targets for GHG, or more specifically methane, emission reductions in their new roadmap once the validation by SBTi is confirmed, potentially later in 2023. It is clear, however, that significant reductions in POME methane emissions will be a key shorter-term action.

3.3 Opportunities for Cross-Sector Learning

Progress and good practices can be found in both sectors discussed above. This section explores cross-sector learning and application opportunities that can contribute to achieving both sectoral and national methane emissions reduction targets. These include the costs of abatement measures, sector-specific standards, public engagement and awareness, and the influencing potential of key players.

[96] See Cenergi (2021).

[97] Sime Darby Plantation (SDP) (2022b).

Firstly, the ability of the O&G sector to offset the costs of methane mitigation methods has been stressed as a compelling motivator for change.[98] Avoiding emissions through abatement technologies such as vapour recovery units, blowdown capture ejectors, and plungers can translate directly to additional production.[99] Here, the value of the captured methane in the O&G sector is calculated as sufficient to cover the cost of many abatement measures.[100] Government-assisted research and development grants could also incentivize the industry to develop new and emerging technological solutions.[101] However, in the palm oil industry, methane is not a main product of the sector, as capturing methane is an additional process separate from the palm oil supply chain. Nevertheless, methane can be combusted as a fuel or converted into electricity. However, this requires substantial investment: for example, the capital expenditure for a recent 2 MW biogas-to-electricity project in Kelantan, Malaysia, was US$2.7 million.[102] Hence, converting POME ponds into methane capture facilities remains costly for small, medium and even large mills. Learning from the success of economic incentives in the O&G sector, the Malaysian government should focus on incentives that would lower costs for mill operators. These could include policy adjustments to make the feed-in-tariff rate and system more attractive, inclusion in carbon credit arrangements, and, importantly, co-funding opportunities to enable palm oil mills, even in remote areas, to participate in capturing methane.[103] Such initiatives would align with the recently announced National Energy Policy,[104] which identifies growth in

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[98] International Energy Agency (IEA) (2022c).

[99] International Energy Agency (IEA) (2022a).

[100] Ibid.

[101] International Energy Agency (IEA) (2021b).

[102] *New Straits Times*, 21 March 2022.

[103] Alternative methods such as POME elimination through evaporation processes, have been shown to have shorter payback periods compared to co-fired boilers or on-grid biogas plants. Refer to Tan and Lim (2019).

[104] Government of Malaysia (2022b).

bioenergy resources, especially from indigenous sources such as palm oil sector waste, as an important element. Biogas contributions to the energy supply in Malaysia were below 0.2 per cent in 2018.[105] The government, furthermore, can incentivize targeted research and development in emerging technologies for reducing or avoiding methane emissions.

Secondly, sector-specific MRV standards have encouraged O&G companies towards transparency and improved action on methane emissions. However, the MRV standards for methane emissions in the palm oil sector are less robust, with no international sector-specific equivalent of the OGMP 2.0. While the SBTi does have sector guidance, it is not specific to methane and covers all FLAG sectors more generally. This means there is not yet a mechanism to drive improved quantification methods, as there is in the ratcheting levels of the OGMP 2.0 framework, which eventually requires the reconciliation of independent bottom-up and top-down methodologies. Considering the niche of POME wastewater, there is potential for producer-leadership on methane MRV standards and more accurate emission quantification, including top-down approaches, for the oil palm sector. Existing certifications, like the RSPO or MSPO, can act as standard-setters in this context. The Council for Palm Oil Producing Countries, jointly founded by Malaysia and Indonesia, may be an alternative platform.

Thirdly, sustainability transitions in the palm oil sector have largely been fuelled by environmental concerns of consumers in international markets. Indeed, the connection between homeless orangutans and deforestation is perhaps more immediately relatable[106] than the environmental impacts of faraway offshore O&G facilities. Furthermore, overshadowed by CO_2, there remains a low awareness of methane and its impacts on the climate in general.[107] Hence, strategies for raising public awareness and concern for methane emission reduction in a broader scope, and in the O&G sector specifically, may take lessons from the

[105] Government of Malaysia (2021).

[106] Greenpeace (2019).

[107] Mar, Unger, Walderdorff, and Butler (2022).

oil palm experience. Indeed, international market pressure from O&G importers is now gathering momentum: Japan, a major importer of Malaysian liquefied natural gas,[108] has begun to highlight the importance of methane emissions management for cleaning Japan's energy supply, and has initiated new methane abatement projects with Petronas.[109] As noted above, there have already been extensive explorations on the links between methane and public health, though scientific evidence specifically focused on Malaysia is lacking. This public health angle, spearheaded by local civil society groups, is one channel through which Malaysians can connect with methane reduction action in both sectors, further encouraging governments and industries to intensify efforts.

Fourthly, the multinational nature of companies in both sectors may present both challenges and opportunities moving forward. Petronas is the regulator of all other PACs in the Malaysian O&G sector. While Petronas can play an important role in influencing other players, there may be instances where other PACs are more advanced in their MRV and mitigation actions. The international footprint of major operators may also complicate support for improving national emission inventories. For example, Shell Malaysia's operational Scope 1 methane emissions are already included within Shell Global's sustainability reporting.[110] Likewise, palm oil multinationals like SDP with operations overseas may find it challenging to maintain MRV standards across different jurisdictions. At the same time, as a key node in the global palm oil supply chain, SDP can play an important influencing role through its commitment to address Scope 3 methane emissions from its suppliers as well—as a "first among equals". Such challenges and opportunities strengthen the need for MRV transparency to aid a broader understanding of corporate decision-making and increase sectoral confidence in a widespread commitment to reduce methane emissions.[111]

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[108] Statista (2023c).

[109] Bernama (2023).

[110] Shell Global (2022).

[111] Amin, Shukor, Yin, et al. (2022).

Finally, while the O&G and palm oil (wastewater) sectors are the highest reported methane emitters in Malaysia, other sectors are also relevant to the GMP. For example, solid waste is Malaysia's third major emissions contributor, as reported to the UNFCCC. More focus on methane action in this sector is also required to ensure Malaysia's response to signing the GMP is indeed comprehensive. Hence, cross-sectoral learning on equivalent mitigation approaches – such as methane capture and utilization at landfill sites—should be explored,[112] though minimizing waste generation is also a crucial strategy. We also note there are additional potential sources of methane emissions which may be relevant to other sectors in Malaysia and are not presently reported to the UNFCCC, including reservoirs and aquaculture.[113]

4. OUTLOOK: TRANSPARENCY AND PROGRESS ON METHANE EMISSIONS IN MALAYSIA

At the time of writing, more than eighteen months have passed since Malaysia joined the GMP. While signing is an important step, more must be done for Malaysia to demonstrably fulfil its commitments. This report highlights both ongoing challenges and substantial grounds for optimism. We list below several key messages to conclude this report.

1. *There is no clear national plan for methane action yet*. Since signing the GMP, there has not been any demonstrable government initiative focusing on joined-up methane action at the national level. Malaysia includes methane in the scope of its NDC but has no methane-specific target. It does not have a methane strategy or policy, and sector-specific regulations focusing on methane emissions are either not present, unclear, or publicly inaccessible. The 2009 NPCC remains in review,

[112] Rocky Mountain Institute (2022).

[113] Chow, Bakhrojin, Haris, et al. (2018).; Yuan, Xiang, Liu, et al. (2019).

the announced CCA is further delayed, and the potential air quality and health co-benefits of methane action do not appear to be recognized in governance. As an emerging policy field, there appears a need to enhance governance capability in methane abatement—including dedicated policy personnel, consultation papers, funded research projects, and specialized policy networks.

2. *There are indications emissions are falling due to positive corporate action*. In both the O&G and palm oil sectors, effective methane avoidance and capture initiatives predate the GMP. Furthermore, key players in Malaysia's top two methane-intensive sectors have already committed to net zero pathways, with methane emission reductions central to short-term progress to 2030. This means emissions, as reported publicly, seem to have already peaked and started to decline, and should be expected to rapidly fall further if action can be scaled across all industry players, including, for instance, methane capture in all palm oil mills and tight controls on methane emissions throughout the O&G industry.
3. *Quantifying reductions with confidence remains challenging*. Different reporting boundaries (e.g., corporate versus national), different reporting and baseline years, and incomplete information on assumptions and uncertainties in quantification approaches make independent reconciliation and aggregation of reported emissions challenging. Therefore, Malaysia and its corporations may be missing an opportunity to gain recognition for an active stance towards methane reduction through a lack of coherent reporting. Top-down measurement-based emission quantification, which is yet to be demonstrated in Malaysia, is a key option to verify the existing uncertain bottom-up accounts of reductions and identify additional mitigation opportunities. Therefore, further effort, which can draw on global expertise, is needed to improve emissions reporting, identify effective mechanisms to track progress nationally, and assess mitigation options. Funding opportunities exist for collaboration between the UN Environment Programme's International Methane

Emissions Observatory (IMEO)[114] and local scientists to implement top-down studies in Malaysia, to build more local capacity. Additionally, bilateral government collaborations can enhance methane quantification capabilities aligned with global methane commitments.[115]

4. *Improvements in corporate MRV in the coming years are expected*. While some standards remain confidential (e.g., within the MPM regulatory process), key companies have joined international frameworks featuring transparency and MRV measures like the OGMP 2.0 and, in a broader climate context, the evolving SBTi.[116] O&G companies adhering to OGMP 2.0 will need to deploy increasingly complex methane MRV approaches over just a few years, including investing more in top-down approaches. Improved corporate MRV and transparency should enable improved reporting quality and quantification confidence under the 1B2 category in Malaysia's national GHG inventory, moving towards Tier 3 approaches within the GMP's timeframe to 2030. Equivalent methane-focused MRV approaches in the more geographically concentrated palm oil sector will likely require more nationally driven leadership, though building on existing good practices embedded in the national inventory.
5. *Methane reduction is a "low-hanging fruit"*. Methane is a major initial lever to reduce GHG emissions up to 2030 in the climate plans of leading Malaysian industry players. Action to improve methane-related processes in the key O&G and palm oil sectors thus presents a valuable opportunity to contribute to global climate mitigation within the long-term national interests of Malaysia. However, methane's importance is not always recognized more widely or made explicit, with information

[114] United Nations Environment Programme (UNEP) (2021b).

[115] Petronas (2023d).

[116] Science Based Targets Initiative (SBTi) (2023).

often presented across multiple documents or through the lens of "CO_2 equivalence". Reducing other GHG emissions in net zero pathways may be more challenging. Therefore, decisive methane action is needed even while plans for these further crucial greenhouse gas emission reductions are developed and articulated in more detail.

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