

Methane Mitigation Action Plans Guidelines for EU Member States

Edited by

2Celsius Association

Author

Mihai Stoica (2Celsius)

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Disclaimer

The opinions put forward in these guidelines are the sole responsibility of the author(s) and do not necessarily reflect the views of the Federal Ministry for Economic Affairs and Climate Action (BMWK).

Introduction and Context

Methane is a potent greenhouse gas, second only to carbon dioxide in its contribution to climate change. It has over 80 times the warming potential of CO₂ on a 20-year timescale, making near-term action on methane crucial¹. In the European Union (EU), methane emissions primarily come from agriculture (~54% of EU methane), waste (~27%), and energy (~17%)². Reducing methane can deliver immediate climate benefits and improve air quality (since methane contributes to ground-level ozone and pollution)³. The EU and its Member States have committed to ambitious methane reduction goals under the *Global Methane Pledge*, a voluntary instrument aiming to cut global methane emissions at least 30% from 2020 levels by 2030⁴. Achieving these goals is also integral to the EU's climate neutrality target by 2050⁵.

This document provides a comprehensive **Methane Roadmap and Action Plan (M-RAP) Guidelines** for EU Member States. It is aligned with the Climate and Clean Air Coalition's M-RAP framework, which is built on five core pillars: **(1) emissions sources and quantification, (2) analytics for prioritizing mitigation, (3) target setting, (4) implementation pathways, and (5) monitoring, reporting & verification (MRV)**⁶. The guidelines cover all key sectors – **Agriculture, Energy, Waste**, and other relevant sources – and are designed to be **generic enough for adaptation by any EU country**. Each country can use these guidelines to develop or update its national methane mitigation plan consistent with EU strategies and international commitments.

The roadmap is structured to provide clear, actionable measures for each sector, along with tools like data tables, checklists, and templates. It emphasizes cross-sector synergy (e.g. promoting biomethane production from waste and agricultural residues), stakeholder engagement, and robust MRV frameworks to track progress. By following this template, Member States can ensure their methane action plans are **M-RAP-aligned**, support EU policy, and contribute to global climate goals.

¹ European Commission. *Methane Emissions*. https://energy.ec.europa.eu/topics/carbon-management-and-fossil-fuels/methane-emissions_en

² International Energy Agency. *European Union Methane Action Plan*. <https://www.iea.org/policies/17024-european-union-methane-action-plan>

³ Bessagnet, B., Belis, C. A., Crippa, M., Dentener, F., van Dingenen, R., & Thunis, P. (2024). *Trends of methane emissions and their impact on ozone concentrations at the European and global levels* (EUR 32005 EN). Publications Office of the European Union. <https://doi.org/10.2760/376659>

⁴ BBC News. *COP26: US and EU announce global pledge to slash methane*. <https://www.bbc.com/news/world-59137828>

⁵ International Energy Agency. *European Union Methane Action Plan*. <https://www.iea.org/policies/17024-european-union-methane-action-plan>

⁶ Climate and Clean Air Coalition. *M-RAP Roadmap Template Guidance – Working Final*. <https://www.ccacoalition.org/sites/default/files/resources/M-RAP%20Roadmap%20Template%20Guidance%20-%20Working%20Final.pdf>

M-RAP Framework and Principles

The M-RAP approach provides a harmonized methodology for methane action planning. Countries are encouraged to structure their plans around five key building blocks:

- **Emissions quantification.** Develop a transparent, accurate **baseline of methane emissions** across sectors. This involves gathering inventory data (e.g. national GHG inventory) and improving measurement methods. Reliable quantification is the foundation for setting targets and tracking progress.
- **Mitigation analytics** - Use data and analysis to **prioritize mitigation actions**. Identify the largest methane sources and the most cost-effective abatement measures in each sector. For example, analytics might show livestock emissions as a top priority in an agricultural country, whereas leak prevention might be paramount in a country with extensive oil & gas infrastructure.
- **Target setting** - Establish clear **methane reduction targets** at national and sectoral levels. Targets should align with EU and global goals – for instance, a national goal to cut methane by ~30% by 2030 (mirroring the Global Methane Pledge), with further reductions by 2050 to support climate neutrality. Sector-specific targets (e.g. for agriculture, waste, energy) can provide additional accountability.
- **Implementation pathways** - Lay out detailed **sector-by-sector action plans** to achieve these targets. This includes policies, regulations, and programs for each sector (as detailed in later sections), timelines for rollout, and assignment of responsibilities. Implementation pathways turn targets into concrete steps.
- **Monitoring, Reporting & Verification (MRV)** - Establish a robust framework to **monitor progress, report emissions, and verify outcomes**. Regularly update methane inventories, require companies to measure and report emissions (for example, using direct measurements in energy sector per OGMP 2.0 standards), and set up verification mechanisms (third-party audits, satellite monitoring, etc.) to ensure transparency and accuracy.

By designing national plans around these pillars, Member States can ensure consistency with the M-RAP template and facilitate progress tracking over time. The subsequent sections of this document expand on these principles with specific strategies, tools, and templates.

Alignment with EU Strategy and International Goals

Methane mitigation plans should be framed within the context of EU-wide policies and global climate commitments. The EU's Methane Strategy (2020) underscores a cross-sector approach, targeting **energy, agriculture, and waste** as priority areas covering

nearly all anthropogenic methane emissions⁷. This guideline aligns with that strategy by addressing all three sectors and encouraging integrated actions.

Each Member State's plan should also support the EU's overall climate targets. Under the European Climate Law and related policies, the EU aims to reduce total greenhouse gas emissions by 55% by 2030, 90% by 2040⁸ and achieve net-zero by 2050. The European Commission's analysis indicates that a **35–37% cut in methane by 2030** (from 2020 levels) is needed to meet the 55% overall GHG reduction goal⁹. Thus, national methane targets should be set ambitiously (around one-third reduction by 2030), complementing CO₂ reduction efforts.

Internationally, EU countries are participants in the **Global Methane Pledge**¹⁰, committing to the 30% methane reduction goal by 2030. National methane action plans can be a key vehicle for delivering on this pledge. Countries are encouraged to integrate their methane targets into their Nationally Determined Contributions (NDCs) under the Paris Agreement and other international reporting. This ensures that methane reduction is recognized as part of their contribution to limiting global warming to 1.5–2°C.

Furthermore, Member States should consider alignment with sector-specific international initiatives:

Energy. Align with emerging global standards for oil and gas methane management (e.g. Oil & Gas Methane Partnership (OGMP) 2.0 reporting framework¹¹) and contribute to global efforts in the fossil energy sector (such as the GMP Energy Pathway launched in 2022¹²).

Agriculture. Support the Global Methane Pledge **Food and Agriculture Pathway** (launched at COP27)¹³ by adopting best practices in livestock and rice production, and

⁷ European Commission. *Communication on an EU strategy to reduce methane emissions (COM(2020) 663 final)*. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0663>

⁸ Council of the European Union. *2040 climate target: Council agrees its position on a 90% emissions reduction*. <https://www.consilium.europa.eu/en/press/press-releases/2025/11/05/2040-climate-target-council-agrees-its-position-on-a-90-emissions-reduction/>

⁹ Climate Bonds Initiative. *Methane Abatement Now: Financing Agrifood Transition in the EU*. <https://www.climatebonds.net/data-insights/publications/methane-abatement-financing-agrifood-transition-eu>

¹⁰ Climate and Clean Air Coalition. *Global Methane Pledge*. <https://www.globalmethanepledge.org/sites/default/files/documents/2023-11/Global%20Methane%20Pledge.pdf>

¹¹ Oil & Gas Methane Partnership 2.0. *The partnership*. <https://www.ogmpartnership.org/partnership>

¹² Global Methane Pledge. *Energy Pathway – Annual Report*. <https://www.globalmethanepledge.org/annual-report/energy-pathway>

¹³ Global Methane Pledge. *Waste Pathway*. <https://www.globalmethanepledge.org/annual-report/waste-pathway>

share experiences through networks like the Global Research Alliance on Agricultural Greenhouse Gases¹⁴.

Waste. Support the GMP Waste Pathway¹⁵ and follow best practices from the CCAC Waste Initiative for landfill and wastewater methane mitigation.

Finance & Innovation: Leverage EU funding (e.g. Innovation Fund, Horizon Europe) and international support (e.g. Methane Finance Sprint which mobilized funding¹⁶) for methane-reducing projects and technologies.

By ensuring consistency with EU legislation (like the new **EU Methane Regulation 2024 for the energy sector**¹⁷) and global pledges, national plans will be both credible and effective. Alignment avoids policy gaps and maximizes synergies, for instance by using EU-level monitoring infrastructure or funding mechanisms to support national actions.

Note: Table 1 below allows each country to summarize its baseline and targets in alignment with these broader goals.

National Methane Emissions Profile and Targets

Each Member State should begin by **documenting its methane emissions profile** and defining targets. This section provides a template for summarizing baseline emissions and setting targets in a clear, comparable format.

Identify a baseline year (commonly **2020** for alignment with global goals, or the latest inventory year) and note total methane emissions and sector breakdown. Use official inventory data (e.g. UNFCCC submissions). Table 1 provides a structure for recording baseline emissions by sector.

Table 1: Baseline Methane Emissions by Sector (to be filled by each country)

¹⁴ Global Research Alliance on Agricultural Greenhouse Gases. *About us.* <https://globalresearchalliance.org/about/>

¹⁵ Climate and Clean Air Coalition. *Global Methane Pledge: A moment of momentum.* <https://www.ccacoalition.org/news/global-methane-pledge-moment-momentum>

¹⁶ European Commission. *EU announces €175m financial support to reduce methane emissions at COP28.* <https://ec.europa.eu/commission/presscorner/detail/en>

¹⁷ European Union. *Regulation (EU) 2024/1787 of the European Parliament and of the Council of 13 June 2024 on methane emissions reduction in the energy sector and amending Regulation (EU) 2019/942.* <https://eur-lex.europa.eu/eli/reg/2024/1787/oj/eng>

Sector	Baseline Year (e.g. 2020) Emissions	% of National Methane Total
Agriculture	X kt CH ₄ (or CO ₂ e)	Y%
Energy (Oil, Gas, Coal)	X kt CH ₄	Y%
Waste (Landfills, Wastewater)	X kt CH ₄	Y%
Other Sources	X kt CH ₄ (e.g. other industrial or natural sources, if significant)_	Y%
Total	X kt CH₄	100%

Example: In the EU aggregate, agriculture is ~54%, waste ~27%, energy ~17%. Each country’s profile will vary (e.g. countries with large livestock populations will have higher agriculture share, while gas-producing countries may have higher energy share).

Based on the baseline, set targets for methane emission reduction. Targets can be absolute emission levels or percentage reductions. Ensure at minimum a 2030 target (consistent with EU’s 2030 climate timeframe) and a long-term 2050 goal. Intermediate milestones (e.g. 2040) help track progress. Table 2 offers a template for target-setting.

Table 2: Methane Emission Targets

Target Year	National Methane Emissions Target	Reduction vs. Baseline	Notes
2030	X kt CH ₄ or CO ₂ e	Y% (relative to 2020)	e.g. aligns with -30% GMP pledge
2040	X kt (optional milestone)	Y%	(if applicable)
2050	X kt	Y%	e.g. net-zero methane growth or specific reduction contributing to climate neutrality

Each country should justify its targets in the context of EU and global objectives. For example, an EU Member State might adopt a ~30-35% methane cut by 2030 to support the overall EU goal of 35-37% reduction by 2030 (given the EU’s climate modeling)¹⁸. The 2050 target could be set to ensure minimal anthropogenic methane (for climate neutrality), recognizing that some residual emissions may persist in sectors like agriculture but could be offset by removals.

¹⁸ European Commission. *Communication on an EU strategy to reduce methane emissions (COM(2020) 663 final)*. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0663>

It is recommended to integrate these targets into national climate strategies, laws, or the NDC. Clear targets signal political commitment and guide sectoral policy development.

Sector-by-Sector Strategic Actions for Methane Reduction

This section outlines strategic mitigation actions for each major sector: **Agriculture, Energy, Waste, and Other/Cross-Cutting**. These actions are aligned with M-RAP principles and EU best practices, but should be tailored to national circumstances. Member States should select and elaborate the measures most relevant to their emissions profile.

Agriculture Sector

Agriculture is often the largest methane source (mainly from livestock digestion and manure). Mitigation in this sector can be challenging but offers significant opportunities through innovation and improved practices¹⁹. Key strategic actions include:

- **Reduce Enteric Fermentation Emissions.** Promote dietary adjustments and feed additives that lower methane from ruminants. Examples include providing **low-methane feed supplements** (e.g. 3-NOP or seaweed-based additives²⁰) and improving feed quality/digestibility. Breeding for lower-emission livestock and herd health improvements also help reduce enteric emissions²¹.
- **Improved manure management.** Encourage systems that prevent methane formation in manure. For instance, promote **anaerobic digesters** on farms to capture biogas from manure and use it as energy, while making sure fugitive methane emissions from digesters are kept in check. This not only cuts methane but also produces renewable energy (biomethane). Where digesters aren't feasible, promote composting or frequent manure removal from barns to aerobic storage²².
- **Rice paddy management (if applicable).** For countries with rice cultivation, support alternate wetting and drying techniques or other water management practices in rice paddies to reduce methane from anaerobic decomposition²³. Introduce rice cultivars and farming practices that emit less methane.

¹⁹ European Environmental Bureau. *Beyond net-zero emissions in agriculture*. <https://eeb.org/wp-content/uploads/2021/07/Beyond-Net-zero-emissions-in-agriculture.pdf>

²⁰ Irish Co-operative Organisation Society (ICOS). *Methane reducing 3-NOP feed additive approved by the European Commission*. <https://icos.ie/2022/02/28/methane-reducing-3-nop-feed-additive-approved-by-the-european-commission/>

²¹ de Haas, Y., Veerkamp, R. F., de Jong, G., & Aldridge, M. N. (2021). Selective breeding as a mitigation tool for methane emissions from dairy cattle. *Animal*, 15(1), 100123. <https://doi.org/10.1016/j.animal.2021.100123>

²² Livestock and Poultry Environmental Learning Community. *Aerobic manure treatment*. <https://lpecl.org/aerobic-manure-treatment/>

²³ The Climate Drive. *Reduce rice cultivation emissions via integrated methods*. <https://www.theclimatedrive.org/action-library/reduce-rice-cultivation-emissions-via-integrated-methods>

- **Livestock herd management & diversification.** Implement initiatives to optimize herd sizes and improve productivity per animal²⁴ (e.g. higher milk yield per cow reduces overall herd methane intensity). Incentivize diversification **away from high-methane livestock** where feasible, supporting farmers to shift towards lower-emission livestock or plant-based production²⁵. Demand-side measures can include public awareness campaigns to **rebalance diets toward lower-emission foods** (more plant-based, less red meat)²⁶, in line with health and sustainability goals.
- **Leak Prevention in Agricultural Energy Use.** Ensure any on-farm biogas or biomethane systems have minimal leakage. Promote proper maintenance of biogas digesters, gas storage, and distribution used in agriculture to avoid inadvertent methane releases²⁷.
- **Policy incentives and support.** Leverage the Common Agricultural Policy (CAP) and national funds to support methane-reducing practices²⁸. For instance, provide subsidies or carbon credits for farmers adopting methane abatement (such as feed additives or biogas systems). Align agricultural policy with climate goals (current analysis shows a need to redirect significant CAP funds towards methane abatement in farming). Develop extension services and farmer training programs on methane mitigation techniques.
- **Research and innovation.** Invest in R&D for new solutions like methane inhibitors, vaccines for methanogenic microbes in ruminants, or breeding programs for low-emitting cattle²⁹. Participate in EU research projects or knowledge-sharing networks to stay updated on emerging technologies.

By implementing such measures, countries can achieve substantial methane cuts in agriculture while maintaining food productivity. Ensuring a **just transition** for farmers is

²⁴ Papadopoulos, G., Papantonatou, M.-Z., Uyar, H., Kriezi, O., Mavrommatis, A., Psiroukis, V., Kasimati, A., Tsiplakou, E., & Fountas, S. (2025). Economic and environmental benefits of digital agricultural technological solutions in livestock farming: A review. *Smart Agricultural Technology*, 10, 100783. <https://doi.org/10.1016/j.atech.2025.100783>

²⁵ European Commission, Directorate-General for Climate Action. *Incentives for Climate Change Mitigation across the Agri-food Value Chain – Input paper #1: Policy options*. https://climate.ec.europa.eu/document/download/cdf7e657-ac93-4706-a1b9-3b1adba80dbd_en?filename=policy_crcf_agrifood_tw1_input_en.pdf&prefLang=el

²⁶ van Dijk, W. M., Righi, S., Ramsden, S., & van Zelm, R. (2022). The role of mitigation options for reducing methane emissions in dairy systems: A review. *Journal of Cleaner Production*, 375, 134149. <https://doi.org/10.1016/j.jclepro.2022.134149>

²⁷ European Environmental Bureau. *Exposed: Uncontrolled biogas expansion funded by public purse*. <https://eeb.org/exposed-uncontrolled-biogas-expansion-funded-by-public-purse/>

²⁸ Ecologic Institute. *Leveraging the Common Agricultural Policy to accelerate livestock emission reductions – examples from five Member States*. <https://www.ecologic.eu/sites/default/files/publication/2025/Leveraging-the-Common-Agricultural-Policy-LR.pdf>

²⁹ Climate and Clean Air Coalition. *Better breeding to cow-burp vaccines: Emerging solutions could curb agricultural emissions*. <https://www.ccaoalition.org/news/better-breeding-cow-burp-vaccines-emerging-solutions-could-curb-agricultural-emissions>

crucial. Provide technical and financial support so that especially smallholders are not adversely affected by the changes (e.g. offer incentives, ensure fairness in any livestock reduction policies).

Energy Sector (Oil, Gas, and Coal)

Methane emissions from the energy sector come from **fossil fuel production and handling**, notably natural gas (production, processing, transmission, distribution), oil (associated gas), and coal mining. The EU has recently enacted a regulation targeting methane in this sector, reflecting best practices that should be adopted nationally³⁰.

Key actions include:

- **Leak Detection And Repair (LDAR).** Establish mandatory LDAR programs for all oil and gas infrastructure (upstream production sites, pipelines, storage, LNG terminals, and even gas distribution networks in cities). Companies must regularly survey equipment to detect leaks and repair them promptly. EU rules require leaks to be fixed generally within 5-15 days of detection, illustrating the urgency. Regular LDAR not only cuts emissions but often pays for itself by saving valuable gas.
- **End routine venting and flaring.** Ban or strictly limit the practice of venting (direct release of methane) and routine flaring (burning of gas) in oil and gas operations. These should only occur in exceptional safety or emergency circumstances. Instead, require gas capture or utilization. For instance, mandate that new oil wells install gas capture equipment, and implement a **phase-out schedule for venting/flaring** at existing facilities. For coal mines, prohibit venting of methane; capture it or use ventilation air methane oxidizers, especially as part of mine closure plans.
- **Improve measurement & reporting.** Require companies to implement **improved MRV for energy sector methane**. This includes direct measurement of emissions where feasible (using devices or sensors), reconciliation of measurements with inventories, and public reporting of methane emissions. The OGMP 2.0 framework can be used as a guideline for tiered improvement of company reporting. Robust MRV ensures transparency and helps identify super-emitters for priority action.
- **Methane emissions transparency.** Implement transparency requirements such as reporting the methane intensity of gas and oil sold. The EU is introducing methane intensity profiling of importers – similarly, countries can publish data on methane leakage rates in domestic production and imported fuels. This can create accountability and allow buyers to choose lower-emission gas sources.
- **Mitigation of abandoned sites.** Develop programs to address methane from **abandoned coal mines and inactive oil/gas wells**. Require identification and

³⁰ European Union. *Regulation (EU) 2024/1787 of the European Parliament and of the Council of 13 June 2024 on methane emissions reduction in the energy sector and amending Regulation (EU) 2019/942*. <https://eur-lex.europa.eu/eli/reg/2024/1787/oj/eng>

monitoring of such sites, and implement mitigation (e.g. plugging wells, flooding mines, or extracting and flaring mine methane). The national plan should assign responsibility to agencies to manage these legacy emissions, often a significant source if left unchecked.

- **Infrastructure and technology upgrades.** Encourage upgrades that reduce methane slip, such as improved compressor seals, vapor recovery units on oil storage tanks, and replacement of old gas distribution pipelines that leak (especially old cast iron pipes in cities). Support R&D for new tech like methane oxidation catalysts or improved detection (e.g. drone or satellite monitoring for leaks).
- **Regulatory and economic instruments.** Enforce regulations (like the EU methane regulation for energy) via national law. Establish **penalties for non-compliance** with leak repair or venting limits to ensure industry accountability. Alternatively or additionally, consider market-based instruments: e.g. a performance standard or low methane-intensity requirement for gas suppliers, or including oil & gas methane in emissions trading or crediting mechanisms. Some jurisdictions plan methane performance standards for gas (like a max 0.2% leakage rate) to push industry action.
- **International collaboration.** Since energy methane can involve imported fuels, collaborate with other countries and support global initiatives for supply chain methane reduction. This might involve joining importers' alliances to require lower upstream emissions or providing technical aid to reduce flaring in countries exporting gas to the EU.

By aggressively controlling leaks and routine emissions in energy, operators and countries can often achieve **quick and cost-effective methane reductions**, as many measures have low or even negative net cost (the value of captured gas offsets the cost)³¹. These actions also improve safety and resource efficiency. Ensuring proper enforcement (e.g. assigning competent national authorities to oversee compliance) is crucial for effectiveness.

Waste Sector (Solid Waste & Wastewater)

Methane from waste comes mainly from **landfills (decomposing organic waste)** and **wastewater treatment (anaerobic decomposition in sewage)**. Waste sector emissions are highly preventable with proper waste management practices³². Strategic actions include:

³¹ International Energy Agency. *Global Methane Tracker 2023: Strategies to reduce emissions from oil and gas operations*. <https://www.iea.org/reports/global-methane-tracker-2023/strategies-to-reduce-emissions-from-oil-and-gas-operations>

³² Kurniawan, T. A., Hassan, G. K., Al-Hazmi, H. E., Othman, M. H. D., Goh, H. H., Aziz, F., Anouzla, A., Ali, I., Khan, M. I., Khan, M. M. H., & Mąkinia, J. (2024). Landfill mining: A step

- **Reduce organic waste to landfills.** Implement policies to **divert organic waste from landfills**³³, since decomposing organic matter (food scraps, green waste) produces landfill methane. This can include:
 - **National or EU-aligned targets to limit landfilling.** For example, the EU Landfill Directive limits municipal waste landfilling to **10% by 2035**³⁴. Adopting or strengthening such targets nationally will directly cut methane.
 - **Mandatory separate collection** of biowaste (food and garden waste) so it can be composted or anaerobically digested instead of landfilled. Many EU countries are implementing this under the Waste Framework Directive³⁵.
 - **Bans on landfilling untreated organic waste.** For instance, some countries like Sweden have banned landfilling of organic waste³⁶. Such bans force alternatives like composting, which yields much lower methane.
 - **Food waste reduction initiatives.** Encourage reduction of food waste at source and redistribution (donations) to minimize disposal³⁷. Less food waste generated means less potential methane.
 - **Landfill gas capture and utilization.** Landfill operators should capture methane and either flare it or, preferably, use it for energy (generate electricity or upgrade to biomethane). Set performance standards for gas capture (e.g. a minimum capture efficiency or surface methane emission limits). Regular monitoring of landfill

forward to reducing CH₄ emissions and enhancing CO₂ sequestration from landfill. *Journal of Hazardous Materials Advances*, 100512. <https://doi.org/10.1016/j.hazadv.2024.100512>

³³ Somers, J. C. (2025). Household landfill diversion and the impact on methane emissions. *Journal of Environmental Economics and Management*, 132, 103174. <https://doi.org/10.1016/j.jeem.2025.103174>

³⁴ Circular Cities and Regions Initiative. *Landfill Directive – Directive (EU) 2018/850*. <https://circular-cities-and-regions.ec.europa.eu/support-materials/eu-regulations-legislation/landfill-directive-directive-eu-2018850>

³⁵ European Commission. *Waste Framework Directive*. https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

³⁶ Frost & Sullivan Institute. *Waste management in Sweden: Turning trash into treasure*. <https://frostandsullivaninstitute.org/waste-management-in-sweden-turning-trash-into-treasure/>

³⁷ Sundin, N., Persson Osowski, C., Strid, I., & Eriksson, M. (2022). Surplus food donation: Effectiveness, carbon footprint, and rebound effect. *Resources, Conservation and Recycling*, 181, 106271. <https://doi.org/10.1016/j.resconrec.2022.106271>

methane emissions (e.g. surface scans) should be mandated to detect leaks³⁸. Consider regulations akin to California's Landfill Methane Rule which enforces gas capture and monitoring³⁹.

- **Pre-treatment of waste.** Require **stabilization of organic waste before disposal**. Mechanical-biological treatment (MBT) of waste can significantly reduce the biodegradable content going to landfills by composting it partially, thus cutting methane generation⁴⁰. Ensuring that only stabilized or inert waste goes to landfill is a best practice.
- **Wastewater treatment improvements.** Upgrade wastewater treatment plants (WWTPs) to reduce methane⁴¹. This includes capturing methane in anaerobic digesters at sewage treatment facilities (and using it as biogas energy), covering anaerobic lagoons, and improving treatment processes to minimize anaerobic conditions. Sludge management should include gas capture (per the EU's Urban Wastewater Treatment Directive requirements). Small or rural wastewater systems might use biogas capture in anaerobic digesters where feasible.
- **Leak management in gas utility networks (if counted in waste sector).** In some contexts, biogas from waste is injected into grids. Ensure those injections and biogas facilities have leak detection. (Gas distribution was covered under energy, but if any portion is managed by waste utilities, it should also follow LDAR practices).
- **Circular economy and recycling.** Broader waste reduction and recycling efforts indirectly aid methane mitigation by reducing the volume of organic waste. Implement national strategies on composting, biogas use, and material recycling to keep organic carbon out of anaerobic landfill conditions. Promote the use of compost and digestate on lands (closing the loop) which also improves soils⁴².
- **Enforce existing regulations.** Fully enforce EU waste directives that have climate co-benefits. For example, ensure compliance with the Landfill Directive targets and the Waste Framework Directive's recycling goals. Strengthen national laws by

³⁸ Omid, A., Bourlon, E., Khaleghi, A., Tarakki, N., Martino, R., Stuart, J., & Risk, D. (2025). Most landfill methane emissions escape detection in EPA21 surface emission monitoring surveys. *Waste Management*, 207, 115104. <https://doi.org/10.1016/j.wasman.2025.115104>

³⁹ Waste Dive. *California's landfill methane rule proposal tightens gas rules*. <https://www.wastedive.com/news/california-draft-landfill-methane-rule-proposal-summary/761110/>

⁴⁰ Fei, F., Wen, Z., Huang, S., De Clercq, D., & Caicedo, L. (2018). Mechanical biological treatment of municipal solid waste: Energy efficiency, environmental impact and economic feasibility analysis. *Journal of Cleaner Production*, 178, 731–739. <https://doi.org/10.1016/j.jclepro.2018.01.060>

⁴¹ Global Methane Initiative. *Wastewater: Reducing methane emissions from wastewater treatment*. https://www.globalmethane.org/documents/ww_fs_eng.pdf

⁴² Lu, J., Li, X., Huang, X., Durán-Jiménez, G., Guo, J., El-Mashad, H. M., & Zhang, R. (2021). Post-treatment of food waste digestate towards land application: A review. *Journal of Cleaner Production*, 312, 127694. <https://doi.org/10.1016/j.jclepro.2021.127694>

adding explicit methane considerations – e.g., require landfill methane monitoring and reporting annually as part of environmental permits⁴³.

- **Innovation and best practices.** Encourage emerging solutions like **landfill mining**⁴⁴ (to remove old waste and eliminate methane sources) or bio-covers that oxidize methane at landfill surfaces⁴⁵. Pilot new technologies and share best practices through EU networks - e.g. the International Methane Emissions Observatory for identifying high-emitting landfills via satellite⁴⁶.

In sum, the waste sector strategy is to **prevent methane formation by keeping organics out of landfills, and where methane is formed, capture it**. Many waste methane measures also create jobs in recycling or composting industries and improve public health by reducing local air pollution and odors. They are essential for meeting both climate and environmental objectives.

Other Sectors and Cross-Cutting Measures

While agriculture, energy, and waste are the dominant sources, countries should not neglect other methane-emitting sectors or cross-sector opportunities.

- **Other Methane Sources.** Identify any significant niche sources in the national context. For example:
 - *Forestry and wildfires.* Wildfires and burning of biomass release methane⁴⁷. Forest management to reduce wildfire risk (like controlled burns or rapid fire suppression) could indirectly cut methane⁴⁸, though CO₂ is the larger concern here.
 - *Wetlands and peatlands.* Drained peatlands emit methane. Restoration of wetlands/peatlands might reduce methane emissions over time (while also

⁴³ Environment Agency. *Guidance on monitoring landfill gas surface emissions (LFTGN07 v2, 2010)*. <https://assets.publishing.service.gov.uk/media/5a74f8bded915d502d6cc7ad/LFTGN07.pdf>

⁴⁴ Kurniawan, T. A., Hassan, G. K., Al-Hazmi, H. E., Othman, M. H. D., Goh, H. H., Aziz, F., Anouzla, A., Ali, I., Khan, M. I., Khan, M. M. H., & Maqinia, J. (2024). Landfill mining: A step forward to reducing CH₄ emissions and enhancing CO₂ sequestration from landfill. *Journal of Hazardous Materials Advances*, 100512. <https://doi.org/10.1016/j.hazadv.2024.100512>

⁴⁵ Abichou, T., Powelson, D., Chanton, J., Escoriza, S., "Mitch", Stern, J., & Fleiger, J. (2015). Modeling the effects of vegetation on methane oxidation and emissions through soil landfill final covers across different climates. *Waste Management*, 36, 230–240. <https://doi.org/10.1016/j.wasman.2014.11.026>

⁴⁶ Duren, R. M., Thorpe, A. K., Kivi, R., Suto, H., Foster, K. T., Riris, H., Elder, C., Yurganov, L., Crisp, D., & Miller, C. E. (2022). Connecting methane point source emissions to global and regional atmospheric methane enhancements. *Science Advances*, 8(26), eabn9683. <https://doi.org/10.1126/sciadv.abn9683>

⁴⁷ Zhao, J., Ciais, P., Chevallier, F., Canadell, J. G., van der Velde, I. R., Chuvieco, E., Chen, Y., Zhang, Q., He, K., & Zheng, B. (2025). Enhanced CH₄ emissions from global wildfires likely due to undetected small fires. *Nature Communications*, 16, 804. <https://doi.org/10.1038/s41467-025-56218-w>

⁴⁸ Swedish University of Agricultural Sciences. *Forest management can reduce the risk of large wildfires*. <https://www.slu.se/en/news/2025/08/Forest-management-can-reduce-the-risk-of-large-wildfires/>

sequestering carbon)⁴⁹. Include these actions if relevant, though they often fall under broader land use policy.

- *Geological seeps*. In rare cases, natural geological methane seepage (e.g., in tectonic areas) might be significant locally⁵⁰. There's limited scope to mitigate these, but monitoring can be done.
- **Biomass burning & bioenergy**. Ensure that policies on biomass usage (e.g. agricultural burning of crop residues) discourage open burning, which releases methane and other pollutants⁵¹. Promote alternatives like soil incorporation of residues or controlled bioenergy production.
- **Just transition and workforce**. Methane mitigation will affect various communities (farmers, coal miners, oil & gas workers, waste management workers). Implement cross-cutting measures to ensure a *just transition*: worker re-training programs (e.g. training coal miners or oil workers to work in methane leak detection, biogas operations, or other green jobs), financial support for regions heavily dependent on high-methane industries to diversify their economies, and stakeholder engagement to incorporate feedback from affected groups.
- **Public awareness & behavior change**. Cross-cutting campaigns to influence behavior can amplify sectoral measures. For instance, educate the public on food waste reduction (impacting waste sector), dietary choices (impacting agriculture demand), or reporting gas leaks (public can report suspected gas leaks in cities, aiding energy sector efforts). Public buy-in makes policies more effective⁵².
- **Climate financing and private sector involvement**. Encourage cross-sector financing mechanisms. Green bonds or climate funds can be mobilized for methane projects in any sector⁵³. For example, a national green fund could support both a landfill gas project and an agricultural digester. Engage the private sector by highlighting the economic value in capturing unavoidable methane and by offering incentives like tax breaks for companies investing in methane abatement.

By covering these additional areas, the roadmap remains comprehensive. It ensures that no major methane source is overlooked and that opportunities cutting across sectors (like

⁴⁹ Günther, A., Barthelmes, A., Huth, V., Joosten, H, Jurasinski, G., Koebsch, F., & Couwenberg, J. (2020). Prompt rewetting of drained peatlands reduces climate warming despite methane emissions. *Nature Communications*, 11, 1644. <https://doi.org/10.1038/s41467-020-15499-z>

⁵⁰ Etiope, G. (2009). Natural emissions of methane from geological seepage in Europe. *Atmospheric Environment*, 43(7), 1430–1443. <https://doi.org/10.1016/j.atmosenv.2008.03.014>

⁵¹ Climate and Clean Air Coalition. *Waste sector solutions*. <https://www.ccacoalition.org/content/waste-sector-solutions>

⁵² Dabla-Norris, E., Khalid, S., Magistretti, G., & Sollaci, A. (2023). *Public support for climate change mitigation policies: A cross country survey* (IMF Working Paper No. 2023/223). International Monetary Fund. <https://doi.org/10.5089/9798400258138.001>

⁵³ Climate Policy Initiative & Climate Bonds Initiative. *Methane Abatement in Sustainable Taxonomies*. <https://www.climatepolicyinitiative.org/wp-content/uploads/2025/12/Methane-Abatement-in-Sustainable-Taxonomies.pdf>

biomethane use or financial tools) are harnessed. Each Member State can expand on relevant “other” sources or cross-cutting actions based on its unique national circumstances.

Policy and Implementation Readiness Checklists

To facilitate action, it is useful to periodically assess readiness in terms of policy framework and implementation capacity. Below are two checklists – one for policy readiness and one for implementation readiness. These serve as practical tools for policymakers to ensure all necessary elements are in place for the methane mitigation plan to succeed.

Policy Readiness Checklist

National methane baseline established. Up-to-date inventory of methane emissions by source (with any data gaps identified and plans to improve quantification).

Methane reduction targets set. Official adoption of 2030 (and other) methane targets, consistent with EU/global goals, in national climate or environmental strategy.

High-level endorsement: Government endorsement of the methane action plan (e.g. cabinet or ministry approval), ensuring political buy-in.

Legislative Framework: Existence of laws/regulations empowering methane mitigation:

- e.g. Updated waste management laws to enforce organics diversion and landfill gas capture.
- Integration of methane objectives into agricultural and environmental policies (like linking to CAP strategic plans).

Institutional Coordination Mechanism: A task force or committee is in place that brings together relevant ministries (Environment, Energy, Agriculture, Waste, etc.) for coordinated action. Clear assignment of lead agency for overall plan coordination (often Environment/Climate Ministry).

Budget and Funding Strategy: Identification of funding sources (national budget allocations, EU funds, international grants, private sector investment) to support the plan’s initiatives. Incentive programs (subsidies, grants, or carbon credit schemes) prepared for sectors like farming and waste companies.

Stakeholder Consultation and Support: Key stakeholders (industry associations, farmer groups, waste operators, NGOs, local authorities) have been consulted in plan development. Their roles are acknowledged and they broadly support the plan’s goals.

Policy Coherence Check: Alignment ensured with other national policies – e.g. climate

strategy, air quality plan, energy strategy, agricultural policy – to avoid contradictions. (Methane plan should complement efforts to reduce CO₂ and improve air quality.)

Implementation Readiness Checklist

[] **Implementation team and responsibilities.** Dedicated teams or units within ministries/agencies are designated to implement actions in each sector. Focal points or “owners” for each major action are identified.

[] **Capacity building.** Training programs or guidance materials are prepared for those who will carry out the measures – e.g. training for farmers on new manure management techniques, training for oil/gas inspectors on LDAR procedures, training for landfill operators on gas systems.

[] **Monitoring systems in place.** Systems to collect data on methane emissions and mitigation are operational or under development. For instance:

- An improved emissions reporting system for industries (per EU MRV rules).
- Methodologies for tracking reductions from projects (e.g. how to quantify methane avoided by a new digester).
- Database or registry to compile and publicize progress.

[] **Enforcement mechanisms.** Agencies have the authority and resources to enforce regulations (inspectors, monitoring technology, penalties). For example, an enforcement plan for regular inspections of oil & gas facilities, or checks on landfill compliance.

[] **Outreach and guidance.** Clear guidance documents, toolkits, or protocols have been issued to stakeholders for each major measure, e.g. a manual on conducting LDAR, best practice guide for feed additives, guidance for municipalities on organics collection. Outreach events or extension services are arranged to disseminate this information.

[] **Ongoing stakeholder engagement.** Forums or working groups are established for continuous stakeholder engagement during implementation. This could include, for example, a regular meeting with agricultural unions to review progress on farm measures, or community input sessions for waste projects, especially if new facilities are being built.

[] **Communication plan.** A public communication strategy is set to raise awareness of the methane plan and its benefits. This ensures transparency and helps maintain public support, e.g., periodic public reports or dashboards on methane emissions, success stories, and highlighting co-benefits like improved health or energy savings.

[] **Review and adaptation process.** A mechanism to periodically review implementation progress and adapt the plan if needed. For instance, a mid-term review around 2027-2028

to assess if actions are on track for 2030 targets, with the flexibility to introduce additional measures or policies if current efforts fall short.

By using these checklists, policymakers can verify that both the **policy groundwork** and the **practical execution arrangements** are in place. Any unchecked items represent gaps to address proactively, thus de-risking the implementation phase.

Stakeholder Engagement and Collaborative Action

Effective methane mitigation requires the active involvement of a wide range of stakeholders. Early and continuous **stakeholder engagement** ensures that the action plan is realistic, enjoys broad support, and leverages the knowledge and resources of all parties:

Government agencies. Collaborate across ministries and agencies. Environmental ministries may lead, but success hinges on agriculture ministries (for farm measures), energy regulators (for oil/gas rules), local governments (for waste management), and others. Establish inter-ministerial coordination committees (as noted in the checklist) to break silos and facilitate information sharing.

Industry and private sector. Engage businesses in all relevant sectors:

- Oil & gas companies should be partners in detection and repair programs – involve them in creating practical guidelines and encourage voluntary early action.
- Farms and agribusinesses need outreach through farmer associations, cooperatives, and agricultural extension services. Pilot projects on farms can demonstrate methane-reducing techniques (e.g. a demonstration farm for new feed or a community biogas plant) and encourage wider adoption. The government should strengthen policies that encourage farmers to join or form cooperatives, as associative structures improve access to EU funding, enable collective investments, and increase competitiveness.
- Waste management companies and utilities should be consulted on setting achievable landfill gas capture goals and on designing organics collection systems that work locally. Public-private partnerships can help finance infrastructure like digesters or gas capture systems.

Technology providers and innovators. Engage companies offering methane mitigation technologies - from feed additives to gas leak detection drones, so that the plan reflects the latest solutions and so that these providers can tailor their products to national needs.

Civil society and communities. NGOs, environmental groups, and community organizations often have valuable expertise and can help with public awareness. They can also serve as watchdogs to keep implementation on track. Communities near sources like residents around landfills or oil/gas sites should be involved, as they have a direct stake in

emission reductions for odor, health, and safety reasons. Including civil society in consultation builds transparency and trust.

Scientific and academic experts. Involve researchers and experts from universities or research institutes in plan refinement and monitoring. They can contribute to emissions quantification (e.g. studies to better measure emissions locally), advise on best practices, and help evaluate the effectiveness of measures over time. Consider establishing a scientific advisory panel for the methane action plan.

International partners. Leverage support from EU institutions (e.g. the Commission's expertise, the European Environment Agency for data, or EU funding programs), and international initiatives (CCAC, Global Methane Pledge partners). These external stakeholders can provide technical assistance, capacity building, or peer learning opportunities like twinning programs between countries.

Engagement methods. To operationalize stakeholder collaboration, use inclusive approaches:

- Conduct workshops and stakeholder meetings during the action plan drafting to gather input.
- Set up sector-specific working groups, e.g. an Agricultural Methane Working Group with farmers, scientists, officials.
- Develop a grievance or feedback mechanism for stakeholders to voice concerns during implementation, important for community acceptance of projects like new biogas facilities or changes in farming practices.
- Sign voluntary agreements or memoranda of understanding with industry groups for methane reduction commitments beyond regulations.

Building capacity: Part of engagement is empowering stakeholders with the knowledge and tools to act. The plan should include capacity-building initiatives (as in the checklist) – from training farmers on new techniques to helping landfill operators optimize gas systems. When stakeholders feel capable and heard, they are more likely to champion the mitigation efforts.

Ultimately, broad stakeholder engagement creates a sense of **shared ownership** of the methane mitigation goal. It helps to identify and resolve implementation challenges early (stakeholders can flag issues and co-develop solutions) and ensures that the plan's benefits – like improved health from better air quality, economic gains from captured energy, and international climate leadership – are well communicated and realized by all.

Monitoring, Reporting, and Verification (MRV) Framework

A strong **MRV framework** is essential to track the progress of the methane action plan, ensure transparency, and meet both EU and international reporting obligations. The MRV system should cover **emissions monitoring** and **policy performance tracking**.

- Continuously improve the national methane emissions inventory. Incorporate the latest data and methodologies for key sources:
 - Use **tier 2 or tier 3 methods** for significant categories (e.g. detailed country-specific calculation methods for enteric fermentation or facility-level data for oil & gas, rather than simple default factors).
 - Encourage or require large emitters (e.g. companies in energy sector, large landfills, wastewater utilities) to report their methane emissions annually with high accuracy. The new EU energy sector rules mandate improved measurement and reporting – align national requirements accordingly.
 - Integrate data from direct measurement initiatives. For instance, utilize satellite data or aerial surveys that detect methane hotspots (the EU’s Copernicus satellite program and the International Methane Emissions Observatory can be resources for identifying unexpected emissions).
 - Regularly recalibrate and verify inventory estimates with empirical data (research studies or on-site measurements) to reduce uncertainty.
 - **Sectoral MRV Protocols:** Develop specific MRV protocols for each sector’s mitigation measures:
- If implementing feed additive programs in the **agriculture sector**, monitor participants and estimate reductions achieved (perhaps through animal trials or extrapolation from scientific studies). Track number of digesters built and estimate methane captured from them. Surveys on livestock numbers and manure management practices can feed into tracking progress beyond just emission numbers (since ag emissions are diffuse, proxies help measure action).
- Require **energy sector** companies to report detected leaks and repairs (e.g. number of leaks found, volume of gas leaked/captured) as part of an LDAR program. Maintain a database of venting/flaring events. Some of this is in line with OGMP 2.0 reporting which can be adopted; companies would report emission sources and mitigation status. Verification should include spot inspections or third-party audits of company reports.
- Have **landfill operators** report annual methane collected versus estimated methane generated (capture efficiency). Monitor compliance with waste diversion targets (e.g. percentage of organic waste diverted from landfills). Use remote sensing to spot any large uncaptured emissions from landfills. For wastewater, track how many plants have anaerobic digesters and their biogas utilization.
- Establish a clear **reporting timeline and responsibility**. For example, assign an agency (like an Environment Agency) to compile an **annual methane progress report**. This report would include updated emission figures, status of key initiatives

(e.g. “X number of leaks repaired, Y biogas units installed, Z% landfill diversion achieved”), and an assessment of whether the country is on track for its targets.

- Report progress to the European Commission as needed (the EU may request updates as part of Effort Sharing Regulation compliance or as part of Global Methane Pledge follow-ups).
- Incorporate methane outcomes into broader climate reporting (e.g. Biennial Transparency Reports under the Paris Agreement).
- Use **third-party verification** where possible to build credibility:
 - Independent auditors or expert teams can review the annual methane reports or specific project outcomes. For instance, verify that reported emissions reductions from a new regulation are actually.
 - Public transparency is a form of verification – by publishing data publicly, external experts and civil society can scrutinize and flag discrepancies. Consider publishing an open-data portal for methane emissions and even real-time data where available (such as live data from continuous emissions monitoring at facilities).
 - Participate in international peer review processes if available (e.g. if CCAC or UNFCCC reviews national methane plans or inventories, engage fully).
- The MRV system should feed back into **policy improvement**. If monitoring shows a certain measure is underperforming or emissions are not dropping as fast as expected, there should be a mechanism to investigate why and adjust the strategy. For example, if landfill methane isn’t decreasing as planned, verification might reveal compliance issues or technical problems – leading to policy tightening or additional support.
- **Capacity for MRV:** Invest in the technical capacity for MRV – this includes tools (monitoring equipment, software systems for data management) and training for staff. Engage national statistical offices or environment agencies to ensure they have resources to handle increased methane data. The EU and international partners can provide support (e.g. JRC or the CCAC can offer guidance on MRV improvements).

In summary, MRV is the backbone that **keeps the methane action plan accountable and on track**. By measuring accurately, reporting transparently, and verifying results, Member States can confidently demonstrate progress to their citizens and the international community, and make informed decisions to steer their methane mitigation actions effectively.

Conclusion

This document provides EU Member States with a structured, M-RAP-aligned template to tackle methane emissions across all key sectors. By setting clear targets, implementing targeted sectoral measures, engaging stakeholders, and rigorously tracking progress, countries can achieve rapid methane reductions that yield significant climate and health

benefits. Methane mitigation is a **“no-regrets” strategy** – it is cost-effective in many cases and delivers quick wins for the climate. Moreover, it complements CO₂ reduction efforts by addressing near-term warming and helping to avoid climate tipping points.

Each Member State should adapt these guidelines to its national context – filling in data, choosing the most relevant actions, and integrating with its own policies. While the exact mix of measures will vary, the overarching approach of this plan remains applicable EU-wide. Collective action on methane will strengthen the EU’s leadership in climate change mitigation and support global efforts to limit warming in line with the Paris Agreement.

By using this roadmap as a living document – updating it with new science, technology, and policy learnings – EU countries can continuously improve their methane action. The path outlined here leads to cleaner air, improved public health, and a safer climate. Swift and sustained implementation of these methane mitigation strategies will be a key component of achieving Europe’s climate goals and ensuring a healthier environment for all citizens.