Measuring greenhouse gas emissions in health systems

CSM Centre for Sustainable Medicine

NHS

ATACH Alliance for Transformative Action on Climate and Health
WHO-hosted network

World Health Organization

Measuring greenhouse gas emissions in health systems

Discussion draft

Centre for Sustainable Medicine

NHS

ATACH
Alliance for Transformative Action on Climate and Health
WHO-hosted network

World Health Organization

Contents

Acknowledgements

This report was co-led by the Centre for Sustainable Medicine at the National University of Singapore (Singapore), Greener NHS, NHS England (United Kingdom of Great Britain and Northern Ireland) and the World Health Organization (WHO) Environment, Climate Change and Health Department (Switzerland).

The co-leads were Nick Watts (Centre for Sustainable Medicine); Christopher Gormley (Greener NHS, NHS England); and Diarmid Campbell-Lendrum and Elena Villalobos Prats (WHO Environment, Climate Change and Health Department).

This document was written by Thomas Andrew (Centre for Sustainable Medicine), Hiten Patel (Greener NHS), Amy Savage (WHO Environment, Climate Change and Health Department), Jit Sohal (Centre for Sustainable Medicine), Sammy Bishop (Greener NHS), Olena Zotova (WHO Environment, Climate Change and Health Department), Elizabeth Loke (Centre for Sustainable Medicine), Robin Simpson (Greener NHS) and Aruzhan Shalabayeva (Centre for Sustainable Medicine).

The concepts behind the report were presented for discussion at several international workshops, with participation of WHO country offices, representatives from ministries of health, academia and other country stakeholders. Several drafts were written and circulated during the preparation of the report.

Gratitude is expressed to the following WHO and PAHO staff for their valuable input: Daniel Buss (PAHO Department of Social and Environmental Determinants of Health Equity), Sally Edwards (WHO Asia-Pacific Centre for Environment and Health, WPRO), Mohamed Eissa (WHO Egypt Country Office), Ahammadul Kabir (WHO Bangladesh Country Office), Bonifacio Magtibay (WHO Philippines Country Office).

The co-leading organizations thank the following representatives who participated in the Alliance for Transformative Action on Climate and Health (ATACH) task team on Measuring greenhouse gas (GHG) emissions of national health systems and other external contributors for their contributions:

Erlend T. Aasheim (Directorate of Health, Norway), Maria Sol Aliano (Health Care Without Harm, Argentina), Nermeen Ashour (Egypt Health Authority, Egypt), Martijn van Bodegraven (National Institute for Public Health and the Environment (RIVM), Centre for Sustainability, Environment and Health, the Netherlands), Tinia de Bruycker (National Institute for Public Health and the Environment (RIVM), Centre for Sustainability, Environment and Health, the Netherlands), Jannie Coenen (National Institute for Public Health and the Environment (RIVM), Centre for Sustainability, Environment and Health, the Netherlands), Hristo Dikanski (Aga Khan Health Services, Switzerland), Glenn A. Cruz (Department of Health, Philippines), Matthew Eckleman (Northeastern University, USA), Andreas Ekvall (Health Care Without Harm, France), Sarin KC, (Health Intervention and Technology Assessment Program Foundation (HITAP), Thailand), Johnaliz A. Khow (Department of Health, Philippines), Ronald Law (Department of Health, Philippines), Manfred Lenzen (The University of Sydney, Australia), Laurita R. Mendoza (Department of Health, Philippines), Diego Moreno Heredia (The Ministry of Health and Social Protection, Colombia), Diana Picon Manyari (Health Care Without Harm, France), Fawzia Rasheed (Aga Khan Health Services/ the London School of Hygiene and Tropical Medicine, United Kingdom), Jérôme Ribesse (Synergie Santé Environnement, Canada), Antonella Risso (Universidad Peruana Cayetano Heredia/The Lancet Countdown LATAM, Argentina) (Bituin S. Reyes (Department of Health, Philippines), June Philip O. Ruiz (Department of Health, Philippines), Wilasinee Samniang (Health Intervention and Technology Assessment Program Foundation (HITAP), Thailand), Marta Santamaría Molina (UNESCO Chair in Life Cycle and Climate Change ESCI-UPF, Spain), Ilija Sazdovski (UNESCO Chair in Life Cycle and Climate Change ESCI-UPF, Spain), Melissa T. Sena (Department of Health, Philippines), Misganaw Tewachew Hunegnaw (Ministry of Health, Ethiopia), Sanskrithi Thakur (India, Health Care Without Harm), Susanne Waaijers-van der Loop (National Institute for Public Health and the Environment (RIVM), Centre for Sustainability, Environment and Health, the Netherlands) for review and technical inputs.

Hossam Abdelggaffar (Ministry of Health and Population, Egypt), Ahmad al-brmawi (Ministry of Health, Jordan), Valentine Bekka (Ministry of Health, Labour, Solidarity and Families, France), Iris Blom (London School of Hygiene & Tropical Medicine, The Netherlands), Barbara Bond (Health Service Executive, Ireland), Do Manh Cuong (Ministry of Health, Vietnam), Do Phuong Hien (Ministry of Health, Vietnam), Miriam Kugele (Aga Khan University, Pakistan), Le Ha Thanh (National Economic University, Vietnam), Le Thai Ha (Ministry of Health, Vietnam), Le Thi Phuong Mai (Ministry of Health, Vietnam), Mengyu Li (University of Sydney, Australia), Vugar Mammadov (Ministry of Health, Azerbaijan),Bertrand Millet (Ministry of Health, Labour, Solidarity and Families, France), Rose Kemunto Mokaya (Ministry of Health, Kenya), Francisca Molina (Spanish Agency for International Cooperation and Development (AECID), Spain), Marina Morales Ibor (Ministry of Health, Spain), Aoife O'Neill (Health Service Executive, Ireland), Sagun Paudel (Public Health Initiative, Nepal), Phan Thi Thu Hang (Ministry of Health, Vietnam), Héctor Prados Cabrera (Tragsatec, Spain), Jodi Sherman (Yale/Lancet Commission on Sustainable Healthcare, USA), Mxolisi Sibanda,(The Commonwealth Secretariat, The United Kingdom), Madeleine Skellern (Department of Health and Aged Care, Australia), Cecilia Sorensen (Global Consortium on Climate and Health Education, USA) for technical contributions.

WHO thanks the Spanish Agency for International Development Cooperation (AECID) for financial support towards production of this guidance.

External contributors declared no conflicts of interest. All the experts participated in their individual capacities and not as representatives of their countries, governments or organizations. Their participation does not constitute responsibility for the content of this publication.

Abbreviations

ATACH	Alliance for Transformative Action on Climate and Health
CO_2e	carbon dioxide equivalent
GHG	greenhouse gas
GHG Protocol	Greenhouse Gas Protocol
LCA	lifecycle assessment
MRIO	multi-regional input–output
NHA	national health account
NHS	National Health Service
WHO	World Health Organization

Glossary

Adaptation The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects.

Base year A defined reference year against which an organization can compare current and future changes in emissions.

Carbon dioxide equivalent The mass of carbon dioxide that would produce the same global warming effect as one unit mass of a given greenhouse gas.

Climate-resilient and low-carbon health systems Health systems that are capable of anticipating, responding to, coping with, recovering from and adapting to climate-related shocks and stress, while minimizing greenhouse gas emissions and other negative environmental impacts, to deliver high-quality care and protect the health and well-being of present and future generations.

Co-benefits The positive effects that a policy or measure aimed at one objective could have on other objectives, thereby increasing the total benefits for society or the environment.

Decarbonization The process by which countries, individuals or other entities aim to achieve a zero fossil carbon existence. Decarbonization typically refers to a reduction in carbon emissions associated with electricity, industry and transport.

Emission factor A coefficient that quantifies the average mass of greenhouse gas emissions per unit activity or expenditure.

Greenhouse gases Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths, contributing to the greenhouse effect.

Health systems All the activities whose primary purpose is to promote, restore and/or maintain health – that is, the people, institutions and resources, arranged together in accordance with established policies, to improve the health of the population they serve, while responding to people's legitimate expectations and protecting them against the cost of ill health through a variety of activities whose primary intent is to improve health.

Low-carbon health systems Health systems that are capable of implementing transformative strategies towards reducing greenhouse gas emissions in their operations, reducing short- and long-term negative impacts on the local and global environment.

Mitigation (of climate change) A human intervention to reduce emissions or enhance the sinks of greenhouse gases.

Net-zero emissions Net-zero emissions are achieved when greenhouse gases emitted into the atmosphere are balanced by anthropogenic removals. Where multiple gases are involved, the quantification of net-zero emissions depends on the climate metric chosen to compare emissions of different gases, such as global warming potential or global temperature change potential, and the chosen time horizon.

Operational boundary The activities and sources of emissions sources included in an assessment of emissions.

Organizational boundary The organizations and institutions included in an assessment of emissions.

Resilience The capacity of social, economic and environmental systems to cope with a hazardous event, trend or disturbance, by responding or reorganizing in ways that maintain their essential function, identity and structure, while maintaining the capacity for adaptation, learning and transformation.

Universal health coverage Where all people have access to the full range of high-quality health services they need, when and where they need them, without financial hardship. It covers the full continuum of essential health services, from health promotion to prevention, treatment, rehabilitation and palliative care across the life course.

Executive summary

Why greenhouse gas measurement matters

Climate change is a growing health crisis, driving increased mortality from heat, malnutrition, and disease, and placing increasing pressure on health systems worldwide. Despite the Paris Agreement goal of limiting long-run warming to 1.5 °C, global temperatures have already exceeded this threshold over the course of a single year *(1)*. The health sector contributes to approximately 5% of global emissions *(2)*. It is imperative that health systems rapidly prepare for further increases in global temperatures, while also reducing their own carbon footprints.

Efforts to improve measurement should not delay action. Proven decarbonization interventions can and should be implemented immediately, even as measurement systems are being developed.

Measurement of greenhouse gas (GHG) emissions is central to credible decarbonization planning over the long term. It enables target-setting, identification of emissions hotspots, design of interventions, public accountability, and tracking of progress over time. Without GHG emissions measurement, action risks being misdirected, unaccountable, ineffective or insufficient to meet national and global climate targets.

Purpose of this guidance

This document has two aims. First, it defines a common approach for health system emissions measurement that is aligned with international standards and best practice. Second, it sets out how health systems can develop the necessary internal capabilities to measure their emissions consistently and effectively over time.

The document is limited to emissions measurement and closely related activities such as emissions reporting and boundaries, target-setting, quality assurance and data governance. For practical operational guidance on delivery of decarbonization programmes, the World Health Organization (WHO) *Operational framework for building climate resilient and low carbon health systems* outlines how health systems can systematically reduce their emissions and build resilience to increasing climate risks *(3)*.

Practical case studies of high-impact decarbonization actions are available on the Alliance for Transformative Action on Climate and Health (ATACH) community of practice website *(4)*. This document is complemented by the work of other ATACH task teams that are developing additional material to support climate-resilient and low-carbon health systems.

Detailed standards for organizational emissions accounting, base year assessment and target-setting that may be applied to health systems include the Greenhouse

Gas Protocol (GHG Protocol) Corporate Accounting and Reporting Standard *(5)*, ISO 14064–1:2018 *(6)* and the Science Based Targets Initiative (SBTi) Corporate Net-Zero Standard *(7)*.

Defining a health system's emissions

Health systems must clearly and publicly define three components of a footprint for a base-year emissions assessment:

- Organizational boundary: the organizations and institutions included. Expenditure is the most consistent and comprehensive way to define the health system boundary in practice.
- Operational boundary: the activities and emissions sources included. By default, emissions of all GHGs across the entire domestic and international GHG footprint of the health system should be included (i.e. aligned with Scopes 1–3 of the GHG Protocol).
- The base year of a first assessment should be the most recent typical year of system operation with comprehensive data availability. In practice, this year typically lies within five years of the publication date for a first assessment. If possible, countries should avoid using years affected by COVID-19 or other external shocks as base years. If robust time series data are available, older base years may be appropriate in some contexts.

Maturity framework

If the world is to reach net zero, emissions measurement must become routine across all sectors, including health care. Rapid and significant progress can be made with modest resources, but sustained action requires routine and embedded measurement integrated with existing systems and led by in-country technical teams.

This guidance introduces a five-stage maturity framework for assessing and developing these capabilities. The stages are applied across six key dimensions of emissions measurement: base-year emissions definition; footprint modelling; data collection and management; monitoring and reporting; technology requirements; and aspects of emissions data governance.

The framework is a practical tool to guide self-assessment and drive continuous improvement of emissions measurement capabilities. This is not a one-size-fits-all approach, and it allows systems to identify the next appropriate meaningful step in developing GHG measurement.

For high-emitting and high-ambition health systems, reaching Stage 4 (systemization) is a crucial early step if net-zero commitments are to be taken seriously. The 10 key milestones to reach this stage are set out in Box 1. Failure to reach this level well before 2030 does not represent a gap in technical potential but demonstrates misalignment between stated ambition and actual delivery.

Next steps

To support the implementation of this guidance, the ATACH task team on emissions measurement will, in collaboration with partners, develop a series of in-depth technical briefs, case studies, reference material libraries and practical guidance targeted at analysts and technical leads working to deliver emissions measurement in real-world settings. Section 6 provides an example of technical guidance on developing GHG models in health systems.

Box 1. Stage 4 of the maturity framework: key milestones for high-emitting and high-ambition health systems

GHG measurement boundary

1. Published and comprehensive scope: a public document makes clear the base year; the organizational boundary, which is clearly mapped to a comprehensive account of national health system expenditure; and the operational boundary, which includes all Kyoto Protocol GHGs plus desflurane, sevoflurane and isoflurane, and all upstream supply chain emissions, including international sources. All the "must include" organizations and sources of emissions listed in Tables 2 and 3 are included in the boundary scope.

2. Base-year review: a public commitment has been made to review base-year emissions on a regular basis, ideally every five years. The first base-year assessment should be no more than five years earlier than its year of publication, except where robust historic data exist.

GHG modelling

3. High volume of activity data: activity data make up 15–50% of total emissions across all scopes, calculated using a hybrid model approach.

Data collection and management

4. Regular data collections: mandatory, standardized and regular whole-system data collections are in place to fill gaps in activity data.

Monitoring and reporting of carbon data

5. Regular publication: routine publication of emissions data every year (for emissions calculated on an activity basis) or every two years (for emissions calculated on a spend basis) are in place.

6. Monitoring and validating impact: emissions impacts of specific interventions and non-GHG indicators of performance (i.e. not only system-wide emissions totals) are tracked and published.

Technology

7. Model ownership: the GHG model and data infrastructure are fully owned, operated and updated by a technical team embedded in the health system.

8. High-quality, reproducible modelling: structured databases underpin the model, with version control, audit trails and clear processes for updating emission factors and assumptions.

Data governance, responsibilities, quality assurance and skills

9. Senior ownership: a named senior lead is responsible for health system emissions data and public reporting.

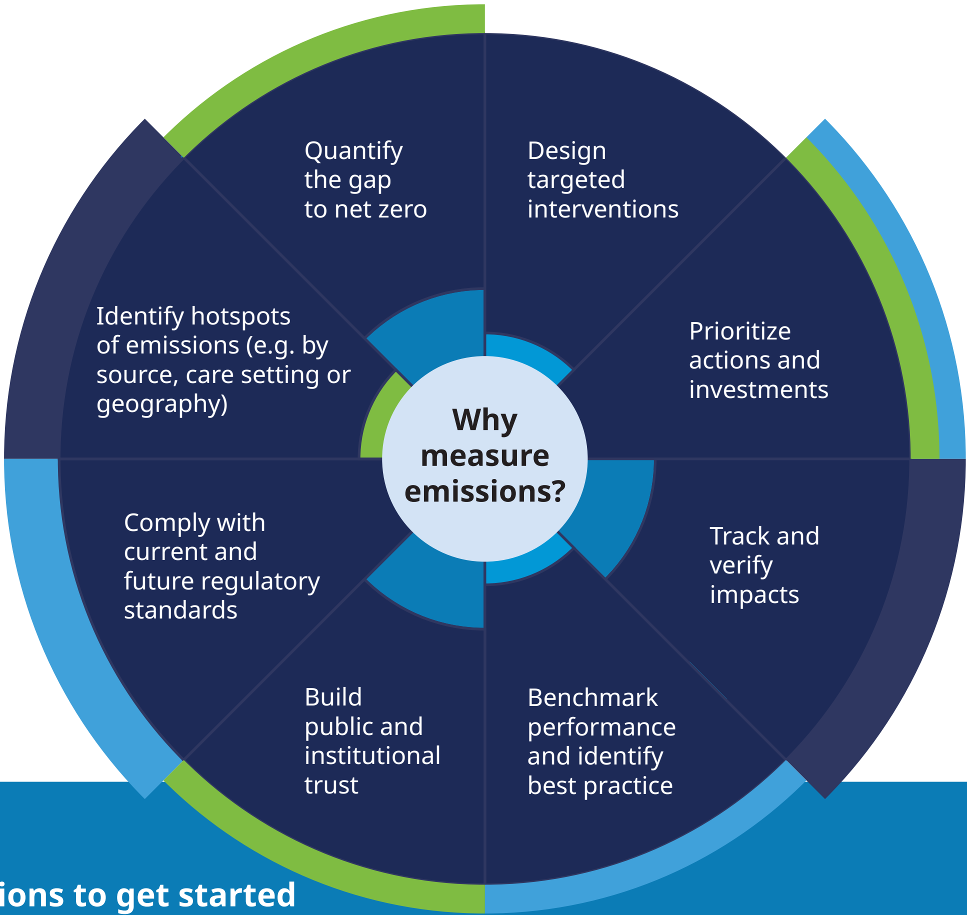
10. External review: third-party quality assurance, expert group, peer review or other external verification has been carried out for a published emissions calculation methodology.

References

1. State of the global climate 2024. Geneva: World Meteorological Organization; 2025 (https://library.wmo.int/idurl/4/69455, accessed 16 September 2025).
2. Romanello M, Walawender M, Hsu SC, Moskeland A, Palmeiro-Silva Y, Scamman D, et al. The 2024 report of the Lancet Countdown on health and climate change: facing record-breaking threats from delayed action. Lancet. 2024;404(10465):1847–1896. https://doi.org/10.1016/S0140-6736(24)01822-1.
3. Operational framework for building climate resilient and low carbon health systems. Geneva: World Health Organization; 2023 (https://iris.who.int/handle/10665/373837, accessed 16 September 2025).
4. ATACH community of practice. Alliance for Transformative Action on Climate and Health (https://www.atachcommunity.com/, accessed 16 September 2025).
5. The Greenhouse Gas Protocol: a corporate accounting and reporting standard, revised edition. Washington, DC: World Resources Institute and World Business Council for Sustainable Development; 2004 (https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf, accessed 16 September 2025).
6. ISO 14064–1:2018. Greenhouse gases. Geneva: International Organization for Standardization; 2018 (https://www.iso.org/standard/66453.html).
7. SBTi corporate net-zero standard. London: Science Based Targets Initiative; 2023 (https://sciencebasedtargets.org/resources/files/Net-Zero-Standard.pdf, accessed 16 September 2025).

Measuring greenhouse gas emissions in health systems: A snapshot

Measurement of greenhouse gas (GHG) emissions is critical to support health systems in reducing their contribution to the climate crisis, ultimately protecting our health.



Six actions to get started

START

Move now. Implement proven high-impact 'quick wins' that can reduce emissions in the real world, even as measurement systems are being developed.

Review data and begin to integrate it. Conduct a thorough review of all existing data sources and integrate what is most readily available into an emissions model.

Define what you are measuring. Agree and document a formal organisational boundary (who's included?) and operational boundary (what emissions are tracked?) and a base year for health system GHG emissions.

Plan to improve. Use the maturity framework to plan a strategy for improving modelling, collecting new data to fill gaps, reporting transparently, and using measurement to inform action.

Establish a first estimate. Look at external sources and/or produce a spend-based assessment to quickly get a system-wide estimate.

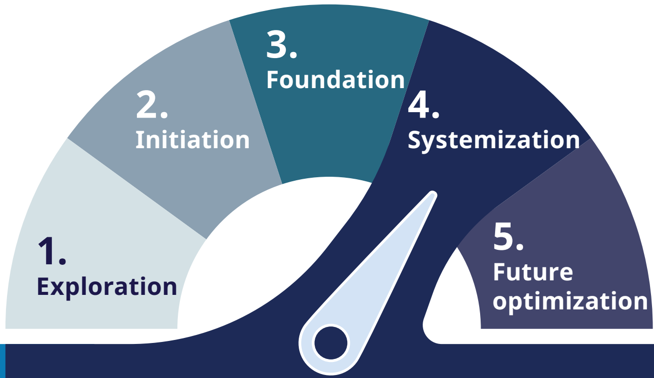
Get organised. Assign clear roles and responsibilities, and involve senior leadership early.

Maturity framework: key milestones for high-emitting and high-ambition health systems

This framework guides health systems through **five stages** of emissions measurement maturity. For **high-emitting and high-ambition** health systems, reaching these GHG measurement milestones is a crucial step if net zero commitments are to be taken seriously. Failure to reach this level of emissions measurement capability **well before 2030** would demonstrate misalignment between stated ambition and actual delivery.

The stages

Progress through five stages of measurement maturity



The dimensions Develop capability across core areas	**Key milestones** For credible net zero commitments, high-ambition health systems should aim to achieve these **milestones** by Stage 4 (Systemization)	
GHG measurement boundary	☐ Published and comprehensive boundary and base year that reflect the entire health system, all Kyoto Protocol GHGs and desflurane, sevoflurane and isoflurane, and international supply chains	☐ Base-year review commitment, ideally every five years
GHG modelling	☐ Activity data used to calculate 15-50% of all emissions	
Data collection and management	☐ Regular, mandatory and standardised data collections in place, calculated through a hybrid method	
Monitoring and reporting of emissions data	☐ Published monitoring and validation of specific interventions and non-GHG indicators of performance	☐ Regular publication of whole-system emissions data, at least every two years
Technology	☐ Model fully owned, operated and updated by the health system	☐ Quality, reproducible modelling using structured databases
Data governance, responsibilities, quality assurance and skills	☐ Third-party quality assurance, expert group or peer review, or other external verification of a published methodology	☐ Senior ownership of emissions data

1 Introduction and background

Audience:

Ministries of health, national health agencies, subnational health authorities and technical analysts.

Purpose:

This section sets out the health and policy context for this guidance and explains why routine, system-wide greenhouse gas (GHG) measurement is essential to support long-term decarbonization.

Key messages:

- Different health systems bear different responsibilities to measure and reduce emissions, depending on their current emissions footprint, climate resilience needs, system performance and resources.
- Measurement enables hotspot identification, gap-to-target quantification, prioritized investments, tracking and verification of interventions, benchmarking, trust and compliance.
- Quick wins are possible, but sustained progress requires embedded, in-country measurement.
- This guidance focuses strictly on measurement and should be read alongside operational decarbonization resources and guidance.

Climate change impacts our health in multiple ways, such as injury and death during extreme weather events, heat-related mortality, increased malnutrition from reduced food security, spread of vector-borne diseases to new regions, and strain on our health systems *(1)*. Although the landmark Paris Agreement in 2015 set an ambitious target of limiting global warming to 1.5 °C, current efforts have made insufficient progress towards this goal *(2)*. The GHG emissions of the health sector comprise approximately 5% of global GHG emissions *(3)*.

To reduce emissions at a rate consistent with the Paris Agreement, GHG measurement must become routine in all sectors, including health care. Health authorities must be engaged in national coordination mechanisms and contribute to climate planning processes, including the integration of health-sector commitments into nationally determined contributions.

1.1 Context of health system emissions

Health systems vary significantly in both overall performance and emissions profiles, with higher-performing systems contributing to far greater emissions. The World Health Organization (WHO) *Operational framework for building climate resilient and low carbon health systems* sets out five decarbonization and resilience pathways, based on each system's performance, proxied by the universal health coverage service coverage index and level of emissions (Table 1) *(4)*.

These differentiated pathways acknowledge that countries starting with low-emitting, underresourced health systems may need to prioritize performance and climate resilience, even if emissions may rise temporarily in some cases. In contrast, countries with high-performing health systems and high emissions must immediately work towards net zero.

In the long term, all countries should aim for a high-performance, net-zero, climate-resilient health system. This cannot be achieved without effective emissions measurement.

Table 1. Pathways for strengthening climate resilience and low-carbon sustainability of health systems

Area	Health system performance[a,b]	Health-sector GHG emissions[c]	Climate resilience and low-carbon pathways
1	Low	Low	Focus on climate resilience while adopting sustainable low-carbon technologies
2	Medium	Low	Strengthen climate resilience while introducing sustainable low-carbon interventions
3	Medium	Medium	Strengthen both climate resilience and low-carbon sustainability
4	High	Medium	Strengthen low-carbon sustainability while promoting climate resilient health systems
5	High	High	Focus on achieving net-zero emissions while continuing to promote climate resilience
Target	High	Low	Net-zero emissions and climate resilience by 2050

[a] For health system performance, **high** is preferable.
[b] Health system performance is represented by the universal health coverage service coverage index.
[c] For health-sector GHG emissions, **low** is preferable.

Source: Operational framework for building climate resilient and low carbon health systems. Geneva: World Health Organization; 2023.

1.2 Why measure emissions?

Effective measurement of GHG emissions is foundational to reaching net zero in health systems (Fig. 1). Measurement allows health systems to:

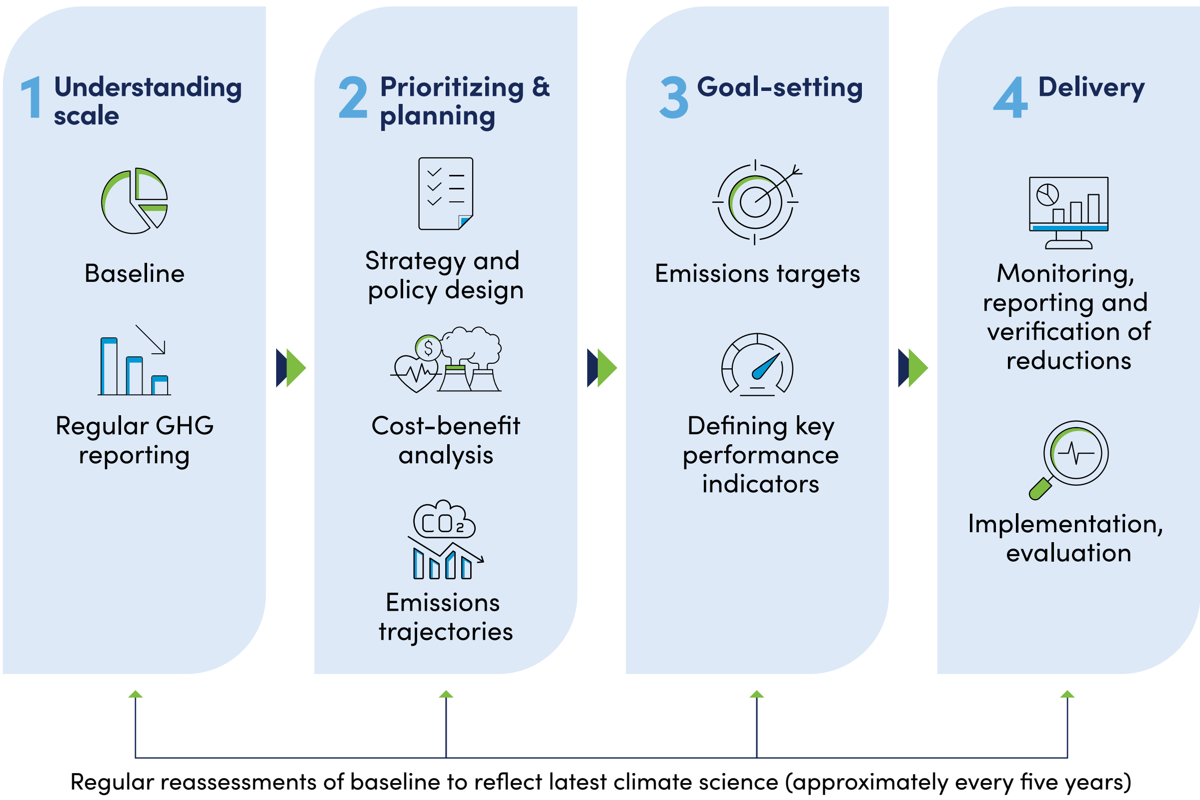
- identify hotspots of emissions (e.g. by source, care setting or geography);
- quantify the gap to net zero and the average rate of reduction required to get there;
- design targeted decarbonization interventions in the health system;
- prioritize actions and investments based on lifetime costs, cost savings, GHG impacts, and health and other societal co-benefits;
- track and verify impacts of decarbonization interventions;
- benchmark performance both within a system and internationally, identifying areas of best practice in delivery of low-carbon health care;
- build public and institutional trust in decarbonization strategies and efforts;
- meet regulatory standards with existing and growing national, financial, industry or other emissions reporting requirements in the future.

Rapid and significant emissions reductions can be made with modest resources, but sustained action requires routine and embedded measurement integrated with existing systems and led by in-country technical teams. Emissions measurements should be integrated with efforts to build climate resilience and improve performance, especially in lower-emission and lower-performing systems.

All countries can immediately pursue proven interventions, using emissions data to validate, improve and scale efforts over time.

Health systems will progress their measurement at different paces, and partial or stepwise measurement is still valuable. Modelling the emissions of a health system is a complex task that relies on assumptions, spend-based emission factors, and other modelling choices that introduce inevitable uncertainty into estimates. Countries must not wait for "perfect" data to make interventions but should develop capabilities over time. Insufficient modelling efforts, however, cannot be accepted indefinitely, especially in the health systems that bear the greatest responsibility for historical and current emissions.

Fig. 1. Roles of GHG measurement in supporting health system decarbonization



Source: Centre for Sustainable Medicine, National University of Singapore.

1.3 Alliance for Transformative Action on Climate and Health (ATACH) task team on measuring GHG emissions in health systems

This guidance was developed by the ATACH task team on measuring GHG emissions in health systems.

ATACH task teams

ATACH is a WHO-hosted platform leveraging the collective power of member countries and areas and non-state actors to support the implementation of climate-resilient and low-carbon sustainable health systems and promote healthy climate action in key health-determining sectors. ATACH task teams are established based on identified country needs and bring together ATACH members to develop specific technical products that support country-level implementation of climate change and health priorities. See the ATACH community of practice website for more information (https://www.atachcommunity.com/).

The task team was convened through an open call for expressions of interest from ATACH members, including representatives from ministries of health and technical institutions working on GHG assessments in health systems and facilities. Contributors to the task team were selected based on a set of criteria to ensure technical capacity and experience relevant to the scope of the guidance. The process for developing this guidance included:

- reviews of grey and peer-reviewed scientific literature on GHG emissions assessment, both inside and outside of health care;
- reviews of existing assessments completed by countries to identify best practices and approaches;
- building on previous technical guidance developed by WHO with expert input, such as the *Operational framework for building climate resilient and low carbon health systems (4)*;
- consultation with and technical input from leading experts in GHG emissions assessment and monitoring, particularly as applied to health systems, facilities, and products. These experts came from academic and research institutions, public administration, nongovernmental organizations, and independent consultancies, all with a proven track record of developing, supporting, and/or implementing GHG emissions assessments in health systems, facilities, and products;
- iterative drafting and review of the guidance by a core team of authors from the organizations co-leading the task team, with multiple opportunities for inputs from expert contributors engaged in the task team. Inputs were collected through feedback meetings and surveys circulated to the task team at the onset, midway and final stages of the guidance development process.

2 Scope and boundaries of health system emissions measurement

Audience:

Ministries of health, national health agencies, subnational health authorities and technical analysts.

Purpose:

This section sets out how to define a health system for emissions measurement purposes.

Key messages:

- ☑ Health systems should be defined broadly consistently, but should also reflect how each country understands the health system.
- ☑ Use comprehensive financial accounts to define an organizational boundary.
- ☑ Consider materiality, influence, dependency and data availability to guide inclusion of organizations.
- ☑ The operational boundary should include all international and domestic emissions (aligned with Greenhouse Gas Protocol (GHG Protocol) Scopes 1–3 or ISO 14064–1 Categories 1–5) and all Kyoto Protocol gases, plus desflurane, sevoflurane and isoflurane. Other activities should and could be considered for inclusion.
- ☑ Base years for new assessments should reflect the most recent "typical" year of operations with available data, with review roughly every five years and, where necessary, a public restatement of base-year emissions. At the time of publication in 2025, the most appropriate base year for countries that are yet to develop a base-year assessment is likely between 2021 and 2025.

A base-year assessment provides a consistent reference point for measurement, targets, progress tracking and effective planning. A GHG inventory is a regular (typically every one or two years) publication of emissions that can be compared with the base-year assessment over time. These reports are often accompanied by other, non-GHG key performance indicators associated with decarbonization progress. Base-year assessments and GHG inventories should be defined and modelled using consistent methods to enable meaningful comparison.

Multiple standards provide strict criteria and definitions on emissions inventories (e.g. GHG Protocol, ISO 14064–1:2018, and national and sector-specific standards). This document does not mandate adherence to a specific standard. Instead, it highlights common themes across these frameworks that are relevant for health systems. Standards will continue to develop and improve over time. In September 2025, ISO and the GHG Protocol announced a new partnership to align and merge parts of their accounting frameworks.

A health system base-year assessment has three components that should be clearly and publicly defined:

- Organizational boundary: the organizations and institutions included.
- Operational boundary: the activities and emissions sources included.
- Base year: the year of measurement against which future changes are measured.

There must be some flexibility in health system boundary definition to allow for individual contexts, but convergence in definitions is important. A consistent understanding of what is included in a health system footprint enables meaningful benchmarking and comparison and shared understanding of what decarbonization commitments mean.

Defining the boundary is also a governance task. A responsible authority – typically, a national ministry of health or designated health agency – should lead the process of definition. In practice, this definition also helps clarify who is responsible for measurement and oversight. In most cases, this is a national-level policy process, but responsibilities may need to be shared or negotiated in decentralized or cross-border contexts.

The sections below outline how to define boundaries, scopes and base years in a technically robust way, adapted to local contexts that reflect how the health system functions. These decisions will form the basis for all subsequent measurement activities, including methodology, data collection, reporting, technology and governance.

2.1 Defining a health system boundary (organizational boundary)

A health system boundary defines which organizations and institutions are included in an assessment of emissions. The goal is to capture the full scale and structure of the health system.

WHO defines a health system as "(i) all the activities whose primary purpose is to promote, restore and/or maintain health; (ii) the people, institutions and resources, arranged together in accordance with established policies, to improve the health of the population they serve, while responding to people's legitimate expectations and protecting them against the cost of ill-health through a variety of activities whose primary intent is to improve health" *(5)*.

Each country's health system is structured differently. Some countries include long-term residential care as part of the health system; in other countries, health and social care are managed as separate domains. In some countries, private health-care providers are peripheral; in other countries, private providers are central to the functioning of the health system. Boundary definitions should reflect these realities. A rigid universal definition is neither feasible nor desirable, but a high degree of consistency is still possible and necessary.

An expenditure-based boundary definition is the most consistent and comprehensive way to define the health system in practice – it reflects everything that happens in the system, regardless of provider type, ownership or funding source. This also enables easy alignment with spend-based emissions assessments that are the foundation of system-wide emissions modelling.

Approaches that rely on generic emissions calculators or that scale up estimates from samples of individual hospitals risk omitting substantial sources of emissions, such as centrally procured medicines and services, infrastructure development, or out-of-pocket health-care spending. These sources of emissions are not always visible at the facility level and may not be reliably inferred through sample data.

Countries are encouraged to use the System of Health Accounts as a point of reference for organizational boundary definitions *(6)*. WHO has worked with more than 190 countries to produce national health accounts (NHAs) built on the System of Health Accounts framework, which can serve as comprehensive and well-defined boundaries for health systems. If other country- or system-specific expenditure boundary definitions are used, health systems should be able to describe how their defined boundary maps to the System of Health Accounts framework, and clearly state a justification for any differences.

Table 2 summarizes the organizations that must, should and could be included in a health system's organizational boundary for emissions measurement purposes.

Table 2. Classification of actors and organizations for inclusion in a health system organizational boundary

Code	Description	Inclusion
HP.1	**Hospitals**	
HP.1.1	General hospitals	Must
HP.1.2	Mental health hospitals	Must
HP.1.3	Specialized hospitals	Must
HP.2	**Residential long-term care facilities**[a]	
HP.2.1	Long-term nursing care facilities	Should
HP.2.2	Mental health and substance abuse facilities	Should
HP.2.9	Other residential long-term care facilities	Should
HP.3	**Providers of ambulatory health care**	
HP.3.1	Medical practices	Must
HP.3.2	Dental practices	Must
HP.3.3	Other health-care practitioners	Must
HP.3.4	Ambulatory health-care centres	Must
HP.3.4.1	Family planning centres	Must
HP.3.4.2	Ambulatory mental health and substance abuse centres	Must
HP.3.4.3	Freestanding ambulatory surgery centres	Must
HP.3.4.4	Dialysis care centres	Must
HP.3.4.9	All other ambulatory centres	Must
HP.3.5	Providers of home health-care services	Must
HP.4	**Providers of ancillary services**	
HP.4.1	Providers of patient transportation and emergency rescue	Must
HP.4.2	Medical and diagnostic laboratories	Must
HP.4.9	Other providers of ancillary services	Must
HP.5	**Retailers and other providers of medical goods**	
HP.5.1	Pharmacies[b]	Must
HP.5.2	Retail sellers and other suppliers of durable medical goods and appliances	Could
HP.5.9	All other miscellaneous sellers and suppliers of pharmaceuticals and goods	Could
HP.6	**Providers of preventive care**	**Must**
HP.7	**Providers of health-care system administration and financing**	**Must**
HP.7.1	Government health administration agencies	Must
HP.7.2	Social health insurance agencies	Must
HP.7.3	Private health insurance administration agencies	Must
HP.7.9	Other administration agencies	Must
HP.8	**Rest of economy**	
HP.8.1	Households as providers of home health care	Could
HP.8.2	All other industries as secondary providers of health care	Could
HP.8.9	Other industries not elsewhere classified	Could
HP.9	**Rest of the world**[c]	**Could**

[a] Residential care homes for elderly people and providers of meal delivery services are classified under HP.8.2 even if these organizations also provide some nursing and/or personal care.
[b] This category includes only health-related activity in retail pharmacies – not all expenditure by pharmacies is included. Items such as cosmetics, dietetic products and natural products are excluded from health expenditure within a national health account.
[c] Such as citizens receiving medical treatment overseas.

National health systems should consider the following tests when deciding whether to include or exclude an organization or actor from the health system boundary. These three tests should be applied and considered together as a guide for inclusion:

- Materiality: does the entity or activity contribute significantly to total emissions? (For example, does a quick estimate suggest it would be above a 1–5% materiality[1] threshold of total activity or emissions?)
- Influence: does the health ministry have influence, oversight, regulatory control, financing responsibility or procurement responsibility over the entity or activity?[2]
- Dependency: is the entity or activity essential to maintaining health services? Would its absence require a substantive increase in activity elsewhere in the system to maintain coverage?

Where one or more of these criteria are met for an organization or actor, it should be included in the health system boundary, or its exclusion should be disclosed with a timebound plan to collect the necessary data to include it within the boundary in future. If an organization does not meet any of these tests, it may be considered outside of the boundary.

By default, all providers and enablers of health care should be included, but some pragmatic exclusions are acceptable where justified. For example, private providers may be excluded if they are not part of core delivery (e.g. if they are responsible for less than 5% of total activity, provided public-sector referral to and procurement of private services are still included); long-term nursing care may be excluded if it is considered separate from the health system (e.g. if it operates as part of a social care system under distinct legislative and governance systems); or health system administrative bodies (e.g. insurance agencies) may be excluded if emissions are minimal and data are unavailable. Where possible, health systems should quantify these sources of emissions to confirm that their exclusion does not materially affect the total footprint of the system.

Conversely, systems may choose to include some context-specific organizations that fall outside the NHA if relevant, such as medical education or research institutions, or emissions from the domestic manufacture of pharmaceuticals for exports – particularly if these organizations are under direct oversight of a health ministry and considered material to system functioning.

---

1 Materiality is context-dependent, but many international standards, including the GHG Protocol and Science Based Targets Initiative (SBTi), discuss a 5% threshold of total emissions as a reasonable basis for determining whether an exclusion materially affects the integrity of the boundary definition. A materiality threshold is not the same as a permissible quantity of emissions that an organization can leave out of its inventory. Health system boundaries are much more difficult to define than typical organizational boundaries under the GHG Protocol. In this context, the threshold should be treated as an indicative decision aid for boundary definitions rather than a rigid cutoff. It is referenced to ensure exclusions are transparent and to suggest an upper bound for what might be acceptable. Many sources of emissions that are under 5% can – and must – be included within a health system emissions assessment.

2 This is complementary to the GHG Protocol "equity share" and "control" approaches, which use a definition of control that works for companies but cannot easily be applied to complex health systems that typically involve thousands of individual companies and government bodies working in combination.

Case study

Baseline estimates of health system GHG emissions in Australia

Context

In 2023, Australia's first National Health and Climate Strategy was released *(7)*. This document outlines priorities for the following five years to address the health and well-being impacts of climate change, and to develop a sustainable and resilient health system that supports healthy, sustainable and resilient communities. One of the four core objectives of this strategy is health system decarbonization.

To achieve health system decarbonization, Australia identified the need to establish a clear understanding of the major sources of emissions within its health system.

Action taken

The Department of Health, Disability and Ageing used a hybrid assessment model to produce estimates of health system GHG emissions *(8)*. This model combined activity-based estimation and environmentally extended input–output assessment methods to provide a comprehensive national view of baseline health system emissions.

Defining the boundary was an important first step for this estimation. The health system boundary was defined using the Australia and New Zealand Standard Industrial Classification and the 116 input–output industry groups, as defined by the Australian Bureau of Statistics. Specifically, the health system was defined to encompass three input–output industry groups:

- 8401 – health-care services (hospitals, general practice and specialist medical services).
- 8601 – residential care and social assistance services (aged-care residential services and social assistance).
- 1801 – human pharmaceutical and medicinal product manufacturing (manufactured pharmaceutical and medicinal products for human use).

A range of data sources were used to generate production-based (Scope 1) and Scope 2 emissions estimates, including the national inventory by economic sector and data from the National Greenhouse Energy and Reporting Scheme. To generate Scope 3 emissions estimates, the production-based estimates from the national inventory were combined with national accounts (expenditure) data using multi-regional input–output (MRIO) analysis to map emissions to consumption sectors, with deductions made from the resulting consumption inventory to avoid double-counting of Scope 1 and Scope 2 emissions.

2.2 Defining emissions scopes (operational boundary)

Once an organizational boundary is set, health systems must identify which emissions-generating activities to include. These should cover all direct and indirect emissions, broadly aligned with Scopes 1–3 under the GHG Protocol (Box 2) or Categories 1–5 of ISO 14064–1, and reflect the full international lifecycle emissions of goods and services used and disposed by the system.

By default, all sources of emissions should be considered for inclusion, with any exclusions explicitly stated and justified. Table 3 categorizes these activities into "must include", "should include" and "could include" sources of emissions, with some illustrative examples of the activities that fall into each category.

Table 3. Classification of emissions sources for inclusion in a health system operational boundary

Sources of emissions	Illustrative examples in care settings (not exhaustive)
Must include	
Emissions of all GHGs under the Kyoto Protocol – carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, nitrogen trifluoride – plus desflurane, sevoflurane and isoflurane.	Direct release of desflurane in an operating theatre Emissions of carbon dioxide from a natural gas power plant that provides electricity to a hospital through the grid Methane emissions from cattle used to produce meat served in a hospital canteen
Emissions from direct burning of fossil fuels or waste (Scope 1) and the emissions it takes to produce them (Scope 3 well-to-tank)	Diesel burned in an engine to drive an ambulance Natural gas burned in boilers to heat water Diesel burned in generators to power a hospital or provide backup power
Emissions from the direct release or leakage of GHGs (Scope 1)	Release of nitrous oxide to the atmosphere during use in a maternity ward or leaked from manifold systems Leakage of hydrofluorocarbon refrigerant gases from an air-conditioning unit
Emissions generated to produce electricity, heat, cooling or steam (Scope 2) used by the health system, and the emissions it takes to produce required fuels and distribute the energy (Scope 3 well-to-tank)	Use of electricity to light and run office equipment in a primary care practice, purchased from the grid Heating a nursing station with steam supplied by a nearby factory
Emissions generated to produce, transport and distribute every good and service the health system uses, including international supply chains (Scope 3)	Emissions to treat and distribute the water used by a hospital All emissions generated domestically and overseas to manufacture, package and transport a pack of paracetamol to a hospital's pharmacy (from raw materials to the shelf) All emissions generated domestically and overseas associated with the services of an outsourced cleaning company A newly purchased MRI scanner, where embodied carbon was generated during manufacture and transport
Emissions from use and disposal phases of the highest-carbon medicines – volatile anaesthetic gases and nitrous oxide) (Scope 1) and metered-dose inhalers (Scope 3)	Propellant hydrofluorocarbon gases released during the regular use of a metered-dose inhaler Propellant gases released when disposing of a half-used metered-dose inhalers Direct release of nitrous oxide in an operating theatre or leakage from manifold systems

Sources of emissions	Illustrative examples in care settings (not exhaustive)
Must include	
Treatment and disposal of waste and wastewater generated by the health system (Scope 1 if treated on-site; Scope 3 if treated off-site)	Transport and landfilling of general waste from hospital wards, including methane emissions during landfilling Autoclave treatment and incineration of hazardous medical waste
Business travel of staff for work purposes outside of normal commuting (Scope 3)	Hospital executive taking a return flight to an international conference paid for by the health system District nurse driving a personal vehicle for in-community visits and being reimbursed for travel expenses
Staff and patient travel to and from health-care sites (Scope 3)	Nurse driving a petrol car to and from work at a local clinic Patient taking a public bus to and from an outpatient appointment
Should include	
Public-funded health-care imports (Scope 3)	Citizen receiving specialist care abroad that is funded, prescribed or otherwise recommended by the domestic health system
Disposal of medicines, medical devices packaging, and other goods dispensed to patients and consumed outside of health systems (Scope 3)	Landfilling of used prescription medicine blister packs disposed of in a bin at a patient's home
Market-based assessments of electricity emissions, only if reported alongside location-based (Scope 2)	Hospital purchasing verified renewable energy certificates for all its electricity consumption
Emissions from combustion of biomass, biofuels or biogenic wastes that are considered carbon-neutral on a lifecycle basis, but can be reported optionally (out of scope)	Biodiesel used in a backup generator Wood burned for heating and cooking in a rural health facility
Visitor travel to and from health-care sites where emissions are additional (Scope 3 or potentially out of scope)	Family member travelling by taxi to visit a patient in hospital Note: if a patient and visitor drive together to and from an appointment, the emissions from the journey should be counted only once
GHG emissions associated with telehealth (Scope 3)	Home energy use associated with a remote consultation
Could include	
Other environmental, co-pollutant or co-benefits tracking (out of scope)	Air pollutant emissions from incinerators Plastic waste from single-use items Cooling or ozone-depleting substances not classified as GHGs Water usage footprint Public health benefits from increased walking and cycling to work
Voluntary offsets or carbon removals, only if reported separately; this must not be reported as "negative" emissions or count towards meeting targets (out of scope)	A high-quality, verified credit exists for a mangrove restoration project, but full gross emissions are reported without subtracting this offset effect
Private-funded health-care imports (e.g. citizens receiving care abroad, funded out-of-pocket or by private insurance) (Scope 3)	Patient flying overseas and paying out-of-pocket for an elective surgery
Investments (e.g. using Partnership for Carbon Accounting Financials guidance) (Scope 3)	Health system managing a pension fund that invests in oil and gas companies

Box 2. Emissions scopes and relevance for health systems

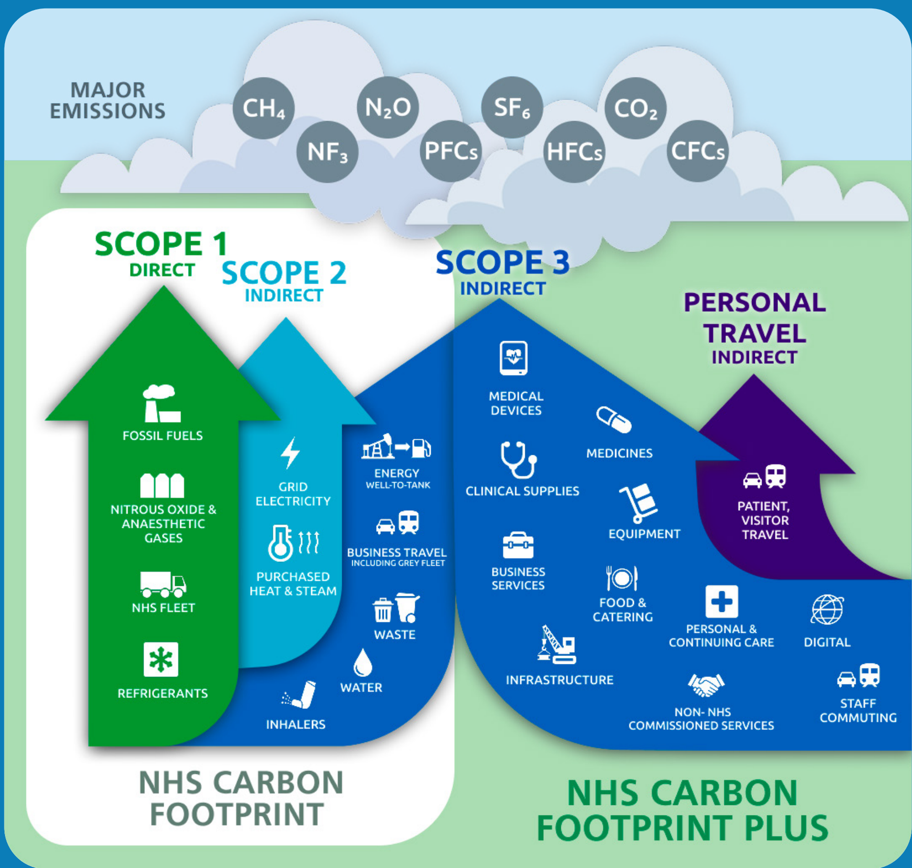
The GHG Protocol Corporate Standard classifies a company's GHG emissions into three scopes:

- Scope 1: direct emissions from owned or controlled sources.
- Scope 2: indirect emissions from the generation of purchased energy, including electricity, heat, and steam.
- Scope 3: all other indirect emissions that occur in the value chain of the reporting company, including both upstream and downstream emissions.

In practice, this terminology is typically useful only to an audience that already understands the GHG Protocol. Health system emissions reporting should use clear, consistent definitions, and avoid technical jargon where possible, to ensure data can be understood and used across the health system rather than only by technical specialists.

This may mean using terminology that is familiar to health workers (e.g. "metered-dose inhalers" instead of "Scope 3, Category 11: use of sold products"), although tracking emissions by scope is useful for compliance reasons.

Fig. 2. GHG Protocol scopes in the context of the National Health Service (NHS)



Source: Five years of a greener NHS: progress and forward look. London: NHS England; 2025

2.3 Defining a base year

The base year is the reference point against which a health system can benchmark future changes in emissions. If a base-year assessment has not yet been carried out, it should be the most recent year with comprehensive, representative data on health system activity.

The optimal base year for each health system will vary between countries and local contexts. At the time of writing this publication, the base year is likely to fall between 2021 and 2025 for new assessments. Comparisons between health systems across this range of reporting periods are still valid – utility and transparency of base years is more important than international uniformity.

Several secondary considerations may apply when selecting a base year:

- Atypical years for the health system that distort scale or composition of emissions should be avoided where possible, such as years affected by COVID-19, major one-off capital infrastructure projects, or periods where systems were affected by natural disasters, conflicts or other factors.
- If year-on-year volatility or data gaps exist, a multiyear average may offer a more stable reference point, although this will make calculations more challenging.
- A financial or calendar year may be selected based on the health system's data and reporting cycles.
- Consistency with national base years may be important (e.g. if a government has established a specific base year for public-sector decarbonization).

In general, a fixed-target base year is recommended, because it allows emissions data to be compared on a like-for-like basis over a longer timeframe. Some health systems, however – particularly those undergoing rapid expansion – may opt for a rolling base-year approach. This method, described by the GHG Protocol *(9)*, shifts the base-year period forward at regular intervals and is designed for organizations where the boundary is frequently expanding or contracting. A rolling base-year approach requires greater technical capabilities and resource commitments than a fixed-year approach.

Health systems should avoid using long-term historical base-year assessments if this prevents the use of high-quality health system data. Although a 1990 base year is used in international climate commitments,[3] this is not usually appropriate for health systems because it does not reflect the current structure or functioning of the health systems and typically requires back-casting of data. These historical base-year assessments, however, can provide a useful, globally stable reference point for comparisons with national targets or estimation of cumulative historical emissions.

Health systems should be prepared to recalculate base-year emissions when significant methodological changes occur or on a routine cycle (typically, every five years), to ensure the benchmark remains relevant and fit for purpose. Base-year emissions should be recalculated and restated when organizational or operational boundaries change, an improved methodology changes totals materially, a material error is discovered, or data quality improves substantially (Box 3).

---

[3] The 1990 base year was adopted by a number of countries under the Kyoto Protocol. This represents a consistent benchmark against which international emissions can be compared.

Box 3. Re-baselining and tracking emissions over time in the Science Based Targets Initiative (SBTi)

The SBTi provides summary guidance on how to reassess and, where necessary, recalculate base-year emissions *(10)*. The following steps are required:

1. Assess whether the changes in the GHG inventory represent 5% or more of base-year emissions. If this threshold is met or exceeded, proceed to Step 2.
2. Recalculate the base-year emissions (known as re-baselining). Organizations should update their base years retrospectively to account for significant changes in accordance with the GHG Protocol.
3. Review any existing targets and assess whether they are affected by the base-year emissions recalculation.
4. The affected target(s) must be assessed to ensure they are still in line with SBTi criteria:
    - If the affected targets are still in line, the organization does not need to submit a formal target(s) update to the SBTi. In this case, if the base year, target ambition, method and target year remain the same, the organization is simply updating its base-year emissions.
    - If the affected targets are not in line, the organization needs to update its target(s).

The SBTi encourages organizations to maintain their existing base years. It acknowledges, however, that in some cases base years may no longer be representative of business activities, or historic data may not be available. If necessary, organizations can select a new base year that represents current business activities and has verifiable data, but they must provide clear evidence for the reasons behind selecting a new base year.

Case study

Assessing the carbon footprint of the National Health Service (NHS) in England

Context

The NHS in England provides publicly funded health services, delivering more than 1.6 million interactions with patients every day. This includes primary and community care, mental health care and hospital care.

In October 2020, the NHS in England became the world's first health system to commit to reaching net-zero emissions. Set against a 1990 baseline, this means:

- net zero for emissions that the NHS controls directly by 2040 – the NHS Carbon Footprint;
- net zero for the emissions that the NHS can influence by 2045 – the NHS Carbon Footprint Plus.

Action taken

Assessing the carbon footprint of the NHS in England is vital to enable identification and prioritization of actions to achieve the net-zero ambitions. The NHS has been analysing emissions associated with its activities since 2008, with continuous improvements to the approach over time.

NHS emissions calculated using a hybrid approach were reported in 2020 *(11)*. This process started with figures from the United Kingdom Government on total health-care spending, with staff, patient and visitor travel modelled separately. This ensured a comprehensive approach to emissions quantification. For emissions categories where detailed activity data and emission factors were available, these were used, with the relevant spend removed from the expenditure part of the model. The approach was published in *Lancet Planetary Health (12)*.

Methodological improvement has continued. The latest estimates of NHS emissions are now based on detailed expenditure data from individual NHS organizations. This combines the same comprehensive coverage of emissions, but also the ability to produce subnational breakdowns and analysis, which will support further targeting of mitigating action and better monitoring of progress over time. A higher number of emissions categories are now modelled with detailed activity data (including electricity and gas consumption, inhalers and anaesthetics, waste and water, and owned and leased fleet emissions). Emissions associated with fugitive refrigerant gases have been added into the model, so all the "must include" categories in Table 3 are now explicitly included, along with some of the "should include" categories. The updated methodology has been published to share the improved approach *(13)*.

Throughout, ensuring a clear boundary and scope for the emissions estimates has been key and has driven improvement in the methodology over time. It has also guided policy development, ensuring action is being taken across all high-priority areas of emissions *(14, 15)*.

3 Guiding principles for health system emissions measurement

Audience:

Ministries of health, national health agencies, subnational health authorities and technical analysts.

Purpose:

This section outlines eight core principles to guide emissions measurement in health systems.

Key messages:

- ☑ Following these principles helps support credible, effective and context-sensitive action on low-carbon health systems.
- ☑ Applied well, these principles will help support strategies that improve health outcomes, reduce operating costs and strengthen resilience, alongside credible emissions reduction.

3.1 Apply fair effort towards a common goal

Health systems have different responsibilities but a shared goal – advancing emissions measurement to support low-carbon, climate-resilient health systems.

As with broader global decarbonization, the principle of common but differentiated responsibilities and respective capabilities *(14)* should guide measurement efforts. This principle acknowledges the unequal distribution of the causes and impacts of climate change worldwide and the universal right to development, including the development of high-quality health systems that enable the provision of universal health coverage.

High-emitting systems, almost always located in higher-income countries, bear greater responsibility for climate change and have greater access to resources. These systems should take the lead in advancing measurement techniques and sharing their findings. Resource-constrained systems should focus on high-impact areas, balancing measurement with cost-effective decarbonization, expansion of universal health coverage, and improvements to climate resilience.

Early movers play a wider role. Their efforts build shared evidence, generate transferable insights, and support capacity-building through partnerships and sharing of data. As more systems begin to measure emissions, evidenced by the growing list of ATACH members completing base-year emissions assessments since 2020, the collective impact extends beyond individual countries *(16)*.

3.2 Measure with purpose

Emissions measurement should support decision-making rather than exist to be ticked off a checklist. GHG measurement should support prioritization, resource allocation, monitoring and accountability. The value of emissions measurement lies in the quality of decisions and actions it enables rather than in the volume or precision of the data it produces.

Establishing an emissions base-year assessment is a key step that enables the identification of hotspots of emissions across the system, supports strategic decarbonization action planning, informs decision-making, and allows meaningful progress tracking over time. Once a minimum viable standard is in place, teams should prioritize next steps by asking the following questions:

- What decision will this enable? Are near-term decisions being prioritized?
- Is measurement meaningful or just available?
- Could effort be better applied elsewhere?

3.3 Prioritize intervention over perfection

Waiting for perfect data risks delaying real progress – it is better to act on what is already known. Although measurement is essential, it must not be a barrier to progress. Health systems should act on what is already known, even if the carbon impacts cannot yet be fully quantified. Existing data should be reviewed and prioritized for emissions calculations, and any new data collections should focus on the highest-impact areas and minimize additional reporting burdens. Many high-impact interventions – such as expanding the role of renewable energy, improving energy efficiency, minimizing waste or addressing overprescribing – can be pursued with confidence even in the absence of detailed emissions data, because it can deliver cost savings, health co-benefits and efficiency improvements. The ATACH library of case studies of "first wins" highlights concrete examples of interventions that are effective and feasible and bring multiple co-benefits to improve health and efficiency *(17)*.

Every kilogram of avoided carbon dioxide equivalent (CO_2e) counts. Early action to reduce emissions builds momentum and demonstrates that progress is possible, even while measurement systems are maturing.

3.4 Align to global standards, adapt to local realities

Use recognized international methodologies to ensure credibility and comparability, while allowing for adaptation to local contexts. The health sector does not exist in isolation, and an established set of global, national and industry-specific standards for measurement and reporting already exist. These standards are designed to be comprehensive and rigorous, although none is designed specifically for health systems. An inability to meet every single technical specification of a standard does not invalidate the insights produced from an emissions measurement project, particularly when it meaningfully informs planning, prioritization and improvement.

Although these standards differ in focus and scope, they all encourage comprehensive and systematic emissions reporting. Flexibility ensures measurement approaches remain feasible, interpretable and relevant to how health systems function.

3.5 Report transparently and clearly

Emissions reporting should be as transparent and comprehensible as possible. This means clearly and publicly documenting system boundaries, data sources, assumptions, methodologies, peer reviews, institutional responsibilities and review cycles rather than only emissions data.

Reporting should use clear, consistent definitions and avoid technical jargon where possible. Using terminology that makes sense to health workers is likely to have greater impact than using standardized carbon reporting language (e.g. "metered-dose inhalers" rather than "Scope 3, Category 11: use of sold products").

Clear, audience-specific communication increases the likelihood of emissions data being understood, trusted and used across the health system rather than only by technical specialists. Health systems should aim to publish emissions updates regularly, ideally at a frequency aligned with other regular reporting, such as annual reports. High-emitting and high-ambition countries should, at a minimum, aim to publish annual updates.

3.6 Apply consistent methods and track changes

Consistency across reporting cycles is critical for assessing progress, identifying trends, and evaluating the impact of interventions. Health systems should establish clear governance and protocols for regular data collection, measurement and publication. Where updates to methods are required, these changes should be documented transparently and explained clearly.

As models grow in complexity, version control and structured analytical processes become essential. Without clarity on how models have changed, it is impossible to distinguish underlying emissions reductions from the artefacts of changes in methods. Health systems should document and disclose the data sources used for activity, expenditure and emission factors, and quantify uncertainty in emissions for both the national total and major sources of emissions.

3.7 Start pragmatically and improve

Measuring emissions is a new undertaking for almost all health systems, but most health systems already hold relevant data (e.g. energy bills, procurement, or pharmacy data) that can be converted into emissions insights. Initial estimates will likely rely on assumptions or sample data.

In the early stages of calculation, systems should aim to generate insights that can inform immediate action and decision-making. Small improvements can yield disproportionately large benefits. For example, conducting an audit of desflurane use could provide the evidence basis for rapid, targeted phase-out policies that achieve both carbon and cost savings.

Systems should commit to improvements over time by refining methods, expanding datasets and strengthening institutional capability.

3.8 Define boundaries broadly and refine

When establishing a base-year emissions assessment, it is better to start with a wide definition of what constitutes the health system and its boundary (see Section 2). This helps to ensure key emission sources are not missed and clarifies responsibility early on.

Health systems often have overlapping roles across public, private and supporting services. Defining the boundary broadly at the outset enables technical staff to identify data needs, understand the impact of distinct parts of the system, and make informed choices about where to target for improved measurement. It also puts systems in a better position to meet future reporting requirements – such as financial disclosures or statutory national reporting – which are likely to become more stringent over time.

Narrowing a boundary's definition in the future is far easier – technically and politically – than trying to expand it once initial reporting structures are in place.

4 Framework for building emissions measurement capability in health systems

Audience:

- Ministries of health, national health agencies, subnational health authorities and technical analysts.

Purpose:

- This section introduces a structured maturity framework to assess and strengthen GHG measurement capability over time.

Key messages:

- ☑ Current approaches vary widely. This framework can be used to self-assess, prioritize next steps, and plan improvements across six core dimensions of measurement.
- ☑ Progress will be incremental and uneven, with early efforts focusing on high-impact areas rather than perfection.
- ☑ The framework defines five stages, from exploration to future optimization, with high-emitting and high-ambition systems expected to reach systemization (Stage 4) before 2030 to keep net-zero commitments credible.
- ☑ At Stage 4, measurement is fully integrated into operations and reporting, enabling public tracking of intervention impacts and verification of progress.

Approaches to emissions measurement in health systems are highly varied, ranging from heuristic and global-average approaches to advanced, fully integrated national systems for monitoring and reporting GHG data. This variation reflects differences in development, resources, technical expertise, political will and prioritization. In some contexts, the barrier to improvement is capacity and resources; in other contexts, it is alignment and ambition.

This section introduces a structured maturity framework to help health systems assess and strengthen their GHG measurement capabilities (Table 4). It recognizes that health systems are at different starting points and there is no single path to improvement. It offers a structured way to understand progress across key building blocks, which will occur incrementally, and often unevenly, across different aspects of the emissions measurement landscape.

The framework supports health systems to:

- understand the first steps for developing GHG measurement capabilities, and how they could evolve over time;
- self-assess their current and planned levels of GHG measurement capabilities, identifying areas of relative strengths and weaknesses;
- provide a vision for what comes next – no health system today is measuring GHGs at the level of detail required to achieve net zero, so what is the future of emissions measurement likely to look like?

Early efforts should prioritize high-impact areas, avoid perfectionism and build foundations for improvement over time. For high-income and high-emitting systems, rapidly progressing to an advanced level of maturity is essential for decarbonization commitments to be credible.

4.1 Five maturity stages for emissions measurement

The framework defines five maturity stages of GHG measurement in health systems. These reflect how systems typically evolve from initial awareness to embedded, system-wide GHG tracking.

Stage 1: exploration – start here

In the first stages of GHG measurement, measurement activity is often ad hoc, dependent on small teams or individuals, and shaped by the data or tools that are most readily available. Systems at this stage may not yet have a defined plan for GHG measurement, but motivation and sufficient awareness exist to begin exploratory efforts. The focus should be on mapping what is available, identifying gaps and outlining next steps.

Stage 2: initiation – prioritize high-impact areas

A basic plan or framework starts to take shape, and efforts are made to improve high-priority areas – typically those with the most accessible data, such as whole-system expenditure or electricity consumption. Early roles and responsibilities are identified, and choices are made about modelling methods, tools or reporting formats. The focus is on securing early wins that demonstrate value, feasibility and the ability to improve measurement rapidly.

Stage 3: foundation – establish lasting capability

The system has built most of the technical, institutional and personal foundations for consistent measurement as a regular health system function. Clear standards, definitions and data processes are implemented to improve consistency and reliability of emissions measurement. Dedicated technical staff are trained to conduct emissions analysis, and emissions data governance structures and processes are formalized. Data collection, storage and quality assurance transition from ad hoc to routine practices. As a result, the system becomes capable of generating consistent, repeatable and transparent estimates of GHG emissions. Emissions measurement is not yet fully integrated into day-to-day reporting, but the essential infrastructure is in place for policy design and future improvements in measurement.

Stage 4: systemization – embed emissions in everyday reporting

High-emitting and high-ambition health systems should aim to reach this level as quickly as possible if their commitments to net zero are to be seen as credible.

Emissions measurement and reporting are no longer isolated functions but are integrated into the existing reporting systems used to manage whole-system performance. Measurement systems are aligned with financial, operational or clinical reporting, enabling routine and accessible reporting at the national – and ideally subnational – level.

Emissions data are reported publicly and used to guide future planning and validate the impact of past interventions. Reaching this stage will allow countries to move beyond broad pledges and deliver measurable, verifiable progress.

Reaching this stage requires planning, time and sustained investment in data infrastructure and workforce skills. It is, however, entirely within reach for advanced health systems, and is already being demonstrated in leading contexts. For high-emitting health systems in high-income contexts, failure to reach this level well before 2030 represents a gap not of technical potential, but of institutional ambition and alignment.

Stage 5: future optimization – improve and push towards net zero

This stage means doing what no health system has yet achieved: advancing measurement to the level where, if net zero were achieved, it would rapidly be reflected in emissions data. The milestones at this level are intentionally less clearly defined because actions remain under active development.

Systems at this level are likely to use increasing volumes of supplier-, category- and product-specific emissions data and detailed and complex analytics methods, and to link carbon metrics to health outcomes. Emissions data could be used dynamically to guide resources and support real-time decision-making. Measurement tools will be user-friendly and open-access and will improve over time. Skills will become more widespread, and health leaders will be held accountable for their progress on emissions reductions.

Reaching this stage is not only a technical challenge. It also requires strategic planning and deep integration of emissions data within the health system. Engaging in international collaboration to improve health system emissions measurement and accounting capabilities will increase the likelihood of countries reaching this level.

4.2 Core components of emissions measurement

The framework is used to outline the stages for five core dimensions critical to effective emissions tracking. This list of dimensions is not exhaustive and could be expanded in future:

- GHG measurement definition: the operational, organizational and time periods over which emissions are measured.
- GHG modelling approaches: the technical approaches and methodologies used to calculate emissions at the health system level.
- Data collection and management: the availability, granularity and quality of source data and processes that are in place to collect relevant data.
- Monitoring and reporting: how emissions (and related non-GHG indicators) are tracked and disclosed.
- Technology requirements: the digital infrastructure used to manage and process data.
- Data governance, responsibilities, quality assurance and skills: the institutional conditions that ensure quality, accountability and continuity in emissions data.

Table 4. Maturity framework for emissions measurement capability in health systems

1. Exploration	2. Initiation	3. Foundation	4. Systemization	5. Future optimization
GHG measurement boundary				
Exploratory work into boundary definitions carried out Initial mapping of national emissions estimates to health context	Internal definition of organizational and operational boundaries agreed using NHAs or other comprehensive assessment of national health system spend	Boundaries and base year are clearly and publicly defined in an assessment of base-year emissions Operational boundary includes all GHGs, covers upstream supply chain emissions, including international, and most "must include" elements from Tables 2 and 3 are included in the boundary	**Key milestone 1 –** published and comprehensive scope: a public document makes clear the base year; the organizational boundary, which is clearly mapped to a comprehensive account of national health system expenditure; and the operational boundary, which includes all Kyoto Protocol GHGs plus desflurane, sevoflurane and isoflurane, and all upstream supply chain emissions, including international sources. All the "must include" organizations and sources of emissions listed in Tables 2 and 3 are included in the boundary scope **Key milestone 2 –** base-year review: a public commitment has been made to review base-year emissions on a regular basis, ideally every five years. The first base-year assessment should be no more than five years earlier than its year of publication, except where robust historic data exist. Any discrepancy between the organizational boundary and the System of Health Accounts framework is clearly documented and justified	Base-year emissions are reviewed and, if necessary, recalculated after a defined period All changes in the new base-year definition, calculation or methodology since the previous publication are clearly documented
GHG modelling				
Emissions estimates produced using proxy methods (e.g. global studies or national emissions shares) Initial exploration of modelling approaches conducted	Spend-based estimate of system emissions produced using spend-based emission factors Piloted integration of activity data as available (e.g. surveys, individual facilities, or specific categories such as electricity)	Activity data make up 5–15% of total emissions across all scopes, calculated using a hybrid model approach Model is developed with emission factors designed for the country being modelled, especially for spend Methodology is fully documented internally and repeatable	**Key milestone 3 –** high volume of activity data: activity data make up 15–50% of total emissions across all scopes, calculated using a hybrid model approach Emissions model is fully traceable from each individual input data line to emissions output Emissions model is capable of disaggregation of emissions to subnational level (e.g. by care setting or geography) Emissions model uses a modular structure that can integrate new sources of activity data when they are collected Sensitivity and uncertainty analyses conducted	Increases in volumes of supplier-, category- or product- specific activity data are integrated over time Dynamic, modular emissions model with predictive analytics capabilities Model outcomes can be linked to wider analyses of health outcomes, cost-effectiveness and equity Integration of outputs with procurement and clinical decision-making tools

1. Exploration	2. Initiation	3. Foundation	4. Systemization	5. Future optimization
		Data collection and management		
Initial review of relevant data sources (e.g. procurement, energy) conducted	Thorough review of existing data carried out and some activity data collected Gaps in activity data identified and plans for regular data collections are in place New data collections initiated for high-impact sources on a whole-system or sample basis	Standardized data collection covers key additional emissions sources across the health system with high (>50%) coverage and response rates Data validation and completeness checks are embedded in data collection processes	**Key milestone 4 –** regular data collections: mandatory, standardized and regular whole-system data collections are in place to fill gaps in activity data Activity data are routinely shared back to submitters with associated carbon impacts Contextual performance indicators such as policy adoption, governance structures, or existence of local decarbonization plans are included in data collections Data collection supports benchmarking, routine model updates and performance monitoring	Real-time or near-real-time data collection for key data inputs Fully automated data pipelines from collection to model outputs Time lags between real-world activity, data collection, calculation and emissions reporting are increasingly short
		Monitoring and reporting of emissions data		
Initial internal or external reports on GHG emissions developed	Standardized reports or dashboards used for internal reporting At least one initial assessment of GHG emissions shared internally or published	Commitment and plans for regular, public emissions reporting are in place Benchmarking and targets are introduced for internal performance monitoring At least one initial assessment of GHG emissions is published	**Key milestone 5 –** regular publication: routine publication of emissions data every year (for emissions calculated on an activity basis) or every two years (for emissions calculated on a spend basis) are in place **Key milestone 6 –** monitoring and validating impact: emissions impacts of specific interventions and non-GHG indicators of performance (i.e. not only system-wide emissions totals) are tracked and published Emissions reporting is linked to sustainability strategies, and performance metrics, including non-GHG metrics, are used for both internal and public performance monitoring	Machine-readable emissions and non-GHG performance indicator data are readily available Near real-time monitoring of intervention impacts and returns on investment for carbon, cost and co-benefits Health system is held to account on performance against stated goals Processes for detailed post hoc evaluations of interventions are in place

1. Exploration	2. Initiation	3. Foundation	4. Systemization	5. Future optimization
		Technology		
Data and calculations handled manually and on an ad hoc basis (e.g. in spreadsheets)	Development of standard spreadsheet tools for emissions calculation and data storage	Core elements of the model are transitioned to structured databases, with some calculations still taking place in spreadsheets Infrastructure is in place for secure data storage and processing	**Key milestone 7 –** model ownership: the GHG model and data infrastructure are fully owned, operated and updated by a technical team embedded in the health system **Key milestone 8 –** high-quality, reproducible modelling: structured databases underpin the model, with version control, audit trails and clear processes for updating emission factors and assumptions Dashboards or other data platforms provide tailored access to emissions data for decision-makers at all levels of the health system Internal reporting integrates core health, procurement and finance systems	Seamless integration of emissions data with national health data and climate data systems Open API infrastructure for third-party sharing, innovation and research
		Data governance, responsibilities, quality assurance and skills		
Initial mapping of individuals, departments and agencies that own relevant data conducted	Early roles for GHG data ownership defined at organization or programme level Key staff have taken on introductory training or other learning in emissions measurement Ad hoc quality assurance checks introduced for early outputs	Roles and responsibilities for GHG data are formalized at multiple levels of the health system Dedicated team or focal point is fully trained in GHG measurement Internal quality assurance and review processes are standardized and implemented across reporting cycles	**Key milestone 9 –** senior ownership: a named senior lead is responsible for health system emissions data and public reporting **Key milestone 10 –** external review: third-party quality assurance, expert group, peer review or other external verification has been carried out for a published emissions calculation methodology GHG data responsibility is formalized across multiple levels of leadership structures of the health system A dedicated sustainability team or unit is responsible for system-wide GHG measurement Staff in all parts of the health system have access to emissions measurement training if needed for day-to-day working	GHG monitoring is fully integrated as a core function of regular health system reporting

5 Summary and next steps

Audience:

- ATACH task team members, technical teams, ministries of health, and academic and implementation partners.

Purpose:

- This section sets out how the task team will convert this strategic document into practical, adoptable guidance for measurement teams.

Key messages:

- ☑ The task team will coordinate across ATACH and publish modular, standalone technical resources aligned with this guidance.
- ☑ Early suggestions of future outputs are proposed.

The ATACH task team will continue to build on this work and collaborate with stakeholders by producing a suite of technical resources targeting the specific needs of these analysts. Resources will provide deeper technical guidance aligned with the more strategic boundary definitions, principles and maturity framework introduced in this document. The first of these resources is set out in Section 6.

The task team will consult with ATACH members to prioritize the most useful outputs and ensure alignment with needs, and work closely with other ATACH task teams to ensure consistent approaches and strengthen the coherence of sustainability guidance for health systems. These resources will be made available as modular, standalone documents that can be adapted and adopted by national systems.

The task team welcomes feedback and collaboration as this work continues, with the aim of strengthening collective capability and accelerating decarbonization across the global health community. Possible outputs include the following:

- Deep dives into components of the maturity framework: practical guidance on building capability across each of the dimensions, with options to expand.
- Selection and use of MRIO models in hybrid calculations: how to choose an appropriate MRIO model, align it with health accounts, and interpret its results.
- Identifying, sourcing and calculating emission factors: guidance on how to source, select, calculate and use activity-based emission factors into hybrid models.
- Reporting against targets: recommendations for tracking progress against targets over time and updating base-year emissions, aligned with WHO guidance on target setting *(18)*.
- Data governance, skills and responsibilities: clarifying ownership and quality assurance requirements, and resourcing needs.
- Technology and infrastructure: options for developing, maintaining and scaling emissions models, including software, data structures and integration with data infrastructure.
- Designing high-impact data collections: prioritization and design of data collections to fill gaps while minimizing reporting burdens.
- Turning data into action: estimating the potential impact of interventions on costs, emissions and co-benefits; developing business plans; evaluating progress; and decision-making.
- Dealing with uncertainty in emissions measurement: including data sampling, dealing with incomplete datasets, uncertainty associated with top-down/hybrid approaches, and calculating and reporting uncertainty estimates.

6 Technical guidance: developing a whole-system footprint model

Audience:

Technical analysts and sustainability programme leads in ministries, agencies, health systems and other health-care organizations.

Purpose:

This technical guidance provides a practical development pathway for building and improving a national whole-system footprint model with incremental improvements in complexity.

Key messages:

- ☑ The simplest models are spend-based (external publications or a national model mapped to health accounts and an appropriate MRIO model). These can rapidly improve to hybrid models by integrating activity data, removing overlapping spend and reconciling results.
- ☑ Use lifecycle-based and facility data as inputs to a hybrid model rather than substitutes.
- ☑ Consider future improvements to models throughout development cycles, including version control, subnational disaggregation, and routine methodological improvements to integrate new activity data.

This section is the first in a series of practical, technical resources to support analysts in implementing effective emissions measurement in health systems. These resources will evolve over time as experience grows and approaches are refined and may be updated as standalone documents.

A false equivalence is commonly made between top-down and bottom-up approaches to health system footprinting. In reality, only models that use a whole-system, top-down view – grounded in comprehensive health expenditure data and supplemented with detailed activity data where available (hybrid models) – can provide a complete, credible footprint of an entire system.

A footprint should assess the overall scale and composition of emissions across the entire health system. Models based on robust, comprehensive accounts of national health spending combined with spend-based emission factors tailored to local contexts offer the only robust foundation for a comprehensive footprint model. This approach ensures full system coverage from the outset, avoids the sampling biases inherent in facility-only collections, and provides a coherent modelling basis for future refinement.

As models mature, spend-based assessments hit functionality limits. They lack the precision and granularity needed to accurately track year-on-year changes in emissions, especially below national level or in detailed emissions categories. Spend-based models should therefore be supplemented with activity data wherever available. This shift forms the basis of a hybrid model that retains the breadth of spend-based assessment with the specificity of activity-based estimates.

Model infrastructure must be designed to allow the rapid integration of new activity data while eliminating related spend to avoid double-counting. These data may come from full-system reporting or be extrapolated from sample-based data collections, and may be paired with lifecycle assessment (LCA)-derived emission factors where applicable (Box 4).

Technical analysts should begin by reviewing existing global assessments of their emissions, and then build a first national model using top-down expenditure data. From here, activity data can be integrated when available, resulting in a progressively more detailed and precise hybrid model. This evolution from top-down estimates to complex and integrated hybrid modelling is fundamental to credible emissions tracking. It ensures early completeness, supports progressive improvement, and avoids the pitfalls of bottom-up-only approaches.

In contrast to this structured model development pathway, some health systems rely on tools or assessments developed by external organizations. Although these can offer rapid outputs – especially for a first assessment – they can also lack transparency, flexibility and alignment-by-design with national data systems. Methods, assumptions and emission factors may not be fully disclosed or appropriate for local contexts, especially in lower-income or import-dependent economies that are not well-represented in many input–output models. The most effective emissions measurement models will be built, owned and maintained by the health systems they serve.

Box 4. Combined role of system-wide models, LCAs and facility-based data collection

System-wide modelling based on expenditure is the only way to achieve a complete and credible assessment of a health system's emissions. It enables emissions to be assessed across the full health system using comprehensive national datasets such as NHAs or full-system ledgers. These models use structured financial data to ensure no part of the system is missed and can apply context-appropriate emission factors, produce outputs that reflect how ministries define the health system, and allow for rapid integration of activity data wherever available.

LCAs have a key role to play. Footprints of health system emissions are themselves a form of LCA. LCA approaches can also be used to analyse the impacts of individual products, processes or clinical pathways, and quantify emissions across the full lifecycle of functional units. Lifecycle-based approaches are already used in health system models to inform emission factors, especially where emissions are concentrated at the point of use. For example, they are highly effective in assessing emissions from fuel use, or the manufacture, use and disposal of metered-dose inhalers. Lifecycle-based approaches are valuable in hybrid models as a source of emission factors to link with activity data.

Facility-focused data collections and tools – from comprehensive data collections to calculator tools, samples and ad hoc data submissions – can also play an important supporting role in collecting data. They are useful for staff engagement, local intervention design, and collecting sample data for incorporation into national models. They cannot produce credible national footprints if used in isolation. These approaches are at risk of missing major emissions sources such as central procurement, informal care, or household out-of-pocket spending on health care. They typically rely on small sample sizes that may not be representative, and generic tools may use emission factors developed in high-income countries that are often inappropriate in low- and middle-income countries or import-dependent settings. There is a risk that these methods produce unstable estimates where totals increase as more data are collected and discovered, unless results are integrated into a structured top-down hybrid model.

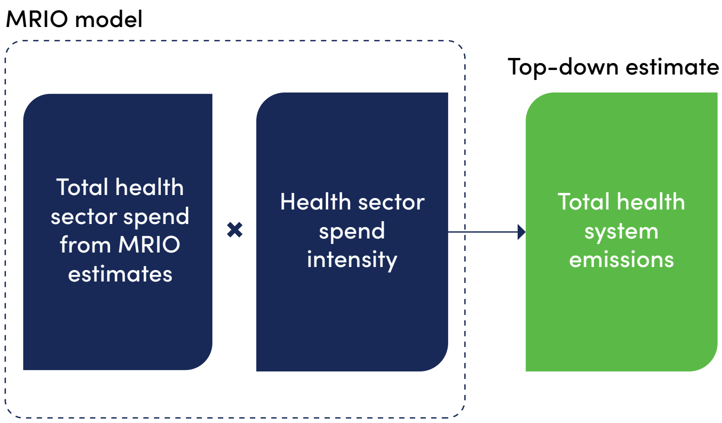
System-wide top-down (and hybrid) models based on expenditure are the only approaches capable of delivering a complete and reliable picture of health system emissions. LCA and facility-level analyses have valuable and complementary roles to play in whole-system measurement of health systems, but only as components within a broader framework.

6.1 An evolving data model of a health system footprint

This section describes the typical evolution of how health system emissions models work in terms of increasing model complexity. Each stage reflects a different way of structuring and using data to calculate emissions.

Importantly, a model at a later stage in this process is not guaranteed to be more accurate or more useful. A well-developed hybrid model at Stage 3, for example, could yield better results than a Stage 5 model if it contains a higher volume and quality of activity-based data to arrive at a national estimate of emissions.

6.1.1 Stage 1: top-down estimated expenditure model developed using only MRIO model insights

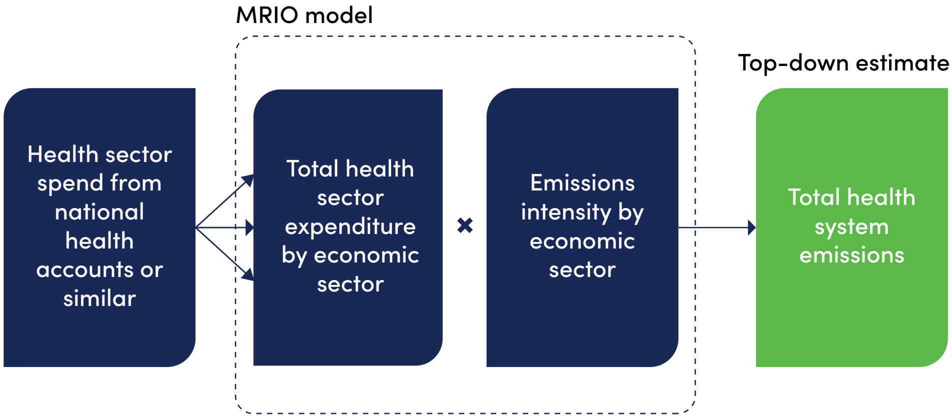


The simplest approaches to GHG modelling provide a high-level estimate of total health system emissions derived from MRIO models,[4] applied to total domestic health expenditure. These may come from high-quality estimates of global health-care emissions that break down results into national emissions, or from combining total health spending with MRIO-based emissions intensities across one or more economic sectors such as human health and social work activities. In its simplest form, this is the product of one expenditure value with the supply chain intensity of a relevant economic sector.

This approach offers a rapid and comprehensive system-wide estimate but is limited by its reliance on aggregated economic classifications, the "black box" of MRIO modelling. It also lacks the ability to disaggregate results by category or organization. In general, these estimates of health-care emissions are most accurate for large economies that are well-represented in input–output databases; they are less likely to be suited for smaller economies, countries with high import dependence, or countries with rapidly changing economies.

[4] MRIO models are economic models of global trade and transactions that link spending in different economic sectors and countries to the emissions created along their entire supply chains. In this context, they can be used to convert health system expenditure data into a complete, system-wide footprint of upstream GHG emissions. In the future, the ATACH task team will publish practical guidance on selecting, interpreting and using MRIO models for health footprinting applications.

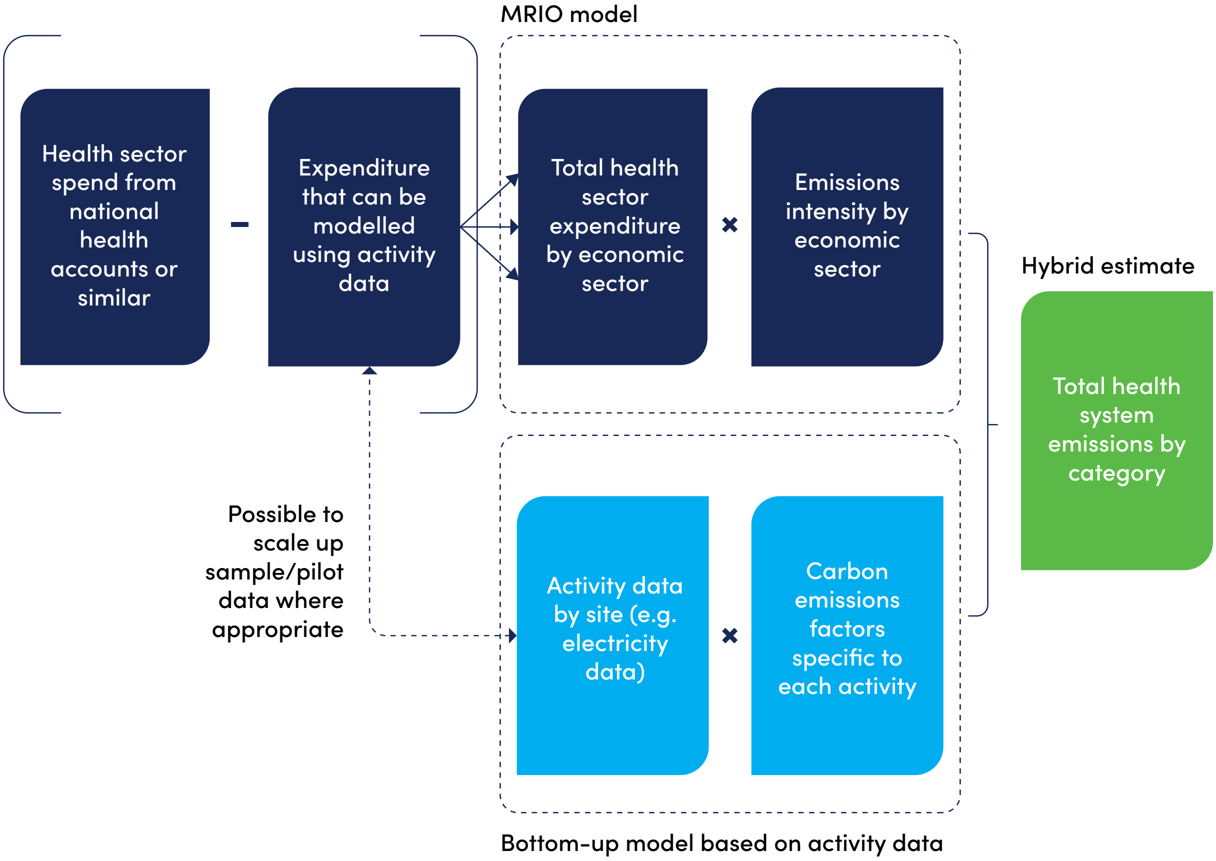
6.1.2 Stage 2: top-down reported expenditure model using health system accounts data



The second stage improves on a basic global model of a single sector by explicitly defining the health expenditure boundary using NHAs or similar data. These spend data can then be mapped to many domestic and international economic sectors, and non-carbon-generating lines of expenditure such as wages can be excluded. Care must be taken to align NHA data years with MRIO years to avoid misalignment in emission factor application. At this stage, MRIO models provide only the emissions intensities of spending. This approach provides a clear boundary definition and a detailed breakdown of emissions by expenditure category that can be traced directly from financial data, offering greater insight into the emissions hotspots of the system.

Care must be taken with MRIO-based approaches to ensure the use and disposal phases of products are captured properly. For example, spend-based multipliers from MRIO models for a petroleum products sector typically cover only the upstream supply chain emissions of manufacturing and transporting fuels (often referred to as "well-to-tank"), not emissions from combustion. For sources of emissions with significant use and downstream emissions contributions (such as fuels, anaesthetic gases or inhalers), spend-based emission factors should be adjusted to include these use-phase and end-of-life impacts. One practical approach is to estimate the average purchase price per unit (e.g. per litre based on local fuel prices) with an activity-based emission factor for consumption (e.g. an emission factor per litre of fuel), to create a composite factor that reflects both Scope 1 and Scope 3 emissions per unit spend.

6.1.3 Stage 3: hybrid model using readily available activity data

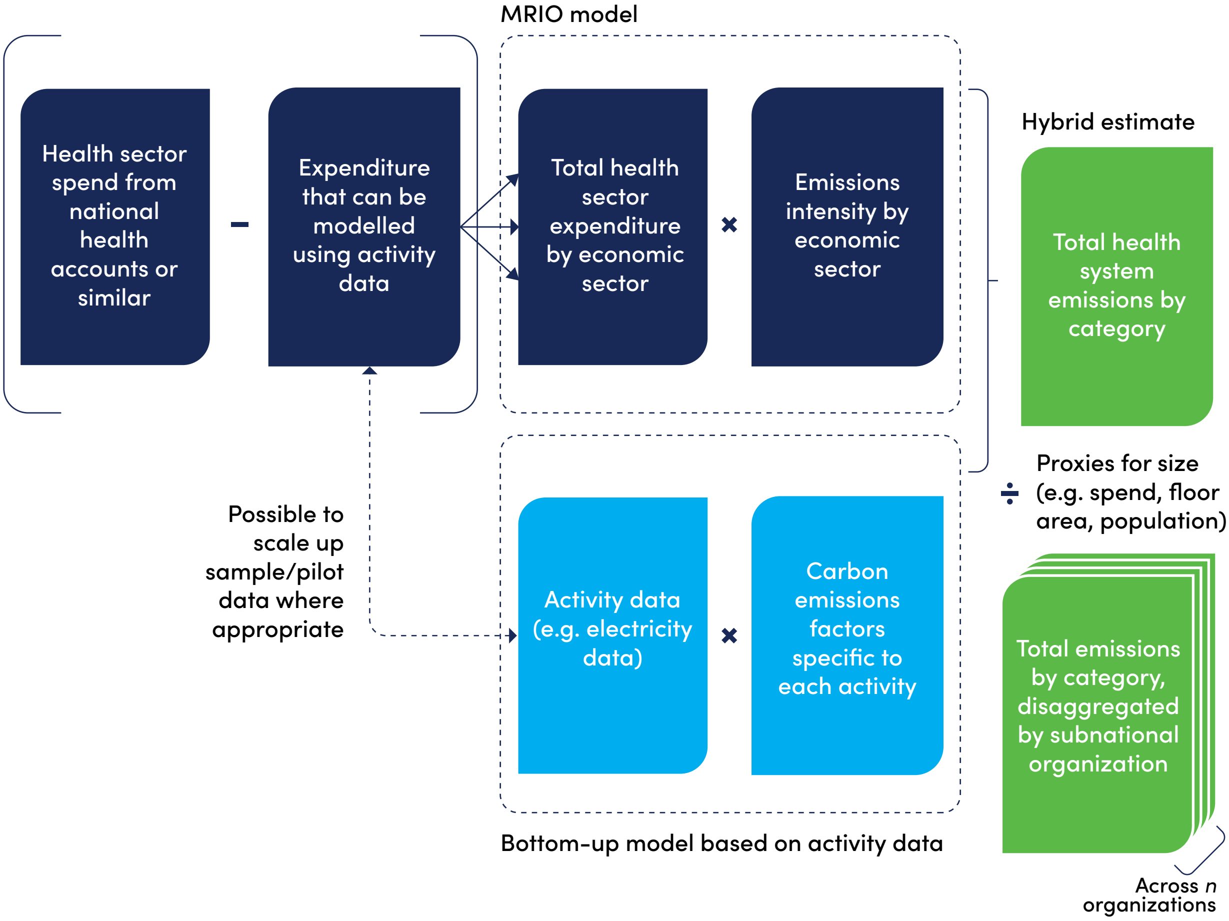


Building on the structured financial mapping of spend to economic sector in Stage 2, systems can begin to integrate activity data, such as metered electricity use or volume of anaesthetic gases, into a hybrid model. These datasets may be comprehensive or may use sample-based approaches to extrapolate the system's activity. If extrapolating sample activity data, this should be carried out with appropriate statistical approaches (e.g. weighted stratified sampling by facility type, to ensure all tertiary and secondary hospitals and primary care facilities are represented and treated as distinct sources of activity).

For any category where activity data are introduced, the corresponding spend-based emissions must be removed from the model to avoid double-counting. It is essential to validate that activity-based estimates align reasonably closely to the spend-based estimates they replace. Large discrepancies could suggest a data quality or methodological error, or could represent a structural difference between activity and MRIO-based approaches for that source of emissions.

Hybrid models offer significantly improved accuracy and relevance for intervention design and can enable year-on-year tracking in categories that use high levels of activity data. Over time, increasing volumes of activity data can be integrated into the hybrid model through new data collections.

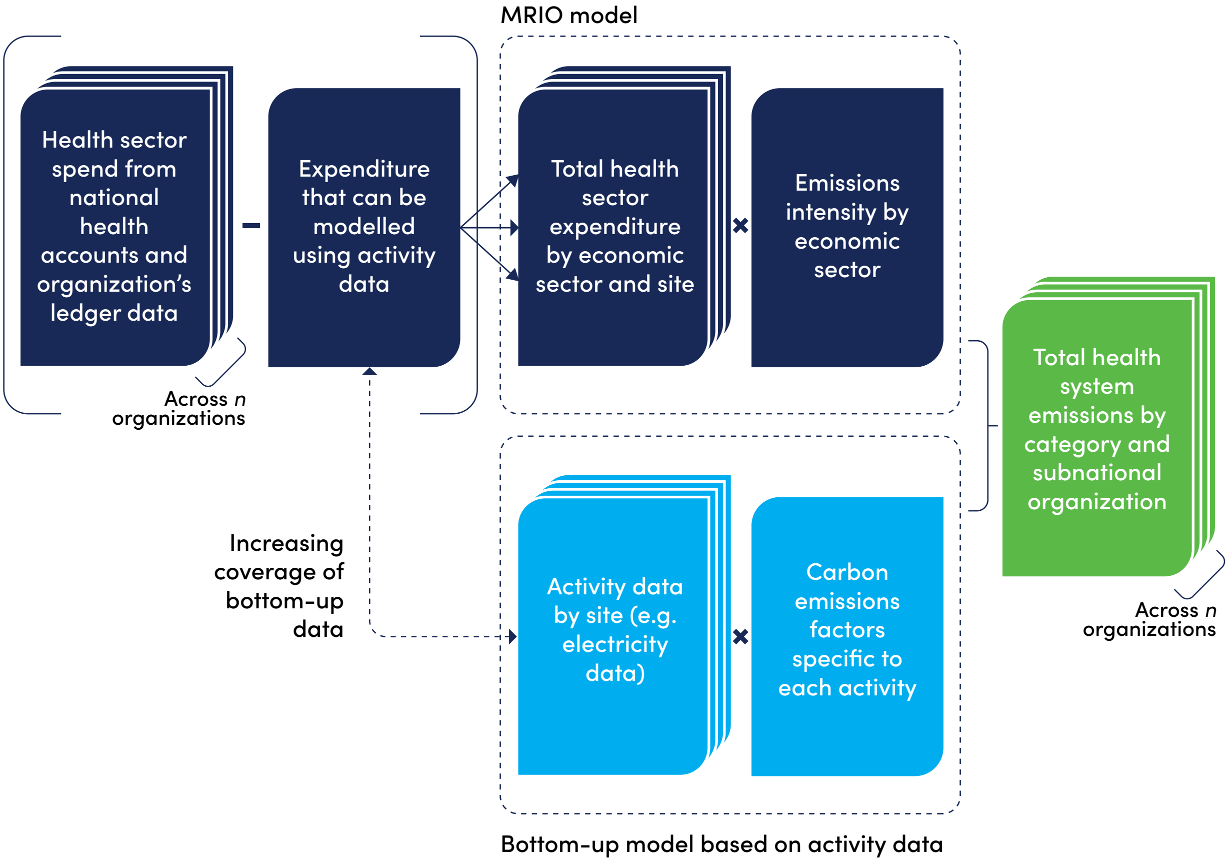
6.1.4 Stage 4: hybrid model disaggregated to subnational organizations



Beyond the continued development of a hybrid model by including increasing volumes of activity data, health systems also typically wish to calculate contributions to the national footprint from subnational organizations (e.g. secondary care versus primary care, or at the state, regional, local authority or site level).

The simplest way of doing this is to disaggregate national results using proxy data such as spend, population served, floor area or number of beds. These approaches are good for communicating what the contribution to a national footprint is, on average, for different parts of the health system, but they do not account for the true underlying variation between organizations' emissions intensities unless supplemented with local data.

6.1.5 Stage 5: subnational hybrid model calculated from subnational financial data



The final stage represents a fully disaggregated hybrid model, where each organization's expenditure and activity data are converted to emissions from the outset. This approach uses local expenditure and activity data – consistent with the national total – to break down emissions. Every spend line and every activity for every organization is linked to an emissions output, allowing a full and comprehensive approach that supports detailed intervention targeting and subnational reporting.

This five-stage framework illustrates how health system emissions modelling can evolve from basic top-down estimates to highly detailed, organization-level hybrid models. Early stages prioritize breadth of coverage via expenditure data, while later stages progressively enhance granularity, accuracy and utility by incorporating higher volumes of activity data and enabling detailed subnational disaggregation. Developing a model this way requires continued improvement across the other elements of health system measurement, including governance, reporting and data systems.

Case study

Measuring the greenhouse gas footprint of the health system in the Philippines

Context

The Department of Health in the Philippines is leading efforts to "green" the country's health system. The Health Facility Development Bureau of the Department of Health introduced the Green and Safe Health Facilities Manual to guide public and private health facilities towards resilience, sustainability and improved health outcomes *(19)*. This effort is supported by the Green Viability Assessment Tool, which enables the Department of Health to track and assess the performance of hospitals, clinics and other health facilities in key areas, including resource consumption, operational efficiency and climate resilience.

Building on these foundations, and in collaboration with Government agencies, regional authorities, health-care providers and international partners including the Asian Development Bank and the Centre for Sustainable Medicine, the Department of Health has undertaken the country's first base-year assessment of health system GHG emissions. The Philippines is one of the most climate-vulnerable countries in the world, and the Department of Health recognizes the urgent need to reduce health-care emissions while increasing resilience and improving access.

Action taken

The assessment uses a hybrid approach that combines facility-level activity data with national expenditure data. Hospital activity data collected through the Green Viability Assessment Tool, covering electricity, fuel, water and waste in more than 200 hospitals, were validated, aggregated and extrapolated to calculate activity-associated emissions for all secondary health-care facilities nationwide.

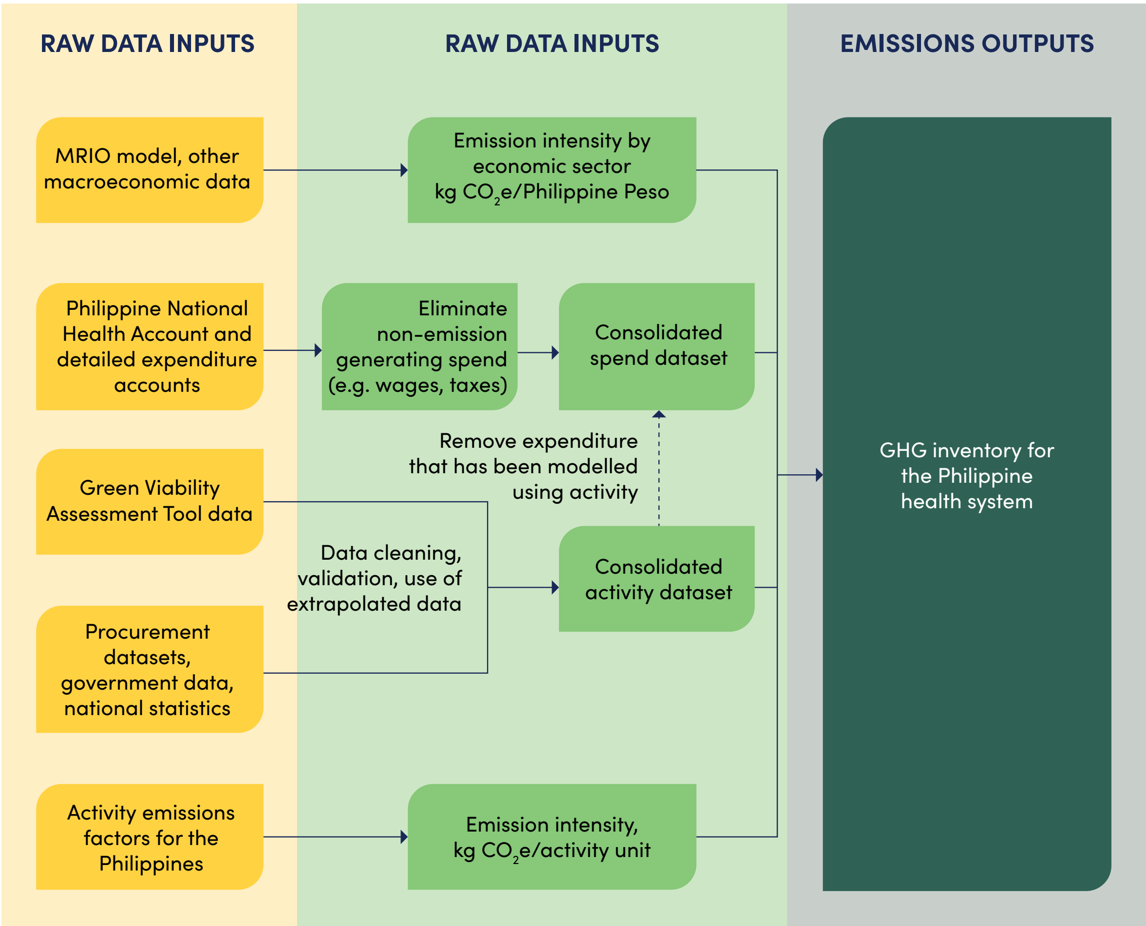
The Department of Health worked with other national and regional agencies and institutions (including the Climate Change Commission, the Department of Energy, the Philippine Statistics Authority, regional centres for health development and individual hospitals) to develop a detailed expenditure dataset for the entire health system. The Philippine National Health Account is the foundation for understanding whole-of-system spending, and more detailed financial datasets aided in mapping NHAs accurately to emission factors from an MRIO model.

This enabled the creation of a comprehensive emissions model that highlights hotspots of emissions across the entire system.

Lessons learned

- Cross-system collaboration: the level of detail in the baseline assessment was made possible by close collaboration between multiple data owners. Strong leadership and coordination from the centre were crucial in the model development process.
- Comprehensive hybrid model coverage: hospital-based activity data from the Green Viability Assessment Tool and other sources added valuable detail to the model, but full coverage of emissions could not have been achieved without the use of national-level expenditure data.
- Targeted data collection and leveraging existing data: by using information already collected for other purposes (e.g. procurement, energy monitoring or national accounting), the Department of Health was able to generate emissions estimates without placing additional reporting burdens on the system. This was supplemented by Green Viability Assessment Tool data collections, which added high-value insight into hospital-level emissions hotspots.
- Regional input: strong collaboration between the regional centres for health development helped collect actionable data from all 18 administrative regions, enabling more targeted decarbonization strategies.

Fig. 3. Modelling approach for measuring health system emissions in the Philippines



Case study

Measuring the environmental footprint of the health-care sector in the Netherlands

Context

In November 2022, sector-wide targets for Dutch care providers were set for the period up to 2050. One of the targets was to achieve a 55% reduction in CO_2e emissions by 2030 (relative to 2018), with an interim milestone of 30% reduction by the end of 2026. An assessment of emissions from the Dutch health-care sector was required to achieve this.

Action taken

The assessment of GHG emissions from the Dutch health-care sector is organized as a national effort that builds on an institutional framework.

Method selection

- Top-down analysis: a major part of the sector's GHG emissions is estimated using an environmentally extended MRIO analysis. This method uses financial data to quantify health-care expenditure, linking the data with environmental impact factors from databases such as EXIOBASE.
- Bottom-up LCAs: for specific products, such as emissions associated with the use of anaesthetic gases or pressurized metered-dose inhalers, LCA results are used. These LCA results are then integrated with the broader top-down evaluation to produce a footprint.

Data were gathered across multiple sources and harmonized by aligning classification systems and applying a common impact assessment framework so that all emissions are reported in CO_2e. This ensures top-down and bottom-up data are directly comparable and can be aggregated.

This enabled the application of a hybrid approach combining top-down MRIO analysis with targeted bottom-up LCAs to capture system-wide emissions and add impacts from stressors not captured in the MRIO analysis. This included unreported gases (e.g. anaesthetics), household-level use-phase gases (e.g. pressurized metered-dose inhalers) and sector-adjacent emissions (e.g. private travel).

Results are published and available with open access on the website of the National Institute for Public Health and the Environment *(20)*.

References

1. Summary for policymakers. In: Lee H, Romero J, editors. Climate change 2023: synthesis report. contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva: Intergovernmental Panel on Climate Change; 2023 (https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf, accessed 16 September 2025).
2. FCCC/PA/CMA/2024/10. Nationally determined contributions under the Paris Agreement: synthesis report by the secretariat. Bonn: United Nations Framework Convention on Climate Change; 2024 (https://unfccc.int/documents/641792, accessed 16 September 2025).
3. Romanello M, Walawender M, Hsu SC, Moskeland A, Palmeiro-Silva Y, Scamman D, et al. The 2024 report of the Lancet Countdown on health and climate change: facing record-breaking threats from delayed action. Lancet. 2024;404(10465):1847–1896. https://doi.org/10.1016/S0140-6736(24)01822-1.
4. Operational framework for building climate resilient and low carbon health systems. Geneva: World Health Organization; 2023 (https://iris.who.int/handle/10665/373837, accessed 16 September 2025).
5. Health systems strengthening: glossary. Geneva: World Health Organization; 2007 (https://cdn.who.int/media/docs/default-source/documents/health-systems-strengthening-glossary.pdf, accessed 16 September 2025).
6. Organisation for Economic Co-Operation and Development, European Union, World Health Organization. A system of health accounts 2011: revised edition. Paris: Organisation for Economic Co-Operation and Development; 2017 (https://www.who.int/publications/i/item/9789240042551, accessed 16 September 2025).
7. National Health and Climate Strategy: resources collection. Canberra: Australian Government Department of Health, Disability and Ageing; 2023 (https://www.health.gov.au/resources/collections/national-health-and-climate-strategy-resources-collection, accessed 16 September 2025).
8. De Sain R, Irwin A, McGushin A, Dryburgh L, Cooper G, Skellern M. Estimates of Australian health system greenhouse gas emissions, 2021–22. Canberra: Australian Centre for Disease Control; 2024 (https://www.health.gov.au/sites/default/files/2025-04/estimates-of-australian-health-system-greenhouse-gas-emissions-2021-22.pdf, accessed 16 September 2025)
9. The Greenhouse Gas Protocol: a corporate accounting and reporting standard, revised edition. Washington, DC: World Resources Institute and World Business Council for Sustainable Development; 2004 (https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf, accessed 16 September 2025).
10. Science based targets FAQs. London: Science Based Targets Initiative; 2025 (https://sciencebasedtargets.org/faqs, accessed 16 September 2025).

11. Delivering a “net zero” national health service. London: NHS England and NHS Improvement; 2020 (https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2020/10/delivering-a-net-zero-national-health-service.pdf, accessed 16 September 2025).
12. Tennison I, Roschnik S, Ashby B, Boyd R, Hamilton I, Oreszczyn T, et al. Health care’s response to climate change: a carbon footprint assessment of the NHS in England. Lancet Planet Health. 2021;5(2):e84–e92. https://doi.org/10.1016/s2542-5196(20)30271-0.
13. Simpson R, Tennison V, Episkopou E, Bagga Y, Patel H, Caunt M, et al. Five years of a Greener NHS: an improved carbon footprint assessment of the National Health Service in England. Pre-print at SSRN: https://doi.org/10.2139/ssrn.5506082.
14. United Nations Framework Convention on Climate Change. Bonn: United Nations Framework Convention on Climate Change; 1992 (https://unfccc.int/resource/docs/convkp/conveng.pdf, accessed 16 September 2025).
15. Five years of a greener NHS: progress and forward look. London: NHS England; 2025 (https://www.england.nhs.uk/long-read/five-years-greener-nhs-progress-forward-look/, accessed 7 October 2025).
16. Progress tracker. Alliance for Transformative Action on Climate and Health; 2025 (https://www.atachcommunity.com/our-impact/progress-tracker/, accessed 16 September 2025).
17. First wins library. Alliance for Transformative Action on Climate and Health; 2025 (https://www.atachcommunity.com/resources/first-wins-library/, accessed 16 September 2025)
18. Target setting for low carbon sustainable health systems. Geneva: World Health Organization; 2024 (https://iris.who.int/handle/10665/377724, accessed 16 September 2025).
19. Green and safe health facilities manual. Manila: Department of Health of the Philippines; 2021 (https://www.washinhcf.org/wp-content/uploads/2023/07/Green-and-Safe-Health-Facilities-Manual_2021.pdf, accessed 16 September 2025).
20. Sustainable care. Bilthoven, Netherlands: National Institute for Public Health and the Environment; 2025 (https://www.rivm.nl/duurzamezorg/onderzoek, accessed 16 September 2025).

Annex 1. Checklist: key milestones for high-emitting and high-ambition health systems

Measurement of greenhouse gas (GHG) emissions is central to credible decarbonization planning over the long term. It enables target-setting, identification of emissions hotspots, design of interventions, public accountability, and tracking of progress over time. Without GHG emissions measurement, action risks being misdirected, unaccountable, ineffective or insufficient to meet national and global climate targets.

For high-emitting and high-ambition health systems, reaching these 10 GHG measurement milestones is a crucial step if net zero commitments are to be taken seriously. Failure to reach this level of emissions measurement capability well before 2030 would demonstrate misalignment between stated ambition and actual delivery.

This checklist aims to support ministries of health, national health agencies, subnational health authorities and technical analysts in reaching Stage 4 of the maturity framework. The checklist outlines the key milestones expected for high-emitting and high-ambition health systems and is intended to be used in conjunction with the full guidance document *Measuring greenhouse gas emissions in health systems*.

Milestone		Completed?
1	Published and comprehensive scope: a public document that makes clear:	☐
	• the organizational boundary, which is clearly mapped to a comprehensive account of national health system expenditure;	☐
	• the operational boundary, which includes all Kyoto Protocol GHGs plus desflurane, sevoflurane and isoflurane, and all upstream supply chain emissions, including international sources;	☐
	• the base year of assessment.	☐
	See Section 2 of *Measuring greenhouse gas emissions in health systems* for all the organizations and sources of emissions that must, should and could be included in the boundary scope and selection of base year.	
2	Base-year review: a public commitment has been made to review base-year emissions on a regular basis, ideally every five years. The first base-year assessment should be no more than five years earlier than its year of publication, except where robust historic data exist.	☐
3	High volume of activity data: activity data make up 15–50% of total emissions across all scopes, calculated using a hybrid model approach.	☐
4	Regular data collections: mandatory, standardized and regular whole-system data collections are in place to fill gaps in activity data.	☐
5	Regular publication: routine publication of emissions data every year (for emissions calculated on an activity basis) or every two years (for emissions calculated on a spend basis) are in place.	☐
6	Monitoring and validating impact: emissions impacts of specific interventions and non-GHG indicators of performance (i.e. not only system-wide emissions totals) are tracked and published.	☐
7	Model ownership: the GHG model and data infrastructure are fully owned, operated and updated by a technical team embedded in the health system.	☐
8	High-quality, reproducible modelling: structured databases underpin the model, with version control, audit trails and clear processes for updating emission factors and assumptions.	☐
9	Senior ownership: a named senior lead is responsible for health system emissions data and public reporting.	☐
10	External review: third-party quality assurance, expert group, peer review or other external verification has been carried out for a published emissions calculation methodology.	☐

World Health Organization
Department of Environment, Climate Change and Health
20 Avenue Appia
CH-1211 Geneva 27
Switzerland
www.who.int/teams/environment-climate-change-and-health