HYDROPOWER REPORTING GUIDELINE

CLIMATE-CHANGE MITIGATION

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ACKNOWLEDGEMENTS

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The principal authors were Cristina Diez and María Ubierna (Open Hydro) with valuable contributions by working group members: Isabel Cristina Giraldo Ospina (EPM), Jan Kristensen (Statkraft), Pedro Sirgado (EDP Produção), Pimhein Kool (FMO), Olivier Tricca (EIB), Raúl Alfaro-Pelico (Rocky Mountain Institute), Emanuele Quaranta (European Commission Joint Research Centre), and Miroslav Marence (UNESCO IHE Delft).

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DISCLAMER

This reporting guideline is the product, and reflects the collective endeavour, of the working group. The recommendations and guidance presented in this document represent the consensus view of the working group; however, they do not necessarily represent the opinions of the institutions with which working group members are affiliated. Nor does this report represent the views of any other external organisations that are acknowledged for their input and review.

The individuals and organisations that contributed to this reporting guideline are not responsible for any opinions or judgements it contains. Any errors or omissions are the sole responsibility of Open Hydro.

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For a climate resilient future

ABOUT THE GUIDELINE

THE INITIATIVE

The Net Zero Climate Resilient Hydropower Initiative is a multi-stakeholder activity that promotes the development of a commonly agreed climate-related reporting mechanism for hydropower assets. Its purpose is to advance the availability and quality of climate-related metrics at the project level. The aim is to mobilise investment in the financing and/or refinancing of hydropower assets that can demonstrate their contribution to a climate-resilient, zero-carbon planet.

The Net Zero Climate Resilient Hydropower Initiative has four main objectives:

Alignment with internationally recognised frameworks

This initiative sets out a standard consistent with other internationally recognised frameworks, such as the Task Force on Climate-related Financial Disclosures (TCFD) recommendations (TCFD, 2017) and the EU taxonomy for sustainable activities. The initiative is intended to facilitate compliance but is not a substitute for financier, investor, or other stakeholder requirements.

Accessible reporting and disclosure

The initiative enables organisations to track and report progress towards net-zero emissions and other climate change pledges.

Adaptable and comparable criteria

The initiative's criteria and metrics focus on hydropower. They are, however, adaptable to other renewable energy resources. The initiative improves the consistency, comparability, and reliability of reporting, building a bridge between climate metrics and financial reporting.

Demonstration of value – hydropower's transformational role for water and energy

TThe initiative's recommendations and guidance consider the physical and transitional risks and opportunities relating to climate change in the context of hydropower. It also demonstrates the complementarity of hydropower and other renewable energies.

THE REPORT

The Net Zero Climate Resilient Hydropower Initiative is producing three reports covering climate-change mitigation, resilience, and adaptation reporting.

This Hydropower Climate-change Mitigation Reporting Guideline is the first in the series. In response to the 2015 Paris Agreement to limit global warming to 1.5 °C compared to pre-industrial levels, this reporting guideline focuses on climate change mitigation and the conservation of water resources. The United Nations Framework Convention on Climate Change (NFCCC) estimates that reaching this goal will require a 45% reduction in global emissions by 2030 from 2010 levels, and net-zero emissions by 2050 (UNEP, 2021). Recent research shows that greenhouse gas (GHG) emissions from hydropower reservoirs could represent 5% of global GHG emissions (Harrison, 2021). Only 2.5% of the water on the planet is freshwater and already one third of the population is living in water-stressed areas. With the current consumption rate and the projected growth in population, the world may face a 40% shortfall in water availability by 2030 (UN, 2018). The United Nations Framework Convention on Climate Change (UNFCCC) estimates that the protection and restoration of freshwater resources can account for 10% of the global mitigation goal of the Paris Agreement (UNFCCC, 2021).

Common standards by which to understand, quantify, and report GHG emissions, and to assess GHG emission reduction activities in relation to hydropower assets, are crucial if the industry is to reduce CO2 and CH4 emissions. Such standards will aid understanding of water usage, and support the role of hydropower in sustainable water management.

The need for sustainable water management drives investors, developers, and governments to advance long-term management plans for water bodies and river basins. To achieve this, we can draw on the Water-Energy-Food-Ecosystem (WEFE) Nexus, with input from all stakeholders, taking into account regional development and climate change impacts.

A Strategic Environmental and Social Impact Assessment (SESIA) is another important instrument in the process of preparing long-term sustainable management plans.

In the context of the hydropower sector, this report sets out specific reporting requirements relating to climate-change mitigation. It establishes concepts and methods to standardise reporting. The report describes the granularity of information needed to understand and quantify GHG emissions and GHG reduction activities. It provides guidance on aggregating that information to deliver consolidated reporting at the corporate level, bringing the sector in line with mainstream disclosure requirements and recommendations – such as those outlined by the Task Force on Climate-related Financial Disclosure (TCFD) and the GHG Protocol for both GHG inventory and corporate reporting. A clear and standardised presentation of GHG emissions from hydropower assets will enable evaluation of a company's risks, opportunities, performances, and prospects.

The report was constructed through a multi-stakeholder consultation process in 2021 and 2022, and draws on a wide range of expertise. The resulting standardised reporting guideline developed under a framework of three aims:

- ✓ To reach net-zero emissions by 2050
- ✓ To limit global warming to 1.5 °C, following the 2015 Paris Agreement, the Sustainable Development Goals (SDGs), and emerging science and technology
- ✓ To prioritise mitigation strategies that will reduce exposure to climate-related transition risks, inform long-term company strategy, and ensure the sector operates in a net-zero economy.

APPLICABILITY

This standardised reporting guideline on climate-change mitigation builds on existing standards and frameworks – such as the TCFD, the EU taxonomy for sustainable activities, the GHG Protocol, and the Science-based Target Initiative (SBTi) – to provide recommendations for the hydropower sector. Its purpose is to quantify and account for GHG emissions from activities in the hydropower sector.

The reporting guideline set out here can be applied to any type and size of hydropower asset worldwide, including storage power plants (SPPs), pumped storage hydropower (PSH), and run-of-river (RoR) hydroelectric projects. Between them, SPPs and PSH provide the main bulk energy and water storage for power systems.

Storage power plants (SPPs) store water in reservoirs behind dams and can modulate the flow released downstream; reservoirs can be artificial or can exploit existing lakes. Pumped storage hydropower (PSH) consists of two bodies of water (generally, two reservoirs, or a river as lower reservoir) connected by a turbine-pump system. PSH pumps water to an upper reservoir during periods of low energy demand and uses it to produce electricity by releasing water to the lower reservoir through the turbines. The reservoirs of closed-loop PSH stations (also known as pure PSH) are not connected to natural watercourses and do not utilise natural (river) inflows. Mixed PSH stations (also known as pump-back facilities) utilise natural inflows from rivers, creeks, and groundwater, in addition to the pumped water in the upper reservoir. RoR projects utilise the natural flow of bodies of water and have limited storage capacity. If storage capacity is below the mean daily inflow, the reservoir is often considered to be an RoR facility.

This reporting guideline provides reporting recommendations for GHG accounting to inventory the emissions at the asset level and to aggregate those emissions at the corporate level. SPPs can be emitters or sinks of GHG emissions (Ubierna, 2021). The guideline includes methodologies to assess whether assets are GHG emitters or sinks. In the case of GHG emitters, it enables assessment of potential emissions reduction and their accounting, contributing to corporate net-zero targets.

The guideline is helpful in a variety of ways:

- It provides project-level information that facilitates participation in voluntary and mandatory GHG programmes
- It increases consistency and transparency of emissions reporting across the hydropower sector
- It enables identification and assessment of GHG reduction activities at a hydropower asset for use in meeting project and/or corporate emission targets
- It guides owners of power utilities and assets in preparation of a GHG inventory that represents an accurate and fair account of their emissions that can be consolidated with the data of other business units

- It facilitates the application of a number of reporting frameworks to the hydropower sector, including the GHG Protocol for Project Accounting and the GHG Corporate Accounting and Reporting Standard; the SBTi Corporate Net-Zero Standard; and the TCFD recommendations
- It simplifies and reduces the resources required to compile and report GHG emissions data

It should be noted that the following guideline does not guarantee a particular result concerning consolidated GHG emissions at the corporate level, nor acceptance or recognition by existing GHG programs and climate-related requirements and frameworks.

BEYOND THE SCOPE OF THE REPORT

The focus of the reporting guideline is GHG emissions from, or relating to, hydropower assets. It does not address broader sustainability issues, such as water quality, downstream flow regimes, biodiversity loss, sediment management, and other environmental effects. It does acknowledge that low-carbon projects and interventions to reduce GHG emissions have links to these other sustainability issues. Social and governance issues, such as stakeholder consultation, and/or engagement with, or resettlement of, indigenous peoples are outside the scope of the guideline. The guideline follows the TCFD recommendations relating to GHG emissions at the asset level included the Srategy and Metrics and Targets area; the TCFD recommendations on Governance and Risk Management Process are beyond the scope of the guideline. For further information about how this guide aligns with TCFD recommendations, see Appendix 1, Mapping of the guideline to the TCFD recommendations.

Data gathering, quality and uncertainty, confidentiality issues, and verification processes by third parties consulted for the reporting are beyond the scope of this guideline.

INTENDED AUDIENCE

This reporting guideline is written for hydropower asset owners and utility companies to help align asset level information with corporate reporting requirements. The guidance is written for the perspective of an asset owner (or developer). It sets out metrics to quantify hydropower asset emissions and report on actions taken to reduce them. The reporting metrics outlined below are aligned with TCFD recommendations. These metrics and targets can flow through to companies' quarterly reports for investors and support a company's GHG inventory, in line with GHG Protocol standards. The information generated will also be of interest to financial institutions that consider GHG emissions in their project financing decisions, and to private sector investors.

This reporting guideline enables hydropower owners and operators to screen, assess, and report to decision-makers on climate-change mitigation measures and activities – for internal and/or external purposes. It facilitates a clear understanding of reporting requirements by international organisations, and upcoming regulations. Understanding what the requirements mean for a hydropower asset encourages effective reporting. Stakeholders and decision-makers comprise:

- Power utilities
  Sustainability reporting – to assess the utility portfolio across technologies or business units; to enable peer benchmarking; and to inform business strategy to seek new business opportunities. It also adds value to quarterly investor reports

- Financial institutions
  Project leads involved in financing new and existing projects can use the criteria to assess the project and ensure alignment with the 2015 Paris Agreement targets. The guideline enables the streamlining of climate-related disclosure.

CONTENTS

INTRODUCTION

WHY THE NEED FOR CLIMATE REPORTING?

There is an urgent need to reduce GHG emissions to tackle climate change and limit global warming to 1.5 °C compared to pre-industrial levels. Halving emissions by 2030 and achieving net-zero emissions by 2050 requires finance to move to sustainable sectors, alongside robust and consistent corporate commitments.

With investors looking for sustainable portfolios, climate-related information is increasingly critical if the hydropower sector is to efficiently direct capital to investment that drives climate-change mitigation and adaptation solutions. Since the Paris Agreement and the 2015 United Nations 2030 Agenda for Sustainable Development, global initiatives have emerged to improve and increase the disclosure of climate-related information, to facilitate and accelerate investment in clean-energy projects, and to support decarbonisation.

CORPORATE REPORTING

There has been rapid and significant buy-in from governments and organisations worldwide to increase disclosure since the TCFD began its work in 2015. Their first set of recommendations were published in 2017. These have been adopted widely and are applicable to organisations across sectors and jurisdictions.

The recommendations are intended to solicit decision-useful, forward-looking information that can be integrated with mainstream financial filings. What began as a set of recommendations for public and private companies is expected to become part of the regulatory framework in many jurisdictions, including the European Union, Canada, Japan, the United Kingdom, and South Africa. In other words, up to a third of the world's hydropower capacity could be subject to mandatory climate-related disclosure in the coming years. However, as recently as 2021, proponents of TCFD – including power utilities and independent power producers – represented only 15% of global hydropower capacity (Open Hydro, 2021).

The TCFD recommends disclosure at the corporate level in four core areas: governance, strategy, risk management, and metrics and targets. The recommendations go beyond corporate governance to help companies and others understand the implications of climate-related physical risks and the financial risk of transitioning to a lower carbon economy.

Climate-related reporting is a powerful tool for peer benchmarking, as the Carbon Disclosure Project (CDP) shows. The CDP is the leading global disclosure system to measure and manage environmental impacts. It encompasses companies, cities, states, and regions. In 2018, the CDP redesigned its climate change questionnaire to align fully with the TCFD recommendations. Since the 2015 Paris Agreement, company disclosure using CDP questionnaires has grown over 140%; in 2021 a record 13,000 companies disclosed through the CDP system (CDP, 2021).

The CDP system can be crucial for companies because investors use the data to inform decision-making, while corporations use it to analyse and engage with their supply chain to manage carbon emissions and climate-change risks. The CDP's annual A-List promotes businesses leading the world on environmental transparency and action.

Moreover, the TCFD recommendations have influenced the CDP's Climate Change Questionnaire on water security and deforestation. It follows a similar structure to the TCFD, enabling companies to organise their environmental management according to common principles of good practice.

While the CDP requires users to submit a questionnaire through their online portal, the Global Report Initiative (GRI) Standards aim to support companies in developing their own sustainability reports. What makes the GRI particularly useful is its flexibility. Organisations can use the GRI's three Standards (Universal, Sector, and Topic) to prepare public-facing reports for specific users (investors or consumers, for example), for a particular purpose.

The TCFD recommendations and widely used reporting approaches, such as the CDP and the GRI, provide a general framework and draw on existing reporting systems for specific pieces of information. An example would be the disclosure of GHG emissions under the Greenhouse Gas Protocol, which quantifies and accounts for Scope 1, Scope 2, and Scope 3 emissions.

The Greenhouse Gas (GHG) Protocol is a multi-stakeholder partnership formed in 1998 to develop internationally accepted GHG accounting and reporting standards for businesses. Since the first edition of the GHG Protocol Corporate Accounting and Reporting Standard in 2001, it has achieved broad adoption and acceptance among businesses, NGOs, and governments. As of 2022, there are two GHG Protocol standards:

- The GHG Protocol Corporate Accounting and Reporting Standard – a step-by-step guide for companies to quantify and report their GHG emissions. There is a supplement that now incorporates reporting of Scope 3 emissions – The Corporate Value Chain (Scope 3) Standard.
- The GHG Protocol for Project Accounting – an accounting tool for quantifying GHG reductions resulting from mitigation projects, assessing key impacts in the life-cycle of a project.

The two standards provide different benefits. This can lead to different corporate-level results following the consolidation of results based on the GHG Project Protocol.

PROJECT REPORTING

The above international recommendations and initiatives encourage corporate-level disclosure, promoting a shift to low carbon portfolios which investors are enthusiastic about, while, financiers screen on emission reduction activities at the project level their assets portfolio. Regional taxonomies also incentivise projects that contribute to decarbonisation.

The recent European Commission (EC) taxonomy and the Climate Bonds Initiative (CBI) Taxonomy require hydropower projects to provide climate-change mitigation data in order to meet eligibility criteria and, thus, access green finance. One condition that hydropower projects need to demonstrate is that they are sufficiently low carbon – that is, below a set threshold of power density or emissions intensity metrics. Under the CBI Taxonomy, this criterion is the determining factor for eligibility.[1] Hydropower projects must cross this threshold before there is any assessment of adverse impacts in terms of other environmental and social issues.

Taxonomies serve a specific purpose but do not provide a platform for project-level reporting or categorisation of direct and indirect emissions to facilitate accounting at the corporate level. The metrics they require (under the EU Taxonomy for Sustainable Finance, for example) often need further clarification. Helpfully, VGBe, an international technical association for companies operating power plants (including hydropower), provides an interpretation of the criteria on climate change mitigation and adaptation (VGBE, 2022).

Hydropower projects generally provide a source of clean energy with significantly lower lifetime greenhouse gas emissions than most energy technologies; however, projects can be a source of emissions. Projects are site-specific, and the evolution of emissions (CH4 or CO2) over time will depend on the particular climatic, geographic, edaphic, and hydrologic settings of the hydropower reservoir and its catchment. For example, hydropower reservoirs in non-alpine regions are responsible for carbon emissions with a rate 10 times as high as those in alpine regions (1.07 gCO2e/kWh vs 14 gCO2e/kWh), as a result of a higher rate of methane biogenic emissions from non-alpine reservoirs (Mahmud, 2019).

WHY SECTOR-SPECIFIC GUIDANCE?

Although taxonomies provide hydropower specific criteria, they do not address the challenges of climate information reporting and alignment at the corporate level. To mobilise investment in hydropower projects and businesses, and for a

[1] The CBI mitigation criterion states that if the project was in operation before 2020, it must demonstrate a power density greater than 5 W/m2, or an emissions intensity threshold of less than 100 gCO2e/kWh. If the project began after 2020, it needs to demonstrate a power density greater than 10 W/m2, or an emissions intensity threshold of less than 50 gCO2e/kWh. Similarly, EU taxonomy defines hydropower facilities as low carbon if they have a power density lower than 5 W/m2, and a lifecycle emission lower than 100 gCO2e/kWh once allocated to hydropower use. It is important to note that the lifecycle emissions threshold will decline staggered to 0 gCO2e/kWh by 2050

company to achieve net-zero targets, more forward-looking information is needed, which goes beyond a need to understand a company's current GHG emissions and related risks.

The global frameworks outlined above have lacked granularity. There has more recently been a recognition that sector-specific guidance would encourage further uptake of climate-related reporting and disclosure. For example, under the Industry-led Initiative Spotlight launched in early 2022, the TCFD has showcased initiatives that reveal sector-specific information in a form consistent with the broader TCFD recommendations.

The TCFD Spotlight features Open Hydro's Net Zero Climate Resilient Hydropower Initiative. In addition, the TCFD Electric Utilities Preparer Forum[2] advances the implementation of TCFD recommendations by providing a snapshot (including examples of good practice) of how member companies make climate-related financial disclosures. It concludes that companies should consider breaking down climate-related financial disclosures across different business segments and types of activity, providing that more granular detail does not distort an understanding of the consolidated corporate position.

With reference to different reporting approaches, the GRI Sector Program includes renewable energy as one of their Sector Standards. In addition, the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) are leading the development of a new GHG Protocol guidance to account for land-use change and carbon removal.

These steps towards sector-specific guidance respond to the need for more clarity and accountability to ensure actionable commitments by different sectors. In the hydropower industry this need has prompted the development of this Hydropower Climate-change Mitigation Reporting Guideline. It enables the hydropower sector to take information consistent with scientific guidance and models of hydropower GHG emissions, and to present it in a form aligned to TCFD recommendations. It facilitates carbon pricing as a climate-change mitigation mechanism.

NET-ZERO TARGETS, CARBON PRICING AND GHG REDUCTION OPPORTUNITIES

Alongside increasing attention on climate-related reporting and disclosure, many countries and corporates are committing to net-zero emissions targets. These targets play a crucial role in limiting global warming to 1.5 °C. However, reaching net-zero GHG emissions goes beyond achieving net-zero CO2 emissions, and emissions of some GHGs – such as methane and nitrous oxide – are more difficult to tackle.

The Science-based Targets Initiative (SBTi) comprises a coalition established to enable companies to set emissions reduction targets. It defines and promotes best practice in emissions reduction and in setting net-zero targets in line with climate science. Targets are considered 'science-based' if they are in line with what the latest climate science deems necessary to meet the goals of the Paris Agreement. Led by the CDP, the SBTi has developed an initiative to enable companies to align with the 1.5 °C pathway and guidance to support electric utilities when setting science-based targets for their sector.

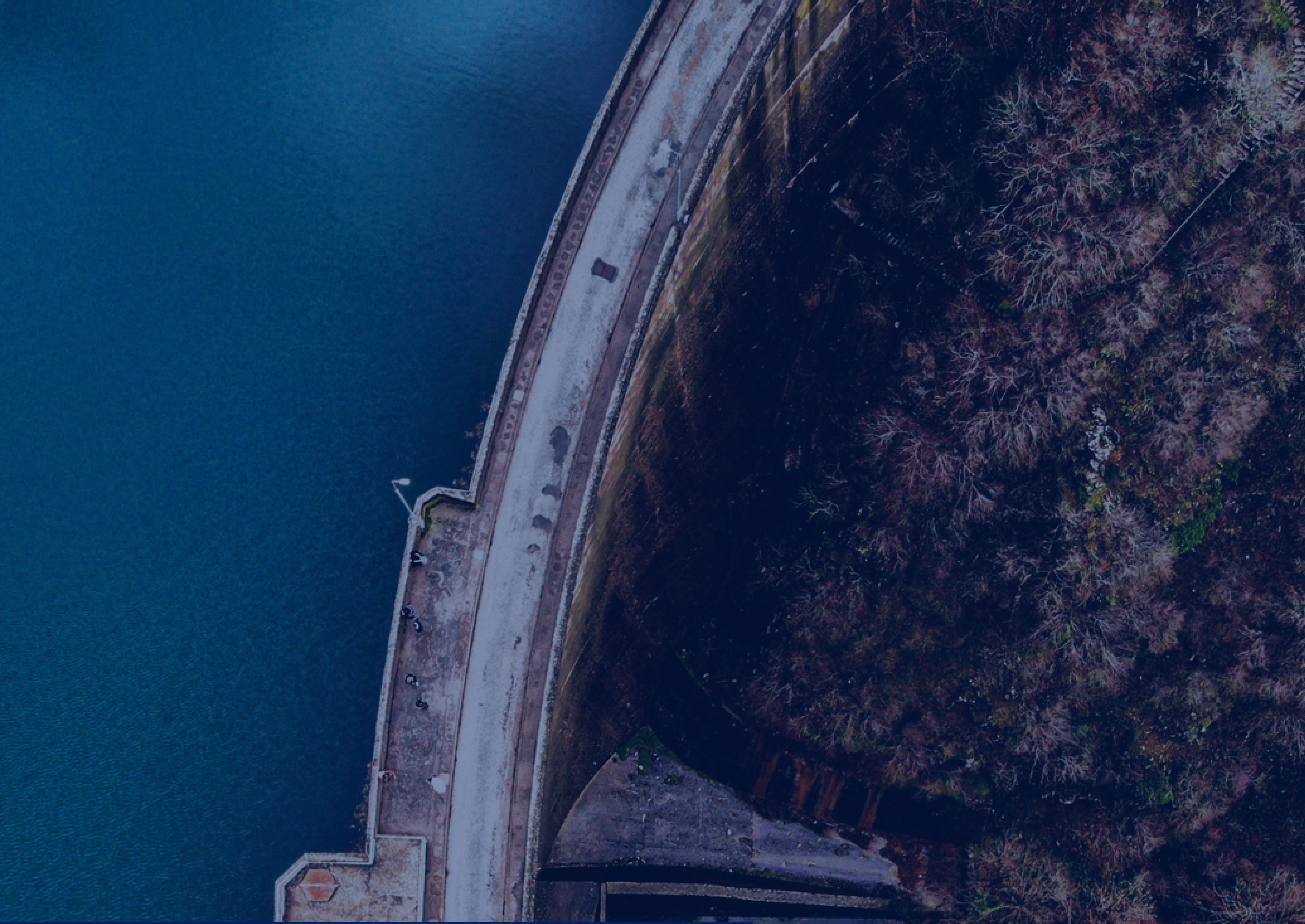
The pathway to net-zero emissions in the electricity sector implies a shift to renewable energy; however, the future emissions pathways consider most renewable energy GHG emissions to be negligible, which is unrealistic. It is an approach that penalises hydropower projects that are GHG sinks and underestimates the emissions from high-emitter projects.

Hydropower projects with high emissions, or that operate above emissions thresholds, or that need to achieve net-zero goals can reduce emissions. Carbon pricing can be an effective mechanism to drive investment and the technological change required to reduce emissions at the asset level. As well as encouraging emission reduction activities at the project level, internal carbon pricing can hedge

[2] The TCFD Electric Utilities Preparer Forum is a collaboration between CLP, EDF, EDP, EnBW, Enel, Iberdrola and the World Business Council for Sustainable Development (WBCSD). https://www.tcfdhub.org/resource/tcfd-electric-utilities-preparer-forum/

transitional risk deriving from changes in the regulatory environment.

International carbon markets play a significant role in cost-effectively reducing global GHG emissions. They have established a framework of standard accounting rules and have created a novel, aspirational mechanism. The number of emissions trading systems worldwide is increasing, so the level of ambition required is increasing as well. Ideally, markets should only deal in high-quality emission reduction credits, moving towards removal credits that will balance residual emissions to achieve net-zero goals.



Climate-change Mitigation reporting

GHG emissions understanding

GHG EMISSIONS UNDERSTANDING

REPORTING RECOMMENDATIONS

At the asset level, identify the source of emissions and provide the following information for each scope

Scope 1 emissions

Provide direct GHG emissions

- in absolute terms (metric tonnes of CO_2 equivalent)
- as emission intensity (gCO2 e/kWh)
- as a percentage of the total corporate emissions

Scope 2 emissions

Provide indirect GHG emissions

- in absolute terms (metric tonnes of CO2 equivalent)
- as emission intensity (gCO2e/kWh)
- as a percentage of total corporate emissions

Scope 3 emissions

Provide indirect GHG emissions not considered in Scope 2 (if available)

- in absolute terms (metric tonnes of CO2 equivalent)
- as emissions intensity (gCO2e/kWh)
- as a percentage of total corporate emissions

For all the scopes include:

- types of GHG included in the calculations
- baseline year, justification for the selection, emissions for that year, and the context for any significant change in the GHG emissions calculation
- a comprehensive description of the calculation approach, scope and methodologies, standards, and tools used for the estimation of GHG emissions, including the input data, emission factors used, global warming potential used, assumptions and gaps considered, and lifecycle chosen, including references for all sources
- for multipurpose storage hydropower plants, provide the allocation methodology used for the reservoir emissions associated with hydropower use in Scope 1 (if relevant).

GUIDANCE

For a company to estimate the emissions of a hydropower asset, the operational boundary needs to be defined and must be applied consistently across the portfolio. Companies need to define the organisational boundary (using an equity share, financial control, or operational control approach) consistently across the GHG inventory (see guidance section on project-level and corporate-level alignment).

Depending on the source of emissions, reporting requirements categorise emissions as direct (Scope 1) or indirect (Scope 2 and Scope 3):

Scope 1 accounts for direct GHG emissions from the hydropower project that is owned or controlled by the company:

For the operation of the hydropower project, consider:

- net GHG emissions from the reservoir(s)
- GHG emissions from fuel for company vehicles used in relation to the hydropower plant
- GHG emissions from fuel combustion on site
- GHG emissions from backup power (thermal or diesel generators, for example) required as a result of variable electricity generation

Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the company at the hydropower asset.

For the operation of the hydropower plant, include:

- GHG emissions from the generation of purchased electricity consumed at the hydropower asset; for example, if the project needs to use electricity from the grid or other sources of energy to start operations, or to pump water to the upper reservoir.

Scope 3 accounts for emissions that are a consequence of the activities of the company at the hydropower asset, but occur from sources not owned or controlled by the company.

For the construction of the hydropower plant, include:

- GHG emissions from raw material extraction and equipment manufacturing, including the dam core, pipelines, powerhouse, and electromechanical equipment
- GHG emissions during the building and construction processes, including the use of fuel and electricity by on-site equipment installation and usage
- GHG emissions from the consumption of fossil fuel used for the transportation of materials and purchased goods

For the operation of the hydropower plant, include:

- GHG emissions from unrelated anthropogenic sources (UAS) (such as agriculture, water treatment, waste management)[1]
- GHG emissions from O&M of the civil structure (such as repairing cracks in the dam body, in the powerhouse, or replacing pipework)
- GHG emissions from O&M of the electromechanical equipment (such as replacement of generators and turbines, changing lubricant oils, and replacing seal plates)
- GHG emissions from other sources of energy used on site (for example, heating or ventilation)[2]

METHODOLOGIES: MEASURING AND ESTIMATING GHG EMISSIONS

The **GHG Protocol methodology**[3] is the most widely recognised and used international standard for calculating GHG emissions. According to the Task Force on Climate-related Financial Disclosures (TCFD), GHG emissions should be calculated in line with the GHG Protocol methodology to allow for aggregation and comparability across business units, organisations, and jurisdictions (TCFD, 2021).

The **GHG Protocol** requires companies to identify **direct emissions (Scope 1)** in four main categories: stationary combustion, mobile combustion, process emissions, and fugitive emissions. It requires companies to use the most accurate calculation approach available. In the recent Land Sector and Removals Guidance (Greenhouse Gas Protocol, 2022), the GHG encourages companies to separately account and report on biogenic and non-biogenic CO2 emissions. It includes a section on methane emissions from flooded land, relevant to the impoundment of reservoirs, which is adapted from the 2019 Refinement to the IPCC Guidelines, Chapter 7, Wetlands (IPCC, 2019).

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the 2019 Refinement guide the preparation of annual GHG inventories to address CO2 and CH4 emissions from reservoirs (IPCC, 2019). When estimating emissions of CO2 and CH4, the guidelines differentiate between reservoirs that are less than or equal to 20 years old (land converted to flooded land), or more than 20 years old (flooded land remaining flooded land). This approach is taken because after an initial phase of

[1] Longer water residence time resulting from flooding can lead to higher GHG emissions and, hence, have influence over GHG emissions from upstream activities

[2] When provided by a supplier or contractor

[3] GHG Protocol establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions. https://ghgprotocol.org/

typically 20 years or less, CO2 emissions largely arise from the catchment. They are estimated as emissions from other managed land categories and are not included as part of the reservoir emissions in order to avoid double-counting. In terms of CH4, high levels of emissions can occur in the first 20 years following flooding. Accordingly, different formulas to estimate CH4 emissions are suggested for reservoirs below or above the 20-year threshold

The **GHG Protocol Scope 2 Guidance** defines two approaches for calculating Scope 2 emissions from purchased renewable and other forms of energy:

- A location-based approach – designed to reflect the average emissions intensity of the power grids from which energy is consumed. It typically uses grid-average emission factors
- A market-based approach – intended to help companies reflect the impact of the emissions from their selected electricity products (for example, supplier-specific emission rates and power purchasing agreements)

Pumped hydropower storage plants consume electricity from the grid for several hours a day to pump water. There are Scope 2 emissions associated with the electricity consumed. A market-based approach may be appropriate to reflect the balancing services that these hydropower assets provide to the grid.

The **GHG Corporate Value Chain (Scope 3) Standard** provides 15 categories for Scope 3 emissions (Greenhouse Gas Protocol, 2004). This information may be useful for asset owners when creating their Scope 3 inventory, to help identify and prioritise emission-reduction opportunities. Hydropower companies can use this information to report Scope 3 emissions at the asset level, where purchased goods and services may be the main category. The Standard provides a decision tree for selecting a calculation method for emissions from purchased goods and services based on the level of available data. The GHG Protocol Scope 3 Calculation Guidance (Greenhouse Gas Protocol, 2013) contains the calculation methods available for each of the categories, including emissions from purchased goods and services. The GHG Protocol provides a Scope 3 screening tool that gives a rough estimate of the inventory of Scope 3 emissions. The GHG Protocol recently launched the GHG Emissions Calculation Tool. This is an excel-based tool with emission factors embedded, which aids Scope 3 emissions calculations in the hydropower context.[4]

The **International Organization for Standardization (ISO)** has developed cross-sector methodologies to support GHG accounting. ISO 14067:2018 provides principles, requirements, and guidelines for the quantification and reporting of the life cycle carbon footprint of a product, and ISO 14064-1:2018 provides principles and requirements at the organisation level for the quantification and reporting of GHG emissions and removals.[5] These methodologies are supported by other national and international frameworks such as the **EU Sustainable Finance Taxonomy** (recommendation 2013/179/EU), or the Programa País Carbono Neutralidad (PPCN) in Costa Rica.[6]

Different methods are available to measure and estimate GHG emissions, which can be used for a hydropower asset to calculate their direct (Scope 1) and indirect emissions (Scope 2 and Scope 3). The measurements guidelines and the modelling tools below assume the simplification of having a single reservoir as the source for a single hydropower plant. However, hydropower schemes seldom operate with only one reservoir, for example, in cascade systems. New calculation methodologies use the models below to aggregate the information of all the hydropower plants in the same catchment. Total emissions from all reservoirs are then distributed among hydropower plants in the catchment, in proportion to their annual generation (Sintef, 2021).

Direct measurement of GHG emissions by monitoring concentration

There are two key reference guidelines by which to plan and conduct measurement campaigns to

[4] GHG Protocol tools enable companies to develop comprehensive and reliable inventories of their GHG emissions. https://ghgprotocol.org/calculation-tools#cross_sector_tools_id

[5] Access ISO14067:2018 https://www.iso.org/standard/71206.html and ISO 14064-1:2018 https://www.iso.org/standard/66453.html

[6] 2013/179/EU: Commission Recommendation of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations Text with EEA relevance https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013H0179 and in Costa Rica, Dirección de cambio climático. Programa País Carbono Neutralidad. https://cambioclimatico.go.cr/programa-pais-carbono-neutralidad/

estimate net GHG emissions from freshwater reservoirs before and after construction. Both date from a decade ago, however, there are new methods, models, and equipment now in use, which should be considered when consulting the following guidelines:

- **IEA Hydropower, Guidelines for the Quantitative Analysis of Net GHG Emissions from Reservoirs** (Volume 1, Measurement Programmes and Data Analysis), provide advice and recommendations for performing measurement campaigns and data analysis to obtain estimates – and understand their associated uncertainties – of net GHG emissions from man-made reservoirs (IEA Hydro 2012).
- The **International Hydropower Association (IHA), GHG Measurement Guidelines for Freshwater Reservoirs** provide guidance both to estimate net GHG emissions from freshwater reservoirs to ensure that assessments are objective, and to make it easier to compare, transfer, and use data globally (IHA, 2010).

Modelling tools

The web-based **G-res tool** uses data to estimate the change in emissions resulting from the impoundment of an existing or planned reservoir.[7] The output results provide information on the following GHG emission scopes:

- Scope 1: net GHG emissions from the reservoir
- Scope 3: GHG emissions from UAS. These emissions can be attributed to activities within the catchment, which are calculated based on the proportions of sources of nutrients and carbon flowing into the reservoir.
- Scope 3: GHG emissions during construction of the dam. The tool estimates GHG emissions associated with the materials used to build the reservoir, and the transport required in constructing the dam and other infrastructure. The emissions are calculated based on the materials used and their emission factors. The tool offers three options depending on the amount of data available. In the first, users input a value for construction emissions based on their own assessment. In the second, users input numbers based on four key activities and materials. In the third, users input a more detailed assessment of granular items, should that data be available.

The IEA Hydropower, Guidelines for the Quantitative Analysis of Net GHG Emissions from Reservoirs (Volume 2, Modeling) provide a framework for performing quantitative analysis of net GHG emissions and changes in carbon stock (IEA Hydro, 2015).

Additional methodologies and sources of information

Some taxonomies like the EU taxonomy) and the CBI use a power density threshold to determine whether a life cycle based GHG emission assessment is required. However, this does not exclude those projects from disclosing their emissions, and does not necessarily mean that those projects will be considered to have zero emissions.

The European Investment Bank (EIB) Project Carbon Footprint Methodologies provide a method to calculate for reservoirs CO2 diffusive emissions, CH4 diffusive emissions, and CH4 bubbling emissions. For each output value the methodology provides an emissions factor, which is multiplied by the flooded total surface area (European Investment Bank, 2022).

GLOBAL WARMING POTENTIAL VALUES

Global Warming Potential (GWP) is a measure of how much energy a unit quantity of a specified GHG will absorb over a given period of time, relative to a unit quantity of carbon dioxide (CO2). GWP values enable comparison of the global warming impacts of different gases. Table 1 shows GWP values for 100- and 20-year time horizons. The data are taken from the IPCC Sixth Assessment Report (AR6), (IPCC, 2021) and from the IPCC Fifth Assessment Report (AR5) (IPCC, 2014). The AR5 data are included here because they are sometimes used for inventory and reporting purposes. The use of the latest (AR6) values for a 100-year period is recommended.

Perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and chlorofluorocarbons (CFCs) (referred to as the F gases), are not significant in relation to hydropower assets. Although their emissions might be short lived in the atmosphere, their GWP value means their presence has a high impact.

[7] The Greenhouse gas Reservoir tool https://g-res.hydropower.org/

Table 1. Global Warming Potentials for 100- and 20-year

GHG	100-year time period		20-year time period	
	AR5	AR6	AR5	AR6
CO_2	1	1	1	1
CH_4 fossil origin	28	29.8	84	82.5
CH_4 non fossil origin	28	27	84	79.7
N_2O	265	273		273
HFC-32		771		2693
HFC-134a		1526		4144
CFC-11		6226		8321
PFC-14		7380		5301

For further information on their GWP, see Table 7.15 of the IPCC Sixth Assessment Report (IPCC, 2021).

ALLOCATION OF GHG EMISSIONS TO MULTIPURPOSE STORAGE HYDROPOWER PLANTS

Almost half the large dams worldwide are single purpose. Of these single purpose dams, most are used for either irrigation or hydropower. Multipurpose reservoirs constitute 17% of all types of large dams (IEA, 2021).

A GHG management plan should include a methodology to allocate GHG emissions to the services provided by multipurpose reservoirs. There are some key areas for consideration and IEA Hydro (2018) provides best practice guidance in 'Managing the carbon balance of freshwater reservoirs'. It outlines methodologies to allocate net GHG emissions from reservoirs to different water users. In summary, storage hydropower plant owners should consider the following:

- Physical allocation – in direct proportion to the use of the reservoir, where GHG emissions are primarily proportional to water consumption, water use, or water footprint.
- Economic approach – in direct proportion to the use of the reservoir, where the GHG emissions are primarily proportional to the actual cost or commercial value of the service provided.
- Scientific approaches
    - Based on the method and location of water extraction: GHG emissions are determined by the process of extraction
    - Based on the operational mode: GHG emissions differ according to the mode of operation
    - Based on temporal variations in GHG emissions over the lifecycle: GHG emissions can vary dependent on seasons or over many years, and may not be evenly distributed over time
    - Based on the production of GHG emissions by water users: users may be direct producers of GHG emissions and the allocation should be directly related to that production.

The approach selected needs to be used consistently across the portfolio. The processes may be complex, especially in reservoir cascade systems. When operations are not coordinated (through different ownership or diverse jurisdiction, for example), it can be challenging to agree on an allocation methodology with all stakeholders. If agreement cannot be reached, it is possible to account for all reservoir emissions.

OTHER CONSIDERATIONS

Assessing project-level emissions during the design phase

This reporting guideline outlines the requirement for hydropower assets to comply with annual reporting at the corporate level. It follows an attributional approach where the emissions calculated for each asset can be attributed to the corporate level on an annual basis, in accordance with the GHG Protocol Corporate Accounting and Reporting Standard.

A consequential approach to emissions reporting can also be of great value. This provides a detailed lifecycle assessment of a project's GHG emissions, which highlights the potential impacts of a hydropower project or upgrade. Lifecycle assessments are useful during the design phase and provide the information that is often required to move a project forward. In the hydropower context, the reporting of reservoir emissions should follow a net approach over a lifecycle of 100 years (Levasseur, 2020). However, this approach does not provide results that can be consolidated at the corporate level.

Owners of hydropower assets can develop a lifecycle assessment (LCA) to calculate an average emissions figure that can be helpful for power purchase agreements and certification compliance when seeking climate financing. The LCA can be used to produce an Environmental Product Declaration (EPD). These comprehensive reports include specific environmental information – for example, an EPD for the emissions of the electricity generated in a hydropower plant.

The GHG Protocol for Project Accounting quantifies the benefits of climate-change mitigation projects by following a consequential approach (Greenhouse Gas Protocol, 2005).

GHG emissions: Assessment during construction

The construction stage can contribute between 50% and 70% of the dams' total construction and operations emissions, according to studies of hydropower plants in the United States (Song, 2018).

The design of the dam influences the type and quantity of materials and, hence, the associated emissions. One study estimated the material production emissions of an earth-core rockfill embankment dam were 46% less than for a concrete gravity dam of the same scale (Zhang, 2015).

Pipeline manufacturing is another major contributor to the total construction GHG emissions of diversion dams, given that they are usually made of carbon-intensive steel or PVC materials. A study (Gallagher, 2015) calculated the environmental impacts of three small-scale run-of-river hydropower plants in the United Kingdom and found that polyethylene pipework accounted for around 53 to 60% of the total construction GHG emissions, followed by turbine and generator (19–23%), and powerhouse (13–17%).

With reference to dam construction processes, factors such as hydrological conditions, hydraulics, soil and sediment characteristics, hydropower plant designs, and construction techniques will influence the GHG emissions of the building process (Song et al., 2018). In this context, EPDs are a useful tool for asset managers and developers who wish to know the environmental impact of various construction materials. They aid informed decisions when assessing potential Scope 3 emissions.

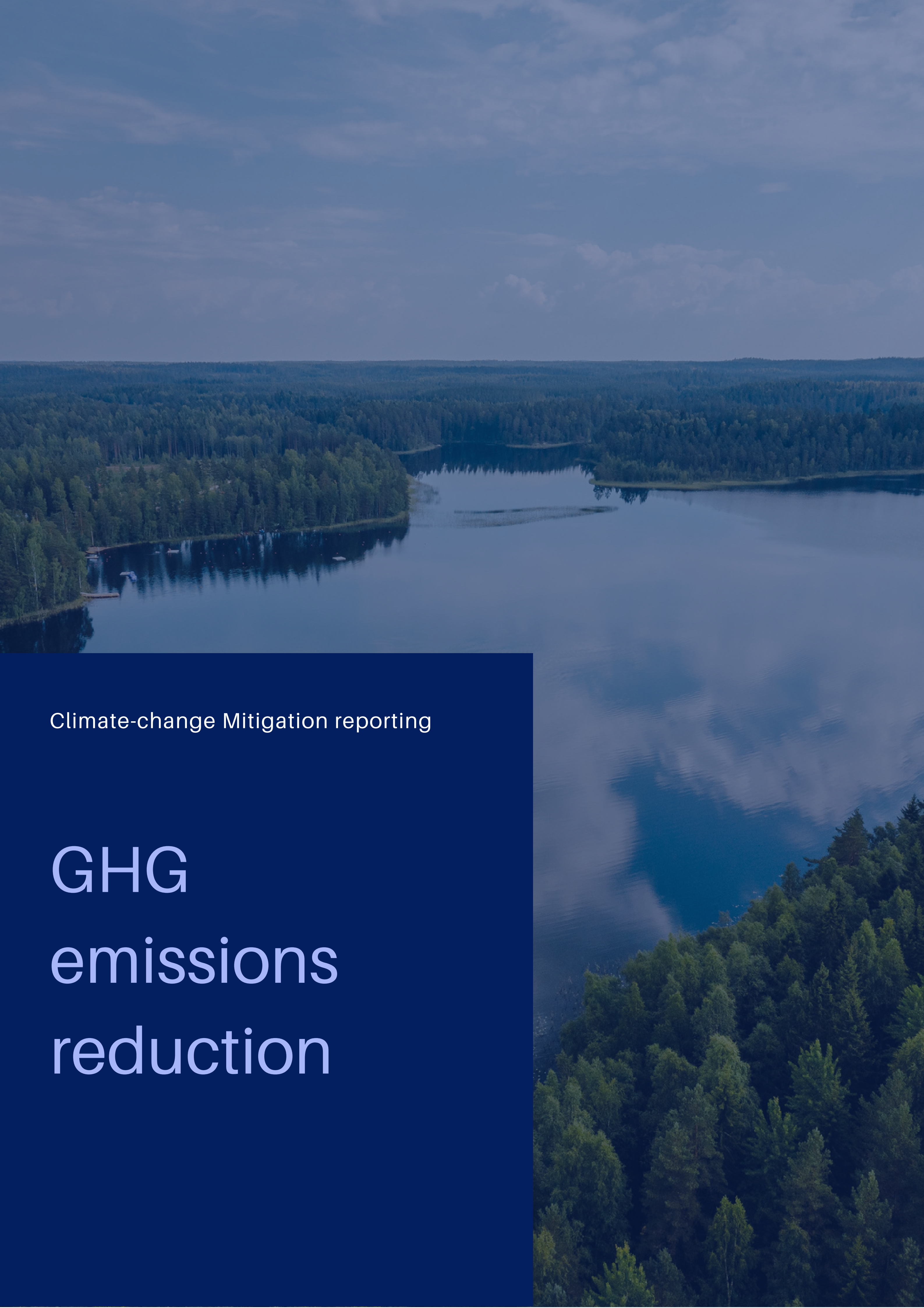
However, GHG emissions are only one component of the impact of the resources and processes associated with dam construction. Considering other metrics, hydropower projects have the lowest Ozone Layer Depletion indicator, the highest Energy Returned on Energy Invested ratio, and is the best form of renewable energy for reducing pressure on mineral resources (when compared in a study to solar PV) (Hydropower Europe, 2022).

GHG emissions: End-of-life considerations

Hydropower asset owners and developers must consider the end-of-life of a project in terms of decommissioning construction components and the recycling of valuable metals and equipment. Dam removal also releases trapped sediment downstream into rivers.

The demolition stage is often excluded from lifecycle emissions assessment because, in many cases, the infrastructure remains to preserve the adapted ecosystems and environments, even though it no longer produces electricity.

The selection of components for the decommissioning process to be included in the calculation of GHG emissions has a significant impact. For example, if we consider only the transport of materials (to landfill or recycling sites) and the energy consumed by demolition machines, studies have shown that end-of-life emissions are low enough to be negligible (Suwanit, 2011 and Pang, 2015). However, including the effect of sediment trapped by the dam significantly alters calculated GHG emissions. Research published in 2007 found that the decomposition of sediment can generate a quantity of emissions that is around 18 to 65 times higher than in the construction stage phase, and 3 to 25 times higher than during the O&M period (including reservoir emissions) (Pacca, 2007).



Climate-change Mitigation reporting

GHG emissions reduction

GHG EMISSIONS REDUCTION

REPORTING RECOMMENDATIONS

At the asset level, present the following information:

Emissions reduction

The reporting of reductions in GHG emissions that occur as a direct consequence of a change to a project, should include:

- whether the emissions reduction contributes to Scope 1, Scope 2, and/or Scope 3
- CO_2 and CH_4 reported separately, if possible (see section on Understanding GHG Emissions, Reporting recommendations)
- the methodology, tools, exclusions or inclusions, assumptions used for the estimation or calculation, including the input data, GWP, selected lifecycle, and references to all sources of information
- a plan for GHG emissions monitoring and frequency.

Emissions capture and removal

The reporting of GHG emissions removed as a direct consequence of activities to remove them from the hydropower project, should include:

- a description of the activity selected and the baseline year
- whether the emissions reduction contributes to Scope 1, Scope 2, and/or Scope 3
- CO_2 and CH_4 reported separately, if possible (see section on Understanding GHG Emissions, Reporting recommendations)
- the methodology, tools, exclusions or inclusions, assumptions used for the estimation or calculation, including the input data, GWP, selected lifecycle, and references to all sources of information
- a monitoring plan aligned with the accounting requirements of the GHG Protocol Land Sector and Removal Guidance

Measuring the trade-off between costs and benefits of mitigation activities

The reporting should include the cost of GHG emissions mitigated through activities that reduce GHG emissions.

In the case of carbon removals, such as afforestation – measure the rate of emissions per unit quantity of the activity (for example, in tonnes of CO_2e hectare per annum).

In the case of carbon capture from reservoirs, measure the rate of emissions capture (in tonnes per volume of water).

In the case of new technologies to remove methane from water, measure the rate of the utilisation of the resulting biofuel (reporting final emissions compared to the original emission at source).

Climate finance and carbon credits and offsets

It is useful to take into consideration the carbon credits associated with the asset, which are tradable, under voluntary programmes or established markets.

The reporting should set out whether the emissions reduction project is financed by a corporation's internal emissions trading programme. It should also look at whether the project qualifies for green finance or climate finance.

GUIDANCE

The GHG Project Protocol (2005) is an accounting tool that provides a means for climate change mitigation projects (GHG projects) to quantify the effect of a specific activity or set of activities intended to reduce GHG emissions, increase carbon storage, or carry out GHG removal from the atmosphere. In a GHG emissions inventory, this would appear as a year-on-year decrease in Scope 1, Scope 2, and/or Scope 3 emissions. GHG reduction refers to either a reduction in GHG emissions or an increase in removals or storage relative to baseline emissions.

The potential for emissions reduction as a direct or indirect consequence of these activities can encourage the modernisation of hydropower assets to reduce Scope 1 emissions intensity. The information reported can be part of the economic analysis of a modernisation or rehabilitation project. It includes external factors such as environmental benefit to society, comparing a given scenario with a mitigation project and one without a mitigation project.

The guidance section presents activities and initiatives that are currently available to reduce and remove emissions. Depending on the jurisdiction, specific formats can be used to report emissions reduction activities. As an example, the Costa Rica INTE B5 Standard provides a suitable criterion for this reporting.[1]

EMISSIONS REDUCTION

Many activities can reduce the GHG emissions reported in Scope 1, Scope 2, and Scope 3. The reduction can be reported in absolute terms or per unit of production (intensity of emissions – gCO2e/kWh). Where it is a reduction in absolute terms, the project emits a lower quantity of GHG emissions than before the activity´s implementation. An activity that increases the generating capacity can leave the absolute emissions unchanged but appear as a decrease in GHG emissions intensity.

For scope 1 and 2

The activities outlined below reduce emissions, either in absolute terms or in terms of emissions intensity reporting for Scope 1 and Scope 2. At the same time, these modernisation activities provide emissions avoidance relative to what are otherwise technically and economically viable alternatives (see section Emissions Avoidance for further detail):

- The modernisation of existing projects with new technologies makes assets more efficient than older versions. It also increases generation output and improves plant flexibility to provide ancillary services *(Decrease in emissions intensity)*
- Upgrades to the power plant, leading to an increase in the hydropower installed capacity and generation. *(Decrease in emissions intensity)*
- Implementation of hybrid projects – for example, solar floating PV, or combination with wind systems, or with heat generation. Improves the efficiency of the hydropower plant and the hybrid plant. *(Decrease in emissions intensity and potential reduction in absolute terms)*
- Pumped-storage project attached to an existing hydropower plant (under some conditions; see below). *(Decrease in emissions intensity)*
- Replace fossil fuel-powered vehicles and work equipment to utilise low-carbon power sources, or electricity from low-carbon generation. *(Reduction in absolute terms)*
- Other projects to improve the energy efficiency of hydropower facilities. *(Decrease in emissions intensity)*

The substitution of electro-mechanical equipment with modern, more efficient one increases they hydropower plant´s capacity and availability. The percentage increase varies depending on the equipment´s age and which components are new (Goldberg, 2011). A recent study estimates that the weighted efficiency (that is, the overall efficiency of the complete range of operation, including part load) could increase by 6.3% if all related parts are renewed. However, a more realistic estimate is 5.5% where the components to be renewed are between

[1] More information in Dirección de Cambio Climático del Ministerio de Ambiente y Energía (MINAE) Costa Rica (2018). Guía para la participación en el Programa País de Carbono Neutralidad. https://cambioclimatico.go.cr/wp-content/uploads/2019/07/Guia-Carbono-Neutralidad-DCC-Parte-1.pdf

40 and 50 years old (which is the case for many hydropower plants in Europe) (Quaranta, 2021).

The modernization options considered above have limited or no impact in the environment, especially in Europe.

The hybridisation of hydropower assets can bring additional benefits to hydropower generation. Floating photovoltaic (FPV) panels on the surface of the reservoirs reduces evaporation by up to 70% on the covered surface, which means an increase in available flow that can be used for hydroelectric generation or other purposes (Hydropower Europe, 2022). Besides adding power and reducing evaporation (that leads to increased water availability), FPV panels also reduce algae and lower natural methane emissions. This reduces absolute GHG emissions (MacIntyre, 2020, and Rosa-Clot, 2020). Projects can also exploit the heat given out by the hydropower plant operations (Goričanec, 2014).

Adding a reservoir to incorporate pumped storage in an existing hydropower asset may contribute to reduced emissions intensity. The creation of an upper (or lower) reservoir can cause an increase in absolute emissions, but a reduction in emissions intensity. The creation of an artificial reservoir that is off stream, closed loop, with no river flow, sediment flow, or organic matter input would avoid an increase of emissions once it began operations. Where relevant it is recommended that vegetation should be removed in the impoundment area of the new reservoir to minimise adverse impacts, including GHG emissions.

Two existing reservoirs can be connected to optimize water storage and allocation, and pump-as-turbines (PATs) can be installed for turbine and pump operation, with a net benefit because no additional GHG emissions would be created (Gimeno-Gutiérrez, 2015). Compared to batteries, pumped storage hydropower shows a lower impact in a lifecycle assessment, except in terms of the transformation of the natural landscape (Immendoerfer, 2017). Although, batteries would require as large or larger area as PSH to be comparable with PSH energy capacity. Batteries do not have to be expensive centralised installations with a large capacity. The required capacity can be broken down into small units and distributed across a number of sites, producing a fast response. However, batteries have particular requirements with regard to the materials from which they are made, how they can be operated, and how they are decommissioned at end of life. Batteries are particularly well suited to fast-response short-term balancing requirements. PSH assets can hold large amounts of energy and can provide long-term storage. They have a lifespan of up to 100 years (compared to below 20 years for batteries). For this reason, batteries should be regarded as a complementary technology rather than as a substitute.

It should be noted that the grid emissions from the electricity used to store energy must be accounted for both in batteries and in PSH assets.

Established nature-based solutions can improve the energy efficiency of hydropower facilities, such as installing green rooftops on the powerhouse. In addition, there are often unexploited opportunities to harvest energy to improve efficiency and, as a consequence, reduce GHG emissions intensity. Examples would be the exploitation of excess heat from the generators and of the residual kinetic energy downstream of draft tubes (Quaranta, 2022).

For scope 3

Other activities can contribute to reduction of Scope 3 emissions in relation to hydropower projects, such as:

- management of unrelated anthropogenic emissions, or other sources of organic matter;
- improvement in manufacturing processes in the supply chain.

Both urban areas and agriculture upstream of a hydropower project can introduce high levels of organic matter to the water inflow of the reservoir. Unrelated anthropogenic emissions can result from lack of water treatment plants or the drainage of nutrients from agricultural land. Such factors contribute to total reservoir emissions, and managing these sources can reduce a hydropower project's Scope 3 emissions. Similarly, actions that decrease sediment yield upstream in the catchment – such as check dams and nature-based solutions – minimise the sediment load entering the reservoir.

Scope 3 emissions from upstream anthropogenic activities (urban, agricultural, or deforestation) should be reported in absolute terms. Metrics can be difficult to define and will vary depending on the activity. Some nature-based initiatives – the Blue Energy Mechanism, for example – link metrics for reforestation to an increase in hydropower generation.[2]

Pre-impoundment clearance

In the design phase account should be taken of the GHG emissions reduction potential from pre-impoundment clearance. This should include assessment of organic matter stock change and soil organic carbon stock change, which should be aligned with GHG Protocol Land Sector and Removals Guidance (Greenhouse Gas Protocol, 2022). Pre-impoundment clearance of an area to be flooded by a reservoir is a commonly applied engineering measure. It involves removal of vegetation, buildings, structures, solid waste landfill, and other potentially dangerous materials (Li, et al., 2017). One study shows that flooded foliage can contribute to an average increase in CH4 and CO2 emissions of 33% and 28%, respectively (Faria, 2015). Vegetation clearing is a practical measure to minimise GHG emissions after reservoir impoundment.

Reasons for clearance include –

- Flooded vegetation causes anaerobic fouling with high levels of methane and other GHG emissions
- Floating debris and other solids clog outlet structures and/or crush dam structures (Zhang, 2015)
- Organic matter and other pollutants in the flooded area risk water quality deterioration after impoundment (Godshalk, 1985)
- Risk of epidemics in reservoir areas and downstream can be caused by pathogenic microorganisms after impoundment (Morley, 2010)

Clearing vegetation prior to impoundment might not be necessary at some sites (Salignat, 2011). In some places it might not be technically or economically feasible if, for example,

- clearance of the area is technically challenging because of access problems arising from the topography of the site
- export of the biomass produced from cutting the vegetation is not feasible

Pre-impoundment clearance requires an investment of materials and energy – and thus creates GHG emissions. Hydropower asset owners need to calculate the climate-change mitigation benefits of pre-impoundment clearance, against the additional GHG emissions associated with that clearance.

Land use emissions factors include emissions released when land and vegetation are altered or removed in the construction phase. Therefore, the assessment should calculate GHG emissions from the machinery used to clear and remove vegetation, including trees – as well as the direct land use impact. Asset owners and planners should consider the net effect of laying bare woodland and agricultural land. For marshland, the total area should be included, even if some masses are naturally laid bare.

When vegetation clearance is not considered favourable the project design can incorporate additional measures to manage water quality and GHG emissions in the reservoir and downstream areas, such as use of a water intake in the upper layers of the reservoir for turbine flow.

EMISSIONS CAPTURE AND REMOVAL

Keeping below the 1.5 °C target requires solutions to actively remove GHG from the atmosphere to accelerate the pace of emissions reduction. Mitigation strategies to avoid fossil-fuel generation and to reduce emissions intensity from power systems – such as greenfield hydropower projects, modernising hydropower infrastructure, and upgrading existing installed capacity – might not be enough on their own to reach net-zero emissions. Therefore, emissions capture and removal solutions are intended to offset residual emissions after sectors decarbonise. In the event that the 1.5 °C target is exceeded, these solutions will be required to bring global temperatures down again later in the century (IPCC, 2022).

Afforestation, reforestation, and agroforestry systems in the catchment area are effective solutions for carbon removal. Plants, through photosynthesis, remove CO2 from the atmosphere and store it naturally in the trees, ground vegetation, and soil – a green solution that also achieves sediment yield reduction and land-use change.

Technological carbon-removal has significant potential; however, scalability remains a challenge,

[2] More information on The Global Innovation Lab for Climate Finance website, the Blue Energy Mechanism https://www.climatefinancelab.org/project/blue-energy-mechanism/

as does the issue of sustainability. For example, bioenergy with carbon capture and storage (BECCS) involves growing bioenergy crops, such as grasses and trees, burning them in power stations, stripping the CO2 from the resulting waste gases, and compressing it into a liquid for underground storage. Other capture technologies aim to prevent atmospheric methane emissions by capturing the methane bubbles formed as water passes through turbines. One study shows that biomethane can be trapped with a yield of 60% (Kikuchi, 2008). Unlike CO2, methane can be used as a biofuel to produce energy. Burning biomethane emits CO2 but as CO2 is a far less potent GHG, it reduces the CO2e impact. At present, capture technology solutions to remove methane from water at scale are being developed to make methane capture more feasible. This could also generate additional revenues at existing hydropower dams.[3]

In line with the GHG Protocol Land Sector and Removals Guidance, hydropower companies should account for and report Scope 1 or Scope 3 CO2e removal, as set out below:

1. Ongoing storage monitoring

A plan should be developed for the monitoring of carbon storage, to account for reversals, and to report emissions from the stored carbon.

2. Traceability

Companies should ensure traceability throughout the CO2 removal pathway. The traceability should cover transfer to a sink, where used (where CO2 is transferred from the atmosphere to non-atmospheric pools), transfer to the final carbon storage pools, and intermediate processes.

3. Primary data

Hydropower companies should use empirical data specific to the sinks and pools where carbon is stored.

4. Uncertainty

If removals are statistically significant andcompanies provide quantitative uncertainty estimates.

5. Reversals accounting

Net carbon stock losses of previously reported removals should be reported in the year the losses occur – either as net CO2 emissions, if the carbon pools are part of the GHG inventory boundary in the reporting year, or as CO2 reversals, if the carbon pools are no longer in the GHG inventory boundary in the reporting year. If companies lose the ability to monitor carbon stocks associated with previously reported removals, they should assume previously reported removals are emitted and report this as a reversal.

METRICS TO MEASURE THE TRADE-OFFS BETWEEN COST AND BENEFITS OF MITIGATION AND EMISSIONS REDUCTION ACTIVITIES

Apply carbon pricing (see carbon pricing section) to calculate the cost of GHG emissions avoided or reduced through energy efficiency activities that displace fuel combustion or fossil-fuel-based generation, or activities that manage unrelated anthropogenic sources and other sources of organic matter.

CARBON CREDITS AND OFFSETS

Carbon offset mechanisms support climate regulations and policies. They are used to scale up GHG emissions reductions with the aim of meeting climate-change goals. An offset mechanism enables the sale of hydropower GHG emissions reduction (in the form of carbon credits) on domestic or international markets. To be tradeable, the carbon credit must be verifiable. The hydropower asset or emissions reduction activity can produce carbon credits to trade on established or voluntary carbon markets (VCMs).

Offsets programmes under the United Nations Framework Convention on Climate Change (UNFCCC) include Joint Implementation (JI) and the Clean Development Mechanism (CDM), both developed under the Kyoto Protocol (Annex B Party). The Paris Agreement, Article 6, updates the Kyoto mechanisms; its application is under development.

To date, the CDM has been successful in mobilising capital towards low-carbon investments in developing countries in efforts to scale up GHG emissions reductions. The CDM certifies carbon credits of hydropower projects that comply with the

[3] An example is the technology from Bluemethane https://www.bluemethane.com/

eligibility criteria for project emissions (that is, with a power density greater than 4 W/m2). This includes emission reduction activities that transfer generating capacity to less GHG-intensive sources.

The JI has faced regulatory challenges in issuing credits; therefore, its implementation has been less successful than the CDM. The Paris Agreement, Article 6, enables countries to cooperate voluntarily to achieve the emission reduction targets set out in their Nationally Determined Contributions (NDCs). Article 6.2 creates the basis for trading in GHG emissions reductions (or "mitigation outcomes") across countries. Article 6.4 is expected to be similar to Kyoto's CDM.

For hydropower projects, voluntary markets provide a means to reduce overall GHG emissions figures using offsets. They can also issue credits from their own carbon emissions reduction activities. In the voluntary market, buyers purchase Verified Emission Reductions (VERs) that are produced by emission reduction activities at the project level. Various carbon crediting programmes verify and trace carbon credits, such as the Verified Carbon Standard (VCS) Program and the Gold Standard.[4] To date, voluntary markets have not recognised emissions reduction from carbon capture and storage, or from utilisation activities. A new initiative was created in 2021 under the VCS Program to boost these types of activities.[5]

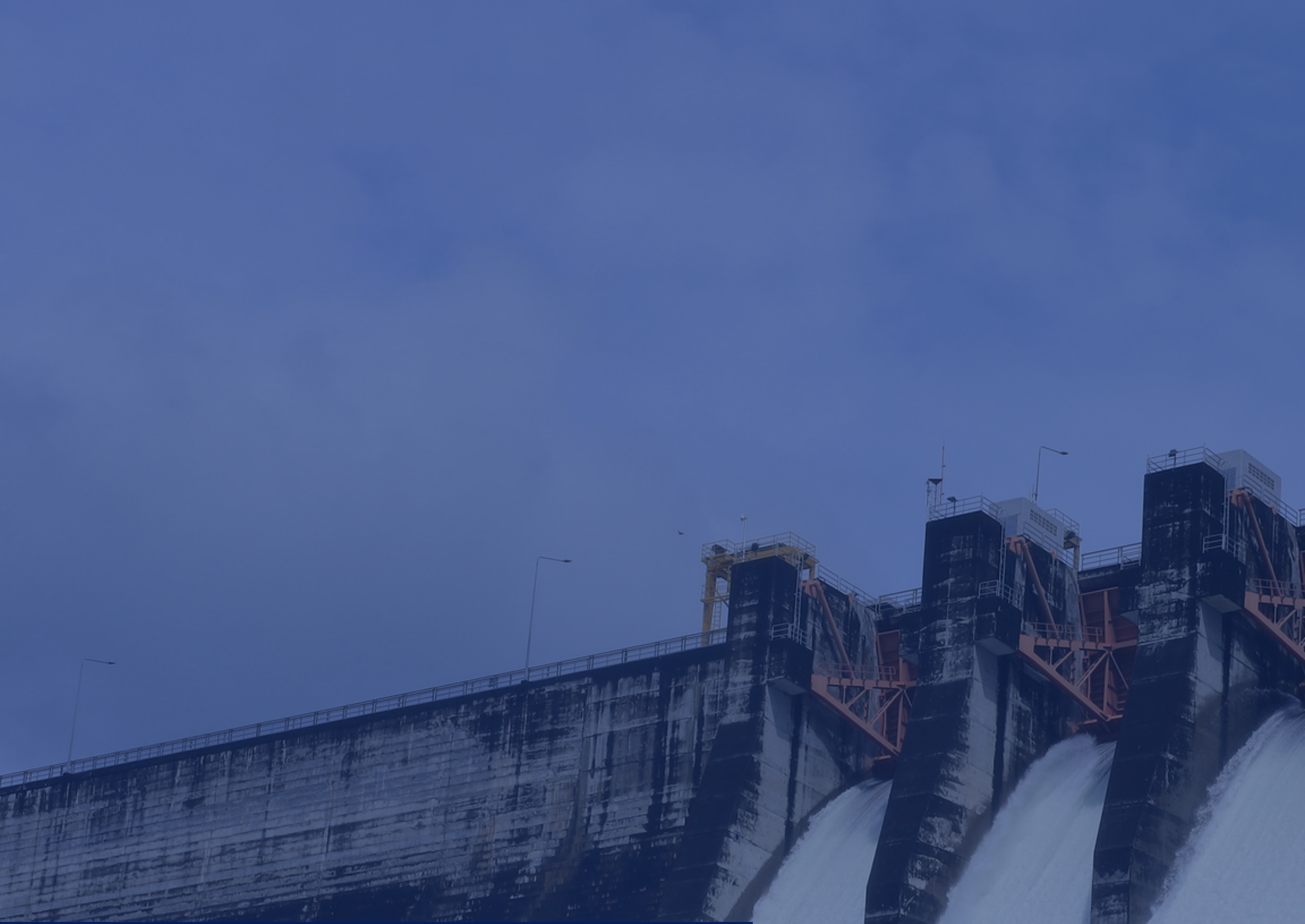
Some companies have also established an internal trading mechanism enabling business units to trade allocated carbon credits.

Hydropower projects can receive finance linked to climate commitments – known as results-based climate finance (RBCF). Climate finance investors use RBCF structures to drive low-emissions or emissions reduction outcomes from activities such as greenfield hydropower or modernisation projects. Some RBCF programmes require certified emission reduction (CER) units, generated from a CDM project activity.

Since 2021, hydropower projects can be financed or refinanced by climate bonds that follow the CBI Hydropower Criteria (Climate Bonds Initiative, 2021). The eligibility criteria include GHG emissions thresholds. Projects that were operational before 2020 must comply with a power density greater than 5 W/m2 or a GHG emissions intensity lower than 100 g CO2e/kWh. For projects that have become operational during or after 2020, the thresholds rise to a power density of 10 W/m2 or a GHG emissions intensity of 50 g CO2e/kWh. Emissions reduction activities can bring a project in under these thresholds.

[4] More information on https://verra.org/project/vcs-program/ and https://www.goldstandard.org/

[5] More information on https://www.ccsplus.org/



Climate-change Mitigation reporting

GHG emissions avoidance

GHG EMISSIONS AVOIDANCE

REPORTING RECOMMENDATIONS

Asset-level information report:

Emissions avoided

GHG emissions (units in absolute terms in metric tonnes of CO_2e per year) avoided **as a direct consequence** of the development of a new project or an activity in an existing project. For comparison, include figures for the energy source that is being used as a baseline and is being displaced by this new development.

GHG emissions (units in absolute terms in metric tonnes of CO_2e per year) avoided **as an indirect consequence** of the upgrade, modernisation, or hybridisation of an existing project. Include references for the sources of assumptions used for the calculation.

GUIDANCE

This reporting guideline informs the transitioning of investment portfolios to low-carbon alternatives. Developers of new hydropower assets should calculate their GHG emissions avoidance relative to current viable, comparable alternatives for electricity generation. Hydropower base-load generation is generally compared to base-load generation at thermal, coal, or gas power plants, which have higher median lifecycle emissions than hydropower. As energy sources change, hydroelectric generation is likely to be compared with viable alternatives with lower emissions, making the case for hydropower development more marginal. It is necessary to understand the role of pumped storage hydropower in this decarbonisation context. It enables the penetration of intermittent renewable energy sources by providing a balancing service. Thus, emissions avoidance can be reported relative to fossil-fuel based generation.

DIRECT CONSEQUENCES

Any improvement in hydropower capacity (either increased installed power or efficiency) translates into a potential increase in electricity generation. This increase in electricity generated in the hydropower plant can be compared to other electricity-generating technologies with similar functions, services, and operational time frames, such as thermal power plants. The difference in CO_2e emissions associated with hydropower production compared to another energy technology can be expressed as a difference in the emission rate per kWh generated.

To assess avoided emissions, use a lifecycle assessment that includes fuel supply chain emissions and the manufacturing of the energy technology. Hydroelectricity has lower median lifecycle GHG emissions when compared to electricity generated by sources such as lignite coal, natural gas, biomass, solar photovoltaic, and geothermal. For example, Table 2 presents the lifecycle emissions of various electricity supply technologies according to IPCC AR5 (Schlömer, 2014).

A recent study (Ubierna, 2021) confirms that hydropower is a low-carbon technology. The study gives a figure of 23 g CO_2e/kWh for median emissions from global hydropower over a 100-year lifetime using a net approach, which is similar to the median emissions given by the IPCC AR5. However, the study found a wider spread than previously reported by the IPCC, with a minimum of -922 g CO_2e/kWh (an emissions sink) and a maximum of 4295 g CO_2e/kWh (a high emitter). This highlights the need for more accurate field measurements of climate change effects.

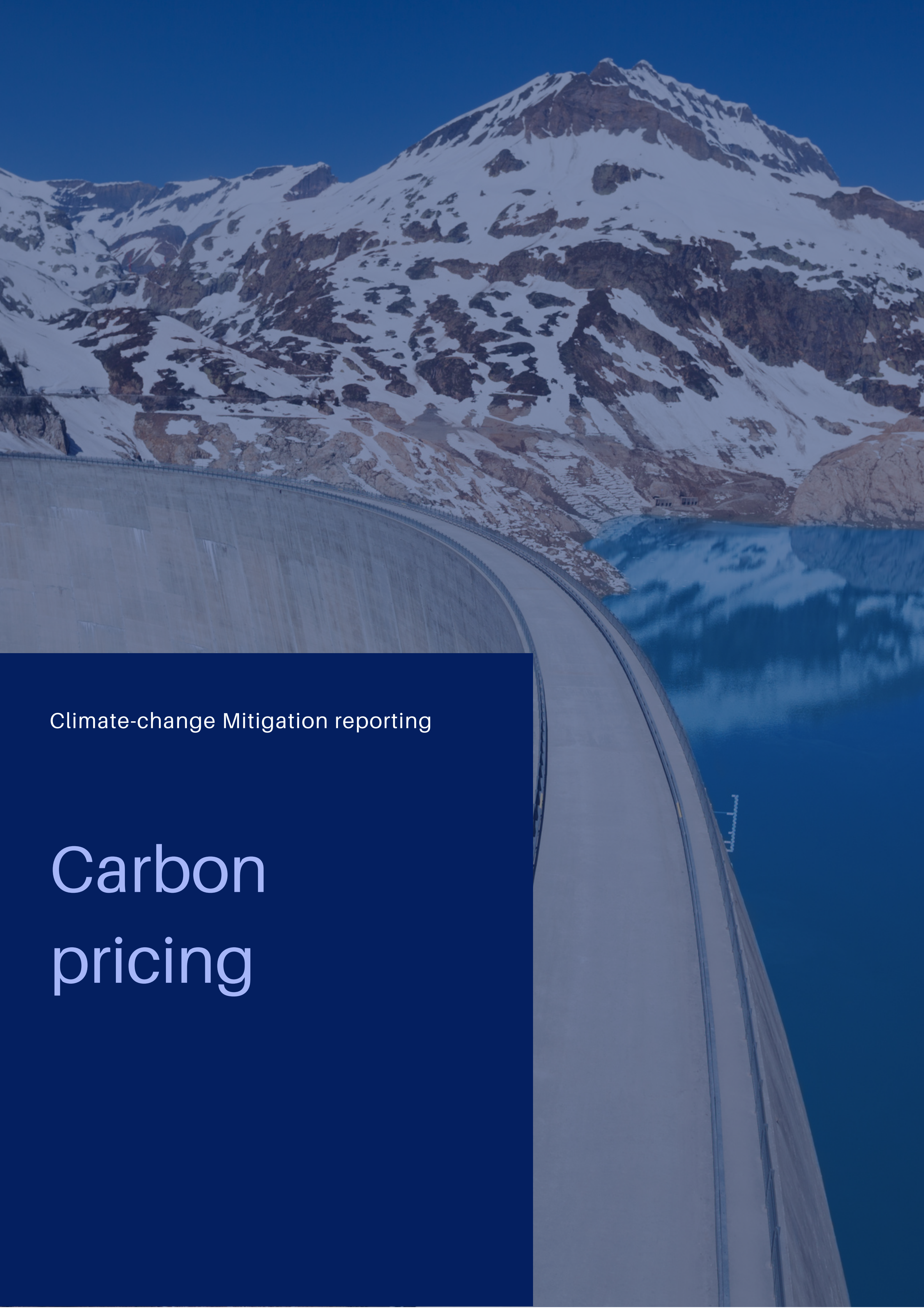
Table 2. Lifecycle emissions for various energy technology from IPCC AR5 (Schlömer, 2014)

Energy technology	**Lifecycle emissions [gCO_2e/kWh] (Min/Median/Max)**
Coal	740 / 820 / 910
Natural gas combined cycle	410 / 490 / 650
Biomass	130 / 230 / 420
Solar PV	18 / 48 / 180
Geothermal	6 / 38 / 79
Hydropower	1 / 24 / 2200
Nuclear	3.7 / 12 / 110
Wind onshore	7 / 11 / 56

INDIRECT CONSEQUENCES

When evaluating the benefits of an activity, in addition to displacing fossil fuel generation, hydropower can increase the use of intermittent renewable energy sources such as wind and solar. The activity can increase the ability of a power grid to integrate these sources by increasing storage capacity (for example, in a PSH project; in increased reservoir capacity; in reservoir interconnection), improving ancillary services (for example, by implementing digitalisation, automation, and using modern and flexible equipment), and incorporating dispatch modelling (digitalisation) to provide reliability and flexibility to the network.

One study of conditions in Germany and Sweden (Hirth, 2016) shows that the dispatch flexibility of hydropower storage compensates for wind power output variability. It concludes that hydropower helps to mitigate the wind value drop in electricity supply. It further states that upgrading hydropower turbines reduces hydro capacity limitations, helps boost the value of wind power, and increases the value of hydroelectricity. Finally, in a 2020 study of energy strategy and the effect of PVS on power system stability, high PV penetration was observed to lead to overvoltage. Participation of more than 20 % of solar power in centralised systems affects the frequency stability adversely (Impram, 2020). Pumped storage hydropower again has an important role to play here in providing stability to centralised generating systems.



Climate-change Mitigation reporting

Carbon pricing

CARBON PRICING

REPORTING RECOMMENDATIONS

Asset-level information report:

External carbon price

Establish whether the jurisdiction where the asset is located has implemented, or intends to implement, a carbon pricing regulation (such as a carbon cap and trade scheme, or a carbon tax).

Using this information, report the monetary cost of the CO_2e emissions associated with the project.

Internal carbon price

Establish the internal carbon price for the asset. Specify whether it is a hypothetical cost – a shadow carbon price – or whether it the asset incurs a cost in a financial flow. Define the time horizon(s). That is, cost should be expressed as units of currency per tonnes of CO_2e and the reference year; for example, EUR 7/tCO_2e in 2020.

Include a reference to the source or basis for the price(s) chosen for different time horizons. It should be credible, preferably from reputable scientific research and aligned with a 2 °C pathway or lower).

Explain for what purpose and how the carbon price has been applied. If the carbon price leads to a cost in a financial flow, explain any internal mechanisms or initiatives that enable these costs to be offset in other parts of the business.

If the pricing within the jurisdiction varies according to the GHG emitted (CO_2, CH_4, for example), the costs must be broken down in the same way.

GUIDANCE

EXTERNAL COST OF GHG EMISSIONS

After mapping emissions, companies should examine their asset's exposure to current and estimated future carbon prices by assessing climate policies in the countries where they operate or plan to expand.

Carbon pricing is an economic signal to emitters and plays an essential role in driving the transition to a decarbonised economy. Around the world, governments and public authorities have implemented or are implementing a price for carbon emissions to encourage emissions reduction and stimulate clean technology. Emissions trading systems (ETS, see below) and carbon taxes are the most common contexts in which a carbon price is established. They can be complementary in regulated markets. The price is flexible in an ETS, reflecting environmental impact, while a carbon tax guarantees a carbon price, unrelated to environmental outcome.

Emissions Trading Systems (ETS)

An ETS is a carbon market where regulated entities can buy and sell emissions units in line with their emissions targets. An ETS establishes a market price for GHG emissions.

There are two main types of ETS

- Cap-and-trade system – an ETS holds an overall emissions limit. The system distributes emissions allowances, without cost or through auctions, for the number of emissions units equivalent to the cap.
- Baseline-and-credit system – baseline emission levels are defined for the regulated entities. Credits are issued for reductions of emissions

below that level. Entities with emissions above their baseline level can purchase credits.

A **carbon tax** sets a tax on GHG emissions; that is, a price per metric tonne of CO2 e. Therefore, the price is defined, unlike the emissions reduction outcome.

While high-income countries were the first to implement carbon pricing initiatives, middle-income countries are now introducing carbon pricing as well. Up-to-date information on the carbon pricing initiatives of countries and subnational jurisdictions is available at the World Bank's Carbon Pricing Dashboard.[1]

Climate-change regulations are underpinned by considerations of long-term forecasts and the cost of emissions to the wider society, and carbon prices vary according to the discount rate applied for intergenerational analysis. That is, when reporting on externalities – the cost of emissions to the wider society – it is necessary to include the carbon taxes applied in some countries.

The **social cost of carbon** is the expected economic damage caused by a metric tonne of carbon dioxide (expressed as USD/tCO2e)

The USA uses a more detailed analysis that includes an estimation of the social cost of carbon (USD/tCO2), the social cost of methane (USD/tCH4), and the social cost of nitrous oxide (USD/tN2O) (United States Government, 2021) . This enables a fuller understanding of the benefits of reducing these GHG emissions and the full impact to society if these emissions are allowed to increase.

A recent study estimates the social cost of carbon at the country level and finds vast differences between countries. For example, India has a median value of USD 85.4/tCO2; Canada has a negative value of USD -8.2 /tCO2 (Ricke, 2018).

SHADOW OR INTERNAL CARBON PRICE

Internal carbon accounting can be used to manage transition risk, support net-zero corporate targets, and improve investment decision making (McKinsey, 2021).

Carbon prices are essential for analysing and assessing economic impacts of carbon emissions. They contribute to an estimation of the financial impact of regulatory change, the hedging of transition risk, and encourage emissions reduction.

Setting an internal cost for GHG emissions from an asset or investment helps in the evaluation of their financial impact on a project. It supports decision-making to identify low-carbon investment opportunities. Carbon pricing can be expanded to cover assessment of carbon costs of materials and other goods used for the refurbishment of an existing asset, or the construction of a new plant. It assists evaluation of exposure to carbon risks throughout the supply chain – in the case of equipment manufacturing, for example (Scope 3 emissions reporting).

There are several approaches to assigning a cost to an asset's carbon emissions, including the two outlined below.

- **Shadow pricing** is a hypothetical cost per tonne of carbon emissions. It is used to better understand how pricing of carbon emissions can affect the project's business case or the CapEx. This hypothetical cost can reveal the risks and opportunities of a project development and its supply chain, which is useful in the planning of a new project, or an upgrade to an existing asset. It also supports strategic decision-making for future capital investment. It contributes to risk analysis by quantifying the potential impact of regulatory change arising from alignment with the Paris Agreement. The application of this mechanism does not result in actual financial flows.

- **Internal pricing** creates financial flows. It enables a project to be charged for its associated carbon emissions. It directly affects operational business decisions because it is included in the OpEx. This charge is usually placed in a fund to invest in clean technology and emissions reduction activities that help transition towards lower-carbon operations. Companies can establish internal trading mechanisms at the corporate level, enabling business units to trade carbon credits within the company.

Companies can use the carbon price set in the asset's jurisdiction as a basis for their internal carbon price. Companies can also consider a range of carbon prices to reflect price differences across jurisdictions. The internal carbon price should

[1] More information on https://carbonpricingdashboard.worldbank.org/

generally be set higher than the price in the regulated market of the asset's jurisdiction. It should factor in future increases as governments raise their level of ambition.

It can be helpful to consider different time horizons to help predict carbon price changes resulting from the development of climate-change policies. However, changes to price can occur in a matter of months. For example, the EU ETS, Europe's carbon market, tripled its carbon price from January 2021 to almost reach EUR 100 per metric tonne of CO2e in January 2022.[2]

In 2021, EU policymakers proposed legislation to accelerate emissions reduction by 2030, including reform to the carbon market. It is expected that this will have an upward impact on carbon prices in Europe. This regulation could benefit the hydropower sector as long as it remains lower-carbon intensive than other energy sources. Although the jurisdiction's carbon price might not apply to hydropower generation, it could affect the cost-effectiveness of hydropower technology and new business lines for the sector, such as hydrogen production. Industry estimates suggest that hydrogen produced from renewable energy would need a CO2e price above EUR 100 to be cost-effective (Reuters, 2022).

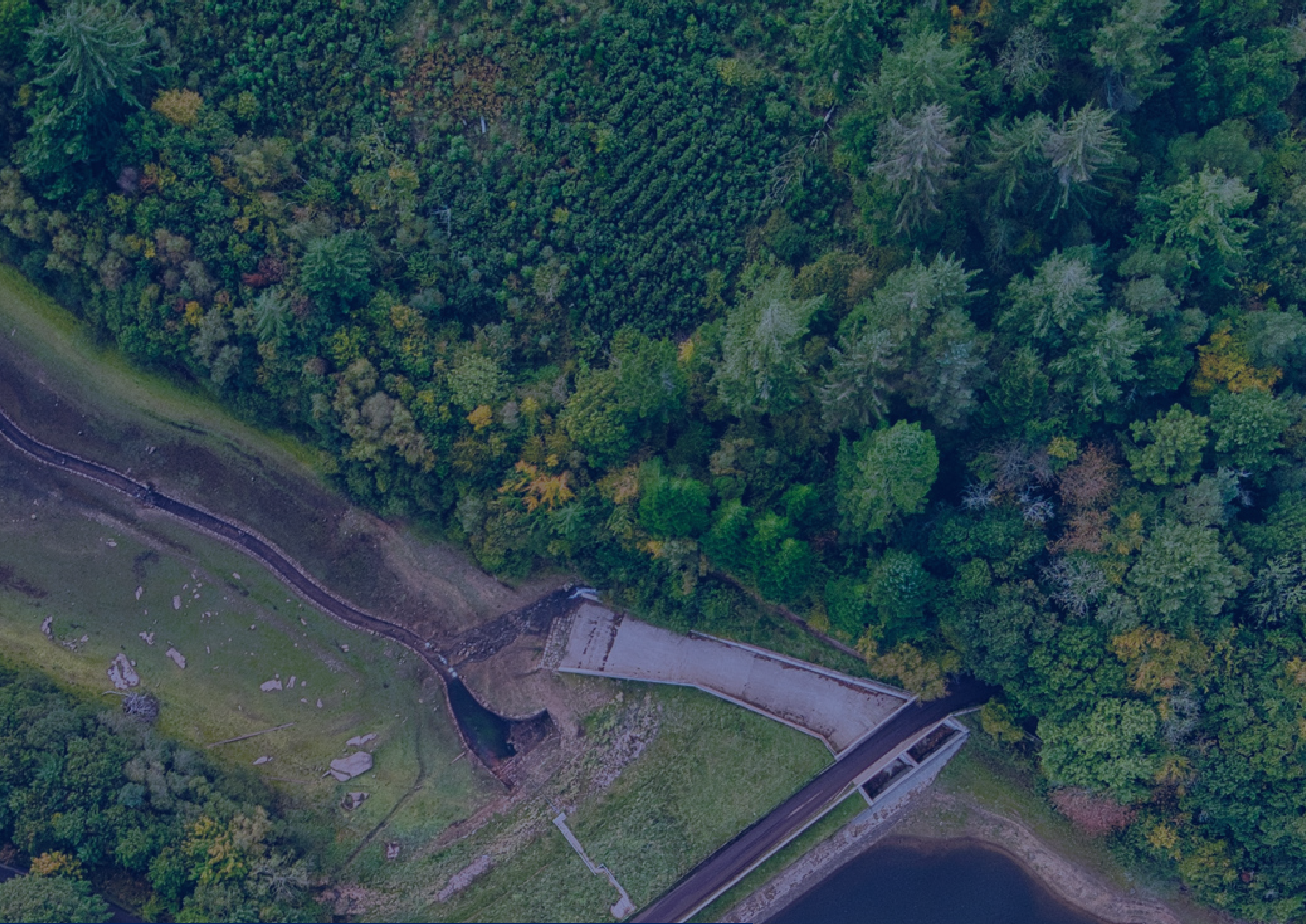
The internal carbon price should be consistent with the carbon price use for corporate strategy to limit global warming to 2 °C or below. In 2020, the High-Level Commission on Carbon Prices set a range of USD 40 to USD 80/tCO2e, rising to between USD 50 and USD 100/tCO2e by 2030 (The World Bank, 2017). This is intended to encourage emissions reductions and achieve the climate targets of the Paris Agreement. In 2017, the Carbon Pricing Corridors initiative (CDP, 2018) identified the carbon prices needed to decarbonise the electric power sector by 2050, setting them at USD 30–58/tCO2 e by 2025 and USD 30–100/tCO2e by 2030. The United Nations Global Compact (2016) goes beyond this and calls on companies to adopt an internal carbon price of at least USD 100/tCO2e to keep GHG emissions consistent with a 1.5 °C to 2 °C pathway.

Companies that do not implement an internal carbon price are implicitly using zero as the price for CO2e emissions.

Companies seeking funding from financial institutions should note that institutions are increasingly using carbon pricing as a tool in the economic assessment of projects. Financial institutions strive to identify and mitigate the climate risks associated with projects that are inconsistent with their climate goals. Carbon pricing is a way to represent a carbon footprint as a financial cost. It can integrate the cost of emissions to the wider society into project appraisal and thereby correct a market failure: in many developing economies, carbon price regulations are non-existent.

To fully utilise the potential of internal carbon pricing and support its implementation at the corporate level, the Carbon Pricing Unlocked research partnership has published a number of guides (Ecofys et al., 2017). For example, ACCIONA has established a fund which receives money from businesses in the group by charging an internal price for carbon emissions. The money is reinvested in actions to reduce GHG emissions. Funding for the decarbonisation activities is awarded through an internal tendering mechanism. Charging the price of carbon to operating costs is one of the most effective measures any company can take in the fight against the climate emergency (ACCIONA, 2021).

[2] A tonne of CO2 cost EUR 33 in January 2021 and ended cost EUR 96 in January 2022. Access the data on https://ember-climate.org/data/carbon-price-viewer/



Climate-change Mitigation reporting

Freshwater management and restoration

FRESHWATER MANAGEMENT AND RESTORATION

REPORTING RECOMMENDATIONS

Asset-level information report:

Water management

Report on water use and use priority associated with the hydropower asset.

If there is a water quality monitoring plan in place, describe management procedures and whether they comply with water quality standards applicable to the jurisdiction.

Companies must engage with compliance on downstream environmental flows.

Water conservation

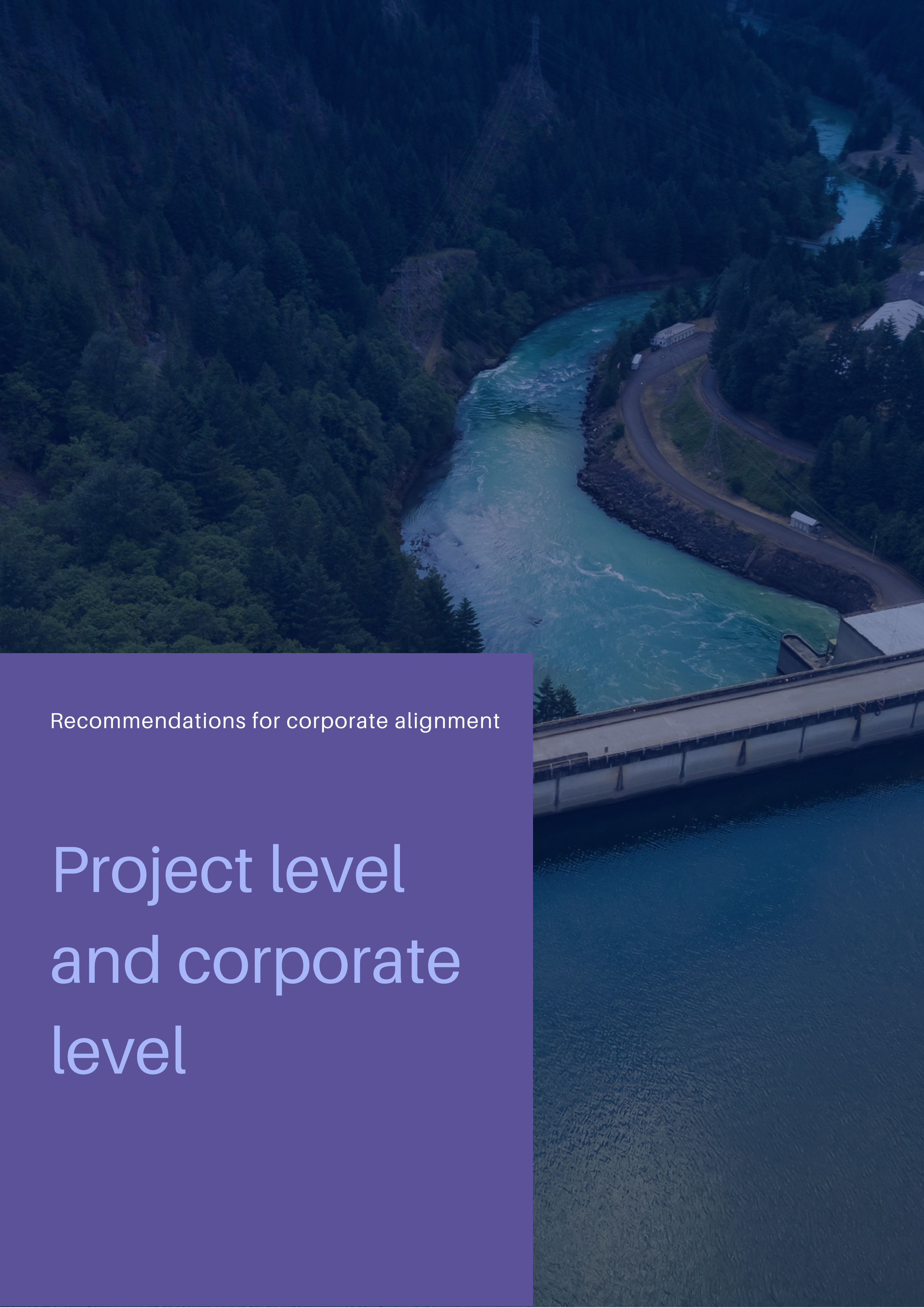
Report on engagement and actions with other water users and upstream water users that affect the water inflow (including sediment and nutrient load).

Report on engagement and actions with downstream water users that might be affected by hydropower operations.

GUIDANCE

Water should be understood and managed at a local level – typically, at river basin. Companies should account for all interactions with water, and minimise impact (for example, through reduced withdrawals, efficiency improvements, or by changing business activities). Hydropower operators should have a robust monitoring and accounting system in place for all aspects of freshwater management at the asset level.[1]

[1] For further information, see the CDP Water Security Reporting Guidance, 2022. https://www.cdp.net/en/guidance/guidance-for-companies



Recommendations for corporate alignment

Project level and corporate level

PROJECT LEVEL AND CORPORATE LEVEL

REPORTING RECOMMENDATIONS

Hydropower companies should align the reported information with their business strategy. To achieve this, the methodologies, calculations, and definitions used for reporting must be clear. This aids comparability and benchmarking between business units and companies with high proportions of hydropower in their portfolio.

GHG emissions

Define the organisational boundary approach used to consolidate GHG emissions at the corporate level.

Report GHG emissions for Scope 1, Scope 2, and Scope 3 according to the organisational boundary chosen.

- For an equity share approach, use the percentage of GHG emissions aligned with the company's ownership of each asset
- For a control approach, use the total GHG emissions of each asset over which the company has control.

Report GHG emissions for Scope 1 and Scope 2 combined in relation to net-zero targets. Companies may subdivide emissions data within scopes by facilities or business units to facilitate transparency and comparability over time.

Emissions reductions and offsets

Report information on offsets that have been purchased or developed outside the inventory boundary, differentiating between GHG storage/removal and emissions reduction projects. Specify whether the offset/reduction has been verified/certified and/or approved by an external GHG programme.

Carbon prices

Report information on external and internal carbon prices, explaining the basis for the carbon price used. Include a projected carbon price evolution and the assumed frequency of recalculation. Explain the purpose of the internal carbon price – such as offsetting emissions, and/or establishing a decarbonisation fund to incentivise reduction measure. Report on whether it enables business units to trade allocated carbon credits.

Report on the carbon credits associated with each asset, on which are tradable, and whether under voluntary programmes and/or on established markets.

Report on the internal payment for carbon costs.

Report on whether these payments are used to offset emissions.

Report on whether the payments are used for decarbonisation funds invested in measures to reduce the carbon footprint.

Report projects and activities that are aligned with a carbon offset programme.

Climate-related risks and opportunities

For each hydropower asset identify the risks (present and transitional) and opportunities relevant to the organisation over the short, medium, and long term.

Define the scenario analysis used at the corporate level.

Report on the proportion of assets and/or operating, investing, or financing activities that are materially exposed to present and transitional risk as a fraction of total electricity generation. Report the operational boundary approach used to define the proportion

Impact on financial performance

Provide the percentage of renewable energy generation in the portfolio.

Provide figures for low-carbon generation (below 100 gCO2e/kWh) as a percentage of total generation.

For those required to disclose under the EU taxonomy, provide the percentage of capital expenditure (CapEx), operating expenditure (OpEx), and revenue that are aligned with the taxonomy.

Provide the current and forecast percentage of CapEx to be used in the alignment of the company with achieving the 1.5 °C target.

GUIDANCE

GHG EMISSIONS

Definition of the organisational boundary

High-level organisational boundaries determine which business operations and facilities are part of the GHG inventory. Due to differences in legal and organisational structures, the criteria organisations use to determine boundaries will vary.

The consolidation policy selected should be applied at all levels of the organisation to ensure that GHG emissions data are aggregated consistently at all levels of the organisation.

According to the GHG Protocol Corporate Standard, two approaches can be used to consolidate GHG emissions for corporate reporting:

- Equity share approach. A company accounts for GHG emissions from operations according to its share of equity in those operations. Typically, the economic risk and reward from an operation is proportional to the company's share of ownership of that operation. Equity share will typically be the same as the ownership percentage.
- Control approach. A company accounts for 100% of GHG emissions from operations over which it has control. It does not account for GHG emissions from operations in which it owns an interest but has no control. When using the control approach to consolidate GHG emissions, companies should choose between operational or financial control criteria.
  - Operational control. A company accounts for 100% of the emissions from operations over which it, or one of its subsidiaries, has operational control. However, having operational control does not necessarily mean that it has the authority to make all decisions concerning operations. In the case of a leased asset, a company may report emissions as Scope 3. State clearly the reasons why the company does not have operational control.
  - Financial control. A company accounts for 100% of emissions from operations over which it or one of its subsidiaries has financial control.

In the hydropower industry the choice of control approach can have substantial consequences for the GHG inventory, because it often has complex ownership/operational structures. The operational control approach is consistent with the accounting and reporting practice of companies that report on emissions from facilities that they operate.

Consolidation of GHG emissions from the asset level to the corporate

As described in the section 'GHG emissions understanding', each GHG emissions source should be accounted for separately. The accuracy and transparency of the calculated emissions depend on the quality of the data collected, the rigor of quality control measures, and proper documentation. The GHG Protocol Corporate Standard outlines five accounting principles (relevance, completeness, consistency, transparency, and accuracy) derived from established financial accounting and reporting. Their application will ensure that the GHG inventory constitutes an accurate and fair representation of the company's GHG emissions.

A consolidation approach serves as the framework on which to build a GHG inventory that can provide a high-level perspective of a company's total emissions. It should serve the company's business goals and decision-making needs both externally and internally. It should include all emissions, calculated at the asset level. GHG sources and sinks must be identified to determine the project's GHG effect. Specify how emissions from GHG sources and sinks will be monitored. Frequency of monitoring should be monthly.

When compiling a GHG emissions inventory, companies should use the same approach for all Scope 1, Scope 2, and Scope 3 emissions.

When compiling a GHG emissions inventory, companies should use the same approach for subsequent reporting periods to ensure consistency when tracking emissions over time.

The disclosure of Scope 1, Scope 2, and Scope 3 emissions should correspond to the metrics and targets outlined by the TCFD recommendations.

Before accounting for Scope 3 emissions, companies should consider which business goal or goals they intend to achieve. For example, it can be useful to consider the supply chain, and the potential for future carbon regulations to significantly increase the cost of components. Additionally, companies may encounter reputational risk if they do not consider their broader corporate supply chain activities.

Operations or activities excluded from a company's Scope 1 and Scope 2 inventories (as a result of the organisational boundary) can be significant when accounting for Scope 3 emissions. The Corporate Value Chain (Scope 3) Standard identifies minimum boundaries for Scope 3 categories to help companies understand which activities should be accounted for (Greenhouse Gas Protocol, 2013).

The Scope 3 emissions identified at the asset level (see section 'GHG emissions understanding') correspond mainly to the category of purchased goods & services. To consolidate Scope 3 emissions, companies need to identify their emissions for all Scope 3 categories defined by the GHG protocol.

Transmission and Distribution

This reporting guideline focuses on hydropower generation activity and does not consider other activities in the value chain. For vertically integrated power companies and where otherwise applicable, emissions associated with electricity lost in T&D should be included in Scope 2. Losses resulting from illegal connection, from fraud, or from theft of energy, should be considered in Scope 3. For power purchased for sale to customers from a power generator or from the grid, the emissions associated with electricity lost in the T&D should be included in Scope 3, category 3.[1]

EMISSION REDUCTIONS AND OFFSETS

The purchase or sale of allowances, offsets, or credits should be reported under 'optional information' in the company's public GHG report.

When companies implement internal projects that reduce GHG emissions (for example, when an efficiency increase is produced through modernisation projects), the resulting reductions within the company's boundaries should be reported in the inventory. They do not need to be reported separately unless sold, traded externally, or used as an offset or credit.

CLIMATE-RELATED RISKS AND OPPORTUNITIES

According to the TCFD, climate-related risks are divided into two categories.

- Transition risks – relate to the transition to a low carbon economy. They are classified in four sub-categories: policy and legal, technology, market, and reputation.

[1] Update in chapter 4 in GHG Protocol Corporate Accounting and Reporting Standard and SBTi Quick Start guide for Electric Utilities (SBTi, 2020)

- Physical risks – relate to the physical impacts of climate change. They are classified in two sub-categories: acute and chronic.

In relation to GHG emissions, Table 3 below presents a list of potential transition risks identified for the hydropower sector. Additional transition risks should be considered on climate resilience and adaptation.

Table 3. Climate change mitigation transition risks for hydropower

Transition risk	**Potential impact on hydropower project**
Policy and legal	Substitution of hydropower by lower carbon options, reducing hydropower profit margins. GHG emissions-reduction laws or regulations introduced or pending in regions where the company, its suppliers, or its customers operate Increase in carbon price in the asset's jurisdictionGHG-related lawsuits directed at a company or an entity in the value chain
Market	Changes in supply and demand for generation Changes in sales margins Changes in investment strategies Suppliers to the asset passing on higher energy- or emissions-related costs Supply chain business interruption risk Changes in GHG emissions calculation due to an increase of more accurate reporting Price changes on carbon markets
Technology	Falling costs of low-carbon batteries or other competing technologies
Reputation	Stigmatisation of the hydropower sector: not being seen as a low-carbon option Increased shareholder pressure resulting from climate disclosures Consumer backlash, stakeholder backlash, or negative media coverage about a company, its activities, or related entities; for example, in relation to GHG management practices, or emissions in the value chain

The hydropower sector is exposed to physical climate-related risks such as extreme weather events – for example, torrential rains and floods, and changes in temperature. These risks can affect the GHG emissions of the whole supply chain of a hydropower plant, including the electricity distribution infrastructure. Climate change will strongly influence parameters such as temperature and the littoral zone, which will have a direct impact on the reservoir's GHG emission pathways.

Table 4 below shows a list of the main physical risks for hydropower facilities in relation to GHG emissions. Additional physical risks will be considered on climate resilience and adaptation.

Table 4. Climate change mitigation physical risks for hydropower

Physical risks	**Hydropower project**
Acute	Extreme weather events increase organic matter transport to the reservoir, and so increase GHG emissions Extreme events require altering the drawdown procedures of reservoirs, which increases GHG emissions
Chronic	Increase in temperature increases GHG emissions Decrease in average annual precipitation can decrease hydropower output

An increase in long-term temperature alters the average temperature of a reservoir and changes its stratification, affecting CH4 bubbling and degassing fluxes. A combination of extreme precipitation events with a decrease in average annual precipitation may cause lowering of reservoir levels uncovering littoral areas. This results in variations in CH4 ebullition flux, which declines with increasing water column depth (Harrison, 2021).

The TCFD recommendations encourage organisations to undertake historical and forward-looking analysis when considering risk and opportunities analysis.

Efforts to mitigate climate change can create opportunities for organisations. The TCFD has identified five areas of climate-related opportunities: resource efficiency, energy source, products and services, markets, and resilience. Table 5 below shows these climate-related opportunities across the value chain for hydropower generation.

Table 5. Climate-related opportunities for hydropower

Climate-related opportunities	**Hydropower project**
Resource efficiency	Efficiency and cost savings. A reduction in GHG emissions can correspond to decreased costs and increased operational efficiency Innovation. A comprehensive approach to GHG management provides incentives for innovation in supply chain management
Energy source	Renewable energy generation. Low-emissions services are increasingly valuable to customers. Demand will continue to grow for products and activities that demonstrably reduce emissions throughout the value chain
Products and services	New hybrid projects. Innovation and development help lower emissions per energy unit New technology. Capture or reduction of GHG emissions provides attractive opportunities for investors and stakeholders Shadow carbon pricing. Implementation of a shadow carbon price aids assessment of hybrid projects Internal carbon pricing. Implementation of an internal carbon price encourages innovation in new technologies to decrease GHG emissions
Markets	Market access. Offering hydropower as an investment opportunity for the refinancing of existing assets and the building of new assets that are climate-aligned
Resilience	Company differentiation. External parties are increasingly interested in documented emissions reductions. Providing Scope 1, Scope 2, and Scope 3 inventories is a best practice that can differentiate companies in an increasingly environmentally conscious marketplace

IMPACT ON FINANCIAL PERFORMANCE

The financial impacts of climate-related issues are driven by the specific climate-related risks and opportunities to which the organisation is exposed, its strategic and risk management decisions, and willingness to seize opportunities as they arise. Table 6 below shows a list of climate-related financial impacts for hydropower generation.

Table 6. Climate-related financial impacts for hydropower

Climate-related financial impacts	Hydropower generation
Financial performance	Change in profitability/cash flow from exploiting climate opportunities Changes in profitability/cash flow arising from changes in upstream costs Changes in profitability/cash flow arising from carbon pricing costs Changes in profitability/cash flow arising from carbon pricing regulations
Financial position	Carrying surplus assets to guard against exposure to physical and transitional risk Financial provision in asset valuations to account for climate risks and opportunities

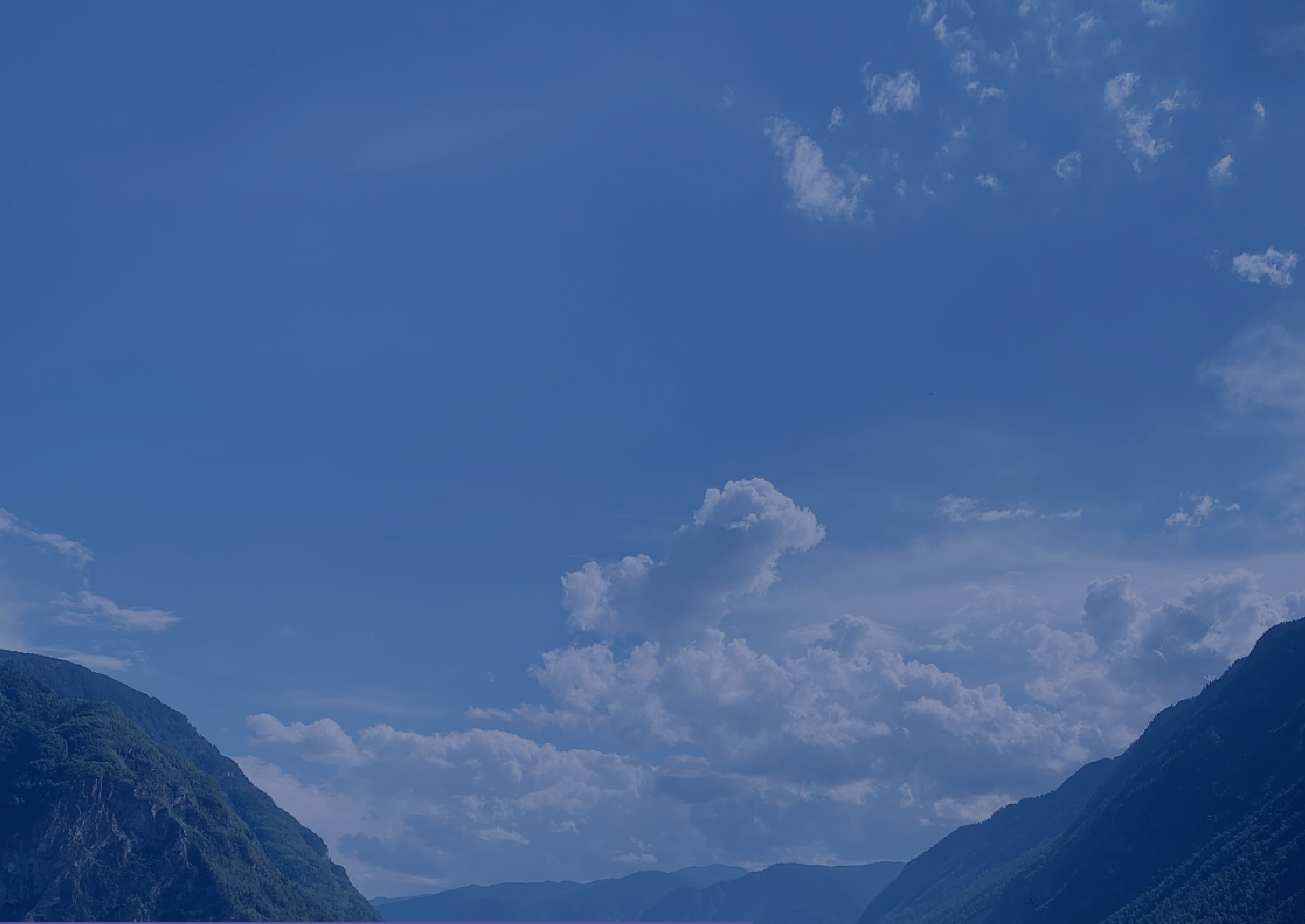
To assess assets and liabilities, a company should use the same consolidation rules for GHG accounting as for financial accounting. Equity share and financial control approaches result in closer alignment between GHG accounting and financial accounting. Companies should record GHG emissions as liabilities, and emissions allowances/credits as assets. Following TCFD recommendations, companies can account for actual impacts (those that have already occurred as a result of climate-related risks or opportunities) and make provision for potential impacts (those that may occur in the future due to climate-related risks or opportunities) (TCFD, 2021).

Applying different carbon prices to different time horizons can help companies internally hedge transition risks, particularly for long-term projects. For example, a company can vary its price internally when evaluating investments.

Example: Acciona varies its internal price as follows –

€36 per tonne of CO2e for near-term projects, €45 per tonne of CO2e for projects that extend through to 2030, and €72 per tonne of CO2e for those that continue through to 2050.

For GHG emissions reduction targets, companies can calculate an 'implicit carbon price' by dividing the cost of abatement/procurement by tonnes of carbon. This calculation helps quantify the capital investment required to meet climate-related targets. It is frequently used as a benchmark for implementing a more strategic internal carbon price.



Recommendations for corporate alignment

Net-zero targets

NET-ZERO TARGETS

REPORTING RECOMMENDATIONS

Companies should include the following in setting net-zero targets in line with the requirements of the SBTi:

Scope 1 and Scope 2 targets

Provide Scope 1 and Scope 2 percentage reduction targets from a base year. The targets should be aligned with the pathway to a 1.5 °C goal.

Specify the percentage of total emissions covered by this target.

For example, in line with the SBTi's Sectoral Decarbonisation Approach (SDA), set a target for 2030 of 72% reduction of Scope 1 emissions per MWh of electricity generation, starting from the base year 2019. This target covers 93% of the company's total emissionsand 46% reduction of Scope 1 and Scope 2 absolute emissions within the same timeframe.

Additionally, provide a Scope 1 and Scope 2 intensity emissions target (in metric tonnes of CO2e per MWh generated) or absolute emissions target (in metric tonnes of CO2e) consistent with the pathway to a 1.5 °C goal.

Provide the methodology used to set the target and a link to the company's annual GHG inventory.

Scope 3 target

Provide Scope 3 emissions targets as percentage reductions in absolute terms (percentage of metric tonnes of CO2e) or as percentage reductions in emissions intensity (metric tonnes in CO2e per MWh generated) from a base year aligned with the pathway to a 1.5 °C goal.

Specify the Scope 3 categories included.

For example, 90% emissions reduction per MWh from all sold electricity, or 80% reduction of absolute Scope 3 emissions by 2030 from the base year 2016, aligned with the pathway to a 1.5 °C goal.

GUIDANCE

This guidance follows the SBTi Criteria and Recommendations, Version 5.0 (SBTi, 2021). These state that Scope 3 targets must be consistent with the level of decarbonisation required to keep global temperature increases well below 2 °C compared to preindustrial temperatures. The SBTi's 1.5 °C pathway for power generation is based on an IPCC 2018 Special Report (IPCC, 2018) that outlines the characteristics of five shared socio-economic pathways (SSPs), where the Low Energy Demand (LED) scenario, is used as the upper limit.

This section provides guidance on how to use project-level Scope 1, Scope 2, and Scope 3 emissions data to model net-zero targets and account for emissions reduction activities.

Companies with one project should also have net-zero objectives, for example, the Itaipú dam project.[1] Net-zero objectives help the planning and

[1] Itaipú dam is a binational project between Brazil and Paraguay. Commissioned in 1974, it has a hydropower installed capacity of 14,000 MW. Itaipú Binational owns and operates the project. https://www.itaipu.gov.br/en/press-office/news/itaipu-annouces-commitments-advance-clean-and-renewable-energy

integration of emissions reduction activities in the modernisation of a hydropower plant.

INTRO TO SCIENCE-BASED TARGETS INITIATIVE

Organisations are committing to net-zero targets because the IPCC has urged action to avoid the most significant effects of climate breakdown. The report states a need to halve GHG emissions before 2030, achieve net-zero emissions before 2050, and limit global temperature rise to 1.5 °C.

The Science Based Targets initiative (SBTi)[2] is an authority on best practice for emissions reduction and net-zero targets in line with climate science. Science-based targets enable companies to demonstrate a pathway to achieve GHG emissions reductions to align with 1.5 °C and net-zero. The SBTi provides resources and validation for companies to account for and report on activities to meet the goals of the IPCC Special Report on 1.5 °C (IPCC, 2018).

Before setting the science-based targets, a company needs to understand current or most recent Scope 1, Scope 2, and Scope 3 emissions within its boundaries. When a net-zero target has been set, a company tracks progress towards the target annually, providing reports on emission changes, reasons for any substantial variation, and emission reduction projects. Every five years the SBTi requires companies to review and, if necessary, revalidate their targets to keep them up to date with the latest science. Any change in the calculation of GHG emissions for the base year, or the submission of new targets, can trigger an earlier review and revalidation process.

TARGET-SETTING CONSIDERATIONS

Before setting a target for Scope 1, Scope 2, and Scope 3 emissions, the company needs to define the following

- **Base year**: the most recent year for which data are available and that is representative of the GHG emissions profile. Base year emissions should be retroactively recalculated to reflect any change that has a significant impact on the baseline emission figures, such as a change in the calculation methodology or discovery of significant errors. The base year should be the same for all targets as a best practice.
- **Target year**: must be a minimum of 5 years and a maximum of 10 years from the date the target is submitted to the SBTi for assessment. The SBTi recommends that targets should also be set for the long term, that is, up to 2050.
- **Target boundary:** the target must have the same boundary as the GHG emissions inventory (see section on Guidance, Definition of the organisational boundary) The boundary is defined by the company's complete operational or financial control or if the company holds equity shares by the shares of equity in operation. The SBTi does allow subsidiaries to submit targets, which might be helpful for reporting for companies that separate generation from transmission and distribution. The parent companies must include subsidiaries in their target boundary, regardless of whether the subsidiary has its own SBTi target.

The company decides whether to set i) a single target covering total Scope 1, Scope 2, and Scope 3 emissions, ii) a separate target for all relevant Scope 3 emissions categories, or iii) a target dividing Scope 3 emissions into multiple, category-specific targets.

The company should establish its own target double-counting policy. The policy should address double counting of GHG emissions reductions and offsets, as well as allowances issued by external trading schemes. The company should specify how reductions and trades relating to other targets and schemes will be reconciled with the corporate target and, accordingly, which types of double-counting situations are regarded as relevant.

SCOPE 1 AND SCOPE 2

Setting a target requires both the selection of a target-setting method and consolidation of emissions, as well as the definition of a baseline scenario and the setting of a target year. Depending on the approach chosen, the target can be reduction in absolute emissions, or reduction of emissions intensity. Intensity targets do not necessarily lead to a reduction in absolute emissions. Absolute emissions targets do not allow comparisons of GHG emissions intensity amongst

[2] Further information on https://sciencebasedtargets.org/

peers, and do not necessarily track efficiency improvements.

There are two target setting methods

- **Absolute contraction approach.** All companies reduce emissions at the same percentage rate regardless of initial emissions. This is applicable across sectors and should be aligned with at least 1.5 °C ambition thresholds. The minimum reduction is 4.2% in annual linear terms from the base year. It is recommended that the baseline hear should be as recent as possible to produce a forward-looking target, although it can be from 2015 onwards.

- **Sectoral Decarbonization Approach (SDA).** Power companies should reduce their emissions intensity to a common value by 2050. To set a target using the SDA method, the amount of electricity generated must be recorded for the base year and estimated for the target year. The SBTi tool provides a calculation of the company's target in absolute emissions and in emissions intensity (tCO_2e/MWh). The absolute emissions reduction is derived from the reduction in emissions intensity and the estimate of electricity to be generated in the target year.

When consolidating emissions, power companies may exclude up to 5% of Scope 1 and Scope 2 emissions combined within the organisation's inventory boundary. Scope 2 emissions are only considered separately from Scope 1 in the absolute contraction approach. For the purpose of setting a target for Scope 2, emissions are divided into renewable energy supply and purchased heat and steam. A percentage-reduction emissions target can be set in relation to a renewable electricity supply if it aligns with the procurement of 80% of electricity from renewable sources by 2025, and 100% by 2030. When using the SDA method, companies should model heat- and steam-related emissions (which fall under Scope 2 emissions in a corporate inventory) as if they were part of their direct emissions (Scope 1). This is because the International Energy Agency's Energy Technology Perspectives (IEA ETP) pathways that underlie SDA methods do not take purchased heat and steam into account.

SCOPE 3

Scope 3 targets help companies understand whether current business models are compatible with a low-carbon future. Scope 3 emissions are often much greater than Scope 1 and Scope 2 emissions. However, in the utilities sector (including multi-utility services, electricity utilities, independent power producers and energy traders, and gas utilities) Scope 1 and Scope 2 emissions are much greater than Scope 3 emissions (CDP, 2013).

The SBTi does not require a reduction target for Scope 3 emissions unless they constitute 40% or more of the total Scope 1, Scope 2, and Scope 3 emissions. This assumes that companies account for all relevant Scope 3 emissions categories in line with the GHG Protocol Corporate Value Chain Standard. The criteria state that at least two-thirds of Scope 3 emissions must be covered by the target.

For Scope 3 emissions, the target can be framed as a supplier and customer engagement target, as well as an absolute target or emissions intensity target, as with Scope 1 and Scope 2.

- **Absolute emissions target.** Companies can use the Absolute Contraction approach or the SDA approach, as described above for Scope 1 and Scope 2 targets. The minimum ambition for a Scope 3 target using these two approaches is well below 2 °C compared to pre-industrial temperatures. The minimum annual linear reduction rate is 2.5% under the Absolute Contraction approach, and the well below 2 °C alignment option of the SDA pathways approach. However, companies are encouraged to pursue greater efforts toward a 1.5 °C trajectory, with a minimum annual linear reduction rate of 4.2% in absolute terms.

- **Intensity target.** These can be physical intensity targets or economic intensity targets. In light of the difficulty of measuring and reducing Scope 3 emissions, economic intensity targets are accepted for Scope 3.[3]

    - **Physical intensity metrics** (for example, tCO_2e/MWh generated) are best suited to use in sectors that create a uniform product, such as the hydropower sector.

[3] See the SBTi Corporate Manual, Version 2, Table 5, The main advantages and disadvantages of absolute, physical intensity, economic intensity, and engagement targets. https://sciencebasedtargets.org/resources/files/SBTi-Corporate-Manual.pdf

  - **Economic intensity metrics** (for example, tCO_2e per unit value added) are a means to normalise emissions for sectors with varying products. The SBTi does not recommend that companies set economic intensity targets for their operational emissions (Scope 1 and Scope 2) where they have direct influence over emissions reduction and can use more robust methods.

- **Supplier or customer engagement target.** This kind of target can be used for upstream or downstream Scope 3 emissions categories where engagement efforts could lead to a reduction in emissions. The company can focus on critical or strategic suppliers – such as manufacturers – based on a variety of factors, such as operational risk.

PROGRESS TOWARDS THE TARGETS

Hydropower companies should consider that only emissions reductions count as reduction activities. Offsets do not count as emissions reductions towards meeting a target, although a company can still use them to achieve overall emissions reductions in excess of their pathway targets. Similarly, avoided emissions do not count as emissions reductions against targets, such as emissions avoided by substituting hydropower in place of fossil-fuel based electricity generation.

Appendix 1

Mapping the TCFD Recommendations

APPENDIX 1: MAPPING THE TCFD RECOMMENDATIONS

The TCFD recommendations, published in 2017, are around four core business areas – governance, strategy, risk and opportunities, and metric and targets. They offer 11 recommendations for the disclosures of material information on climate risks and opportunities. Below is a summary mapping of the reporting in the present climate mitigation guideline to the TCFD recommendations.

The guideline does not address Governance or Risk Management process area as per TCFD. The Risk Management recommended disclosures for TCFD are very process driven. The information of the guideline more closely aligns with Strategy and Metrics and Targets. TCFD released guidance on Risk Management in 2020 to learn more about it https://assets.bbhub.io/company/sites/60/2020/09/2020-TCFD_Guidance-Risk-Management-Integration-and-Disclosure.pdf

Extended information can be found in TCFD (2021). Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures, which updates and supersedes the 2017 Annex "Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures" https://assets.bbhub.io/company/sites/60/2021/07/2021-TCFD-Implementing_Guidance.pdf

For the metrics and targets core area, see the guidance on Metrics, Targets, and Transition Plans that TCFD released in 2021 (TCFD, 2021).

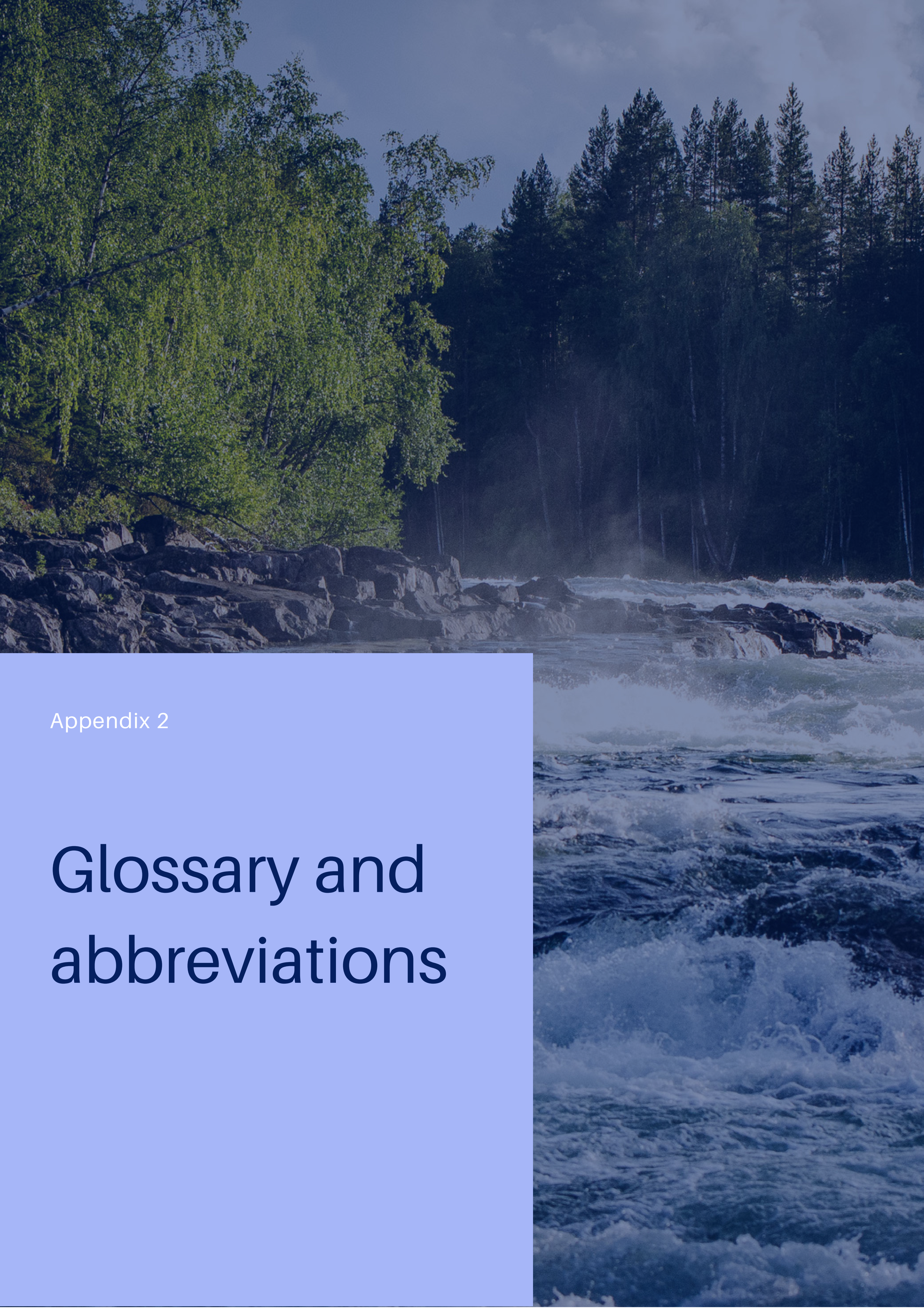
Relevant to Strategy a), Strategy c), and Metrics and Targets a) is the Task Force's Guidance on Scenario Analysis for Non-Financial Companies. https://assets.bbhub.io/company/sites/60/2020/09/2020-TCFD_Guidance-Scenario-Analysis-Guidance.pdf

Core areas	Recommendation	Hydropower Reporting Guideline: Climate-change Mitigation	Practical steps
Governance Disclose the organisation's governance around climate-related issues and opportunities	(a) Describe the board's oversight of climate-related risks and opportunities.	NA	
	(b) Describe management's role in assessing and managing climate-related risks and opportunities.	NA	
Strategy Disclose the actual and potential impacts on climate-related risks and opportunities on the organisation's business, strategy and financial planning	(a) Describe the climate-related risks and opportunities the organisation has identified over the short-, medium-, and long-term.	**Carbon pricing** ▪ External carbon price **Project-level and corporate level** ▪ Climate-related risks and opportunities	Identify the risks (physical and transition) and opportunities for each hydropower asset relevant to the organisation over the short, medium and long term Define the scenario analysis used at the corporate level Proportion of assets and/or operating, investing, or financing activities materially exposed to physical and transition risks as a fraction of the total electricity generation and operational boundary approach used to define the proportion
	(b) Describe the impact of climate-related risks and opportunities on the organisation's businesses, strategy, and financial planning.	**Carbon pricing** ▪ External carbon price **Project level and corporate level** ▪ Impact on financial performance (actual)	Provide the percentage of renewable energy in your portfolio Provide the percentage of low-carbon generation of your total generation Provide the percentage of CAPEX, OPEX and revenue aligned with EU Taxonomy Provide the current percentage of CAPEX in energy transition
	(c) Describe the resilience of the organisation's strategy, taking into consideration different climate-related	**Carbon pricing** ▪ External carbon price **Project level and corporate level**	Provide the forecast percentage of CAPEX in energy transition Provide the amount of issued carbon credits associated with the asset

Core areas	Recommendation	Hydropower Reporting Guideline: Climate-change Mitigation	Practical steps
	scenarios, including a 2°C or lower scenario.	▪ Climate-related risks and opportunities on GHG emissions ▪ Impact on financial performance (potential)	
Risk Management Disclose how the organisation identifies, assesses and manages climate-related risks	(a) Describe the organisation's processes for identifying and assessing climate-related risks.	NA	
	(b) Describe the organisation's processes for managing climate-related risks.	NA	
	(c) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organisation's overall risk management	NA	
Metrics and Targets Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities	(a) Disclose the metrics used by the organisation to assess climate-related risks and opportunities in line with its strategy and risk management process.	**GHG emissions reduction** ▪ Emissions reduction ▪ Emissions capture and removal ▪ Metrics to measure the trade-offs between cost and benefits of mitigation and carbon reduction activities ▪ Carbon credits and offsets	Provide the GHG emissions reduced as a direct consequence of an activity for an existing project Provide the GHG emissions monitoring of the activity Provide the GHG emissions avoided as a direct consequence of an activity of an existing project Estimate the GHG emissions avoided as indirect consequences of the upgrade, modernisation, or hybridisation of an existing project Provide the GHG emissions removed as a direct consequence of activities that remove GHG emissions from the hydropower project

Core areas	Recommendation	Hydropower Reporting Guideline: Climate-change Mitigation	Practical steps
		GHG emissions avoidance ▪ GHG emissions avoided **Freshwater management** ▪ Water management ▪ Water conservation **Carbon pricing** ▪ External carbon Price **Project level and corporate level** ▪ Climate-related risks and opportunities on GHG emissions	Provide the cost of GHG emissions avoided through activities Provide information on any metrics used as part of the strategy and risk management process to reduce emissions.
	(b) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks.	**GHG emissions understanding** ▪ Scope 1 emissions ▪ Scope 2 emissions ▪ Scope 3 emissions	Provide the GHG emissions for each scope in absolute terms (metric tonnes of CO_2 equivalent) and the emission intensity (gCO_2e/kWh) Type of GHG gases that have been included in the calculations Baseline year , justification for the selection, emissions of that year and the context for any significant change in the GHG emissions calculation Comprehensive description of the calculation approach, scope and methodologies, standards, and tools used for the estimation of the GHG emissions, including the input data, emission factors used, global warming potential used, assumptions and gaps considered, and lifecycle chosen, including the reference to all the sources For multipurpose reservoirs, provide the allocation methodology used for the reservoir emissions to hydropower use Identify the risks (physical and transition) and opportunities for each hydropower asset relevant to the organisation over the short, medium and long term

Core areas	Recommendation	Hydropower Reporting Guideline: Climate-change Mitigation	Practical steps
	(c) Describe the targets used by the organisation to manage climate-related risks and opportunities and performance against targets.	**Carbon pricing** ▪ Internal carbon Price **Net Zero targets** ▪ Scope 1 and 2 ▪ Scope 3 ▪ Progress towards the targets	Is the emissions reduction project financed by a corporation´s internal emissions trading programme? Does the project count with green finance or climate finance? Has the jurisdiction where the asset is located implemented or intends to implement a carbon pricing regulation? What is the cost of a tonne of carbon dioxide equivalent (CO_2e) that applies to your project, if any? What is the internal carbon price applicable for the asset? Report information on offsets that have been purchased or developed outside of the inventory boundary Provide scope 1 and scope 2 percentage reduction target from a base year consistent with a level of decarbonisation for 1.5°C trajectory Specify the target's coverage of corporate's total emissions Provide scope 3 target as absolute based percentage targets or intensity targets from a base year consistent with level of decarbonisation for a 1.5°C trajectory. Specify the scope 3 categories included.



Appendix 2

Glossary and abbreviations

APPENDIX 2: GLOSSARY AND ABBREVIATIONS

GLOSSARY

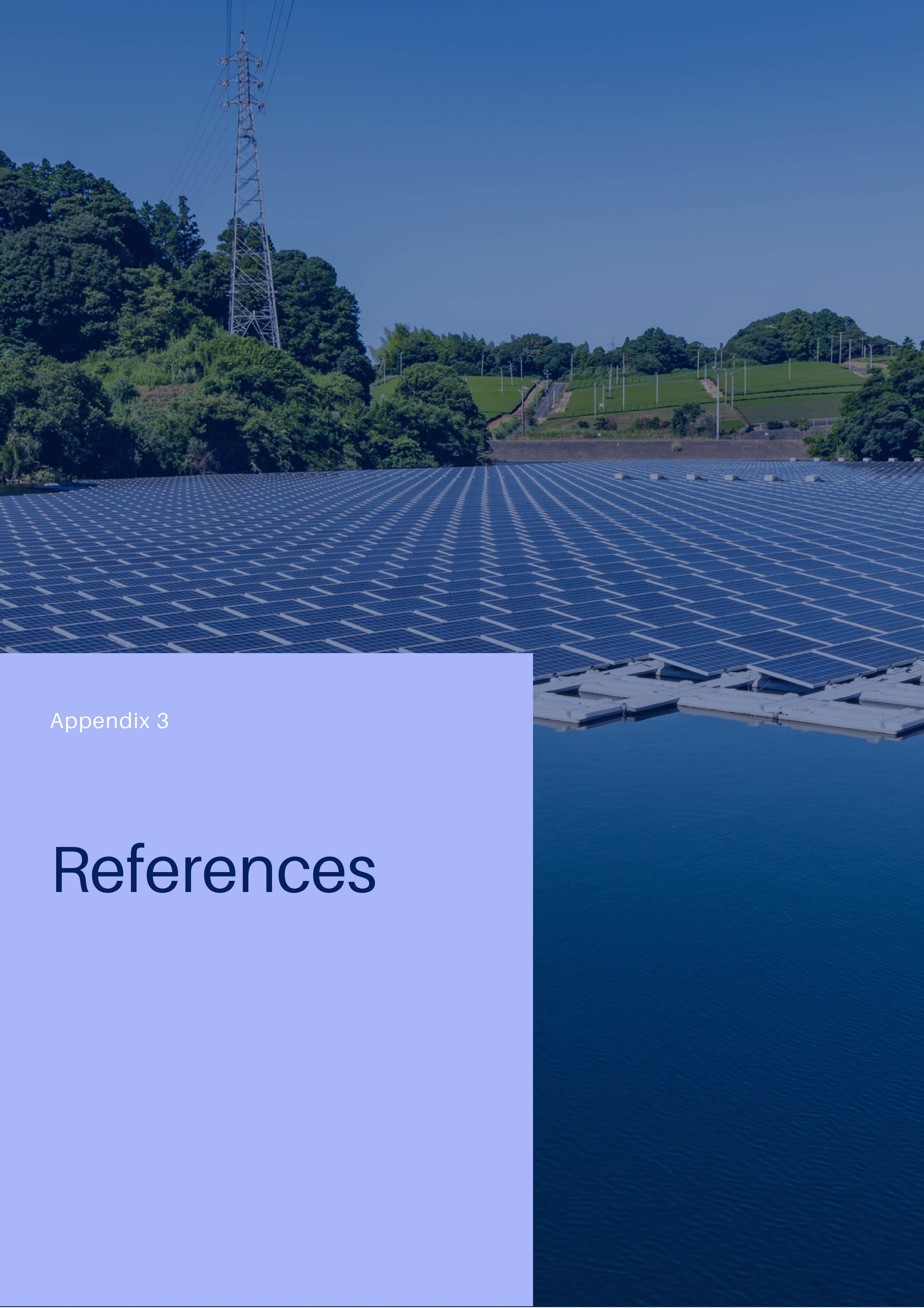
The glossary outlines the concepts of this reporting guideline as they relate to climate-change mitigation in the hydropower sector.

Absolute greenhouse gas (GHG) emissions	The total quantity of GHG emitted
Carbon pricing	An instrument that captures the external costs of GHG emissions and ties them to their source through a price, usually in the form of a price on the carbon dioxide (CO_2) emitted
Consolidation approach	How an organisation sets boundaries for GHG accounting. Helps define whether emissions are classified as direct GHG emissions (Scope 1) or indirect GHG emissions (Scope 2 and Scope 3)
Direct GHG emissions	Emissions from sources owned or controlled by the reporting entity
Financier	A person concerned in the management of large amounts of money on behalf of governments or other large organisations to finance hydropower projects
GHG emissions intensity	GHG emissions intensity refers to the amount of GHG emissions per unit of electricity generated
GHG emissions inventory	A list of emission sources and the associated emissions quantified using standardised methods. It covers accounting and reporting of the seven greenhouse gases covered by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).
GHG removal	Process or outcome of processes to remove GHGs from the atmosphere through anthropogenic activities and durably store in geological, terrestrial, or ocean reservoirs, or in products.
Global warming potential (GWP)	The cumulative radiative forcing – both direct and indirect effects – over a period of time, resulting from the emission of a unit mass of gas relative to the reference gas CO_2. It is the metric by which to compare the ability of GHG to trap heat in the atmosphere
Indirect GHG emissions	Emissions that are a consequence of the activities of the reporting entity but occur at sources owned or controlled by another entity
Investor	A person or group of people that puts its money into a business or other organisation in order to make a profit
Net zero	A state in which anthropogenic GHG emissions are balanced through anthropogenic reduction and/or removal activities
Organisational boundary	The process by which a company applies an approach to consolidate their GHG emissions. The selected approach should be applied consistently to define the

	businesses and operations that constitute the company for the purpose of accounting and reporting GHG emissions
Scope 1 emissions	Direct GHG emissions from sources owned or controlled by the reporting entity (the company)
Scope 2 emissions	Indirect emissions from the generation of purchased energy
Scope 3 emissions	All indirect emissions (not included in Scope 2) resulting from the organisation’s operations, which are not owned or controlled by the company, including upstream and downstream emissions

ABBREVIATIONS

AR5	IPCC Fifth Assessment Report
AR6	IPCC Sixth Assessment Report
BECCS	Bioenergy with carbon capture and storage
CAPEX	Capital Expenditures
CBI	Climate Bonds Initiative
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CDP	Carbon Disclosure Project
CFC	Chlorofluorocarbons
CH_4	Methane
COP26	Conference of the Parties (COP), United Nations Climate Change Conference, Glasgow, November 2021
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EIB	European Investment Bank
EPD	Environmental Product Declaration
ETS	Emissions Trading Systems
EU	European Union
EUR	Euro
FPV	Floating photovoltaics
g	gram
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
GWP	Global Warming Potential
IEA	International Energy Agency
HFC	hydrofluorocarbons
IHA	International Hydropower Association
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
Kg	kilogram
kWh	kilowatt-hour
LCA	Life Cycle Assessment
LED	Low Energy Demand
m^2	square metre
MW	megawatt
MWh	megawatt hour
NGO	non-governmental organisation
O&M	Operation and Maintenance
OPEX	Operating Expense
PFC	perfluorocarbons
PSH	pumped storage hydropower
RBCF	Results-based climate finance
SBTi	Science-based Targets initiative
SDA	Sectoral Decarbonization Approach
SDGs	Sustainable Development Goals
SESIA	Strategic Environmental and Social Impact Assessment
SPP	storage power plants
t	metric tonne
TCFD	Task Force on Climate-related Financial Disclosures
T&D	Transmission and Distribution
UAS	unrelated anthropogenic sources
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
VCM	Voluntary Carbon Market
VCS	Verified Carbon Standard
VER	Verified Emission Reduction
VRE	Variable Renewable Energy
WBCSD	World Business Council for Sustainable Development
WEFE	Water-Energy-Food-Ecosystem
WRI	World Resources Institute



Appendix 3

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Net Zero Climate Resilient Hydropower Initiative aims to promote the development of a commonly agreed climate-related reporting for hydropower assets to advance in the availability and quality of climate-related disclosure at the project level. In doing so, the aim is to help the effective mobilisation of climate investment to finance or refinance hydropower assets that demonstrate their contributions towards a climate-resilient, zero-carbon planet.

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