

Hydropower Criteria

Development of Eligibility Criteria for the
Climate Bonds Standard & Certification Scheme

Background Paper

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Version 1.0



Climate
Bond
Certified

Definitions

Accredited Assessor: An accredited assessor is an individual who has 1) Completed a programme of training authorised by the Hydropower Sustainability Assessment Council, 2) Obtained a License which represents an agreement between the Accredited Assessor and the Hydropower Sustainability Assessment Protocol governance council regarding the terms and conditions of their accreditation, and 3) Adopted a code of conduct and compliance with all the terms of that License. The Climate Bonds Initiative is not engaged with this accreditation process.

Approved Verifiers: Organisations approved by the Climate Bonds Initiative to provide assurance services to issuers of Certified Climate Bonds. The duties of Approved Verifiers include providing assurance that the requirements of the Climate Bonds Standard (including these and other sector specific Criteria) are met.

Certified Climate Bond: A Climate Bond that is certified by the Climate Bonds Standard Board as meeting the requirements of the Climate Bonds Standard, as attested through independent verification.

Climate Bond: A climate bond is a bond used to finance – or refinance - projects needed to address climate change. They range from wind farms and hydropower plants to rail transport and building sea walls in cities threatened by rising sea levels. Only a small portion of these bonds have been labelled as Green or Climate Bonds by their issuers.

Climate Bonds Initiative (CBI): An investor-focused not-for-profit organisation, promoting large-scale investments that will deliver a global low-carbon and climate-resilient economy. The Initiative seeks to develop mechanisms to better align the interests of investors, industry and government so as to catalyse investments at a speed and scale sufficient to avoid dangerous climate change.

Climate Bond Certification: allows the issuer to use the Climate Bond Certification Mark in relation to that bond. Climate Bond Certification is provided once the independent Climate Bonds Standard Board is satisfied the bond conforms with the Climate Bonds Standard.

Climate Bonds Standard (CBS): A screening tool for investors and governments that allows them to identify Green Bonds where they can be confident that the funds are being used to deliver climate change solutions. This may be through climate mitigation impact and/or climate adaptation or resilience. The CBS is made up of two parts: the parent standard (Climate Bonds Standard V3.0) and a suite of sector-specific eligibility Criteria. The parent standard covers the certification process and pre- and post-issuance requirements for all certified bonds, regardless of the nature of the capital projects. The Sector Criteria detail specific requirements for assets identified as falling under that specific sector. The latest version of the CBS is published on the Climate Bonds Initiative website

Climate Bonds Standard Board (CBSB): A board of independent members that collectively represents \$34 trillion of assets under management. The CBSB is responsible for approving i) Revisions to the Climate Bonds Standard, including the adoption of additional sector Criteria, ii) Approved Verifiers, and iii) Applications for Certification of a bond under the Climate Bonds Standard. The CBSB is constituted, appointed and supported in line with the governance arrangements and processes as published on the Climate Bonds Initiative website.

Green Bond: A Green Bond is a bond the proceeds of which are allocated to environmental projects. The term generally refers to bonds that have been marketed as “Green”. In theory, Green Bonds proceeds could be used for a wide variety of environmental projects, but in practice they have mostly been the same as Climate Bonds, with proceeds going to climate change projects.

Hydropower assets and projects: Assets and projects relating to the construction, acquisition and/or management of hydropower facilities and dedicated infrastructure. These facilities might include run-of-river, impoundment and pumped storage. Marine applications using similar technology are not within the scope of the document.

Industry Working Group (IWG): A group of key organisations that are potential issuers, verifiers and investors convened by the Climate Bonds Initiative. The IWG provides feedback on the draft Sector Criteria developed by the TWG before they are released for public consultation.

Technical Working Group (TWG): A group of key experts from academia, international agencies, industry and NGOs convened by the Climate Bonds Initiative. The TWG develops the Sector Criteria - detailed technical criteria for the eligibility of projects and assets as well as guidance on the tracking of eligibility status during the term of the bond. Its draft recommendations are refined through engagement with finance industry experts in convened Industry Working Groups and through public consultation. Final approval of Sector Criteria is given by the CBSB.

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The Climate Bonds Initiative gratefully acknowledges the Technical and Industry Working Group members who supported the development of the Hydropower Criteria. Proposals were agreed by consensus in the Technical Working Group, noting a variety of views on specific issues, and considering the feedback from the Industry Working Group. Technical and Industry Working Group Members are listed in Appendix 1.

1 Introduction

1.1 Funding the goals of the Paris Agreement

The current trajectory of climate change, expected to lead to a global warming of 2.7-3.1°C by 2100,¹ poses an enormous threat to the future of the world's nations and economies. The aim of the Paris Agreement is to limit warming to a global average of no more than 2°C higher than pre-industrial levels by the end of the century, and ideally no more than 1.5°C. The effects of climate change and the risks associated even with a 2°C rise are significant: rising sea levels, increased frequency and severity of hurricanes, droughts, wildfires and typhoons, and changes in agricultural patterns and yields. Meeting the 2°C goal requires a dramatic reduction in global greenhouse gas (GHG) emissions.

At the same time, the world is entering an age of unprecedented urbanisation and related infrastructure development. Global infrastructure investment is expected to amount to USD 90 trillion by 2030, more than the entire current infrastructure stock.²

To ensure sustainable development and avoid dangerous climate change, this infrastructure needs to be low-carbon and resilient to physical climate impacts, without compromising the economic growth needed to improve the livelihoods and wellbeing of the world's poorer citizens. Ensuring that the infrastructure built is low-carbon raises the annual investment needs by 3–4%.³ Climate adaptation needs add another significant amount of investment, estimated at USD 280–500 billion per annum by 2050 for a 2°C scenario.⁴

1.2 The role of bonds

Traditional sources of capital for infrastructure investment (governments and commercial banks) are insufficient to meet these capital needs; institutional investors, particularly pension and sovereign wealth funds, are increasingly looked to as viable actors to fill these financing gaps.

Capital markets enable issuers to tap into large pools of private capital from institutional investors. Bonds are appropriate investment vehicles for these investors as they are low-risk investments with long-term maturities, making them a good fit with institutional investors' liabilities (e.g., pensions to be paid out in several decades).

Bond financing works well for low-carbon and climate-resilient infrastructure projects post-construction, as bonds are often used as refinancing instruments. Labelled Green Bonds are bonds with proceeds used for green projects, mostly climate change mitigation and/or adaptation projects, and labelled accordingly. The rapid growth of the labelled green bond market has shown in practice that the bond markets can provide a promising channel to finance climate investments.

The Green Bond market can reward bond issuers and investors for sustainable investments that accelerate progress toward a low-carbon and climate-resilient economy. Commonly used as long-term debt instruments, Green Bonds are issued by governments, companies, municipalities, commercial and development banks to finance or re-finance assets or activities with environmental

¹ According to Climate Tracker, under current policies we could expect 2.7 – 3.1°C: <http://climateactiontracker.org/global.html>

² The Global Commission on the Economy and Climate (2018), 'Unlocking the Inclusive Growth Story of the 21st Century: Accelerating Climate Action in Urgent Times': <https://newclimateeconomy.report/2018>

³ The Global Commission on the Economy and Climate (2016), 'Better Growth, Better Climate': http://newclimateeconomy.report/2016/wp-content/uploads/sites/2/2014/08/BetterGrowth-BetterClimate_NCE_Synthesis-Report_web.pdf

⁴ UNEP (2018), 'Adaptation Gap Report 2018': file:///C:/Users/12035/Downloads/AGR_2018.pdf

benefits. Green Bonds are regular bonds with one distinguishing feature: proceeds are earmarked for projects with environmental benefits. Green Bonds are in high demand and can help issuers attract new types of investors.

A green label is a discovery mechanism for investors. It enables the identification of climate-aligned investments even with limited resources for due diligence. By doing so, a green bond label reduces friction in the markets and facilitates growth in climate-aligned investments.

Currently Green Bonds only account for less than 0.2% of a global bond market of USD 128 trillion.⁵ The potential for scaling up is tremendous. The market now needs to grow much bigger, and quickly.

1.3 Introduction to the Climate Bonds Standard and the Climate Bonds Initiative

Activating the mainstream debt capital markets to finance and refinance climate-aligned projects and assets is critical to achieving international climate goals. Robust labelling of Green Bonds is a key requirement for that mainstream participation. Confidence in the climate objectives and the use of funds of Green Bonds is fundamental their credibility and ensuring they play a valuable role in building a low-carbon and climate-resilient economy. Trust in the green label and transparency of the underlying assets are essential for this market to reach scale; but investor capacity to assess green credentials is limited, especially in the fast-paced bond market.

The Climate Bonds Initiative therefore created the Climate Bonds Standard & Certification Scheme, which aims to provide the green bond market with the trust and assurance that it needs to achieve scale. The Climate Bonds Initiative is an investor-focused not-for-profit organisation whose goal is to promote large-scale investments through Green Bonds and other debt instruments to accelerate a global transition to a low-carbon and climate-resilient economy aligned with the goals of the Paris Agreement.

The Climate Bonds Standard & Certification Scheme is an easy-to-use tool for investors and issuers to assist them in prioritising investments that truly contribute to addressing climate change. It is made up of the overarching Climate Bonds Standard detailing management and reporting processes, and sets of Sector Criteria detailing the requirements that assets in different sectors must meet to be eligible for certification. The Certification Scheme requires issuers to obtain independent verification, pre- and post-issuance, to ensure the bond meets the requirements of the Climate Bonds Standard.

The goal of the Standard & Certification Scheme is to accelerate investment in a global transition to a low-carbon, climate-resilient economy. Certified bonds are required to be compatible with a highly carbon-constrained world by linking to assets and projects generating little in the way of emissions. This is referred to as 'low carbon-compatibility' (or 'low GHG-compatibility') throughout the document.

Existing Sector Criteria cover solar energy, wind energy, marine renewable energy, geothermal power, buildings, transport (land and sea), biofuel production, forestry, agriculture, waste management and water infrastructure. In addition to hydropower, additional Sector Criteria currently under development include Electricity Grids & Storage.

The Sector Criteria development process brings together technical and industry experts to recommend the eligibility Criteria for projects/assets that determine whether the related bonds are certified under the Climate Bonds Standard. This helps drive higher climate standards, greater transparency and better reporting for projects and assets linked to Climate Bonds.

⁵ <https://www.icmagroup.org/regulatory-policy-and-market-practice/secondary-markets/bond-market-size>

1.4 The development of Sector Criteria for Hydropower

Hydropower is recognized as having a prominent role in meeting a significant proportion of future electricity needs. In their Nationally Determined Contributions (NDCs) submitted to the UNFCCC, 109 countries cited specific renewable energy targets, and hydropower accounts for nearly half of the technology-specific additional renewable capacity implied by NDCs⁶. In 2019, hydropower generated 58% of the world's renewable electricity.⁷ Hydropower dams and reservoirs often have multiple purposes beyond hydropower generation, including water storage and supply for domestic, industrial and agricultural use, and flood control.

In 2016, the Climate Bonds Initiative launched a group of experts (in a Technical Working Group, or 'TWG') to develop the necessary and appropriate criteria for investments in hydropower. The aim was to develop Criteria that can identify and monitor hydropower facilities that are low GHG-compatible, climate-resilient and meet environmental/social good practice, while also screening out projects that may not meet these conditions for eligibility. These criteria therefore provide a tool for investors and issuers to determine whether bonds linked to hydropower assets are considered consistent with a carbon-constrained world that limits warming to no more than a global average of 2°C higher than pre-industrial levels.

To support this effort, a Hydropower Industry Working Group (IWG) made up of potential bond issuers, investors, financial intermediaries and verifiers was also convened to provide input by highlighting green investment opportunities in the sector and commenting on trends in the market, scope, practicality and best practice.

One challenge to note is that, while the atmospheric science underlying climate change is increasingly well understood, the science of the freshwater carbon cycle which hydropower projects impact is still in its infancy. This makes it difficult to make firm predictions about the potential positive and negative impacts of hydropower on GHG emissions and, in turn, to produce recommendations accordingly. These concerns are outlined in more detail in Sections 3.3 and 3.4 below. Given the limited science base, the TWG have taken a conservative approach.

Therefore, one of the recommendations made is that the Criteria will be reviewed within the next three years to assess whether the scientific evidence around the freshwater carbon cycle has advanced such that it may allow for more accurate measurements of hydropower GHG emissions.

1.5 This document and associated documents

This document supports the [Hydropower Criteria](#). It captures the issues raised and discussed by the TWG, as well as the arguments and evidence in support of the Criteria. It is structured as follows:

Section 2 provides a brief overview of the hydropower sector: its current status, trends and role in mitigating and adapting to climate change.

Section 3 outlines the objectives and principles of the Hydropower Criteria. It states that a hydropower asset must pass two sets of requirements to be eligible for certification: (i) mitigation requirements and (ii) adaptation, resilience and other environmental and social requirements.

Section 4 describes the rationale behind the mitigation requirements.

Section 5 discusses any differences from the mitigation requirements for two special cases: pumped storage and cascade systems.

⁶ International Renewable Energy Association (2017), 'Untapped potential for climate action: Renewable energy in Nationally Determined Contributions': <http://www.irena.org/publications/2017/Nov/Untapped-potential-for-climate-action-NDC>

⁷ Renewable Energy Policy Network (2021), 'Renewables 2020 Global Status Report': <http://www.ren21.net/reports/global-status-report/>

Section 6 describes the rationale behind the adaptation, resilience and other environmental and social requirements.

Section 7 provides a brief reminder of disclosure requirements.

As noted above, the Hydropower Criteria will be reviewed no later than three years after launch, or potentially earlier if the need arises, at which point the TWG will take stock of issuances that arise in the early stages, as well as any developments in improved methods and data, that have occurred in the interim. More specifically, in respect of decarbonisation pathways for the power sector, CBI will review the emissions intensity thresholds for all renewable energy sector criteria within 2 years of the launch of these Criteria.

As a result, the Criteria are subject to revision over time. However, Certification will not be withdrawn retrospectively, and revisions made to the Hydropower Criteria will not be applied to existing Certifications.

2 Sector Overview

2.1 What is hydropower?

2.1.1 Types of hydropower

The IPCC classifies hydropower into three main categories⁸: run-of-river, storage (reservoir) and pumped storage. In addition, in-stream technology – a new and less developed technology - represents a fourth category. All of these are within the scope of the Criteria in principle, although some are more likely to be bond-financed than others.

Run-of-river

A run-of-river hydropower facility converts energy drawn from river flows to produce electricity. In a run-of-river hydropower facility, a portion of the river water is diverted to a channel or pipeline (penstock) to convey the water to a hydraulic turbine. The hydraulic turbine is connected to a generator to produce electricity. The electricity production profile will depend mainly on the local river flow conditions, though short-term storage (hourly, daily) may be included to meet varying demand. Smaller installed capacities are more likely to be run-of-river.

Storage (reservoir or impoundment)

A storage hydropower facility includes a reservoir with the capability of storing water for electricity generation over weekly, monthly or seasonal time scales. The generating stations are located at the dam toe or further downstream and connected to the reservoir through tunnels or pipelines. The design of the reservoir will depend on the landscape, which might be inundated river valleys, where the reservoir will be an artificial lake, or high-altitude lakes. One power plant may be connected with several reservoirs as well as to neighbouring watersheds or rivers if applicable.

For clarity, this document will refer to storage (reservoir) hydropower as impoundment hydropower.

Pumped storage

A pumped storage hydropower (PSH) plant is essentially an energy storage system rather than an energy source. In a typical pumped storage plant, water is pumped from a lower reservoir and stored in an upper reservoir during off-peak hours, and then drawn from the upper reservoir to provide peaking, ancillary and other services. Although the energy losses during the process of pumping can make the pumped storage plant a net energy user, pumped storage facilities provide large-scale energy storage system benefits. In fact, pumped storage is the largest-capacity form of grid energy storage now readily available worldwide and is predicted to grow significantly over coming years to help manage increasing penetration of intermittent renewable technologies such as wind and solar.

In-stream/hydrokinetic technology

In-stream/hydrokinetic technology refers to turbines which convert energy from flowing water without the need of a hydraulic head. Hydrokinetic technology is a less mature⁹ form of hydropower being developed to capture energy from tides, currents, free-flowing rivers, pipes and engineered waterways.

Note, however, that any applications of hydropower technology in marine rather than inland waterway contexts are not within the scope of the Criteria and are instead covered under the [Marine Renewables Sector Criteria](#).

⁸ Kumar, A., T. Schei, A. Ahenkorah, R. Caceres Rodriguez, J.-M. Devernay, M. Freitas, D. Hall, Å. Killingtveit, Z. Liu (2011), Hydropower, in IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

⁹ For this reason it will not receive much more attention in the document. We include it here for completeness.

While these categories are useful for illustrating the potential scope of the Criteria, it is a principle of the Sector Criteria that different categories of hydropower should not be automatically assumed to have a greater or lesser environmental and social impact, but rather should be assessed on a case-by-case basis.

2.1.2 Scale categories of hydropower

Hydropower is also often categorised by size, although there is no consensus on how to do so. Small-scale is most commonly less than 10-50 MW and large-scale is often in the hundreds of MW.¹⁰ The International Commission on Large Dams defines a large dam as either: a dam with a height of 15m or greater from lowest foundation to crest; or (ii) a dam between 5-15m high impounding more than 3 million cubic metres.¹¹ Large dams have received a great deal of scrutiny and controversy for many years over their potential impacts on the environment and affected communities, from disrupted hydrology to corruption and population displacement.¹² Against this history, small hydropower is often promoted as a low-cost technology suitable for remote, off-grid communities with minimal environmental impact.¹³

A principle of the Sector Criteria adopted early on by the TWG is that there should be no distinction made between large and small hydropower in the assessment, as it cannot be simply assumed that small hydropower automatically has a lesser environmental and social impact. The impacts of a badly sited “small” dam can be significant, just as well-sited and well-designed large dams can have limited impacts. In addition, scientists have raised the possibility that the cumulative ecological and hydrological impacts of many small facilities can be significant.¹⁴ The IPCC also states that general concepts like “small” or “large” hydro are not technically or scientifically rigorous indicators of the characteristics and impacts of the hydropower plants.¹⁵ Hydropower is a highly site-specific technology, where each project is tailor-made for a particular location, within a given river basin, to meet specific needs for energy and water management services.

2.2 The significance of hydropower

2.2.1 Hydropower today

Hydropower is currently the world’s most significant renewable energy technology, contributing a fifth of global installed electricity capacity and approximately 16% of generation.¹⁶ Over a third of non-PSH hydroelectric capacity is found in East Asia and the Pacific; roughly similar amounts are found in the rest of Asia, Europe, North and Central America, and South America; and only 3% in Africa.¹⁷ Latin America is the most dependent region, with 52% of its generating capacity made up from hydropower.¹⁸ Europe contains a significantly higher ratio of PSH to non-PSH capacity than other

¹⁰ Kumar, A., T. Schei, A. Ahenkorah, R. Caceres Rodriguez, J.-M. Devernay, M. Freitas, D. Hall, Å. Killingtveit, Z. Liu (2011), Hydropower, in IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

¹¹ http://www.icold-cigb.net/GB/dams/definition_of_a_large_dam.asp

¹² Kumar et al. *ibid*; WCD (2000), Dams and Development: A New Framework for Decision-Making, the Report of the World Commission on Dams, Earthscan Publications; International Rivers (2016), “Problems with Big Dams”, International Rivers website: <https://www.internationalrivers.org/problems-with-big-dams>.

¹³ Liu, H., Masera, D. and Esser, L., eds. (2013). World Small Hydropower Development Report 2013. United Nations Industrial Development Organization; International Center on Small Hydro Power. Available from: www.smallhydropowerworld.org

¹⁴ <http://www.indiaenvironmentportal.org.in/files/file/environmental%20degradation%20&%20hydroelectric%20projects.pdf>; Kibler, K.M., Tullos, D.D. (2013), “Cumulative biophysical impact of small and large hydropower development in Nu River, China”, Water Resources Research 49(6):3104-3118

¹⁵ Kumar et al. *ibid*;

¹⁶ Renewable Energy Policy Network (2021), ‘Renewables 2020 Global Status Report’: <http://www.ren21.net/reports/global-status-report/>

¹⁷ IHA (2020), 2020 Hydropower Status Report, International Hydropower Association, available at: https://hydropower-assets.s3.eu-west-2.amazonaws.com/publications-docs/2020_hydropower_status_report.pdf

¹⁸ Derived from US Energy Information Administration International Energy Statistics

regions.¹⁹ Currently, there is still large untapped potential remaining in South America, Africa and Asia. Table 1 presents some basic statistics for hydropower capacity and generation.

Table 1: Global hydropower in numbers (statistics for 2019)²⁰

Global installed capacity	Non-pumped: 1,150 GW; Pumped: 158 GW
Global growth in capacity in 2019	Non-pumped: 18.5 GW; Pumped: (2.3) GW
Global generation	4,306 TWh/year; 17% of global electricity
Global technical potential	14600 - 16400 TWh/year
Average global load factor	38%
Proportion of world's electricity storage for grid systems	96%
Top 5 countries, capacity	China 356 GW Brazil 109 GW USA 103 GW Canada 81 GW India 50 GW
Top 5 countries, growth in 2016	China 11.4 GW Brazil 6.3 GW Ecuador 2 GW Ethiopia 1.5 GW South Africa 1.3 GW

2.2.2 The role of hydropower in mitigating and adapting to climate change

Hydropower is likely to remain a prominent energy option in the global push to decarbonise, due to its potential scale, low GHG emissions, important role in grid support and energy storage capability. While the issue of reservoir emissions has attracted increasing attention over recent years, evidence indicates that *on average*, and acknowledging the highly context-specific nature of the technology, hydropower has one of the lowest GHG footprints of any electricity generation technology (see Sections 3.3 and 4 and Appendix 3).

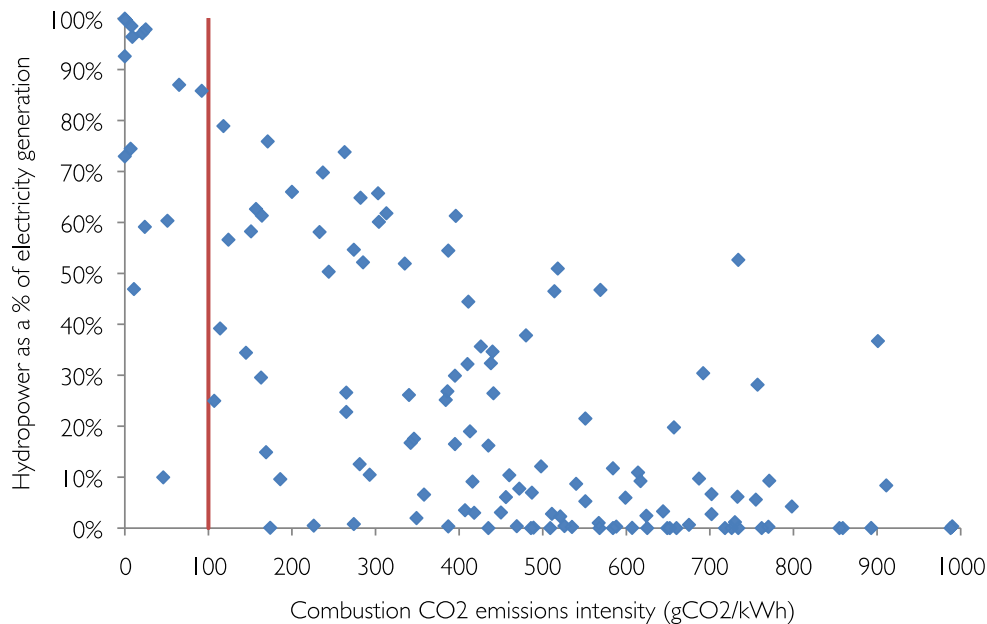
Modelling suggests that near-total decarbonisation of the power sector by the latter half of the century is required for a global emissions pathway consistent with a 2° scenario (see Section 4.4.3). This implies a global average power sector emissions intensity (emissions per unit of output) well below 100 gCO₂e/kWh. Most of the world's cleanest grids have a high proportion of hydropower (Figure 1). Historically, no country other than France has ever achieved a grid carbon intensity of less than 100 gCO₂/kWh without a significant amount of hydropower. France decided in the 1970s to commit to nuclear power. Only one country in the world (Denmark) has lowered emissions below 200 gCO₂e/kWh with almost no domestic hydropower or nuclear power, which it achieves partly through imports from its major hydropower-generating neighbours, Norway and Sweden, when wind

¹⁹ IHA (2020), 2020 Hydropower Status Report, International Hydropower Association, available at: https://hydropower-assets.s3.eu-west-2.amazonaws.com/publications-docs/2020_hydropower_status_report.pdf

²⁰ IHA (2020), *ibid.*; IHA (2019), 2019 Hydropower Status Report, International Hydropower Association, available at: https://hydropower-assets.s3.eu-west-2.amazonaws.com/publications-docs/2019_hydropower_status_report.pdf IEA (2010), Renewable Energy Essentials: Hydropower, International Energy Agency, available at: http://www.iea.org/publications/freepublications/publication/hydropower_essentials.pdf. Kumar, A., T. Schei, A. Ahenkorah, R. Caceres Rodriguez, J.-M. Devermay, M. Freitas, D. Hall, A. Killingveit, Z. Liu (2011), Hydropower, in IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

speeds are low. Countries which have achieved ultra-low-carbon grids ($< 25 \text{ gCO}_2\text{e/kWh}$) in large part through significant use of hydropower include Iceland, Ethiopia, Costa Rica, Norway, Paraguay, Sweden, Switzerland and Tajikistan.

Figure 1: percentage of hydropower and grid emissions intensity of 136 countries



Source: CBI analysis; data from EIA International Energy Statistics and IEA 'CO₂ emissions from fuel combustion' (2017)

In addition to low GHG generation, depending on type, hydropower is able to provide flexible and fast-ramping generation, ancillary services such as frequency and voltage support, and storage. It is increasingly recognized that large-scale deployment of renewable energy will require storage to compensate for the variable generation of wind and solar resources. Pumped storage is currently the most proven and reliable form of large-scale electricity storage, providing 96% of the world's storage. While impoundment hydropower is also deployed to balance supply and demand, pumped storage has the additional benefit of being able to reduce curtailment. Operational flexibility has the further benefit of helping to reduce transmission congestion,²¹ improving the resilience of grids which may be under stress from increased load, age or resource variability.

Dams and reservoirs have multiple purposes beyond hydropower generation, including water storage and supply for domestic, industrial and agricultural use, and flood control. Along with good demand management and water governance, improved water storage can promote food security, economic development and increased resilience in a changing climate.

Ultimately hydropower's role in mitigating and adapting to climate change will require a balanced appraisal of the advantages, disadvantages and trade-offs of each project. See Sections 3.3 and 3.4 for further discussion.

2.2.3 Looking forward for hydropower

Globally, hydropower installed capacity grew by 2.1% per year on average over the 2015-2019 period; in 2019, the growth rate was 1.2%.²² driven in part by increased demand for clean electricity and water management services. Brazil and China led the way in new capacity added in 2019, accounting for 30% and 26%, respectively.²³ Technological, economic and policy trends relevant to

²¹ US Department of Energy (2016), 'Hydropower Vision: A New Chapter for America's Renewable Electricity Source'

²² IHA (2020), Ibid.

²³ Ibid.

hydropower include:

- A range of decarbonisation policy drivers worldwide, including targets, feed-in tariffs, concessional finance, and future increased demand for offsets from carbon markets;
- Increasing awareness of the need for grid infrastructure modernization and resilience;²⁴
- Long-distance, high-voltage transmission lines integrating hydropower into larger electricity markets (for example, SIEPAC in Central America and CASA-1000 in Central Asia²⁵);
- Growing realization of the need for storage in low-carbon electricity systems, including the development of hybrid energy systems that integrate hydropower with variable renewable technologies to offset their intermittency; and
- Innovations to improve the economics and range of locations for hydropower such as modular systems, ultra-low-head turbines²⁶ and hydropower in man-made conduits.²⁷

²⁴ US DoE *ibid.*

²⁵ IHA (2015), 2015 Hydropower Status Report, International Hydropower Association, available at: <https://www.hydropower.org/2015-hydropower-status-report>

²⁶ Bishop, N. and Linke, D. (2015), New Pathways for Hydropower: Getting Hydropower Built—What Does It Take?, Report by the Hydro Research Foundation with UT-Battelle for the US Department of Energy, available at: http://www.hydrofoundation.org/uploads/3/7/6/1/37618667/new_pathways_for_hydro_final_ornlrm2015_48-1.pdf; Hydro Green Energy (2016) company website: <http://hgenergy.com>

²⁷ Bishop et al. *ibid.*; Leviathan Energy (2016), “Power from your pipes”, company website: <http://www.benkatina.com/>

3 Objectives and Principles of the Hydropower Criteria

3.1 Guiding principles

The objective of CBI has been to develop Hydropower Criteria that can maximize viable bond issuances with verifiable environmental and social outcomes. This means the Criteria need to balance the following objectives:

- They form a set of scientifically robust, verifiable targets and metrics; and
- They are usable by the market, which means they must be understandable for non-scientific audiences, implementable at scale, and affordable in terms of assessment burden.

The Criteria should:

- Enable the identification of eligible assets and projects (or use of proceeds) related to hydropower investments that can potentially be included in a Certified Climate Bond;
- Deploy appropriate eligibility Criteria under which the assets and projects can be assessed for their suitability for inclusion in a Certified Climate Bond; and
- Identify associated metrics, methodologies and tools to enable the effective measurement and monitoring of compliance with the eligibility Criteria.

Given that a number of protocols relevant to hydropower already exist (see Section 6.4 and Appendix 4), the TWG has taken care not to reinvent the wheel, but rather draw from these existing protocols and guidance.

The highly context-specific nature of hydropower means that each asset or project should be assessed on a case-by-case basis. As mentioned in Section 2, a decision was made early on not to apply any automatic exemptions based on assumptions that certain types or size of a facility have a lower impact than others.

The Criteria are made up of two components, both of which need to be satisfied for assets to be eligible for inclusion in a Certified Climate Bond.

These are:

1. Climate Change Mitigation Component – addressing whether the asset or project is sufficiently 'low GHG' to be compliant with rapid decarbonisation needs across the power sector - see Sections 4 and 5 for details.
2. Climate Change Adaptation and Resilience Component – addressing both whether the facility is itself resilient to climate change and not adversely impacting the ability of affected populations to adapt. This encompasses a broad set of environmental and social topics – see Section 6 for details.

3.2 Potentially eligible assets

The following assets in the hydropower sector are potentially eligible for inclusion in a Certified Climate Bond, subject to meeting the eligibility Criteria discussed in this document and summarized in the associated Hydropower Criteria document.

- Power stations:
 - Run-of-river
 - Impoundment
 - Pumped storage
- Applications of in-stream technology

- Dedicated infrastructure such as transmission lines

Although previously mentioned, for the further avoidance of doubt, the Criteria cover hydropower facilities relating to inland waterways. They do not cover tidal power located in marine or estuary environments (covered under the [Marine Renewables Sector Criteria](#)) or any other kind of marine application.

3.3 Aspects of climate performance to be assessed

3.3.1 Overview

The primary *climate-related* issues which the Hydropower Criteria need to address are:

- Low GHG-compatibility: hydropower facilities affect the natural carbon cycle of the catchment in which they are situated to greater and lesser extents, resulting in a net change in GHG emissions which may be positive or negative and can range from negligible to (in rare cases) very sizeable. The question of when hydropower facilities can be regarded as low GHG assets compatible with a low-carbon economy therefore needs to be addressed (Sections 3.3.2 and 4);
- Adaptation & resilience: the extent to which hydropower facilities are (or can be made to be) resilient to changing hydrological patterns and/or can provide climate adaptation services. There may also be concerns a project could exacerbate climate impacts for local or regional populations, which should be assessed (Sections 3.3.3 and 6.2).

Low GHG-compatibility rests in the ability of hydropower to provide clean energy with lifecycle GHG emissions well below those of fossil fuel power stations, particularly because, as a non-intermittent source, hydropower is often favoured over other renewables. In fact, its reliability as a source of power is evidenced by the long list of countries, from Canada to Tajikistan, which use hydropower as their main generating technology. Hydropower can also make a substantial contribution to integrating intermittent renewables into grid systems. However, the risk of high levels of GHG emissions remains and needs to be tested, as a small minority of impoundment hydropower facilities have been demonstrated to have very high life-cycle emissions of the same order of magnitude as thermal facilities²⁸ (see Appendix 3). This has been found geographically to be very context-dependent and therefore the risk of high levels of GHG emissions needs to be tested on a case-by-case basis.

Climate adaptation services can include improved water supply, drought mitigation and flood regulation by properly designed and sited dams and reservoirs. Poorly designed facilities could, however, add to water and food insecurity as well as exacerbate flood risk. Water scarcity and extreme weather events may pose risks to the ongoing viability of hydropower in some locations, and prompt additional design and efficiency requirements.

The issues relating to adaptation, mitigation potential and certification differ according to the type of facility. For example:

- Run-of-river and in-stream facilities with little-to-no storage potential typically have more variable generation profiles dependent on precipitation and seasonal variation, and may experience greater challenges in adapting to changing hydrological patterns.
- Impoundment hydropower reservoirs are built for a range of purposes, such as irrigation and drinking water supply; electricity generation may not be the primary purpose. This may increase adaptive capacity, but also raises difficulty in establishing the proportion of lifecycle emissions which can be attributed to electricity generation alone. As mentioned, some impoundment facilities also run the risk of being significant emissions sources.
- Pumped storage can be viewed as a component of a broader storage strategy to smooth out

²⁸ Bruckner et al. (2014), Energy Systems. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press

intermittent generation from wind and solar and enable a higher proportion of such intermittent resources to be integrated into supply grids.²⁹

These issues are summarised in Table 2 and discussed in more depth in Sections 3.3.2 and 3.3.3.

Table 2: Summary of climate-related issues for different types of hydropower

Climate-related issue	Run-of-river	Impoundment	Pumped storage
Mitigation			
Lower lifecycle emissions than thermal	Almost certainly	In the majority of cases, but depends on a range of factors	Comparison is not always appropriate given PSH's storage function
Comparable or lower lifecycle emissions than other renewables	Almost certainly	May require scrutiny and depends on a range of factors	Comparison with other storage options may be more relevant
Ability to support increasing variable renewable energy	Limited capability	Yes, compensation for variable generation	Yes, compensation for variable generation and reduced curtailment
Adaptation & Resilience			
Resilience	Most vulnerable to water stress	Vulnerable to water stress; resilience to extreme weather most vital, for safety reasons	Not vulnerable to streamflow variation
Adaptation services	Limited capability	Water supply and flood risk regulation, if well-designed and operated	Can add to water storage
Adaptation risks	Generally less likely to exacerbate flood and ecosystem risks, but should nevertheless be scrutinized, particularly cumulative impacts of multiple projects	Evaporative losses can reduce water availability. Poor design and operation could contribute to water and food insecurity, erosion, or poor flood control. Most potential ecosystem and social impact.	Does not add to water scarcity if using natural lake. Can add to downstream erosion. Less likely to increase flood risk.

The interrelationship between water and energy consumption and provision – the ‘water-energy nexus’ -- has gained prominence in international policy dialogue.³⁰ All forms of energy generation require water, and it would not necessarily be correct to assume that a water-stressed area could support a thermal or nuclear power station better than it could support a hydropower plant (see Section 2.3.3 for further discussion). However, hydropower is far more constrained by geography, and this may affect its resilience to changed hydrology more than other technologies.

3.3.2 Hydropower and climate change mitigation

Climate change mitigation potential rests in the ability of hydropower to provide clean energy with lifecycle GHG emissions well below those of fossil fuel power stations. The sources of hydropower lifecycle emissions include reservoir emissions from the modification of the natural carbon cycle in the catchment; production and transportation of materials; construction of dams, facilities and

²⁹ Impoundment facilities can also assist in balancing the system by being on stand-by for periods of low supply, but they differ in that they can store potential energy, but cannot convert electrical energy to potential energy as pumped storage can.

³⁰ D. Glassman, M. Wucker, T. Isaacman and C. Champilou (2011), The Water Energy Nexus: Adding Water to the Energy Agenda, World Policy Institute Policy Paper

transmission lines; and operational emissions, such as energy used in pumping systems and buildings.

While it is well known that there are GHG emissions from natural lakes and man-made reservoirs, these are part of a larger freshwater carbon cycle which is still poorly understood. The emissions derive principally from solid and dissolved organic carbon products that flow from the landscape into watercourses and undergo a series of natural reactions that lead both to the sequestration of carbon in sediments as well as to the generation of GHG emissions. Freshwater carbon flows also reach the sea where they undergo a similar set of marine processes.

While the presence of large water bodies (such as natural or manmade lakes) obviously affects these processes, there is very limited scientific understanding of the overall freshwater carbon cycle. However, it is agreed that there are substantial emissions of both CO₂ and CH₄ (methane) from natural freshwater systems of rivers, lakes and wetlands.

The GHG emissions from the freshwater carbon cycle are currently addressed through two dominant science streams:

- 1) Extensive work has been done to measure emissions of GHGs (primarily CH₄) from built reservoirs and natural lakes and to model and predict their evolution. This sometimes considers the nature of the upstream catchment but is limited downstream to the point where water is discharged from the reservoir, and associated degassing. It generally does not consider the quantity and fate of carbon flows and processes further downstream and how a reservoir may alter those dynamics.
- 2) Higher-level work is being undertaken on the overall freshwater carbon cycle at whole river/catchment scale. This considers overall sources, fluxes and processes of carbon along the length of streams and rivers as well as the final discharge to the ocean (some work also considers the fate of transported carbon in the ocean – and whether it is sequestered or remains active).

Work on hydropower has drawn primarily from the first stream and the consideration of hydropower Criteria necessarily focuses on this dimension. The TWG did recognise the importance of the second stream because it will enable a determination of the net impact of impoundment and its operation on the overall freshwater carbon cycle. This will, in turn determine, the potential climate impact of any water resource project. However, limited consideration has been given to the second stream as this is considerably more complex and requires further scientific evidence.

Reservoirs and lakes are significant sources of emissions and it is these that are considered by the Criteria. When land is flooded through natural flow variability or to create a reservoir, the decomposition of flooded organic matter and soils releases CO₂ and CH₄, in addition to the CO₂ and CH₄ generated by organic matter from the upstream catchment. Carbon emissions from watercourses, including lakes, are thus a continuous feature of the freshwater cycle. Clear accounting of the net change in these GHG emissions is vital to determine the impact of any water resource investment and its compatibility with the policy ambition of reducing GHG emissions.

Emissions estimates are naturally highly specific to the geography and ecology of the area, as well as to engineering design. It should also be understood that these are simply part of a larger process. Many natural terrestrial habitats emit GHGs, so it is important to predict the net change, i.e., the impact on GHG emissions throughout the freshwater system from the investment.

In the absence of sufficient scientific evidence or methodology to measure downstream impacts, a conservative approach considers simply the net emissions from changes to natural or manmade lakes. The key sources of variation in emissions per unit of reservoir surface area include:³¹:

³¹ Kumar, A., T. Schei, A. Ahenkorah, R. Caceres Rodriguez, J.-M. Devernay, M. Freitas, D. Hall, Å. Killingtveit, Z. Liu (2011), Hydropower, in IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, Cambridge University Press; N. Barros, J. J. Cole, L. J. Tranvik, Y. T. Prairie, D. Bastviken, V. L. M. Huszar, P. del Giorgio and F. Roland (2011), "Carbon emission from hydroelectric reservoirs linked to reservoir age and latitude", Nature Geoscience 4:593-596

- Reservoir location, environmental conditions and climate
- Temperature
- Flow rate
- Carbon stock and type of flooded area (for example, peatland or woodland would be higher than grassland)
- Depth, residence time of water, and depth of water intake structure
- Water quality
- Reservoir age

In addition, GHG intensity (gCO₂e/kWh) estimates will depend on:

- Power density (W capacity per m² reservoir)
- Load / capacity factor
- Technological performance (turbine efficiency)

Also important to note is that hydropower can contribute further to reducing grid emissions by improving the feasibility of intermittent renewables through grid reliability services: flexible generation, ramping capability and energy storage. This can result in greater renewable generating capacity and reduced curtailment than would otherwise be possible. Assessing where and whether this is the case, though, poses a challenge.

See Appendix 3 for an overview of hydropower lifecycle emissions estimates from the literature.

3.3.3 Hydropower and climate adaptation and resilience

There is increasing awareness of the dependence of all forms of electricity generation on adequate water resources.³² Changed precipitation, glacier cover and hydrological patterns pose a particular risk to hydropower.³³ Significantly reduced streamflow in some locations could negatively impact the capacity and/or storage of a hydroelectric power station, or in extreme cases render it inoperable. In regions that are prone to sedimentation, climate change could exacerbate the management of sediment inflow to hydropower projects.

Instances where drought has had severe impacts on hydropower generation have occurred recently in Tasmania,³⁴ Kenya³⁵ and Venezuela.³⁶ Drought events have in the past led to electricity rationing in Brazil, with a severe impact on industry and efforts to diversify its energy mix.³⁷ Many of the world's most water-stressed river basins, such as the Balkhash and Sirdaryo in Central Asia,³⁸ contain or are planning hydroelectric facilities.

A recent study in Nature Climate Change employing a hydrological-electricity system model³⁹

³² M. T. H. van Vliet, D. Wiberg, S. Leduc and K. Riahi, "Power-generation system vulnerability and adaptation to changes in climate and water resources", *Nature Climate Change* 6:375-381

³³ ADB (2012), *Climate Risk and Adaptation in the Electric Power Sector*, Asian Development Bank

³⁴ Harris, M. (2016), "Falling reservoir levels strain Hydro Tasmania's supply", *HydroWorld.com*, available at: <http://www.hydroworld.com/articles/2016/03/falling-reservoir-levels-strain-hydro-tasmania-s-supply.html>

³⁵ DFID (2009), *Water storage and hydropower: supporting growth, resilience and low-carbon development*, a DFID evidence-into-action paper, UK Department for International Development

³⁶ Hambling, D. (2016), "Hydro power falters in persistent drought", *The Guardian*, available at:

<http://www.theguardian.com/news/2016/mar/30/weatherwatch-hambling-venezuela-hydroelectric-dam-guri-dry-reservoirs-colombia>

³⁷ CEE (undated), *Brazil's Power Market Crisis, Case Study*, Center for Energy Economics, Jackson School of Geosciences, University of Texas at Austin; Poindexter, G.B. (2016), "2016 drought eases and continues in Brazil, affecting hydroelectric power generation", *HydroWorld.com*, available at:

<http://www.hydroworld.com/articles/2016/03/2016-drought-eases-and-continues-in-brazil-affecting-hydroelectric-power-generation.html>;

³⁸ Luomi (2014), 'Sustainable Energy in Brazil: Reversing Past Achievements or Realizing Future Potential', *Oxford Institute for Energy Studies*

³⁹ WRI (2013), *Aqueduct country and river basin rankings: a weighted aggregation of spatially distinct hydrological indicators*, World Resources Institute Working Paper December 2013

³⁹ van Vliet et al. *ibid.*

concluded that 61-74% of the world's hydropower stations⁴⁰ are located in regions expected to face "considerable declines in streamflow" by the period 2040-2069, resulting in a potential loss of overall capacity of 1.2-3.6% by the 2050s, and monthly maximum reductions of 9.6-17%. These figures suggest potentially serious seasonal impacts in some regions. The study predicted "consistent increases in annual mean streamflow for high-latitude regions" and "consistent decreases in streamflow" for "the United States, southern and central Europe, Southeast Asia and southern parts of South America, Africa and Australia."⁴¹ Good quality hydrological modeling, streamflow monitoring and improved forecasting techniques are therefore essential elements of making hydropower climate-resilient.

The study concluded that a 10% increase in the efficiency of hydropower could offset the impact of water constraints in most regions. While most of the more recently-built large hydropower projects will operate at close to their theoretical limit for efficiency in optimal conditions,⁴² there is potential for improved efficiency in many existing facilities. As an additional resilience strategy, this could include a variety of improved efficiency options such as re-turbining existing hydropower facilities with more efficient units.

In addition to drought, hydroelectric infrastructure will also need to be resilient to extreme weather and flooding, illustrated by the difficulties facing the Oroville Dam in California after heavy rains in February 2017. Options include physical infrastructure enhancements such as increasing dam height, dam design, improved spillway design, turbines resilient to maximum water speeds and sediment loads, improved planning and maintenance, and overall flood management strategies such as upstream afforestation and enhanced forecasting methods.⁴³

The need for hydropower not to exacerbate climate change impacts for external stakeholders also needs to be considered. In some cases, over-exploitation of hydropower, or poorly planned and managed hydropower, could do so by restricting flow, damaging ecosystems and reducing water quality. Hydropower in the Yongding basin in China is thought by some to have contributed to the dramatic decline of a river which was once an important source of water to Beijing.⁴⁴ Deforestation, eroded riverbanks and high sediment loads caused by hydropower facilities and other dams have been linked to serious flooding in India.⁴⁵

While hydroelectric facilities do not consume water in the sense that a thermal power station consumes fuel, "water consumption" or the "net water footprint of hydropower" is nevertheless a phrase which crops up in discussion of the environmental impacts of hydropower, referring to evaporative losses from the reservoir.⁴⁶ This could potentially reduce the water available to downstream users, adding to any climate-induced water stress.

Natural ecosystems play a role in regulating water flow and avoiding siltation. As a consequence, protecting ecosystem services may be seen as an adaptation strategy relevant to hydropower. At the broadest scale, some academics and conservationists argue that evapo-transpiration by the Amazon rainforest is regionally important in maintaining rainfall patterns,⁴⁷ which would be relevant to most South American hydropower.

⁴⁰ Note that hydropower facility capacities vary enormously, so this percentage does not necessarily reflect the percentage of capacity affected.

⁴¹ The study examined a range of global mitigation scenarios (Representative Concentration Pathways) as set out in the IPCC Fifth Assessment Report.

⁴² Kumar et al. *ibid.*

⁴³ ADB (2012), *Climate Risk and Adaptation in the Electric Power Sector*, Asian Development Bank

⁴⁴ South China Morning Post (2011), "Future sold down the river", available at: <http://www.scmp.com/article/988561/future-sold-down-river>

⁴⁵ Wikes, T. and Asokan, S. (2014), "Hydro-power plants blamed for deadly floods in India", Reuters, available at: <http://in.reuters.com/article/uk-india-flood-idINKBN0DF10F20140429>

⁴⁶ Hogeboom, R.J., Knook, L., Hoekstra, A.Y. (2018), 'The blue water footprint of the world's artificial reservoirs for hydroelectricity, irrigation, residential and industrial water supply, flood protection, fishing and recreation', *Advances in Water Resources* 113 (2018) 285–294

⁴⁷ Fearnside, P.M. (2004), "Environmental Services as a Basis for the Sustainable Use of Tropical Forests in Brazilian Amazonia", in Ortega, E. & Ulgiati, S. (editors): *Proceedings of IV Biennial International Workshop Advances in Energy Studies*, Unicamp, Campinas, SP, Brazil; Mulligan, M., Rubiano, J.R., Burke, S. & Van Soesbergen, A. (2013), *Water Security in Amazonia*, Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project

In terms of adaptation services, water scarcity will be perhaps the foremost concern as the world adapts to climate change. Water management infrastructure which helps populations adapt is seen as key to avoiding future conflict,⁴⁸ increasingly reflected in the investment priorities of international financial institutions. Impoundment facilities could potentially aid adaptation by regulating water supply. Well-designed reservoirs can store excess rainfall and release water during drier periods, mitigating both drought and flood risk.

3.4 Other environmental and social impacts

Large dams have generated considerable controversy over a number of decades. The landmark World Commission on Dams Report of 2000⁴⁹ emerged from worldwide growing opposition to dams on environmental and social grounds.

The social, environmental and governance problems associated with large dams have included:⁵⁰

- Population displacement and loss of livelihood due to flooding of houses and farmland
- Ecological impacts of both the reservoir and modification of river flow
 - barriers to fish migration and population fragmentation of all types of species
 - eutrophication and algal blooms
 - loss/damage to riparian ecosystems and downstream wetlands
- Downstream impacts on water quantity and quality, particularly trans-boundary
 - reduced water security
 - water scarcity exacerbating conflict risk
 - loss of livelihood
- Loss of amenity and cultural heritage
- Sediment redistribution, leading to upstream flood risk and downstream erosion
- Public health impacts
 - opportunities for disease vectors to breed and pathogens to spread
 - loss of food security (agriculture and aquaculture)
 - reduction in water quality
- Corruption and human rights violations
- Inequitable distribution of environmental/social cost and economic benefit
- Poor financial performance of public investment
- Cumulative impacts from multiple dams in a catchment

The potential scale and seriousness of these impacts, and the sensitivities around them, are recognized and are addressed clearly by the Hydropower Criteria. Note that:

- In the case of hydropower, we view adaption, resilience and other environmental and social issues as being particularly closely interlinked. For this reason, the Criteria include a comprehensive assessment procedure to address all these issues in tandem (see Section 6.2).
- We do not make the assumption that any particular type or size of hydropower project is likely or unlikely to have significant environmental or social impacts and emphasise the need to assess each project in its own context.

⁴⁸ Kumar et al. *ibid.*

⁴⁹ WCD (2000), *Dams and Development: A New Framework for Decision-Making*, the Report of the World Commission on Dams, Earthscan Publications, London and Sterling, VA

⁵⁰ Kumar et al. *ibid.*; WCD *ibid.*; DFID *ibid.*; International Rivers (2016), "Problems with Big Dams", International Rivers website: <https://www.internationalrivers.org/problems-with-big-dams>; IFC (2015), *Hydroelectric Power: A Guide for Developers and Investors*, International Finance Corporation

4 Climate Change Mitigation Requirements

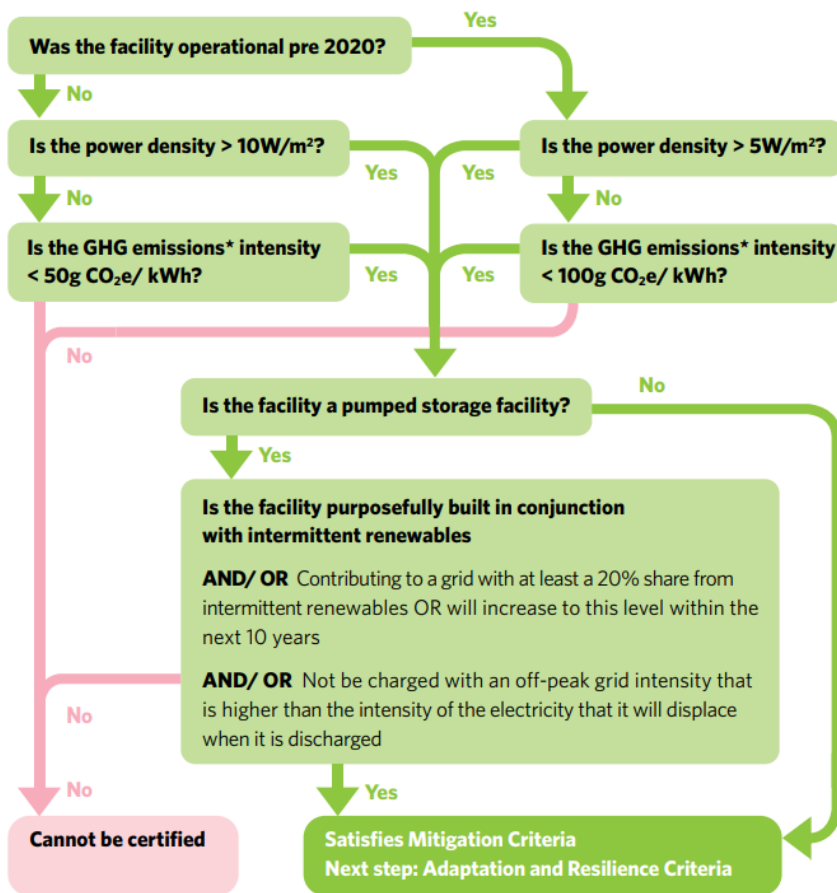
4.1 An overview of the Mitigation Component of the Hydropower Criteria

Figure 2 below summarises the decision tree for the Mitigation Component of the Hydropower Criteria for all facilities. *Additional* considerations for pumped storage facilities are addressed separately in Section 5.1 given their additional services and impacts.

The Mitigation Component comprises:

1. **A Predictive Screen** based on power density: designed to identify facilities that are highly unlikely to generate problematic emissions. Such facilities pass the Mitigation Component with no further steps.
2. **A GHG Assessment** of emissions intensity. Those facilities which do not pass the Predictive Screen move onto a GHG Assessment, a desktop methodology for predicting the GHG emissions due to the facility compared to a 'no project' counterfactual, based on site characteristics. Here, GHG emissions are expressed as an intensity in units of gCO₂e per kWh of electricity produced.
3. **A Low GHG-Compatibility Test**. The emissions intensity derived from the GHG Assessment is compared to a threshold to determine whether it has a sufficiently low GHG footprint. Facilities whose estimated emissions intensity falls below the Low GHG-Compatibility Test threshold pass the Mitigation Component of the Hydropower Criteria with no further steps.
 - a. **Allocation**: Many hydropower facilities are incorporated into dams and reservoirs which were built primarily for water storage or other purposes; therefore, it is reasonable to consider that a hydropower facility in this circumstance would be accountable for only a proportion of the emissions of that dam or reservoir. For simplicity, the Low GHG-Compatibility Test initially assumes 100% of the emissions are allocated to the hydropower facility. If the facility does not pass the Low GHG-Compatibility Test on this basis, an allocation assessment is completed; that is, the portion of emissions apportioned to hydropower rather than to other services is determined – and the Low GHG-Compatibility Test is applied to only this allocated number. Facilities whose estimated allocated emissions and associated emissions intensity fall below the Low GHG Compatibility Test threshold pass the Mitigation Component.
 - b. **Demonstration: G-res or Onsite Specific Assessment**: To demonstrate compliance with the GHG emissions intensity threshold, issuers must estimate GHG emissions from either:
 - i. The use of the G-res tool; OR
 - ii. A full on-site specific assessment.

Figure 2: Decision tree showing steps that determine whether a facility passes or fails the Low GHG-Compatibility Test of the Hydropower Criteria [This includes additional considerations for pumped storage facilities which are covered in detail in Section 5.1]



The remainder of this Section summarises the discussions and recommendations of the TWG relating to each of these components.

Note that while this section uses terminology in places which is particularly applicable to impoundment facilities, the Mitigation Component applies to all types of hydropower and not just impoundment facilities.

4.2 GHG Assessment

4.2.1 Purpose of the GHG Assessment

The purpose of the Climate Bonds Standard is to screen and certify only those 'low-carbon assets' compatible with an energy mix which stays within at least the 2° warming limit set out by the Paris Agreement (and ideally within the 1.5° warming limit).

Whether or not an electricity generation asset or technology is low-carbon is gauged by its emissions intensity, that is, the quantity of GHGs it emits for each unit of electricity generated (gCO₂e/kWh).

This approach allows not only ready comparison between different energy sources and technologies, but also helps form our understanding of the energy mix compatible with scientific analysis of the global GHG budget given projections of electricity demand.

The purpose of this GHG Assessment, therefore, is to estimate the GHG emissions for which the hydropower facility is responsible, expressed as an average *emissions intensity* over the asset's lifetime (i.e., gCO₂e per kWh generated), that can be used to check if falls under the appropriate GHG emissions intensity threshold (i.e., the Low GHG-Compatibility Test; Section 4.4).

This is fundamentally different to the purpose of other methodologies and tests designed to quantify *the amount of mitigation* an asset or technology achieves compared to a business-as-usual scenario.

For example, the UNFCCC CDM estimates emissions reductions of a facility compared to a counterfactual where *the facility does not exist, and other capacity is built in its place*. For this, it has to make comparisons with the historic carbon intensity of the grid and make assumptions about its carbon intensity going forwards.

Alternatively, energy efficiency driven GHG Assessments aim to assess the additionality impact of green finance being deployed. If it is financing an improvement over business as usual, regardless of the size of that improvement, it would be deemed green.

4.2.2 Boundary of the GHG Assessment

In practice, this means that the GHG Assessment for the Climate Bonds Standard needs to estimate the GHG footprint of the hydropower facility as a whole, including the reservoir and upstream and downstream impact and not just the incremental footprint of any specific investment (see Box 1).

For the purposes of clarification, this means that in the case of a retrofit or the addition of a new turbine to an existing facility, the GHG Assessment would estimate not just the incremental impact of the investment, but the new footprint of the whole facility post-investment, to see if post-retrofit, the facility is producing sufficiently 'low-carbon power' to qualify for certification under the Climate Bonds Standard.

However, the assessment should include only those emissions associated with and allocated to the hydropower function, which means the following are *excluded*:

1. The GHG emissions associated with any pre-existing natural water body; and
2. The GHG emissions associated with the broader range of services that the facility might provide.

Box 1: Defining the scope of the facility, its footprint and the GHG Assessment

There are two distinct concepts in determining the scope of the application of these criteria:

1. The *facility boundary*: we take this here to mean the "unit of development" where the investment takes place: any dam, reservoirs, engineered structures, engineered changes to watercourses, equipment for the generation of electricity and transmission lines.
2. The *facility footprint*: refers to the set of impacts that the facility may have, including within the facility boundary, upstream or downstream impacts.

4.2.3 Emissions scope of the GHG Assessment

GHG accounting procedures acknowledge three different 'scopes' or sources of emissions which may be enumerated in any assessment of the climate impact of a technology⁵¹:

⁵¹ <http://www.ghgprotocol.org/calculation-tools/faq>

- Scope 1: Direct GHG emissions resulting from on-site processes⁵²
- Scope 2: Indirect GHG emissions from consumption of purchased electricity⁵³
- Scope 3: Other indirect emissions resulting from activities elsewhere in the value chain, such as fuel and material extraction, manufacture, transport, etc.
- As a fourth category, we also discuss below the indirect mitigation impacts that hydropower can offer through its support of intermittent renewables at scale in the grid.

Below is discussed which ‘scopes’ or sources of emissions are included in the GHG Assessment.

Scope 1

The Scope 1 emissions from hydropower – that is, reservoir emissions – have naturally received the most attention in climate finance/policy discussions. This reflects the fact that reservoir emissions have the potential to be highly significant. These emissions are due to biophysical and biochemical processes engendered by alteration of the natural state of the water body, i.e., decomposition of inundated vegetation, silt build-up across the catchment area, etc. Carbon dioxide, methane and nitrous oxide are GHGs that are released as a result over the full lifecycle of the reservoir. This represents the alteration of the natural carbon cycle, and it is appropriate given the potential scale of these emissions to include them in the scope of the GHG Assessment.

However, natural water bodies also emit GHGs, so it also seems appropriate that any assessment of reservoir emissions following impoundment needs to be compared to the pre-existing situation. That is, that the GHG emissions associated with the pre-existing natural water body and terrestrial landscape are netted off in the GHG Assessment.

In summary then, Scope 1 emissions due to any disruption of the natural watercourse should be assessed (i) on a whole-catchment level, (ii) as the net difference compared to the previous state, and (iii) over the full lifetime of the reservoir.

Scope 2

For all facilities except pumped storage, Scope 2 emissions from electricity use are treated as negligible. Therefore, it is not proposed that Scope 2 emissions are included in the GHG Assessment for facilities. See Section 5.1 for further discussion on this issue with respect to pumped storage.

Scope 3

Scope 3 emissions in the case of hydropower mainly take the form of emissions released in the production of materials used to construct dams, in particular cement and steel. Evidence from the limited literature available suggests that on a per kWh basis these are typically small; large dams tend to support large amounts of electricity generation. We note that, even for large dams, construction emissions tend to be low on an emissions intensity basis, though with some outliers.⁵⁴

Given this uncertainty, in the interest of keeping the GHG Assessment as simple as possible, it is proposed that Scope 3 emissions associated with dam construction are not included. This is also compatible with other Climate Bonds Standard Sector Criteria, where embedded emissions are currently excluded.

Other i.e., indirect impacts (grid support, balancing, reserve services, other renewables integration)

⁵² Note that Scope 1 often refers to ‘smokestack’ combustion emissions. Here we take any emissions which are released directly to the atmosphere on-site to be Scope 1 emissions.

⁵³ Or, less often, from heat or steam.

⁵⁴ Figures compiled by the IPCC suggest that the median of construction and operation emissions is 4 gCO₂e/kWh. See Appendix 3. Other studies suggest they are typically low (< 10 gCO₂e/kWh). Refs: Kumar et al. *ibid.*; Hertwich et al. (2015), ‘Integrated life cycle assessment of electricity supply scenarios confirms global environmental benefit of low-carbon technologies’, PNAS May 19, 2015. 112 (20) 6277-6282; Raadal, H., Gagnon, L., Modahl, I., & Hanssen, O. (2011). Life cycle greenhouse gas (GHG) emissions from the generation of wind and hydro power. *Renewable and Sustainable Energy Reviews*, 15(7), 3417-3422.

The electricity-related benefits of hydropower include the capacity to provide both baseload and peak generation together with ancillary services provided through fast-responding, flexible generation to compensate for load variations over many time scales. In addition, hydropower can provide flexible energy storage to balance intermittent renewable technologies, ensuring grid stability and frequency control, as well as (in the case of pumped storage) reduce curtailment.

Therefore, the TWG has explored ways in which the further CO₂ avoidance that the facility may make possible indirectly in the grid through its support for intermittent renewables could be taken into account and netted off from the calculated Scope 1 emissions. Unfortunately, no straightforward, robust method to do this was identified.

One approach discussed was to model the power system as a whole and determine the direct and indirect impact of hydropower on that full system. This is the approach taken by the World Bank for its economic analysis of hydropower projects. However, there is no standardised model or method for this that can be co-opted at this stage for use by an individual bond issuer who is not experienced at such an in-depth, systems-based assessment.

Additionally, exploratory analysis was undertaken to determine whether and how the indirect mitigation impact of any facility could be estimated, drawing on discussions and examples of assessing the impact of large-scale renewables on system reliability⁵⁵ in order to consider the additional output from renewables enabled by hydropower and use this in a calculation of revised emissions intensity. However, an appropriate level of confidence that the proposed approach is robust was not reached.

Due to these challenges in establishing a robust, user-friendly methodology, at this stage, other indirect impacts via support to an intermittent grid are not proposed to be included in the GHG Assessment.

In summary

- It is proposed that the GHG Assessment should include only Scope 1 emissions, assessed over the asset lifetime.
- Scope 2 and 3 emissions on a per kWh basis are likely to be immaterial, and this is backed up by the lifecycle analysis literature.
- Other indirect impacts via support to an intermittent grid will not be included in the GHG Assessment at this time due to the lack of a straightforward but robust methodology for issuers to follow.

4.2.4 Approved assessment methodologies and associated reporting requirements

As detailed above, unless the facility is exempted via the Predictive Screen based on the power density, potential bond issuers seeking certification will need to estimate and report on reservoir GHG emissions by assessing the net change in catchment emissions for which the hydropower facility has been/is likely to be responsible.

Measuring emissions of existing reservoirs on-site is time-consuming and expensive, although guidelines do exist. Estimating the emissions of planned reservoirs is even more difficult given the number of factors involved (Section 2.3.2).

Despite this, it is important for issuers not to have to ‘reinvent the wheel’ and for results to be comparable across facilities and bonds. The Criteria therefore require a standardized methodology

⁵⁵ Karier, T. and Fazio, J. (2017), ‘How hydropower enhances the capacity value of renewables and energy Efficiency’, *The Electricity Journal* 30 (2017) 1–5. And, Tande, J.O.G. and Korpas, M. (2012), ‘Impact of Offshore Wind Power on System Adequacy in a Regional Hydro-based Power System with Weak Interconnections’, *Energy Procedia* 24 (2012) 131 – 142
<http://www.nrel.gov/docs/fy15osti/63038.pdf> <http://www.science.smith.edu/~jcardell/Courses/EGR325/Readings/ieee-capacity-value.pdf>

for assessing emissions in order to be both streamlined and fair, and to make certification practically feasible.

The G-res tool has been developed through collaboration between the International Hydropower Association and the UNESCO Chair for Global Environmental Change. This web-based tool allows the estimation of the net change in GHG emissions attributable to the introduction of a reservoir in a landscape, whether for an existing or planned reservoir. Following the new framework proposed by Prairie et al. (2017),⁵⁶ it also presents the net emissions for the complete lifetime (100 years) of reservoirs and not only for specific years as obtained with field measurements. Using publicly available data on reservoirs and their catchments, the G-res tool provides an easier method to assess GHG impacts than large-scale field measurement campaigns and multi-year studies.

Like all estimation tools, it has limitations and some imprecision. Estimating emissions from diverse natural ecosystems and water bodies requires some simplification of the complex processes that occur in nature. However, as a desktop model utilizing the latest science it is accepted by the TWG to represent the best available tool currently available to estimate the GHG emissions associated with a reservoir or group of reservoirs, while recognizing that further fieldwork and assessment is always encouraged in case of high predicted emissions.

For this reason, in order to demonstrate compliance with the climate impact threshold, it is proposed that issuers estimate GHG emissions from either:

- (i) The use of the G-res tool; OR
- (ii) A full on-site specific assessment.

It is envisaged that most would prefer the option of using the G-res tool, as this will be considerably less expensive than a full on-site specific assessment, but the option of using a bespoke on-site assessment is also offered for those that have already undertaken such assessments or intend to do so for other purposes.

Box 2 provides further information on the G-res tool. Box 3 provides further information on the requirements for a site specific assessment.

Box 2: GHG estimation using the G-res tool

Available online at: www.hydropower.org/gres

Objectives of the tool: The G-res tool provides a web interface to estimate the net GHG footprint of a reservoir based on the best current scientific knowledge and reasoning. This tool aims to be sufficiently flexible to assess reservoirs in any location where data on local environmental conditions modulating GHG fluxes (climate, land coverage, nutrient status, geographic characteristics) can be obtained.

Development: The tool is an output of a joint IHA/UNESCO research project. Building on a new conceptual framework⁵⁷ developed in cooperation with researchers from the University of Quebec at Montreal (UQÀM), the Norwegian Foundation for Scientific and Industrial Research (SINTEF) and the Natural Resources Institute of Finland (LUKE), and approved by the scientific community, the tool uses a series of models based on over 500 published empirical measurements from more than 200 reservoirs worldwide.

⁵⁶ Prairie, Y.T., Alm, J., Beaulieu, J., Barros, N., Battin, T., Cole, J., del Giorgio, P., DelSontro, T., Guérin, F., Harby, A., Harrison, J., Mercier-Blais, S., Serça, D., Sobek, S., Vachon, D. (2017), 'Greenhouse Gas Emissions from Freshwater Reservoirs: What Does the Atmosphere See?', *Ecosystems* <https://doi.org/10.1007/s10021-017-0198-9>

⁵⁷ Prairie, Y.T., Alm, J., Beaulieu, J., Barros, N., Battin, T., Cole, J., del Giorgio, P., DelSontro, T., Guérin, F., Harby, A., Harrison, J., Mercier-Blais, S., Serça, D., Sobek, S., Vachon, D. (2017), 'Greenhouse Gas Emissions from Freshwater Reservoirs: What Does the Atmosphere See?', *Ecosystems* <https://doi.org/10.1007/s10021-017-0198-9>

A modelling framework was developed putting together all the available data to create models that would allow anyone having access to the predictive parameters to estimate the GHG emissions of a freshwater reservoir. The G-res results were validated based on unpublished measured data provided by the industry.

Accessibility: The tool was launched in May 2017 as a fully integrated web-based tool. It has been designed to use only easily available and accessible data on climate, catchment and the reservoir. The user interface automatically populates the input tables with values adopted from global databases for existing reservoirs. For proposed projects, it also contains a complementary functionality that helps populating all the required parameters to run the G-res, if they were not available.

Scope: In determining the net impact of introducing a reservoir, G-res distinguishes among four carbonic GHG emission pathways: diffusive CO₂ emissions as well as diffusive, bubbling and degassing CH₄ emissions. It also integrates the GHG balance of the landscape prior to the project and takes account of displaced emissions (where some natural emissions that would have occurred regardless of the presence of the network are displaced at the surface of the reservoir). For diffusive emissions, it estimates the net impact of introducing a reservoir into a catchment over the complete lifetime of a reservoir (using 100 years as the default value for a lifetime).

It also accounts for the emissions from the reservoir surface resulting from human activity occurring within or outside the reservoir, which are unrelated to the creation of the reservoir itself, known as Unrelated Anthropogenic Sources (UAS). In addition, the framework includes an optional module to estimate emissions associated with the construction phase of the dam. It also includes a method for apportioning the net GHG footprint among the services that the reservoir provides. This apportionment is discussed more in Section 4.3.

Improvement over existing estimation methodologies: In the past, estimating the GHG footprint of reservoirs where there were no direct measurements was generally done by applying averages obtained from measurements of nearby systems or reservoirs of the same climate type (or latitude). However, these proxies may not be representative and do not account for the specific environmental conditions of individual reservoirs. In addition, this approach assumes that GHG emissions are constant in time, when there is considerable evidence that they significantly decrease in the early years following impoundment (e.g., Teodoru et al. 2012).

Limitations: Although G-res improves our modeling approach for GHG emissions, it has some limitations associated with current available data and scientific knowledge. For example, G-res is not able to adequately describe cascading systems (unless very simple), where one reservoir receives water from one or multiple upstream reservoirs. At the present time, the G-res tool considers reservoirs in a cascade as independent, a limitation arising from a lack of scientific data on the subject.

Moreover, again due to lack of data, G-res currently evaluates only carbonic GHG emissions and not N₂O. However, the few reservoir N₂O measurements available suggest that it represents only a small fraction of GHG emissions in most reservoirs.⁵⁸

The tool also does not account for the potential beneficial impact of reservoirs on hydrological emissions elsewhere, such as the extent to which emissions from seasonal flooding of wetlands is often reduced by reservoirs.

In this context, the G-res tool should be viewed largely as a flag determining whether the potential emissions of a reservoir are likely to be important or not.

⁵⁸ Bridget R. Deemer, John A. Harrison, Siyue Li, Jake J. Beaulieu, Tonya DelSontro, Nathan Barros, José F. Bezerra-Neto, Stephen M. Powers, Marco A. dos Santos, J. Arie Vonk; Greenhouse Gas Emissions from Reservoir Water Surfaces: A New Global Synthesis, BioScience, Volume 66, Issue 11, 1 November 2016, Pages 949–964

Oversight of the assessment: When a user overrides any default value when using G-res, it will be flagged in the final emissions report. If the user wants to make a claim using the results from the tool, its results will be reviewed by the G-res team (currently IHA, UQAM, UNESCO). This would confirm the accuracy of the results obtained and act as an approval stamp attesting the quality and rigour of the use of the G-res tool.

Further technical information:

G-res User Guide: <https://www.hydropower.org/publications/the-ghg-reservoir-tool-g-res-user-guide>

G-res Technical document: <https://www.hydropower.org/publications/the-ghg-reservoir-tool-g-res-technical-documentation>

User guidelines for the Earth Engine functionality: <https://www.hydropower.org/publications/the-ghg-reservoir-tool-g-res-user-guidelines-for-the-earth-engine-functionality>

Box 3: On-site assessment

For issuers evidencing their emissions intensity via an on-site assessment, it is required that the assessment be carried out in line with the IEA Hydro Framework as described in ‘Guidelines for the Quantitative Analysis of Net GHG Emissions from Reservoirs,’ issued in two volumes:

- Volume 1: Measurement Programmes and Data Analysis. These guidelines provide best practices that aim to assist the reader to measure, analyze data and model net GHG emissions from multipurpose reservoirs.
- Volume 2 – Modelling: Guidelines for Quantitative Analysis of Net GHG Emissions from Reservoirs. This defines procedures and best practices for the modeling of GHG Emissions from Freshwater Reservoirs. From this framework, readers can undertake sufficient analysis and study to understand the process of GHG emissions from an existing or planned reservoir correspondent to long-term horizons.

These Guidelines are compatible with the G-res tool methodology,

For further information see: <http://www.ieahydro.org/annex-xii-hydropower-and-the-environment>

4.3 Allocation of estimated GHGs

4.3.1 Overview

Reservoirs often provide a range of services and economic benefits other than hydroelectricity, including regulating flows for water supply, flood control, drought support, irrigation, fisheries and recreation.⁵⁹ In many cases, generating hydroelectricity is not the primary purpose of the reservoir. While of course hydropower can be pivotal to the economic justification for the reservoir, it may not be, and it should be acknowledged that some reservoirs might still be built even if there were no hydropower element. Figure 3 illustrates the mix of single and multipurpose reservoirs globally, based on a sample of 498 reservoirs from IHA/UNESCO’s G-res database.

It is arguable, therefore, that it is not justified to apportion all the emissions to hydropower in a multi-purpose reservoir.

To address this, it is proposed that a hydropower facility should be deemed to meet the Low GHG-Compatibility Test so long as the emissions apportioned or allocated to hydropower fall below the threshold (even if the full, unallocated scope 1 emissions do not).

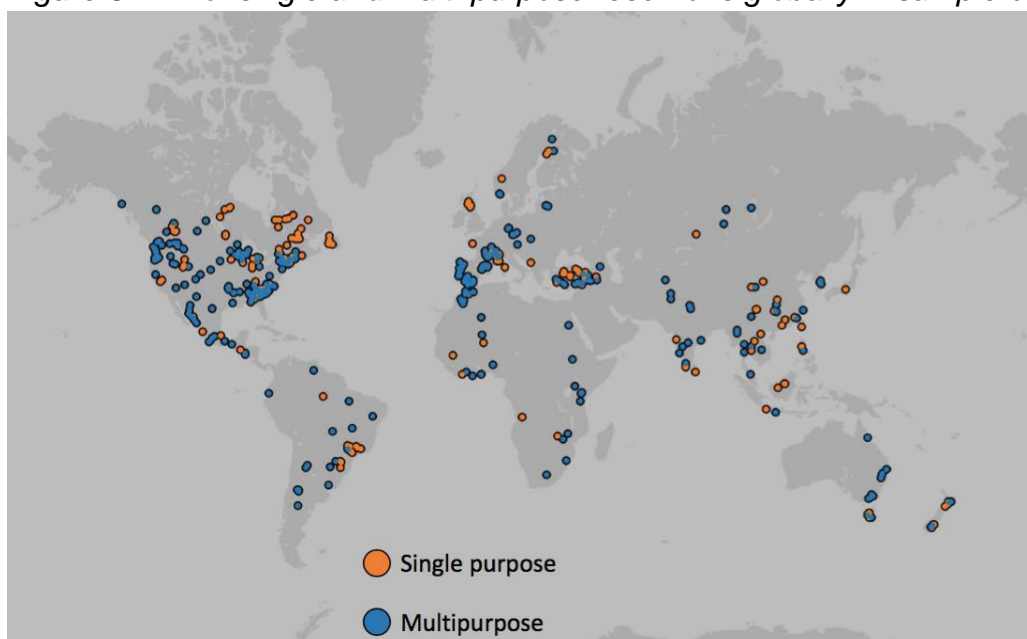
⁵⁹ UNESCO/IHA, *ibid*.

To apply this approach, an allocation method is needed to determine the relative importance of different reservoir services and allocate emissions to them proportionally. The G-res tool includes such an allocation mechanism, and given the proposed use of the G-res tool for assessing GHG emissions in total, for simplicity and consistency it is proposed that this allocation methodology be used to determine the allocated emissions for a hydropower facility for the purposes of the Low GHG-Compatibility Test.

For issuers undertaking a GHG Assessment via an on-site assessment, the methodology of the Allocation Module in the G-res tool (using the Operating Regime variant), should be replicated to allocate the estimated unallocated emissions to the multiple services that reservoir may provide.

The rationale for this is given in the section below.

Figure 3: Mix of single and multi-purpose reservoirs globally in sample of 498 reservoirs



Source: UNESCO/IHA

4.3.2 The allocation methodology in the G-res tool

The G-res tool includes a module to allocate the net GHG footprint of the reservoir to the various reservoir services. The following eight services have been included for allocation:

- Flood control
- Fisheries
- Irrigation
- Navigation
- Environmental flow
- Recreation
- Water supply
- Hydroelectricity

The UNESCO/IHA consortium explored three different approaches to how GHG emissions would be allocated across these services. These are based on, respectively, the economic benefit of hydropower as a share of the overall economic benefit of the reservoir; the volume of water released by hydropower compared to other services; and the hierarchy of services detailed by the operating regime. These are described in Table 3 below.

Under the operating regime approach, GHG emissions are allocated based on the hierarchy of services in the operating regime, i.e., the operational prioritisation of the services. Operating regimes could be informed either by explicit prioritisation (as in some countries such as India, Turkey or Pakistan) or by Operating Rule Curves (ORCs).

Table 3: Approaches to allocation

Approach	Principle	Inclusivity	Implementation
Economic	GHG emissions are allocated based on relative economic benefit provided by the service. In principle, we consider this approach to be most conceptually robust, as decision making is normally based on the economic merits of a project which caused the resultant GHG emissions.	This approach should be possible for all reservoirs. We currently have devised simple methods of including the four most common services.	This approach is the most data intensive, however we have developed a simplified method which we believe is a robust and implementable tier 1 solution.
Volumetric	Allocation based on the changes in volume of water of the reservoir required to fulfill the service. The main conceptual issue is that water is consumed by some services (irrigation) and not by others where the water is only moved from the reservoir.	There are difficulties in including flood control, recreation and commercial fishing within this approach.	Data requirements of water use over long periods of time may be available to operators.
Operating regime	Approach based on the hierarchy of services in the operating regime. The principle encounters issues for some reservoirs in which hydropower is a major service, but the operation is dominated by irrigation needs.	Should be able to include all services.	Operating hierarchy should be known to operators.

Source: UNESCO/IHA, 'The Scientific Basis of the G-res Tool'

ORCs are derived through the use of sophisticated multi-objective optimisation techniques which prescribe a target reservoir level at specific times over the year as a guideline for operators. Operators will therefore release or store water to achieve the level prescribed by the ORC depending on the circumstances at the time.

Therefore, the operational prioritisation of the services changes over time and so the length of time a service is prioritised can be used for allocation.

To implement the operating regime approach, the user must identify the importance, or primacy, of each service. Identifying the primacy is performed using the criteria set out in Table 4 below.

Table 4: apportionment of GHG emissions under the UNESCO/IHA methodology

Service primacy		Apportionment of GHG emissions	Notes	
Primary		80%		
Secondary		15%	There may be up to three services in each level. GHG emissions are split equally among the services in each level.	Where there are no secondary services, the apportionment (15%) is split between the primary services.
Tertiary		5%		Where there are no tertiary services, the apportionment (5%) is split between the secondary services.

Source: UNESCO/IHA

It is recognised that all three allocation approaches have weaknesses and drawbacks for practical allocation. For this reason, there has been some discussion in the TWG about which allocation methodology it would be best to adopt, or even whether one can be adopted at all. However, there is a strong feeling that there is a need for allocation of emissions to hydropower, and therefore a preferred allocation methodology should be selected.

The UNESCO/IHA consortium recommended the allocation approach based on the operating regime of the reservoir. The operating regime should be known by the user and therefore will be the most easily implementable of the identified approaches. The economic-based approach has conceptual robustness; however, at this stage it would require further development to apply consistently and effectively in practice.

Taking this into account, it is proposed that the operating regime approach be used to apportion emissions for the purposes of the Mitigation Criteria.

4.4 Low GHG-Compatibility Test

4.4.1 Overview

As mentioned above, the purpose of the Climate Bonds Standard is to certify only low-carbon assets consistent with achieving the target of limiting global warming to no more than 2°C, and ideally 1.5°C, as set out in the Paris Agreement. Therefore, the purpose of the ‘Low GHG-Compatibility Test’⁶⁰ is to determine whether a hydropower facility is consistent with the very tight GHG budget required to achieve at least the 2°C goal.

To establish this, consideration has been given to:

- What the modelling literature suggests the global power sector’s GHG budget might be;
- What it means for an individual facility to be consistent with the overall global and power sector-specific GHG budgets required to achieve a 2°C scenario;
- What this implies in terms of an emissions intensity benchmark for hydropower; and
- The extent to which this is consistent with eligibility Criteria for other energy technologies under the Climate Bonds Standard.

Note that where the modelling literature provides guidance on power sector emissions, this only relates to direct combustion emissions of the power sector (as far as we are aware). Naturally, with hydropower, GHGs from biological processes are the primary concern. Any quantitative analysis presented in this section based on modelling therefore requires adjustment to take this into account.

⁶⁰ This document talks specifically about a ‘low GHG’, rather than a ‘low-carbon-compatibility’, test because methane is a potentially important component of hydropower GHG emissions.

4.4.2 The basic form of the Low GHG-Compatibility Test

The Low GHG-Compatibility Test aims to set an eligibility threshold for hydropower facilities that are compatible with the global power sector emissions envelope. The basic form of the test is:

Emissions intensity of the hydropower facility \leq A suitable emissions intensity threshold

where emissions intensity is expressed in terms of the average gCO₂e/kWh electricity generated over the asset's lifetime.⁶¹ The net change in the pre-existing carbon cycle within the footprint of a hydropower facility is treated as analogous to the direct 'smokestack' emissions of a fossil fuel power station and is referred to as its Scope 1 emissions (as explained in Section 4.2.3).

With this metric, the emissions can be compared directly with other types of generation. This is valuable, as it enables us to explore the idea of a threshold for 'low-carbon power'. All renewables are not equal, with different emissions profiles, but with a common metric we can seek to promote a 'technology-agnostic' approach, acknowledging that individual governments and operators determine the preferred power mix within a local development, social and economic context.

As noted above, in contrast to other frameworks such as the Clean Development Mechanism, the purpose of the Low GHG Compatibility Test is not to estimate the quantity of emissions reductions which the asset achieves relative to a business-as-usual scenario, but rather to test consistency with a low emissions future.

4.4.3 Using climate models and scenarios to inform the Low GHG-Compatibility Test

It would be ideal to be able to derive a simple emissions intensity benchmark for the global power sector from the Integrated Assessment Models (IAMs) used to model climate scenarios. It is not within the scope of this paper to provide a thorough overview of the IAM literature, but three papers containing IAM meta-analyses were examined to see what guidance the literature can provide on the scale of decarbonisation required across the power sector.

A review of IAMs by Rogelj et al. (2015) states that "likely 2°C scenarios ... emit almost zero carbon emissions from electricity by 2050".⁶² A synthesis of model results by Kriegler et al. (2014) indicates zero or even negative emissions by 2050 from the electricity sector to achieve a 450 ppm atmospheric concentration scenario (a medium-likelihood scenario for achieving 2°).⁶³ A model intercomparison by Luderer et al. (2012) states that "the models consistently show an almost full scale decarbonisation of the electricity sector by the middle of the 21st century."⁶⁴

These models have different results, and of course there is no single correct answer. However, they corroborate the scale of power sector emissions reductions indicated by IEA modelling. The IEA's Energy Technology Perspectives (ETP) model indicates that a Sustainable Development Scenario (SDS) requires a reduction in carbon intensity of electricity generation from 463 gCO₂/kWh in 2019 to below zero in net terms by around 2055.⁶⁵

⁶¹ The emissions profile of the asset changes over time as there is less and less organic matter to degrade. Assessing over the lifetime of the asset rather than using a snapshot gives a fairer reflection of its overall emissions intensity.

⁶² Rogelj et al. (2015), 'Energy system transformations for limiting end-of-century warming to below 1.5°C', *Nature Climate Change* 5:519-538.

⁶³ Kriegler et al. (2014), 'The role of technology for achieving climate policy objectives: overview of the EMF 27 study on global technology and climate policy strategies', *Climatic Change* 123(3): 353-367

⁶⁴ Luderer (2012), 'The economics of decarbonizing the energy system—results and insights from the RECIPE model intercomparison', *Climatic Change* 114(1): 9-37

⁶⁵ <https://webstore.iea.org/energy-technology-perspectives-2020>; "The trajectory for emissions in the Sustainable Development Scenario is consistent with reaching global net-zero CO₂ emissions by around 2070."

However, using any of these models as guidance for a hard-and-fast emissions intensity threshold for hydropower is problematic for the following reasons:

- IAMs are subject to large uncertainties because by their very nature they are reducing a complex real-world process with social, economic, technological and physical science dimensions to a limited set of quantitative inputs and outputs.
- Due to the uncertainties inherent in climate modelling, scenarios are generally presented as having a probability of limiting warming to 2°C (or some other temperature). Generally, a 2°C scenario is considered to be one that limits warming to below 2°C with a probability of at least 66%, though some models use a probability of at least 50%. Further, some scenarios do not match the objective of limiting warming to 2°C, but instead denote the degree of radiative forcing or atmospheric concentration of CO₂ which they result in.
- The models do not disaggregate to the level of different technologies within the power sector but provide indicators in the form of budgets or average carbon intensities across the power sector more broadly.⁶⁶
- These indicators are at global levels. In reality, each country will have specific considerations driving its optimal energy mix, and the associated emissions from that.

Because of this, the approach chosen has not been to pick a power sector emissions intensity benchmark from any one IAM and use it as a rigid threshold for hydropower. Instead, the approach is guided by the sense of direction and scale of reductions in power sector emissions described by climate models, while also recognising there may need to be some flexibility due to differing local resource and political contexts.

The IEA's ETP 2DS scenario is used in Appendix 2 to illustrate the scale of technological change required in the global power sector to meet a 2° scenario. We underline that the numbers in this analysis should not be interpreted over-literally and encourage readers to view them as indicative. But the main points from this analysis are as follows:

- As mentioned above, the 2DS scenario indicates a required average emissions intensity across the global electricity sector in 2050 of 35g CO₂e/kWh, down from 519 gCO₂e/kWh in 2014.
- IEA analysis takes into account GHG emissions from fossil fuel combustion only and does not incorporate non-combustion emissions from hydropower and geothermal.
- To adjust for this, our analysis maintains the fossil fuel intensity and overall energy mix from the IEA 2DS but also incorporates emissions intensity factors for hydropower and geothermal from non-combustion emissions.
- With geothermal and hydropower together accounting for 20% of power generation in 2050 in the 2DS scenario, by including estimates of their non-combustion emissions, the estimated global emissions intensity in 2050 is revised to 43g CO₂e/kWh – above the IEA's 35g CO₂/kWh average emissions intensity that is compatible with a 2DS scenario.
- The vast bulk of emissions reductions needs to come from decarbonising fossil fuel capacity and switching away from it to zero-emitting sources. However, small increments in hydropower emissions intensity have a material impact on whether the sector can meet a target emissions intensity. For example, in the analysis each increment in hydropower emissions intensity of 1g CO₂e/kWh implies a further 26.9 TWh of generation is required from zero-GHG sources to meet the GHG budget in 2050. This is roughly equivalent to the current wind output of Canada. That is, the world's GHG budget is so tight that it is reasonable to place precautionary limits on even typically low-emitting power sources such as hydropower, particularly as they are so long-lived.

⁶⁶ Many models do not disaggregate by technology; those that do often focus on primary energy supply, in which case fossil fuels used for power generation are included in the same category as those for transport, industry, etc.

4.4.4 Proposed emissions intensity threshold for hydropower

Recognising the diversity of these models, their assumptions and known uncertainties, the adoption of any one figure from any single study as a basis for a hard and fast emissions intensity threshold would show false precision. However, these models and analyses can still provide useful guidance to assist in setting such a threshold. A number of clear and consistent messages can be taken from them:

- The GHG budget for the global power sector is very low, and this needs to be reflected by the Criteria.
- The models indicate a clear direction of travel for the global power sector, namely: drastic and rapid decarbonisation across the sector within just three decades.
- Reducing power sector emissions is often seen as one of the cheapest and most politically acceptable mitigation options, hence power sector reductions are much steeper than for global emissions as a whole.
- This needs to happen despite increasing global demand for electricity. Low-carbon technologies in the form of renewables, nuclear power and carbon capture and storage (CCS) need to expand rapidly not only to replace fossil fuels, but also to meet this increased demand.
- The vast bulk of power sector emissions reductions will obviously come from a switch away from thermal energy sources. However, the tight GHG budget suggests a high degree of ambition is required and it is reasonable to place precautionary limits on hydropower.

These precautionary limits need to strike a balance which sets us on the right path in terms of overall decarbonisation, but allows flexibility due to the different political, technical and geographic circumstances of individual countries.

To achieve this, a direct emissions intensity threshold of 100g CO₂e/kWh for hydropower is proposed for facilities initially operational prior to 2020, and of 50g CO₂e/kWh for facilities initially operational during or after 2020.⁶⁷ This is based on the following reasoning:

- An emissions intensity threshold is sought which will at least maintain, and ideally further improve, the emissions performance of the hydropower sector as capacity expands.
- A threshold of 100g CO₂e/kWh would lead to the average sector performance improving, while not being so stringent as to produce the perverse result of discouraging a large number of projects which would be preferable to thermal alternatives. However, given the longevity of hydropower facilities (which can have operating lifetimes in excess of 100 years), it is desirable to have a significantly lower threshold for new facilities given such construction is effectively locking in energy generation for a very extended period.
- More specifically:
 - Today, on average, hydropower is already a low-emitting source of electricity generation. The state of scientific knowledge is evolving, and evidence to date suggests a median direct emissions intensity across hydropower of 24-28g CO₂e/kWh⁶⁸ compared to around 310-350g CO₂e/kWh for even the most efficient combined cycle gas turbine (CCGT) power station (see Appendix 3).⁶⁹
 - We expect by far the majority of hydropower projects to continue to fall well below 100g CO₂e/kWh, and by discouraging high-emitting facilities, the average emissions intensity of hydropower will decline.
 - Given the distribution of emissions intensity, which is weighted towards lower values (e.g., see Figure 4a), this leaves room for (likely a minority of) hydropower facilities to

⁶⁷ It is noted that this member was not in agreement with the establishment of 10W / 50g thresholds for facilities becoming operational in 2020 or thereafter.

⁶⁸ The G-res database median is broadly in line but slightly lower than this once emissions have been allocated – see Section 4.4.5.

⁶⁹ See Table A2 in Appendix 2

- be above the observed industry average, but not so far above that in aggregate they would impact significantly on the average emissions intensity of the sector.
- More specifically, IEA analysis has previously suggested average emissions intensity of new-build electricity capacity should be ~50 gCO₂e/kWh over the period 2020-2040.⁷⁰

On a case-by-case basis, such a threshold would then meet the main objectives of:

- Reducing or limiting hydropower's average emissions, thereby demonstrating a strong contribution to reducing the global power sector GHG budget;
- Being unlikely to result in instances of hydropower projects which are clearly preferable to fossil fuel alternatives being ineligible for certification;
- Being unlikely to result in low-performing hydropower projects which would significantly raise the sector average being certified; and
- Being consistent with the mitigation criteria already adopted by the Climate Bonds Standard for other forms of renewable energy (see Box 4).

Lastly, hydropower facilities provide critical storage services that indirectly help enable the mitigation impacts achieved through the roll-out of intermittent renewables. As discussed in Section 4.2.3, we have been unable to establish a robust methodology to account for this positive indirect impact. Therefore, even a hydropower facility with an emissions intensity of 100 gCO₂e/kWh or above based on Scope 1 emissions only may well have a net emissions intensity below 100 gCO₂e/kWh, were indirect mitigation impacts able to be robustly estimated and netted off.

Box 4: Consistency with mitigation criteria for other forms of renewable energy under the Climate Bonds Standard

The most direct comparison for hydropower is the emissions threshold set for geothermal and bioenergy facilities. All these renewable energy sources have the potential for significant emissions from biological or physical processes rather than from combustion. Discussions are ongoing regarding an appropriate emissions threshold for electricity from biomass. However, the eligibility Criteria for Geothermal assets were approved in 2016.

These Geothermal Criteria require eligible facilities to be below an emissions threshold of 100g CO₂e/kWh. Emissions included in this assessment are the direct emissions of carbon dioxide (and to a lesser extent methane) resulting from the release of naturally-occurring, non-condensable gases (NCGs) from the geothermal fluid during the energy extraction process. Based on the available literature, emissions from other elements of lifecycle emissions are immaterial on a gCO₂/kWh basis and therefore do not need to be accounted for in assessing performance against this threshold. Therefore, the focus of the Hydropower Criteria on Scope 1 emissions associated with the reservoir is consistent with the approach taken with geothermal, and the same emissions threshold is proposed for both sources of renewable energy. Historically, about two-thirds of global geothermal capacity has released direct emissions of less than 100g CO₂e/kWh.

CBI has also previously approved Criteria for Wind and Solar facilities. Both Wind and Solar have zero Scope 1 emissions, and therefore are automatically eligible for Certification, as long as they have no fossil fuel back-up. The Solar Criteria state that solar (with concentrated solar thermal in mind) can have backup of up to a maximum of 15% of generation. This is also consistent with a 100g CO₂e/kWh threshold in the vast majority of realistic cases.⁷¹

⁷⁰ IEA (2015) Energy Technology Perspectives 2015

⁷¹ The threshold is consistent with direct emissions of up to $100/0.15 = 667$ gCO₂e/kWh. According to the IEA's 'CO₂ Emissions From Fuel Combustion', world average Scope 1 emissions are 449 gCO₂e/kWh for gas-fired power and 793 gCO₂e/kWh for oil-fired power. NREL's CSP database indicates that oil-fired backup is rare compared to gas, and molten salt thermal storage can in any case be used as a substitute for either. Therefore it is technically possible that the Standard could certify a CSP plant with direct emissions exceeding 100 gCO₂e/kWh, but this is an unlikely scenario.

For geothermal and hydropower emissions, the evidence suggests that Scope 1 emissions are very likely to outweigh Scope 2 + 3 emissions, and these can be considered immaterial. For solar and wind, it should be borne in mind that Scope 3 emissions are not always insignificant. If we were to view 100g CO₂e/kWh as an approximate ballpark for the *lifecycle* (rather than just Scope 1) emissions of a low-carbon technology, the lifecycle analysis literature suggests that, with the exception of a few outliers,⁷² wind and solar projects tend to fall below this threshold.

That said, as with all the Climate Bonds Standard Sector Criteria, but particularly perhaps for hydropower, where knowledge, tools and experience are developing rapidly, we will revisit our assumptions, data and Criteria on a regular basis. In respect of decarbonisation pathways for the power sector, CBI will review the emissions intensity thresholds for all renewable energy sector criteria within 2 years of the launch of these Criteria.

4.4.5 Testing the implications of these thresholds

Use of the G-res data set

Observations from the G-res data set have been used to test the implications of these thresholds.

The IHA manages a data set of reservoirs with hydropower in all climatic zones, derived from the IHA/UNESCO G-res tool (Box 2, Section 4.2.4 and Box 5 below). The robustness of the Low GHG-Compatibility Test thresholds could theoretically also be tested similarly against other data points from the literature, but inherent problems of comparability arise given (i) they will undoubtedly vary in what they are measuring (in terms of scope, emissions pathway, etc.) and (ii) they are snapshots rather than lifetime averages. They are also usually given as flux estimates without accompanying data on reservoir surface area and capacity factor.

Box 5: The G-res data set

Each reservoir used in the development of the model has an emissions estimate for one or more of the four GHG emissions pathways (diffusive CO₂, diffusive, bubbling and degassing CH₄) described in Box 2. The initial source for the GHG emissions data was a study by Barros et al. (2011).⁷³ Those data were revised by comparing with the information from the original sources and complemented by data from more recent papers. After a complete review of the actual and past scientific literature on CO₂ and CH₄ emissions from reservoirs, 275 field assessments of diffusive CO₂ emissions, 197 of diffusive CH₄ emissions, 57 of bubbling CH₄ emissions and 51 of degassing CH₄ emissions were compiled from 223 reservoirs located in various regions of the world.

G-res Technical document: <https://www.hydropower.org/publications/the-ghg-reservoir-tool-g-res-technical-documentation>

Analysis

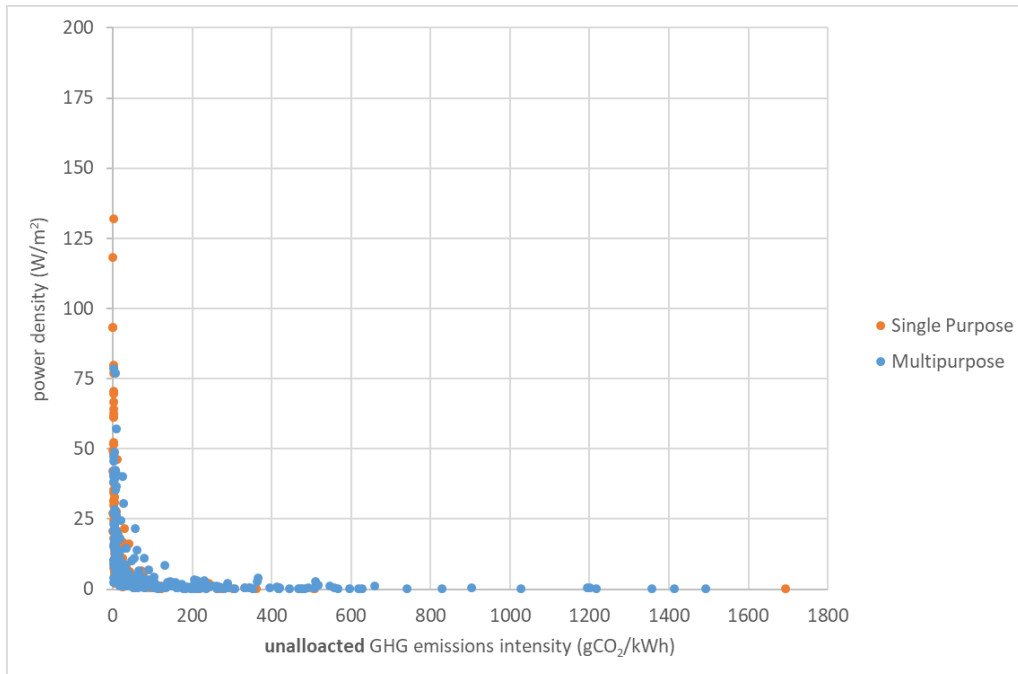
The median emissions intensity of the reservoirs in the G-res database is 19 gCO₂e/kWh allocated and 30 gCO₂e/kWh unallocated (see Section 4.3 for explanation of these terms), but as expected, this covers a large range of values. The data set is heavily weighted towards the lower end, with a much smaller number of high emissions-intensity facilities raising the median. The median emissions intensity of reservoirs below 100 gCO₂e/kWh is 13.4 gCO₂e/kWh (allocated).

⁷² These are: small scale crystalline silicon PV; PV with low insulation or manufactured in a country with a carbon-intensive grid; remote onshore wind farms associated with high transportation requirements; and carbon-intensive land use change; concentrated solar thermal at insufficient scale. See tables and references in Appendix 2.

⁷³ N. Barros, J. J. Cole, L. J. Tranvik, Y. T. Prairie, D. Bastviken, V. L. M. Huszar, P. del Giorgio and F. Roland (2011), "Carbon emission from hydroelectric reservoirs linked to reservoir age and latitude", *Nature Geoscience* 4:593-596

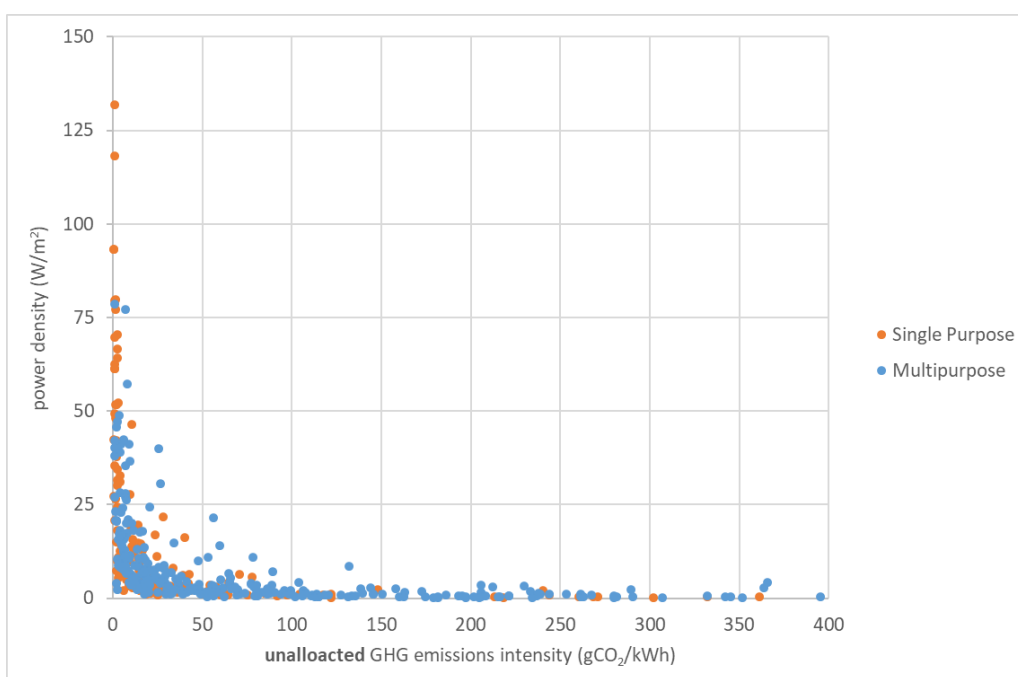
When considering unallocated emissions, as in Figure 4a, 27% of the 498 facilities in the G-res database would exceed the threshold of 100 gCO₂e/kWh for facilities operating pre-2020. This includes 21 single-purpose reservoirs (12% of single-purpose reservoirs) and 111 multi-purpose reservoirs (35% of multi-purpose reservoirs).

Figure 4a: Emissions intensity of 498 reservoirs; unallocated emissions, full range



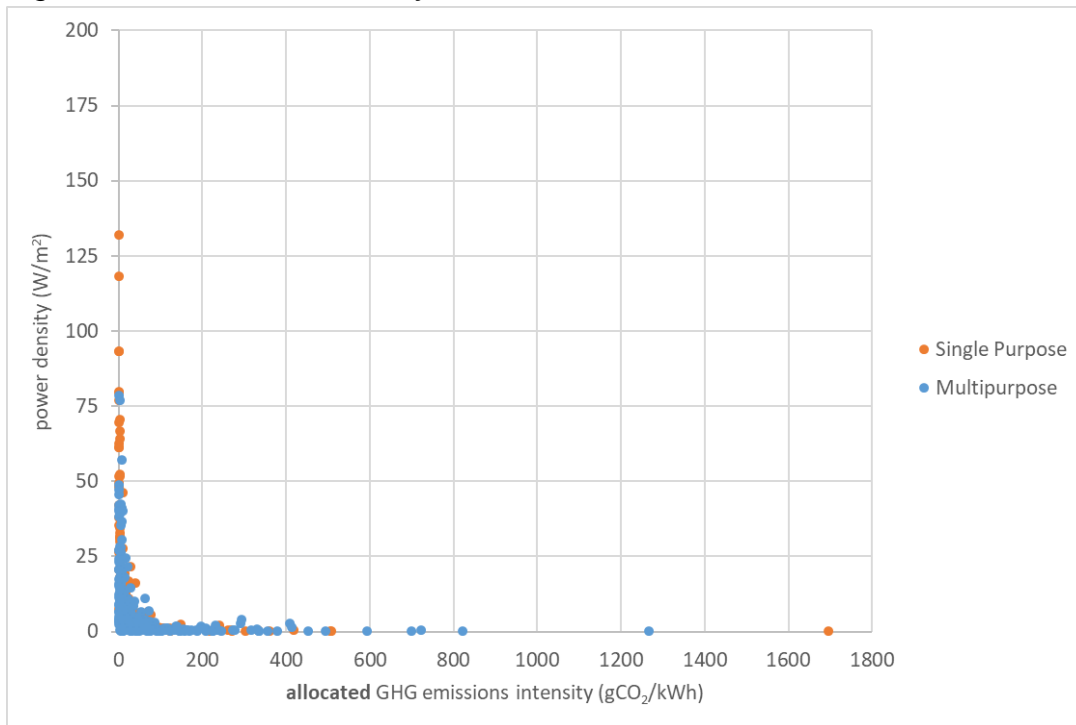
Source: IHA G-res database

Figure 4b: Emissions intensity of 498 reservoirs – unallocated emissions, below 400 gCO₂e/kWh



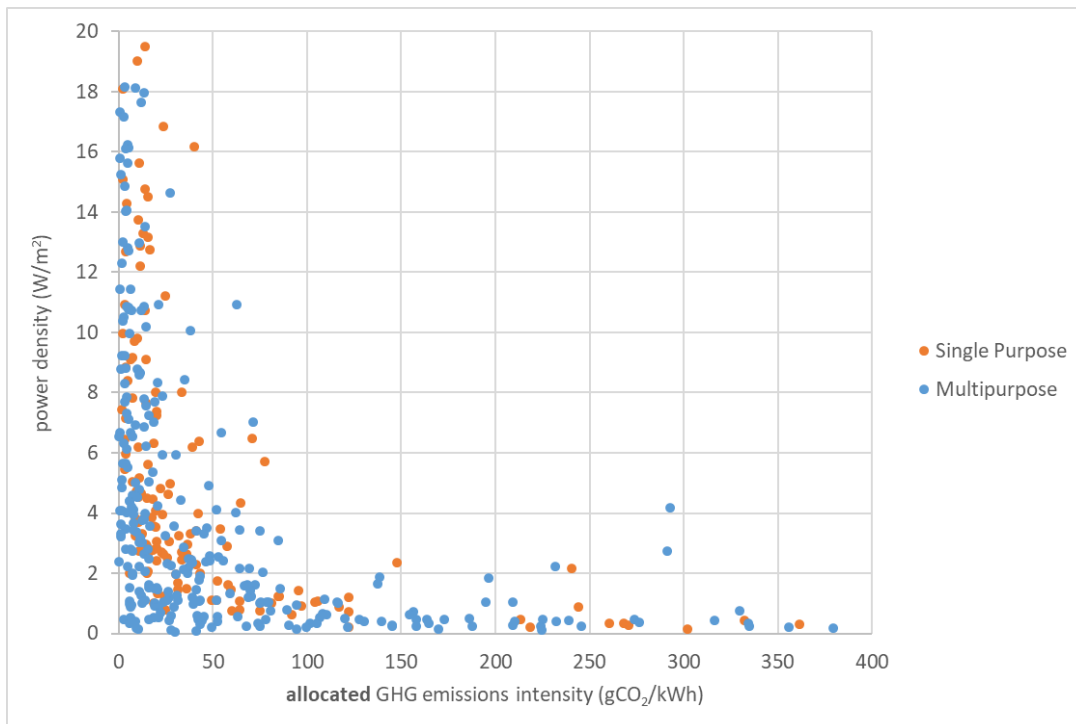
Source: IHA G-res database

Figure 5a: Emissions intensity of 498 reservoirs; allocated emissions, full range



Source: IHA G-res database

Figure 5b: Emissions intensity of 498 reservoirs – allocated emissions, below 400 gCO₂e/kWh



Source: IHA G-res database

When considering allocated emissions (allocated based on operating regime), as in Figures 5a and b, 16% of the 498 facilities in the G-res database would exceed the threshold of 100g CO₂e/kWh. This includes the same 21 single-purpose reservoirs but now only 58 multi-purpose reservoirs (18% of multi-purpose reservoirs). That is, using the allocation methodology, 12% of multipurpose reservoirs that would otherwise not meet the threshold would now do so. These implications are consistent with the intended rationale of the Mitigation Component of the Hydropower Criteria, namely, to ensure multi-purpose hydropower facilities are only accountable for the emissions arising from the hydropower service, and that the majority of certifiable facilities are low emissions to keep the sector average down, with the inclusion of a few higher-emissions-intensity facilities to allow flexibility according to local circumstances.

4.5 Predictive Screen

4.5.1 Rationale for the Predictive Screen

As illustrated above, the majority of hydropower facilities emit very little in the way of GHGs per kWh compared to fossil fuel power stations. As GHG Assessments take time and resources, it would, therefore, be preferable to waive the requirement for facilities' emissions to be assessed if they are highly unlikely to be problematic. This is decided via a 'predictive screen': a preliminary test which determines which facilities can be assumed to have low emissions.

The ideal predictive screen is an efficient and accurate classifier, that is, a simple test using few rules and readily available input data which (i) categorises high-risk facilities correctly 100% of the time and (ii) categorises low-risk facilities correctly in as many cases as possible. While many different factors are known to be determinants of hydropower emissions, if a clear statistical relationship can be shown to exist between just one or two of these factors and emissions intensity, then this relationship can be used as the basis of a predictive screen.

4.5.2 Precedents

Predictive screens for hydropower have precedence in the work of UNFCCC and IEA.⁷⁴ For example, the UNFCCC chose a predictive screen based on power density (facility capacity / reservoir surface area) for the Clean Development Mechanism, using a threshold of 10 W/m² (that is, reservoirs above this threshold were assumed to have zero emissions).

4.5.3 Proposed Predictive Screen for the Mitigation Component of the Hydropower Criteria

A simple power density threshold of 5 W/m² is proposed for facilities subject to a GHG threshold of 100 gCO₂e/kWh and 10 W/m² for facilities subject to a GHG threshold of 50 gCO₂e/kWh.

The state of knowledge and the observations of reservoir emissions have moved on considerably since the UNFCCC threshold was set 15 years ago. In the justification of the threshold proposed here, a range of scientific literature has been reviewed, as well as observations from the G-res data set. These references and observations suggest that these thresholds are feasible and likely to give accurate results. Incorporating other factors known to affect emissions is not practically feasible and would not improve the screen's accuracy or efficiency.

⁷⁴ UNFCCC (2006), Thresholds and Criteria for the Eligibility of Hydroelectric Power Plants With Reservoirs as CDM Project Activities, Annex 5 to CDM Board Executive Board Report (EB23), available at: https://cdm.unfccc.int/EB/023/eb23_repan5.pdf; IEA (2015), 'Guidelines for Quantitative Analysis of Net GHG Emissions from Reservoirs. Vol 2'

Why power density?

The scientific literature to date has suggested statistical relationships between emissions *flux* (related to emissions intensity as described in Box 6) and various other factors. Barros et al. (2011)⁷⁵ found dissolved organic carbon, reservoir age, depth and latitude to be significant factors, while Deemer et al. (2016)⁷⁶ suggested annual precipitation, primary productivity, nutrient load and age.⁷⁷ Note that a statistically significant relationship need not be a *strong* relationship.

However, as noted above, the predictive screen needs to be simple and use only factors which would be easy for an asset owner to determine, otherwise it does not fulfill its purpose of saving time and resources. Factors which would need detailed and/or site-specific study, or would themselves be uncertain, such as nutrient load, are inappropriate. The emissions intensity considered by the Criteria is an average over the asset lifetime, therefore reservoir age is irrelevant.

One simple option could be to have a screen based solely on installed capacity. Indeed, many screening tools used in the financial sector use capacity as the screening factor. However, as Figure 6a illustrates, installed capacity alone is not a good predictor of emissions intensity and many facilities with relatively small installed capacities have an emissions intensity greater than 100 gCO₂e/kWh. In fact, nearly a quarter of facilities less than 50 MW in size exceed the threshold (after allocation).

Alternatively, the predictive screen could be based on latitude. Again, many financial screening tools tend to label as higher risk facilities located in tropical zones. But only one of the studies referenced above (Barros et al.) found latitude to be a consistently significant predictor of emissions flux while the other (Deemer et al.) did not.⁷⁸ That latitude is a weak predictor of emissions intensity is supported by the dataset in the G-res tool. Figures 6b and 6c below demonstrate a wide range of emissions intensity (using allocated emissions) across a range of climate zones. According to this dataset, 27% of tropically-located facilities would not meet the 100 gCO₂e/kWh threshold, but neither would 15% of temperate-zone facilities, 20% of sub-tropical and 5% of boreal. Hence, like the CDM, we have decided that latitude is not a sufficiently strong basis for a predictive screen.

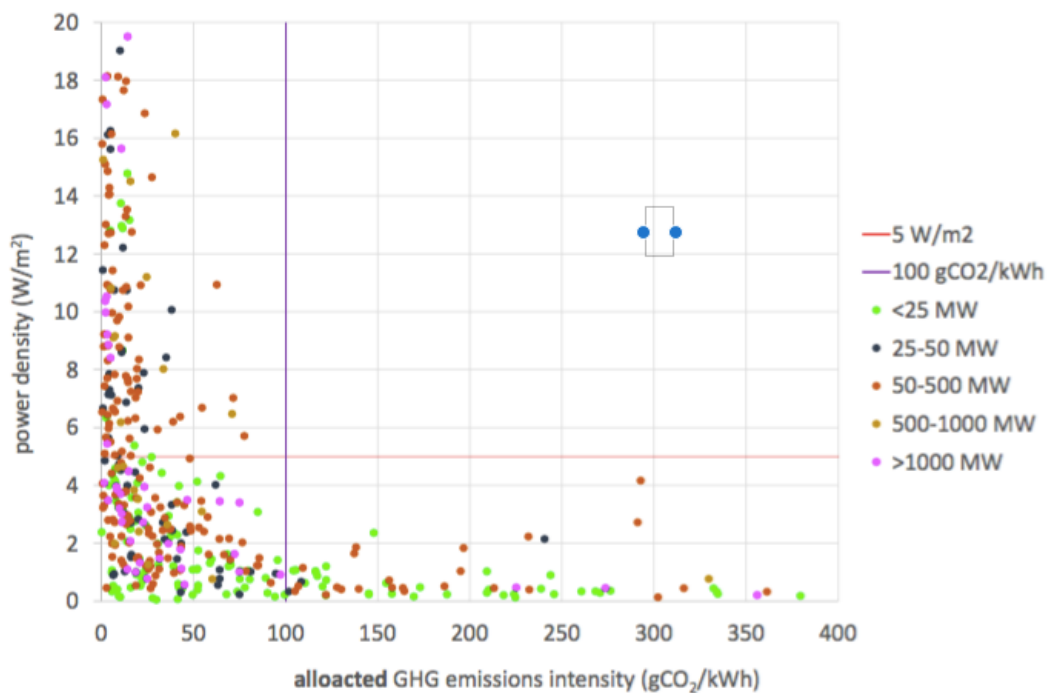
⁷⁵ N. Barros, J. J. Cole, L. J. Tranvik, Y. T. Prairie, D. Bastviken, V. L. M. Huszar, P. del Giorgio and F. Roland (2011), "Carbon emission from hydroelectric reservoirs linked to reservoir age and latitude", *Nature Geoscience* 4:593-596

⁷⁶ Bridget R. Deemer, John A. Harrison, Siyue Li, Jake J. Beaulieu, Tonya DeSontro, Nathan Barros, José F. Bezerra-Neto, Stephen M. Powers, Marco A. dos Santos, J. Arie Vonk; Greenhouse Gas Emissions from Reservoir Water Surfaces: A New Global Synthesis, *BioScience*, Volume 66, Issue 11, 1 November 2016, Pages 949–964

⁷⁷ Note that some of the factors mentioned here were found to be significant for some GHGs but not others.

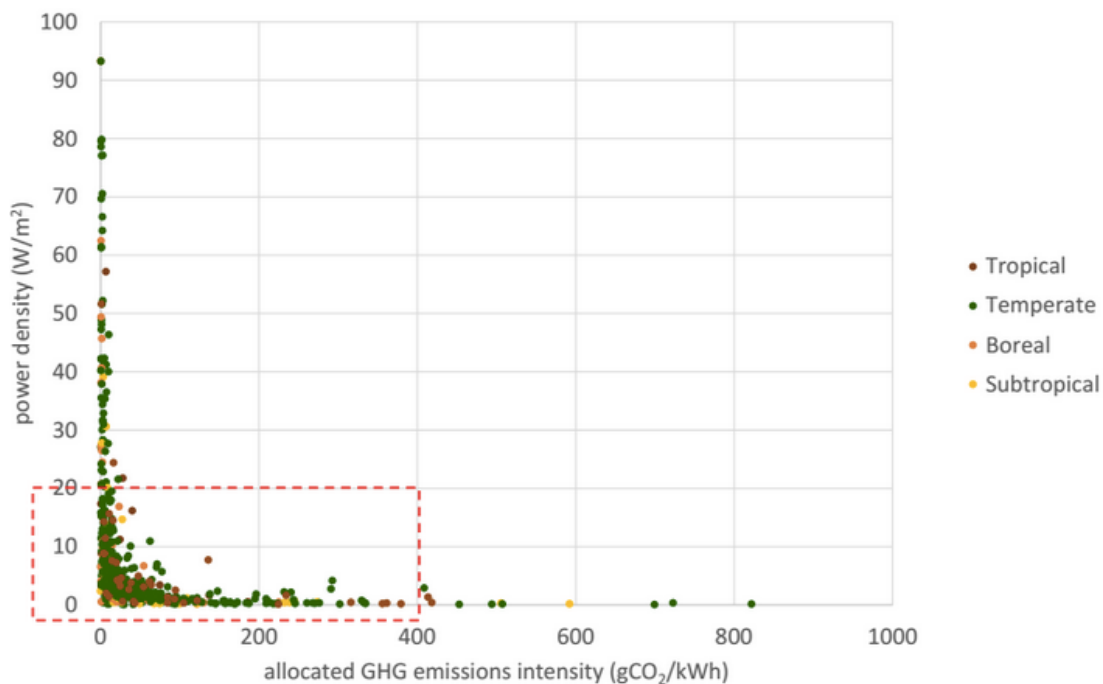
⁷⁸ The Deemer et al. paper mentioned above found that latitude was unrelated to CO₂ flux; "only weakly" related to CH₄ flux; and a significant predictor of N₂O flux in some but not all regression model formulations (which is in any case less material as N₂O is a more minor reservoir GHG).

Figure 6a: Emissions intensity range – cut by installed capacity – based on emissions allocated using operating regime methodology



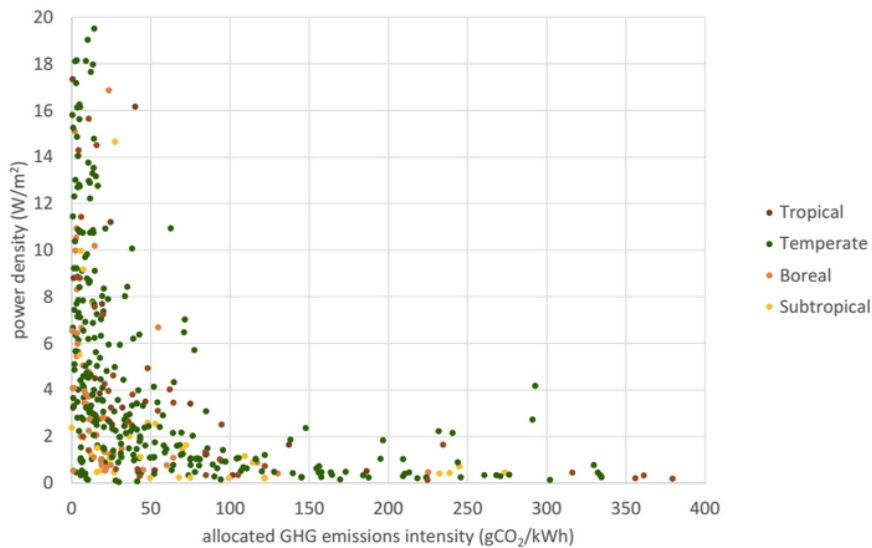
Source: IHA G-res database

Figure 6b: Emissions intensity range – cut by climate zone – based on emissions allocated using operating regime methodology.



Source: IHA G-res database

Figure 6c: Zoomed in emissions intensity range – cut by climate zone – based on emissions allocated using operating regime methodology



Source: IHA G-res database

However, as Figures 6a-6c also illustrate, power density can be the basis of a simple and effective screen, as it has a clear inversely proportional relationship to emissions intensity (see Box 6). It is also the predictive screen used by the CDM assessment methodology.

Whether generation density (kWh/m²/year) could also be an appropriate predictive screen was also discussed, but it was believed that this would be infeasible given the difficulty in forecasting capacity factor in advance.

Box 6: Relationship between power density and emissions intensity

The power density of a hydropower facility is its nameplate capacity divided by the surface area of its reservoir. It is related to emissions intensity as follows:

$$\begin{aligned}
 \text{emissions intensity} &= \frac{\text{emissions (gCO}_2\text{e/day)}}{\text{electricity generation (kWh/day)}} \\
 &= \frac{\text{reservoir area (m}^2\text{)}}{\text{power (kW)}} \times \frac{\text{GHG flux (gCO}_2\text{e/m}^2\text{/day)}}{\text{capacity factor x no. hours in day}} \\
 &= \frac{1}{\text{power density (kW/m}^2\text{)}} \times \frac{\text{GHG flux (gCO}_2\text{e/m}^2\text{/day)}}{\text{capacity factor x no. hours in day}}
 \end{aligned}$$

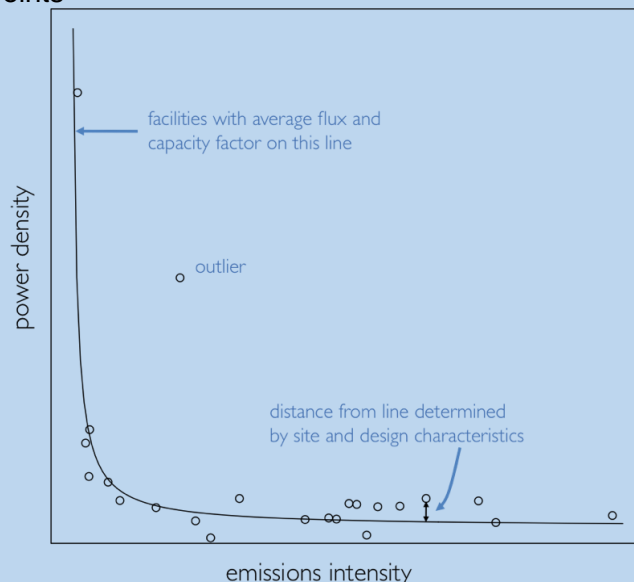
GHG flux is a measure of the quantity of a gas moving through a square metre of the reservoir in a day and is commonly used in scientific reporting of reservoir emissions.

The relationship between power density and emissions intensity shown above is a mathematical rather than a statistical one. However, this is not to say that power density will always be precisely inversely proportional to emissions intensity, because both GHG flux and capacity factor will vary from facility to facility. This introduces a statistical element to the relationship. GHG flux is determined by a variety of complex, site-specific factors which are still the subject of ongoing scientific inquiry, as described in the text. Capacity factor is determined by efficiency, but also by the purpose for which the facility is designed and operated. For example, a facility which is operated to

provide baseload power will have a much higher capacity factor than one designed to provide peaking and reserve power.

We should expect therefore the observed relationship between power density and emissions intensity to be something like an underlying inverse relationship with some variation due to GHG flux and capacity factor.

Figure 7: Illustration of the relationship between power density and emissions intensity: Using hypothetical data points



Why 5 W/m² for facilities subject to an emissions intensity threshold of 100 gCO₂e/kWh and 10 W/m² for facilities subject to an emissions intensity threshold of 50 gCO₂e/kWh

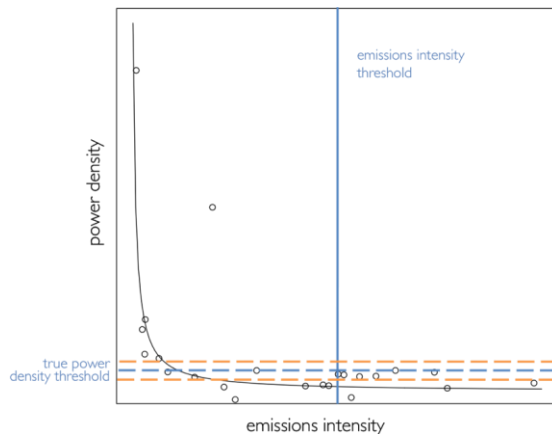
While the CDM threshold figures of 4 W/m² and 10 W/m² are well-known, these were derived at a time when scientific knowledge of reservoir emissions was at a much earlier stage. The 5 W/m² threshold for facilities subject to an emissions intensity threshold of 100 gCO₂e/kWh and 10 W/m² for facilities subject to an emissions intensity threshold of 50 gCO₂e/kWh have been derived based on more up-to-date evidence and research as described below.

The choice of power density threshold is a trade-off between certainty that high-risk facilities will not be misclassified, and the possibility that more issuers will be attracted to seek certification from a streamlined process. It also depends on the emissions intensity threshold chosen for the Low GHG-Compatibility Test (see Section 4.4).

For any desired emissions intensity threshold, a power density value can be set above which facilities are assumed (or known) to have emissions below the threshold. The shape of the emissions intensity vs. power density curve is fairly flat at high emissions intensities. This means that small increments in the power density threshold have the potential to place many high-emitting facilities in the wrong or right category.

This is shown in Figure 8. The blue dashed line represents the power density threshold which correctly categorises all facilities above the 100g emissions intensity threshold as at risk of being higher-emitting. A small shift upward (top orange line) would have the effect, with more data points, of requiring a few more low-emitting facilities to undergo assessment. A small shift downward (bottom orange line) misclassifies several facilities as low risk. Correct classification of large numbers of high-emitting facilities can therefore be fairly sensitive to a power density threshold which is slightly too low.

Figure 8: Effect of small changes in the power density threshold on classification of moderate-to-high emitting facilities



The optimal power density threshold can only be known over time from observation. The robustness of the power density threshold could theoretically be tested against various data points from the literature, but again, the G-res data set has been taken as a reasonable place to start these observations, for the reasons given in Section 4.4 above.

According to the statistical relationship between power density and emissions intensity observed in this dataset, and as illustrated in Figures 4a-6c above, as expected there is a general inversely proportional relationship between power density and emissions intensity that forms the basis of the proposed predictive screen.

Stress testing - how well does it work – does it effectively ‘screen in’ high emission intensity facilities?

Reviewing Figure 5b, assuming an emissions intensity threshold of 100 gCO₂e/kWh, once allocation has been taken into account, from the 498 data sets in G-res, no reservoir with emissions > 100 gCO₂e/kWh has a power density > 5 W/m². That is, no ‘high emissions intensity’ facility would have been screened out and exempted from a GHG Assessment, with a proposed power density screen of 5 W/m².⁷⁹ If the predictive screen were set at 4 W/m², then one facility would be categorised as ‘low emissions intensity’ when in fact it was not. Given the uncertainty inherent in these emissions intensity estimates, this may be viewed as inconsequential. However, the threshold has been raised slightly to 5 to be conservative as this provides a margin of error, bearing in mind the trade-off mentioned above.

Stress testing - how well does it work – does it effectively ‘screen out’ all low emission intensity facilities?

Figures 4a-5b show that there are likely to be large numbers of low emissions intensity facilities (with emissions intensities < 100gCO₂e/kWh) that are not screened out by a predictive screen of 5W/m², and will therefore need to go through a GHG Assessment.

While we would prefer a screen that screened more facilities out in order to reduce transaction costs for issuers, given the analysis of installed capacity and latitude above, we cannot find a factor which would sufficiently improve the predictive power of the screen. For that reason, we have chosen to stick with a single power density threshold set at 5W/m² as based on the G-res data set on the understanding that this (i) categorises high-risk facilities correctly (with a margin of error) 100% of the time and (ii) categorises low-risk facilities correctly in as many cases as possible.

The same rationale and results apply for the adoption of the 10W/m² predictive screen for facilities subject to the 50 gCO₂e/kWh threshold.

⁷⁹ Other data points from the literature could be derived and tested in this manner, but inherent problems of comparability arise given (i) they will undoubtedly vary in what (in terms of scope, pathway, etc.) they are measuring and (ii) they will be snapshots rather than lifetime averages.

5 Mitigation Requirements for Special Cases

5.1 Pumped storage

5.1.1 Issues relating to pumped storage

Like other forms of hydropower, pumped storage can emit GHGs from its reservoirs. These should be treated by the Criteria the same as other forms of hydropower. As it happens, the power densities of pumped storage facilities tend to be exceptionally high. Therefore, we expect the vast majority of pumped storage facilities to be considered low risk, and to pass the predictive screen described in the Mitigation Test described in Section 4.

However, it is also important to note that pumped storage varies in a number of key respects from run-of-river and impoundment hydropower. First, it plays an enhanced role in supporting the stability of the main grid through the storage, back-up and peaking services it provides. Compared to most other energy storage technologies, pumped storage provides higher power ratings, larger energy storage capabilities and better environmental performance.⁸⁰ It is a proven, commercially available, and reliable technology that compares favorably in terms of costs to most other energy storage solutions. As of 2019, pumped storage constituted approximately 96% of the total energy storage capacity in the world.⁸¹

As the penetration of variable renewable generation technologies has increased, pumped storage facilities are increasingly used to help manage the variability and uncertainty associated with wind and solar power generation (peaking and smoothing services), and also enable greater integration of wind and solar resources into the system by reducing the curtailments of excess variable renewable generation (storage of surplus renewable electricity). The value of these services increases with increasing penetration of renewables in the grid.

Therefore, pumped storage is often viewed as key supporting infrastructure for the roll out of intermittent renewables. On this basis, pumped storage has been argued by some to be critical to supporting a rapid transition to a decarbonised power sector.

However, on a facility-by-facility basis, there are two main challenges for certification of pumped storage assets:

- (i) While recognizing the very important role that pumped storage is likely to play in supporting grid decarbonisation, it cannot automatically be assumed that this is the case for any given facility. In some cases, a facility may now and for the foreseeable future be supporting thermal generation. If a certification decision rested on the argument that the pumped storage facility contributes to the roll out of renewables, we would want to test this is indeed the case.

One simple way to do this might be to look for trends in renewables deployment in the grid and set a threshold for renewables penetration. This is challenging as there can be a chicken-and-egg situation. Often pumped storage might need to be built in advance of renewables, incentivizing and enabling that roll out. Therefore, ideally, there would be a need to look forward to estimate, credibly, the likely future grid mix and emissions intensity to determine whether the pumped storage will be part of a system that is rapidly transitioning to renewables.

Exploring options or rules of thumb to do this have been challenging. Credible forward projections of the grid mix are difficult to establish – policy objectives can change and be

⁸⁰ Sternberg A. and Bardow, A. (2015), 'Power-to-What? – Environmental assessment of energy storage systems', *Energy Environ. Sci.*, 2015,8, 389-400

⁸¹ IHA (2020), 2020 Hydropower Status Report, International Hydropower Association, available at: https://hydropower-assets.s3.eu-west-2.amazonaws.com/publications-docs/2020_hydropower_status_report.pdf

delayed. Instead, it may be better to look for credible evidence of future deployment, either through demonstration of PPA auctions and/or well-advanced programmes and projects to install additional intermittent renewable capacity.

Even assuming future changes to the grid can be credibly demonstrated, there remains the challenge for the Criteria of establishing a suitable threshold for the penetration of intermittent renewables in the grid.

Two options have been explored:

- Set a threshold for the carbon intensity of the grid, for example 400g or 500g CO₂e/kWh. However, a grid made up of fossil fuels (mostly gas) and nuclear, with no intermittent renewables, could meet this threshold, so it is not a good indicator of the level of intermittent renewables in the grid.
 - Set a threshold more specifically around the percentage of intermittent renewables in the grid. Reviewing grid mixes, at present it seems that only a handful of countries globally have more than 5% of intermittent renewable energy penetration in their grid, and the vast majority are well below 5%. A high threshold would exclude projects in many countries, even if on close examination they were indeed supporting renewables roll-out, unless alternative Criteria are also available.
- (ii) While often assumed, it may not always be the case that the facility itself is carbon neutral or beneficial, leading to carbon emissions savings. Studies in the United States have demonstrated that pumped storage charged during off-peak hours when a significant amount of coal is deployed, coupled with relatively low renewables penetration, can actually increase emissions compared to a no-storage case.⁸²

However, this problem decreases and resolves at higher levels of renewables penetration. So again, it would be important to understand the current and projected penetration of intermittent renewables in the grid.

According to one study (Goteti et al., 2017), energy modeling techniques can predict the level of intermittent renewables penetration at which the storage becomes carbon neutral (identified as 18% for the Midcontinent ISO in the United States), although this is sensitive to energy market conditions. It is therefore highly case-specific and it is not practical to ask issuers to commission case-by-case energy modeling studies to assess such questions. Therefore, it is difficult to set an appropriate penetration rate that can be applied globally in the Criteria.

Instead, we can ask in which circumstances a pumped storage facility would not be carbon neutral. This could happen if the primary purpose of the pumped storage is to provide economic peaking power, charging off-peak when electricity is cheap. This is illustrated by Figure 9, a simplified version of a chart demonstrating the case of the Midcontinent ISO from Goteti et al. It is similar to a merit order chart, which ranks the order in which different resources are dispatched based on marginal cost. The x-axis shows the cumulative capacity which would be deployed depending on demand. Whereas a merit order chart shows marginal cost on the y-axis, Figure 9 shows the emissions intensity of the plant coming online at each point.⁸³ The vertical dotted lines show the sections of the merit order at which pumped storage would be charged during off-peak hours (A) and discharged during peak hours (B) if it were to be added to the grid. The pumped storage would be charged by off-

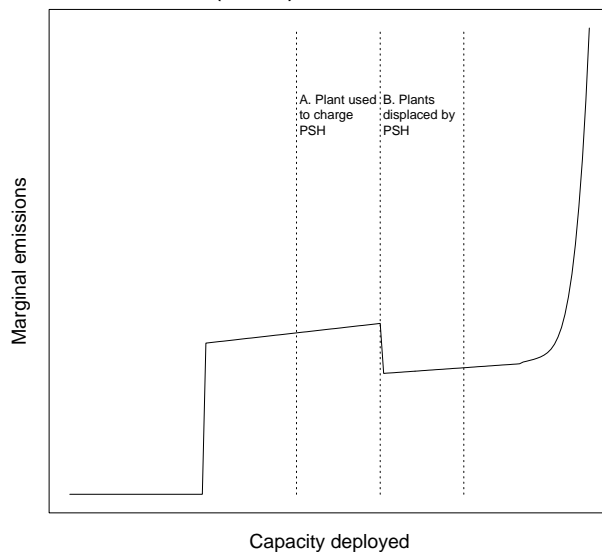
⁸² Goteti, N.S., Hittinger, E. & Williams, E. Energy Syst (2017). <https://doi.org/10.1007/s12667-017-0266-4>; Hittinger, E. and Azevedo, I.M.L., 'Bulk Energy Storage Increases United States Electricity System Emissions', Environmental Science & Technology 2015 49 (5), 3203-3210 DOI: 10.1021/es505027p; Michael T Craig et al 2018, 'Carbon dioxide emissions effects of grid-scale electricity storage in a decarbonizing power system', Environ. Res. Lett. 13 014004; Argonne National Laboratory (2014), 'Modelling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States': <http://www.ipd.anl.gov/anlpubs/2014/07/105786.pdf>. The Goteti et al. paper is summarised in a web article here: <https://theconversation.com/does-energy-storage-make-the-electric-grid-cleaner-90001>

⁸³ Typically in a merit order chart the y-axis shows marginal cost, and different plants coming online are displayed as discrete columns, but in this simplified version we are using a continuous line.

peak sources which are naturally cheaper and lower down in the merit order than the sources they would displace. In this example, the pumped storage would be charged by off-peak sources which are higher-emitting than the sources they would displace. This could happen, for example, if cheap coal were deployed during off-peak hours and more expensive gas were used for peaking.

The question remains, then, on how to identify this situation. Ideally it would be identified by comparing off-peak and peaking grid intensities. However, international data is not available on how grid intensities typically vary over the day.

Figure 9: Simplified scenario where addition of storage to a grid will result in higher emissions, adapted from Goteti et al. (2017)



These issues are likely to be considered further by the Climate Bonds Electricity Transmission, Distribution and Storage Technical Working Group and will be kept under review.

5.1.2 Mitigation Criteria for pumped storage

While case-by-case detailed modelling for pumped storage is not possible, some practical rules of thumb can be devised which rule out the cases which are at the highest risk of not being GHG-beneficial. Taking into account the challenges outlined above, the following Mitigation Criteria are put forward for pumped storage facilities:

1. The facility is demonstrably being purposefully built in conjunction with intermittent renewables, as in the Hatta Dam project in the United Arab Emirates, for example. *This captures those cases where there is high certainty that the pumped storage is facilitating the roll-out of intermittent renewables.*

OR

2. The facility is contributing to a grid which already has a share of intermittent renewables deployment of at least 20% OR has credible evidence of programmes in place that will increase the share of intermittent renewables to this level within the next 10 years. Evidence of such credible programmes might be the current development of renewable energy facilities that are due to come online in the near term, or the auction of PPAs for renewables. *This captures those cases where renewable penetration is already, or soon will be, sufficiently high that it is highly unlikely that pumped storage is being charged, on average, with high-GHG-intensity sources.*

OR

3. The facility can credibly demonstrate that the pumped storage will not be charged with an off-peak grid intensity that is higher than the intensity of the electricity that it will displace when it

is discharged. For example, by demonstrating that there is no combination of the following in the merit order: (i) mid-merit coal and (ii) gas used at times of peak demand.

AND

4. Must pass the same reservoir emissions criteria as other facilities, as described in Section 4.

As political and other circumstances can change, compliance with such criteria would need to be kept under regular review.

5.2 Cascade systems

As noted in Box 2, cascading systems, where one reservoir receives water from one or multiple reservoirs upstream, are not directly integrated in the current version of G-res for lack of detailed information on their GHG emissions as a system, although very simple systems could be assessed. This issue will be kept under review as use of the Criteria develops.

6 Adaptation and Resilience Requirements

6.1 An overview of the Adaptation & Resilience Component of the Criteria

This section describes the Adaptation & Resilience (A&R) Component of the eligibility Criteria for hydropower assets and projects under the Climate Bonds Standard. This component of the Criteria views the potential climate adaptation and resilience impacts/benefits of hydropower as inextricably linked to a broad range of environmental and social issues and proposes to assess these in the round.

Section 6.2 below describes the scope of this component in terms of the key factors that need to be assessed to ensure that Certified Climate Bonds are delivering on key climate outcomes in line with the overall objectives of the Standard. Section 6.3 describes practical aspects of this component, to ensure that any transaction burden for issuers is minimised, while maintaining rigour and robustness in assessment. Section 6.4 describes existing tools. Section 6.5, 6.6 and 6.7 then describe the Adaptation and Resilience Component of the Hydropower Criteria that it is believed balances these needs, leveraging these tools where appropriate.

6.2 Key aspects to be assessed under this Component

As noted elsewhere in this document, much attention has been paid to potential negative environmental and/or social impacts of hydropower dams and establishing appropriate safeguards to minimize or eradicate the likelihood of those negative impacts. However, multi-purpose hydropower reservoirs often deliver a number of services relevant to adaptation, such as water storage, flood prevention, etc., which should also be acknowledged.

That said, the A&R Component focuses on safeguarding against negative outcomes. The Criteria do not extend to assessment of the full range of potential and actual adaptation services delivered. Adaptation services that could or should be delivered are highly case-specific. Therefore, it would be exceptionally difficult to establish simple Criteria for expected adaptation services that could or should be delivered.

The proposed assessment methodology nevertheless includes a minimum bar, namely that an assessment has been done of the facility's potential adaptation services and its fit with national and/or regional policies and plans for adaptation. More information on this is given in Sections 6.5 & 6.6 below.

In terms of which of the many complex and interconnected environmental and social issues should be assessed under these Criteria, the following points are noted:

- The Climate Bonds Standard is focused on climate impacts – including low GHG-compatibility (mitigation) and also climate adaptation and resilience. Defining resilience can be challenging. However, it is clear that many topics which have been a part of environmental and social assessments for a number of years overlap significantly with the resilience of affected populations and ecosystems and their ability to adapt to climate change.

The most obvious example is the potential impact of climate change on hydrological conditions, and consequently water supply and local livelihoods. Another is climate change exacerbating ecological problems such as impaired species migration and algal blooms. Environmental and social impacts such as these, already complex and interconnected, become more so when climate change impacts and risks are taken into account, and there is a logic to addressing all key environmental factors, rather than trying to separate them out.

The Climate Bonds Standard does not usually address primarily social impact issues, and there has been debate about whether they are within scope, but as this is particularly a known, longstanding concern in the case of hydropower, it has been considered necessary to include them. On a more practical basis as well, the tools explored for these assessments (more detail below) intrinsically encompass social factors in any case.

- One of the goals of the Climate Bonds Standard is to bring transparency and consistency to the evaluation of Green Bonds. By including these factors in the Criteria for hydropower assets, we can ensure these outcomes are delivered, and investors and other stakeholders are not in the position of attempting to independently access and interpret issues using ESG frameworks of varying and/or unknown quality and completeness in respect of these highly inter-connected and complex factors.

The A&R Component therefore takes a broad interpretation of resilience, encompassing a range of environmental and social aspects. Its concept of climate resilience is explicitly not limited to the resilience of the hydropower facility itself to climate change, but rather also encompasses the facility's impact on the resilience of affected ecosystems and populations.

6.3 Practical requirements for this Component

Leverage existing tools

The potential adaptation and resilience impacts of hydropower is a vast topic and the A&R Component will require consideration of a highly complex and varied set of issues across the environmental and social spectrum with a long history of assessment by project developers and funders. There is no value in Climate Bonds Standards reinventing the wheel on any of these issues. The A&R Component therefore needs to leverage an existing set of guidance which is robust and has widespread recognition amongst a diverse set of stakeholders.

However, it should be noted that existing tools and standards do not always fully or explicitly cover the additional, often interrelated impacts connected to climate adaptation and resilience. Many of the risk assessments and management processes specified by existing ES guidelines will be a prerequisite for identifying A&R risks, but more may be needed to fully address them given that this is an emerging topic.

Minimise the assessment burden

In addition, there needs to be a balance between rigour and practicality. Any Criteria with a prohibitively expensive assessment burden will discourage certification. Any methodology adopted therefore need to avoid this.

A binary 'pass'/'fail' outcome rather than scores or grades

Certification decisions under the Climate Bonds Standard are binary – bonds are either certified or not. Therefore, the A&R Component needs to be framed in terms of pass/fail thresholds. Where an assessment tool provides scores or grades for a facility, consideration has been given to what threshold 'score' or result should represent a pass for the purposes of Climate Bonds Certification.

Retrospective application

Hydropower-related bonds may raise finance for new, greenfield facilities, for retrofits or upgrades to existing facilities, or they may be a straight refinancing of an existing facility. Indeed, this latter option is most likely given that bonds are primarily a refinancing tool. Therefore, any proposal and associated approved assessment tool under this Component needs to be usable for both new and existing facilities.

This is not a straightforward issue; as in the case of refinancing, the facility may have been operating for a number of years. It may have been compliant with best practices in place at the time of its implementation, but may not meet current best practice requirements. The selected methodology

and tool will therefore need to be able to address and resolve any ‘legacy issues’ that may be identified.

6.4 Existing tools and guidelines considered

Appendix 4 summarises a range of existing tools and guidelines which the A&R Component of the Hydropower Criteria could potentially have drawn from.

Of these, those with the most potential to be leveraged for the Hydropower Criteria are listed below, with a brief indication of whether they were taken forward for further consideration or not.

- The World Commission on Dams (WCD) Report of 2000⁸⁴ emerged from worldwide growing opposition to dams on environmental and social grounds. It set out a number of strategic priorities and principles for minimising environmental and social risks and impacts. These have been extremely influential but are generally perceived as direction-setting rather than setting verifiable operational standards.⁸⁵
- The Low Impact Hydropower Institute Certification Programme is relevant for hydropower in the USA. However, the programme does not address climate change and social issues.
- The Rapid Basin-wide Hydropower Sustainability Assessment Tool has been developed by the Mekong River Commission, Asian Development Bank and WWF to assess hydropower development in a basin-wide context. It is believed the guidance it provides is not transferable to other geographical contexts.
- In addition, all the Multilateral Development Banks have generic environmental and social guidelines for their projects. The IFC’s Environmental and Social Performance Standards are frequently used as a benchmark for other guidelines and assessment tools. However, again, while they are extremely influential, as guidelines, they do not constitute a set of verifiable operational standards.
- The Hydropower Sustainability Assessment Protocol (HSAP) builds on the work of the World Commission on Dams. It offers a way to assess the performance of a hydropower project across more than 20 sustainability topics against international best practice. Assessments are based on objective evidence and the results are presented in a standardised way, making it easy to see how existing facilities are performing and how well new projects are being developed. Further information on the HSAP is given in Box 7.
- The Hydropower Sustainability Environmental, Social and Governance Gap Analysis Tool (hereafter the “ESG Gap Analysis Tool”) has recently been developed under the same governance framework and body as HSAP. It is in essence a streamlined version of HSAP, focusing on a narrower set of ESG topics, and includes a new topic on climate change mitigation and resilience. It evaluates against international good practice. Again, assessments are based on objective evidence and the results are presented in a standardised way. Further information on the ESG Gap Analysis Tool is given in Box 8.
- The IFC’s *Hydroelectric Power: A Guide for Developers and Investors* strongly overlaps with the HSAP in some areas but has more emphasis on technical aspects and financial performance, and less on environmental and social issues.

⁸⁴ WCD (2000), *Dams and Development: A New Framework for Decision-Making*, the Report of the World Commission on Dams, Earthscan Publications, London and Sterling, VA

⁸⁵ IIED (2014), ‘Watered down? A review of social and environmental safeguards for large dam projects’, International Institute for Environment and Development

- The World Bank developed and piloted Hydropower and Dams Sector Climate Resilience Guidelines in conjunction with Mott MacDonald; the tested guidelines were launched in May of 2019. With its climate resilience focus, this is highly relevant to the A&R Component.

6.5 Proposal: leverage the ESG Gap Analysis tool

It is the requirement of the A&R Component of the Hydropower Criteria that a facility seeking inclusion in a Certified Climate Bond has undergone an assessment under the ESG Gap Analysis Tool. The rationale for this is given below. *Whether the performance of the facility under that assessment is sufficient for certification is determined by the scoring/threshold methodology described in Section 6.6.*

There is agreement among the technical experts consulted that the HSAP is the most thorough and widely-accepted environmental and social assessment framework for hydropower. Further and significantly, it is more than a set of guidelines, instead establishing a standardised assessment framework and process. While it is not a 'pass'/fail' test of whether a facility is sustainable, it provides a way of assessing and grading it over a wide range of topics, including those identified as needing assessment prior to certification under the Climate Bonds Standard. It also benefits from wide stakeholder engagement and support in its development and implementation (including the International Hydropower Association, governments, NGOs and multilateral and commercial financial institutions), and by an objective, managed deployment process, where assessments are carried out by accredited assessors.

However, it is considered that, for the purposes of encouraging certifications under the Climate Bonds Standard, assessment under the full HSAP may be viewed as too onerous and costly by some developers given that the scope of an HSAP assessment goes beyond standard environmental, social and governance aspects (for example, economic viability) and looks at proven best practice as well as basic good practice. Given the above, insisting upon use of the HSAP in the Hydropower Criteria might deter certifications.

It is therefore proposed to leverage the streamlined ESG Gap Analysis Tool under the HSAP, with the understanding that:

- This tool matches the needs of the Climate Bonds Standard for a comprehensive adaptation and resilience scope, addressing key environmental and social topics, as well including a new section explicitly addressing the impacts of climate change in terms of ensuring adaptation and resilience. In particular:
 - All but one of the topics included in the ESG Gap Analysis Tool are drawn across from the full set of HSAP topics, and therefore have been subject to robust development, testing and consultation during the development of the HSAP.
 - The only exception is the new Climate Change Mitigation and Resilience section included in the ESG Gap Analysis Tool, which is still in the process of being added to HSAP. However, that section draws on the existing implicit considerations of climate resilience in the HSAP (where resilience has been embedded in each topic area, rather than previously being explicitly identified in its own topic area). It also draws on criteria to assess the climate resilience of hydropower facilities in guidelines recently completed by Mott McDonald for the World Bank. The requirements relating to Climate Change Mitigation drew from the technical discussions of the experts assembled for the purposes of developing the Hydropower Criteria, and therefore are supported by the analysis and views presented in Section 4 of this document. The ESG Gap Analysis tool therefore has the advantage compared to other systems or tools of explicitly integrating climate resilience aspects into the assessment, taking into account the latest developments and findings.
 - Those topics included in the HSAP but not included in the ESG Gap Analysis tool are those that are not critical to the Climate Bonds Standard, given its climate and

environmental focus, and therefore this streamlining to key ESG issues is advantageous for the purposes of the Standard. For example, topics included in the HSAP but not in the ESG Gap Analysis tool include integrated project management, asset reliability and efficiency, and economic viability.

- Having noted above that the A&R Component does not seek to establish required adaptation services that any facility must deliver to be eligible for certification, there is still a minimum bar in the ESG Gap Analysis Tool relating to adaptation services. This is that it requires an assessment to be carried out regarding the facility's potential adaptation services and fit with national and/or regional policies and plans for adaptation.
- The focus of the ESG Gap Analysis Tool is identifying 'significant gaps', that is, instances where the project falls short of international good practice. A performance of no significant gaps compared to *good* practice within a topic is equivalent to Level 3 in the full HSAP, whereas a performance deemed to be consistent with international *best* practice is equivalent to Level 5 of the full HSAP. Box 9 gives a summary of what a performance in line with international good practice would represent. Significantly, a useful comparison of HSAP and World Bank Safeguards with the WCD strategic priorities is presented in a report by the IIED.⁸⁶ The key takeaways from this are that the HSAP and the WCD are overall in broad alignment, recognizing that as distinct processes they do not overlap 100%. The HSAP, and by extension, the ESG Gap Analysis Tool go further on many topics, though there are differences in some technical details of the processes recommended by the HSAP and the WCD.⁸⁷ Given this broad alignment between the HSAP level 3/'no significant gaps' in the ESG Gap Analysis Tool, and the WCD strategic priorities, using the ESG Gap Analysis tool rather than the full HSAP has been deemed appropriate for the purposes of assessing an acceptable level of performance for hydropower facilities – subject to the precise performance requirements as described in the following section.
- The streamlined nature of the ESG Gap Analysis Tool is expected to minimise transaction costs for the issuer seeking certification compared to requiring assessment under the HSAP, while still ensuring consistency and comparability of all applications for certification. At this early stage of development and roll-out of the ESG Gap Analysis tool, it is difficult to estimate the likely cost of assessment but based on pilot assessments done to date it is estimated that it might be in the range of US\$30,000 - 40,000⁸⁸ (perhaps more or less depending on the complexity or otherwise of the project). For example, if many aspects of the assessment are not applicable for a particular project, the assessment cost should be lower. In addition, if facilities are located in the same basin, then there is the potential to evaluate them under one assessment, or at least use shared information across two assessments, again potentially lowering the cost. This compares favourably with an estimated cost which can surpass US\$ 100,000 for assessment under the full HSAP.
- The Tool is applicable to the full range of hydropower facilities (run-of-river, impoundment and pumped storage) at various stages of development, from preparation to implementation to operation. The only caveat is that projects will need to be well advanced in the preparation

⁸⁶ IIED (2014), *Watered down? A review of social and environmental safeguards for large dam projects*, International Institute for Environment and Development

⁸⁷ The potentially most significant of these is grading the explicit inclusion of human rights in ES impact assessment at Level 5 rather than Level 3. HSAP does, however, address human rights implicitly in its coverage of resettlement, indigenous people and labour and working conditions.

⁸⁸ The cost of the management plan to address any gaps would depend on their number and how much capacity building is required to address them.

stage, as feasibility studies and other documentation will be needed as evidence. However, this caveat is an advantage to the Climate Bonds Standard as it minimises the risk that facilities will be certified on the basis of very preliminary feasibility assessments. For example, for assessments in the project preparation stage, pre-existing environmental/social impact assessments and management plans, resettlement plans, stakeholder engagement plans, and feasibility studies would be considered key documents.

- Likewise, the ability to carry out an assessment on an operational project is advantageous for the bond market, where it is likely that many bonds will relate to refinancing of existing facilities. What is being assessed here is the ongoing impact of that facility in operation. The assessor should consider any legacy issues, including those arising from the project's original development. The HSAP Background Document provides guidance on how legacy issues should be addressed under various relevant topics.
- The Tool has the same strong governance framework as the HSAP, with broad stakeholder representation involved in the development and management of the Tool and assessments carried out using it, including industry representatives, governments, NGOs, multilateral development banks and commercial banks. Broad support for any Criteria is critical, but particularly for hydropower, which can be a contentious area.
- The Tool has a strong, in-built assessment framework, utilising the accredited assessors' programme used by the full HSAP. Under this approach, there is oversight and training of assessors and their resulting assessments, giving valuable credibility to the results. This framework is also advantageous to the Climate Bonds Standard as it takes the burden of assessment off the Climate Bonds Standard approved verifiers.

Box 8 provides further detail on the ESG Gap Analysis Tool to support these views.

One point of clarification:

- If a facility has already undergone assessment under the full HSAP, then the results can be translated into the necessary scoring methodology described in the next section, given the closeness of the ESG Gap Analysis Tool and the HSAP. Therefore, there is no additional requirement for that facility to also undergo an assessment under the ESG Gap Analysis Tool. There would however still be a need for a management plan and an assessment under the new Climate Change Mitigation and Resilience section if not previously undertaken.

Box 7: The Hydropower Sustainability Assessment Protocol (HSAP or 'the Protocol')

<http://www.hydrosustainability.org/Protocol.aspx>

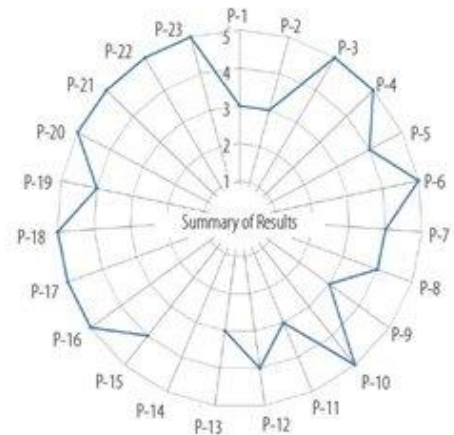
Origins: The Protocol was developed through 30 months (2008–10) of cross-sector engagement, including a review of the World Commission on Dams Recommendations, the World Bank Safeguard Policies and the IFC Performance Standards. During this period, a multi-stakeholder forum jointly reviewed, enhanced and built consensus on what a sustainable hydropower project should look like. A draft of the Protocol was released in 2009, was trialed in 16 countries across six continents and subjected to further consultation involving 1,933 individual stakeholders from 28 countries. The final version was produced in 2010.

Purpose: The Protocol is a framework to assess the sustainability of a hydropower project and promote the continuous improvement of performance. It includes over 100 definitions of basic good practice and proven best practice across a range of topics. It can be used in multiple ways, including the independent review of sustainability issues, guiding appraisal of sustainability issues, and comparison with international best practice.

The 'spider diagram' below shows the environmental, social, technical and economic topics which are included. Within these, the Protocol also includes 'cross-cutting issues' such as climate change and human rights, which feature in multiple topics.

Example List of Topics Assessed:

P-1 Communications and Consultation	P-13 Project-Affected Communities
P-2 Governance	P-14 Resettlement (Not relevant)
P-3 Demonstrated Need and Strategic Fit	P-15 Indigenous Peoples
P-4 Siting and Design	P-16 Labour and Working Conditions
P-5 Environmental and Social Management	P-17 Cultural Heritage
P-6 Integrated Project Management	P-18 Public Health
P-7 Hydrological Resource	P-19 Biodiversity and Invasive Species
P-8 Infrastructure Safety	P-20 Erosion and Sedimentation
P-9 Financial Viability	P-21 Water Quality
P-10 Project Benefits	P-22 Reservoir Planning
P-11 Economic Viability	P-23 Downstream Flow Regimes
P-12 Procurement	



What can be assessed: The Protocol has been designed to work on projects and facilities anywhere in the world. It can be used to evaluate run-of-river, impoundment and pumped storage facilities at any stage of project development, from preparation to implementation and operating stage. It includes:

- The early stage tool, a screening tool for potential hydropower projects
- The preparation tool, which covers planning and design, management plans and commitments
- The implementation tool, used through the construction phase
- The operation tool, used on working projects

Output: For each sustainability topic, performance is scored from 1 to 5. Five represents proven best-practice, 3 represents international good practice. Box 9 gives more detail on what level 3 implies.

Governance: The Protocol is governed by a multi-stakeholder body, using a consensus approach. This body includes representatives of social NGOs (Oxfam, Transparency International) and community organisations, environmental NGOs (WWF, The Nature Conservancy), developed and developing country governments (China, Zambia, Iceland, Norway), commercial and development banks (the World Bank), and the hydropower sector. It meets four times a year to guide the Protocol's work programme. The IHA is responsible for the Protocol's day-to-day operations, as well as other tasks such as overseeing training and accreditation, liaising on assessments, and coordinating governance activities.

Assessment methodology: To ensure high quality assessments, all commercial use of the Protocol is carried out by accredited assessors. These assessors are required to have significant experience in the hydropower sector or relevant sustainability issues and have passed a rigorous accreditation course. An official assessment delivers a substantial report of more than 100 pages backed up with appendices citing verbal, documentary and visual evidence. Publication is required for any claims to be made against the assessment result. In such cases the draft final report is published online with a 60-day period for comments.

Alignment with other assessments: The Protocol is aligned with the World Commission on Dams Recommendations, the World Bank Safeguard Policies and the IFC Performance Standards.

Box 8: The ESG Gap Analysis Tool ('The ESG Tool')

Origins: The ESG Tool has been developed out of, and based on, the HSAP, focusing on a streamlined set of topics and sub-topics from the Protocol. The Tool was developed throughout 2016 under the oversight of the Protocol Governing Committee and has been pilot tested. It was released for use in July 2018.

Scope: The tool has 12 sections, focused on a range of ESG factors, to be used to assess projects for significant gaps against international good practice. It does not include those elements in the Protocol that relate to broader factors beyond ESG, e.g., economic viability. It also includes a new section, not previously included as its own section in the Protocol: 'Climate Change Mitigation and Resilience'. For details on the 12 sections of the ESG tool, see the "ESG Gap Analysis Tool" document. For detail on how each element will be assessed, please see the corresponding documentation for the Protocol.

Output: For each section of the assessment, the number of significant gaps against international good practice is recorded. 'No significant gaps' is equivalent to international good practice, i.e., a score of 3 in the Protocol. See Box 9 for more information on what a score of 3 or 'no significant gaps', implies.

What can be assessed: Like the HSAP, the ESG Gap Analysis Tool can be used at any stage of hydropower development, from the preparation stage to the implementation or operating stage. It has been designed to work on projects and facilities anywhere in the world. It can be used to evaluate run-of-river, impoundment and pumped storage facilities.

Governance: The ESG Tool is managed and governed by the same governing body as the Protocol (see Box 7 above).

Assessment methodology: As with the full Protocol, to ensure high quality assessments, all official/commercial use of the Protocol is carried out by accredited assessors. These assessors have significant experience of the hydropower sector or relevant sustainability issues and have passed a rigorous accreditation course. The same rules apply regarding publication as for the full Protocol.

Alignment with other assessments: The ESG Tool is aligned with the new World Bank Environmental and Social Framework, which was launched in October 2018,, and existing IFC Environmental and Social Performance Standards.

Box 9: What does a Level 3 score under the Protocol imply

'No significant gaps' under the ESG Gap Assessment Tool has been deemed to represent a level of performance in line with international good practice. It is equivalent to a score of Level 3 under the HSAP. The following is the explanation within the HSAP document for what a facility needs to do in general to obtain Level 3.

Assessment: Suitable, adequate and effective assessment.

This would typically encompass (as appropriate to the topic and lifecycle stage) identification of the baseline condition, including relevant issues, appropriate geographic coverage, and appropriate data collection and analytical methodologies; identification of relevant organisational roles and responsibilities, and legal, policy and other requirements; appropriate utilisation of expertise and local knowledge; and appropriate budget and time span.

At Level 3 the assessment encompasses the considerations most relevant to that topic but tends to have a predominantly project-focused view or perspective and tends to give stronger emphasis to impacts and risks than it does to opportunities.

Management: Suitable, adequate and effective management processes.

These would typically encompass (as appropriate to the topic and lifecycle stage) development and implementation of plans that: integrate relevant assessment or monitoring findings; are underpinned by policies; describe measures that will be taken to address the considerations most relevant to that topic; establish objectives and targets; assign roles, responsibilities and accountabilities; utilise expertise appropriate to that topic; allocate finances to cover implementation requirements with some contingency; outline processes for monitoring, review and reporting; and are periodically reviewed and improved as required.

Stakeholder engagement: Suitable, adequate and effective assessment.

This would typically encompass (as appropriate to the topic and lifecycle stage) identification of the baseline condition including relevant issues, appropriate geographic coverage, and appropriate data collection and analytical methodologies; identification of relevant organisational roles and responsibilities, and legal, policy and other requirements; appropriate utilisation of expertise and local knowledge; and appropriate budget and time span.

At Level 3 the assessment encompasses the considerations most relevant to that topic but tends to have a predominantly project-focused view or perspective and to give stronger emphasis to impacts and risks than it does to opportunities.

Stakeholder support: There is general support amongst directly affected stakeholder groups for the assessment, planning or implementation measures for that topic, or no significant ongoing opposition by these stakeholders.

Outcomes: As appropriate to the topic and the lifecycle stage, there may be exhibited avoidance of harm, minimisation and mitigation of negative impacts; fair and just compensation; fulfillment of obligations; or effectiveness of implementation plans.

Compliance: No significant non-compliances or non-conformances.

6.6 Performance level required to pass the A&R Component

As noted above, a key requirement under the A&R Component is for the hydropower facility to be assessed against the ESG Gap Analysis Tool by an accredited assessor. This assessment will identify any significant gaps that the facility demonstrates against international good practice across the full range of topics. If any significant gaps are identified, an Environmental and Social Action Plan (ESAP) must be established to address those gaps, including details on how and when these gaps will be closed.

However, in order for the facility being assessed to pass the A&R Component, it is necessary that the following level of performance (as verified by the accredited assessor) is demonstrated:

- The assessment must demonstrate:
 - No more than 10 significant gaps in total across the assessment of the full range of ESG topics. *N.B. If some section(s) are not deemed applicable for a particular facility,*

and no assessment is made for that section(s) then this maximum gap threshold will be reduced accordingly⁸⁹; AND

- No more than 2 significant gaps in each topic assessed;

AND

- The resulting ESAP to address any significant gaps must demonstrate that:
 - The majority (i.e., more than 50%) of significant gaps identified will be closed within 12 months; AND
 - All remaining significant gaps will be closed within 24 months.

AND

- The issuer commits to re-engage the accredited assessor immediately following these 24 months to confirm that these gaps have indeed been closed within the timeframe(s) specified in the ESAP.

If any of these conditions are not met, the facility will not pass the A&R Component of the Hydropower Criteria and will not be eligible for inclusion in a Certified Climate Bond.

Of course, however credible the plans to close any identified gaps, there is always a risk that issuers may not be able to close them in the stated timeframe(s). If an issuer is unable to close any identified gaps within the stated timeframe(s), certification under the Climate Bonds Standard will be withdrawn. Although issuers would have already obtained the capital raised under that bond, this would affect their green credibility and therefore any investor take-up of future Green Bond issuances.⁹⁰

It is believed that this combination of performance metrics represents a strong, reinforcing set of requirements, and therefore a relatively high bar for performance. Together, the requirements aim to ensure that the facility, while it may not be perfect (as few are), is nonetheless very close to international good practice (with respect to both each topic assessed and also overall at the time of certification) and will be fully in line with international good practice in all respects within a realistic but relatively short timeframe.

At this time, it is difficult to say what proportion of facilities would meet these requirements, as the ESG Gap Analysis Tool is very new.

Reading across from the 29 assessments⁹¹ that had been done prior to February 2018 under the HSAP, taking into account only those aspects that are assessed under the ESG Gap Analysis Tool, it is estimated that 17 (or 63%) of the 27 assessed facilities would pass these performance thresholds. Of these, 9 were deemed to have zero significant gaps, and an additional 8 were deemed to have fewer than 10 gaps with credible plans to close all of the gaps within the maximum allowed 24-month period.

However, it should be noted that:

- These 29 assessments did not include the elements assessed under the new Climate Change Mitigation and Resilience section of the ESG Gap Analysis Tool. As this is a new component, it is possible that a number of facilities will be deemed to have some significant gaps under this section. Therefore, the numbers above could over-estimate likely pass rates.
- Those seeking assessment under the HSAP to date are likely to be those facilities that consider themselves to be above average in terms of performance, and likely to score relatively highly. Therefore, as a sample set it could be skewed towards higher performers

⁸⁹ For example, if only 80% of the sections are deemed applicable, there should be a maximum of 8 significant gaps.

⁹⁰ However, assessment is performed on a particular bond and associated asset. Therefore an issuer is always free to apply for certification for a second bond regardless of the outcomes of the first.

⁹¹ This includes one project on which the ESG Gap Analysis Tool was tested and excludes 'early stage' assessments which do not involve scoring.

(often with strong involvement from international financial institutions) and not entirely representative of the full spectrum of hydropower facilities around the world.

- In any case, this is a very small sample size representing 2% of the world's installed capacity, and only experience will give a clear indication of actual pass rates. This will be monitored on an ongoing basis.

One final, important point of clarification:

For the avoidance of doubt, it is stressed that the Mitigation Component of these Criteria as described in Section 4 are an essential requirement for eligibility for certification. If the facility cannot demonstrate the necessary power density or emissions intensity, it will not be eligible for inclusion in a Certified Climate Bond, even if the above performance requirements relating to the allowable significant gaps under the ESG Gap Analysis Tool are met.

6.7 No predictive screen for the A&R Component

As the types of assessments described above take time and resources, it would be preferable to waive the assessment requirements for facilities whose adaptation and resilience impacts are unlikely to be problematic. This could theoretically be decided via a 'predictive screen' analogous to the one described in Section 4.5 for the Mitigation Component: a preliminary test which determines which facilities can be assumed to have low risk of significant impacts.

However, it has not been possible to establish a predictive screen for the A&R Component. The following options were explored but rejected for the reasons given:

- Country-level exemption based on the strength of policy/regulation and enforcement of those regulations in that country. The logic was to follow the approach adopted by the Equator Principles, where facilities in a list of 'Designated' countries simply need to comply with national laws, regulations and permits, while facilities in 'Non-Designated' countries are required to meet the stipulated requirements as described above.

This has intuitive appeal, and Box 10 below provides some arguments in support of this approach. However, no existing analysis was found to provide objective support to this approach in the context of the development of hydropower facilities. Furthermore, there will also be inconsistency in the performance of hydropower projects under regulations in different jurisdictions and there is no guarantee that a project will perform well simply because the country in which it is located is highly regulated.

- Size-based or type-based exemption, where (very) small scale facilities or run-of-river facilities are exempt from the need to carry out the assessment outlined above. This approach would be based on the often general assumption that larger hydropower projects have greater impacts than small ones, which, if averaged over many projects would probably be correct overall.

However, there is a strong feeling within the expert community and the experts consulted in the development of these criteria that "even small hydropower projects can have significant impacts if sited in sensitive locations or designed and operated in ways that increase rather than minimise adverse project-specific impacts, or the cumulative impacts on the river basin setting. Conversely, very large projects can also have minimal impacts if sited in uninhabited areas with minimal local and downstream biodiversity. Project impact is always likely to be dominated by site-specific considerations."⁹²

⁹² IIED (2014), Watered down? A review of social and environmental safeguards for large dam projects, International Institute for Environment and Development

Furthermore, the WCD did not identify size thresholds for considering environmental and social impacts of hydropower or other dams, but rather it indicates assessments needed to be made in relation to a particular dam and river basin context.

For these reasons, no predictive screen is proposed for the A&R Component, and a uniform and feasible tool to screen all hydropower assets and projects is preferred. Therefore, all facilities will need to be assessed by the ESG Gap Analysis Tool and will be subject to the performance scoring methodology described above.

Box 10: Arguments in support of a ‘Designated country’ approach to a predictive screen

As described above, one option for a predictive screen for the A&R Component is to remove the need for a full assessment in countries with sound regulatory regimes and robust political processes. These countries should not be viewed as having foolproof systems. However, several arguments could be made in support of the idea that some regulatory regimes are sufficient:

- There is considerable regulatory and industrial experience with hydropower within most of these countries.
- The EU has a robust regulatory framework. EU countries are regulated by both the Water Framework and Environmental Liability Directives, as well as national legislation. The Water Framework Directive requires surface waters to meet good ecological and chemical status, the assessment of which includes hydro-morphological status. It requires monitoring regimes, river basin management plans, trans-boundary cooperation and public participation. The Environmental Liability Directive requires operators to prevent or remediate any damage to the status of water bodies as defined in the WFD. The European Commission has taken the Austrian government to court over a hydropower project which, in its view, infringes the Water Framework Directive.⁹³
- Similarly, the USA has a whole set of laws and agreements relevant to hydropower going back decades. These include the Water Resources Planning Act (establishing river basin management), Clean Water Act (banning the licensing of hydropower projects unless state authorities are satisfied they will comply with water quality standards), the National Environmental Policy Act (requiring the Federal Energy Regulatory Commission to do an environmental assessment when licensing hydropower) and Endangered Species Act (requiring consideration of impacts on listed species in hydropower licensing).⁹⁴
- Countries with a robust democratic culture already have mechanisms in place to deal with objections to hydropower projects, and a democratic culture allows for potential ES impacts to be identified by stakeholders directly, without a formal assessment needing to raise them. For example, the controversial HidroAysén project in Chile was cancelled in 2014 after years of protest regarding its environmental impacts.
- Where relevant, these democratic mechanisms typically include indigenous groups who are often vociferous about large infrastructure projects. Canada has a government department dedicated to meeting the Government’s commitments to indigenous peoples. The US Government has recently consulted on how the views of Native American tribes can be better incorporated into infrastructure decisions.⁹⁵

While these arguments were considered, they were ultimately rejected, and a decision made not to apply a ‘Designated country’ approach, for reasons explained in the text.

⁹³ European Commission (2014), Environment: Commission takes Austria to Court over failure to protect water quality on Schwarze Sulm river: http://europa.eu/rapid/press-release_IP-14-448_en.htm

⁹⁴ Hydropower Reform Coalition ‘Laws Governing Hydropower Licensing’: <http://www.hydroreform.org/resources/laws>

⁹⁵ US Department of the Interior, *Tribal Input on Federal Infrastructure Decisions*: <https://www.bia.gov/WhoWeAre/AS-IA/ORM/TribalInput/index.htm>

6.8 Free, Prior & Informed Consent (FPIC) Requirement

Generally, Free, Prior & Informed Consent (FPIC) of Indigenous Peoples is considered to be outside the strict climate change scope that we set for the Climate Bonds Standard. However, in the case of the Hydropower Criteria, due to the nature of the assets being so interlinked with surrounding communities where project activities may lead to the removal or relocation of habitation or significant impact on their culture and livelihood, it was felt that the Criteria should have an additional requirement that FPIC must be achieved in accordance with the UN Declaration of the Rights of Indigenous Peoples.⁹⁶ This Declaration recognizes the specific right of Free, Prior and Informed Consent that pertains to indigenous peoples affected by a project.

To enable this, a working group of the Hydropower Sustainability Assessment Council (HSAC) was established in late 2018 to review the current definition of this topic in the Hydropower Sustainability Assessment Guidelines on Good International Industry Practice (HGIIP), which determines how the topic is assessed in both the Hydropower Sustainability Assessment Protocol (HSAP) and also the Hydropower Environmental, Social and Governance Gap Analysis (HESG) tools. Specifically, the objective was to find stronger agreement on the language that defines good international industry practice in the hydropower sector on this topic, and how this practice should be assessed at the project level. The FPIC-WG was tasked to review the existing safeguards and standards of various IFIs, and to commission a study on international law relating to FPIC.

The FPIC working group comprised representatives of each multi-stakeholder HSAC chamber and was guided by an expert group including representatives of indigenous peoples, specialist consultants and accredited assessors.

Their recommendations led to revisions in the HSAP and ESG Gap Analysis Tool to further strengthen the provisions for FPIC in those tools. The amendments were approved by the HSAC Governance Committee.

⁹⁶ <https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html>

7 Disclosure Requirements

It is the intention of the Climate Bonds Standard to promote greater disclosure and transparency around the use of proceeds generated through the issuance of Green Bonds, and the climate, green and social impacts of these bonds. A high degree of transparency is critical to avoid greenwashing, and thereby engender confidence on the part of investors and enable strong growth in the Green Bonds market.

To this end, in order to be eligible for Certification, it is proposed that bond issuers are required to make publicly available the information on compliance of underlying assets with the requirements under the Hydropower Criteria. This includes: the power density and (if applicable) the GHG Assessment; the accredited assessor's report on the ESG gap analysis and associated plans to close any significant gaps identified therein; and information on whether FPIC has been achieved. We accept that some of the information in the ESG gap analysis may be subject to reasonable commercial confidentiality considerations but urge as much disclosure as possible.

Certification under the Climate Bonds Standard exclusively relates to the attributes of the use of proceeds of a designated debt instrument as set out under the applicable Sector Criteria. For the avoidance of doubt, certification does not address any other aspect of the designated debt instrument or the nominated projects and assets which are not covered by the Climate Bonds Standard, such as compliance with national or international laws, broader ESG attributes, or creditworthiness.

We further encourage disclosure of any identified impacts on protected areas such as Ramsar and UNESCO World Heritage sites not already covered by the requirements of the ESG Tool.

Appendix 1: TWG and IWG members

TWG Members & Observers

TWG members:

Alliance for Global Water Adaptation - John Matthews
 IEA Technology Collaboration Program on Hydropower – Niels Nielsen
 IHE Delft - Miroslav Marenc
 IIED - Jamie Skinner
 Independent Consultant and IHA accredited assessor - Joerg Hartmann
 International Hydropower Association – Eddie Rich and formerly Richard Taylor and Cameron Ironside
 IUCN - James Dalton
 (Former Commissioner) National Planning Commission, South Africa - Mike Muller
 Norwegian Ministry of Petroleum & Energy - Oivind Johansen
 RMT Renewables Consulting Ltd – Richard Taylor
 State Secretariat for Economic Affairs (SECO) – Daniel Menebhi
 TNC - Jorge Gastelundi - David Harrison
 Water Power & Law Group PC - Richard Roos-Collins
 WWF - Jian-hua Meng

TWG observers:

Pravin Karki, Rickard Liden, Diego Rodriguez, of World Bank Group – acting in a personal capacity

CBI Technical Advisor:

Independent Consultant - Helen Jackson

IWG Members

Hydro Tasmania - Alex Beckitt
 Brookfield Renewable (Brazil) - A Fonseca dos Santos
 Amec Foster Wheeler - Murray Simpson
 Hindustan Electric Power Ltd - Awadh Gir
 Eletrobras - Pedro Luiz de Oliveira Jatoba
 EDF - Alexandre Marty, Jean Copreaux
 Mott McDonald - Bruno Trouille
 CECEP (China) - Chang He, Wenqin Lu
 EBRD - Christian Carraretto
 FMASE (Brazil) - Philip Hauser
 S&P Trucost - Derek Ip
 ERM - Duncan Russell, Sarah Fee
 M&G Investment - David Kemp
 Citi - Courtney Lawrence
 NAB - David Jenkins
 JP Morgan - Charles Gooderham
 DNV-GL - Mark Robinson
 PwC (Canada) - David Greenall
 EY (China) - Judy Li
 Zhongcai Green Finance - Yang Yeo
 EY (Aus) - Pip Best
 Emergent Ventures India - Atul Sanghal
 Kestrel Consulting - Monica Reid
 Lianhe - Jingyun Liu
 TUV Nord -Tahsin Choudhury

Appendix 2: The power sector GHG budget according to the IEA 2DS scenario: analysis for the Low GHG-Compatibility Test

The purpose of this Appendix is to explore a single, well-known 2° modeling scenario and what it implies for: (i) power sector technology choices; and (ii) hydropower emissions intensities that would keep power sector emissions within the GHG budget implied by the scenario.

A2.1 Summary of the IEA Energy Technology Perspectives 2017 2DS Scenario

The International Energy Agency's *Energy Technology Perspectives* series explores scenarios aligned with a reasonable probability of limiting global temperature increases by 2100 to various increments. Historically, these have been 2°, 4° and 6°, respectively (the 2DS, 4DS and 6DS scenarios), while the 2017 version explored the 2DS and a 'Beyond 2DS' scenario limiting temperature increases to 1.75°C. The IEA describes the 2DS scenario as follows:

"The 2DS lays out an energy system deployment pathway and an emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C. The 2DS limits the total remaining cumulative energy-related CO₂ emissions between 2015 and 2100 to 1,000 GtCO₂. The 2DS reduces CO₂ emissions ... by almost 60% by 2050 (compared with 2013), with carbon emissions being projected to decline after 2050 until carbon neutrality is reached."

Overall, the 2DS scenario estimates a required average emissions intensity across the global electricity sector in 2050 of 35g CO₂e/kWh, down from 519g CO₂e/kWh in 2014; a reduction of 93%, while electricity demand increases by about 80%. This significant decarbonisation can only be achieved via a substantial shift from high emissions fossil fuels to low-carbon technologies.

Hydropower output nearly doubles by 2050 in the 2DS but hydropower generation retains a similar overall share in the global technology mix, growing only 2% from 16% in 2014 to 18% in 2050.

The scenario is summarised in Table A1.

Table A1: Characteristics of the global electricity sector in 2014 and in 2050, according to the International Energy Agency's 2DS Scenario

	2014	2050 (2DS)
Generation		
Fossil fuels w/o CCS	15,885 TWh (67% of global generation)	2,718 TWh (6% of global generation)
Hydropower (excl. PSH)	3,895 TWh (16% of global generation)	7,619 TWh (18% of global generation)
Geothermal	77 TWh (~0% of global generation)	931 TWh (2% of global generation)
All other sources inc. fossil fuels with CCS	3,961 TWh (17% of global generation)	31,277 TWh (74% of global generation)
Total global electricity generation	23,819 TWh	42,546 TWh
Associated average emissions intensity		
Fossil fuels w/o CCS ¹	775g CO ₂ /kWh	583g CO ₂ /kWh
Electricity sector overall	519g CO₂/kWh	35g CO₂/kWh

Source: IEA Energy Technology Perspectives 2017 model results download: <http://www.iea.org/etp/etp2017>.

¹Figures in this row are calculated through the method set out in Box A1.

However, it is our understanding that this analysis takes into account GHG emissions from fossil fuel combustion only and does not incorporate Scope 1 non-combustion emissions. That is, emissions from reservoirs (for hydropower) and the release of non-condensable gases (for geothermal) are not accounted for.

A2.2 Incorporating non-combustion emissions

This section estimates the GHG intensity which is implied by the technology choices in the 2DS scenario if Scope 1 non-combustion emissions are included. The fossil fuel emissions intensity and overall energy mix set out in Table A1 are maintained, but emissions intensity factors for hydropower and geothermal are incorporated.

Although the state of scientific knowledge is evolving, a mean hydropower emissions intensity figure has not been found in the literature reviewed for this document (see Appendix 3). Evidence to date suggests a median direct emissions intensity of 24-28 gCO₂e/kWh,⁹⁷ and the median reported by IPCC is 28 gCO₂e/kWh. As the distribution of hydropower emissions intensities clusters at the lower end with a long tail (see Section 4.4.5), the mean is probably a little higher than this. We use an estimate of 30 gCO₂e/kWh here. The mean emissions intensity of 122 gCO₂e/kWh for geothermal is taken from the literature.⁹⁸ Given the emerging state of scientific knowledge on both topics, these figures should in any case be viewed as approximate.

With geothermal and hydropower together accounting for 20% of power generation in the 2DS scenario, by including estimates of their non-combustion emissions, the estimated global emissions intensity in 2050 in the 2DS scenario is revised to 43 gCO₂e/kWh.

A2.3 Implications for the power sector GHG budget

This section explores trade-offs in the power sector technology mix if an overall emissions intensity of 35 gCO₂e/kWh is still to be attained when non-combustion emissions are included.

Figure A1 condenses these trade-offs into two dimensions: the average emissions intensities of technologies with Scope 1 emissions (fossil fuels without CCS, hydropower, geothermal) on the x-axis; and the percentage of generation from all other technologies ('zero emissions technologies') on the y-axis. In this way we can plot lines of constant emissions intensity representing technology choices between which we are indifferent in terms of emissions intensity alone. The dashed line represents 519 gCO₂e/kWh, and the solid line represents the target of 35 gCO₂e/kWh.

The situation in 2014 is shown by the point in the bottom right corner. Point A shows the absolute limit of what could be achieved by reducing the carbon intensity of fossil fuel power stations without any further efforts to improve the share of renewables. Points B and C show what would be achieved through the hydropower and geothermal shares (respectively) set out in Table A1. (Note that this seems small because the *share* of these two resources has increased only a small amount while the *absolute* amount they generate has more than doubled. It does not imply they have little to contribute to a low-carbon energy system).

Point D shows that after those steps, a target of 35 gCO₂e/kWh can only be met by a very large scale switch from fossil fuels to zero GHG sources.⁹⁹ Point E is the same in all respects apart from the emissions intensity of hydropower doubling from 30 to 60 gCO₂e/kWh. The figures for each point are described in Table A2.

Points B and C illustrate that hydropower (and geothermal) emissions are *relatively* small in the scheme of things; the vast bulk of emissions reductions needs to come from decarbonising fossil fuel capacity and switching away from it to zero-emitting sources. However, points D and E show that, even though hydropower is a relatively low-emitting technology, the GHG budget is so tight that the emissions intensity of hydropower can make a material difference. There is a trade-off. For point E to

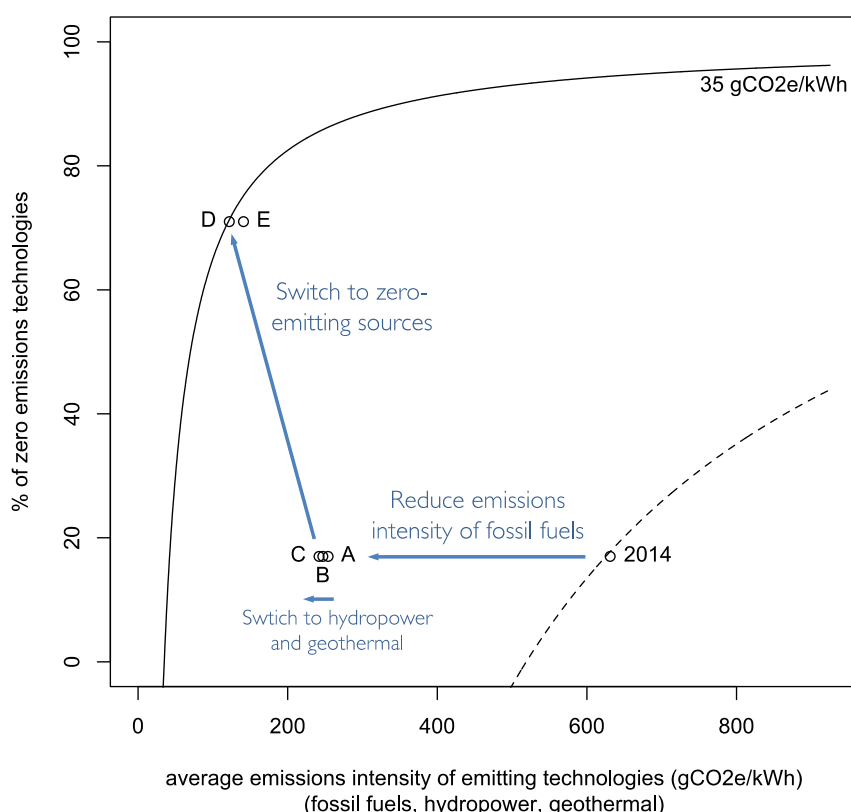
⁹⁷ The G-res database median is broadly in line with, but slightly lower than, this once emissions have been allocated – see Section 4.4.5.

⁹⁸ Bertani, R., & Thain, I. (2002, July). Geothermal Power Generating Plant CO₂ Emissions Survey. IGA News, (49), 1–3.

⁹⁹ Note that in this case, because the share of fossil fuels is now so much less than hydropower, the average emissions intensity of emitting technologies is now substantially less than the theoretical minimum for a fossil fuel power station, odd though this may seem at first glance.

be on the curve, a further 1.9% of global generation capacity would need to be switched from fossil fuels to zero-emitting sources. In fact, for every rise in hydropower emissions intensity of 1g CO₂e/kWh, a further 26.9 TWh of generation is required from zero GHG sources.¹⁰⁰ This is roughly equivalent to the current wind output of Canada.¹⁰¹ That is, the world's GHG budget is so tight that it is reasonable to place precautionary limits on even low-emitting power sources such as hydropower, particularly as they are so long-lived.

Figure A1: Trade-offs in the power sector technology mix



Source: CBI analysis

Box A1: Mathematics behind the analysis

The total emissions intensity of the electricity system e_t can be expressed as the weighted average of the emissions intensities of component technologies as follows:

$$e_t = \sum e_i p_i$$

where e_i and p_i are, respectively, the emissions intensity of generation source i and its proportion of generation.

In ETP 2017, IEA states that in 2014 the average CO₂ emissions intensity for the global power sector was 519g CO₂/kWh. Given that only CO₂ from combustion is included in this figure, the average CO₂ emissions intensity for fossil fuel generation alone can be derived as follows:

$$e'_t = e'_{ff} p_{ff} + e'_o p_o$$

¹⁰⁰ Note that this is the average over the increment in hydropower emissions intensity from 30 to 60g CO₂e/kWh. Mathematically the relationship is not a linear polynomial so the TWh of zero-emitting generation required to compensate for a 1g CO₂e/kWh increment varies over this range.

¹⁰¹ US Energy Information Agency International Energy Statistics

where e'_{ff} and $e'_{o=0}$ are the average *combustion* emissions intensities of fossil fuel and all other generation, respectively; and p_{ff} , p_0 are their proportions. A prime ' is used to denote a *combustion emissions* intensity and an e without a prime denotes an emissions intensity comprising all/any sources of GHGs.

Rearranging:

$$e'_{ff} = e'_{ff}/p_{ff} = 519/0.67 = 775 \text{ g CO}_2/\text{kWh} = e_{ff}$$

As this analysis also considers non-combustion GHG emissions from the power sector, the emissions intensities of hydropower e_h and geothermal e_g are incorporated as follows:

$$e_t = e_{ff}p_{ff} + e_h p_h + e_g p_g = e_e p_e$$

where p_h and p_g are the proportions of hydropower and geothermal in the generation mix respectively; e_e is the average emissions intensity of all emitting sources; and p_e the proportion of emitting sources in the generation mix.

$p_e = 1 - p_0$ can be substituted in the above to derive the trade-off curve presented in Figure A.2:

$$e_e(1 - p_0) = e_t$$

$$p_0 = 1 - e_t/e_e$$

Table A2: Figures underlying the points in Figure A1

	2014	A	B	C	D	E
Percentage of generation						
Fossil fuels	67%	67%	65%	63%	9%	9%
Hydropower	16%	16%	18%	18%	18%	18%
Geothermal	~0%	~0%	~0%	2%	2%	2%
Zero emissions	17%	17%	17%	17%	71%	71%
Average Scope 1 GHG emissions intensity (gCO ₂ e/kWh)						
Fossil fuels w/o CCS	775	307	307	307	307	307
Hydropower	30	30	30	30	30	60
Geothermal	122	122	122	122	122	122
Emitting technologies	631	254	247	242	122	141
Electricity sector overall	524 ¹	210	205	201	35 ¹	41

Source: see Table A1 for figures from IEA ETP 2017; 307g CO₂e/kWh represents a CCGT power station operating at 60% efficiency, based on the UK Department for Energy and Climate Change fuel conversion factor for natural gas. This compares with a lowest empirical value of ~311g CO₂e/kWh taken from Weisser D. (2007) 'A guide to life-cycle greenhouse gas (GHG) emissions from electric supply technologies', Energy Volume 32, Issue 9, 1543-1559; all other figures are calculated.

Notes: ¹This figure is higher than that in Table A1 because it includes GHGs other than combustion emissions

Appendix 3: Estimates of hydropower lifecycle emissions from the literature

Table A3: Hydropower lifecycle estimates in detail

Quantity	Estimate	Source (see below table)
<i>Total lifecycle estimates including reservoir emissions</i>		
All hydropower, range	0-2200 gCO ₂ e/kWh ³	1
All hydropower, interquartile ¹ range	3-185 gCO ₂ e/kWh ²	1
All hydropower, median	28 gCO ₂ e/kWh	1
Run-of-river, range	3-13 gCO ₂ e/kWh ²	2
Pumped storage, single study	5 gCO ₂ e/kWh ²	2
Impoundment, range	0-165 gCO ₂ e/kWh ^{2,4}	2
<i>Lifecycle estimates excluding reservoir emissions</i>		
Run-of-river	as above	2
Pumped storage	as above	2
Impoundment, range	0-43 gCO ₂ e/kWh ^{2,3,4}	2
Impoundment, interquartile ¹ range	< 10 gCO ₂ e/kWh ²	2
Impoundment, median	4 gCO ₂ e/kWh ²	2
Impoundment, individual studies	2.9 gCO ₂ e/kWh ≤ 6 gCO ₂ e/kWh production of bulk materials	3

Notes: ¹ The 50% of studies closest to the median, between the 25th and 75th percentiles. ² Estimated from chart as actual figures not given in source. ³ Upper end of range is an extreme outlier. ⁴ Emissions are assumed to be negligible in some cases where the primary purpose of the reservoir and dam is not electricity generation.

Sources: 1. Bruckner T., I. A. Bashmakov, Y. Mulugetta, H. Chum, A. de la Vega Navarro, J. Edmonds, A. Faaij, B. Fungtammasan, A. Garg, E. Hertwich, D. Honnery, D. Infield, M. Kainuma, S. Khennas, S. Kim, H. B. Nimir, K. Riahi, N. Strachan, R. Wiser, and X. Zhang (2014), *Energy Systems*. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; 2. Kumar, A., T. Schei, A. Ahenkorah, R. Caceres Rodriguez, J.-M. Devernay, M. Freitas, D. Hall, Å. Killingtveit, Z. Liu (2011), *Hydropower*, in *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*; 3 Hertwich et al. (2015), 'Integrated life cycle assessment of electricity supply scenarios confirms global environmental benefit of low-carbon technologies', *PNAS* May 19, 2015. 112 (20) 6277-6282; 4 Raadal, H., Gagnon, L., Modahl, I., & Hanssen, O. (2011). Life cycle greenhouse gas (GHG) emissions from the generation of wind and hydro power. *Renewable and Sustainable Energy Reviews*, 15(7), 3417-3422.

Table A4: Lifecycle GHG emissions of different low-carbon technologies from the literature

Technology	Emissions intensity estimate (gCO ₂ e/kWh)	Estimate explanation	Source
Solar PV (Utility scale - estimates associated with domestic-level PV can be much higher and are omitted)	16-57	lifecycle GHG, mid-points of ranges for different PV technologies	1
	30 17-50	amorphous Si lifecycle GHG: mean from 3 studies full range found in studies (this source is unclear about power rating and some higher figures presented for crystalline Si systems are omitted as they are assumed to be small-scale, in accordance with findings of 4)	2
	13-130	lifecycle GHG range (outliers associated with low insolation or high grid emissions in country of manufacture)	3
	9-60	lifecycle GHG range, amorphous & crystalline Si; cases where power rating > 10kW	4
	48 18-180	lifecycle GHG: median range (the upper end of this range is a 3kW domestic application)	5
Solar thermal	23, 33	lifecycle GHG, mid-points of ranges for trough and tower	1
	14-200 14-200	lifecycle GHG: means found in 4 studies full range found in studies (estimates for central receivers are at the lower end; upper end cases are relatively small scale)	2
Hydropower	6, 78	impoundment, lifecycle GHG, mid-points of ranges for two types of reservoir (unspecified)	1
	4-47 2-75	lifecycle GHG: means found in 10 studies full range found in studies	2
	2-20	lifecycle GHG range	3
	24 1-2200	lifecycle GHG: median range	5
Wind (onshore)	8	lifecycle GHG, mid-point	1
	5-46 5-124	lifecycle GHG: means found in 18 studies full range found in studies (outliers associated with high transportation requirements and carbon-intensive land use change)	2
	3-41	lifecycle GHG range	3
	11 7-56	lifecycle GHG: median range	5
Wind (offshore)	11	lifecycle GHG, mid-point	1
	5-13 5-24	lifecycle GHG: means found in 5 studies full range found in studies	2
	12 8-35	lifecycle GHG: median range	5
Marine	15-23 10-50	lifecycle GHG: means found in 4 studies full range found in studies	2
	17 6-28	lifecycle GHG: median range	5
Geothermal	15-53 11-78	lifecycle GHG: means found in 4 studies full range found in studies	2
	38 6-79	lifecycle GHG: median range	5
Nuclear	3-35	lifecycle GHG range	3
	12 4-110	lifecycle GHG: median range	5

Technology	Emissions intensity estimate (gCO ₂ e/kWh)	Estimate explanation	Source
Biomass	15-650	lifecycle GHG, electricity only, full range found in studies (highly dependent on feedstock)	2
	9-130	lifecycle GHG range	3

Sources: 1 Hertwich et al. (2015), 'Integrated life-cycle assessment of electricity-supply scenarios confirms global environmental benefit of low-carbon technologies', *PNAS* 112(20) 6277-6282; 2 Amponsah et al. (2014), 'Greenhouse gas emissions from renewable energy sources: A review of lifecycle considerations', *Renewable and Sustainable Energy Reviews* 39:461-475; 3 Turconi et al. (2013), 'Life cycle assessment (LCA) of electricity generation technologies: Overview, comparability and limitations', *Renewable and Sustainable Energy Reviews* 28:555-565; 4 Varun et al. (2009), 'Energy, economics and environmental impacts of renewable energy systems', *Renewable and Sustainable Energy Reviews* 13 (2009) 2716–2721; 5 Schlömer S. et al. (2014), Annex III: Technology-specific cost and performance parameters. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*;

Table A5: IPCC reporting on GHG emissions associated with electricity generation technologies

Life cycle CO ₂ equivalent (including albedo effect) from selected electricity supply technologies. Arranged by decreasing median (gCO ₂ e/kWh) values			
Technology	Min	Median	Max
Currently commercially available technologies			
Coal – PC	740	820	910
Biomass – co-firing with coal	620	740	890
Gas – combined cycle	410	490	650
Biomass – dedicated	130	230	420
Solar PV – utility scale	18	48	180
Solar PV – rooftop	26	41	60
Geothermal	6.0	38	79
Concentrated solar power	8.8	27	63
Hydropower	1.0	24	2200
Wind offshore	8.0	12	35
Nuclear	3.7	12	110
Wind onshore	7.0	11	56
Pre-commercial technologies			
CCS – Coal – PC	190	220	250
CCS – Coal – IGCC	170	200	230
CCS – Gas – combined cycle	94	170	340
CCS – Coal – oxyfuel	100	160	200
Ocean (tidal and wave)	5.6	17	28

Sources: IPCC (2014). IPCC Working Group III – Mitigation of Climate Change, Annex III: Technology - specific cost and performance parameters; IPCC (2014). IPCC Working Group III – Mitigation of Climate Change, Annex II Metrics and Methodology.

Appendix 4: Environmental and Social Standards and Assessment Tools

We reviewed a range of existing tools which the Hydropower Criteria could potentially have drawn from in addressing ES issues. Table A6 summarises them and comments on their suitability.

Table A6: Summary of existing Environmental and Social Standards and Assessment Tools

Standard/tool	Description and comments
Financial institutions	
Equator Principles http://www.equator-principles.com/resources/equator_principles_III.pdf	<p>"The Equator Principles is a risk management framework, adopted by financial institutions, for determining, assessing and managing environmental and social risk in projects. It is primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making."</p> <ul style="list-style-type: none"> • requires conducting an ES assessment / ESIA • for Non-Designated countries refers to IFC PS and 'World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines)' • Designated countries must meet local regulations, as well as ES assessment, management system and plans, stakeholder engagement and grievance mechanisms
World Bank Safeguard Policies / New Environmental and Social Framework http://www.worldbank.org/en/news/press-release/2016/08/04/world-bank-board-approves-new-environmental-and-social-framework http://consultations.worldbank.org/Data/hub/files/consultation-template/review-and-update-world-bank-safeguard-policies/en/materials/the_esf_clean_final_for_public_disclosure_post_board_august_4.pdf	<p>Purpose is 'to identify, avoid, and minimize harms to people and the environment.'</p> <p>Appears to be a work in progress designed to supersede IFC Performance Standards</p> <p>Designed to be harmonised with IFC Performance Standards. Changes compared to IFC are:</p> <ul style="list-style-type: none"> • Land Acquisition, Restrictions on Land Use and Involuntary Resettlement • Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities • New topic #9: requirement for financial intermediaries (FIs) to put in place an environmental and social management system with associated procedures. • New topic #10: Stakeholder Engagement and Information Disclosure <p>A new legal agreement called an 'ES commitment Plan'</p> <p>#4 contains on Annex on safety of dams</p> <p>Stipulation to obtain 'Free, Prior, and Informed Consent' of IP/SSA when a project will: (a) have adverse impacts on land and natural resources subject to traditional ownership or under customary use or occupation; (b) cause relocation; or (c) have significant impacts on cultural heritage.</p>
'World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines)' http://www.ifc.org/wps/wcm/connect/554e8d80488658e4b76af76a6515bb18/Final+-+General+EHS+Guidelines.pdf?MOD=AJPERES	<p>'A set of general and industry-specific examples of Good International Industry Practice (GIIP) as defined in IFC's Performance Standard 3'</p> <p>'provide performance levels and measures acceptable to IFC'</p> <p>Cross-cutting issues are: Environmental (releases, etc.), OHS, Community safety, construction and decommissioning</p> <p>More technical detail about acceptable releases than safeguards. Many different sector-specific guidelines, but none for hydropower.</p>
EBRD Performance Requirements http://www.ebrd.com/what-we-do/strategies-and-policies/approval-of-new-governance-policies.html	<p>Categorises projects according to their likely ES risks/impacts</p> <p>Basically follows same structure as World Bank safeguards</p>

Standard/tool	Description and comments
IFC Environmental and Social Performance Standards	See World Bank Safeguard Policies / New Environmental and Social Framework
Hydro-specific	
World Commission on Dams	<p>The WCD Report of 2000 proposed a decision-making framework based on core values of equity, efficiency, participatory decision-making, sustainability and accountability and strategic principles:</p> <ul style="list-style-type: none"> • Gaining public acceptance • Comprehensive options assessment • Addressing existing dams • Sustaining rivers and livelihoods • Recognising entitlements and sharing benefits • Ensuring compliance • Sharing rivers for peace, development, and security <p>While the WCD core values and strategic priorities have received wide endorsement and landmark status, major financial institutions have by and large considered the WCD Report framework as useful but non-binding guidance. The HSA Protocol is widely viewed as a more practical and detailed successor to the WCD Report.</p>
Hydropower Sustainability Assessment Protocol	See Box 7 in Section 6.5
IFC Hydroelectric Power: A Guide for Developers and Investors	Strongly overlaps with HSAP, but with more emphasis on technical aspects and financial performance, and less on ES issues. Thorough reference work on hydropower projects, rather than a verifiable set of guidelines. For example, Table 12.1 in the chapter on environmental and social impacts provides a good summary of these impacts with mitigation options for each, but no actual stipulations. Refers to more generic guidelines such as the IFC's Performance Standards and the Equator Principles.
World Bank Hydropower and Dams Sector Climate Resilience Guidelines	Climate resilience focus
Low Impact Hydropower Institute Certification Programme	Only US facilities are eligible. Clearly developed in the context of a pre-existing robust regulatory framework. Detailed specifics on fish passage, watershed/shoreline, recreational resources.
RSAT (Rapid Basin-wide Hydropower Sustainability Assessment Tool) http://www.mrcmekong.org/about-mrc/completion-of-strategic-cycle-2011-2015/initiative-on-sustainable-hydropower/rsat-overview-the-basin-wide-hydropower-sustainability-assessment-tool/	<p>Mekong River Commission. Backing of WWF & ADB</p> <p>Focuses on the Integrated Water Resources Management principles and practices in river basin planning and management across sectors and the collection of basin-wide baseline data to inform planning and decision making and monitor change.</p> <p>We assume it is too specific to its geographical context to be applicable here.</p> <p>Has some topics which could be relevant for A&R: flood & drought management; specific fisheries management topic.</p>
Other	
Climate Bonds Water Standard https://www.climatebonds.net/files/Water_Criteria_of_the_ClimateBondsStandard_October2016(1).pdf	<p>Detailed scorecard for assessing grey water infrastructure assets' vulnerability to climate change impacts. Questions relate to allocation mechanisms, governance, technical diagnostics and ecological baselines and impacts, monitoring and management.</p> <p>If the vulnerability assessment finds climate change is likely to significantly impact the project, an adaptation plan is required.</p>
Natural Capital Protocol Toolkit/ Finance Sector Supplement http://naturalcapitalcoalition.org/protocol/protocol-toolkit/ http://naturalcapitalcoalition.org/wp-content/uploads/2016/11/Financ	<p>"The Natural Capital Protocol, released in July 2016, is a decision-making framework that allows organizations to identify, measure and value their direct and indirect impacts and dependencies on natural capital."</p> <p>It is an environmental accounting tool for guiding internal decision-making, therefore not relevant.</p>

Standard/tool	Description and comments
<u>e_Sector_Supplement_Briefing_Paper-FNL-14-Nov-2016.pdf</u>	The Finance Sector Supplement is a work in progress. It is focused on providing information at the level of financial products rather than projects/assets.
International Association for Impact Assessment Social Impact Assessment Guidelines https://www.iaia.org/uploads/pdf/SIA_Guidance_Document_IAIA.pdf	Guide to doing a Social Impact Assessment, not a set of requirements that projects should meet.