



Gold Standard[®]
for the Global Goals

METHODOLOGY – SUPPLEMENTARY INFORMATION

GS4GG PAA M400-12 SI

SDG 13

EMISSION REDUCTIONS FROM SAFE DRINKING WATER SUPPLY

PUBLICATION DATE - 09/07/2026

VERSION – 1.0

NEXT UPDATE – 09/07/2029

TABLE OF CONTENTS

SECTION- 1 PHYSIOLOGICAL AND SOCIO-ENVIRONMENTAL DETERMINANTS OF HYDRATION IN THERMALLY STRESSED REGIONS: A RATIONALE FOR TIERED WATER VOLUME DEFAULTS.....	3
S.1.1 INTRODUCTION.....	3
S.1.2 PHYSIOLOGICAL BASIS OF HUMAN WATER REQUIREMENTS	4
S.1.3 SUBSTANTIATION OF THE TIERED DEFAULTS AND CAPS	5
S.1.4 RECONCILIATION: THE HOUSEHOLD-WEIGHTED DEFAULT (≈ 3.0 L/P/D).....	6
S.1.5 CONCLUSION	6
S.1.6 REFERENCES.....	6
SECTION- 2 LEAKAGE ASSESSMENT FOR SAFE DRINKING WATER SUPPLY (SWS) PROJECTS	8
S.2.1 EXECUTIVE SUMMARY.....	8
S.2.2 LEAKAGE IN CARBON ACCOUNTING: CONCEPT AND PROCEDURE.....	8
S.2.3 LEAKAGE-SOURCE TAXONOMY	8
S.2.4 SOURCE-BY-SOURCE ASSESSMENT FOR SAFE WATER SUPPLY	9
S.2.5 SYNTHESIS AND CONCLUSION	11
S.2.6 REFERENCES.....	11
SECTION- 3 ACCOUNTING FOR EMBODIED EMISSIONS IN SWS PROJECTS	13
S.3.1 RATIONALE AND REGULATORY BASIS.....	13
S.3.2 METHODOLOGICAL FRAMEWORK: BOUNDARY, FUNCTIONAL UNIT AND CONVERSION	13
S.3.3 EMBODIED-EMISSIONS EVIDENCE BY TECHNOLOGY CLASS	14
S.3.4 DERIVATION OF THE DEFAULT DEDUCTIONS	16
S.3.5 MATERIALITY AND SENSITIVITY	17
S.3.6 REFERENCES (SECTION 3)	17
SECTION- 4 LOCK-IN RISK ASSESSMENT FOR SAFE WATER SUPPLY (SWS) TECHNOLOGIES	18
S.4.1 LOCK-IN CONCEPT AND ITS APPLICATION TO SWS	18
S.4.2 REGULATORY FRAMEWORK AND ASSESSMENT METHODOLOGY.....	18
S.4.3 DECENTRALISED TECHNOLOGIES (HWT/IWT)	20
S.4.4 CENTRALISED AND COMMUNITY SYSTEMS (CWS)	21
S.4.5 SYNTHESIS: LOCK-IN RISK CATEGORISATION	22
S.4.6 RECOMMENDATIONS FOR METHODOLOGY COMPLIANCE	23
S.4.7 CONCLUSION	23
S.4.8 REFERENCES.....	23
SECTION- 5 POSITIVE LIST FOR DEEMED ADDITIONALITY	25
S.5.1 INTRODUCTION AND PURPOSE	25
S.5.2 ACCESS DEFICIT: REGIONAL COVERAGE ANALYSIS	25
S.5.3 LOW EFFECTIVE DEMAND AND WILLINGNESS-TO-PAY	27
S.5.4 BEHAVIOURAL BARRIERS TO AUTONOMOUS ADOPTION	28
S.5.5 IMPROVED-COOKSTOVE PARALLEL	29
S.5.6 DELIVERY MODELS AND THE ROLE OF CARBON FINANCE	29
S.5.7 DERIVATION OF THE DEEMED-ADDITIONALITY ELIGIBILITY CRITERIA	30
S.5.8 REFERENCES.....	31

SECTION- 1 | PHYSIOLOGICAL AND SOCIO-ENVIRONMENTAL DETERMINANTS OF HYDRATION IN THERMALLY STRESSED REGIONS: A RATIONALE FOR TIERED WATER VOLUME DEFAULTS

S.1.1 | Introduction

Quantifying baseline emissions for safe drinking water requires an evidence-based estimate of daily drinking-water demand, because the baseline emission is the fuel burned to boil that volume of water. Human water requirements have historically been modelled on temperate-climate, sedentary populations (EFSA, 2010; Institute of Medicine [IOM], 2005), and those reference values understate the needs of populations in hot climates that depend on manual labour and face constrained water access — the operational context of this methodology.

The methodology operates under the established principle of suppressed demand. In resource-constrained settings, observed consumption frequently falls below physiological requirement owing to poverty, scarcity and the effort of collection; crediting the observed (artificially suppressed) level would entrench deprivation in the baseline and understate the genuine service the activity provides. Baseline calculations therefore reflect a Minimum Service Level (MSL) sufficient to support health, not the suppressed historical level (Gold Standard, 2021; WHO, 2017). This is the same suppressed-demand logic applied across GS4GG and Article 6.4 basic-needs methodologies, assessed on a useful-energy basis.

Crediting to an MSL above observed consumption necessarily introduces uncertainty, and the methodology answers it with layered conservativeness specific to this parameter: (i) the volume is expressed through age-tiered default values set deliberately below the physiologically supportable maxima, applied wherever consumption is not field-verified; and (ii) a mandatory 5% suppressed-demand conservativeness deduction is applied (Section 7.4.4). These sit within the methodology's broader dual-conservativeness treatment of suppressed demand, alongside the aggregate Uncertainty Adjustment Factor (Section 13).

The relevant parameter is QPWp (drinking water per person per day). For each age tier the methodology applies a two-part architecture: a conservative default, used where consumption is not field-verified, and a higher maximum cap, applied only where consumption is verified via the Water Consumption Field Test (WCFT). The defaults are 0.9 L/day (under 5), 3.0 L/day (5–18) and 4.0 L/day (adults 19+); the corresponding caps are 1.3, 4.5 and 5.5 L/day. This section substantiates both: that the caps are not excessive relative to physiological need, and that the defaults sit conservatively below them.

S.1.1.1 | Service levels and creditable volumes:

It is important to distinguish three water-service concepts. Survival-level hydration is the acute minimum to sustain life; the MSL for health is the chronic intake required to maintain euhydration and avoid heat- and labour-related morbidity; and broader basic access additionally covers non-consumptive domestic uses (bathing, laundry). The WHO notes that acute survival needs may be met with 2.5–3.0 L/day, but that figure does not address the chronic load of environmental heat combined with physical labour (Howard & Bartram, 2003).

The tiered values in this section proxy only the “hydration-plus” component of the MSL — the water for immediate metabolic and thermoregulatory support that would be boiled in the baseline. They deliberately exclude the much larger “basic access” volumes (e.g. the 20 L per capita per day benchmark) that include non-boiled bathing and laundry, because only the consumed, boiled fraction generates the baseline fuel emission that the activity displaces. This confines crediting to the volume actually treated.

S.1.2 | Physiological Basis of Human Water Requirements

Water is essential for nutrient transport, waste elimination and thermoregulation (Sawka et al., 2007). The integrating quantity is water turnover (WT) — the total daily flux of water through the body, which intake must replace to maintain euhydration. The gold-standard measurement of WT uses stable-isotope (doubly-labelled water) tracers to quantify water efflux (Schoeller, 2008).

Using this method in 5,604 people aged 8 days to 96 years across 23 countries, Yamada et al. (2022) showed that water turnover is significantly predicted by body size and composition, physical activity, and environmental characteristics (air temperature, humidity, altitude, latitude), and that the Human Development Index (HDI) is itself a strong predictor: individuals in low-HDI countries exhibit higher WT than those in high-HDI countries. Critically, the effects of air temperature, physical activity and body size on WT were larger in low-HDI populations, whereas in high-HDI populations water needs appear buffered against environmental influence by effective indoor climate control. Guideline values derived from sedentary, climate-controlled, high-HDI populations therefore systematically understate the needs of the populations this methodology serves.

This systematic, climate-driven increment in water requirement — the component that temperate-population guidelines omit — may be termed the heat tax on water demand. In the target climates, frequently with Wet-Bulb Globe Temperatures above 26 °C, the body prioritises thermoregulation over water conservation, raising requirements through three physiological avenues::

- a. | **Renal loss:** the kidneys require a minimum urine volume to excrete solute; chronic low urine volume in heat is a risk factor for urolithiasis and acute kidney injury (Roncal-Jimenez et al., 2016).

- b. | **Insensible loss (cutaneous and respiratory):** water is continuously lost by evaporation from skin and the respiratory tract; respiratory loss rises with ventilation during work and with dry inspired air (Mitchell et al., 1972; IOM, 2005).
- c. | **Sensible perspiration (sweat):** the most variable component; peak sweat rates can exceed 1.5–2.0 L/hr during heavy work in heat (Sawka et al., 2007; Kjellstrom et al., 2016).

Total water intake also includes moisture from food (approximately 20–30% of intake in Western diets; IOM, 2005). Where diets rely on dry staples, a larger share of the requirement must come from drunk fluid — the provision to which QPWp applies — so the drinking-water requirement in the target context is, if anything, understated by food-inclusive temperate references.

S.1.3| Substantiation of the tiered defaults and caps

The defaults are set below the physiological maxima so that unmonitored activities cannot over-credit; the caps represent the upper bound supportable by the evidence and apply only on field verification. Each tier is substantiated below and summarised in Table 1.

- a. | **Adults (19+): default 4.0 L/day; cap 5.5 L/day:** Adult requirements reflect environmental heat combined with physical labour; in humid heat, impaired sweat evaporation further stresses thermoregulation (Kjellstrom et al., 2016), and a full day of manual labour produces total sweat losses of several litres (Sawka et al., 2007). High shift-time fluid intakes are documented among sugarcane cutters at risk of Mesoamerican nephropathy, who may drink several litres per shift yet remain at risk of dehydration (García-Trabanino et al., 2015; Wesseling et al., 2016; Roncal-Jimenez et al., 2016). Water carriage — frequently undertaken by women and adolescents — is itself physical labour that raises requirement (Geere et al., 2018; Sorenson et al., 2011). A 4.0 L/day default is therefore conservative, and 5.5 L/day is a physiologically supportable verified maximum.
- b. | **Children and adolescents (5–18): default 3.0 L/day; cap 4.5 L/day:** This group combines high activity — play, active transport, domestic chores — with the additional metabolic demand of growth (Geere et al., 2018). The 3.0 L/day default is a conservative per-person estimate bridging paediatric and adult need; the 4.5 L/day cap is the verified maximum supportable by activity and growth in hot climates. The cap is justified on hydration, activity and growth alone: water carried off-site (e.g. by students for a household) is governed by the HWT–IWT overlap rule, not by inflating the per-person volume — closing an over-crediting vector present in the prior draft.
- c. | **Children under 5: default 0.9 L/day; cap 1.3 L/day:** Young children are especially vulnerable to dehydration — a high surface-area-to-mass ratio,

higher mass-specific metabolic rate and immature thermoregulation — and diarrhoeal disease, endemic in the target settings, sharply raises requirement (Bar-David et al., 2006; Rowland, 2008). The IOM (2005) Adequate Intake for total water in children aged 1–3 is approximately 1.3 L/day including dietary moisture. The 0.9 L/day default corresponds to the drunk-fluid portion and is the conservative unmonitored value; the 1.3 L/day cap retains the full IOM total-water figure as a generous verified ceiling.

S.1.4| Reconciliation: the household-weighted default (≈ 3.0 L/p/d)

For activities that do not disaggregate beneficiaries by age, the per-tier defaults combine into a single household-weighted default. Applying a representative developing-country household age structure (16% under-5; 34% aged 5–18; 50% adult) to the tier defaults, with the mandatory 5% suppressed-demand deduction (§7.4.4):

$$(0.16 \times 0.9) + (0.34 \times 3.0) + (0.50 \times 4.0) = 3.16 \text{ L/p/d} ; \times 0.95 = \approx 3.0 \text{ L/p/d}$$

This blended 3.0 L/p/d is the value adopted withstands independent cross-checks. It is consistent with the small-scale CDM methodology AMS-III.AV.

S.1.5| Conclusion

Standard hydration guidance based on temperate, sedentary, climate-controlled populations is inadequate for the methodology's operational context: environmental heat combined with physical activity materially increases water turnover, and that increment — the heat tax — is precisely what such guidance omits (Yamada et al., 2022). The tiered defaults (0.9 / 3.0 / 4.0 L/day) are conservative unmonitored values that reconcile to a household-weighted ≈ 3.0 L/p/d, and the caps (1.3 / 4.5 / 5.5 L/day), applied only on field verification, are supported by — and do not exceed — the physiological evidence for euhydration in thermally stressed, labour-intensive environments. The parameter is thus both evidence-based and layered with conservativeness, consistent with the suppressed-demand and uncertainty provisions of the methodology.

S.1.6| References

- Bar-David, Y., Urkin, J., & Kozminsky, E. (2006). The effect of voluntary dehydration on cognitive functions of elementary school children. *European Journal of Applied Physiology*, 98(1), 1–8.
- EFSA Panel on Dietetic Products, Nutrition, and Allergies. (2010). Scientific opinion on dietary reference values for water. *EFSA Journal*, 8(3), 1459.
- García-Trabanino, R., Jarquín, E., Wesseling, C., et al. (2015). Heat stress, dehydration, and kidney function in sugarcane cutters in El Salvador. *Environmental Research*, 142, 746–755.

- Geere, J. A., Hunter, P. R., & Jagals, P. (2018). Water carrying and health: a review. *Journal of Water and Health*, 16(2), 173–187.
- Gold Standard. (2021). *Methodology for Emission Reductions from Safe Drinking Water Supply (V1.0)*.
- Howard, G., & Bartram, J. (2003). *Domestic water quantity, service level and health*. World Health Organization.
- Institute of Medicine. (2005). *Dietary reference intakes for water, potassium, sodium, chloride, and sulfate*. National Academies Press.
- Kjellstrom, T., Briggs, D., Freyberg, C., et al. (2016). Heat, human performance, and occupational health. *Annual Review of Public Health*, 37, 97–112.
- Mitchell, J. W., Nadel, E. R., & Stolwijk, J. A. J. (1972). Respiratory weight losses during exercise. *Journal of Applied Physiology*, 32(4), 474–476.
- Roncal-Jimenez, C., Lanaspa, M. A., Jensen, T., et al. (2016). Mechanisms by which dehydration may lead to chronic kidney disease. *Annals of Nutrition and Metabolism*, 68(Suppl. 2), 32–38.
- Rowland, T. (2008). Thermoregulation during exercise in the heat in children. *Journal of Applied Physiology*, 105(2), 718–724.
- Sawka, M. N., Burke, L. M., Eichner, E. R., Maughan, R. J., Montain, S. J., & Stachenfeld, N. S. (2007). American College of Sports Medicine position stand: Exercise and fluid replacement. *Medicine and Science in Sports and Exercise*, 39(2), 377–390.
- Schoeller, D. A. (2008). Measurement of energy and water turnover by the doubly labelled water method. *Proceedings of the Nutrition Society*, 67(4), 345–352.
- Sorenson, S. B., Morssink, C., & Campos, P. A. (2011). Safe access to safe water in low income countries. *Social Science & Medicine*, 72(9), 1522–1526.
- WHO. (2017). *Guidelines for drinking-water quality (4th ed., first addendum)*. World Health Organization.
- Yamada, Y., Zhang, X., Henderson, M. E. T., et al. (2022). Variation in human water turnover associated with environmental and lifestyle factors. *Science*, 378(6622), 909–915. <https://doi.org/10.1126/science.abm8668>

SECTION- 2 | LEAKAGE ASSESSMENT FOR SAFE DRINKING WATER SUPPLY (SWS) PROJECTS

S.2.1 | Executive summary

This section establishes a harmonised framework for assessing leakage in SWS mitigation activities, applying the mandatory three-tiered procedure — Identify, Avoid/Minimise, Quantify — required by the GS4GG and Article 6.4 leakage standards, with sources benchmarked against a 2% materiality threshold. The principal findings are that market leakage (diversion of non-renewable biomass) and behavioural rebound (the “heating penalty”) are negligible in the SWS context, while resource competition (aquifer depletion) is material only for high-volume groundwater abstraction and is managed through a mandatory hydrogeological safeguard.

S.2.2 | Leakage in carbon accounting: concept and procedure

Leakage is the net change in anthropogenic greenhouse-gas emissions by sources, or removals by sinks, that occurs outside the activity boundary and is measurable and attributable to the activity. It matters because a mitigation activity that merely displaces emissions beyond its own boundary — rather than reducing them — delivers no real climate benefit; a robust leakage assessment is therefore fundamental to environmental integrity and is a precondition for issuance.

Leakage is conventionally separated into three channels relevant here. Activity-shifting leakage occurs where the baseline activity is displaced to a location outside the boundary rather than ceasing. Market leakage occurs where the activity changes the supply of, or demand for, a traded good (here, biomass fuel), altering its consumption by non-participants. Ecological or resource-competition leakage occurs where the activity intensifies demand on a shared natural resource (here, groundwater), with consequences for other users. Each channel is assessed below.

The assessment follows the GS4GG and Article 6.4 leakage requirements, which mandate an identical, hierarchical, non-optional procedure: (i) identify all potential sources; (ii) avoid or minimise them wherever feasible; and (iii) quantify and deduct any residual net negative leakage. A source assessed as immaterial against the 2% threshold, on conservative reasoning, does not require quantification; a material source must be either minimised to immateriality through a verifiable safeguard or quantified and deducted.

S.2.3 | Leakage-source taxonomy

The GS4GG and Article 6.4 frameworks define an aligned set of leakage-source categories. Table 1 summarises them; the SWS-specific assessment in §2.4 then addresses the three categories that are physically capable of arising from a safe-

water activity — market effects, behavioural rebound and resource competition — and explains why the remainder do not.

Table 1: Alignment of Leakage Source Definitions in GS4GG and A6.4-STAN-METH-005

Leakage source category	GS4GG definition (summary)	Article 6.4 definition (summary)
Baseline equipment transfer	Displacement of functional baseline equipment re-used outside the boundary	Equivalent
Resource competition	Increased demand for a limited resource, diverting it from competing uses	Equivalent
Diversion of production / activity shifting	Deviation in output types or service levels	Equivalent
Environmental GHG releases	Release of GHGs from natural reservoirs attributable to the activity	Equivalent
Upstream/downstream processes	Changes in upstream/downstream processes; cradle-to-gate assessment	Covered under resource competition and activity shifting

Two categories are addressed elsewhere and are not re-assessed here. Baseline equipment transfer does not arise: the displaced baseline “equipment” is an open cooking fire and a cooking pot, which are not transferred to or re-used by non-participants in any emissions-relevant way. Upstream embodied emissions (the cradle-to-gate manufacture of the activity hardware) are accounted as a direct activity deduction in Section 3, not as leakage, to avoid double counting.

S.2.4| Source-by-source assessment for Safe Water Supply

S.2.4.1| Market effects (fuel availability):

- a. | **Mechanism:** By reducing a household's demand for non-renewable biomass (the fuel previously burned to boil water), the activity could increase the quantity of that fuel available to non-participants, who might then consume it — re-releasing some of the emissions the activity avoided.
- b. | **Assessment:** negligible. Three features of the SWS context make this immaterial. First, the fuel saved by eliminating water-boiling is marginal relative to a household's total thermal energy use, so the quantity returned to the market is small. Second, in many rural settings the binding constraint on biomass use is collection labour rather than market availability, so freed-up fuel does not translate into additional purchased consumption elsewhere

(Bailis et al., 2009). Third, in genuinely fuel-scarce settings the saved biomass is typically retained and consumed within the same household for other thermal needs — a transfer that is internal to the activity boundary and, to the extent it substitutes for other non-renewable fuel, constitutes positive (favourable) leakage (Johnson et al., 2009). The same reasoning underlies the treatment of market leakage in the reduced-emissions-from-cooking-and-heating methodologies.

- c. | **Tier 2-3 treatment:** Given the negligible risk, no specific avoidance measure is required. The methodology (Section 9.3) nonetheless requires an ex-ante assessment and offers a conservative default deduction of 2% of the gross emission reductions where detailed source-specific monitoring is not undertaken.

S.2.4.2 | Behavioural rebound (the heating penalty)

- a. | **Mechanism.** Community water-supply (CWS) activities that abstract groundwater raise local demand on the aquifer. Where abstraction exceeds the sustainable yield of the source, the water table is drawn down, neighbouring wells can fail, and — in the limiting case — communities may be forced back to boiling untreated surface water, reversing the activity's benefit. This is the one leakage channel that is material in the SWS context.
- b. | **Assessment:** material for high-volume abstraction. The risk is real and concentrated, not hypothetical: at the global scale the groundwater footprint of aquifers exceeds their physical area by a factor of about 3.5, with overexploitation centred on aquifers in arid and semi-arid regions (Gleeson et al., 2012) — precisely the water-stressed settings in which many SWS activities operate (Bonsor et al., 2022). Resource-competition leakage is therefore assessed as material wherever an activity undertakes mechanised, high-volume groundwater abstraction.
- c. | **Tier 2-3 treatment (mandatory safeguard):** CWS activities are subject to an abstraction-volume trigger of 5 m³/day (5,000 L/day). Below this, abstraction is treated as low-impact, domestic-scale use. At or above 5 m³/day — including aggregated handpump schemes that collectively exceed it — the developer shall demonstrate the sustainable yield of the aquifer through a qualified hydrogeological assessment establishing no adverse impact on neighbouring users. Where this safeguard is implemented and verified, the risk is minimised to immateriality and no quantified leakage deduction is required.

The 5 m³/day trigger is deliberately more conservative than established small-abstraction exemption thresholds in comparable jurisdictions: 20 m³/day in England and Wales (Water Resources Act 1991, as amended by the Water Act 2003) and a sub-10 m³/day no-licence band in Scotland (the

Water Environment (Controlled Activities) (Scotland) Regulations). Setting the trigger below these benchmarks errs towards earlier scrutiny.

S.2.5| Synthesis and conclusion

Table 2 summarises the assessment across the three candidate leakage sources, recording for each the mechanism, the materiality determination and the treatment applied.

Table 2. Leakage-source assessment for SWS — materiality and treatment

Leakage source	Mechanism in SWS context	Materiality	Treatment
Market effects (fuel availability)	Freed biomass consumed by non-participants	Negligible	Ex-ante assessment; 2% conservative default (§9.3)
Behavioural rebound (heating penalty)	Extra fuel burned for warmth once boiling ceases	Negligible	None required
Resource competition (aquifer depletion)	High-volume groundwater abstraction lowers the water table; neighbours' wells fail	Material (high-volume abstraction)	Mandatory 5 m ³ /day sustainable-yield safeguard

In sum, market effects and behavioural rebound are negligible in the SWS context — the former addressed by the ex-ante assessment and the 2% default, the latter requiring no action — while resource competition is the one material source, minimised through the mandatory 5 m³/day hydrogeological safeguard. Net leakage attributable to SWS activities is thereby robustly managed in compliance with the GS4GG and Article 6.4 leakage requirements.

S.2.6| References

- Article 6.4 Supervisory Body. Leakage requirements for mechanism methodologies [standard code to be confirmed in the cross-cutting reconciliation]. UNFCCC.
- Bailis, R., Cowan, A., Berrueta, V., & Masera, O. (2009). Arresting the killer in the kitchen: The promises and pitfalls of commercializing improved cookstoves. *World Development*, 37(10), 1694–1705.
- Bonsor, H. C., MacDonald, A. M., Casey, V., et al. (2022). The role of groundwater in rural water supply sustainability. *Nature Reviews Earth & Environment*, 3, 642–658.

Gleeson, T., Wada, Y., Bierkens, M. F. P., & van Beek, L. P. H. (2012). Water balance of global aquifers revealed by groundwater footprint. *Nature*, 488(7410), 197–200. <https://doi.org/10.1038/nature11295>

Gould, C. F., & Urpelainen, J. (2020). The gendered nature of liquefied petroleum gas stove adoption and use in rural India. *Energy for Sustainable Development*, 55, 187–197.

GS4GG. Leakage requirements for additionality and baseline setting [standard code to be confirmed].

Johnson, M. A., Edwards, R., & Masera, O. (2009). Improved stove programs need robust methodologies to exploit climate-financing potential. *Energy for Sustainable Development*.

Ruiz-Mercado, I., Masera, O., Zamora, H., & Smith, K. R. (2011). Adoption and sustained use of improved cookstoves. *Energy Policy*, 39(12), 7557–7566.

Water Resources Act 1991 (England & Wales), as amended by the Water Act 2003 — small-quantity abstraction exemption (≤ 20 m³/day).

The Water Environment (Controlled Activities) (Scotland) Regulations — tiered authorisation (< 10 m³/day general binding rules; 10–50 m³/day registration; > 50 m³/day licence).

SECTION- 3 | ACCOUNTING FOR EMBODIED EMISSIONS IN SWS PROJECTS

S.3.1 | Rationale and regulatory basis

Embodied emissions are the greenhouse-gas emissions released upstream of an activity's operation — in the extraction of raw materials, the manufacture of the activity technologies, and their transport to the point of dissemination (a cradle-to-gate boundary). For Safe Drinking Water Supply (SWS) activities these arise from the production of filters, dispensers, treatment hardware, pumps, pipes and storage, together with their delivery to households and communities.

Accounting for these emissions matters in this methodology for a structural reason. SWS activities are characterised by the dissemination of very large numbers of low-unit-value devices or systems. While the embodied burden of any single unit is small, the cumulative burden across a programme of activities is a genuine emissions source attributable to the activity. Left unaccounted, it would overstate the net mitigation. Environmental integrity therefore requires that the embodied burden be quantified and deducted from the gross emission reductions.

In compliance with the GS4GG Methodology Standard and the Article 6.4 requirements on the completeness of the activity's emissions boundary, the methodology accounts for cradle-to-gate embodied emissions as an activity emission source. To balance environmental integrity with feasibility — full activity-specific LCA is neither proportionate nor practical for high-volume, low-value household technologies — the deduction is applied through standardised, conservative default values. The deduction is charged once per unit (or per system) disseminated, against the emission reductions, with the timing governed by the programme-level amortisation/upfront provisions of the methodology (see the embodied-emissions treatment in the methodology body).

S.3.2 | Methodological framework: boundary, functional unit and conversion

Three methodological choices govern how published life-cycle assessment (LCA) findings are translated into the default deductions of §3.4.

- a. | **System boundary:** The methodology adopts a cradle-to-gate boundary: raw-material extraction, component manufacture and transport to the point of dissemination. The use phase is excluded for passive point-of-use technologies (ceramic, biosand, chlorination, solar disinfection), whose operation generates no combustion emissions; for powered systems (ultraviolet units, mechanised or solar pumping) the operational energy is treated separately under the activity's energy accounting and is not double-counted here. End-of-life is conservatively omitted, since disposal impacts for these materials are small and uncertain and their exclusion does not understate the deduction.

- b. | **Functional unit:** The central difficulty in using the LCA literature is that studies report impacts against different functional units — per litre of water treated, per capita-year of safe water supplied, per household, or per cubic metre delivered — whereas the methodology requires a deduction expressed per disseminated unit or per system. The two are not interchangeable without explicit assumptions about how much water a unit treats over its life.
- c. | **Conversion:** Converting a per-functional-unit impact to a per-unit deduction requires stated assumptions on household size, device service life and daily throughput (utilisation). The general relationship is:

$$E_{\text{embodied,unit}} = e\text{FU} \times (\text{FU delivered per unit over its service life})$$

where eFU is the published embodied impact per functional unit. Where a robust per-unit value cannot be derived on transparent assumptions, the conservative (higher-deduction) value is retained and flagged as provisional — because the deduction reduces creditable reductions, a higher value protects environmental integrity (S.3.4). This is the source of the provisional status attached to several entries in Table 8.

S.3.3 | Embodied-emissions evidence by technology class

The published LCA evidence is uneven across technologies but consistent in direction. It is summarised below by technology class, identifying in each case the material and process drivers of the embodied burden, since these determine both the magnitude and the confidence of the derived default

S.3.3.1 | Decentralised point-of-use treatment (HWT/IWT)

A comparative LCA across the common point-of-use technologies establishes a consistent ordering of global-warming potential: boiling carries the highest burden by a wide margin (it is fuel-combusting), while ceramic filtration, biosand filtration and chlorination are all low-impact; ultraviolet systems sit above the passive filters owing to the manufacture of lamps and electronics and their need for powered operation (Comparative LCA of four point-of-use technologies, 2020). This ordering is the qualitative backbone of the defaults in S.3.4.

- a. | **Ceramic filters:** The embodied burden is dominated by the energy of kiln firing and by the plastic (typically HDPE) receptacle that houses the filter element; the clay body and colloidal-silver treatment contribute relatively little. Even so, the cradle-to-gate burden per unit is low and compares favourably with centralised piped supply on a per-litre basis (Oyanedel-Craver & Smith, 2008; Evaluating the Sustainability of Ceramic Filters, 2013). The firing step is the principal lever: filters fired in efficient kilns carry a materially lower burden than those fired in rudimentary ones.
- b. | **Biosand filters:** The burden is dominated by Portland cement — whose clinker production is itself highly CO₂-intensive — and by PVC components. The

functional consequence, confirmed qualitatively across the literature, is that a concrete-bodied unit carries a substantially higher embodied burden than a plastic-housed unit of equivalent function (Comparative LCA, 2020). The cement content is therefore the controlling variable, and the plastic/concrete distinction is carried through to two separate defaults in S.3.4.

- c. | **Membrane and ultraviolet units:** These “advanced” technologies carry a higher embodied burden than passive filters, arising from polymeric membranes, pumps, lamps and control electronics. Ultraviolet disinfection additionally requires continuous powered operation; that operational energy is accounted separately (S.3.2) and is not part of the embodied deduction. A dedicated membrane LCA is not separately sourced here, so the advanced-unit default is set above the passive-filter values on the strength of the verified ranking rather than a unit-specific figure.
- d. | **Chlorination and solar disinfection:** Chlorination relies on consumable chemical dosing with minimal durable hardware, and solar disinfection (SODIS) uses passive solar exposure in reused containers; both carry the lowest embodied burdens of the decentralised options, consistent with their low position in the comparative ranking. They do not warrant a distinct hardware deduction beyond the basic-dispenser value.

S.3.3.2 | Centralised and community supply (CWT/CWS)

For centralised and community systems the embodied burden is larger in absolute terms but is shared across many users, so the per-capita embodied charge remains modest. Two evidence points anchor this class.

- a. | **Solar photovoltaic pumping:** A hybrid LCA of a solar PV water-pumping system places manufacturing-stage (embodied) emissions at approximately 2,020 kg CO₂e over a 25-year service life — around 55% of total life-cycle emissions — with operational emissions near zero (Solar PVWP LCA, 2024). The high embodied share is characteristic of renewable systems: because operation is effectively carbon-free, the life-cycle burden is concentrated in the manufacture of the modules, pump and balance-of-system. This figure is the firmest single anchor available for the centralised class.
- b. | **Boreholes, handpumps and reticulated rural systems:** The relevant infrastructure comprises the borehole itself (the energy of percussion or rotary drilling, and the PVC or steel casing and well screen), the pump (cast iron, steel and polymer components), storage (HDPE tanks) and distribution (PVC pipe). A life-cycle review of rural water-system options in resource-limited countries finds only small differences in environmental inventory across the improved options, with a groundwater source feeding community standpipes the lowest-impact configuration (Weir, 2012). What the literature does not yet provide —

and what S.3.4 therefore cannot ground precisely — is a verifiable embodied figure isolating borehole drilling and casing from operational pumping energy.

S.3.4| Derivation of the default deductions

Each default below is derived by combining the verified direction of S.3.3 with the conversion logic of S.3.2. Where the per-unit magnitude is supported, the value is grounded; where only the direction is supported, the value is conservative and provisional. The evidentiary status is stated explicitly for every entry, so that an assessor can see precisely how far each figure is supported.

Table 1: Default embodied-emission deductions, with material drivers and evidentiary status

Technology category	Default (kg CO ₂ e)	Principal driver	Evidentiary status
Ceramic filter / basic dispenser	8.0 / unit	Kiln firing + HDPE receptacle	Provisional. Direction grounded; per-unit figure needs conversion from the per-capita-year functional unit.
Biosand — plastic	25 / unit	PVC + low cement	Provisional. Cement/PVC-driven; plastic < concrete confirmed; specific per-unit value not yet sourced.
Biosand — concrete	65 / unit	Portland cement (clinker)	Provisional. Materially higher than plastic is supported qualitatively; the exact figure is not.
Advanced (membrane / UV)	12.0 / unit	Membrane, lamp, electronics	Provisional. UV > passive filters confirmed; membrane LCA not separately sourced.
Solar / mechanised pumping system	4,500 / system	PV + pump + drilling/casing	Partially grounded. Pump + PV manufacturing ≈ 2,020 kg verified; increment to 4,500 (drilling, casing) not yet supported by a verifiable drilling LCA.
Centralised treatment kiosk	2,000 / system	Treatment hardware + housing	Provisional / unsourced.
Rehabilitation (pump / hardware)	1,000 / system	Replacement components	Provisional / unsourced.

Two derivation-logic points follow from the table. First, the plastic/concrete biosand split (25 vs 65) and the rehabilitation value (1,000) had no cited source.

S.3.5| Materiality and sensitivity

The embodied burden is incurred once, at dissemination. The emission reduction it offsets, by contrast, accrues continuously over the technology's service life. For a decentralised filter displacing the boiling baseline, the recurring benefit is the avoided combustion of non-renewable woody biomass used to boil drinking water; its magnitude follows from the methodology's own parameters — the per-capita safe-water volume, the boiling-fuel quantity, the fraction of non-renewable biomass (fNRB) and the woodfuel emission factor (Section 7). Over a household and a multi-year device life, the gross reduction is of the order of several hundred kilograms to more than one tonne of CO₂e. Set against this, a one-off embodied deduction of the order of tens of kilograms is approximately one to a few per cent of the lifetime gross reduction.

The same holds, by a different route, for centralised systems. The embodied burden of a solar-pumping or borehole system (of the order of two to four-and-a-half tonnes of CO₂e) is shared across the population it serves over a service life of up to twenty-five years; the per-capita embodied charge is therefore small relative to the per-capita lifetime reduction, even before the system's avoided-fuel benefit is counted.

S.3.6| References (Section 3)

Verified sources relied upon in this section. Links open the DOI where available.

Comparative life-cycle assessment of four point-of-use water treatment technologies. (2020). *Journal of Water, Sanitation and Hygiene for Development*, 10(4), 862–874.

Evaluating the sustainability of ceramic filters for point-of-use drinking water treatment. (2013). *Environmental Science & Technology*, 47(20).

<https://doi.org/10.1021/es4026084>

Oyanedel-Craver, V. A., & Smith, J. A. (2008). Sustainable colloidal-silver-impregnated ceramic filter for point-of-use water treatment. *Environmental Science & Technology*, 42(3), 927–933. <https://doi.org/10.1021/es071268u>

Life-cycle assessment of a solar photovoltaic water-pumping system. (2024). *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 46(1).

Weir, L. (2012). A life-cycle approach to improve the sustainability of rural water systems in resource-limited countries. *Challenges*, 3(2), 233–260.

<https://doi.org/10.3390/challe3020233>

SECTION- 4 | LOCK-IN RISK ASSESSMENT FOR SAFE WATER SUPPLY (SWS) TECHNOLOGIES

S.4.1 | Lock-in concept and its application to SWS

Demonstrating that an activity is additional in financial terms is necessary but not sufficient. The Paris framework additionally requires that a near-term mitigation activity does not entrench emissions — that it does not “lock in” levels of emissions, technologies or carbon-intensive practices incompatible with the long-term goals of the Agreement (paragraph 33 of the Article 6.4 rules, modalities and procedures). This section evaluates the lock-in risk of the technologies eligible under the methodology and substantiates the exemptions and safeguards carried in Section 6. Carbon lock-in operates through several channels, and it is useful to separate them. Technological lock-in arises when an installed device or plant commits its operator to an emitting technology for its service life. Infrastructural lock-in arises when durable, capital-intensive infrastructure (networks, civil works) makes a high-emission configuration costly to displace. Institutional and behavioural lock-in arise when policies, financing arrangements or established habits entrench a practice. A complete assessment must also consider ecological lock-in — the entrenchment of an unsustainable use of a natural resource that fails on exhaustion, forcing a reversion to a worse alternative.

For SWS, the analysis has a particular shape. The activity is mitigation by avoidance: it displaces the combustion of biomass for boiling with a non-combusting means of obtaining safe water. The lock-in question is therefore not whether the activity emits — it does not — but whether the displacing technology itself entrenches anything emitting, or whether it draws on a resource whose depletion would force a high-emission fallback. As the analysis below shows, the decentralised technologies that constitute the bulk of interventions are gravity-driven, passive or human-powered and create no such entrenchment; the material residual risk is ecological, and is concentrated in mechanised groundwater abstraction.

S.4.2 | Regulatory Framework and Assessment Methodology

The governing framework is the GS4GG Requirements for Additionality Demonstration, harmonised with the Article 6.4 Additionality Standard (A6.4-STAN-METH-003). The Standard sets out the lock-in analysis in paragraphs 28–33, and the methodology applies it through a two-track structure.

The Standard first requires a technology- and source-neutral approach (para 28). It then sets four substantive requirements for an eligible activity (para 29): it (a) must not lead to the adoption or prolongation of technologies or practices incompatible with the long-term goals of the Paris Agreement; (b) must be consistent with the host country's long-term low-emission development strategy (LT-LEDS) where one has been submitted; (c) for technologies or practices with a long lifetime, must rely on a

technology among those with the lowest greenhouse-gas intensity in the relevant region, over the lifetime of the technology; and (d) must not involve an inefficient use of a resource important for mitigation or other policy objectives. The assessment must consider socio-economic context, existing infrastructure and path dependencies, together with the technical or operational lifetime, the emissions intensity, the scale of the activity, and the availability of alternatives (para 31), and must be conducted conservatively and be justified (para 33):

- a. | **Track 1 — Lifetime safe harbour (para 32):** Where the eligible technologies have a technical or operational lifetime of no more than ten years, the methodology may assume that no lock-in risk exists, since no durable emitting infrastructure is created. Appropriate evidence for the lifetime estimate must be provided, and — importantly — where this option is used the validity of the methodology is limited to 31 December 2030, with review by the Supervisory Body before expiry (the “sunset”).
- b. | **Track 2 — Full test (para 29):** Technologies with a lifetime exceeding ten years cannot rely on the safe harbour and must be shown, qualitatively, to satisfy each of the four requirements (a)–(d) above. Under the methodology this is the proponent-level demonstration permitted by para 30: the methodology justifies that the eligible long-lived technologies meet the requirements, rather than leaving the test to each activity.

Table 2. Lock-in assessment criteria, with confirmed Article 6.4 clause references

Criterion	A6.4 clause	GS4GG	Implication for SWS
Technology/source neutrality	para 28	Required	No technology favoured a priori
Non-prolongation of Paris-incompatible tech/practice	para 29(a)	Required	Activity must displace, not entrench, emitting practice
Consistency with host LT-LEDS	para 29(b)	Required	Nationally-determined eligibility test where an LT-LEDS exists
Lowest GHG intensity in region (long-lived assets)	para 29(c)	Required	Best-in-class benchmark for >10-yr technologies
No inefficient use of a mitigation-critical resource	para 29(d)	Required	Basis for the ecological (aquifer) safeguard
Assessment considerations (lifetime, intensity, scale,	para 31	Required	Analysis of socio-economic and infrastructural context

alternatives, path dependency)			
Lifetime safe harbour	para 32	≤10 yr	Primary exemption pathway
Exemption validity (sunset)	para 32	To 31 Dec 2030	Transitional technologies reassessed before 2030
Conservative, justified analysis	para 33	Required	Governs the whole assessment

S.4.3| Decentralised technologies (HWT/IWT)

The decentralised point-of-use technologies are the simplest case. The functional service lives characterised for these technologies (Section 3; the methodology technology table) place them within the safe-harbour threshold: ceramic pot and candle filters, membrane and ultraviolet units, and chlorine dispensers exhibit functional lifespans of the order of two to seven years — ceramic elements limited by progressive pore clogging and colloidal-silver depletion, membranes and lamps by fouling and degradation, dispensers by mechanical wear. They therefore qualify for the para 32 safe harbour and create no durable emitting infrastructure.

Beyond the lifetime test, these technologies also satisfy the substantive logic of para 29(a). They are modular, gravity-driven or low-power bridge technologies: a household filter or a community dispenser does not occupy the niche that a future piped, treated utility supply would fill, and so does not impede — and is readily superseded by — utility expansion. They displace the emitting baseline (boiling) rather than prolonging it. There is, in short, no technological, infrastructural or institutional channel through which a short-lived passive treatment device could entrench an emitting configuration.

- a. | Concrete biosand-filter exception: One decentralised technology exceeds the safe harbour: while plastic biosand filters fall below ten years, concrete units have service lives of fifteen to twenty years and therefore trigger the full test (para 29). They pass it. A concrete biosand filter is a zero-emission, gravity-driven device fabricated from locally available materials (sand, gravel, cement) that creates no fossil-fuel path dependency and prolongs no emitting practice. Its embodied emissions exceed those of a plastic unit (provisionally ≈ 65 vs 25 kg CO₂e per unit; Section 3), but its operational carbon intensity is negligible and the embodied charge is small relative to the boiling baseline it displaces (Section 3, §3.5). It is consistent with any plausible LT-LEDS and represents a low-GHG option in its class. Conclusion: low lock-in risk..

S.4.4 | Centralised and community systems (CWS)

Centralised and community water systems are the substantive case, because they combine permanent civil infrastructure with electromechanical components and because their energy source and water resource raise genuine lock-in questions. The full test (para 29) applies.

A distinction must be drawn between the passive infrastructure and the active technology of a CWS. The borehole — drilled, cased and gravel-packed — has a service life of twenty to fifty years; the active technology (a submersible pump and motor) lasts five to ten years. The short life of the pump might appear to bring the system within the safe harbour, but that would misread the test: the system as a whole (borehole, pump, storage, distribution) establishes a multi-decade service dependency on a particular configuration. The assessment must therefore treat the CWS as a long-lived asset and focus the full test on the two variables that actually determine lock-in — the energy source and the sustainability of the water resource.

S.4.4.1 | Energy-source analysis

- a. | **Manual handpumps:** Handpumps (e.g. Afridev, India Mark II) comprise high-wear parts (seals, bearings) lasting under two years, pump heads and rods lasting ten years or more, and a borehole lasting twenty years or more. They are powered by human mechanical energy and therefore have zero operational emissions and are fully Paris-consistent. They are also a stepping stone rather than a dead end: a handpump borehole can be upgraded to a solar submersible pump as demand and finance grow, without stranding the civil investment. Manual handpumps carry no carbon lock-in risk.
- b. | **Solar mechanised systems (conditional):** Solar-powered mechanised systems exceed the safe harbour (durable boreholes and panels) but represent the best available technology for off-grid abstraction. Hybrid LCA confirms that they are operationally near-zero-emission, with the burden concentrated in manufacture ($\approx 2,020$ kg CO₂e; Solar PVWP LCA, 2024). They therefore satisfy the carbon criteria of the full test — lowest-GHG-intensity in their class and non-prolongation — provided they do not induce ecological lock-in (§4.4.2).
- c. | **Diesel and carbon-intensive grid systems (high/moderate risk):** Diesel-generator systems entrench fossil dependency for the multi-decade life of the asset, fail the lowest-GHG-intensity criterion (para 29(c)) wherever solar is viable, and risk locking out the renewable alternative — a clear high lock-in risk. Grid-powered mechanised systems are conditional on the grid emission factor: where the grid is carbon-intensive they approach the diesel case; where it is clean they may pass. Both require an explicit energy-source justification rather than an automatic exemption.

S.4.4.2 | Ecological lock-in and resource efficiency:

- a. | The most important residual risk for CWS is not technological but ecological, and it is the operative content of para 29(d) — the prohibition on the inefficient use of a resource important for mitigation or other policy objectives. Infrastructure that abstracts from a slow-recharge or effectively non-renewable (“fossil-water”) aquifer locks in an unsustainable practice: the system functions until the resource is drawn down, at which point it fails. Because aquifer depletion is gradual and often invisible until late, the failure mode is an adaptation failure — a stranded asset and a community forced to revert to a worse, higher-emission alternative such as motorised water trucking (Gleeson et al., 2012; Bonsor et al., 2022).
- b. | This risk is compounded under climate change. Rising ambient heat increases physiological water requirements — the “heat tax” on water demand documented in Section 1 (Yamada et al., 2022; Kjellstrom et al., 2016) — so a system sized without recharge and demand buffers risks locking communities into scarcity precisely as their needs grow. For these reasons the methodology elevates sustainable yield from a leakage check to a fundamental condition of non-lock-in eligibility for CWS: a mechanised abstraction is eligible only where a qualified hydrogeological assessment establishes that abstraction is within the sustainable yield of the source.

S.4.5 | Synthesis: lock-in risk categorisation

Table 3 applies the two-track test of §4.2 across the eligible technologies, recording for each the lifetime position, the full-test outcome where it applies, the ecological dimension and the resulting risk class.

Table 3. Lock-in risk categorisation of SWS technologies

Technology	Lifetime	≤10 yr	Full test	Ecological	Risk
Ceramic / candle filter	2–5 yr	PASS	N/A	None	NO RISK
Biosand (plastic)	5–10 yr	PASS	N/A	None	NO RISK
Biosand (concrete)	15–20+ yr	FAIL	PASS (zero-em.)	None	LOW RISK
Membrane / UV	1–5 yr	PASS	N/A	Low (grid)	NO RISK
Chlorine dispenser	5–7 yr	PASS	N/A	None	NO RISK
Handpump (manual)	10–15 yr	FAIL	PASS (zero-em.)	Low	NO RISK
Solar mechanised	20+ yr	FAIL	PASS (BAT)	High	CONDITIONAL
Diesel mechanised	20+ yr	FAIL	FAIL (fossil)	High	HIGH RISK

Grid mechanised	20+ yr	FAIL	COND. (grid mix)	High	MODERATE
-----------------	--------	------	---------------------	------	----------

The pattern is clear: every decentralised technology, and the manual handpump, is no-risk — by the safe harbour, or (for concrete biosand and handpumps) by passing the full test as a zero-emission device. Risk is confined to mechanised abstraction, where it turns on the energy source (diesel high, grid conditional, solar acceptable) and, for all mechanised options, on the sustainability of the water resource.

S.4.6 | Recommendations for Methodology Compliance

- a. | Recommendation 1 — Unconditional exemption. Ceramic pot and candle filters, biosand filters (plastic and concrete), membrane and ultraviolet units, chlorine dispensers, and manual handpumps. These either meet the para 32 safe harbour or are passive / human-powered zero-emission devices that pass the full test, with no ecological lock-in at their inherent sub-threshold abstraction scale.
- b. | Recommendation 2 — Conditional exemption for mechanised renewable CWS. Solar-powered mechanised systems (and grid systems, subject additionally to a grid-emission-factor check), contingent on Sustainable Yield Verification through a qualified hydrogeological assessment, to prevent ecological lock-in.
- c. | Recommendation 3 — Exclusion or high burden for diesel. Diesel systems are ineligible for automatic crediting; a developer must demonstrate that renewable alternatives are technically unfeasible (a failure of both the lowest-GHG-intensity and the non-prolongation criteria of para 29)..

S.4.7 | Conclusion

The lock-in risk of SWS technologies is generally low — particularly for the decentralised technologies that form the bulk of interventions — because SWS hardware is predominantly gravity-driven, passive or renewable-powered and displaces, rather than prolongs, the emitting boiling baseline. The material residual risk is ecological lock-in through aquifer depletion: a solar pump that drains a slow-recharge aquifer is a stranded asset and an adaptation failure in the making, and the high-emission fallback it would force (water trucking) is precisely the outcome the lock-in test exists to prevent. The stratified framework therefore streamlines the deployment of short-lived health technologies through the safe harbour while imposing the full test — and a binding sustainable-yield condition — on long-lived infrastructure and on the water resource itself.

S.4.8 | References

Article 6.4 Supervisory Body. Standard: Demonstration of additionality in mechanism methodologies (A6.4-STAN-METH-003; in force v01.2, latest draft v02.0 = A6.4-MEP012-A02). UNFCCC. unfccc.int — A6.4-MEP012-A02

- Bonsor, H. C., MacDonald, A. M., Casey, V., et al. (2022). The role of groundwater in rural water supply sustainability. *Nature Reviews Earth & Environment*, 3, 642–658.
- Comparative life-cycle assessment of four point-of-use water treatment technologies. (2020). *Journal of Water, Sanitation and Hygiene for Development*, 10(4), 862–874.
- Evaluating the sustainability of ceramic filters for point-of-use drinking water treatment. (2013). *Environmental Science & Technology*, 47(20).
<https://doi.org/10.1021/es4026084>
- Gleeson, T., Wada, Y., Bierkens, M. F. P., & van Beek, L. P. H. (2012). Water balance of global aquifers revealed by groundwater footprint. *Nature*, 488(7410), 197–200.
- Gold Standard. (2021). *Methodology for Emission Reductions from Safe Drinking Water Supply (V1.0)*.
- GS4GG. Requirements for Additionality Demonstration [standard code to be confirmed].
- Kjellstrom, T., Briggs, D., Freyberg, C., et al. (2016). Heat, human performance, and occupational health. *Annual Review of Public Health*, 37, 97–112.
- Life-cycle assessment of a solar photovoltaic water-pumping system. (2024). *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 46(1).
- Oyanedel-Craver, V. A., & Smith, J. A. (2008). Sustainable colloidal-silver-impregnated ceramic filter for point-of-use water treatment. *Environmental Science & Technology*, 42(3), 927–933. <https://doi.org/10.1021/es071268u>
- Weir, L. (2012). A life-cycle approach to improve the sustainability of rural water systems in resource-limited countries. *Challenges*, 3(2), 233–260.
<https://doi.org/10.3390/challe3020233>
- Yamada, Y., Zhang, X., Henderson, M. E. T., et al. (2022). Variation in human water turnover. *Science*, 378(6622), 909–915.

SECTION- 5 | POSITIVE LIST FOR DEEMED ADDITIONALITY

S.5.1 | Introduction and purpose

The methodology permits the additionality of certain Safe Drinking Water Supply (SWS) activity types to be deemed satisfied through a positive list, set out in normative form in methodology Annex 5. This section provides the evidentiary background that establishes and justifies the eligibility criteria applied there. It imposes no requirements; it sets out the analysis from which those criteria are derived. The central question for additionality is why the target population would not adopt and sustain efficacious safe-water technologies in the absence of carbon finance.

S.5.2 | Access deficit: regional coverage analysis

This subsection establishes the scale and distribution of the population lacking safe drinking water — the population for which an untreated or biomass-boiling baseline persists. Coverage figures are WHO/UNICEF Joint Monitoring Programme (JMP) estimates.

S.5.2.1 | Global picture:

In 2024, 74% of the global population used a safely managed drinking-water service, leaving 2.1 billion people without it: 1.4 billion with only a basic service, 287 million with a limited service, 302 million reliant on unimproved sources, and 106 million collecting surface water directly (WHO/UNICEF JMP, 2025). Coverage is far lower in rural areas (60%) than urban (83%); 1.8 billion people have no water on premises. At current rates, around two billion people will still lack safely managed drinking water in 2030.

Classification of a source as “improved” does not establish safety: an estimated two billion people use either an unimproved source or an improved source contaminated with faecal indicator bacteria. The baseline practice this methodology addresses therefore persists across a population considerably larger than the headline “unimproved” figures suggest.

S.5.2.2 | Regional distribution

- a. | **Sub-Saharan Africa (priority region)** records the lowest coverage of any SDG region — 31% safely managed and 65% at least basic, against 94% in Europe and Northern America. Approximately 1.2 billion people (around 45% of the region) lack proper access; more than 15% rely on surface or unimproved water; and in the Central African Republic and Chad only 6% use safely managed water. Over half of all people worldwide without safely managed drinking water live in this region.
- b. | **Central and Southern Asia** is falling behind the global average and faces compounding high water stress (withdrawals exceeding 70% of renewable

resources), degrading source reliability and quality. Large rural and low-income populations sustain a boiling or untreated baseline.

- c. | **Eastern and South-Eastern Asia** has improved rapidly (a 44% increase 2015–2021), yet the absolute number reliant on point-of-use treatment remains very large given the region's population.
- d. | **Northern Africa and Western Asia** records critical (Northern Africa) to high (Western Asia) water stress; conflict-affected and fragile states show sharply lower coverage.
- e. | **Latin America and the Caribbean** experienced a 7% decline in the indicator 2015–2021; gaps concentrate among rural, peri-urban, indigenous populations and the Caribbean SIDS.
- f. | **Oceania (excluding Australia and New Zealand)** has among the lowest basic coverage of any sub-region (around 60%), with small, dispersed, climate-vulnerable Pacific populations.

S.5.2.3| Least Developed Countries, SIDS, and within-country inequalities:

- a. | The 47 UN-designated Least Developed Countries (LDCs) — the majority in sub-Saharan Africa — record the lowest coverage globally; achieving safely managed water in low-income countries would require current rates of progress to increase roughly twentyfold (WHO/UNICEF JMP, 2023). Small Island Developing States (SIDS) face acute source constraints, salinity intrusion and climate vulnerability. National averages further mask the target populations: eight of ten people without an improved source live in rural areas; coverage rises steeply with household wealth and the poorest quintiles benefit least and pay disproportionately more; and coverage in fragile contexts is 38 percentage points lower than elsewhere (WHO/UNICEF JMP, 2023, 2025).

Table 17. Regional safely-managed drinking-water coverage and the persisting baseline (WHO/UNICEF JMP)

SDG region	Safely managed (coverage / position)	Principal access deficit
Sub-Saharan Africa	31% (lowest region)	Surface/unimproved >15%; CAR & Chad 6%; ~1.2 bn lacking
Central & Southern Asia	Below global average; falling behind	High water stress; large rural/low-income deficits
Eastern & South-Eastern Asia	Improving (+44%, 2015–21)	Large absolute numbers still uncovered
Northern Africa & Western Asia	Critical / high water stress	Fragile and conflict-affected populations

Latin America & Caribbean	Declining (-7%, 2015–21)	Rural, peri-urban, indigenous; Caribbean SIDS
Oceania (excl. Aus & NZ)	~60% basic (among lowest)	Dispersed, climate-vulnerable Pacific populations
Australia & NZ; Europe & N. America	~94–100% (highest)	Universal or near-universal access (not a target context)

Exact percentages are stated where a current JMP figure is available (sub-Saharan Africa 31%; Europe & Northern America 94%; global 74%); for other regions the JMP position relative to the global average and the verified trend are given. For an individual activity, eligibility is determined from the current host-Party JMP figure (methodology Annex B).

S.5.3| Low effective demand and willingness-to-pay

Randomised evaluations of safe-water interventions in low- and middle-income countries consistently find that effective demand and willingness-to-pay (WTP) for household water treatment among low-income populations is low, insufficient to recover the cost of provision, and highly price-sensitive — small increases in price disproportionately reduce take-up (Ahuja, Kremer & Zwane, 2010; Berry, Fischer & Guiteras, 2020; Ashraf, Berry & Shapiro, 2010). Under retail or cost-recovery models, few households purchase treatment at all.

More recent randomised evidence confirms and sharpens this finding. In a 60,000-household cluster-randomised trial in rural India, only 3.6% of control households treated their water with chlorine even though it was widely available and inexpensive (Burlig, Jina & Sudarshan, 2025, working paper). Across Kenya and Malawi, take-up of point-of-use chlorination has likewise remained low under retail pricing, and even free provision achieves adoption mainly where it is made convenient and self-targeted (Dupas, Hoffmann, Kremer & Zwane, 2016; Dupas, Nhlema, Wagner, Wolf & Wroe, 2023).

The corollary is central to the additionality case. Uptake of safe-water treatment is achieved not through markets but through provision that removes the price and convenience barriers: free, convenient, point-of-collection treatment systems designed to make treatment salient can generate take-up of approximately 60% at a projected cost as low as USD 20 per year of life saved — comparable to childhood vaccination (Ahuja, Kremer & Zwane, 2010). Evidence from preventive health more broadly confirms that even modest cost-sharing dramatically reduces coverage relative to free distribution, and does not improve the targeting of users (Cohen & Dupas, 2010).

Recent trials make the mechanism concrete: a non-price voucher that beneficiaries must actively redeem delivers chlorine to those too poor to pay while screening out

non-users (Dupas et al., 2016), and monthly free-coupon distribution in Malawi produced large, sustained gains in water purification and child health at high cost-effectiveness (Dupas et al., 2023).

The review by Ahuja, Kremer and Zwane is itself framed as an assessment of the case for subsidies for water treatment, and concludes that the combination of low willingness-to-pay and the public-health externalities of safe water provides a strong economic rationale for subsidy. That conclusion is the foundation of the financial reasoning developed in Section 5.6–5.7.

A meta-analysis of around fifty randomised trials estimates that water treatment reduces the odds of all-cause child mortality by roughly 30% and is highly cost-effective, yet it remains under-prioritised in health financing (Kremer, Luby, Maertens, Tan & Więcek, 2023, working paper) — underscoring the role of external, including carbon, finance in closing the affordability gap.

S.5.4 | Behavioural barriers to autonomous adoption

The low demand documented in Section 5.3 is not explained by income alone; it reflects systematic behavioural factors identified across the preventive-health and household-energy literatures. These barriers explain why a purely market-based or unsubsidised model does not, and would not, achieve adoption and sustained use among the target population.

- a. | **Low salience of an invisible risk:** Microbiological water contamination, like indoor air pollution, is not directly perceptible. Households frequently do not perceive it as a significant health hazard and do not prioritise it over visible, immediate developmental needs (Mobarak et al., 2012; Ahuja, Kremer & Zwane, 2010).
- b. | **Upfront-cost aversion and present bias:** The costs of treatment are immediate and certain, whereas the benefits — avoided diarrhoeal disease — are future and probabilistic. Households therefore systematically under-invest in preventive health, a pattern repeatedly observed in pricing experiments (Cohen & Dupas, 2010; Ahuja, Kremer & Zwane, 2010).
- c. | **Reliance on a free, habitual baseline:** Households overwhelmingly rely on a free baseline practice — untreated water, or boiling on an existing cooking fire — and are consequently unwilling to pay much for a new technology. This was shown directly for the closely analogous case of improved cookstoves, where reliance on a free traditional stove drove very low willingness-to-pay for cleaner alternatives (Mobarak et al., 2012).
- d. | **Sustained-use and maintenance failure:** Even where an efficacious technology is provided, behaviour can undermine its impact: in a four-year randomised follow-up, households used a laboratory-validated improved stove irregularly and inappropriately, failed to maintain it, and usage declined over time, so that the initial benefits dissipated (Hanna, Duflo & Greenstone, 2016).

The same risk applies to household water treatment, whose health benefits depend on consistent, correct, sustained use.

- e. | **Behavioural self-targeting:** A small, non-monetary effort to obtain a free product — such as redeeming a voucher — itself screens for genuine users, because those unwilling to take even a costless action are unlikely to use the product. This allows interventions to reach and target likely users without imposing a price barrier (Dupas, Hoffmann, Kremer & Zwane, 2016).

S.5.5| Improved-cookstove parallel

The additionality case for SWS closely mirrors the established case for improved cookstoves under the reduced-emissions-from-cooking-and-heating methodologies, and the parallel is instructive because the cookstove evidence base is the more mature.

In both sectors, an efficacious, emissions-reducing household technology must displace a free, habitual, biomass-fuelled baseline. In both, randomised evidence shows low demand, low willingness-to-pay, low perception of the underlying health risk, and reliance on the free baseline (Mobarak et al., 2012). In both, the realised emission and health benefits depend on sustained correct use, which behaviour can undermine and which therefore requires programme support rather than one-off provision (Hanna, Duflo & Greenstone, 2016). The deemed-additionality logic accepted for improved cookstoves applies with at least equal force to safe drinking water: willingness-to-pay for water treatment is no higher than for cookstoves, and the displaced baseline (boiling, or untreated consumption) is likewise free.

Recent evidence keeps this parallel current. A 2022 umbrella review of improved-cookstove and clean-fuel adoption across low- and middle-income countries finds that, despite abundant evidence, adoption efforts have repeatedly disappointed, with affordability and behavioural barriers decisive and some 2.6 billion people still reliant on solid fuels (Boudewijns et al., 2022) — the same configuration of barriers this methodology confronts for water.

S.5.6| Delivery models and the role of carbon finance

The additionality of these activities does not depend on free distribution specifically. It follows from the financial non-viability of supplying the technology to the target population at a cost-recovering price, given the low willingness-to-pay established in §5.3. Carbon finance functions as a subsidy that bridges the gap between the full delivered cost of the technology and the price the target households are willing and able to pay. This reasoning holds across the delivery models used in practice.

- a. | **Free distribution:** The technology is provided at no charge; the activity earns no beneficiary revenue and depends on carbon (and any grant) finance. Uptake is maximised, consistent with the finding that free, convenient provision achieves the highest sustained take-up (Ahuja, Kremer & Zwane, 2010; Cohen

& Dupas, 2010). Recent randomised trials evidence this directly: free coupons and non-price vouchers achieve sustained uptake and large child-health gains at high cost-effectiveness, and the redemption step self-targets likely users (Dupas et al., 2016, 2023).

- b. | **Carbon-subsidised (below-cost) sales:** The technology is sold below its full delivered cost, with carbon revenue covering the shortfall. A modest co-payment may be retained for behavioural reasons — to screen for likely users or to confer ownership — but, given the steep price-sensitivity of demand, the price must remain well below cost to achieve meaningful uptake, and the activity does not recover its full cost from beneficiaries (Ashraf, Berry & Shapiro, 2010; Berry, Fischer & Guiteras, 2020). Consistent with this, recent home-delivery trials show that low prices still permit very high take-up (over 90%), while higher prices — though they can be privately profitable — sharply curtail uptake (Burlig, Jina & Sudarshan, 2025, working paper).
- c. | **Results-based and instalment models:** Carbon revenue is disbursed against verified delivery or sustained use, or underwrites consumer financing (instalments, micro-credit) that the affordability constraint would otherwise preclude. In each case the activity remains dependent on carbon finance to close the affordability gap.

What unifies these models — and what the eligibility criteria capture — is not the absence of any beneficiary payment but the absence of full cost recovery: the target households cannot, at a price they will pay, fund the delivered cost of the technology, and carbon finance is necessary to bridge that gap. The case for subsidy is the central conclusion of the safe-water evaluation literature, answered in the affirmative given low willingness-to-pay and the public-health externalities of safe water (Ahuja, Kremer & Zwane, 2010).

Conversely, where an activity does achieve full cost recovery from beneficiaries — for example, a tariff-funded community water system that is financially viable without carbon finance — the financial-non-viability basis does not hold and additionality cannot be deemed; such activities are directed to the standard investment-analysis route. This articulation is consistent with the treatment of delivery models in the reduced-emissions-from-cooking-and-heating methodologies, under which free distribution, subsidised sales and results-based models are each eligible provided the activity is not financially viable without carbon finance.

S.5.7| Derivation of the deemed-additionality eligibility criteria

The criteria applied in methodology Annex B follow directly from the analysis above. Each criterion, and its basis, is set out below.

- a. | **Criterion 1 — Eligible technology:** The positive list comprises the efficacious, baseline-displacing point-of-use and non-cost-recovering technologies for which the demand, behavioural and delivery evidence has been established

(section 5.3–5.6): household and institutional water treatment (ceramic and biosand filters, membrane and ultraviolet units, chlorination, solar disinfection) and non-cost-recovering community dispensers.

- b. | **Criterion 2 — Eligible context:** The activity must serve a population that lacks safely managed drinking water at baseline (Section 5.2) and is low-income (the affordability driver of low demand, section 5.3–5.4). Tier 1 (LDCs and SIDS) reflects the lowest-coverage, special-treatment contexts; Tier 2 (other eligible developing-country host Parties) applies the host-Party national poverty line and the section 6.7 common-practice test, the latter capturing the low observed penetration that the low demand produces.
- c. | **Criterion 3 — Financial condition (no full cost recovery):** The operative financial test, broadened beyond free distribution per section 5.6: the activity must not achieve full cost recovery from beneficiaries, such that carbon finance is necessary to bridge the affordability gap. This is the methodology-level expression of the financial non-viability that places the activity types on the positive list (Section 5.7).
- d. | **Criterion 4 — Regulatory condition:** The activity must not be mandated by enforced law or binding policy, consistent with the regulatory-surplus requirement; a mandated activity is not additional.

Table 18. Mapping of evidence to the deemed-additionality criteria

Criterion (methodology Annex B)	Evidentiary basis (this section)
1. Eligible technology	Efficacious baseline-displacing POU/non-cost-recovering technologies covered by the demand and delivery evidence (§5.3–§5.6)
2. Eligible context (low access; low-income; below common practice)	Regional access deficit (§5.2); affordability as the driver of low demand (§5.3–§5.4); low penetration as the observed consequence
3. No full cost recovery	Delivery-model analysis (§5.6) and the financial-non-viability/positive-list mechanism (§5.7)
4. Not mandated	Regulatory surplus (additionality first principles)

Cross-reference — The normative statement of these four criteria, the Positive List table and the application procedure are in methodology Annex 5. This section is their evidentiary basis and is not itself normative.

S.5.8| References

Ahuja, A., Kremer, M., & Zwane, A. P. (2010). Providing safe water: Evidence from randomized evaluations. *Annual Review of Resource Economics*, 2(1), 237–256. <https://doi.org/10.1146/annurev.resource.012809.103919>

- Amrose, S., Burt, Z., & Ray, I. (2015). Safe drinking water for low-income regions. *Annual Review of Environment and Resources*, 40, 203–231. 10.1146/annurev-environ-031411-091819
- Ashraf, N., Berry, J., & Shapiro, J. M. (2010). Can higher prices stimulate product use? Evidence from a field experiment in Zambia. *American Economic Review*, 100(5), 2383–2413. <https://doi.org/10.1257/aer.100.5.2383>
- Berry James & Fischer Greg & Guiteras Raymond, 2020. "Eliciting and Utilizing Willingness to Pay: Evidence from Field Trials in Northern Ghana," *Journal of Political Economy*, University of Chicago Press, vol. 128(4), pages 1436-1473..
- Boudewijns, E. A., Trucchi, M., van der Kleij, R. M. J. J., Vermond, D., Hoffman, C. M., Chavannes, N. H., et al. (2022). Facilitators and barriers to the implementation of improved solid fuel cookstoves and clean fuels in low-income and middle-income countries: An umbrella review. *The Lancet Planetary Health*, 6(7), e601–e612. [https://doi.org/10.1016/S2542-5196\(22\)00094-8](https://doi.org/10.1016/S2542-5196(22)00094-8)
- Burlig, F., Jina, A., & Sudarshan, A. (2025). The value of clean water: Experimental evidence from rural India. Becker Friedman Institute Working Paper No. 2025-40. [Working paper.] bfi.uchicago.edu/working-paper/2025-40
- Cohen, J., & Dupas, P. (2010). Free distribution or cost-sharing? Evidence from a randomized malaria prevention experiment. *Quarterly Journal of Economics*, 125(1), 1–45. <https://academic.oup.com/qje/article-abstract/125/1/1/1880305>
- Dupas, P., Hoffmann, V., Kremer, M., & Zwane, A. P. (2016). Targeting health subsidies through a nonprice mechanism: A randomized controlled trial in Kenya. *Science*, 353(6302), 889–895. <https://doi.org/10.1126/science.aaf6288>
- Dupas, P., Nhlema, B., Wagner, Z., Wolf, A., & Wroe, E. (2023). Expanding access to clean water for the rural poor: Experimental evidence from Malawi. *American Economic Journal: Economic Policy*, 15(1), 272–305. <https://doi.org/10.1257/pol.20210121>
- Hanna, R., Duflo, E., & Greenstone, M. (2016). Up in smoke: The influence of household behavior on the long-run impact of improved cooking stoves. *American Economic Journal: Economic Policy*, 8(1), 80–114. <https://doi.org/10.1257/pol.20140008>
- Kremer, M., Luby, S., Maertens, R., Tan, B., & Więcek, W. (2023). Water treatment and child mortality: A meta-analysis and cost-effectiveness analysis. NBER Working Paper No. 30835. [Working paper.] <https://doi.org/10.3386/w30835>
- Mobarak, A. M., Dwivedi, P., Bailis, R., Hildemann, L., & Miller, G. (2012). Low demand for nontraditional cookstove technologies. *Proceedings of the National Academy of Sciences*, 109(27), 10815–10820. <https://doi.org/10.1073/pnas.1115571109>
- Daniel, D., Marks, S.J., Pande, S. et al. Socio-environmental drivers of sustainable adoption of household water treatment in developing countries. *npj Clean Water* 1, 12 (2018). <https://doi.org/10.1038/s41545-018-0012-z>.

WHO/UNICEF Joint Monitoring Programme. (2023). Progress on household drinking water, sanitation and hygiene 2000–2022: Special focus on gender. WHO & UNICEF.

WHO/UNICEF Joint Monitoring Programme. (2025). Progress on household drinking water, sanitation and hygiene 2000–2024: Special focus on inequalities. WHO & UNICEF.

World Bank. (2017). Reducing inequalities in water supply, sanitation, and hygiene in the era of the SDGs: WASH Poverty Diagnostic synthesis report. World Bank Group.

World Bank. (2025). June 2025 global poverty update: 2021 PPPs and new global poverty lines. World Bank Group.

.