REDUCTION ROADMAP FINLAND 1.0

Background Report

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Reduction Roadmap

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1. Introduction

1.1 Background for the roadmap

The Reduction Roadmap Finland establishes an absolute, science-based emission reduction target for Finland's built environment. Modelled on the Danish Reduction Roadmap 3.0 framework (2026), the Finnish roadmap translates global climate science and planetary boundary research into explicit greenhouse gas (GHG) allowance limits for construction activities. Rather than relying on incremental or relative percentage reductions from historical benchmarks, the roadmap calculates the remaining carbon budget compatible with international climate agreements and downscales this budget directly to national building typologies.

1.2 Urgency of climate action in the built environment

Global warming is projected to exceed 1.5 °C within the next few years under current trajectory models, driving global mean temperature rise beyond 2.6 °C by 2100 in the absence of rapid mitigation (UNEP, 2026). The remaining global carbon budget to limit warming to 2.0 °C with a 67% likelihood stood at approximately 860 GtCO2 at the beginning of 2026 (Forster et al., 2026). At the global level, the building and construction sector faces a dual imperative: a growing global population will need approximately 2 billion new affordable and safe homes by the end of the century. Simultaneously, emissions from construction need to be brought down by 80–90% (UNEP & GlobalABC, 2026). These two trajectories are pulling in opposite directions.

1.3 Institutional and policy context

Finland maintains the European Union's most ambitious statutory target, aiming for national climate neutrality by 2035 and carbon negativity thereafter (Climate Act 423/2022). However, achieving this target faces severe headwinds. In 2024, Finland's land use, land-use change, and forestry (LULUCF) sector transitioned from a historic carbon sink into a net emissions source of 13.5 MtCO2e (Statistics Finland, 2026). With natural carbon sinks diminished, emissions from active economic sectors—most notably the built environment—must decline significantly faster than previously assumed.

The built environment generates approximately 30% of Finland's national GHG emissions, distributed in most years evenly across three operational spheres: new construction (~1/3), building renovation (~1/3), and infrastructure works (~1/3). Statutory limit values enacted under Government Decree 2/2026 stipulate maximum whole-life carbon emissions for select building types starting in 2026. However, these legal limits were formulated through political negotiations rather than carbon budget constraints and are insufficiently ambitious to guarantee alignment with safe climate thresholds (Koskela & Tiainen, 2025). Furthermore, annual state monitoring via the Medium-Term Climate Plan does not isolate the built environment as a standalone sector, necessitating external scientific initiatives such as the Reduction Roadmap.

2. Methodological framework

2.1 Top-down allocation

This roadmap employs – similarly to the Danish one – a top-down allocation methodology that cascades from global planetary limits down to individual building square metres. The calculation follows four sequential stages:

1. **Global carbon budget & Safe Operating Space:** Identifying the total cumulative CO2 emissions quota and annual sustainable flow rate defined by international Earth system science.
2. **National population downscaling:** Allocating Finland's fair share of the global budget based on an egalitarian equal-per-capita distribution principle.
3. **Sectoral budget allocation:** Reserving a portion of Finland's national carbon budget for the construction sector via the “grandfathering” (acquired rights) principle. In other words, each sector inherits a similar relative share of emissions as before.
4. **Typological limits per square metre:** Dividing the cumulative construction carbon budget by projected gross floor area (GFA) production to yield maximum allowable emissions caps in kgCO2e/m²/year.

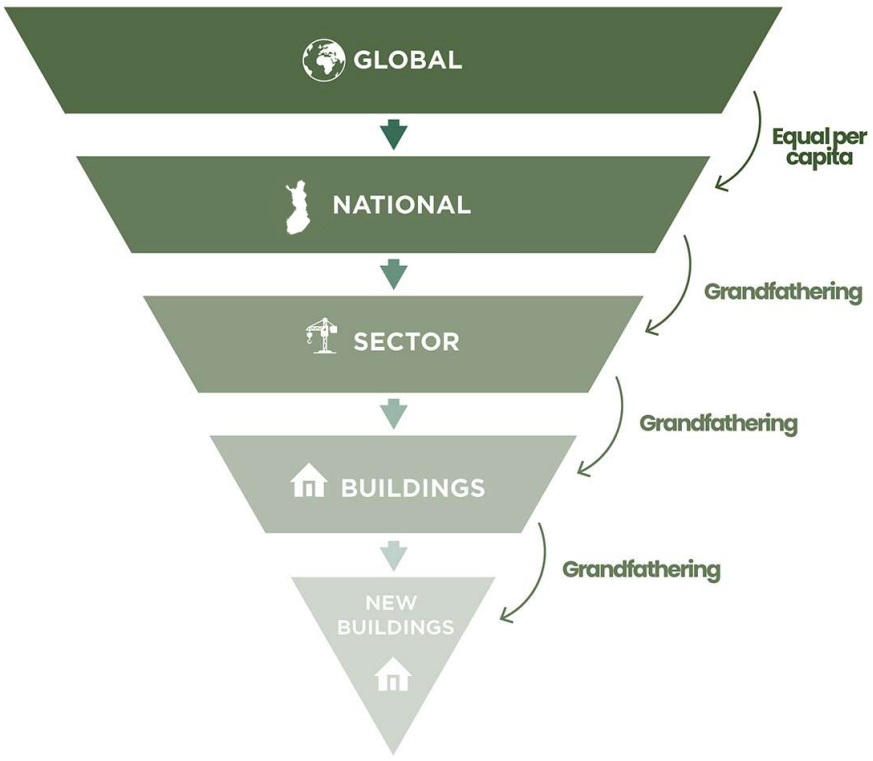


Figure 1. *Top-down allocation process (adapted from Reduction Roadmap Denmark).*

Translating the global limits to sub-national scales follows two choices, as in the Danish roadmap:

1. **Egalitarian principle (equal-per-capita):** In this approach, every human being on Earth is entitled to an equal share of the remaining global emissions space. This principle governs the division of the global carbon budget between nations.
2. **Grandfathering principle (acquired rights):** Sectors retain their historical relative proportion of national emissions. In Finland, new construction historically accounts for approximately 8% of total national emissions (or 25% of built environment emissions). Grandfathering assumes this share remains constant during budget allocation.

There are also other ways of allocating global, national, or sectoral carbon budgets (see section 4). Here, we follow the above-described approach of the Danish Reduction Roadmap for comparability.

2.2 Global carbon budgets and safe operating space

The remaining carbon budgets are based on the climate system indicators published by Forster et al. (2026). Table 1 presents the updated remaining global CO_2 budgets from the start of 2026 across various temperature thresholds and exceedance probabilities.

While cumulative carbon budgets define finite allowances towards a temperature cap, the safe operating space defines the maximum continuous annual emission flow rate compatible with long-term planetary stability (Rockström et al., 2009; Richardson et al., 2023). Based on Earth system downscaling by Petersen et al. (2025), the global safe operating space for all human greenhouse gas emissions is quantified at 2.51 $GtCO_2e$/year at a 95% confidence level.

When the 2.51 $GtCO_2e$ annual global budget for a safe operating space is partitioned among atmospheric gases, long-lived CO2 accounts for only 1% of the long-term regenerative allowance, with methane (67%) and nitrous oxide (14%) consuming the vast majority to prevent runaway forcing. Because the building construction footprint consists almost entirely of fossil energy and industrial CO2 from material manufacturing, the long-term regenerative emission budget for construction approaches zero. Consequently, building construction must reach net-zero fossil emissions rapidly.

The Paris Agreement legally commits signatories to hold warming well below 2.0 °C while pursuing efforts to cap warming at 1.5 °C. In this roadmap, the core reference scenario is established as the 1.5 °C target at 67% probability. In this scenario, the global remaining emissions budget was 80 $GtCO_2$ at the beginning of 2026. Considering the shrinking budget windows, alternative pathways for 1.7 and 2.0 °C are also modelled to illustrate the severity of delayed regulatory action.

Table 1. *Remaining global carbon budgets from beginning of 2026 in $GtCO_2$ across temperature limits and likelihoods without an overshoot (Forster et al., 2026).*

Temperature target	Probability range				
	17%	33%	50%	67%	83%
1.5°C global warming	340	210	130	80	30
1.7°C global warming	930	650	500	390	300
2.0°C global warming	1800	1310	1050	860	690

2.3 Allocation to Finland's population

Finland's current population of 5.51 million is projected by the United Nations to evolve so that it represents approximately 0.061% of the global population over the 2026–2050 period (UN, 2026). Hence, applying the egalitarian equal-per-capita allocation grants Finland 0.061% of the remaining global carbon budget. This translates into different national carbon budgets depending on the targeted global warming limit and probability rate, as shown in Table 2.

For this roadmap, we have selected to base the calculations on a 67% probability rate. Higher certainty would tighten and lower certainty loosen the remaining carbon budget.

***Table 2**. Calculated Finnish national carbon budgets from 2026 in $MtCO_2$ based on an egalitarian allocation.*

Temperature target	Carbon budget for Finland following different probability rates (MtCO2)				
	17%	33%	50%	67%	83%
1.5°C global warming	207	128	79	49	18
1.7°C global warming	567	397	305	240	183
2.0°C global warming	1098	799	641	525	421
				Selected for this roadmap	

2.4 Allocation to the Finnish construction sector and floor area

Based on mean historical rates from 2015–2025, approximately 7.0 million m² of gross floor area (GFA) are built per year (Statistics Finland, 2026). Residential and industrial buildings contribute to the largest share of the annual new construction (Table 3), and we assume that construction volumes as well as distribution between different building types will remain constant over the coming decades.

To establish the baseline, we have used a comprehensive sample of 2 120 buildings constructed in Finland between 2020 and 2024 from a report to the Ministry of the Environment by One Click LCA (2024). By combining this dataset with annual construction statistics, we construct a robust baseline of 4.3 $MtCO_2e$/year for construction in Finland by multiplying the 5.25 Mm^2 heated floor area of new construction (converted from 7.0 Mm^2 of GFA with a statistical conversion factor derived from the RYHTI database) by the median whole-life carbon emissions of 816 $kgCO_2e/m^2$ (One Click LCA, 2024).

Finland's total annual territorial greenhouse gas emissions stood at 49 $MtCO_2e$ in 2024 (Statistics Finland, 2026), while the national consumption-based carbon footprint reached 52 $MtCO_2e$ (Eurostat, 2026). By dividing the median whole-life carbon emissions by Finland's consumption-based emissions, we arrive at an allocation of roughly 8% of the national carbon budget reserved for new construction, which reflects the construction sector's historical contribution to national GHG emissions. This share also correlates with previous research findings (Ottelin et al., 2021).

2.5 Allocation and reduction scenarios for building types

Finally, we define a reduction roadmap towards a safe operating space for different building types, which is different for each building type. We do this by multiplying Finland's annual total carbon budget and building-type-specific share of the construction sector's annual new construction emissions (from One Click LCA, 2024) and dividing this outcome by the projected annual construction area of the building type in question.

For the roadmap, we have estimated an exhaustion time for the carbon budgets. This has been done by assuming a linear reduction from two different starting points: the legal limit value of 2026, and the median carbon footprint from the One Click LCA report (2024). The linear reduction has been calculated by determining the constant annual decrease in emissions intensity ($kgCO_2/m^2/a$) required to reach the safe operating space without exceeding the allocated cumulative carbon budget.

To exemplify the annual reduction needs, we compare these results to building-type-specific legal limit values for 2026 and 2029 (Valtioneuvosto, 2026). We also compare the results to the low carbon construction roadmap of the Confederation of Finnish Construction Industries, which describes a baseline and an innovative path to emission reductions (Laine et al., 2024).

***Table 3**. Annual new floor areas, whole life carbon median and limit values ($kgCO_2e/m^2/a$) for different building types.*

Building type	Share of annual GFA	GHG median 2024	GHG limit 2026	GHG limit 2029
1 Attached and row houses*	22%	14	16	12
2 Apartment Blocks	25%	14	16	13
3 Offices	2%	19	20	17
4 Retail, wholesale and cultural buildings	3%	20	22	18
5 Hotels, hostels and dormitories	3%	23	25	22
6 Educational buildings, day care, schools	6%	20	20	16
7 Sports halls	1%	19	21	18
8 Hospitals and healthcare	3%	27	29	28
9 Warehouses, industrial, logistics	20%	17	24	21
9 Swimming halls, ice halls	1%	22	24	21
9 Other buildings	15%	16**	19**	16**

** Includes single-family and leisure homes.*
*** Weighted average of all other building types*

The above-described robust method of the Reduction Roadmap has uncertainties and development needs, which are described in section 4.

3. Results for Finnish new construction

3.1 Depletion timelines and required reductions

Should Finnish construction continue at baseline emission levels without immediate mitigation, new building construction will exhaust its entire Paris-aligned carbon budget in an alarmingly short period. If a 67% probability rate is accepted, the carbon quota for 1.5 degrees will run out in one year, and for 2 degrees in 10 years. However, with a linear reduction rate these exhaustion times effectively double (Table 4).

***Table 4**. Carbon budget depletion timelines and required annual emission reduction trajectories for Finnish new building stock.*

All new buildings	**Target threshold for global warming** (67% probability)		
	1.5°C	**1.7°C**	**2.0°C**
Remaining carbon budget (MtCO2)	4.0	19.7	43.5
Exhaustion time, baseline without action (years)	< 1	4	10
Exhaustion time, linear reduction (years)	1	9	20
Required annual reduction from baseline ($kgCO_2/m^2/a$)	Not achievable	2	0.8
Required annual reduction from limit values ($kgCO_2/m^2/a$)		2.8	1.2

To limit warming to 1.5 °C with a 67% likelihood, baseline emissions from new construction must decrease directly to the safe operating space of 0.5 $kgCO_2/m^2/a$, due to the vanishingly small remaining emission budget. For a 1.7 °C goal, the annual required reduction would be 2 $kgCO_2/m^2/a$. For 2.0 °C, baseline emissions need to decline by 0.8 $kgCO_2/m^2/a$ annually until 2045.

However, applying a single uniform limit value across all building types is sub-optimal because structural requirements, operational profiles, and decarbonisation potentials vary significantly between building uses and typologies. Differentiating limit values ensures that easier-to-decarbonise typologies achieve deeper reductions, relieving pressure on complex structures while preserving the national average target.

3.2 Results for different building types

3.2.1 Reduction scenarios

If the construction volumes of different building types were to remain in the range relative to the previous decade, carbon budgets can be presented for each typology following an emission quota compatible with 1.5, 1.7 or 2.0 degrees of global warming (Table 5).

Table 5. *Remaining carbon budget for the construction of different building types in Finland.*

Building type	Remaining total carbon budget		
	1.5°C	1.7°C	2.0°C
1 Attached and row houses	0.8 $MtCO_2$	3.7 $MtCO_2$	8.1 $MtCO_2$
2 Apartment Blocks	0.9 $MtCO_2$	4.2 $MtCO_2$	9.2 $MtCO_2$
3 Offices	0.1 $MtCO_2$	0.5 $MtCO_2$	1.1 $MtCO_2$
4 Retail, wholesale and cultural buildings	0.1 $MtCO_2$	0.6 $MtCO_2$	1.4 $MtCO_2$
5 Hotels, hostels and dormitories	0.2 $MtCO_2$	0.7 $MtCO_2$	1.6 $MtCO_2$
6 Educational buildings, day care, schools	0.3 $MtCO_2$	1.3 $MtCO_2$	3.0 $MtCO_2$
7 Sports halls	0.05 $MtCO_2$	0.2 $MtCO_2$	0.5 $MtCO_2$
8 Hospitals and healthcare	0.2 $MtCO_2$	1.0 $MtCO_2$	2.2 $MtCO_2$
9 Warehouses, industrial, logistics	0.9 $MtCO_2$	4.2 $MtCO_2$	9.2 $MtCO_2$
9 Swimming halls, ice halls	0.1 $MtCO_2$	0.3 $MtCO_2$	0.6 $MtCO_2$
9 Other buildings	0.6 $MtCO_2$	3.0 $MtCO_2$	6.5 $MtCO_2$

3.2.2 Results for apartment blocks

Apartment blocks represent the largest share of annually built floor area that falls within the scope of GHG limit values. Their emission reduction pathways are presented in Table 6 and Figure 2. The timeframe for reductions extends from 1 year (for a 1.5-degree goal) to 20 years (for a 2.0-degree allowance).

The reduction rate has been calculated using the median carbon footprint of 14 $kgCO_2/m^2/a$ (One Click LCA, 2024), which is lower than the legal limit of 16 kg. The latter value exceeds the carbon budget for 2 degrees of global warming, and it is notable that lower limit values were proposed already in an earlier study to the Ministry of the Environment (2024). Those would have been in line with 1.7 or 1.8 degrees of global warming. If current limit values remain unchanged, our results indicate that the maximum limit value for 2032 should not exceed 6.0 $kgCO_2/m^2/a$. Only then, the regulation would comply with 2 degrees of global warming.

3.2.3 Results for educational buildings

Educational buildings consist mostly of schools and daycare centres. These are typically realised through public procurements, which would enable the use of efficient public climate policy. As shown in Table 7 and Figure 3, the remaining reduction time frame extends from 1 to 20 years, according to the climate change mitigation target between 1.5 and 2.0 degrees. Some cities, such as Tampere and Vantaa, have set stricter requirements for their educational buildings. These comply with a 1.7 global warming limit and with the recommendation from the report to the Ministry of the Environment by One Click LCA (2024) that suggested clearly lower limit values than required by regulation.

***Table 6**. Carbon budgets for apartment blocks ($kgCO_2e/m^2/a$).*

Year	Target threshold for global warming (67% probability)					
	1.5°C	1.6°C	1.7°C	1.8°C	1.9°C	2.0°C
2026	14.0	14.0	14.0	14.0	14.0	14.0
2027	0.5	11.0	12.3	12.8	13.1	13.3
2028	0.5	8.0	10.6	11.7	12.2	12.5
2029	0.5	5.0	8.9	10.5	11.3	11.8
2030	0.5	2.0	7.2	9.3	10.4	11.1
2031	0.5	0.5	5.4	8.2	9.5	10.4
2032	0.5	0.5	3.7	7.0	8.6	9.6
2033	0.5	0.5	2.0	5.8	7.7	8.9
2034	0.5	0.5	0.5	4.6	6.8	8.2
2035	0.5	0.5	0.5	3.5	5.9	7.5

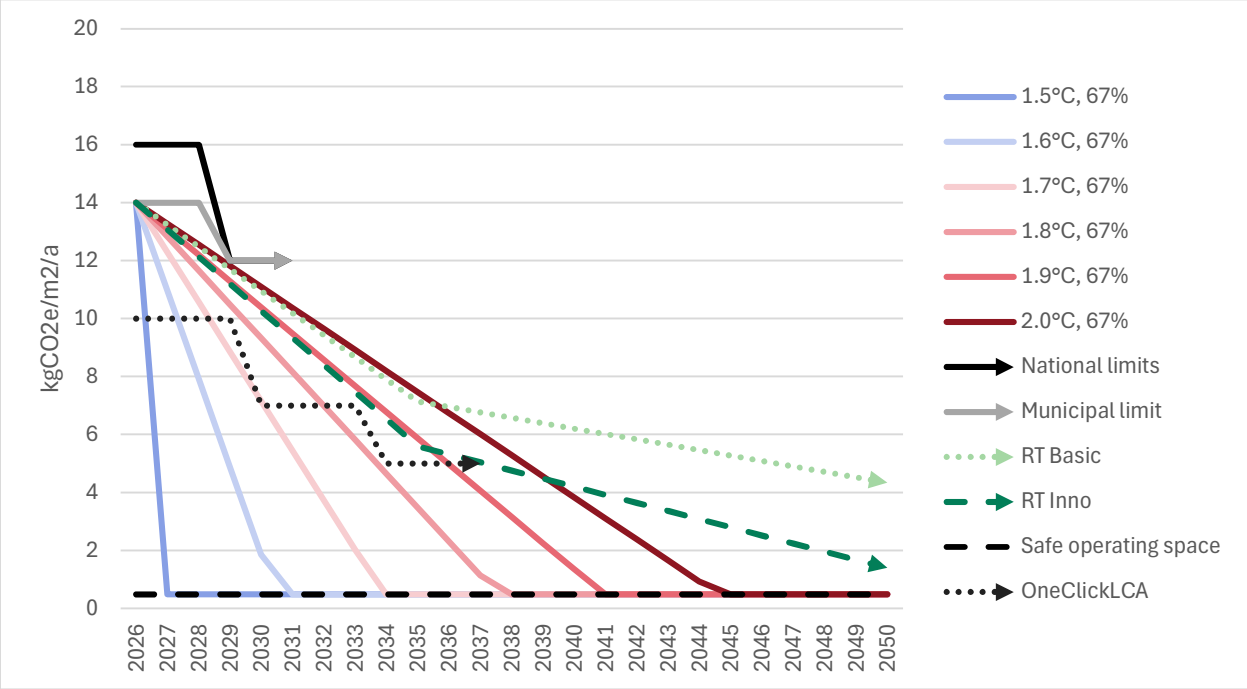


Figure 2. Reduction trajectories for Finnish apartment blocks.

***Table 7**. Carbon budgets for educational buildings ($kgCO_2e/m^2/a$).*

Year	Target threshold for global warming (67% probability)					
	1.5°C	1.6°C	1.7°C	1.8°C	1.9°C	2.0°C
2026	20.0	20.0	20.0	20.0	20.0	20.0
2027	0.5	15.7	17.6	18.3	18.7	19.0
2028	0.5	11.3	15.1	16.7	17.4	18.0
2029	0.5	7.0	12.7	15.0	16.1	16.9
2030	0.5	2.6	10.2	13.3	14.8	15.8
2031	0.5	0.5	7.8	11.6	13.5	14.8
2032	0.5	0.5	5.3	10.0	12.3	13.8
2033	0.5	0.5	2.9	8.3	11.0	12.7
2034	0.5	0.5	0.5	6.6	9.7	11.7
2035	0.5	0.5	0.5	5.0	8.4	10.6

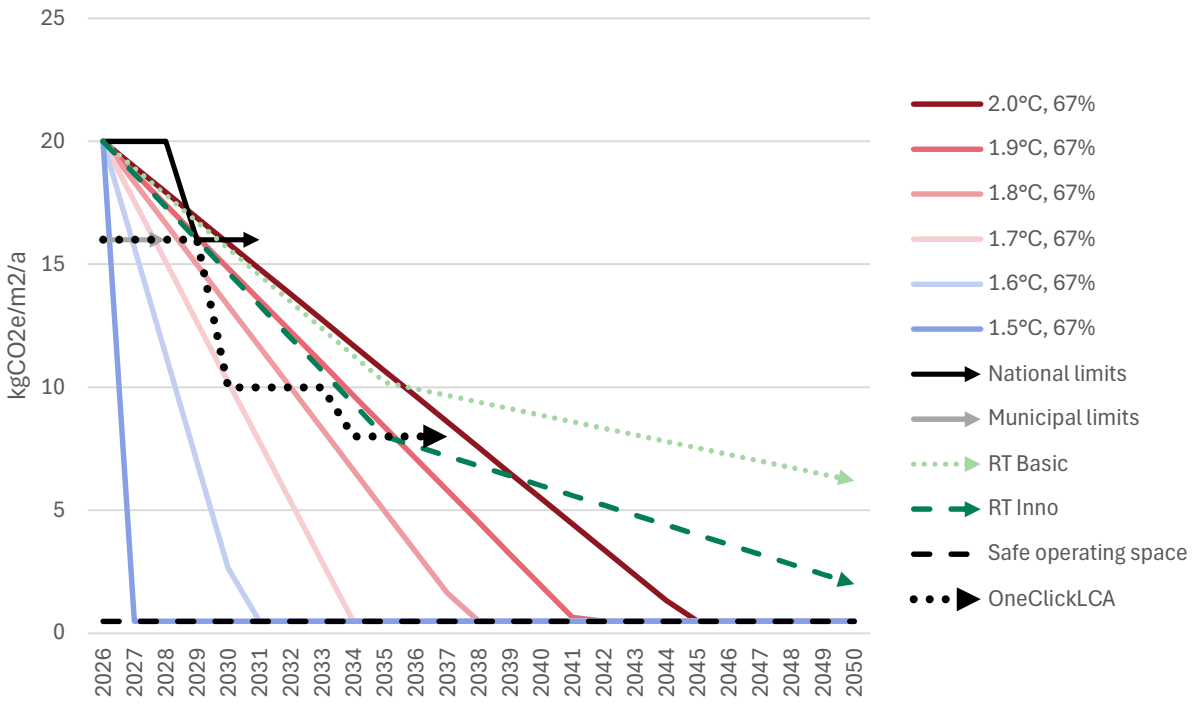


Figure 3. Reduction trajectories for Finnish educational buildings.

4. Limitations, uncertainties, and development needs

4.1 Allocation methods and budget priorities

The allocation methods used are prone to errors and debate. It is not possible to know precisely how global population, emissions, construction volumes, and production methods of construction products change as a function of time. In addition, the remaining carbon budgets are tied to ongoing pollution rates, as well as to the findings of climate science related to climate feedback and tipping points. Hence, the budget is a robust annual estimation that needs to be updated regularly. For reference, the Danish Reduction Roadmap has already been updated three times.

In addition to the equal-per-capita allocation applied in this roadmap, it is arguable that some other allocation method should be used. Several alternatives have been developed for different purposes, stemming from different starting points. These include, for example, historical emissions and consequent “climate debt”, capability for reduction measures, utilitarian allocation to most important societal needs, and so on. Choosing another allocation method would change or complement the results of this calculation (see e.g., Steininger et al., 2020).

A fundamental limitation of the grandfathering allocation principle is that it assumes historical sector proportions should persist indefinitely. This could lock development into a path dependency that might limit needed societal transformation. Whereas the grandfathering allocation approach is straightforward and makes robust allocations possible, it fails to evaluate social essentiality. Critical sectors such as food production, healthcare, or security require baseline carbon allocations to maintain human life, whereas all unconstrained new construction may not be equally essential. Future iterations of the roadmap need to explore reserving carbon budget shares for essential societal functions before distributing remaining allowances to construction.

4.2 Methodological harmonisation of CO2 vs CO2e

A critical methodological challenge involves gas metric alignment. Global carbon budgets from climate physics are measured exclusively in CO_2 mass, whereas building life cycle assessment (LCA) standards measure multi-gas greenhouse impact in CO_2-equivalent (CO_2e). Furthermore, short-lived climate pollutants (methane and nitrous oxide) dominate agricultural and waste budgets but represent a minor fraction of building material supply chains. These gas conversion factors are adjusted to ensure whole-life carbon accounting remains scientifically sound.

4.3 Production-based versus consumption-based accounting

A significant divergence exists between national environmental reporting conventions. Production-based territorial accounting (used in UNFCCC reporting) tracks emissions physically generated within Finnish borders. In contrast, consumption-based accounting applies Input-Output LCA to encompass imported construction materials and global supply chains. Building LCA standards (EN 15978) utilise process-based LCA. These perspectives are harmonised by calibrating building LCA limits against consumption-based national benchmarks.

4.4 Discrepancy between the national LCA method and top-down carbon budget

The safe operating space follows a top-down, holistic carbon budgeting. In contrast, the legally required national assessment method excludes several parts of a building's life cycle, such as maintenance (life cycle module B2), refurbishment (B5), or use of water (B7). Furthermore, the standardised LCA method only accounts for the first 50 years of a building's life cycle, due to growing uncertainty that is related to future repair and energy scenarios.

In addition, foundations, stabilisation, infrastructure connections, groundworks, parking facilities and many other important and carbon-intensive constituents are ruled out of the physical system boundary of the national assessment method. Limitations like these are not Finland-specific, but stem from the practical limitations of life cycle assessment and its application in European regulation.

For the purposes of this roadmap, we have addressed this limitation by building the model so that the truncated life cycle emissions – following the national assessment method – are used for defining the safe operating space. Hence, the roadmap matches the legally defined system boundary.

4.5 Carbon removals and carbon negativity

Finland's Climate Act mandates that the nation must become carbon negative during the 2040s. Achieving negative emissions requires active atmospheric carbon dioxide removal (CDR), as Finland's land-use sector has become a net source of emissions. Therefore, different societal sectors, construction included, will probably face the need to transition from being a carbon source to a net carbon sink in the coming decades. This, in turn, may lead to sectoral CDR requirements. In the future revisions of this roadmap, means for achieving carbon negativity need to be addressed and corresponding accounting methods selected.

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