LUXEMBOURG SOVEREIGN SUSTAINABILITY BOND

GREEN PROJECTS

Methodological guide for the estimation of positive environmental impacts

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Prepared for the Luxembourg Sustainability Bond Committee

by

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Ministry of Environment, Climate and Sustainable Development, Department for Climate and Sustainable Development; Department for Natural Resources, Water and Forests; Finance Department

Water Management Administration

Environment Administration

Ministry of Mobility and Public Works, Department for Mobility and Transport, Accounting Department

Ministry of Energy, Department for Energy Efficiency

Ministry of Housing, expert for sustainable housing

Société Nationale des Chemins de Fer Luxembourgeois, Department for Infrastructure Management

Luxtram, Department for new lines

SEBES and waste water treatment stations, leading engineers and directors

City of Luxembourg, experts; engineering consultants TR Engineering

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Abbreviations

ASIF	Activity, modal Structure, Intensity of fuel use, Fuel carbon content
BOD	Biological oxygen demand
CFL	Société National des Chemins de Fer Luxembourgeois
COD	Chemical oxygen demand
CO_2e	Carbon dioxide equivalent
EC	European Commission
EPC	Energy performance certificate
EU	European Union
GHG	Greenhouse Gas
HBEFA	Handbook of Emission Factors for Road Transport
HMWB	Heavily modified water body
ICMA	International Capital Market Association
I_2M_2	Multimetric Macroinvertebrate Index
ITU	Intermodal Transport Unit
KPI	Key Performance Indicator
kWh	Kilowatt-hour
LENOZ	Luxembourg Sustainability Certificate for Residential Buildings
NECP	National integrated Energy and Climate Plan
NOx	Nitrous oxide
N_{tot}	Total Nitrogen
NZEB	Nearly zero-energy building
O_2	Oxygen
PED	Primary energy demand
pkm	Passenger-kilometer
P_{tot}	Total Phosphorous
PM	Particulate matter
t	Tonne
THM	Trihalomethanes
TI	Thermal insultation
tkm	Tonne-kilometer
TSS	Total suspended solids

Overview of indicators

Indicator ID & Name	Unit of measurement
Transport sector	
TCM1: Number of low carbon vehicles available and deployed	Number of vehicles
TCM2.1: Number of users served on new tram and train lines	Number of users/year
TCM2.2: Number of additional passengers transferred through the upgraded train stations from rail to rail or from other modes to rail, max capacity	Number of users/year
TCM2.3: Number of additional trains entering train station	Number of trains/year
TCM3: Length of new tram lines / new rail lines built	Kilometers
TCM4: Passenger-kilometers on additional low carbon transport infrastructure	pkm or tkm
TCM5.1: Modal shift passengers or freight Number of passenger-kilometers transferred to the tram/train from motorized road vehicles Number of tonne-kilometers enabled due to modal freight shift from road to rail	pkm or tkm
TCM5.2: Modal shift freight Number of freight containers and semi-trailers (intermodal transport unit, ITU) and tonnes transferred from road to rail transport	Number of ITU Tonnes of freight
TCM6: Avoided CO_2e emissions due to modal shift in passenger transport	Tonnes CO_2e until 2050
TB1: Biodiversity compensation for habitats and species	Hectares of protected and restored areas (number of eco-points)
Drinking water and waste water treatment sector	
WW1: Volume of water treated (respecting national and EU requirements)	m^3 / year % for capacity increase % for phosphorus and nitrogen elimination
WW2: Number of users served	Drinking water: number of users Waste water treatment: population equivalent [p.e.]
WW3: Water / waste water treated with micropollutant treatment or other advanced treatment, above EU requirements	Number of installations m^3/ year (max. capacity)
WCM1: Amount of sewage sludge treated in anaerobic digestion	Tonnes of dry solids/year
WCM2: Amount of biogas generated and used for energy generation	m^3/year

Ecosystem restoration	
EB1: Area of protected and restored habitats	Hectares of protected and restored areas
EB2: Increase of number and types of protected habitats *national protected habitats and EU Natura 2000 habitats*	Number and types of protected areas
EB3: Trees and hedges planted, net positive balance *indigenous species* (EB3 is a further specification of EB2)	Number of trees m^2 of hedges
EB4: Increase of habitat mosaic favorable for macroinvertebrates within the water body of the river, different milestone indicators	
EB4 M1: Until year 2026: Description of planned works to improve the hydro-morphology of the river and to create habitats for macroinvertebrates	Qualitative description
EB4 M2: From year 2027: Hydro-morphological inventory of river	Qualitative & quantitative, improvement of classification of river over the next 10 years
EB4 M3: From year 2029/2030: Increase of macroinvertebrates species	Number and type of macroinvertebrates species, Multimetric Invertebrate Index I_2M_2
EB5: Fish passage constructed	Number of fish passages
EB6: Number of bird species using the project area as habitat	Qualitative description Number of records/data points of viewings of specific bird species held in the national biodiversity database
ECA1: Spatial extent of renaturalized flood plain and volume of flood water retention	m^3
EP1: first flush mechanism	Qualitative & quantitative description
Energy efficiency in affordable housing	
EE1: Floorspace per energy performance certificate class	m^2 per EPC class (AA-BB) NZEB standard
ECM1: CO_2e emissions	Tonnes CO_2e / year

1. Introduction

The purpose of the methodological guide is to provide an overview of the methodologies and assumptions used for the determination and the calculation of key impact metrics as described in the Luxembourg Sustainability Bond Framework and additional environmental indicators for the green projects of the Luxembourg Sustainability Bond. Luxembourg intends to issue annual impact reports alongside annual allocation reports until the full allocation of the bond proceeds, covering the proceeds allocation years 2018-2022.

2. Impact management and reporting principles

The impact reporting follows the method of reporting on proceeds allocation and is done on a project-by-project approach. In the preparation of the impact report Luxembourg strives for transparency and realistic assumptions, robustness and as well as workability and clear attribution, good documentation using references to publicly available data (whenever possible). Methodological approaches and system boundaries are clearly stated for the calculations of the avoided greenhouse gas (GHG) emissions for the low carbon transport sector using market practices.

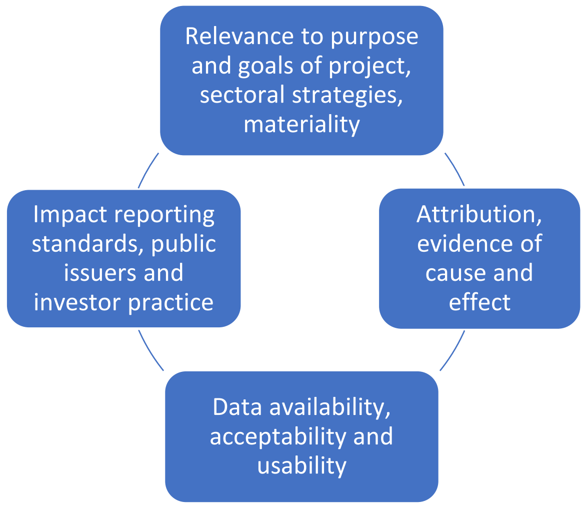
For all green indicators the impact report states if the listed information includes expected or realized data and if the figures are annual or absolute indicating the period covered by the assessments. While there was a general strive towards selecting indicators that provide quantitative information, some impact indicators can only be reported on in a qualitative or descriptive manner.

Data sources for the preparation of the methodological guide and the estimation of environmental impact include public reports, financing laws and regulations as well as data provided by the respective ministries, their administrations and the entities preparing, implementing and operating the projects. Where data could not be provided by project operators and authorities, assumptions have been made based on the principle of prudence including conservative estimates and clearly stating boundaries and limitations.

The full positive impact of the environmental projects has been estimated by the consulting team. The impact share of the Luxembourg Sustainability Bond will be a share of the full positive impact, corresponding to the Luxembourg Sustainability Bond financing contribution to the total project financing covering the total costs of each project.

3. Selection of indicators

The determination and the selection of the indicators for the green projects was an iterative process guided by the indicator’s relevance and materiality to the main purpose and goals of the projects, the sectoral country-wide strategies and applicable regulations as well as individual sustainability targets of the entities implementing the projects. The level of attribution, evidencing cause and effect, linked to the theory of change was integrated into the selection process of the indicators together with considerations of data availability, acceptability, usability, and practicality.

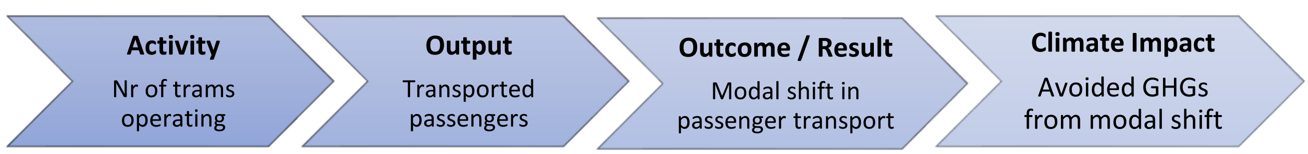


In order to ensure comparability of the indicators and foster standardization, the selection of the indicators was guided by the leading impact guidance documents, including the ICMA Green Bond Principles (2020), Harmonized Framework for Impact Reporting; the Nordic Public Sector Issuers (2020), Position Paper on Green Bonds Impact Reporting and the Climate Bonds Initiative Sectoral Guidelines where applicable.

The determination and the choice of metrics and indicators was also guided by the work of the EU expert group on sustainable finance's Taxonomy Report Technical Annex (March 2020), the draft and final delegated acts on the EU Sustainable Taxonomy, Annexes I and II on climate mitigation and adaptation (November 2020, June 2021) and directions given by the EU Green Bond Standard Usability Guidance.

Indicators used by other European sovereign and relevant public sector green bond issuers have been reviewed, including the European Investment Bank's climate and sustainability awareness bond impact frameworks. The most commonly used indicators by the green, social and sustainability bonds listed on the Luxembourg Green Exchange have been used for guidance in indicator selection. The indicator determination and selection process also considered the main indicators employed by leading green impact investors as stated publicly in their green bond impact frameworks.

The selected indicators are on different levels of the impact value chain, which rates the extent of the positive contribution to the environmental objective that is ultimately intended. For reasons of practicability, output- and outcome-based metrics can serve as proxies for the ultimate, but often difficult to measure, impact. This is especially the case for some activities that are compatible with the EU taxonomy for sustainable activities. Below an example of different types of indicators along the impact value chain using the example of a zero-carbon city tram.



The following sections of this methodological guide address for each of the green investment sectors the description and definition of chosen key performance indicators (KPIs), the context and rationale behind the selection of KPIs and key data sources. Methodologies for determining the KPIs are presented, including for the GHG assessment, the scopes, system boundaries, emission factors as well as key assumptions. Where relevant, the verifiable baseline or reference point selected for documenting the improvement of the KPIs over time are listed.

4. Low carbon transport projects

The low carbon transport portfolio consists of seven low carbon transport projects. It is i.a. composed of the construction of tram lines operated by Luxtram in the city center of Luxembourg and being extended to the airport in the coming years, including the purchase of tram vehicles. The remaining six projects are projects undertaken by the national railway company CFL (Société National des Chemins de Fer Luxembourgeois). The CFL projects are key infrastructure projects and do not include the purchase of vehicle fleets.

4.1. Luxembourg's mobility strategies

All transport projects included in the sustainability bond portfolio are part of a new mobility concept for Luxembourg, detailed in the Modu 2.0. Mobility Strategy for 2025 and approved by the government in 2018. Modu 2.0 - Stratégie pour une mobilité durable (2018) - Contexte - Portail TRANSPORTS - Luxembourg (public.lu). Objectives of the new mobility concept relevant to the sustainability bond project portfolio include a fifty percent increase in passenger numbers of public transport due to new infrastructure of CFL, a reorganization of regional train network, and a reduction by 25% of trains that have six minutes or more of delay (compared to 2017). The 2025 mobility strategy aims to increase the use of public transport from 19% to 22% for work related trips and from 38% to 45% for school related travel (compared to 2017). It further includes the optimization of the time needed to change from one mode of transport to another to encourage the increased use of public transport.

The Transport Master Plan (Plan directeur sectorial "Transport" PST) PST-RGD.pdf (public.lu) prepared in 2018 provides the legal framework to implement the projects and measures laid out in the Modu 2.0 strategy. This plan lists 40 high priority transport projects, the seven transport projects financed by the Luxembourg sustainability bond being among the highest-ranking priority projects.

While the selection of indicators considers the sectoral targets on modal shifts, performance data for these indicators have not always been available on the individual project level, this is especially the case for infrastructure projects in and around train stations. These projects are all elements of a set of measures to improve the timetable, to reduce delays and further improve the service to encourage the use of public transport by 2025. The projects are described in the strategies of Luxtram[1] and CFL[2] .

Luxembourg's Integrated Climate and Energy Plan 2021-2030[3] provides an overview of the key developments planned for further integrating sustainable mobility and electromobility in vehicle stock.

4.2. Indicators and methodologies for low carbon transport projects

This section provides an overview of the indicators for the public transport projects. Due to the variety of transport projects, the individual projects respond to the selected indicators where materiality, attribution and data availability are relevant. The below table lists the key performance indicators of the transport projects:

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1 Un tracé multimodal | Luxtram.lu – Un tram pour la Ville de Luxembourg
2 CFL | Notre stratégie, CFL | Nos projets, CFL | Nos défis en termes de développement durable, CFL | Certifications
3 https://ec.europa.eu/energy/sites/ener/files/documents/lu_final_necp_main_en.pdf

Indicator ID & Name	Unit of measurement, Frequency of monitoring	Description	Source of data
TCM1: Number of low carbon vehicles available and deployed	Number, annual	Activity data on number of low carbon vehicles available and deployed.	Luxtram
TCM2.1: Number of users served on new tram and train lines	Number of users/year, annual	Activity data on number of users on new lines, this can include additional passengers or maintenance of existing customer base due to service quality improvement; maximum capacity and actual operations.	Luxtram, CFL
TCM2.2: Number of additional passengers transferring through the upgraded train stations from rail to rail or from other modes to rail	Number of users/year, Absolut (estimates based on capacity)	Activity data based on number of parking spots available in new park & ride parking next to train station, based on vehicle occupancy rate and utilization factor of parking increasing over time.	Assumptions by consultants with CFL input
TCM2.3: Number of additional trains entering train stations	Number of trains/year, annual	Hourly train activity data provided by CFL, assuming 12 hours per day and 365 days of operation.	CFL with assumptions by consultants
TCM3: Length of new tram lines / new rail lines built	Kilometers km, absolute, no monitoring	Length of low carbon infrastructure built.	Luxtram, CFL
TCM4: **Passenger-kilometers on additional low carbon transport infrastructure**	pkm annual	Describes the distance driven by the passengers using the new transport infrastructure.	Luxtram, CFL
TCM5.1: Modal shift **Number of passenger-km transferred to the tram/train from motorized road vehicles** **Number of tonne-kilometers enabled due to modal freight shift from road to rail**	pkm or tkm, annual	Describes the extent of the modal shift to low carbon mobility modes, which has the potential to lead to lower CO_2e emissions and other pollutants (particulate matter, nitrous oxides). Describes the distance over which the passengers, which have shifted from motorized vehicles to rail/tram, would have been transported in the reference scenario. Describes the distance over which the freight, shifted from road to rail, is transported by rail.	Luxtram, CFL, Reference distance and transport mode split in reference scenario for passenger transport provided by Ministry of Mobility and Public Works (rough estimates)
TCM5.2: Modal shift freight: **Number of freight containers and semi-trailers (ITU) and tonnes transferred from road to rail transport**	Number of ITU (intermodal transport units), tonnes, annual	Activity data of the multimodal freight station. An ITU weights 25 tonnes. Maximum capacity and actual operations.	CFL
TCM6: Avoided CO2e emissions due to modal shift in passenger transport	t CO_2/a, annual	Avoided CO_2e emissions due to modal shift in passenger transport.	See section 4.3.

Table 1: Overview of key performance indicators for low carbon transport projects

Additional indicators for the transport sector:

Indicator	Unit of measurement	Description	Source of data
Material recovery rate Material recyclability rate	%	This indicator has been selected from the list indicators recommended in the Product Circularity Datasheet Luxembourg[4] for the circularity of the vehicles used by Luxtram. The rates have been calculated based on ISO22628.	Luxtram: Product datasheet of URBOS Saragossa tram, Luxtram uses the same vehicles
Length of bicycle lanes constructed	km	The construction of bicycle lanes in the city center of Luxembourg.	Luxtram
Length of tracks greened	km	The greening of the tram tracks in the city center of Luxembourg.	Luxtram
Rate of trains being on time	%	The rate of trains being on time for the entire train network operated by CFL is a key indicator for the CFL company. The projects included in the sustainability bond will contribute to reaching the CFL target of improving the rate from 89 % in 2018 to 92% by 2024 on the entire network.	CFL CFL Annual Reports

Table 2: List of additional indicators used for low carbon transport projects

4.3 Methodologies for assessing the modal shift and calculating the avoided CO_2e emissions due to modal shift in passenger transport

A. Methodologies and systems boundaries

Indicator: avoided CO_2e emissions, absolute values, ex-ante (expected) until 2050, ex-post (realized) annual values possible after completion of work and start of operations.

*The **methodology** for the impact calculation builds on the following methodological approaches:*

- IFI Transport Method: https://unfccc.int/sites/default/files/resource/Transport_GHG%20accounting.pdf (2015), **ASIF** (Activity, modal Structure, Intensity of fuel use, Fuel carbon content) method. This sector methodology is part of the International Financial Institutions interim guidelines for a harmonized approach on GHG accounting (March 2021)[5].
- SNCF Method: https://www.sncf-reseau.com/sites/default/files/2019-04/SNCF-methodologie__1.pdf,

[4] https://pcds.lu/
[5] https://unfccc.int/sites/default/files/resource/Interim_Guideline_on_GHG_Accounting_and_reporting%201Mar.pdf

- https://www.changing-transport.org/publication/greenhouse-gas-in-passenger-and-freight-transport/

Reference scenario/baseline: The project is not realized and the initial situation (modal split) persists with changing vehicle fleet over the years. The same number of passengers are transported from starting point to end point of the respective tram and train destinations with the modal split of the initial situation, respecting the principle of service equivalence of the reference scenario.

System boundaries: The following emission sources are considered when calculating avoided emissions:

- Geographical system boundaries: Length of the tram lines and new rail lines (and the distance that needs to be driven with the passenger car or bus using the same start and end point as with the tram or train). This selection is conservative as additional avoided emissions are expected to occur as a result of passengers (especially) switching from passengers' vehicles to tram, bus or rail already before boarding the train on the new rail lines. However due to the difficulties to assess these emissions, they were neglected.
- GHG avoidance calculations are limited to passenger transport on the new rail lines. No freight is expected to be transported on the new train line.
- The following transport modes and fuels are considered:
    - passenger cars (gasoline, diesel, full electric, plug-in hybrid),
    - bus (diesel, electric),
    - train/tram (diesel, electric).

Emission scope:

Direct, scope 1 emissions from vehicles utilizing the tram and train infrastructure in the project scenario and scope 1 emissions from passenger vehicles (passenger cars and busses) in the reference scenario are covered by the calculations. In particular, for vehicle use, tank-to-wheel emissions are considered. The calculations exclude indirect emissions e.g. from the materials and the construction of tram infrastructure and rail infrastructure and neglect emissions from administration and maintenance buildings and operations.

Scope 2 emissions from electricity generation of the electricity used by the public transport vehicles are not taken into account, as the operators buy 100% renewable electricity to operate the tram in Luxembourg city and the passenger transport on CFL train lines. This renewable electricity is to a large extent procured through renewable energy guarantees of origin (GO)[6]. The calculations do not include emissions from power generation for electricity used in electric cars and busses in the reference scenario, this is a conservative approach.

B. Description of mitigation activity

The description of the mitigation activity provides the basis for the impact calculation.

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[6] The assumption used in this report that power consumption which is covered by the purchase of GOs is assumed to be free of CO_2 emissions is to a certain extend standard practice. However, the authors would like to point to the fact that another methodological approach might also be considered: This approach would build an analysis of the actual impact of purchasing GOs on the overall net emissions in the relevant power grid. In short, the purchase of GOs does not in any case lead to an overall reduction in grid emissions, as it may simply shift the use of fossil fuel based electricity to other consumers. For this methodological approach, more data and research would be needed.

<u>Luxtram project</u>

By 2024, 16.2 km of new tram lines will be put in operation by Luxtram. In detail, the installation of the new tram lines is planned as follows:

New tram lines	Planned distance	Planned number of stations	Year of completion
LuxExpo – Place de l'Etoile	5.4 km	11	2018
Place de l'Etoile – Gare	2.2 km	4	2020
Gare – Bonnevoie Lycee Technique	1.2 km	2	2022
Bonnevoie LT – Cloche d'Or	3.5 km	5	2023
LuxExpo – Aérogare/Findel	3.9 km	2	2024
Total (all new tram lines)	16.2 km	-	-

Table 3: New tram lines by Luxtram.

The vehicle-km driven and expected to be driven by the tram vehicles on the tram network have been provided by Luxtram[7].

<u>CFL train line Luxembourg – Bettembourg project</u>

The new train line of 7.5 km will be put in operation in 2025.

The vehicle-km expected to be driven by the trains on the new train line have been provided by CFL.

<u>CFL train line Hamm – Sandweiler project</u>

CFL builds a second track on the train line Hamm – Sandweiler in order to maintain and improve the quality of service on this line. Compared to the reference scenario (i.e. the second track is not built and service may not be appropriately maintained), the project could potentially mitigate emissions because of a potential higher reliability of the service. However, a robust estimation of the impact of this mitigation activity is not possible and may be negligible compared to the avoided emission impact of the other transport projects covered by the bond. Therefore, the available activity data have been collected but the avoided emissions have not been calculated.

C. Calculation of emissions generated in the reference scenario

The following descriptive equations provide the general approach how emissions in the reference scenario have been calculated (i.e. emissions in the case the project would not be implemented):

In order to calculate the total emissions from passenger cars and buses that would transport the passengers in absence of the project implementation (reference), the following steps are taken:

1. Estimation of passenger-km that passengers would travel on average on roads in absence of tram/ rail project based on passenger-km of tram/rail in project case, respecting an equivalent road distance (reference distance) to the related tram/rail origins and destinations.

[7] Luxtram (data from Luxtram only covered 2018-2030, the further development of occupancy was assumed to be constant up to 2050).

2. Estimation of vehicle-km per reference mode by multiplying passenger-km on road from (1) times the different mode shares for cars, busses and non-motorized transport and dividing through average occupancy rate of the vehicle.

   Rough estimates of mode shares have been provided by the Ministry of Mobility and Public Works. The share of fuels used and expected to be used by the different modes/vehicle fleets has been provided by the Ministry of Environment, Climate and Sustainable Development based on the Integrated National Climate and Energy Plan 2030 and long term climate mitigation strategies (see Table 4 below). The average occupancy rate of the vehicles has been provided by Luxtram[8] and CFL for the projects and by the Ministry of Mobility and Public Works for the vehicles (passenger cars and busses) in the reference scenario.
3. Calculation of emission factor for each reference mode by multiplying emission factor for different fuels from HBEFA (see below) times the share of fuels (see below).
4. Estimation of reference emissions in each reference mode by multiplying vehicle-km from (2) times emission factors from (3).
5. Total emissions in reference scenario are then the sum over all emissions from the considered transport modes (cars, busses) in the reference scenario.

Emissions are calculated for greenhouse gases CO_2e as well as for air pollutants PM10, PM2.5 and NO_x.

Fuel share of modes	2018	2030	2040	2050[9]
Passenger cars, reference scenario				
gasoline-powered	37%	30%	13%	0%
diesel-powered	62%	20%	4%	0%
electric vehicles	1%	25%	54%	84%
plugin hybrid vehicles	0%	25%	29%	16%
Buses, reference scenario				
diesel-powered	95%	0%	0%	0%
electric vehicles	5%	100%	100%	100%
hydrogen-powered	0%	0%	0%	0%
Trams (Luxtram), project				
diesel-powered	0%	0%	0%	0%
electric vehicles (renewable electricity)	100%	100%	100%	100%
Trains Luxembourg – Bettembourg (CFL), project				
diesel-powered	-	0%	0%	0%
electric vehicles (renewable electricity)	-	100%	100%	100%

Table 4: Fuel share in the reference and project scenario. Source: CFL and Luxtram (project information), Ministry of Environment, Climate and Sustainable Development for passenger cars (reference scenario up to 2040[10]), Ministry of Mobility and Public Works for buses (reference scenario up to 2050). Note that the train between Luxembourg and Bettembourg will be put in operation in 2025.

CO_2e / PM10 / PM2.5 / NO_x emission factors are based on the Handbook of Emission Factors for Road Transport (HBEFA)[11]. HBEFA is used by the Governments of Germany, Switzerland, Austria, Sweden,

[8] Data from Luxtram only covered 2018-2030, the further development of occupancy was assumed to be constant (up to 2050)
[9] Data 2041-2050 are obtained through extrapolation (linear, based on data 2035-2040) by INFRAS.
[10] Data 2041-2050 are obtained through extrapolation (linear, based on data 2035-2040) by INFRAS.
[11] HBEFA - Handbook Emission Factors for Road Transport

Norway and France. As there is no Version of HBEFA for Luxemburg, the French HBEFA average emission factors are used as proxy values in this study, i.e. the average situation of France is assumed regarding average vehicle fleet, traffic situations, and slopes etc. This is a conservative approach, as the emission factors for a Luxembourg specific vehicle fleet would likely be higher (in the reference scenario). The share of different fuels (gasoline, diesel, electric, plugin-hybrids) however is country specific for Luxembourg and based on data for 2030, 2035 and 2040 provided by the Ministry of Environment, Climate and Sustainable Development and has been linearly interpolated between the years and extrapolated until 2050 by expert judgment by INFRAS.

Particulate matter emissions (PM10 and PM2.5) include both exhaust and non-exhaust emissions. Non-exhaust emissions for trams and trains are taken from an earlier study by INFRAS (2007)[12].

D. Calculation of emissions generated in project scenario

In order to calculate the total emissions from trams/trains in the project scenario (may be run by diesel or electricity), the following steps are taken:

1. Determine the emission factors for the tram/ train system in the project scenario (source INFRAS, see below).
2. Estimation of project emissions by multiplying tram/train vehicle-km (see point B) times emission factors from (1).

Note that as the use of 100% green electricity is assumed in this assessment, the tram/ train systems in the project scenario do not contribute to CO_2 emissions, only to the emissions of air pollutants PM10 and NO_x.

E. Calculation of avoided emissions

Total avoided emissions from the entire project are calculated by taking the difference in emissions of the reference scenario *without* the project (result from step (5) in section (C) above) and of the scenario *with* the project (result from step (2) in section (D) above.

Avoided emissions are calculated for greenhouse gases CO_2e as well as for air pollutants PM10, PM2.5 and NO_x.

F. Attribution to financing

The sustainability bond is only contributing part of the required total financial contribution that is required to create the environmental impacts. The following steps should be taken:

1. Calculation of the fraction of the sustainability bond in overall financial contribution as follows: The share financed equals the amount of the sustainability bond divided by the total financial contribution.
   Please note that the total financial contribution needs to represent the entire investment that is necessary to implement all relevant components to realize the calculated impact. In particular,

[12] INFRAS 2007: PM10-Emissionen Verkehr. Teil Schienenverkehr. https://www.bafu.admin.ch/dam/bafu/de/dokumente/luft/fachinfo-daten/pm10-emissionen_schienenverkehr.pdf.download.pdf/pm10-emissionen_schienenverkehr.pdf

this includes not only the investment for stationary infrastructure such as rail tracks, tunnels, bridges, train stations, electric equipment etc., but also for mobile infrastructure including the rail vehicle stock.[13]

2. Calculation of the GHG (or sustainability) impact that is attributed to the sustainability bond by multiplying the total avoided emissions (from section (E) above) times the fraction of the sustainability bond in overall financial contribution (from step (1) here).

4.4 Methodology for biodiversity compensation in infrastructure projects

The infrastructure projects partly have negative impacts on protected habitats and species. These must be compensated according to national and, if applicable, European legislation. Either by implementing compensation measures under the responsibility of the project developer or by paying a corresponding contribution into the national compensation fund. In the second case, the Nature and Forest Agency is responsible for the implementation of the compensation measures. The compensation mechanism, La compensation écologique - Natur - Portail de l'environnement - emwelt.lu - Luxembourg (public.lu), is a key element of the law of the 18th of July 2018 concerning the protection of nature and natural resources. The legal background is further described in chapter 6.1. of this methodological guide.

TB1 Biodiversity indicator: Biodiversity compensation for protected habitats and species	
Unit of measurement	Area [hectares] of protected and restored areas. Specific measures for protected species. In absence of area data, the number of eco-points to be compensated are listed.
Frequency of monitoring	Absolute. For compensation measures under the responsibility of the project developer and adapted monitoring over 25 years is mandatory.
Description	This indicator states the extent to which biodiversity compensation needs to be undertaken following a loss of biodiversity due to the construction of the project.
Baseline	Impact assessment with full habitat inventory study and species related inventories.
Data sources	Data sourced from the impact assessments including a habitat inventory (ecosystem balance study) laying out the habitat situation before and after realization of the project. Documents provided by the project developer.

[13] The consideration of all necessary investments related to a mitigation action for impact attribution as proposed here may be seen as good practice and is followed e.g. also by SNCF (Methodology applied to the Green Bonds Programme of SNCF Réseau, September 2017), https://www.sncf-reseau.com/sites/default/files/2019-04/SNCF-methodologie__1.pdf. However, a more adequate approach to attribution of GHG impacts in the context of blending public funding and commercial finance would be to consider the contribution of different financing sources in terms of grant equivalent to the incremental costs of mitigation action. An introduction to the concept is provided in Fuessler et al 2019: Blending climate finance and carbon market mechanisms. Options for the attribution of mitigation outcomes. A World Bank CPF/TCAF Discussion Paper. https://www.infras.ch/en/projects/attributing-mitigation-outcomes-between-climate-finance-and-international-carbon-markets/

5. Water treatment and waste water treatment projects

The sustainability bond portfolio contains one drinking water treatment plant, which will serve 90 percent of the population of Luxembourg and seven waste water treatment plants, representing a mix of new plants, upgrades and renovations of existing plants.

5.1. Sectoral strategy and regulatory context

5.1.1 Drinking water treatment

The SEBES drinking water treatment plant responds to the needs of a rapidly increasing population and is being constructed to new and advanced levels of treatment technologies[14]. The treatment levels of the new installation enable to achieve a drinking water quality beyond what is required in the Grand-Ducal Regulation of 7 October 2002[15], respecting the law on water protection and management of 19 December 2008[16] and will be in compliance with the new EU Drinking Water Directive[17] approved by the EU parliament end of 2020, which will enter into force in 2021 and will be transposed by Luxembourg into national legislation within the coming two years.

5.1.2. Waste water treatment

The majority of the waste water pollution load in Luxembourg, namely 98%, is connected to one of the 117 biological waste water treatment plants having a collected capacity of 1.092.735 population equivalents (p.e). For the Grand-Duchy of Luxembourg, the EU Directive from 21 May 1991 concerning urban waste water treatment (91/271/CEE) and its amendment (98/15/EC) from 27 February 1998 is currently applicable for waste water treatment stations above 2,000 population equivalent. This EU regulation has been transposed into national law through the Grand-Ducal Regulation of the 13th of May 1994[18], which is still valid today.

5.2. Indicators and methodologies

A set of indicators has been selected to respond to both drinking water and waste water treatment projects, as well as indicators more specifically for waste water treatment projects, based on the anaerobic treatment of sewage sludge and the use of biogas for energy generation.

WW1 Water indicator: Volume of water treated	
Unit of measurement	m^3 / year, % for capacity increase, % for phosphorus and nitrogen elimination
Frequency of monitoring	Absolute (for maximum capacity), no monitoring Annual data, annual monitoring

[14] https://sebes.lu/fr/actualite/nouvelle-station/
[15] Règlement grand-ducal du 7 octobre 2002 relatif à la qualité des eaux destinées à la consommation humaine. - Legilux (public.lu)
[16] https://sebes.lu/wp-content/uploads/2017/01/Loi-du-19.12.2008-Protection-et-gestion-des-eaux.pdf
[17] https://ec.europa.eu/environment/water/water-drink/legislation_en.html
[18] Règlement grand-ducal du 13 mai 1994 relatif au traitement des eaux urbaines résiduaires. - Legilux (public.lu)

Description/Purpose	Key activity level, operational indicators for the performance of the water and waste water treatment plants, where water is treated respecting EU and national water quality requirements. Phosphorous and nitrogen percentage elimination is included as an indicator because the values to be reached by the waste water treatment plants are often higher than requested by regulation. Other water quality parameters on each plant level that are stricter than required are stated as such in the impact report.
Baseline	Status quo
Data sources	Realized and expected performance data have been provided by the plant operators, public documentation on their websites, the Ministry of Environment, Climate and Sustainable Development and the Water Management Authority. Realized performance data can be collected through the annual reports of the operating company as soon as the project is operational, as well as through annual activity reports of the Water Management Administration[19].

WW1: Definitions and methodologies

Drinking water treatment plant:

The volumes of water treated in the drinking water treatment plant are published annually on the company's website. The water quality is checked monthly by independent analysis and on a regular basis by the Water Management Administration. Monthly water quality reports are published by the operator of the treatment plant, including measurement methodologies[20].

Water treatment plants:

The waste water treatment plants are designed to meet or outperform national water quality thresholds. The national Water Management Administration defines individual water quality thresholds for each plant based on the minimal performances prescribed by the EU directives on urban waste water treatment (91/271/CEE)[21] and applying in many cases stricter requirements, depending on the specificities (size, pollution level) of the river receiving the treated water. The national pollution thresholds for the treated waste water are often significantly stricter and lower (especially for the chemical oxygen demand COD) than the EU threshold (EU: COD 125 mg/l O_2). Phosphorous and nitrogen elimination parameters to be reached by the plants are also often stricter than prescribed by the above EU regulation (EU: minimum percentage reduction of P_{tot} at 80% and N_{tot} at 70%).

The volumes of waste water treated, water quality parameters, and compliance rates of fully operating waste water treatment plants are published each year in the annual activity report of the Water Management Administration[22] available online. Projects included in the sustainability bond portfolio will be reported on annually by the Water Management Administration as soon as they will be fully operational.

[19] https://eau.gouvernement.lu/fr/services-aux-citoyens/publications.html
[20] https://sebes.lu/fr/qualite-de-leau/potable-du-sebes/
[21] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31991L0271&from=FR
[22] Publications - Administration de la gestion de l'eau // Le gouvernement luxembourgeois

WW2 Water indicator: Number of users served	
Unit of measurement	Drinking water: Number (#) of users Waste water treatment: population equivalent [p.e.]
Frequency of monitoring	Absolute (for capacity and additional capacity), no monitoring Annual data, annual monitoring
Description / Purpose	Key activity level, operational indicator for the performance of the water and waste water treatment plants. Indicators include maximal capacity, annual performances and capacity increase. The [p.e.] is expressed per day.
Baseline	Status quo
Data sources	Realized and expected performance data provided by the plant operators, public documentation on their websites, the Ministry of Environment, Climate and Sustainable Development and the Water Management Authority. Realized performance data can be collected through the annual reports of the operating company as soon as the project is operational.

WW2: Definitions and methodologies

Drinking water treatment plant:

The number of users served by the drinking water treatment plant is calculated, based on the statement from the operator that the plant will serve 90 percent of the population of the country of Luxembourg, applying the latest population data (1.1.2021: 634,730 people).

Waste water treatment plants:

For waste water treatment plants, the number of users served is expressed in population equivalents [p.e.]. The p.e. corresponds to the average waste water pollution load generated by one person **per day** (based on a consumption of 150 litres per day), expressed by the following parameters in Luxembourg and published in the annual activity reports of the national Water Management Administration[23].

Population equivalent [p.e.] parameters applied in Luxembourg		
Parameters		Specific pollution load
Chemical oxygen demand	COD	120 g / (p.e. x day)
Biochemical oxygen demand	BOD5	60 g / (p.e. x day)
Total suspended solids	TSS	70 g / (p.e. x day)
Total Nitrogen	Ntot	12 g / (p.e. x day)
Total Phosphor	Ptot	1.8 g / (p.e. x day)

Table 5: Parameters of population equivalent definition

[23] https://eau.gouvernement.lu/fr/services-aux-citoyens/publications/2021/Rapports-dactivite-de-lAdministration-de-la-Gestion-de-lEau/Rapport-activites-2019.html

WW3 Water indicator: Water / waste water treated with micropollutant treatment or other advanced treatment, above EU requirements	
Unit of measurement	Number (#) of installations with advanced treatment technologies m^3 / year (max. capacity)
Frequency of monitoring	Absolute, no monitoring
Description / Purpose	The elimination of micropollutants and other pollutants above EU requirements is an additional water/waste water treatment steps to reach higher levels of pollution control and protection of the environment.
Baseline	EU regulation
Data sources	Information from the Water Management Authority and the plant operators.

WW3: Definitions and methodologies

The drinking water treatment plant aims to reach lower pollution thresholds than fixed by EU regulation and the national water management authority not only for micropollutants but also for specific pesticides and their metabolites, trihalomethanes (THM, due to switch from chlore to UV disinfection), manganese, and aluminum (due to switch from aluminum-based flocculation to an iron-based process).

Micropollutants is a collective term and encompasses a variety of organic pollutants and heavy metals, which are present at very low concentrations (one billionth of gram per litre, one millionth of a gram per litre) in rivers or other water bodies. These pollutants can harm aquatic life and drinking water resources even at very low concentrations. Sources of micropollutants relevant for some of the listed waste water treatment plants are for example human medicines, x-ray contrast mediums, estrogenes, biozides, corrosion protection substances, industrial chemicals, fragrances, sweeteners[24]. The decision to install the costly micropollutant treatment step has been taken by the Water Management Authority based on a detailed cost-benefit analysis and the expected future development of the waste water composition in the water collection area as well as the characteristics of the water body receiving the treated water.

WCM1-WCM2: Climate mitigation indicators Sewage sludge anaerobic digestion and use of biogas for energy generation	
Unit of measurement	WCM1: Annual amount of sewage sludge that is treated in anaerobic digestion tonnes of dry solids per year WCM2: Annual amount of biogas generated and used for energy generation m^3/year
Frequency of monitoring	Annual data, annual monitoring.
Description / Purpose	The anaerobic treatment of the sewage sludge and utilization of the biogas for energy purposes has a strong climate, environmental and economic value. The construction and operation of facilities for the treatment of sludge by anaerobic digestion with the resulting production and utilization of biogas for electricity or heat production is considered a sustainable climate mitigation activity under the EU sustainable activity taxonomy C (2021) 2800 final Annex I, Sect. 5.6 [25].

[24] As explained for the largest waste water treatment project in the Luxembourg sustainability bond project portfolio : Projet d'extension de la station d'épuration de Beggen - Commune de Walferdange

[25] Section 5.6. of the Annex I to the 21 June 2021 delegated act on the EU sustainable activity taxonomy (C(2021) 2800 final)

Baseline	The baseline situation of sewage sludge treatment is described in the annual report on waste from waste water treatment plants published by the Environment Agency of Luxembourg[26].
Data sources	Data provided by the operators of the treatment plants.

WCM1-WCM2: Definitions and methodologies

Waste water treatment plants:

Most of the waste water treatment plants in the sustainability bond portfolio produce biogas from the sewage sludge for subsequent electricity and/or heat production. The biodigesters are financed completely from public funds and by the proceeds from the sustainability bond. The use of the biogas for energy purposes varies from plant to plant, some produce energy on site, some channel the biogas to a communal co-generation plant for off-site energy generation. The renewable energy generation performed or enabled by the waste water treatment plants is not part of the financing of the sustainability bond. Data concerning the production of electricity [kWh_e, year] and or heat [kWh_{th}, year] has nevertheless been collected from the operators of the respective sustainability bond projects to document subsequent use of the biogas for energy purposes.

Baseline situation of sewage sludge treatment:

The waste water treatment plants in Luxembourg collectively produced 8565 t dry sludge in 2019. The sewage sludge generated in Luxembourg's larger waste water treatment stations (>10,000 p.e.) is generally stabilized anaerobically and mostly also dewatered in a centrifuge before being forwarded for further treatment or use. Such treatment stations often collect sludge from smaller waste water treatment stations for inclusion in their process. Based on 2019 data[27], about 20% of the dewatered sludge is subsequently used as organic nitrogen fertilizer in agriculture mostly in Luxembourg (with a small part being used in agriculture in France), generating N_2O emissions[28], which are very small 26% of the dewatered sewage sludge is treated by combustion, mainly in a Luxembourg based cement plant replacing standardized fossil fuels for clinker production, leaving a small part of the sewage sludge being control-combusted in a German waste incinerator with thermal usage. The main part of the sewage sludge, about 54%, however is treated in composting stations, out of which 39% is treated in Luxembourg in a facility that uses active ventilation and operates fully aerobically – without methane generation. The remaining part is used in composting stations mainly in France.

[26] Administration de l'Environnement (2021), Jahresbericht der Kläranlagenspezifische Abfälle 2019, https://download.data.public.lu/resources/boues-depuration/20210209-100254/210202-klarschlammjahresbericht-2019.pdf
[27] Administration de l'Environnement (2021), Jahresbericht der Kläranlagenspezifische Abfälle 2019, p.28
[28] 0.001 Gg N_2O in 2018 from agricultural soils from sewage sludge in Luxembourg. Source: Luxembourg Ministry of Environment, Climate and Sustainable Development (2020), Luxembourg's National Inventory Report 1990-2018, Submission under the UNFCCC and the Kyoto Protocol (p.491). N_2O Global Warming Potential of 298 (IPCC Forth Assessment Report).

6. Ecosystem restoration and biodiversity

The sustainability bond portfolio includes one EUR 10 million project related to the ecological revalorization of the Pétrusse valley at the heart of the city of Luxembourg. This project consists of the creation of new protected habitats, the renaturalization of the river as well as the improvement of park infrastructure. The renaturalization of the river encompasses an improvement of the morphology of the river and close river areas, flood protection and structures to reduce pollution and improve the water quality of the river[29].

6.1. Indicators and methodologies for ecosystem restoration projects

EB1-EB3: Biodiversity indicators for flora: protected habitats	
Unit of measurement	**EB1: Area of protected and restored habitats:** Area [hectares] of protected and restored areas, national protected habitats and EU Natura 2000 habitats **EB2: Number and types of protected habitats:** Number and types of protected areas **EB3: Trees and hedges planted, net positive balance:** Number of trees, indigenous species, area [m^2] of hedges, indigenous species
Frequency of monitoring	Absolute, no monitoring planned
Description / Purpose	The three indicators are key indicators for the biodiversity objectives to be achieved by the renaturation of the river Pétrusse and the river parc infrastructure with regards to vegetation. EB3 is just a further specification of EB2. Indicators reported under EB3 are also included in EB2.
Baseline	Full habitat inventory study/ecosystem balance study of 2020 before the renaturation.
Data sources	Data sourced from the mandatory habitat inventory (ecosystem balance study) laying out the habitat situation before and after the renaturation. Documents provided by the Ministry for Climate, Environment and Sustainable Development.

EB1-EB3: Definitions and methodologies

In 2020, a complete inventory of all land uses within the project area has been carried out. The inventory was realized according to the methodology and the definition of land uses and especially protected biotopes and habitats of protected species as given by the following national regulations:

- National nature conservation law 2018
- Regulation instituting a digital eco-point assessment and compensation system
- Regulation establishing protected biotopes, habitats of community interest and the habitats of species of community interest for which the conservation status has been assessed as unfavorable, and specifying what actions are to be regarded as reduction, destruction or deterioration of these features

[29] https://www.vdl.lu/sites/default/files/media/document/prasentation_renaturation_hollerich_0.pdf

- Ministerial decree relating to the methods of calculation of the digital system of evaluation and compensation in eco-points

The protected habitat inventory is part of a mandatory ecosystem balance study that assesses in form of eco-points the ecological value of the project area before and after implementation of a project. This valuation system has been introduced as part of a financial compensation system to prevent net biodiversity loss where the balance (before/after) can be translated into a financial value (1 EUR/eco-point).

The ecosystem balance study provides the data for the biodiversity indicators EB1-EB3 and the values listed in the impact report are net positive balance figures and expected impact data based on project design, differentiating between purely nationally and European protected habitats (Natura 2000). The performed ecosystem inventory from 2020 serves as baseline. While this assessment already includes the expected development within the project area, the actual development of the affected surfaces could be assessed by repeating the survey 5 or 10 years after the renaturation works in order to evaluate the impact of the project on protected biotopes and habitats of protected species.

The above-mentioned survey includes an inventory of all trees and hedges within the project area, distinguishing between native and non-native species[30]. This allows to evaluate the development of the number or area of these ecological structural elements within the project area over time.

EB4 Biodiversity indicator: **Increase of habitat mosaic favorable for macroinvertebrates within the water body of the river**	
Description / Purpose	The new habitats created by the renaturalization of the river will foster the increase of the macroinvertebrate population and diversity within the water body of the river Pétrusse. Macroinvertebrate populations are particularly good indicators for the healthy state of a river and the level of natural degradation. The contribution to biodiversity will be evaluated in three steps.
EB4 M1	Until year 2026: Description of planned works to improve the hydro-morphology of the river and to create habitats for macroinvertebrates
Unit of measurement	Qualitative description
Frequency of monitoring	Absolute, annual monitoring of progress of works
Baseline	N/A
Data sources	Engineering studies of planned renaturalization works provided by the engineering company involved in the development of the project.
EB4 M2	From year 2027: Hydro-morphological inventory of river
Unit of measurement	Qualitative & quantitative, improvement of classification of river over the next 10 years
Frequency of monitoring	Absolute, monitoring is planned about 3 years after project completion. Hydro-morphological inventories are performed every 6 years (next expected inventories in 2021, 2027).
Baseline	The latest hydro-morphological inventory dates from 2015 and serves as a baseline. Pétrusse river reached classification 5, worst class in 2015.

[30] Based on the check list of vascular plants.

Data sources	A hydro-morphological inventory of the river is performed every 6 years based on 31 parameters, following a methodology compliant with the EU water directive (Dir 2000/60/CE). The results are available at [Eau - Geoportal Luxembourg (geoportail.lu).](geoportail.lu)
EB4 M3	From year 2029/2030: Increase of macroinvertebrates species
Unit of measurement	Number (#) and type of macroinvertebrates species, Multimetric Invertebrate Index I_2M_2
Frequency of monitoring	Absolute, a macroinvertebrates analysis could be performed in later years, no such monitoring planned at this stage.
Baseline	Detailed study of macroinvertebrates in the Pétrusse river conducted in 2018 by Luxembourg Institute of Science and Technology.
Data sources	Data provided by the Ministry of Environment, Climate and Sustainable Development. Baseline information from scientific studies performed by the Luxembourg Institute of Science and Technology.

EB4: Definitions and methodologies

The river Pétrusse is currently classified as a Heavily Modified Water Body "HMWB" and both ecological quality and species richness of, among others, the macroinvertebrate fauna of the Pétrusse are very poor.

Macroinvertebrate populations are particularly good indicators for the healthy state of a river and the level of natural degradation. The biodiversity effects of the hydro-morphological changes after project implementation will be observed in a first instance at the level of new habitat diversity and related conditions (e.g. river flow speed) favorable for the development of a diverse macroinvertebrate population. In the long run, modifications at the level of macroinvertebrate assemblages may also be visible as a biodiversity impact of the project activity. Hence, three metrics have been chosen to describe the macroinvertebrate biodiversity impact due to the improvement of the river morphology. First, the description of structural works to be performed as per project design, which will increase the natural habitat mosaic favorable for macroinvertebrates. Second (starting in year 3 after project completion), a hydro-morphological inventory will be performed, the metric will be an improvement of official classification of the river from baseline category 5 (worst). The classification follows the methodology of the EU water framework directive (Dir 2000/60/CE)[31]. Third, earliest 6 years after project completion an expected increase of the macroinvertebrate species diversity and overall population (multimetric macroinvertebrate index I_2M_2) can be measured and compared to a solid baseline study, which has been performed in 2018/2019 by the Luxembourg Institute of Science and Technology for the Pétrusse river[32]. It is important to note that a positive change in the macroinvertebrate population is not only dependent on a successful renaturalization of the river Pétrusse within the project area, but also depends very much on the physico-chemical, chemical and other anthropological pressures on the upstream river areas, outside the control of this project.

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[31] https://ec.europa.eu/environment/water/water-framework/index_en.html

[32] Luxembourg Institute of Science and Technology LIST (2019), Monitoring opérationnel des macro-invertébrés dans le cadre d'un projet de la rénaturation de la Pétrusse

EB5 Biodiversity indicator: Fish passage constructed	
Unit of measurement	Number of fish passages constructed
Frequency of monitoring	Absolute, annual monitoring of construction works
Description / Purpose	The fish passage will contribute to the introduction of fish populations
Baseline	No fish passage. Baseline studies of fish populations in river Pétrusse performed in 2019.
Data sources	The construction plans of the fish passage have been provided by the engineering company tasked with the planning of the project. Fish population inventory studies have been provided by the Water Management Administration.

EB5: Definitions and methodologies

Creating a favorable environment for fish migration is part of the objectives of the renaturation of the river Pétrusse. For this purpose, the installation of a specially dimensioned fish passage is necessary at the confluents of the Pétrusse and the Alzette river. The new morphology of the river will allow regeneration and migration of river fauna even when water levels are low (aiming at 50-65 migration days due to generally low water levels of the Pétrusse) for the target fish, the river trout, or brown trout. Baseline fish studies have been performed and practically no fish are currently found in the river Pétrusse.

EB6 Biodiversity indicator: Number of bird species using the project area as habitat	
Unit of measurement	Qualitative & quantitative, Number (#) of records/data points of viewings of specific bird species held in the national biodiversity database over a longer time period.
Frequency of monitoring	2025 and 2029: Review records of viewings held in national biodiversity database
Description / Purpose	Expected increase of records held in national biodiversity database concerning viewings of bird species, especially species bound to near-natural waters and wetland habitats within project area.
Baseline	500 recorded data points on specific bird species in the project area from 2010-2021
Data sources	The bird species datapoints have been retrieved from the publicly available national biodiversity database hosted by the National natural history museum

EB6: Definitions and methodologies

While there has been no specific inventory of birds performed within the project area before the start of the project, the national biodiversity database, hosted by the National natural history museum, contains more than 500 data on birds within the narrower project area in the period between 2010 and 2021. Based on these baseline data and the recommended review of the records of the biodiversity database in year 5 and 10, a qualitative statement on the change in the use of the area, especially by bird species bound to near-natural waters and wetland habitats, can be made at a later stage.

ECA1 Climate adaptation indicator: Spatial extent of renaturalized flood plain and capacity of flood water retention	
Unit of measurement	m^3
Frequency of monitoring	Absolute, no monitoring planned
Description / Purpose	Flood risk reduction for once in 100-year river flow events through capacity increase for water retention of the river after natural rehabilitation of the river area.
Baseline	N/A
Data sources	The data have been provided by the engineering company tasked with the planning of the project (and confirmed by the *Administration de la Gestion de l'Eau*).

ECA1: Definitions and methodologies

An important objective of the project is the reduction of flooding that regularly occurs and is expected to occur more often due to climate change for example after torrential rain events. The activity is a nature-based solution, addressing the chronic and acute water-related hazard. The renaturalized riverbed will allow the river to expand into natural river flood plains in case of high-water flows and reduce potential damage from flooding. The capacity increase for water retention of the river after rehabilitation, for once in 100-year river flow events (HQ100 at flow speeds of $55m^3/s$) has been chosen as an indicator for the climate adaptation activity[33]. Values stated in the impact report are values calculated based on modeling with the MIKE Zero and MIKE 21 (by DHI Group) programs at project planning stage.

EP1 Water quality and pollution reduction indicator: first flush mechanism	
Unit of measurement	Qualitative
Frequency of monitoring	Absolute, no monitoring planned
Description / Purpose	Improvement of water quality by installation of a structure separating the first flush rain water in the city of Luxembourg and diverting it to the water treatment.
Baseline	Detailed analysis of the water quality in the affected section of the river from 2011[34].
Data sources	The description of the project and baseline studies have been provided by the engineering companies involved in the preparation of the project.

EP1: Definitions and methodologies

In a large part of the urban area of the city of Luxembourg, the drainage of waste water and rainwater is carried out in a separate system. However, pollutant loads from various sources also enter the rainwater sewer system by: i) direct input of pollutants, ii) faulty connections, and iii) discharge from the connected surfaces via the street inlets.

[33] Despite an increase in retention volume of HQ100, the planners project a slight reduction in retention volume of -745 m^3 for HQ10 ($35m^3/s$), attributable to a bridge located in the project area, limiting expansion.

[34] Centre de recherche public Gabriel Lippmann (2012): Bilanzierung von Stoffflüssen an einem Staukanal im Trennkanalsystem St. Quirin der Stadt Luxemburg, DEV EVA 44/110525, 18 pp.

In rainy weather, these pollutant loads enter the Pétrusse without any intermediate treatment. Particularly in longer dry weather periods, particles settle on the surface of the canals and are mobilized at the beginning of rain events. The accumulated pollutant load is then discharged into the Pétrusse in a gush-like manner, the so-called "first flush"[35]. Such pollution loads put further pressure on the small river system and are not in line with the development of a good ecological state of the river as prescribed by the EU Water Framework Directive. To avoid these problems, a separating structure is planned, which will feed the permanent highly pollutant loaded runoff (approx. 3 l/s) directly into the waste water sewer system. In addition, a volume is provided in the structure which is loaded with the first runoff peak in the event of the occurrence of a "first flush". The part of the rainwater runoff that follows, which is significantly less loaded, will be discharged into the Pétrusse as before. Based on a detailed analysis of the water quality in the affected section of the river from 2011[36] (baseline), the effects of this measure on water quality can be analyzed after implementation. According to the baseline study, it is expected that such a first flush system can reduce the chemical oxygen demand (COD), particulates, oils, heavy metals (Iron, Zinc) of the Pétrusse river by ca. 45-80%.

[35] TR-Engineering (2019): Réalisation des ouvrages first flush, Ouvrage de captage du bassin versant 2

[36] Centre de recherche public Gabriel Lippmann (2012): Bilanzierung von Stoffflüssen an einem Staukanal im Trennkanalsystem St. Quirin der Stadt Luxemburg, DEV EVA 44/110525, 18 pp.

7. Affordable housing projects and energy efficiency considerations

The Luxembourg sustainability bond includes a portfolio of 17 affordable housing projects, that are built according to high energy efficiency standards. This section presents the chosen indicators to document the environmental performance related to the energy efficiency and greenhouse gas emissions of this portfolio.

7.1. Sectoral strategy and regulatory context

National strategic and regulatory context on energy efficiency and sustainability in residential buildings

National targets regarding the development of energy efficiency in Luxembourg are presented in Luxembourg's 4th National Energy Efficiency Action Plan (NEEAP 2017)[37] and are further defined by Luxembourg's National Energy and Climate Plan (NECP, 2020[38]). The revised version of EU Directive 2010/31/EU on the energy performance of buildings introduced the concept of 'nearly zero-energy buildings' (NZEB). This EU Directive specifies that all new buildings must meet this standard by 31 December 2020. For this purpose, national implementation and action plans for increasing the number of nearly zero-energy buildings are required. Luxembourg's Grand-Ducal Regulation of 23 July 2016[39] concerning energy performance of residential buildings prescribes that with effect from 1 January 2017 all new residential buildings must meet the nearly zero-energy standard. As the first country in the EU, Luxembourg has therefore introduced the 'nearly zero energy building' standard on a mandatory basis for residential buildings already on 1 January 2017. Therefore all residential buildings offering affordable housing that have received a building authorization after 1 January 2017 respect the NZEB standard.

Luxembourg's definition of nearly zero energy buildings (NZEB)

According to the fourth National Energy Efficiency Action Plan (NEEAP, 2017[40]), the energy efficiency standard of the nearly zero-energy building (NZEB) in Luxembourg generally corresponds to an AA or BB energy efficiency class building[41]. The NZEB threshold for Luxembourg is currently fixed for residential buildings at 45 kWh/m^{2}yr primary energy demand but is finally calculated based on a reference project. This calculation has become even more detailed and stringent in regards to the insulation requirements and the technical equipment installed within the buildings, when the new Grand-Ducal Regulation from 9 June 2021[42] regarding the energy performance of buildings entered into force on 1st of July 2021. The individual thresholds (kWh/m^{2}yr) for an NZEB classification therefore changes depending on the situation of the building, using a set of reference buildings for the respective NZEB thresholds.

[37] https://mea.gouvernement.lu/fr/energie.html

[38] https://ec.europa.eu/energy/sites/ener/files/documents/lu_final_necp_main_en.pdf

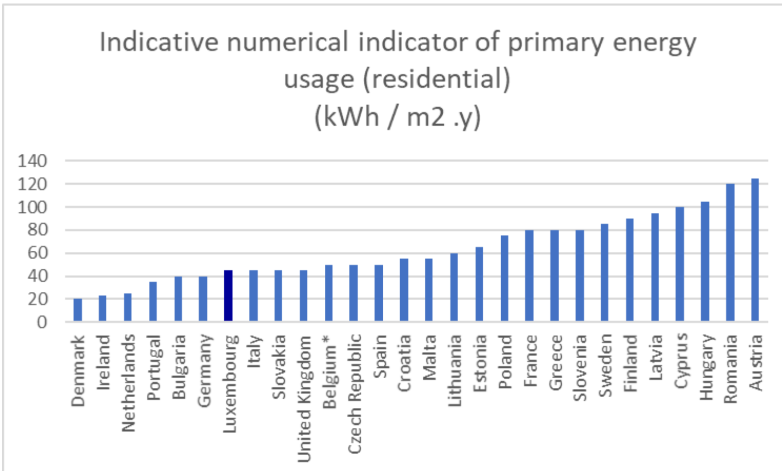
[39] Recueil de Legislation A-N°146, 1er août 2016, http://legilux.public.lu/eli/etat/leg/rgd/2016/07/23/n8/jo . The Grand-Ducal regulation A-N°227 du 5 avril 2019, further specifies the new energetic performance of residential buildings. http://legilux.public.lu/eli/etat/leg/rgd/2019/03/07/a227/jo

[40] https://ec.europa.eu/energy/sites/ener/files/documents/lu_neeap_2017_en.pdf

[41] https://www.myenergy.lu/fr/mediatheque1/telechargements/telecharger/921, Le certificat de performance énergétique pour bâtiments - Lois et règlements - Particuliers - myenergy

[42] Règlement grand-ducal du 9 juin 2021 concernant la performance énergétique des bâtiments. - Legilux (public.lu)

It is important to point out that Luxembourg's NZEB values are already stringent in comparison to other European countries. The European Commission Report "Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU" from November 2019 lists the NZEB thresholds for residential buildings for EU member states. The new Luxembourg building energy performance regulation from 9 June 2021 introduces even more ambitious requirements coming into effect in 2023 on the level of heat production (heat pumps in the reference buildings) and utilization of renewable energies.



Graph: Indicative primary energy usage of European countries, reference: European Commission Report, Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU, Nov. 2019[43]

A voluntary certification for new buildings based on ecological, economic, and social criteria, the Luxembourg Sustainability Certificate for Residential Buildings or LENOZ, has been introduced on 1 January 2017. The LENOZ certification integrates environmental aspects of building materials used and indoor air quality considerations[44]. The uptake of the LENOZ certification has been modest so far. Three single family houses included in the Sustainability Bond portfolio (Kehlen) will however apply for the LENOZ certification.

7.2. Indicators and methodologies for the energy efficiency in residential buildings

EE1: Energy efficiency indicator: Floorspace per energy performance certificate class ECM1: CO_{2e} emissions	
Unit of measurement	EE1: m^2 floor space per energy performance certificate (EPC) class AA to BB corresponding to NZEB standard ECM: t CO_{2e} / year
Frequency of monitoring	Calculated at project design stage or reviewed after project completion (as built). No monitoring planned.

43 An average has been taken for Belgium and Ireland, which values in the report were 30-70 kWh / m2.y and 15-30 kWh / m2.y, respectively.

44 https://guichet.public.lu/en/citoyens/logement/construction/performances-energie/certificat-lenoz.html

Description / Purpose	Measure of energy and climate performance of residential buildings of the affordable housing portfolio.
Baseline	N/A
Data sources	The number of m^2 with an energy performance classification of AA or BB and t CO_{2e}/year data are retrieved from the energy performance certificates for the respective affordable housing projects. These certificates have been requested from the different building contractors through the Ministry in charge of social and affordable housing and analyzed individually. The government of Luxembourg, through the Ministry of Energy, has recently started the development of a central database for the collection of energy performance certificates.

EE1, ECM1: Definitions and methodologies

The indicator EE1 describes the floor space that has an AA - BB energy performance class, corresponding to the NZEB standard in Luxembourg depending on building type, location and reference building. The table 6 below lists applied thresholds for the portfolio of affordable housing buildings included in the Luxembourg sustainability bond portfolio. The applicable NZEB threshold for a specific building is listed in the respective energy performance certificate (EPC) or "Energiepass". The energy performance certificate contains information on primary energy demand, thermal insulation, CO_2e emissions and lists the generation of renewable energy from photovoltaic. The CO_2e emission value, used for the ECM1 indicator also contains emissions of other gases than CO_2 (for example methane), emitted during the generation, conditioning, and transport of energy.

The information on the EPC follows the latest Luxembourg regulation on energy efficiency, the regulation lists in detail the methodologies applied, and is accompanied by a software to use in applications.

Thresholds for residential buildings in Luxembourg		**Energy performance (primary energy demand) (cat / kWh / m^2y)**	**Thermal insulation (cat / kWh / m^2y)**	**Environnemental performance (kg CO_2e/ m^2y)**
Multifamily houses	AAA "passive house"	**45**	**14**	**10**
Multifamily houses	BBB low energy consumption house	75	27	17
Single family houses	AAA "passive house"	**45**	**22**	**11**
Single family houses	BBB low energy consumption house	75	27	17

Table 6: Applied thresholds for the portfolio of affordable housing buildings included in the Luxembourg sustainability bond

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