Methodology | June 2022

Method Description
Impact Report
NRW Sustainability Bond #8

Indicators, Data & Methods

This report is based on the results of a study conducted on behalf of the State Government of North Rhine-Westphalia. The authors are responsible for the content.

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Content

1 Scope of the Report

The Wuppertal Institute analysed the NRW Sustainability Bond #8 (2021) on behalf of the State Government of North Rhine-Westphalia (NRW). The report at hand provides a description of the data and methods used to derive indicators reported in the main report (investor briefing).

It is based on the further development of methods and data already described in previous publications such as the full reports for the NRW Sustainability Bond #5 (Teubler et al., 2019) and #6 (Teubler et al., 2019) as well as the first method description developed for the impact assessment for NRW Sustainability Bond #7 (Teubler & Hennes, 2021). It also draws on other works by the authors such as the methodology for the impact assessment of the Green Bond Baden-Württemberg (Teubler & Brauneis, 2022) and the Social Bond of the NRW.BANK (Teubler, 2021).

Projects in the Sustainability Bond #8 were classified by the issuer into 14 different categories from A to N (see also State of North Rhine-Westphalia (2021a)). Of these categories, the categories A to F are more closely related to desired social effects and G to N to desired ecological effects. However, numerous projects also relate to other sustainability dimensions, which is represented by their association with more than one sustainable development goal (SDG) in many cases. For climate change mitigation purposes in particular, additional greenhouse gas savings can be attributed to several social programmes such as promoting low-carbon public transport services. The report at hand therefore differentiates between social and environmental effects, but considers potential GHG savings as an additional category of co-benefits.

Section 2 of the report describes changes to the methodology as a consequence of the update of the issuer's framework as well as further development of the indicator methodology by the authors. It particular describes how indicators are qualified, how robustness of values is evaluated, how effects are attributed and how effects can be accumulated.

Section 3 describes social effects in categories A to F. Only projects with at least one quantified indicator (above the input level) are discussed here.

Section 4 describes environmental effects in categories G to N. Again, only projects where at least one indicator was quantified are discussed.

Section 5 describes methods and data for the estimation of GHG savings in the following systems: low-carbon public transport, cycling infrastructure as well as construction and modernization of buildings.

Section 6 lists all literature sources.

The annex contains a table with a full list of all quantified indicators, their quality as well as robustness.

2 Update of the Methodology

Previous impact reports for the Sustainability Bond NRW applied a slightly different methodology than shown in the report at hand. They were based on the distinction of effects that measure success of programmes compared to indicators that account for the input by or participation of actors (see Teubler & Hennes, 2021 for a full rationalization and description of the indicator classification in previous impact reports for bonds #6 and #7).

Since then, the State of NRW has changed its approach to the categorization of projects. The projects in the current Sustainability Bond (as well as previous bonds) have been re-arranged to fit more closely with the recommendations of the Green and Social Bond Principles by ICMA (State of North Rhine-Westphalia, 2021a). This results in a more granular differentiation of State programmes and their contribution to different sustainability goals. It is also intended to present the effects of all previous bonds in an accumulated manner in the future (e.g., summing up the job creation in a project over several years of funding). In addition, funding in the impact report is now allocated to the most recent budget expenditures. This makes it even more unlikely that any type of result has already been reported by the State's institutions. Hence, the need for estimates and appropriate models has increased.

Although these changes alone merit an update of the methodology, the authors´ approach to the qualification and quantification of social effects has been advanced as well. The goal of the new approach is to qualify reported values more clearly and consistent according to the following characteristics:

- **Qualification**: What is the context of the measured effect?
- **Robustness**: How was the value determined?
- **Attributability**: Is the State of NRW the sole promoter of the effect?
- **Accumulability**: Which values can be summed up over a period of time?

The following sections discuss each criterion and the solution in the report at hand.

Qualification of reported values

The quality of an indicator should, similar to the original approach in the impact report for NRW Sustainability Bond #6, convey to the reader if the reported value is just describing the intervention or if it also provides information on the desired outcomes of an intervention or programme. Introducing a simplified Theory-of-Change approach (see Teubler (2022) for a more detailed description of the approach), indicators are now classified according to their location in a linear cause-effect chain:

- Activity-Indicators are classified as D (standard reporting practice) and measure the materialization (promoted activities) of State funding on the level of projects and entities.
- Output-Indicators are classified as C (best-practice) and report the tangible results of State funding on the level of projects and entities.
- Intermediate outcome-indicators are classified as B (best-in-class) and report desired effects on the societal level in a close temporal and regional context.
- Long-term outcome-indicators are classified as A (best-needed) and report on desired persistent changes on the societal level in a region.

As a rule of thumb, activity-indicators are the easiest values to measure and can often directly be based on evaluation or monitoring reports. Long-term outcomes on the other hand require a lot more evidence and usually cannot be attributed to one cause alone without applying a simplified and "mechanistic" view on how policies and interventions develop in society. As a consequence, the need for data (and evidence) increases from D to A.

In this scheme or "outcome-pathway", two types of indicators are not explicated in the report at hand. First it is assumed, that the final impacts of the State`s projects –direct contribution to Sustainable Development Goals – cannot be measured within the framework of a Sustainability Bond. Such indicators would require a more complex theory of change (with non-linear interactions between actors and alternative causal strands), a more robust data basis and in most cases, empirical research and a study design that incorporates randomized events. This is also the reason why indicators with quality A (as pre-conditions for achieving overarching goals) are very rare (in fact, the report at hand does not report one such indicator).

The second type of indicators not accounted for are input-indicators (classified as E in the scheme). It is assumed that inputs to the cause-effect chain can be mainly attributed to the funding for a specific purpose. As such, the issuer's own report on eligible assets (State of North Rhine-Westphalia, 2021b) already provides a rationale and data basis for these interventions. As a result, each budget expenditure dedicated to a specific project described in the issuer’s framework is considered to be an indicator with quality E.

Robustness of reported values

Information on the robustness of a reported value conveys to the reader how an indicator was determined. Ideally, all reported values stem directly from official sources (or commissioned studies) and were gathered under high scrutiny (e.g., by State agencies such as IT.NRW). Although such values are not validated by the authors of the report at hand, it is assumed that they are primary data and robust.

However, even in this case, there might not be a clear indication to what extent different actors contributed to that effect. It is therefore not surprising, that most reported values in the report at hand make use of auxiliary variables (such as cost factors in regulations) or simple models in order to estimate the effects in reference to the funding in the bond. In addition, there are also values reported by sources, that can be considered results from third parties or personal communication. These results are not directly gathered by government agencies or published in studies and are therefore deemed not to be verifiable.

Robustness is qualified in five different levels (as shown in table 1) with 1 attributed to the highest and 5 attributed to the lowest robustness according to a recently developed methodology by the authors (Teubler & Brauneis, 2022). Robustness can be directly applied to the quality of the indicator (A-D) with the help of indices.

D_2 for example translates into: the value reported describes an activity (D) on project level funded by the State of NRW and has been directly estimated on the basis of primary data (2).

table 1: robustness criteria for data collection and quantification

Robustness	Criteria	Example
1	primary data (directly monitored or evaluated)	the number of returned researchers in the *return programme for highly qualified young researchers from abroad*
2	directly estimated from primary data	States' share (estimate) for women shelters places (monitored) in NRW compared to funding from all sources (State and EU funding)
3	calculated with the help of secondary sources or auxiliary variables	the number of social school worker jobs based on annual lump costs per person awarded by the associated regulation
4	estimated on the basis of models with a simplified universal mechanism	conservative estimate for number of created jobs for persons with disabilities based on maximum funding per job available
5	results from 3rd party reporting without the possibility for validation	GHG savings from projects in ERDF Funding

source: own compilation based on Teubler & Brauneis (2022)

Attribution of effects to the issuer

Previous reports focused on indicators that could clearly be attributed to the issuer alone (the State of NRW and its institutions) or could be related to the State's share of total funding (all other programmes were either not assessed at all or indirectly reported as data from 3rd parties). This is a dubious undertaking for many of the eligible assets for two reasons. First, even a 100 % public funding by the State does not necessarily exclude additional interventions of private actors. And secondly, only few programmes and projects are evaluated in a way that allow for the robust allocation of means to different or (if possible) distinct purposes. However, there is reliable information on many of the desired effects of State programmes that could be reported, but cannot be attributed to the issuer due to a lack of data on the stakeholders. The authors therefore decided to introduce two distinct categories of reported effects: full contribution and partial contribution. A full contribution in this regard is defined as follows:

*The **full contribution** of the issuer to a reported value is achieved if there is either a high confidence that the State is the sole contributor of a monitored effect or if the funds by the State can be directly attributed to an estimate made by the analysts.*

All other values are considered to be a partial contribution, where it is not possible to attribute the actual contribution of the State or NRW and its institutions in a robust manner.

Accumulation of effects within and with other bonds by the issuer

The summation of reported values requires a process of normalization. Units of reported values have to be selected in a manner that clusters similar effects or similar target groups. This allows for a summary of results as shown in the main report for investors (while still allowing to report on distinct indicators). As a convention in line with the criterion of attributability, only effects that have the same unit and the same level of attribution can be added up. The following table 2 shows all units of comparison for the report at hand.

table 2: clustering and normalization of reported values in the report at hand

Unit of comparison*	Description	Example for an indicator
beneficiaries [1]	funding desired outputs or outcomes for target groups of a programme	equivalent of paid student tickets
jobs created/sustained [1]	funding of salaries or job creation for desired tasks and/or among target groups	returned researchers
projects [1]	funding of public or private projects facilitating desired project results	equivalent of paid urban development projects
entities [1]	funding of public or private entities facilitating certain desired tasks	competence centres women and profession
[ha] of sustainable land-use	funding to enable, expand or sustain sustainable land-use	re-afforestation of damaged forests
vehicles [1]	funding the purchase of low-carbon vehicles	equivalent of promoted low-carbon vehicles
[MWh] of RE production/storage	funding of the installation of renewable energy systems	equivalent of promoted solar battery capacity
[m^2] of new buildings	funding of construction efforts of energy-efficient buildings	expansion of universities and university clinic buildings
[m^2] of building area renovated	funding of modernization efforts to decrease the energy-use of buildings	modernization of universities and university clinic buildings
animals benefiting [1]	funding of efforts for animal-friendly agriculture	equivalent of animals in animal-friendly husbandry
* All reported values refer to annual funding in a given year. However, there might be a temporal distortion between reported values and funding in the States' budget (e.g., if remaining funds are allocated after a programme ends or if evaluated effects from previous years are attributed to estimates for the current reporting period).		

source: own compilation

Overview of indicator characterization

The following table 3 summarizes the characteristics of quantified values in this impact report.

table 3: overview of characteristics of reported values for NRW Sustainability Bonds

Qualification	Robustness	Attribution	Accumulation
A: long-term outcome (best-needed) **B**: intermediate outcome (best-in-class) **C**: output (best-practice) **D**: activity (standard practice)	**1**: reported primary data **2**: calculated based on primary data **3**: calculated with the help of auxiliary variables **4**: estimated on the basis of models **5**: third party reporting (non-validated)	**full contribution**: State of NRW is sole contributor or effects can be directly attributed based on allocated funding **partial contribution**: other actors are clearly or likely contributing to the effect	beneficiaries [1] jobs created/sustained [1] projects [1] entities [1] [ha] of sustainable land-use vehicles [1] [MWh] of RE production/storage [m2] of new buildings [m2] of building area renovated animals benefiting [1]

source: own compilation

The role of investors for the NRW Sustainability Bond

Recent studies by scholars as well as stakeholders in the finance industry have started to dispute the positive sustainability impacts that are associated with investments and in particular with sustainable Use-of-Proceeds (UoP) bonds. It is argued that these financial products can lead to "*rebranding without additionality*" (Migliorelli, 2021, p. 2), "*cannot claim to enable [sustainable] activities*" (Horster, 2021, p. 54) and are "*likely to be ineffective*" (Krahnen et al., 2021, p. 3). They are even compared to hot air balloons: "*[T]he booming green bond market might be comparable to a hot air balloons festival: great to raise awareness and turn people's heads towards the sky, but if the objective is to reach the moon, we will need more than hot air*" (Dupre et al., 2018). Although we were not asked to investigate this question for the impact report at hand, we find it important to include such a discussion on these issues here, as it sheds light not only on the role of sustainable-labelled bonds in the sustainable finance sector but also on the role of investors, issuers and external reviewers like us.

According to Krahnen et al. (2021), there are three major misconceptions by investors that also affect the achievement of sustainability goals. Investors (wrongly) assume that (a) their source of funding is attributed to particular projects, that (b) funding leads to additional investments into similar projects and that (c) by selecting a labelled sustainable product, non-sustainable projects are negatively affected. Krahnen et al. (2021) argue that none of these assumptions hold true under scrutiny, particularly when looking at the secondary

market (bonds or equities). And there is empirical evidence that this is the case. For example, Migliorelli (2021) finds that the growth for labelled sustainable finance is higher than the growth of the overall investments into sustainable sectors or activities. Thus, at least some of these products do not contribute to more sustainable investments or projects.

An investigation of the impacts like the report at hand cannot address the third issue of segregation (the assumption of sustainable securities having a negative effect on other sectors), because this would require a more macro-economic point of view as well as a corresponding empirical investigation. However, we think that there are plausible arguments to be made that the NRW Sustainability Bond does indeed contribute to sustainability goals and that investors are supporting these efforts.

Regarding the first issue of attributability, there are three indications that financing and re-financing from the bond can indeed directly be attributed to sustainable projects. First, the issuer provides a rationale as well as exclusion criteria for the selection of eligible projects. Projects are selected in line with the State's Sustainability Strategy, mapped to specific SDGs and are restricted to discretionary spending (State of North Rhine-Westphalia, 2021a, 2021b). The proceeds "*[...] will be exclusively used to finance or re-finance, in part or in full, new and/or existing eligible proceeds with clear environmental or social benefits"(State of North Rhine-Westphalia, 2021a, p. 1)*. Secondly, a second-party opinion provider (ISS ESG, 2021) verified (before issuance) that these projects are in line with the issuer's sustainability strategy and sustainability objectives. And thirdly, the report at hand provides or investigates quantitative evidence for the assumption that the funding can be at least partially and, in some cases, even fully attributed to desired social or environmental outputs, outcomes and objectives. We therefore argue that all investor capital involved is attributable to sustainable projects as well even if the allocation of proceeds (described in the issuer's section on management of proceeds) is considered to be a "*[...] virtual allocation [...]*" that "*[...] re-finances the entire balance sheet [...]*" as critics argue (Dupre et al., 2018b, p. 6).

The question of additionality (the second of investors' beliefs) is the most difficult to provide evidence for as well as against. Since the spending already took place, it cannot be robustly investigated what would have happened otherwise. Again, there are two perspectives this issue can be looked at: the issuer and the investor. From the point of view of the issuer, a clear case can be made that most of the State's spending is additional. The State finances or co-finances social and environmental projects that go beyond mandatory spending (for e.g., salaries which are not eligible) and that would probably not have been provided by other, especially private, actors. Doing so could even violate non-competition regulations that are in place[1] to ensure that state actors do not distort the market. The projects of the bond would therefore not exist or at least not have the same size without the State's intervention. However, this also means that these projects would probably also be funded without the existence of the bond. The question for the investor regarding additionality is therefore:

What happens to the net proceeds of the bond and do they increase spending on the same or similar projects?

[1] For example as defined in Article 107 of part three on the Treaty on the Functioning of the European Union (https://eur-lex.europa.eu/eli/treaty/tfeu_2016/art_107/oj)

There are two indications that corroborate this claim. First, there is an obligation in the issuer's framework that "*[...] the proceeds will be exclusively used to finance or re-finance, in part or in full, new and/or existing eligible proceeds with clear environmental or social benefits*" (State of North Rhine-Westphalia, 2021a, p. 3). Secondly, an argument can be made that the continuity of the bond in terms of its project selection and its growth in volume over the years[2] is an indication for the success of the sustainable finance strategy of the State. As net proceeds have, in all likelihood, increased with the volume as well, at least some of this additional spending can be attributed to the success of the bond and thus the investors. This potential cause-effect relationship is of course weaker than other, more dominant, causal strands such as different governments prioritizing different objectives and an overall increase in federal and EU funds. The question of additionality therefore remains open to future investigations by the analysts. However, for the time being, we consider the NRW Sustainability Bond to be both attributional and additional for the issuer (and find it likely that both characteristics are true for the investor as well).

Outlook on methodology

The next steps involve a further normalization and qualification of the process. Firstly, the presented units of comparison need to be adjusted, and potentially expanded, to also include projects of previous bonds. This allows for the accumulation of effects from 2014 (Sustainability Bond #1) until now. Apart from potential data issues, a method has to be developed that ensures that no double-counting occurs and that perennial effects can be attributed to a given budget period.

Secondly, the described Theory-of-Change (ToC) approach for an outcome-pathway needs to be further operationalized. In praxis, it will not be possible to draw-out all causal relationships between all projects in the Bond and their corresponding SDGs. Therefore, a more generic clustering mechanism needs to be applied that provides a plausible narrative for the causal mechanisms involved. This would in turn allow to place all indicators more robustly and comprehensively on visualized outcome pathways.

Thirdly, it will be investigated whether the bi-polar attribution rule (full or partial) should and can be further differentiated. For some projects the State of NRW is the main actor in the system, even if additional funding is acquired (e.g., when funding day-care for children). On the other hand, there are programmes that merely provide an small incentive for stakeholders to act in a particular way (e.g., promotions for electric vehicles). It is planned to identify reliable criteria to distinguish both types of attribution in a consistent manner.

[2] From budget results of EUR 0.7bn in 2014 to EUR 2.7bn in 2019 (before the pandemic), to more than EUR 4.1bn in 2021 (including extra spending to combat health and societal issues from Covid-19).

3 Social Effects

A: Affordable basic infrastructure

In total, EUR 572.2m of the budget result are allocated to three projects and programmes in Bond #8. 100% could be assessed in the report at hand.

Broadband expansion/Digitalization

The largest funding in this category (EUR 393.2m) is allocated to broadband expansion for households, industries as well as schools, universities and hospitals. Since this measure is part of the NRW Sustainability Bond (#4 to now #8), considerable progress has been made in this regard. According to reports by the Federal Ministry for Digital and Transport (BMVI, 2022), the access of households in NRW to bandwidths of 50 Mbit/s and more increased between 2017 and 2021 from 83.3% to now 96.5% (difference of 13.2%). For commercial locations, it increased even more from 80.0% in 2017 to 95.4% in 2021 (increase of 15.4%). The state funding in Sustainability Bond #8 contributes to these achievements in relation to both private investments and federal funding. According to PwC (2021), about 390,000 households were promoted as a result of both federal funding (EUR 948m) and state funding since 2015. If typical promotional shares are assumed (50% from federal, 40% from co-funding by NRW), the budgeted funding for NHA NRW #8 (EUR 305.2 for co-financing as budget result in 2021) therefore attributes to circa 102,600 households that will benefit from better bandwidth in the future.

Public transportation for low-income citizens

The State of NRW supports financially price discounts of its municipalities for social tickets. There are different public transport systems and different tariff landscapes in the State. It is therefore not possible to attribute the support of the State to an actual number of beneficiaries or any desired societal outcomes beyond these discounts. However, a typical social ticket price can be used to estimate the overall effect. Assuming a monthly rate of approximately EUR 40 per ticket (e.g., VRR (2021)), the State funding of EUR 40m alone, is sufficient to fund 83,000 tickets in 2021.

Public transportation for pupils and students

In line with the methodology of previous impact reports (from #2 onward), it can be estimated how much GHG is potentially saved by usage of pupil and student tickets compared to car travel (see section Co-Benefits for Climate Change Mitigation). Based on a funding of EUR 139m and in reference to the current GHG intensities of transport systems in Germany[3], Bond #8 can be attributed to 9.5% of the total costs of the tickets. As a result, circa 117,300 tickets and 11,000 tonnes of potentially saved GHG emissions per year can be attributed to the bond.

[3] 152 g CO_2e/pkm for cars and 91 g CO_2e/pkm for public transport systems (own calculations based on the Website of the Federal Environmental Agency UBA; see https://www.umweltbundesamt.de/bild/vergleich-der-durchschnittlichen-emissionen-0)

B: Access to essential services

In total, EUR 2,450m of the budget result are allocated to 33 projects and programmes in Bond #8. Of this sum, EUR 1,091m or 45% could be assessed in the report at hand.

Investment programme for hospitals and nursing schools

The State's expenditures in Bond #8 for hospitals and nursing schools amounts to EUR 112.4m. At an annual promotion of EUR 20,400 per nursing seat (MAGS, 2021a), this funding is sufficient for 5,500 students (partial contribution).

Vaccination against SARS-CoV-2

The total funding for this programme has been increased. From a budget plan of EUR 100m, the budget plan was increased to EUR 483m with a federal co-funding of additional EUR 436.1m (Vorlage 17/5070, 2021). The funds are intended for purposes of (1) purchasing vaccine supplies (0.6% of total state and federal funding), (2) procurement and logistics (3.3%), (3) reconstitution and separation of vaccines (2.4%), (4) scientific support (0.1%), (5) provision of unscheduleable expenses (1.1%), (6) vaccination costs of doctors (49.3%) and (7) costs for vaccination centres (43.2%). The last item is assumed with costs of EUR 0.5m to EUR 1.0m per month and centre (the budget plan estimates EUR 0.75m on average). We estimate that the expenditures in Bond #8 of EUR 389.3m can be allocated to a direct of funding of EUR 84.1m (43.2% for centres as well as 50% co-financing) and that these funds are sufficient to finance 9 facilities (full contribution).

Professional education of geriatric nurses

The State of NRW supports the education of geriatric nurses with EUR 45.5m, which is equivalent to the promotion of 10,000 students per year (at EUR 380 school cost lump sum per student according to §5 of AltPflG NRW).

Return programme for highly qualified young researchers from abroad

In 2021, EUR 5.3m were used to facilitate the return of 16 researchers and their research groups (primary data).

PlusKita and language courses at childcare facilities

The budget results in 2021 amount to expenditures of EUR 100.3m for these measures. According to the lump sum calculation from previous impact (Teubler & Hennes, 2021), this funding can be attributed to circa 2,600 full-time positions for pedagogical educators with additional qualification in language support (at an assumed yearly salary of EUR 39,004, according to oeffentlicherdienst.info (2022)).

Measures at day care centres in response to the coronavirus pandemic

This funding is aimed at the provision of day-to-day helpers for day-care centres during the pandemic (budget plan EUR 132.2m) as well as funding for Covid-19 related schooling and equipment (budget plan EUR 14.7m) (State of North Rhine-Westphalia, 2020). The current expenditures for 2021 of EUR 121.5m attributes equivalently to EUR 109.3m for day-to-day support and EUR 12.2m for other measures. Day-to-day helpers are funded for seven months with funds of EUR 2,100 per month (State of North Rhine-Westphalia, 2021b). The budget result of EUR 109.3m can therefore be translated into the promotion of circa 7,400 day-to-day helpers.

Social work at schools

The State promotes social workers at schools with EUR 47.5m, which corresponds to the promotion of 733 social workers (at annual costs of EUR 64,815 per position in line with the previous lump cost factor in Teubler & Hennes (2021)).

Bund-Länder-Covenant for the expansion of universities (State's share)

The third Bund-Länder-Covenant is financed by both federal and State budgets (with expenditures of EUR 343m in 2021). It is intended to recruit additional staff, increase the proportion of women in professorships, enable high-quality studies, increase success of studies, increase the proportion of first-year students and increase the number vocationally qualified students at universities (see GWK (2021) for a detailed monitoring of 2019). Although the base year for comparison (and financing) is 2005, the third (current) covenant covers the period of 2016 to 2020 (financed until 2023).

The current funding period focuses mainly on additional first-year students. Additional first-year students are funded with EUR 26,000 for four years, which is co-financed 50/50. The additional 31,516 first-year students in NRW can therefore be attributed to funds of EUR 102.4m.

Exemption to contribution for parents for the last two years of day care

The last two years of day-care are exempt from costs for parents in NRW (Ministerium des Innern NRW, 2022), which is promoted in Bond #8 with expenditures of EUR 417.7m. This is equivalent to 298,224 children (partial contribution) above the age of 3 in 2021/2022 (Ministerium der Finanzen NRW, 2022, p. 59).

Support for family centres

In 2021, EUR 65m were attributed to family centres in socially deprived areas in NRW. Based on a lump promotion of EUR 20,000 per centre and year (see Teubler & Hennes, (2021)), this funding can be attributed to 3,300 family centres (partial contribution).

C: Affordable housing

In total, EUR 72.2m of the budget result are allocated to three urban development programmes in Bond #8. Of this sum, EUR 39.4m or 54.2% could be assessed in the report at hand.

Urban development programmes

Several urban development programmes are addressed here, of which the following could be assessed using the same metric: "Urban Reconstruction in the West", "Growth and Sustainable Renewal" and "Social Cohesion". The current report on the NRW urban development programme 2021 (MHKBG, 2021) lists projects for a total funding of EUR 368m. From this reporting alone, it is not possible to distinguish what projects are related to which parts of the programme. However, it can be estimated how many projects would be promoted from the NRW Sustainability Bond alone (activity-indicator) when accounting for the State’s share. From the overall funding, EUR 195m and therefore 53% are allocated to state funding. In addition, 60 projects for EUR 33m out of 294 projects are attributed to a special programme for sport facilities and are therefore not attributable to the programmes addressed in the bond. The remaining funding under consideration of the

State's share can then be used to estimate the number of projects. Budget results of EUR 32.3m for "Urban Reconstruction in the West" and "Growth and Sustainable Renewal" represent full funding of 12 projects (project equivalents with full contribution) and EUR 7.1m for "Social Cohesion" represents 3 projects.

D Employment generation

In total, EUR 4.9m of the budget result are allocated to 3 projects in Bond #8. Of this sum, EUR 1.9m or 39% could be assessed in the report at hand.

Occupational integration of people with disabilities

The State of NRW promotes directly the creation of jobs for persons with disabilities. Up to EUR 20,000 are provided for each job created (MAGS, 2022). Attributed to the 2021 budget expenditures of EUR 1.9m, at least 96 new jobs were created in this manner as an intermediate outcome of the programme (or even more, but at a lower contribution by the State).

E Food Security and sustainable food systems

In total, EUR 2.4m of the budget result are allocated to 1 programme in Bond #8. Of this sum, EUR 1.7m or 69% could be assessed in the report at hand.

EU school programme

The EU school programme provides fruit and vegetables as well as dairy products to pupils in its member countries. In addition to the overall EU funding for Germany between 2017 and 2023 (EUR 32.21m for fruits and vegetables, EUR 14.53m for dairy), federal funds of EUR 2.85m are provided (Federal State of NRW, 2021). The State of NRW funded the programme in 2021 with EUR 2.4m (expenditures) and monitors the overall success of the programme. Regarding fruit and vegetables, 227,000 pupils benefited in 2020/2021, and 229,000 in 2021/2022 (LANUV NRW, 2022).

These outcomes can be considered a contribution to beneficiaries in relation to funding for fruit and vegetables compared to dairy (68.9%). Thus, on average, EUR 1.65m of the funding in this category led to benefits for 228,000 school children (partial contribution).

F Socioeconomic advancement and empowerment

In total, EUR 173.0m of the budget result are allocated to 11 projects in Bond #8. Of this sum, EUR 48.7m or 28% could be assessed in the report at hand.

Fight against poverty and social exclusion

Out of EUR 9.3m (budget result 2021), circa EUR 3.0m are used to prevent homelessness or help homeless persons to find a home ("Endlich ein Zuhause") (MAGS, 2019). In 2021, 22 communities received funding for that purpose. Based on the success of previous years, it can be estimated that (on average) EUR 2,071 are needed to help one person (Teubler & Hennes, 2021). This translates into a potential of 1,400 persons that benefited from the programme in 2021 (output-indicator).

European Social Fund 2014-2020 (State's share)/Programmes "No dead-end qualification"/"No dead-end qualification (compact)"

Out of EUR 23.8m (budget expenditures in 2021), EUR 5.2m are used to facilitate the career-entry for pupils in NRW. Based on the overall number of participants over the entire project period, total funds of EUR 21.0m (2014-2020) can be attributed to 5,842 participants of the programme (activity-indicator) (MAGS, 2021b). This translates into a potential of 1,400 persons that benefited from the programme in 2021 (each participant is supported for 18 months).

Equality and potential development in work and society

This programme is budgeted with EUR 0.8m in 2021. Most of the funds are used for 16 competence centres for women and jobs (activity-based indicator with partial contribution) (Ministerium der Finanzen NRW, 2021b). In some regions of NRW, this also includes the support of female entrepreneurs, woman's organizations and networking projects.

Protection from violence

The funds in this category are intended to support women's shelters and their staff (43% of budget plan), women's counselling centres as well as specialized counselling centres for the protection from forced marriage (46% of budget plan) and funds for the implementation of the state action plan to combat violence against women and girls (Ministerium der Finanzen NRW, 2021b). An additional budget of EUR 3.0m is also allocated to these projects as part of the "Schutz vor Gewalt Corona" (protection from violence Corona), which acknowledges the additional demand for such services during the Covid-19 pandemic.

The overall success of these projects is monitored and funds have been expanded over the recent years. Regarding the budget result of EUR 21.9m for 2021 as well as the additional Covid-19 funding, a budget of EUR 10.8m can be partially attributed to 624 places in women's shelters (monitored output-indicator), and a budget of EUR 11.67m to 62 specialized consulting centres (monitored activity-indicator). These effects were calculated based on the budget results and allocated according to the most current reporting in (MHKBG, 2020).

Since May 2020, the state government has also been funding apartments for men affected by violence at four locations. Currently, 16 such places (monitored output-indicator) are promoted in NRW with a budget result of EUR 0.6m (MHKBG, 2022).

Promoting integration of migrants living together in diversity

The State supports various projects at a municipal level in order to integrate migrants into society (Ministerium der Finanzen NRW, 2021a). Out of budget expenditures of EUR 20.4m, EUR 16.6m could be directly associated with personnel expenses in the 54 municipal integration centres in NRW. These centres mainly work with migrants who have been in North Rhine-Westphalia for a long time and provide possibilities to support integration and self-organization of the participants. Based on the annual funding for these persons in two similar programmes (Bezirksregierung Arnsberg 2022h, 2022a), it is estimated that 300 such jobs are either created or sustained with a full contribution (output-indicator).

4 Environmental Effects

G Renewable energy

In total, EUR 10.9m of the budget result are allocated to two projects in Bond #8. 100% could be assessed in the report at hand.

Photovoltaic funding

Expenditures in the Bond promote the expansion of PV capacity with EUR 10.9m. It is intended to promote installations for both multi-family homes and the industrial sector.

By doing so, the State of NRW is partially responsible (partial contribution) for additional PV capacity in NRW in 2021. We estimate that, based on the PV growth between 2018 and 2020 (Landesverband Erneuerbare Energien Nordrhein-Westfalen, 2018), an additional capacity of 544 MW_P could be materialized. Assuming full-load hours of 873 h/a for NRW (ibid), this additional capacity is sufficient to produce 475,500 MWh of renewable electricity.

H Energy efficiency

In total, EUR 129.2m of the budget result are allocated to two projects in Bond #8. Of this sum, EUR 34.2m or 26% could be assessed in the report at hand.

Energy systems of the future, system transformation, innovation, e-mobility and energy efficiency

This project is budgeted with EUR 124.1m in 2021. The State of NRW supports projects in "progres.nrw", a programme for rational use of energy, renewable energies and energy saving with the main components "product launches" (EUR 28.8m) and "low-emission mobility" (EUR 24.5m) (Landtag NRW (State Parliament NRW), 2020).

Through the various funding opportunities, such as funding for the purchase of electric cars, expansion of charging infrastructure or cargo bikes, at least 5,762 projects were partially supported for the "low-emission mobility" part (Bezirksregierung Arnsberg, 2022b, 2022c, 2022d). In the area of "market introduction", at least 5,278 projects were partially financed, such as for example the construction of battery storage or ventilation systems (Bezirksregierung Arnsberg, 2022e, 2022g, 2022f).

Based on the shares of funding for particular projects as well as the maximum funding amount per product promoted (conservative estimation), the following indicators can be estimated (see table 4).

table 4: indicator quantification for progres.nrw (category H of the Bond)

Type of promotion	Programme	Allocated expenditures	lump-factor for funding	Indicator value (partial contribution)
cargo bikes	low-emission mobility	EUR 1.3m	EUR 500 per bike	2,636 low-carbon vehicles
electric vehicles	low-emission mobility	EUR 12.3m	EUR 8,000 per car	1,532 low-carbon vehicles
charging stations for electric vehicles	low-emission mobility	EUR 2.4m	EUR 1,500 per station	1,582 stations
solar battery capacity	market launch	EUR 14.7m	EUR 100 per kWh	147.1 MWh capacity
ventilation systems with heat recovery	market launch	EUR 3.6m	EUR 2,000 per home	1,777 projects

source: Bezirksregierung Arnsberg, 2022d, 2022b, 2022c, 2022e, 2022g; Landtag NRW (State Parliament NRW), 2020

I Pollution prevention and control

In total, EUR 35.1m of the budget result are allocated to five projects in Bond #8. Of this sum, EUR 10.1m or 29% could be assessed in the report at hand.

Energy research offensive and real laboratories

In this category EUR 10.1m were budgeted in 2021. Besides technological implementations of scientific findings and developing ideas into marketable products, the initiative also offers new processes and solutions for various sectors. Different projects regarding the realization of new ideas for products, services or processes or innovating existing products and procedures are funded (reported activity indicator). The Bond #8 promotes 376 research projects (partial contribution) for climate protection and environmental economics (Energieforschung.NRW, 2022).

J Environmentally sustainable management of living natural resources and land use

In total, EUR 81.8m of the budget result are allocated to six projects in Bond #8. Of this sum, EUR 74.9m or 92% could be assessed in the report at hand.

Responsible agriculture

This category is funded with EUR 39.1m, consisting of EUR 11.9m for the promotion of agriculture that respects the environment and animals and EUR 27.2m of subsidies under the EU Rural Development Regulation (EAFRD) - State’s share (The European Agricultural Fund for Rural Development, 2018). Through the funds the percentage of organic farms and ecologically managed land is increased. The budget result promotes 69,000 ha (full contribution) of sustainable land-use. The calculations are based on results from 2014 to 2020 for supported area in four different categories (agri-environment and climate measures, organic farming (introduction/maintenance), compensation under Natura 2000,

compensation for mountain areas) in relation to overall funding from all sources (output indicator calculated with the help of auxiliary variables).

Improvement of animal welfare

In order to improve housing conditions for animals EUR 2.0m are budgeted. Based on the results from 2014 to 2020 for animals in summer grazing or straw rearing in relation to overall funding from all sources, 56,800 animals benefitted through the programme (full contribution- output indicator calculated with the help of auxiliary variables) (The European Agricultural Fund for Rural Development, 2018). Besides promoting animal welfare, animal owners are supported to meet social expectations in this area.

European Agricultural Fund for Rural Development – EAFRD (State's share)

Through the State's share of the EAFRD, a network of 45 biological stations is supported (full contribution) (Dachverband der biologischen Stationen in Nordrhein-Westfalen, 2021). They serve as an important link between private and public efforts in order to implement conservation work on site. The areas are protected from intensive economic exploitation and can therefor develop in a more environment-friendly way. The budget result of EUR 33.8m created/sustained 300 full-time work positions (output indicator calculated with the help of auxiliary variables). The calculations are based on funding for project hours (EUR 60.95/hour) and hours per year of full-time (1,706 hours/a) in North Rhine-Westphalia (Ministerium des Innern des Landes Nordrhein-Westfalen, 2005).

K Clean transportation

In total, EUR 45.9m of the budget result are allocated to one project in Bond #8. 100% could be assessed in the report at hand.

Infrastructure for cyclists and pedestrians

The expansion of local mobility benefits pedestrians and cyclists. In this category, short-haul routes in particular are promoted. The investment of EUR 45.9m enabled 171 km of cycle paths to be added since 2017 (partial contribution) (Die Landesregierung Nordrhein-Westfalen, 2022). The calculation is carried out by means of the share of this year's budget in the sum invested so far (Teubler & Hennes, 2021). For every million euros invested, 2.1 km of cycle paths can be built (output indicator calculated with the help of auxiliary variables).

L Sustainable Water and wastewater management

In total, EUR 57.2m of the budget result are allocated to one project in Bond #8. However, the available information on the outputs and desired outcomes of the programme "flood protection and river restauration" was insufficient to estimate any type of quantified indicator.

M Climate change adaption

In total, EUR 59.6m of the budget result are allocated to two projects in Bond #8. Of this sum, EUR 51.6m or 87% could be assessed in the report at hand.

Climate Action/Regional Climate Adaptation Measures (LIFE)/Adaptation to climate change

In order to achieve the State's climate goals and to develop the protection of nature, the EU programme LIFE supports environmental and conservation projects (activity indicator) (Europäische Kommission, 2021). In 2021, 8 projects were promoted (partial contribution-directly monitored) with budget expenditures of EUR 0.3m. Since 2014, the total funding exceeds EUR 41m.

Forests reforestation

In order to cope with damaged spruce wood due to storm, droughts and bark beetles, the State supports the re-afforestation of damaged forests (Landesregierung NRW (State Government of NRW), 2019; Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz, 2021). In the #8 Bond, EUR 51.26m were funded, which contribute to an area of 90,000 ha of sustainable land-use (full contribution- monitored intermediate outcome indicator).

N Green buildings

In total, EUR 467.6m of the budget result are allocated to two projects in Bond #8. Of this sum, EUR 304.7m or 65% could be assessed in the report at hand.

Modernisation of university buildings

Expenditures of EUR 62.8m are associated with new or modernized university buildings. It can be estimated, in line with previous cost estimates (see section "Modernisation of educational and public health facilities"), that 5,691 m^2 of new buildings are funded in addition to the renovation of 1,972 m^2 of such floor space (full contribution).

Conservation, remediation and enlargement of university clinics as well as other investments

Bond expenditures of EUR 408.8 can be associated with 49,109 m^2 newly constructed clinical buildings and 97,748 m^2 of renovated floor space in this area. These estimates are based on the assumptions and data in previous calculations as well (see section "Modernisation of educational and public health facilities").

5 Co-Benefits for Climate Change Mitigation

This chapter describes how the calculation of avoided greenhouse gas emissions (GHG reduction) is carried out (sometimes also referred to as scope 4 emissions)[4].

The GHG reduction potentials are estimated with the help of the indicator "Carbon Footprint". This indicator corresponds to the internationally recognised methodology of the Intergovernmental Panel on Climate Change on the classification and characterisation of greenhouse gases (Qin, Manning, Chen, et al., 2007; Qin, Manning, Marquis, et al., 2007). The Carbon Footprint records the greenhouse gases emitted by products and services over their entire life cycle. It expresses the greenhouse gas potential, i.e., the influence on anthropogenic warming of the global climate. The emissions of various greenhouse gases are measured with the respective global warming potential for 100 years in the unit CO2 equivalents (CO2 equivalent or CO2e) (Bernstein et al., 2008).

In the presented method description, published GHG factors of the Research Centre for Energy Economics e.V., the German Federal Environment Agency and the energy balances of the federal states are used. These GHG factors (e.g., CO2e for 1 kWh of electricity) usually refer to the use phase only (e.g., the combustion of fuel) and therefore do not include upstream and downstream processes (utilities, infrastructures, and end-of-life).

Conventions and Variables

Even if certain standards have been established in the Harmonized Framework, they do not specify a specific procedure for determining the Carbon Footprint or the avoidance of GHG emissions (also called GHG savings in this report). Therefore, the following conventions and variables had to be defined for each project group (the issue of double-counting and additionality is further discussed in the following section).

Reference system: In order to calculate the GHG reductions, an initial or reference system must be defined against which the savings are measured. This is the previous system or business-as-usual and its emissions. An investment measure can either replace the original system with a system with lower emissions (e.g., increasing the heating efficiency of buildings) or provide alternative services with lower GHG emissions (e.g., using a public transport system instead of a car). The difference between the emissions of the subsidised system and those of the initial system results in the potentials for GHG reduction.

Lifetime and Continuity: As the reduction of greenhouse gases occurs only after the realisation of the funded projects, the calculation of the GHG reduction potential is based on forecasts (ex-ante analyses). For this reason, the useful life (lifetime) must be estimated for each implemented measure. During this time, the funded projects help to reduce GHG savings every year. It is also assumed that the surrounding systems undergo no changes during the same time frame (continuity).

In reality, some of the projects will not provide their full services for the entire lifetime assumed and changes in the surrounding systems are likely to decrease GHG mitigation

[4] This section of the report has not been changed compared to the previous reports (Teubler et al., 2019)

effects (e.g., if an energy system becomes more climate-friendly with the shutdown of coal plants).

Attribution: In determining the GHG reduction, the share of the State's budget spending in the overall financing of the project must be taken into account. If, for example, a project is State funded for only 50% of its costs, only half of its GHG savings can be attributed to the bond.

Proportion of GHG reduction financed: There are also measures towards climate protection, which only partially lead to GHG reductions. This applies in particular to the construction and renovation of buildings, where further legal requirements such as accessibility, fire protection or occupational safety play a role.

Auxiliary variables: Wherever sufficient data was not available to assign the funding sums to physical systems; auxiliary variables were derived from the literature. These "proxies" estimate the influence of the investment on the physical changes of a system and are cost-factors for the most part. The refurbished net floor area per euro invested for example, is determined based on the refurbishment costs of real and comparable buildings.

Double-Counting and Additionality

A fundamental problem in the quantitative evaluation of avoided emissions (GHG reduction potentials) arises in the attribution of impacts to different actors of a system. In addition to the issuers and investors of the bond, these are all actors in the funded projects themselves. Since each tonne of GHG can only be saved once, double counting must be avoided, although financing and re-financing might be considered to be added sustainable value.

Universities, for example, own their properties and invest in the conversion and new construction of their buildings. However, its users mainly cause the heating energy consumption of a building: university staff, students, and visitors.

The actual effect occurs through the implementation of the measure and should be attributed to the operator. On the other hand, many of the measures described here could not be realised without financial subsidies or loans.

In the process of estimating Carbon Footprints for e.g., companies, this is usually achieved using so-called attribution rules. For avoided emissions in the context of bonds, the authors use the terms ***financed*** or ***induced*** **GHG reduction** ***potentials*** or ***savings***.

Limitations

Several assumptions are necessary to calculate the financed GHG savings for the project categories. These assumptions relate to costs on the one hand (e.g., construction costs of a building) and to the physical changes on the system on the other hand (e.g., the actual difference in energy demand after an energetic refurbishment). These assumptions were usually made from a conservative point of view, rather underestimating the positive effects for the environment. Exceptions of this rule are assumptions regarding the replacement of buildings. If new energy-efficient buildings are constructed, but old buildings are further in use, then the overall energy demand of a university increases, thus also emitting more GHG emissions.

The following table 5 lists the assumptions made for calculations and estimates their effect on the avoidance of GHG emissions.

table 5: Estimation of the effects of assumptions on the potential for avoided GHG emissions
(underestimated: conservative results; overestimation: optimistic results)

Bond Category	Assumptions	Impact on GHG emissions	Over- and under-estimation
Student Tickets & Cycle Paths	Modal shift assumptions in the area of bike paths	The GHG reduction potentials are probably lower in the analysis than in reality, because data from conservative scenarios were used and public transport systems are not taken into account.	+ (underestimated)
	Modal shift assumptions in the area of semester tickets	The robustness of the empirical survey cannot be validated. However, it can be assumed that the effects are higher in some universities and lower in others.	o (no final estimate)
	Assumptions on the cost of cycle paths	The cost factor for the construction of municipal cycle paths is based on a 5-year average and can be considered robust. The cost factor for high-speed cycle paths is based on published construction costs. Since many of the cycle paths concerned are still under construction at the time of the analysis, the real costs could be higher. This would lead to an overestimation of the GHG reduction potentials for fast cycle paths in the analysis.	o (no final estimate)
University & Clinical Buildings	New buildings replace old buildings	The GHG reduction potentials are rather overestimated due to this assumption, because the total heating energy requirement of a university facility increases if existing buildings continue to be used.	- (overestimated)
	Assumptions on construction costs	The data used cannot be used to calculate robust average values for the construction costs of new buildings and those to be renovated. The actual usable area increased or converted by the investments, and thus the GHG reduction potentials, cannot be reliably determined.	o (no final estimate)
	Assumptions on the use of funds	Only clear budget titles were allocated as part of the investment allocation. The resulting GHG reduction potentials are therefore underestimated with a high degree of certainty, especially since a relatively high proportion was assumed for the initial installation (52%).	+ (underestimated)
	Non-consideration of the electricity consumption	Additional GHG reduction potentials could be realised through savings in electricity consumption. However, this is not the case for all building types and uses.	o (no final estimate)

Bond Category	Assumptions	Impact on GHG emissions	Over- and under-estimation
	Assumptions for saving heating energy in buildings	For the new and replacement construction of buildings, data from the existing stock of public buildings were used, which lead to energy and GHG savings compared to the EnEV standard and with regard to the usable area. It can be assumed that in reality greater savings will be achieved. However, the development measures were only mapped on the basis of a reference building. The allocation of these specific GHG reduction potentials to all implemented measures is therefore subject to high uncertainties.	+ (underestimated)

source: own presentation

Public transportation for pupils and students

The funding for students and pupils supports the public transportation system in NRW by financing the reduced tariffs for pupils, students and trainees, while also promoting the improvement of services. The Public Transport Act of North Rhine-Westphalia stipulates in Section §11a (1) that EUR 134.5m per year is to be invested for this purpose. Of this amount, at least 87.5% is used to offset the cost of tickets. Of this, approximately 18.5 % is used for semester tickets (according to the Ministry of Finance in NRW). The remaining 12.5% can be used for other financing measures, such as further development of the system or quality improvements.

In order to determine the total costs for the semester ticket and the respective share of the bond in the total costs, the quantity of tickets sold for each year is offset against the ticket price as well as the costs for the regional expansion of public transportation and added to the investments from the bond. The shares of the total costs calculated in this way also correspond to the share of the bond in the expected reductions for greenhouse gases. The data were collected both on the basis of data from the Ministry of Finance in NRW and on the basis of tariff data (see (KCM NRW, 2021) for the most recent data).

The GHG reduction of the semester tickets was measured by the car-km avoided per ticket. A study by the Wuppertal Institute on the use of the semester ticket shows that 1,242 person-kilometres (pkm) per year are not covered by car due to the semester ticket per student (Müller, 2011). The study is based on an empirical survey of the mobility behaviour of students at Bielefeld University. The results are not representative for other universities in NRW and therefore cannot be generalised. Due to a lack of alternative data, the figure of 1,242 pkm per student (or 621 pkm per ticket) is nevertheless chosen as a basis for the calculation. In contrast to the other project groups, only the reduction for one year is considered, since the semester ticket is only financed for two semesters (one year). Based on data from the Federal Environment Agency, 152 g CO2e per car-km are assumed for the GHG reduction through avoided car-km (Umweltbundesamt, 2022).

Non-urban fast cycle paths and urban cycle paths

The initial system for the construction of cycle paths is the car traffic that occurs if there were no cycle paths (GHG reductions from avoided car km). Although further effects in the area of public transports could occur, it is unclear whether this modal shift (people switching from a public transport system towards cycling) would affect the GHG emissions of these

systems in any way. Conversely, it is also not assumed that the climate impact of public transports will be negatively affected.

Data on the influence of the construction of cycle paths on the modal split can be found in the feasibility study of the cycle fast track (RS RM) between Gladbeck, Bottrop and Essen (Regionalverband Ruhr, 2014). Based on statistics of purposes and number of routes in NRW, an estimation of the passenger car km saved is carried out. With a primary settlement region, a conservative assumption, on average 1,131 car-km per km of cycle distance and day, are avoided by high-speed cycle paths.

In the area of municipal cycle paths, no data is available on the avoidance of car kilometres. In a first approximation therefore, the assumptions about the fast cycle paths are adopted. However, it is assumed that municipal cycle paths only have a substituting effect on car use for paths up to 5 km in length (60% of paths or 679 car-km per km cycle path per day).

The cost factors to be determined make it possible to identify the added cycle routes with the help of the investments made by the State of NRW within the bond. For municipal cycle paths, they are based on data supplied from the Ministry of Transport of the State of NRW. The 5-year average (2016-2020) of the added cycle paths in municipal construction load is EUR 209,000 per km.

No sufficient data were available for cycle paths. Instead, the average construction costs per km of cycle path were calculated from existing projects (see table 6). Accordingly, the average construction costs are EUR 1.23m per kilometre built.

table 6: Construction costs for different cycle path projects

Project	Length	Costs
RS1 Duisburg - Hamm	101 km	EUR 184m
RSW Mittleres Ruhrgebiet Gladbeck - Bottrop -Essen	17 km	EUR 39m
Regio Velo Isselburg-Bocholt - Velen	61 km	EUR 39m
RSW OWL Minden-Herford	50 km	EUR 26m
RSW Aachen-Herzogenrath-Kerkrade	30 km	EUR 21m
RSW Köln-Frechen	8 km	EUR 6m
RSW Neuss-Düsseldorf-Langenfeld/Monheim	31 km	EUR 32m
RM	17 km	EUR 39m
in TOTAL	**315 km**	**EUR 385m**

source: own calculation based on web publications

Based on data from the Federal Environment Agency, 152 g CO2e per car-km are assumed for the GHG reduction through avoided car-km (Umweltbundesamt, 2022).

Modernisation of educational and public health facilities

The Sustainability Bond covers also funding for buildings of universities and university clinics (new buildings and refurbishment). Increasing the energy efficiency in these

buildings (in particular for the end-use of heat) is one of its major goals. Only parts of the investments are used to reduce the energy demand of buildings or to develop buildings with a low energy standard. Some investments are also used to provide equipment or rents. Refurbishments are also not restricted to energy-efficiency measures alone but cover for example requirements for safety or health measures. It is therefore necessary to estimate the shares for actual GHG mitigation potentials from

- the construction of new (general) university buildings with lower heat demand compared to existing buildings,
- the construction of new clinical university buildings with lower heat demand compared to existing buildings,
- higher heat efficiency after refurbishment in (general) university buildings,
- higher heat efficiency after refurbishment in clinical university buildings.

The investments in the bond correspond to actual investments in the State's budget, but do not allow differentiating into these four segments with GHG relevance. Therefore, additional information on the State's investments is drawn from the budget, that allows allocating the funding in higher detail.

The allocation for general university buildings is based on the funding for the programme Hochschulbaukonsolidierungsprogramm (HKoP; programme for the construction of university buildings) and funding for the Hochschulmodernisierungsprogramm (HMoP; programme for the modernisation of buildings). Both investments are assumed to use 52 % of their funds for equipment (assumption by the Ministry of Finance). In addition, only 45 % of investments into refurbishment measures lead to higher energy efficiency in buildings. The latter value describes the energy refurbishment ratio and is based on a study on the refurbishment of public buildings in Germany (Hebel et al., 2011). Investments into clinical university buildings are listed individually in the State's budget and can therefore be used to generate a more specific allocation. Based on the years 2015 to 2021, average values were calculated for the shares of funds that are used for new buildings and funds that are used for refurbishments. For a reference energy refurbishment a ratio of 53.6% (based on the "Bettenturm Münster", a university clinical building) is assumed.

Specific GHG emission factors for educational and public health facilities

The following table 7 shows the GHG emission factors for heat demand and heat sources in public buildings. The electricity demand of university buildings and its GHG emissions is not included in the quantification due to a lack of data. While electricity use in public buildings can have a large effect on the actual GHG emissions, it could not be allocated to the investments in the bond. However, this effect is not necessarily positive, as for example the installation of new medical equipment can also increase the electricity demand in a building.

table 7: Emission factors for the heat demand in public buildings

Energy source	Emission factor (without upstream)	Data source	Spatiality	Share in buildings
Gas*	202 g CO_2e/kWh	FfE (2010)	Germany	55.8 %
Oil, light*	266 g CO_2e/kWh	FfE (2010)	Germany	23.1 %
District heating	229 g CO_2e/kWh	(Agentur für Erneuerbare Energien e.V. 2014)	NRW	21.1 %
Electricity	820 g CO_2e/kWh	LAK (2015)	NRW	0.0 %
Emission Factor	**222 g CO_2e/kWh**			**100 %**

** Roughly 79 % of heat is provided in form of gas and oil. According to the Agency for Renewable Energies in Germany (AGEB, 2013) 70.7 % of heat by these energy carriers is provided in form of gas.*

source: own calculations based on statistics for heat demand in public buildings

Efficiency gains are calculated by comparing the average heat demand of existing public buildings to the average heat demand of new public buildings. This simplification is required, because the actual efficiency gains in the university buildings funded by the bond are unknown. This also leads to a conservative estimation of the GHG effects in most cases; as older buildings are usually refurbished first, and new buildings often exceed the legal requirements for energy efficiency.

Calculation of GHG emission savings in educational and public health facilities

The heat demand of buildings in the class "Universities and Research" is estimated in a 2013 study by the Federal Ministry of Transportation and Construction (Deilmann et al., 2013). This study contains data on the share for energy carriers as well as the average heat demand in regard to the age of the buildings before and after an energy-related refurbishment. The following table 8 shows the results sorted by the year of construction as well as their share of the overall existing buildings. These potential savings are used for all new university buildings funded by the Sustainability Bond.

table 8: Heat energy savings in university buildings (Germany)

Year of construction	Heat demand in existing buildings	Heat demand after refurbishment (base-case for new buildings)	Share of existing buildings
until 1976	236.3 kWh/(m^2a)	108.5 kWh/(m^2a)	80 %
1977 - 1983	209.9 kWh/(m^2a)	107.4 kWh/(m^2a)	6 %
1984 - 1995	167.9 kWh/(m^2a)	104.9 kWh/(m^2a)	6 %
from 1995 onward	129.6 kWh/(m^2a)	104.9 kWh/(m^2a)	8 %
Heat energy savings		**117.2 kWH/(m^2a)**	**100 %**

source: own calculations based on Deilmann et al. (2013)

Linking the data in Table 4 and Table 5 results in GHG emission savings of 26 kg CO2e per m2 for new university buildings when compared to the building stock (222 g CO2e per kWh at a difference of 117.2 kWh/(m2a)).

The available data on State funding does not include the area of newly constructed buildings. Instead, data on recently constructed university buildings was used to generate a cost factor on the amount of useful area that can be constructed per EUR. This results in an average of the sample of 250 m2 per EURm (see also table 9). A lifetime of 50 years for new university building is assumed (Stibbe & Stratmann, 2014).

table 9: Construction of useful area based on investments for university buildings in NRW

Building	Construction costs	Net area	Promoted share by State of NRW	Cost factors (calculated)
FH Aachen, replacement construction f. Kalverbenden/Zentr.	EUR 12.5m	3,900 m^2	100 %	312.0E-6 m^2/€
RWTH Aachen, auditorium centre Claßenstr. (R 6)*	EUR 45.0m	14,000 m^2	100 %	311.1E-6 m^2/€
Univ. Dortmund, Replacement New Building Chemistry/Physics (EE)	EUR 82.3m	14,661 m^2	100 %	178.1E-6 m^2/€
FH Niederrhein, Replacement new multi-building (EE)	EUR 20.0m	6,900 m^2	75 %	258.8E-6 m^2/€
FH Bielefeld, Replacement new construction, network expansion (EE)	EUR 279.3m	60,400 m^2	100 %	216.3E-6 m^2/€
FH Düsseldorf, ENB 1. BA*	EUR 170.0m	54,000 m^2	100 %	317.6E-6 m^2/€
in Total	**EUR 609m**	**153,861 m^2**	**average (weighted)**	**250 m^2 per million euro**
* *refers to costs according to cost estimations*				

source: own calculation; information on construction costs and constructed area are based on press releases

In order to calculate the GHG reduction potential of buildings in university hospitals, the costs per m2 of usable space are required, analogous to new buildings in general universities (see table 10). The information on the construction costs determined or estimated is taken from the budget for Title Groups 06 103 to 06 108 (each Title 891 30). The corresponding floor areas are taken from the websites of the individual clinics. All construction measures are assumed to have a 100 % share of funding, which means that the simple average of total investment and total net floor area can be used to determine the cost factor.

table 10: Net additional floor space for investments in new buildings in university clinics

Institutions	Building costs	Net floor area	Specific cost factor
Cologne: CIO Centre (ambulatory)	EUR 77.9m	13,500 m^2	312.0E-6 m2/€
Aachen: Extension building for intensive surgical care	EUR 41.2m	8,643 m^2	311.1E-6 m2/€
Düsseldorf: Medical Research Centre I	EUR 79.9m	19,650 m^2	178.1E-6 m2/€
Düsseldorf: Medical Research Centre II	EUR 26.2m	7,970 m^2	258.8E-6 m2/€
Bonn: New building parent-child centre	EUR 71.9m	11,787 m^2	216.3E-6 m2/€
Bonn: Neurology, psychiatry and palliative medicine(NPP)	EUR 64.6m	12,842 m^2	317.6E-6 m2/€
in Total	**EUR 361.6m**	**74,392 m^2**	**206 m^2 per million euro**

source: own calculations on the basis of the NRW budget (medium-term financial planning 2016-2018) and publications of the clinics examined.

A lifetime of 66 years for new university clinics is assumed (Hebel et al., 2011).

Calculation of GHG emission savings in refurbished educational and public health facilities

The determination of the cost factor and the reduction of the heating energy requirement of renovated buildings in general universities are based on data from a facade renovation at the Ruhr University Bochum (A. Krewald, personal communication, 2017). Construction costs of EUR 87.9 m were incurred to renovate a 52,300 m2 site. Thus, investments of EUR 1m lead to the redevelopment of 594 m2. The share of the energy-related renovation quota is already taken into account in the allocation of investments. Taking into account the general heating energy demand in universities and a reduction in heating energy demand of probably 88 kWh/m2 (NF 1-6 buildings), potential GHG reductions of 19.6 kg CO2e per m2 are achieved.

The “Bettenturm” in Münster serves as a reference for the renovation of buildings in university clinics, for which a number of data is available:

- The construction costs for facade works (energetic refurbishment) amount to EUR 20.6 million.
- The total construction costs amount to EUR 38.5 million with a subsidy amount of EUR 45.9 million.
- The estimated transmission heat loss before completion of works is 2.23 W/(m^2K) and 0.62 W/(m^2K) after refurbishment.
- 875 beds are in the renovated building.

Based on these data and taking into account the heating degree-days in Germany in 2016 (3005 HDD according to Eurostat) and the energy expenditure figure for a condensing boiler (1.03), the reference values for hospital renovations shown in table 11 can be determined. A service life of 20 years is also assumed.

table 11: Reference value for GHG reduction potentials for the renovation of hospital buildings

Reference level	Reference value
Share of construction costs in funding amount	84.0 %
Share of energy-efficient refurbishment in construction costs (already taken into account when allocating investments)	53.6 %
Difference in transmission heat requirement per bed	3,156 kWh/bed
Number of refurbished beds	42.4 bed per EUR m
GHG factor for the provision of heating energy	0.222 kg CO_2e/kWh
GHG reduction potential per bed	**702 kg CO_2e per bed and year**

source: own calculation

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Appendix: Detailed Indicator Table

Category (quantified share in %)	budget results	Indicators	Indicator Quality	Expenditures per category	Indicator Value*	
A: Affordable Basic Infrastructure (100% assessed here)	EUR 572.2m	equivalent of promoted broadband access points (a)	C_3	53.3%	102,600	beneficiaries (full contribution)
		equivalent of paid social tickets (a)	D_3	7.0%	83,300	beneficiaries (full contribution)
		equivalent of paid student tickets (a)	D_3	3.9%	117,400	beneficiaries (full contribution)
B: Access to Essential Services (45% assessed here)	EUR 2,450.1m	equivalent of paid vaccination centres	C_2	3.4%	9	entities (full contribution)
		equivalent of promoted seats at nursing schools	D_3	4.6%	5,500	beneficiaries (partial contribution)
		equivalent of promoted geriatric nurse students	D_3	1.9%	10,000	beneficiaries (partial contribution)
		returned researchers	C_1	0.2%	16	jobs created/sustained (full contribution)
		equivalent of paid pedagogical teachers (b)	D_3	4.1%	2,600	jobs created/sustained (full contribution)
		equivalent of promoted day-care centre helpers (c)	D_3	4.5%	7,400	jobs created/sustained (partial contribution)
		equivalent of paid social school workers (a)	C_3	1.9%	700	jobs created/sustained (full contribution)
		equivalent of promoted first-year student places (d)	C_3	4.2%	31,519	beneficiaries (partial contribution)
		children benefiting from day-care exemptions for parents	C_5	17.0%	298,200	beneficiaries (partial contribution)
		equivalent of promoted family centres (a)	C_3	2.7%	3,300	entities (partial contribution)
C: Affordable Housing (54% assessed here)	EUR 72.7m	equivalent of paid urban development projects (e)	D_2	54.2%	15	projects (full contribution)
D: Employment Generation (39% assessed here)	EUR 4.9m	equivalent of jobs promoted for persons with disabilities (f)	B_3	39.3%	96	jobs created/sustained (partial contribution)
E: Food Security and sustainable food systems (69% assessed here)	EUR 2.4m	equivalents of students supported with healthy meals	C_2	68.9%	228,000	beneficiaries (partial contribution)
F: Socioeconomic advancement and empowerment (28% assessed here)	EUR 173.0m	equivalent of vulnerable persons receiving help (a)	B_3	1.7%	1,400	beneficiaries (full contribution)
		equivalent of students supported for career-entry (a)	B_2	3.0%	1,400	beneficiaries (full contribution)
		competence centers women and profession	D_1	0.4%	16	entities (partial contribution)
		promoted women shelter places	C_2	6.3%	624	beneficiaries (partial contribution)
		promoted women counseling centers	D_2	6.7%	62	entities (partial contribution)
		promoted men shelter places	C_1	0.4%	16	beneficiaries (partial contribution)
		equivalent of paid personnel for integration centres	C_3	9.6%	300	jobs created/sustained (full contribution)
G: Renewable Energy (100% assessed here)	EUR 10.9m	equivalent of PV production in NRW (g)	C_4	100.0%	474,500	[MWh] of re production/storage (partial contribution)
H: Energy Efficiency (26% assessed here)	EUR 129.2m	equivalent of promoted low-carbon vehicles	C_3	10.5%	4,200	vehicles (partial contribution)
		equivalent of promoted solar battery capacity	C_3	11.4%	100	[MWh] of re production/storage (partial contribution)
		equivalent of promoted charging stations	D_3	1.8%	1,600	projects (partial contribution)
		equivalent of promoted ventilation systems with heat recovery	C_3	2.8%	1,800	projects (partial contribution)
I: Pollution Prevention & Control (29% assessed here)	EUR 35.1m	promoted research for climate protection & environmental economics	D_1	28.8%	376	projects (partial contribution)
J: Environmentally sustainable management of living natural resources and land use (92% assessed here)	EUR 818m	equivalent of sustainable land-use	C_3	47.8%	69,000	[ha] of sustainable land-use (full contribution)
		equivalent of animals in animal-friendly husbandry	C_3	2.5%	56,800	animals benefiting (full contribution)
		equivalent of paid full-time project work for biological stations	C_3	41.3%	300	jobs created/sustained (full contribution)
K: Clean transportation (100% assessed here)	EUR 45.9m	additional lanes for bicyles	C_3	100.0%	171	[km] of bicycle lanes (partial contribution)
L: Sustainable water and wastewater management (no indicator)	EUR 57.2m	not available (n.a.)	n.a.	n.a	n.a.	no indicator
M: Climate change adaptation (86% assessed here)	EUR 59.6m	promotion of nature-conservation projects	D_1	0.5%	8	projects (partial contribution)
		re-afforestation of damaged forests	B_1	86.0%	90,000	[ha] of sustainable land-use (full contribution)
N: Green buildings (65% assessed here)	EUR 467.6m	expansion of universities and university clinic buildings	D_4	55.9%	54,800	[m2] of new buildings (full contribution)
		modernization of universities and university clinic buildings	D_4	9.2%	99,700	[m2] of building area renovated (full contribution)

* rounded in most cases to avoid the appearance of accuracy where it is not warranted
(a) potential number based on funding alone (without other promotions)
(b) representing the funding of full-time positions for language support only
(c) funding for only 7 months at a monthly rate of EUR 2,100 per day-to-day helper
(d) based on no. of additional first-year students in 2020
(e) based on lump promotion and States' share for urban development programs in NRW (including other programs)
(f) the initial promotion relates to job creation and is therefore considered a intermediate-outcome rather than project output
(g) based on PV capacity growth in previous years in NRW and average full-load hours for the State