Final Report | October 2019

Impact Report
NRW Sustainability Bond #5

Analysis of the Sustainability Bond #5 issued in 2019 by the German State of North Rhine-Westphalia (NRW)

Wuppertal Institut

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.

Project Duration: August 2019 - October 2019

Authors:
Jens Teubler, Lena Hennes, Prof. Dr. Oscar Reutter,

Project Coordination:

Jens Teubler

Wuppertal Institut Klima, Umwelt, Energie gGmbH

Department Sustainable Production and Consumption

Döppersberg 19, 42103 Wuppertal

jens.teubler@wupperinst.org

Scientific Advisor:
Prof. Dr. Oscar Reutter

Cited as:

Teubler, J.; Hennes, L.; Reutter, O. (2019). Impact Report NRW Sustainability Bond #5. Analysis of the Sustainability Bond #5 issued in 2018 by the German State of North Rhine-Westphalia (NRW). Final report on behalf of the Ministerium der Finanzen Nordrhein-Westfalen. Wuppertal Institut Klima, Umwelt, Energie gGmbH. Wuppertal, 2019.

Content

Tables

Figures

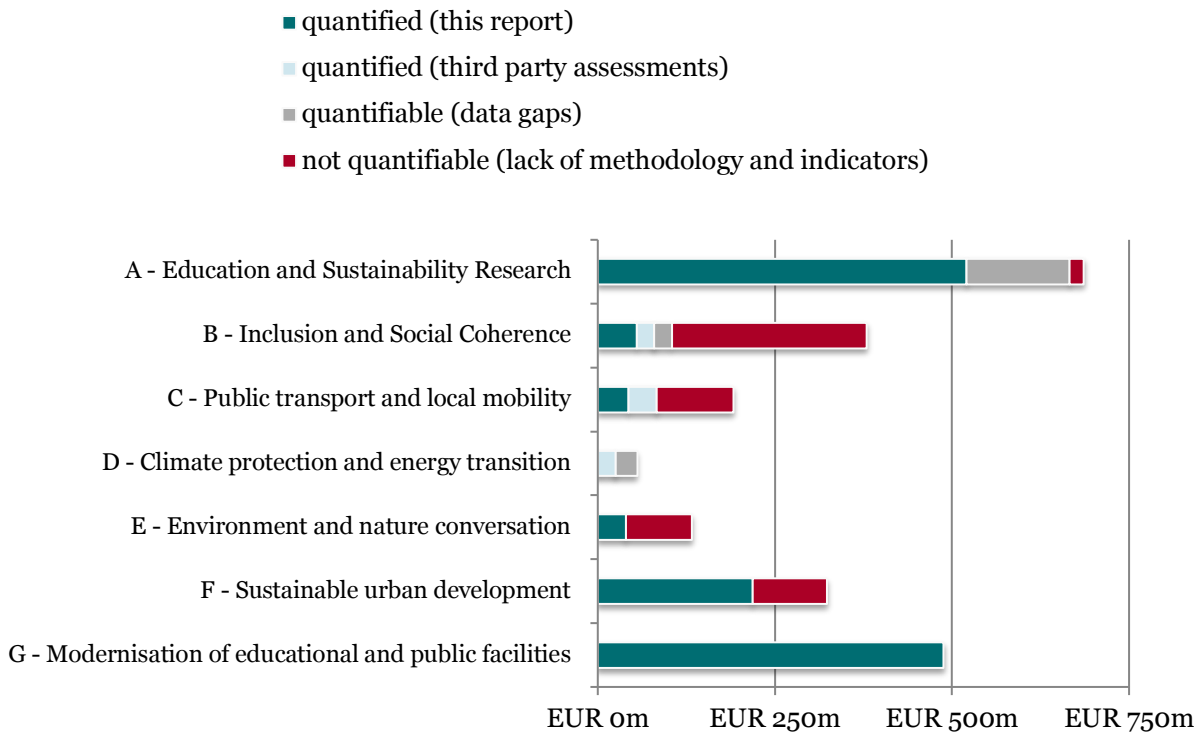
1 Summary

The Wuppertal Institute conducted an impact analysis of the NRW Sustainability Bond #5 of 2019 on behalf of the State Government of North Rhine-Westphalia (NRW). The most recent bond has a volume of EUR 2.25 bn, a term of 15 years and consists of 52 eligible projects from the State's 2018 general budget (sustainable value-added was confirmed in a second party opinion by ISS-oekom[1]). This report analyses the contribution of the bond to climate mitigation, sustainable land use and social impacts. It also includes information on the impacts of the previous four bonds (NRW Sustainability Bond #1 to #4).

The impact report at hand is based on data that was collected until September 2019 and is published in advance of the full report. Any changes in data until October 2019 will be documented later in the full report.

Figure 1-1 shows the project categories in the bond and quantifies the shares that could be directly associated with either environmental or social impacts. 60.5% or EUR 1,365m of the overall investments could be directly quantified in the paper at hand. Additional EUR 91m (4.0%) has been assessed by third parties and is also reported in this briefing. The remaining EUR 601m (35.5%) could either not be quantified due to lack of data or are not quantifiable at all within existing scientific frameworks.

Figure 1-1: Share of quantified investments in the Sustainability Bond #5



source: own calculation based on methods and data depicted in this report

[1] see https://www.nachhaltigkeit.nrw.de/fileadmin/download/5._Nachhaltigkeitsanleihe_SPO_LandNRW_final.pdf

Co-Benefits of projects in the bond

Some projects induce positive environmental and social impacts alike. The refurbishment and construction of university clinical buildings, for example, is quantified as part of the measures that reduce GHG emissions. The intended purpose, however, is to prevent health hazards, improve research capabilities and patient care. The same is true for over EUR 129.8m invested into public transportation for pupils and students (of which only EUR 21.0m were directly allocated to tickets for students and their climate mitigation effect), as additionally financed improvements into public traffic systems are beneficial to all citizens. These types of co-impacts are often not quantifiable in all their dimensions. The Wuppertal Institute plans to look deeper into this kind of effects in the future and for up-coming NRW Sustainability Bonds.

Further Information: NRW Sustainability Strategy

The NRW Sustainability Bond #5 is part of the *Sustainability Strategy NRW*, which aims to improve the sustainable development of the whole State of NRW. It comprises almost 70 indicators, which relate to the 19 fields of action in the strategy and to the 17 Sustainable Development Goals by the United Nations (SDGs). The first indicator report of this strategy was published in 2016.

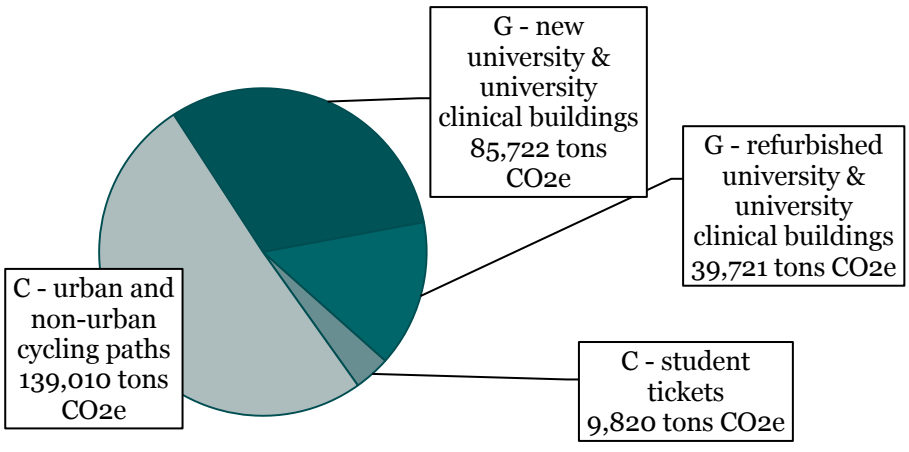
Regular updates of the results are also presented on a dedicated website (**http://www.nachhaltigkeitsindikatoren.nrw.de/sdgs**). The Sustainability Strategy NRW (including the indicator report) is going to be updated in the future, aligning the methodology more closely with the federal Sustainability Strategy of 2017.

Environmental Impacts

Quantified GHG Savings in NRW Sustainability Bond #5

The estimated avoided GHG emissions in the bond can be traced back to investments of EUR 362m for 7 different measures. The measures are part of investments in category C (student tickets, urban cycle paths and non-urban fast cycle paths) and G (new and refurbished university and university clinical buildings). As a result, the measures are expected to save ca. 274,300 tons of CO_2 equivalents (CO_2e) over their lifetime (see Figure 1-2).

Figure 1-2: Quantified GHG savings (over lifetime) in the NRW Sustainability Bond #5



source: own calculation based on methods and data depicted in this report

Results for each measure range from 122 tons CO2e per year to 9,820 tons per year (see Table 1-1). All of these measures, with exception of student tickets, are likely to save emissions beyond the 15-year term of the Sustainability Bond.

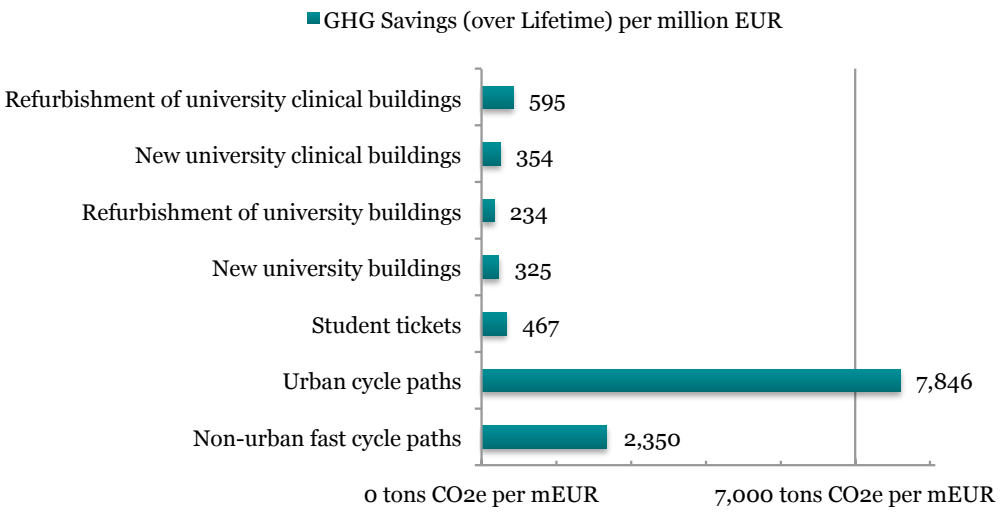
Table 1-1: GHG savings of measures in categories C (Public Transport and Mobility) and G (Modernization of Educational and Public Health Facilities)

	GHG savings per year	GHG savings over Lifetime	average Lifetime (assumption)
	tons CO2e per year	*tons CO2e in total*	*years*
Non-urban fast cycle paths	501	15,038	30
Urban cycle paths	4,132	123,972	30
Student tickets	9,820	9,820	1
New university buildings	245	12,269	50
University buildings (refurbishment)	122	2,445	20
New university clinical buildings	1,113	73,453	66
University clinical buildings (refurbishment)	1,864	37,276	20

source: own calculation based on methods and data depicted in this report

Figure 1-3 also depicts the normalised efficiency of the different measures for climate protection (GHG savings over life time per EUR 1m). The highest efficiency measured can be attributed to the construction of cycle paths, in particular to cycle paths in urban areas.

Figure 1-3: Efficiency of climate protection measures for quantified investments



source: own calculation based on methods and date depicted in this report

Overview on GHG savings (NRW Sustainability Bond #5)

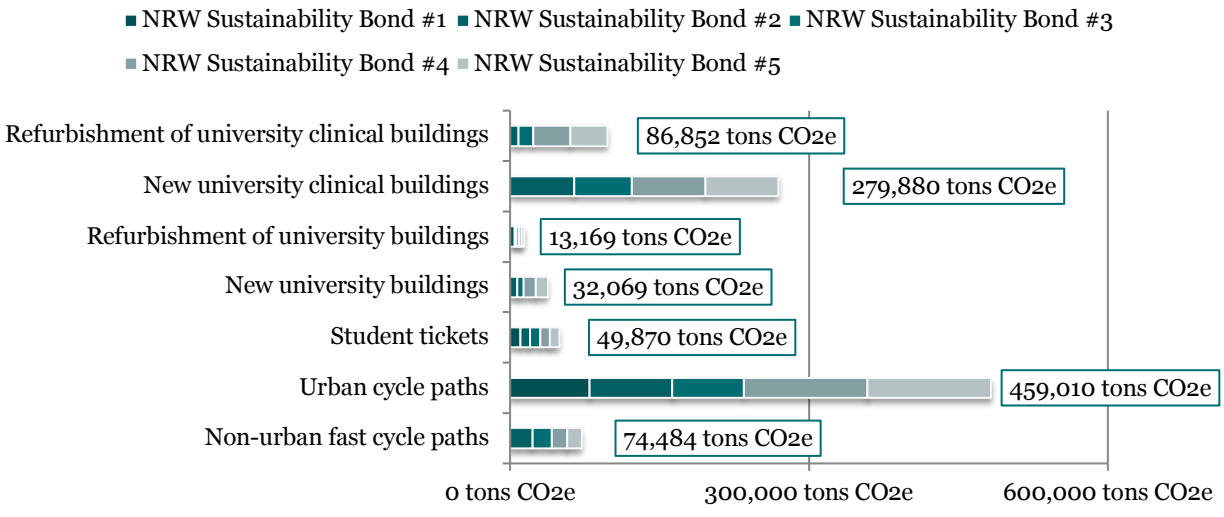
Table 1-2 summarizes the results for potential GHG savings from the bond.

Table 1-2: Results on GHG savings according to ICMA framework 2015[2]

Energy Efficiency (EE)	Signed Amount	Share (of investment)	Eligibility for green bonds	EE Component	Annual energy savings		Annual GHG emissions avoided	
Project name	million EURO	%	% of signed amount	% of signed amount	GWh/a		in 1,000 tonnes of CO2-equivalents	
					100%	financed	100%	financed
New university buildings	86.4	100	100	43.6	1.1	1.1	0.25	0.25
University buildings (refurbishment)	40.6	100	100	25.8	0.5	0.5	0.12	0.12
New university clinical buildings	230.7	100	100	90.0	5.0	5.0	1.11	1.11
University clinical buildings (refurbishment)	130	100	100	48.2	8.4	8.4	1.86	1.86
Low Carbon Transport (LCT)	**Signed Amount**	**Share (of investment)**	**Eligibility for green bonds**	**LCT Component**	**Annual savings of car km**		**Annual GHG emissions avoided**	
Project name	million EURO	%	% of signed amount	% of signed amount	million passenger km/a		in 1,000 tonnes of CO2-equivalents	
					100%	financed	100%	financed
Student tickets	21.0	9.0	100	100	765	70	109.1	9.82
Urban cycle paths	15.8	100	100	100	29.1	29.1	4.13	4.13
Non-urban fast cycle paths	6.4	100	100	100	3.5	3.5	0.50	0.50

source: own calculation based on methods and data depicted in this report

Figure 1-4: GHG savings over lifetime of projects from 2014 to 2018 in the portfolio



source: own calculation based on methods and data depicted in this report

[2] The authors of the ICMA framework recently published an update. The changes to the result table could not be integrated in the impact analysis at hand, but will be in upcoming reports. This will include reporting on the overall absolute emissions where possible (see also https://www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/June-2019/Handbook-Harmonized-Framework-for-Impact-Reporting-WEB-100619.pdf).

All of the quantified categories for climate protection in the Sustainability Bond #5 were already part of the Sustainability Bonds #4 (2018), #3 (2017), #2 (2016) and #1 (2015). They can therefore be aggregated to a five-year portfolio (see Figure 1-4). This was not possible for singular measures like solar thermal energy generation (Bond #3) or co-generation of heat and power (Bond #2). In total, EUR 1,287m were invested over five years (2014 - 2018) that help to induce GHG savings of over 995,329 tons CO2e over the assumed lifetime of measures.

Additional environmental impacts for NRW Sustainability Bonds #1 to #5 (third party assessments)

The NRW Sustainability Bonds also include ca. EUR 250m investments into other projects that improve ecological developments over the course of four years (2014-2018). These projects not only help to mitigate GHG emissions by e.g. additional capacities for renewable energies or by improving energy efficiency. They also contain measures to increase resource efficiency or waste avoidance in companies. The State's funding within the Sustainability Bond facilitates investments from other actors, thus creating leverage for joint efforts to reduce environmental impacts in these areas.

The „Effizienz Agentur NRW“ (efa+) and „Ökoprofit“ provide consulting services for companies that want to reduce their energy consumption, resource throughput and GHG emissions. EFRD is a European fund for regional development. One of the main goals of EFRD-sponsored projects is to facilitate efforts to reduce GHG emissions.

While the projects themselves are beyond the scope of this analysis, some of their results are reported here in form of third-party assessments. Table 1-3 shows the State's investments into such projects from the bond category D (Climate Protection and Energy Transition), in addition to investments from private, municipal, federal and European funds. As the current EFRD report was not available at the time of the impact report, investments and effects still refer to the timeframe from 2014 until 2017.

Table 1-3: Third party assessments and quantified effects in category D

Type	State funding (NRW Bond #1 to #5)	Investments outside the Sustainability Bond (budget years 2014-2018)	Environmental Savings (2014-2018)*
Effizienz Agentur NRW efa+ (as part of resource efficient economy)	circa EUR 25m	EUR 53.1m in the scope of resource efficiency (validated)	65,313 tons of CO2e
			12,819 tons of material resources
			467,211 m^3 of water
		EUR 492.2m in the scope of financing (validated)	145,358 tons of CO2e
			20,719 tons of material resources
			200,763 m^3 of water
Ökoprofit NRW (as part of resource efficient economy)	circa EUR 1.3m	EUR 63.5m	90,061 tons of CO2e
			9,034 tons of waste
			504,602 m^3 of water
EFRD (2014-2020) (priority axis 3 on CO2 reduction)	EUR 96.3m	only for budget years 2014-2017 (no report for 2018 as of yet)	
		circa EUR 530m	454,424 tons of CO2e
**Different methods were used to calculate the ecological impacts of the projects. The results are not summable. These numbers refer to the most recent reporting in the projects (including retrospective adjustment of data).*			

source: correspondence with related agencies

Sustainable Land Use

EUR 133.2m of the NRW Sustainability Bond #5 can be attributed to the protection of natural resources. Measures in this project category E aim at nature conservation, flood protection, animal welfare or sustainable farming and land use. The latter could be directly associated with investments in the bond. EUR 40.2m or 30% of the investments in this category promote an area for sustainable land use of 457,710 ha (see Table 1-4).

Some of the other subcategories also partly promote sustainable land use such as areas for biotopes within nature conservation or flood protection areas. For these subcategories, however, it was not possible to directly allocate investments to individual measures with a corresponding land reference. However, these types of investments are currently under investigation for additional quantification and reporting in future NRW Sustainability Bonds.

Table 1-4: Results of the quantification of the subsidized sustainable land use

Subcategory	Investment volume (2018)	Area supported per year (2018) (estimates)
Responsible Agriculture	EUR 8.9 m	72,438 ha
EAFRD (State's share)	EUR 31.3 m	385,272 ha
in TOTAL	**EUR 40.2 m**	**457,710 ha**

source: own calculation based on methods and data depicted in this report

Social Impacts

A large portion of the social impacts from investments in the bond cannot be directly quantified due to lack of data or appropriate methodologies. Numerous projects benefiting education, inclusion, social cohesion as well as co-benefits of projects in other areas are therefore not part of the impact assessment. Social tickets (part of category C) for example enabled the social integration and increased mobility of approximately 300,000 people in 2015[3]. The funding of student tickets on the other hand was quantified for this report in terms of GHG savings, while in fact also improving the universal access to education for roughly 600,000 students.

Other examples for indirect social impacts from funding in the bond are the exemption from parental contributions for the last year of day-care for children, supporting 54 municipal integration centres for migrants, and an overall increase of 24% in integration for children with special educational needs (learning together).

Some social impacts can be either estimated based on published data (with help of so-called lump sums for costs per impact) or at least reported in form of third party assessments (see the following section on the enlargement of universities and for job creation, funding and qualification).

[3] see https://www.landtag.nrw.de/Dokumentenservice/portal/WWW/dokumentenarchiv/Dokument/MMD17-717.pdf

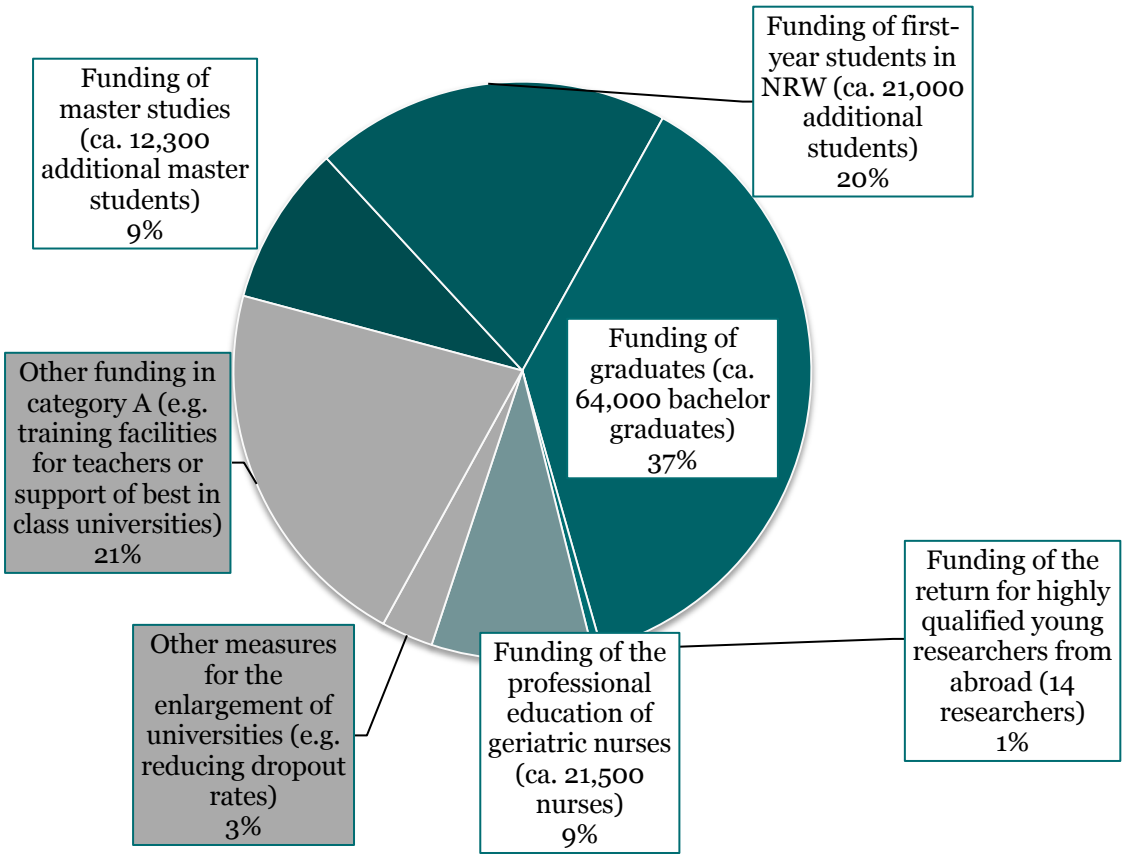
Improving and standardising methods for social impact reporting in the NRW Sustainability Bond is currently under investigation by the Wuppertal Institut. The findings will be integrated into future reports.

Enlargement of Universities

The enlargement of universities is part of the State's funding into education and sustainability research (bond category A as part of e.g. the Bund-Länder-Covenant for the expansion of universities). Out of EUR 686m, 79% or EUR 475.6m were invested to finance additional student capacities, reward universities for graduates or to reduce the number of dropouts. Based on current State grants for universities, these investments supported 21,000 additional first-year students, 12,300 additional master students and the graduation of 64,000 bachelor students in 2018 (see Figure 1-5). Furthermore, the professional education of ca. 21,500 geriatric nurses was financed. EUR 3.5m was also used to bring back 14 researchers back to NRW as part of the "return programme for highly qualified researchers from abroad".

Table 1-6 lists the lump sums and quantification factors used for the estimation of these effects. Future impact reports will also investigate whether the number of teachers in training facilities can be estimated.

Figure 1-5: Allocation of funding in category A (total of EUR 686.0m)



source: own calculations (number of bachelor graduates on the basis of 2017 as new statistics were not available at the time of publication)

Job Creation, Funding and Qualification

The NRW Sustainability Bond #5 investments dedicated to *Inclusion and Social Coherence* total EUR 379.3m. Some of this funding in category B was used to create new jobs for people with disabilities, fighting long-term unemployment or social workers in schools. These social workers support the State's efforts to school success and cultural participation for disadvantaged children. By relating the available funding for these three measures, it can be quantified that the Sustainability Bond NRW #5 provides at least 125 new jobs for people with disabilities (newly created jobs) and 725 jobs for social workers in NRW (costs for material and salary per year). All three projects also show how investments into social development can also lead to an improvement of economic indicators (job creation). A funding of EUR 5.1m is also used for programmes to fight long-term unemployment. Within the "Model project for the integration of long-term unemployed people in NRW" ca. 400 persons could be brought into employment. This project is used as an example to estimate a lump sum of EUR 34,400 per job resulting in 148 long-term unemployed persons that could be brought into employment through the funding of EUR 5.1m.

Additional third-party assessments allowed estimating that the Bond helped 2,000 people suffering from social and economic disparities (the majority under 25 years old) to improve their long-term job qualification and integration. These funds are part of the European Social Fund and therefore co-funded by the EU, the Federal Government and private investors.

Table 1-5 shows the allocated investments of the Bond and their estimated effects in this category.

Table 1-5: Social Impacts for Integration and Social Cohesion

Inclusion and Social Cohesion	Sustainability Bond NRW #5 funding	Type of quantification	Social Impact
Employment opportunities for persons with disabilities	EUR 2.5m*	direct	**job creation:** ca. 125 to 250 new jobs
Social School Work	EUR 47.2m	direct	**job funding:** ca. 725 jobs
Fighting long term unemployment	EUR 5.1m	direct	**job integration:** ca. 150 jobs
European Social Fund	EUR 25.0m	3rd party	**job qualification and integration**: ca. 2,000 participants
** The EUR 2.5m are only part of the EUR 6.6m that is used to provide employment opportunities.*			

source: own calculation based on reported data and calculated lump sums for scaling

Broadband Expansion

A majority of the investments for urban development (68% of category F) is used to sponsor the telecommunication infrastructure in NRW in form of broadband connections with 50 Mbits/s and more, in particular for areas that lack a market-based expansion. The programme aims to improve social and economic access by households and businesses alike, while also providing opportunities for a green economy (e.g. reducing work-related traffic with help of home-office solution or even enabling the settlement of companies in rural areas in the first place).

Quantifying the effect of funding for broadband connections is rather difficult though, as the costs of an access point increase exponentially with higher penetrations rates. Using data on NRW broadband expansion in the past (from an interactive website by the Federal Ministry of Transport and Digital Infrastructure[4]), it could be estimated that the funds of EUR 218,5m enable 109,336 broadband connections for households, institutions and industry.

Social impact indicators for the Sustainability Bond NRW #5

Table 1-6 summarizes the scalable social impact indicators for the Sustainability Bond NRW #5, which are mainly based on fix lump sums in the different State programmes (e.g. such as re-fundable costs for social workers).

It is recommended to integrate appropriate literature and evaluation data when using these indicators in another context or further impact assessments of bonds.

Table 1-6: Social Impact Indicators for Sustainability Bond NRW #5

Impact indicator	Scaling Factor	Metric
First-year students	EUR 18,000 per student	lump sum
Graduates	EUR 4,000 per graduate	lump sum
Master student place	EUR 10,000 per place over 2 years	lump sum
Funding of geriatric nurses	EUR 2,870 per student	lump sum
Jobs for persons with disabilities	EUR 20,000 per job created	maximum funding
Jobs for social school workers	EUR 65,000 per job	lump sum
Jobs for long-term unemployed persons	EUR 34,400 per job	lump sum (estimate)
Broadband connections	EUR 2,000 per access point	factor based on cost sample for NRW

source: own calculation

[4] see https://www.bmvi.de/SharedDocs/DE/Artikel/DG/breitbandatlas/breitbandatlas.html

Methods and Data

GHG factors (Global Warming Potential for 100 years without upstream) are drawn from the research centre for energy economics (FfE, 2010), the balance of energy for German federal states (LAK, 2017) as well as data by the Federal Environmental Agency (UBA) (UBA & TREMOD 5.63, 2014).

The energy efficiency potentials for new buildings refer to the heat demand (electricity is not considered due to lack of data) of public buildings in the building stock of Germany from different years of construction (Deilmann et al., 2013). On average, 117 kWh per m² and year could be saved compared to average buildings in these sectors. It is also assumed that 52% of the State's funding is used for initial furniture and does not contribute to higher energy efficiencies. Costs for construction of university buildings and university clinical buildings are based on press releases on current and past construction projects by universities in NRW. The allocation of funding (new and refurbished buildings) was conducted with help of the State's budget plan (which includes individual plans for each university clinic).

The quantification of GHG savings for refurbished buildings required additional data on the share of construction measures for purposes of energy efficiency, the costs thereof and the reduced energy demand after refurbishment. They are based on two reference refurbishment measures at the university hospital of Munster and the university of Bochum. As a result, final heat savings of 3,156 kWh per bed (clinics) and 88 kWh per m² (gross area of usage for university buildings) were calculated.

GHG savings from Low Carbon Transport are based on avoided trips with cars. For bicycle paths, data from a feasibility study for the fast bicycle track RS1 was used: 177,719 km by car can be avoided for 22,439 ways per day in a conservative case (Regionalverband Ruhr, 2014). While the costs of fast bicycle tracks were drawn from press releases, costs of urban cycle paths are based on statistics by the Ministry of Transport of the State of NRW. It is also assumed that urban cycle paths only avoid car emissions for ways up to 5 km.

Avoided car emissions for student tickets are based on an empirical study from 2011 by the Wuppertal Institute (Müller, 2011): 1,242 car km per year and student could be avoided in Bielefeld. The allocation of the number of tickets in use, the costs of student tickets and their co-funding by the State of NRW are based on data provided by the Ministry of Finance of the State of NRW and a report on public transport in NRW (KCM NRW, 2018).

In the case of sustainable land use and social impacts, data was provided by the relevant Ministry for Environment, Agriculture, Conservation and Consumer Protection and the Ministry of Culture and Science of the State of NRW. Additional data was drawn from publicly available data on funding (e.g. re-fundable lump sums in applications) within the related projects as well as evaluation reports (e.g. intermediate reports of the European Social Fund).

Data for social impacts in the area of the enlargement of universities and other training facilities are based on statistics on the number of students and graduates in NRW (IT.NRW, 2018) as well as data by Ministry of Culture and Science of the State of North Rhine-Westphalia (www.mkw.nrw).

2 Background and Scope

The federal state of North Rhine-Westphalia (NRW) (Germany) emits an annual Sustainability Bond since 2015 that consists of projects in the budget closely linked to sustainable development (NRW Sustainability Bonds #1 to #5).

The Bond focuses on projects that ensure social and ecological sustainability and is part of the "strategy for sustainability" in North Rhine-Westphalia (Landesregierung NRW, 2016). The 5th Bond was issued in 2019 with a volume of EUR 2.25bn, referring to 52 eligible projects from the States' 2018 budget.

While ISS-oekom provided a second party opinion on the eligibility of the selected projects for a sustainability bond (ISS-oekom, 2019), the Wuppertal Institute has been asked to analyse the impacts in regard to a sustainable development for the fourth year in a row (see Jens Teubler, Oskar Reutter, Katrin Bienge, & Lena Hennes, 2019) for the full German report on the NRW Sustainability Bond #4).

The 5th Sustainability Bond is clustered in seven different project categories and can be associated with the Sustainable Development Goals (SDGs) by the United Nations (Nino, 2016), as shown in Table 2-1).

Table 2-1: Project categories in the Sustainability Bond #5 NRW

Project category	SDGs'
A Education and Sustainability Research (EUR 868.0m)	SDG 4 – Ensure inclusive and quality education for all and promote lifelong learning SDG 9 – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
B Inclusion and Social Coherence (EUR 379.3m)	SDG 1 – End poverty in all its forms everywhere SDG 10 – Reduce income inequality within and among countries
C Public transport and local mobility (EUR 192.0m)	SDG 9 – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation SDG 11 – Make cities and human settlements inclusive, safe, resilient and sustainable
D Climate protection and energy transition (EUR 55.9m)	SDG 7 – Ensure access to affordable, reliable, sustainable and modern energy for all SDG 13 – Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy
E Environment and nature conversation (EUR 133.2m)	SDG 2 – End hunger, achieve food security and improved nutrition and promote sustainable agriculture SDG 15 – Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
F Sustainable urban development (EUR 323.5m)	SDG 9 – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation SDG 11 – Make cities and human settlements inclusive, safe, resilient and sustainable
G Modernisation of educational and public facilities (EUR 487.7m)	SDG 3 – Ensure healthy lives and promote well-being for all at all ages SDG 13 – Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy

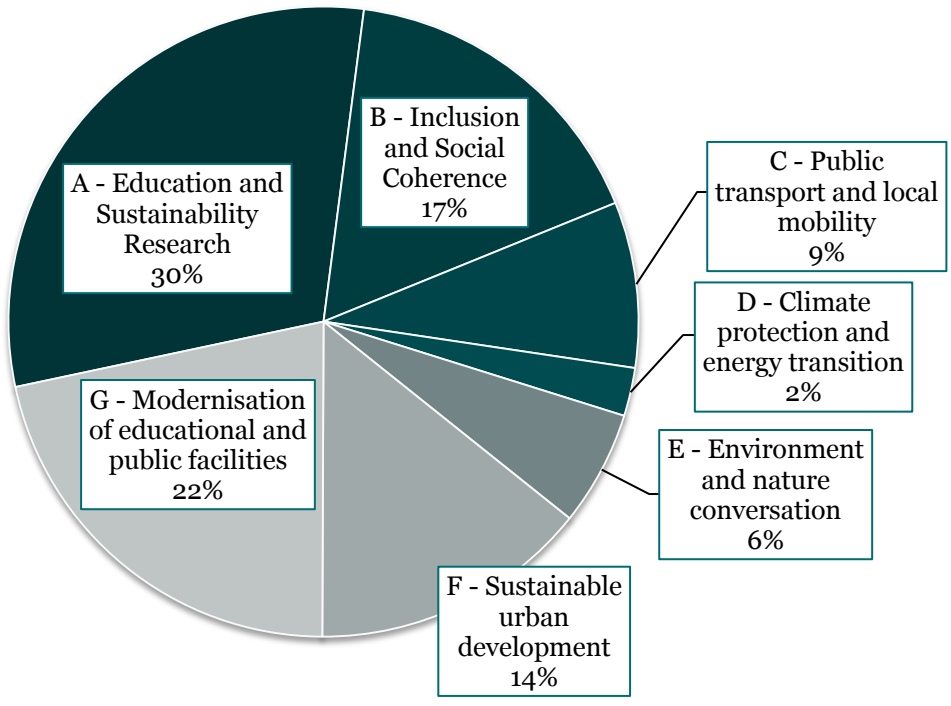
source: own compilation based on Ministry of Finance of NRW, 2019

The goal of the project is to evaluate positive sustainability effects for the Sustainability Bond #5 NRW. It covers not only the mitigation effects on climate change (avoided greenhouse gas emissions), but also further environmental and social impacts.

The volume of the Sustainability Bond #5 NRW (issued in 2019) is distributed among the seven project categories shown in Figure 2-1. The categories "Education and sustainability research" (A, 30 %) and "Modernisation of university and public health buildings" (G, 22 %) account for the largest share of funding. The categories "inclusion and social cohesion" and "local public transport and local mobility" each have a share of 17% respectively 9%. The other three project categories together account for only 22% of the volume.

The project categories cannot be clearly classified according to their ecological, economic and social impact. For example, the construction of a new, energy-efficient university building will also create new study places, so that this measure will have positive ecological, social and economic effects at the same time.

Figure 2-1: Proportion of funding from the 5th Sustainability Bond NRW (issued in 2018).



source: own compilation based on use of proceeds for NRW Sustainability Bond #5

The impact analysis is based on the "Harmonized Framework for Impact Reporting" (The World Bank et al., 2015), which also provides a uniform presentation of the results of an impact analysis. Going into the fifth year, the Wuppertal Institute has continuously advanced the scope of the impact assessment of the Sustainability Bond NRW.

3 Methodology for Greenhouse Gas Emissions (GHG)

This chapter describes how the calculation of avoided greenhouse gas emissions (GHG reduction) is carried out (sometimes also referred to as scope 4 emissions)[5].

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 (Intergovernmental Panel on Climate Change, 2014; Qin 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 CO_2 equivalents (CO_2 equivalent or CO_2e) (Bernstein, Pachauri, Reisinger, & Intergovernmental Panel on Climate Change, 2008).

In the presented impact analysis, 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. CO_2e 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).

3.1 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 section 3.2).

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 realization 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).

[5] This section of the report has not been changed compared to the previous report (Jens Teubler, Oskar Reutter, Katrin Bienge, & Lena Hennes, 2019)

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 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 has to 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 on the basis of the refurbishment costs of real and comparable buildings.

3.2 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, regardless of the fact that 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, the heating energy consumption of a building is mainly caused by its users: 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 realized without financial subsidies or loans.

In the process of estimating Carbon Footprints for e.g. companies, this is usually achieved by the use of 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***.

3.3 Limitations

A number of assumptions are necessary to calculate the financed GHG savings for the project categories C and G. 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 an university increases, thus also emitting more GHG emissions.

Table 3-1 lists the assumptions made for calculations and estimates their effect on the avoidance of GHG emissions.

Table 3-1: Estimation of the effects of assumptions on the potential for avoided GHG emissions (grey: no final estimation; green: avoided GHG underestimated; red: avoided GHG overestimated)

Bond Category	Assumptions	Impact on GHG emissions
Category C Public Transportation and Local Mobility	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.
	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.
	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.
Category G Modernisation of educational and public health facilities	Assumptions for the replacement of new 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.
	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.
	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%).
	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.
	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.

source: own presentation

4 Estimation of Impacts for Sustainability Bond #5

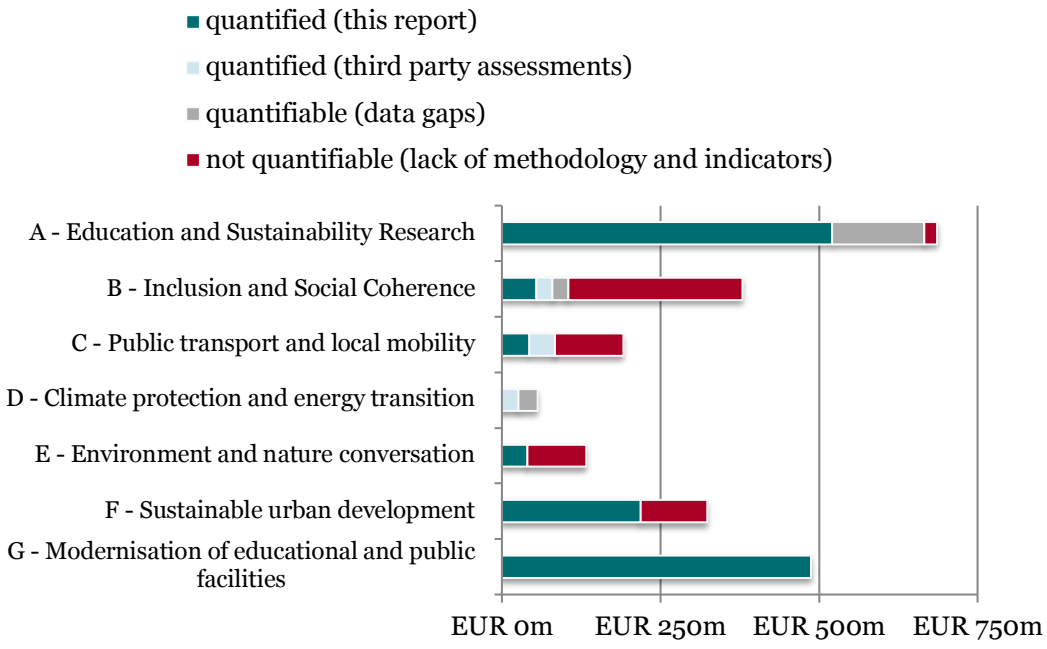
The NRW Sustainability Bond #5 provides environmental (green) and social benefits. The environmental impacts are mostly GHG reduction potentials achieved through energy efficiency measures and investments into means of transport with lower GHG emissions. Previous bonds also included quantifiable investments into renewables (e.g. solar thermal panels) and the co-generation of heat and power. Additional environmental impacts can be achieved by sustainable land use (quantified in this report) as well as resource-efficiency in companies (reported by other parties).

Social impacts in form of indicators could be quantified for students in universities (first-year students, bachelor graduates and capacities for master students) as well as jobs in the social sector (social workers in schools) and for people with disabilities. Further social impacts include job qualification as part of the European Social Fund, but also access to broadband internet.

The report at hand includes quantifications for 54.1% of the investments in the bond, totalling EUR 1,221m. These quantifications cover 6 out of 7 bond categories. A further 4% or EUR 91m could be reported on the basis of other assessments. The remaining investments are either not quantifiable for lack of data (EUR 201m or 8.9%) or lack of methodologies and indicators (EUR 745m or 33.0%). While these shares might decrease with future impact assessments, some impacts might never be quantifiable.

All results depicted in this report are based on model calculations, available data and assumptions described in the following sections. They are, for the most part, to be considered ***estimates***.

Figure 4-1: Breakdown of the quantified, quantifiable and non-quantified shares of the 2019 Sustainable Bond



source: own assessment based on methods and data in this report

4.1 Co-Impacts

The Sustainable Development Goals of the United Nations have 17 different goals and more than 100 indicators for measurement. This diversity attests to the fact that sustainable development covers several interconnected ecological and social areas at once. Improving education for example (SDG 4) is very likely to reduce poverty (SDG 1) as well as overall inequalities in a society (SDG 10).

The same is true for many of the projects in a sustainability bond, as quantified impacts are not always the only impacts and not even the most important impact of an investment in the State budget. The focus on GHG savings by modern buildings for example neglects the fact that university buildings are built and re-furbished for other reasons than climate protection. The improvement of clinical buildings improves patient care, and a new laboratory in a university provides additional research capacities. Beneficiaries are not only employees and students, but the society as a whole.

To account for all these benefits would require appropriate indicators for each impact and an additional methodology for the combination of these impacts. This type of multiple-impact or multiple-benefit assessment usually relies on the monetisation of impacts and already exists for some areas. However, it is still not far advanced even for well-researched areas such as energy-efficiency measures[6] and thus not feasible for the impact assessment of sustainable financing.

The report at hand only quantifies single impacts in one particular area of the environment or society. However, quantifying possible co-impacts of the NRW Sustainability Bond is currently under investigations by the Wuppertal Institut (see section 6.2 in this report).

[6] see e.g. https://combi-project.eu/ for an example of such a methodology

4.2 A: Education and Sustainability Research

Category A funds projects that enlarge education capacities for teachers, trainees and students. It also promotes research for sustainable development and innovation.

4.2.1 Volume in category A

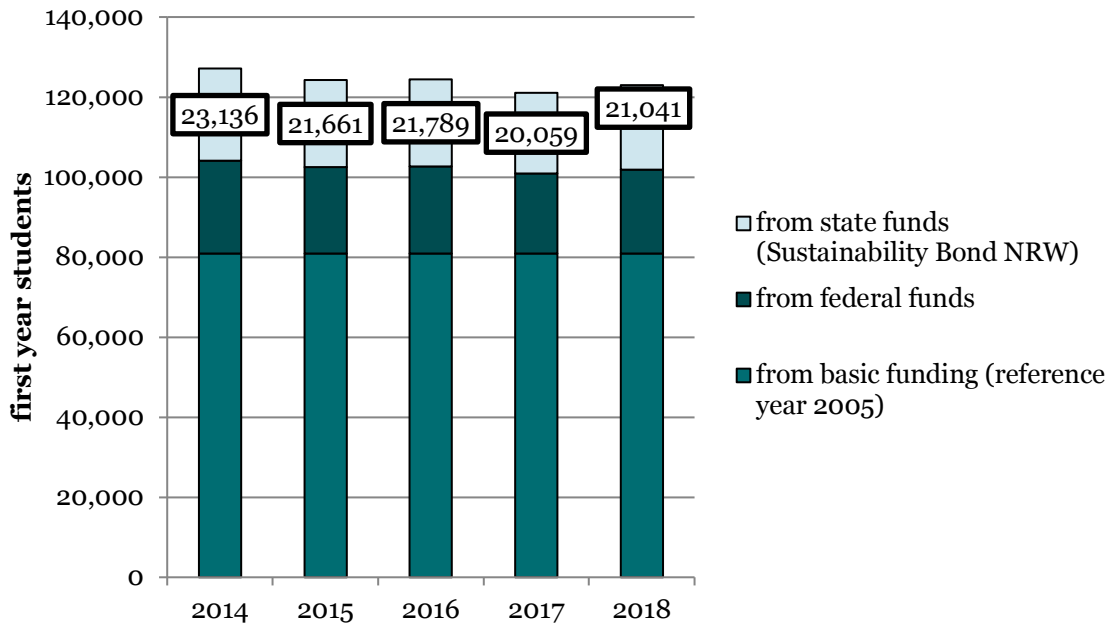
The overall funds amount to EUR 686.0m. EUR 607.3 are invested into the expansion of universities (EUR 475.6m), training facilities for teachers and special education training (EUR 66.5m), the return programme for highly qualified young researchers from abroad (EUR 3.5m) and professional training for geriatric nurses (EUR 61.7m). An additional EUR 24.9m are in support of "best in class" universities. Funds for sustainability research amount to EUR 38.0m and for consumer education to EUR 15.9m.

The report at hand quantifies the funds for the expansion of universities as part of the Bund-Länder-Covenant for the expansion of universities (State's share of the "Hochschulpakt") as well as funding for e.g. geriatric nurses or the return programme for scientists.

4.2.2 Data and Results

One impact of the "Hochschulpakt" is the expansion of university capacities in terms of first-year students. Using a baseline of 80,903 first-year students in NRW in 2005, it can be shown that additional capacities could be provided for roughly 42,000 students each year between 2014 and 2018 (see Figure 4-2). Half of these students can be allocated to investments in the sustainability bond.

Figure 4-2: Allocation of funds for first-year students to the sustainability bond



source: IT.NRW, 2018

The overall investments in the sustainability bond for the Hochschulpakt III (EUR 475.6m in 2018) also helped to increase the overall number of graduates and increased the capacities for master students. The report at hand allocates funding in the Hochschulpakt III after the fact, because annual budgets also include funds from the previous programmes or might be the result of transfer postings between budget years. The reported additional first-year students are therefore used as basis for allocating additional funding for master student places, bachelor graduates and other purposes.

Table 4-1: Individual plans for additional master students in NRW between 2014 and 2020

Universities in NRW	Plan for additional master students from 2014-2020	Plan for additional master students in 2018/2019 (2018)
RTWH Aachen	7,146 students	1.428 students
FH Aachen	1,830 students	376 students
Uni Bielefeld	3,282 students	607 students
FH Bielefeld	760 students	135 students
Uni Bochum	5,981 students	705 students
FH Bochum	618 students	128 students
Uni Bonn	4,609 students	966 students
Uni Rhein-Sieg	830 students	155 students
Uni Dortmund	4,430 students	609 students
FH Dortmund	1,016 students	210 students
Uni Duisburg-Essen	4,570 students	667 students
Uni Düsseldorf	1,731 students	363 students
FH Düsseldorf	873 students	165 students
Uni Gelsenkirchen	1,045 students	197 students
Uni Hagen	1,616 students	570 students
FH Hamm-Lipstadt	210 students	35 students
Uni Köln	5,712 students	885 students
Sporthochschule Köln	404 students	67 students
FH Köln	2,156 students	438 students
Uni Münster	5,482 students	940 students
FH Münster	1,800 students	381 students
Uni Niederrhein	1,194 students	250 students
Uni Ostwestfalen-Lippe	560 students	111 students
Uni Paderborn	3,546 students	496 students
FH Rhein-Waal	577 students	132 students
FH Ruhr-West	494 students	139 students
Uni Siegen	3,413 students	527 students
FH Südwestfalen	792 students	166 students
Uni Wuppertal	3,389 students	466 students
in TOTAL	**70,066 students**	**12,314 students**

source: based on contracts with the universities of NRW (Ministry of Culture and Science of the State of North Rhine-Westphalia, 2016)

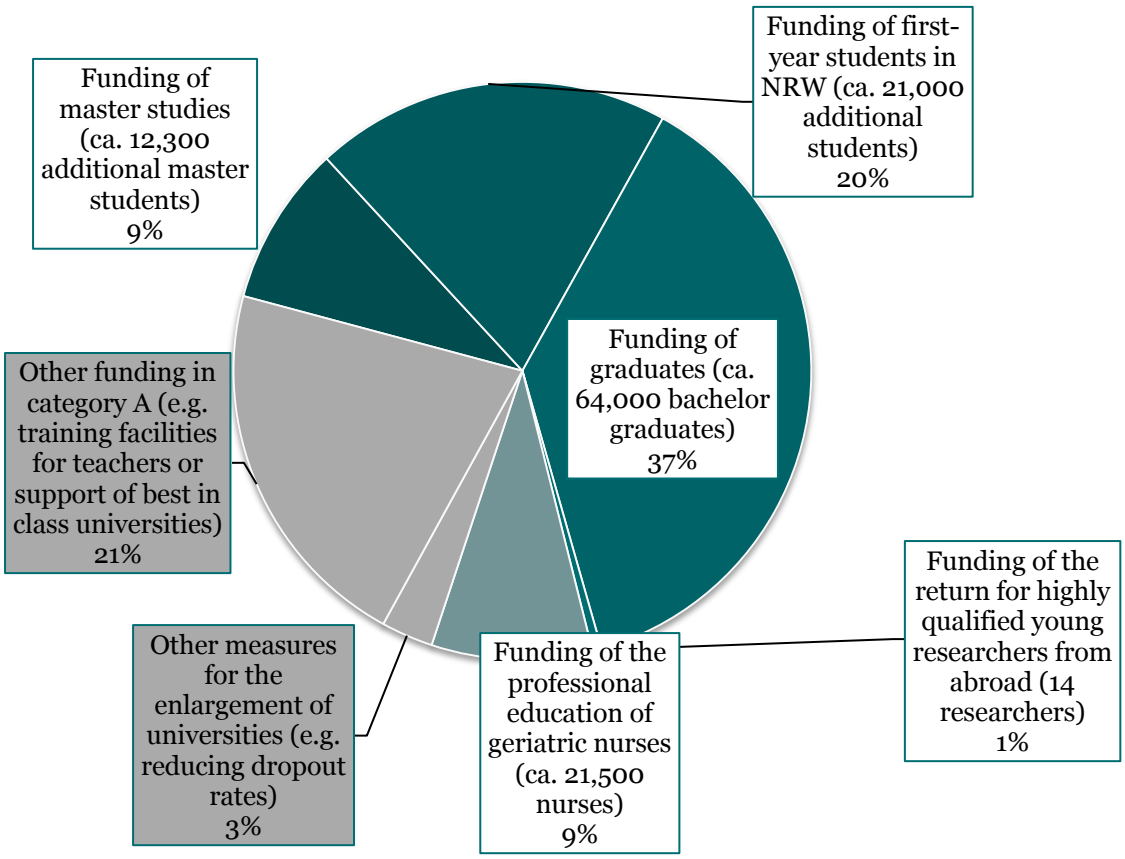
The lump sum for one additional first-year student (compared to 2005) is 13,000 EUR each from State and federal funds(Heads of the Federal and State governments of Germany, 2014). This funding is provided over a period of 4 years, resulting in EUR 136.8m of funding in the Sustainability Bond for 21.000 additional first-year students (EUR 3,250 per student and year).

The universities in NRW (including universities of applied science) also plan to provide capacities for additional 12,300 master student places in 2018/2019 (Ministry of Culture and Science of the State of North Rhine-Westphalia, 2016), receiving 10,000 EUR for each place over 2 years (or EUR 5,000 per year). These additional master student places equal funds in the Sustainability Bond of EUR 61.6m (see Table 4-1). Bachelor graduates are funded with EUR 4,000 each, which requires an additional EUR 257.3m from the funds in the Sustainability Bond.

The remaining EUR 260m are attributed to the professional education of geriatric nurses (EUR 61.7m for ca. 21,500 nurses), the return programme for scientists (14 researchers for EUR 3.5m in 2018) as well as other measures for the enlargement of universities (EUR 20.0m), training facilities for teachers (EUR 66.5) or support for best-in-class universities (EUR 24.9m).

Figure 4-3 shows the overall results for category A.

Figure 4-3: Overview of social impacts in category A (EUR 686m in total)



source: own compilation based on data in this report

4.3 B: Inclusion and Social Coherence

Project category B on Inclusion and Social Cohesion funds projects that recognize diversity and provide equal opportunities for people with disabilities, migrant background and/or otherwise disadvantaged people (e.g. poor people). It includes measures for employment and education as well as integration.

4.3.1 Volume in category B

The total volume of category B amounts to EUR 379.3m. The largest share (64% or EUR 242.9m) is attributed to "Language skills in early childhood, family centres and non-contributory day care". This includes numerous projects and programmes regarding language courses at child care facilities, the promotion of cooperation of family formation and counselling centres with family centres and the exemption to contribution for parents for the last day care year. The rest of the investments in B are used for "Inclusion, integration and qualification" (EUR 89.2m or 23%) and "Social school work" (EUR 47.2m or 12%).

About 15% of this volume could be quantified in the report at hand (see Figure 4-1), 7% is reported elsewhere and ca. 7% of this volume could very likely be quantified in the future if data is provided (potentially allowing to generate a scalable social impact indicator). However, for about 72% of the funds there is either no method to do so or the funding is allocated in a way that quantifiable impacts cannot be generated at all (e.g. by indirectly funding institutions with a social agenda).

Among the potentially quantifiable funds there are 3 project groups that require data in order to generate scalable indicators. EUR 2.5m of the EUR 25 m for the European Social Fund ESF provide in fact funds for language courses for refugees and should be relatable to the number of participants or even success rates (e.g. in relation to achieved language competence). The programme currently funds language teachers as well as travel expenses for participants[7] and aims at a language competence level of A1 (EU, ESF Nordrhein-Westfalen, & Ministerium für Kinder, Familie, Flüchtlinge und Integration des Landes Nordrhein-Westfalen, 2017). Also quantifiable are EUR 5.1m that are invested into fighting long term unemployment (e.g. by counting the number of successfully integrated people).

EUR 25m into "language course at child facilities" on the other hand, will be quantified in the future. This programme is currently under evaluation, including an analysis of the funding spent and its effects. The duration of this study (SEIKA-NRW) is from 2015 to 2020[8].

Table 4-1 shows the break-down in funds that were quantified in this report, funds that were quantified based on other reports, potentially quantifiable segments and funds without a potential for quantification.

[7] The progamme funds 80% of the costs of 300 lessons (45 minutes each based on lump sums for teachers) as well as travel expenses of participants (EUR 15 per person).

[8] https://www.dji.de/ueber-uns/projekte/projekte/sprachbildung-und-entwicklung-im-kita-alltag-seika-nrw.html

Table 4-1: Quantified and quantifiable volume in category B

Sub-Categories	Investment volume	quantified (this report)	quantified (other reports)	quantifiable (lack of data)	not quantifiable
Inclusion, integration and qualification	EUR 89.2m	EUR 7.6m	EUR 23.0m	EUR 2.0m	EUR 56.6m
Language skills in early childhood education, support	EUR 242.9m	-	-	EUR 25.0m	EUR 218.0m
Social school work	EUR 47.2m	EUR 47.2m	-	-	-
in Total	**EUR 379.2m**	**EUR 54.8m**	**EUR 23.0m**	**EUR 27m**	**EUR 274.6**

source: own compilation

4.3.2 Third Party Assessments in category B

The State funding into the European Social Fund (ESF) in category B relates to the priority axis B in this European Fund ("promoting social inclusion and combating poverty and all forms of discrimination"). The German implementation report (Bundesministerium für Arbeit und Soziales, 2018) reports that 42.000 participants were promoted in 2017 alone. Out of the accumulated participants of 150,000 until end of 2017, 39.0% were women, 72.5% lived in unemployed households and 59.5% were long term unemployed.

For NRW (Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen, 2018), it is reported that 5.402 participants were part of projects and programmes that aim at the long term integration into the labour market (4,834 of these participants were under 25 years old). The Sustainability Bond contains a funding for ESF priority axis B of EUR 23.0m[9], while the overall funds (European funds, federal funds, private funds and State funds combined) in this category amount to EUR 387.8m from 2014 to 2020. The State of NRW provides EUR 150m of state funds for priority B. It can therefore be estimated that 38.6% of the participants (ca. 2,000) directly benefit from investments in the bond.

An explicit example of this funding is the programme "Kooperative Ausbildung an Kohlestandorten", aimed at apprenticeships for young people in regions with coal sites. In 2017, the State of NRW provided EUR 0.73m out of a larger co-financed fund of ca. EUR 3.3m (Ehlert, personal communication, 15 January 2019). As Apprenticeships in the programme are funded with EUR 900 per month and apprentice, the investments in the bond alone could provide support for 67 apprenticeships per year.

[9] EUR 2.5m of the EUR 25.5 are allocated to language courses for refugees.

Table 4: Third party assessments for category B on social inclusion and cohesion

Sub-Categories of B	Investments in Bond	Reported Funding	Reported Effects (estimates for NRW)
European Social Fund 2014-2020	EUR 25 m	EUR 23.0m	2,000 participants in programmes for education and long term integration into the labour market (e.g. 67 apprenticeships in regions with coal-sites)

source: Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen, 2018

4.3.3 Jobs for persons with disabilities (quantified social impact in category B)

EUR 2.5m of the total investments can be quantified indirectly as part of the EUR 3.2m funding for "Employment opportunities for persons with disabilities". The programme aims at the creation of 250 new jobs for people with disabilities in inclusion companies. With a maximum funding of EUR 20,000 for each newly created job, this relates to at least 125 new jobs (Gesellschaft für innovative Beschäftigungsförderung mbH, 2018).

4.3.4 Social school work (quantified social impact in category B)

About 12% of the overall investments in category B is used to promote the education and participation for disadvantaged children. By doing so, the State of NRW continues financing on social school work that has been discontinued by the Federal Government in 2014. Initially provided for 3 years (until 2017), funding is now secured until 2021 (Bildungsportal des Landes NRW, 2019).

The State programme provides ca. EUR 47.2m per year to 53 cities and municipalities in order to provide assistance for targeted youth work and reducing social disadvantages in this area. The funding is focused on promoting jobs for social workers, that help to

- reduce absenteeism in schools,
- improve school success,
- reduce school drop-out numbers,
- and increase the participation of students in sports and cultural activities.

A first evaluation of the programme in 2017 (Gabler et al., 2017) concludes that while there is still an information gap (e.g. only half of the parents entitled to apply for benefits from the programme know about them), children from poor households are overrepresented when it comes to benefiting from services such as additional school excursion or joint lunch. It is also estimated that the programme itself has financed 1.700 skilled social workers so far. The impact of this category of the bond can therefore be directly be related to the financing of these jobs. The State of NRW promotes jobs in this area based on generalized costs of ca. EUR 50,000 on an annual gross salary and direct material expenses of ca. EUR 15,000, summing up to refundable costs of EUR 64,815 per year.

Thus, EUR 47.2m in the bond amount to potential 725 jobs for school social workers, which is about 27% of the financed social workers so far or 14 social worker per municipality.

4.3.5 Fighting long-term unemployment (quantified social impact in category B)

A funding of EUR 5.1m is also used for programmes to fight long-term unemployment. Within the "Model project for the integration of long-term unemployed people in NRW" ca. 400 persons could be brought into employment. This project is used as an example to estimate a lump sum of EUR 34,400 per job resulting in 148 long-term unemployed persons that could be brought into employment through the funding of EUR 5.1m.

4.4 C: Public Transportation and Local Mobility

Category C projects are investments into reduced ticket fares for certain groups (e.g. students) and the development of infrastructures for low-carbon mobility (e.g. roads for biking).

4.4.1 Volume in category C

The volume in category C totals EUR 192m, of which EUR 129.8m are invested into public transportation for students and pupils, EUR 22.2m into transportation infrastructure (cycle path's) and EUR 40m into public transportation for low-income citizens.

The latter refers to the so-called "social tickets", which mainly aims at social impacts such as participation, integration or mobility. It has been reported (third party assessments) for 2015, that circa 300,000 people benefit from these tickets (Landtag NRW, 2017). It is questionable whether the social ticket will actually lead to a GHG reduction though, since a considerable proportion (67%) of ticket recipients cannot fall back on a car in any case (KCM, 2015).

Overall, investments of EUR 43m or 22.4% of this category were directly allocated with quantifiable effects on the climate (quantified effects).

4.4.2 Allocation of investments for category C

The funding for students and pupils in category C supports the public transportation system in NRW by financing the reduced tariffs for pupils, students and trainees, while also promoting the improvement of services and quality (Finanzministerium Nordrhein-Westfalen, 2016). The Public Transport Act of North Rhine-Westphalia stipulates in Section §11a (1) that EUR 130 million 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 EUR 113.75m, approximately EUR 21m is used for semester tickets (according to the NRW Ministry of Finance). The remaining 12.5% can be used for other financing measures, such as further development of the system or quality improvements.

The remaining EUR 92.75m are used for funding into trainee and pupil tickets. Although these tickets are also expected to lead to a GHG reduction, there is no reliable data source available to estimate the effects. Similar to social tickets, it is also questionable whether many pupils and trainees regularly use a car or have a driving licence at all. On the other hand, the investments into urban and non-urban cycle paths (EUR 22.2m) are fully taken into account for quantification as they all relate to the costs of construction.

4.4.3 Data basis and calculation of the GHG reduction of semester tickets

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 the basis for the calculation. In contrast to the other project groups, only the reduction for one year is taken into account, since the semester ticket is only financed for two semesters (one year).

In order to determine the total costs for the semester ticket and the share of the bond in the total costs, the quantity of tickets sold for each year (2014 to 2018) is offset against the ticket price as well as the costs for the regional expansion (EUR 120m) and added to the investments from the bond.

Table 4-2 shows the result of this calculation. 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, 2019 for the most recent data).

Table 4-2: Calculation of the share of expenses for semester tickets from the bond in the total costs for semester tickets

Reverence year	2014	2015	2016	2017	2018
Sold tickets with NRW extension (98% of all semester tickets)	1.11 m pcs.	1.16 m pcs.	1,19 m pcs.	1,21 m pcs.	1,210 m pcs.
Price of the semester ticket with NRW extension	EUR 46.00	EUR 48.10	EUR 49.50	EUR 50.90	EUR 52.80
Income from semester tickets with NRW extension	EUR 50.83m	EUR 55.60m	EUR 58.88m	EUR 61.46m	EUR 64.05m
State financing share (NHA NRW; constant over four years)	EUR 21.04m	EUR 21.04m	EUR 21.04m	EUR 21.04m	EUR 21.04m
Costs for regional tickets (EUR 120 per ticket)	EUR 135.31m	EUR 141.55m	EUR 145.65m	EUR 147.86m	EUR 148.53m
Total costs semester ticket	**EUR 207.18m**	**EUR 218.20m**	**EUR 225.57m**	**EUR 230.36m**	**EUR 233.59m**
Share of NHA NRW in total costs	**10.2%**	**9.6%**	**9.3%**	**9.1%**	**9%**

source: own calculation

Based on data from the Federal Environment Agency, 142 g CO_2e per car-km are assumed for the GHG reduction through avoided car-km (Umweltbundesamt (UBA), 2016). In total (see Table 4-3), between 99,500 and 109,174 tonnes of CO2e per year can thus be avoided, of which 9,800 to 10,100 tonnes of CO2e per year are attributable to investments in the bond.

Table 4-3: THG reduction potential for the promotion of semester tickets in the NHA NRW

Year of bond issue	2014	2015	2016	2017	2018
Total GHG reduction potentials for semester tickets in NRW	99,450 t CO_2e/a	104,040 t CO_2e/a	107,050 t CO_2e/a	108,676 t CO_2e/a	109,174 t CO_2e/a
THG reduction potentials for the NHA NRW (Share in %)	10,100 t CO_2e/a (10.2%)	10,030 t CO_2e/a (9.6%)	9,990 t CO_2e/a (9.3%)	9,927 t CO_2e/a (9.1%)	9,820 t CO_2e/a (9%)

source: own calculation

4.4.4 Data basis and calculation of GHG reduction of 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 (RS1) between Duisburg and Hamm. (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 there. In the "zero case" scenario, a conservative design, 1,760 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 are available on the avoidance of car km. 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 1,060 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 from the Ministry of Transport of the State of NRW. The 5-year average (2012-2016) 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 4-4). Accordingly, the average construction costs are EUR 1.16m per kilometre built.

Table 4-4: Considered construction costs and length of the fast cycle paths

Cycle path	Length	Cost
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
Average cost per km	1 km	EUR 1.16

source: own calculation based on web publications

For the GHG reduction by avoided car-km 142 g CO_2e per car-km are assumed (Umweltbundesamt (UBA), 2016). Table 4-5 shows the results of the analysis for GHG reduction by cycle path construction within the NHA.

The service life of a cycle path is 30 years for a bituminous pavement.

Table 4-5: Built-up cycle paths and GHG reduction potential through cycle path construction in the bond

Year of the bond issue	Effect	2014	2015	2016	2017	2018
Non-urban fast cycle paths	Annual GHG reduction	0 t CO_2e/a	744 t CO_2e/a	658 t CO_2e/a	580 t CO_2e/a	501 t CO_2e/a
	GHG reduction over lifetime (30 years)	0 t CO_2e	22,322 t CO_2e	19,737 t CO_2e	17,387 t CO_2e	15,038 t CO_2e
	Kilometres built up	0.0 km	8.2 km	7.2 km	6.4 km	5.5 km
Urban cycle paths	Annual GHG reduction	2,668 t CO_2e/a	2,746 t CO_2e/a	2,406t CO_2e/a	3,350 t CO_2e	4,132 t CO_2e/a
	GHG reduction over lifetime (30 years)	80,032 t CO_2e	82,386 t CO_2e	72,186 t CO_2e	100,433 t CO_2e	123,972 t CO_2e
	Kilometres built up	48.8 km	50.2 km	44.0 km	61.2 km	75.5 km

source: own calculation

4.5 D: Climate Protection and Energy Transition

The investment volume in category D amounts to EUR 55.9m. 35% or EUR 19.8 of this sum are allocated State investments in the European Fund for Regional Development (ERDF). The effects of these funds are reported in the current implementation report for NRW and therefore refer to the budget year 2017 (Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie des Landes Nordrhein-Westfalen, 2018).

EUR 30.5m (or 54% of the investments) are used for the State's other efforts towards climate protection, energy transition, renewable energies and energy efficiency. These funds are potentially quantifiable, but could not be quantified due to lack of data.

The last category refers to resource efficiency with EUR 5.6m or 11% of the investments. These funds are used to help companies in order to reduce energy use, GHG emissions, waste and water use. They are part of the public funding for Effizienzagentur NRW efa+ and Ökoprofit NRW.

Table 4-6 list all investments in category D and their breakdown into quantifiable assets as well as assets which effects where report elsewhere (see next section).

Unfortunately, none of the investments in this category could be quantified directly in the report at hand.

Table 4-6: Quantified and quantifiable volume in category D

Sub-Categories	Investment volume	quantified (this report)	quantified (other reports)	quantifiable (lack of data)	not quantifiable
Energy transition, renewable energies and energy efficiency	EUR 30.5m	-	-	EUR 30.5 m	-
European Regional Development Fund (ERDF) 2014-2020 (State's share)	EUR 19.8m	-	EUR 19.8	-	-
Resource Efficiency	EUR 5.6m	-	EUR 5.6m	-	-
in Total	**EUR 55.9m**	**-**	**EUR 25.4m**	**EUR 30.5m**	**-**

source: own compilation

4.5.1 Third party assessments in category D

Category D covers a number of measures which lead to GHG reductions but which could not be quantified in this analysis due to insufficient data. These include the expansion of renewable energies and measures to increase resource and energy efficiency. Between 2014 and 2016, EUR 162 million were invested. The resulting ecological effects, however, were partly estimated by the participating institutions themselves.

Table 4-7 shows the results of the business support within the framework of the "NRW Efficiency Agency" (efa+), Ökoprofit and the use of ERDF funds. The Efficiency Agency and Ökoprofit provide consultancy services that support companies and business networks in reducing their consumption of energy and resources. ERDF is a European fund for the promotion of regional development that draws on EU, federal and state funds. This fund is divided into various priorities or thematic areas. Priority axis 3 focuses on the reduction of greenhouse gas emissions.

While the projects themselves are beyond the scope of this analysis, some of their results are reported here in form of third party assessments. Table C shows the State's investments into such projects from the bond category D (Climate Protection and Energy Transition), in addition to investments from private, municipal, federal and European funds. As the current EFRD report was not available at the time of the impact report, investments and effects still refer to the timeframe from 2014 until 2017.

Table 4-7: Overview of quantified effects in category D from other reports

Type	State funding (NRW Bond #1 to #5)	Investments outside the Sustainability Bond (budget years 2014-2018)	Environmental Savings (2014-2018)*
Effizienz Agentur NRW efa+ (as part of resource efficient economy)	circa EUR 25m	EUR 53.1m in the scope of resource efficiency (validated)	65,313 tons of CO_2e
			12,819 tons of material resources
			467,211 m^3 of water
		EUR 492.2m in the scope of financing (validated)	145,358 tons of CO_2e
			20,719 tons of material resources
			200,763 m^3 of water
Ökoprofit NRW (as part of resource efficient economy)	circa EUR 1.3m	EUR 63.5m	90,061 tons of CO_2e
			9,034 tons of waste
			504,602 m^3 of water
ERDF (2014-2020) (priority axis 3 on CO_2 reduction)	EUR 96.3m	only for budget years 2014-2017 (no report for 2018 as of yet)	
		circa EUR 530m	454,424 tons of CO_2e
**Different methods were used to calculate the ecological impacts of the projects. The results are not summable. These numbers refer to the most recent reporting in the projects (including retrospective adjustment of data).*			

source: correspondence with related agencies

4.6 E: Environmental protection and nature conversation

Within project category E, a total of EUR 133,2 million from the fifth NHA was invested in measures that contribute to the conservation of biological diversity in NRW. Thus, this category refers to SDG14 and 15 (Ministry of Finance of the State of North Rhine-Westphalia 2017). The following subcategories are integrated in the category:

- Protection of nature, landscape and biodiversity Nature conservation and landscape management (EUR 28.3m)
- Flood protection and river restoration (EUR 64.7m)
- Responsible agriculture (EUR 8.9m)
- European Agricultural Fund for Rural Development – EAFRD (State's share) (EUR 31.3m)

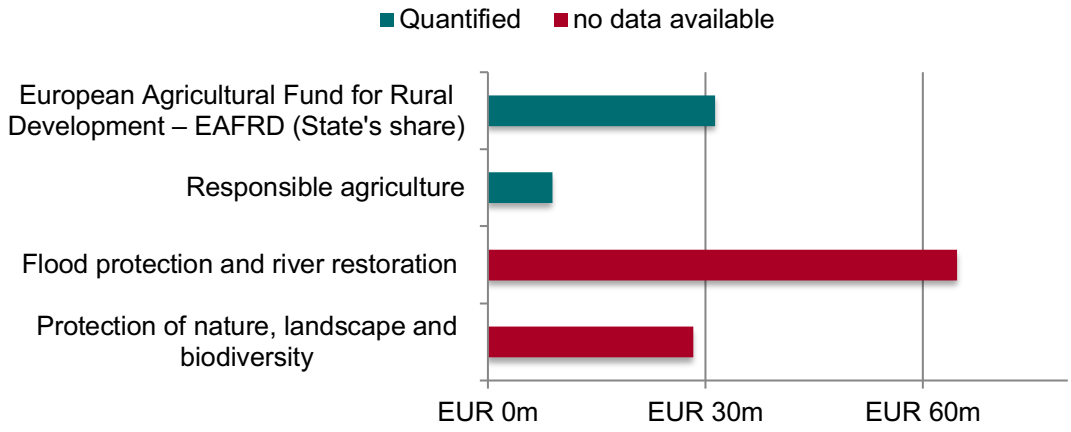
4.6.1 Investment volume taken into account

Of the total volume of EUR 133.2 million, EUR 40.2m can be allocated to quantifiable sustainable land use. These are “responsible agriculture" and the EAFRD funding.

The other subcategories also partly lead to sustainable land use, e.g. areas for the biotope network that are promoted within the subcategory "nature conservation and landscape management" or also areas for flood protection and near-natural watercourse construction. For these subcategories, however, it was not possible to directly allocate investments to individual measures with a corresponding land reference.

Figure 4-4 shows the investments, divided into the corresponding subcategories, as well as the investment volumes that could be stored with quantifiable data.

Figure 4-4: Overview of the investment shares within project group E for which sustainable land use could be quantified.



source: own assessment based on calculations in this report

4.6.2 Data basis and calculation of land use

Data from the Ministry for the Environment, Agriculture, Nature Conservation and Consumer Protection of the State of North Rhine-Westphalia (MULNV) as well as data from the "Gemeinschaftsaufgabe zur Verbesserung der Agrarstruktur und des Küstenschutzes" (GAK) (Bundesminsterium für Ernährung und Landwirtschaft 2016) was used to evaluate sustainable land use. Since investments into programmes in the bond do not correspond exactly to the amounts in the relevant reports from 2014 and 1015, area factors per EUR have been calculated and used for scaling the estimated effects.

A total of 30% of the investment volume in project category E was quantified for areas with sustainable use. Table 4-8 shows the quantified areas and their allocation to the corresponding subcategories. A total of 457,710 ha of subsidised land was identified.

Table 4-8: Results of the quantification of the subsidised sustainable land use within the framework of environmentally friendly and animal-friendly agriculture

Subcategory	Investment volume (2018)	Area supported per year (2018) (estimates)
Responsible Agriculture	EUR 8.9 m	72,438 ha
EAFRD	EUR 31.3 m	385,272 ha
in TOTAL	**EUR 40.2 m**	**457,710 ha**

source: own calculation

4.7 G: Modernisation of educational and public health facilities

Category G covers 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. Table 4-9 shows the investments by the State as well as their listing in the States' budget.

Table 4-9: Investments in project category G

Topic	Title	Budget items	Investments (EUR 487.7m)
Modernisation of university buildings	*Modernisation of university buildings*	# 06 100 891 20, 06 110 685 20, 894 20	EUR 127.0m
Modernisation of university clinical buildings	*Conservation and remediation of existing facilities*	# 06 102 TG 63, 06 103-108 891 20	EUR 145.2m
	Enlargement and other investments	# 06 103-108 891 30	EUR 215.1m
in total			**EUR 487.7m**

source: use of proceeds for NRW Sustainability Bond #5

4.7.1 Volume for GHG reductions

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 from 2018, but do not allow to differentiate into these four segments with GHG relevance. Therefore, additional information on the States' investments are drawn from the budget, that allow to allocate the funding in higher detail.

4.7.2 Investments into GHG relevant measures in category G

The allocation for general university buildings is based on the funding for the *Hochschulbaukonsolidierungsprogramm* (HKoP; programme for the construction of university buildings) and funding for the *Hochschulmodernisierungsprogramm* (HMoP; programme for the modernisation of buildings).

The States' budget for 2017[10] lists EUR 50m for HKoP (assumed to be mainly used for new buildings and building extensions) and EUR 30.8m for HMoP (assumed to be mainly used for refurbishment). Out of EUR 127.0m investments in the bond, it is therefore assumed that 61 % are used for new buildings and 39 % are used for refurbishment measures.

Both investments are assumed to use 52 % of their funds for equipment (assumption by the Ministry for Finances). 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, Jahn, & Clausnitzer, 2011).

As a result, EUR 37.7m are direct investments into new general university buildings and EUR 10.5m investments into energy refurbishment in the same segment.

Investments into clinical university buildings are listed individually in the States' budget and can therefore be used to generate a more specific allocation. Based on the 2018 listings for Bonn, Münster, Cologne, Aachen, Düsseldorf and Essen, 57.6 % of the funds are used for new buildings and 32.4 % for refurbishment measures. Considering also a reference energy refurbishment ratio of 53.6 % (based on the "Bettenturm Münster"), the following funds are allocated: EUR 207.6m are used for new buildings, EUR 62.6m for energy refurbishment and EUR 36.2m for other purposes such as equipment. Table 4-10 shows the resulting investments in category G into measures with direct GHG mitigation potential and other measures.

Table 4-10: Allocation of funding with GHG relevance in category G for the Sustainability Bond 2018

Topic	Measures for GHG mitigation/avoidance	Investments into measures for GHG emission reduction	Investments into other measures (e.g. equipment)
General university buildings	New and Extensions	EUR 37.7m	EUR 78.8m
	Energy Refurbishment	EUR 10.5m	
Clinical university buildings	New and Extensions	EUR 207.6m	EUR 36.2m
	Energy Refurbishment	EUR 62.6m	

source: own allocations based on information provided by the Finanzministerium das Landes Nordrhein-Westfalen and the 2018 budget of the State of North Rhine-Westphalia

[10] The contribution of funds to new and refurbished buildings is still based on the State's budget for 2017, as not all necessary information was available during the assessment.

4.7.3 Specific GHG emission factors for general and clinical university buildings

Table 4-11 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 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 4-11: Emission factors for the heat demand in university buildings

Energy source	Emission factor (without upstream)	Data source	Spatiality	Share in buildings
Gas*	202 g CO2e/kWh	FfE (2010)	Germany	55.8 %
Oil, light*	266 g CO2e/kWh	FfE (2010)	Germany	23.1 %
District heating	229 g CO2e/kWh	(Agentur für Erneuerbare Energien e.V., 2014)	NRW	21.1 %
Electricity	820 g CO2e/kWh	LAK (2015)	NRW	0.0 %
Emission Factor	**222 g CO2e/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

4.7.4 Heat demand in new 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.

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. Table 4-12 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 (see the next section for energy savings after refurbishment).

Table 4-12: 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/(m²a)	108.5 kWh/(m²a)	80 %
1977 - 1983	209.9 kWh/(m²a)	107.4 kWh/(m²a)	6 %
1984 - 1995	167.9 kWh/(m²a)	104.9 kWh/(m²a)	6 %
from 1995 onward	129.6 kWh/(m²a)	104.9 kWh/(m²a)	8 %
Heat energy savings		**117,2 kWh/(m²a)**	**100 %**

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

Linking the data in Table 4-12 and Table 4-11 results in GHG emission savings of 26 kg CO_2e per m² for new university buildings when compared to the building stock (222 g CO_2e per kWh at a difference of 117.2 kWh/(m²a)).

4.7.5 Calculation of GHG emission savings in new university buildings

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 4-13).

Table 4-13: Construction of useful area based on investments for university buildings in NRW (* refers to costs according to cost estimations)

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 m²	100 %	312.0E-6 m²/€
RWTH Aachen, auditorium centre Claßenstr. (R 6)*	EUR 45.0m	14,000 m²	100 %	311.1E-6 m²/€
Univ. Dortmund, Replacement New Building Chemistry/Physics (EE)	EUR 82.3m	14,661 m²	100 %	178.1E-6 m²/€
FH Niederrhein, Replacement new multi-building (EE)	EUR 20.0m	6,900 m²	75 %	258.8E-6 m²/€
FH Bielefeld, Replacement new construction, network expansion (EE)	EUR 279.3m	60,400 m²	100 %	216.3E-6 m²/€
FH Düsseldorf, ENB 1. BA*	EUR 170.0m	54,000 m²	100 %	317.6E-6 m²/€
in Total	**EUR 609m**	**153.861 m²**	**average (weighted)**	**250 m² per million euro**

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

Taking into account the assumed savings in heating energy, the associated factor for GHG reduction and a life of 50 years (Stibbe & Stratmann, 2014), the EUR 37.7 million bond investment will potentially build 9,400 m² of building space, which could lead to annual savings of 245 t CO_2e. GHG emissions are reduced by up to 12,269 t CO_2e compared with existing buildings and over the life of the building.

4.7.6 Data basis and calculation of the GHG reduction of new buildings in university clinics

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. 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 4-14: Net additional floor space for investments4-2 in new buildings in university clinics

Intentions	Building costs	Net floor area	Specific cost factor
Köln: CIO Zentrum (ambulant)	EUR 77.9m	13,500 m²	312.0E-6 m2/€
Aachen: Erweiterungsgebäude für intensive Operationspflege	EUR 41.2m	8,643 m²	311.1E-6 m2/€
Düsseldorf: Medizinisches Forschungszentrum I	EUR 79.9m	19,650 m²	178.1E-6 m2/€
Düsseldorf: Medizinisches Forschungszentrum II	EUR 26.2m	7,970 m²	258.8E-6 m2/€
Bonn: Neubau Eltern-Kind-Zentrum	EUR 71.9m	11,787 m²	216.3E-6 m2/€
Bonn: Neurologie, Psychiatrie und Palliativmedizin (NPP)	EUR 64.6m	12,842 m²	317.6E-6 m2/€
Sum	**EUR 361.6m**	**74,392 m²**	**206 m² per EUR m**

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

Taking into account the assumed savings of heating energy, the associated factor for GHG reduction and a life of 66 years (Hebel et al., 2011), the investments of the EUR 207.6 million bond will potentially create 42,800 m² of building space (see Table 4-14), which could lead to annual savings of 1,113 t CO_2e.

GHG emissions are reduced by up to 73,500 t CO_2e compared with existing buildings and over the life of the building.

4.7.7 Data basis and calculation of the GHG reduction of renovated buildings in general universities

The determination of the cost factor and the reduction of the heating energy requirement of renovated buildings in general universities is 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 10.5m lead to the redevelopment of 6,250 m² (at costs of EUR 1,680 per 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 (see chapter 4.7.4) and a reduction in heating energy demand of probably 88 kWh/m² (NF 1-6 buildings), potential GHG reductions of 19.6 kg CO_2e per m2 are achieved.

A total of 122 t CO_2e per year are saved in this way. GHG emissions could be reduced by up to 2,500 t CO_2e over a service life of 20 years (EnEV stipulates financial amortisation).

4.7.8 Data basis and calculation of the GHG reduction of renovated buildings in university clinics

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

- The construction costs for façade 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/(m²K) and 0.62 W/(m²K) 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 4-15 can be determined.

Table 4-15: 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

With investments of EUR 62.6 million for energy-related refurbishment, an estimated 2,650 beds will be refurbished, which would lead to annual GHG savings of 1864 t CO_2e. If a service life of 20 years is also assumed here, GHG emissions can be reduced by a total of 37,300 tonnes of CO_2e.

4.7.9 Summary of results for category G

Table 4-16 summarises the results in category G for the NHA NRW #5.

Table 4-16: Results of the impact assessment in category G

Measure	Investments in the bond for GHG reduction	Annual GHG reduction	GHG reduction potential over service life
Construction of new university buildings	EUR 37.7m	245 tons CO_2e / a	12,269 tons CO_2e
Refurbishment of university buildings	EUR 10.5.m	122 tons CO_2e / a	2,445 tons CO_2e
Construction of new university clinical buildings	EUR 207.6m	1,113 tons CO_2e / a	73,453 tons CO_2e
Refurbishment of university clinical buildings	EUR 62.6m	1,864 tons CO_2e / a	37,276 tons CO_2e

source: own calculation

4.8 F: Sustainable Urban Development

4.8.1 Broadband Expansion

The state of NRW invests EUR 218.5m into the expansion of broadband connections (50 Mbit/s and more) for households, but also companies and public institutions. These investments are provided in form of co-funding; in particular for communities where such infrastructure projects are currently not feasible from an economic point of view. This expansion is not only funded by state governments in Germany, but also from a federal point of view (up to 50 % from federal funds and up to 40 % from state funds). It is the goal of the federal as well as states' government to achieve a nearly 100 % broadband coverage in Germany in a foreseeable future.

Although broadband expansion is not necessarily directly economic feasible (in turns of direct revenues for communities), it is assumed that it prevents external costs in the future, while also providing additional benefits even in the most rural areas. Positive effects range from economic growth, efficiency and productivity gains to additional employment. As such, broadband expansion contributes to an economic sustainable development, but also higher life quality in schools and households (Wernick & Bender, 2016).

While these impacts cannot be measured in direct relation to the investments in the sustainability bond, the number of additional access points can be estimated. A 2013 study on behalf of the German Federal Ministry for Economic Affairs and Energy (TÜVRheinland, atesio GmbH, & TU Dresden, 2013) estimated cost factors per access between EUR 810 (for penetrations rates between 75 and 95 %) and EUR 3,850 (for the remaining 5 % up to 100 %). This large range can be explained by the availability of different technological options, different aims for bandwidth, but most importantly by the different length of cables and necessary excavations in different rural and non-rural regions.

In order to calculate a rough estimate, the authors use data from the German Federal Ministry of Transport and Digital Infrastructure. 13 different regions and cities in NRW (that already expanded their broadband accessibility) were selected to calculate a ratio between funding broadband expansion and resulting access points for households, companies and institutions (see Table 4-17). This covers more than 50,000 access points with an overall funding of EUR 100m.

Related to the EUR 218.5m in the Sustainability Bond NRW #5 (from the states' 2018 budget), it can thus be estimated that these investments help to provide more than 109,000 broadband connections in North Rhine-Westphalia. By comparison, literature data from the 2013 study (TÜVRheinland et al., 2013) results in a range between 42,000 and 200,000 connections per year (with decreasing annual values as lower populated areas are more likely to be connected last).

Table 4-17: Funding for broadband connections in selected regions in NRW

Region	Federal Funds	Other Funds (including state funds)	Overall Funding	house-holds	compa-nies	institu-tions	overall access	Funds per access
unit	*EUR*	*EUR*	*EUR*	*amount*	*amount*	*amount*	*amount*	*EUR*
Rheinisch-Bergischer Kreis	5.147.788	84.311	5.232.099	5.476	752	26	6.254	837
Gemeinde Nümbrecht	8.696.934	0	8.696.934	7.561	125	31	7.717	1.127
StädteRegion Aachen - A 85	3.604.911	0	3.604.911	3.004	67	10	3.081	1.170
Rhein-Sieg-Kreis	9.896.621	1.979.325	11.875.946	7.893	244	185	8.322	1.427
Stadt Duisburg	8.958.584	0	8.958.584	4.168	1.502	98	5.768	1.553
Stadt Mönchengladbach	4.515.513	0	4.515.513	2.279	161	7	2.447	1.845
Kreis Recklinghausen	14.998.498	0	14.998.498	5.969	627	7	6.603	2.271
Gemeinde Neuenkirchen	10.897.849	1.755.256	12.653.105	3.268	386	13	3.667	3.451
Stadt Bielefeld	7.893.418	0	7.893.418	1.861	379	7	2.247	3.513
Stadt Bonn	1.326.326	0	1.326.326	128	80	54	262	5.062
Gemeinde Westerkap-peln	4.427.340	885.469	5.312.809	956	70	8	1.034	5.138
Kreis Düren	14.045.903	1.134.044	15.179.947	2.526	208	112	2.846	5.334
Stadt Ahaus	198.503	39.700	238.203		35		35	6.806
All selected projects	**EUR 94,61m**	**EUR 5,88m**	**EUR 100,49m**	**45.089**	**4.636**	**558**	**50.283**	**1.998**

source: selected (NRW) regions from Breitbandatlas (https://www.bmvi.de/SharedDocs/DE/Artikel/DG/breitbandatlas/breitbandatlas.html)

5 GHG Savings: Key Figures and long term development

The following sections list key figures of climate change mitigation in the Sustainability Bond NRW #5 as well as previous bonds. It compares the GHG saving effects to the investments and over time.

5.1 Efficiency of GHG savings in Sustainability Bond NRW #5

The investments in the bond are the main input for the calculation of greenhouse gas savings. They are related to costs of related measures as well as the effects of the financed projects.

Each investment is usually provided with a technical lifetime in this process. While annual expenditures for e.g. student tickets relate to a lifetime of 1 year, buildings save energy and greenhouse gas emissions every year until they have to be dismantled or refurbished again (with expected lifetimes of 20 years and more).

Table 5-1 lists the annual GHG savings for 7 different measures in the bond categories C (Public Transportation and Local Mobility) and G (Modernisation of educational and public health facilities). While the annual effects for student tickets are the largest by far, they only relate to annual spending in the budget (or rather the demand of students for 1 ticket per semester).

Urban cycle paths on the other hand show a moderately smaller effect for the budget year 2018, but are expected to reduce the demand for car travel for 30 years and more (leading to overall savings of more than 120,000 tons of GHG).

Table 5-1: GHG savings of measures in the project categories C and G

Measure	GHG savings per year	GHG savings over Lifetime	average Lifetime (assumption)
	tons CO_2e per year	*tons CO_2e in total*	*years*
Non-urban fast cycle paths	501	15,803	30
Urban cycle paths	4,132	123,972	30
Student tickets	9,820	9,820	1
New university buildings	245	12,269	50
University buildings (refurbishment)	122	2,445	20
New clinical buildings	1,113	73,453	66
Clinical buildings (refurbishment)	1,864	37,276	20

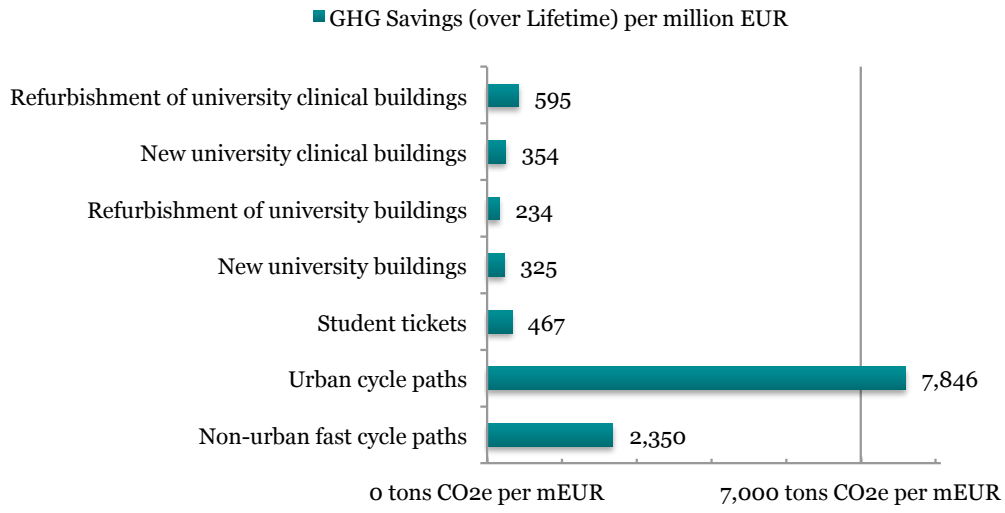
source: own calculation based on methods and data depicted in this report

By relating the GHG savings over lifetime to the money invested (as well as re-financed in the bond), it can be shown which measures are the most efficient. The highest efficiency measured in GHG savings per million euros invested (see Figure 5-1), can be attributed to the construction of cycle paths. Even at a much lower assumption for the technical lifetime, these two areas would show a very high efficiency (e.g. non-urban cycle tracks would still have a normalised efficiency of ca. 780 tons per EURm at a lifetime of only 10 years). This high efficiency cannot be attributed to large climate protection effects for cycling alone (or the underlined empirical data used to calculate the effects). Partly responsible for this effect are also the costs of different measures with particular high costs for building construction and refurbishment.

However, focusing on the comparison of these efficiencies can be misleading. Buildings, in particular the building types in the bond, provide co-benefits that affect numerous areas of sustainable development. Clinical and non-clinical university buildings prevent health hazards, improves research capabilities and patient care. The same is true for over EUR 130m invested into public transportation for pupils and students (of which only EUR 21.0m were directly allocated to tickets for students and their climate mitigation effect), as additionally financed improvements of supply and quality in public traffic are beneficial to all citizens.

Finally, not every climate protection measure provides in fact additional GHG savings as a whole. The calculation scheme at hand for example assumes that old buildings are replaced by new buildings funded by the State's budget. If this is not the case or if energy savings for heat are partly or overcompensated by additional demand for electricity, the resulting net effect can be negative for the climate as the overall GHG emissions of a university or clinic increase instead.

Figure 5-1: Normalised[11] efficiency of climate protection measures for quantified investments



source: own calculation based on methods and data depicted in this report

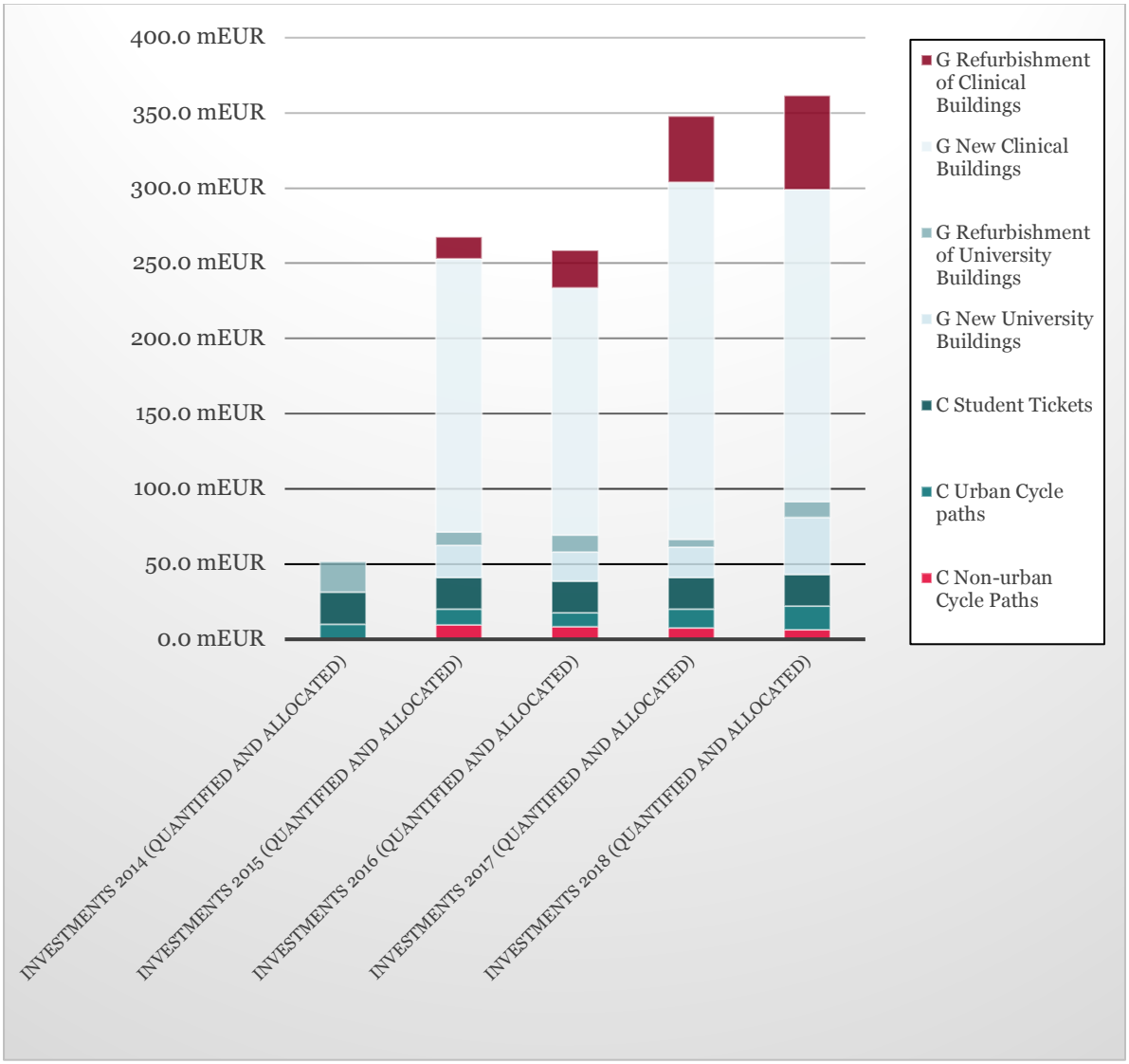
[11] The efficiency factors refer to the assessed investments only and the GHG savings over the assumed average lifetime of measures.

5.2 GHG Savings from 2014 to 2018

A number of project categories have been part of the NRW Sustainability Bond for several years now. They also relate to the same or extended programmes, allowing to compare the effects from the budget years 2014 to 2018. With the exception of solar thermal energy (Bond #3) and co-generation of heat and power (Bond #2), they can therefore be aggregated to a five-year portfolio.

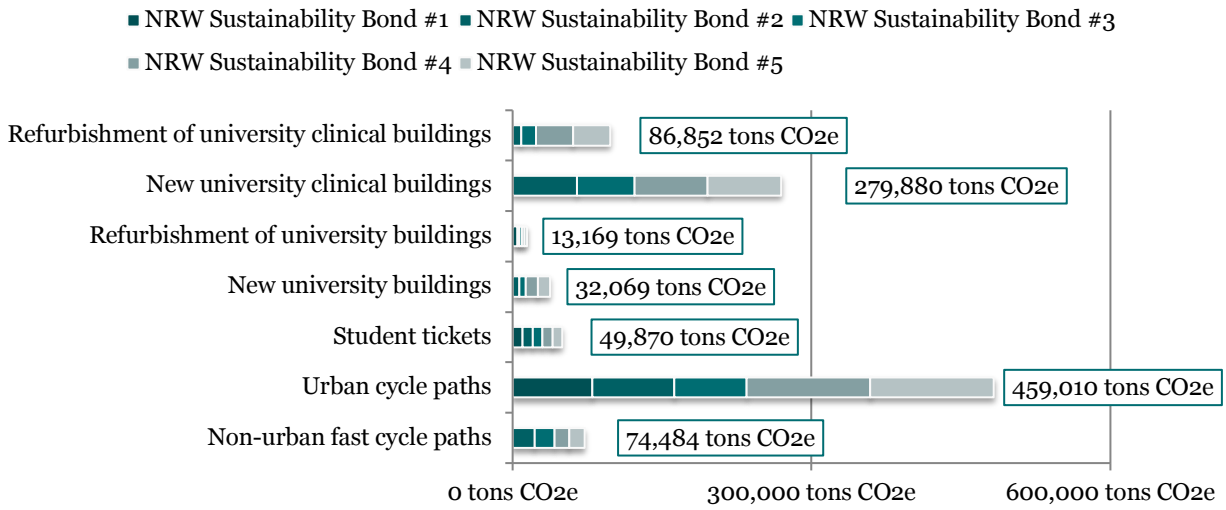
The budget expenditures related to the NRW bond has increased continuously over these 5 years from EUR 50m in 2014 to EUR 360m in 2018 (see Figure 5-2; only accounting for investments directly associated with GHG savings). The largest increase in investments can be allocated to new and refurbished clinical buildings: quantifiable investments increased from EUR 196m in 2015 to EUR 270m in 2018.

Figure 5-2: Quantifiable investments for climate protection projects from 2014 to 2018 in the portfolio of NRW Sustainability Bonds



Over the course of five years (2014 – 2018) EUR 1,287m were invested, inducing potential GHG savings of ca. 1 million tons CO_2e over the assumed lifetime of the measures (see Figure 5-3). About 46 % of these savings could be attributed to the construction of cycle paths in NRW alone, while the construction of new clinical buildings makes up another 28% of the overall financed savings.

Figure 5-3: GHG savings over lifetime of projects from 2014 to 2018 in the portfolio for NRW Sustainability Bonds



source: own calculation based on methods and data depicted in this report

6 Discussion

The section summarizes the results of the report and provides an outlook for future studies.

6.1 Discussion of the results of the impact report

This impact report is fifth in a row, including investments in the NRW Sustainability Bonds #4, #3, and #2, but also covering selected projects from NRW Sustainability Bond #1 (budget year 2014). During this time, not only the bond size has increased by a large margin from EUR 750m to EUR 2,25m, but also investments in the bond that could be associated with impacts (EUR 260m in #1 compared to EUR 1,500m in #4). The report at hand quantifies 65% of the investments, while also stating that circa 27% of the bond are currently not quantifiable due to lack of data or methodologies.

In terms of environmental impacts, direct quantifications are still mainly restricted to potentials to avoid GHG emissions (GHG reductions or savings). Other environmental effects are either attributed to a small share of the bond (circa EUR 40m reported to provide sustainable land use), or stem from third party assessments where investments from other stakeholders also play an important role (e.g. less than EUR 6m that help companies to also reduce waste, water and material use).

The directly quantified GHG savings from investments in the bond have increased over the five Sustainability Bonds, with the largest increase from investments for educational buildings and the highest effect attributed to urban cycle paths. Since most of the funded projects have a larger lifetime, these effects potentially also take place after the bond term (10 or 15 years) runs out. Overall, it has been estimated that the fifth Sustainability Bond induces annual GHG savings of ca. 18,000 CO_2 equivalents and ca. 275,000 CO_2 equivalents over the lifetime of the measures.

In terms of social impacts, the current NRW Sustainability Bond #5 could also directly be associated with

- 22,000 additional first year students
- 12,200 additional master student places,
- 64,300 bachelor graduates,
- 21,000 geriatric nurses in training,
- 14 researchers brought back to NRW,
- 125 to 250 new jobs for persons with disabilities,
- 725 social workers,
- 150 integrated long term unemployed persons
- 109,000 new broadband connections.

In total, circa EUR 745m were invested from the State budget in 2018 for these quantified impacts (out of category A, B and F), matching 58% of the NRW Sustainability Bond #5.

Further social and environmental impacts could be drawn from third party assessments, totalling a funding of EUR 90m or 4% of the bond.

6.2 Outlook: Assessment of additional impacts and methods

The results in this report mainly build on previous developed methods and collected data, although updates of datasets were integrated wherever possible. New developments in the indicator set only affected social impacts from an obvious cause-effect-relationship.

The next report of the NRW Sustainability Bond aims to expand the existing indicator set, while also improving the overall methodology in three separate work packages:

(1) Definition of social impacts

(2) Development of methods for co-impacts

(3) Introducing additional environmental indicators

Step (1) provides a first classification of social impact indicators. This will enable the authors to differentiate better between indirect effects that cannot be limited to investments in the measures only and direct effects that can be directly related to the investment size of measures in bond (quantifiable and scalable).

Step (2) focuses on the development of a method for the qualification and quantification of so called co-impacts. Co-impacts are benefits of measures that occur in different dimensions of sustainability – such as the co-existing energy efficiency and health effects of the modernisation of clinic. The researchers aim to provide a first description of necessary steps for quantifying these effects based on the example of new bicycle paths in cities.

Step (3) aims to expand the available indicator set in the area of ecology, in particular for sustainable land use and biodiversity. Its results will be based on an extensive desk research and a first matching of suitable indicators with measures in the Bond.

The results of these three work packages will be part of the extended report of the NRW Sustainability Bond #6 in 2020.

7 References

AGEB. (2013). Anwendungsbilanzen für die Endenergiesektoren in Deutschland in den Jahren 2011 und 2012 mit Zeitreihen von 2008 bis 2012. *Studie Beauftragt Vom Bundesministerium Für Wirtschaft Und Technologie, Projektnummer*, *23*(11).

Agentur für Erneuerbare Energien e.V. (2014). Spezifische CO2-Emissionen der Fernwärmeerzeugung - Wärme - NRW - Daten und Fakten zur Entwicklung Erneuerbarer Energien in einzelnen Bundesländern. Retrieved 7 February 2018, from föderal erneuerbar website: https://www.foederal-erneuerbar.de/landesinfo/bundesland/NRW/kategorie/waerme/auswahl/734-spezifische_co2-emis

Bernstein, L., Pachauri, R. K., Reisinger, A., & Intergovernmental Panel on Climate Change. (2008). *Climate change 2007 : synthesis report*. Geneva, Switzerland: IPCC.

Bildungsportal des Landes NRW. (2019). Weiterfinanzierung der sozialen Arbeit an Schulen im Rahmen des Bildungs- und Teilhabepakets. Retrieved 15 January 2019, from https://www.schulministerium.nrw.de/docs/FamilieBildung/Bildungs-und-Teilhabepaket/Kontext/Schulsozialarbeit-isdBuT/index.html

Bund und Länder. *Verwaltungsvereinbarung zwischen Bund und Ländern gemäß Artikel 91 b Abs. 1 Nr. 2 des Grundgesetzes über den Hochschulpakt 2020 (zweite Programmphase).* , Pub. L. No. BAnz Nr. 103 (2013).

Bundesministerium für Arbeit und Soziales. (2018). *Operationelles Programm ESF Bund Deutschland 2014-2020* [Durchführungsbericht]. Retrieved from https://www.bmas.de/SharedDocs/Downloads/DE/PDF-Publikationen/esf-durchfuehrungsbericht-2017.pdf;jsessionid=217A5B06418459EBA12C27CF03EE70E5?__blob=publicationFile&v=1

Deilmann, C., Behnisch, M., Dirlich, S., Gruhler, K., Hagemann, U., Petereit, R., & Petereit, K. (2013). Systematische Datenanalyse im Bereich der Nichtwohngebäude–Erfassung und Quantifizierung von Energieeinspar-und CO 2-Minderungspotenzialen [Systematic data analysis in the area of non-domestic buildings–recording and quantification of energy saving and CO 2 reduction potentials]. *BMVBS Online Publication*, *27*(2013), 1–201312202611.

Ehlert. (2019, January 15). *written correspondence (Kooperative Ausbildung an Kohlestandorten).*

EU, ESF Nordrhein-Westfalen, & Ministerium für Kinder, Familie, Flüchtlinge und Integration des Landes Nordrhein-Westfalen. (2017, July 10). *Basissprachkurse zur Arbeitsmarktintegration von Flüchtlingen ESF - Richtlinienprogramm zur basalen Sprachförderung*. Retrieved from https://www.mags.nrw/sites/default/files/asset/document/esf_basissprachkurse_arbeitsmarktintegration_fluechtlinge.pdf

FfE. (2010). *Basisdaten von Energieträgern*. Retrieved from https://www.ffe.de/download/wissen/186_Basisdaten_Energietraeger/Basisdaten_von_Energietraegern_2010.pdf

Finanzministerium Nordrhein-Westfalen. (2016, February). *Zweite Nachhaltigkeitsanleihe des Landes Nordrhein-Westfalen Verwendung der Erlöse Informationen zu den geeigneten Projekten*.

Gabler, A., Vorreiter, N., Kotlenga, S., Mahnoli, F., Nägele, B., & Pagels, N. (2017). *Evaluation des Programms Soziale Arbeit an Schulen in Nordrhein-Westfalen*. 247.

Gesellschaft für innovative Beschäftigungsförderung mbH. (2018, September 5). *Landesprogramm „Integration unternehmen!" NRW Kurzinformationen*.

Heads of the Federal and State governments of Germany. (2014, December 11). *Verwaltungsvereinbarung_Hochschulpakt_III_vom_11.12.2014.pdf*. Retrieved from https://www.bmbf.de/files/Verwaltungsvereinbarung_Hochschulpakt_III_vom_11.12.2014.pdf

Hebel, E. von, Jahn, K., & Clausnitzer, K.-D. (2011). *Der energetische Sanierungsbedarf und der Neubaubedarf von Gebäuden der kommunalen und sozialen Infrastruktur* [Abschlussbericht].

Intergovernmental Panel on Climate Change. (2014). *IPCC: Greenhouse gas emissions accelerate despite reduction efforts - Many pathways to substantial emissions reductions are available*. Retrieved from http://www.ipcc.ch/pdf/ar5/pr_wg3/20140413_pr_pc_wg3_en.pdf

ISS-oekom. (2019, February 13). *5._Nachhaltigkeitsanleihe_SPO_LandNRW_final.pdf*. Retrieved from https://www.nachhaltigkeit.nrw.de/fileadmin/download/5._Nachhaltigkeitsanleihe_SPO_LandNRW_final.pdf

IT NRW. (2018). *Statistische Berichte - Hochschulen in Nordrhein-Westfalen 2017/2018* [Statistic]. Düsseldorf: Information und Technik Nordrhein-Westfalen, Geschäftsbereich Statistik.

IT.NRW. (2018, August 8). *Studierende Haupthörerinnen und Haupthörer nach Hochschularten*. Retrieved from https://www.it.nrw/node/1070/pdf

Jens Teubler, Oskar Reutter, Katrin Bienge, & Lena Hennes. (2019). *Impact Report NRW Sustainability Bond #4. Analysis of the Sustainability Bond #4 issued in 2018 by the German State of North Rhine-Westphalia (NRW). Final Report on behalf of the Ministerium der Finanzen Nordrhein-Westfalen*. Wuppertal: Wuppertal Institut Klima, Umwelt, Energie gGmbH.

KCM. (2015, September). *Sozialtickets in NRW*. Kompetenzcenter Marketing NRW.

KCM NRW. (2018). *NRW-Tarifreport 2017/2018* [Jahresbericht]. Retrieved from Kompetenzcenter Marketing NRW website: https://www.kcm-nrw.de/fileadmin/kcm/Dateien/PDF/NRW_TarifReport_2017.pdf

KCM NRW. (2019). *NRW-Tarifreport 2018/2019* [Jahresbericht]. Retrieved from Kompetenzcenter Marketing NRW website: https://www.kcm-nrw.de/fileadmin/kcm/Dateien/PDF/NRW_TarifReport_2017.pdf

Krewald, A. (2017). *Daten zur Sanierung von Gebäuden der Ruhr-Universität Bochum*.

LAK. (2015). *Energiebilanzen der Bundesländer*. Länderarbeitskreis Energiebilanzen.

LAK. (2017). CO2-Bilanzen – Länderarbeitskreis Energiebilanzen. Retrieved 30 January 2018, from lak-energiebilanzen.de website: http://www.lak-energiebilanzen.de/co2-bilanzen/

Landesregierung NRW. (2016). *Sustainability Strategy for North Rhine-Westphalia*. Retrieved from State Government of North Rhine-Westphalia website: https://www.nachhaltigkeit.nrw.de/fileadmin/download/Nachhaltigkeitsstrategie/NHS_EN_v17_Screen_Einzelseiten.pdf

Landtag NRW. (2017, September 22). *Kleine Anfrage: Beabsichtigt die schwarz-gelbe Landesregierung in NRW die Landesförderung der Sozialtickets zu streichen?* Retrieved from https://www.landtag.nrw.de/Dokumentenservice/portal/WWW/dokumentenarchiv/Dokument/MMD17-717.pdf

Ministerium der Finanzen des Landes Nordrhein-Westfalen. (2018). Website - NRW budget for 2017 (including supplementary budget) [Interactive]. Retrieved 6 February 2019, from haushalt.fm.nrw.de website: http://www.haushalt.fm.nrw.de/grafik/index.php?type=2

Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen. (2018). *Jährlicher und abschließender Durchführungsbericht für das Ziel 'Investitionen in Wachstum und Beschäftigung'* (p. 90). Retrieved from https://www.mags.nrw/sites/default/files/asset/document/esf_durchfuehrungsbericht_2017.pdf

Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie des Landes Nordrhein-Westfalen. (2018). *Jährlicher und abschließender Durchführungsbericht für das Ziel 'Investitionen in Wachstum und Beschäftigung'* (No. 2017.2). Retrieved from https://www.efre.nrw.de/fileadmin/dummydata/files/pdf/Durchfuehrungsbericht_2017.pdf#page=1&zoom=auto,-274,848

Ministry of Culture and Science of the State of North Rhine-Westphalia. (2016). Hochschulvereinbarung und Hochschulverträge. Retrieved 15 October 2019, from https://www.mkw.nrw/hochschule-und-forschung/hochschulen/hochschulvereinbarung-und-hochschulvertraege

Ministry of Finance of NRW. (2019, February). *5._Nachhaltigkeitsanleihe__Deutsch.pdf*. Retrieved from https://www.nachhaltigkeit.nrw.de/fileadmin/download/5._Nachhaltigkeitsanleihe__Deutsch.pdf

Müller, M. (2011). *Das NRW-Semesterticket – Akzeptanz, Nutzung und Wirkungen dargestellt am Fallbeispiel der Universität Bielefeld [The NRW semester ticket – acceptance, use and impact by the example of the university Bielefeld]*. Retrieved from http://nbn-resolving.de/urn:nbn:de:bsz:wup4-opus-39366

Nino, F. S. (2016). Sustainable development goals - United Nations. Retrieved 10 February 2017, from United Nations Sustainable Development website: http://www.un.org/sustainabledevelopment/sustainable-development-goals/

Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K., Tignor, M., & Miller, H. (2007). *IPCC fourth assessment report: climate change 2007 (AR4)*. Cambridge University Press, Cambridge, UK. Retrieved from www. ipcc. ch.

Regionalverband Ruhr. (2014). *Machbarkeitsstudie RS1 Radschnellweg Ruhr Regionalverband [Feasibility study of the RS1 cycle path]*. Retrieved from http://www.rs1.ruhr/fileadmin/user_upload/RS1/pdf/RS1_Machbarkeitsstudie_web.pdf

State of North Rhine-Westphalia (NRW). (2018, February). *Sustainability Bond #4*. Retrieved from https://www.nachhaltigkeit.nrw.de/fileadmin/download/180308_Sustainability_Bond__4_Eligible_Assets.pdf

Stibbe, J., & Stratmann, F. (2014, May). *Bau- und Instandsetzungsbedarf in den Universitäten - Soll-Ist-Vergleich für den Zeitraum 2008 bis 2012*. Retrieved from http://www.dzhw.eu/pdf/pub_fh/fh-201405.pdf

The World Bank et al. (2015, December). Green Bonds Working Towards a Harmonized Framework for Impact Reporting. Retrieved 29 December 2016, from http://treasury.worldbank.org/cmd/pdf/InformationonImpactReporting.pdf

TÜVRheinland, atesio GmbH, & TU Dresden. (2013). Szenarien und Kosten für eine kosteneffiziente flächendeckende Versorgung der bislang noch nicht mit mindestens 50 Mbit/s versorgten Regionen. Retrieved 25 October 2018, from https://www.bmwi.de/Redaktion/DE/Publikationen/Studien/kostenstudie-zum-breitbandausbau.pdf?__blob=publicationFile&v=5

UBA, & TREMOD 5.63. (2014). *Vergleich der durchschnittlichen Emissionen einzelner Verkehrsmittel im Personenverkehr - Bezugsjahr: 2014*. Retrieved from https://www.umweltbundesamt.de/sites/default/files/medien/376/bilder/dateien/vergleich_der_emissionen_einzelner_verkehrsmittel_im_personenverkehr_bezugsjahr_2014_tremod_5_63_0.pdf

Umweltbundesamt (UBA). (2016). *Vergleich der Emissionen einzelner Verkehrsmittel im Personenverkehr Bezugsjahr 2014 tremod 5.63*. Retrieved from https://www.umweltbundesamt.de/sites/default/files/medien/376/bilder/dateien/vergleich_der_emissionen_einzelner_verkehrsmittel_im_personenverkehr_bezugsjahr_2014_tremod_5_63_0.pdf

Wernick, C., & Bender, C. (2016). Die Rolle der Kommunen beim Breitbandausbau im ländlichen Raum aus ökonomischer Sicht. *WIK-Bericht Im Auftrag Des BMWi, Bad Honnef*.