# Secondary school student participation in Carbon Footprint Assessment for Schools


Sebastian Albert-Seifried
Büro Ö-Quadrat
Turnseestraße 44
79102 Freiburg
Germany
sas@oe2.de

Lena Tholen
Wuppertal Institute
Doeppersberg 19
42103 Wuppertal
Germany
lena.tholen@wupperinst.org

Amelie Straßen
Wuppertal Institute
Doeppersberg 19
42103 Wuppertal
Germany
amelie.strassen@wupperinst.org

Maike Venjakob
Wuppertal Institute
Doeppersberg 19
42103 Wuppertal
Germany
maike.venjakob@wupperinst.org

Lotte Nawothnig*
Wuppertal Institute
Doeppersberg 19
42103 Wuppertal
Germany
lotte.nawothnig@wupperinst.org

Dieter Seifried
Büro Ö-Quadrat
Turnseestraße 44
79102 Freiburg
Germany
seifried@oe2.de

Amelie Vogler
University of Graz
Merangasse 18/I
8010 Graz
Austria
amelie.vogler@edu.uni-graz.at

Oliver Wagner
Wuppertal Institute
Doeppersberg 19
42103 Wuppertal
Germany
oliver.wagner@wupperinst.org

*Correspondence:
lotte.nawothnig@wupperinst.org



## Keywords

schools, greenhouse gas emissions, tool, carbon footprint, self-efficacy



## Abstract

More and more cities are setting themselves ambitious climate protection targets, including $CO_2$ neutrality. Schools are important institutions of cities and therefore they have to play a central role in achieving this goal.

With the investment backlog building up and pressure from the Friday for Future movement increasing, the Wuppertal Institute and Büro Ö-quadrat have initiated the project Schools-4Future, aiming to support secondary schools to become climate-neutral. In cooperation with secondary school students and teachers, the project team evaluated the existing situation of the participating schools and developed GHG-balances and feasible climate protection concepts. For this purpose, an Excel-based carbon footprint (CF) assessment tool for schools has been developed which is freely available. The tool covers all important emission areas, including heating energy, electricity use, travel to and from schools, school trips, the school canteen and paper consumption. The students were found capable to conduct the CF assessment with the guidance of the teacher, information materials and support of the researchers. So far, six pilot schools have completed their CF assessment with emissions ranging between 335 and 944 kg $CO_2$ per person.

In this paper we present the tool and compare the CF assessment of some schools. We further elaborate on how the tool and project has increased the climate awareness and self-efficacy of students and even stimulated measures by the school board.


## Introduction

For a long time, the investment backlog in German schools has been a recurring topic in public debate and many schools are in dire need for renovation. It comes as no surprise that schools are among the biggest emitters in the public sector with a large greenhouse gas (GHG) reduction potential. Beyond this, schools play a critical role in achieving Germany's climate protection goals as they lay the foundation of knowledge for a responsible next generation. Given this dire need for renovations and improvements, schools are faced with immense challenges when it comes to contributing to climate protection. But the retrofitting of all German school buildings is a lengthy process and, not least, also a political and financial struggle. Therefore, new, flexible, and easy-to-use approaches are needed.

Reduction measures that derive from behavioral changes are one way to fill in the gap. While the actual amount of reduced emissions might be negligible, the students that change their behavior can act as multipliers, encouraging others in the peer group or at home to reflect upon one's own habits (Mezirow, 2003). This in turn can lead to an increased feeling of self-efficacy which describes the belief in one's own ability to perform a certain task or achieve a certain result. Students can also exert political pressure on decision-makers to invest more in climate protection by qualifying and publishing their findings.

Therefore, in addition to technical improvements at schools, it is crucial to increase the awareness on this topic, to inform students and to show them the various possibilities to make an impact (in the school environment and beyond). Recent research shows that climate change-focused communication and teaching approaches that increase students' self-efficacy and perceived benefits of sustainable energy behavior can contribute to students' commitment regarding sustainable energy (Janmaimool and Chontanawat, 2021).

One approach to deal with climate change and climate protection in schools and, at the same time, to identify the status quo and the potentials of $CO_2$ reduction is the measurement of the carbon footprint (CF). Calculating the schools initial CF, reassessing it and observing changes/reductions can be an effective approach to increase the students' self-efficacy as it provides direct feedback loops (Hamann et al., 2016). Especially in the realm of GHG emission reductions this is very important as the reduction otherwise remains invisible.

Measuring the CF is not a new approach: More and more public institutions as well as private companies rely on carbon footprints to assess and later reduce their emissions (Jones and Kammen, 2011). CFs therefore are an established method for quantifying GHG emissions, assessing potential reductions and further an important tool for raising awareness of the impact of the private and public sectors (Jurić and Ljubas, 2020). Although the range of approaches and methods is very large, there are only limited tools that focus on carbon assessments of schools. In Germany, there are some programs and initiatives that begin with a simple CF assessment in their first phase. Examples are the initiatives fifty/fifty, Energie gewinnt and Klimaschulen Hamburg (fifty fifty, 2021; Landesinstitut Hamburg, 2012). However, they only focus on the energy consumption, neglecting the fields of mobility and school canteen.

Two examples for a more comprehensive analysis of $CO_2$ emissions in schools was made by Gamarra et al., who published the analysis of a comprehensive sustainability performance of high schools (Gamarra et al., 2019) as well as the life-cycle assessment of five schools in Spain and Portugal (Gamarra et al., 2021). An analysis of the energy consumption in schools in over 20 countries is provided by Dias Pereira et al. (Dias Pereira et al., 2014), which attempts to derive a benchmark based on a literature review. More recently, a tool developed by Greenpeace Germany has been introduced in the context of the Schools for Earth project. It provides an easy-to-use online interface where the data needed to calculate the emissions can be easily entered (Greenpeace, 2021). However, it is lacking transparency with regard to methods and its biased calculation of green electricity generated by Greenpeace is critical.

To overcome the aforementioned gaps, the Schools4Future project developed a freely available $CO_2$ balancing tool for schools, which aims to sensitize schools to climate protection measures. We present the tool and elaborate on differences in the CF assessments of some schools. We also seek to answer the question whether the tool is appealing and easy-to-use for students and teachers alike. Finally, we explain how the tool and project has increased the climate awareness and self-efficacy of students and even stimulated measures by the school board.

## Materials and methods: The Excel Tool

The Schools4Future $CO_2$ assessment tool is designed to be used by students and therefore offers easy handling yet complex calculation options. The tool contents of three key areas mobility, heating and electricity, as well as food in the school canteen and consumables (paper). Each area has a different color that is attributed to respective sheets to facilitate the handling. On each page there is a short instruction for quick data entry. For example, regarding electricity the tool distinguishes between electricity production from PV and electricity use. For the CF assessment the electricity use is usually taken from the electricity bill and therefore includes all consumption from lighting and IT as well as electric pumps for the heating system.

The calculations (e.g., the conversion of kilowatt hours to $CO_2$ emissions) are done automatically, so that the advantages of Excel are fully exploited here. The emissions factors used are integrated into the summary. This ensures transparency, while also enabling to adapt the freely available tool to schools in other countries given prior adaptation to the country-specific emission factors.

Descriptive figures, which are also created automatically when entering the data, have been integrated to immediately visualize the results and by that making them more comprehensive. In an extra sheet, all results of the single areas are summarized. In addition, the total emissions per school and per student are illustrated. The tool also automatically generates the results in pie charts and bar charts. Hence, the tool generally allows the students to conduct the CF assessment on their own fostering the students' self-efficacy. However, some support by teachers, school staff and authorities is needed to collect the specific data in the first place (e.g. providing the electricity and gas bills, information on the size of the photovoltaic systems, the amount of paper used and a list of all school trips conducted in one year).

## Case study

The Excel tool was developed within the Schools4Future project aiming at raising awareness of the GHG reduction potentials in schools. In mid-2020, twelve secondary schools in Germany have been selected as pilot schools to test the $CO_2$ assessment tool. The schools were selected based on different criteria: geographical diversity, school type, social milieu and general need for renovation. The $CO_2$ reduction potential also played an important role. Until now, six schools have already completed the CF calculations, making the timing ideal for a mid-term evaluation of the project. Table 1 shows some central conditions that are important to consider before assessing the GHG emissions:

The table shows that the schools differ regarding their size and location. School 1, 2 and 5 are significantly smaller than the other schools. It also shows that each school uses a different heating system ranging from conventional fossil fuel-based systems (School 1 and 6) to district heating (School 4 and 5) and wood chips (School 3) to integrated systems such as CHP (School 2). All schools have in common that they have a photovoltaic system (5–35 kWp). The average commuting distance of the students account for 5.2 km with the average commuting distance of the rather rural School 1 being particularly long (7.8 km) and the one of the centrally located School 4 and School 6 being particularly short (3.6 km).

In order to measure the emissions of the mobility sector, surveys were conducted in all schools. The students actively participated in the development of the survey which was then accessible either as printed version or online via a QR code. In

**Table 1. Overview of participating pilot schools with completed CF assessments.**

| | School 1 | School 2 | School 3 | School 4 | School 5 | School 6 |
|---|---|---|---|---|---|---|
| City | Kirchzarten | Freiburg | Wuppertal | Wuppertal | Wuppertal | Pulheim |
| Number of students | 520 | 625 | 1370 | 1420 | 400 | 1440 |
| Number of teachers | 52 | 80 | 125 | 143 | 41 | 160 |
| Heating systems | gas | CHP | wood chips | district heating | district heating | gas |
| | (Oil as backup) | Gas for peak demand | Oil for peak demand | (Gas as backup) | - | - |
| PV system: yes/no Capacity | Yes | Yes | Yes | Yes | Yes | Yes |
| | 30 kWp | 35 kWp | 5.5 kWp | 32.7 kWp | 4,8 kWp | 1.1 kWp |
| Location of the school | rather rural 1 km from center | urban 4 km from center | outskirt 7 km from center | urban <1 km from center | urban | rather rural |
| Commuting distance (av.) | 7.8 km students<br>8.2 km teachers | 5.4 km students<br>10.6 km teachers | 5.3 km students<br>19.4 km teachers | 3.6 km students<br>11.1 km teachers | 6.2 km students<br>10.3 km teachers | 3 km students<br>15.4 km teachers |
| Regional/ organic food<br>Vegetarian alternatives | Yes<br>Yes | Yes<br>Yes | Yes<br>Yes | hardly<br>twice/week | Yes<br>yes | unclear |
| Meals served per day | 150 | 170 | 735 | 210 | 500 | 200 |

some schools the students even prepared, conducted and evaluated the survey on their own with the help of the provided CF-assessment tool. As part of the survey, students and teachers were asked how far they commute to school and what mode of transport they choose to get to school.

With regard to the school food, most school canteens take into account aspects such as regional and organic food. They also mostly offer vegetarian alternatives. However, the low number of meals sold per day (except School 3 and 5) reveal that less than half of the students and teachers actually make use of the offer.

In all six schools, students were involved in the CF assessment and in schools 3 to 6, the $CO_2$ assessment tool was used. Support was given by the caretakers, school authorities and the secretariat to obtain the data. In addition, there was at least one teacher in each school who was responsible for the project. In the six pilot-schools where the CF assessment was carried out by a larger group or by younger students, the teachers played an important role in the coordination of the work and communication and therefore had an important share in the success of the project. The schools were supported by the Schools4Future project team, i.e. scientists with many years of experience in the field of carbon footprints and carbon assessments. The tool offers the possibility to enter the data in a very flexible way. Therefore, the schools also proceeded very differently and the time span used for the CF assessment ranged from one week to half a year depending on how the schools organized the assessment (Wagner et al., 2021).

## Results

The following section firsts present and compares the data derived from the case study, followed by an assessment of the project's potential to increase the motivation and the feeling of self-efficacy of the project participants.

### COMPARISON OF THE CARBON FOOTPRINT ASSESSMENT

The CF assessment of the six schools shows different results concerning the GHG emissions they produce (Table 2). This is not unusual, as schools have different preconditions and circumstances. In particular, the size of the school and the number of students and teachers have a significant influence on $CO_2$ emissions. The age of the building (and the time of the last refurbishment of the building) also leads to higher or lower GHG emissions. In order to be able to compare the different schools, the $CO_2$ emissions per student were calculated for this paper.

Not surprisingly the emissions deriving from building energy use outnumber the emissions related to the transport sector in most cases (except for School 2 and 5), while GHG emissions deriving from canteen and consumables are very low in comparison.

In terms of energy consumption, the $CO_2$ balance strongly depends on the school's heating system, the building substance and possible renovations. A particularity of School 3 is the wood chipping heating system, backed up by a conventional oil heater. Because of occasional shutdowns of the wood chipping heating system for repairs and maintenance and because of both systems running in parallel at peak load

Table 2. Overview of GHG emissions in different areas for the six pilot schools with completed CF assessment.

| Building energy use | School 1 | School 2 | School 3 | School 4 | School 5 | School 6 |
|---|---|---|---|---|---|---|
| Heating | 234 kg $CO_2$ | 161 kg $CO_2$ | 377 kg $CO_2$ | 64 kg $CO_2$ | 48 kg $CO_2$ | 336 kg $CO_2$ |
| Electricity use | 72 kg $CO_2$ | 108 kg $CO_2$ | 282 kg $CO_2$ | 105 kg $CO_2$ | 153 kg $CO_2$ | 91 kg $CO_2$ |
| PV system | -9 kg $CO_2$ | -23 kg $CO_2$ | -1 kg $CO_2$ | -8 kg $CO_2$ | -4 kg $CO_2$ | 0 kg $CO_2$ |
| **Building energy use total** | **297 kg $CO_2$** | **246 kg $CO_2$** | **658 kg $CO_2$** | **161 kg $CO_2$** | **197 kg $CO_2$** | **427 kg $CO_2$** |
| **Mobility** | | | | | | |
| Commute students | 117 kg $CO_2$ | 105 kg $CO_2$ | 109 kg $CO_2$ | 49 kg $CO_2$ | 183 kg $CO_2$ | 22 kg $CO_2$ |
| Commute teachers | 22 kg $CO_2$ | 26 kg $CO_2$ | 78 kg $CO_2$ | 44 kg $CO_2$ | 37 kg $CO_2$ | 67 kg $CO_2$ |
| School trips | 13 kg $CO_2$ | 96 kg $CO_2$ | 33 kg $CO_2$ | 36 kg $CO_2$ | 55 kg $CO_2$ | 15 kg $CO_2$ |
| Exchange pgrogams | 0 kg $CO_2$ | 214 kg $CO_2$ | 26 kg $CO_2$ | 5 kg $CO_2$ | 0 kg $CO_2$ | 78 kg $CO_2$ |
| **Mobility total** | **153 kg $CO_2$** | **442 kg $CO_2$** | **245 kg $CO_2$** | **134 kg $CO_2$** | **275 kg $CO_2$** | **183 kg $CO_2$** |
| **Canteen and consumables** | | | | | | |
| Canteen | 25 kg $CO_2$ | 27 kg $CO_2$ | 38 kg $CO_2$ | 34 kg $CO_2$ | 37 kg $CO_2$ | 36 kg $CO_2$ |
| Paper | 4 kg $CO_2$ | 6 kg $CO_2$ | 3 kg $CO_2$ | 6 kg $CO_2$ | 7 kg $CO_2$ | 3 kg $CO_2$ |
| **Canteen and consumables total** | **29 kg $CO_2$** | **34 kg $CO_2$** | **41 kg $CO_2$** | **39 kg $CO_2$** | **44 kg $CO_2$** | **39 kg $CO_2$** |
| **Total GHG emissions per student** | **479 kg $CO_2$** | **722 kg $CO_2$** | **944 kg $CO_2$** | **335 kg $CO_2$** | **516 kg $CO_2$** | **648 kg $CO_2$** |

hours, the oil heater considerably deteriorates the overall GHG emission. This results in School 3 having the worst value of the six schools. A good practice example is School 2, which was (partly) refurbished energetically in the last years and is now equipped with a combined heat and power plant (CHP).

Since all schools have a PV system, they are also credited with a value towards their carbon footprint. Depending on the size of the system, the value is higher or lower. The largest system is installed at School 2. Here, more than 14,000 kg of $CO_2$ emissions could be credited in 2019. At School 6, the PV system is too small to save significant impact on the emissions related to one student.

The three main factors that led to greater use of cars and public transport, and thus higher GHG emissions, were longer distance to schools, rather rural, hilly areas and areas that are not cycle-friendly. This applied to both students and teacher commuting. Furthermore, the $CO_2$-carbon assessment tool also allows to evaluate GHG emissions by school trips and student exchange programs such as the Erasmus program, an EU program for education, training, youth and sport. It turns out that the trips by plane are particularly significant. School 2 stands out here, with a number of intercontinental student exchanges trips, including destinations in Australia and South America. With almost 200 tons of $CO_2$ emissions, it is by far the highest value and clearly exceeds the emissions caused by travelling to school every day. Regarding the mobility sector, School 1 has the lowest emissions with only about 7 tons of $CO_2$ for school trips. The large spread in the per students' emissions in the mobility sector are best visible in Figure 1, which gives a visual representation of the GHG emissions in different sectors for the six pilot schools.

In all six schools, the excel-tool was also used to estimate the GHG emissions from the school canteen, based on a selection of typical meals served leading to total GHG emissions ranging from 13 tons to 52 tons $CO_{2eq}$. The emissions per student from the school canteen show a relatively small range between 25 and 38 kg $CO_{2eq.}$/student. The small share relative to the overall GHG emissions can mainly be attributed to the relatively low number of meals sold and the high proportion of vegetarian products with much lower $CO_2$ balance in some schools. Organic and regional products also have a positive effect on the $CO_2$ balance.

#### CONTRIBUTION TO THE STUDENTS' FEELING OF SELF-EFFICACY

In order to examine the question of how the tool enables students (and teachers) to experience self-efficacy and motivates them to implement climate protection measures, the Schools4Future project also closely observed the students' and teachers' feedback as well as the produced outcome reflected in the climate protection measures developed following the CF assessment. One finding was that almost all the students were highly motivated to carry out a concrete project and to determine the current status quo of the school with regard to climate protection.

The tool helped the students to make emissions tangible, which directly led to discussions on how to reduce this value. Already during the work on the $CO_2$ balance, the students enthusiastically got engaged in collecting ideas for the reduction of GHG emissions. In addition, several discussions took place with different actors, like the school management, the canteen operators, the caretakers and others. In one school, the students independently organized a climate-day, which was attended by the facility management and city officials, including the city-mayor. This climate day let to committed investments of 500,000 Euro by the city facility management for measures on the heating system and the implementation of smaller measures, such as the construction of a parking facility for bicycles. In other schools the discussion with the school board is less progressed and assisted by the project team.

Learning through research: the students have learned a lot about emissions and climate protection during the project. This can be verified by the fact that the students presented the results of the $CO_2$ balance to the school public, the press or local politicians without significant support from the teachers or scientists.

Overall, it can be stated as a result that the schools' self-efficacy has increased through their own recording of greenhouse gas emissions. The students were able to acquire new competencies and use them in discussions with decision-makers as well as in their own everyday school life.

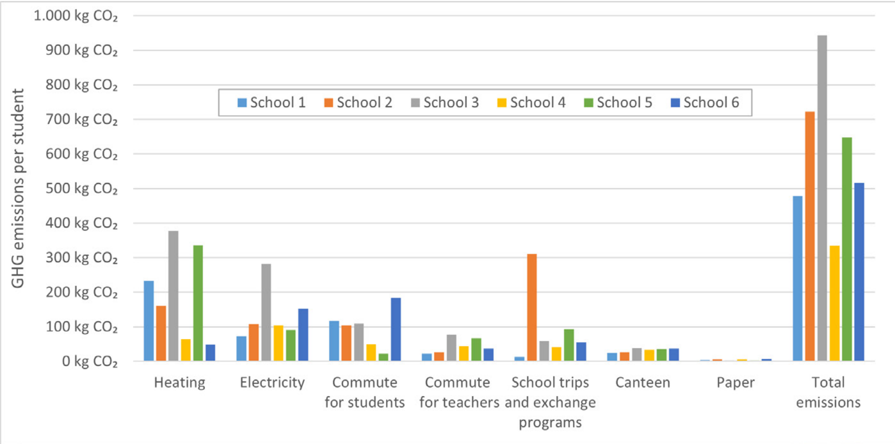


*Figure 1. Comparison of GHG emissions per student for different schools.*

On the one hand, they were able to develop their own possibilities for action, for example, by making decisions at the schools to no longer use airplanes for school trips in the future. On an individual level, it became clear that many individual decisions have an effect on the school's overall $CO_2$ balance. If many teachers and students come by bicycle, this noticeably reduces the school's $CO_2$ emissions. On the other hand, the results presented were able to trigger considerable pressure for action among the cities' decision-makers.

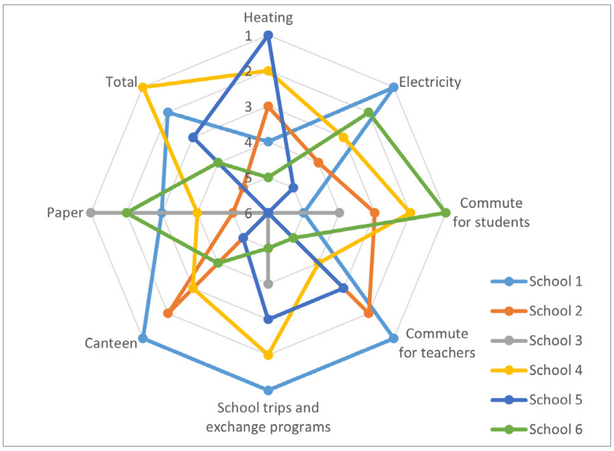


*Figure 2. Ranking of per-student GHG emissions in different sectors for all six pilot schools with completed CF assessment.*

## Discussion

A major challenge for the S4F team was the fact that it was almost impossible to introduce the tool to classes in the field due to the ongoing COVID-19 pandemic. While this proved to be a challenge in the first place, the project team addressed this challenge by creating an online-based version of the $CO_2$ assessment tool that allows students and teachers to work on the assessment in parallel and to enter the data from anywhere (e.g., from home). It also led to a sudden increase of integrating digital tools and platforms in the school context which encouraged students at some schools to conduct e.g., additional surveys to assess data on the school canteen's food and possible climate protection measures.

Other challenges concern the assessment of emissions related to nutrition: Many students struggled with the selection of ingredients as, logically, not all ingredients can be incorporated. The tool has already been improved by adding and specifying ingredients accordingly. While this will reduce the inaccuracy, it will naturally never be complete. However, the foremost goal of the tool is not accuracy but accessibility, which is sufficiently fulfilled as its practical relevance to the reality of students' lives can contribute to closing the knowledge-awareness-action gaps of existing climate protection learning settings to some extent.

Once put into place, it would be valuable to analyze whether the assessment of GHG at one school effectively leads to (significant) reduction measures. In this context, school comparison should also be shed light on if the tool and its assessment explain the source of emissions to such an extent that students can learn from each other. To this end, the project foresees peer-to-peer-learning-events amongst the schools to encourage reciprocal learning. In addition, the uploaded data might serve as a trigger to increase efforts if one school performs particularly good in one area A (mobility) while performing bad in another area B (nutrition). Figure 2 shows the ranking of per-student GHG emissions in different sectors for all six pilot schools with completed CF assessment. The figure shows that the schools perform very differently in different emission sectors, indicating that all schools have significant saving potential in one field or another and could potentially learn from each other.

Therefore, comparison possibly induces competition which in turn improves the overall climate change mitigation efforts of all participating schools. Further, comparisons increase the public and political pressure to spend more on energy efficiency and other climate protection measures in schools. To this end, it would be advisable to facilitate comparison through an online tool which automatically mirrors the emissions of different schools for different sectors. After completion of the $CO_2$ balances, discussions can take place in the schools about the areas in which climate protection measures can be taken to reduce the $CO_2$ footprint. For example, many schools underestimated how high the $CO_2$ emissions are for school trips if airplanes are used for this purpose. The carbon footprint is the first step to plan climate protection measures in a targeted way and it is a good instrument to quantify the effect of implemented measures and thus function as a feedback loop that helps to motivate further climate protection activities.

While the testing at various other schools in Germany is still underway, prospective research could focus on the question whether the data assessed qualify for comparative analysis of different school-based climate protection approaches within Germany and beyond. Accordingly, it is recommended to attentively follow the development of other tools around the world, compare them and make adjustments (i.e., adjusting the emission factors) wherever necessary, based on the findings. The project team believes that the method can be applied to other European schools without significant adjustments. To this end we consider the development of a tool which can be applied throughout Europe to enable comparison between schools of different European/EU countries.

## Conclusion

Students all over Europe are faced with the consequences of climate change. And similarly, to the current Covid-19 pandemic, this crisis cannot be solved by any one country on its own. While the pandemic has certainly not helped in reducing the investment backlog in German schools, it has pushed the digitalization in schools all around Europe, thus also facilitating the means of international cooperation and exchange between schools. What better way could there be to build upon these achievements for an international Schools4Future movement in which students not only support each other with turning their schools green but also grasp the importance of international cooperation?

## References

Dias Pereira, L., Raimondo, D., Corgnati, S.P., Gameiro da Silva, M., 2014. Energy consumption in schools – A review paper. Renewable and Sustainable Energy Reviews 40, 911–922. https://doi.org/10.1016/j.rser.2014.08.010

fifty fifty – energy savings in schools (in German: Energiesparen an Schulen) [WWW Document], n.d. URL https://www.fifty-fifty.eu/

Gamarra, A.R., Herrera, I., Lechón, Y., 2019. Assessing sustainability performance in the educational sector. A high school case study. Science of The Total Environment 692, 465–478. https://doi.org/10.1016/j.scitotenv.2019.07.264

Gamarra, A.R., Lago, C., Herrera-Orozco, I., Lechón, Y., Almeida, S.M., Lage, J., Silva, F., 2021. Low-Carbon Economy in Schools: Environmental Footprint and Associated Externalities of Five Schools in Southwestern Europe. Energies 14. https://doi.org/10.3390/en14196238

Greenpeace, 2021. SCHOOLS FOR EARTH Schools and their students on the path towards climate neutrality and sustainability (in German: Schulen machen sich gemeinsam mit Schüler:innen auf den Weg Richtung Klimaneutralität und Nachhaltigkeit) [WWW Document]. URL https://www.greenpeace.de/schoolsforearth

Hamann, K., Baumann, A., Löschinger, D., 2016. Psychology in Environmental Protection: Handbook for Promoting Sustainable Action (in German: Psychologie im Umweltschutz: Handbuch zur Förderung nachhaltigen Handelns). oekom, München.

Janmaimool, P., Chontanawat, J., 2021. Do University Students Base Decisions to Engage in Sustainable Energy Behaviors on Affective or Cognitive Attitudes? Sustainability 13, 10883. https://doi.org/10.3390/su131910883

Jones, C.M., Kammen, D.M., 2011. Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities. Environ. Sci. Technol. 45, 4088–4095. https://doi.org/10.1021/es102221h

Jurić, Ž., Ljubas, D., 2020. Comparative Assessment of Carbon Footprints of Selected Organizations: The Application of the Enhanced Bilan Carbone Model. Sustainability 12. https://doi.org/10.3390/su12229618

Landesinstitut Hamburg, 2012. Practical guide for climate protection in schools (in German: Praxisleitfaden für Klimaschutz an Schulen). Hamburg.

Mezirow, J., 2003. Transformative Learning as Discourse. Journal of Transformative Education 1, 58–63. https://doi.org/10.1177/1541344603252172

Wagner, O., Tholen, L., Nawothnig, L., Albert-Seifried, S., 2021. Making School-Based GHG-Emissions Tangible by Student-Led Carbon Footprint Assessment Program. Energies 14, 8558. https://doi.org/10.3390/en14248558