Investigating the role of emissions deriving from user transport in sustainable refurbishment strategies for buildings relying on low-carbon energy.

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Abstract. Refurbishing existing buildings constitutes a significant role in reducing emissions from the built environment. Their optimization demands time simultaneously to the urgency to fulfill the sustainable development goals 9, 11, 12, and 13. Therefore, actions taken at the municipal level are deterministic for future outcomes as many municipalities manage large building portfolios and thus hold significant mitigation potential. This paper investigates the role existing institutional buildings have for greenhouse gas abatement when the scope is expanded from building scale to include the urban environment. The aim is to determine the importance of considering the location of buildings when evaluating refurbishment strategies. There is a potential for a more significant reduction of emissions when including user transport. The role of travel-induced emissions from users, visitors, and employees in institutional buildings is potentially more critical than refurbishment for buildings already operating on low-carbon energy. Parts of a previously developed theoretical framework are tested to aid a Norwegian municipality in its emissions abatement strategy. The study assesses the carbon emissions deriving from refurbishment and the location of an institutional building. Inventory data from building, transport routes, and transport modes are assessed with a case study approach, while generic data derives from literature. The result indicates the importance of addressing locations of institutional buildings within the urban form rather than optimizing separate entities. Truncation errors can offset the benefit of building optimization in areas dependent on low-carbon electricity if travel-induced emissions are omitted from the assessment. The framework reveals that it is better to build a new building at another location in some instances when transport-related emissions are reduced.

Keywords: building stock, built environment, travel-induced emissions, location, institutional buildings, municipality

1. Introduction

Buildings in Europe contribute to approximately 40% of total energy use and GHG emissions [1]. The European Union (EU) state that major refurbishments are needed to reach the climate goals in 2050 due to inadequate energy standard in the existing building stock [2]. The road transport sector is also
accountable for a large share of the total energy use and emissions in the EU [3]. Although, decarbonization of the two sectors progresses as net-zero energy and emission buildings become the norm while battery electric vehicles (BEVS) continue to take market shares (e.g., in Norway) [4-6]. However, a growing urban population increases the demand for housing, and to avoid passing the planetary boundaries, efficient utilization of the buildings that already are around us must increase [2, 7, 8]. Nevertheless, the problem prevails as refurbishment rates remain low in Europe [2], and new pathways for decarbonization are necessary.

The literature has, in some aspects, expanded the scope to not only focus on optimizing buildings but also consider their role on an urban scale. Anderson et al. [9] argued that emissions are omitted when studies are focused on reducing emissions either on a building or urban scale while not considering the relationship between them. Hence, the role of building user transport is investigated on three different urban scales, and results demonstrate that emissions deriving from transportation can be significant [9]. Norman et al. [10] compared a high- and low-density scenario per building and square meter. The necessity for urban planning policies that reduce transport distances and optimization of the energy system in buildings were two of the recommendations for lowering GHG emissions. However, the urban planner needs to be cautious as applying policies based on engineered solutions does not necessarily consider the social aspects. Adherence to the heterogeneity of the built environment and its stakeholders gives rise to what Rittel and Webber [11] define as ‘wicked problems’ as new problems will arise when implementing a solution. Thus, a definite solution is never achieved as the ripple effect will cause new problems to solve and demand further solutions. Hence the planner must be satisfied with a solution that is considered good enough [11]. Other studies have investigated consumption patterns based on the location of buildings within a city and municipality which included emissions deriving from buildings and user mobility [12, 13]. The assessments have been performed on a city and neighborhood scale [14, 15]. Lausselet et al. [15] assess a zero-emission neighborhood illuminating the issue of refurbishments over time and that transportation of building users constitutes a significant share of the total GHG emissions in addition to the embodied and operational emissions from buildings.

The strategic decision on a municipal level can contribute significantly to a low carbon transition. Hence, as research progresses to address the carbon emission deriving from the built environment on an urban scale, the role of municipalities increases. They tend to operate with large building portfolios, and their buildings provide services for the inhabitants. Thus, strategic placement and refurbishment of them have the potential to reduce GHG emissions from both buildings and transport. The role of user transportation in the total reduction of GHG could be even more critical in the future as buildings rely on low-carbon electricity mixes and produce their renewable energy. Moreover, certain publicly governed buildings generate a rigid flow of building users transporting themselves to and from them. Regarding the urgency to refurbish existing building stock, it is intricate to aid municipalities in finding strategies that reduce building and transport-related emissions. Thus, holistic frameworks consider the emissions deriving from buildings and user transport needed. To guide the research, are the following research questions asked:

1. How can the emissions deriving from user transport and a public building be analyzed and included in sustainability assessments?
2. What are the insights from including user transport in refurbishment assessments?

2. Method
The paper applies a theoretical approach meaning that assumptions are made, and calculations are simplified. A case study approach in a Norwegian municipality that operates one of the largest public building portfolios in the country is applied. Based on the information obtained from the case study, two refurbishment and new building scenarios for an existing school are developed. Finally, this
section then continues to explain the method used for calculating the emission deriving from the user transportation.

2.1. The building portfolio
The municipal real estate portfolio consists of a vast range of buildings with a combined area of 800 000 m² [16]. The municipality's growing population is a concern since publicly owned land is scarce. However, the population is predicted to grow steadily, increasing the demand for public services such as schools. Furthermore, third-party audits have concluded that existing building stock needs to be improved to align with the current standard [16, 17]. The municipality uses a framework for categorizing existing building stock into three levels (A, B, or C) based on quality. An A-level building is a building that performs better than the minimum requirements in the existing building norm (TEK17) [18]. Upgrading a building from C-level to A-level is not an adequate solution because of the high economic investment needed. The best solution for a C-level building is to keep it for the remaining functional lifetime and then demolish it. The land is then utilized for other purposes or used to build a new modern public building that provides services for the inhabitants. Thus, the most interesting buildings to investigate are the ones categorized as B-level buildings since decisions must be made whether to refurbish them to reach A-level or downgrade to C-level. The consequences of wrongful decisions will prevail for a long time and harm sustainability goals set by the municipality [19]. Figure 1 below presents a theoretical framework based on current practice in the investigated municipality.

![Figure 1. Technical framework for categorizing buildings into A, B, or C-level. Adapted from Svein Bjørnberg in [19].](image)

Three public schools categorized as B-level buildings were identified based on the existing framework. The schools belong to three different school districts, and through the municipality website, a list containing all the housing addresses of the respective school district was obtained.

2.2. Building emissions
Scenarios were developed to calculate the emissions deriving from refurbishing or rebuilding the schools. The two first scenarios assumed that the schools are refurbished to reach the minimum energy requirement in the Norwegian building or passive house standard [18, 20]. The passive house standard
state that a school building cannot use more than 15 kWh/m² for heating, and emissions are not allowed to exceed 20 kg CO₂-eq/m²a [19]. Since the limit for maximum energy use is given as in TEK17, the assumed value for the passive house scenario was 65 kWh/m²a based on [21]. The last two scenarios assume that new buildings are built to align with the TEK17 or passive house standard. The lifetime of the school is assumed to be 60 years, and the schools will demand additional refurbishments after 30 years. In Table 1 below are the conditions when calculating the embodied and operational emissions for the four scenarios.

Table 1. The table below presents the assumed values for embodied emissions and energy use during the operational phase for the four scenarios.

| Refurbishment | Embodied emissions (EM) first 30 years (kg CO₂-eq/m²a) | EM from refurbishment after 30 years. (kg CO₂-eq/m²a) | Energy use (kWh/m²a) |
|---------------|-------------------------------------------------------|------------------------------------------------------|----------------------|
| TEK17         | 2.87                                                  | 2.23                                                 | 110                  |
| Passive house | 2.87                                                  | 2.23                                                 | 65                   |
| New building  |                                                       |                                                      |                      |
| TEK17         | 6.37                                                  | 2.23                                                 | 110                  |
| Passive house | 4.36                                                  | 2.23                                                 | 65                   |

Comments: For a new school, embodied emissions are assumed to be 6.37 kg CO₂-eq/m² and 4.36 kg CO₂-eq/m² for the low carbon scenario. In the refurbishment scenarios, it is assumed that the best available technology is used (BAT), and embodied emissions are 55% lower than for a new TEK17 building [22]. Necessary refurbishments are assumed after 30 years, and decarbonization of the material supply chains is believed to be 65% lower than the new TEK17 building scenario. Energy use TEK17 [18]. Energy use passive house [20, 21].

In addition to the applied scenarios were two electricity mixes assumed based on the Norwegian standard NS3720. The first assumes an average electricity mix (136 g CO₂-eq/kWh) for 2015-2075, where electricity is produced in Norway and imported from surrounding countries in Europe. The second electricity mix (17 g CO₂-eq/kWh) is an average between 2015 and 2075, assuming that all electricity is produced within Norway [23].

2.3. Transport mode and emissions
Approximately one-fifth (17%) of total GHG emissions in Norway derives from road transport, and a half of that share (49%) derives from cars [24]. There are over 100'000 light-duty vehicles registered in the investigated municipality, with the primary fuel sources of the cars being 28% gasoline, 25% diesel, 23% electric, and 24% other (mainly hybrid cars) [25]. A travel survey comparing two counties, including the investigated municipality, was used to obtain the modal share among the inhabitants in the investigated municipality. The modal shares were divided into walking, bicycle, public transport, car driver, car passenger, and others. Moreover, the study analyzed the modal share into groups based on travel distance [26]. The selected transport modes to investigate in the study were car and bus. The car types were divided based on the registered car types mentioned above. The cars were divided based on the share of registered vehicles in the municipality and it was assumed that the share of gasoline, diesel,
and hybrid cars decrease five percent every fifth year as people transform to electric cars whilst the fleet is fully electric in 30 years. Data obtained from [27] provided the gram of CO2 driven per km for buses and cars. The values were selected for car and bus transport on busy roads with a 50 km/h speed limit. The buses were 40 percent assumed to be diesel and 60 percent electric by the start of the analysis. No consideration for the energy content in the fuel sources was taken in this study as a general value from [27] was used. It was assumed that all buses would be electric after 20 years. The carbon content for the electric vehicles was calculated through a simple approach by multiplying the kilowatt-hours per km with the two-electricity mix assumed in NS 3720:2018 [23]. The electric cars were assumed to use 0.2 kWh/km and bus 1.7 kWh/km [28-30]. Finally, the investigated schools house children under the legal driving age were the categories for car driver and user-provided in the travel survey added together for simplicity.

2.4. Travel distance
As mentioned earlier, addresses for the three school districts were available to download on the municipality website. There were 1571, 1396, and 1318 addresses retrieved from each school. The transport routes to and from the schools were calculated with an application programming interface (API) key from Google. The API key enables the communication between Microsoft Excel and Google maps. The visual basic application (VBA) provided in Microsoft Excel was used to code a function that enabled retrieval of travel distances using car and bus between two points. The next step was the potential reduction in the use of cars and buses assessed by changing the location of the schools. The possible location to build a new school was theoretical and based on areal views in Google maps. Five new locations were tested for one school and four for the other two. No reduction of car or busses was achieved for two schools and no further analysis of them in this study. Table 2 presents the number of cars and buses for each distance group, and each group's average trip length was determined. The average trip length was multiplied by two since roundtrips with the same transport mode were assumed.

Table 2. The first column in the table contains the distance the addresses were categorized by and the modal shares. The results of the simulations are presented in the second, third, and fourth columns. Alternative location number six (Alt location 6) achieves the highest reduction in cars and buses. Thus, it was the alternative location compared with the school’s current location.

| Location now | Alt location 1 | Alt location 6 |
|--------------|----------------|---------------|
| < 1 km       | 321            | 470           | 745 |
| Car (5%)     | 16             | 24            | 37  |
| Bus (1%)     | 3              | 5             | 7   |
| 1-2.9 km     | 947            | 744           | 503 |
| Car (31%)    | 294            | 231           | 156 |
| Bus (6%)     | 57             | 45            | 30  |
| 3-4.9 km     | 33             | 80            | 52  |
| Car (32%)    | 11             | 26            | 17  |
| Bus (8%)     | 3              | 6             | 4   |
| 5.0-9.9 km   | 16             | 23            | 17  |
| Car (45%)    | 7              | 10            | 8   |
| Bus (20%)    | 3              | 5             | 3   |
| Total reduction cars | -11 % | -34 % |
| Total reduction busses | -8 % | -31 % |

3. Results
The following section presents the results from the scenario when the school is refurbished to align with TEK17 and passive house standards. Results for the current location and building a new school at another location according to the technical requirements presented. In Figure 2 are the results of
refurbishing the existing school to reach A-level and align with the current energy requirements in TEK17 or passive house standard in Norway. The lighter colours in the bar chart represent the first 30 years, while the darker colour indicates the remaining years.

![Bar chart showing emissions](chart.png)

**Figure 2.** In the figure are the results from the refurbishment scenarios (TEK17 = red, passive house = blue) and transportation emissions induced by the exiting location of the school. The lighter colour indicates the emission for the first 30-years while the darker represents the remaining 30.

The results reveal that the emission from the school is reduced significantly due to lower operational emissions when supplied with the electricity produced solely in Norway. The emission from transportation is lower than from the school. In the scenario when the school is refurbished to reach the same energy use as required in the Norwegian passive house standard, the gap between transport and school building emissions is reduced. However, building emissions are still higher in the 60-year perspective. The transport emissions deriving from transport are higher than the buildings during the first 30-years in the low carbon scenario. However, once the transportation becomes electric, the emissions reduce significantly.

In Figure 3 are the total emission given in kg CO2-eq, and the percentage change presented when a new school according to the energy requirements in the TEK17 or passive house standard at the location that reduced the share of car and bus transport the most. Building a new school according to TEK17 or passive house standard increases the emissions due to the higher embodied emissions during the first 30-years. Nevertheless, emissions deriving from transportation are reduced, and therefore was the absolute reduction in kg CO2-eq for the first and remaining 30 years investigated (see results Figure 4).
On the left side are the results for the first 30-years presented, and on the right are the remaining 30-years added.

![Graph showing emissions reduction](image)

**Figure 3.** The results of relocating the school reduce the induced transportation emissions by 2.74E+05 kg CO2-eq when supplied with the Norwegian electricity mix scenario and 6.10E+05 kg CO2-eq with the mix of electricity produced in Norway and Europe. The increased embodied emissions result in higher total emissions for the new building scenarios than refurbishment scenarios.

The results reveal that it is better to build a new school according to passive house standards at the other location, considering both electricity mixes. Building a new school, according to TEK17, will generate higher emissions in the first 30 years than refurbishing it at its current location. However, in the scenario with electricity produced in Norway and abroad, the total emissions are lower with a 60-year perspective if the location is changed even if constructing according to TEK17 standard.

![Graph showing emissions comparison](image)

**Figure 4.** The figure above presents the results of total emissions when building a new school according to the TEK17 or passive house standard compared to refurbishing the school at its current location. On
the left-hand side are the results for the first 30 years and while the right-hand side presents the total emissions after 60 years. Reductions are only achieved for the passive house scenario for the first 30-years whilst considering the whole lifetime reduces total emission in all scenarios except building according to TEK17 standard with electricity partly produced outside Norway. It is better to refurbish the school building at its current location in that specific scenario.

4. Discussion

As illuminated in the introduction, buildings and user transportation contribute significantly to the total emissions in the built environment. Results from this study and previous studies indicate that they should not be treated as separate entities [9, 10, 15]. The energy requirements in the passive house standard are stringent [20], and even though the cost aspect was omitted in this study, they are most likely higher than building according to TEK17. The assessment showed that building a new school according to TEK17 at an optimized location can be more sustainable. The studies mentioned in the introduction investigated dwellings [9, 10, 12-15] while this study evaluated public buildings. The benefit of evaluating the schools in this assessment is that the division into the district provides natural boundaries to the transport routes to include in the assessment. This approach is beneficial for assessing schools in Norwegian or other municipalities that divide their schools into districts since it limits the possible transport routes. In this paper, routes were limited to cars and buses. The paths available for bicycles and walking need to be assessed as well. Because there is a possibility that addresses within a certain distance might have shorter trip lengths, motorized transport might need to go a long distance to arrive at the same point.

This study aimed to evaluate user transportation when deciding the optimum strategy for refurbishing or building a new school building. The theoretical approach applied means that many assumptions were made. Thus, the results are an indication, not a fact. The refurbish and new building scenarios were simplified with data based on assumptions and facts available in the literature. The modal share among the inhabitants was based on travel survey data that excludes most children traveling to and from the schools. Thus, a test was made to see at which point the emissions deriving from user transport exceed those from the school building based on its current placement.

![Figure 5](image_url)

**Figure 5.** In the figure is total kg CO2-eq presented in a scenario when car and bus transport is increased by two percentage points for each distance interval. The increase in car and bus users reveals that transport emissions surpass the embodied and operational emissions from the school at its current location, given that it is provided with a low carbon electricity mix.

Figure 5 above, the results after increasing the shared car and bus transport for each distance group by two percentage points. The emissions deriving from transportation when charging the electric
vehicles and supplying the school with the low-carbon electricity mix are higher than the embodied and operational emissions from the building when refurbishing the building according to passive house standards. Thus, revealing the sensitivity in the assumption concerning transport and refurbishment actions. Further, detailed life cycle assessments for the embodied and operational phases and case-specific travel surveys are recommended. The assessment performed in this study did not include the embodied emissions deriving from transportation. The emissions would most likely increase significantly depending on the cut-off point in an assessment. The embodied emissions of electric vehicles are higher than for conventional vehicles thus are alterations in the results expected, and public transport was assumed to be limited to busses. The inclusion of other modes of public transport like trams or subways might procedure fewer emissions during the operational phase, albeit including the embodied emission of the necessary infrastructure might change the scenario In this study, the assumption was made that all vehicles become electric at a certain point, and a test was made to see what happens when the utilization of electric cars is lower. In Figure 6 are the results after the assumption that a maximum of 89.5% of the vehicles are electric while the remaining 11.5% are hybrid vehicles using gasoline. No similar changes were made for the public transport scenarios. The results are shown for the scenario when the existing school is refurbished according to the energy requirement in the passive house standard.

**Figure 6.** The results from the assumption that not all cars become fully electric within 60-years reveal that, in similarity to the results in Figure 5, emissions deriving from transport become higher. This result represents the pre-requisites given in the method and that no more than 89.5 percent of the cars are electric. The remaining 11.5 were assumed to be hybrid cars using gasoline.

The results imply the importance of the vehicle types assumed in the assessments since a scenario with fewer electric vehicles increases the argument for building a new school at another location. However, more detailed work is needed as the results are highly theoretical. Nevertheless, it illuminates the potential benefits of having a holistic approach when evaluating refurbishments. Moreover, there are many uncertainties regarding future electricity mixes and transport use. However, the boundaries of the school districts enable some predictability and the possibility of finding a location that reduces motorized transport. The municipality needs to balance the hard and soft aspects in their future solutions as the rise of wicked problems is unavoidable if all three columns of sustainability are going to be achieved [11, 16]. Using the method applied in this study, an optimized, engineered solution was found, although without consideration to the softer social aspect that influences modal choice among inhabitants. The planners need to be aware of how changes in governmental policies and the heterogeneity of the built environment might change the outcome of a solution and give rise to new issues. This study benefitted from the confinement of the school districts, while a reconfiguration might change the result for the better or worse. For example, it was discovered that the current location of
some of the schools (not categorized at B-level) that belong to other districts was in the proximity of the schools assessed on this study. Hence an even better solution might have been found if they had been included in the assessment as well. It is possible that redeveloping one school and merging it with another in its proximity might reduce total GHG emissions the most. Thus, finding an agile solution is essential, albeit challenging, as the consequences of the decision to refurbish its current or build new at another location will prevail for a long time.

Commonly, schools are utilized for other activities, such as sports. Thus, future studies should consider these aspects since, for example, the size of an indoor gymnasium might induce transport to a higher or lesser extent depending on its location. Finally, the scarcity of publicly owned land is a problem for urban planners in the municipality [16, 17] which this study did not consider. Thus, future work needs to assess this as it can significantly reduce the available options for building a new building at another location, and the municipality perhaps needs to procure more land.

5. Conclusion
Suppose the boundaries are known for the urban environment influenced by the buildings assessed. Then, it is possible to predict the emission. Although, detailed information regarding modal share, transport distance, vehicle types, and the dynamic nature of the sector make assessments challenging. Making reasonable assumptions when coupling buildings and transport regarding lifetime is another difficult task. Nevertheless, there is a risk of sub-optimization when not expanding the scope from building to urban scale. By expanding the scope, there is a potential for a more significant reduction of greenhouse gases if the impact of user transport is included in the assessments as well.

References
[1] Comission European. Report from the Commission to the European Parliament and the Council Progress by Member States Towards Nearly Zero-Energy Buildings. 2013.
[2] Commission European. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions a Renovation Wave for Europe - Greening Our Buildings, Creating Jobs, Improving Lives. Brussels 2020.
[3] Parliament European. Co2 Emissions from Cars: Facts and Figures (Infographics) 2019 [Available from: https://www.europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics].
[4] Energy U.S. Department of. A Common Definition for Zero Energy Buildings. 2015.
[5] Kristjansdottir Torhildur Fjeldheim Henning, Selvig Eivind, Risholt Birgit, Time Berit, Georges Laurent, Dokka Tor Helge, Bourelle Julien S, Bohne Rolf, Cervenka Zdena. A Norwegian Zeb-Definition Embodied Emission. 2014.
[6] Bu Christina. What Norway Can Teach the World About Switching to Electric Vehicle. TIME. 2022.
[7] Rockström Johan, Steffen Will, et al. A Safe Operating Space for Humanity. Nature. 2009;461(7263):472-5.
[8] Programme United Nations Environment. Emissions Gap Report 2020. United Nations; 2020 09 DECEMBER 2020. Report No.: DEW/2310/NA.
[9] Anderson J. E., Wulffhorst G., et al. Expanding the Use of Life-Cycle Assessment to Capture Induced Impacts in the Built Environment. Building and Environment. 2015;94:403-16.
[10] Norman J., MacLean H. L., et al. Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions. Journal of Urban Planning and Development. 2006;132(1):10-21.
[11] Rittel Horst W. J., Webber Melvin M. Dilemmas in a General Theory of Planning. Policy Sciences. 1973;4(2):155-69.
[12] Saner Dominik, Heeren Niko, et al. Housing and Mobility Demands of Individual Households and Their Life Cycle Assessment. Environmental Science & Technology. 2013;47(11):5988-97.

[13] Ottelin J., Heinonen J., et al. New Energy Efficient Housing Has Reduced Carbon Footprints in Outer but Not in Inner Urban Areas. Environmental science & …. 2015.

[14] Stephan André, Crawford Robert H., et al. Multi-Scale Life Cycle Energy Analysis of a Low-Density Suburban Neighbourhood in Melbourne, Australia. Building and Environment. 2013;68:35-49.

[15] Lausselet C., Ellingsen L. A. W., et al. A life-Cycle Assessment Model for Zero Emission Neighborhoods. Journal of Industrial Ecology. 2020;24(3):500-16.

[16] Kommune Bærum. Klimastrategi 2030 Bærum Kommune2018 [updated 28.02.2018. 32]. Available from: https://www.baerum.kommune.no/globalassets/styrende-dokumenter/klimastrategi/klimastrategi-2030.pdf.

[17] Kommune Bærum. Eiendomsstrategi 2020-2030 2020 [Available from: https://www.baerum.kommune.no/globalassets/politikk-og-samfunn/politikk/for-folkevalgte/presentasjoner-møter-og-seminarer/formannskapet/eiendom-2024-for-formannskapet-28-oktober-2020.pdf.

[18] Byggkvalitet Direktoratet for. Byggteknisk Forskrift (Tek17) Med Veiledning 2017 [Available from: https://dibk.no/regelverk/byggteknisk-forskrift-tek17/.

[19] Kommune Bærum. Eiendom - Delstrategi for Oppgradering Og Verdibevarende Velikehold, 2016-2020-Status 2017 [13]. Available from: https://www.baerum.kommune.no/innsyn/politikk/wfdocument.ashx?journalpostid=2017254890&dokid=3823048&versjon=7&variant=A&.

[20] Norge Standard. Criteria for Passive Houses and Low Energy Buildings- Non Residential Buildings. 2012.

[21] UngEnergi. Passivhus 2020 [Available from: https://ungenergi.no/miljoteknologi/bygg/passivhus/.

[22] Mie Fugleseth Haakon Haanes, Oddbjørn Dahlstrøm Andvik, Anne Sigrid Nordby,. Klimavennlige Byggematerialer - Potensial for Utslippskutt Og Barierer Mot Bruk. 2020. Contract No.: 629292-01.

[23] Norway Standards. Method for Greenhouse Gas Calculations for Buildings. 2018;1:40.

[24] Miljøstatus. Klimagassutslipp Fra Veitrafikk I Norge 2021 [Available from: https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/klimagassutslipp-fra-veitrafikk/.

[25] Norway Statistics. Bærum (Viken) 2022 [Available from: https://www.ssb.no/kommuneefakta/berum.

[26] PROSAM. Reisevaner I Oslo Og Viken. En Analyse Av Nasjonal Reisevaneundersøkelse 2018/19. 2019 02.2021. Contract No.: 242.

[27] Norway Statistics. Drivstofferbruk Og Utslipp Per Kjøpte Kilometer for Et Utvalg Av Trafikksituasjoner Og Kjøretøygrupper. 2016. G/Km 2016 [Available from: https://www.ssb.no/318322/drivstofforbruk-og-utslipp-per-kjøtte-kilometer-for-et-utvalg-av-trafikkssituasjoner-og-kjoretegygrupper.2016.g-km.

[28] Database Electric Vehicle. Energy Consumption of Full Electric Vehicles 2022 [Available from: https://ev-database.org/cheatsheet/energy-consumption-electric-car.

[29] Xylia Maria, Leduc Sylvain, et al. Locating Charging Infrastructure for Electric Buses in Stockholm. Transportation Research Part C: Emerging Technologies. 2017;78:183-200.

[30] Bus Sustainable. Electric Bus Range, Focus on Electricity Consumption. A Sum-Up 2020 [Available from: https://www.sustainable-bus.com/news/electric-bus-range-focus-on-electricity-consumption-a-sum-up/.