Modern Environmental Science and Engineering (ISSN 2333-2581)
October 2017, Volume 3, No. 10, pp. 701-707
Doi: 10.15341/mese(2333-2581)/10.03.2017/004
Academic Star Publishing Company, 2017
www.academicstar.us

Environmental Indicators to Monitor the Swedish Construction and Real Estate Management Sector

Kristina Einarsson, Linda Lagnerö, and Hans-Olof Karlsson Hjorth

Swedish National Board of Housing, Building and Planning, SE-371 23 Karlskrona, Sweden

Abstract: A monitoring system with environmental indicators has been developed to monitor the environmental impact from the construction and real estate management sector in Sweden, at a national level and from a lifecycle perspective. The indicators are based on the Environmental accounts from Statistics Sweden and will be updated every year starting 2016. Data is so far available for the period of 1993-2014.

Environmental indicators enable to follow the development of the environmental impact of the sector. Seven indicators are selected to monitor the most significant environmental impact:

• air emissions — greenhouse gases, nitrogen oxides, particulate matter
• use of energy — fossil energy, renewable energy, nuclear power
• use of health and environmentally hazardous chemicals
• generated waste

The environmental indicators show the following results: The construction and real estate management sector emitted 11.6 megatonnes of CO2e in Sweden in 2014, from a life cycle perspective. In comparison with the total annual greenhouse gas emissions in Sweden the sector accounted for 19 percent. The total energy used in the sector accounted for 120 TWh, of which 110 TWh is from domestic use and correspond to 30 percent of the domestic energy used in Sweden, from a life cycle perspective. The sector also contributes to emissions in other countries through imported products. An estimate of greenhouse gas emissions linked to imported products show that the emissions are big outside Sweden, about 8.7 megatonnes CO2e. The sector import more environmentally hazardous chemicals than those produced in Sweden.

The environmental indicators show that the environmental impact from the construction and real estate management sector is significant from a life cycle perspective. The indicators will be used to evaluate improvement and inform policy and practice.

Key words: life-cycle assessment, policy and regulation, environmental indicators, construction and real estate management sector

1. Introduction

The Swedish building authority (Swedish National Board of Housing, Building and Planning or Boverket in Swedish) is responsible for building up and disseminating knowledge about the impact on the environment from the construction and real estate management sector, hence the sector. Environmental indicators have been developed in order to measure and track the progress of the environmental impact from the sector. The method used was developed during the years 2009-2014 and has been presented in two studies [1, 2] and in three reports [3-5]. It is developed by KTH Royal Institute of Technology, in cooperation with Statistics Sweden.

The environmental indicators are selected to reflect the national Environmental Quality Objectives (EQO) in Sweden and cover the most significant environmental impact from the sector. They are intended to be communicable and based on available data. The indicators to monitor the environmental impact are as follows:

Corresponding author: Kristina Einarsson, M.Sc, Project Manager, Investigator; research areas/interests: environmental impact from the construction sector. E-mail: kristina.einarsson@boverket.se.

- air emissions — greenhouse gases, nitrogen oxides, particulates,
- energy — fossil energy, renewable energy, nuclear power
- use of health and environmentally hazardous chemicals
- generated waste

The Environmental indicators show the environmental impact from the sector from a lifecycle perspective. The starting point was to describe the environmental impact based on activities during a building's life cycle, and translate it to a sector level. This includes the environmental impact of all construction activities that occur during a year in the sector. It applies to activities during the manufacturing stage, construction stage, in the finished building, from the demolition phase and transport within and between the various stages. The statistics on waste are under development. The reporting of this indicator differs so far compared to the rest, as it does not emanate from a life cycle perspective.

Emissions from imported construction products are shown separately. Export of building products and household energy is not included.

Environmental indicators show:

- how much is emitted/used in the sector
- the share of Sweden’s total emissions/usage in the sector
- development over time – however they are dependent of the economic situation and the outdoor temperature

2. Method

The basis for the environmental indicators is the National and Environmental Accounts produced by Statistics Sweden. The method used is a so-called input-output analysis (IOA), adjusted for the special needs from the Swedish building authority to illustrate the environmental impact from the sector from a lifecycle perspective.

This adjusted method of an IOA for the construction and real estate management sector was developed by KTH Royal Institute of Technology in collaboration with Statistics Sweden on behalf of the Swedish building authority. It is based on similar analyses previously made for the energy sector and the agricultural sector. The used method is described in two papers [1, 2] and three reports [3-5]. It has been improved in the past years and the method described below differs slightly on some points.

The National Accounts is an internationally comparable accounting system. Environmental Accounts are based on National Accounts and aims at describing the relationship between economic activities and the impact on the environment. Economic data from the National Accounts is expanded with environmental statistics for each industry such as emissions, fuel usage and chemicals.

An input-output table from the National Accounts describes the relationships between different industries within an economy. It shows how output from one industry is used as input in other industries and vice versa. An environmentally extended input-output analysis therefore enables estimating the impact on the environment from a certain industry, both through direct and indirect effects.

The adjusted input-output method used aims to capture environmental impact throughout a life cycle perspective from the sector, i.e., from the production of material used as input in the building process until the building is demolished. It differs from a traditional IOA regarding industry classification, redistribution of space heating, renovations and additions for imports (see below section 2.1-2.3).

2.1 Industrial Classification

In National and Environmental Accounts, industries are classified according to the EU:s recommended standard, NACE (corresp. to ISIC). The building authority’s definition of the sector is represented well by the industries Construction of buildings (NACE 41),

specialized construction activities (NACE 43) and Real estate activities (NACE 68).

In the European National and Environmental Accounts, however, the construction industry normally is presented as an aggregate, (NACE 41-43), which also includes civil engineering (NACE 42). One reason for this is that the requirements from the European Commission on reporting input-output statistics within the EU are on this aggregated level. To enable analysis of the environmental impact from the construction of buildings only, i.e., NACE 41 and NACE 43, and from the real estate management, NACE 68, a disaggregation of the official statistics has been made in this project.

The method used for disaggregating the construction industry has been improved compared to the previously used method. Further improvement of the disaggregation method would be useful and our hopes are that eventually the official statistics will be presented on this disaggregated level.

To sum up, by disaggregating the construction industry and by analysing chosen parts of the construction industry together with the real estate activities industry our approach differs from an ordinary input-output analysis.

The environmental indicators are available from 1993-2014. However, due to the change in the industrial classification from NACE Rev.1.1 to NACE Rev. 2 the time series is only consistent for the periods 1993-2007 and 2008-2014 separately.

2.2 Redistribution of Space Heating

In National and Environmental Accounts the major part of the space heating is excluded from the real estate management industry (NACE 68), due to European praxis. Only a minor part of the space heating is included in NACE 68, such as heating of stairwells. The major part, however, is included in other sectors, such as other service industries, the household sector, the government sector and non-profit organisations.

Capturing the lifecycle perspective of the sector therefore requires a redistribution of the energy used for space heating, with the intention to burden the real estate management industry with the environmental impact linked to space heating.

Compared to National and Environmental accounts the redistribution of space heating involves a so-called extended system boundary. The redistribution of space heating implies that information from different industries is combined. The life cycle perspective of the sector is captured in a better way, but any comparison with statistics for other industries will be misleading.

A corresponding redistribution is done for environmental impacts from for example repairs and renovation of existing buildings.

2.3 Additions for Imports

The products used as input in the sector are either produced within the country or imported from other countries.

The environmental impact of imports does not take place in Sweden, but in the countries where the products are manufactured. Environmental indicators should highlight the total environmental impact of the sector from a life cycle perspective. Hence, emissions from the production of imported products must be taken into consideration.

Different countries have different modes of production. Our experiences are that if emissions from imported products are handled as if they were produced in Sweden, they are underestimated. When it comes to greenhouse gas emissions, Statistics Sweden has improved the method and estimate emissions from imports by assumptions regarding the production in different countries, which would give a more accurate result. A better estimation of the emissions from import is planned for the rest of the indicators as soon as data is available.

3. Results and Discussion

3.1 Environmental Impact from the Sector

The environmental impact from the sector was between 4-31 percent as share of the total domestic emissions or use in Sweden for chosen indicators, see Table 1. The contribution from imported products is considerable. See especially the greenhouse gas emissions which are nearly doubled when emissions from imported products are included in the total emissions from the sector. For the greenhouse gas indicator, the estimation of emissions from imports is improved compared to the method presented in the paper from 2013 [2].

Table 1 The total emissions and use for chosen indicators during 2014.

Environmental indicators for the sector 2014	**Emissions from the sector, domestic production**	**The share of the sector, domestic emissions in Sweden**	**Total emissions, domestic production and imported**
Greenhouse gases *(thousand tonnes CO2e)*	11568	19%	20248
NO_x*(thousand tonnes)*	29	11%	43
Particles *(thousand tonnes)*	13	25%	15
Environmental indicators for the sector 2014	**Use in the sector, domestic production**	**The share of the sector, domestic use in Sweden**	**Total use, domestic and imported**
Total energy used *(TWh)*	110	30%	120
– Renewable energy (TWh)	72		74
– Fossil energy (TWh)	28	17%	36
– Electricity for heating from nuclear power (TWh)	10		10
Chemicals hazardous for the environment (*thousand* tonnes)	65	4%	230
Chemicals hazardous for the health *exclusive cement* (*thousand* tonnes)	991	10%	1838
Generated waste (million tonnes)	8867	31%	-
thereof non-hazardous waste (thousand tonnes)	8265	32%	-
thereof hazardous waste (thousand tonnes)	602	23%	-

3.2 Greenhouse Gases

The total greenhouse gas emission from the sector was 20.2 megatonnes of carbon dioxide equivalents in 2014, including emissions from imported products (Fig. 1). Of those, 11.6 megatonnes were released in Sweden. Compare with total annual greenhouse gas emissions in Sweden this amounts to about 19 percent. The indicators are dependent of the actual climate, e.g., in 2010 the higher emission is explained by the colder temperature that year.

When allocating the annual total greenhouse gas emissions from the construction and real estate management sector to sub-sectors, you can see that a large part of the annual greenhouse gas emissions comes from construction (new buildings/demolition) and real estate management (renovation/ reconstruction). These emissions correspond to about 70 percent of the total level (Fig. 2). For 2014, an increase in construction's share can be seen while emissions from real estate management heating decline compared to 2013.

3.3 Energy Use

The total energy used in the sector amounted to 120 TWh in 2014, including imported products. Of these, 110 TWh was used in Sweden, equivalent to about 30 percent of total energy used in Sweden. Out of the 120 TWh, 74 TWh was from renewable energy, 36 TWh from fossil energy and 10 TWh from electricity for heating from nuclear power (Fig. 3). The total energy

usage in the sector varies from year to year, depending on how the temperature varies; this applies to the energy for heating. Cold years the use of fuel increases.

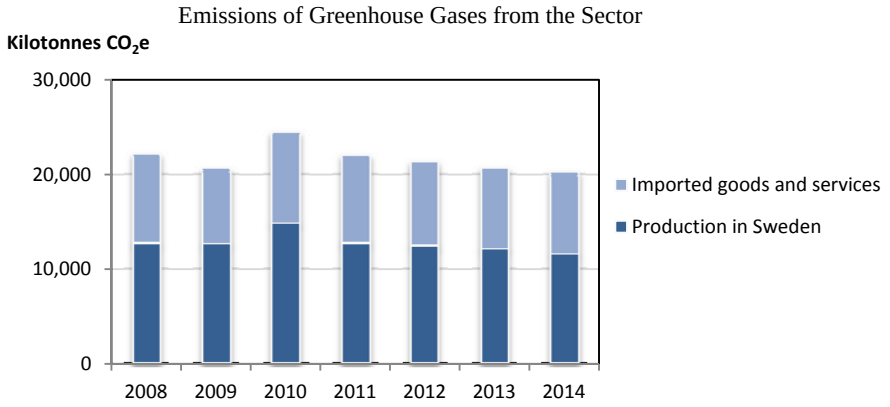

Fig. 1 Total greenhouse gas emissions from the construction and real estate management sector in kilotonnes of carbon dioxide equivalent (CO2e) released in Sweden (domestic emissions) and from imported products, viewed from a lifecycle perspective.

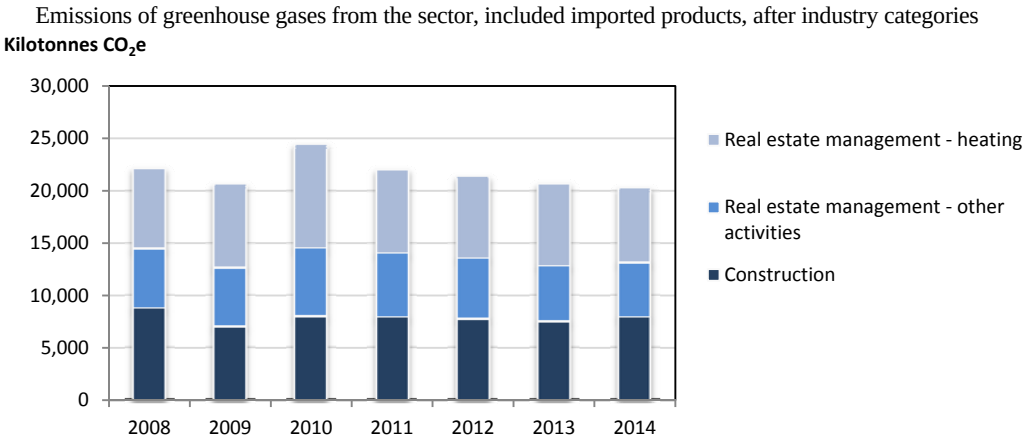

Fig. 2 Total greenhouse gas emissions from the construction and real estate management sector in kilotonnes of carbon dioxide equivalent (CO2e) allocated to industry categories, viewed from a lifecycle perspective.

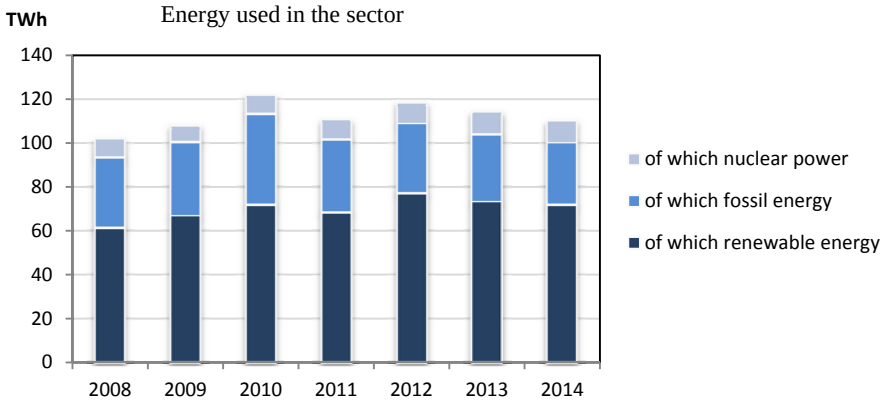

Fig. 3 Total energy used between 2008 and 2014 in the construction and real estate management sector divided into energy types. The use of fossil energy includes coal and coke, petroleum and petroleum products, natural and town gas and peat, fossil waste, etc. The renewable energy are solid biomass, liquid biomass, biogas, biogenic waste, hydropower, solar and wind power, etc.

3.4 Use of Hazardous Chemicals

In 2014 the use of chemical products hazardous for the health in the sector amounted to nearly 1.8 megatonnes if cement was excluded and approximately 3.1 megatonnes if cement was included (see Fig. 4). Chemical products hazardous for the environment amounted to a much lower level, 230 kilotonnes in 2014.

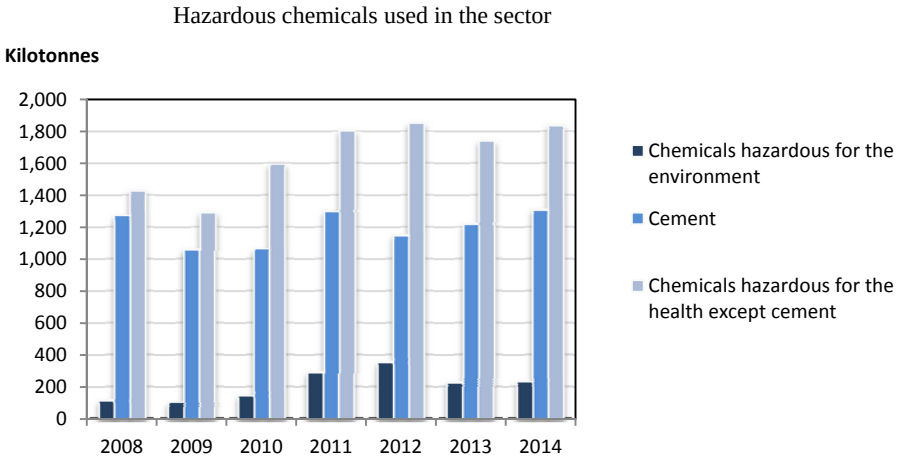

Fig. 4 Total use (incl. imports) of health and environmentally hazardous chemical products (kilotonnes) from the construction and real estate management sector during 2008-2014.

The results include the use of chemical products that are classified as health or environmental hazardous in the sector. Examples of such products are paint, thinners and insulation. Products not included in the analysis are for example tar, asphalt and bitumen, as these are not classified and therefore not included in the Environmental Accounts. However, the quantitatively smaller amounts of additives in the asphalt are classified according to the Regulation (EU) No 1272/2008 on classification, labelling and packaging of chemical substances and mixtures (CLP), and are therefore included in the calculations.

The manufacture of cement, lime and gypsum accounts for a large proportion of the use of hazardous chemical products. These products are mainly classified as corrosive (C) and/or irritating (Xi) according to the CLP Regulation. Products of cement are primarily a health and safety problem in the work environment. After the product has hardened it has no longer these properties. In order to avoid other hazardous chemicals to “disappear” in the statistics we have chosen to present cement separately.

4. Development Needs

Even though the method is ready to be used as it is presented in this paper, there are needs of further development of the indicators, according to the Swedish building authority. For example a better estimation of the emissions from imports is needed for the rest of the indicators (the greenhouse gas indicator has a better estimate). It is a big difference in accounting as if the products were produced in Sweden or in the country of origin, due to different modes of production.

The indicators are dependent of the economic situation and outside temperature. This will be visualized in the figures in the future. The indicators are also possible to regionalize. That is of interest for the evaluation of the EQO. The waste indicator is based on official waste statistics and there is an ongoing development of them since the data so far is inadequate.

5. Conclusions

The Swedish building authority's environmental indicators show the following about the sectors environmental impact: The sector emitted 11.6 megatonnes of carbon dioxide equivalent (CO2e) in Sweden in 2014. Compared to the total annual greenhouse gas emissions in Sweden this is about 19 percent. The sector's total energy used in Sweden was 30 percent. Both indicators calculated from a life cycle perspective. This means that the sector is responsible for 4-31 percent of the society's environmental impact for selected indicators for domestic emissions/use in Sweden.

The sector also contributes to emissions in other countries via imports. An estimate of greenhouse gas emissions linked to imported products show that they are big outside Sweden, about 8.7 megatonnes. The sector imports more environmentally hazardous chemicals than those produced in Sweden.

The results show the importance of having a broader perspective in the analysis of environmental impacts. For example, the constructions phase (material manufacturing) and the contribution of imports is important to include. And a large part of the environmental impact is missed if only domestic emissions are reported.

The method can be used for follow-up purposes. Several countries could use the method as statistics are available and the basis of the method is internationally harmonized. The European requirements for international reporting cover the entire construction sector and real estate management sector. It is desirable to have a finer breakdown of the sector. Sharp focus on the environmental impact of buildings creates a need for better statistics/finer division.

Acknowledgement

The authors thank the KTH Royal Institute of Technology and Statistics Sweden for developing the method.

References

[1] S. Toller, A. Wadeskog, G. Finnveden and S. Miliutenko, Environmental impacts of the Swedish building and real estate management sector, *Journal of Industrial Ecology* 15 (2011) (3) 394-404

[2] S. Toller, A. Carlsson, A. Wadeskog, S. Miliutenko and G. Finnveden, Indicators for environmental monitoring of the Swedish building and real estate management sector, *Building Research & Information* (2013) 1-10.

[3] Boverket, *Bygg-och fastighetssektorns miljöpåverkan*, Karlskrona, Sweden, 2009.

[4] Boverket, Miljöindikatorer för bygg-och fastighetssektorn 1993-2007, Report No. 2011:2. Karlskrona, Sweden, 2011.

[5] Boverket, Miljöpåverkan från bygg-och fastighetssektorn, Report No. 2014:23. Karlskrona, Sweden, 2014.