Web based EPD-tool for evaluation of contractors' design

L.Strömberg
NCC (Nordic Construction Company), Solna, Sweden

ABSTRACT: This article proposes using of current EN standards and verification rules for environmental product declaration (EPDs) as a basis for evaluation of contractors' design for infrastructural projects. The proposed conceptual framework for verification of credibility of climate impact assessment for infrastructural projects is based on the Swedish- based, the International EPD® System. Several Swedish and Norwegian stakeholders were engaged in this joint project to understand driving forces and obstacles and provide key insights to the successful implementation on such verification framework for evaluation and comparison of alternative design options. In order to perform a sharp test of some main hypothesizes, about how it's possible to create verified climate calculations four of the project participants collected data from ongoing infrastructural projects and tested to perform project-specific verified climate calculations.

1 INTRODUCTION

Sweden faces major challenges in the climate field. Where the government and parliament now have taken the initiative with the goal of Sweden as a nation to be climate neutral by 2050 (The Swedish government proposition, 2012). An active involvement of various market players is necessary to manage with the adoption of this goal to the practical work in scarp infrastructural projects. With this background the biggest Swedish client, the Swedish Transportation Administration, Trafikverket (STA) establishes requirements for suppliers regarding energy and climate gas emissions accounting and reporting (Trafikverket, 2016).

Current reporting of climate efficiency to the STA in infrastructural projects takes place after the tender was submitted and is a part of contract' requirements. STA uses to take up a default calculation of climate impact for some mainly used traditional building materials and infrastructural solutions based on generic industry wide-used emission factors. The contractors and suppliers then need to streamline this pre-determined traditional engineering solution to become more environmentally friendly.

However the key factor to achieve the climate neutrality goal is to establish a meaningful fair and standard-based procedure for verification of climate impact from contractor' design in early phases and bidding process. This procedure should support establishment of a business-to-business relation between different market stakeholders to reduce the actual climate gas emissions. It will be a big improvement if we can match the supplier' and contractor' internal investments to more environmentally friendly solutions and the client's evaluation in tendering process. Clients should start to demand calculation of project specific actual climate emissions so the suppliers can "make business" with innovative climate-efficient solutions and products.

There are some contractors in Sweden which already conduct Life Cycle Assessments (LCAs) in order to improve project's environmental performance. However LCAs can be conducted in many ways and if using different system boundaries, different assessment methods,

and the way to model the entire life cycle the results will be incomparable. At present LCAs and climate calculations aren't standardized and are performed in different ways, in different commercial LCA-software with different LCA-methods by different players in the Swedish construction industry.

An industry-wide standardized basis would make it possible to create an unbroken information flow with LCA-data between material suppliers, contractors and clients. A common ground would allow the use of the same LCA-calculation model for various purposes such as company's internal monitoring of the climate performance in infrastructural projects, internal product development, purchasing, monitoring for the environmental management system, public procurement, creation of business strategies, reporting according to building assessment schemes (BREEAM, LEED, DGNB etc) and reporting to clients.

The current lack of a reliable industry wide-used LCA-calculation model and a verification procedure for project specific life cycle data is anticipated to become an important barrier to design and sell products with improved environmental performance. At the same time, Environmental Product Declarations (EPDs) for building materials and building parts, based on LCA, have been increased at the Nordic market during last years. Many manufactures have been developed EPDs for their products. However the "middle" chain in the communication between the manufactures and the client, the contractor hasn't started yet produce verified LCAs in EPD-format for infrastructural projects. There is still no general acceptance of EPDs as an industry-wide LCA-specification.

Knowledge and experience of using such standardized climate calculations according to the EPD-format is still very low. In Sweden, the STA starts to encourage contractors to use project-specific EPDs as a verification of project's climate impact since the spring 2016 (Trafikverket, 2016). Product-specific EPDs are also required for public procurement in some bigger Norwegian projects (Johannessen, 2016) and building assessment schemes (LEED, BREEAM etc).

EPD is in the broad sense a market driven format for communication of LCA based environmental information business-to-business and more recently also business-to-consumer. A key component in LCA in EPD-format is a method description document, referred to as Product Category Rules (PCR). A PCR defines the LCA-model, calculation method and data requirement (The International EPD System, 2016).

PCRs are available for engineering constructions (e g bridges) and construction materials. However each PCR is linked to a particular EPD-program operator (e g EPD Norway or the International EPD® System in Sweden). EPDs from different operators aren't comparable yet. The calculation rules of carbon dioxide emissions differ between the current EPD-systems in Europe, which can be misleading when comparing products and processes. However it already addressed within the framework of the EPD/PCR and also for the ongoing work in the EU-project (Eco-Platform, 2016).

The contractors and material suppliers start climate optimization of their product/solution as well as optimization of supply chain often as a part of an internal strategical work with energy and climate reduction. An innovative climate-efficient solution is often created by contractors long before the actual bidding process. Verified LCAs and climate calculations, performed in EPD-format will support contractor's internal work with the supply chains, support internal product optimization and in the same time will allow reporting to the client according to the same LCA-model. In this case the supplier doesn't need to disclose the recipe for its innovative products and designs, but a third part will audit and evaluate the quality of the provided LCAs and climate calculations. If a particular vendor claims that he can build sustainable and "green" engineering constructions this should be verified by an EPD. EPDs are the only LCA-format, which is allowed to use in procurement to evaluate and compare alternative designs (ISO/TR 14025: 2000).

To use climate and energy calculations in the bidding for evaluation and rewarding of the best environmentally-friendly design requires specifying some key parameters for the LCA-calculation model. To archive the Swedish climate reduction goal contractors should be rewarded for using of innovative environmentally-friendly materials/solutions in the bidden process. This means that there is a need for a verification procedure to compare in a fair and easily way the project specific emission factors for contractors' alternative designs. It can be archived with support of a digital EPD-tool, which was discussed and developed as a first draft in this joint project.

The follow driving forces to use the EPD-tool has been identified:

- Achieve multiple customer requirements, e g building assessment schemes' requirements, internal product development etc with less cost
- Reduce purchasing costs (fewer suppliers with better environmental performance)
- Easier to get into a deal with a well-established process for EPDs
- Trustworthy quantitative and qualitative communication on the market with environmental product declarations for truly environmentally friendly products
- Identify the most environmentally sensitive components and processes in company's product portfolio and work strategically with the improvement
- Purchasing cost control and project development goal to much the client' requirements to improve the environmental performance
- Be able to steer towards increasing of renewable and recycled content in products/products, which is required by EU-directives
- Able to meet future EU requirements with a well-established control of the environmental performance of internal processes.

2 CONTEXT

2.1 *The joint project*

The joint project organization has been formed by several contractor companies, building material manufactures, branch organizations and clients. Different stakeholders from some biggest Nordic building companies as NCC, Skanska, Peab, Svevia, Veidekke, some public clients as STA and municipalities, industry joint organizations as The Swedish Construction Federation (BI) and The Swedish Building Material Federation have participated at this joint project.

2.2 *Goal and scope*

In this paper, EPDs are investigated as a means to overcome some current barriers for assessment of contractor' designs in the bidding process. The contractors at this joint project decided to investigate the using of a standard verification process of LCA-results according to some European standards on EPDs and PCRs (EN 15804:2014, PCR: Highways (except elevated highways), streets and roads, 2013, PCR: Bridges and elevated highways, 2013).

The main goal of this joint project was to develop a conceptual framework for calculation of climate impact from infrastructural constructions, as bridges and roads in EPD-format. The scope was to investigate difficulties and driving forces to deliver climate calculations in EPD-format using data from current-used production and planning systems in Swedish and Norwegian contractor companies.

2.3 *Review of existing LCA-models*

Various available LCA-models for bridges and roads have been evaluated in this project: EKA-model for asphalt roads (Martinsson, 2014), ETSI-model for bridges (Brattebo, 2012) and Klimatkalkylmodell for infrastructural projects (Trafikverket, 2016). All these LCA-models were evaluated to be compatible with requirements according to PCRs for bridges and roads (PCR: Highways (except elevated highways), streets and roads, 2013, PCR: Bridges and elevated highways, 2013) and European standard for EPD (EN 15804:2014). The analysis has showed that all available at the present LCA-models for bridges and roads have some deviations from the requirements according to the standards' requirements.

2.4 *Verified LCA-model*

The steering group in this joint project defined a need for an industry-wide LCA-model, which can support entrepreneurs and other actors to perform a rough calculation of climate impact in the early project stage/bidding and gradually improve climate performance throughout the project. One challenge for that is to be able to plan for the reduction of climate impact already in

the early planning stage where detailed knowledge of solutions and purchased material is missing.

To make comparison of different project alternatives, it is crucial to develop definitions and adoption of a LCA-model as a basis for comparison. The same system boundaries and data quality should be applied into such industry joint LCA-model to allow using of different commercial LCA-software. Comparable data structure on the collected project data should to be broken down to various building components/material according to the EN 15978 (EN 15978:2011). The different input and out flows in performed LCAs should be allocated to related life cycle phases according to EN 15804. The same method of calculation, such as CML-method, according to EPD/PCR' requirements should be used.

There was a request from the companies involved in this project not to develop separate LCA- models for various contract types. A comprehensive LCA-model should fit for all contract types. Swedish municipalities have need for a simplified climate calculation in order to procure suppliers with better environmental performance. Municipalities need to use a model, which supports climate calculation in early planning stage and bidding process. Municipalities would then integrate this LCA-model with their overall work on environment improvement.

Reporting according to the EPD-format includes a mix of accounting and consequence LCAs. For example, Module D of an EPD is such a "consequence LCA ", where all potential missing emissions and "credit" to other product systems should be reported. Even for the use phase should disclose various potential usage scenarios far ahead in time, for example, a particular source of energy.

An important question is how to include the climate impact of the operation and maintenance at the LCAs. The supplier should get credit for using of innovative solutions and products without any maintenance alternatively with shorten the service life. It isn't enough to calculate the climate impact only from the material production (Modules A1-A3), since maintenance and operation actions (Module B1-7) are planned for the entire construction or the construction part and seldom on the material level [6]. Contractors can control this part of building process and can contribute with more environmentally-friendly solutions for A4-C4, e g by optimization of planning, design and production processes. Using environmental assessment only for A1-A3 in evaluation of alternative contractor' designs may leads to a sub-optimization.

The Working Group in this joint project conducted a comprehensive survey of the issues that needed to be sorted out in order to achieve the project goals. In order to perform a sharp test of some main hypothesises about how it's possible to conduct verified climate calculations a configuration of a commercial web-based application to quantify the carbon footprint and energy demand was done in this project.

2.5 *Pre-verification of EPD-tools*

A pre-verification of a digital LCA-tool to produce EPDs doesn't replace the single EPD-verification, but it makes the verification procedure simpler as the tool has been pre-verified to provide selected generic data in accordance with a specified PCR. This is different from EPD Process Certification, which replaces EPD-verification. EPD Process Certification means that the internal procedures and processes of a company to generate verified EPDs are checked yearly by an accredited certification body. There is a possibility to pre-verify and register a digital EPD-tool in the International EPD® System, with the purpose to generate EPDs based on verified data. Alternative uses of the tool (e.g. based on forecasted data or internal improvement of products) could also be foreseen.

For the pre-verification of a digital tool, based on LCA-model according to a specific PCR, e g for bridges or roads following functions in the tool and outside of the tool are required (The International EPD System, 2016):

- Checking of few examples with input data for climate calculations (a material recipe or so-called BoM)
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- Used LCA-databases must be approved, verified and structured according to EN 15804
- Verification of links between building materials, machinery, etc. in the BoM and emission factors, which were used to calculate the environmental impact

- Control of the used system boundaries for the LCA-model (according to PCR and EN 15804)
- Monitoring of the final EPD-report
- The tool should be pre-verified by EPD-operator, Environdec.

2.6 *Verification procedure*

The project has developed a draft for a verification procedure for delivering LCA-data between different players and from different LCA-tools. In the verification procedure were included all important ingredients according to EN 15804, EN 15978, PCRs for bridges and roads and the International EPD® System' requirements for pre-verification of EPD-tools and EPDs. An LCA-model for a standardized climate calculation should include, for example, the generic or project specific emission factors from verified LCA-databases. It must be made very clear boundaries of what should be included in a standard climate calculation, what doesn't and how to verify the accuracy of each calculation step.

The workflow for the calculation of climate impact in EPD-format starts with the BoM-template preparation. Next, it has to be selected or created a mapping of the BoM' items to emissions factors in a LCA-database. The LCA-calculation method should be chosen as well. Then the calculation results should be presented in the pre-defined Word-template for an EPD-report. These steps have been implemented in the developed EPD-tool. Then several project participants tested this EPD-tool in order to calculate climate impact (GWP) and total primary energy for several infrastructural projects.

2.7 *Developed EPD-tool*

The developed EPD-tool can be a delivering hub for communication with verified climate calculations between various market players. Material producers can upload their EPDs for materials; contractors can perform standardized climate calculations for design options before a bidding process etc. Following roles can use the EPD-tool:

- Client, who can evaluate competitive contractor' designs; compare project specific climate calculations with the baseline etc.
- Third part verifier, who can get an easy access to necessary information, required for the verification process for EPDs.
- User with own LCA-tool, who need to verify their LCAs and climate calculations. In this case the user uploads a standardized BoM template with data on an infrastructural project to the EPD-tool. Then calculation of climate impact according to the standardized LCA-model can be done in the EPD-tool. If a calculation result from user's own LCA-tool has deviation less than 5% from a calculation result from the EPD-tool then the own tool calculation can be accepted for verification.
- User with own pre-verified LCA-tool can just upload the final calculation results from the own tool.
- User without LCA-tool can use the developed EPD-tool to perform verified climate calculations for ongoing projects.
- EPD-operator, Environdec performs pre-verification of commercial LCA-tools and final verification of EPDs.

This joint project was concentrated to define some main requirements for a pre-verification process of the developed web-based EPD-tool. All requirements for that were defined in project meetings by the steering and working groups with support of the external consulting Thinkstep AG (Thinkstep, 2016) and the Swedish EPD-operator, Environdec (The International EPD System, 2016). Thinkstep has done some necessary configurations of an existing commercial web based application, LCA service in order to match some of the first requirements from this joint project.

The pre-verification of the developed EPD-tool requires checking of the input data. In this joint project an Excel-based template for preparation of BoM with pre-configured input structure was created. The BoM data was then collected for each infrastructural project from companies' cost estimation systems. The joint project has even developed a pre-configured Word

template with a standard report layout according to the EPD-format. This Word-template was used for the final EPD-report, se Figure 1.

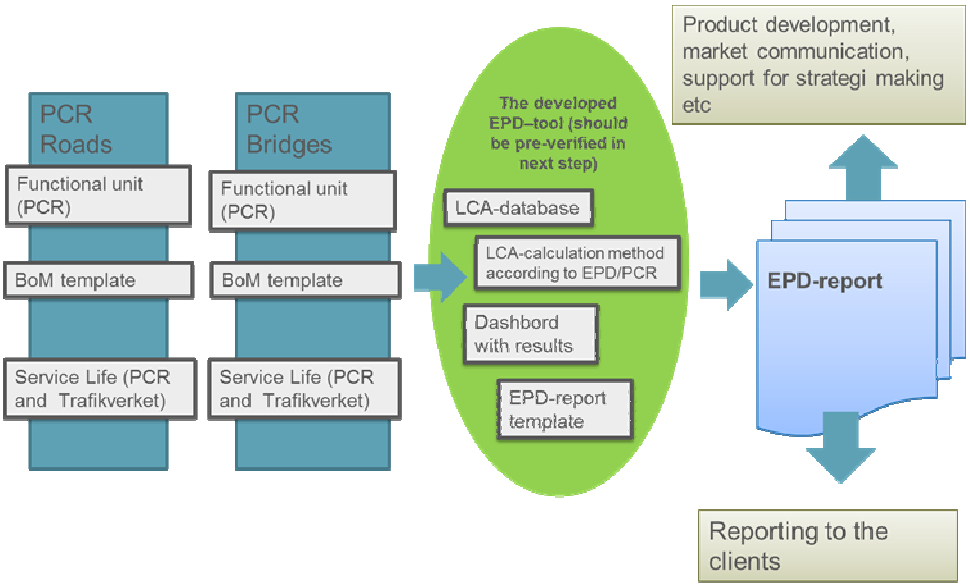

Figure 1. The conceptual framework for the developed EPD-tool for infrastructural constructions (bridges and roads).

2.8 *Developed EPD-tool*

The infrastructures considered for this pilot project are bridges and roads. Four of the group members are participating actively with project examples in order to test the developed EPD-tool. Each participant chose one or two infrastructure example in order to collect data and test this web-based digital tool. The following infrastructure projects have been selected by the four participants for testing:

1. PEAB: bridge over Norrbo River, Sweden (bridge)
2. NCC: road project V27, Borås, Sweden (road)
3. NCC: bridge at the road V27, Borås, Sweden (bridge)
4. Veidekke Industri AS: an airfield in Oslo, Norway (road)
5. Skanska: Motorway E 18, Sweden (road).

Each participant collected life cycle inventory data for the selected infrastructure in the predefined Excel-based template (BoM template). The functional unit for the pilot project is 1 piece of infrastructure. For this reason, the collected data has to be entered in the corresponding BoM for 1 piece of infrastructure (either one bridge or one road). All life cycle phases (materials preparation, construction, operation/maintenance and end-of-life) can be covered in the application depending on what is specified in the BoM. The system boundaries considered as default in the delivered BoM template are described in the following Figure 2.

Participants provided information and data about the construction stage of their infrastructural projects (including materials, transport to construction site and construction site works). Even the material and energy flows for the operation and maintenance were added in the BoM template. The material flows have been collected for A1-A3 and the energy or operating materials flows for B2, according to the PCR' requirements for bridges. Since no specific information about the allocation of materials in maintenance is given in the roads PCR, the same approach as for bridges is assumed. Energy carriers and water are allocated to B2.

It was made some general assumption on the end-of-life scenarios, e g the amount of material to landfill, incineration and recycling. Module C1 (demolition, deconstruction) is not considered in the used BoM template, since no detailed data (e.g. energy, water, etc.) was available.

Upstream Module		**Core Module**	**Downstream Module**						**Other environmental information**
Construction			Operation	Maintenance	End-of-Life				
Raw material supply (extraction, processing, recycled material) Transport to manufacturer Manufacturing	Transport to construction site	Construction of the bridge	Use/application Operational energy use Operational water use	Maintenance, Repair Replacement Refurbishment	Deconstruction / demolition	Transport to end-of-life	Waste processing for reuse Recovery or recycling	Disposal	Benefits and loads beyond the system boundaries (BLBSB)
A1-A3	A4	A5	B1, B6, B7	B2-B5	C1	C2	C3	C4	D
X	X	X	MND	X	MND	X	X	X	X

Figure 2. System boundaries of the BoM template for the tested infrastructural projects (X = declared module; MND = module not declared).

The main intention with the Excel-based BoM template for data collection was that each user can modify this BoM according to their needs following some guidelines and can adapt it for the different project phases. For example if the user wants to analyse a project in tender phase, the BoM template will have to be adapted accordingly. This means that not all life cycle stages and/ or material positions will be covered or given a value. For example, the construction site and therefore the groundworks might not be known yet in the tender phase and will not be included in the BoM for an early stage (e.g. soil and gravel will be set up to zero). It is therefore very important to describe exactly which project phase is being analysed and what is covered in the BoM. The filled out BoM template should be uploaded then to the EPD-tool. All calculations on climate impact can then be performed in the EPD-tool based on the inventory data collection in the uploaded BoM. The considered system boundaries have to be documented at the end in an EPD report with the final results, which can be delivered to a client.

Swedish construction companies use various IT-based internal systems to store the production and planning information. In one of these systems, cost calculation systems entrepreneurs use to create a spreadsheet with the planned purchase of building materials and machine hours for each infrastructural project. The recipes in entrepreneurial cost calculation systems usually contain fragmented input data for the Modules A1 to A3. It is important to note that the cost calculation systems have been developed to be able to make a very rough estimation of project costs. A cost calculation usually is updated for various projects steps: tender, design and production. In some isolated cases the project cost can be updated after commissioning of a project. In this case this cost calculation will content total final cost for the whole infrastructural project: purchased building materials, cost for all work performed and additional costs. However this follow-up calculation isn't the established practice in the construction industry today.

Input data for other life cycle stages are even more difficult to collect from the current production and planning systems. Data for operation and maintenance, percentage of recycled content in building materials, transport of building materials to the construction site are examples of input data for LCA-calculations, which aren't stored in the production and planning system. There are various proposals on how this would be done in the future, for example as part of the information in Building Information Model (BIM).

Another important aspect is that the selection and comparison of design options are currently conducted in the design software such as AutoCAD, Revit etc. Some construction companies try to link the analysis of design options from the CAD/BIM software and the cost calculation system in "real time". This is far from a workable routine standardized in the industry.

The created BoM template in this branch-joint project was based on the rules for the implementation of comparable EPDs for bridges and roads. PCRs must be followed in order to compare the EPDs for infrastructural constructions with similar function. The project participants had to manually modify the project data from their cost calculation systems to match the requirement by EN 15804, EN 15978 and PCRs.

3 RESULTS

The challenge was to break down the vision with this project to a technical specification for implementation of the project. Firstly, several participated contractors tested data collection process and LCA-calculation method, which is recommended by PCRs. Secondly, the project participants created a technical specification for configuration of a web based digital EPD-tool. The verification procedure to check the accuracy of project specific climate calculation was a part of the created specification.

Benefits for the industry from this joint project is more knowledge on the existing gap between the long-term overall planning by the EU and the Swedish government and the contractor's practical work on climate issues in engineering projects. The project has also identified and clarified the requirements for the continued industry-wide cooperation in the development of a verification procedure for calculating of climate impact for civil engineering structures.

Lack of a common business model for using of verified climate calculations and EPDs between different markets players makes it difficult to get any advantage for more sustainable solutions in the infrastructural projects. High cost to produce EPDs for materials/building parts/infrastructural projects discourages the broad-wide use of EPDs as well. The automation of EPD process creation can be achieved by using the developed pre-verified EPD-tool. This tool will reduce the cost of project-specific EPDs.

The working group and the steering committee have had several discussions regarding the approach and the verification process for LCA-data and climate calculations from various commercial LCA-tools. EPD is an environmental declaration of the final product. Adoption of the EPD-format to set up, measure and follow up operational goal for a scarp project should be developed. There are also some uncertainties with using of EPDs as a verification document for a project design’s environmental performance in the tenders. For example it’s unclear with current PCR/EPD- system how to aggregate single EPDs for the construction elements (tunnel, bridge) to calculate the total environmental impact of the entire infrastructural project. Harmonization of the various functional units, assumptions mm in different PCRs for civil engineering structures (bridges, tunnels, etc.) must be standardized by ISO/EN. It would be a great practical benefit to include bridges, tunnels and even a few more of engineering structures in the scope of the same PCR.

Contractors' internal IT-systems for monitoring of ongoing projects (e g Cost Planning System) have a different data structure to store project information, which isn’t compatible with EPD/PCR’ requirements. There is a need for a technical solution to automate collection of project specific data, according to requirements in PCR/EPD. At the moment data collection for climate calculations requires a manual handling. Routines and support to collect data for the entire life cycle of engineering works should be established in the construction companies. This will support unbroken information flow with LCA-data between different market players.

A greater transparency through reporting of climate impact from infrastructural projects in accordance with the internationally established standards will stimulate development of innovative environmentally friendly products. It will also lead to the climate gas reduction and achievement of the goal for Sweden 2050.

4 RECOMMENDATION TO THE NEXT STEP

More tests of the developed EPD-tool should be done for validation of the verification procedure. During this joint project it is foreseen that the participants test some testing examples for one design scenario. More testing scenarios should be developed in the next step (early design, tender, planning, production, additional works and reporting to the client).

This project was the very first stage in developing of a pre-verified EPD-tool for engineering works. The pre-verification of the developed EPD-tool will be done in the next step.

For early planning stage or tender phase should be an industry-wide agreement with listed assumption on the system boundaries (e g level of detail on the bill of materials) and generic emission factors to be used for different materials/construction parts. This industry-wide agreement can be implemented in the developed EPD-tool in the next step.

In the meantime clients should encourage the using EPDs for building parts and the whole infrastructural project. Evaluation of the climate impact from contractor' alternative designs should be done in early tender phase as evaluation of a soft parameter in procurements. This will ensure achievement of the goals of climate neutrality year 2050.

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