### **Innovative Pavement Contracts to Reduce CO2-emissions**

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ABSTRACT. The Norwegian Public Roads Administration (NPRA) has an ambition of reducing CO2emissions from maintenance works by 50 % by 2030. Therefore, a contract strategy involving several new incentives for reaching this goal has been developed. The most important of these is weighting of CO2emissions in monetary terms when awarding paving contracts. This paper describes how this strategy has been implemented for pavement maintenance contracts. An essential component of the strategy is the use of Environmental Product Declarations (EPD's). The first part of the paper describes the framework for EPD's and how an EPD-calculator has been developed specifically for the paving industry. We then go on to describe how the strategy has been implemented in NPRA pavement contracts, and the results achieved so far. In 2021 about 25 % of all NPRA pavement maintenance contracts included CO2-weighting, while in 2022 almost 90 % of all contracts uses this mechanism for allocation. All bituminous materials (asphalt) in the contracts must be documented by EPD's in accordance with EN 15804 + A2:2019. The calculation of CO2-emissions is based on the project specific EPD's. The bidding prices are adjusted according to differences in calculated total CO2-emissions, using a fixed price for CO2. This mechanism has been developed further by combining CO2-weighting with estimated life-cycle costs based on performance related parameters regarding permanent deformations and wear from studded tires. Improved properties for resisting deformations and wear guaranteed by the contractor is used to calculate an increase in expected pavement life, thus reducing the calculated annual cost. This combination of mechanisms implies that there are good incentives for the contractor to optimize the materials with the aim of achieving longer pavement service life as well as lower CO2-emissions. This approach has been used in two pilot-contracts in 2021 and is being used in four pilot contracts in 2022.

An important factor for successful implementation of the new contract strategy is trust, transparency, and accountability regarding calculated CO2-emissions. In Norway this has been achieved by the development of a tool for calculating project specific EPD's. There is also a system in place for third party verification of compliance with the EPD-values for CO2-emissions throughout the contract period.

Experiences with the new contract strategy have been positive, with a reported reduction of 13 % in CO2emissions per ton asphalt from 2020 to 2021.

Keywords. Innovative Pavement Contracts, CO2-Emissions, Life-Cycle Costs.

### Introduction

The Norwegian Public Roads Administration (NPRA) is an administrative body and a provider of national public services, subordinate to the Ministry of Transport. The NPRA is responsible for most of the Norwegian national road network (riksveger), which consists of 10,500 km of main roads. The NPRA is responsible for planning, construction, operating, and maintaining this part of the road network. The NPRA is to strive to reduce the environmental impacts of construction, operation, and maintenance of the road network, and to provide useful services through cost-effective use of public funds. This contributes to Norway's fulfilment of its climate and environmental goals. For construction, maintenance, and operations the goal is to cut greenhouse gas emissions by 50 % by 2030 (Norwegian Ministry of Transport, 2021). The NPRA has developed a contracting strategy for operations and maintenance that implies that all contracts must contain requirements related to the environment, climate, and sustainability in accordance with overall goals and the nature of the tasks involved in the contract. This paper describes how this strategy has been implemented for pavement maintenance contracts. An essential component of the strategy is the use of Environmental Product Declarations (EPD's). The first part of the paper describes the framework for EPD's and how an EPD-calculator has been developed specifically for the paving industry. We then go on to describe how the strategy has been implemented in NPRA pavement contracts, and the results that have been achieved so far.

### Framework for EPD in Norway

An EPD is a concise document that summarizes the environmental profile of a component, a finished product, or a service in a standardized and objective way. The requirements for how an EPD is made are specified in the standard ISO 14025 *Environmental labels and declarations* – *Type III.* An EPD is created based on of a life-cycle analysis (LCA) according to ISO 14040 *Environmental management* – *Life cycle assessment* – *Principles and framework* and ISO 14044 *Environmental management* – *Life cycle assessment* – *Requirements and guidelines.* The content of an EPD must also comply with requirements and guidelines in ISO 14020 *Environmental labels and declarations* – *General principles* and are recommended to meet the requirements of ISO 14021 *Environmental labels and declarations* – *Self-declared environmental claims.* The standardized methods ensure that environmental information within the same product category can be compared across material types and products, making it possible for the customer to assess and make choices based on the environmental declarations.

The Norwegian EPD foundation (*EPD-Norge*) is a program operator for EPD type III according to ISO 14025. The program has established a system for verification, registration, and publication of EPD's as well as maintenance of registers for EPD and Product Category Rules (PCR). The PCRs for construction products for the European market are in compliance with EN 15804 *Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products* + A2:2019. The framework of the EPD-Norge programme is shown in Figure 1.



Figure 1. Framework of the EPD-Norge programme (EPD-Norge, 2019)

The light grey boxes show activities relating to administration and the EPD-forum, the green boxes show activities relating to the development of EPD's and verification and the dark grey boxes show activities relating to PCR development. The blue box represents PCR hearings.

### EPD-calculator for the Norwegian asphalt industry

To make implementation of the use of EPD's in the Norwegian asphalt industry more practical the Norwegian Contractors Association (EBA), together with EPD-Norge and other partners including the NPRA, in 2017 developed a cloud-based computer program for generating EPD's for asphalt materials. The program can be used by each individual supplier (contractor) to generate project specific EPD's including transportation and in-situ construction works. This makes the process of producing project specific EPD's effective and simple, while at the same time ensuring transparency and trustworthiness through a common database containing basic environmental data (e.g., CO2 per kg for each type of material). This database is administered by the system operator (*LCA.no*) and cannot be accessed or changed by the users of the system. The development of the EPD-generator has been an important prerequisite for the rapid implementation of e.g., CO2-weighting when allocating pavement contracts by the NPRA and other public clients. A system overview of the EPD-generator is shown i figure 2.



Figure 2. System overview of the EPD-generator computer program for asphalt (Iversen, 2021)

# Use of EPD's in pavement contracts

In recent years the annual production of asphalt in Norway has been about 7 million metric tonnes. Of this about 20 - 25 % has been warm mix asphalt, i.e. asphalt produced at lower temperatures than normal hot mix asphalt (EBA, 2020). In 2020 the average CO2-emissons in NPRA pavement maintenance contracts was about 62 kg CO2/tonne asphalt, when including the production and construction installation stages (A1 – A5):

- A1: Production of raw materials
- A2: Transportation of raw materials
- A3: Production of asphalt mix
- A4: Transport of asphalt mix
- A5: In situ paving works

The average contribution of the different stages to CO2-emissions for asphalt in the NPRA pavement maintenance contracts in 2020 was as shown in Figure 3. The figures are based on EPD's from all contracts.



Figure 3. Average proportion of CO2 emissions for different stages (A1-A5) of asphalt in NPRA contracts 2020

The NPRA have actively supported and cooperated with the Norwegian asphalt industry in their efforts to reduce CO2-emissions from production of asphalt pavements. The best tool is to use incentives and mechanisms in the contracts. Together with EBA the NPRA have gradually phased in the use of EPD's in pavement maintenance contracts, beginning in 2018. The steps have been:

- (1) Requirement for contractors to deliver any available EPD's
- (2) Requirement for contractors to deliver EPD's in all contracts
- (3) Use of CO2-weighting in allocation of some contracts, based on EPD's
- (4) Use of CO2-weighting in allocation of more contracts, and increasing the price of CO2
- (5) Use of CO2-weighting combined with life-cycle costs in pilot contracts

The mechanisms used in CO2-weighting in allocation of contracts is as follows:

- The EPD's are used to calculate a CO2-budget for each bidder on the contract, including the production and construction installation stages (A1 A5)
- The bidder with the lowest total CO2-budget has no addition to the bidding sum
- The other bidders have their bidding sums increased by adding 5 NOK per kg CO2 they are over the lowest bidder's CO2-budget (≈ 0,5 €/kg CO2).
- The contract is allocated to the bidder with the lowest adjusted bidding sum
- The contract sum is equal to the original bidding sum of the winning contractor

At the end of the contract an account of actual CO2-emissions must be provided by the contractors. If the final account deviates more than 5 % from the original CO2-budget, then a bonus (5 NOK/kg CO2 for lower total emissions) or a penalty (10 NOK/kg CO2 for higher total emissions) is triggered.

There has been some discussion about the price of CO2 used for calculating the adjusted bidding prices. In the first year this mechanism was used a price of 2 NOK/kg CO2 was used, but this was found to be too low to have the desired effects. After consultation with the contractor association (EBA) the price was increased to its current level of 5 NOK/kg CO2. It is important that the price of CO2 is high enough to allow contractors to make the necessary investments, e.g. in production plants, and still be competitive.

In 2021 about 25 % (7 of 27) of NPRA pavement maintenance contracts used CO2weighting. Two of these were pilot contracts which combined CO2-weighting and life-cycle costs. In 2022 CO2-weighting is being used in almost 90 % (24 of 27) of the contracts, of which four use combination of CO2-weighting and life-cycle costs (pilot contracts).

Using EPD's directly in allocation of contracts requires that both the client and the bidding contractors can trust in their validity and that they can be verified throughout the contract period. Therefore, the NPRA requires that the contractors submit extra background information about the EPD's, which is used to verify them throughout the contract period. This includes, among other things, information about:

- Type and amount of binder, including any biogenic binder
- Amount of recycled asphalt, including bitumen content
- Type an amount of additives
- Type and amount of aggregates within each fraction size
- Information about transportation of raw materials
- Sources of energy used in production plant and planned production temperature
- Information about transport of asphalt from production plant to site

• Information about equipment used for laying and compacting asphalt on site

In addition, the NPRA uses a third-party verification process, which is described in a later section of this paper.

## Combining CO2-weighting with life-cycle costs in allocation of contracts

Although the focus on CO2-emissions from asphalt production is important, it is even more important that the CO2-emissions over the total life cycle of pavements is as low as possible. It is also important to achieve as low life-cycle costs as possible. A long pavement life is usually beneficial for both goals, and it is important to avoid sub-optimal solutions. Therefore, the NPRA have tried out a mechanism where CO2-weighting is combined with estimated life-cycle costs in contract allocation. There were two such pilot contracts in 2021, and four more are being carried out in 2022.

In these pilot contracts the bidders are free to choose their own mix designs, irrespective of requirements given in the pavement design manual (NPRA, 2021) regarding materials and composition. They must fulfil functional requirements related to stability against permanent deformations, resistance to rutting from studded tires, good durability, and acceptable friction. For the pilot contracts rutting is assumed to be the critical parameter for length of pavement life. Rutting is caused by permanent deformation and wear from studded tires. A normal pavement life is expected if the values given in Table 1 are achieved for stability (wheel track) and resistance to wear from studded tires (Prall-value).

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Parameter	Standard	AADT 5 000-10 000	AADT > 10 000
Stability (Wheel Track PRD <sub>AIR</sub> )	NS-EN 12697-22	7 %	5 %
Stability (Wheel Track WTS <sub>AIR</sub> )	NS-EN 12697-22	0,06	0,04
Wear (Prall-value)	NS-EN 12697-16	25	22

Table 1. Requirements related to rutting for achieving normal pavement life

In the pilot contracts the normal pavement life is assumed to be 10 years. The bidders may choose to offer different asphalt qualities regarding rutting. If so, the calculation rules used to transform these to changes in pavement life are shown in Table 2.

Table 2. Rules for calculating changes in pavement life

	Percentage of vehicles using		
	studded tyres		
Damage mechanism/Test method	Low	Medium	High
	< 40 %	40 - 60 %	>60 %
Prall (change in pavement life in % for each unit	0,5 %	1 %	2%
change in Prall-value for AADT >10 000)			
Prall (change in pavement life in % for each unit	0	0,5%	1 %
change in Prall-value for AADT 5 000 – 10 000)			
Wheel Track (increased pavement life in % for each	12 %	10%	8 %
unit decrease in WT-value (PRD <sub>AIR</sub> ))			

As an example, one may consider a road section with medium level of vehicles using studded tyres and an  $AADT > 10\ 000$ . If a contractor e.g., offers a Prall value = 19 this is an improvement

of 3 units compared to the requirement for achieving a normal pavement life of 10 years. Using the rules in Table 2 this is transformed to an increase of 3 % in pavement life, i.e. 0.3 years. If the same contractor also offers a WT-value (PRD<sub>AIR</sub>) = 3.5 %, this represents a 1.5 unit improvement compared to the value given in Table 1. This means a calculated improvement in pavement life of 1.5 \* 10 % = 15 %, i.e. 1.5 years. The total calculated increase in pavement life is thus 1.8 years compared to the assumed normal pavement life of 10 years.

When allocating the contract, the bidding sum is first corrected for CO2-emissions as described in the previous section of this paper. Then the annual cost is calculated as follows:

$$Annual \ cost = \frac{Bidding \ sum \ adjusted \ for \ CO2 \ [NOK]}{Adjusted \ pavement \ life \ [years]}$$
(1)

The contract is allocated to the bidder with the lowest calculated annual cost. The contract sum equals the original bidding sum. In the case of deviation between offered quality in the bid and actual quality in-situ, the penalty is calculated as the value of lost pavement life.

### Third party verification of EPD's

The increased use of EPD's in pavement contracts has triggered a need for independent, thirdparty verification. Therefore, the NPRA has involved the notified body according to the Construction Products Regulation, *Kontrollrådet*, to act as an independent verifier of the EPD's that are used in the contracts. *Kontrollrådet* is established as a private foundation. It is accredited for certification of products, quality systems and environmental systems, including Class P – Aggregates and Class S – Asphalt and Bituminous Mixtures. One of their tasks is to certify asphalt production plants according to NS-EN ISO 9001 and 14001. During their annual visits to the production plants, they now also do a verification of the EPD's used in the contracts, e.g. energy sources, aggregate types, bitumen grade, additives etc. They report back to the NPRA about their findings. Together with the contractor organisation (EBA) the NPRA have taken the initiative to develop a simple certification process for asphalt EPD's. The aim is to have this ready for use before the 2023 paving season.

### Conclusion - Results of the new contract strategy

The main result of the new contract strategy is that the contractors have a real incentive to reduce CO2 emissions when doing pavement maintenance for the NPRA. In the last two years (2020 - 2021) the NPRA has seen a reduction in the average CO2 emissions per tonne asphalt of about 13 % in pavement contracts, from 62 kg CO2 per tonne asphalt in 2020 to 54 kg CO2 per tonne asphalt in 2021.

The NPRA also observes that innovative approaches are being implemented by the contractors to minimise the CO2 emissions for all stages of the paving process. One example is the use of biogenic binders to replace some of the bitumen. Many producers have also changed to alternative energy sources for heating of materials in their production plants, e.g. LNG, biogas/bio-oil or wooden pellets. They are also focusing on optimising the supply chain of materials used in asphalt production, e.g. reducing the transport distances for aggregates. Reduction in production temperature, ensuring low water content in aggregates and increased use of recycling are other examples of typical measures being taken.



Figure 4. Asphalt with added biogenic binder on E14 near Meråker (Photo: Ellinor Hansen, NPRA)

The pilot contracts combining CO2-weighting with life-cycle costs inspires contractors to utilise their best knowledge and craftmanship to produce pavements with long pavement lives with a minimum life cycle cost and low CO2 emissions.

Allocating contracts based on other criteria than lowest bid obviously means that the NPRA may be paying more for pavement maintenance in a given year, but contributing to reducing CO2 emissions in the long run with the lowest possible life-cycle costs. In 2022 the NPRA are paying about 8.5 million NOK ( $\approx \in 850,000$ ) more than if the lowest bids had been allocated for every contract. This represents about 0.8 % of the total value of the pavement maintenance contracts this year. In addition come the costs associated with any bonuses for further reduction of CO2 during the contract period. Weighting of CO2 alone or in combination with life-cycle costs was decisive for allocation of 7 of 27 contracts in 2022, i.e. the contract was not awarded to the bidder with the lowest price.

It has been a quite steep learning curve for all parties involved. The NPRA have taken measures to increase the knowledge needed in the organisation to be able to implement the new contract strategy and acknowledge that this effort must be continued in the years to come. The NPRA still needs to gather more experience with the new contract strategy, and to further refine and develop it together with the pavement industry.

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