

Construction estimate for an immersed tunnel - comparison with the Planning Act

1. Introduction

The remarks to the Planning Act of April 2009 estimated an immersed tunnel to cost EUR 5.5 billion. This was based on a feasibility study prepared by Cowi-Lahmeyer and published by the Danish and German Ministries of Transport in 1999.

The current construction estimate for an immersed tunnel is based on a new conceptual design prepared by Rambøll-Arup-TEC JV, which reveals a lower construction estimate in that the cost of a tunnel solution is now expected to cost EUR 5.09 billion. The estimate comprises the costs of the planning phase amounting to EUR 252.5 million which has been granted pursuant to the Planning Act and the supporting appropriation document (aktstykke) of 3 June, 2010. It should be noted that the current construction proposal was prepared prior to the Environmental Impact Assessment.

This document analyses the key reasons for the difference between the two construction estimates.

First, it is important to point out that there is a significant difference between the two immersed tunnel projects even if, superficially, there are many similarities.

With regard to the preparations for the current conceptual design, Rambøll-Arup-Tec JV has embarked on the design of an entirely new immersed tunnel solution inspired by the feasibility study's conceptual design. This is to ensure that the tunnel solution will offer the best technical solution based on current construction and civil engineering know-how.

This document, therefore, exclusively focuses on the main differences between the two projects. It does not provide a full overview of all the differences between the two projects. For an overview of some of the major technical differences between the two projects, please refer to the appendix.

¹ The document is a supplement to the consolidated construction estimate. For a full explanation of the component elements in the construction estimate, please refer to this document.

Table 1: Construction estimate

2008 prices	Construction estimate 2010*	Planning Act	Difference
Construction costs	EUR 3.49 billion	EUR 4.34 billion	EUR -0.85 billion
Other works	EUR 0.26 billion	EUR 0.02 billion	EUR 0.2 billion
Total construction costs**	EUR 3.75 billion	EUR 4.36 billion	EUR -0.61 billion
Project management, operational preparations etc.	EUR 0.70 billion	EUR 0.51 billion	EUR 0.19 billion
Reserves	EUR 0.64 billion	EUR 0.71 billion	EUR -0.07 billion
Total gross costs**	EUR 5.09 billion	EUR 5.58 billion	EUR -0.49 billion
Expected EU subsidy	EUR 0.62 – 1.1 billion	EUR 0.63 billion	EUR -0.01 – +0.47 billion
Total net costs**	EUR 3.99 – 4.48 billion	EUR 4.97 billion	EUR -0.98 – -0.49 billion

* The construction estimate comprises the EUR 252.5 million which has already been granted in accordance with the Planning Act and the supporting appropriation document of 3 June, 2010.

** The total can differ from the individual items after rounding up

2. Construction costs

It is estimated that the construction costs of a tunnel project will amount to EUR 3.49 billion, which is EUR 0.85 billion less than the Planning Act. The change can be divided into two elements c.f. Table 2: 1) the difference between the projects 2) Harmonisation between the bridge and the tunnel project.

Table 2: Changes to construction costs

2008 prices	
Difference between the projects	EUR -0.75 billion
Harmonisation	EUR 0.11 billion
Total	EUR -0.84 billion

The two items are analysed in the following section.

Difference between the projects

Femern A/S' tunnel consultant, Rambøll-Arup-TEC JV, has prepared a construction estimate for the tunnel project which is EUR 0.9 billion below the construction estimate in the Planning Act. This is due to the number of differences between the two projects, c.f. Box 1

Box 1: Changes in the tunnel project with major financial consequences

Increases

Increased costs for railway and road system	+ EUR 147.7 million
Increased costs for installations	+ EUR 134.2 million
Full emergency lane on motorway	+ EUR 53.7 million
Sprinkler system for fire prevention	+ EUR 47.0 million
Lighting in road tunnel	+ EUR 20.1 million

Savings

Standardisation and reduction in number of elements etc.	EUR – 778.5 million
Tunnel length from 18.5 m to 17.6 m	EUR – 228.2 million
Changed ventilation system	EUR – 214.8 million
Reduced dredging of materials	EUR – 174.5 million

N.B. The list is not exhaustive. All amounts in 2008 prices.

Among the changes that have resulted in increases are additional costs for rail and road facilities of around EUR 0.1 billion. These costs include the added costs of 4-5 km extra motorway and railway on Fehmarn and Lolland as well as changes to the estimates for the rail facilities in the tunnel.

Another significant increase is the increased costs for the technical installations of around EUR 0.1 billion which comprises costs for intelligent traffic control systems and improved communication and marking systems.

Added to this are the increased costs of a full emergency lane, the installation of sprinkler systems for fire prevention on the road and railway and the addition of lighting in the road tunnel, bringing the total extra expenses to around EUR 120.8 million.

With regard to the changes that have led to the savings, four elements of major importance should be taken into consideration.

The biggest savings of around EUR 0.8 billion derive from the optimisation of the tunnel elements which, to a significant extent, allows the elements to be standardised, which will reduce production costs. Moreover, the number of standard elements has been reduced from around 120 to around 79, which not only lowers production costs, but also the costs of immersing the elements, i.e. owing to fewer immersion operations. In addition, the number of element assemblies will be reduced accordingly.

Under the conceptual design, the overall length of the tunnel is reduced by almost 1 km, which means savings of approx. EUR 0.2 billion.

The changes to the ventilation system (longitudinal ventilation as opposed to transverse ventilation) result in overall savings of EUR 0.2 billion. In particular, this is because the changes to the tunnel ventilation system enable the tunnel's transverse section to be reduced so that the need for special ventilation channels, and for a ventilation island, has been eliminated. As a result, certain specialised tunnel constructions are no longer necessary.

One effect of the optimisation of the tunnel design and the tunnel's reduced length is that the amount of excavated material will be reduced by around 4.5 million m³, resulting in savings in relation to dredging and the subsequent deposit of material. Overall, this means savings of around EUR 0.2 billion.

Harmonisation between the bridge and tunnel projects

Femern A/S has examined the two construction estimates for a bridge and a tunnel solution to allow for the two projects to be compared. Accordingly, the same costs for the same services have been applied (salaries, concrete, steel etc.) as have similar assumptions regarding the costs of auxiliary inputs etc. in both construction estimates. In addition, costs relating to the contractor's guarantee deposit have been included. These were not included in the consultants' construction estimate.

This harmonisation has added EUR 103.1 million to the tunnel consultants' construction estimate.

3. Other works and reserves

The Planning Act's construction estimate comprised a total of EUR 0.7 billion for certain other works (EUR 26.8 billion) and reserves (EUR 0.7 billion). It was known that there would be a need for further funds for other works, but these costs were assumed to be covered by reserves and with a few exceptions not specified further.

In connection with the preparation of the current construction estimate, Femern A/S has carried out a detailed assessment of the costs of other works which are assessed to total EUR 0.3 billion.

A detailed calculation of the need for reserves for client and contractor risks has also been carried out and around 1 per cent of the total gross cost has been allocated as free reserves. This means that there is deemed to be a need for reserves of EUR 0.6 billion.

In the current construction estimate, a total of EUR 0.9 billion has been allocated for other works and reserves, which is EUR 0.2 billion more than estimated in the Planning Act. At a rough estimate, it is estimated that the costs of other works have increased by approx. EUR 94.0 million while the reserves for client risks, contractor risks and free reserves have risen by approx. EUR 67.1 million.

The higher costs should be seen against the fact that the current construction estimate contains a more detailed assessment of the need for reserves and costs for other works than in the preparations for the Planning Act. The current estimate for reserves and other works has thus become more comprehensive and more robust than that for the Planning Act.

Project Management, operational preparations, etc.

The final difference is the increase in respect of project management, operational preparations etc. which, at the current time, are expected to amount to EUR 0.7 billion against the Planning Act's EUR 0.5 billion. This constitutes an increase of approx. EUR 0.2 billion due to several factors.

In the first place, the planning phase proved more expensive because of the increased requirements with regard to the environmental investigations. This was dealt with in the supporting appropriation document of 3 June, 2010, which accepted increases of approx. EUR 53.7 million.

Secondly, based on a review of the expected costs relating to the tendering process with a total contract sum of over EUR 4.0 billion, it is estimated that there is an additional need for around EUR 40.3 million extra for this phase above what was anticipated when the Planning Act was approved.

Thirdly, the extended construction period (expected opening in 2020 rather than 2018) etc. has increased expenditure for the client organisation and for external consultancy in the region of EUR 80.5-94.0 million.

Appendix – Technical comparison between the conceptual design and the feasibility study

	Conceptual design	Feasibility study 1996 – 1999
Length		
- Immersed tunnel, km	17.6 km	18.5 km
- Closed tunnel length (incl. portals)	18.14 km	n.a.
- Road length	25.5 km	Approx. 20.4 km
Standard elements		
Number	79	Approx. 120
Length	217 m	Approx. 150 – 175 m
Maximum weight	Approx. 73,500 t	Approx. 68.000 t
Height of transverse section	8.9 m	9.95 m
Width of transverse section	42.2 m	43.0 m
Special elements		
Number	10	Approx. 10
Length	46 m	Variable
Dredging volumes	15.5 million. m ³	>20 million m ³
Ventilation issues		
Ventilation islands	No	Yes
Ventilation principle	Longitudinal	Transversal
Air intake / outtake	Exclusively in portal buildings, no ventilation island and no ventilation towers	Ventilation towers in the portal buildings and in the ventilation island in the middle of the Fehmarnbelt
Safety conditions		
Distance between emergency exit	108 m	Approx. 170 m
Fire prevention	Fire service contact point every 108 m Sprinkler system	Fire service contact point every 170 m. No sprinklers
Emergency lane	Yes – full emergency lane	No
Escape route and installation corridors	Between the two road tubes	Between the two road tubes and between the two rail tubes