Programme Area: Carbon Capture and Storage

Project: Thermal Power with CCS

Title: Classification of Cost Estimate in Context of Global CCS White Paper 'Toward a Common Method of Cost Estimation for CO2 Capture and Storage at Fossil Fuel Power Plants'

Abstract:

This note provides a summary of how the CAPEX cost estimate provided in D4.1 maps on to the GCCSI's proposed approach to standardise CCS cost estimates.

Context:

The ETI's whole energy system modelling work has shown that CCS is one of the most cost effective technologies to help the UK meet its 2050 CO2 reduction targets. Without it the energy system cost in 2050 could be £30bn per annum higher. Consequently, ETI invested £650,000 in a nine month project to support the creation of a business case for a large scale gas with CCS power plant, to include an outline scheme and a 'template' power plant design (Combined Cycle Gas Turbine with post combustion capture), identify potential sites in key UK industrial hubs and build a credible cost base for such a scheme, benchmarked as far as possible against actual project data and as-built plant. The ETI appointed engineering and construction group SNC-Lavalin to deliver the project working with global infrastructure services firm AECOM and the University of Sheffield's Energy 2050 Institute.

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TECHNICAL NOTE

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Project:	Thermal Power with CCS GBC	**Project No.:**	181869
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Introduction

The UK Government retains the belief that CCS could play a crucial role in the future energy system. The ETI's analysis has shown that the best route to reliable, cost-effective and investable CCS in the UK is to build one or more power with CCS schemes, using best-proven technologies in the most beneficial locations at size which maximises the benefits of scale. However, stakeholders in CCS would need compelling evidence of the business case for a power with CCS project. Therefore the ETI has identified a need to develop a clear vision of what a cost-effective gas power with CCS scheme might look like and provide a clear and credible performance and cost information for such a scheme. To achieve this, the Generic Business Case project involved developing an outline scheme and 'template' power plant design (Combined Cycle Gas Turbine (CCGT) with post combustion capture) and identifying how this might be built and operated at selected sites around the UK.

SNC-Lavalin has developed a template plant design, a capital cost estimate, and an operating cost model for a large scale deployment of CCGT + CCS for the UK. SNC-Lavalin has been supported by AECOM who have identified potential site locations for such a plant and the University of Sheffield who have supported the project with technical and policy expertise.

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The GBC project reviewed and compared 5 separate regions in the UK for the deployment of CCGT + CCS and analysed the scale of such a scheme for 1 to 5 trains[1] of CCGT + CCS.

Objective of Technical Note

In March 2013, the Global CCS Institute published a paper entitled 'Toward a Common Method of Cost Estimation for CO_2 Capture and Storage at Fossil Fuel Power Plants' (Global CCS Institute, 2013). This paper presents terminology that the Institute has put forward as a suggested standard for the categorisation of cost categories for power and CCS projects.

Earlier in 2017, SNC-Lavalin produced a capital cost and operating cost estimate for the Energy Technologies Institute which contained the elements detailed in the Global CCS paper; however, categorised the costs differently. This technical note aims to identify the cost within each category as detailed in Table 4 of the Global CCS Institute paper from the SNC-Lavalin cost estimates, and identify any differences, additions, or omissions from the reference classifications.

Definitions

Bare Erected Cost (BEC) – total cost for equipment and labour (direct and indirect). May include sales tax if applicable.
Total Plant Cost (TPC) – BEC + engineering, procurement, and construction costs as well as design and project contingencies
Total Overnight Cost (TOC) – TPC + owner's costs including insurance, land costs, surveys, permitry and consenting, and start-up costs
Total Capital Requirement (TCR) = TOC + cost escalation and interest costs during construction

Table 4	SNC-Lavalin Estimate	Differences/Limitations
Bare Erected Cost	Equipment + materials + labour + subcontracts + site enabling (includes temp facilities)	In some subcontracts, the contractor's fees and detailed design that may be included in TPC by the CCS Institute definition are included as BEC. These subcontracts include: • HV connections • Gas pipelines • CO_2 pipelines
Total Plant Cost	= Above costs + Contractor's Soft Costs, Commissioning (Contractor), Contingency	These items are itemised in each area of SNC-Lavalin's estimate, or included in the subcontracts above.

[1] A 'train' in this context means a single gas turbine with a heat recovery steam generator (and steam turbine), a single capture unit with one absorber vessel and one stripper and a single compressor. Multiple trains then feed into a single CO_2 export pipeline.

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Table 4	SNC-Lavalin Estimate	Differences/Limitations
Total Overnight Cost	= Above costs + Owner's Costs, • Owner's Commissioning, Owner's Start-up, Land Acquisition, feasibility studies, insurance, permitting, finance costs, pre-paid royalties, initial chemicals and inventory, start-up • Other site specific requirements: improvements beyond battery limits, economic development incentives	SNC-Lavalin did include most owner's costs, with the exceptions of royalties and financing costs. SNC-Lavalin's scope did not include improvements beyond battery limits, unusual site improvements beyond basic site assumptions, economic development.
Total Capital Requirement (TCR)	Interest during construction, cost escalations during construction	SNC-Lavalin were instructed to specifically exclude these elements from the cost estimate.

Overall, the SNC-Lavalin Capital Cost estimate has a clear Total Plant Cost (TPC) if Owner's costs, which are a separate line item on each of the 4 main pages, as well as first fills, spares, and start-up are removed.

The Total Overnight cost may be ascertained with additional estimating effort to determine additional site specific costs that were beyond the scope of the Generic Business Case, such as transmission upgrades and local economic development incentives.

Total Capital Requirement may be determined based on the Total Overnight cost using a time-based financing model and assumptions for interest rates and cost escalation. A basic construction schedule was provided as a part of the Generic Business Case to assist in the time-distribution of construction spend.

SNC-Lavalin Cost Estimate

Table 4	SNC-Lavalin Estimate	References
Bare Erected Cost	Detailed equipment list formed basis for major equipment costs Cost Estimate detailed for equipment, materials, labour, and subcontracts Add in site enabling works, which includes temporary site facilities Deviation: Contractor's costs included in subcontract estimate for connection costs 23.3 to 29%). Included in	Major Equipment List - 181869-0001-T-ME-MEL-AAA-00-00001 Capital Cost Model – 181869-0001-T-PC-CAL-AAA-00-00006 Cost Estimating for Site Selection – 181869-0001-T-EM-TNT-AAA-00008. Not all backup could be submitted to the ETI

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Table 4	SNC-Lavalin Estimate	References
	Technical Note for Cost estimating for Site Selection Deviation 2 – BEC includes process/design contingency. This is detailed as Design Margin in the Capital Cost report.	due to IP (confidential supplier bids). Detailed Report – Plant Performance and Capital Cost Estimate, – 181869-0001-T-EM-REP-AAA-00-00004, Section 2.12 Design Criteria
Total Plant Cost	Capital Cost Estimate Details Total Plant cost, but deletions are required: • Contractor's commissioning • First Fills • Spares • Owner's Costs • Start-up Costs Contractor's Contingency is included at a rate of 10% in the contractor's costs. Project Contingency may be added back at this point with reference to the Contingency values detailed in the Capital Cost Report, Section 8.14 Uncertainty, or Attachment 14. Deviation: some specific costs are not identified in the Capital Cost model, such as commissioning costs for pipelines. The cost data provided is protected by IP and as such the subcontractor costs cannot be presented in greater detail.	Capital Cost Model – 181869-0001-T-PC-CAL-AAA-00-00006 Contractor's Contingency – Detailed Report – Plant Performance and Capital Cost Estimating – – 181869-0001-T-EM-REP-AAA-00-00004, Attachment 9
Total Overnight Cost	Total Cost as presented in estimate. Deviation: Does not include costs beyond scope, such as transmission upgrades, or economic development incentives.	Capital Cost Model – 181869-0001-T-PC-CAL-AAA-00-00006 Detailed Report – Plant Performance and Capital Cost Estimate – 181869-0001-T-EM-REP-AAA-00-00004
Total Capital Requirement (TCR)	Not in Scope, although documents have been provided to assist in the valuation of construction related costs (financing, over time	EPC Schedule – Detailed Report – Plant Performance and Capital Cost Estimating, – 181869-0001-T-EM-REP-AAA-00-00004, Attachment 12

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Table 4	SNC-Lavalin Estimate	References
		Cost Distribution Through Construction – Detailed Report – Plant Performance and Capital Cost Estimating, – 181869-0001-T-EM-REP-AAA-00-00004, Attachment 13

OPEX

The OPEX estimate format is suggested by the Global CCS Institute as a breakdown between Fixed and Variable O&M costs. The following table details the cost breakdown as recommended in Table 5 of the Global CCS Institute Paper referenced in this document and a comparison the SNC-Lavalin OPEX estimate submitted:

Cost Element	SNC-Lavalin	Comments/References
Fixed O&M Costs		
Operating Labour Maintenance Labour Administrative and Support Labour	Labour is listed under Fixed Expenses in the summary, and subcategorised under these areas: Operations, Maintenance, Reservoir Team, Exec/Senior Management, and Administration. Reservoir team could be combined with operations, whilst management and administration could be combined as well.	Plant Operating Cost Modeling – 181869-0001-T-EM-0REP-AAA-00-00005 Operating Cost Model – 181869-0001-T-PC-CAL0AAA-00-00004
Maintenance Materials	Not specifically identified Assumed as part of small tools and consumables (Other Expenses), 2 years spares, maintenance by year costs, and maintenance subcontract costs.	Operating Cost Report – Attachment 2 – Maintenance Routine, Attachment 4- O&M Subcontracts
Property Taxes	Included in 'Other Expenses' as Local Taxes.	Plant Operating Cost Modeling – 181869-0001-T-EM-0REP-AAA-00-00005, Section 6.9
Insurance	Included in 'Other Expenses' though separated in discussion in major report	Plant Operating Cost Modeling – 181869-0001-T-EM-0REP-AAA-00-00005, Section 6.8

Cost Element	SNC-Lavalin	Comments/References
Variable O&M Costs		
Fuel	Identified as a 5-year average rate, but adjustable in OPEX model provided	Plant Operating Cost Modeling – 181869-0001-T-EM-0REP-AAA-00-00005, Section 9.3
Other Consumables	Consumables schedule	Plant Operating Cost Modeling – 181869-0001-T-EM-0REP-AAA-00-00005, Section 9.3
Waste Disposal	Included in Variable costs	Plant Operating Cost Modeling – 181869-0001-T-EM-0REP-AAA-00-00005, Section 9.3, Figure 13
CO_2 Transport	Capital Cost	Capital Cost Model – 181869-0001-T-PC-CAL-AAA-00-00006
CO_2 Storage	Capital Cost	Capital Cost Model – 181869-0001-T-PC-CAL-AAA-00-00006
Byproduct Sales	Not considered (revenue)	
Emissions Tax	Cost of Carbon estimated for this report Carbon credit (revenue) not considered as out of scope	Plant Operating Cost Modeling – 181869-0001-T-EM-0REP-AAA-00-00005, Section 5.6

OPEX costs overall are in alignment with the guidance provided by the Global CCS Institute guidelines provided. Analysis in the context of the Global CCS Institute nomenclature and classification did not identify any major deviations or omissions.

Estimate Categories – Levels of Cost Estimates

SNC-Lavalin has described its cost estimate as a Class IV or slightly better, as detailed in the Detailed Report – Plant Performance and Capital Cost Estimate – 181869-0001-T-EM-REP-AAA-00-00004 Section 2.18, based on the AACE classifications. SNC-Lavalin has described the OPEX estimate as in alignment with the principles of an AACE Class IV estimate, as explained in the Plant Operating Cost Modeling – 181869-0001-T-EM-0REP-AAA-00-00005, Section 6.

In comparison, the Global CCS Institure Classification would fall between a Class I and a Class II. The engineering design information is more aligned with a Class I estimate, as detailed engineering has not been performed for each piece of equipment, and flow diagrams have not been done for the other disciplines. The Cost Basis; however, means that based on the engineering data available, recent cost data is available, and materials and labour costs are available and may be scaled to suit.

This would place the SNC-Lavalin estimate on the more refined end of the Class I estimate, moving toward Class II.

Summary

Most cost data is available from SNC-Lavalin's work on the capital cost estimates to determine costs up to Total Overnight costs, with the exception of a few items that were out of scope. The exception to this is contractor costs on connection subcontracts, for which an estimated figure has been provided. The data is not presented in the Global CCS Institute recommended format, but not difficult to extract.

The cost estimate work for operating costs falls within the guidelines provided by the Global CCS Institute.