INSITUTE OF APPRAISERS & COST ENGINEERS (IACE)
(A Division of the Nigerian Society of Engineers)

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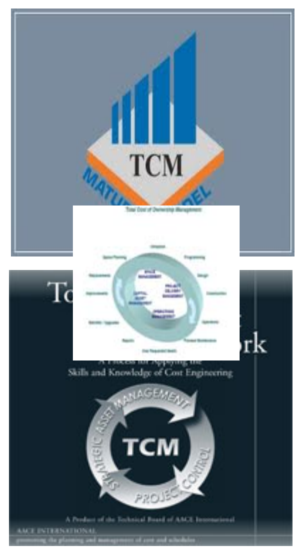
Theme:

COST ENGI₦€£RING
in Total Cost Management of the Economy

By



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PROTOCOLS
President, Nigerian Society of Engineers
Chairman, institute of Appraisers & Cost Engineers
Hon. Minister, Industry, Trade & Investment
Hon. Minister of State, Ministry of Niger Delta Affairs
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Fellows & Members of NSE
Accredited Valuers, Accredited Cost Engineers & Accredited Engineering Economists
Gentlemen of the Press
Distinguished Ladies & Gentlemen
Greetings.

1.0 INTRODUCTION

I have taken it upon myself this morning to discuss with your noble selves how Cost Engineering skills and knowledge can be integrated through the work process of Total Cost Management (TCM).

We shall also examine how Cost Engineering skills and knowledge can be integrated within the competency of a cost engineering professional and the collective competencies of an organization, to add value to and aid sustainability of an enterprise.

From here we would need to explore and understand how cost engineering skills and knowledge about individual resource types guide and control the process of creation of an asset.

2.0 WHAT IS TOTAL COST MANAGEMENT

At this juncture we might just define some key terms that will aid understanding of the framework of our discussion. It is thus necessary to put the searchlight now on Total Cost Management, and then Cost Engineering.

2.1 TOTAL COST MANAGEMENT (TCM)

The Constitution of AACE (formerly *American Association of Cost Engineers*) defines Total Cost Management as follows:

> "*Total Cost Management is the effective application of professional and technical expertise to plan and control resources, costs, profitability and risks*."
> Simply stated, "*it is a systematic approach to managing cost through the life cycle of any enterprise, program, facility, project, product, or service"*.
> This is accomplished through the application of cost engineering and cost management principles, proven methodologies and the latest technology in support of the management process.

TCM can also be explained as the sum of the practices and processes that an enterprise uses to manage the total life cycle cost investment in its portfolio of strategic assets.

2.1.1 <u>Example of TCM Process</u>

An independent Power Producer (IPP) could construct, operate, maintain, rehabilitate, and then decommission a gas turbine during its life cycle. The IPP makes significant investments at each phase of the gas turbine life cycle.

TCM process comes into play when in managing these investments, the IPP monitors gas turbine operating costs and profitability; evaluates alternative investment opportunities; and initiates, plans, and controls improvement projects.

2.1.2 Elements of TCM

To gain more insight to this concept, it is necessary to contextualise the elements or words total, costs, and enterprise.

Total here speaks of TCM's comprehensive approach to managing the total resource investment during the life cycle of the enterprise's strategic assets. In doing TCM, costs mean any investment of resources in the enterprise's assets including time, monetary, human, and physical resources. Enterprise has been recurring in this discussion, and can be any endeavour, business, government, group, individual, or other entity that owns, controls, or operates strategic assets. The latter is portmanteau term for any unique physical or intellectual property that is of long term or ongoing value to the enterprise.

Cost Engineers regard "capital assets" as synonymous with strategic assets, although the term "strategic assets" may encompass things that are regarded as expenses. Such asset could be a factory, a concert production, a software programme, or a building. It is important to know that investments on strategic assets are made through the execution of projects and programmes.

Projects are temporary endeavours for creating, modifying, manufacturing, or retiring strategic assets, with known start and end terms. Strategic assets include products and services, since before a product can be made or a service performed, many investments must have been made by way of projects execution for research, development, design, and so on.

2.1.3 TCM in Enterprise Undertaking

To get a picture of how TCM figures in an enterprise's undertakings, or activities, we might for example look at a company that designs and manufactures mobile phones. Through the execution of research and design projects the phone's design is created, and the latter becomes a strategic asset.

The company has to develop a particular manufacturing process or layout to manufacture some of, and assemble the phone components. Such process design/layout developed through execution of projects is a strategic asset. It is then necessary to carry out another project to design, procure, and construct the plant for the production of the phones. Such physical plant is also a strategic asset.

To operate the plant, workers are hired and trained. Workers initial training, the plant's commissioning and startup are executed as projects, and constitute strategic assets. This new plant must be maintained and eventually decommissioned. Each component of this phone maker's strategic asset portfolio highlighted above, requires investments realised through the execution of projects whose costs must be managed. Each component of the phone company's strategic asset portfolio would need investments that are injected through the execution of projects whose costs must be managed. The reality is that each component of the enterprise's asset portfolio has its own life cycle with cost investments to integrate over time. And all the components are interrelated.

It is this complex interaction of the asset portfolio component costs over their various life cycles, and during operations that creates the imperative of a total cost management process.

3.0 DEFINITION OF COST ENGINEERING

In defining TCM it was said inter alia "... *This is accomplished through the application of cost engineering and cost management principles* ..." While discussing elements of TCM we also said that cost Engineers equate capital assets to strategic assets.

Let us then define Cost Engineering. Jelen's Cost & Optimization Engineering (Ed. Humphreys, K.K, 1991 3rd Edition) defines Cost Engineering as:

> "*that area of engineering principles where engineering judgement and experience are utilised in the application of scientific principles and techniques to problems of cost estimating, cost control, profitability analysis, project management, and planning and scheduling*".

Cost Engineering embraces the principles of several disciplines and branches into business planning, management science, optimisation, operations research, accounting, and economics inter alia.

4.0 REQUIRED SKILLS & KNOWLEDGE OF A COST ENGINEER

The required skills and knowledge of a cost Engineer are broadly in the areas of (I) supporting or foundation skill and knowledge, (ii) cost estimating, (iii) cost control, (iv) planning and scheduling, (v) contract management, (vi) economic analysis and business planning.

4.1 FOUNDATION SKILLS AND KNOWLEDGE

Under the foundation skills and knowledge, the cost Engineer is expected to have a grounding in engineering economy, computers, statistics and probability. He also is trained in optimization, productivity management, human relations/behavioural science, organisational structures, and measurements.

4.2 COST ESTIMATING

In the cost estimating field he is grounded in the basics of estimating. He has an understanding of contractor's costs such that for example if given the construction drawings of a simple structure or system, he can complete the quantity take off of relevant items, and prepare a Bill of Engineering Measurement and Evaluation (BEME).

Similarly on Owners' Costs he is conversant with the use of factors, ratios indices, escalation, and inflation in capital cost estimation. And if given for example the baseline data for an existing facility plus the standard parametric measures, location factors, and escalation/inflation factors, estimate the cost of a comparable prepared facility at another location.

4.3 COST CONTROL

The cost Engineer can develop work breakdown structures encompassing the total structure, major components, sub-components, and sub-sub-components. He should also be able to determine overall percent complete for a combination of unlike work tasks or an entire project using earned value techniques e.g.

- Budgeted Cost of Work Scheduled (BCWS)
- Budgeted Cost of Work Performed (BCWP)
- Actual Cost of Work Performed (ACWP)
- Budget of Completion (BAC)
- Estimate of Completion (EAC)
- Schedule Variance (SV)
- Cost Variance (CV)
- Schedule Performance Index (SPI)
- Cost Performance Index (CPI)

Generally on cost control, the cost Engineer should be able to combine engineering tasks (which are systems oriented), procurement tasks (which are commodity oriented), and construction tasks (which tend to be area oriented) to provide integrated engineering-procurement-construction control.

4.4 PLANNING & SCHEDULING

4.4.1 Planning

It is within the competence of the cost Engineer to plan a project by developing logic diagram that will identify the correct relationships of all related work. This usually involves an assessment of site limitations, equipment deliveries, engineering/design restraints, availability of resources, and the requirements or enforcement of a completion date. This function does not develop activity times and resources.

4.4.2 Scheduling

With his knowledge of scheduling basics, the cost Engineer can with Arrow Diagram Method (ADM) Logic diagram calculate early start, early finish, late start, late finish total float and free float times for all activities. The critical points and minimum project completion time can also be identified using this method.

The same early/late start/finish and float time can be calculated by the cost Engineer using Precedence Diagram (PDM) logic diagram, also identifying critical path(s) and minimum project completion time.

4.4.3 Schedule Control

In construction or manufacturing projects the cost Engineer can establish progress control system for a combination of the following types of work packages:

(i) Packages composed entirely of single, measurable units of work, e.g. Placement of concrete (cubic metres), or installation of a component (number).

(ii) Those composed of a number of separate, overlapping tasks, each with a different unit of measure. For example major pipe installation includes the tasks of hanger installation, pipe erection, valve installation, and welding.

(iii) work packages composed of easily identified sequential tasks, e.g. those associated with installation of a piece of mechanical equipment receipt, setting, alignment, grouting, test.

(iv) The ones involving level of effort or apportioned effort such as management, administration, HSE, quality control/quality assurance, etc.

(v) Packages for which start and completion are well defined, but there is no basis for determining intermediate progress e.g. rotating equipment alignment, testing, and planning.

4.5 CONTRACT MANAGEMENT

The cost Engineer performs Contract Management through Contracting Arrangement, and Contract Administration.

4.5.1 Contract Arrangement

While performing contracting arrangement, the cost Engineer understands the relationship between risk allocation and contract type. He is thus in a position to recommend the most suitable type of contract to adopt in a particular project from among –

Fixed – price contracts (or lump sum)
Unit – price contracts
Cost – plus contracts – (a) Fixed fee
- (b) Incentive fee
- (c) Award fee
- (d) Time & Materials (T&M) contracts

He is able to, during this phase to structure the contracting roles among the different potential parties like project – owner, Engineer, project manager, prime contractors, and sub-contractors.

The cost Engineer also arranges/prepares the following documents that may form part of bidding and contract packages:

(a) Invitation to Bid or Request for Proposal
(b) Bid form
(c) Agreement
(d) General Conditions
(e) Supplementary or Special Conditions
(f) Technical Specifications
(g) Drawings
(h) Addenda
(i) Modifications
(j) Bid Bond and Contract Bond
(k) Performance Guarantee
(l) Equipment Warranties

4.5.2 Contract Administration

Performing this function, the cost Engineer administers the various types of bonds, insurance, and taxes that may be required as part of a construction contract. If he is given information on payment terms from client to contractor, the current time value of money for the contractor, the timing of contractor requests for payment from the owner, and the timing of owner reimbursement of contractor, he can determine the method of payment that is economically most advantageous. From the terms of the contract and time – value of money, he can calculate the effective cost of a ‘retention’.

The cost Engineer is knowledgeable on “liquidated damages”, while also conversant with factors that impact on contractors’ markup e.g. risk, competition, desired rate of return, current economic conditions etc.

4.6 ECONOMIC ANALYSIS AND BUSINESS PLANNING

4.6.1 Budgeting & Cash Flow

Having prepared the schedule for completion of each component account, and estimated the rate of incurring costs in each component account, the total amount of indirect costs, and the rate of incurring the latter, the cost Engineer can develop the cost “s-curve” for a project.

With the projected expense and progress curves for the project, the Naira value of the contract, and the payment terms of the contract, he can develop the cash flow profile for a project.

4.6.2 Value Engineering

The cost Engineer performs Value Engineering by estimating the costs of alternatives that meet the project’s required functions but at lower costs than the winning quoted options. In doing this he provides the user/owner with specific, technically accurate alternatives, appropriate to the stage of project development than can be implemented.

Value engineering can be performed by the cost Engineer during the planning, design and final phases of a project, product, programme, system or technique. But the best phase to apply value engineering is early in the design phase of a product. At this point, modification or redirection in the design can be realised without extensive redesign, leading to savings in time and money for the client. VE carried out during early stages of design is known as value planning. The procedure is used to analyse predesign documents, for the purposes of defining the project’s functions, and achieve consensus on the projects direction and approach by the project team.

Value engineering is also performed during schematic design (i.e up to 15% design completion), during design development (i.e. up to 45% design completion), and completion documents (up to 100% design completion). Benefits of conducting VE studies at several stages of design completion include (i) definition/confirmation of project functions, (ii) verification of technical and management approaches, (iii) analysis of the selection of equipment and materials, (iv) assessment of the project's economics and technical feasibility.

At the schematic design and design development stages, the value engineering/analysis team analyses the drawings and specifications from each technical discipline.

In the construction and manufacturing during the completion documents stage, the value engineering/analysis team analyses the design drawings and specifications, as well as details and equipment selection that would have been more clearly defined by this time.

When value engineering is performed at a 90% to 100% completion stage just before tendering, it focuses on buildability, economics and technical feasibility, methods and phasing of construction, as well as procurement are considered. At this later stage of design the objectives of value engineering include (i) minimizing costs and maximizing value, (ii) reducing the potentials for claims, (iii) analysing management and administration, (iv) review the design, equipment and materials used.

At the stage of construction the alternatives value engineering presents to the Owner are products of evaluation of Value Analysis Change Proposals (VACPs) of the contractor. The latter seek to reduce the costs or duration of construction, or more precisely the present alternative methods of construction without reducing performance, acceptability, or quality. Quite often to encourage the contractor to propose worthwhile VACPs, the owner and the contractor share the resultant savings when that is allowed by the contract.

5.0 COST ENGINEER IN FORENSIC ENGINEERING

The cost Engineer is expected to be knowledgeable in forensic assessment for the purpose of relating causation and responsibility (or entitlement) to performance in aid of resolution of disputes in a legal context and/or to support long term performance improvement.

He is able to manage changes and claims juggling a variety of factors like scope, compensation, relief, damages, delay, or other seeds of disagreement. He is able to discern the major reasons for contract changes especially the role of project scope definition in such changes. Therefrom he is in a position to determine the different types of schedule delay relating to the contract changes and claims, and be able to recommend which ones are excusable, non-excusable, compensatory, or concurrent. With this knowledge and experience the cost Engineer can predict the potential effects of disputes on project performance.

The cost Engineer understands the roles of the various elements of cost in context of disputes and claims, vis-à-vis bonds, retainage, performance guarantees, liquidated damages, demurrage, legal costs, etc.

His knowledge of means and methods of resolving dispute and claims e.g. negotiation, mediation, arbitration, and/or litigation, and other alternative dispute resolution forms come in handy in managing contentious situations in projects.

If I have introduced the role of the Cost Engineer to you or refreshed you on his function in management of the economy, my aim is satisfied.

I thank you all for listening.

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