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Petroleum and natural gas industries — Life-cycle costing —

Part 3: **Implementation guidelines**

Industries du pétrole et du gaz naturel — Estimation des coûts globaux de production et de traitement —

Partie 3: Lignes directrices sur la mise en oeuvre

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 15663 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15663-3 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*.

ISO 15663 consists of the following parts, under the general title *Petroleum and natural gas industries — Life-cycle costing*:

— *Part 1: Methodology*

— *Part 2: Guidance on application of methodology and calculation methods*

— *Part 3: Implementation guidelines*

Introduction

The principle objective of ISO 15663 is to speed up the adoption of a common and consistent approach to life-cycle costing within the oil industry. This will happen faster and more effectively if a common approach is agreed internationally.

Life-cycle costing is the systematic consideration of all relevant costs and revenues associated with the acquisition and ownership of an asset. It is an iterative process of estimating, planning and monitoring costs and revenues throughout an asset's life. It is used to support the decision making process by evaluating alternative options and performing trade-off studies. While it is normally used in the early project stages evaluating major procurement options, it is equally applicable to all stages of the life-cycle, and at many levels of detail.

This part of ISO 15663 has been produced to provide guidance on practical steps that can be taken to introduce the organizational and functional aspects of life-cycle costing into the offshore oil and gas business. It focuses on the implementation issues identified by the industry, both those common to all and those specific to each participant. Key issues addressed are

— **life-cycle costing within the organization**:
how it should be organized, coordinated and managed;

— **the contract**:
the procedural elements of incorporating life-cycle costing within pre-qualification, tender and responses;

— **risk and uncertainty**:
primarily viewed from the contractual standpoint within risk sharing or risk transfer frameworks (such as alliances);

— **communication**:
across the supplier chain (operator <----> contractor <----> vendor), how it can be achieved and configuration control or an audit trail maintained.

Experience has demonstrated that

— **for the operator**, life-cycle costing integrates readily with existing appraisal techniques, can quantify and optimize costs and revenues over the total life of a field development, thereby reducing uncertainty,

— **for the contractor**, life-cycle costing provides techniques to support the extension of his role into areas such as maintenance management, integrated service provision, engineering services contracts and life-cycle costing consultancy,

— **for the vendor**, life-cycle costing provides a common and consistent basis for demonstrating improved service and quality, thereby extending his role beyond technical compliance and lowest price.

There are opportunities and challenges for all parties within the oil production industry to benefit from the introduction and use of life-cycle costing techniques.

The aim of this part of ISO 15663 is to provide practical guidance to operators, contractors and vendors in the introduction and role of life-cycle costing techniques. It seeks to address the issues associated with life-cycle costing within evolving industry custom and practice. This is illustrated in Figure 1 which shows the evolving situation.

From Figure 1 it can be seen that

— vendors are often involved in early project stages such as FEED, during which they can add value in the area of system design,

— contractors and vendors are playing an increasing role in conceptual design and operations support.

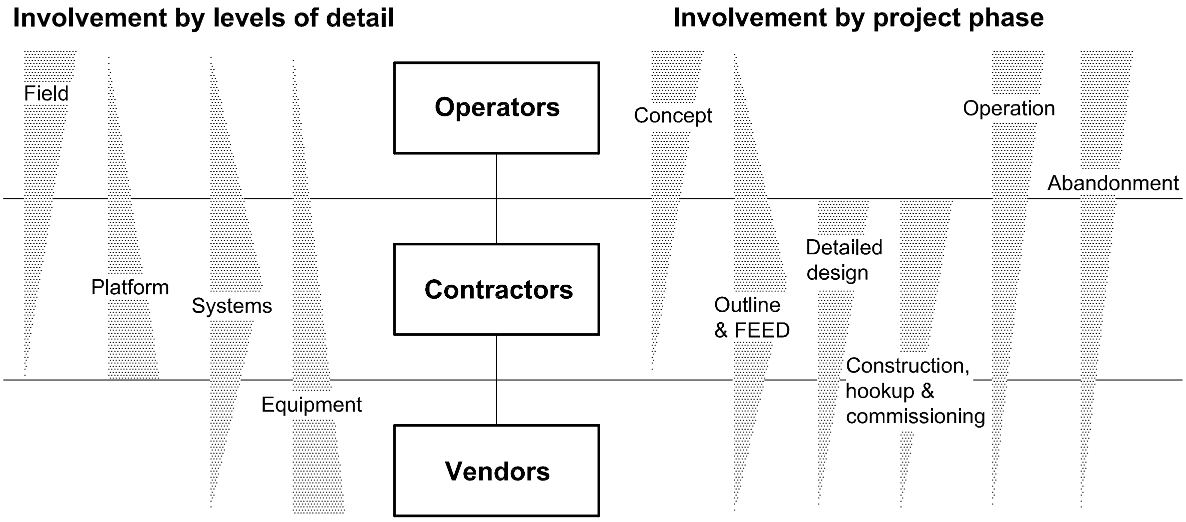


Figure 1 — The traditional role of participants is evolving and becoming less distinct

For a life-cycle costing implementation strategy, two key components emerge. These are the **interface issues** (the relationships between participants at the boundaries) and the **internal business processes** required to support the management and presentation of the information flowing across the interfaces.

In practical terms, these translate into the need for a non-prescriptive life-cycle costing implementation strategy that provides a basic framework to assist in the development and introduction of an engineering and design strategy and support strategy at all levels, together with its translation into a contract.

It should be noted that, whilst the provision of plant and equipment which has been optimized for whole life cost (WLC) performance may require its selling price to be increased, the integration of WLC/life-cycle costing principles into an equipment manufacturer's business should enable this optimum performance to be achieved without a significant increase in selling prices.

Equipment vendors and purchasers therefore need to work towards ensuring that wherever possible value, and not price, is increased by the life-cycle costing process.

This part of ISO 15663 is structured into the following sections:

— **the project or field life-cycle**;
implementation issues specific to the different phases of the life-cycle.

— **common issues**;
a variety of concerns common to all participants, the key one being the need for a focal point, or coordinator, within each organization.

— **the operator**;

— **the contractor**;

— **the vendor**.

The three last-mentioned sections addressing the implementation issues are considered important to each participant.

Recognizing that there are cultural and procedural differences across different companies in the industry, this part of ISO 15663 does not set out to be prescriptive, but to isolate and amplify the issues under a series of headings. The guiding principle is that the life-cycle costing discipline does not stand in isolation, but should be integrated within existing support functions to extend their capability.

Petroleum and natural gas industries — Life-cycle costing —

Part 3: Implementation guidelines

1 Scope

This part of ISO 15663 provides guidelines for the implementation of life-cycle costing for the development and operation of the facilities for drilling, production and pipeline transportation within the petroleum and natural gas industries. This part of ISO 15663 is applicable when making decisions on any option which has cost implications for more than one cost element or project phase. The process can be applied to a wide range of options, particularly when decisions are being considered on the following:

— the process concept;

— equipment location;

— project execution strategies;

— health, safety and environment;

— system concept and sizing;

— equipment type;

— equipment configuration;

— layout;

— maintenance and logistic support strategies;

— manning strategy;

— manning levels;

— operation strategies;

— facility modifications;

— spares and support strategy;

— reuse and/or disposal.

This part of ISO 15663 is applicable to all project decisions, but the extent of planning and management of the process will depend on the magnitude of the costs involved and the potential value that can be created.

The guidelines will be of value when decisions are taken relating to new investments in projects or during normal operation to optimize revenue.

2 Terms, definitions and abbreviated terms

For the purposes of this part of ISO 15663, the following terms, definitions and abbreviated terms apply.

2.1 Terms and definitions

2.1.1
benefit
creation of a capital asset, earning of revenue or improvement of a project environment

2.1.2
budget
estimate approved by management or the client as the cost control mechanism for a project

2.1.3
capital expenditure
money used to purchase, install and commission a capital asset

2.1.4
constraint
limit imposed externally or internally by the project which rules out the selection of an option if it is exceeded

2.1.5
cost breakdown structure
structure which relates to the methods that an organization will employ to record and report costs

2.1.6
cost driver
major cost element which, if changed, will have a major impact on the life-cycle cost of an option

2.1.7
cost element
identifiable part of the life-cycle cost of an option which can be attributed to an activity

2.1.8
life-cycle
cycle which comprises all development stages, from commencement of the study up to and including disposal of an item of equipment or function

2.1.9
life-cycle cost
discounted cumulative total of all costs incurred by a specified function or item of equipment over its life-cycle

2.1.10
life-cycle costing
process of evaluating the difference between the life-cycle costs of two or more alternative options

2.1.11
net present value
sum of the total discounted costs and revenues

2.1.12
operating expenditure
money used to operate and maintain, including associated costs such as logistics and spares

2.1.13
sensitivity analysis
process of testing the outcome of a life-cycle costing so as to establish if the final conclusion is sensitive to changes in assumptions

2.2 Abbreviated terms

CAPEX capital expenditure

EPIC engineer, procure, install and commission

FEED front-end engineering design

FMEA failure mode and effects analysis

FMECA failure mode, effects and criticality analysis

NPV net present value

OPEX operating expenditure

OREDA® offshore reliability database

RCM reliability centred maintenance

WLC whole life cost

3 Life-cycle costing within the asset life-cycle

3.1 General

The primary purpose of life-cycle costing is to assist in the delivery of the highest possible added value, i.e. profit, within a field development or project. It achieves this by extending profit improvement opportunities through a process of progressive optimization. The greatest benefit is realized when life-cycle costing is integrated across the entire life-cycle. While the life-cycle costing principles are identical across all phases, the organization in each phase differs in terms of

— the actions that need to be taken;

— the contribution each participant can make.

Figure 2 shows the “standard” field or project life-cycle together with some of the technical decisions taken at each stage, which may be the subject of life-cycle cost studies.

The technical processes in Figure 2 apply to both the original field development and subsequent changes made to the design.

Time scales, from concept to conclusion of commissioning, have been considerably shortened in recent years due to business pressures from the operators. Contractor and vendor selection is happening earlier in the life-cycle, with increased emphasis on their capability and performance. Contracting strategies are evolving in parallel, with a variety of partnering, alliance and framework agreements being established. It is in this context that the life-cycle is discussed.

3.2 Concept selection

3.2.1 Scope of this stage

The scope of this stage normally includes gross comparisons of the major technical options. Processing and delivery are considered as well as procurement options (lease or buy) and the options for operation and support. The work normally includes examining and comparing alternative technical solutions. The focus is on the major cost and revenue trade-offs with minimum detail.

3.2.2 Contributions

This stage is normally undertaken by the operator in conjunction with a contractor who will help evaluate concepts within an accelerated procurement programme or within an alliance framework. Vendor contributions are likely to be limited to advice on major packages.

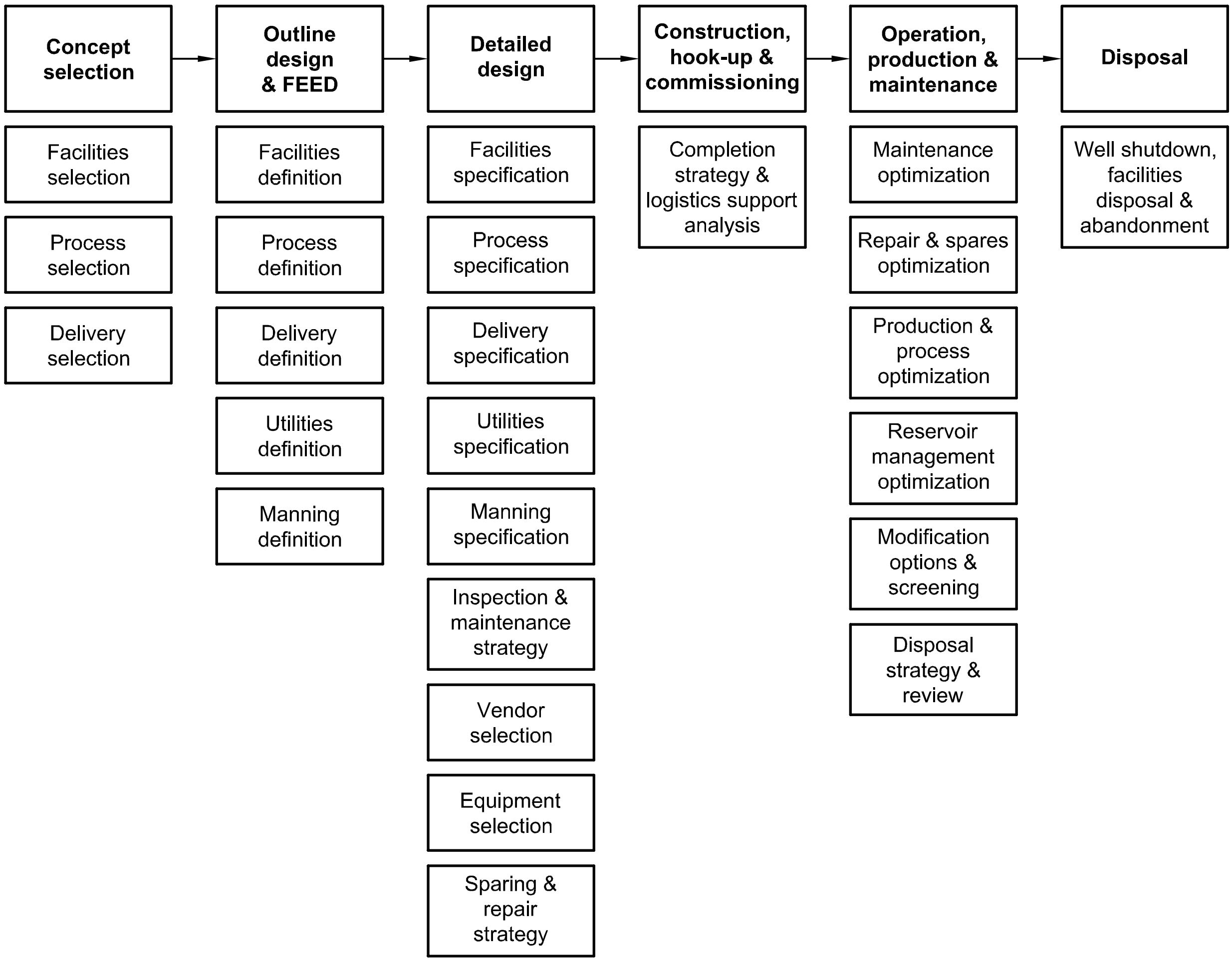


Figure 2 — Technical processes

3.2.3 Life-cycle costing activities

At the start of concept, a coordinator should be appointed with responsibility for developing the life-cycle costing strategy for the overall programme. In the majority of instances, the coordinator would come from the operator. Considerations in developing the strategy include ensuring that life-cycle costing contributes towards the development of the engineering and design, support and contract strategies; in practice this requires discussion and agreement from other internal functions and partners to achieve buy-in.

Consideration should also be given to generating a plan for conducting the work in detail for the system concept and in outline for later stages.

This plan should include

— **resource requirements**: to establish a budget for internal and external resources,

— **who should undertake the work**: potentially a team comprising operator, contractor, vendor and consultant personnel,

— **how the work will be conducted**: assessment criteria, constraints, options to be appraised and potential sources of data (internal and external),

— **training needs**: both general (to raise awareness for all team members) and specific (for those who will undertake the work),

- **life-cycle costing deliverables on completion of concept**: covering the contribution towards decision-making, establishing an audit trail for future phases and the inclusion of life-cycle costing within any future competitions (requirements specification and tender assessment),
- **the methodology to be used**: this should be the methodology detailed in ISO 15663-1:2000, Figure 1 [2], or an alternative methodology together with a justification as to why the standard methodology cannot be used,
- **the reporting relationships of those involved in undertaking the work**: particularly the reporting relationship with the manager accountable for delivering asset value,
- **the audit requirements**, in particular any requirements for independent assessment of work carried out at each life-cycle stage.

Potentially, the work can be undertaken by a team supplemented by contractors, vendors and consultants. The value in their contribution is in supplementing the operators' expertise so that either a broader range of concepts can be examined, or information provided that allows concepts to be compared at the same level of definition. This is likely to be particularly true where new or novel concepts are proposed; input from contractors and vendors may reduce uncertainty for these options.

At this stage in the programme, external support should be selected on the basis of capability, competence and track record.

Where a number of contractors have been asked to make proposals for the most suitable concept for a specified development as part of a design competition, it may be appropriate to specify that any bid be supported by life-cycle cost information. The cost headings can be specified together with the data sources and estimating process to be used. The aim should be to ensure bids can be compared on an equal basis and all important costs have been included.

3.3 Outline design/FEED

3.3.1 Scope of this stage

The scope of this stage includes the identification and examination of the technical options for facilities, processes and delivery leading to the definition of a preferred technical solution. Sizing and scoping the required utilities (power generation, accommodation, water supply, logistic support, etc.) and examining the cost trade-offs between facilities/processes and utilities are also within the scope of this stage. Life-cycle costing activity stops when a preferred solution is identified, it does not attempt to optimize the solution. Overall layout, weight and dimensions are normally fixed on completion of outline design.

3.3.2 Contributions

This stage is normally undertaken by the operator in conjunction with a contractor who will evaluate the technical options. Vendors’ contributions are likely to add significant value with their specialist knowledge of the cost and performance of alternative options.

3.3.3 Life-cycle costing activities

The life-cycle costing work undertaken during concept selection will include the identification of a preferred option together with a corresponding outline engineering and design, support and contracting strategy, all culminating in a requirement specification. This will define the content of the life-cycle costing programme during this stage. It is at the beginning of this phase that the process of making decisions on competing equipment options normally starts.

For life-cycle costing the principal objective in this phase is to evaluate alternative methods of meeting specific functional requirements and not to optimize the defined system solution. The most important feature of the life-cycle costing activities in this phase is knowing when to stop work. For example, if life-cycle costing analysis at concept identified the provision of water to the platform as an issue (either a risk item or cost driver), then work in outline design concludes when waste heat evaporation is identified as the solution. It will then be the objective of life-cycle costing activities during detailed design to develop and optimize the waste heat evaporation solution.

The work will require input from operator, contractor and vendor, irrespective of the contractual arrangements. The operator's contribution is in the provision of operating and support experience and data. It is likely that the contractor will undertake the majority of the work, and the vendor can assist in the definition and evaluation of specific systems within his area of expertise.

3.4 Detailed design

3.4.1 Scope of work

The scope of work at this stage will include system and equipment optimization within constraints defined during outline design.

3.4.2 Contributions

The contractor's role should be to provide the system definition, maintain the overall facility configuration and deal with integration issues. The vendor is often best placed to undertake the majority of life-cycle costing activity at this stage and will need to respond to functional specifications provided by the contractor.

3.4.3 Life-cycle costing activities

During detailed design, life-cycle costing is concerned with optimization of the system solutions selected at outline design. Outline design will also have ranked the different processes and systems required by their contribution to life-cycle costs. It is probable that the majority of life-cycle costs will arise from a small number of processes and this is where effort should be concentrated. It is these processes that offer the greatest potential for added value in detailed design.

The same approach is applicable to the system optimization work; it is likely that the greatest opportunity for cost reduction lies in the major cost drivers at system level.

The vendor should be best placed for this system optimization work, with assistance from the contractor. The contractor's primary focus should be integration issues at the facility level including operations and maintenance strategy. There is a mutual dependence between the contractor and vendor at the system boundaries.

The vendor contribution to life-cycle costing activities is dependent on their life-cycle costing capability and the contractor may need to supply life-cycle costing assistance in some cases. Vendors of critical systems are likely to have been involved in earlier phases. Where appropriate, life-cycle costing expertise should be one of the criteria used in vendor selection.

During this phase it is strongly urged that consideration be given to carefully evaluating the selection of items which may have a low unit cost and would typically be considered as “bulk” items. Due to their prevalence and potential impact on maintenance loading, many of these items could contribute significantly to the life-cycle cost of maintaining an asset and in many cases also contribute to lost production costs.

Vendors can often provide information regarding the potential impact of their products on life-cycle costs. Items for further consideration are

— compression fittings,

— gaskets,

— gas detectors,

— instrumentation valves,

— tube and pipe supports.

One method of addressing this situation is to develop three lists as shown below. The lists can then be used to make judgements on how many items on each list are to be subjected to life-cycle costing studies.

Equipment	Value

Equipment	Number installed

Equipment	Criticality

Development of such tables will focus attention on the equipment where life-cycle costing studies are likely to have most benefit. Where equipment has a high initial value, such studies can reduce costs to the minimum consistent with the required duty. Equipment with low initial value can also be significant if there are a large number of units installed. Items such as compression fittings do not represent a large proportion of the CAPEX, but can if they are of poor quality, lead to lost revenue, high downtime and significant replacement costs.

The third focus area is the most critical equipment. From regularity or availability studies or on the basis of previous experience, a ranking of the main unavailability contributors can be provided. The lead candidates from each list should be followed up and the systems optimized.

The major challenge for the contractor is to obtain commitment from the vendors to minimize life-cycle cost, particularly where optimization leads to a lower cost procurement solution, i.e. how to reward the vendor for improved NPV. A potential solution is to increase the vendors' overall revenue by extension of his role, both into earlier (preferred supplier) and later phases (support) of the programme. This issue is further discussed in clause 7.

During this stage the operator has a supporting role at detailed design in the provision of in-house operating and support data. It is at this phase that difficulties with data will become most apparent. System level optimization requires more detailed operating and support cost data and where a contractual commitment to support is required, increased uncertainty will lead to higher risk premiums and higher prices. It is in the operator’s interest to make operations and support data accessible to all who have a need to know. Deficiencies found can be translated into requirements placed on the data collection systems established during the operating and support phase, see ISO 14224 [1].

It should be noted that there are a number of difficulties in selecting vendors on a life-cycle cost basis. The difficulties include the following:

— each vendor will have collected data on equipment performance in a different way;

— the performance of the equipment may be different in the proposed application;

— the sample data on which performance predictions are made may be very small.

In the majority of cases this means that data uncertainty is high if proposals from different vendors are being compared. This will need to be taken into account in any analysis. The uncertainty is reduced if alternative equipment from the same vendor is being compared. The most effective approach is to select vendors on their equipment range and their life-cycle costing capability, and then work with them after order placement to optimize the equipment delivered for the specified application.

3.5 Construction, hook-up and commissioning

3.5.1 Scope of work

The scope of work at this stage includes support to change control and project managers assessing the impact of concessions on overall support costs.

3.5.2 Contributions

The majority of work at this stage is likely to be undertaken by contractors. Vendors should assist in evaluating the impact of installation changes on the performance predicted for their equipment.

3.5.3 Life-cycle costing activities

Life-cycle costing in this phase is a policing activity, examining concession and change proposals to determine their impact on overall profitability. As there are likely to be a large number of minor concessions, some form of filtering is required to minimize unnecessary effort. Procedures should be established to scrutinize minor concessions at the equipment level to ensure they do not result in significant impact at the facility level. Major problems encountered that result in programme slippage should be subject to life-cycle costing assessment to examine the trade-offs between rectification options, time and revenue.

3.6 Operation and maintenance

3.6.1 Scope of work

The work at this stage will include support for a wide range of studies covering all facets of facility operation and support. Modifications to the facility may also involve life-cycle costing studies. If major modifications are involved this will require reference to the issues considered above under concept, outline design, detail design and installation and commissioning.

3.6.2 Contributions

The work will be carried out by a mix of operators, contractors and vendors depending on the contractual arrangements (who is responsible for operations and support) and the subject being examined.

3.6.3 Life-cycle costing activities

Contract strategies for operation and maintenance will have been initiated at concept and developed and implemented in subsequent project phases. During the operations phase, the role of life-cycle costing is to assist in the examination of change which may arise from

— problems, such as obsolescence;

— changes in production rates, water cuts or gas fraction;

— facility life extension due to improved extraction techniques or new tiebacks;

— proposed cost improvement programmes in areas such as maintenance optimization, condition monitoring and sparing strategies;

— expiry of in-service support contracts, leading to a need to re-evaluate, negotiate and potentially compete.

In all cases, the project cycle repeats, going through concept, outline and detailed design, etc. The cycle may be accelerated, but in the majority of cases the change can be anticipated and planned in advance.

Where support is contracted out, reward may be tied to incentive schemes and life-cycle costing can assist in valuing and defining the incentives. In addition, life-cycle costing in operations may take on broader responsibilities associated with the provision of information to future programmes. The availability of operating history and expert judgement can make life-cycle costing studies at this stage much easier than at other stages.

3.7 Disposal

3.7.1 Scope of work

The work at this stage will include examination of when and how to decommission and dispose of all or part of the asset.

3.7.2 Contributions

The work is likely to be carried out by the operator in conjunction with specialist contractors.

3.7.3 Life-cycle costing activities

The work carried out at earlier stages will have considered the options in this phase. A basic disposal plan should have been agreed during outline design, but timing, schedule and final strategy will need to be decided in the light of actual production experience. The generic options are as follows:

— decommission the facility and dispose;

— re-use the facility in whole or part;

— sell on the asset (facility and field) as a going concern prior to the end of field life.

In comparing these options, there are timing differences between the first two and sale of the asset. Where asset sale is considered, life-cycle costing can be used to investigate the cost, revenue and time trade-offs.

Where decommission and disposal is preferred, the appraisal techniques for evaluating disposal options are based on selection of the best practical environmental option taking into account cost, safety and the environment. These techniques are evolving and costing includes the use of shadow pricing and valuation on the basis of energy value. Developments in this area may in the future influence the appraisal criteria applied at early phases.

4 Common implementation issues

4.1 Summary

A number of implementation issues, as listed below, are critical to the successful completion of life-cycle cost studies at all life-cycle stages:

— **the life-cycle costing coordinator**: a focal point for life-cycle costing is needed for all participants (operator, contractor and vendor) to introduce and manage life-cycle costing within each organization;

— **training on the methodology** to be used and raising general awareness;

— **preparation of a common and consistent source of data and assumptions** that can be used as a basis for all life-cycle cost studies. See 4.4 for more details;

— **the contract**: the introduction of life-cycle costing into the contracting process through tender specification, bid preparation, assessment and the resultant contract;

— **data and uncertainty**: a common concern as to how to include this in studies;

— **value definition and assessment**: while assessment criteria are dictated by the operator, all need to understand and apply the principles.

Each of these topics is discussed below.

4.2 The life-cycle costing coordinator

4.2.1 General

The main purpose in establishing the role of a life-cycle costing coordinator within a project is to ensure accountability for life-cycle costing is maintained throughout the programme. Amongst other things, the responsibility of the coordinator is to ensure that

— issues that influence the life-cycle costs of the project are considered within the development phase,

— the potential trade-offs between cost and revenue remain a central component of the work programme,

— life-cycle costing requirements and outcomes are communicated to the external customer and suppliers,

— problems identified during life-cycle cost studies are resolved within the required time and budgets.

4.2.2 Role and responsibility of the life-cycle costing coordinator

4.2.2.1 Summary

The roles and responsibilities of the life-cycle costing coordinator can be summarized as follows:

— develop and plan the project life-cycle costing strategy;

— develop internal life-cycle costing procedures;

— facilitate and coordinate study activities;

— be responsible for handover and maintaining project continuity;

— take responsibility for training.

The extent of the role will vary across projects and organizations between a part-time and full-time commitment.

4.2.2.2 Developing and planning the project life-cycle costing strategy

Strategic issues that the life-cycle costing coordinator is responsible for within a typical project may include

— early appraisal and scoping of design option life-cycle costing studies in support of concept and FEED,

— initiating and maintaining a file for common data and assumptions,

— specifying the extent to which life-cycle costing should be incorporated in any pre-qualification activities,

— developing requests for life-cycle costing information in tender documentation,

— assessment of tender responses in the context of the business case and providing input to design selection,

— establishing initial operations and support budgets,

— identifying critical components of risk-reward strategy in advance of contract award.

It is the responsibility of the life-cycle costing coordinator to ensure that

— a consistent approach is applied throughout the project,

— all important decision points with life-cycle costing implications are identified early,

— the scope of the assessment process is adequately identified.

In addition, the coordinator is responsible for identifying resource requirements and study timescales.

4.2.2.3 Developing internal life-cycle costing procedures

The requirement for life-cycle costing procedures should be considered at the following two levels:

— the need for procedures describing how to undertake life-cycle costing, when it should be done, at what level of detail, etc.;

— the need for change in existing organization/project procedures to ensure that these do not block the implementation of life-cycle costing or place barriers to its execution, e.g. the design to procurement relationship, or purchase on the basis of minimum CAPEX. The challenge is to change the process to implement life-cycle costing as the “built in” way of working. This is the most difficult component in developing procedures, as it is seeking to effect a cultural change in the organization.

4.2.2.4 Facilitating and co-ordinating study activities

The planning of assessments and the identification of resource requirements are the responsibility of the life-cycle costing coordinator. At the start of the appraisal process, the coordinator is responsible for

— establishing the life-cycle costing assessment objectives,

— identifying study options,

— agreeing appraisal criteria,

— establishing the communications links with the functions who will contribute to or influence the study,

— identifying conflict between life-cycle costing and other functional requirements, e.g. if availability and reliability targets are specified, that they are consistent with targets defined for NPV.

4.2.2.5 Responsible for handover and maintaining project continuity

It is likely that over the life of a development or project many personnel changes will occur (not least in the role of life-cycle costing coordinator) and the focus of the work will shift between operator, contractor and vendor across the project phases. It the responsibility of the life-cycle costing coordinator to establish procedures to ensure that continuity is maintained. The principal mechanism recommended to maintain continuity and support the audit trail is for the coordinator to maintain a file of common data and assumptions.

4.2.3 The life-cycle costing coordinator's place in the project

The coordinator interacts with virtually all business functions, and tends to fulfil a central role within the project. The coordinator acts as a conduit between the engineering/design and commercial functions, translating the technical solution into its impact on the commercial and business strategy. In the majority of cases, the information flow is two-way, with the coordinator both seeking and providing information. It is unlikely that all functions are present within the organization, for example, contractors and vendors are unlikely to have an economics function.

4.2.4 Life-cycle costing coordinator skill set and background

The most important attributes for the life-cycle costing coordination role are as follows:

— a business focus that is able to bridge the gap between the technical and commercial functions;

— a broad understanding of all the functions within the organization (given the wide range of interaction required);

— good communication skills: interface management is a significant component of the work; and,

— a relatively senior individual.

Life-cycle costing is within the capability of the majority of existing functions, each offering its own advantages, for example:

— operations and maintenance specialists have a vested interest in ensuring that OPEX is given a voice in the procurement phases;

— estimators have the necessary costing background, usually coupled with a broad understanding of the engineering implications;

— risk and safety specialists are pan-organization or pan-project experts accustomed to interfacing with a broad range of functions;

— engineering/design specialists have an awareness of the impact of options on the overall requirements.

4.3 Training and competence

The life-cycle costing training needs on a project will vary with the size and complexity of the project and with the contract terms and conditions. For example, a complex high pressure/high temperature gas processing plant at the forefront of technology will have many more areas requiring life-cycle costing analysis than a simple oil processing platform. Also life-cycle costing techniques should be used extensively on alliance style projects whereas they will not be so relevant on lump-sum EPIC contracts.

Assuming a fairly complex alliance-style project, nearly all project staff will require familiarization with life-cycle costing objectives and principles. This may be achieved by mentions in project handbooks, procedures, etc. or via kick-off meetings or team-building sessions to which most staff are invited. Another forum for dissemination of life-cycle costing information is during value engineering/cost reduction sessions. It is vital that commitment to life-cycle costing is shown by the project senior management for the technique to be effective.

More specific training in life-cycle costing techniques should be provided for the engineering manager and his lead engineers, together with any project engineers. This could comprise a one-day course which explains the principles and practice of life-cycle costing. Training in the use of appropriate techniques and models (where applicable) should also be given during this course. Further training should then be cascaded down from the lead engineers to others who may be required to use life-cycle costing techniques. This training may take place “on the job”.

Training in life-cycle costing should be managed and audited by the life-cycle costing coordinator to ensure consistency of approach and conformance with the project life-cycle costing guidelines.

4.4 Preparation of a common and consistent source of data and assumptions

A file should be prepared and maintained of common and consistent sources of data and assumptions. The file is proposed as a vehicle for providing continuity across project phases and communicating life-cycle costing information up and down the supply chain. Its implementation (document, database or model) and contractual significance may vary across projects or organizations, but its purpose is to

— provide life-cycle costing supporting information to the business case,

— provide the starting point for life-cycle costing input to risk management. The major assumptions together with sensitivity analysis, provide information for inclusion in the business risk register,

— provide life-cycle costing supporting information to requests for tender,

— enable those working at later project phases to confirm or challenge earlier assumptions and to provide them with some insight into the reasons behind initial decisions,

— support the project review and audit process throughout the life cycle.

It may typically be

— initiated by the operator at concept,

— updated by the contractor during outline design,

— maintained by the contractor during detailed design with input from vendors,

— used as the baseline to assess proposed changes during the operating and support phases.

Information content will evolve with the project, and some elements may cross-reference to other documentation to avoid replication and potential error.

4.5 The contract

4.5.1 General

Of all the implementation issues, the incorporation of life-cycle costing within a contractual framework is seen as a critical success factor. It can be achieved in the following two ways:

— **through evolution**: a low-risk approach where life-cycle costing is progressively introduced by making some part of the payment related to life-cycle costing performance;

— **through revolution**: a higher-risk approach where life-cycle costing is introduced immediately as the basis for letting a contract. This approach requires significant levels of life-cycle costing awareness, well established data sources and expertise from the participants in the process.

The implementation of life-cycle costing in a contractual context needs to be considered within the existing activities of

— **prequalification**, both for contractors and vendors;

— **development of the tender documentation**, which sets the requirements for the bid responses and subsequent evaluation;

— **contract award** and post-contract performance monitoring.

4.5.2 Prequalification

From all customer standpoints, the intention of prequalification is to reduce the number of eventual tenderers to a manageable level. Extending prequalification criteria to incorporate references to life-cycle costing may include questions that expose

— the potential tenderer's internal procedures for estimating and generating life-cycle costing estimates and how they relate to International Standards on life-cycle costing, the intention being to elicit information on the extent to which life-cycle costing is integrated into their engineering and business processes,

— relevant previous experience in the application of life-cycle costing, paying particular attention to the benefits that were achieved,

— their understanding of the financial and economic rules applicable to the work,

— their access to data to support their ability to conduct life-cycle costing assessments,

— an indication of their willingness to agree to contracting to elements of life-cycle costing,

— their familiarity with related disciplines such as reliability prediction (FMECA, FMEA, availability modelling, etc.), logistic support analysis (RCM, training, maintenance, handbooks, etc.), performance modelling, and spares modelling.

To incorporate the contribution that contractors and vendors can make in early project phases, it may be possible to develop contractual framework arrangements that allow discrete studies to be let as part of the operators' overall risk reduction programme. The advantages of this approach are as follows:

— it provides an economic route to enlisting expert advice,

— it does not preclude the ability to compete subsequent project phases,

— it introduces continuity across the project phases by allowing the development of partnering arrangements.

This approach will significantly improve the contribution of life-cycle costing to a programme and simultaneously improve communication and awareness between participants.

4.5.3 Development of the tender documentation

With the reductions in time from discovery to first oil or gas, the contractual distinction between concept, outline and detailed design has become increasingly blurred. Contractual requirements may cross traditional project phase boundaries and it is important that life-cycle costing requirements follow suit. The tender document should reflect the need to maintain life-cycle costing continuity through each phase by defining the need for responses to questions, such as:

— the tenderer’s approach to conducting life-cycle costing within the programme;

— the range of options that will be considered and how a solution will be identified;

— estimating techniques to be applied;

— modelling techniques to be applied;

— analysis to be applied to the outcomes (sensitivity analysis and trade-off analysis, identification of cost drivers);

— how life-cycle costing risk will be managed during the programme;

— statements on the information required from the operator (economic criteria, level of design definition, cost breakdown structure);

— their proposals for overcoming deficiencies in data availability and reducing uncertainty.

To reduce potential clarification questions from tenderers, the operator may provide the following information:

— **specific options to be considered**, for example, the requirements for a baseline option;

— **data that will be provided**, such as cost rates (manpower, transportation, etc.), expected revenue, production rates, taxation and required rates of return;

— **reporting requirements**, such as frequency, level of detail, handover requirements to the next project phase;

— **the marking scheme**: the relative importance of life-cycle costing proposals within the overall response.

Some of this information may be sensitive to the operator and may be substituted by “industry norms” or synthetic rates. Real data may be released once a contract has been let.

Inclusion of life-cycle costing estimates in the tender response assumes that preparatory analysis has been undertaken by the operator that has exposed the issues and set the agenda for the required responses. The tender documentation should enable the bidders to respond to life-cycle costing requirements in a common and consistent manner. In addition to the topics identified above, features that may assist with this process are:

— **specification of the cost elements**: the cost breakdown structure that should be used by the tenderer (where preparatory work has exposed the cost drivers);

— **statements of contractual intent**: specification of the cost elements to be included in future contractual negotiations, for example, all CAPEX and selected elements of the support and OPEXs;

— **issue of a “standard” model**: to be used by all tenderers in their response. While offering advantages in standardizing the response, this approach places the onus on the operator to produce a competent and comprehensive model;

— **release of a project comparator**: this could be the results of previous work that has led to a particular option being favoured. The objective is to provide a target for the tenderer to meet and improve upon;

— **supporting justifications**: a requirement for the tenderer to justify the data used in the response. The principal focus of this is to ensure that bidders do not provide overly optimistic estimates, particularly in the area of support.

To realize the full benefits of life-cycle costing, the tender document uses functional specifications since the use of prescriptive technical specifications constrains the tenderer's ability to innovate and reduces the potential value of life-cycle costing.

4.5.4 Contract award

Current industry practice is tending towards the use of gainshare contracts with a risk/reward strategy focused towards the CAPEX elements of the programme. By including life-cycle costing within the process, decisions taken on a CAPEX basis can be better informed on the value of the investment in relation to the potential downstream consequences. Within this contractual regime, the operational and support aspects can be taken into account through such measures as

— insisting that all proposals for CAPEX improvement be accompanied by an assessment of life-cycle cost implications, specifically to examine the risks to the maintenance of an acceptable NPV,

— nominating the operations function as the coordinator for the life-cycle costing programme,

— using the life-cycle costing estimates as the basis for developing the operations and support budgets,

— insisting that no CAPEX reductions are considered that reduce the project NPV.

Currently the majority of contractors and vendors have no control over how the facility or systems are used once commissioned. A low-risk approach to extending the contract arrangements into the operations and support phase may include

— consideration of low-risk items or support cost elements as candidates for firm price support arrangements from the contractor and/or vendor,

— extension of contracting terms to incorporate service provision against specified performance targets, such as required availability or reliability,

— risk/reward schemes based upon the support contract value balanced by the contribution of the individual system/equipment to NPV.

The consequence of these changes is that data will assume a contractual status, driving the establishment of accurate data collection and analysis techniques by the contractors and vendors to support the work. This experience will lead to better estimates for future programmes, but the difficulties of comparing actual performance with data assumptions should not be underestimated. Problems include the following:

— a significant number of failure instances will be needed before there can be sufficient confidence that performance does not match predictions;

— a number of failures can be caused by bad operation or maintenance practices;

— operational conditions may change from that originally envisaged.

4.5.5 Alliances

Alliances and partnering are an increasing feature of the offshore business. All the general features described in the previous sections are equally appropriate to this contractual arrangement. In addition, a number of specific issues, as listed below, should be resolved within the workshare agreement:

— a policy statement on how potential conflicts that may arise during design optimization will be resolved. For example, CAPEX/OPEX trade-offs may change the financial value of individual participants' contributions to the investment;

— definition of the resourcing and responsibility for life-cycle costing. With increasing technical and commercial responsibility being transferred to contractors, it is likely that they will undertake the life-cycle costing programme with support from vendors;

— the use of a single standardized approach to life-cycle costing across all participants, such as common procedures, common models, etc.;

— equality of life-cycle costing information;

— agreed investment criteria. This is of particular relevance where contractors and vendors are assuming significant risk. In this instance, the criteria are influenced by their needs in terms of return on investment.

4.6 Data and uncertainty/new technology

The majority of risks stem from uncertainty or lack of data, e.g. through the introduction of new technology. In the short to medium term, the availability of reliable operating and support cost data is seen as a potential obstacle to the successful introduction of life-cycle costing to contractual negotiations by all participants. In the longer term, the involvement of contractors and vendors in the operation and support of platforms, systems and equipment will prompt the establishment of relevant data collection systems. One area in which there will always be uncertainty is the performance assessment of new and emerging technologies.

Data has been identified as an issue for improvement. Companies who wish to benefit from life-cycle costing should consider the following:

— feedback of information from live fields;

— how availability of accurate operating, reliability and maintenance data can be improved (see ISO 14224 [1]);

— the standardization of life-cycle costing data.

Practical steps that can be taken to minimize the impact of uncertainty in data include:

— focus on design differences between potential solutions or offerings from contractors and vendors; for example, in the absence of supporting evidence, recognize that the use of life-cycle costing to discriminate between identical technical solutions from different suppliers is unlikely to add value. However, where supportive data is available, this should be carefully considered and may in fact prove useful in differentiating between similar technical solutions from different vendors. Some vendors may have approached the challenge of collecting data in a different way from operators/maintainers; this should not prejudice the use of these data in an appropriate manner. Those vendors who have actively sought, collected and collated data which verify the impact of their products on life-cycle costing should be provided with opportunities to present their case during the early stages of the project;

— estimate by analogy: comparisons with similar equipment;

— estimate at a higher level using generic data or industry standard data or “norms”;

— perform sensitivity analysis to test the impact of potential errors and uncertainty on NPV;

— extend formal risk management techniques to include life-cycle costing issues;

— introduce formal methods from other disciplines, such as reliability analysis, FMECA, training needs analysis, etc. to provide a practical basis for predictions;

— extend the tender to require the contractor/vendor to use formal methods, such as those identified in the previous step, in support of his offering;

— use a common and consistent record of all significant information and assumptions supporting the work;

— use all of the above to identify opportunities to introduce low-risk contractual support arrangements for discrete activities that build up the contractor’s and vendor’s operating and support experience and knowledge base.

5 The operator perspective

5.1 General

The operator, contractor and vendor perspectives are intended to be reviewed and understood by all groups, i.e. operators should read the other two perspectives in addition to their own. This will lead to a greater appreciation of the challenges and benefits of the life-cycle costing process.

Traditionally, the term “operator” has been applied to the major exploration and production companies. The principal focus of these companies is revenue, together with the assumption of all the responsibilities associated with safety, production and costs. This role is evolving with increasing involvement of contractors and vendors throughout the life-cycle.

From a life-cycle costing implementation perspective, Figure 2 illustrates a number of aspects of the operators' role:

— the decisions taken at concept determine the majority of life-cycle costs. As the operators initiate the overall process, they have the greatest influence on life-cycle costs: the operators are responsible for the overall engineering and design and support strategies and the extent to which life-cycle costing is applied through the programme. Their commitment will determine the attitude and commitment of their partners and suppliers;

— given the overlapping role of the participants, a growing number of developments proceed on the basis of alliance partnerships, integrated teams are a growing feature of future business. This has an impact on the role of the operator in life-cycle costing, specifically in developing and describing his requirements and communicating these to his partners and suppliers;

— the contractors' role is expanding with growing involvement at the concept phase and later in operation and support (with vendor assistance). Risk transfer/sharing can assist this process, but only if realistic methods of measuring life-cycle cost performance can be formulated and agreed. Life-cycle costing can assist established risk management techniques by offering a common basis for communication in this process.

The message that emerges from the above is that implementation of life-cycle costing for the operator should take account of the following key issues:

— **commitment**: this has primarily arisen as a contractor and vendor concern, that operators will specify the use of life-cycle costing, but ultimately take the procurement decisions on the basis of lowest competitive CAPEX. Conversely, the operator may specify life-cycle costing as a component of the decision criteria in a competition, but finds contractors delivering superficial responses because the contract extends only to CAPEX;

— **focal point**: to deliver the commitment, a “champion” is required within the operators' organization to introduce a life-cycle costing perspective to the engineering and design and support strategies. This focal point can be delivered within existing organizational structures;

— **risk**: life-cycle costing brings its own particular perspective to established risk assessment and management techniques. This is an interface issue;

— **the contracting strategy**: this will reflect the engineering and design and support strategies initiated at the concept phase. The ultimate objective is to contract on the basis of life-cycle costing at all the interfaces. Contracts based on life-cycle costing are difficult to implement due to problems of measurement.

5.2 Commitment to life-cycle costing

Experience from other business sectors suggests that commitment to life-cycle costing throughout the whole industry will come from a combination of clear messages, progressive introduction and time. The starting point for the operator is to integrate life-cycle costing within existing corporate approval procedures in order that it is seen to be used internally. Commitment from contractors will be gained when operator internal procedure and practice is translated into external requirements.

Practical steps that can be taken to embody life-cycle costing within existing internal procedures can include

— appointment of single authorities/individuals responsible for delivering the CAPEX, OPEX and revenue,

— definition of the corporate criteria for life-cycle costing assessment,

— a statement on the minimum range of options that should be considered in all assessments, such as

  — a definition of a common content, format and structure for the evaluation of competing options involving significant costs beyond the capital stage;

  — the establishment and communication of minimum thresholds in order that life-cycle costing is applied intelligently;

  — the extension of the approvals procedures to revisit, review and reset the CAPEX and OPEX budgets at all project phases.

Translation of the above into the requirements placed on contractors can be achieved through measures such as:

— the incorporation of the internal procedures into external policy statements issued in invitations to tender;

— prescription of capability and experience of working to life-cycle costing methods as a prequalification criteria;

— provision of operator life-cycle costing information to the contractor. For example, the results of operator studies from the previous phase expressed as targets to the contractor;

— publication of the weighting attached to life-cycle costing within the overall bid evaluation procedure;

— statements of intent that a subsequent contract may incorporate elements of operation and/or support.

5.3 Life-cycle costing — A focal point

5.3.1 General

Successful implementation of life-cycle costing within the industry needs a single point of responsibility in each organization (operator, contractor and vendor). This issue is considered crucial — the key role of a coordinator within a project — their roles, responsibilities and interfaces, and which of the established project functions may take on this role. This section deals with the aspects unique to the operator, whilst clause 4 presents those elements common to all participants.

The unique aspects of the coordinator's role within the operator organization are

— **defining the life-cycle costing strategy**: it is the operator that initiates the overall development process and the life-cycle costing coordinator should contribute towards the engineering and design and support strategies,

— **providing continuity**: it is only the operator who sees the “big picture” and is involved in all project phases. The life-cycle costing coordinator should assume responsibility for continuity across phases.

5.3.2 Defining the strategy

The life-cycle costing coordinator with the operator will contribute towards and be constrained by some components of the engineering and design and support strategies. The engineering, design and support strategies should be implemented in the contract strategy. This is discussed in more detail in clause 4.

Elements of the engineering and design strategy will include the following commercial considerations:

— **asset ownership**: there are significant implications for the role of life-cycle costing where lease or rent versus purchase features as an option;

— **competition**: how the programme will be competed defines the role and extent of life-cycle costing in the pre-qualification, requirements specification and tender assessment;

— **procurement source**: alliances and partnerships may limit the technical solutions and options for operation and maintenance.

The engineering and design strategy should also consider programme considerations as follows:

— **first-oil date**: the scope for accelerated procurement, its value and the sensitivity of NPV to changes;

— **field development**: the implications of this project within a larger field development programme.

The following additional issues should be considered:

— **procurement boundary**: there may be life-cycle costing implications for items that lie either at the boundary or outside the boundary of the proposed procurement, e.g. downstream facilities;

— **work breakdown structure**: what level of detail should be considered at each phase of procurement, e.g. when is the overall facility considered at process, system and equipment levels;

— **cost breakdown structure**: what level of detail should be considered at each phase of procurement, e.g. level 1, 2, 3 and 4 estimates;

— **budget considerations**: what financial constraints exist on CAPEX expenditure that limit the range of commercial, programme and technical options and limit trade-offs between CAPEX and OPEX for NPV improvement;

— **focus**: what issues are dominant in the procurement being considered. Some procurements may be driven by commercial considerations and others by technical considerations. Life-cycle costing should assist in highlighting the dominant issues to be addressed in the next phase of the work.

Elements of the support strategy should include the following commercial considerations:

— **operation and support alternatives**: life-cycle costing can assist in assessing the potential for contractor/vendor operation and support by identifying which elements can be adequately defined and costed;

— **procurement strategy "knock-on" effects**: decisions taken during procurement may limit the range of options that life-cycle costing can consider for operations and support, e.g. scope for independent competition on this issue;

— **performance**: life-cycle costing can assist with the identification of contractual performance measures for critical support elements by identifying the data requirements from a life-cycle costing standpoint;

— **flexibility during operations and support**: given potential changes in use through life (field size, production rates, chemistry, etc.), life-cycle costing can quantify the effects of field uncertainty and the resultant CAPEX/OPEX trade-offs;

— **disposal**: life-cycle costing can expose opportunities for asset reuse or redeployment and consequential impacts on the current operating and support phase for maintenance of its material state.

Elements of the support strategy should include the following programme considerations:

— **timing**: how long can decisions on operations and support be deferred, e.g. until better life-cycle costing information becomes available;

— **timescales**: life-cycle costing can assess the impact of differing periods of contractual support, taking into account production profiles, life extension, upkeep cycles and planned updates;

— **other support programmes**: assessing the impact of external dependencies such as existing spares pools, preferred suppliers and equipments and internal infrastructure;

— **scope of supply**: as for the engineering and design strategy, life-cycle costing can assist the support strategy in the level of detail considered for operations and support in both the work breakdown structure and cost breakdown structure;

— **budget considerations**: life-cycle costing can be used to make judgements on whether operating and support budgets for the overall facility and individual components can be increased or reduced from normally accepted values.

5.3.3 Providing continuity

As the initiator of the life-cycle costing process, the coordinator has a responsibility for ensuring that all significant life-cycle costing assumptions made during different project phases are consistent and can be audited. A mechanism for providing continuity is to gather all the relevant information together into a single document. How it may be implemented is dependent on organizational preferences — it may take the form of a document or database and may cross-reference to other documentation. The important feature is that it is ongoing and is updated throughout the project life-cycle, for example:

— initiated by the operator at concept;

— updated by the contractor during outline design;

— maintained by the contractor during detailed design with input from vendors;

— used as the baseline to assess proposed changes during the operations and support phase.

5.4 Risk

A component of life-cycle costing is the identification and quantification (in NPV terms) of the major risks associated with the recommended option and its engineering and design, support and contract strategy.

The outcome of life-cycle costing contributes towards the content of the risk register. The coordinator can assist risk management by taking responsibility for

— quantifying the subjective outcome of the risk assessment in a common and consistent manner. This would typically concentrate on the high/high risks and measure their impact on NPV,

— providing additional focus to the assessment through identification of the cost drivers.

Once included in the risk register, the coordinator can assist in developing mitigation strategies in specific areas, such as:

— minimizing risk to revenue through examination of CAPEX/OPEX trade-offs that improve operating performance;

— quantifying the effect of programme slippage or acceleration as an input to a risk/reward scheme;

— valuing risk transfer for specific components of the support programme as part of a contracting strategy.

5.5 The contractual framework

5.5.1 General

Currently, the majority of contracts placed by the operator for field development are CAPEX based. These are implemented in variety of different ways, ranging from lump sum to gainshare where the contractor assumes some risks. Life-cycle costing introduces an OPEX perspective and it may be incorporated into existing contractual frameworks with varying degrees of risk transfer. The following two steps have been identified to illustrate the range of contractual impact possible:

— **step 1**: where life-cycle costing is used to influence the design;

— **step 2**: where life-cycle costing is used to assist identifying and contracting for elements of operation and support.

These steps represent an increasing commitment to, and reliance upon, life-cycle costing as part of the overall contracting strategy. They may be introduced either in an evolutionary manner, where the individual approaches are introduced progressively on a project-by-project basis, each one building on experience gained, or in a revolutionary manner, where more than one approach is introduced into a single project simultaneously.

The contractual considerations of each approach are discussed below.

5.5.2 Influencing the design

This is the starting point for life-cycle costing, where the primary objective for the operator is to introduce a quantitative means of assessing different design options in the context of CAPEX/OPEX/revenue trade-offs. To influence the design, a fast and efficient process needs to be in place within the project to allow additional CAPEX to be justified. This means that the capital release needs to be flexible and a clear project procedure needs to be defined which is linked to the life-cycle costing outcomes.

This option has no contractual significance to the contractor other than a requirement to undertake life-cycle costing work to support the identified design. In defining the contractual requirement, the operator should

— identify the requirement to the contractor to undertake life-cycle costing as part of the programme of work;

— identify the assessment criteria by which the contractor is to assess trade-offs.

In addition, the operator may provide a point of contact for additional information and provide an indication of the level and depth expected in the work. The outcome of the work does not necessarily lead to further work at later phases.

5.5.3 Contracting elements of support

In this step, the operator seeks to achieve progressive risk transfer to the contractor through firm price contracts for elements of operation and support. In addition to the contractual requirements of the previous steps, the operator should also

— state his intention to contract for specific support elements,

— set financial targets for the elements of support that will be contracted out,

— propose timescales for the period of support.

The practical consequences of this step are that the operator may wish to seek independent estimates to identify the targets and that there will be increased focus on the risk assessment undertaken by the contractor.

5.5.4 Contract administration

To support incentive schemes within a contractual framework based on life-cycle costing, a form of standard costing system should be provided to measure performance and achievement. Activity associated with this should cover the collection of actual cost and performance data for analysis and comparison with agreed targets. The tender document within the contractual framework should clearly define responsibility for this activity.

As part of the contract, negotiation arrangements should be made as to how future changes arising from practical operating experience can be accommodated during the currency of the contract and within the incentive arrangement. The contract should include agreed methods covering

— future proposals for OPEX improvement and how they can be accompanied by an assessment of life-cycle costing implications, specifically to examine the risks to the maintenance or improvement of NPV,

— the make-up and structure of the operator and contractor/vendor team to evaluate and agree the proposed changes,

— data collection and its role in supporting the assessment of performance.

6 The contractor perspective

6.1 General

The operator, contractor and vendor perspectives are intended to be reviewed and understood by all groups, i.e. those from within the contractor's sector should read the other two perspectives in addition to their own. This will lead to a greater appreciation of the challenges and benefits of the life-cycle costing process.

The basis on which a contractor will conduct life-cycle costing activities within a project will depend on the operator's requirements. On some contracts the role of the engineering contractor should be restricted to determination of the best life-cycle costing solution for given field data, a final product requirement and specified economic evaluation criteria. In some recent cases, the contractor responsibility has been extended both to earlier and later stages of the asset life-cycle.

The range of involvement by contractors in terms of level of detail and project phase is indicated in Figure 1 (see Introduction).

The contractor, with his relationship to both operator and vendor, has a pivotal role and in this respect is key to the successful introduction and continued evolution of life-cycle costing within the industry. The key issues in implementing life-cycle costing within the contractor are

— **the development and organization of a capability**: irrespective of the contractual relationship between the operator and contractor, it is likely that the majority of life-cycle costing work is undertaken by the contractor, with the operator coordinating and specifying the requirements at a high level,

— **contractual risk**: the extension of the contractors' role into early and later project phases will lead to greater involvement in life-cycle costing risk identification and assessment, together with the assumption of contractual risks for elements of support.

6.2 Developing and organizing a capability

A life-cycle costing capability is developed by a contractor in order to meet the requirements of operators.

Within the contractor organization, life-cycle costing is just another function that contributes towards the development of the solution. This can be met by existing project team members (given suitable training) or from a centralized function, such as existing project services or operations support groups. The advantage of a central source for life-cycle costing expertise is that it provides consistency across the organization.

Within the constraints defined in the operators' requirement, the life-cycle costing approach should be tailored to provide an economic response. Steps that can be taken include the following:

— identify the need for undertaking life-cycle costing in the contract;

— establish with the operator project-specific economic evaluation criteria, e.g. discount rates;

— perform an initial crude assessment to identify those components that contribute significantly to NPV, i.e. cost drivers;

— where there is limited opportunity to greatly influence a particular element, give less attention to such elements than those with greater influence;

— focus more effort on high-risk items;

— constrain the data requirements to reflect the level of design definition, focus on design differences and use sensitivity analysis to quantify uncertainties in data and estimates;

— use the best available data from operators, contractors, vendors or other organizations;

— develop a standard approach within the organization, and adapt or map onto the different requirements from operators. This can cover a range of topics such as modelling techniques, cost and work breakdown structures.

Vendors of critical equipment and systems are an integral part of the process, whether introduced to the project through competition or as a partner. Life-cycle costing is only one of a number of criteria used in selecting vendors. The criteria can be split into two broad categories:

— those where life-cycle costing assessment of their products will add no value to the development of an optimal solution and where the vendor has no requirement to develop a life-cycle costing capability, i.e. off-the-shelf items such as galley equipment;

— those supplying systems and equipment where there is opportunity to optimize the design from a life-cycle costing standpoint. Consideration should be given to improving the reliability of life-cycle costing analysis by devolving work to those critical equipment vendors who have developed a life-cycle costing capability. For others, the contractor will have to provide significant support in the assessment of their equipment and systems.

6.3 Risk — A contractual perspective

6.3.1 General

For the contractor, life-cycle costing is a technique that can assist in the extension of their role into areas such as maintenance management, integrated service provision and engineering services. These opportunities also present the contractor with potential for additional risks and associated potential for rework, dependent on the contractual scope of work defined by the operator. The generic steps below identify the role of life-cycle costing in supporting existing business (design trade-off) and extending the business (contracting for support). Each step represents increased financial risk (and opportunity) to the contractor:

— **step 1: design trade-off**
  Where life-cycle costing is used as a design trade-off tool, financial implications to the contractor may arise through technical performance guarantees.

— **step 2: contracting for elements of support**
  Where life-cycle costing is used by the operator to assist in identifying and contracting for elements of operation and support, there is a direct financial consequence to the contractor through the prices quoted.

6.3.2 Design trade-offs

Guarantees required by the operator may be accompanied by contractual penalties for failure to meet the technical performance requirement. Life-cycle costing can provide a quantitative basis for assessing the impact of performance variation on production revenue by

— reviewing the specified level of performance: a relaxation may enable the contractor to offer a lower-cost or -risk solution leading to an improved NPV for the operator,

— assessing the level of incentives and penalties in relation to the contractor's performance for contractually agreed targets on NPV.

The most convenient vehicle for the discussion between operator and contractor on these issues is the file which contains the data sources and assumptions.

The most effective mechanism the contractor can use to tailor the work is a top-down approach. This focuses on the range of options examined and sacrifices the level of detail considered to ensure that the coverage is complete. In early phases of development, such as concept and outline design, it may be possible to defer work to later phases without compromising the value of the work undertaken.

7 The vendor perspective

7.1 General

The operator, contractor and vendor perspectives are intended to be reviewed and understood by all groups, i.e. those from within the vendor's sector should read the other two perspectives in addition to their own. This will lead to a greater appreciation of the challenges and benefits of the life-cycle costing process.

The range of involvement by vendors in terms of detail and project phase is indicated in Figure 1 (see Introduction).

For the vendor, life-cycle costing is a technique that can be used to demonstrate improved service and quality, thereby extending their role beyond equipment supply. As such, the specification of life-cycle costing from clients does not constitute a threat, but represents a potential for increased opportunity and profitability, by adding value to a field development project in all phases through vendor involvement.

For the vendor to achieve this potential, a value-optimization competence is required. In addition there are challenges that should be addressed with regard to operational data, internal competence and contracts.

7.2 The application of life-cycle costing for the vendor

While the requirement to undertake life-cycle costing is increasingly being specified by customers, its impact on the vendor is somewhat different from that on the customer.

For the operator, life-cycle costing is concerned with optimizing CAPEX, OPEX and revenue, with the focus generally on the CAPEX/OPEX trade-offs. As such, for the operator life-cycle costing is primarily focused on their costs. For the vendor, life-cycle costing impacts on both income (product sales) and costs. This is shown in Figure 3.

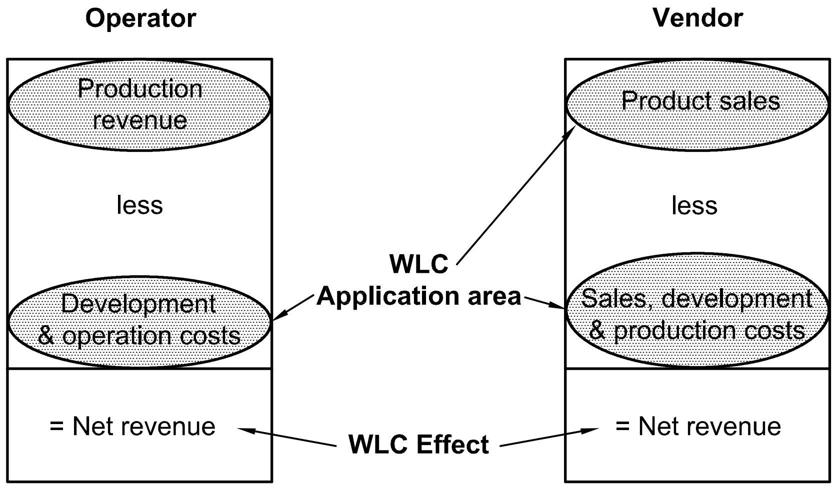


Figure 3 — Life-cycle costing can affect vendors' income and costs

The aim of life-cycle costing is to optimize the operator’s profitability. The consequence for the vendors is that it may adversely affect both the vendors' sales revenue and costs. To counter this, the vendor should focus his attention on using life-cycle costing to improve the products which generate income.

The critical areas in the short term for the vendor are the following:

— the ability to win contracts in the ever-more-demanding market;

— the internal competence of the vendor to deliver and demonstrate added value to customers;

— client dedication and competence;

— the speed of the change.

The critical areas in the long term are to stay competitive through:

a) integration of economics into all functions of the company, leading to lower-cost production;

   Functions to be considered leading to lower-cost production include

   — production,

   — maintenance,

   — warehousing,

   — logistics,

   — marketing,

   — procurement.

b) development of new life-cycle costing-based system solutions.

   The vendor is no longer simply selling equipment, but supplying package solutions to meet overall client needs.

   The vendor should be able to demonstrate an understanding of the project life-cycle and how he can contribute to lowering costs through

   — production competence,

   — engineering competence,

   — product development competence (especially in relation to framework agreements),

— maintenance and support competence,

— optimization competence.

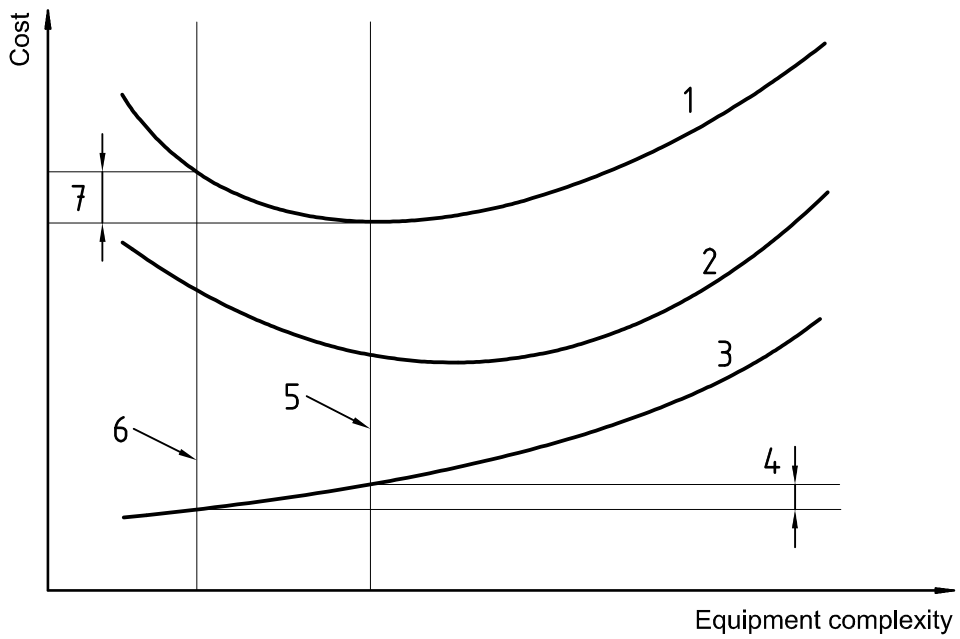
In all of these, the vendor should also be able to demonstrate how his equipment/systems will be used.

To date, the vendor’s competence in the production and engineering fields has been demonstrated by his equipment and unit prices. In the future, with increased vendor involvement in the field development projects, the focus will shift more towards the overall competence of the company. The vendor’s product will be his competence to arrive at the most cost-effective solution for the total package to fill a function over its lifetime.

This will spread throughout the supply chain, and is equally applicable for the relationship between vendors, their suppliers and subcontractors.

7.3 Profitability potential for vendors

The opportunity for the vendor in the application of life-cycle costing is illustrated in Figure 4.



Key

1 Total cost to operator (WLC)
2 OPEX
3 CAPEX
4 Vendor opportunity
5 Best solution
6 Minimum acceptable technical standard
7 Operator opportunity

Figure 4 — Life-cycle costing provides an opportunity for the vendor to demonstrate that higher-cost equipment adds value

The adoption of functional specifications can lead towards solutions offering the minimum acceptable technical performance with competition on lowest price. This may be in neither the operator nor the vendor’s best interest. The use of life-cycle costing can arrive at the optimum solution (as defined by the operator's decision criteria) that maximizes operator profitability, even if this increases the initial cost. This gives a potential for the vendors to improve their profitability through offering higher-value equipment and demonstrating added value to the client.

If the vendor can build up an understanding of the operator's total costs in relation to the vendor's equipment, this will result in the following:

— the vendor improving his revenue by getting paid for improved quality, efficiency or maintainability by demonstrating added value to the operator;

— the client achieving lower total cost for the function the equipment is to fulfil, thereby improved profitability;

— the vendor being better placed to extend the scope of his supply by contracting for elements of support.

In addition, the vendor's contribution towards design improvements, for example by being involved in outline design and FEED, can be reimbursed based on commercial competitiveness.

In offering options which have increased CAPEX justified by the expectation of future OPEX savings, the operator should be made aware that there is some risk that future expectations may not be realized.

7.4 Communication

7.4.1 The communication loop

The objectives of a life-cycle costing-based procurement are

— **for the operator/contractor**, to evaluate the solutions offered by the vendor based on added value to the project;

— **for the vendor**, to evaluate and select the solution, based on the vendor's range of products, that offers the most value to the customer.

The operator and contractor's attention will generally be focused towards the bid evaluation. However, from the vendor's perspective, the greatest potential lies in offering the optimum solutions to fit the need from the variety of solutions the vendor can offer. The most important factor in achieving the objectives of all participants is two-way communication, see Figure 5. To enable the vendor to offer the best solution to cover the needs, the client should communicate, or the vendor should request, the following:

— the need, e.g. capacities and operating level over the lifetime;

— evaluation criteria with lifetime, and how to balance OPEXs against investment (usually assessed using NPV or net present cost, with a defined discount rate);

— constraints, such as limitations on topside weight, power consumption, footprint or access for maintenance (typically determined by previous work);

— cost parameters outside the vendor's control, e.g. energy costs, in order that the vendor can perform the trade-offs between alternatives, such as high efficiency and high price vs. low efficiency and low price.

For the vendor, communication is focused on

— ensuring he has adequate information to optimize his offer against the client needs,

— demonstrating the value of the solution to the client. This could for example be in terms of lower cost, maintainability, efficiency or reliability.

The client will only evaluate the solutions offered. However, the vendors are frequently unable to offer the solution from their range of products that best fits the clients need. This is normally due to lack of information on the clients need, perception of total value and evaluation criteria.

7.4.2 Responding to life-cycle costing enquiries

When responding to a life-cycle costing-based enquiry, the main issues are to

— clarify the evaluation criteria and their impact,

— identify the client’s need, operating level and conditions over lifetime,

— clarify the availability of data from the customer, together with the data requirements for the bid,

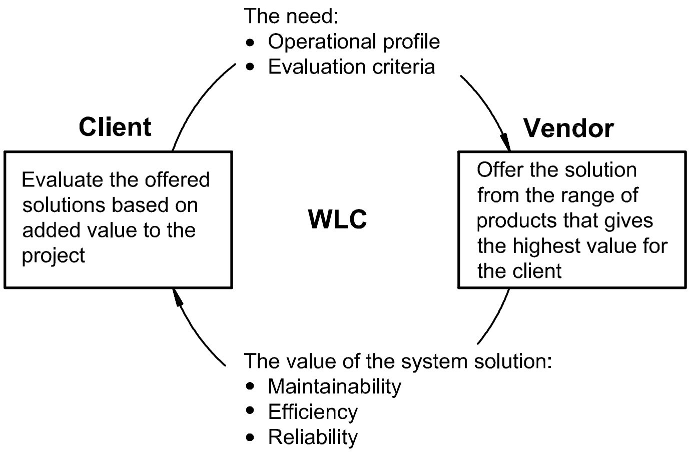


Figure 5 — The vendor should ensure that two-way communication is established

— identify the cost drivers,

— put together a package that gives the lowest life-cycle cost by focusing attention on the cost drivers,

— demonstrate the value of the package solution in the bid response.

The focus should be on how the bids will be evaluated (how much importance does the client attach to life-cycle costing) and on the client's needs. When the cost drivers have been identified, the potential for cost reductions (arising from design improvements or changes in the support or maintenance strategy) can be defined. Alternatives which indicate reduced life-cycle costing can be evaluated in relation to their impact on the offered price.

The focus should be on the areas where added value to the client can be demonstrated, and on how to communicate the value or the cost-reduction potential for the package.

7.4.3 Life-cycle costing evaluation of vendors or subcontractors

A life-cycle costing bid evaluation requires

— an integrated technical and commercial evaluation,

— technical differences to be quantified and form part of the commercial evaluation,

— the cost drivers and the elements/parameters affecting these to be identified.

To achieve a professional evaluation, a predetermined baseline is beneficial. In most life-cycle costing evaluations it is the difference between alternatives that are of interest, and not the quantification of the total life-cycle cost. A common trap is to examine details on equipment that are practically identical, where the cost differences are smaller than the uncertainty in the data. It is on the design differences, in the form of efficiency curves, capacities, configurations and resulting availability figures, that cost differences can be identified and qualified. In life-cycle costing evaluation, the focus should be on design differences between alternatives.

7.4.4 Data

One of the major challenges for a vendor is to obtain access to operational/historic data for his own equipment. A system and procedure for continuous data collection and adjustment should be established by vendors in order to demonstrate their commitment to offering life-cycle costing-based solutions. This will provide the basis for

— identifying cost drivers,

— determining the contribution his products make towards the client's profitability,

— defining the value of design improvements,

— staying competitive in the market place.

Most operators are not unwilling to give out data, but they do not necessarily have it structured in a manner that allows it to be used directly. It is often spread across different databases in different parts of the organization, and it may be difficult to establish the total overview. To get the information can take time and energy, and it might not be the right data. The vendor should have a clear strategy for obtaining access to operational data on his equipment. This can include

— defining which equipment and what type of data are required,

— getting support at a high enough level in the operator organization,

— having an understanding and overview of the relevant operating departments,

— developing, understanding and interpreting relevant databases,

— identifying and targeting key personnel operating the databases,

— obtaining support from these key persons,

— planning ahead; collecting the relevant information will take longer than that allowed for in responding to a typical enquiry.

7.5 Contracts

The use of life-cycle costing will lead to different forms of contract. Some companies have required a guarantee on the future life-cycle costing in relation to the vendor's package offering. This is difficult to quantify even after the costs have occurred. Why costs turn out to have a different magnitude than estimated is also hard to demonstrate, thereby presenting challenges in obtaining legally binding guarantees.

Another obstacle is that few vendors seem to be willing to accept a responsibility for the total life-cycle costing. Unless they have taken steps to collect and understand information on the OPEXs of their equipment, they should be faced with considerable uncertainty in the costs, and this will attract a high risk premium. This means that the cost increases.

Another approach is to require guarantees on the elements affecting the cost drivers, like efficiency curves and performance over time. This seems natural, since improved capability in relation to these factors will invariably be the reason for selecting the vendor.

Combined purchase and maintenance contracts are becoming more prevalent. This makes life-cycle costing-based bid evaluation easier, since the vendor is directly responsible for significant elements of the OPEXs.

For all parties (operator, engineering contractor and vendor) probably the most difficult contractual aspect in relation to life-cycle costing is the topic of bonus and incentive schemes. In the current climate, all parties are working together to deliver a working facility with a focus and bonus on time and CAPEX. The problem lies in the difference in overall economic objectives of the parties.

The operator’s profitability is derived from overall performance and costs over life, whilst the engineering contractor's and the vendor's profitabilities are related to the contract payment from the operator and the number of engineering hours, usually supported by a bonus where a technically acceptable solution is delivered under target CAPEX and on time.

As long as the focus of the operator was to develop the field at the lowest possible CAPEX, the incentive schemes were orienting the parties to work in the same direction. With a focus on life-cycle costing, a different approach to bonus and incentive schemes is necessary.

For the vendor, this issue of how to split the cost savings/added value is much easier. As long as life-cycle costing is the evaluation criterion, the vendor decides it as shown in Figure 6.

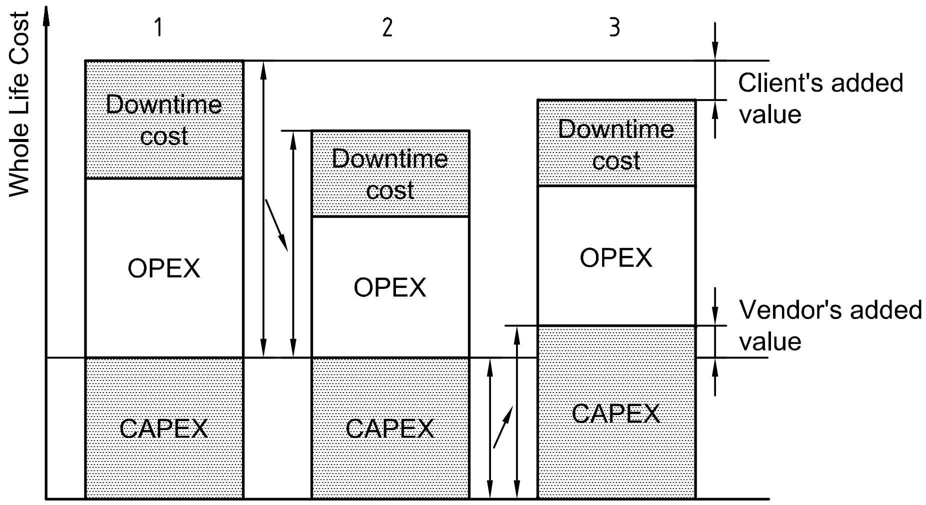


Figure 6 — Incentive schemes should share benefits between participants

Solutions with lower OPEXs or downtime costs (see column 2 in Figure 6), have a higher value for the client compared to traditional solutions with the same CAPEX (see column 1 in Figure 6). To enable a vendor to offer the solution which optimizes the life-cycle costing, it is likely that an increased investment will be needed and, in order to remain profitable, this will be passed onto the client in the form of a higher initial price. This will then result in the situation shown in column 3 in Figure 6. The vendor and the client thereby share the investment and the benefits arising. It is important for the vendor to be able to demonstrate to the client that this additional investment offers an appropriate return. An incentive scheme may be built into the contract as a method of securing this arrangement between the vendor and the client.

Independent of approach, incentive schemes should have bonus and penalty limits. The aim of any guarantee is to ensure that what is promised is delivered. When a penalty is invoked, the result should not be bankruptcy for the vendor, but an unprofitable contract. While the operators and contractors are aware of the need to balance bonus and incentive schemes with the vendor's financial commitment, the onus is on the vendor to suggest mechanisms for how this may be achieved. The aim is to ensure that the vendor receives an equitable share in any NPV improvements delivered to the operator.

When considering what can be justified as an equitable share, vendors need to understand that uncertainties associated with contracting on the basis of life-cycle costing may result in operations having both higher initial price and higher future OPEXs not recoverable from the vendor. Each contract should be considered on an individual basis and an appropriate contract scheme developed.

7.6 Internal competence

7.6.1 Challenges

The main challenges facing the vendor when integrating life-cycle costing within his own organization are

— integrating economics/life-cycle costing into the engineering disciplines, so that life-cycle costing becomes part of the engineering process focused on client needs,

— convincing the client that the alternative solutions offered constitute the most profitable outcome for the client,

— establishing a role in early project phases and assisting in the definition of the project need.

The first item is the most difficult. It requires a cultural change by refocusing daily activities in the organization towards value creation for the client. It requires pan-organizational involvement — all disciplines are involved, including marketing, sales, engineering, development, etc. A “champion” or coordinator is required, as outlined in clause 4.

The second and third items are equally important, and involve building up a capability in demonstrating the value of the vendor's own solutions and his optimization competence. The vendor can add significant value to the early project phases (concept and outline design) through his specialist process/system expertise and his broad experience base in his specialist area in other industries.

In his sphere of expertise, the vendor may possess a much broader experience base than the operator or contractor. The vendors are likely to supply solutions for various needs across the oil and gas industry and often also to other industries. This implies that vendors may be more likely to assess the requirement in their area of competence more accurately than the operator or contractor. This competence can be used to assist in the assessment of different concepts, leading into the assessment and specification of system solutions in outline design.

7.6.2 Training

Training is a common issue for the industry, operators, contractors and vendors alike. For the vendor, the most important issue is developing an understanding of the operator's needs through industry initiatives such as:

— developing an understanding of International Standards on life-cycle costing;

— common industry training programmes;

— integration into the education system.

Internally, the training focus for the vendor is as follows:

— life-cycle costing is to become standard practice in the different disciplines;

— a changed focus from only technology;

— cross-discipline boundaries;

— a way of achieving the company objectives.

7.6.3 A practical approach

When carrying out life-cycle costing evaluations it is important to recognize that costs are assessed from the client's perspective; it is his value that will be optimized. Factors to bear in mind are to

— adopt the client’s calculating/optimization assumptions,

— use an appropriate level of detail and focus on design differences,

— gain access to operational experience,

— be clear on the evaluation criteria (can vary).

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