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Petroleum, petrochemical and natural gas industries — Life cycle costing

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Petroleum, petrochemical and natural gas industries — Life cycle costing

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Preface

This Standard was prepared by the Standards Australia Committee ME-092, Materials, equipment, structures and related services for petroleum, petrochemical and natural gas industries.

The objective of this document is to specify requirements for and give guidance on the application of life cycle costing to create value for the development activities and operations associated with drilling, exploitation, processing and transport of petroleum, petrochemical and natural gas resources. This document covers facilities and associated activities within different business categories (upstream, midstream, downstream and petrochemical).

The life cycle costing process as described in this document is applicable when making decisions between competing options that are differentiated by cost and/or economic value. This document is not concerned with decision-making related to the economic performance of individual options or options differentiated by factors other than cost or economic value.

Guidance is provided on the management methodology and application of life cycle costing in support of decision-making across life cycle phases. The extent of planning and management depends on the magnitude of the costs involved, the potential value that can be created and the life cycle phase. It also provides the means of identifying cost drivers and provides a cost-control framework for these cost drivers, allowing effective cost control and optimization over the entire life of an asset.

This document is identical with, and has been reproduced from, ISO 15663:2021, *Petroleum, petrochemical and natural gas industries — Life cycle costing*.

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Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement)

This first edition cancels and replaces ISO 15663-1:2000, ISO 15663-2:2001 and ISO 15663-3:2001, which have been technically revised. The main changes compared to the previous editions are as follows:

— Clause 3: several new terms, definitions, symbols and abbreviations;

— Clause 4: a new clause has been introduced;

— Clause 5 and Clause 6: new clauses describing life cycle costing management and methodology which have been restructured from previous editions;

— Annex A: contains restructured text from ISO 15663-3:2001;

— Annex C: new annex describing life cycle costing techniques which also includes text from ISO 15663-2:2001;

— Annex B, Annex D, Annex E and Annex F are new annexes, but contain also some elements from the previous editions.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

Cost management within the petroleum, petrochemical and natural gas industries is important and will benefit from the adoption of a common and consistent approach to life cycle costing.

Life cycle costing is the systematic consideration of costs and revenues associated with alternative options required to fulfil the objectives of the business. It is an iterative process of planning, estimating and monitoring costs and revenue differences throughout an asset's life. It is used to support the decision-making process by evaluating alternative options and performing trade-off studies. While the largest benefits are typically achieved in the early life cycle phases, it is equally applicable to all life cycle phases and at many levels of detail.

The petroleum, petrochemical and natural gas industries have historically assessed the financial viability of project options based on minimum capital expenditure and achieving project schedule, whilst operating expenditures and lost revenue have received less focus in the decision-making process. This has ignored potentially large cost factors and has in some cases resulted in selecting non-optimal solutions.

Recognizing this situation, life cycle costing is increasingly being applied by a variety of organizations within the industry. All participants in the process — operators, contractors and vendors — can have a substantial impact on the life cycle cost, and it is not until all are involved that the benefits sought from the use of life cycle costing will be realized.

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Petroleum, petrochemical and natural gas industries — Life cycle costing

1 Scope

This document specifies requirements for and gives guidance on the application of life cycle costing to create value for the development activities and operations associated with drilling, exploitation, processing and transport of petroleum, petrochemical and natural gas resources. This document covers facilities and associated activities within different business categories (upstream, midstream, downstream and petrochemical).

The life cycle costing process as described in this document is applicable when making decisions between competing options that are differentiated by cost and/or economic value. This document is not concerned with decision-making related to the economic performance of individual options or options differentiated by factors other than cost or economic value.

Guidance is provided on the management methodology and application of life cycle costing in support of decision-making across life cycle phases. The extent of planning and management depends on the magnitude of the costs involved, the potential value that can be created and the life cycle phase. It also provides the means of identifying cost drivers and provides a cost-control framework for these cost drivers, allowing effective cost control and optimization over the entire life of an asset.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14224:2016, *Petroleum, petrochemical and natural gas industries — Collection and exchange of reliability and maintenance data for equipment*

ISO 19008:2016, *Standard cost coding system for oil and gas production and processing facilities*

ISO 20815:2018, *Petroleum, petrochemical and natural gas industries — Production assurance and reliability management*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Terms and definitions

3.1.1
abatement cost
cost generated for the removal or reduction of an undesirable item

Note 1 to entry: An item can be several types of avoided emissions, e.g. emissions to air and water, but most commonly used for CO_2 emission reductions. See further information in Clause C.7.

Note 2 to entry: Abatement cost can be both CAPEX and OPEX cost elements.

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3.1.2
asset
item, thing or entity that has potential or actual value to an organization

Note 1 to entry: Physical assets usually refer to equipment, inventory and properties owned by the organization. Physical assets are the opposite of intangible assets, which are non-physical assets such as leases, brands, digital assets, licenses, intellectual property rights, reputation or agreements.

Note 2 to entry: A grouping of assets referred to as an asset system (see ISO 55000:2014, 3.2.5) could also be considered as an asset.

[SOURCE: ISO 55000:2014, 3.2.1, modified — Note 1 to entry not included.]

3.1.3
best available techniques
BAT
latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicates the practical suitability of a particular measure for limiting discharges, emissions and waste

[SOURCE: OSPAR Convention:1992, Appendix 1]

3.1.4
break-even price
$\boldsymbol{U_{PV}}$
price which applied flat to the production sold gives N_{PV}=0

Note 1 to entry: The production can be related to material such as oil, equipment or services. See further information in C.6.3.8.

3.1.5
break-even volume
volume where a stream of revenues and cost balance results in N_{PV}=0

Note 1 to entry: The volume can be related to material such as oil, equipment or services that generates income. See further information in C.6.3.7.

3.1.6
capital efficiency index
CEI
$\boldsymbol{I_{CE}}$
NPV of a project after tax divided by the absolute value of the NPV of cash flow after tax up to a defined end point

Note 1 to entry: The capital efficiency index illustrates value creation relative to capital exposure. See further information in C.6.3.9.

Note 2 to entry: The absolute value of the net present value of cash flow after tax applies until the point where annual cash flow becomes positive [see Formula (C.8)].

3.1.7
capital expenditure
CAPEX
investment used to purchase, install and commission an asset

Note 1 to entry: See further information regarding estimation of CAPEX in Clause C.2.

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3.1.8
code of resource
COR
hierarchical structure of SCCS that classifies all project resources according to the type of contract/resource that is involved in the activity and has an associated set of rates

Note 1 to entry: Specific code of resource structure exist, i.e. SCCS is described in ISO 19008:2016. COR codes can be found at https://standards.iso.org/iso/19008.

[SOURCE: ISO 19008:2016, 2.1]

3.1.9
committed costs
fixed costs that cannot be eliminated or even cut back without having a major effect on profits or on the organization's objectives

3.1.10
constraint
limit imposed externally or internally by the project that rules out the selection of an option if the limit is exceeded

3.1.11
cost breakdown structure
structure related to the methods that an organization employs to record and report costs

Note 1 to entry: Specific cost breakdown structure exists, i.e. SCCS is described in ISO 19008:2016. See https://standards.iso.org/iso/19008.

3.1.12
cost data
cost information associated with a defined cost element

Note 1 to entry: Cost data can be qualitative or quantitative cost information.

3.1.13
cost driver
major cost element which, if changed, will have a major impact on the life cycle cost of an option

3.1.14
cost element
subset at any level of the total cost for a cost breakdown structure

Note 1 to entry: The cost of an object/item, resource, activity or a combination of those.

Note 2 to entry: Specific cost element exists when ISO 19008:2016 is applied, i.e. the term 'cost item' as defined in 3.1.16.

3.1.15
cost issue
cost element which, if changed, will not have a major impact on the life cycle cost of an option

3.1.16
cost item
particular part/level that is coded/classified using the SCCS

[SOURCE: ISO 19008:2016, 2.2]

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3.1.17
discount rate
d
rate of return used in determining the net present value of future cash flow

Note 1 to entry: The discount rate is normally given on an annual basis, but can also be given based on another time period, e.g. a monthly or quarterly basis.

Note 2 to entry: See further information in C.6.2.

3.1.18
economic evaluation measure
quantitative measure used to quantify economic characteristics

Note 1 to entry: Economic evaluation measures may apply for the economic comparison where only subsets of costs are needed (e.g. subset of CAPEX, OPEX and revenue factors).

Note 2 to entry: See further information in C.6.3.

3.1.19
fixed cost
cost that does not vary with production volume or with the level of activity

Note 1 to entry: Fixed cost is not necessarily constant throughout all life cycle phases of an asset or an activity.

Note 2 to entry: Both CAPEX and OPEX can have fixed cost items.

3.1.20
initial investment
first investment for a project

Note 1 to entry: Initial investment is a part of the overall CAPEX or the overall CAPEX for the project itself and will depend on the type of project. The timing of initial investment can vary and is important to describe in the LCC calculations in a given project.

3.1.21
internal rate of return
IRR
$\boldsymbol{d_R}$
rate of return of future net cash flow that gives $N_{PV}=0$

Note 1 to entry: See further information in C.6.3.4.

3.1.22
item
subject being considered

Note 1 to entry: The item can be an individual part, component, subunit, equipment, system, plant or installation.

[SOURCE: IEC 60050-192:2015, 192-01-01, modified — Note 1 to entry has been adjusted.]

3.1.23
life cycle
series of identifiable stages through which an item goes, from its conception to disposal

Note 1 to entry: The identified stages are defined as *life cycle phases* (3.1.28).

[SOURCE: IEC 60050-192:2015, 192-01-09, modified — Note 1 to entry has been added.]

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3.1.24
life cycle cost
LCC
L_{CC}
total cost incurred during the life cycle

Note 1 to entry: LCC is the discounted sum of CAPEX, OPEX and LOSTREV, see C.6.3.3.

Note 2 to entry: Total cost of ownership is sometimes used in preference to LCC when explaining the application of life cycle costing (i.e. the methodology) but it is not used in this document. See further information in 4.2.

[SOURCE: IEC 60050-192:2015, 192-01-10, modified — Notes 1 and 2 to entry have been added.]

3.1.25
life cycle cost analysis
LCC analysis
systematic evaluations and calculations carried out to assess competing options using economic evaluation measures of as part of life cycle costing

Note 1 to entry: The economic evaluation measures are described in C.6.3.

3.1.26
life cycle cost model
LCC model
mathematical relationship between cost elements and life cycle cost differences

Note 1 to entry: The LCC model will contain different economic evaluation measures as described in C.6.3.

3.1.27
life cycle costing
process of evaluating the difference between the life cycle cost of two or more alternative options

Note 1 to entry: Life cycle costing can involve quantitative and/or qualitative assessment.

3.1.28
life cycle phase
discrete stage in the life cycle with a specified purpose

Note 1 to entry: The different life cycle phases are further described in 4.5.

3.1.29
lost revenue
LOSTREV
income loss that occurs when generated income are less than expected due to external or internal factors

Note 1 to entry: When the generated income is related to production, ISO 20815:2018, 3.1.25 defines lost revenue as: Total cost of lost or deferred production due to down time. Production and time loss categories are defined in ISO 20815:2018, Clause G.3.

Note 2 to entry: See further information regarding estimation of lost revenue in Clause C.4, and see also ISO/TS 3250:—[1].

3.1.30
net present value
NPV
N_{PV}
present value that is calculated by discounting the future net cash flow with the required rate of return as the discount rate

Note 1 to entry: In this document, the term net present value is used, even though the industry sometimes uses also the term present value reflecting the same discounted value. See further information in C.6.3.2.

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3.1.31
operating expenditure
OPEX
expenses used for operation and maintenance, including associated costs such as logistics and spares

Note 1 to entry: See further information regarding estimation of OPEX in Clause C.3.

3.1.32
payback period
Y_{PB}
period after which the initial investment has been paid back by the accumulated net revenue counted from the first income

Note 1 to entry: The payback period is also sometimes called pay-out time. See further information in C.6.3.6.

Note 2 to entry: When the payback period is calculated, it is important to state whether it is based on the summation of nominal values or based on discounted values where the latter can lead to a somewhat longer payback period.

3.1.33
physical breakdown structure
PBS
hierarchical structure of SCCS that defines the types of physical asset components of field installations being delivered by the activity

Note 1 to entry: Specific physical breakdown structure exists, i.e. SCCS is described in ISO 19008:2016. PBS codes can be found at https://standards.iso.org/iso/19008.

[SOURCE: ISO 19008:2016, 2.6, modified — Note 1 to entry has been added.]

3.1.34
production availability
ratio of production to planned production, or any other reference level, over a specified period of time

Note 1 to entry: This measure is used in conjunction with analysis of delimited systems without compensating elements such as substitution from other producers and downstream buffer storage. Battery limits need to be defined in each case.

Note 2 to entry: See further information in ISO 20815:2018.

[SOURCE: ISO 20815:2018, 3.1.46, modified — Notes 1, 3, 4 and 5 to entry have not been included, new Note 2 to entry has been added.]

3.1.35
profitability index
PI
I_P
ratio of NPV of the project divided by the discounted CAPEX

Note 1 to entry: See further information in C.6.3.5.

3.1.36
required rate of return
discount rate requirement by the decision-maker for minimum profit for the investment project

3.1.37
revenue
income generated from normal business activities

3.1.38
revenue gain
generated income that is higher than expected due to external or internal factors

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3.1.39
risk
combination of the probability of an event and the consequences of the event

Note 1 to entry: This definition is based on ISO/IEC Guide 51:2014, 3.9 that defines risk as combination of the probability of occurrence of harm and the severity of that harm, where the probability of occurrence includes the exposure to a hazardous situation, the occurrence of a hazardous event and the possibility to avoid or limit the harm. "Harm" has been replaced by "event" in the definition to cope with production assurance purpose. It is also similar to the definition of the "level of risk" given in ISO Guide 73:2009, 3.6.1.8 (i.e. "combination of consequences and their likelihood").

[SOURCE: ISO 20815:2018, 3.1.54, modified — Note 2 to entry not included.]

3.1.40
standard activity breakdown structure
SAB
hierarchical structure of SCCS that defines the type of activity that is being performed

Note 1 to entry: Specific standard activity breakdown structure exists, i.e. SCCS is described in ISO 19008:2016. SAB codes can be found at https://standards.iso.org/iso/19008.

[SOURCE: ISO 19008:2016, 2.8, modified — Note 1 to entry has been added.]

3.1.41
standard cost coding system
SCCS
standard system for classification and coding cost estimates, monitoring and final quantities and cost data

Note 1 to entry: The SCCS code comprises three individual hierarchical coding structures named PBS, SAB and COR, each based upon a different aspect/facet of the scope of work.

Note 2 to entry: In this document, SCCS means the use of ISO 19008:2016.

[SOURCE: ISO 19008:2016, 2.7, modified — Note 2 to entry has been added.]

3.1.42
sustainability
state of the global system, including environmental, social and economic aspects, in which the needs of the present are met without compromising the ability of future generations to meet their own needs

[SOURCE: ISO Guide 82:2019, 3.1, modified — Notes to entry not included.]

3.1.43
uncertainty
<of a quantity> inability to determine accurately what is or will be the true value of a quantity

Note 1 to entry: Uncertainty can have different meanings. It can be used as a measure of variability within a population, which is a type of uncertainty often referred to as stochastic (or aleatory) uncertainty. Uncertainty can also have a subjective meaning (epistemic uncertainties).

Note 2 to entry: Uncertainty of input data is particularly important for life cycle costing. See further information in 6.4.4 and D.5.

Note 3 to entry: Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequences, or likelihood.

[SOURCE: ISO 14224:2016, 3.95, modified — Note 1 to entry has been adjusted, and Notes 2 and 3 to entry have been added.]

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3.1.44
variability
variations in performance measures for different time periods under defined framework conditions

[SOURCE: ISO 20815:2018, 3.1.62, modified — Note 1 to entry not included.]

3.1.45
weighted average cost of capital
WACC
average after-tax cost of a company's various capital sources, including stocks and interest-bearing debt

Note 1 to entry: WACC is the average rate a company expects to pay to finance its assets. See further information in C.6.3.2.

3.2 Abbreviated terms

DRILLEX	drilling expenditures
EPC	engineering procurement and construction
EPCI	engineering procurement construction and installation
EPIC	engineering procurement installation and commissioning
FEED	front-end engineering design
FID	final investment decision
FPSO	floating production storage and offloading
HSE	health safety and environment
LCCMP	life cycle costing management plan
LNG	liquefied natural gas
MU	monetary units

4 Application

4.1 Users of this document

This document is intended for users responsible or involved in life cycle costing and associated activities such as:

— Installation/plant/facility: Operating facility, e.g. HSE, engineering, construction, installation, operation and maintenance personnel.

— Operator/owner/company: Project management and control, technology development, technology qualification, concept and system design, HSE, integrity management, maintenance management, production assurance, etc.

— Contractor: Main contractor for engineering, procurement, construction, drilling, installation, operation, maintenance services, etc.

— Vendor/manufacturer/supplier: Technology development, technology qualification, system design to ensure product quality and improvements, etc.

— Authority/regulatory body: Regulatory requirements that can refer to this document to enhance HSE, production availability, system availability, operability, maintenance and resource utilization.

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— Consultant: Consultancy services for supporting system design, production assurance and reliability management, technical safety, etc.

— Industry: Any other user involved in life cycle costing activities in the industry.

4.2 Framework conditions

The objective associated with life cycle costing is to provide decision support for selecting between alternative options (e.g. technical and operational items), which are aligned with overall corporate business objectives. Figure 1 illustrates that this is different from company economics and project economics.

The following applies as part of defining the framework:

— when establishing a consistent cost breakdown structure for the competing options, ISO 19008:2016, related to cost coding, shall be evaluated for use (see 6.3.1 and Annex C);

— when establishing qualified data input and calculation of operating expenditures, revenue and lost revenue, ISO 14224:2016 and ISO 20815:2018, related to reliability data, production assurance and reliability management, shall be used (see Annex C);

— consideration should be given to quality management, for which ISO 9000:2015, ISO 9001:2015 or ISO 29001:2020 can be used;

— consideration can be given to social responsibility, for which ISO 26000:2010 can be used.

The LCC model is the quantitative model used when comparing competing options. This LCC model can be different from economic models used by the operator for other purposes. In such specific cases, explanation of essential differences should be given.

In the majority of cases, a spreadsheet model represents the most cost efficient and flexible solution for an LCC model for comparison of options (see 6.4.2). The LCC model developed should be simple enough to be transparent to the user, but accurate enough to represent the difference between options.

Life cycle cost is defined as the total cost incurred during the life cycle. As indicated in Figure 1, life cycle cost is derived numerically. This numerical output is sometimes referred to as the total cost of ownership rather than LCC, to provide distinction between life cycle costing as an activity and LCC as an output. While LCC and total cost of ownership can be considered numerically equivalent, LCC is used in this document. Total cost of ownership is not used to prevent possible confusion of with so-called "ownership cost", which can exclude cost elements and cost drivers that are included in LCC. Similarly, ownership cost may include costs relating to project economics (e.g. depreciation) that do not form part of LCC.

IEC 60300-3-3:2017 provides a general introduction to the concept of life cycle costing and covers all industry applications.

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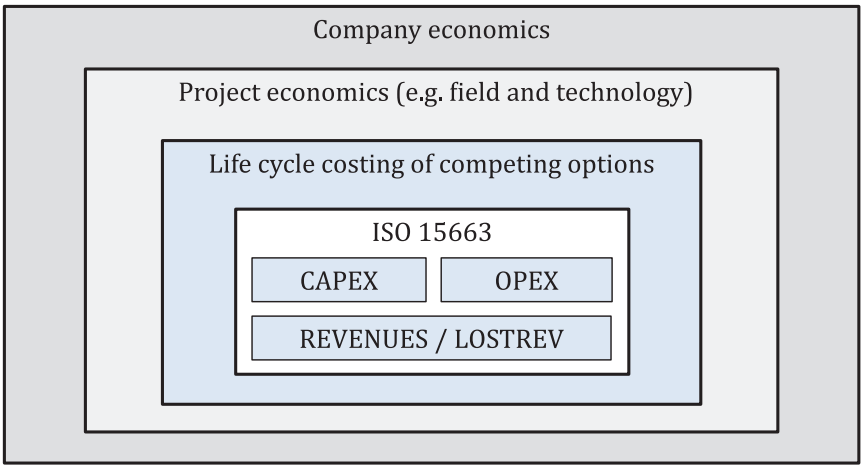

Figure 1 — Framework conditions for life cycle costing

4.3 Limitations

4.3.1 General

This document specifies requirements and provides guidance for application and implementation for undertaking life cycle costing. Some limitations are described below.

— This document focuses on life cycle cost comparison between competing options for a subject matter (see also 4.6). This document is not intended for the entire project economy evaluation of field development projects or investment appraisals, for which all cost issues need to be covered. Comparative life cycle costing will include only the relevant cost elements. Thus, this document also provides guidance for use in the selection of the relevant cost elements to ensure cost-effective life cycle costing.

— The detailed analyses required to accurately predict life cycle cost will, in many cases, require input data and information derived from other efforts, such as reliability modelling, maintenance analysis, logistic, material and spares studies or other techniques that help develop individual cost element estimates. This document will not address in detail how to apply these specialist techniques. These techniques are not unique to life cycle cost analysis and are described in other relevant International Standards, such as ISO 14224:2016 and ISO 20815:2018. See also Annex C.

— This document does provide typical life cycle costing calculation methods and describes the common and best practice analytical concepts. Potential users are made aware that companies will often have specific requirements in areas such as the treatment of cash flow, discounting assumptions, views on uncertainty and risk management, guidelines on margin and their own decision support metrics and economic decision-making criteria. This document enables users to conform with life cycle costing requirements or reveal nonconformance and possibly (as needed) describe company specific issues used in this context.

— Capital projects may require extensive value engineering studies to support incremental investments. The sensitivity analyses usually associated with value engineering can be varied and diverse. This document provides case specific examples, but it is important to understand the basic concepts and tailor them to particular study requirements as required.

— Contractual relationships between operators, equipment suppliers and engineering contractors can be complex and difficult to manage consistently. This document identifies common contractual considerations, some potential pitfalls and recommendations for successful outcomes when collaborating with third parties. It cannot be exhaustive in terms of covering all potential scenarios, relationships or contracting plans. The user should understand the basic life cycle costing concepts prior to starting a life cycle costing study which involves third parties.

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— A more specific consideration between different companies is joint venture agreements, usually between oil and gas operating companies. In these situations, individual company economic considerations and investment decision criteria can be different between partners. For example, the treatment of cash flow can be different between companies.

— It is recognized that making a decision on any option is not always driven by cost or economic value considerations. Different business drivers or objectives can determine the decision, even if some of these drivers could not be quantified in equivalent cost and/or benefits. For example, the opportunity to use and test new technology, HSE targets, sustainability, climate change impact, energy efficiency, risk mitigation or opportunity exploitation, local or technical constraints, budget limitations or cost exposure, value of reputation, market context or contractual schemes, could drive or contribute to determining the final decision between options.

— This document provides recommendations on typical roles and competency expectations for staff involved in life cycle costing which are not intended to be considered requirements.

4.3.2 HSE considerations

Health, safety and environmental constraints prevail over cost when evaluating competing options. HSE considerations are therefore important when scoping life cycle costing (see 6.2) to assess whether competing options conform with the minimum set of HSE requirements. The recommended option (see 6.5) shall always conform to these HSE requirements. The degree of technical, operational, organizational or human HSE related issues amongst competing options can vary or is only important for some of the competing options. The choice of life cycle costing subject matters should also have a management focus for enhancing HSE level (see 4.6).

Depending on the life cycle costing subject matter and associated competing options, how and when to reflect HSE can vary when quantifying the main elements of life cycle costing, i.e. CAPEX, OPEX and revenue factors (REVENUES or LOSTREV). The LCC analysis can then be difficult and can form an important condition or uncertainty for final decision-making, where decision criteria (e.g. regulatory safety requirements and company HSE targets) will also apply. Increased CAPEX to enhance HSE level can be preferred over the higher cost (OPEX and LOSTREV) arising from the failure consequence of unacceptable HSE level (see e.g. ISO 14224:2016, Table C.2). Increased OPEX and LOSTREV due to potential hazards and accidental events may be explicitly formulated to reveal this, to support decision-making. The HSE implications during the life cycle phases shall also be considered when using life cycle costing for selecting between competing options. Further information regarding environmental aspects is provided in Clause C.7.

HSE considerations for the purpose of life cycle costing can require support from risk management, risk analysts and technical HSE personnel (see e.g. ISO 20815:2018, Clauses C.2, F.4, and I.20, and ISO 31000:2018). The balance between HSE and cost should also be considered when the life cycle costing subject matter is comparison of different preventive maintenance options, e.g. optimizing test interval for safety critical equipment as defined in ISO 14224:2016, 3.84 (see also ISO 20815:2018, Clause I.16, and ISO/TR 12489:2013).

4.3.3 Sustainability and climate change considerations

Sustainability and climate change considerations are part of the life cycle costing activities, not only in conjunction with associated costs, but also in terms of expected performances and benefits of each option, in support to the decision-making process. This can be related to mitigation and adaptation measures.

The carbon footprint of a product (as defined in ISO Guide 84:2020, 3.1.32) can vary between the competing options and over the life cycle. Depending on the business objectives and authority requirements, the LCC analysis should include the relevant factors.

This document also has economic evaluation measures that cover abatement cost (see Clause C.7). This can lead to a higher LCC of a selected (recommended) option that achieves better carbon footprint performances than a less expensive option.

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Corporate and authority requirements or targets can affect the degree the LCC analysis alone forms basis of decision-making, or whether the life cycle costing provides support to more overall decision-making addressing aspects outside the scope of this document, such as sustainable procurement (see ISO Guide 82:2019 and ISO 20400:2017).

IOGP report 437[20] can also be considered when evaluating different competing options related to sustainability.

4.4 Benefits of life cycle costing

Applying life cycle costing has several benefits. 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 their role beyond technical conformance and lowest price.

Figure 2 illustrates the degree of participants involvement on the level of detail and the life cycle phase. This allows them to easily recognize where the maximum value can be reached in applying life cycle costing in their work processes.

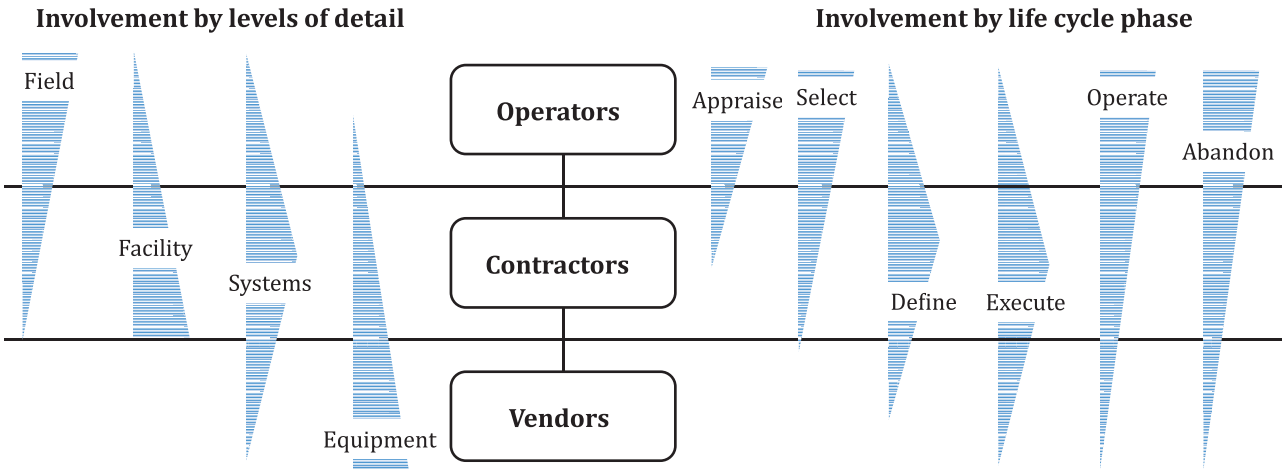

Figure 2 — The role of participants with respect to level of detail and life cycle phase

The systematic application of life cycle costing in a project development context will include any or all of the following benefits:

A. Strategic alignment: All engineering decisions being made by considering the consequences on OPEX and their effect on the revenue profile, in accordance with the corporate objectives of adding value on investments.

B. Improved framework for performance contracts and life cycle costing: Enhancing the overall quality level of materials and services in the supply industry through the development of performance contracts amongst operators, contractors and vendors with complementary metrics besides CAPEX, e.g. operating phase metrics (systems availability guarantee and risk-sharing clauses).

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C. Improved decision criteria for selecting a profitable option: Supporting the decision-making process with the establishment of predefined criteria to rank and analyse the options with respect to their added value.

D. Increased operating predictability: To perform life cycle costing assessments, it is necessary that operating expenditure elements are identified at an early stage. In this sense, operating experience plays an important role in preventing cost underestimation and cost overruns. Technical operating experience is also a valuable resource that can be introduced early in a project development to select and evaluate options to be compared.

E. Targeted planning of the life cycle costing activities: An integrated planning for all stages of development ensures that the resources required for life cycle costing assessments will be available in an adequate time to provide the necessary inputs to the task of comparing options for a process function and consider the effects of these decisions on other process functions. The use of an LCC model enables the identification, targeting and reduction of cost drivers. Then, a sensitivity analysis may indicate critical functions that will become targets for research and development, technology transfer and a focus for management effort.

F. Long-term economical perspective: The quantitative approach to life cycle costing provides an early diagnosis of the project's economic performance over time. This feature allows a common basis to compare not only the functions within a project, but also an integrated economical approach to the business portfolio.

4.5 Life cycle costing within the life cycle phases

The primary purpose of life cycle costing is to assist 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. The different life cycle phases are defined in Table 1.

Table 1 — Life cycle phases (for asset/project) — for facility owner/operating company

Id.	Life cycle phase	Phase outcome/ delivery	Phase outcome/ delivery (for a project in existing asset)
0	Explore	Identified business opportunities	Identified business opportunities
1	Appraise	Feasible installation concept(s)	Feasible solution(s)
2	Select	A selected (preferred) installation concept	A selected (preferred) solution
3	Define	A defined (matured) installation concept for final investment decision (FID)	A defined (matured) solution for final investment decision (FID)
4	Execute	The installation is ready to start production/operation	The solution has been installed and is ready to start production/operation
5	Operate	End of installation operating life	End of (modified) installation operating life
6	Abandon	The facility has been removed and disposed	The facility has been removed and disposed

NOTE 1 Facility owner/operating company can be oil company, rig owner, etc.

NOTE 2 The life cycle phases are defined for the purpose of this document and further sub-division is given in Figure B.1.

The typical scope and objectives of life cycle costing activities for each life cycle phase are as follows:

— Explore (e.g. identification of business opportunities). Life cycle costing activities for this phase are business opportunities, ranked utilizing high-level life cycle costing considerations.

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— Appraise (e.g. identification and assessment of feasible concepts). The scope of this phase normally includes gross comparisons of the major technical options. The focus is on the major cost and revenue trade-offs with adequate levels of detail.

— Select (e.g. concept development and concept selection). In this phase, alternative technical and operational solutions are normally examined and compared, aiming at selecting a preferred concept. Processing and delivery are considered as well as procurement options (lease or buy) and the options for operation and support.

— Define (e.g. conceptual/outline system design and front-end engineering design). Life cycle costing activities in this phase typically include the identification and examination of the technical options for facilities, processes and delivery leading to a defined (matured) preferred concept or technical solution for FID.

— Execute (e.g. engineering, procurement, fabrication, testing, installation and commissioning). The scope of work will include system and equipment optimization within constraints defined during the life cycle phase 'Define', and also support change control and project managers assessing the impact of concessions the relevant economic evaluation measures.

— Operate (e.g. operation and maintenance, modification and life extension). For normal operations and maintenance, the work at this stage supports the optimization of a wide range of facility operations and support. Life cycle costing is also applicable when assessing modifications to the facility or the potential to extend operations beyond the original design life. If major modifications are involved, this requires reference to the issues considered above under the 'Select', 'Define' and 'Execute' life cycle phases.

— Abandon (e.g. disposal and decommissioning). The work in this phase will typically include examination of when and how to decommission and dispose of all or part of the asset.

See Annex B for further details and guidance on life cycle costing activities for each of the life cycle phases.

Time to market, from concept to conclusion of commissioning, is shortened due to business and economic drivers. Contractor and vendor selection are performed early in the life cycle, with increased emphasis on their capability and performance. Contracting strategies evolve in parallel, with a variety of partnering, alliance and framework agreements being established.

From a vendors' perspective, it is possible to add most of their value in the systems design since they are often involved in the early life cycle phases such as the life cycle phase 'Define'. On the other hand, contractors can experience benefits coming from life cycle costing principles in all life cycle phases. For operators, it is important that a life cycle costing methodology be established in order to capture value especially in conceptual, operational and abandonment phases.

4.6 Life cycle costing subject matters

Life cycle costing is a methodology used in the oil and gas industry to determine the most cost-effective offer between alternative competing options that satisfy and improve technical, operational, health, safety, environmental and regulatory requirements. Decision-making is made throughout the life cycle of an oil and gas asset starting at the life cycle phase 'Appraise' through the 'Select', 'Define', 'Execute' and 'Operate' life cycle phases and even finally in the life cycle phase 'Abandon'.

The greatest opportunity of influencing the life cycle cost of an asset and its ultimate profitability is the 'Select' and 'Define' life cycle phases of a project (see Figure 3). Decisions and selections made in these two phases have repercussions in the later phases of a project, as the ability to make subsequent changes diminishes and the cost of change increase significantly. Hence, the importance of making the right decision in the 'Select' and 'Define' life cycle phases of a project.

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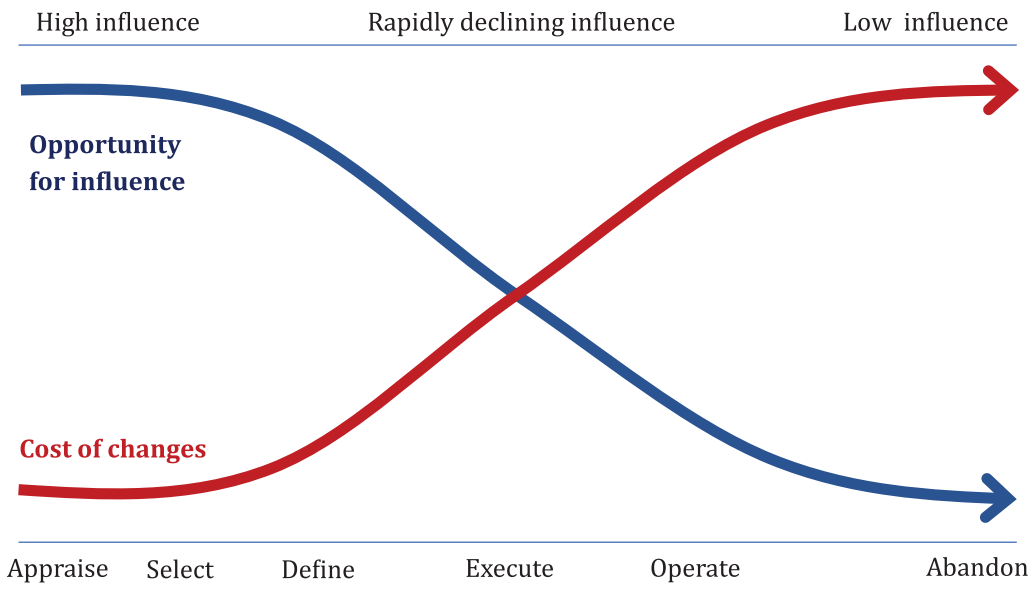

Figure 3 — Opportunity for influence vs cost of change

Two primary life cycle costing decisions taken in the life cycle phase 'Select' for a project are:

— facility concept selection;

— process concept selection.

Examples include topside vs. subsea development, topside vs. subsea compression and full processing offshore vs. onshore treatment.

Having defined the concept to be developed, subsequent life cycle cost decisions to be made during subsequent life cycle phases may include:

— system concept and sizing;

— equipment type, configuration, vendor selection;

— layout and equipment location;

— future facility modifications;

— health, safety and environment;

— project execution strategy;

— maintenance and operation strategies;

— manning strategy and levels;

— logistic support strategy;

— spares and support strategies;

— decommissioning planning and strategy;

— reuse and/or disposal.

The list above illustrates typical life cycle costing subject matters, and that they vary between life cycle phases. Identified life cycle costing subject matters are subject to the life cycle costing methodology as described in Clause 6.

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4.7 Technology development

Decisions to develop and deploy new technologies in capital projects or during operations in support of performance improvements are partly based on consideration of life cycle economics. Life cycle cost analysis can be used as the basis for comparing alternative technology solutions or as input into the assessment of larger systems also subject to critical economic evaluations.

Comparing alternatives which include new technologies should consider the risks and uncertainties associated with the ability to qualify to specification and on schedule. These development factors are fundamental for relating expenditures and revenues. They require careful breakdown of cost related elements and rigorous data analysis and modelling to be carried out. Life cycle costing can be used to help subdivide technology development and deployment elements and assist with incremental economic comparisons of alternatives.

A characteristic of new technology projects is the challenge in handling uncertainties associated with input data, analysis results and ranking of alternatives, but analysis methods and techniques can be applied to reflect and describe the ranges of uncertainty. Depending on the complexity of the uncertainties, life cycle costing methodology can employ advanced simulation and detailed probabilistic assessments to critical areas requiring further attention.

5 Management of life cycle costing

5.1 General

Management of life cycle costing is important to add value and ensure cost-efficiency.

Clause 4 provides background and framework conditions for life cycle costing required to evaluate differences between costs and revenues when considering alternative competing options. Understanding the detailed analyses required to accurately predict relevant economic evaluation measures (e.g. life cycle cost) and to evaluate complex trade-offs between uncertain and variable revenues and associated cost elements requires disciplined and critical examination and structured (decision support) management.

Life cycle costing as a capability area within organizations should be developed in terms of ability to consistently and reliably predict the total costs and revenues for the life cycle of an asset, with respect to competing options. The capabilities are required for application in both capital project environments and where incremental investments may be considered to improve HSE, production availability, and equipment and system performance during the life cycle phase 'Operate'. Life cycle costing also provides better decision support to assess the potential benefits and value of developing and deploying new technologies.

Regardless of whether life cycle costing is used in capital projects, performance improvement initiatives or the development and deployment of new technologies, organizations leveraging the techniques should use it to help confirm proposed solutions are commercially attractive and that results are developed in a manner that can be presented alongside or integrated with other assessments of indirect and non-economic benefits.

Because analysis supports significant investment considerations, it is crucial that management of life cycle costing capability aims for levels that are sufficiently developed and recognized in their role supporting high quality decision-making. It further aims to ensure that the economic objectives of projects are properly stated to allow effective life cycle costing to be carried out and that roles and responsibilities of those involved in life cycle costing are clearly defined. Management of life cycle costing also covers strategy and planning requirements, contractual considerations and systems to evaluate effectiveness through formal review and feedback activities. It also provides frameworks to ensure that life cycle costing competencies and knowledge (i.e. standardized methods and application of life cycle costing methodology) are obtained and practiced in a quality-oriented manner for the users of this document.

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This clause covers typical life cycle costing objectives, roles and responsibilities. It describes strategy, planning and contractual considerations, the assessment of life cycle costing effectiveness and minimum training and competency expectations. It has been written principally from the perspective of the operating companies who require high quality LCC analysis and evaluation to meet their end user needs, and also because they are more likely to have life cycle costing professionals within their organizations. It is recognized that engineering companies, equipment vendors and other entities involved in the project and operations value-chain have important roles in the planning and execution of effective LCC analysis.

Life cycle costing activities have an interdisciplinary character that requires expertise in economics, accounting, engineering and operations research and data analysis. Therefore, implementing a life cycle costing system involves management and can involve (depending on the organization) utilizing a team that can share competencies and resources in an effective and efficient manner to perform LCC analyses that have quality and sufficient accuracy.

An organization shall include elements of life cycle costing requirements in a management system. These elements can consist of:

— developing capability and competencies in life cycle costing techniques and best practices that adhere to this document;

— identification of high-level subject matters for which key life cycle costing activities and organizational roles need to be incorporated.

— inclusion of the selected life cycle costing considerations in project and operations strategies and planning cycles.

— defining the need for a project to establish roles, resources and competency requirements for carrying out life cycle costing activities;

— inclusion of life cycle costing requirements in contracting strategies reflecting customer-client relationship(s);

— incorporating life cycle costing considerations as a decision support element in the selected commercial decisions associated with the acquisition of equipment and/or services.

This document recommends that the listed processes and activities are initiated only if they can be considered to add value.

5.2 Objectives for management of life cycle costing

The main objectives for management of life cycle costing are:

— to achieve agreement at a management level on asset objectives and how life cycle costing is linked to these objectives;

— to communicate these objectives and the role of life cycle costing throughout the organization;

— to define the purpose of life cycle costing prior to any activities taking place.

Other underlying objectives are:

— describing the application of the principles of life cycle costing to support projects and operations to achieve business planning objectives;

— providing direction on key life cycle costing methods used in investment evaluations and decisions through detailed description of the techniques and presentation of case-specific examples;

— providing additional references on the latest best practices and sources of the related information needed to carry out complex life cycle costing analysis;

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— helping to communicate the role that life cycle costing has in both capital project and operational phases environments;

— identifying typical roles and responsibilities of analysts, decision-makers and others providing inputs to life cycle costing activities;

— providing guidance on planning, executing and assuring life cycle costing including contractual considerations and expected training and competence requirements.

5.3 Roles and responsibilities

The organization shall determine and provide the persons necessary for effective execution of the life cycle costing function, and this should be described in the life cycle costing management plan (see 5.4 and A.1.3).

An individual or organizational unit should be assigned the role of life cycle costing coordination (e.g. through a life cycle costing coordinator) to undertake the following tasks:

a) develop and plan the life cycle costing strategy;

b) develop life cycle costing project procedures;

c) facilitate and coordinate study activities;

d) organize training of all key personnel.

The persons involved in life cycle costing may change depending on the life cycle costing subject matter portfolio and the life cycle phase of the asset.

Life cycle costing coordination can benefit from having a life cycle costing coordinator for large programmes having many subject matters. The life cycle costing coordinator can be a person or group already part of the project group.

Organizational units or assigned persons having responsibility for performing life cycle costing shall:

a) understand the life cycle costing methodology;

b) be able to tailor the life cycle costing activities to the needs of the project;

c) provide the focus for identification and evaluation of alternative options;

d) ensure that issues that influence the life cycle costing and the relevant economic evaluation measures of the project are considered, and that potential trade-offs between cost and revenue remain a key topic;

e) resolve problems identified during life cycle costing within required time and budgets;

f) communicate the results to others — it is only by doing this that decisions can be influenced.

In order for the full benefits of life cycle costing to be achieved, the effect on the overall value of an asset over its lifetime should be considered when making all major decisions. Life cycle costing is therefore the responsibility of all individuals who take these decisions.

5.4 Strategy and planning – life cycle costing management plan

5.4.1 Life cycle costing management plan

The strategy and policy for life cycle costing shall be defined, together with the means of evaluating whether business objectives can be achieved better by use of life cycle costing as described in this document.

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Plan(s) for managing life cycle costing in specific projects shall be prepared outlining all defined life cycle costing activities. The planning output should be included in an LCCMP or included in another planning document. The planning output should be updated for each life cycle phase, including the life cycle phase "Operate", to accumulate asset specific know-how for cost-effective future decision support.

Life cycle costing activities (e.g. ranging from coarse qualitative cost/benefit evaluations to detailed quantitative studies), as defined in LCCMP should be carried out where benefits in terms of increased asset value can be realized by selecting the best option between competing alternatives. The options to be studied should be selected on a systematic basis by considering the major contributions to capital and operating expenditures and revenue impact (i.e. lost revenue and revenue gain). The content of a typical LCCMP is provided in A.1.2.

5.4.2 Life cycle costing process

The life cycle costing methodology consists of four steps. These four steps are illustrated in Figure 4 and are further described in Clause 6. Any life cycle costing activity shall follow these four steps. If alternative steps are defined during the planning process, then these shall be justified.

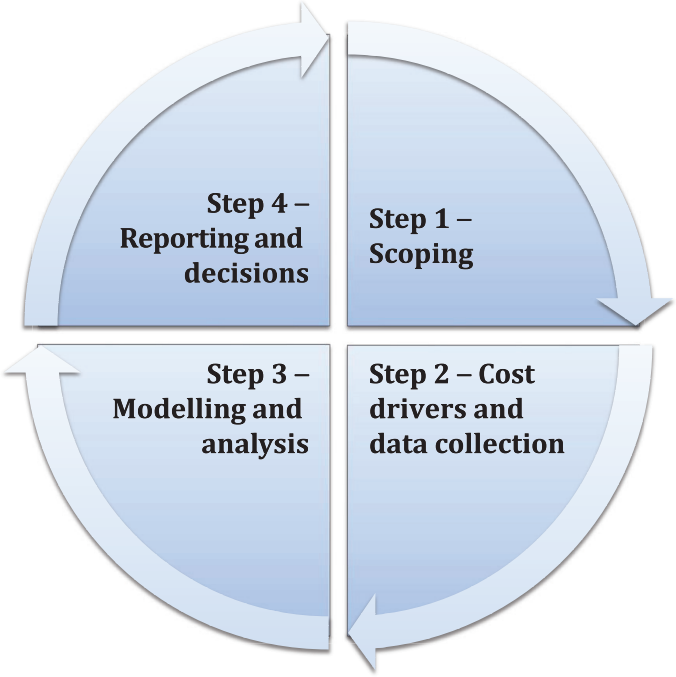

Figure 4 — The life cycle costing process

The life cycle costing process applies to all identified life cycle costing subject matters (see 4.6).

The overall process is iterative and may be repeated a number of times in a project. The reason for the repetition will typically be dependent on the outcome of the previous iteration. This can result in the need to assess further technical or operational options, challenge initial assumptions or constraints, or respond to changes elsewhere within the LCCMP.

Iteration should be carried out for all major cost drivers and areas where there is potential for creating value. This should be agreed on a project basis. The iteration may be deferred to the next life cycle phase (see 4.6) when this does not lead to committed costs at the next stage.

Because the process is iterative, it should be integrated into the overall project planning so that the outcome of each iteration can coincide with the decision points in the project. The LCCMP also provides the means by which the interaction with other team members can be defined and established.

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When planning the work, the range of options identified at the start of work do not necessarily represent the full range of options. This is because the opportunities, and hence the options, do not become apparent until at least one iteration has been completed.

The life cycle costing process contains a large number of tasks. Not all tasks are needed in every iteration and the level of detail considered in each task will vary according to the needs of the study. The work undertaken and the LCCMP shall be tailored to meet the objectives and constraints defined.

The output from the process shall be retained as documented information.

The value of a well-documented process will become apparent when the requirements for assessment and internal consistency are considered, the results are produced, and further iterations take place.

5.5 Contractual strategies

The incorporation of life cycle costing within a contractual framework is important. This can be achieved by the following two approaches:

— A low-risk approach where life cycle costing is progressively introduced by making some part of the payment related to life cycle costing performance.

— A high-risk approach where life cycle costing is introduced immediately as the basis for establishing a contract. This approach requires significant levels of life cycle costing awareness, well-established data sources and expertise from the participants in the process.

A typical example of the first approach is the post-market service contract that a vendor or contractor could be asked to provide for the maintenance and operation of their equipment.

Typical examples of the second approach are the leased floater contracts in which the treatment and storage floaters for oil, gas, LNG, etc. are built, owned and operated by the contractor and the operator pays a daily fee.

The implementation of life cycle costing in a contractual context shall be considered within the following activities:

a) prequalification, both for contractors and vendors;

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

c) contract award and post-contract performance monitoring.

Further description and guidance on contractual issues related to life cycle costing are provided in A.1.4.

5.6 Assessment and feedback

An asset owner may require evidence that all of the decisions and assumptions made at all stages of the life cycle costing methodology meet the needs of the business. This requires that an assessment method is established to meet the needs for internal audit (consistency checks) and external audit (feedback to others). Annex F provides guidance on assessment and feedback.

5.7 Training and competence

Training in life cycle costing can be required to ensure consistency of approach. The life cycle costing training needs of a project will vary with the size and complexity of the project and with the contract terms and conditions. The life cycle costing training needs should be considered in conjunction with life cycle costing planning (see A.1.2) and coordination (see A.1.3).

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6 Methodology

6.1 General

The methodology for the life cycle costing activities is based on the 4-step process elements shown in Figure 4. The tasks underlying the methodology detailed in this clause are illustrated in Figure 5.

The 4-step methodology applies for all identified life cycle costing subject matters. In these steps several tasks are listed which will assist the user in assessing the scope and scale of the work. These are described in 6.2 to 6.5. The life cycle costing techniques shall be used in accordance with Annex C.

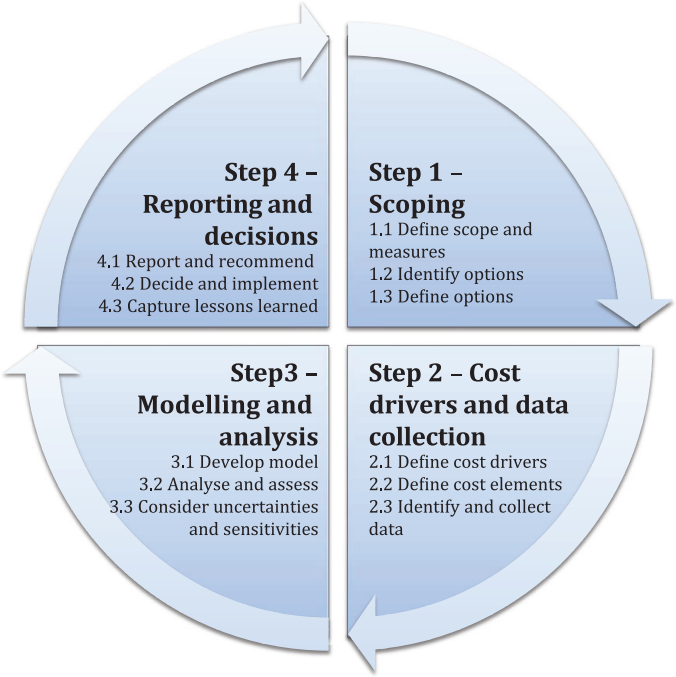

Figure 5 — Sub-division of the life cycle costing methodology

The contribution of life cycle costing to a project is important as any other support functions, such as design, HSE, reliability management or engineering. Each of these functions provides its own unique perspective on the problem and each examines some aspects of performance. Life cycle costing adds a long-term economic perspective and provides the means to compare alternative options on a common economical basis. Life cycle costing cannot be carried out in isolation and should interact with the other functions as part of the team approach.

6.2 Step 1 — Scoping

6.2.1 Objective

Step 1 is the starting point for the life cycle costing process. This step is critical for the successful implementation of life cycle costing in any project, i.e. identification of the important competing options for the relevant life cycle costing subject matters. The objective of this step is to develop a fundamental understanding of the issues, relationships, assumptions and requirement underpinning the work. This can only be achieved by discussion with asset owners and members of the project team. Results of such interaction will enable improved decision support and added business value by the selection option.

From a planning perspective, consideration of the tasks in this step will provide the basis for identifying the scope of the work and the resources required. This should be described in the project planning and/or in a dedicated LCCMP (see A.1.2).

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Step 1 is always required, both initially and in subsequent iterations. In later iterations its scope can be reduced to a check by the user that the initial task outcomes are still applicable.

A description of each of the tasks in Step 1 is given in 6.2.2 to 6.2.4. These subclauses also provide practical guidance for the user on how they can be implemented in terms of the discussions to be held, the questions to be asked and the outputs to be produced. Although each task is described separately, the discussions that will take place will cover many of the tasks simultaneously.

6.2.2 Define scope and measures

6.2.2.1 Identify objectives

The objectives shall be agreed upon and documented in accordance with the organization's governance and project procedures prior to the commencement of the life cycle costing activity (e.g. a study). The subject matter (e.g. functions, systems and/or equipment) and the project execution strategies being examined shall be maintained as documented information (e.g. in the LCCMP), to ensure organizational learnings on future situations requiring similar subject matter decision support. In application of the life cycle costing in subsequent phases, this task may be limited to reconfirmation.

Identification of overall life cycle costing objectives should:

a) establish the focus area and the reasons for doing the work;

b) define what functions, systems or equipment are to be examined.

The overall objectives should be discussed with all identified persons who have responsibility for life cycle costing, to ensure they have a full understanding of what needs to be achieved. Potential participants can include the following disciplines:

— design and engineering;

— procurement and contracts;

— health, safety and environment;

— reliability engineering;

— cost estimation;

— planning;

— construction;

— installation and commissioning;

— operations and maintenance;

— economics and budgeting;

— finance and cost accounting.

Discipline participants may come from vendor, contractor or operator organizations depending on project requirements and the life cycle costing subject matter(s). Early scoping studies may not require the involvement of vendors/contractors. Life cycle costing evaluation can benefit from their involvement from the life cycle phase 'Select'.

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6.2.2.2 Identify constraints

The constraints which apply to the life cycle costing subject matters in general, and to the competing options being considered, should be identified. These arise from the following three principal sources:

— project constraints on what can be achieved within the life cycle costing work (typically arising from resource and time-scale limitations on the work);

— technical and possibly operational constraints which limit the options available;

— budgetary constraints, such as limitations on CAPEX or OPEX, or alternatively the outcome can be subject to specified economic evaluation measures (e.g. minimum IRR of 10 % before an option merit further consideration).

Constraints can be imposed by third parties or other external influences. Examples of such constraints are regulatory requirements, frame agreements, production quotas, environment discharge, use of BAT or health and safety issues.

All constraints that will impact on the life cycle costing should be retained as documented information.

6.2.2.3 Establish economic evaluation measures

Life cycle costing measures will be quantitative economic evaluation measures, but non-economic issues such as HSE and sustainability (arising from regulation or organization's governance) can also be part of the decision criteria to select amongst competing options.

A range of economic evaluation measures exist. A selection of economic evaluation measures shall be done for the life cycle costing as defined in the LCCMP (see A.1.2.3):

a) net present value (NPV);

b) life cycle cost (LCC);

c) internal rate of return (IRR);

d) profitability index (PI);

e) payback period;

f) break-even volume;

g) break-even price;

h) capital efficiency index (CEI).

These economic evaluation measures and their calculation formulas shall be used in accordance with C.6.3.

For the ranking of options, economic evaluation measures are not always calculated in full, but limited to the estimation of differences (e.g. NPV or LCC). Irrespective of the selected economic evaluation measure(s), the differences between options should be considered under the following three categories:

— CAPEX;

— OPEX;

— REVENUES or LOSTREV.

In the case of competing options where decommissioning costs make a significant influence, the decommissioning costs should be separated out explicitly.

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In applying these economic evaluation measures, the need and ability to compare options on a like-for-like basis should be considered. In these circumstances, alternative techniques, such as the use of equivalent annual costs, may be applied.

The economic evaluation measures are not only used to rank the options, but also to provide the basis for determining the cost drivers within an option with implications for the modelling required.

6.2.3 Identify potential options

The identification of potential competing options shall follow a structured approach.

Options and sub-options for the life cycle costing subject matter under review should be identified by a multidisciplinary team.

Many techniques are available to identify options. A well-proven technique to generate options and identify cost drivers is a functional/cost analysis of the investment. This technique is part of value engineering and function analysis workshops (see Clause C.5).

In some circumstances, the options may be predefined as the only potential technical (or operational) solutions available.

6.2.4 Define options

The identified potential options (see 6.2.3) are subjected to a screening process. The method adopted for this process should also be qualitative, as the aim is to find justifiable reasons for excluding options. The output will be an agreed set of options that are subject to both technical/operational and life cycle costing evaluation.

The screening process should be applied consistently, with each option subject to the same assessment criteria. A typical range of screening criteria may include:

— Is it technically feasible?

— Is it practical (constructability, operability and maintainability)?

— Does it meet contract deliverability requirements?

— Can it meet or shorten the schedule?

— Are the risks acceptable (technical, financial, revenue, health, safety and environmental)?

— Is consistent with the objectives stated in Step 1 scoping activities?

— Will it meet current and expected future regulatory requirements (HSE, etc.)?

6.3 Step 2 — Cost drivers and data collection

6.3.1 Objective

The objective of Step 2 is the development of a structured breakdown of cost through consideration of the associated cost elements. The systematic approach defines the cost data to be collected and used as part of life cycle costing activities. Expensive data collection programmes are unlikely to yield significantly greater value than one that contains only the essential information necessary to meet life cycle costing objectives. The critical requirement is to focus on the cost drivers.

The aim is to align the need for information, as defined by the cost elements, balanced with the ability of the project or operation to respond adequately.

Performing Step 2 properly enables greater understanding and appreciation of:

— how to calculate costs;

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— how to perform sensitivity analysis with a clear focus on the cost drivers;

— practical issues associated with data collection, such as data sources, access to data, and data quality.

When determining the cost elements in life cycle costing, ISO 19008:2016 shall be considered when classifying these agreed costs.

Annex D contains further information related to data input for life cycle costing activities.

6.3.2 Identify potential cost drivers

A philosophy of including all attributable costs should be adopted. In practice, this is usually tailored to enable the work to be shaped into manageable proportions by limiting it to the significant attributable costs only.

Although the life cycle costing evaluations can be intuitive to a large extent, these evaluations should adhere to the following steps:

a) For each option, identify the costs which incur over the equipment, system or product life. These will be expected to include costs, such as purchasing, operation, maintenance, support services and disposal costs of the option.

b) Address each option in turn, consider the unique features and determine the costs (CAPEX and/or OPEX) associated with each of the following items:

   1) environmental and societal factors, such as footprint, communities where facilities are built and operated, synergy with local industries (suppliers/consumers), other processes, safety systems and transportation;

   2) utilities, such as demands on cooling systems, power generation and accommodation;

   3) supporting infrastructure, such as warehousing, administration services, and other relevant facility support items;

   4) revenue losses, including a clear description of where the losses are incurred, for example at asset, system or equipment level.

c) Compare options to identify the common costs. Where costs are common to all options, a judgment can be made to either include or exclude such common cost elements from the life cycle costing assessment.

The following factors can be considered:

— exclusion of common cost elements where they represent a significant proportion of the total costs can distort the perspective of the assessment;

— inclusion of too many common cost elements can mask key variations and important differentiators between options.

Common costs are normally only included in cases where there are requirements to estimate the absolute costs of owning the asset.

The output from these activities is a list of cost elements for possible inclusion in the life cycle costing assessment. For each option, each cost element shall be reviewed to determine if it is likely to be a cost driver.

The output from this task is a preliminary list of cost elements with the potential cost drivers highlighted.

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6.3.3 Define cost elements

The list of potential cost drivers (see 6.3.2) is the basis for the task of defining the cost elements for inclusion in the life cycle costing assessment.

Identification of the cost elements associated with an asset or a system requires both the function of the asset and the interrelationships/dependencies with other systems to be evaluated.

The minimum level of detail necessary to discriminate between the options shall be determined. All cost elements initially identified (see 6.3.2) should be addressed and estimated. The main focus of this task should be to establish the cost elements for the selected potential cost drivers.

For the remaining cost elements, it should be determined if:

— they have any other significance in discriminating between the options;

— it is possible to group any of the cost elements under a single heading, posing a significance in discriminating between the options.

The output from this task is a defined list of cost elements and cost drivers to be included in the analysis.

6.3.4 Identify and collect data

The defined list of cost elements (see 6.3.3) should be structured by considering the way in which costs are acquired and recorded. The way the individual cost elements will be calculated should be considered when creating the cost breakdown structure.

The cost element list should be as accurate as possible to meet the project specific life cycle costing requirements. The output will be a cost breakdown structure.

A review of available data sources should be performed as an initial activity, to ensure sufficient data quality. When the sources of data necessary to obtain the cost elements are established, a data collection process can be implemented with the required quality control.

Annex D contains further information related to the data collection process.

6.4 Step 3 — Modelling and analysis

6.4.1 Objective

The objective of Step 3 is to establish a life cycle costing model in order to:

— produce economic evaluation measures (see C.6.3) showing the difference in cost between selected options;

— produce a ranking of options;

— compare and analyse the cost drivers;

— undertake sensitivity analysis to determine what can change the ranking;

— identify uncertainties and risks.

The quality of both the model and the analysis will be significantly enhanced when a team is involved in the work. A team approach provides different perspectives on the same problem and through such interaction generates additional ideas on the opportunities.

6.4.2 Develop model

An LCC model may be different from an economic model used by operators for other purposes, as its requirement is to compare and rank competing options.

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In the majority of cases, a spreadsheet model may represent the most cost efficient and flexible solution, although bespoke software applications can be an alternative. The model developed should be simple enough to be transparent to the users but detailed enough to evaluate the differences between the competing options (see Clause C.6).

Where proprietary or specialized software is used to create models, the outputs should be integrated into the overall model to allow a true comparison between options. This is needed to ensure consistency with the decision criteria defined for the LCCMP.

The LCC model shall be validated to ensure it is credible, accurate and gives realistic results before it is used for analysis.

6.4.3 Analyse and assess

The following information will enable the evaluation to be carried out:

— a ranking of the options in accordance with the decision criteria specified;

— a summary of economic evaluation measures (e.g. life cycle cost, and for each option, identifying the cost drivers).

The results should be evaluated by scrutinizing the ranking and the cost drivers.

To enable confidence in the results, important questions to be answered include but are not limited to:

— are the individual cost totals in line with expectations?

— why do some options perform better than others – can this be explained?

— how does the impact of the timing of the costs vary between options?

6.4.4 Consider uncertainties and sensitivities

The starting point for option elimination should be an examination of the lower-ranked options. From the experience gained in the work, it should be possible to make a judgement on whether these options could ever achieve top ranking. Where there is any doubt, the lower-ranked options may be subject to the same uncertainty and sensitivity checks as the other options.

While estimates by their nature will be subject to some error, what is important is the relative error of one estimate to another and not its absolute error. Where estimates are produced from a common source, the relative error is likely to be reduced since all estimates will embody the same basic assumptions.

For the options that remain, the robustness of the ranking is established by examining the uncertainty associated with the cost drivers in each option. Uncertainties refer to the unknown, single, true value of some quantities needed to predict the estimation used in the life cycle costing. The sensitivity of the options to changes in a number of typical key parameters should be examined (e.g. cost of installation and operation, production profiles, product selling price and exchange rates). Uncertainties also include future events that can happen.

Some options can be better than others in accommodating changes in the production stream or key parameters, such as earlier-than-expected water breakthrough in field reservoir. Where a number of cost drivers for the asset are outside the control of the project, then it is appropriate to perform an uncertainty or a sensitivity analysis in which more than one parameter is changed so as to determine the accumulated effect and the range of uncertainty in the results.

For each factor subject to uncertainty and sensitivity analysis, it shall be established:

a) by how much the estimate has to change to alter the ranking and hence the decision?

b) how likely is the estimate to change by that amount?

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