NORSOK STANDARD

COMMON REQUIREMENTS

LIFE CYCLE COST FOR SYSTEMS AND EQUIPMENT

O-CR-001
Rev. 1, April 1996

CONTENTS

1 FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and remove unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and are jointly issued by OLF (The Norwegian Oil Industry Association) and TBL (The Federation of Norwegian Engineering Industries). NORSOK standards are administered by NTS (Norwegian Technology Standards Institution).

The purpose of this industry standard is to replace the individual oil company specifications for use in existing and future petroleum industry developments, subject to the individual company's review and application.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of this standard will be used to provide input to the international standardization process. Subject to implementation into international standards, this NORSOK standard will be withdrawn.

All annexes are normative.

The described LCC model has been developed on a spreadsheet and is available as an Excel file. For further information contact the NORSOK administration at NTS.

This standard replaces Life cycle cost, P-CR-002, Rev. 1, December 1994. Minor changes are made to clause 1, Foreword and clause 4.1, Definitions and it is renamed and renumbered.

2 SCOPE

The scope of this standard is to standardize Life Cycle Cost calculation methods for systems and equipment.

3 NORMATIVE REFERENCES

NORSOK O-DP-001	Operational principles.

4 DEFINITIONS AND ABBREVATIONS

4.1 Definitions

Normative references	Shall mean normative in the application of NORSOK standards.
Informative references	Shall mean informative in the application of NORSOK standards.
Shall	Shall is an absolute requirement which shall be followed strictly in order to conform with the standard.
Should	Should is a recommendation. Alternative solutions having the same functionality and quality are acceptable.
May	May indicates a course of action that is permissible within the limits of the standard (a permission).
Can	Can-requirements are conditional and indicates a possibility open to

	the user of the standard.
System and Equipment Purchase Cost	The total purchase cost within a vendors scope of supply.
Installation Cost	The total cost to install the system and equipment within the vendors scope of supply.
Commissioning Cost	The total cost to commission, and where necessary certify, the installed system and equipment.
Insurance Spares Cost	The total purchase cost for the initial spares holding for the system and equipment within the vendors scope of supply, necessary to obtain the required system regularity.
Reinvestment Cost	The total cost to remove, refurbish or purchase, install and commission systems and equipment that is predicted to exceed its design life during the life of the production facility.
Manhour Cost	The total maintenance manhour cost required to maintain the system and equipment within the vendors scope of supply. The manhour cost to include preventive maintenance, servicing and corrective maintenance. The cost for corrective maintenance to include maintenance carried out offshore and maintenance carried out onshore.
Spare Part Consumption	The total cost of spare parts and consumables, over the design life of the system and equipment, necessary to complete the predicted work load for all maintenance actions (i.e. preventive maintenance, corrective maintenance and servicing).
Logistic Support Cost	The total logistic support cost predicted to be necessary to support the maintenance requirements for the system and equipment within the vendors scope of supply (e.g. supply boat, diving support vessel).
Energy Consumption Cost	The total energy consumption cost for the system and equipment within the vendors scope of supply. It shall include the cost of the fuel required to generate the power and associated CO_2 tax.
Deferred Production Cost	The total cost of deferred production due to the probability of failure of system and equipment.
Baseline Cost	Baseline cost data, for comparison with vendor input, will be based on historic records for similar equipment within the vendors scope of supply.
Life Cycle Cost Design Optimisation and Evaluation Model	A computer model programmed in Excel. The model contains the formulas shown in clause 5.5 and the assumptions provided in Annex A. The model is structured for input of variable data and calculation

of results. It enables the user to evaluate and optimise system and equipment design and calculate the result based on Life Cycle Cost. The model also provides an option to take tax considerations into account. A smaller model for simpler cost calculations is also available.

4.2 Abbrevations

CDP	Cost of deferred production
CMM	Corrective maintenance manhours (annual average)
CMSP	Corrective maintenance spare parts (annual average consumption)
MTTR	Mean time to repair
PMM	Preventive maintenance manhours (annual average)
PMSP	Preventive maintenance spare parts (annual average consumption)

5 CALCULATION METHOD

5.1 General

This section defines the calculation method to complete Life Cycle Cost evaluation and optimisation for system and equipment.

The calculations are automated in the LCC-model attached to the standard on a diskette. The diskette also contains a small model for quick cost calculations on a higher level.

5.2 Applications

The LCC model may be used for:

- Design optimisation (evaluating different system designs).
- Bid evaluation.

5.3 Uncertainty

Qualification shall be accomplished by quantifying uncertainty in the results of the Life Cycle Cost evaluation.

5.4 Assumptions

To complete the Life Cycle Cost calculations within the model, assumptions shall be made.The necessary assumptions are shown in annex A.

5.5 Calculation method

5.5.1 General

This section defines the calculations that provide the basis to complete Life Cycle Cost evaluation and optimisation, and the formulas required.

5.5.2 Value of money related to time

The base year for the analysis shall be established. All costs shall be discounted back to this base year to take into account the time value of money. For this the following formula is applied:

$$\sum_{t=0}^{n} = \frac{S_t}{(1+k)^t}$$

Where:

S_t = Net cost in year t. This can be assumed equal for all the years, it can vary according to production, or it can have some other given variation throughout the lifetime.

N = The lifetime of the equipment/function to be evaluated. When the required lifetime of the equipment exceeds the expected lifetime, the required life is used.

K = The discount rate/interest rate to be used for the evaluation.

5.5.3 Capital cost

Capital cost shall be calculated by adding the following cost elements :

- Equipment purchase cost.
- Installation cost.
- Commissioning cost.
- Insurance spares cost.
- Reinvestment cost.

Where there is a deviation between when the investments will be made and the base year for the evaluation, capital cost shall be discounted back to the base year as shown in clause 5.5.2.

5.5.4 Operating Cost

General

Operating cost shall be calculated by adding the following cost elements:

- Manhour cost.
- Spare parts consumption cost.
- Logistic support cost.
- Energy consumption cost.

For costs that will be constant through the lifetime, multiply the annual cost with a discount factor f to get the cost over the lifetime.

$$f = \frac{1}{(1+k)^{t1-t0}} \sum_{t=1}^{m} \frac{1}{(1+k)^t}$$

Where:

t0 = The base year for the evaluation.

t1 = The time for startup of operations.

m = Number of years in operation.

k = The discount rate/interest rate to be used for the evaluation.

a) Manhour Cost

Manhour cost shall be calculated as the sum of:

- Corrective maintenance manhours.
- Preventive maintenance manhours.
- Servicing manhours.

Corrective Maintenance

The formula for average annual corrective maintenance manhours (CMM) is as follows :

$$CMM = \lambda_T \cdot 8760 \cdot MTTR \cdot A \cdot M$$

Where:

CMM	=	Average annual manhour cost for corrective maintenance.
λ_T	=	Total failure rate as number of failures per hour. This includes all failures. (Equals 1/Mean Time Between Failures).
8760	=	Number of hours in a year.
MTTR	=	Mean Time To Repair. The time in hours it takes to repair the faulty item back to operating condition.
A	=	The number of men required to do the work. This also includes the safety aspect.
M	=	The manhour rate.

The average annual costs shall be discounted as shown in clause 5.5.2.

Preventive Maintenance

The formula for annual preventive maintenance manhours (PMM) is as follows:

PMM = Number of times per year x Manhours x Manhour rate

Where:

Manhours	=	The number of manhours required to perform the preventive maintenance routine.

The average annual cost shall be discounted as shown in clause 5.5.2.

Servicing

Calculations shall be as for Preventive Maintenance.

b) Spare Parts Consumption

Spare parts consumption shall be calculated as the sum of:

- Spare parts for corrective maintenance.
- Spare parts for preventive maintenance.
- Spare parts for servicing.

Corrective Maintenance

The formula for average annual corrective maintenance spare parts (CMSP) consumption shall be as follows:

$$CMSP = \lambda_T \; x \; 8760 \; x \; Average\,corrective\,spares$$

Where:

CMSP	=	Average annual corrective maintenance spares consumption.
λ_T	=	Total failure rate as number of failures per hour. This includes all failures. (Equals 1/Mean Time Between Failures).
8760	=	Number of hours in a year.

Average annual spares = Average spares needed for repair of the equipment.

The average annual cost shall be discounted as shown in clause 5.5.2.

Preventive Maintenance

The formula for average annual preventive maintenance spare parts (PMSP) consumption is as follows :

PMSP = Number of times per year x Average spare parts consumption per PM routine

Servicing

Calculations shall be the same as for Preventive Maintenance.

c) Logistic support cost

Logistic support cost shall be calculated as the sum of all logistic support activities necessary to maintain the equipment.

The average annual cost shall be discounted as shown in clause 5.5.2.

d) Energy consumption cost

For an equipment package where the power requirement is constant throughout the lifetime and not dependent of the production the formula for average annual energy consumption cost is as follows:

$$EC = \sum_{l=0}^{100\%} \left[\frac{Q_l \cdot O_l}{\mu_{l1} \cdot \ldots\ldots \cdot \mu_{ln}} \right] \cdot C$$

Where:

Q_l = Power requirement at operational level *l* for the equipment requiring power (e.g.

a pump).

O_l	=	Average fraction of time the equipment will be operated at operational level *l*.
l	=	Operational level in steps from 0 to 100% (Max required capacity).
μ_{ln}	=	Efficiency at operation level *l* for related equipment in the power transmission (i.e. gear, converter, el. motor).
C	=	Cost per kWh based on fuel consumption and CO_2-tax.

The average annual cost shall be discounted as shown in clause 5.5.2.

For an equipment package where the power requirement is varying throughout the lifetime, e.g. follows the production profile, the formula will be the same but will have to be calculated with different distributions (O_l) for operational level for each year and be discounted.

5.5.5 Cost of deferred production

The formula for cost of deferred production (CDP) is as follows :

$$CDP = E \cdot p \cdot D \cdot L \cdot C_{DP}$$

Where:

CDP	=	Cost of Deferred Production.
E	=	Average number of critical failures per year.
p	=	Probability of production reduction.
D	=	Duration of production reduction.
L	=	Quantity of production loss per time unit.
C_{DP}	=	Cost of one hour downtime per year throughout the lifetime calculated as the difference in Net Present Value between a production profile with the simulated availability and one with one hour lower availability per year.

This is a general formula that can be adjusted to different configurations where:

E	=	$\lambda_C \cdot 8760$ = Critical failure rate as number of failures per hour x Number of hours in a year.
p	=	1 at configuration 1x100%.
	=	$1 - e^{-(n-1)\cdot\lambda train \cdot T}$ at a configuration with n trains and one can go down without causing production reduction. T equals average total downtime for critical failures for the component evaluated.
L	=	Dependent on configuration and location in the system for the unit being evaluated.
C_{DP}	=	Field dependent.

5.5.6 Life cycle cost

Life Cycle Cost for the system and equipment to be evaluated equals the sum of the following cost elements:

- Capital Cost.
- Operating Cost.
- Cost of Deferred Production.

5.5.7 Uncertainty

The uncertainty of the calculations shall be assessd in relation to the confidence in input data. To get an estimate of the uncertainty involved the cost elements can be assumed independent and Normal distributed. The standard deviation σ can then be calculated as follows:

$$\sigma_T = \sqrt{\sum \sigma_e^2}$$

Where:

σ_T = The total standard deviation.

σ_e = Standard deviation for cost element *e*.

When using the above formula after evaluating two alternatives A and B and finding that A has the lowest Life Cycle Cost, the result is indicated reliable when:

$$LCC_A + \sigma A < LCC_B - \sigma_B$$

ANNEX A ASSUMPTIONS (NORMATIVE)

THE FOLLOWING ASSUMPTIONS SHALL BE MADE AND BE INCLUDED IN THE MODEL PRIOR TO OPTIMISATION AND EVALUATION OF SYSTEM AND EQUIPMENT DESIGN

PARAMETER	**VALUE**	**DENOMI-NATION**	**COMMENTS**
Fuel gas:			For power generation
CO_2 tax	0.82	NOK/Sm^3	
Price of sales gas		NOK/Sm^3	When gas sales contract is applicable
Price of transport		NOK/Sm^3	When gas sales contract is applicable
Value of alternate use		NOK/Sm^3	Equals price of sales gas minus cost of transport
Gas turbine efficiency		m^3/MW Day	For power generation
Cost per kw hour			
- CO_2 tax	0.273	NOK/kwh	Calculated from CO_2 tax per Sm^3 and gas turbine efficiency
- Alternate use		NOK/kwh	Calculated from value of alternate use and gas turbine efficiency
- Total cost		NOK/kwh	Equals the sum of CO_2 tax and alternate use
Diesel fuel:			
Price	1.30	NOK/litre	
- CO_2 tax	0.82	NOK/litre	
- Cost of diesel	2.12	NOK/litre	Equals the sum of CO_2 tax and the cost of diesel
Manhour cost:			
Offshore Manhour		NOK/hour	
Onshore Manhour		NOK/hour	
Logistic support cost:			
ROV		NOK/day	
Support vessel		NOK/day	
Supply boat		NOK/day	
Cost of deferred production		NOK/hour a year	See clause 5.6.5
Annual operating hours		Hours/year	Hours the equipment will be in operation

Timing:			
Base year			See clause 5.5.2
Investment year			See clause 5.5.3
Operation start-up			The year when production starts
Life of field			From start of production

Discounting:			
Discount rate		%	Relevant rate supplied by the Operating Company
Discount factor			
- Investment			Calculated as shown in clause 5.5.3
- Operating cost			Calculated as shown in clause 5.5.4

ANNEX B LIFE CYCLE COST MODEL FOR SYSTEMS AND EQUIPMENT (NORMATIVE)

CONTENTS

Project XXX **Output form** **Form 1**
Design eval. **LCC SUMMARY**
LCC Evaluation
Inquiry No. XXXXXX Equipment Package

Aggregated main cost elements

Cost elements	**Design A**		**Design B**		**Baseline**	
	Cost :	**Note:**	**Cost :**	**Note:**	**Cost :**	**Note:**
CAPITAL COST OPERATING COST COST OF DEFERRED PRODUCTION						
LIFE CYCLE COST		1		1		1

Delta LCC

Cost elements relative to the lowest bid	**Design A**		**Design B**		**Baseline**	
	Cost :	**Note:**	**Cost :**	**Note:**	**Cost :**	**Note:**
CAPITAL COST OPERATING COST COST OF DEFERRED PRODUCTION						
LIFE CYCLE COST		2		2		2

Relative cost distribution

Cost elements	**Design A**	**Design B**	**Baseline**
CAPITAL COST OPERATING COST COST OF DEFERRED PRODUCTION			
DEVIATION FROM THE LOWEST LCC			

Uncertainty

Result from evaluation of the uncertainty involved
Furter investigation should be made to reduce the result range

Notes :
1. All costs in Base Year kNOK
2. Delta LCC based on lowest bid set to zero.

Comments :
Costs are shown pre tax.

Date :	Prepared by :
Date :	Checked by :

Project XXX **Design eval.** **LCC Evaluation** **Inquiry No. XXXXXX Equipment Package**	**Output form** **LIFE CYCLE COST ELEMENTS**	**Form 2**

Cost elements:	**Design A** Cost :	Pr. year:	Note:	**Design B** Cost :	Pr. year:	Note:	**Baseline** Cost :	Pr. year:	Note:
CAPITAL COST Equipment Purchase Cost Installation Cost Commisioning Cost Insurance Spares Cost Reinvestment Cost									
OPERATING COST Manhour Cost Spare Parts Consumption Cost Logistic Support Cost Energy Consumption Cost									
COST OF DEFERRED PRODUCTION									
LIFE CYCLE COST									

All costs in Base Year NOK
Costs are shown pre tax.

Notes :

Comments :

Date :	Prepared by :
Date :	Checked by :

Project XXX | **Input form** | **Form 3**
Design eval. | **CAPITAL COST**
LCC Evaluation
Inquiry No. XXXXXX Equipment Package

Cost elements	Year	Design A		Design B		Baseline	
		Item :	Price:	Item :	Price:	Item :	Price:
Equipment Purchase Cost	1995	Total		Total		Total	
Installation Cost	1996	Total		Total		Total	
Commisioning Cost	1996	Total		Total		Total	
Insurance Spares Cost	1995	Total		Total		Total	
Reinvestment Cost	2000	Total		Total		Total	

All costs in Base Year NOK

Comments :

Reinvestment is structured under investment as a cost occuring just once. After tax calculations treat this as an operating cost according to the tax laws.

Date :	Prepared by :
Date :	Checked by :

Project XXX **Input form** **Form 4**
Design eval. **PREVENTIVE MAINTENANCE COST**
LCC Evaluation
Inquiry No. XXXXXX Equipment Package

Preventive Maintenance

Equipment :	Preventive maintenance aktivities	Design A			Design B			Baseline		
		Interval [Months]	Manhours [h]	Spares [NOK]	Interval [Months]	Manhours [h]	Spares [NOK]	Interval [Months]	Manhours [h]	Spares [NOK]
Equipment number 1										
Equipment number 2										
Equipment number 3										
Equipment number 4										
Equipment number 5										
Equipment number 6										
Equipment number 7										
Equipment number 8										
Average per year										

Comments :

Date :	Prepared by :
Date :	Checked by :

Project XXX | **Input form** | **Form 5**
Design eval. | **SERVICING COST**
LCC Evaluation
Inquiry No. XXXXXX Equipment Package

Servicing

Equipment :	**Servicing aktivities**	**Design A**			**Design B**			**Baseline**		
		Interval [Weeks]	**Manhours [h]**	**Spares [NOK]**	**Interval [Weeks]**	**Manhours [h]**	**Spares [NOK]**	**Interval [Weeks]**	**Manhours [h]**	**Spares [NOK]**
Equipment number 1										
Equipment number 2										
Equipment number 3										
Equipment number 4										
Equipment number 5										
Equipment number 6										
Equipment number 7										
Equipment number 8										
Average per year										

Comments :

Date :	Prepared by :
Date :	Checked by :

Project XXX **Design eval.** **LCC Evaluation** **Inquiry No. XXXXXX Equipment Package**	**Input form** **CORRECTIVE MAINTENANCE COST**	**Form 6**

Corrective Maintenance

Equipment :	**Failure Modes**	**Design A**			**Design B**			**Baseline**		
		Interval [Months]	**Manhours [h]**	**Spares [NOK]**	**Interval [Months]**	**Manhours [h]**	**Spares [NOK]**	**Interval [Months]**	**Manhours [h]**	**Spares [NOK]**
Equipment number 1										
Equipment number 2										
Equipment number 3										
Equipment number 4										
Equipment number 5										
Equipment number 6										
Equipment number 7										
Equipment number 8										
Average per year										

Comments :

Date :	Prepared by :
Date :	Checked by :

Project XXX
Design eval.
LCC Evaluation
Inquiry No. XXXXXX Equipment Package

Input form
LOGISTIC SUPPORT COST

Form 7

Support	Design A		Design B		Baseline	
	Interval [Years]	Time Period [Days]	Interval [Years]	Time Period [Days]	Interval [Years]	Time Period [Days]
ROV						
Supply boat						
Support vessel						

	Design A	Design B	Baseline
Average usage ROV per year Cost per year			
Average usage supply boat per year Cost per year			
Average usage support vessel per year Cost per year			

Annual logistic cost			

Comments :

Date :	Prepared by :
Date :	Checked by :

Project XXX	**Input form**	**Form 8**
Design eval.	**ENERGY CONSUMPTION COST**	
LCC Evaluation		
Inquiry No. XXXXXX Equipment Package		

Power using equipment :

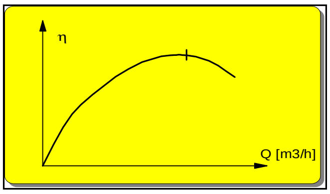
Energy consumer 1

Energy consumption profile : **Constant**

Yearly operating hours :
8760

Fraction op. time at level	**Operation level [% of max]**	**Design A**			**Design B**			**Baseline**		
		Power consumption [kWh]	**Efficiency driver [%]**	**Efficiency trans'n [%]**	**Power consumption [kWh]**	**Efficiency driver [%]**	**Efficiency trans'n [%]**	**Power consumption [kWh]**	**Efficiency driver [%]**	**Efficiency trans'n [%]**
	10 %									
	20 %									
	30 %									
	40 %									
25 %	50 %									
	60 %									
	70 %									
25 %	80 %									
	90 %									
50 %	100 %									
	110 %									
	120 %									
100 %										

Average gross consumption	kWh	kWh	kWh
Annual energy consumption cost	NOK	NOK	NOK
Total energy consumption cost	NOK	NOK	NOK



Comments :

Date :	Prepared by :
Date :	Checked by :

Project XXX | **Input form** | **Form 9**

Design eval. | **ENERGY CONSUMPTION COST**

LCC Evaluation

Inquiry No. XXXXXX Equipment Package

Power using equipment :

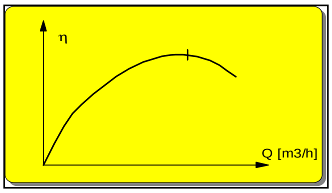
Energy consumer 2

Energy consumption profile : **Constant**

Yearly operating hours :
8760

Fraction op. time at level	Operation level [% of max]	Design A Power consumption [kWh]	Design A Efficiency driver [%]	Design A Efficiency trans'n [%]	Design B Power consumption [kWh]	Design B Efficiency driver [%]	Design B Efficiency trans'n [%]	Baseline Power consumption [kWh]	Baseline Efficiency driver [%]	Baseline Efficiency trans'n [%]
	10 %									
	20 %									
	30 %									
	40 %									
25 %	50 %									
	60 %									
	70 %									
25 %	80 %									
	90 %									
50 %	100 %									
	110 %									
	120 %									
100 %										

	Design A	Design B	Baseline
Average gross consumption	kWh	kWh	kWh
Annual energy consumption cost	NOK	NOK	NOK
Total energy consumption cost	NOK	NOK	NOK



Comments :

Date :	Prepared by :
Date :	Checked by :

Project XXX	Input form	Form 10
Design eval.	ENERGY CONSUMPTION COST	
LCC Evaluation		
Inquiry No. XXXXXX Equipment Package		

Power using equipment :

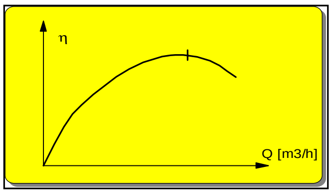
Energy consumer 3

Energy consumption profile :	**Constant**

Yearly operating hours :
8760

Fraction op. time at level	**Operation level [% of max]**	**Design A**			**Design B**			**Baseline**		
		Power consumption [kWh]	**Efficiency driver [%]**	**Efficiency trans'n [%]**	**Power consumption [kWh]**	**Efficiency driver [%]**	**Efficiency trans'n [%]**	**Power consumption [kWh]**	**Efficiency driver [%]**	**Efficiency trans'n [%]**
	10 %									
	20 %									
	30 %									
	40 %									
25 %	50 %									
	60 %									
	70 %									
25 %	80 %									
	90 %									
50 %	100 %									
	110 %									
	120 %									
100 %										

	Design A	Design B	Baseline
Average gross consumption	kWh	kWh	kWh
Annual energy consumption cost	NOK	NOK	NOK
Total energy consumption cost	NOK	NOK	NOK



Comments :

Energy consumer 3

Total energy consumption cost for the alternatives	**Design A**	**Design B**	**Baseline**
Cost per year			
Cost over the lifetime	NOK	NOK	NOK

Date :	Prepared by :
Date :	Checked by :

Project XXX | **Input form** | **Form 11**

Design eval.

COST OF DEFERRED PRODUCTION

LCC Evaluation

Inquiry No. XXXXXX Equipment Package

Base case unavailability XX %
Economic impact

Equipment :	Impact on prod. [Y/N]	Config.	Design A			Design B			Baseline		
			MTBF c [Years]	MTTR c [Hours]	Prod. loss [Prod.h]	MTBF c [Years]	MTTR c [Hours]	Prod. loss [Prod.h]	MTBF c [Years]	MTTR c [Hours]	Prod. loss [Prod.h]
Equipment number 1	Y	1x100%									
Equipment number 2	Y	2x100%									
Equipment number 3	Y	2x50%									
Equipment number 4	Y	3x50%									
Equipment number 5	Y	4x25%									
Equipment number 6	Y	4x33%									
Equipment number 7	Y										
Equipment number 8	Y										
Estimated unavailability											
Economic impact over the lifetime											

Definitions :

MTBF c = Mean Time Between CRITICAL Failures
MTTR c = Mean Time To Repair CRITICAL Failures. The time it takes to do the job, NOT the manhours

Notes :

For equipment in a train a sligthly different formula has to be applied for calculating production loss.
The probability of secondary failures are then calculated from average MTBFc and MTTRc for the train.

Comments :

Date :	Prepared by :
Date :	Checked by :

Project XXX | **Qualification form** | **Form 12**

Design eval. | **UNCERTAINTY IN THE RESULTS**

LCC Evaluation

Inquiry No. XXXXXX Equipment Package

	Design A			Design B			Baseline		
		Std. dev.			Std. dev.			Std. dev.	
Cost elements:	**Value:**	**Absolute**	**Relative**	**Value:**	**Absolute**	**Relative**	**Value:**	**Absolute**	**Relative**
CAPITAL COST									
Equipment Purchase Cost									
Installation Cost									
Commisioning Cost									
Insurance Spares Cost									
Reinvestment Cost									
OPERATING COST									
Manhour Cost			20 %			20 %			20 %
Spare Parts Consumption Cost			20 %			20 %			20 %
Logistic Support Cost			20 %			20 %			20 %
Energy Consumption Cost			2 %			2 %			2 %
COST OF DEFERRED PRODUCTION			4 %			4 %			4 %
LIFE CYCLE COST									
HIGH									
MED.									
LOW									

Notes:

1. The above analysis is performed to quantify the uncertainty in the LCC-evaluation
2. The above is based on variation with baseline data.
3. The different cost elements are based on Normal Distribution.

Comments :

Date :	Prepared by :
Date :	Checked by :

Project XXX | **Qualification form** | **Form 13**

Design eval. | **BASIC ASSUMPTIONS**

LCC Evaluation

Inquiry No. XXXXXX Equipment Package

Parameter	Value	Denom.	Origin	Comment
Fuel gas:				For power generation
CO2 - tax	82	øre/Sm3		
Price sales gas		"		When sales gas contract is applicable
Price transport		"		When sales gas contract is applicable
Alt. use	N/A	"		The price of sales gas minus cost of transp.
Gas turbine efficiency	8000	m3 per MW per day		For power generation
Cost pr. kWh:				
CO2 - tax	0,273	NOK/kWh		From CO2-tax per Sm3 and gas turbine effic
Alt. use gas	N/A	"		From value of alt. use and gas turbine efficie
Total cost per kWh	0,273	"		The sum of CO2-tax and alt. use
Diesel:				
Price	130	øre/litre		
CO2 - tax	82	"		
Cost of diesel	212	"		The sum of CO2-tax and the cost of diesel
Manhour cost offshore		NOK/hour		
Manhour cost onshore		NOK/hour		
ROV		NOK/day		
Supply boat		NOK/day		
Support vessel		NOK/day		
Cost of deferred prod.		NOK/hour a year		See clause 5.6.6
Yearly operational hours	8 760	hours		Hours the equipment will be in operation
Base year	1995			See clause 5.5.2
Investment year	1995			See clause 5.5.3
Operation from year	1998			The year when production starts
Life of the field	20	years		From start of operation
Discount rate	7,0%			Relevant rate supplied by the operator
Discouting factors :				Calculated as shown in clause 5.5.2
Discouting factor investments	1,0000			Calculated as shown in clause 5.5.3
Discounting factor operating costs	9,2532			Calculated as shown in clause 5.5.4
Option for calculation	Pre tax			
Ordinary income tax	28 %		Norwegian tax regulations	Of ordinary income
Extra offshore tax	50 %		"	Of ordinary income minus free income
Free income	5 %		"	Of one years investment over five years

Comments :

Date :	Prepared by :
Date :	Checked by :

Project XXX Design eval. LCC Evaluation Inquiry No. XXXXXX Equipment Package	Qualification form CALCULATION METHOD	Form 14

General
The calculations are based on the formulas outlined in NORSOK Standard P-CR-002 Common Requirements Life Cycle Cost

Discounting
For all cost the time value of money is taken into account by discouting them back to the value at the base year for evaluation.

Tax calculations
For capital cost the Norwegian tax laws give :

After tax cost = Investment - [(Σ Investments the last 6 years / 6)x(Ordinary income tax + Extra offshore tax)
+ (Σ Investments the last 6 years) x Tax free income x Extra offshore tax]

For operating costs the equations are :

After tax cost = Pre tax cost x [1 - (Ordinary income tax + Extra offshore tax)]

Cost of deferred production
Mean Downtime (MDT) is for this calculations equal to Mean Time To Repair (MTTR) for corrective failures, i.e. waiting time and start up time are assumed zero.

Date :	Prepared by :
Date :	Checked by :

ANNEX C USER GUIDE LCC MODEL FOR SYSTEMS AND EQUIPMENT (NORMATIVE)

CONTENTS

1 INTRODUCTION

1.1 Calculating LCC

LCC-calculations are done to aid a decision making process. In many cases it is not necessary to perform a complete LCC-analysis. It is often enough to estimate the differences between alternatives for the major cost elements. The LCC-model provides input functions/ cells for the different cost elements. You, as the user, can perform a complete analysis and generate reports or choose to use only some of them at an aggregated level.

The diskette also contains a small spreadsheet (LCC-calc.xls) that can be used at an aggregated level for calculating the time value of money.

1.2 Description

The LCC-model (LCC.xlw) is made as a workbook in Excel 4.0. The workbook contains a spreadsheet and a hidden macro-file. The macro-file is the software (program) that controls and helps using the spreadsheet and should not be changed.

The spreadsheet is a protected document. This implicates that you are only allowed to enter values in the input cells. Formulas are then protected against accidental overwriting. If you want to change the content in a cell that are protected, you can unprotect the document and change the content in the cell. After doing this the document should be protected again.

1.3 Installation

For the model to be able to operate at an adequate speed, the workbook should be copied from the diskette to the hard disk. The name of the file is LCC.xlw.

The small spreadsheet for aggregated calculations, LCC-calc.xls, should also be copied.

1.4 Adjustment to screen

The spreadsheet is adjusted to a 17" screen. For other screen sizes it may be advantageous to adjust the zooming to fit the page to the screen.

2 MAIN STRUCTURE

Based on the input data there will be generated a report that consists of:

- LCC Summary (Output form)
- Life Cycle Cost Elements (Output form)
- Capital Cost (Input form)
- Preventive Maintenance Cost (Input form)
- Servicing Cost (Input form)
- Corrective Maintenance Cost (Input form)
- Logistic Support Cost (Input form)
- Energy Consumption Cost (Input form)
- Cost of Deferred Production (Input form)
- Uncertainty in the Results (Qualification form)
- Basic Assumptions (Qualification form)
- Calculation Method (Qualification form)

In addition there can be created a report that shows the cost elements for the different alternatives per year pre tax and after tax.

The above elements correspond to the buttons at the top of the spreadsheet and the different forms are thus found by clicking the respective button as shown below.

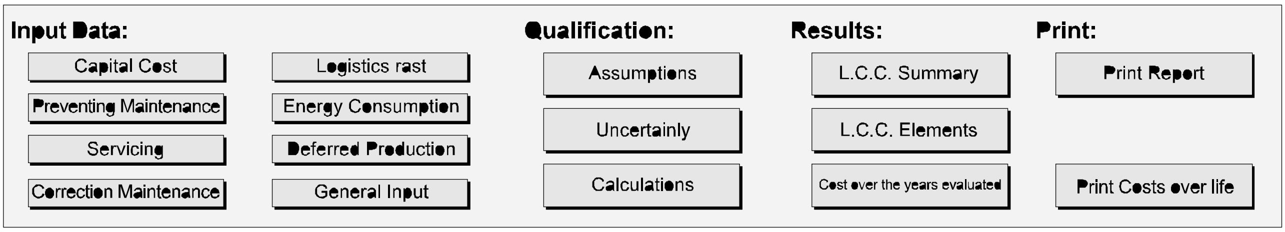


Figure 1

2.1 Summary of calculation procedures

Use of the LCC-model contains the following steps:

1. Fill in the field and company specific data in the Assumptions form.
2. Fill in what is to be evaluated in the General Input form.
3. Fill in the rest (or relevant) cost element input forms.
4. Qualify the calculations through the following qualification forms; Assumptions, Uncertainty and Calculation.
5. The results are shown aggregated, per cost element and per year.
6. Print LCC-report or cost distribution over life.

3 INPUT OF DATA

All input data for the alternatives to be evaluated are entered into the relevant input form. There are eight different input forms. Field and company specific data like economic parameters and field life are entered in the form; Basic Assumptions.

3.1 General input

The opening input window is shown in page 2. The window contains information on what is to be evaluated. Only the yellow fields shall be filled in.

Heading

Project, discipline and evaluating objects are written here. This will be the heading on each side of the report.

Alternatives to be evaluated

Number of alternatives to be evaluated are entered through clicking the button and choosing from the dialogue box.

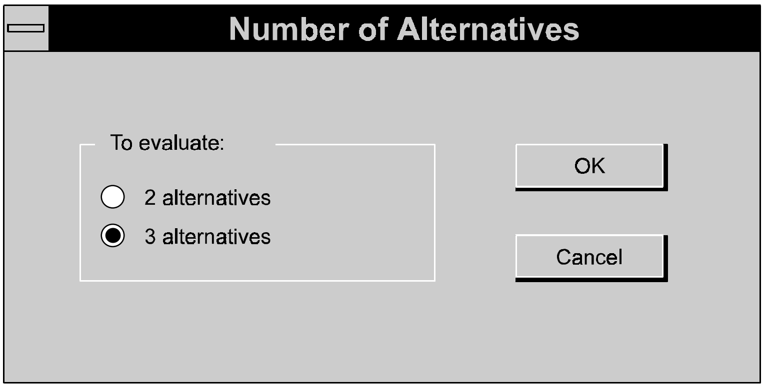


Figure 2

The model allows for two or three alternatives. The names of the alternatives can also be entered.

Energy consumption
Number of energy consuming units are entered by clicking the button and choosing from the dialogue box.

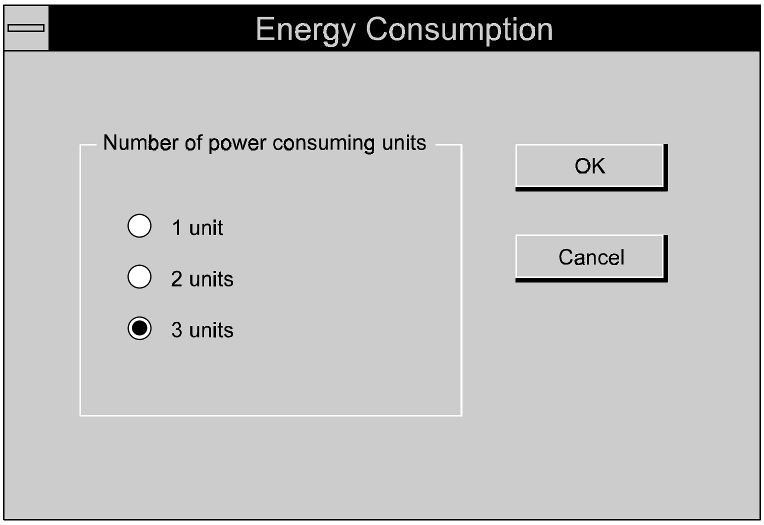


Figure 3

The model allows for one to three different power consuming units. Then equipment information are entered.

Equipment
Here the different equipment/ units in the system/ equipment to be evaluated are listed.

The other evaluation alternatives like pre/ after tax calculations, discount rate and field life time are entered under Assumptions.

3.2 Capital cost

Capital cost is split into the following cost elements:

- Equipment purchase cost.
- Installation cost.
- Commissioning cost.
- Insurance spares cost.
- Reinvestment cost.

For each element, the year when the expenditure occurs, have to be entered. The elements can be split into a lower (more detailed) level and entered with name and cost of the various items for the different alternatives.

Reinvestment cost is entered under capital cost, even though it is treated as an operating cost for tax calculations

3.3 Preventive maintenance cost

The equipment listed under General Input are shown as default equipment. This can be changed by overwriting. For each alternative, different maintenance activities associated with the equipment can be listed, such as maintenance intervals, workload in man-hours and spare part consumption. Man-hour rates are specified under assumptions.

3.4 Servicing cost

Service cost is entered the same way as the preventive maintenance cost. Intervals between servicing activities are counted in weeks.

3.5 Corrective maintenance cost

Corrective maintenance cost is entered the same way as the preventive maintenance cost. Interval between failures are counted in years.

3.6 Logistic support cost

Logistic support cost covers:

- ROV.
- Supply boat.
- Support vessel.

For each 3 different intervals with time period each time can be entered for the different alternatives. The unit costs are given under assumptions

3.7 Energy consumption cost

This cost element has up to three forms dependent on what number of power consuming units were specified under General Input.

Energy consumption can be specified as constant through the lifetime or as varying. This is done by clicking the button and choosing from the dialogue box.

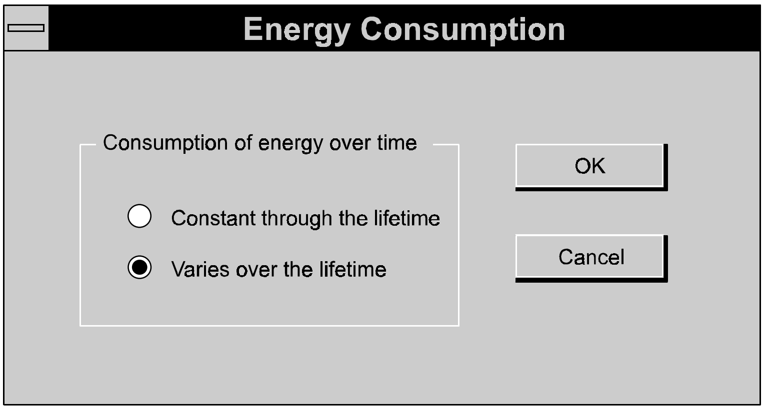


Figure 4

Constant
Yearly operating hours for this equipment must be entered.

For the different operation levels (denominated as percentages of maximum) the percentage of time the equipment is running at this levels are entered. This is to get a good representation of how the equipment efficiency curve fits to the operation. In the example shown below the equipment is run at 50% of max. for 25% of the time, at 70% for 50% of the time and at 100% for 25% of the time.

Fraction op.time at level	Operation level % of max	Design A			Design B		
		Power consumption (kWh)	Efficiency driver (%)	Efficiency trans`n (%)	Power consumption (kWh)	Efficiency driver (%)	Efficiency trans`n (%)
	10%						
	20%						
	30%						
	40%						
25%	50%	4000	90,0%	90,0%	400	90,0%	90,0%
	60%						
50%	70%	4500	90,0%	90,0%	450	90,0%	90,0%
	80%						
	90%						
25%	100%	5000	90,0%	90,0%	500	90,0%	90,0%
	110%						
	120%						
100%							

Figure 5

For these levels power consumption is entered. There is a possibility to include efficiency losses i.e. in driver and transmission.

Varies over time
For this table operating hours have to be filled in for each year. Average quantum per hour to be handled by the equipment will vary from year to year. For each alternative there are three columns to make it possible to get three points on the efficiency curves. The cells for **operation level as percentage of average quantum per hour** and for **percentage of operation at that level** must be filled in. One can choose to use only one column, but percentage of operation at level must then be 100% and operation level will then be the annual average.

The energy consumption forms are all the same. To switch between the forms press the button with the unit number. When the message shown below appears there are not specified that many power consuming units. To change this go to the General Input form.

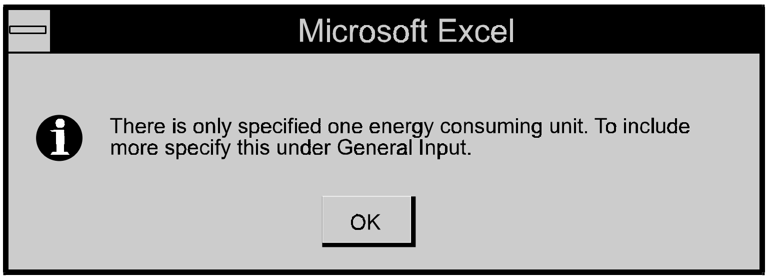


Figure 6

3.8 Cost of deferred production

The equipment given under General Input is listed, but can be altered. For the different equipment, impact on production is answered by Y/N. For the equipment with production impact configuration is chosen by clicking the respective button and selecting from the dialogue box.

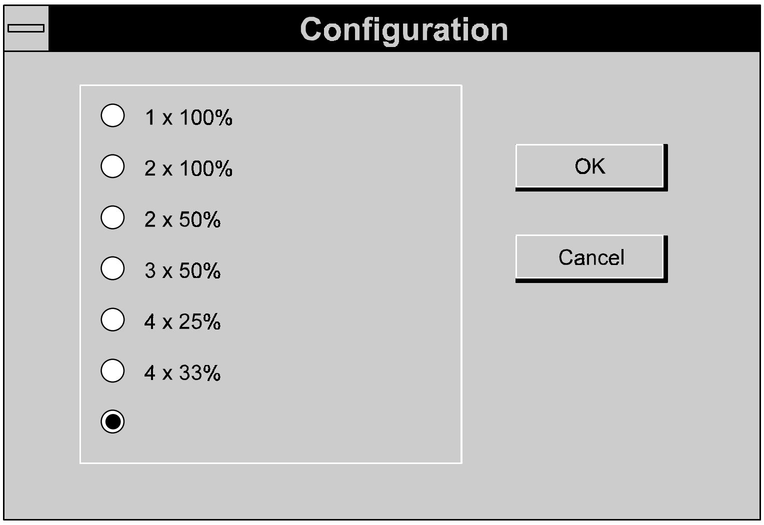


Figure 7

Further, the mean time between critical failures (MTBFc) and mean time to repair critical failures (MTTRc) are entered.

When evaluating alternatives with different configurations one can use different lines and fill in MTBFc and MTTRc only for the respective alternatives.

4 QUALIFICATION

4.1 Basic assumptions

This form contains all the economic assumptions and field data.

For calculating the cost of energy the cost of fuel gas and the gas turbine efficiency must be entered.

Cost of deferred production is given as the cost of one hour downtime per year. This is found by calculating the difference between the Net Present Value of two slightly different production profiles.

Base year for evaluation is normally the present year. Life of field is from start of operation.

Under option for calculation, clicking the alternatives button gives the choice of pre tax or after tax calculation.

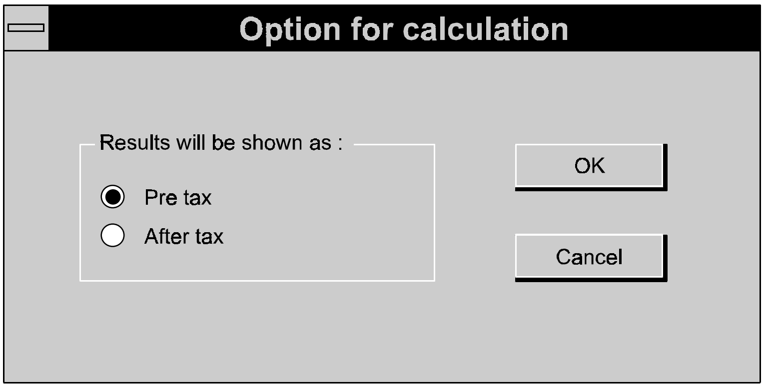


Figure 8

4.2 Uncertainty in the results

In this form the uncertainty involved is calculated based on the assumption that the cost elements are independent and Normal distributed. Input is given as the relative standard deviation for the different cost elements, e.g. +/-10%.

4.3 Calculation method

This form outlines the calculation method. See also the standard Common Requirements Life Cycle Cost.

5 RESULTS

5.1 LCC summary

The LCC Summary form shows the aggregated cost, delta LCC and relative cost distribution for the main cost elements:

- Capital cost.
- Operating cost.
- Cost of deferred production.

Aggregated main cost elements are a summary of the Life Cycle Cost Elements form.

Delta LCC sets the lowest cost among the alternatives to zero and show how much higher the other alternatives are. This is done for the main cost elements and for the total LCC.

Relative cost distribution shows the distribution of the main cost elements within the alternatives.

Deviation from the lowest LCC sets the lowest alternative to zero and shows the relative difference for the others. This is the main result number from the calculations.

Uncertainty

Based on the results from evaluating the uncertainty there will come up a message "Uncertainty involved is acceptable" if the lowest alternative plus its standard deviation is lower than the second best alternative minus its standard deviation. If this is not the case the message "Further investigation should be made to reduce the result range" will appear.

5.2 Life cycle cost elements

This form shows the total cost and cost per year for the different cost elements.

For capital cost the cost per year equals the investment. If investments are done in the base year for evaluation, cost per year and total cost will be equal.

5.3 Costs over the years evaluated

By clicking this button one gets access to a number of forms showing the cost elements per year pre tax and after tax for the different alternatives.

6 PRINTOUTS

6.1 Print report

By pressing this button there will be printed a report corresponding to the forms in the model as shown in appendix B.

6.2 Print costs over life

By pressing this button there will be printed a report of the different cost elements for the different alternatives for each year pre tax and after tax as shown in appendix B.

7 PROBLEM SOLVING

7.1 Locked cells

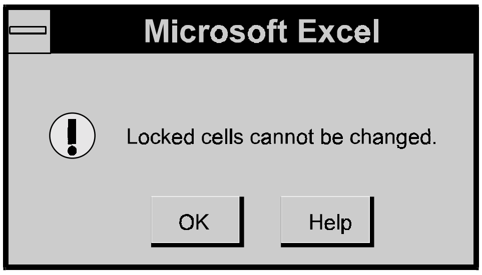


Figure 9

Locked cells are not supposed to be changed. If this still is desirable it can be done through **Options / Unprotect document**. When the changes are done the document should be protected again through **Options / Protect document**. The spreadsheet is protected to ensure that formulas are not overwritten by accident.

7.2 Slow operation

Due to the size of the model it can give a relatively long responding time. This can be improved by using a faster computer with a larger memory.

The smaller spreadsheet LCC-calc.xls will operate much faster, but cannot handle detailed calculations like the big LCC-model.

7.3 Number not shown

When the numbers are shown just as ######### this can be solved by expanding the column with. The document must then first be unprotected. Expanding too much can cause a problem when printing the reports.