

NORSOK STANDARD

COMMON REQUIREMENTS
LIFE CYCLE COST FOR PRODUCTION FACILITY

O-CR-002
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Please note that whilst every effort has been made to ensure the accuracy of the NORSOK standards neither OLF nor TBL or any of their members will assume liability for any use thereof.

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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 standardisation process. Subject to implementation into international standards, this NORSOK standard will be withdrawn.

This standard is based on O-CR-001, Life cycle cost for systems and equipment.

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.

2 SCOPE

The scope of this standard is to standardise Life Cycle Cost calculation methods necessary to establish the facility design that gives the best field economics.

This is achieved by:

- Design for the life of the field rather than the plateau period.
- Design the facility based on the minimum equipment and utilities required for the process. All additional equipment are justified related to the profit contribution.
- Design for optimum production regularity.
- All relevant design alternatives are identified and evaluated related to total cost/profit contribution during the lifetime of the facility.

The upstream boundaries have been defined to include the wellheads on the individual production wells. The downstream boundaries have been defined to include the export facility including injection and reinjection. Storage capacity and drilling are not included.

The standard should be used by the organisations responsible for the design during the development phase of the project, and for modification projects and optimisation during operations.

3 NORMATIVE REFERENCES

NORSOK O-DP-001	Operational principles
NORSOK O-CR-001	Life cycle cost for systems and equipment
ISO/WD 14224	Petroleum and natural gas industries - "Collection of reliability and

4 DEFINITIONS AND ABBREVIATIONS

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.
Availability	The fraction of time a component or a system is capable of performing its intended duty. The term is used in connection with analysis of systems that can be modelled binary.
Regularity	A measure of how a production system, a transportation system or a process system is capable of meeting the demand for deliveries. Terms such as production availability and deliverability are used to define regularity.
Life Cycle Cost Model for Production Facility	A computer model programmed on a spreadsheet. The model contains the formulas outlined in the standard 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 production facility design and calculate the result based on Life Cycle Cost. The model also enables taking tax considerations into account.
Design and administration cost	The total engineering and project administration cost from the project start to operation.
Equipment and material purchase cost	The total purchase cost associated with the system.
Fabrication cost	The total fabrication cost associated with the system.
Installation cost	The total cost of installing the systems and equipment.
Commissioning cost	The total cost to commission, and when necessary certify, the installed systems and equipment.
Insurance spares cost	The total purchase cost for the initial spares holding for the systems and equipment, 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 facility, and for planned extra equipment installations during operation when the production or the downstream handling are expected to change.

Man-hour cost	Man-hour cost is defined as the cost of the needed man-hours per year to operate and maintain the facility/equipment: • Fixed crew. • Workload dependent crew. • Contractors. • Vendors.
Spare parts consumption cost	The total cost of spare parts and consumables over the design life of the facility and systems, 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 necessary to support operation and maintenance requirements for the facility and system (e.g. supply boat, diving support vessel, helicopters)
Energy consumption cost	The total energy consumption cost for the facility and systems. It shall include the cost of fuel required to generate the power and associated CO ₂ tax.
Insurance cost	The total cost related to insurance for the production facility.
Onshore support cost	The total cost of the required onshore support services and administration.
Cost of deferred production	The total cost of deferred production due to probability of failure of system and equipment.

4.2 Abbreviations

ISO	International Organisation for Standardisation
NTS	Norwegian Technology Standards Institution

5 CALCULATION METHOD

5.1 General

This clause defines the calculation method to complete Life cycle cost evaluation and optimisation for production facility.

The calculations are automated in the LCC-model attached to the standard.

5.2 Applications

The LCC model for production facility can be used for:

- Optimising production facility.
- System optimisation during the engineering phase.
- Modification projects and optimisation during operations.

5.3 Cost elements

The cost elements to be included are:

Capital cost:

- Design and administration cost.
- Equipment and materials purchase cost.
- Fabrication cost.
- Installation cost.
- Commissioning cost.
- Insurance spares cost.
- Reinvestment cost.

Operating cost:

- Man-hour cost.
- Spares and consumables consumption cost.
- Logistic support cost.
- Energy consumption cost.
- Insurance cost.
- Onshore support cost.

Cost of deferred production.

5.4 Uncertainty

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

This can be done by:

- For rough/early estimates:
Assume the calculated total over the lifetime for each cost element is Normal distributed and independent. By estimating the uncertainty related to the cost elements the total uncertainty involved can be calculated as follows, expressed as the standard deviation:

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

Where:

- σ_T = The total standard deviation
- σ_e = Standard deviation for cost element e

- For medium/risk adjustment estimates:
As for rough estimates but estimating the uncertainty for each cost element for each year throughout the lifetime.
- For accurate estimates:
Estimating the uncertainty for all the variables and parameters in the calculations and simulating based on the different distribution functions and dependencies. The quality on the input data can seldom justify this workload.

5.5 Assumptions

To complete the Life cycle cost calculations within the model, assumptions shall be made. The necessary assumptions are shown in Annex A.

5.6 Formulas

5.6.1 General

This clause defines the calculations that provide the basis to complete Life cycle cost evaluation and optimisation, and the formulas required.

The most accurate calculations are achieved when using the formulas defined in O-CR-001, Life cycle cost for systems and equipment and aggregating up the results from equipment level to facility level. All the information required for these calculations are not available until late in the field development. Formulas are therefor defined here that use historic information that are normally available in company databases or through rough estimates.

5.6.2 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.

5.6.3 Capital cost

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

- Design and administration cost.
- Equipment and materials purchase cost.
- Fabrication 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 5.6.2

The way the cost elements are calculated shall be stated. An example of this is shown in Annex B.

5.6.4 Operating cost

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

- Man-hour cost.
- Spare parts and consumables consumption cost.
- Logistic support cost.
- Energy consumption cost.
- Insurance cost.
- Onshore support cost.

The cost of the different elements in the different years shall be discounted back to the base year as shown in clause 5.6.2.

The way the cost elements are calculated shall be stated. An example of this is shown in Annex B.

5.6.5 Cost of deferred production

Cost of deferred production shall be calculated by adding the following cost elements:

- Cost of deferred oil production.
- Cost of lost gas export.

The way of calculating Cost of deferred production shall be stated. The formula is outlined in Annex B.

5.6.6 Life cycle cost

Life cycle cost for the facility or the systems to be evaluated equals the sum of the following cost elements:

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

5.6.7 After tax calculations

5.6.7.1 Capital cost

After tax capital cost = Pre tax capital cost

*- [(Sum of investments last 6 years / 6) x (Tax ordinary income + Special offshore tax)
+ (Sum investments last 6 years x Tax free income x Special tax offshore)]*

5.6.7.2 Operating cost

After tax operating cost = Pre tax operating cost

x [1 - (Tax ordinary income + Special offshore tax)]

5.6.7.3 Cost of deferred production

The effect of tax on cost of deferred production is the same as for operating cost.

6 COST ESTIMATION

6.1 General

Cost estimation is to be performed within the framework given in clause 5.

6.2 Data sources

The most common sources for input data to the cost estimation is outlined in Annex C.

6.3 Data adjustment

Historic data shall be adjusted for:

- Difference in system design and capacity.
- Difference in oil characteristics.
- Time in operation.
- Time value of money.
- Cost development over time / trend prediction.

The required adjustment of historic information for estimation of the different cost elements are outlined in Annex D.

6.3.1 System design and capacity

Adjustment shall be made for significant differences in system design and in different number of equipment units within the system to be evaluated and the existing systems source of the historic data.

6.3.2 Oil characteristics

Adjustment shall be made for significant differences in expected lifetime or failure frequencies for equipment due to characteristics of the oil or fluid handled.

6.3.3 Time in operation

Failures normally have higher frequency early in operation (running in period), and after long time in operation when the equipment is starting to deteriorate. Adjustment shall be made for the operating phase of the reference systems and equipment.

Due to product development and feedback to the vendors, equipment quality is normally improved over time. Adjustment of historic data shall be made for significant design improvements.

6.3.4 Time value of money

Adjustment shall be made for the cost difference due to time between the historic records and the time of investment.

For cost adjustment the cost index for the oil industry over the relevant years shall be used.

Cost forecasting shall be made for trend prediction

6.4 Forecasting cost development

When the time span from the evaluation to cost occurrence and the deviation between cost development rate and the inflation rate is significant, methods for trend prediction shall be used to forecast the future cost development.

For expected cost development close to the inflation:

- Adjustment of the costs per year for inflation shall be performed when using a nominal discount rate.
- Adjustment for inflation shall not be done when using a real term interest rate.

6.5 Data qualification

The sample of historic data shall be large enough to get an acceptable accuracy on the data in relation to the decision to be made.

Man-hours and spare parts consumption shall be averaged over enough years to give an accurate enough calculation.

7 OPTIMISATION

The facility design can be optimised through LCC to ensure the best field economics. This is achieved by:

- Design for the life of the field rather than the plateau period.
- Design the facility based on the minimum equipment and utilities required for the process. All additional equipment are justified related to the profit contribution.
- Design for optimum production regularity.
- All relevant design alternatives are identified and evaluated related to total cost/profit contribution during the lifetime of the facility.

7.1 Design for the lifetime

The development of the cost elements over the years are taken into account when the elements are estimated.

7.2 Minimum equipment

The main process and utilities are initially defined as the minimum necessary to run the process. Other configurations, capacities and additional equipment are justified from resulting in a lower LCC through the framework outlined in this standard and the model.

7.3 Optimum production regularity

The optimum production regularity for the facility is defined through optimising the systems of the process as outlined in the standard and the model, and aggregating the results to a facility level. To define the result with more accuracy a new regularity study should be done with the optimised configurations and capacities.

7.4 Design alternatives

Design alternatives are identified from defining the opportunities for improvement from the cost drivers (major cost elements) found in the LCC evaluation.

8 RESULT QUALIFICATION

The results shall be qualified in relation to the decisions to be made.

The uncertainty of the calculations shall be assessed in relation to the confidence in input data.

9 INFORMATIVE REFERENCES

None.

ANNEX A ASSUMPTIONS (NORMATIVE)

The following assumptions shall be made and be included in the model prior to optimisation of production facility and system design

PARAMETER	VALUE	DENOMINATION	COMMENTS
Investment year			
Start of production			
Field lifetime			
Production profile availability		%	
Production availability		%	
Discount rate		%	
Tax ordinary income	28	%	
Extra offshore tax	50	%	
Tax free income	5	%	of investment
Insurance		%	of investment
Oil price			
Gas sales price			Applicable when gas is exported
Gas transport cost			Applicable when gas is exported
Net gas price			Applicable when gas is exported

PRODUCTION LEVEL	TIMESPAN RELATIVE TO INVESTMENT		DISCOUNT FACTOR
	FROM & INCL. [No of years]	TO & INCL. [No of years]	
Build-up period	2	2	
Plateau production	3	5	
From plateau production to 75% of plateau production	6	8	
From 75% of plateau production to 50% of plateau production	9	11	
From 50% of plateau production to 25% of plateau production	12	14	
From 25% of plateau production to closedown	15	17	
Closedown	18		

ANNEX B FORMULAS (NORMATIVE)

1 CAPITAL COST

Design and administration cost

*Design and administration cost = Engineering manhours x Manhour rate engineering
+ Administration manhours x Manhour rate administration*

Equipment and materials purchase cost

*Equipment and materials purchase cost = Equipment price + Delivery cost
+ Material price x Quantity*

Fabrication cost

*Fabrication cost = Direct fabrication manhours per ton x tons
x Manhour rate fabrication contractor + Associated materials cost*

Manhour rate fabrication contractor includes indirect fabrication costs.

Installation cost

*Installation cost = Installation manhours x Manhour rate installation contractor
+ Associated materials cost
+ Tow-out and heavy lift cost (i.e. for module installation offshore)*

Commissioning cost

*Commissioning cost = (Offshore manhours commissioning contractor
x Offshore manhour rate commissioning contractor)
+ (Offshore manhour operator crew
x Offshore manhour rate operator crew)
+ (Offshore manhours vendor x Offshore manhour rate vendor)
+ (Inshore manhours commissioning contractor
x Inshore manhour rate commissioning contractor)
+ (Inshore manhour operator crew
x Inshore manhour rate operator crew)
+ (Inshore manhours vendor x Inshore manhour rate vendor)
+ (Flotel dayrate x Days contracted)
+ Logistic support cost commissioning*

Insurance spares cost

Insurance spares cost = Purchase cost for the initial spares holding.

Reinvestment cost

*Reinvestment cost = Removal cost old equipment + Purchase cost new equipment
+ Installation cost new equipment + Commissioning cost new equipment*

The reinvestment cost shall be discounted from the years the costs are occurring to the base year of the evaluation. For after tax calculations reinvestment cost is treated as an operating cost.

2 OPERATING COST

Manhour cost

$$\begin{aligned} \text{Average annual manhour cost} = & [(\text{Corrective maintenance manhours crew} \\ & + \text{Preventive maintenance manhours crew} \\ & + \text{Servicing manhours crew}) \\ & \times \text{Manhour rate operator crew}] \\ & + [(\text{Corrective maintenance manhours contractor} \\ & + \text{Preventive maintenance Manhours contractor} \\ & + \text{Servicing manhours contractor}) \\ & \times \text{Manhour rate maintenance contractor}] \\ & + \text{Workload independent manhour cost operator} \end{aligned}$$

Personnel transport and catering are included in the manhour rate.

The average annual manhour cost shall be discounted as shown in clause 5.6.2.

Spare parts and consumables consumption cost

$$\begin{aligned} \text{Average annual spares and consumables consumption cost} = & \sum \text{Average per year} [\text{Spares Consumption} \times (\text{Cost of spares} + \text{Transport})] \\ & + \text{Storage cost assigned spares} \\ & + \text{Consumption of consumables} \times (\text{Price} + \text{Transport cost per unit}) \end{aligned}$$

Where:

Spares consumption =	Spare parts for corrective maintenance + Spare parts for preventive maintenance + Spare parts for servicing
Storage cost assigned spares =	The annual cost to store and preserve the spares assigned to the system to be evaluated.
Consumption of consumables =	The average annual consumption of consumables

The average annual spare parts consumption cost shall be discounted as shown in clause 5.6.2.

Logistic support cost

$$\begin{aligned} \text{Average annual logistic support cost} = & \text{Average annual ROV cost} \\ & + \text{Average annual supply boat cost} \\ & + \text{Average annual support vessel cost} \\ & + \text{Average annual helicopter cost} \end{aligned}$$

Other elements can be included. Logistic support cost is defined as the sum of all logistic support activities necessary to maintain the production facility/equipment.

Ordinary personnel transport is included in the manhour rate.

The average annual logistic support cost shall be discounted as shown in clause 5.6.2.

Energy consumption cost

The formula for the **total** energy consumption cost is:

Energy consumption cost =

$$\sum_{t=0}^n \sum_{\text{Equipment}} \frac{\text{Power requirement}_t \times \text{Time in operation}_t \times \text{Cost of power}}{(1+k)^t}$$

Where:

t=0	=	Startup operation
n	=	Number of years in operation
Power Requirement _t	=	Power load at rated capacity for the facility/system in year t
Time in Operation _t	=	Number of hours in operation in year t.
Cost of Power	=	Cost of fuel per kW + CO ₂ tax per kW
k	=	The discount rate/interest rate to be used for the evaluation.

When the power requirement is assumed equal each year the formula is:

Annual average energy consumption cost =

$$\sum_{\text{Equipment}} \left(\text{Power requirement}_t \times \text{Time in operation}_t \times \text{Cost of power} \right)$$

For more exact calculations see O-CR-001, Life cycle cost for systems and equipment.

The average annual energy consumption cost shall be discounted as shown in clause 5.6.2.

Insurance cost

Annual insurance cost = The annual cost to insure the production facility

Onshore support cost

Annual onshore support cost = Annual cost of the onshore support organisation

Cost of deferred production

The formula for production loss (PL) on a system or equipment level is as follows:

$$PL_t = E \cdot p \cdot D \cdot L$$

Where:

PL _t	=	Production loss in year t
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

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 1 x 100%
- $1 - e^{-(n-1) \cdot \lambda_{train} \cdot T}$ 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 on the facility for the system being evaluated. The effect on the overall production regularity is taken into account through the relation between system unavailability and the systems contribution to the overall availability. This can be extracted from a regularity study which is normally done very early in the project.

The formula applies to both oil production loss and gas export loss. To get the cost per year for these elements the production loss is multiplied with the unit cost of lost production.

The cost of deferred production for the different years shall be discounted and summed up as shown in clause 5.6.2.

For rougher estimations Cost of deferred production can be calculated as averages over wider time intervals with due regard to production level.

ANNEX C DATA SOURCES (NORMATIVE)

1 DATA SOURCES

This section outlines the sources from which the input data for the calculations can normally be obtained.

1.1 Capital cost

Design and administration manhours can normally be extracted from company or contractor databases.

Equipment and material purchase cost can be obtained from company or vendor databases.

Fabrication cost can be obtained from company or vendor databases.

Installation cost can be obtained from company or vendor databases.

Commissioning cost can be obtained from company or vendor databases.

Insurance spares cost can be taken from present storage levels for similar equipment

Reinvestment cost due to extra installations can be taken from company or vendor databases.

For new equipment adjustments shall be made from comparison with similar existing equipment.

1.2 Operating cost

Manhours per system can be extracted from company maintenance management systems.

Spare parts consumption per system can be extracted from company material management systems

Logistic support cost are based on information in the vendor maintenance schedule.

Energy consumption cost are based on either the technical documentation of existing equipment or the master equipment list.

Insurance cost can normally be produced by economics department of the company on the basis of existing insurance contracts.

Onshore support cost are given in the Plan for development and operation. When not available the economics department of the Company can produce records for existing fields.

1.3 Cost of deferred production

Failure data can be extracted from reliability databases, such as OREDA.

Cost of downtime is based on the production profile given in the Plan for development and operation. For fields already in operation actual and predicted future production form the basis.

ANNEX D DATA ADJUSTMENT (NORMATIVE)

1 CAPITAL COST

Design and administration cost

- Adjustment for facility/system capacity.
- Adjustment for duration of engineering and construction.
- Adjustment for engineering cost development due to contract/cooperation form.

Equipment and material purchase cost

- Adjustment for time difference between historic data and investment.
- Adjustment for cost development over time.
- Adjustment for system design and capacity.
- Adjustment for system improvements leading to deviation in purchase cost.

Fabrication cost

- Adjustment for system design and capacity.
- Adjustment for cost development over time.
- Adjustment for effect of contract/cooperation form.

Installation cost

- Adjustment for system design and capacity.
- Adjustment for cost development over time.
- Adjustment for effect of contract/cooperation form.

Commissioning cost

- Adjustment for system design and capacity.
- Adjustment for cost development over time.
- Adjustment for effect of contract/cooperation form.

Insurance spares cost

- Adjustment for effect on storage level of more units installed when storage is serving more installations.
- Adjustment for cost development over time.
- Adjustment for difference in philosophy for storage location.

Reinvestment cost

- When reinvesting in equipment with an expected life shorter than the life of the facility:
Adjustment for system capacity relative to the throughput requirement for the remaining life of the facility.
- Adjustment for oil characteristics.

2 OPERATING COST

Manhours

- Adjustment for difference in system design and capacity.
- Adjustment for oil characteristics.
- Adjustment for time in operation.

Spare parts consumption

- Adjustment for difference in system design and capacity.
- Adjustment for oil characteristics.
- Adjustment for time in operation.
- Adjustment for cost development over time.

Logistic support cost

- Time difference in historic records.

Energy consumption cost

- Adjustment for time in operation.

Insurance cost

- Adjustment for difference in size of the basis for premium calculation.

Onshore support cost

- Adjustment for difference in philosophy for onshore support and maintenance.

3 COST OF DEFERRED PRODUCTION

Adjustment for field and facility characteristics.

ANNEX E LIFE CYCLE COST MODEL FOR PRODUCTION FACILITY (NORMATIVE)

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LCC summary	1
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Life Cycle Cost for the Evaluated Configuration

2x50%

PRE TAX	Value [kNOK]
CAPITAL COST	0
OPERATING COST	0
COST OF DEFERRED PRODUCTION	0
LIFE CYCLE COST	0

AFTER TAX	Value [kNOK]
CAPITAL COST	0
OPERATING COST	0
COST OF DEFERRED PRODUCTION	0
LIFE CYCLE COST	0

Cost Breakdown

CAPITAL COST	Value [NOK]
Design and Adm Cost	0
Equip. and Matr. Purchase Cost	0
Fabrication Cost	0
Installation Cost	0
Commissioning Cost	0
Insurance Spares Cost	0
Reinvestment Cost	0
Other Capital Costs	0

OPERATING COST per year on plateau	Value [NOK]
Manhour Cost	0
Spares and Consumables Consumption Cost	0
Logistic Support Cost	0
Energy Consumption Cost	0
Insurance Cost	0
Onshore Support Cost	0
Other Operating Costs	0

Estimated Effect of Different Configurations

LCC	Configuration					
	1x100%	2x100%	2x50%	3x50%	4x25%	4x33%
Pre Tax	0	0	0	0	0	0
After-tax	0	0	0	0	0	0

Date : Prepared by :

Date : Checked by :

Project XXX

Design Evaluation

LCC Evaluation

SYSTEM ASSESSMENT

DESIGN OPTION

Size

kW

Capacity

m3/h

Configuration

!

2x50%

LIMITING FACTORS

Option	Estimation basis	Evaluated Option
Configuration	! 1x100%	2x50%
Weight [tonne]		0
Space [m2]		0

CAPITAL COST

Option	Estimation basis	Evaluated Option	Invest Year
Configuration	! 1x100%	2x50%	
Design and Adm Cost		0	1996
Equip. and Matr. Purchase Cost		0	1996
Fabrication Cost		0	1996
Installation Cost		0	1996
Commissioning Cost		0	1996
Insurance Spares Cost		0	1996
Reinvestment Cost		0	1996
Other Capital Costs		0	1996
Capital Cost		0	
Capital Cost, Pre-tax		0	
Capital Cost, After tax		0	

OPERATING COST

Option	Estimation basis	Evaluated Option					
Configuration	! 1x100%	2x50%					
Production level	Plateau	Build-up	Plateau	Plat.-0,75	75-50%	50-25%	25-Close
Manhour Cost		0	0	0	0	0	0
Spares and Consumables Consumption Cost		0	0	0	0	0	0
Logistic Support Cost		0	0	0	0	0	0
Energy Consumption Cost		0	0	0	0	0	0
Insurance Cost		0	0	0	0	0	0
Onshore Support Cost		0	0	0	0	0	0
Other Operating Costs		0	0	0	0	0	0
Operating Cost per year in period	0	0	0	0	0	0	0
Operating Cost, Pre-tax		0					
Operating Cost, After-tax		0					

COST OF DEFERRED PRODUCTION

Option	Estimation basis	Evaluated Option					
Configuration	! 1x100%	2x50%					
Production level	Plateau	Build-up	Plateau	Plat.-0,75	75-50%	50-25%	25-Close
Part of system throughput unavail. giving lost prod.		0,00 %	0,00 %	0,00 %	0,00 %	0,00 %	0,00 %
System throughput unavailability	0,0000 %	0,0000 %	0,0000 %	0,0000 %	0,0000 %	0,0000 %	0,0000 %
Mean Time to Critical Failure [Hours]							
Mean Time To Repair Critical Failures [Hours]							
Cost of Deferred Prod. per year in period		0	0	0	0	0	0
Cost of Deferred Prod., pre-tax		0					
Cost of Deferred Prod., After-tax		0					

LCC

Pre Tax	0
After-tax	0

Date :

Prepared by :

Date :

Checked by :

COST VARIATION MATRIX

Effect of different configurations (relative to 1x100%)

CAPITAL COST	1x100%	2x100%	2x50%	3x50%	4x25%	4x33%
Design and Administration	1	1,2	1,2	1,3	1,4	1,6
Equip. and Matr. Purchase	1	2	1,3	2	2,1	2,2
Fabrication	1	2	1,4	2,1	2,2	2,3
Installation	1	1,5	1,3	2	2,1	2,2
Commissioning	1	1,6	1,6	1,7	1,8	1,9
Insurance Spares	1	1,4	1,3	1,4	1,5	1,5
Reinvestment	1	2	1,3	2	2,1	2,2
Other Capital Costs	1	1	1	1	1	1

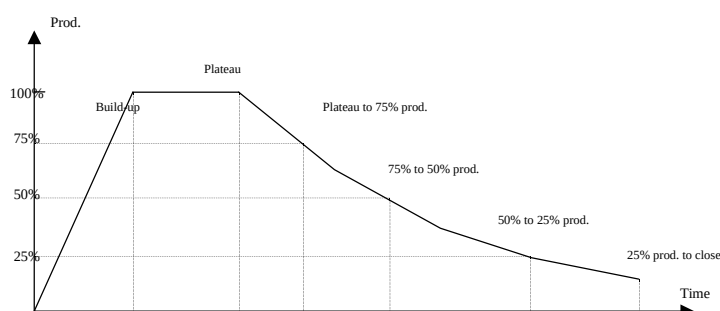
OPERATING COST	1x100%	2x100%	2x50%	3x50%	4x25%	4x33%
Manhour Cost	1	1,3	1,7	1,9	2,2	2
Spares and Consumables Consump. Cost	1	1,3	1,7	1,9	2,2	2
Logistic Support Cost	1	1,1	1,1	1,2	1,3	1,3
Energy Consumption Cost	1	1	1,2	1,2	1,5	1,3
Insurance Cost	1	2	1,3	2	2,1	2,2
Onshore Support Cost	1	1,1	1,1	1,2	1,3	1,3
Other Operating Costs	1	1	1	1	1	1

LIMITING FACTORS	1x100%	2x100%	2x50%	3x50%	4x25%	4x33%
Weight	1	2	1,4	1,8	1,9	2,1
Space	1	2	1,6	2,2	2,4	2,6

Cost development through the lifetime (relative to plateau level)

OPERATING COST	Build-up	Plateau	Plat.-0,75	75-50%	50-25%	25-Close
Man-hour Cost	120 %	100 %	100 %	70 %	50 %	50 %
Spares and Consumables Consump. Cost	120 %	100 %	100 %	70 %	50 %	50 %
Logistic Support Cost	120 %	100 %	100 %	70 %	50 %	50 %
Energy Consumption Cost	120 %	100 %	100 %	70 %	50 %	50 %
Insurance Cost	120 %	100 %	100 %	70 %	50 %	50 %
Onshore Support Cost	120 %	100 %	100 %	70 %	50 %	50 %
Other Operating Costs	120 %	100 %	100 %	70 %	50 %	50 %

COST OF DEFERRED PRODUCTION	Build-up	Plateau	Plat.-0,75	75-50%	50-25%	25-Close
Part of system throughput unavail. giving lost prod.	100 %	100 %	100 %	100 %	100 %	100 %



Date :	Prepared by :
Date :	Checked by :

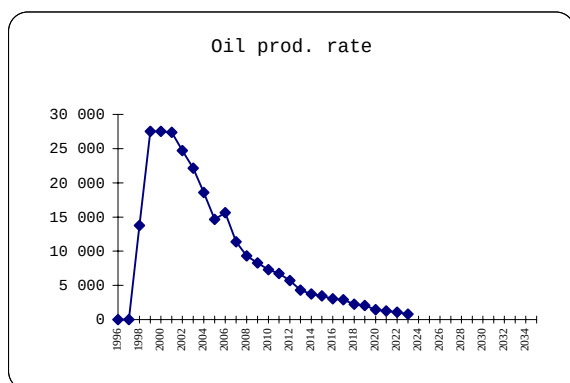
CALCULATING ASSUMPTIONS

Basic Assumptions

Timing	
Investment year	1996
Start of Production	1998
Operating hours per year	8520

Financial		
Discount rate	7,0%	
Tax Ordinary Income	28,0%	
Extra Offshore Tax	50,0%	
Tax Free Income	5,0%	of inv.
Insurance	1,5%	of inv.

Income		
Oil Price	115	NOK/barrel
Gas Sales Price	0,72	NOK/Sm3
Gas Transp. Cost	0,25	NOK/Sm3
Net Gas Price	0,47	NOK/Sm3
Part of lost gas export leading to lost income	100,0%	



Production Profile

Year	Oil prod. rate Sm3/Day	Gas export rate MSm3/D	Cost of 1 hour downtime NOK
1996	0	0,00	0
1997	0	0,00	0
1998	13 750	0,00	414 353
1999	27 500	0,00	828 707
2000	27 500	0,00	828 707
2001	27 400	0,00	825 693
2002	24 700	0,00	744 329
2003	22 160	0,00	667 787
2004	18 570	0,00	559 603
2005	14 650	0,00	441 475
2006	15 630	0,00	471 007
2007	11 370	0,00	342 633
2008	9 321	0,00	280 886
2009	8 280	0,00	249 516
2010	7 320	0,00	220 587
2011	6 720	0,00	202 506
2012	5 700	0,00	171 768
2013	4 320	0,00	130 182
2014	3 730	0,00	112 403
2015	3 440	0,00	103 664
2016	3 030	0,00	91 308
2017	2 890	0,00	87 090
2018	2 240	0,00	67 502
2019	2 070	0,00	62 379
2020	1 430	0,00	43 093
2021	1 270	0,00	38 271
2022	1 068	0,00	32 184
2023	803	0,00	24 198
2024			0
2025			0
2026			0
2027			0
2028			0
2029			0
2030			0
2031			0
2032			0
2033			0
2034			0
2035			0

Main Periods

Main Periods	Time relative to investment		Discount factor	Average cost of downtime per hour	Discounted average cost of downtime per hour
	From & incl.	To & incl.			
Build-up period	3	3	0,8734	414 353	361 912
Plateau production	4	9	4,1633	742 471	522 489
From plateau production to 75 % of plateau production	10	10	0,5439	441 475	240 133
From 75 % of plateau production to 50 % of plateau production	11	11	0,5083	471 007	239 436
From 50 % of plateau production to 25 % of plateau production	12	16	2,0843	259 226	109 997
From 25 % of plateau production to close down	17	19	0,9512	138 118	44 217
Closedown	20				

Date :	Prepared by :
Date :	Checked by :

ANNEX F USER GUIDE LCC MODEL FOR PRODUCTION FACILITY (NORMATIVE)

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.

LCC is the economic evaluation method to apply when no specific part of the income can be related to the object for evaluation. LCC looks at the cost side and takes into account the effect on the income side of failures in the object reducing production.

To arrive at a optimised production facility the different systems have to be optimised within the framework of the production profile given, and the results aggregated up to facility level. The LCC-model provides a tool for these optimisations within the given framework.

1.2 Description

The LCC-model (Facility.xlw) is made as a workbook in Excel 5.0. The workbook contains spreadsheets and hidden macro-files. The macro-files are the software (program) that controls and helps using the spreadsheet and should not be changed.

The spreadsheet is a protected document. This implies 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 is 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 Facility.xlw.

1.4 Adjustment to screen

The spreadsheet is adjusted to a 14" screen. For other screen sizes it may be advantageous to adjust the zooming to fit the page to the screen.

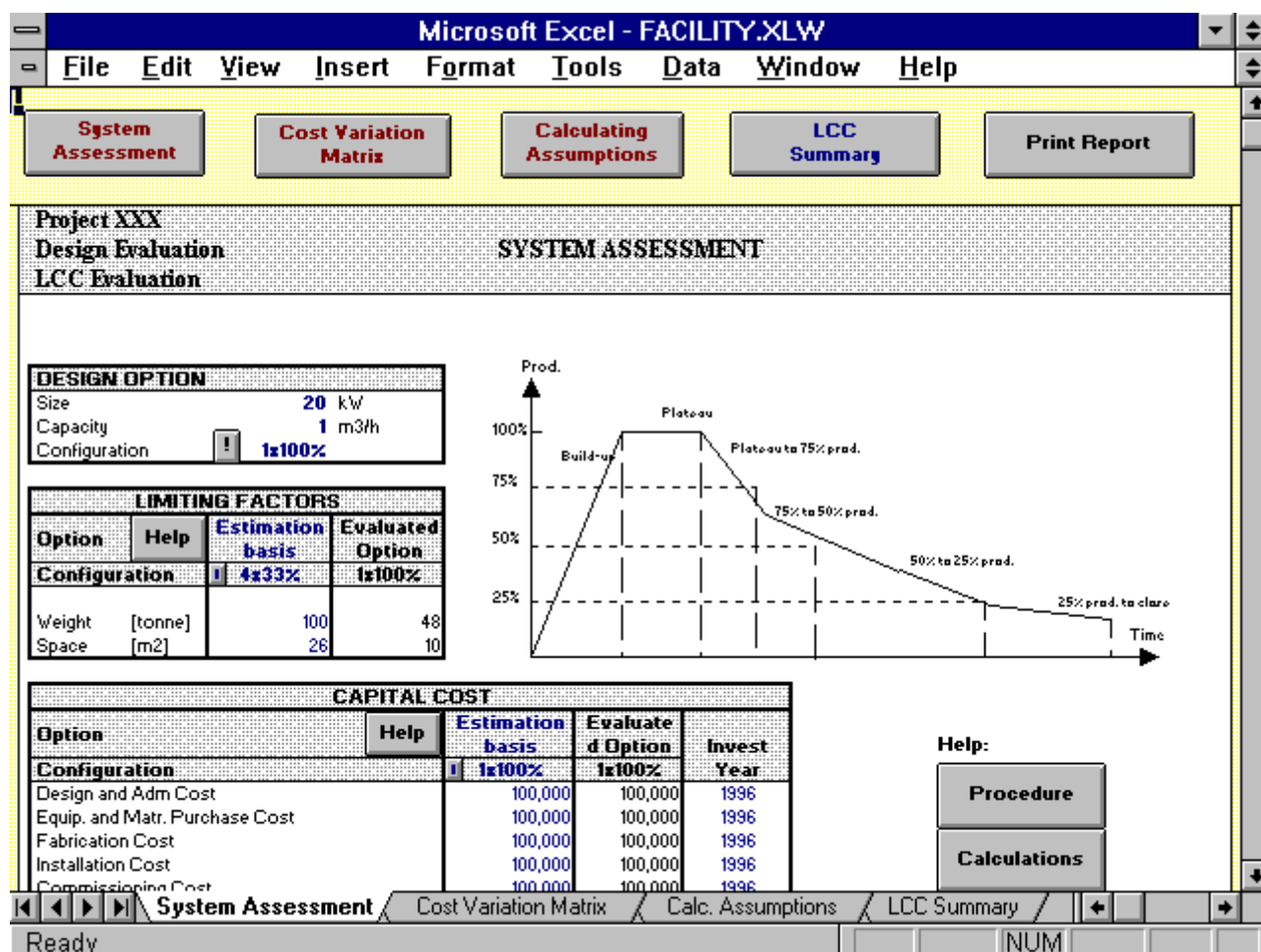


Figure 1

2. MAIN STRUCTURE

2.1 General

The model is structured with due regard to the level of information available in the early phases of a field development project and the approach of optimising the production facility through:

- Designing for the life of the field rather than the plateau period.
- Designing the facility based on the minimum equipment and utilities required for the process. All additional equipment are justified related to the profit contribution.
- Designing for optimum production regularity.
- To identify and evaluate all relevant design alternatives in relation to total cost/profit contribution during the lifetime of the facility.

The data is put in on an aggregated level for each cost element and dealt with in relation to the points listed above.

2.2 Model structure

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

- LCC Summary (Output form)
- System Assessment (Input form)
- Cost Variation Matrix (")
- Calculating Assumptions (")

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.

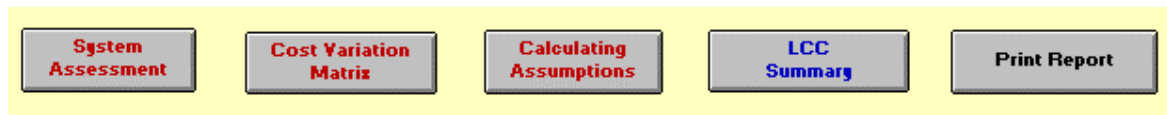


Figure 2

2.3 Summary of Calculation Procedures

Use of the LCC-model contains the following steps:

1. Fill in the project, discipline and object for evaluation in the heading of the **System Assessment** sheet.
2. In the **Calculating Assumptions** sheet fill in
 - Basic Assumptions
 - Production Profile
 - Main Periods
3. In the **Cost Variation Matrix** sheet alter the default values of
 - effect of different configurations
 - cost development over the lifetimeto give a fair representation of the object to be evaluated.
4. In the **System Assessment** sheet fill in baseline data and the configuration from which they were obtained for the elements under
 - Capital Cost
 - Operating Cost
 - Cost of Deferred Production
 - Limiting Factors
5. Evaluate the effect of different configurations by clicking the **Evaluate Options** button on the bottom of the System Assessment sheet.
6. Fill in the selected option for the report in the System Assessment sheet.
7. Print report.

3 INPUT OF DATA

3.1 Heading

In the opening sheet enter System Assessment in the heading:

- Project.
- Discipline.
- Object for evaluation.

This will be the heading on each side of the report.

3.2 Calculating assumptions

This form contains all the economic assumptions and field data.

3.2.1 Basic assumptions

Assumptions are to be entered within:

- Timing.
- Financial.
- Income.

The investment year will be the base year for evaluation to which all costs are discounted.

The discount rate to be used in an LCC-evaluation of an object to which a part of the income cannot be related, should be a risk free rate. Risk should be evaluated separately.

3.2.2 Production profile

Calculation of Cost of Deferred Production is automated on the bases of the oil production rate and gas export rate to be entered in this table.

3.2.3 Main periods

In order to make the calculations practicable and still accurate enough for the decision to be made, the field lifetime is split into periods:

- Build-up period.
- Plateau production.
- From plateau to 75% of plateau production.
- From 75% of plateau production to 50% of plateau production.
- From 50% of plateau production to 25% of plateau production.
- From 25% of plateau production to close down.

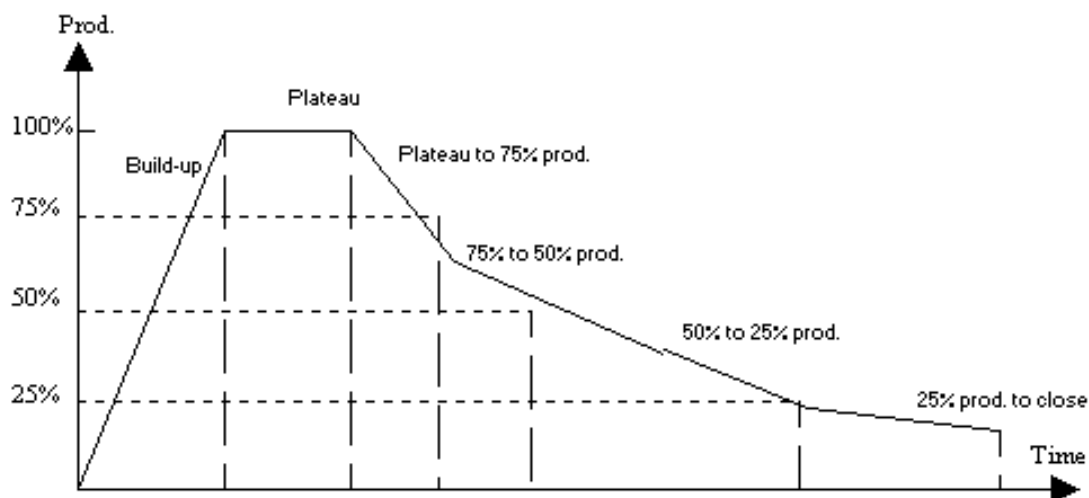


Figure 3

The startyear of the periods and closedown are to be entered in relation to investment year under Basic Assumptions. They should be consistent with the production profile entered.

3.3 Cost variation matrix

Through the Cost Variation Matrix it is taken into account:

- The effect of different configurations (relative to 100%).
- The cost development through the lifetime.

3.3.1 Effect of different configurations

Effect of different configurations are entered for the elements under:

- Capital Cost.
- Operating Cost.
- Limiting Factors.

This is done by altering the values in the matrix. E.g. if going from 1x100% to 2x100% will increase the Design and Administration Cost by 20%, this is put under 2x100% as 1.2.

For 1x100% which sets the scale, the number is to be 1.

The altered values can be set back to the default values, or the default values can be edited through clicking the buttons on the top of the sheet.



Figure 4

3.3.2 *Cost development over the lifetime*

Cost development over the lifetime is entered for the elements under:

- Operating Cost.
- Cost of Deferred Production.

The numbers to be entered are the average level of the cost elements in the main periods in relation to the cost level on the plateau. The periods are the ones defined under Calculating Assumptions.

The numbers for Part of System Throughput Giving Lost Production to be entered are the changes over the periods of the number given in Estimation Basis in the System Assessment sheet.

3.4 **System assessment**

In the **System Assessment** sheet fill in baseline data and the configuration from which they were obtained for the elements under

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

3.4.1 *Design option*

DESIGN OPTION	
Size	20 kW
Capacity	1 m3/h
Configuration	 2x50%

Figure 5

The design option is the present option to be considered for the evaluation. By clicking the button



Figure 6

the following dialogue box will appear:

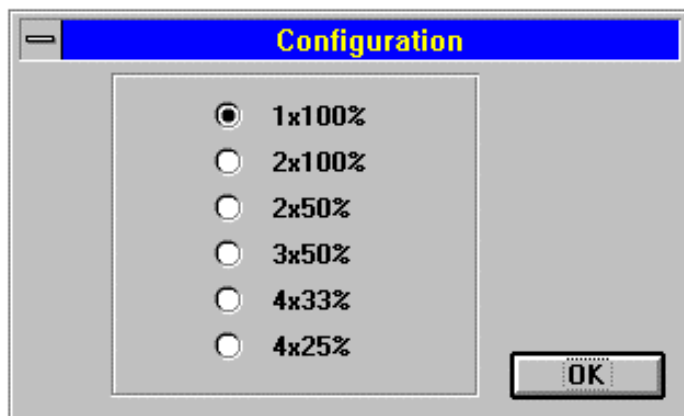


Figure 7

3.4.2 Capital cost

Capital cost is split into the following cost elements:

- Design and Administration Cost.
- Equipment and Materials Purchase Cost.
- Fabrication Cost.
- Installation Cost.
- Commissioning Cost.
- Insurance Spares Cost.
- Reinvestment Cost.

The basis for LCC evaluation of an object is the aggregated cost element data entered under Estimation Basis together with the configuration from which the data has been obtained.

For each element, the year when the expenditure occurs, also has to be entered.

CAPITAL COST			
Option	Estimation basis	Evaluated Option	Invest Year
Configuration	1x100%	2x50%	
Design and Adm Cost	100.000	120.000	1996
Equip. and Matr. Purchase Cost	100.000	130.000	1996
Fabrication Cost	100.000	140.000	1996
Installation Cost	100.000	130.000	1996
Commissioning Cost	100.000	1.000.000	1996
Insurance Spares Cost	100.000	130.000	1996
Reinvestment Cost	100.000	130.000	1996
Other Capital Costs	100.000	100.000	1996
Capital Cost	800.000	1.880.000	
Capital Cost, Pre-tax		1.880.000	
Capital Cost, After tax		395.171	

Figure 8

The effect on the evaluated option of configuration differences are calculated through the relative numbers given in the Cost Variation Matrix.

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

3.4.3 Operating cost

Operating cost is split into the following cost elements:

- Manhour Cost.
- Spares and Consumables Consumption Cost.
- Logistic Support Cost.
- Energy Consumption Cost.
- Insurance Cost.
- Onshore Support Cost.

As for Capital Cost the numbers to be entered are:

- Aggregated cost element data.
- Configuration from which the data was obtained.

OPERATING COST							
Option	Estimation basis	Evaluated Option					
Configuration	1x100%	2x50%					
Production level	Plateau	Build-up	Plateau	Plat-0,75	75-50%	50-25%	25-Close
Manhour Cost	100.000	204.000	170.000	170.000	119.000	119.000	85.000
Spares and Consumables Consumption Cost	100.000	204.000	170.000	170.000	119.000	119.000	85.000
Logistic Support Cost	100.000	132.000	110.000	110.000	77.000	77.000	55.000
Energy Consumption Cost	100.000	144.000	120.000	120.000	84.000	84.000	60.000
Insurance Cost	100.000	156.000	130.000	130.000	91.000	91.000	65.000
Onshore Support Cost	100.000	132.000	110.000	110.000	77.000	77.000	55.000
Other Operating Costs	100.000	120.000	100.000	100.000	70.000	70.000	50.000
Operating Cost per year in period	700.000	1.092.000	910.000	910.000	637.000	637.000	455.000
Operating Cost, Pre-tax		7.321.682					
Operating Cost, After-tax		1.610.770					

Figure 9

The following is calculated for the evaluated option through the Cost Variation Matrix:

- Effect of different configurations.
- Cost development over time.

3.4.4 Cost of deferred production

The mean time to critical failures (MTBFc) and mean time to repair critical failures (MTTRc) are entered. These are the average numbers for the total of the system to be evaluated.

Part of system throughput unavailability giving lost production is the number defining the effect on the overall availability of the object for evaluation closing down independent of the objects configuration. There are mainly two factors to consider:

- Train configuration on which the system is a part. On a 2x50% train the effect on production of the system shutting down is 50%.
- The dependencies with the other systems. This can be found from regularity studies from the relation between system unavailability and the contribution to the overall unavailability.

COST OF DEFERRED PRODUCTION							
Option	Estimation basis	Evaluated Option					
Configuration	1x100%	2x50%					
Production level	Plateau	Build-up	Plateau	Plat.-0,75	75-50%	50-25%	25-Close
Part of system throughput unavail. giving lost prod.	50,00 %	50,00 %	50,00 %	50,00 %	50,00 %	50,00 %	50,00 %
System throughput unavailability	0,1140 %	0,1140 %	0,1140 %	0,0958 %	0,0389 %	0,0001 %	0,0001 %
Mean Time to Critical Failure [Hours]	8760						
Mean Time To Repair Critical Failures [Hours]	10						
Cost of Deferred Prod. per year in period		2.012.709	3.606.530	1.801.729	779.608	1.436	765
Cost of Deferred Prod., pre-tax		18.365.928					
Cost of Deferred Prod., After-tax		4.040.504					

Figure 10

Cost of Deferred Production is calculated for the evaluated option for each main period based on the failure data, configuration, effect on overall regularity and production profile.

3.4.5 Limiting factors

For the limiting factors weight and space data can be entered together with the configuration from which they are obtained. The values resulting from different configurations are calculated through the relative numbers in the Cost Variation Matrix.

LIMITING FACTORS		
Option	Estimation basis	Evaluated Option
Configuration	1x100%	2x50%
Weight [tonne]	100	140
Space [m2]	26	42

Figure 11

4 EVALUATION

4.1 Evaluate options

The effect of different configurations can be evaluated by clicking the **Evaluate Options** button on the bottom of the System Assessment sheet.



Figure 12

This gives a matrix with the Life Cycle Cost for all the configurations pre tax and after tax. To get a report and a detailed cost breakdown on the feasible option with the lowest cost, enter this under Design Option in the System Assessment sheet and press the print button.

4.2 LCC summary

The LCC Summary form shows the results for the evaluated option pre tax and after tax for:

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

A further cost element breakdown follows below.

The estimated effect of the different configurations are shown at the bottom of the sheet.

5 OPTIMISATION

An optimisation of the different systems of the facility on the basis of high level information available in the early phases of a project is achieved through the approach outlined above.

To arrive at an optimised production facility all the systems are optimised and aggregated to facility level. This includes arriving at the optimum production regularity for the facility. It also allows for justifying additional equipment when this gives an added value to the project.

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 D. The report contains:

- LCC Summary.
- System Assessment.
- Cost Variation Matrix.
- Calculating Assumptions.

7 PROBLEM SOLVING

7.1 Locked cells

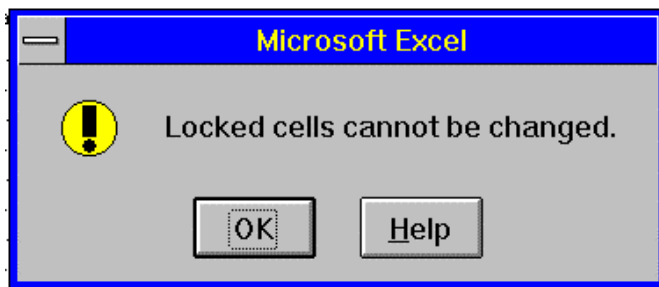


Figure 13

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.

7.3 Number not shown

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