

*Guidelines for*

# **FEASIBILITY STUDY**

## **INTRODUCTION**

This document describes the best practices to be followed during the preparation of a Feasibility Study for the Facilities Development of an upstream asset. Amongst the principal deliverables of a Feasibility Study is the Cost Estimates to be used for Economics Evaluation of a potential opportunity or a hydrocarbon discovery; the required accuracy of these costs estimates varies with the stage of the Project (see next section).

## **SCOPE OF THE FEASIBILITY STUDY**

The objective of the Facilities Feasibility Study preparation, described within this document, is to provide the facility area professionals with the best practices to lead the facility study preparation to a level which guarantees an easy and correct interaction with others professional areas and with the multidisciplinary integrated team.

The technical process deliverable will be the "*Facility Feasibility Study*" for each of the considered concept alternatives. It would have a level of accuracy which allows the multidisciplinary integrated team to prepare the PROJECT Feasibility Study to be included in the deliverables for GATE submission.

The expected concept alternative economic estimate accuracy normally are: +/- 40% for the Gate 1 and +/-30% in for the Gate 2 Decision Points. Therefore, the facility study should be carried out according to these accuracy requirements.

## OVERVIEW

Within the screening process of the potential development for a given hydrocarbon accumulation, the full range of Concept Alternatives have to be investigated.

The wide set of concept alternatives is defined by the Multifunctional Project Team at the very beginning of this Screening phase. The range of Alternatives will be the input of the screening process, performed by the multidisciplinary team, where a reduced range of alternatives is prepared for the following "Select" phase.

Within the "Select" phase, the reduced range of Selected Concept Alternatives will be investigated. The range of Concept Alternatives will be the input of the screening and optimisation process performed by the multidisciplinary team as final activity, whereas each solution will be presented and only one alternative will be recommended to the Decision Maker(s).

The workflow described in this document is applicable to both mentioned development project phases – (Screening and Select). The main difference between the same activities performed within the two phases is the level of detail, and therefore the accuracy of the Costs Estimates associated.

## WORKFLOW STEPS

A definition of the activities during the Screening and Selection phases is hereafter reported, subdivided in steps. The steps follow a purely conceptual sequence, which means that activities listed within the initial steps might be performed in parallel. Moreover, a certain degree of "recycling" and refining is recommended as new data become available.

The "Data Gathering" step and the following Kick Off Meeting (KOM) are in sequence and not repeatable.

Within the workflow, the following main steps have been identified and described:

- Step 1 - Data Gathering
- Step 2 - Main Process and Utility Design
- Step 3 - Subsea, on shore and off shore pipeline and Main Items Design
- Step 4 - Logistics and Construction Requirements
- Step 5 - General Layouts
- Step 6 - Execution Schedule Definition
- Step 7 - Costs Estimates
- Step 8 - Preparation of Facilities Study Final Documentation

These steps are described in the following sections.

## **STEP 1: DATA GATHERING**

### *Main Activities:*

- Technical assessment for systems definition and design

The "Data Gathering" step is preliminary to any technical activity which will be performed by facility area professionals within the Screening and Selection phases.

The objective is to gather all the technical and non technical (i.e. commercial, legal etc.) data and information needed by facilities professional to correctly identify and design all the feasible facilities concept alternatives, which will be developed throughout the rest of the Feasibility Study activities.

### *Description*

Within this step, the facility engineering team gathers all the data needed to perform the facility technical design activities.

In the screening phase, part of the information and data come from the exploration/appraisal of the well and from analogous or surrounding fields, both through the company's database and through sector studies and publications.

The related data should (including an eventual appraisal well's data) feed the facility technical work flow as well within the phase, especially in case of new fluid characterization which might have a very strong impact on the process and therefore on the overall CAPEX.

Some more gathering activities should also be performed in order to have site surveys maps and reports, location, information about state and ownership of the surrounding facilities, possible export routes in the area, final product specifications.

In the "Select" phase part of the needed information are already contained in the previous (Gate 1) documentation package, in the facilities study (preliminary), in the HSEQ plan, in the strategic impact assessment and in the Selection Phase's Terms of Reference (TOR).

The latest Company Technology Plan and emerging technologies assessment studies should be analysed as well, to give to the facility team the overview of the applicable and most up to date technologies, in order to maximise the final asset value and to reach the highest level of economic efficiency.

The initial list of required data should be filled and checked for completeness.

### **Input data**

The facilities engineer shall be provided of the following documents to be able to fully undertake the facility feasibility study:

1. Appraisal Well Final report
2. Discovery Well Final Report
3. Preliminary Facilities Study (if any)
4. Pre-feasibility Study (if available)

These documents should contain all the needed data and information.

*The multifunctional Project team is responsible of the common activities of modelling, screening and optimising development concept alternatives.*

The Data usually needed to perform the facilities technical activities are:

- Reservoir Fluid characterisation
- Wells Production Parameters (WHTP, peak rate, water cut, etc.)
- Reservoir Depletion Strategy (water/gas injection requirements)
- Well numbers, location, etc.
- Export Options
- Final Products Specifications
- Geographic Information
- Metocean/Logistics data

After completing this initial data gathering exercise, the Multifunctional Project Team should formally kick off the engineering activities with a **Project Kick-Off Meeting** (KOM) where all the personnel involved should agree the basis and objectives of the work to be performed.

## **STEP 2: MAIN PROCESS AND UTILITY DESIGN**

### *Main Activities:*

- Definition of Material and Energy Balance
- Definition of the relations among the process systems, with particular emphasis to the required auxiliary systems
- Definition of the process flow for hydrocarbons main process and for relevant Utilities
- Definition of requirements for energy supply.

The level of detail of each task is determined by the phase in which the workflow is performed: simple definition for Screening, conceptual design of essential parts for the Select phase.

The main objective of this step is to perform the activities which allow the definition and the preliminary design of the process and main utilities systems.

### *Description*

In the Screening phase this step is limited to the definition of the main process and utilities systems, while in the Select phase the preliminary design is performed.

The definition and design activities are repeated for each concept alternative defined by the "Multifunctional Project Team".

The concept alternative has been previously outlined by the multifunctional integrated team taking into consideration all the gathered information and environmental and commercial constraints.

It is the process engineer's duty to verify, within this step, the technical feasibility of the process concept alternative such as no technical issues will arise during the following Project phases (in case the process concept alternative would pass through the screening and optimisation activities performed by the multidisciplinary integrated team).

Data referred to fluid characterization (composition and phase behaviour) as well as production parameters (namely: well head pressure, peak rate, plateau rate, minimum required pressure at the delivery point, fluid temperature, hydrocarbon final specifications etc.) should be made available to the process engineer through the other professional areas under the supervision of the multidisciplinary integrated team.

During this initial phase different treatment/process options should be taken into consideration in order to identify the concept alternative which minimise potential environmental and strategic issues. It implies a very close collaboration with HSE experts, in terms of applied procedures and project criteria.

### **Input data**

The information and documents needed to perform the Main Process and Utility Design are:

- Reservoir studies (including risk analysis with related production scenarios);
- Laboratories fluid reports;
- Indications about final product specifications;
- Concept alternatives description produced by the multifunctional integrated team;
- General layout and plant location.

### **Main Deliverables**

- Process Flow Diagrams
- Basic Heat and Materials Balance
- Single-Line Electrical Block Diagrams and Power requirements

### **STEP 3: PIPELINES AND MAIN ITEMS DESIGN**

#### *Main Activities:*

- Flow assurance study
- Definition of risers/sealine/pipeline diameters, wall thickness, route and length, and requirements for compression/pumping stations
- Identification of the main Process Items and Relevant Utilities
- Definition of the principal items for the Power Generation and Distribution Systems

The objectives of this step are to define and optimise the main items having a significant impact on the development project, and to execute a conceptual design activity on long lead items (e.g. turbines, pressure vessels, rotating machinery)

A parallel activity is also to verify the market availability and lead time of the right items for the project purposes.

#### *Description*

During the screening phase, the definition of the main items required by the main Process Systems and by relevant utilities is performed. The subsea system, onshore/off shore Pipeline and Risers together with related main items (pumping or compression station) are also dealt with. The definition activities are repeated several times depending on the number of Concept Alternatives defined by the "Multifunctional Project Team".

In the Select phase, the conceptual design of the main items required by the principal process Systems and by the related utilities is performed including control system philosophy. In the same way on/off shore Pipeline and Risers with related items (pumping or compression station) are considered. The design activities are repeated for a reduced number of Concept Alternatives selected by the "Multifunctional Project Team" at the end of the Screening phase.

In both the Screening and Select phases the definition of the pipelines/sealines and risers must be strongly interfaced with the activities of drilling and completion area, due to the impact of General Field Map and Layout (wellhead location, etc.) to pipe layout and routes. The match between well schemes and facilities layout alternatives to check development schemes compatibility is performed within the Multifunctional Project Team, by the facilities engineers and petroleum/reservoir engineers. Then, quantitative analysis will be performed by facilities discipline specialists.

The result of the step activities will be the definition of main characteristics and dimensioning of main items, pipelines/sealines and risers. Those tools which enable the pipeline engineer to perform the calculations in steady state and transient flowing conditions and pipeline network simulators are used within this step.

Other tools and case histories are also taken into consideration to verify flow assurance parameters (i.e. hydrate formation, wax and asphaltene deposits, minimum required pressure at delivery point etc.) and pipelines configurations. Laboratories might also be involved at this step.

Site surveys, geotechnical investigations, meteo-marine data should be available to correctly evaluate development concept alternatives (see step 1).

More than one production scenario will result from reservoir risk analysis, so different plant and facility sizes will have to be considered in terms of capacity and peak production rates. The main items of the process systems, of the pumping or compression stations and of the main utilities may also be affected.

### **Input Data**

The data generally required to perform this step are the following:

- Site Surveys, geotechnical investigations, meteo-marine data
- Alternative Development Concept General Layout
- Production Scenario:
  - Fluid characterization and risked flowing conditions
  - Risked production parameters
- Alternative Development Concept Quantified Process Flow Diagrams
- Definition of requirements for energy supply

Note: As “risked production parameters” we intend the range of, gas rate, oil rate, WTHP (well tubing head pressure) WTHT (well tubing head temperature), WC (well water cut), GOR (gas oil ratio) which are output from each production scenario’s risk analysis.

### **Main Deliverables**

- Flow Assurance Assessment Study
- Pipelines basic data sheets
- Pipelines Item list
- Simplified Process Equipment Data sheets
- Simplified Power Generation and Distribution Systems Equipment Data sheets
- Preliminary Long Lead Items (LLI) list

## **STEP 4: LOGISTICS AND CONSTRUCTION REQUIREMENTS**

### *Main Activities:*

- Identify main fabrication requirements
- Identify main storage requirements
- Define Construction philosophy
- Outline General heavy lifting requirements
- Outline special items, pipelines and platform/FPSO/TLP installation requirements

The Logistic and Construction Requirements activity leads to the definition and first design of the means necessary for transportation, storage, accommodation of material and personnel and the solution and organisation of construction, erection, installation of the plant, in both the temporary locations and the final site.

### *Description*

In the Screening phase, the preliminary requirements on logistics are defined in order to evaluate the need of spaces, accesses, personnel accommodations, provision of special tools for components and structures transportation and installation, etc.

Within the Screening phase activities, the logistic interface with HSEQ workflow should be maximised in order to identify all the possible strategic impact which may arise for each concept alternative (transportation, civil infrastructure, access roads and accommodations, etc.)

In the Select Phase the requirements on logistics are analysed more in details and the availability of preliminary estimates on materials, equipment, manpower etc. enables the Project Team to better define the logistics requirements and the associated costs.

In both cases the outputs of the activity will be, in different degrees of completion and for the various conceived concept alternatives:

- Preliminary logistic study;
- Preliminary Project execution plan;
- installation sequence drawings;
- technical contribution to qualitative evaluation of possible environmental effect
- the preliminary EIA (for the Concept Phase only)
- identification of Hazards in project execution and operations;
- feed to qualitative risk analysis.

Moreover the activities can be repeated as a function of the risk analysis results, in order to better assess the Concept Alternatives.

### **Input Data**

- Concept Alternatives general layouts and structures location

- Item Lists

**Main Deliverables**

- Construction Philosophy
- Logistic Study
- Preliminary Manpower estimates and Execution Schedule
- Installation Sequence for the main systems

## **STEP 5: GENERAL LAYOUTS**

### *Main Activities:*

- Definition of the Processing Plant Layout
- Definition of the Export Pipelines Routes
- Definition of the Temporary facilities, utilities and other infrastructures layouts

This step leads to main equipment, main support structures and main systems layout definition. In case of offshore Project, the principal characteristics of the structures should be taken into consideration: PLT, FPSO, TLP, DDCV, CT, Semisub.

### *Description*

The activity described within this step consists in the analysis (Screening phase) and the preliminary definition (Select phase) of the Layouts and Logistics requirements of the main equipments and the systems necessary for plant realization. Basic Layout drawings for equipment allocation have to be prepared.

Layout drawings contain, besides the required main components, the following items:

- On-shore plants: main buildings, roads and structures needed to contain, move and support components or systems.
- Off-shore plants: main modules, decks, supporting systems, storage systems, as well as subsea layout and export systems.

The described process will be repeated several times depending on the number of Concept Alternatives defined by the "Multifunctional Project Team".

### **Input Data**

- Concept Alternatives process flow diagrams.
- Concept Alternatives simplified item data sheets and item list
- Concept Alternatives pipelines data sheets
- Concept Alternatives list of pipelines and related items
- Concept Alternatives general layouts and structures location
- Item list (for Logistic and Temporary Facilities requirements)
- References of the principal local and international legislation, as well as Company's Best Practices

### **Main Deliverables**

- preliminary plot plan;
- preliminary general arrangements;
- pipelines and subsea sealines layout drawings;
- technical contribution to qualitative evaluation of possible environmental effects
- the preliminary EIA (for the Select phase only);
- identification of Hazards in project execution and operations;
- feed to qualitative risk analysis.

## **STEP 6: EXECUTION SCHEDULE DEFINITION**

### *Main Activities:*

- Market analysis and minimum lead time definition for the principal components of the Process/Utility systems
- Market analysis and minimum lead time definition for the principal components of the Pipelines/Compression/Pump stations systems
- Definition of the start/end construction time for each major unit of the Facilities
- Definition of the correct time sequence for the Construction phase
- Definition of the time requirements for special items transportation, special liftings and construction of any temporary facility needed.

The objective of this step is to define the time schedule required for the realization of the facilities plant for the different concept alternatives under examination; to define the start and completion date of the proceeding phases; and to estimate timing and quantity of personnel required during the various execution phases.

### *Description*

Defining a preliminary execution schedule for the various alternative is necessary in order to:

- provide input to the Economic Analysis of the alternatives (Phased Costs)
- define the date of production start-up for each alternative
- estimate timing and quantity of personnel required during the various execution phases of the development project (from design to construction and operation)
- to evaluate time for plant abandonment
- to support the following construction costs estimate (manpower etc.)

Within this step, facilities professionals should dialogue with Drilling and Completion area in order to efficiently schedule execution and installation activities, especially if the project comprises off-shore structures.

The facilities design construction and operation time will be used together with the time estimates by other professional areas to prepare a complete Project Schedule by the "Multifunctional Project Team"

### **Input Data** (*for all the Alternatives under screening*)

- Main Process Systems And Utilities Design
- Preliminary Material Management Strategy
- Pipeline/Sealine Characteristics And Layout
- Main Equipment / Materials Data Sheets & Quantities
- Plant And Structures Layout
- Construction And Installation Philosophy
- logistic studies
- Other available data e.g. productivity index etc.

**Main Deliverables**

- Long Lead Items database
- Process and Utility Systems Execution schedule
- Pipelines execution schedule
- Overall Engineering, Procurement and Construction Schedules for all the Alternatives considered
- Manpower diagrams and update to the Logistic Study

## **STEP 7: COSTS ESTIMATES**

### *Main Activities:*

- Analyse COMPANY databases, historical costs records and Industry's benchmarking
- Estimate engineering costs
- Estimate Equipment and Bulk materials costs
- Estimate Construction/Fabrication costs
- Estimate Logistics and Temporary Facilities costs
- Estimate Operating Costs (OPEX)
- Preliminary definition of the final decommissioning and abandonment costs

This activity is aimed at the CAPEX and OPEX estimate for the plant facilities, based on the data and information evaluated or defined during the previous steps.

### *Description*

Screening Phase costs estimate methodology can be: Capacity Factored or T.I.C. Curves (based on cost of other project of known capacity), or use of a specialist software e.g. IHS Que\$tor.

Selection Phase costs estimate can be: based on Equipment/factored, T.I.C. or Parametric Model methodology.

In any case, the expected accuracy of the estimates is:  
+/-40% in the Screening phase  
+/-30% in the Select phase.

### **Input Data**

- Alternatives general description
- Company database (Analogous projects)
- Industry publications/benchmarking (also with database e.g. Wood Mackenzie)
- Main process, utilities, pipelines, subsea and naval systems design
- Main Items data sheets
- Plant and Structures layout.
- Construction and installation criteria
- Logistic Studies – Temporary Requirements
- Production Risk Analysis
- Decommissioning and abandonment study (if available)

### **Main Deliverables**

- Engineering Phases Costs Estimates
- Equipment / Bulk Materials CAPEX
- Construction / Fabrication CAPEX
- Logistics and Temporary Facilities CAPEX
- Operating and Maintenance Costs (OPEX) as a function of the production rates
- Estimate of Decommissioning and Abandonment costs

## **STEP 8: PREPARATION OF FINAL DOCUMENTATION**

### *Main Activities:*

- Collect and rationalise all the data and main information developed during this phase in order to prepare a complete support package for the decision maker and a proper Basis of Design to start the following PROJECT phase.

This task is aimed at the collection and organization of the technical documentation for the plant facilities, based on the data and documents evaluated or defined during the previous steps.

The result of the step is to produce a homogeneous and complete technical documentation necessary for the following activities.

Part of the document of Facilities Study are produced and collected for use by the Project Team, for Decision Making, while most of them will be reported to the succeeding phase of Basic Design.

During preparation of final documentation it is normally good practice to prepare a list of observations related to the good and bad development of the Screening & Select activities, in order to contribute to the production of a "Project Lesson Learned" document.

A lesson learned form is filled by discipline experts or project engineer, then lessons learned are gathered in the project lesson learned database and they are ready to be disseminated to the other members of the project team or externally to other projects.