

Key design activities, FEL1 through FEL3

Among the most difficult aspects of project development is defining the scope and content required in each front end loading (FEL) phase to meet the objectives of orderly and successful progress.

Section 5.2: "Front End Loading: The Foundation of Project Development" clarifies requirements at different levels for various purposes and each phase. Figure 5-2 summarizes, at a very high level, the typical activities within each phase, while Table 5-1 presents a more detailed description of the expected status of 31 key elements of the project at the end of each phase. In this table, the status of information progresses from "None" to "Defined," while the corresponding overall project deliverables range from "Started" to "Complete."

The table below expands on the level of effort put into each Project Input Area in the first three project phases. The 11 project input areas summarize those areas of engineering and design activity that progress and develop throughout the project. The "Activity or Scope Item" section summarizes key items within the "Project Input Area." The subsequent three parts in each section outline in narrative terms the level of development for individual or groups of key items for phases FEL1 through FEL3.

The level of effort during each phase will be clarified by studying this table in conjunction with Figure 5-2 and Table 5-1. Together, the three parts form a strong foundation to build upon, recognizing that each project will have its own unique or specific requirements.

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Project Input Area	1. Project Background
Activity or Scope Item	Define: <ul style="list-style-type: none"> ▪ project objectives, benchmarks, and key performance indicators ▪ scope of facilities and battery limits for project, noting interdependencies with off-project work ▪ influential location, regional, and country factors ▪ climatic data ▪ project, land, resource, and technology ownership ▪ intended implementation approach ▪ project development history ▪ business environment ▪ strategic case for project ▪ business case (e.g., markets, revenue, industry structures, and financial performance required of project) ▪ summary of reviews and actions arising ▪ constraints and dependencies
FEL1 Activities	Assemble preliminary public domain data specific to project location Define location of project facilities (project site often assumed) Understand conceptually business drivers that will support this type of project Define known project constraints
FEL2 Activities	Obtain preliminary site-specific data, including field investigation results Complete site selection studies and establish site ownership Define sound business case to support FEL3 investigations Complete FEL1 reviews and incorporate remaining work into FEL2
FEL3 Activities	Complete and incorporate into project definition, detailed site-specific information, test work, and field investigations to meet accuracy requirements for FEL3 Understand land, resource, and technology ownership issues, and include in project definition strategies for acquisition Provide input to business case to support investment decision for project Clarify remaining FEL phase work and define risk mitigation required in FEL4 to cover scope definition, cost estimates, schedule, and implementation plan
Project Input Area	2. Process Definition
Activity or Scope Item	Define: <ul style="list-style-type: none"> ▪ metallurgical test programs to uniquely characterize processing route, based on representative samples of feed materials ▪ plant capacity reflecting availability and reliability analyses ▪ process design criteria, based on results of test programs ▪ process flow diagrams (PFDs) ▪ piping and instrumentation diagrams (P&IDs)

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	<ul style="list-style-type: none"> ▪ mass and energy balances ▪ water balances ▪ waste stream characterization and management
FEL1 Activities	<p>Conduct bench-scale tests to support development of process design and mass and energy balances</p> <p>Typically, complete test work on preliminary samples</p> <p>Develop draft process design criteria, based on experience</p> <p>Identify major hazards</p> <p>Complete technology trade-off studies, and select preferred technology routes for project</p> <p>Develop block diagrams and mass balances for each option</p> <p>Develop preliminary PFDs for base case</p> <p>Complete preliminary capacity studies</p> <p>Define product streams and specifications</p> <p>P&ID development not required for FEL1</p>
FEL2 Activities	<p>Complete test work to support definition of process design criteria, flow sheet, and mass and energy balances</p> <p>Define operating and design flows, and size process equipment to suit each option</p> <p>Complete hazard studies on options</p> <p>Provide base-case draft PFDs and attendant data tables for confirmation in FEL3</p> <p>Develop P&IDs, and define major lines and control functionality</p>
FEL3 Activities	<p>Complete pilot-scale tests to develop process definition for project, including:</p> <ul style="list-style-type: none"> ▪ PFDs, with definition of nominal and minimum flow duties ▪ define and quantify all process streams ▪ freeze mass and energy balances for implementation ▪ freeze P&IDs, ready for detail design ▪ complete hazard studies on preferred options ▪ freeze process equipment list and equipment sizing ▪ develop detailed process description as baseline for engineering design in FEL4
Project Input Area	3. Engineering Development
Activity or Scope Item	<p>Define:</p> <ul style="list-style-type: none"> ▪ engineering criteria for scope development ▪ outcomes of project value analyses ▪ value-improving practices for application to project
FEL1 Activities	<p>Develop design criteria from standard industry practices</p> <p>Define:</p> <ul style="list-style-type: none"> ▪ value-improving practices for project ▪ value engineering opportunities for FEL2

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FEL2 Activities	Update preliminary design criteria and standards Define value engineering opportunities for FEL3
FEL3 Activities	Develop detailed design criteria for all disciplines and ensure they are reflected in calculations and engineering definition as baseline design criteria for FEL4 Complete value-improving practices and reflect outcomes in final definition
Project Input Area	4. Project Layout
Activity or Scope Item	Develop project layouts of major equipment and all work breakdown structure (WBS) elements, definitions aligning with complete project scope Develop WBS for complete project, including: <ul style="list-style-type: none"> ▪ process plant ▪ on-site development and infrastructure ▪ off-site development and infrastructure Define: <ul style="list-style-type: none"> ▪ topography and survey, including site grid(s) ▪ battery limits for project ▪ interfaces for material flows, services, and utilities crossing battery limits ▪ responsibility for providing services, materials, and other items crossing battery limits Prepare conceptual design or specification of each project option and inputs, including conceptual site plans, general arrangements, and layouts
FEL1 Activities	Develop conceptual layouts for each option, relying on benchmark and public domain data Use conceptual project location to define project scope Define WBS to area level Start facilities description Complete conceptual battery limits locations and quantification List preliminary tie-in and plant shutdown requirements
FEL2 Activities	Develop preliminary layouts for each project option Freeze project location and plot plan Define major equipment and all WBS element locations Define WBS to facility level Provide preliminary facilities descriptions Define functionality required of WBS elements, major equipment, and expected operating modes Define locations for services and utilities crossing battery limits, and identify major tie-ins and shutdown strategies
FEL3 Activities	Freeze site selection, plot plan, and project layout Define WBS to system level and, for complex projects, to subsystem level Locate all major equipment based on vendor data Freeze general arrangements for major equipment and facilities

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	<p>Ensure layouts reflect implementation plan (e.g., regarding modularization)</p> <p>Ensure mechanical equipment list is firm, pending receipt of vendor data in FEL4</p> <p>Define tie-ins and cross battery limit process lines, services, and utilities</p> <p>Obtain operator input for tie-in work in operating facilities</p>
Project Input Area	5. Process Plant
Activity or Scope Item	<p>Define proposed implementation and start-up strategies</p> <p>Select and specify equipment and materials</p> <p>Define material and equipment supply sources</p> <p>Select and specify control system</p> <p>Prepare process plant arrangements</p> <p>Quantify materials and equipment requirements</p> <p>Prepare facilities description</p>
FEL1 Activities	Complete project definition to conceptual level for all potential options, with detailed requirements to support study
FEL2 Activities	Complete project definition to preliminary status for all options, with detailed requirements to support study
FEL3 Activities	Complete project definition for selected option ready for detailed design, with detailed requirements to support study
Project Input Area	6. Site Development and Infrastructure
Activity or Scope Item	<p>Define:</p> <ul style="list-style-type: none"> ▪ site development for on- and off-site infrastructure ▪ construction infrastructure for project, which allows alignment of engineering design with proposed implementation plan
FEL1 Activities	Complete project definition for all options to conceptual level, with detailed requirements to support study
FEL2 Activities	Complete preliminary documentation for all options, with detailed requirements to support study
FEL3 Activities	Complete project definition for selected option and ensure ready for detailed design, with detailed requirements to support study
Project Input Area	7. Project Schedule
Activity or Scope Item	<p>Ensure schedule reflects:</p> <ul style="list-style-type: none"> ▪ preliminary bid packaging, including construction contracts ▪ long-lead equipment and material procurement durations taken from budget quotes ▪ lead times on other packages from industry benchmarks ▪ construction durations from benchmark data, adjusted for labour productivity and regional conditions ▪ work breakdown by disciplines, showing procurement and construction interdependencies <p>Set key milestones for:</p> <ul style="list-style-type: none"> ▪ approval and project finance

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	<ul style="list-style-type: none"> ▪ completion of outstanding investigations and test work ▪ work and services to be performed by others ▪ project review and approval ▪ preliminary commissioning durations for facility, including all infrastructure ▪ progress reviews with time to assess impact on cost and schedule for changes arising
FEL1 Activities	<p>Prepare preliminary project schedule for each option, indicating milestones for each phase sequenced into:</p> <ul style="list-style-type: none"> ▪ FEL2 ▪ FEL3 ▪ FEL4 <p>Prepare preliminary schedule for FEL2</p> <p>Document assumptions made in preparing schedule</p>
FEL2 Activities	<p>Develop detailed schedule for FEL3</p> <p>Document assumptions made in preparing schedule</p>
FEL3 Activities	<p>Prepare project schedule for FEL4 that:</p> <ul style="list-style-type: none"> ▪ is based on developing a commissioning and start-up plan ▪ is resource loaded ▪ is aligned with packaging and contracting structures ▪ represents all project disciplines ▪ reflects completion of construction packages ▪ documents data and assumptions underpinning schedule development
Project Input Area	8. Capital Cost Estimate
Activity or Scope Item	<p>Define material and equipment quantities required for construction of project for:</p> <ul style="list-style-type: none"> ▪ mine (if applicable) ▪ process plant ▪ site development and infrastructure <p>Where options carried to phase completion, provide:</p> <ul style="list-style-type: none"> ▪ estimates for surviving options, clearly defining base case ▪ budget prices for major equipment supply, sourced from multiple vendors <p>Estimate project indirect costs for:</p> <ul style="list-style-type: none"> ▪ owner's costs (i.e., financing, staffing, training, spares, working capital, and other internal costs) ▪ engineering, procurement, and construction management (EPCM), or engineering, procurement, and construction (EPC) services cost ▪ escalation (if it is in scope) ▪ risk provisions ▪ contingency

FEL1 Activities	Provide AACE International Class 4 or 5 cost estimate, supported by detailed basis of estimate document and attendant backup materials
FEL2 Activities	Provide AACE International Class 3 capital cost estimate for each option, supported by detailed basis of estimate document and attendant backup materials
FEL3 Activities	Provide AACE International Class 2 capital cost estimate, supported by detailed basis of estimate document and attendant backup materials Estimate underpinned by: <ul style="list-style-type: none"> ▪ up to 40% engineering definition for project ▪ quantity take-offs ▪ firm vendor bids on major equipment and materials ▪ assessment of expected construction unit cost and productivity ▪ implementation plan defining contracting, packaging, and management strategies for project
Project Input Area	9. Operating Cost Estimate
Activity or Scope Item	Define: <ul style="list-style-type: none"> ▪ basis for estimate ▪ sources of quantity data ▪ sources of cost data, including any budget quotes ▪ project facility scope, to allow comparison of consumables for scope of operating cost estimate ▪ data date
FEL1 Activities	Develop operating cost estimate for typical steady-state year for options considered Factor preliminary operating costs from parametric models, allowances, benchmarked data, and preliminary assessments of reagent and utility consumption Ensure expected accuracy of operating cost estimate is in range of: <ul style="list-style-type: none"> ▪ Low: -15% to -30% ▪ High: +20% to +50%
FEL2 Activities	Develop operating cost estimate for options considered, with sensitivity analysis for production changes and step changes in consumables (power, utilities, etc.) Provide fixed and variable operating costs based on operating parameters defined in study, using vendor data, budget quotes, and benchmarked data Summarize supply or cost risks and opportunities, and record mitigation activities in risk register Ensure expected accuracy range of operating cost estimate is in range of: <ul style="list-style-type: none"> ▪ Low: -10% to -20% ▪ High: +10% to +30%
FEL3 Activities	Develop operating cost estimate, for designated production period, including any anticipated changes in consumables

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	<p>Provide fixed and variable operating costs, based on operating parameters defined in study, using vendor data, firm quotes, estimated consumptions, and unit rates</p> <p>In basis of estimate document, summarize unit costs, exchange rates, growth provisions, escalation, and other variables to define operating cost</p> <p>Conduct quantitative risk analysis on operating costs to determine contingency; identify risks and opportunities, and record mitigation activities in risk register</p> <p>Ensure expected accuracy range of the operating cost estimate is in range of:</p> <ul style="list-style-type: none"> ▪ Low: -5% to -15% ▪ High: +5% to +15%
Project Input Area	10. Health, Safety, Environment, Community (HSEC) and Sustainability
Activity or Scope Item	<p>Define:</p> <ul style="list-style-type: none"> ▪ data and analysis outcomes to enable preparation of environmental and social impact assessment (ESIA) ▪ ESIA statement ▪ HSEC and sustainability policies for project ▪ key performance indicators and design criteria for environmental sustainability and community interface outcomes and performance ▪ status of permitting process and outcomes that drive project definition ▪ environmental sustainability and community interface risks and opportunities included in risks and opportunities register <p>Define procedures and management and monitoring plans that pertain to HSEC, to be adopted in project construction and operation, including:</p> <ul style="list-style-type: none"> ▪ HSEC monitoring plan ▪ project closure plan ▪ stakeholder mapping and planned engagement ▪ appropriate signed understandings and benefit agreements with communities
FEL1 Activities	<p>Prepare desktop study of potential environmental impacts to identify process and fatal flaws per option</p> <p>Set project objectives, which include HSEC and sustainability key performance indicators</p> <p>Establish high-level HSEC and sustainability policies for project</p> <p>Map stakeholders</p> <p>Start collecting baseline environmental data</p>
FEL2 Activities	<p>Initiate and build environmental and community impact field-data collection protocols</p> <p>Define standards and criteria to be adopted for project development</p> <p>Define all waste streams and discharges, and align them with process definition</p> <p>Clearly define stakeholder impacts of project implementation, and begin public consultation</p>

	<p>Firm up permitting processes, requirements, and timelines</p> <p>Draft definition of health and safety regulations and requirements</p> <p>Draft local labour analysis and influx management plan</p> <p>Start to negotiate memorandum of understanding with impacted communities</p>
FEL3 Activities	<p>Finalize ESIA and submit for approval to governing authority to grant environmental project certificate(s)</p> <p>Make timely applications and secure required permits</p> <p>Define high-level environmental management plan</p> <p>Continue public participation and finalize influx management plan</p> <p>Have in place benefit agreements with communities</p>
Project Input Area	11. Project Implementation Plan (PIP)
Activity or Scope Item	<p>Define project definition and implementation strategy, including:</p> <ul style="list-style-type: none"> ▪ project overview with context and location ▪ scope of services to be provided to manage project ▪ project organization chart ▪ scope of facilities detailed sufficiently to manage scope change (project design basis [PDB]) ▪ battery limits ▪ project delivery strategies ▪ authorities and delegations for both owner and EPCM/EPC contractor
FEL1 Activities	
FEL2 Activities	<p>Decide on project definition, implementation strategy, and approach for PIP</p> <p>Define project organization</p> <p>Set WBS area and sub-area</p> <p>Define contracting and packaging strategy for major contracts and equipment</p> <p>Make PIP generally available in preliminary form</p> <p>Populate PIP with summary data produced from study</p> <p>Start detailed PDB</p>
FEL3 Activities	<p>Fully develop and detail PIP and get owner approval</p> <p>Review completeness of PIP</p> <p>Finalize baseline, namely:</p> <ul style="list-style-type: none"> ▪ PDB final ▪ WBSs defined ▪ project schedule mapped to WBS ▪ capital cost estimate finalized ▪ procurement and contracting plan finalized ▪ project engineering team organization final