FRONT END LOADING (FEL)
ACCORDING TO IPA

A. What is IPA?

Independent Project Analysis Inc. (IPA), based in Ashburn, Virginia, provides analysis of projects to assess the status of the projects and to identify areas of concern which may require attention. A historical perspective is brought to bear on project management issues by identifying how decisions of other companies in similar situations and projects have worked out.

Prior to 2010, IPA database contained over 4000 project plants including over 500 service / infra-structure (off-site type) projects, 80 plus power plants and over 100 in the mega project category. IPA now has over 16,000 projects of all types and sizes in their current database.

Some of the companies which are part of the IPA database include:

EPC Companies	Oil & Gas / Refinery	Petro Chemicals / Others
Agra Simons	BP	Dow Chemical
Bechtel	Chevron	Dupont
Brown & Root	Conoco	FMC Corp
Fluor Daniel	Exxon / Mobil	Honeywell
Foster Wheeler	Husky	Nova Chemicals
Jacobs	Marathon Oil	Union Carbide
Koch	Phillips Petroleum	
M. W. Kellogg	Shell	
Stone & Webster	Suncor	
	Syncrude	
	Texaco	

Key project outcomes are predicted in the following areas:

- The level of project definition (or Front End Loading)
- The Value Improving Practices employed to date
- The completeness of the Project Execution Plan
- The overall project costs
- The capital cost contingency allowance
- The time required for engineering in relation to construction
- The time required for construction
- These outcomes will assess whether the expected cost, schedule and performance results for the project are realistic, identify the underlying sources of risk, and determine whether best industry practices have been followed.

B. Definitions of FEL

1. FEL is a process that draws together an organization's financial resources, facilities, people and organizations to translate business and technological opportunities into capital products. It must ensure at its conclusion that the **project meets its business objectives.** It aligns the people to the defined scope and execution plans so that costly changes in the later phases of the project are minimized.

2. FEL is a process that will define the project in sufficient detail that changes in the production engineering, construction and start-up phases will be minimized.

3. Key products of the FEL phase include:

   - Engineering documents such as PFD's, P&ID's, plot plans, heat and material balances single line electrical and major equipment specifications.
   - Strategy for executing the project (including resources based schedules).
   - A cost estimate typically perhaps to the ±10% range (but more likely at the ±20% range).
   - Alignment and agreement by all corporate functions and stakeholders regarding the project's objective and scope.

4. To repeat, the purpose of front end loading process is to secure a detailed definition of a project's scope (in terms of the detailed design basis, cost estimate and schedule) needed to meet the business objectives for the capital investment intended.

5. FEL is a value-added process that defines quality, detail design basis, cost estimate, schedule, project execution plan and strategy for authorization.

6. FEL includes the following principles:

   - The business drivers must be the primary ones for capital project investment.
   - Teams are to be multi-functional and fully qualified
   - People with the necessary skills needed and experience must be involved
   - Key members must have the authority to make decisions
   - Roles, responsibilities, expectations must be defined
   - To improve productivity, the most competitive available technology is to be used
   - Eliminate non-income producing investment by applying value improving practices (eg. process simplification, value engineering, constructability, safety reviews)
   - Complete FEL with full participation of all the stakeholders who will be committed to a no change philosophy once the process designs are accepted and frozen
   - Continuity of key members must be maintained throughout the FEL work phases

7. <u>Typical FEL- 1 Stage (Business Planning - Project Business Case)</u>

   - Leader is generally the business manager
   - Equivalent to a Scoping phase to confirm a viable business case to consider the project
   - Most attractive alternative selected in terms of technology and site location
   - Issues addressed include: market analysis, environmental, regulatory, technology, conceptual and economics (ROI)
   - Engineering is conceptual to allow for a ±30% cost estimate to support "Go - No Go"
   - Engineering effort at this stage is about 1% of total

8. Typical FEL- 2 Stage (Facility Planning - Finalize Project / Process Concepts)

- Normally, this stage is completed to support the authorization to proceed
- Equivalent to the Design Basis Memorandum (DBM) or Pre-Front End Engineering Design (Pre-FEED)
- Refinement of the chosen technology and basic process designs (PFD's)
- Preliminary project execution plan
- Issues addressed include: process designs, scope definition, hazard reviews, site conditions, initial equipment layout and health/safety/environment/regulatory criteria
- Cost estimate at ±20% accuracy
- Project team cross-functional and process oriented team
- Value improving practices (process simplification, reliability, design to capacity etc.)
- Engineering at about 5% of total
- Commitment to purchase long lead equipment

9. Typical FEL- 3 Stage (Project Planning - Detailed Engineering & Project Execution Plan)

- Equivalent to the Engineering Design Specification (EDS) phase or Front End Engineering Design (FEED)
- Continue designs to support cost estimate to ±10-15% accuracy for Project Authorization
- Engineering should be about 25% of total
- Finalize and issue P&ID's
- Conduct HAZOP reviews
- Reviews such as value engineering, constructability, quality standards, etc.
- Value Improving Practices (VIP's)
- Comprehensive Project Execution Plan including Procurement and Construction Plans
- Formal risk analysis on cost estimate
- Complete a firm detailed design basis for the project including PFD's, P&ID's, and plot plans, etc.
- Strategy developed for implementing all remaining phases of the project

10. Project Authorization

- Upon completion of FEL - 3, the cost estimate will be submitted for approval of the funding requirements and project authorization to proceed.

11. Project Implementation

- Akin to the Detailed Engineering phase to complete the engineering and procurement deliverables to support construction
- This phase includes construction mobilization and work execution

12. Start-up and Operation

- At Mechanical Completion of the construction work
- Includes pre-commissioning, start-up and commissioning to project completion and turnover

C. The FEL Index (Score)

1. FEL proceeds and is not finished until a full design basis package is completed. FEL includes project definition and process design. The final score is recorded typically before Project Authorization at the completion of the FEL- 3 Stage.

2. The FEL Index score ranges are as follows:
    - 3.0 – 4.75 Best Practical
    - 4.8 – 5.75 Good
    - 5.8 – 6.75 Fair
    - 6.8 – 7.75 Poor
    - 7.8 – 9.1 Considered only as screening study
    - 9.2 – 12.0 Worst score

3. The "Best Practical" level at FEL- 2 is only between 7.3 to 7.7 (poor) due to the early development of the designs and planning. The IPA industry average is only 8.1 (screening study)

4. The "Best Practical" level at FEL- 3 at Project Authorization is 4.0 to 4.75. 3.0 is the absolute best score, but this requires engineering to be 70% complete. More typically, engineering completeness at funding authorization would be 20-30% (but with good participation and buy-in of all participants). The industry average for process related projects at Project Authorization is rated only "fair" at 6.0.

5. FEL Index is composed of three equally weighted factors:

- The completeness of work on site related items and the site factor
    - Soils and hydrological work
    - Plot plans
    - Site specific health and requirements
    - Site specific environmental and regulatory requirements
- Status of project execution planning
    - Engineering scope definition
    - Use of Value Improving Practices
    - Proper resources to meet objectives
- Status of project engineering for the facility
    - Executed with minimal changes

6. Plot Plans
    - The actual equipment to be used and laid out. Planning studies done and deemed definitive when the plot plans are approved by the Owners.

    Soils & Hydrology
    - Amount of data available about the soil integrity, contamination, load bearing capacity and presence of the underground obstructions.

    Permitting Requirements
    - Factor rated preliminary if all known regulatory and permitting requirements are addressed and recorded.

Health & Safety Requirements

- Factor deemed preliminary if only preliminary HAZOP's (what if scenarios) conducted on PFD's. Definitive and formal HAZOP's done on advanced P&ID's and detailed equipment layouts.

7. <u>Project Execution Planning</u>

   - Composition of the full team including roles and responsibility
   - Details of the contracting strategy planned
   - Development of detailed and integrated project schedule, resource loaded, and incorporates the effects of equipment delivery dates, interferences, resource loading turnover and commissioning sequences for start-up.

8. <u>Engineering Design Factor</u>

   Characterized by the level of total engineering effort completed at authorization plus the amount of Owner/Operator input into the design. If the input is not available, there is an increased potential for design changes, which leads to cost growth, schedule slip and possible performance reduction.

D. <u>Value Improving Practices VIP's</u>

1. VIP's are techniques and tools aimed at elimination of waste, reduction of investment (ie. costs) and reduction of non-value added activities. They improve overall capital productivity. If done at the right time and with optimal effectiveness, they can reduce overall costs by about 10%.

2. Successful VIP application requires a formal disciplined approach. It must be scheduled and resourced very early in a project's life. To have maximum effect on project costs, they need to be implemented at the optimal time. Adequate resources must be set aside and the activities must be done thoroughly. Implementation of the VIP process at the wrong time will create more rework which will negatively impact cost and schedule.

3. When capital expenditure is the preferred alternative versus other strategies to avoid such expenditures, consideration should be given to:

   - Use of vendor standard hardware
   - Less redundancy and back-up systems/controls
   - Design plants to capacity with minimal or no pre-investment
   - Use more industry standard designs and specifications
   - Avoid too much flexibility
   - Less operational platforms and "nice-to-have" additions
   - Design facilities with less space
   - Localized MCC's next to equipment
   - Fewer buildings

4. Strategies to avoid capital expenditure include:

   - Eliminate the source of waste instead of building facilities to treat waste

- Buy the product instead of making it
- Lease the chemicals and equipment
- Have contractors supply the services
- Training and accountability instead of fully automating the process operation

5. VIP's will increase the value of the designed facilities by reducing the non-critical scope items, increasing reliability, simplifying the process, improving the technology and hardware, and facilitating the project execution.

E. Categories of VIP's

1. There are twelve (12) categories of Value Improving Practices listed by IPA. Typically, a process type project employs only 24% of the VIP's. For utilities and off-sites type of work, this drops to only 22%. So there is room to make significant improvements in project execution over the industry norm.

2. The IPA Audit looks for the rigorous application of VIP's. To support a best practical score, 40-60% of the VIP's are expected to be implemented.

3. The following seven (7) are Process related VIP's which should be thoroughly implemented early in the FEL- 2 stage:

    - **Technology Selection** – To assess whether the best technology has been selected over all options available, ie. the most competitive available technology.

    - **Process Simplification** - A disciplined analytical method, combining or making unnecessary one or more chemical or physical processing steps, eg. eliminate heating then cooling simultaneously, or concentration then dilution, etc.

    - **Classes of Plant Quality** - Establishes the necessary quality facility to meet the business goals. Used to determine design allowances, redundancy, sparing philosophy and room for expansion.

    - **Design To Capacity** - Assessing the need for "safety factors" to be built into equipment for future production increases.

    - **Process Reliability Modeling** - Or reliability simulation to determine the most economical sizing, spacing and storage conditions that meet operability goals while minimizing cost.

    - **Waste Minimization** - To implement the designs to minimize the production of waste products.

    - **Energy Optimization** - Optimizing the life cycle costs by examining power and heating requirements for a particular process.

4. Process Simplification

Applied at the 10-15% design complete stage and focused on issues on process systems. Success yields approximately 10% reduction in investment costs by identifying new technology opportunities or capital avoidance strategies using:

- Value Analysis
  What processes add value and which do not.
  - Eg. any hold-up or storage where no chemical or physical change occurs
  - Most material handling
  - Tasks that do (heating) and then undo (cooling) - let down and then pressurize

- Quality and Yield Analysis
  Examines yield losses and product quality and what customers will buy.

- Product Sequence/Transition Analysis
  Examines the suitability of the present process for mix of the products produced. Includes:
  - Pattern Analysis - array and volumes of products produced
  - Inventory Analysis - type and suitability of inventory
  - Equipment Analysis - product life cycles and reliability
  - Cost/Time Analysis - rate which cost is added to the process
  - Process Control Analysis - avoidance of in-process storage, minimize cycle times and minimize flexibility

5. The Next Two VIP's Involve the Owner's Operations, Maintenance and Safety Personnel:

Customized Standards & Specification
"Fit for Purpose" - Related to operating efficiency, product quality, maintenance and safety. Elimination of specific clauses in codes, specifications and standards that exceed the actual needs of the facility being designed. Eliminate "gold plating".

Predictive Maintenance
Need for equipment with moving parts to be monitored and repairs to be made before failure.

6. The Last Three (3) VIP's Include:

Traditional Value Engineering (VE)
Identifies "discretionary elements" (hardware, materials etc.) which may be eliminated without affecting the project objective and on improving life cycle costs. Eliminating or modifying items that do not add value to the business needs. VE is generally conducted at the 20-35% design complete stage and when successful, can achieve another 10% reduction in investment costs. Most projects over $100M will have a VE analysis facilitated by specialists.

Constructability Reviews
Identify ways to reduce costs or save time during the construction phase.

Use of 3D CAD
Extensive use of 3D CAD during FEL and detailed engineering. "Clash checks" and visual aids by the model for construction and operation reviews.