Process Development

The product of a development effort is to deliver the information needed to commercialize a product. The Process development effort should run first prior to and then continue in parallel to the Front End Loading work flow to deliver a Basis of Design (BOD) document that includes reports, spreadsheets, and drawings that cover the following efforts. Many times the Process Development effort is documented in a Process Work Up document. This document becomes a subset of the information that makes up the BOD. A Process Work UP unusually includes the following information:

1. Setup and guide feedstock characterization and qualification of suppliers.
2. Analyze, develop options, and assess research using Six Sigma experimental methods to recommend path forward.
3. Scope and define a pilot system that will deliver critical parameter definition validating the feedstock to fuel conversion process.
4. Programmed documentation of the development effort including reasoning and decision-making pathways presenting technical options versus desired economic performance targets.
5. Evaluation and identification of best in class scalable methods and operational application of developed pilot scale technology. Using the pilot system, define the economic, schedule, and technical application reality of constructing a safe, operable, and maintainable full scale system.
6. Using bench scale technology bases translating through pilot scale experimentation, demonstrate scaling factor characterization and validation of basis modeling to verify predictable performance expectations at increased plant scale throughput.
7. Equipment design detail evaluation and application to complex material handling and conversion processes.
8. System integration of physical equipment, information, and control systems which yield operational performance data that results not only in desired product quality control, but also enables the evaluation of product development possibilities to meet emerging market conditions for increased high value product sets.

The process development effort in conjunction with the preliminary project engineering should deliver a permitting strategy that includes all aspects of pilot permitting operations with the intent to use that as the road map full scale plant permitting. The permit process is usually the critical path on any pilot scale development and full scale installation for technologies involved in the proposed system.

Basis of Design

A Basis of Design (BOD) is the descriptive details upon which detail design will deliver on the process development efforts that produce the data and information that allow the selection of unit operation equipment, operating parameters, and both capital and operational economics. The products from this effort is usually described in the third stage of a Front End Loading workflow or an FEL3:

1. Complete PFD's (Process Flow Diagrams).
2. A process configuration based on complete PFD's.
3. Material and energy balances based on current modeled information that show all streams and critical control mechanisms.
4. The details the process development experiments that would validate these expectations need to be included as information becomes available.
5. The material and energy balances as effected by performance expectation, validation, and experimentation resulting in data from scalable and integrated proof of principle runs.
6. The equipment list that includes all the major process equipment sized to reflect the material balances with the information generated in the process development effort from a set of vendors most suited to provide equipment to execute a full scale project based on the technology. This is the vendor based value engineering that optimizes equipment selection based on the owner's process development effort.
7. An equipment list that includes basic descriptions adequate for budget pricing.
8. Identification of all stream characterization needs and, as a minimum, propose viable dispositions for each value stream and the methods and/or strategies for mitigating any remaining waste streams to fully account for all mass and energy moving through the boundary limits of the process.
9. Identify the required utilities and provide approximate consumptions and optimization analysis.
10. The instrumentation and control philosophy including the type of measurement devices that must be specified for service in the application.
11. All the required building design bases with brief descriptions and preliminary sizes and an analysis of the options of construction and permitting approaches for the buildings.
12. Preliminary layouts which will include all equipment and buildings.

13. An analysis of the concepts of control, staffing, access, and material flow that must be taken into account throughout the boundary limits of the system to insure the expected system performance and associated operation expense expectations are met.
    Identify and verify the operator interface and system control and data acquisition (SCADA) concepts with preliminary information flow diagrams that will include on line critical control measurements coupled with the off line analytical testing and information needs to produce the operational and financial performance information required for the plant.

Process Development Project Steps

1. Define the characteristic variable
2. Develop the needed test method
3. Valid the response
4. Determine the factors to explore
5. Establish the factor levels needed
6. Establish scale A baseline
7. Screen, model, optimize
8. Analyze manufacturability
9. Make data based decisions
10. Repeat and refine

Process Development Play Book

A. Program Information
    a. Statement of Business Purpose
    b. Strengths, Weaknesses, Objects and Targets (SWOT)
    c. Schedule Milestones
    d. Cost Parameters
B. Product Information
    a. Product Chemistry and Feasibility
    b. Material Balance (MFD)
    c. Raw Material Information
    d. Safety Information
C. Measurements and Methods
    a. Product Specifications
    b. Reagent Specifications
    c. Utility Specifications
    d. Testing, Sampling and Statistical Validation Requirements
    e. Test Methods
D. Process Information
    a. Process Description

        a. General Processing Steps
        b. Order of Operations
        c. Sequential System Inputs and Outputs (SIPOC)
        d. Critical Control Points
        e. Safety Limits
    b. Equipment Information
    c. Scale-Up
        a. Experience versus Model
        b. Scale Up Basis of Design (BOD)
    d. Technical Feasibility and Risks
    e. Process Studies
E. Manufacturing Information
    a. Production Rate
    b. Cross Contamination Considerations
    c. Cold Start, Warm Start Procedures
    d. Normal Stop, Emergency Stop, Warm Stop Procedures
    e. Reclaim Blending Procedures
    f. Out of Spec Rework Procedures
    g. Troubleshooting Guide
    h. Failure and Emergency Recovery Procedures
    i. Hazards, Regulatory, Compliance and Operational Safety
F. General Reference
    a. PFD
    b. P&ID
    c. General Arrangements
    d. Lab Notebook
    e. Standards Table