

Guidelines and Rationale for COGs/ROI Calculations in Process-based Proposals to the IN 21st Century Fund

In order for reviewers to properly evaluate a process-based proposal, the text of the proposal should include either a preliminary cost-of-goods (COGs) analysis or a preliminary return-on-investment (ROI) analysis. These early-stage analyses aim for accuracy within the 25-40% range and are based on standard short-cut, quick estimation techniques. Experience at the Fund over the past several years has shown that process-based proposals that lack these sorts of economic analyses do not fare well in the review process.

A process-based proposal is one in which one or more product streams are to be produced for sale and/or a waste stream is to be remediated. Examples include processes which might produce fuel grade ethanol via fermentation of crop waste, biodiesel from purified waste cooking oil, a nutraceutical from a genetically modified crop, or biogas from pyrolyzed animal wastes. These processes will typically consist of multiple interconnected unit operations – mixers, reactors, separators, heat exchangers etc. – that may be operated in batch, continuous or semi-continuous modes to produce the product stream or remediate the waste stream. Process-based proposals to the Fund will typically contain requests for funding to equip and operate a pilot-scale process, smaller than the intended commercial scale process, but large enough to demonstrate the technical feasibility of the entire integrated process and to generate information to support more detailed (and more accurate) economic analyses making the case for subsequent advancement of the project to commercial scales. Presuming that the technical feasibilities of the individual unit operations have been demonstrated at laboratory bench scales – by the proposers or within the technical literature – and are documented within the proposal, the decision to move forward to pilot-scale operations hinges to a large extent on whether or not the preliminary economics of the process make sense.

The COGs analysis is useful for processes aimed at producing a specific product: here the idea is to estimate the cost to produce a given product per unit volume or mass considering the fixed capital, raw material and direct expense costs. If the COGs is significantly less than the market prices of anticipated competing courses for the product, the case can be made that the proposed process should be profitable and that the investment to assemble a pilot scale process is warranted. The ROI analysis goes further than the COGs analysis and is useful for both product production and waste remediation scenarios: the idea is to compute the rate of return on the investment required to set up and operate the process and includes the expenses associated with research, land acquisition, construction, capital equipment acquisition and depreciation, raw materials, operation and taxes and the income associated with product sales. The ROI analysis may also incorporate additional factors such as tax credits, subsidies, cap-and-trade allowances and so on. If the return on investment exceeds some reasonable threshold value, say 10 to 15%, the case can be made that it makes economic sense to proceed with the project as there is a likelihood that the investment in the process will provide a better rate of return than could be had via a similarly-sized investment with financial institutions.

Both the COGs and ROI analysis are underpinned by several pieces of information that build upon on another:

1. an overall process flow-sheet depicting the unit operations, typically corresponding to the individual pieces of equipment in the process, to be used in the process and their interconnections;
2. for a given basis of operation (e.g. flow rate or amount of a product to be produced or of a waste to be remediated), complete material balances describing amounts and/or flow rates of each component in each stream entering and exiting each unit operation for a given basis of operation, here judicious use of component lumping may be made;
3. raw material needs corresponding to the material balances;
4. for the same basis of operation, an energy balance around each unit operation detailing the energy consumed or generated in each;
5. selection and sizing of equipment for each unit operation based on the material and energy balances
6. calculation of utility requirements (e.g. steam, cooling water, electricity) corresponding to the energy balances for each piece of equipment;

This information should be provided in the proposal to support the COGs or ROI estimates.

COGs and ROI estimates can be built with short-cut cost estimation techniques that are based on the equipment types, material amounts/flow rates, equipment sizes and utility needs. These types of calculations and short-cut procedures may be found with helpful reference data and examples in several sources, including Plant Design and Economics for Chemical Engineers by Peters and Timmerhaus (McGraw-Hill), Systematic Methods of Chemical Process Design by Biegler, Grossmann and Westerberg (Prentice Hall) and Jensen's Cost and Optimization Engineering by Humphreys (McGraw-Hill).

These calculations and types of analyses fall within the domain of process engineering and are typically conducted by chemical and petroleum engineers, and to some extent by civil and mechanical engineers as well. If the proposing team does not include expertise in one or more of these domains, the proposers are strongly urged to work with either an IN-based process engineering design firm or with faculty at an IN-based engineering college so that a credible analysis may be mounted.