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ESTIMATING COSTS OF PROCESSES DEVELOPED THROUGH UTILIZATION RESEARCH IN THE U.S. DEPARTMENT OF AGRICULTURE

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ESTIMATING COSTS OF PROCESSES DEVELOPED THROUGH UTILIZATION RESEARCH IN THE U.S. DEPARTMENT OF AGRICULTURE[1,2]

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The authors of this paper comprise a two-man Commercial Feasibility Group in the Eastern Marketing and Nutrition Research Division of the Agricultural Research Service of the U.S. Department of Agriculture. I want to describe to you the work we perform in the areas of process evaluation, cost estimating, and determining the economic feasibility of new products and processes; and the methods we employ in carrying out this work.

First, I would like to give you a background picture of the framework within which we operate. The physical facilities at our location, which is in suburban Philadelphia, were built in 1940 and have been operated as a research laboratory continuously since that time. At present this research facility has a total staff of some 390 people, of whom approximately 245 are classed as professionals and the rest are support personnel. The facility is subdivided into a number of research units, each called a Laboratory.

The authors are in the Engineering and Development Laboratory, which is staffed chiefly with chemical engineers. The remaining Laboratories are staffed chiefly with chemists, and, in general, each one works in a specific commodity area, such as dairy products, animal fats, etc. The research facility administers and conducts a program of both basic and applied research

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[2]Paper to be published in "1971 Transactions of the American Association of Cost Engineers".

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which is aimed at developing new and improved products and processing technology utilizing farm commodities. The research is chiefly of a chemical, chemical engineering and food engineering nature. Our research developments are widely publicized through the issuance of news releases and technical bulletins, through publication in scientific, technical and trade journals and through the issuance of patents. This publicizing is done with the hope and the expectation that the more promising of our research developments will be adopted and put into commercial use by industry. I might say that we have achieved notable success in a number of cases. For example, "instant" mashed potatoes, in flake form, was a development of our research facility, and now has commercial production of some 125-150 million lbs. a year.

To encourage commercialization of our research developments by interested industrial companies, we cooperate fully in furnishing them with the technological information and know-how that we have developed, including, in many cases, the projected costs of operation on a commercial scale. The authors, comprising a two-man Commercial Feasibility Group, have the responsibility of preparing the estimates of projected commercial costs on our research developments.

You may have become aware by now that the authors' position and function, while similar in many respects to that of cost engineers in industry, also differs in some important aspects. In industry, cost estimates and projections are highly confidential; with us, they are intended, at least the final versions, to be publicized widely and freely to all comers. Secondly, unlike an industrial company, the U.S. Department of Agriculture does not build a manufacturing facility for any of the products or processes it develops. This means that the authors have very little opportunity to check the degree of accuracy of their cost estimates against the actual realized cost figures for a manufacturing plant that is subsequently built and operated. Thus, we are able to assess the accuracy of our results only indirectly. We do get some confirmations. For example, on a dehydrated carrot dice product, our estimate showed a factory selling price of about 53¢ a lb. A commercial company subsequently came on the market with this product priced at 55¢ a lb. We felt this constituted a pretty good confirmation of our figures.

Again, we also have no "data bank" or back-log of company cost records to make use of in our estimates. People well versed in cost estimation say that one of the best sources of cost data to use in an estimate is company records on previously-completed projects. In our case, these cost figures just do not exist.

So you see we do labor under some handicaps. But our position does have a few compensations. We aren't likely to find ourselves in the situation where our employer, having built a plant on the basis of our favorable cost estimate, finds that the operation has turned out to be strictly a money-loser, whereupon we wind up in the doghouse or worse.

One other point. A two-man economic evaluation staff is a small one. Considering the fairly wide range of activities which we undertake, we have not had the opportunity to become experts in any one area, such as, for example, capital cost estimation, or operating cost estimation, or profitability analysis, or market forecasting, although we do engage in all of these functions plus others.

Let me describe the procedure we follow in a typical economic evaluation for a new product. As an example of a completed estimate, I have passed out a reprint of an article that we had published recently in "Food Product Development" magazine[3].

An assignment to prepare a cost estimate generally reaches us with one of two backgrounds: (1) it is being studied in the Engineering and Development Laboratory by chemical engineers, and usually with some pilot-plant data accumulated, or (2) it has been developed strictly on the laboratory scale by one of the commodity research groups at our facility, and a preliminary economic feasibility study is desired before going ahead with further development work. In the former case, much of the data required for reliable scale-up and cost estimation are known. In the latter case, where these data are lacking, more assumptions must be made by the estimator, and consequently, the range of uncertainty in the estimate will be wider. However, in either case the same general principles of procedure are followed. Estimates that we publish are usually based on extensive pilot-plant studies.

The first step in preparing the estimate is to determine the exact technology of the process: what process steps are to be employed, in what sequence, and what conditions will be employed for each step. For a chemical reaction, the conditions would include reaction time, temperature, pressure, degree of agitation, proportion of reactants, etc. This nailing-down of the process must be done in close cooperation with the research chemists or engineers on the project. Tied in with this step is the drawing up of a flow sheet which accurately depicts the processing steps and their sequence.

A vital question at this point is the scale of operation or the productive capacity of the plant to be estimated on. If the product is

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[3] "Explosion-Puffed Apples are Commercially Feasible", by R. L. Stabile, V. A. Turkot, N. H. Eisenhardt and J. Cording, Jr., Food Product Development, 4, No. 8, pp. 80-88, December 1970-January 1971. A copy of this reprint is available by writing to the authors.

a new one, a projection of annual sales demand must be made. If the uses to which the product can be put are known, an estimate of annual sales can be made from the size of the current market for similar existing products now being sold. Sometimes, particularly when the request for cost work comes from one of our chemical laboratories, the uses to which the new product can be put are not yet well known. In these cases, one has to make some sort of educated guess as to a suitable plant capacity on which to base the estimate.

Also, fairly early in the estimate, some "basic assumptions" or "ground rules", if you will, for the specific estimate are drawn up. These might include, typically, whether the plant is to be "grass-roots" or an addition to an existing plant; the length of the plant operating season, particularly for the processing of agricultural commodities; general geographic area of plant location; and other similar factors.

Having determined the technology, drawn up the flow sheet, determined the scale of operations and made the basic assumptions, the estimators can now draw up a material balance and designate hourly rates for the various process flow streams.

Next, the selection of equipment to conduct the various processing steps must be made. The cost estimators must function here to some extent as process engineers and design engineers. While we are guided by what has been used in laboratory or pilot plant studies, still, as most of you know, operations on the large scale are often best performed somewhat differently. At any rate equipment requirements are determined, specific types of equipment are selected, and scale-up to plant size from the lab or pilot plant equipment is done. The scale-up procedures used are, of course, fairly well known and I need not dwell on them.

Next, the equipment is costed. Costs can be obtained from the literature, including sources such as those listed at the end of this paper, references 1 through 8. Updating of literature costs to the present is done by use of cost indexes such as the Marshall and Stevens Index published in Chemical Engineering magazine. In many cases, vendors' quotes can readily be obtained. For preliminary cost estimation purposes, these need not be as exact as quotes for purchase. Quotes are preferred to literature figures since they are up-to-date.

After all major equipment has been tabulated and costed, estimation of the total capital cost can be made. Here a standard form is used. To estimate capital costs, other than the cost of processing equipment, we do not use detailed material and labor estimates. Costs of items such as equipment erection, piping, instrumentation, etc. are estimated as percentage factors of purchased equipment, based on percentages found in various literature references, and also in part based on the estimators' knowledge of the process technology involved.

Next we proceed to the estimation of operating costs. Here again we use a standard form, which was developed by predecessors of ours in the cost estimation function at our Laboratory. While the details of this form may differ from those used by others to estimate manufacturing costs, essentially the same cost items are included as in other published methods of estimating operating costs that I have seen. We generally itemize the costs per day of plant operation, and usually also per unit of plant output, such as per pound of product. It is also feasible to compute operating costs on the annual basis. In fact, some of the cost items are generally computed first on the annual basis and then converted to the daily basis, such as insurance, real estate taxes, maintenance and repair, and depreciation. Care must be taken when converting to use as the divisor or multiplier the number of actual working days per year assumed for the process.

On the operating cost sheet, we first compute and sum up all the costs of making and selling the product. To arrive at a factory selling price, one of two methods is used. If the product is one that is comparable to existing ones already on the market, such as for example, a new source of animal feed, then its most likely selling price can be estimated from the current market prices of comparable products. By comparing this likely selling price with the total estimated costs of making and selling the product, one can determine whether the project would be likely to yield an adequate rate of return on the invested capital.

If the product is a new one not closely comparable to an existing product, we take our estimated total cost to make and sell, and add on a net income figure corresponding to a minimum acceptable rate of return on the invested capital. This rate is not a fixed one; we have been using 12 to 15% for food products. The net return on investment for most companies in the food processing industry runs at this level or lower. We also add a figure for taxes on net income,usually at the 50% rate; that is, taxes on income are equal in amount to net income after taxes. Adding these two items to all the previously estimated costs to make and sell gives us a factory selling price.

Working capital is usually estimated in conjunction with the operating cost sheet. One simple method we sometimes employ is to use one to two months'sales as the required working capital. However, the nature of the business will affect the average annual amount of working capital needed, particularly in a seasonal industry such as fruit and vegetable processing. Since working capital is accounted for mainly as inventories and accounts receivable, less accounts payable, these three items can be approximated without too much difficulty, and their algebraic sum used as the working capital.

We also have a more or less standard form for a brief financial analysis, which summarizes the important dollar items on an annual basis and also computes the payout time.

In some cases a given new product is to be produced in an existing plant which also makes other products. In the example I have handed out (EXPLOSION-PUFFED APPLES ARE COMMERCIALLY FEASIBLE), the new product will be produced partly through use of new facilities and partly through shared use of existing facilities. The capital cost of all the new facilities is charged directly against the new product. For use of existing facilities, a charge which we have labelled as "rent" is computed and entered as an operating cost item. Development of this charge is itemized in Table IV in the handout.

In the publication on explosion-puffed apple pieces we have also shown a simple version of an "economic production chart" for the assumed plant. This is also known as a break-even or Rautenstrausch chart, and its preparation is described in the Cost Engineers' Textbook edited by F. C. Jelen (5). It shows graphically how costs and profits vary with annual production rate. We have also included a chart showing the variation of the selling price of the product over a range of costs for the raw material. This last chart covers one small aspect of sensitivity analysis.

Another aspect of our work is that the computer age has caught up with us, as it probably has also with many of you. One of our recent capital and operating cost estimates, a rather complicated one, we had done for us by the Icarus Corporation[4] of Silver Spring, Maryland, using their CØST computer program. The CØST program has the benefit of containing a large data bank of dollar cost figures for many different types of equipment. We estimate that use of this computer service, in this instance, saved us at least four weeks of time and several thousand dollars in estimators' salaries.

We have also investigated the possible use of several other commercially-available computer services for cost estimation. Some of these would appear to be applicable for our work, but so far we have not actually used any of these other than the Icarus program mentioned above.

We have also, ourselves, written recently a simple computer program which calculates fixed capital cost, working capital, daily operating costs, and the financial analysis. It does essentially via computer the same calculations which we perform by hand. So far we still use our hand method of calculation for some cases because it is more flexible, but we back it up with the computer estimate to check for discrepancies or errors. We have found some errors by such checking. However, we have found the computer program to be more advantageous when a number of versions of the cost estimate must be run through with different values for some of the inputs. Here the savings in time and effort over hand calculation, and the reduced likelihood of arithmetic errors, are significant.

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[4]Use of a Company or Product name by the Department does not imply approval or recommendation of the product to the exclusion of others which may also be suitable.

For those who are interested, a copy of our own computer program for calculating fixed capital costs, operating cost, working capital, and a financial analysis may be obtained without charge by writing to the authors.

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