## Abstract

This paper examines the economic impacts of energy production from food processing wastes, and the production of high value food derivatives from food processing made possible by such developments. Construction and operation phases of industrial development are analyzed by modifying conventional interindustry techniques substantially.

# ASSESSING THE REGIONAL ECONOMIC IMPACT OF NEW BIOMASS ENERGY DEVELOPMENT

by

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# ASSESSING THE REGIONAL ECONOMIC IMPACT OF NEW BIOMASS ENERGY DEVELOPMENT

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New industries producing energy from biomass have important implications for regional economic development, as well as for increased availability of domestic energy supplies. However, it is often difficult to apply standard methods of regional economic analysis in these situations because the development alternatives incorporate new production technologies. For example, when using interindustry analysis in estimating multiplier impacts, it is often assumed that the input requirements of the new industry are similar to those of an existing industrial sector. The impacts are easily calculated by assuming that the new industry's output is an addition to an existing sector's deliveries to final demand. These simplifying assumptions are unlikely to be an accurate reflection of the interindustry relationships fostered by the development of alternative energy industries. Because of major differences in production processes, the input requirements are likely to differ substantially from those in other energy sectors. Similarly, the new industry may purchase a different proportion of its inputs locally. It is difficult to know the proportions of new energy output delivered to final demand or substituted for current domestic production or imports into the region.

This paper investigates the extent to which these empirical difficulties can be mitigated when examining alternative energy developments. The success of this endeavor depends upon cost engineering and other data

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obtained through a multi-disciplinary research effort involving economists, food scientists and agricultural engineers at Cornell University (Kalter et al.). The information was essential in estimating input coefficients and understanding physical production interrelationships within regions. While this research focused on the commercial feasibility of a new regional ethanol industry based upon biomass feedstocks derived from a variety of food processing wastes, this paper examines the production of ethanol from cheese whey (an abundant by-product of cheese manufacturing in several regions of the United States). Whey, unlike many other agricultural waste products, contains adequate sugar to be economically attractive for possible conversion to energy products. Because its disposal is often costly or creates environmental problems, whey, as contrasted with corn, can be acquired at low cost. This could lead to the commercial feasibility of ethanol conversion facilities even in corn deficit regions and may permit the production of additional high value food derivatives by the dairy manufacturing industry.

ETHANOL MANUFACTURING FACILITIES

Regardless of where a new ethanol industry is developed, the investment decision is a private one. The size of the resulting production facilities depends on a number of physical and economic considerations; one of the most critical is feedstock availability. Based on current cheese whey production, several regions within New York State, for example, could support conversion facilities ranging in size from 1 to 5 million gallons of annual capacity. For purposes of illustration, this paper analyzes the introduction of a 2.5 million gallon conversion plant assumed to be located in Northern New York.

Biomass conversion facilities of this type produce two marketable products: ethanol and a high-mineral-medium-protein by-product, which can be used as animal feed. For a 2.5 million gallon facility, 6,250 tons of dry by-product are produced annually. In 1980, when the study was initiated, the wholesale price of ethanol in the East was estimated to be $1.35 per gallon. The wholesale price for the by-product was derived from a least-cost feed ration programming model and was estimated at $140 per ton. Based on these prices, the total value of combined output is $4,450,000 annually. The necessary capital and operating costs are based on detailed engineering designs, and are given by major category in the first two columns of Table 1.

Several regional industries would supply inputs to an ethanol facility while other inputs would be imported. In addition to providing feedstock, the cheese industry is assumed to alter its production processes to recover much of the protein contained in raw cheese whey prior to shipment to a conversion facility. Indeed a strong rationale for whey conversion is that it also provides an environmentally acceptable method of disposal for the lactose permeate remaining after deproteinization (Kalter et al.). To date, the waste disposal problem has inhibited the cheese industry's adoption of protein extraction technology. The protein concentrate recovered by the cheese industry is used as an ingredient in many processed foods, in bakery items, as a topping for cottage cheese and as a substitute for the more expensive non-fat dry milk. Approximately 9,100 tons of dry protein concentrate can be extracted from the whey needed by a 2.5 million gallon ethanol plant. In 1980, the value of annual production is estimated conservatively at $10,261,000 although changes in trade policy, price

Table 1

SUMMARY OF REQUIRED COSTS FOR ETHANOL PRODUCTION AND WHEY PROTEIN EXTRACTION FACILITIES[a]

| Category | Ethanol Facility (2.5 mm gal.) | | Modifications to Cheese Manufacturing Plants | |
|---|---|---|---|---|
| | Capital | Annual Operating | Capital | Annual Operating |
| Construction Materials Repair and Maintenance | $5,433,000 | $268,000 | | $236,000 |
| Coal (for process heat) | | 301,000 | | |
| Chemicals and Petroleum | | 148,000 | | |
| Machinery | 1,314,000 | 40,000 | $4,810,000 | |
| Other Manufacturing | 1,991,000 | 71,000 | | 1,656,000 |
| Transportation and Utilities | 124,000 | 522,000 | 49,000 | 994,000 |
| Wholesale and Retail Trade | | 78,000 | | 14,000 |
| Services | 953,000 | 127,000 | | 331,000 |
| Employee Compensation | | 695,000 | | 1,498,000 |
| Other Value Added | | 100,000 | | |
| Total | $9,815,000 | $2,350,000 | $4,859,000 | $4,729,000 |

Source: Kalter et al. 1980.

[a]1980 values, rounded to nearest $1000.

supports and market penetration could affect this value substantially. The resulting product value, plus the capital investment and purchased inputs necessary for its extraction (Table 1), suggest that the direct regional impacts of changes in dairy manufacturing are more important economically than those associated with the conversion facilities.

## APPLICATION OF INTERINDUSTRY ANALYSIS TO THE ETHANOL INDUSTRY

Several modifications to the conventional interindustry analysis are required to analyze this industrial development situation. First, one needs to consider explicitly the time stream over which impacts will occur, particularly to differentiate between a construction and a production phase. A second modification accommodates both the addition of a new industrial sector into the interindustry model and the possible adjustments to technical coefficients for existing sectors. Modifications of a similar nature are discussed conceptually in the context of agricultural development projects by Stripe et al.

The construction requirements by the dairy manufacturing sector and the new ethanol industry can be represented in an interindustry model by a change in investment final demand for the output of other regional industries. In order to analyze these potential impacts, the first step is to construct an interindustry model of the regional economy prior to any changes in the rate of capital investment. It must be recognized that the direct and indirect effects of this change in investment final demand are distributed throughout the construction period. As a result, these effects are distinct from those generated during the useful economic life of the new investment.

The analysis of the production operations phase is more complex. Before one can examine the impacts of changes in deliveries to final demand from the new investments, the structure of the regional interindustry table must be changed to reflect the introduction of a regional industry that currently does not exist. The introduction of a new sector implies that the interindustry model used to study the construction phase is no longer appropriate. The endogenous portion of the input-output model must be expanded by a new row and column, reflecting transactions among the new ethanol industry and the rest of the economy. Because the dimensions of the Leontief inverse change, the nature of the direct and indirect effects of final demand changes will be altered. To permit protein extraction, the model's technical coefficients for the cheese processing sector must be altered to reflect modifications in technology.

Input requirements for the ethanol industry (the construction of the new column) are easier to ascertain than the distribution of industry sales (the construction of the new row). When cost engineering estimates are available, the only remaining difficulty in constructing the column is determining the proportions of the inputs imported or purchased locally. Construction of the new row depends on assumptions regarding the distribution of products from ethanol production. Ethanol and its by-product can be marketed in several ways, and distributed to final and intermediate users in an infinite variety of ways. The conventional approach in interindustry analysis relies on an extreme assumption -- that all direct increases in output go to final demand. In the case of new alternative energy facilities, economic incentives may lead to import substitution by intermediate users within the region. By examining several hypothetical distributions, one can determine the sensitivity of the regional impacts to different market allocations.

## AN EMPIRICAL APPLICATION

As alluded to above, the empirical application used here for illustration involves the potential development of an ethanol industry in a four-county region of Northern New York. Given this setting, the interindustry relationships within the economy had to be estimated. This was accomplished by using a nonsurvey technique for developing regional interindustry tables (Boisvert and Bills). This technique relies on the most recent 496 sector national input-output table (U.S. Department of Commerce). Regional technical coefficients for sector aggregates are developed by weighting the national coefficients by regional employment shares calculated from unpublished employment securities data. A major advantage of this non-survey approach is the systematic identification of competitive and non-competitive imports to the region. Prior to incorporating the new ethanol sector into the model, 20 endogenous sectors were designed to correspond to major economic activities within the region as well as those sectors most directly affected by the development of this new industry (Batista et al.).

### Construction Phase Impacts

To estimate the regional impacts of the construction phase, the $14,674,000 of combined capital investment due to construction (as reported in Table 1) were treated as changes in investment final demand. Several items of specialized equipment could not be purchased locally, leading to a substantial import component ($5,723,000 or 39 percent) to the investment package. The resulting direct and indirect change in regional sales is estimated by premultiplying the remaining investment final demand vector (totaling $8,951,000) by the Leontief inverse. Employment and value-added impacts are estimated by premultiplying this sales vector by vectors of direct employment and value-added coefficients, respectively.

The combined direct plus indirect sales in all sectors from this new investment are estimated at $15,076,000, about 1.7 times the increase in regional investment final demand (Table 2). Because of leakages due to imports of major components, this total regional impact is only 3 percent above total capital costs. Based on the detailed engineering analysis, a two-year construction period would be reasonable and this impact would be distributed over the entire period. The data in table 2 assume an equal distribution. Thus, annual sales would increase by $7,538,000, 48 percent of which would be value added. Over 130 employees would be added to the regional workforce.

It is hardly surprising that major impacts would occur in manufacturing and construction. Just over 40 percent of the sales are in manufacturing, along with 35 percent of the increase in value added. Construction accounts for about 35 percent of both sales and value added increases.

Operation Phase

Although the economic impacts due to the industrial construction are important to the region, they are sustained only over a two-year period. The impacts from the operating phase are sustained over a much longer period. The annual operating expenses in Table 1 were used as the basis for modifying the cheese manufacturing sector and for constructing the new column for the new ethanol sector in the "operation phase" interindustry table. Approximately 23 percent of the value of the variable inputs in

Table 2

ANNUAL DIRECT AND INDIRECT CHANGES IN ECONOMIC ACTIVITY DUE TO DEVELOPMENT OF ETHANOL INDUSTRY IN NORTHERN NEW YORK

| Sector | Construction Phase[a] | | | Operation Phase[b] | | |
|---|---|---|---|---|---|---|
| | Sales | Value Added | Employment | Sales | Value Added | Employment |
| | ------thousands------ (1980 dollars) | | number | ----------thousands---------- (1980 dollars) | | number |
| Agriculture | $ 16 | $ 5 | c | $ 96 (96)[d] | $ 35 | 3 |
| Mining and Construction | 2,591 | 1,255 | 33 | 322 (38) | 158 | 40 |
| Food Manufacturing | 32 | 7 | c | 13,351 (100) | 2,869 | 78 |
| Other Manufacturing | 3,147 | 1,257 | 51 | 1,827 (82) | 731 | 31 |
| Transportation, Communication and Utilities | 439 | 256 | 6 | 1,133 (57) | 646 | 15 |
| Trade and Services | 1,313 | 843 | 43 | 1,977 (84) | 837 | 55 |
| Ethanol | - | - | - | 3,330 (0) | 2,079 | 45 |
| Total | $7,538 | $3,623 | 133 | $22,036 (79) | $7,355 | 267 |

[a]Approximately 39 percent of the investment final demand is assumed to be imported into the region. The impacts are calculated from the interindustry model prior to the introduction of the new industry and represent annual changes as though activity were distributed equally over the assumed two-year construction period (see Batista for details).

[b]These are annual impacts based on the interindustry model after the introduction of the new sector and modifications to the cheese manufacturing sector for protein extraction. The new output from both the ethanol sector and cheese processing are assumed to be delivered to final demand. Because the new protein output from cheese processing did not require additional milk purchases, the impacts due only to additional processing of the same values of milk were estimated using procedures from Blandford and Boisvert.

[c]Less than 0.5.

[d]This is the percentage of the impact due to the change in cheese manufacturing final demand.

ethanol production is assumed to be imported, while 34 percent is value added. The cheese manufacturing column was adjusted to reflect the new technology for protein extraction by adding the new expenditures to the original column of transactions, prior to recalculating technical coefficients. This procedure did not adequately account for the fact that this new joint product of cheese production requires no additional milk purchases from the dairy sector. Thus, in order to avoid a double counting of milk input, the impact of the new deliveries of cheese manufacturing products to final demand are net of direct and indirect purchases due to the milk embodied in cheese processing. The adjustment procedure, developed by Blandford and Boisvert, is one of isolating the processing component in food manufacturing.

Assuming that all ethanol production and protein concentrate are delivered to final demand ($13,636,000), and that the feed by-product is sold to the dairy industry, the total increase in annual sales is estimated at just over $22 million, 33 percent is in the form of value added. (By using half of the ethanol production to displace energy imports, the impact was reduced by about 6 percent.) As one would expect, the ethanol and food manufacturing sectors combined account for a high proportion of the increases in sales and value added, 76 percent and 67 percent, respectively (Table 2).

## CONCLUSIONS

This paper has demonstrated how detailed economic engineering data can be combined with interindustry analysis to estimate regional impacts of alternate energy developments. Although the case examined is a small scale project, it is particularly interesting in that it leads to changes in energy industry itself. Approximately 79 percent of the direct and indirect effects are due to changes in the cheese industry and ethanol production from cheese whey also resolves a waste disposal problem. Both factors could contribute importantly to the economic well being of a food processing sector in rural areas.

The analysis also generates information that is useful in evaluating the extent to which public investment or activity in support of the construction phase of a project is compatible with the operation phase. In many large scale development situations, for example, the level of economic activity surrounding construction is higher than that in the operation phase. As demonstrated by Smith et al., this can place a short-term burden on local resources and lead to inappropriate public investments, particularly those in support of the influx of new people during construction. While these considerations are less important for this relatively small scale investment project, a comparison of the impacts between the two phases suggests that such problems would be minimal even if the scale were much larger. Because ethanol production also facilitates changes in the dairy manufacturing sector, the annual impacts during operation are larger than for the construction phase. With the exception of manufacturing, employment in all major sectors is higher under the operation phase than the construction phase. Thus, careful planning should facilitate the transition from construction to operation.

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