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ECONOMIC EFFECTS OF MINNESOTA PEATLAND DEVELOPMENT

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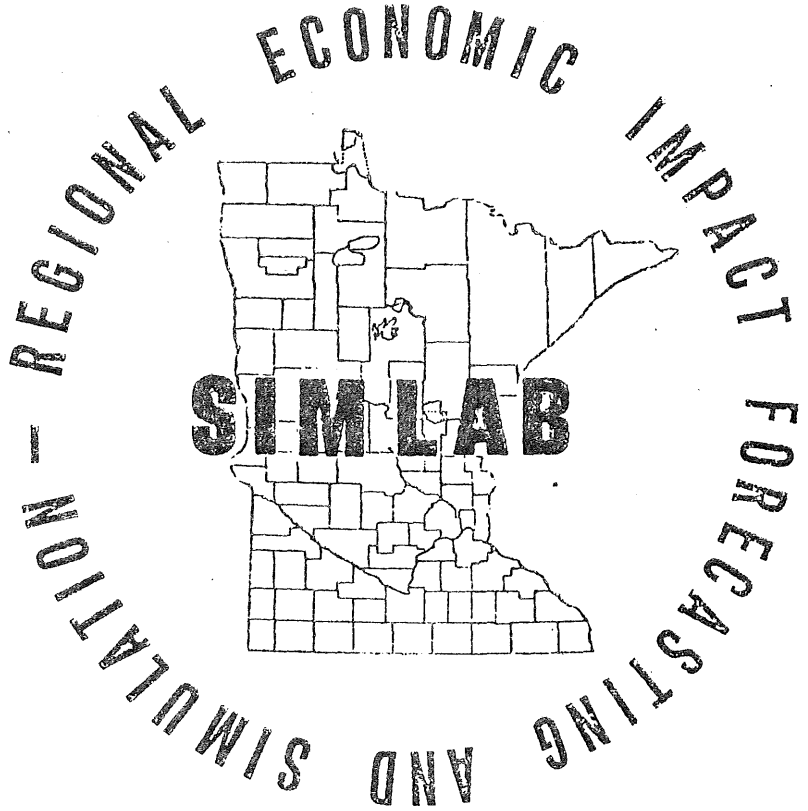

February 2, 1979

Report on Socio-Economic Effects of Peat
Resource Development in Northern Minnesota, Phase II Peat
Program, Minnesota Department of Natural Resources

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ABSTRACT

Commercial peatland utilization in northern Minnesota has been determined to have significant potential for affectin g local communities. Regional socio-economic impacts of projected peatland development are identified and measured by use of a computer-based economic impact forecasting and simulation system for this report. Results of the computer simulations are reported for an eight-county study region with and without peatland development,for selected years in the period from 1977 to 2000.

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ECONOMIC EFFECTS OF MINNESOTA PEATLAND DEVELOPMENT[1/]

Patrick D. Meagher, Wilbur R. Maki, and Leonard A. Laulainen, Jr.

The Study Region

Northern Minnesota peat deposits occur in a vast area extending from the Red River Valley to the North Shore of Lake Superior. Peatland development may occur in many parts of this region. This development would have significant impacts on existing social and economic conditions.

Existing conditions differ considerably within the region. At the western edge, agriculture is the principal economic activity. In the east, timber, tourism, and taconite mining constitute the economic base. Thus, the northern Minnesota region has subregions with different patterns of economic growth and development which would be affected by the peatland development. Although some impacts may occur in Beltrami County, as described in the concluding section, this study focuses on the eight-county Arrowhead Region in Northern Minnesota and Douglas County, Wisconsin (Figure 1).

Preliminary analysis indicates that most peatland development impacts would occur within this primary study area. The study area includes extensive areas of peatland, especially in Koochiching and Aitkin Counties. Firms and industries which sell equipment, parts, supplies, and services to the taconite industry already are located in Virginia, Hibbing, Ely, and other places in the study area. Should peatland development occur, it is very likely that the existing study area infrastructure, which is developed to serve one extractive industry, would be easily extended to serve the peat industry. The study area also includes the Duluth-Superior metropolitan area, which is a potential market for peat products and serves as a base for retailing, service, and other industries which may be affected by peatland development. Finally, the taconite industry is a heavy energy user which may seek an alternative energy source, such as peat, in the event that natural gas supplies are curtailed.[2/]

Study Objectives

Existing peatland development and future uses for peat are described and evaluated in this report. Scenarios for future development of the study area peat industry are described in terms of employment, earnings, capital investment, and value of production. Forecasts of the potential impacts of peatland development on regional industry production, employment, earnings, and population are presented. These impacts are determined by using SIMLAB, an acronym for a regional socio-economic computer model developed at the University of Minnesota for quantative analysis of the direct, indirect, and induced socio-economic effects of events like peatland development.

1/ Readers requiring a more detailed examination of socio-economic conditions and their trends in the entire northern Minnesota region are referred to the report, Socio-Economic Effects of Peat Resource Development in Northern Minnesota, by Wilbur R. Maki, Leonard A. Laualinen, Jr., and Patrick D. Meagher, prepared for the Minnesota Department of Natural Resources, 1978.

2/ Tom Alexander, "New Fears Surround the Shift to Coal", Fortune, 98(10), November 20, 1978, 50-60.

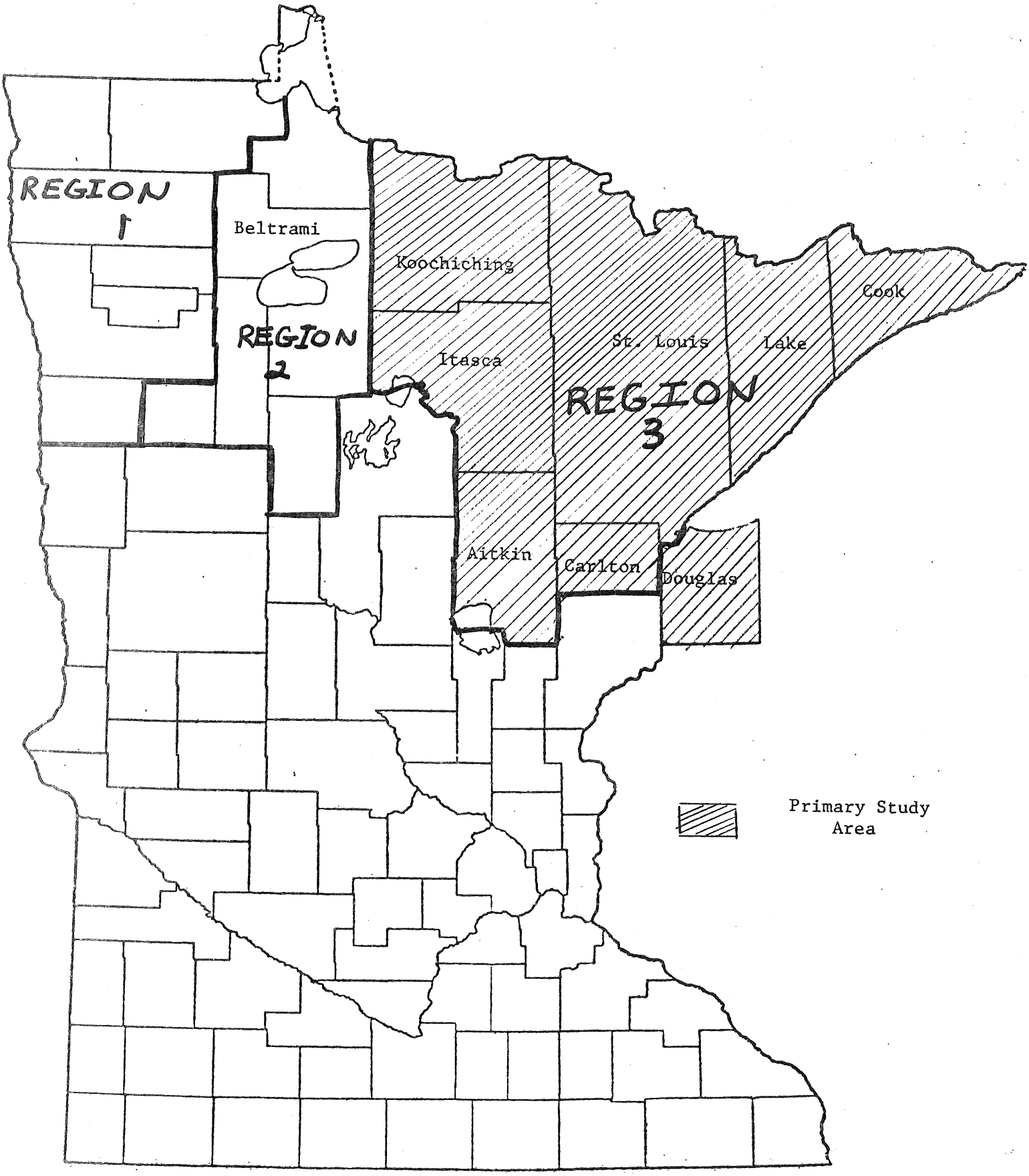

Figure 1. Substate Development Regions and Primary Study Area, Northern Minnesota and Douglas County, Wisconsin, 1979.

Direct effects are changes in the volume of production, employment, and earnings experienced by study area firms which furnish supplies, materials, and services to peat-related industry. Other area business firms are indirectly affected if they furnish goods and services to directly-affected firms. Household spending of peat industry payrolls generates induced effects on the retail, wholesale, and service sectors of the area economy. Regional population may increase through migration in response to job opportunities created by these direct, indirect, and induced effects.

The varied effects of development, or existing industry expansion and contraction, are traced quantitatively in SIMLAB. In this process, monetary calculations and projections are made in 1970 dollars. Real changes in income and output resulting from peatland development can then be compared.3/

The concluding chapter of the report summarizes these results and makes suggestions for further research.

3/ Further details on how SIMLAB works can be found in the Appendix.

PRESENT AND POTENTIAL PEATLAND DEVELOPMENT

Present Development

About 3,350,000 acres of peatland are located in the primary study area with about 1,150,000 acres, or one-third, being located in Koochiching County. Of the study area peatland, about 20,000 acres are already developed, with about 14,000 acres, or about two-thirds, being located in Aitkin County. Nearly all the developed acres are in agricultural production, with about 10,000 acres in hay, 2,500 in grain, and the rest in wild rice. Some acreage is also devoted to peat extraction for horticultural purposes, such as at the site near Cromwell in Carlton County.

A search of available literature and expert consultation reveals that future peatland development options fall into only five different industry groups.4/ The industry groups are crop agriculture, chemical production, including synthetic natural gas, synthetic gas distribution, peatcoke production, and peat extraction or mining.

Potential Expansion

In the agricultural sector, peatland development refers to its use in crop production, potentially for cold season crops such as spinach, brocolli, carrots, celery, cabbage, and in production of forage grasses, and grain. This activity would require initial investment in land clearing and drainage and subsequent expenditures to sustain crop production. Aitkin County is the most likely location for agricultural development because of the large amount of peatland there which is already served by a well-developed road network. Although, conceivably, any of the above-mentioned crops may be grown, this study focuses on further expansion of hay and, possibly, feedgrain production. These two activities already use about 12,500 acres of the 20,000 acres of peatland devoted to agriculture (with hay accounting for about 10,000 acres). Expanding production of these crops would make possible increased production from the regional livestock industry.

Other possibilities for peatland agricultural production seem less likely than those already identified. Wild rice could be produced, but sustained access to mass markets remains uncertain. Peatland development may result in expansion for horticultural purposes, primarily soil improvement by the home gardener. This market is likely to be limited because of low per capita use, and because of the high transportation costs of the bulky product. For these reasons, the existing and potential impacts due to wild rice production and horticulture are minimal and, hence, are not considered here.

In the industrial sector, peat development may take the form of industrial chemical production, including "... activated carbon for waste water filtration, coke for metallurgical purposes, and chemicals such as furfural, fumic acid and, phenols and alcohol", as reported in testimony presented before the Minnesota

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4/ The discussion in this section has benefited greatly from conversations with Professor Rouse Farnham, Department of Soils; and Professor Ervin Oelke, Department of Agronomy, University of Minnesota, St. Paul; and Mr. A.M. Rader of the Minnesota Gas Company.

Legislature.[5] No Minnesota peatland is used currently for production of industrial chemicals. Production of coke for metallurgical purposes is one option inasmuch as it may become economically attractive should an anticipated shortage of metallurgical coal develop in the 1980's.[6]

Other industrial uses appear less likely.[7] Peat-sand filters are currently used in Minnesota for filtration of sewage effluent from campgrounds and wayside rest stops. Peat is also used as an oil absorbent medium for controlling oil spills. The potential peatland development for production of environmental products is unknown or, at best, small because of the availability of other products. For these reasons, environmental uses for peat products also are not given further consideration here.

Peatland development may occur as a result of the use of peat in energy production. Peat may be burned directly or it may be gasified into a fuel gas which is usually referred to as "synthetic natural gas", a terminology used here even though it is a contradiction in terms. Peat fired plants have been built in Finland to produce heat and electricity. This study focuses on peat gasification. This option is being actively considered in Minnesota in the face of possible natural gas shortages.[8] Should peat gasification occur, utilities would distribute the gas to users within Minnesota and elsewhere. For this reason, the impacts of distribution and use of the synthetic gas are also considered in this report.

Finally, peat utilization for industrial chemicals and/or for gasification will necessarily involve peat mining. Although peat has been mined for centuries in Europe, foreign mining techniques are not likely to be used in Minnesota. These techniques require much labor and, hence, are extremely costly. At present, very little is certain about the best peat mining method to use in Minnesota so, the peat mining cost and employment estimates presented in the next chapter are tentative and subject to further revision.

To summarize, prospects of peatland development for agricultural purposes are high in Aitkin County. Also, peat coke and synthetic natural gas may be produced from peat. Some, or all, of the gas used by regional industries and/or homeowners may eventually be derived from peat. Peat coke and gas production will necessarily require extraction or mining of peat. The vast tracts of peatland

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5/ Minnesota Department of Natural Resources Peat Program: Testimony presented to the Senate Natural Resources and Agricultural Committee, October 12, 1977.

6/ "A Smoldering Crisis in Coke", Business Week, Number 2561, November 20, 1978, 73-76.

7/ An excellent survey of existing and technically feasible uses for peat in chemical production is Charles H. Fuchsman, The Industrial Chemical Technology of Peat, Bemidji State University, Bemidji, Minnesota, submitted to the Minnesota Department of Natural Resources, February, 1978.

8/ Private communication from Mr. A.M. Rader, Minnesota Gas Company, 1978.

in Koochiching County are a particularly likely location for some or all of this mining activity. In the next chapter, scenarios concerning these potential uses of peat are presented as the next step toward estimation of peatland development impacts.

PEATLAND DEVELOPMENT SCENARIOS

Assumptions concerning the magnitude of peatland development, the markets for peat-derived products, and the timing of development are elements of the development scenarios used in this report. Starting with these scenarios, the potential impacts of peatland development were estimated using SIMLAB. Five kinds of peat-related industry are in the development scenarios. These are, hay and/or small grain production, synthetic natural gas production and distribution, peat coke production, and peat mining. Details of development scenarios involving these industries are explained in this chapter.

Crop Production

Crop production on peatland is confined to Aitkin County in the agricultural scenario. More than 425,000 acres of undeveloped peatland were reported for Aitkin County in 1977.[9/]

The agricultural development scenario assumes that initial peatland production of hay and oats in equal in value to between 10 to 15 percent of the estimated value of study area livestock production in 1970, or about $6,000,000 (in 1970 dollars). This increase in the supply of feed is conservatively assumed to result in an increase of equal amount in the value of study area livestock production or, $6,000,000 (1970 dollars). At season average prices reported for 1970, $6,000,000 represents 308,000 tons of hay or 9,520,000 bushels of oats. At yields reported for Aitkin County in recent years,[10/] 385,000 acres would be required to produce this much hay or, 187,000 acres would be needed to produce this much oats. Thus, Aitkin County has sufficient peatland acreage to justify the assumptions made here.

Assuming that peatland crop production would not be feasible until suitable technology was available to make the value of production per worker equal to the value in conventional cropland production, yields an estimate of about 150 persons employed in peatland production. Assuming that earnings per worker in peatland agriculture are the same as earnings in other study area crop production, then total earnings would be about $1,200,000 (in 1970 dollars) for the 150 persons employed. Employment and earnings in the livestock sector are assumed not to change.

9/ Private communication from Professor Rouse Farnham, University of Minnesota, 1978.

10/ In 1970, the season average price for oats was $.63 per bushel. For hay, the price was $19.50 per ton, baled. In 1976, the yield for oats was 51 bushels per acre and, for hay, theyield was 0.8 tons per acre. These data are from the U.S. Department of Agriculture and Minnesota Department of Agriculture, Crop and Livestock Reporting Service, Minnesota Agricultural Statistics, annual issues, St. Paul, Minnesota.

Synthetic Natural Gas Production

Peat gasification and production of chemical by-products head the list of potential uses for peat and have been the subject of extensive engineering study.[11] A peat gasification plant would produce synthetic natural gas (for fuel) plus valuable chemical by-products, including benezine, oils, phenol, ammonia, and sulfur. A pilot plant producing 80,000,000 cubic feet of synthetic gas per day would be constructed, operated, and evaluated preliminary to scaling up operation to produce 250,000,000 cubic feet of gas per day.[12] Total costs, employment, and production in the full-scale plant would be three times the estimates presented in the engineering study for the smaller plant.

The gasification plant scenario represents the economic characteristics of an economically feasible full-scale gasification plant. Annual synthetic gas plant cost estimates (1970 dollars) are as follows:

Peat Feed	$59,000,000
Supplies & Services	29,460,000
Labor	14,700,000
Capital	78,750,000
Total	$181,910,000

These cost estimates were prepared as follows: A partial peat extraction technology may be implemented at a cost of as little as$5 (1976 dollars) per ton of peat.[13] In this study, it is assumed that, by the time the details have been worked out, the extraction cost would total $6, which yields a total annual extraction cost of $108,000,000 (1976 dollars) given a total input of 18,000,000 tons of 30 percent moisture peat annually.[14] The $108,000,000 total is deflated to $59,000,000 in 1970 dollars.[15] Operating expenses were projected using data reported in the pilot plant engineering report multiplied by three to reflect the scaling up to full production. The $29,460,000 total is the resulting operating cost estimate after deflating to 1970 dollars. The projected labor force was derived by first multiplying the pilot plan t work force[16] by three to yield an estimate of 1,400 workers. After taking into account the possiblity that worker productivity in the full scale plant may be slightly greater, and that worker productivity in a plant built in the 1980's may be slightly greater than in one

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11/ Institute of Gas Technology, Experimental Program for the Development of Peat Gasification, submitted by Minnesota Gas Company to the United States Energy Research and Development Administration, April 1977.

12/ Institute of Gas Technology, Ibid., p. ix.

13/ Institute of Gas Technology, Ibid., p. ix.

14/ Minnesota Gas Company, Research Necessary to Develop Peat as a Source of Energy In Minnesota, by A.M. Rader, Assistant Vice President, Research, April 1977.

15/ The deflator is 1.83 for the mining sector. See the data on U.S. Gross National Product by sector in current and constant dollars in various issues of The Survey of Current Business.

16/ Institute of Gas Technology, op. cit., p. ix.

built with the currently available technology described in the Institute of Gas Technology study, an estimate of 1,260 workers was used in this study. After evaluation of SIMLAB projections of average annual earnings per worker in study area industries for 1985, an estimate of $11,660 (1970 dollars) for gas plant workers was used to derive an estimated gas plant payroll of $14,700,000. At $11,660, each gas plant worker would be earning about $3,600 or $300 per month more than the SIMLAB projected 1985 study area average of $8,000.[17/] This differential should be large enough to ensure the gas plant an adequate labor supply. At the same time, it is $100 annually less than the $12,760 in earnings per worker projected for the study area taconite industry. Taconite firms are likely to maintain a differential of at least this size in order to retain their work force. If the gas plant found it necessary to pay the taconite industry worker annual wage of $14,760 (1970 dollars) projected by SIMLAB for 1985, then the gas plant payroll would be about $18,600,000.

Capital costs are the return to investment in the plant which must be paid if investors are to recover the cost of the plant. The full scale plant is projected at $750,000,000, in 1976 dollars, or about $525,000,000 in 1970 dollars.[18/] Assuming that investors will require a 15 percent annual rate of return on the $525,000,000 yields an annual capital cost estimate of $78,750,000.

Once annual operating costs have been projected, it is possible to derive the price of synthetic gas which must be received if production costs are to be covered. Gas revenues need not cover all production costs because some $45,000,000 of chemical by-products will also be produced. The estimated value of by-products was made by first noting that the pilot plant would produce by-products worth $30,000,000 in 1977.[19/] This figure was multiplied by three to estimate the value of by-products from the full-scale plant, which was then divided by two in order to convert to 1970 dollars and obtain the $45,000,000 estimate. Considering the annual revenue of approximately $45,000,000 from by-products, a price at the plant for synthetic gas of approximately $1.70 (1970 dollars) per 1,000 cubic feet would cover all costs, including capital costs.

Operating at 90 percent of capacity (360 days per year) the full-scale plant would produce 81 billion cubic feet of gas per year. Letting the algebraic variable P_G be the price of 1,000 cubic feet of gas, the total annual revenues, P_T, of the plant are given by the formula,

$$P_T = 81{,}000{,}000 \times P_G + \$45{,}000{,}000.$$

If all annual costs are to be recovered, then total revenues must equal total costs, or

$$P_T = 81{,}000{,}000 \times P_G + \$45{,}000{,}000 = \$181{,}910{,}000.$$

17/ Minnesota Department of Employment Security data are the basis for projections.

18/ Institute of Gas Technology, Op. Cit., p. 12.

19/ Institute of Gas Technology, Ibid., p. 15.

Solving algebracially for P_G, then,

$$P_G = \frac{\$181,910,000 - \$45,000,000}{81,000,000}, \text{ or}$$

$$P_G = \$1.70.$$

Thus, a synthetic gas price of approximately $1.70 (1970 dollars) per 1,000 cubic feet would cover all costs, including capital.

Construction of the full-scale synthetic gas plant would require an employed work force of about 2,700 each year for three years and an annual study area expenditure of about $105,000,000 (in 1970 dollars). These projected values were arrived at by first assuming that the $525,000,000 (in 1970 dollars) cost of the plant is 60 percent buildings and 40 percent equipment. The cost of equipment was ignored since it would be manufactured outside the study area and shipped in. Sixty percent of $525,000,000 is $315,000,000, which, spread over three years, is $105,000,000 annually. Construction employment was projected from U.S. data, which show $33,240 worth of construction performed per worker in 1970 and a projected $39,100 worth to be performed during the early 1980's.[20/]

Synthetic Natural Gas Delivery

Synthetic gas delivery incurs expenses and generates added employment. These expenditures and employment are for day-to-day operation, maintenance, and repair of the synthetic gas delivery system.

Synthetic gas from peat may be delivered to users through existing pipelines, by truck and/or rail, and/or through separate pipelines. In this report it is assumed that the synthetic gas will simply be fed into an expanded existing regional pipeline system. Thus, unit synthetic gas delivery employment and other expenses will be the same as those incurred for delivery of a similar volume of natural gas.

Available data indicate that in 1970, 57.2 billion cubic feet of natural gas was delivered in the Study Region.[21/] Gas utility employment was 187 persons. On the basis of this information, delivery of 81 billion cubic feet of synthetic

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20/ Initial estimates of regional output per worker by industry are their National counterparts calculated from output data in the U.S. Department of Commerce, Bureau of Economic Analysis, Summary Input-Output Tables of the U.S. Economy: 1968, 1969, 1970, BEA Staff Paper No. 27, Washington, D.C., September 1975. Employment data are from the U.S. Department of Labor, Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985, Bulletin 1831, Washington, D.C., 1975. These estimates are then adjusted upward or downward to correspond to what is known about regional productivity. Future trends in productivity over time are in the Bureau of Labor Statistics document.

21/ Minnesota Energy Agency, Management Information Systems Research Center and Agricultural Experiment Station, University of Minnesota, Economic Data Base for Long-Range Energy Planning in Northeast Minnesota and Douglas County, Wisconsin, August 1975, Chapter 6. Employment data is from the U.S. Department of Commerce and the Minnesota Department of Employment Security.

gas would result in added employment of 225 persons.[22] SIMLAB projects the average annual earnings of study area gas utility employees to be $9,550 (1970 dollars) in 1985. Since workers hired to operate the expanded system would be new employees, it is assumed that they would earn a little less. Assuming annual earnings of $9,450 (1970 dollars) per employee, annual earnings generated by synthetic gas distribution would total $2,126,000 (1970 dollars).

The gas distribution scenario assumes that the gas utility purchases gas at $1.70 per 1,000 cubic feet from the synthetic gas plant. Purchases of supplies materials, and business services from study area firms were projected on the basis of those made by the natural gas utility. Synthetic gas utility annual capital costs were assumed to total $20,000,000 (1970 dollars), which, at a 15 percent rate of return, would service an investment of $133,000,000 (1970 dollars). Total annual gas utility costs are thus projected at $170,000,000 (1970 dollars). If revenues were to cover these costs, then the price of synthetic gas, delivered, would be $2.10 (1970 dollars) per 1,000 cubic feet.

At least two alternatives for marketing of synthetic gas exist and are considered in this report. One alternative would be to sell all the gas outside the study area. In this case, the only social and economic impacts occuring within the study area would be those resulting from the production of the gas. Another alternative would be to sell part of the gas to users within the study area as a substitute for some,but not all, of the natural gas utilized currently. If the peat gas is more expensive, then user costs will rise, thus resulting in lower profits for gas-using businesses and/or higher consumer prices for goods and serivces produced in the study area. More details of these alternatives are presented in the next chapter.

Peat Coke Production

Peat coke is the principal chemical currently produced from peat. A peat coke plant of minimum viable size would produce 10,000 tons per year of coke. Total plant employment is projected to be 30 full-time persons. Additional persons would be needed to harvest peat, but the number is uncertain since the harvesting methods to be used are unknown. About 300,000 tons of peat, in its natural state, would be required annually. Capital investment in the plant would be about $3,100,000 (1970 dollars).[23]

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[22] The estimate of 225 persons is calculated as follows: 81 billion cubic feet ÷ 57.2 billion cubic feet = 1.42. Then, 1.42 x 187 = 265, an estimate of the number of persons required to operate the pipeline if it existed today. Projected increases in pipeline worker productivity expected to occur by the mid-1980's result in the estimate of 225 persons used in this study.

[23] Peat coke plant data are from Fuchsman, op. cit., p. 114. The capital investment estimate presented by Fuchsman has been deflated to 1970 dollars by the authors.

Assuming a capital investment of $3,100,000 and a 15 percent rate of return, annual capital costs would be about $465,000 (1970 dollars). Assuming peat extraction costs of $6 (1976 dollars) per ton, then the costs would total $980,000 (1970 dollars).

Labor costs would add $350,000 (1970 dollars) annually, assuming an annual wage of $11,660 (1970 dollars), the same as in the synthetic gas plant. Maintenance, local taxes, and insurance would add another $300,000 to annual costs.[24] Finally, preparation of peat for coking would equal the cost of mining or harvesting the peat (i.e., $980,000) annually.

No attempt was made by the authors of this report to calculate the revenue a peat coke plant would earn since the peat coke could command different prices, depending on the exact nature and use of the carbon product it is turned into and, the value of the by-products of the coking process are unknown.[25] It is assumed, however, that the peat coke would be sold outside the study area.[26]

Peat Mining

Both a peat coke plant and a gasification plant would require the mining or extraction of peat. The mining scenario used in this report is a peat mining industry producing sufficient peat for a gas plant, a coke plant, and a small production for horticultural purposes.

Discussion of the peat input requirements of a coke plant and a gas plant presented earlier in this chapter indicates that about 18,500,000 tons of peat would be needed at a total projected extraction cost of about $60,000,000 (1970 dollars). At the time of this writing, details on how the peat will be extracted have not been worked out and no estimates of peat mining employment were available to the authors. Thus, it was necessary to estimate peat mining employment. It seems reasonable to assume that worker productivity in a new Northern Minnesota extractive industry would have to be somewhat greater than in the existing taconite industry if the new industry were to be economically viable. The principal reason for this is that the new industry would probably have greater capital costs per worker than the established industry with its older stock of plant and equipment. In view of the SIMLAB 1985 projection of $42,000 (in 1970 dollars) for taconite industry production per worker, it was assumed that production per worker in the peat mining industry would be about 25-30 percent greater or about

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24/ Estimates of the annual cost of maintenance, taxes, and insurance were derived from financial ratios in the gasification plant engineering study. See Institute of Gas Technology, op. cit., Table 6.

25/ See Fuchsman, op. cit., pp. 112-115, for a discussion of possible final products and by-products.

26/ Fuchsman, Ibid, p. 115, doubts that a market exists anywhere in Minnesota.

$53,500 (1970 dollars). At this level of productivity, about 1,120 workers will be needed to extract the 18,500,000 tons of peat annually. Assuming that peat mine workers are paid the same as taconite industry workers are projected to be in 1985, or $12,760 (1970 dollars) total annual earnings will be about $14,300,000 (1970 dollars).

Composite Development Scenario

Discussion in this chapter has reviewed assumptions concerning the magnitude of peatland development and the markets for peat-related products. An assumption concerning the timing of peat industry development is needed to complete the scenario because development impacts must be measured relative to social and economic conditions expected to prevail at the time development occurs.

The simplest situation was assumed with regard to timing, namely that peatland crop production, peat gasification and distribution, peat coke production, and peat mining will commence simultaneously in 1985. In each peat industry, the initial levels of production, employment, and earnings are as explained in the individual industry scenarios (Table 1).

The value of production (Gross Output) in each peat industry is projected to grow between 1985 and 2000. Projected growth in Gross Output would occur for different reasons in different industries. In the SIMLAB model, peatland agriculture production is linked to production of livestock products which, in turn, is determined by personal consumption expenditures in the study area. As study area earnings and consumer expenditures rise, consumption of livestock products rises and, with it, peatland agricultural production. Similarly, peat mining output is linked to output of synthetic gas and chemical by-products and to production of peat coke so, as production of these goods increases, so does peat mining output. Synthetic gas and chemical by-product output are allowed to increase at about eight-tenths of one percent per year, a rate chosen to represent efficiency improvements in the gas and coke plants as old equipment wears out and new, improved equipment replaces it. Peat mining output also increases over time. The volume of synthetic gas delivered by the gas utility also is allowed to increase slowly because of efficiency improvements. Similar assumptions concerning efficiency, which are derived from published sources,[27] are built into each of the 55 industries in the study area SIMLAB model. All these assumptions concern changes in the productive efficiency of labor. Thus, as shown in Table 1, employment is steady or slowly declining as production grows.

Earnings are also projected to increase in all five industries except peatland agriculture where the employment declines because worker productivity increases wipe out the effects of increasing earnings per worker. Projected

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27/ U.S. Department of Commerce, Summary Input-Output Tables of the U.S. Economy, op. cit., and U.S. Department of Labor, The Structure of the U.S. Economy in 1980 and 1985, op. cit.

Table 1. Projected Gross Output, Employment, Earnings (in 1970 Dollars) and Purchases of Specified Peat Industry, Northern Minnesota and Douglas County, Wisconsin, 1985 and 2000.

Industry	Gross Output: Value of Production at Producer Prices		Employment		Earnings		Purchases of Supplies Materials and Services from Study Area Firms*	
	1985	2000	1985	2000	1985	2000	1985	2000
	(dol.)	(dol.)	(no.)	(no.)	(dol.)	(dol.)	(dol.)	(dol.)
Peatland Agriculture	6,000,000	9,000,000	150	100	1,200,000	850,000	1,380,000	2,140,000
Peat Mining	60,000,000	65,000,000	1,120	1,160	14,300,000	18,500,000	13,500,000	15,600,000
Synthetic Gas and Chemical By-Products	181,910,000	217,340,000	1,260	1,300	14,700,000	21,000,000	26,150,000	30,110,000
Peat Coke	3,000,000	4,000,000	30	30	350,000	510,000	620,000	810,000
Synthetic Gas Distribution	170,000,000	196,000,000	225	225	2,126,000	2,600,000	11,760,000	13,580,000
Total	420,910,000	491,340,000	2,785	2,815	32,676,000	43,460,000	53,410,000	62,240,000

* Data shown are net of purchases from other peat industries. For example, purchases of the synthetic gas plant do not include peat purchased from the peat mining sector.

increases in earnings per worker by industry used in SIMLAB are from published sources.28/

Table 1 shows estimates of the potential direct or first-hand effects of peatland development on study area socio-economic conditions. There are also the indirect and induced effects explained in the Introduction. All these potential impacts of peatland development are examined in the next chapter.

28/ Estimates of regional earnings per worker are their National counterparts calculated from earnings data in U.S. Water Resources Council, 1972 OBERS Projections, Regional Economic Activity in the U.S., Volume 1, Washington, D.C., April 1974. Employment data is from U.S. Department of Labor, Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985, op. cit. These estimates are then adjusted upward or downward to correspond to regional earnings data supplied by the U.S. Department of Commerce, Regional Economic Information System.

ECONOMIC IMPACT MEASUREMENT

Potential economic impacts of peatland development reported here were measured using SIMLAB. A brief review of SIMLAB methodology may be of help in interpreting the data.

SIMLAB Methodology

The first step in socio-economic impact measurement is preparation of a benchmark or baseline projection. Baseline projections are designed to represent study area economic events as they would unfold in the absence of peatland development. SIMLAB baseline projections are made in a series of calculations following a certain logical sequence. In the projections, the area economy is treated as part of the National economy which provides markets for the basic or export producing industries within the study area, such as the taconite industry. Projected trends in spending (for supplies and materials) and of employment and earnings in study area economic base industries are thus derived from projected trends in national economic conditions as represented by U.S. Gross Output.29/ Gross Output is, simply, the value of production as it leaves the plant.

Business activity, as well as employment, and earnings, in other study area industries is determined by the level of activity in the economic base industries. Thus, employment and earnings in all study area industries are ultimately determined by National economic conditions.

Employment and earnings are, in turn, significant factors in determining migration-caused shifts in regional population. The regional population trends in labor force participation and fertility then determine the number of persons seeking work or the available labor force. This logical sequence, beginning with projections of study area export markets, is followed by the SIMLAB model in projecting study area socio-economic conditions.

In SIMLAB analysis, development scenarios are statements of assumptions concerning the appearance of new industry. Fed into the SIMLAB system, the scenarios cause the generation of data representing the evolution of the regional economy under changed (from the baseline) circumstances. Since all other assumptions are held to be the same, differences in the two projections, baseline and development, represent estimated socio-economic impacts.

Principal Indicators of Impacts

All SIMLAB projections and impact estimates are in terms of socio-economic indicators. Indicators used to measure the effects of peat industry development are population, industry gross output, employment, and earnings from wages and salaries.

29/ Projections of U.S. Gross Output by industry used in SIMLAB are from the U.S. Department of Labor, Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985, Bulletin 1831, Washington, D.C., 1975.

These indicators are used as measures of study area socio-economic conditions and the impacts of peat industry development because they are easily interpreted by the general public. Population is a useful indicator because it is of interest to government officials who manage the supply of public services. Gross output represents the level of study area business activity and is often interpreted by government, businessmen and individuals as a measure of an area's economic health. Employment and earnings statistics are important measures of the economic welfare of individuals. Use of these indicators facilitates straight forward comparison of study area economic conditions under alternative scenarios of peat industry development.

Selection of Scenarios for Impact Analysis

The impacts of two alternative composite scenarios of study area peatland development are considered here. Each alternative includes crop production, peat gasification, gas distribution, peat coke, and peat mining. Only composite scenarios are considered for a number of reasons. The impacts of crop production and peat coke production are not measured separately because these industries are too small to have measurable impacts relative to the present amount of economic activity in the study area. Peat mining is not considered separately because it is unclear why peat would be mined and shipped outside the study area. Obviously, peat mining, peat gasification, and gas distribution are interrelated industries that must be considered simultaneously in impact analysis.

Under these circumstances, two principal scenarios involving peat-related industries emerge. In one scenario, the synthetic natural gas from peat is sold only outside the study area. In the other, some gas is substituted for natural gas consumed within the study area, a situation which seems particularly cogent at the present time in view of possible natural gas curtailments. These scenarios could have considerably different impacts. In the first, the impacts are solely from peat industry purchases of supplies and services and from workers hired to produce the peat-derived products. In the second, there may be additional impacts stemming from the substitution of synthetic natural gas derived from peat for curtailed supplies of natural gas. These impacts may occur if the synthetic natural gas is significantly more expensive than the natural gas it replaces. Substitution of the more expensive fuel may raise study area energy costs to business and homeowners. This will obviously be a hardship for homeowners. The effect on business is also of potential concern since, for reasons explained below, higher energy costs may reduce the rate of study area economic growth and offset, to some extent, the increases in study area economic activity caused by peat industry development.

Both scenarios are examined separately here. Because construction-related impacts would preceed impacts from production and consumption of peat-derived products, the impacts of constructing the peat industry facilities should be considered first. In impact analysis, construction impacts must be taken into account for their own sake. Furthermore, economic conditions at the beginning of the period of peat industry production may be significantly affected by carried-over effects of construction activity with implications for the nature of production period impacts. For example, study area population and labor force may be larger as a result of construction activity and this may affect the process of adjustment to the production period conditions. Only one set of construction impacts must be considered here since the peat industry facilities involved in the two scenarios are identical.

Impacts From Construction of Peat Industry Facilities

Construction of peat industry facilities would have significant impacts on Study Area socio-economic conditions. Direct effects would be generated by the household spending of construction workers and by construction industry spending for supplies, materials, and services furnished by Study Area firms. These would also have indirect and induced effects as defined in the Introduction. The magnitude of these impacts would depend on the magnitude and timing of peat industry development. Under assumptions already explained, peatland crop production, peat gasification and distribution, peat coke production, and peat mining would commence simultaneously in 1985. Construction of peat industry facilities is assumed to occur in 1982, 1983 and 1984. The synthetic gas plant would be the principal part of this construction activity. Expenditures on gas plant buildings, excluding equipment, would amount to about $105 million (1970 dollars) annually for three years. A modest amount of construction activity, about $10 million per year, is assumed for the other peat industries during the 1982-1984 period.

Construction of the peat industry facilities will generate increases in study area business volume which, in turn, would lead to increases in employment and earnings. However, these effects will endure only as long as construction continues. Construction will also generate an influx of construction workers, their families, and other persons responding to employment opportunities associated with construction activities. These additional people may require additional public services, as well as housing. Decisions concerning these needs may be required of study area public officials. Hence, the potential population influx during the construction period is a matter of interest to government. SIMLAB forecasts of construction period population changes in the study area are presented in Table 2.

In Table 2, SIMLAB baseline population projections by age-sex category for 1977, 1982, and 1984 are presented. For 1982 and 1984, forecasts of the additional number of persons present in the study area in each age category under the assumption of peat industry construction are shown in the columns following the 1982 and 1984 baseline projections. Total population in each age category during construction is the sum of corresponding elements in baseline and impact columns.

Table 2 shows that during the first year of construction in 1982, the population increase is projected to be 1.6 percent or about 6,000 persons. Study Area employment would increase about 3,350 persons of which 2,700 persons would be employed constructing the peat industry facilities.[30/] Thus, in the first year of construction, most of the impacts would not be diffused through the study area economy. The population impacts would consist primarily of construction workers and their families.

30/ Supplementary employment data not shown in Table 2 are from the SIMLAB computer runs which generated the population impact estimates.

Table 2. Estimated and Projected Total Population in Specified Age Groups, Peat Study Region, 1977-1984: Construction Phase.*

Age Group	1977 Baseline	1982 Baseline	1982 Construction Impact	1984 Baseline	1984 Construction Impact
			(number)		
1-5	32,761	35,463	0	37,821	499
6-13	44,703	41,969	1,128	43,397	2,459
14-17	31,376	20,712	509	19,862	1,170
18-24	47,298	46,468	1,284	43,616	2,573
25-34	45,178	57,216	1,453	65,998	3,960
35-54	78,682	78,240	1,169	78,445	3,184
55-64	39,912	36,976	315	36,150	770
65+	42,644	43,453	103	43,819	201
Column Total	362,554	360,497	5,961	369,108	14,816
Grand Total	362,554	366,458		383,924	

* The baseline projection represents study area socio-economic events as they would unfold in the absence of peat industry development. The impact forecast represents the deviation from the baseline caused by peat industry development. Thus, total forecast population in the event of development is the sum of baseline and impact forecasts.

By the third year of construction, in 1984, the Study Area economy will have had time to expand to produce the additional goods and services needed to meet the requirements of the construction industry and the households of construction workers. This expansion will create additional job opportunities so that in 1984, employment is projected to increase by about 8,200 persons over its 1984 baseline level, with 2,700 people employed in peat industry construction. Table 2 shows that the projected population change is 14,800 persons or 4 percent above the 1984 baseline level of 369,108.

The First Scenario: Impacts From Peat Industry Operation Only

With construction completed in 1984, the peat industries would commence operations in 1985. For the study area economy, the year 1985 will be a year of transition from the earlier impacts of construction to the later impacts of day-to-day operation. Impacts from operation will begin to emerge clearly after a period of adjustment so, the tables which follow show SIMLAB forecasts of peat industry operation impacts beginning in 1986.

Population

Table 3 shows the projected impacts of peat industry operation on Study Area population. In Table 3, the projected impacts increase with time as can be seen by comparison between 1986, 1995, and 2000. This phenomenon is not caused primarily by growth in the peat industries. It is the result of a downward trend in the Study Area population which can be seen in the baseline projection. During the computer analysis, this trend was traced to downward trends in employment in taconite mining and manufacturing after the mid-1980's (shown in Table 5). Employment in these two study area economic base industries is projected to decline because of anticipated increases in worker productivity resulting from modernization and mechanization of plants and equipment.31/ The peat industries appearance in the study area at the onset of declining employment in mining and manufacturing has a sustaining effect on the Study Area economy. People who would otherwise leave the study area when they become unemployed because of trends in mining and manufacturing are able to stay because of opportunities generated by the peat industry development. The sustaining effect is not strong enough to reverse the downward trend in study area population. This can be seen in Table 3 by noting that in the year 2000 the population is projected to be 347,959 with peat industry development as compared to 387,391 in 1995. Indeed, Study Area population with peat industry development in the year 2000 is projected to be less than the baseline population in 1995.

Gross Output

Gross output, the value of production in producer's prices, is a measure of study area business volume. Peat industry operations will affect study area business volume primarily through purchases of supplies, materials, and services from other area firms, and through spending of peat industry payrolls. Secondary

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31/ Anticipated increases in productivity are from the Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985, op. cit.

Table 3. Estimated and Projected Total Population in Specified Age Group, Peat Study Region, 1977-2000: Development Phase.*

Age Group	1977 Baseline	1986 Baseline	1986 Development Impact	1995 Baseline	1995 Development Impact	2000 Baseline	2000 Development Impact
1-5	32,761	40,025	1,219	35,098	3,612	24,877	3,672
6-13	44,703	44,517	2,802	49,814	2,925	44,608	4,314
14-17	31,376	21,633	1,500	20,529	1,042	21,118	1,273
18-24	47,298	38,776	1,963	25,866	3,560	21,937	1,727
25-34	45,178	73,885	5,405	50,590	5,653	24,864	6,121
35-54	78,682	80,805	4,923	104,074	9,881	111,543	10,632
55-64	39,912	35,375	983	31,395	1,450	30,970	1,873
65+	42,644	43,988	-77	41,153	749	37,504	926
Column Total	362,554	379,004	18,718	358,519	28,872	317,421	30,538
Grand Total	362,554	397,722		387,391		347,959	

* The baseline projection represents study area socio-economic events as they would unfold in the absence of peat industry development. The impact forecast represents the deviation from the baseline caused by peat industry development.

effects will occur when firms serving the peat industry or the households of peat industry employees respend part of their revenues for materials and payrolls.

Table 4 shows projected baseline levels of gross output by study area industries for 1977, 1986, 1995, and 2000. Forecasts of increases in gross output because of peat industry operation are shown for 1986, 1995, and 2000. All data in Table 4 are in hundreds of 1970 dollars. Thus, changes over time represent differences in the quantity of goods produced and/or sold. In 1986, the projected gross output from the peat industries, sectors 2, 4, 7, 8, and 12, is the sum of the peat industry data in the third column in Table 4, or $444,428,000. The projected impact on other study area industries is the sum of the other data in the same column, or $185,006,000. The total impact is $624,434,000.

Of the 180,006,000 dollar impact, 26 percent of it is in manufacturing, 19 percent in trade, 14 percent in services, and 14 percent in construction. So, 73 percent of the increase in business volume caused by peat industry operation is found in only four study area industries. Examination of the detailed computer output from which Table 4 was prepared revealed that about one-half of the increase in manufacturing output was in consumer items like food and kindred products.[32/] The other half was in industrial products like machinery. Increases in gross output in trade and services are primarily caused by increases in consumer spending. Construction is for facilities used by business firms and for homes. Thus, increases in study area business volume caused by peat industry operation seem about equally attributable to increases in purchases by industry and consumers.

Employment

Table 5 shows projected baseline levels of employment in study area industries and forecasts of employment increases caused by peat industry operations. Examination of the projected employment increases reveals that the principal impacts will be in the peat industries themselves and in trade (sector 13), services (sector 15), and government (sector 17). In 1986, it is projected that 2,887 persons would be employed in peat industries and an additional 9,537 persons in other industries. Of the 9,537 persons, 2,834 would be in trade, 2,316 in services, and 1,972 in government. The markets for these industries are primarily study area households, suggesting that the principal employment impacts from peat industry operations stem from stimulation of consumer spending.

This conclusion is somewhat different than the one concerning gross output. It was concluded the the largest gross output increases seemed equally attributable to industrial and consumer spending. An important reason for the difference is that worker productivity is less in trade and services than in the manufacturing industries which produce goods used by other industries. Thus, an increase of, say, $100,000 in business volume in trade and services requires the hiring of more workers than a similar business volume increase in manufacturing.

32/ Individuals wishing to inspect the detailed SIMLAB computer printouts may arrange to do so by contacting the authors.

Table 4. Estimated and Projected Value of Gross Output (in 1970 Dollars) in Specified Industry for Baseline and Development Options, Peat Study Region, 1977-2000.*

Industry No.	Industry Title	1977 Baseline	1986 Baseline	1986 Development Impact	1995 Baseline	1995 Development Impact	2000 Baseline	2000 Development Impact
		(1,000's of 1970 Dollars)						
1.	Agriculture & Agr. Services	92,174	123,098	4,199	140,215	5,704	144,652	6,284
2.	Peatland Agriculture	-	-	6,103	-	8,947	-	9,015
3.	Iron Ores	585,403	694,487	0	887,772	0	1,017,504	0
4.	Peat Mining	-	-	59,199	-	63,952		65,098
5.	Construction	264,434	333,298	24,596	333,298	24,596	333,298	24,596
6.	Manufacturing	982,075	1,265,671	46,579	1,478,311	80,139	1,590,747	82,319
7.	Peat Coke	-	-	3,023	-	3,806	-	3,719
8.	Peat Chemicals & Synthetic Gas	-	-	198,122	-	213,324	-	217,339
9.	Transportation	190,347	235,537	3,789	276,387	11,651	298,491	11,943
10.	Communication	37,266	52,645	2,724	68,550	5,317	76,230	5,596
11.	Utilities	129,768	182,502	7,560	254,180	21,937	300,028	22,768
12.	Synthetic Gas Distribution	-	-	177,981	-	193,232	-	195,686
13.	Trade	469,289	629,916	33,827	751,759	73,117	764,702	75,233
14.	Finance,Insurance,Real Est.	217,237	279,034	14,557	341,030	51,880	330,086	55,384
15.	Services	296,229	392,328	25,093	436,139	53,186	412,982	55,321
16.	Other Industry	26,103	27,717	366	29,492	288	30,710	250
17.	Government	209,735	268,285	16,716	277,610	35,985	252,274	38,117
	Column Total	3,500,060	4,484,518	624,434	5,274,743	847,061	5,551,964	868,668
	Grand Total	3,500,060	5,108,912		6,121,804		6,420,632	

* The baseline projection represents study area socio-economic events as they would unfold in the absence of peat industry development. The impact forecast represents the deviation from the baseline caused by peat industry development.

Table 5. Estimated and Projected Total Employment in Specified Industry for Baseline and Development Options, Peat Study Region, 1977-2000.*

		1977	1986		1995		2000	
		Baseline	Baseline	Development Impact	Baseline	Development Impact	Baseline	Development Impact
				(number)				
1.	Agriculture & Agri. Services	3,680	3,716	118	3,088	108	2,732	96
2.	Peatland Agriculture	-	-	147	-	133	-	102
3.	Iron Ores	13,933	15,831	0	13,036	0	11,579	0
4.	Peat Mining	-	-	1,165	-	1,181	-	1,161
5.	Construction	7,233	8,305	614	6,950	513	6,285	465
6.	Manufacturing	22,608	26,438	974	25,333	1,381	24,068	1,225
7.	Peat Coke	-	-	28	-	33	-	31
8.	Peat Chemicals & Synthetic Gas	-	-	1,315	-	1,329	-	1,308
9.	Transportation	5,069	5,345	113	4,805	213	4,474	186
10.	Communication	1,241	1,275	67	1,061	82	919	68
11.	Utilities	1,427	1,533	82	1,467	157	1,406	141
12.	Synthetic Gas Distribution	-	-	232	-	232	-	225
13.	Trade	35,219	42,567	2,834	41,363	4,313	37,152	4,011
14.	Finance,Insurance,Real Estate	5,669	6,771	435	7,512	1,189	6,634	1,195
15.	Services	25,878	36,939	2,316	39,748	4,734	37,059	4,832
16.	Other Industry	1,866	2,063	12	2,029	5	2,014	14
17.	Government	24,921	30,174	1,972	25,576	3,396	20,806	3,180
	Column Total	148,744	180,957	12,424	171,968	18,999	155,128	18,240
	Grand Total	148,774	193,381		190,967		173,368	

* The baseline projection represents study area socio-economic events as they would unfold in the absence of peat industry development. The impact forecast represents the deviation from the baseline caused by peat industry development.

Earnings

Baseline projections of earnings from wages and salaries in study area industries and forecasts of impacts from peat industry operations are presented in Table 6. In 1986, peat industry earnings are projected at $34,428,000 (1970 dollars) and the earnings increase in other industries is $61,227,000.

Earnings data in Table 6 includes only earnings from wages and salaries. Income from other sources, such as rents, interest, dividends, and social security, is not included. Income from these other sources is not likely to be significantly affected by peat industry development and operation.

Second Scenario: Impacts From Consumption of Synthetic Natural Gas Within the Study Area

Synthetic natural gas from peat may be used within the primary study area as a substitute for curtailed supplies of natural gas. It is also possible that synthetic gas will be much more expensive than natural gas. If so, energy costs to gas users will rise, especially if they cannot substitute a lower cost fuel.

If energy costs rise, economic growth in the primary study area may slow down for at least two reasons. Higher energy costs may force households to spend less on other items. This may reduce the rate of growth in the study area retailing and service industries. In addition, higher energy costs to business and industry may reduce profits. Reduced profits may then result in reduced investment in new plants and equipment. Ultimately, reduced investment may result in fewer new job openings and lower levels of employment in the study area. The alternative to higher energy costs -- sharp curtailment of energy use -- would inhibit economic growth even more than the high energy costs.

At present the SIMLAB model does not forecast the effects of higher energy costs on household consumption expenditures. A statistical study of how household spending patterns are altered by increases in energy costs relative to the cost of other goods would provide the information needed to modify the SIMLAB model for this capability. The model already has the capability to forecast the effects of higher energy costs on the rate of new investment. Accordingly, a computer simulation run was made in an attempt to determine if higher cost gas supplies would ultimately result in lower levels of investment and hence employment in the study area.

The computer run was made under the assumptions that study area gas supplies would be five times more expensive than natural gas and that one-half the extra cost would be passed on to consumers and one-half would be absorbed in lower business profits. The computer results showed study area employment was not adversely affected over the fifteen-year period 1985-2000, which suggests that the impacts of peat industry development would be the same in both scenarios considered here.

However, this conclusion must be considered a tentative one. As already mentioned, the SIMLAB model does not take possible adverse effects on household expenditures into account. In addition, a fifteen-year period may not be long enough for significant effects on investment and hence employment to appear. Finally, increased energy costs may be shared differently than was assumed.

Table 6. Estimated and Projected Total Earnings From Wages and Salaries of Employed Work Force in Specified Industry for Baseline and Development Option, Peat Study Region, 1977-2000.*

Industry No.	Industry Title	1977 Baseline	1986 Baseline	1986 Development Impact	1995 Baseline	1995 Development Impact	2000 Baseline	2000 Development Impact
					(1,000's of 1970 Dollars)			
1.	Agriculture & Agr. Services	25,148	26,513	439	23,365	864	20,929	725
2.	Peatland Agriculture	-	-	1,174	-	1,104	-	854
3.	Iron Ores	155,797	208,973	0	195,413	0	188,285	0
4.	Peat Mining	-	-	14,446	-	17,353	-	18,503
5.	Construction	102,405	143,456	7,420	136,272	10,076	135,739	10,037
6.	Manufacturing	149,985	215,677	8,102	255,076	13,625	271,802	13,290
7.	Peat Coke	-	-	350	-	494	-	506
8.	Peat Chemicals & Synthetic Gas	-	-	16,308	-	19,524	-	20,837
9.	Transportation	53,503	73,108	2,519	84,552	4,037	86,663	3,889
10.	Communication	14,661	21,865	1,033	27,176	2,119	28,193	2,122
11.	Utilities	13,355	16,450	447	17,019	1,776	17,310	1,714
12.	Synthetic Gas Distribution	-	-	2,150	-	2,506	-	2,596
13.	Trade	162,903	213,291	13,607	239,456	23,569	232,374	24,487
14.	Finance,Insurance,Real Est.	42,078	57,790	1,156	69,368	3,382	69,180	12,222
15.	Services	139,535	223,745	9,717	255,647	29,668	244,227	31,798
16.	Other Industry	13,214	14,893	70	14,890	68	14,908	55
17.	Government	197,864	260,139	16,717	269,463	35,986	244,127	38,117
	Column Total	1,070,448	1,475,900	95,655	1,587,697	166,151	1,553,737	181,752
	Grand Total	1,070,448	1,571,555		1,753,848		1,735,489	

* The baseline projection represents study area socio-economic events as they would unfold in the absence of peat industry development. The impact forecast represents the deviation from the baseline caused by peat industry development.

Further analysis of other possibilities seems fruitless at this time. More specific information on the cost of synthetic gas to users is needed and the SIMLAB model should be modified. Modification and adequate testing would be time consuming and expensive and should only be undertaken when it is clear that more specific gas cost information will be available. This information should include the expected price of natural gas and the cost of synthetic gas at the time the synthetic gas is substituted for natural gas. In addition, information on which natural gas users will switch to another fuel should be available.

CONCLUSION

Peat industry development has been shown to have measurable potential effects on study area population, gross output, employment, and earnings. This study focused on development of five peat industries -- crop agriculture, snythetic gas (and chemical) production, synthetic gas distribution, peat coke production, and peat mining. One economically viable example of each was included in a composite development scenario assumed to begin in 1985. Potential impacts from this scenario were projected using SIMLAB. Forecasts show that by 1986, the composite peat development scenario would result in a study area population increase of about 18,700 persons. At the same time, study area gross output would increase about $529,400,000 (1970 dollars), employment would increase about 12,400 persons, and earnings from wages and salaries would increase about $95,650,000 (1970 dollars). In addition, this scenario would also have a significant supportive or sustaining effect on the study area economy should there be a downturn in the study area manufacturing or taconite industries toward the end of the century.

A second scenario assumed that fuel gas from peat would be substituted for natural gas used within the study. The results show a five-fold increase in gas prices. Under the very narrow and specific assumptions explained in the text, no decline in study area employment stemming from higher energy costs was forecast by SIMLAB. However, this conclusion must be viewed as tentative until more complete information on how study area gas users would adjust to higher prices becomes available.

In demonstrating these results, this study has exhausted available information. Yet, many information gaps remain. In particular, more complete information is needed on peat extraction and drying procedures and the labor force needed to do this. In addition, more specific information is needed on the location of the proposed peat gasification plant. This is particularly important because some socio-economic impacts from gasification may spill outside the primary study area into Beltrami County, and to Bemidji, if the plant is located very near the western edge of Koochiching County, or in Beltrami County. If the plant is actually located in Beltrami County the study area must be expanded to include the large impact area. The geographic incidence of these impact would change. Their magnitude, however, would be very nearly the same as those reported here.

More specific information on location is needed to evaluate impacts on the demand for roads, utilities, schools, and other public services. Available information does not make this possible. Increased demand for services could have obvious implications for local public finances that should be addressed in any further work.

APPENDIX : GLOSSARY OF SIMLAB METHODOLOGY AND PROCEDURES

This glossary introduces the Minnesota Regional Development Simulation Laboratory,called SIMLAB, to the readers of the report on the socio-economic impacts of peat industry development. SIMLAB is a computer-based regional socio-economic forecasting model which can be applied to private and public sector decision-making and policy problems. SIMLAB has been developed for quantative analysis of the direct, indirect and induced socio-economic effects or impacts of events like Northeastern Minnesota peatland development. Direct effects include peat industry employment of part of the regional labor force and purchases of inputs from area business firms. Other area business firms become indirectly affected if they furnish inputs to directly affected firms. Household spending induced by mining company payrolls affects the area retail, wholesale, and service sectors. In addition, regional population may increase through migration in response to job opportunities created by these direct, indirect, or induced effects. Demand for essential public services may also increase.

These effects of development are typical of the kind SIMLAB can trace, account for, and measure or project quantitatively. SIMLAB can also be used to analyze existing industry expansion or contraction. This analysis can currently be conducted statewide, at the region or multi-county level, and for minor civil divisions. For direct, indirect, and induced socio-economic effects within these political jurisdictions and geographic areas, SIMLAB provides its users with quantitative information and forecasts derived from core input-output models of the National and regional economies interacting with a series of modules each consisting of a data base and related computational procedures.

SIMLAB consists of a core regional input-output model or production module which interacts with a system of other modules to form a dynamic regional input-output simulation model with up to ninety-five sectors of industrial detail. The function of each SIMLAB module may be described as follows:

a. The market module links the regional economy with the National economy so that SIMLAB embraces an economic base theory of regional economic activity which is explained in this Appendix.

b. The investment module contains relationships for measuring and forecasting spending by regional firms for plant and equipment.

c. Demand module relationships represent the consumption behavior of the final users of regional products and services.

d. Employment module relationships link the volume of production in each sector to employment in each sector.

e. The value-added module relationships estimate the pool of funds from which depreciation,business taxes,and investment in new plant and equipment must be drawn.

f. The labor force module relationships represent the demographic and economic forces determining regional labor supply and demand.

g. Population module relationships include variables representing the demographic and economic forces determining changes in regional population.

h. The production module contains the core regional input-output model which interacts with the other modules.

The first section of this glossary explains what an input-output model is and the assumptions upon which it is based. The next section contains a numerical illustration of how an input-output model is used to trace and account for the effects of industry expansion, contraction, or new industry development. A final section explains the logic of the SIMLAB procedure.

Input-Output Models

An input-output model of a city, county, region, state, national, or other area economy disaggregates the area economy into a set of interacting industry, final demand, and import sectors. Producing industries buy raw materials, semi-finished and finished goods, capital, and labor in the area to produce their products which, in turn, are sold to other producing industries, and to final users in the area. Final demand includes the consumption of households, capital formation, government purchases, and exports. Imports are purchases of producing industries, both as goods reworked into products for resale and as capital equipment. Households and governments also purchase imports. Households furnish labor services to producing industries and government, receiving, in return, wages and salaries used to purchase consumer goods and services. Exports of area-produced goods provide dollar inflows which become personal income and profits and which are used, on balance of payments account, to pay for imports. Imports represent dollar outflows which have no further effect on regional income and profits.

These dollar flows among area producing industries, households, and governments are used by an input-output model as measures of the degree of economic interrelatedness among these groups. Measures of interrelatedness are used to analyze and estimate the direct, indirect, and induced effects discussed previously.

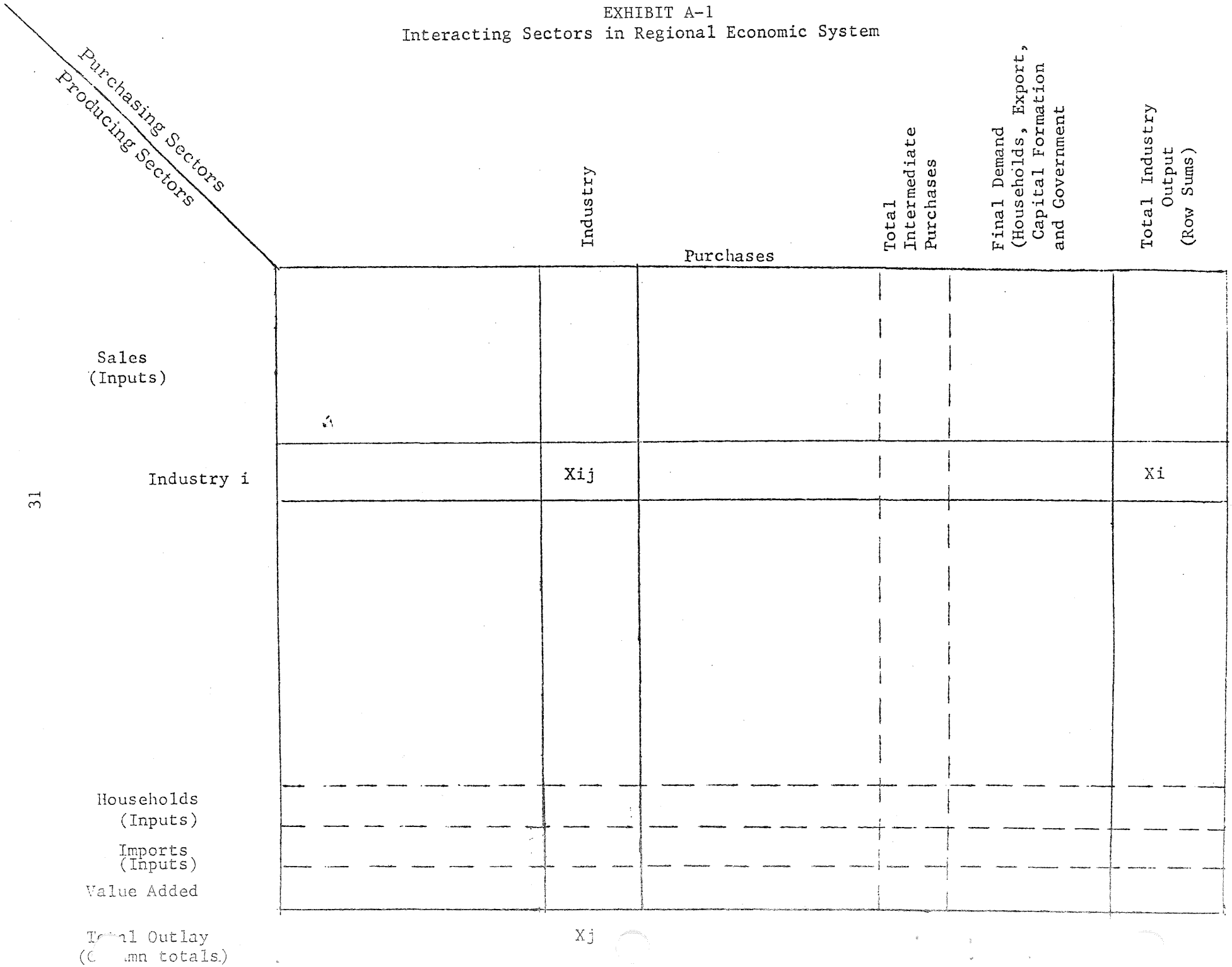
Strong linkages among local industries coupled with a relatively low level of imports implies a high degree of regional economic self-sufficiency. With relatively little dependence on external sources of essential goods and services, the regional effects of an external stimulus, such as copper-nickel development, will be strong and widespread because of the expanded local labor force which has high expenditures for locally-available goods and services. Imports of manufactured products, however, reduce the potential impacts of the labor force expansion. Measurement of interdependencies between exports, imports, and regional household spending, therefore, is an essential element of an impact analysis.

Transactions table

In input-output analysis, a so-called transactions table is prepared for use in measuring first-order interdependencies. Each data element x_{ij} in the transactions table shows the dollar volume of (1) purchases of each industry, i, as a user of goods produced by industry j, and (2) sales of the same goods from industry j to industry i. Thus, the table cross-classifies industries into their separate roles as users and suppliers. The dollar volume of purchases is usually measured over the course of a year.

Exhibit A-1 illustrates the input-output transactions table used in the preparation of the SIMLAB production module. The left margin of the table lists the regional industries producing goods used in production by regional industries listed along the top margin. Thus, a typical element in Exhibit A-1 shows the dollar value of intermediate product purchased by the j^{th} sector, a user, from the i^{th} sector, a producer. Each element can be thought of as a link in a chain connecting each industry, the intermediate users of its products and households

EXHIBIT A-1
Interacting Sectors in Regional Economic System



with regional industry. Households furnish inputs of labor services to industries listed along the top. Regional industries also produce goods used by regional households and government or for capital investment. These users are represented by the column of entries summarily labeled "final demand" in the top margin. Regional industries may also export output to industries and final users located outside the region as indicated by the column of entries labeled "export" in the top margin. The sum of all purchases by an industry, including any imports of intermediate and primary products, is its total outlay as recorded in the bottom row of entries. Total output for each industry is the sum of all sales to intermediate users, final demand, and export; and is recorded as an entry in the column at the far right. Total outlay and total outputs for a given industry are defined so as to be equal, so the transactions table provides a complete accounting of regional cash flows.

An input-output transactions table for the United States economy has been constructed by the Department of Commerce using primary data sources.[1/] The National transactions table is then used as a secondary data source in constructing regional transactions tables following methods extensively discussed in published literature.[2/]

The transactions table is a source of information on regional interindustry interactions. Because there is often a complex network of feedbacks among interacting industries, a change in final demand or exports is said to have a multiplier effect. It is a matrix of interindustry interactions,called the production module in SIMLAB terminology, which is at the core of the SIMLAB procedure for measuring the effects of new industries and other kinds of marked change in the regional economy. The following numerical example illustrates how the SIMLAB production module works.

Production Module Illustration

The illustrative input-output table (Table A-1) shows only three intermediate producing and purchasing sectors. But existing industry or a new industry activity may be included as any of the three sectors. However, in this illustration, we use the manufacturing sector as a surrogate for all industries being analyzed. For discussion purposes, therefore, manufacturing is synonymous with the industry whose impacts are under study.

Interrelationships between primary and intermediate inputs and gross outputs are illustrated by the hypothetical three-industry economy. All numerical values are given in millions of dollars. Thus, the $2 million listed in the manufacturing column and the services row means that $2 million worth of services are supplied to the manufacturing sector for use in producing manufactured goods. The manufacturing sector also purchased $4 million worth of agricultural products, $7 million

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1/ U.S. Department of Commerce, Social and Economic Statistics Administration/ Bureau of Economic Analysis, Input-Output Structure of the U.S. Economy: 1967, 3 Volumes, Washington, D.C., 1974.

2/ W.I. Morrison and P. Smith, "Nonsurvey Input-Output Techniques at the Small Area Level: An Evaluation", Journal of Regional Science, Vol. 14, No. 1, 1974, pp. 1-14.

Table A-1. Interindustry transactions showing specified gross output disbursements, by purchasing sector.

Producing Sector	Purchasing Sector: Intermediate Demand: Agriculture	Intermediate Demand: Manufacturing	Intermediate Demand: Services	Final Demand: Households	Final Demand: Export	Gross Output
Agriculture	2	4	3	7	0	16
Manufacturing	5	7	5	2	5	24
Services	3	2	4	8	3	20
Households	4	6	7	0	3	21
Import	2	5	0	4	--	11
Total (Gross) Outlay	16	24	20	21	11	92

worth of its own products, $6 million worth of labor services from households, and $5 million of imports from outside the region -- a total of $24 million worth of purchased inputs. The entry in the manufacturing row of the gross output column indicates that the output of the manufacturing sector was sold for a total of $24 million. Of the $24 million of product, $2 million was purchased by local households and $5 million was exported to buyers outside the area. The $7 million of final demand is viewed as exogeneous, or external, to the three producing sectors. Similarly, the household inputs and imports, are viewed as external inputs. They are not part of the local interindustry transactions,which include only the sales and purchases of intermediate product, not final product.

Since total manufacturing costs are listed as $24 million, it may seem as though the manufacturing industry made zero profit. This is not so because the primary inputs from the household sector are defined, in this illustration, to include stockholder's equity, or dividends, and retained earnings. Thus, the input-output table is a balance sheet of historical facts. Like a balance sheet, the illustrative input-output table summarizes the results of business activity carried on over one production period.

Input-Output Coefficients

SIMLAB analysis is based on an input-output table prepared by the U.S. Department of Commerce for the Year 1970. This is the most recent table currently available. An input-output table already nine years old is more useful than it first seems because it can be used to derive information about underlying economic relationships which are not likely to change much over time. This information is derived by calculating the ratio of the amount purchased from an industry named in the left-hand column to the amount in the column total of the purchasing industry. The result is the amount that is purchased from the industry listed at the left in order to produce $1 of product by the industry shown at the top of the column, as shown in Table A-2.

The input-output ratios are sometimes called technical coefficients of production, an interpretation which is based on certain assumptions:

1. If the coefficients of production are to represent the mix of inputs used per unit of output in the production process, then the relative prices of all goods and services must remain fixed since microeconomic theory demonstrates that in a competitive economy the mix of inputs used by producers, and the mix of outputs produced, will vary with changes in relative prices. It is important to note, however, that it is relative prices or price ratios which matter, not the overall level of prices. If all prices double, relative prices are unaffected. Thus, to the extent that all prices move together, the constant relative price assumption is not entirely unrealistic.

2. Interpreting the coefficient as representing the value of goods a producing industry must purchase from a supplying industry to produce one dollar's worth of output implies that this relationship holds true at all levels of output. However, microeconomic theory demonstrates that changes in the scale of output may change the efficiency with which one or more inputs is utilized, changing the yield of product per unit of input. This phenomenon is referred to as economies of scale. Input-output analysis ignores economies of scale, an assumption which becomes

Table A-2. Purchases of specified gross output per $1 of gross outlay, by purchasing sector.

Producing Sector	Purchasing Sector		
	Agriculture	Manufacturing	Services
	(dollars)		
Agriculture	.1250	.1667	.1500
Manufacturing	.3125	.2917	.2500
Services	.1875	.0833	.2000
Households	.2500	.2500	.4000
Imports	.1250	.2083	.0000
Total	1.0000	1.0000	1.0000

generally more accurate as changes in scale of production become smaller.

Because relative prices and/or the scale of production generally change over periods of time, these assumptions of input-output analysis can cause errors in projections made using input-output information. Since the northern Minnesota input-output table is based on 1970 data, the technical coefficients of production derived from it pertain to 1970. Provided the commodity flow data in the input-output table is accurate, the technical coefficients are valid statements of historical fact. However, if the 1970 coefficients are used to analyze events in a later year, then the possibility of error arises either from changes in relative prices or from economies of scale. There is insufficient data on the Minnesota economy to determine if relative prices have changed, or if there have been substantial economies of scale since 1970.

Knowledge of the technical coefficients of production makes it possible to trace the effects on the economy of expansion by any existing or new industry. Once expansion gets underway, supplies and materials are purchased from regional supplying industries, adding a new component to interindustry transactions. When these industries expand their output, they require more intermediate goods from the industries supplying them. The input-output coefficients prescribe how much the output of all industries supplying an expanding industry will increase. In turn, a third tier of industries supplying the second tier of industries will increase their output, so that total output of the regional economy increases by more than the output from the expanding industry. Similarly, additional wages paid to expanding industry workers who, in turn, spend on consumer goods, leads to a larger increase in total wages, provided the extra wages represent a net addition in the number of jobs in the economy and/or an increase in the total earnings of a fixed number of workers. If the hiring of workers leads to a reshuffling of existing workers at the same earnings levels, then there is no net impact from wage expenditures. SIMLAB automatically calculates the net number of new jobs and the resulting net change in earnings attributable to the industry expansion.

Using Input-Output Tables to Trace and Measure the Impact of Industry Expansion

Tracing the spending and respending of industry expansion from their point of initial appearance in the northern Minnesota economy through successive tiers of intermediate goods producers could be a tedious task which is made unnecessary once the matrix of input-output coefficients of production is known.

Algebraic rearrangement of the data in Tables A-1 and A-2 demonstrates a means of estimating the effects of industry expansion on the output of northern Minnesota industries when, of course, the real northern Minnesota input-output table is used. The total output of each sector can be represented for the three producing sectors -- agriculture (1.1), manufacturing (1.2) and services (1.3)-- as follows:

Table III

$$16 = .1250 \times 16 + /1667 \times 24 + .1500 \times 20 + 7 \qquad (1.1)$$

$$24 = .3125 \times 16 + .2917 \times 24 + .2500 \times 20 + 7 \qquad (1.2)$$

$$20 = .1875 \times 16 + .0833 \times 24 + .2000 \times 20 + 11 \qquad (1.3)$$

Thus, in Equation 1.1, total agriculture output equals the total amount of agricultural output needed to produce a dollar's worth of agricultural output times total agricultural output (.1250 x 16), plus the amount of agricultural output needed to produce a dollar's worth of manufactured goods times the total manufacturing output (.1667 x 24), plus the amount of agricultural output needed to produce a dollar's worth of services times the total output of services (.1500 x 20), plus agricultural output sent to final demand (7). Equations 1.2 and 1.3 are similarly interpreted.

The three preceding equations may be arranged in matrix form as follows:

$$\begin{bmatrix} 16 \\ 20 \\ 24 \end{bmatrix} = \begin{bmatrix} .1250 & .1667 & .1500 \\ .3125 & .2917 & .2500 \\ .1875 & .0833 & .2000 \end{bmatrix} \cdot \begin{bmatrix} 16 \\ 20 \\ 24 \end{bmatrix} + \begin{bmatrix} 7 \\ 7 \\ 11 \end{bmatrix} \qquad (2.1)$$

Each array, or matrix, in brackets can be treated algebraically. Hence, this expression can be rearranged to give

$$\begin{bmatrix} 16 \\ 20 \\ 24 \end{bmatrix} - \begin{bmatrix} .1250 & .1667 & .1500 \\ .3125 & .2917 & .2500 \\ .1875 & .0833 & .2000 \end{bmatrix} \begin{bmatrix} 16 \\ 20 \\ 24 \end{bmatrix} = \begin{bmatrix} 7 \\ 7 \\ 11 \end{bmatrix} \qquad (2.2)$$

$$\left(\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} .1250 & .1667 & .1500 \\ .3125 & .2917 & .2500 \\ .1875 & .0833 & .2000 \end{bmatrix} \right) \begin{bmatrix} 16 \\ 20 \\ 24 \end{bmatrix} = \begin{bmatrix} 7 \\ 7 \\ 11 \end{bmatrix} \qquad (2.3)$$

or

$$\begin{bmatrix} 16 \\ 20 \\ 24 \end{bmatrix} = \left(\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} .1250 & .1667 & .1550 \\ .3125 & .2917 & .2500 \\ .1875 & .0833 & .2000 \end{bmatrix} \right) \begin{bmatrix} 7 \\ 7 \\ 11 \end{bmatrix} \qquad (2.4)$$

or

$$\begin{bmatrix}16\\20\\24\end{bmatrix} = \begin{bmatrix}1 - .1250 & -.1667 & -.1550\\ -.3125 & 1-.2917 & -.2500\\ -.1875 & -.0833 & 1-.2000\end{bmatrix}^{-1} \begin{bmatrix}7\\7\\11\end{bmatrix} \qquad (2.5)$$

Thus, Equation 2.5 shows total outputs on the left as a function of an inverse matrix containing the input-output coefficients of production multiplied by the matrix of final consumption. The remaining problem is to compute the inverse matrix. Texts on linear algebra show how to compute the inverse.[3/] This done, Equation 2.5 becomes the following:

$$\begin{bmatrix}16\\20\\24\end{bmatrix} = \begin{bmatrix}1.3500 & .3606 & .3658\\ .7344 & 1.6619 & .6569\\ .3930 & .2577 & 1.4041\end{bmatrix} \begin{bmatrix}7\\7\\11\end{bmatrix} \qquad (2.6)$$

The large nine element array in Equation 2.6 shows the relationship between final consumption, represented by the single column array on the right, and total output in the three sectors represented by the single column array to the left of the equal sign. Each element in a column of the large array shows the total dollar production required directly and indirectly from the industry listed at the top of the column for each dollar of delivery to final demand by the industry listed for that row. For example, it shows that agricultural output will have to increase by $1.35 for each extra dollar of agricultural product delivered to final consumption. Why does output increase by more than a dollar? For two reasons: One, as shown in Table A-1, agriculture consumes some of its own output. It takes feed grain to raise livestock, for instance. Second, because, as agriculture expands, it requires more intermediate goods from other industries which, in turn, require more intermediate goods from agriculture.

The nine-element array of numbers in Equation 2.6 is often called the matrix of final demand multipliers, or the "Leontief inverse", in input-output terminology. An array of multipliers fifty-five elements square is used by SIMLAB.

The nine element array of multipliers in Equation 2.6 provides a means of illustrating how SIMLAB estimates the impact of industry expansion. Suppose final demand in the hypothetical, three-sector economy is projected to reach $9 million, $8 million and $12 million, respectively, for agriculture, manufacturing, and services. Given the projected final demand, total output required to meet this demand can be calculated using the demand multipliers. Rewriting Equation 2.6 with a new final demand column, but with x's to represent the as yet unknown new levels of total sectoral output, yields:

$$\begin{bmatrix}x_a\\x_m\\x_s\end{bmatrix} = \begin{bmatrix}1.3500 & .3606 & .3658\\ .7344 & 1.6619 & .6569\\ .3930 & .2577 & 1.4041\end{bmatrix} \begin{bmatrix}9\\8\\12\end{bmatrix} \qquad (3.1)$$

which, in turn, yields:

3/ See: Richard A. Bilas, Microeconomic Theory: A Graphical Analysis, McGraw Hill, 1967, p. 298. The illustration is taken from this text.

$$x_a = 9(1.3500) + 8\ (.3606) + 12\ (.3658) = 19.42$$

$$x_m = 9(.7344) + 8\ (1.6619) + 12\ (.6569) = 27.79 \qquad (3.2)$$

$$x_s = 9(.3930) + 8\ (.2577) + 12\ (1.4041) = 22.45$$

Thus, total output attributable to the increase in final demand from the levels in Equation 2.6 is the sum of the differences in total sectoral output before and after the increase (in million dollars), or:

$$(19.42 - 16) + (27.79 - 24) + (22.45 - 20) = 3.42 + 3.79 + 2.45$$

$$= 9.66 \qquad (3.3)$$

Using data on the number of persons employed in each sector, the number of persons employed per dollar of output in each sector in the base period can be calculated. Suppose the number of persons employed per dollar of output in each sector is 0.0003 in agriculture, 0.0002 in manufacturing and 0.0005 in services. Then the total employment attributable to the projected levels of production are as follows:

.0003 x \$19.42 million = 5,826 (agriculture) (4.1)

.0002 x \$27,79 million = 5,558 (manufacturing) (4.2)

.0005 x \$22.45 million = 11,225 (services) (4.3)

The dollar figures are the projected levels of agricultural, manufacturing, and service output required to meet the projected levels of final demand.

SIMLAB Theory Overview

Use of the input-output multipliers to project socio-economic variables requires projections of regional final demands. In the SIMLAB model, the final demand components are exports to the rest-of-world, investment in plant and equipment, inventory accumulation, personal or household consumption, and government. The SIMLAB sequence of calculations starts with regional exports because the underlying model is an economic base model of regional economic activity.[4/]

Economic base industries are those which produce goods and services for sale outside the region, generating an inflow of dollars on regional balance of payments account in the process. The inflow sustains regional economic activity and, if the inflow increases, causes the level of regional activity to grow through the system of linkages between the base industry or industries and other regional industries supplying the base industry. As previously shown in this Appendix, the input-output multipliers provide a complete quantitative description of these linkages.

4/ Walter Isard, Methods of Regional Analysis: An Introduction to Regional Science, the MIT Press, 1960, Chapter 6.

The input-output multipliers also provide a complete quantitative description of the linkages among regional industries supplying those producing for the other regional final demands. These consist of investment in plant and equipment, inventories, households, and government. Because there are SIMLAB modules for projecting these final demands, as well as exports, the SIMLAB model utilizes all interindustry linkages represented by the input-output multipliers in generating projections.

Once the output required of forecast final demands has been calculated, the SIMLAB program compares the required output levels with the capacity of regional industries. Capacity is determined by existing plant and equipment and by regional labor supply. If capacity is less than the forecast required output, the actual level of output forecast is the capacity level. However, in the model, investment in new plant and equipment and/or inmigration of workers to fill open jobs will occur in subsequent years and regional production and employment will grow as long as more capacity is needed.

Once the actual level of output is forecast, the SIMLAB program proceeds to use the calculated output levels to project regional employment, work force, and population. The system is then closed, recursively, by using these results in the projection of final demands and production in the next year. This sequence of calculations is repeated for as many years as desired, beginning in the base year 1970. Beginning with 1970 means data is generated which can be compared with historical data in validating SIMLAB projections.