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An Energy Input-Output Table of Pakistan for 1979-80 and Some Applications

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1. INTRODUCTION

In order to enhance the indigenous supply of energy, Pakistan has launched various investment programmes as a consequence of which 28 percent and 43.2 percent of total public investment has been invested in the energy sector, respectively, in the Fifth and the Sixth Five Year Plans. However, despite the sharp increase in investment for indigenous exploration and production, the domestic supply of energy has registered an insignificant increase.

Despite substantial increases in energy prices, the growth of the commercial primary energy consumption has increased from 6.8 percent per annum in 1973-74 1979-80 to 7.8 percent per annum in 1979-80 – 1984-85. In fact, Pakistan's energy policies have not succeeded in delinking the growth rate of GDP from primary energy consumption, which has partly been achieved in industrialized countries and in many developing countries. For the period of 1973-74 to 1979-80, the primary energy/GDP elasticity was 1.20, whereas, it has increased to 1.24 for 1979-80 to 1984-85.

The lack of impact on the mobilization of domestic energy sources and on the curtailment of demand for energy, has also resulted in the continuation of import dependence, especially of oil, over time. With oil consumption growing at a rate of 5.3 percent per annum, the energy imports equalized almost 60 percent of the merchandise export earnings, during the first half of the Eighties. It is noted that this 60 percent compares unfavourably with the average of 28 percent of oil-importing developing countries.

The above mentioned developments as well as social and environmental considerations evoked an awareness in recent years that Pakistan requires a more rigorous integrated supply-demand energy sector planning, which allows for the

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inter and intra-sectoral linkages in the economy, as the production of goods and services depends, in whole or in part, on energy inputs.

The energy input-output model provides us an appropriate analytical tool for this approach, because it makes explicit use of the inter and intra-sectoral linkages. Furthermore, in its analytical application, it considers, not only, the direct effect of energy use, but also, it indicates the indirect use of energy by taking into account all rounds of production.

This paper will demonstrate the usefulness of energy input-output analysis for the planning of energy flows. In Section 2, the first disaggregated energy input-output table of Pakistan will be presented together with the description of compilation procedures. Some preliminary applications regarding the costs, requirements, balances and conservation potentials of energy are taken up in Sections 3, 4, 5 and 6. In Section 7, the main findings will be summarized.

2. THE ENERGY INPUT-OUTPUT TABLE FOR 1979-80[1]

An appropriate analytical tool to analyse the total energy requirements in order to produce the final demand for energy is the energy input-output model. Apart from the direct energy requirements, the indirect energy requirements, which are measured through the energy embodied in non-energy goods and services, are also used in the production process of the final demand.

An appropriate impact analysis of the energy requirements is guaranteed, if the classical Leontief input-output is extended and modified. The extension lies in the distinctions between primary and secondary energy sectors. The latter receives primary energy as an input and converts it into secondary energy sources. This process allows us to trace back the primary energy content in the secondary energy flows which must be equal, if we take into account the energy losses in converting energy from primary to secondary energy forms.

The modification results in the compilation of inter-industry energy flows in physical units while the non-energy flows are reported in monetary values. This modification ensures that the energy conservation condition is met. This condition implies that the total primary energy intensity of a product equals the total secondary intensity of the product plus the amount of energy lost in energy conversion. The compilation of the energy input-output flows in physical units can only be relaxed with the occurrence of uniform inter-industry energy prices. However, the condition of the uniform inter-industry prices is not applicable in Pakistan, as prices differ across sectors. Therefore, whereas the classical model includes inter-industry activities only in monetary values, the appropriate model for energy analysis depicts

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[1] A copy of the entire table can be obtained from the authors.

the energy flows in physical terms (i.e. TJ; BTU; TOE or any other common denomination) and the non-energy flows in monetary values. Hence, we obtain a transaction table which is constructed in 'hybrid' units.

A common approach to obtain energy flows in physical units is to compute the total monetary flows in a conventional transaction table first and then convert the data to physical units by means of prices (Subba Rao *et al.* 1981). In this paper, however, the table of physical energy flows has been compiled directly, as in Pakistan they are documented more accurately.

The two main sources used to compute the physical energy transactions of the Pakistan's economy in 1979-80 were, the Energy Year Book (EYB) of the DGER (Energy Year Book 1985), and a study conducted by IED-consultants for the Sixth Five-Year Plan (1983). Additional figures were taken from the annual reports of Water and Power Development Authority (WAPDA) and Karachi Electricity Supply Corporation (KESC), the National Transport Research Centre (NTRC) and the Census of Mining Industries (CMI), (Federal Bureau of Statistics 1983, KESC Annual Report 1982; NTRC 1985; WAPDA 1979-80. All figures were converted to Terajoules (1 TJ = 10^{12} Joules) as the common denomination.

In an attempt to generate maximum insight in energy consumption, given the present data base, the intra-industry sectoral disaggregation has been pursued by taking the total consumption of industry from the EYB and using the shares of the sectors from the IED study. However, a few adjustments were required, due to, for example, unreported coal mining and under-rating kerosene consumption in the EYB. Also, in the agricultural sector, diesel consumption had to be adjusted, as the reported EYB data do not include diesel consumption of tractors, which is reported under the transport sector. In addition, several corrections were required for the energy consumption reported for the 'commercial', 'other/government' and 'domestic final demand' sectors, as these sectors are reported quite inaccurately in the EYB.

With the physical flows calculated, the values of monetary flows can, in principle, be obtained by means of prices. Due to data unavailability or inadequacy, however, several adjustments and recalculations had to be made. Apart from the sources already mentioned, the annual report of the Attock Refinery (Attock Refinery Ltd 1980) was also used. At this stage, the monetary flows of the non-energy sectors have to be updated to 1979-80, given the fact, that the most recent input-output table of Pakistan is for 1975-76 (Saleem *et al.* 1985). For this purpose the well-known RAS-method (modified) has been applied. Techniques, described in the SAM-compilation (Havinga *et al.* 1985) have been used to generate the updated intermediate inputs and outputs of the sub-sectors. Among other things, this implies that the imports have been reported competitively with domestically produced goods.

3. DIRECT AND INDIRECT ENERGY COSTS (IN VALUES)

As discussed earlier, the focal point of the use of an energy input-output table is its property to quantify not only the direct but also, the indirect energy consumption of an economy. The theoretical basis for the calculation of total energy requirements of the various economic sectors is the well-known classical input-output model given as:

$$X = AX + Y \qquad \dots \qquad \dots \qquad \dots \qquad \dots \qquad (1)$$

and

$$X = (I - A)^{-1}\, Y \qquad \dots \qquad \dots \qquad \dots \qquad \dots \qquad (2)$$

X denotes the vector of total output, Y the vector of final demand for domestic and imported goods and services minus total imports, A the coefficient matrix of domestic and imported inputs, and $(I - A)^{-1}$ the Leontief-Inverse. The coefficients of $(I - A)^{-1}$ quantify the total additional supply of sector i, if the final demand of sector j increases by one unit. This model underlies the well-known restrictions, e.g. the fixed proportions production functions, and the assumption that domestic and imported goods are produced with identical input coefficients, etc.

For the analysis of the energy costs (ECO), an extended version of the classical model is required. The extended model can be used not only for the analysis of the energy sectors but also for various other purposes. Its general equation is

$$Z = B\,(I - A)^{-1}\, Y \qquad \dots \qquad \dots \qquad \dots \qquad \dots \qquad (3)$$

where B stands for the coefficient matrix of any economic variable (energy, labour, capital, etc.). $\hat{Y}$ is the diagonal matrix of the final demand. By using Equation (3), a split is provided between intermediate demand and final demand, as Z only comprises intermediate demand. We therefore obtain the total demand as

$$X = B\,(I - A)^{-1}\, \hat{Y} + \hat{Y} \qquad \dots \qquad \dots \qquad \dots \qquad (4)$$

For the analysis of the total energy costs, matrix B has to be split in two components. The first part, comprising the coefficients of energy sectors, is required for the pre-multiplication of the inverse. The other part comprising the non-energy sectors, is equated to zero. The final demand is split accordingly as

$$ECO = \left(\frac{A_1}{0}\right) \left[I - \left(\frac{A_1}{A_2}\right)\right]^{-1} \left(\frac{\hat{Y}_1}{Y_2}\right) + \left(\frac{\hat{Y}_1}{0}\right) \qquad \dots \qquad \dots \qquad (5)$$

Where index 1 indicates energy sectors and index 2 non-energy sectors. When determining energy costs for the production of goods and services, it should be kept in mind that only the direct costs of energy sources are applicable. For instance, for the production of shoes, only the costs of electricity should be treated and not the costs of producing electricity through conversion from coal and/or gas as its primary energy sources. Therefore,Equation 5 should be slightly modified to control the aspect of double counting of primary and secondary energy sources. When the modification is incorporated in Equation 5 the equation reads as follows:

$$ECO = \left(\frac{A_{11}\ A_{12}}{0\quad 0}\right)\ \left[I - \left(\frac{0\quad A_{12}}{A_{21}\ A_{22}}\right)\right]^{-1}\ \left(\frac{\hat{Y}_1}{Y_2}\right) + \left(\frac{\hat{Y}_1}{0}\right) \quad \ldots \qquad (6)$$

Equation 6 differs from that applied in Beutel and Murdter (1975) wherein the Leontief-Inverse, apart from the energy-energy transactions (A_{11}), is shown to have equated the energy-industry transactions (A_{12}) to zero also. Their application, however, leads to underreporting of the energy costs because they do not allow for energy-industry interactions in their impact analysis.

As we are, here, interested in the monetary values of energy costs, the energy flows in the input-output table, like the non-energy flows, are denoted in Rupees. The results are presented in Table 1.

Column 8 indicates that the overestimation of total energy costs due to double counting of the primary and the secondary energy sources lies between 1.62 percent and 4.33 percent for the non-energy sectors and between 7.12 percent and 53.63 percent for the energy sectors. As expected, the largest overestimations are found in the primary sectors i.e., crude oil and coal, because it is there where the double counting accumulates, given the primary to secondary energy conversions. Furthermore, the total energy costs by sectors reported in Column 6, give an increase of 100 Rupees in final demand, which correspond with those found for other developing countries. Given the state of industrial development, the most energy-intensive sectors are transport, iron and steel, cement, brick and glass, fertilizer and petroleum products. These results are obtained due to the direct consumption of energy sources. As regards the other sectors, like construction, agriculture and agro-based industries, Column 7 shows that they become more energy intensive due to the energy embodied in the non-energy inputs.

4. DIRECT AND INDIRECT ENERGY REQUIREMENTS IN PHYSICAL UNITS

For a consistent analysis of energy requirments and forecasts, it is essential that the inter-industry energy flows are denoted in physical units. Similarly, the formulation of the energy model must allow for the energy conservation condition. Therefore, it is fundamental to apply the hybrid-unit energy model instead of the

Table 1

Direct (DE), Indirect (IE) and Total (TE) Effects of Energy Costs

Sectors	Equation 5			Equation 6				Overestimation (percent) (8)
	DE (1)	IE (2)	TE (3)	DE (4)	IE (5)	TE (6)	Indirect/Total (5) : (6) = (7)	
Crude Oil	6.94	4.63	11.57	6.94	0.59	7.53	0.08	53.63
Coal	1.37	2.77	4.14	1.37	1.90	3.28	0.58	26.42
Gas	0.10	1.65	1.75	0.10	1.53	1.63	0.94	7.12
Power	16.59	2.65	19.25	16.59	0.42	17.01	0.02	13.12
Petrol Products	54.70	12.80	67.50	54.70	5.75	60.46	0.10	11.66
Non-energy Petrol	38.05	8.31	46.36	38.05	6.63	44.68	0.15	3.76
Mining + Quarry	0.45	9.33	9.78	0.45	8.97	9.42	0.95	3.81
Agriculture	2.05	7.71	8.76	2.05	7.38	9.43	0.78	3.53
Iron + Steel	10.75	6.51	17.26	10.75	6.20	16.95	0.37	1.83
Cement	21.23	8.74	29.97	21.23	8.25	29.48	0.28	1.67
Brick + Glass	21.97	16.53	38.51	21.97	15.82	37.80	0.42	1.88
Chemicals	5.94	3.01	8.94	5.94	2.86	8.79	0.33	1.71
Fertilizer	20.26	11.75	32.01	20.26	11.17	31.43	0.36	1.84
Textile	1.50	6.52	8.02	1.50	6.30	7.80	0.81	2.82
Pulp + Paper	6.39	3.53	9.92	6.39	3.33	9.72	0.34	2.02
Sugar Refining	1.23	5.99	7.22	1.23	5.77	6.99	0.82	3.16
Metal Products	2.60	1.77	4.37	2.60	1.68	4.29	0.39	1.98
Equipment + Machinery	1.85	4.64	6.50	1.85	4.47	6.32	0.71	2.81
Leather + Footwear	0.28	6.55	6.83	0.28	6.35	6.63	0.96	3.01
Food + Beverage	0.62	6.23	6.85	0.62	6.02	6.64	0.91	3.26
Ind. Nec. + Constr.	0.87	11.24	12.11	0.87	11.00	11.86	0.93	2.07
Road Transport	18.85	17.45	36.29	18.85	15.98	34.83	0.46	4.21
Rail Transport	24.86	20.34	45.20	24.86	18.53	43.39	0.43	4.18
Air Transport	24.43	18.66	43.09	24.43	16.87	41.30	0.41	4.33
Water Transport	22.35	18.99	41.33	22.35	17.28	39.62	0.44	4.31
Commercial	1.61	3.56	5.17	1.61	3.40	5.01	0.68	3.22
Government	3.89	4.23	8.11	3.89	3.94	7.83	0.50	3.58

alternate energy model. Without going into a theoretical exposition about the differences between the two models [see Miller and Blair (1985)], the hybrid-unit energy model will be presented

$$A^{*} = Z^{*}(\hat{X}^{*})^{-1} \quad \dots \quad \dots \quad \dots \quad \dots \quad (7)$$

$$\delta = F^{*}(\hat{X}^{*})^{-1} A^{*} \quad \dots \quad \dots \quad \dots \quad \dots \quad (8)$$

$$\alpha = F^{*}(\hat{X}^{*})^{-1} (I - A^{*})^{-1} \quad \dots \quad \dots \quad \dots \quad (9)$$

Equations 8 and 9 reflect the direct and total energy requirement coefficient matrix, respectively. Following the construction of an inter-industry transaction matrix in hybrid-units, we define a new transaction matrix Z^{*}, a corresponding total output vector X^{*} and final demand vector Y^{*} for which the energy rows are measured in energy units and the non-energy rows in rupees. To isolate the energy rows, the matrix product $F^{*}(\hat{X}^{*})^{-1}$ is constructed of which (1) F_k^{*} is equal to X_k^{*} for the primary energy sectors and (2) F_k^{*} refers to the total energy of type K to the production process, and X_k^{*} refers to total energy output for secondary energy sectors. The ratio of F_k^{*} to X_k^{*} is the conversion efficiency.

When calculating the total energy requirements, only the coefficients of the primary or the secondary energy sources should be summed up. The summation of both primary and secondary energy sources leads to double counting. For that matter, by definition, the separate summation of the total primary and secondary energy requirements must equal when the energy model reflects the energy conservation condition.

In the case of the power sector, an additional refinement can be considered. On the one hand, electricity is a primary energy source when it is generated by hydel power, but on the other hand, it is a secondary energy source when it is generated from oil products and gas. In Pakistan 58.21 percent of all electricity was generated by hydel power stations and 41.79 percent by thermal units in 1979-80. Taking this distinction into account as a rough method we added the respective share (58.21 percent) of total power requirements to total primary energy requirements of other primary energy sources (crude oil, coal, gas).

Table 2 presents the direct, indirect and total physical requirements for Pakistan in 1979-80. When reading the table, we have to keep in mind that the energy requirements of the energy sectors are given in TJ/TJ, and those of non-energy sectors in TJ/1 million Rupees. Thus the textile industry, for example, requires directly 0.5 TJ to deliver goods worth 1 million Rupees to final demand and indirectly 2.2 TJ. The total of 2.7 TJ is equivalent to the cumulated quantity of all energy sources. It is, however, not equivalent to the primary energy content of the products which is only 1.7 TJ (2.0 when including hydropower).

Table 2

Direct and Indirect Energy Requirement in Pakistan 1979-80 in Physical Units[1, 2]

Sector	Energy Requirement (Primary and Secondary Energy Sources)			Primary Energy Requirement				Primary Energy Requirement including Hydel			
	Direct Col. 1	Indirect Col. 2	Total Col. 3	Direct Col. 4	Indirect Col. 5	Total Col. 6	Share Col. 7	Direct Col. 8	Indirect Col. 9	Total Col. 10	Share Col. 11
Crude Oil	0.011	1.015	1.026	0.011	1.002	1.013	14.1	0.011	1.004	1.015	25.0
Coal	0.006	1.021	1.027	0.006	1.008	1.015	56.8	0.006	1.010	1.016	61.4
Gas	0.000	1.004	1.004	0.000	1.002	1.003	92.1	0.000	1.003	1.003	92.8
Power	0.804	1.119	1.923	0.804	0.048	0.852	5.7	0.804	0.630	1.434	5.7
Petrol. Products	1.123	1.131	2.254	1.123	0.057	1.180	4.8	1.123	0.067	1.191	5.6
Non-energy Petrol	11.289	1.321	12.609	11.289	0.572	11.861	4.8	11.289	0.676	11.965	5.6
Mining + Quarrying	0.080	2.534	2.615	0.080	1.393	1.474	94.5	0.080	1.526	1.606	95.0
Agriculture	0.465	2.316	2.781	0.465	1.141	1.606	71.0	0.465	1.399	1.864	75.0
Iron + Steel	3.910	2.693	6.603	3.910	0.811	4.721	17.2	3.910	1.715	5.625	30.5
Cement	11.717	3.204	14.921	11.717	0.754	12.471	6.0	11.717	1.665	13.381	12.4
Brick + Glass	8.313	5.200	13.513	8.313	3.352	11.666	28.7	8.313	3.646	11.960	30.5
Chemicals	2.393	1.538	3.931	2.393	0.374	2.767	13.5	2.393	0.953	3.347	28.5
Fertilizer	7.796	4.109	11.905	7.796	1.182	8.978	13.2	7.796	2.246	10.042	22.4
Textile	0.528	2.189	2.717	0.528	1.159	1.687	68.7	0.528	1.512	2.040	74.1
Pulp + Paper	3.512	1.841	5.353	3.512	0.655	4.167	15.7	3.512	0.924	4.435	20.8
Sugar Refining	0.510	1.732	2.242	0.510	0.960	1.470	65.3	0.510	1.120	1.631	68.7
Metal Products	1.201	0.744	1.945	1.201	0.239	1.441	16.6	1.201	0.433	1.634	26.5
Equipment + Machinery	0.643	1.540	2.183	0.643	0.749	1.392	53.8	0.643	1.008	1.652	61.1
Leather + Footwear	0.125	2.110	2.235	0.125	1.301	1.425	91.3	0.125	1.532	1.657	92.5
Food + Beverage	0.279	1.794	2.073	0.279	1.068	1.347	79.3	0.279	1.229	1.508	81.5
Ind. Nec + Constr.	0.262	4.349	4.611	0.262	3.251	3.513	92.5	0.262	3.656	3.918	93.3
Road Transport	2.400	4.453	6.854	2.400	1.482	3.882	38.2	2.400	1.618	4.018	40.3
Rail Transport	6.482	9.385	15.867	6.482	2.153	8.635	24.9	6.482	2.439	8.921	27.3
Air Transport	2.650	3.904	6.554	2.650	0.861	3.511	24.5	2.650	0.939	3.590	26.2
Water Transport	6.124	8.782	14.906	6.124	2.052	8.176	25.1	6.124	2.154	8.278	26.0
Commercial	0.270	0.965	1.235	0.270	0.455	0.725	62.7	0.270	0.572	0.842	67.9
Government	0.584	1.266	1.850	0.584	0.374	0.958	39.0	0.584	0.620	1.204	51.5

Notes : [1] In TJ/TJ for energy sectors and TJ/1 mill. Rs for non-energy sectors.

[2] The direct energy requirement is the summation of primary and secondary energy sectors.

In the coal industry, e.g., the total primary energy requirement (including hydel) to produce one TJ of final demand is 1.0162 TJ. This quantity consists of one unit primary energy which is delivered to final demand and 0.0162 TJ primary energy consumed at all stages of production.

A more general observation which can be ascertained from the results is, that in more than half of the industries, the direct energy requirements are larger than the indirect requirements. This observation is contradictory to the experiences of industrialized countries, where most of the industries have larger indirect than direct energy requirements. These findings for Pakistan prove the low level of linkages of its economic sectors.

To complete the analysis of the results, we compare the figures calculated in this section with those for West Germany in 1978. Table 3 gives the results.

As the values for Germany were given in DM, they had to be converted into Rupees. The official exchange rate was used for this purpose. As many services and goods are not traded and the exchange rate is influenced by other factors than trade, the official exchange rate might not reflect the difference in purchasing power of the two currencies accurately. Furthermore, we have to consider that the structure of goods of a sector differs from one country to the other. We, therefore, have to read the results of Table 3 only as orders of magnitude and not as exact results.

Table 3

Total Primary Requirements in the FRG (1978) and Pakistan (1979-80)[1]

Sector	FRG	Pakistan
Crude Oil	1.065	1.015
Coal	1.075	1.016
Gas	1.039	1.003
Petrol Products	1.116	1.191
Agriculture	1.277	1.864
Cement	3.620	13.381
Brick + Glass	2.754	11.960
Chemicals	4.070	3.347
Textile	1.667	2.040
Pulp + Paper	2.159	4.435
Food + Beverages	1.271	1.508
Road Transport	1.296	4.018
Rail Transport	3.145	8.920
Air Transport	4.107	3.590

Note : [1] For energy sectors in TJ/TJ; for non-energy sectors in TJ/1 mill Rs output.

The comparison of the total primary energy requirements between the two countries shows that on the one hand, some sectors (e.g. Cement; Brick and Glass) show a substantially higher total primary energy demand per unit of output in Pakistan than in West Germany. This directly proves the inefficient manner of energy use in these sectors. On the other hand, for sectors with a similar requirement of total primary energy use, per unit of output (e.g. Textile; Food; Chemicals; Agriculture), one has to consider the fact that in Pakistan, these sectors and the economy in general, are far less equipped with energy consuming appliances. The almost equal quantities can be accounted for only by the lack of energy efficiency of the existing stock of equipment.

Summarizing the above observations, one can state that there is ample scope for energy conservation in Pakistan. For that matter, increasing energy efficiency will lead to energy conservation without reducing the level of economic activities.

5. ENERGY BALANCE OF FINAL DEMAND

On the basis of the total impact multipliers of energy requirements (i.e. Column 10 of Table 2), a world-wide total primary energy requirement, for the production of the final demand, can be obtained. This estimation allows the assessment of Pakistan's self-sufficiency in energy in all rounds of production, domestic and foreign. Therefore, we apply Equations 10 and 11,

$$E_d^p = F(X^*)^{-1}\,(I-A^*)^{-1}\,Y_d \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

$$E_f^p = F(X^*)^{-1}\,(I-A^*)^{-1}\,Y_f \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

where Equation 10 denotes the demand for domestic and imported primary energy of domestically produced final demand of consumption, investment and exports. Equation 11 denotes the demand for primary energy required abroad for the production of imported final demand. Table 4 gives the results.

From Table 4, it is observed, for instance, that the textile industry, consumed world-wide 45794 TJ of which 40510 TJ was required for final demand met by the domestic products and 5284 TJ for the final demand met by the imported products. For total domestic and imported final demand of consumption, investment, exports and change in stocks, a production of 762 798 TJ primary energy is required the world over. As only 347 232 TJ is produced indigenously (including hydel power), the overall self-sufficiency is only 45.5 percent. This figure, however, is substantially lower than the domestic share of total energy supply (domestic primary energy production plus imported primary and secondary energy) which is 57.4 percent. These results show that Pakistan depends on foreign energy sources to a larger extent than estimated by the official data, due to the fact, that the national accounts data do not include the indirect demand for primary energy embodied in imported goods.

Table 4

Primary Energy Requirement of Domestic and Imported Final Demand
(in TJ)

Sector	Col. 1	Col. 2	Grand Total
Crude Oil	0.0	0.0	0.0
Coal	619.9	0.0	619.9
Gas	14513.4	0.0	14513.4
Power	35666.0	0.0	35666.0
Petrol. Products	66646.3	21820.1	88466.4
Non-energy Petrol	7986.0	0.0	7986.0
Mining + Quarrying	439.1	2923.3	3362.4
Agriculture	117026.1	4590.2	121616.3
Iron + Steel	448.0	0.0	448.0
Cement	466.7	0.0	466.7
Brick + Glass	7249.7	1971.8	9221.5
Chemicals	10754.9	5190.2	15945.1
Fertilizer	383.9	4142.3	4526.2
Textile	40509.8	5284.5	45794.3
Pulp + Paper	3576.3	1647.8	5224.1
Sugar Refining	10821.1	18.6	10839.6
Metal Products	2025.5	951.9	2977.5
Equipment + Machinery	6698.3	19712.6	26410.9
Leather + Footwear	6446.6	36.2	6482.8
Food + Beverage	45561.2	4977.9	50539.1
Ind. Nec. + Constr.	148844.6	1721.9	150566.4
Road Transport	63463.7	0.0	63463.7
Rail Transport	11942.9	0.0	11942.9
Air Transport	11158.0	0.0	11158.0
Water Transport	6382.1	0.0	6382.1
Commercial	31088.2	0.0	31088.2
Government	37090.7	0.0	37090.7
Total	687808.7	74989.3	762798.1

Notes : Col. 1 = Total domestic and imported primary energy requirements of domestic final demand (i.e. consumption, investment, exports).

Col. 2 = Total primary energy requirement of imported final demand (i.e. consumption, investment, exports).

When talking about energy self-sufficiency and dependence, one has to consider that the total energy requirement calculated above is partly used for the production of goods for export. Additional conclusions can, therefore, be drawn from a comparison of direct trade of energy and total primary energy requirements of foreign trade.

As the direct imports of primary and secondary energy sources in Pakistan amount to 257 191 TJ and the exports to 49 955 TJ, the direct energy deficit of the country is 207 236 TJ. However, the direct and indirect deficit of primary energy, that is including the primary energy embodied in imported and exported goods, is substantially larger. Estimations show that the total imports based on intermediate and final demand products require 415 566 TJ for their production and the total exports 126 144 TJ, which results in a deficit of 289 721 TJ (an increase of 40 percent). This again indicates that Pakistan is far more dependent on foreign primary energy than reflected by the direct requirements alone.

6. ENERGY CONSERVATION: COMPARISON OF DIRECT AND TOTAL IMPACTS

Energy conservation, as part of a rational energy policy, means a more efficient use of available energy sources. That it does not adversely affect the level of economic activities and social well-being has been shown by the "energy service" approach (Pintz 1986).

For Pakistan, only few data are available regarding the potential for energy conservation. These data include only direct conservation, since the estimations do not apply energy input-output models. It is, however, obvious that there is also an indirect contribution to conservation. Assuming, for instance, a conservation of petroleum products in one of the industrial sectors, the total output of the oil-refining sector decreases. Therefore, not only less primary oil is required, but also less input from all other sectors. As the production of these inputs requires energy, the lower quantity of inputs demands less energy and less intermediate inputs at the backward round of production. Again, these reduced quantities mean less energy consumption and less input of other intermediate products. This process can be traced back to primary inputs. To sum up, the conservation occurs in all rounds of backward production.

Here, the total primary energy conservation potential is demonstrated for industry, as it has been surveyed best in Pakistan. We assume the following direct conservation potential of the various sectors which is technically feasible and financially profitable (USAID 1985).

Sector	In Percent	Sector	In Percent	Sector	In Percent
9	22.4	14	29.9	19	14.2
10	39.9	15	14.9	20	24.0
11	24.9	16	20.0	21	14.8
12	22.6	17	24.5		
13	30.0	18	19.5		

The direct energy conservation in industry can be assessed: it amounts to 54454 TJ.

When calculating the total impact, we find that instead of 658254 TJ, only 580195 TJ had been required, which brings the total conservation to 78059 TJ. This validates that the direct energy conservation alone underestimates the conservation potential; the total impact is substantially higher (in our example by 43 percent). We have to undestand, however, that part of total conservation had occurred abroad so that Pakistan's energy consumption had not been reduced by the overall difference. A calculation of this effect is, unfortunately, not possible with the presently available data.

7. CONCLUDING REMARKS

This paper has demonstrated that the energy input-output model can be applied as an appropriate tool for integrated supply-demand energy planning in Pakistan, given the present data available. The first (disaggregated) energy input-output table of Pakistan for 1979-80 has been compiled and has been presented so that the hybrid energy input-output model could be developed. By means of various applications it has been shown that this energy model is suitable for integrated energy planning. Apart from the direct energy requirements for the production of goods and services, the indirect energy requirement can also be quantified, because the model explicitly allows for the inter-industry energy and non-energy flows in all stages of production.

The findings of the various applications of the energy model confirm that the indirect effects have a considerable impact on the quantification of the energy costs and physical energy requirements for production and, hence, should be accounted for. Moreover, the findings indicate that the average energy self-sufficiency of Pakistan is much lower than the official data describe. Finally, it has been shown in a preliminary analysis that the energy input-output model is suitable for the quantification of the energy conservation potential.

REFERENCES

Attock Refinery Ltd (1980). *Annual Report 1979-80*. Rawalpindi.

Beutel, J. H. Mürdter (1984). *Input-Output-Analyse der Energiestrome 1975.* München.

Directorate General of New and Renewable Energy Resources (1985). *Energy Year Book.* Islamabad

Havinga, I. *et al.* (1985). "Social Accounting Matrix of Pakistan for 1979-80". Islamabad: Pakistan Institute of Development Economics.

IED Consultants (1983). *Report on the Sixth Plan 1983-88 - Energy.* Islamabad.

KESC, (1982). *69th Annual Report 1980-81.* Karachi.

Miller, R. and P. Blair (1985). "Input-Output Analysis: Foundations and Extensions" Cliffs, Englewood.

National Transport Research Centre (1985). *Transport Statistics* Vol. II, 1984. Islamabad.

Pakistan, Government of (1983). *Census of Mining Industries 1979-80.* Karachi: Federal Bureau of Statistics.

Pintz, P. (1986). "Demand-side Energy Policy as an Alternative Energy Strategy for Pakistan". *Pakistan Development Review.* Vol. XXV, No. 4. pp. 631-644.

Saleem, M. *et al.* (1985). "Final PIDE Input-Output Table of Pakistan's Economy 1975-76". Islamabad: Pakistan Institute of Development Economics. (Research Report Series No. 144).

Subba, Rao S. *et al.* (1981). "Determination of Energy Costs and Intensities of Goods and Services in the Indian Economy – An Input-Output Approach". In M. Chatterji (ed.), *Energy and Environment in Developing Countries.* Chichester pp. 205–221.

USAID (1985). "National Energy Conservation Programme". Islamabad. (Mimeographed).

WAPDA: *Annual Report 1979-80.* Lahore.

Comments on "An Energy Input-Output Table of Pakistan for 1979-80 and Some Applications"

This paper develops the methodology using the energy input-output model for setting up a disaggregated energy input-output table for Pakistan for the year 1979-80. The paper also shows use of the table as an aid to integrated energy planning. My comments are in two parts. First, the classical (Leontief) input-output model is extended to incorporate the distinctions between the primary and secondary energy supplies, and the relevant matrices are developed. This is a significant step to prevent double counting of certain energy inputs. Since industrial production involves energy as well as non-energy quantities, so a hybrid system is adopted: the energy flows are given in energy units of Terajoules (10^{12} Joules), while the non-energy flows are given in monetary terms.

In the case of Pakistan, the monetary flows of the non-energy sectors have been updated from 1975-76 by the RAS-method, while the energy flows have been compiled directly (instead of through the monetary transactions) on the assumption that direct energy data is available more accurately from, (i) the Energy Year Book of the DGER, (ii) a study conducted by IED Consultants for the Sixth Five-Year Plan, and (iii) other subsidiary reports. This assumption is open to some question (for example, the EYB data on non-commercial energy consumption seems too low), and deduction of the energy consumption from the corresponding costs may be more reliable.

Secondly, the effects of total costs are studied in Table 1, which shows the extent of the overestimation due to double counting in the un-modified equations. From the Input-Output table, the authors have derived several other tables viz. Table 2 for direct and indirect energy requirements and Table 3 for total primary energy requirements of domestic and imported final demand. This paper provides valuable insights into the mechanisms of various interactions between sectors, the direct and indirect energy requirments, the overall primary energy requirement and the possible avenues for energy conservation.

The authors have shown that the primary energy requirments in the Cement, Brick and Glass industries in Pakistan were considerably higher than those in West Germany, thus indicating considerable inefficiency in their use of energy. This reflects inefficient burning and the use of obsolescent technologies. They have also stressed the ample scope for the improvement of energy conservation in Pakistan viz.

from 20 percent to 40 percent. In the end, they have made a thought-provoking remark saying that, the average energy self-sufficiency of Pakistan was much lower than that described in the official documents: this is probably in line with a general ostrich-like attitude of officials here and elsewhere.

In conclusion, I, as a Physicist, do not mind a few matrices here and there, but I feel that this paper is highly mathematical, and I doubt if the average energy technologist, or even consultant, in Pakistan can successfully grapple with it. I quote a colleague with an overseas Ph.D., who has been a University Professor of Electrical Engineering; "the paper suggests certain mathematical models which may prove interesting to the economists but are a little too involved for practicing engineers". I wonder if a simpler presentation could be developed to take care of this aspect. After all, mathematics is only a tool for achieving our purpose, which should be operated with a basic understanding.

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