Revising the EIO-LCA Energy, Conventional Pollutants and Global Warming Potential Vectors

It has been suggested that the EIO-LCA model had been overestimating fuel use for certain industries. Initially, we utilized purchase data to estimate fuel use by sector. However, we discovered that this caused overestimation in some sectors. Our data source to date had been a workfile from the Bureau of Economic Analysis (BEA, 2002) that reported year 1992 fuel purchases for each Input-Output sector. We feel that purchases included not only fuel for energy, but also fuel for feedstock, and potentially "pass through" purchases where sectors bought fuel, and resold or transported it to other sectors, thus inflating fuel use in some sectors.

Another flaw we found in our investigation of the original energy vector was that natural gas usage was being underreported. For example, one million dollars of output in the eating and drinking places sector was reported as having used zero natural gas. Upon further investigation, we found that the only purchases of natural gas being reported by the previous vector were those made directly from the extraction companies. One of those major purchasers was Natural gas distribution. However, many commercial and industrial consumers acquire their natural gas from distribution companies, meaning that many consumers, such as those in the eating and drinking places IO sector, were being reported as using zero natural gas. To correct for this, we used the BEA-reported commodity 'Revenues from natural gas distribution' as the estimate for natural gas purchases. These values plus the original natural gas values were utilized whenever the 1992 BEA data was used for rebuilding the energy vector.

Energy

In order to remedy the problem, we probed the various government websites for the necessary data. For the mineral sectors, we used the Fuel and Electric Report published online by the U.S. Census Bureau (USCB, 2002a). This document reports fuel and electricity usage in physical units for the 211 through 213 NAICS industry subsectors for the year 1997. Fuel presented in this report included electricity, coal, natural gas, light fuel oil (distillate or diesel), and heavy fuel oil (residual). The Bridge Between NAICS and SIC (USCB, 2002b) served to map the NAICS sectors to SIC sectors, which were then mapped into BEA IO sectors, using an already constructed map. Although a report in SIC form would have been preferable, one advantage to using the NAICS data is that when the 1997 benchmark table is released later this year, we will not have to search for this data again.

The manufacturing sectors were estimated using the 1998 Manufacturing Energy Consumption Survey (MECS) Consumption of Energy (EIA, 2002a). This report presents fuel and electricity usage by BTU, in 2 and 4 digit SIC form, with the same fuels as above. Those sectors listed only in 2 digit form were mapped to 4 digit form by a weighted average scheme utilizing the 1992 workfile purchase data. We feel this is allowable because most of the major users of energy in this report were reported in 4 digit form, and hence, not needing the weighted average scheme. Any error introduced using the weighted average would be almost negligible.

Energy usage in the transportation sectors was estimated using energy consumption data from the Transportation Energy Data Book (edition 20), published by the U.S. Department of Energy (USDOE, 2000). Table 2.5 reports consumption of energy by fuel type and transportation mode in BTUs. The modes include Highway (auto, motorcycle, bus, light truck, other truck) and Non-Highway modes (air, water, pipeline, and rail) of transportation. Fuels presented were gasoline, diesel fuel, liquefied petroleum gas, jet fuel, residual fuel oil, natural gas, and electricity. Energy use by automobiles (less an estimation of energy usage for taxi cabs utilizing the BEA data), motorcycles, light trucks, and recreational water were assumed to be out of scope for the EIO model, and not included. Diesel usage from trucking was mapped to the following sectors: 'Trucking and Courier Services, except air', 'Wholesale Trade', and 'Retail Trade, except eating and drinking place' using the same method utilized for manufacturing. Energy usage for pipelines was mapped such that natural gas energy usage went to Natural gas transportation (not in our "transportation sector") and all electricity usage went to 'Pipelines, except natural gas'. Energy usage from rail travel was mapped such that 'Railroad and related services' received all diesel fuel usage and all electricity usage went to 'Local and suburban transit and interurban highway passenger transportation', the sector containing local subways and rail transit systems. Although it is unlikely that the allocations are all or nothing, without more detailed data, we feel this is the best we can do.

All fuels and sectors not covered by the above reports were estimated using the previous data source, that is, 1992 workfile fuel purchases with 1992 producer prices (provided by Joshi). Since all manufacturing, mineral extraction, and transportation use is covered in detailed reports, we feel that the purchases reported for all other sectors in the BEA workfile do represent actual use, that is, the probability of use for feedstock or pass through is virtually zero. Also, no better data seems to exist.

Another correction we made to the fuels vector, and very soon to all vectors, is to use an estimated output for 1997. Previously, the coefficients for the vectors were calculated using 1992 values for output. We have estimated 485-sector 1997 output by utilizing the 97-sector output for 1997 and the weighted averages from the 1992 485-sector to 97-sector mapping (BEA, 2001). This will remain the case until the 1997 benchmark IO table is released by the BEA, expected sometime late 2002.

Finally, all data not reported in BTUs was converted using US EPA conversion factors (USEPA, 2002). Data reported in physical units were directly used. Data from the BEA workfile was converted to BTUs first using 1992 Producer Prices (USCB, 2002c, USCB, 2002d), arriving at the proper physical units, and then using the EPA conversion factors. This data was then converted into joules by using 1055 joules per BTU (EIA, 2002b).

Tables 1 and 2 below show comparisons between the old vector, the rebuilt vector, and an energy consumption report published by the EIA entitled State Energy Data Report 1999 (EIA, 2002c). Because the EIA report was given in BTUs, we left the data in the tables in BTUs for easier comparison. The rebuilt vector appears to be a good approximation, whereas the old vector is off by orders of magnitude, except for transportation, where it overestimates usage by only around 50%. We feel that the new energy data vector appropriately represents actual energy use. We have decided that reporting the data in Terajoules as opposed to metric tons is the most appropriate metric.

This allows users to sum up energy data per sector much easier, preventing a proliferation of conversion factors from being required, although electricity usage will be left in million kilowatt hours.

Table 1 Rebuilt and Old vs. EIA Report (in trill BTU)

Sector	Rebuilt Vector	Old Vector	EIA Report	New vs. EIA	Old vs. EIA
Industrial and Commercial	26100	22447000	25700	-2%	-87242%
Transportation	7600	11400	7300	-4%	-56%
Electrical services	20200	17459900	20200	0%	-86335%

Table 2 Rebuilt vs. Old Vector (in trill BTU)

Sector	Old Vector	New Vector	%diff
Industrial and Commercial	22447000	26100	-85904%
Transportation	11400	7600	-50%
Electrical services	17459900	20200	-86335%

Ind and Comm: net energy - lpg, asphalt, road oil, wood, waste, and "other" Petroleum products
Transportation: total - auto energy use (-cabs), l.truck, water recreation, natural gas pipeline (added to I&C), trade (wholesale and retail) diesel use(added to I&C)
Electrical Services: total - nuclear and water power input

Global Warming Potential and Conventional Pollutants

One immediate consequence of the revising the fuels/energy vector is that global warming potential must be revised. The vector is estimated using energy use and emissions factors given in Satish Joshi's thesis, *Comprehensive Product Life-Cycle Analysis Using Input Output Techniques* (Joshi, 1998). These factors are a compilation of EPA AP-42 factors, along with factors from IPCC reports. Since no better approximation seems to be available, we estimate N20 emissions at 10% of NOx emissions. Once emissions of CO2, N20, and CH4 are estimated using these factors, their global warming potential is estimated using values given on the EPA Global Warming Website (EPA, 2002).

The conventional pollutant vector also underwent a minor revision. The current method of using the EPA AIRS database is still the best way (USEPA, 2002). However, in order to include emissions from mobile sources, in particular PM-10 from diesel use, we used the emissions data from the Transportation Energy Data Book (USDOE, 2000). These emissions were mapped according the fuel use in a similar method used to map the fuel usage.

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