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APPENDIX 1
NOTES ON DATA

Data availability and accuracy presented a central problem in the writing of this monograph. Unlike many countries, Singapore does not have a Ministry of Energy or other administrative body dealing specifically with energy affairs. Few aspects of Singapore's energy statistics are covered by official sources. Others are incomplete or completely absent. Published and unpublished unofficial sources use varying definitions, accounting conventions, and conversion factors, adding to the problem of accuracy.

Much of the data presented in this study has been estimated on the basis of industry sources. Besides the specialist trade journals, industry personnel who are based in Singapore and who maintain close contacts with the Energy Program of the East-West Center in Honolulu have constituted the most important sources of information for this study. As noted in the introduction, gaps and inconsistencies in the figures presented are unavoidable, and a margin of error is to be expected. Quantitative data and estimates thus require considerable caution.

Consumption Data

The domestic aggregate energy consumption data presented in Chapter 2 draw heavily from the studies done by Ang (1986, 1987,

1988). The data presented in that work are based on many sources including national and international publications, and unpublished data provided by the utilities and oil companies (see Ang 1986, appendix A). Data on domestic consumption of major petroleum products for 1980–87 (Table 2.2), which exclude bunkers and refinery fuel use and loss, were derived from a Singapore-based affiliate of a major oil company. Figures for gasoline consumption include naphtha.

The energy balance for 1986 (Table 2.3) is from the International Energy Agency's study of energy statistics of non-OECD countries, *World Energy Statistics and Balances 1971–87*. The energy balances given in this source were prepared in close collaboration with the Asian Development Bank, the Statistical Office of the United Nations and the World Energy Conference. Considerable use was made of the World Energy Survey data base of the United Nations. This was supplemented by materials obtained directly from the countries concerned and through wide contacts with industry sources. The energy balance in Table 2.3 is in terms of net calorific value (NCV), which takes into account the latent heat in condensation of water vapour produced during fuel combustion. Oil's NCV is less than its gross calorific value (GCV) by 5 per cent while manufactured and natural gas have an NCV which is less than GCV by 9 to 10 per cent. There is no distinction between the two measures for electricity.

The production and consumption of electricity and gas over 1977–87 given in Tables 2.5 and 2.6 constitute the only energy data available from any national statistical source. The annual reports published by the PUB and conference papers presented by personnel of the Board provide further information on Singapore's electricity and gas utilities.

Trade Data

Although a time series of crude imports volumes for Singapore can be constructed by extracting data from official trade statistics, there are two serious deficiencies in accounting the flows. First, official statistics exclude trade with Indonesia. While official Indonesian statistics of crude exports by destination are available, there is reason

to believe that the reliability of the data on bilateral trade with Singapore is less than satisfactory (Krause 1987*a*, p. 64 fn. 5). Krause (ibid.) suggests that the continued balance of payments surplus reported by Indonesian statistics on that country's trade account with Singapore implies an inadequate coverage of imports. The existence of illicit trade between the two neighbouring countries (Reiger 1985), however, makes the use of Indonesian data on exports to Singapore also potentially hazardous. Data on Singapore's imports of Indonesian crude, including those under third-party processing deals, are provided by what is regarded as the most comprehensive and reliable source, the Jakarta U.S. Embassy's annual *Petroleum Report Indonesia*.

Secondly, crude imports involved in third-party transactions have been officially reclassified and excluded from published statistics since 1980 (*Energy in the ESCAP Region: Policies, Issues and the Potential for Regional Cooperation*, p. 125). The Department of Statistics does not provide a definition of third-party processing. There is some ambiguity involved in the categorizations of "third party" in an industry where transactions over particular parcels of crudes and refined products may occur many times over. In a typical third-party processing arrangement, a trading company or brokerage firm buys crude from a primary supplier, arranges for its refining, and lifts the refined product output in return for a payment of a processing fee. As a working definition of the term "third-party processing" used in industry circles and trade journals, it refers to any processing not done on refiners' own account or under term processing contracts.

Figures for the volume of Indonesian crude processed, including third-party processing deals, have been incorporated in Table 4.5. As it has not been possible to obtain time-series data on third-party processing volumes by source of non-Indonesian crudes, such data have been left out. Third-party processing volumes fluctuate considerably within relatively short time periods, and conservative estimates by Singapore industry sources place the volume of non-Indonesian crudes processed at between 50,000 and 100,000 b/d over 1985–87. Although such large volumes make Table 4.5 seriously incomplete, the table does serve to describe the broad trends in crude throughput. Recent trends in third-party processing activity are discussed where possible in the text.

Production Data

There are no comprehensive published statistics for the volume output of the refining industry in Singapore. The Department of Statistics provides a "Quarterly Index of Production" of manufacturing establishments in the *Yearbook of Statistics Singapore*. Manufacturing establishments, defined as those employing more than ten workers, are classified under the Singapore Standard Industrial Classification (SSIC) at the 3-digit level. The relevant category is Petroleum Refineries and Petroleum Products (code 353/4). The Department also releases a series for the Quantity of Output of Selected Manufactured Products, which, however, includes only three refined products (jet fuel, diesel, and fuel oil).

Table 4.8 gives estimates of refinery output by volume of major products from 1980 to 1987. LPG and non-fuel products constitute small proportions of total output, estimated to be no more than 5 per cent of total output, and are left out. The volume output of each major product was estimated as a residual balance, utilizing figures for total exports and domestic consumption by major product category (for total demand) and total imports by major product category (which, together with domestic output of major products, constitutes total supply). Stock changes and refinery fuel and loss, for which there is no available time-series data, were not initially taken into account. The resulting figures for domestic output of major products were then cross-checked and adjusted for consistency with independent output data available to the Energy Program. Since the figures on exports and imports are based on official trade data, the output figures do not incorporate the product yields of spot processing. While this underestimates the volume output of refined products, there is no reason why the percentage composition of product yields should be skewed.

Measurements and Conversions

Any analysis of an energy economy begins with the conversion of several energy commodities to a common unit of measure. Precise scientific units include the calorie (cal), joule (J), British thermal unit (BTU) and kilowatt-hour (kWh). Units used in commerce and industry such as tonnes of oil equivalent and barrels of oil equivalent

are less precise because the commodities on which they are based do not possess uniform energy content. Nevertheless, for the purposes of this study, units commonly used in industry constitute the most appropriate measures.

The energy measurement unit used throughout the study has been barrels per day (b/d), except in a few cases where convention has set the unit otherwise and where conversion to a b/d oil equivalent would add little to the discussion. The b/d unit is often used as an abbreviation for "one barrel per day for one year", that is, 365 barrels. The approach taken in presenting basic energy data in a common unit is termed the "partial substitution model" (*World Energy Statistics and Balances 1971–87*). In this model, electricity and gas (the only other forms of energy presently significant in Singapore) are expressed in terms of the amount of oil that produces the same amount of heat.

The metric tonne of 1,000 kg. is one of the most commonly used units of weight, and tonnes of oil equivalent (TOE) are often used for measuring units of energy. The table in (A) below converts liquid fuels from TOE measures to b/d oil equivalent measures. (B) similarly converts common measures for gas and electricity to their b/d oil equivalent. (C) gives some useful non-energy conversion factors. (D) lists the most common metric system multiples and naming conventions for electricity measurement.

(A) Conversion Table for TOE and B/D for Liquid Fuels

Crude and Refined Products (thousand TOE)	B/d for 1 Year (oil equivalent measure)
LPG	31.9
Motor gasoline[a]	23.3
Kerosene	21.3
Jet fuel	21.0
Diesel	20.0
Fuel oil	19.1
Crude oil (n.f.d.)[b]	20.0
Petroleum products (n.f.d.)[b]	20.0

[a]Includes naphtha and petrochemical feedstocks.
[b]Not further defined.

(B) B/D Oil Equivalent of Gas and Electricity

1 million cubic feet of natural gas = .450 barrels per day (dry gas)
1 million cubic feet of town gas = .229 barrels per day
1 GWh (gigawatt-hours) of electricity = 5.49 barrels per day (assuming 30 per cent efficiency)

(C) Other Miscellaneous Conversion Factors

1 cubic metre = 37.88 cubic feet
1 cubic metre = 6.289 barrels
1,000 barrels = 2.74 barrels per day for one year
1 barrel = 159 litres

(D) Metric System Multiples and Electricity Conventions

kilo = $\times 10^3$	kilowatt (kW)
mega = $\times 10^6$	megawatt (MW)
giga = $\times 10^9$	gigawatt (GW)