3. Methodology for Data Preparation

3.1 Choice of Start Year, End Year, and Discount Rate

Following data are required to be entered in AIM/Enduse for the start year of calculation – Service demand (for each service kind), Specific service output, Specific energy input, Operating rate, Fixed cost, Operational cost, Stock, Share and Emission coefficient (for each device), Price and Emission coefficient (for each energy kind). Start year should be the latest year for which the above-mentioned data are either directly available from published sources or easily estimated by the user team using the methodology described in section 3.4 of this chapter. It is advised that user teams select 2000 as reference year. However, if required data are not available for 2000, then reference year should be the latest year for which data are available. This should be updated to 2000 once updated statistics are available.

The choice of end year of calculation should depend on the trade-off between i) the need for long term perspective required for GHG mitigation policy analysis, and ii) the level of confidence that the user team can place in long-term projections of service demands and characteristics of future technologies. Most energy optimization models for analyzing technological options for GHG mitigation have 30-50 year horizon. For application of AIM/Enduse, a time horizon extending up to at least 2032 is recommended, since it coincides with Rio+40.

Each year in AIM/Enduse can be treated as either calendar year or financial year. This choice should depend on the definition of year adopted in the majority of sector-level publications of data that the user team refers to from within a country.

For the choice of annual discount rate, the user team is advised to refer to its definition in Appendix A.

3.2 Classification of Region, Energy, Sectors and Services

Region classification is not used in current version of AIM/Enduse model. Only one region, i.e. the country for which the model is to be set up, is considered.

Classification of energy should be based on standard classification used in IEA Energy Balance Tables or IPCC documents. Appendix H lists a standard classification of energy, calorific values, emission coefficients, and prices.

Choice of sectors and services should depend on i) importance of a sector in national energy system, ii) importance of a service in its sector's energy use, and iii) availability of data for service demand and technologies used for satisfying a service. Choice of unit of service demand should also depend on the availability of data. As far as possible, the unit of service demand should be such that it is a measurable representation of the service being provided. Appendix D gives two possible classifications of sectors and services. Exact classification adopted by the user team should depend on its own judgment.

3.3 Classification and Definition of Technologies

3.3.1 Energy device

The extent of detail while classifying the devices should depend on the availability of technology level data from published sources. In AIM/Enduse, a technology is represented in terms of a single device or a sequence of multiple devices (refer to Appendix A for definitions of device and technology). Each device is identified by its energy and material inputs and service outputs. A device can have multiple inputs and multiple outputs. Appendices J and L show examples of technologies as represented in AIM-India and AIM-Japan respectively. Technologies of most industrial processes can be represented in terms of sequence of multiple devices. Such disaggregated representation of technologies allows the user to introduce improvement options at each distinct device or stage of operation.

3.3.2 Removal process

This classification can be based on standard removal processes available in industries for reducing SO_2 or NO_x emissions. SO_2 removal processes can be broadly categorized as coal washing (pre-combustion stage), limestone addition (in-situ combustion stage), and flue gas desulfurization (post-combustion stage) technologies. NO_x removal processes can be broadly categorized as removal technologies used for stationary sources of emission like power plants, industrial boilers and furnaces, and those used for mobile sources of emission like transport vehicles. Appendix G provides a partial list of standard removal processes and their characteristics.

3.4 Estimation of Data for Start Year

3.4.1 Estimation of service demands

Data for service demands in start year should be obtained from published sources. Reliable domestic sources of information (e.g. publications by ministries, government agencies, industry associations, independent research organizations) should be preferred over international sources. Appendix E provides a list of some reliable international publications of country level statistics.

Choice of units for service demands is important. While on one hand the unit of a service demand should represent a good measure of the service, on the other hand it should be convenient from the point of estimating data (see Appendix D for possible choices of units). In case the data for a service demand is not available in desired unit, then either it should be converted to desired unit or the unit of service demand should be changed. Reasonable assumptions need to be made for conversion of data to desired unit. Table 3.1 shows some examples of methodology for conversion of data.

Table 3.1. Examples of methodology for conversion of service demand data in desired unit

Ex. no.	Service	Desired unit A	Unit in which data is available B	Additional assumptions required	Expression for conversion to desired unit
1	Road passenger transport	Person-km	Vehicle-km	C = Average persons per vehicle	A = B * C
2			Bi = Vehicle-km in vehicle category i	Ci = Average persons per vehicle in category i	A = ∑ (Bi * Ci)
3			Bi = No. of vehicles in category i	Ci = Average persons per vehicle in category i Di = Average yearly km traveled by a vehicle in category i	A = ∑ (Bi * Ci * Di)
4	Residential cooking	Kgoe of useful energy service for cooking	Bi = Kgoe of energy used by stoves of type i	Ci = Average efficiency of stoves of type i	A = ∑ (Bi * Ci)
5			No. of households	C = Kgoe of daily useful energy service required for cooking by a typical household	A = B * C
6	Residential lighting	Lumen-hr	Bi = KWh of electricity used by lamp of type i	Ci = Lumens of light delivered by lamp of type i Di = Watt rating of lamp of type i	A = ∑ {Bi * (Ci / Di) * 1000}

Note: These are mere examples; Exact methodology for estimating a particular service demand will depend on the specific data that are available to the user team.

3.4.2 Estimation of data for devices

Following data are required by AIM/Enduse for each technology in the start year: Fixed cost, Operational cost, Life, Specific service output, Specific energy input, Stock, Share, Operating rate, and Emission coefficients (for SO_2 and NO_x). These data should be estimated based on a combination of following steps:

1. Obtaining data from published sources: Often, all the data required for AIM/Enduse can not be obtained directly from published sources.
2. Using standard assumptions about efficiency, cost, and other parameters: Such assumptions should be made if all the data can not be obtained from published sources. Appendices F, K and M provide some standard assumptions for selected technologies.
3. Final estimation using bottom-up accounting approach: Final estimation of data required by AIM/Enduse should be made using both the data obtained from published sources and the standard assumptions, and making sure that

fundamental relationships between different parameters are not violated. Table 3.2 shows some examples of this methodology.

Table 3.2. Examples of methodology for estimation of device data in start year

Ex. no.	Parameters for which data or standard assumption are available	Desired unit of device	Additional assumptions required	Estimation of parameters required by AIM/Enduse			
				Specific service output	Specific energy input	Stock	Share
1	Ai = Population (no. of physical units) of device i, for all devices satisfying a particular service Bi = Quantity of service output delivered per unit input of fuel k by device i	One physical unit of device	Ck = Calorific value of fuel k Di = Average activity of one unit of device i in a year (unit of this may be hours, or service output delivered) Ei = Amount of fuel k used by a unit of activity of device i	Bi * Di * Ei	Di * Ei * Ck	Ai	Ai * Bi * Di * Ei / ∑ (Ai * Bi * Di * Ei)
2	Ai = Service output delivered in a year by device i Bi = Quantity of service output delivered per unit input of fuel k by device i	One physical unit of device	Ck = Calorific value of fuel k Di = Activity of one unit of device i in a year (its unit may be hours, or service output delivered) Ei = Amount of fuel k used by one unit of activity of device i	Bi * Di * Ei	Di * Ei * Ck	Ai / (Bi * Di * Ei)	Ai / ∑ Ai
3	Ai = Amount of fuel k used in a year by device i Bi = Quantity of service output delivered per unit input of fuel k by device i	One physical unit of device	Ck = Calorific value of fuel k Di = Activity of one unit of device i in a year (its unit may be hours, or service output delivered) Ei = Amount of fuel k used by one unit of activity of device i	Bi * Di * Ei	Di * Ei * Ck	Ai / (Di * Ei)	Ai * Bi / ∑ (Ai * Bi)
4	Ai = Amount of fuel k used in a year by device i	One unit of service output	Ck = Calorific value of fuel k	1	(1 / Bi) * Ck	Ai * Bi	Ai * Bi / ∑ (Ai * Bi)

	Bi = Quantity of service output per unit input of fuel k by device i	of device

Table 3.2 Examples of methodology for estimation of device data in start year (continued)

Ex. no.	Parameters for which data or standard assumption are available	Desired unit of device	Additional assumptions required	Estimation of parameters required by AIM/Enduse			
				Specific service output	Specific energy input	Stock	Share
5	A = Total energy used in a year by all devices satisfying a particular service Bi = Quantity of service output delivered per unit input of fuel k by device i	One unit of service output of device	Ck = Calorific value of fuel k Di = Share of device i in total energy used A	1	(1 / Bi) * Ck	Bi * Di * Ai / Ck	(Bi * Di * Ai / Ck) / ∑∑ (Bi * Di * Ai / Ck)

Note:
i) These are average estimates for each classification of device. If the user selects aggregate classification of device that in reality comprises multiple types of devices with different characteristics, then average data for the aggregate classification must be entered in ‘Stock’ table (see section 8 in Appendix C) and data for most recent or efficient type of device in that classification must be entered in ‘Device’ table (see section 6.1 in Appendix C). Data for both aggregate classification of device and specific type of device can be estimated using methods described in this table.
ii) Estimates for Fixed cost, Operational cost, and Life of a technology can be directly obtained from published sources like manufacturers’ manuals.
iii) These are mere examples; Exact methodology estimating a particular technology’s parameters will depend on the specific data that are available to the user team.

3.4.3 Estimation of data for removal processes

Appendix G briefly outlines the methods used for estimation of characteristics of some standard removal processes used in power plants, industries and transport sector. It also provides estimates for these processes.

3.5 Projection of Service Demands

It must be realized that long-term demand projections may not be accurate. Therefore, it is recommended that in addition to selecting a forecasting methodology that incorporates most determinants of service demands, users must also consider multiple demand scenarios in order to assess robustness of model results to accuracy of demand projections. Several alternative approaches exist for projecting service demands over 30-50 years. We briefly describe some general approaches below.

3.5.1 Obtaining projections from authoritative sources

User team should first obtain projections of service demands from authoritative sources like governmental five-year plans or expert estimates. Often projections for all service demands cannot be obtained from such sources. Moreover, projections available are typically for near-term and not for 30-50 years. In some cases, assumptions about growth rates may be made based on near-term projections.

3.5.2 Using a quantitative method to project service demands

A wide spectrum of quantitative methods can be used for long term projection of service demands. Complexity and data requirement of methods vary widely in this spectrum. On one end, complex models like CGE (e.g. AIM/CGE) that model the structure of an economy, can be adopted. On the other end, statistical methods like linear regression, or non-linear regression using an exponential or polynomial function, can be adopted.

While using such methods the user may sometimes project a service demand as a function of 'drivers'. Table 3.3 lists examples of drivers for various services. Choice of method and drivers is often restricted by the availability of time-series data. Judgment of user team is crucial in selecting the method and drivers.

Examples of methodologies for projection of demands adopted in case of India and Japan are illustrated in chapters 4 and 5 respectively. It must, however, be noted that these are mere examples and not necessarily the most desirable approaches in the context of a particular country.

Table 3.4. List of possible drivers for service demands

Service	Driver
Services in agriculture sector	GDP; Gross physical output of agriculture; Gross monetary output of agriculture; Irrigated area
Services in transport sector	GDP; Gross monetary output of transport
Road transport services	Length of roads; Road vehicles per km road
Road passenger transport service	Private vehicles per capita
Rail transport services	Length of railway tracks; Rail traffic per km
Freight transport services	Revenue from freight transport
Services in residential sector	Private final consumption expenditure; Number of households; Income per household;

Services in urban residential sector	Number of urban households; Income per urban household
Services in rural residential sector	Number of rural households; Income per rural household
Services in commercial sector	GDP; Gross monetary output of commercial services
Services in restaurants / hotels	Value added / employment in restaurants / hotels
Services in hospitals / clinics	Value added and employment in hospitals / clinics
Services in corporate and government offices	Value added in corporate and government offices
Services in industrial sector	GDP; Industry value added
Services in a particular industry	Gross monetary output of a industry

3.6 Projection of Improvement in Devices

Improvements in efficiency, cost and emission coefficient of a device occur over time due to several factors including 'learning-by-doing' and 'economies of scale' effects. Following are some examples of approaches that can be used for these projections:

3.6.1 Obtaining improvement targets from authoritative sources

Sometimes near-term improvement targets can be found in publications of sectoral plans by governments/government-agencies.

3.6.2 Top-runner methodology

An approach popularly known as 'top-runner' methodology in Japan, assumes that the 'best' performing technology in a particular year will become 'average' performing after a certain period of time. This period of time can vary from 2-5 years in case of a rapidly growing industry in a growing economy to 10-20 years in case of a matured industry in a slow economy. Judgment of user team is crucial in making these assumptions.

3.6.3 Assuming fixed rates of improvement

Fixed rates of improvement can be assumed for each technology based on recent trends and considering efficient technologies from developed countries as benchmarks. Appendix F provides improvement potential of selected advanced technologies. Appendix M provides characteristics of technologies in AIM-Japan including advanced technologies in Japan.

3.7 Projection of Maximum Share of Devices

Ideally, maximum share of a device should be 100% from the year of its introduction. This implies that service demand in a given year will be met by most economic devices (with least annualized capital cost and running cost for newly recruited devices, and least running cost for old devices). However this phenomenon is not fully observed in reality especially in developing economies.

In the past, several socio-economic-institutional barriers existing in developing countries have prevented early penetration of efficient devices. Although this situation is changing with ongoing economic reforms, several barriers continue to exist. Therefore, upper bounds on penetration of new and future technologies need to be introduced in different sectors. User teams should use their understanding of the domestic socio-economic-institutional context and opinions of experts to decide upper bounds on future share on devices.

Several factors that are not incorporated in costs, play crucial role in determining competitiveness of technologies in certain markets even in developed countries. For example, reliability of performance during use, service quality including perceived quality, effectiveness of delivery and maintenance services, and constraints of production or delivery capacities, are among such factors. User teams are advised to consider all such factors while applying upper bounds on shares of technologies.

In addition to projecting maximum shares under business-as-usual scenario, user teams should build additional scenarios based on different forecasts about progress of economic and institutional reforms in future.